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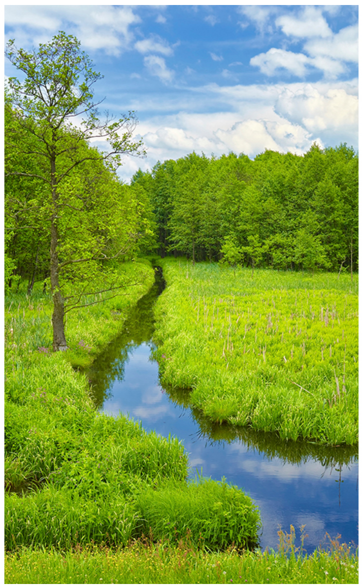
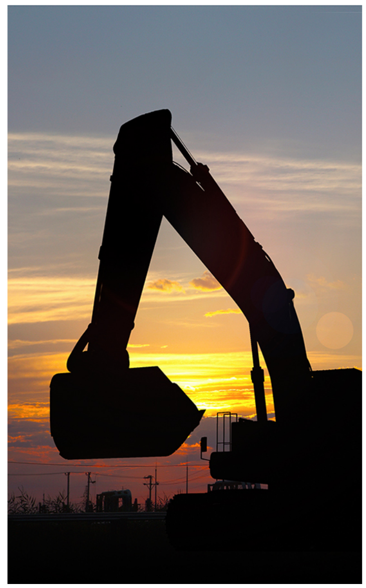


Report

LNAPL Delineation, Mobility and Recoverability Study Report

Former Willow Run Powertrain
Ypsilanti, Michigan

Prepared for: RACER Trust

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Partners in Sustainability

Executive Summary

Petroleum product usage in historical operations has resulted in light non-aqueous phase liquid (LNAPL) being present in the subsurface across the Former Willow Run Powertrain facility (Site). The purpose of the evaluation presented herein was to delineate and assess the potential mobility and recoverability of the LNAPL at the Site. Perhaps most importantly, this evaluation was undertaken to identify areas where there is a reasonable expectation that recoverable LNAPL exists and to evaluate what fraction of the LNAPL in these areas might be recoverable. The ultimate goal was to provide a realistic expectation of what can reasonably be accomplished through any future LNAPL recovery efforts that may be undertaken at the Site. This report was prepared by Conestoga-Rovers & Associates (CRA) on behalf of the RACER Trust (RACER), and includes the results of the cumulative efforts of CRA and Arcadis to characterize the mobility and recoverability of the Site LNAPL based on work that commenced in 2010. This work included the following tasks:

- A Site-wide laser induced fluorescence (LIF) survey
- A Site-wide soil core sampling and petrophysical testing program
- The estimation of LNAPL transmissivities
- An examination of historical well gauging data

The following Site-wide conclusions are made based on the results this evaluation:

- The vast majority of the Site LNAPL is present at residual level saturations and, therefore, is effectively immobile.
- Observations of LNAPL in wells and LNAPL infiltrating sewers indicate that some portion of the Site LNAPL is able to move to these low pressure macropores, likely through preferential pathways.
- The footprint or perimeter of the Site LNAPL is stable (i.e., not moving or expanding over time). Consequently, any localized areas where LNAPL may be mobile are not destabilizing the overall LNAPL areas (i.e., not promoting migration of the LNAPL areas).
- The fraction of LNAPL that is theoretically mobile and recoverable is estimated to have an upper bound of 15% of the in-place LNAPL (by volume). The percentage of Site LNAPL that may be actually recoverable under field conditions is predicted to be much less than 15%.

In conclusion, the results of the evaluations presented herein indicate that the LNAPL at the Site is already stable, and the vast majority will remain in the subsurface as unrecoverable residual following any recovery efforts that may be implemented.

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List of Acronyms

API	American Petroleum Institute
ASTM	ASTM International
bgs	Below ground surface
CRA	Conestoga-Rovers & Associates
EC	Electrical conductivity
ft	Feet
ITRC	Interstate Technology and Regulatory Council
LIF	Laser induced fluorescence
LNAPL	Light non-aqueous phase liquid
mS/m	Millisiemens per meter
PAH	Polycyclic aromatic hydrocarbons
PTS	PTS Laboratories
RACER	RACER Trust
RCES	Remedial Cost Estimate Summary
RE	Reference Emitter
Site	Former Willow Run Powertrain
UV	Ultraviolet
UVOST	Ultra-violet optical screening tool

Section 1.0 Introduction

Petroleum product usage in historical operations has resulted in light non-aqueous phase liquids (LNAPL) being present in the subsurface across the Former Willow Run Powertrain facility (Site). The purpose of the evaluation presented herein was to delineate and assess the potential mobility and recoverability of the LNAPL at the Site. Perhaps most importantly, this evaluation was undertaken to identify areas where there is a reasonable expectation that recoverable LNAPL exists and to evaluate what fraction of the LNAPL in these areas might be recoverable. The ultimate goal was to provide a realistic expectation of what can reasonably be accomplished through any future LNAPL recovery efforts that may be undertaken at the Site.

This report was prepared by Conestoga-Rovers & Associates (CRA) on behalf of the RACER Trust (RACER), and includes the results of the cumulative efforts of CRA and Arcadis to characterize the mobility and recoverability of the Site LNAPL based on work that commenced in 2010.[1,2] The earliest work conducted by Arcadis was a Site-wide evaluation, but with significant access limitations due to the semi-operational status of the Site at the time. The previous CRA work focused on the LNAPL in the eastern portion of the Site. This report presents the methodology and results of the most recent study, which focused on the LNAPL in the central and western portions of the Site in order to complete a comprehensive Site-wide assessment of LNAPL conditions. This report is organized as follows:

- Section 1.0 – Introduction
- Section 2.0 – Methodology
- Section 3.0 – Results
- Section 4.0 – Data Interpretation and Conclusions
- Section 5.0 – References

Where appropriate, the results of the previous LNAPL mobility/recoverability evaluations are included in order to facilitate a holistic Site-wide discussion.

As a primer on the occurrence and behavior of LNAPL in the subsurface, the following appendices are provided that illustrate the technical fundamentals behind the methodology and interpretation of results presented herein:

[1] The previous Arcadis work is summarized in the Arcadis report entitled *Summary of Field Activities, General Motors Willow Run Plant, January-February 2010* (December, 2010).
[2] The report presenting the results of the previous CRA work is provided here as Appendix A.

- A list of common LNAPL-related terms and definitions is provided in Appendix B
- A general discussion on LNAPL release dynamics, the creation of a multi-phase fluid system (i.e., LNAPL body), LNAPL saturation/residual saturation, mobility/body stability, chemical/physical properties, etc. is provided in Appendix C

The following definitions are among the most pertinent concepts touched on throughout the remainder of this report:

LNAPL Migration: describes LNAPL movement on a “plume” scale, referring to the expansion of the perimeter of an LNAPL plume/body/area in some or all directions (i.e., the overall LNAPL body or body periphery is continuing to grow in one or more directions). All migrating LNAPL is mobile; but not all mobile LNAPL is necessarily promoting migration. Mobile LNAPL can be present within the interior of an LNAPL body that is not migrating.

LNAPL Mobility: a more localized description of the potential for LNAPL to move at any point within an LNAPL body. LNAPL may be mobile where the LNAPL is continuous at saturations above residual saturation. Because LNAPL residual saturation within a LNAPL body varies from the vadose zone to the saturated zone, LNAPL mobility may also vary due to fluctuations in the water table elevation. The presence of mobile LNAPL within an LNAPL body does not necessarily mean that the LNAPL body as a whole is migrating.

LNAPL Stability: an LNAPL body that is not expanding or migrating is deemed to be a stable LNAPL body/area. A LNAPL body that is migrating or expanding (i.e., footprint of LNAPL body is growing) is deemed to be unstable. Stable LNAPL bodies can contain localized areas of mobile LNAPL, with the overall footprint remaining unchanged over time.

Section 2.0 Methodology

The following field activities were conducted to complete the LNAPL delineation and mobility/recoverability evaluation:

- Utilized laser induced fluorescence (LIF) survey data to further characterize and define the lateral and vertical extents of the LNAPL impacts at the Site and select locations for the collection of soil core samples
- Collected relatively undisturbed soil cores to represent the overall impacted area spatially, all apparently unique LNAPL-soil type pairs, and including the areas of highest/worst-case impacts (i.e., highest LNAPL saturations)

- Submitted the soil cores for laboratory photography and petrophysical testing to estimate LNAPL mobility/recoverability potential

The methodology used to evaluate the LIF data, collect soil cores and complete the laboratory testing for the most recent sampling event focusing on the West and Central LNAPL Areas is presented below. The methodologies employed for the Eastern LNAPL Area are detailed in Appendix A.

It is noted that additional laboratory testing was conducted during the previous Eastern LNAPL Area evaluation in order to develop LNAPL analytical modeling inputs. The analytical modeling was previously performed to develop a line of evidence pertaining to LNAPL mobility by estimating LNAPL velocities and comparing the estimates against a de minimis value of 10^{-6} cm/sec suggested by ASTM International (ASTM, 2007). However, analytical modeling tools employ many simplifying assumptions that will result in a large potential for error at all but the simplest sites (i.e., sites with a single LNAPL type and relatively homogeneous soils). As such, analytical modeling was omitted from the scope of the evaluation for the remainder of the Site following discussions between CRA and the Michigan Department of Environmental Quality (MDEQ) due to the following points:

- The Site has multiple LNAPL types that have been in the ground variable durations (i.e., different LNAPL types and differing degrees of degradation/weathering have resulted in significantly varied LNAPL compositions and physical properties across the Site)
- The Site has an extremely complex subsurface due to soil heterogeneities and extensive subsurface infrastructure

The LIF survey data and laboratory test results are presented in Section 3.0. A discussion regarding the mobility evaluation results is presented in Section 4.0.

2.1 LIF / UVOST Survey

The LIF survey was performed by Matrix Environmental LLC of Osseo, Minnesota using the Ultra-Violet Optical Screening Tool (UVOST) system. An initial Site-wide LIF mobilization was conducted with the oversight of Arcadis in January-February 2010 (site-wide, see Arcadis 2010). Additional LIF surveys were completed with the oversight of CRA in October 2010 (Eastern LNAPL Area, see Appendix A) and October-November 2011 (West and Central LNAPL Areas) in order to further delineate and characterize the Site LNAPL areas. Collectively, the UVOST investigations were conducted at a total of two hundred ninety-three locations throughout the Site. In general, the UVOST probe was pushed to a depth ranging from fifteen to twenty-seven feet (ft) below ground surface (bgs).

The LIF technology detects LNAPL by screening for the presence of polycyclic aromatic hydrocarbons (PAHs) present in petroleum fuels during the advancement of a specialized direct-push probe. The LIF probe is equipped with a sapphire window through which a laser is directed. The laser light is absorbed by PAH molecules in contact with the window as the probe is advanced. This addition of energy (photons) to the PAHs causes them to fluoresce as they return to ground state after excitation. A portion of the fluorescence emitted from any encountered PAHs is returned through the sapphire window and conveyed by a fiber optic cable to a detection system at the surface. The emission data from the pulsed laser light is averaged into one reading per one-second intervals and is recorded continuously. The emission data is reported as percent of the fluorescence intensity of a standard hydrocarbon mixture used to calibrate the equipment called the "reference emitter" (%RE). For example, an LIF location producing a reading of 100%RE is fluorescing at exactly the same intensity as the standard hydrocarbon mixture. Other things being equal (LNAPL and soil types), LIF response is proportional to the amount of PAHs present. More specifically, LIF response is proportional to LNAPL saturation (i.e., percent of the pore space that is filled with LNAPL). Where multiple LNAPL types and complex subsurface conditions are present, LIF data are less definitive and data interpretation is much more complicated. However, LIF data constitute the best basis for characterizing LNAPL-impacted areas regardless of complexity by:

- Providing definitive delineation of LNAPL/free product impacts vertically and laterally both above and below the water table
- Identifying locations within LNAPL–impacted areas with the highest mobility/recoverability potential by determining the relative intensity of impacts across the plume (i.e., a location producing an LIF response of 300%RE will generally represent a higher LNAPL saturation and greater potential for mobile and/or recoverable LNAPL than a location producing an LIF response of 100%RE for a given LNAPL type)

In addition, the LIF instrumentation measures the intensities of four different wavelengths of light produced when a given LNAPL fluoresces. The proportions of each wavelength that comprise the overall fluorescence response are unique to a given petroleum product type, allowing the real-time identification of LNAPL types in the field. It is important to note that LIF survey results, by themselves, cannot:

- Specifically quantify LNAPL saturation, mobility or recoverability (without follow-up targeted well installation and/or soil core sampling to "calibrate" LIF responses)
- Detect dissolved or vapor phase contamination – Limits of detection will vary from 100-1000 ppm total petroleum hydrocarbons (TPH) depending on fuel/LNAPL type

The electrical conductivity (EC) of the soil was also measured and logged along with the LIF data. The magnitude of soil EC provides an indication of the types of soils encountered as different soil types have different capacities for conducting electrical current (based primarily on grain size/organic content). The system used with UVOST expresses EC in terms of millisiemens per meter (mS/m). In general, larger grain size soils such as sands and gravels will exhibit EC values less than 100 mS/m, while finer-grained soils with higher organic contents such as clays will exhibit EC values greater than 100 mS/m. The main features of a typical UVOST result with both LIF and EC logs explained are shown in Appendix D.

In summary, LIF data constitutes the best first step in an LNAPL investigation by quickly identifying:

- Where the LNAPL is (and isn't)
- What the LNAPL is
- Where the "hot-spots" are for a given LNAPL type

Where sites are as complex as the subject Site, the sophistication of the LIF dataset is particularly useful in the development of subsequent sampling or well installation strategies that will efficiently and effectively target the desired areas and cover the range of different LNAPL types encountered. This provides a degree of confidence when designing characterization strategies at complex sites that has not been possible historically.

2.2 Soil Core Sampling

CRA collected relatively undisturbed soil cores in select locations that were deemed to have the greatest potential for the presence of mobile and/or recoverable LNAPL based on LIF results and inferences from the results of the Eastern LNAPL Area evaluation (see Appendix A). The following conclusions regarding LNAPL types and mobility were made based on the results of the Eastern LNAPL Area evaluation:

- None of the sampling locations where the LIF results showed a mix of diesel and heavier oil-range LNAPL types showed potential LNAPL mobility during subsequent soil core petrophysical testing
- All of the sample locations where the LIF results indicated only kerosene-range LNAPL showed potential LNAPL mobility during subsequent soil core petrophysical testing
- Sampling locations where the LIF results showed a diesel-range LNAPL and LIF responses greater than 300%RE exhibited potential LNAPL mobility during soil core testing

These conclusions formed the basis for a more targeted soil core sampling strategy in the Central and Western portions of the Site. Accordingly, the following strategy was employed in the selection of soil core locations in the Central and Western LNAPL Areas:

- None of the LIF locations that showed a mix of diesel and heavier oil-range LNAPL types were selected for soil core sampling (i.e., assumed immobile based on Eastern LNAPL Area results)
- Soil core samples were obtained from among the locations where the LIF results indicated only kerosene-range LNAPL

- Soil core samples were obtained from among the locations where the LIF results showed a diesel-range LNAPL and LIF responses greater than 300%RE

The methodology employed to select soil core locations for the Eastern LNAPL Area evaluation is detailed in Appendix A. In total, soil core samples have been obtained from 28 locations across the Site via Geoprobe. Once at the appropriate depth below ground surface, soil cores were collected using the Geoprobe Macrocore sampling system. Macrocore samples were collected in 2-inch diameter, 5-foot long, clear acetate liners. In general, one or two 5-foot long cores were collected from each borehole to obtain a 5 to 10-foot vertical soil profile across the LNAPL impacted zone. Upon retrieval from the ground, the cores were sealed at each end to prevent fluid loss, stored on dry ice to freeze the cores and preserve the pore fluids, and shipped to PTS Laboratories (PTS) in Santa Fe Springs, California for soil core photography and subsequent LNAPL mobility/recoverability testing.

2.3 Core Photography

Core photography was performed consistent with ASTM International (ASTM) D5079. More specifically, frozen soil cores were cut open along the vertical length of the sample tube to enable photographs to be taken of the soil cores. Soil cores were allowed to partially thaw along the surface prior to photographing. The partial thawing was allowed to enable LNAPL, where present, to pool to the surface of the profile. Photographs were taken in both white light and ultraviolet (UV) light. The white light photographs displayed the natural state (color, texture) of the soil profile including any pooled LNAPL, where applicable. The UV photos were used to identify LNAPL by the same principal described with respect to the LIF/UVOST technology. As previously mentioned, LNAPL tends to fluoresce when exposed to UV light. For a given pairing of LNAPL and LNAPL-impacted soil type, the intensity of fluorescence is proportional to the amount of LNAPL, with higher intensities corresponding to greater LNAPL saturations. UV photos also provide qualitative information regarding the type of LNAPL. Generally speaking, lighter end petroleum compounds, such as gasoline or kerosene, tend to fluoresce white or blue; middle distillates including diesel and No. 2 fuel oil tend to fluoresce blue, yellow or gold; and heavier end compounds such as oils and coal tars tend to fluoresce red or brown.

Core photographs were provided by the laboratory to CRA to enable the identification of discrete (two tenths of a foot) intervals of maximum UV fluorescence. Select intervals were then designated for laboratory testing of mobility parameters.

2.4 Laboratory Testing

Discrete soil intervals of maximum UV fluorescence were determined qualitatively from the core photography. Core photography of the soil in the core under white light was also considered to evaluate the pore structure and gradation of the soil/rock samples in the respective sample zones for maximum porosity. These locations in the core soil samples were selected for one or more of the following laboratory tests (with methods shown in parentheses where applicable):

- Pore fluid (water and LNAPL) saturations (American Petroleum Institute [API] RP40)
- LNAPL saturations and residual saturations using a Water Drive method (Proprietary/API RP40)

Additional laboratory testing was completed for the purpose of conducting LNAPL analytical modeling for the East LNAPL Area (see Appendix A). As discussed in Section 2.0, LNAPL analytical modeling was not performed for the Central and Western LNAPL Areas.

The key laboratory test method used to test samples obtained during this mobilization is further described below.

2.4.1 LNAPL Saturation and Residual Saturation Testing

One soil core subsample per location was subjected to initial and residual LNAPL saturation testing via the Water Drive method. This test is considered to yield a LNAPL residual saturation value that is more representative of LNAPL mobility and recoverability conditions under realistic pressure gradients and drainage conditions than other available tests (i.e., 1,000g centrifugal method or water/LNAPL drainage/imbibition capillary pressure testing). An additional subsample was selected for the determination of pore fluid saturations (i.e., initial LNAPL and water saturations) for certain locations with more than one discrete interval of comparable fluorescence (i.e., similar LNAPL saturation levels). This was conducted to ensure that the zones of maximum LNAPL impacts were tested to allow a conservative evaluation of LNAPL mobility/recoverability. For each location, the discrete soil interval(s) of maximum UV fluorescence were selected for the respective testing.

LNAPL saturations in soil were determined by the laboratory using the API RP40 Method (via a Dean-Stark extraction procedure). Initial LNAPL saturations were determined either from the Pore Fluids Saturation test or the Residual Saturation by Water Drive test. Subsamples selected for the Water Drive test were additionally driven to residual LNAPL saturation by flushing the sample with multiple pore volumes of water under 25 psi confining pressure.

The potential for LNAPL mobility/recoverability was evaluated by comparing laboratory-measured initial LNAPL saturations to residual saturations. Any locations having initial LNAPL saturations that exceeded the corresponding residual LNAPL saturations were deemed to be potentially mobile, and therefore potentially recoverable. Where applicable, the difference between the initial LNAPL saturation and the residual LNAPL saturation for a given sample represents an upper bound estimate of the potentially recoverable fraction.

Section 3.0 Results

The LIF survey, soil core photography and laboratory test results for the latest mobilization (Central and West LNAPL Areas) are discussed in the following sections. Where appropriate, results from the LNAPL mobility/recoverability evaluation for the Eastern LNAPL Area are included in order to present a Site-wide discussion on the potential mobility and recoverability of the LNAPL.

3.1 LIF / UVOST Survey

A total of 293 LIF locations have been completed at the Site. The locations of the 293 LIF survey points are identified in Figure 3.1 (January-February 2010 survey denoted as ARC-1, 2, 3…282, October 2010 survey denoted as LIF-1, 2, 3…62 and October-November 2011 survey denoted as LIF-100, 101, 102…209). The LIF output for each location (vertical profile graphs of relative fluorescence response against depth below ground surface) is provided as Appendix E (October 2010 survey and October-November 2011 survey) and Appendix F (January-February 2010 survey).

The results of all LIF survey events are summarized in Table 3.1, Figure 3.2 and Figure 3.3. In general, the results indicate that three main LNAPL types are observed at the Site: a lighter kerosene-range product, a diesel-range product, and heavier oil.[3] It is noted that the following were considered to be background or insignificant response scenarios in the development of Table 3.1, Figure 3.2 and Figure 3.3:

- Locations where response levels are less than 10%RE throughout the entire vertical profile.
- Locations with shallow (0-5ft bgs) results at or greater than 10%RE but clean at water table depth. Sub-slab and other shallow vadose zone responses are assumed to be the result of concrete dust interference or LNAPL that is present below residual levels and effectively unrecoverable (i.e., either interference or insignificant response).

As shown in Figure 3.3, multiple petroleum LNAPL types are co-located (spanning different vertical intervals) and/or commingled to a significant extent, resulting in a highly complex LNAPL distribution that likely resulted from many different LNAPL releases at different times throughout the Site's history. Maximum LIF response levels varied from 24.00 – 585.50 %RE. In general, the depths of the maximum response levels were as shallow as 1.97 ft bgs and as deep as 19.71 ft bgs. The maximum depths of LNAPL impacts were observed to fluctuate from 3.72 – 20.26 ft bgs. In order to establish the spatial distribution of the LNAPL impacts with respect to current water table elevations, the LIF results were cross-referenced with well gauging data. The comparison showed that the majority of the LNAPL impacts are found beneath the water table as evidenced by the representative examples provided in Figure 3.4.

[3] The LIF spectral fingerprints provide approximations of product types, and should not be assumed to be as accurate as LNAPL fingerprinting via laboratory gas chromatography

The LIF responses noted at LIF-013, -058, and -063 along the eastern property line indicate that some level of off-Site migration of LNAPL has taken place historically onto Willow Run Airport property. The extent of LNAPL impacts in this area have not been fully delineated to date.

3.2 Core Photographs

The locations selected for soil core sampling are shown on Figure 3.1. The resulting soil core photographs are provided in Appendix G. CRA reviewed the photographs and identified discrete intervals of UV fluorescence (i.e., LNAPL impacts) and corresponding soil types for each sample location. In addition, CRA identified the zone(s) of highest LNAPL saturations and potential for mobility/recoverability (i.e., maximum UV fluorescence) for each sample location where impacts were noted. This method of sample selection insured a conservative evaluation of potential mobility/recoverability since the section of the soil core exhibiting the most intense fluorescence selected for testing represents the section with the highest LNAPL saturation (i.e., greatest potential for the presence of mobile/recoverable LNAPL). Where possible, the zones of maximum fluorescence from the core photos were then compared with the corresponding LIF data to confirm that the results from the different datasets were in general agreement. A summary of the zones/subsamples of maximum fluorescence for each location from the core photography selected for laboratory testing is provided in Table 3.2.

3.3 LNAPL Saturation and Residual Saturation

As previously noted, at least one saturation and/or residual saturation test was completed for each of the soil core locations. Pore fluid saturation tests were conducted on twelve soil core subsamples. Water Drive residual saturation testing was conducted on twenty-eight core subsamples (i.e., one subsample per location). The LNAPL saturation and residual saturation test results are provided in Appendix H and summarized in Table 3.2.

The initial LNAPL saturation results obtained from the above testing indicate that LNAPL saturations across the Site vary from 4.3% to 58.6%. With respect to the subsamples subjected to Water Drive testing, LNAPL was released from the soil during the tests at the following locations: LIF-9, LIF-25, LIF-61, LIF-113, LIF-153, LIF-173 ARC-025 and ARC-065. This indicates that LNAPL is present at these locations at saturations exceeding residual levels (i.e., potentially mobile and/or recoverable). No LNAPL was released during Water Drive testing for the remainder of the respective subsamples, indicating that the LNAPL at the majority of the tested locations is present at saturations less than residual levels (i.e., immobile and/or unrecoverable). Given that the LNAPL saturation at the vast majority of the sample locations are observed to be in the residual range, these test data also suggest that the overall LNAPL areas are stable (i.e., there is not a significant quantity of potentially mobile LNAPL anywhere along the peripheries of the various LNAPL areas).

The fraction of the in place LNAPL that is potentially recoverable for each location with LNAPL saturations exceeding residual is also estimated in Table 3.2. These estimates should be viewed as an upper limit to the potentially recoverable LNAPL due to the conservative strategy employed in sample selection. That is, results represent a best-case recovery scenario that is not representative of the overall vertical extent of impacts since only the most highly saturated portion of each core was tested.

3.4 In-Well LNAPL Observations

Consistent with the preceding test results, the fact that LNAPL is observed in wells (and infiltrates sewers) at the Site indicates that there is some mobile fraction present. However, this does not necessarily indicate that the overall LNAPL-impacted areas are expanding or migrating over time. For example, the extent of in-well LNAPL thickness measurements recorded from 2008-2011 are depicted on Figure 3.5. An examination of the limits of in-well LNAPL observations over the respective time period indicates that the perimeters of the various LNAPL-impacted areas are stable (i.e., not expanding over time). The apparent plume expansion along the east property boundary beginning in November 2010 was due to the installation of a new well (CRA-617-M) where LNAPL was observed. Given the overall historical dataset and the results of the evaluation provided herein, it is unlikely that this observation is indicative of any recent LNAPL body expansion/migration.

Section 4.0 Data Interpretation and Conclusions

The vast majority of the Site LNAPL is effectively immobile according to the lines of evidence presented here. Furthermore, both the soil core test results and the historical well monitoring results presented indicate that the LNAPL is stable/non-migrating.

More specifically, the results of the LNAPL saturation and residual saturation results and analytical modeling indicate that potentially mobile/recoverable LNAPL is only present in very limited portions of the Site (see Figures 4.1 and 4.2). As previously discussed, the Eastern LNAPL Area evaluation included the locations that had the greatest potential for the presence of mobile/recoverable LNAPL based on the LIF results. The evaluation of the Central and Western LNAPL Areas focused solely on the locations having the greatest potential for the presence of mobile and recoverable LNAPL. Of the 28 Site-wide locations selected for soil core sampling and petrophysical testing, only 8 locations (or less than 30%) exhibited LNAPL saturation levels that were high enough that potentially mobile/recoverable LNAPL may be present (i.e., above residual levels). These locations are shown on Figure 4.3. Of the 8 locations with potentially mobile/recoverable LNAPL, the potentially recoverable fraction exceeded one-third of the in-place LNAPL at 4 sample locations. In other words, only 4 of the 28 worst-case locations (or approximately 15% of worst-case locations) exhibited potentially recoverable fractions that might be considered significant.

On a Site-wide basis, the actual fraction of overall LNAPL that might be significantly recoverable will be much less than 15% given the following:

- The assessment is based on a sample group representing locations deemed to have best-case recoverability potential. The majority of the Site LNAPL is present at lower impact levels/saturations (based on the LIF results).
- Soil core testing focused on the most heavily impacted portions of the worst-case locations (i.e., worst-case two-tenths of a foot interval at each worst-case location). Saturation levels are variable across the vertical extent of impacts at each location and average saturations across this vertical extent will be much lower than the small interval representing the peak saturation levels that was tested.
- The laboratory testing is conducted in a manner that produces very conservative upper limit estimates of mobility/recoverability potential (i.e., pressure gradients induced in the laboratory are much higher than typical gradients at environmental sites).
- Subsurface heterogeneities and LNAPL recovery technology limitations will further limit how much LNAPL can actually be recovered compared with laboratory estimates.
- The majority of the most LNAPL-saturated soils are present below the water table, which will result in any recovery effort being made more difficult by the need for significant dewatering to access the bulk of the impacted zone (i.e., water will be preferentially recovered over LNAPL).

The preceding conclusions are also supported by earlier work by Arcadis (2010) that utilized different methods to conclude the following:

- Approximately 10% of the LNAPL at the Site is potentially recoverable. In other words, 90% of the LNAPL at the Site is likely to remain in place even after active recovery attempts.
- LNAPL baildown testing resulted in estimates of LNAPL transmissivity that were mostly within or just slightly above the de minimis recoverability range suggested by the Interstate Technology and Regulatory Council (ITRC) of 0.1-0.8 ft^2/day (ITRC, 2009).

In conclusion, the results of the evaluations presented herein indicate that the LNAPL at the Site is already stable. In addition, given that the realistically recoverable fraction of the in-place LNAPL is extremely small, it is unlikely that active recovery efforts will significantly reduce the quantity of in-place LNAPL.

Section 5.0 References

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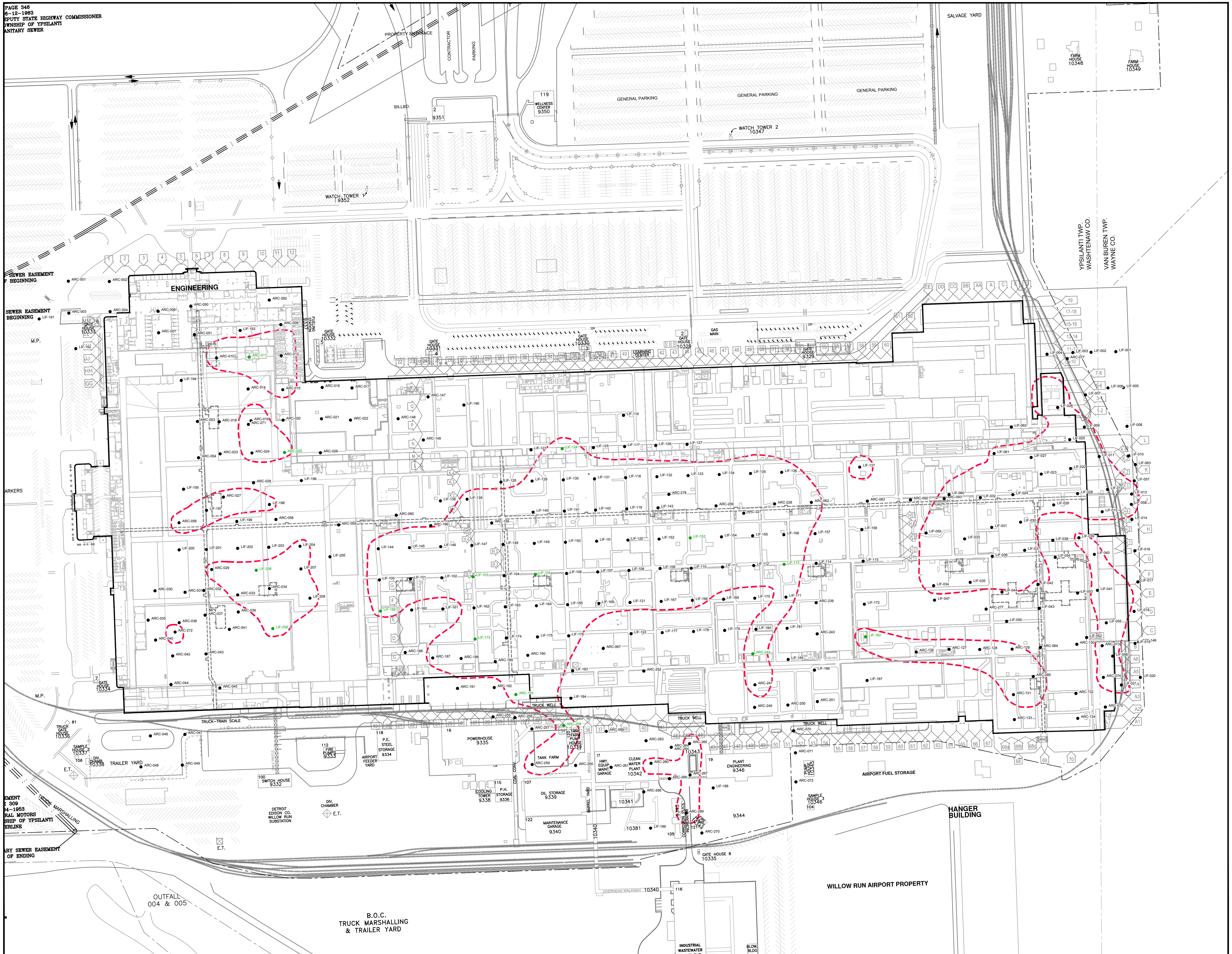


№	Revision	Date	Initial

0 75 150ft

LEGEND

PROPERTY LINE

BUILDING

LIF-001 LASER-INDUCED FLOURESCENCE (LIF) BORING

LIF-182 LIF BORING/SOIL CORE LOCATION

APPROXIMATE EXTENT OF LNAPL (BASED ON LIF RESULTS AND HISTORICAL WELL MONITORING)

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

FORMER WILLOW RUN POWERTRAIN
Ypsilanti, MI

LIF AND LNAPL MOBILITY STUDY

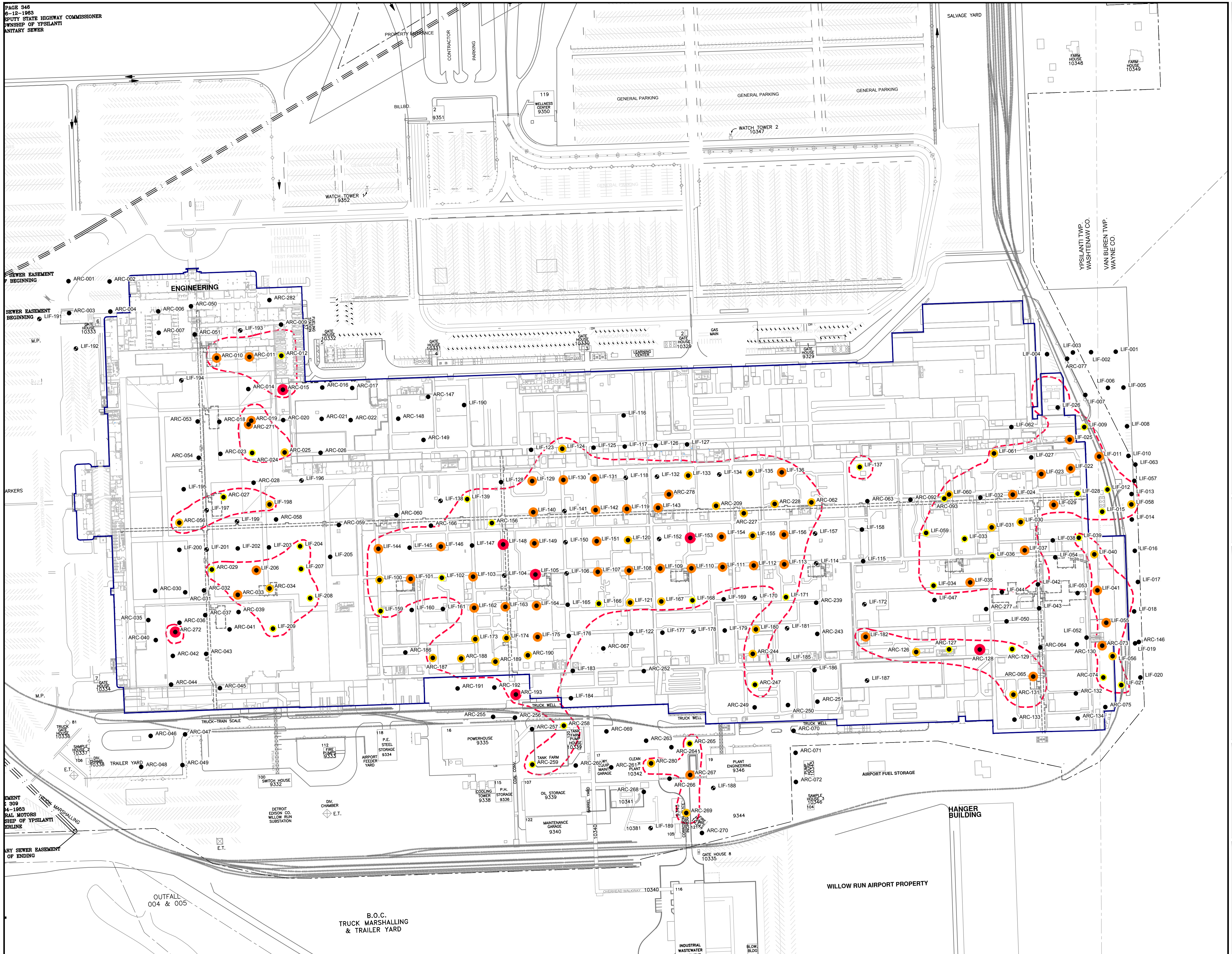
LIF AND SOIL CORE LOCATIONS

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager:	Reviewed By:	Date:	
S. ADAMOWSKI	M. ROUSSEAU	FEBRUARY 2012	
Scale: 1:150	Project №: 17358-T01	Report №: 021	Drawing №: FIGURE 3.1

17358-T01(021)GN-WI001 DEC 5/2013



Nº	Revision	Date	Initial

N

0 75 150ft

LEGEND

- PROPERTY LINE
- BUILDING
- LIF-001 LASER-INDUCED FLOURESCENCE (LIF) BORING
- APPROXIMATE EXTENT OF LNAPL (BASED ON LIF RESULTS AND HISTORICAL WELL MONITORING)

MAXIMUM LIF RESULT

- LIF NOT COMPLETED (REFUSAL ENCOUNTERED)
- %RE INDICATIVE OF BACKGROUND CONDITIONS OR SHALLOW (0 - 5' BGS) RESULTS AT OR GREATER THAN 10%RE BUT CLEAN AT WATER TABLE
- 10 - 100 %RE
- 100 - 200 %RE
- 200 - 400 %RE
- 400 - 600 %RE

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

FORMER WILLOW RUN POWERTRAIN
Ypsilanti, MI

LIF AND LNAPL MOBILITY STUDY

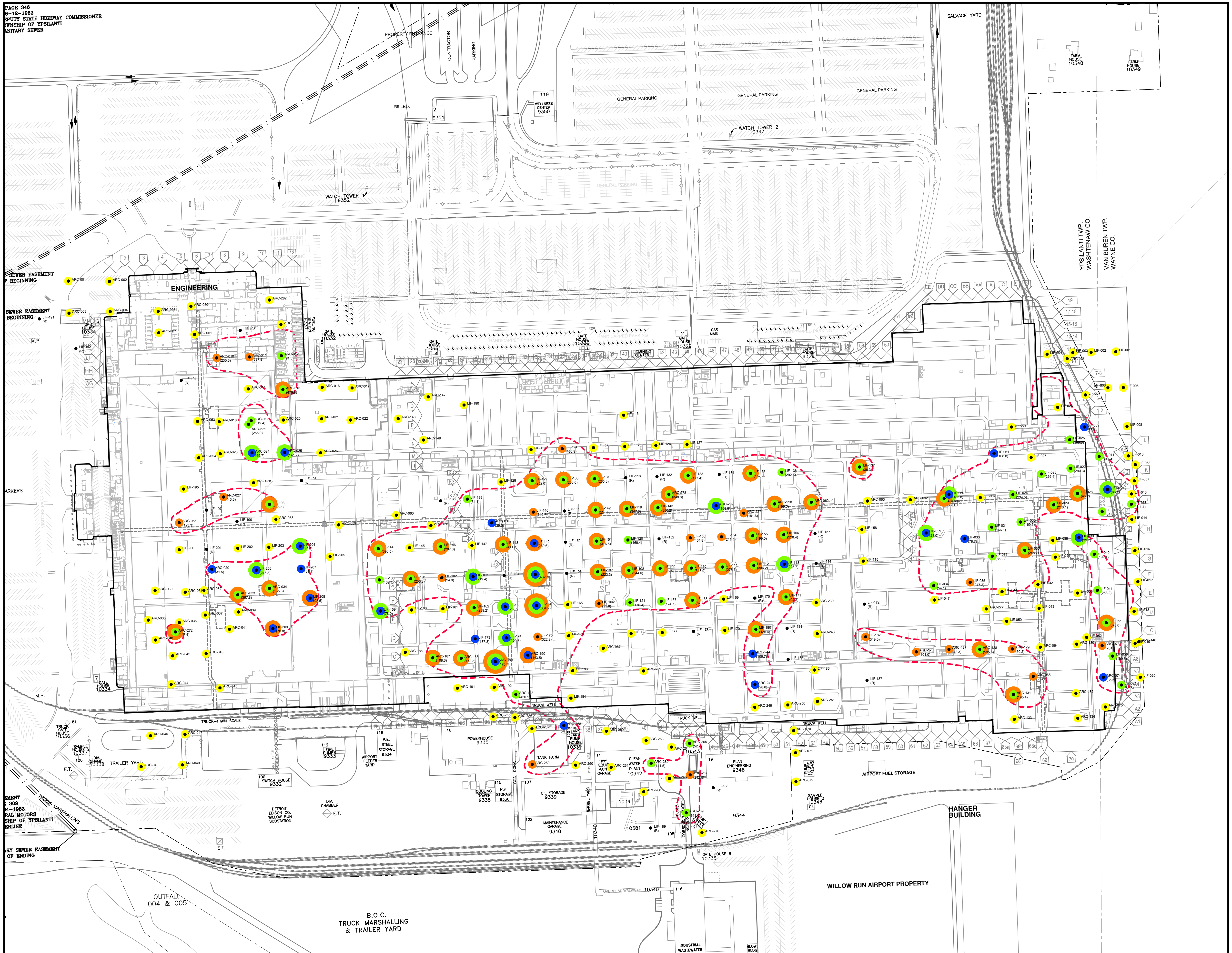
LIF SURVEY RESULTS

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager:	Reviewed By:	Date:	
S. ADAMOWSKI	M. ROUSSEAU	JANUARY 2012	
Scale: 1:150	Project Nº: 17358-T01	Report Nº: 021	Drawing Nº: FIGURE 3.2

17358-T01(021)GN-WI003 DEC 5/2013



Nº	Revision	Date	Initial

0 75 150ft

LEGEND

PROPERTY LINE

BUILDING

LIF-001 LASER-INDUCED FLOURESCENCE (LIF) BORING

APPROXIMATE EXTENT OF LNAPL (BASED ON LIF RESULTS AND HISTORICAL WELL MONITORING)

CLEAN AT WATER TABLE

KEROSENE-RANGE LNAPL

DIESEL-RANGE LNAPL

HEAVIER OIL-RANGE LNAPL

(370) MAXIMUM LIF RESPONSE (%RE)

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

FORMER WILLOW RUN POWERTRAIN
Ypsilanti, MI

LIF AND LNAPL MOBILITY STUDY

LNAPL PRODUCT TYPES

CONESTOGA-ROVERS & ASSOCIATES

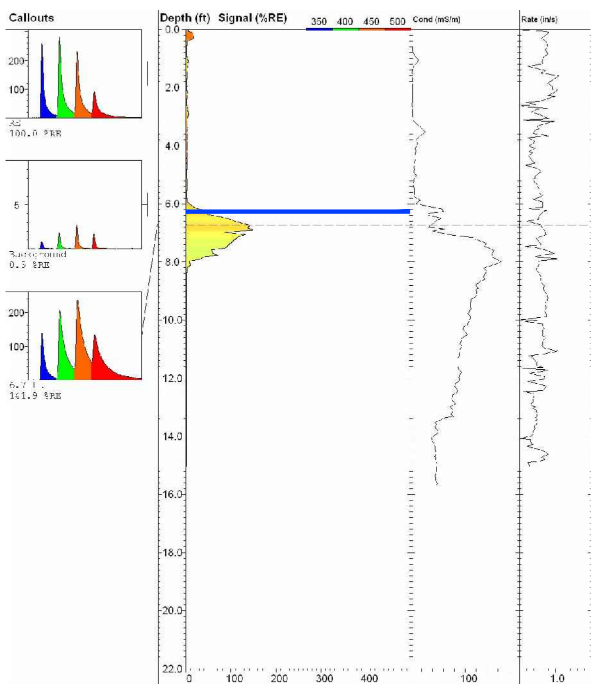
Source Reference:

Project Manager:	Reviewed By:	Date:
S. ADAMOWSKI	M. ROUSSEAU	JANUARY 2012

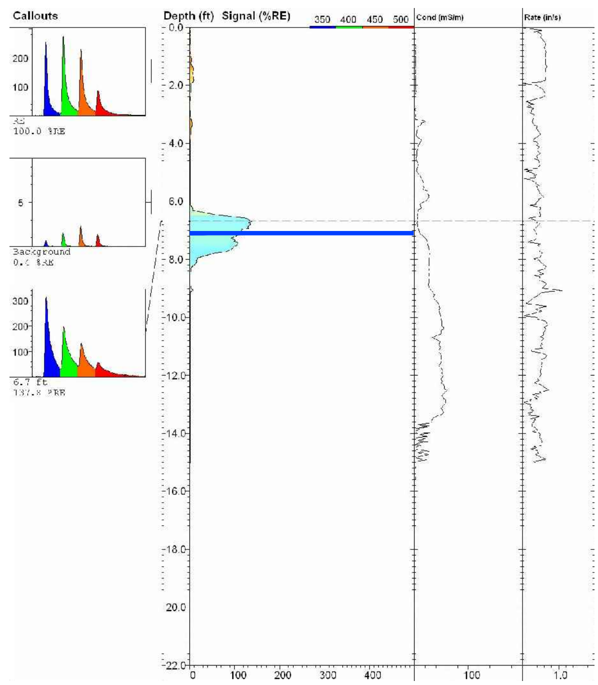
Scale:	Project Nº:	Report Nº:	Drawing Nº:
1:150	17358-T01	021	FIGURE 3.3

17358-T01(021)GN-WI002 DEC 5/2013

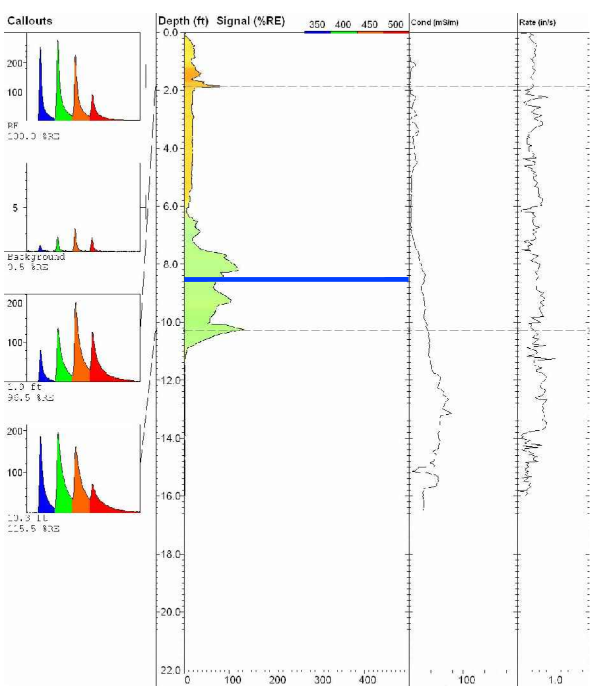
LIF-124



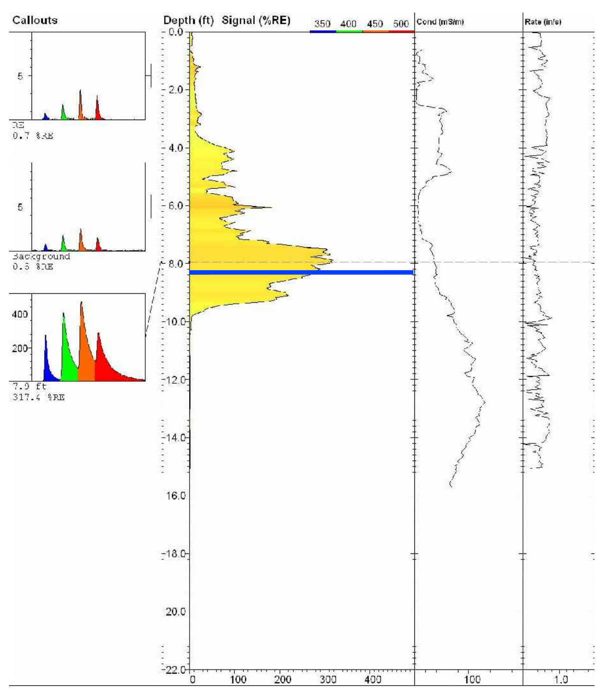
LIF-173



LIF-180



LIF-182

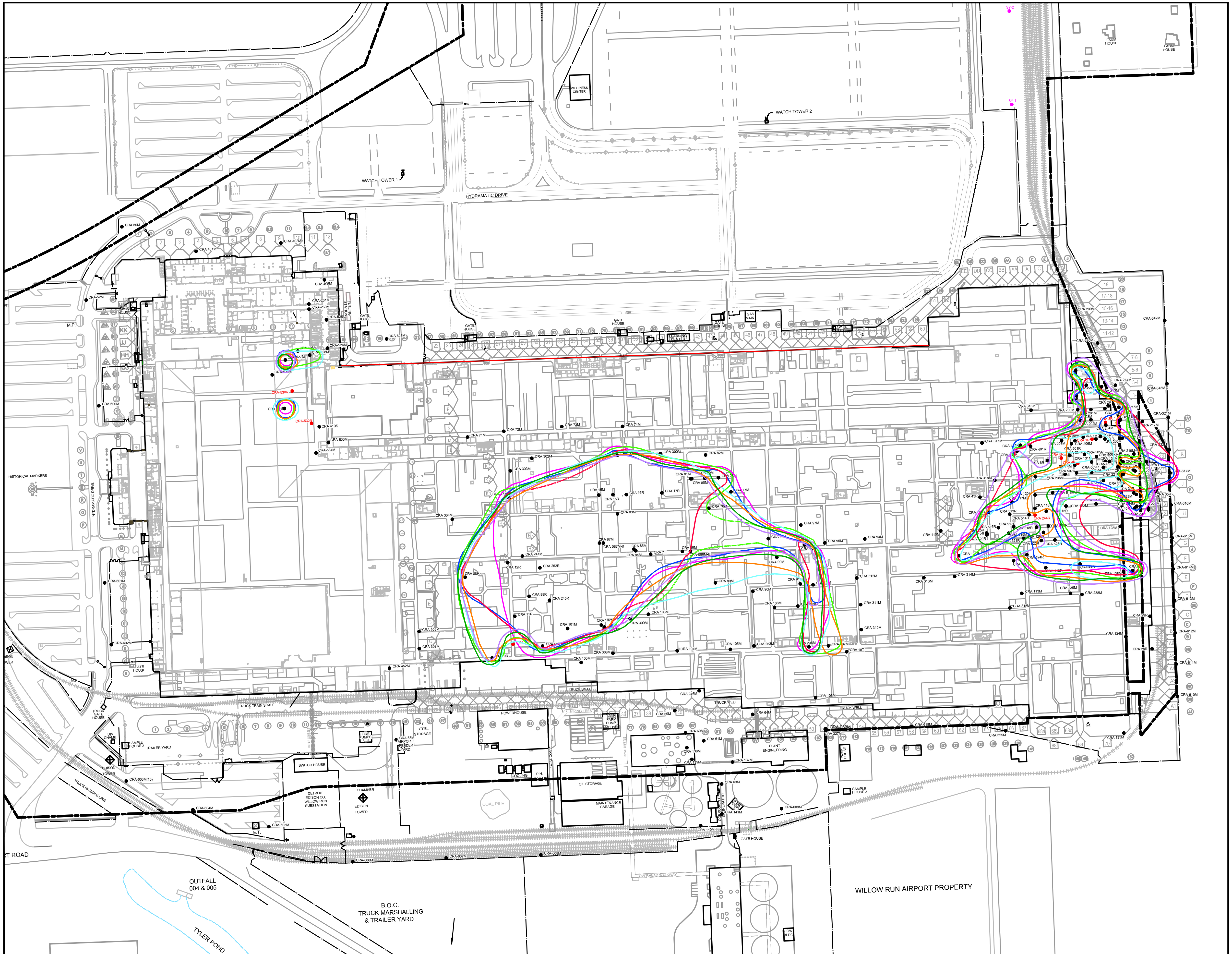


LEGEND

WATER TABLE

figure 3.4

EXAMPLE LIF OUTPUTS WITH WATER TABLE
LIF AND LNAPL MOBILITY STUDY
FORMER WILLOW RUN POWERTRAIN
Ypsilanti, Michigan



NO	Revision	Date	Initial

0 75 150ft

LEGEND

- CRA-342M ● EXISTING MONITORING WELL LOCATIONS
- CRA 3R ● EXISTING RECOVERY WELL LOCATIONS
- SY-1 ● SALVAGE YARD WELLS (LOCATIONS ESTIMATED NOT SURVEYED)
- PROPERTY BOUNDARY (NOT FIELD VERIFIED)
- SURFACE WATER
- RAILROAD
- LNAPL APRIL 2008
- LNAPL AUGUST 2008
- LNAPL APRIL 2009
- LNAPL DECEMBER 2009
- LNAPL APRIL 2010
- LNAPL NOVEMBER 2010
- LNAPL APRIL 2011
- LNAPL JUNE 2011

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

FORMER WILLOW RUN POWERTRAIN
Ypsilanti, MI

LIF AND LNAPL MOBILITY STUDY

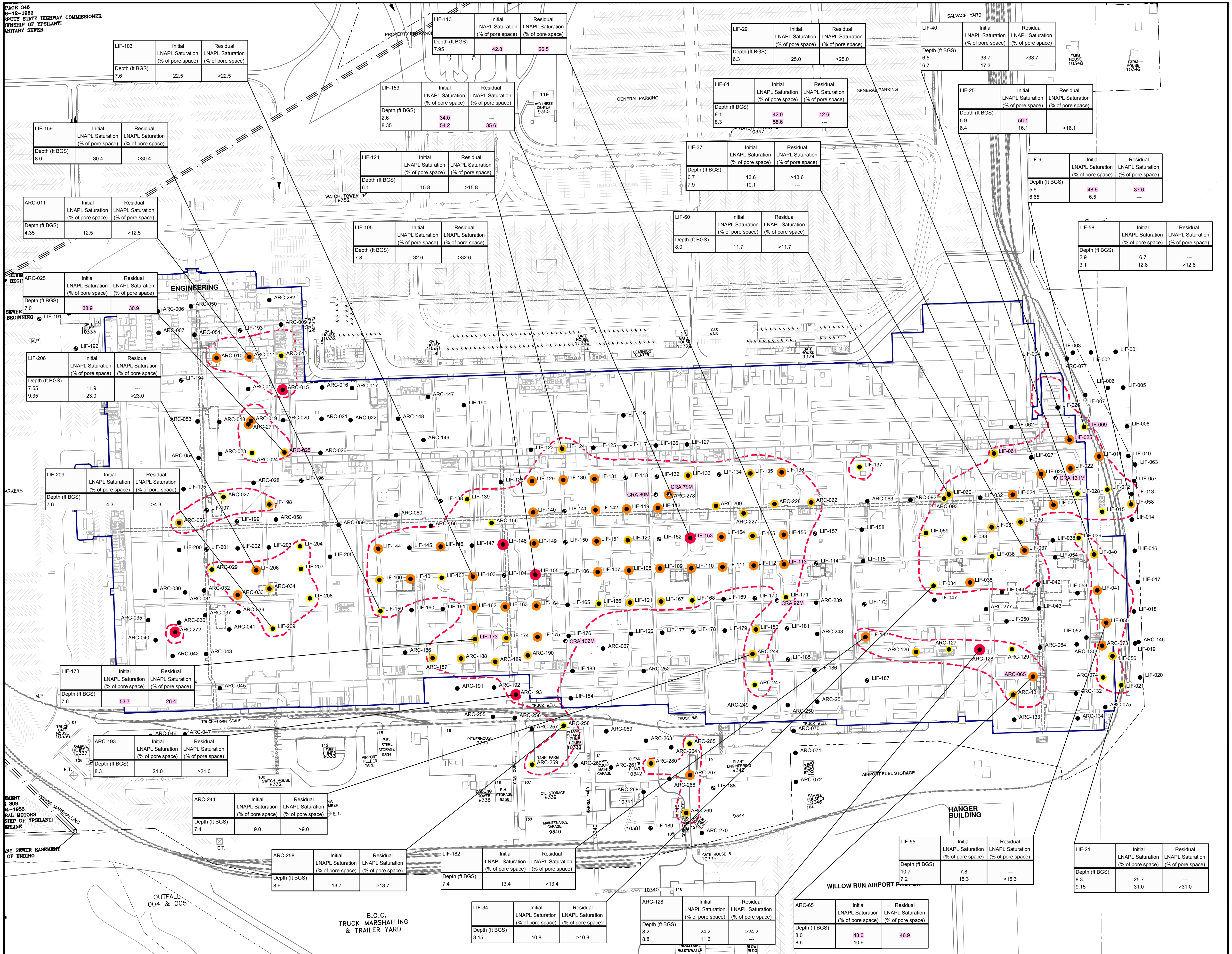
EXTENT OF LNAPL FROM
IN WELL READINGS (2008 - 2011)

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager:	Reviewed By:	Date:	
S. ADAMOWSKI	M. ROUSSEAU	MARCH 2012	
Scale: 1:150	Project No: 17358-T01	Report No: 021	Drawing No: figure 3.5

17358-T01(021)GN-WI007 DEC 5/2013



LIF-103 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
7.6	22.5	>22.5

LIF-113 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
7.95	42.8	26.5

LIF-153 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
2.6	34.0	---
8.35	54.2	35.6

LIF-159 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
8.6	30.4	>30.4

LIF-124 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
6.1	15.8	>15.8

ARC-011 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
4.35	12.5	>12.5

LIF-105 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
7.8	32.6	>32.6

ARC-025 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
7.0	38.9	30.9

LIF-206 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
7.55	11.9	---
9.35	23.0	>23.0

LIF-209 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
7.6	4.3	>4.3

LIF-173 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
7.6	53.7	26.4

ARC-193 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
8.3	21.0	>21.0

ARC-244 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
7.4	9.0	>9.0

ARC-258 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
8.6	13.7	>13.7

LIF-182 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
7.4	13.4	>13.4

LIF-34 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
8.15	10.8	>10.8

ARC-128 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
8.2	24.2	>24.2
8.8	11.6	---

ARC-65 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
8.0	48.0	46.9
8.6	10.6	---

LIF-55 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
10.7	7.8	---
7.2	15.3	>15.3

LIF-21 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
8.3	25.7	---
9.15	31.0	>31.0

LIF-29 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
6.3	25.0	>25.0

LIF-61 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
8.1	42.0	12.6
8.3	58.6	---

LIF-40 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
6.5	33.7	>33.7
6.7	17.3	---

LIF-25 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
5.9	56.1	---
6.4	16.1	>16.1

LIF-37 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
6.7	13.6	>13.6
7.9	10.1	---

LIF-9 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
5.6	48.6	37.6
6.65	6.5	---

LIF-60 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
8.0	11.7	>11.7

LIF-58 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
2.9	6.7	---
3.1	12.8	>12.8

Nº	Revision	Date	Initial

0 75 150ft

LEGEND

- PROPERTY LINE
- BUILDING
- LIF-001 LASER-INDUCED FLOURESCENCE (LIF) BORING
- CRA 131M MONITORING WELL
- APPROXIMATE EXTENT OF LNAPL (BASED ON LIF RESULTS AND HISTORICAL WELL MONITORING)

MAXIMUM LIF RESULT

- LIF NOT COMPLETED (REFUSAL ENCOUNTERED)
- %RE INDICATIVE OF BACKGROUND CONDITIONS OR SHALLOW (0 - 5' BGS) RESULTS AT OR GREATER THAN 10%RE BUT CLEAN AT WATER TABLE
- 10 - 100 %RE
- 100 - 200 %RE
- 200 - 400 %RE
- 400 - 600 %RE
- LOCATIONS WITH POTENTIALLY MOBILE/RECOVERABLE LNAPL

LOCATION

LIF-34 Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
8.15	10.8	>10.8

RESULT

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

FORMER WILLOW RUN POWERTRAIN
Ypsilanti, MI

LIF AND LNAPL MOBILITY STUDY

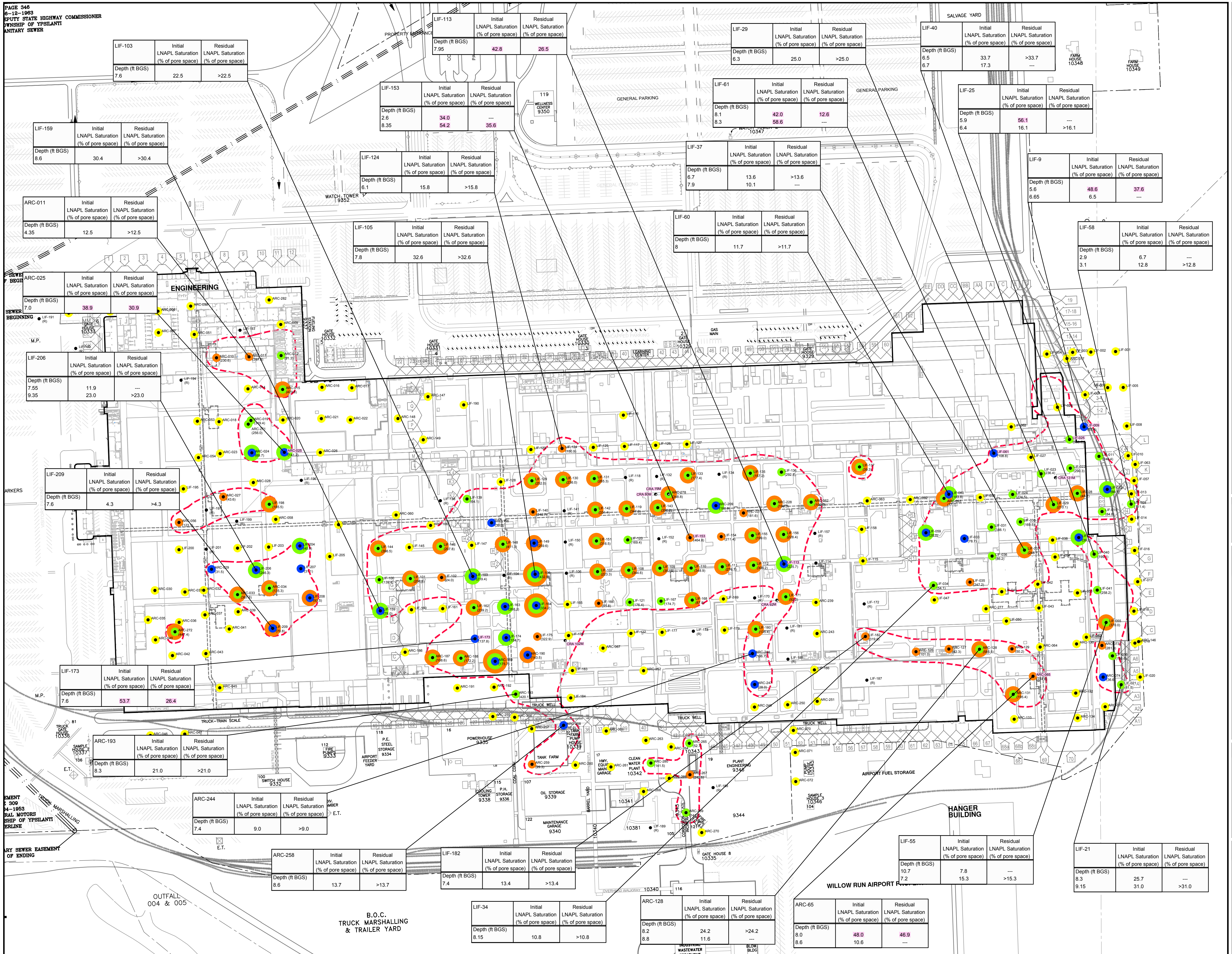
LNAPL SATURATIONS AND LIF SURVEY RESULTS

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager: S. ADAMOWSKI	Reviewed By: M. ROUSSEAU	Date: FEBRUARY 2012	
Scale: 1:150	Project Nº: 17358-T01	Report Nº: 021	Drawing Nº: FIGURE 4.1

17358-T01(021)GN-WI005 DEC 5/2013



Nº	Revision	Date	Initial

0 75 150ft

LEGEND

- PROPERTY LINE
- BUILDING
- LIF-001 LASER-INDUCED FLOURESCENCE (LIF) BORING
- CRA 131M MONITORING WELL
- APPROXIMATE EXTENT OF LNAPL (BASED ON LIF RESULTS AND HISTORICAL WELL MONITORING)
- CLEAN AT WATER TABLE
- KEROSENE-RANGE LNAPL
- DIESEL-RANGE LNAPL
- HEAVIER OIL-RANGE LNAPL
- (370) MAXIMUM LIF RESPONSE (%RE)
- LOCATIONS WITH POTENTIALLY MOBILE/RECOVERABLE LNAPL

LOCATION — LIF-34

Depth (ft BGS)	Initial LNAPL Saturation (% of pore space)	Residual LNAPL Saturation (% of pore space)
8.15	10.8	>10.8

— RESULT

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

FORMER WILLOW RUN POWERTRAIN
Ypsilanti, MI

LIF AND LNAPL MOBILITY STUDY

LNAPL SATURATIONS AND LNAPL PRODUCT TYPES

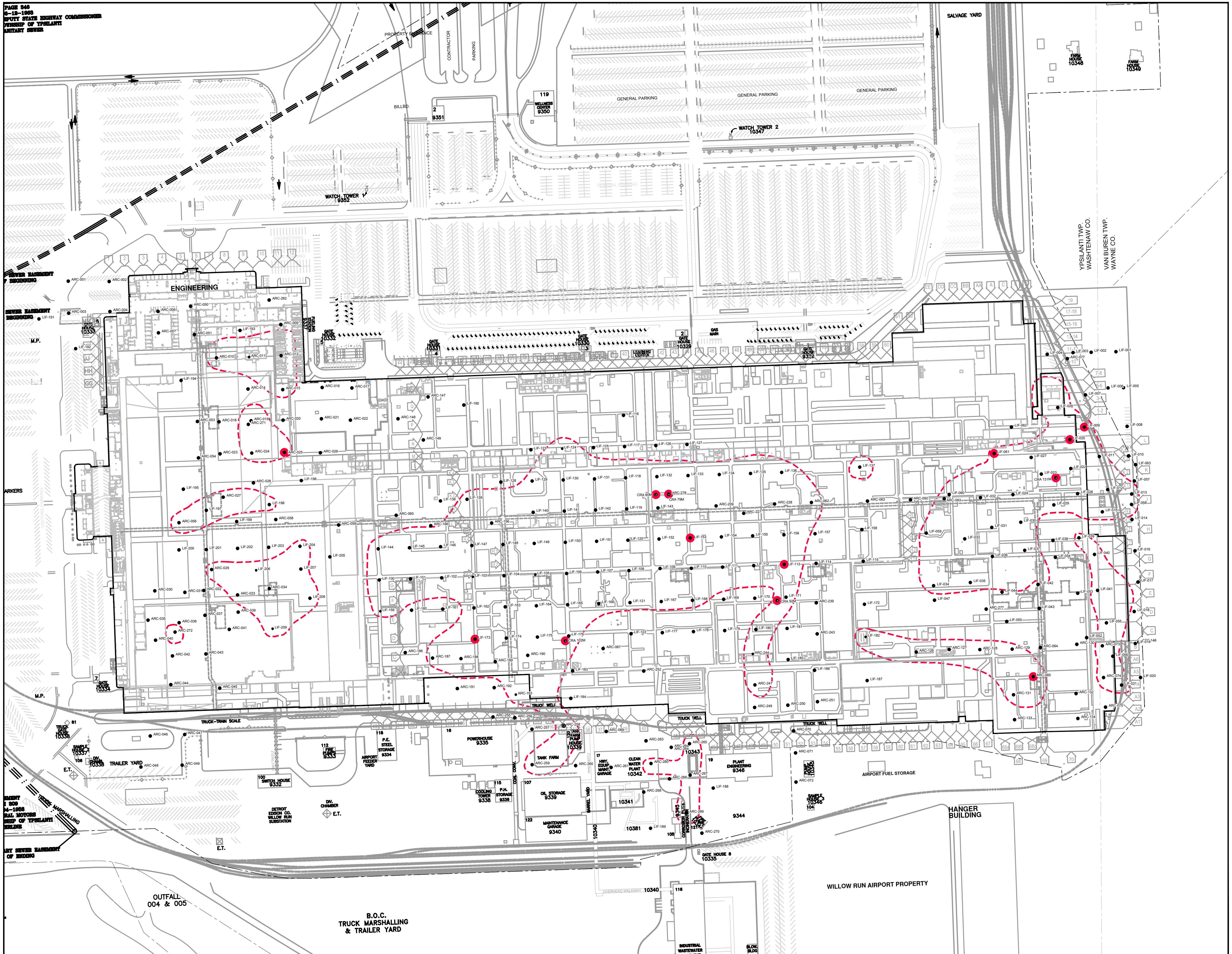
CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager:	Reviewed By:	Date:
S. ADAMOWSKI	M. ROUSSEAU	FEBRUARY 2012

Scale:	Project Nº:	Report Nº:	Drawing Nº:
1:150	17358-T01	021	FIGURE 4.2

17358-T01(021)GN-WI004 DEC 5/2013



Nº	Revision	Date	Initial

0 75 150ft

LEGEND

- PROPERTY LINE
- BUILDING
- LIF-001 LASER-INDUCED FLOURESCENCE (LIF) BORING
- CRA 131M MONITORING WELL
- APPROXIMATE EXTENT OF LNAPL (BASED ON LIF RESULTS AND HISTORICAL WELL MONITORING)
- LOCATIONS WITH POTENTIALLY MOBILE/RECOVERABLE LNAPL

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

FORMER WILLOW RUN POWERTRAIN
Ypsilanti, MI

LIF AND LNAPL MOBILITY STUDY

LOCATIONS WITH POTENTIALLY MOBILE/RECOVERABLE LNAPL

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

Project Manager:	Reviewed By:	Date:	
S. ADAMOWSKI	M. ROUSSEAU	APRIL 2012	
Scale: 1:150	Project Nº: 17358-T01	Report Nº: 021	Drawing Nº: FIGURE 4.3

17358-T01(021)GN-WI008 DEC 5/2013

TABLE 3.1

SUMMARY OF LASER-INDUCED FLUORESCENCE SURVEY RESULTS AND SOIL CORE SAMPLING PROGRAM
FORMER WILLOW RUN POWERTRAIN
YPSILANTI, MICHIGAN

Location ID	*LIF Total Depth (feet bgs)*	*Max LIF Result (%RE)*	*Depth of Max LIF Result (feet bgs)*	*Maximum Depth of Impacts (feet bgs)*	*Approximate LNAPL Type(s) (inferred from LIF results)*	*Soil Core Sample Interval (feet bgs, where applicable)*
LIF-001	16.02	--	--	--	--	--
LIF-002	16.04	--	--	--	--	--
LIF-003	16.07	--	--	--	--	--
LIF-004	16.00	--	--	--	--	--
LIF-005	16.03	--	--	--	--	--
LIF-006	16.02	--	--	--	--	--
LIF-007	16.00	--	--	--	--	--
LIF-008	16.00	--	--	--	--	--
LIF-009	16.03	63.43	7.29	9.51	kerosene-range	5-10
LIF-010	15.98	--	--	--	--	--
LIF-011	16.03	240.44	5.64	9.44	diesel-range	--
LIF-012	11.49	66.08	8.25	11.49	kerosene/diesel-ranges	--
LIF-013	20.07	--	--	--	--	--
LIF-014	16.03	--	--	--	--	--
LIF-015	16.00	84.82	6.66	11.38	diesel-range	--
LIF-016	16.03	--	--	--	--	--
LIF-017	16.09	--	--	--	--	--
LIF-018	16.03	--	--	--	--	--
LIF-019	16.09	--	--	--	--	--
LIF-020	16.07	--	--	--	--	--
LIF-021	22.03	81.49	3.40	8.41	diesel-range	2-12
LIF-022	20.20	290.33	7.56	10.80	diesel-range	--
LIF-023	19.44	236.41	8.90	11.84	diesel-range	--
LIF-024	20.03	234.49	6.48	9.48	diesel-range	--
LIF-025	10.59	303.65	7.80	10.44	diesel-range	5-10
LIF-026	4.45	--	--	--	--	--
LIF-027	5.08	--	--	--	--	--
LIF-028	20.01	48.15	6.16	6.62	diesel/heavier oil-ranges	--
LIF-029	20.01	210.10	6.50	11.30	diesel/heavier oil-ranges	1-8
LIF-030	16.01	169.53	8.51	10.19	diesel-range	--
LIF-031	17.11	166.06	3.06	9.78	diesel-range	--
LIF-032	0.96	--	--	--	--	--
LIF-033	16.17	78.73	6.40	9.04	kerosene-range	--
LIF-034	16.00	54.08	7.75	8.23	diesel-range	5-10
LIF-035	16.04	247.19	7.62	9.49	heavier oil-range	--
LIF-036	16.00	86.25	1.97	10.31	diesel-range	--
LIF-037	16.00	248.69	6.68	8.61	diesel/heavier oil-ranges	5-10
LIF-038	1.94	--	--	--	--	--
LIF-039	16.01	39.23	7.15	7.97	kerosene/diesel-ranges	--
LIF-040	15.93	199.10	5.64	7.85	diesel-range	5-10
LIF-041	16.00	258.22	6.24	7.63	diesel-range	--
LIF-042	5.21	--	--	--	--	--
LIF-043	16.02	--	--	--	--	--
LIF-044	16.00	--	--	--	--	--
LIF-047	16.00	--	--	--	--	--
LIF-050	15.98	--	--	--	--	--
LIF-052	16.02	--	--	--	--	--
LIF-053	11.14	--	--	--	--	--
LIF-054	1.48	--	--	--	--	--
LIF-055	20.00	370.02	6.99	14.16	diesel/heavier oil-ranges	4-14
LIF-056	16.00	199.62	6.78	8.96	diesel-range	--
LIF-057	16.00	--	--	--	--	--
LIF-058	20.15	111.365	4.07	4.61	diesel-range	2-7
LIF-059	16.06	28.03	6.49	6.67	kerosene/diesel-ranges	--
LIF-060	16.05	183.82	6.46	9.88	kerosene/diesel-ranges	5-10
LIF-061	16.01	108.77	7.26	8.64	kerosene-range	5-10
LIF-062	16.05	--	--	--	--	--
LIF-063	16.00	--	--	--	--	--
LIF-100	19.02	139.40	8.11	9.26	diesel range	
LIF-101	15.03	206.80	7.67	8.41	diesel and heavier oil ranges	
LIF-102	15.01	24.00	6.08	7.96	heavier oil range	
LIF-103	16.14	219.40	7.52	9.41	diesel and kerosene ranges	6-11
LIF-104	--	--	--	--	--	
LIF-105	18.10	432.50	11.29	14.59	diesel, heavier oil and kerosene ranges	7-12

TABLE 3.1

SUMMARY OF LASER-INDUCED FLUORESCENCE SURVEY RESULTS AND SOIL CORE SAMPLING PROGRAM
FORMER WILLOW RUN POWERTRAIN
YPSILANTI, MICHIGAN

Location ID	*LIF Total Depth (feet bgs)*	*Max LIF Result (%RE)*	*Depth of Max LIF Result (feet bgs)*	*Maximum Depth of Impacts (feet bgs)*	*Approximate LNAPL Type(s) (inferred from LIF results)*	*Soil Core Sample Interval (feet bgs, where applicable)*
LIF-106	--	--	--	--	--	
LIF-107	15.01	223.30	7.96	10.64	diesel and heavier oil ranges	
LIF-108	15.08	344.60	8.76	10.65	diesel and heavier oil ranges	
LIF-109	15.11	352.90	8.32	10.24	diesel and heavier oil ranges	
LIF-110	15.17	348.90	7.50	9.08	diesel and heavier oil ranges	
LIF-111	15.11	276.70	8.00	9.37	diesel and heavier oil ranges	
LIF-112	15.01	306.20	8.16	10.12	diesel and heavier oil ranges	
LIF-113	15.17	225.70	8.41	10.24	diesel and kerosene ranges	7-12
LIF-114	--	--	--	--	--	
LIF-115	--	--	--	--	--	--
LIF-116	--	--	--	--	--	--
LIF-117	--	--	--	--	--	--
LIF-118	--	--	--	--	--	
LIF-119	21.13	347.00	9.63	17.62	diesel and heavier oil ranges	
LIF-120	19.09	169.40	9.01	10.16	diesel range	
LIF-121	18.37	176.40	7.66	13.19	diesel range	
LIF-122	--	--	--	--	--	--
LIF-123	--	--	--	--	--	--
LIF-124	15.04	150.90	6.90	8.10	heavier oil range	5-10
LIF-125	--	--	--	--	--	--
LIF-126	--	--	--	--	--	--
LIF-127	--	--	--	--	--	--
LIF-128	--	--	--	--	--	--
LIF-129	15.06	252.00	6.15	8.41	diesel and heavier oil ranges	
LIF-130	20.06	236.00	6.01	10.50	diesel and heavier oil ranges	
LIF-131	16.54	265.30	6.11	8.89	diesel and heavier oil ranges	
LIF-132	--	--	--	--	--	
LIF-133	16.07	177.40	8.40	9.14	diesel and heavier oil ranges	
LIF-134	--	--	--	--	--	
LIF-135	15.09	157.20	7.19	8.39	diesel and heavier oil ranges	
LIF-136	17.91	292.50	9.86	10.26	diesel range	
LIF-137	15.07	39.30	7.12	7.56	diesel and heavier oil ranges	
LIF-138	--	--	--	--	--	
LIF-139	15.05	64.10	6.77	7.78	diesel range	
LIF-140	17.13	340.70	6.38	8.37	heavier oil range	
LIF-141	--	--	--	--	--	
LIF-142	26.99	331.10	19.71	20.26	diesel and heavier oil ranges	
LIF-143	20.06	350.20	9.29	10.53	diesel and heavier oil ranges	
LIF-144	16.30	396.50	9.63	11.07	diesel and heavier oil ranges	
LIF-145	--	--	--	--	--	--
LIF-146	15.00	207.80	7.67	9.13	diesel and heavier oil ranges	
LIF-147	--	--	--	--	--	--
LIF-148	18.92	411.30	7.40	14.50	diesel and heavier oil ranges	
LIF-149	18.00	259.60	3.61	14.17	heavier oil and kerosene ranges	
LIF-150	--	--	--	--	--	
LIF-151	19.19	316.50	7.37	15.93	diesel and heavier oil ranges	
LIF-152	--	--	--	--	--	
LIF-153	15.08	464.80	4.23	9.11	heavier oil range	2-12
LIF-154	15.01	211.40	9.45	9.68	heavier oil range	
LIF-155	15.06	199.00	8.57	11.11	diesel and heavier oil ranges	
LIF-156	15.16	228.40	8.55	9.55	diesel and heavier oil ranges	
LIF-157	--	--	--	--	--	
LIF-158	--	--	--	--	--	--
LIF-159	15.01	78.00	8.77	9.53	diesel and kerosene ranges	6-11
LIF-160	--	--	--	--	--	--
LIF-161	--	--	--	--	--	--
LIF-162	15.06	239.20	7.37	9.17	diesel and heavier oil ranges	
LIF-163	20.05	268.20	7.29	14.52	diesel and kerosene ranges	
LIF-164	22.00	334.20	9.28	15.19	diesel, heavier oil and kerosene ranges	
LIF-165	--	--	--	--	--	--
LIF-166	15.03	55.80	5.89	6.30	heavier oil range	
LIF-167	17.19	174.70	8.28	10.05	diesel range	
LIF-168	15.05	87.80	2.40	10.21	diesel and heavier oil ranges	
LIF-169	--	--	--	--	--	--

TABLE 3.1

SUMMARY OF LASER-INDUCED FLUORESCENCE SURVEY RESULTS AND SOIL CORE SAMPLING PROGRAM
FORMER WILLOW RUN POWERTRAIN
YPSILANTI, MICHIGAN

Location ID	*LIF Total Depth (feet bgs)*	*Max LIF Result (%RE)*	*Depth of Max LIF Result (feet bgs)*	*Maximum Depth of Impacts (feet bgs)*	*Approximate LNAPL Type(s) (inferred from LIF results)*	*Soil Core Sample Interval (feet bgs, where applicable)*
LIF-170	--	--	--	--	--	
LIF-171	15.10	92.20	9.45	9.98	diesel and heavier oil ranges	
LIF-172	--	--	--	--	--	
LIF-173	15.03	137.80	6.69	8.17	kerosene range	5-10
LIF-174	14.99	154.70	8.42	9.50	diesel and kerosene ranges	
LIF-175	16.04	322.90	8.12	11.24	heavier oil range	
LIF-176	--	--	--	--	--	--
LIF-177	--	--	--	--	--	--
LIF-178	--	--	--	--	--	
LIF-179	--	--	--	--	--	--
LIF-180	15.97	135.40	10.25	10.80	diesel and heavier oil ranges	
LIF-181	--	--	--	--	--	
LIF-182	15.07	319.00	7.88	9.70	heavier oil range	5-10
LIF-183	--	--	--	--	--	--
LIF-184	--	--	--	--	--	--
LIF-185	--	--	--	--	--	
LIF-186	--	--	--	--	--	--
LIF-187	--	--	--	--	--	
LIF-188	--	--	--	--	--	
LIF-189	--	--	--	--	--	
LIF-190	--	--	--	--	--	--
LIF-191	--	--	--	--	--	
LIF-192	--	--	--	--	--	
LIF-193	--	--	--	--	--	
LIF-194	--	--	--	--	--	
LIF-195	--	--	--	--	--	--
LIF-196	--	--	--	--	--	
LIF-197	--	--	--	--	--	
LIF-198	15.07	185.50	2.79	5.04	diesel and heavier oil ranges	
LIF-199	--	--	--	--	--	
LIF-200	--	--	--	--	--	--
LIF-201	--	--	--		--	
LIF-202	--	--	--	--	--	--
LIF-203	--	--	--	--	--	--
LIF-204	15.09	40.90	2.46	4.53	diesel and kerosene ranges	
LIF-205	--	--	--	--	--	--
LIF-206	19.08	246.30	12.22	13.49	diesel and kerosene ranges	6-16
LIF-207	15.04	31.10	0.19	3.72	kerosene range	
LIF-208	16.08	93.50	9.18	10.30	kerosene and heavier oil ranges	
LIF-209	15.03	70.80	8.02	9.61	kerosene and heavier oil ranges	6-11
ARC-001	14.42	--	--	--	--	--
ARC-002	15.03	--	--	--	--	--
ARC-003	14.05	--	--	--	--	--
ARC-004	30.05	--	--	--	--	--
ARC-006	15.00	--	--	--	--	--
ARC-007	25.99	--	--	--	--	--
ARC-009	14.99	--	--	--	--	--
ARC-010	15.00	230.60	4.92	9.00	heavier oil-range	--
ARC-011	13.52	397.80	4.05	9.00	heavier oil-range	3-8
ARC-012	15.03	91.30	8.91	10.00	diesel-range	--
ARC-014	15.02	--	--	--	--	--
ARC-015	16.03	479.80	4.88	9.50	diesel/heavier oil-ranges	--
ARC-016	14.99	--	--	--	--	--
ARC-017	15.09	--	--	--	--	--
ARC-018	16.08	--	--	--	--	--
ARC-019	18.04	319.40	8.57	14.00	diesel-range	--
ARC-020	15.02	--	--	--	--	--
ARC-021	15.04	--	--	--	--	--
ARC-022	15.06	--	--	--	--	--
ARC-023	14.99	--	--	--	--	--
ARC-024	18.03	69.70	8.67	17.50	kerosene/diesel-ranges	--
ARC-025	15.04	141.20	7.87	15.00	kerosene/diesel-ranges	6-11
ARC-026	15.00	--	--	--	--	--
ARC-027	18.23	43.60	9.20	18.00	heavier oil-range	--
ARC-028	15.01	--	--	--	--	--
ARC-029	20.00	31.50	12.97	20.00	kerosene-range	--

TABLE 3.1

SUMMARY OF LASER-INDUCED FLUORESCENCE SURVEY RESULTS AND SOIL CORE SAMPLING PROGRAM
FORMER WILLOW RUN POWERTRAIN
YPSILANTI, MICHIGAN

Location ID	*LIF Total Depth (feet bgs)*	*Max LIF Result (%RE)*	*Depth of Max LIF Result (feet bgs)*	*Maximum Depth of Impacts (feet bgs)*	*Approximate LNAPL Type(s) (inferred from LIF results)*	*Soil Core Sample Interval (feet bgs, where applicable)*
ARC-030	15.06	--	--	--	--	--
ARC-031	15.00	--	--	--	--	--
ARC-032	18.11	--	--	--	--	--
ARC-033	22.03	367.80	10.12	14.50	diesel/heavier oil-ranges	--
ARC-034	20.00	135.30	9.42	15.00	diesel/heavier oil-ranges	--
ARC-035	16.01	--	--	--	--	--
ARC-036	18.02	--	--	--	--	--
ARC-037	7.42	--	--	--	--	--
ARC-039	16.02	--	--	--	--	--
ARC-040	18.07	--	--	--	--	--
ARC-041	18.01	--	--	--	--	--
ARC-042	3.80	--	--	--	--	--
ARC-043	15.01	--	--	--	--	--
ARC-044	15.02	--	--	--	--	--
ARC-045	16.00	--	--	--	--	--
ARC-046	15.02	--	--	--	--	--
ARC-047	15.09	--	--	--	--	--
ARC-048	10.12	--	--	--	--	--
ARC-048A	15.01	--	--	--	--	--
ARC-049	15.09	--	--	--	--	--
ARC-050	4.11	--	--	--	--	--
ARC-051	15.07	--	--	--	--	--
ARC-053	13.71	--	--	--	--	--
ARC-054	15.05	--	--	--	--	--
ARC-056	18.08	123.30	4.56	14.00	heavier oil-range	--
ARC-058	5.14	--	--	--	--	--
ARC-059	15.34	--	--	--	--	--
ARC-060	14.99	--	--	--	--	--
ARC-062	15.05	100.50	7.77	10.50	diesel/heavier oil-ranges	--
ARC-063	15.04	--	--	--	--	--
ARC-064	15.00	--	--	--	--	--
ARC-065	17.03	224.60	7.57	9.50	heavier oil-range	5-10
ARC-067	15.10	--	--	--	--	--
ARC-069	15.08	--	--	--	--	--
ARC-070	15.01	--	--	--	--	--
ARC-071	15.01	--	--	--	--	--
ARC-072	15.00	--	--	--	--	--
ARC-073	15.00	281.30	6.65	9.00	heavier oil-range	--
ARC-074	15.00	36.60	8.54	15.00	kerosene-range	--
ARC-075	15.00	--	--	--	--	--
ARC-077	15.03	--	--	--	--	--
ARC-092	15.05	--	--	--	--	--
ARC-093	15.17	77.10	6.41	15.00	diesel/heavier oil-ranges	--
ARC-126	16.01	101.00	7.90	10.00	heavier oil-range	--
ARC-127	15.04	42.30	6.05	10.00	heavier oil-range	--
ARC-128	17.00	585.50	7.62	17.00	diesel/heavier oil-ranges	5-10
ARC-129	15.01	50.20	4.98	15.00	heavier oil-range	--
ARC-130	15.05	--	--	--	--	--
ARC-131	15.07	195.40	8.03	10.00	diesel/heavier oil-ranges	--
ARC-132	15.01	--	--	--	--	--
ARC-133	16.03	--	--	--	--	--
ARC-134	15.00	--	--	--	--	--
ARC-146	16.11	--	--	--	--	--
ARC-147	15.03	--	--	--	--	--
ARC-148	15.08	--	--	--	--	--
ARC-149	15.02	--	--	--	--	--
ARC-156	15.00	39.00	7.33	15.00	kerosene-range	--
ARC-166	15.02	--	--	--	--	--
ARC-186	15.00	--	--	--	--	--
ARC-187	20.04	108.60	8.10	14.50	diesel/heavier oil-ranges	--
ARC-188	15.08	172.20	7.88	9.50	diesel/heavier oil-ranges	--
ARC-189	16.05	175.70	7.38	11.00	Motor oil, Diesel, kerosene	--
ARC-190	15.72	143.50	7.60	10.00	Motor oil, kerosene	--
ARC-191	15.06	--	--	--	--	--
ARC-192	15.04	--	--	--	--	--
ARC-193	16.00	420.10	8.92	11.00	diesel-range	7-12
ARC-209	16.15	163.90	7.17	11.00	kerosene/diesel-ranges	--
ARC-227	16.02	181.60	7.58	11.00	heavier oil-range	--
ARC-228	19.55	199.00	8.99	14.00	diesel/heavier oil-ranges	--
ARC-239	15.09	--	--	--	--	--
ARC-243	15.04	--	--	--	--	--
ARC-244	15.16	106.70	8.41	12.00	kerosene-range	7-12
ARC-247	15.01	28.00	8.39	15.00	kerosene-range	--
ARC-249	15.13	--	--	--	--	--
ARC-249MN	15.00	--	--	--	--	--
ARC-250	15.27	--	--	--	--	--
ARC-251	15.01	--	--	--	--	--
ARC-252	15.14	--	--	--	--	--
ARC-255	15.05	--	--	--	--	--

TABLE 3.1

SUMMARY OF LASER-INDUCED FLUORESCENCE SURVEY RESULTS AND SOIL CORE SAMPLING PROGRAM
FORMER WILLOW RUN POWERTRAIN
YPSILANTI, MICHIGAN

Location ID	*LIF Total Depth (feet bgs)*	*Max LIF Result (%RE)*	*Depth of Max LIF Result (feet bgs)*	*Maximum Depth of Impacts (feet bgs)*	*Approximate LNAPL Type(s) (inferred from LIF results)*	*Soil Core Sample Interval (feet bgs, where applicable)*
ARC-256	15.08	--	--	--	--	--
ARC-257	13.87	--	--	--	--	--
ARC-258	15.05	87.00	8.75	15.00	kerosene-range	6-11
ARC-259	15.09	29.30	15.09	15.00	heavier oil-range	--
ARC-260	15.00	--	--	--	--	--
ARC-261	15.17	--	--	--	--	--
ARC-263	15.03	--	--	--	--	--
ARC-264	15.04	--	--	--	--	--
ARC-265	15.06	52.70	10.27	15.00	diesel-range	--
ARC-266	15.00	--	--	--	--	--
ARC-267	18.00	242.50	10.87	12.50	heavier oil-range	--
ARC-268	15.00	--	--	--	--	--
ARC-269	17.00	141.00	8.93	15.00	diesel-range	--
ARC-270	15.05	--	--	--	--	--
ARC-271	19.05	256.00	8.60	14.50	diesel-range	--
ARC-272	21.99	447.40	11.39	17.00	diesel/heavier oil-ranges	--
ARC-277	14.99	--	--	--	--	--
ARC-278	15.53	348.80	7.12	10.00	diesel/heavier oil-ranges	--
ARC-280	16.03	141.50	5.95	11.50	diesel-range	--
ARC-282	15.37	--	--	--	--	--

Locations that are clean throughout the entire vertical profile (all results less than 10%RE)
Locations with shallow (0-5' bgs) results at or greater than 10%RE but clean at water table depth

TABLE 3.2

SUMMARY OF LABORATORY SOIL CORE TESTING PROGRAM AND LNAPL SATURATION RESULTS
FORMER WILLOW RUN POWERTRAIN
YPSILANTI, MICHIGAN

Soil Core ID	*Soil Core Sample Interval (feet bgs)*	*Soil Core Sub-Sample Selected for Respective Tests (feet bgs)*		*LNAPL Saturation Results*		*Potentially Mobile/Recoverable Fraction (% of in place LNAPL)*
		Pore Fluids Saturation Test	*Residual Saturation by Water Drive*	*Initial Saturation (% of pore space)*	*Residual Saturation (% of pore space)*	
LIF-9	5-10	6.65		**6.5**		**0.0**[a]
			5.6	**48.6**	**37.6**	**22.6**
LIF-21	2-12	8.3		**25.7**		**0.0**[a]
			9.15	**31.0**	**>31.0**	**0.0**
LIF-25	5-10	5.9		**56.1**		**55.4**[b]
			6.4	**16.1**	**>16.1**	**0.0**
LIF-29	0-10		6.3	**25.0**	**>25.0**	**0.0**
LIF-34	5-10		8.15	**10.8**	**>10.8**	**0.0**
LIF-37	5-10	7.9		**10.1**		**0.0**[a]
			6.7	**13.6**	**>13.6**	**0.0**
LIF-40	5-10	6.7		**17.3**		**0.0**[a]
			6.5	**33.7**	**>33.7**	**0.0**
LIF-55	4-14	10.7		**7.8**		**0.0**[a]
			7.2	**15.3**	**>15.3**	**0.0**
LIF-58	2-7	2.9		**6.7**		**0.0**[a]
			3.1	**12.8**	**>12.8**	**0.0**
LIF-60	5-10		8.0	**11.7**	**>11.7**	**0.0**
LIF-61	5-10	8.3		**58.6**		**57.3**[b]
			8.1	**42.0**	**12.6**	**70.0**
LIF-103	6-11		7.6	**22.5**	**>22.5**	**0.0**
LIF-105	7-12		7.8	**32.6**	**>32.6**	**0.0**
LIF-113	7-12		7.95	**42.8**	**26.5**	**38.1**
LIF-124	5-10		6.1	**15.8**	**>15.8**	**0.0**
LIF-153	2-12	2.6		**34.0**		**26.5**[b]
			8.35	**54.2**	**35.6**	**34.3**
LIF-159	6-11		8.6	**30.4**	**>30.4**	**0.0**
LIF-173	5-10		7.6	**53.7**	**26.4**	**50.8**
LIF-182	5-10		7.4	**13.4**	**>13.4**	**0.0**
LIF-206	6-16	7.55		**11.9**		**0.0**[a]
			9.35	**23.0**	**>23.0**	**0.0**
LIF-209	6-11		7.6	**4.3**	**>4.3**	**0.0**

TABLE 3.2

SUMMARY OF LABORATORY SOIL CORE TESTING PROGRAM AND LNAPL SATURATION RESULTS
FORMER WILLOW RUN POWERTRAIN
YPSILANTI, MICHIGAN

Soil Core ID	*Soil Core Sample Interval (feet bgs)*	*Soil Core Sub-Sample Selected for Respective Tests (feet bgs)*		*LNAPL Saturation Results*		*Potentially Mobile/Recoverable Fraction (% of in place LNAPL)*
		Pore Fluids Saturation Test	*Residual Saturation by Water Drive*	*Initial Saturation (% of pore space)*	*Residual Saturation (% of pore space)*	
ARC-011	3-8		4.35	**12.5**	**>12.5**	**0.0**
ARC-025	6-11		7.0	**38.9**	**30.9**	**20.6**
ARC-065	5-10	8.6		**10.6**		**0.0**[a]
			8.0	**48.0**	**46.9**	**2.3**
ARC-128	5-10	8.8		**11.6**		**0.0**[a]
			8.2	**24.2**	**>24.2**	**0.0**
ARC-193	7-12		8.3	**21.0**	**>21.0**	**0.0**
ARC-244	7-12		7.4	**9.0**	**>9.0**	**0.0**
ARC-258	6-11		8.6	**13.7**	**>13.7**	**0.0**

[a]Residual saturation testing was not performed on these sub-samples. It is estimated that the LNAPL saturation level in these sub-samples is immobile and unrecoverable based on the residual LNAPL saturation values determined for the other sub-sample at this location.

[b]Residual saturation testing was not performed on this sub-sample. The reported mobility/recoverability range is estimated with reference to an assumed residual LNAPL saturation of 25%.