LNAPL Active Recovery System Conceptual Site Model

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The Hartford Area Hydrocarbon Plume Site
Hartford, Illinois

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EXECUTIVE SUMMARY

This Light Non-Aqueous Phase Liquid (LNAPL) Active Recovery System Conceptual Site Model (CSM) Report was prepared for The Hartford Area Hydrocarbon Plume Site (Site) in Hartford, Illinois to understand the LNAPL distribution and characteristics and, therefore, facilitate the development of the most appropriate LNAPL recovery method(s).

The Site geology consists of alternating alluvial deposits of clay and silt. This alluvium overlies alluvial sands and sandy glacial outwash that ranges from 60 to 150 feet thick. The permeable zones within the alluvium are locally known (in descending order) as the North Olive, the Rand and the EPA Strata. These deposits are overlain and bounded by several clay deposits identified (in descending order) as the A Clay Stratum, which overlies the entire Site, and localized deposits of the B Clay, the C Clay, and the D Clay Strata. The regionally extensive Main Sand underlies the fine-grained alluvial deposits.

Groundwater within the North Olive and Rand Strata, during the period of October 2004 through October 2005, occurred as isolated areas of perched water though, immediately northeast of the Site, groundwater in the Rand Stratum appeared to be confined. Groundwater in the EPA Stratum, during this period, has been confined and hydraulically connected to the Main Sand. The Rand and EPA Strata both reflected a groundwater divide immediately northeast of the Site. The divides trended along a general northwest/southeast axis with groundwater flow on the southern sides of the divide being in a southwesterly direction towards Hartford and that on the northern side flowed away from Hartford. As groundwater in the EPA Stratum flowed southwesterly beyond the extent of the underlying D Clay Stratum, it merged with the Main Sand groundwater flow. Groundwater in the Main Sand, during this period, was confined where it underlies the C Clay and the D Clay Strata in the northern area of the Site. However, the Main Sand became unconfined generally south of West Date and East Forest Streets. The local groundwater flow in the Main Sand has generally been to the north-northwest due to large-scale water pumping for industrial production processes located north of the Site.

Maps from previous site investigations have shown LNAPL within the Main Sand based on gauging of monitoring wells. In 1978, three primary areas of LNAPL accumulation were depicted. The largest area was shown as being centered under Elm Street in the center of northern Hartford. An intermediate area was shown as being centered under Birch Street, also in the center of northern Hartford while the

smallest area was depicted adjacent to North Olive Street between East Cherry and East Date Streets. In 1982, the depicted LNAPL extended just beyond Rand Avenue and the three separate LNAPL areas identified in 1978 were now shown as being connected. A new observation consisted of a small isolated, and separate, area of LNAPL immediately east of the intersection of East Elm and North Olive Streets. The 1978 and 1982 apparent LNAPL thicknesses were essentially the same, with the exception of the newly depicted LNAPL area. In 1990, the identified LNAPL extent was significantly smaller. The gauged extent of LNAPL appears to have been reduced due to LNAPL recovery efforts that began in 1978. These efforts consisted of the operation of recovery wells since the late 1970s and, subsequently, operation of a soil vapor extraction (SVE) system and an additional recovery well since the early 1990s. More recent Site investigations since 2004 have observed isolated LNAPL in both the Rand and EPA Strata. However, the recent findings in both the Rand and EPA Strata are not considered to represent new or separate LNAPL areas but rather are simply a result of additional investigative data points.

Characterization of the LNAPL in the Main Sand reveals it is comprised predominantly of gasoline range organic (GRO) compounds though mixtures of GROs and diesel range organic (DRO) compounds have been found in the northern and easternmost portions of Hartford. LNAPL samples from both the EPA and Rand Strata, comparatively, consisted predominantly of DROs though there were GROs detected within the LNAPL in the EPA Stratum. LNAPL soil saturations (i.e., the percentage of the soil pore space containing LNAPL) ranged from 0 to 10.2% with only one sample exhibiting a higher range of saturation (21.8 to 40.2%).

Residual LNAPL is found to some degree in all of the permeable strata and is also present within the intervening clay strata. However, mobile LNAPL (sufficient saturation and volume to flow into a well) is primarily restricted to the Main Sand Stratum. The areas of shallowest identified residual LNAPL were detected at ROST locations at North Olive Street, Elm Street and near Rand Avenue. However, the identified LNAPL extent in the North Olive, Rand and EPA Strata and the interpreted extent in the clay strata are both limited in comparison to the extent encountered in the Main Sand Stratum. The fluctuating Main Sand groundwater surface serves as the approximate bottom (or vertical extent) of the observed LNAPL. In general, the LNAPL (within the Main Sand) is bounded by Watkins Street to the south and Illinois Route 3 to the west.

The present-day extent of the LNAPL within the Main Sand has decreased compared to the apparent historical maximum extent. This may be due, at least in part, to previous remedial effort(s). The reduction of the gauged LNAPL extent since 1978 suggests the LNAPL is currently stable and is not migrating. The LNAPL saturations indicate that the existing LNAPL cannot, and does not, form a “pool” beneath Hartford, rather it occurs as isolated, relatively immobile lenses of disseminated product in the soil pores.

1.0 INTRODUCTION/PURPOSE

This document was prepared, on behalf of the Hartford Working Group (HWG), as part of the process to meet the requirements of the Administrative Order on Consent (AOC) with the United States Environmental Protection Agency (USEPA) in the matter of The Hartford Area Hydrocarbon Plume Site (Site) (Docket No. R7003-5-04-001) (USEPA, undated). Clayton Group Services, Inc., *A Bureau Veritas Company* (Clayton), was retained by the HWG to prepare the Light Non-Aqueous Phase Liquid (LNAPL) Active Recovery System Conceptual Site Model (CSM) Report. The HWG is comprised of the Atlantic Richfield Company (Atlantic Richfield), The Premcor Refining Group Inc. (Premcor), Shell Oil Products US (Shell) and Sinclair Oil Corporation (Sinclair).

The LNAPL CSM Report addresses the area associated with the identified LNAPL located in the northern portion of Hartford, Illinois. LNAPL is an environmental industry term used to identify the presence of petroleum, a mixture of organic molecules, within the subsurface. It is desirable to remove LNAPL to the extent practical from the subsurface because of the potential to volatilize (offgas) into the unsaturated (vadose) zone creating vapors that may reach the surface and enter buildings or impact other receptors. In addition, though petroleum is only slightly soluble in water, its presence may result in exceedances of certain groundwater objectives. The need for a CSM for any petroleum-impacted site is critical because the distribution and behavior of LNAPL is site-specific and, consequently, potential recovery methods cannot be predicted by comparison to other sites.

Data collected by Clayton during 2003, 2004 and 2005 regarding the geology, hydrogeology and nature and extent of the LNAPL is presented in this CSM. ENSR Corporation (ENSR 2004, 2005), working in cooperation with Clayton on behalf of the HWG, has also provided investigative data obtained in 2004 and 2005 which has been reviewed for this CSM. The CSM presents the information and data available at the time of preparation of the document.

The purpose of this report is to present information regarding the identified LNAPL at the Site, including subsurface distribution, and characterization within the context of the physical setting. This LNAPL CSM provides the basis to facilitate the development of appropriate LNAPL recovery methods for the Site.

2.0 SITE DESCRIPTION

2.1 LOCATION AND SETTING

Hartford, Illinois is located in Madison County on the east bank of the Mississippi River upstream from St. Louis, Missouri. Hartford lies approximately 3,000 feet east of the Mississippi River. The Shell Oil Company Tannery property and the Premcor Terminal/Former Refinery facility are located directly east of Hartford while the Shell Rand Avenue Site is located to the northeast of the Village. The Hartford Wood River Terminal is located directly north of Hartford, across Rand Avenue. The BP (fka Amoco) Former Refinery Facility is located north-northeast of Hartford across Rand Avenue. The ConocoPhillips facility (former Shell facility) is located east of the Premcor Facility with a portion also abutting the north boundary of Premcor. Numerous underground petroleum pipelines are present in the area including three corridors located in the northern portion of Hartford. These corridors include the Elm Street corridor, the North Olive Street corridor and the Rand Avenue corridor. The general location of Hartford, Illinois, along with the site and adjoining property boundaries are shown in Figure 2-1.

The geographical region around Hartford is collectively known as the American Bottoms, a shallow valley 30 miles long and 11 miles across at its widest point (Schicht 1965). The present landscape and underlying 130 feet of unconsolidated deposits beneath the Hartford area were created by alluvial and glacial processes during the last 125,000 years. The Mississippi River, the dominant creator of this landscape, frequently changed its course during the Pleistocene period. During this period, the valley was filled with sandy glacial outwash known as the Mackinaw Member of the Henry Formation.

The uppermost geologic unit is the Cahokia Alluvium, which consists of sands, silts, and clays of channel, floodplain, and modern river origin. In recent times, the migration of the Mississippi River across the bottomlands has reworked the upper part of the valley fill, while spreading floodwaters deposited silt and clay along the sides of the channel and in backwater areas. The channel migration, cut-and-fill, and flooding have produced complex heterogeneous deposits.

The Cahokia sands and Henry Formation outwash deposits range in thickness from 60 to 150 feet. These deposits comprise the most extensive and thickest aquifer in the region. In the Hartford area, this

aquifer is referred to as the Main Sand. The Main Sand Aquifer is the primary source for large-quantity water production in the Hartford area.

The Hartford site boundaries have been defined in the AOC as being bounded by Rand Avenue to the north, the nearest railroad tracks to the east side of Olive Street to the east, Donna Drive and the south boundary of Hartford Park to the south, and Illinois State Highway 3 to the west. The Hartford site boundaries may differ from the Hartford corporate boundaries. Figure 2-2 shows the ground surface topography of the northern portion of Hartford.

2.2 SITE HISTORY AND PREVIOUS WORK

Historical aerial photographs are presented in Appendix A. In general, environmental concerns are located within an area bounded by Hawthorne Street to the south, North Olive Street to the east, Illinois State Highway 3 to the west, and Rand Avenue to the north (Figure 2-3) (Clayton 2004a). Therefore, investigative and remedial activities have focused on this area.

Since 1966, odor complaints along with occasional fires in subsequent years have been documented in buildings at the Site. These issues have both been attributed to petroleum vapor intrusions. In 1978, petroleum had been identified, in monitoring wells, and depicted as underlying the majority of northern Hartford. In 1978 and 1979, two wells were installed in Hartford to recover hydrocarbon. Recovery well RW-1 was installed on property located on the east side of North Delmar Avenue just north of West Forest Street. RW-2 was installed on the west side of North Olive Street midway between East Cherry and East Date Streets. In 1992 a Vapor Control System (VCS) was installed at the Site to further address the identified problems. The VCS was designed as a soil vacuum extraction (SVE) system to extract petroleum vapors from the unsaturated zone where residual LNAPL was present and from the top of the LNAPL hydrocarbon in the Main Sand. A third product recovery well was installed in the early-1990s on the south side of East Birch Street between North Market and North Olive Streets.

Investigations conducted in 1982 indicated the extent of gauged petroleum beneath the Site had not changed significantly since 1978. However, 1990 investigations indicated the LNAPL extent had decreased. Major subsurface investigations and interim remedial activities were conducted by the HWG during 2004. The investigations included cone penetration testing (CPT)/rapid optical screening tool

(ROST) activities (Clayton 2004b). The ROST enables identification of microscopic droplets of product present within the soil matrix of the subsurface through the use of a laser, which causes the product to fluoresce. Subsequent activities included borings and monitoring probe/well installations with chemical and geotechnical soil analysis, baildown tests and hydrocarbon characterization by simulation distillation analyses (Clayton 2004c). New soil vapor extraction (SVE) wells were also installed to enhance the existing VCS.

In 2005, the HWG conducted further work including additional borings and associated monitoring probe/well installations with associated chemical and geotechnical analyses. Subsequently, the HWG completed additional CPT/ROST investigative activities along with additional baildown tests and hydrocarbon characterization by gas chromatogram analyses. Finally, soil core samples were obtained to further evaluate LNAPL mobility and recoverability. Additional new soil vapor extraction (SVE) wells were also installed to further enhance the existing VCS.

2.3 GEOLOGY/HYDROGEOLOGY

A generalized interpretation of the subsurface geology in the investigation area was developed to simplify the recognition and identification of the various geologic strata within Hartford. Two generalized cross sections trending west to east, and one trending north to south are shown in Figure 2-4. The geologic units consist of alternating alluvial deposits of clay and silt overlying the regionally extensive Main Sand. The permeable zones within the alluvial deposits have been identified (in descending order) as the North Olive Stratum, the Rand Stratum, and the EPA Stratum. These deposits are overlain and bounded by several clay deposits identified (in descending order) as the A Clay, B Clay, C Clay, and D Clay Strata to simplify the identification of the individual clay strata. A finer- grained portion of the Main Sand is referred to as the Main Silt. The Main Silt overlies and is hydraulically connected to the Main Sand.

The North Olive Stratum is composed primarily of silt with lesser amounts of clay and trace sand. The Rand Stratum is also composed primarily of silt with lesser amounts of clay and trace sand. The composition of the Rand Stratum is similar to that of the North Olive Stratum, and also that of the Main Silt in some areas. The EPA Stratum is composed primarily of sand with lesser amounts of silt and trace clay. The Main Silt consists primarily of silt to fine-grained sand with varying amounts of clay. The grain

size of the Main Sand is generally coarser than the deposits in the Main Silt. The clay strata are generally silty clays.

A sequence of alternating alluvial clay and silt deposits (North Olive and Rand Strata) overlie much of the laterally extensive and massive deposits of the Main Sand throughout northern Hartford. The uppermost clay deposit, referred to as the A Clay Stratum, forms the upper deposit throughout Hartford. Another clay deposit, referred to as the B Clay Stratum, underlies and defines the extent of the North Olive Stratum, where present, and overlies the Rand Stratum. The Rand Stratum, where present, is underlain by another clay referred to as the C Clay Stratum. The C Clay Stratum overlies the EPA Stratum, where present, and Main Sand. A fourth clay deposit referred to as the D Clay Stratum, underlies and defines the extent of the EPA Stratum and overlies the Main Sand.

The North Olive and Rand Strata grade laterally and are hydraulically connected with the Main Silt, where the B and C Clay Strata pinch out south of Watkins Street. Based on the geotechnical data and stratigraphic analysis, the Main Silt is an extension of the North Olive and Rand Strata. Further details regarding the site geology are presented in Appendices B, C and D.

Areally extensive deposits of unconsolidated valley fill along the Mississippi River cover approximately 175 square miles from south of Alton to south of Cahokia, Illinois. These valley deposits average 120 feet thick and are known as the American Bottoms. The American Bottoms encompasses an extensive aquifer along the eastern banks of the Mississippi River. The American Bottoms Aquifer is the aquifer of interest and it is referred to as the Main Sand Aquifer at the Site. The overlying North Olive and Rand Strata at the Site contain limited areas of perched groundwater. The confined EPA Stratum is hydraulically connected to the Main Sand.

Natural groundwater movement beneath the American Bottoms is westerly, draining from the limestone bluffs (east wall of the floodplain valley) located east of Hartford, to the Mississippi River (Engineering-Science 1992). However, the natural movement of groundwater in the American Bottoms has been altered in the Hartford vicinity due to large-scale industrial water pumpage. The combined pumping rate from these areas is greater than 10,000 gallons per minute (GPM) (Farmayan et al., 1998). The withdrawal of water to be used in industrial production processes has created cones of depression in the water table in the vicinity of Hartford to the north (on BP Amoco property), and to the northeast and the

northwest (on ConocoPhillips property). In addition, pumping is conducted at the Premcor Facility to the east and by the Village of Hartford within the southwestern portion of Hartford. Figure 2-5 presents the approximate locations of the pumping centers. In general, the net effect of this drawdown has resulted in localized altered flow in the Main Sand to the north and northwest.

Groundwater elevations within the Main Sand have fluctuated significantly over the years. Site data indicates that the groundwater elevation neared a high of approximately 416 feet mean sea level (MSL) during 1993 (Premcor 2003). Historically, groundwater elevations in the Hartford area have been as low as approximately 380 to 385 feet MSL in the mid-1950's, which is approximately 15 to 20 feet lower than present conditions (Schicht, 1965). This low was attributed to a period of maximum industrial pumping of groundwater in the area and the lowest mean Mississippi River stage.

The North Olive Stratum has only contained scattered areas of perched water since October 2004. Therefore, a representative groundwater map of this stratum only presents the elevation data and saturated thickness identified in October 2005 (Figure 2-6). A generalized groundwater flow map of the Rand Stratum indicates a groundwater divide, located northeast of the Site, trending along a general northwest/southeast axis (Figure 2-7). Groundwater flow on the southern side of the divide is in a southwesterly direction towards Hartford and that on the northern side flows away from Hartford. In general, groundwater in the Rand Stratum, south of Rand Avenue, is also considered to represent localized areas of perched water.

The generalized groundwater flow map of the EPA Stratum indicates a groundwater divide, located northeast of the Site, trending along a general northwest/southeast axis (Figure 2-8). Groundwater flow on the southern side of the divide is in a southwesterly direction towards Hartford and that on the northern side flows away from Hartford. However, as groundwater flows southwesterly beyond the extent of the D Clay Stratum, it flows northwestward within the Main Sand because these strata are hydraulically connected (Figure 2-9).

The generalized groundwater flow map of the Main Sand indicates a groundwater flow trend that is northerly to northwesterly within Hartford with localized northeasterly flow on the east side of the Village between Hawthorne and Elm Streets (Figure 2-10). The overall northerly groundwater flow direction at the Site is consistent with historical interpretations and the operation of the pumping centers at the

ConocoPhillips River Dock and Amoco BP properties. Further details regarding the site hydrogeology are presented in Appendix E.

2.4 IN-SITU HYDRAULIC CONDUCTIVITY TESTING

Clayton (2004c, d and in-progress a) conducted both field and laboratory tests to evaluate permeability of the strata in the northern portion of Hartford (Tables 2-1 and 2-2). The testing included in-situ slug tests and laboratory permeability analyses. The North Olive Stratum hydraulic conductivity ranged from 2.9E-04 to 1.4E-06 centimeter/second (cm/s) (8.9E-05 average) in the area of the Hartford Community Center. At this same location, the hydraulic conductivity of the clay strata ranged from 1.7E-04 to 6.0E-09 cm/s (5.7E-05 cm/s average). The Rand Stratum hydraulic conductivity ranged from 7.9E-03 to 5.5E-05 cm/s (2.8E-03 cm/s average). In the northeastern portion of Hartford, the hydraulic conductivity of the EPA Stratum ranged from 3.8E-04 to 1.5E-05 cm/s (2.0E-04 cm/s average). The hydraulic conductivity for the unconfined Main Sand, in the central portion of Hartford ranged from 1.6E-02 to 3.1E-02 cm/s (2.2E-02 cm/s average or 61 feet/day average). Pump tests performed at the Premcor Facility suggest the hydraulic conductivity of the Main Sand is on the order of 1.0E-01 to 1.0E-02 cm/s (Clayton 2005a).

Based on the permeability testing and slug tests, the average hydraulic conductivity values differs by two orders of magnitude between the North Olive and Rand Strata, though there appears to be no significant difference between the North Olive Stratum and the clay strata. However, hydraulic conductivity data derived from slug testing provides results that can vary within one order of magnitude. Furthermore, the hydraulic conductivity analyses of these strata are limited in both number and extent. The average hydraulic conductivity of the EPA Stratum was within the range of values for both the North Olive and the Rand Strata. As expected, there is a significant difference between the Main Sand average hydraulic conductivity results and those of the overlying strata. The difference between the Main Sand and the overlying alluvial silts and clays ranges from one to three orders of magnitude.

3.0 LNAPL FINDINGS

Clayton (Clayton 2004b, c, in-progress a) has generally defined the lateral and vertical extent of the LNAPL at the Site. Data points for this definition were controlled by available access areas, rights of way and associated utility corridors and easements. The LNAPL extent has been determined by two primary means, the ROST investigations and the presence of product in monitoring probes/wells. The ROST identifies LNAPL, which may or may not be of sufficient saturation and volume to flow into a well. ROST-identified LNAPL, which is not of sufficient saturation and volume to flow into a well, is termed residual LNAPL. The permeable strata, underlying the Site, provide the primary pathways for liquid and vapor (through volatilization) migration of LNAPL throughout the subsurface, thus, the focus of this section is on the LNAPL occurrence in these strata. The LNAPL composition has also been characterized primarily by evaluation of gas chromatographs, simulated distillation analyses and other physical analyses (e.g., density, interfacial tension, saturations and viscosity). Currently, Clayton is evaluating this data to develop LNAPL remedy selection(s).

Petroleum hydrocarbons may exist in one or more of four phases within the subsurface. Specifically; they may exist as a separate non-aqueous phase liquid (NAPL), dissolved phase in groundwater, volatilized into soil as gas or as adsorbed molecules to soil (Newell et al. 1995). Though subsurface hydrocarbons can exist in all four phases, this section focuses on the hydrocarbons present in LNAPL as it constitutes the bulk of the hydrocarbon mass at the Site. Current research has shown that the traditional concept of a “pancake” or “lake” of LNAPL floating on the groundwater surface is not an accurate representation of LNAPL within the permeable deposits beneath Hartford (Sale 2003).

The presence or absence of LNAPL in a monitoring well is not a direct indicator of LNAPL occurrence in the formation or LNAPL recoverability at a well location. LNAPL does not saturate, or completely fill, the pore space of the soil in either the vadose or saturated zones. Instead, it shares the pore space with water and air. When LNAPL exceeds residual saturation it can drain into monitoring wells. Residual saturation is the amount of a fluid that remains in a porous medium after displacement by another fluid. Residual NAPL saturations in unconsolidated sands at ambient conditions typically range from 14 to 30 percent (Wilson et al., 1990). The LNAPL at the Site generally exists at residual saturations in the vadose zone, the capillary fringe and the saturated zone (due to the historical groundwater fluctuations).

However, at some locations LNAPL saturations are greater than residual levels as discussed above. Groundwater is the wetting fluid preferentially coating the soil grains (Sale 2003) (Figure 3-1).

LNAPL saturations are a key aspect to evaluate in developing LNAPL remediation strategies. Since lower hydrocarbon saturations decrease the relative permeability to LNAPL, they are indicative of lower mobility, which consequently, inhibits the ability to recover LNAPL. In addition, LNAPL recovery, which began in 1978 with skimming and was enhanced in the early 1990s by an SVE system and later in 2005 by High Vacuum Remediation (HVR) pilot testing (including low and high vacuum "bioslurping" and drawdown pilot testing in a dual phase extraction mode), has contributed, in part, to decreased LNAPL saturation in areas where applied. This on-going recovery appears to have decreased the area and volume of LNAPL present. Removal of this LNAPL has also decreased the area where active liquid recovery of LNAPL is practical. However, this does not preclude removal of GRO LNAPL through the vapor phase in these areas.

3.1 LNAPL AND SOIL CHARACTERIZATION

Characterization of the LNAPL was completed by an evaluation of capillary gas chromatography analysis, conducted by Torkelson Geochemistry, Inc. (Torkelson), supplemented by analyses of simulated distillation, kinematic viscosity and density and also by the ROST data. Table 3-1 summarizes the findings while Figure 3-2 depicts the results. As the properties of refined products vary due to a number of factors including the petroleum source and the refining process itself, the following results are only discussed in a representative manner and should not be construed as identifying the origin of the LNAPL.

The majority of the LNAPL in the Main Sand beneath the Site consists of gasoline range organics (GROs) except in the northern and easternmost portions, which contain separate phase mixtures of primarily GROs with varying percentages of diesel range organics (DROs). The LNAPL in both the EPA and Rand Strata consists predominantly of DROs though there are mixtures containing smaller amounts of GROs in the EPA Stratum.

As part of the on-going LNAPL remedy selection process, the recoverability of the LNAPL is being evaluated using soil core analysis. This work consisted of (1) collection of soil cores at five representative areas across the Site, (2) ultraviolet (UV) photography of the soil cores to enable

visualization of the LNAPL (by fluorescence) within the soil matrix, and (3) analysis, conducted by PTS Laboratories, Inc. (PTS), to evaluate the physical properties of the LNAPL. The analyses included the following parameters: initial and residual fluid saturations, final water production vs. capillary pressure, total porosity, effective (total) porosity, air permeability, hydraulic conductivity, grain density, bulk density, air-filled porosity, grain size analysis, and free product mobility. The results of these analyses, along with other fluid property analyses including density, viscosity and surface tension, will be used in developing analytical models to evaluate LNAPL recoverability (Clayton in-progress b). In addition, a measure of LNAPL mobility was determined, in part, by centrifuging soil core samples at velocities equal to 1,000 times the force of gravity. Both measured and calculated hydrocarbon saturations were used later in this report to evaluate actual LNAPL thicknesses in the formation. The Torkelson and PTS results will be presented and discussed in more detail as part of the LNAPL Active Recovery System Selection Technical Memorandum (Clayton in-progress b). Electronic copies of the Torkelson and PTS analytical reports were transmitted to the USEPA and the Illinois Environmental Protection Agency (Illinois EPA) as they were received from the laboratory. Paper copies of the reports are maintained at Clayton's office in Downers Grove, Illinois.

The preliminary findings of the soil core analysis include:

- The LNAPL soil saturations ranged from 0 to 10.2% except for one sample that exhibited a saturation value between 21.8 to 40.2% (31'-33' sampling interval at HMW-44/HCSB-1).
- The LNAPL recoverability data (comparing the initial saturations prior to centrifuging with the residual saturations after centrifuging) revealed very limited to no recoverability in the upper, more cohesive, soils. The degree of recoverability correlates well with the initial LNAPL saturation (i.e., higher initial residual saturation equated to higher recoverability).

Overall, the findings of the core analyses and LNAPL characterization will substantially assist in the design of a LNAPL recovery system that will be based primarily upon the geology of the area and the amount of recoverable product present.

3.2 LNAPL SPECIFIC THICKNESS

LNAPL in the subsurface does not exist as a "pancake" of fluid. In a typical unconfined aquifer, it is present at or above the water table and is disseminated in the pores of the strata along with water and

air. Its mobility is determined by gradient, which is the primary driving force for movement, and by capillary pressures which tend to restrict its movement. If the LNAPL saturation in the pores exceeds a minimum, known as the irreducible saturation, LNAPL may flow into a monitoring well until the level of fluid in the well rises to the highest point of LNAPL entry. The thickness of LNAPL in a well is primarily a function of LNAPL buoyancy and the height of mobile LNAPL above the water table, which is a function of the amount of LNAPL present, the size of the pores, and LNAPL saturation. Therefore, the gauged LNAPL thickness in a monitoring well generally exceeds the actual saturated LNAPL thickness in the formation. The gauged LNAPL thickness in a well is commonly referred to as an apparent thickness. The difference between the two thicknesses is due to several factors including capillary forces and hydrocarbon density (Newell et al. 1995). Therefore, LNAPL thickness in a monitoring well does not accurately represent the vertical extent of product in the formation. Recent methods, discussed further in Appendix F, to estimate the actual petroleum thickness in a formation have been developed that use data from analysis of soil cores, specifically, LNAPL saturation results.

The specific thickness of LNAPL (D_o), is representative of the actual amount of LNAPL in a formation. For example, if you had a core of soil separated into its respective media (i.e., air, water, LNAPL, and soil), D_o is a normalized volume of LNAPL ($feet^3/feet^2$) per unit surface area, but is expressed as a thickness (in units of feet) (Figure 3-3). At equilibrium, due to capillary forces in soil, the measured LNAPL thickness in a monitoring well, b_o, is always greater than D_o.

D_o is calculated as follows:

$$D_o = \text{LNAPL \%} * \text{porosity} * \text{soil core interval (ft.)}$$

where:

LNAPL % = petroleum saturation (in % of pore volume)

porosity = site-specific total porosity (in %)

soil core interval = interval of LNAPL impacted core (in feet)

The collection of soil cores from varying soil types across the site, near wells with measurable LNAPL, and discrete sampling and analyses of LNAPL saturations provides a good representation of the amount of LNAPL in each formation. It also eliminates the need for general “rule of thumb correction factors to estimate true LNAPL thickness from apparent LNAPL thickness which are based on the “pancake

model". Correction factors based on soil type and LNAPL type were developed to provide more accurate estimations of LNAPL specific thickness across the site. This approach is recommended by USEPA (RTDF 2005). Further detail regarding D_o and the correction factors are presented in Appendix F.

The gauged LNAPL extent data, based on the apparent LNAPL thickness in monitoring points within the Main Sand, the EPA and the Rand Strata in Hartford, have been evaluated using the results of the analyses from the five soil core locations. No D_o calculation was made for the North Olive Stratum because no LNAPL was found in any monitoring well in the North Olive Stratum in October 2005, or in any gauging event conducted during 2004 and 2005.

As part of this evaluation, the conditions at each monitoring point containing LNAPL were compared to the conditions of the five core sampling locations resulting in a determination of a "best fit" correction factor based on soil and LNAPL type for the areas containing a mixture of both GRO and DRO. In the case of the GRO-only impacted area, the data obtained at the three locations sampled in this area were averaged to obtain a single correction factor for the GRO-only impacted area. The correction factors were applied to each monitoring point in the Main Sand containing measurable LNAPL thicknesses in October 2005 to present a comparison of the LNAPL specific thickness with the apparent LNAPL thickness. The D_o results for the Rand, the EPA and the Main Sand Strata are presented in Figures 3-4 through 3-6, respectively. As shown by these figures, the LNAPL specific thickness beneath the Site is less than the apparent LNAPL thicknesses gauged in the monitoring wells. The October 2005 D_o values for the Main Sand range from less than 0.01 (several locations) to 1.38 feet (near the intersection of West Birch and North Delmar Avenue) of LNAPL compared to the gauged apparent thicknesses which ranged from 0.02 (alley between West Elm and West Date Streets) to 5.29 (also near the intersection of West Birch and North Delmar Avenue) feet. LNAPL was only encountered and gauged at one location each in both the Rand and the EPA Strata during October 2005. The gauged LNAPL thickness in the Rand was 2.56 feet with a D_o value of 0.51 feet (near the intersection of North Olive Street and East Rand Avenue) while the EPA gauged and D_o values were 0.25 and 0.02 feet (near the intersection of East Birch and North Market Streets), respectively.

3.3 LNAPL DISTRIBUTION IN PERMEABLE STRATA

The majority of the LNAPL resides in the Main Sand underneath the northern portion of the Site. The defined extent (horizontal and vertical) of LNAPL within the North Olive, Rand, EPA Strata and the clay strata are significantly less than the extent determined in the Main Sand Stratum. However, a more permeable zone, such as the North Olive Stratum would be a preferential pathway for LNAPL and vapor migration relative to the clay strata. Portions of the Main Sand Stratum contain substantial vadose zones, as a result of topographic highs, such as in the central portion of Hartford along Elm Street which would be a preferential pathway for vapors. To varying degrees, both ephemeral groundwater and topographic features within the North Olive and Rand Strata may have influenced the observed LNAPL distribution in these units. For example, LNAPL, upon encountering the underlying clay strata, will preferentially migrate in the direction of a dip in the base of an unsaturated, more permeable stratum such as the North Olive or Rand Strata due to the influence of gravity. In the presence of groundwater, whether ephemeral or not, the water surface generally inhibits continued vertical movement of the LNAPL. Lateral LNAPL flow would be facilitated by existing groundwater gradients. In general, as presented in Section 2.3, groundwater is absent in the North Olive and Rand Strata though there are occasional areas of perched water in these horizons along with limited groundwater flow within the Rand Stratum in the northeast portion of the Site. Figures 3-7 through 3-9 show the shallow LNAPL distribution near the ground surface and within the North Olive and Rand Strata, respectively. After reaching groundwater, transport will tend to be more laterally, facilitated by the groundwater gradient (gravity flow) within the permeable stratum resulting in lateral spreading until there is no longer a sufficient LNAPL volume to enable LNAPL migration. Therefore, the extent of lateral migration is largely dictated by the magnitude of the release.

Figure 3-7 shows the depth to the first encountered residual LNAPL (based on the ROST response). Four areas in northern Hartford contain residual LNAPL within the upper ten feet of the surface. These locations are identified with red circles in Figure 3-7. The formation at this depth generally consists of the A Clay stratum. One area (represented by a group of three adjacent red circles) is located along North Olive Street between East Birch Street and East Rand Avenue. A second area is represented by a single location at North Olive Street between East Elm and East Forest Streets. The third (represented by two red circles) is located along the Elm Street, one near North Market Street and one between North Market Street and North Delmar Avenue. The fourth area is represented by a single location northwest

of the Hartford Community Center. Overall, the soil analytical results (Figure 3-10), specifically, the distribution of benzene, ethylbenzene, toluene and xylenes (BETX) concentrations, are consistent with the ROST response data. The following discussions of LNAPL distribution in the more permeable strata are based on the ROST results. As indicated above, the ROST identified LNAPL may or may not be of sufficient saturation and volume to flow into a well.

3.3.1 LNAPL Distribution in the North Olive Stratum

The LNAPL in the North Olive Stratum (based on ROST results) is limited in extent (Figure 3-8). The LNAPL is primarily along the vicinity of North Olive Street and along the vicinity of Rand Avenue. The northernmost area of LNAPL is approximately defined by East Rand Avenue to the north and East Birch Street to the south. The southern area is approximately defined by East Date Street to the north and East Watkins Street to the south. Two other apparent, and isolated, LNAPL locations were identified within the North Olive Stratum. One location is approximately midway between East Cherry and East Date Streets. The other isolated occurrence of LNAPL is near the intersection of West Arbor Street and Old St. Louis Road. No LNAPL was detected in any monitoring well in the North Olive Stratum in October 2005 or since monitoring began in October 2004. Therefore, the LNAPL identified in the North Olive Stratum is residual LNAPL.

3.3.2 LNAPL Distribution in the Rand Stratum

The lateral extent of LNAPL (based on ROST responses) within the deeper Rand Stratum unit (Figure 3-9) is more widespread than in the overlying North Olive Stratum. The extent of LNAPL in the Rand Stratum (as identified by the ROST results) is present in four separate areas.

One of the three main occurrences of LNAPL is in the northeast corner of Hartford in the vicinity of North Olive Street. It is bounded by East Rand Avenue to the north. It extends west to North Delmar Avenue near the Hartford Community Center, just beyond East Birch Street to the south and easterly into the northwest corner of the Shell Tannery property. The second LNAPL area extends along both North Olive Street and Elm Street. It is approximately bounded by East Date Street to the north, slightly beyond East Forest Street to the south and North Market Street to the west. The third significant extent within the Rand is approximately bounded by West Arbor Street to the north, North Delmar Avenue to the east,

West Cherry Street to the south and Old St. Louis Road to the west. The fourth area of identified LNAPL occurs midway between East Cherry and East Date Streets.

LNAPL was measured in only one monitoring well in the Rand Stratum, during October 2005, at the intersection of East Birch Street and North Market Street (Figure 3-4). A laboratory sample of the LNAPL indicated it was almost entirely DRO. The remaining LNAPL identified in the Rand Stratum is residual LNAPL.

3.3.3 LNAPL Distribution in the Rand Stratum Unrelated to Site

Another area of LNAPL (based on ROST responses) was identified north of Hartford near of the intersection of Old St. Louis Road and North Delmar Avenue. This area of LNAPL is interpreted to be unrelated to the Site due to the physical separation of this LNAPL area from the identified LNAPL at the Site. The lack of continuity is most apparent in Figure 3-9, which shows the extent of LNAPL in the Rand Stratum. As shown in this figure, the Rand Stratum, though present to the north and south of the West Rand Avenue corridor, it is not present under West Rand Avenue itself. This gap would preclude LNAPL from migrating northerly within the Rand Stratum from the Site to this area.

3.3.4 LNAPL Distribution in the EPA Stratum

The area of LNAPL identified in the EPA Stratum (based on ROST responses), extends just beyond East Cherry Street to the south and trends northwesterly, corresponding to the stratum extent, to the intersection of Old St. Louis Road and North Delmar Avenue to the north (Figure 3-11). LNAPL was measured in only one EPA Stratum monitoring well in October 2005 near the intersection of East Rand Avenue and North Olive Street (Figure 3-5). Laboratory analysis of the LNAPL at this location indicated it was predominantly diesel range organics though a significant fraction of gasoline range organics was also identified (70 percent DRO/30 percent GRO). The remaining LNAPL identified in the EPA Stratum is residual LNAPL.

3.3.5 LNAPL Distribution in the Main Sand Stratum

Upon reaching the Main Silt/Sand, LNAPL encountered an aquifer which formed a barrier inhibiting continued vertical migration. The LNAPL within the vadose zone of the Main Silt/Sand, which is considered for this report as being the portion of the Main Sand that is shallower than approximately 25 feet below ground surface (bgs), was identified in only one area in the central portion of northern Hartford (Figure 3-12). The extent of LNAPL is approximately bounded by East Watkins Street to the south. It is generally limited to West Date Street to the north and to the vicinity of North Delmar Avenue and North Market Street to the west and east, respectively, due to geologic controls. Generally, this area represents the only significant unsaturated presence of the Main Silt/Sand at the Site.

Historically, as discussed in Section 2.3, the Main Sand groundwater elevation has fluctuated between approximately 380 and 416 feet MSL. Table 3-2 presents the ROST-response depths in the Main Sand. The average elevation of the deepest identified ROST response is at 385 feet MSL. The historic low groundwater elevation is generally consistent with the ROST-indicated average low groundwater elevation, with several exceptions, such as at HROST-116 (approximately 67 feet bgs – 365 feet MSL) near the intersection of North Delmar Avenue and West Elm Street, and nine other ROST response locations that extend as deep as approximately 374 feet bgs. It is possible that past groundwater elevations may have been lower than the recorded low of 380 feet MSL, and/or the ROST equipment may have “transported” LNAPL to these depths. The magnitude of historical groundwater fluctuation within the Main Sand caused significant vertical distribution, or smearing of LNAPL within this stratum.

Figures 3-11 and 3-13 present the LNAPL (based on ROST responses) in the Main Sand and EPA Strata and in the Main Sand below the D Clay, respectively. As shown in Figures 3-6 and 3-11, LNAPL was limited to northern Hartford and did not extend further south than Maple Street. LNAPL was identified north of Rand Avenue.

3.3.6 Apparent LNAPL Thickness in the Main Sand

LNAPL was identified in numerous monitoring wells in the Main Sand Stratum throughout northern Hartford during October 2005 (Figure 3-6). In general, the extent of gauged LNAPL extended from East Watkins Street to the south, Old St. Louis Road to the west, Rand Avenue to the north and the railroad

tracks to the east. The extent of the gauged LNAPL, though similar to the ROST-determined LNAPL extent, is slightly smaller in area. In the absence of additional releases and sufficient LNAPL head (from previous releases) to continue to drive LNAPL migration, stabilization of the LNAPL is expected to occur once it reaches steady state with the subsurface environment. A key finding, identified by the recent work in Hartford, is the stability of the gauged LNAPL extent over a period of nearly thirty years. As shown in Figures A-5 through A-9 in Appendix A, LNAPL gauging events in Hartford were initially conducted in 1978 with subsequent events in 1982 and 1990. Comparing the historic maps with the figure presenting October 2005 Main Sand LNAPL gauging results (Figure A-9), both of which present snapshots in time, shows the gauged lateral extent of the LNAPL has not grown. Instead, it appears to have decreased compared to the 1982 findings. As stated previously, the presence of LNAPL in a monitoring well within the interior of the gauged extent does not mean the LNAPL is migrating.

3.4 BAILDOWN TESTING AND HVR RECHARGE ANALYSES

LNAPL recharge for selected wells was measured during 2004 and 2005, following baildown testing and High Vacuum Remediation (HVR) short-term extraction events. The LNAPL recharge data allowed the plotting of LNAPL recharge curves to evaluate recharge rates and efficiencies across the area of concern (H_2A Environmental). In addition, this data allowed the calculation of LNAPL hydraulic conductivities and transmissivities (commonly referred to as oil conductivity or K_n and oil transmissivity or T_n). The recharge rates and efficiencies and the oil conductivities and transmissivities then provide a semi-quantitative evaluation of LNAPL recovery potential. Well locations for this analysis were selected on the basis of LNAPL thickness and spatial coverage of the area of concern. Further discussion of LNAPL recharge will be presented by Clayton (in progress b) in the LNAPL Active Recovery System Selection Technical Memorandum.

A summary of well, event type, date of event, LNAPL thickness, depth to top of product, density, K_n (individual event and average for each well), and T_n (individual event and average for each well) is provided in Table 3-3. Summary graphs of LNAPL recharge as a percentage of original LNAPL thickness and LNAPL recharge in feet versus time are provided separately for the baildown tests and the HVR events (Graphs 3-1 through 3-4). Contour maps of average K_n and T_n are provided in Figures 3-14 and 3-15.

The following table summarizes general statistics for the baildown tests and HVR events.

Statistic	**Minimum**	**Maximum**
No. of Baildown Tests Analyzed	N/A	17
No. of HVR Events Analyzed	N/A	50
Total No. of Recharge Analyses	N/A	67
Depth to Product (DTP) below Top of Casing	27.75 feet	34.94 feet
LNAPL Thickness	0.47 feet	3.89 feet
Oil Conductivity (K_n) Range	2.29 E-7 cm/s	2.64 E-2 cm/s
Oil Transmissivity (T_n) Range	1.05 E-5 cm^2/s	1.01 E0 cm^2/s

As noted in the table above, both K_n and T_n varied by five orders of magnitude across the site. The average K_n and T_n contour maps provide order of magnitude contours that identify areas of substantially higher K_n and T_n in the area of historically greatest LNAPL thickness, along the axis from HMW-44C to MP-45C. Four additional localized areas around wells MP-50C, HMW-19, MP-39C, and MP-35D exhibited substantially higher K_n and T_n values.

For most of the wells where multiple baildown tests and/or HVR events were performed, K_n and T_n values decreased, sometimes substantially, as fluid levels dropped in the formation for any given well. Three wells (HMW-20, MP-45C and MP-39C) showed a reversal of this trend. Graph 3-5 graphically depicts the T_n values by well and identifies trend lines for each well.

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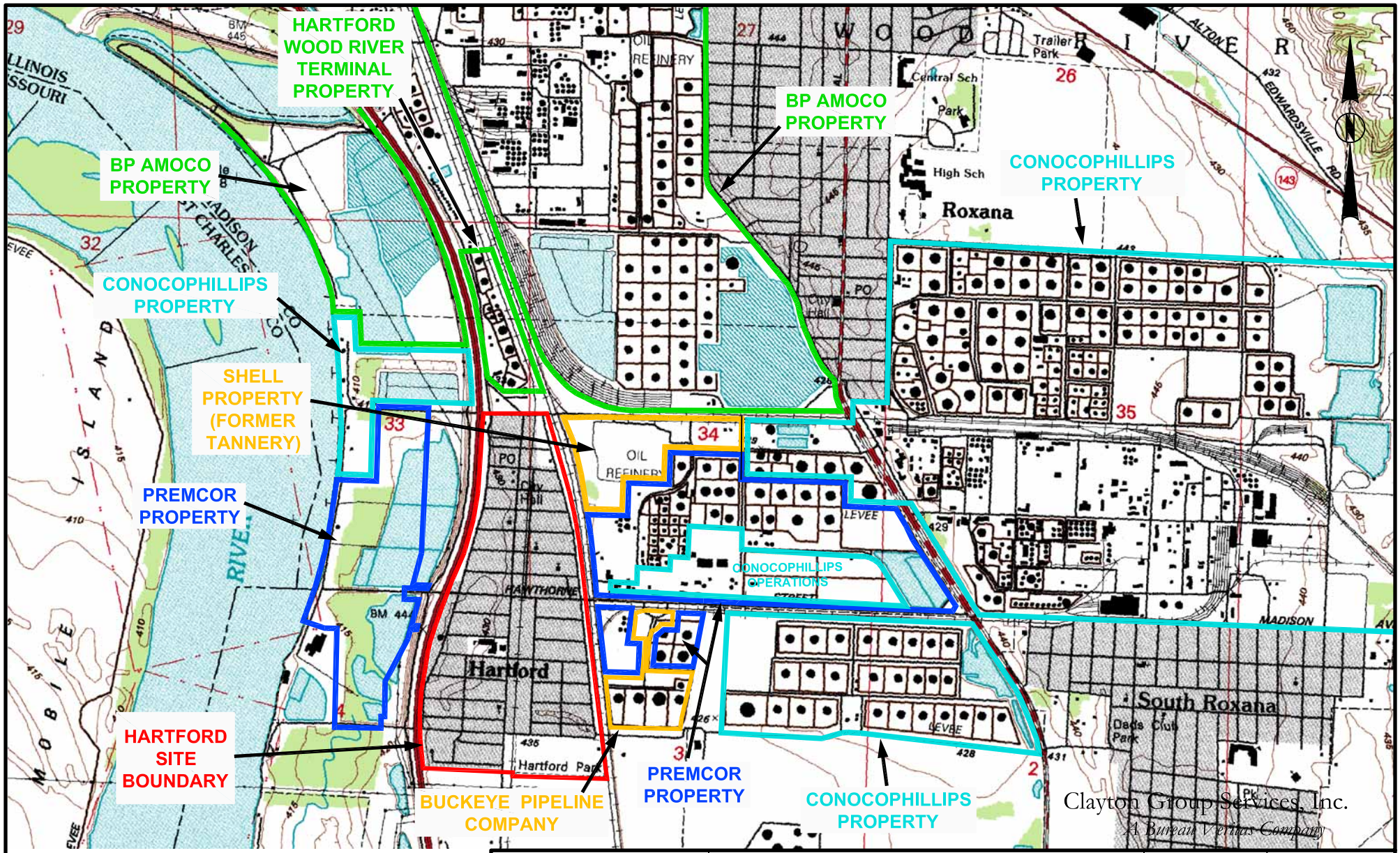
FIGURES



** NOT TO SCALE **

SOURCE:
USGS 7.5 MINUTE SERIES TOPOGRAPHIC MAP
(WOOD RIVER, ILL.–MO. – rev.1994)

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PRJ NO.	15–03095.14

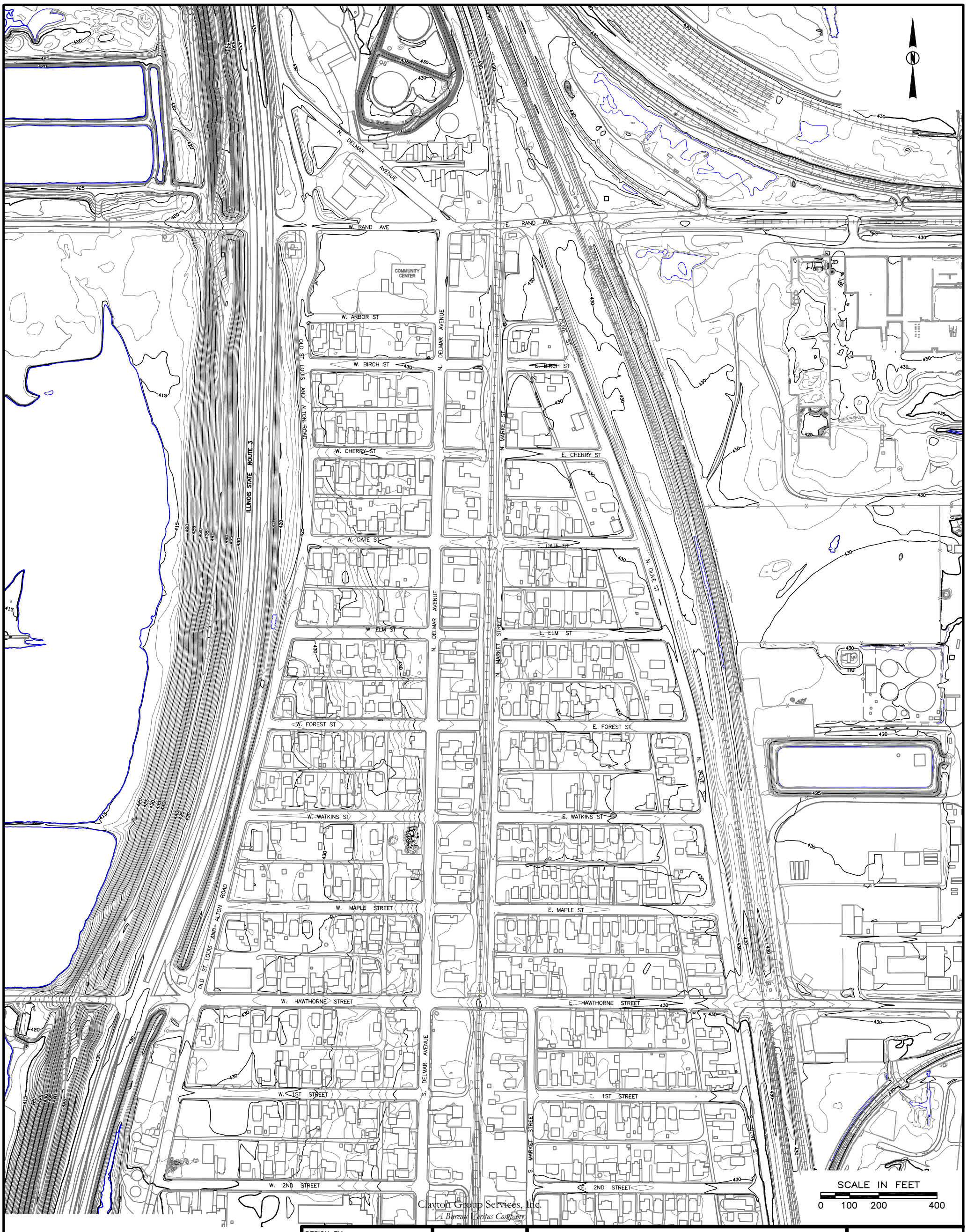
VILLAGE OF HARTFORD, IL
AND SURROUNDING AREA MAP

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

BUREAU VERITAS

FIGURE

2–1



NOTES:

1. MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTIAL MAPPING CONSULTANTS, INC.
2. CONTOUR INTERVAL = 1' FOOT

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DATE:	11-15-05
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PROJECT NO.:	15-03095.14

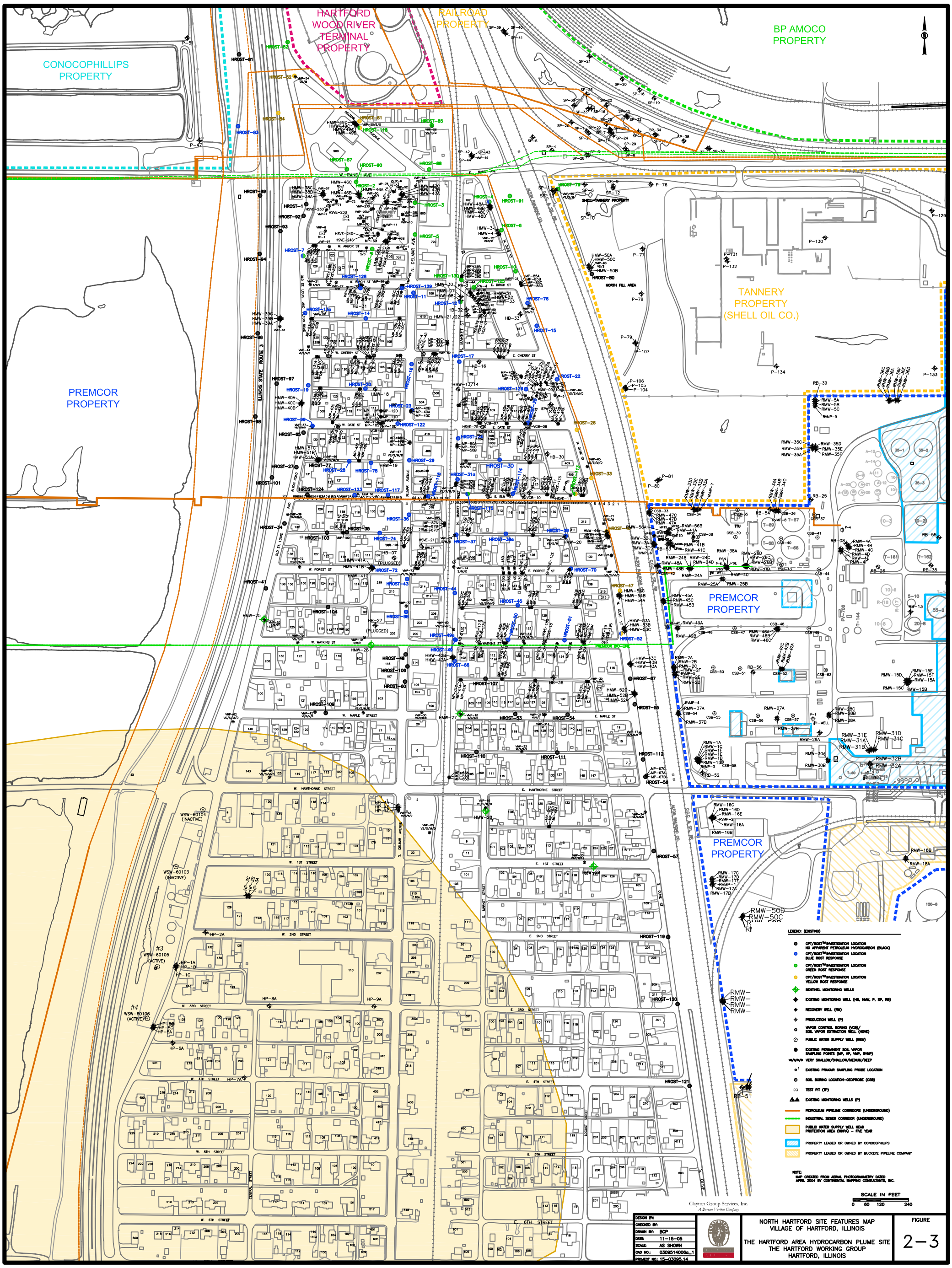
BUREAU VERITAS 1828

NORTH HARTFORD TOPOGRAPHIC MAP
VILLAGE OF HARTFORD, ILLINOIS

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

FIGURE

2-2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HARTFORD WOOD RIVER TERMINAL PROPERTY
RAILROAD PROPERTY
BP AMOCO PROPERTY
TANNERY PROPERTY (SHELL OIL CO.)
PREMCOR PROPERTY
PREMCOR PROPERTY
PREMCOR PROPERTY
ILLINOIS STATE ROUTE 3
W. RAND AVE
E. RAND AVE
W. ARBOR ST
W. BIRCH ST
E. BIRCH ST
W. CHERRY ST
E. CHERRY ST
W. DATE ST
E. DATE ST
W. ELM ST
E. ELM ST
W. FOREST ST
E. FOREST ST
W. WATKINS ST
E. WATKINS ST
W. MAPLE STREET
E. MAPLE STREET
W. HAWTHORNE STREET
E. HAWTHORNE STREET
W. 1ST STREET
E. 1ST STREET
W. 2ND STREET
E. 2ND STREET
W. 3RD STREET
E. 3RD STREET
W. 4TH STREET
E. 4TH STREET
W. 5TH STREET
E. 5TH STREET
W. 6TH STREET
E. 6TH STREET
N. DELMAR AVE
S. DELMAR AVENUE
N. MARKET ST
S. MARKET STREET
N. OLIVE ST
S. OLIVE ST
OLD ST. LOUIS AND ALTON ROAD
ALTON RAILROAD CO.
C.C.C.& STL. RR
LOCUST STREET
CENTRAL STREET
SHELL-TANNERY PROPERTY
NORTH FILL AREA
WSW-60104 (INACTIVE)
WSW-60103 (INACTIVE)
#3 WSW-60105 (ACTIVE)
#4 WSW-60106 (ACTIVE)
LEGEND: (EXISTING)
CPT/ROST™ INVESTIGATION LOCATION NO APPARENT PETROLEUM HYDROCARBON (BLACK)
CPT/ROST™ INVESTIGATION LOCATION BLUE ROST RESPONSE
CPT/ROST™ INVESTIGATION LOCATION GREEN ROST RESPONSE
CPT/ROST™ INVESTIGATION LOCATION YELLOW ROST RESPONSE
SENTINEL MONITORING WELLS
EXISTING MONITORING WELL (HB, HMW, P, SP, RB)
RECOVERY WELL (RW)
PRODUCTION WELL (P)
VAPOR CONTROL BORING (VCB)/ SOIL VAPOR EXTRACTION WELL (HSVE)
PUBLIC WATER SUPPLY WELL (WSW)
EXISTING PERMANENT SOIL VAPOR SAMPLING POINTS (MP, VP, VMP, RVMP)
VS/S/M/D VERY SHALLOW/SHALLOW/MEDIUM/DEEP
EXISTING PRAXAIR SAMPLING PROBE LOCATION
SOIL BORING LOCATION-GEOPROBE (CSB)
TEST PIT (TP)
EXISTING MONITORING WELLS (P)
PETROLEUM PIPELINE CORRIDORS (UNDERGROUND)
INDUSTRIAL SEWER CORRIDOR (UNDERGROUND)
PUBLIC WATER SUPPLY WELL HEAD PROTECTION AREA (WHPA) - FIVE YEAR
PROPERTY LEASED OR OWNED BY CONOCOPHILIPS
PROPERTY LEASED OR OWNED BY BUCKEYE PIPELINE COMPANY
NOTE: MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
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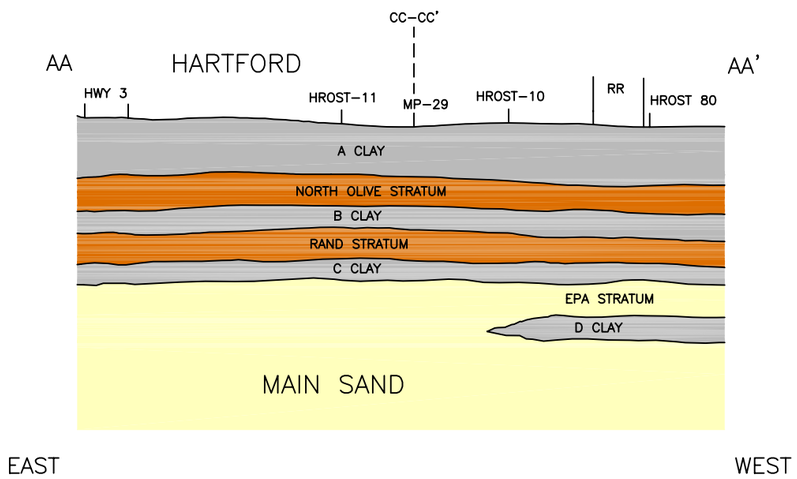
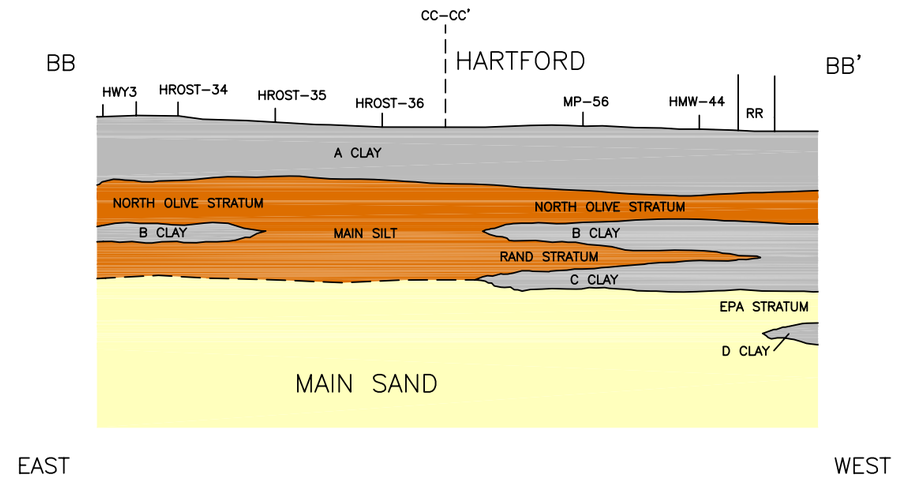
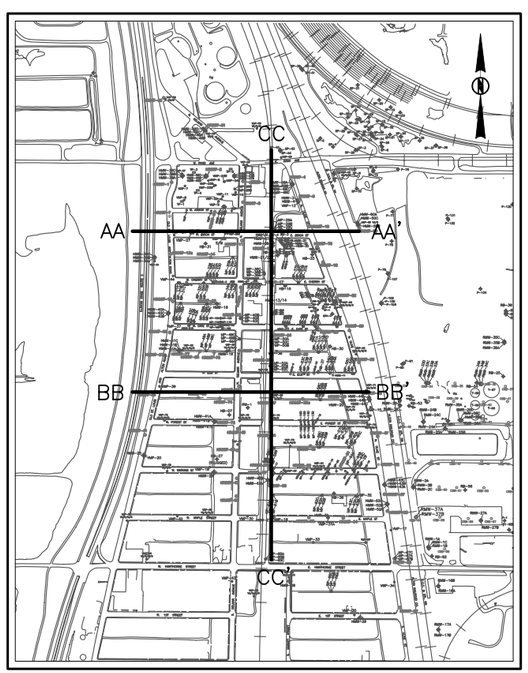
Clayton Group Services, Inc.
A Bureau Veritas Company
DESIGN BY:
CHECKED BY:
DRAWN BY: BCP
DATE: 11-15-05
SCALE: AS SHOWN
CAD NO.: 0309514006a_1
PROJECT NO.: 15-03095.14
NORTH HARTFORD SITE FEATURES MAP
VILLAGE OF HARTFORD, ILLINOIS
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS
FIGURE
2-3







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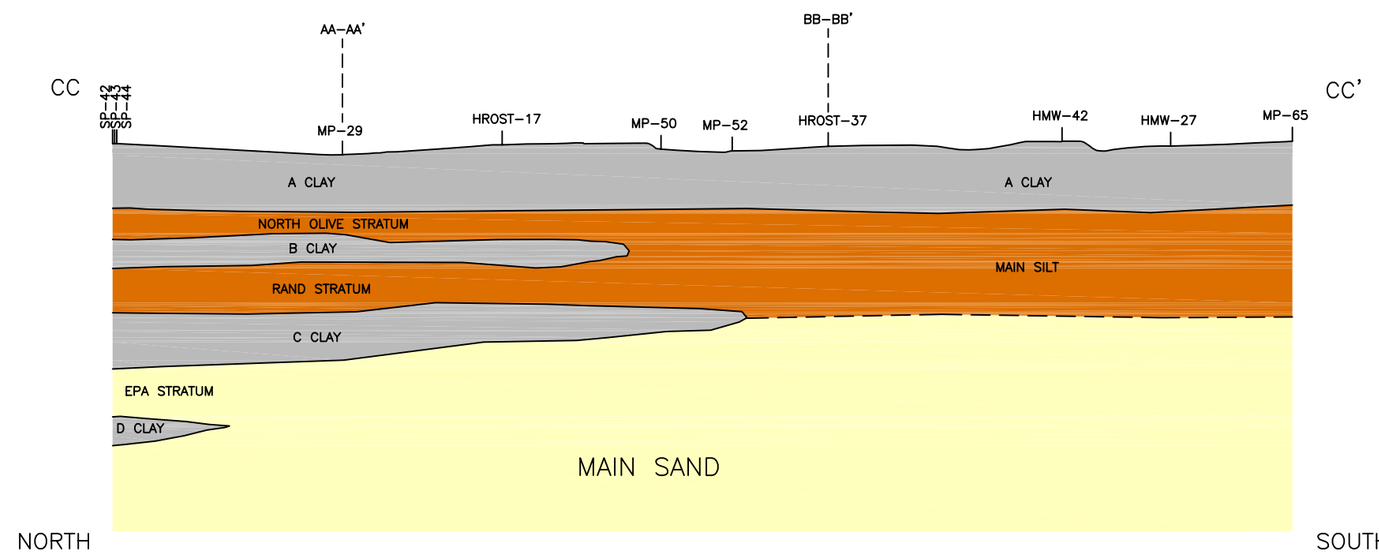

NOTES:

1. VERTICAL AND LATERAL EXTENT OF GEOLOGIC STRATA REFLECT GENERALIZED REPRESENTATIONS FOR THE PURPOSE OF SIMPLIFYING THE UNDERSTANDING AND IDENTIFICATION OF THE MAJOR LITHOLOGIC STRATA WITHIN THE STUDY AREA.
2. VERTICAL EXTENT OF STRATA NOT TO SCALE.
3. BASE OF MAIN SAND NOT SHOWN.

Clayton Group Services, Inc.
A Bureau Veritas Company

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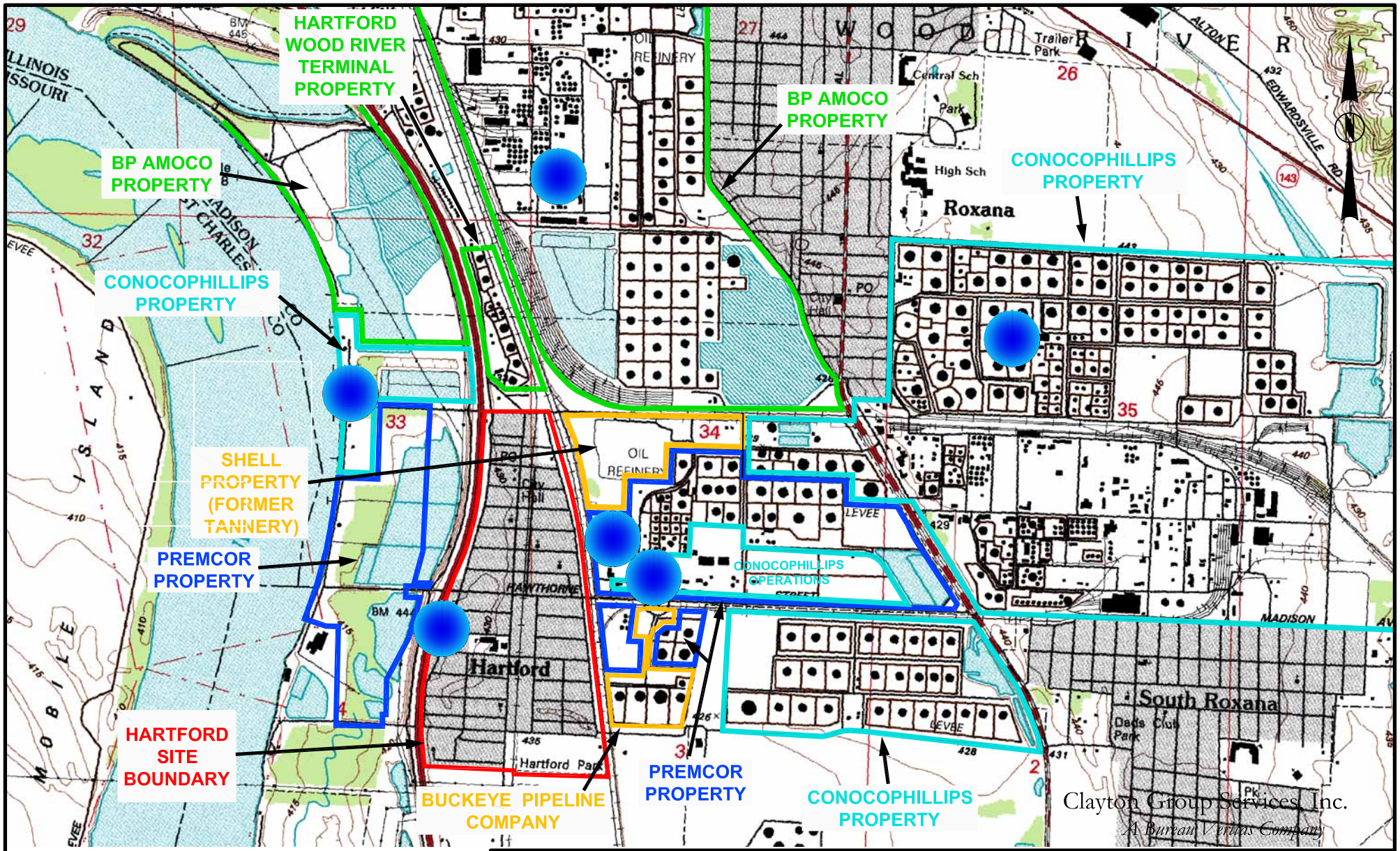
GENERALIZED GEOLOGIC CROSS SECTIONS
AA–AA', BB–BB', AND CC–CC'

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

BUREAU VERITAS

FIGURE
2–4



LEGEND

PUMPING CENTERS

** NOT TO SCALE **

SOURCE:
USGS 7.5 MINUTE SERIES TOPOGRAPHIC MAP
(WOOD RIVER, ILL.–MO. – rev.1994)

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DATE	11–15–05
SCALE	AS SHOWN
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PUMPING CENTERS IN THE VICINTY OF HARTFORD, IL.

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

BUREAU VERITAS

FIGURE

2–5

PREMCOR RIVER DOCK MISSISSIPPI RIVER WATER GAUGE

ELEV.= 399.72 (OCTOBER 4, 2005)

N. DELMAR AVENUE
W. RAND AVE
E. RAND AVE
COMMUNITY CENTER
W. ARBOR ST
W. BIRCH ST
E. BIRCH ST
W. CHERRY ST
E. CHERRY ST
W. DATE ST
E. DATE ST
W. ELM ST
E. ELM ST
W. FOREST ST
E. FOREST ST
W. WATKINS ST
E. WATKINS ST
E. MAPLE STREET
E. HAWTHORNE STREET
ILLINOIS STATE ROUTE
OLD ST. LOUIS AND ALTON ROAD
N. MARKET STREET
OLIVE STREET
ALTON RAILROAD CO.
C.C.C. & STL. RR
B10 FIRE WATER POND 5 MIL. GALLONS

HMW-49A (0.18)*
MP-73 DRY
MP-74 DRY
MP-72 DRY
HMW-46A (0.07)*
MP-75 DRY
MP-71 DRY
HMW-47A (0.22)*
HMW-38A DRY
MP-70 NM
MP-76 DRY
HMW-48A 415.26 (0.45)
MP-68 DRY
MP-78B DRY
MP-69 DRY
HMW-45A 416.57 (1.02)
MP-29A DRY
MP-85A (0.08)*
MP-79A (0.13)*
MP-80A DRY
MP-83A DRY
MP-30A DRY
MP-32A DRY
MP-36A DRY
MP-31B 410.79 (1.72)
MP-33B DRY
MP-34A (0.05)*
MP-35B DRY
MP-37A DRY
MP-42A DRY
HMW-13 (0.16)*
MP-38A DRY
MP-39A (0.13)*
MP-45A DRY
MP-47A DRY
MP-41A DRY
MP-43A (0.02)*
MP-46A DRY
MP-44B DRY
MP-57B (0.16)*
HMW-51A DRY
MP-48A DRY
MP-55A (0.11)*
MP-54A (0.13)*
MP-56A (0.22)*
HMW-44A 413.86 (0.73)
MP-57A (0.03)*
HMW-54A DRY
HMW-53A (0.04)*
HMW-43A (0.25)*

RMW-7A 408.21 (1.55)
RMW-6A (0.24)*
RMW-36A (0.09)*
RMW-5A 412.46 (2.26)
RMW-35A 416.40 (5.96)
RMW-33A 412.91 (1.47)
RMW-34A 416.28 (5.09)
RMW-47A (0.08)*
RMW-3A 412.08 (0.62)
RMW-48A (0.02)*
RMW-24A DRY
RMW-26A DRY
RMW-45A (0.44)*
RMW-49A (0.28)*
RMW-46A (0.45)*
RMW-2A (0.16)*
RMW-42A 411.48 (1.61)
RMW-28A (0.33)*
RMW-9A 420.10 (14.89)
RMW-10A 417.40 (7.52)
RMW-11A 414.52 (5.27)
RMW-13A 422.11 (16.43)
RMW-12A 420.47 (13.79)
RMW-4A 414.10 (2.59)
RMW-14A 412.45 (2.00)
RMW-15A 416.17 (8.18)

LEGEND

- MONITORING WELL (HMW, RMW)
- MONITORING PROBE (MP)
- 412.08 GROUNDWATER ELEVATION
- (0.62) LINEAR FEET OF WATER IN PROBE/WELL
- NM NOT MEASURED
- (0.16)* WATER IN PROBE/WELL IS WITHIN THE SUMP OF WELL AND/OR BELOW BASE OF STRATUM
- INTERPRETED EXTENT OF STRATUM (DASHED WHERE EXTRAPOLATED)

NOTES:

1. TOP OF CASING (TOC) ELEVATIONS USED IN THIS MAP FOR VILLAGE WELLS WERE OBTAINED BY SURVEY COMPLETED BY CMT, INC. IN 2003 AND 2004. TOC ELEVATIONS FOR ALL PREMCOR FACILITY WELLS WERE OBTAINED BY SURVEYS COMPLETED BY CMT, INC. IN 2004 AND 2005. TOC ELEVATIONS FOR ALL OTHER WELLS WERE OBTAINED FROM HISTORICAL SURVEYS BY CMT, INC.
2. MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL, 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.

SCALE IN FEET
0 175 350 700

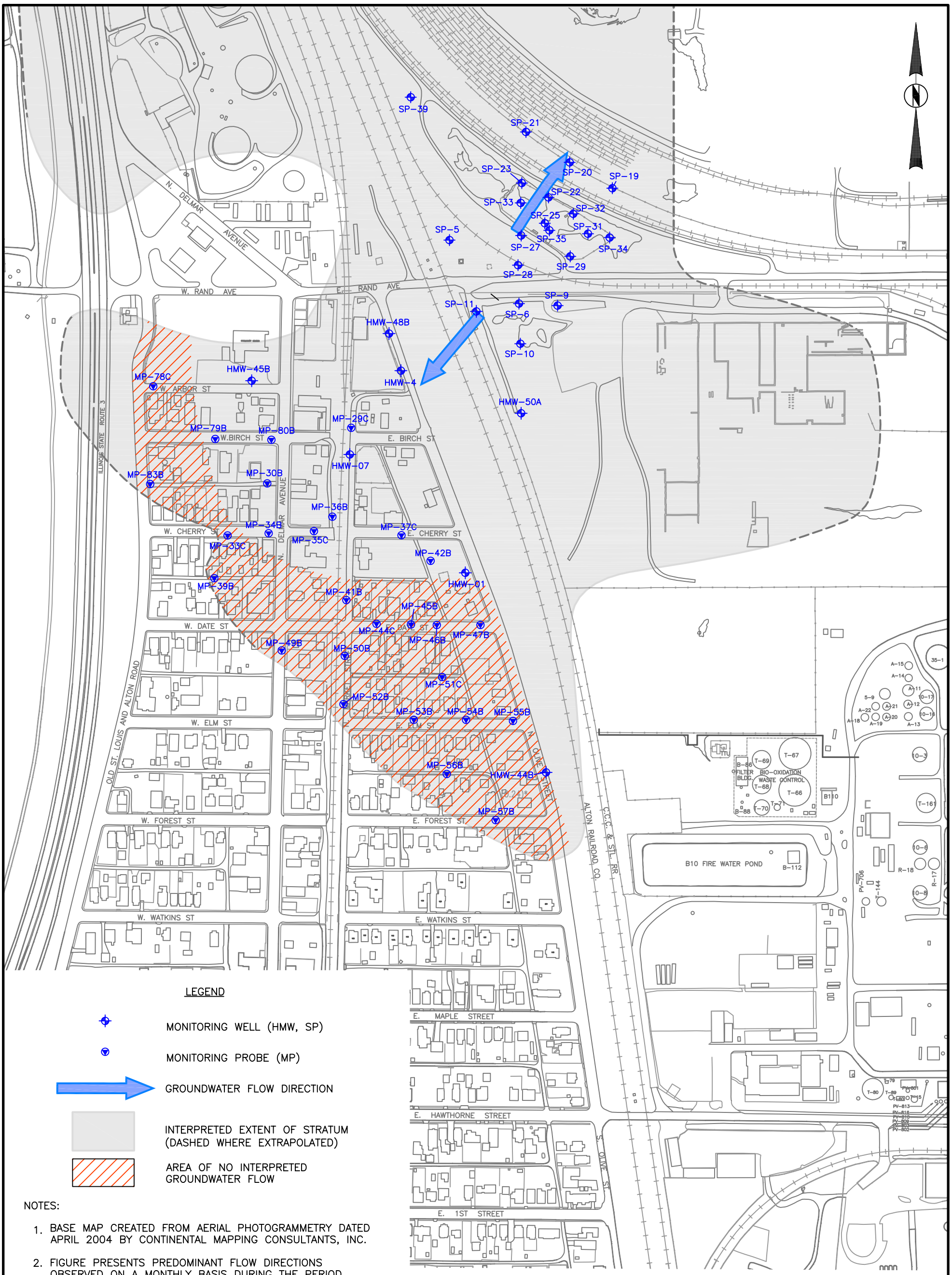
Clayton Group Services, Inc.
A Bureau Veritas Company

CHECK BY	
DRAWN BY	BCP
DATE	12-7-05
SCALE	AS SHOWN
CAD NO.	0309507e71
PRJ NO.	15-03095.14

GROUNDWATER ELEVATION MAP
OCTOBER 4-5, 2005
NORTH OLIVE STRATUM
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

BUREAU VERITAS 1828

FIGURE 2-6



LEGEND

- MONITORING WELL (HMW, SP)
- MONITORING PROBE (MP)
- GROUNDWATER FLOW DIRECTION
- INTERPRETED EXTENT OF STRATUM (DASHED WHERE EXTRAPOLATED)
- AREA OF NO INTERPRETED GROUNDWATER FLOW

NOTES:

1. BASE MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
2. FIGURE PRESENTS PREDOMINANT FLOW DIRECTIONS OBSERVED ON A MONTHLY BASIS DURING THE PERIOD FROM OCTOBER 2004 TO OCTOBER 2005.
3. THE HATCHED AREA WAS CONSIDERED TO REPRESENT LOCALIZED AREAS OF PERCHED WATER OR DID NOT CONTAIN GROUNDWATER. THEREFORE, NO GROUNDWATER FLOW WAS INTERPRETED TO BE PRESENT IN THIS AREA.

SCALE IN FEET

0 150 300 600

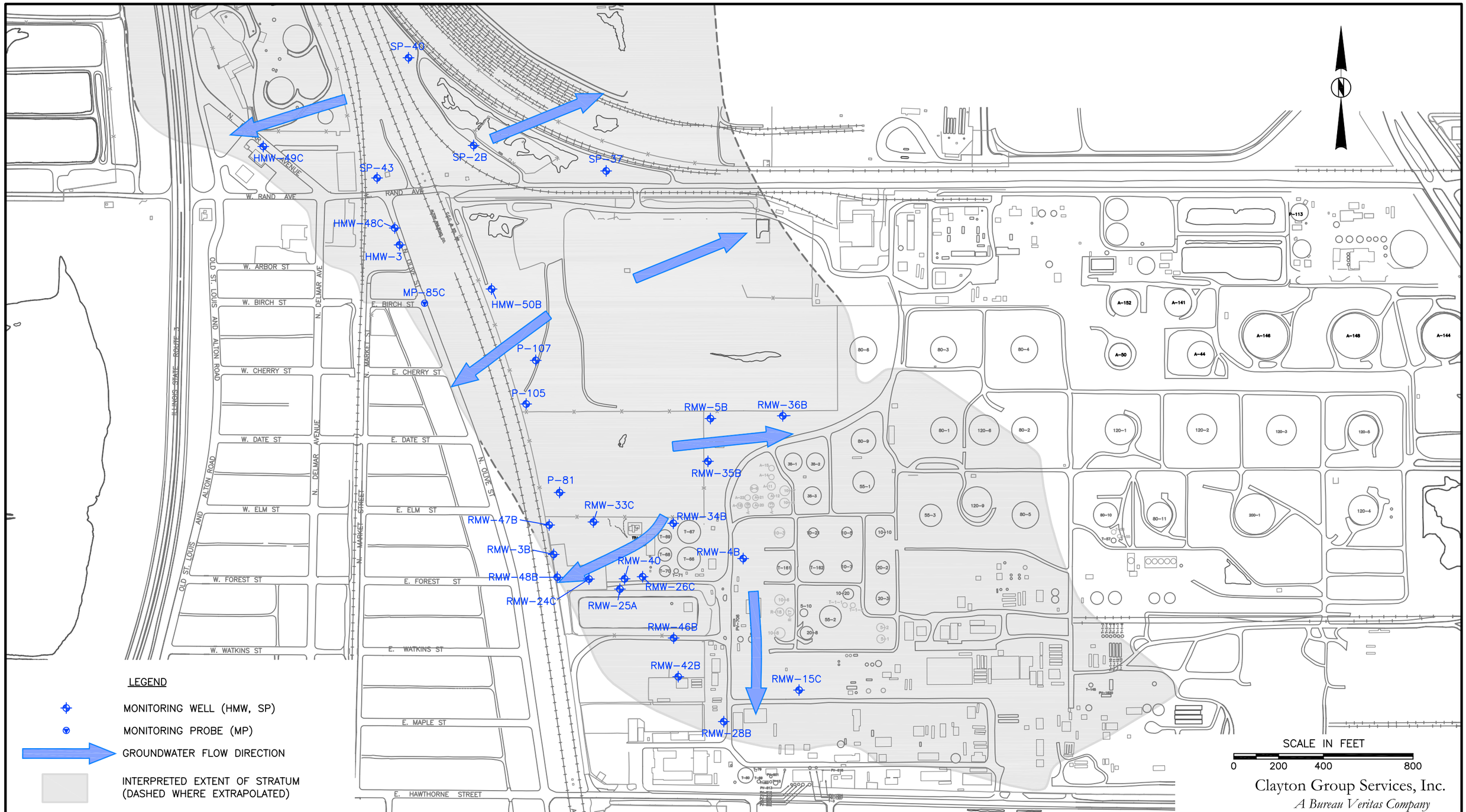
Clayton Group Services, Inc.
A Bureau Veritas Company

CHECK BY	MEM
DRAWN BY	OS
DATE	12-7-05
SCALE	AS SHOWN
CAD NO.	0309514011F2
PRJ NO.	15-03095

GENERALIZED GROUNDWATER FLOW DIRECTION MAP
OCTOBER 2004 – OCTOBER 2005
RAND STRATUM
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

BUREAU VERITAS 1828

FIGURE 2-7



LEGEND

- MONITORING WELL (HMW, SP)
- MONITORING PROBE (MP)
- GROUNDWATER FLOW DIRECTION
- INTERPRETED EXTENT OF STRATUM (DASHED WHERE EXTRAPOLATED)

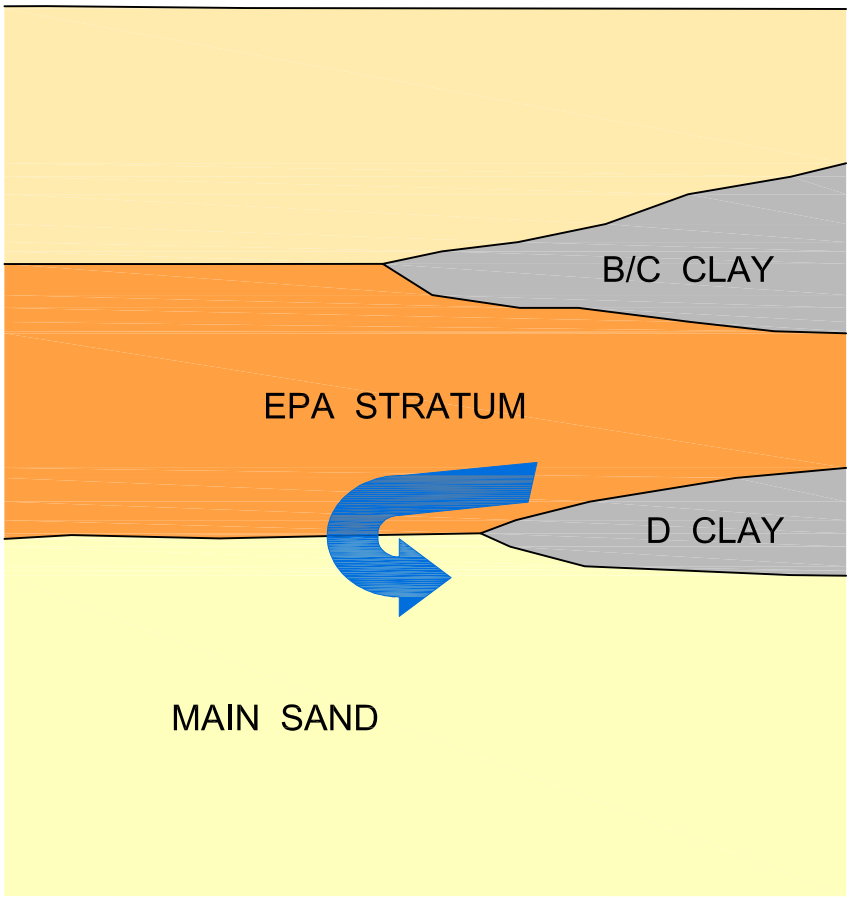
NOTE:
1) BASE MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL, 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
2) FIGURE PRESENTS PREDOMINANT FLOW DIRECTIONS OBSERVED ON A MONTHLY BASIS DURING THE PERIOD FROM OCTOBER 2004 TO OCTOBER 2005.

CHECK BY	MEM
DRAWN BY	BCP
DATE	12-7-05
SCALE	AS SHOWN
CAD NO.	0309514011f3
PRJ NO.	15-03095.14

GENERALIZED GROUNDWATER FLOW DIRECTION MAP
OCTOBER 2004 – OCTOBER 2005
EPA STRATUM
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

BUREAU VERITAS 1828

FIGURE 2-8



LEGEND

GROUNDWATER FLOW DIRECTION

Clayton Group Services, Inc.
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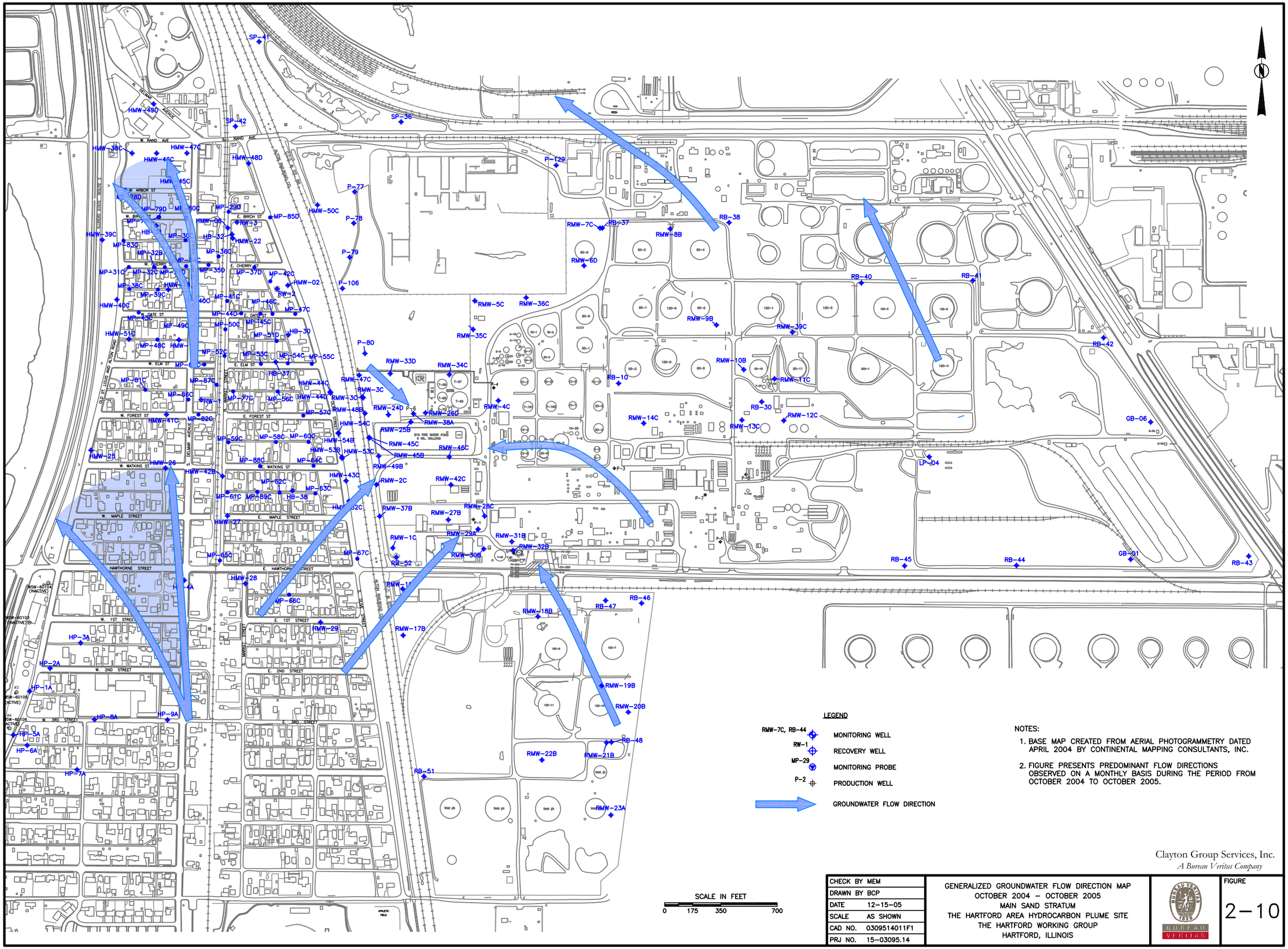
CHECK BY KDC	GROUNDWATER FLOW SCHEMATIC EPA AND MAIN SAND STRATA THE HARTFORD AREA HYDROCARBON PLUME SITE THE HARTFORD WORKING GROUP HARTFORD, ILLINOIS	BUREAU VERITAS	FIGURE
DRAWN BY BCP			2–9
DATE 12–7–05			
SCALE NO SCALE			
CAD NO. 0309514020G			
PRJ NO. 15–03095.14			



NOTES:

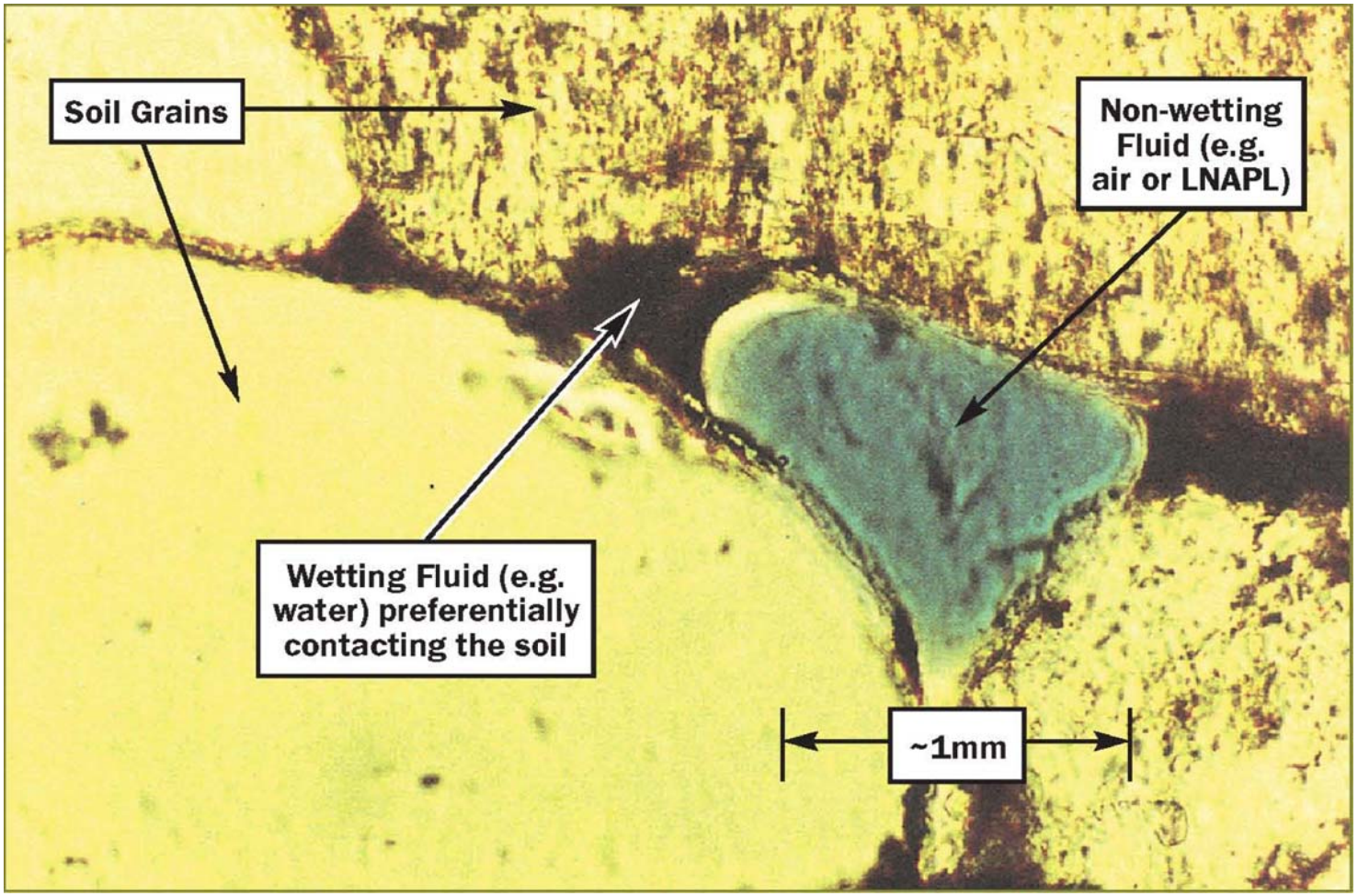
1. BASE MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
2. FIGURE PRESENTS PREDOMINANT FLOW DIRECTIONS OBSERVED ON A MONTHLY BASIS DURING THE PERIOD FROM OCTOBER 2004 TO OCTOBER 2005.

Clayton Group Services, Inc.
A Bureau Veritas Company

CHECK BY	MEM
DRAWN BY	BCP
DATE	12-15-05
SCALE	AS SHOWN
CAD NO.	0309514011F1
PRJ NO.	15-03095.14

GENERALIZED GROUNDWATER FLOW DIRECTION MAP
OCTOBER 2004 – OCTOBER 2005
MAIN SAND STRATUM
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

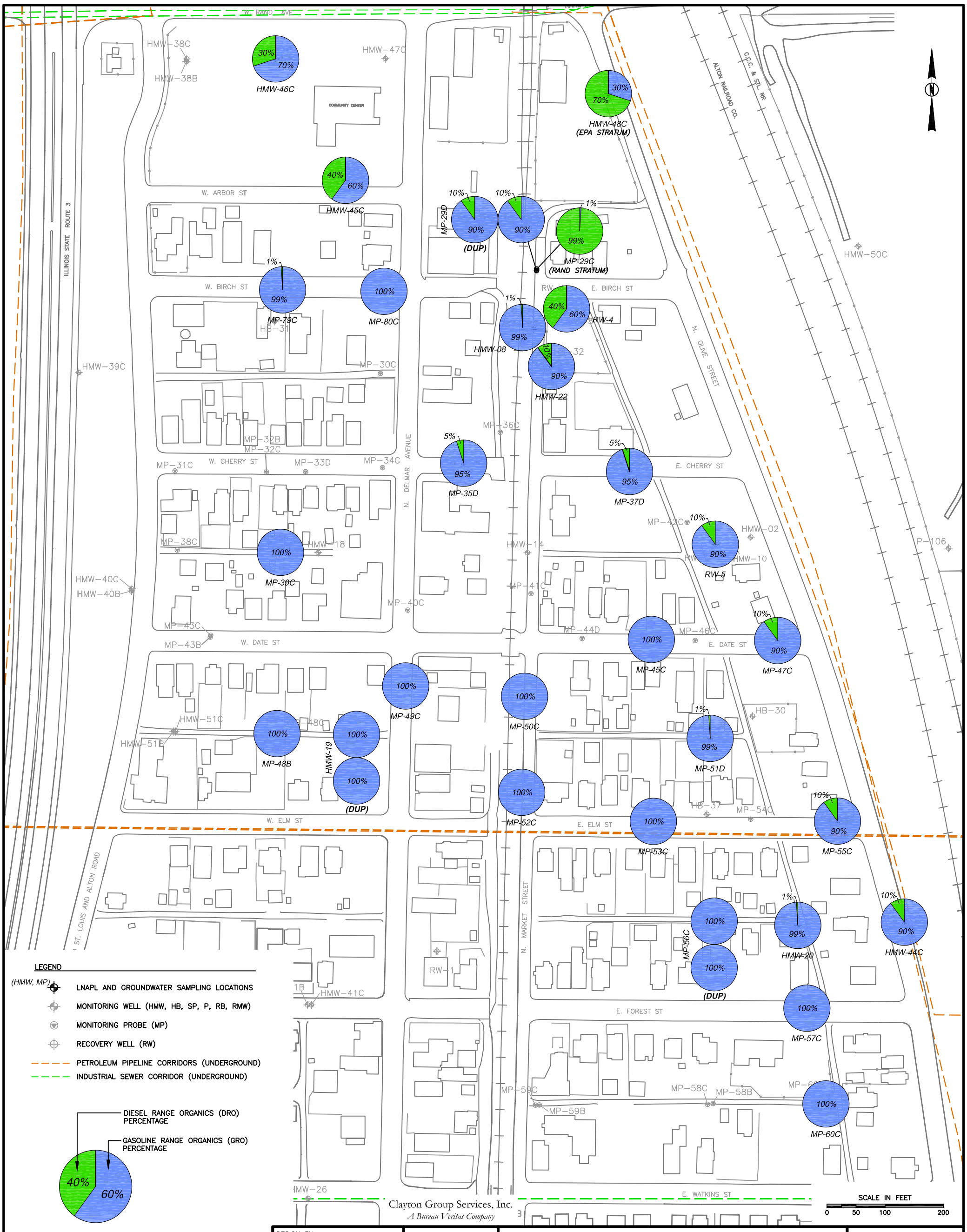
FIGURE
2-10



(FROM WILSON ET AL., 1990)

Clayton Group Services, Inc.
A Bureau Veritas Company

CHK BY	KDC	MULTIPLE FLUIDS IN THE PORE SPACE OF A GRANULAR POROUS MEDIA THE HARTFORD AREA HYDROCARBON PLUME SITE THE HARTFORD WORKING GROUP HARTFORD, ILLINOIS	FIGURE 3–1
DWN BY	OS		
DATE	12–15–05		
SCALE	NONE		
CAD NO.	0309514020A		
PRJ NO.	15–03095		



Clayton Group Services, Inc.
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LEGEND

(HMW, MP) LNAPL AND GROUNDWATER SAMPLING LOCATIONS

MONITORING WELL (HMW, HB, SP, P, RB, RMW)

MONITORING PROBE (MP)

RECOVERY WELL (RW)

PETROLEUM PIPELINE CORRIDORS (UNDERGROUND)

INDUSTRIAL SEWER CORRIDOR (UNDERGROUND)

DIESEL RANGE ORGANICS (DRO) PERCENTAGE

GASOLINE RANGE ORGANICS (GRO) PERCENTAGE

40% 60%

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 1828

LNAPL CHARACTERIZATION

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

FIGURE

3-2

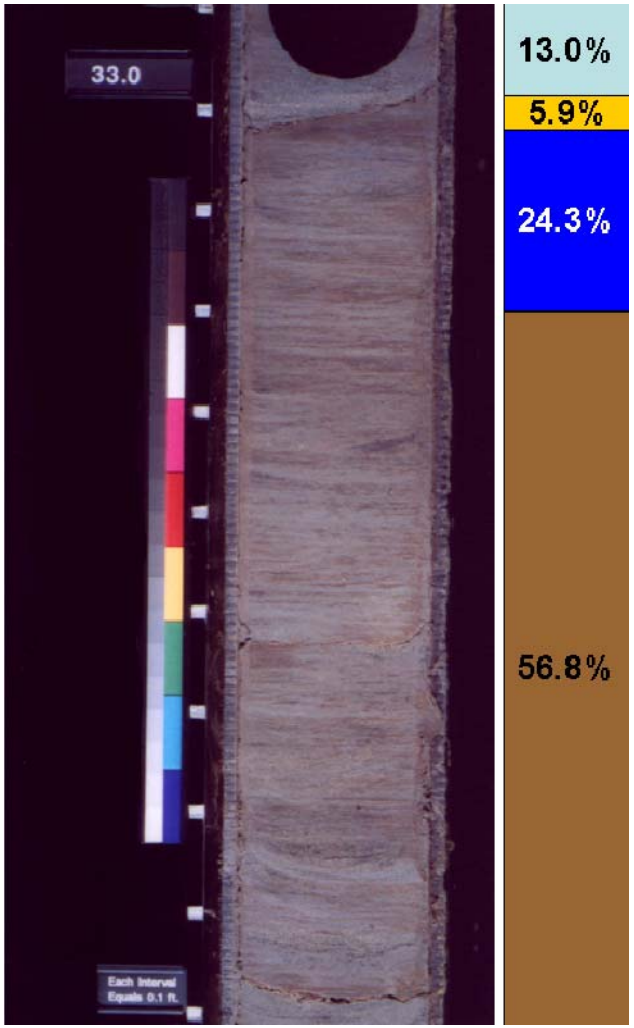
Example (not site specific)

This is a soil core taken at a field site where 5.6 feet of product was measured in a monitoring well. The part shown is the interval affected by product (the tiny dark points in the core). The volumes shown on the right are percentages of material measured from the soil core.

Color Key

- Air
- Product
- Water
- Mineral matter

Soil Type -69% Silt/Clay and 31% Fine Sand
Classified as a silt (ML)



Measured oil in Monitoring Well = 5.6 ft.
Mineral matter 56.8% of total volume
Water 24.3% of total volume
Oil in soil measured 5.9% of total volume
LNAPL Saturation = 13.6% Pore Volume
Porosity = 43.2 %

D_o = LNAPL Saturation * Porosity * Soil interval
(Calculated specific thickness of product in soil)

D_o = 13.6%*43.2%* soil interval (10 ft.) = 0.587 ft3/ft2

The D_o can be used to develop a correction factor that can be applied to the apparent product thickness at other monitoring wells located in the area with similar soil type.

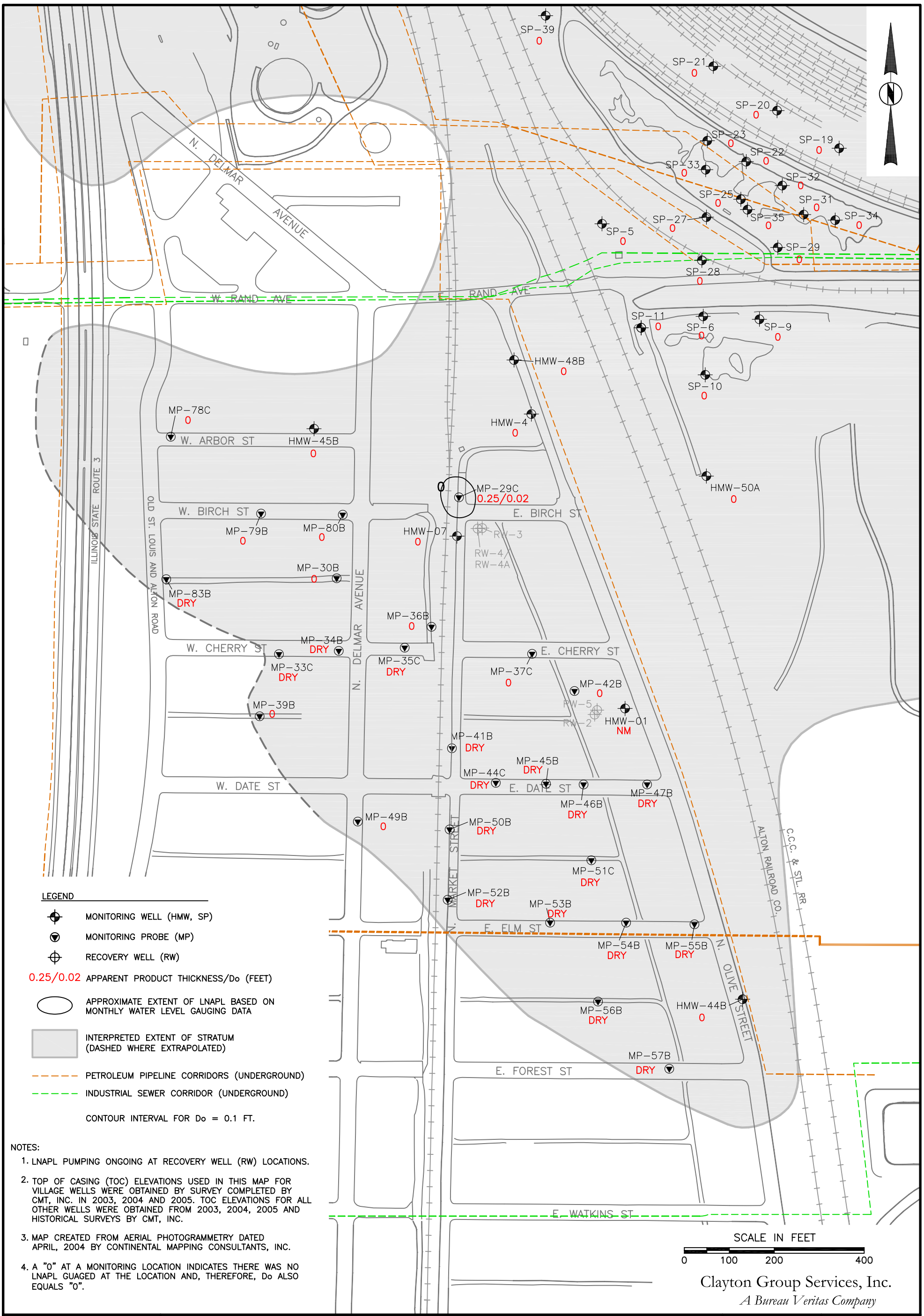
Correction factor = Apparent Product Thickness / D_o

Correction factor = 5.6ft / 0.587ft = 9.5

(FROM RETEC)

Clayton Group Services, Inc.
A Bureau Veritas Company

CHK BY	KDC	SPECIFIC THICKNESS OF LNAPL (Do) IN SOIL THE HARTFORD AREA HYDROCARBON PLUME SITE THE HARTFORD WORKING GROUP HARTFORD, ILLINOIS	FIGURE 3–3
DWN BY	BCP/OS		
DATE	12–15–05		
SCALE	NONE		
CAD NO.	0309514020A		
PRJ NO.	15–03095		



LEGEND

- MONITORING WELL (HMW, SP)
- MONITORING PROBE (MP)
- RECOVERY WELL (RW)
- 0.25/0.02 APPARENT PRODUCT THICKNESS/Do (FEET)
- APPROXIMATE EXTENT OF LNAPL BASED ON MONTHLY WATER LEVEL GAUGING DATA
- INTERPRETED EXTENT OF STRATUM (DASHED WHERE EXTRAPOLATED)
- PETROLEUM PIPELINE CORRIDORS (UNDERGROUND)
- INDUSTRIAL SEWER CORRIDOR (UNDERGROUND)
- CONTOUR INTERVAL FOR Do = 0.1 FT.

NOTES:

1. LNAPL PUMPING ONGOING AT RECOVERY WELL (RW) LOCATIONS.
2. TOP OF CASING (TOC) ELEVATIONS USED IN THIS MAP FOR VILLAGE WELLS WERE OBTAINED BY SURVEY COMPLETED BY CMT, INC. IN 2003, 2004 AND 2005. TOC ELEVATIONS FOR ALL OTHER WELLS WERE OBTAINED FROM 2003, 2004, 2005 AND HISTORICAL SURVEYS BY CMT, INC.
3. MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL, 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
4. A "0" AT A MONITORING LOCATION INDICATES THERE WAS NO LNAPL GUAGED AT THE LOCATION AND, THEREFORE, Do ALSO EQUALS "0".

Clayton Group Services, Inc.
A Bureau Veritas Company

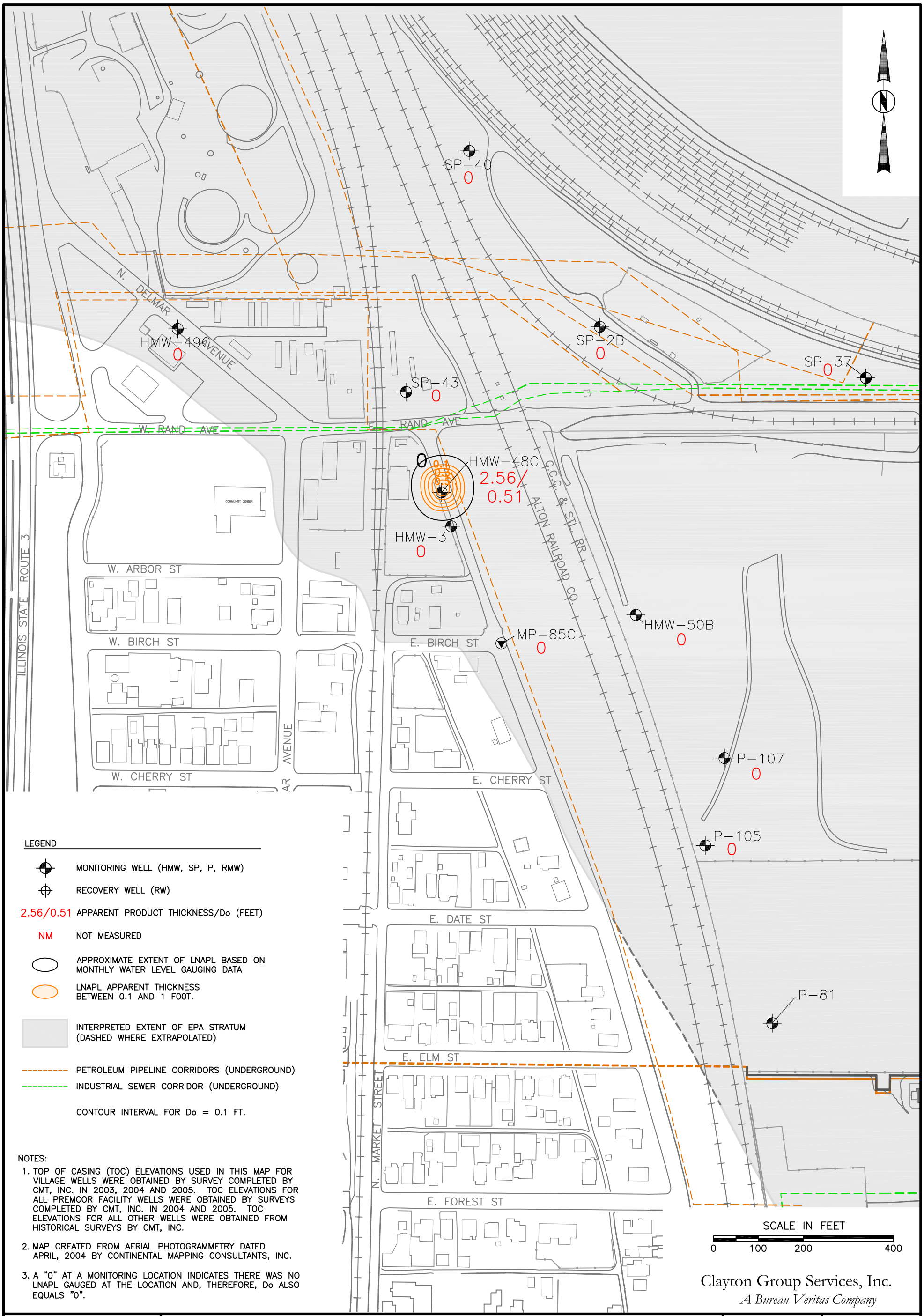
CHECK BY	
DRAWN BY	BCP
DATE	11-15-05
SCALE	AS SHOWN
CAD NO.	0309514007d47a
PRJ NO.	15-03095.14

LNAPL SPECIFIC THICKNESS (Do)
OCTOBER 4-5, 2005 – RAND STRATUM

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

BUREAU VERITAS

FIGURE
3-4



LEGEND

- MONITORING WELL (HMW, SP, P, RMW)
- RECOVERY WELL (RW)
- 2.56/0.51 APPARENT PRODUCT THICKNESS/Do (FEET)
- NM NOT MEASURED
- APPROXIMATE EXTENT OF LNAPL BASED ON MONTHLY WATER LEVEL GAUGING DATA
- LNAPL APPARENT THICKNESS BETWEEN 0.1 AND 1 FOOT.
- INTERPRETED EXTENT OF EPA STRATUM (DASHED WHERE EXTRAPOLATED)
- PETROLEUM PIPELINE CORRIDORS (UNDERGROUND)
- INDUSTRIAL SEWER CORRIDOR (UNDERGROUND)
- CONTOUR INTERVAL FOR Do = 0.1 FT.

NOTES:

1. TOP OF CASING (TOC) ELEVATIONS USED IN THIS MAP FOR VILLAGE WELLS WERE OBTAINED BY SURVEY COMPLETED BY CMT, INC. IN 2003, 2004 AND 2005. TOC ELEVATIONS FOR ALL PREMCOR FACILITY WELLS WERE OBTAINED BY SURVEYS COMPLETED BY CMT, INC. IN 2004 AND 2005. TOC ELEVATIONS FOR ALL OTHER WELLS WERE OBTAINED FROM HISTORICAL SURVEYS BY CMT, INC.
2. MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL, 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
3. A "0" AT A MONITORING LOCATION INDICATES THERE WAS NO LNAPL GAUGED AT THE LOCATION AND, THEREFORE, Do ALSO EQUALS "0".

Clayton Group Services, Inc.
A Bureau Veritas Company

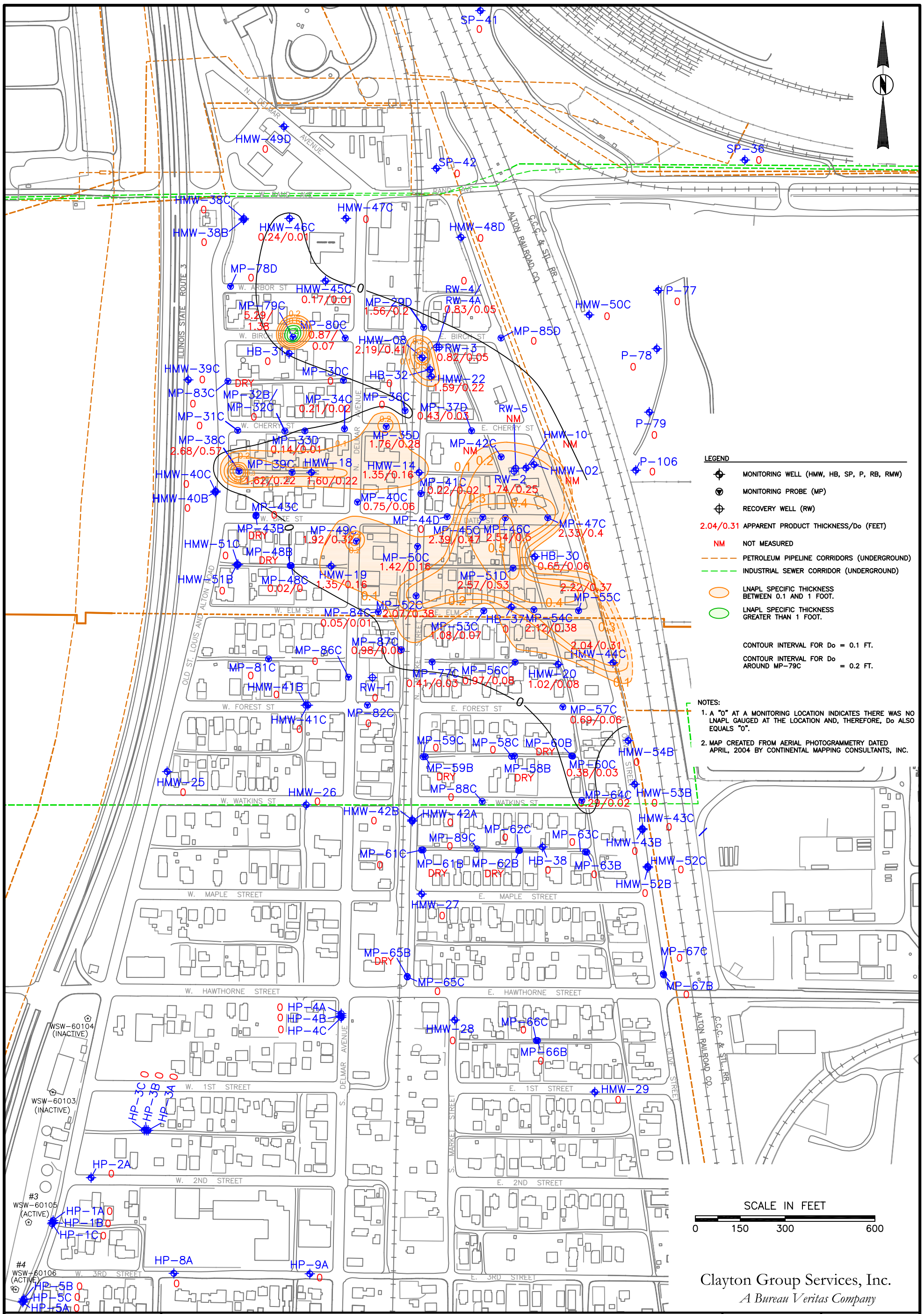
CHECK BY	KDC
DRAWN BY	BCP
DATE	11-15-05
SCALE	AS SHOWN
CAD NO.	0309514007d48a
PRJ NO.	15-03095.14

LNAPL SPECIFIC THICKNESS (Do)
OCTOBER 4-5, 2005 - EPA STRATUM

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

BUREAU VERITAS

FIGURE
3-5



CHECK BY	KDC
DRAWN BY	BCP
DATE	12-15-05
SCALE	AS SHOWN
CAD NO.	0309514007d49e
PRJ NO.	15-03095.14

LNAPL SPECIFIC THICKNESS (Do)
OCTOBER 4-5, 2005
MAIN SAND
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

BUREAU VERITAS

FIGURE 3-6

LEGEND:

- CPT/ROST™ INVESTIGATION LOCATION NO APPARENT PETROLEUM HYDROCARBON (BLACK)
- CPT/ROST™ INVESTIGATION LOCATION BLUE ROST RESPONSE
- CPT/ROST™ INVESTIGATION LOCATION GREEN ROST RESPONSE
- CPT/ROST™ INVESTIGATION LOCATION YELLOW ROST RESPONSE
- CPT/ROST™ INVESTIGATION LOCATION RED/ORANGE ROST RESPONSE
- PETROLEUM PIPELINE CORRIDORS (UNDERGROUND)
- INDUSTRIAL SEWER CORRIDOR (UNDERGROUND)
- 4–10 FT. BGS
- 10–20 FT. BGS
- 20–25 FT. BGS
- 25–30 FT. BGS
- 30+ FT. BGS
- NO APPARENT PETROLEUM HYDROCARBON

BGS = BELOW GROUND SURFACE

NOTES:

1. HROST-SERIES BORINGS 1 THROUGH 80 WERE COMPLETED IN 2004 WHILE HROST-SERIES BORINGS 81 THROUGH 130 WERE COMPLETED IN 2005. ALL HROST-SERIES BORINGS WERE COMPLETED BY FUGRO GEOSCIENCES, INC. USING CPT AND ROST™ METHODOLOGY.
2. THE FOLLOWING HROST LOCATIONS 9, 18, 21, 32, 42, 46, 58, 59, 63, 64, 69, 71, 73, 75, 86, 95, 100, 102, 105, 108 AND 127 WERE NOT COMPLETED DUE TO ACCESSIBILITY OR THE LOCATION WAS NO LONGER DEEMED NECESSARY BASED ON NEARBY RESULTS.
3. RESULTS FROM BORINGS ON LEVEE (HROST-81 AND HROST-83) ADJUSTED TO CORRELATE WITH ELEVATIONS OF SURROUNDING TOPOGRAPHY.
4. TWO OR MORE OF THE INDIVIDUAL ROST™ COLORS REPRESENT A COMMINGLED ROST™ RESPONSE.
5. MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.

SCALE IN FEET

0 120 240 480

Clayton Group Services, Inc.
A Bureau Veritas Company

DESIGN BY:	
CHECKED BY:	KDC
DRAWN BY:	BCP
DATE:	12-7-05
SCALE:	AS SHOWN
CAD NO.:	0309514020B
PROJECT NO.:	15-03095.14

BUREAU VERITAS

INFERRED DEPTH TO FIRST ENCOUNTERED
ROST RESPONSE
SEPTEMBER 2005
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

FIGURE

3-7

LEGEND:

- 0–50% FLUORESCENCE RESPONSE
- 50–150% FLUORESCENCE RESPONSE
- 150–250% FLUORESCENCE RESPONSE
- 250%+ FLUORESCENCE RESPONSE
- CPT/ROST™ INVESTIGATION LOCATION NO APPARENT PETROLEUM HYDROCARBON (BLACK)
- CPT/ROST™ INVESTIGATION LOCATION BLUE ROST RESPONSE
- CPT/ROST™ INVESTIGATION LOCATION GREEN ROST RESPONSE
- CPT/ROST™ INVESTIGATION LOCATION YELLOW ROST RESPONSE
- CPT/ROST™ INVESTIGATION LOCATION RED/ORANGE ROST RESPONSE
- INTERPRETED EXTENT OF NORTH OLIVE STRATUM (DASHED WHERE EXTRAPOLATED)
- PETROLEUM PIPELINE CORRIDORS (UNDERGROUND)
- INDUSTRIAL SEWER CORRIDOR (UNDERGROUND)

NOTES:

1. HROST–SERIES BORINGS 1 THROUGH 80 WERE COMPLETED IN 2004 WHILE HROST–SERIES BORINGS 81 THROUGH 130 WERE COMPLETED IN 2005. ALL HROST–SERIES BORINGS WERE COMPLETED BY FUGRO GEOSCIENCES, INC. USING CPT AND ROST™ METHODOLOGY.
2. THE FOLLOWING HROST LOCATIONS 9, 18, 21, 32, 42, 46, 58, 59, 63, 64, 69, 71, 73, 75, 86, 95, 100, 102, 105, 108 AND 127 WERE NOT COMPLETED DUE TO ACCESSIBILITY OR THE LOCATION WAS NO LONGER DEEMED NECESSARY BASED ON NEARBY RESULTS.
3. RESULTS FROM BORINGS ON LEVEE (HROST–81 AND HROST–83) ADJUSTED TO CORRELATE WITH ELEVATIONS OF SURROUNDING TOPOGRAPHY.
4. TWO OR MORE OF THE INDIVIDUAL ROST™ COLORS REPRESENT A COMMINGLED ROST™ RESPONSE.
5. MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.

SCALE IN FEET
0 125 250 500

Clayton Group Services, Inc.
A Bureau Veritas Company

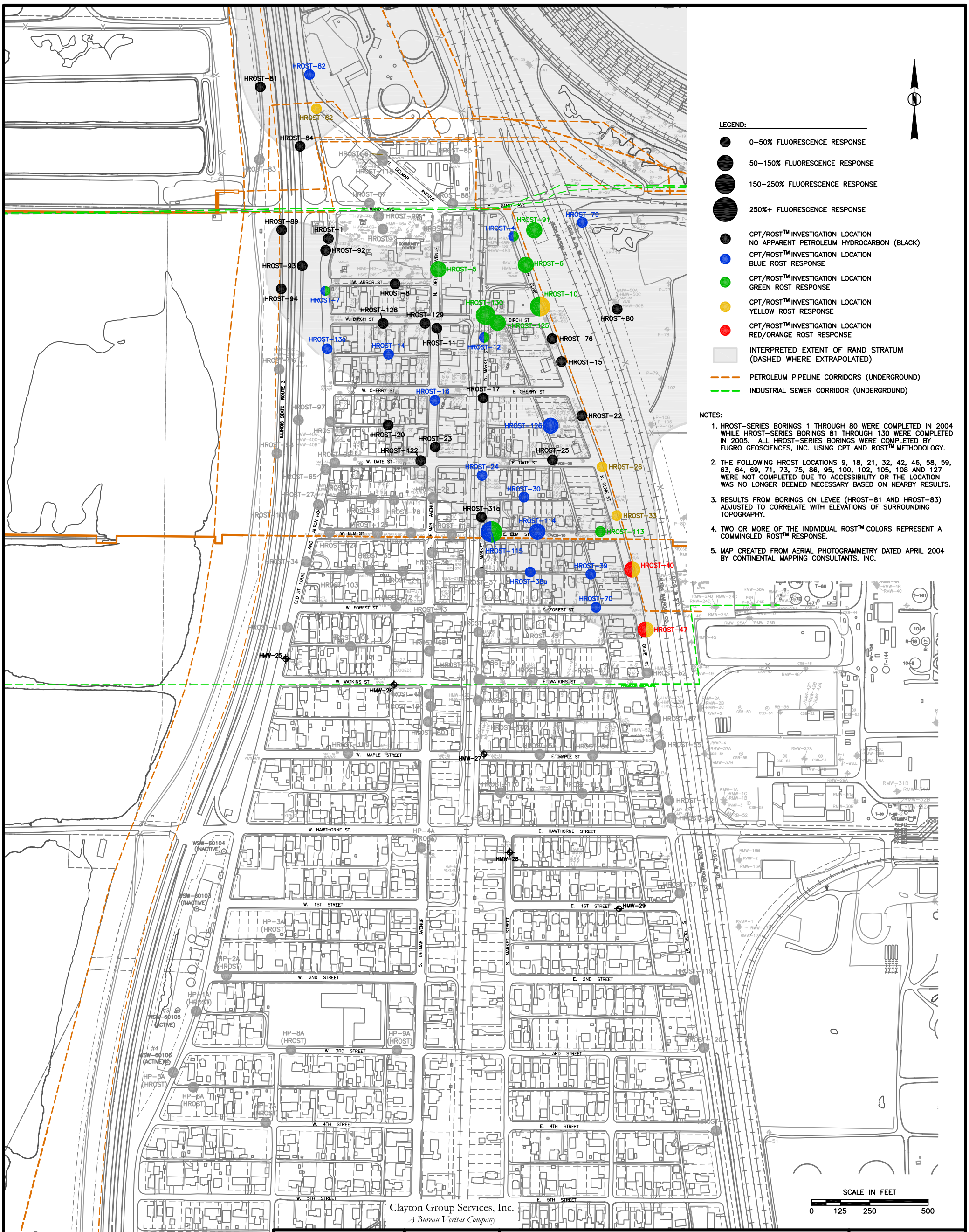
DESIGN BY:	
CHECKED BY:	KDC
DRAWN BY:	BCP/OS
DATE:	12–7–05
SCALE:	AS SHOWN
CAD NO.:	0309514011J1
PROJECT NO.:	15–03095.14

BUREAU VERITAS

ROST RESPONSE IN THE NORTH OLIVE STRATUM
SEPTEMBER 2005

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

FIGURE
3–8



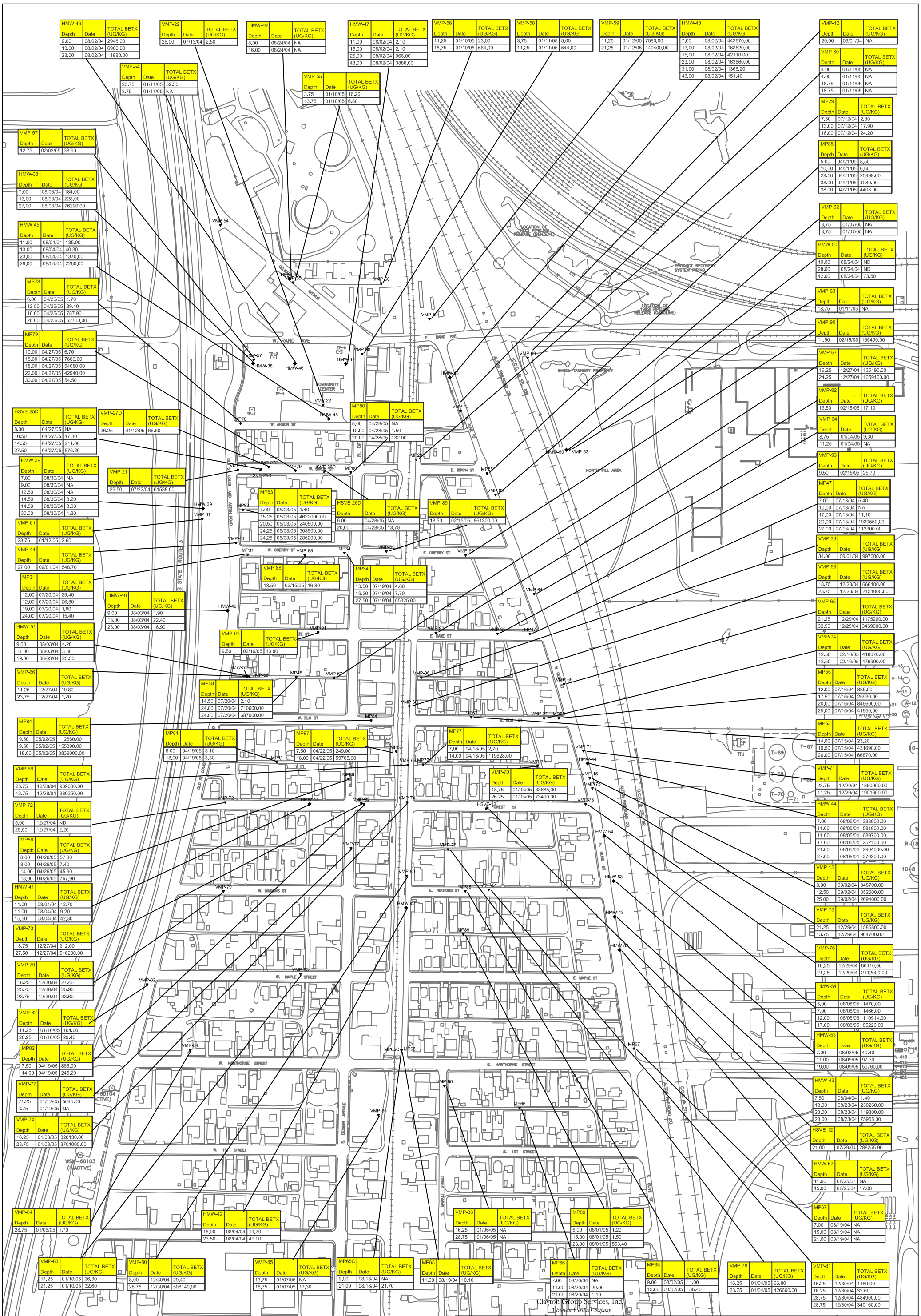
DESIGN BY:	
CHECKED BY:	KDC
DRAWN BY:	BCP/OS
DATE:	12–7–05
SCALE:	AS SHOWN
CAD NO.:	0309514011J2
PROJECT NO.:	15–03095.14

BUREAU VERITAS

ROST RESPONSE IN THE RAND STRATUM
SEPTEMBER 2005

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

FIGURE
3–9



HMW-46 Depth	Date	TOTAL BETX (UG/KG)
9.00	08/02/04	2948.00
13.00	08/02/04	6960.00
23.00	08/02/04	11980.00

VMP-22 Depth	Date	TOTAL BETX (UG/KG)
26.00	07/13/04	2.50

HMW-49 Depth	Date	TOTAL BETX (UG/KG)
8.00	08/24/04	NA
16.00	08/24/04	NA

HMW-47 Depth	Date	TOTAL BETX (UG/KG)
11.00	08/02/04	2.10
15.00	08/02/04	2.10
25.00	08/02/04	966.00
43.00	08/02/04	3888.00

VMP-56 Depth	Date	TOTAL BETX (UG/KG)
11.25	01/10/05	23.00
18.75	01/10/05	664.00

VMP-58 Depth	Date	TOTAL BETX (UG/KG)
3.75	01/11/05	5.00
11.25	01/11/05	544.00

VMP-59 Depth	Date	TOTAL BETX (UG/KG)
11.25	01/12/05	7580.00
21.25	01/12/05	149400.00

HMW-48 Depth	Date	TOTAL BETX (UG/KG)
7.00	08/02/04	443670.00
13.00	08/02/04	163520.00
15.00	08/02/04	42110.00
23.00	08/02/04	163660.00
31.00	08/02/04	1366.20
43.00	08/02/04	151.40

VMP-12 Depth	Date	TOTAL BETX (UG/KG)
20.00	09/01/04	NA

VMP-60 Depth	Date	TOTAL BETX (UG/KG)
4.00	01/11/05	NA
4.00	01/11/05	NA
18.75	01/11/05	NA
18.75	01/11/05	NA

MP29 Depth	Date	TOTAL BETX (UG/KG)
7.50	07/12/04	2.30
13.00	07/12/04	17.90
16.00	07/12/04	24.20

MP85 Depth	Date	TOTAL BETX (UG/KG)
5.00	04/21/05	8.50
10.00	04/21/05	6.60
29.50	04/21/05	25999.00
38.00	04/21/05	4080.00
38.00	04/21/05	4408.00

VMP-62 Depth	Date	TOTAL BETX (UG/KG)
3.75	01/07/05	NA
8.75	01/07/05	NA

HMW-50 Depth	Date	TOTAL BETX (UG/KG)
10.00	08/24/04	ND
28.00	08/24/04	ND
42.00	08/24/04	73.50

VMP-63 Depth	Date	TOTAL BETX (UG/KG)
18.75	01/11/05	NA

VMP-90 Depth	Date	TOTAL BETX (UG/KG)
11.50	02/15/05	165490.00

VMP-67 Depth	Date	TOTAL BETX (UG/KG)
16.25	12/27/04	135190.00
24.25	12/27/04	1059100.00

VMP-92 Depth	Date	TOTAL BETX (UG/KG)
13.50	02/15/05	17.10

VMP-64 Depth	Date	TOTAL BETX (UG/KG)
8.75	01/04/05	9.30
11.25	01/04/05	NA

VMP-93 Depth	Date	TOTAL BETX (UG/KG)
9.50	02/15/05	25.70

MP47 Depth	Date	TOTAL BETX (UG/KG)
7.00	07/13/04	5.40
10.00	07/13/04	NA
17.00	07/13/04	11.10
20.00	07/13/04	1939550.00
27.00	07/13/04	112300.00

VMP-36 Depth	Date	TOTAL BETX (UG/KG)
34.00	09/01/04	997000.00

VMP-68 Depth	Date	TOTAL BETX (UG/KG)
18.75	12/28/04	666100.00
23.75	12/28/04	2151000.00

VMP-65 Depth	Date	TOTAL BETX (UG/KG)
21.25	12/29/04	1175200.00
32.50	12/29/04	3469000.00

VMP-94 Depth	Date	TOTAL BETX (UG/KG)
12.50	02/16/05	418070.00
18.50	02/16/05	476900.00

MP55 Depth	Date	TOTAL BETX (UG/KG)
12.00	07/16/04	885.00
17.50	07/16/04	25930.00
20.00	07/16/04	846600.00
25.00	07/16/04	41950.00

MP53 Depth	Date	TOTAL BETX (UG/KG)
14.00	07/15/04	23.20
19.50	07/15/04	431090.00
26.00	07/15/04	66870.00

VMP-71 Depth	Date	TOTAL BETX (UG/KG)
23.75	12/29/04	1860000.00
11.25	12/29/04	1901600.00

HMW-44 Depth	Date	TOTAL BETX (UG/KG)
7.00	08/05/04	383900.00
11.00	08/05/04	581900.00
11.00	08/05/04	689700.00
17.00	08/05/04	252100.00
21.00	08/05/04	2904000.00
27.00	08/05/04	270300.00

VMP-15 Depth	Date	TOTAL BETX (UG/KG)
8.00	09/02/04	348700.00
12.50	09/02/04	352600.00
25.00	09/02/04	2694000.00

VMP-75 Depth	Date	TOTAL BETX (UG/KG)
21.25	12/29/04	1586800.00
13.75	12/29/04	964700.00

VMP-76 Depth	Date	TOTAL BETX (UG/KG)
16.25	12/29/04	86110.00
21.25	12/29/04	2112000.00

HMW-54 Depth	Date	TOTAL BETX (UG/KG)
5.00	08/08/05	1470.00
7.00	08/08/05	1466.00
12.00	08/08/05	110914.00
17.00	08/08/05	85220.00

HMW-53 Depth	Date	TOTAL BETX (UG/KG)
7.00	08/08/05	40.40
11.00	08/09/05	97.30
19.00	08/09/05	50760.00

HMW-43 Depth	Date	TOTAL BETX (UG/KG)
7.50	08/04/04	1.40
13.00	08/23/04	230260.00
23.00	08/23/04	119800.00
23.00	08/23/04	75955.00

HSVE-12 Depth	Date	TOTAL BETX (UG/KG)
21.00	07/29/04	288255.90

HMW-52 Depth	Date	TOTAL BETX (UG/KG)
11.00	08/25/04	NA
15.00	08/25/04	17.60

MP67 Depth	Date	TOTAL BETX (UG/KG)
7.00	08/19/04	NA
15.00	08/19/04	NA
21.00	08/19/04	NA

VMP-57 Depth	Date	TOTAL BETX (UG/KG)
12.75	02/02/05	38.90

HMW-38 Depth	Date	TOTAL BETX (UG/KG)
7.00	08/03/04	184.00
13.00	08/03/04	228.00
27.00	08/03/04	76290.00

HMW-45 Depth	Date	TOTAL BETX (UG/KG)
11.00	08/04/04	135.00
13.00	08/04/04	40.30
23.00	08/04/04	1370.00
29.00	08/04/04	2260.00

MP78 Depth	Date	TOTAL BETX (UG/KG)
6.00	04/25/05	1.70
12.50	04/25/05	89.40
16.00	04/25/05	787.90
26.00	04/25/05	52700.00

MP79 Depth	Date	TOTAL BETX (UG/KG)
10.00	04/27/05	6.70
18.00	04/27/05	7680.00
18.00	04/27/05	54080.00
22.00	04/27/05	42940.00
30.00	04/27/05	54.50

HSVE-25D Depth	Date	TOTAL BETX (UG/KG)
8.00	04/27/05	NA
10.50	04/27/05	47.30
14.50	04/27/05	211.00
27.50	04/27/05	576.20

VMP-27D Depth	Date	TOTAL BETX (UG/KG)
26.25	01/12/05	66.60

HMW-39 Depth	Date	TOTAL BETX (UG/KG)
7.00	08/30/04	NA
9.00	08/30/04	NA
12.50	08/30/04	NA
14.50	08/30/04	3.20
14.50	08/30/04	3.00
30.00	08/30/04	1.80

VMP-21 Depth	Date	TOTAL BETX (UG/KG)
29.50	07/23/04	61588.00

MP83 Depth	Date	TOTAL BETX (UG/KG)
7.00	05/03/05	1.40
15.25	05/03/05	4622000.00
20.50	05/03/05	240500.00
24.25	05/03/05	308500.00
24.25	05/03/05	286200.00

HSVE-26D Depth	Date	TOTAL BETX (UG/KG)
6.00	04/28/05	NA
20.00	04/28/05	13.70

VMP-89 Depth	Date	TOTAL BETX (UG/KG)
18.50	02/15/05	861300.00

VMP-61 Depth	Date	TOTAL BETX (UG/KG)
23.75	01/12/05	2.60

VMP-44 Depth	Date	TOTAL BETX (UG/KG)
27.00	09/01/04	548.70

MP31 Depth	Date	TOTAL BETX (UG/KG)
12.00	07/20/04	29.40
12.00	07/20/04	26.80
19.00	07/20/04	1.80
24.00	07/20/04	15.40

VMP-88 Depth	Date	TOTAL BETX (UG/KG)
13.50	02/15/05	16.80

MP34 Depth	Date	TOTAL BETX (UG/KG)
13.50	07/19/04	4.60
19.50	07/19/04	7.70
27.50	07/19/04	65325.00

HMW-40 Depth	Date	TOTAL BETX (UG/KG)
9.00	08/03/04	1.90
13.00	08/03/04	22.40
23.00	08/03/04	16.90

HMW-51 Depth	Date	TOTAL BETX (UG/KG)
9.00	08/03/04	4.20
11.00	08/03/04	3.30
19.00	08/03/04	23.30

VMP-91 Depth	Date	TOTAL BETX (UG/KG)
9.50	02/16/05	13.80

VMP-66 Depth	Date	TOTAL BETX (UG/KG)
11.25	12/27/04	10.80
23.75	12/27/04	1.20

MP48 Depth	Date	TOTAL BETX (UG/KG)
14.50	07/20/04	2.10
24.00	07/20/04	710600.00
24.00	07/20/04	687000.00

MP84 Depth	Date	TOTAL BETX (UG/KG)
9.50	05/02/05	112660.00
9.50	05/02/05	155390.00
18.00	05/02/05	3839000.00

MP81 Depth	Date	TOTAL BETX (UG/KG)
8.00	04/19/05	3.10
18.00	04/19/05	3.30

MP87 Depth	Date	TOTAL BETX (UG/KG)
7.50	04/22/05	249.00
16.00	04/22/05	59705.00

MP77 Depth	Date	TOTAL BETX (UG/KG)
7.00	04/18/05	2.70
14.00	04/18/05	119628.00

VMP-69 Depth	Date	TOTAL BETX (UG/KG)
23.75	12/28/04	939600.00
13.75	12/28/04	389250.00

VMP-70 Depth	Date	TOTAL BETX (UG/KG)
18.75	01/03/05	33685.00
26.25	01/03/05	73490.00

VMP-72 Depth	Date	TOTAL BETX (UG/KG)
5.00	12/27/04	ND
25.50	12/27/04	2.20

MP86 Depth	Date	TOTAL BETX (UG/KG)
8.00	04/26/05	57.80
8.00	04/26/05	7.40
14.00	04/26/05	45.90
18.00	04/26/05	767.90

HMW-41 Depth	Date	TOTAL BETX (UG/KG)
11.00	08/04/04	12.70
11.00	08/04/04	9.20
15.50	08/04/04	42.30

VMP-73 Depth	Date	TOTAL BETX (UG/KG)
18.75	12/27/04	912.00
27.50	12/27/04	516200.00

VMP-79 Depth	Date	TOTAL BETX (UG/KG)
16.25	12/30/04	27.40
23.75	12/30/04	25.90
23.75	12/30/04	33.60

VMP-82 Depth	Date	TOTAL BETX (UG/KG)
11.25	01/10/05	104.00
26.25	01/10/05	29.40

MP82 Depth	Date	TOTAL BETX (UG/KG)
7.50	04/19/05	866.00
14.00	04/19/05	245.20

VMP-77 Depth	Date	TOTAL BETX (UG/KG)
21.25	01/12/05	5645.00
3.75	01/12/05	NA

VMP-74 Depth	Date	TOTAL BETX (UG/KG)
16.25	01/03/05	328130.00
23.75	01/03/05	3701000.00

VMP-84 Depth	Date	TOTAL BETX (UG/KG)
28.75	01/06/05	1.70

HMW-42 Depth	Date	TOTAL BETX (UG/KG)
15.00	08/04/04	11.70
23.50	08/04/04	49.00

VMP-86 Depth	Date	TOTAL BETX (UG/KG)
16.25	01/06/05	NA
28.75	01/06/05	NA

MP89 Depth	Date	TOTAL BETX (UG/KG)
5.00	08/01/05	1.20
15.00	08/01/05	1.50
23.00	08/01/05	553.40

VMP-83 Depth	Date	TOTAL BETX (UG/KG)
11.25	01/10/05	26.30
21.25	01/10/05	32.60

VMP-80 Depth	Date	TOTAL BETX (UG/KG)
8.00	12/30/04	29.40
28.75	12/30/04	506140.00

VMP-85 Depth	Date	TOTAL BETX (UG/KG)
13.75	01/07/05	NA
18.75	01/07/05	17.30

MP65C Depth	Date	TOTAL BETX (UG/KG)
9.00	08/18/04	NA
21.00	08/18/04	21.70

MP65 Depth	Date	TOTAL BETX (UG/KG)
11.00	08/19/04	10.10

MP66 Depth	Date	TOTAL BETX (UG/KG)
7.00	08/20/04	NA
11.00	08/20/04	29.00
21.00	08/20/04	1.10

MP88 Depth	Date	TOTAL BETX (UG/KG)
9.00	08/02/05	11.00
15.00	08/02/05	136.40

VMP-78 Depth	Date	TOTAL BETX (UG/KG)
16.25	01/04/05	66.80
23.75	01/04/05	426660.00

VMP-81 Depth	Date	TOTAL BETX (UG/KG)
16.25	12/30/04	1189.00
16.25	12/30/04	32.60
28.75	12/30/04	484900.00
28.75	12/30/04	340160.00

Clayton Group Services, Inc.
A Bureau Veritas Company

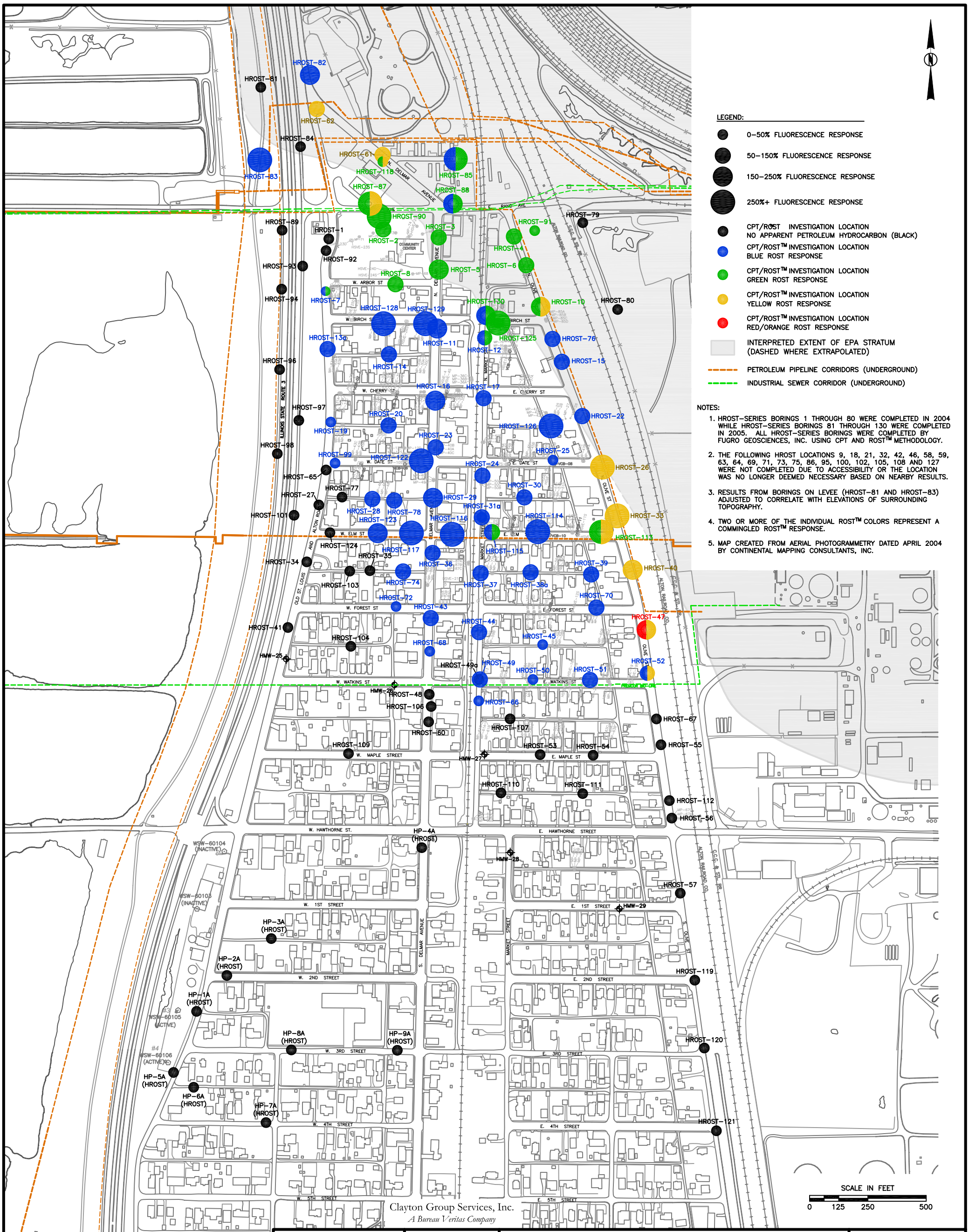
DESIGN BY:	KDC
CHECKED BY:	KDC
DRAWN BY:	SMK
DATE:	11-18-05
SCALE:	AS SHOWN
CAD NO.:	11020502
PROJECT NO.:	15-03095

BUREAU VERITAS

SOIL ANALYSIS RESULTS IN PROFILE

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

FIGURE
3-10

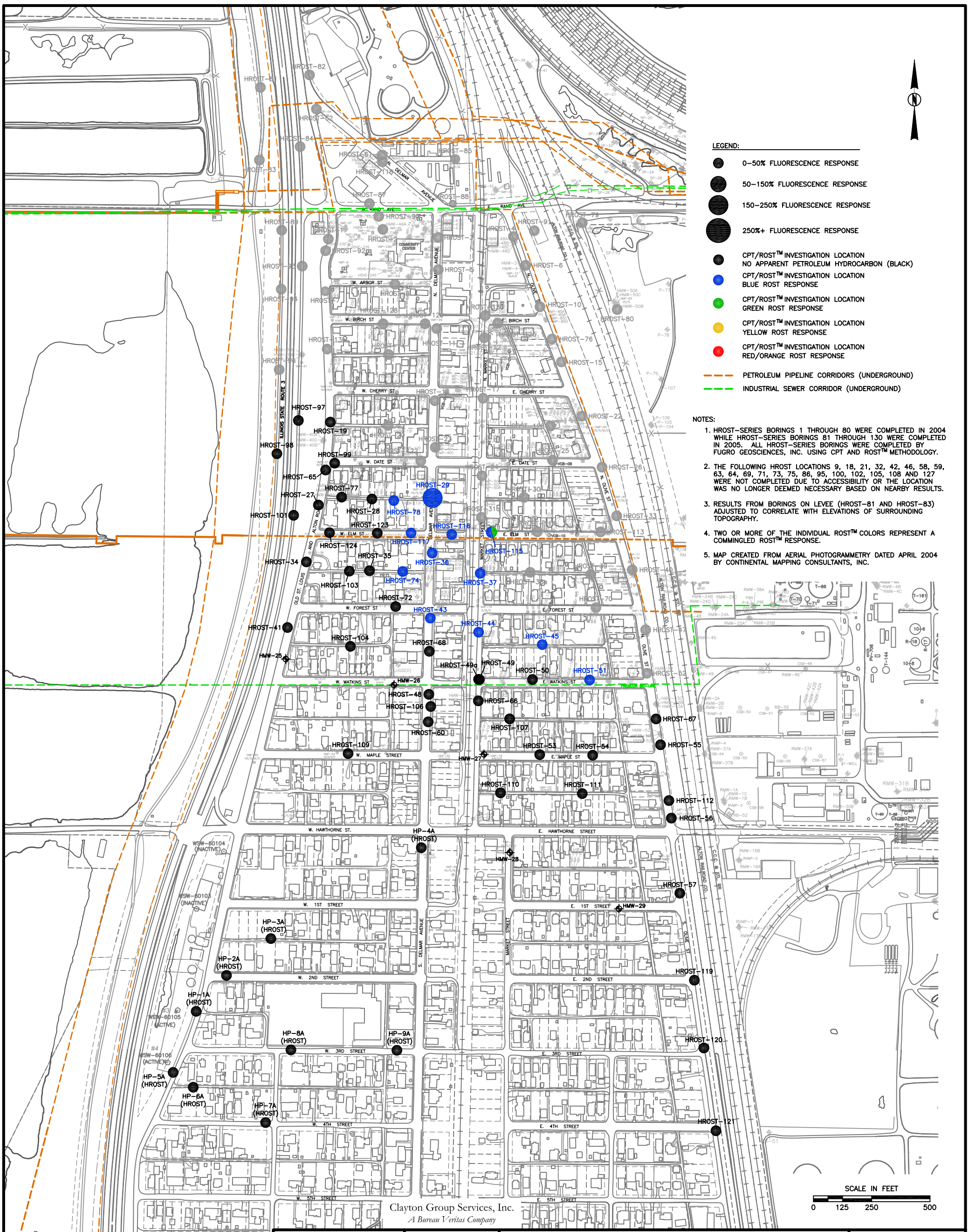


DESIGN BY:	
CHECKED BY:	KDC
DRAWN BY:	BCP
DATE:	12–7–05
SCALE:	AS SHOWN
CAD NO.:	0309514011J3
PROJECT NO.:	15–03095.14

BUREAU VERITAS

ROST RESPONSE IN THE EPA STRATUM AND THE MAIN SAND
SEPTEMBER 2005
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

FIGURE
3–11

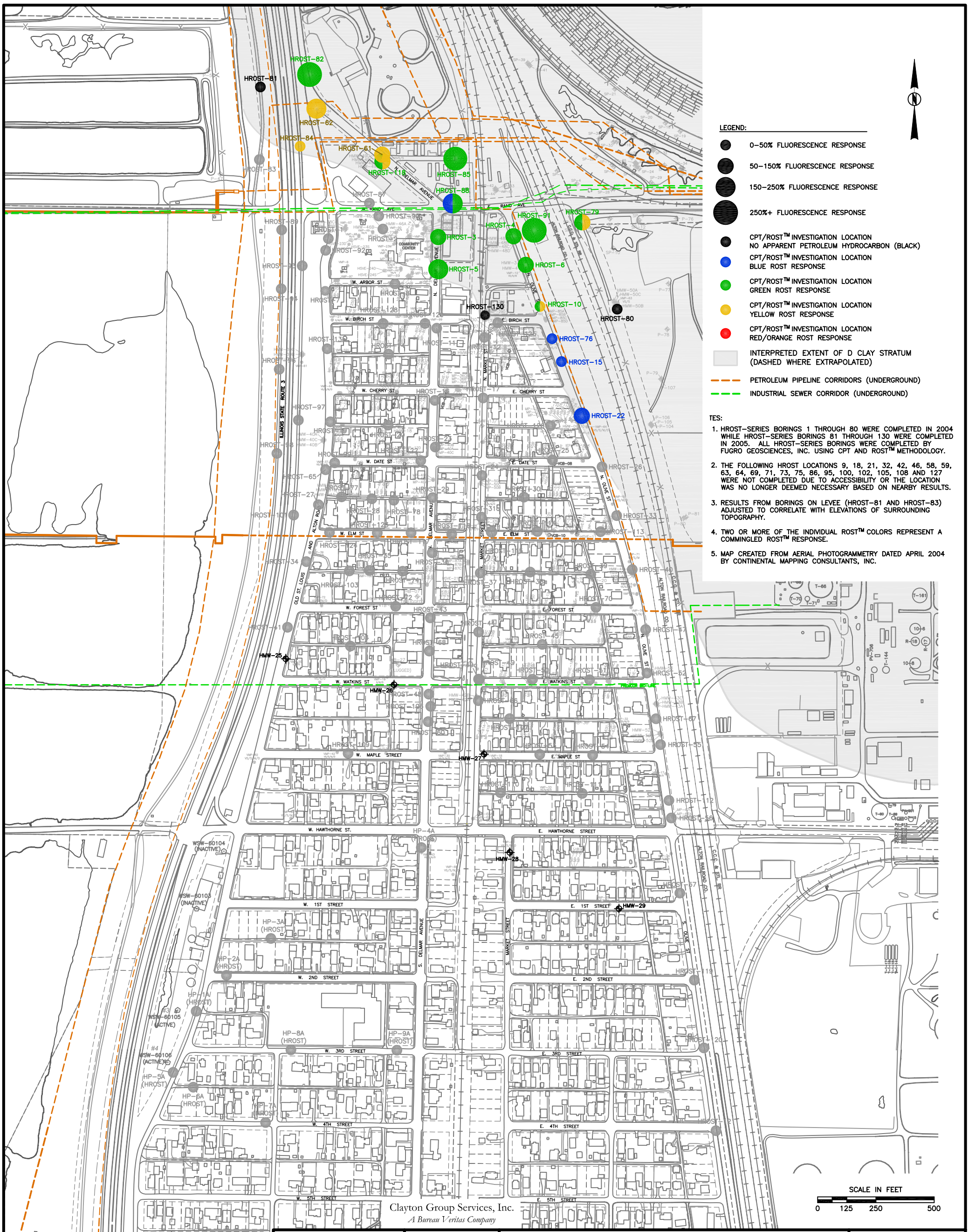


DESIGN BY:	
CHECKED BY:	KDC
DRAWN BY:	BCP
DATE:	12–7–05
SCALE:	AS SHOWN
CAD NO.:	0309514011J4
PROJECT NO.:	15–03095.14

BUREAU VERITAS

ROST RESPONSE IN THE
MAIN SILT/MAIN SAND ABOVE 25 FEET
SEPTEMBER 2005
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

FIGURE
3–12

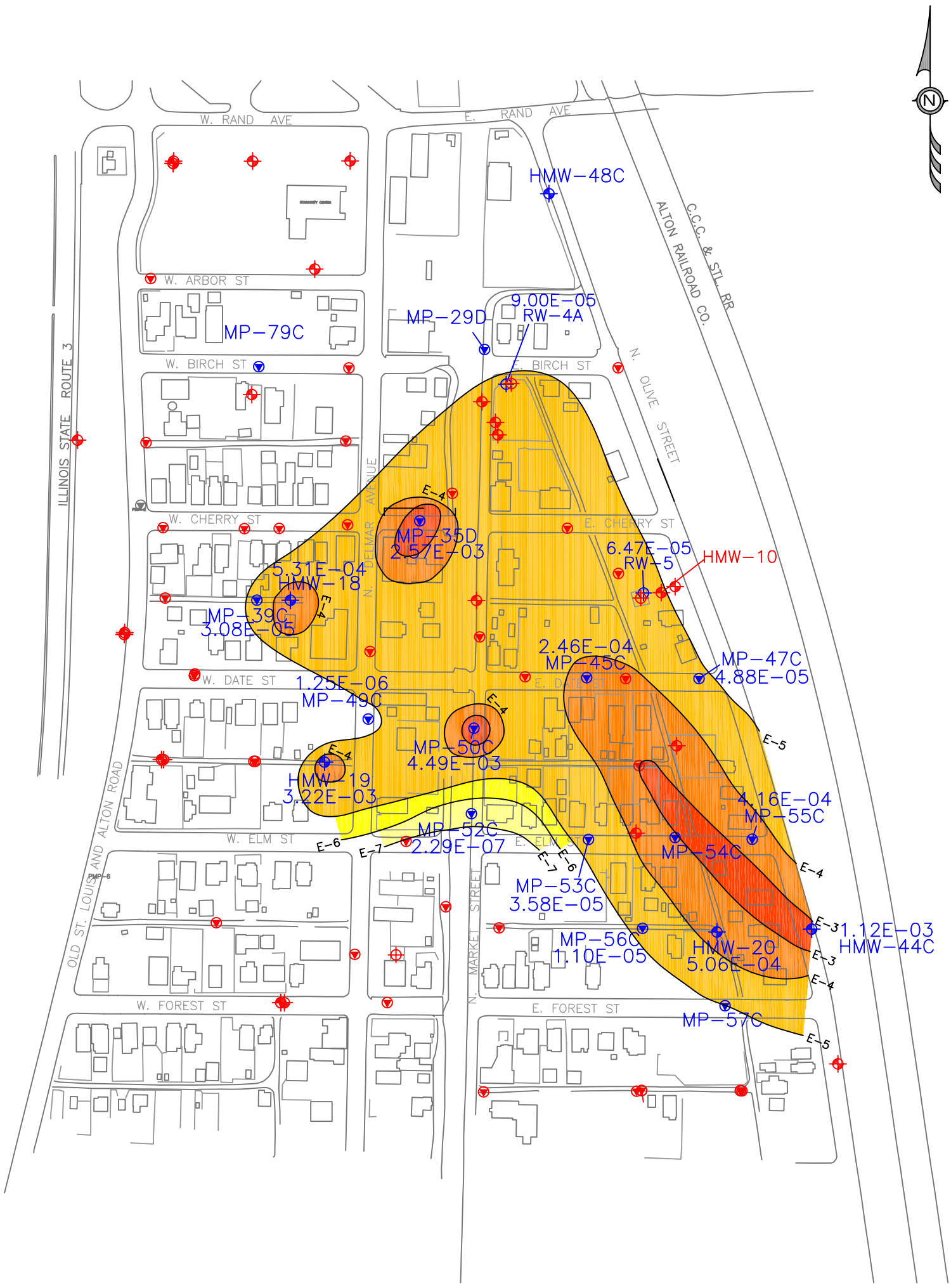


DESIGN BY:	
CHECKED BY:	KDC
DRAWN BY:	BCP
DATE:	12–7–05
SCALE:	AS SHOWN
CAD NO.:	0309514011J5
PROJECT NO.:	15–03095.14

BUREAU VERITAS

ROST RESPONSE IN THE
MAIN SAND BELOW THE D CLAY
SEPTEMBER 2005
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

FIGURE
3–13



LEGEND

RMW-7C, RB-44 — MONITORING WELL

RW-1 — RECOVERY WELL

MP-29 — MONITORING PROBE

LNAPL CONDUCTIVITY (1E-07 TO 1E-06 Kn)

LNAPL CONDUCTIVITY (1E-06 TO 1E-05 Kn)

LNAPL CONDUCTIVITY (1E-05 TO 1E-04 Kn)

LNAPL CONDUCTIVITY (1E-04 TO 1E-03 Kn)

LNAPL CONDUCTIVITY (1E-03 TO 1E-02 Kn)

NOTES:

1. BASE MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
2. BLUE WELLS SIGNIFY WELLS AT WHICH HVR PILOT TESTING WAS PERFORMED.
3. VALUES FOR WELLS HMW-48C, MP-29D, MP-79C WERE NOT CALCULATED BECAUSE THE GAUGED DEPTH TO WATER WAS ABOVE THE MONITORING WELL SCREEN, WHICH VIOLATES THE HUNTLEY 2000 TEST METHOD.

SCALE IN FEET

0 100 200 400

CHECK BY	
DRAWN BY	MLR
DATE	12/13/05
SCALE	AS SHOWN
CAD NO.	154.001.3-14csm
PRJ NO.	154.001

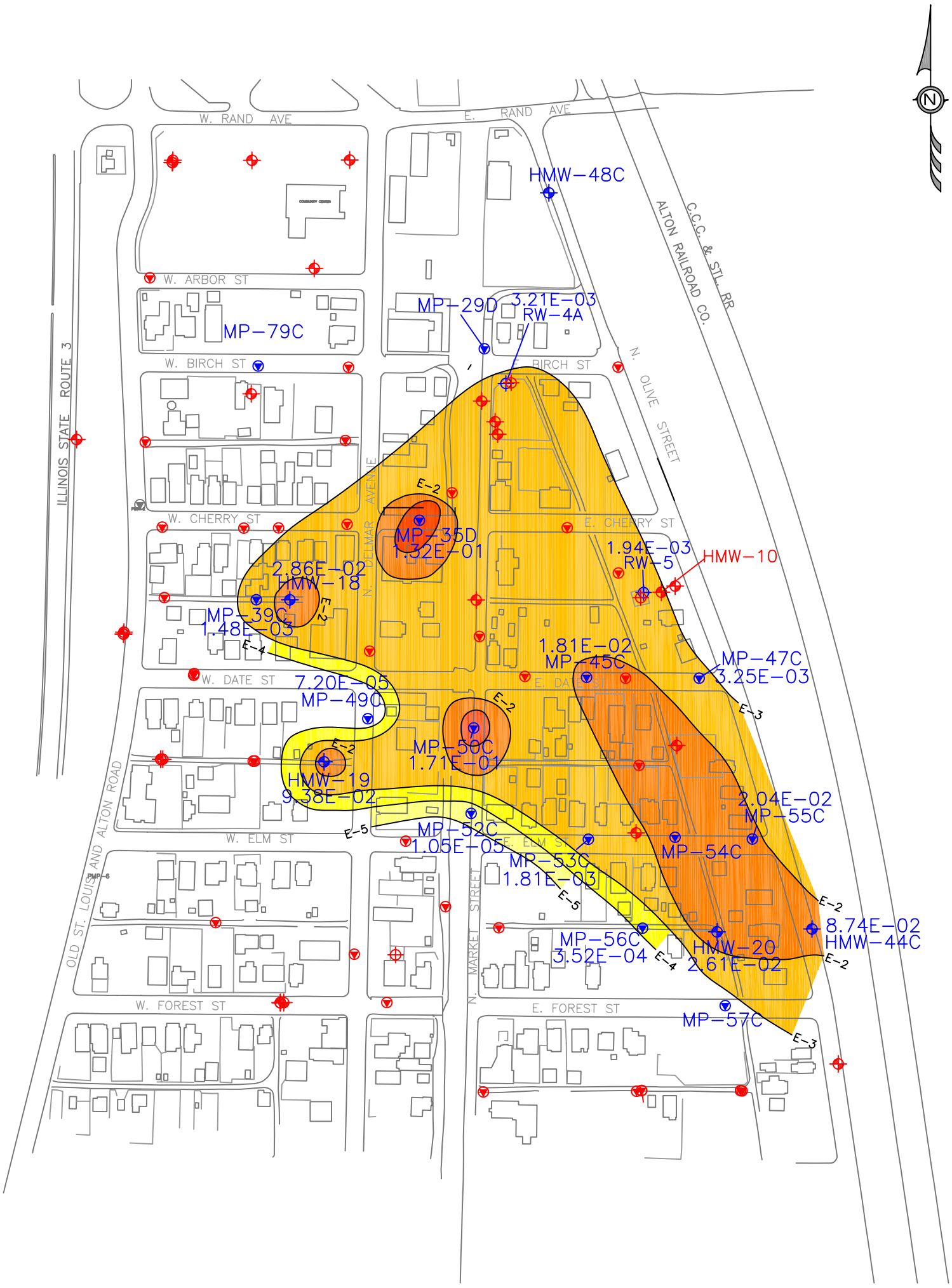
AVERAGE LNAPL CONDUCTIVITY (Kn) CONTOUR MAP
MAIN SAND

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

H2A ENVIRONMENTAL, LTD.

FIGURE

3-14



LEGEND

RMW-7C, RB-44 — MONITORING WELL

RW-1 — RECOVERY WELL

MP-29 — MONITORING PROBE

- LNAPL TRANSMISSIVITY (1E-05 TO 1E-04 Tn)
- LNAPL TRANSMISSIVITY (1E-04 TO 1E-03 Tn)
- LNAPL TRANSMISSIVITY (1E-03 TO 1E-02 Tn)
- LNAPL TRANSMISSIVITY (1E-02 TO 1E-01 Tn)
- LNAPL TRANSMISSIVITY (1E-01 TO 1E-00 Tn)

NOTES:

1. BASE MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
2. BLUE WELLS SIGNIFY WELLS AT WHICH HVR PILOT TESTING WAS PERFORMED.
3. VALUES FOR WELLS HMW-48C, MP-29D, MP-79C WERE NOT CALCULATED BECAUSE THE GAUGED DEPTH TO WATER WAS ABOVE THE MONITORING WELL SCREEN, WHICH VIOLATES THE HUNTLEY 2000 TEST METHOD.

SCALE IN FEET

0 100 200 400

CHECK BY	
DRAWN BY	MLR
DATE	12/13/05
SCALE	AS SHOWN
CAD NO.	154.001.3-15csm
PRJ NO.	154.001

AVERAGE LNAPL TRANSMISSIVITY (Tn) CONTOUR MAP
MAIN SAND

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

H2A ENVIRONMENTAL, LTD.

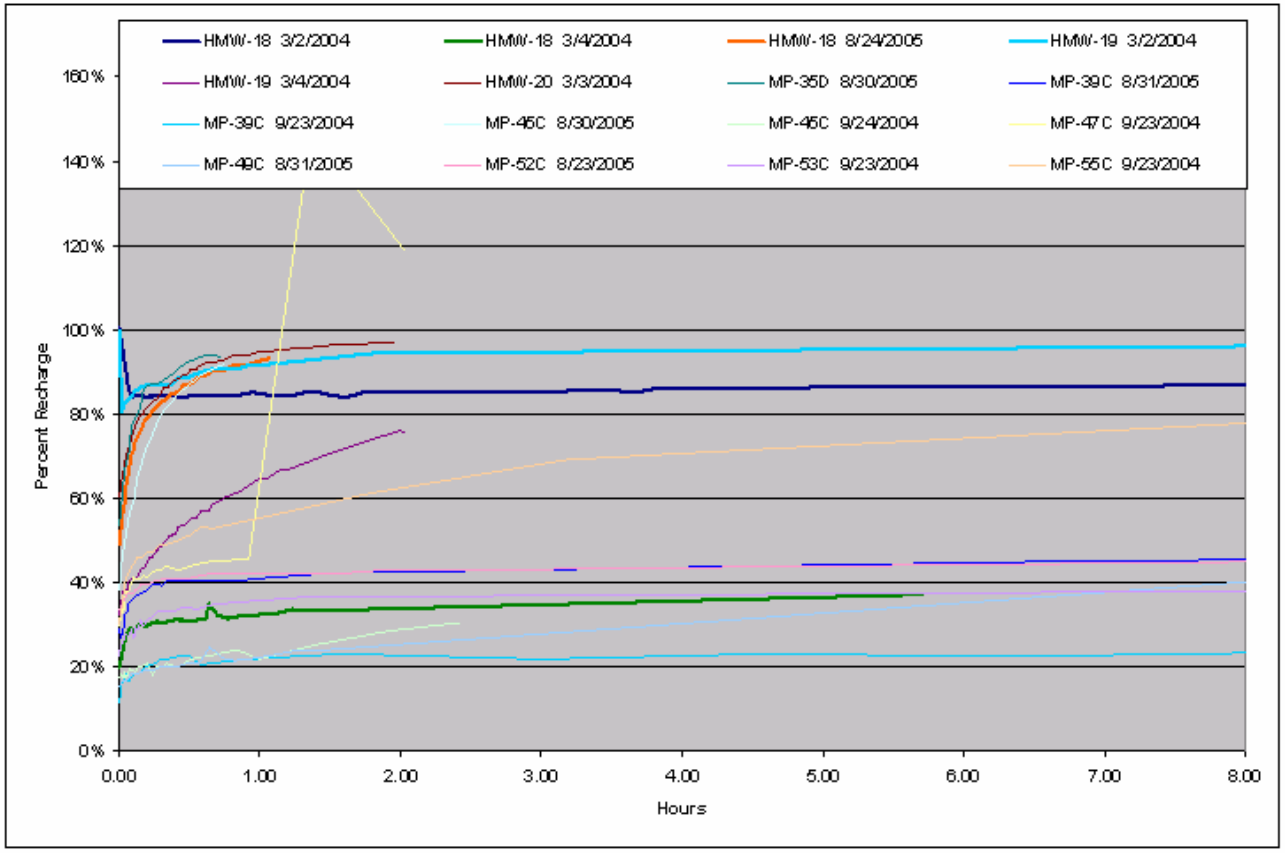
FIGURE

3-15

GRAPHS

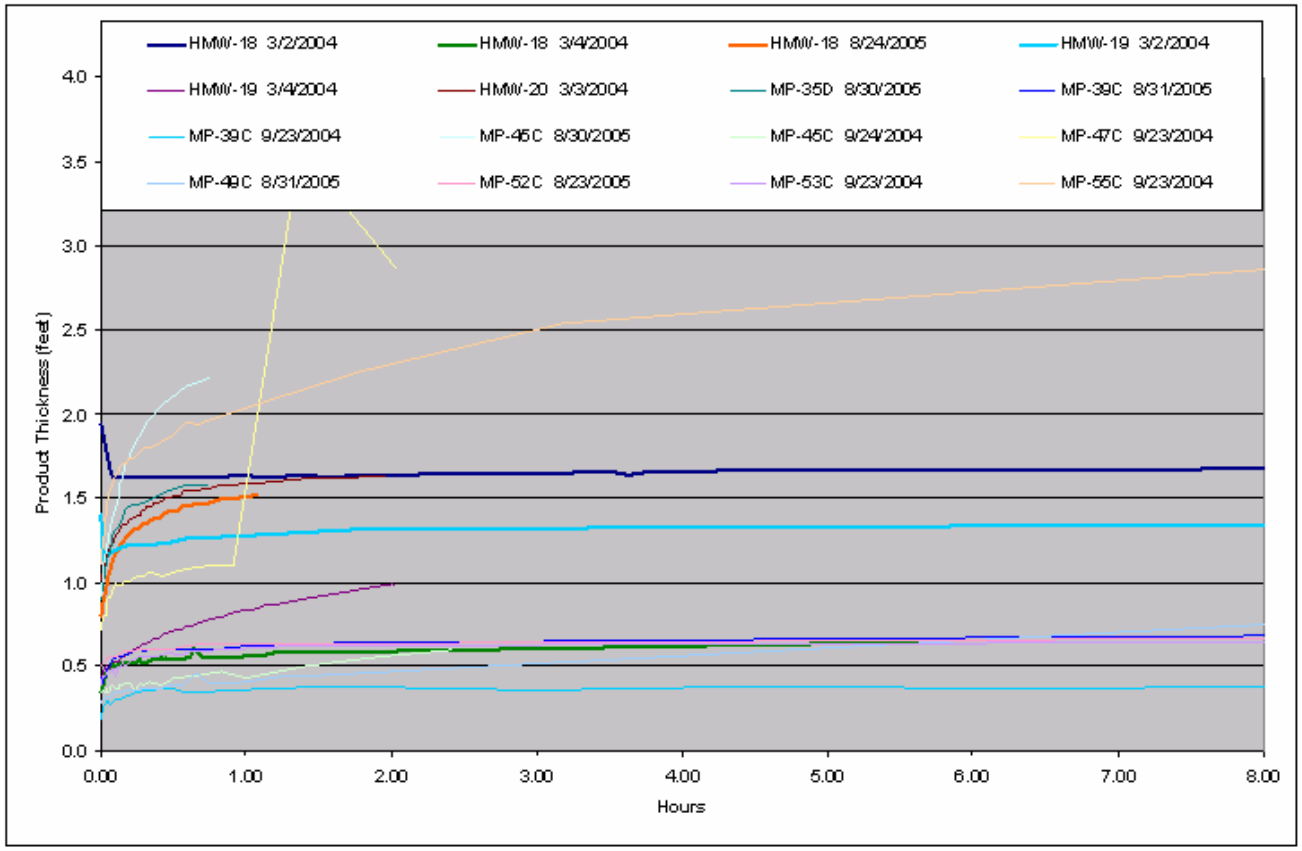
GRAPH 3-1
Baildown Test Recharge as a Percentage of Original Product Thickness
Hartford Area Hydrocarbon Plume Site

The Hartford Working Group / Hartford, Illinois
1190505040 -- Madison County -- ILR 000128249



GRAPH 3-2
Baildown Test Recharge as Product Thickness in Feet
Hartford Area Hydrocarbon Plume Site

The Hartford Working Group / Hartford, Illinois
1190505040 -- Madison County -- ILR 000128249

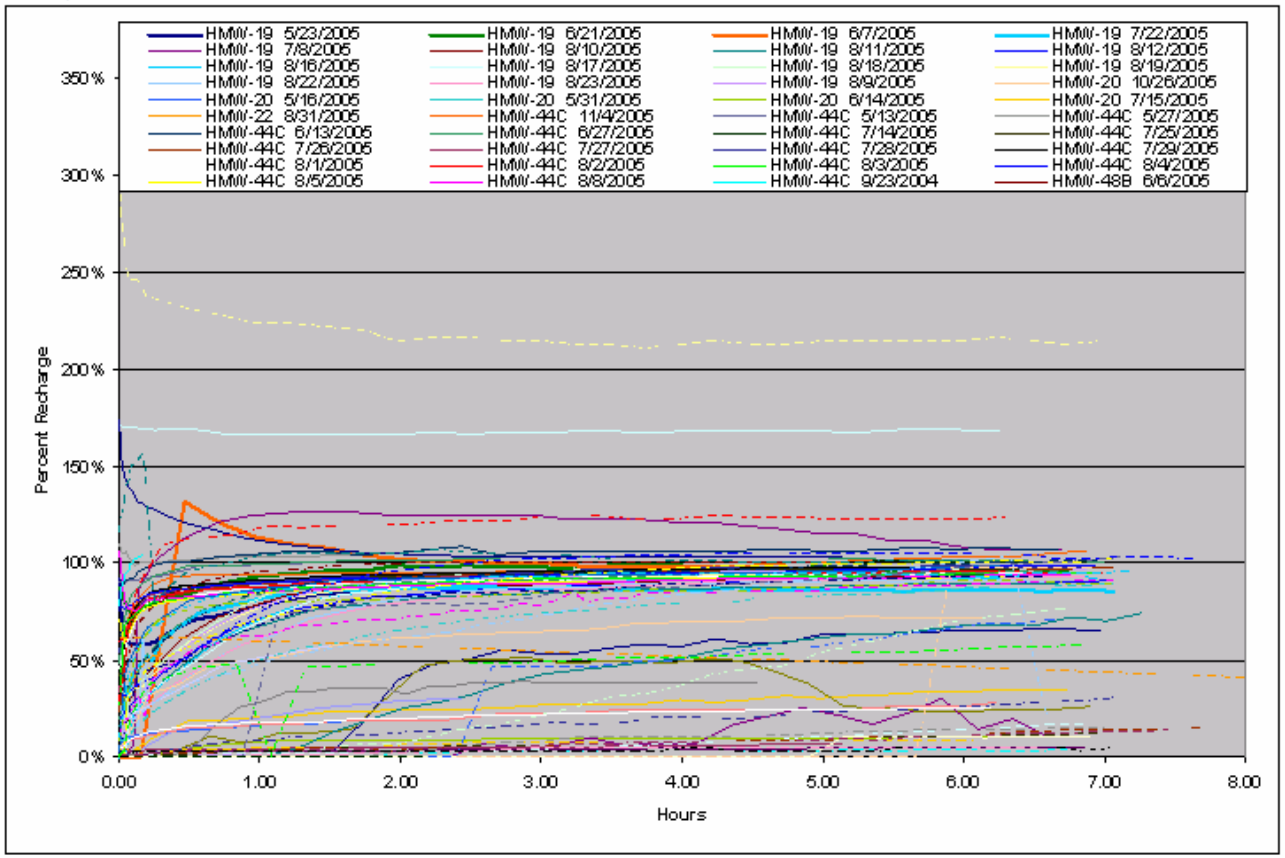


GRAPH 3-3

HiVac Event Recharge as a Percentage of Original Product Thickness

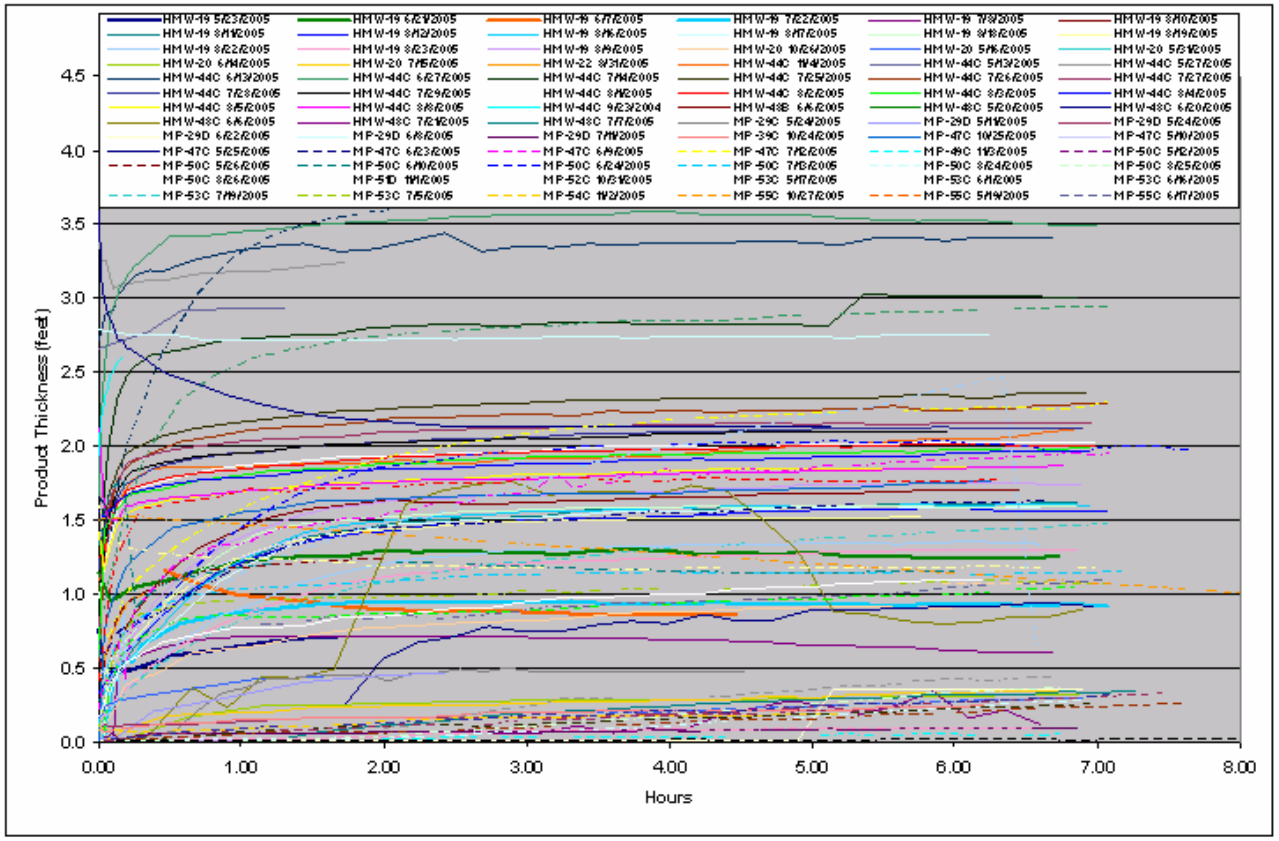
Hartford Area Hydrocarbon Plume Site

The Hartford Working Group / Hartford, Illinois
1190505040 -- Madison County -- ILR 000128249



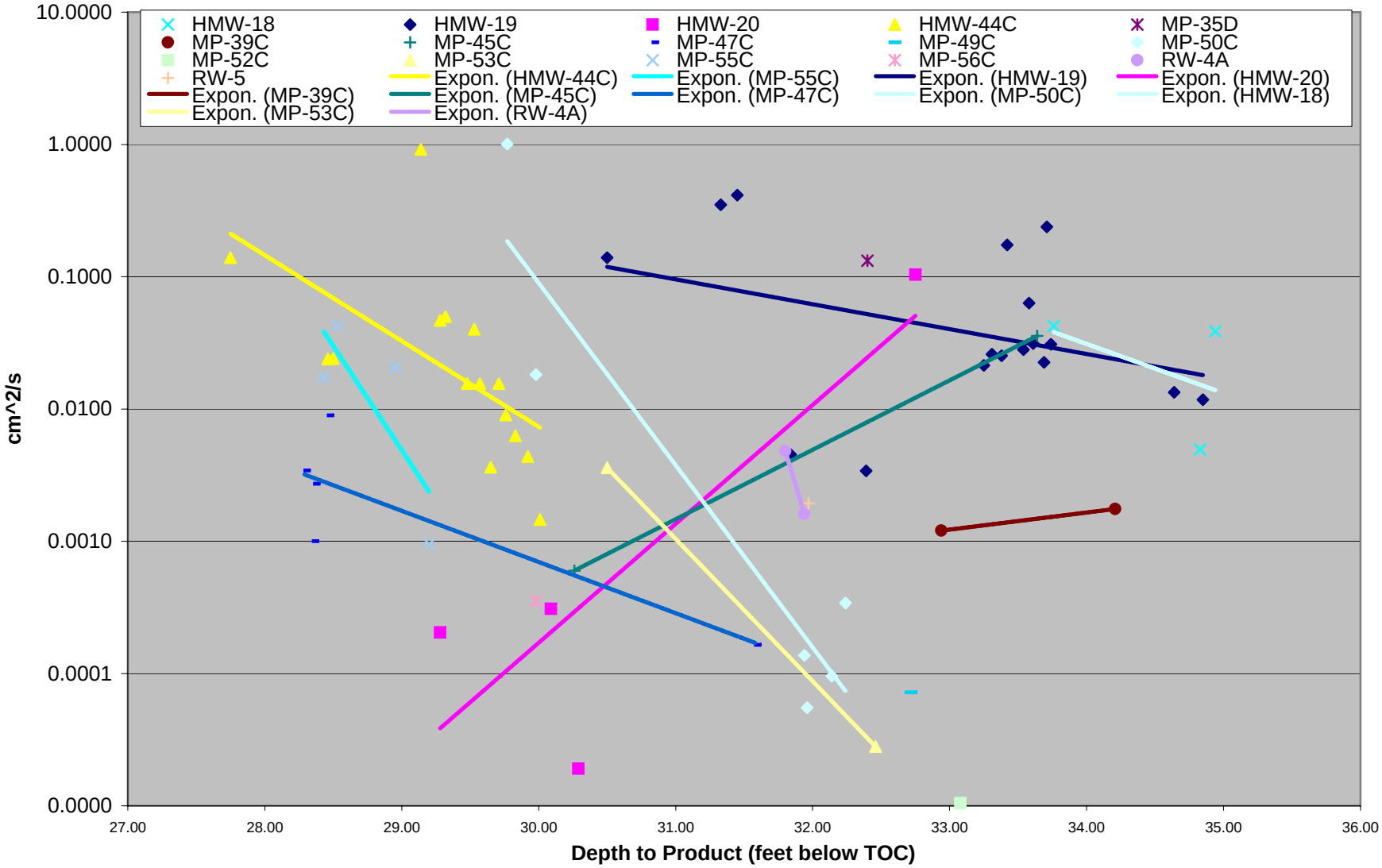
GRAPH 3-4
HiVac Event Recharge as Product Thickness in Feet
Hartford Area Hydrocarbon Plume Site

The Hartford Working Group / Hartford, Illinois
1190505040 -- Madison County -- ILR 000128249



GRAPH 3-5
LNAPL Transmissivity by Well vs. Depth to Product and Trends
Hartford Area Hydrocarbon Plume Site

The Hartford Working Group / Hartford, Illinois
1190505040 -- Madison County -- ILR 000128249



TABLES

TABLE 2-1
HYDRAULIC CONDUCTIVITY/PERMEABILITY ANALYSIS RESULTS - North Olive Stratum
The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

SAMPLE			SAMPLE ANALYSIS							
Boring/Well ID	Date of Collection/ Test	Sample/ Screen Depth (ft bgs)	Tested By	Analytical Method	Falling Head Test Hydraulic Conductivity (cm/sec)	Rising Head Test Hydraulic Conductivity (cm/sec)	Permeability (K) (cm/sec)	Average Hydraulic Conductivity (cm/sec)	Average Hydraulic Conductivity (ft/sec)	Average Hydraulic Conductivity (ft/day)
MP-69	12/07/04	12.0-12.5	PSC	ASTM-D 5084	- -	- -	2.0E-04	- -	6.56E-06	5.67E-01
MP-72	11/30/04	14.5-15.0	PSC	ASTM-D 5084	- -	- -	8.7E-06	- -	2.85E-07	2.47E-02
HMW-45	12/14/04	13.5-14.0	PSC	ASTM-D 5084	- -	- -	1.5E-05	- -	4.92E-07	4.25E-02
HMW-45	08/20/04	14.5-15.0	PSC	ASTM-D 5084	- -	- -	1.60E-05	- -	5.25E-07	4.54E-02
HMW-46	08/19/04	12.5-13.0	PSC	ASTM-D 5084	- -	- -	2.90E-04	- -	9.51E-06	8.22E-01
HMW-47	08/19/04	17.0-17.5	PSC	ASTM-D 5084	- -	- -	1.40E-06	- -	4.59E-08	3.97E-03
Overall Average							8.85E-05	- -	2.90E-06	2.51E-01
Overall Geomean							2.35E-05	- -	7.72E-07	6.67E-02

NOTES:
ft bgs = feet below ground surface
S = Slug test hydraulic conductivity testing method
Bouwer, H. and R.C. Rice. 1976. A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrated Wells. Water Resources Research, Vol. 12, no.3, pp. 423-428.
-- = Not conducted

TABLE 2-1
HYDRAULIC CONDUCTIVITY/PERMEABILITY ANALYSIS RESULTS - Rand Stratum
The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

SAMPLE			SAMPLE ANALYSIS								
Boring / Well ID	Date of Collection/ Test	Sample/ Screen Depth (ft bgs)	Tested By	Analytical Method	Falling Head Test Hydraulic Conductivity (cm/sec)	Rising Head Test Hydraulic Conductivity (cm/sec)	Permeability (K) (cm/sec)	Average Hydraulic Conductivity (cm/sec)	Average Hydraulic Conductivity (ft/sec)	Average Hydraulic Conductivity (ft/day)
HMW-45	12/14/04	26.0-26.5	PSC	ASTM-D 5084	- -	- -	5.5E-05	5.5E-05	1.80E-06	1.56E-01
HMW-04	07/28/05	20.02-25.75	Clayton	Bouwer & Rice	S 2.73E-04	S 6.35E-04	- -	4.54E-04	1.49E-05	1.29E+00
HMW-50A	07/27/05	17.30-27.0	Clayton	Cooper et al	S 4.08E-03	S 1.18E-02	- -	7.94E-03	2.60E-04	2.25E+01
Overall Average								2.82E-03	9.24E-05	7.98E+00
Overall Geomean								5.83E-04	1.91E-05	1.65E+00

NOTES:
ft bgs = feet below ground surface
S = Slug test hydraulic conductivity testing method
Bouwer, H. and R.C. Rice. 1976. A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrated Wells. Water Resources Research, Vol. 12, no.3, pp. 423-428.
Cooper, H. H., J.D. Bredehoeft, and S.S. Papadopulos. 1967. Response of a Finite-Diameter Well to an Instantaneous Charge of Water. Water Resources Research, Vol. 3, no. 1, pp. 263-269.
-- = Not conducted

TABLE 2-1
HYDRAULIC CONDUCTIVITY/PERMEABILITY ANALYSIS RESULTS - Clay Strata
The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

SAMPLE			SAMPLE ANALYSIS							
Boring/Well ID	Date of Collection/ Test	Sample/ Screen Depth (ft bgs)	Tested By	Analytical Method	Falling Head Test Hydraulic Conductivity (cm/sec)	Rising Head Test Hydraulic Conductivity (cm/sec)	Permeability (K) (cm/sec)	Average Hydraulic Conductivity (cm/sec)	Average Hydraulic Conductivity (ft/sec)	Average Hydraulic Conductivity (ft/day)
MP-76	12/09/04	5.5-6.0	PSC	ASTM-D 5084	- -	- -	6.0E-09	- -	1.97E-10	1.70E-05
MP-76	12/09/04	13.5-14.0	PSC	ASTM-D 5084	- -	- -	4.9E-05	- -	1.61E-06	1.39E-01
HMW-45	12/14/04	9.0-9.5	PSC	ASTM-D 5084	- -	- -	1.7E-04	- -	5.58E-06	4.82E-01
HMW-45	12/14/04	20.0-20.5	PSC	ASTM-D 5084	- -	- -	4.9E-08	- -	1.61E-09	1.39E-04
HMW-46	12/14/04	6.0-6.5	PSC	ASTM-D 5084	- -	- -	6.6E-05	- -	2.17E-06	1.87E-01
Overall Average							5.70E-05	- -	1.87E-06	1.62E-01
Overall Geomean							2.77E-06	- -	9.07E-08	7.84E-03

NOTES:
ft bgs = feet below ground surface
S = Slug test hydraulic conductivity testing method
Bouwer, H. and R.C. Rice. 1976. A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrated Wells. Water Resources Research, Vol. 12, no.3, pp. 423-428.
-- = Not conducted

TABLE 2-1
HYDRAULIC CONDUCTIVITY/PERMEABILITY ANALYSIS RESULTS - EPA Stratum
The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

SAMPLE			SAMPLE ANALYSIS								
Boring / Well ID	Date of Collection/ Test	Sample/ Screen Depth (ft bgs)	Tested By	Analytical Method	Falling Head Test Hydraulic Conductivity (cm/sec)	Rising Head Test Hydraulic Conductivity (cm/sec)	Permeability (K) (cm/sec)	Average Hydraulic Conductivity (cm/sec)	Average Hydraulic Conductivity (ft/sec)	Average Hydraulic Conductivity (ft/day)
HMW-49C	07/28/05	29.9'-39.0'	Clayton	Bouwer & Rice	S 2.21E-05	S 8.51E-06	- -	1.53E-05	5.02E-07	4.34E-02
HMW-50B	07/27/05	35.0'-39.6'	Clayton	Bouwer & Rice	S 3.96E-04	S 3.60E-04	- -	3.78E-04	1.24E-05	1.07E+00
Overall Average								1.97E-04	6.45E-06	5.57E-01
Overall Geomean								7.61E-05	2.50E-06	2.16E-01

NOTES:
ft bgs = feet below ground surface
S = Slug test hydraulic conductivity testing method
Bouwer, H. and R.C. Rice. 1976. A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrated Wells. Water Resources Research, Vol. 12, no.3, pp. 423-428.
-- = Not conducted

TABLE 2-1
HYDRAULIC CONDUCTIVITY/PERMEABILITY ANALYSIS RESULTS - Main Sand Stratum
The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

SAMPLE			SAMPLE ANALYSIS								
Boring/Well ID	Date of Collection/ Test	Sample/ Screen Depth (ft bgs)	Tested By	Analytical Method	Falling Head Test Hydraulic Conductivity (cm/sec)	Rising Head Test Hydraulic Conductivity (cm/sec)	Permeability (K) (cm/sec)	Average Hydraulic Conductivity (cm/sec)	Average Hydraulic Conductivity (ft/sec)	Average Hydraulic Conductivity (ft/day)
HMW-25	12/19/03	24.0-38.7	Clayton	Bouwer & Rice	S 1.39E-02	S 1.78E-02	- -	1.59E-02	5.20E-04	4.49E+01
HMW-27	12/19/03	25.0-39.7	Clayton	Bouwer & Rice	S 1.48E-02	S 2.92E-02	- -	2.20E-02	7.22E-04	6.24E+01
HMW-28	12/19/03	25.0-39.7	Clayton	Bouwer & Rice	S 3.31E-02	S 2.81E-02	- -	3.06E-02	1.00E-03	8.67E+01
HMW-29	12/19/03	25.0-39.7	Clayton	Bouwer & Rice	S 2.25E-02	S 1.40E-02	- -	1.83E-02	5.99E-04	5.17E+01
Overall Average								2.17E-02	7.11E-04	6.14E+01
Overall Geomean								2.10E-02	6.89E-04	5.95E+01

NOTES:
ft bgs = feet below ground surface
S = Slug test hydraulic conductivity testing method
Bouwer, H. and R.C. Rice. 1976. A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrated Wells. Water Resources Research, Vol. 12, no.3, pp. 423-428.
-- = Not conducted

TABLE 2-2
AVERAGE HYDRAULIC CONDUCTIVITY VALUES

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

Study Area Hydrostratigraphic Unit	Boring/Well ID in Hydrostratigraphic Unit	Average Hydraulic Conductivity		
		(cm/sec)	(ft/sec)	(ft/day)
North Olive Stratum	MP-69, MP-72, HMW-45, HMW-46, and HMW-47	8.85E-05	2.90E-06	2.51E-01
Rand Stratum	HMW-04, HMW-45 and HMW-50A	2.82E-03	9.24E-05	7.98E+00
EPA Stratum	HMW-49C and HMW-50B	1.97E-04	6.45E-06	5.57E-01
Main Sand	HMW-25, HMW-27, HMW-28, and HMW-29	2.17E-02	7.11E-04	6.14E+01

Geometric Mean Hydraulic Conductivity

Study Area Hydrostratigraphic Unit	Boring/Well ID in Hydrostratigraphic Unit	Geometric Mean Hydraulic Conductivity		
		(cm/sec)	(ft/sec)	(ft/day)
North Olive Stratum	MP-69, MP-72, HMW-45, HMW-46, and HMW-47	2.35E-05	7.72E-07	6.67E-02
Rand Stratum	HMW-04, HMW-45 and HMW-50A	5.83E-04	1.91E-05	1.65E+00
EPA Stratum	HMW-49C and HMW-50B	7.61E-05	2.50E-06	2.16E-01
Main Sand	HMW-25, HMW-27, HMW-28 and HMW-29	2.10E-02	6.89E-04	5.95E+01

TABLE 3-1
LNAPL CHARACTERIZATION SUMMARY TABLE
Main Sand

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

Sample ID	Primary Product	Secondary Product	Simulated Distillation	Kinematic Viscosity	Density
HMW08	Gasoline	Trace Diesel	Not Analyzed	Not Analyzed	Not Analyzed
HMW19	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
HMW19D	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
HMW20	Gasoline	Trace Diesel	Not Analyzed	Not Analyzed	Not Analyzed
HMW22	Gasoline	Diesel <10%	Not Analyzed	Not Analyzed	Not Analyzed
HMW44C	Gasoline	Diesel +10%	Gasoline/ Diesel	Gasoline-Like	Gasoline-Like
HMW45C	Gasoline Approx 60%	Diesel ~40%	Not Analyzed	Not Analyzed	Not Analyzed
HMW46C	Gasoline Approx 70%	Diesel ~30%	Gasoline/ Diesel	Gasoline/ Diesel-like	Diesel-like
MP29D	Gasoline	Diesel ~10%	Gasoline/ Diesel	Gasoline-Like	Gasoline-Like
MP29DD	Gasoline	Diesel ~10%	Not Analyzed	Not Analyzed	Not Analyzed
MP32B	Not Analyzed	Not Analyzed	Gasoline	Gasoline-Like	Gasoline-Like
MP35D	Gasoline	Diesel ~ 5%	Gasoline	Gasoline-Like	Gasoline-Like
MP37D	Gasoline	Diesel <5%	Gasoline	Gasoline-Like	Gasoline-Like
MP39C	Gasoline	None	Gasoline	Gasoline-Like	Gasoline-Like
MP45C	Gasoline	None	Gasoline	Gasoline-Like	Gasoline-Like
MP47C	Gasoline	Diesel <10%	Gasoline/ Diesel	Gasoline-Like	Gasoline-Like
MP48B	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP49C	Gasoline	None	Gasoline	Gasoline-Like	Gasoline-Like
MP50C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP51D	Gasoline	Trace Diesel	Not Analyzed	Not Analyzed	Not Analyzed
MP52C	Gasoline	None	Gasoline	Gasoline-Like	Gasoline-Like

TABLE 3-1
LNAPL CHARACTERIZATION SUMMARY TABLE
Main Sand

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

Sample ID	Primary Product	Secondary Product	Simulated Distillation	Kinematic Viscosity	Density
MP53C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP55C	Gasoline	Diesel ~10%	Gasoline/ Diesel	Gasoline-Like	Gasoline-Like
MP56C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP56CD	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP57C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP60C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP79C	Gasoline	Slight Trace Diesel	Not Analyzed	Not Analyzed	Not Analyzed
MP80C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed

TABLE 3-1
LNAPL CHARACTERIZATION SUMMARY TABLE
EPA and Rand Strata

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

Sample ID	Primary Product	Secondary Product	Simulated Distillation	Kinematic Viscosity	Density
HMW48C EPA Stratum	Diesel Approx 70%	Gasoline ~30%	Diesel	Diesel-like	Diesel-like
MP29C Rand Stratum	Diesel	Trace Gasoline	Diesel	Diesel-like	Diesel-like

TABLE 3-2
DEPTH OF IDENTIFIED ROST RESPONSE IN MAIN SAND
The Hartford Area Hydrocarbon Plume Site

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

ROST Boring	Ground Surface Elevation (ft msl)	Top of Main Silt / Main Sand Elevation (ft msl)	Bottom Elevation of ROST Response in Main Sand (ft msl)	Bottom Depth of ROST Response in Main Sand (ft bgs)	Boring Termination Elevation (ft msl)
HROST-1	429.50	400.00	NA	NA	360.08
HROST-2	430.95	399.95	387.95	43.00	355.99
HROST-3	430.00	390.00	383.50	46.50	359.87
HROST-4	429.34	386.34	377.34	52.00	363.38
HROST-5	430.50	391.00	383.50	47.00	364.11
HROST-6	429.75	389.25	382.75	47.00	355.25
HROST-7	429.75	400.75	389.75	40.00	371.56
HROST-8	431.30	403.30	391.30	40.00	363.30
HROST-10	429.00	389.00	377.00	52.00	362.41
HROST-11	430.25	395.25	386.75	43.50	370.14
HROST-12	430.15	400.65	389.15	41.00	370.16
HROST-13	427.00	408.50	387.50	39.50	370.63
HROST-14	432.25	397.75	388.75	43.50	358.20
HROST-15	429.00	388.50	388.50	40.50	360.65
HROST-16	431.00	401.50	388.50	42.50	369.76
HROST-17	431.25	404.25	388.25	43.00	373.26
HROST-19	426.00	411.50	390.00	36.00	371.68
HROST-20	432.00	403.50	379.50	52.50	372.20
HROST-22	429.15	390.15	386.65	42.50	369.26
HROST-23	431.75	401.84	382.75	49.00	400.60
HROST-24	431.50	401.50	390.00	41.50	389.80
HROST-25	430.00	403.50	390.00	40.00	360.75
HROST-26	429.10	403.60	385.10	44.00	380.25
HROST-27	427.25	414.25	NA	NA	371.09
HROST-28	426.80	405.30	389.30	37.50	386.49
HROST-29	431.75	407.25	388.75	43.00	371.39
HROST-30	431.75	399.75	387.75	44.00	382.83
HROST-31a	430.10	403.10	387.10	43.00	381.78
HROST-33	429.75	403.75	381.25	48.50	377.62
HROST-34	427.75	415.75	NA	NA	367.64
HROST-35	425.60	413.60	NA	NA	369.28
HROST-36	432.00	420.00	374.50	57.50	370.82
HROST-37	431.00	419.00	386.00	45.00	383.37
HROST-38	430.50	398.50	386.50	44.00	381.28
HROST-39	430.75	397.75	385.75	45.00	383.05
HROST-40	429.85	401.85	383.35	46.50	381.49
HROST-41	427.00	413.00	NA	NA	373.17
HROST-43	431.75	415.75	388.75	43.00	368.92
HROST-44	431.00	419.00	384.50	46.50	381.78
HROST-45	431.50	417.50	390.50	41.00	386.30
HROST-47	429.53	398.03	384.53	45.00	378.27
HROST-48	431.00	410.50	NA	NA	369.77
HROST-49	431.75	412.75	392.25	39.50	386.70
HROST-50	430.35	417.35	387.35	43.00	381.20
HROST-51	429.00	416.00	391.00	38.00	383.37
HROST-52	429.65	397.65	389.65	40.00	384.34
HROST-53	431.15	414.65	NA	NA	367.65
HROST-54	430.10	411.60	NA	NA	363.71
HROST-55	428.00	408.50	NA	NA	358.95

TABLE 3-2
DEPTH OF IDENTIFIED ROST RESPONSE IN MAIN SAND
The Hartford Area Hydrocarbon Plume Site

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

ROST Boring	Ground Surface Elevation	Top of Main Silt / Main Sand Elevation	Bottom Elevation of ROST Response in Main Sand	Bottom Depth of ROST Response in Main Sand	Boring Termination Elevation
HROST-56	431.00	412.00	NA	NA	368.60
HROST-57	429.32	417.82	NA	NA	399.38
HROST-60	431.00	412.50	NA	NA	369.73
HROST-61 *	430.50	390.50	NA	NA	389.48
HROST-62	430.10	392.60	389.60	40.50	366.50
HROST-65	425.50	402.00	NA	NA	371.75
HROST-66	432.00	412.50	395.50	36.50	369.02
HROST-67	429.00	405.00	NA	NA	381.91
HROST-68	431.25	415.25	392.25	39.00	368.15
HROST-70	429.75	400.25	389.75	40.00	372.97
HROST-72	426.00	412.50	399.50	26.50	381.74
HROST-74	428.75	413.25	390.75	38.00	384.21
HROST-76	429.00	389.50	393.00	36.00	389.74
HROST-77	425.25	410.25	NA	NA	359.78
HROST-78	431.50	413.50	380.00	51.50	367.69
HROST-79	430.75	385.25	381.75	49.00	381.17
HROST-80	430.75	385.75	NA	NA	387.39
HROST-81	447.01	390.01	NA	NA	374.01
HROST-82	429.39	391.64	389.39	40.00	356.39
HROST-83	442.15	402.40	379.15	63.00	370.15
HROST-84	429.69	390.69	389.69	40.00	356.69
HROST-85	430.09	390.09	374.09	56.00	358.09
HROST-87	430.56	397.56	383.56	47.00	344.21
HROST-88	430.67	389.42	379.67	51.00	359.81
HROST-89	428.07	402.82	NA	NA	368.03
HROST-90	430.34	399.34	383.34	47.00	360.34
HROST-91	429.53	387.28	375.53	54.00	368.53
HROST-92	429.44	400.44	NA	NA	369.44
HROST-93	428.82	399.32	NA	NA	366.82
HROST-94	427.95	399.45	NA	NA	362.99
HROST-96	427.75	400.25	NA	NA	368.04
HROST-97	428.37	412.87	NA	NA	364.59
HROST-98	428.28	413.28	NA	NA	378.28
HROST-99	424.89	414.39	365.89	59.00	359.89
HROST-101	429.03	414.28	NA	NA	357.03
HROST-103	427.70	413.70	NA	NA	368.70
HROST-104	431.31	413.31	NA	NA	345.31
HROST-106	430.96	415.46	NA	NA	358.96
HROST-107	429.69	414.69	NA	NA	364.69
HROST-109	429.25	415.25	NA	NA	375.25
HROST-110	431.36	410.61	NA	NA	358.36
HROST-111	430.79	416.04	NA	NA	361.79
HROST-112	429.45	409.95	NA	NA	360.45
HROST-113	429.88	404.38	373.88	56.00	355.88
HROST-114	430.85	401.35	386.85	44.00	355.85
HROST-115	430.18	402.93	380.18	50.00	360.18
HROST-116	432.45	416.95	365.45	67.00	364.45
HROST-117	430.31	416.3	380.31	50.00	366.31
HROST-118	430.38	388.88	382.38	48.00	360.38
HROST-119	429.59	421.58	NA	NA	362.59

TABLE 3-2
DEPTH OF IDENTIFIED ROST RESPONSE IN MAIN SAND
The Hartford Area Hydrocarbon Plume Site

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

ROST Boring	Ground Surface Elevation	Top of Main Silt / Main Sand Elevation	Bottom Elevation of ROST Response in Main Sand	Bottom Depth of ROST Response in Main Sand	Boring Termination Elevation
HROST-120	429.05	416.04	NA	NA	363.05
HROST-121	429.62	413.62	NA	NA	357.62
HROST-122	432.71	402.46	374.71	58.00	359.71
HROST-123	426.12	413.11	382.12	44.00	349.12
HROST-124	428.19	406.94	NA	NA	369.69
HROST-125	430.38	392.40	385.38	45.00	361.40
HROST-126	430.90	402.90	369.90	61.00	359.90
HROST-128	429.81	394.81	382.81	47.00	368.81
HROST-129	430.31	391.52	385.31	45.00	361.27
HROST-130	429.70	399.74	380.70	49.00	348.49

NOTES:

* = Not in Main Sand
bgs = Below ground surface
msl = Mean Sea Level
NA = Not Applicable - no LNAPL was identified

TABLE 3-3
BAILDOWN TEST AND HVR EVENT LNAPL T AND K VALUE SUMMARY
Hartford Area Hydrocarbon Plume Site

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

Well ID	Type	Date	DTP	Density	Avg Tn	Avg Kn	Cooper et al		L (ft)
							T_n (cm^2/s)(C et al)	K_n (cm/s)(C et al)	
HMW-18	BD	3/2/2004	34.94	0.7649	2.86E-02	5.31E-04	3.86E-02	6.55E-04	1.94
HMW-18	BD	3/4/2004	34.83	0.7649			4.93E-03	9.19E-05	1.76
HMW-18	BD	8/24/2005	33.76	0.7649			4.23E-02	8.46E-04	1.64
HMW-19	BD	3/2/2004	34.85	0.7415	9.38E-02	3.22E-03	1.18E-02	2.74E-04	1.41
HMW-19	BD	3/4/2004	34.64	0.7415			1.34E-02	3.35E-04	1.31
HMW-19	HVR	5/23/2005	31.33	0.7415			3.49E-01	1.37E-02	0.83
HMW-19	HVR	6/7/2005	31.84	0.7415			4.53E-03	1.68E-04	0.88
HMW-19	HVR	6/21/2005	30.50	0.7415			1.39E-01	3.46E-03	1.31
HMW-19	HVR	7/8/2005	31.45	0.7415			4.14E-01	2.34E-02	0.57
HMW-19	HVR	7/22/2005	32.39	0.7415			3.41E-03	1.03E-04	1.08
HMW-19	HVR	8/9/2005	33.25	0.7415			2.13E-02	3.87E-04	1.79
HMW-19	HVR	8/10/2005	33.31	0.7415			2.59E-02	4.64E-04	1.82
HMW-19	HVR	8/11/2005	33.38	0.7415			2.53E-02	4.56E-04	1.81
HMW-19	HVR	8/12/2005	33.42	0.7415			1.74E-01	3.32E-03	1.71
HMW-19	HVR	8/16/2005	33.54	0.7415			2.81E-02	5.30E-04	1.73
HMW-19	HVR	8/17/2005	33.58	0.7415			6.31E-02	1.23E-03	1.67
HMW-19	HVR	8/18/2005	33.61	0.7415			3.12E-02	6.19E-04	1.64
HMW-19	HVR	8/19/2005	33.69	0.7415			2.25E-02	4.53E-04	1.62
HMW-19	HVR	8/22/2005	33.71	0.7415			2.38E-01	5.22E-03	1.48
HMW-19	HVR	8/23/2005	33.74	0.7415			3.08E-02	7.16E-04	1.40
HMW-20	BD	3/3/2004	32.75	0.7428	2.61E-02	5.06E-04	1.04E-01	2.02E-03	1.69
HMW-20	HVR	5/16/2005	30.09	0.7428			3.09E-04	4.00E-06	2.53
HMW-20	HVR	6/14/2005	29.28	0.7428			2.04E-04	2.25E-06	2.97
HMW-20	HVR	7/15/2005	30.29	0.7428			1.91E-05	6.26E-07	0.99
HMW-44C	HVR	5/13/2005	28.50	0.7641	8.74E-02	1.12E-03	2.41E-02	2.67E-04	2.95
HMW-44C	HVR	6/27/2005	27.75	0.7641			1.39E-01	1.31E-03	3.47
HMW-44C	HVR	7/14/2005	28.46	0.7641			2.39E-02	2.61E-04	2.99
HMW-44C	HVR	7/25/2005	29.28	0.7641			4.66E-02	6.32E-04	2.41
HMW-44C	HVR	7/26/2005	29.32	0.7641			5.00E-02	6.95E-04	2.35
HMW-44C	HVR	7/27/2005	29.48	0.7641			1.56E-02	2.24E-04	2.27
HMW-44C	HVR	7/28/2005	29.53	0.7641			4.00E-02	6.06E-04	2.16
HMW-44C	HVR	7/29/2005	29.57	0.7641			1.56E-02	2.37E-04	2.15
HMW-44C	HVR	8/1/2005	29.65	0.7641			3.62E-03	5.51E-05	2.14
HMW-44C	HVR	8/2/2005	29.71	0.7641			1.56E-02	2.42E-04	2.10
HMW-44C	HVR	8/3/2005	29.76	0.7641			9.03E-03	1.40E-04	2.10
HMW-44C	HVR	8/4/2005	29.83	0.7641			6.27E-03	1.02E-04	2.00
HMW-44C	HVR	8/5/2005	29.92	0.7641			4.37E-03	7.12E-05	2.00
HMW-44C	HVR	8/8/2005	30.01	0.7641			1.45E-03	2.39E-05	1.99
HMW-44C	BD	9/23/2004	29.14	0.7641			9.16E-01	1.20E-02	2.50
MP-35D	BD	8/30/2005	32.40	0.7763	1.32E-01	2.57E-03	1.32E-01	2.57E-03	1.69
MP-39C	BD	9/23/2004	32.94	0.7481	1.48E-03	3.08E-05	1.20E-03	2.38E-05	1.66
MP-39C	BD	8/31/2005	34.21	0.7481			1.75E-03	3.78E-05	1.52
MP-45C	BD	9/24/2004	30.26	0.7616	1.81E-02	2.46E-04	6.00E-04	9.94E-06	1.98
MP-45C	BD	8/30/2005	33.64	0.7616			3.57E-02	4.82E-04	2.43
MP-47C	BD	9/24/2004	31.58	0.7569	3.25E-03	4.88E-05	1.64E-04	2.22E-06	2.43
MP-47C	HVR	5/10/2005	28.35	0.7569			1.00E-03	1.33E-05	2.46
MP-47C	HVR	5/25/2005	28.36	0.7569			2.72E-03	4.28E-05	2.07
MP-47C	HVR	6/9/2005	28.46	0.7569			8.93E-03	1.35E-04	2.15
MP-47C	HVR	7/12/2005	28.29	0.7569			3.43E-03	5.02E-05	2.24
MP-49C	BD	8/31/2005	32.72	0.7335	7.20E-05	1.25E-06	7.20E-05	1.25E-06	1.88
MP-50C	HVR	5/26/2005	29.77	0.7410	1.71E-01	4.49E-03	1.01E+00	2.64E-02	1.24
MP-50C	HVR	7/13/2005	29.98	0.7410			1.82E-02	4.90E-04	1.21
MP-50C	HVR	8/24/2005	31.96	0.7410			5.52E-05	1.07E-06	1.68
MP-50C	HVR	8/25/2005	32.24	0.7410			3.41E-04	2.33E-05	0.47
MP-50C	HVR	8/26/2005	32.14	0.7410			9.54E-05	5.60E-06	0.55
MP-50C	HVR	8/29/2005	31.94	0.7410			1.37E-04	2.85E-06	1.57
MP-52C	BD	8/23/2005	33.08	0.7360	1.05E-05	2.29E-07	1.05E-05	2.29E-07	1.50
MP-53C	BD	9/23/2004	32.46	0.7480	1.81E-03	3.58E-05	2.80E-05	5.36E-07	1.71
MP-53C	HVR	7/19/2005	30.50	0.7480			3.59E-03	7.10E-05	1.65
MP-55C	BD	9/23/2004	29.20	0.7705	2.04E-02	4.16E-04	9.54E-04	8.50E-06	3.69
MP-55C	HVR	6/17/2005	28.53	0.7705			4.27E-02	1.30E-03	1.07
MP-55C	HVR	7/6/2005	28.43	0.7705			1.72E-02	1.83E-04	3.07
MP-55C	HVR	7/20/2005	28.95	0.7705			2.06E-02	1.73E-04	3.89
MP-56C	HVR	7/18/2005	29.98	0.7456	3.52E-04	1.10E-05	3.52E-04	1.10E-05	1.04
RW-4A	HVR	8/30/2005	31.80	0.7649	3.21E-03	9.00E-05	4.81E-03	1.28E-04	1.22
RW-4A	HVR	8/31/2005	31.94	0.7649			1.61E-03	5.15E-05	1.02
RW-5	HVR	9/1/2005	31.97	0.7649	1.94E-03	6.47E-05	1.94E-03	6.47E-05	0.97

NOTES: T_n and K_n calculated according to Huntley (2000)

APPENDIX A

HISTORICAL AERIAL PHOTOGRAPHS

LIST OF FIGURES INCLUDED:

A-1 HISTORIC AERIAL – SEPTEMBER 1941
A-2 HISTORIC AERIAL – AUGUST 1955
A-3 HISTORIC AERIAL – AUGUST 1968
A-4 HISTORIC AERIAL – MAY 1974
A-5 HISTORIC AERIAL – JUNE 1978
A-6 HISTORIC AERIAL – APRIL 1988
A-7 HISTORIC AERIAL – MARCH 1993
A-8 HISTORIC AERIAL – APRIL 1998
A-9 HISTORIC AERIAL – APRIL 2004

Legend

Pipeline Installation Date

Early 1940s

4- 8" Pipelines & 3- 8" & 1-3" Pipelines Source:
Wood River Refining Corp. Drwg. # WR00-RB1 1943

Aerial Photo Number - Illinois Department of Transportation
ASCS SJ-2B-146 9/10/41

HISTORIC AERIAL - SEPTEMBER 1941

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

0 60 120 240 360 480 Feet

FIGURE A-1

BUREAU VERITAS

Legend

Pipeline Installation Date

Early 1940s

Early 1950s

4-8" Pipelines & 3-8" & 1-3" Pipelines Source:
Wood River Refining Corp. Drwg. # WR00-RB1 1943

2-10" Pipelines & 2-10" & 1-14" Pipelines Source:
Wood River Refining Corp. Drwg. # WR017-FM3 1952

Aerial Photo Number - Illinois Department of Transportation
ASCS SJ-3P-112 8/23/55

HISTORIC AERIAL - AUGUST 1955
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

0 60 120 240 360 480 Feet

FIGURE A-2

BUREAU VERITAS

Legend

Pipeline Installation Date

Early 1940s — 4-8" Pipelines & 3-8" & 1-3" Pipelines Source: Wood River Refining Corp. Drwg. # WR00-RB1 1943

Early 1950s — 2-10" Pipelines & 2-10" & 1-14" Pipelines Source: Wood River Refining Corp. Drwg. # WR017-FM3 1952

Aerial Photo Number - Illinois Department of Transportation
ASCS SJ-2JJ-116 8/28/68

HISTORIC AERIAL - AUGUST 1968

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

0 60 120 240 360 480 Feet

FIGURE A-3

BUREAU VERITAS
Chevron Group Services, Inc
A Bureau Veritas Company

Legend

Product Releases
Sources:
Illinois EPA ERU, IEMA, NRC,E-S,Inc

Release Date
Product Releases located by best available data

Pipeline Installation Date
Early 1940s
Early 1950s

4-8" Pipelines & 3-8" & 1-3" Pipelines Source:
Wood River Refining Corp. Drwg. # WR00-RB1 1943

2-10" Pipelines & 2-10" & 1-14" Pipelines Source:
Wood River Refining Corp. Drwg. # WR017-FM3 1952

Aerial Photo Number - Illinois Department of Transportation S38-17119 5/6/74

HISTORIC AERIAL - MAY 1974

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

0 60 120 240 360 480 Feet

FIGURE A-4

BUREAU VERITAS

Legend

Gauged Product
Source:
John Mathes & Assoc., Inc.

1978 Product Contours

1978 Gauged Extent

Pipeline Installation Date

Early 1940s

Early 1950s

4-8" Pipelines & 3-8" & 1-3" Pipelines Source:
Wood River Refining Corp. Drwg. # WR00-RB1 1943

2-10" Pipelines & 2-10" & 1-14" Pipelines Source:
Wood River Refining Corp. Drwg. # WR017-FM3 1952

Aerial Photo Number - Illinois Department of Transportation USDA-40-17119 6/9/78

HISTORIC AERIAL - JUNE1978

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

0 60 120 240 360 480 Feet

FIGURE A-5

BUREAU VERITAS
Clayton Group Services, Inc
A Bureau Veritas Company

Legend

Gauged Product
Source:
John Mathes & Assoc., Inc.

1982 Product Contours

1982 Gauged Extent

Pipeline Installation Date

Early 1940s — 4-8" Pipelines & 3-8" & 1-3" Pipelines Source: Wood River Refining Corp. Drwg. # WR00-RB1 1943

Early 1950s — 2-10" Pipelines & 2-10" & 1-14" Pipelines Source: Wood River Refining Corp. Drwg. # WR017-FM3 1952

Early 1980s — 2-10" & 1-14" Pipelines Source: Clark Oil & Refining Corp. Drwg. # WR043-FB-29 1982

Aerial Photo Number - Illinois Department of Transportation 3890-44-IL476 4/7/88

HISTORIC AERIAL - APRIL 1988

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

0 60 120 240 360 Feet

FIGURE A-6

BUREAU VERITAS

Legend

Gauged Product
Source: Engineering-Science, Inc.

1990 Product Contours

1990 Gauged Extent

Pipeline Installation Date

Early 1940s — 4-8" Pipelines & 3-8" & 1-3" Pipelines Source: Wood River Refining Corp. Drwg. # WR00-RB1 1943

Early 1950s — 2-10" Pipelines & 2-10" & 1-14" Pipelines Source: Wood River Refining Corp. Drwg. # WR017-FM3 1952

Early 1980s — 2-10" & 1-14" Pipelines Source: Clark Oil & Refining Corp. Drwg. # WR043-FB-29 1982

Aerial Photo Number - Illinois Department of Transportation NAPP93 5798-253 3/7/93

HISTORIC AERIAL - MARCH 1993

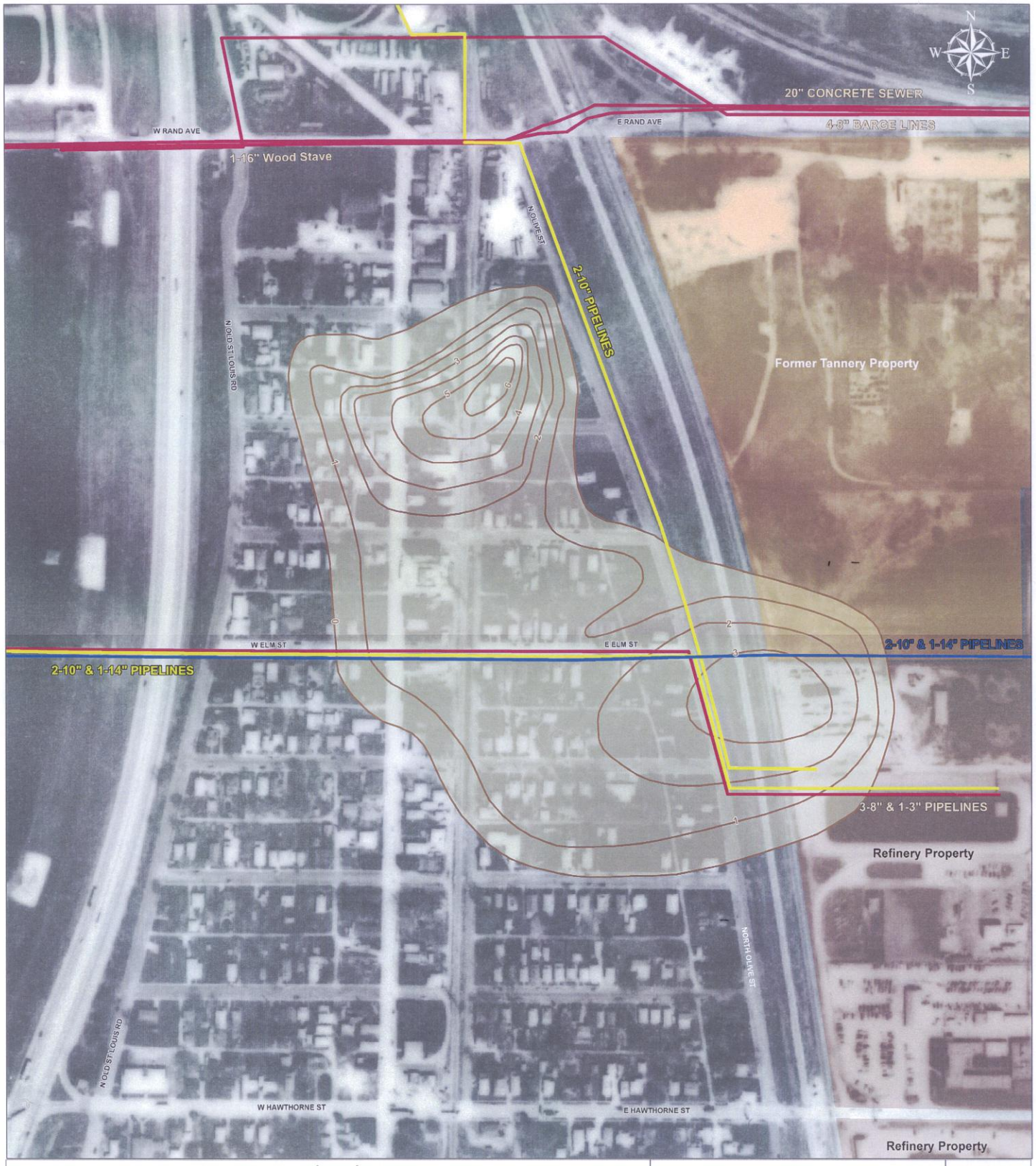
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

0 60 120 240 360 480 Feet

FIGURE A-7

BUREAU VERITAS

Clayton Group Services, Inc.
A Bureau Veritas Company



Legend

Gauged Product
Source: Engineering-Science, Inc.

1990 Product Contours

1990 Gauged Extent

Pipeline Installation Date

Early 1940s

Early 1950s

Early 1980s

4-8" Pipelines & 3-8" & 1-3" Pipelines Source: Wood River Refining Corp. Drwg. # WR00-RB1 1943

2-10" Pipelines & 2-10" & 1-14" Pipelines Source: Wood River Refining Corp. Drwg. # WR017-FM3 1952

2-10" & 1-14" Pipelines Source: Clark Oil & Refining Corp. Drwg. # WR043-FB-29 1982

Aerial Photo Number - Illinois Department of Transportation NAPP 9-44-476 4/2/98

HISTORIC AERIAL - APRIL 1998

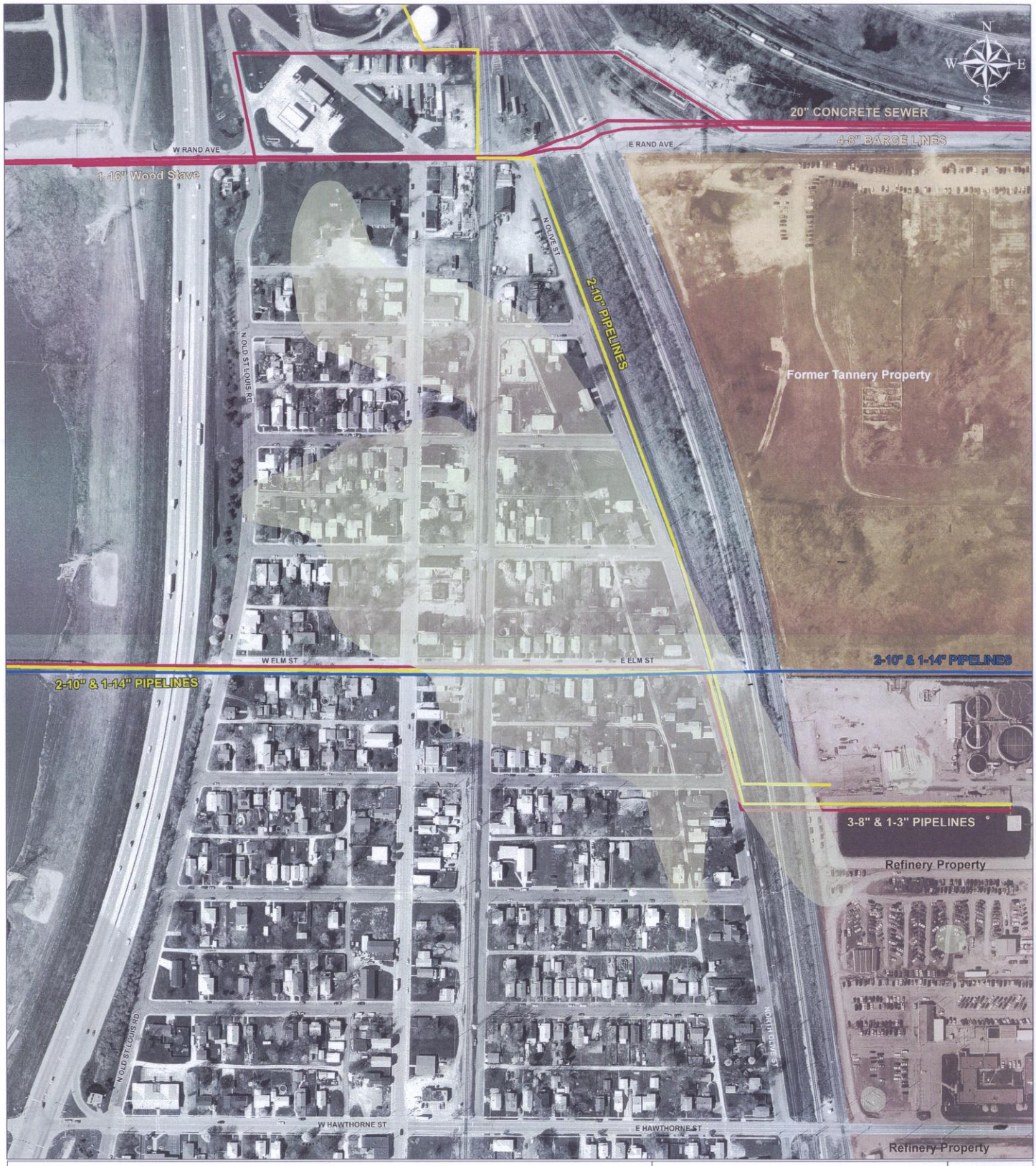
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

0 60 120 240 360 Feet

FIGURE A-8

BUREAU VERITAS

Clayton Group Services, Inc.
A Bureau Veritas Company



Legend

Gauged Product (Source: Clayton Group Services, Inc.)	Pipeline Installation Date	
	Early 1940s	4-8" Pipelines & 3-8" & 1-3" Pipelines Source: Wood River Refining Corp. Drwg. # WR00-RB1 1943
	Early 1950s	2-10" Pipelines & 2-10" & 1-14" Pipelines Source: Wood River Refining Corp. Drwg. # WR017-FM3 1952
10/05 Gauged Extent	Early 1980s	2-10" & 1-14" Pipelines Source: Clark Oil & Refining Corp. Drwg. # WR043-FB-29 1982

Map Created from Aerial Photogrammetry dated April, 2004 by Continental Mapping Consultants, Inc.

HISTORIC AERIAL - APRIL 2004

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

0 60 120 240 360 480 Feet

FIGURE A-9

BUREAU VERITAS

Clayton Group Services, Inc
A Bureau Veritas Company

APPENDIX B

GEOLOGIC CROSS SECTIONS

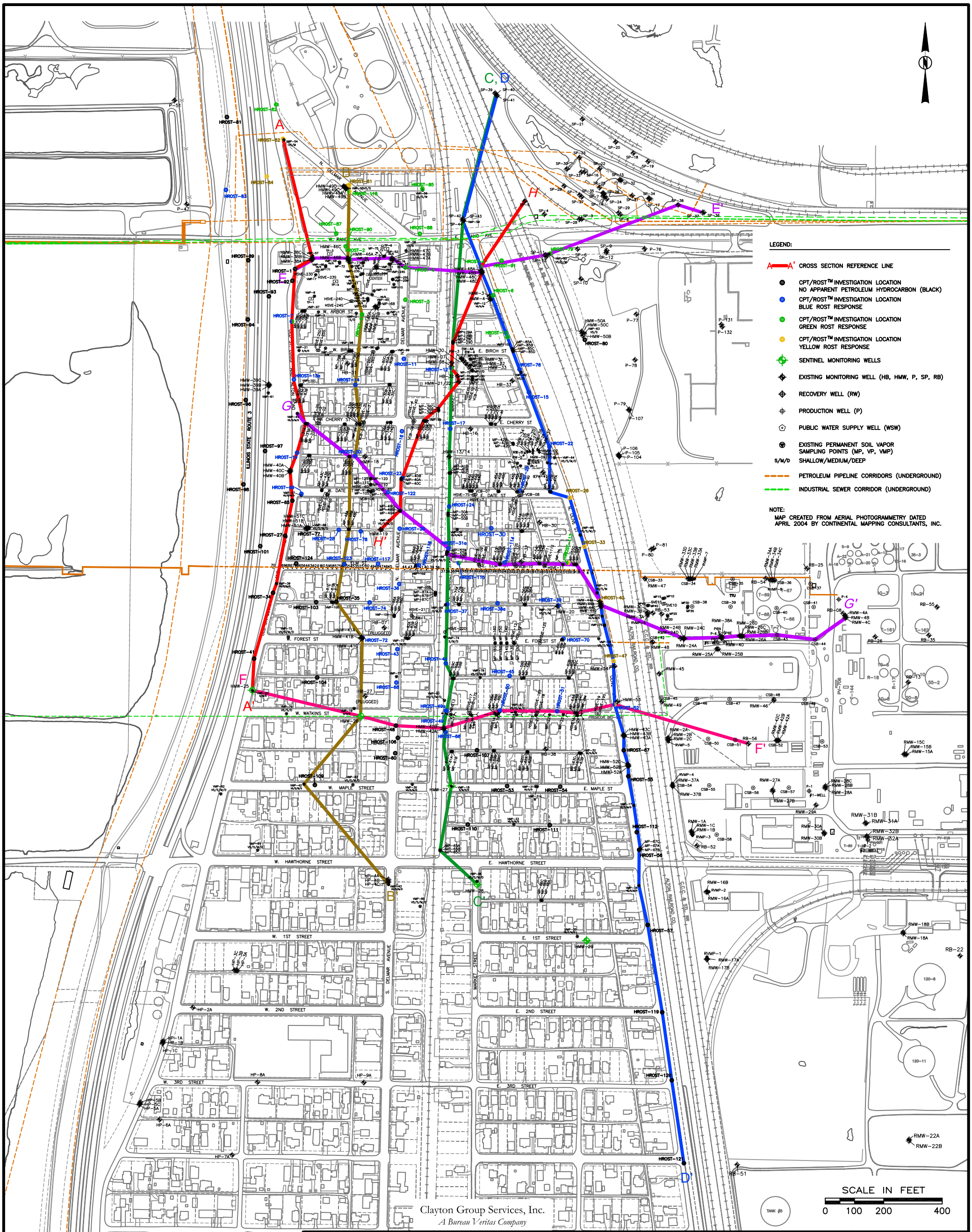
LIST OF FIGURES INCLUDED:

B-1 CROSS SECTION REFERENCE MAP – HARTFORD, IL
B-2 CROSS SECTIONS A-A', B-B', AND C-C' – HARTFORD, IL
B-3 CROSS SECTIONS D-D' – HARTFORD, IL
B-4 CROSS SECTIONS E-E' AND F-F' – HARTFORD, IL
B-5 CROSS SECTIONS G-G' AND H-H' – HARTFORD, IL

Appendix B: Geologic Cross Sections

Geologic cross sections within Hartford have been prepared based on a review of available boring logs, CPT/ROST stratigraphic profiles and geotechnical data. Eight detailed cross-section reference locations are shown in Figure B-1. Geologic cross sections A-A' through H-H' are shown in Figures B-2 through B-5.

As discussed in Section 2.0, the geologic units consist of alternating alluvial deposits of clay and silt overlying the regionally extensive Main Sand. The permeable zones within the alluvial deposits have been identified (in descending order) as the North Olive Stratum, the Rand Stratum, and the EPA Stratum. These deposits are overlain and bounded by several clay deposits identified (in descending order) as the A Clay, B Clay, C Clay, and D Clay Strata to simplify the identification of the individual clay strata. The Main Silt, a portion of the Main Sand, is (1) compositionally finer grained, and (2) laterally grades into the North Olive and Rand Strata (where the B and/or C Clay Strata are absent). The Main Silt overlies and is hydraulically connected to the Main Sand.



DESIGN BY:	
CHECKED BY:	
DRAWN BY:	BCP
DATE:	11-15-05
SCALE:	AS SHOWN
CAD NO.:	0309514020
PROJECT NO.:	15-03095.14

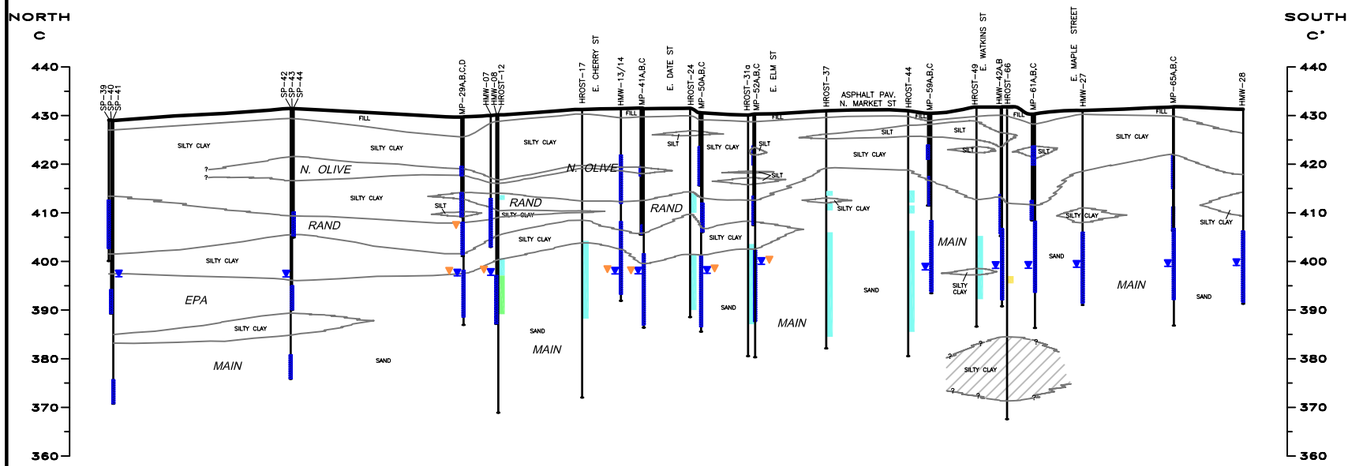
BUREAU VERITAS

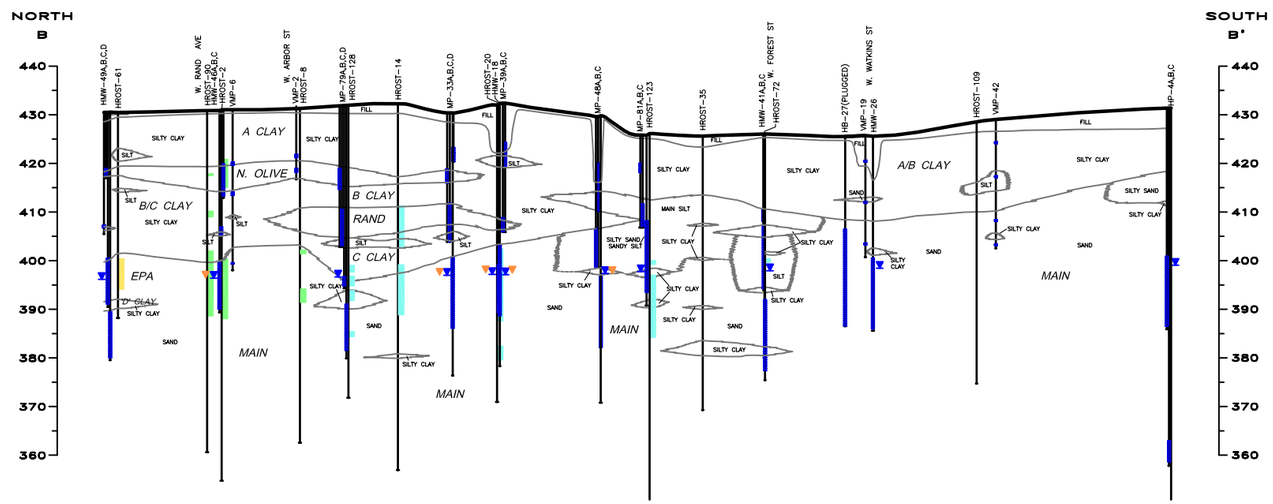
CROSS SECTION REFERENCE MAP

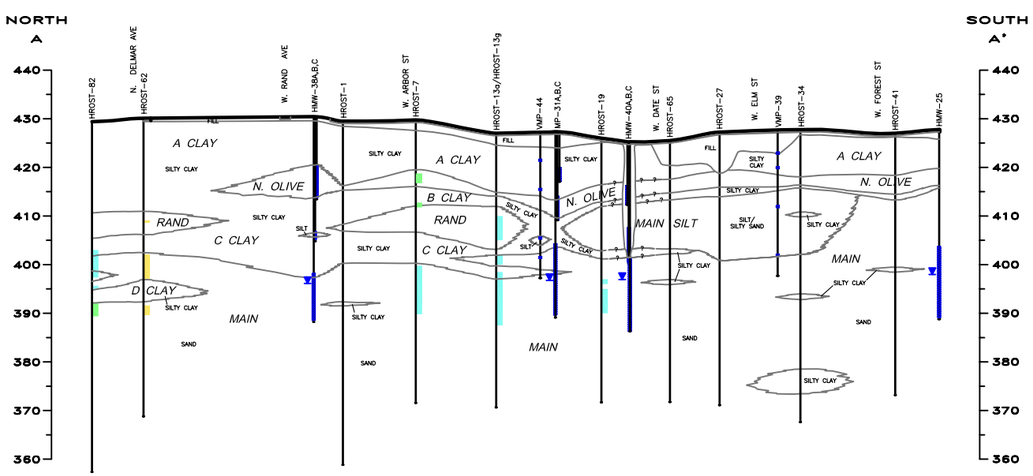
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

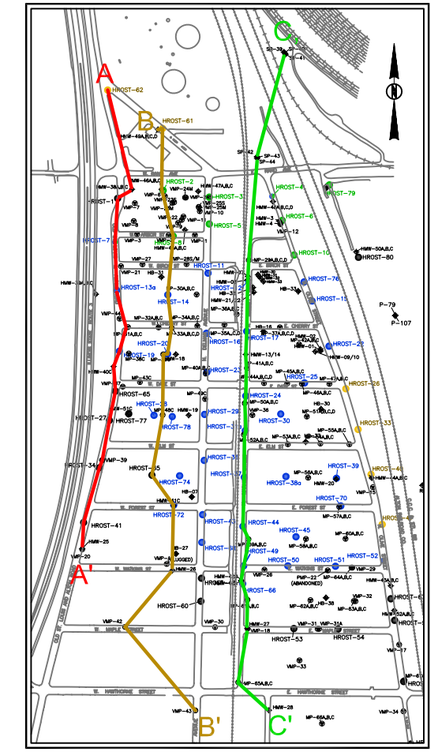
FIGURE

B-1









REFERENCE MAP

LEGEND

- YELLOW ROST RESPONSE
- GREEN ROST RESPONSE
- BLUE ROST RESPONSE
- RED/ORANGE ROST RESPONSE
- GROUNDWATER ELEVATION – MAIN SAND OR EPA STRATUMS (MEASURED SEPTEMBER 20–22, 2004)
- LNAPL ELEVATION (IF PRESENT) – MAIN SAND OR EPA STRATUMS (MEASURED SEPTEMBER 20–22, 2004)
- STORM SEWER INLET
- SCREEN INTERVAL

NOTES:

1. CROSS SECTIONS ARE BASED ON BEST PROFESSIONAL JUDGMENT USING DATA AVAILABLE AT THE TIME OF CONSTRUCTION. THE GEOLOGY PRESENTED IN THE CROSS SECTIONS WAS GENERALIZED TO ILLUSTRATE THE MAJOR LITHOLOGIC UNITS. THE THICKNESS AND EXTENT OF THE LITHOLOGIC UNITS WERE APPROXIMATED AND GEOLOGIC CONTACTS BETWEEN LOCATIONS WERE INFERRED.
2. HROST–SERIES BORINGS WERE COMPLETED IN 2004 AND 2005, BY FUGRO GEOSCIENCES, INC. USING CPT AND ROST™ METHODOLOGY. HROST–SERIES BORINGS, APPENDED WITH A "g", WERE COMPLETED ADJACENT TO THE ORIGINAL HROST–SERIES BORINGS, DURING JANUARY AND FEBRUARY 2004, BY PHILIP ENVIRONMENTAL SERVICES CORPORATION (PESC) USING GEOPROBE® METHODOLOGY. HMW–25 AND HIGHER SERIES BORINGS AND MP SERIES WERE COMPLETED DURING 2004 AND 2005, BY PESC USING GEOPROBE® AND HOLLOW STEM AUGER METHODOLOGY. VMP SERIES BORINGS WERE COMPLETED BY ENSR CORPORATION. REMAINING BORINGS WERE COMPLETED BY OTHERS.
3. GROUND SURFACE ELEVATIONS FOR HMW, MP, VMP AND SOME SP AND HROST LOCATIONS WERE DETERMINED BY SURVEYS BY CMT, INC. GROUND SURFACE ELEVATIONS FOR SOME HROST AND VMP LOCATIONS WERE ESTIMATED FROM AVAILABLE NEARBY GROUND SURFACE ELEVATION SURVEY DATA AT MONITORING FEATURES AND SELECTED SANITARY SEWER MANHOLES. GROUND SURFACE ELEVATIONS FOR SOME SP LOCATIONS, ORIGINALLY SURVEYED TO A DIFFERENT DATUM, HAVE BEEN ADJUSTED TO MATCH THE USGS DATUM USED FOR THE OTHER HARTFORD FEATURES. ELEVATIONS DEPICTED FOR PIPELINES, STORM SEWERS AND OTHER FEATURES WERE ESTIMATED FROM AVAILABLE DATA.
4. VERTICAL COLOR BARS ADJACENT TO HROST–SERIES BORINGS REPRESENT THE LOCATION AND VERTICAL EXTENT OF THE FLUORESCENCE RESPONSE DETECTED BY THE ROST™ TECHNOLOGY. THE PRESENCE OF A COLOR BAR IS NOT A REPRESENTATION OF LIGHT NON–AQUEOUS PHASE LIQUID THICKNESS.
5. TWO OR MORE OF THE INDIVIDUAL ROST™ COLORS REPRESENT COMMINGLED ROST™ RESPONSES.
6. NO ROST™ RESPONSE WAS DETECTED AT THOSE HROST–SERIES BORINGS WITHOUT A VERTICAL COLOR BAR.
7. MAIN SAND, EPA STRATUM, RAND STRATUM AND NORTH OLIVE STRATUM ARE NAMES DEVELOPED FOR LOCAL HYDROSTRATIGRAPHIC UNITS.
8. FEATURES MAY BE PROJECTED ONTO THE CROSS SECTION.

SCALE IN FEET

0 150 300 600

VERTICAL SCALE: 1' = 20'

Clayton Group Services, Inc.
A Bureau Veritas Company

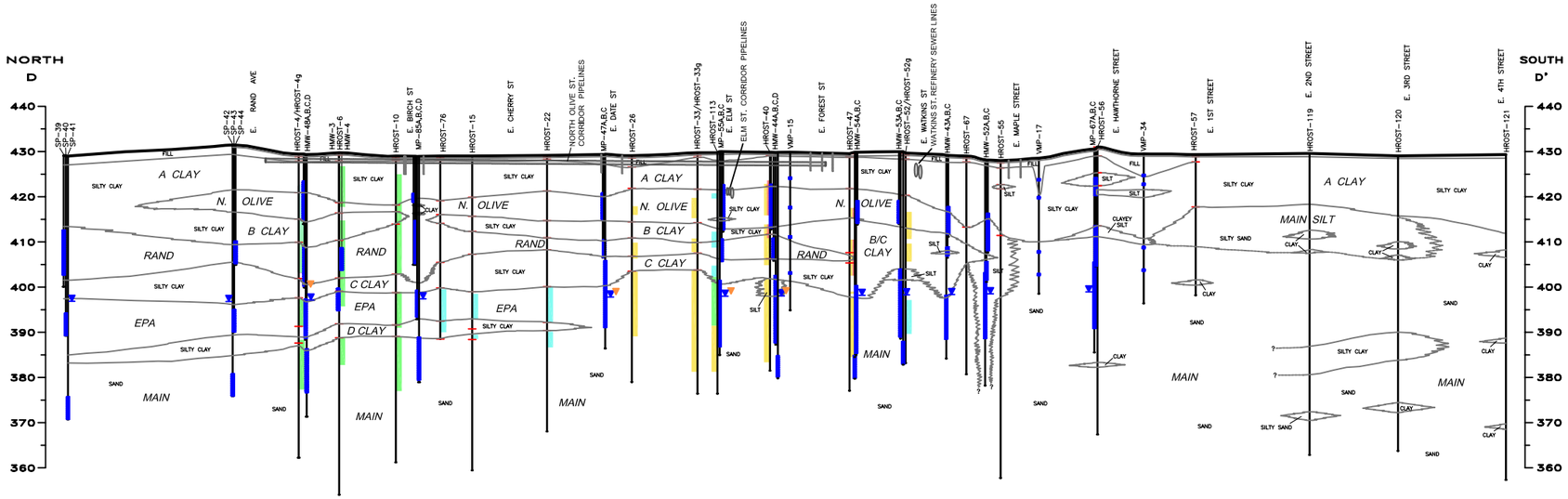
CHECK BY	
DRAWN BY	BCP
DATE	11–15–05
SCALE	AS SHOWN
CAD NO.	15–0309514020B
PRJ NO.	15–03095.14

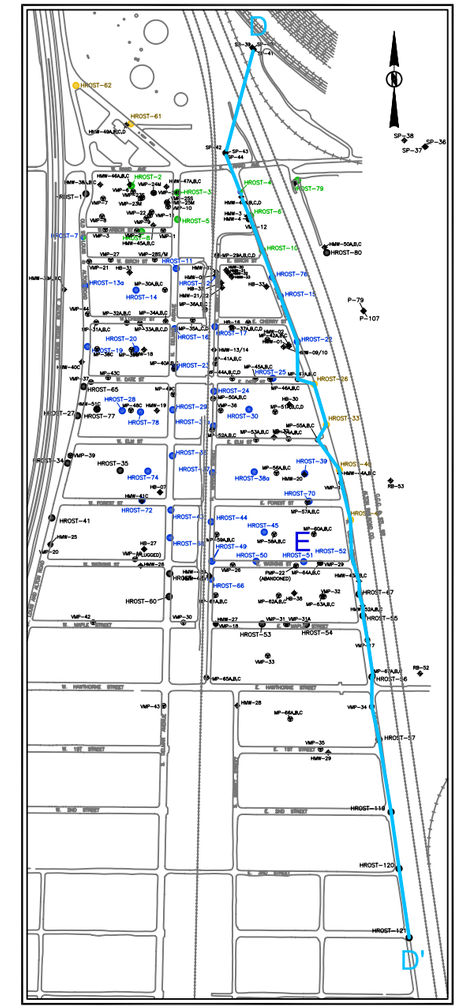
CROSS SECTIONS A–A', B–B', AND C–C'

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

FIGURE

B–2





REFERENCE MAP

SCALE IN FEET

0 150 300 600

VERTICAL SCALE: 1' = 20'

LEGEND

- YELLOW ROST RESPONSE
- GREEN ROST RESPONSE
- BLUE ROST RESPONSE
- RED/ORANGE ROST RESPONSE
- GROUNDWATER ELEVATION – MAIN SAND OR EPA STRATUMS (MEASURED SEPTEMBER 20–22, 2004)
- LNAPL ELEVATION (IF PRESENT) – MAIN SAND OR EPA STRATUMS (MEASURED SEPTEMBER 20–22, 2004)
- STORM SEWER INLET
- SCREEN INTERVAL

NOTES:

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8. FEATURES MAY BE PROJECTED ONTO THE CROSS SECTION.

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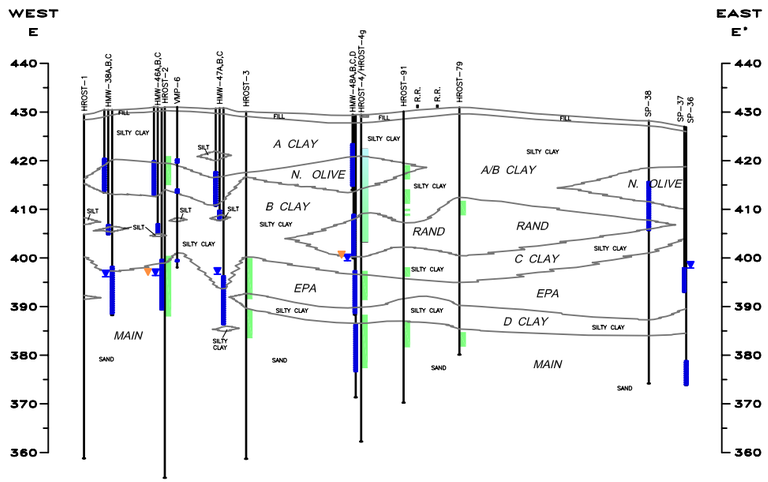
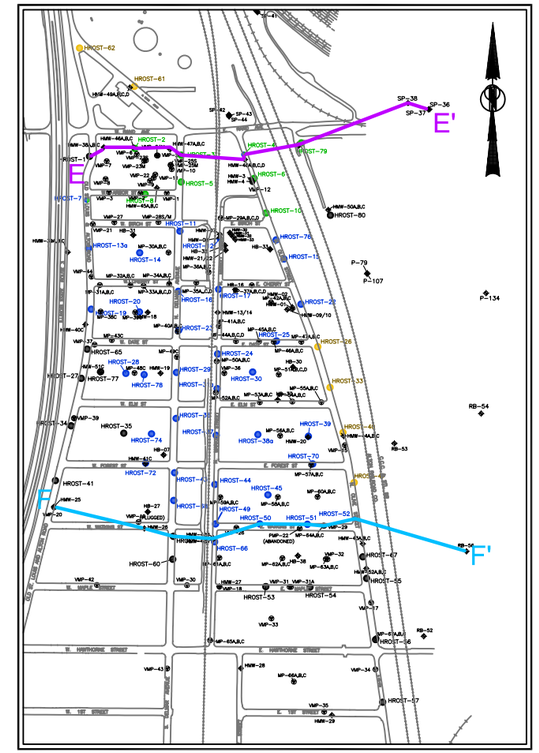
CHECK BY HLM/KDC	CROSS SECTION D–D'	FIGURE
DRAWN BY BCP		B–3
DATE 11–15–05	THE HARTFORD AREA HYDROCARBON PLUME SITE	
SCALE AS SHOWN	THE HARTFORD WORKING GROUP	
CAD NO. 0309514020C	HARTFORD, ILLINOIS	
PRJ NO. 15–03095.14		





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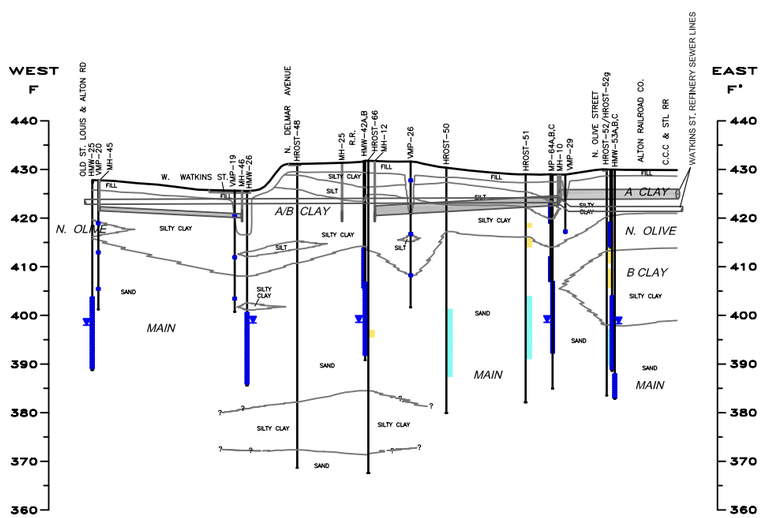

SCALE IN FEET

0 150 300 600

VERTICAL SCALE: 1' = 20'

LEGEND

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- GREEN ROST RESPONSE
- BLUE ROST RESPONSE
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- STORM SEWER INLET
- SCREEN INTERVAL

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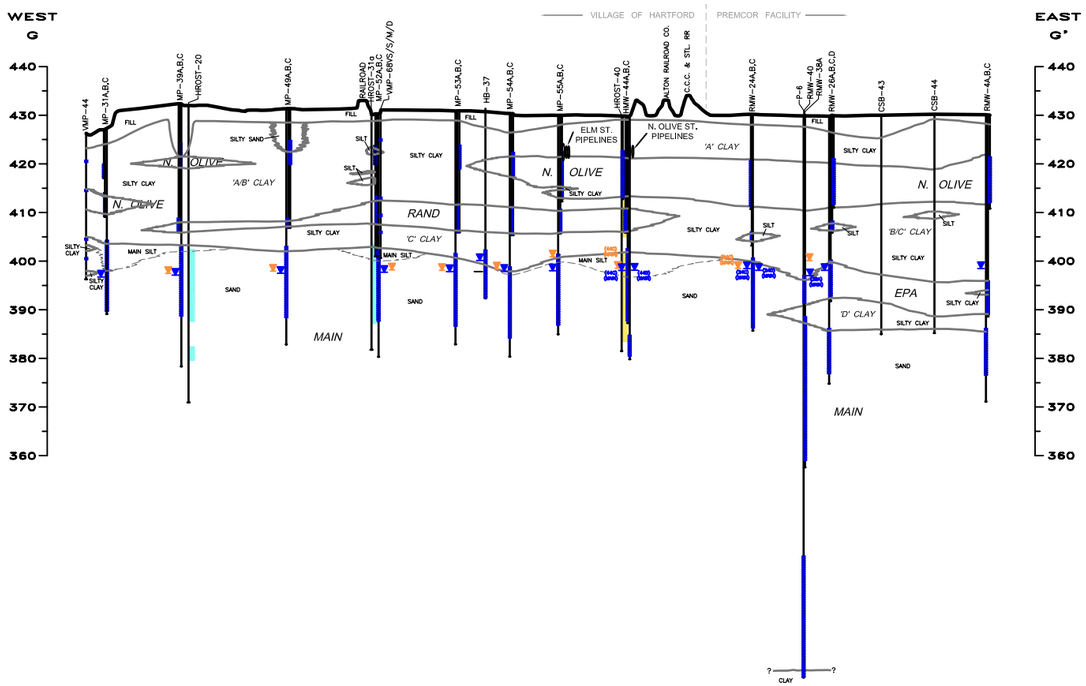
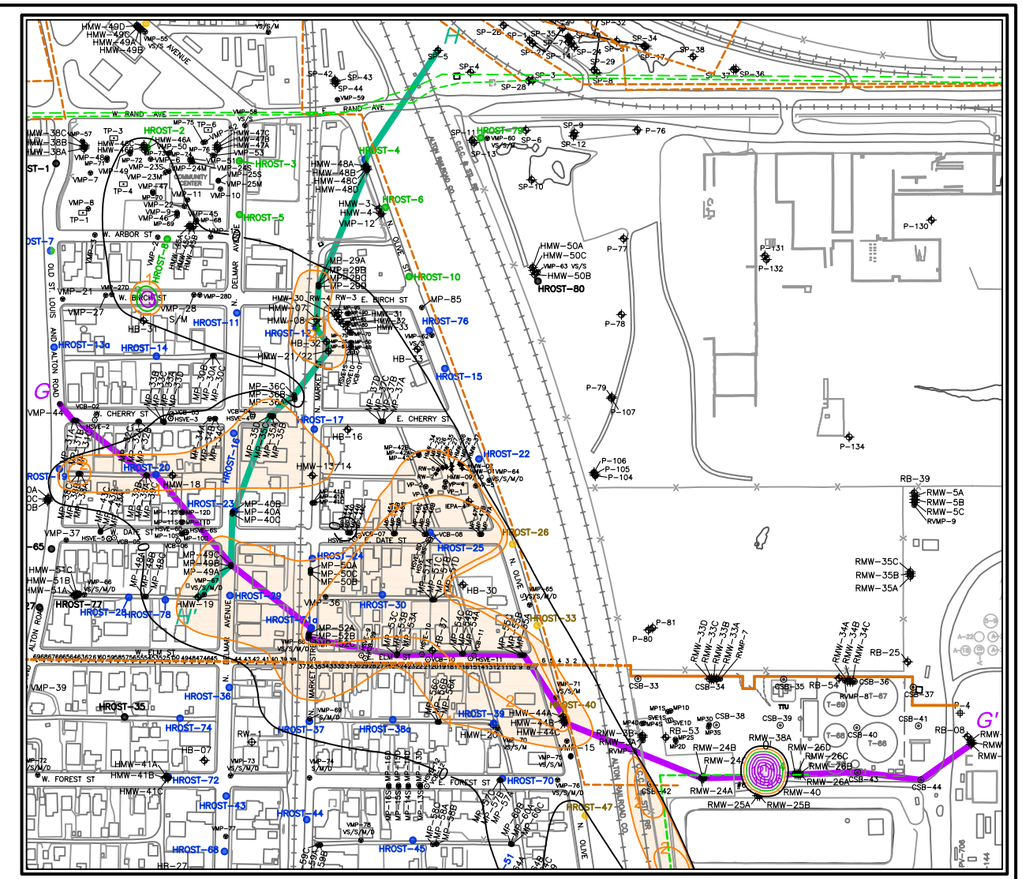
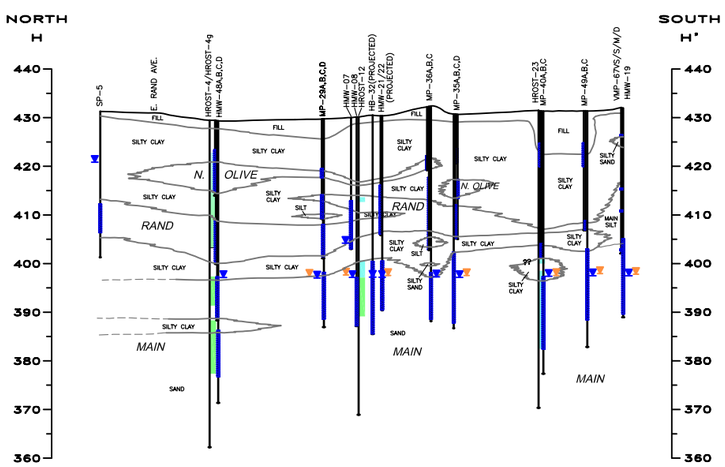
CHECK BY KDC	CROSS SECTIONS E–E' AND F–F' THE HARTFORD AREA HYDROCARBON PLUME SITE THE HARTFORD WORKING GROUP HARTFORD, ILLINOIS		FIGURE B–4
DRAWN BY BCP			
DATE 11–15–05			
SCALE AS SHOWN			
CAD NO. 0309514020D			
PRJ NO. 15–03095.14			





REFERENCE MAP



LEGEND

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SCALE IN FEET

0 150 300 600

VERTICAL SCALE = 1" = 20'

Clayton Group Services, Inc.
A Bureau Veritas Company

CHECK BY KDC	CROSS SECTIONS G–G' AND H–H' THE HARTFORD AREA HYDROCARBON PLUME SITE THE HARTFORD WORKING GROUP HARTFORD, ILLINOIS	BUREAU VERITAS	FIGURE B–5
DRAWN BY BCP			
DATE 11–15–05			
SCALE AS SHOWN			
CAD NO. 0309514020E			
PRJ NO. 15–03095.14			

APPENDIX C

STRATA COMPOSITION

LIST OF FIGURES INCLUDED:

C-1 COMPOSITION OF NORTH OLIVE STRATUM GEOTECHNICAL SAMPLES
C-2 COMPOSITION OF RAND STRATUM GEOTECHNICAL SAMPLES
C-3 COMPOSITION OF EPA STRATUM GEOTECHNICAL SAMPLES
C-4 COMPOSITION OF MAIN SILT GEOTECHNICAL SAMPLES
C-5 COMPOSITION OF MAIN SAND GEOTECHNICAL SAMPLES
C-6 COMPOSITION OF CLAY STRATA GEOTECHNICAL SAMPLES

Appendix C: Strata Composition

Evaluation of Geotechnical Data

Geotechnical samples were collected at various boring locations and depth intervals in Hartford to (1) evaluate the composition (e.g., gravel, sand, silt or clay), moisture content, and fraction organic carbon content of the various alluvial and clay deposits; (2) refine the geologic descriptions; and (3) assist with the interpretation and correlation of the stratigraphic units. The lithologic description and composition of the North Olive, Rand, EPA, Main Sand, and Clay strata in Hartford are summarized in the sections below.

Composition of Strata in the Village of Hartford

The average percentage of sand, silt, and clay in the North Olive Stratum is approximately 12, 71 and 17, respectively. The composition of geotechnical samples collected from the North Olive Stratum is shown in Figure C-1. The average percentage of sand, silt, and clay in the Rand Stratum is approximately 10, 70 and 20, respectively. The composition of the Rand Stratum is similar to that of the North Olive Stratum, and also that of the Main Silt in some areas. The composition of geotechnical samples collected from the Rand Stratum is shown in Figure C-2.

The average percentage of sand, silt, and clay in the EPA Stratum is approximately 68, 22 and 10, respectively. However; these quantities may be skewed (higher or lower), because the above composition is based on only three geotechnical samples collected within the limited extent of the stratum in Hartford. The composition of geotechnical samples collected from the EPA Stratum is shown in Figure C-3. The average percentage of sand, silt, and clay in the Main Silt is approximately 25, 64 and 11, respectively. The composition of geotechnical samples collected from the Main Silt is shown in Figure C-4.

The average percentage of sand, silt, and clay in the Main Sand is approximately 90, 7 and 3, respectively. The composition of geotechnical samples collected from the Main Sand is shown in Figure C-5.

The clay strata consists of an average sand, silt, and clay content of approximately 6, 44 and 50 percent, respectively. The composition of geotechnical samples collected from all of the clay strata is shown in Figure C-6.

Figure C-1

Composition of North Olive Stratum Geotechnical Samples
Village of Hartford

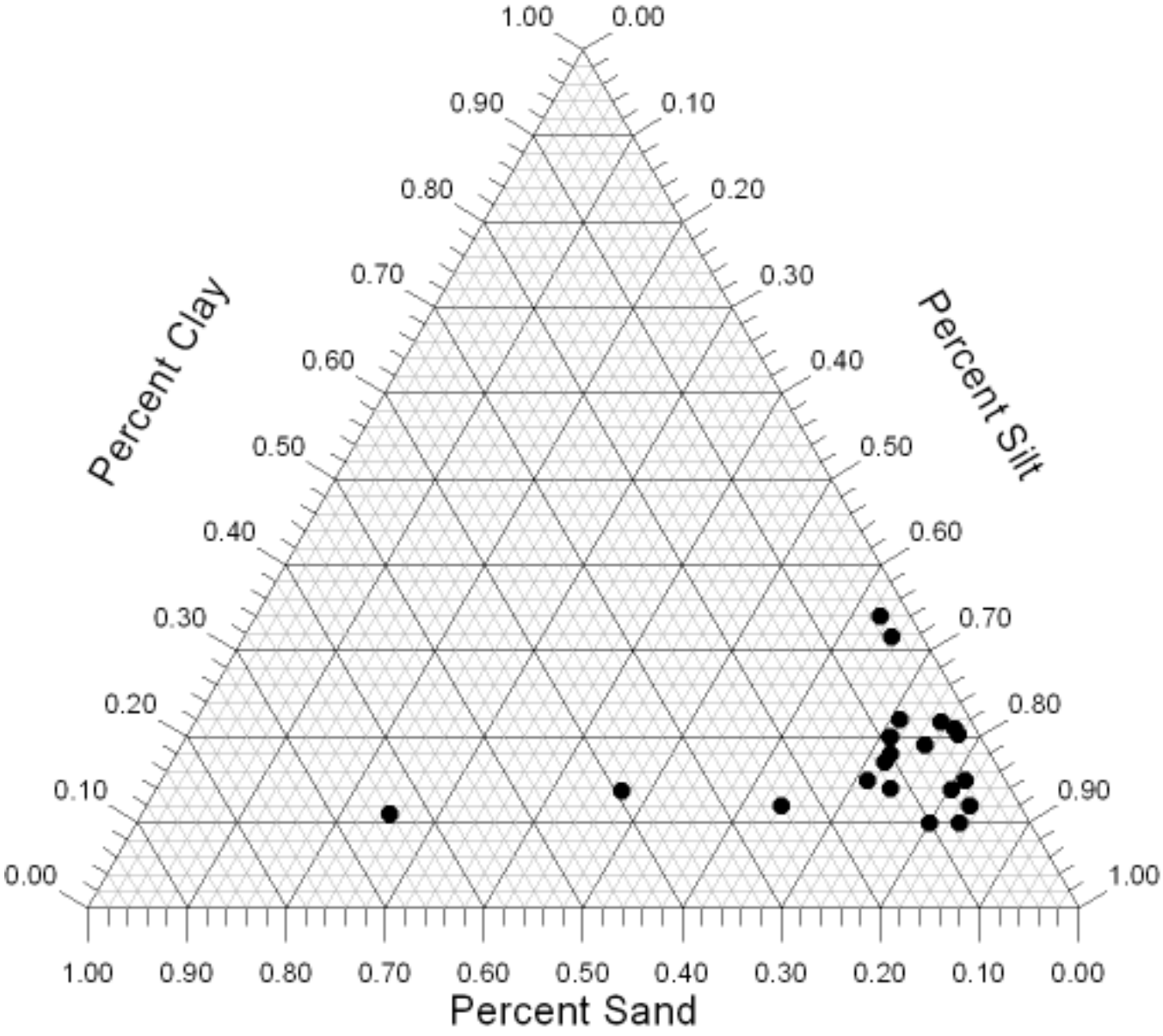


Figure C-2

Composition of Rand Stratum Geotechnical Samples
Village of Hartford

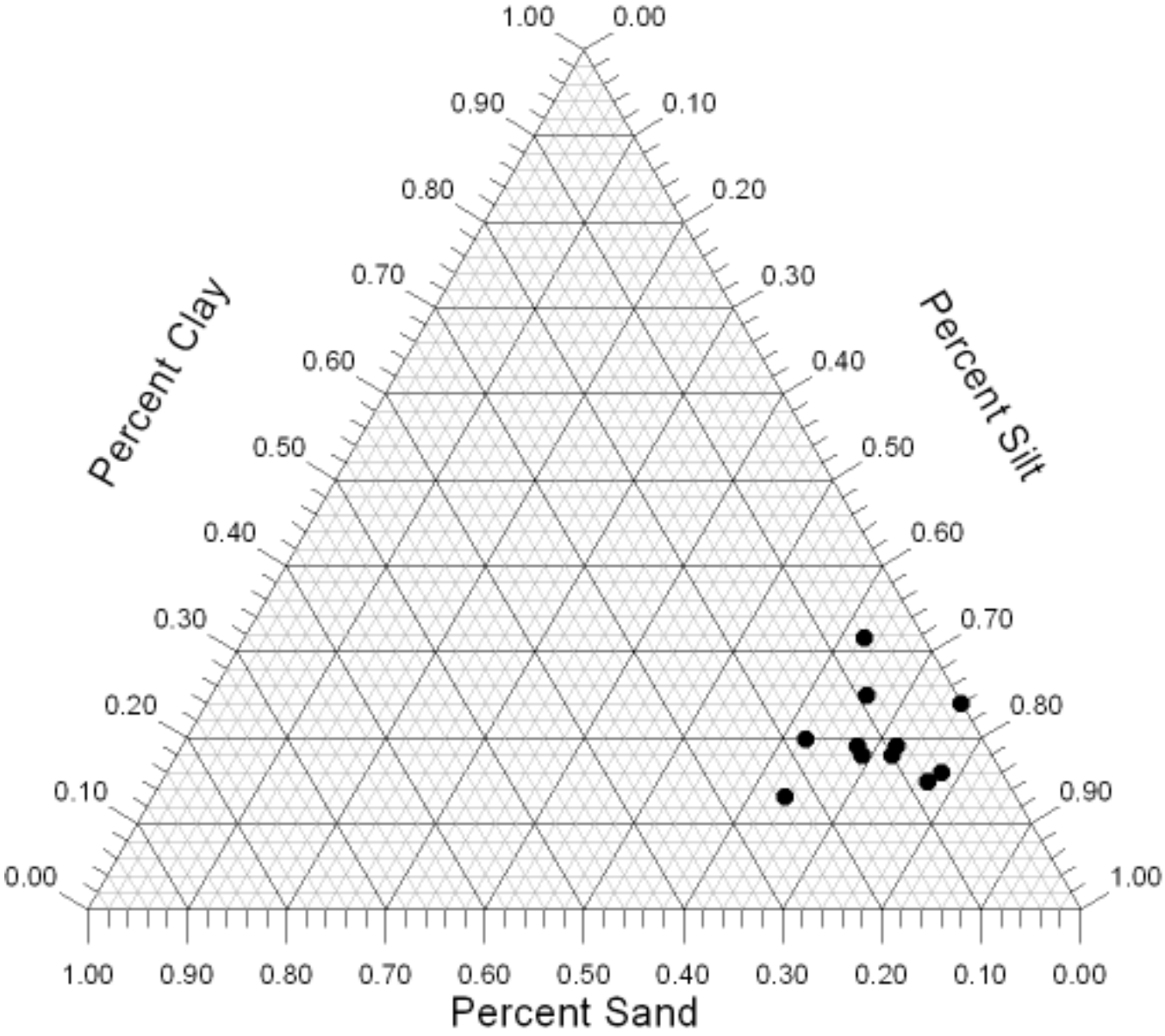


Figure C-3

Composition of EPA Stratum Geotechnical Samples
Village of Hartford

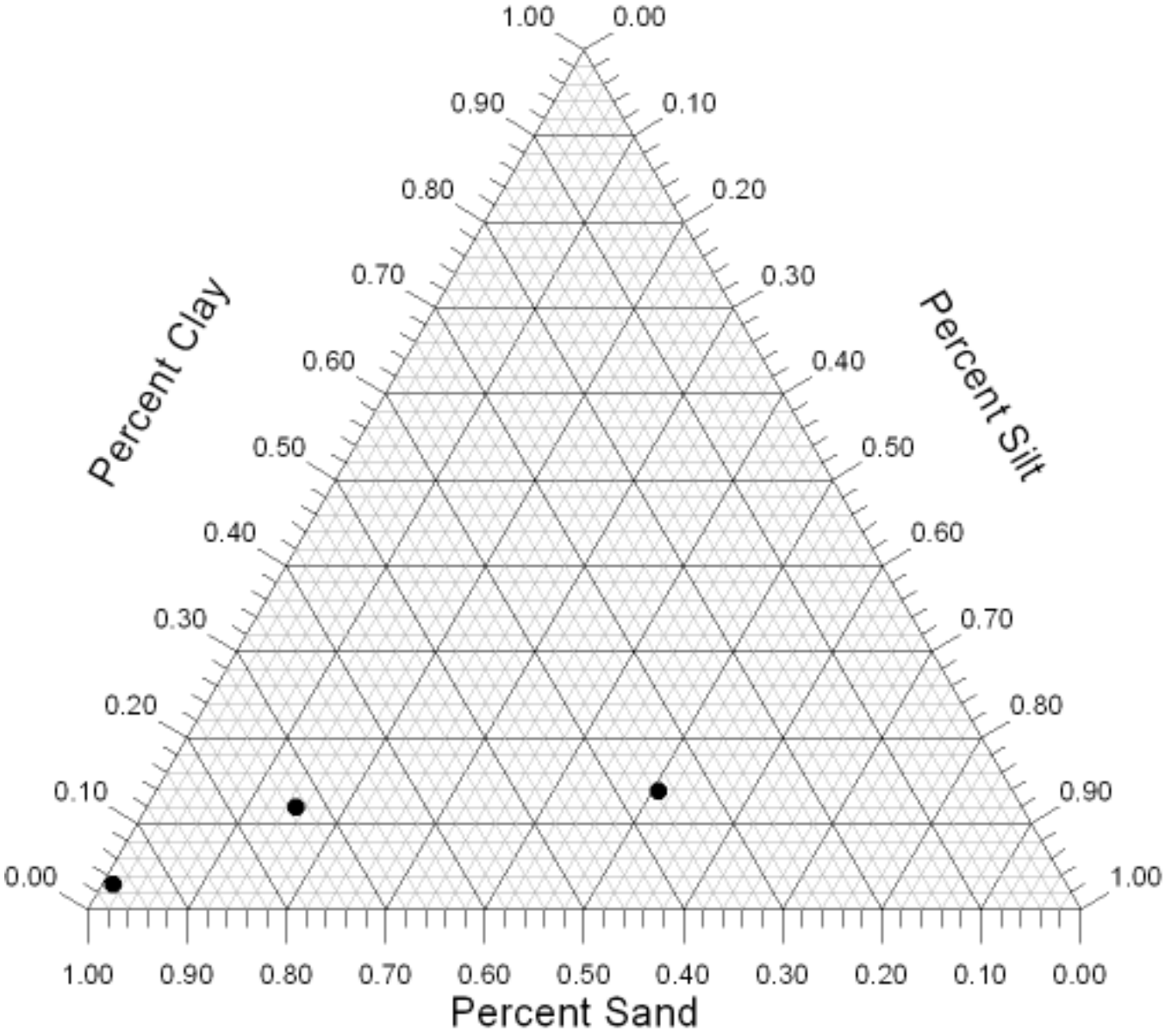


Figure C-4

Composition of Main Silt Geotechnical Samples
Village of Hartford

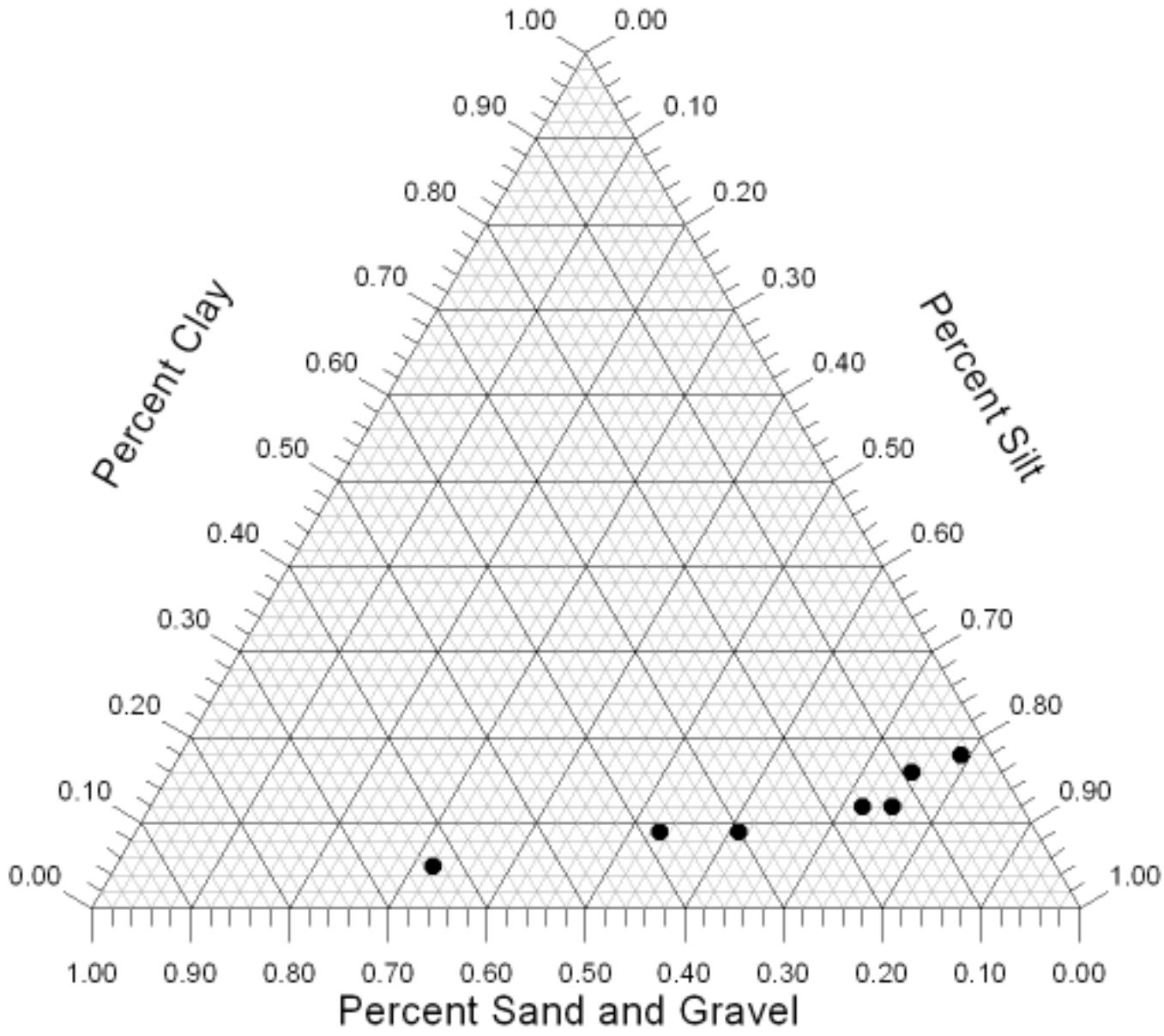


Figure C-5

Composition of Main Sand Geotechnical Samples
Village of Hartford

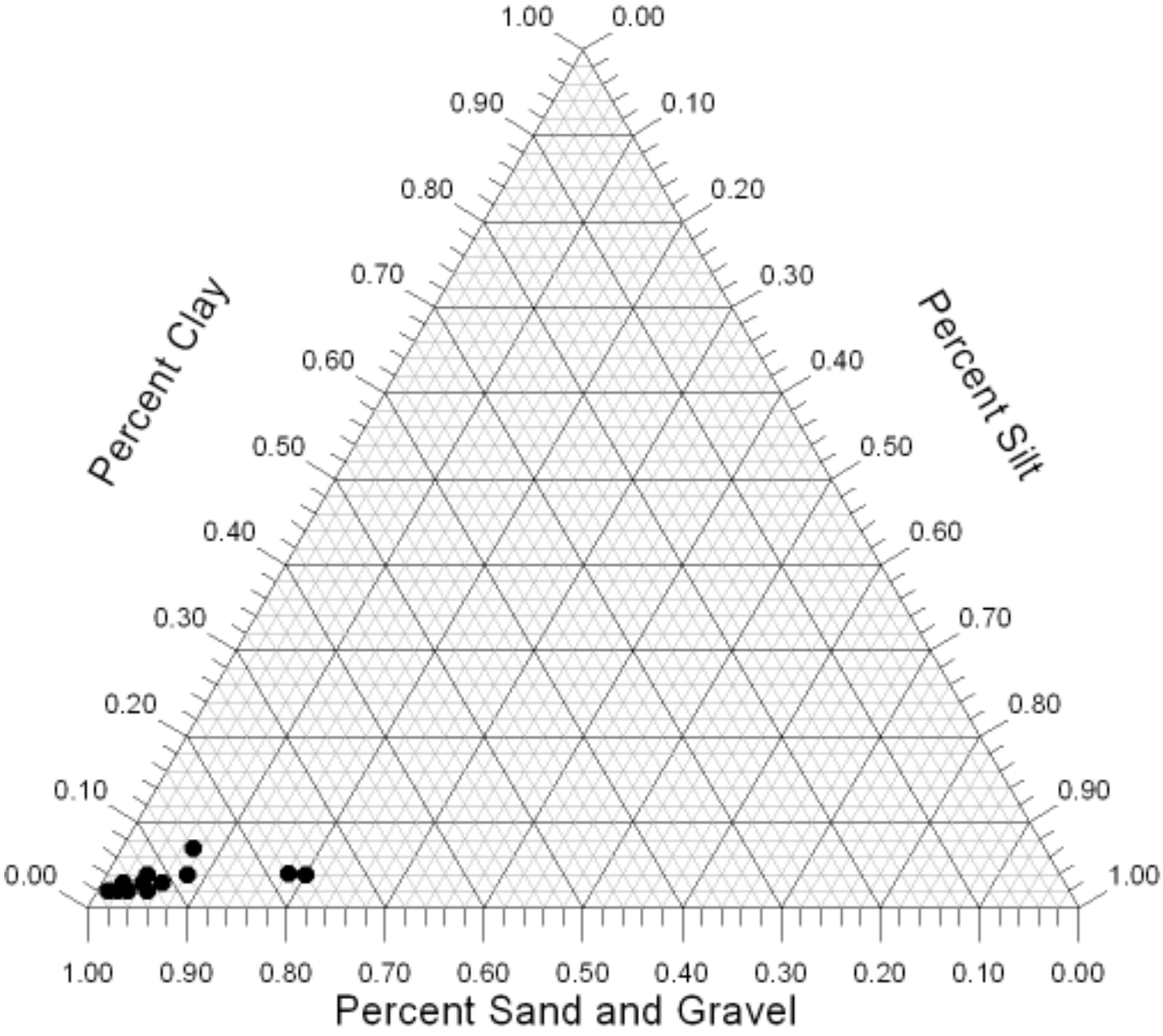
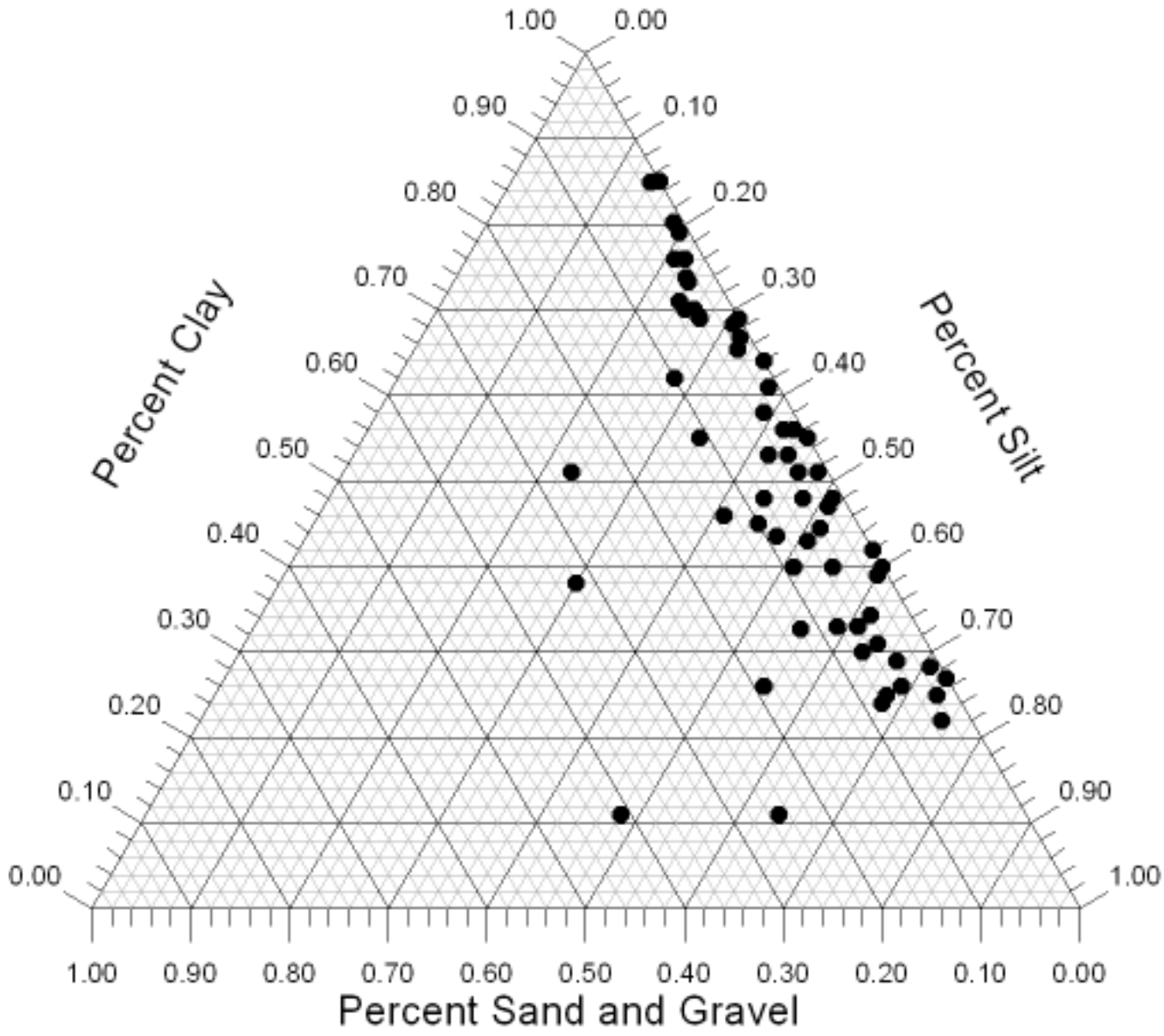


Figure C-6

Composition of Clay Strata Geotechnical Samples
Village of Hartford



APPENDIX D

STRATA ISOPACH AND STRUCTURE CONTOUR

LIST OF FIGURES INCLUDED:

D-1 ISOPACH MAP OF THE A CLAY STRATUM

D-2 STRUCTURE CONTOUR MAP OF THE TOP OF THE NORTH OLIVE/MAIN SILT STRATA BELOW THE A CLAY STRATUM

D-3 STRUCTURE CONTOUR MAP OF THE BOTTOM OF THE NORTH OLIVE STRATUM

D-4 ISOPACH MAP OF THE NORTH OLIVE STRATUM

D-5 ISOPACH MAP OF THE B CLAY STRATUM

D-6 STRUCTURE CONTOUR MAP OF THE TOP OF THE RAND STRATUM

D-7 STRUCTURE CONTOUR MAP OF THE BOTTOM OF THE RAND STRATUM

D-8 ISOPACH MAP OF THE RAND STRATUM

D-9 ISOPACH MAP OF THE C CLAY STRATUM

D-10 STRUCTURE CONTOUR MAP OF THE TOP OF THE EPA STRATUM/TOP OF THE MAIN SAND/BASE OF THE MAIN SILT

D-11 ISOPACH MAP OF THE MAIN SILT

D-12 STRUCTURE CONTOUR MAP OF THE BOTTOM OF THE EPA STRATUM

D-13 ISOPACH MAP OF THE EPA STRATUM

D-14 ISOPACH MAP OF THE D CLAY STRATUM

D-15 STRUCTURE CONTOUR MAP OF THE TOP OF THE MAIN SAND BELOW THE D CLAY STRATUM

Appendix D: Strata Isopach and Structure Contour

Stratigraphic Analysis of Strata in the Village of Hartford

A Clay Stratum

The A Clay Stratum is present throughout Hartford and ranges in thickness from 5 to 24 feet. This stratum is generally thickest (1) near the intersection of West Date Street and North Delmar Avenue, (2) north of West Rand Avenue along Illinois State Route 3, (3) between West Watkins and West Maple Streets, and (4) between East Maple and East Hawthorne Streets. 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, (4) along East Forest Street between North Delmar Avenue and North Olive Street, and (5) between Hawthorne and 3rd Streets in the central portion of Hartford. An isopach map of the A Clay Stratum is shown in Figure D-1.

North Olive Stratum

The North Olive Stratum is encountered at depths ranging from approximately 8 to 15 feet (average 10 feet) below ground surface (bgs) and extends across the majority of the northern portion of Hartford, from the intersection of North Delmar Avenue and Old St. Louis Road south to Date Street. This deposit is bounded by the A and B Clay Strata. The North Olive Stratum also extends along Old St. Louis Road and North Olive Street corridors south of Date Street. However, south of Date Street, the North Olive and B Clay Strata are absent in the central portion of Hartford along North Delmar Avenue and North Market Street corridors. The western extent of the North Olive Stratum is not defined west beyond Illinois State Route 3. This stratum appears to extend slightly east of North Olive Street to the railroad tracks between East Rand Avenue on the north and East Birch Street to the south. It also extends into the Premcor Facility between East Elm and East Watkins Streets and onto the Shell/Tannery property between East Birch and East Elm Street.

The top of the North Olive Stratum in Hartford, where the B Clay Stratum underlies it, is encountered at an approximate elevation of 414 to 424 feet above mean sea level (MSL). The elevation of the base of the North Olive Stratum ranges from 408 to 420 feet above MSL. Structure contour maps of the top and bottom of the North Olive Stratum are shown in Figures D-2 and D-3, respectively. The contour map of the top elevation of the North Olive Stratum also encompasses the top of the Main Silt where it underlies the A Clay (Figure D-2).

The elevation of the top of the North Olive Stratum is highest (approximately 418 to 424 feet above MSL) in the area (1) along the North Olive Street corridor, (2) between West Forest and West Watkins Streets, and (3) near the Hartford Community Center. The elevation of the bottom of this stratum is highest (approximately 417 to 420 feet above MSL) in the area (1) between East Forest and East Birch Streets, east of North Market Street, (2) along West Date Street between North Delmar Avenue and Old St. Louis Road, (3) between West Elm and West Forest Streets along Old St. Louis Road, and (4) north of West Rand Avenue along North Delmar Avenue. The lowest bottom elevation (approximately 410 feet above MSL) is encountered (1) at the intersection of Old St. Louis Road and West Cherry Street, and (2) near the intersection of Old St. Louis Road and West Elm Street.

The North Olive Stratum ranges from less than 1-foot to 10-feet thick. An isopach map of the North Olive Stratum is shown in Figure D-4. This stratum is generally thickest (approximately 6 to 10 feet) (1) along the southern portion of the North Olive Street corridor, (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 Stratum.

B Clay Stratum

The B Clay Stratum underlies the North Olive Stratum and ranges in thickness from less than 1 foot to 12 feet. This stratum 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. An isopach map of the B Clay Stratum is shown in Figure D-5.

Rand Stratum

The Rand Stratum is encountered at depths ranging from approximately 12 to 27 feet bgs (average 19 feet bgs) and is defined by the extent of the C Clay Stratum. This stratum appears to extend across the majority of the northern portion of Hartford south to East Forest Street . The Rand Stratum extends east into the Shell/Tannery Property between East Rand Avenue and East Cherry Street. The western extent of this stratum has not been defined beyond Old St. Louis Road. To the south of Date Street, in Hartford, the Rand Stratum grades laterally into the Main Silt. The Rand Stratum pinches out east of North Olive Street between East Date and East Forest Streets and is locally absent near the intersections of West Rand Avenue, North Delmar Avenue, and Old St. Louis Road where the B and C Clay Strata are undifferentiated.

The top of the Rand Stratum is encountered at elevations ranging from approximately 406 to 415 feet above MSL in Hartford. The elevation of the bottom of this stratum ranges from approximately 400 to 409 feet above MSL. Structure contour maps of the top and bottom of the Rand Stratum are shown in Figures D-6 and D-7, respectively. The top elevation of the Rand Stratum is highest in the area (1) between East Date and East Elm Streets, and (2) near the intersection of East Birch and North Olive Streets. The top elevation of the Rand Stratum is lowest (1) south of the Hartford Community Center along North Delmar Avenue, and (2) near the intersection of Old St. Louis Road and North Delmar Avenue. The bottom of the Rand Stratum is highest between West Cherry and West Elm Streets along North Delmar Avenue and North Market Street. The bottom surface elevation is lowest (1) near the intersection of West Birch Street and North Delmar Avenue, and (2) between East Rand Avenue and East Birch Street.

The Rand Stratum ranges in thickness from less than 1 foot to 11 feet. An isopach map of the Rand Stratum is shown in Figure D-8. The Rand Stratum is thickest in the area (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.

C Clay Stratum

The C Clay Stratum defines the extent of the Rand Stratum and ranges in thickness from less than 1 foot to approximately 8 feet. An isopach map of the C Clay Stratum is shown in Figure D-9. The C Clay Stratum 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 Stratum is thinnest near the intersection of North Market and East Forest Streets.

Main Silt Stratum

The Main Silt is encountered at depths ranging from approximately 6 to 30 feet bgs (average of 16 feet bgs), where the B and/or C Clay Strata are absent and where it is overlain by the A Clay Stratum. This stratum laterally grades into and is compositionally similar to the North Olive and Rand Strata. 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. In a localized area near the intersections of West Date Street and North Delmar Avenue, and East Elm Street and North Market Street, the Main Silt overlies the C Clay Stratum. A structure contour map of the top of the Main Silt and North Olive Stratum is shown in Figure D-2. A structure contour map of the base of the Main Silt and top of the EPA Stratum is shown in Figure D-10.

The top of the Main Silt is encountered at elevations ranging from approximately 407 to 422 feet above MSL, where it underlies the A Clay. The highest top elevation of the Main Silt is generally located (1) near the intersection of East Hawthorne and North Market Streets, (2) along Old St. Louis Road between West Hawthorne and 3rd Streets, (3) along North Olive Street between East 1st and East 2nd Streets, and (4) between West Elm and West Forest Streets along North Delmar Avenue. The top of the Main Silt is lowest in the area (1) between Maple and Watkins Streets, and (2) near the intersection of West Date Street and North Delmar Avenue. The majority of the Main Silt directly overlies the Main Sand (Figure D-10) and ranges in elevation from approximately 396 to 413 feet above MSL. The base of the Main Silt is generally highest (1) in the area bounded by West Watkins Street, 2nd Street, Old St. Louis Road, and North Market Street; and (2) along East Maple Street between North Market and North Olive Streets. The base of the Main Silt is generally lowest (1) between West Date and West Elm

Streets, (2) along old St. Louis Road south of West 3rd Street, (3) between East Hawthorne and East 1st Streets, and (4) between West Forest and West Watkins Streets.

The Main Silt ranges in thickness from approximately 2 to 19 feet. An isopach map of the Main Silt is shown in Figure D-11. It is thickest (1) south of 1st Street, (2) between West Watkins and West Maple Streets along North Delmar Avenue, and (3) between West Elm and West Forest Streets along North Delmar Avenue. The Main Silt is thinnest (1) between West Forest and West Watkins Streets along North Delmar Avenue, and (2) between East Watkins and East Maple Streets. These areas coincide with thick deposits of A Clay Stratum and topographically high bottom elevations of the Main Silt.

It should be noted that there are certain areas where the contact between the Main Silt and Main Sand is gradational and difficult to interpret. Specifically, most of the elevation data for the contact between these strata, in the southern portion of Hartford, were often difficult to interpret and had to be inferred based on the surrounding data points.

EPA Stratum

The EPA Stratum is encountered in the northeastern portion of Hartford at depths ranging from 27 to 46 feet bgs (average of 31 feet bgs). This stratum is defined and separated from the Main Sand by the D Clay Stratum. The EPA Stratum grades laterally into the Main Sand to the south of a southeasterly trending line drawn from the Old St. Louis Road and Delmar Avenue intersection to just north of the East Date Street and North Olive Street intersection. Along this boundary the EPA Stratum and Main Sand are hydraulically connected.

The elevation of the top of the EPA Stratum in the northern portion of Hartford ranges from approximately 395 to 404 feet above MSL. The elevation of the bottom of this stratum ranges from 389 to 398 feet above MSL. Structure contour maps of the top and bottom of the EPA Stratum are shown in Figures D-10 and D-12, respectively. The top elevation of the EPA Stratum is highest (approximately 403 feet above MSL) at the intersection of North Delmar Avenue and Old St. Louis Road. The top elevation of this stratum steadily decreases to the east towards North Olive Street. The bottom of the EPA Stratum is also highest (approximately 398 feet above MSL) near the intersection of North Delmar Avenue and Old St. Louis Road. The bottom elevation of this stratum decreases eastward towards North Olive Street.

The bottom surface elevation of the EPA Stratum is lowest (approximately 389 feet above MSL) near the intersection of East Rand Avenue and North Olive Street.

The EPA Stratum ranges from approximately 4 to 9 feet thick within the northeastern portion of Hartford. An isopach map of the EPA Stratum is shown in Figure D-13. The EPA Stratum is thickest north of West Rand Avenue along North Delmar Avenue, and along North Olive Street. This stratum is thinnest along the northwestern boundary of the Shell/Tannery Property.

D Clay Stratum

The D Clay Stratum underlies the EPA Stratum and ranges in thickness from approximately 2 to 7 feet thick. This clay stratum 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. An isopach map of the D Clay Stratum is shown in Figure D-14.

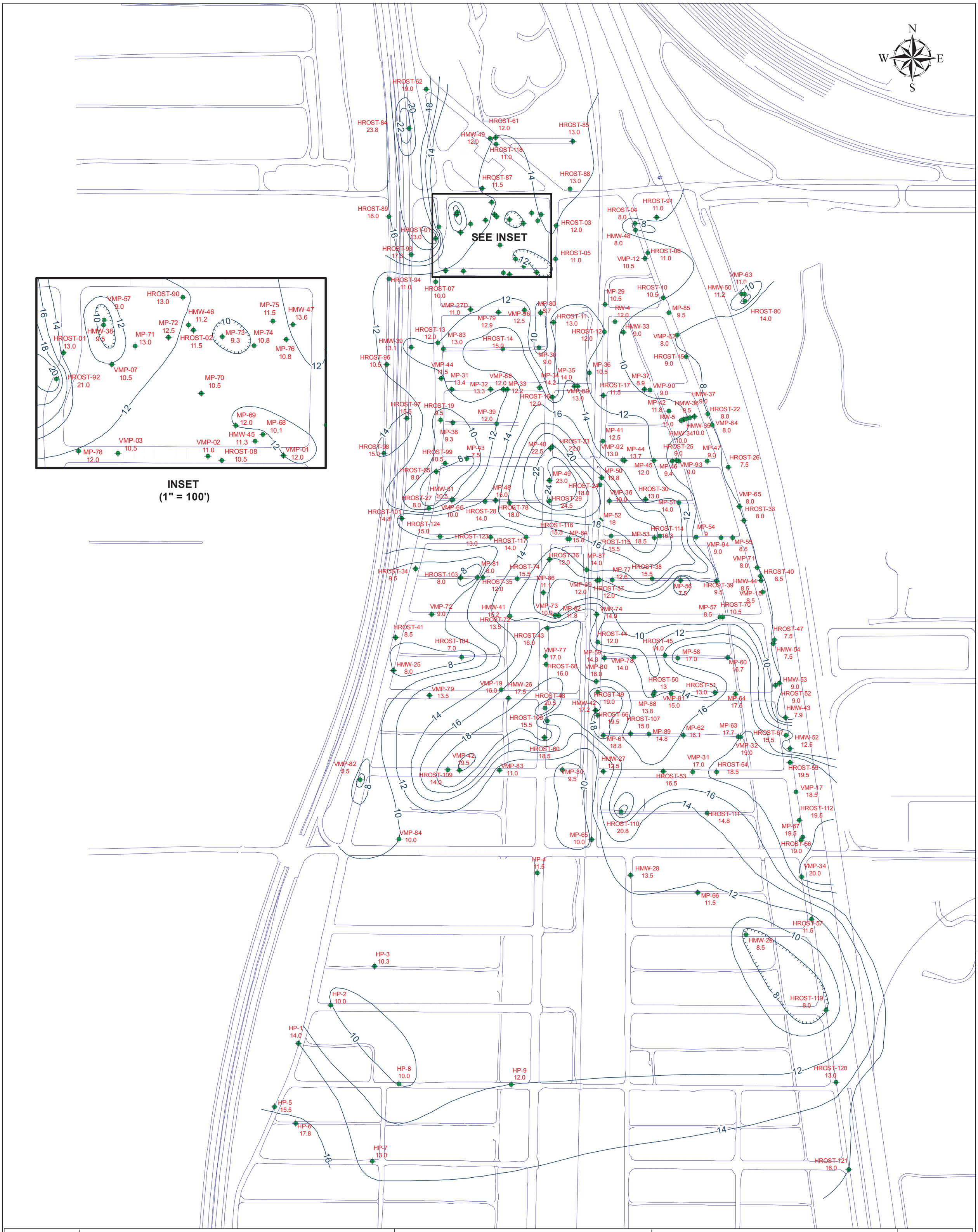
Main Sand

The Main Sand is aerially extensive throughout Hartford and surrounding areas. In Hartford, it is encountered at depths ranging from 19 to 45 feet bgs (average of 28 feet bgs) and ranges in thickness from approximately 80 to 104 feet near the Village Municipal Water Wells. The elevation of the top of the Main Sand varies based on the presence or absence of the overlying clay strata. Where the B and/or C Clay Strata are absent in the central portion of Hartford, the upper surface of the Main Sand is hydraulically connected to the Main Silt, which is overlain by the A Clay Stratum. The contact between the Main Sand and Main Silt is gradational and often times difficult to accurately define. Discontinuous silty clay and clayey silt lenses of limited thickness and extent occur at various depths within the Main Sand.

The top of the Main Sand is encountered at an elevation of approximately 393 to 413 feet above MSL (Figure D- 10). The top of the Main Sand is at the same horizon as the top of the EPA Stratum, where the D Clay is absent. The top of the Main Sand is highest in the area (1) bounded by West Watkins Street, 2nd Street, Old St. Louis Road, and Market Street; and (2) along East Maple Street between North

Market and North Olive Streets. The top surface elevations are lowest in the area (1) bounded by West Birch Street, West Cherry Street, Old St. Louis Road, and North Delmar Avenue; (2) between West Date and West Elm Streets; and (3) near the intersection of Forest Street and North Delmar Avenue. The elevation of the top of the Main Sand generally decreases towards the east-northeast.

Where the Main Sand underlies the D Clay in the northeastern portion of Hartford, the top of the Main Sand is encountered at depths ranging from 39 to 45 feet bgs (approximately 386 to 393 above MSL). A structure contour map of the top of the deep Main Sand below the D Clay is shown in Figure D-15. The top of the Main Sand below the D Clay is highest (approximately 393 feet above MSL) at the intersection of North Delmar Avenue and Old St. Louis Road. The elevation of the top of the Main Sand decreases towards the east-northeast. The thickness of the Main Sand below the D Clay Stratum in Hartford is unknown.



NOTES:
1. Map created from aerial photogrammetry dated April 2004 by Continental Mapping Consultants, Inc.
2. Contours are based on best professional judgement using data available at the time of preparation. The contours are approximate and inferred between locations and may be updated as new data is generated.
3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 112.5 225 450 675 900 1,125 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW, HP)

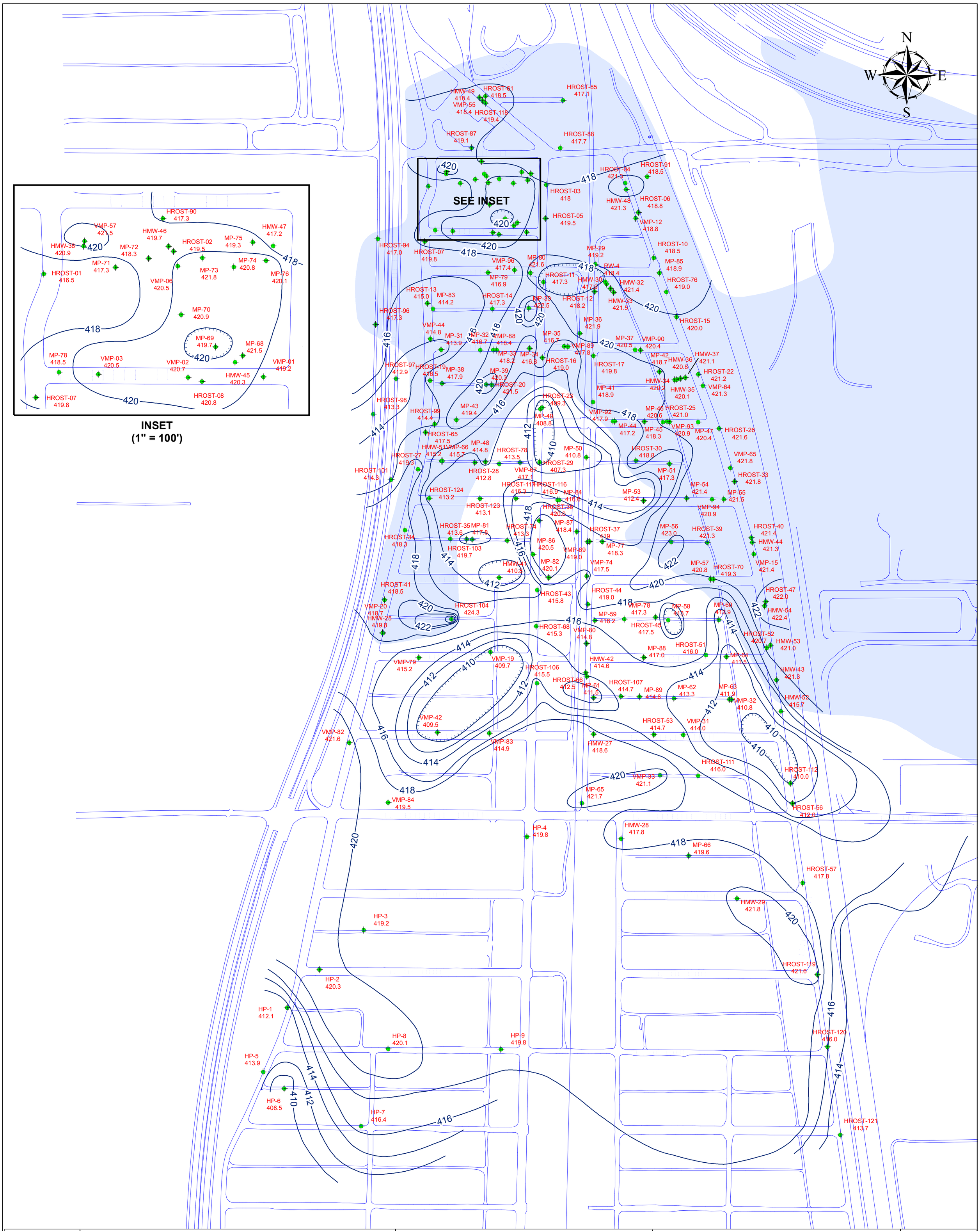
10 THICKNESS OF STRATUM (FEET)

BUREAU VERITAS
Clayton Group Services, Inc
A Bureau Veritas Company

ISOPACH MAP OF THE A CLAY STRATUM

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

FIGURE D-1



NOTES:
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 112.5 225 450 675 900 1,125 Feet

Legend

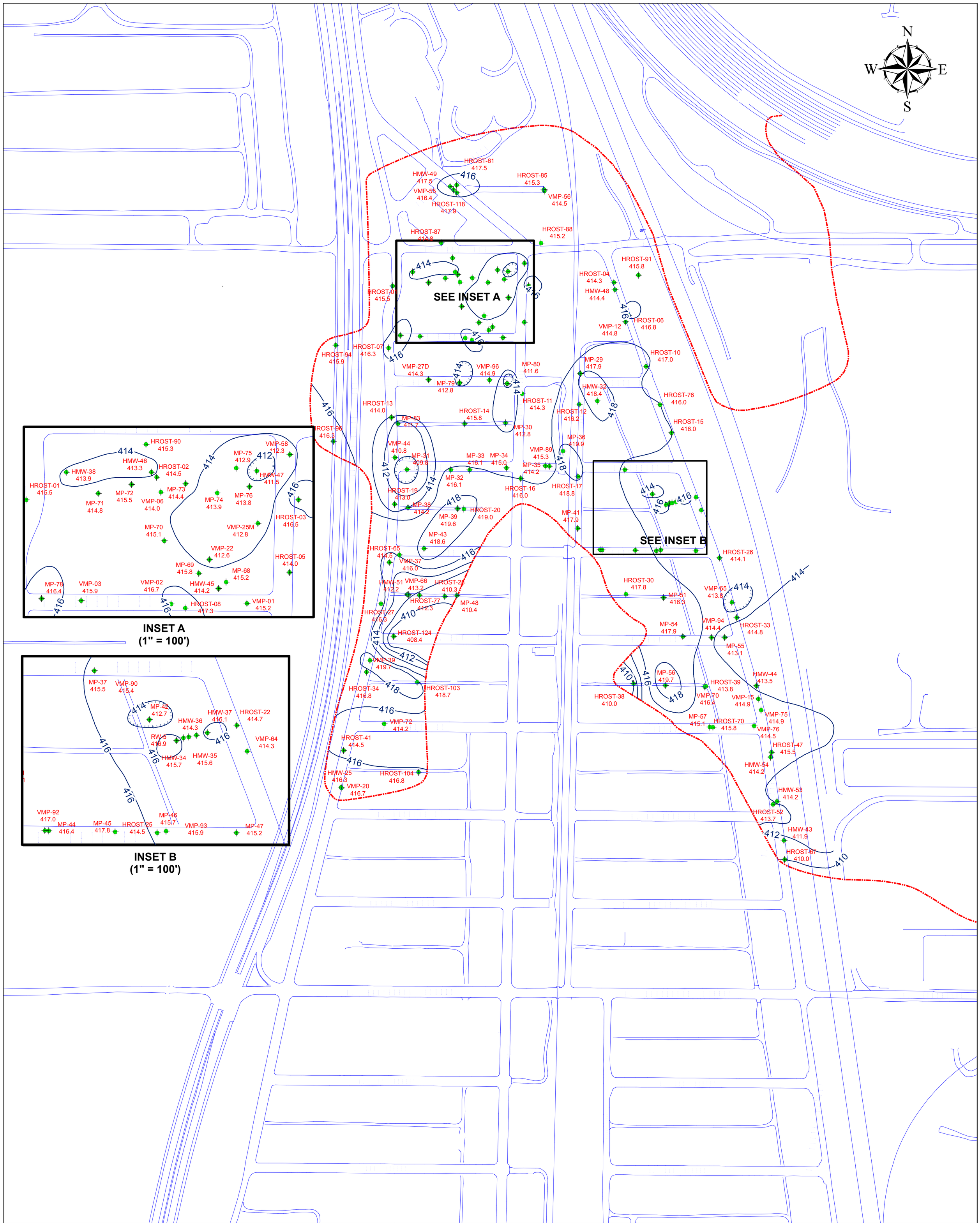
- BORING LOCATION (HROST, HMW, MP, VMP, RW, HP)
- INTERPRETED EXTENT OF NORTH OLIVE STRATUM
- —392— SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

BUREAU VERITAS
Clayton Group Services, Inc
A Bureau Veritas Company

STRUCTURE CONTOUR MAP OF THE TOP OF THE NORTH OLIVE / MAIN SILT STRATA BELOW THE A CLAY STRATUM

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

FIGURE D-2



Clayton Group Services, Inc
A Bureau Veritas Company

NOTES:
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

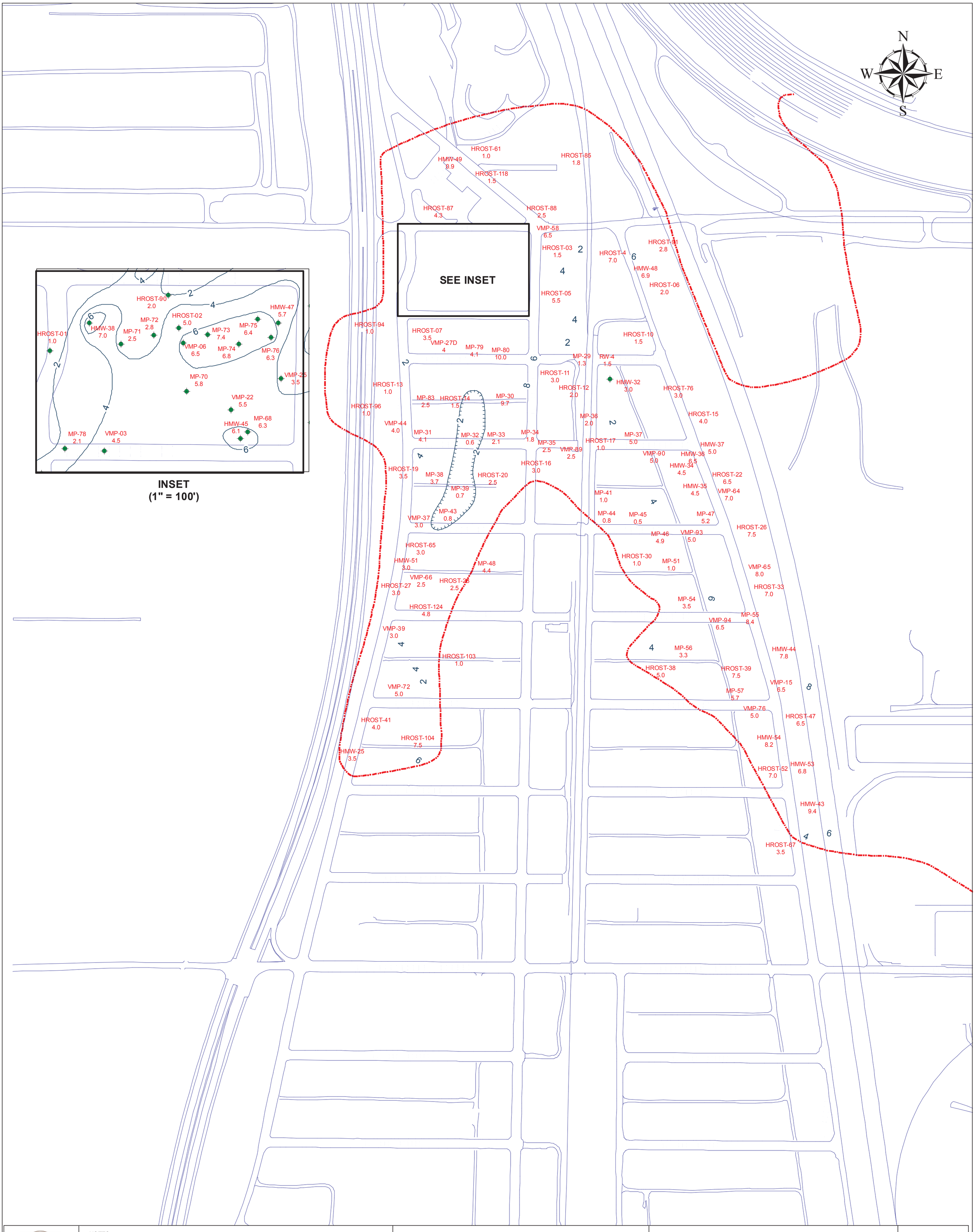
Legend

- BORING LOCATION (HROST, HMW, MP, VMP, RW)
- INTERPRETED EXTENT OF STRATUM
- 392 SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE BOTTOM OF THE NORTH OLIVE STRATUM

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

FIGURE D-3



NOTES:
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 Feet

Clayton Group Services, Inc
A Bureau Veritas Company

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE NORTH OLIVE STRATUM

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

FIGURE D-4

Clayton Group Services, Inc
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE B CLAY STRATUM

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

FIGURE D-5

Clayton Group Services, Inc
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

- BORING LOCATION (HROST, HMW, MP, VMP, RW)
- INTERPRETED EXTENT OF STRATUM
- 392 SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE TOP OF THE RAND STRATUM

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

FIGURE D-6

Clayton Group Services, Inc
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 Feet

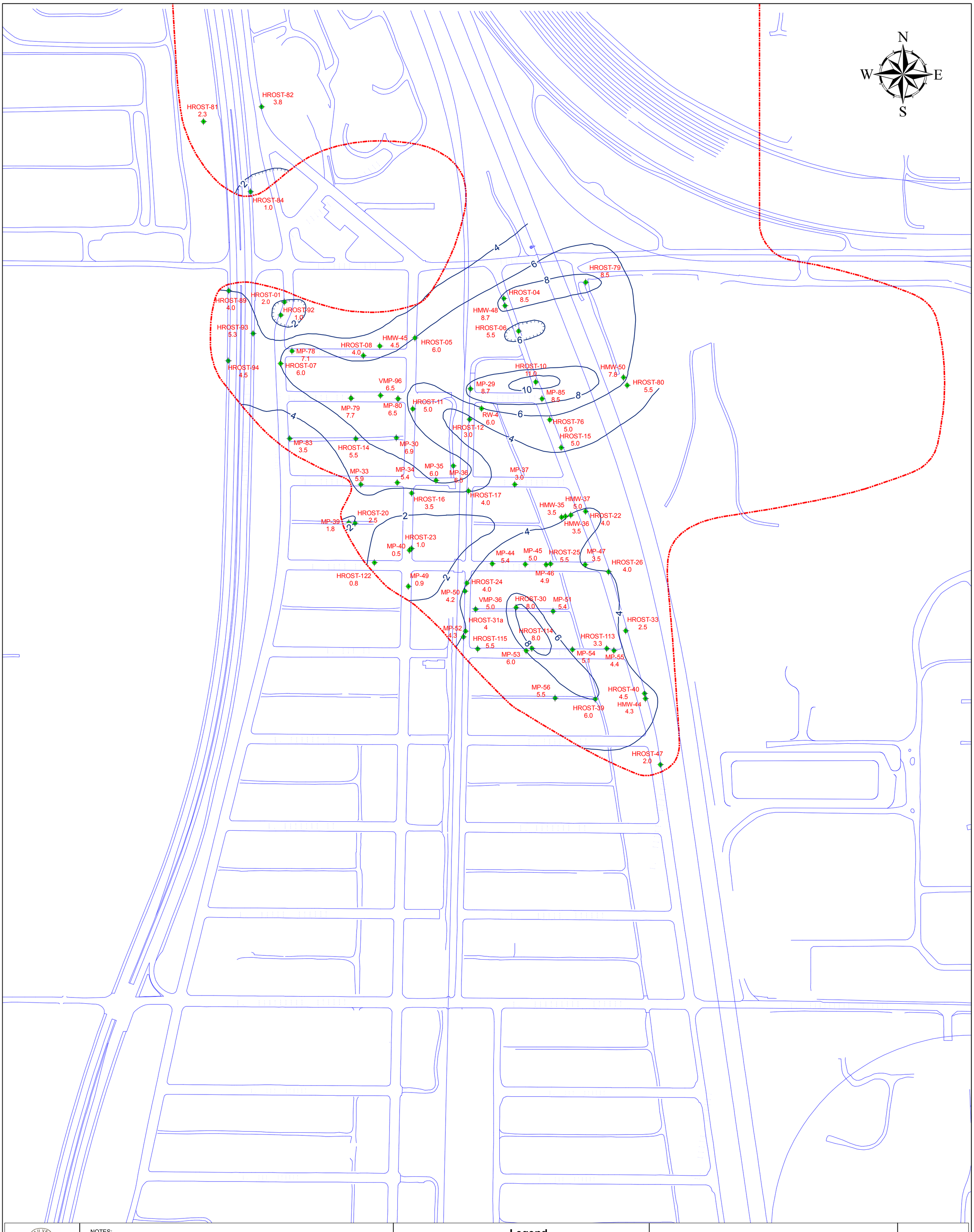
Legend

- BORING LOCATION (HROST, HMW, MP, VMP, RW)
- INTERPRETED EXTENT OF STRATUM
- —392— SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE BOTTOM OF THE RAND STRATUM

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

FIGURE D-7



BUREAU VERITAS

Clayton Group Services, Inc

A Bureau Veritas Company

NOTES:
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET

0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE RAND STRATUM

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

FIGURE
D-8

Clayton Group Services, Inc
A Bureau Veritas Company

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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

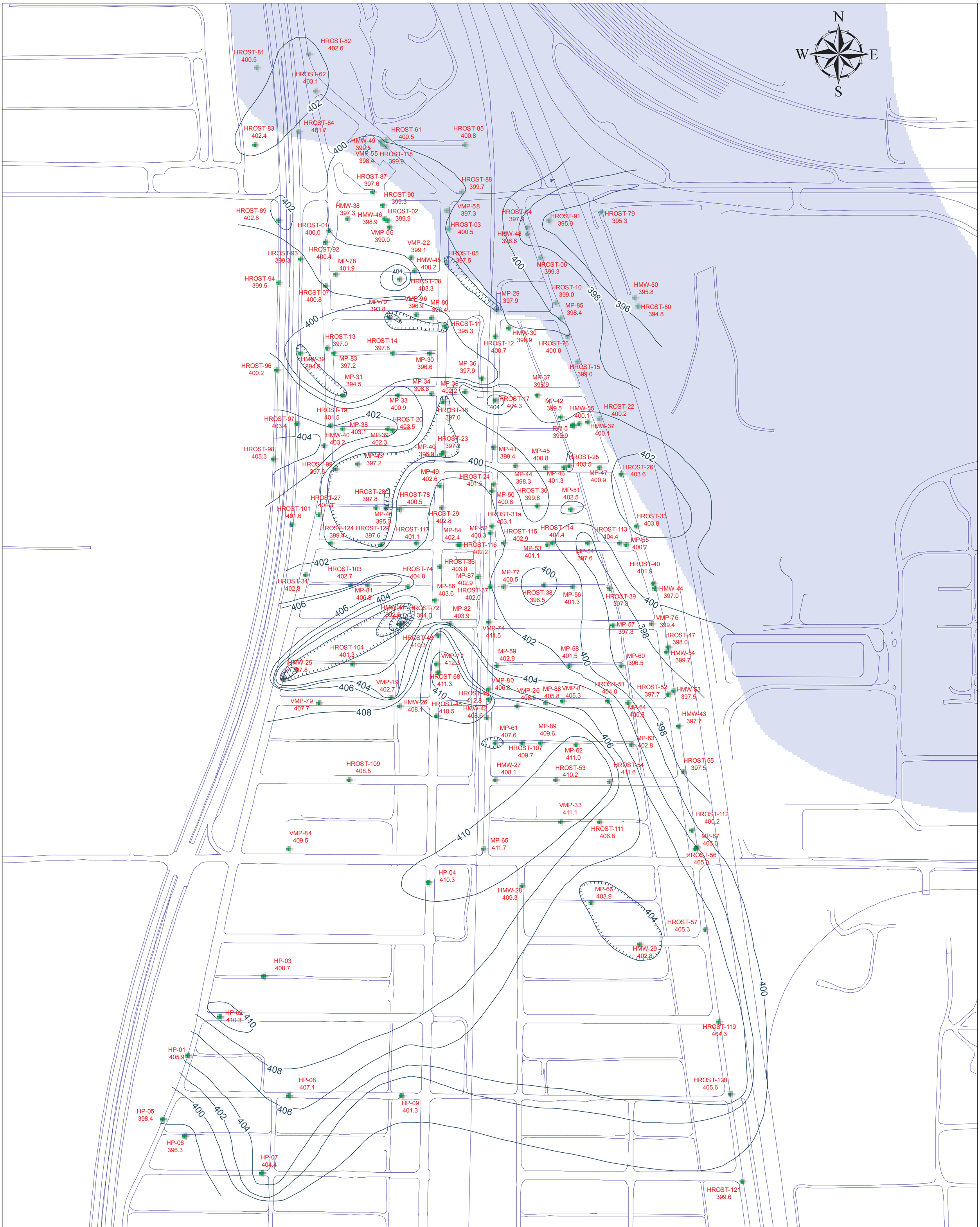
INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE C CLAY STRATUM

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

FIGURE D-9



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NOTES:
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2. Contours are based on best professional judgement using data available at the time of preparation. The contours are approximate and inferred between locations and may be updated as new data is generated.
3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 112.5 225 450 675 900 1,125 Feet

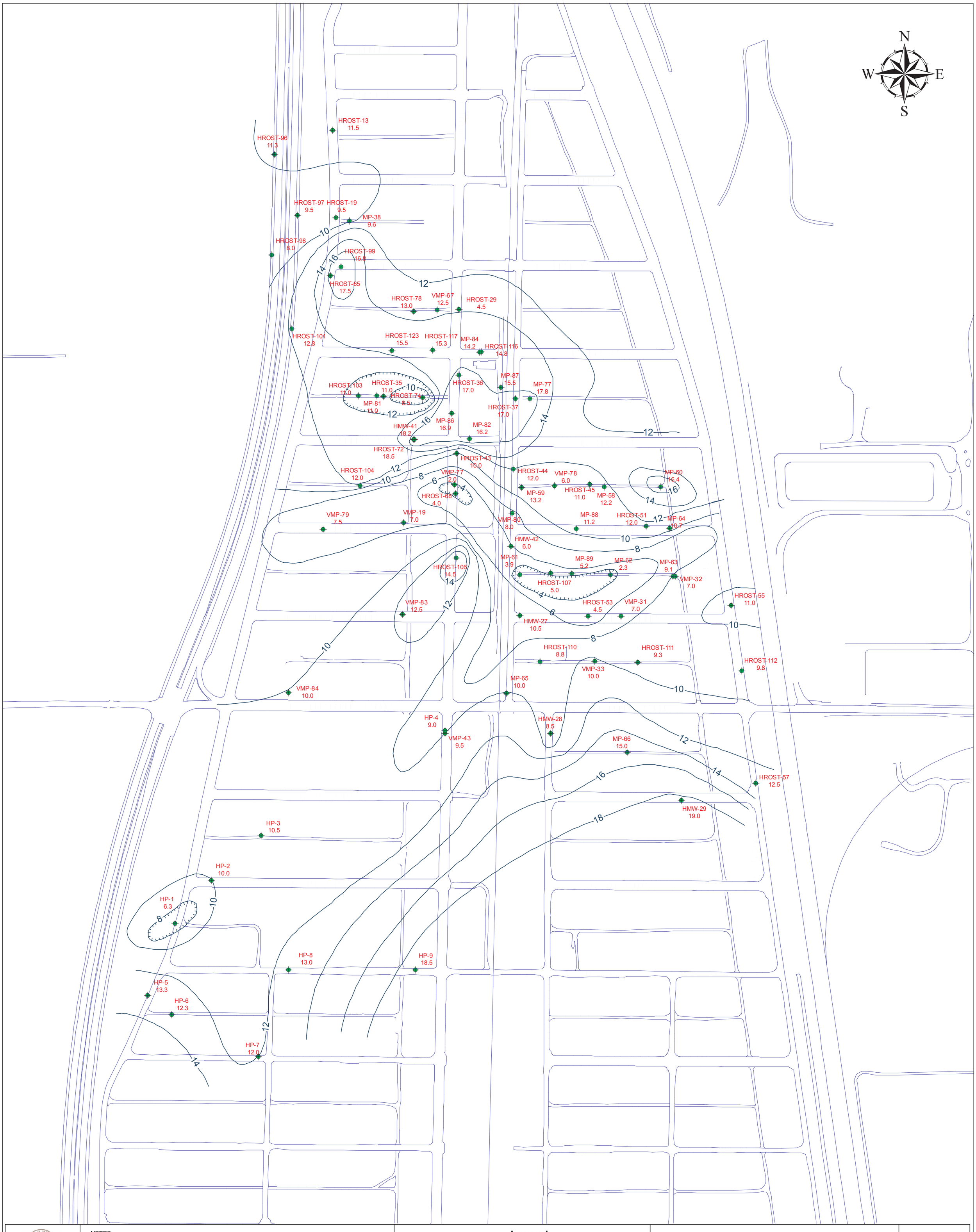
Legend

- BORING LOCATION (HROST, HMW, MP, VMP, RW, HP)
- INTERPRETED EXTENT OF EPA STRATUM
- 392 SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE TOP OF THE EPA STRATUM / TOP OF THE MAIN SAND / BASE OF THE MAIN SILT

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

FIGURE D-10



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4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW, HP)

INTERPRETED EXTENT OF STRATUM

—10— THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE MAIN SILT

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

FIGURE
D-11

Clayton Group Services, Inc
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4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

- BORING LOCATION (HROST, HMW, MP, VMP, RW)
- INTERPRETED EXTENT OF STRATUM
- 392 SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE BOTTOM OF THE EPA STRATUM

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

FIGURE D-12

Clayton Group Services, Inc
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4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

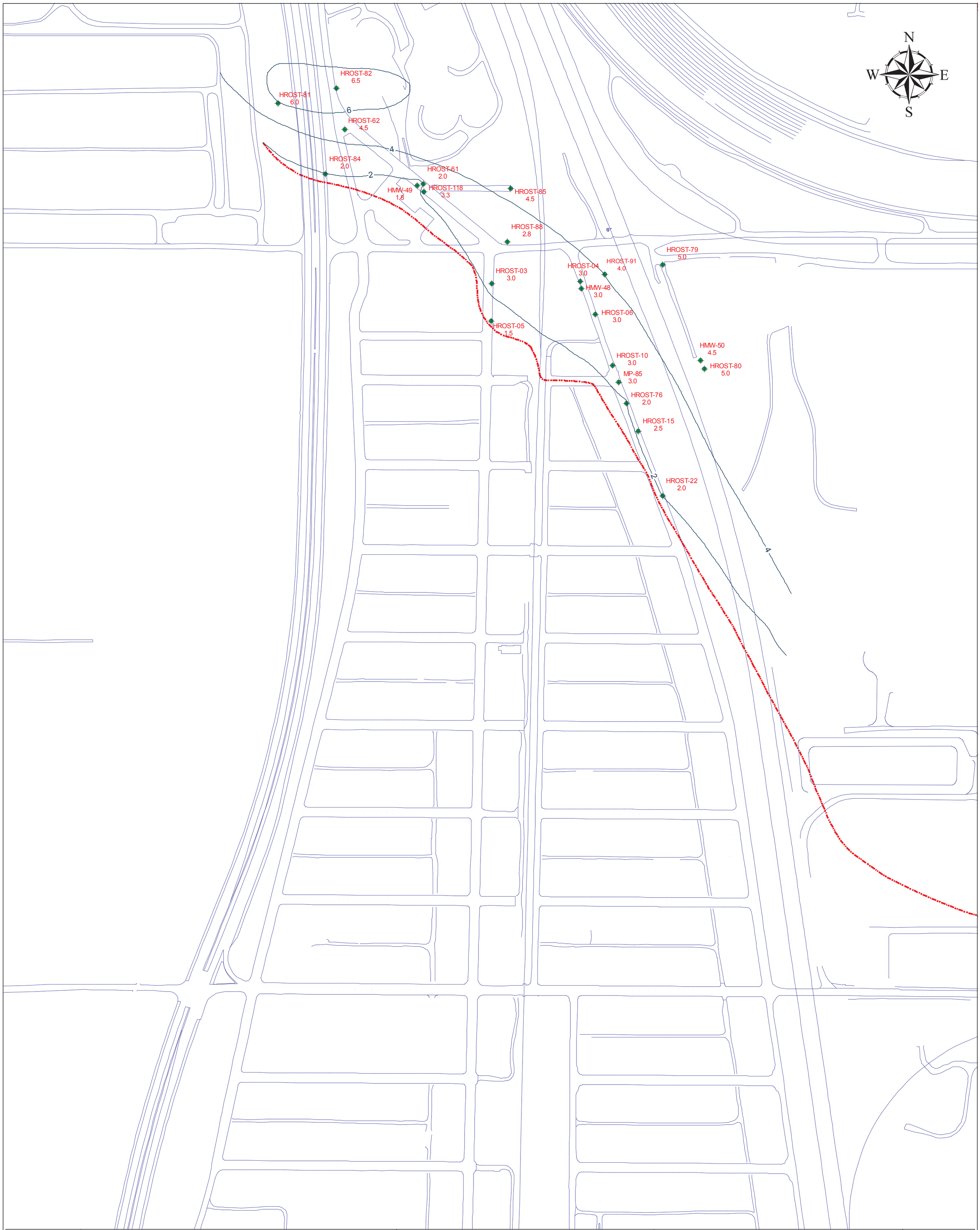
INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE EPA STRATUM

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

FIGURE
D-13



Clayton Group Services, Inc
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE D CLAY STRATUM

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

FIGURE
D-14

BUREAU VERITAS

Clayton Group Services, Inc
A Bureau Veritas Company

NOTES:
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)
INTERPRETED EXTENT OF STRATUM
—392— SURFACE ELEVATION IN FEET ABOVE MSL
LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE TOP OF THE MAIN SAND BELOW THE D CLAY STRATUM

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

FIGURE
D-15

APPENDIX E

HYDROGEOLOGY

Appendix E: Hydrogeology

The hydrogeology of Hartford has been interpreted based on the review and analysis of borings logs, well completion logs, structure contour maps of the permeable strata, and groundwater contour maps. The occurrence of groundwater in the North Olive, Rand, EPA, and the Main Sand strata is briefly discussed below. Groundwater gauging events were conducted on a monthly basis from October 2004 through October 2005 in Hartford and on the adjoining Shell and Premcor properties. The well gauging events were conducted to measure groundwater depths and apparent LNAPL thickness (if present) in order to determine groundwater flow directions. Temporal variability (including precipitation events, Mississippi River-stage height, atmospheric pressure, and groundwater pumping) influences the groundwater elevations on a daily basis in the monitoring wells. Hartford, Premcor and Shell monitoring wells, were used to develop the groundwater flow maps of the Main Sand and the EPA Stratum. Shell and Hartford wells were used to develop the groundwater flow map of the Rand Stratum. Hartford and Premcor monitoring wells were used to create a North Olive Stratum groundwater elevation map.

North Olive Stratum

Groundwater within the North Olive Stratum occurs as isolated areas of perched water on the surface of the underlying B Clay Stratum in Hartford.

Rand Stratum

Groundwater within the Rand Stratum is confined northeast of Hartford at the Shell Rand Avenue site, though this is the only area where the Rand Stratum is completely saturated. In Hartford, groundwater in the Rand Stratum occurs as isolated areas of perched water on the surface of the underlying C Clay Stratum.

EPA Stratum

Groundwater in the EPA Stratum is confined and hydraulically connected to the Main Sand in Hartford, and within the Shell Tannery Property, the Shell Rand Avenue Site and the Premcor Facility.

Main Sand

In Hartford, groundwater in the Main Sand appears to be confined where it underlies the C Clay Stratum and the D Clay Stratum; however, it becomes unconfined generally south of West Date and East Forest Streets. Unconfined groundwater occurs beyond the north, south, and east extent of the B/C Clay Stratum. Groundwater elevations within the Main Sand have been documented to fluctuate significantly over the years. Site data, extending back to 1990, reveals that the groundwater elevation in the Main Sand neared 416 feet MSL during 1993 and was observed to be as low as approximately 397 feet MSL in early 1991. Historically, groundwater elevations in the Hartford area have been as low as 380 feet MSL in the mid-1950's (Schicht, 1965).

APPENDIX F

D_o CALCULATION

Appendix F: D_o Calculation

The following information was provided on behalf of Mr. Andrew Kirkman, of The RETEC Group, Inc., on November 7, 2005.

The fluid characteristics that influence LNAPL distribution and recoverability from the subsurface include the following:

- LNAPL Density
- LNAPL Viscosity
- LNAPL and Water Interfacial tensions

In addition, the soil type can have a large influence on LNAPL distribution and recoverability from the subsurface. Soil characteristics that effect the distribution and presence of LNAPL in the subsurface include:

- Porosity
- Intrinsic permeability
- Pore size distribution
- Soil grain shape

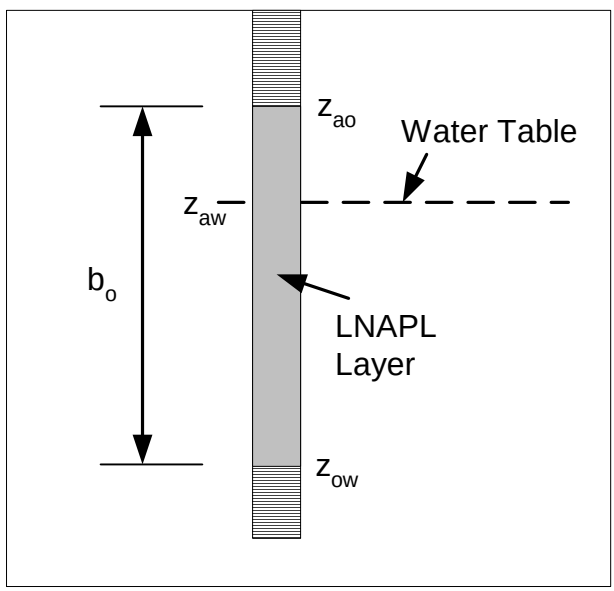
Accounting for these parameters is necessary in order to accurately assess the distribution of LNAPL in the formation and estimate the true amount of LNAPL in the subsurface. Mapping of apparent LNAPL thicknesses measured in monitoring wells at a site with varying soil and LNAPL type is not an accurate depiction of LNAPL extent or magnitude. In order to provide an estimate of the actual LNAPL in the subsurface, the term “LNAPL specific thickness” is proposed to estimate the true amount of LNAPL in the formation.

Because of the variance in soil and LNAPL physical characteristics, the same LNAPL thickness measured at two locations does not always represent the same distribution of LNAPL in the formation or the recoverability of LNAPL. For instance, one foot of LNAPL measured in a well installed in clay will have a much smaller specific thickness than if it were installed in sand. The same is true in terms of saturation. The pore spaces in sand are more interconnected and generally larger in the sand. The clay,

however, has smaller and less interconnected pores and a higher pressure is required to saturate those to the same saturation.

The following schematic (Charbeneau et al., 1999) shows a monitoring well with an LNAPL layer located between the air-NAPL interface z_{ao} and the NAPL-water interface z_{ow}. The total monitoring well LNAPL thickness is b_o. The elevation of the water table, z_{aw}, provides the datum for fluid levels. While the water table is not measured in a monitoring well because of the LNAPL layer, its elevation is easily determined from the elevations z_{ao} and z_{ow}, and the LNAPL specific gravity.

Figure 1



D_o is defined as the specific thickness of LNAPL, which is representative of the amount of LNAPL in a formation. For example, if you had a core of soil separated into its respective media (i.e., air, water, LNAPL, and soil), D_o is a normalized volume of LNAPL ($feet^3/feet^2$) per unit surface area, but is expressed as a thickness (in units of feet). At equilibrium, due to capillary forces in soil, the measured LNAPL thickness in a monitoring well, b_o, is always greater than D_o.

The relationship between measured monitoring well LNAPL thickness, b_o, and the specific LNAPL volume, D_o (the volume of LNAPL per unit surface area) may be calculated from the following equation:

$$D_o(b_o) = \int_{z_{ow}}^{z_{max}} n\, S_o(z)\, dz$$

Where:

Z_{max} = height of oil

Z_{ow} = height of the oil/water interface

S_o = saturation of oil

n = soil porosity

The function $D_o(b_o)$ may be approximated piecewise by a linear function of the form:

$$D_o = \beta\,(b_o - \chi)$$

The most accurate method to estimate LNAPL specific thickness is to collect soil core data, analyze Dean Stark LNAPL saturations and integrate LNAPL saturation over discrete depth intervals to calculate D_o (Adamski, et al, 2003). If LNAPL saturation and soil core data are available, D_o is calculated as follows:

D_o = LNAPL % * porosity * soil core interval (ft.)

Where:

LNAPL % = oil saturation (in % of pore volume)

porosity = site-specific total porosity (in %)

soil core interval = interval of LNAPL impacted core (in feet)

Collection of soil cores from varying soil types across a site and discrete sampling and analyses of LNAPL saturations accurately depicts the true amount of LNAPL in each formation and eliminates the need for correction factors based on buoyancy or LNAPL density. Correction factors based on soil type and LNAPL type will provide accurate estimations of LNAPL specific thickness across a site.

References

Adamski, M., V. Kremesec, R. Kolhatkar, C. Pearson, and B. Rowan, 2001. "LNAPL Saturation, Distribution, and Recovery in Fine Grained Soils," Proceedings of the Petroleum Hydrocarbons and Organic Chemicals in Ground Water Conference and Exposition, pp.178–192. November 14–16, 2001.

Charbeneau, R.J., R.T. Johns, L.W. Lake, and M.J. McAdams, 1999. "Free-Product Recovery of Petroleum Hydrocarbon Liquid." American Petroleum Institute, Publication No. 4682. Ground Water Monitoring & Remediation, 20(3), Summer, pp. 147-158, 2000. June 1999.

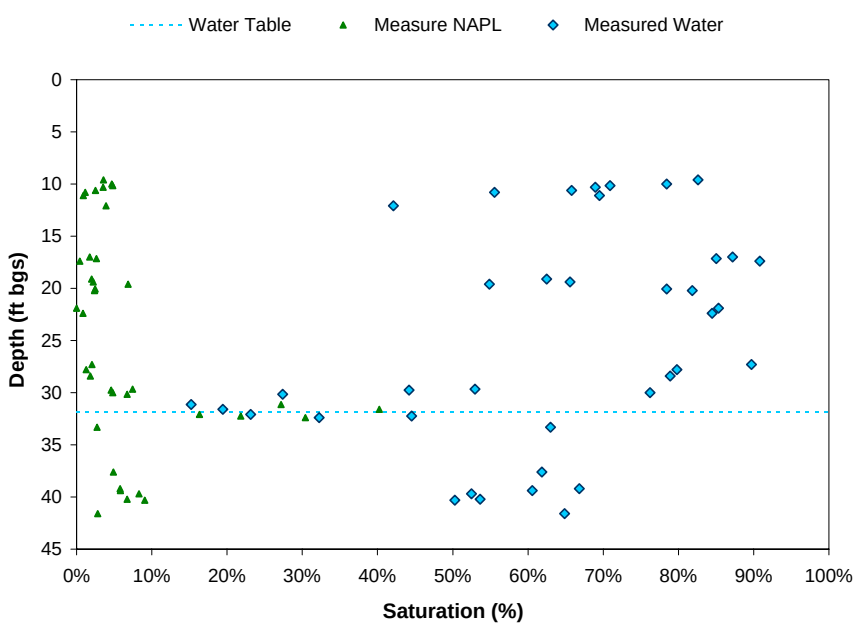
Attachment 2
Specific LNAPL Thicknesses

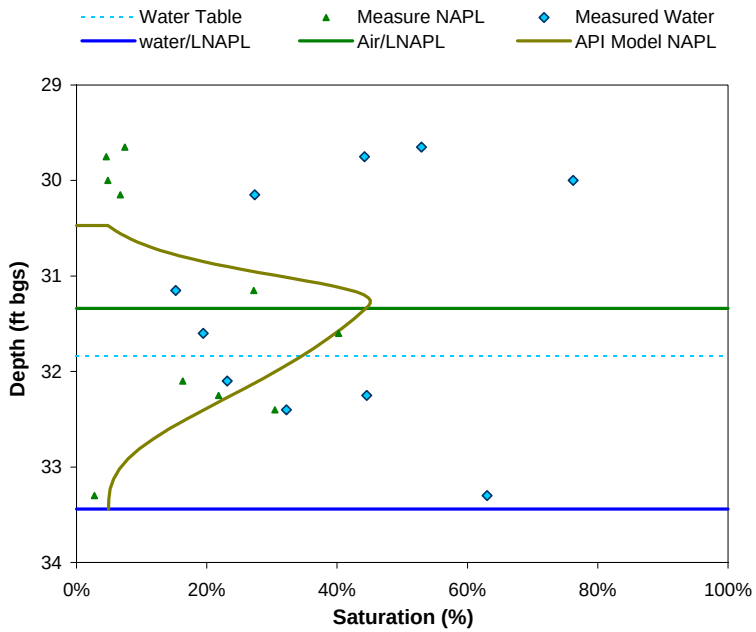
Boring	Corre-sponding Monitoring Well	Date of Measured LNAPL Thickness and Baildown Test	Measured LNAPL Thickness (ft)	D_o (ft)		
				Total for Estimated Mobile Interval[1]	Calculated for Mobile Interval[2]	Total for Smear Zone[1]
HCSB-1	HMW-44C	9/23/2005	2.1	0.30	0.32	0.60
HCSB-2	RW-5	9/23/2005	0.32	0.01	0.02	0.15
HCSB-3	MP-50C	ROST Log 2-19-2004	0.4	0.01	0.02	0.21
HCSB-4	MP-39C	10/5/2005	1.62	0.38	0.22	0.38
HCSB-5	MP-29D	9/20/2005	0.48	0.04	0.02	0.47
HCSB-5	MP-29C	9/20/2005	0.63	0.04	0.03	0.47

Notes:

1 Estimates are based on measured LNAPL saturation data from Dean-Stark core analyses.

2 Represents estimates based on API model that was calibrated to capillary pressure vs. saturation core analysis data.





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

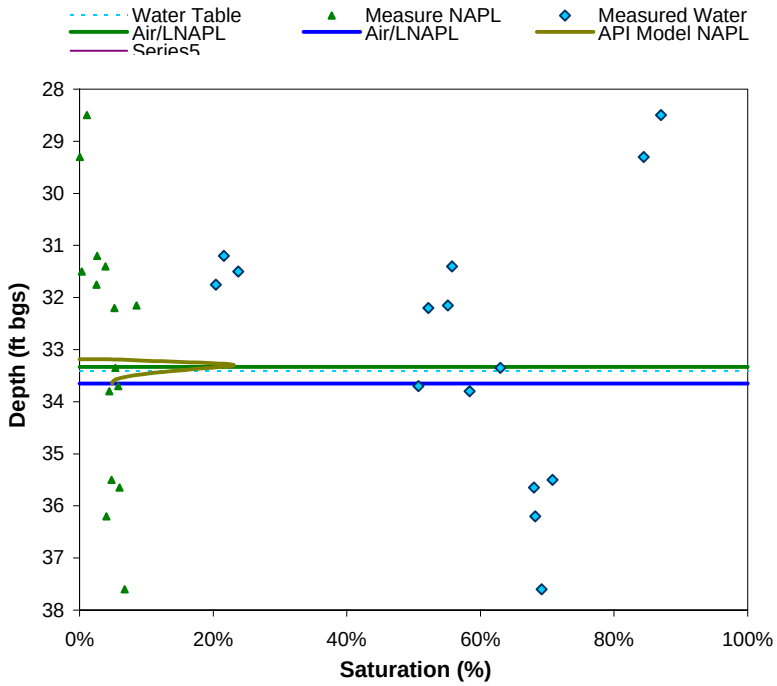
21.9	0.000	0.853	0.53	0.0012	0.0000
22.4	0.009	0.845	0.54		
27.3	0.020	0.897	0.51	0.0041	0.0000
27.8	0.013	0.798	0.47	0.0041	0.0000
28.4	0.018	0.789	0.41	0.0254	0.0000
29.65	0.074	0.529	0.45	0.0026	0.0005
29.75	0.046	0.442	0.43	0.0048	0.0000
30	0.048	0.762	0.39	0.0035	0.0005
30.15	0.067	0.274	0.43	0.0771	0.0554
31.15	0.272	0.152	0.46	0.0673	0.0574
31.6	0.402	0.194	0.43	0.0625	0.0514
32.1	0.163	0.231	0.47	0.0129	0.0096
32.25	0.218	0.446	0.44	0.0172	0.0140
32.4	0.304	0.322	0.44	0.0661	0.0464
33.3	0.027	0.630	0.45	0.0737	0.0000
37.6	0.049	0.619	0.45	0.0338	0.0024
39.2	0.058	0.668	0.35	0.0040	0.0006
39.4	0.058	0.606	0.34	0.0071	0.0022
39.7	0.083	0.525	0.33	0.0124	0.0043
40.2	0.067	0.536	0.33	0.0030	0.0012
40.3	0.091	0.503	0.42	0.0324	0.0060
41.6	0.028	0.649	0.40		

30.905	0.233789
30.934	0.25612
30.963	0.279506
30.992	0.303602
31.021	0.327936
31.05	0.351898
31.079	0.374766
31.108	0.395757
31.137	0.414095
31.166	0.429113
31.195	0.440347
31.224	0.447611
31.253	0.451038
31.282	0.451072
31.311	0.44844
31.34	0.444146
31.445	0.426434
31.55	0.407166
31.655	0.386258
31.76	0.363654
31.865	0.33935
31.97	0.313411
32.075	0.285999
32.18	0.257408
32.285	0.228081
32.39	0.198633
32.495	0.169837
32.6	0.142586
32.705	0.117808
32.81	0.096357
32.915	0.078878
33.02	0.065696
33.125	0.056752
33.23	0.051589
33.335	0.049392
33.44	0.049

31	31.34
DTW	**Corrected water Depth**
33.1	33.44

GS-MP

0.34



API Model Sn

Depth	Sn
33.18323	0
33.18323	0.044088
33.18823	0.052866
33.19323	0.062034
33.19823	0.071574
33.20323	0.081459
33.20823	0.091653
33.21323	0.102109
33.21823	0.11277

Gauging Data - Well MP-42C

Ground Surface Elevation
430.90

Measuring Point Elevation
NA

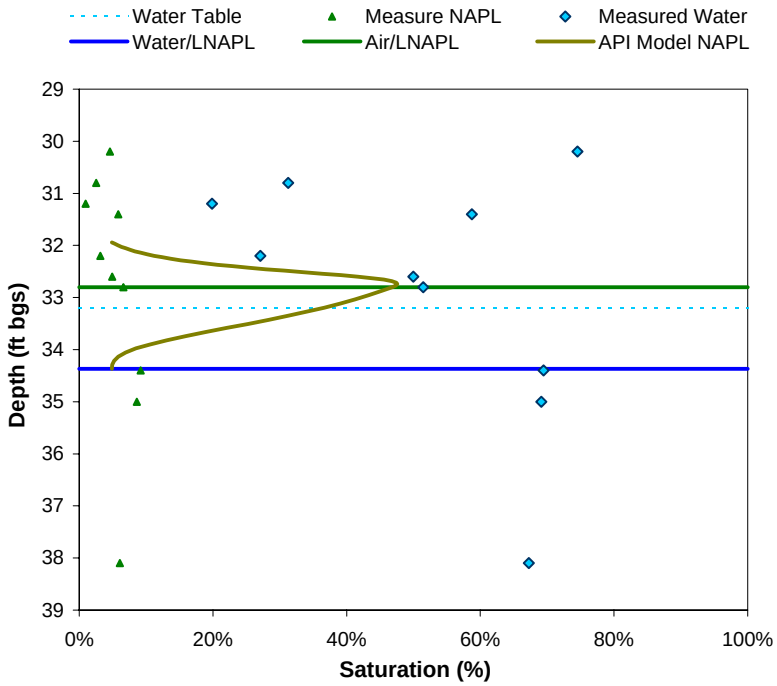
Water Table Elevation
397.49

Estimated Water Table Depth

0	33.41
1	33.41

33.22323	0.123568
33.22823	0.134421
33.23323	0.145236
33.23823	0.155911
33.24323	0.16633
33.24823	0.176373
33.25323	0.185914
33.25823	0.194826
33.26323	0.202985
33.26823	0.210275
33.27323	0.216593
33.27823	0.221854
33.28323	0.225994
33.28823	0.228975
33.29323	0.230786
33.29823	0.231443
33.30323	0.230993
33.30823	0.229509
33.31323	0.227091
33.31823	0.22386
33.32323	0.219964
33.32823	0.215571
33.33323	0.210887
33.34923	0.195603
33.36523	0.180518
33.38123	0.165757
33.39723	0.151451
33.41323	0.137733
33.42923	0.124735
33.44523	0.112578
33.46123	0.101374
33.47723	0.091215
33.49323	0.082174
33.50923	0.074295
33.52523	0.067594
33.54123	0.062061
33.55723	0.057651
33.57323	0.054295
33.58923	0.051893
33.60523	0.050323
33.62123	0.049438
33.63723	0.049066
33.65323	0.049

Sor	
0.049	
9/23/2005	
DTP	**Corrected LNAPL Depth**
32.65	33.33
DTW	**Corrected water Depth**
32.97	33.65
GS-MP	
0.68	



API Model Sn

Depth	Sn
31.94	0.0486
31.96867	0.052926
31.99733	0.057756
32.026	0.063151
32.05467	0.069179
32.08333	0.07592
32.112	0.083461
32.14067	0.091901
32.16933	0.101349

Gauging Data - Well MP-50C

Ground Surface Elevation
430.57

Measuring Point Elevation
NA

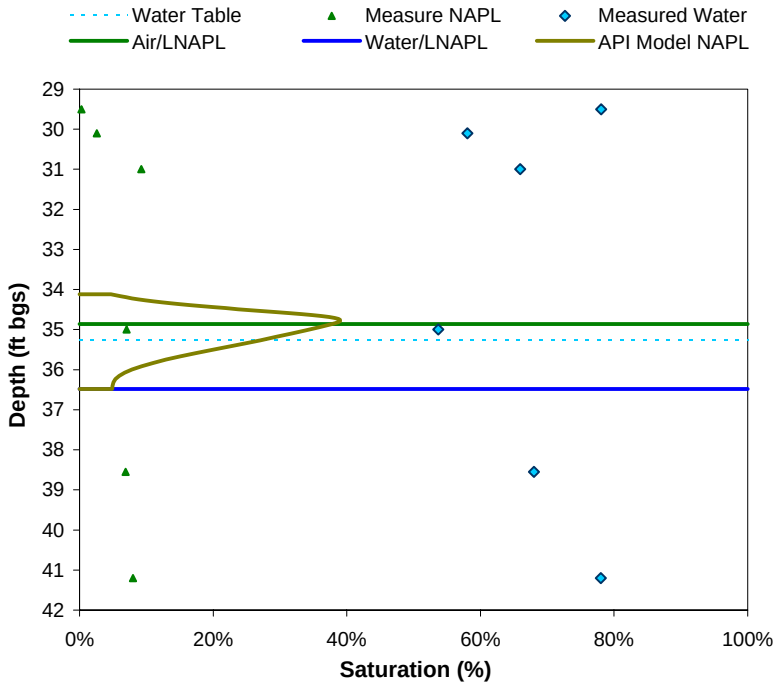
Water Table Elevation
397.36

Estimated Water Table Depth

0	33.21
1	33.21

32.198	0.111927
32.22667	0.123767
32.25533	0.137009
32.284	0.151802
32.31267	0.16829
32.34133	0.186607
32.37	0.206859
32.39867	0.229102
32.42733	0.253302
32.456	0.279305
32.48467	0.306776
32.51333	0.335163
32.542	0.363656
32.57067	0.391203
32.59933	0.416568
32.628	0.438481
32.65667	0.455829
32.68533	0.467877
32.714	0.474432
32.74267	0.475902
32.77133	0.473269
32.8	0.46804
32.8785	0.451248
32.957	0.432828
33.0355	0.412649
33.114	0.390598
33.1925	0.366598
33.271	0.34063
33.3495	0.312767
33.428	0.283211
33.5065	0.252337
33.585	0.220724
33.6635	0.18918
33.742	0.158715
33.8205	0.130465
33.899	0.10556
33.9775	0.084944
34.056	0.069199
34.1345	0.058414
34.213	0.052151
34.2915	0.049478
34.37	0.049

Sor	
0.049	
9/27/2005	
DTP	**Corrected LNAPL Depth**
32.46	32.8
DTW	**Corrected water Depth**
34.03	34.37
GS-MP	
0.34	



API Model Sn

Depth	Sn
34.12	0
34.12	0.047165
34.14467	0.053939
34.16933	0.061355
34.194	0.069467
34.21867	0.078329
34.24333	0.088001
34.268	0.098538
34.29267	0.109996

Gauging Data - Well MP-39C

Ground Surface Elevation
432.34

Measuring Point Elevation
NA

Water Table Elevation
397.07

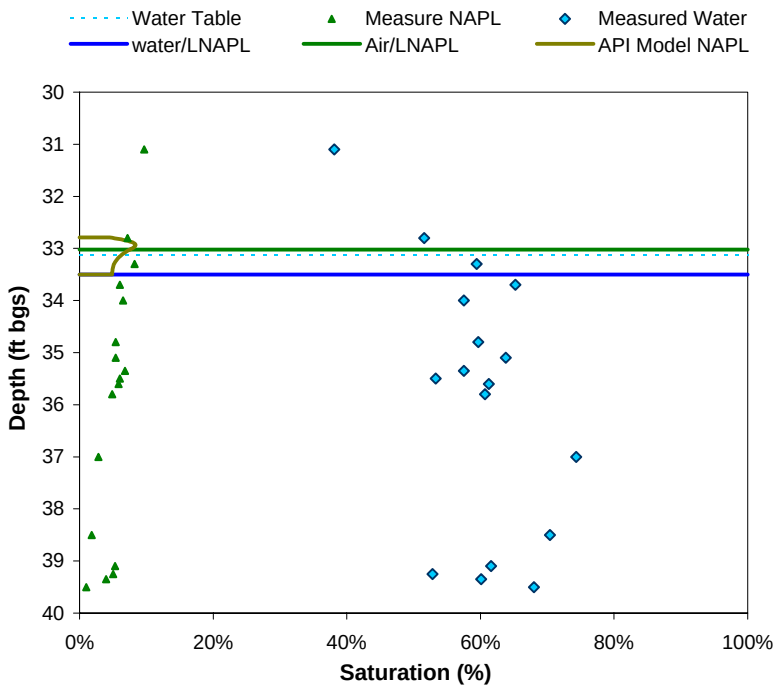
Estimated Water Table Depth

0	35.27
1	35.27

34.31733	0.122424
34.342	0.135863
34.36667	0.15034
34.39133	0.165861
34.416	0.182406
34.44067	0.199913
34.46533	0.218278
34.49	0.237334
34.51467	0.25685
34.53933	0.276519
34.564	0.295965
34.58867	0.314744
34.61333	0.332367
34.638	0.348332
34.66267	0.362163
34.68733	0.373456
34.712	0.381926
34.73667	0.387439
34.76133	0.390034
34.786	0.389922
34.81067	0.387478
34.83533	0.383222
34.86	0.377831
34.941	0.358627
35.022	0.338253
35.103	0.316752
35.184	0.294213
35.265	0.270788
35.346	0.246695
35.427	0.222234
35.508	0.197784
35.589	0.173798
35.67	0.150789
35.751	0.129291
35.832	0.109824
35.913	0.092835
35.994	0.078655
36.075	0.06745
36.156	0.059203
36.237	0.053704
36.318	0.050565
36.399	0.049236
36.48	0.049

Sor	
0.049	
10/5/2005	
DTP	**Corrected LNAPL Depth**
34.59	34.86
DTW	**Corrected water Depth**
36.21	36.48
GS-MP	
0.27	

36.48	0



API Model Sn

Depth	Sn
32.78952	0
32.78952	0.044941
32.79719	0.048878
32.80485	0.05264
32.81252	0.056216
32.82019	0.059596
32.82785	0.062773
32.83552	0.065739
32.84319	0.068486

Gauging Data - Well MP-29C

Ground Surface Elevation

429.74

Measuring Point Elevation

NA

Water Table Elevation

396.62

Estimated Water Table Depth

0	33.12
1	33.12

32.85085	0.07101		
32.85852	0.073306	**Sor**	
32.86619	0.075372	0.049	
32.87385	0.077206		
32.88152	0.078808	**10/5/2005**	
32.88919	0.08018	**DTP**	**Corrected LNAPL Depth**
32.89685	0.081323	32.75	33.02
32.90452	0.082243	**DTW**	**Corrected water Depth**
32.91219	0.082944	33.23	33.5
32.91985	0.083432		
32.92752	0.083717	**GS-MP**	
32.93519	0.083807	0.27	
32.94285	0.083713		
32.95052	0.083445		
32.95819	0.083018	**9/20/05.**	
32.96585	0.082445	**DTP**	**Corrected LNAPL Depth**
32.97352	0.08174	24.05	24.32
32.98119	0.08092	**DTW**	**Corrected water Depth**
32.98885	0.080001	24.68	24.98
32.99652	0.079002		
33.00419	0.077944	**GS-MP**	
33.01185	0.076847	0.3	
33.01952	0.075738		
33.04352	0.072405		
33.06752	0.069322		
33.09152	0.066487		
33.11552	0.063899		
33.13952	0.061552		
33.16352	0.059441		
33.18752	0.057561		
33.21152	0.055904		
33.23552	0.05446		
33.25952	0.053219		
33.28352	0.052171		
33.30752	0.051303		
33.33152	0.050602		
33.35552	0.050053		
33.37952	0.049641		
33.40352	0.049349		
33.42752	0.049159		
33.45152	0.049053		
33.47552	0.049008		
33.49952	0.049		

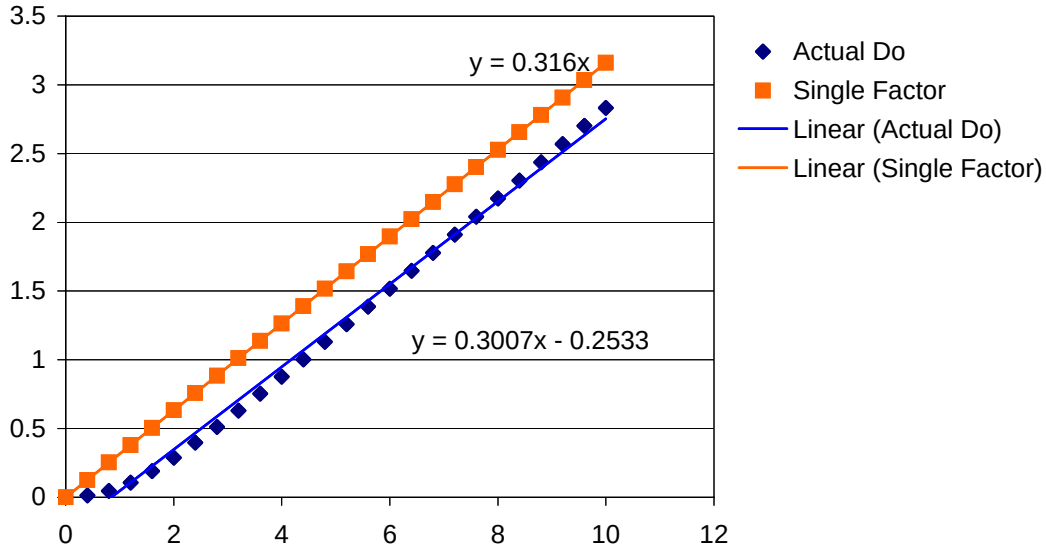
33.49952	0

Specific LNAPL Thickness Correction Factors

	Applicable Range			
	0-1 foot		>1 foot	
Model	β	χ	β	χ
HCSB-1	0.06	0.00	0.29	0.95
HCSB-2	0.07	0.00	0.31	0.92
HCSB-3	0.10	0.00	0.33	0.83
HCSB-4	0.07	0.00	0.30	0.93
HCSB-5	0.07	0.00	0.30	0.93

$$D_o = \beta \left(b_n - \chi \right)$$

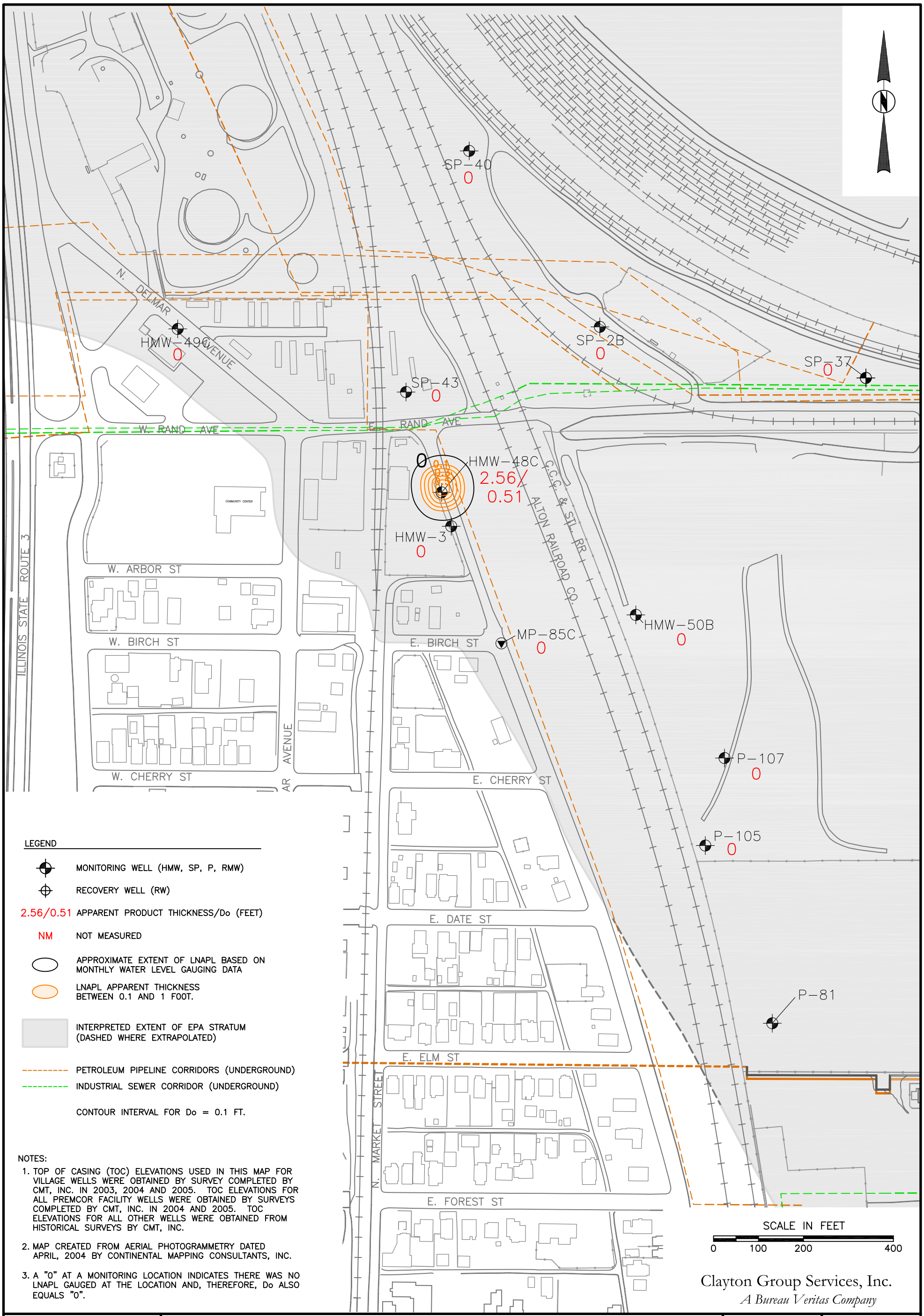
	Do HCSB-1	
bn	API Model	Single Factor
0	0	0
0.4	0.015061459	0.1264
0.8	0.046794121	0.2528
1.2	0.106782	0.3792
1.6	0.190064385	0.5056
2	0.288706431	0.632
2.4	0.397092964	0.7584
2.8	0.511856799	0.8848
3.2	0.630974444	1.0112
3.6	0.752951226	1.1376
4	0.87743555	1.264
4.4	1.003403703	1.3904
4.8	1.130706734	1.5168
5.2	1.258829007	1.6432
5.6	1.388042171	1.7696
6	1.517714439	1.896
6.4	1.647966213	2.0224
6.8	1.778704557	2.1488
7.2	1.90985501	2.2752
7.6	2.041115339	2.4016
8	2.172677251	2.528
8.4	2.304504684	2.6544
8.8	2.436333996	2.7808
9.2	2.568614435	2.9072
9.6	2.700844032	3.0336
10	2.833220096	3.16



Do CALCULATIONS TABLE DEVELOPED BY CLAYTON

Apparent Product Thickness	Do		
	yellow HCSB-1	blue-average HCSB-1 to 4	green HCSB-5
0.1	0.01	0.01	0.01
0.2	0.01	0.02	0.01
0.3	0.02	0.02	0.02
0.4	0.02	0.03	0.03
0.5	0.03	0.04	0.03
0.6	0.04	0.05	0.04
0.7	0.04	0.06	0.05
0.8	0.05	0.06	0.05
0.9	0.05	0.07	0.06
1	0.06	0.08	0.07
1.1	0.04	0.07	0.05
1.2	0.07	0.10	0.08
1.3	0.10	0.13	0.11
1.4	0.13	0.16	0.14
1.5	0.17	0.19	0.17
1.6	0.19	0.22	0.20
1.7	0.22	0.25	0.23
1.8	0.25	0.28	0.26
1.9	0.28	0.32	0.29
2	0.31	0.35	0.33
2.1	0.34	0.38	0.36
2.2	0.37	0.41	0.39
2.3	0.40	0.44	0.42
2.4	0.43	0.47	0.45
2.5	0.46	0.50	0.48
2.6	0.48	0.53	0.51
2.7	0.51	0.57	0.54
2.8	0.54	0.60	0.57
2.9	0.57	0.63	0.60
3	0.60	0.66	0.63
3.1	0.63	0.69	0.66
3.2	0.66	0.72	0.69
3.3	0.69	0.75	0.72
3.4	0.72	0.78	0.75
3.5	0.75	0.82	0.78
3.6	0.78	0.85	0.81
3.7	0.81	0.88	0.84
3.8	0.84	0.91	0.87
4	0.90	0.97	0.93
4.1	0.93	1.00	0.96
4.2	0.95	1.04	0.99
4.3	0.98	1.07	1.02
4.4	1.01	1.10	1.05
4.5	1.04	1.13	1.08
4.6	1.07	1.16	1.11
4.7	1.10	1.19	1.14
4.8	1.13	1.22	1.17
4.9	1.16	1.25	1.20
5	1.19	1.29	1.24
5.1	1.22	1.32	1.27
5.2	1.25	1.35	1.30
5.3	1.28	1.38	1.33
5.4	1.31	1.41	1.36
5.5	1.34	1.44	1.39
5.6	1.37	1.47	1.42
5.7	1.40	1.50	1.45
5.8	1.42	1.54	1.48
5.9	1.45	1.57	1.51
6	1.48	1.60	1.54

Main Sand				
Yellow	Blue	Green	Clean	Wells Removed
MP-47C	MP-79C/D	HMW-38C	HMW-39C	HB-32
MP-55C	MP-80C	HMW-46C	HMW-51C	RW-4
HMW-44C	HB-31	HMW-47C	MP-81C	
HMW-54B	MP-30C	HMW-45C	HMW-41C	
HMW-49D	MP-83C	MP-78D	HMW-25	
	MP-31C	MP-29D	HMW-26	
	MP-38C	RW-4A	HMW-27	
	MP-32B/C	RW-3	HMW-28	
	MP-34C	MP-85D	HMW-29	
	MP-33D	HMW-48D	MP-61C	
	MP-39C	SP-42	MP-89C	
	HMW-18		MP-62C	
	MP-43C		MP-63C	
	MP-48B/C		HMW-43C	
	MP-49C		HMW-52C	
	HMW-19		HB-38	
	MP-84C		MP-65C	
	MP-86C		MP-66C	
	MP-87C		MP-67C	
	RW-1		HP-1A	
	MP-82C		HP-1B	
	HMW-40C		HP-1C	
	HMW-08		HP-2A	
	HMW-22		HP-3A	
	MP-36C		HP-3B	
	MP-35D		HP-3C	
	HMW-14		HP-4A	
	MP-40C		HP-4B	
	MP-41C		HP-4C	
	MP-44D		HP-5A	
	MP-50C		HP-5B	
	MP-52C		HP-5C	
	MP-37D		HP-6A	
	RW-5		HP-7A	
	MP-42C		HP-8A	
	HMW-10		HP-9A	
	HMW-02		HMW-50C	
	RW-2		SP-41	
	MP-45C		SP-36	
	MP-46C		P-77	
	HB-30		P-78	
	MP-51D		P-79	
	MP-53C		P-106	
	HB-37			
	MP-54C			
	MP-77C			
	MP-56C			
	HMW-20			
	MP-57C			
	MP-60C			
	HMW-53B			
	MP-64C			
	MP-59C			
	MP-58C			
	MP-88C			
	HMW-42B			



LEGEND

- MONITORING WELL (HMW, SP, P, RMW)
- RECOVERY WELL (RW)
- 2.56/0.51 APPARENT PRODUCT THICKNESS/Do (FEET)
- NM NOT MEASURED
- APPROXIMATE EXTENT OF LNAPL BASED ON MONTHLY WATER LEVEL GAUGING DATA
- LNAPL APPARENT THICKNESS BETWEEN 0.1 AND 1 FOOT.
- INTERPRETED EXTENT OF EPA STRATUM (DASHED WHERE EXTRAPOLATED)
- PETROLEUM PIPELINE CORRIDORS (UNDERGROUND)
- INDUSTRIAL SEWER CORRIDOR (UNDERGROUND)
- CONTOUR INTERVAL FOR Do = 0.1 FT.

NOTES:

1. TOP OF CASING (TOC) ELEVATIONS USED IN THIS MAP FOR VILLAGE WELLS WERE OBTAINED BY SURVEY COMPLETED BY CMT, INC. IN 2003, 2004 AND 2005. TOC ELEVATIONS FOR ALL PREMCOR FACILITY WELLS WERE OBTAINED BY SURVEYS COMPLETED BY CMT, INC. IN 2004 AND 2005. TOC ELEVATIONS FOR ALL OTHER WELLS WERE OBTAINED FROM HISTORICAL SURVEYS BY CMT, INC.
2. MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL, 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
3. A "0" AT A MONITORING LOCATION INDICATES THERE WAS NO LNAPL GAUGED AT THE LOCATION AND, THEREFORE, Do ALSO EQUALS "0".

Clayton Group Services, Inc.
A Bureau Veritas Company

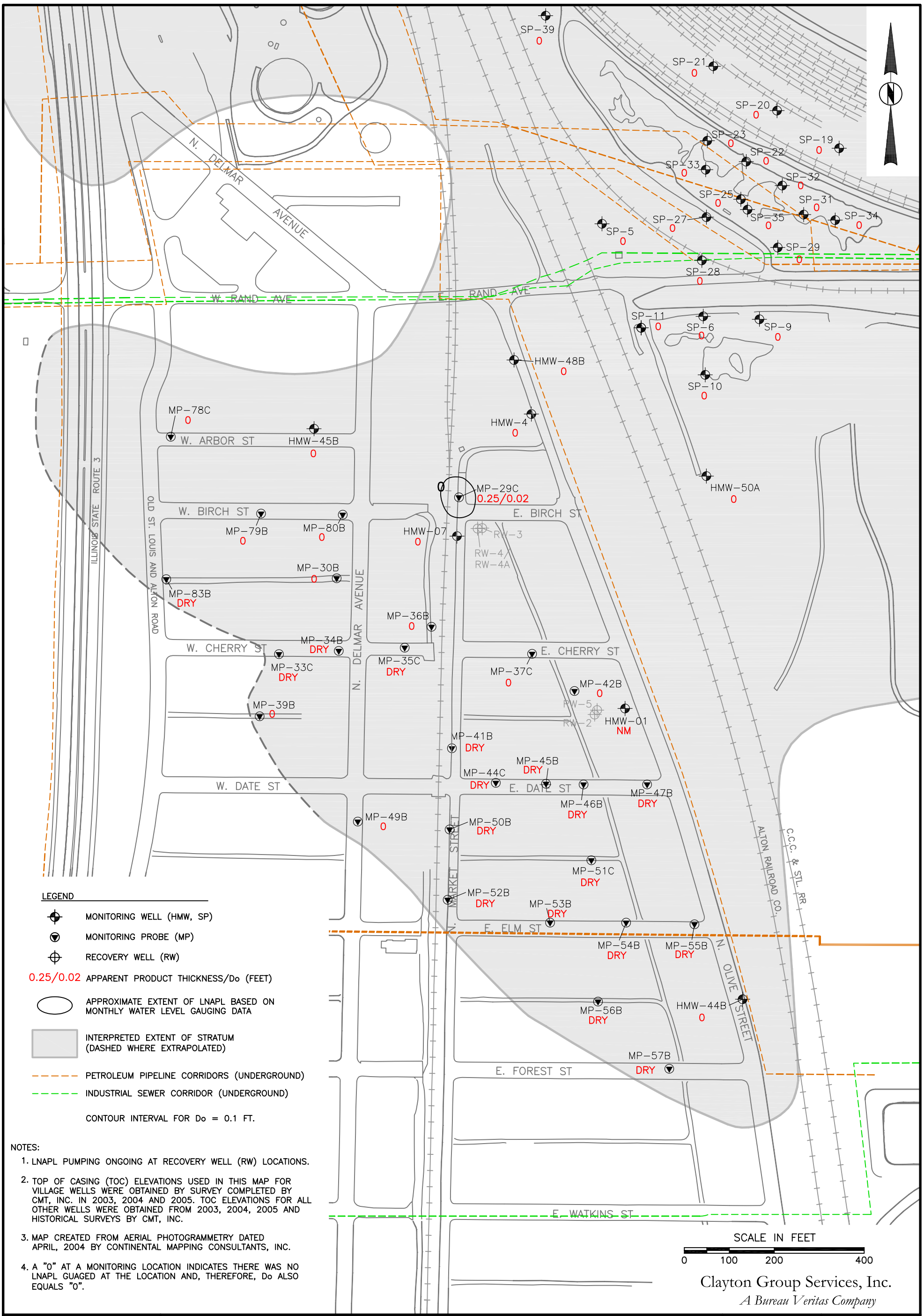
CHECK BY	KDC
DRAWN BY	BCP
DATE	11-15-05
SCALE	AS SHOWN
CAD NO.	0309514007d48a
PRJ NO.	15-03095.14

LNAPL SPECIFIC THICKNESS (Do)
OCTOBER 4-5, 2005 - EPA STRATUM

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

BUREAU VERITAS

FIGURE
3-5



LEGEND

- MONITORING WELL (HMW, SP)
- MONITORING PROBE (MP)
- RECOVERY WELL (RW)
- 0.25/0.02 APPARENT PRODUCT THICKNESS/Do (FEET)
- APPROXIMATE EXTENT OF LNAPL BASED ON MONTHLY WATER LEVEL GAUGING DATA
- INTERPRETED EXTENT OF STRATUM (DASHED WHERE EXTRAPOLATED)
- PETROLEUM PIPELINE CORRIDORS (UNDERGROUND)
- INDUSTRIAL SEWER CORRIDOR (UNDERGROUND)
- CONTOUR INTERVAL FOR Do = 0.1 FT.

NOTES:

1. LNAPL PUMPING ONGOING AT RECOVERY WELL (RW) LOCATIONS.
2. TOP OF CASING (TOC) ELEVATIONS USED IN THIS MAP FOR VILLAGE WELLS WERE OBTAINED BY SURVEY COMPLETED BY CMT, INC. IN 2003, 2004 AND 2005. TOC ELEVATIONS FOR ALL OTHER WELLS WERE OBTAINED FROM 2003, 2004, 2005 AND HISTORICAL SURVEYS BY CMT, INC.
3. MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL, 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
4. A "0" AT A MONITORING LOCATION INDICATES THERE WAS NO LNAPL GUAGED AT THE LOCATION AND, THEREFORE, Do ALSO EQUALS "0".

Clayton Group Services, Inc.
A Bureau Veritas Company

CHECK BY	
DRAWN BY	BCP
DATE	11-15-05
SCALE	AS SHOWN
CAD NO.	0309514007d47a
PRJ NO.	15-03095.14

LNAPL SPECIFIC THICKNESS (Do)
OCTOBER 4-5, 2005 – RAND STRATUM

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

BUREAU VERITAS

FIGURE
3-4

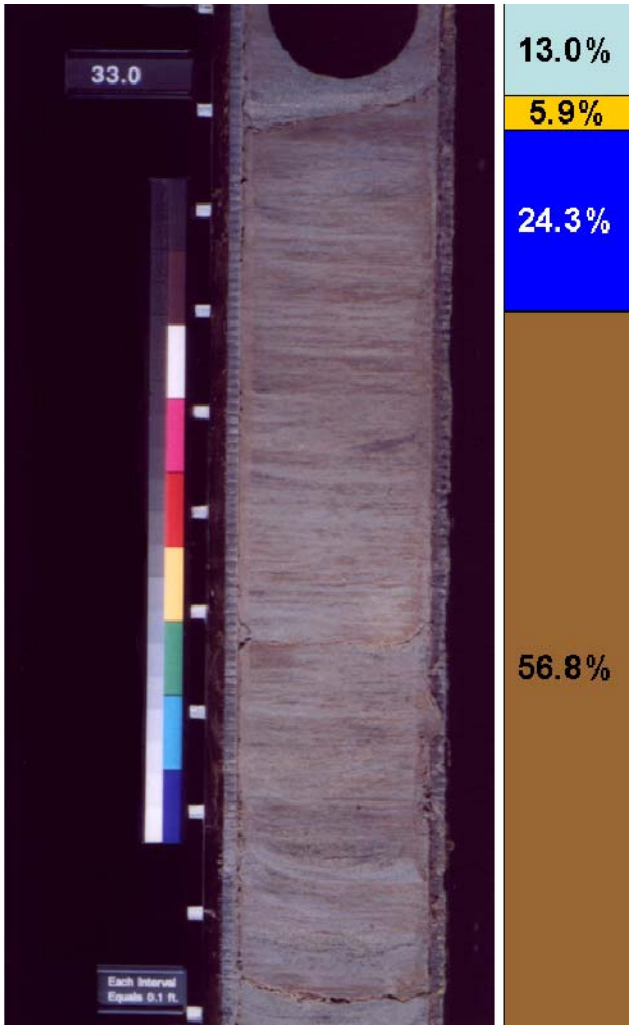
Example (not site specific)

This is a soil core taken at a field site where 5.6 feet of product was measured in a monitoring well. The part shown is the interval affected by product (the tiny dark points in the core). The volumes shown on the right are percentages of material measured from the soil core.

Color Key

- Air
- Product
- Water
- Mineral matter

Soil Type -69% Silt/Clay and 31% Fine Sand Classified as a silt (ML)



Measured oil in Monitoring Well = 5.6 ft.
Mineral matter 56.8% of total volume
Water 24.3% of total volume
Oil in soil measured 5.9% of total volume
LNAPL Saturation = 13.6% Pore Volume
Porosity = 43.2 %

D_o = LNAPL Saturation * Porosity * Soil interval
(Calculated specific thickness of product in soil)

D_o = 13.6%*43.2%* soil interval (10 ft.) = 0.587 ft3/ft2

The D_o can be used to develop a correction factor that can be applied to the apparent product thickness at other monitoring wells located in the area with similar soil type.

Correction factor = Apparent Product Thickness / D_o

Correction factor = 5.6ft / 0.587ft = 9.5

(FROM RETEC)

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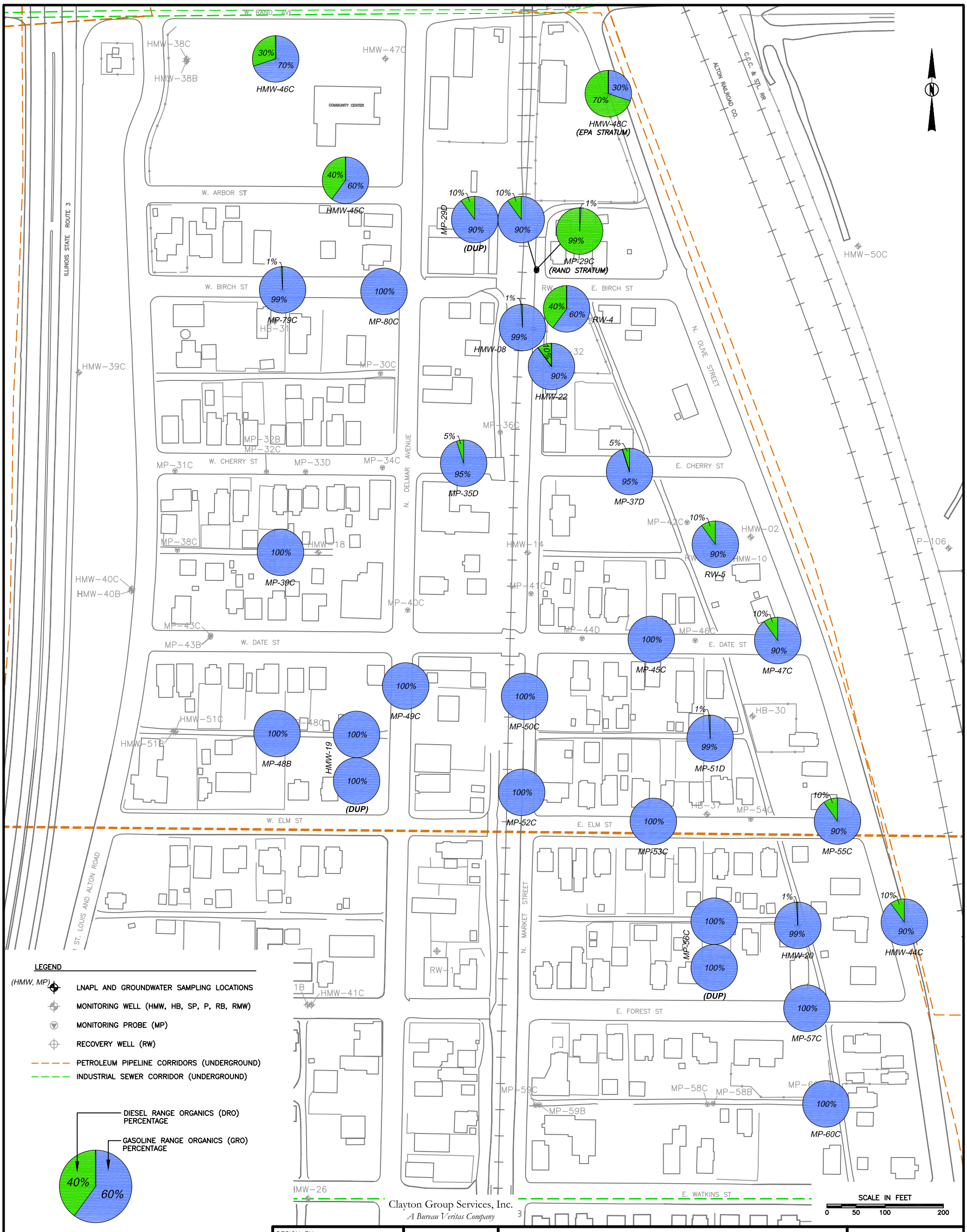
CHK BY	KDC	SPECIFIC THICKNESS OF LNAPL (Do) IN SOIL THE HARTFORD AREA HYDROCARBON PLUME SITE THE HARTFORD WORKING GROUP HARTFORD, ILLINOIS	FIGURE
DWN BY	BCP/OS		3–3
DATE	12–15–05		
SCALE	NONE		
CAD NO.	0309514020A		
PRJ NO.	15–03095		



Clayton Group Services, Inc.
A Bureau Veritas Company

LEGEND

(HMW, MP) LNAPL AND GROUNDWATER SAMPLING LOCATIONS

MONITORING WELL (HMW, HB, SP, P, RB, RMW)

MONITORING PROBE (MP)

RECOVERY WELL (RW)

PETROLEUM PIPELINE CORRIDORS (UNDERGROUND)

INDUSTRIAL SEWER CORRIDOR (UNDERGROUND)

DIESEL RANGE ORGANICS (DRO) PERCENTAGE

GASOLINE RANGE ORGANICS (GRO) PERCENTAGE

40% 60%

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

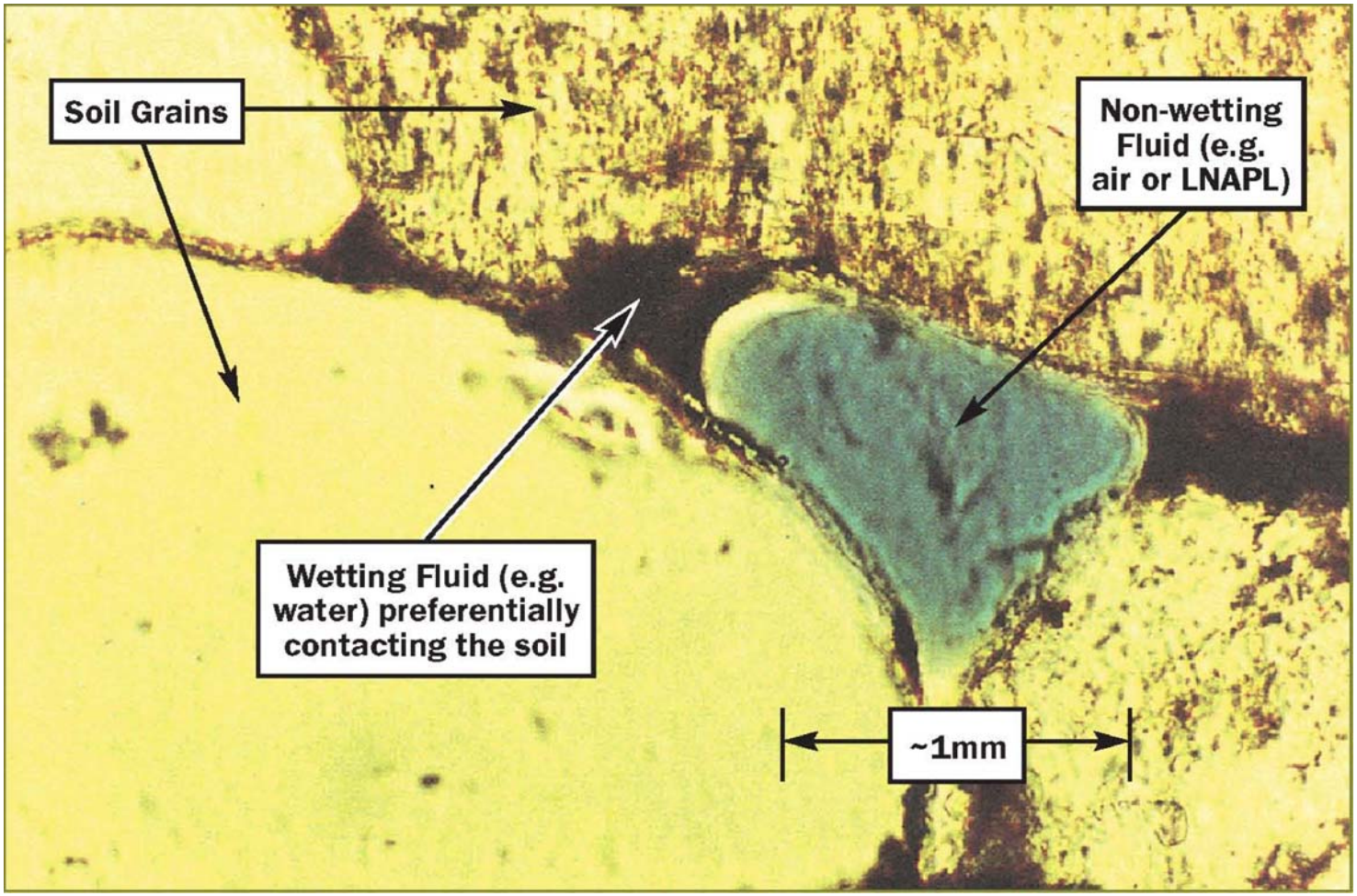
BUREAU VERITAS 1828

LNAPL CHARACTERIZATION

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

FIGURE

3-2



(FROM WILSON ET AL., 1990)

Clayton Group Services, Inc.
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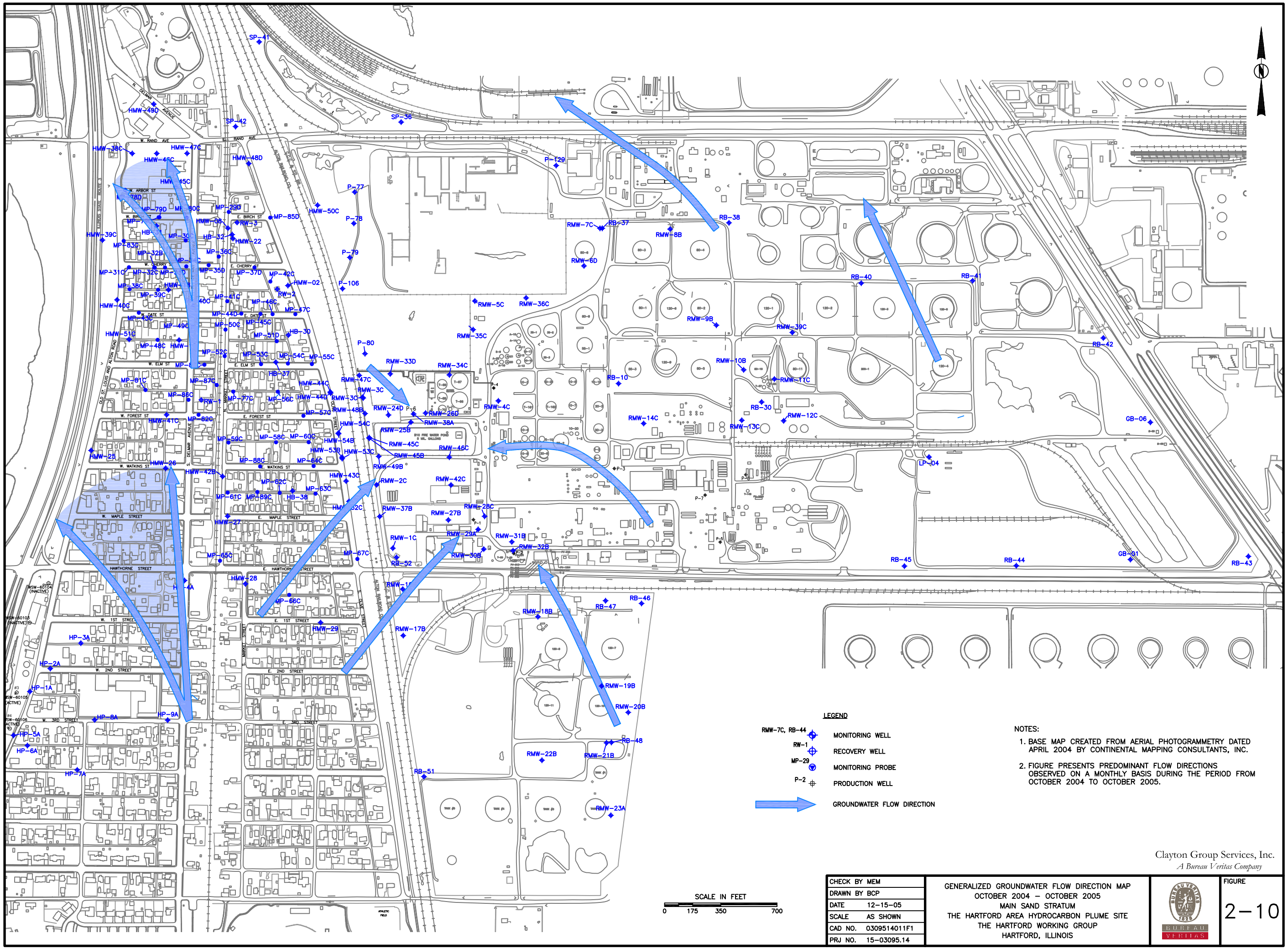
CHK BY	KDC	MULTIPLE FLUIDS IN THE PORE SPACE OF A GRANULAR POROUS MEDIA THE HARTFORD AREA HYDROCARBON PLUME SITE THE HARTFORD WORKING GROUP HARTFORD, ILLINOIS	FIGURE 3–1
DWN BY	OS		
DATE	12–15–05		
SCALE	NONE		
CAD NO.	0309514020A		
PRJ NO.	15–03095		



NOTES:

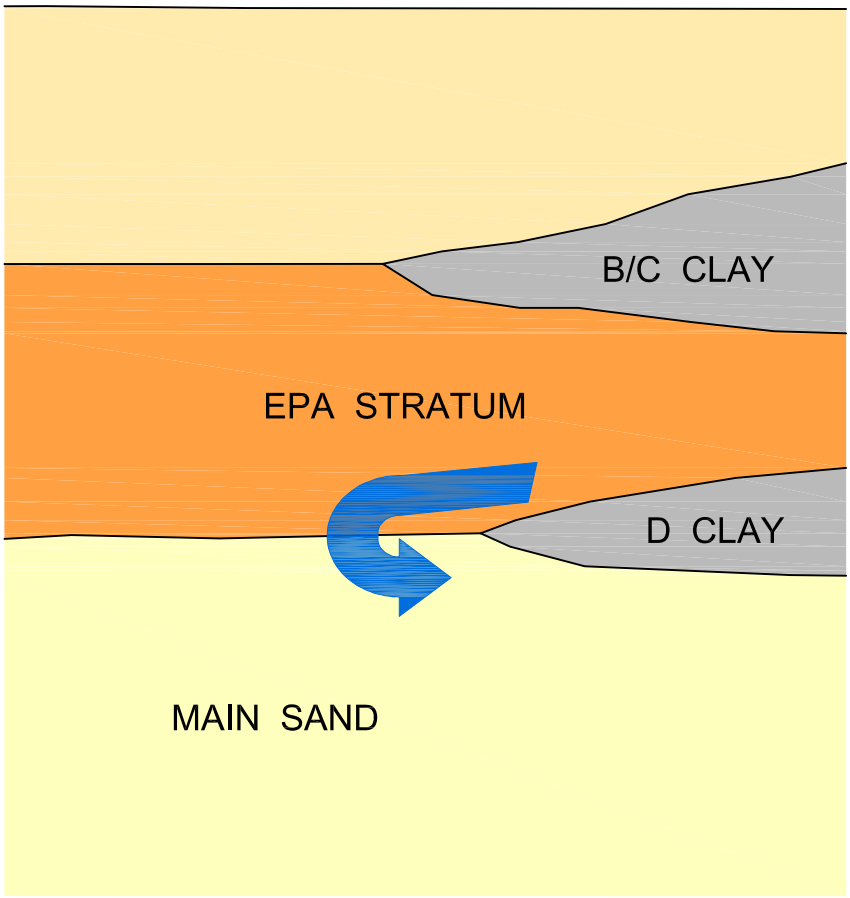
1. BASE MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
2. FIGURE PRESENTS PREDOMINANT FLOW DIRECTIONS OBSERVED ON A MONTHLY BASIS DURING THE PERIOD FROM OCTOBER 2004 TO OCTOBER 2005.

Clayton Group Services, Inc.
A Bureau Veritas Company

CHECK BY	MEM
DRAWN BY	BCP
DATE	12-15-05
SCALE	AS SHOWN
CAD NO.	0309514011F1
PRJ NO.	15-03095.14

GENERALIZED GROUNDWATER FLOW DIRECTION MAP
OCTOBER 2004 – OCTOBER 2005
MAIN SAND STRATUM
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

FIGURE
2-10

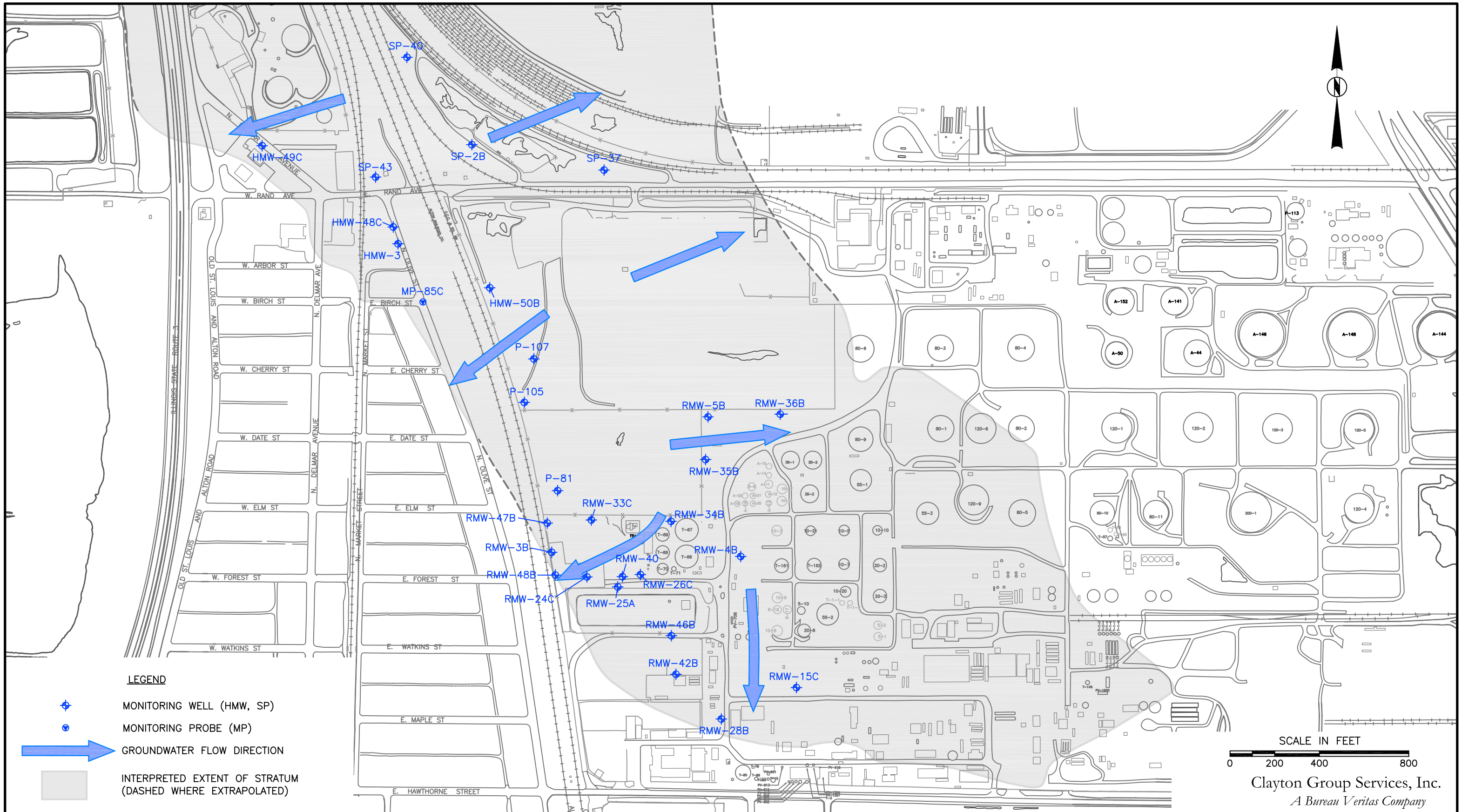


LEGEND

GROUNDWATER FLOW DIRECTION

Clayton Group Services, Inc.
A Bureau Veritas Company

CHECK BY KDC	GROUNDWATER FLOW SCHEMATIC EPA AND MAIN SAND STRATA THE HARTFORD AREA HYDROCARBON PLUME SITE THE HARTFORD WORKING GROUP HARTFORD, ILLINOIS	BUREAU VERITAS	FIGURE
DRAWN BY BCP			2–9
DATE 12–7–05			
SCALE NO SCALE			
CAD NO. 0309514020G			
PRJ NO. 15–03095.14			



LEGEND

- MONITORING WELL (HMW, SP)
- MONITORING PROBE (MP)
- GROUNDWATER FLOW DIRECTION
- INTERPRETED EXTENT OF STRATUM (DASHED WHERE EXTRAPOLATED)

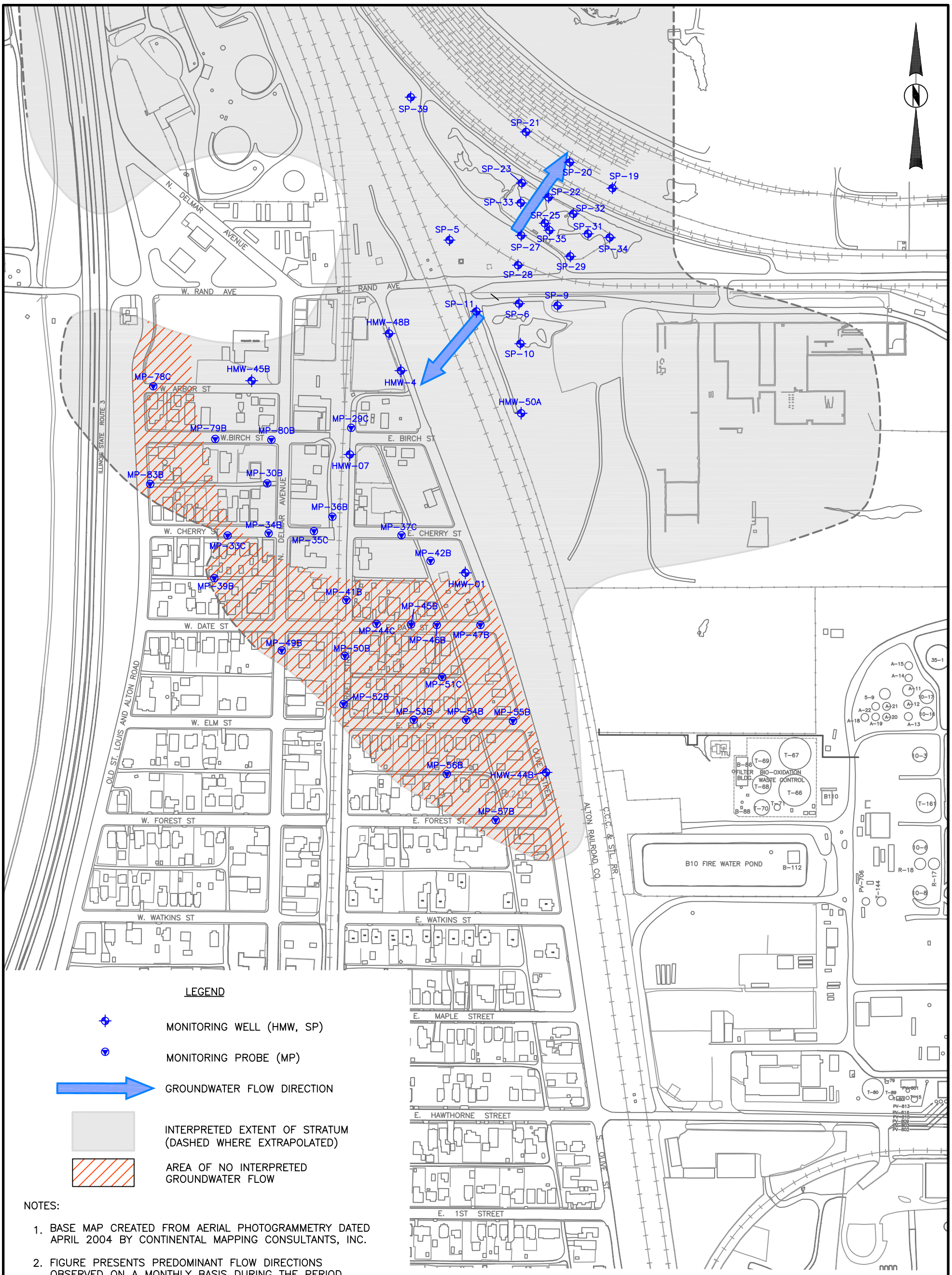
NOTE:
1) BASE MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL, 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
2) FIGURE PRESENTS PREDOMINANT FLOW DIRECTIONS OBSERVED ON A MONTHLY BASIS DURING THE PERIOD FROM OCTOBER 2004 TO OCTOBER 2005.

CHECK BY	MEM
DRAWN BY	BCP
DATE	12-7-05
SCALE	AS SHOWN
CAD NO.	0309514011f3
PRJ NO.	15-03095.14

GENERALIZED GROUNDWATER FLOW DIRECTION MAP
OCTOBER 2004 – OCTOBER 2005
EPA STRATUM
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

BUREAU VERITAS 1828

FIGURE
2-8



LEGEND

- MONITORING WELL (HMW, SP)
- MONITORING PROBE (MP)
- GROUNDWATER FLOW DIRECTION
- INTERPRETED EXTENT OF STRATUM (DASHED WHERE EXTRAPOLATED)
- AREA OF NO INTERPRETED GROUNDWATER FLOW

NOTES:

1. BASE MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
2. FIGURE PRESENTS PREDOMINANT FLOW DIRECTIONS OBSERVED ON A MONTHLY BASIS DURING THE PERIOD FROM OCTOBER 2004 TO OCTOBER 2005.
3. THE HATCHED AREA WAS CONSIDERED TO REPRESENT LOCALIZED AREAS OF PERCHED WATER OR DID NOT CONTAIN GROUNDWATER. THEREFORE, NO GROUNDWATER FLOW WAS INTERPRETED TO BE PRESENT IN THIS AREA.

SCALE IN FEET

0 150 300 600

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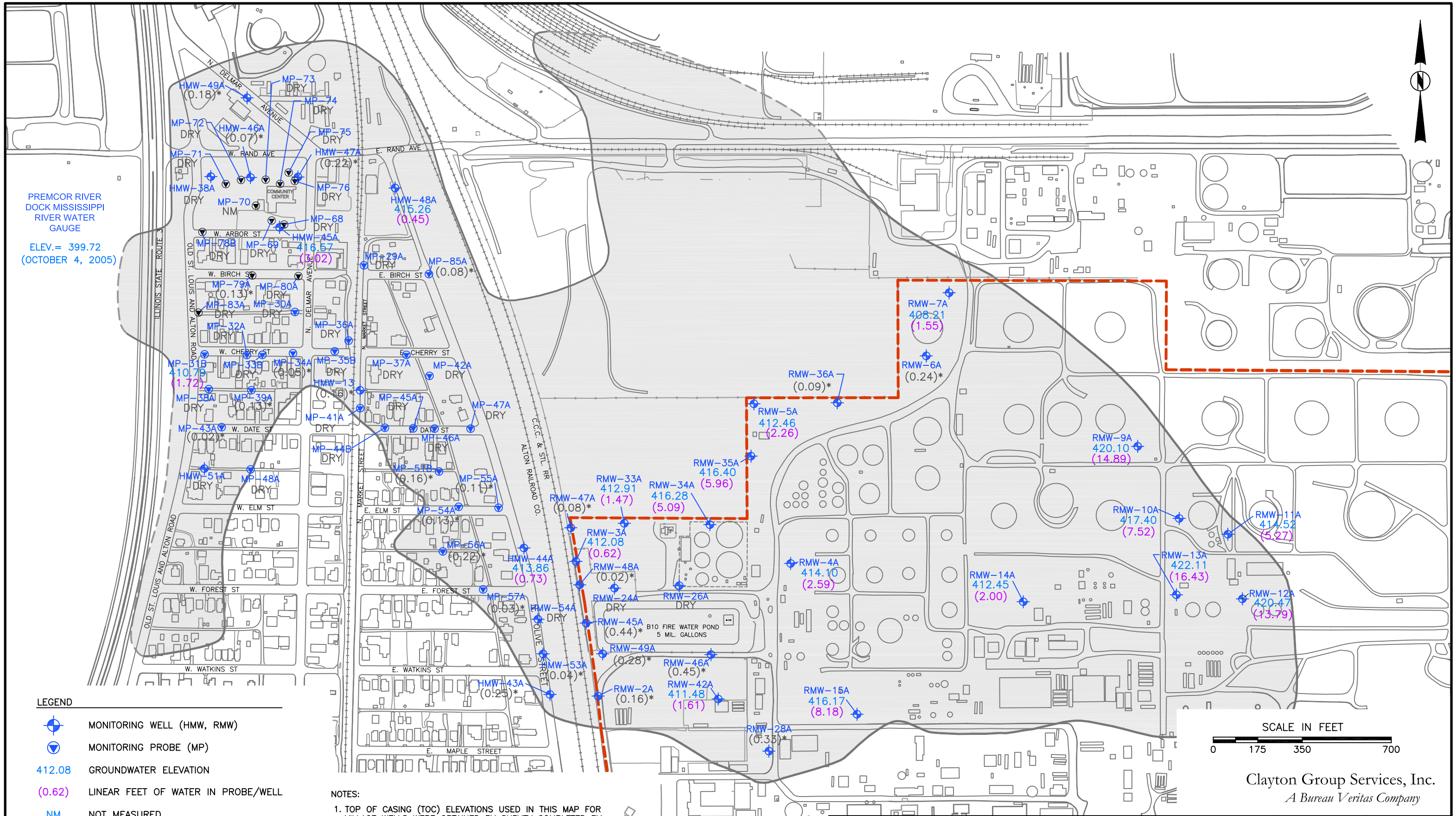
CHECK BY	MEM
DRAWN BY	OS
DATE	12-7-05
SCALE	AS SHOWN
CAD NO.	0309514011F2
PRJ NO.	15-03095

GENERALIZED GROUNDWATER FLOW DIRECTION MAP
OCTOBER 2004 – OCTOBER 2005
RAND STRATUM
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

BUREAU VERITAS 1828

FIGURE 2-7



LEGEND

- MONITORING WELL (HMW, RMW)
- MONITORING PROBE (MP)
- 412.08 — GROUNDWATER ELEVATION
- (0.62) — LINEAR FEET OF WATER IN PROBE/WELL
- NM — NOT MEASURED
- (0.16)* — WATER IN PROBE/WELL IS WITHIN THE SUMP OF WELL AND/OR BELOW BASE OF STRATUM
- INTERPRETED EXTENT OF STRATUM (DASHED WHERE EXTRAPOLATED)

NOTES:

1. TOP OF CASING (TOC) ELEVATIONS USED IN THIS MAP FOR VILLAGE WELLS WERE OBTAINED BY SURVEY COMPLETED BY CMT, INC. IN 2003 AND 2004. TOC ELEVATIONS FOR ALL PREMCOR FACILITY WELLS WERE OBTAINED BY SURVEYS COMPLETED BY CMT, INC. IN 2004 AND 2005. TOC ELEVATIONS FOR ALL OTHER WELLS WERE OBTAINED FROM HISTORICAL SURVEYS BY CMT, INC.
2. MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL, 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.

Clayton Group Services, Inc.
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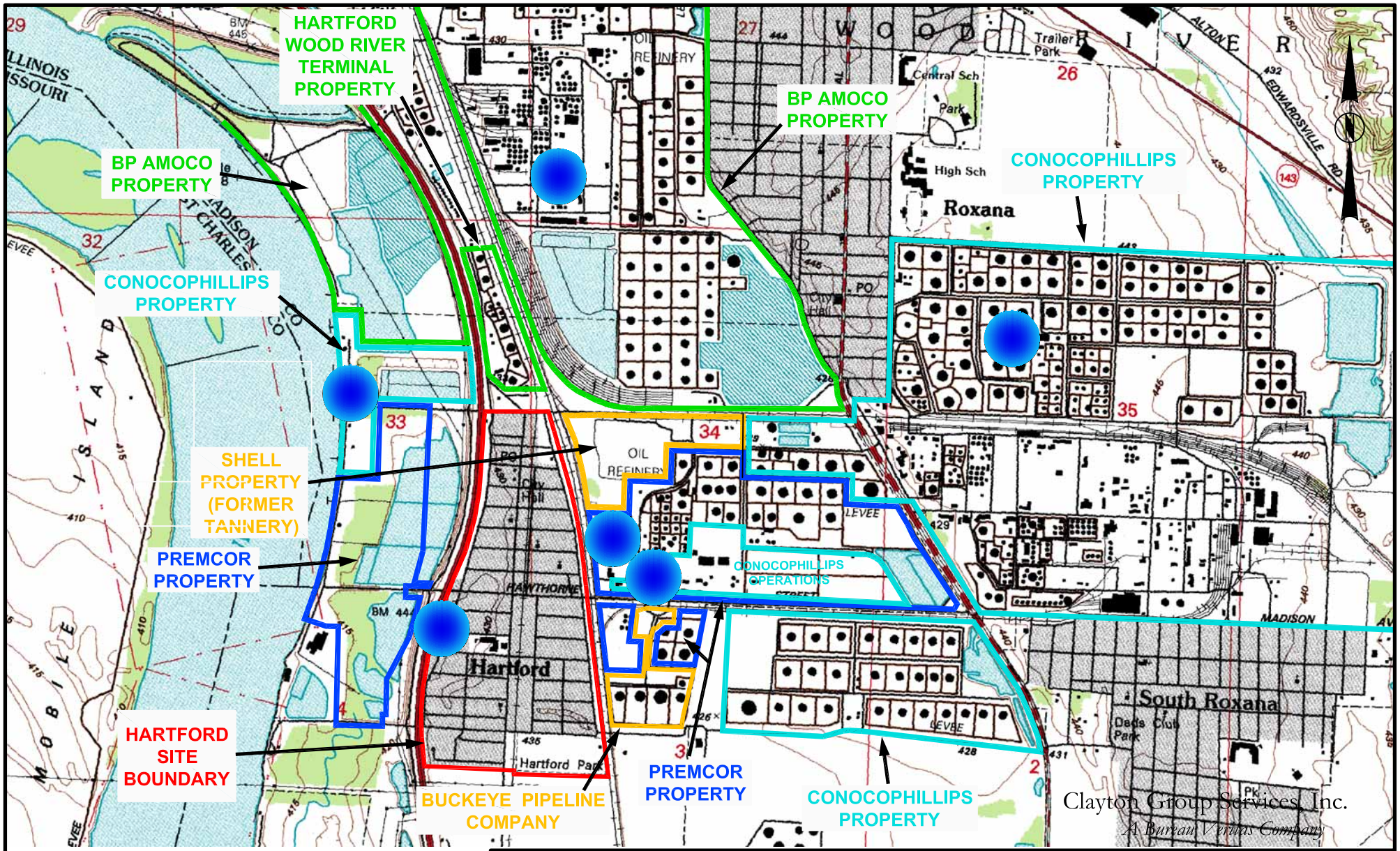
CHECK BY	
DRAWN BY	BCP
DATE	12-7-05
SCALE	AS SHOWN
CAD NO.	0309507e71
PRJ NO.	15-03095.14

GROUNDWATER ELEVATION MAP
OCTOBER 4-5, 2005
NORTH OLIVE STRATUM
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

BUREAU VERITAS 1828

FIGURE 2-6



LEGEND

PUMPING CENTERS

** NOT TO SCALE **

SOURCE:
USGS 7.5 MINUTE SERIES TOPOGRAPHIC MAP
(WOOD RIVER, ILL.–MO. – rev.1994)

CHK BY	
DWN BY	BCP
DATE	11–15–05
SCALE	AS SHOWN
CAD NO.	0309512001b1
PRJ NO.	15–03095.14

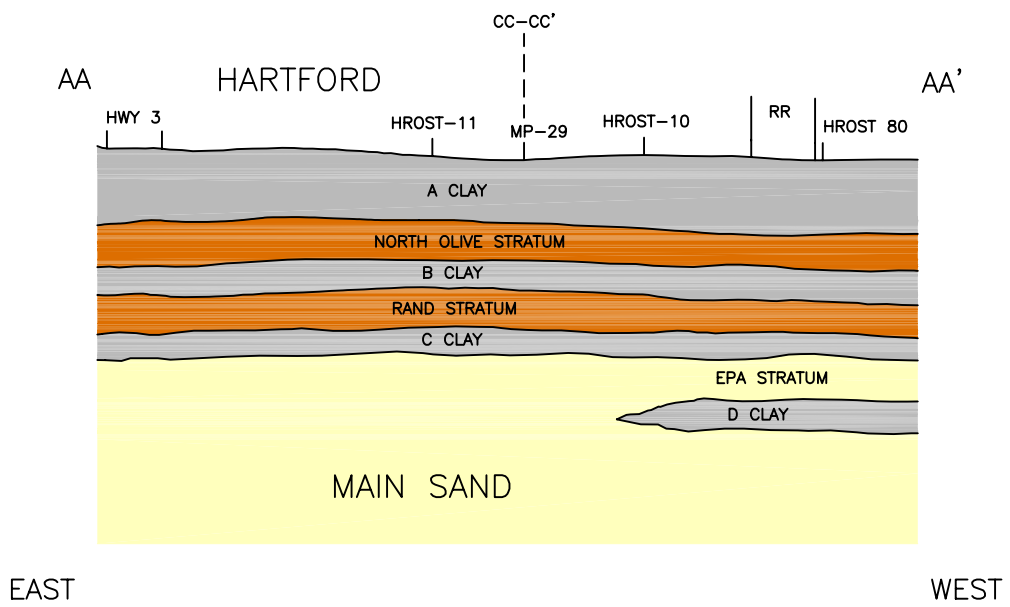
PUMPING CENTERS IN THE VICINTY OF HARTFORD, IL.

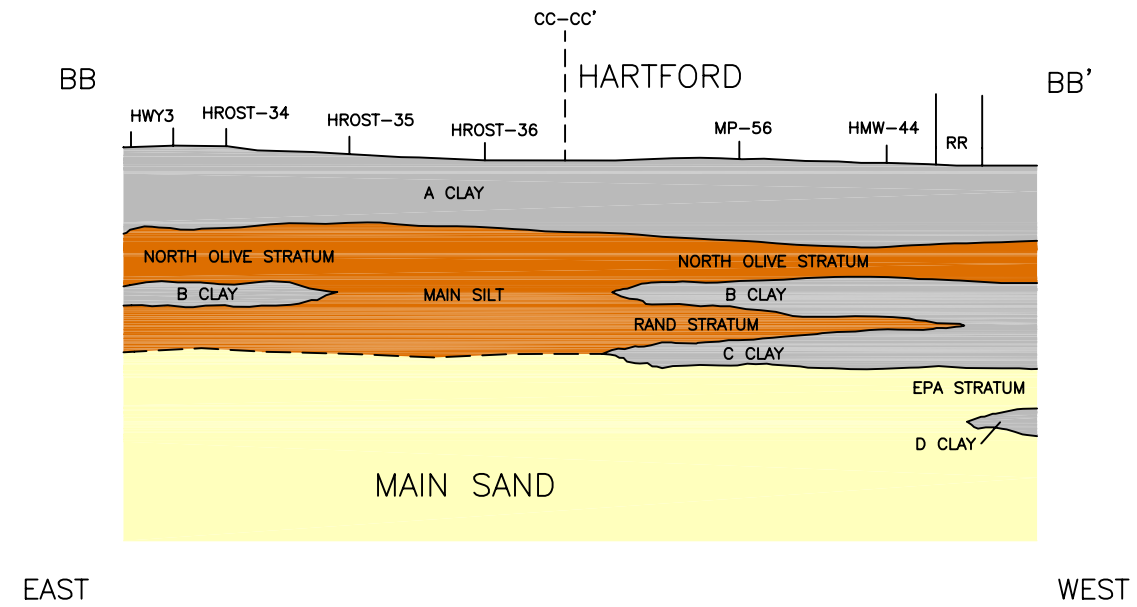
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

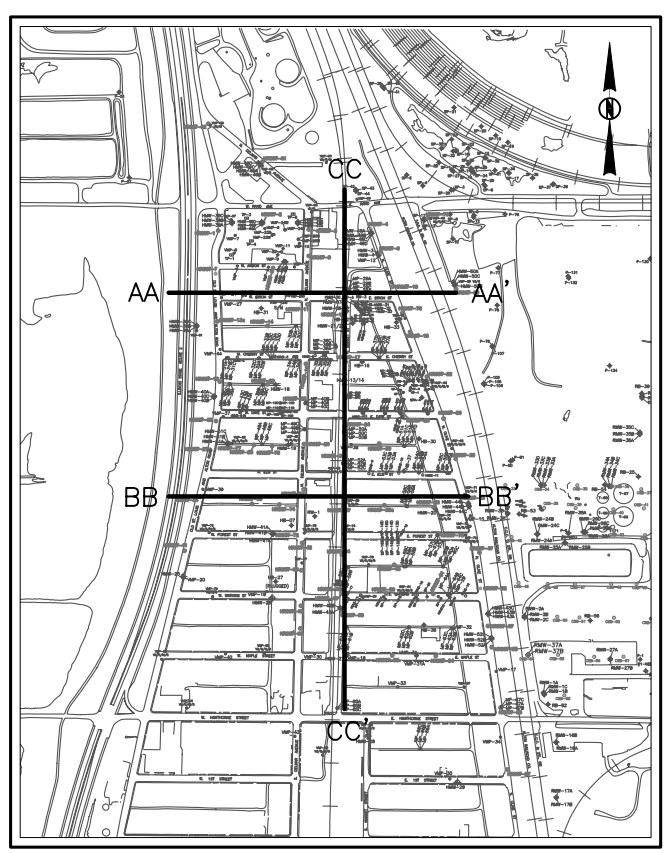
BUREAU VERITAS

FIGURE

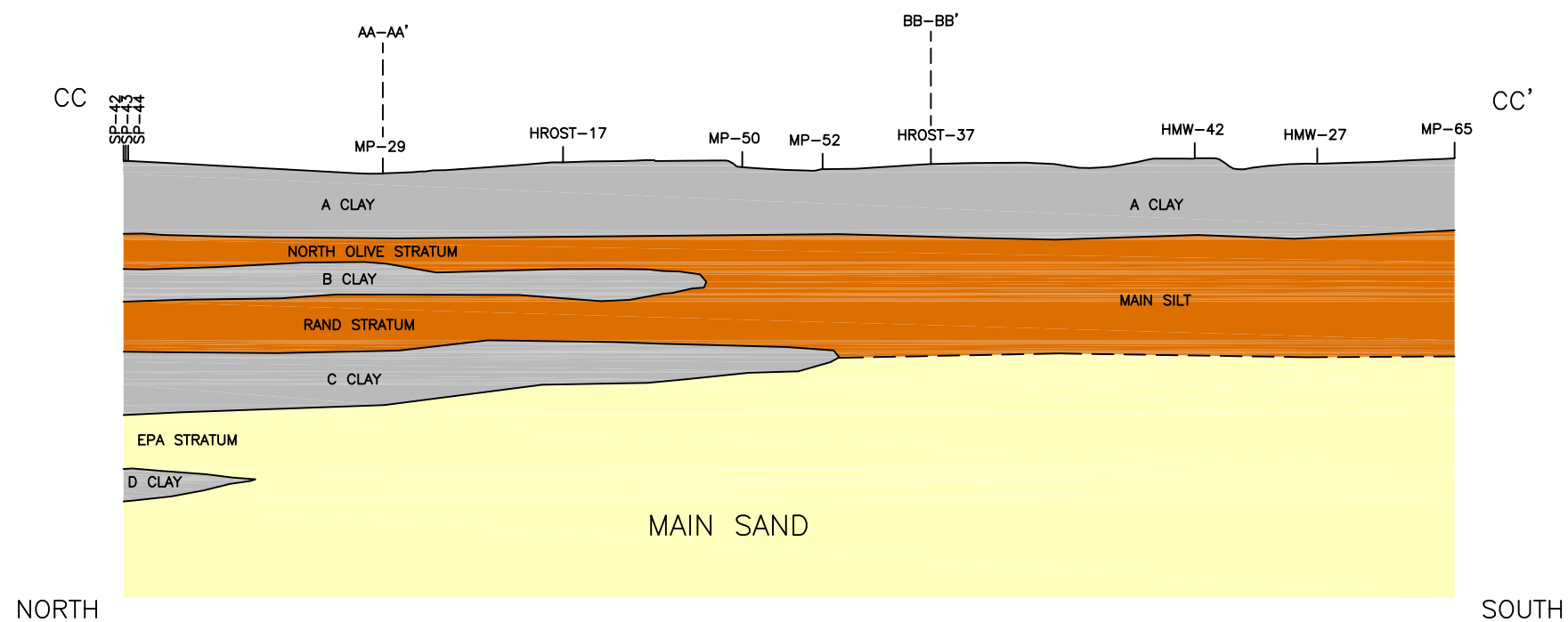
2–5







CROSS SECTION REFERENCE



NOTES:

1. VERTICAL AND LATERAL EXTENT OF GEOLOGIC STRATA REFLECT GENERALIZED REPRESENTATIONS FOR THE PURPOSE OF SIMPLIFYING THE UNDERSTANDING AND IDENTIFICATION OF THE MAJOR LITHOLOGIC STRATA WITHIN THE STUDY AREA.
2. VERTICAL EXTENT OF STRATA NOT TO SCALE.
3. BASE OF MAIN SAND NOT SHOWN.

Clayton Group Services, Inc.
A Bureau Veritas Company

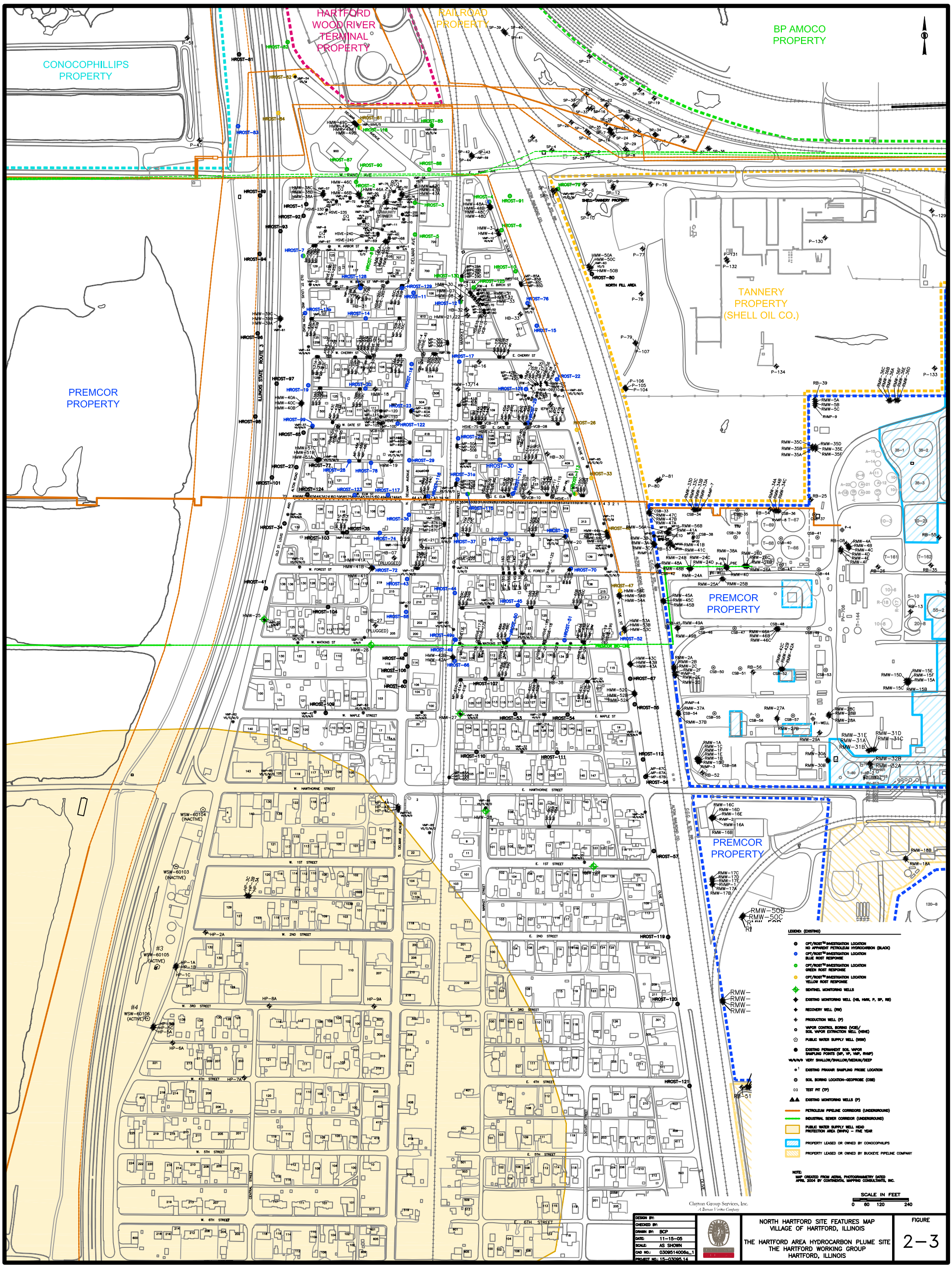
CHECK BY	DJL
DRAWN BY	OS
DATE	12–7–05
SCALE	AS SHOWN
CAD NO.	0309514020a
PRJ NO.	15–03095.14

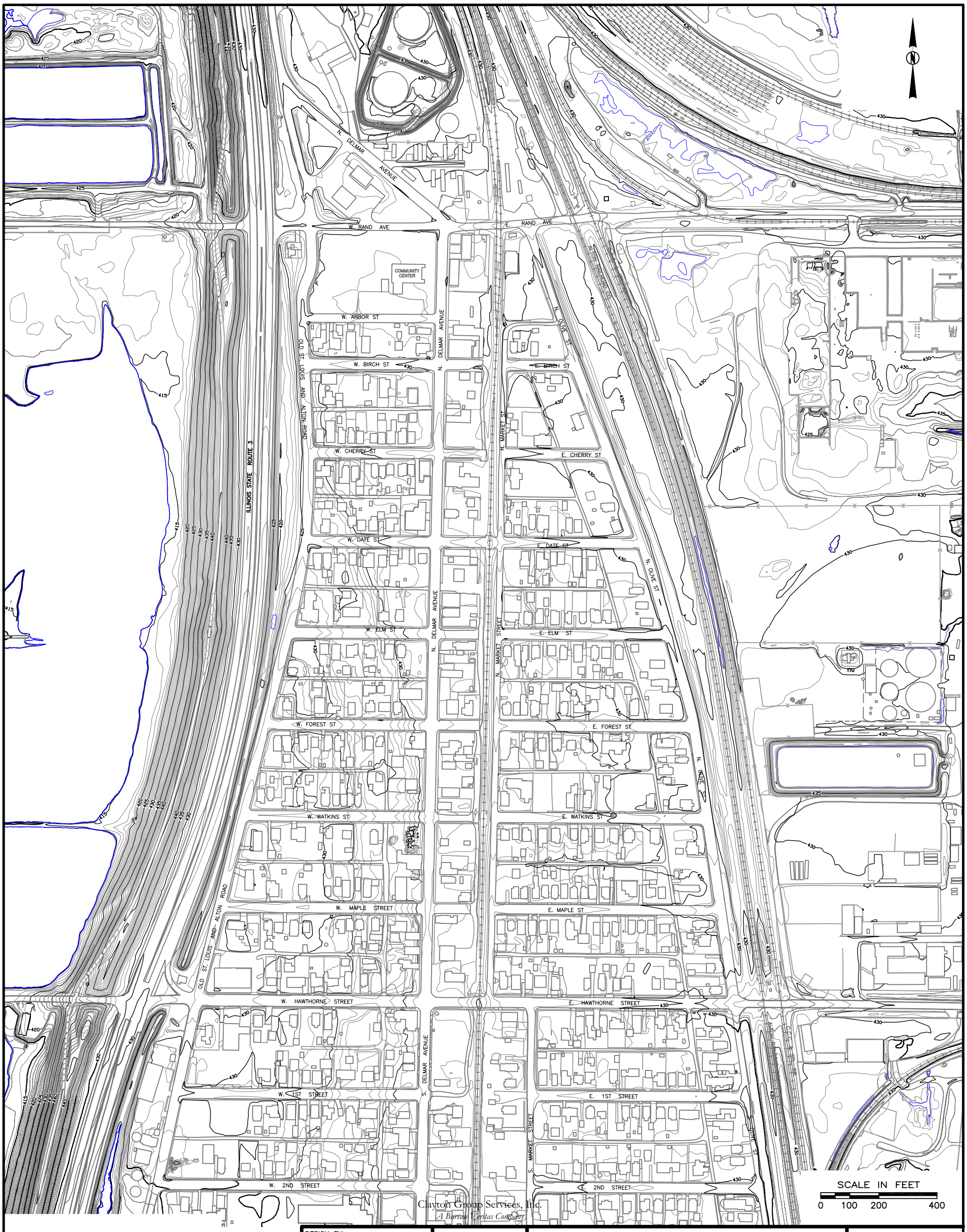
GENERALIZED GEOLOGIC CROSS SECTIONS
AA–AA', BB–BB', AND CC–CC'

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

BUREAU VERITAS

FIGURE
2–4


CONOCOPHILLIPS PROPERTY
HARTFORD WOOD RIVER TERMINAL PROPERTY
RAILROAD PROPERTY
BP AMOCO PROPERTY
TANNERY PROPERTY (SHELL OIL CO.)
PREMCOR PROPERTY
PREMCOR PROPERTY
PREMCOR PROPERTY
ILLINOIS STATE ROUTE 3
W. RAND AVE
E. RAND AVE
W. ARBOR ST
W. BIRCH ST
E. BIRCH ST
W. CHERRY ST
E. CHERRY ST
W. DATE ST
E. DATE ST
W. ELM ST
E. ELM ST
W. FOREST ST
E. FOREST ST
W. WATKINS ST
E. WATKINS ST
W. MAPLE STREET
E. MAPLE STREET
W. HAWTHORNE STREET
E. HAWTHORNE STREET
W. 1ST STREET
E. 1ST STREET
W. 2ND STREET
E. 2ND STREET
W. 3RD STREET
E. 3RD STREET
W. 4TH STREET
E. 4TH STREET
W. 5TH STREET
E. 5TH STREET
W. 6TH STREET
E. 6TH STREET
N. DELMAR AVE
S. DELMAR AVENUE
N. MARKET ST
S. MARKET STREET
N. OLIVE ST
S. OLIVE ST
OLD ST. LOUIS AND ALTON ROAD
ALTON RAILROAD CO.
C.C.C.& STL. RR
LOCUST STREET
CENTRAL STREET
SHELL-TANNERY PROPERTY
NORTH FILL AREA
WSW-60104 (INACTIVE)
WSW-60103 (INACTIVE)
#3 WSW-60105 (ACTIVE)
#4 WSW-60106 (ACTIVE)
LEGEND: (EXISTING)
CPT/ROST™ INVESTIGATION LOCATION NO APPARENT PETROLEUM HYDROCARBON (BLACK)
CPT/ROST™ INVESTIGATION LOCATION BLUE ROST RESPONSE
CPT/ROST™ INVESTIGATION LOCATION GREEN ROST RESPONSE
CPT/ROST™ INVESTIGATION LOCATION YELLOW ROST RESPONSE
SENTINEL MONITORING WELLS
EXISTING MONITORING WELL (HB, HMW, P, SP, RB)
RECOVERY WELL (RW)
PRODUCTION WELL (P)
VAPOR CONTROL BORING (VCB)/ SOIL VAPOR EXTRACTION WELL (HSVE)
PUBLIC WATER SUPPLY WELL (WSW)
EXISTING PERMANENT SOIL VAPOR SAMPLING POINTS (MP, VP, VMP, RVMP)
VS/S/M/D VERY SHALLOW/SHALLOW/MEDIUM/DEEP
EXISTING PRAXAIR SAMPLING PROBE LOCATION
SOIL BORING LOCATION-GEOPROBE (CSB)
TEST PIT (TP)
EXISTING MONITORING WELLS (P)
PETROLEUM PIPELINE CORRIDORS (UNDERGROUND)
INDUSTRIAL SEWER CORRIDOR (UNDERGROUND)
PUBLIC WATER SUPPLY WELL HEAD PROTECTION AREA (WHPA) - FIVE YEAR
PROPERTY LEASED OR OWNED BY CONOCOPHILIPS
PROPERTY LEASED OR OWNED BY BUCKEYE PIPELINE COMPANY
NOTE: MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTAL MAPPING CONSULTANTS, INC.
SCALE IN FEET
0 60 120 240
Clayton Group Services, Inc.
A Bureau Veritas Company
DESIGN BY:
CHECKED BY:
DRAWN BY: BCP
DATE: 11-15-05
SCALE: AS SHOWN
CAD NO.: 0309514006a_1
PROJECT NO.: 15-03095.14
NORTH HARTFORD SITE FEATURES MAP
VILLAGE OF HARTFORD, ILLINOIS
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS
FIGURE
2-3



NOTES:

1. MAP CREATED FROM AERIAL PHOTOGRAMMETRY DATED APRIL 2004 BY CONTINENTIAL MAPPING CONSULTANTS, INC.
2. CONTOUR INTERVAL = 1' FOOT

DESIGN BY:	
CHECKED BY:	
DRAWN BY:	BCP
DATE:	11-15-05
SCALE:	AS SHOWN
CAD NO.:	0309514006a1
PROJECT NO.:	15-03095.14

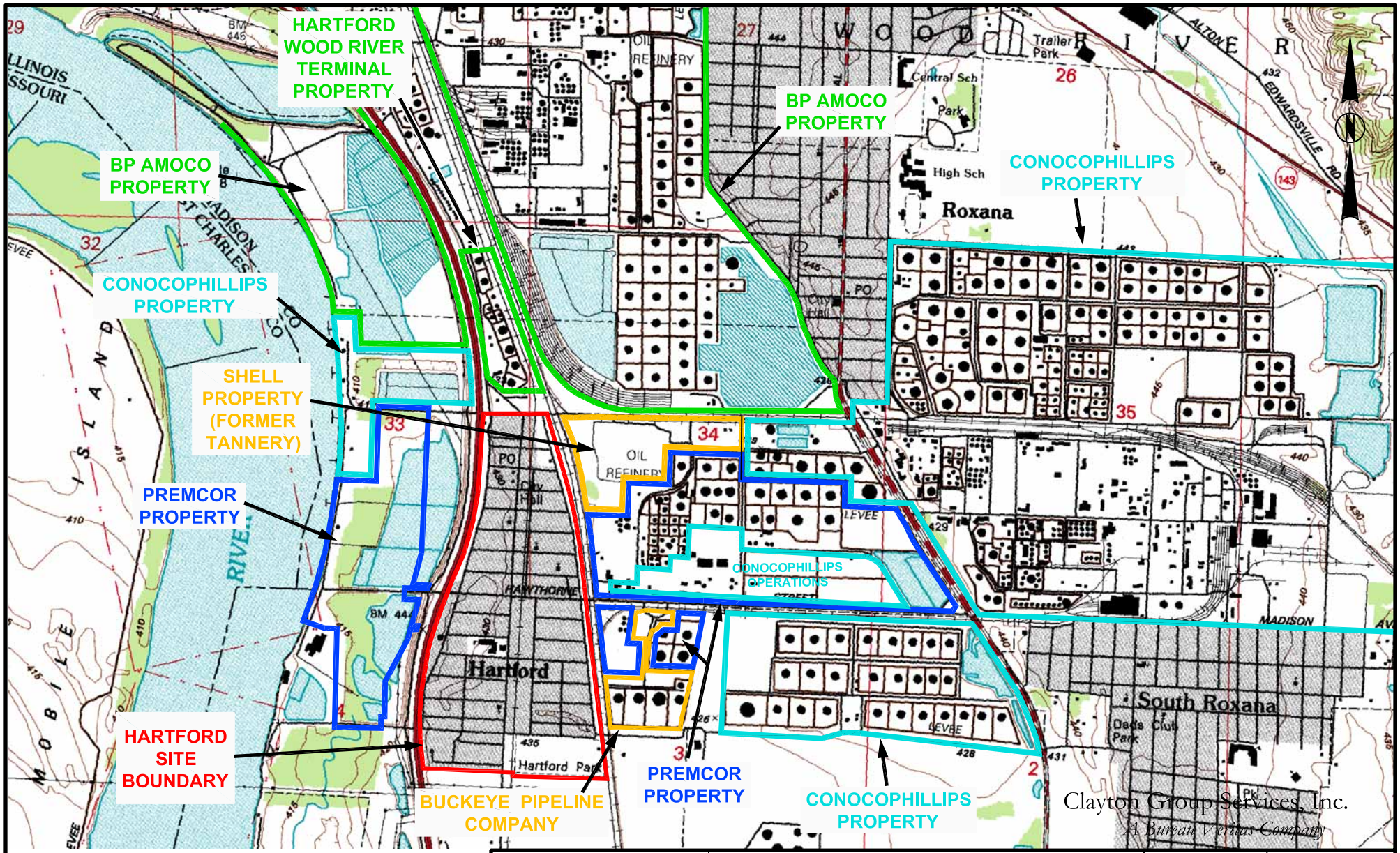
BUREAU VERITAS 1828

NORTH HARTFORD TOPOGRAPHIC MAP
VILLAGE OF HARTFORD, ILLINOIS

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

FIGURE

2-2



** NOT TO SCALE **

SOURCE:
USGS 7.5 MINUTE SERIES TOPOGRAPHIC MAP
(WOOD RIVER, ILL.–MO. – rev.1994)

CHK BY	
DWN BY	BCP
DATE	11–15–05
SCALE	AS SHOWN
CAD NO.	0309512001B
PRJ NO.	15–03095.14

VILLAGE OF HARTFORD, IL
AND SURROUNDING AREA MAP

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

BUREAU VERITAS

FIGURE

2 – 1

TABLE 3-3
BAILDOWN TEST AND HVR EVENT LNAPL T AND K VALUE SUMMARY
Hartford Area Hydrocarbon Plume Site

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

Well ID	Type	Date	DTP	Density	Avg Tn	Avg Kn	Cooper et al		L (ft)
							T_n (cm^2/s)(C et al)	K_n (cm/s)(C et al)	
HMW-18	BD	3/2/2004	34.94	0.7649	2.86E-02	5.31E-04	3.86E-02	6.55E-04	1.94
HMW-18	BD	3/4/2004	34.83	0.7649			4.93E-03	9.19E-05	1.76
HMW-18	BD	8/24/2005	33.76	0.7649			4.23E-02	8.46E-04	1.64
HMW-19	BD	3/2/2004	34.85	0.7415	9.38E-02	3.22E-03	1.18E-02	2.74E-04	1.41
HMW-19	BD	3/4/2004	34.64	0.7415			1.34E-02	3.35E-04	1.31
HMW-19	HVR	5/23/2005	31.33	0.7415			3.49E-01	1.37E-02	0.83
HMW-19	HVR	6/7/2005	31.84	0.7415			4.53E-03	1.68E-04	0.88
HMW-19	HVR	6/21/2005	30.50	0.7415			1.39E-01	3.46E-03	1.31
HMW-19	HVR	7/8/2005	31.45	0.7415			4.14E-01	2.34E-02	0.57
HMW-19	HVR	7/22/2005	32.39	0.7415			3.41E-03	1.03E-04	1.08
HMW-19	HVR	8/9/2005	33.25	0.7415			2.13E-02	3.87E-04	1.79
HMW-19	HVR	8/10/2005	33.31	0.7415			2.59E-02	4.64E-04	1.82
HMW-19	HVR	8/11/2005	33.38	0.7415			2.53E-02	4.56E-04	1.81
HMW-19	HVR	8/12/2005	33.42	0.7415			1.74E-01	3.32E-03	1.71
HMW-19	HVR	8/16/2005	33.54	0.7415			2.81E-02	5.30E-04	1.73
HMW-19	HVR	8/17/2005	33.58	0.7415			6.31E-02	1.23E-03	1.67
HMW-19	HVR	8/18/2005	33.61	0.7415			3.12E-02	6.19E-04	1.64
HMW-19	HVR	8/19/2005	33.69	0.7415			2.25E-02	4.53E-04	1.62
HMW-19	HVR	8/22/2005	33.71	0.7415			2.38E-01	5.22E-03	1.48
HMW-19	HVR	8/23/2005	33.74	0.7415			3.08E-02	7.16E-04	1.40
HMW-20	BD	3/3/2004	32.75	0.7428	2.61E-02	5.06E-04	1.04E-01	2.02E-03	1.69
HMW-20	HVR	5/16/2005	30.09	0.7428			3.09E-04	4.00E-06	2.53
HMW-20	HVR	6/14/2005	29.28	0.7428			2.04E-04	2.25E-06	2.97
HMW-20	HVR	7/15/2005	30.29	0.7428			1.91E-05	6.26E-07	0.99
HMW-44C	HVR	5/13/2005	28.50	0.7641	8.74E-02	1.12E-03	2.41E-02	2.67E-04	2.95
HMW-44C	HVR	6/27/2005	27.75	0.7641			1.39E-01	1.31E-03	3.47
HMW-44C	HVR	7/14/2005	28.46	0.7641			2.39E-02	2.61E-04	2.99
HMW-44C	HVR	7/25/2005	29.28	0.7641			4.66E-02	6.32E-04	2.41
HMW-44C	HVR	7/26/2005	29.32	0.7641			5.00E-02	6.95E-04	2.35
HMW-44C	HVR	7/27/2005	29.48	0.7641			1.56E-02	2.24E-04	2.27
HMW-44C	HVR	7/28/2005	29.53	0.7641			4.00E-02	6.06E-04	2.16
HMW-44C	HVR	7/29/2005	29.57	0.7641			1.56E-02	2.37E-04	2.15
HMW-44C	HVR	8/1/2005	29.65	0.7641			3.62E-03	5.51E-05	2.14
HMW-44C	HVR	8/2/2005	29.71	0.7641			1.56E-02	2.42E-04	2.10
HMW-44C	HVR	8/3/2005	29.76	0.7641			9.03E-03	1.40E-04	2.10
HMW-44C	HVR	8/4/2005	29.83	0.7641			6.27E-03	1.02E-04	2.00
HMW-44C	HVR	8/5/2005	29.92	0.7641			4.37E-03	7.12E-05	2.00
HMW-44C	HVR	8/8/2005	30.01	0.7641			1.45E-03	2.39E-05	1.99
HMW-44C	BD	9/23/2004	29.14	0.7641			9.16E-01	1.20E-02	2.50
MP-35D	BD	8/30/2005	32.40	0.7763	1.32E-01	2.57E-03	1.32E-01	2.57E-03	1.69
MP-39C	BD	9/23/2004	32.94	0.7481	1.48E-03	3.08E-05	1.20E-03	2.38E-05	1.66
MP-39C	BD	8/31/2005	34.21	0.7481			1.75E-03	3.78E-05	1.52
MP-45C	BD	9/24/2004	30.26	0.7616	1.81E-02	2.46E-04	6.00E-04	9.94E-06	1.98
MP-45C	BD	8/30/2005	33.64	0.7616			3.57E-02	4.82E-04	2.43
MP-47C	BD	9/24/2004	31.58	0.7569	3.25E-03	4.88E-05	1.64E-04	2.22E-06	2.43
MP-47C	HVR	5/10/2005	28.35	0.7569			1.00E-03	1.33E-05	2.46
MP-47C	HVR	5/25/2005	28.36	0.7569			2.72E-03	4.28E-05	2.07
MP-47C	HVR	6/9/2005	28.46	0.7569			8.93E-03	1.35E-04	2.15
MP-47C	HVR	7/12/2005	28.29	0.7569			3.43E-03	5.02E-05	2.24
MP-49C	BD	8/31/2005	32.72	0.7335	7.20E-05	1.25E-06	7.20E-05	1.25E-06	1.88
MP-50C	HVR	5/26/2005	29.77	0.7410	1.71E-01	4.49E-03	1.01E+00	2.64E-02	1.24
MP-50C	HVR	7/13/2005	29.98	0.7410			1.82E-02	4.90E-04	1.21
MP-50C	HVR	8/24/2005	31.96	0.7410			5.52E-05	1.07E-06	1.68
MP-50C	HVR	8/25/2005	32.24	0.7410			3.41E-04	2.33E-05	0.47
MP-50C	HVR	8/26/2005	32.14	0.7410			9.54E-05	5.60E-06	0.55
MP-50C	HVR	8/29/2005	31.94	0.7410			1.37E-04	2.85E-06	1.57
MP-52C	BD	8/23/2005	33.08	0.7360	1.05E-05	2.29E-07	1.05E-05	2.29E-07	1.50
MP-53C	BD	9/23/2004	32.46	0.7480	1.81E-03	3.58E-05	2.80E-05	5.36E-07	1.71
MP-53C	HVR	7/19/2005	30.50	0.7480			3.59E-03	7.10E-05	1.65
MP-55C	BD	9/23/2004	29.20	0.7705	2.04E-02	4.16E-04	9.54E-04	8.50E-06	3.69
MP-55C	HVR	6/17/2005	28.53	0.7705			4.27E-02	1.30E-03	1.07
MP-55C	HVR	7/6/2005	28.43	0.7705			1.72E-02	1.83E-04	3.07
MP-55C	HVR	7/20/2005	28.95	0.7705			2.06E-02	1.73E-04	3.89
MP-56C	HVR	7/18/2005	29.98	0.7456	3.52E-04	1.10E-05	3.52E-04	1.10E-05	1.04
RW-4A	HVR	8/30/2005	31.80	0.7649	3.21E-03	9.00E-05	4.81E-03	1.28E-04	1.22
RW-4A	HVR	8/31/2005	31.94	0.7649			1.61E-03	5.15E-05	1.02
RW-5	HVR	9/1/2005	31.97	0.7649	1.94E-03	6.47E-05	1.94E-03	6.47E-05	0.97

NOTES: T_n and K_n calculated according to Huntley (2000)

TABLE 3-2
DEPTH OF IDENTIFIED ROST RESPONSE IN MAIN SAND
The Hartford Area Hydrocarbon Plume Site

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

ROST Boring	Ground Surface Elevation (ft msl)	Top of Main Silt / Main Sand Elevation (ft msl)	Bottom Elevation of ROST Response in Main Sand (ft msl)	Bottom Depth of ROST Response in Main Sand (ft bgs)	Boring Termination Elevation (ft msl)
HROST-1	429.50	400.00	NA	NA	360.08
HROST-2	430.95	399.95	387.95	43.00	355.99
HROST-3	430.00	390.00	383.50	46.50	359.87
HROST-4	429.34	386.34	377.34	52.00	363.38
HROST-5	430.50	391.00	383.50	47.00	364.11
HROST-6	429.75	389.25	382.75	47.00	355.25
HROST-7	429.75	400.75	389.75	40.00	371.56
HROST-8	431.30	403.30	391.30	40.00	363.30
HROST-10	429.00	389.00	377.00	52.00	362.41
HROST-11	430.25	395.25	386.75	43.50	370.14
HROST-12	430.15	400.65	389.15	41.00	370.16
HROST-13	427.00	408.50	387.50	39.50	370.63
HROST-14	432.25	397.75	388.75	43.50	358.20
HROST-15	429.00	388.50	388.50	40.50	360.65
HROST-16	431.00	401.50	388.50	42.50	369.76
HROST-17	431.25	404.25	388.25	43.00	373.26
HROST-19	426.00	411.50	390.00	36.00	371.68
HROST-20	432.00	403.50	379.50	52.50	372.20
HROST-22	429.15	390.15	386.65	42.50	369.26
HROST-23	431.75	401.84	382.75	49.00	400.60
HROST-24	431.50	401.50	390.00	41.50	389.80
HROST-25	430.00	403.50	390.00	40.00	360.75
HROST-26	429.10	403.60	385.10	44.00	380.25
HROST-27	427.25	414.25	NA	NA	371.09
HROST-28	426.80	405.30	389.30	37.50	386.49
HROST-29	431.75	407.25	388.75	43.00	371.39
HROST-30	431.75	399.75	387.75	44.00	382.83
HROST-31a	430.10	403.10	387.10	43.00	381.78
HROST-33	429.75	403.75	381.25	48.50	377.62
HROST-34	427.75	415.75	NA	NA	367.64
HROST-35	425.60	413.60	NA	NA	369.28
HROST-36	432.00	420.00	374.50	57.50	370.82
HROST-37	431.00	419.00	386.00	45.00	383.37
HROST-38	430.50	398.50	386.50	44.00	381.28
HROST-39	430.75	397.75	385.75	45.00	383.05
HROST-40	429.85	401.85	383.35	46.50	381.49
HROST-41	427.00	413.00	NA	NA	373.17
HROST-43	431.75	415.75	388.75	43.00	368.92
HROST-44	431.00	419.00	384.50	46.50	381.78
HROST-45	431.50	417.50	390.50	41.00	386.30
HROST-47	429.53	398.03	384.53	45.00	378.27
HROST-48	431.00	410.50	NA	NA	369.77
HROST-49	431.75	412.75	392.25	39.50	386.70
HROST-50	430.35	417.35	387.35	43.00	381.20
HROST-51	429.00	416.00	391.00	38.00	383.37
HROST-52	429.65	397.65	389.65	40.00	384.34
HROST-53	431.15	414.65	NA	NA	367.65
HROST-54	430.10	411.60	NA	NA	363.71
HROST-55	428.00	408.50	NA	NA	358.95

TABLE 3-2
DEPTH OF IDENTIFIED ROST RESPONSE IN MAIN SAND
The Hartford Area Hydrocarbon Plume Site

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

ROST Boring	Ground Surface Elevation	Top of Main Silt / Main Sand Elevation	Bottom Elevation of ROST Response in Main Sand	Bottom Depth of ROST Response in Main Sand	Boring Termination Elevation
HROST-56	431.00	412.00	NA	NA	368.60
HROST-57	429.32	417.82	NA	NA	399.38
HROST-60	431.00	412.50	NA	NA	369.73
HROST-61 *	430.50	390.50	NA	NA	389.48
HROST-62	430.10	392.60	389.60	40.50	366.50
HROST-65	425.50	402.00	NA	NA	371.75
HROST-66	432.00	412.50	395.50	36.50	369.02
HROST-67	429.00	405.00	NA	NA	381.91
HROST-68	431.25	415.25	392.25	39.00	368.15
HROST-70	429.75	400.25	389.75	40.00	372.97
HROST-72	426.00	412.50	399.50	26.50	381.74
HROST-74	428.75	413.25	390.75	38.00	384.21
HROST-76	429.00	389.50	393.00	36.00	389.74
HROST-77	425.25	410.25	NA	NA	359.78
HROST-78	431.50	413.50	380.00	51.50	367.69
HROST-79	430.75	385.25	381.75	49.00	381.17
HROST-80	430.75	385.75	NA	NA	387.39
HROST-81	447.01	390.01	NA	NA	374.01
HROST-82	429.39	391.64	389.39	40.00	356.39
HROST-83	442.15	402.40	379.15	63.00	370.15
HROST-84	429.69	390.69	389.69	40.00	356.69
HROST-85	430.09	390.09	374.09	56.00	358.09
HROST-87	430.56	397.56	383.56	47.00	344.21
HROST-88	430.67	389.42	379.67	51.00	359.81
HROST-89	428.07	402.82	NA	NA	368.03
HROST-90	430.34	399.34	383.34	47.00	360.34
HROST-91	429.53	387.28	375.53	54.00	368.53
HROST-92	429.44	400.44	NA	NA	369.44
HROST-93	428.82	399.32	NA	NA	366.82
HROST-94	427.95	399.45	NA	NA	362.99
HROST-96	427.75	400.25	NA	NA	368.04
HROST-97	428.37	412.87	NA	NA	364.59
HROST-98	428.28	413.28	NA	NA	378.28
HROST-99	424.89	414.39	365.89	59.00	359.89
HROST-101	429.03	414.28	NA	NA	357.03
HROST-103	427.70	413.70	NA	NA	368.70
HROST-104	431.31	413.31	NA	NA	345.31
HROST-106	430.96	415.46	NA	NA	358.96
HROST-107	429.69	414.69	NA	NA	364.69
HROST-109	429.25	415.25	NA	NA	375.25
HROST-110	431.36	410.61	NA	NA	358.36
HROST-111	430.79	416.04	NA	NA	361.79
HROST-112	429.45	409.95	NA	NA	360.45
HROST-113	429.88	404.38	373.88	56.00	355.88
HROST-114	430.85	401.35	386.85	44.00	355.85
HROST-115	430.18	402.93	380.18	50.00	360.18
HROST-116	432.45	416.95	365.45	67.00	364.45
HROST-117	430.31	416.3	380.31	50.00	366.31
HROST-118	430.38	388.88	382.38	48.00	360.38
HROST-119	429.59	421.58	NA	NA	362.59

TABLE 3-2
DEPTH OF IDENTIFIED ROST RESPONSE IN MAIN SAND
The Hartford Area Hydrocarbon Plume Site

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

ROST Boring	Ground Surface Elevation	Top of Main Silt / Main Sand Elevation	Bottom Elevation of ROST Response in Main Sand	Bottom Depth of ROST Response in Main Sand	Boring Termination Elevation
HROST-120	429.05	416.04	NA	NA	363.05
HROST-121	429.62	413.62	NA	NA	357.62
HROST-122	432.71	402.46	374.71	58.00	359.71
HROST-123	426.12	413.11	382.12	44.00	349.12
HROST-124	428.19	406.94	NA	NA	369.69
HROST-125	430.38	392.40	385.38	45.00	361.40
HROST-126	430.90	402.90	369.90	61.00	359.90
HROST-128	429.81	394.81	382.81	47.00	368.81
HROST-129	430.31	391.52	385.31	45.00	361.27
HROST-130	429.70	399.74	380.70	49.00	348.49

NOTES:

* = Not in Main Sand
bgs = Below ground surface
msl = Mean Sea Level
NA = Not Applicable - no LNAPL was identified

TABLE 3-1
LNAPL CHARACTERIZATION SUMMARY TABLE
Main Sand

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

Sample ID	Primary Product	Secondary Product	Simulated Distillation	Kinematic Viscosity	Density
HMW08	Gasoline	Trace Diesel	Not Analyzed	Not Analyzed	Not Analyzed
HMW19	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
HMW19D	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
HMW20	Gasoline	Trace Diesel	Not Analyzed	Not Analyzed	Not Analyzed
HMW22	Gasoline	Diesel <10%	Not Analyzed	Not Analyzed	Not Analyzed
HMW44C	Gasoline	Diesel +10%	Gasoline/ Diesel	Gasoline-Like	Gasoline-Like
HMW45C	Gasoline Approx 60%	Diesel ~40%	Not Analyzed	Not Analyzed	Not Analyzed
HMW46C	Gasoline Approx 70%	Diesel ~30%	Gasoline/ Diesel	Gasoline/ Diesel-like	Diesel-like
MP29D	Gasoline	Diesel ~10%	Gasoline/ Diesel	Gasoline-Like	Gasoline-Like
MP29DD	Gasoline	Diesel ~10%	Not Analyzed	Not Analyzed	Not Analyzed
MP32B	Not Analyzed	Not Analyzed	Gasoline	Gasoline-Like	Gasoline-Like
MP35D	Gasoline	Diesel ~ 5%	Gasoline	Gasoline-Like	Gasoline-Like
MP37D	Gasoline	Diesel <5%	Gasoline	Gasoline-Like	Gasoline-Like
MP39C	Gasoline	None	Gasoline	Gasoline-Like	Gasoline-Like
MP45C	Gasoline	None	Gasoline	Gasoline-Like	Gasoline-Like
MP47C	Gasoline	Diesel <10%	Gasoline/ Diesel	Gasoline-Like	Gasoline-Like
MP48B	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP49C	Gasoline	None	Gasoline	Gasoline-Like	Gasoline-Like
MP50C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP51D	Gasoline	Trace Diesel	Not Analyzed	Not Analyzed	Not Analyzed
MP52C	Gasoline	None	Gasoline	Gasoline-Like	Gasoline-Like

TABLE 3-1
LNAPL CHARACTERIZATION SUMMARY TABLE
Main Sand

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

Sample ID	Primary Product	Secondary Product	Simulated Distillation	Kinematic Viscosity	Density
MP53C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP55C	Gasoline	Diesel ~10%	Gasoline/ Diesel	Gasoline-Like	Gasoline-Like
MP56C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP56CD	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP57C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP60C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed
MP79C	Gasoline	Slight Trace Diesel	Not Analyzed	Not Analyzed	Not Analyzed
MP80C	Gasoline	None	Not Analyzed	Not Analyzed	Not Analyzed

TABLE 3-1
LNAPL CHARACTERIZATION SUMMARY TABLE
EPA and Rand Strata

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

Sample ID	Primary Product	Secondary Product	Simulated Distillation	Kinematic Viscosity	Density
HMW48C EPA Stratum	Diesel Approx 70%	Gasoline ~30%	Diesel	Diesel-like	Diesel-like
MP29C Rand Stratum	Diesel	Trace Gasoline	Diesel	Diesel-like	Diesel-like

TABLE 2-2
AVERAGE HYDRAULIC CONDUCTIVITY VALUES

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

Study Area Hydrostratigraphic Unit	Boring/Well ID in Hydrostratigraphic Unit	Average Hydraulic Conductivity		
		(cm/sec)	(ft/sec)	(ft/day)
North Olive Stratum	MP-69, MP-72, HMW-45, HMW-46, and HMW-47	8.85E-05	2.90E-06	2.51E-01
Rand Stratum	HMW-04, HMW-45 and HMW-50A	2.82E-03	9.24E-05	7.98E+00
EPA Stratum	HMW-49C and HMW-50B	1.97E-04	6.45E-06	5.57E-01
Main Sand	HMW-25, HMW-27, HMW-28, and HMW-29	2.17E-02	7.11E-04	6.14E+01

Geometric Mean Hydraulic Conductivity

Study Area Hydrostratigraphic Unit	Boring/Well ID in Hydrostratigraphic Unit	Geometric Mean Hydraulic Conductivity		
		(cm/sec)	(ft/sec)	(ft/day)
North Olive Stratum	MP-69, MP-72, HMW-45, HMW-46, and HMW-47	2.35E-05	7.72E-07	6.67E-02
Rand Stratum	HMW-04, HMW-45 and HMW-50A	5.83E-04	1.91E-05	1.65E+00
EPA Stratum	HMW-49C and HMW-50B	7.61E-05	2.50E-06	2.16E-01
Main Sand	HMW-25, HMW-27, HMW-28 and HMW-29	2.10E-02	6.89E-04	5.95E+01

TABLE 2-1
HYDRAULIC CONDUCTIVITY/PERMEABILITY ANALYSIS RESULTS - North Olive Stratum
The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

SAMPLE			SAMPLE ANALYSIS							
Boring/Well ID	Date of Collection/ Test	Sample/ Screen Depth (ft bgs)	Tested By	Analytical Method	Falling Head Test Hydraulic Conductivity (cm/sec)	Rising Head Test Hydraulic Conductivity (cm/sec)	Permeability (K) (cm/sec)	Average Hydraulic Conductivity (cm/sec)	Average Hydraulic Conductivity (ft/sec)	Average Hydraulic Conductivity (ft/day)
MP-69	12/07/04	12.0-12.5	PSC	ASTM-D 5084	- -	- -	2.0E-04	- -	6.56E-06	5.67E-01
MP-72	11/30/04	14.5-15.0	PSC	ASTM-D 5084	- -	- -	8.7E-06	- -	2.85E-07	2.47E-02
HMW-45	12/14/04	13.5-14.0	PSC	ASTM-D 5084	- -	- -	1.5E-05	- -	4.92E-07	4.25E-02
HMW-45	08/20/04	14.5-15.0	PSC	ASTM-D 5084	- -	- -	1.60E-05	- -	5.25E-07	4.54E-02
HMW-46	08/19/04	12.5-13.0	PSC	ASTM-D 5084	- -	- -	2.90E-04	- -	9.51E-06	8.22E-01
HMW-47	08/19/04	17.0-17.5	PSC	ASTM-D 5084	- -	- -	1.40E-06	- -	4.59E-08	3.97E-03
Overall Average							8.85E-05	- -	2.90E-06	2.51E-01
Overall Geomean							2.35E-05	- -	7.72E-07	6.67E-02

NOTES:
ft bgs = feet below ground surface
S = Slug test hydraulic conductivity testing method
Bouwer, H. and R.C. Rice. 1976. A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrated Wells. Water Resources Research, Vol. 12, no.3, pp. 423-428.
-- = Not conducted

TABLE 2-1
HYDRAULIC CONDUCTIVITY/PERMEABILITY ANALYSIS RESULTS - Rand Stratum
The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

SAMPLE			SAMPLE ANALYSIS								
Boring / Well ID	Date of Collection/ Test	Sample/ Screen Depth (ft bgs)	Tested By	Analytical Method	Falling Head Test Hydraulic Conductivity (cm/sec)	Rising Head Test Hydraulic Conductivity (cm/sec)	Permeability (K) (cm/sec)	Average Hydraulic Conductivity (cm/sec)	Average Hydraulic Conductivity (ft/sec)	Average Hydraulic Conductivity (ft/day)
HMW-45	12/14/04	26.0-26.5	PSC	ASTM-D 5084	- -	- -	5.5E-05	5.5E-05	1.80E-06	1.56E-01
HMW-04	07/28/05	20.02-25.75	Clayton	Bouwer & Rice	S 2.73E-04	S 6.35E-04	- -	4.54E-04	1.49E-05	1.29E+00
HMW-50A	07/27/05	17.30-27.0	Clayton	Cooper et al	S 4.08E-03	S 1.18E-02	- -	7.94E-03	2.60E-04	2.25E+01
Overall Average								2.82E-03	9.24E-05	7.98E+00
Overall Geomean								5.83E-04	1.91E-05	1.65E+00

NOTES:
ft bgs = feet below ground surface
S = Slug test hydraulic conductivity testing method
Bouwer, H. and R.C. Rice. 1976. A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrated Wells. Water Resources Research, Vol. 12, no.3, pp. 423-428.
Cooper, H. H., J.D. Bredehoeft, and S.S. Papadopulos. 1967. Response of a Finite-Diameter Well to an Instantaneous Charge of Water. Water Resources Research, Vol. 3, no. 1, pp. 263-269.
-- = Not conducted

TABLE 2-1
HYDRAULIC CONDUCTIVITY/PERMEABILITY ANALYSIS RESULTS - Clay Strata
The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

SAMPLE			SAMPLE ANALYSIS							
Boring/Well ID	Date of Collection/ Test	Sample/ Screen Depth (ft bgs)	Tested By	Analytical Method	Falling Head Test Hydraulic Conductivity (cm/sec)	Rising Head Test Hydraulic Conductivity (cm/sec)	Permeability (K) (cm/sec)	Average Hydraulic Conductivity (cm/sec)	Average Hydraulic Conductivity (ft/sec)	Average Hydraulic Conductivity (ft/day)
MP-76	12/09/04	5.5-6.0	PSC	ASTM-D 5084	- -	- -	6.0E-09	- -	1.97E-10	1.70E-05
MP-76	12/09/04	13.5-14.0	PSC	ASTM-D 5084	- -	- -	4.9E-05	- -	1.61E-06	1.39E-01
HMW-45	12/14/04	9.0-9.5	PSC	ASTM-D 5084	- -	- -	1.7E-04	- -	5.58E-06	4.82E-01
HMW-45	12/14/04	20.0-20.5	PSC	ASTM-D 5084	- -	- -	4.9E-08	- -	1.61E-09	1.39E-04
HMW-46	12/14/04	6.0-6.5	PSC	ASTM-D 5084	- -	- -	6.6E-05	- -	2.17E-06	1.87E-01
Overall Average							5.70E-05	- -	1.87E-06	1.62E-01
Overall Geomean							2.77E-06	- -	9.07E-08	7.84E-03

NOTES:
ft bgs = feet below ground surface
S = Slug test hydraulic conductivity testing method
Bouwer, H. and R.C. Rice. 1976. A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrated Wells. Water Resources Research, Vol. 12, no.3, pp. 423-428.
-- = Not conducted

TABLE 2-1
HYDRAULIC CONDUCTIVITY/PERMEABILITY ANALYSIS RESULTS - EPA Stratum
The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois

1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

SAMPLE			SAMPLE ANALYSIS								
Boring / Well ID	Date of Collection/ Test	Sample/ Screen Depth (ft bgs)	Tested By	Analytical Method	Falling Head Test Hydraulic Conductivity (cm/sec)	Rising Head Test Hydraulic Conductivity (cm/sec)	Permeability (K) (cm/sec)	Average Hydraulic Conductivity (cm/sec)	Average Hydraulic Conductivity (ft/sec)	Average Hydraulic Conductivity (ft/day)
HMW-49C	07/28/05	29.9'-39.0'	Clayton	Bouwer & Rice	S 2.21E-05	S 8.51E-06	- -	1.53E-05	5.02E-07	4.34E-02
HMW-50B	07/27/05	35.0'-39.6'	Clayton	Bouwer & Rice	S 3.96E-04	S 3.60E-04	- -	3.78E-04	1.24E-05	1.07E+00
Overall Average								1.97E-04	6.45E-06	5.57E-01
Overall Geomean								7.61E-05	2.50E-06	2.16E-01

NOTES:
ft bgs = feet below ground surface
S = Slug test hydraulic conductivity testing method
Bouwer, H. and R.C. Rice. 1976. A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrated Wells. Water Resources Research, Vol. 12, no.3, pp. 423-428.
-- = Not conducted

TABLE 2-1
HYDRAULIC CONDUCTIVITY/PERMEABILITY ANALYSIS RESULTS - Main Sand Stratum
The Hartford Area Hydrocarbon Plume Site, Hartford, Illinois

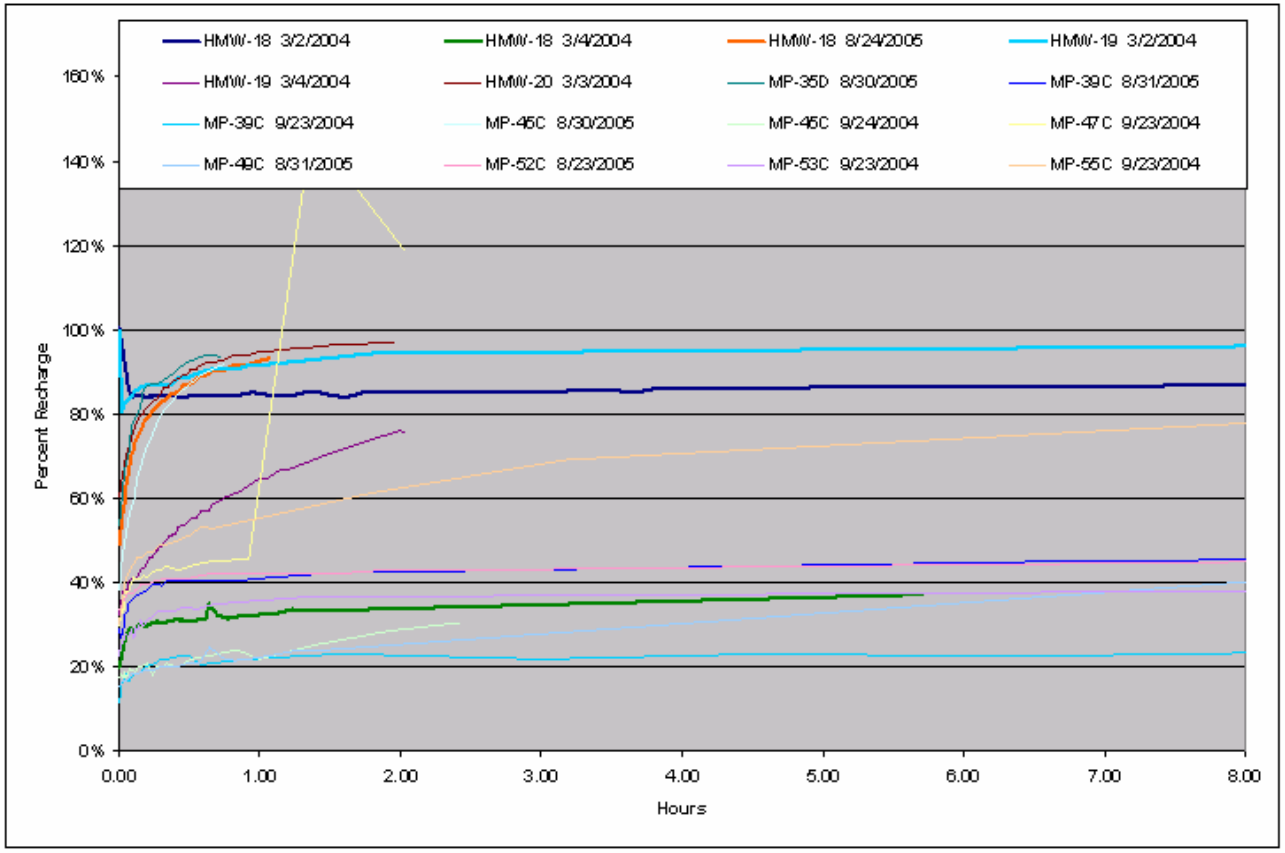
1190505040 -- Madison County -- ILR 000128249
The Hartford Working Group / Hartford, Illinois

SAMPLE			SAMPLE ANALYSIS								
Boring/Well ID	Date of Collection/ Test	Sample/ Screen Depth (ft bgs)	Tested By	Analytical Method	Falling Head Test Hydraulic Conductivity (cm/sec)	Rising Head Test Hydraulic Conductivity (cm/sec)	Permeability (K) (cm/sec)	Average Hydraulic Conductivity (cm/sec)	Average Hydraulic Conductivity (ft/sec)	Average Hydraulic Conductivity (ft/day)
HMW-25	12/19/03	24.0-38.7	Clayton	Bouwer & Rice	S 1.39E-02	S 1.78E-02	- -	1.59E-02	5.20E-04	4.49E+01
HMW-27	12/19/03	25.0-39.7	Clayton	Bouwer & Rice	S 1.48E-02	S 2.92E-02	- -	2.20E-02	7.22E-04	6.24E+01
HMW-28	12/19/03	25.0-39.7	Clayton	Bouwer & Rice	S 3.31E-02	S 2.81E-02	- -	3.06E-02	1.00E-03	8.67E+01
HMW-29	12/19/03	25.0-39.7	Clayton	Bouwer & Rice	S 2.25E-02	S 1.40E-02	- -	1.83E-02	5.99E-04	5.17E+01
Overall Average								2.17E-02	7.11E-04	6.14E+01
Overall Geomean								2.10E-02	6.89E-04	5.95E+01

NOTES:
ft bgs = feet below ground surface
S = Slug test hydraulic conductivity testing method
Bouwer, H. and R.C. Rice. 1976. A Slug Test Method for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrated Wells. Water Resources Research, Vol. 12, no.3, pp. 423-428.
-- = Not conducted

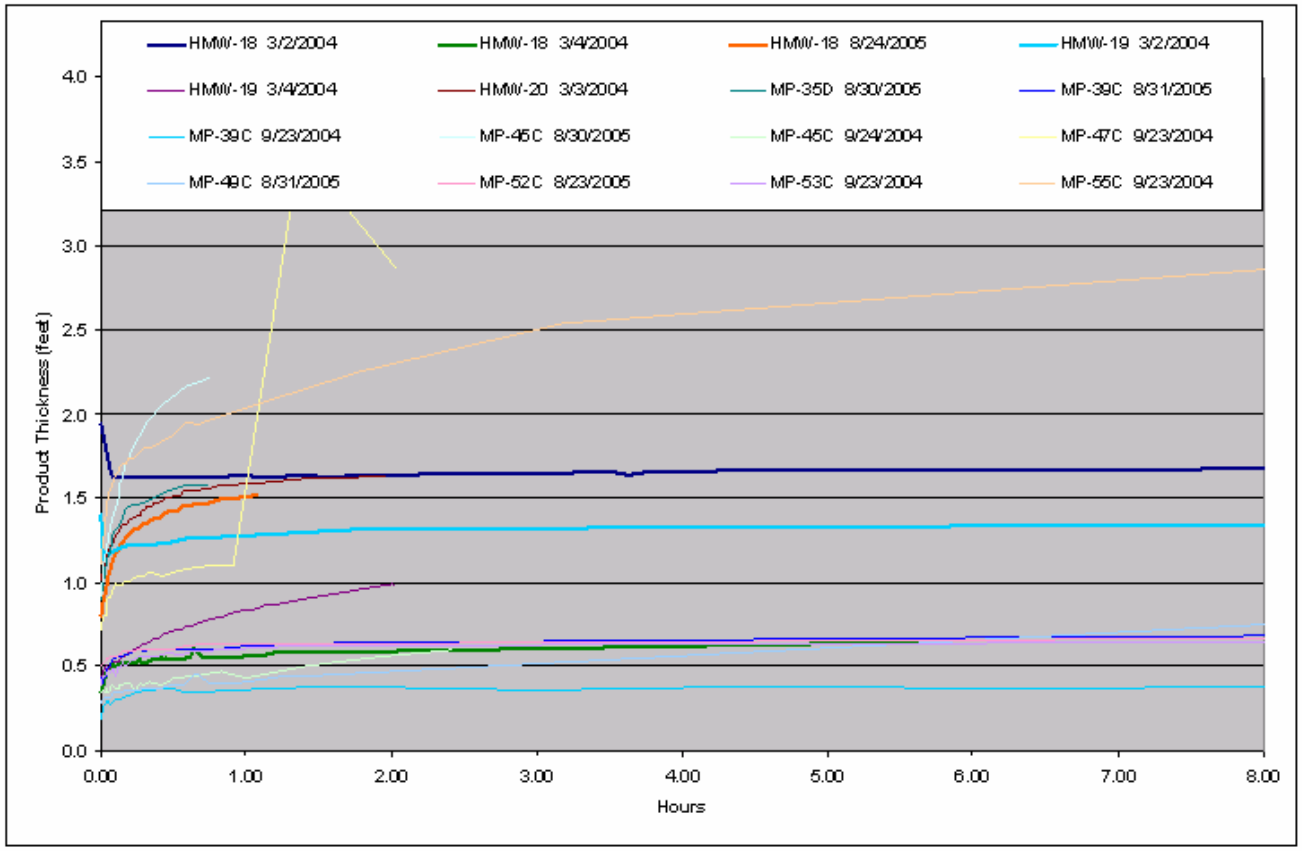
GRAPH 3-1
Baildown Test Recharge as a Percentage of Original Product Thickness
Hartford Area Hydrocarbon Plume Site

The Hartford Working Group / Hartford, Illinois
1190505040 -- Madison County -- ILR 000128249



GRAPH 3-2
Baildown Test Recharge as Product Thickness in Feet
Hartford Area Hydrocarbon Plume Site

The Hartford Working Group / Hartford, Illinois
1190505040 -- Madison County -- ILR 000128249

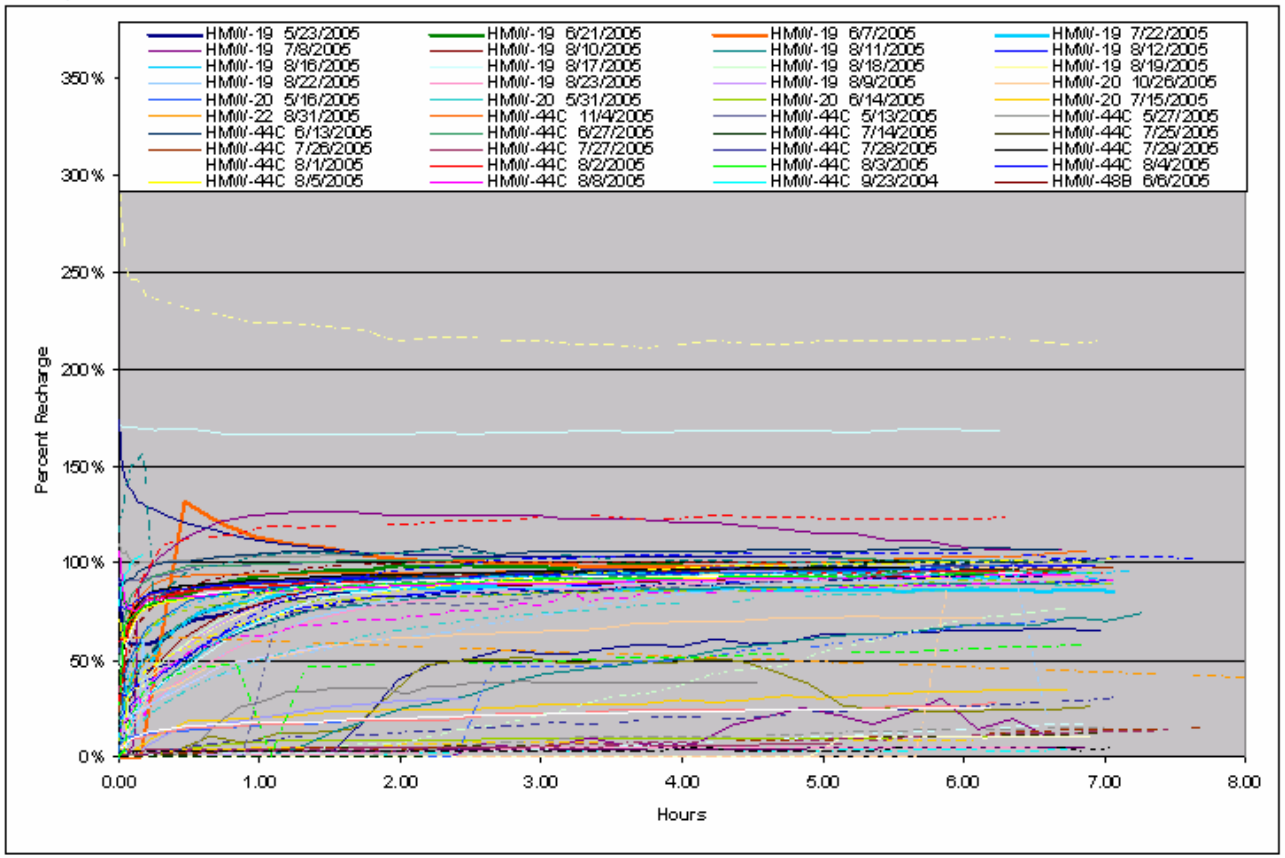


GRAPH 3-3

HiVac Event Recharge as a Percentage of Original Product Thickness

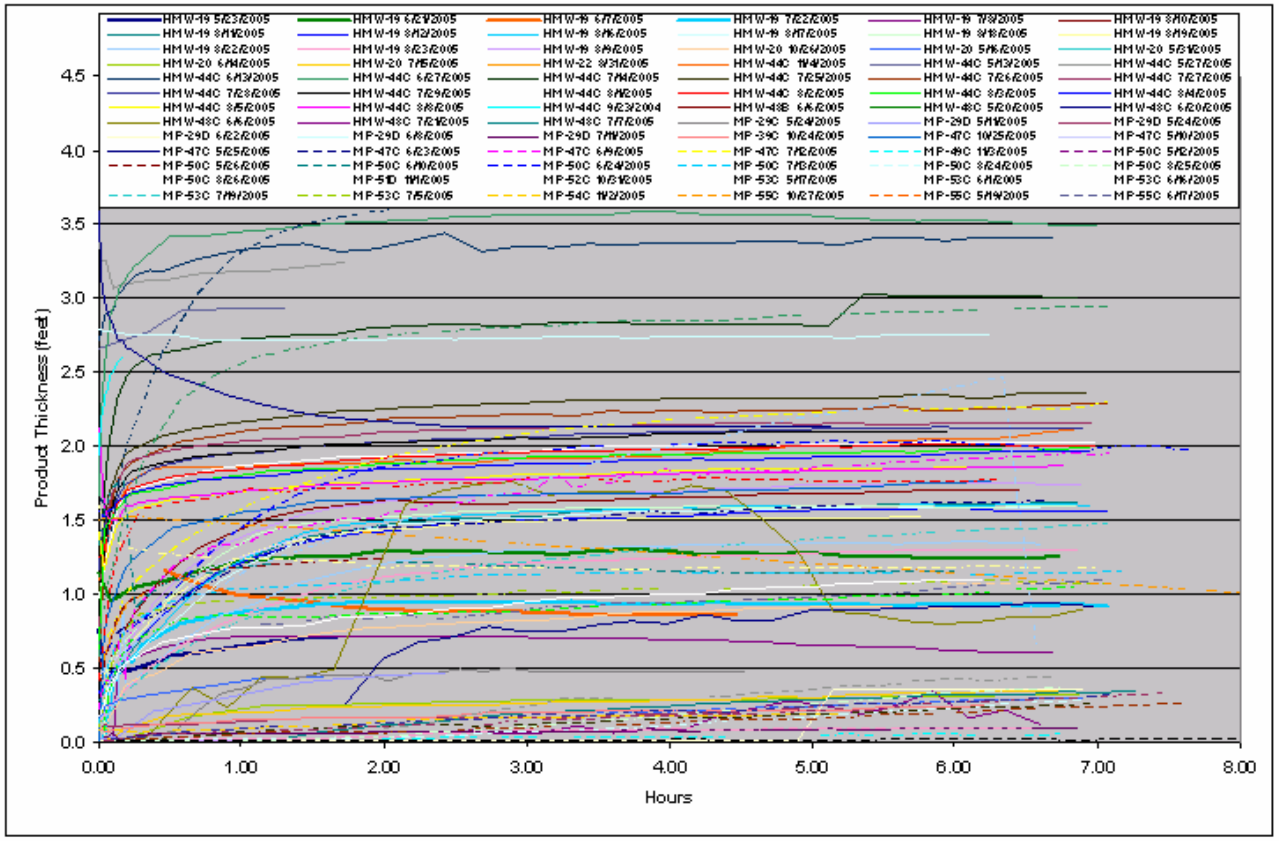
Hartford Area Hydrocarbon Plume Site

The Hartford Working Group / Hartford, Illinois
1190505040 -- Madison County -- ILR 000128249



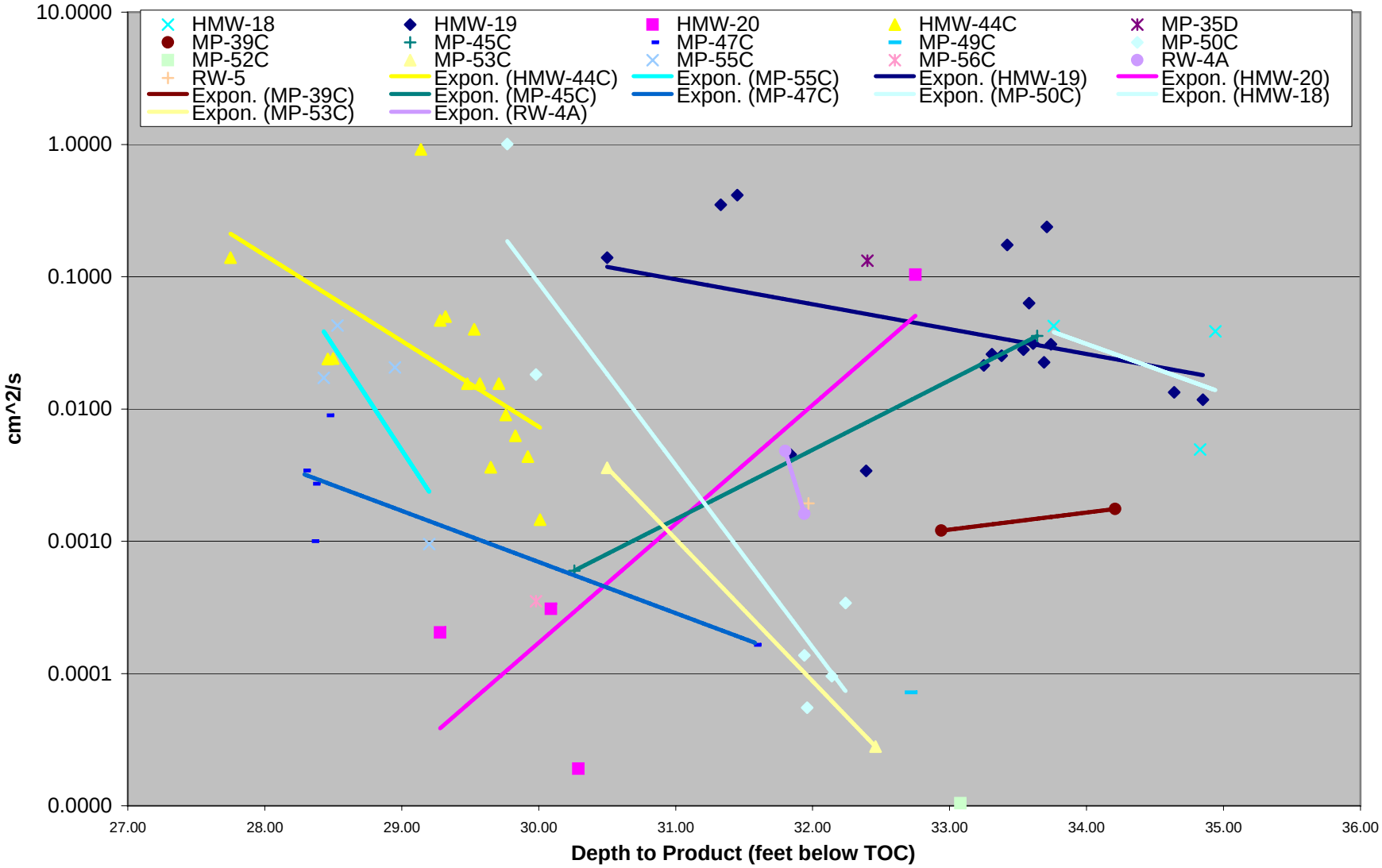
GRAPH 3-4
HiVac Event Recharge as Product Thickness in Feet
Hartford Area Hydrocarbon Plume Site

The Hartford Working Group / Hartford, Illinois
1190505040 -- Madison County -- ILR 000128249



GRAPH 3-5
LNAPL Transmissivity by Well vs. Depth to Product and Trends
Hartford Area Hydrocarbon Plume Site

The Hartford Working Group / Hartford, Illinois
1190505040 -- Madison County -- ILR 000128249



Appendix A: Historical Aerial Photographs

Figures A-1 through A-9 present a series of historical aerial photographs of the Site.

Legend

Pipeline Installation Date

Early 1940s

4- 8" Pipelines & 3- 8" & 1-3" Pipelines Source:
Wood River Refining Corp. Drwg. # WR00-RB1 1943

Aerial Photo Number - Illinois Department of Transportation
ASCS SJ-2B-146 9/10/41

HISTORIC AERIAL - SEPTEMBER 1941

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

0 60 120 240 360 480 Feet

FIGURE A-1

BUREAU VERITAS

Legend

Pipeline Installation Date

Early 1940s

Early 1950s

4-8" Pipelines & 3-8" & 1-3" Pipelines Source:
Wood River Refining Corp. Drwg. # WR00-RB1 1943

2-10" Pipelines & 2-10" & 1-14" Pipelines Source:
Wood River Refining Corp. Drwg. # WR017-FM3 1952

Aerial Photo Number - Illinois Department of Transportation
ASCS SJ-3P-112 8/23/55

HISTORIC AERIAL - AUGUST 1955
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

0 60 120 240 360 480 Feet

FIGURE A-2

BUREAU VERITAS

Legend

Pipeline Installation Date

Early 1940s — 4-8" Pipelines & 3-8" & 1-3" Pipelines Source: Wood River Refining Corp. Drwg. # WR00-RB1 1943

Early 1950s — 2-10" Pipelines & 2-10" & 1-14" Pipelines Source: Wood River Refining Corp. Drwg. # WR017-FM3 1952

Aerial Photo Number - Illinois Department of Transportation
ASCS SJ-2JJ-116 8/28/68

HISTORIC AERIAL - AUGUST 1968

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

0 60 120 240 360 480 Feet

FIGURE A-3

BUREAU VERITAS
Chevron Group Services, Inc
A Bureau Veritas Company

Legend

Product Releases
Sources:
Illinois EPA ERU, IEMA, NRC,E-S,Inc

Release Date
Product Releases located by best available data

Pipeline Installation Date
Early 1940s
Early 1950s

4-8" Pipelines & 3-8" & 1-3" Pipelines Source:
Wood River Refining Corp. Drwg. # WR00-RB1 1943

2-10" Pipelines & 2-10" & 1-14" Pipelines Source:
Wood River Refining Corp. Drwg. # WR017-FM3 1952

Aerial Photo Number - Illinois Department of Transportation S38-17119 5/6/74

HISTORIC AERIAL - MAY 1974

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

0 60 120 240 360 480 Feet

FIGURE A-4

BUREAU VERITAS

Legend

Gauged Product
Source:
John Mathes & Assoc., Inc.

1978 Product Contours

1978 Gauged Extent

Pipeline Installation Date

Early 1940s

Early 1950s

4-8" Pipelines & 3-8" & 1-3" Pipelines Source:
Wood River Refining Corp. Drwg. # WR00-RB1 1943

2-10" Pipelines & 2-10" & 1-14" Pipelines Source:
Wood River Refining Corp. Drwg. # WR017-FM3 1952

Aerial Photo Number - Illinois Department of Transportation USDA-40-17119 6/9/78

HISTORIC AERIAL - JUNE1978

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

0 60 120 240 360 480 Feet

FIGURE A-5

BUREAU VERITAS
Clayton Group Services, Inc
A Bureau Veritas Company

Legend

Gauged Product
Source:
John Mathes & Assoc., Inc.

1982 Product Contours

1982 Gauged Extent

Pipeline Installation Date

Early 1940s — 4-8" Pipelines & 3-8" & 1-3" Pipelines Source: Wood River Refining Corp. Drwg. # WR00-RB1 1943

Early 1950s — 2-10" Pipelines & 2-10" & 1-14" Pipelines Source: Wood River Refining Corp. Drwg. # WR017-FM3 1952

Early 1980s — 2-10" & 1-14" Pipelines Source: Clark Oil & Refining Corp. Drwg. # WR043-FB-29 1982

Aerial Photo Number - Illinois Department of Transportation 3890-44-IL476 4/7/88

HISTORIC AERIAL - APRIL 1988

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

0 60 120 240 360 Feet

FIGURE A-6

BUREAU VERITAS

Legend

Gauged Product
Source: Engineering-Science, Inc.

1990 Product Contours

1990 Gauged Extent

Pipeline Installation Date

Early 1940s — 4-8" Pipelines & 3-8" & 1-3" Pipelines Source: Wood River Refining Corp. Drwg. # WR00-RB1 1943

Early 1950s — 2-10" Pipelines & 2-10" & 1-14" Pipelines Source: Wood River Refining Corp. Drwg. # WR017-FM3 1952

Early 1980s — 2-10" & 1-14" Pipelines Source: Clark Oil & Refining Corp. Drwg. # WR043-FB-29 1982

Aerial Photo Number - Illinois Department of Transportation NAPP93 5798-253 3/7/93

HISTORIC AERIAL - MARCH 1993

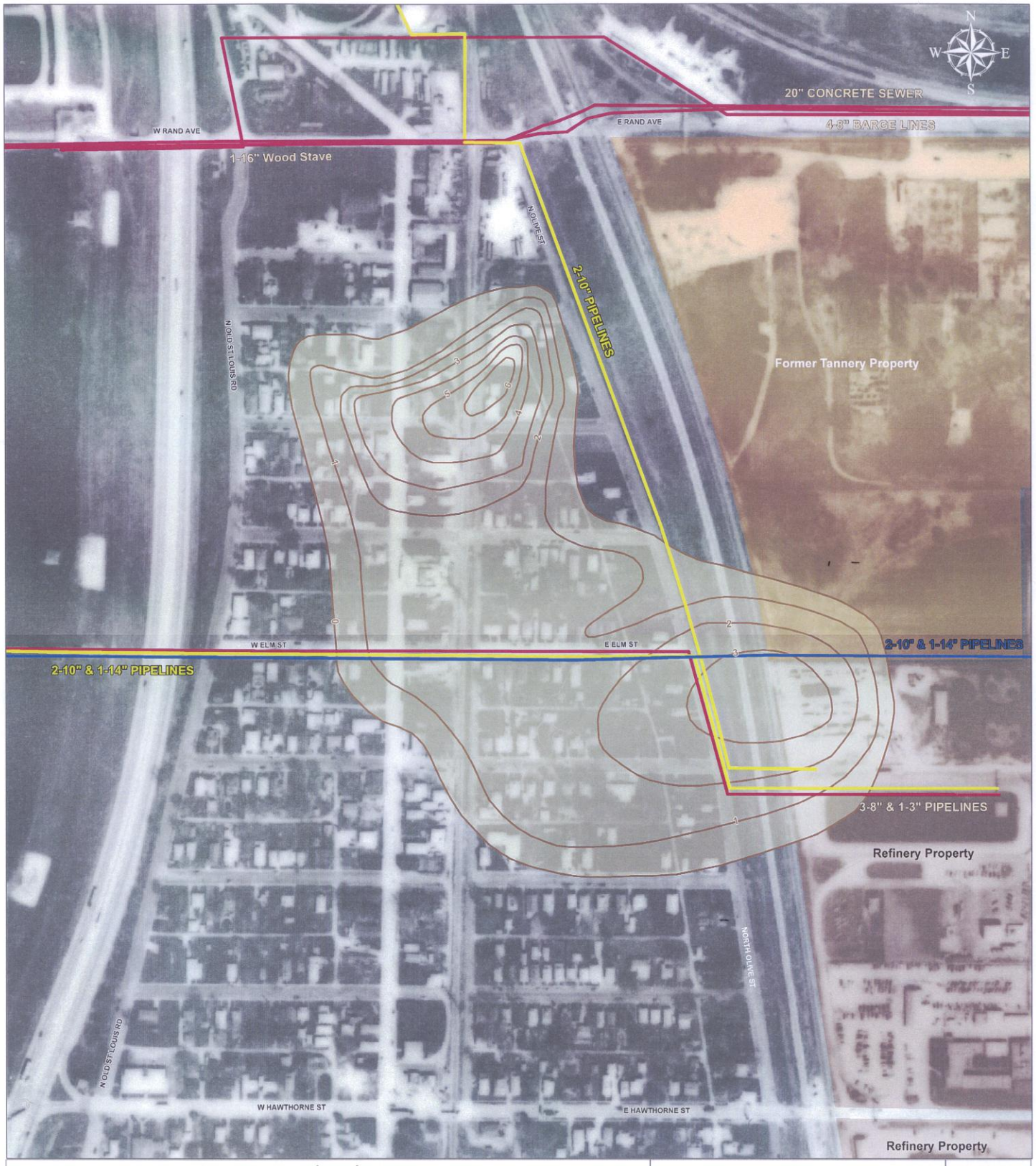
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

0 60 120 240 360 480 Feet

FIGURE A-7

BUREAU VERITAS

Clayton Group Services, Inc.
A Bureau Veritas Company



Legend

Gauged Product
Source: Engineering-Science, Inc.

1990 Product Contours

1990 Gauged Extent

Pipeline Installation Date

Early 1940s

Early 1950s

Early 1980s

4-8" Pipelines & 3-8" & 1-3" Pipelines Source: Wood River Refining Corp. Drwg. # WR00-RB1 1943

2-10" Pipelines & 2-10" & 1-14" Pipelines Source: Wood River Refining Corp. Drwg. # WR017-FM3 1952

2-10" & 1-14" Pipelines Source: Clark Oil & Refining Corp. Drwg. # WR043-FB-29 1982

Aerial Photo Number - Illinois Department of Transportation NAPP 9-44-476 4/2/98

HISTORIC AERIAL - APRIL 1998

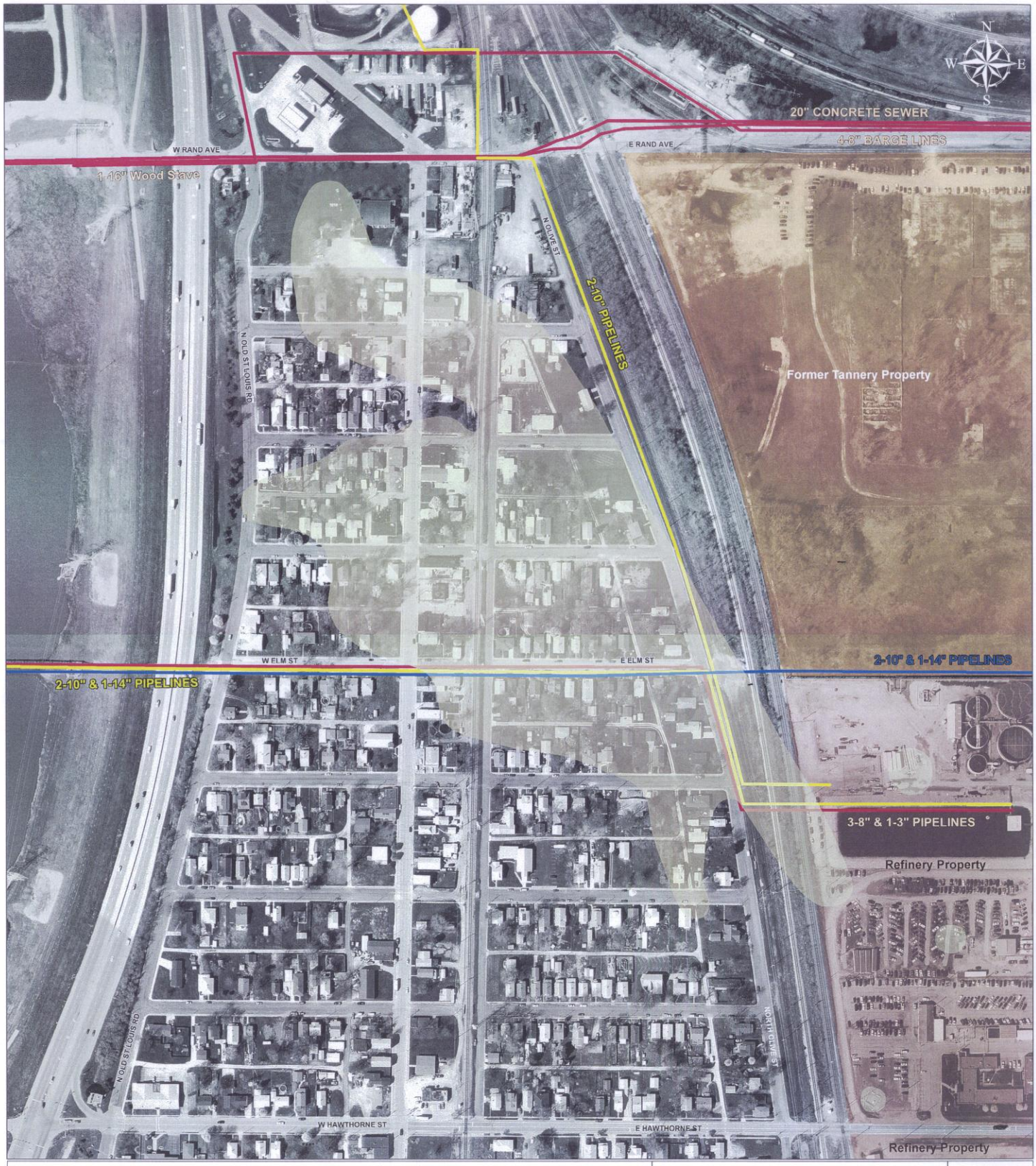
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

0 60 120 240 360 Feet

FIGURE A-8

BUREAU VERITAS

Clayton Group Services, Inc.
A Bureau Veritas Company



Legend

Gauged Product (Source: Clayton Group Services, Inc.)	Pipeline Installation Date	
	Early 1940s	4-8" Pipelines & 3-8" & 1-3" Pipelines Source: Wood River Refining Corp. Drwg. # WR00-RB1 1943
	Early 1950s	2-10" Pipelines & 2-10" & 1-14" Pipelines Source: Wood River Refining Corp. Drwg. # WR017-FM3 1952
10/05 Gauged Extent	Early 1980s	2-10" & 1-14" Pipelines Source: Clark Oil & Refining Corp. Drwg. # WR043-FB-29 1982

Map Created from Aerial Photogrammetry dated April, 2004 by Continental Mapping Consultants, Inc.

HISTORIC AERIAL - APRIL 2004

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

0 60 120 240 360 480 Feet

FIGURE A-9

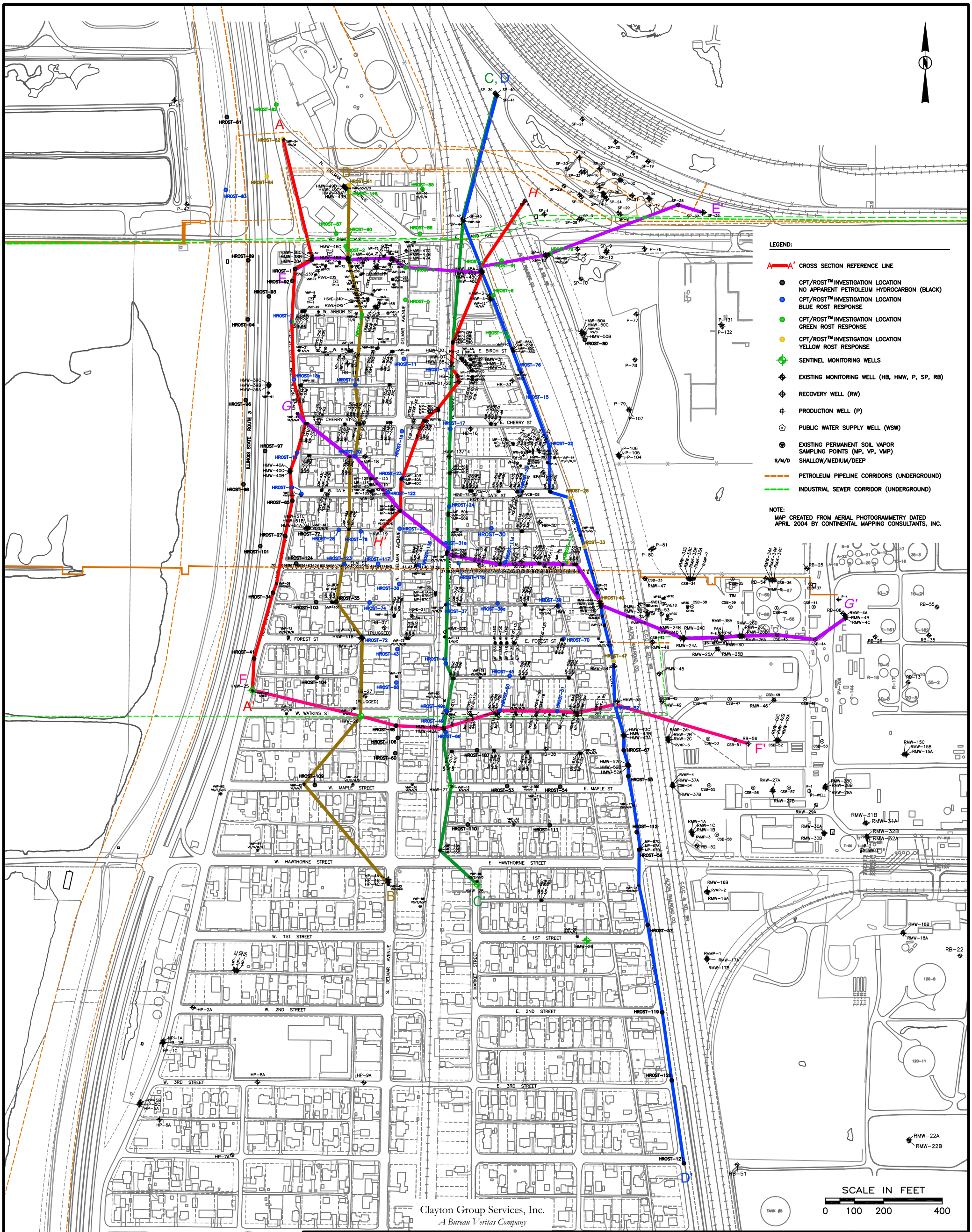
BUREAU VERITAS

Clayton Group Services, Inc
A Bureau Veritas Company

Appendix B: Geologic Cross Sections

Geologic cross sections within Hartford have been prepared based on a review of available boring logs, CPT/ROST stratigraphic profiles and geotechnical data. Eight detailed cross-section reference locations are shown in Figure B-1. Geologic cross sections A-A' through H-H' are shown in Figures B-2 through B-5.

As discussed in Section 2.0, the geologic units consist of alternating alluvial deposits of clay and silt overlying the regionally extensive Main Sand. The permeable zones within the alluvial deposits have been identified (in descending order) as the North Olive Stratum, the Rand Stratum, and the EPA Stratum. These deposits are overlain and bounded by several clay deposits identified (in descending order) as the A Clay, B Clay, C Clay, and D Clay Strata to simplify the identification of the individual clay strata. The Main Silt, a portion of the Main Sand, is (1) compositionally finer grained, and (2) laterally grades into the North Olive and Rand Strata (where the B and/or C Clay Strata are absent). The Main Silt overlies and is hydraulically connected to the Main Sand.



DESIGN BY:	
CHECKED BY:	
DRAWN BY:	BCP
DATE:	11-15-05
SCALE:	AS SHOWN
CAD NO.:	0309514020
PROJECT NO.:	15-03095.14

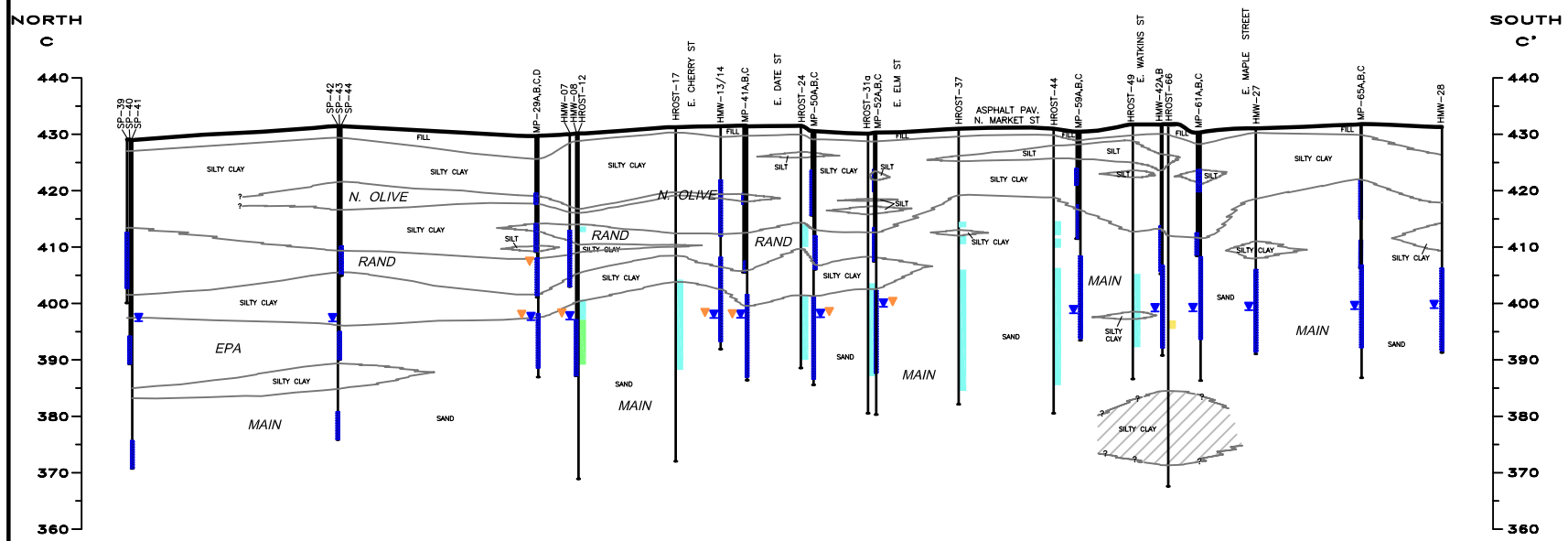
BUREAU VERITAS

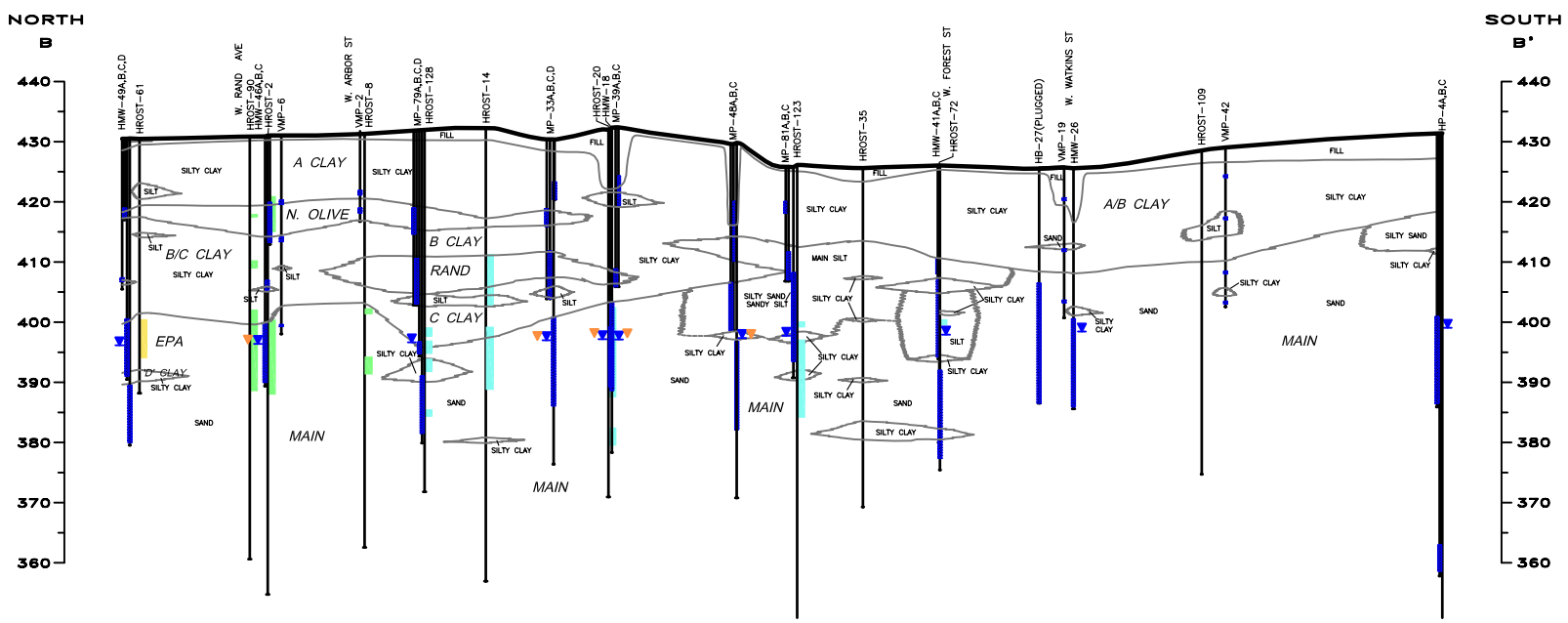
CROSS SECTION REFERENCE MAP

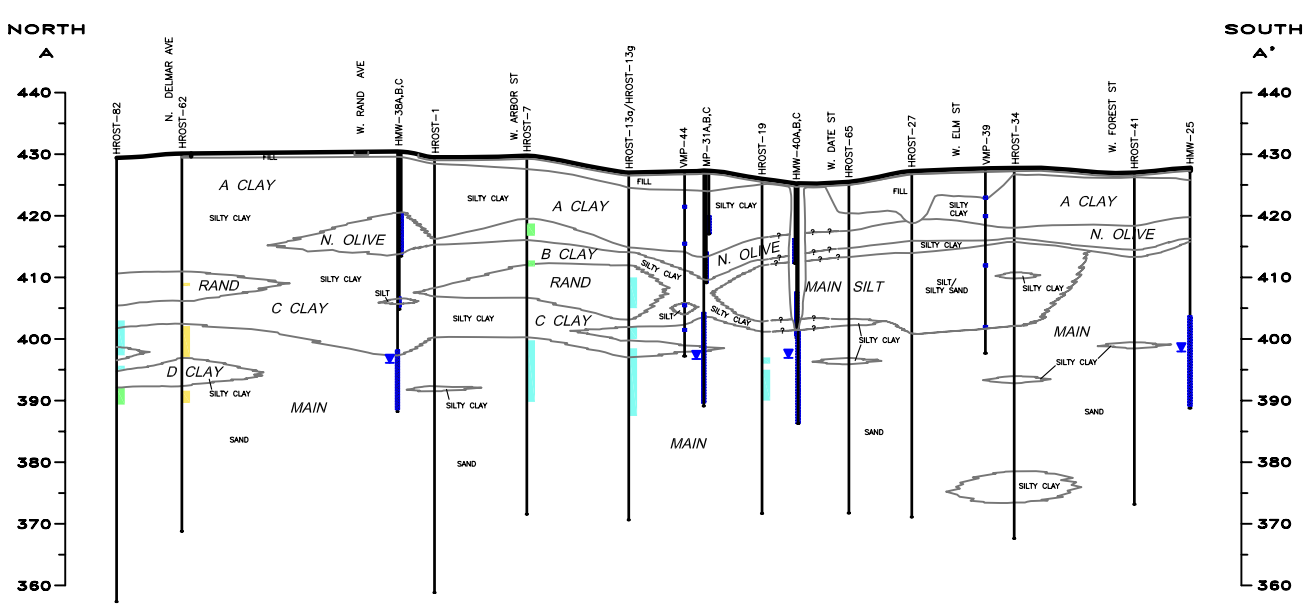
THE HARTFORD AREA HYDROCARBON PLUME SITE
THE HARTFORD WORKING GROUP
HARTFORD, ILLINOIS

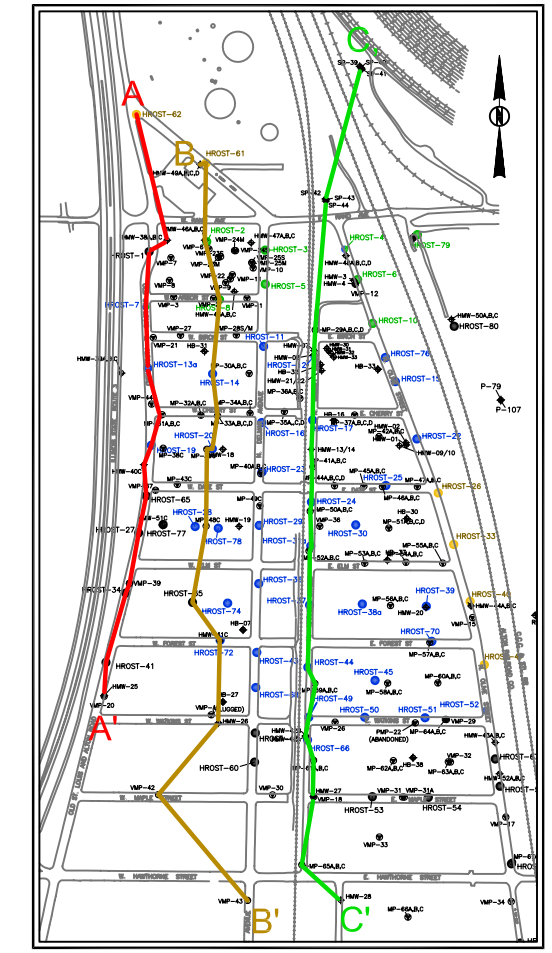
FIGURE

B-1









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- STORM SEWER INLET
- SCREEN INTERVAL

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SCALE IN FEET

0 150 300 600

VERTICAL SCALE: 1' = 20'

Clayton Group Services, Inc.
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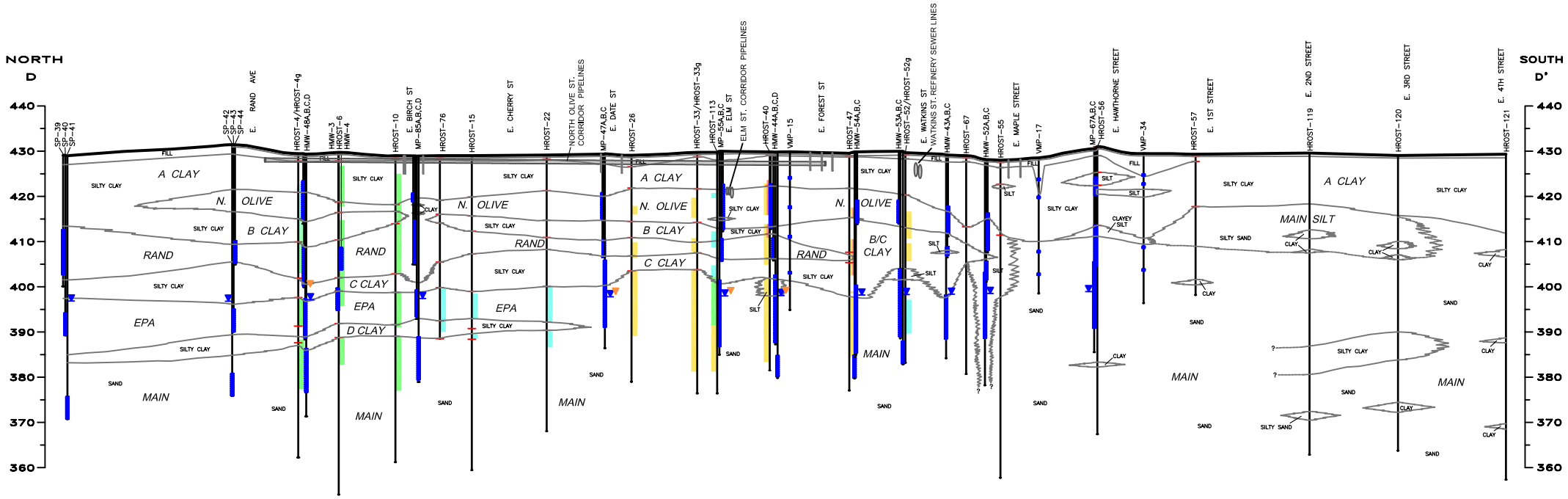
DRAWN BY	BCP
DATE	11–15–05
SCALE	AS SHOWN
CAD NO.	15–0309514020B
PRJ NO.	15–03095.14

CROSS SECTIONS A–A', B–B', AND C–C'

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

FIGURE

B–2



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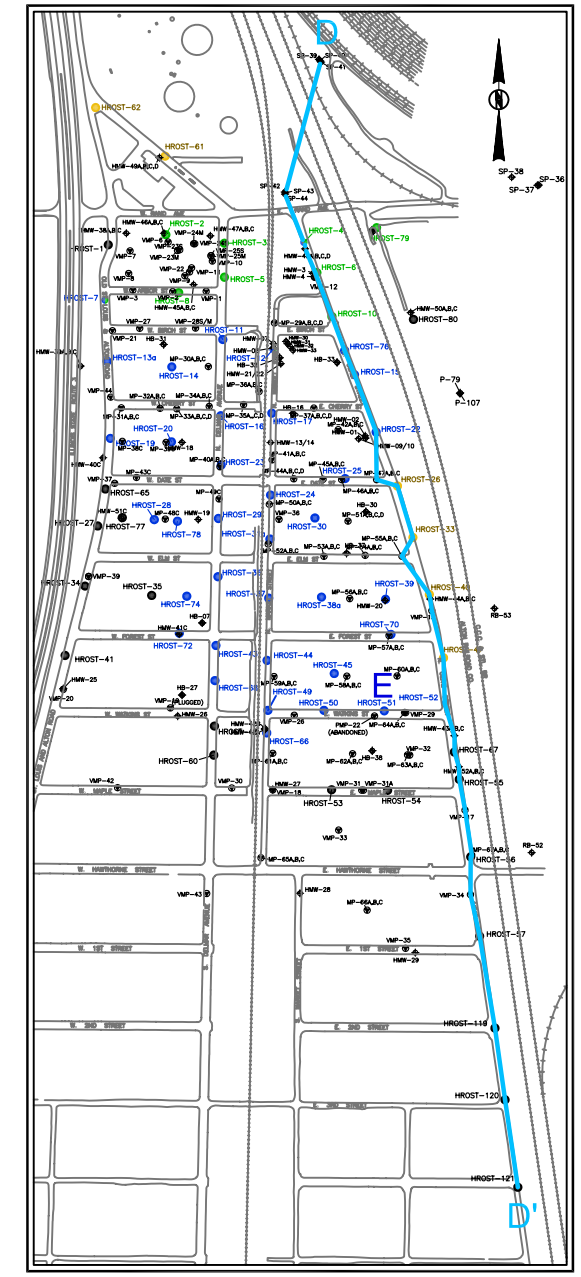

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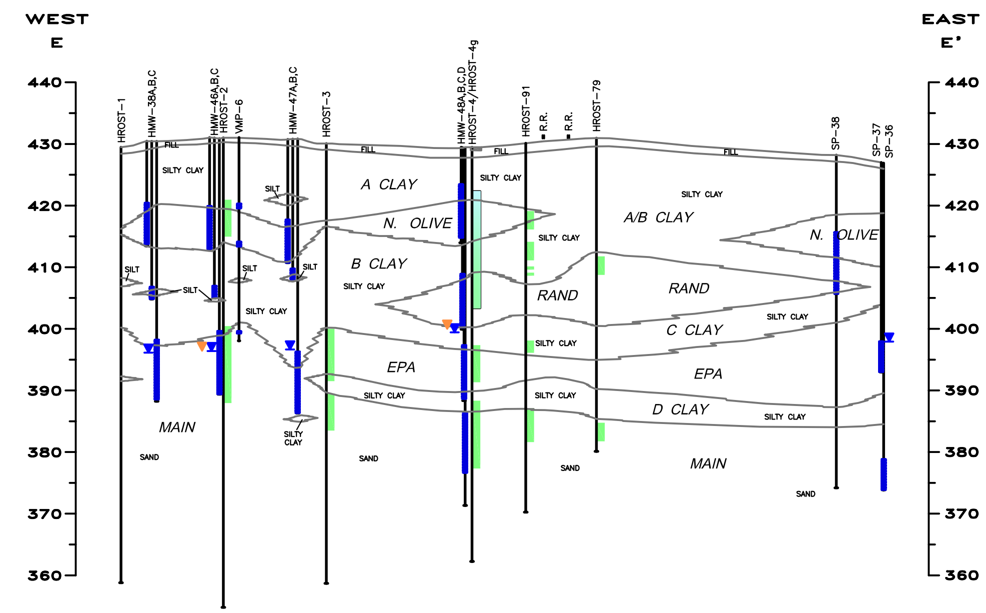
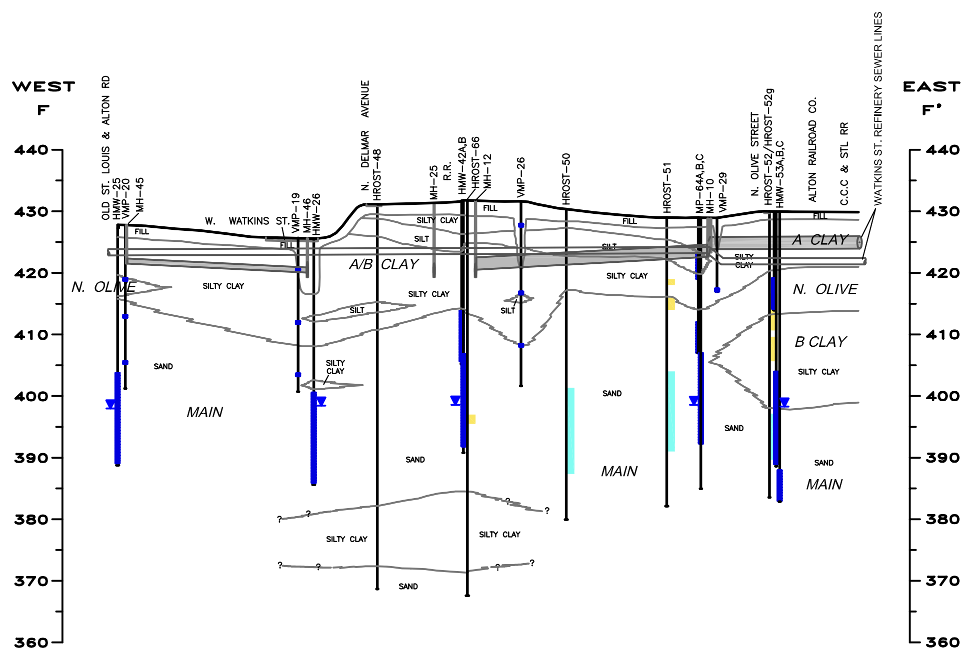
CHECK BY HLM/KDC	CROSS SECTION D–D'		FIGURE
DRAWN BY BCP			
DATE 11–15–05	THE HARTFORD AREA HYDROCARBON PLUME SITE		B–3
SCALE AS SHOWN	THE HARTFORD WORKING GROUP		
CAD NO. 0309514020C	HARTFORD, ILLINOIS		
PRJ NO. 15–03095.14			

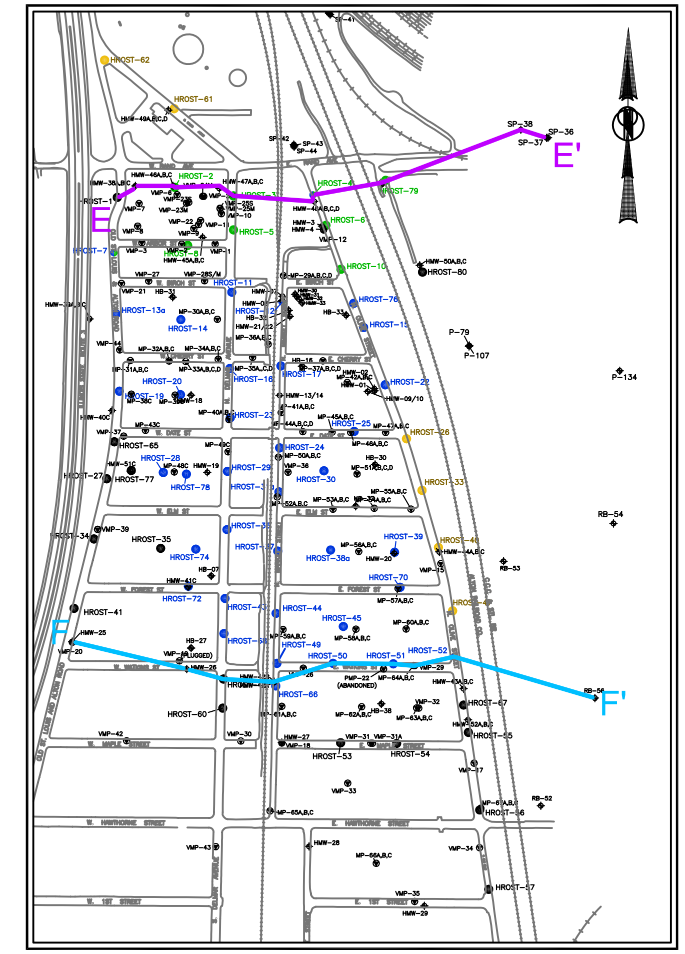




SCALE IN FEET

0 150 300 600

VERTICAL SCALE: 1' = 20'



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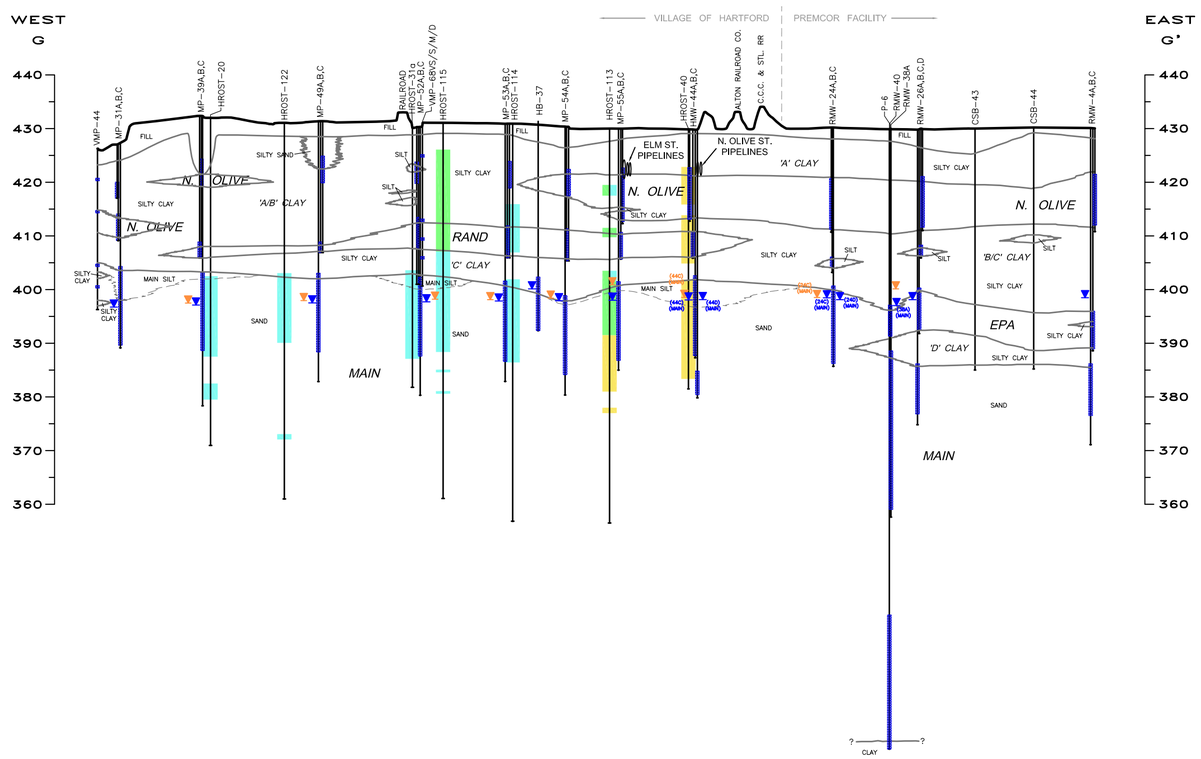
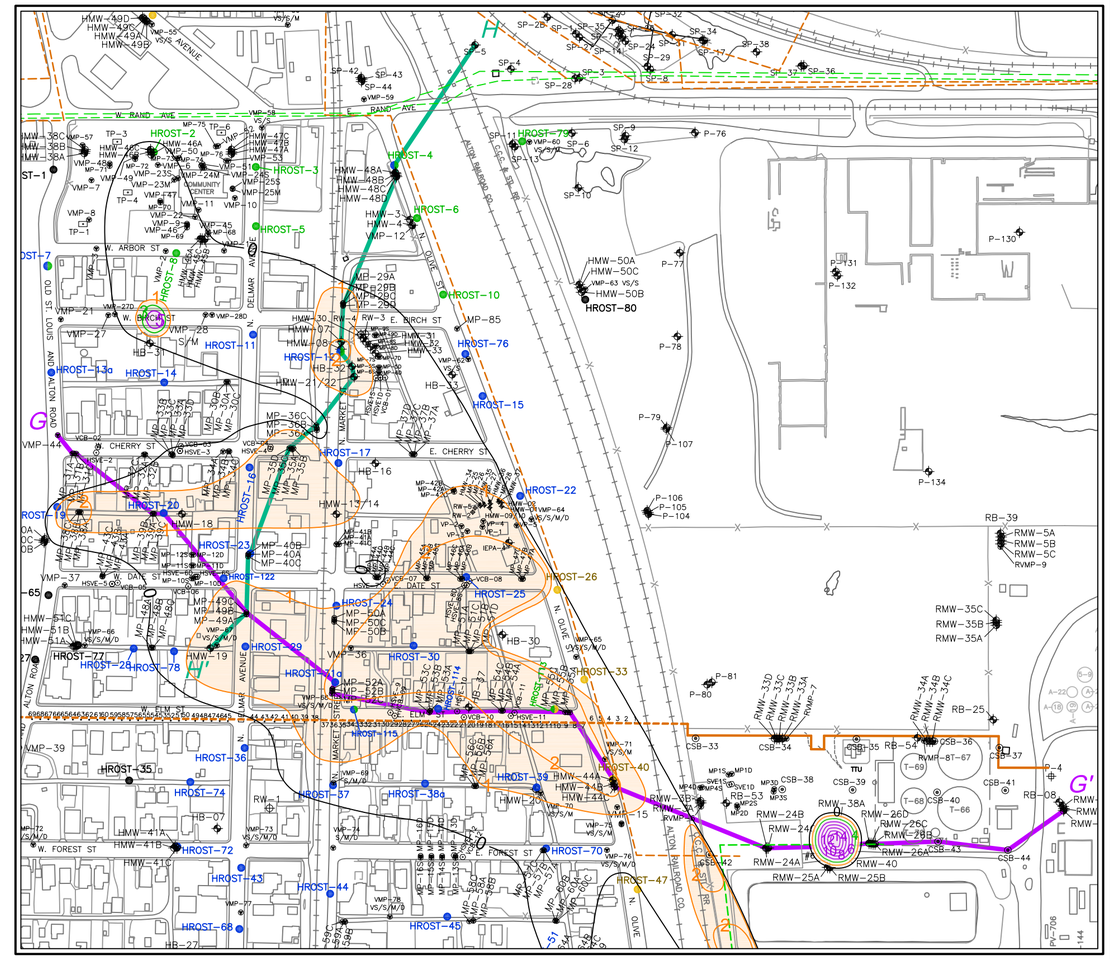
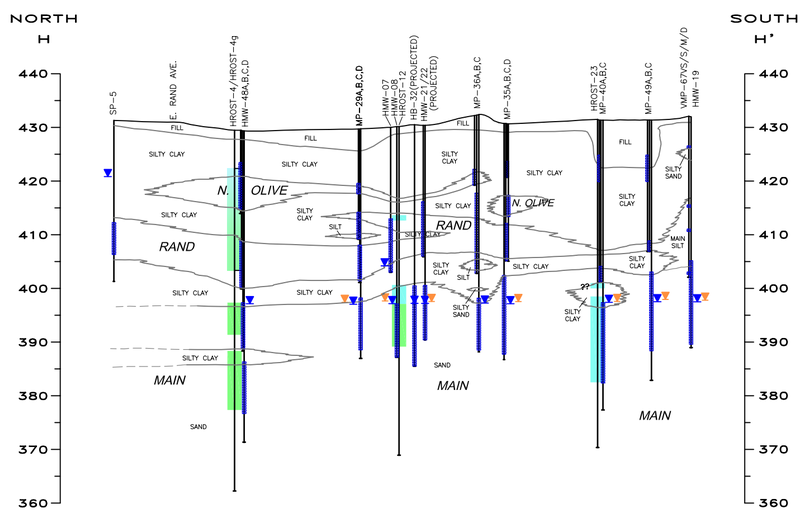
CHECK BY KDC DRAWN BY BCP DATE 11-15-05 SCALE AS SHOWN CAD NO. 03095140200 PRJ NO. 15-03095.14	CROSS SECTIONS E-E' AND F-F' THE HARTFORD AREA HYDROCARBON PLUME SITE THE HARTFORD WORKING GROUP HARTFORD, ILLINOIS	BUREAU VERITAS	FIGURE B-4





REFERENCE MAP



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SCALE IN FEET

0 150 300 600

VERTICAL SCALE = 1" = 20'

Clayton Group Services, Inc.
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CHECK BY	KDC
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DATE	11–15–05
SCALE	AS SHOWN
CAD NO.	0309514020E
PRJ NO.	15–03095.14

CROSS SECTIONS G–G' AND H–H'

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

FIGURE

B–5

Appendix C: Strata Composition

Evaluation of Geotechnical Data

Geotechnical samples were collected at various boring locations and depth intervals in Hartford to (1) evaluate the composition (e.g., gravel, sand, silt or clay), moisture content, and fraction organic carbon content of the various alluvial and clay deposits; (2) refine the geologic descriptions; and (3) assist with the interpretation and correlation of the stratigraphic units. The lithologic description and composition of the North Olive, Rand, EPA, Main Sand, and Clay strata in Hartford are summarized in the sections below.

Composition of Strata in the Village of Hartford

The average percentage of sand, silt, and clay in the North Olive Stratum is approximately 12, 71 and 17, respectively. The composition of geotechnical samples collected from the North Olive Stratum is shown in Figure C-1. The average percentage of sand, silt, and clay in the Rand Stratum is approximately 10, 70 and 20, respectively. The composition of the Rand Stratum is similar to that of the North Olive Stratum, and also that of the Main Silt in some areas. The composition of geotechnical samples collected from the Rand Stratum is shown in Figure C-2.

The average percentage of sand, silt, and clay in the EPA Stratum is approximately 68, 22 and 10, respectively. However; these quantities may be skewed (higher or lower), because the above composition is based on only three geotechnical samples collected within the limited extent of the stratum in Hartford. The composition of geotechnical samples collected from the EPA Stratum is shown in Figure C-3. The average percentage of sand, silt, and clay in the Main Silt is approximately 25, 64 and 11, respectively. The composition of geotechnical samples collected from the Main Silt is shown in Figure C-4.

The average percentage of sand, silt, and clay in the Main Sand is approximately 90, 7 and 3, respectively. The composition of geotechnical samples collected from the Main Sand is shown in Figure C-5.

The clay strata consists of an average sand, silt, and clay content of approximately 6, 44 and 50 percent, respectively. The composition of geotechnical samples collected from all of the clay strata is shown in Figure C-6.

Figure C-1

Composition of North Olive Stratum Geotechnical Samples
Village of Hartford

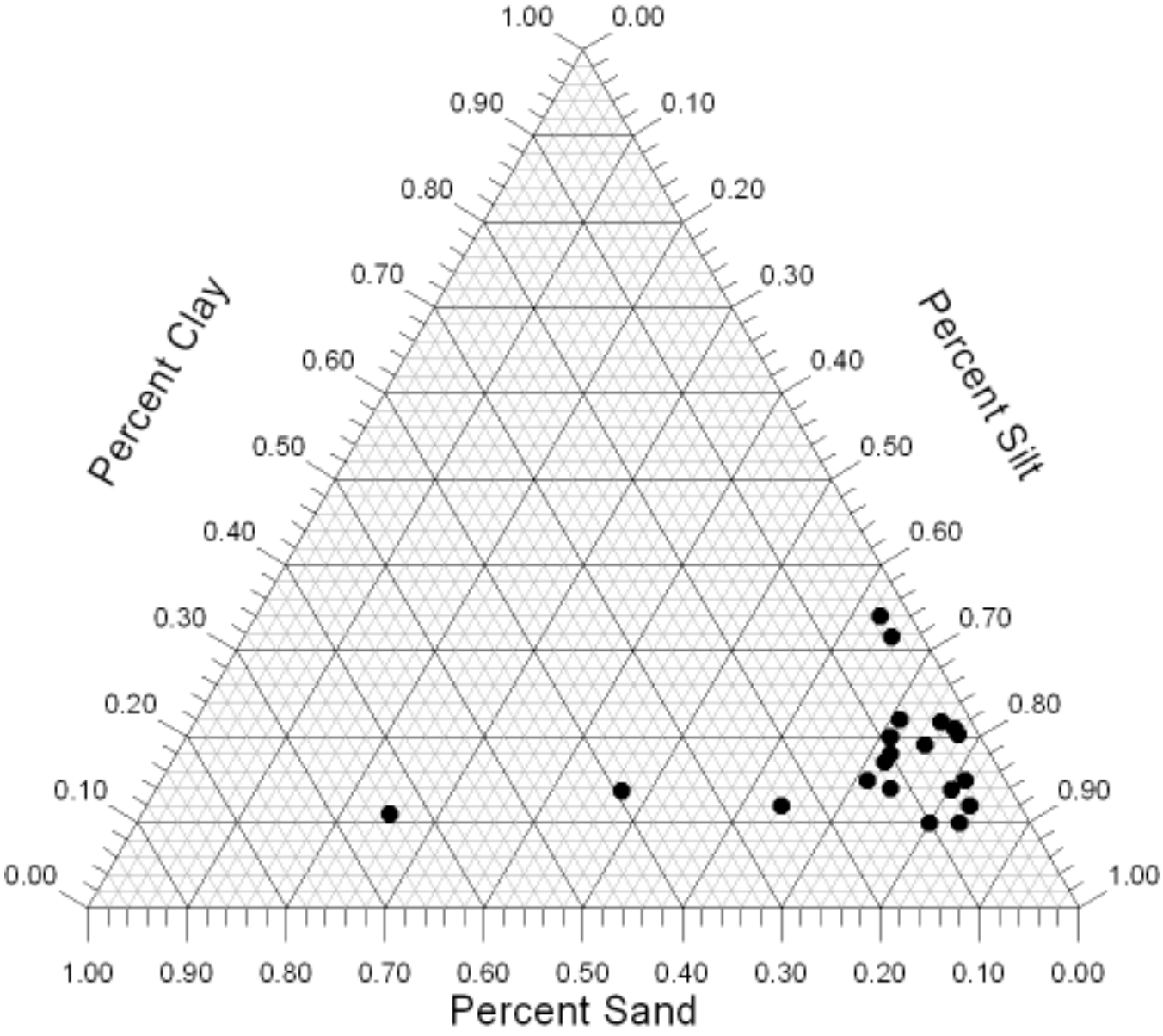


Figure C-2

Composition of Rand Stratum Geotechnical Samples
Village of Hartford

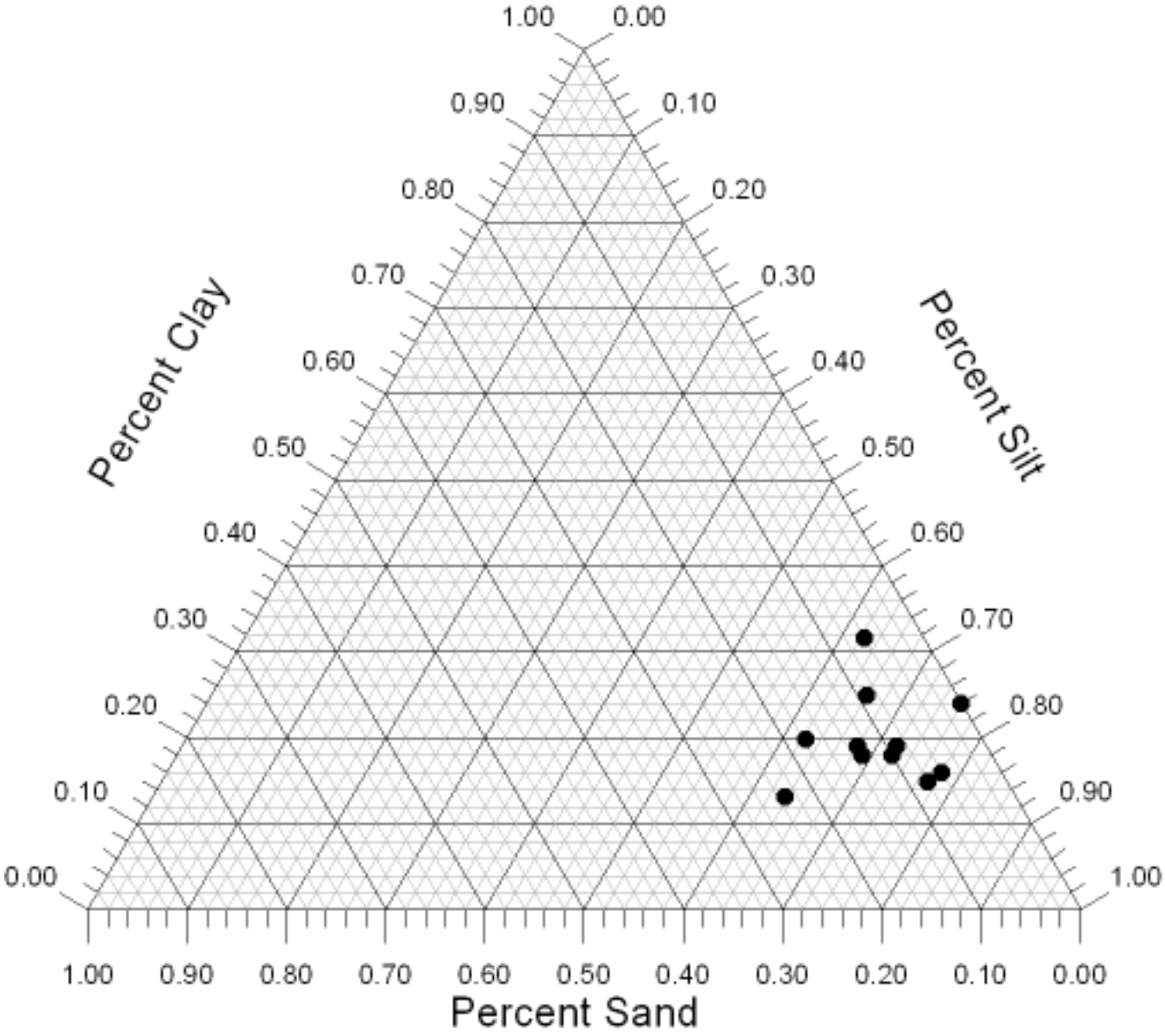


Figure C-3

Composition of EPA Stratum Geotechnical Samples
Village of Hartford

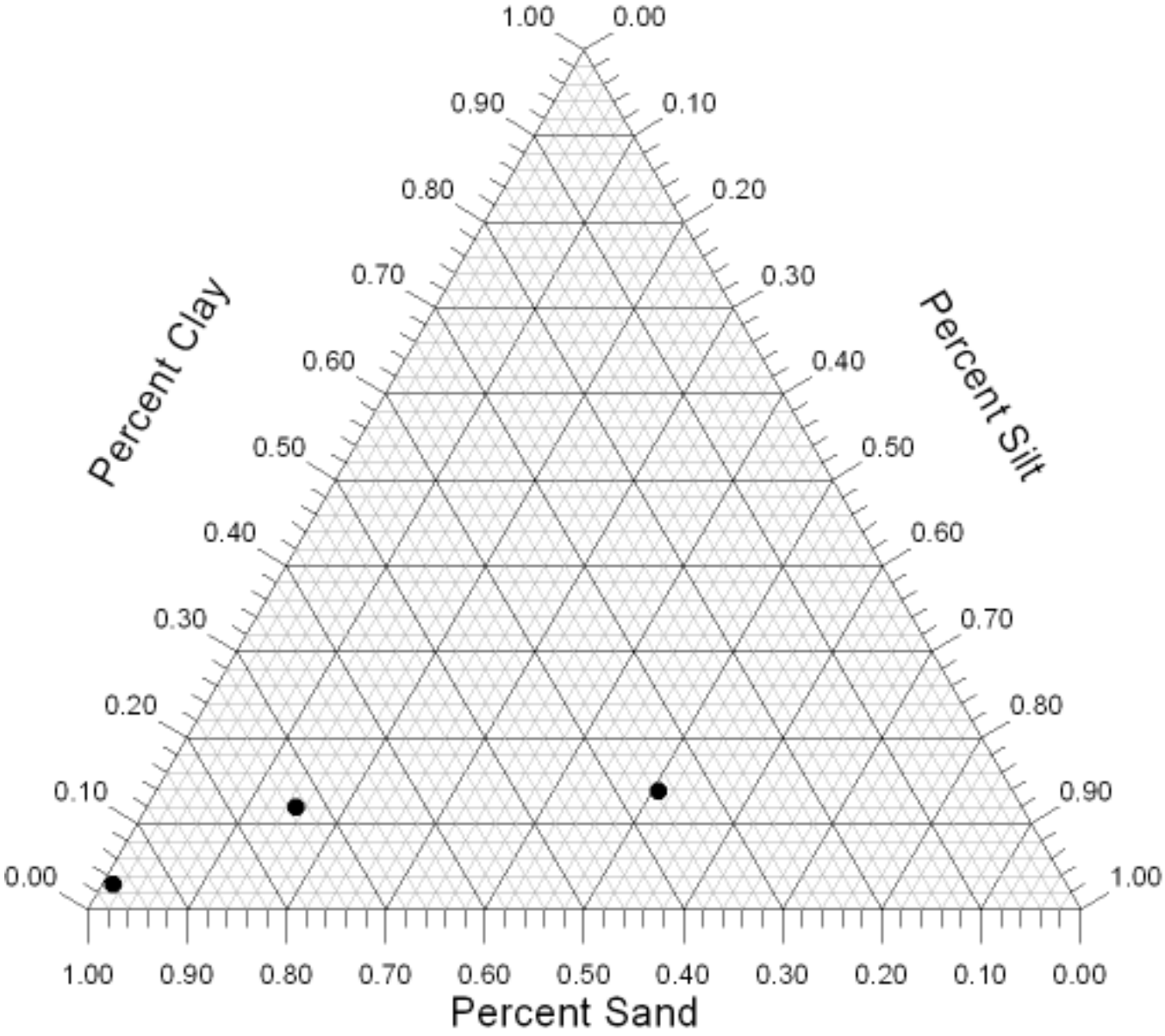


Figure C-4

Composition of Main Silt Geotechnical Samples
Village of Hartford

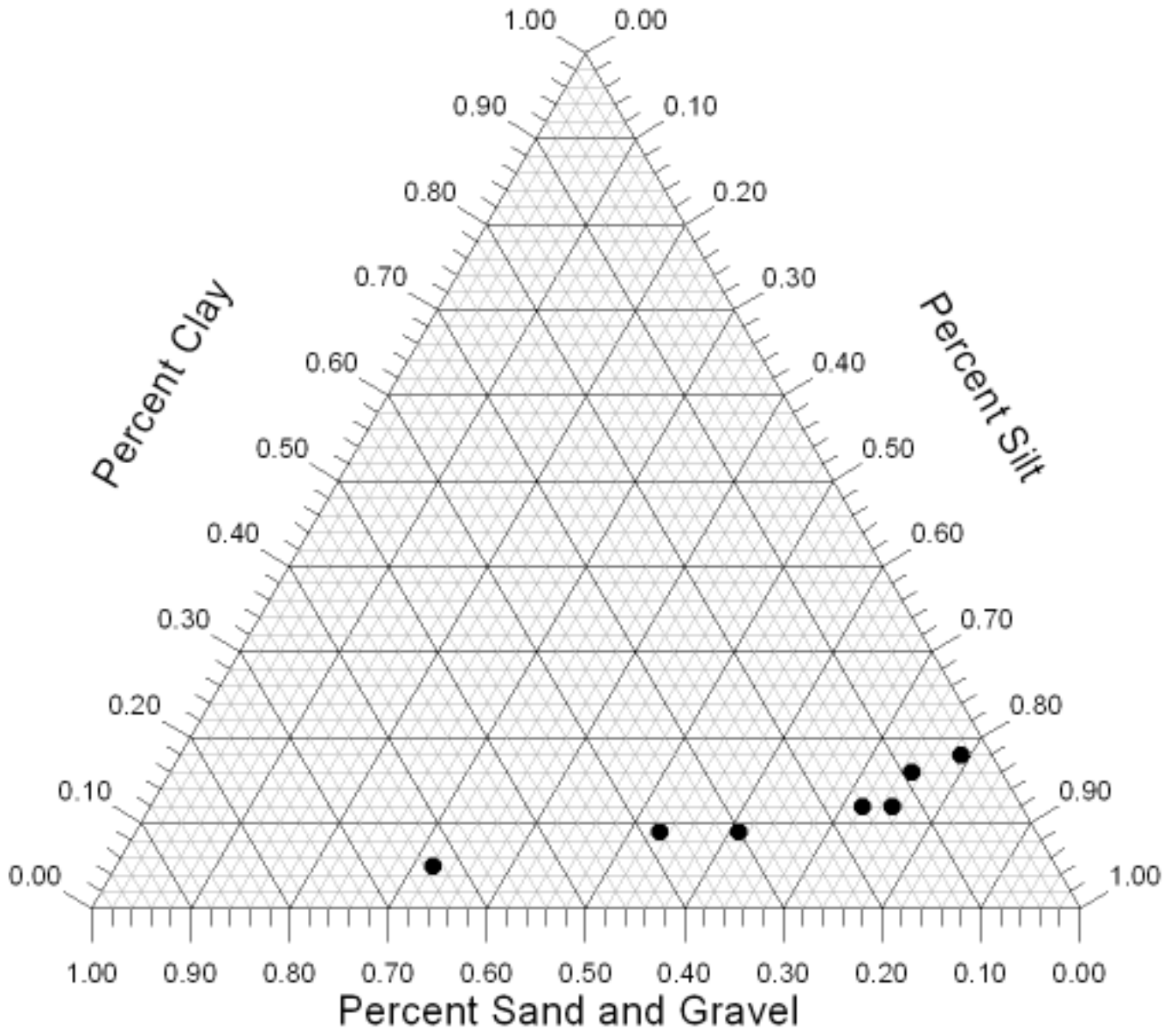


Figure C-5

Composition of Main Sand Geotechnical Samples
Village of Hartford

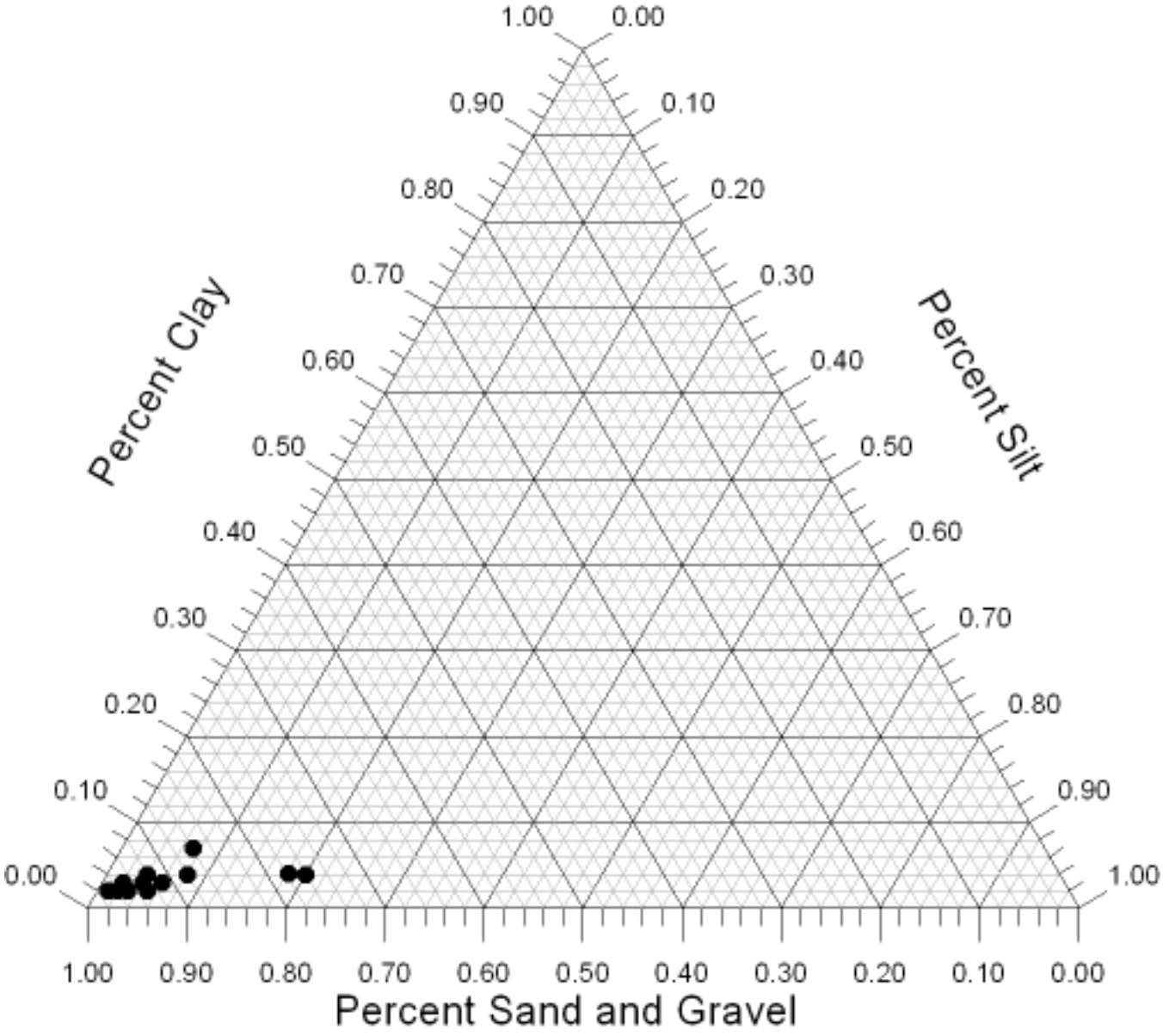
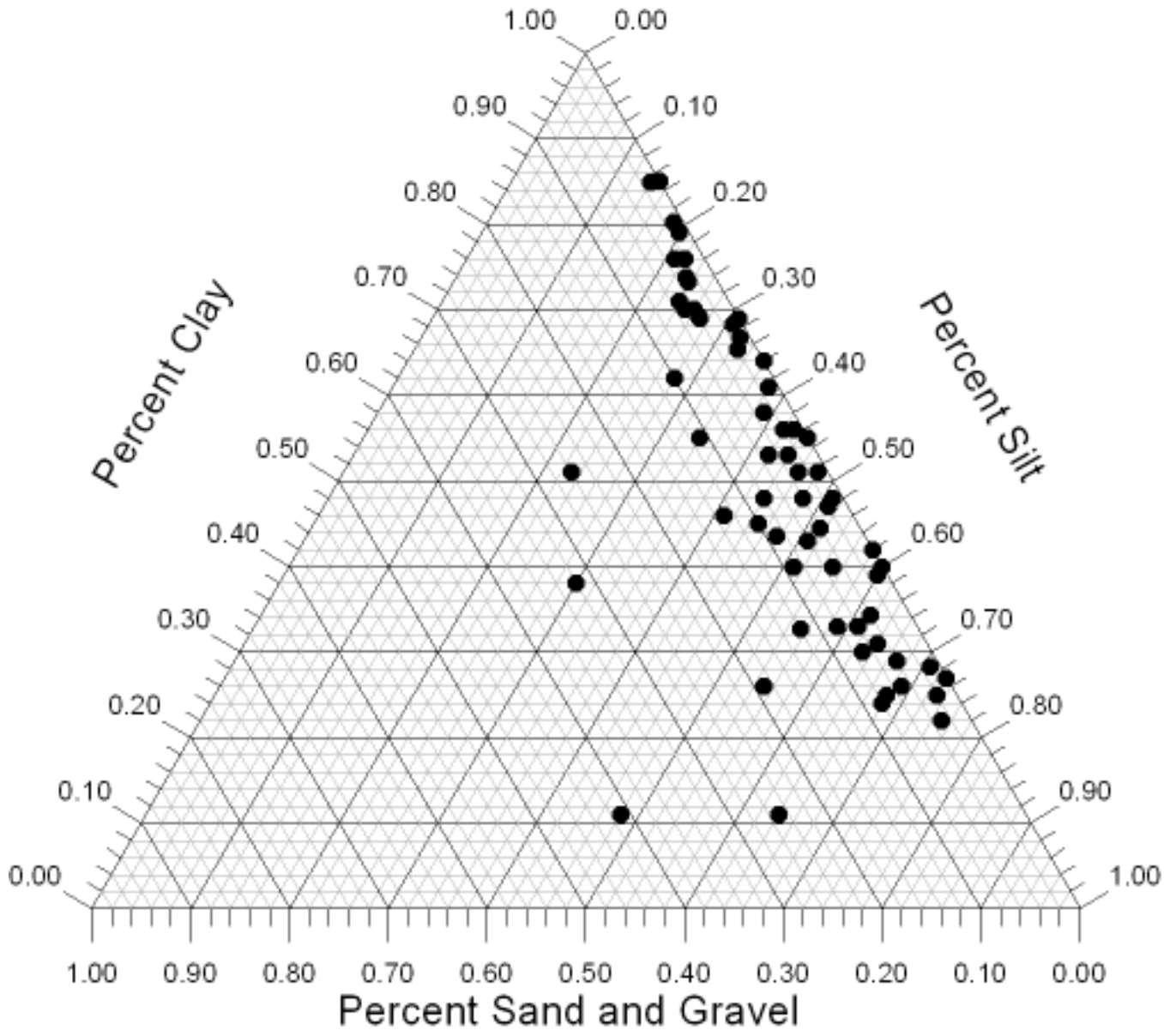


Figure C-6

Composition of Clay Strata Geotechnical Samples
Village of Hartford



Appendix D: Strata Isopach and Structure Contour

Stratigraphic Analysis of Strata in the Village of Hartford

A Clay Stratum

The A Clay Stratum is present throughout Hartford and ranges in thickness from 5 to 24 feet. This stratum is generally thickest (1) near the intersection of West Date Street and North Delmar Avenue, (2) north of West Rand Avenue along Illinois State Route 3, (3) between West Watkins and West Maple Streets, and (4) between East Maple and East Hawthorne Streets. 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, (4) along East Forest Street between North Delmar Avenue and North Olive Street, and (5) between Hawthorne and 3rd Streets in the central portion of Hartford. An isopach map of the A Clay Stratum is shown in Figure D-1.

North Olive Stratum

The North Olive Stratum is encountered at depths ranging from approximately 8 to 15 feet (average 10 feet) below ground surface (bgs) and extends across the majority of the northern portion of Hartford, from the intersection of North Delmar Avenue and Old St. Louis Road south to Date Street. This deposit is bounded by the A and B Clay Strata. The North Olive Stratum also extends along Old St. Louis Road and North Olive Street corridors south of Date Street. However, south of Date Street, the North Olive and B Clay Strata are absent in the central portion of Hartford along North Delmar Avenue and North Market Street corridors. The western extent of the North Olive Stratum is not defined west beyond Illinois State Route 3. This stratum appears to extend slightly east of North Olive Street to the railroad tracks between East Rand Avenue on the north and East Birch Street to the south. It also extends into the Premcor Facility between East Elm and East Watkins Streets and onto the Shell/Tannery property between East Birch and East Elm Street.

The top of the North Olive Stratum in Hartford, where the B Clay Stratum underlies it, is encountered at an approximate elevation of 414 to 424 feet above mean sea level (MSL). The elevation of the base of the North Olive Stratum ranges from 408 to 420 feet above MSL. Structure contour maps of the top and bottom of the North Olive Stratum are shown in Figures D-2 and D-3, respectively. The contour map of the top elevation of the North Olive Stratum also encompasses the top of the Main Silt where it underlies the A Clay (Figure D-2).

The elevation of the top of the North Olive Stratum is highest (approximately 418 to 424 feet above MSL) in the area (1) along the North Olive Street corridor, (2) between West Forest and West Watkins Streets, and (3) near the Hartford Community Center. The elevation of the bottom of this stratum is highest (approximately 417 to 420 feet above MSL) in the area (1) between East Forest and East Birch Streets, east of North Market Street, (2) along West Date Street between North Delmar Avenue and Old St. Louis Road, (3) between West Elm and West Forest Streets along Old St. Louis Road, and (4) north of West Rand Avenue along North Delmar Avenue. The lowest bottom elevation (approximately 410 feet above MSL) is encountered (1) at the intersection of Old St. Louis Road and West Cherry Street, and (2) near the intersection of Old St. Louis Road and West Elm Street.

The North Olive Stratum ranges from less than 1-foot to 10-feet thick. An isopach map of the North Olive Stratum is shown in Figure D-4. This stratum is generally thickest (approximately 6 to 10 feet) (1) along the southern portion of the North Olive Street corridor, (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 Stratum.

B Clay Stratum

The B Clay Stratum underlies the North Olive Stratum and ranges in thickness from less than 1 foot to 12 feet. This stratum 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. An isopach map of the B Clay Stratum is shown in Figure D-5.

Rand Stratum

The Rand Stratum is encountered at depths ranging from approximately 12 to 27 feet bgs (average 19 feet bgs) and is defined by the extent of the C Clay Stratum. This stratum appears to extend across the majority of the northern portion of Hartford south to East Forest Street . The Rand Stratum extends east into the Shell/Tannery Property between East Rand Avenue and East Cherry Street. The western extent of this stratum has not been defined beyond Old St. Louis Road. To the south of Date Street, in Hartford, the Rand Stratum grades laterally into the Main Silt. The Rand Stratum pinches out east of North Olive Street between East Date and East Forest Streets and is locally absent near the intersections of West Rand Avenue, North Delmar Avenue, and Old St. Louis Road where the B and C Clay Strata are undifferentiated.

The top of the Rand Stratum is encountered at elevations ranging from approximately 406 to 415 feet above MSL in Hartford. The elevation of the bottom of this stratum ranges from approximately 400 to 409 feet above MSL. Structure contour maps of the top and bottom of the Rand Stratum are shown in Figures D-6 and D-7, respectively. The top elevation of the Rand Stratum is highest in the area (1) between East Date and East Elm Streets, and (2) near the intersection of East Birch and North Olive Streets. The top elevation of the Rand Stratum is lowest (1) south of the Hartford Community Center along North Delmar Avenue, and (2) near the intersection of Old St. Louis Road and North Delmar Avenue. The bottom of the Rand Stratum is highest between West Cherry and West Elm Streets along North Delmar Avenue and North Market Street. The bottom surface elevation is lowest (1) near the intersection of West Birch Street and North Delmar Avenue, and (2) between East Rand Avenue and East Birch Street.

The Rand Stratum ranges in thickness from less than 1 foot to 11 feet. An isopach map of the Rand Stratum is shown in Figure D-8. The Rand Stratum is thickest in the area (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.

C Clay Stratum

The C Clay Stratum defines the extent of the Rand Stratum and ranges in thickness from less than 1 foot to approximately 8 feet. An isopach map of the C Clay Stratum is shown in Figure D-9. The C Clay Stratum 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 Stratum is thinnest near the intersection of North Market and East Forest Streets.

Main Silt Stratum

The Main Silt is encountered at depths ranging from approximately 6 to 30 feet bgs (average of 16 feet bgs), where the B and/or C Clay Strata are absent and where it is overlain by the A Clay Stratum. This stratum laterally grades into and is compositionally similar to the North Olive and Rand Strata. 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. In a localized area near the intersections of West Date Street and North Delmar Avenue, and East Elm Street and North Market Street, the Main Silt overlies the C Clay Stratum. A structure contour map of the top of the Main Silt and North Olive Stratum is shown in Figure D-2. A structure contour map of the base of the Main Silt and top of the EPA Stratum is shown in Figure D-10.

The top of the Main Silt is encountered at elevations ranging from approximately 407 to 422 feet above MSL, where it underlies the A Clay. The highest top elevation of the Main Silt is generally located (1) near the intersection of East Hawthorne and North Market Streets, (2) along Old St. Louis Road between West Hawthorne and 3rd Streets, (3) along North Olive Street between East 1st and East 2nd Streets, and (4) between West Elm and West Forest Streets along North Delmar Avenue. The top of the Main Silt is lowest in the area (1) between Maple and Watkins Streets, and (2) near the intersection of West Date Street and North Delmar Avenue. The majority of the Main Silt directly overlies the Main Sand (Figure D-10) and ranges in elevation from approximately 396 to 413 feet above MSL. The base of the Main Silt is generally highest (1) in the area bounded by West Watkins Street, 2nd Street, Old St. Louis Road, and North Market Street; and (2) along East Maple Street between North Market and North Olive Streets. The base of the Main Silt is generally lowest (1) between West Date and West Elm

Streets, (2) along old St. Louis Road south of West 3rd Street, (3) between East Hawthorne and East 1st Streets, and (4) between West Forest and West Watkins Streets.

The Main Silt ranges in thickness from approximately 2 to 19 feet. An isopach map of the Main Silt is shown in Figure D-11. It is thickest (1) south of 1st Street, (2) between West Watkins and West Maple Streets along North Delmar Avenue, and (3) between West Elm and West Forest Streets along North Delmar Avenue. The Main Silt is thinnest (1) between West Forest and West Watkins Streets along North Delmar Avenue, and (2) between East Watkins and East Maple Streets. These areas coincide with thick deposits of A Clay Stratum and topographically high bottom elevations of the Main Silt.

It should be noted that there are certain areas where the contact between the Main Silt and Main Sand is gradational and difficult to interpret. Specifically, most of the elevation data for the contact between these strata, in the southern portion of Hartford, were often difficult to interpret and had to be inferred based on the surrounding data points.

EPA Stratum

The EPA Stratum is encountered in the northeastern portion of Hartford at depths ranging from 27 to 46 feet bgs (average of 31 feet bgs). This stratum is defined and separated from the Main Sand by the D Clay Stratum. The EPA Stratum grades laterally into the Main Sand to the south of a southeasterly trending line drawn from the Old St. Louis Road and Delmar Avenue intersection to just north of the East Date Street and North Olive Street intersection. Along this boundary the EPA Stratum and Main Sand are hydraulically connected.

The elevation of the top of the EPA Stratum in the northern portion of Hartford ranges from approximately 395 to 404 feet above MSL. The elevation of the bottom of this stratum ranges from 389 to 398 feet above MSL. Structure contour maps of the top and bottom of the EPA Stratum are shown in Figures D-10 and D-12, respectively. The top elevation of the EPA Stratum is highest (approximately 403 feet above MSL) at the intersection of North Delmar Avenue and Old St. Louis Road. The top elevation of this stratum steadily decreases to the east towards North Olive Street. The bottom of the EPA Stratum is also highest (approximately 398 feet above MSL) near the intersection of North Delmar Avenue and Old St. Louis Road. The bottom elevation of this stratum decreases eastward towards North Olive Street.

The bottom surface elevation of the EPA Stratum is lowest (approximately 389 feet above MSL) near the intersection of East Rand Avenue and North Olive Street.

The EPA Stratum ranges from approximately 4 to 9 feet thick within the northeastern portion of Hartford. An isopach map of the EPA Stratum is shown in Figure D-13. The EPA Stratum is thickest north of West Rand Avenue along North Delmar Avenue, and along North Olive Street. This stratum is thinnest along the northwestern boundary of the Shell/Tannery Property.

D Clay Stratum

The D Clay Stratum underlies the EPA Stratum and ranges in thickness from approximately 2 to 7 feet thick. This clay stratum 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. An isopach map of the D Clay Stratum is shown in Figure D-14.

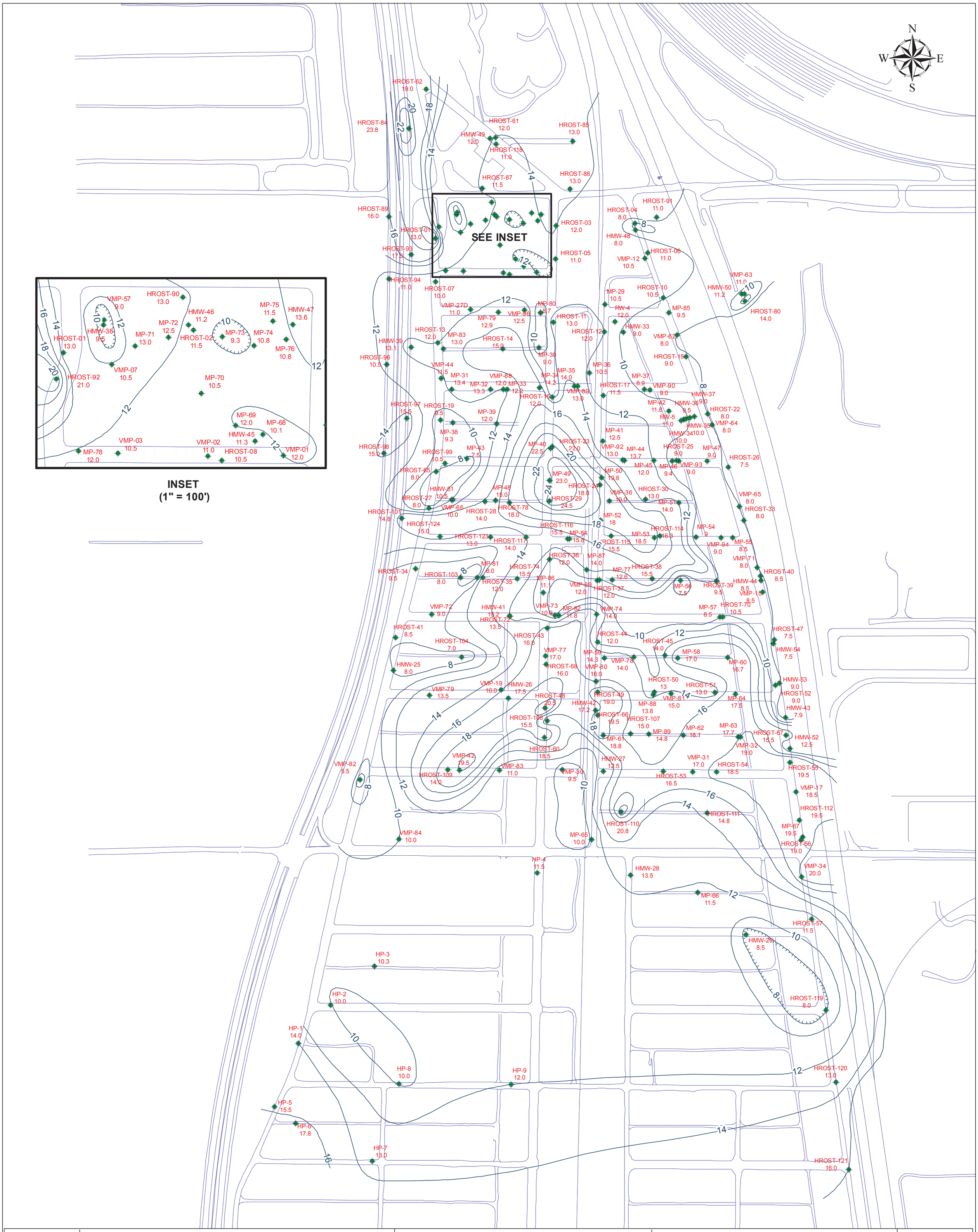
Main Sand

The Main Sand is aerially extensive throughout Hartford and surrounding areas. In Hartford, it is encountered at depths ranging from 19 to 45 feet bgs (average of 28 feet bgs) and ranges in thickness from approximately 80 to 104 feet near the Village Municipal Water Wells. The elevation of the top of the Main Sand varies based on the presence or absence of the overlying clay strata. Where the B and/or C Clay Strata are absent in the central portion of Hartford, the upper surface of the Main Sand is hydraulically connected to the Main Silt, which is overlain by the A Clay Stratum. The contact between the Main Sand and Main Silt is gradational and often times difficult to accurately define. Discontinuous silty clay and clayey silt lenses of limited thickness and extent occur at various depths within the Main Sand.

The top of the Main Sand is encountered at an elevation of approximately 393 to 413 feet above MSL (Figure D- 10). The top of the Main Sand is at the same horizon as the top of the EPA Stratum, where the D Clay is absent. The top of the Main Sand is highest in the area (1) bounded by West Watkins Street, 2nd Street, Old St. Louis Road, and Market Street; and (2) along East Maple Street between North

Market and North Olive Streets. The top surface elevations are lowest in the area (1) bounded by West Birch Street, West Cherry Street, Old St. Louis Road, and North Delmar Avenue; (2) between West Date and West Elm Streets; and (3) near the intersection of Forest Street and North Delmar Avenue. The elevation of the top of the Main Sand generally decreases towards the east-northeast.

Where the Main Sand underlies the D Clay in the northeastern portion of Hartford, the top of the Main Sand is encountered at depths ranging from 39 to 45 feet bgs (approximately 386 to 393 above MSL). A structure contour map of the top of the deep Main Sand below the D Clay is shown in Figure D-15. The top of the Main Sand below the D Clay is highest (approximately 393 feet above MSL) at the intersection of North Delmar Avenue and Old St. Louis Road. The elevation of the top of the Main Sand decreases towards the east-northeast. The thickness of the Main Sand below the D Clay Stratum in Hartford is unknown.



NOTES:
1. Map created from aerial photogrammetry dated April 2004 by Continental Mapping Consultants, Inc.
2. Contours are based on best professional judgement using data available at the time of preparation. The contours are approximate and inferred between locations and may be updated as new data is generated.
3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 112.5 225 450 675 900 1,125 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW, HP)

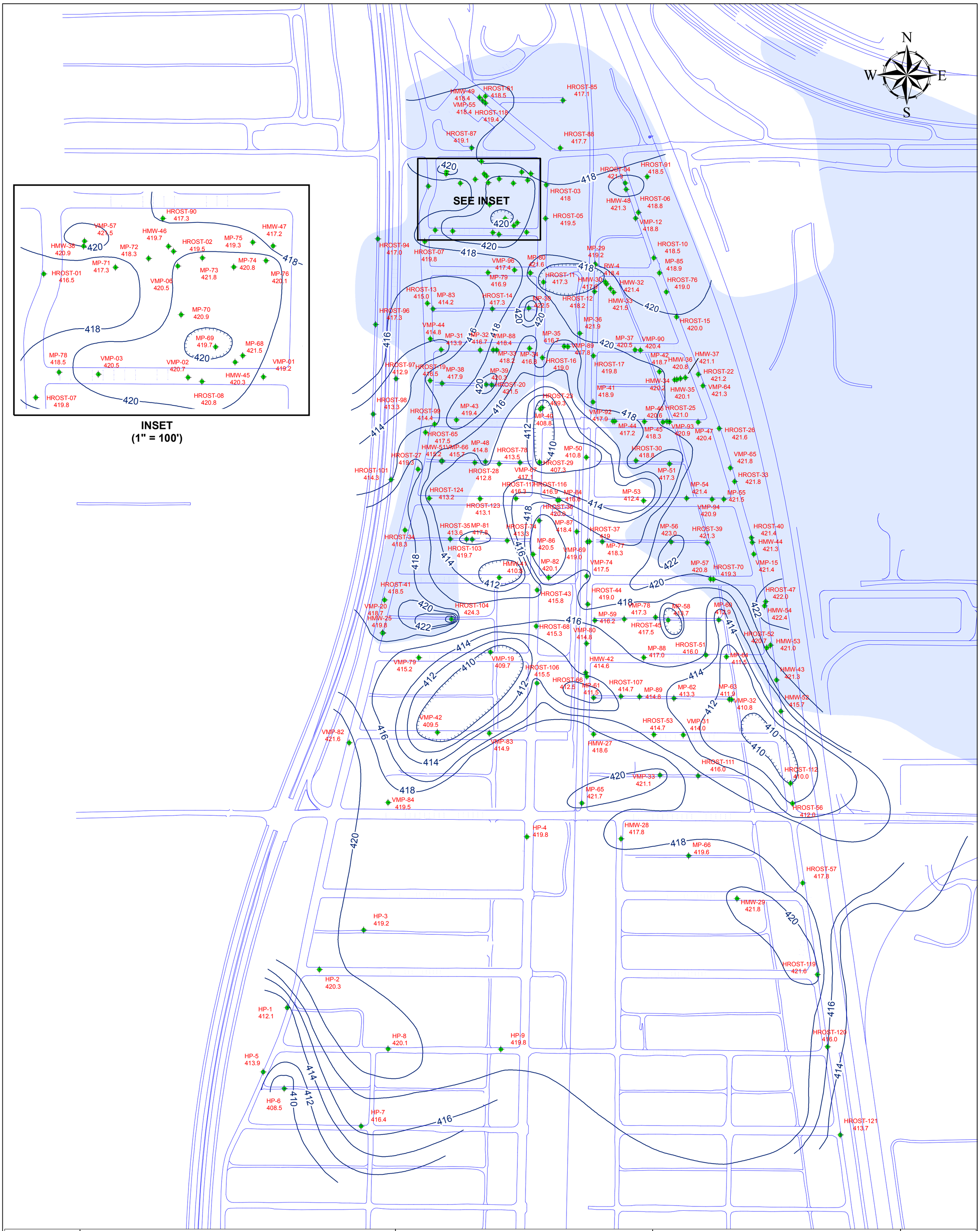
10 THICKNESS OF STRATUM (FEET)

BUREAU VERITAS
Clayton Group Services, Inc
A Bureau Veritas Company

ISOPACH MAP OF THE A CLAY STRATUM

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

FIGURE D-1



NOTES:
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 112.5 225 450 675 900 1,125 Feet

Legend

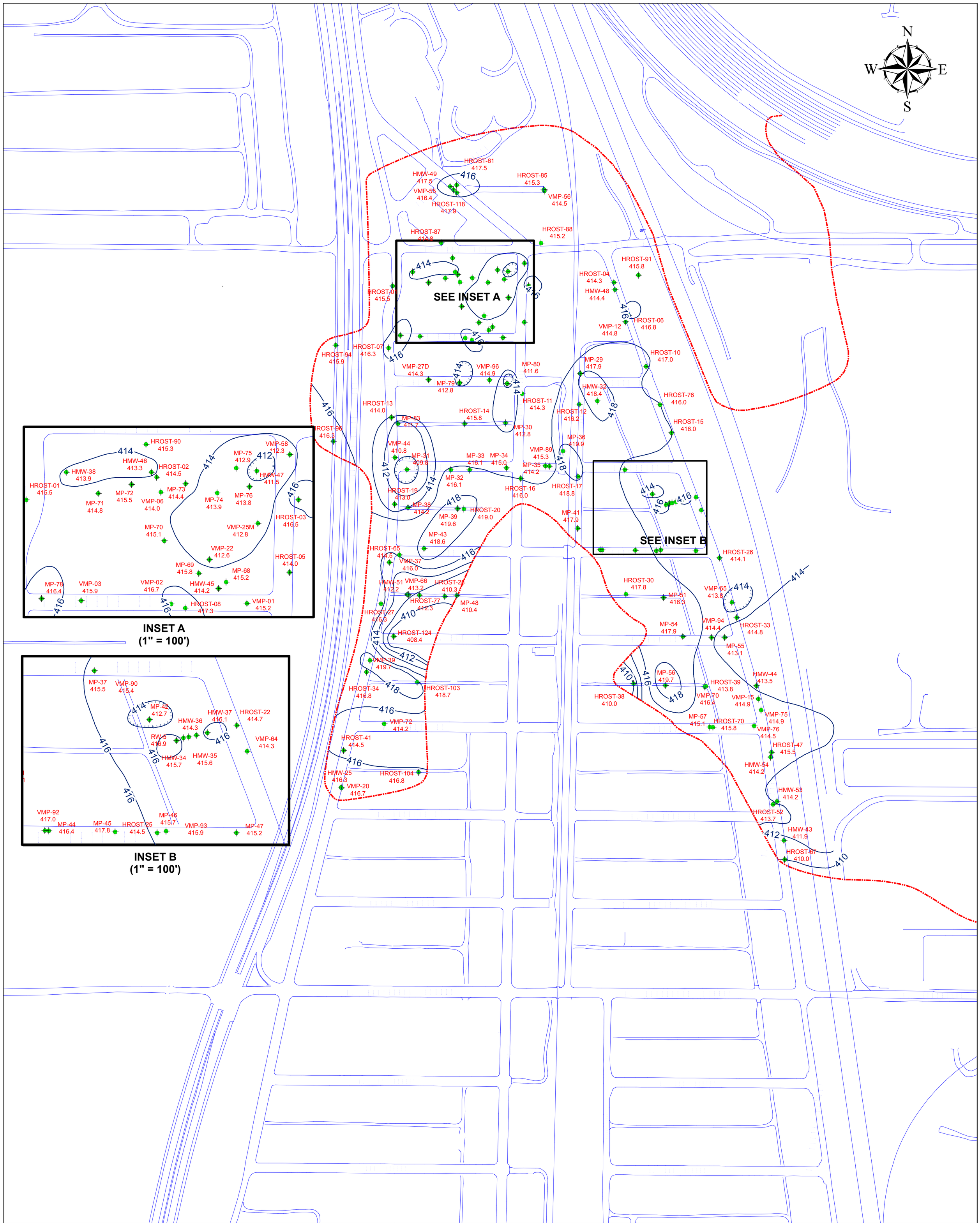
- BORING LOCATION (HROST, HMW, MP, VMP, RW, HP)
- INTERPRETED EXTENT OF NORTH OLIVE STRATUM
- —392— SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

BUREAU VERITAS
Clayton Group Services, Inc
A Bureau Veritas Company

STRUCTURE CONTOUR MAP OF THE TOP OF THE NORTH OLIVE / MAIN SILT STRATA BELOW THE A CLAY STRATUM

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

FIGURE D-2



Clayton Group Services, Inc
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4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

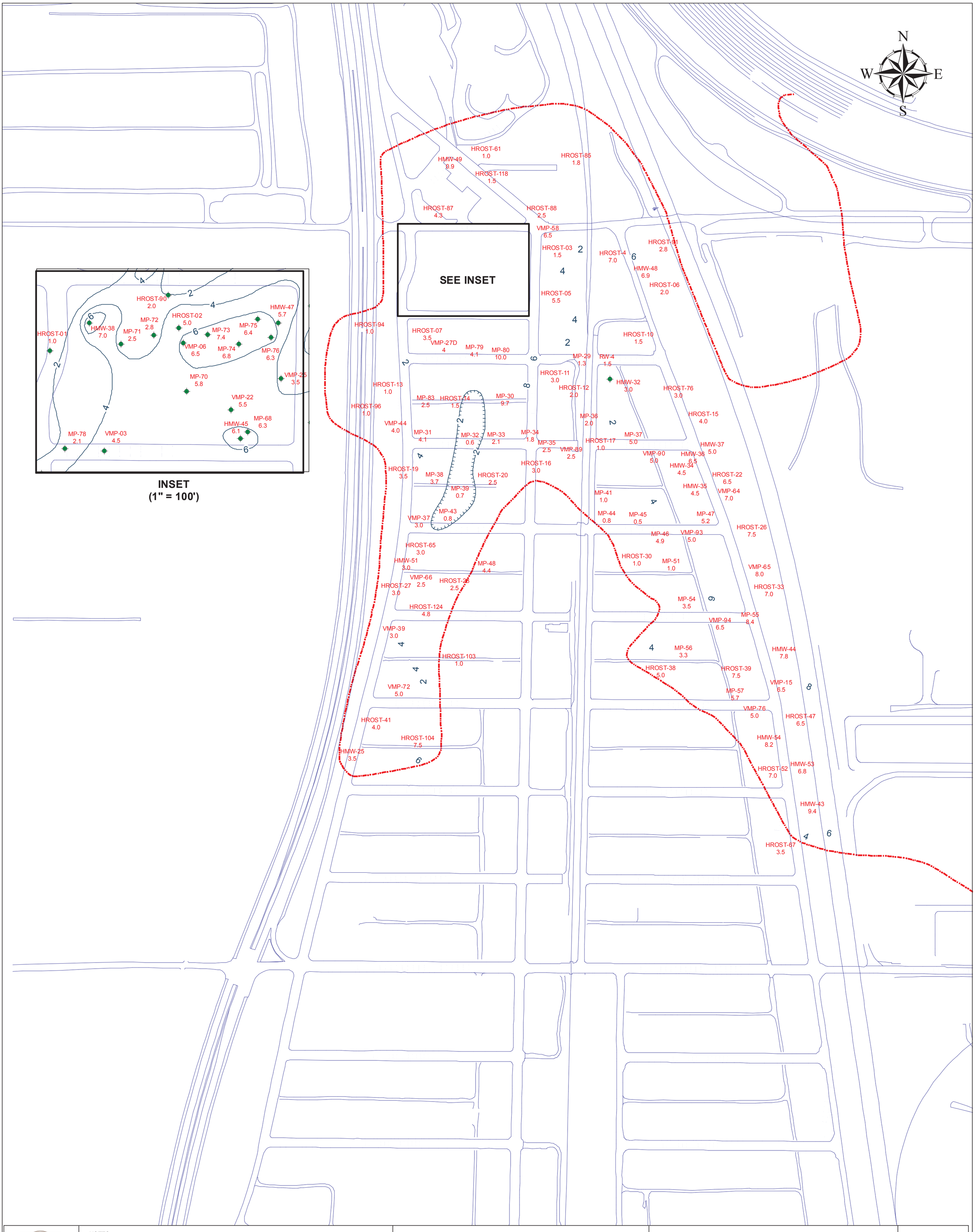
Legend

- BORING LOCATION (HROST, HMW, MP, VMP, RW)
- INTERPRETED EXTENT OF STRATUM
- 392 SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE BOTTOM OF THE NORTH OLIVE STRATUM

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

FIGURE D-3



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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 Feet

Clayton Group Services, Inc
A Bureau Veritas Company

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE NORTH OLIVE STRATUM

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

FIGURE D-4

Clayton Group Services, Inc
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4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE B CLAY STRATUM

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

FIGURE D-5

Clayton Group Services, Inc
A Bureau Veritas Company

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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

- BORING LOCATION (HROST, HMW, MP, VMP, RW)
- INTERPRETED EXTENT OF STRATUM
- 392 SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE TOP OF THE RAND STRATUM

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

FIGURE D-6

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A Bureau Veritas Company

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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 Feet

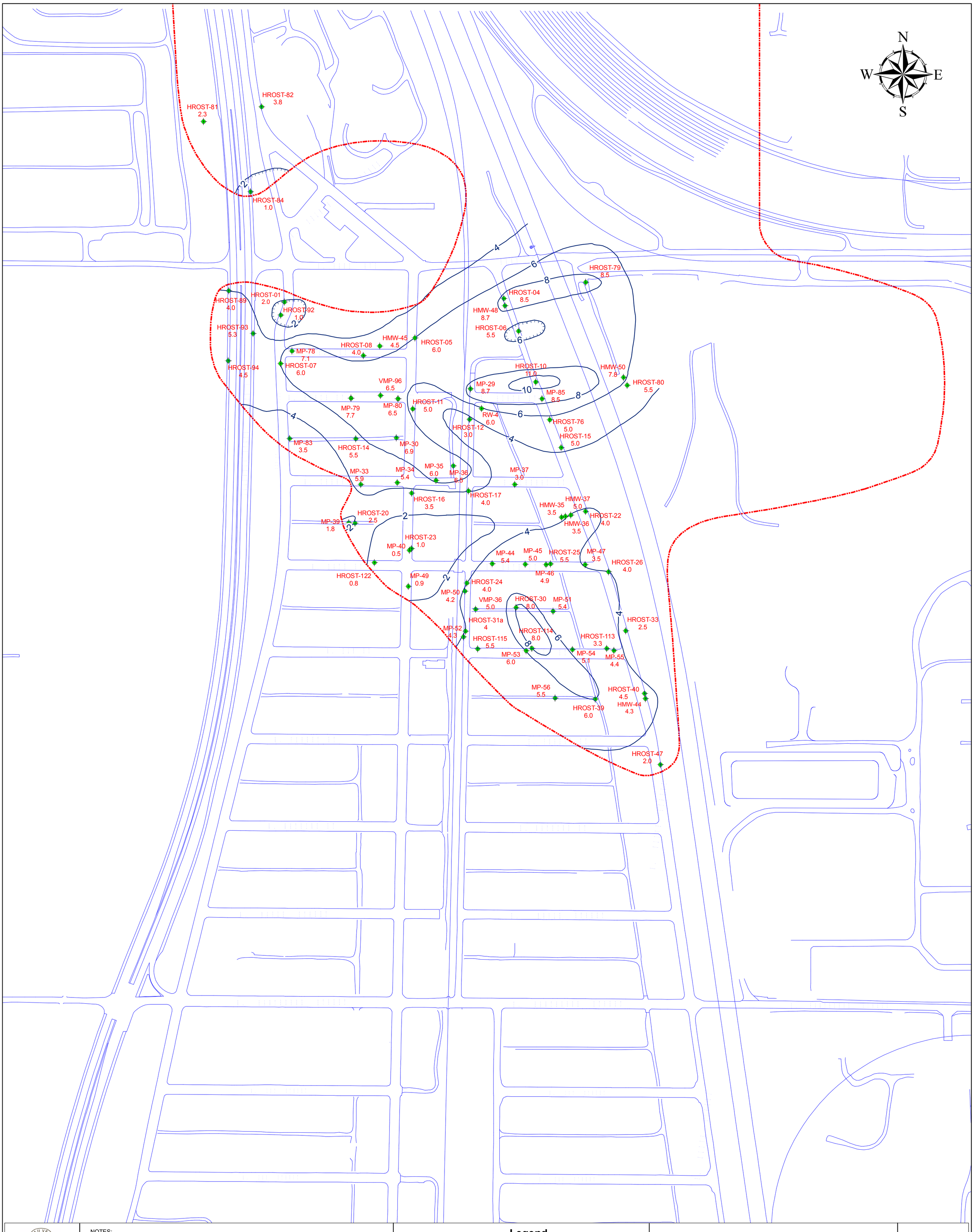
Legend

- BORING LOCATION (HROST, HMW, MP, VMP, RW)
- INTERPRETED EXTENT OF STRATUM
- —392— SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE BOTTOM OF THE RAND STRATUM

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

FIGURE D-7



BUREAU VERITAS

Clayton Group Services, Inc

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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET

0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE RAND STRATUM

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

FIGURE
D-8

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A Bureau Veritas Company

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4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

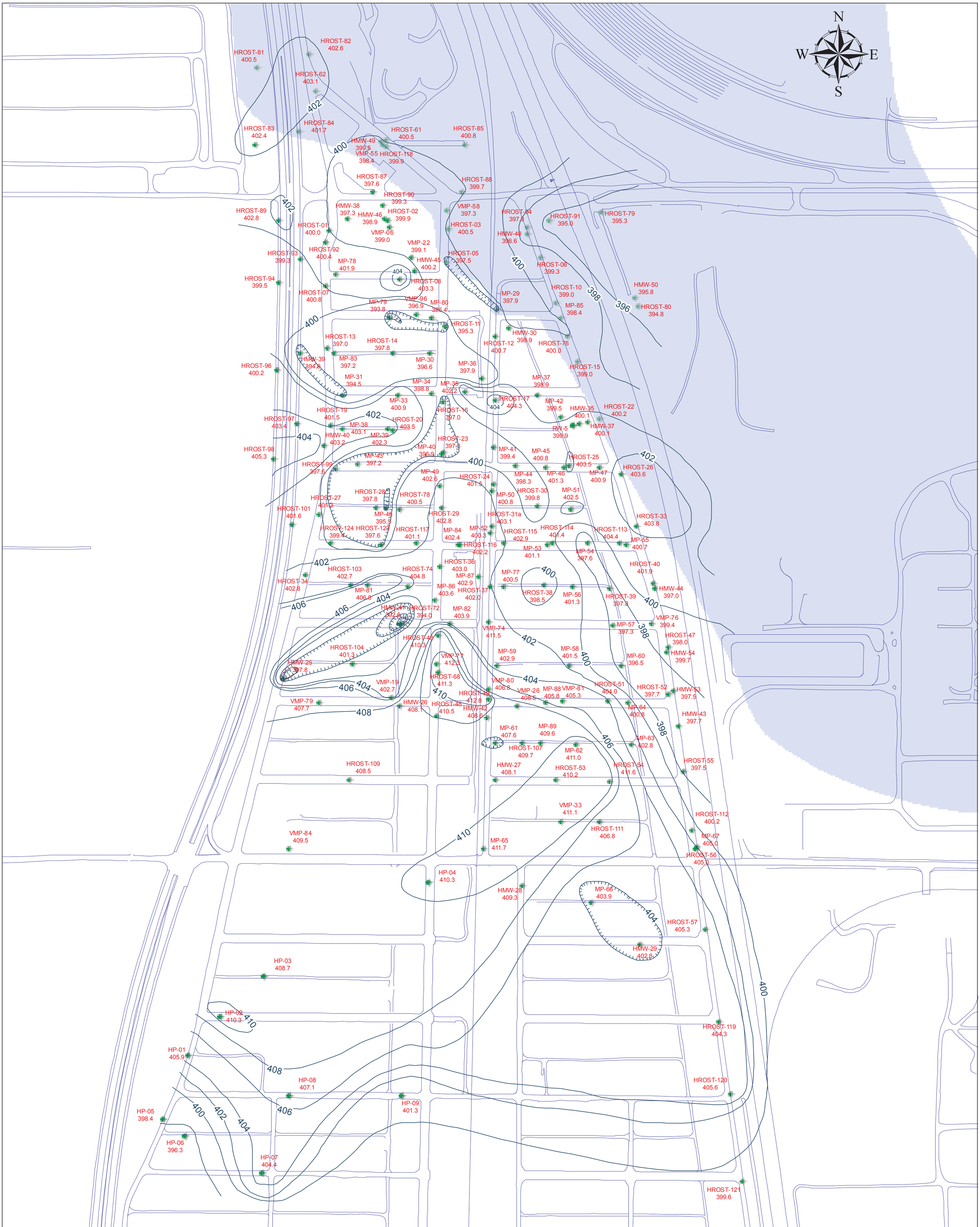
INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE C CLAY STRATUM

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

FIGURE D-9



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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 112.5 225 450 675 900 1,125 Feet

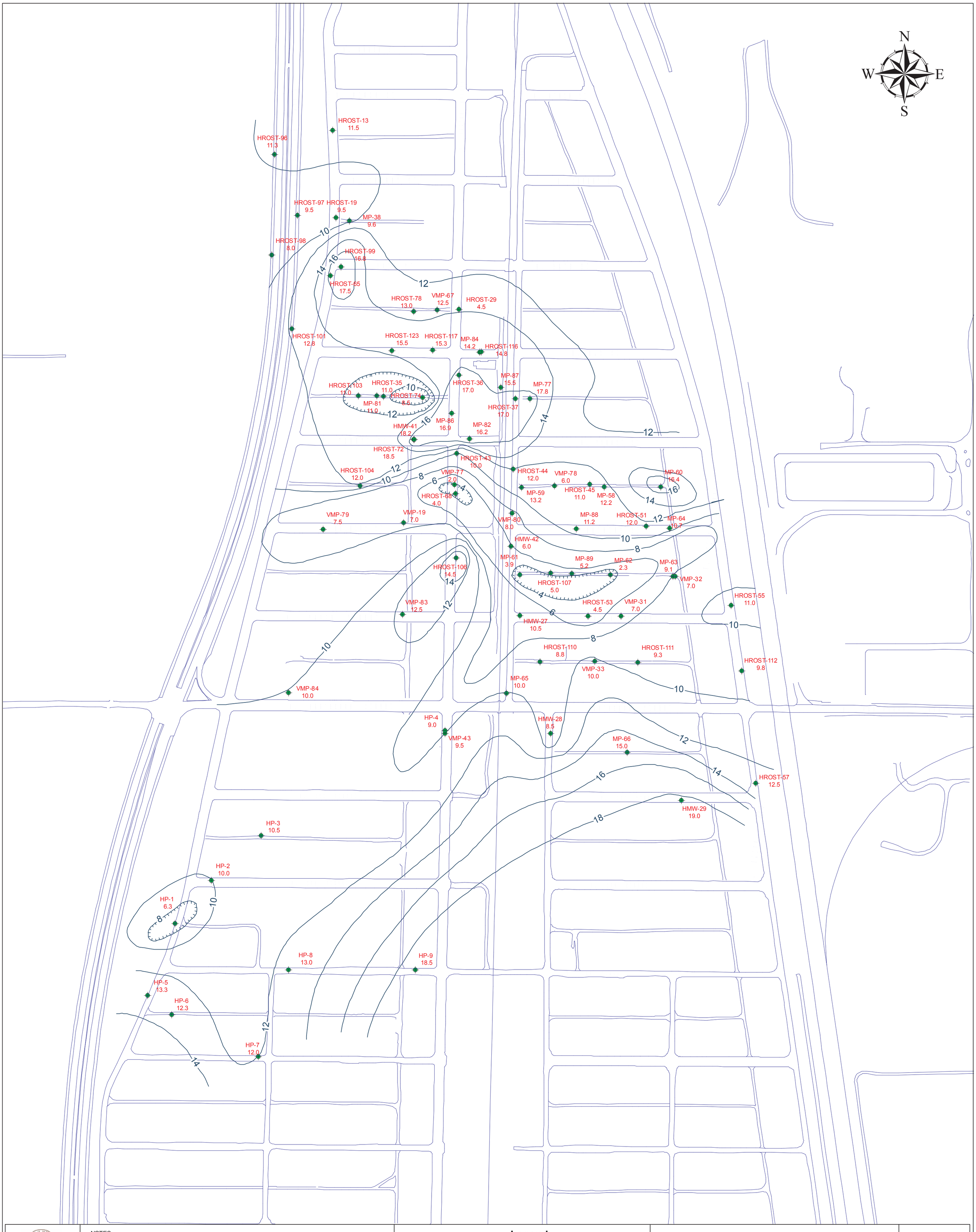
Legend

- BORING LOCATION (HROST, HMW, MP, VMP, RW, HP)
- INTERPRETED EXTENT OF EPA STRATUM
- 392 SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE TOP OF THE EPA STRATUM / TOP OF THE MAIN SAND / BASE OF THE MAIN SILT

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

FIGURE D-10



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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW, HP)

INTERPRETED EXTENT OF STRATUM

—10— THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE MAIN SILT

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

FIGURE
D-11

Clayton Group Services, Inc
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4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

- BORING LOCATION (HROST, HMW, MP, VMP, RW)
- INTERPRETED EXTENT OF STRATUM
- 392 SURFACE ELEVATION IN FEET ABOVE MSL
- LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE BOTTOM OF THE EPA STRATUM

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

FIGURE D-12

Clayton Group Services, Inc
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

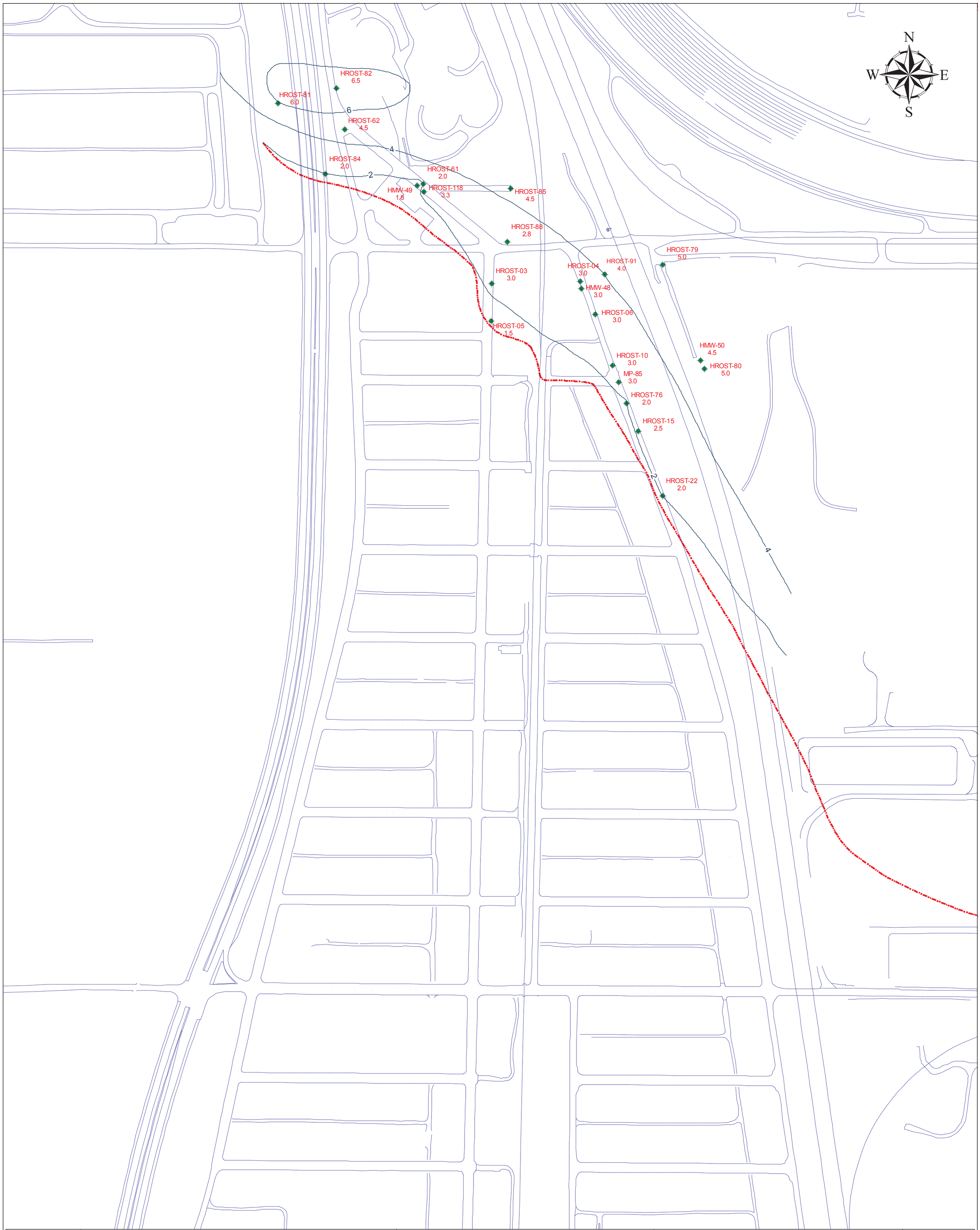
INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE EPA STRATUM

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

FIGURE
D-13



Clayton Group Services, Inc
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NOTES:
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)

INTERPRETED EXTENT OF STRATUM

10 THICKNESS OF STRATUM (FEET)

ISOPACH MAP OF THE D CLAY STRATUM

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

FIGURE
D-14

BUREAU VERITAS

Clayton Group Services, Inc
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3. Main Sand, EPA, Rand, and North Olive Strata, as well as A, B, C, and D Clays are names developed for local units.
4. Contour interval = 2 Feet.

SCALE IN FEET
0 100 200 400 600 800 1,000 Feet

Legend

BORING LOCATION (HROST, HMW, MP, VMP, RW)
INTERPRETED EXTENT OF STRATUM
—392— SURFACE ELEVATION IN FEET ABOVE MSL
LOCALIZED DEPRESSION

STRUCTURE CONTOUR MAP OF THE TOP OF THE MAIN SAND BELOW THE D CLAY STRATUM

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

FIGURE
D-15

Appendix E: Hydrogeology

The hydrogeology of Hartford has been interpreted based on the review and analysis of borings logs, well completion logs, structure contour maps of the permeable strata, and groundwater contour maps. The occurrence of groundwater in the North Olive, Rand, EPA, and the Main Sand strata is briefly discussed below. Groundwater gauging events were conducted on a monthly basis from October 2004 through October 2005 in Hartford and on the adjoining Shell and Premcor properties. The well gauging events were conducted to measure groundwater depths and apparent LNAPL thickness (if present) in order to determine groundwater flow directions. Temporal variability (including precipitation events, Mississippi River-stage height, atmospheric pressure, and groundwater pumping) influences the groundwater elevations on a daily basis in the monitoring wells. Hartford, Premcor and Shell monitoring wells, were used to develop the groundwater flow maps of the Main Sand and the EPA Stratum. Shell and Hartford wells were used to develop the groundwater flow map of the Rand Stratum. Hartford and Premcor monitoring wells were used to create a North Olive Stratum groundwater elevation map.

North Olive Stratum

Groundwater within the North Olive Stratum occurs as isolated areas of perched water on the surface of the underlying B Clay Stratum in Hartford.

Rand Stratum

Groundwater within the Rand Stratum is confined northeast of Hartford at the Shell Rand Avenue site, though this is the only area where the Rand Stratum is completely saturated. In Hartford, groundwater in the Rand Stratum occurs as isolated areas of perched water on the surface of the underlying C Clay Stratum.

EPA Stratum

Groundwater in the EPA Stratum is confined and hydraulically connected to the Main Sand in Hartford, and within the Shell Tannery Property, the Shell Rand Avenue Site and the Premcor Facility.

Main Sand

In Hartford, groundwater in the Main Sand appears to be confined where it underlies the C Clay Stratum and the D Clay Stratum; however, it becomes unconfined generally south of West Date and East Forest Streets. Unconfined groundwater occurs beyond the north, south, and east extent of the B/C Clay Stratum. Groundwater elevations within the Main Sand have been documented to fluctuate significantly over the years. Site data, extending back to 1990, reveals that the groundwater elevation in the Main Sand neared 416 feet MSL during 1993 and was observed to be as low as approximately 397 feet MSL in early 1991. Historically, groundwater elevations in the Hartford area have been as low as 380 feet MSL in the mid-1950's (Schicht, 1965).

Appendix F: D_o Calculation

The following information was provided on behalf of Mr. Andrew Kirkman, of The RETEC Group, Inc., on November 7, 2005.

The fluid characteristics that influence LNAPL distribution and recoverability from the subsurface include the following:

- LNAPL Density
- LNAPL Viscosity
- LNAPL and Water Interfacial tensions

In addition, the soil type can have a large influence on LNAPL distribution and recoverability from the subsurface. Soil characteristics that effect the distribution and presence of LNAPL in the subsurface include:

- Porosity
- Intrinsic permeability
- Pore size distribution
- Soil grain shape

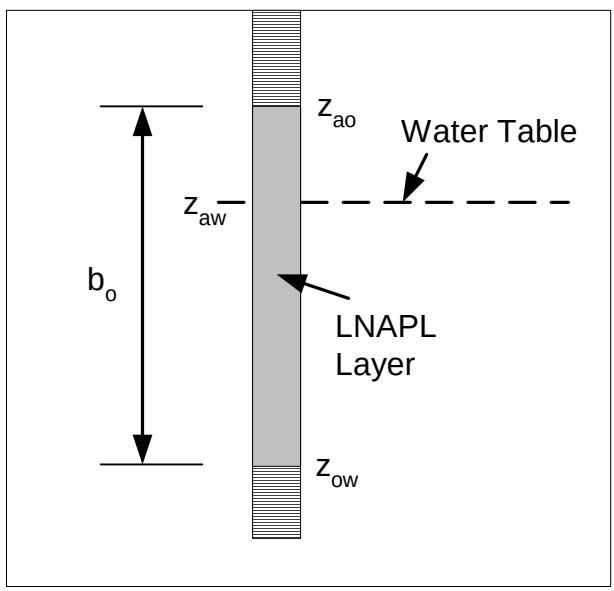
Accounting for these parameters is necessary in order to accurately assess the distribution of LNAPL in the formation and estimate the true amount of LNAPL in the subsurface. Mapping of apparent LNAPL thicknesses measured in monitoring wells at a site with varying soil and LNAPL type is not an accurate depiction of LNAPL extent or magnitude. In order to provide an estimate of the actual LNAPL in the subsurface, the term “LNAPL specific thickness” is proposed to estimate the true amount of LNAPL in the formation.

Because of the variance in soil and LNAPL physical characteristics, the same LNAPL thickness measured at two locations does not always represent the same distribution of LNAPL in the formation or the recoverability of LNAPL. For instance, one foot of LNAPL measured in a well installed in clay will have a much smaller specific thickness than if it were installed in sand. The same is true in terms of saturation. The pore spaces in sand are more interconnected and generally larger in the sand. The clay,

however, has smaller and less interconnected pores and a higher pressure is required to saturate those to the same saturation.

The following schematic (Charbeneau et al., 1999) shows a monitoring well with an LNAPL layer located between the air-NAPL interface z_{ao} and the NAPL-water interface z_{ow}. The total monitoring well LNAPL thickness is b_o. The elevation of the water table, z_{aw}, provides the datum for fluid levels. While the water table is not measured in a monitoring well because of the LNAPL layer, its elevation is easily determined from the elevations z_{ao} and z_{ow}, and the LNAPL specific gravity.

Figure 1



D_o is defined as the specific thickness of LNAPL, which is representative of the amount of LNAPL in a formation. For example, if you had a core of soil separated into its respective media (i.e., air, water, LNAPL, and soil), D_o is a normalized volume of LNAPL ($feet^3/feet^2$) per unit surface area, but is expressed as a thickness (in units of feet). At equilibrium, due to capillary forces in soil, the measured LNAPL thickness in a monitoring well, b_o, is always greater than D_o.

The relationship between measured monitoring well LNAPL thickness, b_o, and the specific LNAPL volume, D_o (the volume of LNAPL per unit surface area) may be calculated from the following equation:

$$D_o(b_o) = \int_{z_{ow}}^{z_{max}} n\, S_o(z)\, dz$$

Where:

Z_{max} = height of oil

Z_{ow} = height of the oil/water interface

S_o = saturation of oil

n = soil porosity

The function $D_o(b_o)$ may be approximated piecewise by a linear function of the form:

$$D_o = \beta\,(b_o - \chi)$$

The most accurate method to estimate LNAPL specific thickness is to collect soil core data, analyze Dean Stark LNAPL saturations and integrate LNAPL saturation over discrete depth intervals to calculate D_o (Adamski, et al, 2003). If LNAPL saturation and soil core data are available, D_o is calculated as follows:

D_o = LNAPL % * porosity * soil core interval (ft.)

Where:

LNAPL % = oil saturation (in % of pore volume)

porosity = site-specific total porosity (in %)

soil core interval = interval of LNAPL impacted core (in feet)

Collection of soil cores from varying soil types across a site and discrete sampling and analyses of LNAPL saturations accurately depicts the true amount of LNAPL in each formation and eliminates the need for correction factors based on buoyancy or LNAPL density. Correction factors based on soil type and LNAPL type will provide accurate estimations of LNAPL specific thickness across a site.

References

Adamski, M., V. Kremesec, R. Kolhatkar, C. Pearson, and B. Rowan, 2001. "LNAPL Saturation, Distribution, and Recovery in Fine Grained Soils," Proceedings of the Petroleum Hydrocarbons and Organic Chemicals in Ground Water Conference and Exposition, pp.178–192. November 14–16, 2001.

Charbeneau, R.J., R.T. Johns, L.W. Lake, and M.J. McAdams, 1999. "Free-Product Recovery of Petroleum Hydrocarbon Liquid." American Petroleum Institute, Publication No. 4682. Ground Water Monitoring & Remediation, 20(3), Summer, pp. 147-158, 2000. June 1999.

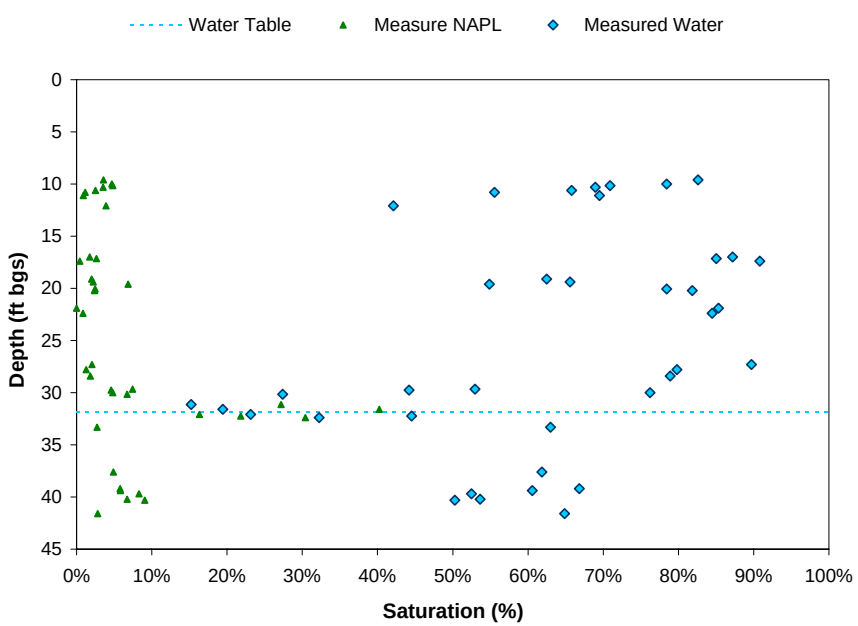
Attachment 2
Specific LNAPL Thicknesses

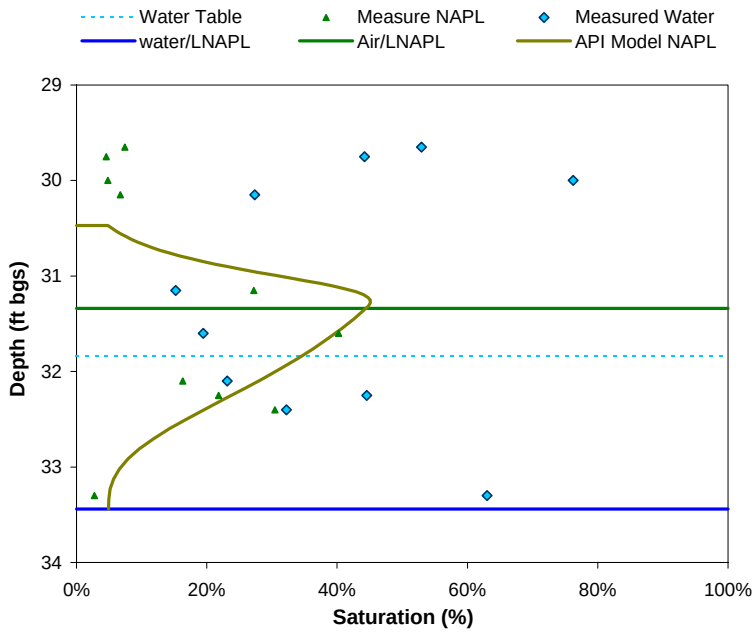
Boring	Corre-sponding Monitoring Well	Date of Measured LNAPL Thickness and Baildown Test	Measured LNAPL Thickness (ft)	D_o (ft)		
				Total for Estimated Mobile Interval[1]	Calculated for Mobile Interval[2]	Total for Smear Zone[1]
HCSB-1	HMW-44C	9/23/2005	2.1	0.30	0.32	0.60
HCSB-2	RW-5	9/23/2005	0.32	0.01	0.02	0.15
HCSB-3	MP-50C	ROST Log 2-19-2004	0.4	0.01	0.02	0.21
HCSB-4	MP-39C	10/5/2005	1.62	0.38	0.22	0.38
HCSB-5	MP-29D	9/20/2005	0.48	0.04	0.02	0.47
HCSB-5	MP-29C	9/20/2005	0.63	0.04	0.03	0.47

Notes:

1 Estimates are based on measured LNAPL saturation data from Dean-Stark core analyses.

2 Represents estimates based on API model that was calibrated to capillary pressure vs. saturation core analysis data.





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

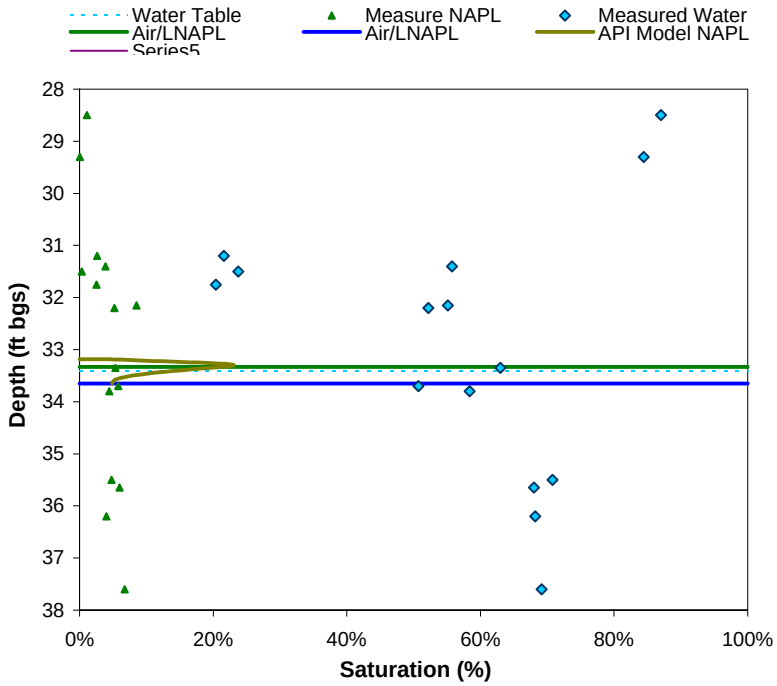
21.9	0.000	0.853	0.53	0.0012	0.0000
22.4	0.009	0.845	0.54		
27.3	0.020	0.897	0.51	0.0041	0.0000
27.8	0.013	0.798	0.47	0.0041	0.0000
28.4	0.018	0.789	0.41	0.0254	0.0000
29.65	0.074	0.529	0.45	0.0026	0.0005
29.75	0.046	0.442	0.43	0.0048	0.0000
30	0.048	0.762	0.39	0.0035	0.0005
30.15	0.067	0.274	0.43	0.0771	0.0554
31.15	0.272	0.152	0.46	0.0673	0.0574
31.6	0.402	0.194	0.43	0.0625	0.0514
32.1	0.163	0.231	0.47	0.0129	0.0096
32.25	0.218	0.446	0.44	0.0172	0.0140
32.4	0.304	0.322	0.44	0.0661	0.0464
33.3	0.027	0.630	0.45	0.0737	0.0000
37.6	0.049	0.619	0.45	0.0338	0.0024
39.2	0.058	0.668	0.35	0.0040	0.0006
39.4	0.058	0.606	0.34	0.0071	0.0022
39.7	0.083	0.525	0.33	0.0124	0.0043
40.2	0.067	0.536	0.33	0.0030	0.0012
40.3	0.091	0.503	0.42	0.0324	0.0060
41.6	0.028	0.649	0.40		

30.905	0.233789
30.934	0.25612
30.963	0.279506
30.992	0.303602
31.021	0.327936
31.05	0.351898
31.079	0.374766
31.108	0.395757
31.137	0.414095
31.166	0.429113
31.195	0.440347
31.224	0.447611
31.253	0.451038
31.282	0.451072
31.311	0.44844
31.34	0.444146
31.445	0.426434
31.55	0.407166
31.655	0.386258
31.76	0.363654
31.865	0.33935
31.97	0.313411
32.075	0.285999
32.18	0.257408
32.285	0.228081
32.39	0.198633
32.495	0.169837
32.6	0.142586
32.705	0.117808
32.81	0.096357
32.915	0.078878
33.02	0.065696
33.125	0.056752
33.23	0.051589
33.335	0.049392
33.44	0.049

31	31.34
DTW	**Corrected water Depth**
33.1	33.44

GS-MP

0.34



API Model Sn

Depth	Sn
33.18323	0
33.18323	0.044088
33.18823	0.052866
33.19323	0.062034
33.19823	0.071574
33.20323	0.081459
33.20823	0.091653
33.21323	0.102109
33.21823	0.11277

Gauging Data - Well MP-42C

Ground Surface Elevation
430.90

Measuring Point Elevation
NA

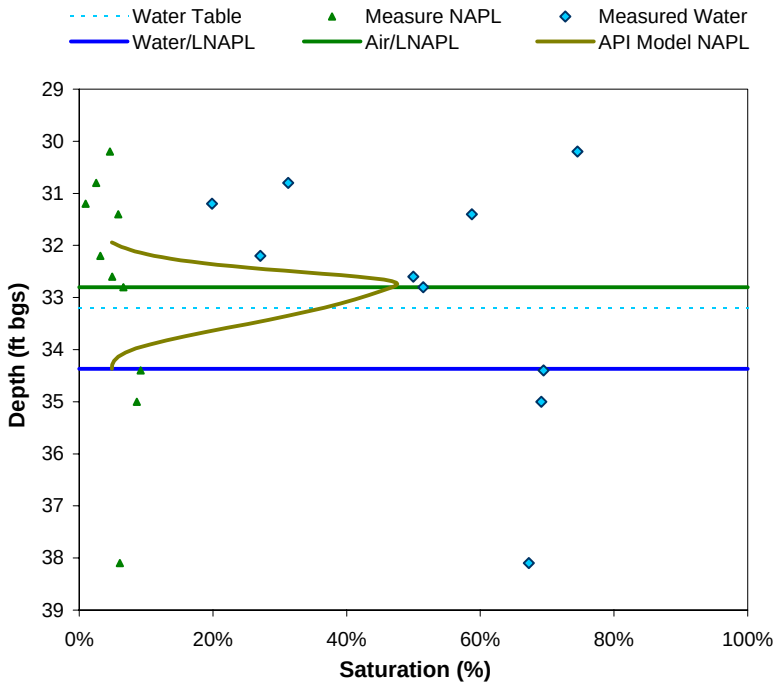
Water Table Elevation
397.49

Estimated Water Table Depth

0	33.41
1	33.41

33.22323	0.123568
33.22823	0.134421
33.23323	0.145236
33.23823	0.155911
33.24323	0.16633
33.24823	0.176373
33.25323	0.185914
33.25823	0.194826
33.26323	0.202985
33.26823	0.210275
33.27323	0.216593
33.27823	0.221854
33.28323	0.225994
33.28823	0.228975
33.29323	0.230786
33.29823	0.231443
33.30323	0.230993
33.30823	0.229509
33.31323	0.227091
33.31823	0.22386
33.32323	0.219964
33.32823	0.215571
33.33323	0.210887
33.34923	0.195603
33.36523	0.180518
33.38123	0.165757
33.39723	0.151451
33.41323	0.137733
33.42923	0.124735
33.44523	0.112578
33.46123	0.101374
33.47723	0.091215
33.49323	0.082174
33.50923	0.074295
33.52523	0.067594
33.54123	0.062061
33.55723	0.057651
33.57323	0.054295
33.58923	0.051893
33.60523	0.050323
33.62123	0.049438
33.63723	0.049066
33.65323	0.049

Sor	
0.049	
9/23/2005	
DTP	**Corrected LNAPL Depth**
32.65	33.33
DTW	**Corrected water Depth**
32.97	33.65
GS-MP	
0.68	



API Model Sn

Depth	Sn
31.94	0.0486
31.96867	0.052926
31.99733	0.057756
32.026	0.063151
32.05467	0.069179
32.08333	0.07592
32.112	0.083461
32.14067	0.091901
32.16933	0.101349

Gauging Data - Well MP-50C

Ground Surface Elevation
430.57

Measuring Point Elevation
NA

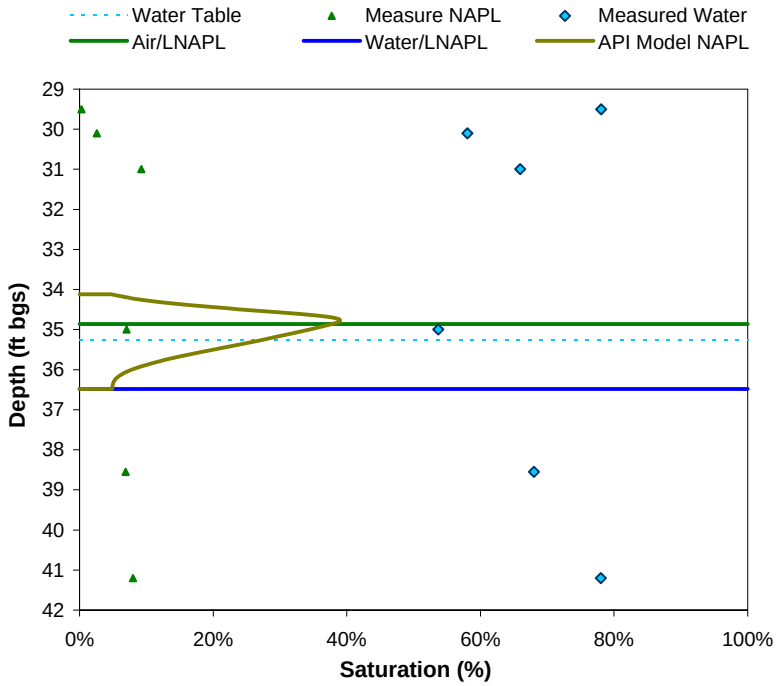
Water Table Elevation
397.36

Estimated Water Table Depth

0	33.21
1	33.21

32.198	0.111927
32.22667	0.123767
32.25533	0.137009
32.284	0.151802
32.31267	0.16829
32.34133	0.186607
32.37	0.206859
32.39867	0.229102
32.42733	0.253302
32.456	0.279305
32.48467	0.306776
32.51333	0.335163
32.542	0.363656
32.57067	0.391203
32.59933	0.416568
32.628	0.438481
32.65667	0.455829
32.68533	0.467877
32.714	0.474432
32.74267	0.475902
32.77133	0.473269
32.8	0.46804
32.8785	0.451248
32.957	0.432828
33.0355	0.412649
33.114	0.390598
33.1925	0.366598
33.271	0.34063
33.3495	0.312767
33.428	0.283211
33.5065	0.252337
33.585	0.220724
33.6635	0.18918
33.742	0.158715
33.8205	0.130465
33.899	0.10556
33.9775	0.084944
34.056	0.069199
34.1345	0.058414
34.213	0.052151
34.2915	0.049478
34.37	0.049

Sor	
0.049	
9/27/2005	
DTP	**Corrected LNAPL Depth**
32.46	32.8
DTW	**Corrected water Depth**
34.03	34.37
GS-MP	
0.34	



API Model Sn

Depth	Sn
34.12	0
34.12	0.047165
34.14467	0.053939
34.16933	0.061355
34.194	0.069467
34.21867	0.078329
34.24333	0.088001
34.268	0.098538
34.29267	0.109996

Gauging Data - Well MP-39C

Ground Surface Elevation
432.34

Measuring Point Elevation
NA

Water Table Elevation
397.07

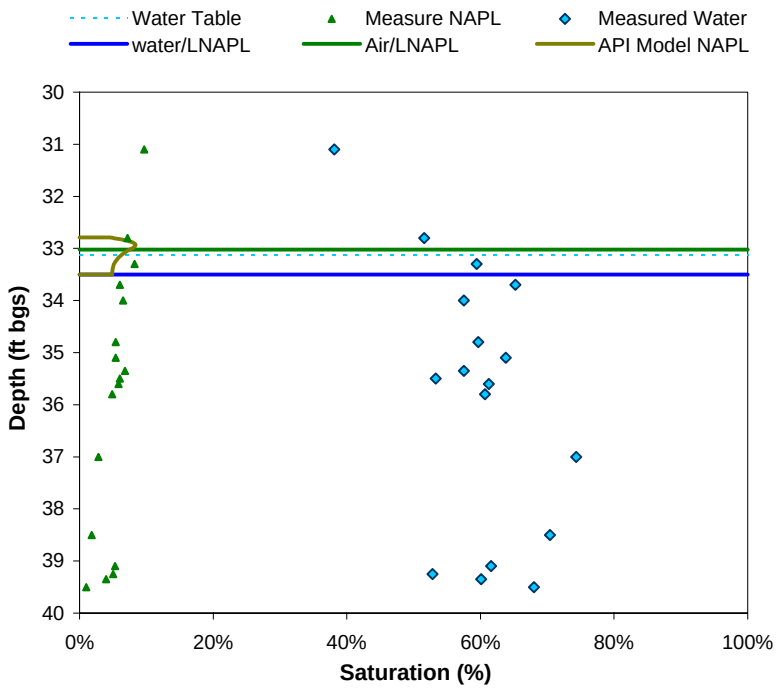
Estimated Water Table Depth

0	35.27
1	35.27

34.31733	0.122424
34.342	0.135863
34.36667	0.15034
34.39133	0.165861
34.416	0.182406
34.44067	0.199913
34.46533	0.218278
34.49	0.237334
34.51467	0.25685
34.53933	0.276519
34.564	0.295965
34.58867	0.314744
34.61333	0.332367
34.638	0.348332
34.66267	0.362163
34.68733	0.373456
34.712	0.381926
34.73667	0.387439
34.76133	0.390034
34.786	0.389922
34.81067	0.387478
34.83533	0.383222
34.86	0.377831
34.941	0.358627
35.022	0.338253
35.103	0.316752
35.184	0.294213
35.265	0.270788
35.346	0.246695
35.427	0.222234
35.508	0.197784
35.589	0.173798
35.67	0.150789
35.751	0.129291
35.832	0.109824
35.913	0.092835
35.994	0.078655
36.075	0.06745
36.156	0.059203
36.237	0.053704
36.318	0.050565
36.399	0.049236
36.48	0.049

Sor	
0.049	
10/5/2005	
DTP	**Corrected LNAPL Depth**
34.59	34.86
DTW	**Corrected water Depth**
36.21	36.48
GS-MP	
0.27	

36.48	0



API Model Sn

Depth	Sn
32.78952	0
32.78952	0.044941
32.79719	0.048878
32.80485	0.05264
32.81252	0.056216
32.82019	0.059596
32.82785	0.062773
32.83552	0.065739
32.84319	0.068486

Gauging Data - Well MP-29C

Ground Surface Elevation

429.74

Measuring Point Elevation

NA

Water Table Elevation

396.62

Estimated Water Table Depth

0	33.12
1	33.12

32.85085	0.07101		
32.85852	0.073306	**Sor**	
32.86619	0.075372	0.049	
32.87385	0.077206		
32.88152	0.078808	**10/5/2005**	
32.88919	0.08018	**DTP**	**Corrected LNAPL Depth**
32.89685	0.081323	32.75	33.02
32.90452	0.082243	**DTW**	**Corrected water Depth**
32.91219	0.082944	33.23	33.5
32.91985	0.083432		
32.92752	0.083717	**GS-MP**	
32.93519	0.083807	0.27	
32.94285	0.083713		
32.95052	0.083445		
32.95819	0.083018	**9/20/05.**	
32.96585	0.082445	**DTP**	**Corrected LNAPL Depth**
32.97352	0.08174	24.05	24.32
32.98119	0.08092	**DTW**	**Corrected water Depth**
32.98885	0.080001	24.68	24.98
32.99652	0.079002		
33.00419	0.077944	**GS-MP**	
33.01185	0.076847	0.3	
33.01952	0.075738		
33.04352	0.072405		
33.06752	0.069322		
33.09152	0.066487		
33.11552	0.063899		
33.13952	0.061552		
33.16352	0.059441		
33.18752	0.057561		
33.21152	0.055904		
33.23552	0.05446		
33.25952	0.053219		
33.28352	0.052171		
33.30752	0.051303		
33.33152	0.050602		
33.35552	0.050053		
33.37952	0.049641		
33.40352	0.049349		
33.42752	0.049159		
33.45152	0.049053		
33.47552	0.049008		
33.49952	0.049		

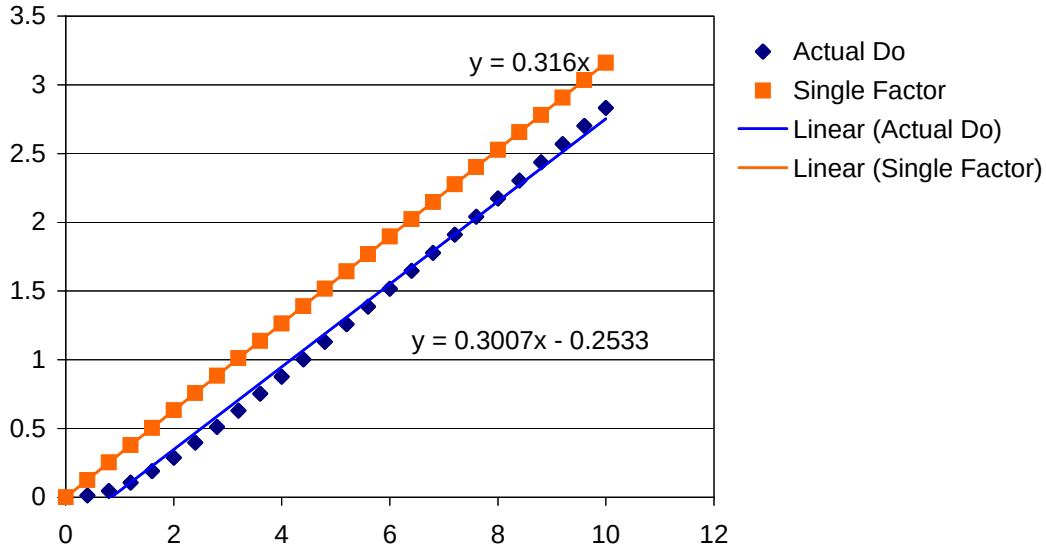
33.49952	0

Specific LNAPL Thickness Correction Factors

	Applicable Range			
	0-1 foot		>1 foot	
Model	β	χ	β	χ
HCSB-1	0.06	0.00	0.29	0.95
HCSB-2	0.07	0.00	0.31	0.92
HCSB-3	0.10	0.00	0.33	0.83
HCSB-4	0.07	0.00	0.30	0.93
HCSB-5	0.07	0.00	0.30	0.93

$$D_o = \beta \left(b_n - \chi \right)$$

	Do HCSB-1	
bn	API Model	Single Factor
0	0	0
0.4	0.015061459	0.1264
0.8	0.046794121	0.2528
1.2	0.106782	0.3792
1.6	0.190064385	0.5056
2	0.288706431	0.632
2.4	0.397092964	0.7584
2.8	0.511856799	0.8848
3.2	0.630974444	1.0112
3.6	0.752951226	1.1376
4	0.87743555	1.264
4.4	1.003403703	1.3904
4.8	1.130706734	1.5168
5.2	1.258829007	1.6432
5.6	1.388042171	1.7696
6	1.517714439	1.896
6.4	1.647966213	2.0224
6.8	1.778704557	2.1488
7.2	1.90985501	2.2752
7.6	2.041115339	2.4016
8	2.172677251	2.528
8.4	2.304504684	2.6544
8.8	2.436333996	2.7808
9.2	2.568614435	2.9072
9.6	2.700844032	3.0336
10	2.833220096	3.16



Do CALCULATIONS TABLE DEVELOPED BY CLAYTON

Apparent Product Thickness	Do		
	yellow HCSB-1	blue-average HCSB-1 to 4	green HCSB-5
0.1	0.01	0.01	0.01
0.2	0.01	0.02	0.01
0.3	0.02	0.02	0.02
0.4	0.02	0.03	0.03
0.5	0.03	0.04	0.03
0.6	0.04	0.05	0.04
0.7	0.04	0.06	0.05
0.8	0.05	0.06	0.05
0.9	0.05	0.07	0.06
1	0.06	0.08	0.07
1.1	0.04	0.07	0.05
1.2	0.07	0.10	0.08
1.3	0.10	0.13	0.11
1.4	0.13	0.16	0.14
1.5	0.17	0.19	0.17
1.6	0.19	0.22	0.20
1.7	0.22	0.25	0.23
1.8	0.25	0.28	0.26
1.9	0.28	0.32	0.29
2	0.31	0.35	0.33
2.1	0.34	0.38	0.36
2.2	0.37	0.41	0.39
2.3	0.40	0.44	0.42
2.4	0.43	0.47	0.45
2.5	0.46	0.50	0.48
2.6	0.48	0.53	0.51
2.7	0.51	0.57	0.54
2.8	0.54	0.60	0.57
2.9	0.57	0.63	0.60
3	0.60	0.66	0.63
3.1	0.63	0.69	0.66
3.2	0.66	0.72	0.69
3.3	0.69	0.75	0.72
3.4	0.72	0.78	0.75
3.5	0.75	0.82	0.78
3.6	0.78	0.85	0.81
3.7	0.81	0.88	0.84
3.8	0.84	0.91	0.87
4	0.90	0.97	0.93
4.1	0.93	1.00	0.96
4.2	0.95	1.04	0.99
4.3	0.98	1.07	1.02
4.4	1.01	1.10	1.05
4.5	1.04	1.13	1.08
4.6	1.07	1.16	1.11
4.7	1.10	1.19	1.14
4.8	1.13	1.22	1.17
4.9	1.16	1.25	1.20
5	1.19	1.29	1.24
5.1	1.22	1.32	1.27
5.2	1.25	1.35	1.30
5.3	1.28	1.38	1.33
5.4	1.31	1.41	1.36
5.5	1.34	1.44	1.39
5.6	1.37	1.47	1.42
5.7	1.40	1.50	1.45
5.8	1.42	1.54	1.48
5.9	1.45	1.57	1.51
6	1.48	1.60	1.54

Main Sand				
Yellow	Blue	Green	Clean	Wells Removed
MP-47C	MP-79C/D	HMW-38C	HMW-39C	HB-32
MP-55C	MP-80C	HMW-46C	HMW-51C	RW-4
HMW-44C	HB-31	HMW-47C	MP-81C	
HMW-54B	MP-30C	HMW-45C	HMW-41C	
HMW-49D	MP-83C	MP-78D	HMW-25	
	MP-31C	MP-29D	HMW-26	
	MP-38C	RW-4A	HMW-27	
	MP-32B/C	RW-3	HMW-28	
	MP-34C	MP-85D	HMW-29	
	MP-33D	HMW-48D	MP-61C	
	MP-39C	SP-42	MP-89C	
	HMW-18		MP-62C	
	MP-43C		MP-63C	
	MP-48B/C		HMW-43C	
	MP-49C		HMW-52C	
	HMW-19		HB-38	
	MP-84C		MP-65C	
	MP-86C		MP-66C	
	MP-87C		MP-67C	
	RW-1		HP-1A	
	MP-82C		HP-1B	
	HMW-40C		HP-1C	
	HMW-08		HP-2A	
	HMW-22		HP-3A	
	MP-36C		HP-3B	
	MP-35D		HP-3C	
	HMW-14		HP-4A	
	MP-40C		HP-4B	
	MP-41C		HP-4C	
	MP-44D		HP-5A	
	MP-50C		HP-5B	
	MP-52C		HP-5C	
	MP-37D		HP-6A	
	RW-5		HP-7A	
	MP-42C		HP-8A	
	HMW-10		HP-9A	
	HMW-02		HMW-50C	
	RW-2		SP-41	
	MP-45C		SP-36	
	MP-46C		P-77	
	HB-30		P-78	
	MP-51D		P-79	
	MP-53C		P-106	
	HB-37			
	MP-54C			
	MP-77C			
	MP-56C			
	HMW-20			
	MP-57C			
	MP-60C			
	HMW-53B			
	MP-64C			
	MP-59C			
	MP-58C			
	MP-88C			
	HMW-42B			