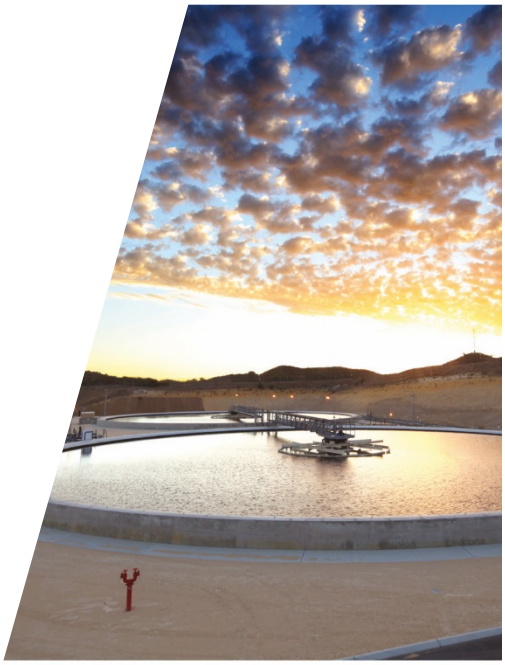
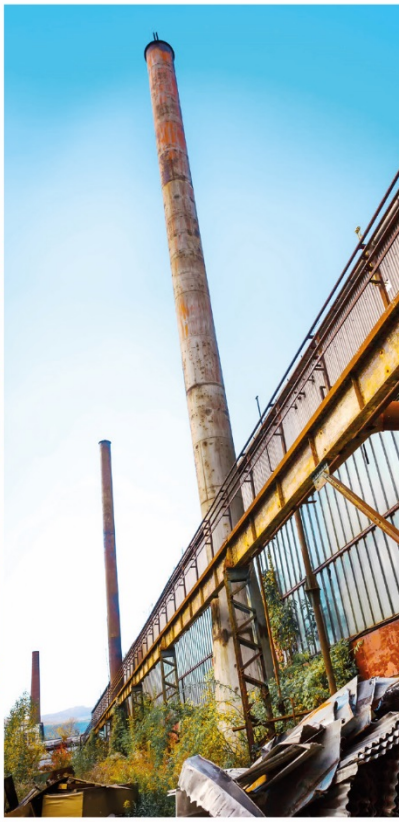


Light Non-Aqueous Phase Liquid Evaluation Update

Former Willow Run Powertrain Plant
Ypsilanti, Michigan









Executive Summary

This report presents an update to the ongoing evaluation of the light non-aqueous phase liquid (LNAPL) that is present in the subsurface at the Former Willow Run Powertrain Plant (Site), in Ypsilanti, Michigan. The purpose of this assessment was to update historical work with respect to the mobility, recoverability and overall stability of the LNAPL, as well as to confirm whether natural LNAPL biodegradation (referred to as natural source zone depletion or NSZD) may represent a viable component of an effective long-term risk-based management strategy.

In assessing post-demolition conditions as they relate to LNAPL mobility, the following factors were considered:

- Increased LNAPL smearing post-demolition will progressively reduce LNAPL mobility over pre-demolition conditions
- The larger fraction of the LNAPL that is submerged below the water table now would result in the LNAPL being predominantly less mobile overall than it was historically
- Very limited observations of LNAPL in the French Drain indicate limited mobility along a very large preferential pathway that intersects the LNAPL body along the eastern Site boundary
- Only one isolated observation of LNAPL daylighting through cracks in the slab (attributed to extenuating circumstances)
- Continued observations of LNAPL stability based on ongoing well gauging under post-demolition equilibrium hydraulic conditions

The post-demolition conditions therefore provide additional lines of evidence to support the conclusions of pre-demolition LNAPL mobility evaluation work which consistently indicated that the LNAPL body is stable and predominantly hydraulically immobile/unrecoverable. Therefore, the mitigation of migration potential is no longer an issue and no technical drivers for LNAPL recovery exist.

The results from the soil gas monitoring, Dynamic Closed Chamber (DCC) and CO_2 Traps represent multiple lines of evidence that NSZD is actively occurring at the Site. It is therefore apparent that the large volume of LNAPL and anaerobic conditions below the slab are resulting in significant LNAPL degradation via methanogenic NSZD processes. The results presented herein therefore confirm that NSZD represents a viable component of the long-term management of residual LNAPL at the Site.

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1. Introduction

This report presents an update to the ongoing evaluation of the light non-aqueous phase liquid (LNAPL) that is present in the subsurface at the Former Willow Run Powertrain Plant (Site), in Ypsilanti, Michigan. The purpose of this assessment was to update historical work with respect to the mobility, recoverability and overall stability of the LNAPL, as well as to confirm whether natural LNAPL biodegradation (referred to as natural source zone depletion or NSZD) may represent a viable component of an effective long-term risk-based management strategy. To this end, this report presents the following:

- A summary of historical evaluations of LNAPL mobility, recoverability and overall stability updated with more recent Site data and observations as appropriate
- A primer on NSZD theory and measurement techniques commonly involved in NSZD monitoring
- The scope of work involved in a comprehensive field and laboratory test program to confirm NSZD activity
- The results of the NSZD evaluation including estimates of LNAPL degradation/NSZD rates

2. Summary of Evaluations Related to the Mobility, Recoverability and Overall Stability of the LNAPL

2.1 Historical LNAPL Evaluation Work

Petroleum product usage in historical operations has resulted in LNAPL being present in the subsurface mainly located beneath the former plant slab. Historical evaluations commenced in 2010 to delineate and assess the potential mobility and recoverability of the LNAPL at the Site. The majority of the Site structures were demolished between 2013 and 2017.

The Conestoga-Rovers & Associates (CRA) report entitled *LNAPL Delineation, Mobility and Recoverability Study Report – Eastern LNAPL Area* (CRA, 2012) presented the results of extensive Site work pertaining to the delineation of LNAPL and the evaluation of its mobility and recoverability potential at the Site prior to commencement of demolition activities. The evaluation focused on data obtained via laser-induced fluorescence (LIF), LNAPL transmissivity (T_n) testing, soil core petrophysical analyses, and groundwater monitoring with results and conclusions summarized as follows:

- Multiple LNAPL types (i.e., cutting oils, transmission fluids, hydraulic fluid, etc.) are present that have been in the ground for variable durations
- An extremely complex subsurface is present below the slab due to soil heterogeneities and extensive subsurface infrastructure, some of which intersected the LNAPL-impacted zones (i.e., sewers)
- Most of the LNAPL was found to be below the water table

- Most of the LNAPL was present at residual level saturations and/or exhibited LNAPL transmissivities at de minimis magnitudes (i.e., less than 0.5 ft^2/day)
- The areal extents of where LNAPL was observed in wells was stable (i.e., no evidence that LNAPL is migrating or expanding over time)
- LNAPL noted in sewers and at the WWTP was attributed to LNAPL infiltrating sewers from the subsurface or entering the sewers via steam tunnel sump pump discharge
- Site monitoring suggested that the Site sewer system was hydraulically influencing an area such that Site hydraulic containment was achieved

The evaluation concluded that most of the LNAPL in the study area was effectively immobile and unrecoverable according to the lines of evidence presented. Isolated areas were identified where LNAPL saturations were observed to be high enough to be potentially mobile and recoverable; however, the age of the LNAPL and the fact that the areal extent of where LNAPL was observed in wells has remained stable over time provided additional lines of evidence that the LNAPL body was stable (i.e., no longer possessed the ability to migrate/expand). Therefore, attempts to recover LNAPL from isolated areas of elevated saturations was concluded to be very unlikely to provide any beneficial change in conditions on a plume-scale. In addition, the exposure controls provided by the permanent concrete surface cover and deed restrictions support the conclusion that some level of fractional LNAPL recovery would not provide value in terms of exposure mitigation.

2.2 Historical Regulatory Review

The LNAPL conditions detailed in the preceding section and other supporting observations and data were presented to the Michigan Department of Environmental Quality (MDEQ)[1] NAPL Technical Assistance and Program Support (TAPSs) Team in May 2014. The MDEQ/EGLE NAPL TAPS Team performed a review of historical documentation for the Site and issued the following recommendations via a June 2014 memorandum:

> *"At minimum, additional delineation of the NAPL bodies is necessary to adequately develop the conceptual site model and to make decisions with certainty about recovery, volume, and stability. Also, long term monitoring of site wells and groundwater collection system should continue and contingencies be developed should NAPL and site characteristics change in the future. Additional recovery testing should be conducted on the mobile portion of NAPL body to better assess feasibility of hydraulic recovery. Finally, additional assessment on the recovery system (storm water system) is needed to determine if it is effectively capturing the recoverable NAPL."*

2.3 Summary of More Recent LNAPL Evaluation Work

The subsequent RCRA Facility Investigation (RFI) LNAPL work has focused on filling data gaps identified by the MDEQ/EGLE NAPL TAPS Team, namely the completion of the delineation of the LNAPL, a more comprehensive evaluation of the recoverability of the potentially recoverable LNAPL, the continued monitoring of LNAPL stability via well gauging, and an assessment of the

[1] The MDEQ has since been renamed and is now known as the Michigan Department of Environment, Great Lakes, and Energy (EGLE).

effectiveness of the storm water system as a remedial component (due to the belief at the time that it was serving as an LNAPL recovery system). These items are discussed in more detail below.

- **LNAPL Delineation:** Additional LNAPL delineation (via LIF) was completed in October 2014 in order to fill the related data gap identified by MDEQ/EGLE. This included confirmation that the LNAPL body remains entirely on-Site, specifically along the eastern property boundary where LNAPL had been historically observed in a single well. Results of additional LIF locations performed on Willow Run Airport property and adjacent to the fence line confirmed that the LNAPL had not migrated to the airport property. These results were submitted to MDEQ/EGLE via a March 2016 memorandum (GHD, 2016).
- **LNAPL Stability Monitoring/Well Gauging:** The monitoring of LNAPL stability continued via quarterly well gauging events (years 2015 to 2018 and semi-annual in 2019). In addition to the pre-existing well network, this monitoring included five new wells installed in October 2014 on Willow Run Airport property. The extent of potentially mobile LNAPL (as defined by where there is evidence of LNAPL in wells whether as a sheen or measurable thickness) has remained within the identified overall LNAPL extent since at least 2008 when regular monitoring and plotting of the data commenced. The regular well gauging continued to confirm the stability of the LNAPL (i.e., there continued to be no evidence that migration may be occurring).
- **LNAPL Recoverability Testing:** The MDEQ/EGLE identified the need for additional LNAPL recoverability testing with the goal of assessing the need for LNAPL recovery and to target locations for its implementation (if required). GHD had proposed the implementation of a comprehensive LNAPL transmissivity test program to fill this data gap; however, this was not implemented as the Site hydraulic conditions had yet to achieve a post-demolition equilibrium state (i.e., the new normal hydraulic conditions had yet to develop, further discussed in Section 2.3.1).
- **Sewer Observations:** It was previously thought that the Site storm sewer system was providing significant hydraulic control and LNAPL recovery at the Site. However, groundwater contour maps from 2014 and 2015 indicated that the inward gradient observed before demolition was no longer present post-demolition. Therefore, it appeared that the hypothesis that the Site storm sewers were providing sufficient hydraulic control and were serving as a large-scale LNAPL recovery system was incorrect. Hydraulic conditions and volumes of LNAPL recovered through the storm sewer system (i.e., at the WWTP) continued to be monitored for some time post-demolition, and volumes of LNAPL observed in the system were noted to diminish following the shutdown of the facility and subsequent removal of infrastructure. It therefore appears that most of the historical LNAPL observed at the WWTP was actually coming from facility operations/infrastructure including dewatering of the steam tunnels rather than from infiltration of LNAPL into sewers from the subsurface. Furthermore, as part of a revised risk management strategy, all of the historic storm sewers that previously collected LNAPL and conveyed it to the WWTP were bulk headed as of November 2017, and are therefore no longer a potential pathway for LNAPL migration.

A number of notable changes have occurred at the Site since the previous LNAPL evaluation in 2012 and the related MDEQ/EGLE NAPL TAPS Memorandum in 2014:

1. Most of the structures and aboveground storm water handling infrastructure were removed from the Site by 2015, with a gradual increase in water table elevation noted over time, such that current hydraulic conditions are significantly different than pre-demolition norms.
2. The volume of LNAPL at the Site WWTP diminished dramatically following the shutdown and decommissioning of the facility, negating the previous hypothesis on the infiltration of LNAPL into Site storm sewers as an indicator of LNAPL mobility (and a potential control).
3. Site storm sewers have been bulk headed, thereby preventing the migration of LNAPL that may enter the abandoned sewers.
4. The French Drain was installed and is operational.
5. Continued long-term monitoring demonstrates that new normal hydraulic conditions have been established.

Each of these items, and related implications with respect to LNAPL mobility, are discussed in the remainder of this section.

2.3.1 Hydraulic Conditions

Changes to the Site hydraulic conditions have been observed as a result of demolition activities. In general, site conditions following demolition have exhibited groundwater gradients from the interior of the Site outward. This is due to the elimination of building storm water handling and previously dewatered below grade infrastructure (tunnels, basements) and the resulting increases in water table elevations that are typical following the demolition of industrial facilities. GHD created a three dimensional visualization (3DV) to provide a comparison of the pre- and post-demolition water table elevations along with the top of LNAPL impacts based on historical LIF results (Figure 1). As can be seen in Figure 1 and in the well gauging plots (Appendix A), there has been a general increase in water levels across the Site. This is particularly apparent in the center of the slab area, with less change noted towards the periphery of the slab. As a result, more of the LNAPL body is submerged below the water table currently compared with typical pre-demolition hydraulic conditions.

The elevated water table/potentiometric surface post-demolition would be expected to predominantly result in reductions in overall LNAPL mobility since LNAPL that is submerged below the water table is generally less mobile than that which is present in the capillary fringe or vadose zones (i.e., saturated zone residual saturation levels will be significantly higher than vadose zone residual saturations). In addition, the observed changes in hydraulic conditions will have exaggerated the smearing of the LNAPL over what has been typical historically, which will provide another mechanism contributing to further immobilization of the remaining LNAPL post-demolition compared with pre-demolition conditions.

In areas where LNAPL is present under confined conditions and intersects preferential pathways, the elevated potentiometric surface may increase hydrostatic pressure, which could induce LNAPL movement into/through the preferential pathways. If this were occurring to any significant extent, it would be expected that it would be exhibited through LNAPL daylighting through cracks in the slab and/or LNAPL movement into the French Drain (i.e., obvious potential to be preferential pathways). These potential preferential pathways are discussed further in the following sections.

2.3.2 LNAPL Daylighting

There has been only one isolated observation of LNAPL daylighting through the slab north of the Yankee Air Museum (YAM) building on May 4, 2018 (approximate location shown on Figure 2). This occurred following a period of intense rainfall where localized storm water was infiltrating at an increased rate into the unlined swales and the unpaved French Drain area during construction activities. The French Drain had been operating at static pump speeds at the time (mechanical issues prevented the ability to increase the pump speed) and was unable to manage the increased groundwater flow and storm water infiltration. There have been no observations of LNAPL daylighting in this area since the swales have been lined and pavement installed over the French Drain. There have been no other observations of LNAPL daylighting anywhere else at the Site. Consequently, this line of evidence does not indicate a concern with LNAPL mobility post-demolition. It is also noted that deed restrictions already in place require the maintenance of impervious cover at the Site, which provides a control against conditions that may cause daylighting/direct contact in the future.

2.3.3 French Drain Observations

The French Drain represents a significant preferential pathway (~14-17 feet deep, ~4 foot wide trench backfilled with gravel and sand mix) that intersects some of the more highly LNAPL saturated areas approaching/along the eastern Site boundary (see Figure 2). In addition, the French Drain is actively pumped, which further enhances the hydraulic gradient that might induce the movement of mobile LNAPL toward the French Drain. Notwithstanding this, there have only been limited observations of LNAPL along the French Drain at CO-3 and Sump-1 (see Figure 2). The entry point of the LNAPL into the drain is unknown but is assumed to be originating from areas where the French Drain intersects the LNAPL plume.

In addition to the minimal observation of LNAPL within the French Drain, the water quality within the French Drain does not exhibit evidence of significant LNAPL impacts. The French Drain discharge is sampled twice per month pursuant to discharge permit requirements, which includes testing for oil and grease. The oil and grease results have ranged from non-detect (2 ppm reporting limit) to a high of 7 ppm (see Appendix B). The majority of the results have been below 2 ppm.

Therefore, the observations above related to the French Drain indicate that the LNAPL is not sufficiently mobile to flow into the significant preferential pathway that the French Drain represents. This line of evidence therefore supports the other observations presented herein as well as the conclusions of the 2012 LNAPL mobility evaluation that the Site LNAPL is stable in overall extent (and has been for years).

2.3.4 WWTP Observations

As previously noted, the observations of LNAPL loading at the WWTP prior to its demolition in 2018 have diminished since the main facility was decommissioned. In other words, the LNAPL in the subsurface was/is not sufficiently mobile to infiltrate the significant preferential pathway that the storm sewer system represented prior to the sewers being bulk headed in 2017. Consequently, this observation provides another line of evidence that Site LNAPL is not mobile enough to flow into a large preferential pathway that it intersects.

2.4 Summary

The previous conclusions regarding LNAPL mobility at the Site are deemed to be sound since current Site conditions would be expected to have the effect of an overall reduction in mobility compared with pre-demolition conditions. This assertion is supported by the following factors:

- Increased LNAPL smearing post-demolition will progressively reduce LNAPL mobility over pre-demolition conditions
- The larger fraction of the LNAPL that is submerged below the water table now would result in the LNAPL being predominantly less mobile overall than it was historically
- Very limited observations of LNAPL in the French Drain indicate limited mobility along a very large preferential pathway that intersects the LNAPL body along the eastern Site boundary
- Only one isolated observation of LNAPL daylighting through cracks in the slab (attributed to extenuating circumstances)
- Continued observations of LNAPL stability based on ongoing well gauging under post-demolition equilibrium hydraulic conditions

The post-demolition conditions discussed herein therefore provide additional lines of evidence to support the conclusions of the pre-demolition LNAPL mobility evaluation that the LNAPL body is stable and predominantly immobile.

A benefit to LNAPL recovery might be realized where there is a risk that LNAPL may migrate/expand into areas that are not already contaminated. At the time of the 2014 MDEQ/EGLE NAPL TAPS team review, the following concerns were considered to be valid:

1. LNAPL infiltrating preferential pathways posed a risk of LNAPL body expansion.
2. LNAPL near the eastern Site boundary could be able to migrate east onto neighboring Willow Run Airport property.

As discussed previously in this memo, there is no evidence that LNAPL movement through preferential pathways is a widespread/significant issue at the Site. With respect to sewers specifically, LNAPL infiltration from the subsurface into Site storm sewers proved to be essentially a non-issue given post-decommissioning observations of the minimal volumes of LNAPL entering the WWTP. In addition, the storm sewers have been bulk headed to prevent the migration of any LNAPL that might enter the abandoned sewers. Finally, the French Drain that has since been installed along the eastern and parts of the southern property boundary would prevent any mobile LNAPL that might be present from migrating off-Site, and observations along the French Drain and discharge water analytical results indicate that minimal LNAPL has entered the French Drain even under active pumping conditions.

Therefore, a driver for cost-effective LNAPL recovery no longer exists since the LNAPL mobility has been demonstrated to be low in general and the overall residual LNAPL body is capped and contained on-Site. Consequently, the past NAPL TAPS Team recommendations do not reflect the current situation at the Site with respect to LNAPL conditions or LNAPL containment infrastructure now in place. Therefore, GHD recommends that no further evaluation of the mobility/recoverability of the LNAPL is needed since LNAPL recovery will add no benefit to the current situation of largely residual LNAPL that is stable on-Site. Where this is the case, the long-term management of stable

residual LNAPL via natural biodegradation (NSZD) is increasingly viewed as an effective sustainable approach. However, NSZD had not been comprehensively evaluated or documented on a site-specific basis. Given the stability of the LNAPL, the lack of benefit to be realized through efforts to recover LNAPL from the subsurface, and the deed restrictions in place to mitigate exposures, NSZD may represent a viable primary component of the long-term management of the residual LNAPL. The following section provides more detail on NSZD processes and the potential role of NSZD in the long-term management of the Site LNAPL.

3. NSZD Background

The management of sites impacted by LNAPL has historically focused on the quick implementation of aggressive remedial/recovery techniques to mitigate perceived risks. While this course of action might be relevant for new releases, it will often be relatively ineffective at sites where LNAPL has been in the ground for more than a few years. Years of academic study and empirical field observation have revealed that:

- Engineered solutions may not result in a tangible beneficial change in conditions at LNAPL sites.
- The risks associated with LNAPL sites may be lower than historically assumed.
- Natural LNAPL biodegradation processes (NSZD) can account for much higher LNAPL mass loss/degradation rates than previously thought.

NSZD processes are widely observed to be active at petroleum LNAPL sites via the following processes:

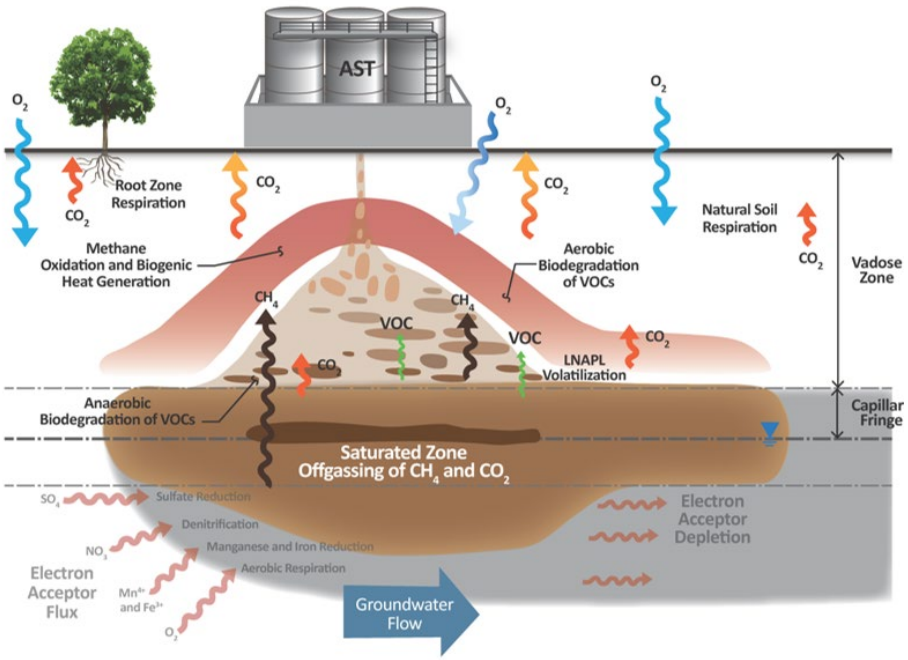
- Dissolution of chemicals of concern (COCs) from the parent LNAPL with subsequent biodegradation in groundwater
- Volatilization of COCs from the parent LNAPL with subsequent biodegradation in the vadose zone
- Direct biodegradation of LNAPL

NSZD has been demonstrated to be ubiquitous at LNAPL sites, producing LNAPL degradation rates that can rival or exceed what can be achieved via engineered means, particularly where the LNAPL has been in the ground for an extended period of time and is largely present as hydraulically immobile residual.[2] The rate of LNAPL biodegradation (NSZD) depends on many factors, including the availability and type of electron acceptors present in the soils and groundwater to enable microbial and/or enzymatic activity[3]. The degradation of LNAPL will generally proceed anaerobically via methanogenesis, producing methane (CH_4) and carbon dioxide (CO_2), with CH_4 subsequently oxidized to CO_2 via an exothermic process in the vadose zone. A conceptual depiction of these processes follows[4].

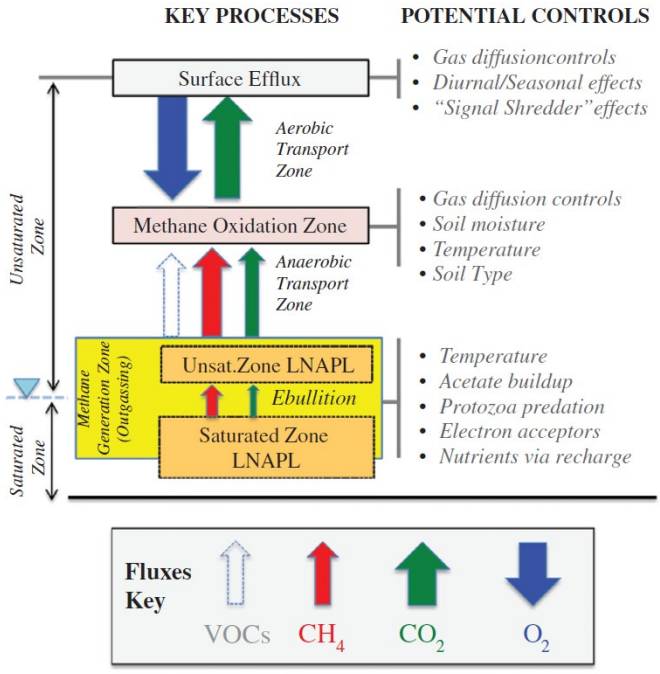
[2] See Garg et al's *Overview of Natural Source Zone Depletion: Processes, Controlling Factors, and Composition Change*, Groundwater Monitoring & Remediation, 2017, doi: 10.1111/gwmr.12219.

[3] ITRC (Interstate Technology & Regulatory Council). *Evaluating Natural Source Zone Depletion at Sites with LNAPL*. LNAPL-1. Washington, D.C.: Interstate Technology & Regulatory Council, LNAPL Teams. April 2009.

[4] From American Petroleum Institute (API) Publication No. 4784, *Qualification of Vapor Phase-related Natural Source Zone Depletion Processes, First Edition*, May 2017.



The production of CH_4 and CO_2 at depth and subsequent oxidation of the CH_4 to CO_2 produces characteristic soil gas concentration gradients as shown conceptually below (from Garg et al)[1].



NSZD monitoring/screening can therefore be performed by looking for characteristic changes in concentrations of CH_4, CO_2 and O_2 with depth and/or at the flux of CO_2 near surface. Since gaseous CO_2 will be the ultimate product of LNAPL mineralization, rates of LNAPL degradation can be estimated by measuring the near surface flux of CO_2 at sites with petroleum hydrocarbon impacts and isolating the portion of the CO_2 that is petrogenic (as opposed to that which is produced by other

natural processes such as plant respiration). The two most common ways this is accomplished is through active short-term testing via Dynamic Closed Chamber (DCC) or longer-term integrated passive sampling via CO_2 Trap.

The DCC is a short-term active sampling device that generates CO_2 flux estimates over the course of several minutes. In order to isolate the portion of the measured CO_2 that is petrogenic (i.e., from LNAPL degradation) from the total CO_2 that will include contributions from modern sources such as plant respiration, a correction is necessary to account for background/modern CO_2. Accordingly, the measured CO_2 flux in the LNAPL-impacted area is corrected by subtracting measured non-petrogenic CO_2 flux obtained from test locations assumed to represent background conditions with comparable surface cover (based on the magnitude of results and/or separation from an LNAPL-impacted area). The lack of unimpacted areas away from LNAPL and the variability in surface cover at many sites will add considerable complexity in siting suitable background locations. As such, the use of the DCC is often used as an initial screening for the identification of CO_2 flux anomalies that can then be evaluated more definitively via CO_2 Trap.

The CO_2 Trap is a passive sampling device that contains a solid-state sorbent material. The sorbent is strongly basic, converting the CO_2 that passes through to stable carbonates that are retained in the Trap. Traps typically remain in place for a timeframe on the order of two weeks, which provides some level of normalization of the temporally variable CO_2 flux measurements. Following the sampling period, Traps are analyzed for total CO_2 and petrogenic CO_2 via unstable isotope analysis (^{14}C radiocarbon dating). The unstable isotope ^{14}C is present in modern carbon sources, but due to a half-life of 5,600 years, is not present in fossil fuel carbon sources. Consequently, CO_2 Trap analysis involves a 'built-in' location-specific background correction based on analytical data that results in much more reliable petrogenic CO_2 flux estimation than can reasonably be accomplished via the DCC method alone.

Ideally, CO_2 flux readings will be obtained in areas that are relatively unsealed with respect to surface cover (i.e., mostly unpaved/undeveloped). The presence of large areas of surface cover within a given study area can inhibit the exchange of ambient oxygen with the subsurface, which in turn can impede the subsurface oxidation of CH_4 to CO_2. In this case, the detected CO_2 flux will under predict the amount of NSZD taking place if methane flux is not also accounted for. Conversely, penetrations in surface cover can create a "chimney effect" whereby the CO_2 flux from a larger area is concentrated through the penetration and into the NSZD test equipment, which can then bias the detected CO_2 flux and related NSZD estimates high. The presence of largely concrete slab surface cover at the Site therefore may present significant complications to the measurement of NSZD activity and the estimation of representative NSZD rates.

4. Scope of Work

As previously mentioned, NSZD had not been comprehensively evaluated or documented on a site-specific basis prior to the work described herein. A demonstration of active NSZD would support the long-term management of residual LNAPL at the Site since NSZD processes play a fundamental role in the long-term depletion of COCs in the LNAPL, thereby reducing COC dissolution and volatilization rates. In addition, the resulting reduction in LNAPL mass over time will lead to a commensurate reduction in LNAPL saturation, further limiting LNAPL mobility potential and

strengthening the overall stability of both LNAPL and dissolved plumes. Therefore evaluating NSZD of the LNAPL conceptual site model was considered.

To assess NSZD at the Site, GHD completed a study of different potential measurement methodologies under different hydraulic conditions. More specifically, GHD conducted active CH_4, CO_2 and O_2 testing using both existing soil gas probes and well headspace to look for the presence of NSZD products and characteristic changes in the concentrations of these gases. In addition, CO_2 flux testing was performed at dedicated locations via DCC as an additional line of evidence of NSZD activity and to provide estimates of NSZD rates. This testing was performed both under current hydraulic conditions with active pumping in the French drain (Hydraulic Condition 1) and under normal non-pumping hydraulic conditions after the pumps had been turned off (Hydraulic Condition 2). A comparison of results between testing events under the different hydraulic conditions was completed in order to evaluate the effect of changes in water table elevation/vadose zone thickness on NSZD rates.

In addition to the active methods described above, the CO_2 Trap method was implemented in two different configurations to provide a more definitive estimate of NSZD rates and to assess the potential bias in results that might be introduced by the chimney effect that can be induced when sampling through perforations in sealed/paved surfaces. The CO_2 Trap testing was performed under current hydraulic conditions with active pumping in the French drain (Hydraulic Condition 1).

It is noted that all NSZD monitoring techniques have benefits and limitations and their use here was not intended to provide precise estimates of LNAPL degradation rates. Rather, the different techniques were used to provide different lines of evidence to confirm that NSZD is occurring and to provide approximate (order of magnitude) range estimates for consideration in LNAPL management strategy decision-making.

5. NSZD Results

5.1 Active CH_4, CO_2 and O_2 Monitoring (Handheld Analyzer)

Multiple rounds of CH_4, CO_2 and O_2 concentration monitoring were conducted between June 4, 2019 and September 23, 2019 using a Landtec GEM5000 Portable Gas Analyzer and a Landtec SEM5000 Portable Methane Detector at selected soil vapor pin locations, monitoring well locations with exposed screens and DCC (flux hood) locations. It is noted that initial monitoring using the Landtec GEM5000 was subsequently supplemented using the Landtec SEM5000 in order to achieve a much lower CH_4 limit of detection at certain monitoring locations. All monitoring locations are indicated on Figure 3 with installation diagrams presented on Figure 4. Soil gas monitoring was completed in the vadose zone, in the well headspace at approximately 1 ft above the water table at monitoring well locations and just below the concrete slab at the gas probe and DCC locations (refer to diagrams on Figure 4). Results of this monitoring are presented graphically in Appendix C.

Evidence of methanogenic NSZD processes in terms of elevated concentrations of CH_4 and CO_2 and reduced concentrations of O_2 in soil gas near surface were widely and consistently observed. The results from two monitoring events which are representative of conditions during active pumping in the French drain (Hydraulic Condition 1) and under normal non-pumping hydraulic conditions after

the pumps had been turned off (Hydraulic Condition 2) are presented in Figures 5 and 6, respectively.

5.1.1 Areal Extent of CH_4

As noted in Figures 5 and 6, CH_4 was widely detected in the subsurface. This suggests that anaerobic degradation of the LNAPL via methanogenesis is active and widespread.

5.1.2 Vertical Distribution of CO_2, CH_4 and O_2

A comparison of the average CO_2, CH_4 and O_2 results at the different depths is presented for the cross sections as indicated on Figure 7 and detailed on Figures 8, 9 and 10 at locations where monitoring wells were in close proximity to gas probe locations and would be expected to be representative of similar subsurface conditions. A comparison of the average soil gas concentrations at depth with near surface at these locations indicates the following general patterns that are typical where NSZD processes are active:

- CH_4 concentrations are reduced as it moves upwards through the vadose zone and is oxidized
- The oxidation of CH_4 results in reduced O_2 content in soil gas at depth compared to near surface
- CO_2 concentrations increase nearer to surface as CO_2 is generated via methanogenesis at depth, with additional CO_2 generated in the vadose zone as CH_4 is oxidized to CO_2

It is noted that certain locations exhibited soil gas distributions that are inconsistent with what is described above. It is GHD's opinion that this is likely the result of accumulations of soil gases below the slab. These data are additionally presented graphically in Appendix D.

5.1.3 Hydraulic Condition

It is noted that, in general, measured concentrations of CO_2, CH_4 and O_2 remained relatively constant throughout the investigation period with minimal change noted between Hydraulic Condition 1 and 2. Although hydraulic conditions were allowed to return to a non-pumping equilibrium (i.e., no drawdown effects in the vicinity of French Drain) during Hydraulic Condition 2, it is not known if this allowed sufficient time for microbial communities to acclimatize and NSZD processes to reach a new equilibrium. Overall, the French Drain pumps were shut off for a 6-week duration between July 12 and August 24. Groundwater elevation contour plots are provided in Appendix E that were used to track the recovery of the water table once the French Drain pumps were shut off to determine when non-pumping equilibrium conditions developed. The length of time the system could be "off" was restricted due to sampling requirements for the Site discharge permit.

5.2 Active CO_2 Flux Measurements (Dynamic Closed Chamber)

CO_2 flux measurements were conducted using a GHD owned LI-COR Biosciences LI-7810 trace gas analyzer DCC. Due to instrument limitations associated with the magnitude of CH_4 concentrations detected near surface, the DCC only produced reliable data at certain locations where CH_4 concentrations were within the measurement range of the trace gas analyzer (confirmed beforehand with the SEM5000 handheld). The DCC CO_2 flux results from two monitoring events conducted July 4, 2019 and September 23, 2019 are included in Tables 1 and 2, respectively, and graphically on Figure 11. Tables 1 and 2 present the NSZD rate estimates developed using the maximum

background or modern carbon flux from the CO_2 Trap results to perform the background correction (i.e., this value is subtracted from each of the individual flux chamber results). This methodology for background correction was performed due to uncertainty with locating background locations far enough from the Site LNAPL to be reliable. It also represents a conservative approach since the maximum of the CO_2 Trap background results was utilized.

Notwithstanding the conservative approach to background correction, the estimated NSZD rates shown in Tables 1 and 2 are well above what is considered typical at LNAPL sites. Based on GHD experience and what is reported in the literature, typical rates are on the order 1,000 gallons of LNAPL degraded per acre per year[1], whereas the estimated rates at the Site exceed this level, in some cases by multiple orders of magnitude, at all locations where NSZD was detected. The elevated rates observed at the Site could be due to the large volume of LNAPL under methanogenic/anaerobic conditions and/or the accumulation of CO_2 beneath the slab (i.e., a lot of NSZD activity). Regardless of the operative mechanism, this dataset provides an additional strong line of evidence that NSZD activity is significant and widespread at the Site.

5.3 Passive CO_2 Monitoring (CO_2 Traps)

Initial results from active flux monitoring were used to select eight study locations for passive CO_2 Trap placement. Locations are indicated on Figure 7. Two rounds of CO_2 Traps were completed using different installation methods (refer to diagrams on Figure 4) in an effort to evaluate the 'chimney effects'. Round 1 was deployed on July 1, 2019 with a prototype CO_2 Trap assembly that recirculates part of the sampled gas flow back into the subsurface through an adjacent vapor pin. Round 2 was deployed on September 1, 2019 with a closed CO_2 Trap to inhibit the recirculation of gas flow. Site hydraulic conditions were similar during both deployments (see contour plots in Appendix E). The Round 1 sample assembly allowed advective flow through the CO_2 Trap, whereas the Round 2 sample assembly did not allow advective flow with any CO_2 entering the trap only able to enter through diffusion.

The CO_2 Traps were deployed and left in-situ for approximately five days during each round of testing. The CO_2 Traps were collected and sent for laboratory analysis of total and petrogenic (via unstable ^{14}C isotope analysis) CO_2 content to determine total CO_2 flux and to isolate the portion of the total derived from LNAPL degradation to estimate NSZD rates. The CO_2 Traps were supplied and analyzed by E-Flux, LLC of Fort Collins, Colorado, USA. The evaluation included one trip blank that was analyzed along with the sampled Traps.

The laboratory CO_2 Trap results are provided in Appendix F and are summarized in Table 3 and Figure 12. As can be seen in Table 3, the CO_2 Trap results provide another layer of confirmation that the LNAPL body is actively biodegrading at rates that are significantly higher than typical levels at LNAPL sites.

The results between both installation methods (with and without advective flow) indicates comparable magnitudes of estimated NSZD rates with differences ranging from 2-25%. With the exception of location CC-011 where results from Round 2 were much lower in comparison to Round 1 due to the sample location being flooded during deployment (limiting the movement of soil gas into the trap), the remainder of the results were comparable between the two rounds. This seems to indicate that the high NSZD rates seen during Round 1 were not due to a concentration of flow into the traps through the associated perforations in the concrete. If this were the case, the

results for the diffusion only event (Round 2) would have been much lower than Round 1 for all locations. The large magnitude of the estimated NSZD rates may therefore be due to an accumulation of soil gases below the slab allowing significant mass transfer though diffusion.

5.4 Summary of Results

The results from the soil gas monitoring, DCC and CO_2 Traps represent multiple lines of evidence that NSZD is actively occurring at the Site. Figure 13 provides a summary of where the various monitoring techniques confirmed NSZD activity. It is apparent that the large volume of LNAPL and anaerobic conditions below the slab are resulting in significant LNAPL degradation via methanogenic NSZD processes.

6. Conclusions

The MDEQ/EGLE NAPL TAPS Team identified the need for additional LNAPL recoverability testing in their June 2014 memorandum with the goal of assessing the need for LNAPL recovery and to target locations for its implementation (if required). At the time, GHD had proposed that this would be best accomplished via the implementation of a comprehensive LNAPL transmissivity test program. As hydraulic conditions at the Site have changed since demolition, and with the benefit of observations associated with the installation of the French drain along the east property boundary, the need for such a program is no longer warranted. The location of the French drain is such that it acts as a barrier to any potential off-site migration and forms a preferential pathway for LNAPL whether or not active pumping is occurring. In addition, significant quantities of LNAPL are not mobilizing into the drain as confirmed by typically non-detect (<0.0002%) hydrocarbon concentration in the discharge water. The lack of widespread LNAPL observations in the French Drain, which intersects a large portion of LNAPL impacts, indicates that mitigation of migration potential is no longer an issue and no technical drivers for LNAPL recovery exist.

The results presented herein confirm that NSZD is actively occurring and supports the long-term management of residual LNAPL at the Site.

7. References

CRA (2012), LNAPL Delineation, Mobility and Recoverability Study Report – Eastern LNAPL Area

GHD (2016), LNAPL Site Characterization and Management Plan Update Former Powertrain Plant, Ypsilanti, Michigan, March 3, 2016

[redacted]

Operating 3D PDFs:
Toggle on/off Layers - Expand "PDF3D Scene" folder to view all available model layers
Rotate - hold down left mouse button
Zoom in/out - scroll up and down using mouse wheel
Pan - hold down right and left mouse buttons
Click here for more advanced viewing instructions

10X VERTICAL EXAGGERATION

LEGEND

PROPERTY BOUNDARY

WATER LEVEL CHANGE (FT)

-7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7

FORMER POWERTRAIN PLANT
YPSILANTI, MICHIGAN

WATER LEVEL CHANGE
(APRIL 2013 TO APRIL 2018)

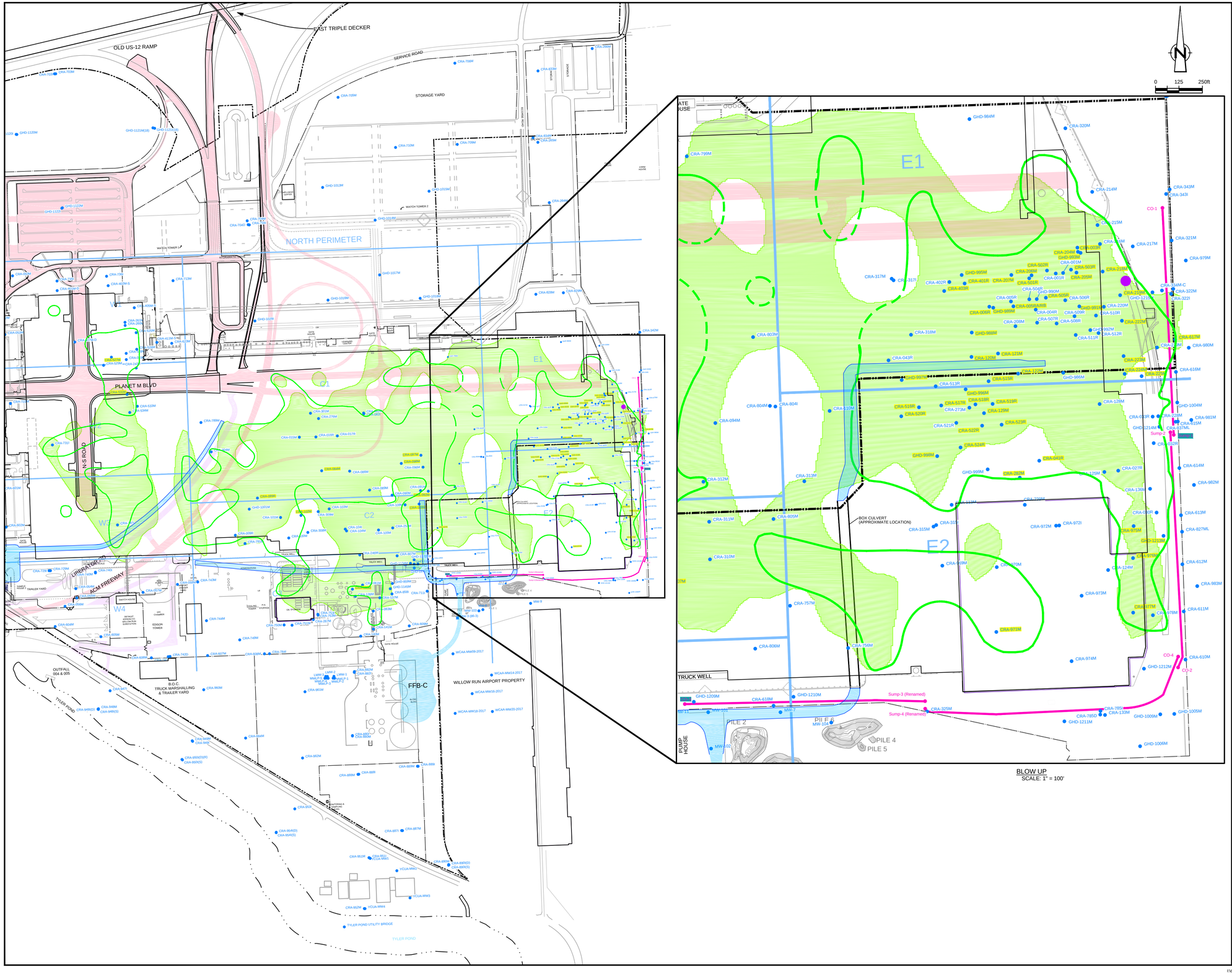
017358

FEB 2019

FIGURE 1

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Created by: milic



BLOW UP
SCALE: 1" = 100'

No	Revision	Date	Initial

LEGEND

- PROPERTY BOUNDARY (OCTOBER 2016)
- SURFACE WATER
- CRA-001M — MONITORING WELL
- ACM LAYOUT (07-27-2018)
- APPROXIMATE EXTENT OF LNAPL (BASED ON LIF RESULTS AND HISTORICAL WELL MONITORING)
- FRENCH DRAIN AS BUILT
- CO-1, SUMP-1 — CLEANOUTS AND SUMPS ALONG FRENCH DRAIN
- LOCATIONS WHERE MEASURABLE LNAPL THICKNESS HAS BEEN OBSERVED IN 2018
- LNAPL OBSERVED IN CLEANOUTS / SUMPS (ENTRY POINT UNKNOWN)
- LNAPL DAYLIGHTING OBSERVED (MAY 4, 2018)
- APPROXIMATE LNAPL EXTENTS AS INDICATED BY LIF RESULTS (FROM 3DV)
- SURFACE STORM WATER FEATURES (2-21-19)

SCALE VERIFICATION

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

Approved

DRAWING STATUS

Status	Date	Initial

AREAL EXTENT OF RESIDUAL LNAPL BODIES AND IN-WELL LNAPL OBSERVATIONS

LNAPL EVALUATION UPATE

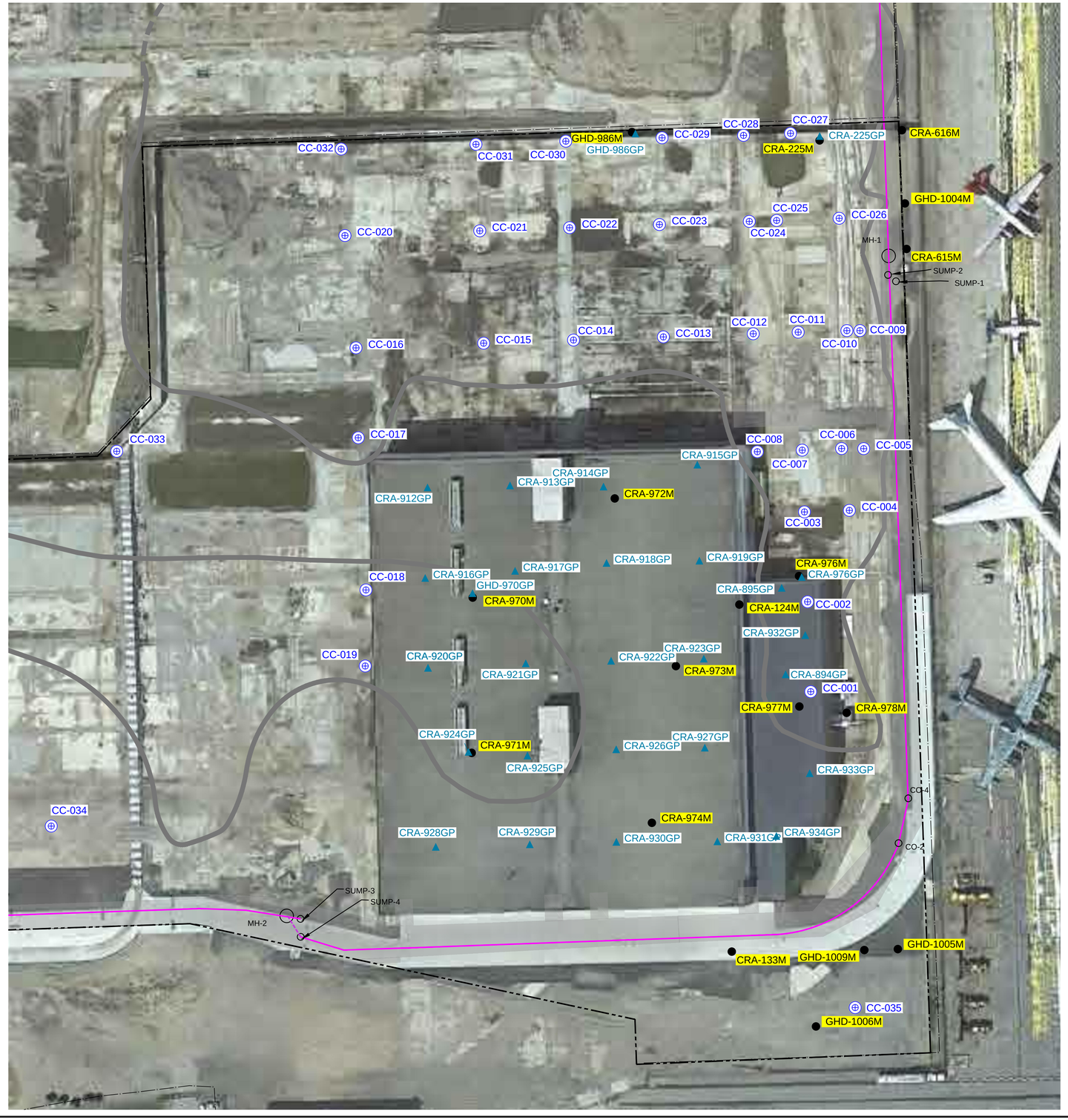
FORMER POWERTRAIN PLANT YPSILANTI, MICHIGAN

GHD

Source Reference:

Project Manager:	Reviewed By:	Date:	
B.L.	W.B.	NOVEMBER 2019	
Scale: AS SHOWN	Project No: 017358-2019	Report No: 045	Drawing No: FIGURE 2

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N

0 25 50ft

No	Revision	Date	Initial

LEGEND

- PROPERTY BOUNDARY
- FRENCH DRAIN
- x FENCE (UPDATED 2-21-19)
- APPROXIMATE EXTENT OF LNAPL (OCTOBER 2018)
- CRA-915GP ▲ GAS PROBE LOCATION
- CC-001 ◎ APPROXIMATE DYNAMIC FLUX CHAMBER LOCATION
- CRA-615M ● MONITORING WELL LOCATION (WITH > 1.0 FEET OF EXPOSED SCREEN)

NOTES:
1. TEST ROADS, ACCESS ROADS AND CURRENT BUILDINGS FROM ACM_EXHIBIT_SITEPLAN_2018-07-27.DGN
2. GOOGLE EARTH (DIGITAL GLOBE 4-23-2019)

SCALE VERIFICATION

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

Approved

DRAWING STATUS

Status	Date	Initial

FORMER POWERTRAIN PLANT YPSILANTI, MICHIGAN

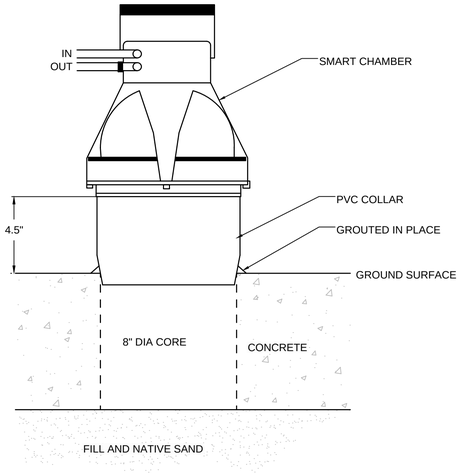
LNAPL EVALUATION UPDATE

NSZD MONITORING LOCATIONS

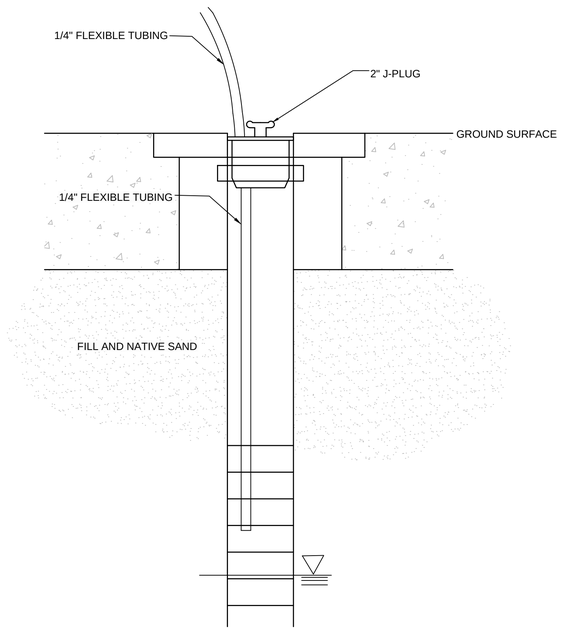
GHD

Source Reference:			
Project Manager: B. LANDALE	Reviewed By: M. LABBE	Date: NOVEMBER 2019	
Scale: AS SHOWN	Project No: 017358-2019	Report No: 045	Drawing No: FIGURE 3

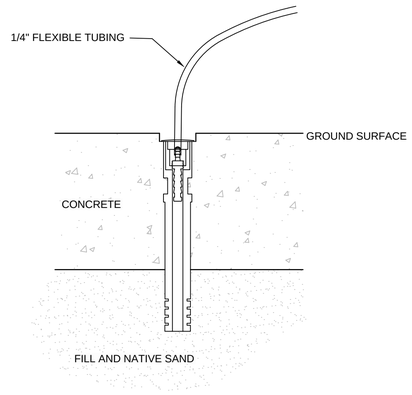
SOIL GAS READINGS



CORE LOCATIONS
SCALE: NTS

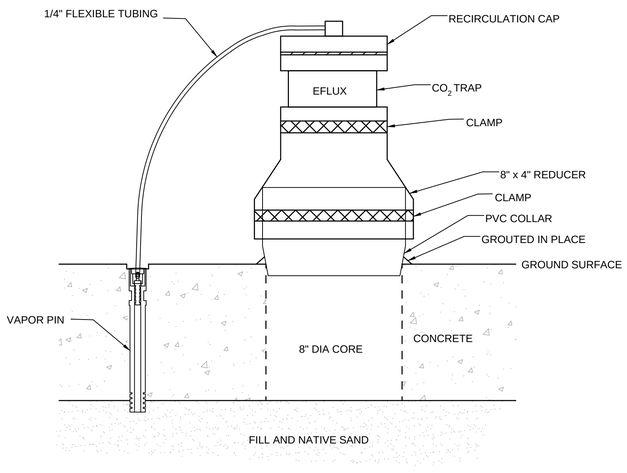


MONITORING WELL LOCATIONS
SCALE: NTS

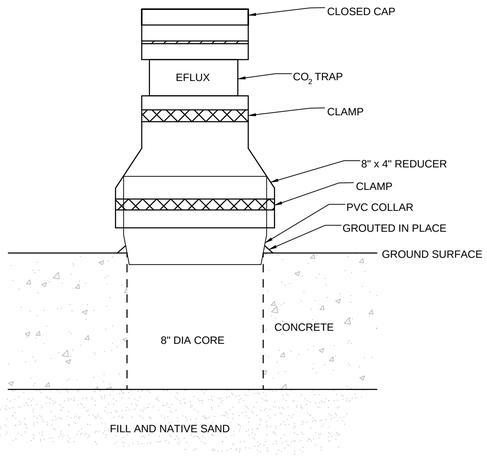


VAPOR PIN LOCATIONS
SCALE: NTS

CO_2 TRAPS



VAPOR PIN CONFIGURATION
SCALE: NTS



CLOSED CONFIGURATION
SCALE: NTS

No	Revision	Date	Initial

SCALE VERIFICATION

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Approved

DRAWING STATUS

Status	Date	Initial

FORMER POWERTRAIN PLANT
YPSILANTI, MICHIGAN

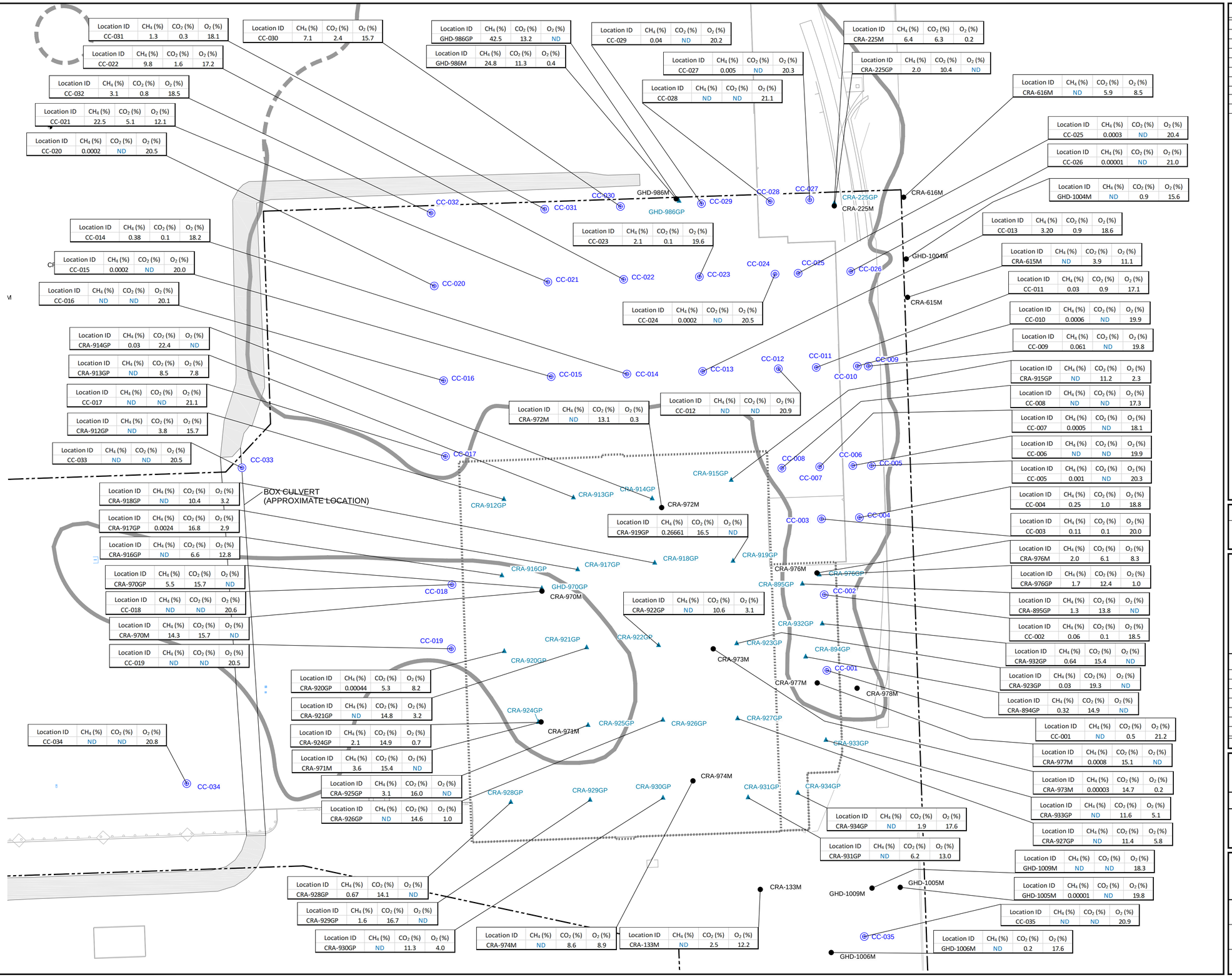
LNAPL EVALUATION UPDATE

DIAGRAMS / SCHEMATICS

GHD

Source Reference:

Project Manager:	Reviewed By:	Date:	
B. LANDALE	M. LABBE	NOVEMBER 2019	
Scale: AS SHOWN	Project No: 017358-2019	Report No: 045	Drawing No: FIGURE 4



NO	Revision	Date	Initial

LEGEND

- PROPERTY BOUNDARY
- BUILDING (PRE-DEMOLITION)
- EXISTING YAM BUILDING FOOTPRINT
- APPROXIMATE EXTENT OF LNAPL (OCTOBER 2018)
- SURFACE STORM WATER FEATURES
- CRA-613M ● MONITORING WELL LOCATION
- CRA-915GP ▲ GAS PROBE LOCATION
- CC-001 ⊕ APPROXIMATE DYNAMIC FLUX CHAMBER LOCATION

Location ID	CH4 (%)	CO2 (%)	O2 (%)
CC-001	ND	0.5	21.2

SOIL GAS READINGS AT MONITORING LOCATIONS (JULY 2-4, 2019)

SCALE VERIFICATION

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

Approved

DRAWING STATUS

Status	Date	Initial

FORMER POWERTRAIN PLANT YPSILANTI, MICHIGAN

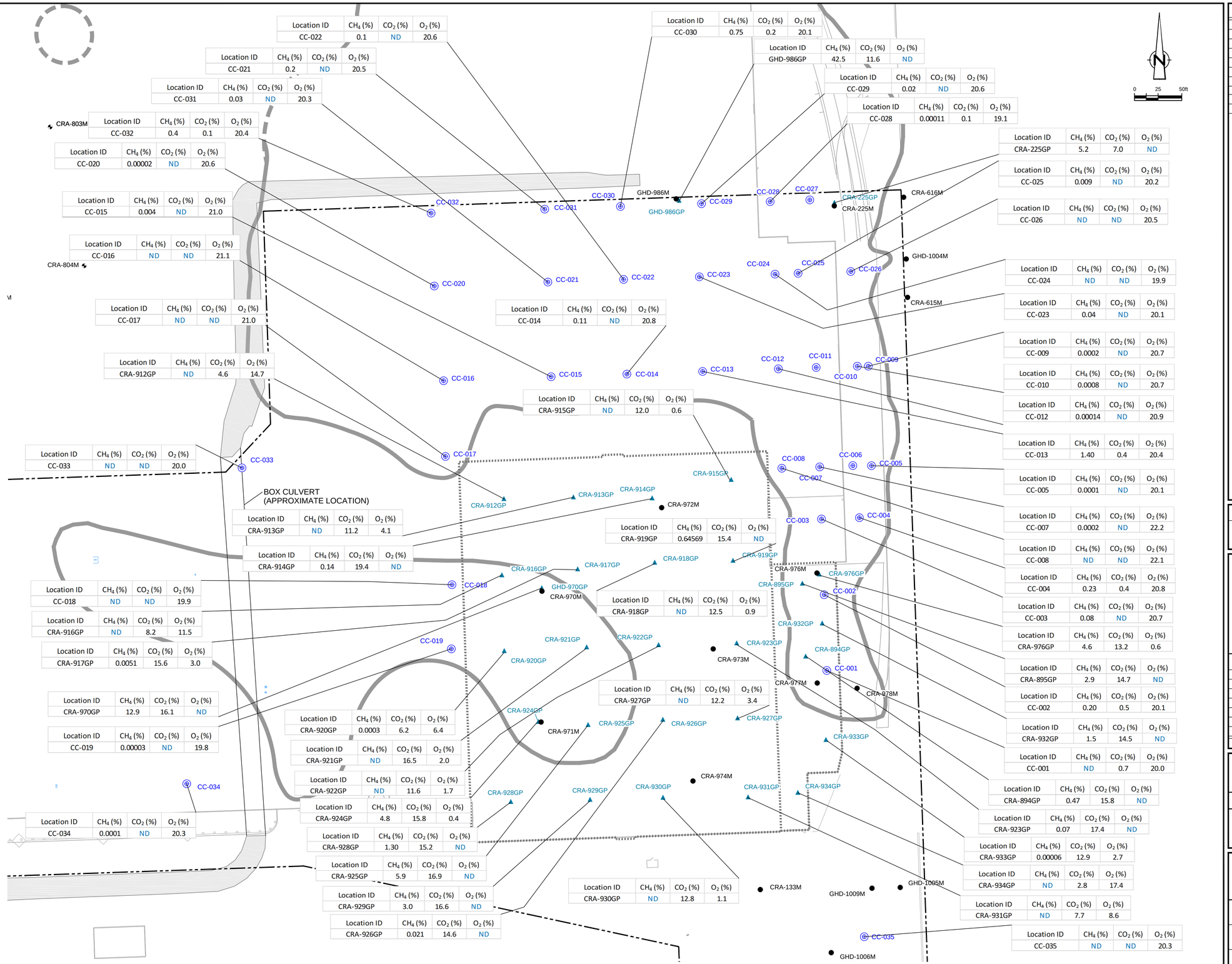
LNAPL EVALUATION UPDATE

SOIL GAS READINGS JULY 2-4, 2019

Source Reference:

Project Manager:	Reviewed By:	Date:	
B. LANDALE	M. LABBE	DECEMBER 2019	
Scale: AS SHOWN	Project No: 017358-2019	Report No: 045	Drawing No: FIGURE 5

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Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-022	0.1	ND	20.6

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-021	0.2	ND	20.5

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-031	0.03	ND	20.3

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-032	0.4	0.1	20.4

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-020	0.00002	ND	20.6

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-015	0.004	ND	21.0

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-016	ND	ND	21.1

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-017	ND	ND	21.0

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-912GP	ND	4.6	14.7

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-033	ND	ND	20.0

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-018	ND	ND	19.9

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-916GP	ND	8.2	11.5

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-917GP	0.0051	15.6	3.0

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-970GP	12.9	16.1	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-019	0.00003	ND	19.8

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-034	0.0001	ND	20.3

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-014	0.11	ND	20.8

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-915GP	ND	12.0	0.6

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-913GP	ND	11.2	4.1

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-914GP	0.14	19.4	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-918GP	ND	12.5	0.9

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-920GP	0.0003	6.2	6.4

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-921GP	ND	16.5	2.0

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-922GP	ND	11.6	1.7

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-924GP	4.8	15.8	0.4

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-928GP	1.30	15.2	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-925GP	5.9	16.9	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-929GP	3.0	16.6	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-926GP	0.021	14.6	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-927GP	ND	12.2	3.4

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-930GP	ND	12.8	1.1

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-030	0.75	0.2	20.1

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
GHD-986GP	42.5	11.6	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-029	0.02	ND	20.6

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-028	0.00011	0.1	19.1

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-225GP	5.2	7.0	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-025	0.009	ND	20.2

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-026	ND	ND	20.5

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-024	ND	ND	19.9

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-023	0.04	ND	20.1

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-009	0.0002	ND	20.7

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-010	0.0008	ND	20.7

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-012	0.00014	ND	20.9

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-013	1.40	0.4	20.4

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-005	0.0001	ND	20.1

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-007	0.0002	ND	22.2

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-008	ND	ND	22.1

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-004	0.23	0.4	20.8

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-003	0.08	ND	20.7

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-976GP	4.6	13.2	0.6

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-895GP	2.9	14.7	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-002	0.20	0.5	20.1

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-932GP	1.5	14.5	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-001	ND	0.7	20.0

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-894GP	0.47	15.8	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-923GP	0.07	17.4	ND

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-933GP	0.00006	12.9	2.7

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-934GP	ND	2.8	17.4

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CRA-931GP	ND	7.7	8.6

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-035	ND	ND	20.3

No	Revision	Date	Initial

LEGEND

- PROPERTY BOUNDARY
- BUILDING (PRE-DEMOLITION)
- EXISTING YAM BUILDING FOOTPRINT
- APPROXIMATE EXTENT OF LNAPL (OCTOBER 2018)
- SURFACE STORM WATER FEATURES
- CRA-613M ● MONITORING WELL LOCATION
- CRA-915GP ▲ GAS PROBE LOCATION
- CC-001 ⊕ APPROXIMATE DYNAMIC FLUX CHAMBER LOCATION

Location ID	CH_4 (%)	CO_2 (%)	O_2 (%)
CC-026	ND	ND	20.5

SOIL GAS READINGS AT MONITORING LOCATIONS (AUGUST 22-23, 2019)

SCALE VERIFICATION

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

Approved

DRAWING STATUS

Status	Date	Initial

FORMER POWERTRAIN PLANT
YPSILANTI, MICHIGAN

LNAPL EVALUATION UPDATE

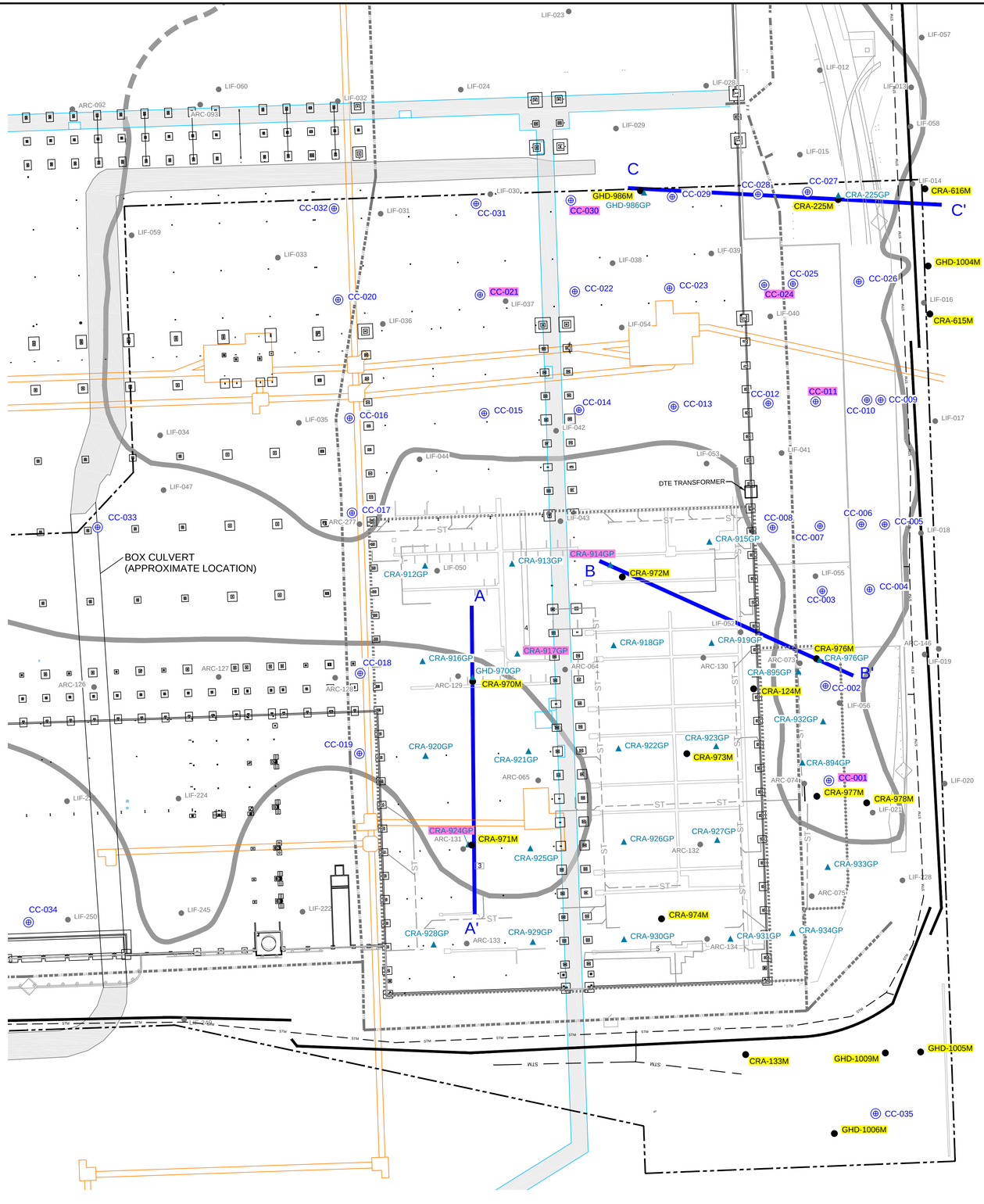
SOIL GAS READINGS
AUGUST 22-23, 2019

GHD

Source Reference:

Project Manager:	Reviewed By:	Date:	
B. LANDALE	M. LABBE	DECEMBER 2019	
Scale: AS SHOWN	Project №: 017358-2019	Report №: 045	Drawing №: FIGURE 6

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No	Revision	Date	Initial

LEGEND

- PROPERTY BOUNDARY
- BUILDING (PRE-DEMOLITION)
- EXISTING YAM BUILDING FOOTPRINT
- APPROXIMATE EXTENT OF LNAPL (OCTOBER 2018)
- ABANDONED STORM SEWER
- ABANDONED STORM SEWER (MAIN LINES)
- EAST SIDE STORM DRAIN
- STEAM TUNNEL
- FORMER TRENCHES AND FLUMES (INCLUDES COOLANT TRENCHES)
- ELECTRIC TUNNEL / DUCT SYSTEM (HISTORIC)
- SURFACE STORM WATER FEATURES
- FOUNDATION FOOTINGS
- LIF-001 — LASER-INDUCED FLUORESCENCE (LIF) BORING
- CRA-915GP — GAS PROBE LOCATION
- CC-001 — APPROXIMATE DYNAMIC FLUX CHAMBER LOCATION
- CRA-615M — MONITORING WELLS WITH > 1.0 FEET OF EXPOSED SCREEN
- FRENCH DRAIN (AS BUILT, NOT SURVEYED)
- CO_2 TRAP LOCATION
- CROSS SECTION LOCATION

SCALE VERIFICATION

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

Approved

DRAWING STATUS

Status	Date	Initial

FORMER POWERTRAIN PLANT YPSILANTI, MICHIGAN

LNAPL EVALUATION UPDATE

CROSS SECTION LOCATIONS

Source Reference:

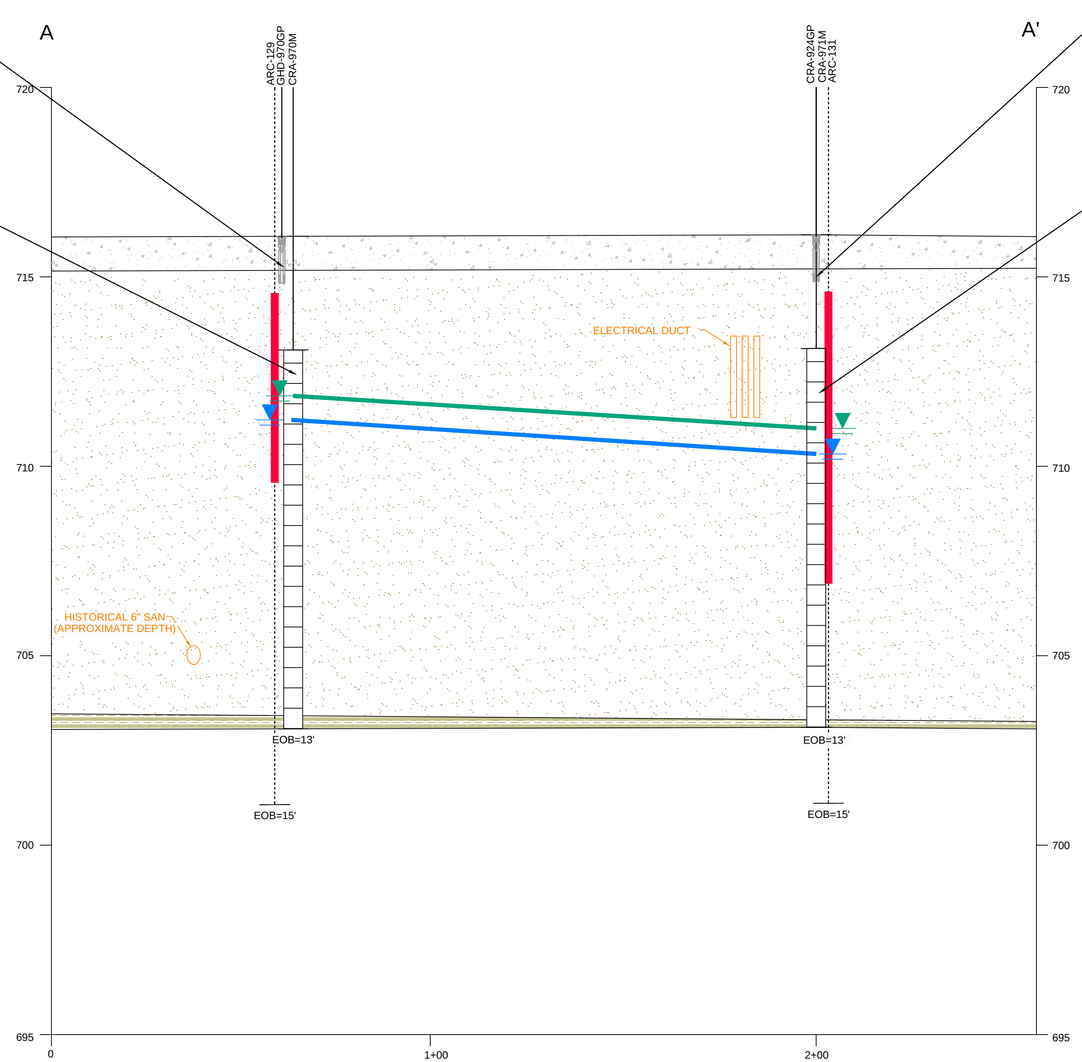
Project Manager:	Reviewed By:	Date:	
B. LANDALE	M. LABBE	NOVEMBER 2019	
Scale: AS SHOWN	Project No: 017358-2019	Report No: 045	Drawing No: FIGURE 7

	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
CRA-970GP	8.7	15.3	ND

	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
CRA-970M	13.0	13.6	2.4

	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
CRA-924GP	3.8	15.0	0.3

	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
CRA-971M	4.9	14.9	0.4



SCALE
1"= 2' VERT
1" = 20' HORIZ

CONCRETE

FILL AND NATIVE SAND

CLAY

APRIL 2019 WL (HYDRAULIC CONDITION 1 - FRENCH DRAIN OPERATIONAL)

AUGUST 2019 WL (HYDRAULIC CONDITION 2 - FRENCH DRAIN NOT OPERATIONAL)

LNAPL IMPACT INDICATED ON LIF LOG

NOTE: WELL HEADSPACE READINGS
MEASURED AT APPROXIMATELY 1'
ABOVE THE WT SURFACE.

No	Revision	Date	Initial

SCALE VERIFICATION

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

Approved

DRAWING STATUS

Status	Date	Initial

FORMER POWERTRAIN PLANT
YPSILANTI, MICHIGAN

LNAPL EVALUATION UPDATE

CROSS SECTION
A - A'

GHD

Source Reference:

Project Manager:	Reviewed By:	Date:	
B. LANDALE	M. LABBE	NOVEMBER 2019	
Scale: AS SHOWN	Project No: 017358-2019	Report No: 045	Drawing No: FIGURE 8

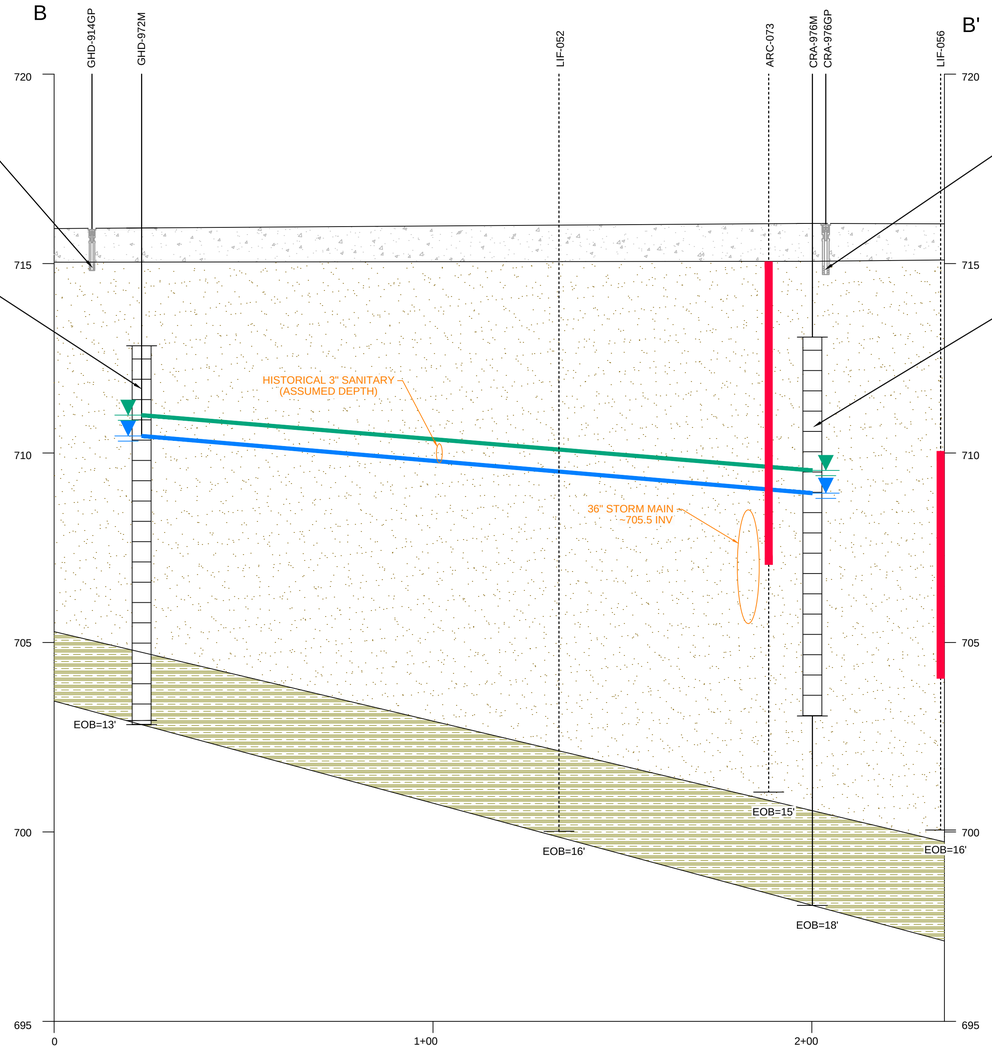
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	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
CRA-914GP	0.1	20.1	ND

	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
CRA-972M	0.01	12.8	0.3

	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
CRA-976GP	3.3	12.6	1.0

	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
CRA-976M	3.7	10.3	2.3



SCALE
1"= 2' VERT
1" = 20' HORIZ

CONCRETE

FILL AND NATIVE SAND

CLAY

APRIL 2019 WL (HYDRAULIC CONDITION 1 - FRENCH DRAIN OPERATIONAL)

AUGUST 2019 WL (HYDRAULIC CONDITION 2 - FRENCH DRAIN NOT OPERATIONAL)

LNAPL IMPACT INDICATED ON LIF LOG

NOTE: WELL HEADSPACE READINGS
MEASURED AT APPROXIMATELY 1'
ABOVE THE WT SURFACE.

No	Revision	Date	Initial

SCALE VERIFICATION

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

Approved

DRAWING STATUS

Status	Date	Initial

FORMER POWERTRAIN PLANT
YPSILANTI, MICHIGAN

LNAPL EVALUATION UPDATE

CROSS SECTION
B - B'

GHD

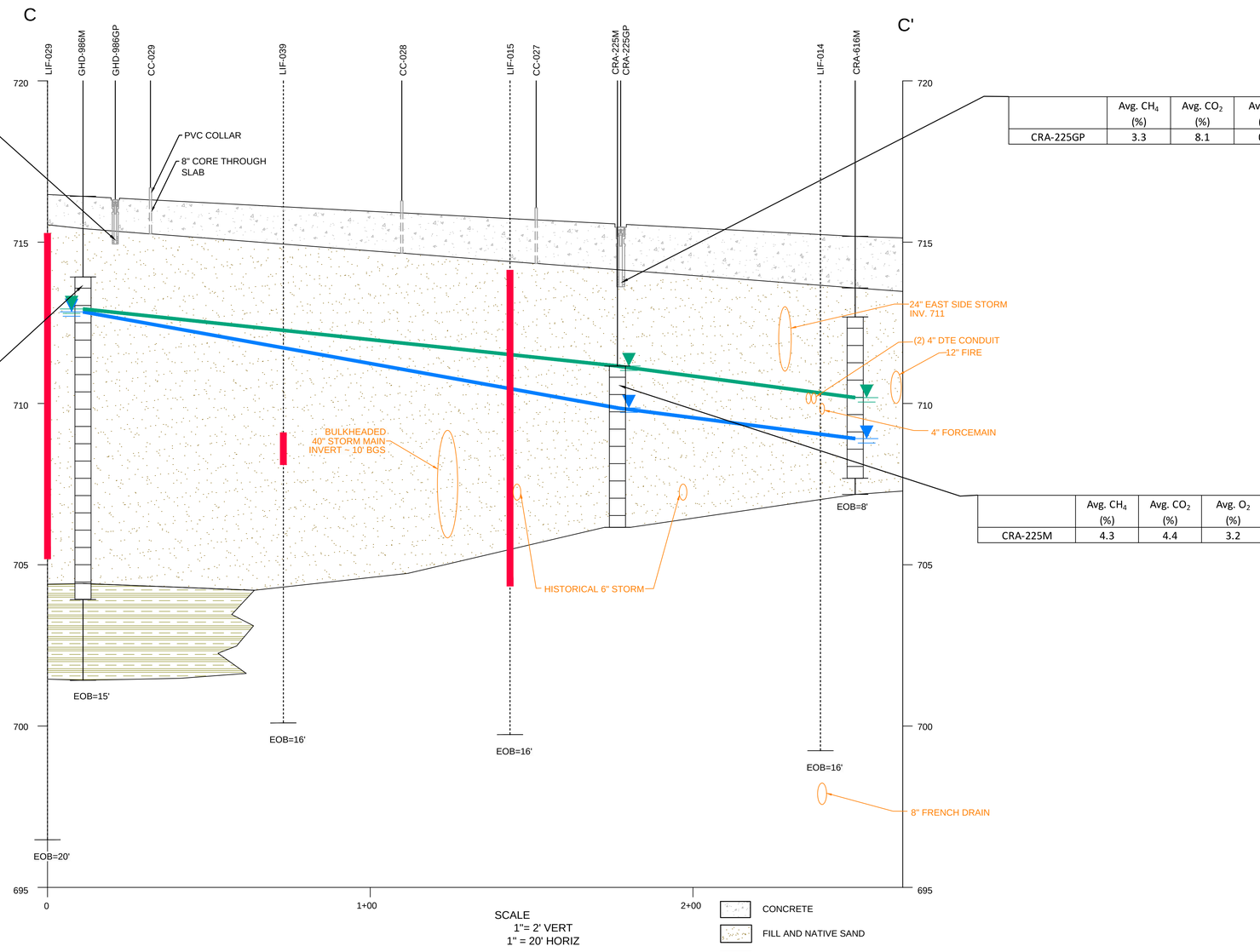
Source Reference:

Project Manager:	Reviewed By:	Date:	
B. LANDALE	M. LABBE	NOVEMBER 2019	
Scale: AS SHOWN	Project No: 017358-2019	Report No: 045	Drawing No: FIGURE 9

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	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
GHD-986GP	40.8	11.6	0.1

	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
GHD-986M	32.5	8.4	2.8



	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
CRA-225GP	3.3	8.1	0.1

	Avg. CH_4 (%)	Avg. CO_2 (%)	Avg. O_2 (%)
CRA-225M	4.3	4.4	3.2

SCALE
1"= 2' VERT
1" = 20' HORIZ

CONCRETE

FILL AND NATIVE SAND

CLAY

APRIL 2019 WL (HYDRAULIC CONDITION 1 - FRENCH DRAIN OPERATIONAL)

AUGUST 2019 WL (HYDRAULIC CONDITION 2 - FRENCH DRAIN NOT OPERATIONAL)

LNAPL IMPACT INDICATED ON LIF LOG

NOTE: WELL HEADSPACE READINGS MEASURED AT APPROXIMATELY 1' ABOVE THE WT SURFACE.

No	Revision	Date	Initial

SCALE VERIFICATION

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

Approved

DRAWING STATUS

Status	Date	Initial

FORMER POWERTRAIN PLANT YPSILANTI, MICHIGAN

LNAPL EVALUATION UPDATE

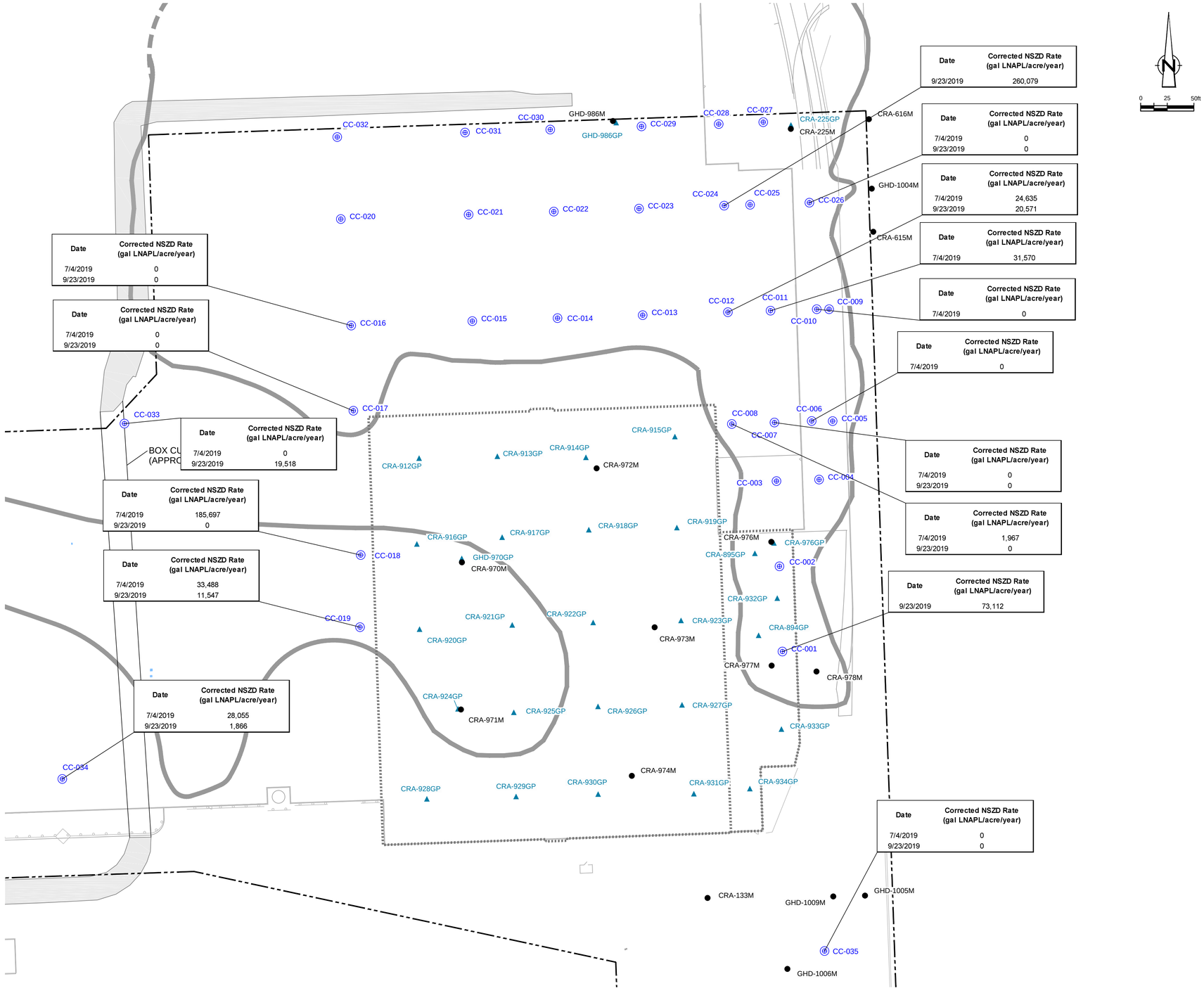
CROSS SECTION C - C'

GHD

Source Reference:

Project Manager:	Reviewed By:	Date:	
B. LANDALE	M. LABBE	NOVEMBER 2019	
Scale: AS SHOWN	Project No: 017358-2019	Report No: 045	Drawing No: FIGURE 10

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Date	Corrected NSZD Rate (gal LNAPL/acre/year)
9/23/2019	260,079

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	0
9/23/2019	0

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	24,635
9/23/2019	20,571

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	31,570

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	0

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	0

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	0
9/23/2019	0

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	1,967
9/23/2019	0

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
9/23/2019	73,112

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	0
9/23/2019	0

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	0
9/23/2019	0

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	0
9/23/2019	19,518

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	185,697
9/23/2019	0

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	33,488
9/23/2019	11,547

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	28,055
9/23/2019	1,866

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	0
9/23/2019	0

No	Revision	Date	Initial

LEGEND

- PROPERTY BOUNDARY
- BUILDING (PRE-DEMOLITION)
- EXISTING YAM BUILDING FOOTPRINT
- APPROXIMATE EXTENT OF LNAPL (OCTOBER 2018)
- SURFACE STORM WATER FEATURES
- CRA-613M ● MONITORING WELL LOCATION
- CRA-915GP ▲ GAS PROBE LOCATION
- CC-001 ⊕ APPROXIMATE DYNAMIC CLOSED CHAMBER (DCC) LOCATION

Date	Corrected NSZD Rate (gal LNAPL/acre/year)
7/4/2019	0
9/23/2019	0

DCC RESULTS

SCALE VERIFICATION

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

Approved

DRAWING STATUS

Status	Date	Initial

FORMER POWERTRAIN PLANT YPSILANTI, MICHIGAN

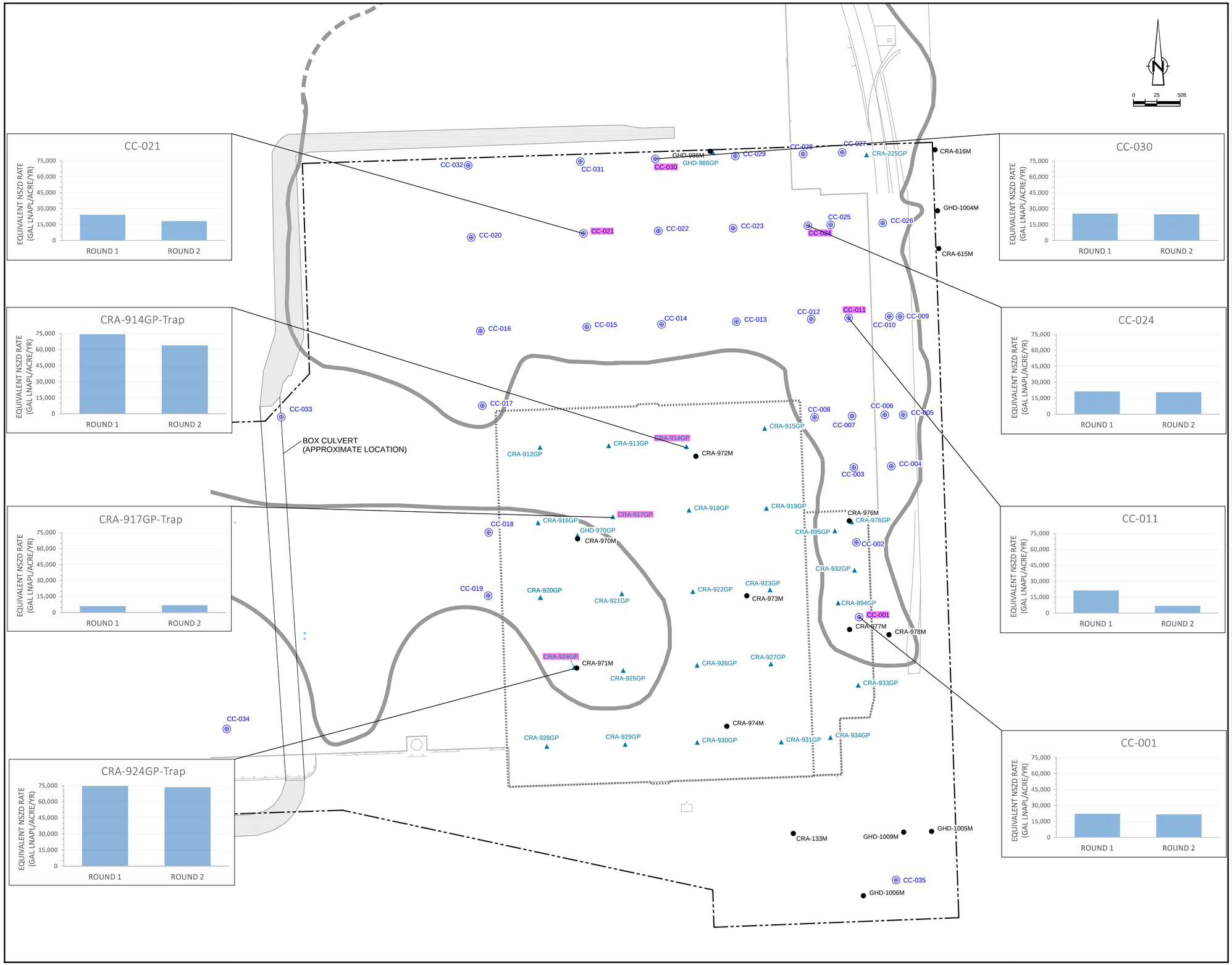
LNAPL EVALUATION UPDATE

DCC RESULTS

Source Reference:

Project Manager:	Reviewed By:	Date:	
B. LANDALE	M. LABBE	NOVEMBER 2019	
Scale: AS SHOWN	Project No: 017358-2019	Report No: 045	Drawing No: FIGURE 11

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No	Revision	Date	Initial

LEGEND

- PROPERTY BOUNDARY
- BUILDING (PRE-DEMOLITION)
- EXISTING YAM BUILDING FOOTPRINT
- APPROXIMATE EXTENT OF LNAPL (OCTOBER 2018)
- SURFACE STORM WATER FEATURES (2-21-19)
- CRA-615M ● MONITORING WELL LOCATION
- CRA-915GP ▲ GAS PROBE LOCATION
- CC-001 ⊕ APPROXIMATE DYNAMIC FLUX CHAMBER LOCATION
- CO_2 TRAP LOCATION

SCALE VERIFICATION

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

Approved

DRAWING STATUS

Status	Date	Initial

FORMER POWERTRAIN PLANT YPSILANTI, MICHIGAN

LNAPL EVALUATION UPDATE

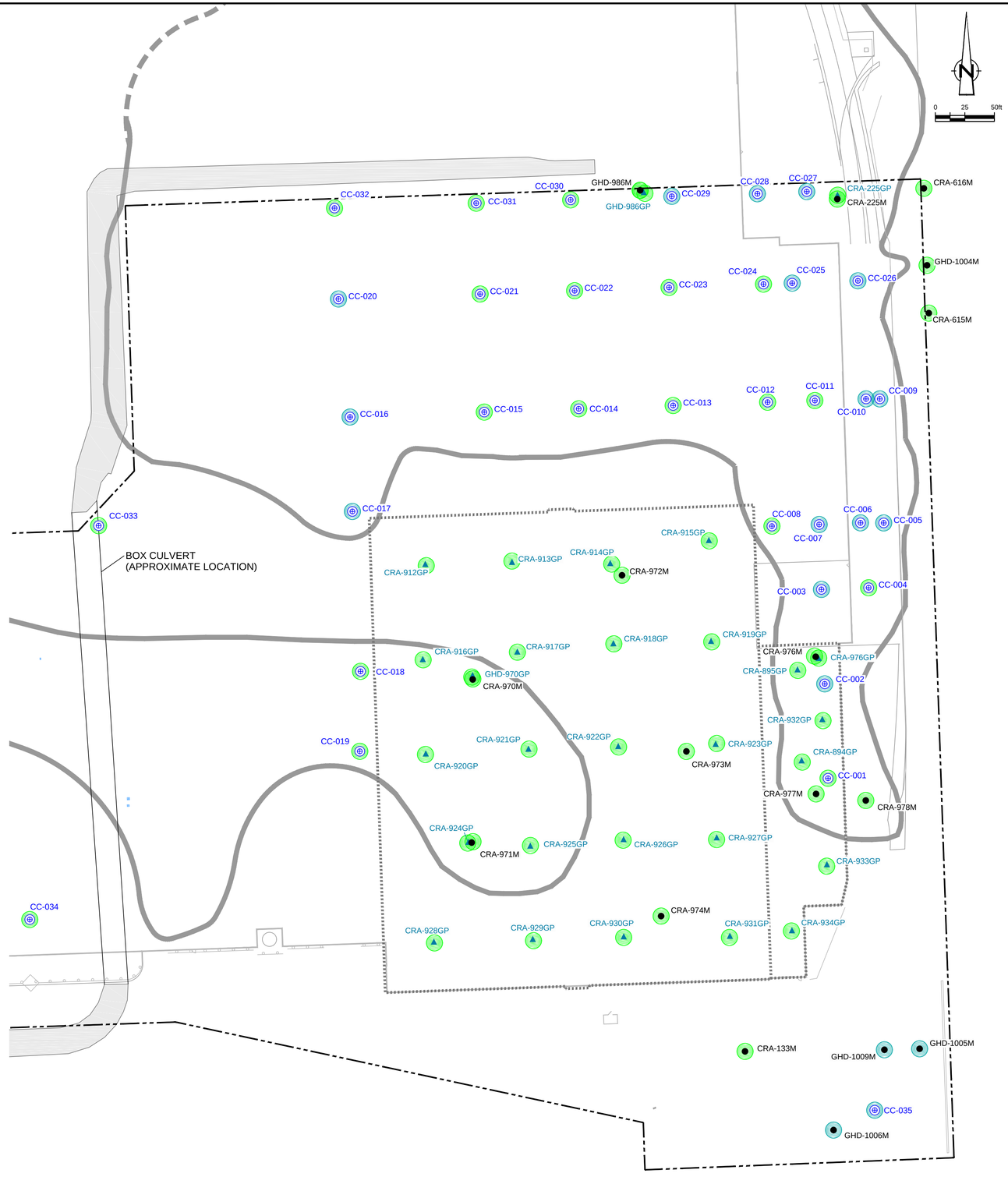
CO_2 TRAP RESULTS

GHD

Source Reference:

Project Manager:	Reviewed By:	Date:	
B. LANDALE	M. LABBE	NOVEMBER 2019	
Scale: AS SHOWN	Project No.: 017358-2019	Report No.: 045	Drawing No.: FIGURE 12

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Location	Evidence of NSZD			
	Elevated CO_2	Elevated CH_4	DCC	CO_2 Trap
CC-001			X	X
CC-002				
CC-003				
CC-004	X	X		
CC-005				
CC-006				
CC-007				
CC-008			X	
CC-009				
CC-010				
CC-011	X		X	X
CC-012			X	
CC-013	X	X		
CC-014		X		
CC-015	X	X		
CC-016				
CC-017				
CC-018			X	
CC-019			X	
CC-020				
CC-021	X	X		X
CC-022	X	X		
CC-023		X		
CC-024			X	X
CC-025				
CC-026				
CC-027				
CC-028				
CC-029				
CC-030	X	X		X
CC-031		X		
CC-032	X	X		
CC-033			X	
CC-034			X	
CC-035				
CRA-133M	X			
CRA-225GP	X	X		
CRA-225M	X	X		
CRA-615M	X			
CRA-616M	X			
CRA-894GP	X			
CRA-895GP	X	X		
CRA-912GP	X			
CRA-913GP	X			
CRA-914GP	X			X
CRA-915GP	X			
CRA-916GP	X			
CRA-917GP	X			X
CRA-918GP	X			
CRA-919GP	X			
CRA-920GP	X			
CRA-921GP	X			
CRA-922GP	X			
CRA-923GP	X			
CRA-924GP	X	X		X
CRA-925GP	X	X		
CRA-926GP	X			
CRA-927GP	X			
CRA-928GP	X	X		
CRA-929GP	X	X		
CRA-930GP	X			
CRA-931GP	X			
CRA-932GP	X	X		
CRA-933GP	X			
CRA-934GP	X			
CRA-970GP	X	X		
CRA-970M	X	X		
CRA-971M	X	X		
CRA-972M	X			
CRA-973M	X			
CRA-974M	X			
CRA-976GP	X	X		
CRA-976M	X	X		
CRA-977M	X			
CRA-978M	X			
CRA-986GP	X	X		
CRA-986M	X	X		
GHD-1004M	X			
GHD-1005M				
GHD-1006M				
GHD-1009M				

Note: Shaded cells are not applicable.

No	Revision	Date	Initial

LEGEND

- PROPERTY BOUNDARY
- BUILDING (PRE-DEMOLITION)
- EXISTING YAM BUILDING FOOTPRINT
- APPROXIMATE EXTENT OF LNAPL (OCTOBER 2018)
- SURFACE STORM WATER FEATURES
- CRA-613M ● MONITORING WELL LOCATION
- CRA-915GP ▲ GAS PROBE LOCATION
- CC-001 ⊕ APPROXIMATE DYNAMIC FLUX CHAMBER LOCATION

EVIDENCE OF NSZD

- NO
- YES

SCALE VERIFICATION

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

Approved

DRAWING STATUS

Status	Date	Initial

FORMER POWERTRAIN PLANT
YPSILANTI, MICHIGAN

LNAPL EVALUATION UPDATE

NSZD SUMMARY

Source Reference:

Project Manager:	Reviewed By:	Date:	
B. LANDALE	M. LABBE	NOVEMBER 2019	
Scale: AS SHOWN	Project No: 017358-2019	Report No: 045	Drawing No: FIGURE 13

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Table 1

Natural Source Zone Depletion Rate Estimates - Flux Chamber Results - 07/04/19
Former Willow Run Powertrain
Ypsilanti, Michigan

Location			Measured CO_2 Flux (µmol/m^2/s)				Uncorrected CO_2 Flux (µmol/m^2/s)	Corrected CO_2 Flux[a] (µmol/m^2/s)	Uncorrected NSZD Rate[b] (gal LNAPL/acre/year)	Corrected NSZD Rate[b] (gal LNAPL/acre/year)
			Minimum	Maximum	Mean	Standard Deviation				
LNAPL Zone	concrete	CC-006	10.77	14.80	12.91	1.66	12.91	0	8,066	0
	concrete	CC-007	-3.68	-3.42	-3.57	0.11	0	0	0	0
	concrete	CC-008	26.78	35.64	29.77	4.15	29.77	3.15	18,605	1,967
	concrete	CC-010	-21.62	-6.36	-13.60	6.25	0	0	0	0
	concrete	CC-011	61.31	100.71	77.13	16.99	77.13	50.51	48,208	31,570
	concrete	CC-012	60.56	74.85	66.04	6.29	66.04	39.42	41,273	24,635
	concrete	CC-016	-3.73	-3.36	-3.58	0.16	0	0	0	0
	concrete	CC-017	1.23	1.58	1.37	0.15	1.37	0	858	0
	concrete	CC-018	321.90	327.34	323.74	2.55	323.74	297.12	202,334	185,697
	concrete	CC-019	73.95	84.43	80.20	4.51	80.20	53.58	50,126	33,488
	concrete	CC-026	8.38	10.05	9.03	0.02	9.03	0	5,644	0
	concrete	CC-033	12.72	15.38	13.86	1.12	13.86	0	8,661	0
	concrete	CC-034	57.21	85.17	71.51	11.42	71.51	44.89	44,692	28,055
	concrete	CC-035	-5.08	-2.12	-3.16	1.36	0	0	0	0

[a]The maximum of the modern CO_2 fluxes from the CO_2 Trap results is subtracted from the mean reading for each respective Flux Chamber. Where the mean reading for an impacted zone location is less than the maximum background value, the corrected CO_2 flux is reported as zero.

[b]Assumes that 1 µmol/m^2/s corrected CO_2 flux represents approximately 625 gallons of LNAPL naturally degraded per acre per year (gal LNAPL/acre/year).

Table 2

Natural Source Zone Depletion Rate Estimates - Flux Chamber Results - 09/23/19
Former Willow Run Powertrain
Ypsilanti, Michigan

Location			Measured CO_2 Flux (µmol/m^2/s)				Uncorrected CO_2 Flux (µmol/m^2/s)	Corrected CO_2 Flux[a] (µmol/m^2/s)	Uncorrected NSZD Rate[b] (gal LNAPL/acre/year)	Corrected NSZD Rate[b] (gal LNAPL/acre/year)
			Minimum	Maximum	Mean	Standard Deviation				
LNAPL Zone	concrete	CC-001	121.94	161.30	143.60	16.31	143.60	116.98	89,749	73,112
	concrete	CC-007	-3.54	-3.07	-3.24	0.21	0	0	0	0
	concrete	CC-008	12.84	15.02	13.89	0.89	13.89	0	8,678	0
	concrete	CC-012	57.80	61.66	59.53	1.60	59.53	32.91	37,209	20,571
	concrete	CC-016	-2.12	0.00	-1.25	0.91	0	0	0	0
	concrete	CC-017	1.66	1.98	1.83	0.13	1.83	0	1,144	0
	concrete	CC-018	10.52	12.11	11.29	0.65	11.29	0	7,053	0
	concrete	CC-019	38.80	55.58	45.10	7.46	45.10	18.48	28,185	11,547
	concrete	CC-024	342.49	506.76	442.75	71.79	442.75	416.13	276,717	260,079
	concrete	CC-026	0.00	12.93	7.50	5.48	7.50	0	4,685	0
	concrete	CC-033	44.68	69.07	57.85	10.05	57.85	31.23	36,155	19,518
	concrete	CC-034	27.33	32.62	29.61	2.22	29.61	2.99	18,504	1,866
	concrete	CC-035	-1.27	0.00	-0.63	0.52	0	0	0	0

[a]The maximum of the modern CO_2 fluxes from the CO_2 Trap results is subtracted from the mean reading for each respective Flux Chamber. Where the mean reading for an impacted zone location is less than the maximum background value, the corrected CO_2 flux is reported as zero.

[b]Assumes that 1 µmol/m^2/s corrected CO_2 flux represents approximately 625 gallons of LNAPL naturally degraded per acre per year (gal LNAPL/acre/year).

Table 3

Natural Source Zone Depletion Rate Estimates - CO_2 Trap Results
Former Willow Run Powertrain
Ypsilanti, Michigan

Location	Round 1 7/1/2019 (Trap with Vapor Pin Connection)				Round 2 9/1/2019 (Closed Trap)			
	Sample ID	Modern CO_2 Flux ($\mu mol/m^2/s$)	Fossil Fuel CO_2 Flux ($\mu mol/m^2/s$)	Equivalent NSZD Rate (gal LNAPL/acre/yr)	Sample ID	Modern CO_2 Flux ($\mu mol/m^2/s$)	Fossil Fuel CO_2 Flux ($\mu mol/m^2/s$)	Equivalent NSZD Rate (gal LNAPL/acre/yr)
CC-001	YPMI-R1-CO2-05	4.29	35.56	22,232	YPMI-R2-CO2-08	4.37	34.75	21,726
CC-011	YPMI-R1-CO2-06	2.92	34.23	21,400	YPMI-R2-CO2-04[a]	1.45	10.76	6,725
CC-021	YPMI-R1-CO2-08	3.64	38.58	24,119	YPMI-R2-CO2-02	2.44	29.04	18,155
CC-024	YPMI-R1-CO2-07	8.54	34.09	21,311	YPMI-R2-CO2-03	8.22	33.11	20,700
CC-030	YPMI-R1-CO2-01	1.01	40.59	25,375	YPMI-R2-CO2-01	0.85	39.58	24,746
CRA-914GP	YPMI-R1-CO2-04	3.87	118.78	74,260	YPMI-R2-CO2-05	4.56	102.13	63,850
CRA-917GP	YPMI-R1-CO2-03	2.40	9.48	5,927	YPMI-R2-CO2-06	2.8	10.83	6,771
CRA-924GP	YPMI-R1-CO2-02	26.62	119.35	74,616	YPMI-R2-CO2-07	26.22	117.53	73,476

[a] Core was flooded during deployment.

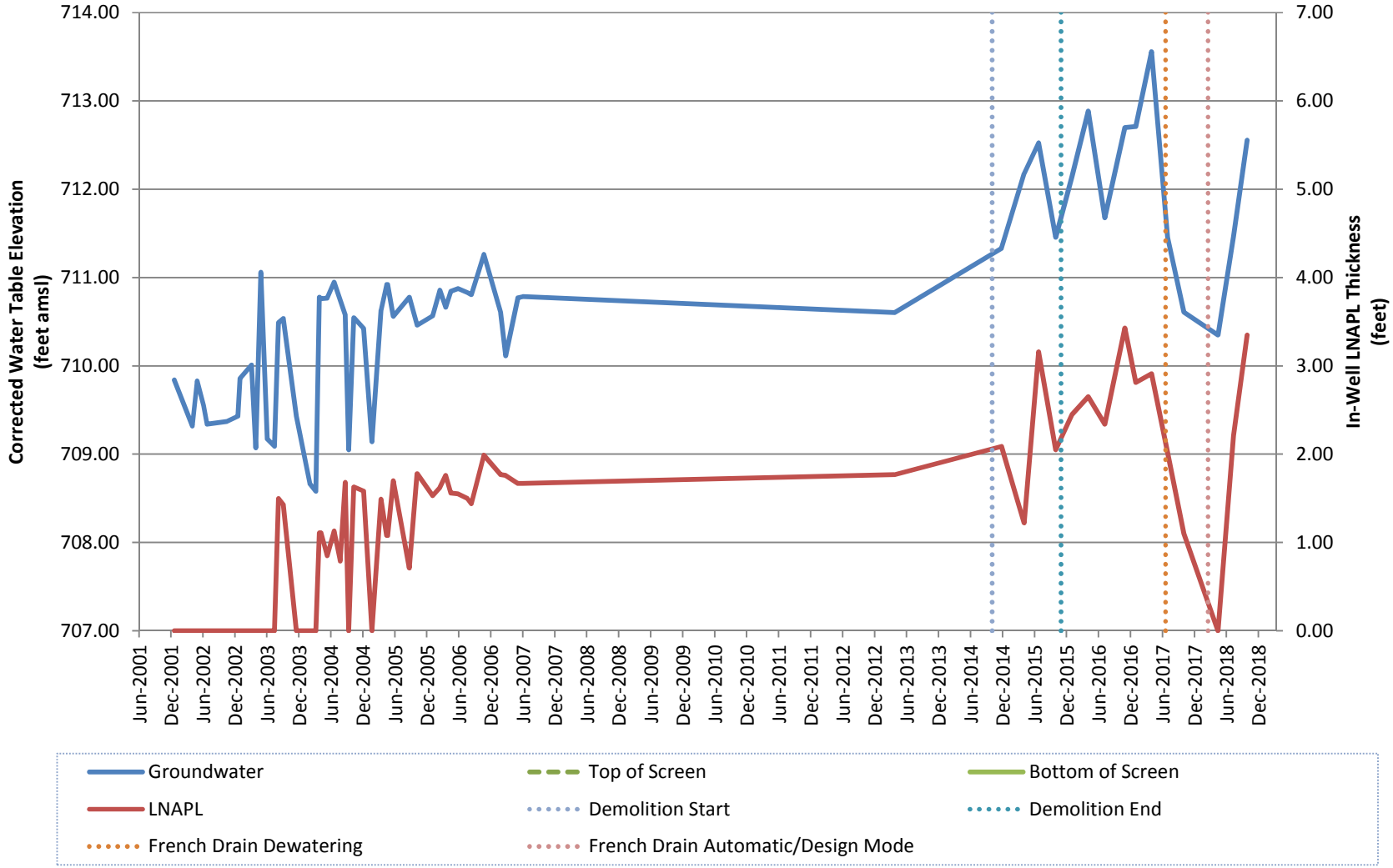
Appendices

Appendix A
Well Gauging Plots

Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

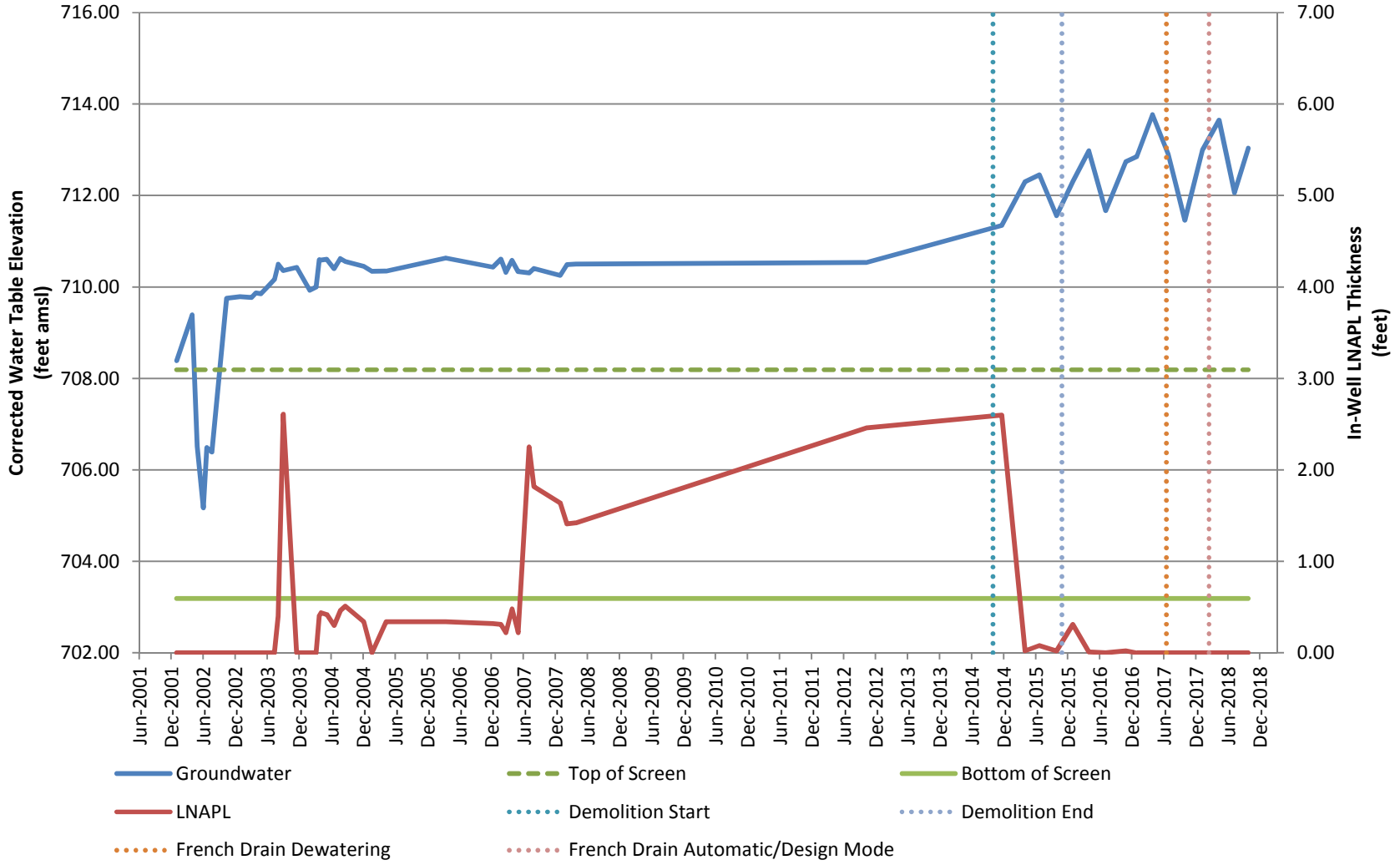
Well Gauging Data Summary: 003RB
RACER Willow Run Powertrain
Ypsilanti, Michigan

Note: Gauging data at 003RA/RB post-demolition (April 2013) included as 003RB



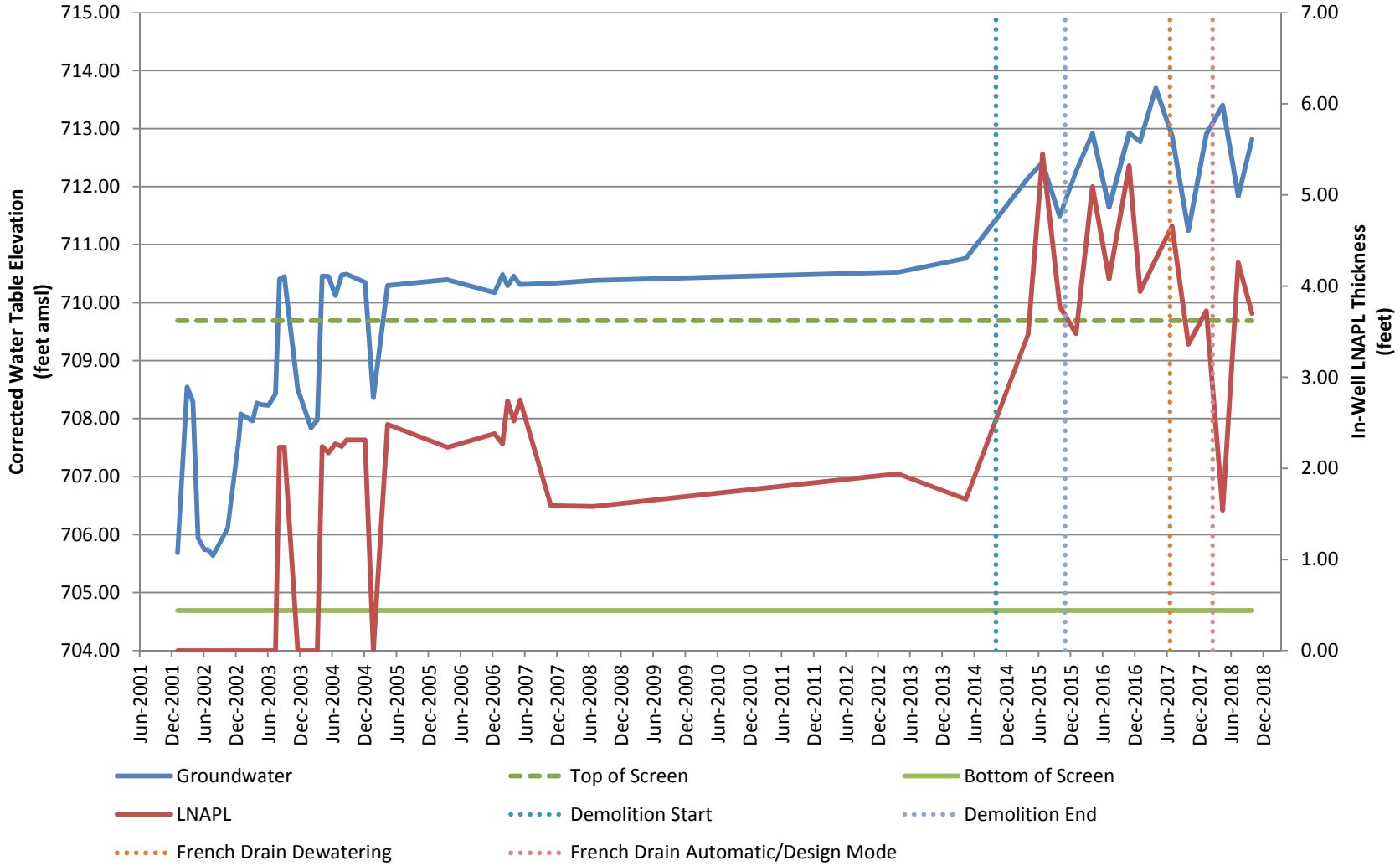
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 005RA
RACER Willow Run Powertrain
Ypsilanti, Michigan



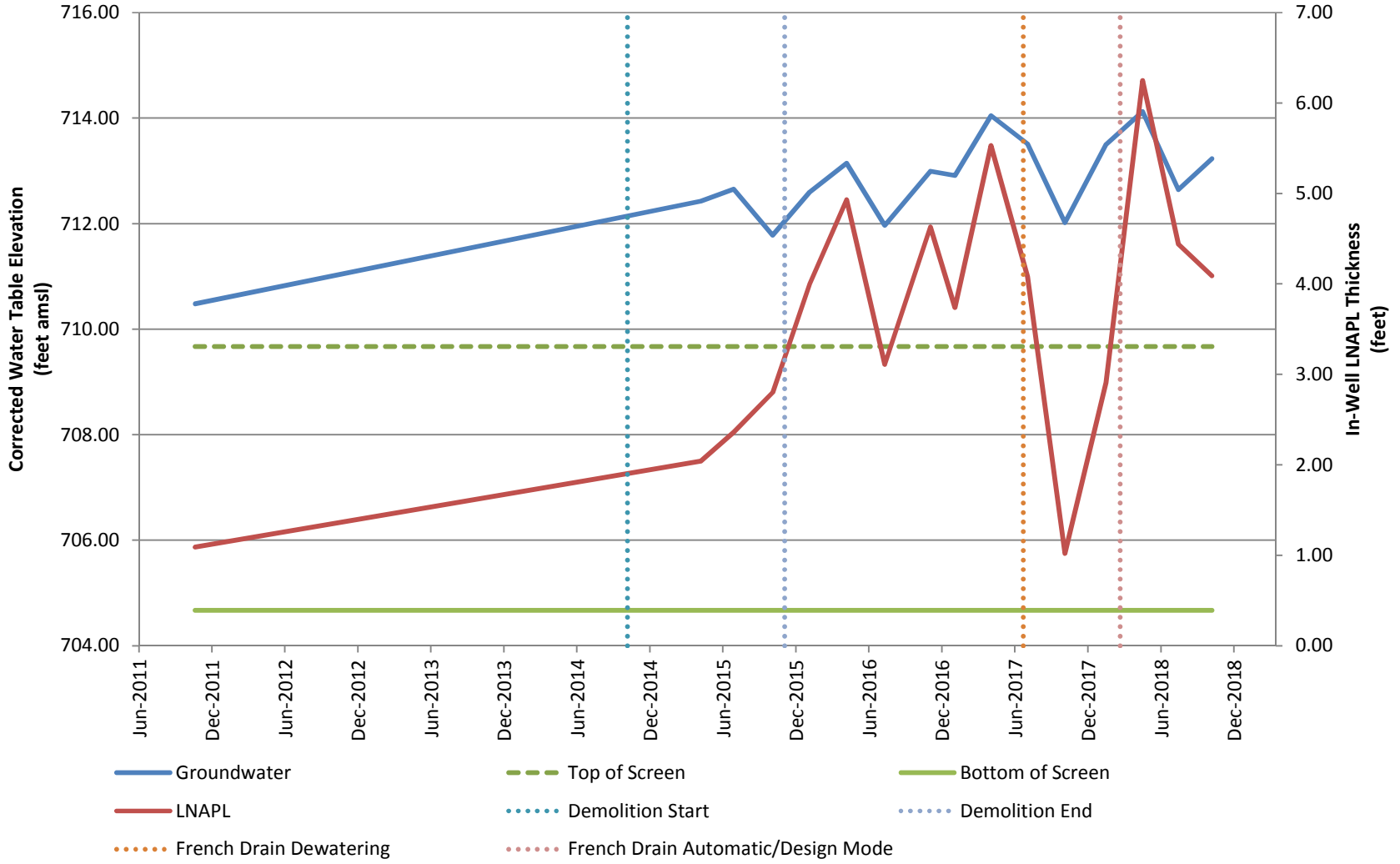
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 005RB
RACER Willow Run Powertrain
Ypsilanti, Michigan

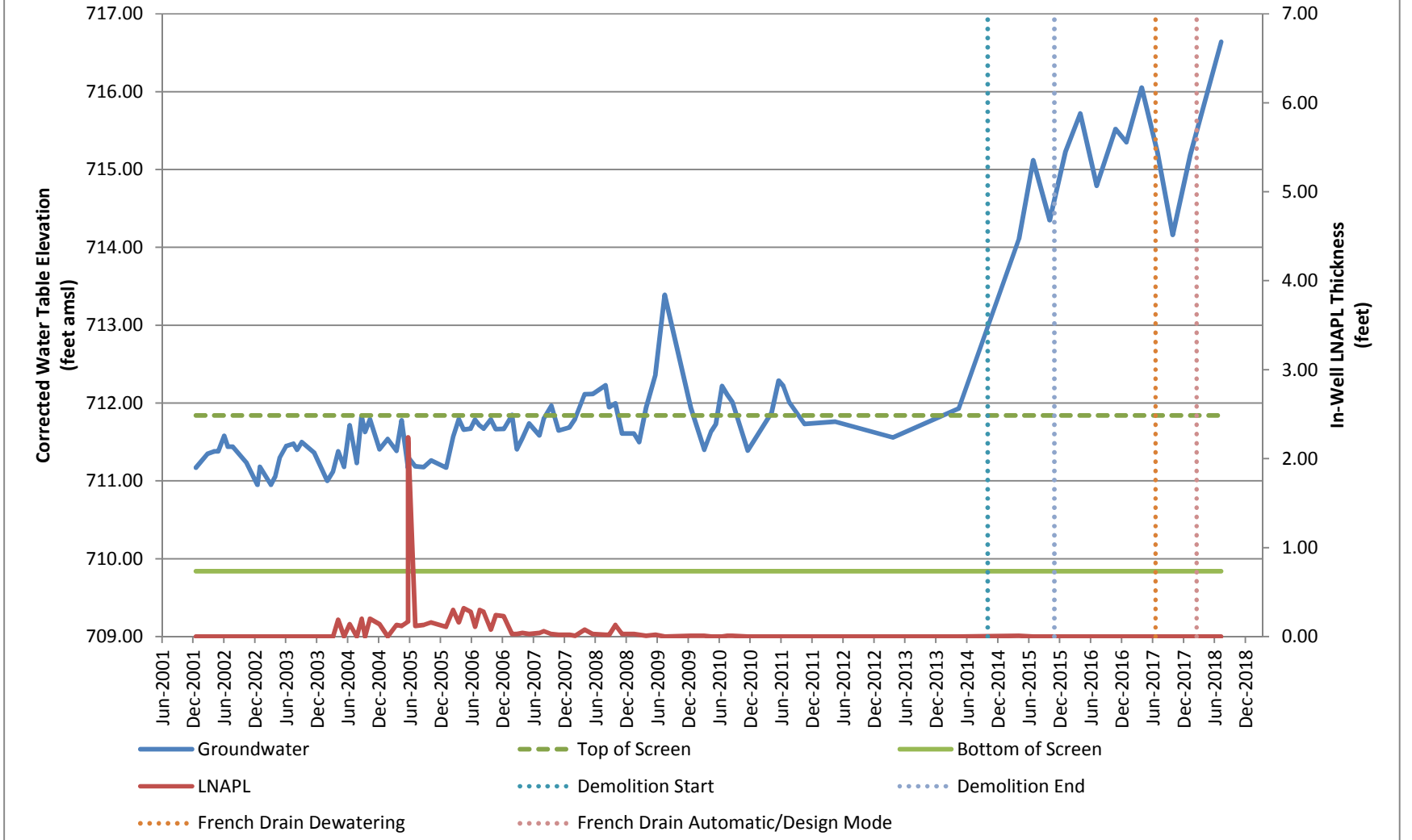


Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 006R
RACER Willow Run Powertrain
Ypsilanti, Michigan

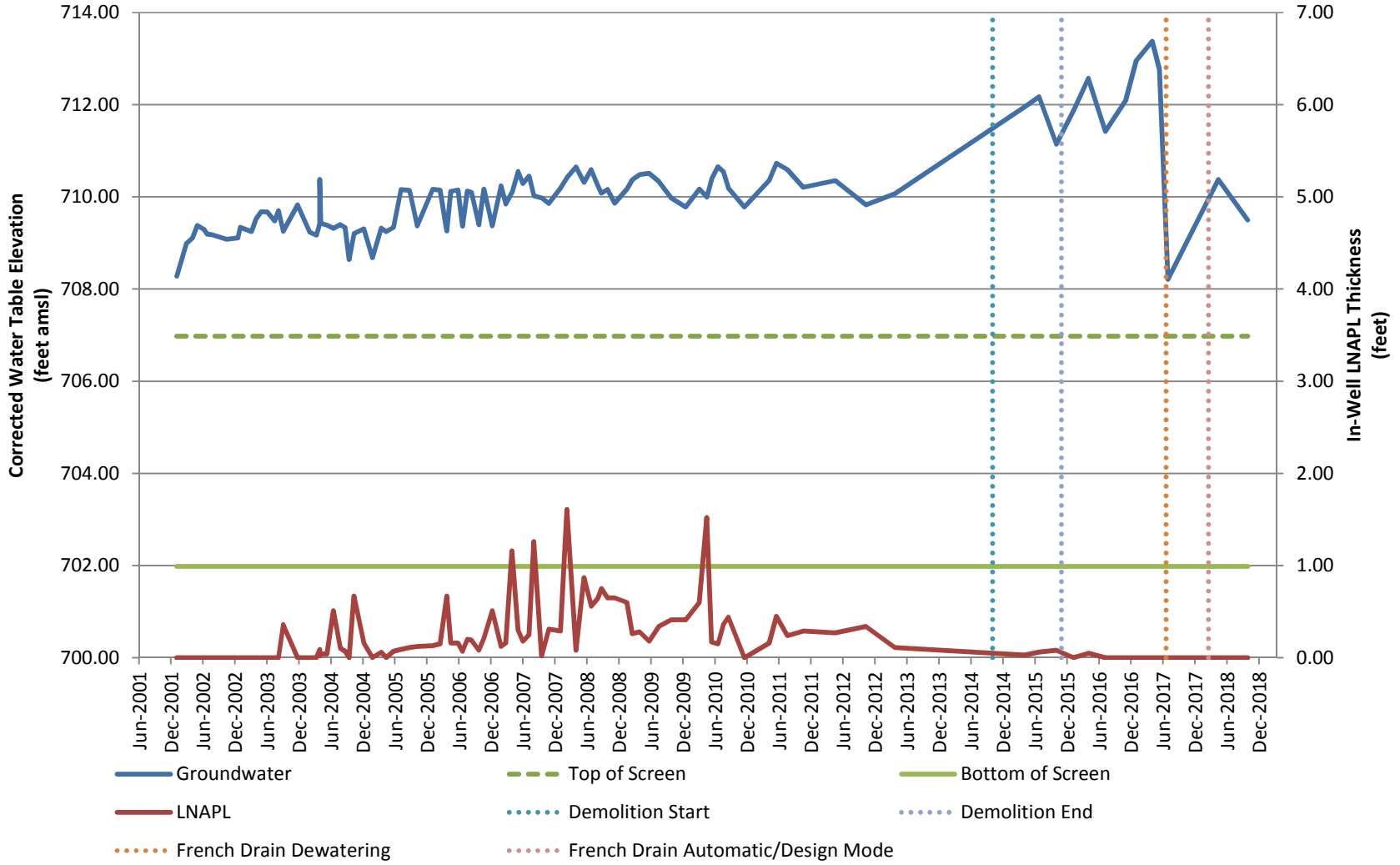


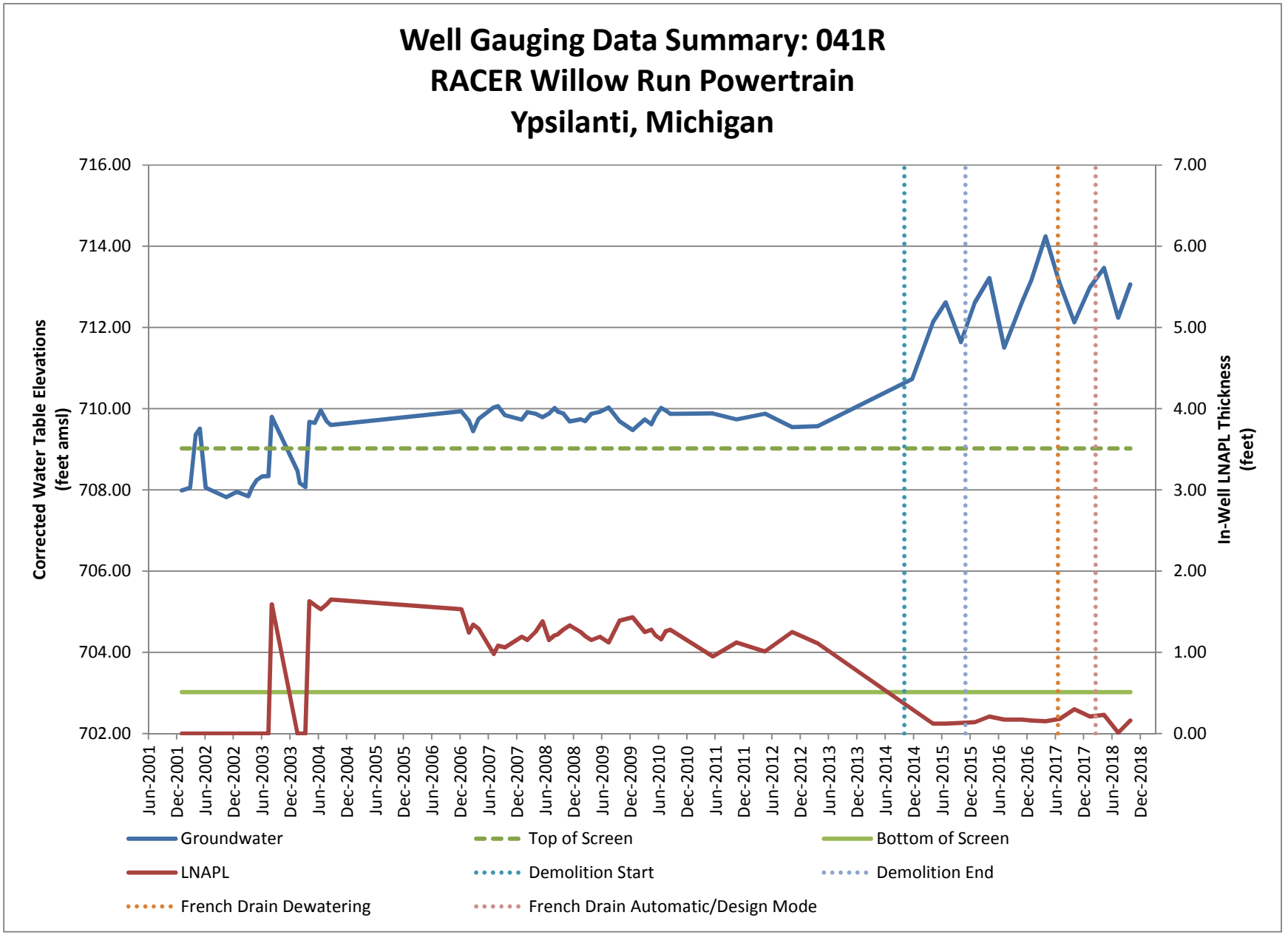
Well Gauging Data Summary: 009R
RACER Willow Run Powertrain
Ypsilanti, Michigan



Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

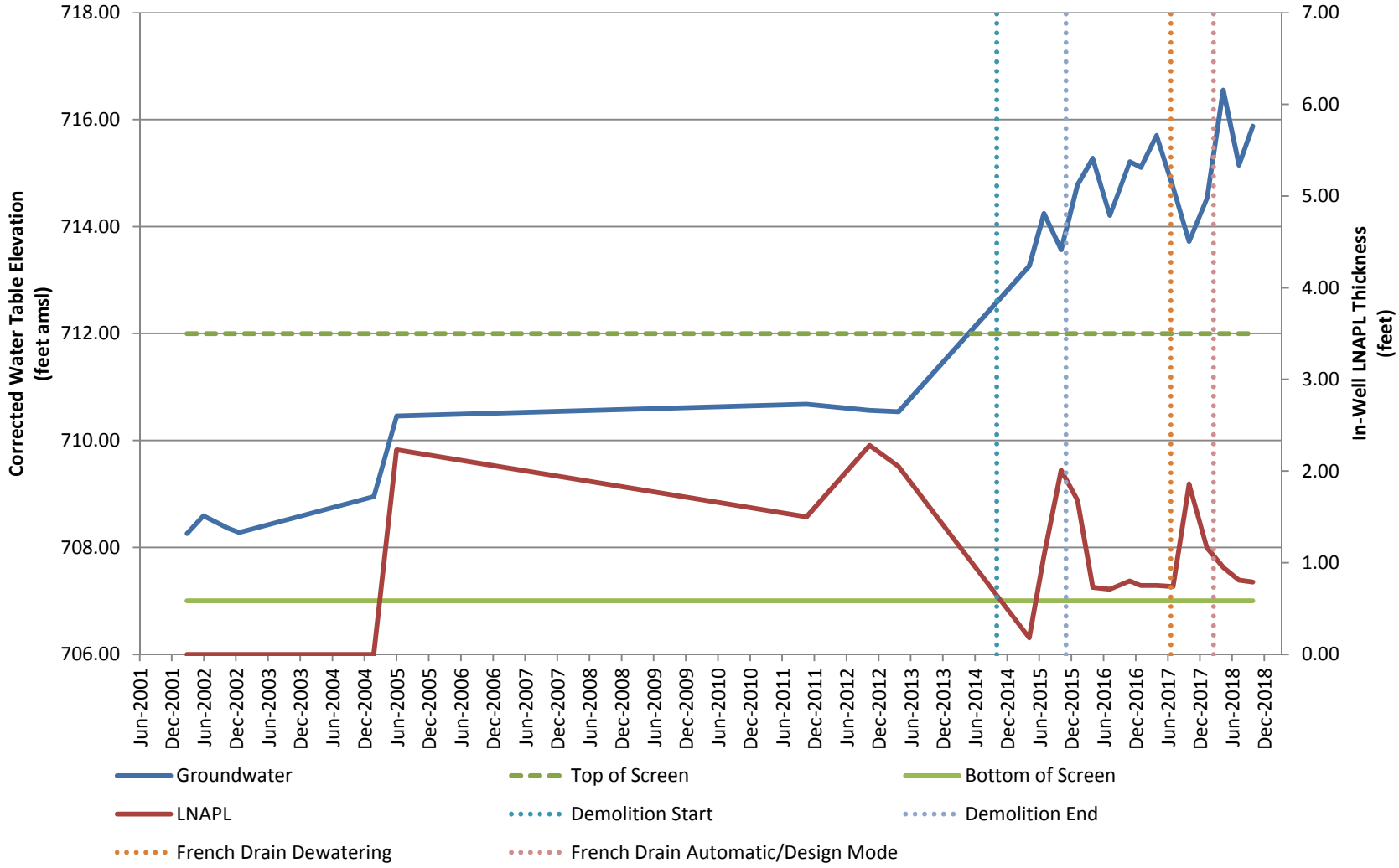
Well Gauging Data Summary: 027R
RACER Willow Run Powertrain
Ypsilanti, Michigan



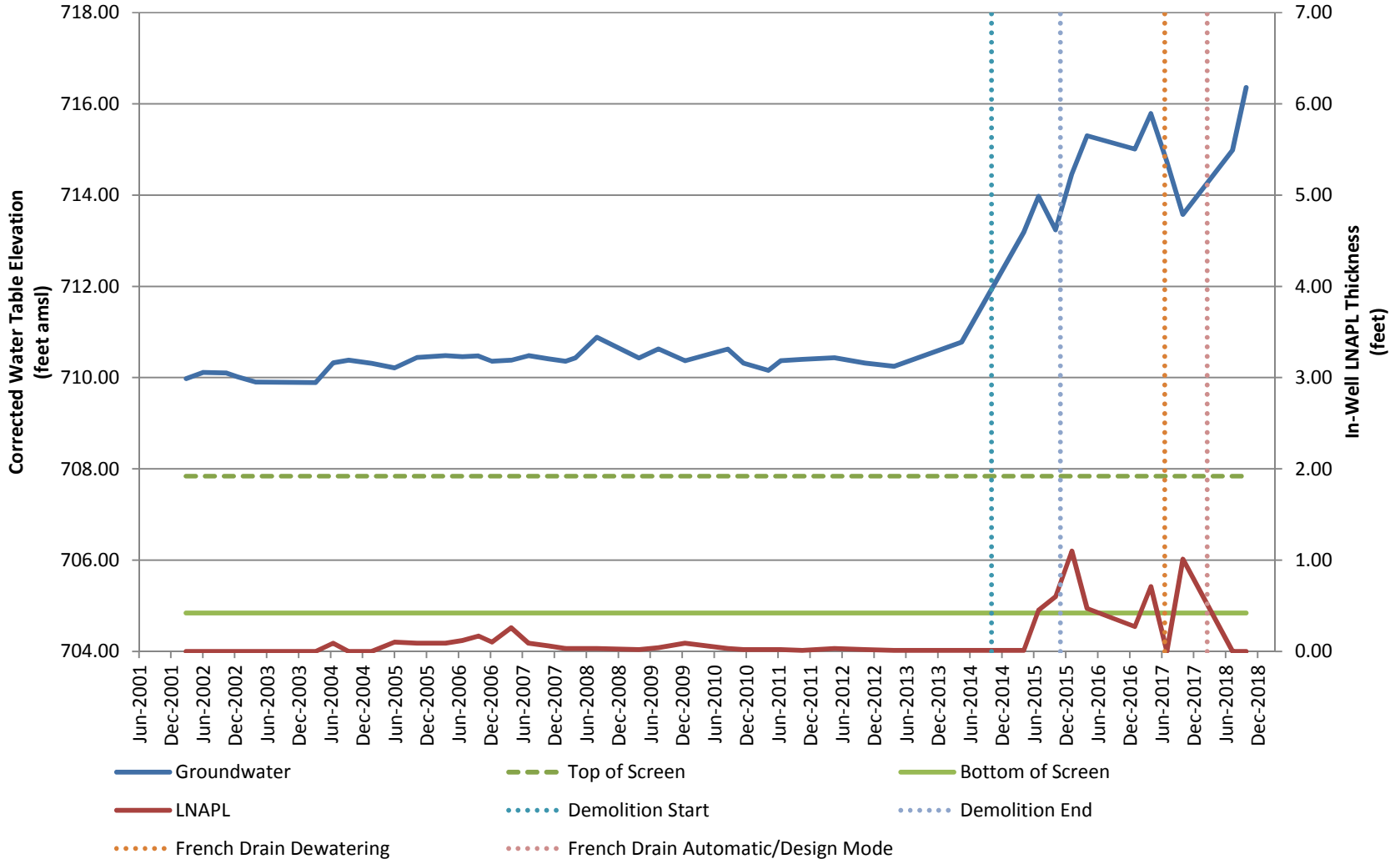

Well Gauging Data Summary: 041R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevations (feet amsl)
In-Well LNAPL Thickness (feet)
716.00
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2001
Dec-2001
Jun-2002
Dec-2002
Jun-2003
Dec-2003
Jun-2004
Dec-2004
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
Dec-2008
Jun-2009
Dec-2009
Jun-2010
Dec-2010
Jun-2011
Dec-2011
Jun-2012
Dec-2012
Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

Note: Top of screen assumed based on a 5 ft screen length

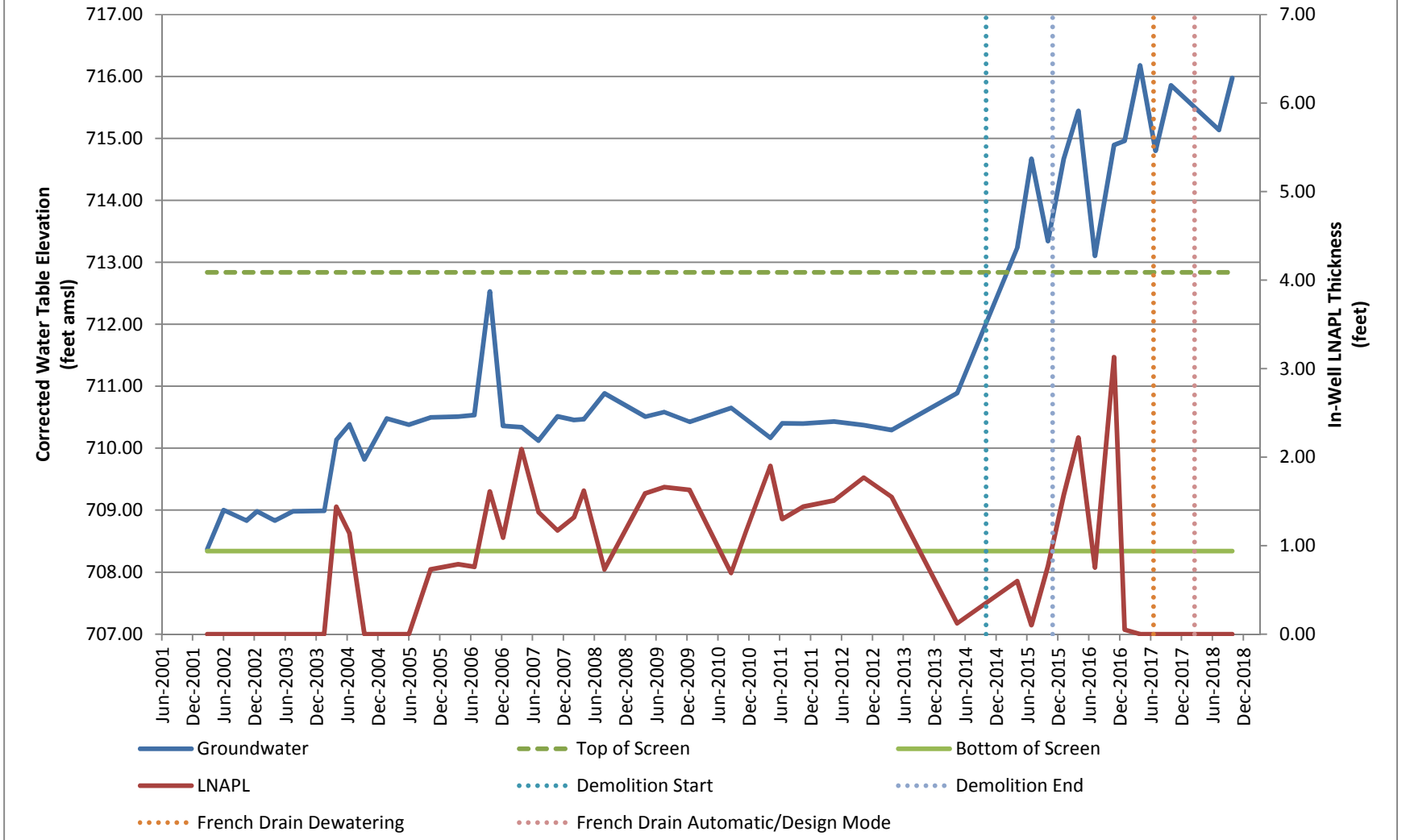
Well Gauging Data Summary: 084M
RACER Willow Run Powertrain
Ypsilanti, Michigan

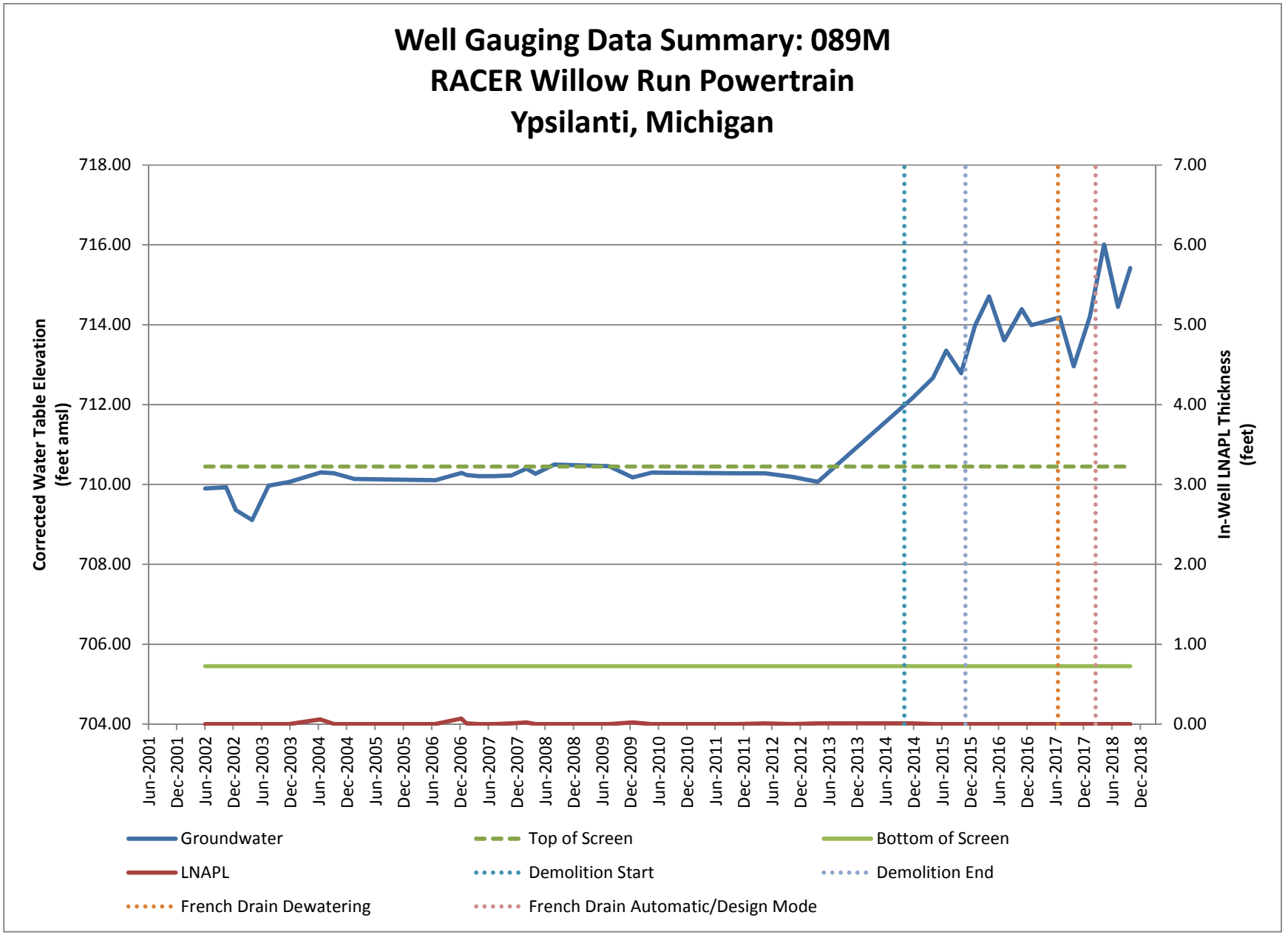


Well Gauging Data Summary: 086M-A
RACER Willow Run Powertrain
Ypsilanti, Michigan

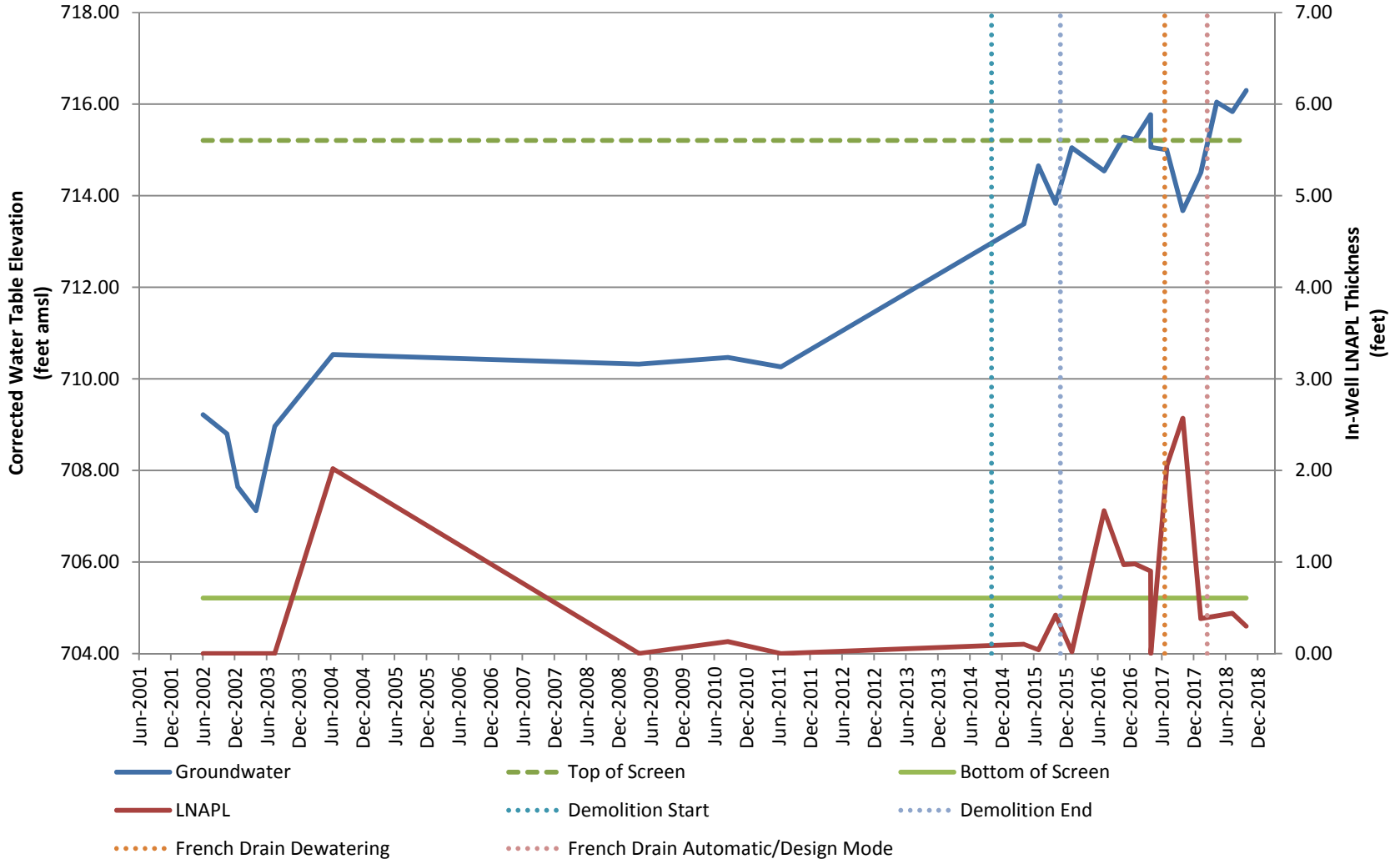


Well Gauging Data Summary: 086M-B
RACER Willow Run Powertrain
Ypsilanti, Michigan

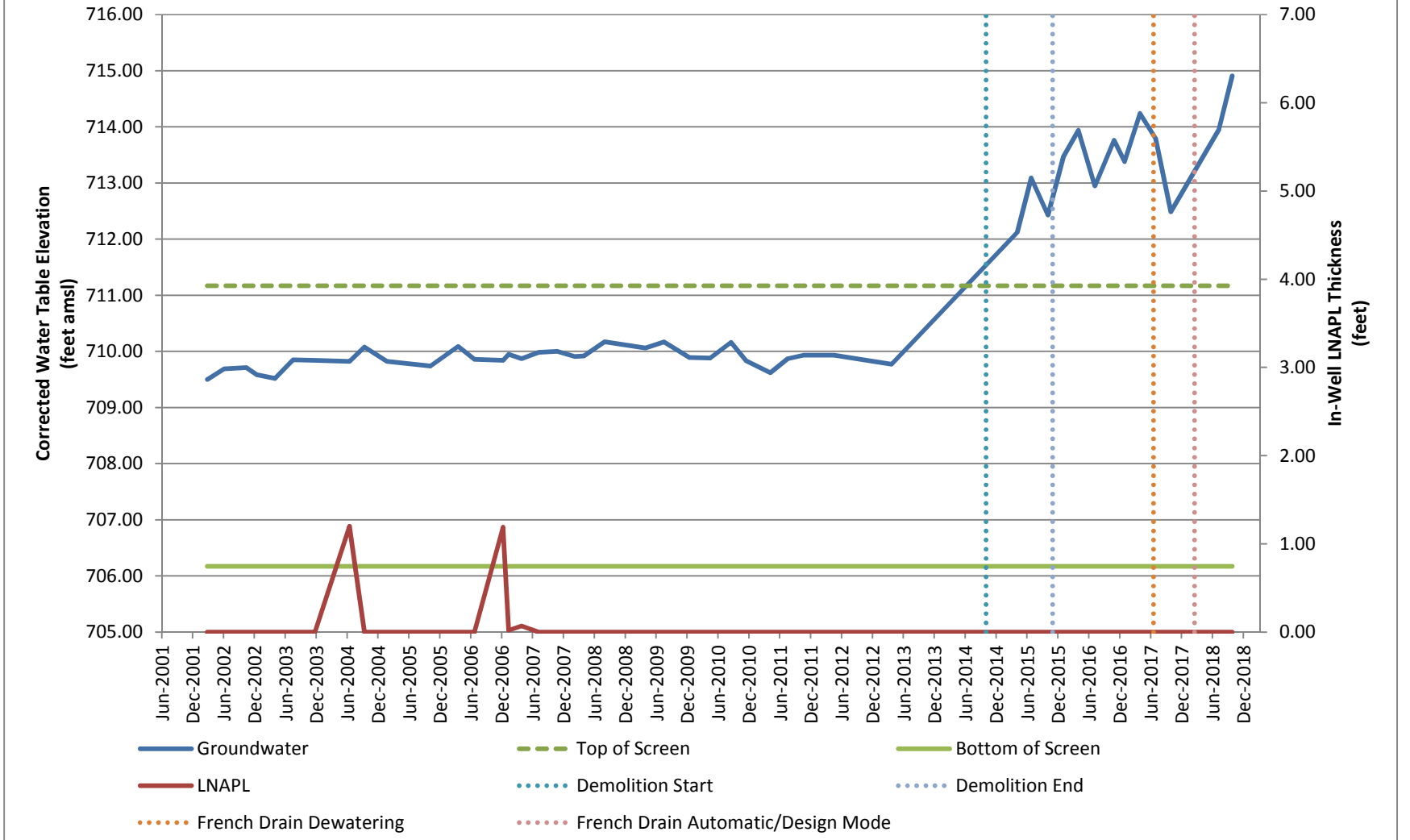



Well Gauging Data Summary: 089M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
718.00
716.00
714.00
712.00
710.00
708.00
706.00
704.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2001
Dec-2001
Jun-2002
Dec-2002
Jun-2003
Dec-2003
Jun-2004
Dec-2004
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
Dec-2008
Jun-2009
Dec-2009
Jun-2010
Dec-2010
Jun-2011
Dec-2011
Jun-2012
Dec-2012
Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

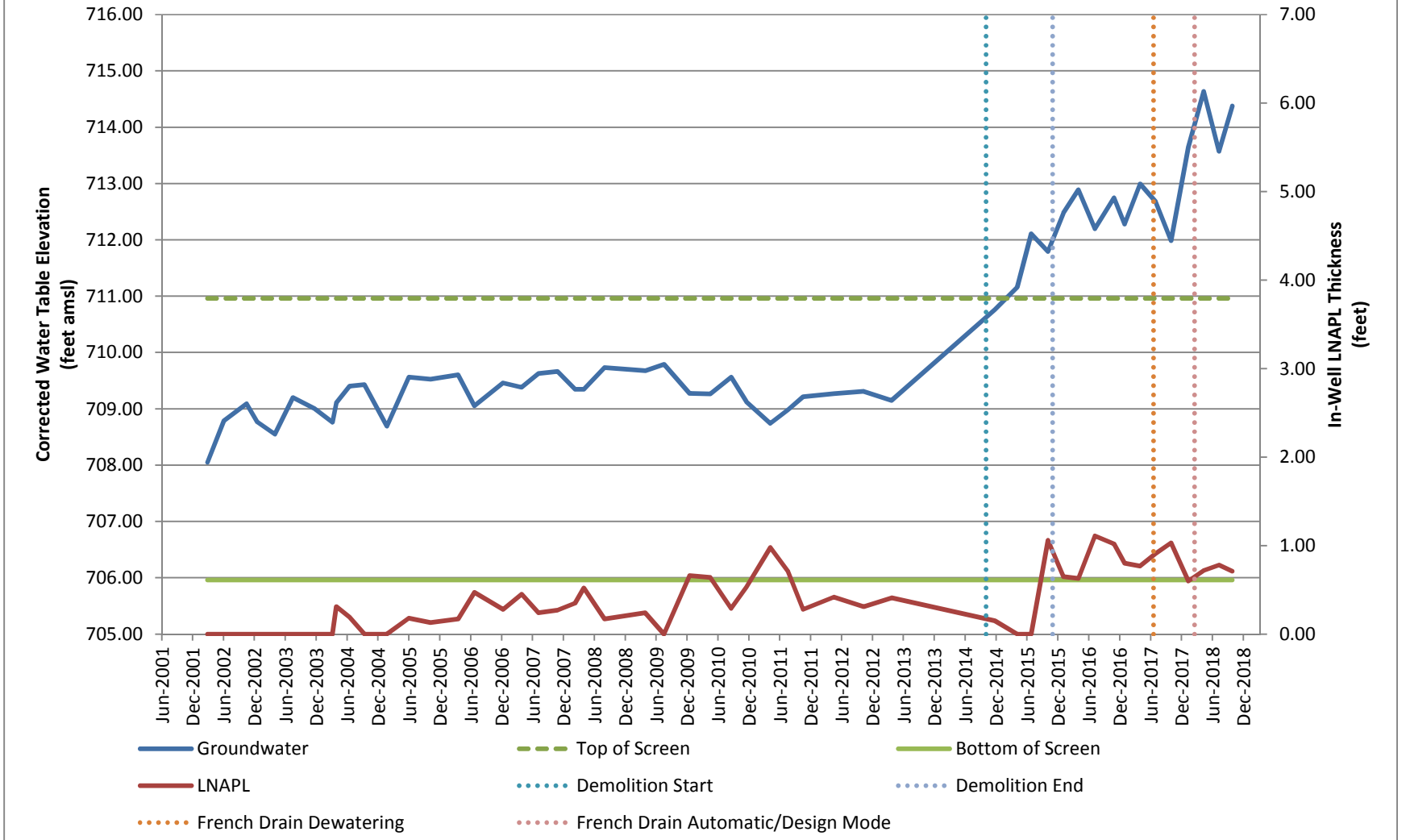
Well Gauging Data Summary: 089R
RACER Willow Run Powertrain
Ypsilanti, Michigan



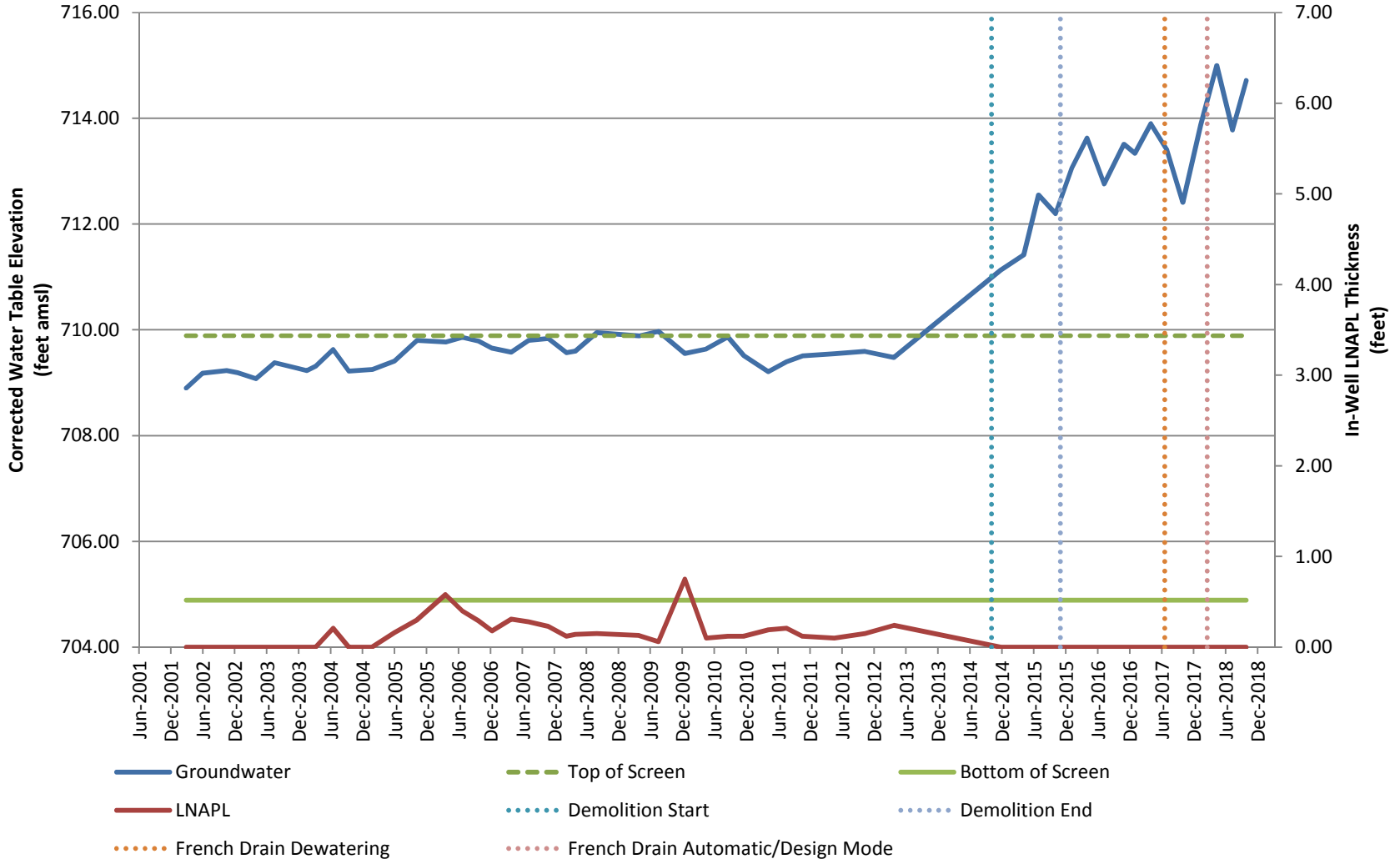
Well Gauging Data Summary: 090M
RACER Willow Run Powertrain
Ypsilanti, Michigan

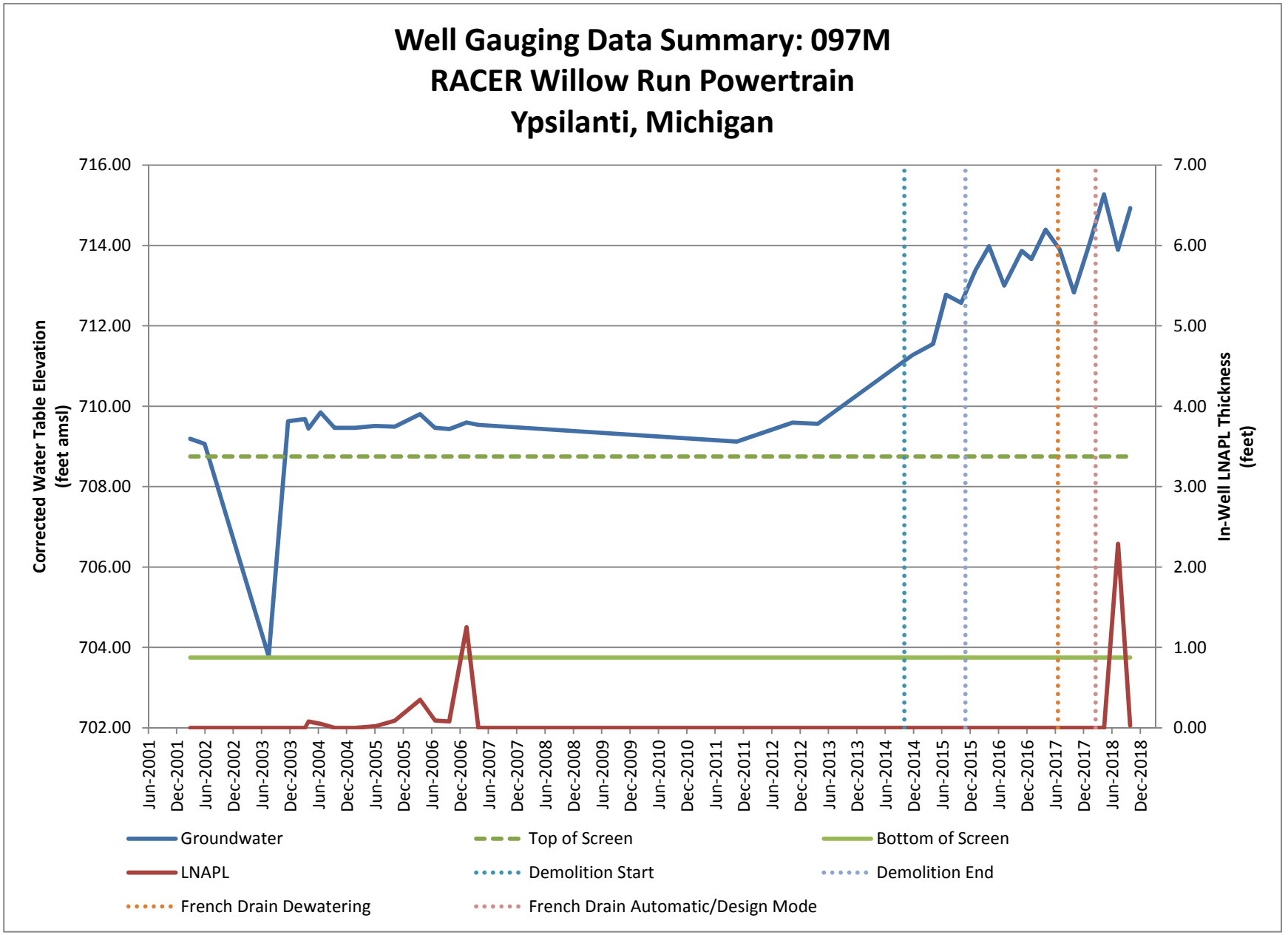


Well Gauging Data Summary: 092M
RACER Willow Run Powertrain
Ypsilanti, Michigan

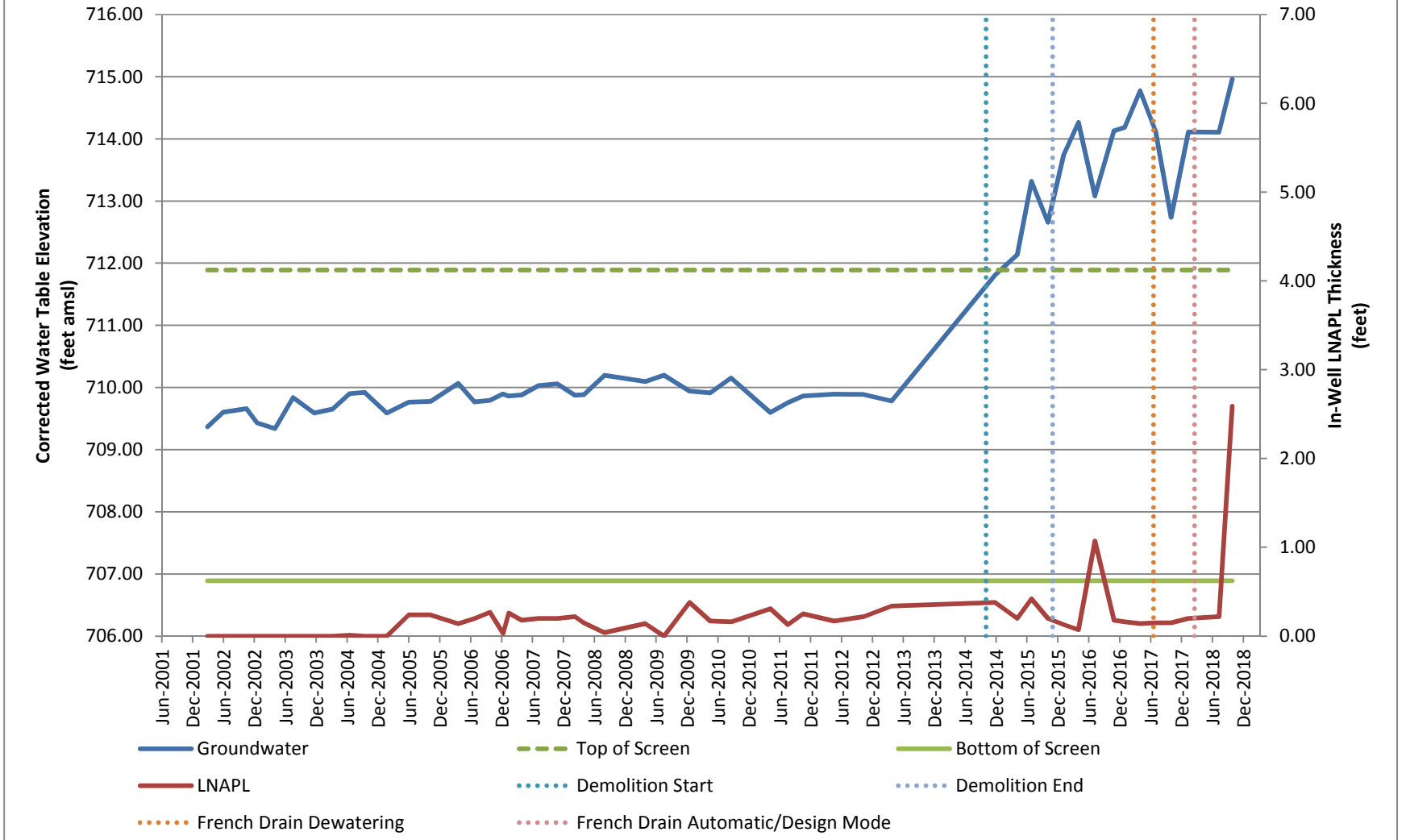


Well Gauging Data Summary: 096M
RACER Willow Run Powertain
Ypsilanti, Michigan



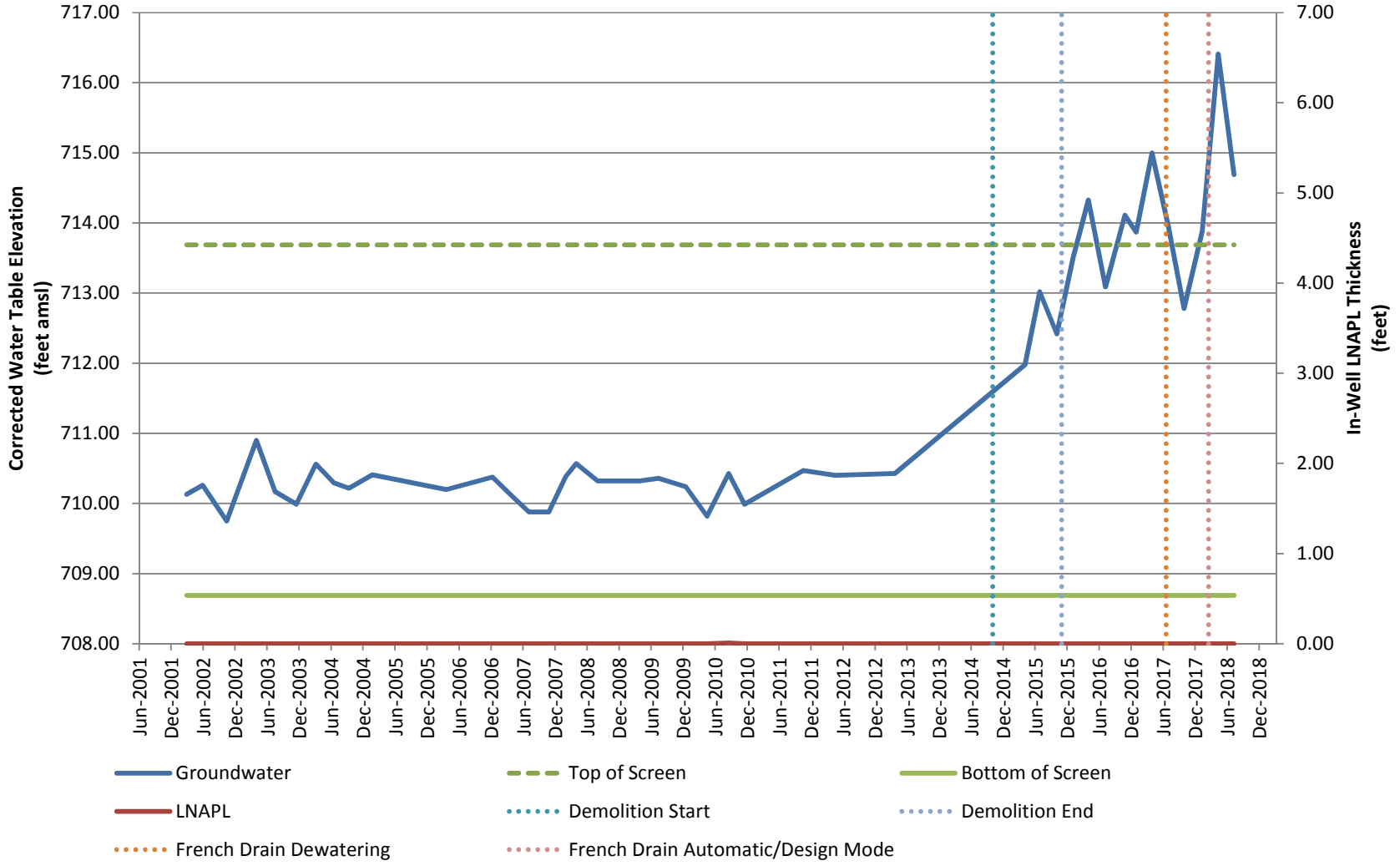

Well Gauging Data Summary: 097M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
716.00
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2001
Dec-2001
Jun-2002
Dec-2002
Jun-2003
Dec-2003
Jun-2004
Dec-2004
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
Dec-2008
Jun-2009
Dec-2009
Jun-2010
Dec-2010
Jun-2011
Dec-2011
Jun-2012
Dec-2012
Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

Well Gauging Data Summary: 098M
RACER Willow Run Powertrain
Ypsilanti, Michigan



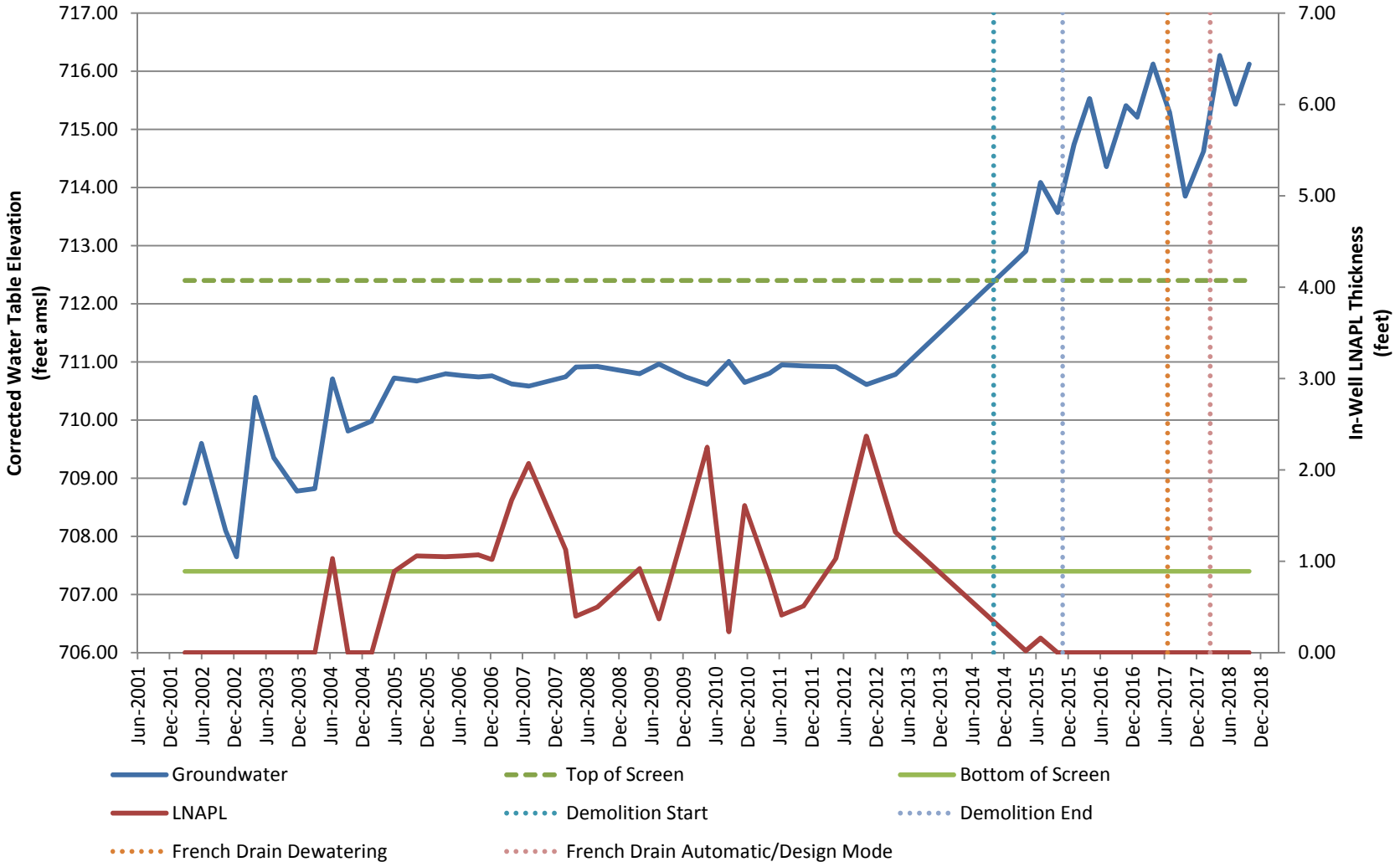
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 100M
RACER Willow Run Powertrain
Ypsilanti, Michigan

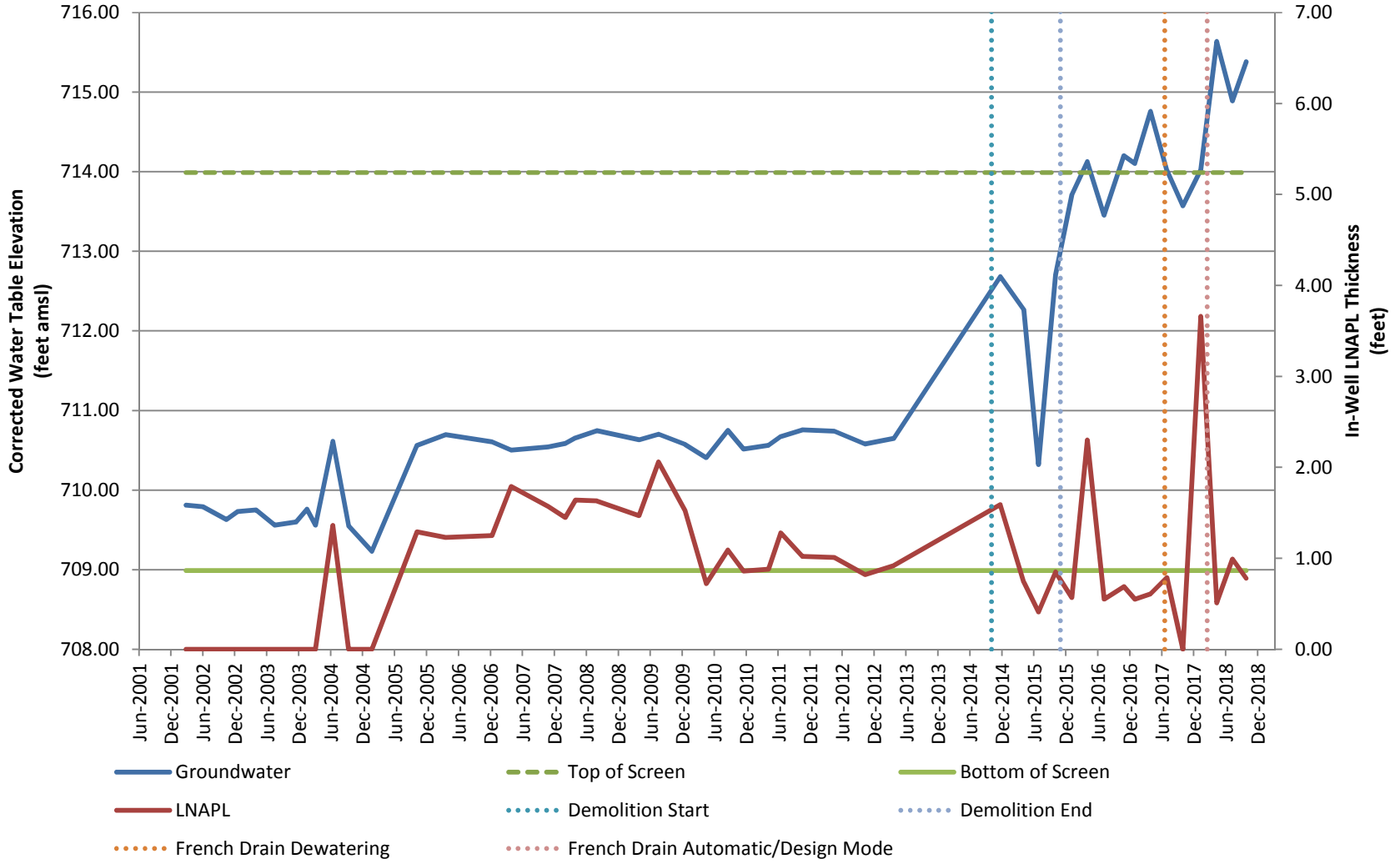


Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

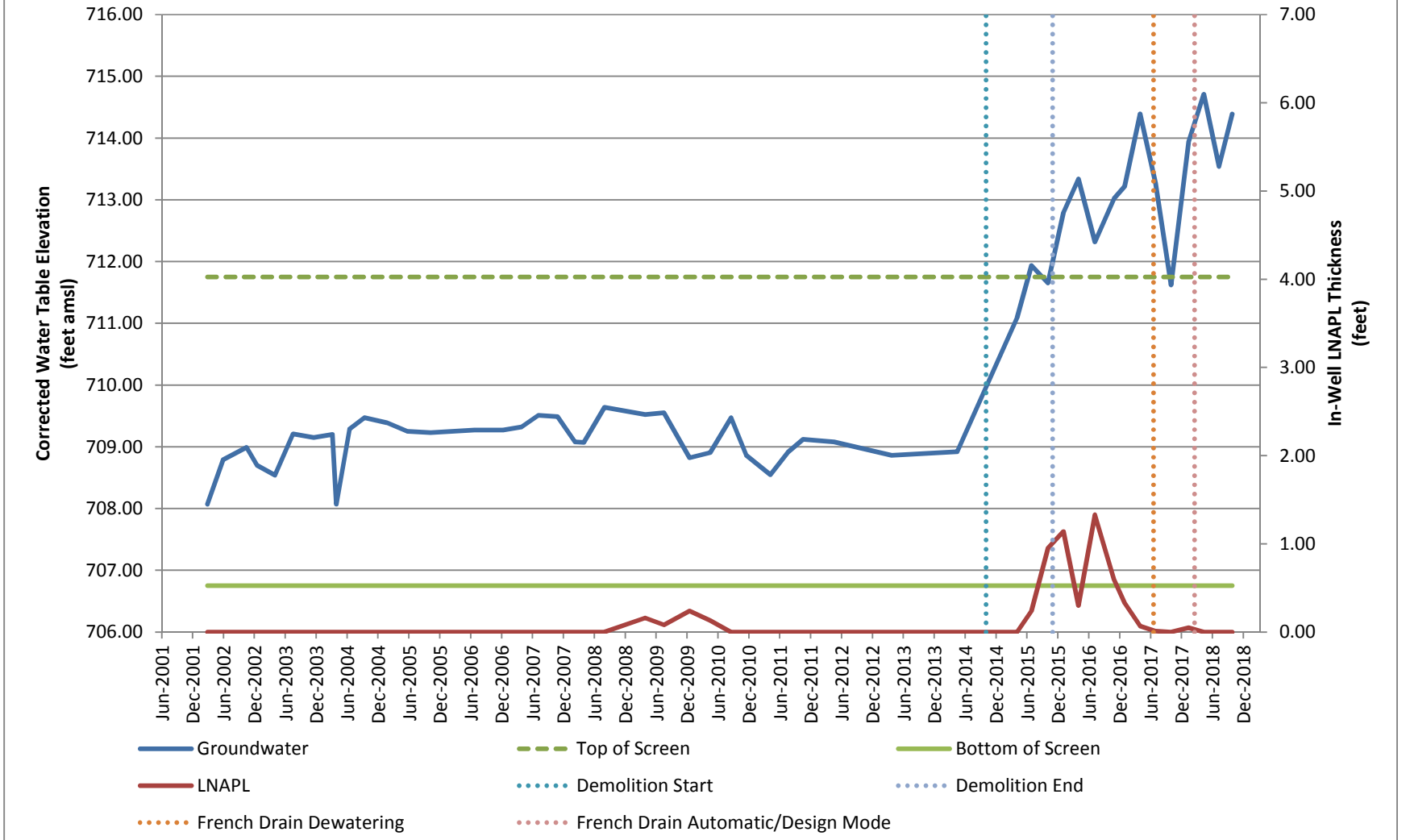
Well Gauging Data Summary: 101M
RACER Willow Run Powertrain
Ypsilanti, Michigan



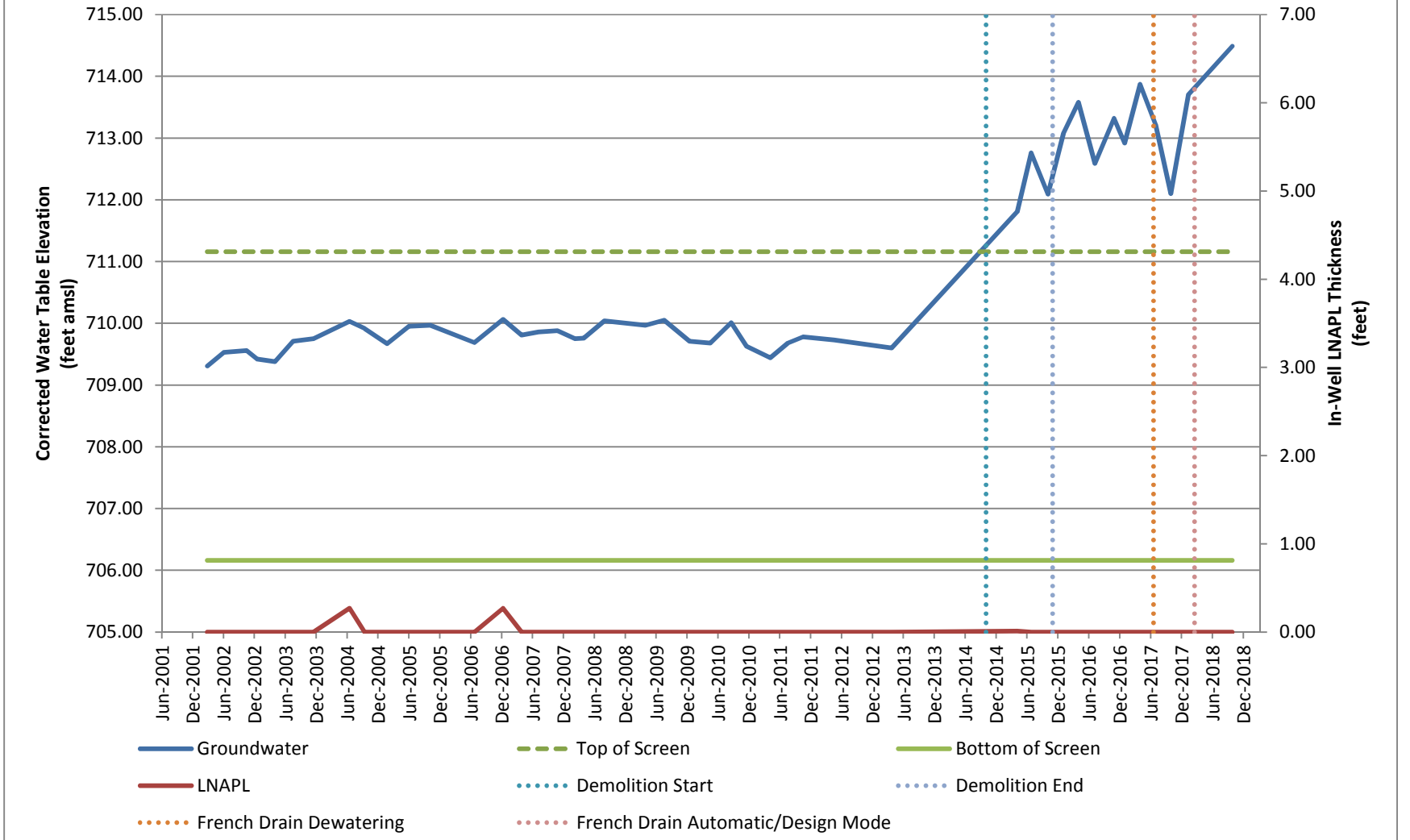
Well Gauging Data Summary: 102M
RACER Willow Run Powertrain
Ypsilanti, Michigan



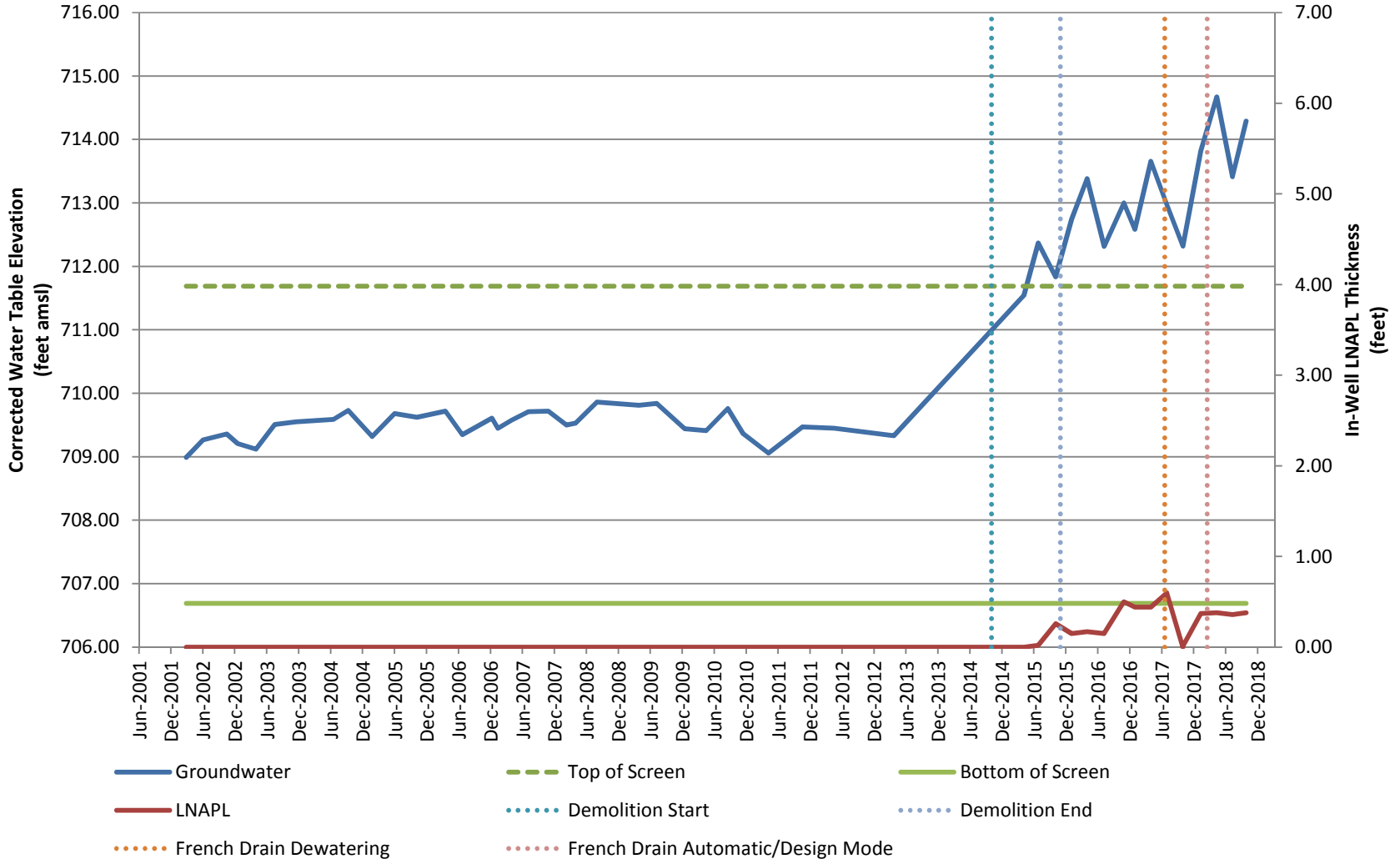
Well Gauging Data Summary: 107M
RACER Willow Run Powertrain
Ypsilanti, Michigan

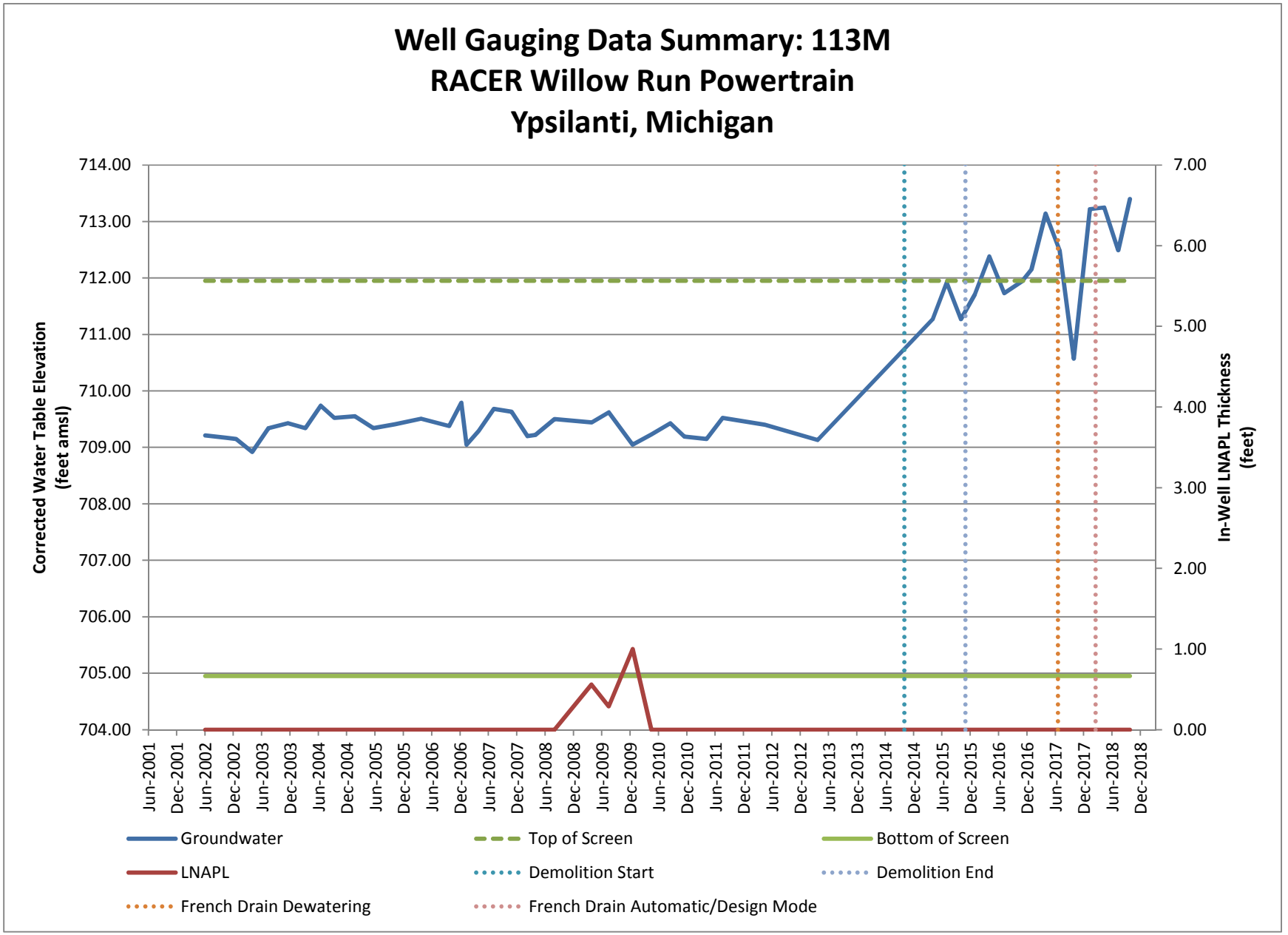


Well Gauging Data Summary: 108M
RACER Willow Run Powertrain
Ypsilanti, Michigan



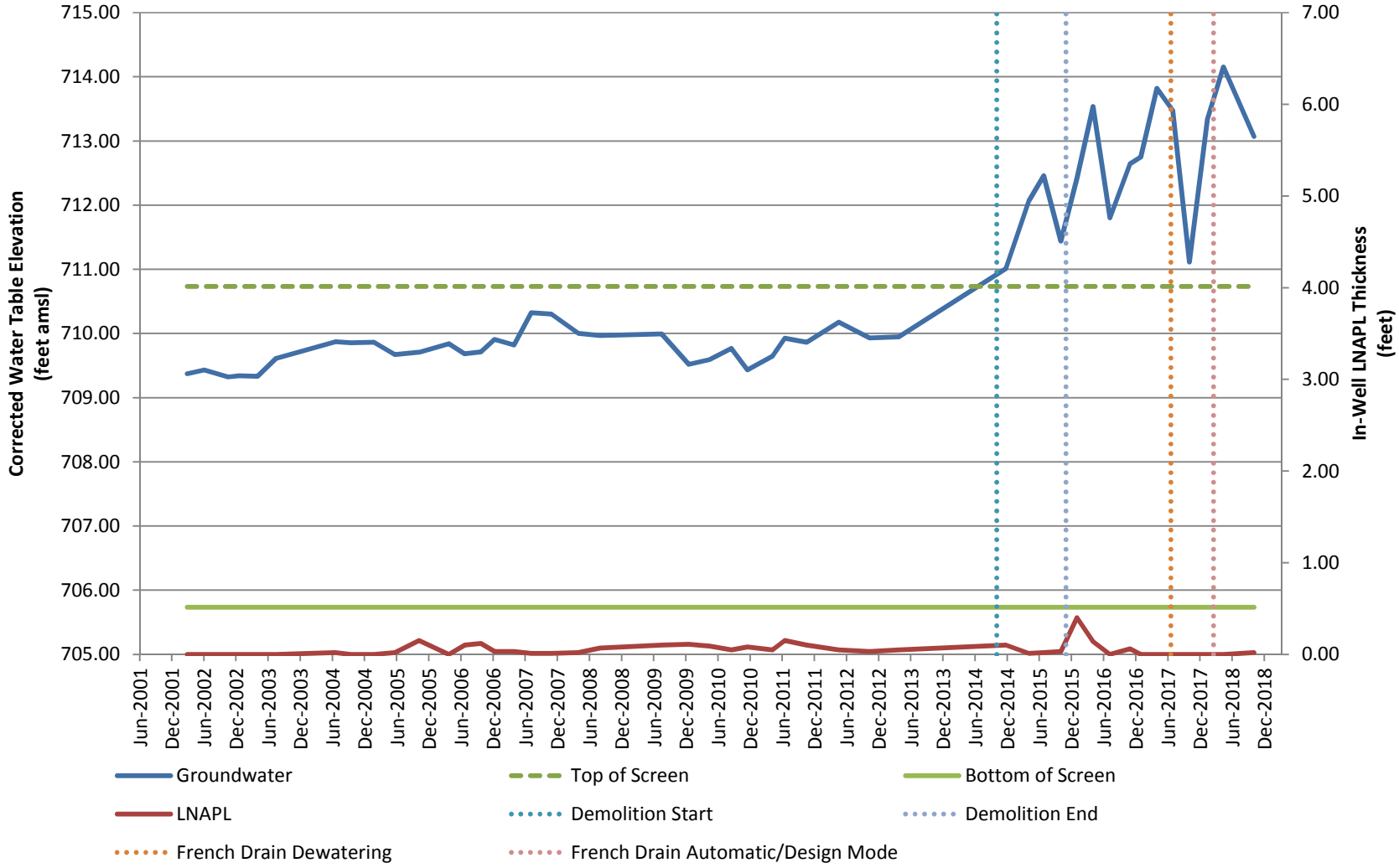
Well Gauging Data Summary: 109M
RACER Willow Run Powertrain
Ypsilanti, Michigan




Well Gauging Data Summary: 113M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
706.00
705.00
704.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2001
Dec-2001
Jun-2002
Dec-2002
Jun-2003
Dec-2003
Jun-2004
Dec-2004
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
Dec-2008
Jun-2009
Dec-2009
Jun-2010
Dec-2010
Jun-2011
Dec-2011
Jun-2012
Dec-2012
Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

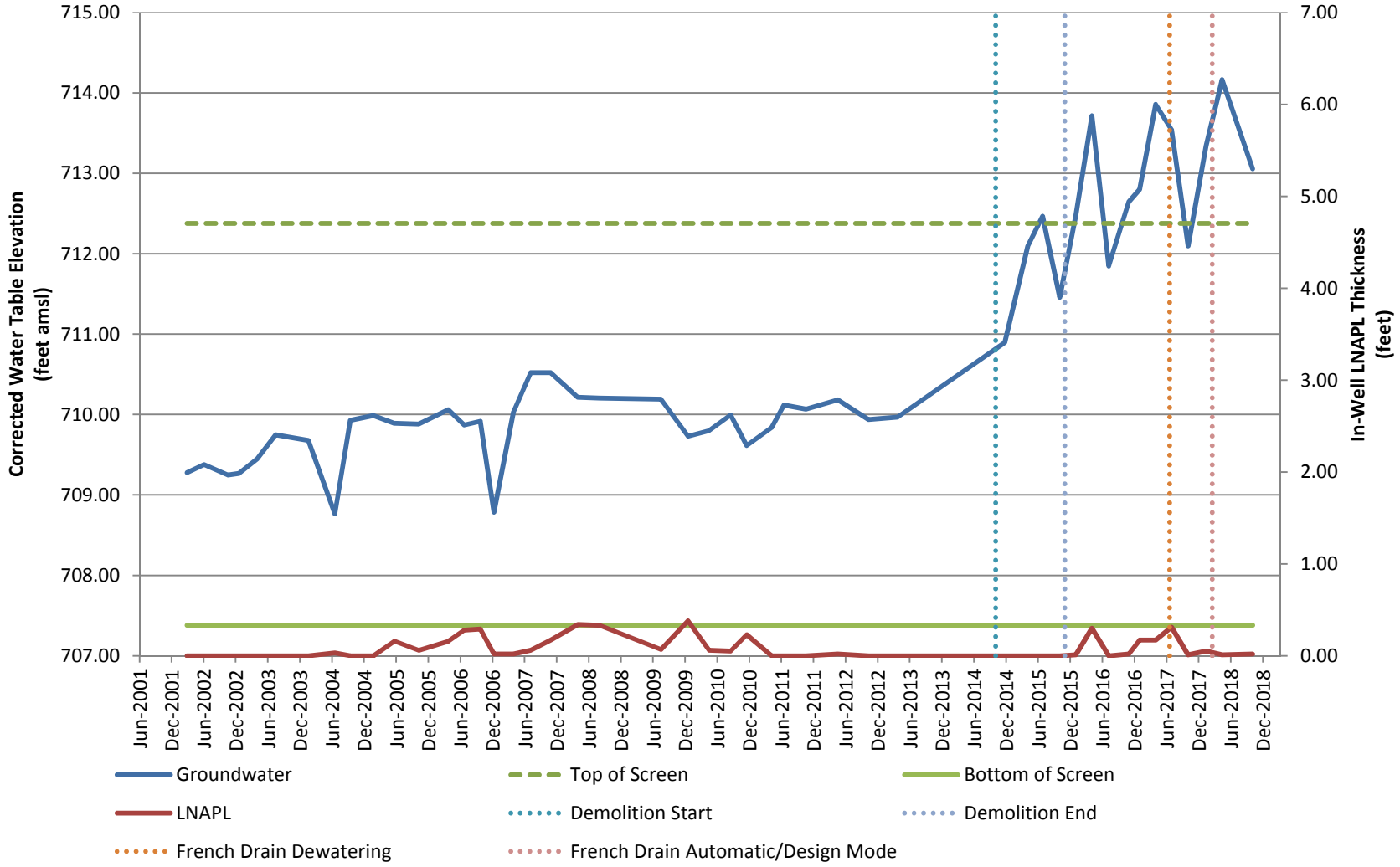
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 120M-A
RACER Willow Run Powertrain
Ypsilanti, Michigan



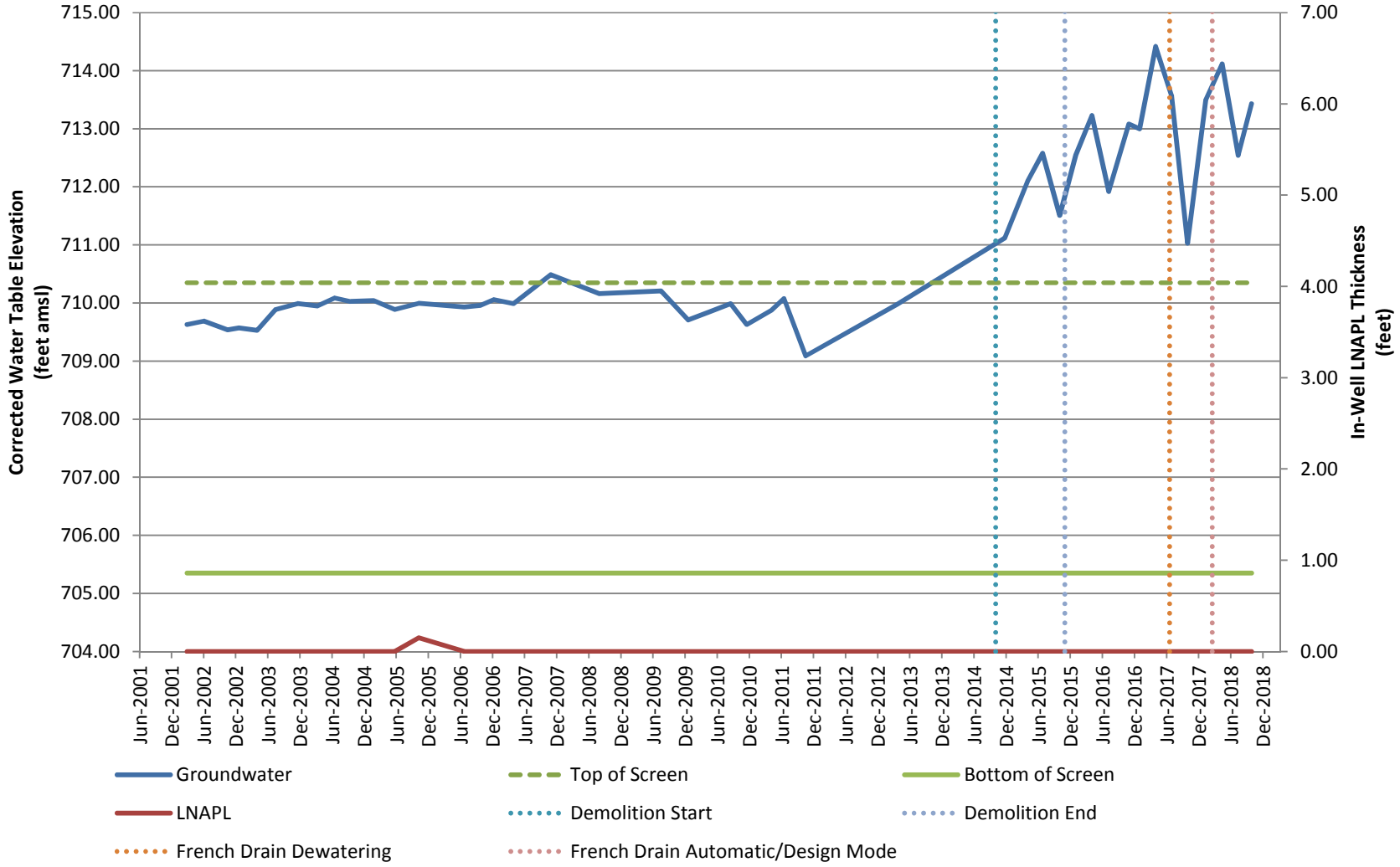
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 120M-B
RACER Willow Run Powertrain
Ypsilanti, Michigan



Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 121M-A
RACER Willow Run Powertrain
Ypsilanti, Michigan



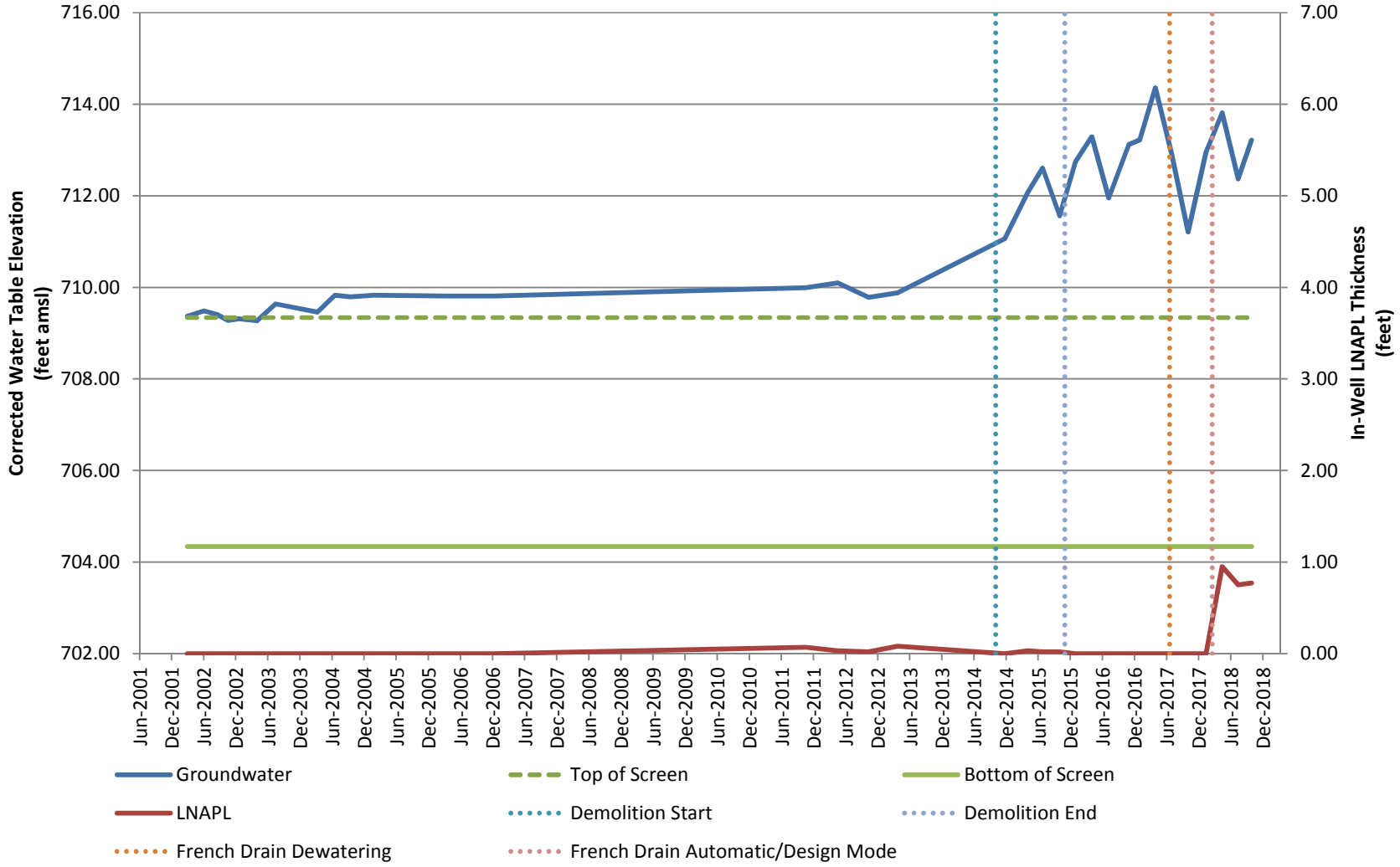
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 121M-B
RACER Willow Run Powertrain
Ypsilanti, Michigan



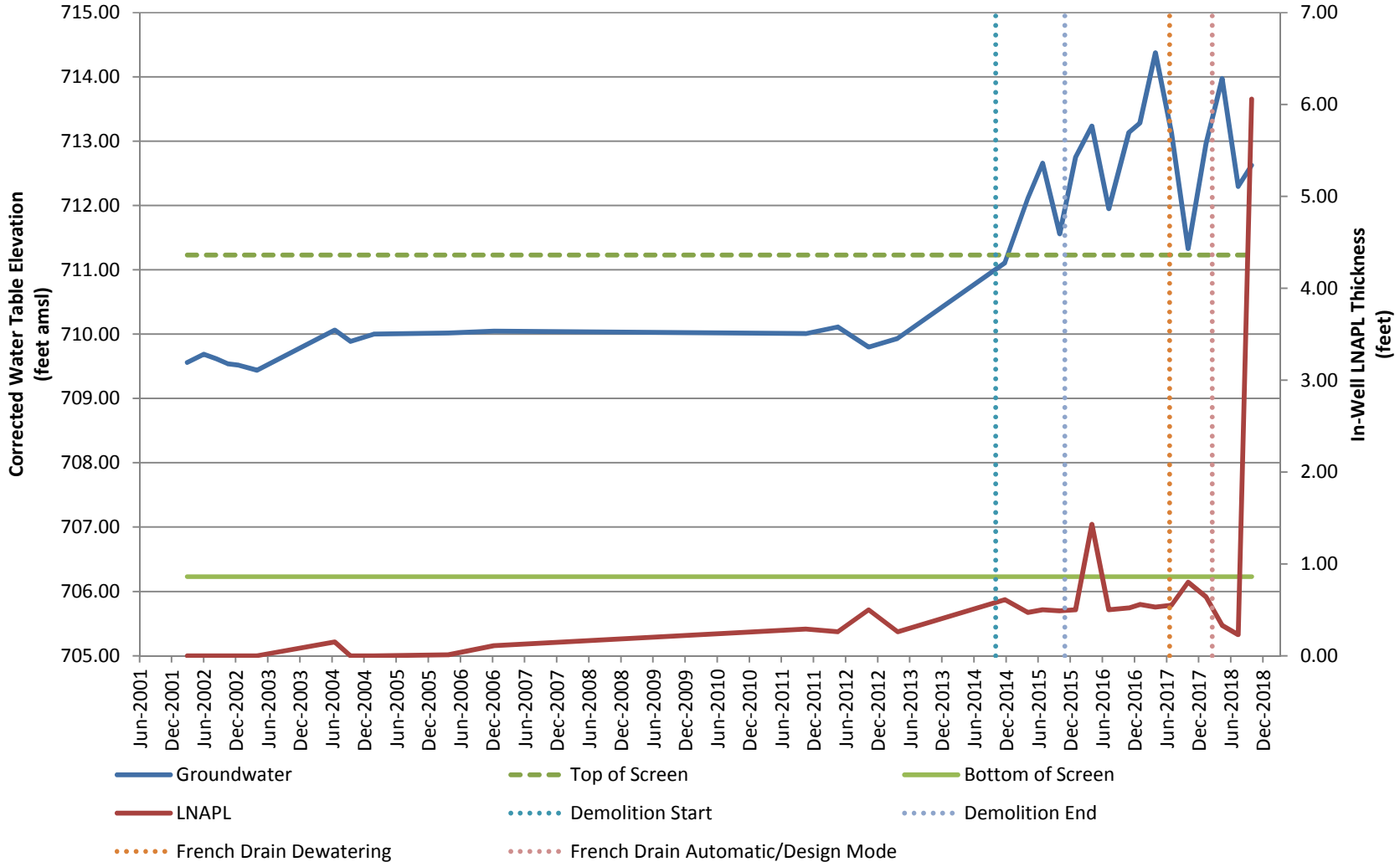
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

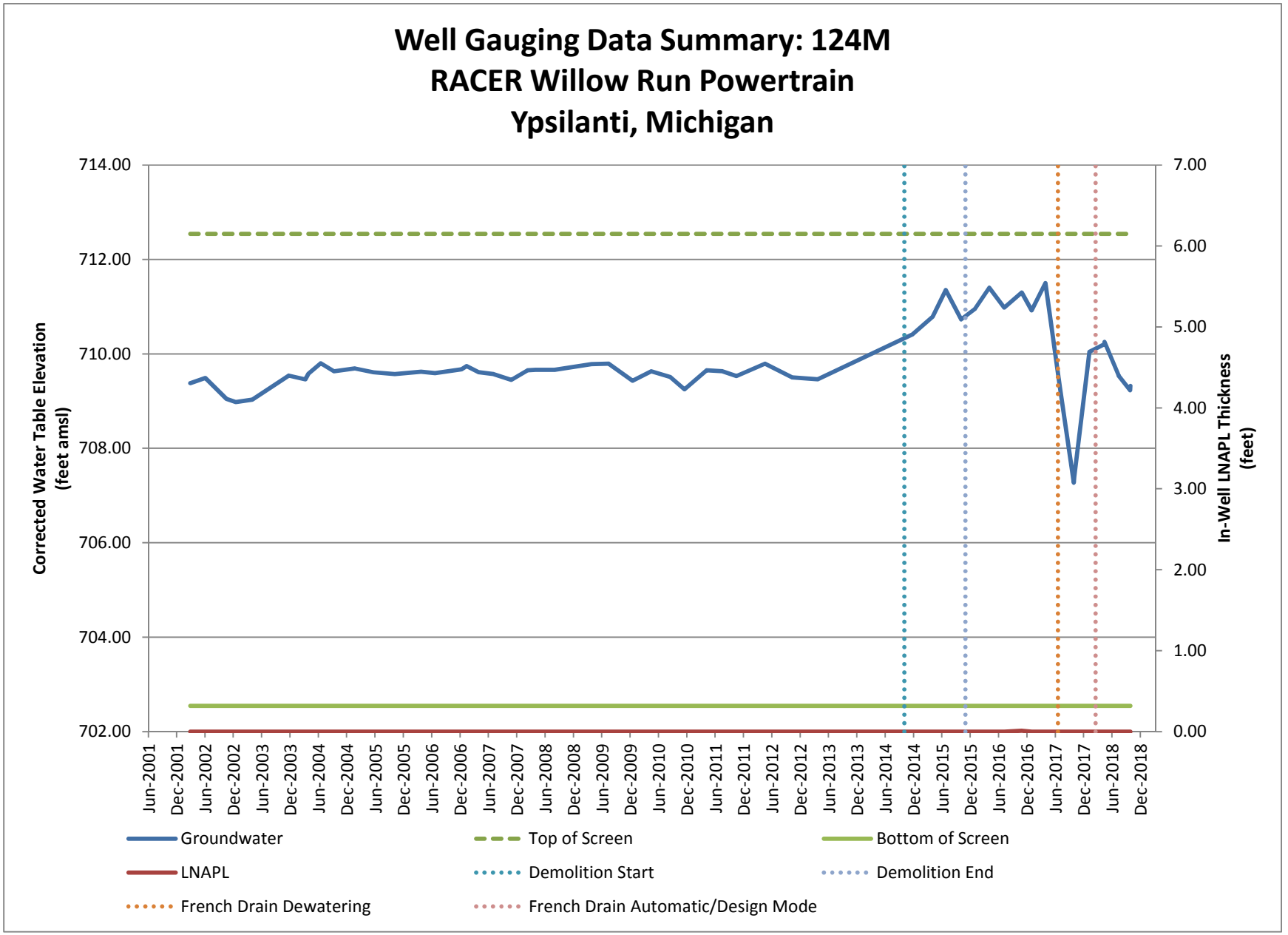
Well Gauging Data Summary: 122M-A
RACER Willow Run Powertrain
Ypsilanti, Michigan



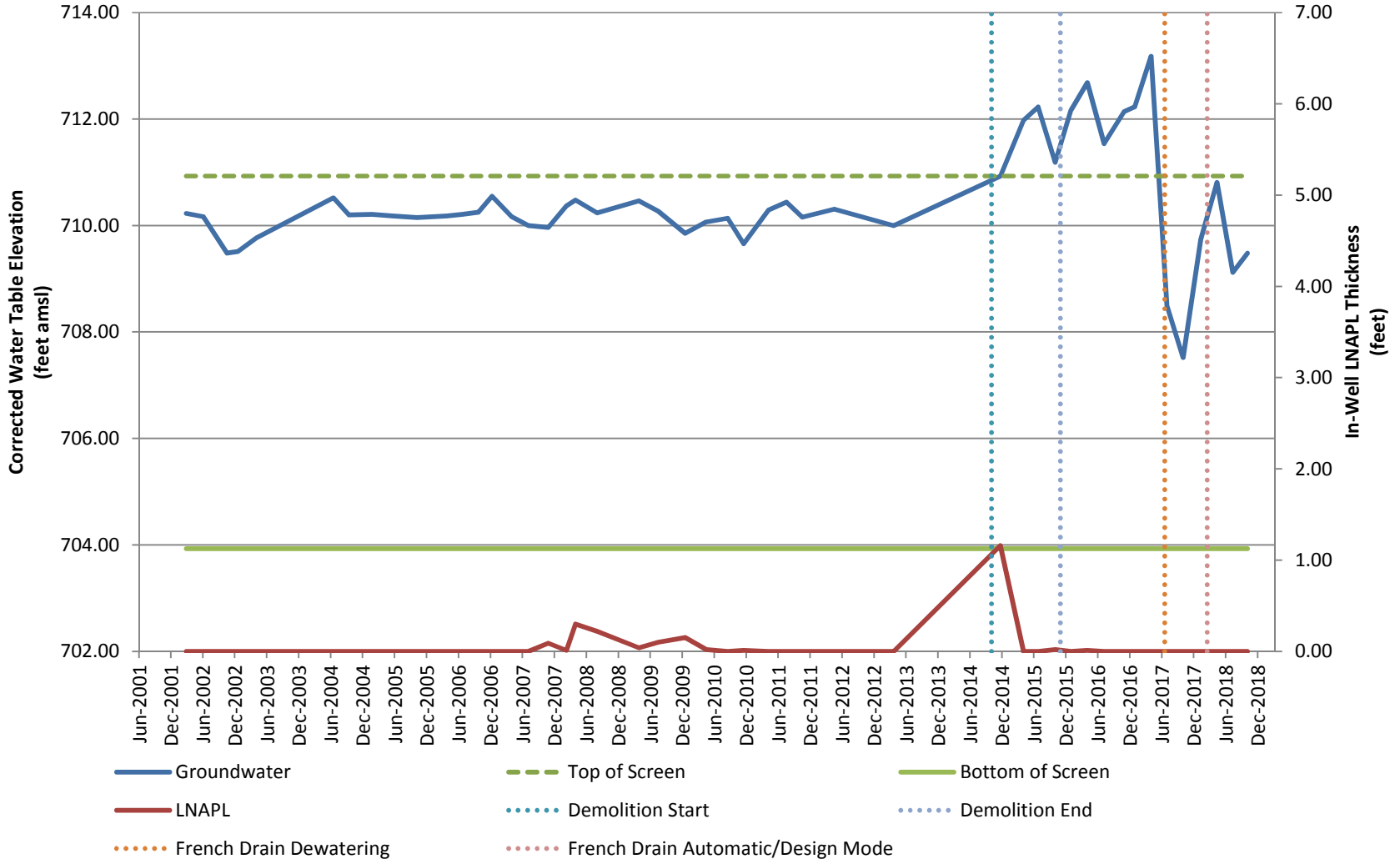
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 122M-B
RACER Willow Run Powertrain
Ypsilanti, Michigan

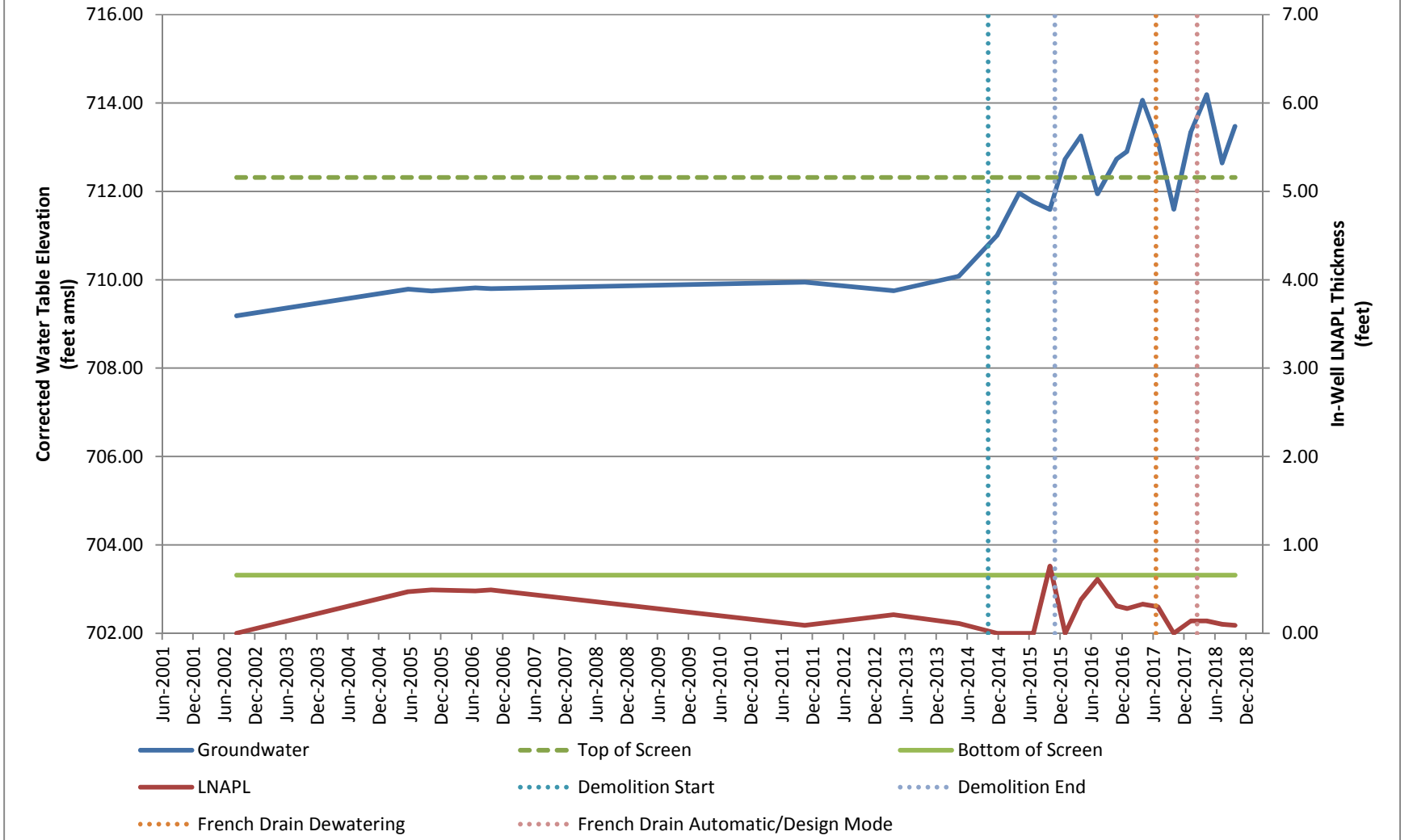



Well Gauging Data Summary: 124M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2001
Dec-2001
Jun-2002
Dec-2002
Jun-2003
Dec-2003
Jun-2004
Dec-2004
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
Dec-2008
Jun-2009
Dec-2009
Jun-2010
Dec-2010
Jun-2011
Dec-2011
Jun-2012
Dec-2012
Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

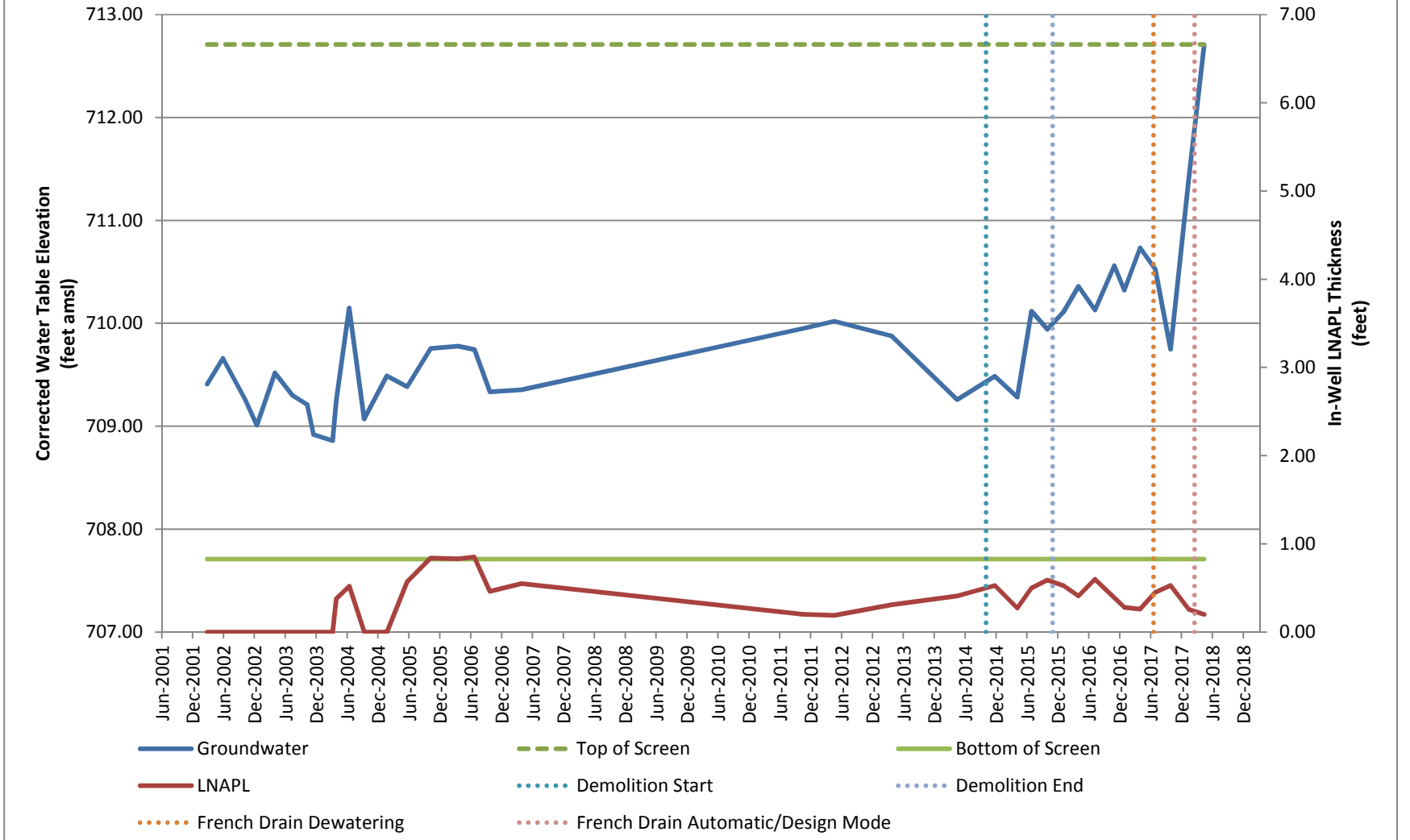
Well Gauging Data Summary: 125M
RACER Willow Run Powertrain
Ypsilanti, Michigan



Well Gauging Data Summary: 129M
RACER Willow Run Powertrain
Ypsilanti, Michigan

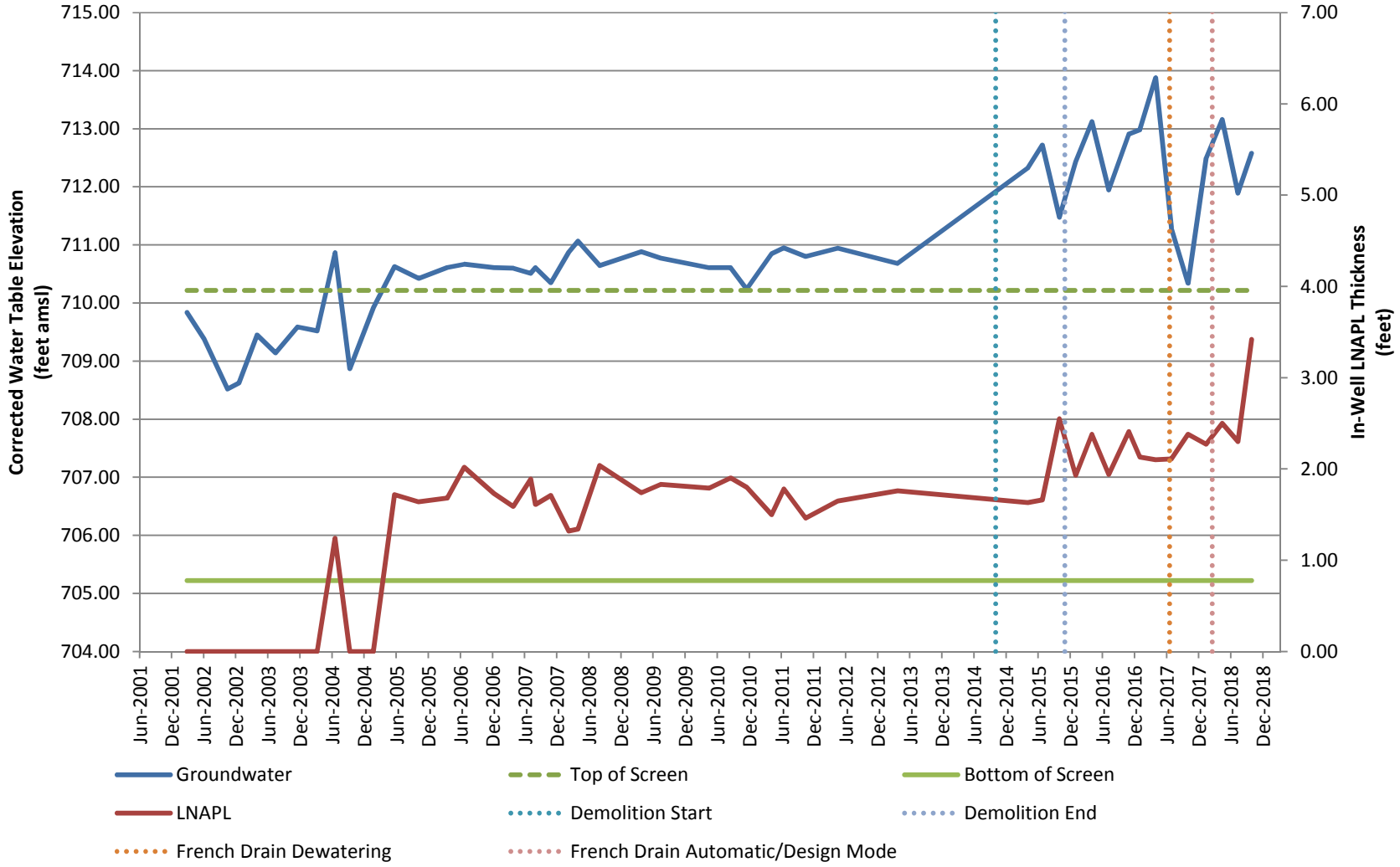


Well Gauging Data Summary: 138M
RACER Willow Run Powertrain
Ypsilanti, Michigan



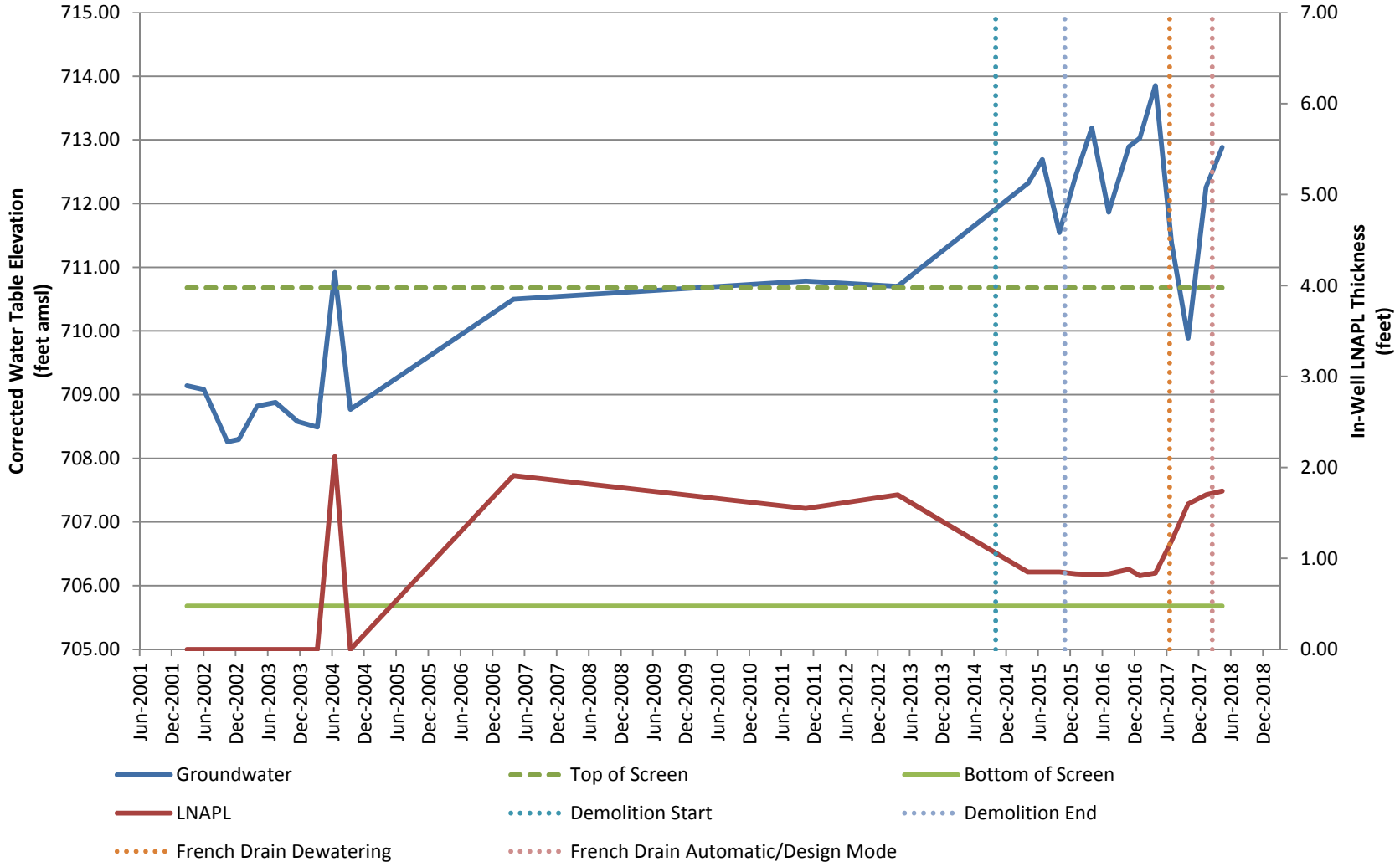
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 204M-B
RACER Willow Run Powertrain
Ypsilanti, Michigan



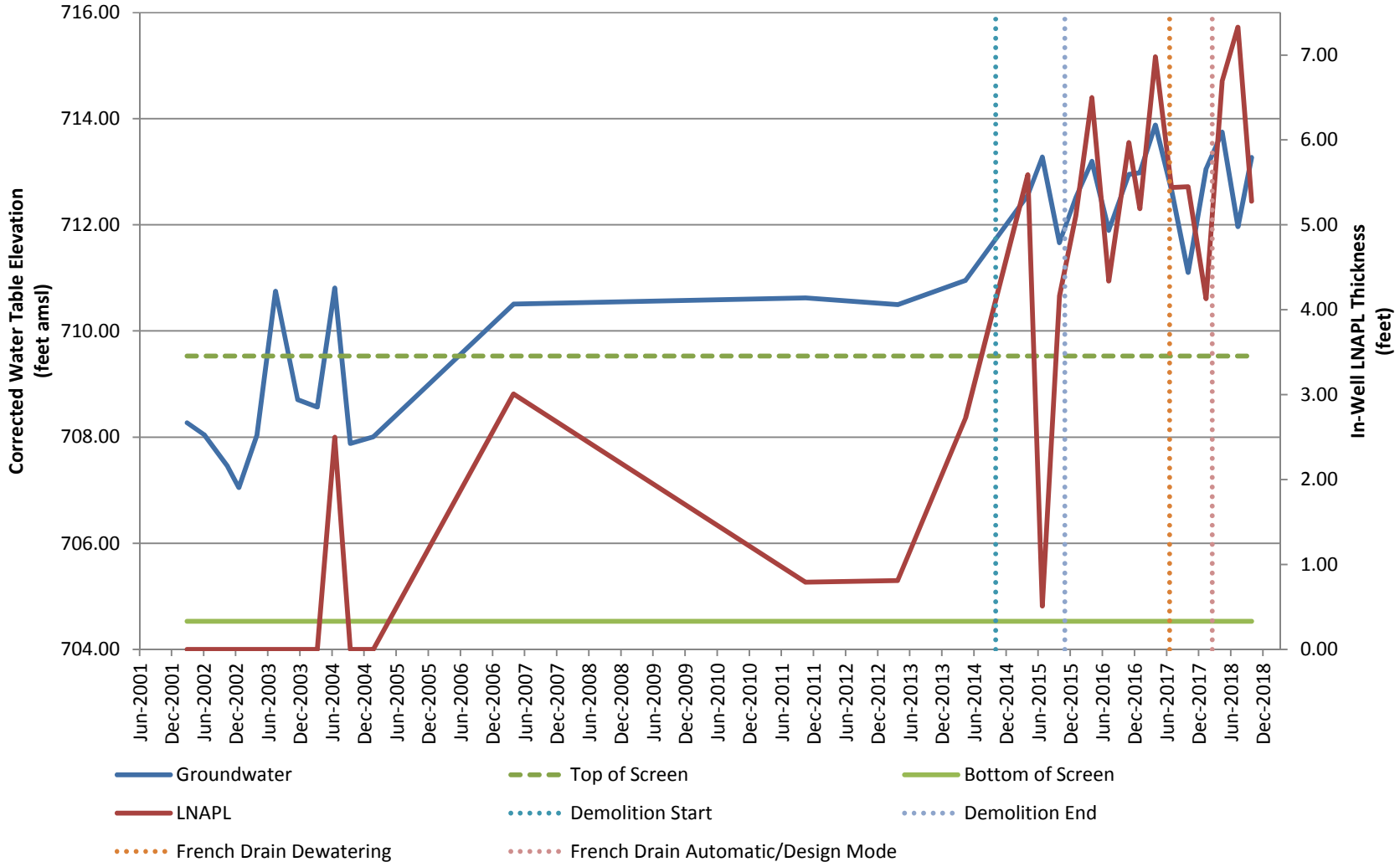
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 205M-B
RACER Willow Run Powertrain
Ypsilanti, Michigan



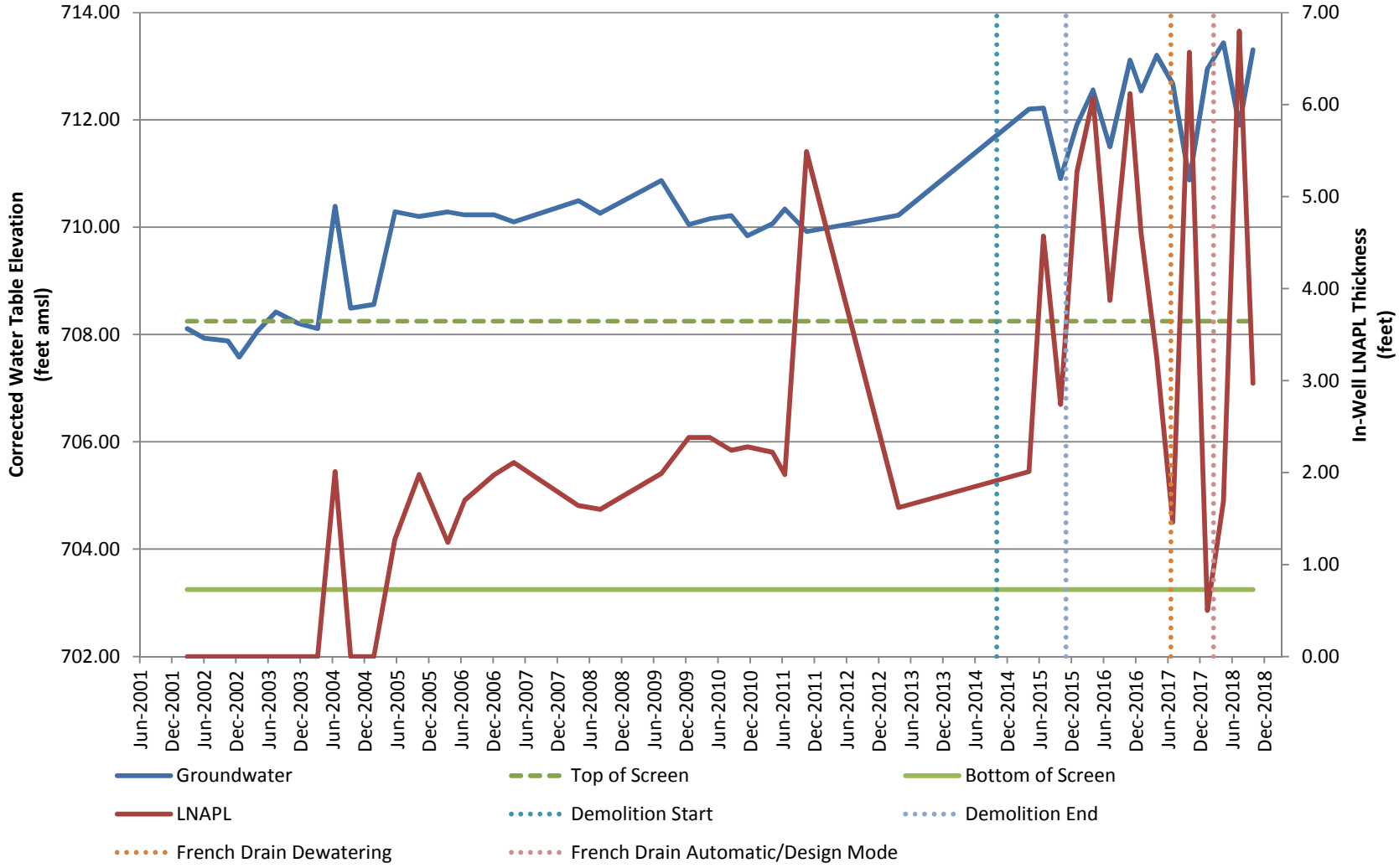
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 206M
RACER Willow Run Powertrain
Ypsilanti, Michigan



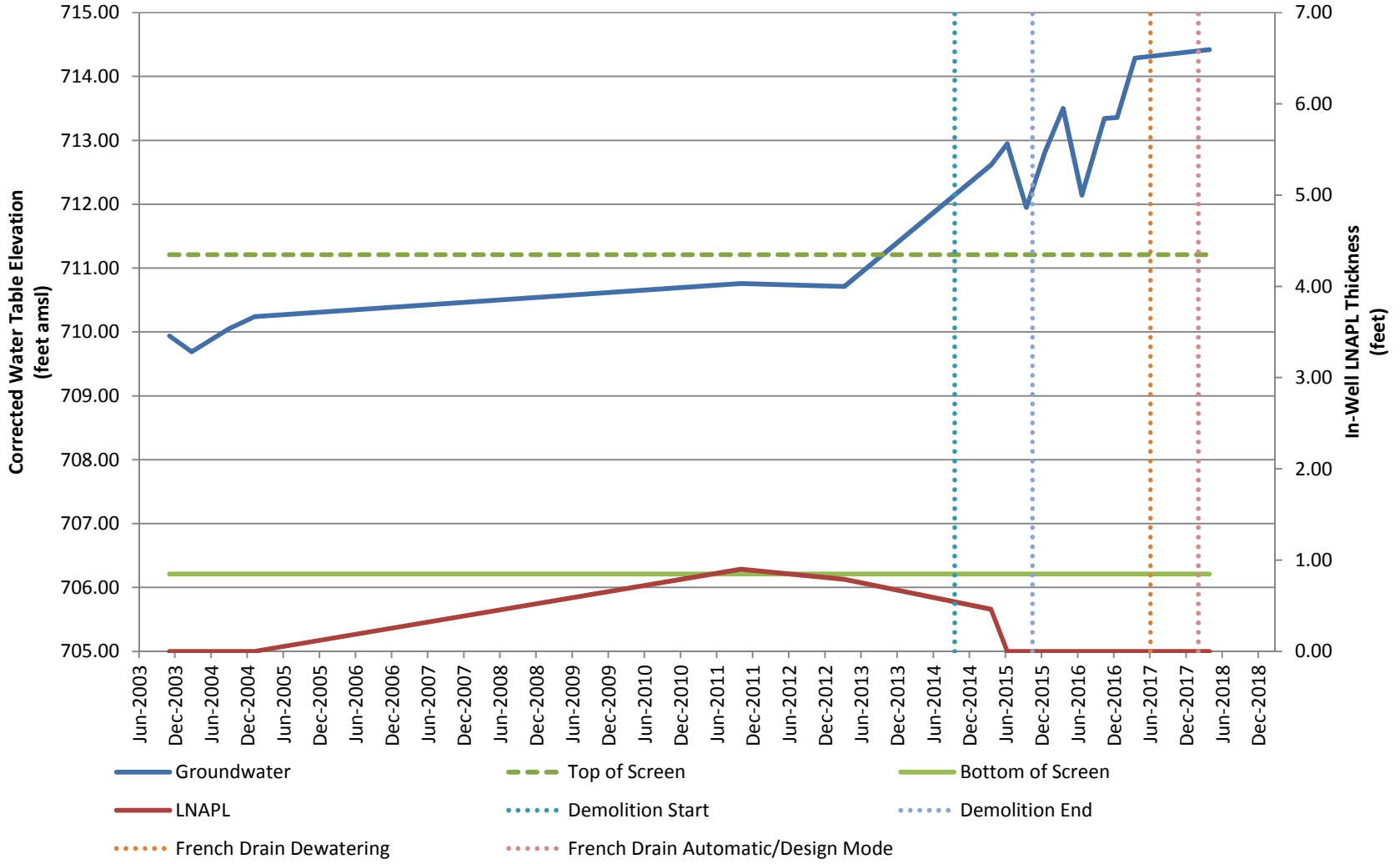
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 207M
RACER Willow Run Powertrain
Ypsilanti, Michigan



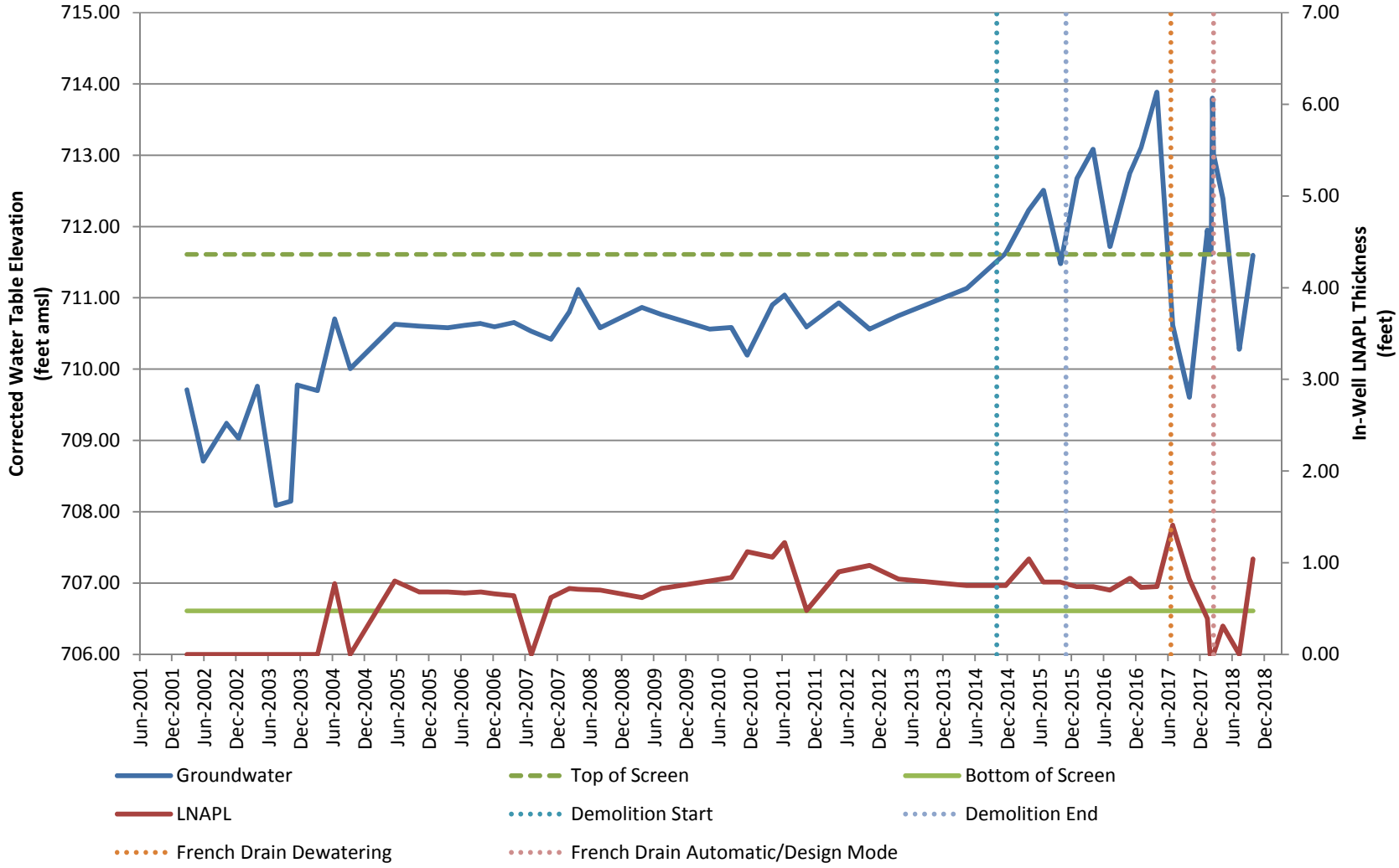
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 208M-B
RACER Willow Run Powertrain
Ypsilanti, Michigan



Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 218M-B
RACER Willow Run Powertrain
Ypsilanti, Michigan



Well Gauging Data Summary: 219M
RACER Willow Run Powertrain
Ypsilanti, Michigan



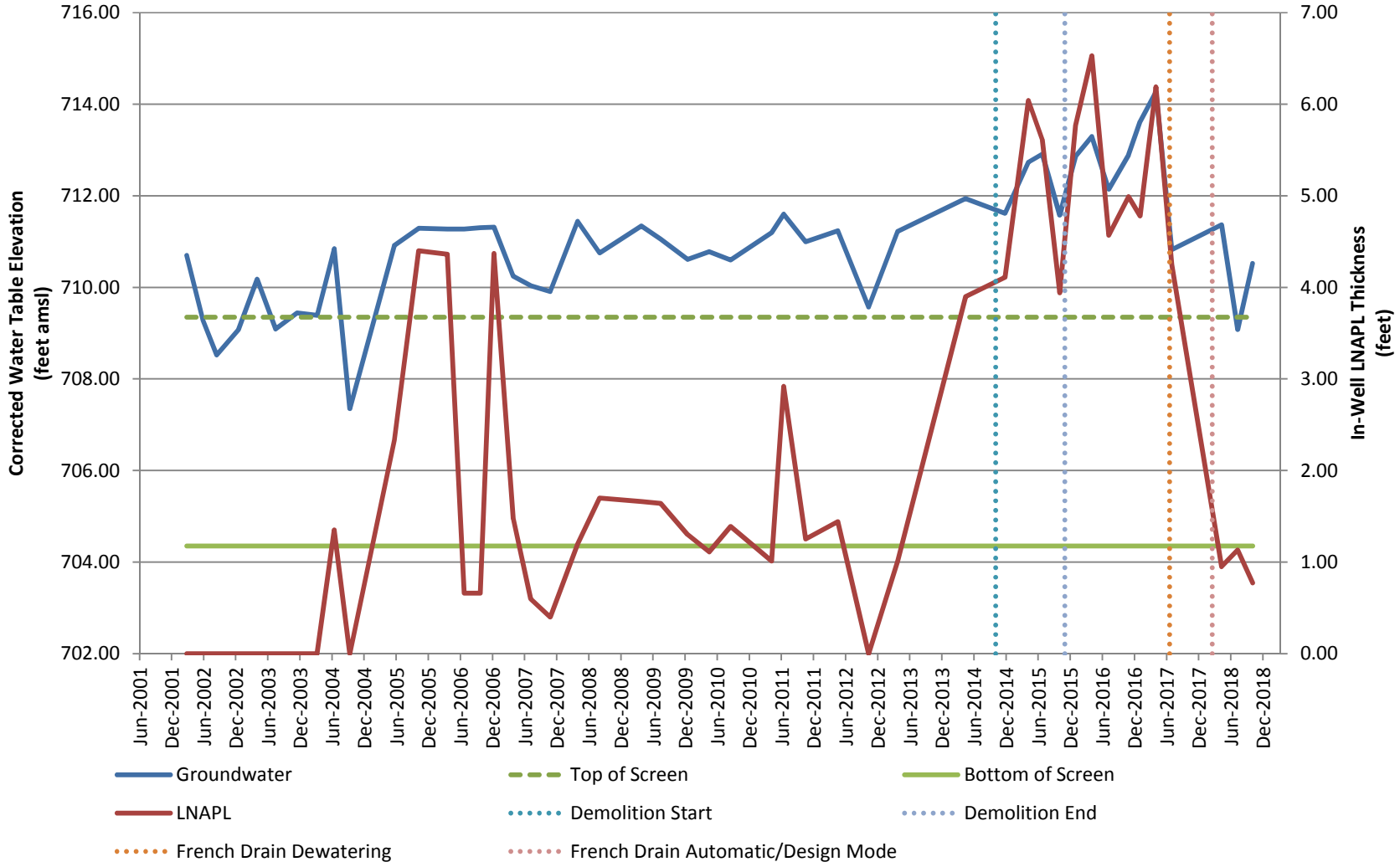
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 222M
RACER Willow Run Powertrain
Yspilanti, Michigan



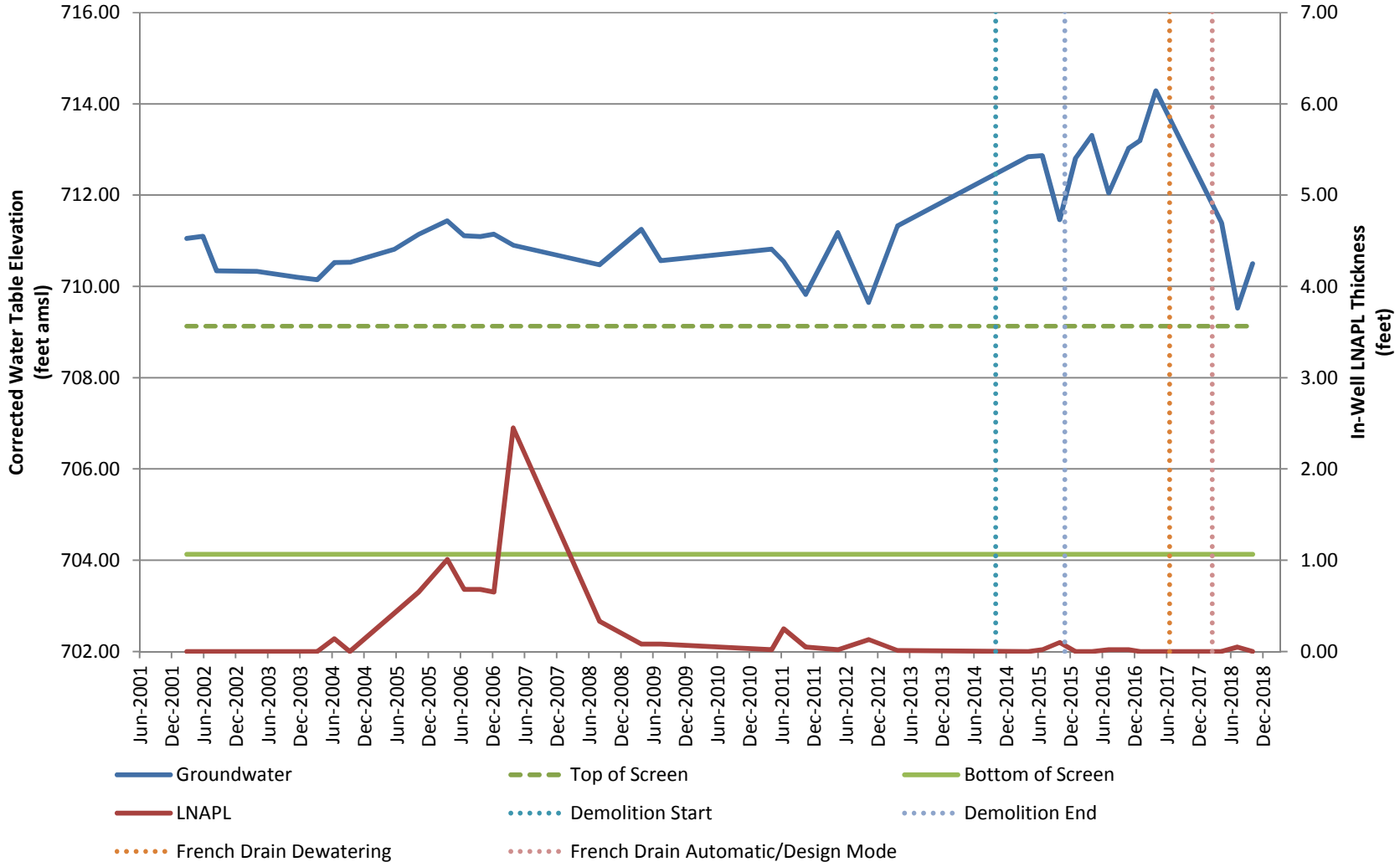
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 223M
RACER Willow Run Powertrain
Ypsilanti, Michigan



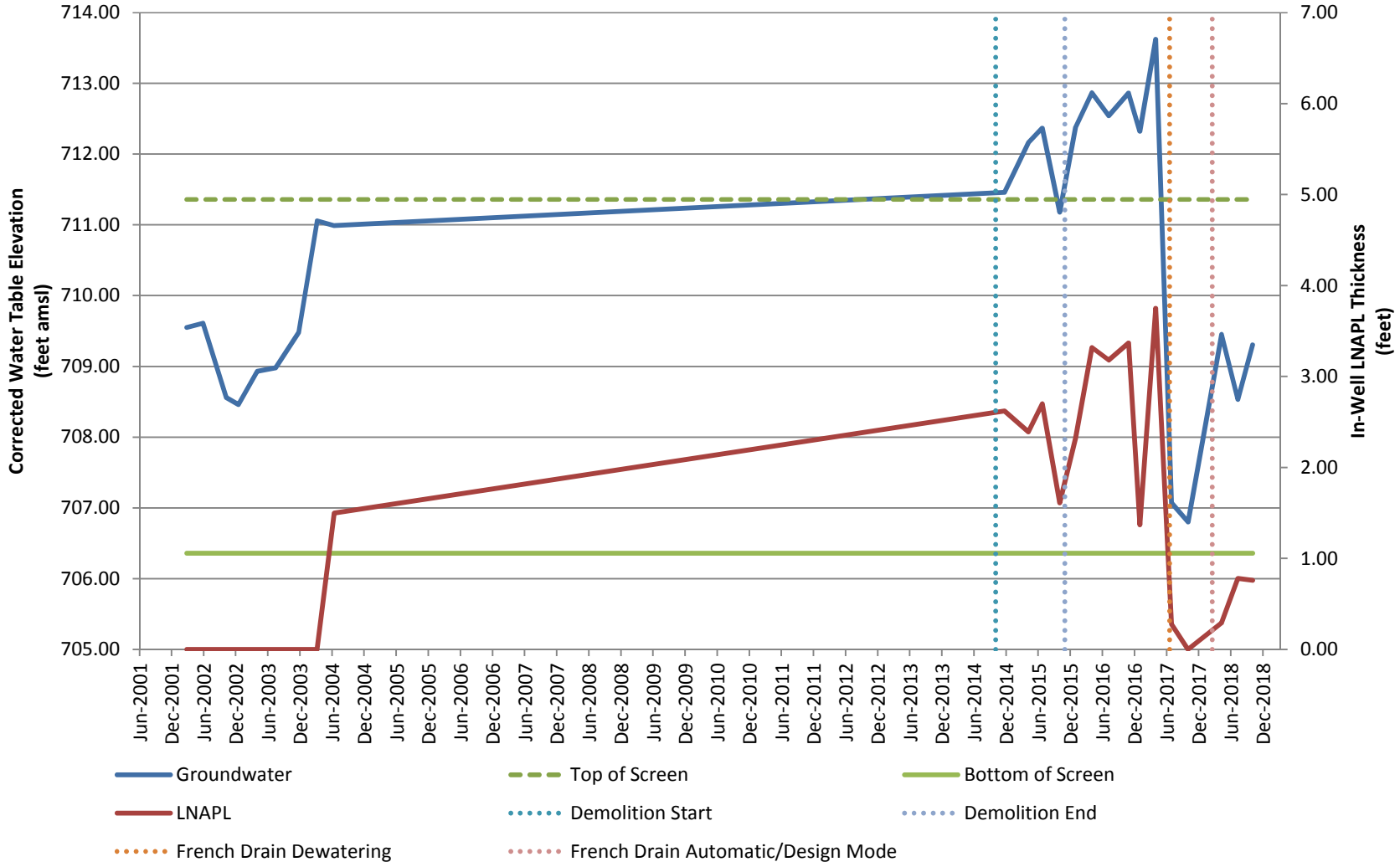
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 224M
RACER Willow Run Powertrain
Ypsilanti, Michigan



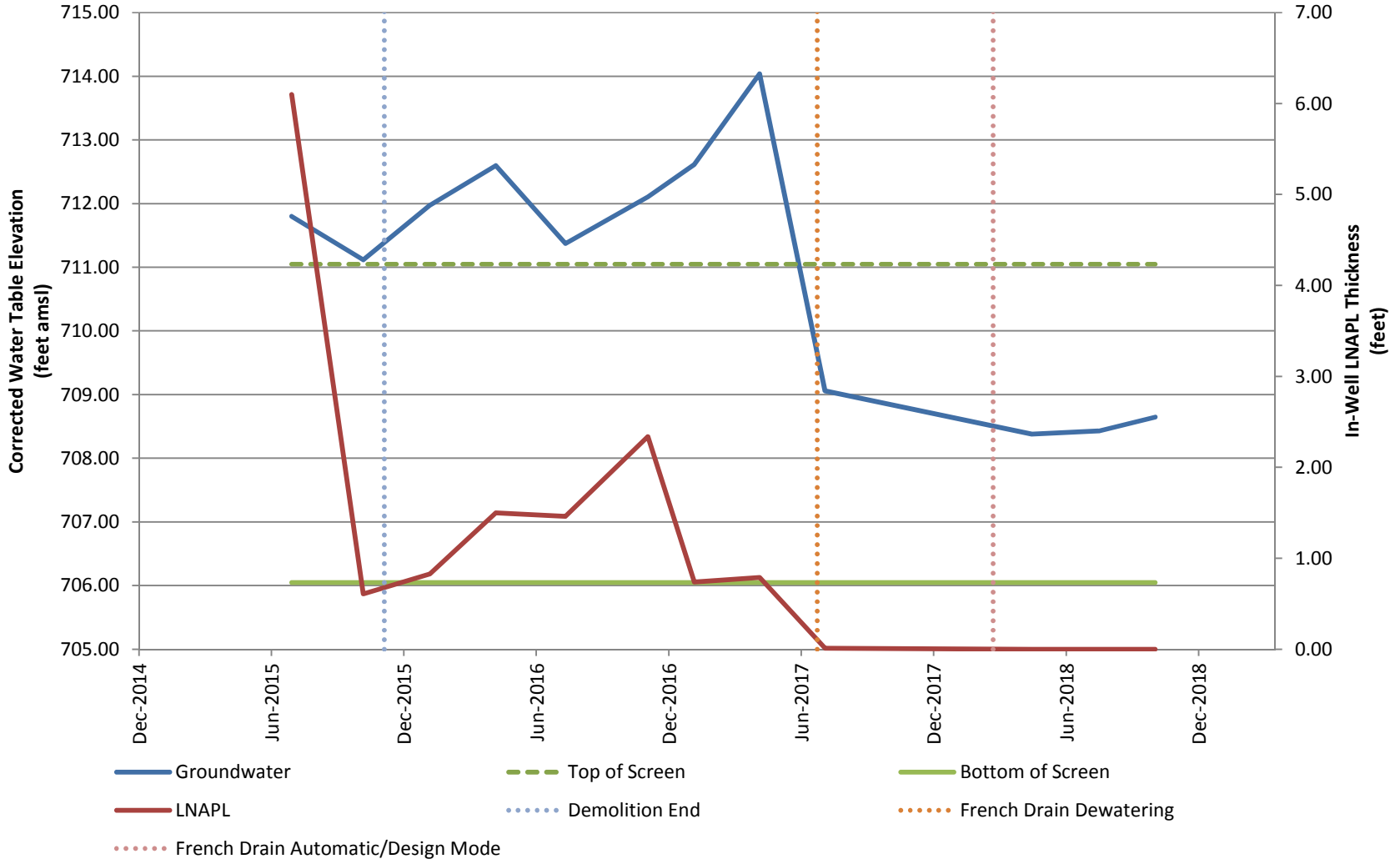
Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

Well Gauging Data Summary: 225M
RACER Willow Run Powertrain
Ypsilanti, Michigan

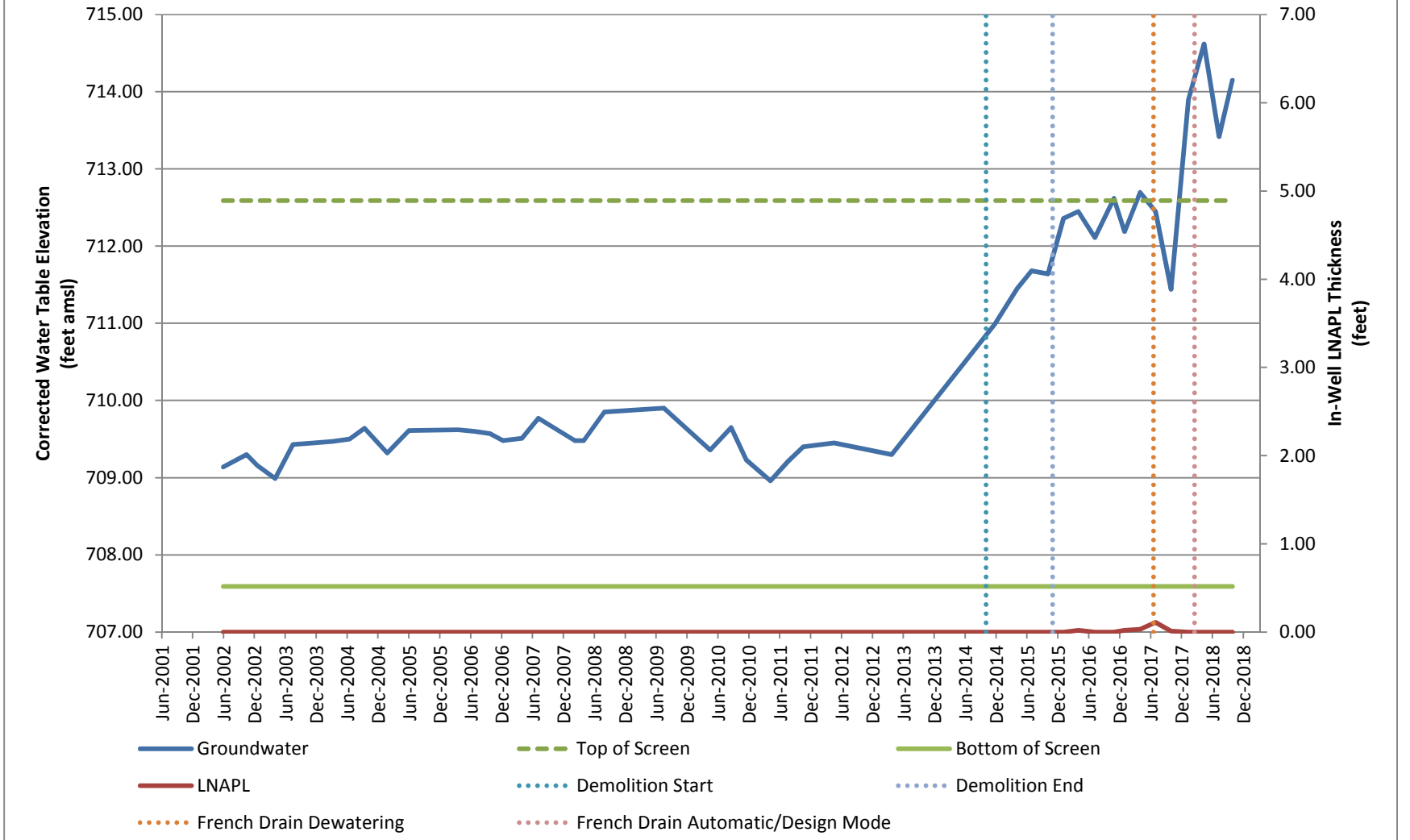


Note: Top of screen assumed based on a 5 ft screen length (from measured well depth)

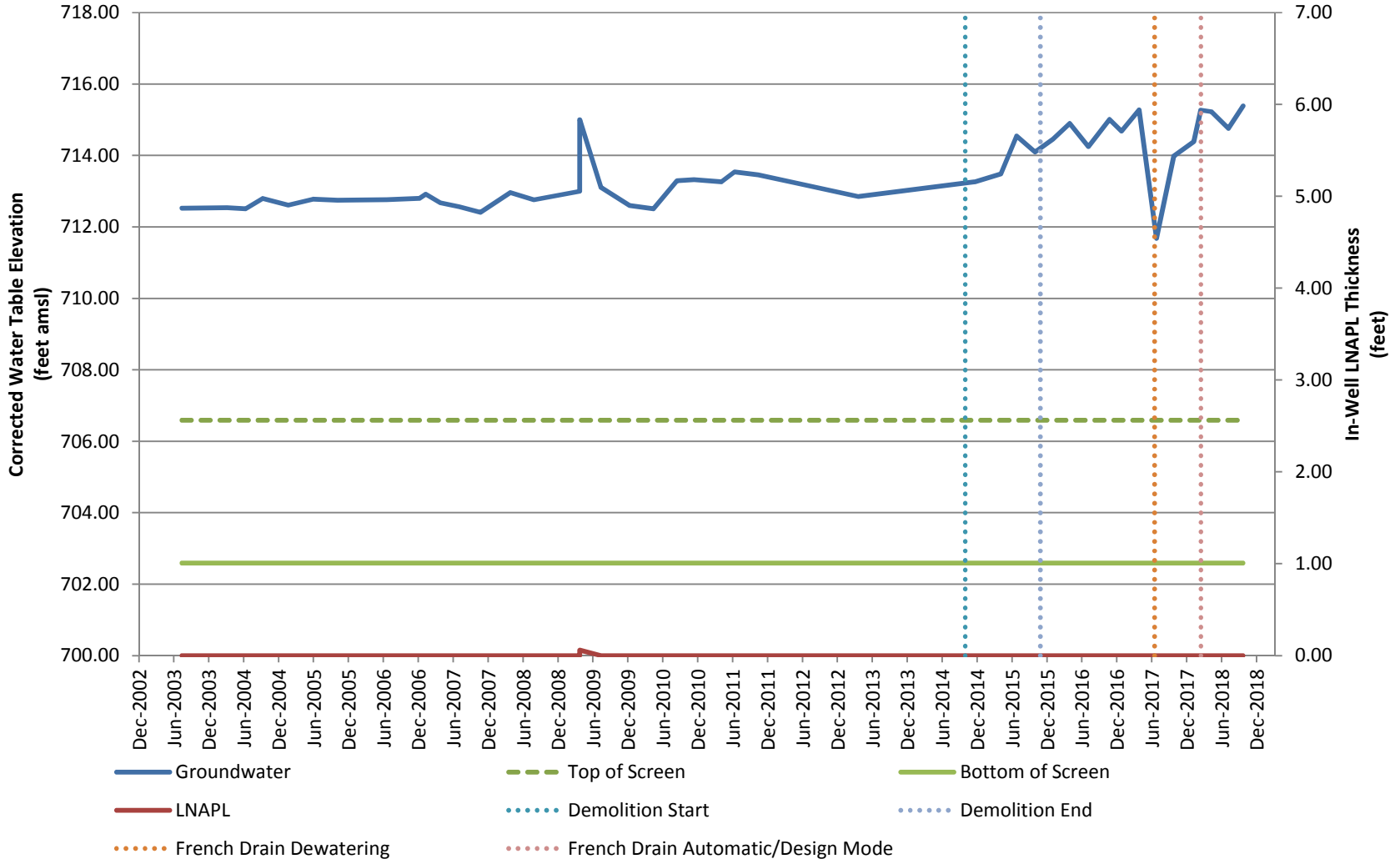
Well Gauging Data Summary: 228M
RACER Willow Run Powertrain
Ypsilanti, Michigan

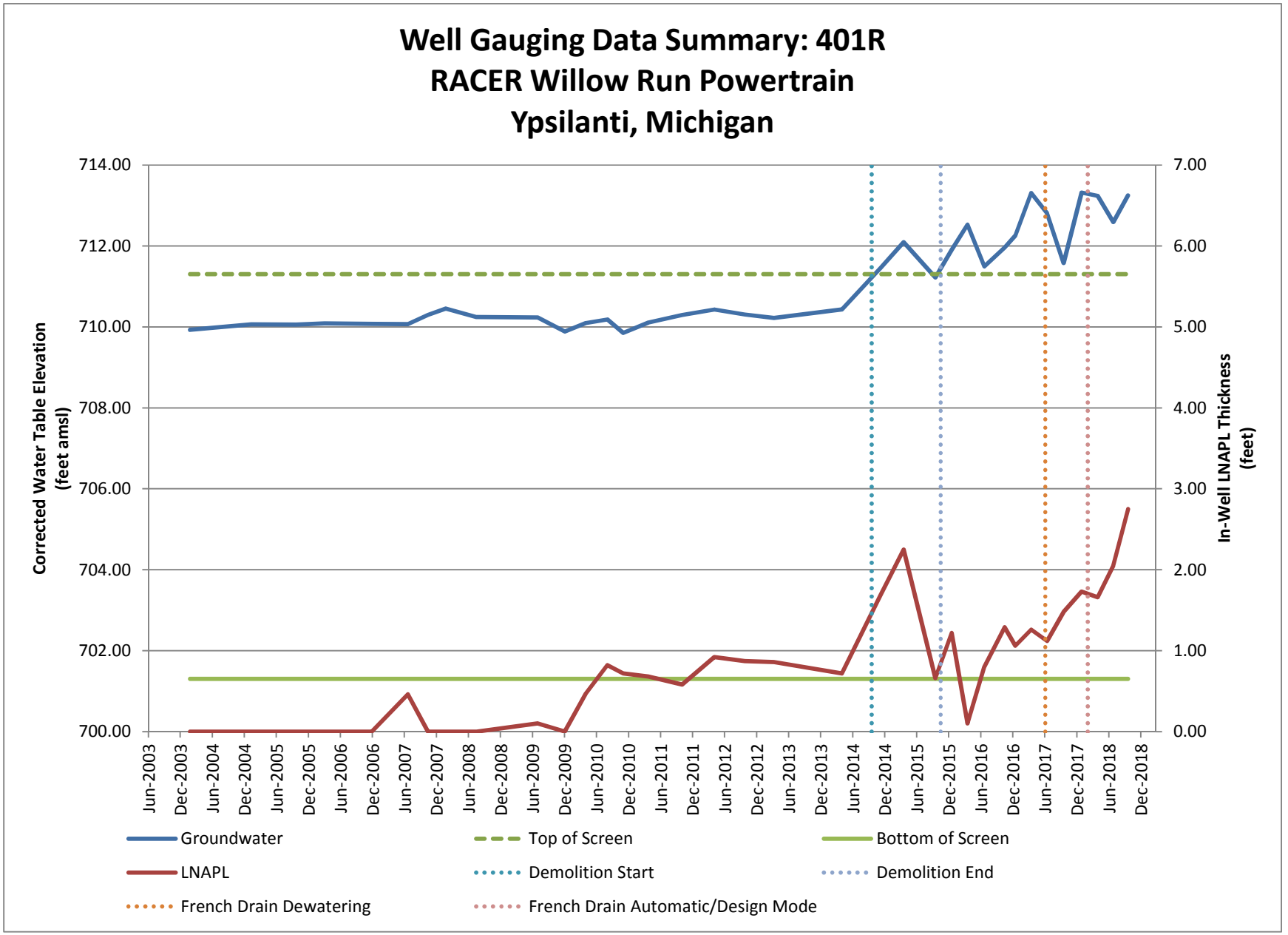


Well Gauging Data Summary: 312M
RACER Willow Run Powertrain
Ypsilanti, Michigan



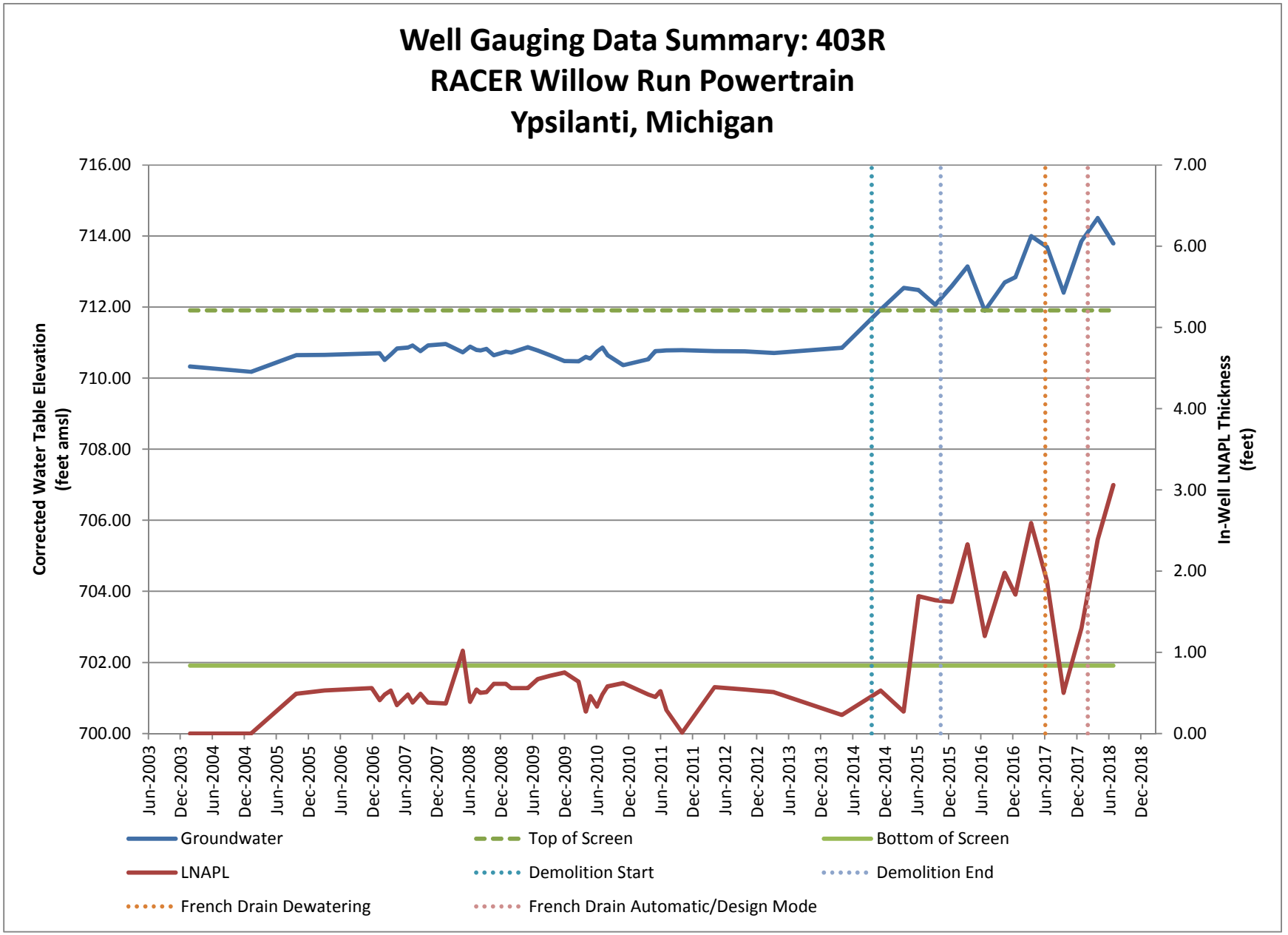
Well Gauging Data Summary: 401M-D
RACER Willow Run Powertrain
Ypsilanti, Michigan

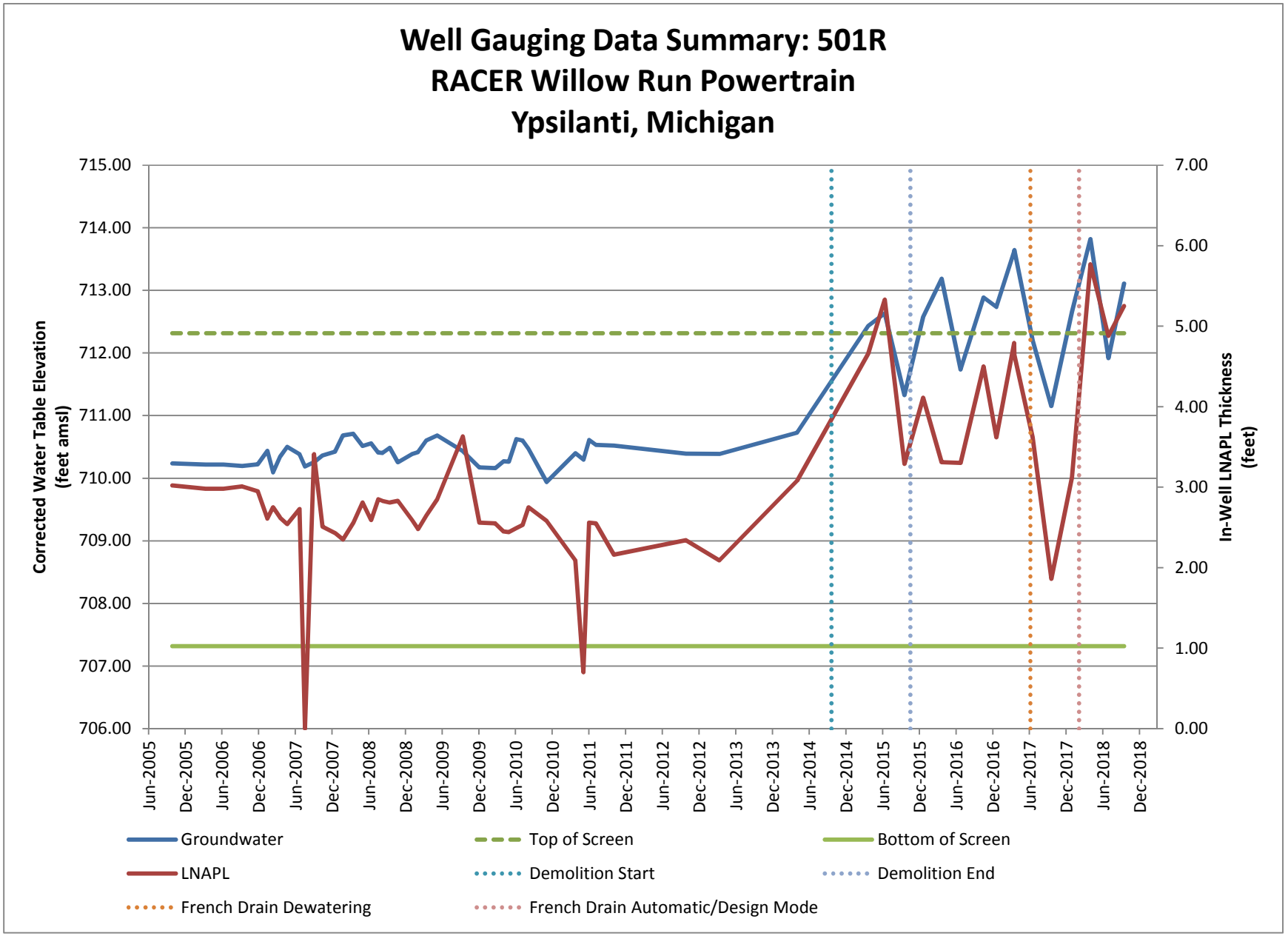


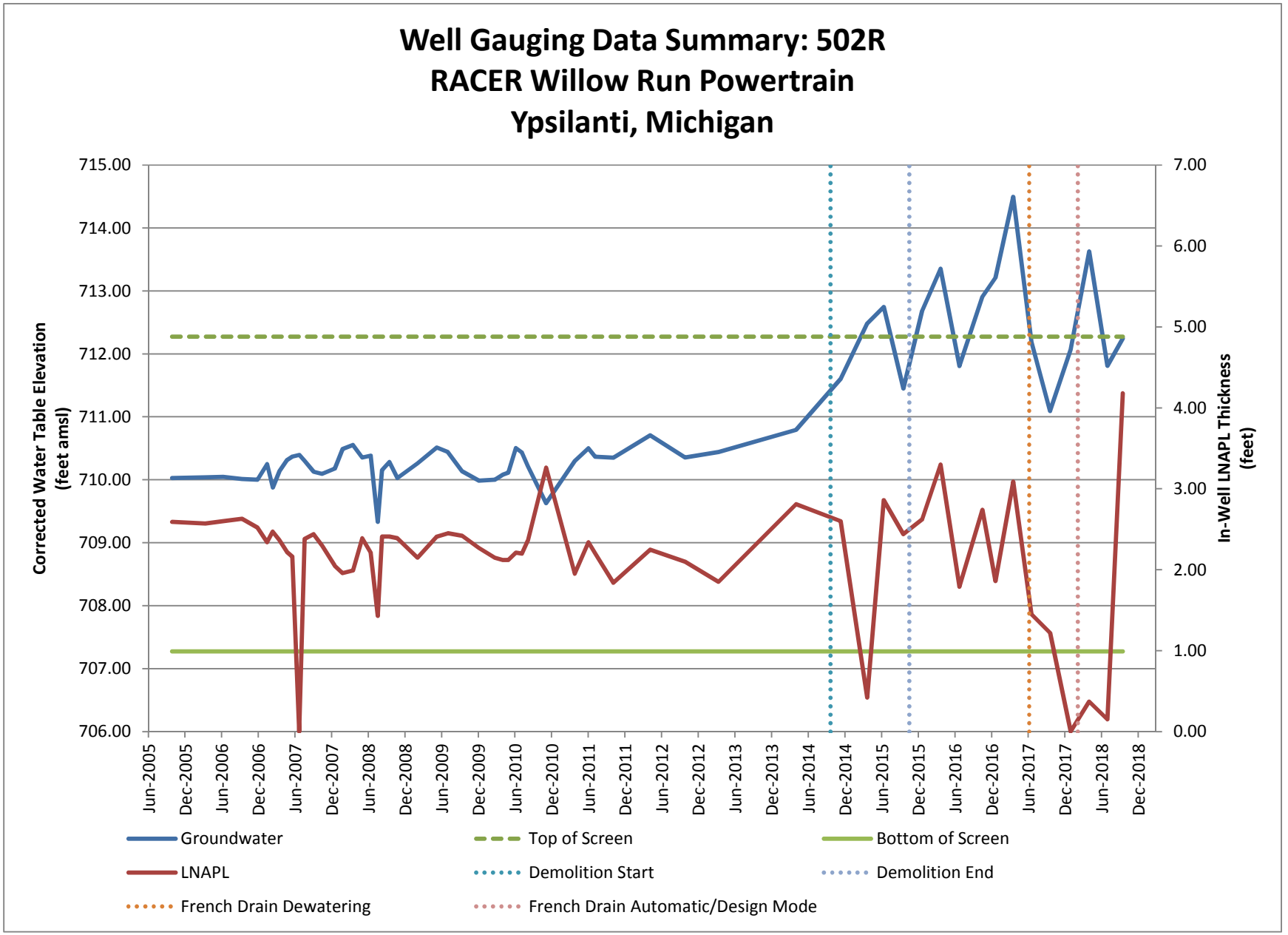

Well Gauging Data Summary: 401R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
714.00
712.00
710.00
708.00
706.00
704.00
702.00
700.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2003
Dec-2003
Jun-2004
Dec-2004
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
Dec-2008
Jun-2009
Dec-2009
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Jun-2011
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Jun-2012
Dec-2012
Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

Well Gauging Data Summary: 402R
RACER Willow Run Powertrain
Ypsilanti, Michigan




Well Gauging Data Summary: 403R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
716.00
714.00
712.00
710.00
708.00
706.00
704.00
702.00
700.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2003
Dec-2003
Jun-2004
Dec-2004
Jun-2005
Dec-2005
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Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

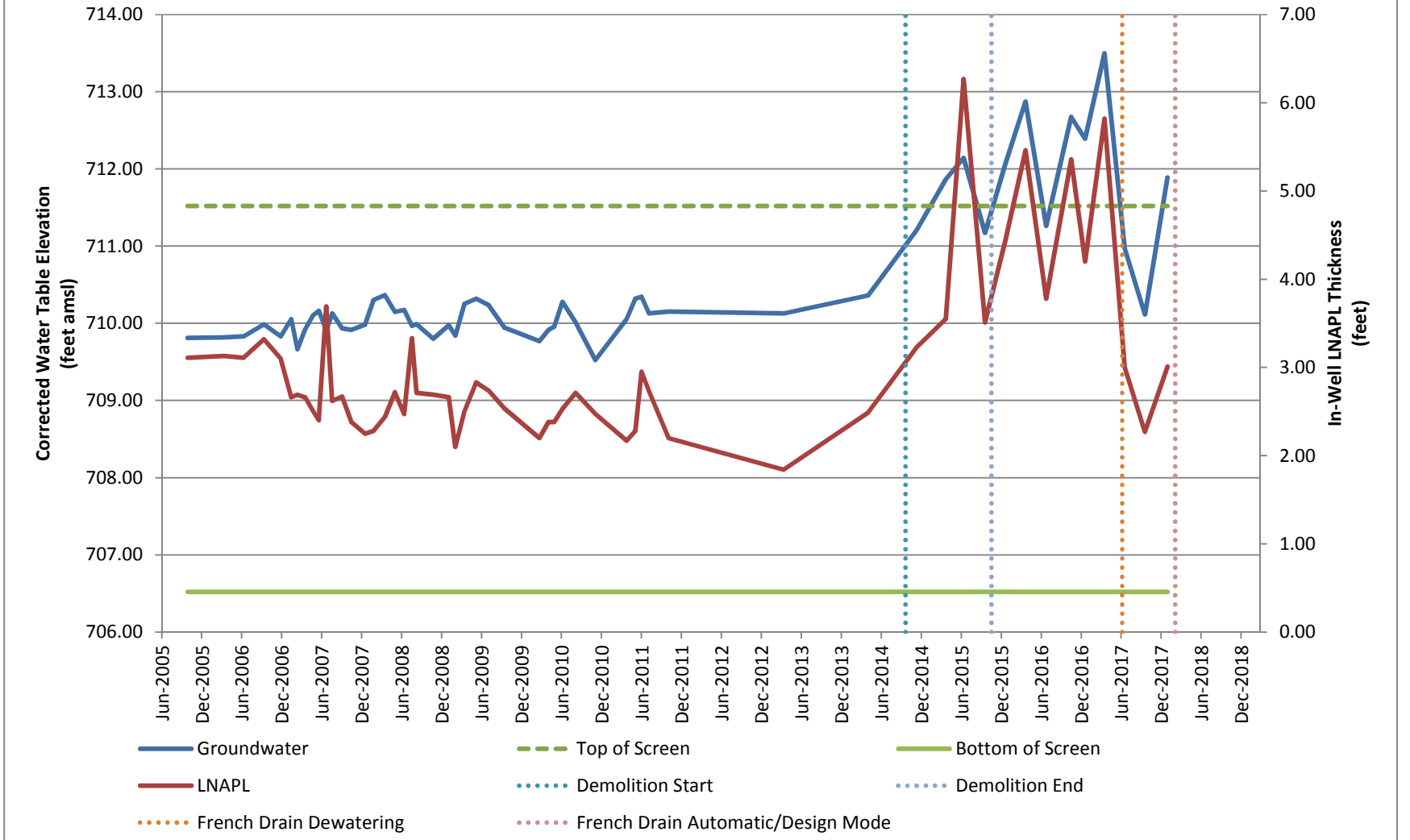

Well Gauging Data Summary: 501R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
715.00
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
706.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2005
Dec-2005
Jun-2006
Dec-2006
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Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

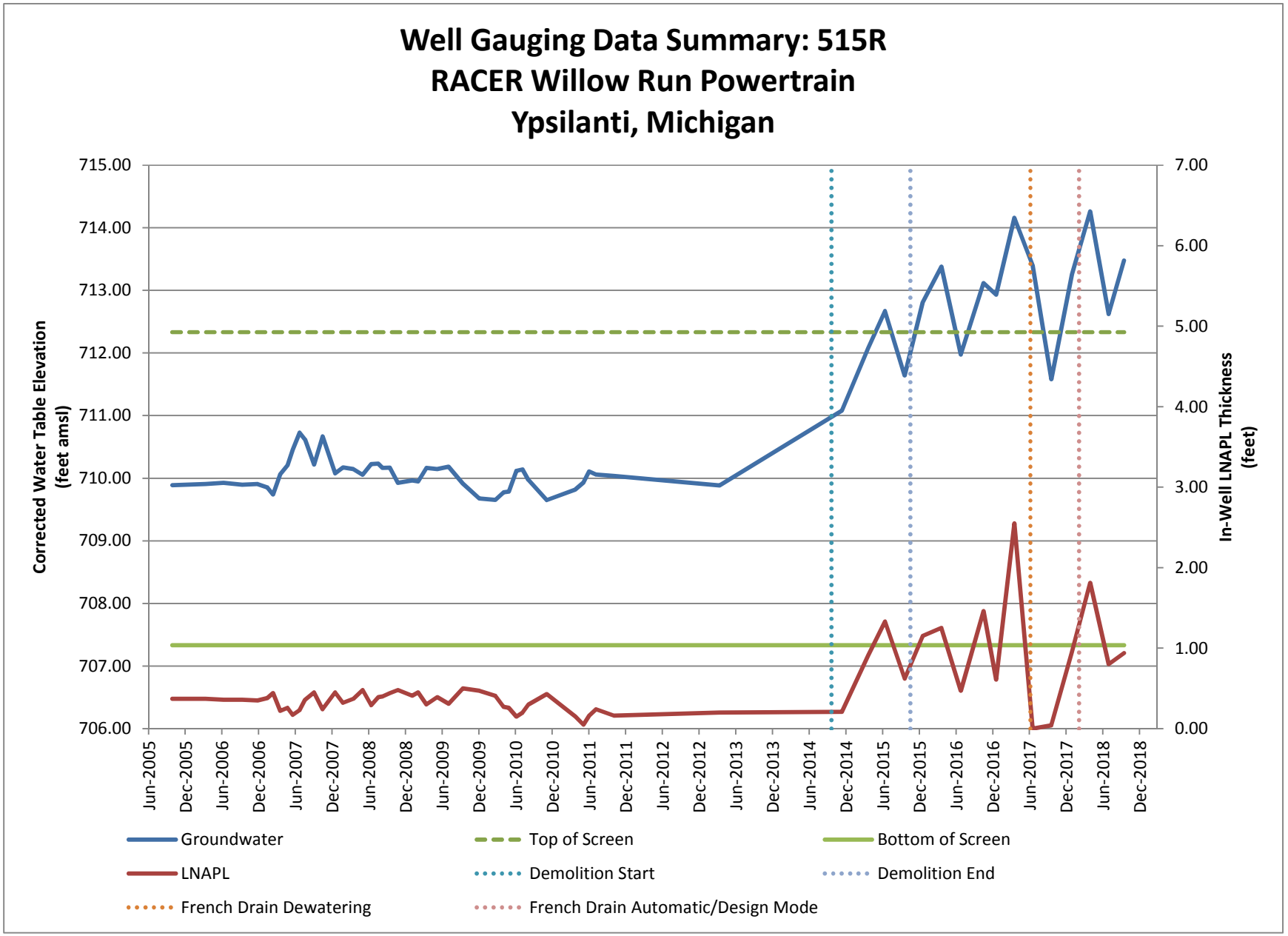

Well Gauging Data Summary: 502R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
715.00
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
706.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2005
Dec-2005
Jun-2006
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Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

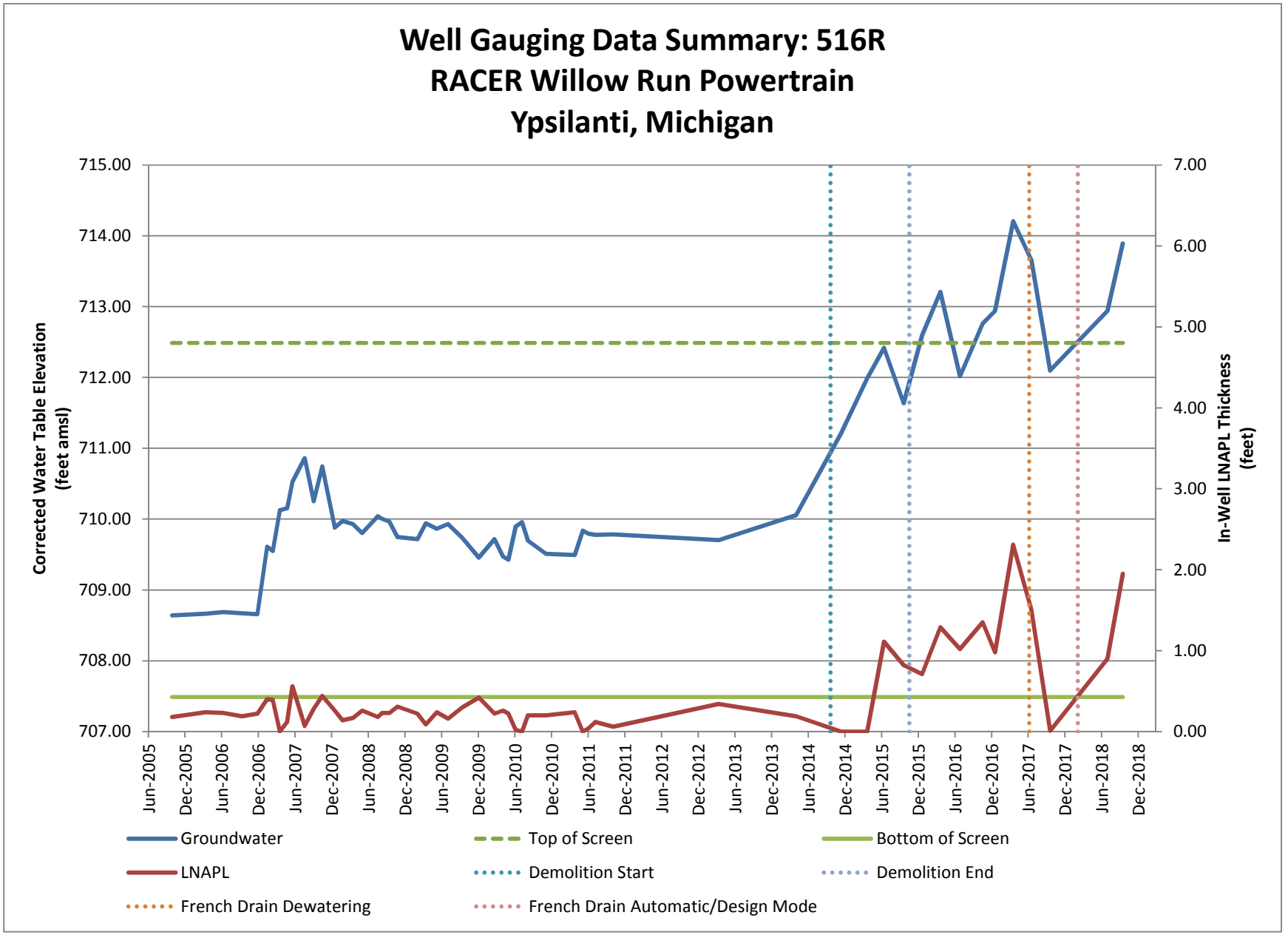
Well Gauging Data Summary: 503R
RACER Willow Run Powertrain
Ypsilanti, Michigan

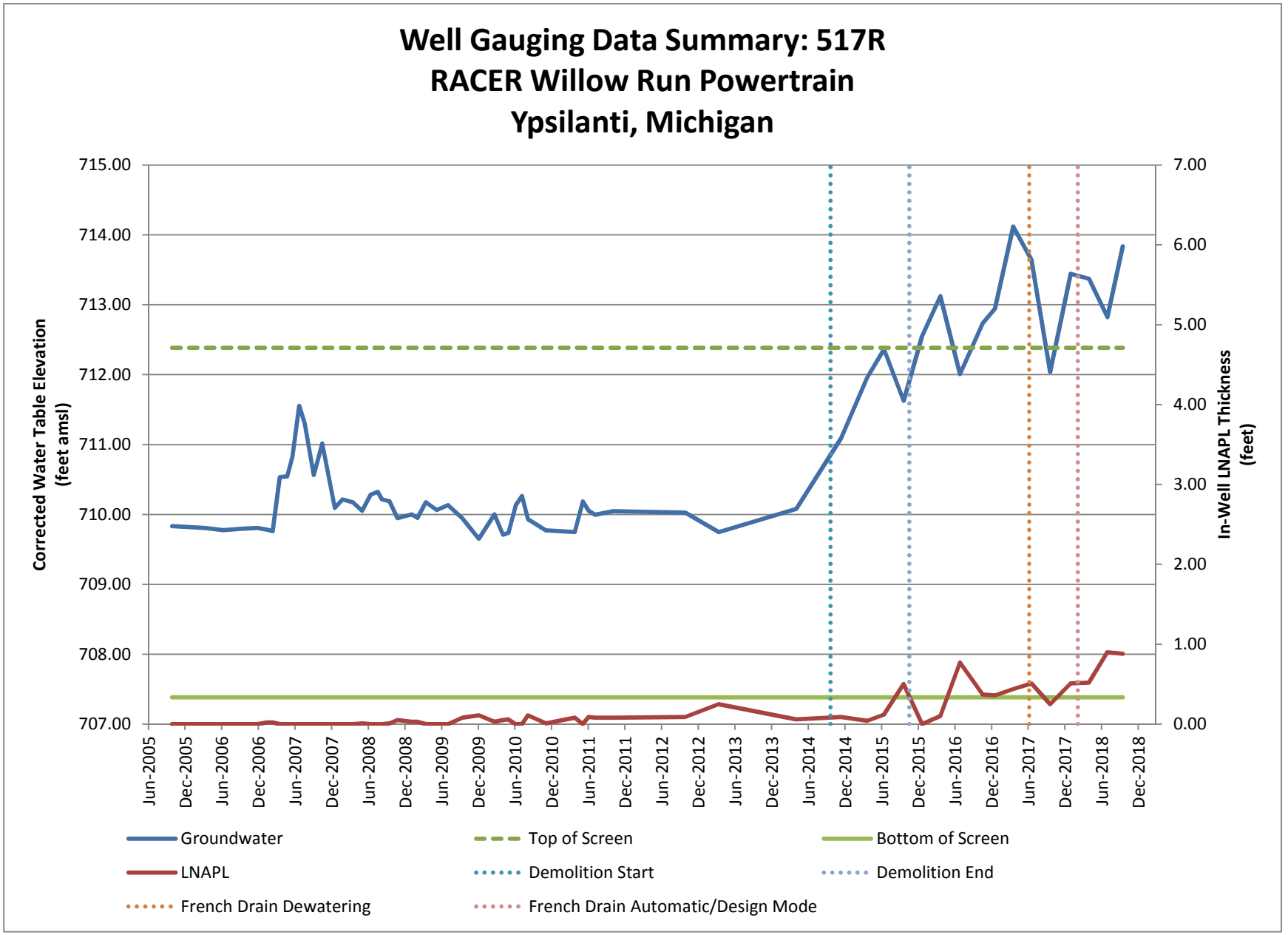


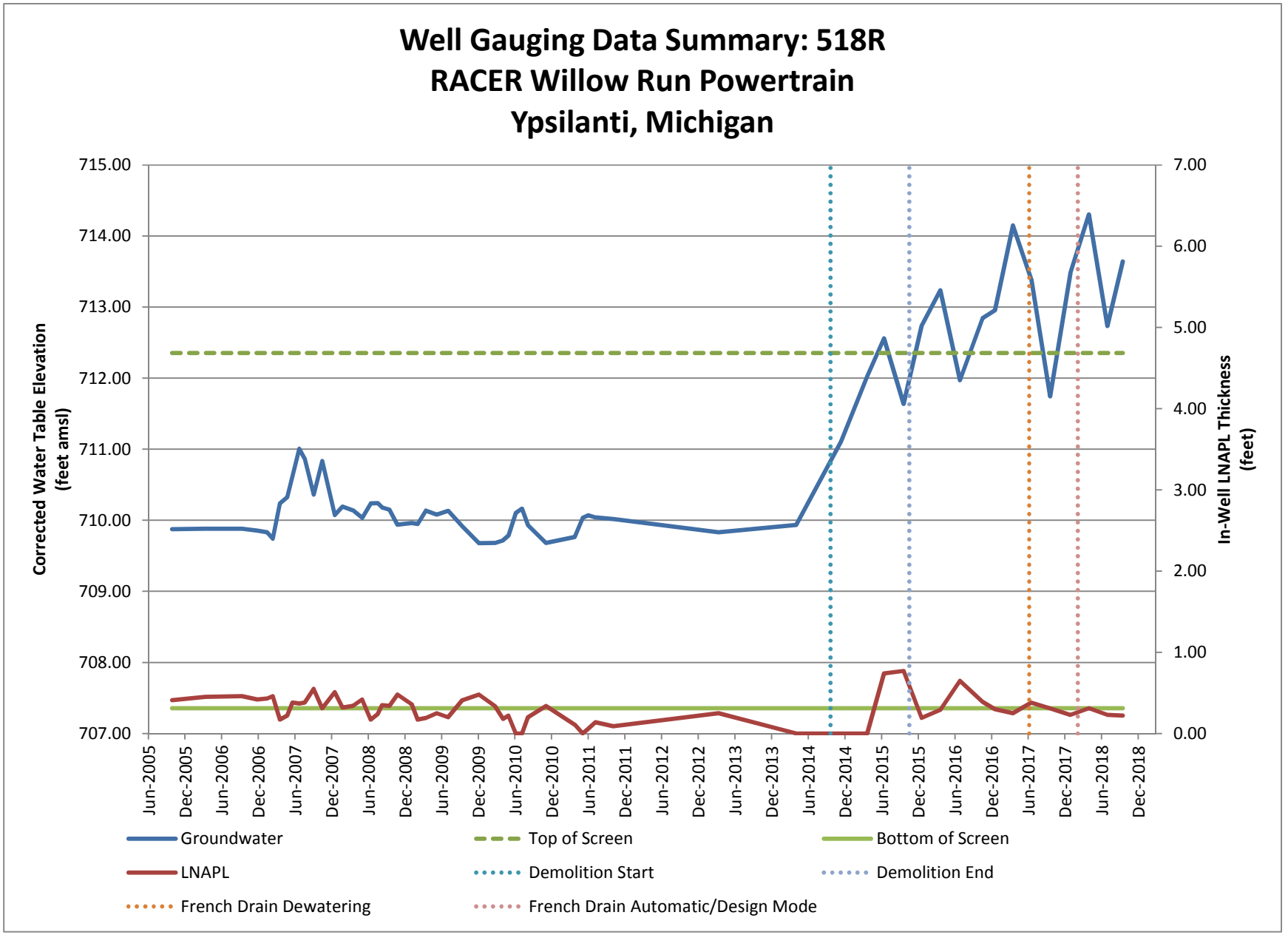
Well Gauging Data Summary: 505R
RACER Willow Run Powertrain
Ypsilanti, Michigan

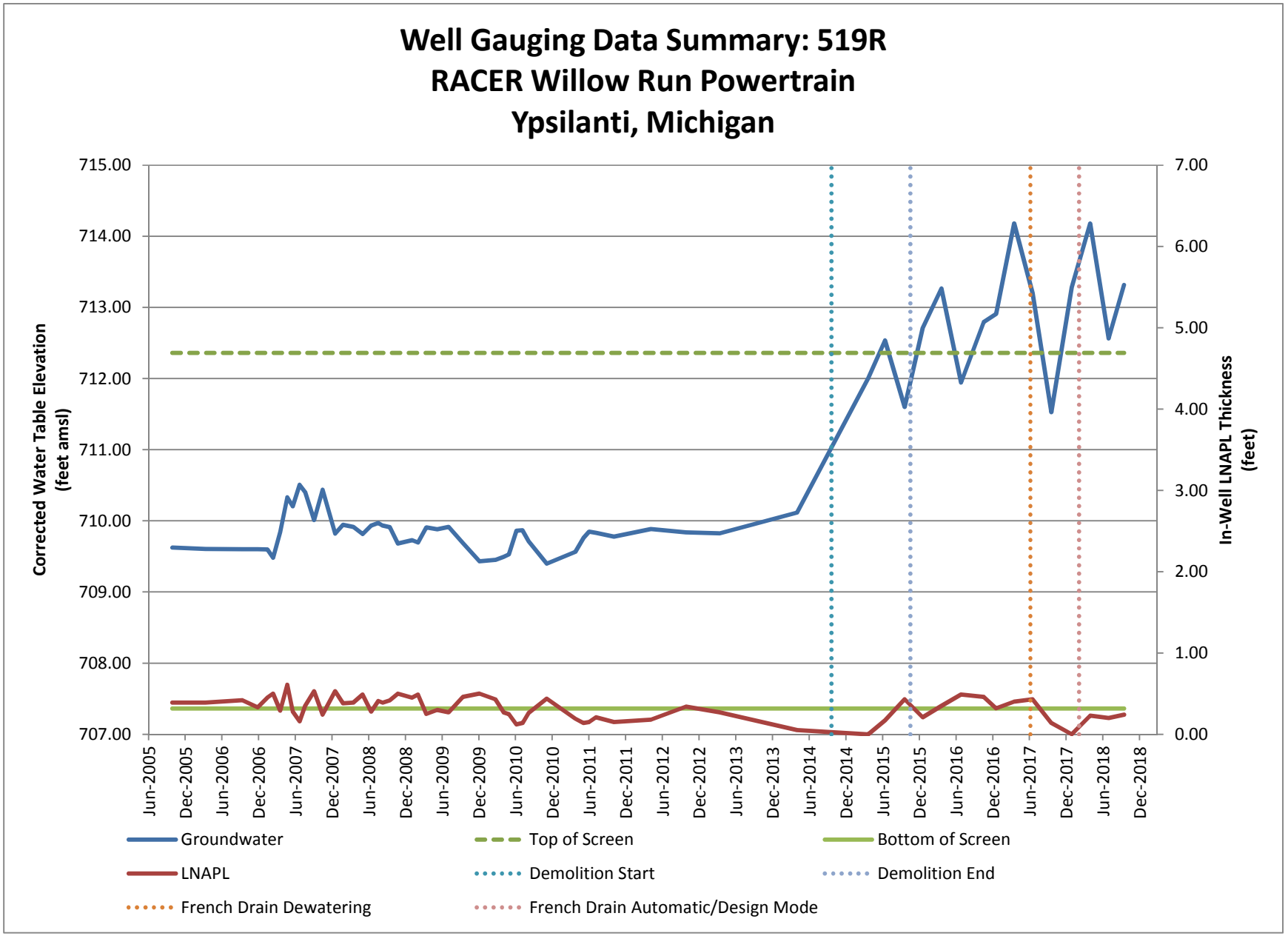


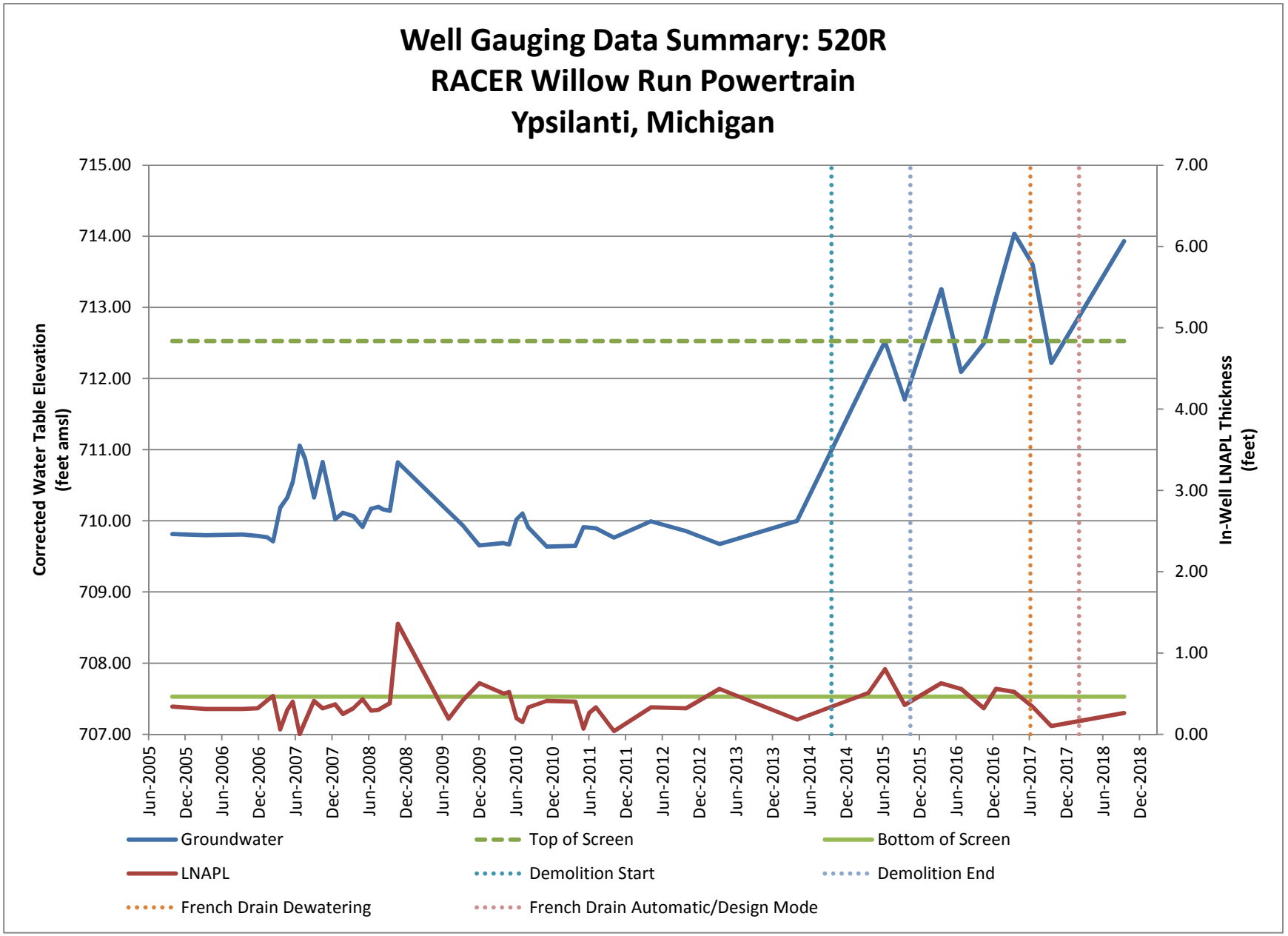

Well Gauging Data Summary: 515R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
715.00
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
706.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
Dec-2008
Jun-2009
Dec-2009
Jun-2010
Dec-2010
Jun-2011
Dec-2011
Jun-2012
Dec-2012
Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

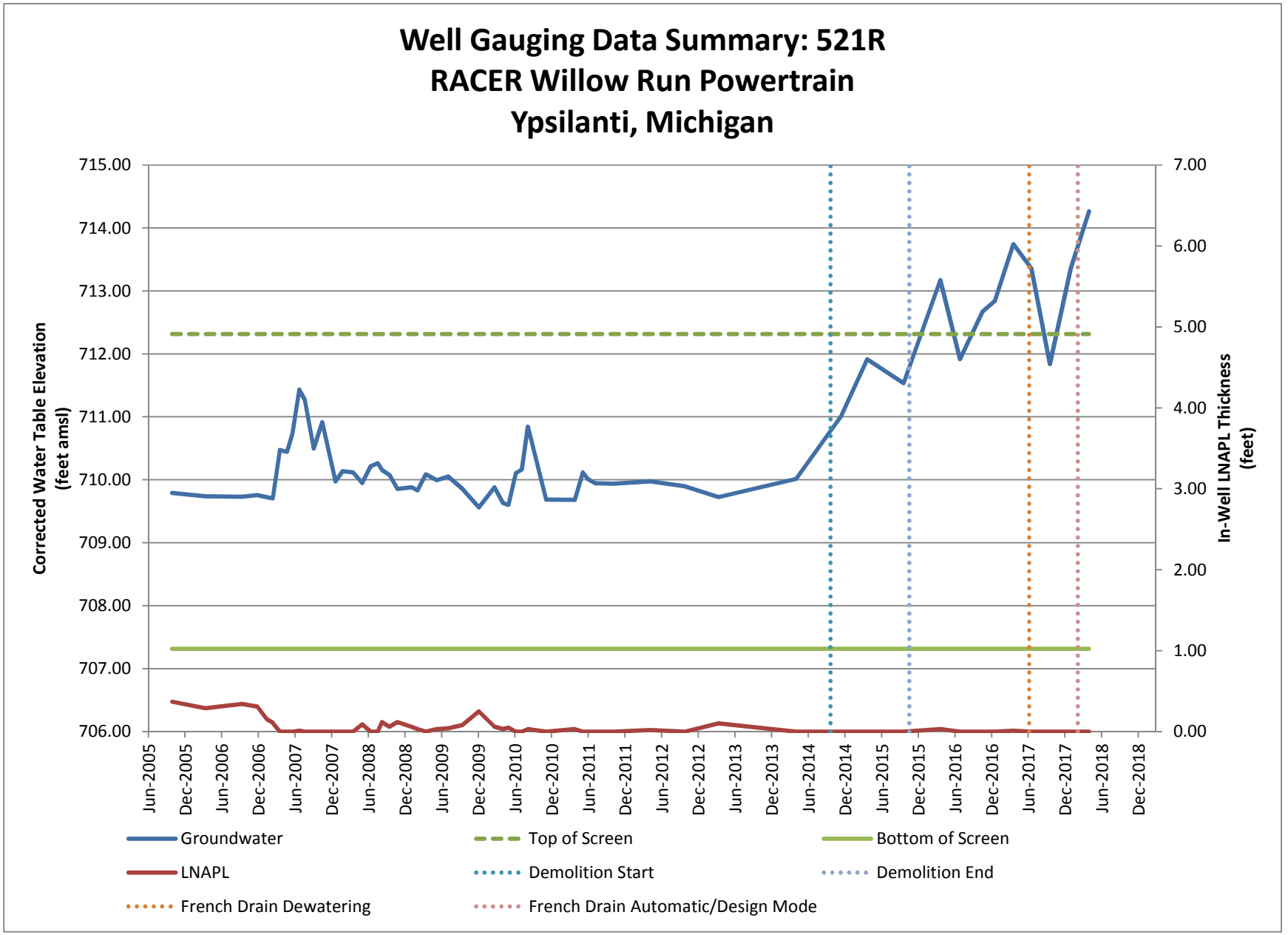

Well Gauging Data Summary: 516R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
715.00
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
Dec-2008
Jun-2009
Dec-2009
Jun-2010
Dec-2010
Jun-2011
Dec-2011
Jun-2012
Dec-2012
Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

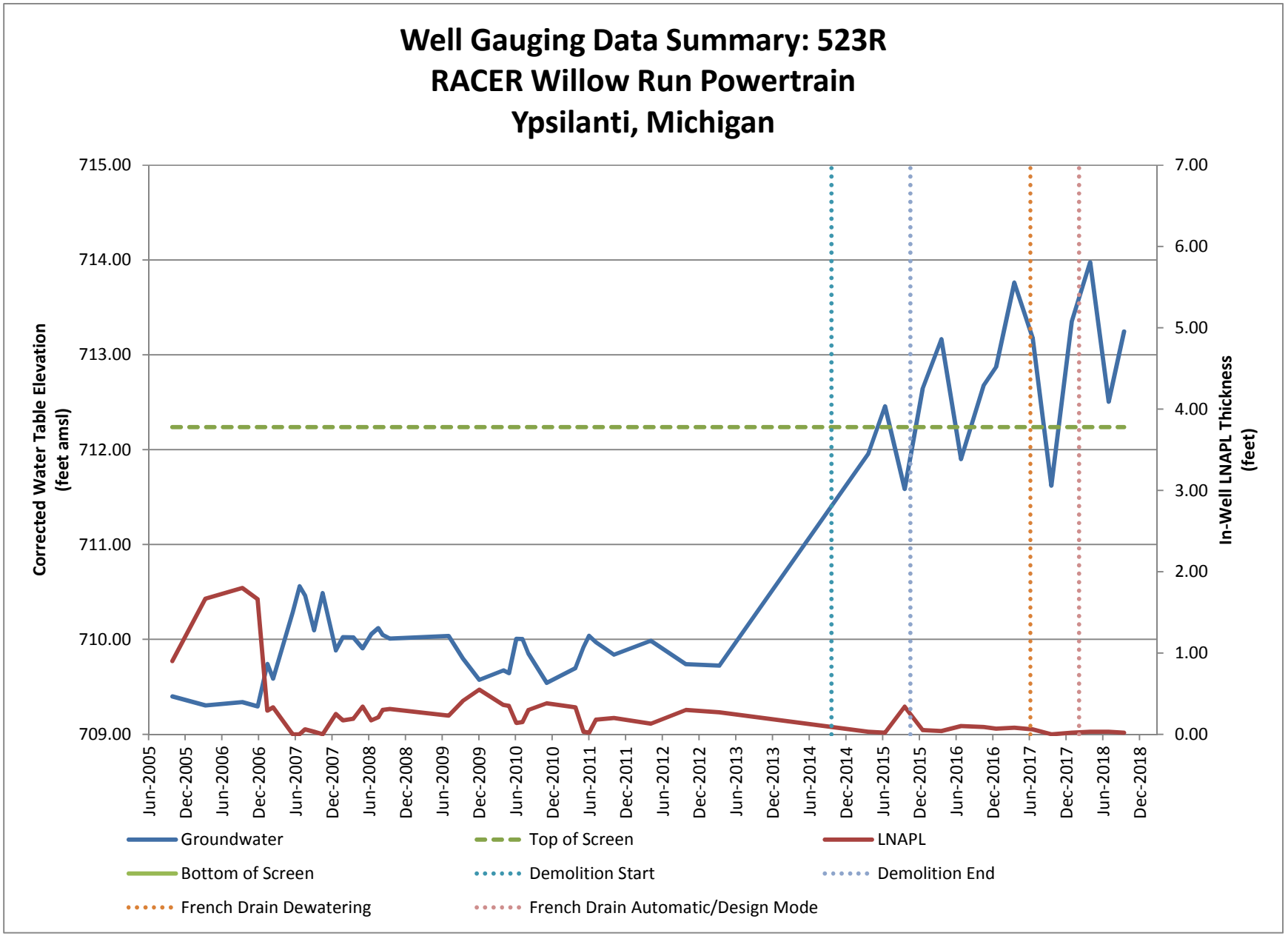

Well Gauging Data Summary: 517R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
715.00
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
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Jun-2008
Dec-2008
Jun-2009
Dec-2009
Jun-2010
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Jun-2011
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Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

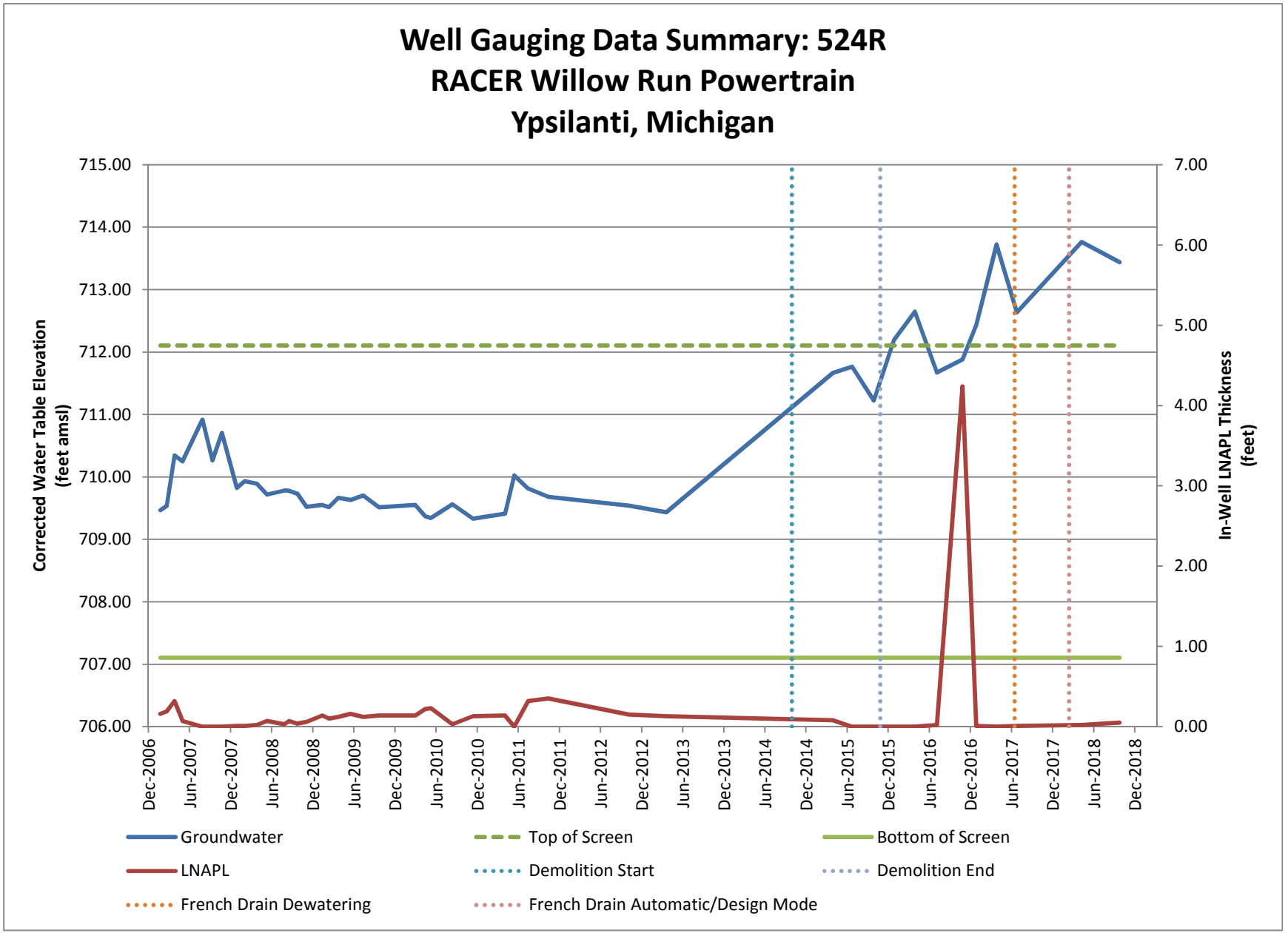

Well Gauging Data Summary: 518R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
715.00
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
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Jun-2011
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Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

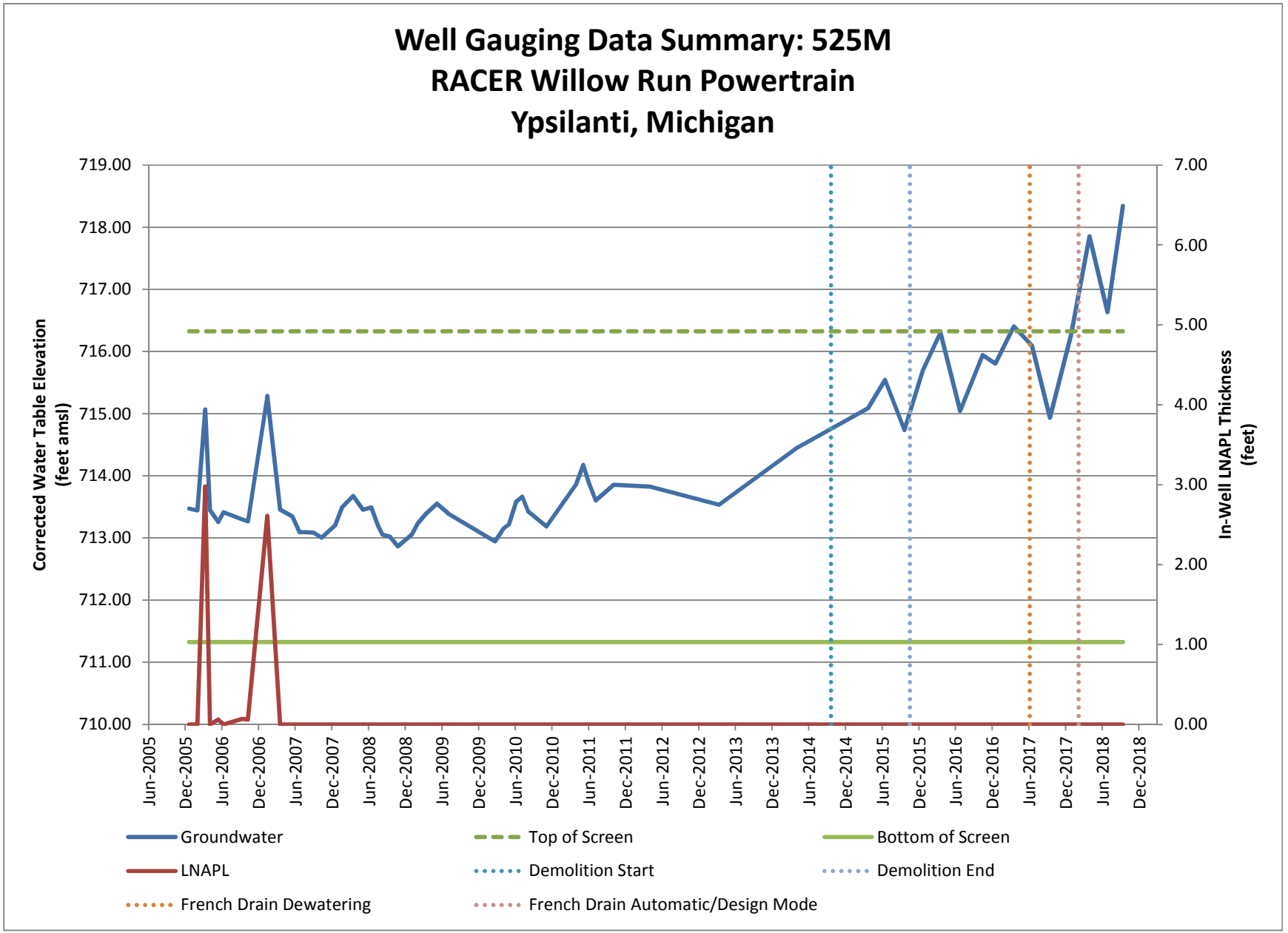

Well Gauging Data Summary: 519R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
715.00
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
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Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

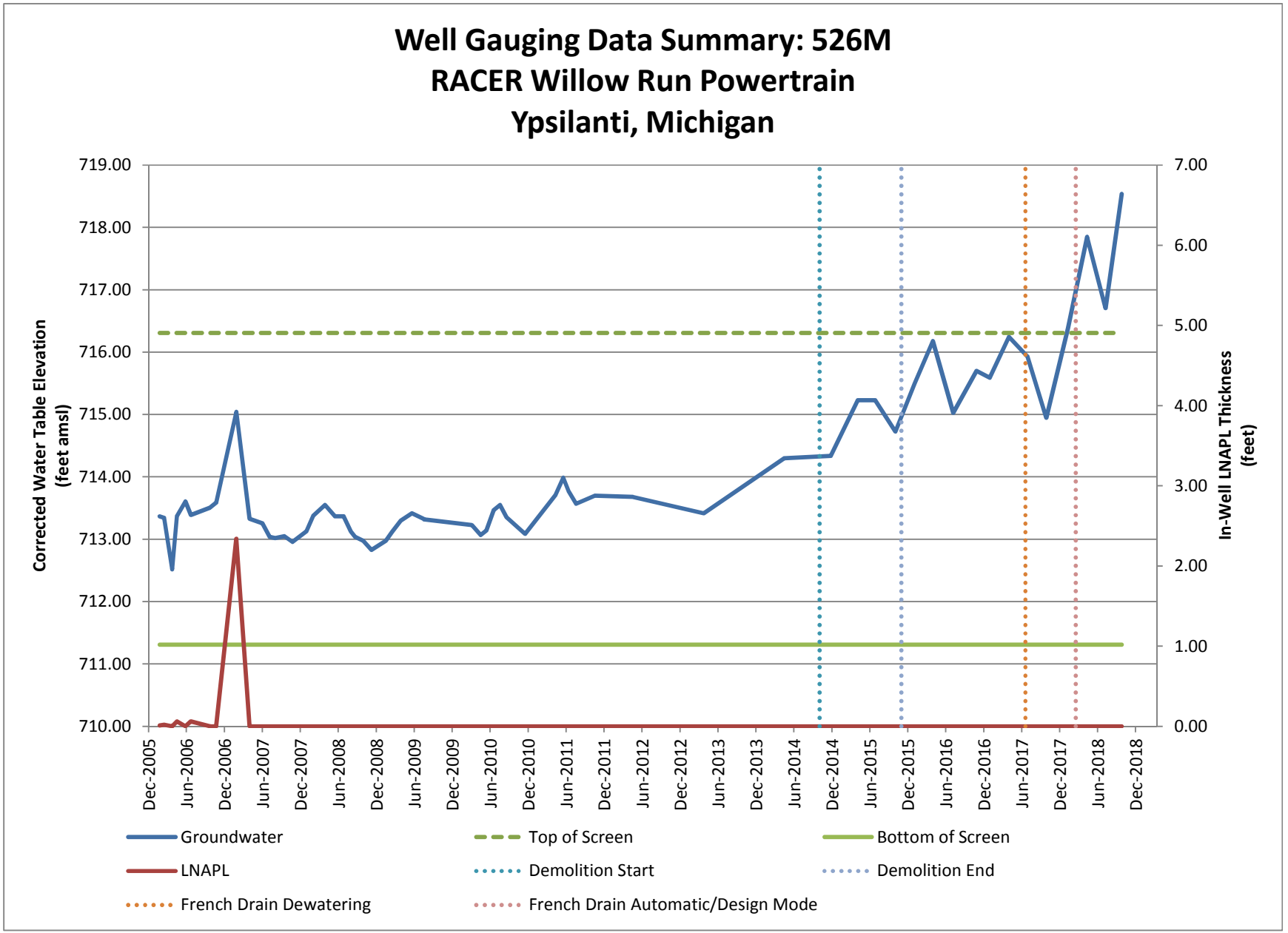

Well Gauging Data Summary: 520R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
715.00
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
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Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

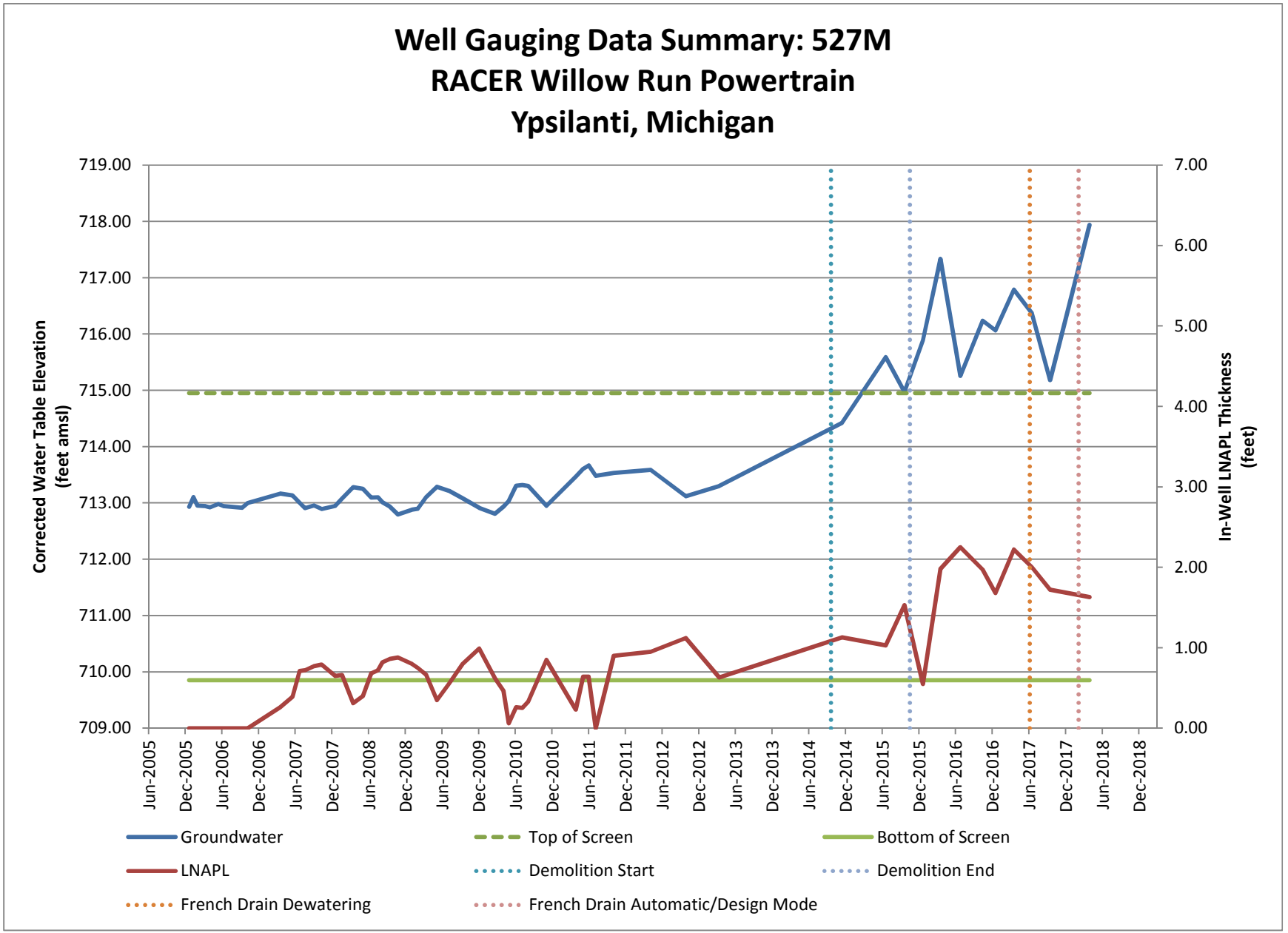

Well Gauging Data Summary: 521R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
715.00
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
706.00
7.00
6.00
5.00
4.00
3.00
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Jun-2005
Dec-2005
Jun-2006
Dec-2006
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Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

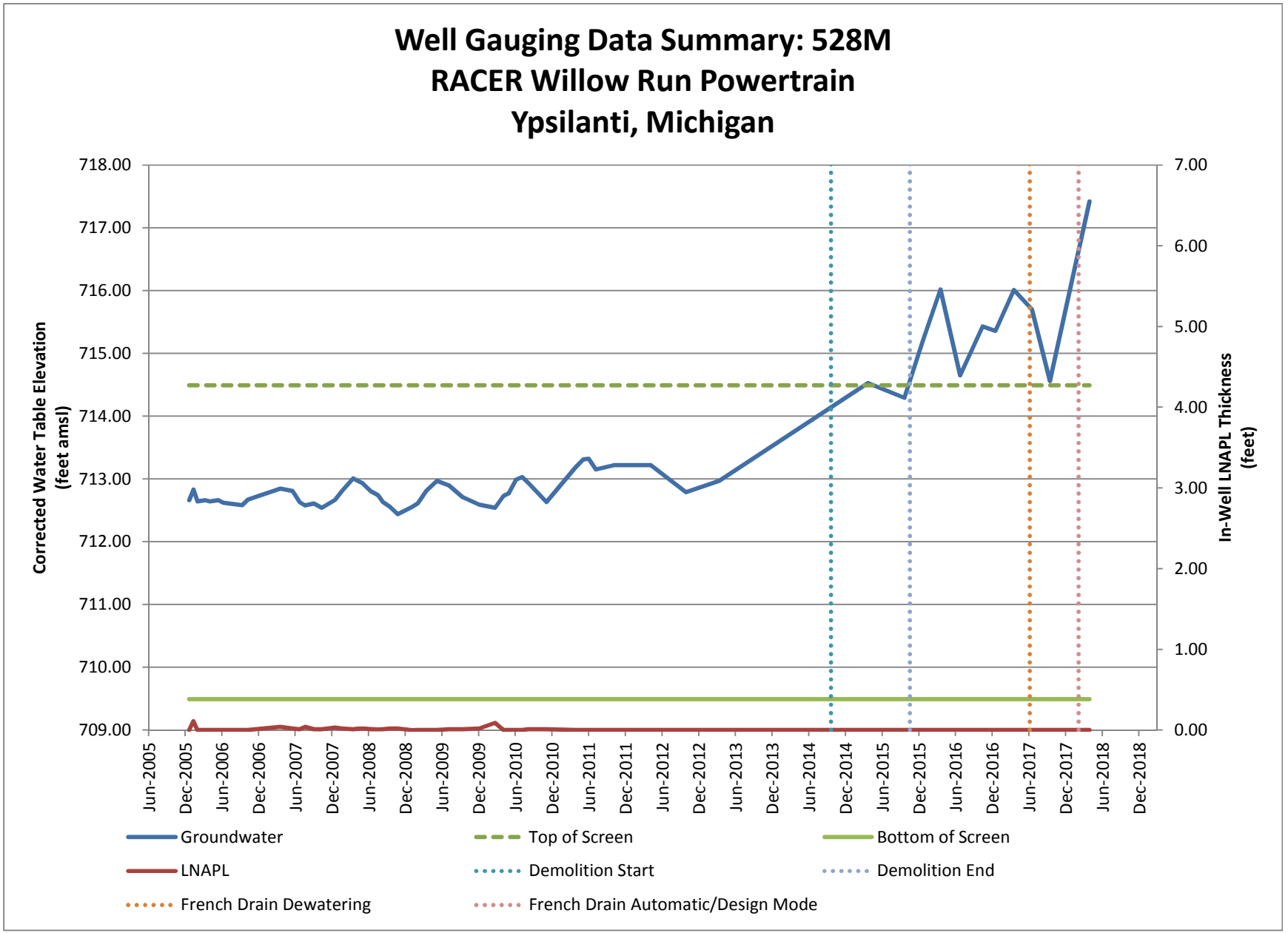

Well Gauging Data Summary: 523R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
715.00
714.00
713.00
712.00
711.00
710.00
709.00
7.00
6.00
5.00
4.00
3.00
2.00
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Jun-2005
Dec-2005
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Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
LNAPL
Bottom of Screen
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

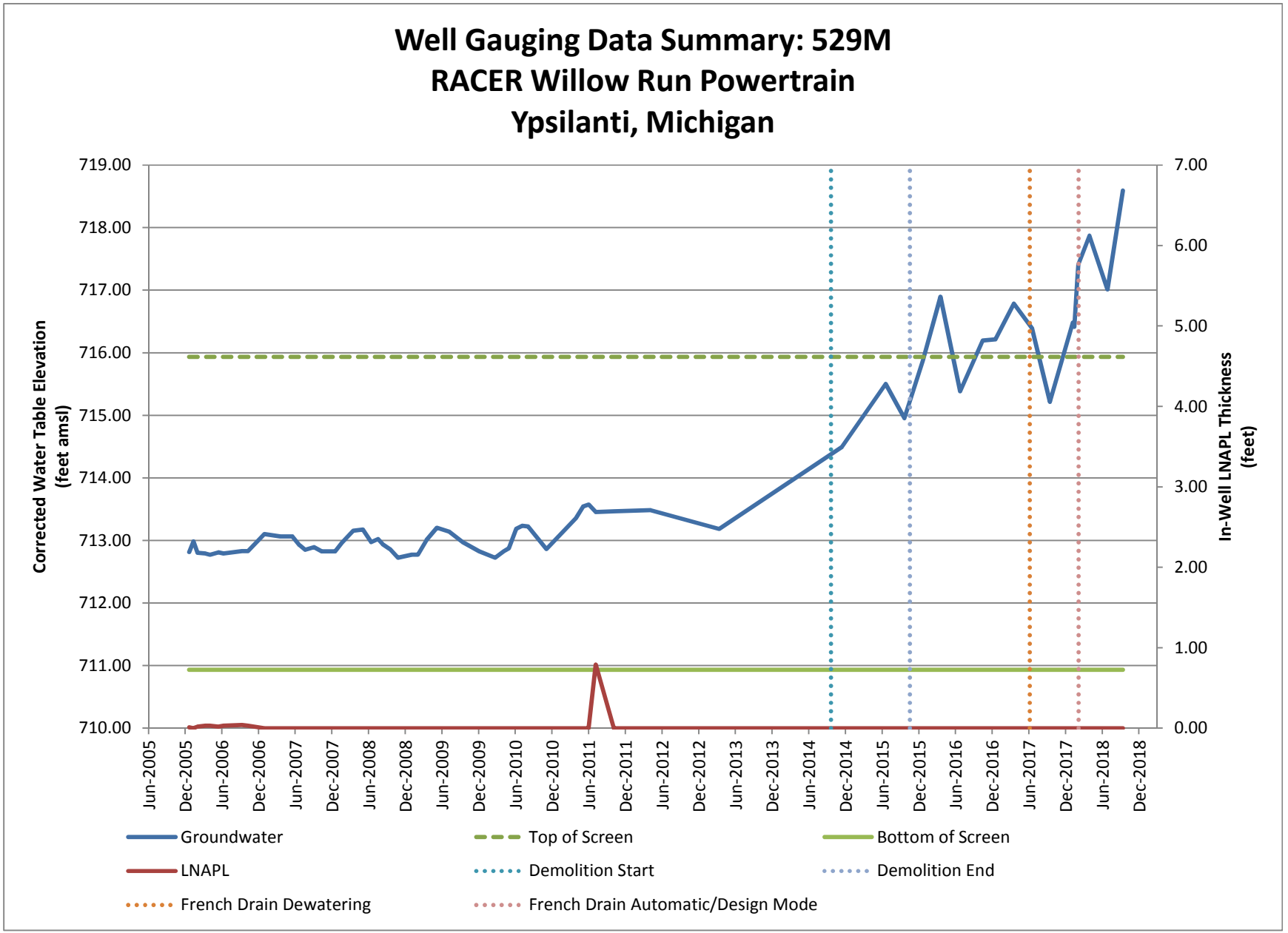

Well Gauging Data Summary: 524R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
715.00
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
706.00
7.00
6.00
5.00
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Dec-2006
Jun-2007
Dec-2007
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Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

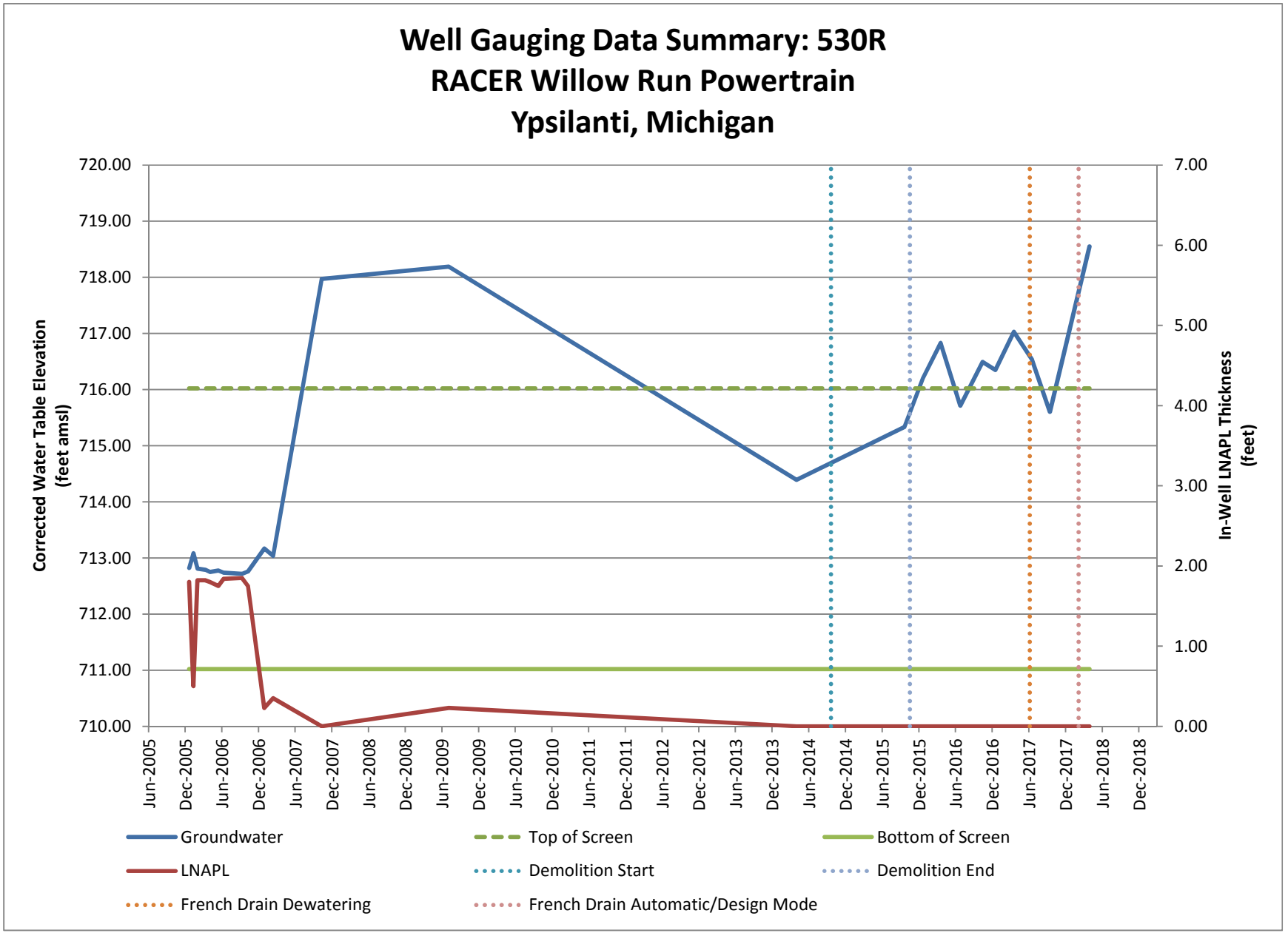

Well Gauging Data Summary: 525M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
719.00
718.00
717.00
716.00
715.00
714.00
713.00
712.00
711.00
710.00
7.00
6.00
5.00
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0.00
Jun-2005
Dec-2005
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Jun-2015
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Jun-2016
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Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

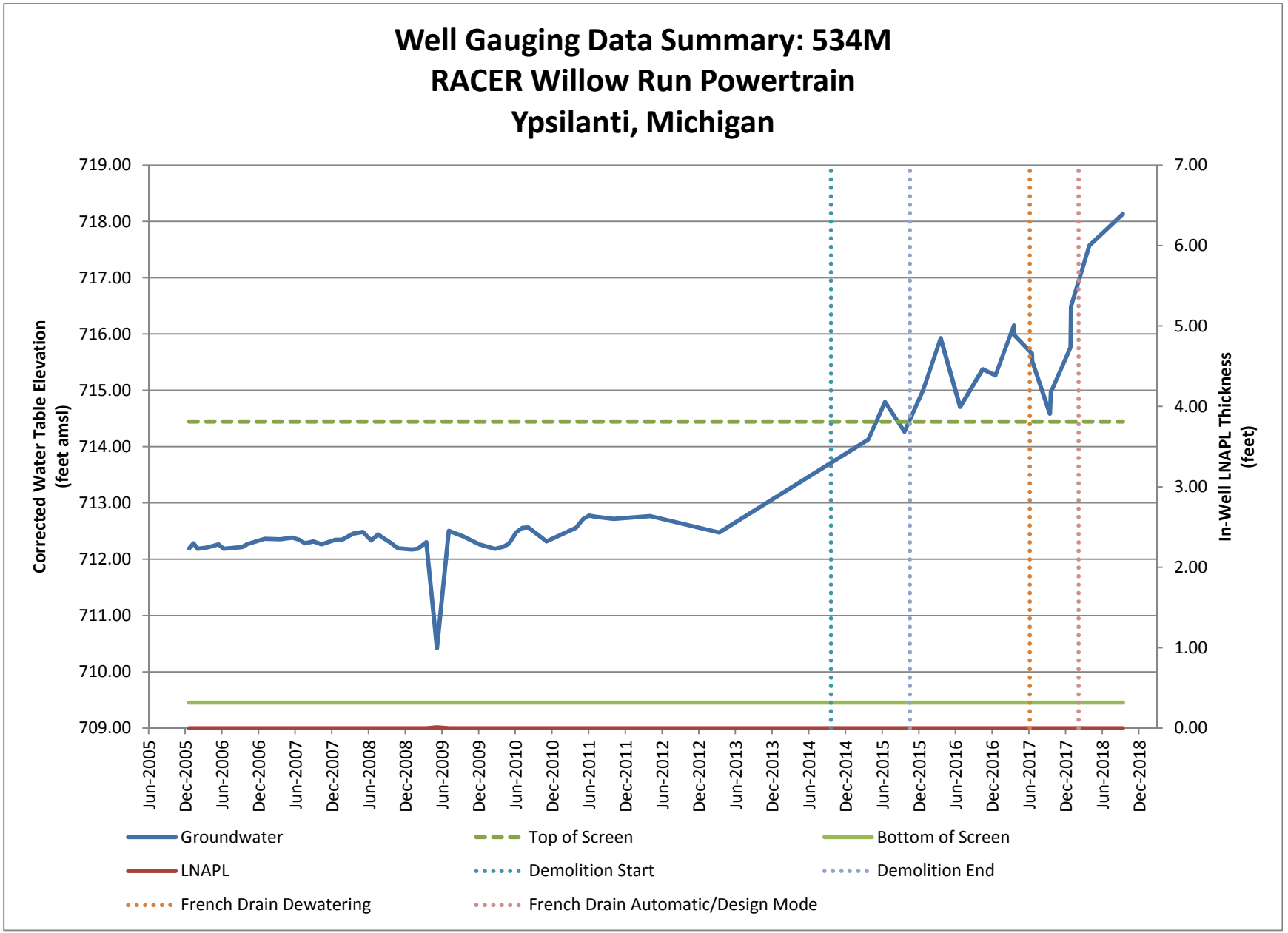

Well Gauging Data Summary: 526M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
719.00
718.00
717.00
716.00
715.00
714.00
713.00
712.00
711.00
710.00
7.00
6.00
5.00
4.00
3.00
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1.00
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Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
Dec-2008
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Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

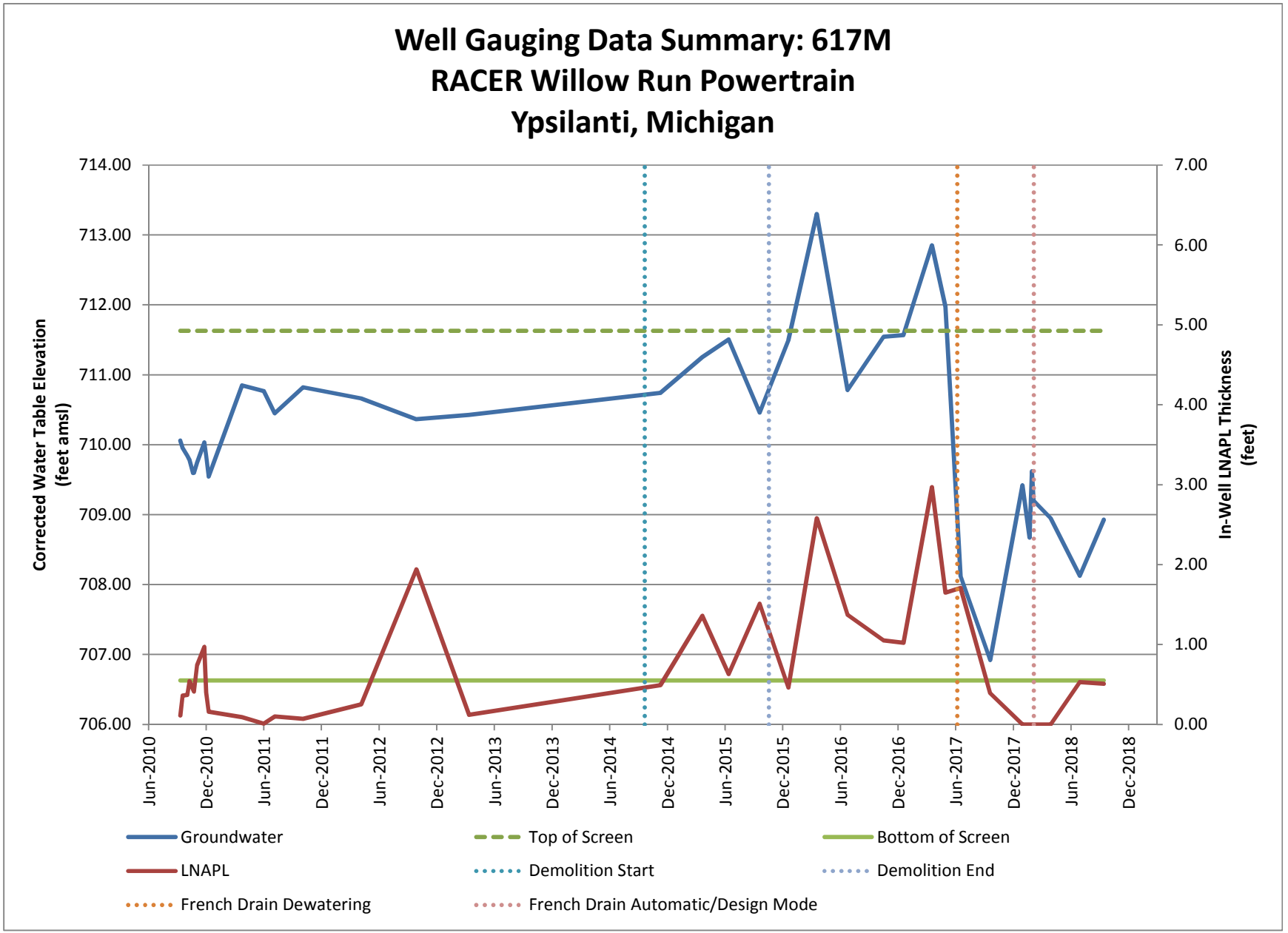

Well Gauging Data Summary: 527M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
719.00
718.00
717.00
716.00
715.00
714.00
713.00
712.00
711.00
710.00
709.00
7.00
6.00
5.00
4.00
3.00
2.00
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Jun-2005
Dec-2005
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Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode


Well Gauging Data Summary: 528M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
718.00
717.00
716.00
715.00
714.00
713.00
712.00
711.00
710.00
709.00
7.00
6.00
5.00
4.00
3.00
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Dec-2005
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Jun-2016
Dec-2016
Jun-2017
Dec-2017
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Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

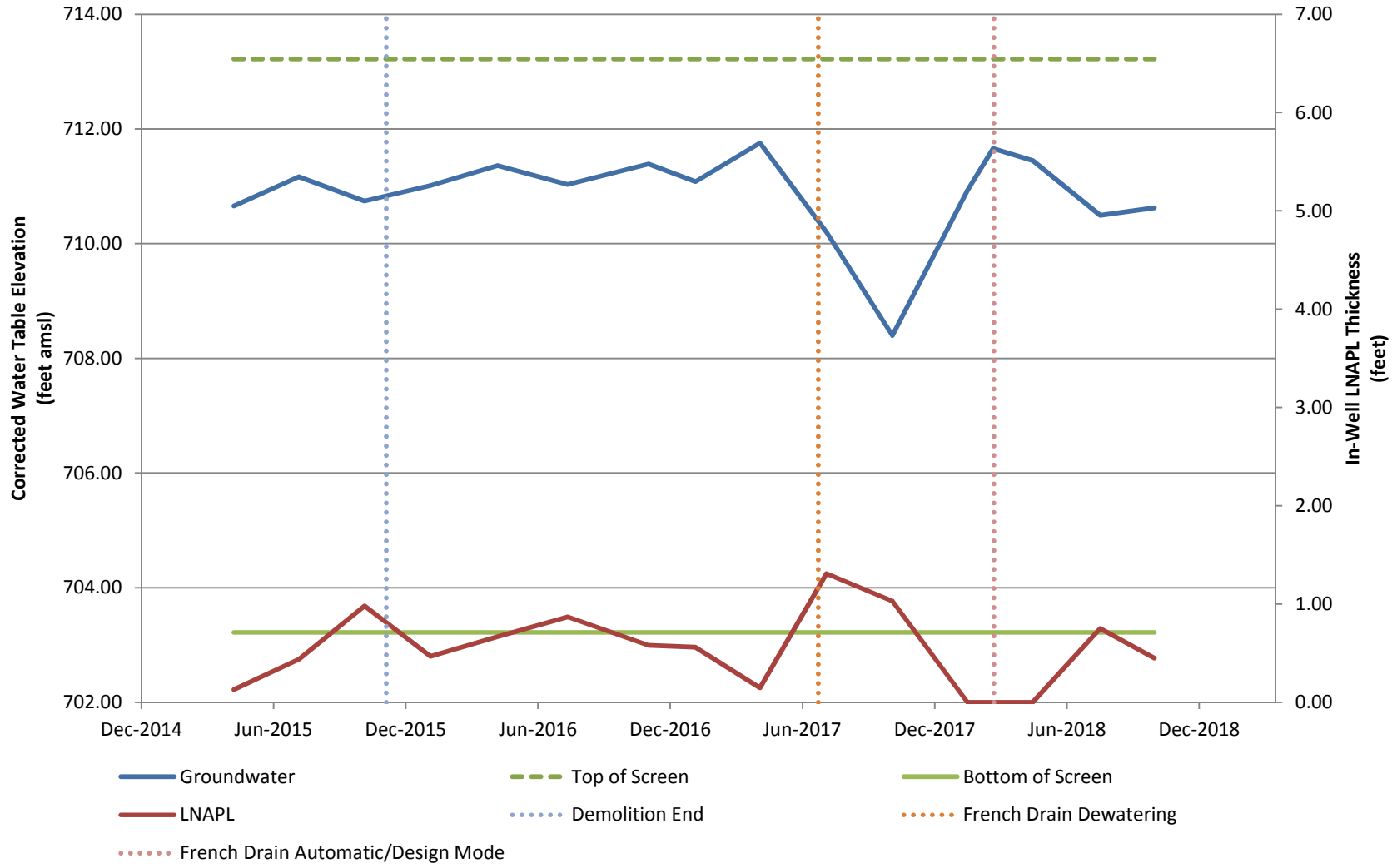

Well Gauging Data Summary: 529M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
719.00
718.00
717.00
716.00
715.00
714.00
713.00
712.00
711.00
710.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
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Jun-2005
Dec-2005
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Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
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Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

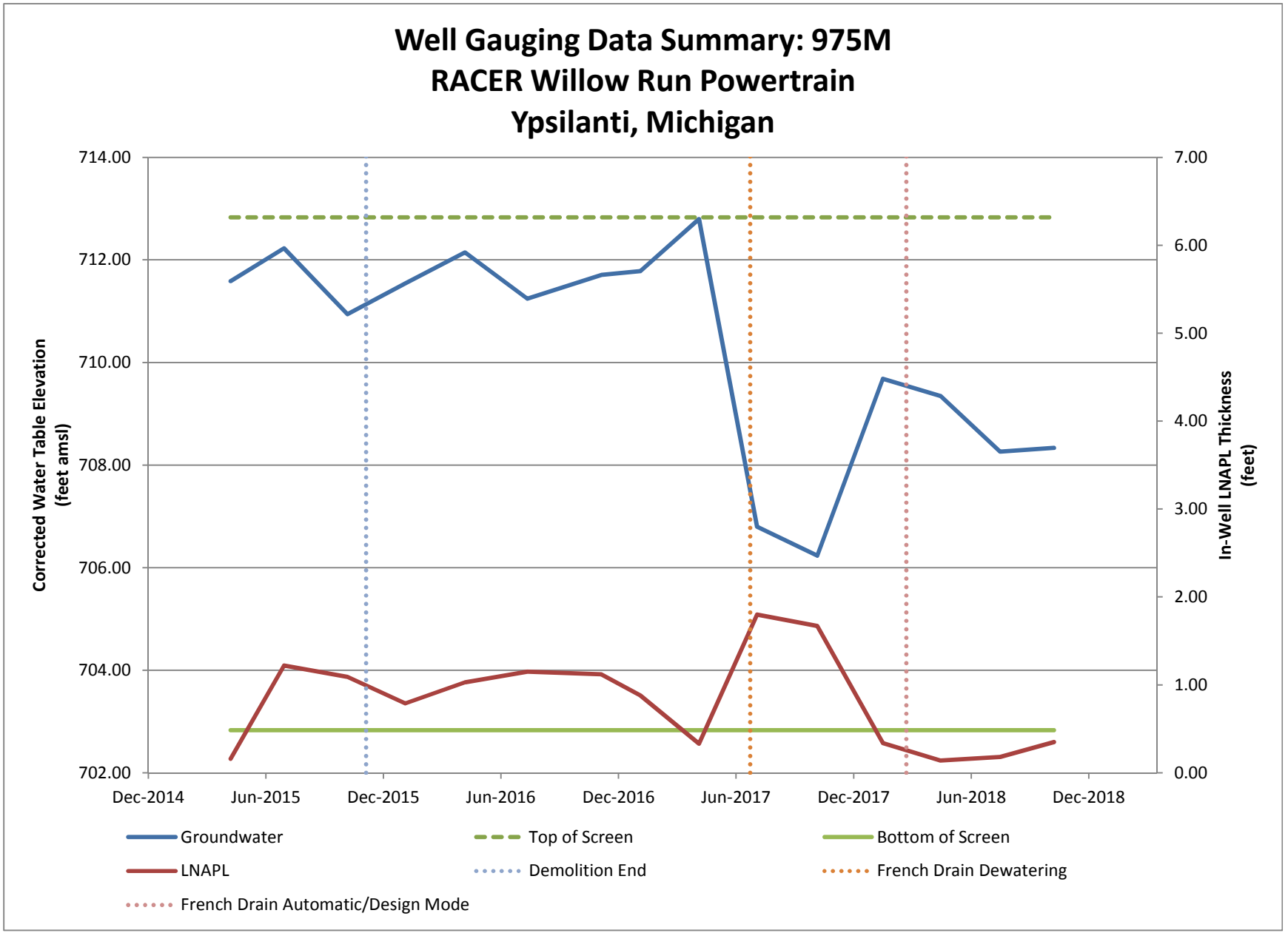

Well Gauging Data Summary: 530R
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
720.00
719.00
718.00
717.00
716.00
715.00
714.00
713.00
712.00
711.00
710.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
Dec-2008
Jun-2009
Dec-2009
Jun-2010
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Jun-2012
Dec-2012
Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

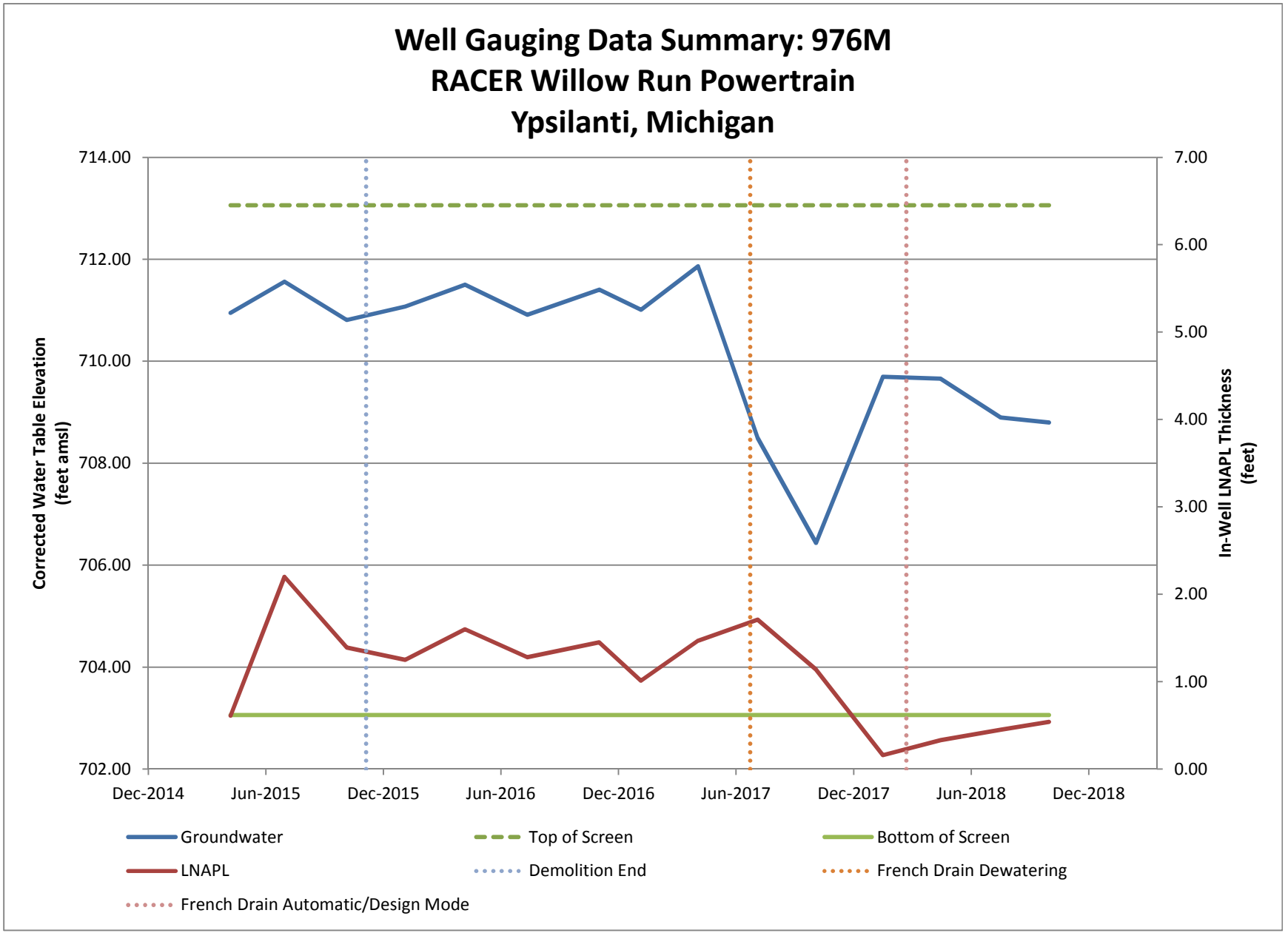

Well Gauging Data Summary: 534M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
719.00
718.00
717.00
716.00
715.00
714.00
713.00
712.00
711.00
710.00
709.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2005
Dec-2005
Jun-2006
Dec-2006
Jun-2007
Dec-2007
Jun-2008
Dec-2008
Jun-2009
Dec-2009
Jun-2010
Dec-2010
Jun-2011
Dec-2011
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Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
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Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

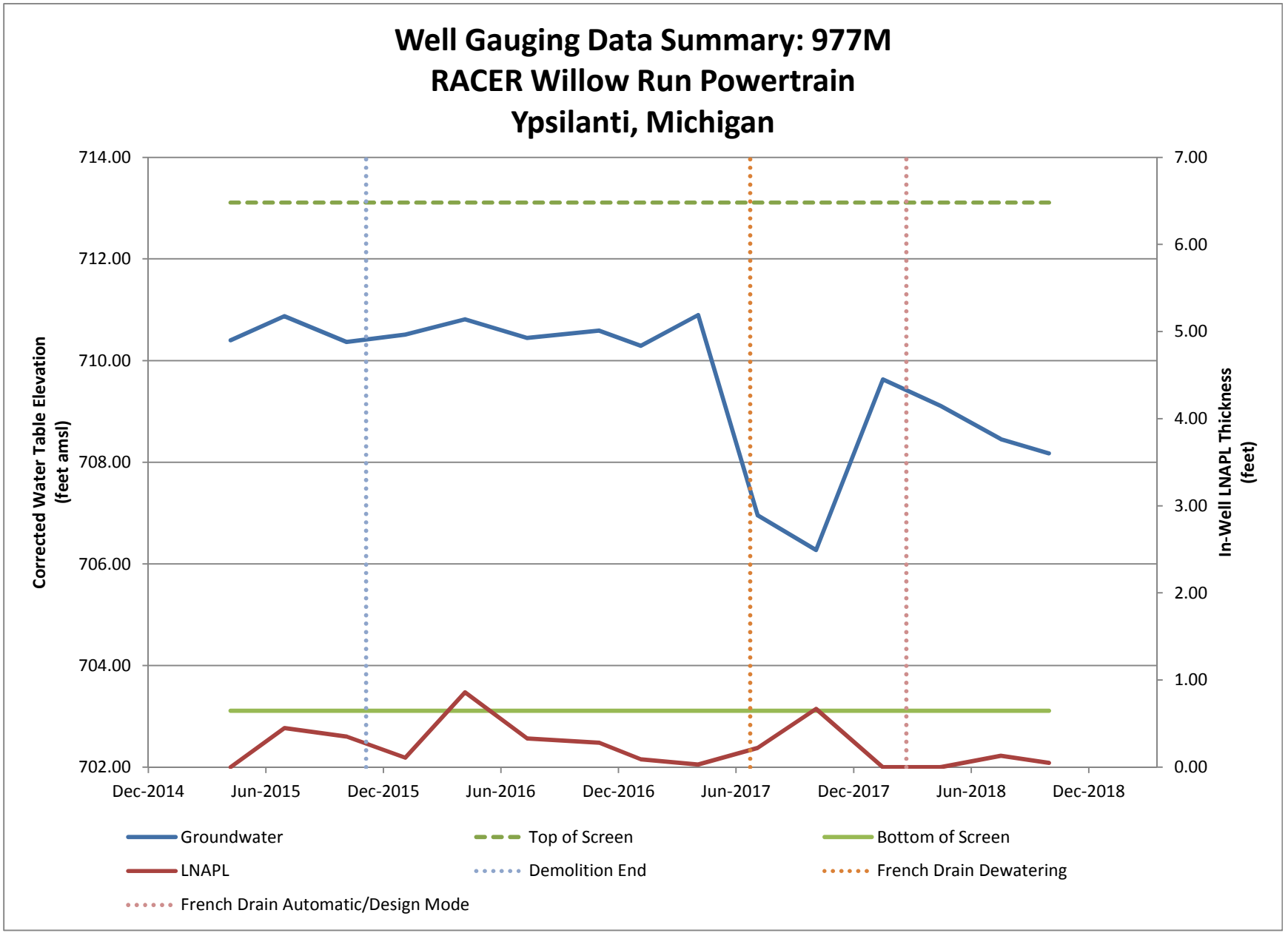

Well Gauging Data Summary: 617M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
714.00
713.00
712.00
711.00
710.00
709.00
708.00
707.00
706.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2010
Dec-2010
Jun-2011
Dec-2011
Jun-2012
Dec-2012
Jun-2013
Dec-2013
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition Start
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

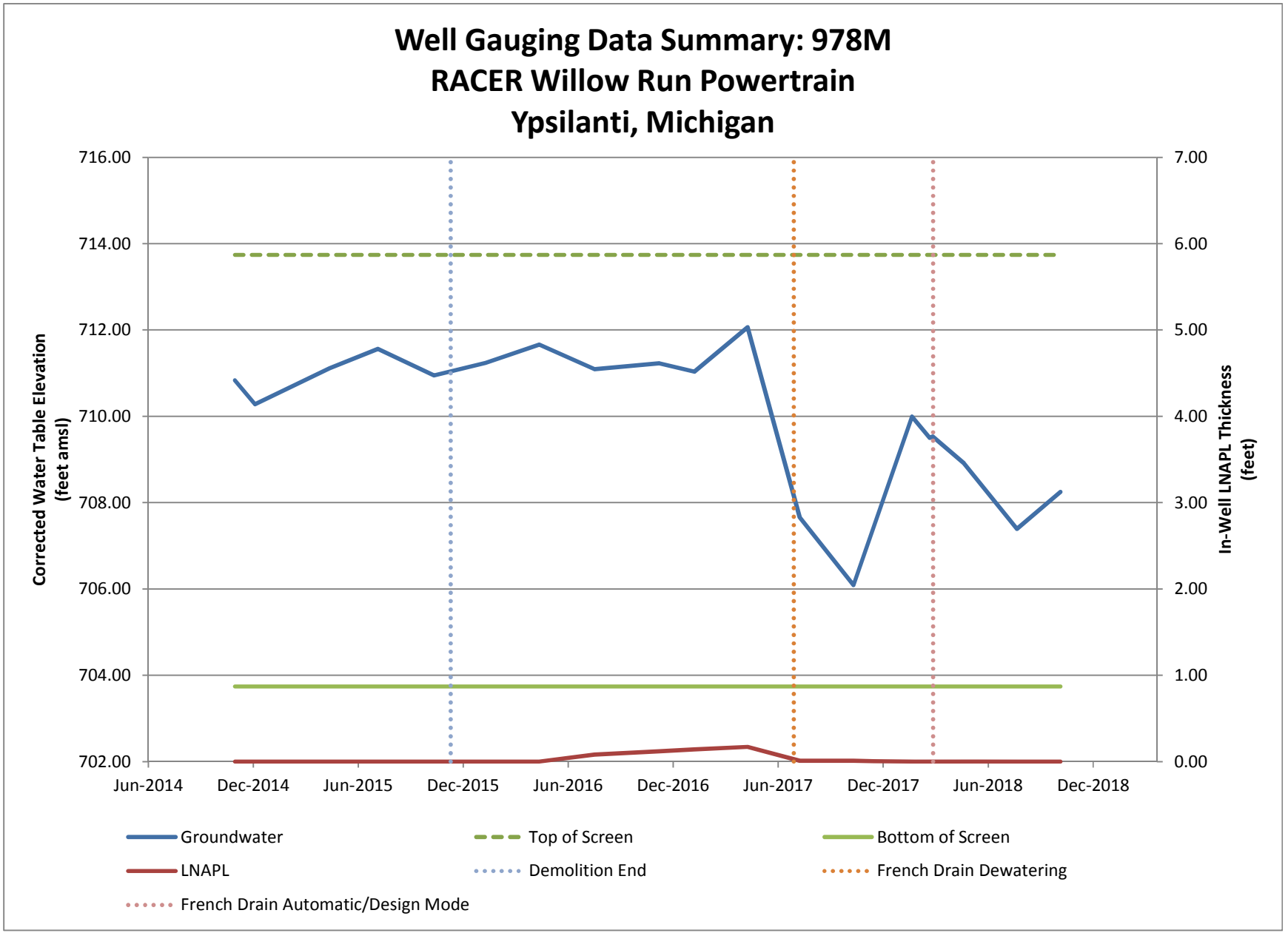
Well Gauging Data Summary: 971M
RACER Willow Run Powertrain
Ypsilanti, Michigan

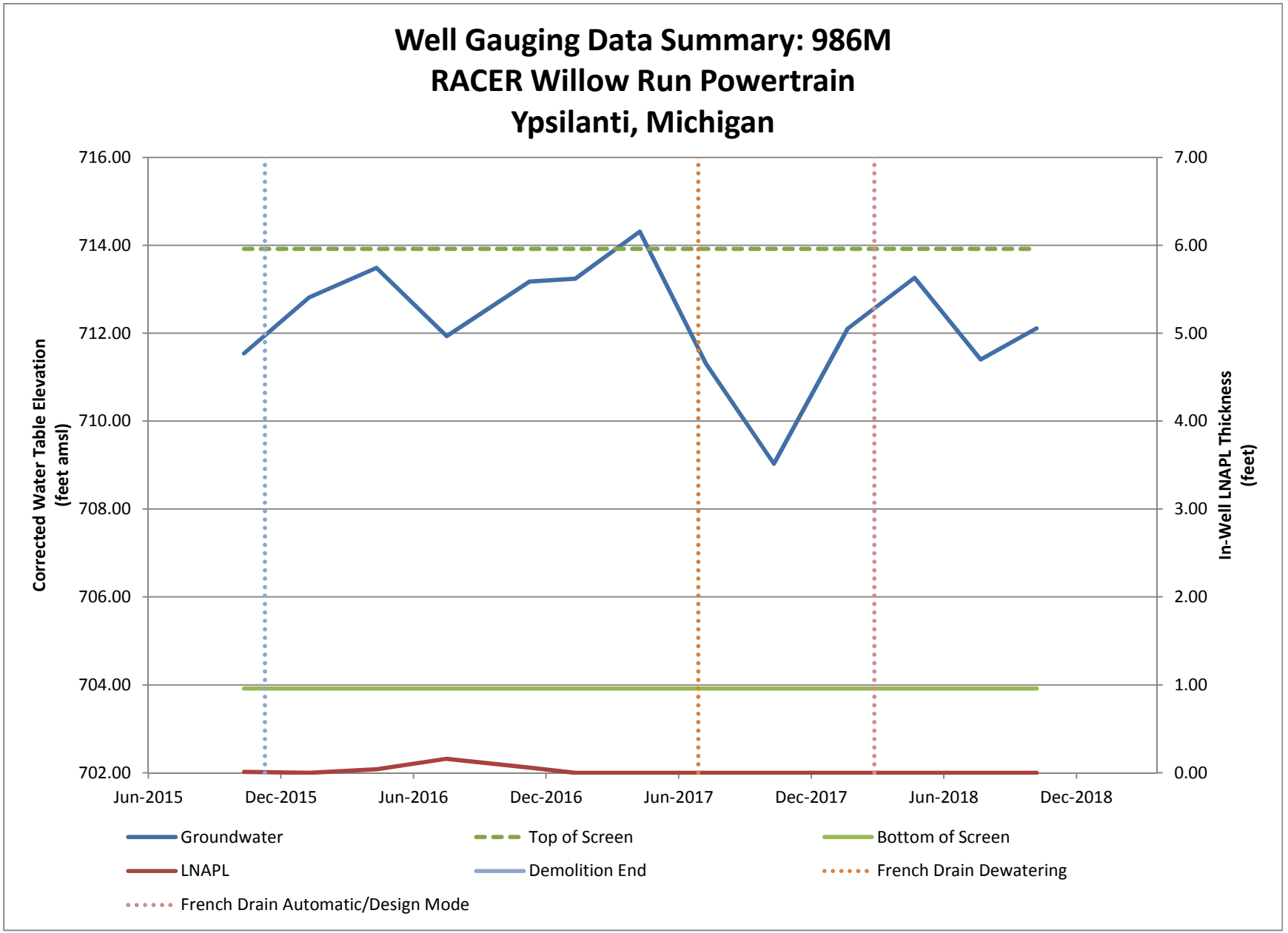


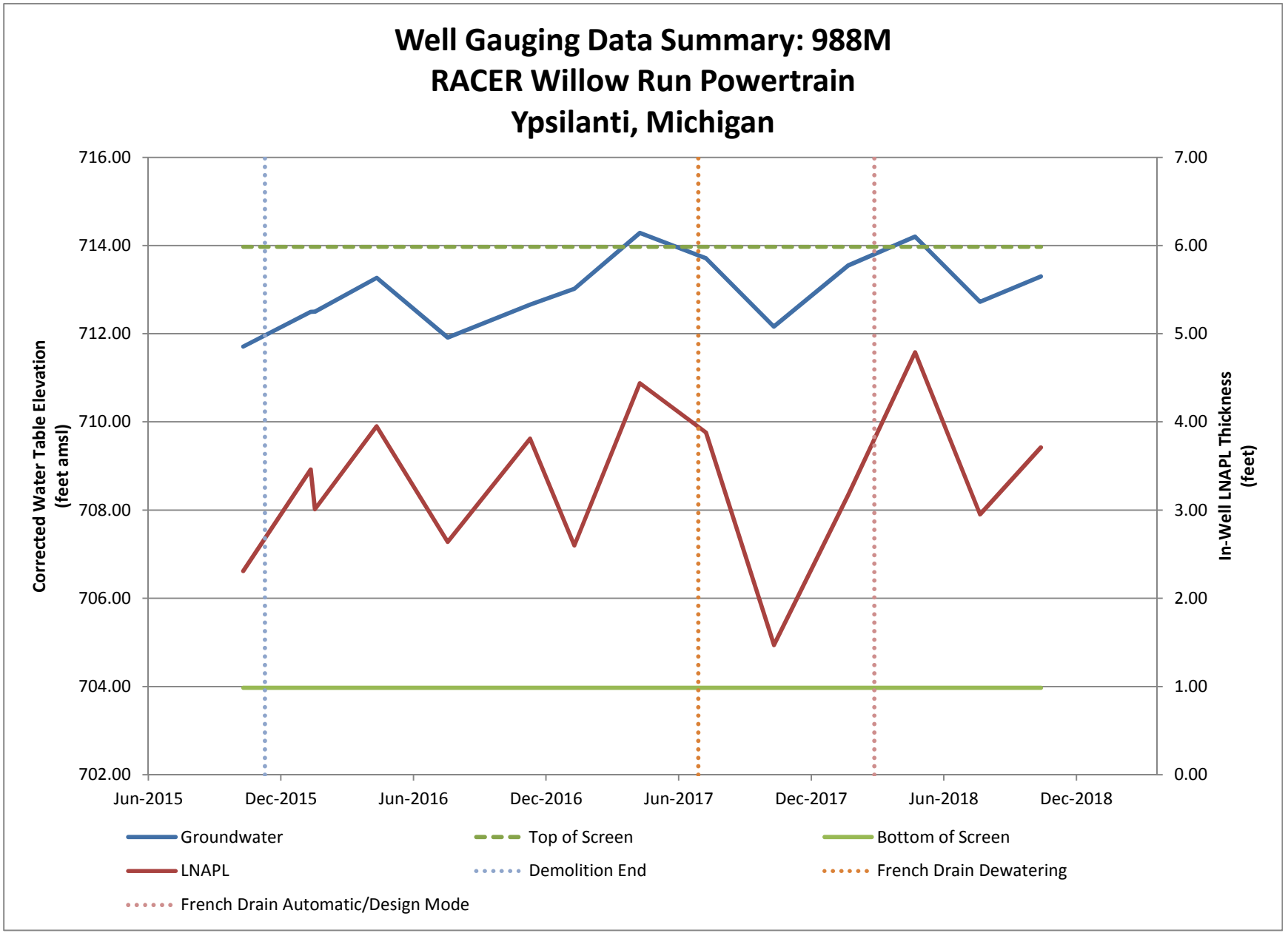

Well Gauging Data Summary: 975M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

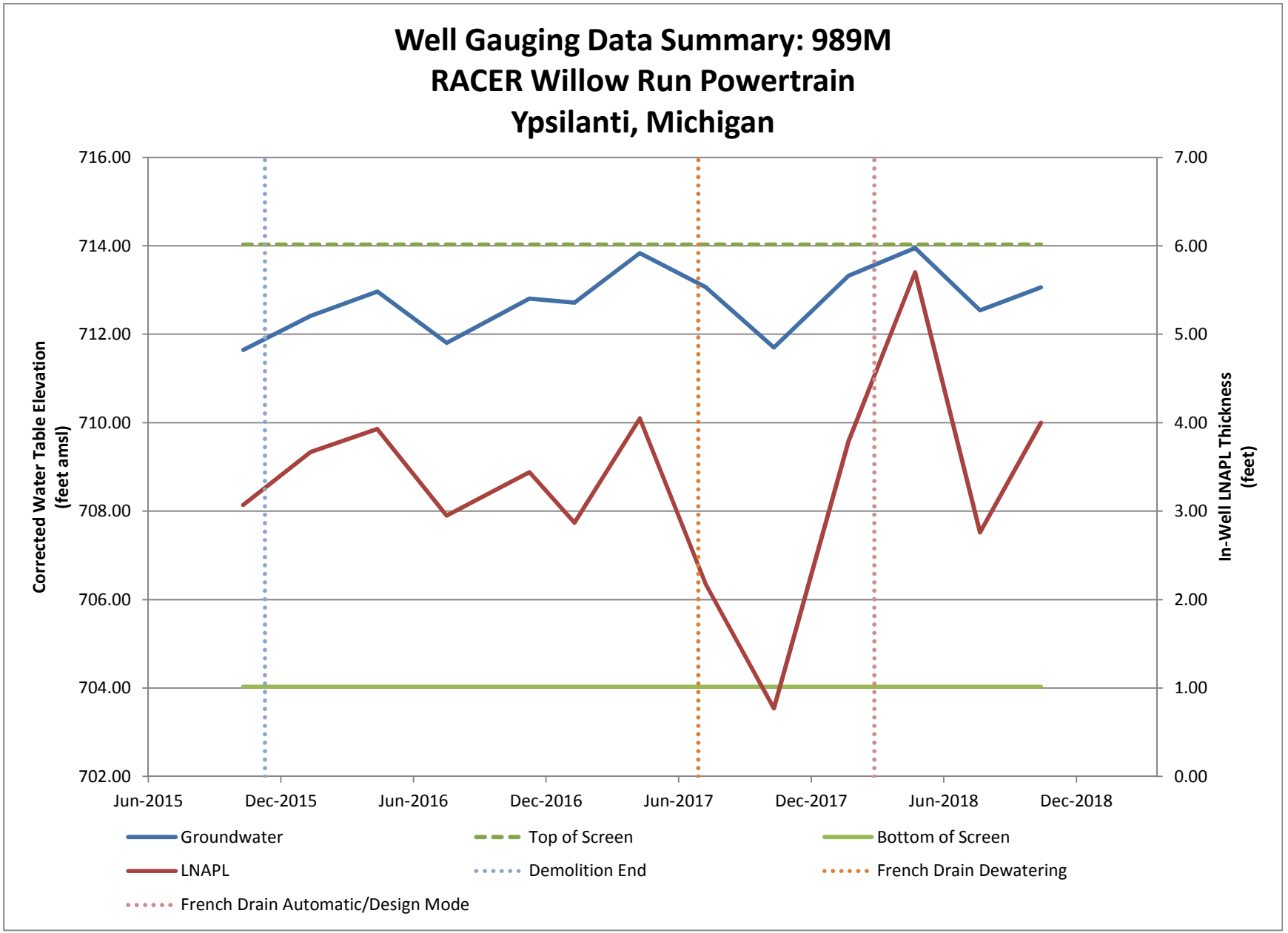

Well Gauging Data Summary: 976M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

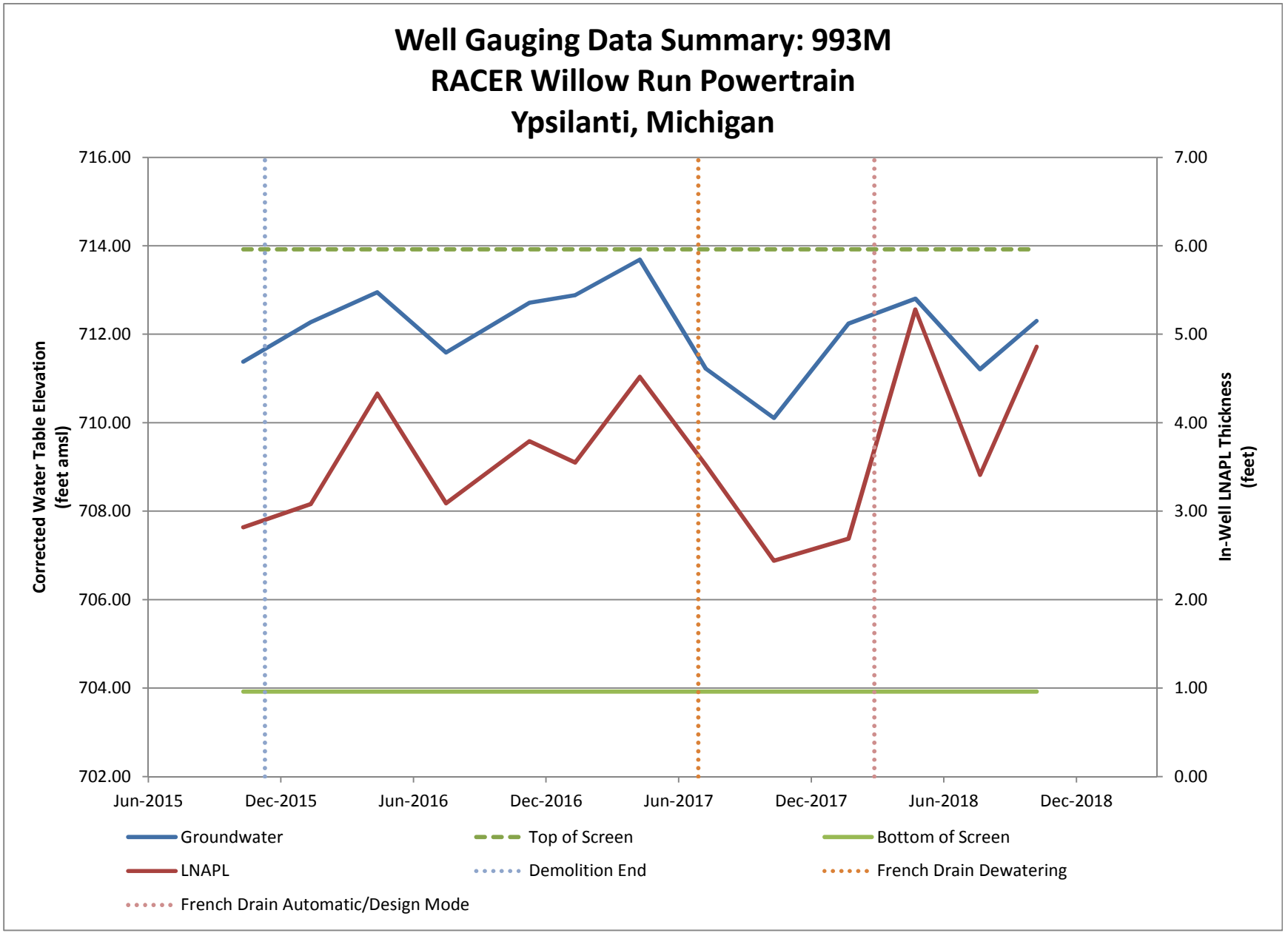

Well Gauging Data Summary: 977M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
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Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode


Well Gauging Data Summary: 978M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
716.00
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
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0.00
Jun-2014
Dec-2014
Jun-2015
Dec-2015
Jun-2016
Dec-2016
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Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

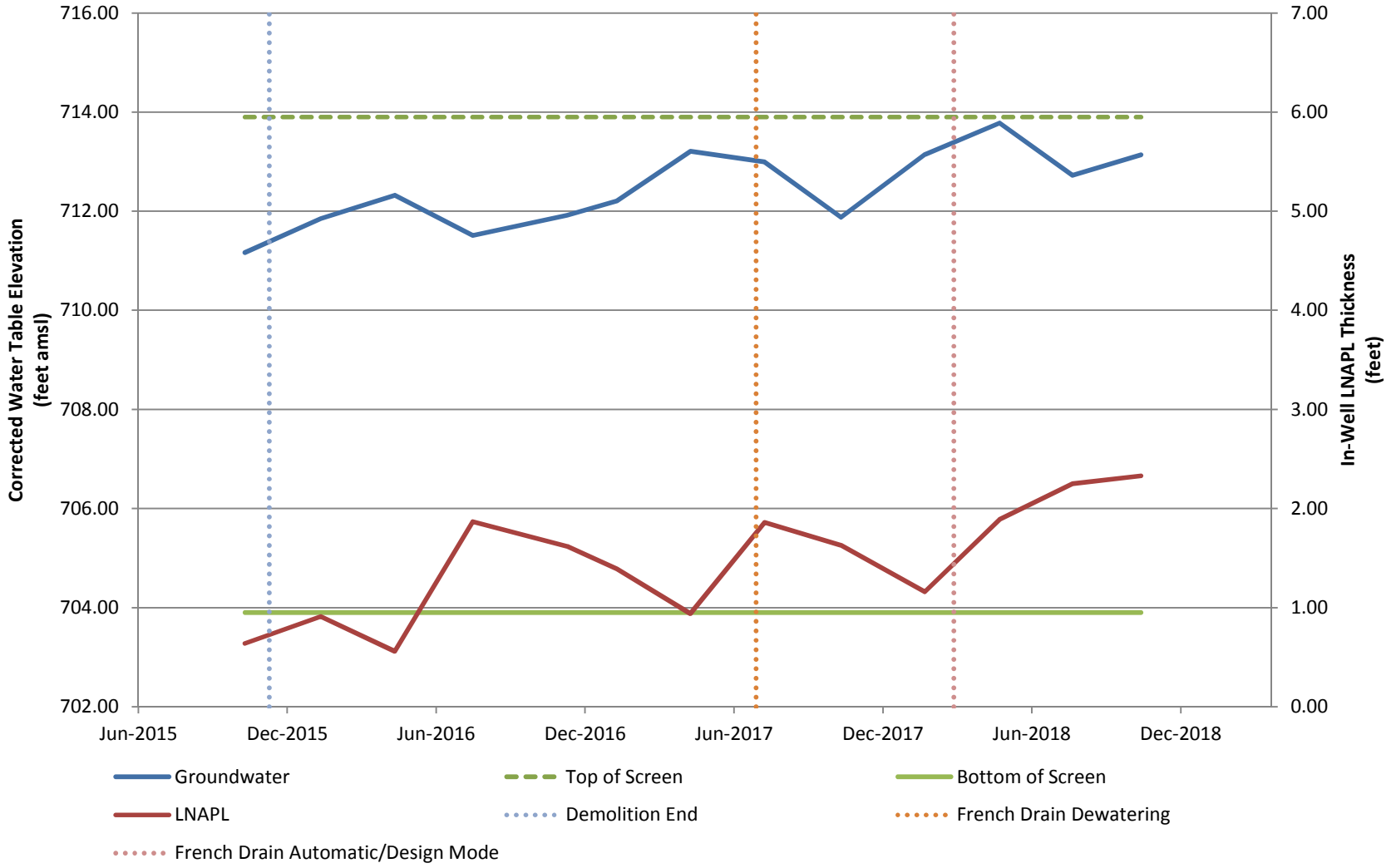

Well Gauging Data Summary: 986M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
716.00
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

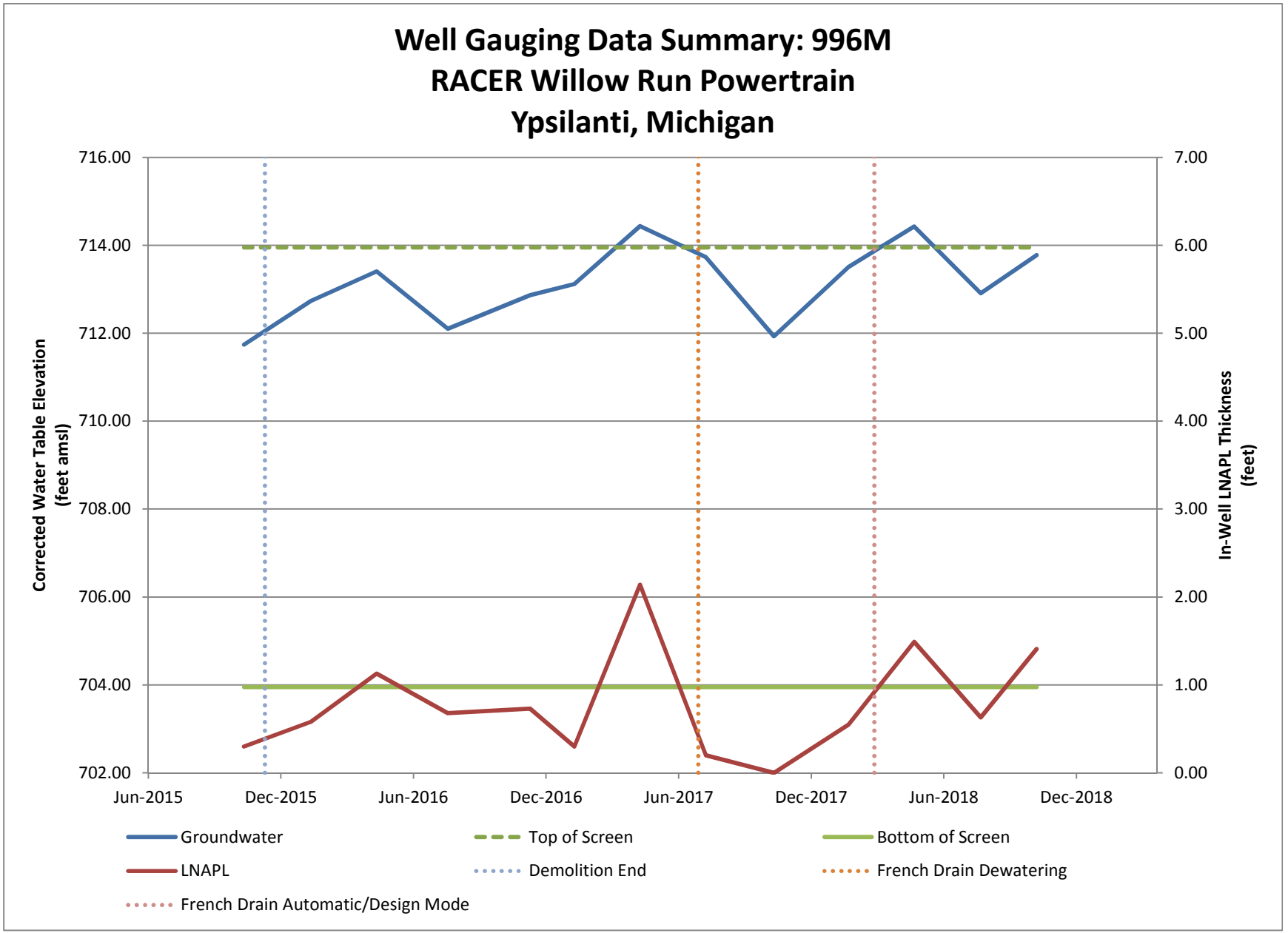

Well Gauging Data Summary: 988M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
716.00
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

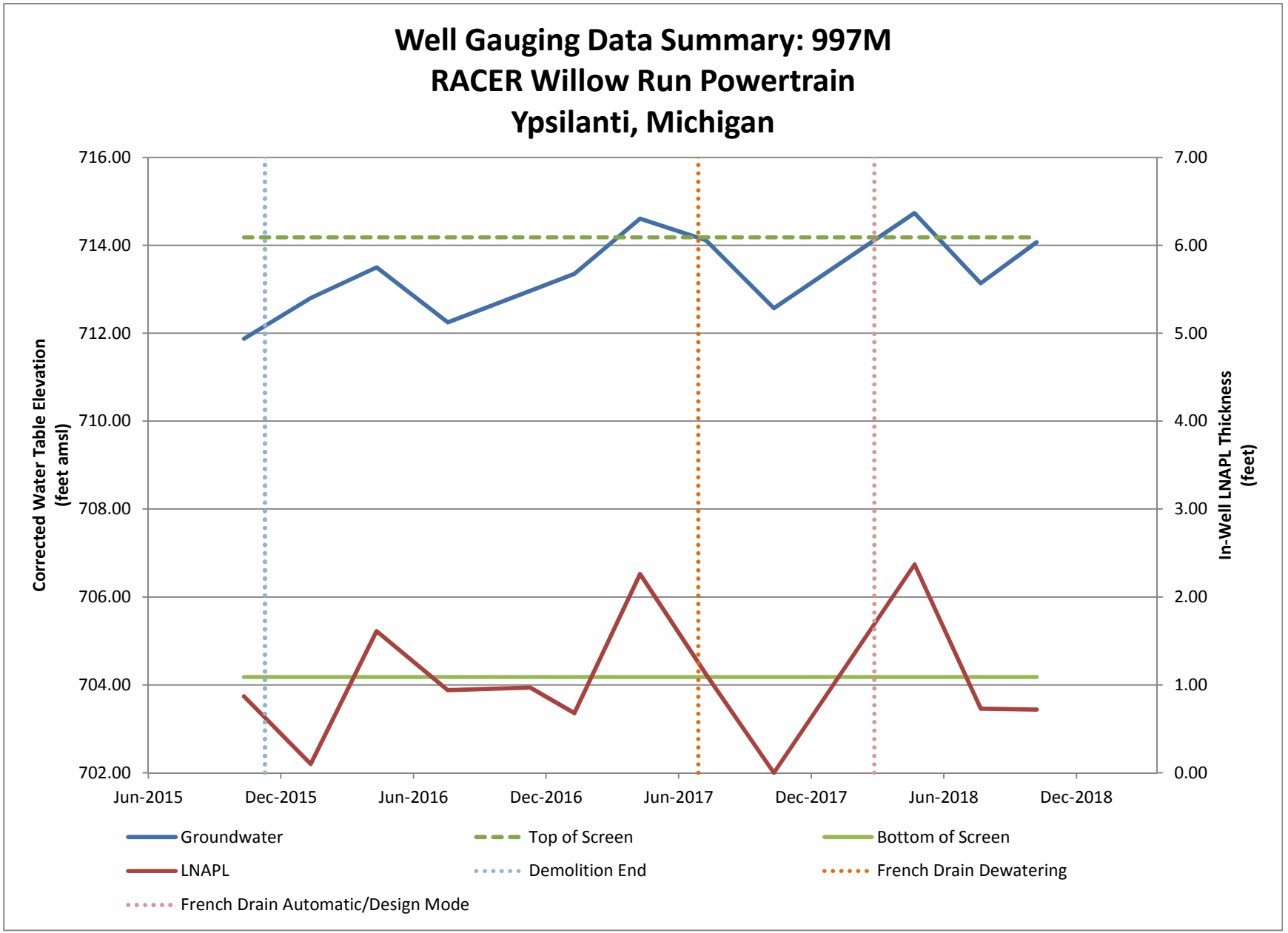

Well Gauging Data Summary: 989M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
716.00
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

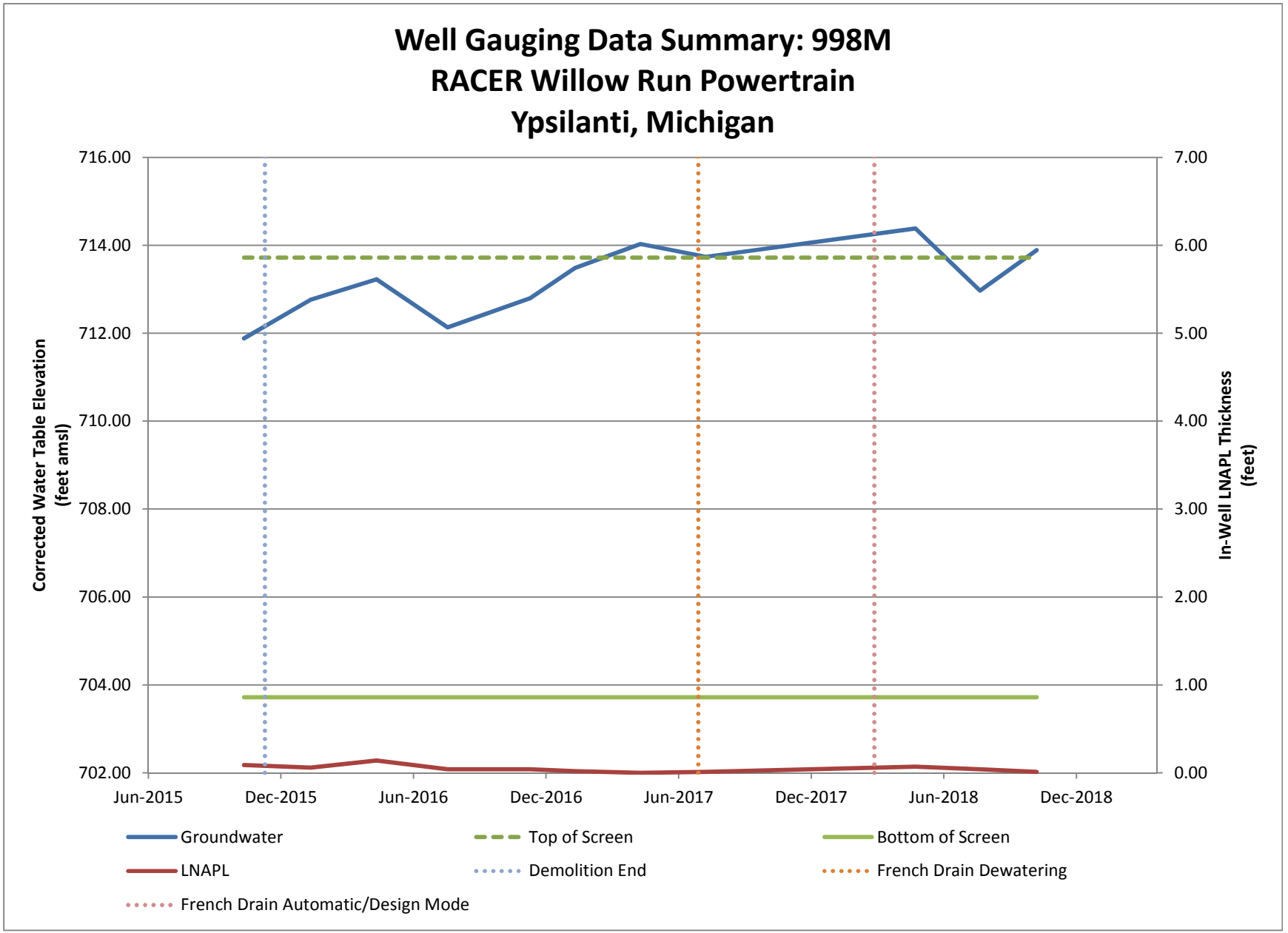

Well Gauging Data Summary: 993M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
716.00
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

Well Gauging Data Summary: 995M
RACER Willow Run Powertrain
Ypsilanti, Michigan




Well Gauging Data Summary: 996M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
716.00
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode


Well Gauging Data Summary: 997M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
716.00
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode


Well Gauging Data Summary: 998M
RACER Willow Run Powertrain
Ypsilanti, Michigan
Corrected Water Table Elevation (feet amsl)
In-Well LNAPL Thickness (feet)
716.00
714.00
712.00
710.00
708.00
706.00
704.00
702.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Jun-2015
Dec-2015
Jun-2016
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Groundwater
Top of Screen
Bottom of Screen
LNAPL
Demolition End
French Drain Dewatering
French Drain Automatic/Design Mode

Appendix B
Hydrocarbon Concentration in Discharge Water

Table B.1

Hydrocarbon Concentration in Discharge Water: MW-102
Former Willow Run Powertrain
Ypsilanti, Michigan

Sample Location	Sample Date	Sample ID	Parameter	Result	Units
MH-102	20171124	GW-17358-112417-DS-007	Oil and grease (HEM), total	5.1 U	mg/L
MH-102	20171207	GW-17358-120717-DS-008	Oil and grease (HEM), total	5.2 U	mg/L
MH-102	20180125	W-17358-012518-DB-075	Oil and grease	2 U	mg/L
MH-102	20180131	W-17358-013118-DB-076	Oil and grease	2	mg/L
MH-102	20180221	W-17358-022118-DB-077	Oil and grease	2	mg/L
MH-102	20180227	W-17358-022718-DA-078	Oil and grease	2 U	mg/L
MH-102	20180309	W-17358-030918-DA-001	Oil and grease (HEM), total	5.0 U	mg/L
MH-102	20180309	W-17358-030918-DA-079	Oil and grease	2 U	mg/L
MH-102	20180316	GW-17358-031618-DA-002	Oil and grease (HEM), total	4.8 U	mg/L
MH-102	20180322	W-17358-032218-DA-010	Oil and grease (HEM), total	5.0 U	mg/L
MH-102	20180329	W-17358-032918-DA-011	Oil and grease (HEM), total	1.2 J	mg/L
MH-102	20180330	W-17358-033018-DA-080	Oil and grease	2 U	mg/L
MH-102	20180411	W-017358-041118-DA-013	Oil and grease (HEM), total	5.2 U	mg/L
MH-102	20180419	W-17358-041918-DA-014	Oil and grease (HEM), total	5.0 U	mg/L
MH-102	20180425	W-17358-042518-DA-081	Oil and grease	2	mg/L
MH-102	20180426	W-17358-042618-DA-015	Oil and grease (HEM), total	4.9 U	mg/L
MH-102	20180427	W-17358-042718-DA-082	Oil and grease	5	mg/L
MH-102	20180504	W-017358-050418-DA-016	Oil and grease (HEM), total	4.9 U	mg/L
MH-102	20180509	W-17358-050918-DB-083	Oil and grease	2 U	mg/L
MH-102	20180518	W-17358-051818-DR-018	Oil and grease (HEM), total	5.0 U	mg/L
MH-102	20180525	W-17358-052518-DA-019	Oil and grease (HEM), total	5.0 U	mg/L
MH-102	20180525	W-17358-052518-DA-084	Oil and grease	2 U	mg/L
MH-102	20180601	W-17358-060118-DB-020	Oil and grease (HEM), total	4.9 U	mg/L
MH-102	20180608	W-17358-060818-DS-021	Oil and grease (HEM), total	1.2 J	mg/L
MH-102	20180621	W-17358-062118-DS-022	Oil and grease (HEM), total	4.9 U	mg/L
MH-102	20180621	W-17358-062118-DB-085	Oil and grease	4	mg/L
MH-102	20180627	W-17358-062718-DR-086	Oil and grease	2 U	mg/L
MH-102	20180628	W-17358-062818-DR-023	Oil and grease (HEM), total	5.2 U	mg/L
MH-102	20180720	W-17358-072018-DR-087	Oil and grease	2 U	mg/L
MH-102	20180727	W-17358-072718-DB-088	Oil and grease	3	mg/L
MH-102	20180802	W-17358-080218-DB-001	Oil and grease (HEM), total	4.9 U	mg/L
MH-102	20180809	W-17358-080918-DB-089	Oil and grease	2 U	mg/L
MH-102	20180809	W-17358-080918-DB-002	Oil and grease (HEM), total	4.9 U	mg/L
MH-102	20180816	W-17358-081618-DB-003	Oil and grease (HEM), total	4.9 U	mg/L
MH-102	20180830	W-17358-083018-DB-090	Oil and grease	2 U	mg/L
MH-102	20180906	W-17358-090618-DA-091	Oil and grease	2	mg/L
MH-102	20180911	W-17358-091118-DA-092	Oil and grease	7	mg/L
MH-102	20181010	W-17358-101018-DB-093	Oil and grease	2	mg/L
MH-102	20181025	W-17358-102518-DB-094	Oil and grease	2 U	mg/L
MH-102	20181109	W-17358-110918-DB-095	Oil and grease	2 U	mg/L
MH-102	20181129	W-17358-112918-DB-096	Oil and grease	2 U	mg/L
MH-102	20181211	W-17358-121118-DB-097	Oil and grease	2 U	mg/L
MH-102	20181218	W-17358-121818-DB-098	Oil and grease	2	mg/L
MH-102	20190117	W-17358-011719-DB-099	Oil and grease	2 U	mg/L
MH-102	20190126	W-17358-012619-DB-100	Oil and grease	2 U	mg/L
MH-102	20190214	W-17358-021419-DB-101	Oil and grease	2	mg/L

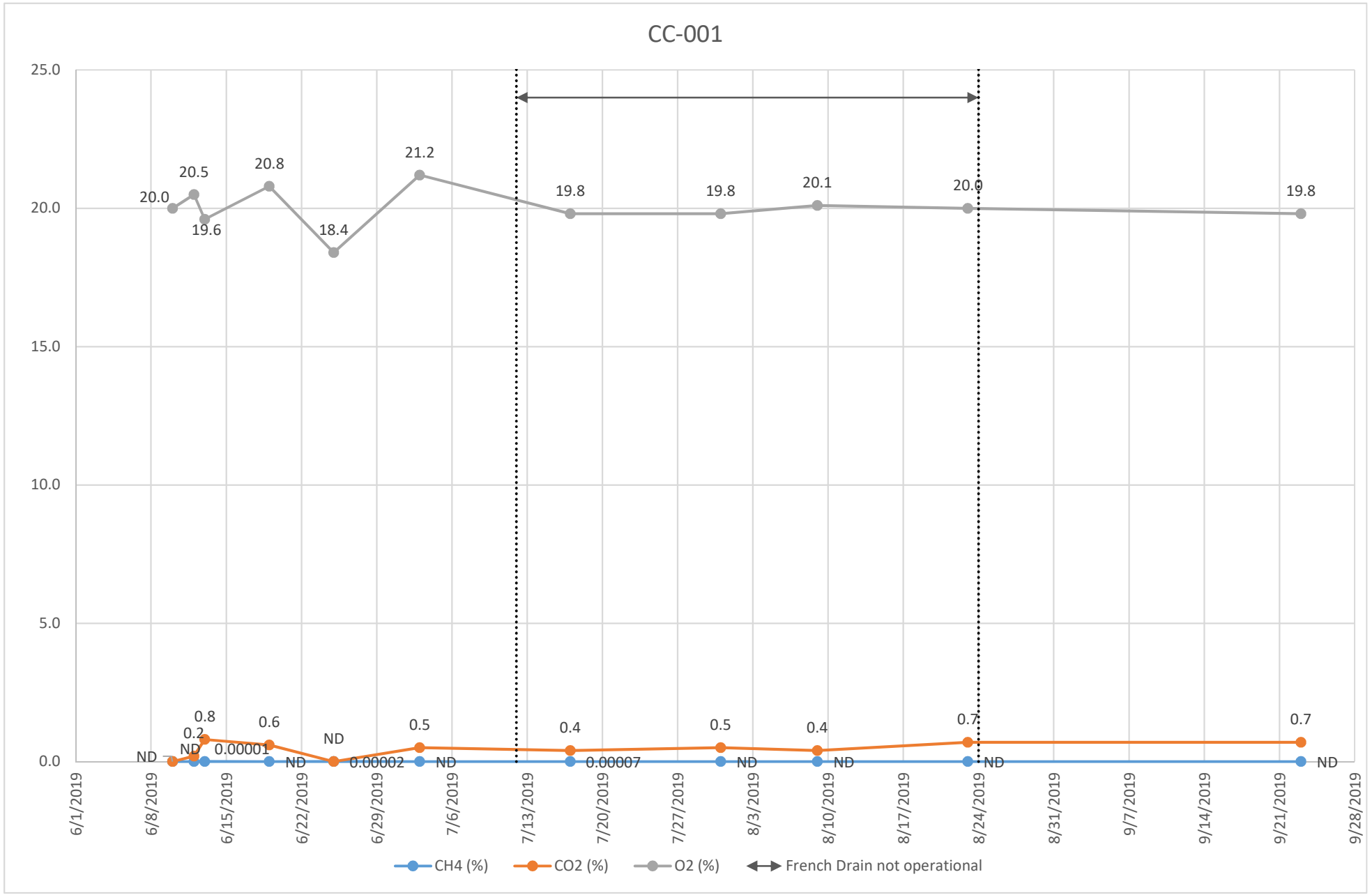
Table B.1

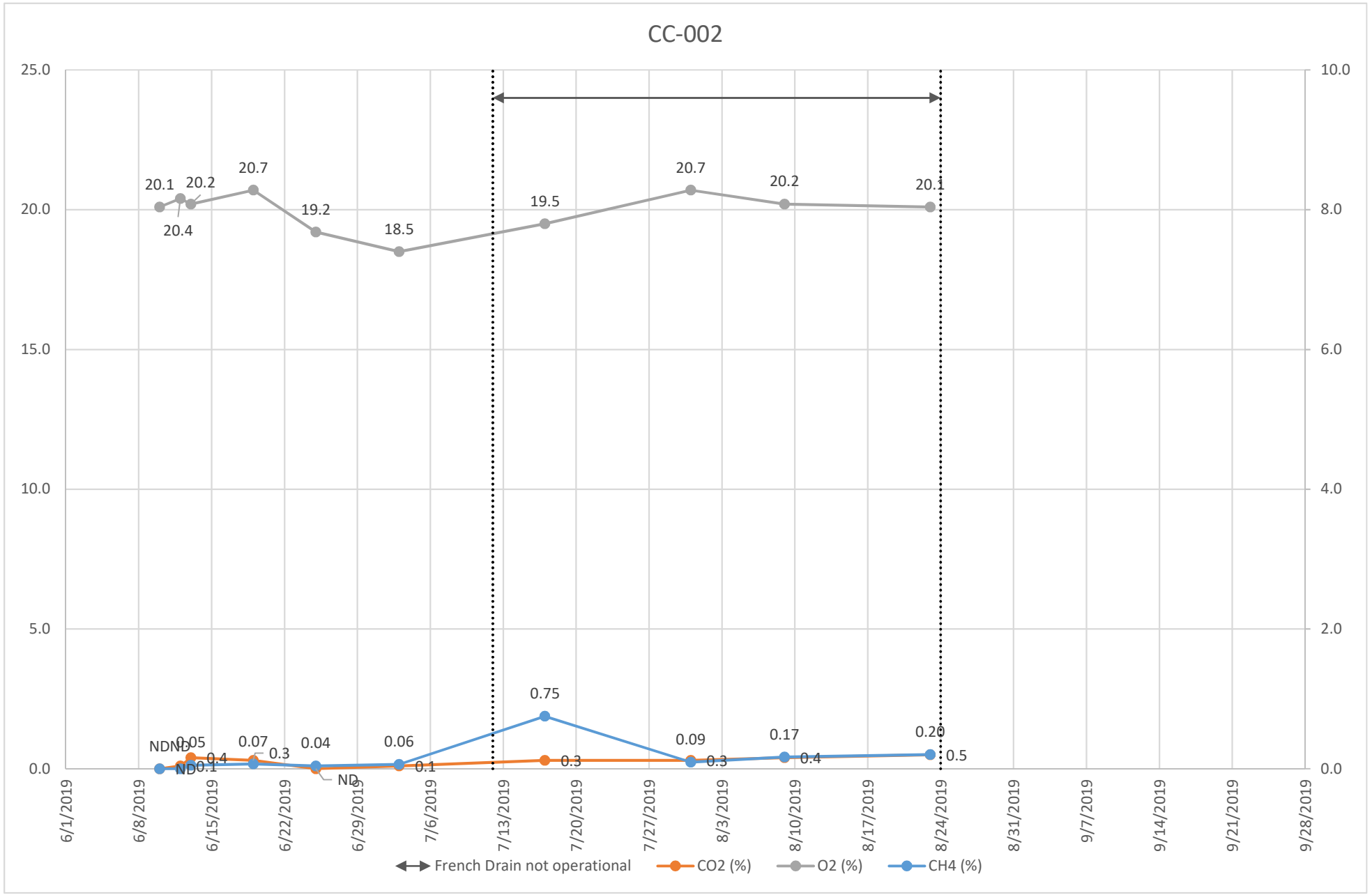
Hydrocarbon Concentration in Discharge Water: MW-102
Former Willow Run Powertrain
Ypsilanti, Michigan

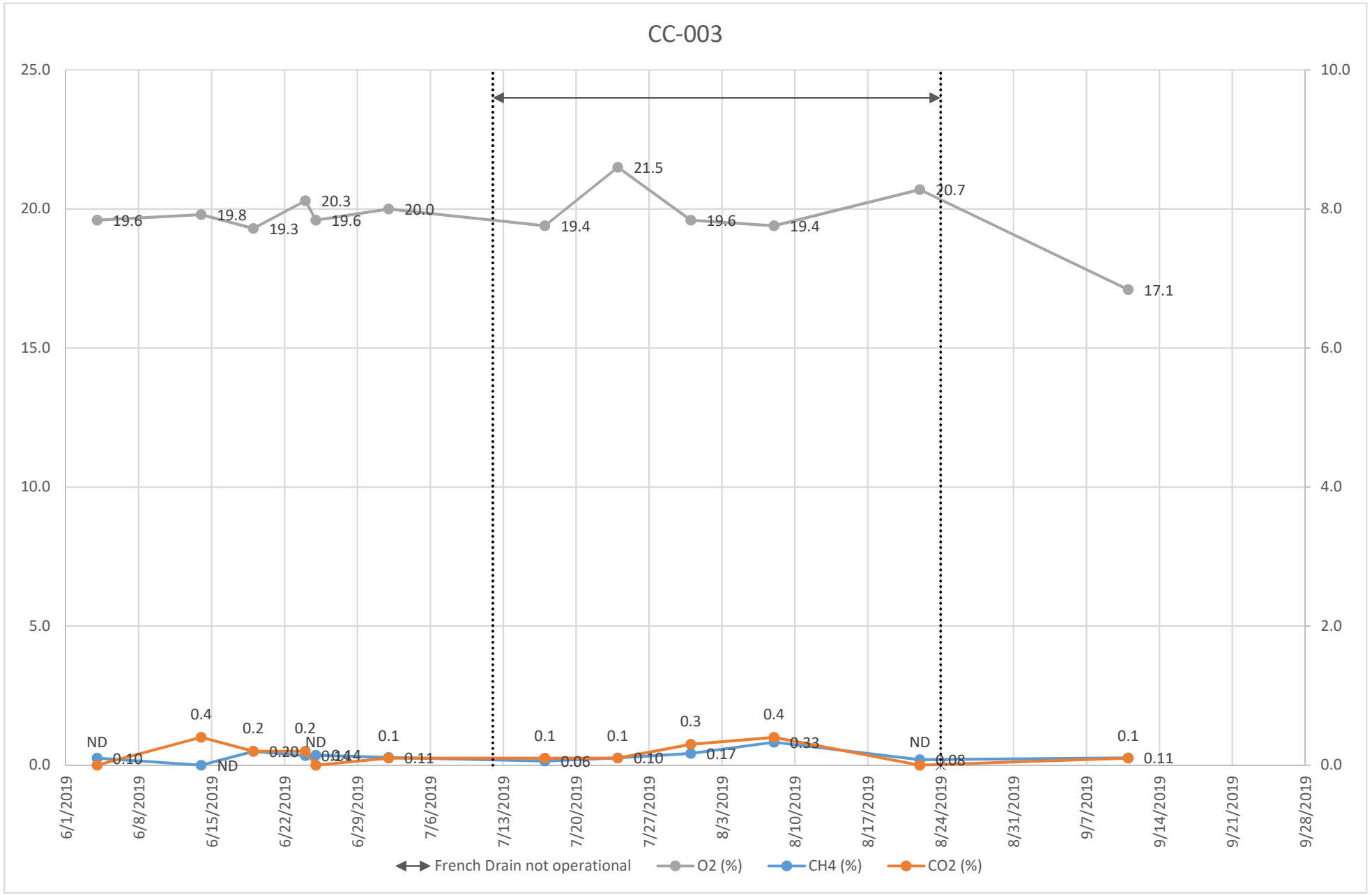
Sample Location	Sample Date	Sample ID	Parameter	Result	Units
MH-102	20190227	W-17358-022719-DB-102	Oil and grease	2 U	mg/L
MH-102	20190307	W-17358-030719-DB-103	Oil and grease	2 U	mg/L
MH-102	20190328	W-17358-032819-DB-104	Oil and grease	2 U	mg/L
MH-102	20190403	W-17358-040319-AM-105	Oil and grease	2 U	mg/L
MH-102	20190424	W-17358-042419-DB-106	Oil and grease	2 U	mg/L
MH-102	20190516	W-17358-051619-DB-107	Oil and grease	2 U	mg/L
MH-102	20190523	W-17358-052319-DB-108	Oil and grease	2 U	mg/L
MH-102	20190604	W-17358-060419-DB-109	Oil and grease	2	mg/L
MH-102	20190606	W-17358-060619-DB-110	Oil and grease	2	mg/L
MH-102	20190710	W-17358-071019-DB-111	Oil and grease	2 U	mg/L
MH-102	20190711	W-17358-071119-DB-112	Oil and grease	2 U	mg/L
MH-102	20190827	W-17358-082719-AM-113	Oil and grease	2 U	mg/L
MH-102	20190829	W-17358-082919-AM-114	Oil and grease	2 U	mg/L
MH-102	20190904	W-17358-090419-AM-115	Oil and grease	2 U	mg/L
MH-102	20190911	W-17358-091119-AM-116	Oil and grease	2 U	mg/L

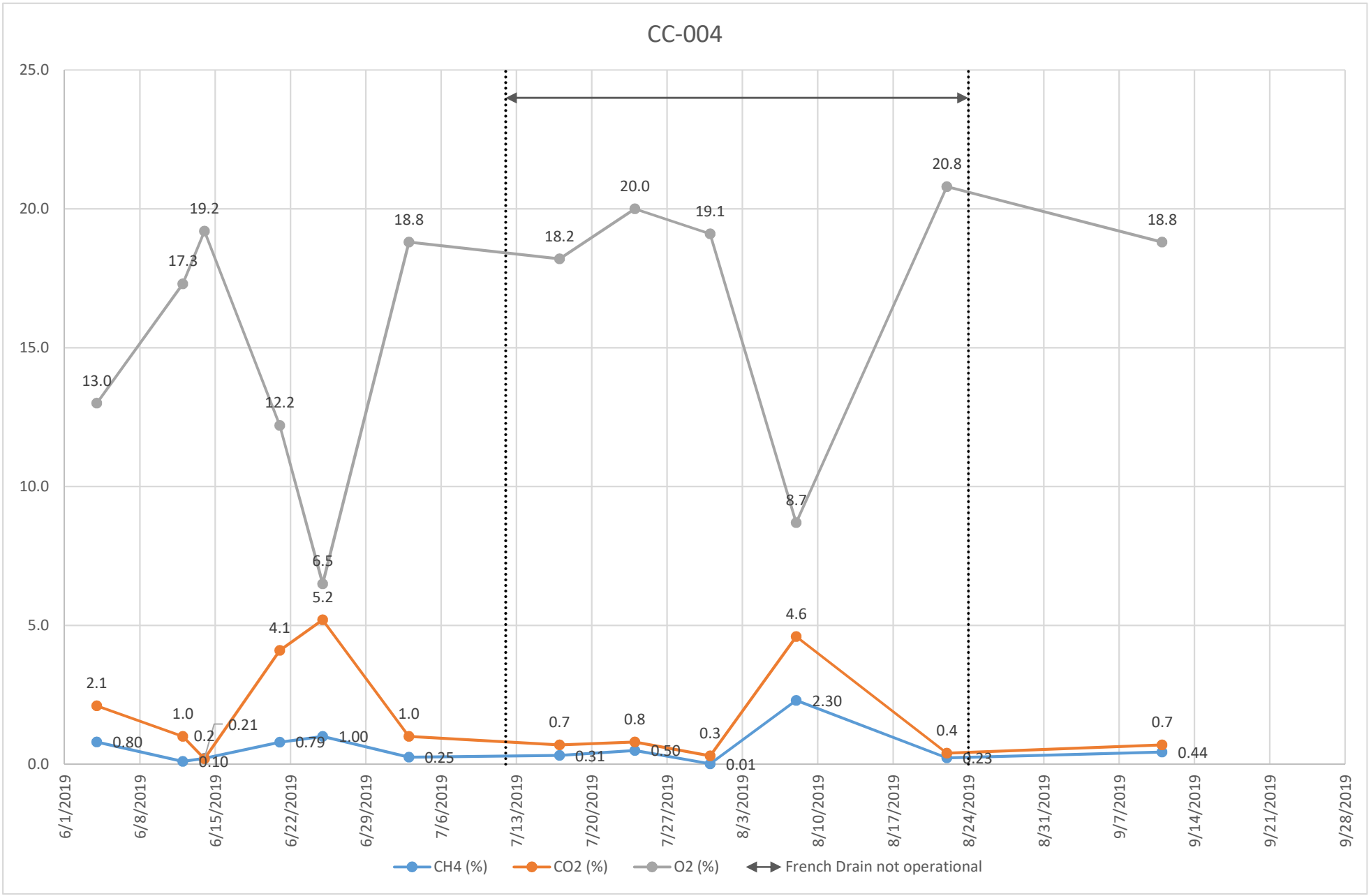
Notes:
U - Indicates the analyte was analyzed for but not detected
J - Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value

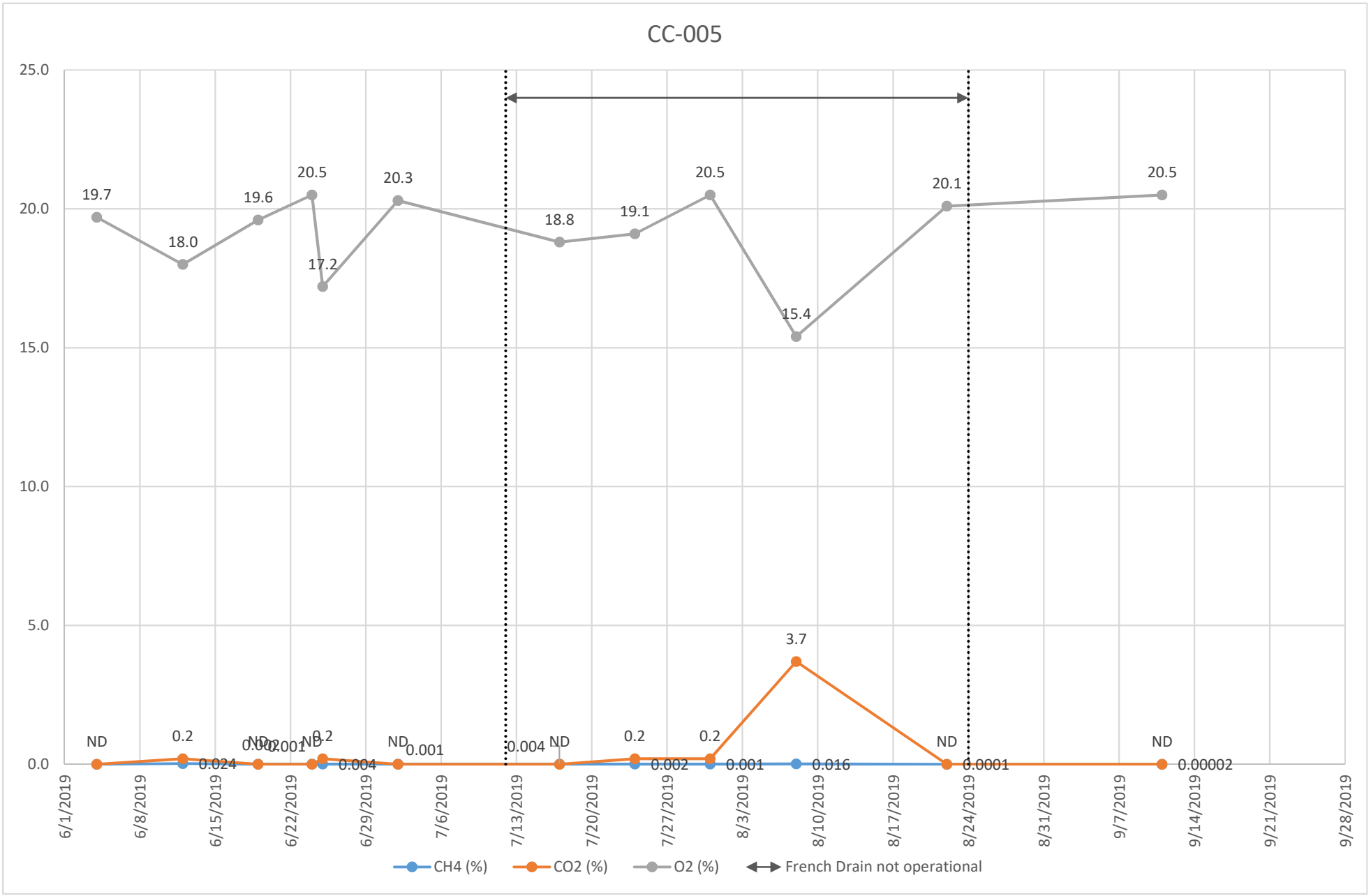
Appendix C
Soil Gas Data Graphs

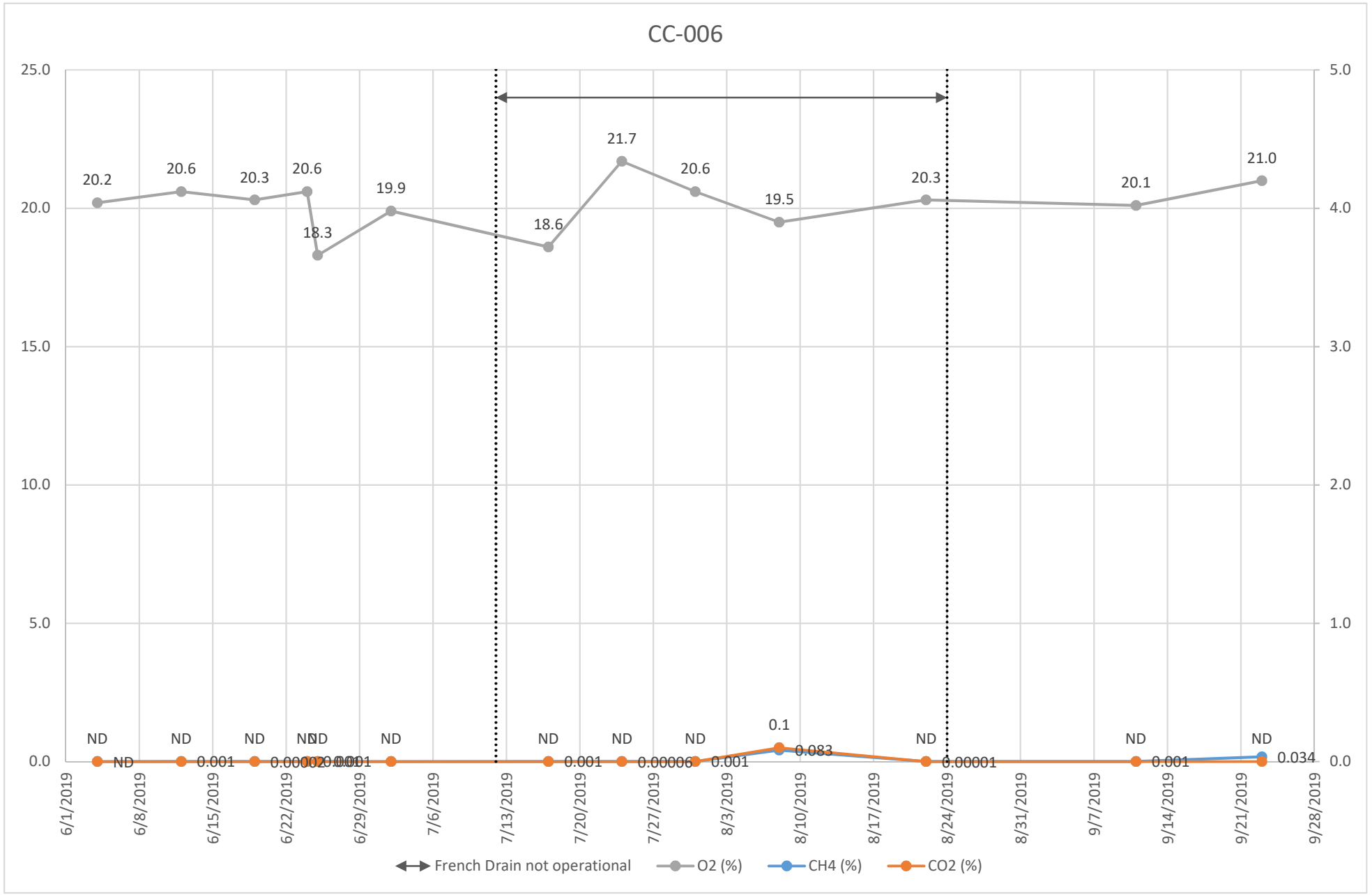

CC-001
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
20.0
20.5
19.6
20.8
18.4
21.2
19.8
19.8
20.1
20.0
19.8
ND
0.2
ND
0.8
0.00001
0.6
ND
ND
0.00002
0.5
ND
0.4
0.00007
ND
0.5
ND
0.4
ND
0.7
ND
0.7
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

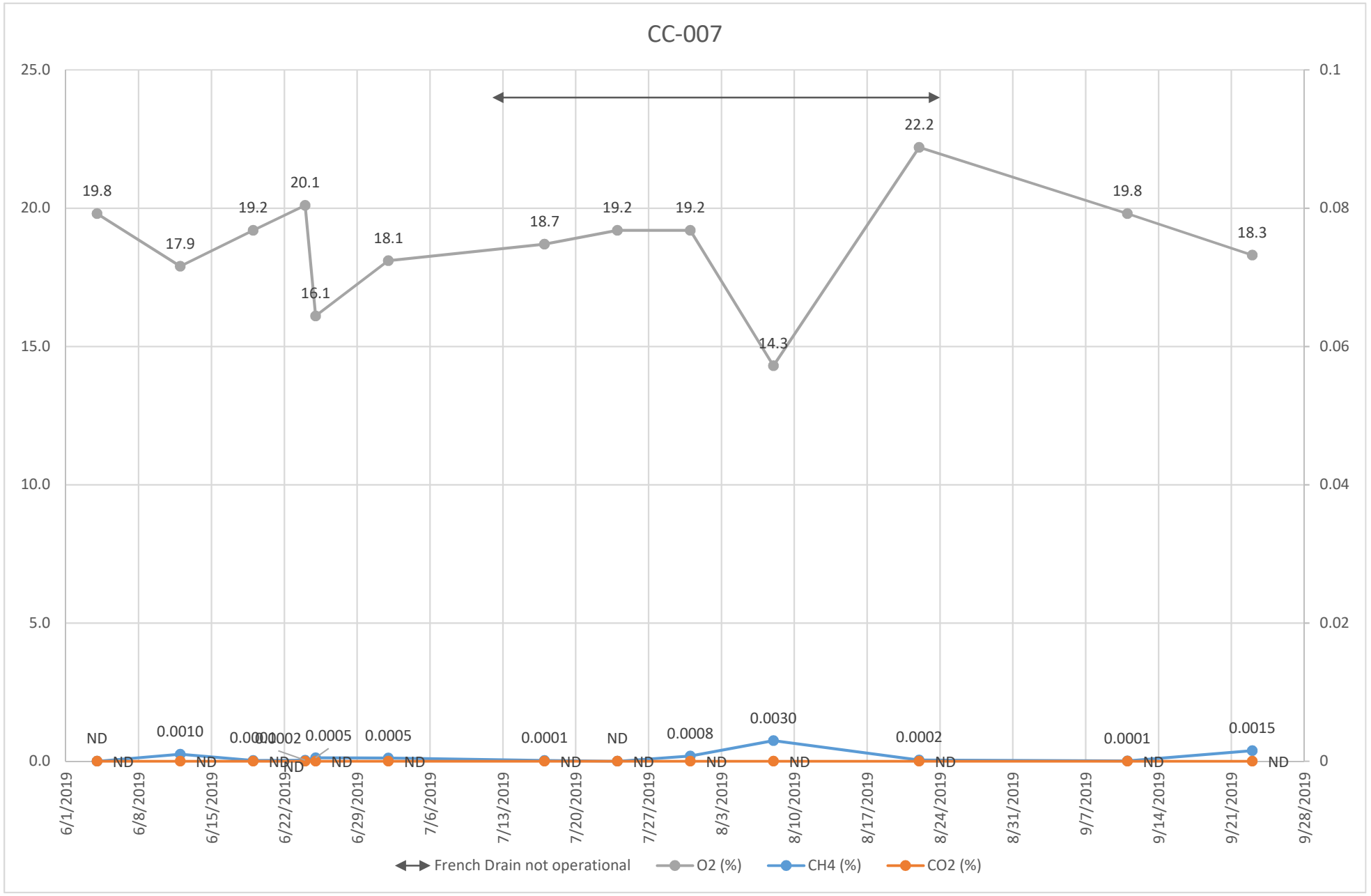

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15.0
10.0
5.0
0.0
10.0
8.0
6.0
4.0
2.0
0.0
20.1
20.2
20.4
20.7
19.2
18.5
19.5
20.7
20.2
20.1
ND
ND
0.05
0.4
0.07
0.3
0.04
ND
0.06
0.1
0.75
0.1
0.3
0.09
0.3
0.17
0.4
0.20
0.5
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
CO2 (%)
O2 (%)
CH4 (%)

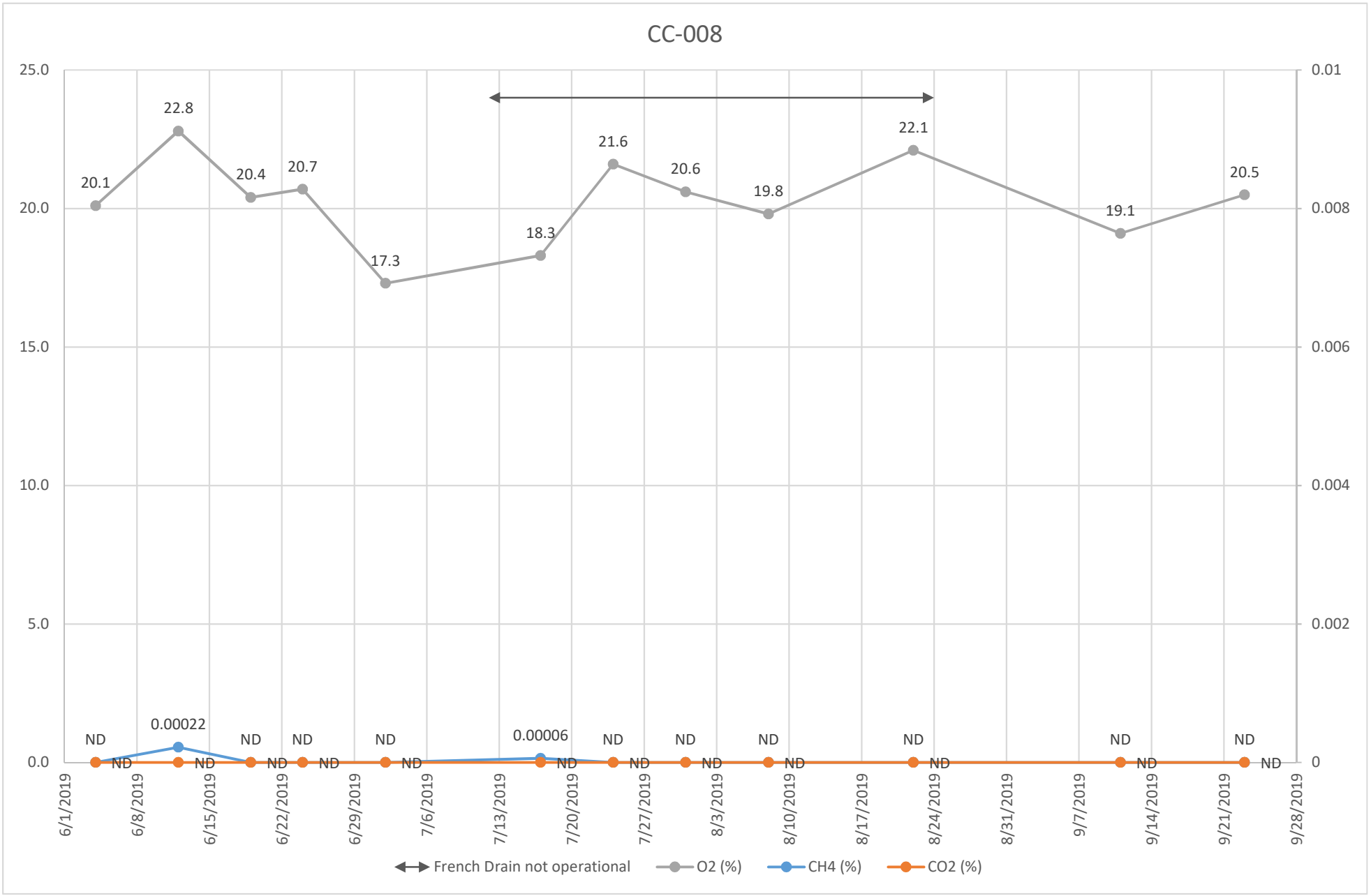

CC-003
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20.0
15.0
10.0
5.0
0.0
10.0
8.0
6.0
4.0
2.0
0.0
19.6
19.8
19.3
20.3
19.6
20.0
19.4
21.5
19.6
19.4
20.7
17.1
ND
0.10
0.4
ND
0.2
0.20
0.2
ND
0.1
0.11
0.1
0.06
0.1
0.10
0.3
0.17
0.4
0.33
ND
0.08
0.1
0.11
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

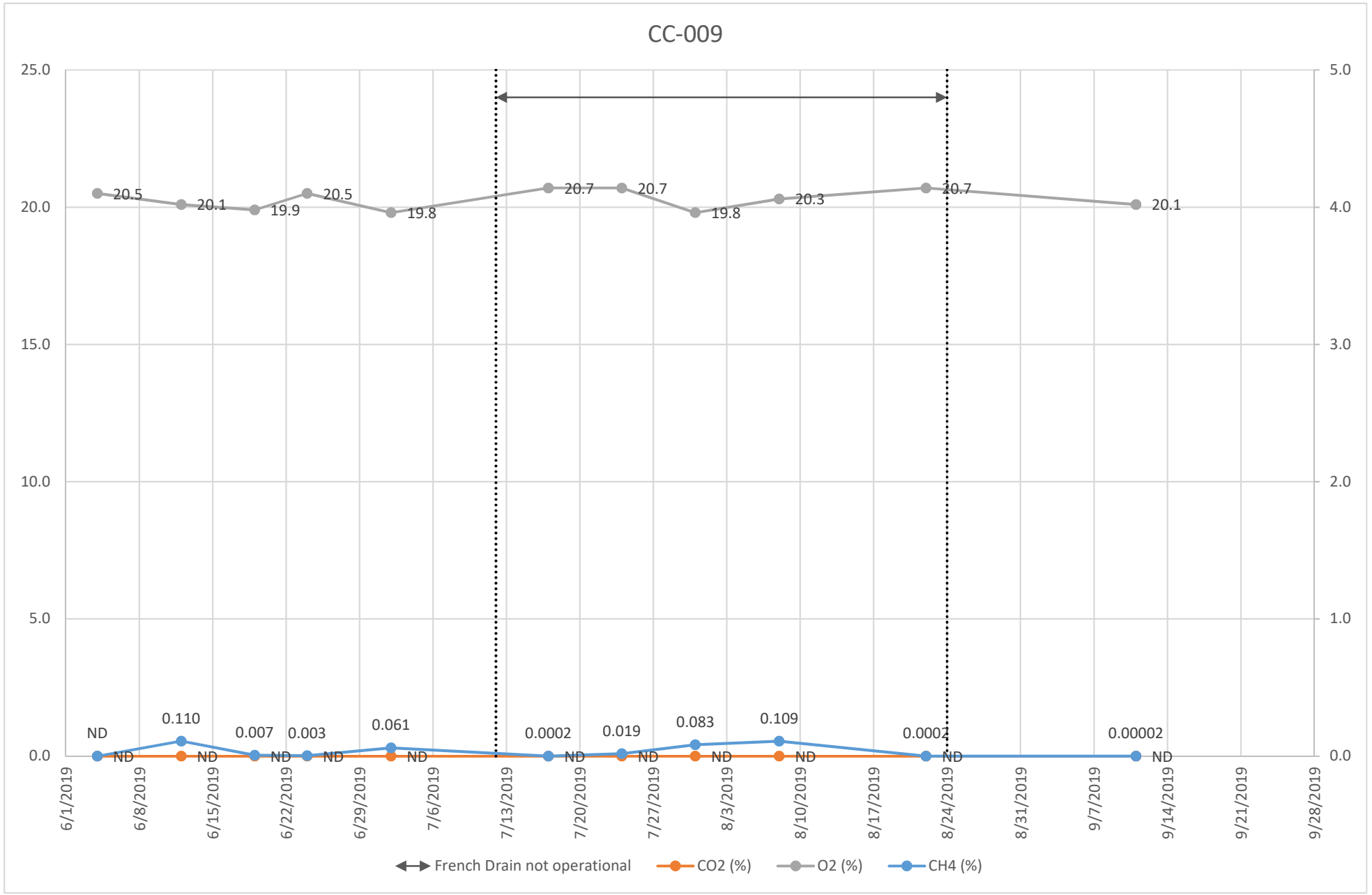

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10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
13.0
17.3
19.2
12.2
6.5
18.8
18.2
20.0
19.1
8.7
20.8
18.8
2.1
1.0
0.2
0.21
4.1
5.2
1.0
0.7
0.8
0.3
4.6
0.4
0.7
0.80
0.10
0.79
1.00
0.25
0.31
0.50
0.01
2.30
0.23
0.44
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

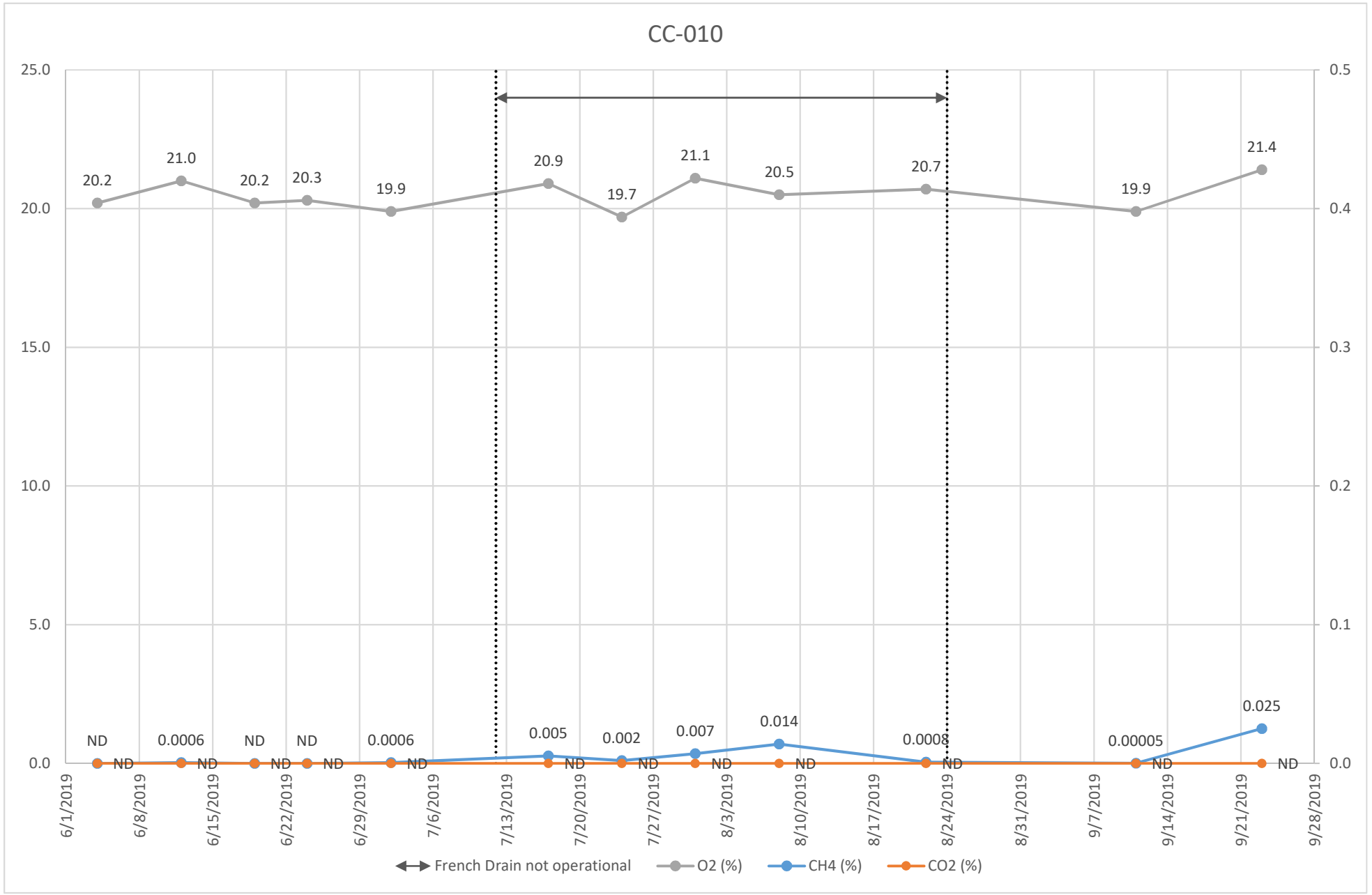

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10.0
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19.7
18.0
19.6
20.5
17.2
20.3
18.8
19.1
20.5
15.4
20.1
20.5
ND
0.2
0.024
ND
0.0001
ND
0.2
0.004
ND
0.001
0.004
ND
0.2
0.002
0.2
0.001
3.7
0.016
ND
0.0001
ND
0.00002
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

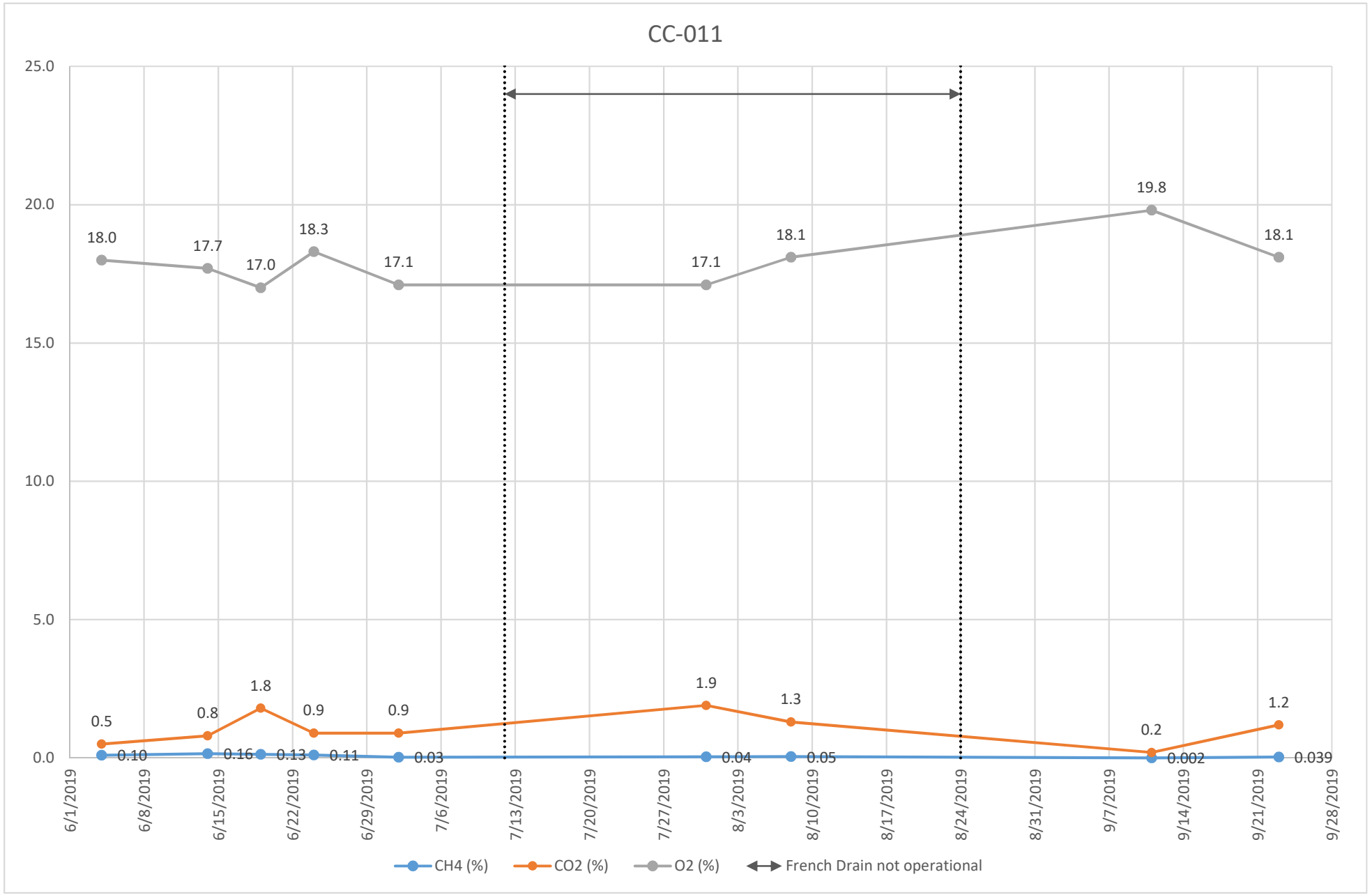

CC-006
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5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
20.2
20.6
20.3
20.6
18.3
19.9
18.6
21.7
20.6
19.5
20.3
20.1
21.0
ND
0.001
0.00006
0.1
0.083
0.00001
0.034
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

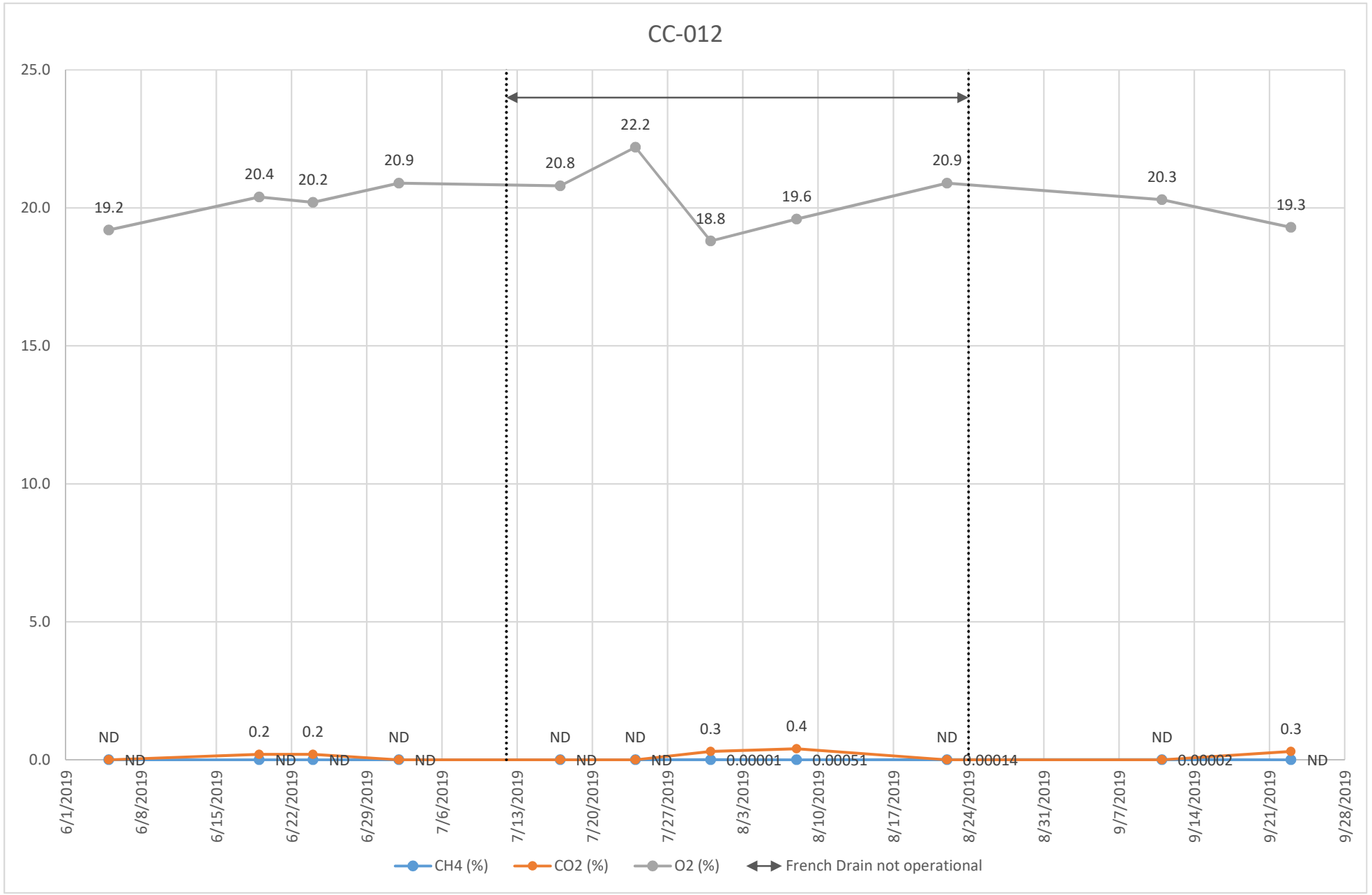

CC-007
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10.0
5.0
0.0
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0.08
0.06
0.04
0.02
0
19.8
17.9
19.2
20.1
16.1
18.1
18.7
19.2
19.2
14.3
22.2
19.8
18.3
ND
0.0010
0.0005
0.0005
0.0001
0.0008
0.0030
0.0002
0.0001
0.0015
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

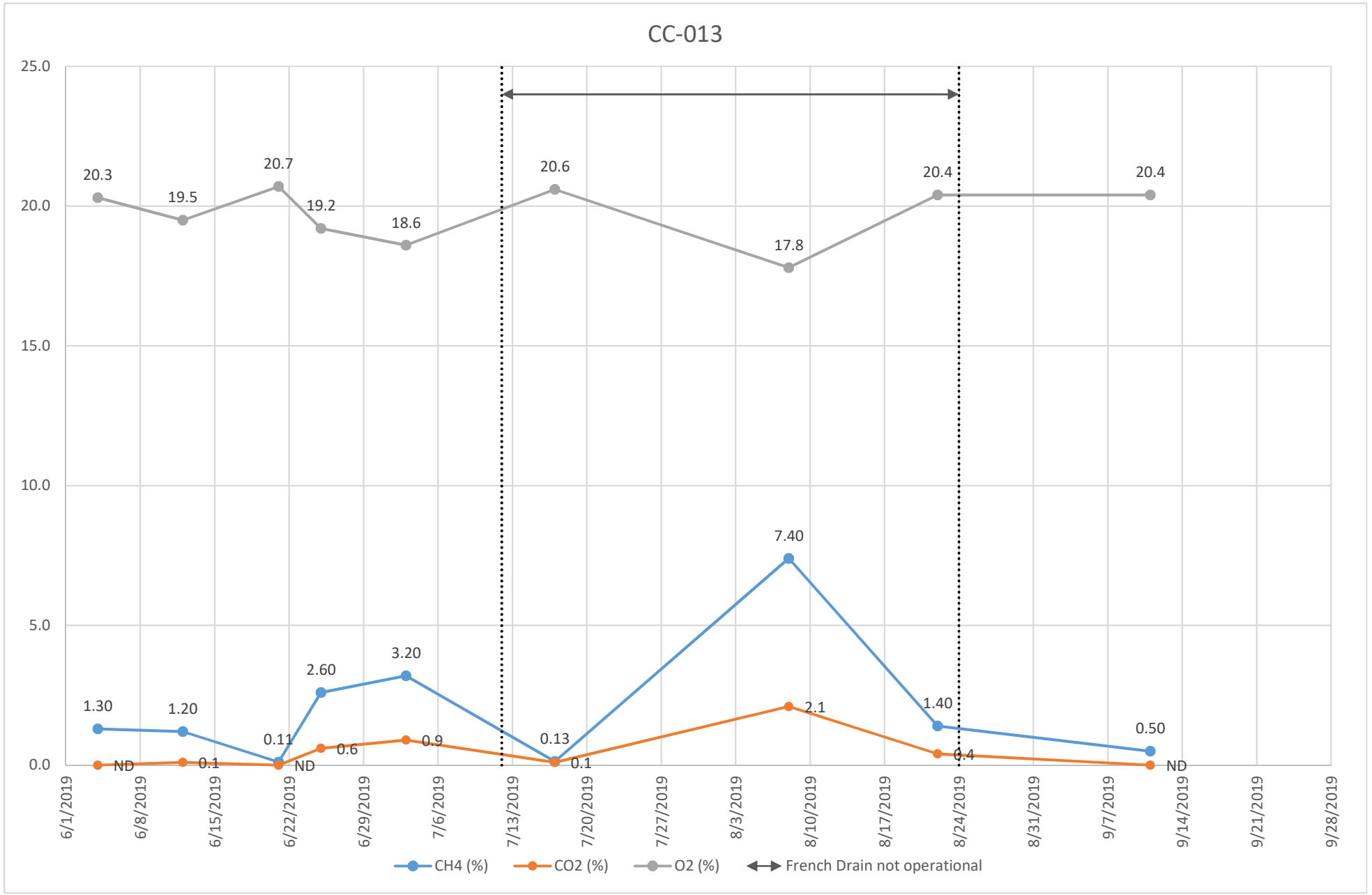

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0.004
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0
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22.8
20.4
20.7
17.3
18.3
21.6
20.6
19.8
22.1
19.1
20.5
ND
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0.00006
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

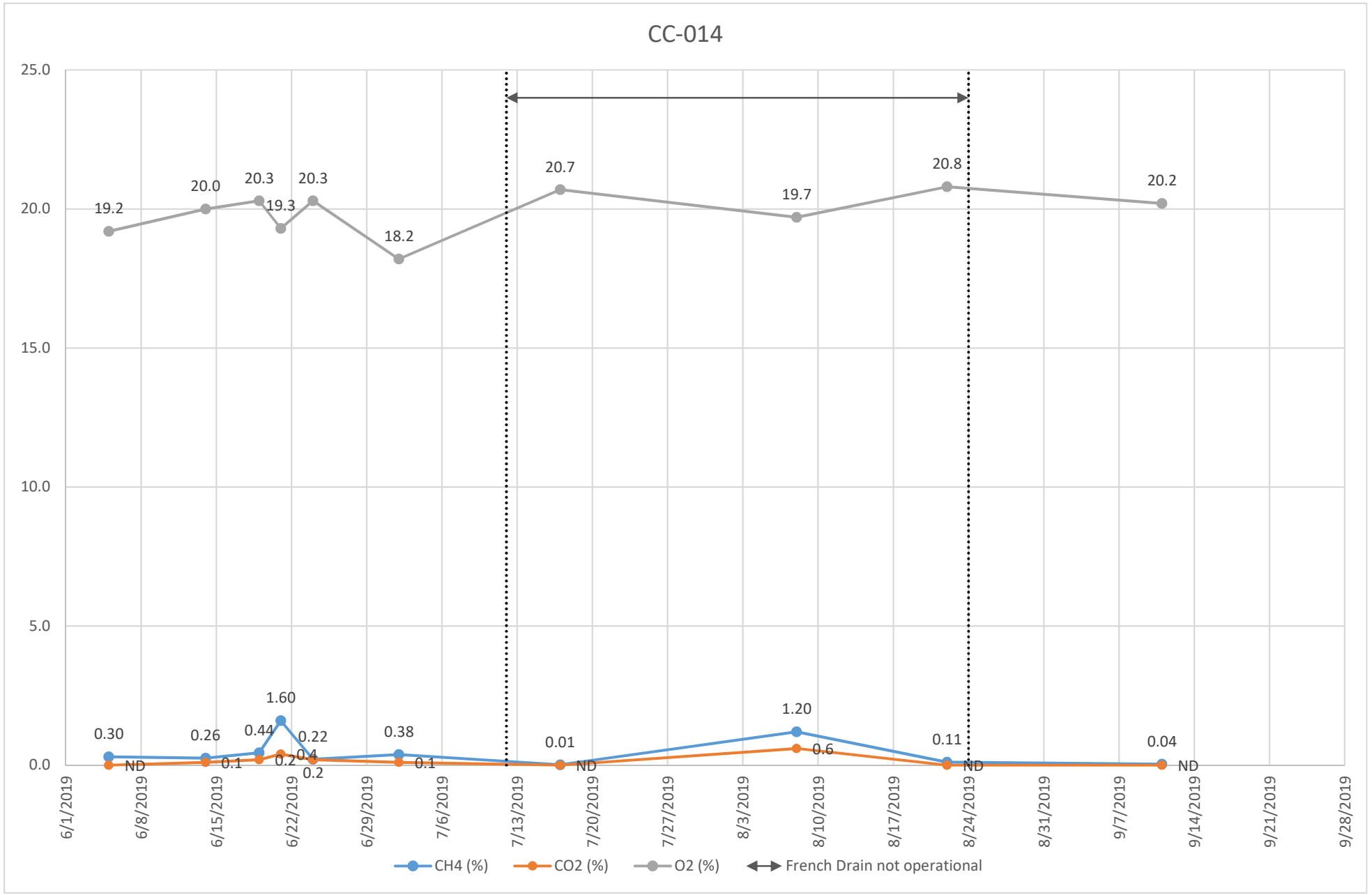

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5.0
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2.0
1.0
0.0
20.5
20.1
19.9
20.5
19.8
20.7
20.7
19.8
20.3
20.7
20.1
ND
0.110
0.007
0.003
0.061
0.0002
0.019
0.083
0.109
0.0002
0.00002
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
CO2 (%)
O2 (%)
CH4 (%)

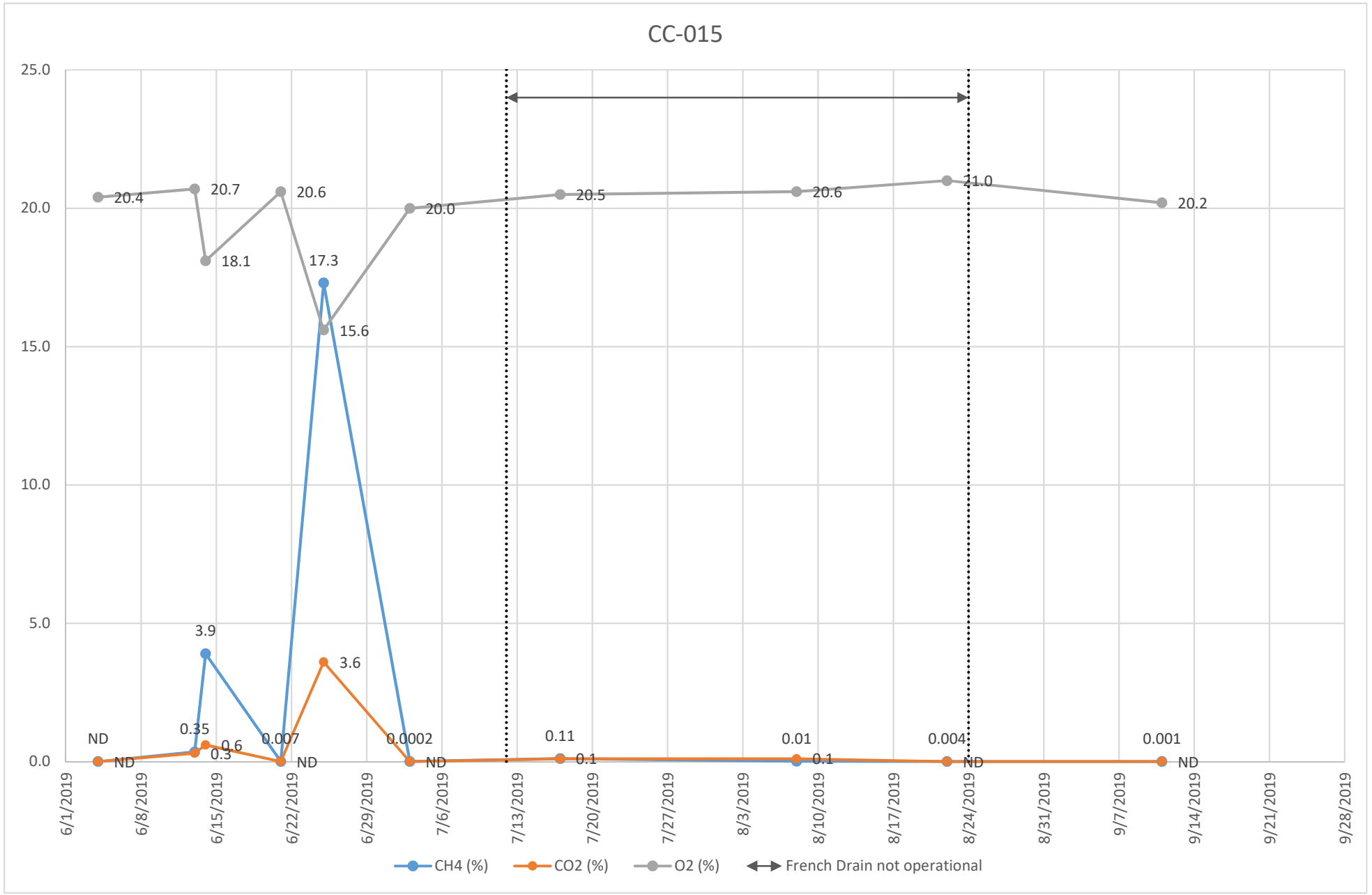

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0.3
0.2
0.1
0.0
20.2
21.0
20.2
20.3
19.9
20.9
19.7
21.1
20.5
20.7
19.9
21.4
ND
0.0006
ND
ND
0.0006
0.005
0.002
0.007
0.014
0.0008
0.00005
0.025
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

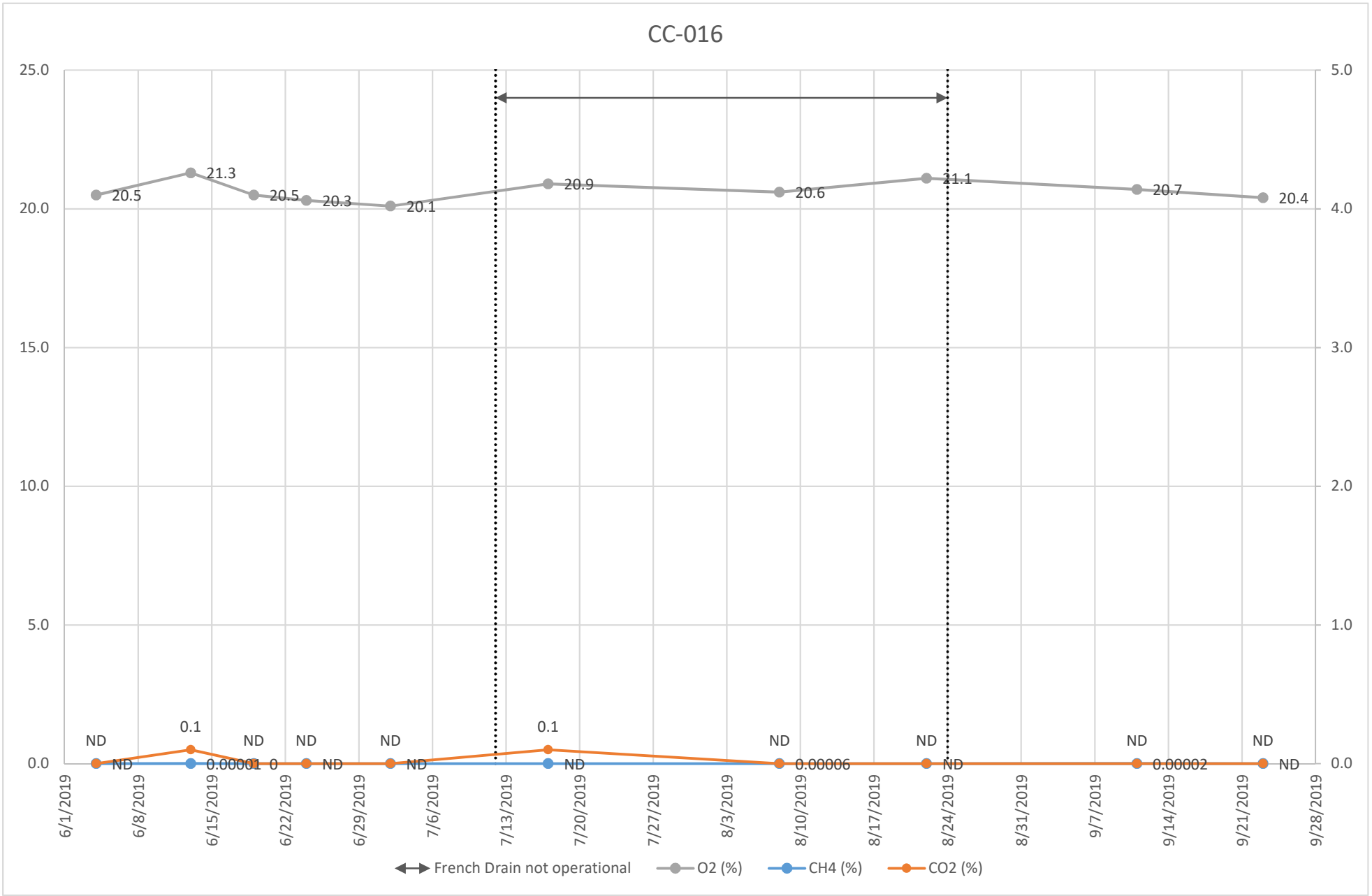

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18.0
17.7
17.0
18.3
17.1
17.1
18.1
19.8
18.1
0.5
0.8
1.8
0.9
0.9
1.9
1.3
0.2
1.2
0.10
0.16
0.13
0.11
0.03
0.04
0.05
0.002
0.039
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

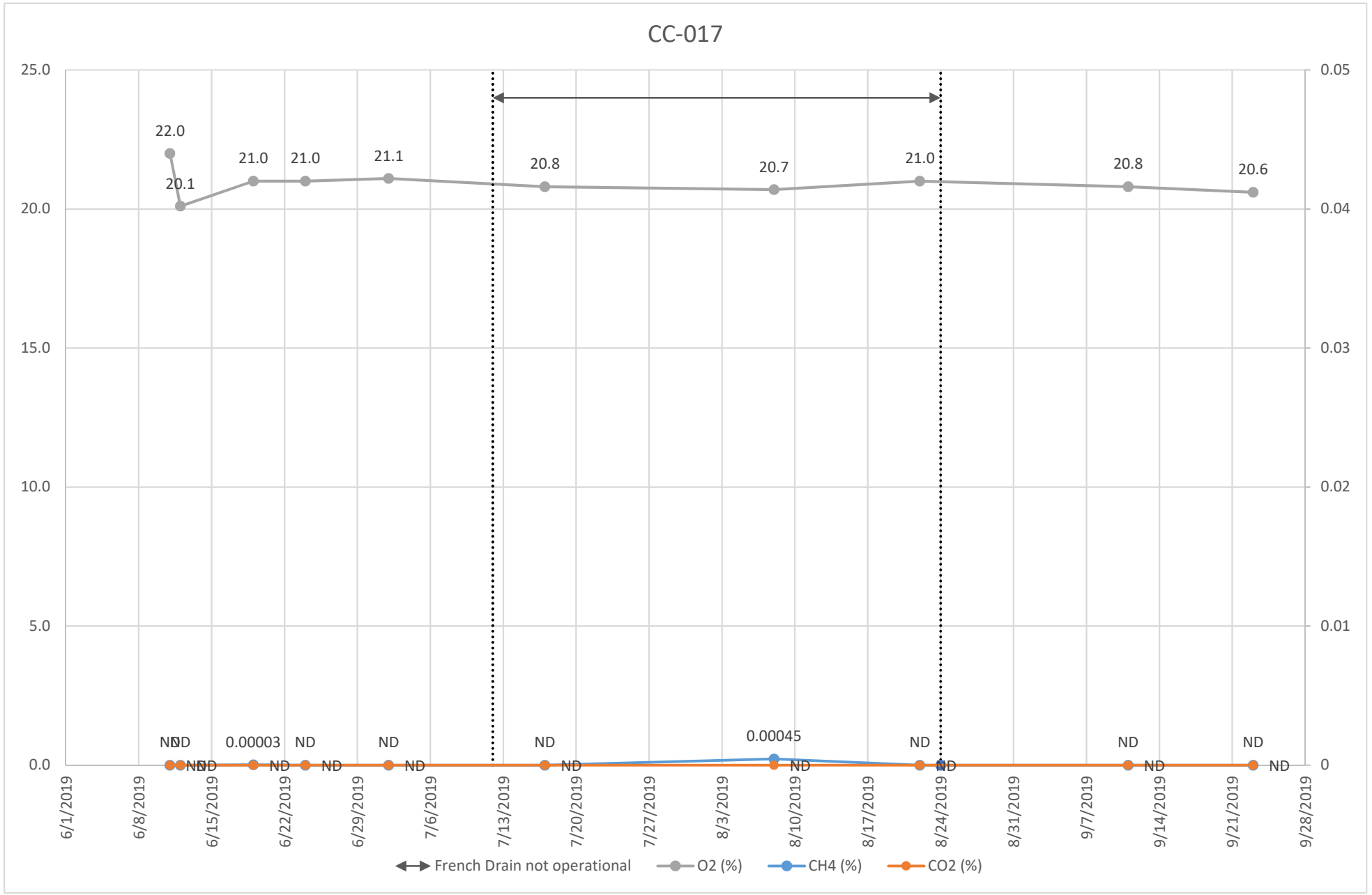

CC-012
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15.0
10.0
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0.0
19.2
20.4
20.2
20.9
20.8
22.2
18.8
19.6
20.9
20.3
19.3
ND
0.2
0.2
ND
ND
ND
ND
0.3
0.4
ND
ND
0.3
ND
ND
ND
ND
0.00001
0.00051
ND
0.00014
0.00002
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

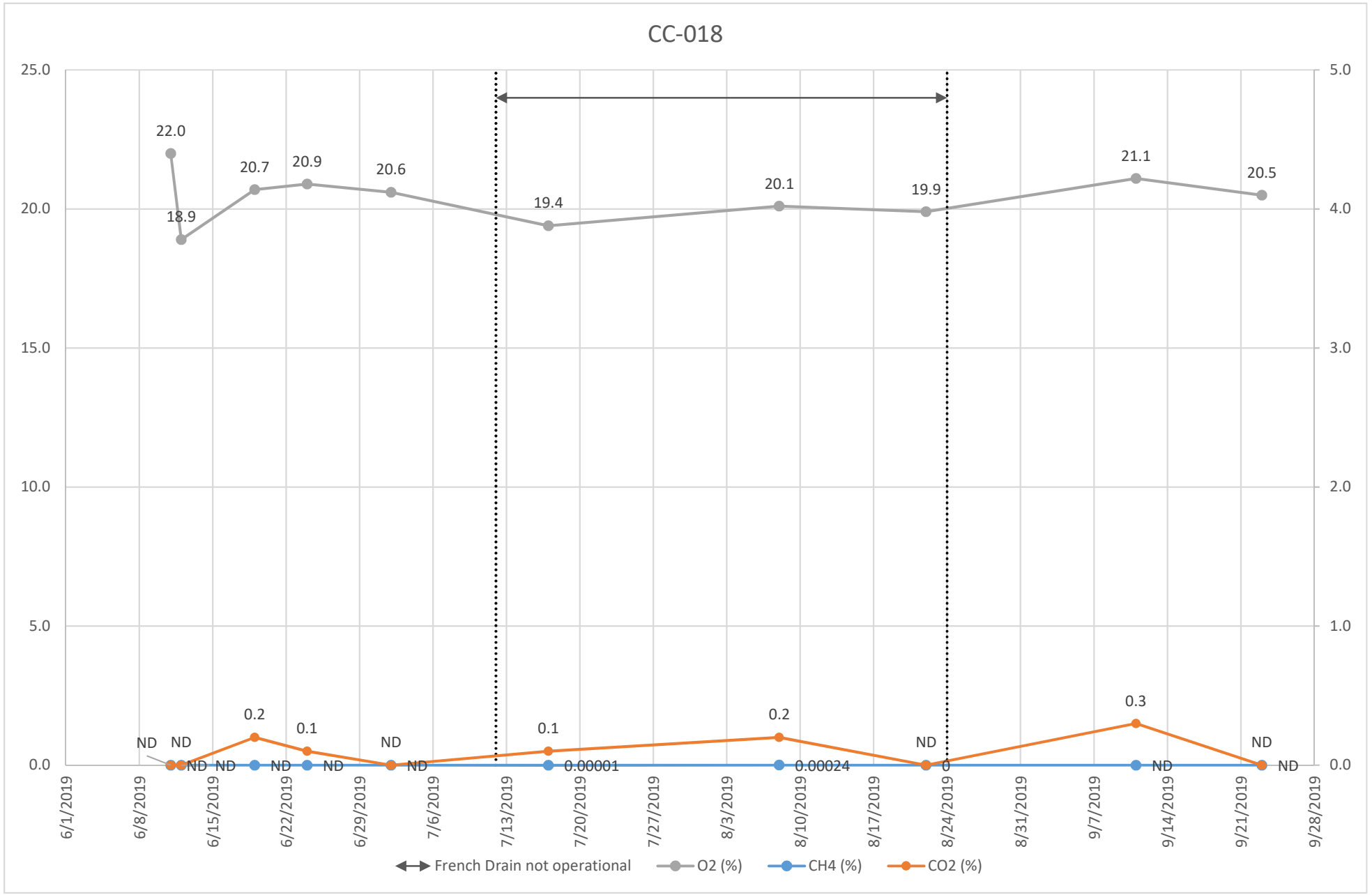

CC-013
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5.0
0.0
20.3
19.5
20.7
19.2
18.6
20.6
17.8
20.4
20.4
1.30
1.20
0.11
2.60
3.20
0.13
7.40
1.40
0.50
ND
0.1
ND
0.6
0.9
0.1
2.1
0.4
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

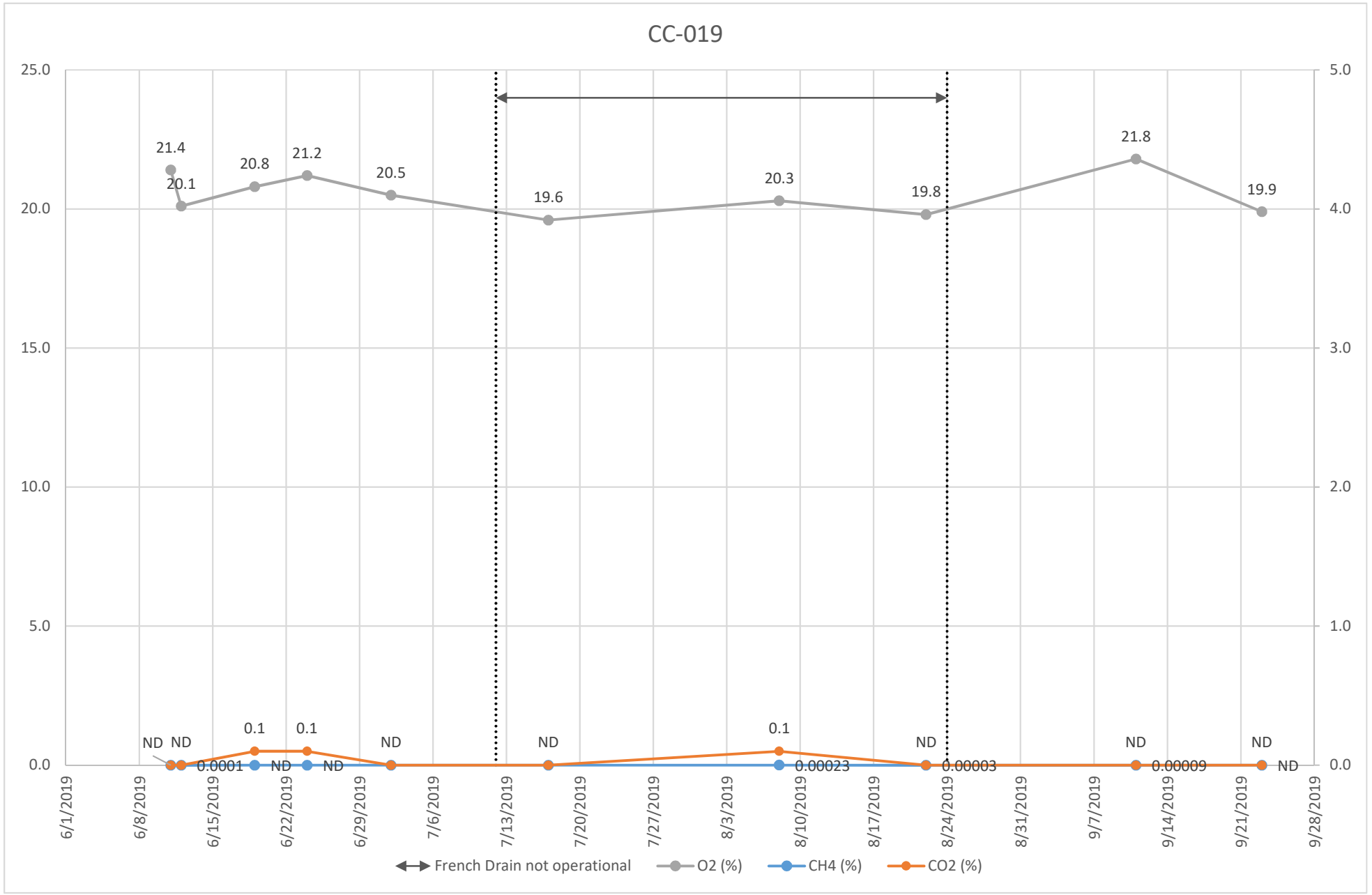

CC-014
25.0
20.0
15.0
10.0
5.0
0.0
19.2
20.0
20.3
19.3
20.3
18.2
20.7
19.7
20.8
20.2
0.30
0.26
0.44
1.60
0.22
0.4
0.2
0.38
0.1
0.01
ND
1.20
0.6
0.11
ND
0.04
ND
ND
0.1
0.2
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

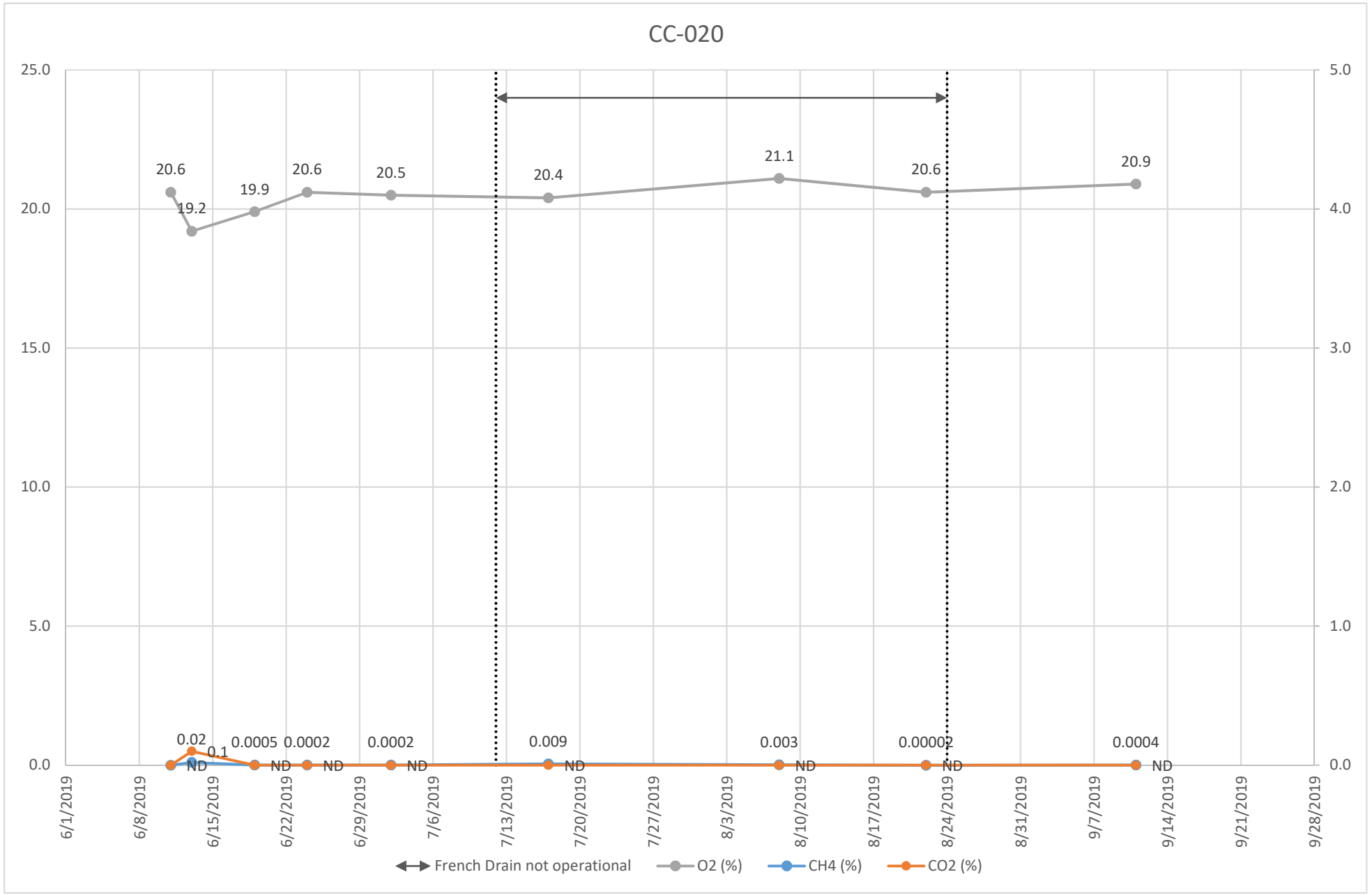

CC-015
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
20.4
20.7
18.1
20.6
17.3
15.6
20.0
20.5
20.6
21.0
20.2
ND
ND
0.35
3.9
0.3
0.6
0.007
ND
3.6
0.0002
ND
0.11
0.1
0.01
0.1
0.004
ND
0.001
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

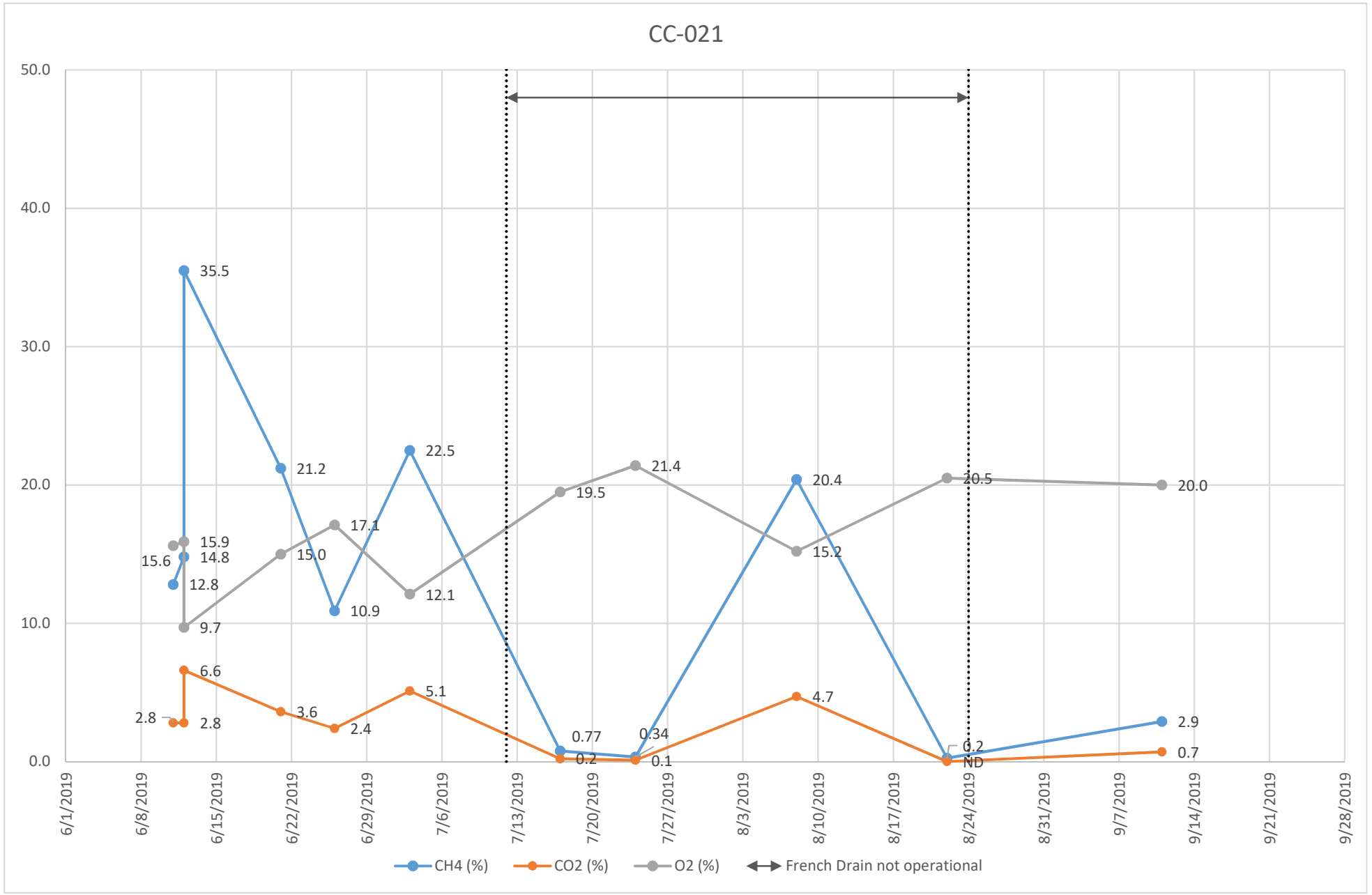

CC-016
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
20.5
21.3
20.5
20.3
20.1
20.9
20.6
21.1
20.7
20.4
ND
0.1
ND
ND
ND
0.1
ND
ND
ND
ND
ND
ND
ND
ND
ND
0.00001
0
ND
ND
ND
0.00006
ND
0.00002
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

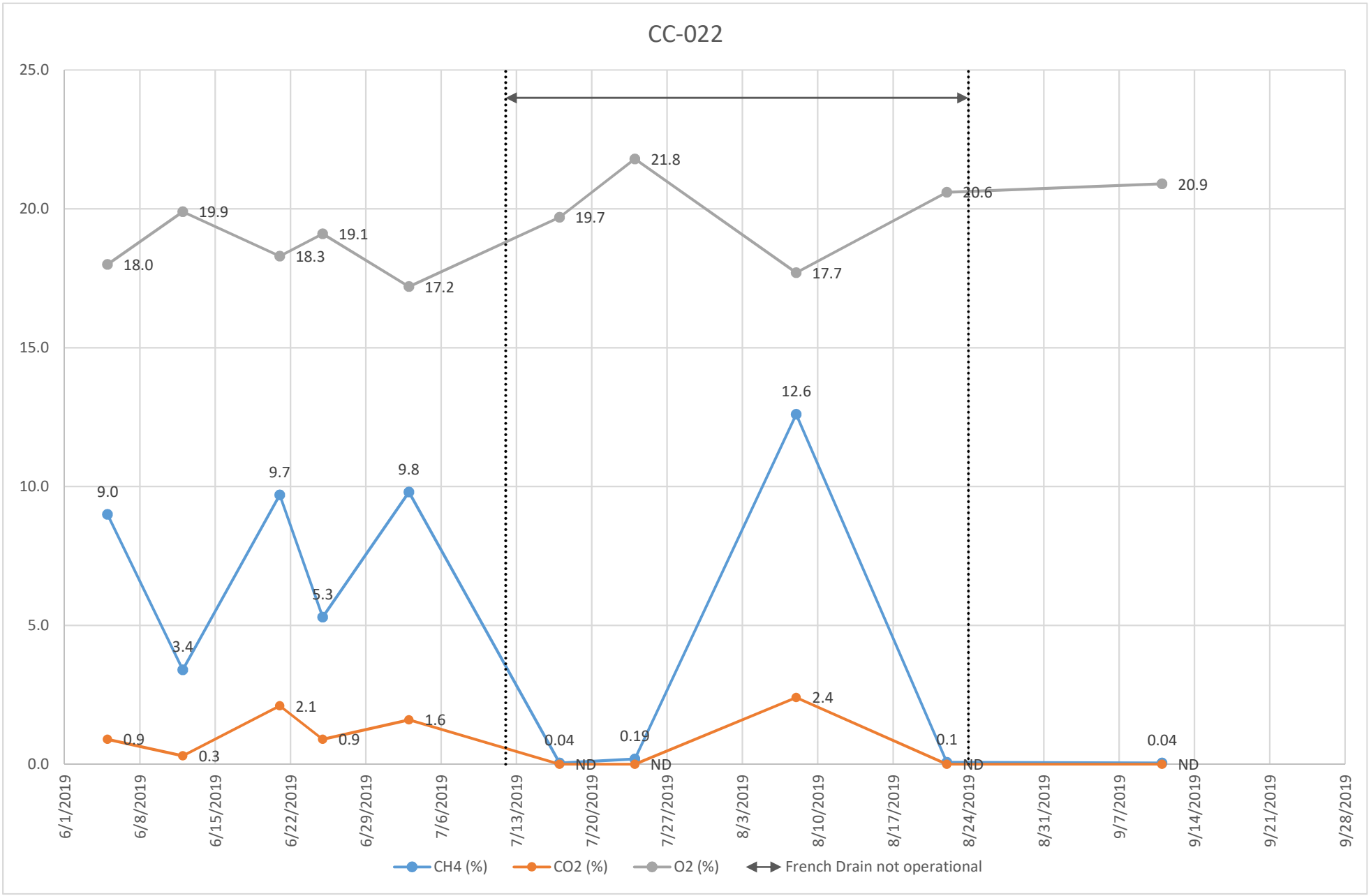

CC-017
25.0
20.0
15.0
10.0
5.0
0.0
0.05
0.04
0.03
0.02
0.01
0
22.0
20.1
21.0
21.0
21.1
20.8
20.7
21.0
20.8
20.6
ND
0.00003
0.00045
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

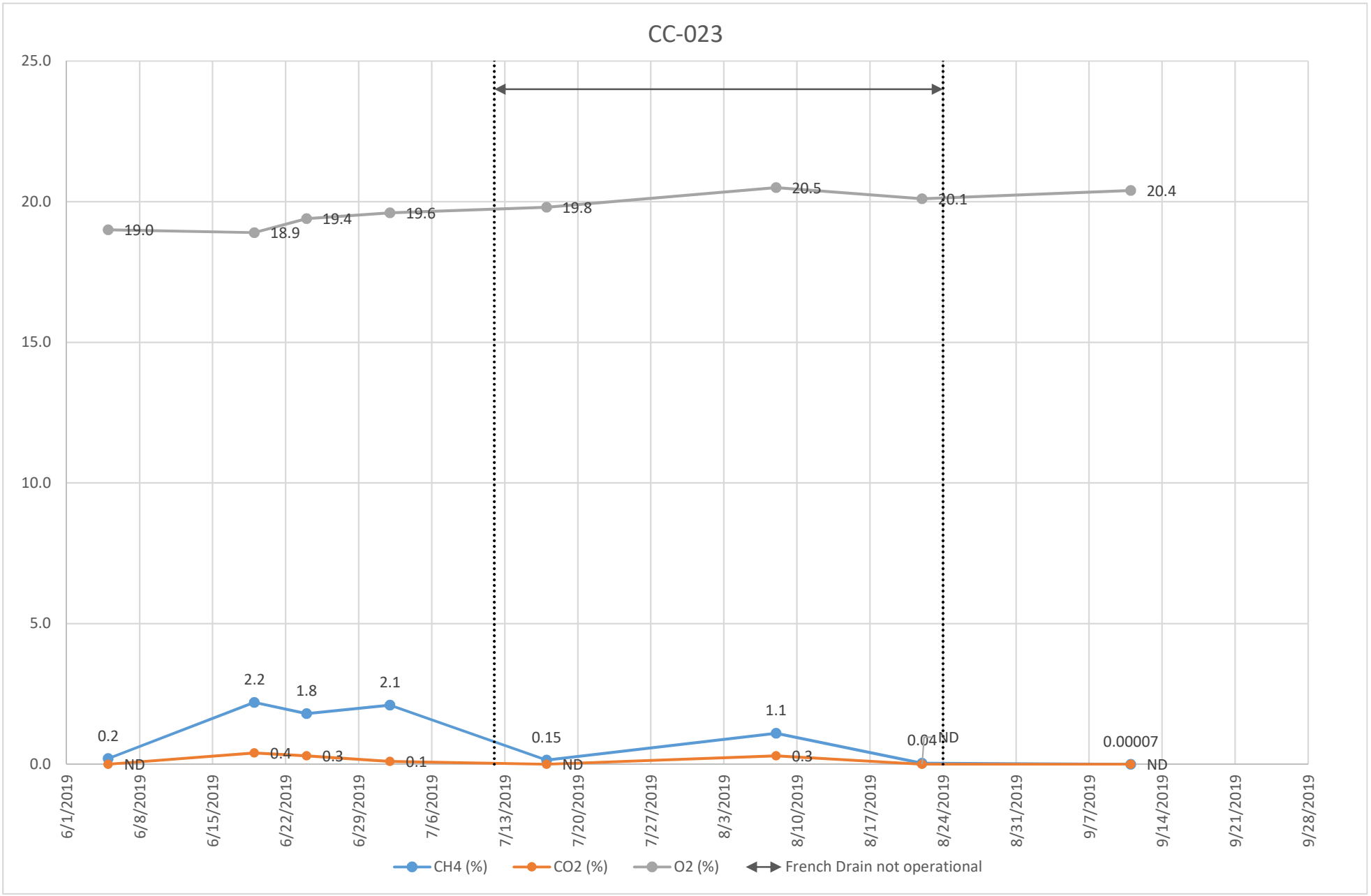

CC-018
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
22.0
18.9
20.7
20.9
20.6
19.4
20.1
19.9
21.1
20.5
ND
ND
ND
ND
ND
ND
ND
ND
0.2
0.1
0.1
0.2
0.3
0.00001
0.00024
0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

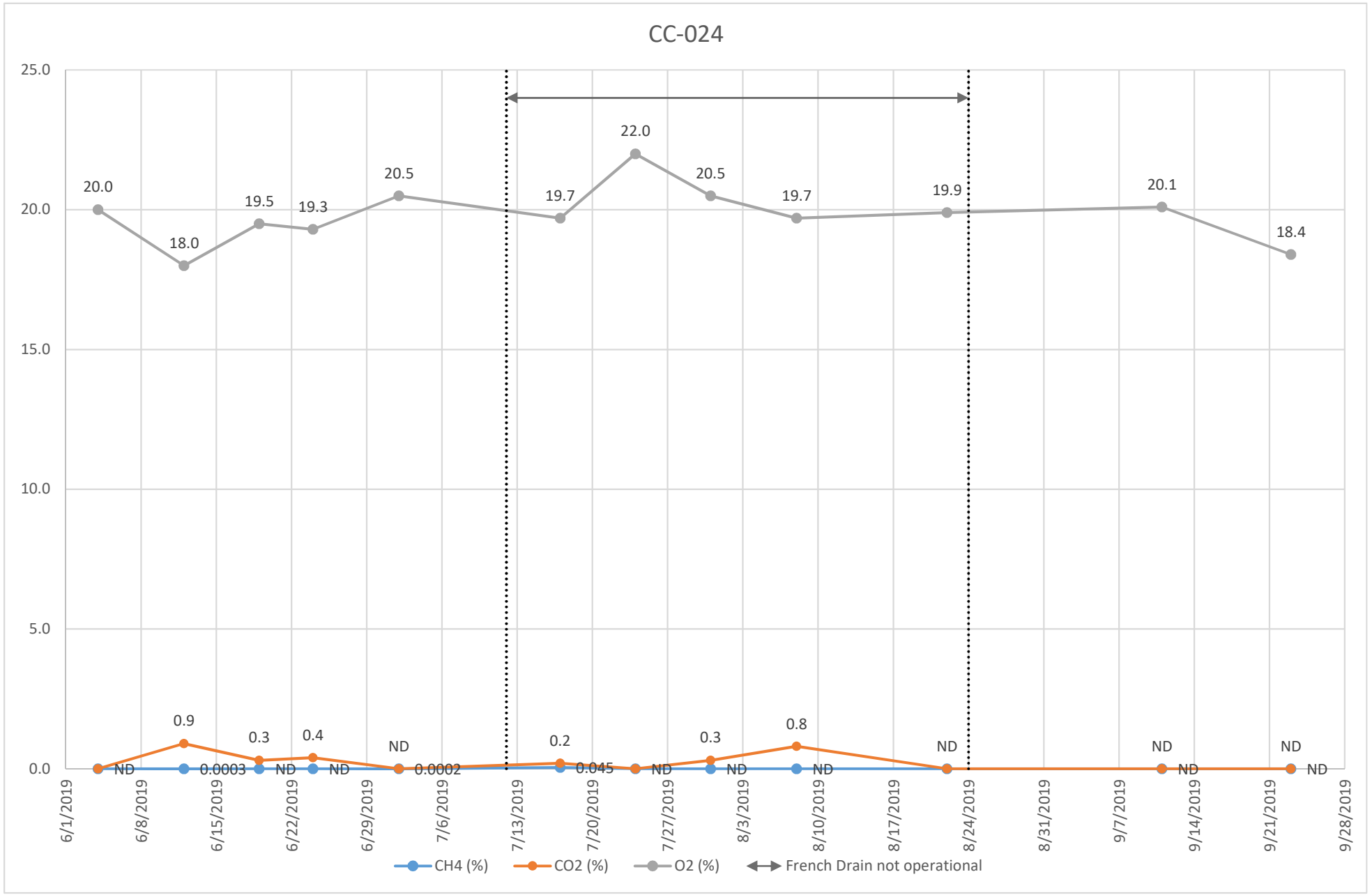

CC-019
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
21.4
20.1
20.8
21.2
20.5
19.6
20.3
19.8
21.8
19.9
ND
ND
0.1
0.1
ND
ND
0.1
ND
ND
0.0001
ND
ND
0.00023
0.00003
0.00009
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

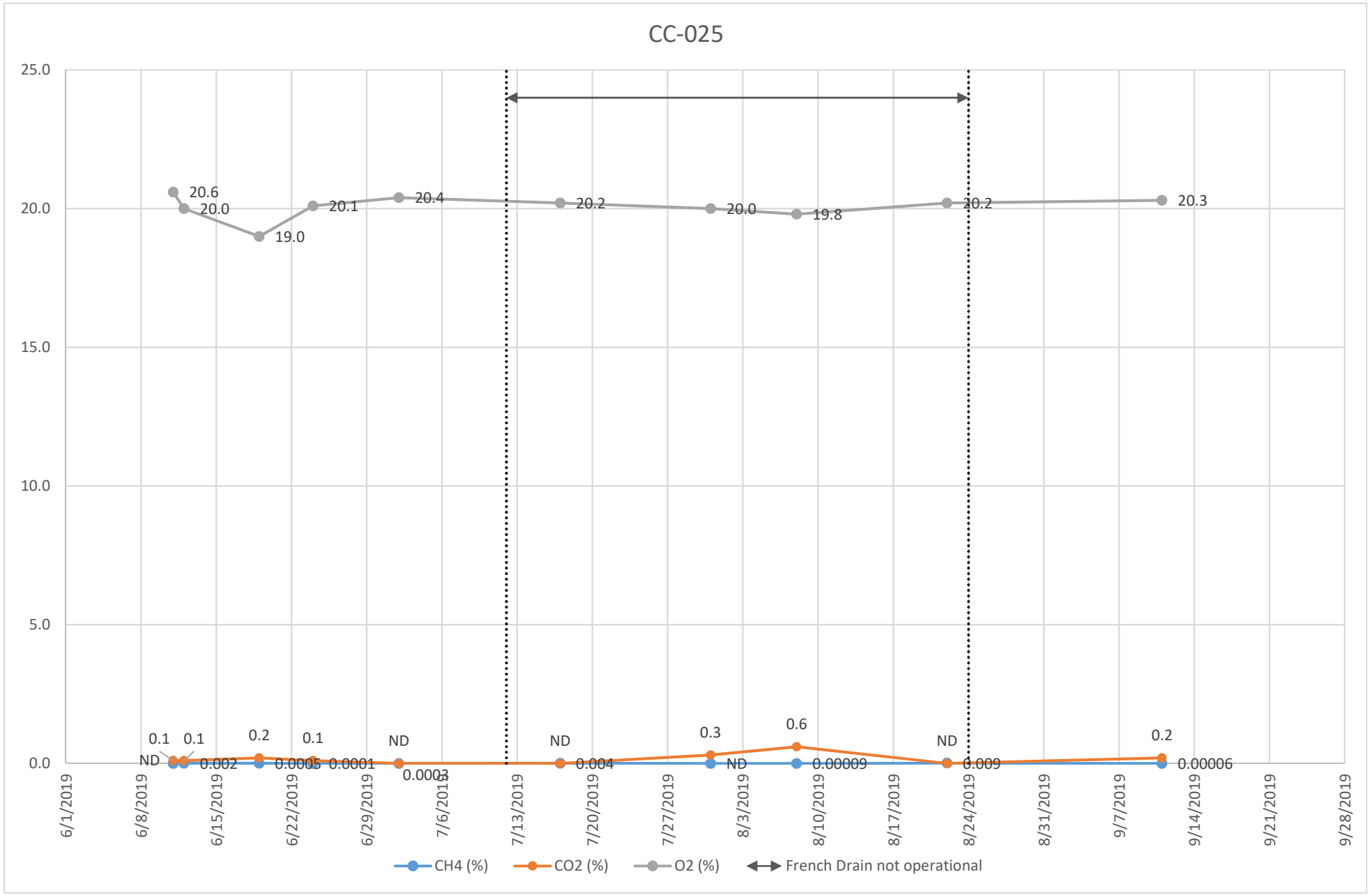

CC-020
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
20.6
19.2
19.9
20.6
20.5
20.4
21.1
20.6
20.9
0.02
0.1
ND
0.0005
ND
0.0002
ND
0.0002
ND
0.009
ND
0.003
ND
0.00002
ND
0.0004
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

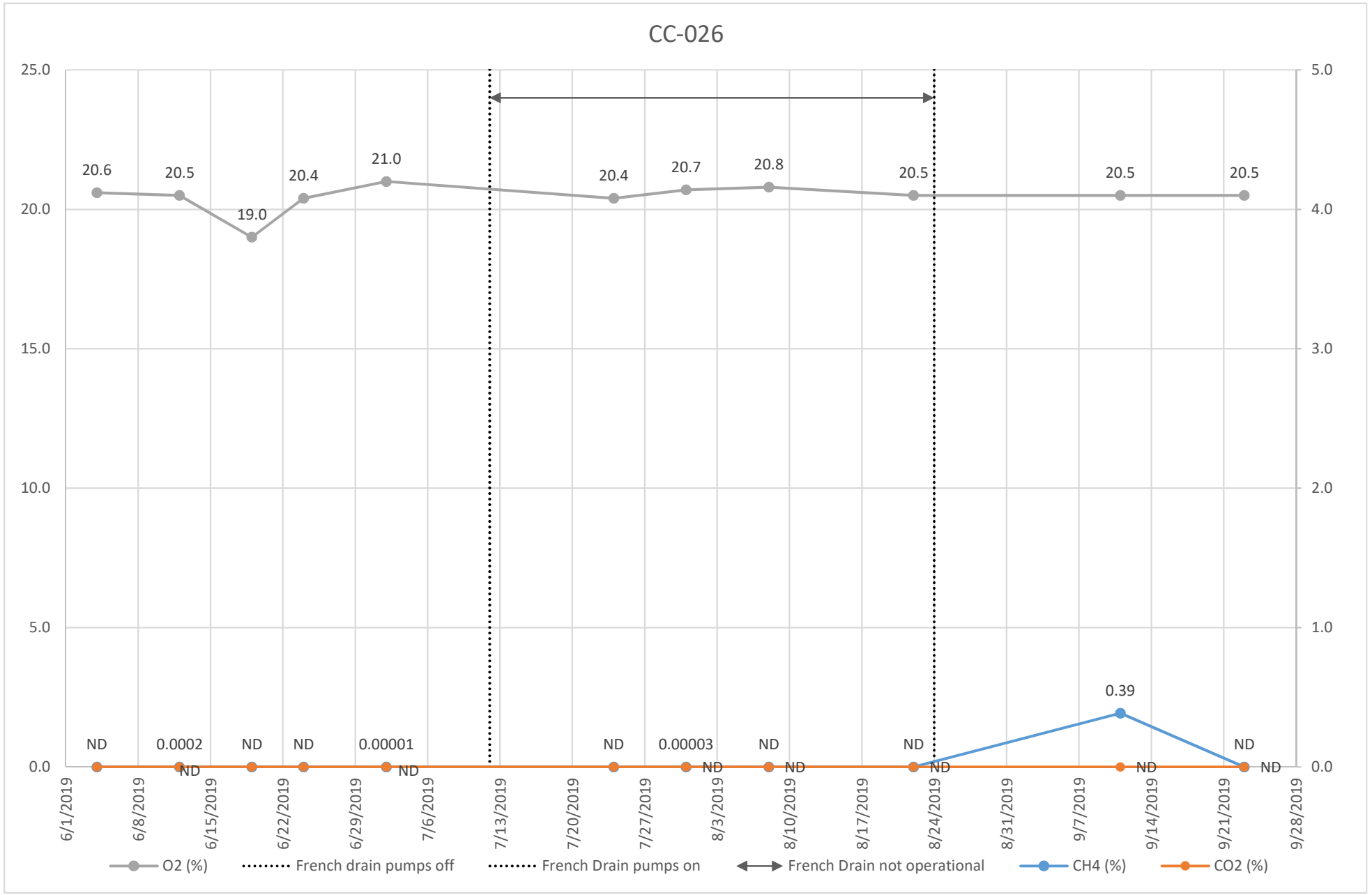

CC-021
50.0
40.0
30.0
20.0
10.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
35.5
21.2
22.5
10.9
0.77
0.34
20.4
0.2
2.9
15.6
15.9
14.8
12.8
15.0
17.1
12.1
19.5
21.4
15.2
20.5
20.0
9.7
6.6
2.8
2.8
3.6
2.4
5.1
0.2
0.1
4.7
ND
0.7
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

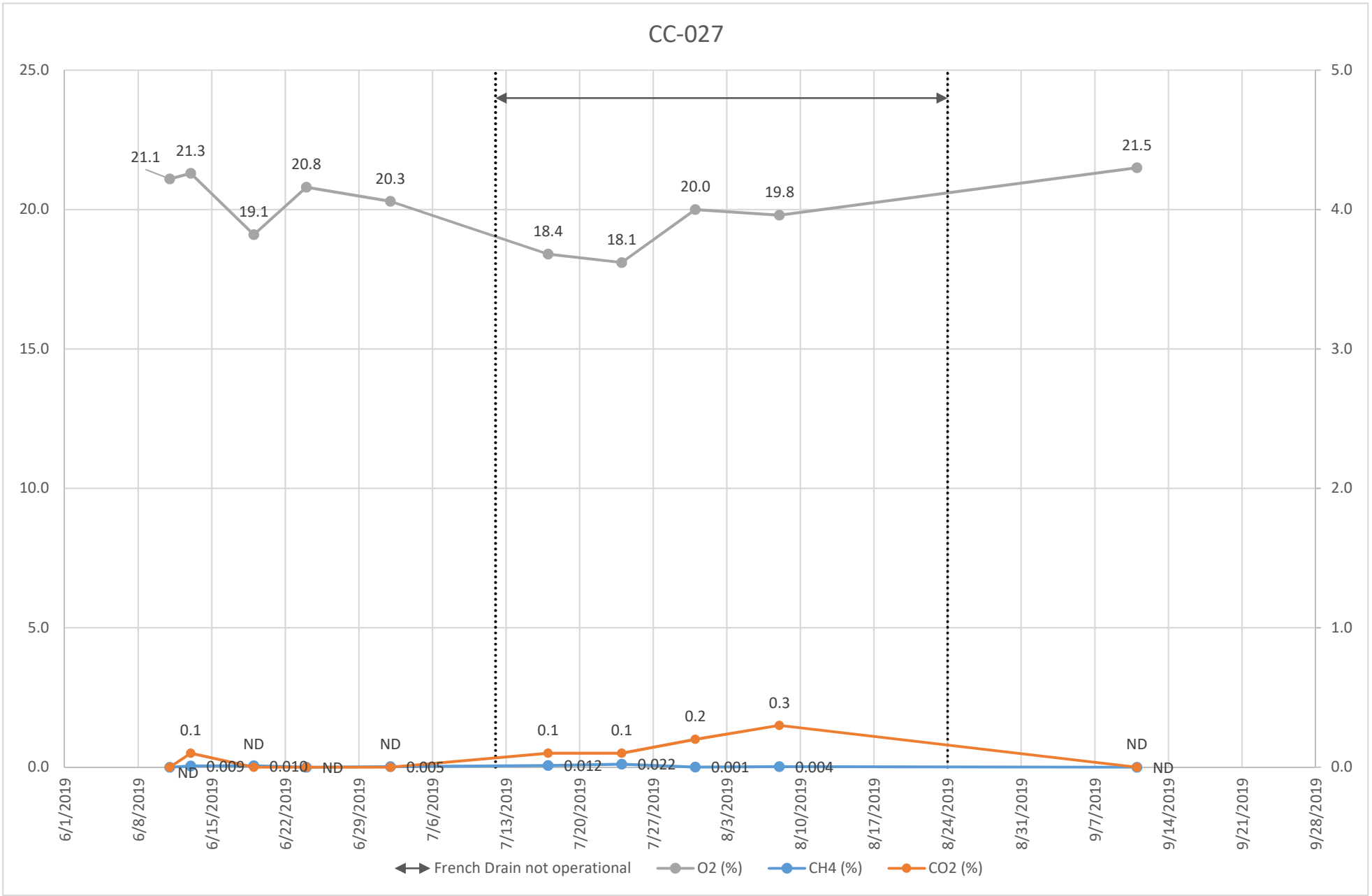

CC-022
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
18.0
19.9
18.3
19.1
17.2
19.7
21.8
17.7
20.6
20.9
9.0
3.4
9.7
5.3
9.8
0.04
ND
0.19
ND
12.6
0.1
ND
0.04
ND
0.9
0.3
2.1
0.9
1.6
2.4
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

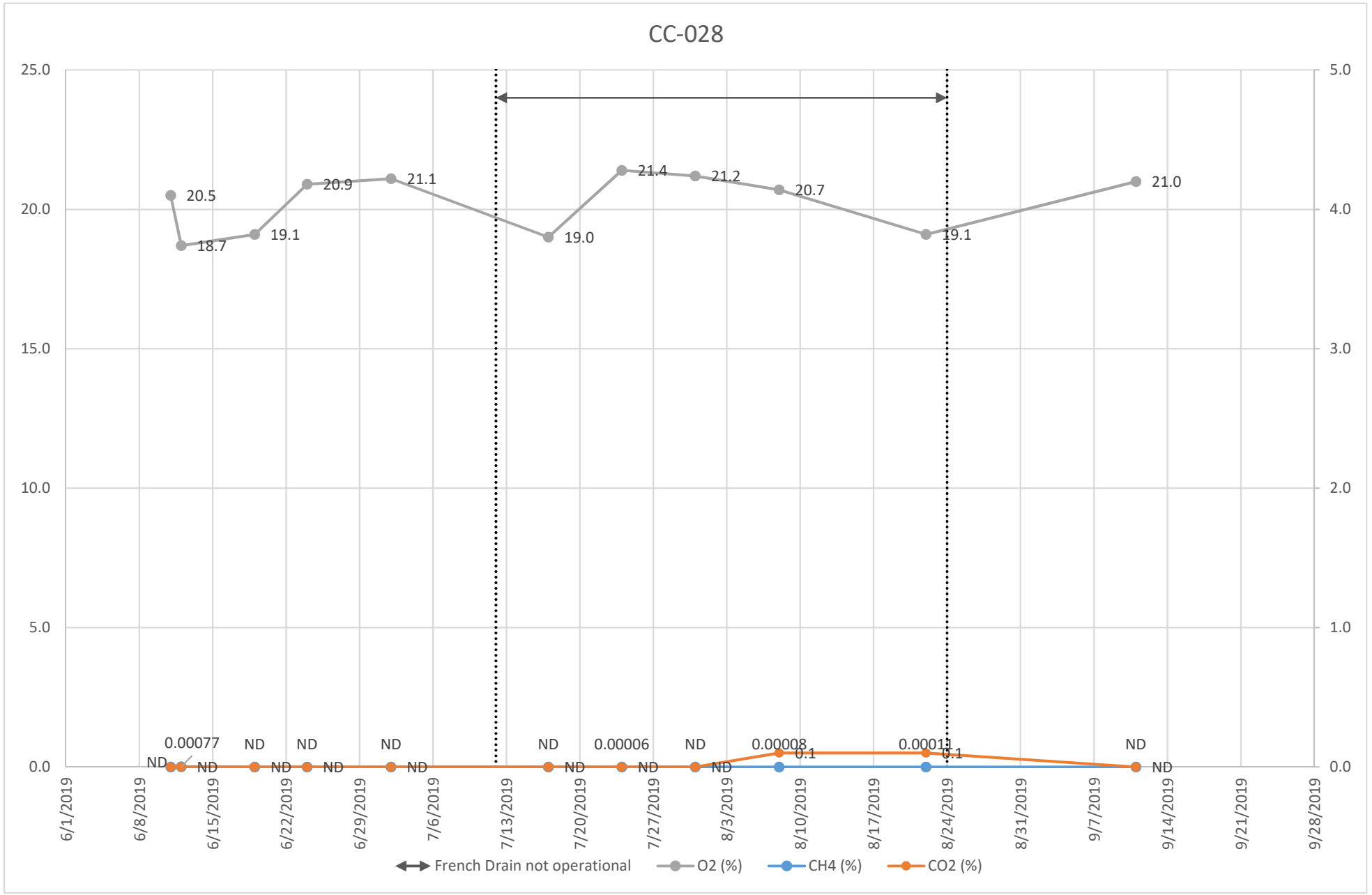

CC-023
25.0
20.0
15.0
10.0
5.0
0.0
19.0
18.9
19.4
19.6
19.8
20.5
20.1
20.4
0.2
2.2
1.8
2.1
0.15
1.1
0.04
0.00007
ND
0.4
0.3
0.1
ND
0.3
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

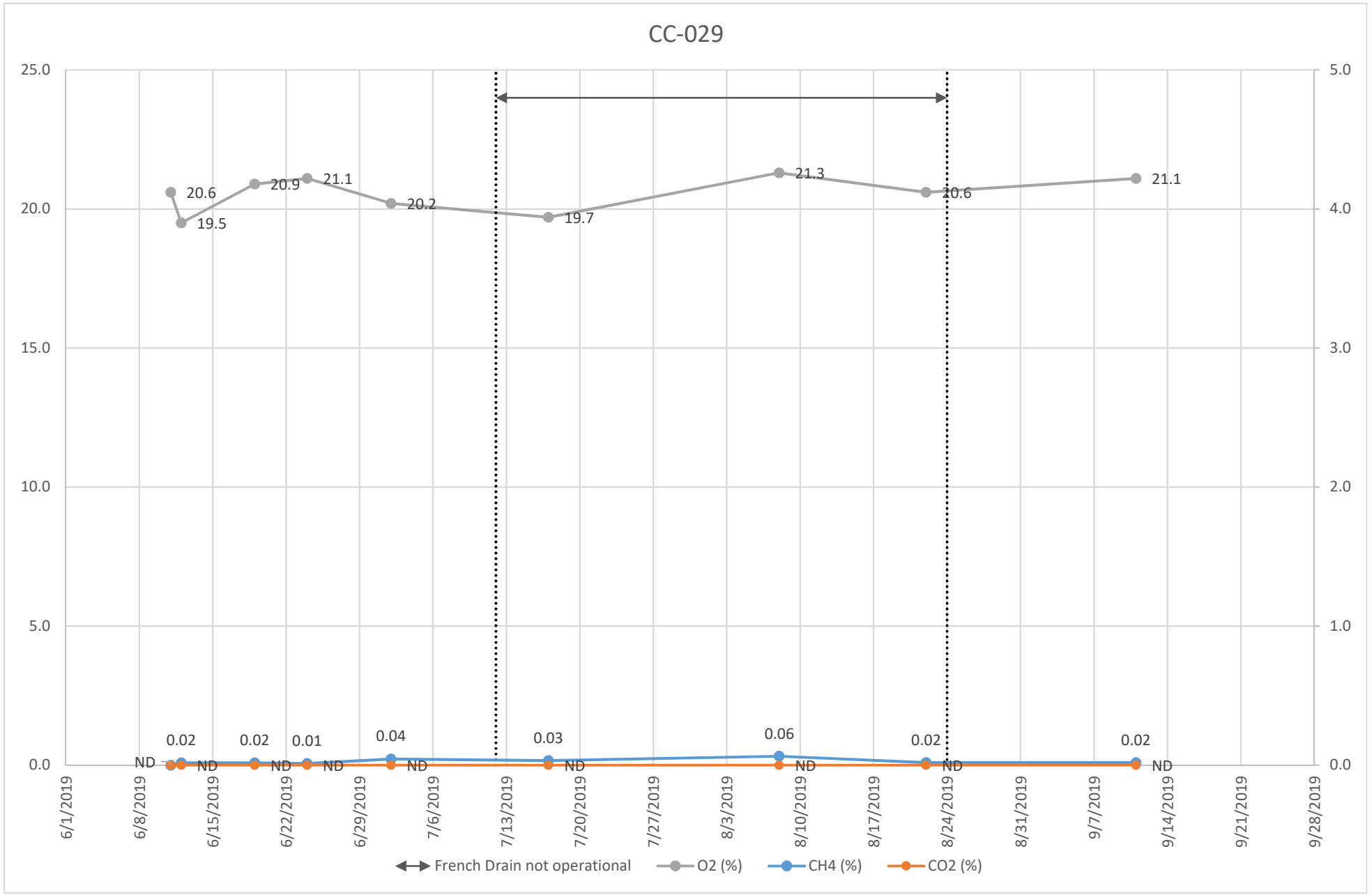

CC-024
25.0
20.0
15.0
10.0
5.0
0.0
20.0
18.0
19.5
19.3
20.5
19.7
22.0
20.5
19.7
19.9
20.1
18.4
0.9
0.3
0.4
ND
0.2
0.3
0.8
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
0.0003
ND
ND
0.0002
0.045
ND
ND
ND
ND
ND
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

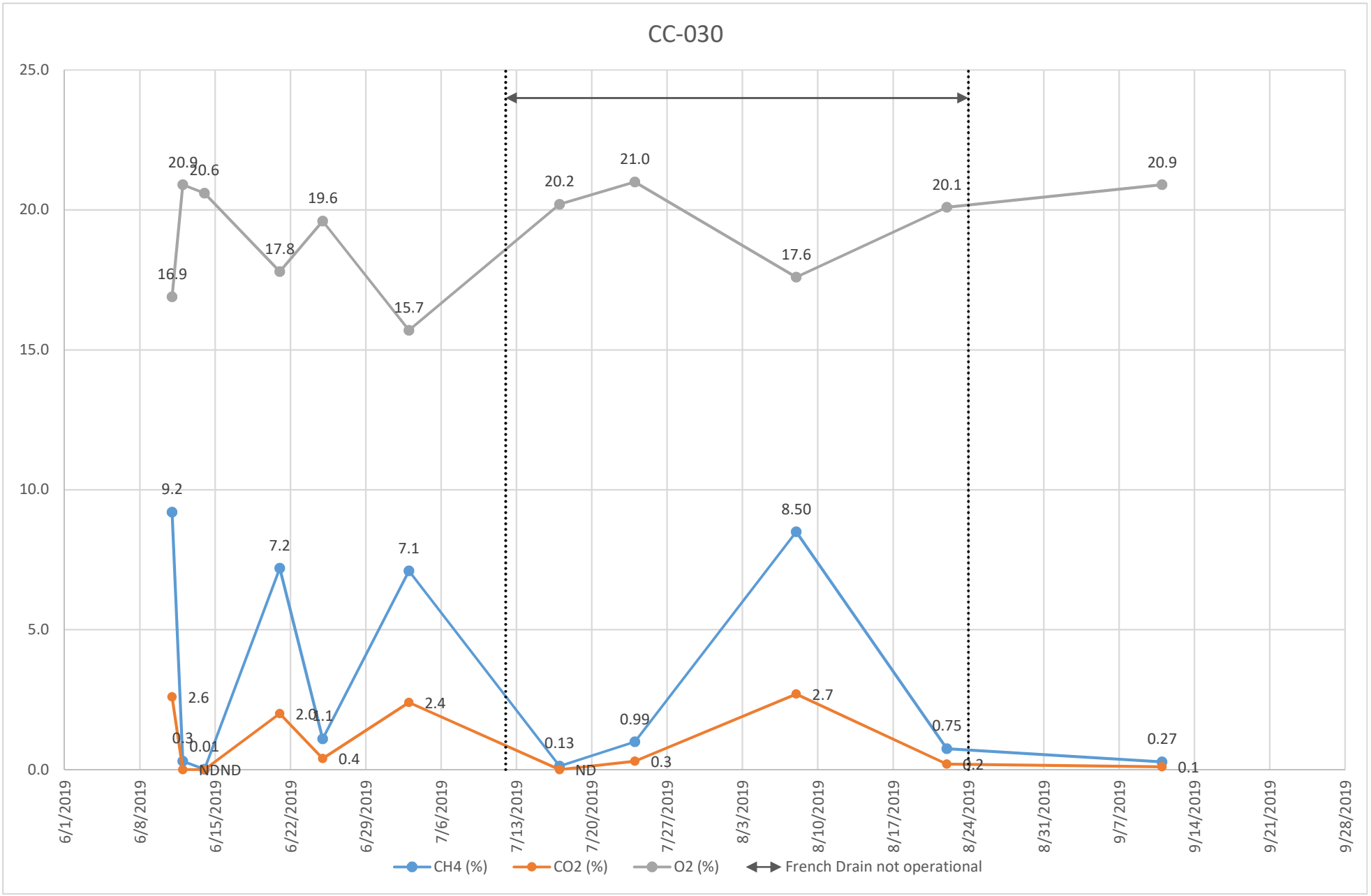

CC-025
25.0
20.0
15.0
10.0
5.0
0.0
20.6
20.0
19.0
20.1
20.4
20.2
20.0
19.8
20.2
20.3
0.1
0.1
0.2
0.1
ND
ND
0.3
0.6
ND
0.2
ND
0.002
0.0001
0.0003
0.004
ND
0.00009
0.009
0.00006
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

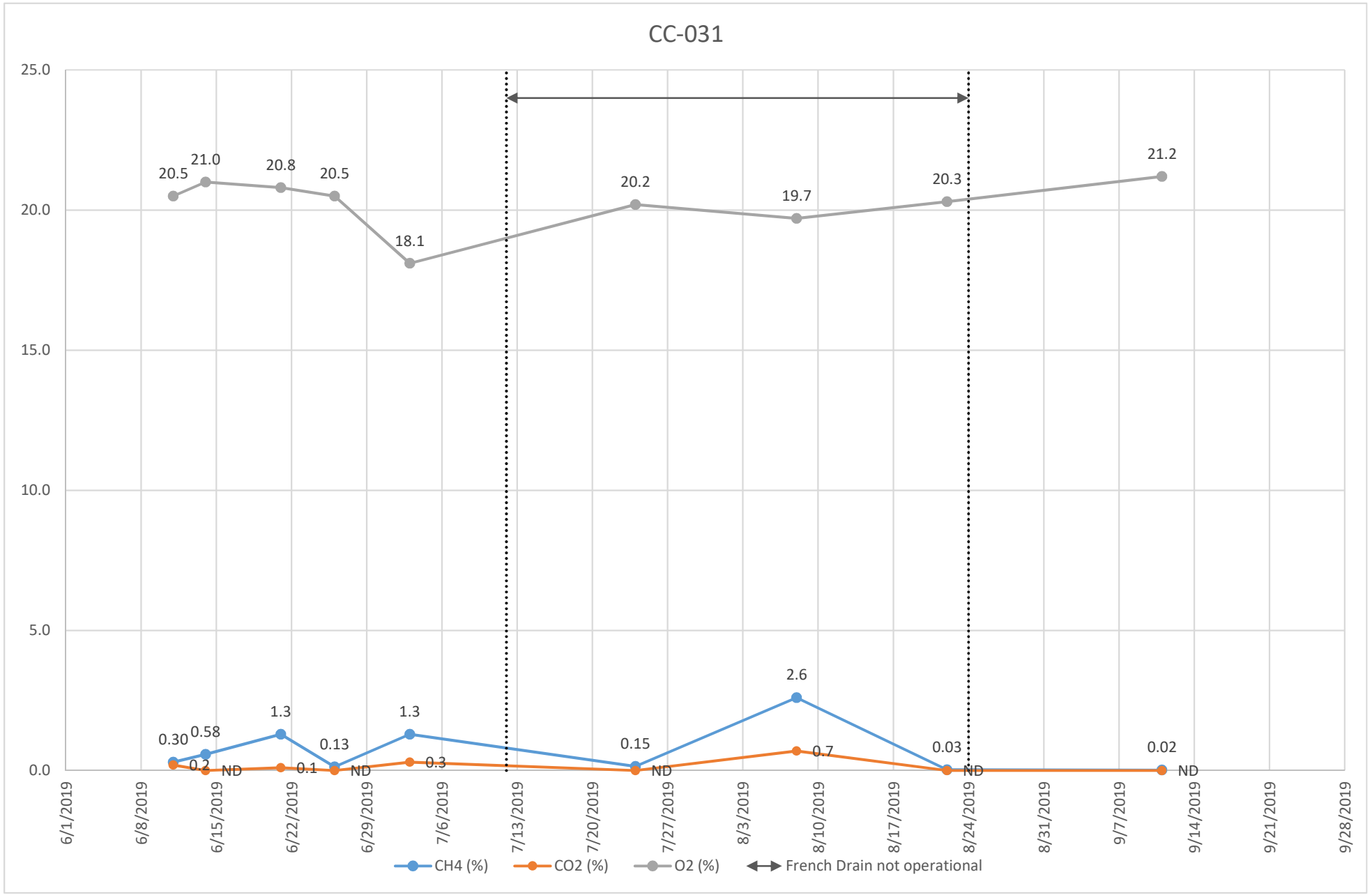

CC-026
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
20.6
20.5
19.0
20.4
21.0
20.4
20.7
20.8
20.5
20.5
20.5
ND
0.0002
ND
ND
0.00001
ND
ND
0.00003
ND
ND
ND
ND
0.39
ND
ND
ND
ND
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
O2 (%)
French drain pumps off
French Drain pumps on
French Drain not operational
CH4 (%)
CO2 (%)

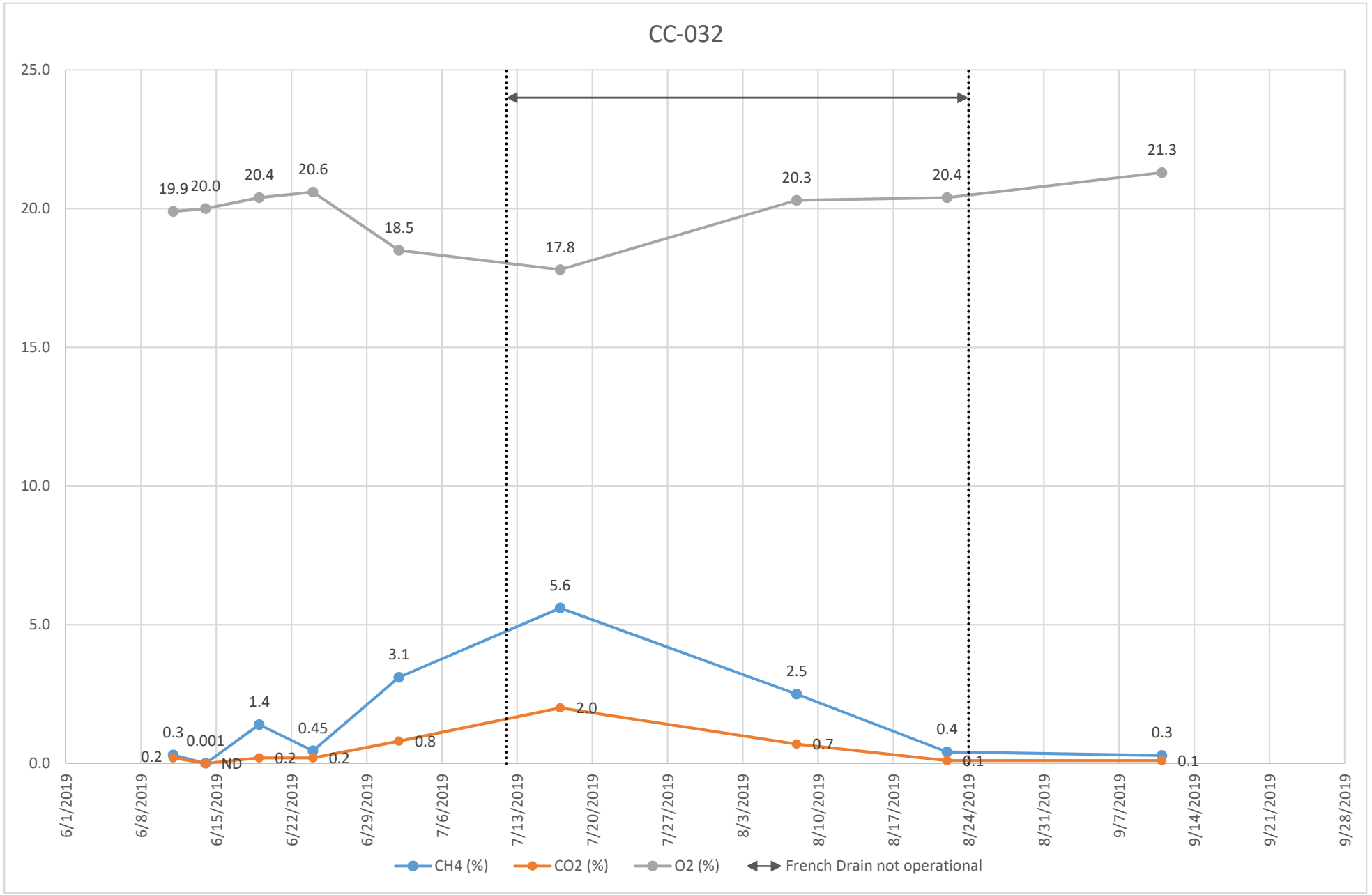

CC-027
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
21.1
21.3
19.1
20.8
20.3
18.4
18.1
20.0
19.8
21.5
0.1
ND
ND
0.1
0.1
0.2
0.3
ND
ND
ND
0.009
0.010
ND
0.005
0.012
0.022
0.001
0.004
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

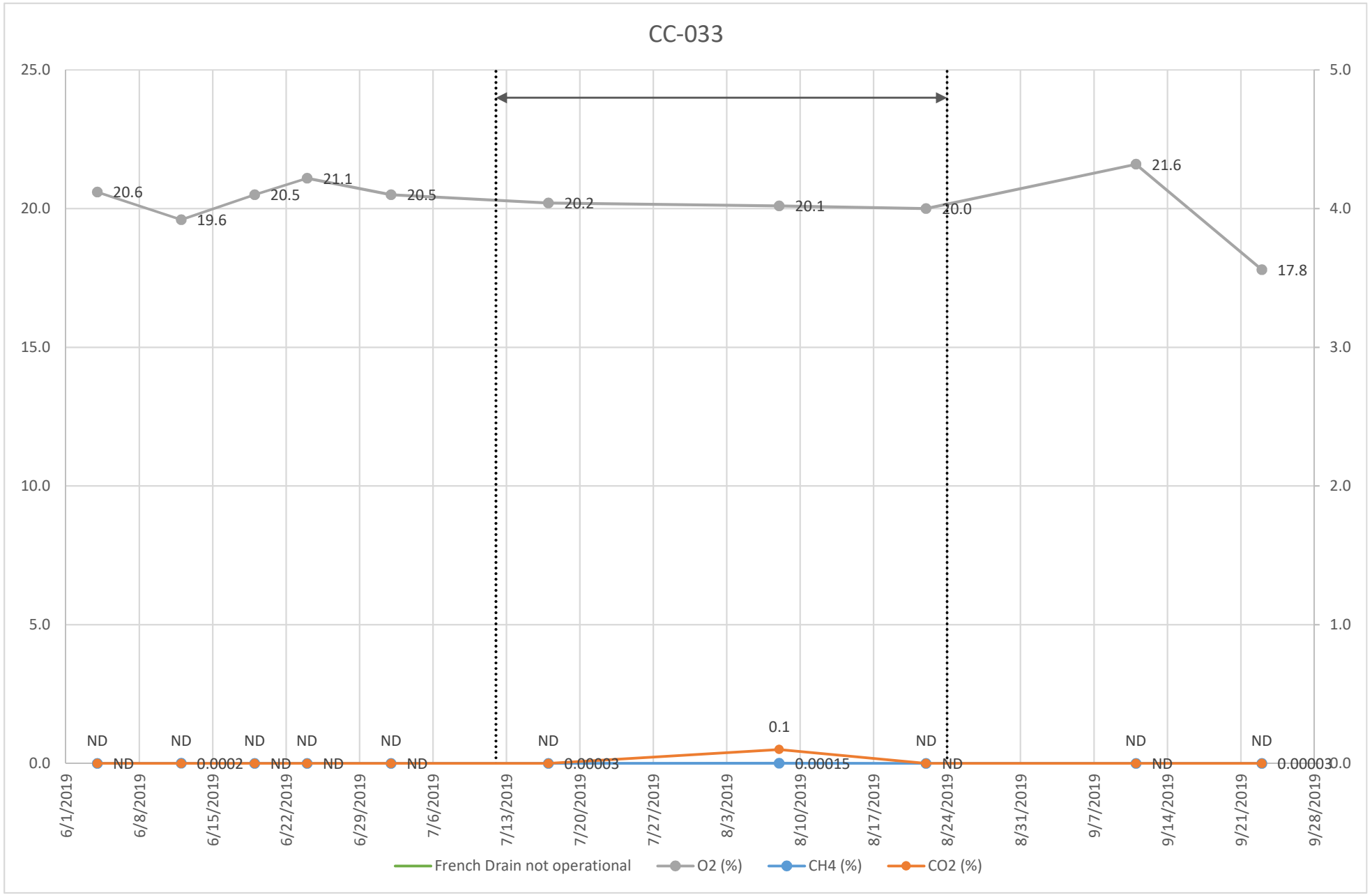

CC-028
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
20.5
18.7
19.1
20.9
21.1
19.0
21.4
21.2
20.7
19.1
21.0
ND
0.00077
ND
ND
ND
ND
ND
ND
ND
0.00006
ND
ND
0.00008
0.1
0.00011
0.1
ND
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

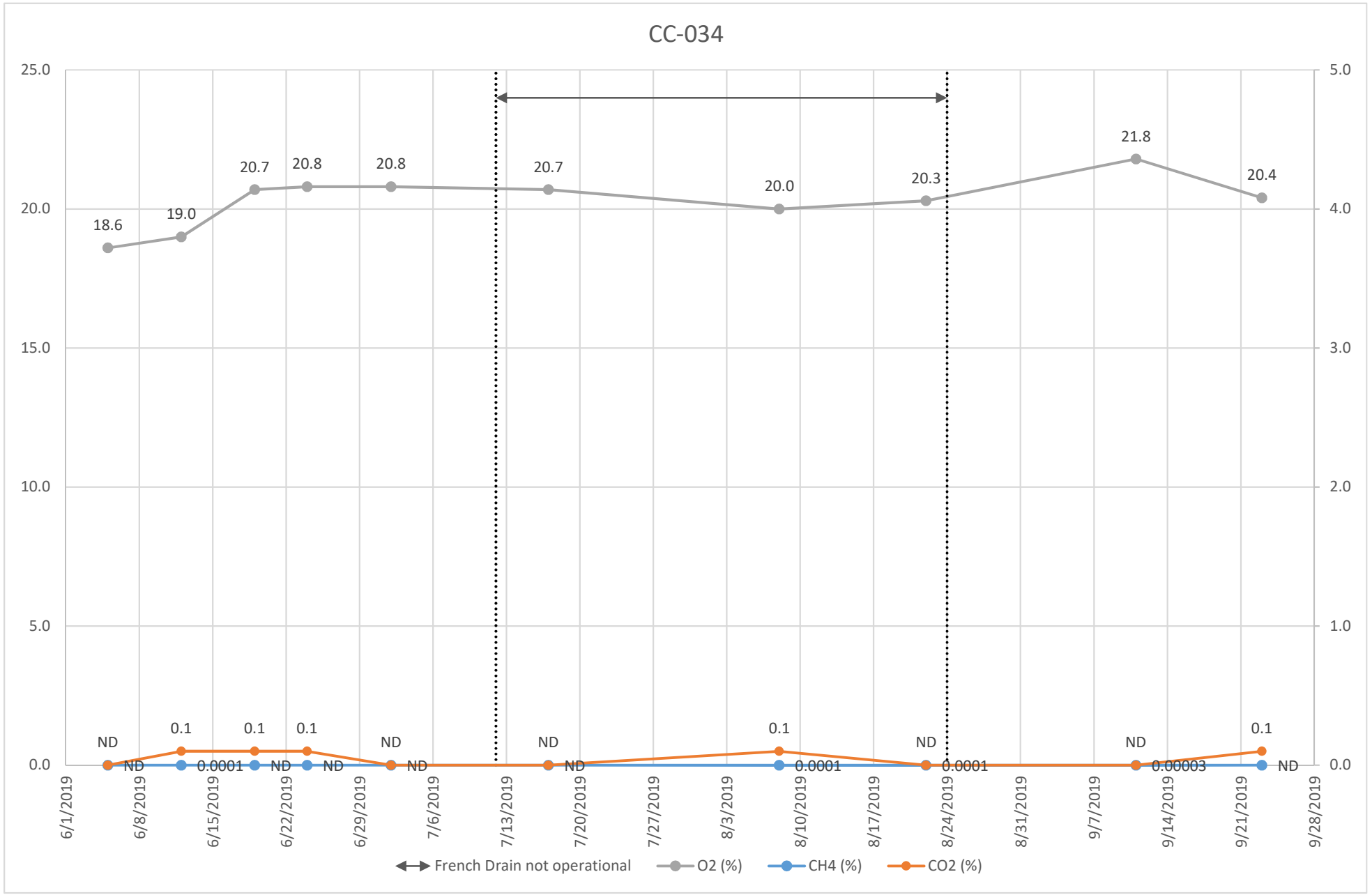

CC-029
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
20.6
19.5
20.9
21.1
20.2
19.7
21.3
20.6
21.1
ND
0.02
ND
0.02
ND
0.01
ND
0.04
ND
0.03
ND
0.06
ND
0.02
ND
0.02
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

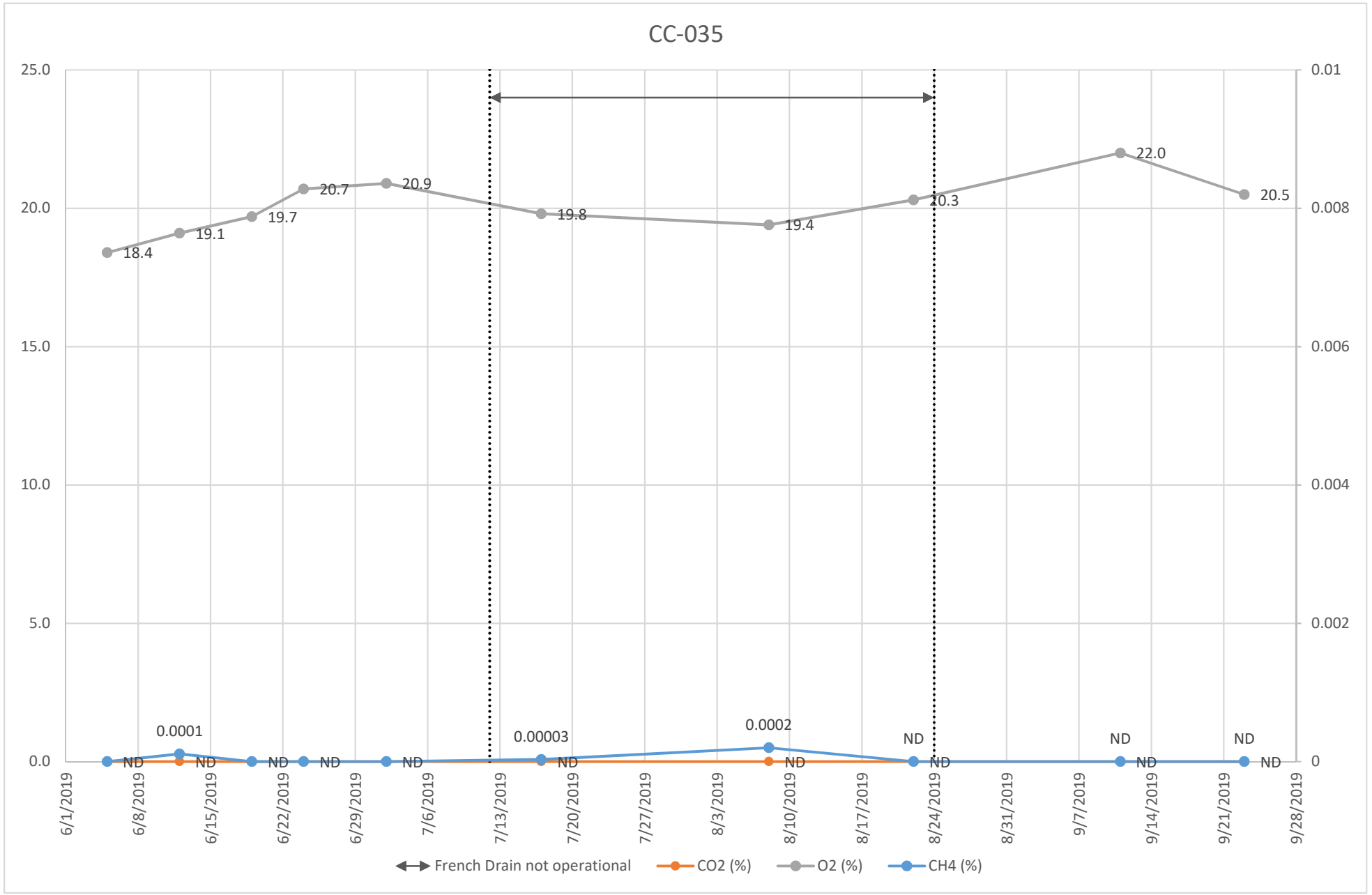

CC-030
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
20.9
20.6
16.9
17.8
19.6
15.7
20.2
21.0
17.6
20.1
20.9
9.2
2.6
0.3
0.01
ND
ND
7.2
2.0
1.1
0.4
7.1
2.4
0.13
ND
0.99
0.3
8.50
2.7
0.75
0.2
0.27
0.1
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

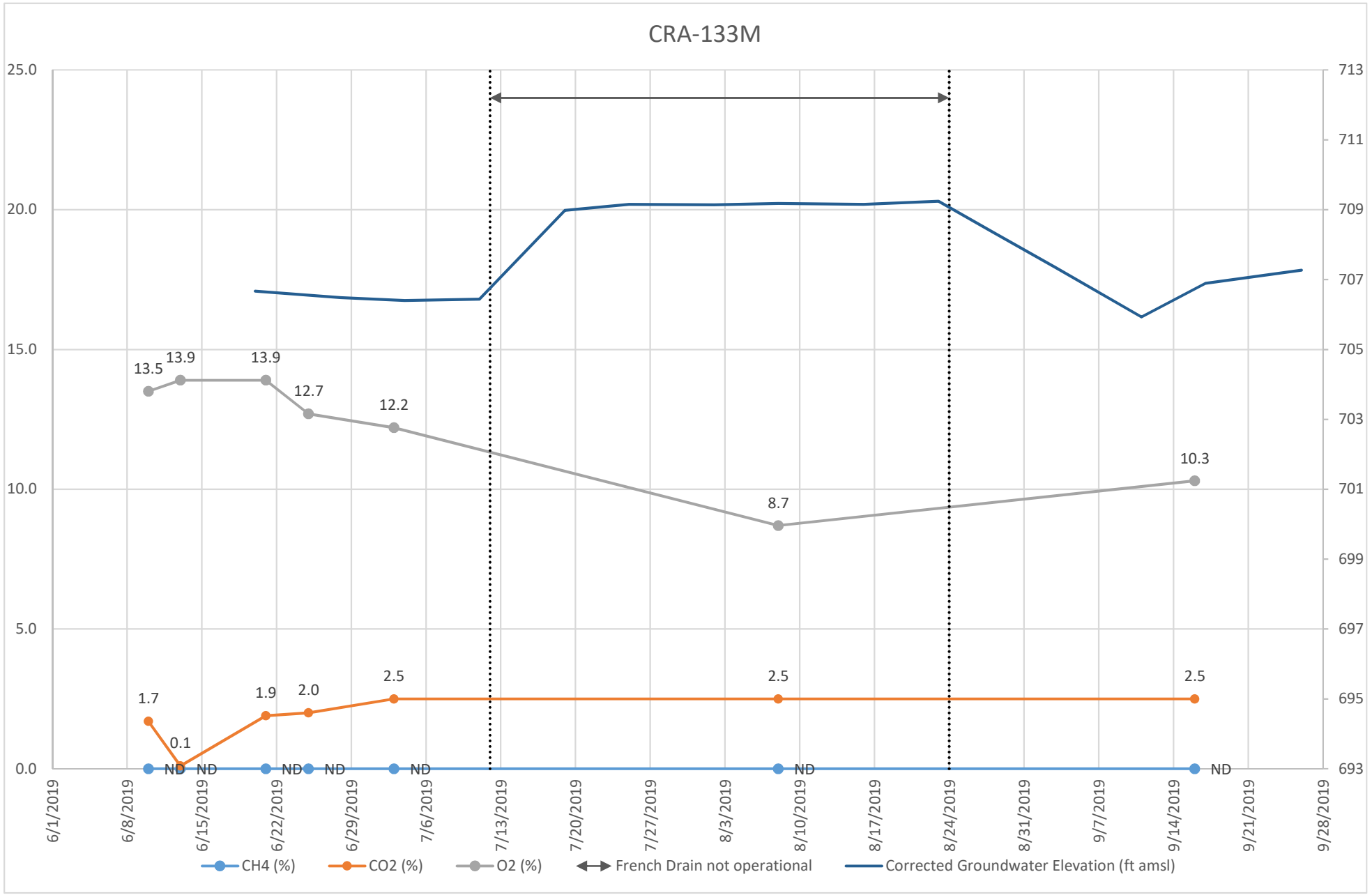

CC-031
25.0
20.0
15.0
10.0
5.0
0.0
20.5
21.0
20.8
20.5
18.1
20.2
19.7
20.3
21.2
0.30
0.58
1.3
0.13
1.3
0.15
2.6
0.03
0.02
0.2
ND
0.1
ND
0.3
ND
0.7
ND
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

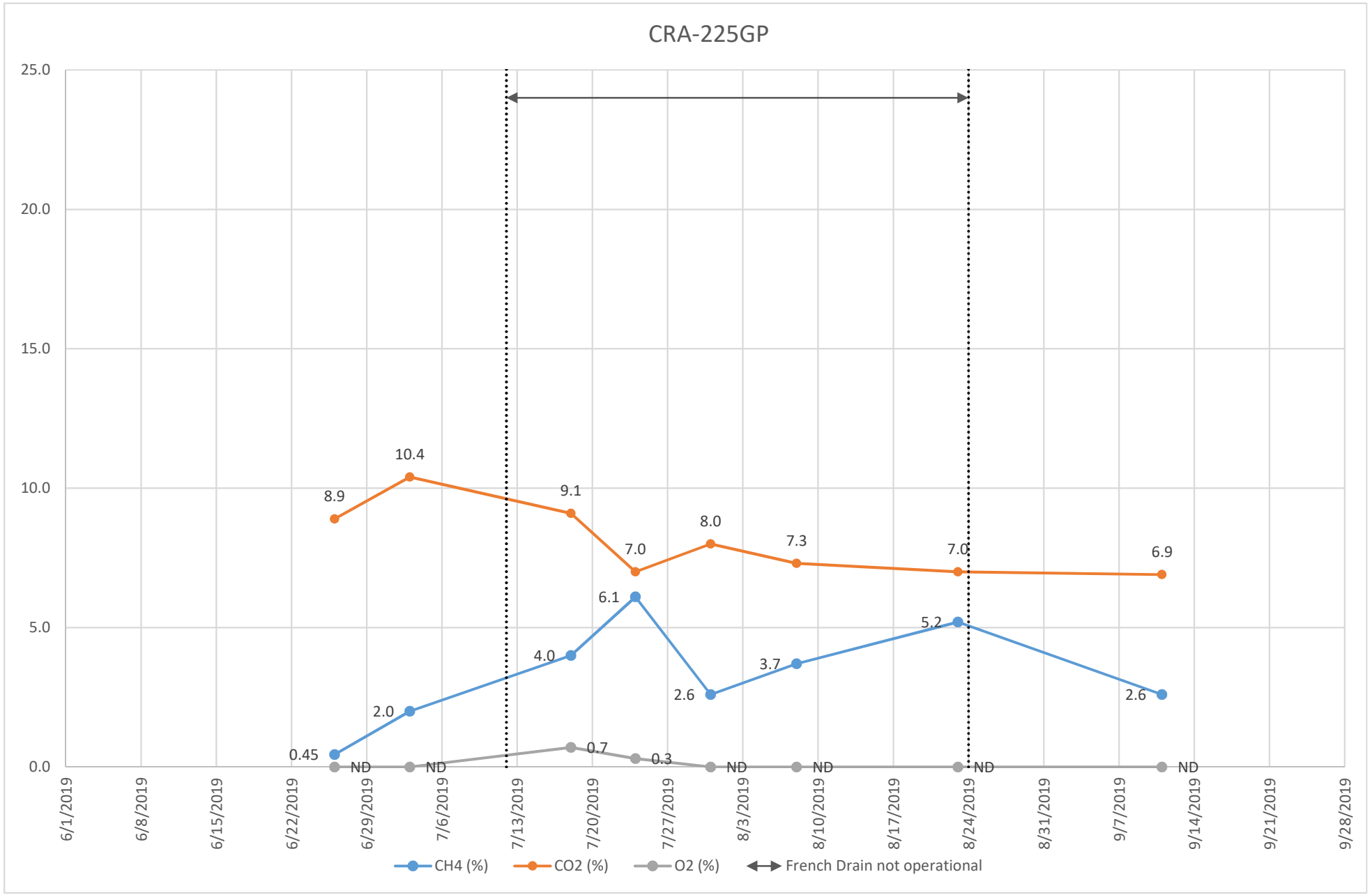

CC-032
25.0
20.0
15.0
10.0
5.0
0.0
19.9
20.0
20.4
20.6
18.5
17.8
20.3
20.4
21.3
0.3
0.001
ND
1.4
0.2
0.45
0.2
3.1
0.8
5.6
2.0
2.5
0.7
0.4
0.1
0.3
0.1
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

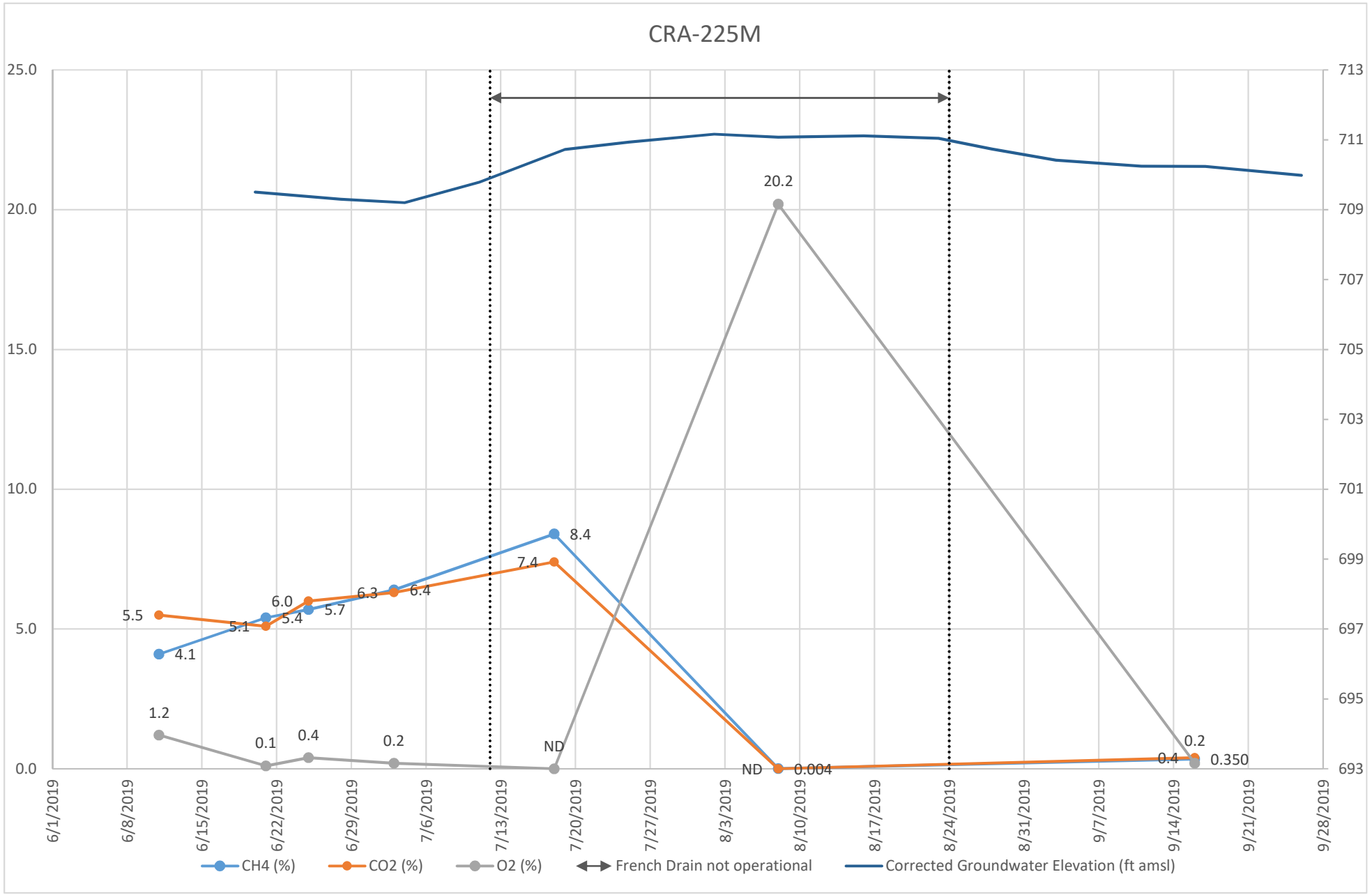

CC-033
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
20.6
19.6
20.5
21.1
20.5
20.2
20.1
20.0
21.6
17.8
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
0.0002
0.00003
0.1
0.00015
0.00003
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

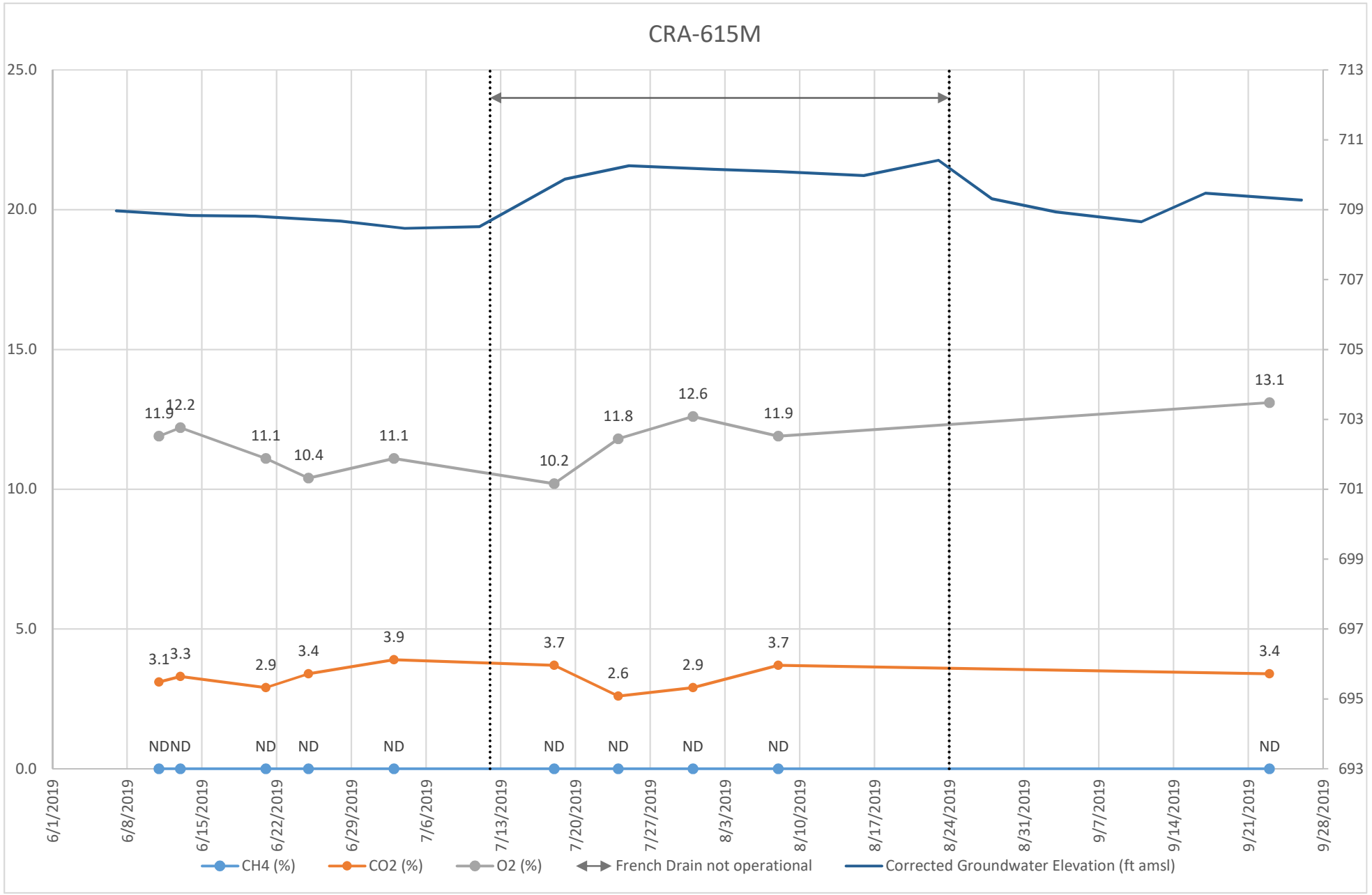

CC-034
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
18.6
19.0
20.7
20.8
20.8
20.7
20.0
20.3
21.8
20.4
ND
0.1
0.1
0.1
ND
ND
0.1
ND
ND
ND
ND
ND
0.0001
ND
ND
ND
ND
0.0001
0.0001
0.00003
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
O2 (%)
CH4 (%)
CO2 (%)

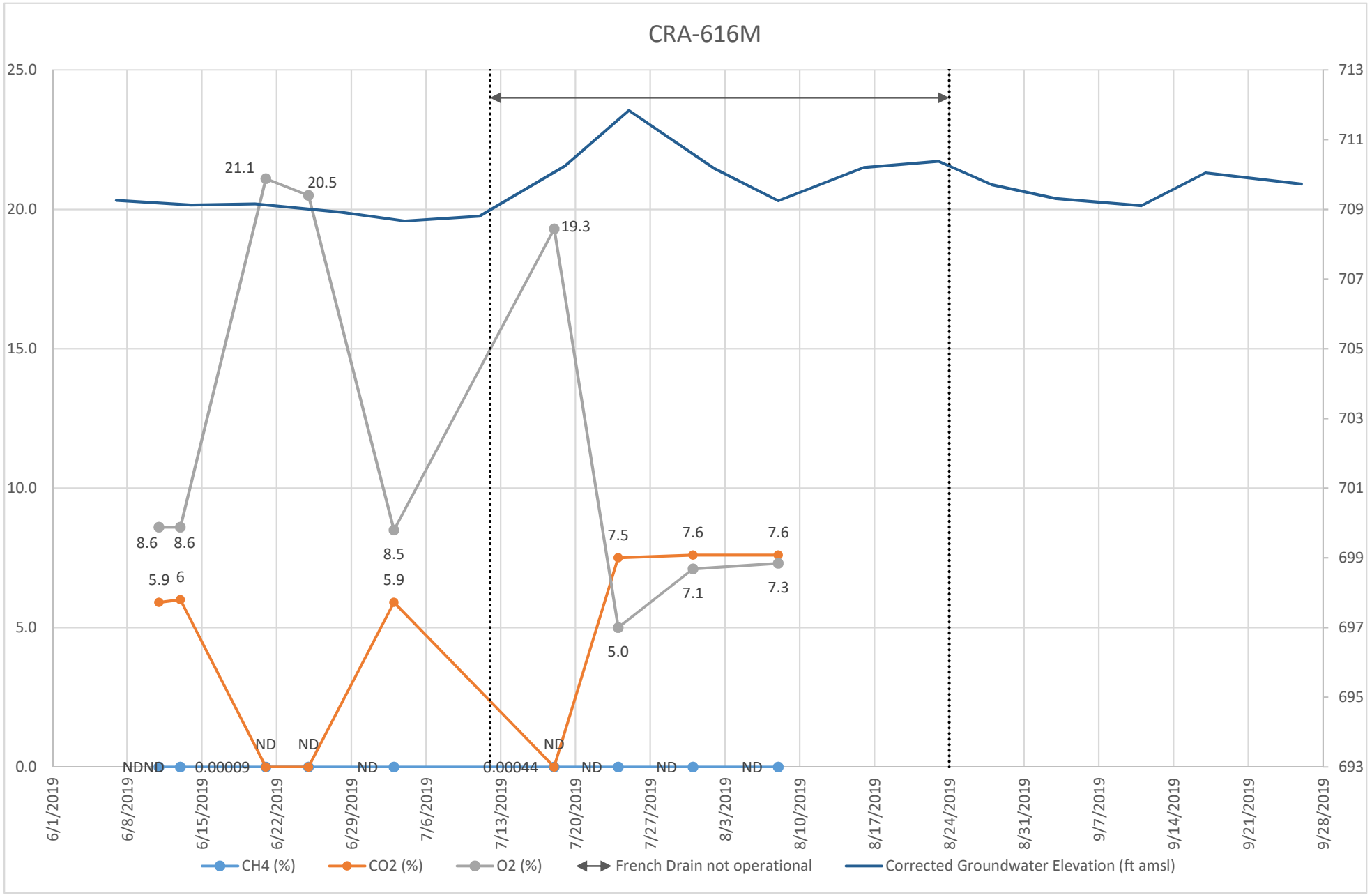

CC-035
25.0
20.0
15.0
10.0
5.0
0.0
0.01
0.008
0.006
0.004
0.002
0
18.4
19.1
19.7
20.7
20.9
19.8
19.4
20.3
22.0
20.5
0.0001
0.00003
0.0002
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
CO2 (%)
O2 (%)
CH4 (%)

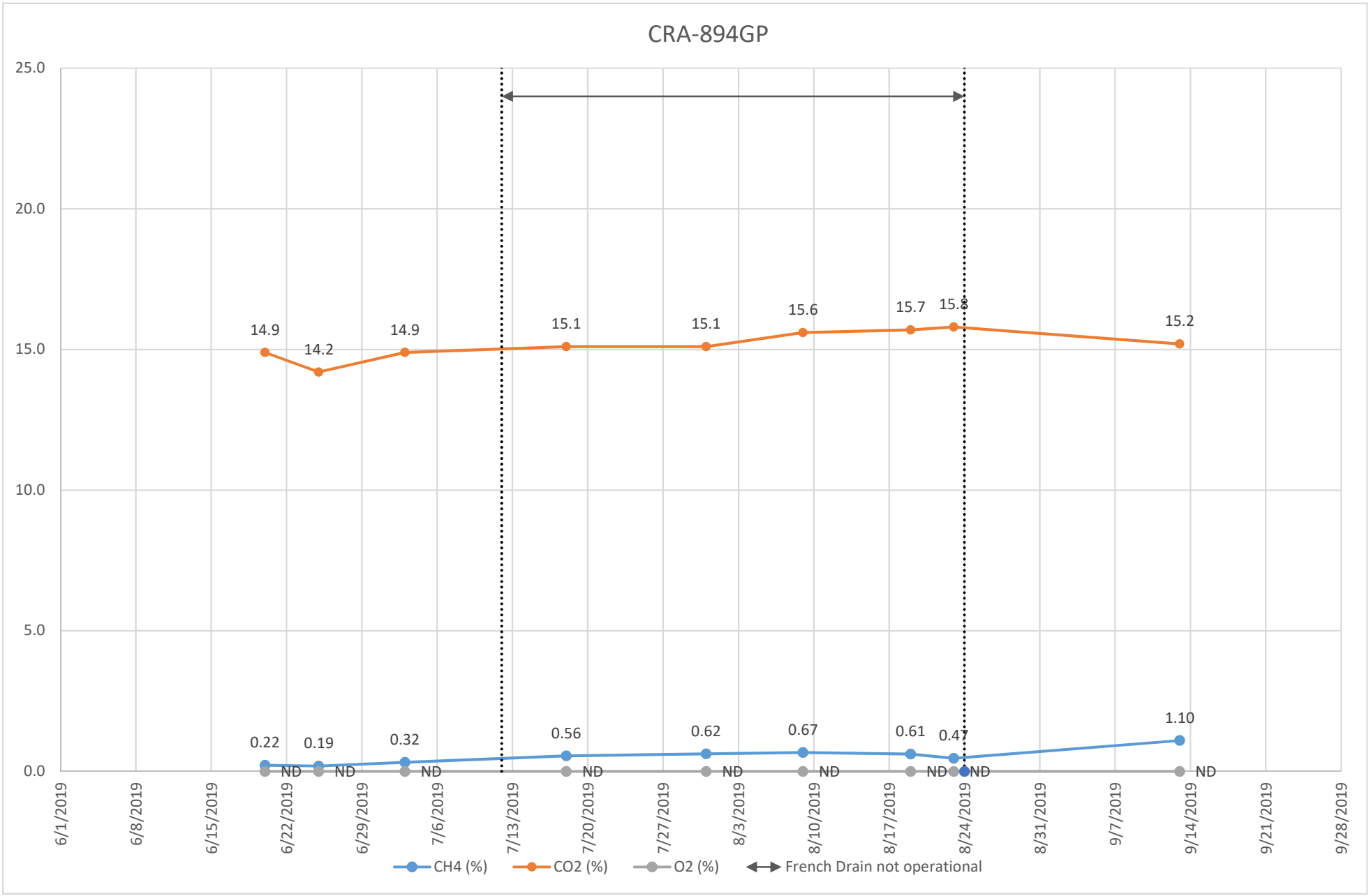

CRA-133M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
13.5
13.9
13.9
12.7
12.2
8.7
10.3
1.7
0.1
1.9
2.0
2.5
2.5
2.5
ND
ND
ND
ND
ND
ND
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational
Corrected Groundwater Elevation (ft amsl)

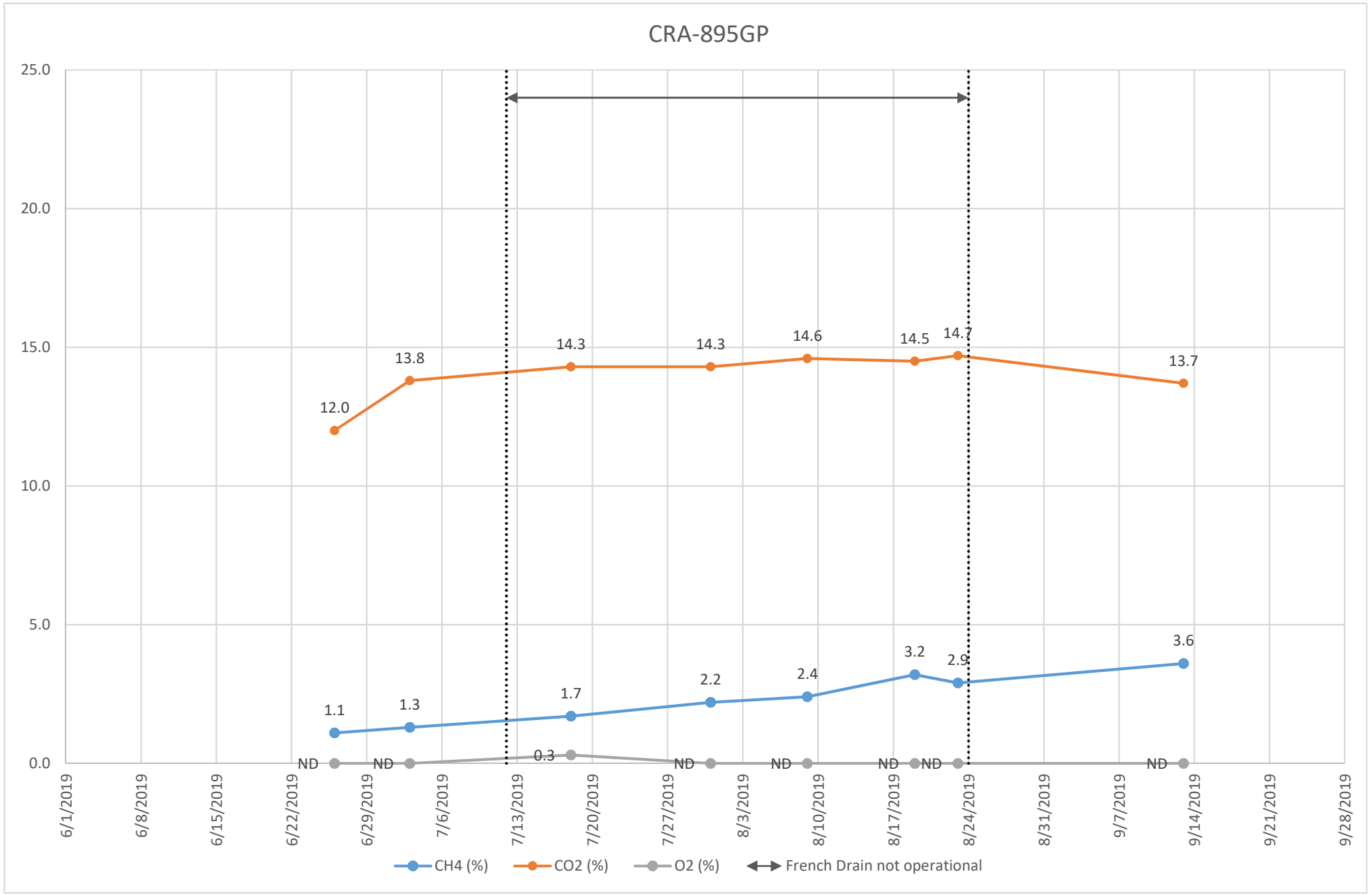

CRA-225GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
8.9
10.4
9.1
7.0
8.0
7.3
7.0
6.9
0.45
2.0
4.0
6.1
2.6
3.7
5.2
2.6
ND
ND
0.7
0.3
ND
ND
ND
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

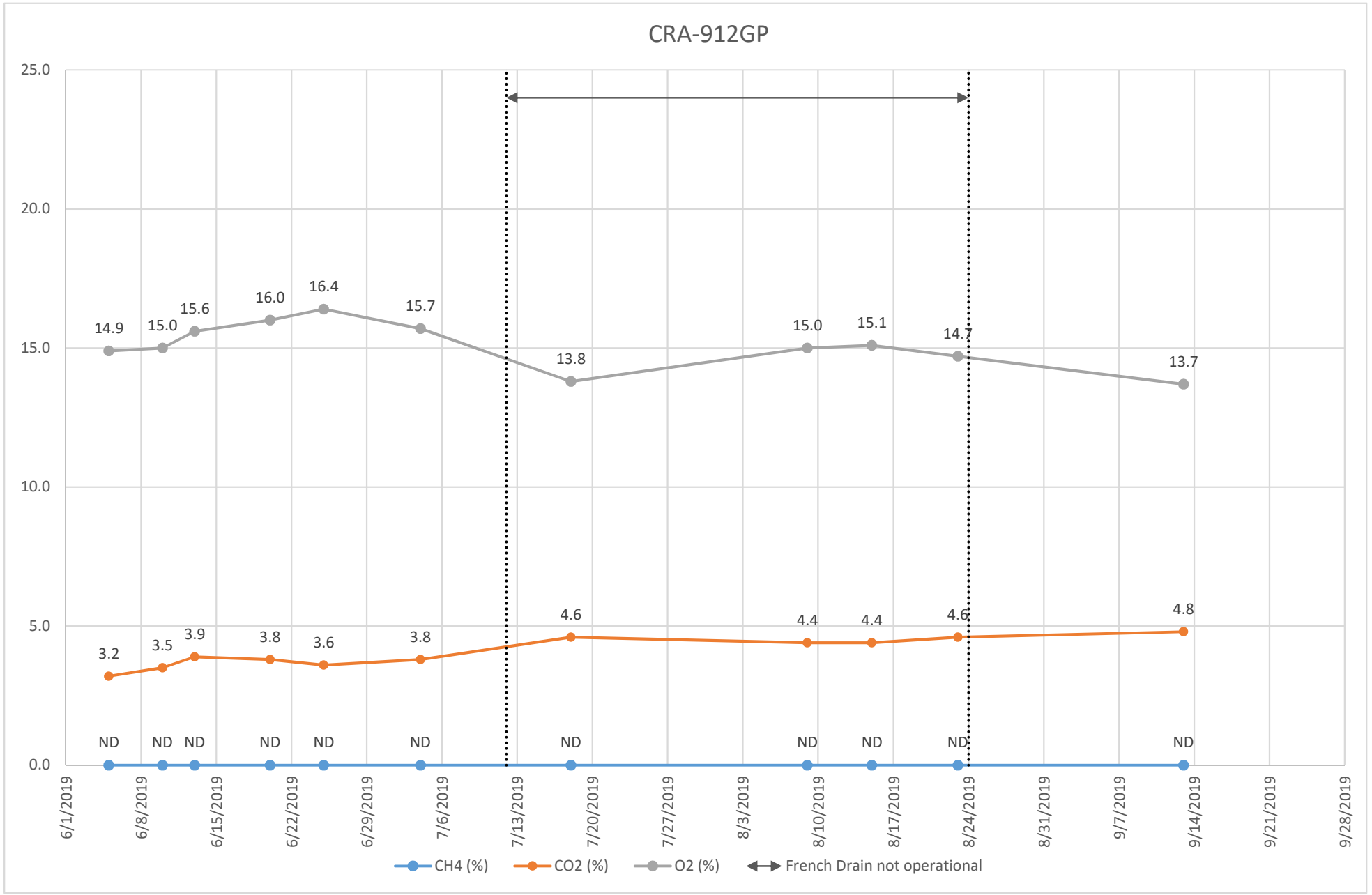

CRA-225M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
20.2
8.4
7.4
6.4
6.3
6.0
5.7
5.5
5.4
5.1
4.1
1.2
0.1
0.4
0.2
ND
ND
0.004
0.4
0.2
0.350
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational
Corrected Groundwater Elevation (ft amsl)

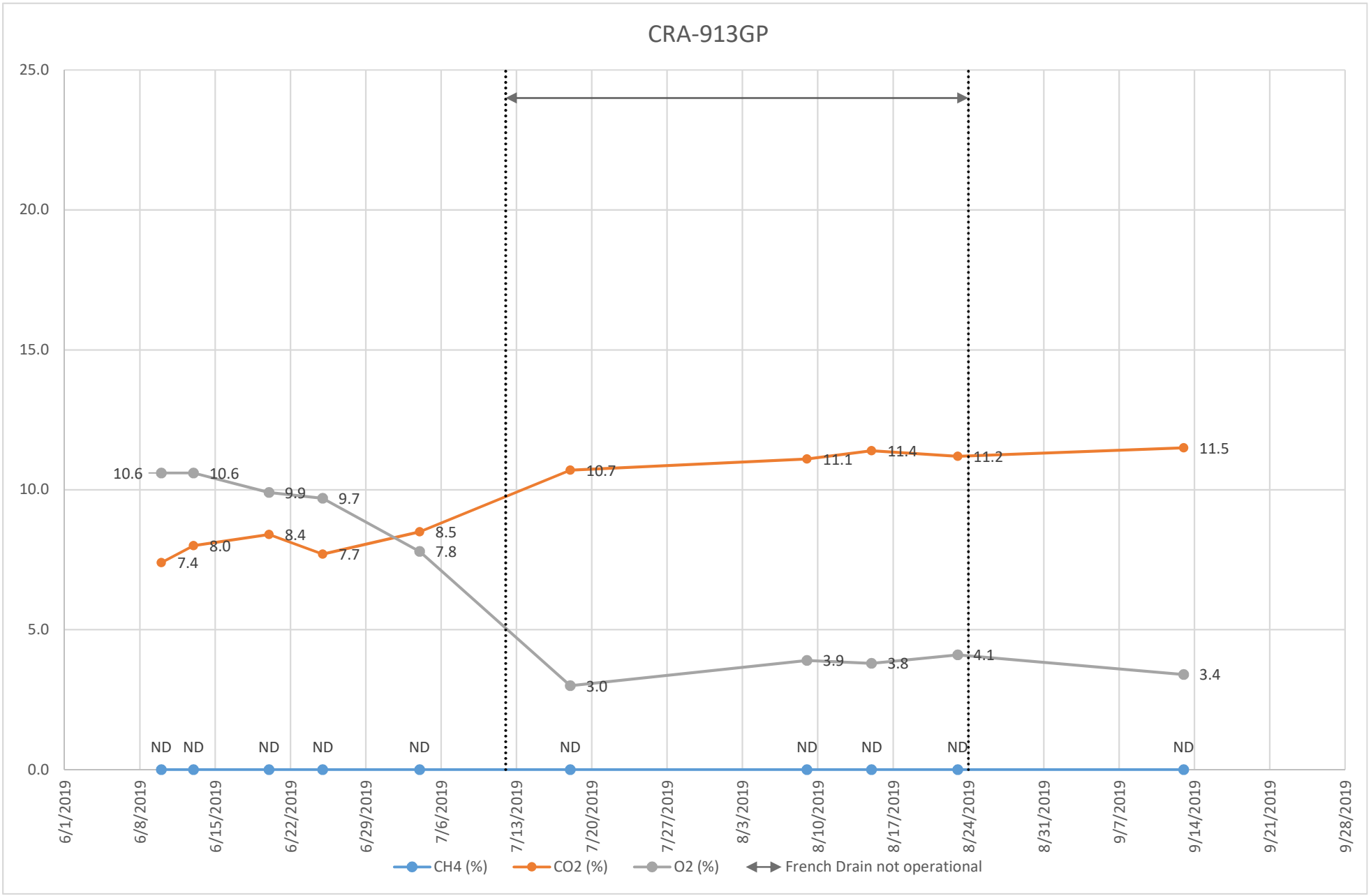

CRA-615M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
11.9
12.2
11.1
10.4
11.1
10.2
11.8
12.6
11.9
13.1
3.1
3.3
2.9
3.4
3.9
3.7
2.6
2.9
3.7
3.4
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational
Corrected Groundwater Elevation (ft amsl)

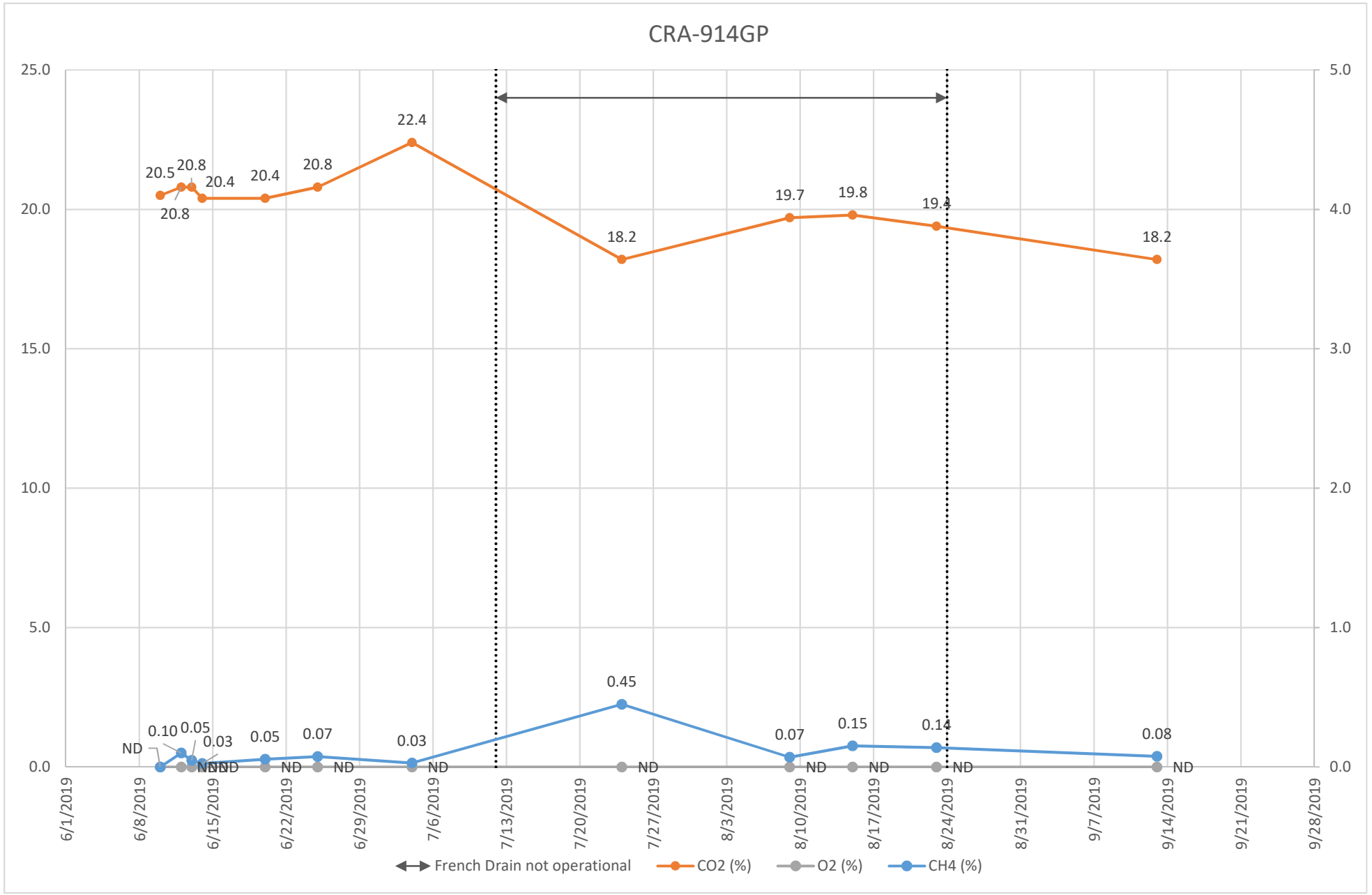

CRA-616M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
21.1
20.5
19.3
8.6
8.6
8.5
7.5
7.6
7.6
5.9
6
5.9
7.1
7.3
5.0
ND
ND
ND
ND
ND
ND
ND
ND
ND
0.00009
0.00044
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational
Corrected Groundwater Elevation (ft amsl)

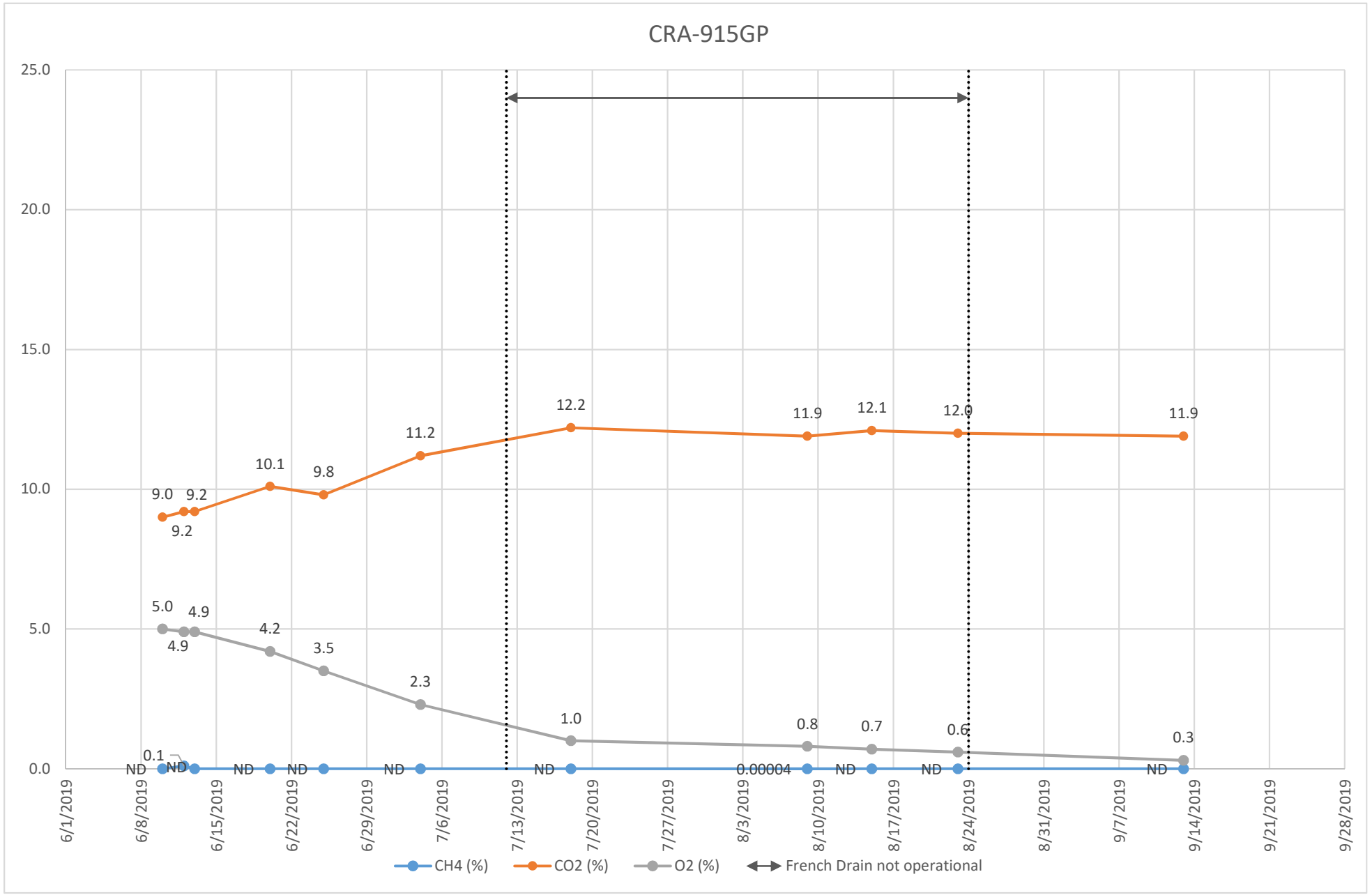

CRA-894GP
25.0
20.0
15.0
10.0
5.0
0.0
14.9
14.2
14.9
15.1
15.1
15.6
15.7
15.8
15.2
0.22
0.19
0.32
0.56
0.62
0.67
0.61
0.47
1.10
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

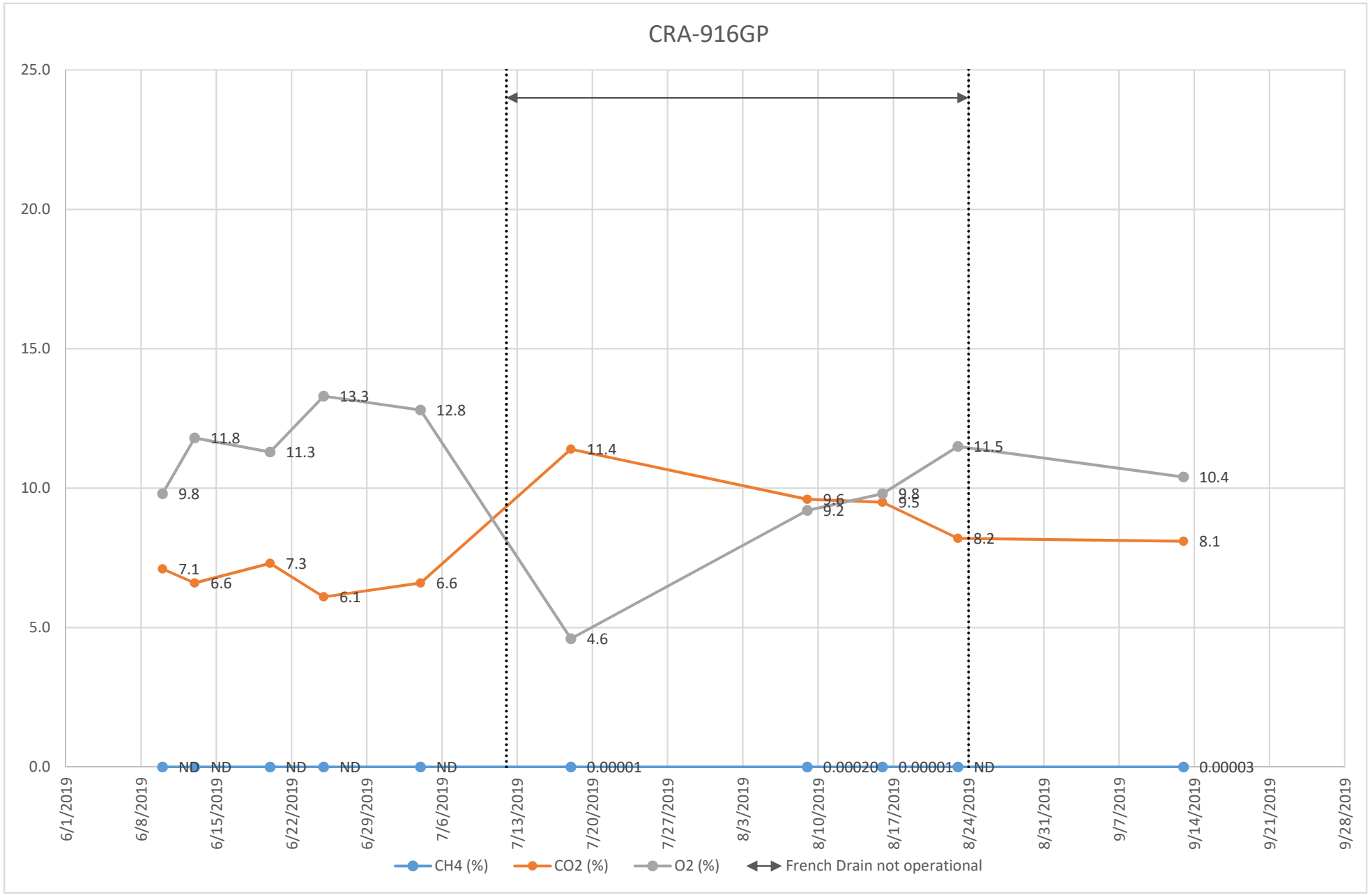

CRA-895GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
12.0
13.8
14.3
14.3
14.6
14.5
14.7
13.7
1.1
1.3
1.7
2.2
2.4
3.2
2.9
3.6
ND
ND
0.3
ND
ND
ND
ND
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

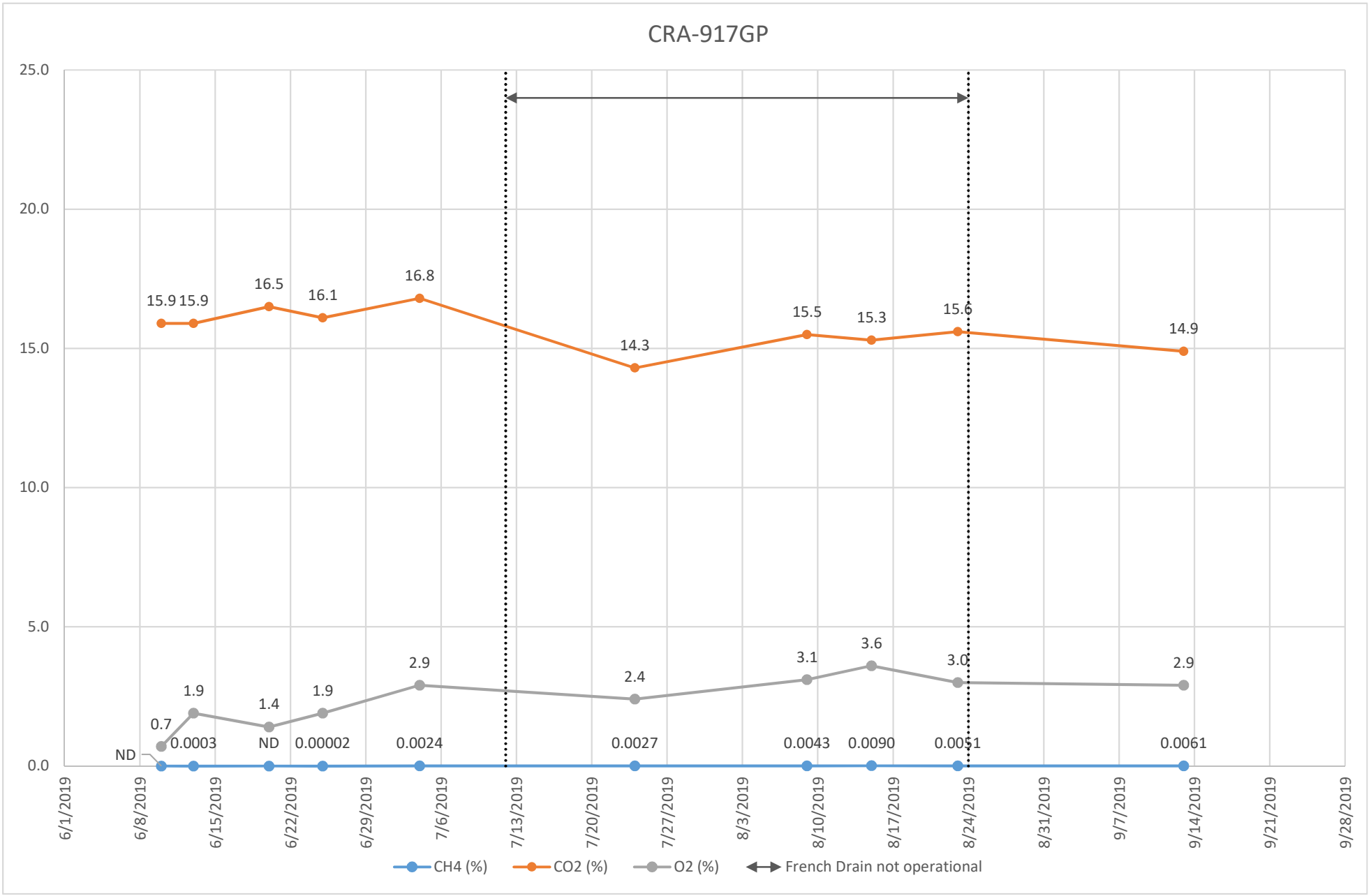

CRA-912GP
25.0
20.0
15.0
10.0
5.0
0.0
14.9
15.0
15.6
16.0
16.4
15.7
13.8
15.0
15.1
14.7
13.7
3.2
3.5
3.9
3.8
3.6
3.8
4.6
4.4
4.4
4.6
4.8
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

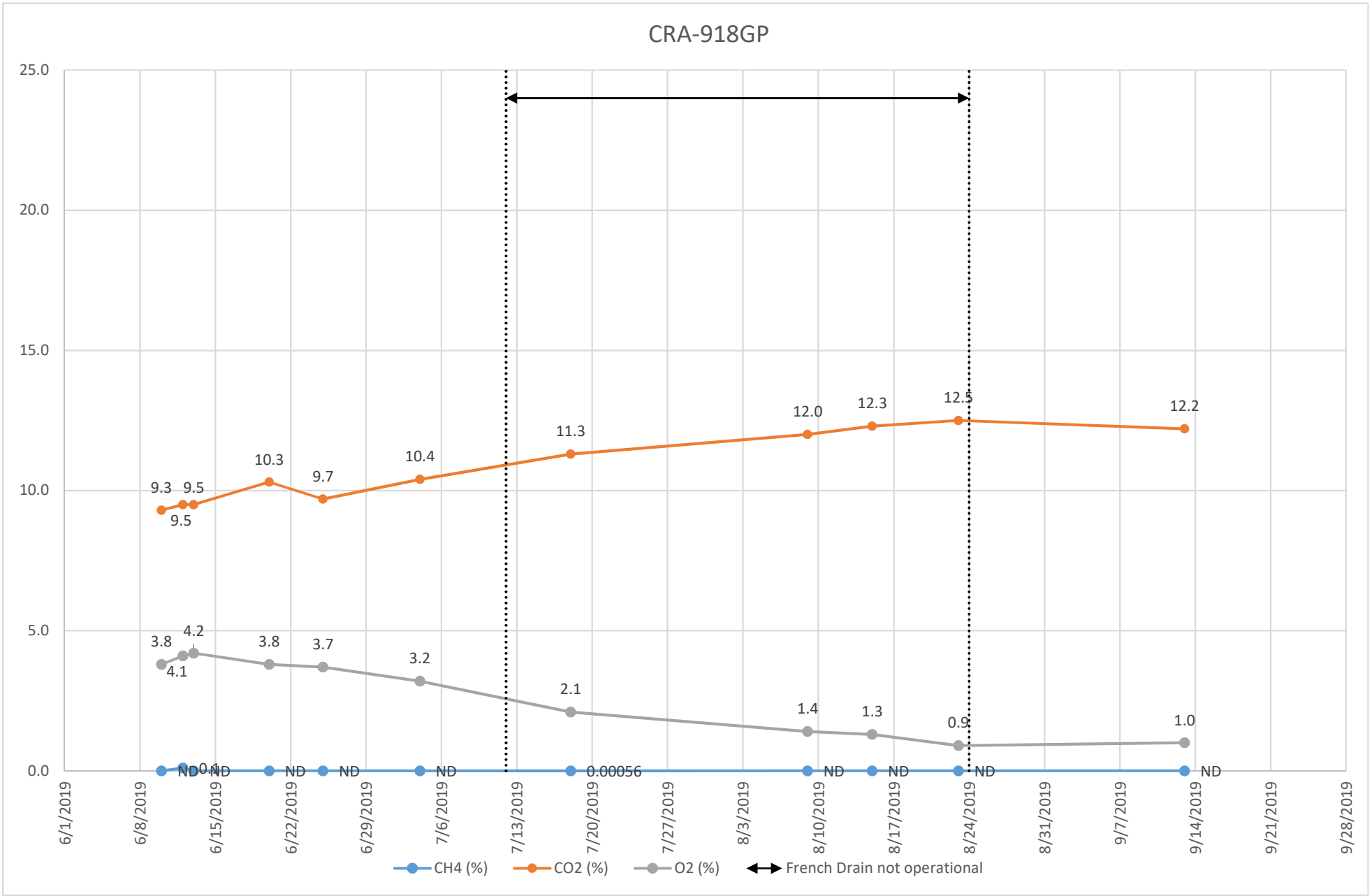

CRA-913GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
10.6
10.6
9.9
9.7
7.8
3.0
3.9
3.8
4.1
3.4
7.4
8.0
8.4
7.7
8.5
10.7
11.1
11.4
11.2
11.5
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

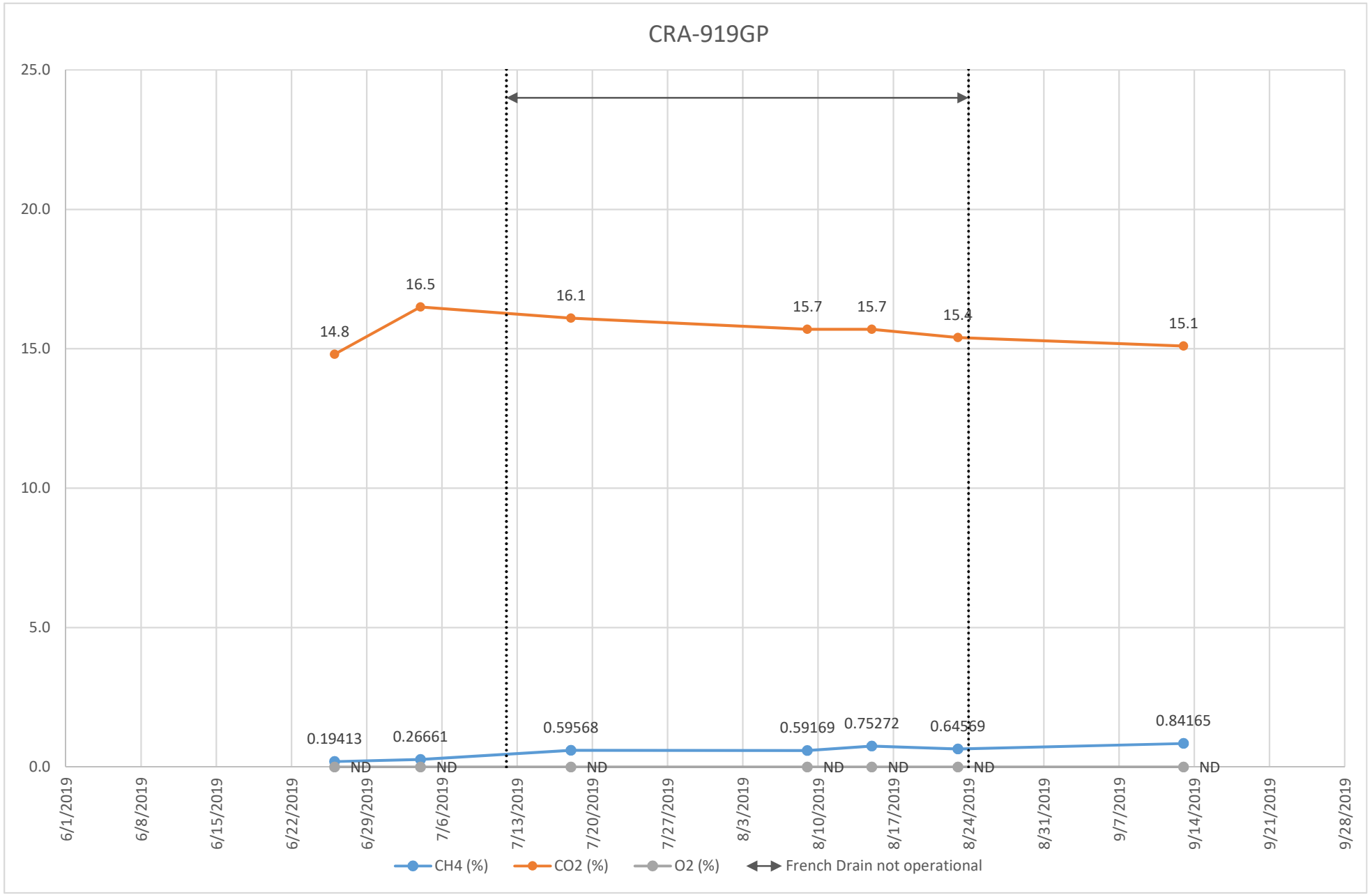

CRA-914GP
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
20.5
20.8
20.8
20.4
20.4
20.8
22.4
18.2
19.7
19.8
19.4
18.2
ND
0.10
0.05
0.03
0.05
0.07
0.03
0.45
0.07
0.15
0.14
0.08
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
CO2 (%)
O2 (%)
CH4 (%)

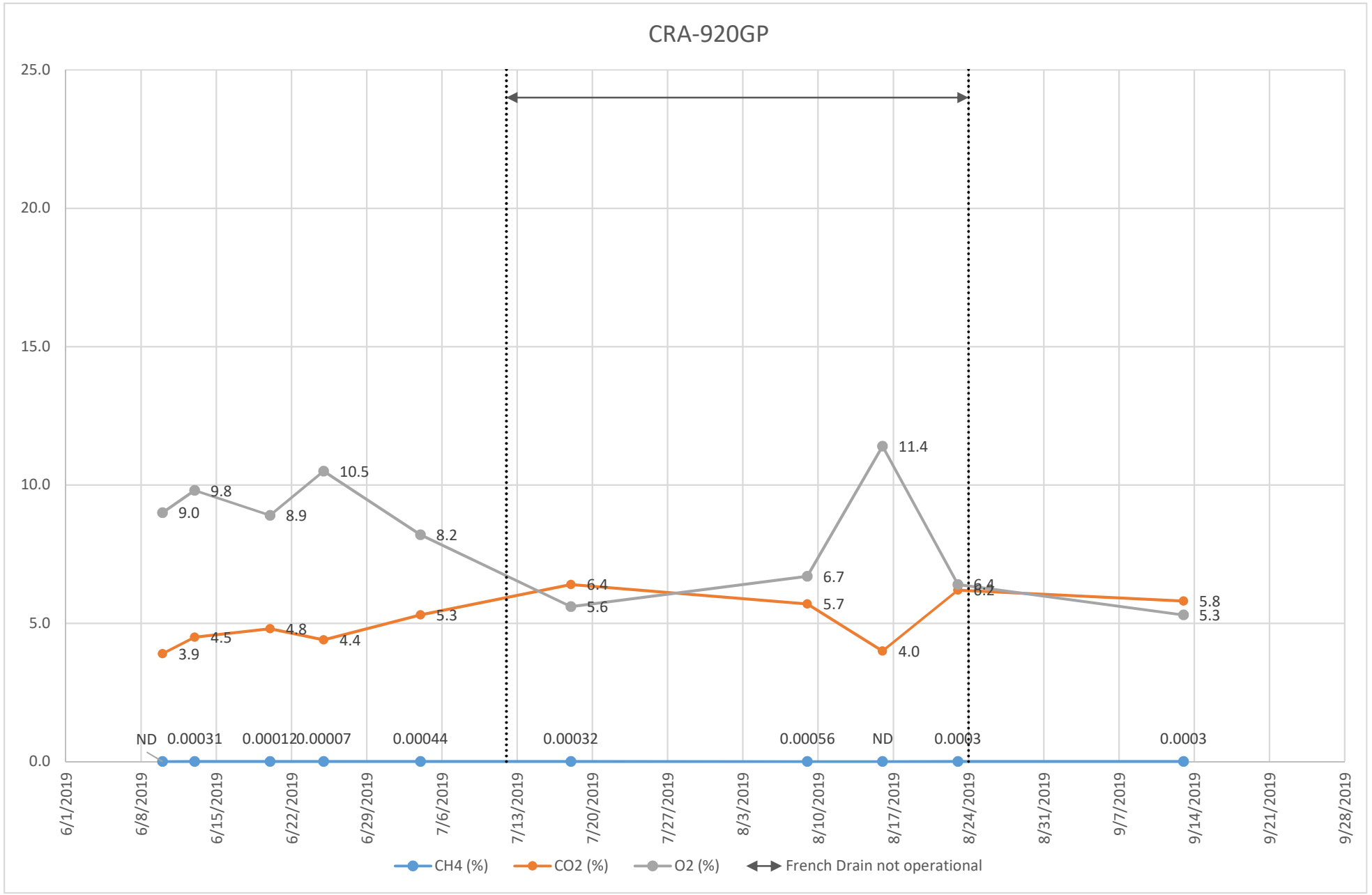

CRA-915GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
9.0
9.2
9.2
10.1
9.8
11.2
12.2
11.9
12.1
12.0
11.9
5.0
4.9
4.9
4.2
3.5
2.3
1.0
0.8
0.7
0.6
0.3
0.1
ND
ND
ND
ND
ND
ND
ND
0.00004
ND
ND
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

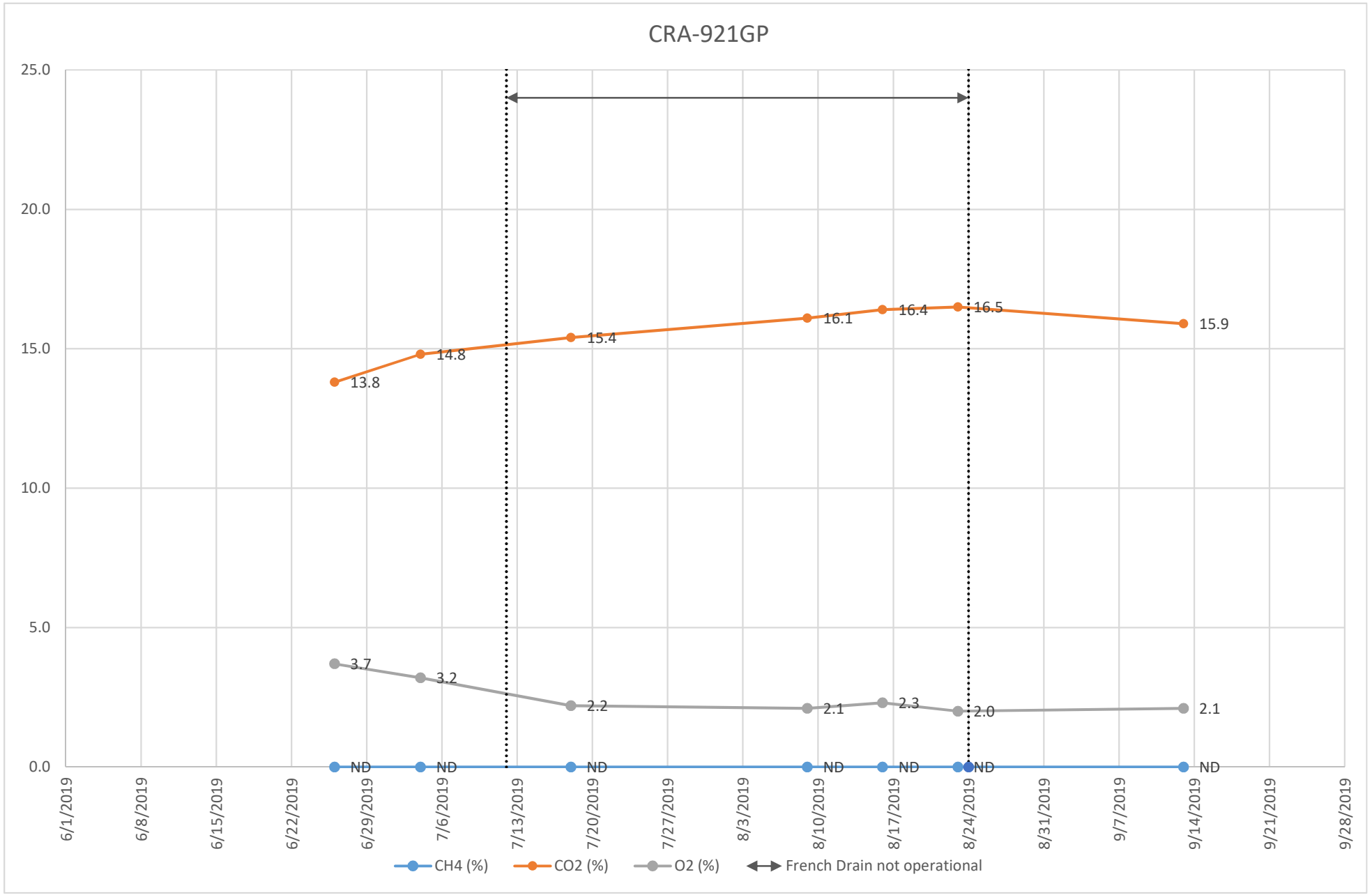

CRA-916GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
9.8
11.8
11.3
13.3
12.8
4.6
9.2
9.8
11.5
10.4
7.1
6.6
7.3
6.1
6.6
11.4
9.6
9.5
8.2
8.1
ND
ND
ND
ND
ND
0.00001
0.00020
0.00001
ND
0.00003
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

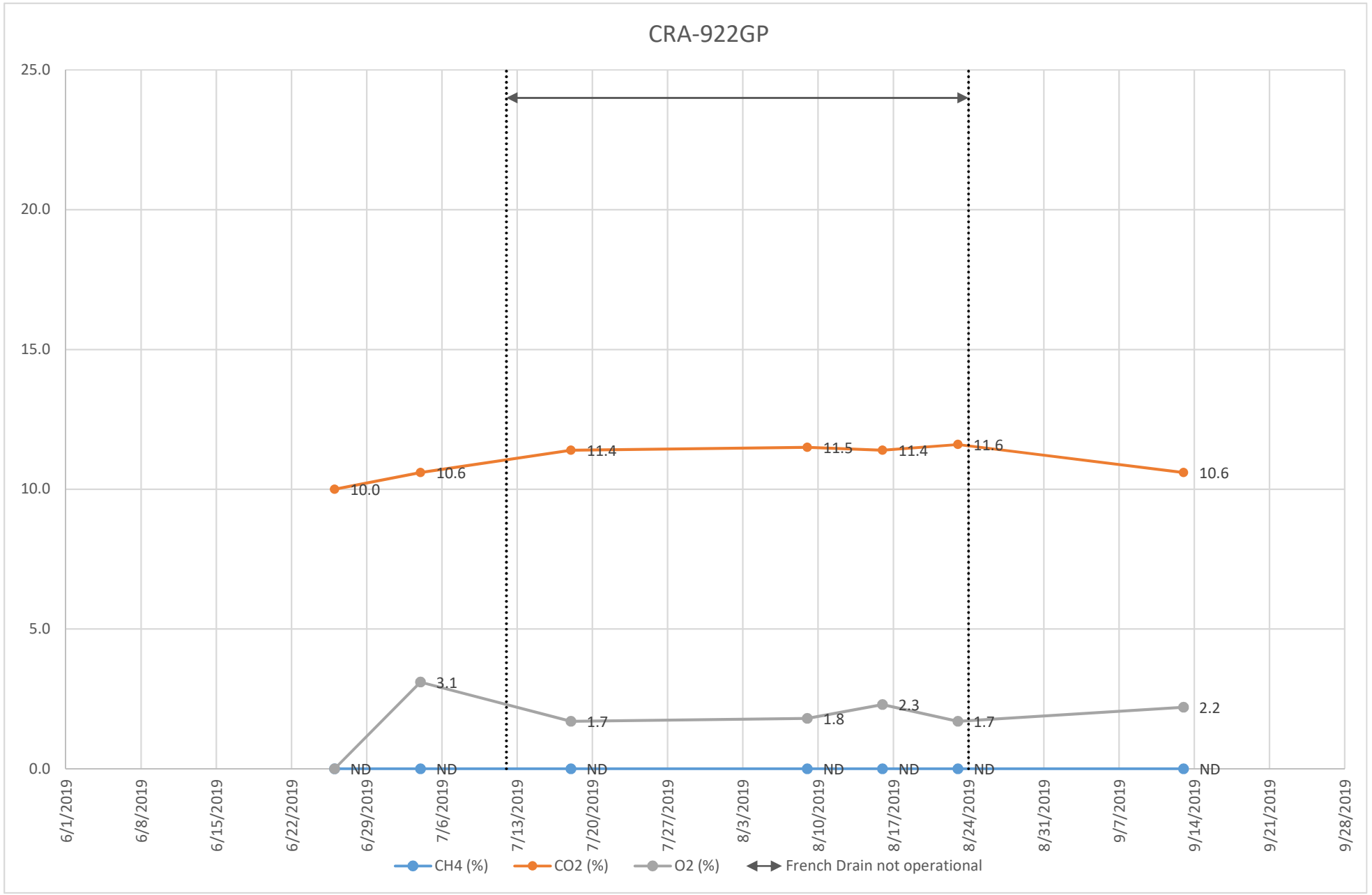

CRA-917GP
25.0
20.0
15.0
10.0
5.0
0.0
15.9
15.9
16.5
16.1
16.8
14.3
15.5
15.3
15.6
14.9
ND
0.7
1.9
0.0003
ND
1.4
1.9
0.00002
2.9
0.0024
2.4
0.0027
3.1
0.0043
3.6
0.0090
3.0
0.0051
2.9
0.0061
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

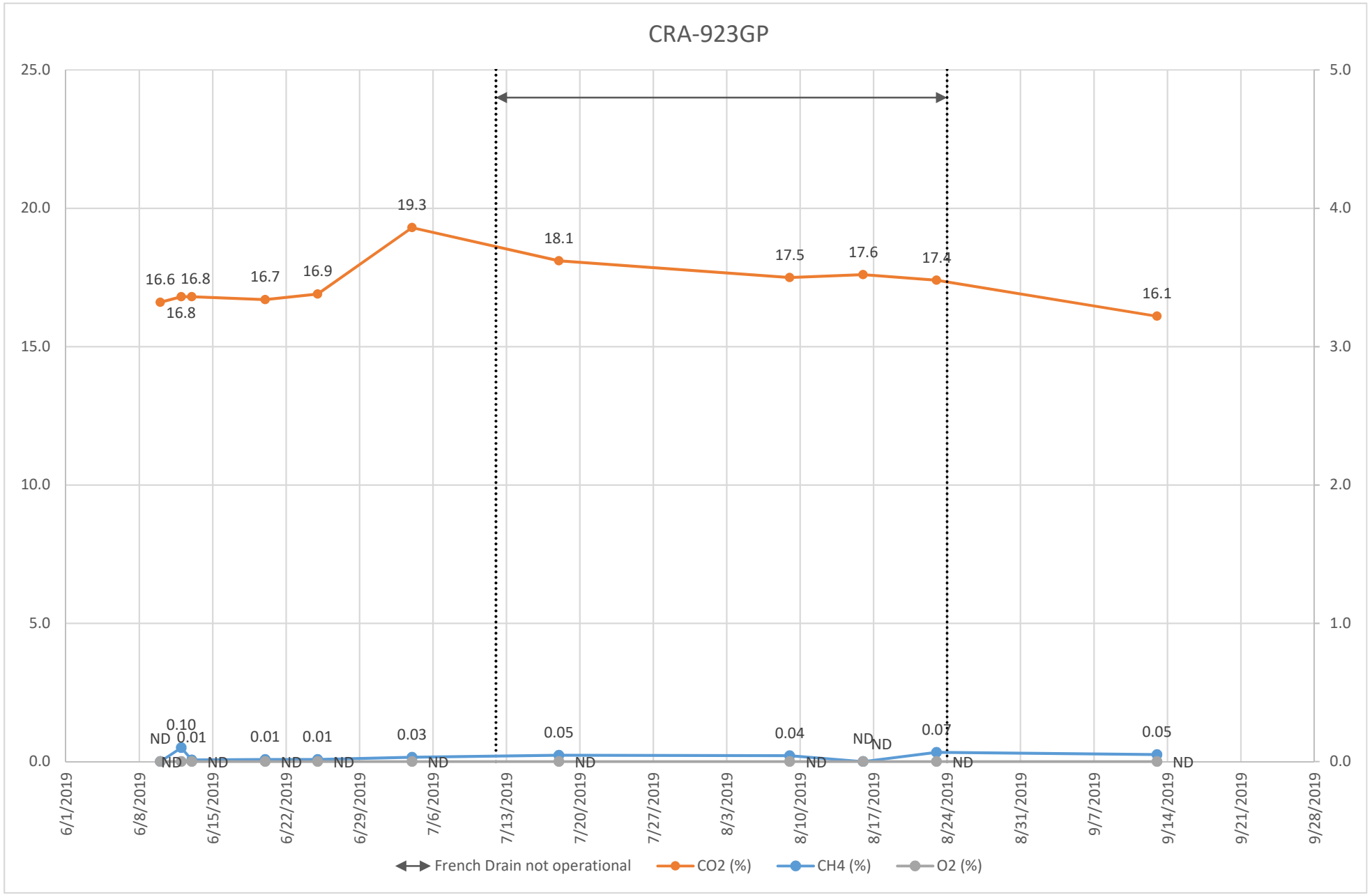

CRA-918GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
9.3
9.5
9.5
10.3
9.7
10.4
11.3
12.0
12.3
12.5
12.2
3.8
4.1
4.2
3.8
3.7
3.2
2.1
1.4
1.3
0.9
1.0
ND
ND
ND
ND
ND
ND
0.00056
ND
ND
ND
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

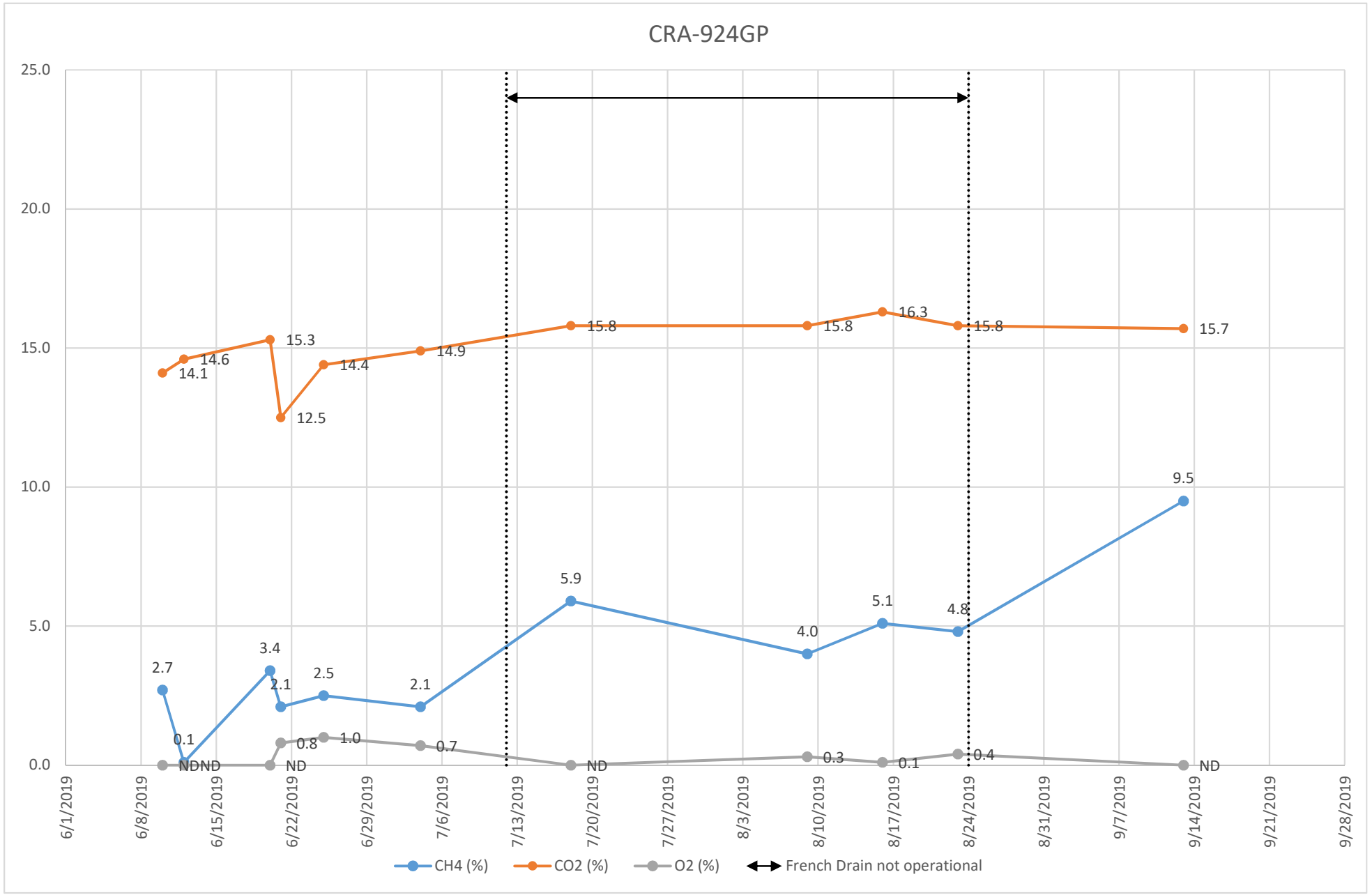

CRA-919GP
25.0
20.0
15.0
10.0
5.0
0.0
14.8
16.5
16.1
15.7
15.7
15.4
15.1
0.19413
0.26661
0.59568
0.59169
0.75272
0.64569
0.84165
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

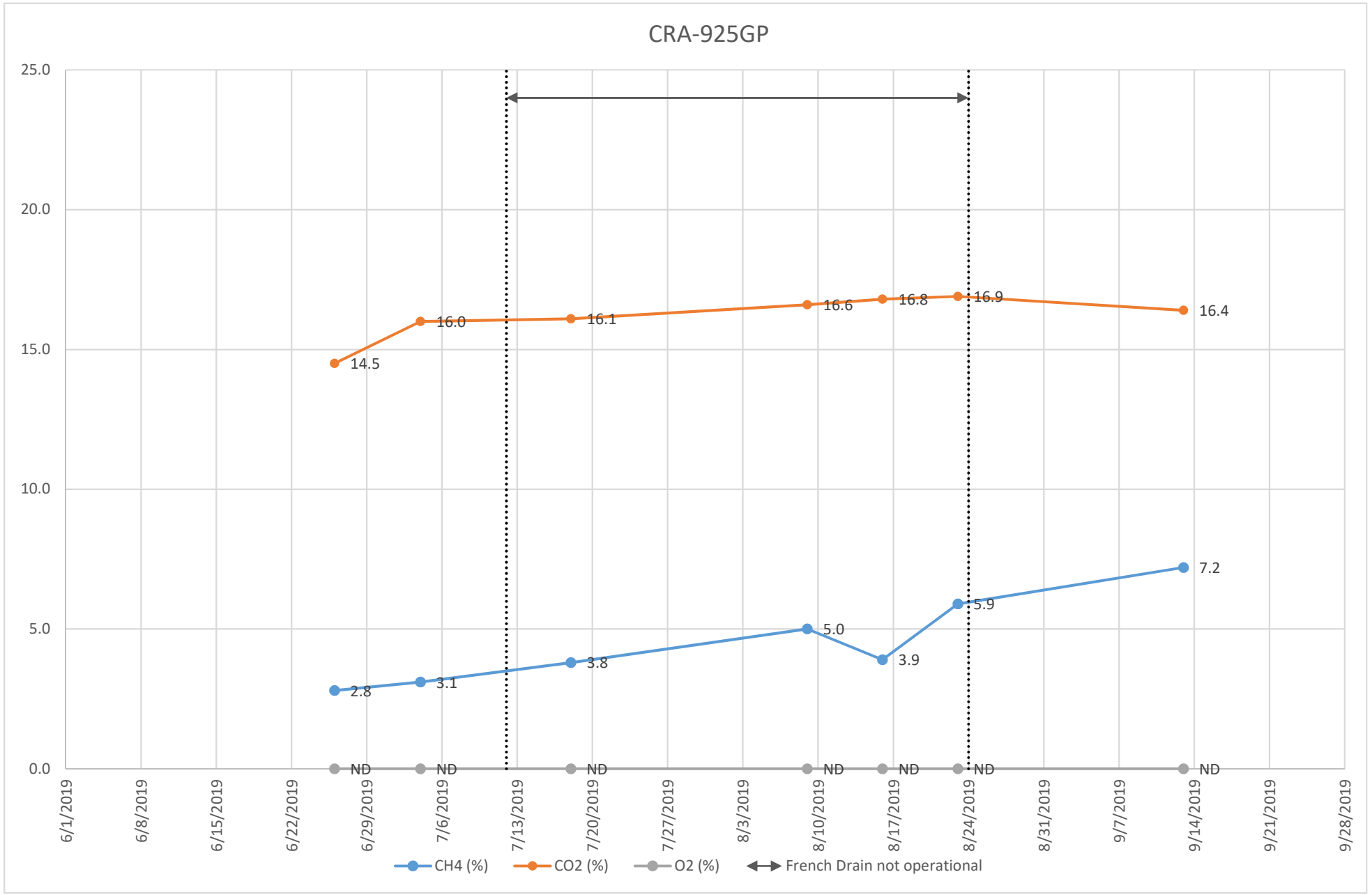

CRA-920GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
9.0
9.8
8.9
10.5
8.2
5.6
6.7
11.4
6.4
5.3
3.9
4.5
4.8
4.4
5.3
6.4
5.7
4.0
6.2
5.8
ND
0.00031
0.00012
0.00007
0.00044
0.00032
0.00056
ND
0.0003
0.0003
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

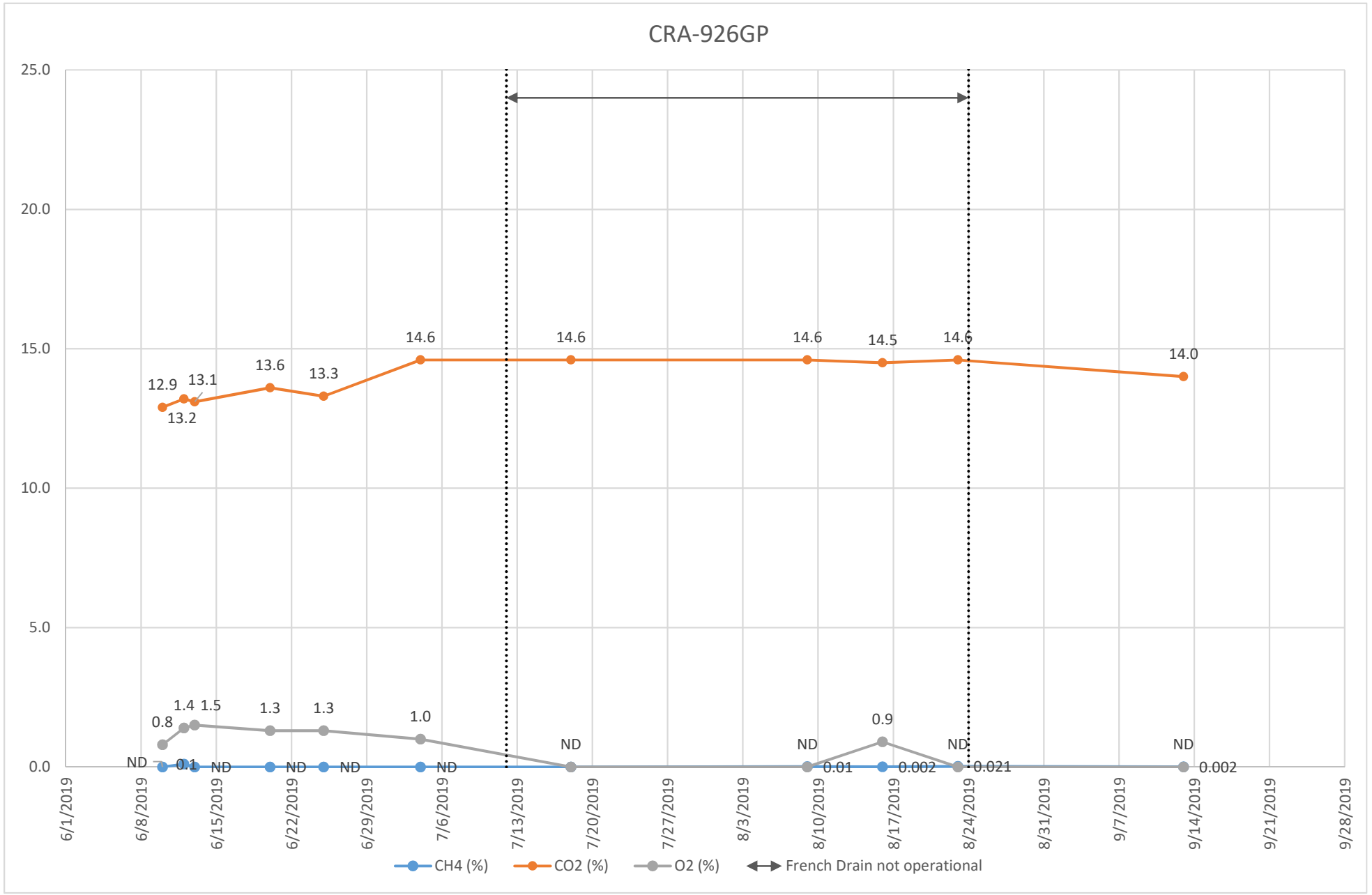

CRA-921GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
13.8
14.8
15.4
16.1
16.4
16.5
15.9
3.7
3.2
2.2
2.1
2.3
2.0
2.1
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

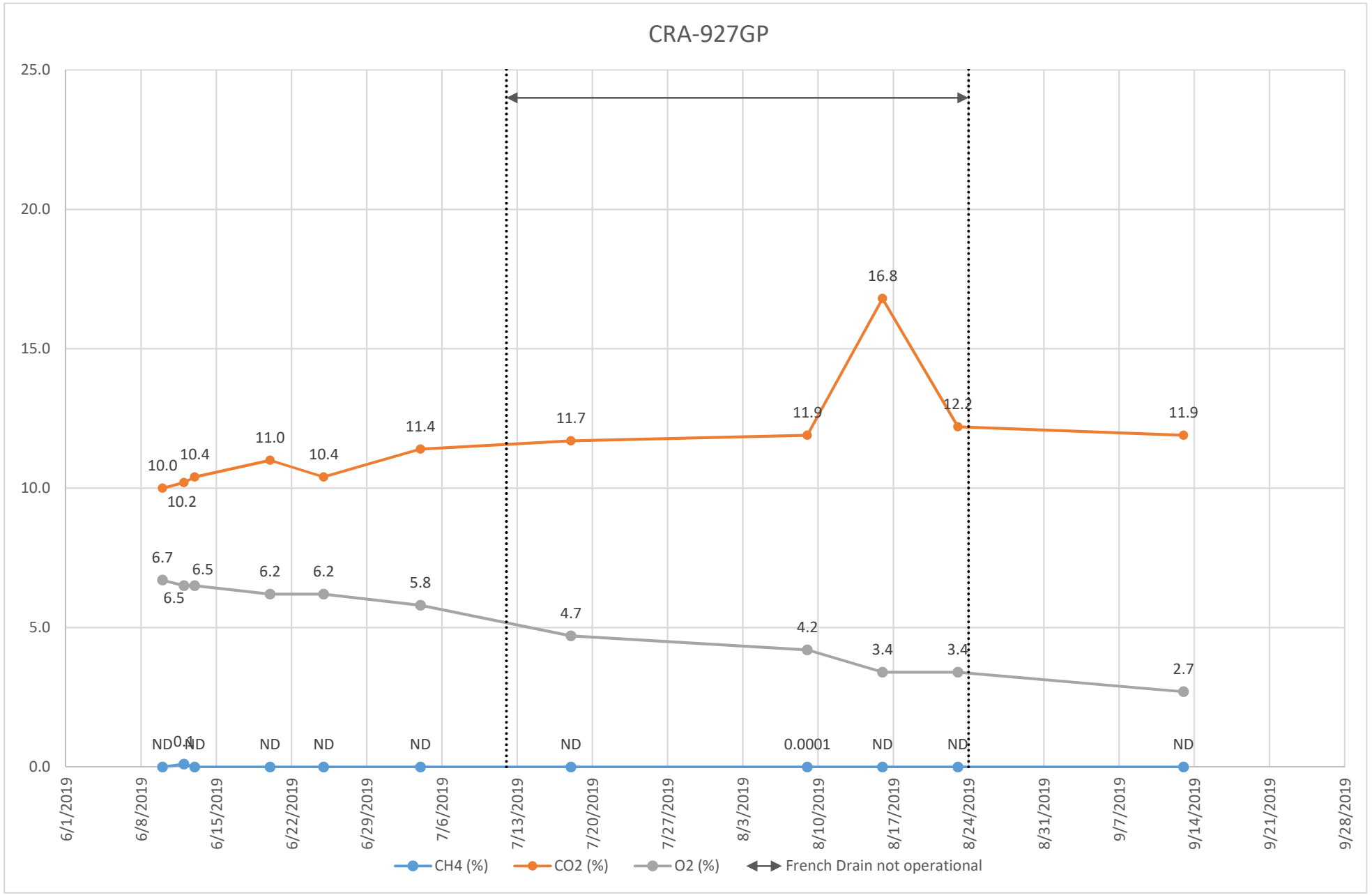

CRA-922GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
10.0
10.6
11.4
11.5
11.4
11.6
10.6
ND
ND
ND
ND
ND
ND
ND
3.1
1.7
1.8
2.3
1.7
2.2
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

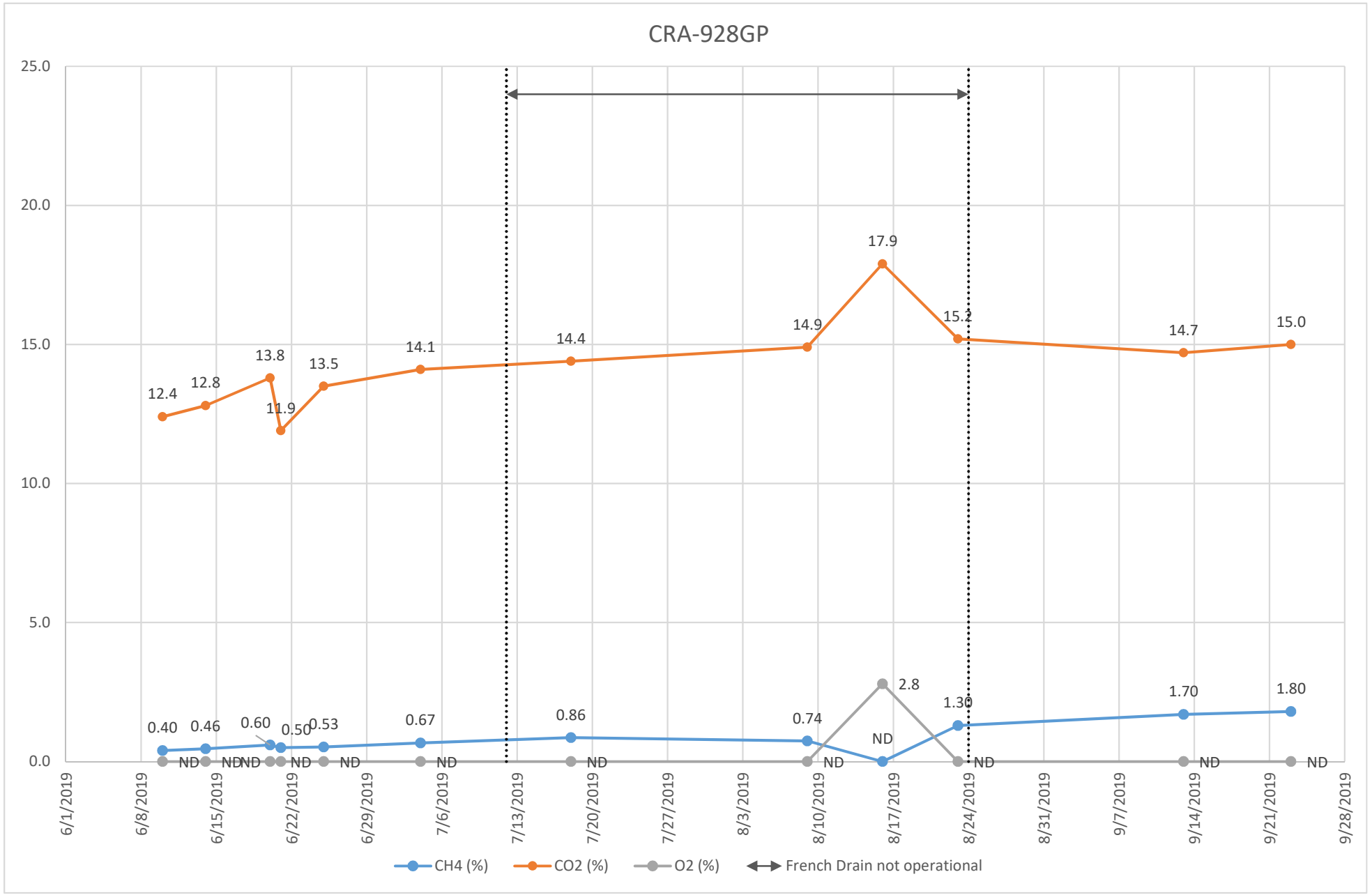

CRA-923GP
25.0
20.0
15.0
10.0
5.0
0.0
5.0
4.0
3.0
2.0
1.0
0.0
16.6
16.8
16.8
16.7
16.9
19.3
18.1
17.5
17.6
17.4
16.1
ND
0.10
0.01
ND
0.01
ND
0.01
ND
0.03
ND
0.05
ND
0.04
ND
ND
0.07
ND
0.05
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
CO2 (%)
CH4 (%)
O2 (%)

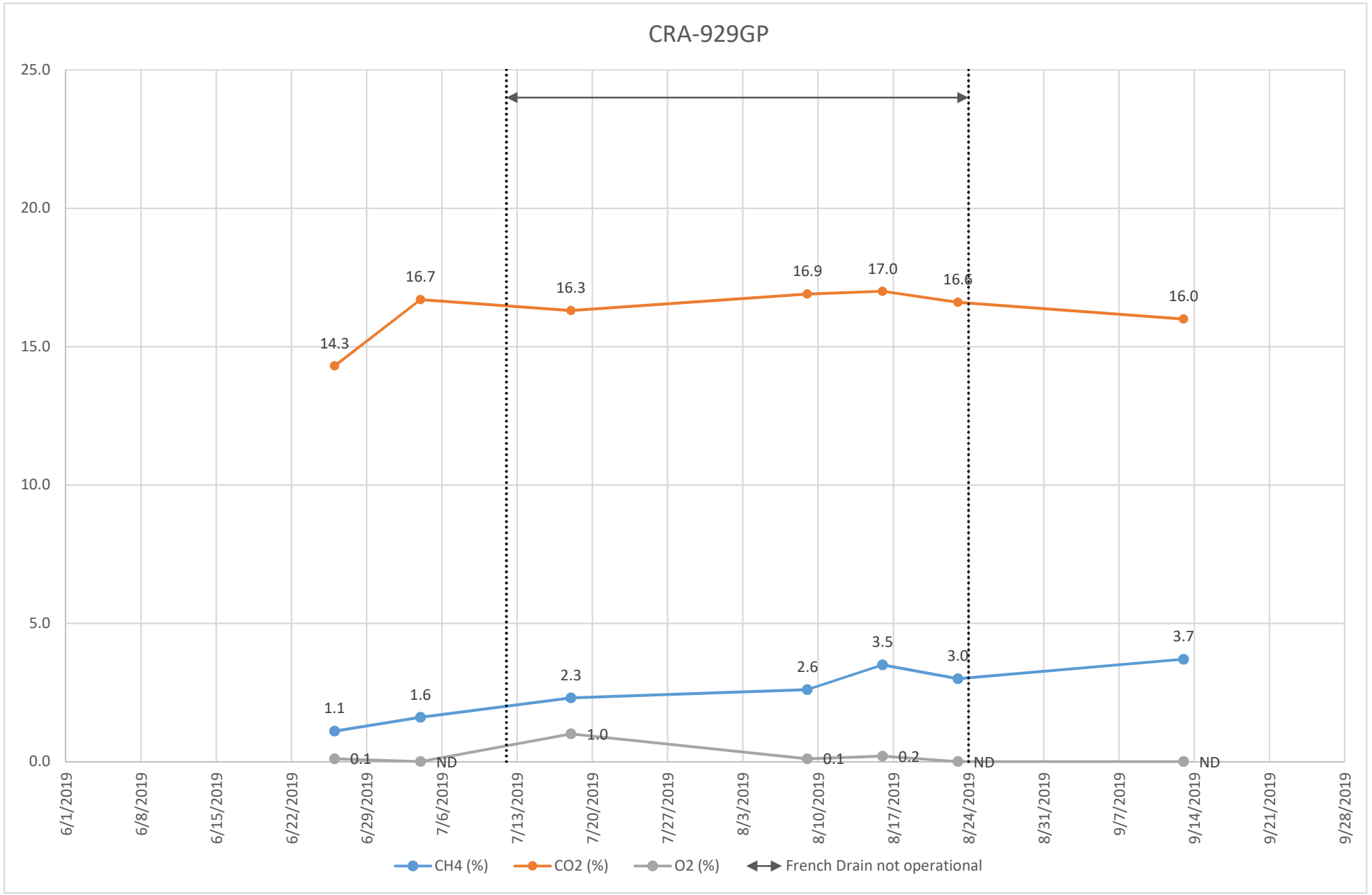

CRA-924GP
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20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
14.1
14.6
15.3
12.5
14.4
14.9
15.8
15.8
16.3
15.8
15.7
2.7
0.1
ND
ND
3.4
2.1
2.5
2.1
5.9
4.0
5.1
4.8
9.5
0.8
1.0
0.7
ND
0.3
0.1
0.4
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

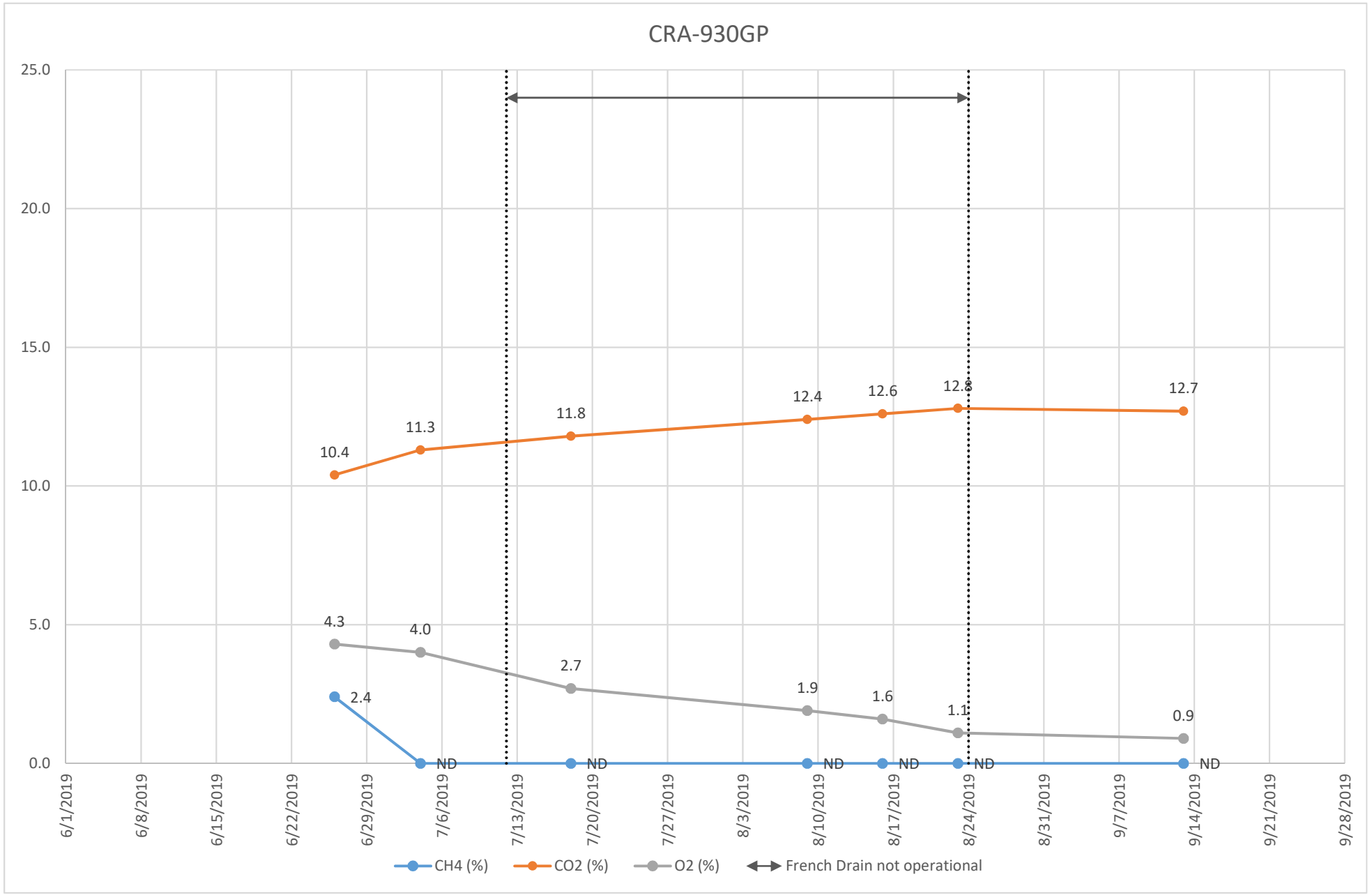

CRA-925GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
14.5
16.0
16.1
16.6
16.8
16.9
16.4
2.8
3.1
3.8
5.0
3.9
5.9
7.2
ND
ND
ND
ND
ND
ND
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

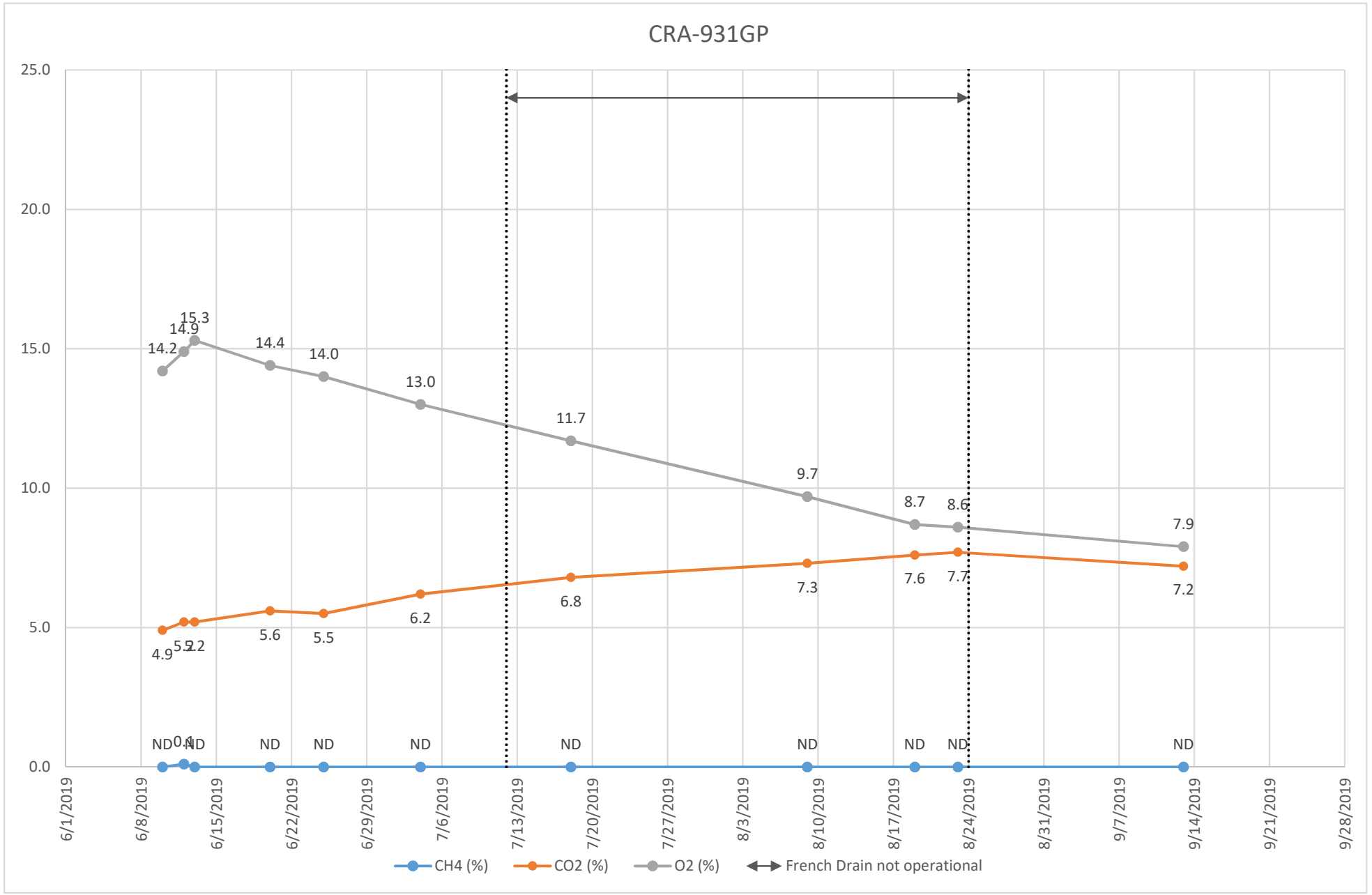

CRA-926GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
12.9
13.1
13.2
13.6
13.3
14.6
14.6
14.6
14.5
14.6
14.0
0.8
1.4
1.5
1.3
1.3
1.0
ND
ND
0.9
ND
ND
ND
0.1
ND
ND
ND
ND
0.01
0.002
0.021
0.002
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

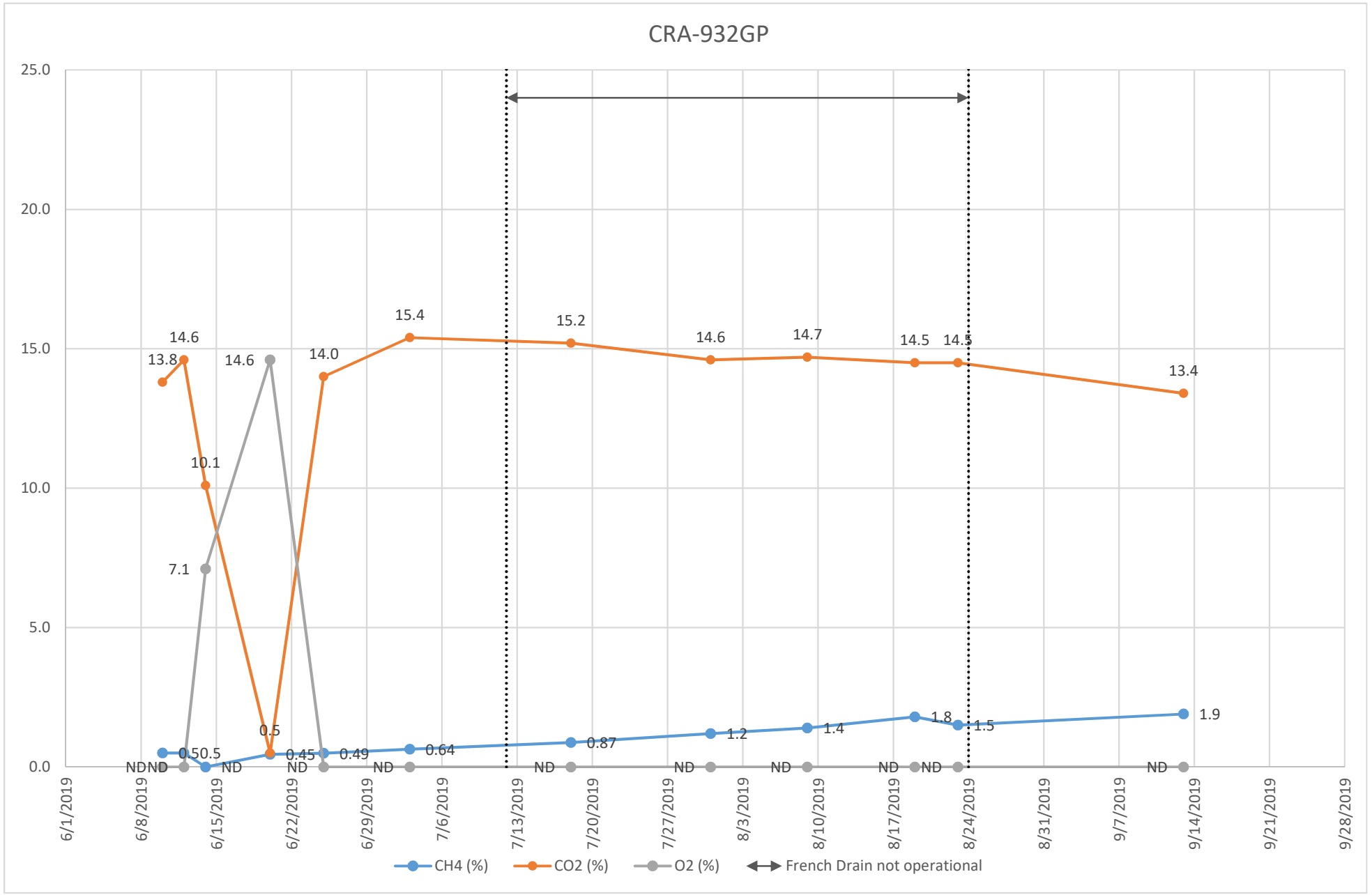

CRA-927GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
10.0
10.4
10.2
11.0
10.4
11.4
11.7
11.9
16.8
12.2
11.9
6.7
6.5
6.5
6.2
6.2
5.8
4.7
4.2
3.4
3.4
2.7
ND
0.1
ND
ND
ND
ND
ND
0.0001
ND
ND
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

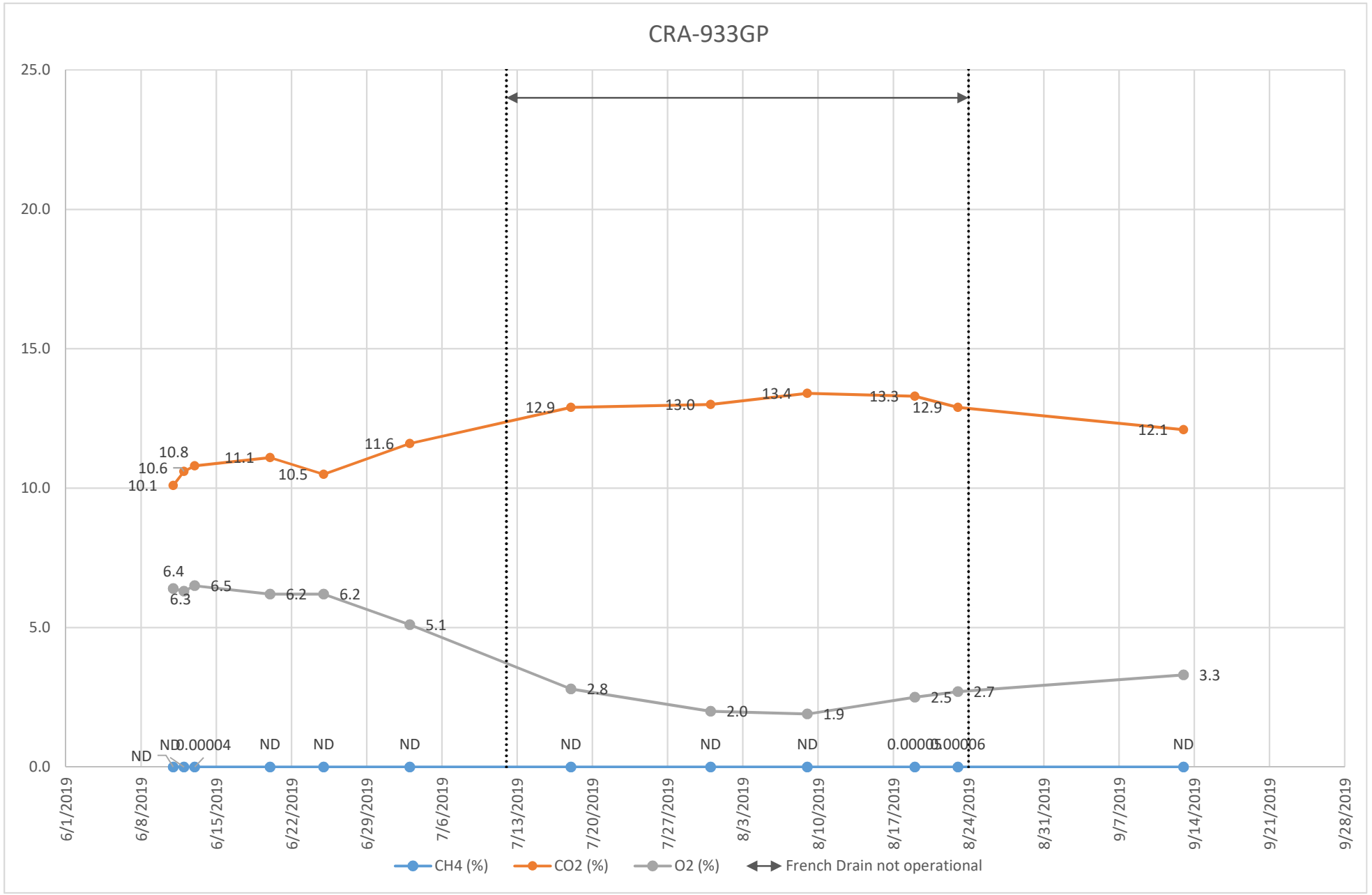

CRA-928GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
12.4
12.8
13.8
11.9
13.5
14.1
14.4
14.9
17.9
15.2
14.7
15.0
0.40
0.46
0.60
0.50
0.53
0.67
0.86
0.74
ND
1.30
1.70
1.80
2.8
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

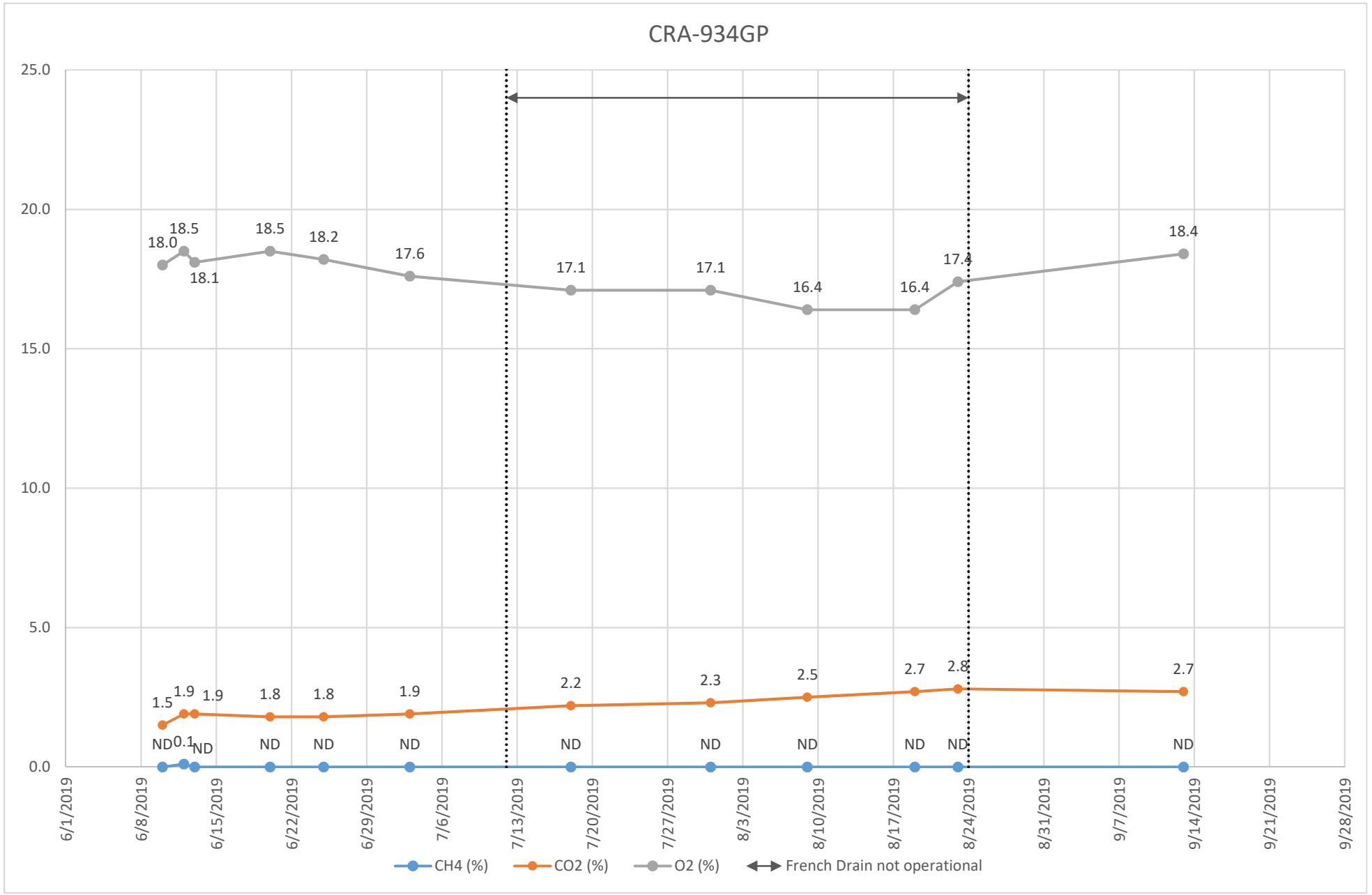

CRA-929GP
25.0
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15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
14.3
16.7
16.3
16.9
17.0
16.6
16.0
1.1
1.6
2.3
2.6
3.5
3.0
3.7
0.1
ND
1.0
0.1
0.2
ND
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

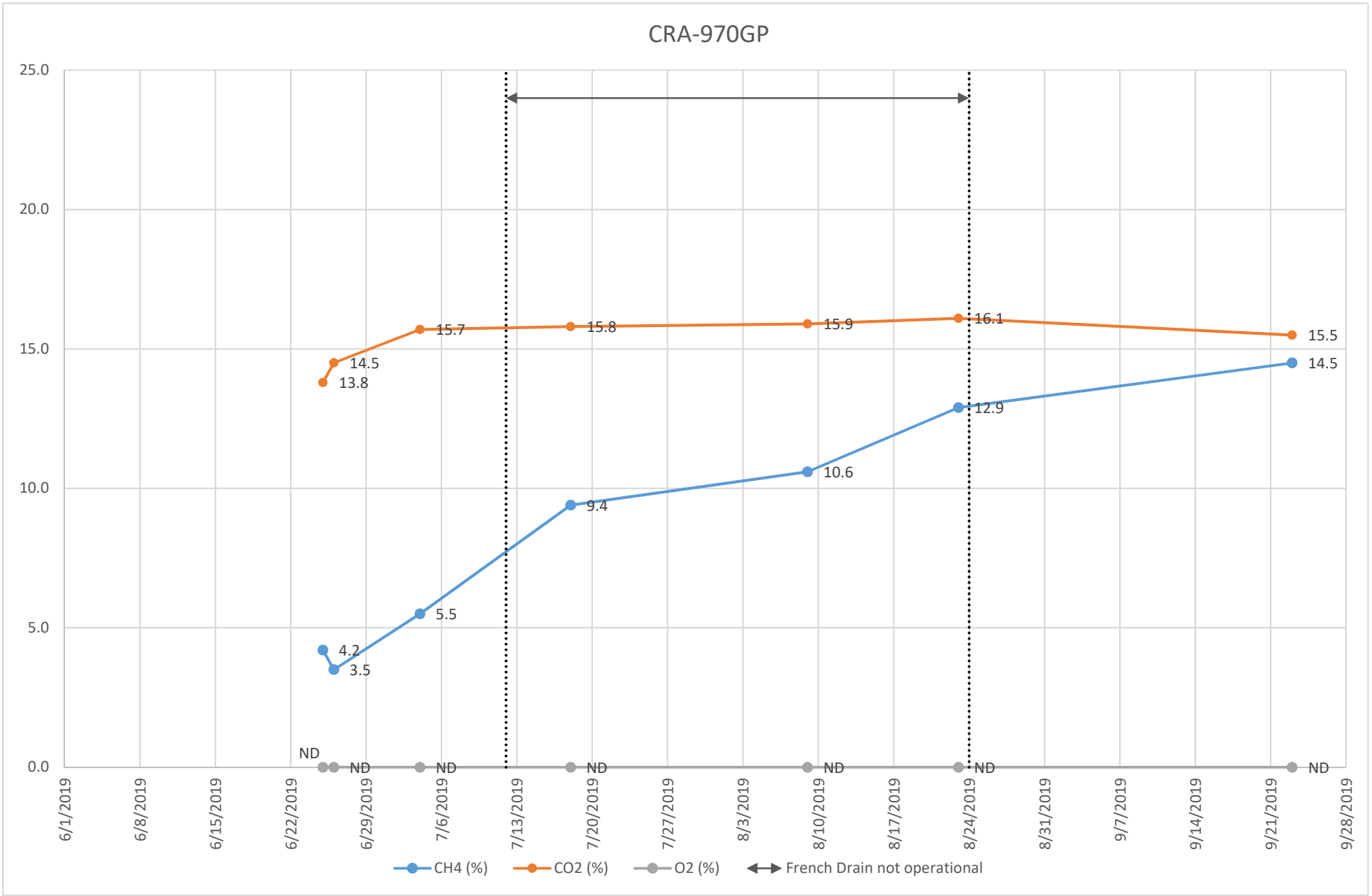

CRA-930GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
10.4
11.3
11.8
12.4
12.6
12.8
12.7
4.3
4.0
2.7
1.9
1.6
1.1
0.9
2.4
ND
ND
ND
ND
ND
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

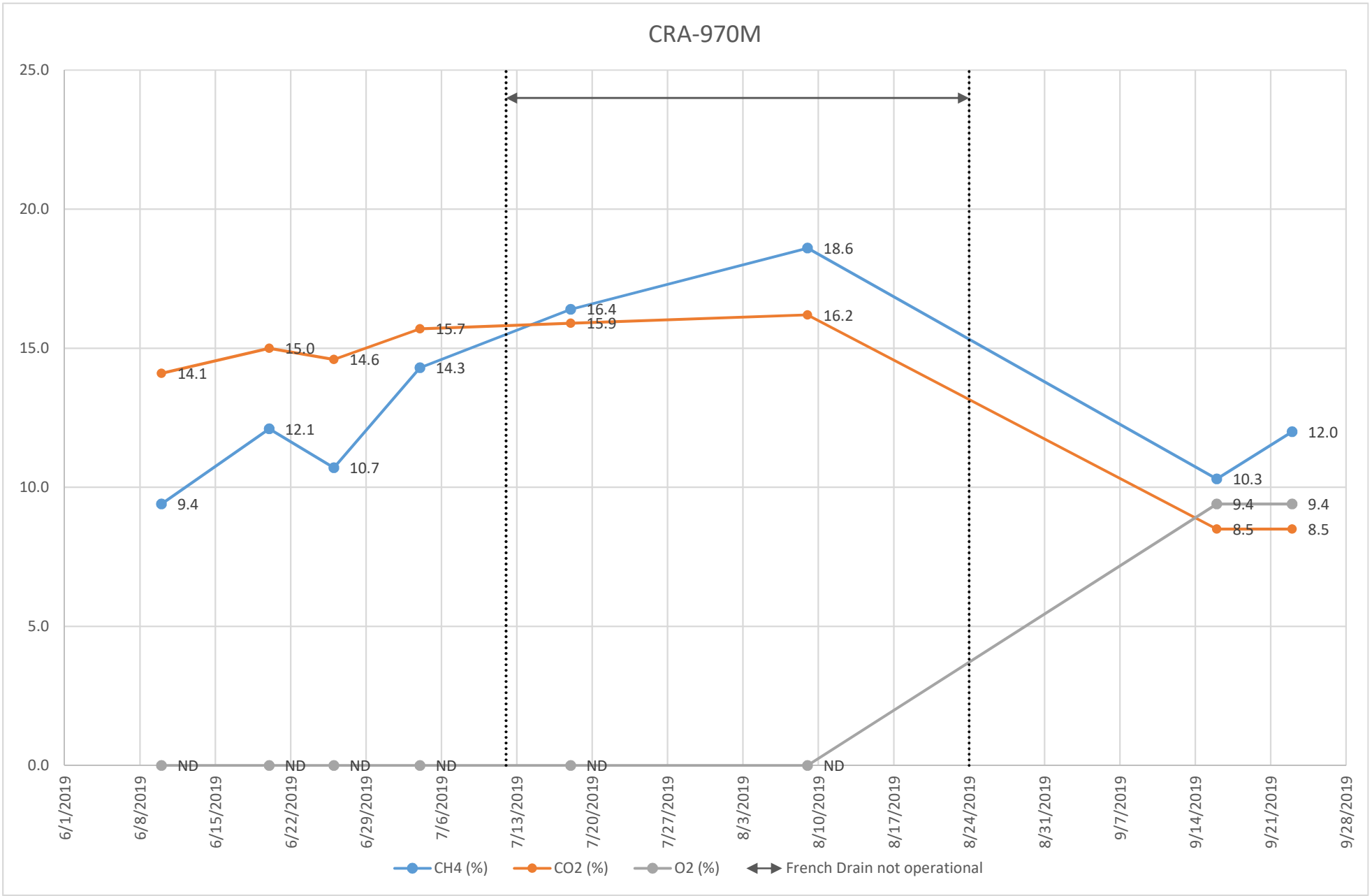

CRA-931GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
14.2
14.9
15.3
14.4
14.0
13.0
11.7
9.7
8.7
8.6
7.9
4.9
5.2
5.2
5.6
5.5
6.2
6.8
7.3
7.6
7.7
7.2
ND
0.1
ND
ND
ND
ND
ND
ND
ND
ND
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

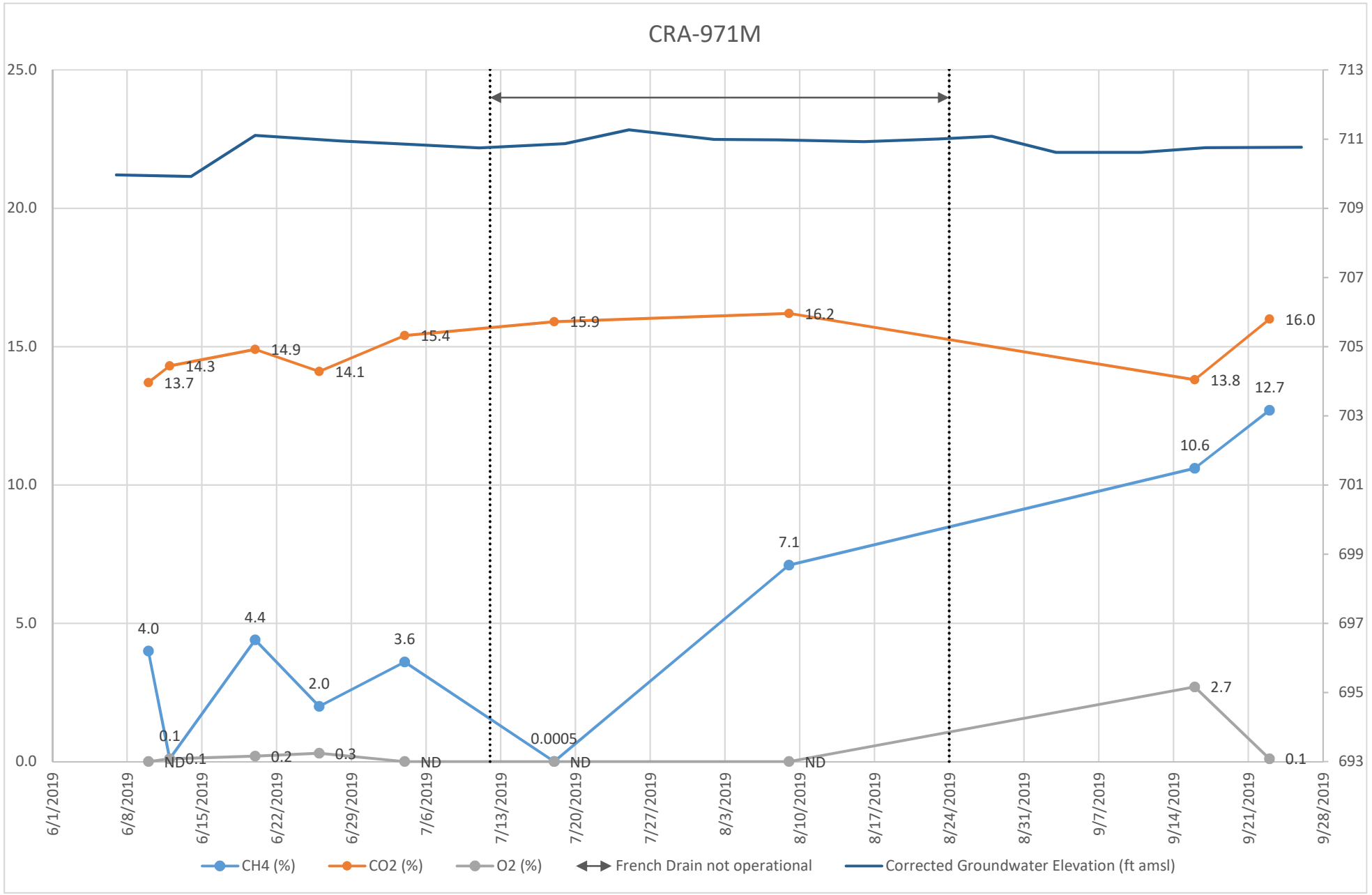

CRA-932GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
14.6
13.8
14.6
14.0
15.4
15.2
14.6
14.7
14.5
14.5
13.4
10.1
7.1
0.5
0.50.5
0.45
0.49
0.64
0.87
1.2
1.4
1.8
1.5
1.9
NDND
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

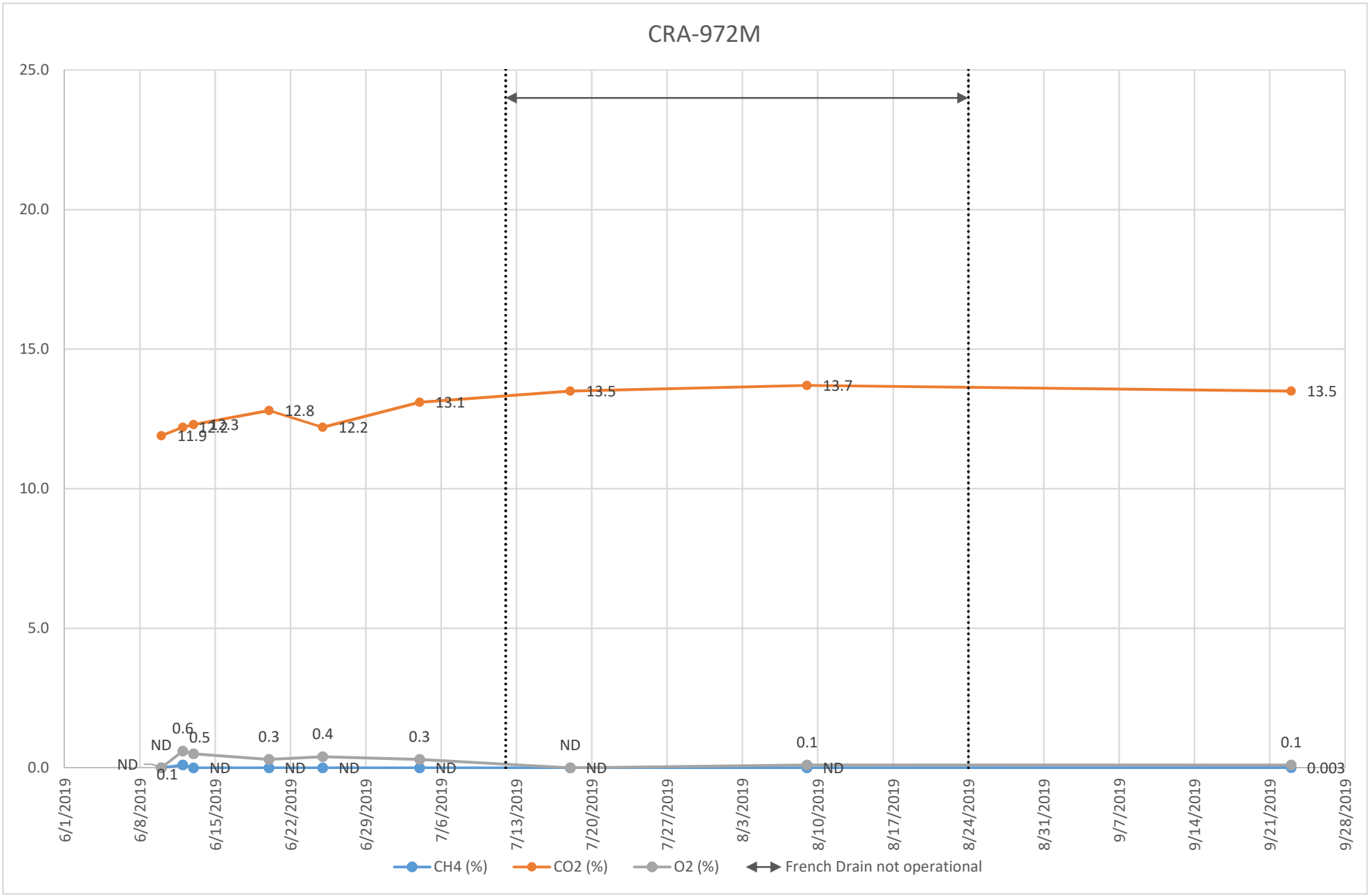

CRA-933GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
10.1
10.6
10.8
11.1
10.5
11.6
12.9
13.0
13.4
13.3
12.9
12.1
6.4
6.3
6.5
6.2
6.2
5.1
2.8
2.0
1.9
2.5
2.7
3.3
ND
ND
0.00004
ND
ND
ND
ND
ND
ND
0.00005
0.00006
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

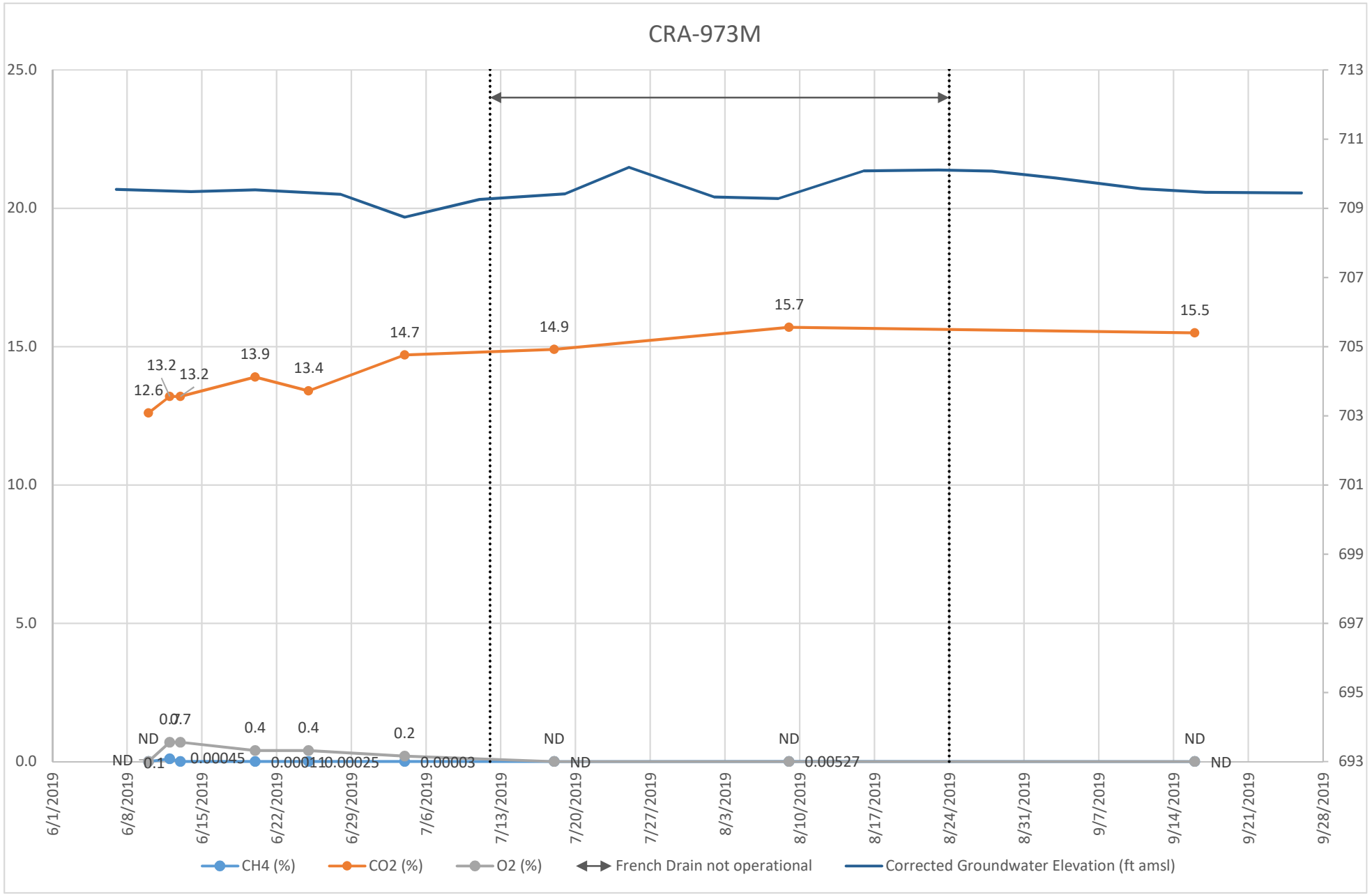

CRA-934GP
25.0
20.0
15.0
10.0
5.0
0.0
18.0
18.5
18.1
18.5
18.2
17.6
17.1
17.1
16.4
16.4
17.4
18.4
1.5
1.9
1.9
1.8
1.8
1.9
2.2
2.3
2.5
2.7
2.8
2.7
ND
0.1
ND
ND
ND
ND
ND
ND
ND
ND
ND
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

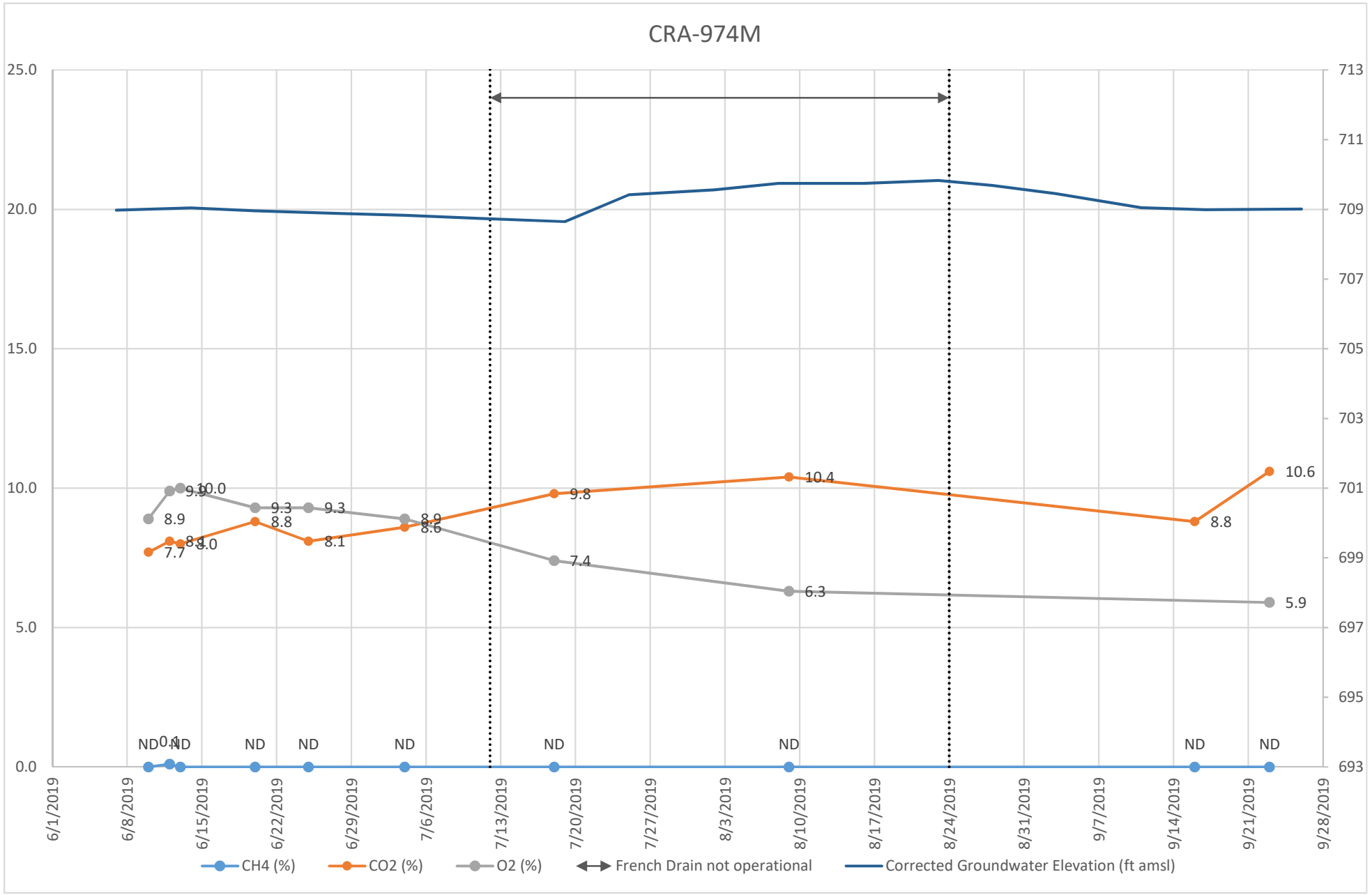

CRA-970GP
25.0
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15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
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6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
13.8
14.5
15.7
15.8
15.9
16.1
15.5
4.2
3.5
5.5
9.4
10.6
12.9
14.5
ND
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

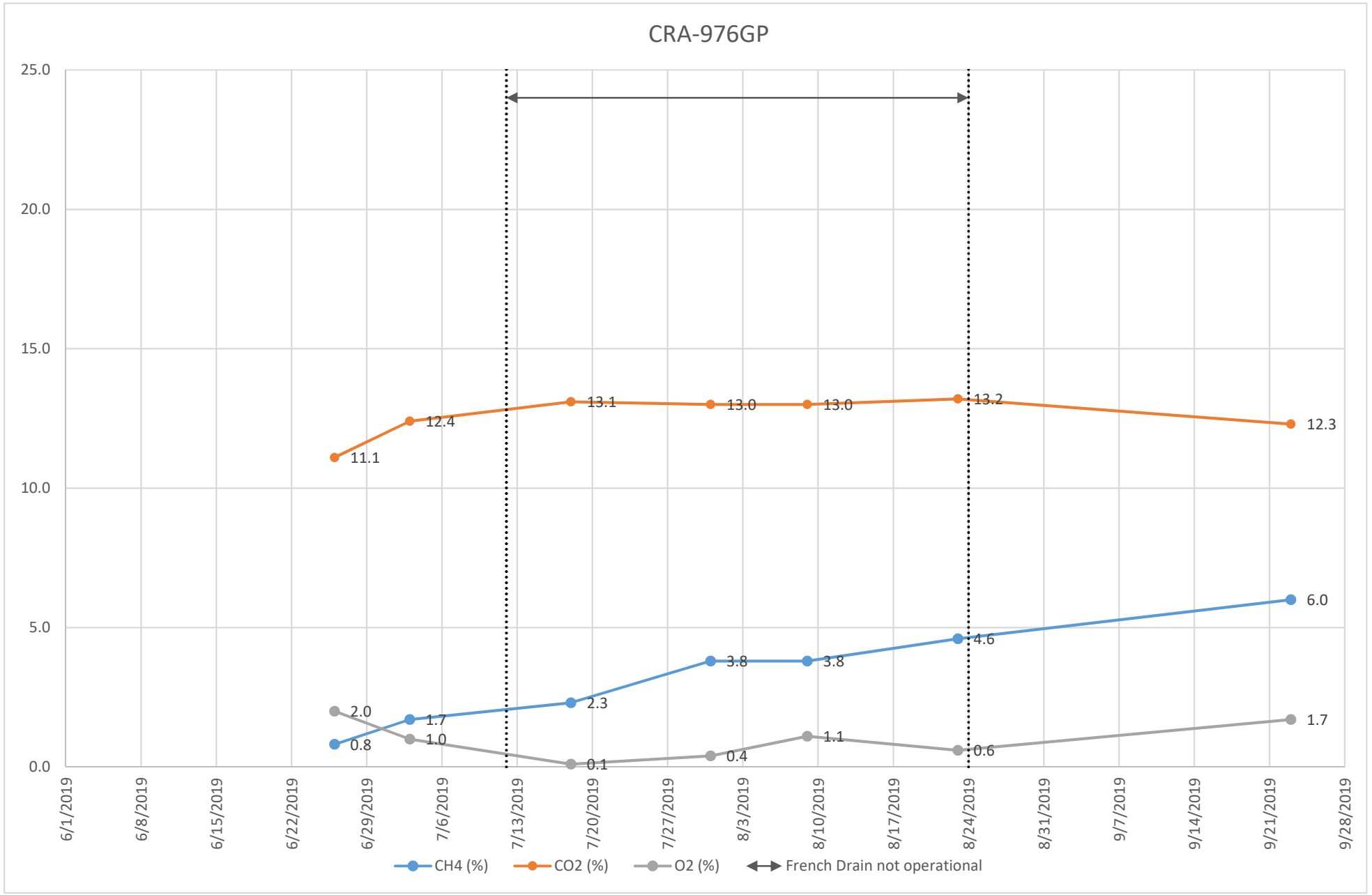

CRA-970M
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
14.1
15.0
14.6
15.7
15.9
16.2
9.4
12.1
10.7
14.3
16.4
18.6
10.3
12.0
ND
ND
ND
ND
ND
ND
9.4
9.4
8.5
8.5
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

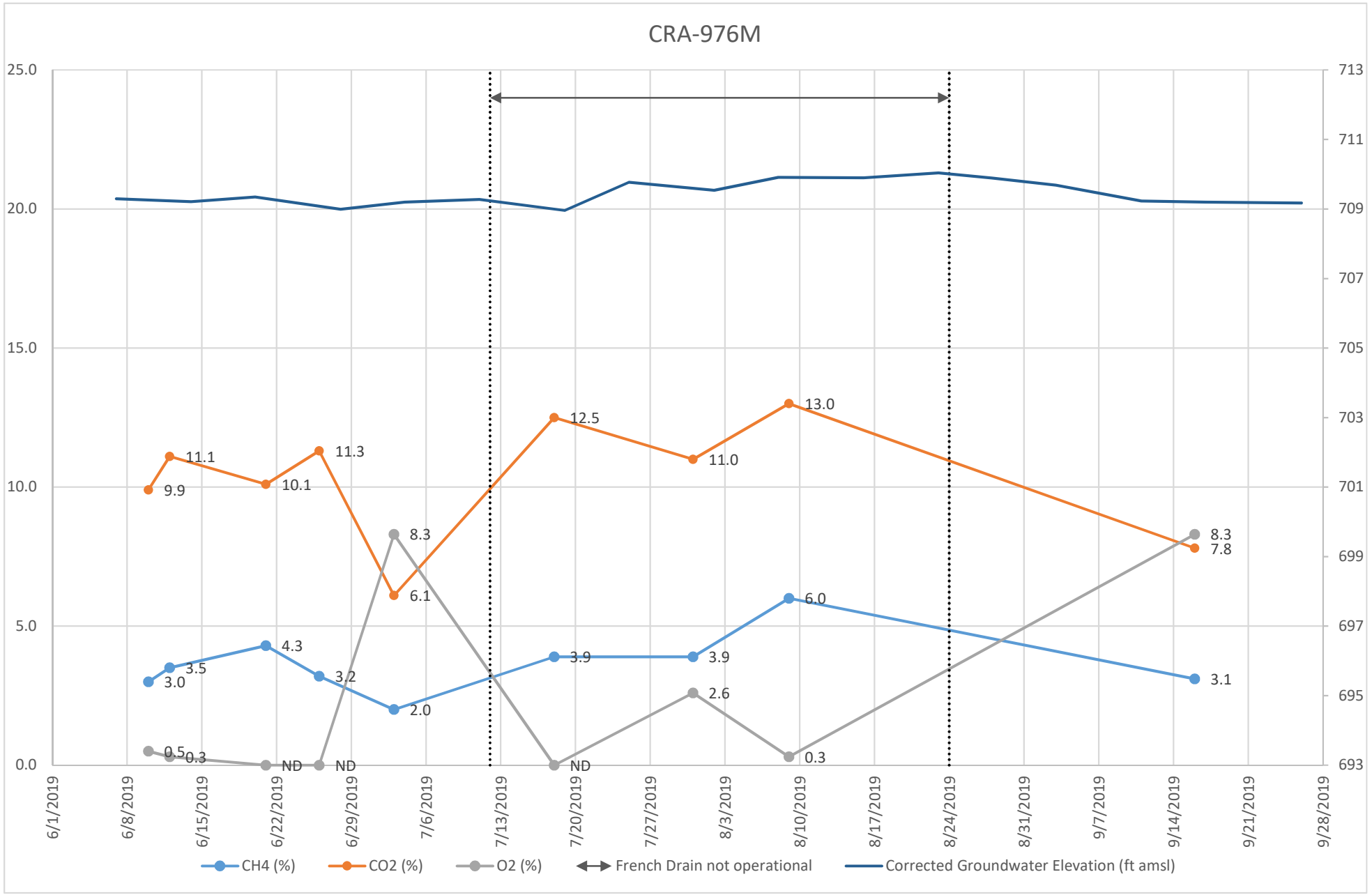

CRA-971M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
13.7
14.3
14.9
14.1
15.4
15.9
16.2
13.8
16.0
4.0
ND
0.1
4.4
2.0
3.6
0.0005
ND
7.1
10.6
12.7
ND
0.1
0.2
0.3
ND
ND
ND
2.7
0.1
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational
Corrected Groundwater Elevation (ft amsl)

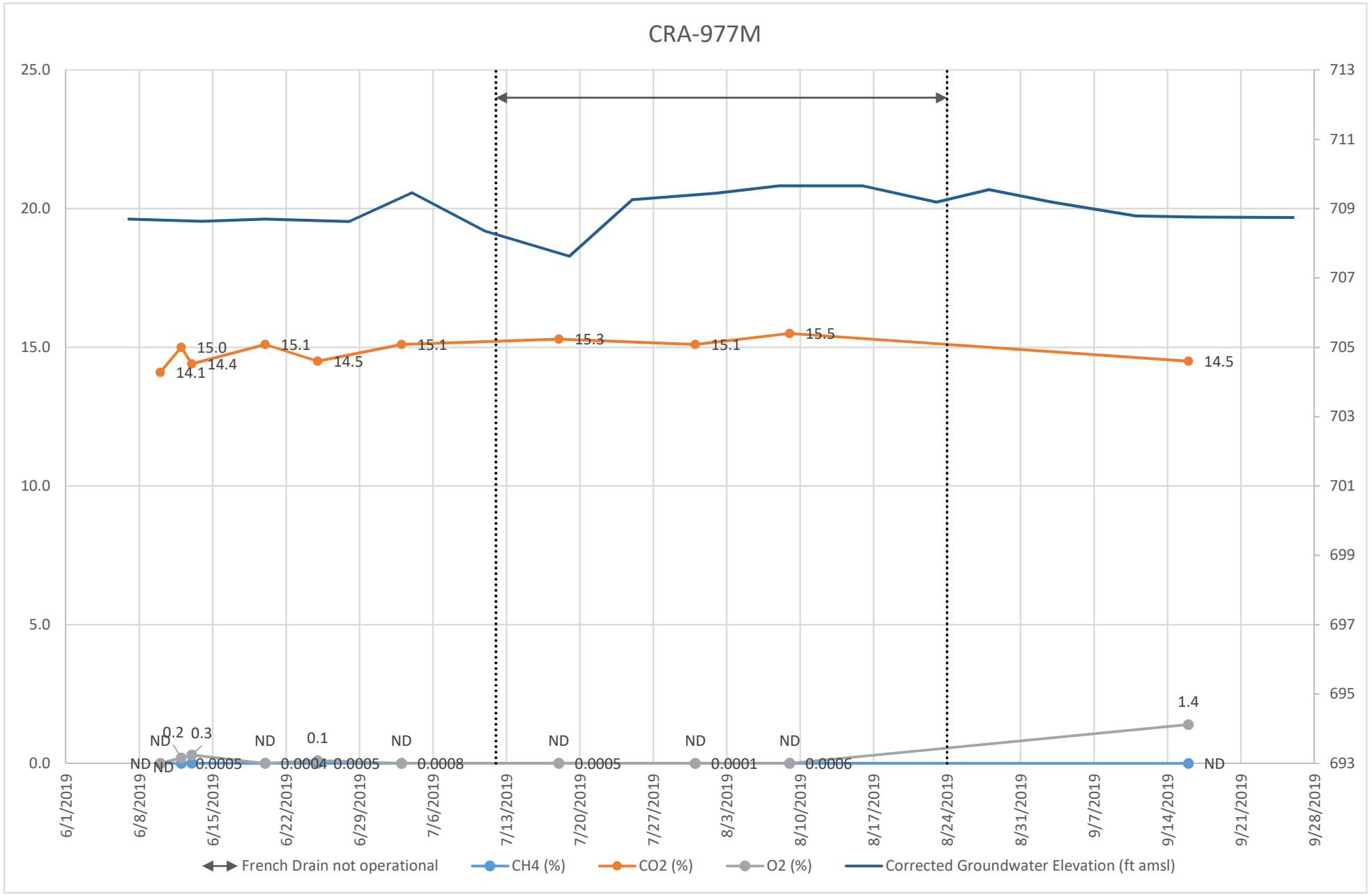

CRA-972M
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
11.9
12.3
12.8
12.2
13.1
13.5
13.7
13.5
ND
0.6
0.5
0.3
0.4
0.3
ND
0.1
ND
0.1
0.003
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

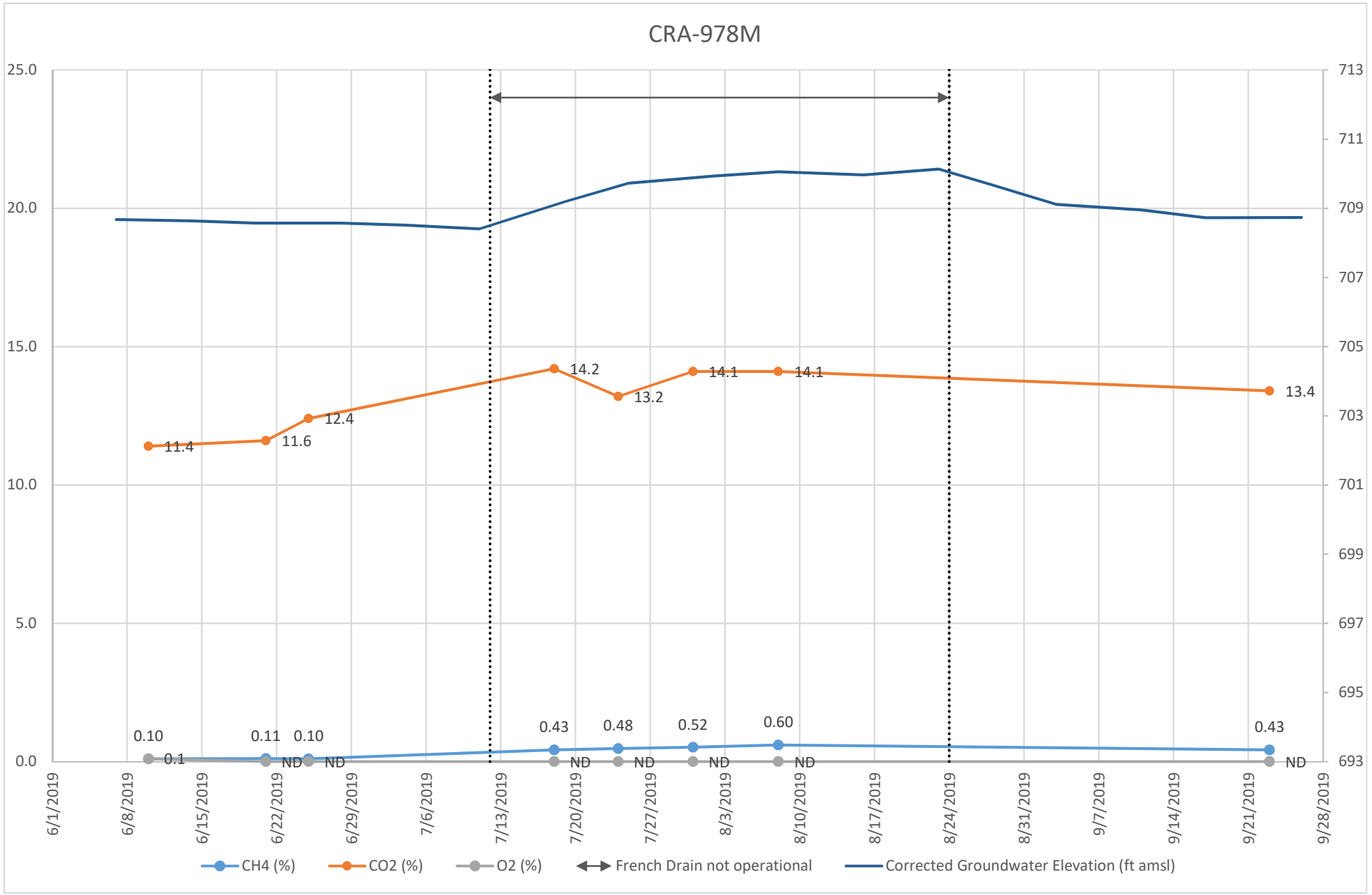

CRA-973M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
12.6
13.2
13.2
13.9
13.4
14.7
14.9
15.7
15.5
ND
0.7
0.4
0.4
0.2
ND
ND
ND
ND
0.1
0.00045
0.00011
0.00025
0.00003
0.00527
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational
Corrected Groundwater Elevation (ft amsl)

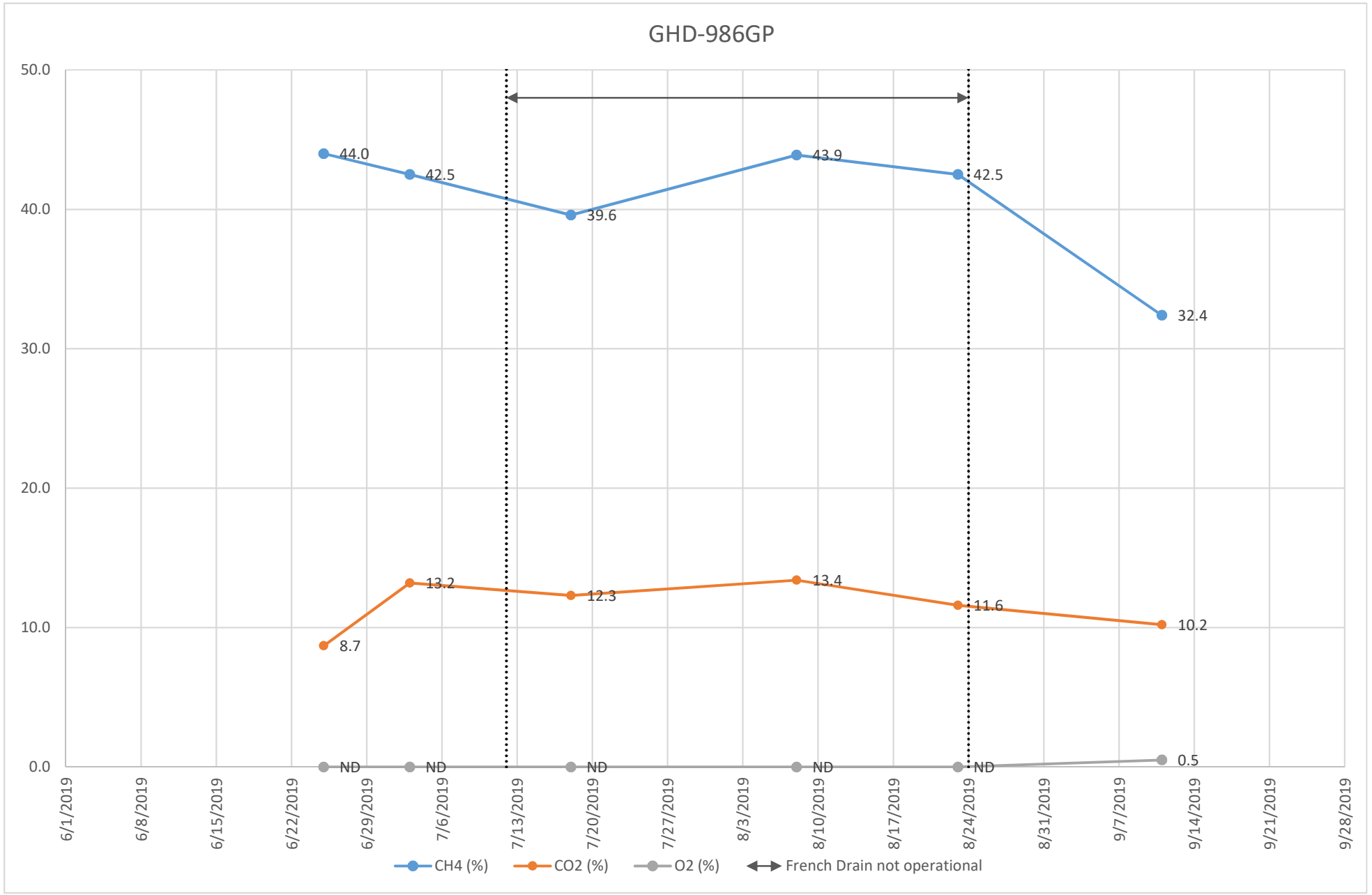

CRA-974M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
ND
0.1
ND
ND
ND
ND
ND
ND
ND
ND
7.7
8.8
8.1
8.6
9.8
10.4
8.8
10.6
8.9
9.9
10.0
9.3
9.3
8.9
7.4
6.3
5.9
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational
Corrected Groundwater Elevation (ft amsl)

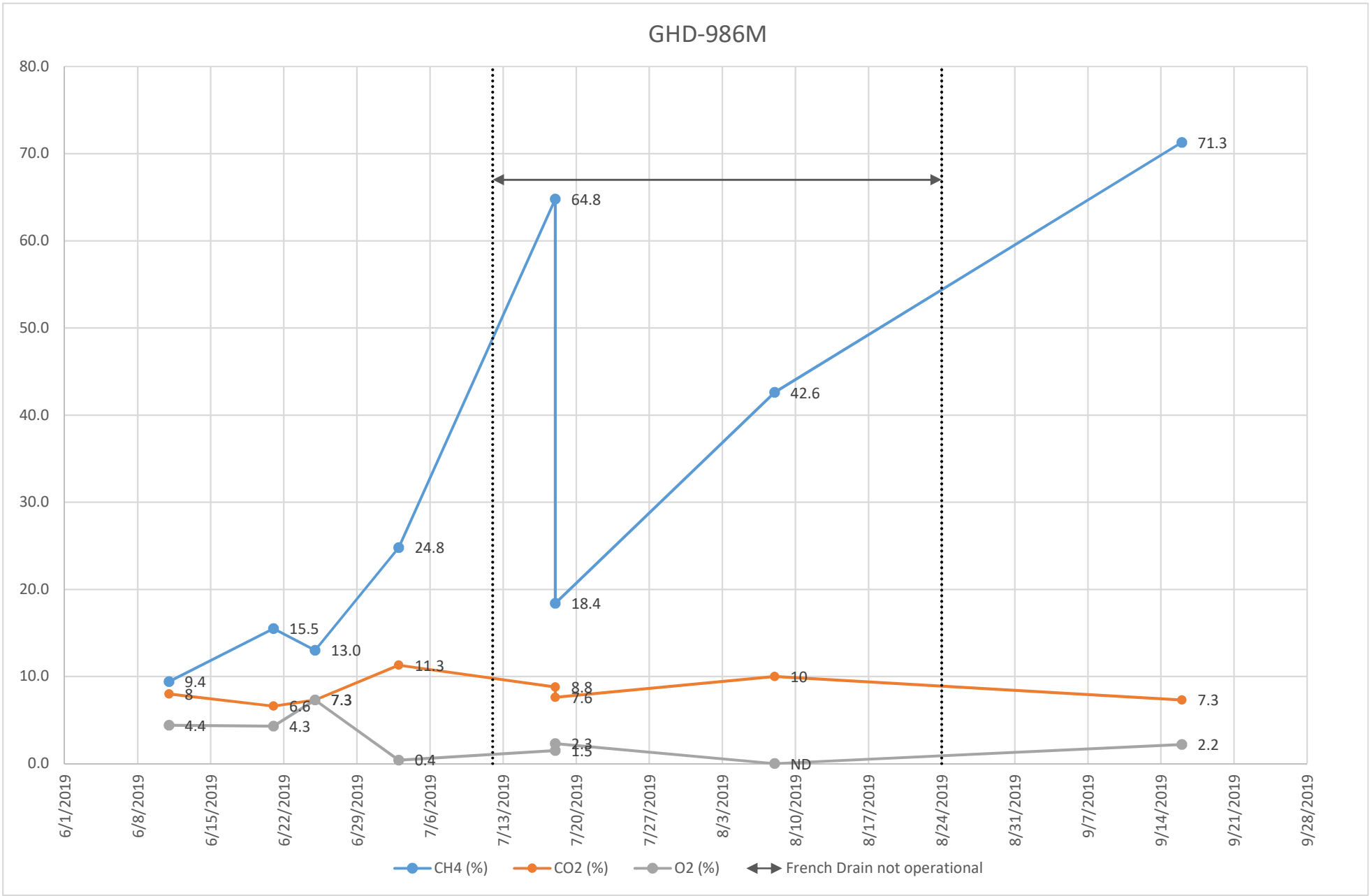

CRA-976GP
25.0
20.0
15.0
10.0
5.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
11.1
12.4
13.1
13.0
13.0
13.2
12.3
0.8
1.7
2.3
3.8
3.8
4.6
6.0
2.0
1.0
0.1
0.4
1.1
0.6
1.7
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

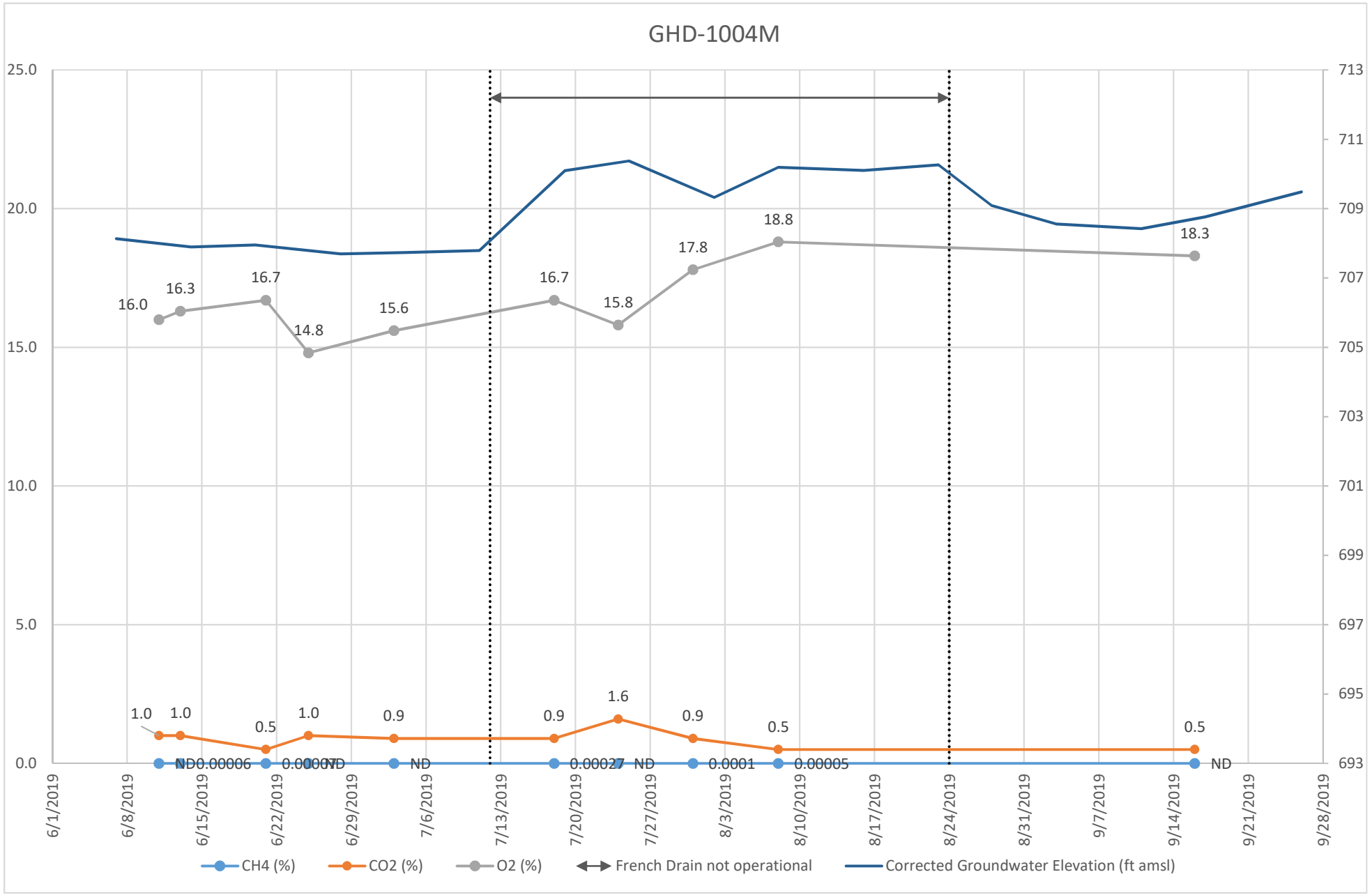

CRA-976M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
9.9
11.1
10.1
11.3
6.1
12.5
11.0
13.0
7.8
3.0
3.5
4.3
3.2
2.0
3.9
3.9
6.0
3.1
0.5
0.3
ND
ND
8.3
ND
2.6
0.3
8.3
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational
Corrected Groundwater Elevation (ft amsl)

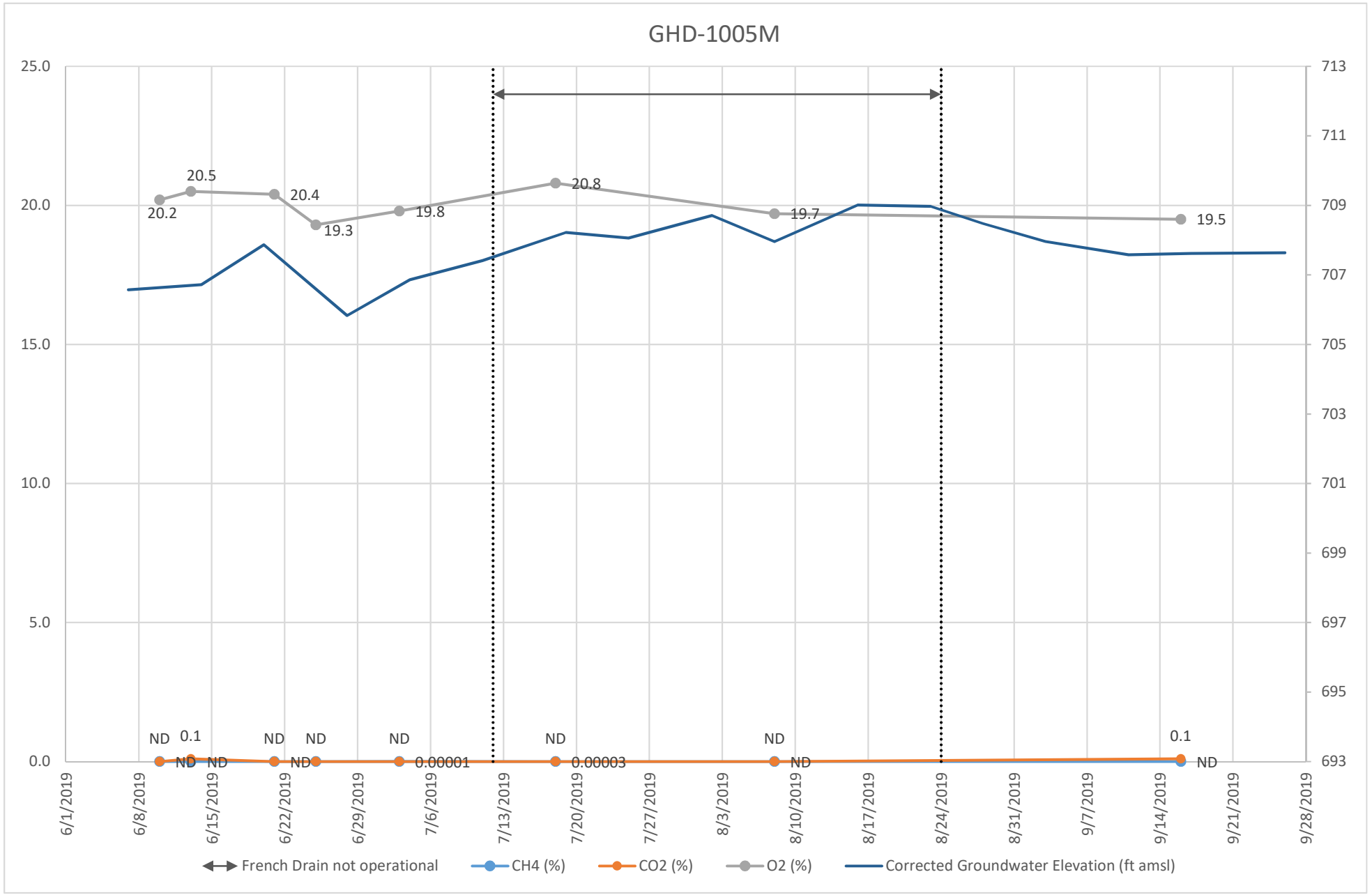

CRA-977M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
15.0
14.1
14.4
15.1
14.5
15.1
15.3
15.1
15.5
14.5
ND
ND
0.2
0.3
0.0005
ND
0.0004
0.1
0.0005
ND
0.0008
ND
0.0005
ND
0.0001
ND
0.0006
1.4
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
CH4 (%)
CO2 (%)
O2 (%)
Corrected Groundwater Elevation (ft amsl)

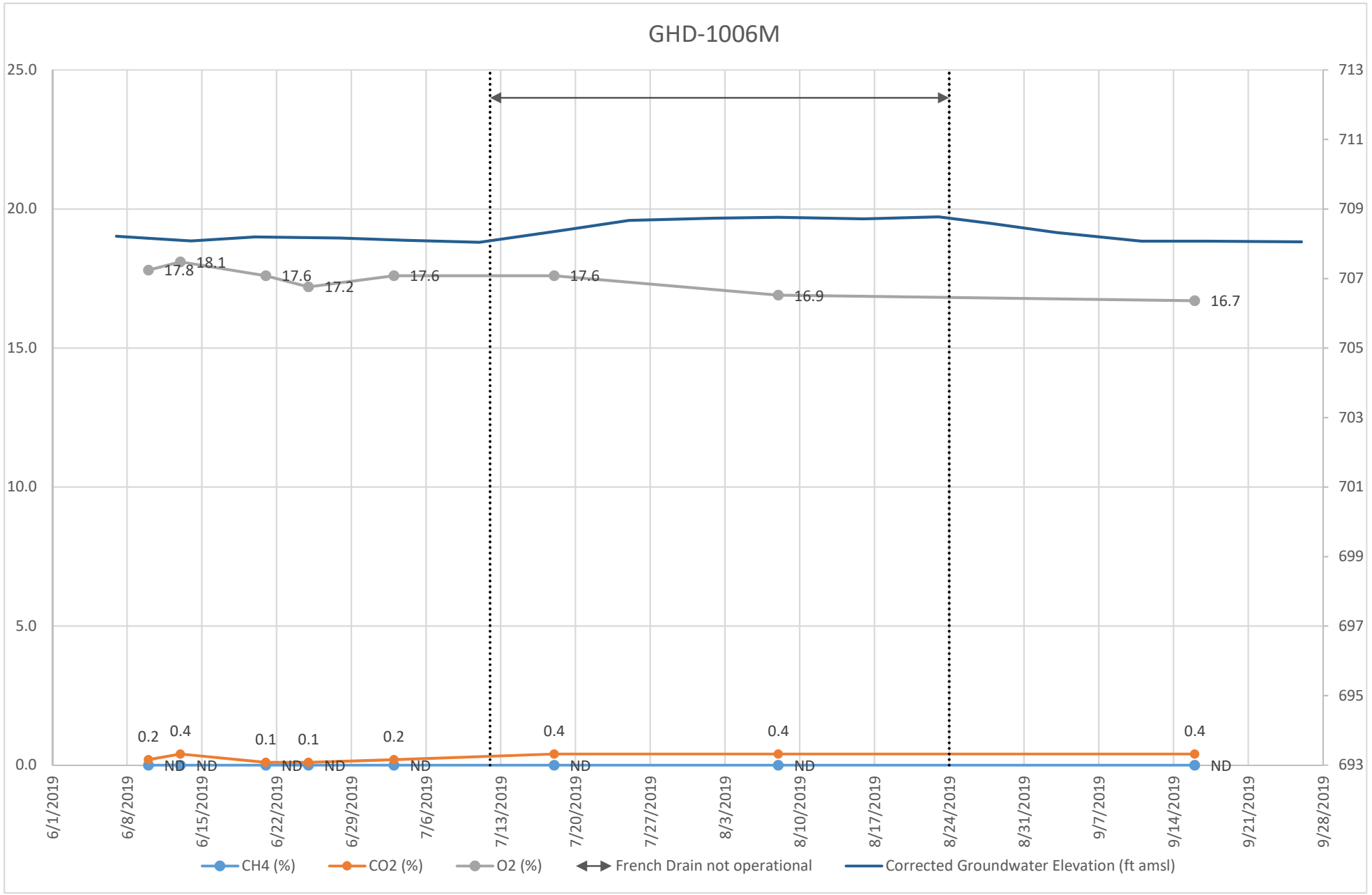

CRA-978M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
11.4
11.6
12.4
14.2
13.2
14.1
14.1
13.4
0.10
0.11
0.10
0.43
0.48
0.52
0.60
0.43
0.1
ND
ND
ND
ND
ND
ND
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational
Corrected Groundwater Elevation (ft amsl)

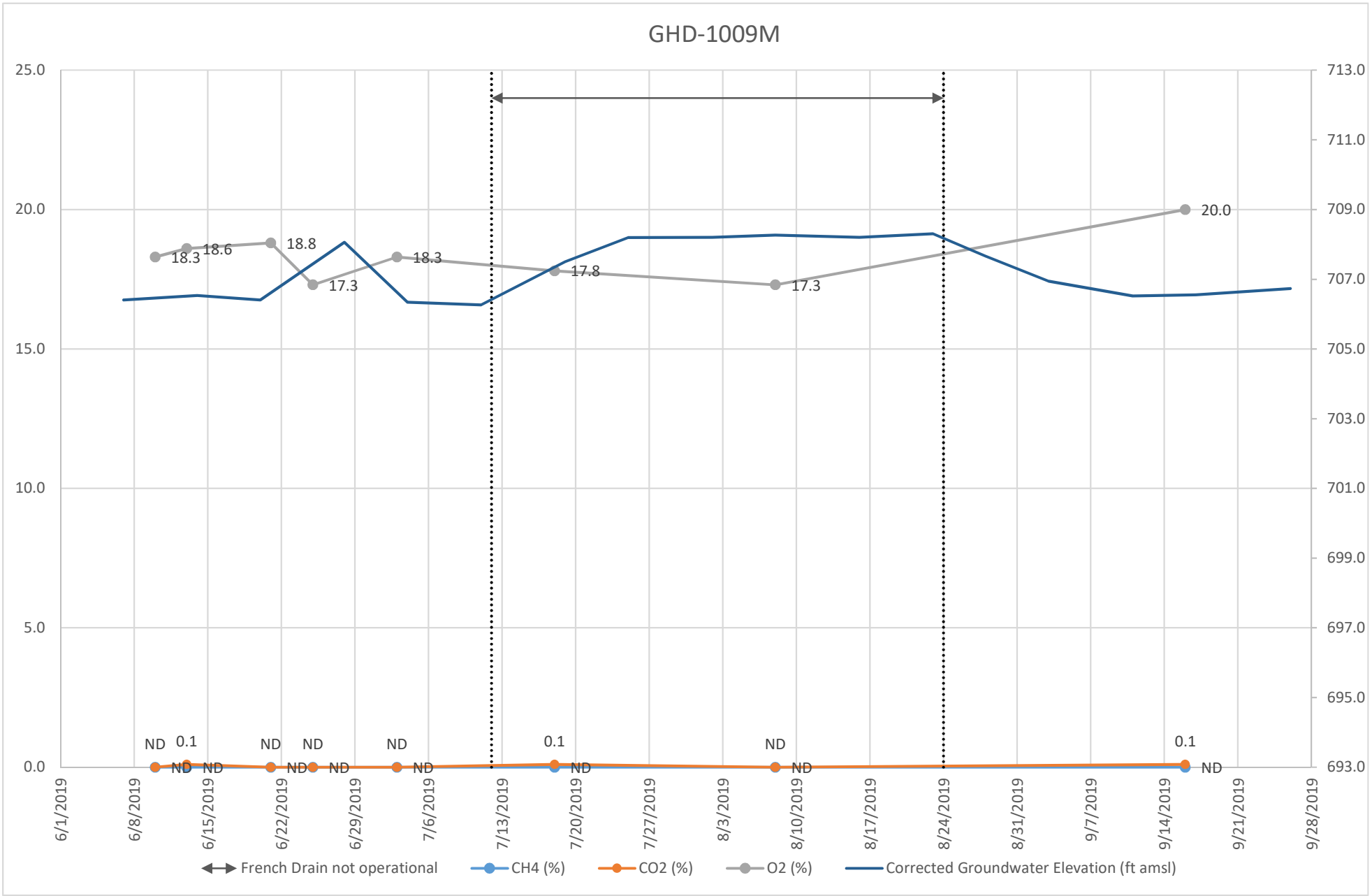

GHD-986GP
50.0
40.0
30.0
20.0
10.0
0.0
44.0
42.5
39.6
43.9
42.5
32.4
13.2
12.3
13.4
11.6
10.2
8.7
ND
ND
ND
ND
ND
0.5
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational


GHD-986M
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
71.3
64.8
42.6
24.8
18.4
15.5
13.0
9.4
11.3
8.8
10
8
6.6
7.6
7.3
7.3
4.4
4.3
0.4
2.3
1.5
ND
2.2
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational

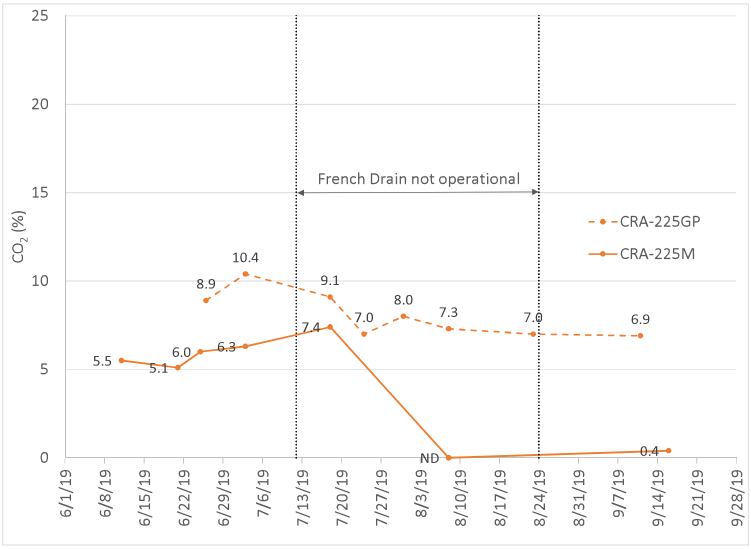

GHD-1004M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
16.0
16.3
16.7
14.8
15.6
16.7
15.8
17.8
18.8
18.3
1.0
1.0
0.5
1.0
0.9
0.9
1.6
0.9
0.5
0.5
ND
0.00006
0.00007
ND
ND
0.00027
ND
0.0001
0.00005
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational
Corrected Groundwater Elevation (ft amsl)

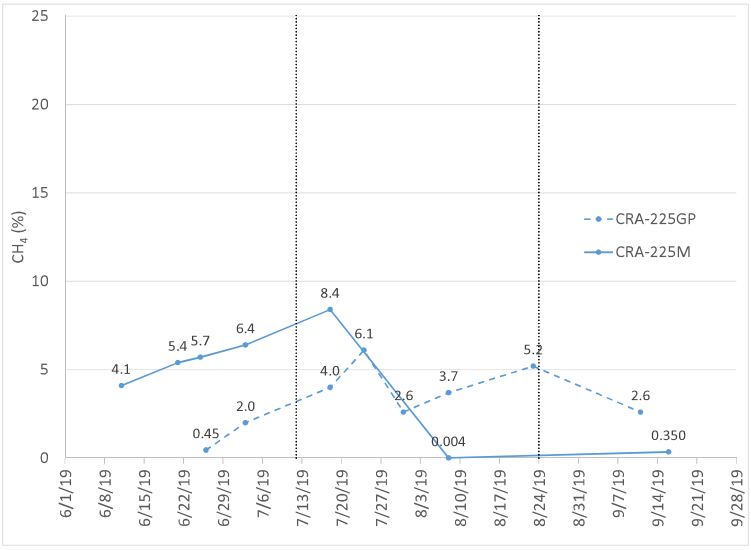

GHD-1005M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
20.2
20.5
20.4
19.3
19.8
20.8
19.7
19.5
ND
0.1
ND
ND
ND
ND
ND
ND
ND
ND
ND
0.00001
0.00003
0.1
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
CH4 (%)
CO2 (%)
O2 (%)
Corrected Groundwater Elevation (ft amsl)

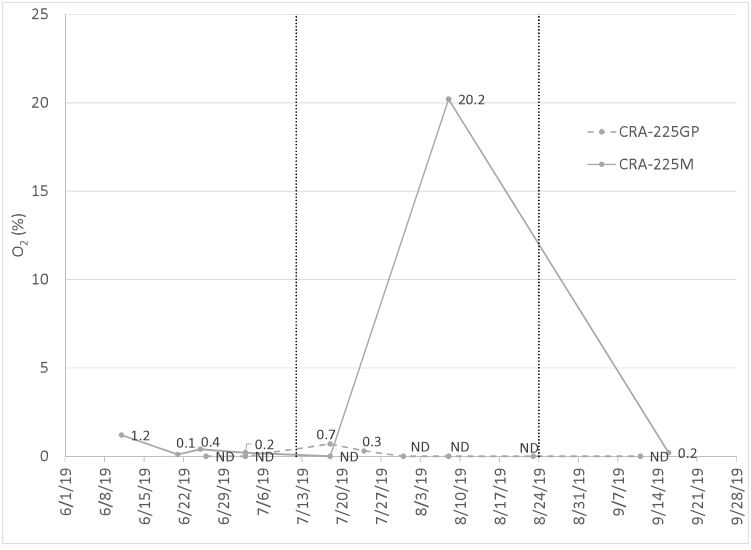

GHD-1006M
25.0
20.0
15.0
10.0
5.0
0.0
713
711
709
707
705
703
701
699
697
695
693
17.8
18.1
17.6
17.2
17.6
17.6
16.9
16.7
0.2
0.4
0.1
0.1
0.2
0.4
0.4
0.4
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
CH4 (%)
CO2 (%)
O2 (%)
French Drain not operational
Corrected Groundwater Elevation (ft amsl)

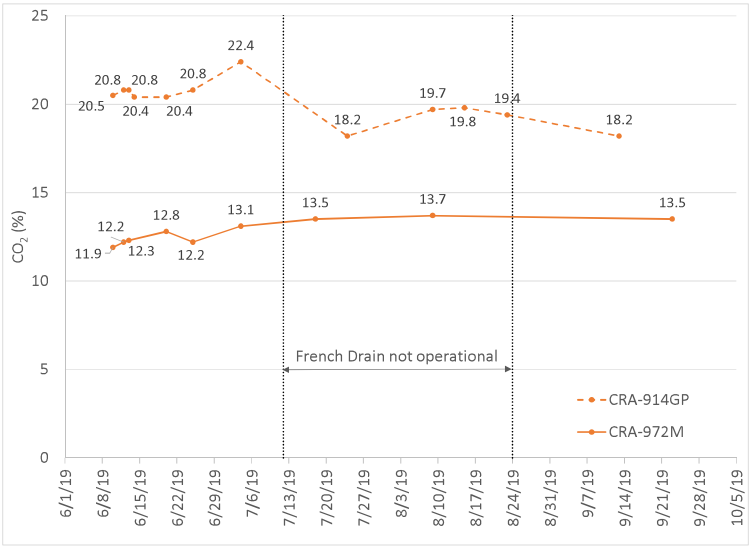

GHD-1009M
25.0
20.0
15.0
10.0
5.0
0.0
713.0
711.0
709.0
707.0
705.0
703.0
701.0
699.0
697.0
695.0
693.0
18.3
18.6
18.8
17.3
18.3
17.8
17.3
20.0
ND
0.1
ND
ND
ND
ND
ND
ND
ND
0.1
ND
ND
ND
0.1
ND
6/1/2019
6/8/2019
6/15/2019
6/22/2019
6/29/2019
7/6/2019
7/13/2019
7/20/2019
7/27/2019
8/3/2019
8/10/2019
8/17/2019
8/24/2019
8/31/2019
9/7/2019
9/14/2019
9/21/2019
9/28/2019
French Drain not operational
CH4 (%)
CO2 (%)
O2 (%)
Corrected Groundwater Elevation (ft amsl)

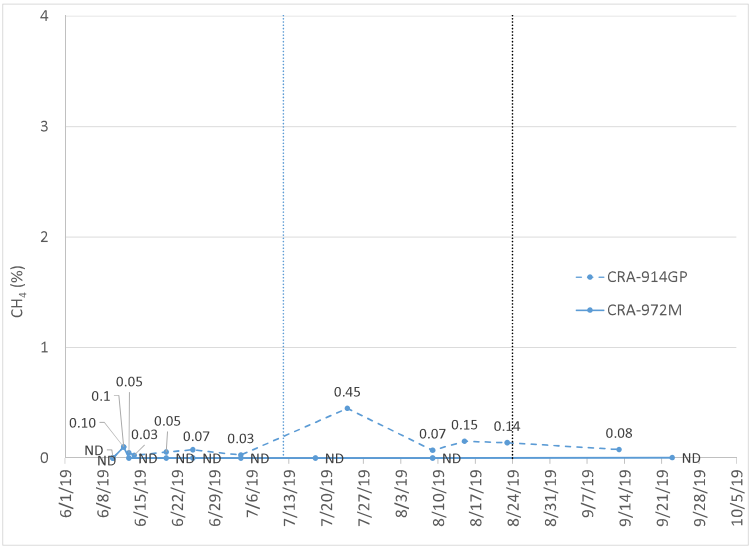
Appendix D
Soil Gas Data Graphs – Monitoring Well and Gas Probe Pairs

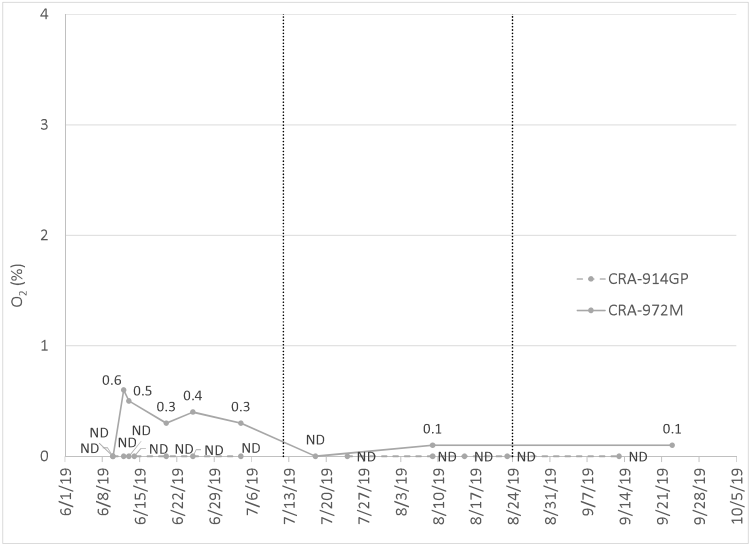

25
20
15
10
5
0
CO_2 (%)
French Drain not operational
CRA-225GP
CRA-225M
10.4
8.9
9.1
8.0
7.3
7.0
6.9
7.0
7.4
6.3
6.0
5.5
5.1
ND
0.4
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
8/17/19
8/24/19
8/31/19
9/7/19
9/14/19
9/21/19
9/28/19

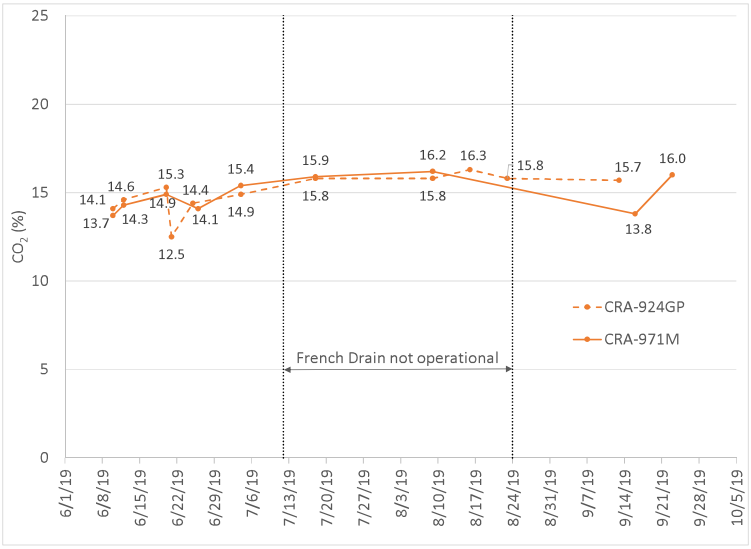

25
20
15
10
5
0
CH_4 (%)
CRA-225GP
CRA-225M
8.4
6.4
5.7
5.4
4.1
6.1
4.0
2.0
0.45
5.2
3.7
2.6
2.6
0.004
0.350
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
8/17/19
8/24/19
8/31/19
9/7/19
9/14/19
9/21/19
9/28/19

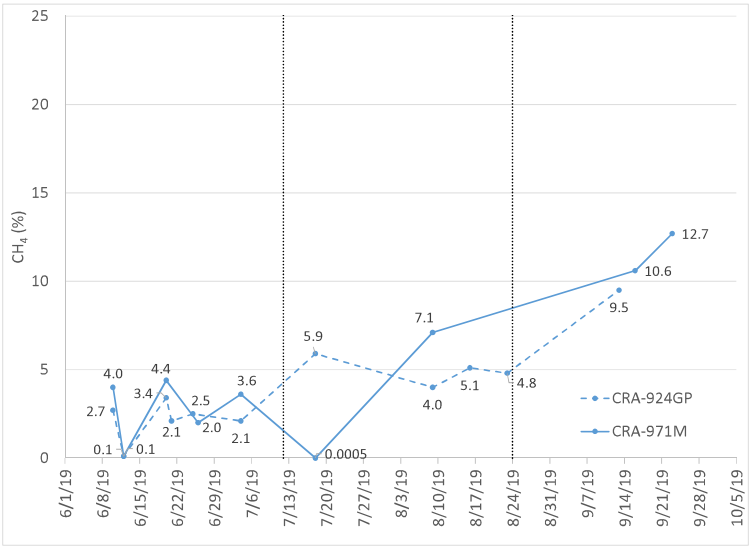

25
20
15
10
5
0
O_2 (%)
CRA-225GP
CRA-225M
20.2
1.2
0.1
0.4
ND
0.2
ND
0.7
ND
0.3
ND
ND
ND
ND
0.2
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
8/17/19
8/24/19
8/31/19
9/7/19
9/14/19
9/21/19
9/28/19

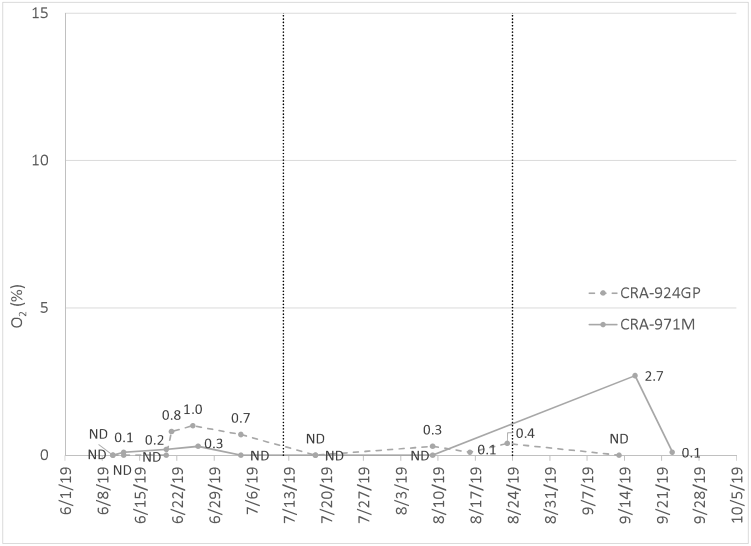

25
20
15
10
5
0
CO_2 (%)
20.8
20.8
20.8
22.4
20.5
20.4
20.4
18.2
19.7
19.8
19.4
18.2
12.2
12.8
13.1
13.5
13.7
13.5
11.9
12.3
12.2
French Drain not operational
CRA-914GP
CRA-972M
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
8/17/19
8/24/19
8/31/19
9/7/19
9/14/19
9/21/19
9/28/19
10/5/19

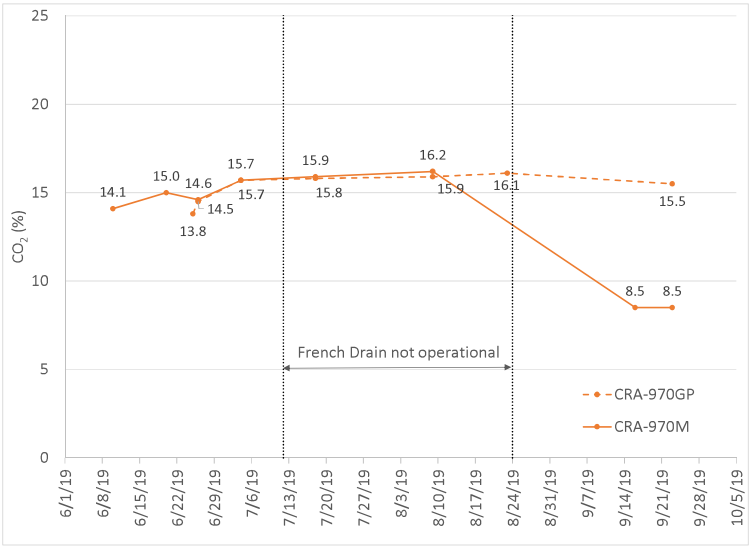

4
3
2
1
0
CH_4 (%)
CRA-914GP
CRA-972M
0.10
0.1
0.05
0.03
0.05
0.07
0.03
0.45
0.07
0.15
0.14
0.08
ND
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
8/17/19
8/24/19
8/31/19
9/7/19
9/14/19
9/21/19
9/28/19
10/5/19

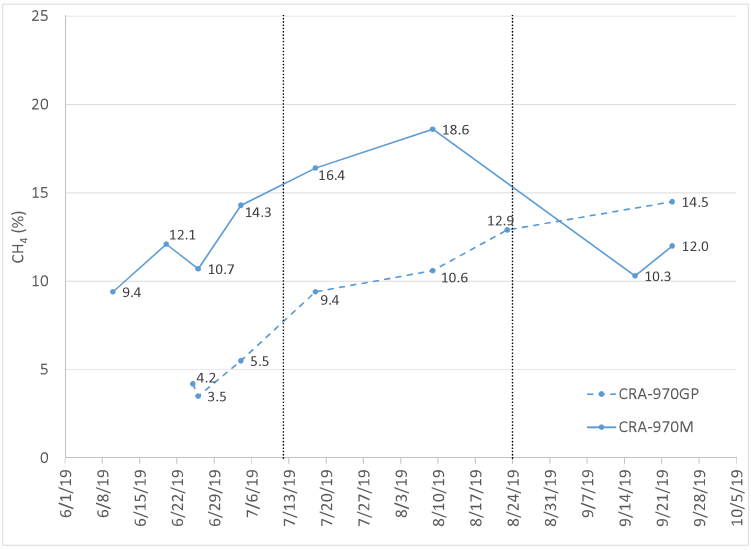

4
3
2
1
0
O_2 (%)
CRA-914GP
CRA-972M
0.6
0.5
0.3
0.4
0.3
0.1
0.1
ND
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
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9/7/19
9/14/19
9/21/19
9/28/19
10/5/19

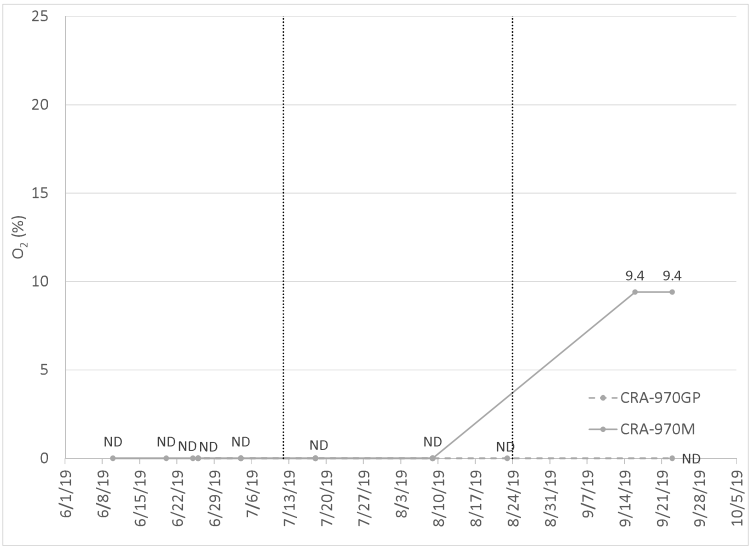

25
20
15
10
5
0
CO_2 (%)
14.1
14.6
15.3
14.4
15.4
15.9
16.2
16.3
15.8
15.7
16.0
13.7
14.3
14.9
14.1
14.9
15.8
15.8
13.8
12.5
CRA-924GP
CRA-971M
French Drain not operational
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
8/17/19
8/24/19
8/31/19
9/7/19
9/14/19
9/21/19
9/28/19
10/5/19

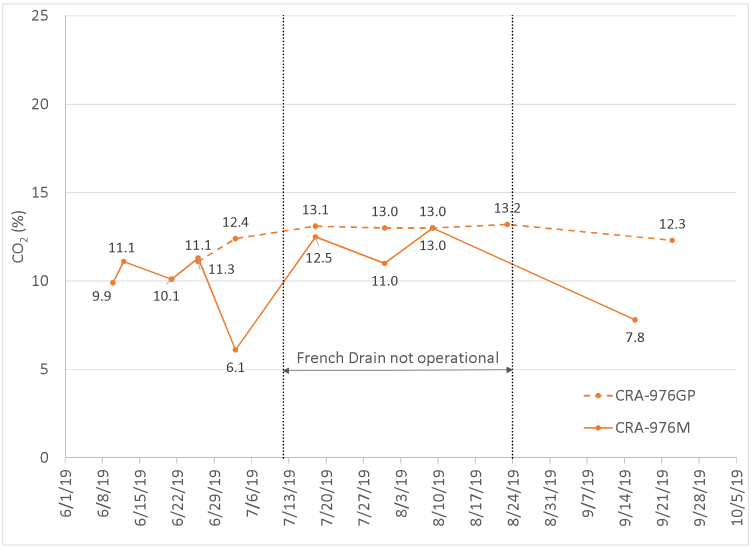

25
20
15
10
5
0
CH_4 (%)
4.0
2.7
0.1
0.1
4.4
3.4
2.1
2.5
2.0
3.6
2.1
5.9
0.0005
7.1
4.0
5.1
4.8
9.5
10.6
12.7
CRA-924GP
CRA-971M
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
8/17/19
8/24/19
8/31/19
9/7/19
9/14/19
9/21/19
9/28/19
10/5/19

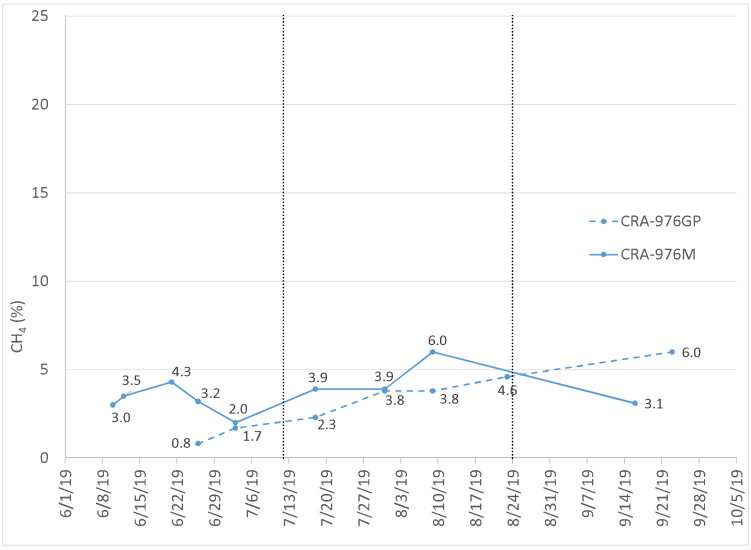

15
10
5
0
O_2 (%)
ND
ND
0.1
ND
0.8
1.0
0.2
ND
0.7
0.3
ND
ND
ND
ND
0.3
ND
0.1
0.4
ND
2.7
0.1
CRA-924GP
CRA-971M
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
8/17/19
8/24/19
8/31/19
9/7/19
9/14/19
9/21/19
9/28/19
10/5/19

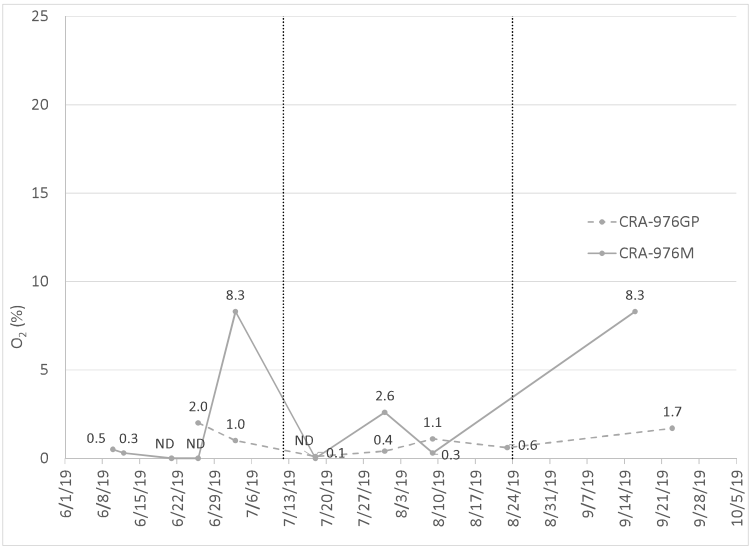

25
20
15
10
5
0
CO_2 (%)
14.1
15.0
14.6
14.5
13.8
15.7
15.7
15.9
15.8
16.2
15.9
16.1
15.5
8.5
8.5
French Drain not operational
CRA-970GP
CRA-970M
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
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9/21/19
9/28/19
10/5/19

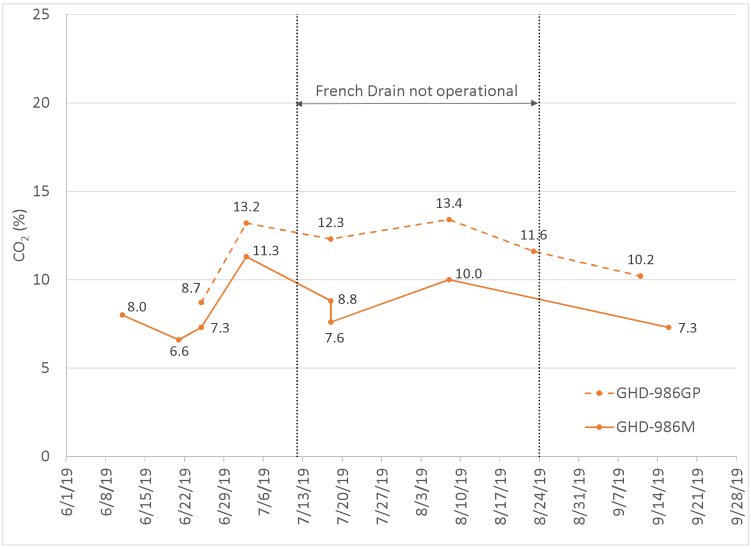

25
20
15
10
5
0
CH_4 (%)
9.4
12.1
10.7
14.3
16.4
18.6
10.3
12.0
14.5
4.2
3.5
5.5
9.4
10.6
12.9
CRA-970GP
CRA-970M
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
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9/21/19
9/28/19
10/5/19

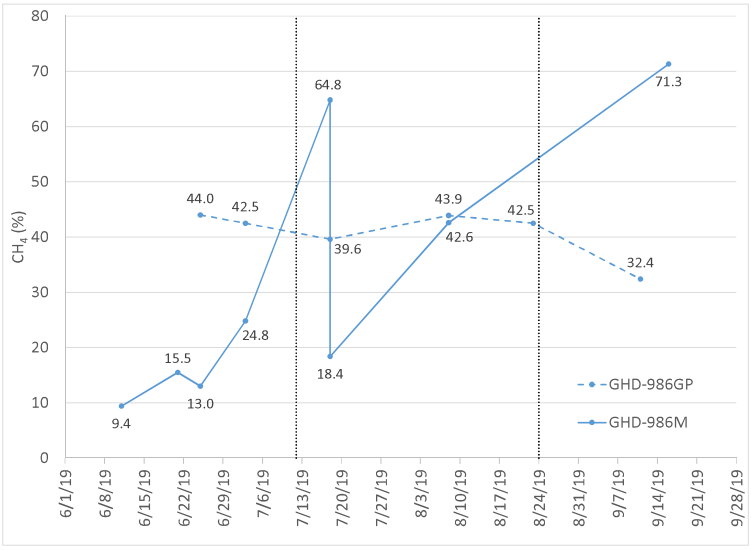

25
20
15
10
5
0
O_2 (%)
ND
ND
ND
ND
ND
ND
ND
ND
ND
9.4
9.4
ND
CRA-970GP
CRA-970M
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
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9/14/19
9/21/19
9/28/19
10/5/19

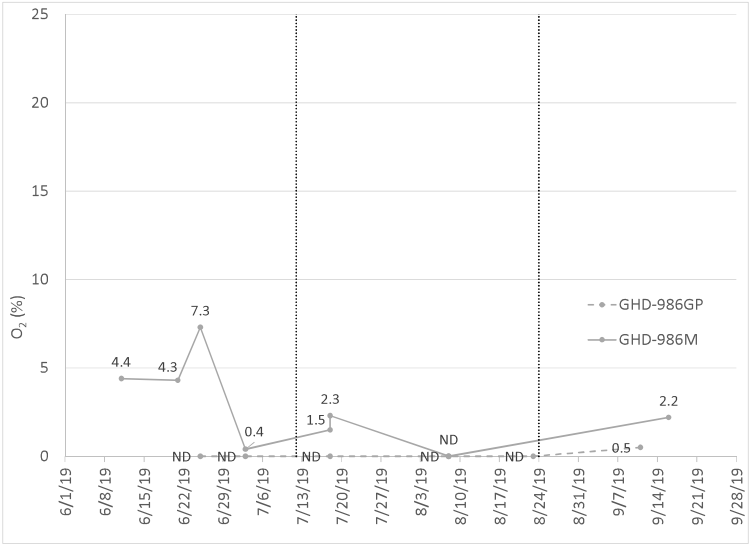

25
20
15
10
5
0
CO_2 (%)
9.9
11.1
10.1
11.1
11.3
12.4
6.1
13.1
12.5
13.0
11.0
13.0
13.0
13.2
12.3
7.8
French Drain not operational
CRA-976GP
CRA-976M
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
8/17/19
8/24/19
8/31/19
9/7/19
9/14/19
9/21/19
9/28/19
10/5/19


25
20
15
10
5
0
CH_4 (%)
3.0
3.5
4.3
3.2
2.0
1.7
0.8
2.3
3.9
3.8
3.9
3.8
6.0
4.6
3.1
6.0
CRA-976GP
CRA-976M
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
8/17/19
8/24/19
8/31/19
9/7/19
9/14/19
9/21/19
9/28/19
10/5/19

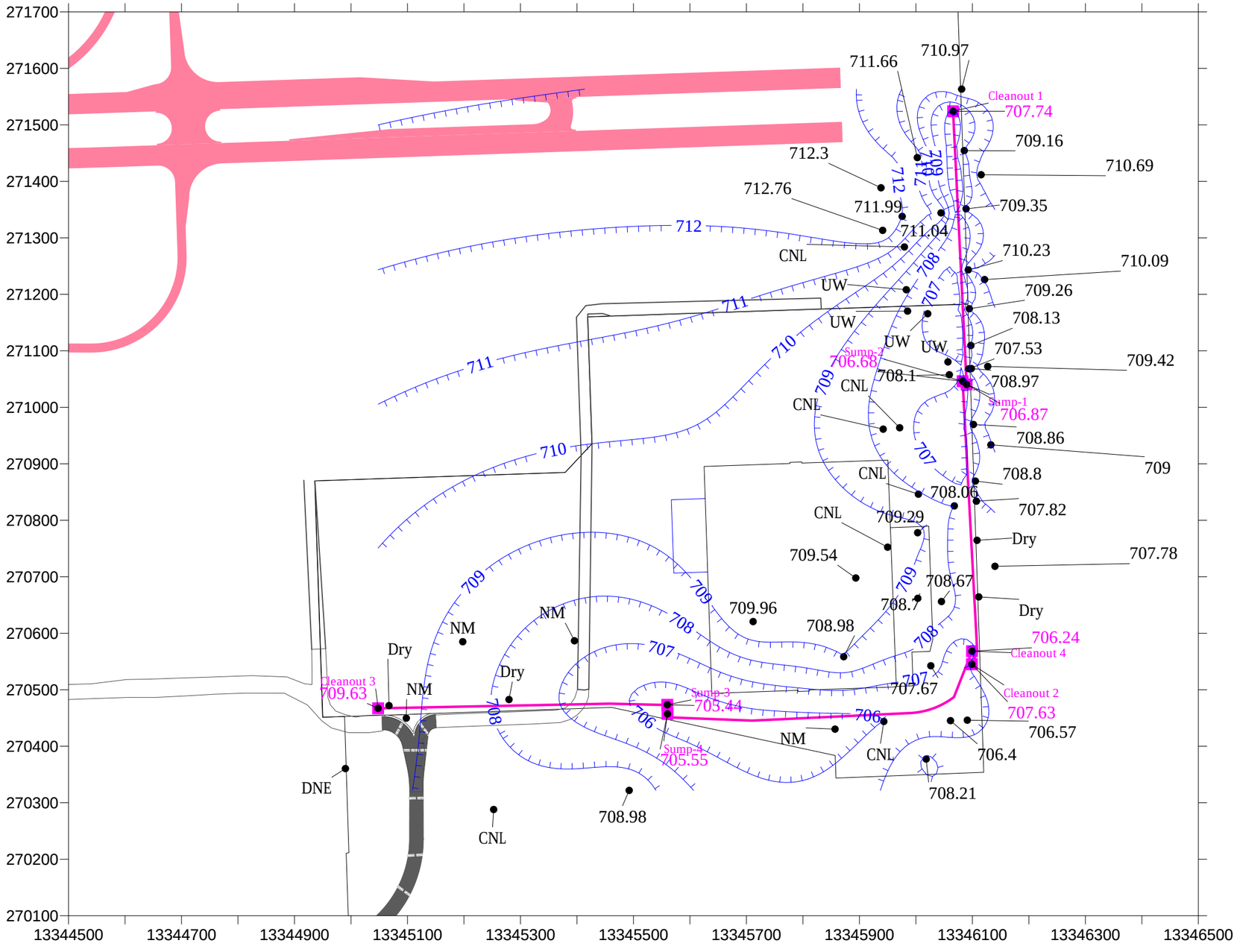

25
20
15
10
5
0
O_2 (%)
0.5
0.3
ND
ND
2.0
8.3
1.0
ND
0.1
0.4
2.6
1.1
0.3
0.6
8.3
1.7
CRA-976GP
CRA-976M
6/1/19
6/8/19
6/15/19
6/22/19
6/29/19
7/6/19
7/13/19
7/20/19
7/27/19
8/3/19
8/10/19
8/17/19
8/24/19
8/31/19
9/7/19
9/14/19
9/21/19
9/28/19
10/5/19


French Drain not operational
CO_2 (%)
GHD-986GP
GHD-986M
8.0
6.6
7.3
8.7
13.2
11.3
8.8
7.6
12.3
13.4
10.0
11.6
10.2
7.3


CH_4 (%)
GHD-986GP
GHD-986M
9.4
15.5
13.0
24.8
44.0
42.5
64.8
39.6
18.4
43.9
42.6
42.5
32.4
71.3


O_2 (%)
GHD-986GP
GHD-986M
4.4
4.3
7.3
0.4
ND
ND
ND
1.5
2.3
ND
ND
ND
0.5
2.2

Appendix E
Groundwater Elevation Contour Plots



0 100 200ft

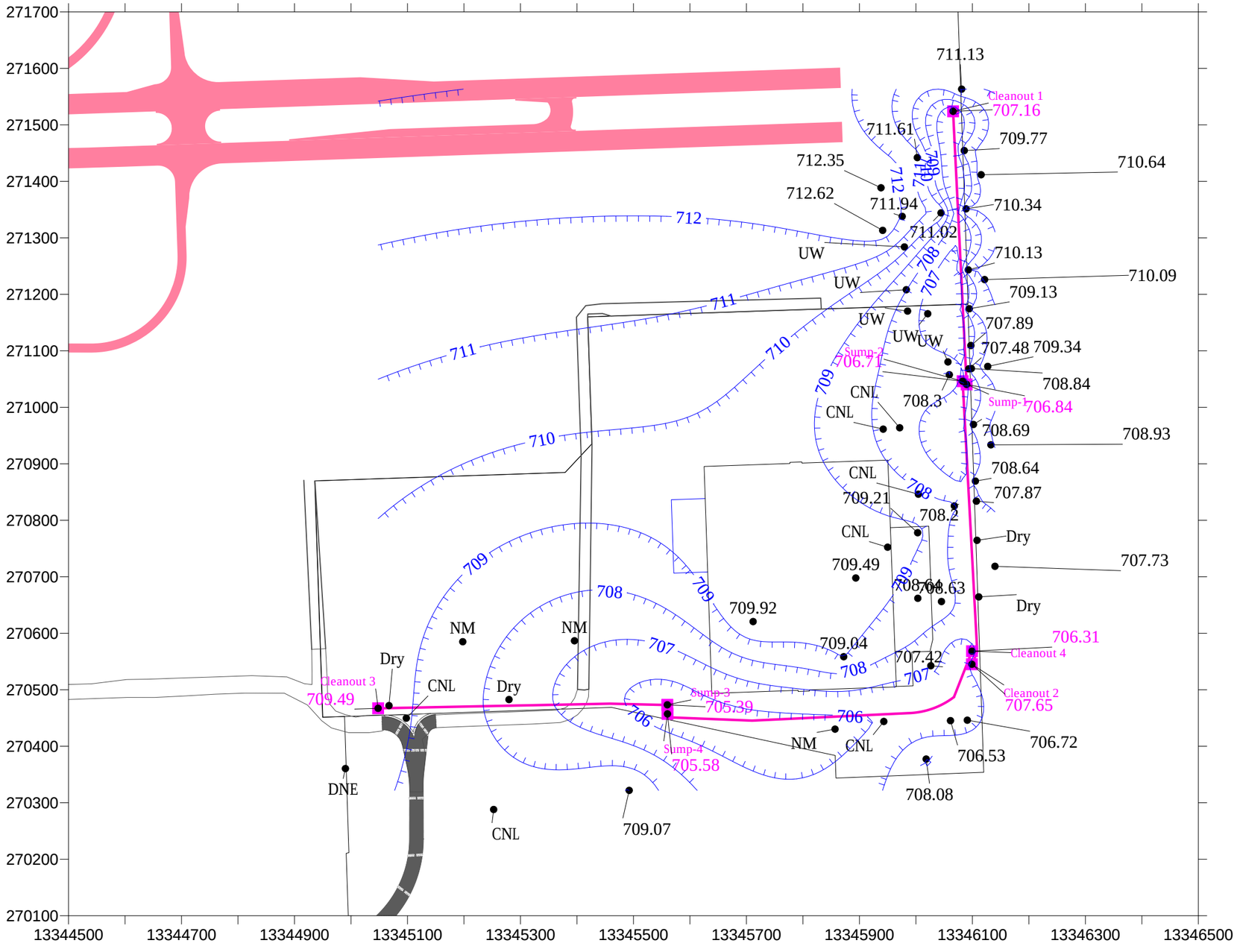
RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

SHALLOW GROUNDWATER FLOW

017358
June 25, 2019

Levels collected 6/7/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

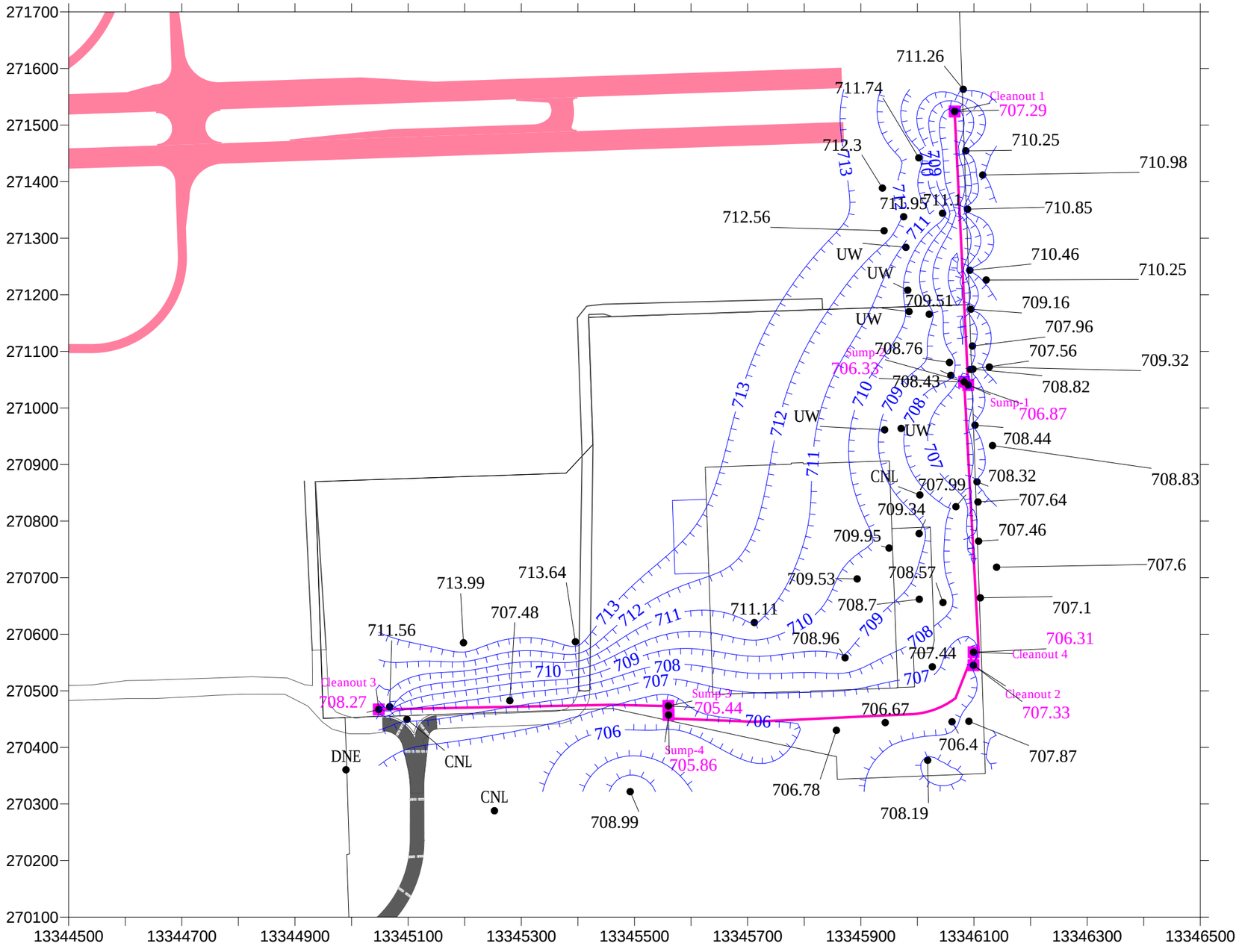
RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

SHALLOW GROUNDWATER FLOW

017358
June 25, 2019

Levels collected 6/14/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

GHD

RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

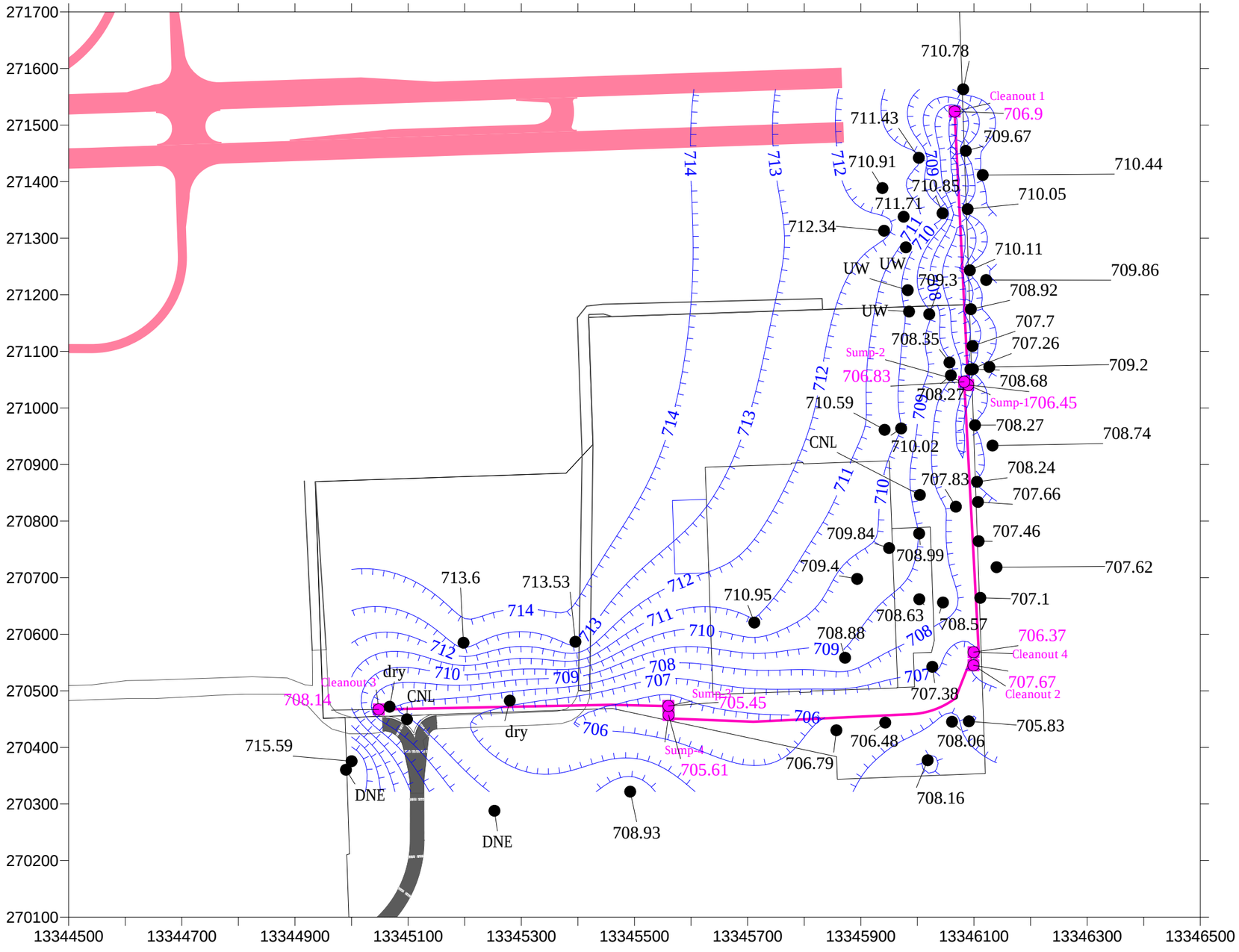
017358

June 25, 2019

SHALLOW GROUNDWATER FLOW

Levels collected 6/20/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

GHD

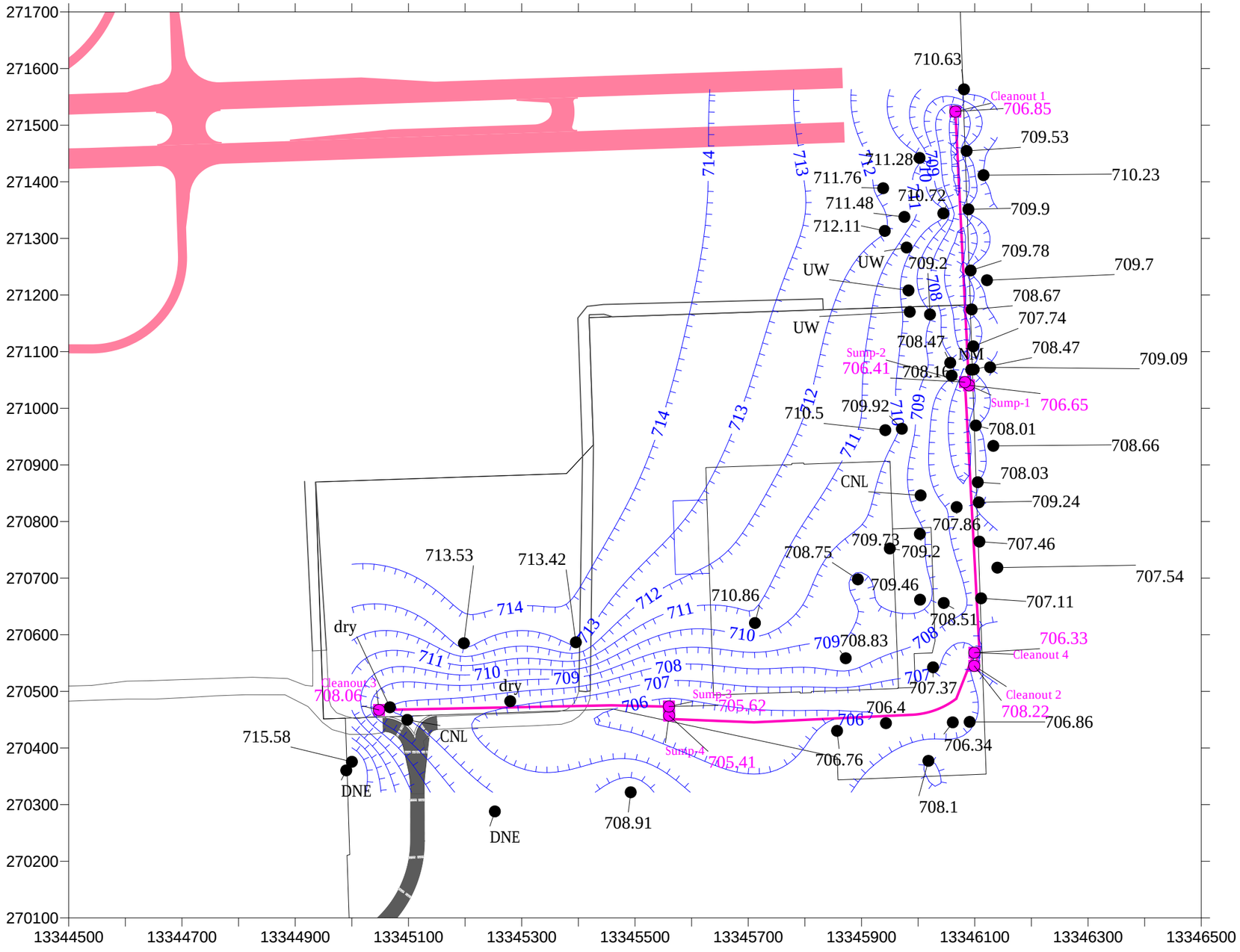
RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

SHALLOW GROUNDWATER FLOW

017358
July 11, 2019

Levels collected 6/28/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

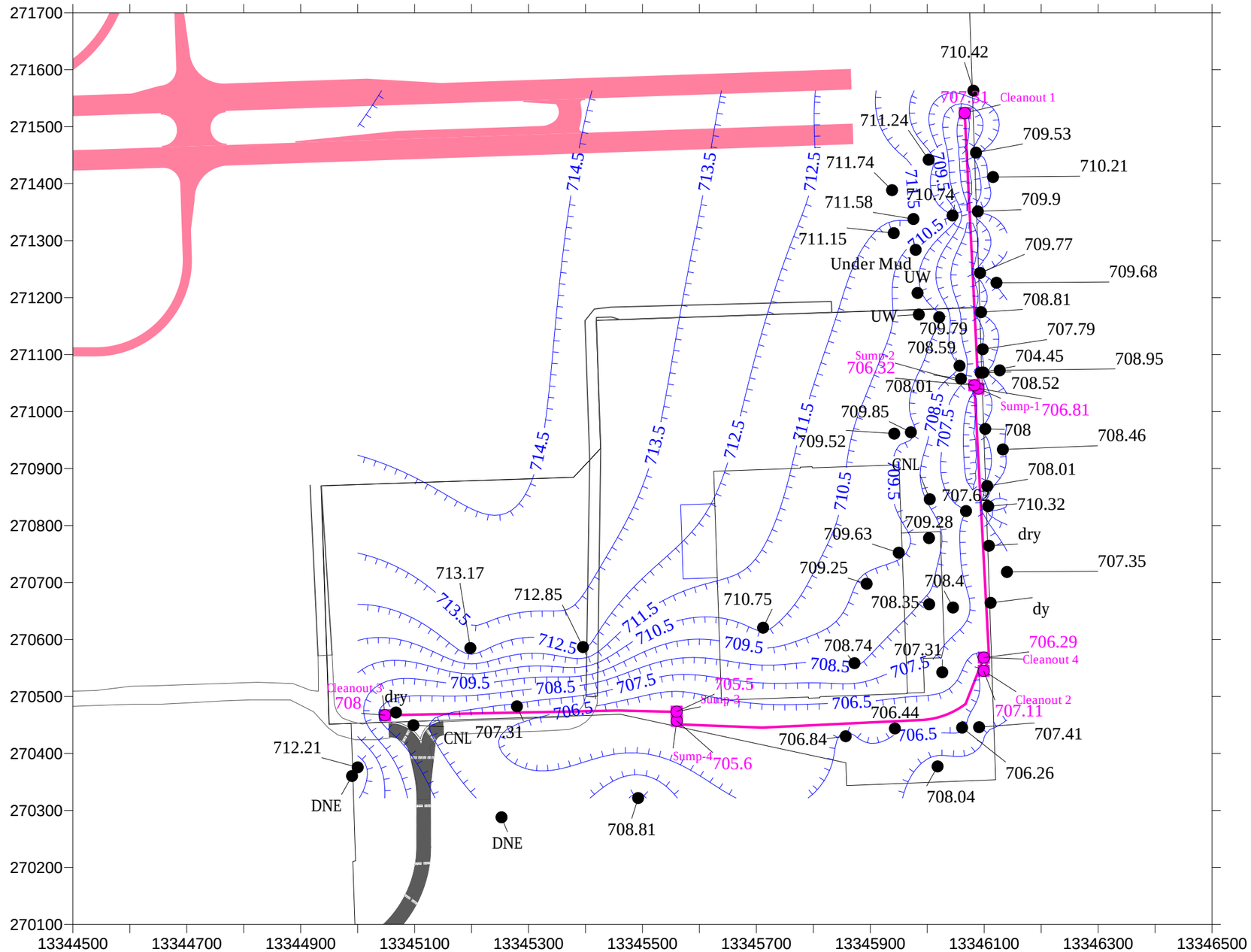
RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

SHALLOW GROUNDWATER FLOW

017358
July 11, 2019

Levels collected 7/4/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

N

GHD

RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

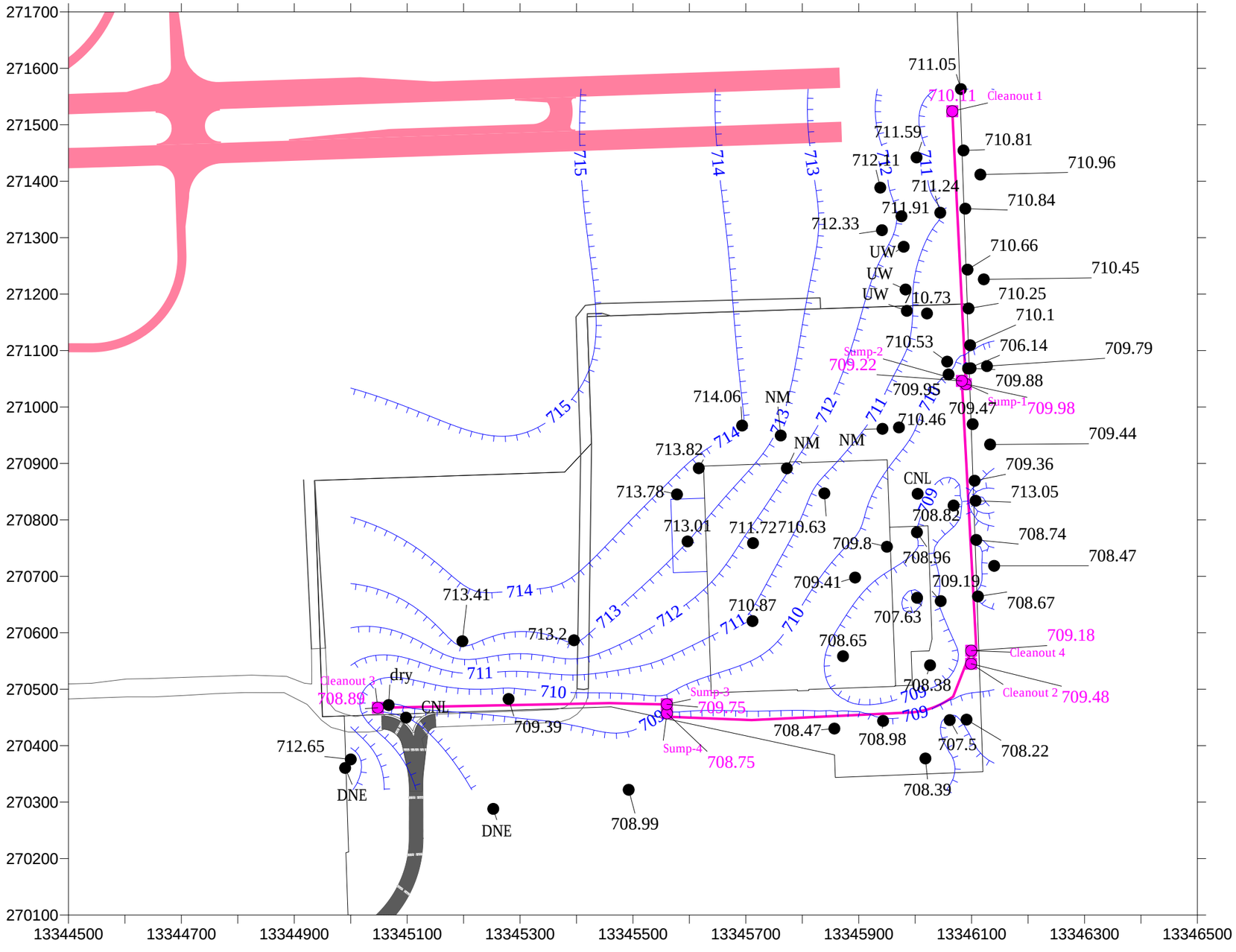
SHALLOW GROUNDWATER FLOW

017358

July 23, 2019

Levels collected 7/11/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

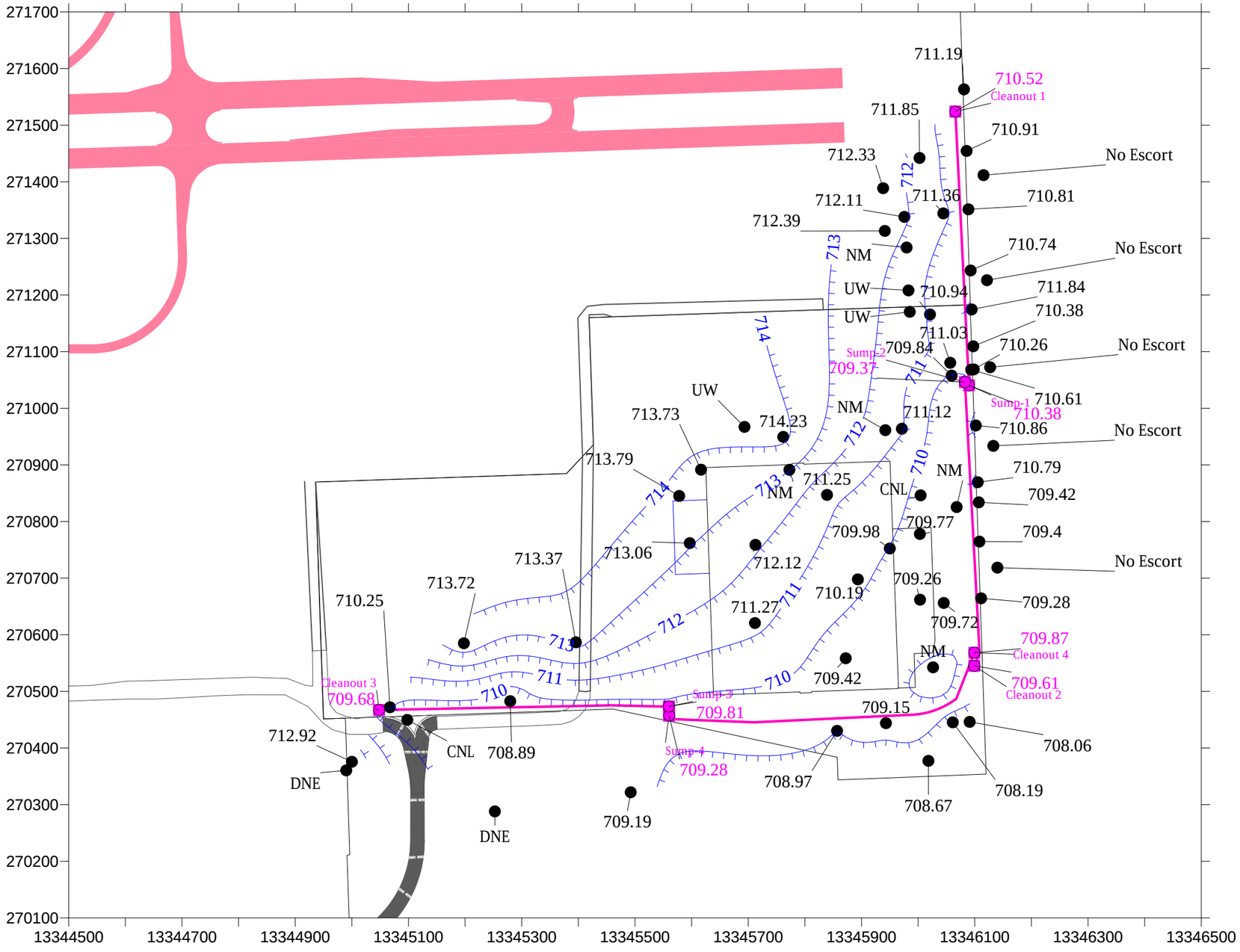
SHALLOW GROUNDWATER FLOW

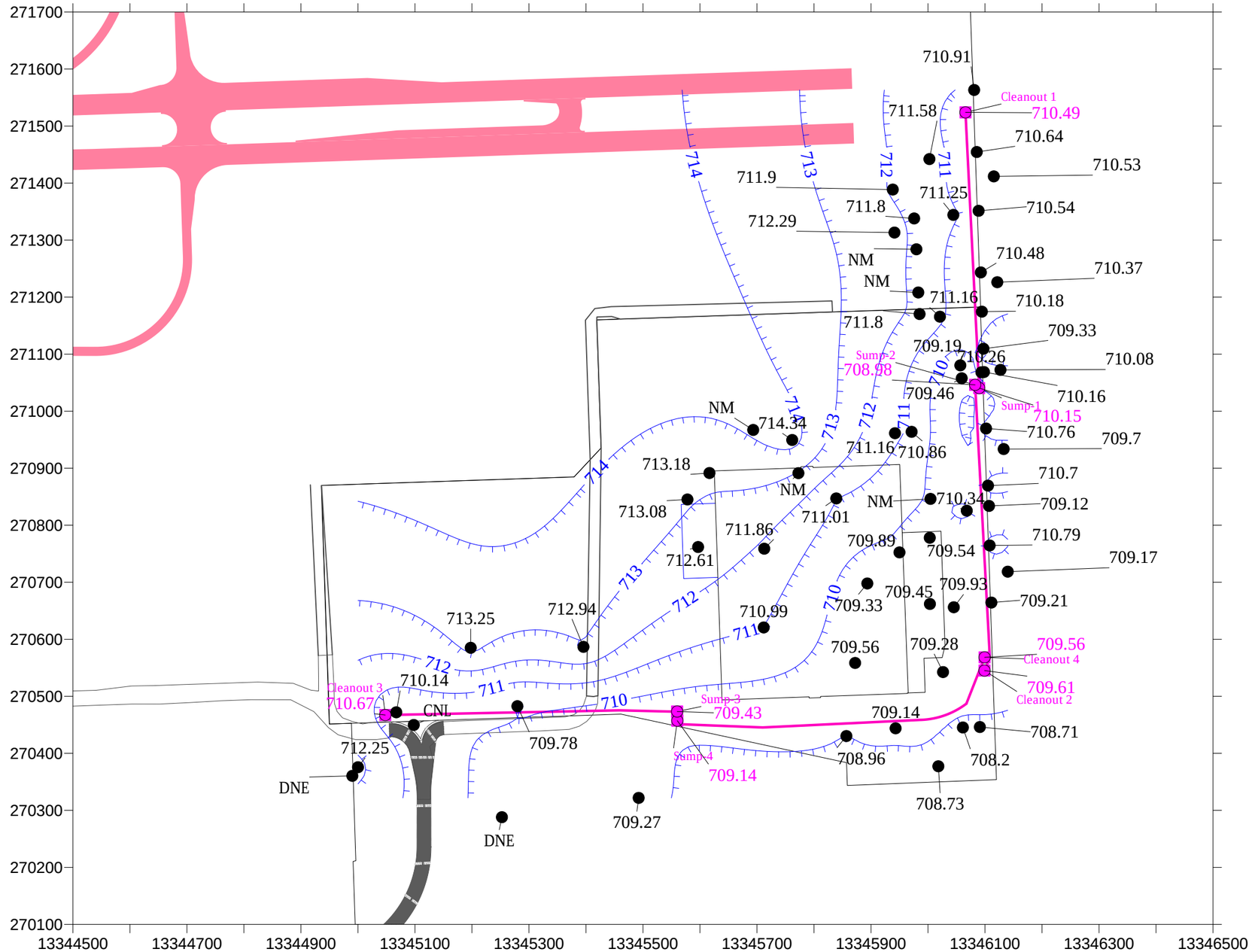
017358

November 19, 2019

Levels collected 7/19/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf


271700
271600
271500
271400
271300
271200
271100
271000
270900
270800
270700
270600
270500
270400
270300
270200
270100
13344500
13344700
13344900
13345100
13345300
13345500
13345700
13345900
13346100
13346300
13346500
711.19
710.52
Cleanout 1
711.85
710.91
712.33
No Escort
712'
711.36
710.81
712.11
712.39
713
NM
710.74
No Escort
UW
710.94
711.84
UW
710.38
711.03
714
709.84
710.26
No Escort
Sump 2
709.37
711
710.61
Sump-1
710.38
UW
713.73
714.23
NM
711.12
712
710.86
No Escort
713.79
710
710.79
NM
711.25
713
NM
CNL
709.42
714
709.77
709.98
709.4
713.37
713.06
712.12
No Escort
713.72
710.19
709.26
710.25
711.27
711
712
709.28
709.72
713
709.87
Cleanout 4
NM
711
710
709.42
709.61
Cleanout 2
Cleanout 3
709.68
710
Sump 3
709.81
709.15
712.92
CNL
708.89
708.06
Sump 4
709.28
708.97
708.19
DNE
708.67
DNE
709.19
0
100
200ft
GHD
RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION
SHALLOW GROUNDWATER FLOW
017358
November 19, 2019
Levels collected 7/25/2019
HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

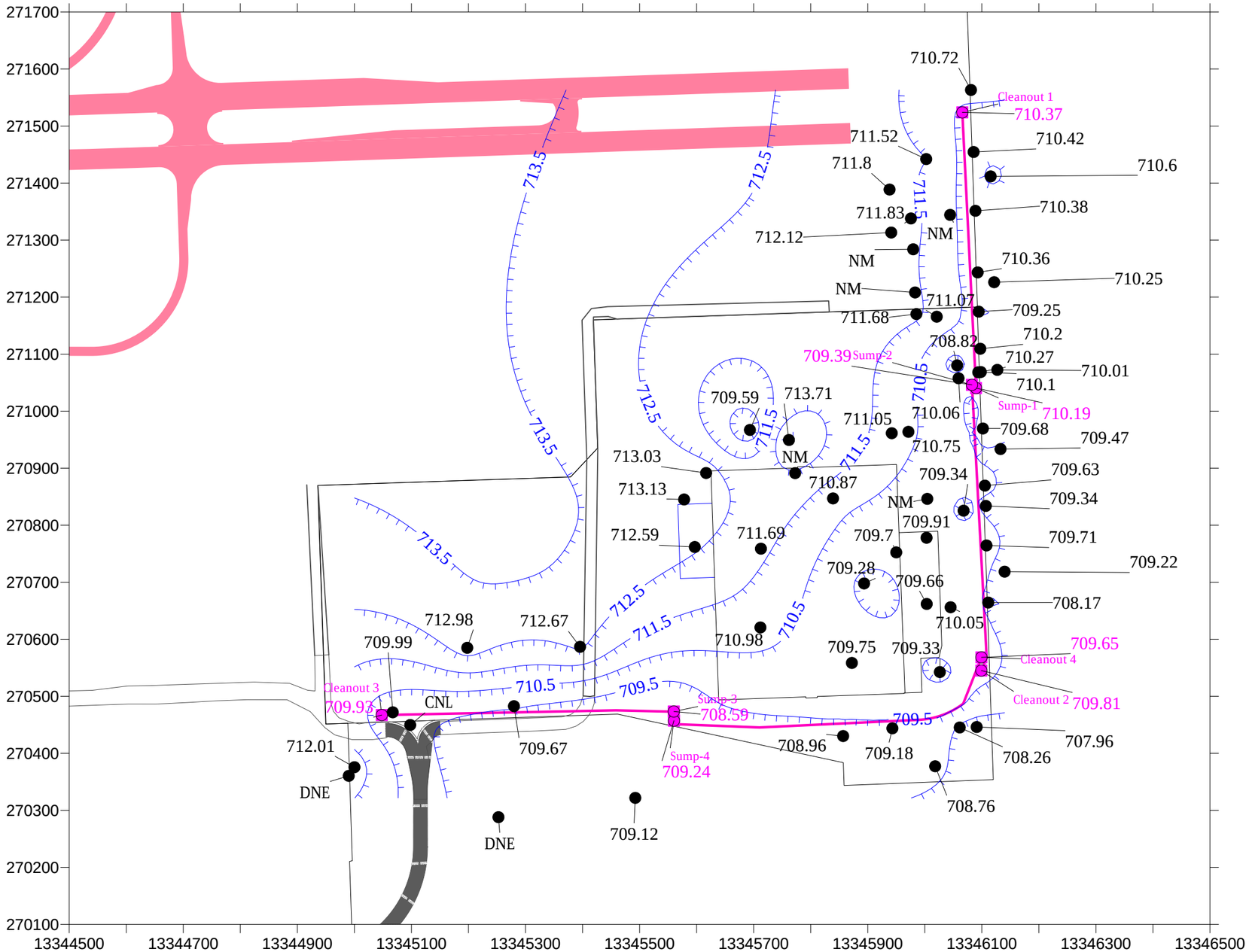
SHALLOW GROUNDWATER FLOW

017358

August 06, 2019

Levels collected 8/2/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

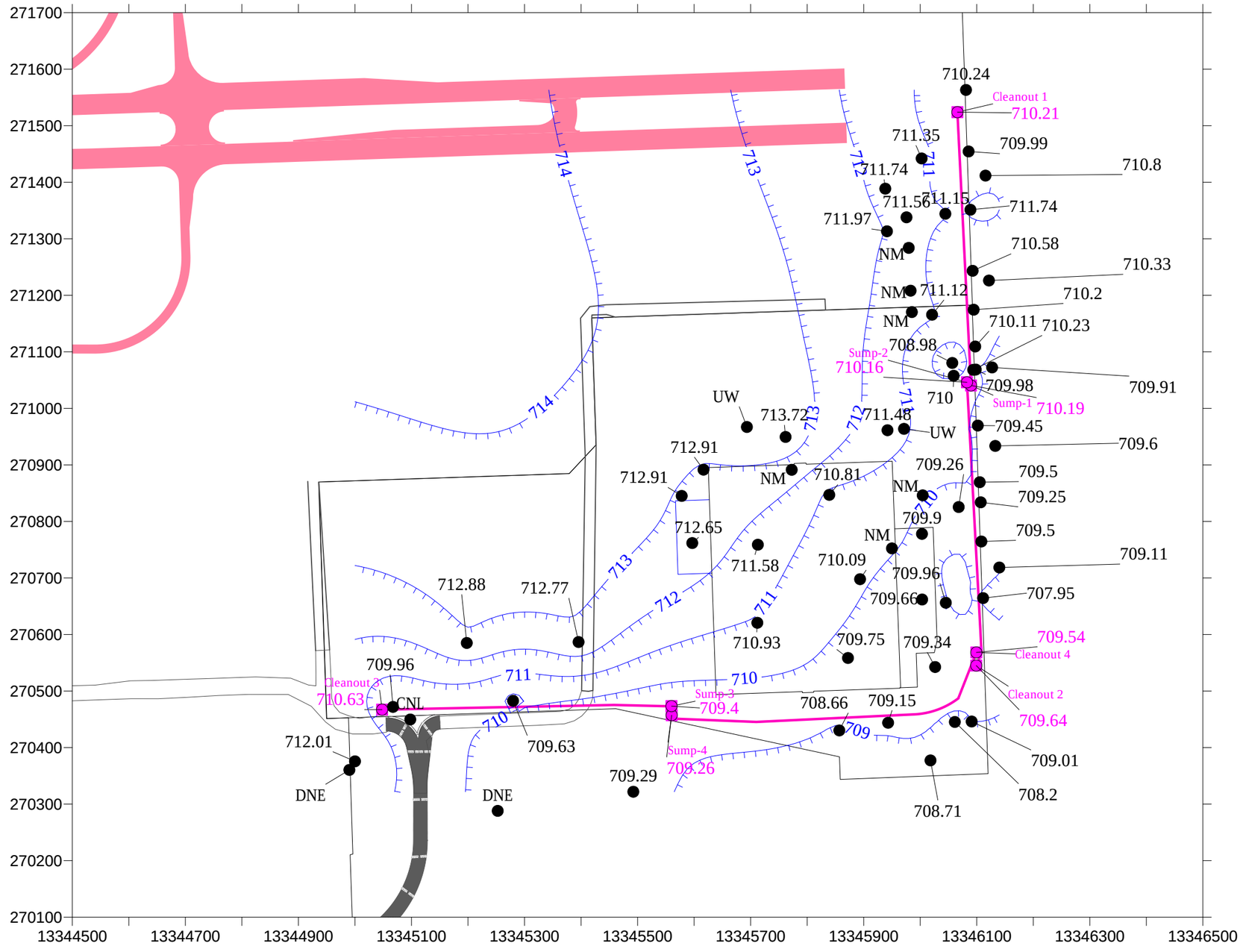
SHALLOW GROUNDWATER FLOW

017358

August 21, 2019

Levels collected 8/8/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

GHD

RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

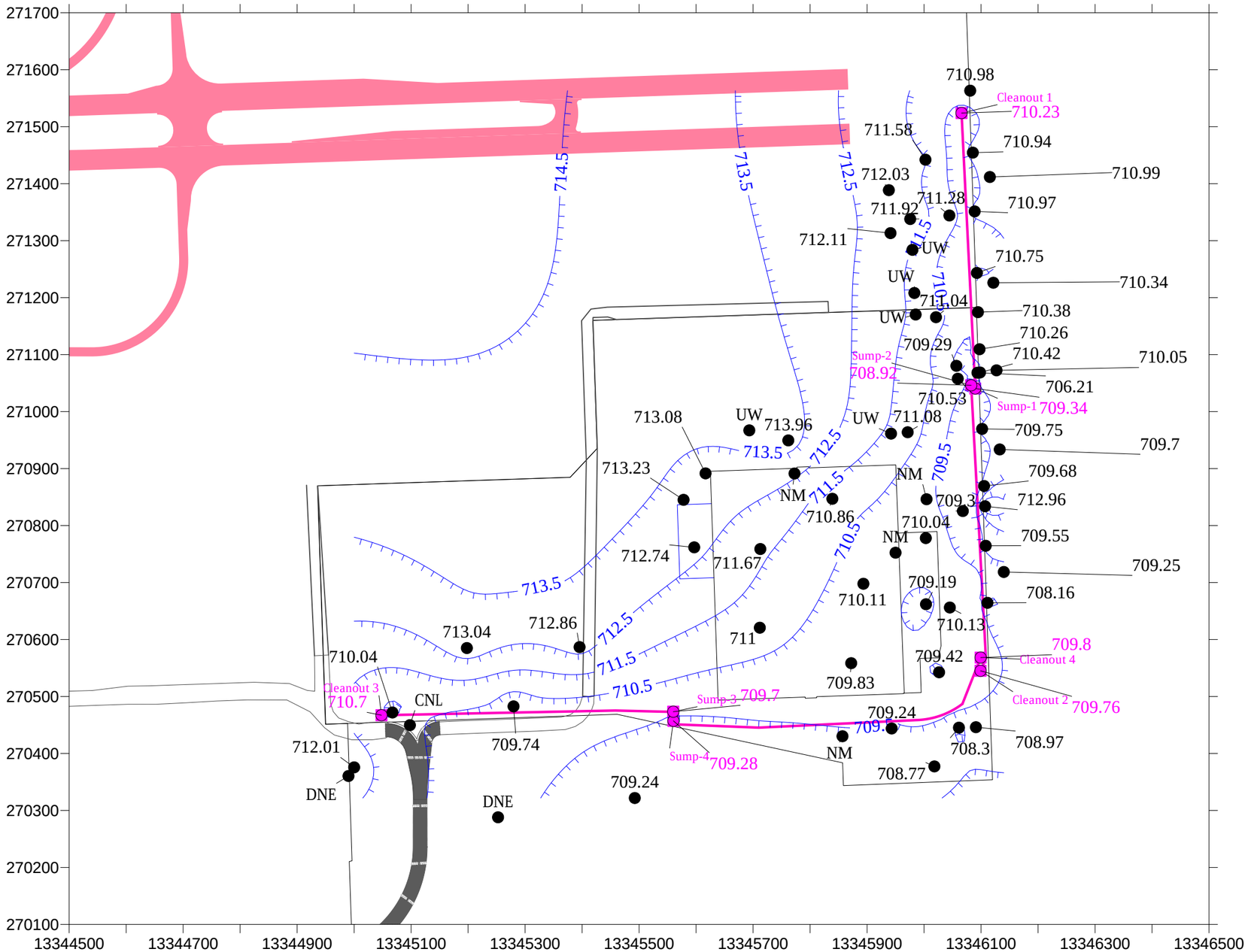
SHALLOW GROUNDWATER FLOW

017358

August 22, 2019

Levels collected 8/16/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

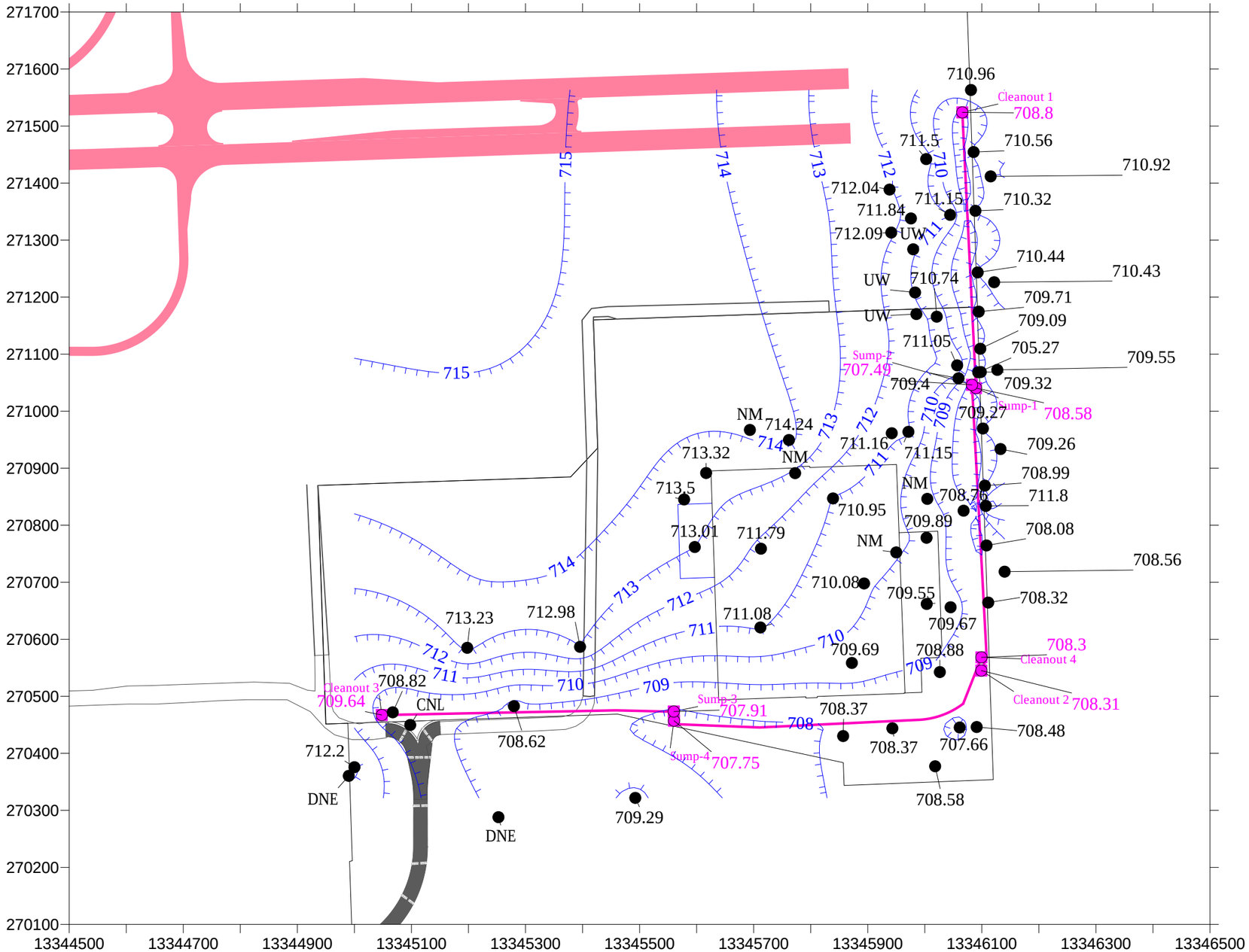
SHALLOW GROUNDWATER FLOW

017358

September 03, 2019

Levels collected 8/23/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

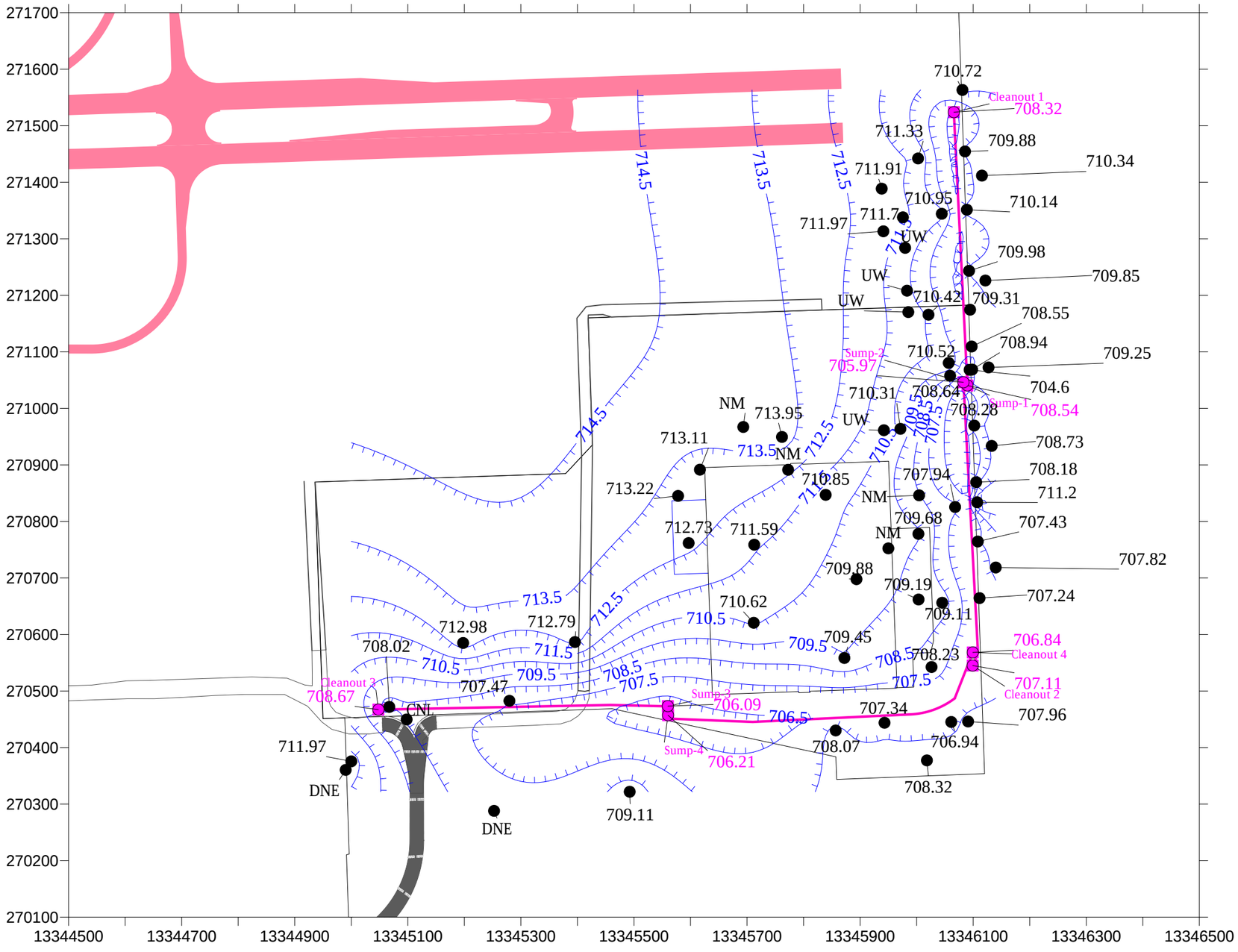
SHALLOW GROUNDWATER FLOW

017358

September 03, 2019

Levels collected 8/28/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

GHD

RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

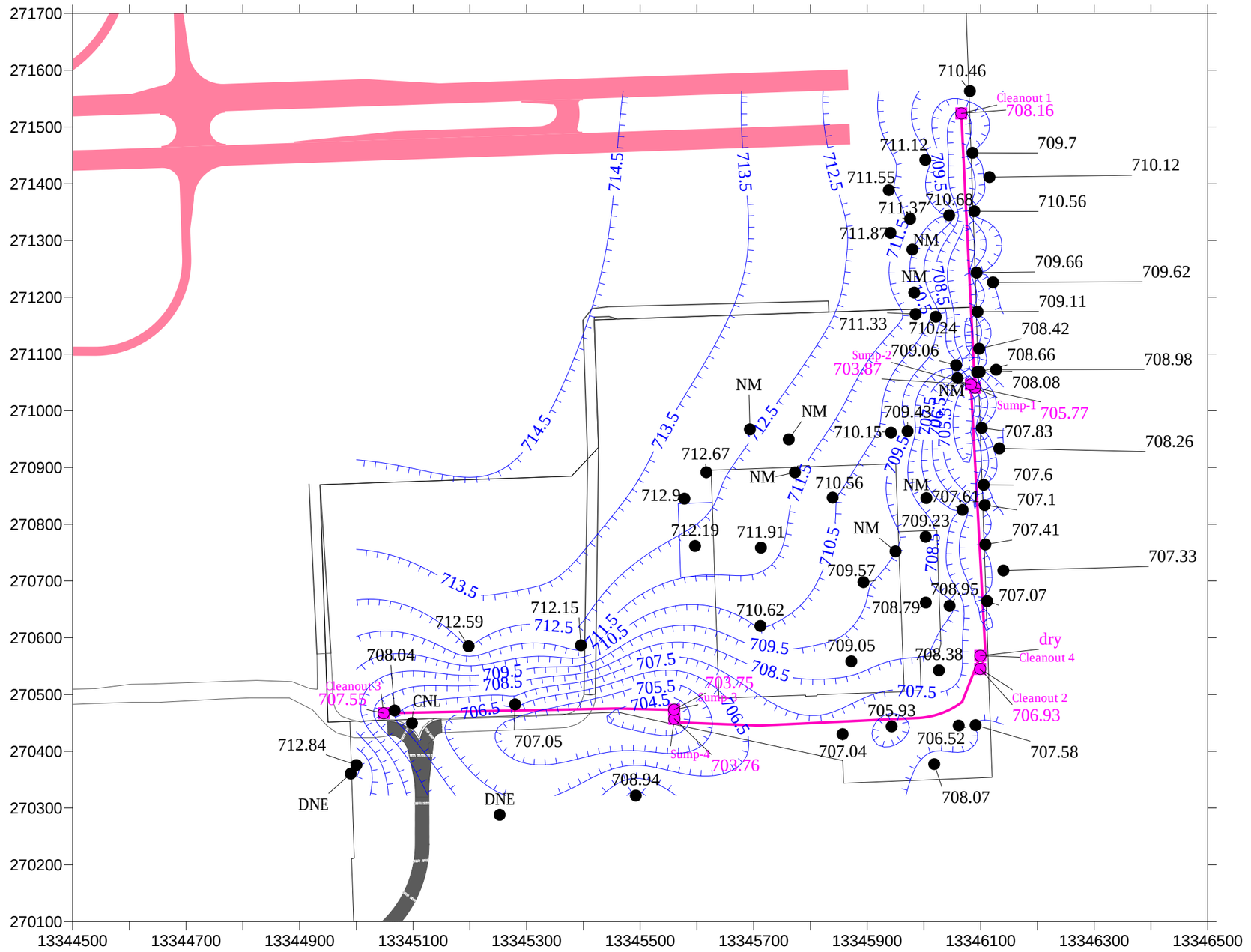
SHALLOW GROUNDWATER FLOW

017358

September 05, 2019

Levels collected 9/3/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

N

GHD

RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

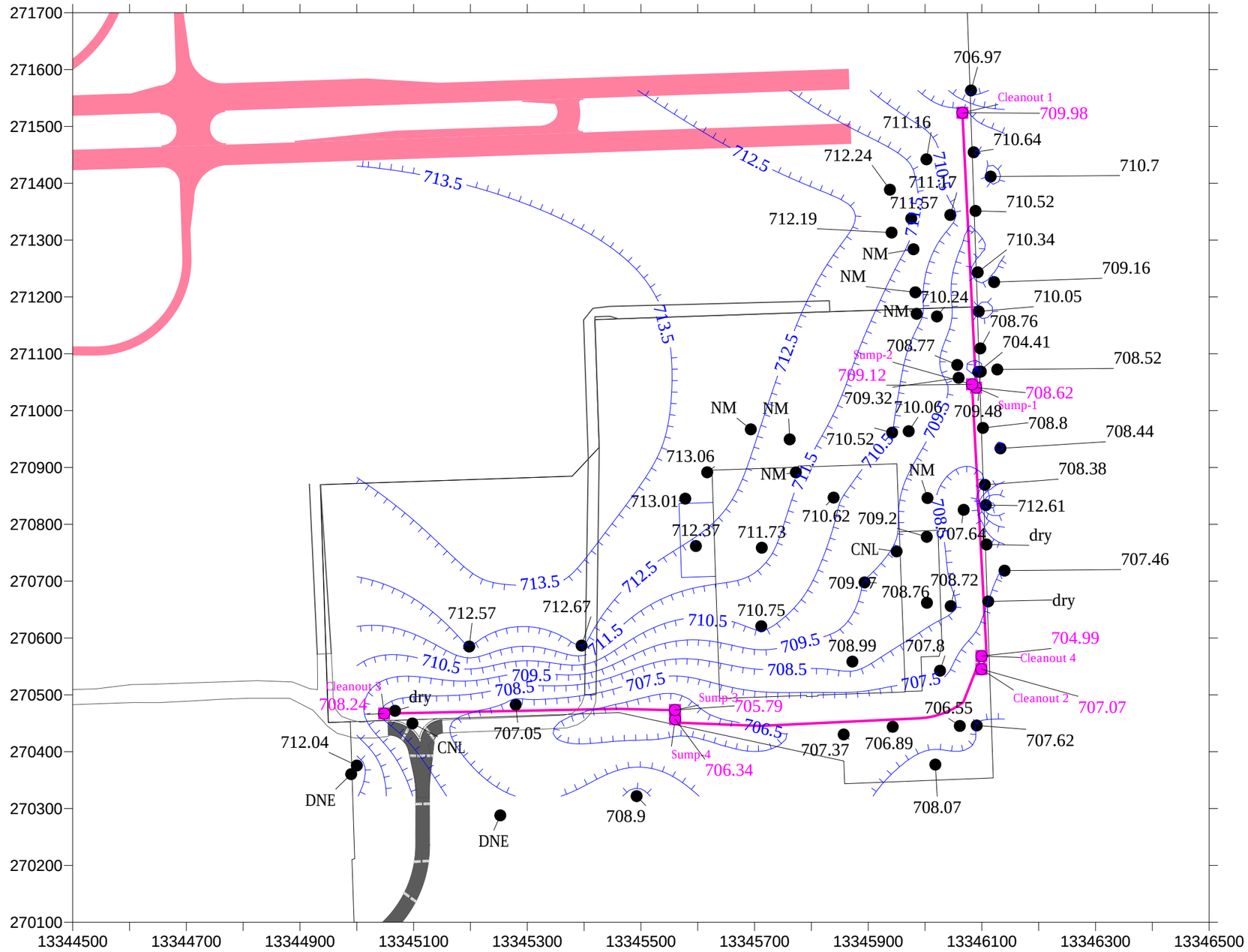
SHALLOW GROUNDWATER FLOW

017358

September 12, 2019

Levels collected 9/11/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

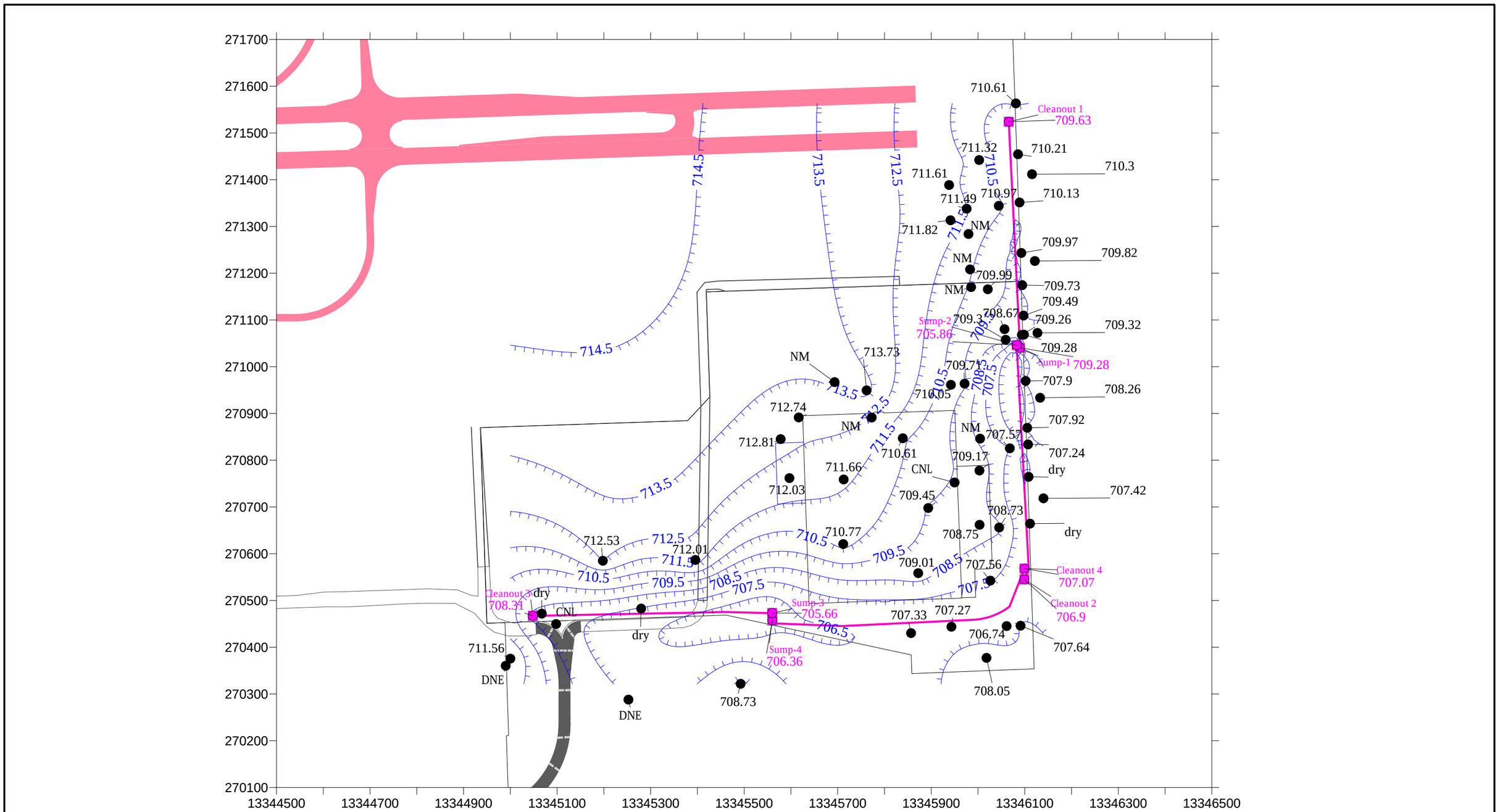
RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

SHALLOW GROUNDWATER FLOW

017358
November 19, 2019

Levels collected 9/17/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf



0 100 200ft

RACER_FORMER WILLOW RUN POWERTRAIN SITE
YPSILANTI, MICHIGAN
FRENCH DRAIN EVALUATION

SHALLOW GROUNDWATER FLOW

017358

November 19, 2019

Levels collected 9/26/2019

HEG file: H:\Software\Surfer.700\Bases\8½ × 11 (portrait) Base - Imperial.srf

Appendix F
CO_2 Trap Laboratory Results

Confidential Report
CO_2 Flux and NSZD Rate Results

MATT ROUSSEAU/MARISSA LABBÉ
GHD
PROJECT: YPSILANTI, MI
SAMPLING DATES:
7/8/2019-7/12/2019

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Report Date: 8/7/2019
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The purpose of this document is to provide sample calculations for the reported results and to explain the method for differentiating petroleum hydrocarbon-derived CO_2 from that produced from natural soil respiration processes. The value of the ^{14}C analysis, site-specific study results and applicable notes, calculation explanations, and references are included.

The Value of the ^{14}C Analysis

How to differentiate between petroleum hydrocarbon-derived CO_2 and natural process-derived CO_2 using CO_2 flux traps:

Unimpacted soils naturally produce CO_2 due to microbial root zone activity and/or the degradation of natural organic matter. Thus, the total measured CO_2 flux at an impacted location is a function of the rates of both natural soil respiration and LNAPL degradation (Sihota and Mayer, 2012). The latter, which is caused by Natural Source Zone Depletion (NSZD), can be estimated by subtracting measured CO_2 fluxes at unimpacted locations from the total measured CO_2 fluxes at LNAPL-impacted locations (Sihota and Mayer, 2012). This spatial "background correction" assumes that bio-based CO_2 fluxes are similar at both impacted and unimpacted locations. This approach is complicated to implement, given that at many industrial facilities it is difficult to find unimpacted areas and vegetation cover can vary across a site. Alternatively, carbon isotope analysis can be used to carry out a location-specific correction for total measured CO_2 fluxes, and this approach effectively overcomes the limitations of the background correction.

Theory of Carbon Isotope Analysis:

Our method for NSZD rate estimation relies on the analysis of ^{14}C, an unstable carbon isotope with an absolute half-life of 5,730 years. ^{14}C is generated by cosmic rays in the atmosphere and is quickly oxidized to $^{14}CO_2$; thus, bio-based living carbon is ^{14}C-rich, while ancient fossil fuel carbon is completely ^{14}C-depleted. Additionally, bio-based organic carbon and the atmosphere have the same characteristic amount of ^{14}C. The short half-life of ^{14}C only allows for dating of samples younger than 60,000 years using accelerator mass spectrometry (Stuiver and Polach, 1977). ^{14}C analysis can therefore be used to differentiate between anthropogenic (i.e., fossil fuel) and natural sources of atmospheric carbon (see Klouda and Connolly, 1995; Levin et al., 1995; Avery et al., 2006), and this analysis is the basis for ASTM D6866-18.

For samples that contain both bio-based and fossil fuel-derived carbon, such as E-Flux's fossil fuel traps, measurement of ^{14}C enables quantitation of *both* source contributions. The fossil fuel-derived percentage of the sample (ff_{sample}) and the bio-based percentage ($1\text{-}ff_{sample}$, or bb_{sample}) are related by the following two-component mass balance (modified from Avery, Jr. et al., 2006):

$$Fm_{sample} = \left(ff_{sample}\right)\left(Fm_{ff}\right) + \left(1 - ff_{sample}\right)\left(Fm_{atm}\right)$$

Here, Fm_x represents the fraction modern, a measure of how close the present $^{14}C/^{12}C$ ratio of the sample is to the ratio from 1950, which is derived from a pre-industrial era standard. Fm_{sample} is the total measured fraction modern of the sample. Fm_{ff} is the fraction modern of only the fossil fuel portion of the sample. This number is 0, as there is no ^{14}C in fossil fuel-derived CO_2. Fm_{atm} is the fraction modern of the part of the sample derived from natural soil respiration processes. This value, currently equal to **1.02** (Cerling et al., 2016, Larsen et al., 2018), has been experimentally determined and is a fixed value at each point in time. By convention, the results of carbon isotope analysis are reported based on a 1950 NBS oxalic acid standard, and so Fm_{sample} is reported as if the analysis took place in 1950. Due to nuclear testing, current ^{14}C atmospheric levels are now higher than they were in 1950. This means that Fm_{atm} is counter-intuitively larger than 1, as the $^{14}C/^{12}C$ sample ratio is higher now than it would have been in 1950.

^{14}C Calculations:

Conversion of Fraction Modern Carbon to Fossil Fuel Carbon:

The equation for calculating the percentage of fossil fuel carbon (ff_{sample}) is derived from the following mass balance:

$$Fm_{sample} = (ff_{sample})(Fm_{ff}) + (1 - ff_{sample})(Fm_{atm})$$

Solving for ff_{sample} yields:

$$ff_{sample} = 1 - \frac{Fm_{sample}}{Fm_{atm}}$$

Fraction modern (Fm_{sample}, from ^{14}C analysis) is reported by convention based on ^{14}C levels from 1950. Because of atomic testing, current environmental ^{14}C levels are approximately 2% higher than they were in 1950 (Cerling et al., 2016, Larsen et al., 2018) and Fm_{atm} is equal to 1.02. This equation then becomes:

$$ff_{sample} = 1 - \frac{Fm_{sample}}{1.02}$$

As percentages must add to 1, the percentage of bio-based carbon (bb_{sample}) can then be calculated using the following equivalence:

$$bb_{sample} = 1 - ff_{sample} = 1 - \left(1 - \frac{Fm_{sample}}{1.02}\right) = \frac{Fm_{sample}}{1.02}$$

Converting Carbon Flux to Equivalent LNAPL Loss Rate:

The intermediate reactions for LNAPL mineralization include methanogenesis, leading to production of methane and CO_2, and the subsequent aerobic oxidation of methane into CO_2:

$$C_8H_{18} + 3.5\ H_2O \rightarrow 6.25\ CH_4 + 1.75\ CO_2 \text{ (methanogenesis)}$$

$$6.25\ CH_4 + 12.5\ O_2 \rightarrow 6.25\ CO_2 + 12.5\ H_2O \text{ (methane oxidation)}$$

$$C_8H_{18} + 12.5\ O_2 \rightarrow 9H_2O + 8\ CO_2 \text{ (overall reaction)}$$

Assuming a conservative LNAPL density of 0.77 g mL^{-1} (upper range of gasoline) and using the molecular weight of C_8H_{18} (octane, 114.23 g mol^{-1}), µmol m^{-2} s^{-1} of CO_2 can then be converted into gal. $acre^{-1}$ yr^{-1} of LNAPL:

$$1\ \frac{\mu\text{mol CO}_2}{\text{m}^2\ \text{s}} \cdot \left(\frac{1\ \mu\text{mol C}_8\text{H}_{18}}{8\ \mu\text{mol CO}_2}\right)\left(\frac{1\ \text{mol C}_8\text{H}_{18}}{1 \times 10^6\ \mu\text{mol C}_8\text{H}_{18}}\right)\left(\frac{114\ \text{g C}_8\text{H}_{18}}{1\ \text{mol C}_8\text{H}_{18}}\right)\left(\frac{1\ \text{mL C}_8\text{H}_{18}}{0.77\ \text{g C}_8\text{H}_{18}}\right)$$
$$\left(\frac{1\ \text{L}}{1000\text{mL}}\right)\left(\frac{1\ \text{gal.}}{3.785\ \text{L}}\right)\left(\frac{4{,}046\ \text{m}^2}{1\ \text{acre}}\right)\left(\frac{3600\ \text{s}}{1\ \text{h}}\right)\left(\frac{24\ \text{h}}{1\ \text{d}}\right)\left(\frac{365\ \text{d}}{1\ \text{yr}}\right) \cdot$$

$$= 625.2\ \frac{\text{gal. C}_8\text{H}_{18}}{\text{acre} \cdot \text{yr}}$$

Note that both the LNAPL formula and its density are assumed, and so this conversion is subject to uncertainty. However, site-specific data can be used if available. Using alternative representative hydrocarbon formulas and densities generally results in conversion factors that are within 10-15% of 625.2 gal. $acre^{-1}$ yr^{-1}. Therefore, the uncertainty associated with these values does not preclude an acceptable estimate.

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Expected Results and Recommendations:

^{14}C-based techniques offer a built-in, location-specific correction as an alternative to the standard background location correction. Early work on a limited number of samples suggested that ^{14}C-corrected results are equivalent to background-corrected results (Sihota and Mayer, 2012; McCoy et al., 2015). However, a more recent comparison spanning 4 different sites suggests that measured carbon fluxes can differ by up to five times among different locations within the same site (Zimbron and Kasyon, 2015). Depending on the location, the resulting difference between background-corrected and ^{14}C-corrected NSZD rate estimates can be up to one order of magnitude. In contrast, the background correction assumes that the non-fossil fuel CO_2 flux is constant across an entire site; large errors in final estimated NSZD rates might therefore be introduced if the background correction is used. Because the ^{14}C measurement is co-located with the CO_2 flux measurement, it is unbiased by spatial uncertainties related to the background location(s) (e.g., vegetation, lithology, unknown impacts, different gas transport regimes, soil moisture).

The fossil fuel CO_2 content of unexposed sorbent as used in the traps is typically around 30% (as of today) and likely results from material processing and handling (e.g., exposure to fossil fuel fumes). This small mass of fossil fuel CO_2 is removed from samples by carrying out a ^{14}C travel blank correction. ^{14}C analysis is performed on CO_2 sorbent sub-samples after homogenization of the entire bottom sorbent layer (see McCoy et al., 2015). The mass of fossil fuel CO_2 in the unexposed travel blank trap (TB) is then subtracted from the mass of fossil fuel CO_2 in each field-deployed trap.

The results in this report are based on proprietary technology used to measure soil gas efflux. All information contained herein is strictly confidential to the customer.

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Project: Ypsilanti, MI
Customer: GHD
Customer Contact: Matt Rousseau, Marissa Labbé
Report Date: 7-Aug-2019

Sample ID	Sampling Information			Raw Results[a]				Final CO_2 Results[b]			^{14}C Results[a]			NSZD Results[b]				
	Deployed	Retrieved	Days in Field	Moisture content (%)	Dry Sorbent Mass (g)	Avg. % CO_2[c]	CV[d] CO_2 (%)	CO_2 content (%)	CO_2 mass (g)	CO_2 Flux (µmol m^{-2} s^{-1})	Fm_{sample} As Reported[e]	bb_{sample} As of Today[f]	ff_{sample} As of Today[f]	Bio-based CO_2 Flux (µmol m^{-2} s^{-1})	ff_{sample} As of Today (TB-corrected)	Fossil Fuel CO_2 (g)	Fossil Fuel CO_2 Flux (µmol m^{-2} s^{-1})	Equivalent NSZD Rate (gal. $acre^{-1}$ yr^{-1})
YPMI-R1-CO2-TB	N/A	N/A	N/A	21.2%	40.95	1.04%	1.28%	-	-	-	64.3	63.04%	36.96%	-	-	-	-	-
YPMI-R1-CO2-01	7/8/19 12:56	7/12/19 15:33	4.11	19.7%	55.15	39.25%	0.56%	38.21%	21.07	41.60	4.108	4.03%	95.97%	1.01	97.58%	20.56	40.59	25375
YPMI-R1-CO2-02	7/8/19 14:22	7/12/19 16:01	4.07	15.9%	52.42	35.96%	0.93%	34.92%	18.30	145.97	19.92	19.53%	80.47%	26.62	81.77%	14.97	119.35	74616
YPMI-R1-CO2-03	7/8/19 14:28	7/12/19 16:07	4.07	21.7%	41.42	4.63%	1.08%	3.60%	1.49	11.88	30.38	29.78%	70.22%	2.40	79.82%	1.19	9.48	5927
YPMI-R1-CO2-04	7/8/19 14:33	7/12/19 15:37	4.04	16.9%	50.16	31.52%	0.85%	30.48%	15.29	122.65	5.23	5.13%	94.87%	3.87	96.85%	14.81	118.78	74260
YPMI-R1-CO2-05	7/8/19 15:22	7/12/19 16:21	4.04	15.8%	52.96	38.53%	0.19%	37.49%	19.85	39.85	12.42	12.18%	87.82%	4.29	89.23%	17.72	35.56	22232
YPMI-R1-CO2-06	7/8/19 15:50	7/12/19 16:11	4.01	23.4%	52.44	36.10%	0.59%	35.06%	18.39	37.15	9.632	9.44%	90.56%	2.92	92.15%	16.94	34.23	21400
YPMI-R1-CO2-07	7/8/19 15:58	7/12/19 16:14	4.01	21.0%	54.50	39.72%	0.45%	38.68%	21.08	42.63	21.59	21.17%	78.83%	8.54	79.96%	16.86	34.09	21311
YPMI-R1-CO2-08	7/8/19 16:04	7/12/19 16:17	4.01	24.2%	54.17	39.56%	0.58%	38.52%	20.87	42.22	10.26	10.06%	89.94%	3.64	91.37%	19.07	38.58	24119

- The flux equivalence is **1** µmol m^{-2} s^{-1} = **625.2** gallons $acre^{-1}$ yr^{-1}, assuming a representative hydrocarbon density of **0.77** g mL^{-1} with the formula **C_8H_{18}**.Trap cross-sectional area is **8.11 × 10^{-3}** m^2 (based on a **4-inch** receiver pipe) for traps **YPMI-R1-CO2-02**, **YPMI-R1-CO2-03**, and **YPMI-R1-CO2-04**. Trap cross-sectional area is **3.24 x 10^{-3} m^2** (based on an **8-inch** receiver pipe) for traps **YPMI-R1-CO2-01**, **YPMI-R1-CO2-05**, **YPMI-R1-CO2-06**, **YPMI-R1-CO2-07**, and **YPMI-R1-CO2-08**.
- Carbonate analysis of each trap/sample is based on method ASTM 4373-14, which does do not provide acceptable variability (CV) standards. Similar methods (e.g., ASTM D513-16) allow typical errors of ≤ 20%. Analysis is therefore conducted in duplicate if the coefficient of variation (CV) of the duplicates is < 5%. If CV ≥ 5%, duplicate analyses are repeated until CV < 5%.
- NA = Not Applicable; ND = Not Detectable.

a. Raw and ^{14}C Results are not TB-corrected.
b. Final CO_2 and NSZD Results are TB-corrected.
c. Refers to the measured weight percentage of CO_2 with respect to the total dry sorbent mass.
d. Refers to the coefficient of variation of CO_2 measurements for each sample: CV = [standard deviation of %CO_2 measurements] / [average %CO_2 measurement]
e. Refers to the reported fraction modern (Fm_{sample}). As is standard in radiocarbon reporting, this value has not been corrected to account for present-day ^{14}C atmospheric levels. This number is originally reported as pMC (percent modern carbon) and is converted into *Fm* for our calculations using the relation 100.0 pMC = 1.0 *Fm* = 100% *Fm*.
f. "As of Today" means that the value has been adjusted to account for the difference between atmospheric ^{14}C levels from the 1950s and today (Stenström et al., 2011). bb_{sample} is the percentage of the total CO_2 that is derived from bio-based (non-fossil fuel) sources. ff_{sample} refers to the percentage of CO_2 that is derived from fossil fuels. The values reported in the ^{14}C Results section are not TB-corrected, but those in the NSZD Results section are.

Results Snapshot:

- The Travel Blank (TB) concentration is **1.04%**; typically, this number is < 2%.
- All trap bottoms, except the bottom of trap **YPMI-R1-CO2-03** were saturated with CO_2 (sorbent saturation is 30%). A saturated bottom means that the actual CO_2 flux measured is an underestimate.
- Trap tops from **YPMI-R1-CO2-01** and **YPMI-R1-CO2-08** are saturated with CO_2 (sorbent saturation is 30%). The maximum measured (raw) top concentration is ***38.12%*** (sample **YPMI-R1-CO2-01**).
- Bio-based carbon fluxes represent the CO_2 contributions from natural soil respiration processes to the total carbon flux; the ^{14}C analysis corrects for this contribution. Average bio-based CO_2 flux is **6.66** µmol m^{-2} s^{-1}, and the coefficient of variation is **125%**. The range of bio-based CO_2 fluxes is between **1.01** and **26.62** µmol m^{-2} s^{-1}. If these interferences were not removed using the results of the radiocarbon analysis, the errors in the NSZD rate estimates would be between **630** and **16640** gallons $acre^{-1}$ yr^{-1}.

Site-specific Sample Calculations:

Grams of Fossil Fuel CO_2:

The mass of fossil fuel-derived CO_2 in each trap is calculated by subtracting the total fossil fuel CO_2 in the travel blank (TB) from the total fossil fuel CO_2 in the trap. Only data that are ***not*** TB-corrected (i.e., ff_{sample} As of Today and raw % CO_2) are used in this calculation. Using Sample 2 as an example:

$$\left(\mathrm{g\ CO_{2(ff)}}\right)_{sample\ 2} = \mathrm{g_{sorbent}} \cdot \left[\left((\%\ \mathrm{CO_2})_{\mathrm{sample}}\left(ff_{sample}\right)\right) - \left((\%\ \mathrm{CO_2})_{\mathrm{TB}}\left(ff_{TB}\right)\right)\right]$$

$$\left(\mathrm{g\ CO_{2(ff)}}\right)_{sample2} = \mathbf{52.42}\ \mathrm{g} \cdot \left[(\mathbf{36.0}\ \% \cdot \mathbf{80.5}\ \%) - (\mathbf{1.04}\ \% \cdot \mathbf{36.96}\ \%)\right]$$

$$\left(\mathrm{g\ CO_{2(ff)}}\right)_{sample\ 2} = \mathbf{14.97}\ \mathrm{g}$$

Here, $g_{sorbent}$ is the mass of sorbent used in the bottom layer of the trap, $(\%CO_2)_{sample}$ is the average weight percentage of CO_2 in the sample, ff_{sample} is the percentage of carbon in the sample derived from fossil fuels, $(\%CO_2)_{TB}$ is the average weight percentage of CO_2 in the travel blank, and ff_{TB} is the percentage of carbon in the travel blank that is derived from fossil fuels. In this example, Sample 2 contains **14.97** g of fossil-fuel derived CO_2.

Fossil Fuel CO_2 Flux:

Converting grams of CO_2 to CO_2 flux requires the cross-sectional area of the receiver (**8.11×10^{-3}** m^2 for a **4**-inch receiver), the number of days that the trap was deployed in the field, and the molecular weight of CO_2 (44 g mol^{-1}). Using Site 2 as an example:

$$\mathrm{Fossil\ Fuel\ CO_2\ Flux} = \frac{\mathrm{g\ fossil\ fuel\ CO_2} \cdot \frac{1\ \mathrm{mol\ CO_2}}{44\ \mathrm{g\ CO_2}} \cdot \frac{1{,}000{,}000\ \mu\mathrm{mol\ CO_2}}{1\ \mathrm{mol\ CO_2}}}{\mathrm{days\ in\ the\ field} \cdot \frac{24\ \mathrm{hr}}{\mathrm{day}} \cdot \frac{3600\ \mathrm{s}}{\mathrm{hr}} \cdot (\mathrm{receiver\ area})}$$

$$\mathrm{Fossil\ Fuel\ CO_2\ Flux} = \frac{\mathbf{14.97}\ \mathrm{g\ fossil\ fuel\ CO_2} \cdot \frac{1\ \mathrm{mol\ CO_2}}{44\ \mathrm{g\ CO_2}} \cdot \frac{1{,}000{,}000\ \mu\mathrm{mol\ CO_2}}{\mathrm{mol\ CO_2}}}{\mathbf{4.1}\ \mathrm{days} \cdot \frac{24\ \mathrm{hr}}{\mathrm{day}} \cdot \frac{3600\ \mathrm{s}}{\mathrm{hr}} \cdot (\mathbf{8.11 \times 10^{-3}}\ \mathrm{m^2})}$$

$$\mathrm{Fossil\ Fuel\ CO_2\ Flux} = 119.35\ \frac{\mu\mathrm{mol\ CO_2}}{\mathrm{m^2 \cdot s}}$$

References

ASTM (2014) Method D4373-14, Rapid Determination of Carbonate Content of Soils.

ASTM (2016) Method D513-16, Total and Dissolved Carbon Dioxide in Water.

ASTM (2018) Method D6866-18, Determining the Biobased Content in Solids, Liquid, and Gaseous Samples Using Radiocarbon Analysis.

Avery, Jr. G. B., Wiley J. D. and Kieber R. J. (2006) Carbon isotopic characterization of dissolved organic carbon in rainwater: Terrestrial and marine influences. *Atmospheric Environment* **40(39)**, 7539-7545.

Cerling T. E., Barnette J. E., Chesson L. A., Douglas-Hamilton I., Gobush K. S., Uno K. T., Wasser S. K. and Xu X. (2016) Radiocarbon dating of seized ivory confirms rapid decline in African elephant populations and provides insight into illegal trade. *Proceedings of the Natural Academy of Sciences* **114(47)**, 13330-13335.

Klouda G. A. and Connolly M. V. (1995) Radiocarbon (^{14}C) measurements to quantify sources of atmospheric carbon monoxide in urban air. *Atmospheric Environment* **29(22)**, 3309-3318.

Larsen T., Yokoyama Y. and Fernandes R. (2018) Radiocarbon in ecology: Insights and perspectives from aquatic and terrestrial studies. *Methods in Ecology and Evolution* **9**, 181-190.

Levin I., Graul R. and Trivett N. B. A. (1995) Long-term observations of atmospheric CO_2 and carbon isotopes at continental sites in Germany. *Tellus B, Chemical and Physical Meteorology* **47**, 23-34.

McCoy K., Zimbron J., Sale T. and Lyverse M. (2015) Measurement of Natural Losses of LNAPL Using CO_2 Traps. *Groundwater* **53(4)**, 658-667. doi:10.1111/gwat.12240

Sihota N. J. and Mayer K. U. (2012) Characterizing vadose zone hydrocarbon biodegradation using carbon dioxide effluxes, isotopes, and reactive transport modeling. *Vadose Zone Journal* **11(4)**, doi:10.2136/vzj2011.0204

Stenström K. E., Skog G., Georgiadou E., Genberg J. and Johansson A. (2011) A guide to radiocarbon units and calculations. Lund University Internal Report, LUNFD6(NFFR-3111)/1-17/(2011).

Stuiver M. and Polach H. A. (1977) Discussion: Reporting of ^{14}C data. *Radiocarbon* **19(3)**, 355–363.

Zimbron J. and Kasyon E. (2015) Combined Use of Isotope Analysis and Passive CO_2 Flux Traps to Estimate Field Rates of Hydrocarbon Degradation. Battelle Remediation Conference, D-002(abstr.), Miami FL.

Confidential Report
CO_2 Flux and NSZD Rate Results

MATT ROUSSEAU/MARISSA LABBÉ
GHD
PROJECT: YPSILANTI, MI
SAMPLING DATES:
9/13/2019 - 9/17/2019

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Report Date: 10/14/2019
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The purpose of this document is to provide sample calculations for the reported results and to explain the method for differentiating petroleum hydrocarbon-derived CO_2 from that produced from natural soil respiration processes. The value of the ^{14}C analysis, site-specific study results and applicable notes, calculation explanations, and references are included.

The Value of the ^{14}C Analysis

How to differentiate between petroleum hydrocarbon-derived CO_2 and natural process-derived CO_2 using CO_2 flux traps:

Unimpacted soils naturally produce CO_2 due to microbial root zone activity and/or the degradation of natural organic matter. Thus, the total measured CO_2 flux at an impacted location is a function of the rates of both natural soil respiration and LNAPL degradation (Sihota and Mayer, 2012). The latter, which is caused by Natural Source Zone Depletion (NSZD), can be estimated by subtracting measured CO_2 fluxes at unimpacted locations from the total measured CO_2 fluxes at LNAPL-impacted locations (Sihota and Mayer, 2012). This spatial "background correction" assumes that bio-based CO_2 fluxes are similar at both impacted and unimpacted locations. This approach is complicated to implement, given that at many industrial facilities it is difficult to find unimpacted areas and vegetation cover can vary across a site. Alternatively, carbon isotope analysis can be used to carry out a location-specific correction for total measured CO_2 fluxes, and this approach effectively overcomes the limitations of the background correction.

Theory of Carbon Isotope Analysis:

Our method for NSZD rate estimation relies on the analysis of ^{14}C, an unstable carbon isotope with an absolute half-life of 5,730 years. ^{14}C is generated by cosmic rays in the atmosphere and is quickly oxidized to $^{14}CO_2$; thus, bio-based living carbon is ^{14}C-rich, while ancient fossil fuel carbon is completely ^{14}C-depleted. Additionally, bio-based organic carbon and the atmosphere have the same characteristic amount of ^{14}C. The short half-life of ^{14}C only allows for dating of samples younger than 60,000 years using accelerator mass spectrometry (Stuiver and Polach, 1977). ^{14}C analysis can therefore be used to differentiate between anthropogenic (i.e., fossil fuel) and natural sources of atmospheric carbon (see Klouda and Connolly, 1995; Levin et al., 1995; Avery et al., 2006), and this analysis is the basis for ASTM D6866-18.

For samples that contain both bio-based and fossil fuel-derived carbon, such as E-Flux's fossil fuel traps, measurement of ^{14}C enables quantitation of *both* source contributions. The fossil fuel-derived percentage of the sample (ff_{sample}) and the bio-based percentage ($1\text{-}ff_{sample}$, or bb_{sample}) are related by the following two-component mass balance (modified from Avery, Jr. et al., 2006):

$$Fm_{sample} = \left(ff_{sample}\right)\left(Fm_{ff}\right) + \left(1 - ff_{sample}\right)\left(Fm_{atm}\right)$$

Here, Fm_x represents the fraction modern, a measure of how close the present $^{14}C/^{12}C$ ratio of the sample is to the ratio from 1950, which is derived from a pre-industrial era standard. Fm_{sample} is the total measured fraction modern of the sample. Fm_{ff} is the fraction modern of only the fossil fuel portion of the sample. This number is 0, as there is no ^{14}C in fossil fuel-derived CO_2. Fm_{atm} is the fraction modern of the part of the sample derived from natural soil respiration processes. This value, currently equal to **1.02** (Cerling et al., 2016, Larsen et al., 2018), has been experimentally determined and is a fixed value at each point in time. By convention, the results of carbon isotope analysis are reported based on a 1950 NBS oxalic acid standard, and so Fm_{sample} is reported as if the analysis took place in 1950. Due to nuclear testing, current ^{14}C atmospheric levels are now higher than they were in 1950. This means that Fm_{atm} is counter-intuitively larger than 1, as the $^{14}C/^{12}C$ sample ratio is higher now than it would have been in 1950.

^{14}C Calculations:

Conversion of Fraction Modern Carbon to Fossil Fuel Carbon:

The equation for calculating the percentage of fossil fuel carbon (ff_{sample}) is derived from the following mass balance:

$$Fm_{sample} = (ff_{sample})(Fm_{ff}) + (1 - ff_{sample})(Fm_{atm})$$

Solving for ff_{sample} yields:

$$ff_{sample} = 1 - \frac{Fm_{sample}}{Fm_{atm}}$$

Fraction modern (Fm_{sample}, from ^{14}C analysis) is reported by convention based on ^{14}C levels from 1950. Because of atomic testing, current environmental ^{14}C levels are approximately 2% higher than they were in 1950 (Cerling et al., 2016, Larsen et al., 2018) and Fm_{atm} is equal to 1.02. This equation then becomes:

$$ff_{sample} = 1 - \frac{Fm_{sample}}{1.02}$$

As percentages must add to 1, the percentage of bio-based carbon (bb_{sample}) can then be calculated using the following equivalence:

$$bb_{sample} = 1 - ff_{sample} = 1 - \left(1 - \frac{Fm_{sample}}{1.02}\right) = \frac{Fm_{sample}}{1.02}$$

Converting Carbon Flux to Equivalent LNAPL Loss Rate:

The intermediate reactions for LNAPL mineralization include methanogenesis, leading to production of methane and CO_2, and the subsequent aerobic oxidation of methane into CO_2:

$$C_8H_{18} + 3.5\ H_2O \rightarrow 6.25\ CH_4 + 1.75\ CO_2 \text{ (methanogenesis)}$$

$$6.25\ CH_4 + 12.5\ O_2 \rightarrow 6.25\ CO_2 + 12.5\ H_2O \text{ (methane oxidation)}$$

$$C_8H_{18} + 12.5\ O_2 \rightarrow 9H_2O + 8\ CO_2 \text{ (overall reaction)}$$

Assuming a conservative LNAPL density of 0.77 g mL^{-1} (upper range of gasoline) and using the molecular weight of C_8H_{18} (octane, 114.23 g mol^{-1}), µmol m^{-2} s^{-1} of CO_2 can then be converted into gal. $acre^{-1}$ yr^{-1} of LNAPL:

$$1\ \frac{\mu\text{mol CO}_2}{\text{m}^2\ \text{s}} \cdot \left(\frac{1\ \mu\text{mol C}_8\text{H}_{18}}{8\ \mu\text{mol CO}_2}\right)\left(\frac{1\ \text{mol C}_8\text{H}_{18}}{1 \times 10^6\ \mu\text{mol C}_8\text{H}_{18}}\right)\left(\frac{114\ \text{g C}_8\text{H}_{18}}{1\ \text{mol C}_8\text{H}_{18}}\right)\left(\frac{1\ \text{mL C}_8\text{H}_{18}}{0.77\ \text{g C}_8\text{H}_{18}}\right)$$
$$\left(\frac{1\ \text{L}}{1000\text{mL}}\right)\left(\frac{1\ \text{gal.}}{3.785\ \text{L}}\right)\left(\frac{4{,}046\ \text{m}^2}{1\ \text{acre}}\right)\left(\frac{3600\ \text{s}}{1\ \text{h}}\right)\left(\frac{24\ \text{h}}{1\ \text{d}}\right)\left(\frac{365\ \text{d}}{1\ \text{yr}}\right) \cdot$$

$$= 625.2\ \frac{\text{gal. C}_8\text{H}_{18}}{\text{acre} \cdot \text{yr}}$$

Note that both the LNAPL formula and its density are assumed, and so this conversion is subject to uncertainty. However, site-specific data can be used if available. Using alternative representative hydrocarbon formulas and densities generally results in conversion factors that are within 10-15% of 625.2 gal. $acre^{-1}$ yr^{-1}. Therefore, the uncertainty associated with these values does not preclude an acceptable estimate.

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Expected Results and Recommendations:

^{14}C-based techniques offer a built-in, location-specific correction as an alternative to the standard background location correction. Early work on a limited number of samples suggested that ^{14}C-corrected results are equivalent to background-corrected results (Sihota and Mayer, 2012; McCoy et al., 2015). However, a more recent comparison spanning 4 different sites suggests that measured carbon fluxes can differ by up to five times among different locations within the same site (Zimbron and Kasyon, 2015). Depending on the location, the resulting difference between background-corrected and ^{14}C-corrected NSZD rate estimates can be up to one order of magnitude. In contrast, the background correction assumes that the non-fossil fuel CO_2 flux is constant across an entire site; large errors in final estimated NSZD rates might therefore be introduced if the background correction is used. Because the ^{14}C measurement is co-located with the CO_2 flux measurement, it is unbiased by spatial uncertainties related to the background location(s) (e.g., vegetation, lithology, unknown impacts, different gas transport regimes, soil moisture).

The fossil fuel CO_2 content of unexposed sorbent as used in the traps is typically around 30% (as of today) and likely results from material processing and handling (e.g., exposure to fossil fuel fumes). This small mass of fossil fuel CO_2 is removed from samples by carrying out a ^{14}C travel blank correction. ^{14}C analysis is performed on CO_2 sorbent sub-samples after homogenization of the entire bottom sorbent layer (see McCoy et al., 2015). The mass of fossil fuel CO_2 in the unexposed travel blank trap (TB) is then subtracted from the mass of fossil fuel CO_2 in each field-deployed trap.

The results in this report are based on proprietary technology used to measure soil gas efflux. All information contained herein is strictly confidential to the customer.

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Project: Ypsilanti, MI
Customer: GHD
Customer Contact: Matt Rousseau/Marissa Labbé
Report Date: 14-Oct-2019

Sample ID	Sampling Information			Raw Results[a]				Final CO_2 Results[b]			^{14}C Results[a]			NSZD Results[b]				
	Deployed	Retrieved	Days in Field	Moisture content (%)	Dry Sorbent Mass (g)	Avg. % CO_2[c]	CV[d] CO_2 (%)	CO_2 content (%)	CO_2 mass (g)	CO_2 Flux (µmol m^{-2} s^{-1})	Fm_{sample} As Reported[e]	bb_{sample} As of Today[f]	ff_{sample} As of Today[f]	Bio-based CO_2 Flux (µmol m^{-2} s^{-1})	ff_{sample} As of Today (TB-corrected)	Fossil Fuel CO_2 (g)	Fossil Fuel CO_2 Flux (µmol m^{-2} s^{-1})	Equivalent NSZD Rate (gal. $acre^{-1}$ yr^{-1})
YPMI-R2-CO2-TB	N/A	N/A	N/A	21.7%	40.92	0.86%	1.29%	-	-	-	69.49	68.13%	31.87%	-	-	-	-	-
YPMI-R2-CO2-01	9/13/19 13:31	9/17/19 16:04	4.1	13.0%	53.76	38.93%	1.11%	38.07%	20.47	40.43	3.637	3.57%	96.43%	0.85	97.89%	20.04	39.58	24746
YPMI-R2-CO2-02	9/13/19 13:30	9/17/19 16:10	4.1	18.5%	50.76	32.29%	0.88%	31.43%	15.95	31.48	9.544	9.36%	90.64%	2.44	92.25%	14.72	29.04	18155
YPMI-R2-CO2-03	9/13/19 13:43	9/17/19 16:02	4.1	15.0%	53.83	39.63%	0.37%	38.77%	20.87	41.33	21.35	20.93%	79.07%	8.22	80.12%	16.72	33.11	20700
YPMI-R2-CO2-04	9/13/19 13:51	9/17/19 16:00	4.1	26.0%	41.35	15.75%	0.40%	14.89%	6.16	12.21	15.28	14.98%	85.02%	1.45	88.09%	5.42	10.76	6725
YPMI-R2-CO2-05	9/13/19 13:57	9/17/19 15:50	4.1	17.7%	49.43	27.99%	0.25%	27.13%	13.41	106.69	6.358	6.23%	93.77%	4.56	95.73%	12.84	102.13	63850
YPMI-R2-CO2-06	9/13/19 14:06	9/17/19 15:45	4.1	22.4%	42.07	4.92%	3.80%	4.06%	1.71	13.63	29.44	28.86%	71.14%	2.80	79.45%	1.36	10.83	6771
YPMI-R2-CO2-07	9/13/19 14:16	9/17/19 15:38	4.1	16.1%	52.00	35.42%	0.22%	34.56%	17.97	143.74	19.84	19.45%	80.55%	26.22	81.76%	14.70	117.53	73476
YPMI-R2-CO2-08	9/13/19 14:20	9/17/19 15:55	4.1	15.8%	53.98	37.19%	0.24%	36.33%	19.61	39.12	12.734	12.48%	87.52%	4.37	88.83%	17.42	34.75	21726

- The flux equivalence is **1** µmol m^{-2} s^{-1} = **625.2** gallons $acre^{-1}$ yr^{-1}, assuming a representative hydrocarbon density of **0.77** g mL^{-1} with the formula **C_8H_{18}**. Trap cross-sectional area is **8.11×10^{-3}** m^2 (based on a **4-inch** receiver pipe) for traps **YPMI-R2-CO2-05**, **YPMI-R2-CO2-06**, and **YPMI-R2-CO2-07**. Trap cross-sectional area is **3.24×10^{-3} m^2** (based on an **8-inch** receiver pipe) for traps **YPMI-R2-CO2-01**, **YPMI-R2-CO2-02**, **YPMI-R2-CO2-03**, **YPMI-R2-CO2-04**, and **YPMI-R2-CO2-08**.
- Carbonate analysis of each trap/sample is based on method ASTM 4373-14, which does do not provide acceptable variability (CV) standards. Similar methods (e.g., ASTM D513-16) allow typical errors of ≤ 20%. Analysis is therefore conducted in duplicate if the coefficient of variation (CV) of the duplicates is < 5%. If CV ≥ 5%, duplicate analyses are repeated until CV < 5%.
- NA = Not Applicable; ND = Not Detectable.

a. Raw and ^{14}C Results are not TB-corrected.
b. Final CO_2 and NSZD Results are TB-corrected.
c. Refers to the measured weight percentage of CO_2 with respect to the total dry sorbent mass.
d. Refers to the coefficient of variation of CO_2 measurements for each sample: CV = [standard deviation of $\%CO_2$ measurements] / [average $\%CO_2$ measurement]
e. Refers to the reported fraction modern (Fm_{sample}). As is standard in radiocarbon reporting, this value has not been corrected to account for present-day ^{14}C atmospheric levels. This number is originally reported as pMC (percent modern carbon) and is converted into *Fm* for our calculations using the relation 100.0 pMC = 1.0 *Fm* = 100% *Fm*.
f. "As of Today" means that the value has been adjusted to account for the difference between atmospheric ^{14}C levels from the 1950s and today (Stenström et al., 2011). bb_{sample} is the percentage of the total CO_2 that is derived from bio-based (non-fossil fuel) sources. ff_{sample} refers to the percentage of CO_2 that is derived from fossil fuels. The values reported in the ^{14}C Results section are not TB-corrected, but those in the NSZD Results section are.

Results Snapshot:

- The Travel Blank (TB) concentration is **0.86%**; typically, this number is < 2%.
- Trap tops are not saturated with CO_2 (sorbent saturation is 30%). The maximum measured (raw) top concentration is **17.15%** (sample **YPMI-R2-CO2-01 top**).
- Bio-based carbon fluxes represent the CO_2 contributions from natural soil respiration processes to the total carbon flux; the ^{14}C analysis corrects for this contribution. Average bio-based CO_2 flux is **6.36** µmol m^{-2} s^{-1}, and the coefficient of variation is **131%**. The range of bio-based CO_2 fluxes is between **0.85** and **26.22** µmol m^{-2} s^{-1}. If these interferences were not removed using the results of the radiocarbon analysis, the errors in the NSZD rate estimates would be between **533** and **16392** gallons $acre^{-1}$ yr^{-1}.

Site-specific Sample Calculations:

Grams of Fossil Fuel CO_2:

The mass of fossil fuel-derived CO_2 in each trap is calculated by subtracting the total fossil fuel CO_2 in the travel blank (TB) from the total fossil fuel CO_2 in the trap. Only data that are ***not*** TB-corrected (i.e., ff_{sample} As of Today and raw % CO_2) are used in this calculation. Using Sample 1 as an example:

$$\left(\mathrm{g\ CO_{2(ff)}}\right)_{sample\ 1} = \mathrm{g_{sorbent}} \cdot \left[\left((\%\ \mathrm{CO_2})_{\mathrm{sample}}\left(ff_{sample}\right)\right) - \left((\%\ \mathrm{CO_2})_{\mathrm{TB}}\left(ff_{TB}\right)\right)\right]$$

$$\left(\mathrm{g\ CO_{2(ff)}}\right)_{sample\ 1} = \mathbf{50.76}\ \mathrm{g} \cdot \left[(\mathbf{38.93}\ \% \cdot \mathbf{96.43}\ \%) - (\mathbf{0.86}\ \% \cdot \mathbf{31.87}\ \%)\right]$$

$$\left(\mathrm{g\ CO_{2(ff)}}\right)_{sample\ 1} = \mathbf{20.037}\ \mathrm{g}$$

Here, $g_{sorbent}$ is the mass of sorbent used in the bottom layer of the trap, $(\%CO_2)_{sample}$ is the average weight percentage of CO_2 in the sample, ff_{sample} is the percentage of carbon in the sample derived from fossil fuels, $(\%CO_2)_{TB}$ is the average weight percentage of CO_2 in the travel blank, and ff_{TB} is the percentage of carbon in the travel blank that is derived from fossil fuels. In this example, Sample 1 contains **20.037 g** of fossil-fuel derived CO_2.

Fossil Fuel CO_2 Flux:

Converting grams of CO_2 to CO_2 flux requires the cross-sectional area of the receiver (**3.24×10^{-2}** m^2 for an **8**-inch receiver), the number of days that the trap was deployed in the field, and the molecular weight of CO_2 (44 g mol^{-1}). Using Site 1 as an example:

$$\mathrm{Fossil\ Fuel\ CO_2\ Flux} = \frac{\mathrm{g\ fossil\ fuel\ CO_2} \cdot \frac{1\ \mathrm{mol\ CO_2}}{44\ \mathrm{g\ CO_2}} \cdot \frac{1{,}000{,}000\ \mu\mathrm{mol\ CO_2}}{1\ \mathrm{mol\ CO_2}}}{\mathrm{days\ in\ the\ field} \cdot \frac{24\ \mathrm{hr}}{\mathrm{day}} \cdot \frac{3600\ \mathrm{s}}{\mathrm{hr}} \cdot (\mathrm{receiver\ area})}$$

$$\mathrm{Fossil\ Fuel\ CO_2\ Flux} = \frac{\mathbf{20.037}\ \mathrm{g\ fossil\ fuel\ CO_2} \cdot \frac{1\ \mathrm{mol\ CO_2}}{44\ \mathrm{g\ CO_2}} \cdot \frac{1{,}000{,}000\ \mu\mathrm{mol\ CO_2}}{\mathrm{mol\ CO_2}}}{\mathbf{4.1}\ \mathrm{days} \cdot \frac{24\ \mathrm{hr}}{\mathrm{day}} \cdot \frac{3600\ \mathrm{s}}{\mathrm{hr}} \cdot (\mathbf{3.24 \times 10^{-2}}\ \mathrm{m^2})}$$

$$\mathrm{Fossil\ Fuel\ CO_2\ Flux} = \mathbf{39.58}\ \frac{\mu\mathrm{mol\ CO_2}}{\mathrm{m^2} \cdot \mathrm{s}}$$

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References

ASTM (2014) Method D4373-14, Rapid Determination of Carbonate Content of Soils.

ASTM (2016) Method D513-16, Total and Dissolved Carbon Dioxide in Water.

ASTM (2018) Method D6866-18, Determining the Biobased Content in Solids, Liquid, and Gaseous Samples Using Radiocarbon Analysis.

Avery, Jr. G. B., Wiley J. D. and Kieber R. J. (2006) Carbon isotopic characterization of dissolved organic carbon in rainwater: Terrestrial and marine influences. *Atmospheric Environment* **40(39)**, 7539-7545.

Cerling T. E., Barnette J. E., Chesson L. A., Douglas-Hamilton I., Gobush K. S., Uno K. T., Wasser S. K. and Xu X. (2016) Radiocarbon dating of seized ivory confirms rapid decline in African elephant populations and provides insight into illegal trade. *Proceedings of the Natural Academy of Sciences* **114(47)**, 13330-13335.

Klouda G. A. and Connolly M. V. (1995) Radiocarbon (^{14}C) measurements to quantify sources of atmospheric carbon monoxide in urban air. *Atmospheric Environment* **29(22)**, 3309-3318.

Larsen T., Yokoyama Y. and Fernandes R. (2018) Radiocarbon in ecology: Insights and perspectives from aquatic and terrestrial studies. *Methods in Ecology and Evolution* **9**, 181-190.

Levin I., Graul R. and Trivett N. B. A. (1995) Long-term observations of atmospheric CO_2 and carbon isotopes at continental sites in Germany. *Tellus B, Chemical and Physical Meteorology* **47**, 23-34.

McCoy K., Zimbron J., Sale T. and Lyverse M. (2015) Measurement of Natural Losses of LNAPL Using CO_2 Traps. *Groundwater* **53(4)**, 658-667. doi:10.1111/gwat.12240

Sihota N. J. and Mayer K. U. (2012) Characterizing vadose zone hydrocarbon biodegradation using carbon dioxide effluxes, isotopes, and reactive transport modeling. *Vadose Zone Journal* **11(4)**, doi:10.2136/vzj2011.0204

Stenström K. E., Skog G., Georgiadou E., Genberg J. and Johansson A. (2011) A guide to radiocarbon units and calculations. Lund University Internal Report, LUNFD6(NFFR-3111)/1-17/(2011).

Stuiver M. and Polach H. A. (1977) Discussion: Reporting of ^{14}C data. *Radiocarbon* **19(3)**, 355–363.

Zimbron J. and Kasyon E. (2015) Combined Use of Isotope Analysis and Passive CO_2 Flux Traps to Estimate Field Rates of Hydrocarbon Degradation. Battelle Remediation Conference, D-002(abstr.), Miami FL.



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