MARATHON

Western Refining Southwest LLC
A subsidiary of Marathon Petroleum Corporation
I-40 Exit 39
Jamestown, NM 87347

December 17, 2021

Mr. Kevin Pierard, Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

RE: Response to Approval with Modifications, Natural Attenuation Assessment and Proposed Work Plan for the Hydrocarbon Seep Area
Western Refining Southwest LLC, Gallup Refinery
EPA ID #NMD000333211
HWB-WRG-20-023

Dear Mr. Pierard:

Attached please find the response to comments contained in the New Mexico Environment Department (NMED) above referenced Approval with Modifications letter dated September 28, 2021. Included with this submittal are two hard copies of replacement pages (text, tables, and figures). Electronic versions of the revised report and the red-line/strike-out report are included.

The document timeline is summarized below:

- Natural Attenuation Assessment and Proposed Workplan for the Hydrocarbon Seep Area, submitted December 15, 2020
- *Disapproval*, received January 26, 2021
- Response to Disapproval, submitted August 27, 2021
- *Approval with Modifications*, received September 28, 2021

If you have any questions or comments regarding the information contained herein, please do not hesitate to contact Mr. John Moore at (505) 879-7643.

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Certification

I certify under penalty of law that this document and all attachments were prepared under my direction of supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Sincerely,
Western Refining Southwest LLC, Gallup Refinery

Ruth A Cade

Ruth Cade
Vice-President

Attachments

cc: D. Cobrain, NMED HWB
L. Tsinnajinnie, NMED HWB
M. Suzuki, NMED HWB
L. Barr, NMOCD
L. King, EPA Region 6
M. Bracey, Marathon Petroleum Corporation
K. Luka, Marathon Petroleum Corporation
J. Moore, Marathon Gallup Refinery
H. Jones, Trihydro Corporation

ATTACHMENT 1

RESPONSE TO COMMENTS

New Mexico Environment Department (NMED) to Western Refining Southwest LLC, Gallup Refinery (Refinery) Comment Letter "Disapproval, Natural Attenuation Assessment and Proposed Workplan for the Hydrocarbon Seep Area" (September 28, 2021)

NMED Comment	Refinery Response
Comment 1:	**Response 1:**
There is a typographical error in the title of the Response. NMED received the document titled *Proposed Work Plan for the Hydrocarbon Seep Area French Drain Soil Sampling Investigation Work Plan* as a separate submittal on December 16, 2020. Remove the reference from the future correspondence. No revision required.	This comment is acknowledged.
Comment 2:	**Response 2:**
In the response to NMED's Disapproval Comment 1, the Permittee states, "[t]he wells evaluated and the data are provided in a new Table 1 and shown on Figure 1." There appears to be a typographical error in the statement since Table 1 (MKTF Wells CVOCs and MNA Analytical Data 2018-2020) does not include the MTBE data. NMED's Disapproval Comment 1 requires the Permittee to evaluate the potential for MTBE degradation and to summarize that information in the data tables. Table 1 must be revised to include the MTBE analytical data. Provide a revised Table 1. Furthermore, Figure 1 (Hydrocarbon Seep Area and MNA Well Set) depicts wells where vinyl chloride has consistently been detected; however, it does not identify the wells that are subject to monitoring the degradation of MTBE or other chlorinated compounds. Figure 1 must be revised to identify the wells that are subject to monitoring MTBE and all chlorinated compounds. Based on the information presented in Attachments A (CVOC Time Series Plots) and B (MTBE Time Series Plots), the wells are subject to monitoring chlorinated compounds and MTBE are identified as wells MKTF-02, -09, -	Text has been added throughout the document to address methyl tert-butyl ether (MTBE). Table 1 has been revised to include MTBE analytical data. Well data for MKTF-04, MKTF-20, and MKTF-21 were added for completeness. An additional figure (Figure 1.B) has been included to identify wells with consistent detections of MTBE, wells with consistent detections of chlorinated volatile organic compounds (CVOCs), and wells with consistent detections of MTBE and CVOCs. Monitoring wells MKTF-02, MKTF-04, MKTF-09, MKTF-10, MKTF-13, MKTF-16, MKTF-17, MKTF-19, MKTF-20, MKTF-21, MKTF-22, MKTF-24, and MKTF-25 will be monitored for the following compounds: • Benzene, toluene, ethylbenzene, and toluene, MTBE, tertiary butyl alcohol (TBA), and CVOCs (i.e., tetrachloroethene, trichloroethene, 1,1-dichloroethane[1,1-

New Mexico Environment Department (NMED) to Western Refining Southwest LLC, Gallup Refinery (Refinery) Comment Letter "Disapproval, Natural Attenuation Assessment and Proposed Workplan for the Hydrocarbon Seep Area" (September 28, 2021)

NMED Comment	Refinery Response
10, -16, -22, -24, and -25, and MKTF-04, -09, -16, -17, -19, -20, -21, -22, -23, -24, and -25 respectively. Provide a revised Figure 1 that depicts the wells that are subject to monitoring chlorinated compounds and MTBE.	DCA], 1,2-dichloroethane [1,2-DCA], 1,1-dichloroethene, and vinyl chloride [VC]) • Ethene, ethane, and methane analysis will be conducted in four monitoring wells with elevated VC concentrations (MKTF-2, MKTF-10, MKTF-24, and MKTF-25) • Dissolved/total iron and manganese, nitrate/nitrite, and sulfate/sulfide to determine their availability as terminal electron receptors and the redox state • Chloride as the end point of 1,1-DCA and 1,2-DCA degradation • Field parameters such as pH, temperature, oxidation-reduction potential (ORP), and dissolved oxygen (DO) Figures 1.A and 1.B present the well network. Note that MKTF-23 is not included in the well network because SPH has been observed. Table 6 has been revised and summarizes the analytes.

New Mexico Environment Department (NMED) to Western Refining Southwest LLC, Gallup Refinery (Refinery) Comment Letter "Disapproval, Natural Attenuation Assessment and Proposed Workplan for the Hydrocarbon Seep Area" (September 28, 2021)

NMED Comment	Refinery Response
Comment 3:	**Response 3:**
In the response to NMED's Disapproval Comment 5, the Permittee states, "Figure 1 has been revised to show those wells with consistent detection of vinyl chloride. Time trend plots of vinyl chloride are also provided for these wells in Attachment 1." Figure 1 indicates that vinyl chloride has consistently been detected in the groundwater samples collected from wells MKTF-02, -10, -24, and -25. The plots included in Attachment A indicate that the vinyl chloride concentrations in the groundwater samples collected from well MKTF-24 are increasing while the cis-1,2-dichloroethene may indicate that an accumulation of vinyl chloride is occurring. Vinyl chloride has the most stringent screening level and is the most toxic among the chlorinated compounds detected at the site. The current anaerobic/reducing conditions of the site does not allow vinyl chloride to be naturally attenuated. Submit a work plan that proposes actions to eliminate vinyl chloride in the vicinity of well MKTF-24; otherwise, discuss the benefits of continuing monitoring vinyl chloride and evaluating the potential for natural attenuation at the site in the response letter.	The Refinery is not proposing an additional workplan for VC removal at this time. VC can biodegrade under both aerobic and anaerobic conditions (USGS 2006). Under mild anoxic conditions, the anaerobic reduction of VC is slower than under stronger reducing conditions associated with a sulfate-reducing or methanogenic redox regime. Given the dissolved hydrocarbon concentrations in this area, reducing conditions are present, and confirmation that sulfate-reducing and methanogenic conditions are also present is warranted. Accordingly, in addition to the sulfide, sampling of dissolved gasses (ethane, ethene and methane) in the four wells showing elevated concentrations of VC (MKTF-02, MKTF-10, MKTF-24, and MKTF-25) is proposed annually. These constituents will be used to evaluate the presence of methane reducing conditions and the VC anaerobic biodegradation by-product (ethene). Current remediation technology for chlorinated ethenes generally involves imposition of these anaerobic conditions, which are likely already present. *USGS 2006. Description, Properties, and Degradation of Selected Volatile Organic Compounds Detected in Ground Water — A Review of Selected Literature, Open-File Report 2006-1338, U.S. Department of the Interior, U.S. Geological Survey.*

New Mexico Environment Department (NMED) to Western Refining Southwest LLC, Gallup Refinery (Refinery) Comment Letter "Disapproval, Natural Attenuation Assessment and Proposed Workplan for the Hydrocarbon Seep Area" (September 28, 2021)

NMED Comment	Refinery Response
Comment 4:	**Response 4:**
In the response to NMED's Disapproval Comment 6, the Permittee states, "[a] trend analysis has been provided in Attachment A and discussed in "Evaluation for CVOCs" on page 7." According to the time trend plots included in Attachment A, the concentrations of most chlorinated compounds are presumably indicated as "not detected" (e.g., vinyl chloride in well MKTF-16) because the limit of detection (LOD) values for chlorinated compounds were elevated due to the required dilution for hydrocarbon constituents (e.g., benzene in well MKTF-16). When elevated hydrocarbon constituent concentrations are present, this interface prevents the accurate assessment of the natural attenuation potential. Discuss the possibility of using separate analytical methods where the dilution of the hydrocarbon constituents is unnecessary and chlorinated compounds can be quantified with a greater sensitivity (e.g., gas chromatography with an electron capture detector) in the response letter.	Method 8260 is the best method for the CVOCs. The lab will attempt to achieve the lowest detection limits as possible without damaging their instruments and risking carry-over. Gas chromograph and electron capture (Method 504.1) is not approved for the CVOCs of interest.

NMED Comment	Refinery Response
Comment 5:	**Response 5:**
In the response to NMED's Disapproval Comment 10, the Permittee states, "Table 1 has been updated to provide all available MNA data for CVOC and MTBE. Table 2 provides the MNA criteria put forth by EPA. Table 3 summarizes the score for the applicable refinery wells and uses the EPA guidelines to characterize the evidence for MNA as either inadequate, limited, adequate or strong." Table 1 lists several water quality parameters; however, it is not clear which parameters are pertinent to the evaluation of MTBE natural attenuation. Provide an explanation in the response letter. In addition, Tables 2 and 3 evaluate evidence of potential natural attenuation for chlorinated compounds; however, these tables do not include the evaluation for MTBE. NMED's Disapproval Comment 10 states, "[t]his [natural attenuation] evaluation must focus on the fate of chlorinated compounds and MTBE." Provide additional tables, similar to Tables 2 and 3, to evaluate the potential of natural attenuation for MTBE at the site.	Per the EPA guidance document "Technical Protocol for Evaluation the Natural Attenuation of MTBE" (API 2007), DO, nitrate, dissolved iron, sulfate, methane, total alkalinity, ORP, pH, temperature, and conductivity provide an indication of the dominant geochemical environment, which may be helpful for identifying potential degradation mechanisms. Table 6 has been revised to include information on which parameters can be used for MTBE MNA evaluation. Tables 2 and 3 are specific to evaluating natural attenuation of CVOC constituents, per the USEPA guidance (USEPA 1998). The API protocol (2007) does not provide a similar procedure. A tiered approach will be used to evaluate the natural attenuation of MTBE, as discussed in the API protocol (2007). The tiered approach relies on multiple lines of evidence: Tier 1 involves evaluating the dissolved-phase MTBE plume (i.e., is the plume stable, increasing, or decreasing); Tier 2 involves analyzing geochemical data to determine if biological activity is present (e.g., DO, ORP, iron); and Tier 3 includes supplemental data to better define the contribution of biodegradation to natural attenuation. Tier 3 is required for only a small number of sites (API 2007) and the Refinery is not going to conduct this level of evaluation at this time.

ATTACHMENT 2

REPLACEMENT PAGES

MARATHON
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Jamestown, NM 87347

December 17, 2021

Mr. Kevin Pierard, Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

RE: Revised Natural Attenuation Assessment and Proposed Workplan for the Hydrocarbon Seep Area
Western Refining Southwest LLC, Gallup Refinery
(dba Marathon Gallup Refinery)
EPA ID# NMD000333211

Dear Mr. Pierard:

Western Refining Southwest LLC, (D/B/A Marathon Gallup Refinery [Refinery]) is submitting this letter in response to a request from the New Mexico Environment Department (NMED) Hazardous Waste Bureau for an assessment of natural attenuation in the hydrocarbon seep area at the Gallup refinery. This request was contained in the following correspondence:

- Letter dated February 1, 2018, *Disapproval, Interim Measures Report Hydrocarbon Seep Area, Western Refining Southwest Inc., Gallup Refinery, EPA ID# NMD000333211, HWB-WRG-15-002*
- Letter dated January 26, 2021, *Disapproval, Natural Attenuation Assessment and Proposed Work Plan for the Hydrocarbon Seep Area*
- Letter dated September 28, 2021, *Approval with Modifications, Response to Disapproval, Natural Attenuation Assessment and Proposed Work Plan for the Hydrocarbon Seep Area*

More specifically, the request is presented in NMED February 2018 letter Comment 12, #2 through #5; relevant portions of which are excerpted as follows:

2. *The field analytical parameters such as dissolved oxygen concentration and oxidation-reduction potential (ORP) must be evaluated and presented to support the argument that reducing conditions and anaerobic degradation are occurring. Also, the ratio of total and dissolved iron concentrations must be examined to support the argument…*
3. *…Revise the Report to propose submittal of a work plan to investigate the occurrence of anaerobic dechlorination.*
4. *The accumulation of vinyl chloride may be occurring based on the site's groundwater conditions. In the plan referenced in Item 3 above, propose to monitor and evaluate the groundwater for analytical parameters pertinent to the accumulation of*

> *degradation of vinyl chloride (e.g., concentrations of daughter products, dissolved oxygen, chloride, redox potential and pH)…*
>
> 5. *The Permittee must evaluate for the occurrence of hydrocarbon and MTBE degradation (e.g., concentrations of the electron acceptors, degradation byproducts, redox potential, and pH). Include all findings and interpretation of the existing data in the revised Report.*

Pursuant to the above request, this letter presents an evaluation of monitored natural attenuation (MNA) using existing monitoring well analytical data and proposes a workplan consisting of a similar evaluation of natural attenuation for future analyses. Findings will be included in an MNA evaluation report. Table 1 and Figure 1.A present the monitoring wells within the area that were evaluated. The MNA wells consist of selected MKTF-designated wells within and hydraulically upgradient of the Hydrocarbon Seep Area. These wells contain chlorinated volatile organic compounds (CVOCs) above the NMED Groundwater Cleanup Levels (New Mexico Administrative Code 20.6.2.3103) and methyl tert-butyl ether (MTBE) above the NMED Tap Water Standards (Risk Assessment Guidance, Table A-1, Tap Water, March 2017). In addition, the selected wells were without observable separate phase hydrocarbon (SPH) in 2020.

Table 1 includes key analytical data collected between 2018 and 2020 for CVOCs, volatile organic compounds (VOC), MTBE, MNA indicator parameters, and relevant field parameters. These data are used to evaluate the potential for MNA in procedures developed by the U.S. Environmental Protection Agency (USEPA) (1998) and the American Petroleum Institute (API) (2007). A more complete data set of laboratory analytical results from the period 2014 through 2020 is used for the statistical trend analysis (Attachments A and B). Figure 1.A shows the location of these wells, and also the wells with SPH detected in the 3rd Quarter 2020 sampling event.

Background

The Hydrocarbon Seep area is located in the western portion of the refinery to the west-southwest of the refinery tank farm. Historically, the Hydrocarbon Seep Area has been impacted by releases of SPH associated with refinery operation. Hydrocarbon seeps were discovered in 2013.

CVOCs detected in groundwater as part of routine quarterly monitoring in this area between 2014 and 2020 include trichloroethene (TCE), 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), tetrachloroethene (PCE), and vinyl chloride. Monitoring wells with consistent detection of vinyl chloride are shown in Figure 1.A. Hydrocarbon VOCs detected above the NMED Groundwater Cleanup Level standards include benzene, toluene, ethylbenzene, and xylenes (BTEX), and MTBE. Monitoring wells with consistent detections of CVOCs and MTBE are shown in Figure 1.B. Table 1 presents recent groundwater analytical data for monitoring wells in the Hydrocarbon Seep Area and nearby Marketing Tank Farm (MKTF) monitoring wells.

Hydrogeology

Surface Conditions

Site topographic features include high ground in the southeast gradually decreasing to a lowland fluvial plain to the northwest. Elevations on the refinery property range from 7,040 feet (ft) to 6,860 feet. Surface soils within most of the area of investigation are primarily Rehobeth silty clay loam. Rehobeth soil properties include alkaline pH (ranging from 8 to 9 standard units) and salinity (naturally occurring and typically measuring up to approximately 8 millimhos per centimeter (MPC 2019).

Local surface water features include the refinery evaporation ponds and a number of small ponds.. The site is located in the Puerco River Valley, north of the Zuni Uplift with overland flows directed northward to the tributaries of the Puerco River. The Puerco River continues to the west to the confluence with the Little Colorado River. The South Fork of the Puerco River is intermittent and retains flow only during and immediately following precipitation events (MPC 2019).

Subsurface Conditions

The shallow subsurface soils consist of fluvial and alluvial deposits comprised of clay and silt with minor inter-bedded sand layers. Very low permeability bedrock (e.g., claystones and siltstones) underlie the surface soils and effectively form an aquitard. The Chinle Group, which is Upper Triassic, crops out over a large area on the southern margin of the San Juan Basin. The uppermost recognized local Formation is the Petrified Forest Formation and the Sonsela Sandstone Bed is the uppermost recognized regional aquifer (MPC 2019). Aquifer test of the Sonsela Bed northeast of Prewitt indicated a transmissivity of greater than 100 ft squared per day (Stone and others, 1983). The Sonsela Sandstone's highest point occurs southeast of the site and slopes downward to the northwest as it passes under the refinery. The Sonsela Sandstone forms a water-bearing reservoir with artesian conditions throughout the central and western portions of the refinery property.

The diverse properties and complex, irregular stratigraphy of the surface soils across the site cause a wide range of hydraulic conductivity ranging from less than 10^{-2} centimeters per second (cm/sec) for gravelly sands immediately overlying the Petrified Forest Formation to 10^{-8} cm/sec in the clay soils located near the surface (Western 2009). Generally, shallow groundwater at the refinery follows the upper contact of the Petrified Forest Formation with prevailing flow from the southeast to the northwest.

Three-dimensional geological modeling using available boring log information strongly suggests that the swale in the area of the hydrocarbon seep area is underlain by a corresponding swale in the shallow alluvium that likely influences shallow groundwater flow in this area. This is shown in Figure 2.

Monitored Natural Attenuation
MNA was assessed for this area following references published by the Interstate Technology Regulatory Council (ITRC) (1999), the USEPA (1998), the New Jersey Department of Environmental Protection (NJDEP 2012), and the American Petroleum Institute (API 2007).

Dissolved organic compounds can be degraded naturally in groundwater, with the rate dependent on the redox state of the groundwater and the presence of suitable electron receptors for microbial degradation (NJDEP 2012). Biodegradation under aerobic (oxidizing) conditions is generally faster than under anaerobic (reducing) conditions, but degradation occurs under both redox regimes.

In general, reducing conditions are present in the subsurface where SPH and dissolved organic compounds (e.g., CVOCs, MTBE, BTEX) are present in groundwater. This has been established by numerous studies (ITRC 2009, Lawrence 2006, and NJDEP 2012).. This redox condition is caused by depletion of oxygen through aerobic biodegradation of the dissolved petroleum. A generalized diagram of typical hydrocarbon groundwater plume redox conditions is shown Figure 3. When a release of hydrocarbons occurs into groundwater, existing microbes catalyze reactions between the electron-donating carbon and the electron acceptors, in a sequence that is most favorable to the microbes (ITRC 2010). In general, the sequence of electron acceptor use is as follows:

$$O_2 > NO_3^- > \text{Mn(III) or Mn (IV)} > \text{Fe(III)} > SO_4^{-2} > CO_2$$

The presence of the oxidized inorganic compounds shown above indicates the potential for biodegradation. Moreover, the presence of the reduced forms of these species generally indicates active biodegradation.

The strongest reducing conditions are generally present in the source area of the hydrocarbon plume where SPH is present. More oxidizing (less reducing) conditions are generally present in the downgradient direction of the dissolved hydrocarbon plume, as shown in Figure 4. Figure 4 also shows the areas of the plume where redox conditions are sufficient to allow reduction of the indicated species.

CVOCs generally require anaerobic conditions for biodegradation. Figure 4 presents a list of CVOCs and the likelihood of biodegradation through various degradation mechanisms/pathways. As shown in this figure, the primary mechanisms for biodegradation are reductive dechlorination and dichloroelimination.

Studies of MTBE aerobic biodegradation indicate that it is less recalcitrant than previously thought (Lawrence 2006 and API 2007). Anaerobic biodegradation proceeds more slowly under reducing conditions ranging from methanogenic to nitrate-reducing.

Evaluation of Current MNA Conditions

Table 1 presents recent (2018 to 2020) groundwater analytical data from the hydrocarbon seep area wells, including organic and inorganic analytes, dissolved oxygen (DO), temperature, and oxidation reduction potential (ORP). This date range was selected to represent current conditions for the analysis of the key MNA parameters. A trend analysis was also conducted using data from the period 2014 through 2020 and is presented in Attachments A and B (CVOCs and MTBE, respectively).

Table 1 includes laboratory analytical data and field data collected during well purging, including temperature, pH, DO, and ORP. Field measurements of DO and ORP can be an indicator of the redox regime of groundwater, with the method of field measurement important to the absolute value of the results. Field pH/ORP is measured using a silver/silver chloride reference electrode. In general, for more accurate measurements of DO/ORP, a groundwater sampling pump and a flow-through cell for well purging and measuring DO/ORP is preferred because this configuration eliminates contact with air. For the DO/ORP data presented in Table 1, measurements were conducted using bailed water from a well, which was then placed into a container for ORP measurement. This procedure introduces oxygen, and actual in situ groundwater conditions would be expected to have a lower, more reducing DO/ORP. Nevertheless, the data in Table 1 can be evaluated in a relative sense for trends.

Evaluation for CVOCs and MTBE

Qualitatively, current conditions and available geochemical data provide multiple lines of evidence that reducing conditions are present in the Hydrocarbon Seep Area. These reducing conditions create a geochemical environment for the anaerobic biodegradation of SPH and dissolved VOCs and may also be conducive to the anaerobic biodegradation of CVOCs (TCE, 1,1-DCA and 1,2-DCA) (USEPA 1998) and MTBE (API 2007).

Evidence for conditions favorable for anaerobic biodegradation of CVOCs and MTBE includes:

- Elevated benzene concentrations indicating that a high dissolved hydrocarbon load is present and anaerobic conditions are occurring. SPH is also present in several areas (Figures 1.A and 1B), which represents a continuing source for dissolved phase hydrocarbons.
- Detection of vinyl chloride, 1,1-DCE, and cis-1,2-DCE, which are typical byproducts of TCE degradation. Vinyl chloride was detected consistently in monitoring wells MKTF-2, MKTF-10, MKTF-24, and MKTF-25, as shown in Figure 1.A.
- Presence of dissolved iron and total iron, indicating likely presence of ferrous iron in response to reducing conditions and anaerobic biodegradation.
- Depleted sulfate in wells with elevated benzene (e.g., MKTF-10, MKTF-16, MKTF-17), indicating reducing condition and sulfate reduction to sulfite as part of anaerobic biodegradation.

- Presence of manganese, indicating availability as an electron receptor for anaerobic biodegradation.
- Occasional detection of nitrite above detection limits, indicating reducing conditions and probable use of nitrate as an electron receptor for anaerobic biodegradation.
- Neutral to slightly basic pH conditions, which are favorable for biodegradation.
- Low ORP measurements, indicating reducing conditions are present particularly for MKTF wells located in the paved areas where SPH is present (Figure 1). Wells located to the west in unpaved areas without SPH and elevated dissolved hydrocarbon such as benzene are generally oxidizing.

For CVOCs specifically, the detection of vinyl chloride, 1,1-DCE, and cis-1,2-DCE is important because they are typical byproducts of TCE degradation. Vinyl chloride was detected consistently in monitoring wells MKTF-2, MKTF 10, MKTF-24, and MKTF-25, as shown in Figure 1.A. Chloride concentrations are generally elevated in the MKTF wells, as shown in Table 1, but do not correlate with areas of elevated CVOCs. In the absence of high chloride from other sources, elevated chloride can be used as an indicator of the biodegradation of CVOCs (NJDEP 2012).

CVOC MNA Scoring Criteria
From a more quantitative standpoint, an evaluation was conducted on a well-by-well basis in accordance with USEPA guidance (USEPA 1998). Table 2 presents the scoring criteria from the USEPA and the applicability of the criteria to the Hydrocarbon Seep Area, given the analytical requirements of the existing approved Sampling Plan (Western 2021) and current field sampling practices. Table 3 shows the implementation of the scoring for each well, and presents the final evaluation score for each well, which summarizes the potential for CVOC natural attenuation (reductive dichlorination). Four categories of scores assess the potential for anaerobic biodegradation of CVOCs, as follows:

> 20	Strong evidence
15 to 20	Adequate evidence
6 to 14	Limited evidence
0 to 5	Inadequate evidence.

As shown in Table 3, the evidentiary scores ranged from 7 to 16, with nine wells deemed “Limited” category and one well deemed “Adequate.”

Statistical Analyses

Statistical analyses were performed to determine if the analytical data results from the current monitoring period represent statistical upward or downward trends in analyte concentrations in the groundwater samples collected from MKTF-designated wells.

Statistical Methods

QAQC and Data Handling

Trace concentrations (estimated results between the reporting limit [RL] and the method detection limit [MDL]) reported since 06/08/2016 were treated as true detected values. Therefore, being the upper bound of non-detect (ND) results, the MDL was used as substitute values for ND values in all statistical evaluations, unless stated otherwise (see Exploratory Data Analysis and General Statistics section). R® (R Core Team, 2020), a programing language and software environment for statistical analysis, was used for all statistical needs.

The statistical evaluation was performed for six chlorinated volatile organic compounds (CVOCs; 1,1-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, cis-1,2-dichloroethene, trichloroethene, and vinyl chloride) and methyl tert-butyl ether (MTBE). All constituents were reported in mg/L. Seven wells for CVOCs (i.e., MKTF-02, MKTF-09, MKTF-10, MKTF-16, MKTF-2, MKTF-24, MKTF-25) and 11 wells for MTBE (i.e. MKTF-04, MKTF-09, MKTF-16, MKTF-17, MKTF-19, MKTF-20, MKTF-21, MKTF-22, MKTF-23, MKTF-24, MKTF-25) were part of the 2020 evaluation.

Exploratory Data Analysis and General Statistics

Exploratory Data Analysis (EDA) was performed on all well-analyte combinations and are presented in Table 4 and Table 5, for the CVOCs and MTBE respectively. For each analyte-location pair, these statistics include the number of samples collected since April 8, 2014, the overall detection rate, the minimum and maximum detected concentrations, the minimum and maximum MDLs reported by laboratories, the overall sample mean, median, and sample standard deviation, and the dates of the range of the first and last sample.

Time Series Plots and Outlier Analysis

Outlier analysis was performed at a 95% confidence level using the Dixon's and Grubbs' tests when the sample size for each analyte-location pair, *n*, was more than 4 but less than 30, with at least one detected result. If the sample size was greater than 25, then the Rosner's test was used instead of or in addition to the two tests mentioned above and up to 3 potential outliers were considered. Because outlier tests' assumptions are often difficult to attain with real data, and the presence of one outlier can mask the detection of another, any extreme and unusual values flagged as outliers by any of the outlier tests (e.g., concentration 3 times greater or 1/3 smaller than the overall concentration) were graphically confirmed using time series plots. The last results were never considered an outlier regardless of their value because they could be the results of a recent event. Results from the outlier analysis are also presented in Table 4 (CVOCs) and Table 5 (MTBE).

For each analyte-location pair, time series plots were constructed to show any potential trend in CVOCs and MTBE. In addition, any graphically confirmed outliers were also shown on the time series plots (Attachments A [CVOCs] and B [MTBE]).

Nonparametric Trend Analysis

Non-parametric trend analysis was conducted for all analyte-location pairs with a sample size equal to or greater than 8 (not including graphically confirmed outliers) and one detected result above the MDL to assess the temporal stationarity of the constituents' concentrations through time. To avoid trends in the MDLs driving the trend analysis results, the USEPA (2009) recommends ND values be assigned "a common value lower than any of the detected measurements" (USEPA 2009, Section 17.3.2 p. 17-31). ND values were assigned half of the minimum MDLs in each location for all analyses related to the trend analysis. Trend analyses were performed using the nonparametric approach, Mann-Kendall's monotonic trend analysis. Traditional Mann-Kendall trend analysis relies on several assumptions such as no serial correlation, no outliers, and no seasonality. The presence of serial correlation was tested for each location using the rank von Neumann ratio test at 95% confidence level and the results were graphically confirmed using Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). The presence of outliers in the data was addressed during the outlier analysis described above. Seasonal effects between the Summer-Fall (May to October) and Winter-Spring (November to April) sampling events were tested using Wilcoxon-Mann-Whitney tests at a 90% confidence level. The assumption of homogeneity of variance between the two seasons for the Wilcoxon tests for each COC-well combination was performed using the traditional Levene's test. In the absence of both serial autocorrelation and seasonal effect, the traditional Mann-Kendall trend analysis test was used. When serial correlation was identified, a modified Mann-Kendall test for serially correlated data using the Yue and Wang (Yue, 2004) variance correction approach was used. When seasonality was present in the data, a standard seasonal Mann-Kendall test, which performs a nonparametric test for a monotonic trend within each season based on Kendall's tau statistic, was used. Finally, if the presence of both serial correlation and seasonality in the data was confirmed the seasonal Mann-Kendall approach was adapted to handle serial correlation. Results from all trend analyses for the CVOC are presented in Table 4 and for MTBE in Table 5.

Results

COVCs

Nonparametric monotonic increasing trends were identified since 2014 for the following analyte-well pairs with 95% confidence (Table 4):

- 1,1-dichloroethene in wells MKTF-10 and MKTF-22
- Vinyl chloride in wells MKTF-02, MKTF-10, MKTF-24

In addition, evidence of decreasing monotonic trends since 2014 was found, with 95% confidence, for 1,1-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, and trichloroethene in wells MKTF-02, MKTF-09, MKTF-24, and MKTF-25.

All other analyte-well pairs showed no evidence of an overall trend since 2014 at a 95% confidence level.

MTBE

The Mann-Kendall (MK) trend analysis test found no evidence of monotonic increasing trends since 2014 for MTBE in the 11 wells with 95% confidence (Table 5). Recent changes in MTBE in well MKTF-17 and MKTF-25 will be monitored moving forward (see time series plot in Attachment B).

In addition, evidence of decreasing monotonic trends since 2014 was found, with 95% confidence, for MTBE in wells MKTF-09, MKTF-16, MKTF-21, and MKTF-24.

All other analyte-well pairs showed no evidence of an overall trend since 2014 at a 95% confidence level.

Proposed Workplan for Natural Attenuation Evaluation for Future Annual Reports

The proposed workplan to evaluate natural attenuation is presented in this section for NMED review and approval. The Refinery proposes that a natural attenuation evaluation be completed annually for the wells discussed in this report: MKTF-02, MKTF-04, MKTF-09, MKTF-10, MKTF-13, MKTF-16, MKTF-17, MKTF-19, MKTF-20, MKTF-21, MKTF-22, MKTF-24, and MKTF-25 (Figures 1.A and 1.B). Sampling will be conducted concurrently with the third quarter monitoring event. Samples will be analyzed for the constituents presented in Table 6 and used as lines of evidence for MNA. These lines of evidence will include:

- BTEX, MTBE, tertiary butyl alcohol (TBA), PCE, TCE, cis-1,2- DCE, 1,1-DCE, 1,1-DCA, 1,2-DCA, and vinyl chloride concentrations
- Ethene, ethane, and methane analysis will be conducted in four monitoring wells with elevated vinyl chloride concentrations (MKTF-2, MKTF-10, MKTF-24, and MKTF-25)
- Dissolved/total iron and manganese, nitrate/nitrite, and sulfate/sulfide to determine their availability as terminal electron receptors and the redox state

- Chloride as the end point of 1,1-DCA and 1,2-DCA degradation
- Field parameters such as pH, temperature, ORP, and DO

The evaluation in future MNA reports will include data tables summarizing these analytes, updating the USEPA quantitative spreadsheet scoring the MNA potential, and updating the MK statistical trend analysis for CVOCs and MTBE. A discussion section will be added summarizing natural attenuation progress, including trends in contaminant concentrations and key MNA indicators. The MNA evaluation will be submitted to NMED in a letter report. Reports will be submitted on March 31 of each year starting in 2022.

If you have any questions or comments regarding the information contained herein, please do not hesitate to contact Mr. John Moore at (505) 879-7643.

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction of supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Sincerely,
Western Refining Southwest LLC, Marathon Gallup Refinery

Ruth Cade
Vice-President

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Tables

TABLE 1. MKTF WELLS VOC AND MNA ANALYTICAL DATA 2018-2020
MARATHON GALLUP REFINERY, GALLUP, NEW MEXICO

Well ID	Date Sampled	PCE (mg/L)	TCE (mg/L)	cis-1,2-DCE (mg/L)	1,1-DCA (mg/L)	1,2-DCA (mg/L)	1,1-DCE (mg/L)	Vinyl Chloride (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylene (mg/L)	BTEX (mg/L)	TPH-GRO (mg/L)	TPH-DRO (mg/L)	MTBE (mg/L)	Chloride (mg/L)	Fe, Dissolved (mg/L)	Fe, Total (mg/L)	Mn, Dissolved (mg/L)	MN, Total (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)	DO (mg/L)	ORP (mV)	pH	T (C)
MKTF-2	12/18/20	ND	<.001	ND	0.0291	-	0.00876	0.0241	0.885	0.161	0.0119	ND	1.0579	9.8	4.55	0.0317	3020	1.03	2.56	6.46	6.14	ND	185	7.24	191.7	6.9	11.5
	09/21/20	ND	<.001	0.0019	0.021	<.001	0.0014	0.027	4	0.52	0.033	0.0063	4.5593	7.9	2.1	0.061	1000	0.22	0.99	1.9	2	ND	64	0.21	285.1	6.7	14.76
	02/25/20	ND	<.001	ND	0.0065	-	0.0018	0.005	0.78	0.57	0.01	0.048	1.408	-	1.8	0.0091	1300	0.34	2	3	3	ND	160	5.77	127.3	8.7	NM
	11/19/19	<0.005	<0.005	0.0031	0.015	0.0047	0.0014	0.017	0.36	0.046	0.003	<0.0075	0.409	2.4	0.65	0.023	1900	0.48	5.7	2.5	2.9	<0.5	330	3.52	145	7.6	14.3
	08/23/19	<0.02	<0.02	<0.02	0.027	0.012	<0.02	0.028	0.99	0.078	0.012	<0.03	1.08	3.9	3.1	0.051	2000	2.4	9.1	2	2.3	<0.5	150	3.01	-104.1	7.1	13.35
	05/06/19	<0.02	<0.02	<0.02	0.019	0.0064	0.0064	0.019	0.95	0.043	0.019	0.11	1.122	5.3	3.5	0.049	1600	3	3.9	1.8	1.9	<0.5	61	1.74	-92.2	6.9	12.31
	03/28/19	<0.02	<0.02	<0.02	0.016	0.0069	0.0073	0.013	0.62	0.01	0.016	0.13	0.776	4.1	3.8	0.047	1400	0.42	1.6	1.6	1.5	<1.0	52	1.92	46.1	8.3	11.18
	11/28/18	<0.01	<0.01	0.0086	0.044	<0.01	0.007	0.028	5.5	0.51	0.082	0.17	6.262	18	2.9	0.099	570	0.078	0.24	0.75	0.74	<0.5	5.6	-	-	7.7	12.95
	08/20/18	<0.01	<0.01	0.0099	0.042	0.0078	0.024	0.0071	2.5	0.14	0.031	0.031	2.702	7.8	1.3	0.1	510	0.027	0.2	0.51	0.52	<0.5	11	-	-	7.2	14.8
	05/01/18	<0.01	0.0018	0.016	0.033	0.0048	0.011	0.0063	2.9	0.24	0.039	0.12	3.299	9.1	3.2	0.097	520	0.03	0.36	0.57	0.62	<0.5	15	-	-	7.5	11.8
	02/06/18	<0.005	0.003	0.014	0.041	<0.005	0.018	0.0037	2.6	0.25	0.049	0.089	2.988	7.7	2.8	0.11	520	0.022	0.57	0.55	0.61	<1.0	20	-	-	8.4	10.26
MKTF-4	03/03/20	<0.005	<0.005	<0.005	0.0091	0.0023	0.013	<0.005	0.8	0.01	0.47	0.56	1.84	8.2	1.8	2.1	220	1.4	6	1.8	1.9	<0.5	9.3	2.02	30.1	8.4	12.89
	10/30/19	<0.005	<0.005	<0.005	0.0055	<0.005	0.0073	<0.005	0.93	0.012	0.71	0.74	2.392	10	0.73	1.8	210	5.4	7.6	1.5	1.6	<0.5	2.9	-	-	-	-
	08/21/19	<0.001	0.00083	0.0091	0.013	0.0015	0.017	<0.001	0.53	0.0091	0.42	0.44	1.3991	6.4	4.3	1.6	220	1.5	5.9	2	2.2	0.12	16	-	-	-	-
	05/13/19	<0.005	0.00087	<0.005	0.0054	0.0016	0.0075	<0.005	0.77	0.013	0.62	0.73	2.133	9.6	5.4	1.7	260	4.5	8	1.6	1.6	<0.5	5.6	-	-	-	-
	03/26/19	<0.005	<0.005	<0.005	0.0047	0.0019	0.0068	<0.005	0.78	0.014	0.62	0.74	2.154	10	5	1.6	240	1.8	6.8	1.6	1.5	<0.5	4.7	-	-	-	-
	11/20/18	<0.002	<0.002	0.0071	0.011	<0.002	0.017	<0.002	1.1	0.011	0.61	0.65	2.37	7.6	4.5	2.2	210	1	5.1	1.5	2.3	<0.5	9.6	-	-	-	-
	9/14/18	<0.010	<0.010	0.008	0.0074	0.0043	0.0077	<0.010	1.1	0.014	0.7	0.86	2.67	12	4.7	1.8	200	3.2	5.7	1.5	1.4	0.083	5.5	-	-	-	-
	5/2/18	<0.010	0.0017	0.0095	0.014	<0.010	0.02	<0.010	1.1	0.016	0.74	0.89	2.75	12	4.9	2.3	200	2.4	5.3	1.5	1.7	<0.5	9.8	-	-	-	-
	2/14/18	<0.010	<0.010	0.011	0.0084	<0.010	0.012	<0.010	0.9	0.014	0.6	0.71	2.22	9.6	5	2.0	220	1.9	5.2	1.5	1.5	<0.5	8.6	-	-	-	-
MKTF-9	03/03/20	-	-	-	-	-	-	-	3.2	0.2	0.012	0.059	3.471	6.3	1	0.53	290	1.4	2.4	4.1	4	ND	46	1.91	51.2	8.0	11.22
	11/18/19	<0.01	<0.01	0.011	0.011	<0.01	0.015	<0.01	3.7	0.23	0.014	0.069	4.013	10	1.0	0.45	220	2.4	3.4	4.2	4.3	<0.5	25	1.46	29.8	7.4	16.1
	08/23/19	<0.02	<0.02	0.012	0.014	<0.02	0.017	<0.02	3.5	0.27	0.021	0.098	3.889	12	3.9	0.42	230	3.8	4.5	4.4	4.5	<0.5	12			6.9	14.84
	05/13/19	<0.01	<0.01	<0.01	0.0068	<0.01	0.0063	<0.01	3.2	0.28	0.025	0.095	3.6	8.4	3.1	0.31	250	3.2	3.8	4.6	4.8	<0.5	8.1	2.41	-74.3	6.5	14.27
	03/26/19	<0.02	<0.02	0.02	0.0091	<0.02	0.0091	<0.02	2.2	0.22	0.019	0.098	2.537	8.2	2.5	0.24	240	3.9	4.4	4.6	4.2	<0.5	10	1.58	-59.9	7.9	12.1
	11/28/18	<0.02	<0.02	0.02	0.022	<0.02	0.034	<0.02	3.3	0.19	0.02	0.073	3.583	9.1	1.8	0.56	260	0.82	1.9	4.1	3.9	<0.5	24	-	-	7.3	13.85
	09/04/18	<0.02	<0.02	0.021	0.09	<0.02	0.028	<0.02	2.7	0.25	0.019	0.084	3.053	11	2.4	0.43	260	0.94	1.8	4.4	4.2	<0.5	17	-	-	NM	NM
	05/02/18	0.0028	0.0032	0.023	0.026	<0.01	0.036	<0.01	2.8	0.28	0.025	0.098	3.203	8.2	2.6	0.49	250	1.4	2.3	3.9	4.4	0.21	22	-	-	NM	NM
	02/14/18	0.002	0.0029	0.026	0.015	<0.01	0.028	<0.01	2.7	0.25	0.024	0.084	3.058	8.7	2.2	0.48	220	1.3	2.3	4	3.9	<0.5	27	-	-	6.9	11.30
MKTF-10	12/18/20	ND	ND	ND	0.04	-	ND	ND	4.67	1.8	0.284	8.6	15.354	-	5.54	ND	937	7.25	10.7	4.81	5.07	ND	ND	2.87	220.4	6.9	11.2
	03/03/20	ND	ND	0.0041	0.047	-	0.0066	0.0089	4.8	1.7	0.65	8.2	15.35	40	1.3	0.0094	970	7.2	12	5.4	5.5	ND	ND	1.61	3	7.8	11.84
	10/30/19	<0.01	<0.01	0.039	0.031	<0.01	0.0059	0.01	5.5	1.7	0.57	7.2	14.97	40	0.35	0.017	1000	14	15	6.2	6.3	<0.5	<2.5	1.4	-1.2	7.2	13.6
	08/22/19	<0.01	<0.01	0.034	0.037	<0.01	0.0075	0.01	4.6	1.6	0.66	7.4	14.26	35	3	0.019	960	7.9	11	5.4	5.6	0.1	<2.5	-	-	7.0	18.34
	05/13/19	<0.05	<0.05	<0.05	0.027	<0.05	0.013	0.023	5.5	1.7	0.9	7.9	16	48	3.5	0.024	460	8.4	8.9	3.4	3.6	<0.5	<2.5	1.78	-87.1	6.2	15.95
	03/26/19	<0.1	<0.1	0.05	0.04	<0.1	<0.1	0.042	5	1.7	0.86	7.9	15.46	50	2.6	0.047	390	7	8.9	3.1	3.1	<0.5	0.4	1.16	-24.4	7.9	11.9
	11/20/18	<0.02	<0.02	0.058	<0.02	<0.02	0.0051	0.0074	11	1.9	1.9	8	22.8	53	2.8	0.01	320	6.1	8.3	2.9	3	<0.5	<2.5	-	-	7.3	12.68
	09/04/18	<0.05	<0.05	0.047	<0.05	<0.05	0.012	0.018	10	1.8	2.4	8.1	22.3	57	2.5	<0.05	340	6.8	7.7	2.9	2.8	<0.5	<2.5	-	-	NM	NM
	05/02/18	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	13	2.1	4.9	9.6	29.6	100	3.7	0.03	380	9.2	11	3.3	3.9	<0.5	<2.5	-	-	NM	NM
	02/14/18	<0.05	<0.05	0.066	<0.05	<0.05	<0.05	0.018	10	1.8	3.7	8.3	23.8	74	2.6	0.014	390	9.7	12	3.7	3.6	<0.5	<2.5	-	-	NM	NM
MKTF-13	10/29/19	-	-	<0.02	-	<0.02	<0.02	-	4.7	0.6	0.11	2.6	8.01	23	7.3	0.33	290	15	20	4.6	4.7	<0.5	0.59	0.85	-8.4	7.2	13.8
	08/20/19	-	-	-	-	-	-	-	0	0	0	0	0			-	-	-	-	-	-	-	-	-	-	NM	NM
	05/09/19	-	-	<0.02	-	<0.02	<0.02	-	3.2	0.32	0.12	2.6	6.24	19	63	0.48	400	26	35	8.2	6.1	<0.5	1.1	-	-	NM	NM
	03/26/19	-	-	<0.02	-	<0.02	<0.02	-	3.5	0.6	0.14	3.5	7.74	27	8.1	0.44	390	24	25	5.1	4.7	<1.0	0.75	-	-	NM	NM
	11/28/18	-	-	<0.02	-	<0.02	<0.02	-	4.5	0.53	0.13	2.8	7.96	24	4.5	1.4	220	10	16	4.4	4.4	<0.5	<2.5	-	-	7.1	14.17
	08/30/18	-	-	<0.02	-	<0.02	<0.02	-	3.5	0.65	0.12	3.2	7.47	26	5.5	1.2	210	16	19	5.1	4.7	0.12	<2.5	-	-	NM	NM
	05/10/18	-	-	<0.001	-	<0.005	0.0025	-	4.8	0.87	0.15	4	9.82	28	30	2	190	14	17	4.6	4.6	0.21	1.2	-	-	NM	NM
MKTF-16	12/23/20	ND	ND	ND	ND	-	ND	ND	14.7	1.32	0.129	ND	16.149	-	-	0.279	-	-	10.7	-	2.54	-	-	0.98	53.8	6.8	14.2
	10/30/19	<0.1	<0.1	<0.1	0.069	<0.1	<0.1	<0.1	15	1.5	0.095	0.43	17.025	33	0.24	4.9	1700	15	17	0.62	5.5	<0.5	<2.5	-	-	NM	NM
	08/22/19	<0.1	<0.1	<0.1	0.064	<0.1	<0.1	<0.1	9.8	0.48	0.043	0.11	10.433	20	3.6	6.8	1800	21	24	0.55	7.1	<0.5	<2.5	-	-	6.8	22.88
	05/14/19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	14	0.71	0.11	0.62	15.44	30	3.4	3	960	5.8	5.8	0.62	2.6	<0.5	0.68	0.97	-78	6.2	15.96
	02/20/19	<0.1	<0.1	<0.1	0.053	<0.1	<0.1	<0.1	21	1.4	0.19	1.6	24.19	48	2.2	1.7	590	2	5.8	0.61	1.7	<0.5	0.41	2.1	-55.1	7.7	13.47
	11/29/18	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	0.89	0.12	0.72	18.73	34	2.6	1.5	620	2.7	4.1	0.69	1.5	<0.5	0.64	-	-	NM	NM
	08/31/18	<0.1	<0.1	<0.1	0.047	<0.1	<0.1	<0.1	17	1.3	0.13	1.4	19.83	50	3.3	1.7	650	1.8	3.6	0.64	1.8	<1.0	1.4	-	-	6.9	23.9
	05/11/18	<0.05	<0.05	<0.05	0.036	<0.05	<0.05	<0.05	19	1.6	0.17	2	22.77	47	2.9	1.9	840	3.4	4.3	0.64	1.9	0.099	1.2	-	-	7.0	18.6
	02/15/18	<0.01	<0.01	<0.01	0.0062	<0.01	<0.01	0.0058	1.8	0.015	0.024	0.23	2.069	8.4	2.4	0.8	760	0.095	18	0.04	0.37	0.13	57	-	-	6.9	15.24
MKTF-17	10/29/19	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	12	1.1	23	3.1	39.2	78	0.7	3.4	240	0.45	4.8	2.5	3.5	<0.5	6.2	2.27	169.9	7.5	14.0
	08/20/19	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.87	0.64	0.0026	0.078	1.5906	7.6	3.3	3	140	0.37	3	4.3	2.8	<0.5	14	-	-	7.0	15.03
	05/09/19	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	2.2	0.49	0.0022	0.15	2.8422	9.1	7.6	3.1	100	0.27	5.4	4.3	3	<0.5	15	1	-93.8	6.4	11.94
	03/26/19	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.98	0.09	<0.005	0.021	1.091	7	1.9	2.8	130	0.23	2.2	4.6	2.7	<0.5	48	3.75	2.7	7.7	10.99
	11/28/18	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0036	0.025	<0.005	<0.0075	0.0286	3	1.6	2.2	110	0.27	2	5.7	2.5	<0.5	120	-	-	7.6	13.56
	08/24/18	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.0027	0.12	<0.005	<0.0075	0.1227	4.7	<1.0	2.4	110	0.39	1.7	5.3	2.4	<0.5	160	-	-	7.3	17.3
	05/04/18	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.047	0.14	0.0011	0.002	0.1901	7.1	1.4	2.8	130	0.17	1.8	7.4	2.7	0.054	68	-	-	7.1	13.8
	02/16/18	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.22	0.21	0.00098	<0.0075	0.43098	3.7	1.36	2.6	100	0.13	1.7	4.9	2.9	<0.5	52	-	-	7.0	13.00

TABLE 1. MKTF WELLS VOC AND MNA ANALYTICAL DATA 2018-2020
MARATHON GALLUP REFINERY, GALLUP, NEW MEXICO

Well ID	Date Sampled	PCE (mg/L)	TCE (mg/L)	cis-1,2-DCE (mg/L)	1,1-DCA (mg/L)	1,2-DCA (mg/L)	1,1-DCE (mg/L)	Vinyl Chloride (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylene (mg/L)	BTEX (mg/L)	TPH-GRO (mg/L)	TPH-DRO (mg/L)	MTBE (mg/L)	Chloride (mg/L)	Fe, Dissolved (mg/L)	Fe, Total (mg/L)	Mn, Dissolved (mg/L)	MN, Total (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)	DO (mg/L)	ORP (mV)	pH	T (C)
MKTF-19	10/29/19	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.6	0.61	0.013	0.61	2.833	17	1	7.9	130	10	15	2.4	2.4	<0.5	0.5	1.1	13.9	7.3	14.5
	08/19/19	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.4	0.72	<0.02	0.69	2.81	18	13	8.3	140	11	19	2.3	2.7	<0.5	<2.5	-	-	6.9	14.10
	05/09/19	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.8	0.77	<0.02	0.61	3.18	19	11	7.8	140	11	15	2.4	2.7	<0.5	0.31	-	-	NM	NM
	03/26/19	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.3	0.71	<0.02	0.61	2.62	17	8.7	6.9	140	9.9	11	2.2	2.6	<0.5	0.34	0.98	-58	7.3	8.91
	11/28/18	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.9	0.63	<0.02	0.57	3.1	15	7.8	10	140	8.3	7.5	2.2	2.4	<0.5	<2.5	-	-	7.1	13.7
	08/24/18	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	1.7	0.71	0.0043	0.74	3.1543	22	7.9	9.7	120	10	15	2.3	2.4	<0.5	<2.5	-	-	NM	NM
	05/04/18	<0.005	<0.005	0.002	<0.005	<0.005	<0.005	<0.005	2	0.87	0.0057	0.82	3.6957	23	9.3	11	130	10	11	2.4	2.4	<0.5	1.2	-	-	NM	NM
	02/16/18	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.9	0.74	0.0037	0.64	3.2837	16	11	10	120	9.6	10	2.4	2.3	<0.5	<2.5	-	-	NM	NM
MKTF-20	2/5/20	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	0.62	0.0039	0.058	0.53	1.21	1	4.6	0.0057	-	-	-	-	-	-	-	-	-	-	-
	11/5/09	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	2.4	<0.010	0.26	0.096	2.76	7	1.5	0.17	140	2.2	4.3	2.1	2	<0.5	1.7	-	-	-	-
	8/21/19	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	4.8	0.009	1.1	3.7	9.61	28	5.1	0.035	3300	20	19	8.1	7.5	<0.5	2.8	-	-	-	-
	5/14/19	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	2.3	<0.010	1.0	3.5	6.80	25	5.4	0.032	3400	22	25	9	8.5	<0.5	36	-	-	-	-
	2/20/19	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	2.1	0.0021	0.23	0.14	2.47	7.3	9.8	0.22	760	47	58	5.5	5.5	<0.5	11	-	-	-	-
	11/29/18	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	3	0.02	0.12	2.5	5.64	17	6.9	0.026	460	2.5	8	2.5	2.6	<0.5	4.3	-	-	-	-
	8/31/19	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	9.9	0.064	0.77	9.1	19.83	70	11	0.096	560	5.3	5.8	2.8	3	<0.5	8.4	-	-	-	-
	5/11/18	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	13	0.14	1.3	13	27.44	76	9.7	0.13	1600	17	16	5.4	5.5	0.097	18	-	-	-	-
	2/15/18	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	12	0.19	0.96	12	25.15	79	5.1	0.055	3100	53	52	17	16	<0.5	15	-	-	-	-
MKTF-21	2/5/20	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.058	<0.005	0.0026	<0.0075	0.06	0.74	0.31	0.05	-	-	-	-	-	-	-	-	-	-	-
	11/5/19	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	5.6	0.0082	1.1	2.8	9.51	27	2.7	0.029	2300	8.3	9	6.2	5.8	<0.5	19	-	-	-	-
	8/22/19	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	5.4	<0.020	0.68	0.5	6.58	17	7.4	0.29	230	16	21	3.4	3.3	<0.5	6.2	-	-	-	-
	5/14/19	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	2.4	<0.020	0.28	0.22	2.9	8.5	9.4	0.29	540	33	42	5.6	5.7	<0.5	6.9	-	-	-	-
	2/20/19	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	2	0.016	1.2	7.1	10.32	40	20	0.015	4600	57	63	14	15	<0.5	880	-	-	-	-
	11/29/18	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	2	<0.020	0.11	0.14	2.25	7.2	3.8	0.22	340	9.3	29	3.6	4.1	<0.5	8.6	-	-	-	-
	8/31/18	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	5.9	0.013	0.8	0.99	7.70	22	2.9	0.5	330	16	18	3.6	3.7	<0.5	7.1	-	-	-	-
	5/11/18	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	4.8	0.0074	0.47	0.67	5.95	17	3.6	0.52	190	31	43	5.8	5.9	0.12	4.3	-	-	-	-
	2/15/18	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	3.4	0.0035	0.31	0.39	4.10	12	3.2	0.39	210	9.2	20	5.2	5	<0.5	23	-	-	-	-
MKTF-22	10/24/19	<0.02	<0.02	<0.02	0.013	<0.02	0.013	<0.02	3.4	0.27	<0.02	<0.03	3.67	9	0.28	2.6	190	6.8	12	2.9	2.9	<0.5	2.9	1.88	39.9	7.3	12.6
	08/20/19	<0.02	<0.02	0.0089	0.013	<0.02	0.017	<0.02	3.2	0.26	0.0087	0.014	3.4827	8.2	2.4	2.7	200	6.8	8.5	2.6	2.9	<0.5	4.7	-	-	7.0	12.40
	05/09/19	<0.02	<0.02	0.012	0.011	<0.02	0.015	<0.02	3.5	0.33	0.0091	<0.03	3.8391	11	2.6	3.3	170	7.3	11	2.6	3.1	<0.5	13	2.07	-81.4	6.4	12.45
	03/26/19	<0.02	<0.02	0.0098	0.01	<0.02	0.014	<0.02	2.4	0.19	<0.02	<0.03	2.59	10	2.9	4.1	150	2.3	8.7	2.5	2.6	<0.5	7.6	1.89	-32	7.5	11.27
	11/28/18	<0.02	<0.02	0.011	<0.02	<0.02	0.014	<0.02	3	0.17	0.0084	<0.03	3.1784	11	2	6	130	1.4	12	2.5	2.5	<0.5	5.8	-	-	7.0	12.75
	08/30/18	<0.02	<0.02	0.008	<0.02	<0.02	0.0081	<0.02	2.2	0.12	0.0056	<0.03	2.3256	11	3.1	5.4	110	3	7.4	2.4	2.5	1.7	3.8	-	-	7.1	14.4
	05/10/18	<0.01	<0.01	0.0097	<0.01	<0.01	0.0082	<0.01	2.5	0.15	0.0088	0.014	2.6728	11	3.5	5.9	110	1.4	4.4	2.4	2.5	0.15	5.8	-	-	7.2	13.8
	02/08/18	<0.01	<0.01	0.0078	<0.01	<0.01	0.0068	<0.01	2.3	0.14	0.0093	0.018	2.4673	10	2.9	5.7	110	1	8.3	2.2	2.5	<1.0	5.2	-	-	5.3	12.62
MKTF-24	12/18/20	<0.005	ND	ND	0.0393	-	ND	0.0332	5.02	0.223	ND	ND	5.243	-	2.47	0.0989	893	0.248	7.25	2.39	2.84	ND	21.8	6.25	211.5	7.0	10.8
	09/19/20	<0.02	ND	ND	0.041	<0.02	0.0061	0.037	6.1	0.24	0.024	ND	6.364	15	0.38	0.12	950	0.26	32	1.9	4.4	-	35	2.65	238.9	7.6	12.35
	02/25/20	ND	ND	ND	0.038	-	0.02	0.028	2.9	0.083	0.011	ND	2.994	7.2	0.71	0.11	940	0.08	1.9	1.9	2.2	0.12	27	1.52	81	9.5	12.87
	10/23/19	<0.01	<0.01	<0.02	0.033	0.0093	0.011	0.037	5	0.31	0.024	<0.03	5.334	17	<0.4	0.11	660	0.59	0.9	2.4	2.3	<0.5	20	2.27	189.4	7.4	13.0
	08/23/19	<0.01	<0.02	0.0086	0.053	<0.02	0.019	0.038	4.1	0.24	0.022	0.012	4.374	15	0.94	0.11	800	1.6	5.3	2.2	2.1	<0.5	34	-	-	7.3	14.0
	05/06/19	<0.01	<0.01	<0.02	0.047	0.0066	0.014	0.022	3	0.12	0.014	<0.03	3.134	8.6	0.65	0.11	1000	5.7	8.3	2.3	2.6	<0.5	42	2.12	-81.9	6.7	14.32
	02/25/19	<0.01	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	NM	NM
	11/18/18	<0.01	<0.01	0.0093	0.076	<0.02	0.019	0.028	4.8	0.2	0.021	<0.03	5.021	16	1.5	0.12	520	0.1	0.7	1.8	2	<0.5	27	-	-	7.3	12.68
	08/20/18	<0.1	<0.02	0.011	0.074	0.0082	0.022	0.032	4.8	0.32	0.025	<0.03	5.145	23	1.4	0.12	560	0.33	1.2	1.8	1.8	<0.5	30	-	-	7.1	12.9
	05/01/18	<0.05	<0.02	0.022	0.066	0.0083	0.016	0.031	5.5	0.3	0.029	0.0065	5.8355	23	1.4	0.13	500	0.26	1.3	1.9	2.1	0.17	29	-	-	7.1	12.3
	02/06/18	<0.1	<0.02	0.017	0.082	<0.02	0.027	0.037	6.3	0.41	0.03	0.015	6.755	21	1.1	0.17	430	0.24	0.78	2.2	2.2	<1.0	30	-	-	8.3	12.43
MKTF-25	12/18/20	ND	0.0097	0.0149	0.0918	-	0.0613	ND	0.629	ND	ND	ND	0.629	-	1.86	0.795	844	ND	4.07	2.98	3.2	ND	68	4.8	165	7.1	11.9
	02/27/20	ND	0.012	0.027	0.1	-	0.063	0.0042	0.42	ND	ND	ND	0.42	2.5	0.32	0.62	980	0.13	5.6	3.2	3.4	-	76	6.28	91.5	8.4	9.86
	10/23/19	<0.005	0.011	0.027	0.11	0.0091	0.059	0.0033	0.37	0.00081	<0.005	<0.0075	0.37081	3	<0.4	0.88	1400	0.28	10	5.4	5.8	<0.5	73	2.66	179.1	7.3	12.8
	08/27/19	0.0016	0.013	0.025	0.13	0.01	0.052	<0.005	0.13	<0.005	<0.005	<0.0075	0.13	1.7	<1.0	0.85	1100	0.25	1.8	3.6	3.9	<0.5	68	-	-	6.8	14.93
	05/06/19	<0.01	0.012	0.035	0.14	0.0061	0.05	0.007	0.37	<0.01	<0.01	<0.015	0.37	3.6	0.4	0.29	860	0.21	4.7	1.8	2.2	<0.5	52	1.6	50.1	6.6	10.81
	02/14/19	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	NM	NM
	11/15/18	<0.01	0.0068	0.029	0.13	<0.01	0.027	<0.01	1.7	0.0029	0.0059	<0.015	1.7088	5	<1.0	0.2	630	0.048	2.9	2.9	3.1	<0.5	50	-	-	7.3	12.28
	08/17/18	<0.01	0.006	0.052	0.14	0.0085	0.049	<0.01	4.5	0.026	0.017	<0.015	4.543	17	1	0.25	540	0.97	12	2.4	3	<0.5	23	-	-	7.1	14.5
	05/06/18	0.0027	0.026	0.053	0.23	<0.005	0.11	0.04	3.4	0.15	0.015	0.009	3.574	12	1.1	0.26	500	0.75	2.6	2.4	2.7	<1.0	28	-	-	7.1	10.5
	02/05/18	0.0023	0.025	0.05	0.22	0.01	0.11	0.003	2	0.11	0.01	0.003	2.123	16	0.58	0.25	520	0.7	4.3	2.6	3.2	<1.0	27	-	-	6.9	10.70

Notes:

- = not sampled	MTBE = methyl tert-butyl ether
BTEX = benzene, toluene, ethylbenzene, xylene	mV = millivolts
C = centigrade	ND = non-detect
DCA = dichloroethane	NM = not measured
DCE = dichloroethene	ORP - oxidation reduction potential measured using an silver/silver chloride reference cell
DO = dissolved oxygen	PCE = tetrachloroethene
Fe = iron	T = temperature
ID = identification	TCE = trichloroethene
mg/L = milligrams per liter	TPH-DRO = total petroleum hydrocarbons - diesel range organics
Mn = manganese	TPH-GRO = total petroleum hydrocarbons - gasoline range organics

- pH, ORP, and temperature were measured during well purging prior to the sampling date

TABLE 6. PROPOSED MNA GROUNDWATER QUARTERLY SAMPLING ANALYSES
MARATHON GALLUP REFINERY, GALLUP, NEW MEXICO

Analyte	Method of Analysis	Significance for MNA	Analyte Used in CVOC or MTBE Evaluation	Utility for MNA Analyses
BTEX	Laboratory	Source of organics for reducing conditions	CVOC, MTBE	Monitor trends
MTBE	Laboratory	Decreasing trends indicate natural attenuation	MTBE	Monitor trends
TBA	Laboratory	Decreasing trends indicate natural attenuation	MTBE	Monitor trends, degradation product of MTBE
PCE	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends
TCE	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of PCE
cis-1,2-DCE	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of TCE
1,1-DCE	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of TCE
1,1-DCA	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends
1,2-DCA	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends
Vinyl chloride	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of cis-1,2-DCE and 1,1-DCE
Ethene [1]	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of vinyl chloride
Ethane [1]	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of vinyl chloride
Methane [1]	Laboratory	Decreasing trends indicate natural attenuation	CVOC, MTBE	Monitor trends, indicator for CVOC and MTBE degradation
Chloride	Laboratory	End product of 1,1-DCA and 1,2-DCA degradation	CVOC	Monitor trends, but dissolved salts may mask trends
Nitrate	Laboratory	Potential electron receptor for biodegradation	CVOC, MTBE	Presence indicates potential for biodegradation
Nitrite	Laboratory	Form of nitrate reduced by biodegradation	CVOC, MTBE	Presence indicates possible biodegradation
Sulfate/sulfide	Laboratory	Potential electron receptor for biodegradation	CVOC, MTBE	Monitor trends
Iron (ferric/ferrous)	Laboratory	Potential electron receptor for biodegradation	CVOC, MTBE	Monitor trends
Manganese	Laboratory	Potential electron receptor for biodegradation	CVOC, MTBE	Monitor trends
Temperature	Field	Rate of natural attenuation	CVOC, MTBE	Monitor trends
pH	Field	Neutral range 6-8 required for biodegradation	CVOC, MTBE	Monitor level and trends
DO	Field	Presence required for aerobic biodegradation	CVOC, MTBE	Monitor level and trends
ORP	Field	Indicates redox state for biodegradation	CVOC, MTBE	Monitor level and trends

[1] Compound will be analyzed in monitoring wells MKTF-2, MKTF-10, MKTF-24, and MKTF-25 only.

Notes:

BTEX = benzene, toluene, ethylenzene, xylene

CVOC = chlorinated volatile organic compound

DCA = dichloroethane

DCE = dichloroethene

DO = dissolved oxygen

MNA = monitored natural attenuation

MTBE = methyl tert-butyl ether

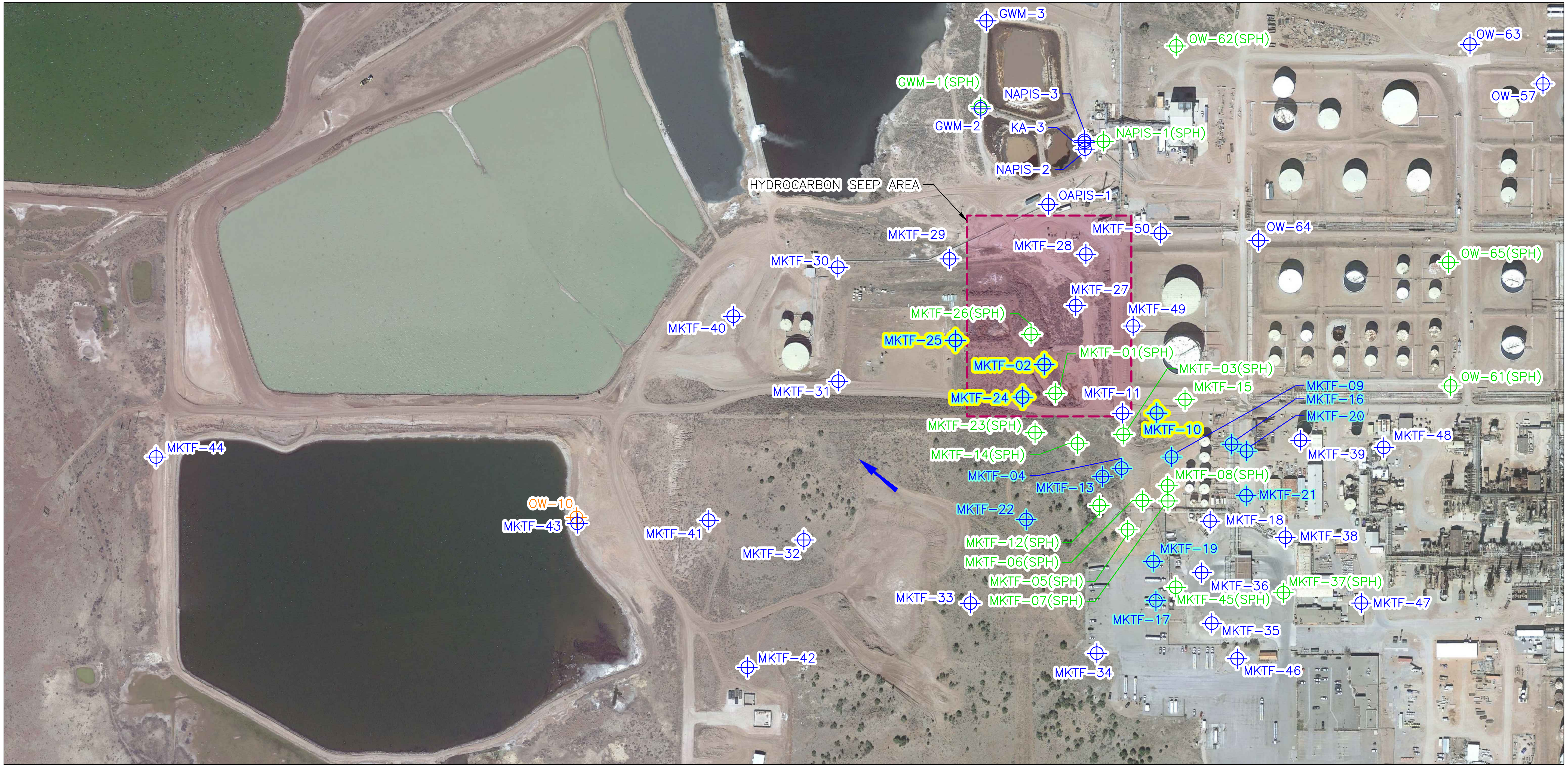
ORP - oxidation reduction potential measured using an silver/silver chloride reference cell

PCE = tetrachloroethene

TCE = trichloroethene

TBA = tert-butyl alcohol

Figures



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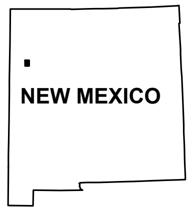
EXPLANATION



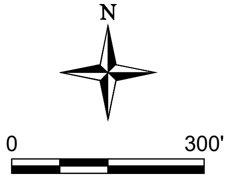
QUADRANGLE LOCATION

NOTE:

SITE LEGAL DESCRIPTION -
TOWNSHIP 15 NORTH,
RANGE 15 WEST, SECTION 33

⌖ OW−10	SONSELA WELL AND DESIGNATION
⌖ MKTF−42	CHINLE/ALLUVIUM INTERFACE WELL AND DESIGNATION
⌖ MKTF−45	SPH MONITORING WELL AND DESIGNATION
⌖ MKTF−17	MKTF MNA WELL
⌖ MKTF−10	MONITORING WELL WITH CONSISTENT DETECTION OF VINYL CHLORIDE
←	GENERAL GROUNDWATER FLOW DIRECTION
▭	HYDROCARBON SEEP AREA

MKTF	MARKETING TANK FARM
MNA	MONITORED NATURAL ATTENUATION
SPH	SINGLE-PHASE HYDROCARBON (DETECTED DURING THIRD QUARTER 2020 SAMPLING EVENT)



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

FIGURE 1.A

HYDROCARBON SEEP AREA AND MNA WELL SET

MARATHON PETROLEUM CORP.
GALLUP REFINING DIVISION
GALLUP, NEW MEXICO

Drawn By: REP	Checked By: MS	Scale: 1" = 300'	Date: 11/12/21	File: 697-MNA-SITE1-202111

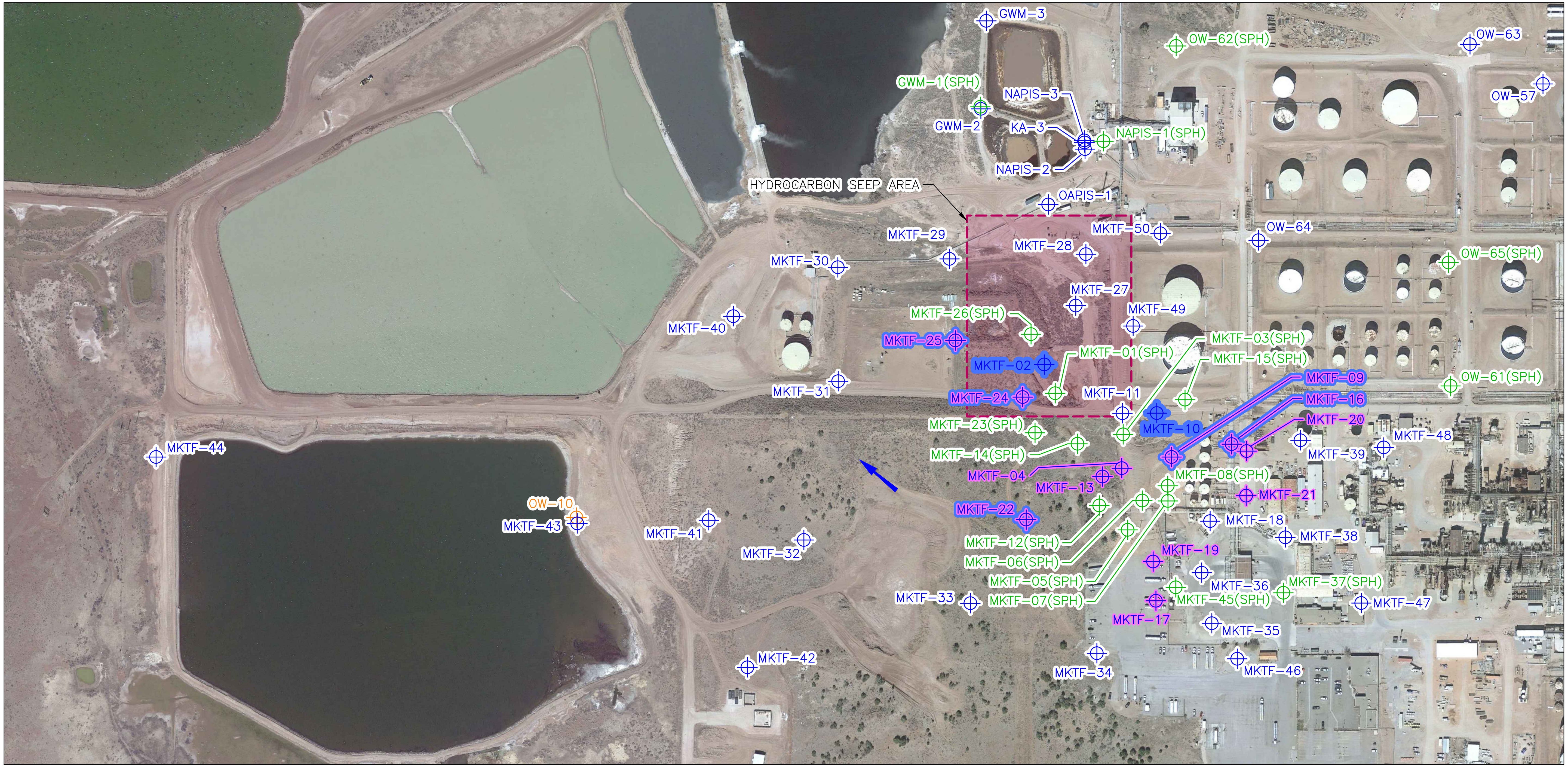
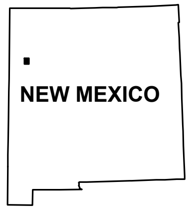


Image Citation: Google Earth Pro Imagery, Publication: March 2016.



QUADRANGLE LOCATION

NOTE:

SITE LEGAL DESCRIPTION -
TOWNSHIP 15 NORTH,
RANGE 15 WEST, SECTION 33

EXPLANATION

OW–10	SONSELA WELL AND DESIGNATION
MKTF–42	CHINLE/ALLUVIUM INTERFACE WELL AND DESIGNATION
MKTF–45	SPH MONITORING WELL AND DESIGNATION
MKTF–17	MKTF MNA WELL
MKTF–04	MONITORING WELL WITH CONSISTENT DETECTION OF MTBE
MKTF–09	MONITORING WELL WITH CONSISTENT DETECTION OF CHLORINATED COMPOUNDS
MKTF–09	MONITORING WELL WITH CONSISTENT DETECTION OF MTBE AND CHLORINATED COMPOUNDS
←	GENERAL GROUNDWATER FLOW DIRECTION
▨	HYDROCARBON SEEP AREA
CVOC	CHLORINATED VOLATILE ORGANIC COMPOUND
MKTF	MARKETING TANK FARM
MNA	MONITORED NATURAL ATTENUATION
MTBE	METHYL TERT-BUTYL ETHER
SPH	SINGLE-PHASE HYDROCARBON (DETECTED DURING THIRD QUARTER 2020 SAMPLING EVENT)

N

0 300'

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1252 Commerce Drive
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FIGURE 1.B

MNA WELLS WITH CVOC AND MTBE DETECTIONS

MARATHON PETROLEUM CORP.
GALLUP REFINING DIVISION
GALLUP, NEW MEXICO

Drawn By: REP	Checked By: MS	Scale: 1" = 300'	Date: 11/12/21	File: 697-MNA-SITE2-202111

ATTACHMENT 3

ELECTRONIC RED-LINE/STRIKE-OUT REPORT

(PLEASE SEE ATTACHED CD)

Western Refining Southwest LLC
A subsidiary of Marathon Petroleum Corporation
I-40 Exit 39
Jamestown, NM 87347

~~August 27, 2021~~
December 17, 2021

Mr. Kevin Pierard, Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

RE: Revised Natural Attenuation Assessment and Proposed Workplan for the Hydrocarbon Seep Area
Western Refining Southwest LLC, Gallup Refinery
(dba ~~Western Refining Southwest, Inc.)~~Marathon Gallup Refinery)
EPA ID# NMD000333211

Dear Mr. Pierard:

Western Refining Southwest LLC, (D/B/A Marathon Gallup Refinery ~~(~~[Refinery]) is submitting this letter in response to a request from the New Mexico Environment Department (NMED) Hazardous Waste Bureau for an assessment of natural attenuation in the hydrocarbon seep area at the Gallup refinery. This request was contained in the following correspondence:

- ~~a l~~Letter dated February 1, 2018, ~~entitled~~ *Disapproval, Interim Measures Report Hydrocarbon Seep Area, Western Refining Southwest Inc., Gallup Refinery, EPA ID# NMD000333211, HWB-WRG-15-002*
- ~~and further defined in a l~~Letter dated January 26, 2021, ~~entitled~~ *Disapproval, Natural Attenuation Assessment and Proposed Work Plan for the Hydrocarbon Seep Area*~~.~~
- Letter dated September 28, 2021, ~~entitled~~ *Approval with Modifications, Response to Disapproval, Natural Attenuation Assessment and Proposed Work Plan for the Hydrocarbon Seep Area*

~~The area identified includes the Marketing Tank Farm area in the southwest portion of the refinery (Figure 1.A).~~

More specifically, the request is presented in NMED February 2018 letter Comment 12, #2 through #5; relevant portions of which are excerpted as follows:

2. *The field analytical parameters such as dissolved oxygen concentration and oxidation-reduction potential (ORP) must be evaluated and presented to support the argument that reducing conditions and anaerobic degradation are occurring. Also, the ratio of total and dissolved iron concentrations must be examined to support the argument…*

3. *…Revise the Report to propose submittal of a work plan to investigate the occurrence of anaerobic ~~dichlorination~~dechlorination.*
4. *The accumulation of vinyl chloride may be occurring based on the site's groundwater conditions. In the plan referenced in Item 3 above, propose to monitor and evaluate the groundwater for analytical parameters pertinent to the accumulation of degradation of vinyl chloride (e.g., concentrations of daughter products, dissolved oxygen, chloride, redox potential and pH)…*
5. *The Permittee must evaluate for the occurrence of hydrocarbon and MTBE degradation (e.g., concentrations of the electron acceptors, degradation byproducts, redox potential, and pH). Include all findings and interpretation of the existing data in the revised Report.*

Pursuant to the above request, this letter presents an evaluation of monitored natural attenuation (MNA) using existing monitoring well analytical data and proposes a workplan consisting of a similar evaluation of natural attenuation for future analyses. Findings ~~would~~ will be included in an MNA evaluation report. Table 1 and Figure 1.A present ~~lists~~ the monitoring wells within the area that were evaluated. The ~~list~~ MNA wells consist~~s~~ of selected MKTF-designated wells within and hydraulically upgradient of the Hydrocarbon Seep Area. These wells contain chlorinated volatile organic compounds (CVOCs) above the NMED Groundwater Cleanup Levels (New Mexico Administrative Code 20.6.2.3103) and methyl tert-butyl ether (MTBE) above the NMED Tap Water Standards (Risk Assessment Guidance, Table A-1, Tap Water, March 2017). ~~and~~In addition, the selected wells were without observable separate phase hydrocarbon (SPH) ~~observed~~ in 2020.

Table 1 includes key analytical data collected between 2018 and 2020 for CVOCs, volatile organic compounds (VOC), ~~methyl tert-butyl ether (~~MTBE~~)~~, MNA indicator parameters, and relevant field parameters. These data are used to evaluate the potential for MNA in ~~a~~ procedures developed by the U.S. Environmental Protection Agency (USEPA) (1998) and the American Petroleum Institute (API) (2007). A more complete data set of laboratory analytical results from the period 2014 through 2020 is used for the statistical trend analysis (Attachments A and B). Figure 1.A shows the location of these wells, and also the wells with SPH detected in the 3rd Quarter 2020 sampling event.

Background

The Hydrocarbon Seep area is located in the western portion of the refinery to the west-southwest of the refinery tank farm. Historically, the Hydrocarbon Seep Area has been impacted by releases of SPH associated with refinery operation. Hydrocarbon seeps were discovered in 2013.

CVOCs detected in groundwater as part of routine quarterly ~~sampling~~monitoring in this area between 2014 and 2020 include trichloroethene (TCE), 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), tetrachloroethene (PCE), and vinyl chloride. Monitoring wells with consistent detection of vinyl chloride are shown in Figure 1.A. Hydrocarbon VOCs detected above the NMED Groundwater Cleanup Level standards include benzene, toluene, ethylbenzene, and xylenes (BTEX), and MTBE. –Monitoring wells with consistent detections of ~~vinyl chloride~~CVOCs and MTBE are shown in Figure 1.B. Table 1 presents recent groundwater analytical data for monitoring wells in the Hydrocarbon Seep Area and nearby Marketing Tank Farm (MKTF) monitoring wells.

Hydrogeology

Surface Conditions

Site topographic features include high ground in the southeast gradually decreasing to a lowland fluvial plain to the northwest. Elevations on the refinery property range from 7,040 feet (ft) to 6,860 feet. Surface soils within most of the area of investigation are primarily Rehobeth silty clay loam. Rehobeth soil properties include alkaline pH (ranging from 8 to 9 standard units) and salinity (naturally occurring and typically measuring up to approximately 8 millimhos per centimeter (MPC 2019).

Local surface water features include the refinery evaporation ponds and a number of small ponds.~~ (one cattle _water pond and two small unnamed spring fed ponds)~~. The site is located in the Puerco River Valley, north of the Zuni Uplift with overland flows directed northward to the tributaries of the Puerco River. The Puerco River continues to the west to the confluence with the Little Colorado River. The South Fork of the Puerco River is intermittent and retains flow only during and immediately following precipitation events (MPC 2019).

Subsurface Conditions

The shallow subsurface soils consist of fluvial and alluvial deposits comprised of clay and silt with minor inter-bedded sand layers. Very low permeability bedrock (e.g., claystones and siltstones) underlie the surface soils and effectively form an aquitard. The Chinle Group, which is Upper Triassic, crops out over a large area on the southern margin of the San Juan Basin. The uppermost recognized local Formation is the Petrified Forest Formation and the Sonsela Sandstone Bed is the uppermost recognized regional aquifer (MPC 2019). Aquifer test of the Sonsela Bed northeast of Prewitt indicated a transmissivity of greater than 100 ft squared per day (Stone and others, 1983). The Sonsela Sandstone's highest point occurs southeast of the site and slopes downward to the northwest as it passes under the refinery. The Sonsela Sandstone forms a water-bearing reservoir with artesian conditions throughout the central and western portions of the refinery property.

The diverse properties and complex, irregular stratigraphy of the surface soils across the site cause a wide range of hydraulic conductivity ranging from less than 10^{-2} centimeters per second (cm/sec) for ~~gravel like~~gravelly sands immediately overlying the Petrified Forest Formation to 10^{-8} cm/sec in the clay soils located near the surface (Western 2009). Generally, shallow groundwater at the refinery follows the upper contact of the Petrified Forest Formation with prevailing flow from the southeast to the northwest.

Three-dimensional geological modeling using available boring log information strongly suggests that the swale in the area of the hydrocarbon seep area is underlain by a corresponding swale in the shallow alluvium that likely influences shallow groundwater flow in this area. This is shown in Figure 2.

Monitored Natural Attenuation

MNA was assessed for this area following references published by the Interstate Technology Regulatory Council (ITRC) (1999), the USEPA (1998), ~~and~~ the New Jersey Department of Environmental Protection (NJDEP 2012), and the American Petroleum Institute (API 2007).

Dissolved organic compounds can be degraded naturally in groundwater, with the rate dependent on the redox state of the groundwater and the presence of suitable electron receptors for microbial degradation (NJDEP 2012). Biodegradation under aerobic (oxidizing) conditions is generally faster than under anaerobic (reducing) conditions, but degradation occurs under both redox regimes.

In general, reducing conditions are present in the subsurface where SPH and dissolved organic compounds (e.g., CVOCs, MTBE, BTEX) are present in groundwater. This has been established by numerous studies (ITRC 2009, Lawrence 2006, and NJDEP 2012). ~~and is generally recognized and accepted~~. This redox condition is caused by depletion of oxygen through aerobic biodegradation of the dissolved petroleum. A generalized diagram of typical hydrocarbon groundwater plume redox conditions is shown Figure 3. When a release of hydrocarbons occurs into groundwater, existing microbes catalyze reactions between the electron-donating carbon and the electron acceptors, in a sequence that is most favorable to the microbes (ITRC 2010). In general, the sequence of electron acceptor use is as follows:

$$O_2 > NO_3^- > Mn(III) \text{ or } Mn(IV) > Fe(III) > SO_4^{-2} > CO_2$$

The presence of the oxidized inorganic compounds shown above indicates the potential for biodegradation. Moreover, the presence of the reduced forms of these species generally indicates active biodegradation.

The strongest reducing conditions are generally present in the source area of the hydrocarbon plume where SPH is present. More oxidizing (less reducing) conditions are generally present in the downgradient direction of the dissolved hydrocarbon plume, as shown in Figure 4. Figure 4 also shows the areas of the plume where redox conditions are sufficient to allow reduction of the indicated species.

CVOCs generally require anaerobic conditions for biodegradation. Figure 4 presents a list of CVOCs and the likelihood of biodegradation through various degradation mechanisms/pathways.

As shown in this figure, the primary mechanisms for biodegradation are reductive dechlorination and dichloroelimination.

Studies of MTBE aerobic biodegradation indicate that it is less recalcitrant than previously thought (Lawrence 2006 and API 2007). Anaerobic biodegradation proceeds more slowly under reducing conditions ranging from methanogenic to nitrate-reducing.

Evaluation of Current MNA Conditions

Table 1 presents recent (2018 to 2020) groundwater analytical data from the hydrocarbon seep area wells, including organic and inorganic analytes, dissolved oxygen (DO), temperature, and oxidation reduction potential (ORP). This date range was selected to represent current conditions for the analysis of the key MNA parameters. A trend analysis was also conducted using data from the period 2014 through 2020 and is presented in Attachments A and B (CVOCs and MTBE, respectively).

Table 1 includes laboratory analytical data and field data collected during well purging, including temperature, pH, DO, and ORP. Field measurements of DO and ORP can be an indicator of the redox regime of groundwater, with the method of field measurement important to the absolute value of the results. Field pH/ORP is measured using a silver/silver chloride reference electrode. In general, for more accurate measurements of DO/ORP, a groundwater sampling pump and a flow-through cell for well purging and measuring DO/ORP is preferred because this configuration eliminates contact with air. For the DO/ORP data presented in Table 1, measurements were conducted using bailed water from a well, which was then placed into a container for ORP measurement. This procedure introduces oxygen, and actual in situ groundwater conditions would be expected to have a lower, more reducing DO/ORP. Nevertheless, the data in Table 1 can be evaluated in a relative sense for trends.

Evaluation for CVOCs and MTBE

Qualitatively, current conditions and available geochemical data provide multiple lines of evidence that reducing conditions are present in the Hydrocarbon Seep Area. These reducing conditions create a geochemical environment for the anaerobic biodegradation of SPH and dissolved VOCs and may also be conducive to the anaerobic biodegradation of CVOCs (TCE, 1,1-DCA and 1,2-DCA) (USEPA 1998) and MTBE (API 2007).

Evidence for conditions favorable for anaerobic biodegradation of CVOCs and MTBE includes:

- Elevated benzene concentrations indicating that a high dissolved hydrocarbon load is present and anaerobic conditions are occurring. SPH is also present in several areas (Figures 1.A and 1B), which represents a continuing source for dissolved phase hydrocarbons.

- Detection of vinyl chloride, 1,1-DCE, and cis-1,2-DCE, which are typical byproducts of TCE degradation. Vinyl chloride was detected consistently in monitoring wells MKTF-2, MKTF-10, MKTF-24, and MKTF-25, as shown in Figure 1.A.
- Presence of dissolved iron and total iron, indicating likely presence of ferrous iron in response to reducing conditions and anaerobic biodegradation.
- Depleted sulfate in wells with elevated benzene (e.g., MKTF-10, MKTF-16, MKTF-17), indicating reducing condition and sulfate reduction to sulfite as part of anaerobic biodegradation.
- Presence of manganese, indicating availability as an electron receptor for anaerobic biodegradation.
- Occasional detection of nitrite above detection limits, indicating reducing conditions and probable use of nitrate as an electron receptor for anaerobic biodegradation.
- Neutral to slightly basic pH conditions, which are favorable for biodegradation.
- Low ORP measurements, indicating reducing conditions are present particularly for MKTF wells located in the paved areas where SPH is present (Figure 1). Wells located to the west in unpaved areas without SPH and elevated dissolved hydrocarbon such as benzene are generally oxidizing.

For CVOCs specifically, the detection of vinyl chloride, 1,1-DCE, and cis-1,2-DCE is important because they are typical byproducts of TCE degradation. Vinyl chloride was detected consistently in monitoring wells MKTF-2, MKTF 10, MKTF-24, and MKTF-25, as shown in Figure 1.A. Chloride concentrations are generally elevated in the MKTF wells, as shown in Table 1, but do not correlate with areas of elevated CVOCs. In the absence of high chloride from other sources, elevated chloride can be used as an indicator of the biodegradation of CVOCs (NJDEP 2012).

CVOC MNA Scoring Criteria

From a more quantitative standpoint, an evaluation was conducted on a well-by-well basis in accordance with USEPA guidance (USEPA 1998). Table 2 presents the scoring criteria from the USEPA and the applicability of the criteria to the Hydrocarbon Seep Area, given the analytical requirements of the existing approved Sampling Plan (~~MPC~~ Western 2021) and current field sampling practices. Table 3 shows the implementation of the scoring for each well, and presents the final evaluation score for each well, which summarizes the potential for CVOC natural attenuation (reductive dichlorination). Four categories of scores assess the potential for anaerobic biodegradation of CVOCs, as follows:

> 20	Strong evidence
15 to 20	Adequate evidence
6 to 14	Limited evidence

- 0 to 5 Inadequate evidence.

As shown in Table 3, the evidentiary scores ranged from 7 to 16, with nine wells deemed “Limited” category and one well deemed “Adequate.”

Statistical Analyses

Statistical analyses were performed to determine if the analytical data results from the current monitoring period represent statistical upward or downward trends in analyte concentrations in the groundwater samples collected from MKTF-designated wells.

Statistical Methods

QAQC and Data Handling

Trace concentrations (estimated results between the reporting limit [RL] and the method detection limit [MDL]) reported since 06/08/2016 were treated as true detected values. Therefore, being the upper bound of non-detect (ND) results, the MDL was used as substitute values for ND values in all statistical evaluations, unless stated otherwise (see Exploratory Data Analysis and General Statistics section). R® (R Core Team, 2020), a programing language and software environment for statistical analysis, was used for all statistical needs.

The statistical evaluation was performed for six chlorinated volatile organic compounds (CVOCs; 1,1-~~D~~dichloroethane, 1,1-~~D~~dichloroethene, 1,2-~~D~~dichloroethane, cis-1,2-~~D~~dichloroethene, ~~T~~trichloroethene, and ~~V~~vinyl ~~C~~chloride) and methyl tert-butyl ether (MTBE). All constituents were reported in mg/L. Seven wells for CVOCs (i.e., MKTF-02, MKTF-09, MKTF-10, MKTF-16, MKTF-2, MKTF-24, MKTF-25) and 11 wells for MTBE (i.e. MKTF-04, MKTF-09, MKTF-16, MKTF-17, MKTF-19, MKTF-20, MKTF-21, MKTF-22, MKTF-23, MKTF-24, MKTF-25) were part of the 2020 evaluation.

Exploratory Data Analysis and General Statistics

Exploratory Data Analysis (EDA) was performed on all well-analyte combinations and are presented in Table 4 and Table 5, for the CVOCs and MTBE respectively. For each analyte-location pair, these statistics include the number of samples collected since April 8, 2014, the overall detection rate, the minimum and maximum detected concentrations, the minimum and maximum MDLs reported by laboratories, the overall sample mean, median, and sample standard deviation, and the dates of the range of the first and last sample.

Time Series Plots and Outlier Analysis

Outlier analysis was performed at a 95% confidence level using the Dixon’s and Grubbs’ tests when the sample size for each analyte-location pair, *n*, was more than 4 but less than 30, with at least one detected result. If the sample size was greater than 25, then the Rosner's test was used instead of or in addition to the two tests mentioned above and up to 3 potential outliers were considered. Because outlier tests' assumptions are often difficult to attain with real data, and the presence of one outlier can mask the detection of another, any extreme and unusual values flagged as outliers by any of the outlier tests (e.g., concentration 3 times greater or 1/3 smaller than the overall concentration) were graphically confirmed using time series plots. The last results were never considered an outlier regardless of their value ~~since~~because they could be the results of a recent event. Results from the outlier analysis are also presented in Table 4 (CVOCs) and Table 5 (MTBE).

For each analyte-location pair, time series plots were constructed to show any potential trend in CVOCs and MTBE. In addition, any graphically confirmed outliers were also shown on the time series plots (Attachments A [CVOCs] and B [MTBE]).

Nonparametric Trend Analysis

Non-parametric trend analysis was conducted for all analyte-location pairs with a sample size equal to or greater than 8 (not including graphically confirmed outliers) and one detected result above the MDL to assess the temporal stationarity of the constituents' concentrations through time. To avoid trends in the MDLs driving the trend analysis results, the USEPA (2009) recommends ND values be assigned "a common value lower than any of the detected measurements" (USEPA 2009, Section 17.3.2 p. 17-31). ND values were assigned half of the minimum MDLs in each location for all analyses related to the trend analysis. Trend analyses were performed using the nonparametric approach, Mann-Kendall's monotonic trend analysis. Traditional Mann-Kendall trend analysis relies on several assumptions such as no serial correlation, no outliers, and no seasonality. The presence of serial correlation was tested for each location using the rank von Neumann ratio test at 95% confidence level and the results were graphically confirmed using Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). The presence of outliers in the data was addressed during the outlier analysis described above. Seasonal effects between the Summer-Fall (May to October) and Winter-Spring (November to April) sampling events were tested using Wilcoxon-Mann-Whitney tests at a 90% confidence level. The assumption of homogeneity of variance between the two seasons for the Wilcoxon tests for each COC-well combination was performed using the traditional Levene's test. In the absence of both serial autocorrelation and seasonal effect, the traditional Mann-Kendall trend analysis test was used. When serial correlation was identified, a modified Mann-Kendall test for serially correlated data using the Yue and Wang (Yue, 2004) variance correction approach was used. When seasonality was present in the data, a standard seasonal Mann-Kendall test, which performs a nonparametric test for a monotonic trend within each season based on Kendall's tau statistic, was used. Finally, if the presence of both serial correlation and seasonality in the data was confirmed the seasonal Mann-Kendall approach was adapted to handle serial correlation. Results from all trend analyses for the CVOC are presented in Table 4 and for MTBE in Table 5.

Results

COVCs

Nonparametric monotonic increasing trends were identified since 2014 for the following analyte-well pairs with 95% confidence (Table 4):

- 1,1-~~D~~dichloroethene in wells MKTF-10 and MKTF-22
- Vinyl ~~C~~chloride in wells MKTF-02, MKTF-10, MKTF-24

In addition, evidence of decreasing monotonic trends since 2014 was found, with 95% confidence, for 1,1-~~D~~dichloroethane, 1,1-~~D~~dichloroethene, cis-1,2-~~D~~dichloroethene, and ~~T~~trichloroethene in wells MKTF-02, MKTF-09, MKTF-24, and MKTF-25.

All other analyte-well pairs showed no evidence of an overall trend since 2014 at a 95% confidence level.

MTBE

The Mann-Kendall (MK) trend analysis test found no evidence of monotonic increasing trends since 2014 for MTBE in the 11 wells with 95% confidence (Table 5). Recent changes in MTBE in well MKTF-17 and MKTF-25 will be monitored moving forward (see time series plot in Attachment B).

In addition, evidence of decreasing monotonic trends since 2014 was found, with 95% confidence, for MTBE in wells MKTF-09, MKTF-16, MKTF-21, and MKTF-24.

All other analyte-well pairs showed no evidence of an overall trend since 2014 at a 95% confidence level.

Proposed Workplan for Natural Attenuation Evaluation for Future Annual Reports

The proposed workplan to evaluate natural attenuation is presented in this section for NMED review and approval. The Refinery proposes that a natural attenuation evaluation be completed ~~on an annual basis~~ annually for the wells discussed in this report: MKTF-02, MKTF-04, MKTF-09, MKTF-10, MKTF-13, MKTF-16, MKTF-17, MKTF-19, MKTF-20, MKTF-21, MKTF-22, MKTF-24, and MKTF-25 (Figures 1.A and 1.B). Sampling will be conducted concurrently with the third quarter monitoring event. Samples will be analyzed ~~using the existing quarterly~~

~~sampling analyte list~~ for the constituents presented in ~~(~~Table 6~~)~~ and used as lines of evidence for MNA. These lines of evidence will include:

- BTEX, MTBE, tertiary butyl alcohol (TBA), PCE, TCE, cis-1,2- DCE, 1,1-DCE, 1,1-DCA, 1,2-DCA, and vinyl chloride concentrations
- Ethene, ethane, and methane analysis will be conducted in four monitoring wells with elevated vinyl chloride concentrations (MKTF-2, MKTF-10, MKTF-24, and MKTF-25)
- Dissolved/total iron and manganese, nitrate/nitrite, and sulfate/sulfide to determine their availability as terminal electron receptors and the redox state
- Chloride as the end point of 1,1-DCA and 1,2-DCA degradation
- Field parameters such as pH, temperature, ORP, and DO ~~pH, temperature, ORP, and DO~~

The evaluation in future MNA reports will include data tables summarizing these analytes, updating the USEPA quantitative spreadsheet scoring the MNA potential, and updating the MK statistical trend analysis for CVOCs and MTBE. A discussion section will be added summarizing natural attenuation progress, including trends in contaminant concentrations and key MNA indicators. The MNA evaluation will be submitted to NMED in a letter report. Reports will be submitted on March 31 of each year starting in 2022.

If you have any questions or comments regarding the information contained herein, please do not hesitate to contact Mr. John Moore at (505) 879-7643.

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction of supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Sincerely,
Western Refining Southwest LLC, Marathon Gallup Refinery

Ruth Cade
Vice-President

Attachments

MARATHON

Western Refining Southwest LLC
A subsidiary of Marathon Petroleum Corporation

I-40 Exit 39
Jamestown, NM 87347

cc: D. Cobrain, NMED HWB
L. Tsinnajinnie, NMED HWB
M. Suzuki, NMED HWB
~~T. McDill~~L. Barr, NMOCD
L. King, EPA Region 6
~~G. McCartney~~M. Bracey, Marathon Petroleum Corporation
K. Luka, Marathon Petroleum Corporation
J. Moore, Marathon Gallup Refinery
H. Jones, Trihydro Corporation

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ATTACHMENT 4

ELECTRONIC REVISED REPORT

(PLEASE SEE ATTACHED CD)

Western Refining Southwest LLC
A subsidiary of Marathon Petroleum Corporation
I-40 Exit 39
Jamestown, NM 87347

December 17, 2021

Mr. Kevin Pierard, Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

RE: Revised Natural Attenuation Assessment and Proposed Workplan for the Hydrocarbon Seep Area
Western Refining Southwest LLC, Gallup Refinery
(dba Marathon Gallup Refinery)
EPA ID# NMD000333211

Dear Mr. Pierard:

Western Refining Southwest LLC, (D/B/A Marathon Gallup Refinery [Refinery]) is submitting this letter in response to a request from the New Mexico Environment Department (NMED) Hazardous Waste Bureau for an assessment of natural attenuation in the hydrocarbon seep area at the Gallup refinery. This request was contained in the following correspondence:

- Letter dated February 1, 2018, *Disapproval, Interim Measures Report Hydrocarbon Seep Area, Western Refining Southwest Inc., Gallup Refinery, EPA ID# NMD000333211, HWB-WRG-15-002*
- Letter dated January 26, 2021, *Disapproval, Natural Attenuation Assessment and Proposed Work Plan for the Hydrocarbon Seep Area*
- Letter dated September 28, 2021, *Approval with Modifications, Response to Disapproval, Natural Attenuation Assessment and Proposed Work Plan for the Hydrocarbon Seep Area*

More specifically, the request is presented in NMED February 2018 letter Comment 12, #2 through #5; relevant portions of which are excerpted as follows:

2. *The field analytical parameters such as dissolved oxygen concentration and oxidation-reduction potential (ORP) must be evaluated and presented to support the argument that reducing conditions and anaerobic degradation are occurring. Also, the ratio of total and dissolved iron concentrations must be examined to support the argument…*
3. *…Revise the Report to propose submittal of a work plan to investigate the occurrence of anaerobic dechlorination.*
4. *The accumulation of vinyl chloride may be occurring based on the site's groundwater conditions. In the plan referenced in Item 3 above, propose to monitor and evaluate the groundwater for analytical parameters pertinent to the accumulation of*

> *degradation of vinyl chloride (e.g., concentrations of daughter products, dissolved oxygen, chloride, redox potential and pH)…*
>
> 5. *The Permittee must evaluate for the occurrence of hydrocarbon and MTBE degradation (e.g., concentrations of the electron acceptors, degradation byproducts, redox potential, and pH). Include all findings and interpretation of the existing data in the revised Report.*

Pursuant to the above request, this letter presents an evaluation of monitored natural attenuation (MNA) using existing monitoring well analytical data and proposes a workplan consisting of a similar evaluation of natural attenuation for future analyses. Findings will be included in an MNA evaluation report. Table 1 and Figure 1.A present the monitoring wells within the area that were evaluated. The MNA wells consist of selected MKTF-designated wells within and hydraulically upgradient of the Hydrocarbon Seep Area. These wells contain chlorinated volatile organic compounds (CVOCs) above the NMED Groundwater Cleanup Levels (New Mexico Administrative Code 20.6.2.3103) and methyl tert-butyl ether (MTBE) above the NMED Tap Water Standards (Risk Assessment Guidance, Table A-1, Tap Water, March 2017). In addition, the selected wells were without observable separate phase hydrocarbon (SPH) in 2020.

Table 1 includes key analytical data collected between 2018 and 2020 for CVOCs, volatile organic compounds (VOC), MTBE, MNA indicator parameters, and relevant field parameters. These data are used to evaluate the potential for MNA in procedures developed by the U.S. Environmental Protection Agency (USEPA) (1998) and the American Petroleum Institute (API) (2007). A more complete data set of laboratory analytical results from the period 2014 through 2020 is used for the statistical trend analysis (Attachments A and B). Figure 1.A shows the location of these wells, and also the wells with SPH detected in the 3rd Quarter 2020 sampling event.

Background

The Hydrocarbon Seep area is located in the western portion of the refinery to the west-southwest of the refinery tank farm. Historically, the Hydrocarbon Seep Area has been impacted by releases of SPH associated with refinery operation. Hydrocarbon seeps were discovered in 2013.

CVOCs detected in groundwater as part of routine quarterly monitoring in this area between 2014 and 2020 include trichloroethene (TCE), 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), tetrachloroethene (PCE), and vinyl chloride. Monitoring wells with consistent detection of vinyl chloride are shown in Figure 1.A. Hydrocarbon VOCs detected above the NMED Groundwater Cleanup Level standards include benzene, toluene, ethylbenzene, and xylenes (BTEX), and MTBE. Monitoring wells with consistent detections of CVOCs and MTBE are shown in Figure 1.B. Table 1 presents recent groundwater analytical data for monitoring wells in the Hydrocarbon Seep Area and nearby Marketing Tank Farm (MKTF) monitoring wells.

Hydrogeology

Surface Conditions

Site topographic features include high ground in the southeast gradually decreasing to a lowland fluvial plain to the northwest. Elevations on the refinery property range from 7,040 feet (ft) to 6,860 feet. Surface soils within most of the area of investigation are primarily Rehobeth silty clay loam. Rehobeth soil properties include alkaline pH (ranging from 8 to 9 standard units) and salinity (naturally occurring and typically measuring up to approximately 8 millimhos per centimeter (MPC 2019).

Local surface water features include the refinery evaporation ponds and a number of small ponds.. The site is located in the Puerco River Valley, north of the Zuni Uplift with overland flows directed northward to the tributaries of the Puerco River. The Puerco River continues to the west to the confluence with the Little Colorado River. The South Fork of the Puerco River is intermittent and retains flow only during and immediately following precipitation events (MPC 2019).

Subsurface Conditions

The shallow subsurface soils consist of fluvial and alluvial deposits comprised of clay and silt with minor inter-bedded sand layers. Very low permeability bedrock (e.g., claystones and siltstones) underlie the surface soils and effectively form an aquitard. The Chinle Group, which is Upper Triassic, crops out over a large area on the southern margin of the San Juan Basin. The uppermost recognized local Formation is the Petrified Forest Formation and the Sonsela Sandstone Bed is the uppermost recognized regional aquifer (MPC 2019). Aquifer test of the Sonsela Bed northeast of Prewitt indicated a transmissivity of greater than 100 ft squared per day (Stone and others, 1983). The Sonsela Sandstone's highest point occurs southeast of the site and slopes downward to the northwest as it passes under the refinery. The Sonsela Sandstone forms a water-bearing reservoir with artesian conditions throughout the central and western portions of the refinery property.

The diverse properties and complex, irregular stratigraphy of the surface soils across the site cause a wide range of hydraulic conductivity ranging from less than 10^{-2} centimeters per second (cm/sec) for gravelly sands immediately overlying the Petrified Forest Formation to 10^{-8} cm/sec in the clay soils located near the surface (Western 2009). Generally, shallow groundwater at the refinery follows the upper contact of the Petrified Forest Formation with prevailing flow from the southeast to the northwest.

Three-dimensional geological modeling using available boring log information strongly suggests that the swale in the area of the hydrocarbon seep area is underlain by a corresponding swale in the shallow alluvium that likely influences shallow groundwater flow in this area. This is shown in Figure 2.

Monitored Natural Attenuation

MNA was assessed for this area following references published by the Interstate Technology Regulatory Council (ITRC) (1999), the USEPA (1998), the New Jersey Department of Environmental Protection (NJDEP 2012), and the American Petroleum Institute (API 2007).

Dissolved organic compounds can be degraded naturally in groundwater, with the rate dependent on the redox state of the groundwater and the presence of suitable electron receptors for microbial degradation (NJDEP 2012). Biodegradation under aerobic (oxidizing) conditions is generally faster than under anaerobic (reducing) conditions, but degradation occurs under both redox regimes.

In general, reducing conditions are present in the subsurface where SPH and dissolved organic compounds (e.g., CVOCs, MTBE, BTEX) are present in groundwater. This has been established by numerous studies (ITRC 2009, Lawrence 2006, and NJDEP 2012).. This redox condition is caused by depletion of oxygen through aerobic biodegradation of the dissolved petroleum. A generalized diagram of typical hydrocarbon groundwater plume redox conditions is shown Figure 3. When a release of hydrocarbons occurs into groundwater, existing microbes catalyze reactions between the electron-donating carbon and the electron acceptors, in a sequence that is most favorable to the microbes (ITRC 2010). In general, the sequence of electron acceptor use is as follows:

$$O_2 > NO_3^- > Mn(III) \text{ or } Mn\ (IV) > Fe(III) > SO_4^{-2} > CO_2$$

The presence of the oxidized inorganic compounds shown above indicates the potential for biodegradation. Moreover, the presence of the reduced forms of these species generally indicates active biodegradation.

The strongest reducing conditions are generally present in the source area of the hydrocarbon plume where SPH is present. More oxidizing (less reducing) conditions are generally present in the downgradient direction of the dissolved hydrocarbon plume, as shown in Figure 4. Figure 4 also shows the areas of the plume where redox conditions are sufficient to allow reduction of the indicated species.

CVOCs generally require anaerobic conditions for biodegradation. Figure 4 presents a list of CVOCs and the likelihood of biodegradation through various degradation mechanisms/pathways. As shown in this figure, the primary mechanisms for biodegradation are reductive dechlorination and dichloroelimination.

Studies of MTBE aerobic biodegradation indicate that it is less recalcitrant than previously thought (Lawrence 2006 and API 2007). Anaerobic biodegradation proceeds more slowly under reducing conditions ranging from methanogenic to nitrate-reducing.

Evaluation of Current MNA Conditions

Table 1 presents recent (2018 to 2020) groundwater analytical data from the hydrocarbon seep area wells, including organic and inorganic analytes, dissolved oxygen (DO), temperature, and oxidation reduction potential (ORP). This date range was selected to represent current conditions for the analysis of the key MNA parameters. A trend analysis was also conducted using data from the period 2014 through 2020 and is presented in Attachments A and B (CVOCs and MTBE, respectively).

Table 1 includes laboratory analytical data and field data collected during well purging, including temperature, pH, DO, and ORP. Field measurements of DO and ORP can be an indicator of the redox regime of groundwater, with the method of field measurement important to the absolute value of the results. Field pH/ORP is measured using a silver/silver chloride reference electrode. In general, for more accurate measurements of DO/ORP, a groundwater sampling pump and a flow-through cell for well purging and measuring DO/ORP is preferred because this configuration eliminates contact with air. For the DO/ORP data presented in Table 1, measurements were conducted using bailed water from a well, which was then placed into a container for ORP measurement. This procedure introduces oxygen, and actual in situ groundwater conditions would be expected to have a lower, more reducing DO/ORP. Nevertheless, the data in Table 1 can be evaluated in a relative sense for trends.

Evaluation for CVOCs and MTBE

Qualitatively, current conditions and available geochemical data provide multiple lines of evidence that reducing conditions are present in the Hydrocarbon Seep Area. These reducing conditions create a geochemical environment for the anaerobic biodegradation of SPH and dissolved VOCs and may also be conducive to the anaerobic biodegradation of CVOCs (TCE, 1,1-DCA and 1,2-DCA) (USEPA 1998) and MTBE (API 2007).

Evidence for conditions favorable for anaerobic biodegradation of CVOCs and MTBE includes:

- Elevated benzene concentrations indicating that a high dissolved hydrocarbon load is present and anaerobic conditions are occurring. SPH is also present in several areas (Figures 1.A and 1B), which represents a continuing source for dissolved phase hydrocarbons.
- Detection of vinyl chloride, 1,1-DCE, and cis-1,2-DCE, which are typical byproducts of TCE degradation. Vinyl chloride was detected consistently in monitoring wells MKTF-2, MKTF-10, MKTF-24, and MKTF-25, as shown in Figure 1.A.
- Presence of dissolved iron and total iron, indicating likely presence of ferrous iron in response to reducing conditions and anaerobic biodegradation.
- Depleted sulfate in wells with elevated benzene (e.g., MKTF-10, MKTF-16, MKTF-17), indicating reducing condition and sulfate reduction to sulfite as part of anaerobic biodegradation.

- Presence of manganese, indicating availability as an electron receptor for anaerobic biodegradation.
- Occasional detection of nitrite above detection limits, indicating reducing conditions and probable use of nitrate as an electron receptor for anaerobic biodegradation.
- Neutral to slightly basic pH conditions, which are favorable for biodegradation.
- Low ORP measurements, indicating reducing conditions are present particularly for MKTF wells located in the paved areas where SPH is present (Figure 1). Wells located to the west in unpaved areas without SPH and elevated dissolved hydrocarbon such as benzene are generally oxidizing.

For CVOCs specifically, the detection of vinyl chloride, 1,1-DCE, and cis-1,2-DCE is important because they are typical byproducts of TCE degradation. Vinyl chloride was detected consistently in monitoring wells MKTF-2, MKTF 10, MKTF-24, and MKTF-25, as shown in Figure 1.A. Chloride concentrations are generally elevated in the MKTF wells, as shown in Table 1, but do not correlate with areas of elevated CVOCs. In the absence of high chloride from other sources, elevated chloride can be used as an indicator of the biodegradation of CVOCs (NJDEP 2012).

CVOC MNA Scoring Criteria

From a more quantitative standpoint, an evaluation was conducted on a well-by-well basis in accordance with USEPA guidance (USEPA 1998). Table 2 presents the scoring criteria from the USEPA and the applicability of the criteria to the Hydrocarbon Seep Area, given the analytical requirements of the existing approved Sampling Plan (Western 2021) and current field sampling practices. Table 3 shows the implementation of the scoring for each well, and presents the final evaluation score for each well, which summarizes the potential for CVOC natural attenuation (reductive dichlorination). Four categories of scores assess the potential for anaerobic biodegradation of CVOCs, as follows:

> 20	Strong evidence
15 to 20	Adequate evidence
6 to 14	Limited evidence
0 to 5	Inadequate evidence.

As shown in Table 3, the evidentiary scores ranged from 7 to 16, with nine wells deemed "Limited" category and one well deemed "Adequate."

Statistical Analyses

Statistical analyses were performed to determine if the analytical data results from the current monitoring period represent statistical upward or downward trends in analyte concentrations in the groundwater samples collected from MKTF-designated wells.

Statistical Methods

QAQC and Data Handling

Trace concentrations (estimated results between the reporting limit [RL] and the method detection limit [MDL]) reported since 06/08/2016 were treated as true detected values. Therefore, being the upper bound of non-detect (ND) results, the MDL was used as substitute values for ND values in all statistical evaluations, unless stated otherwise (see Exploratory Data Analysis and General Statistics section). R® (R Core Team, 2020), a programing language and software environment for statistical analysis, was used for all statistical needs.

The statistical evaluation was performed for six chlorinated volatile organic compounds (CVOCs; 1,1-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, cis-1,2-dichloroethene, trichloroethene, and vinyl chloride) and methyl tert-butyl ether (MTBE). All constituents were reported in mg/L. Seven wells for CVOCs (i.e., MKTF-02, MKTF-09, MKTF-10, MKTF-16, MKTF-2, MKTF-24, MKTF-25) and 11 wells for MTBE (i.e. MKTF-04, MKTF-09, MKTF-16, MKTF-17, MKTF-19, MKTF-20, MKTF-21, MKTF-22, MKTF-23, MKTF-24, MKTF-25) were part of the 2020 evaluation.

Exploratory Data Analysis and General Statistics

Exploratory Data Analysis (EDA) was performed on all well-analyte combinations and are presented in Table 4 and Table 5, for the CVOCs and MTBE respectively. For each analyte-location pair, these statistics include the number of samples collected since April 8, 2014, the overall detection rate, the minimum and maximum detected concentrations, the minimum and maximum MDLs reported by laboratories, the overall sample mean, median, and sample standard deviation, and the dates of the range of the first and last sample.

Time Series Plots and Outlier Analysis

Outlier analysis was performed at a 95% confidence level using the Dixon's and Grubbs' tests when the sample size for each analyte-location pair, *n*, was more than 4 but less than 30, with at least one detected result. If the sample size was greater than 25, then the Rosner's test was used instead of or in addition to the two tests mentioned above and up to 3 potential outliers were considered. Because outlier tests' assumptions are often difficult to attain with real data, and the presence of one outlier can mask the detection of another, any extreme and unusual values flagged as outliers by any of the outlier tests (e.g., concentration 3 times greater or 1/3 smaller than the overall concentration) were graphically confirmed using time series plots. The last results were never considered an outlier regardless of their value because they could be the results of a recent event. Results from the outlier analysis are also presented in Table 4 (CVOCs) and Table 5 (MTBE).

For each analyte-location pair, time series plots were constructed to show any potential trend in CVOCs and MTBE. In addition, any graphically confirmed outliers were also shown on the time series plots (Attachments A [CVOCs] and B [MTBE]).

Nonparametric Trend Analysis

Non-parametric trend analysis was conducted for all analyte-location pairs with a sample size equal to or greater than 8 (not including graphically confirmed outliers) and one detected result above the MDL to assess the temporal stationarity of the constituents' concentrations through time. To avoid trends in the MDLs driving the trend analysis results, the USEPA (2009) recommends ND values be assigned "a common value lower than any of the detected measurements" (USEPA 2009, Section 17.3.2 p. 17-31). ND values were assigned half of the minimum MDLs in each location for all analyses related to the trend analysis. Trend analyses were performed using the nonparametric approach, Mann-Kendall's monotonic trend analysis. Traditional Mann-Kendall trend analysis relies on several assumptions such as no serial correlation, no outliers, and no seasonality. The presence of serial correlation was tested for each location using the rank von Neumann ratio test at 95% confidence level and the results were graphically confirmed using Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). The presence of outliers in the data was addressed during the outlier analysis described above. Seasonal effects between the Summer-Fall (May to October) and Winter-Spring (November to April) sampling events were tested using Wilcoxon-Mann-Whitney tests at a 90% confidence level. The assumption of homogeneity of variance between the two seasons for the Wilcoxon tests for each COC-well combination was performed using the traditional Levene's test. In the absence of both serial autocorrelation and seasonal effect, the traditional Mann-Kendall trend analysis test was used. When serial correlation was identified, a modified Mann-Kendall test for serially correlated data using the Yue and Wang (Yue, 2004) variance correction approach was used. When seasonality was present in the data, a standard seasonal Mann-Kendall test, which performs a nonparametric test for a monotonic trend within each season based on Kendall's tau statistic, was used. Finally, if the presence of both serial correlation and seasonality in the data was confirmed the seasonal Mann-Kendall approach was adapted to handle serial correlation. Results from all trend analyses for the CVOC are presented in Table 4 and for MTBE in Table 5.

Results

COVCs

Nonparametric monotonic increasing trends were identified since 2014 for the following analyte-well pairs with 95% confidence (Table 4):

- 1,1-dichloroethene in wells MKTF-10 and MKTF-22
- Vinyl chloride in wells MKTF-02, MKTF-10, MKTF-24

In addition, evidence of decreasing monotonic trends since 2014 was found, with 95% confidence, for 1,1-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, and trichloroethene in wells MKTF-02, MKTF-09, MKTF-24, and MKTF-25.

All other analyte-well pairs showed no evidence of an overall trend since 2014 at a 95% confidence level.

MTBE

The Mann-Kendall (MK) trend analysis test found no evidence of monotonic increasing trends since 2014 for MTBE in the 11 wells with 95% confidence (Table 5). Recent changes in MTBE in well MKTF-17 and MKTF-25 will be monitored moving forward (see time series plot in Attachment B).

In addition, evidence of decreasing monotonic trends since 2014 was found, with 95% confidence, for MTBE in wells MKTF-09, MKTF-16, MKTF-21, and MKTF-24.

All other analyte-well pairs showed no evidence of an overall trend since 2014 at a 95% confidence level.

Proposed Workplan for Natural Attenuation Evaluation for Future Annual Reports

The proposed workplan to evaluate natural attenuation is presented in this section for NMED review and approval. The Refinery proposes that a natural attenuation evaluation be completed annually for the wells discussed in this report: MKTF-02, MKTF-04, MKTF-09, MKTF-10, MKTF-13, MKTF-16, MKTF-17, MKTF-19, MKTF-20, MKTF-21, MKTF-22, MKTF-24, and MKTF-25 (Figures 1.A and 1.B). Sampling will be conducted concurrently with the third quarter monitoring event. Samples will be analyzed for the constituents presented in Table 6 and used as lines of evidence for MNA. These lines of evidence will include:

- BTEX, MTBE, tertiary butyl alcohol (TBA), PCE, TCE, cis-1,2- DCE, 1,1-DCE, 1,1-DCA, 1,2-DCA, and vinyl chloride concentrations
- Ethene, ethane, and methane analysis will be conducted in four monitoring wells with elevated vinyl chloride concentrations (MKTF-2, MKTF-10, MKTF-24, and MKTF-25)
- Dissolved/total iron and manganese, nitrate/nitrite, and sulfate/sulfide to determine their availability as terminal electron receptors and the redox state

- Chloride as the end point of 1,1-DCA and 1,2-DCA degradation
- Field parameters such as pH, temperature, ORP, and DO

The evaluation in future MNA reports will include data tables summarizing these analytes, updating the USEPA quantitative spreadsheet scoring the MNA potential, and updating the MK statistical trend analysis for CVOCs and MTBE. A discussion section will be added summarizing natural attenuation progress, including trends in contaminant concentrations and key MNA indicators. The MNA evaluation will be submitted to NMED in a letter report. Reports will be submitted on March 31 of each year starting in 2022.

If you have any questions or comments regarding the information contained herein, please do not hesitate to contact Mr. John Moore at (505) 879-7643.

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction of supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Sincerely,
Western Refining Southwest LLC, Marathon Gallup Refinery

Ruth Cade
Vice-President

Attachments

cc: D. Cobrain, NMED HWB
L. Tsinnajinnie, NMED HWB
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J. Moore, Marathon Gallup Refinery
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Tables

TABLE 1. MKTF WELLS VOC AND MNA ANALYTICAL DATA 2018-2020
MARATHON GALLUP REFINERY, GALLUP, NEW MEXICO

Well ID	Date Sampled	PCE (mg/L)	TCE (mg/L)	cis-1,2-DCE (mg/L)	1,1-DCA (mg/L)	1,2-DCA (mg/L)	1,1-DCE (mg/L)	Vinyl Chloride (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylene (mg/L)	BTEX (mg/L)	TPH-GRO (mg/L)	TPH-DRO (mg/L)	MTBE (mg/L)	Chloride (mg/L)	Fe, Dissolved (mg/L)	Fe, Total (mg/L)	Mn, Dissolved (mg/L)	MN, Total (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)	DO (mg/L)	ORP (mV)	pH	T (C)
MKTF-2	12/18/20	ND	<.001	ND	0.0291	-	0.00876	0.0241	0.885	0.161	0.0119	ND	1.0579	9.8	4.55	0.0317	3020	1.03	2.56	6.46	6.14	ND	185	7.24	191.7	6.9	11.5
	09/21/20	ND	<.001	0.0019	0.021	<.001	0.0014	0.027	4	0.52	0.033	0.0063	4.5593	7.9	2.1	0.061	1000	0.22	0.99	1.9	2	ND	64	0.21	285.1	6.7	14.76
	02/25/20	ND	<.001	ND	0.0065	-	0.0018	0.005	0.78	0.57	0.01	0.048	1.408	-	1.8	0.0091	1300	0.34	2	3	3	ND	160	5.77	127.3	8.7	NM
	11/19/19	<0.005	<0.005	0.0031	0.015	0.0047	0.0014	0.017	0.36	0.046	0.003	<0.0075	0.409	2.4	0.65	0.023	1900	0.48	5.7	2.5	2.9	<0.5	330	3.52	145	7.6	14.3
	08/23/19	<0.02	<0.02	<0.02	0.027	0.012	<0.02	0.028	0.99	0.078	0.012	<0.03	1.08	3.9	3.1	0.051	2000	2.4	9.1	2	2.3	<0.5	150	3.01	-104.1	7.1	13.35
	05/06/19	<0.02	<0.02	<0.02	0.019	0.0064	0.0064	0.019	0.95	0.043	0.019	0.11	1.122	5.3	3.5	0.049	1600	3	3.9	1.8	1.9	<0.5	61	1.74	-92.2	6.9	12.31
	03/28/19	<0.02	<0.02	<0.02	0.016	0.0069	0.0073	0.013	0.62	0.01	0.016	0.13	0.776	4.1	3.8	0.047	1400	0.42	1.6	1.6	1.5	<1.0	52	1.92	46.1	8.3	11.18
	11/28/18	<0.01	<0.01	0.0086	0.044	<0.01	0.007	0.028	5.5	0.51	0.082	0.17	6.262	18	2.9	0.099	570	0.078	0.24	0.75	0.74	<0.5	5.6	-	-	7.7	12.95
	08/20/18	<0.01	<0.01	0.0099	0.042	0.0078	0.024	0.0071	2.5	0.14	0.031	0.031	2.702	7.8	1.3	0.1	510	0.027	0.2	0.51	0.52	<0.5	11	-	-	7.2	14.8
	05/01/18	<0.01	0.0018	0.016	0.033	0.0048	0.011	0.0063	2.9	0.24	0.039	0.12	3.299	9.1	3.2	0.097	520	0.03	0.36	0.57	0.62	<0.5	15	-	-	7.5	11.8
	02/06/18	<0.005	0.003	0.014	0.041	<0.005	0.018	0.0037	2.6	0.25	0.049	0.089	2.988	7.7	2.8	0.11	520	0.022	0.57	0.55	0.61	<1.0	20	-	-	8.4	10.26
MKTF-4	03/03/20	<0.005	<0.005	<0.005	0.0091	0.0023	0.013	<0.005	0.8	0.01	0.47	0.56	1.84	8.2	1.8	2.1	220	1.4	6	1.8	1.9	<0.5	9.3	2.02	30.1	8.4	12.89
	10/30/19	<0.005	<0.005	<0.005	0.0055	<0.005	0.0073	<0.005	0.93	0.012	0.71	0.74	2.392	10	0.73	1.8	210	5.4	7.6	1.5	1.6	<0.5	2.9	-	-	-	-
	08/21/19	<0.001	0.00083	0.0091	0.013	0.0015	0.017	<0.001	0.53	0.0091	0.42	0.44	1.3991	6.4	4.3	1.6	220	1.5	5.9	2	2.2	0.12	16	-	-	-	-
	05/13/19	<0.005	0.00087	<0.005	0.0054	0.0016	0.0075	<0.005	0.77	0.013	0.62	0.73	2.133	9.6	5.4	1.7	260	4.5	8	1.6	1.6	<0.5	5.6	-	-	-	-
	03/26/19	<0.005	<0.005	<0.005	0.0047	0.0019	0.0068	<0.005	0.78	0.014	0.62	0.74	2.154	10	5	1.6	240	1.8	6.8	1.6	1.5	<0.5	4.7	-	-	-	-
	11/20/18	<0.002	<0.002	0.0071	0.011	<0.002	0.017	<0.002	1.1	0.011	0.61	0.65	2.37	7.6	4.5	2.2	210	1	5.1	1.5	2.3	<0.5	9.6	-	-	-	-
	9/14/18	<0.010	<0.010	0.008	0.0074	0.0043	0.0077	<0.010	1.1	0.014	0.7	0.86	2.67	12	4.7	1.8	200	3.2	5.7	1.5	1.4	0.083	5.5	-	-	-	-
	5/2/18	<0.010	0.0017	0.0095	0.014	<0.010	0.02	<0.010	1.1	0.016	0.74	0.89	2.75	12	4.9	2.3	200	2.4	5.3	1.5	1.7	<0.5	9.8	-	-	-	-
	2/14/18	<0.010	<0.010	0.011	0.0084	<0.010	0.012	<0.010	0.9	0.014	0.6	0.71	2.22	9.6	5	2.0	220	1.9	5.2	1.5	1.5	<0.5	8.6	-	-	-	-
MKTF-9	03/03/20	-	-	-	-	-	-	-	3.2	0.2	0.012	0.059	3.471	6.3	1	0.53	290	1.4	2.4	4.1	4	ND	46	1.91	51.2	8.0	11.22
	11/18/19	<0.01	<0.01	0.011	0.011	<0.01	0.015	<0.01	3.7	0.23	0.014	0.069	4.013	10	1.0	0.45	220	2.4	3.4	4.2	4.3	<0.5	25	1.46	29.8	7.4	16.1
	08/23/19	<0.02	<0.02	0.012	0.014	<0.02	0.017	<0.02	3.5	0.27	0.021	0.098	3.889	12	3.9	0.42	230	3.8	4.5	4.4	4.5	<0.5	12			6.9	14.84
	05/13/19	<0.01	<0.01	<0.01	0.0068	<0.01	0.0063	<0.01	3.2	0.28	0.025	0.095	3.6	8.4	3.1	0.31	250	3.2	3.8	4.6	4.8	<0.5	8.1	2.41	-74.3	6.5	14.27
	03/26/19	<0.02	<0.02	0.02	0.0091	<0.02	0.0091	<0.02	2.2	0.22	0.019	0.098	2.537	8.2	2.5	0.24	240	3.9	4.4	4.6	4.2	<0.5	10	1.58	-59.9	7.9	12.1
	11/28/18	<0.02	<0.02	0.02	0.022	<0.02	0.034	<0.02	3.3	0.19	0.02	0.073	3.583	9.1	1.8	0.56	260	0.82	1.9	4.1	3.9	<0.5	24	-	-	7.3	13.85
	09/04/18	<0.02	<0.02	0.021	0.09	<0.02	0.028	<0.02	2.7	0.25	0.019	0.084	3.053	11	2.4	0.43	260	0.94	1.8	4.4	4.2	<0.5	17	-	-	NM	NM
	05/02/18	0.0028	0.0032	0.023	0.026	<0.01	0.036	<0.01	2.8	0.28	0.025	0.098	3.203	8.2	2.6	0.49	250	1.4	2.3	3.9	4.4	0.21	22	-	-	NM	NM
	02/14/18	0.002	0.0029	0.026	0.015	<0.01	0.028	<0.01	2.7	0.25	0.024	0.084	3.058	8.7	2.2	0.48	220	1.3	2.3	4	3.9	<0.5	27	-	-	6.9	11.30
MKTF-10	12/18/20	ND	ND	ND	0.04	-	ND	ND	4.67	1.8	0.284	8.6	15.354	-	5.54	ND	937	7.25	10.7	4.81	5.07	ND	ND	2.87	220.4	6.9	11.2
	03/03/20	ND	ND	0.0041	0.047	-	0.0066	0.0089	4.8	1.7	0.65	8.2	15.35	40	1.3	0.0094	970	7.2	12	5.4	5.5	ND	ND	1.61	3	7.8	11.84
	10/30/19	<0.01	<0.01	0.039	0.031	<0.01	0.0059	0.01	5.5	1.7	0.57	7.2	14.97	40	0.35	0.017	1000	14	15	6.2	6.3	<0.5	<2.5	1.4	-1.2	7.2	13.6
	08/22/19	<0.01	<0.01	0.034	0.037	<0.01	0.0075	0.01	4.6	1.6	0.66	7.4	14.26	35	3	0.019	960	7.9	11	5.4	5.6	0.1	<2.5	-	-	7.0	18.34
	05/13/19	<0.05	<0.05	<0.05	0.027	<0.05	0.013	0.023	5.5	1.7	0.9	7.9	16	48	3.5	0.024	460	8.4	8.9	3.4	3.6	<0.5	<2.5	1.78	-87.1	6.2	15.95
	03/26/19	<0.1	<0.1	0.05	0.04	<0.1	<0.1	0.042	5	1.7	0.86	7.9	15.46	50	2.6	0.047	390	7	8.9	3.1	3.1	<0.5	0.4	1.16	-24.4	7.9	11.9
	11/20/18	<0.02	<0.02	0.058	<0.02	<0.02	0.0051	0.0074	11	1.9	1.9	8	22.8	53	2.8	0.01	320	6.1	8.3	2.9	3	<0.5	<2.5	-	-	7.3	12.68
	09/04/18	<0.05	<0.05	0.047	<0.05	<0.05	0.012	0.018	10	1.8	2.4	8.1	22.3	57	2.5	<0.05	340	6.8	7.7	2.9	2.8	<0.5	<2.5	-	-	NM	NM
	05/02/18	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	13	2.1	4.9	9.6	29.6	100	3.7	0.03	380	9.2	11	3.3	3.9	<0.5	<2.5	-	-	NM	NM
	02/14/18	<0.05	<0.05	0.066	<0.05	<0.05	<0.05	0.018	10	1.8	3.7	8.3	23.8	74	2.6	0.014	390	9.7	12	3.7	3.6	<0.5	<2.5	-	-	NM	NM
MKTF-13	10/29/19	-	-	<0.02	-	<0.02	<0.02	-	4.7	0.6	0.11	2.6	8.01	23	7.3	0.33	290	15	20	4.6	4.7	<0.5	0.59	0.85	-8.4	7.2	13.8
	08/20/19	-	-	-	-	-	-	-	0	0	0	0	0			-	-	-	-	-	-	-	-	-	-	NM	NM
	05/09/19	-	-	<0.02	-	<0.02	<0.02	-	3.2	0.32	0.12	2.6	6.24	19	63	0.48	400	26	35	8.2	6.1	<0.5	1.1	-	-	NM	NM
	03/26/19	-	-	<0.02	-	<0.02	<0.02	-	3.5	0.6	0.14	3.5	7.74	27	8.1	0.44	390	24	25	5.1	4.7	<1.0	0.75	-	-	NM	NM
	11/28/18	-	-	<0.02	-	<0.02	<0.02	-	4.5	0.53	0.13	2.8	7.96	24	4.5	1.4	220	10	16	4.4	4.4	<0.5	<2.5	-	-	7.1	14.17
	08/30/18	-	-	<0.02	-	<0.02	<0.02	-	3.5	0.65	0.12	3.2	7.47	26	5.5	1.2	210	16	19	5.1	4.7	0.12	<2.5	-	-	NM	NM
	05/10/18	-	-	<0.001	-	<0.005	0.0025	-	4.8	0.87	0.15	4	9.82	28	30	2	190	14	17	4.6	4.6	0.21	1.2	-	-	NM	NM
MKTF-16	12/23/20	ND	ND	ND	ND	-	ND	ND	14.7	1.32	0.129	ND	16.149	-	-	0.279	-	-	10.7	-	2.54	-	-	0.98	53.8	6.8	14.2
	10/30/19	<0.1	<0.1	<0.1	0.069	<0.1	<0.1	<0.1	15	1.5	0.095	0.43	17.025	33	0.24	4.9	1700	15	17	0.62	5.5	<0.5	<2.5	-	-	NM	NM
	08/22/19	<0.1	<0.1	<0.1	0.064	<0.1	<0.1	<0.1	9.8	0.48	0.043	0.11	10.433	20	3.6	6.8	1800	21	24	0.55	7.1	<0.5	<2.5	-	-	6.8	22.88
	05/14/19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	14	0.71	0.11	0.62	15.44	30	3.4	3	960	5.8	5.8	0.62	2.6	<0.5	0.68	0.97	-78	6.2	15.96
	02/20/19	<0.1	<0.1	<0.1	0.053	<0.1	<0.1	<0.1	21	1.4	0.19	1.6	24.19	48	2.2	1.7	590	2	5.8	0.61	1.7	<0.5	0.41	2.1	-55.1	7.7	13.47
	11/29/18	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	0.89	0.12	0.72	18.73	34	2.6	1.5	620	2.7	4.1	0.69	1.5	<0.5	0.64	-	-	NM	NM
	08/31/18	<0.1	<0.1	<0.1	0.047	<0.1	<0.1	<0.1	17	1.3	0.13	1.4	19.83	50	3.3	1.7	650	1.8	3.6	0.64	1.8	<1.0	1.4	-	-	6.9	23.9
	05/11/18	<0.05	<0.05	<0.05	0.036	<0.05	<0.05	<0.05	19	1.6	0.17	2	22.77	47	2.9	1.9	840	3.4	4.3	0.64	1.9	0.099	1.2	-	-	7.0	18.6
	02/15/18	<0.01	<0.01	<0.01	0.0062	<0.01	<0.01	0.0058	1.8	0.015	0.024	0.23	2.069	8.4	2.4	0.8	760	0.095	18	0.04	0.37	0.13	57	-	-	6.9	15.24
MKTF-17	10/29/19	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	12	1.1	23	3.1	39.2	78	0.7	3.4	240	0.45	4.8	2.5	3.5	<0.5	6.2	2.27	169.9	7.5	14.0
	08/20/19	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.87	0.64	0.0026	0.078	1.5906	7.6	3.3	3	140	0.37	3	4.3	2.8	<0.5	14	-	-	7.0	15.03
	05/09/19	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	2.2	0.49	0.0022	0.15	2.8422	9.1	7.6	3.1	100	0.27	5.4	4.3	3	<0.5	15	1	-93.8	6.4	11.94
	03/26/19	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.98	0.09	<0.005	0.021	1.091	7	1.9	2.8	130	0.23	2.2	4.6	2.7	<0.5	48	3.75	2.7	7.7	10.99
	11/28/18	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0036	0.025	<0.005	<0.0075	0.0286	3	1.6	2.2	110	0.27	2	5.7	2.5	<0.5	120	-	-	7.6	13.56
	08/24/18	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.0027	0.12	<0.005	<0.0075	0.1227	4.7	<1.0	2.4	110	0.39	1.7	5.3	2.4	<0.5	160	-	-	7.3	17.3
	05/04/18	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.047	0.14	0.0011	0.002	0.1901	7.1	1.4	2.8	130	0.17	1.8	7.4	2.7	0.054	68	-	-	7.1	13.8
	02/16/18	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.22	0.21	0.00098	<0.0075	0.43098	3.7	1.36	2.6	100	0.13	1.7	4.9	2.9	<0.5	52	-	-	7.0	13.00

TABLE 1. MKTF WELLS VOC AND MNA ANALYTICAL DATA 2018-2020
MARATHON GALLUP REFINERY, GALLUP, NEW MEXICO

Well ID	Date Sampled	PCE (mg/L)	TCE (mg/L)	cis-1,2-DCE (mg/L)	1,1-DCA (mg/L)	1,2-DCA (mg/L)	1,1-DCE (mg/L)	Vinyl Chloride (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylene (mg/L)	BTEX (mg/L)	TPH-GRO (mg/L)	TPH-DRO (mg/L)	MTBE (mg/L)	Chloride (mg/L)	Fe, Dissolved (mg/L)	Fe, Total (mg/L)	Mn, Dissolved (mg/L)	MN, Total (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)	DO (mg/L)	ORP (mV)	pH	T (C)
MKTF-19	10/29/19	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.6	0.61	0.013	0.61	2.833	17	1	7.9	130	10	15	2.4	2.4	<0.5	0.5	1.1	13.9	7.3	14.5
	08/19/19	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.4	0.72	<0.02	0.69	2.81	18	13	8.3	140	11	19	2.3	2.7	<0.5	<2.5	-	-	6.9	14.10
	05/09/19	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.8	0.77	<0.02	0.61	3.18	19	11	7.8	140	11	15	2.4	2.7	<0.5	0.31	-	-	NM	NM
	03/26/19	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.3	0.71	<0.02	0.61	2.62	17	8.7	6.9	140	9.9	11	2.2	2.6	<0.5	0.34	0.98	-58	7.3	8.91
	11/28/18	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.9	0.63	<0.02	0.57	3.1	15	7.8	10	140	8.3	7.5	2.2	2.4	<0.5	<2.5	-	-	7.1	13.7
	08/24/18	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	1.7	0.71	0.0043	0.74	3.1543	22	7.9	9.7	120	10	15	2.3	2.4	<0.5	<2.5	-	-	NM	NM
	05/04/18	<0.005	<0.005	0.002	<0.005	<0.005	<0.005	<0.005	2	0.87	0.0057	0.82	3.6957	23	9.3	11	130	10	11	2.4	2.4	<0.5	1.2	-	-	NM	NM
	02/16/18	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	1.9	0.74	0.0037	0.64	3.2837	16	11	10	120	9.6	10	2.4	2.3	<0.5	<2.5	-	-	NM	NM
MKTF-20	2/5/20	<0.010	<0.010	<0.010	<0.010	<0.005	<0.010	<0.010	0.62	0.0039	0.058	0.53	1.21	1	4.6	0.0057	-	-	-	-	-	-	-	-	-	-	-
	11/5/09	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	2.4	<0.010	0.26	0.096	2.76	7	1.5	0.17	140	2.2	4.3	2.1	2	<0.5	1.7	-	-	-	-
	8/21/19	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	4.8	0.009	1.1	3.7	9.61	28	5.1	0.035	3300	20	19	8.1	7.5	<0.5	2.8	-	-	-	-
	5/14/19	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	2.3	<0.010	1.0	3.5	6.80	25	5.4	0.032	3400	22	25	9	8.5	<0.5	36	-	-	-	-
	2/20/19	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	2.1	0.0021	0.23	0.14	2.47	7.3	9.8	0.22	760	47	58	5.5	5.5	<0.5	11	-	-	-	-
	11/29/18	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	3	0.02	0.12	2.5	5.64	17	6.9	0.026	460	2.5	8	2.5	2.6	<0.5	4.3	-	-	-	-
	8/31/19	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	9.9	0.064	0.77	9.1	19.83	70	11	0.096	560	5.3	5.8	2.8	3	<0.5	8.4	-	-	-	-
	5/11/18	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	13	0.14	1.3	13	27.44	76	9.7	0.13	1600	17	16	5.4	5.5	0.097	18	-	-	-	-
	2/15/18	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	12	0.19	0.96	12	25.15	79	5.1	0.055	3100	53	52	17	16	<0.5	15	-	-	-	-
MKTF-21	2/5/20	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.058	<0.005	0.0026	<0.0075	0.06	0.74	0.31	0.05	-	-	-	-	-	-	-	-	-	-	-
	11/5/19	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	5.6	0.0082	1.1	2.8	9.51	27	2.7	0.029	2300	8.3	9	6.2	5.8	<0.5	19	-	-	-	-
	8/22/19	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	5.4	<0.020	0.68	0.5	6.58	17	7.4	0.29	230	16	21	3.4	3.3	<0.5	6.2	-	-	-	-
	5/14/19	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	2.4	<0.020	0.28	0.22	2.9	8.5	9.4	0.29	540	33	42	5.6	5.7	<0.5	6.9	-	-	-	-
	2/20/19	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	2	0.016	1.2	7.1	10.32	40	20	0.015	4600	57	63	14	15	<0.5	880	-	-	-	-
	11/29/18	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	2	<0.020	0.11	0.14	2.25	7.2	3.8	0.22	340	9.3	29	3.6	4.1	<0.5	8.6	-	-	-	-
	8/31/18	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	5.9	0.013	0.8	0.99	7.70	22	2.9	0.5	330	16	18	3.6	3.7	<0.5	7.1	-	-	-	-
	5/11/18	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	4.8	0.0074	0.47	0.67	5.95	17	3.6	0.52	190	31	43	5.8	5.9	0.12	4.3	-	-	-	-
	2/15/18	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	3.4	0.0035	0.31	0.39	4.10	12	3.2	0.39	210	9.2	20	5.2	5	<0.5	23	-	-	-	-
MKTF-22	10/24/19	<0.02	<0.02	<0.02	0.013	<0.02	0.013	<0.02	3.4	0.27	<0.02	<0.03	3.67	9	0.28	2.6	190	6.8	12	2.9	2.9	<0.5	2.9	1.88	39.9	7.3	12.6
	08/20/19	<0.02	<0.02	0.0089	0.013	<0.02	0.017	<0.02	3.2	0.26	0.0087	0.014	3.4827	8.2	2.4	2.7	200	6.8	8.5	2.6	2.9	<0.5	4.7	-	-	7.0	12.40
	05/09/19	<0.02	<0.02	0.012	0.011	<0.02	0.015	<0.02	3.5	0.33	0.0091	<0.03	3.8391	11	2.6	3.3	170	7.3	11	2.6	3.1	<0.5	13	2.07	-81.4	6.4	12.45
	03/26/19	<0.02	<0.02	0.0098	0.01	<0.02	0.014	<0.02	2.4	0.19	<0.02	<0.03	2.59	10	2.9	4.1	150	2.3	8.7	2.5	2.6	<0.5	7.6	1.89	-32	7.5	11.27
	11/28/18	<0.02	<0.02	0.011	<0.02	<0.02	0.014	<0.02	3	0.17	0.0084	<0.03	3.1784	11	2	6	130	1.4	12	2.5	2.5	<0.5	5.8	-	-	7.0	12.75
	08/30/18	<0.02	<0.02	0.008	<0.02	<0.02	0.0081	<0.02	2.2	0.12	0.0056	<0.03	2.3256	11	3.1	5.4	110	3	7.4	2.4	2.5	1.7	3.8	-	-	7.1	14.4
	05/10/18	<0.01	<0.01	0.0097	<0.01	<0.01	0.0082	<0.01	2.5	0.15	0.0088	0.014	2.6728	11	3.5	5.9	110	1.4	4.4	2.4	2.5	0.15	5.8	-	-	7.2	13.8
	02/08/18	<0.01	<0.01	0.0078	<0.01	<0.01	0.0068	<0.01	2.3	0.14	0.0093	0.018	2.4673	10	2.9	5.7	110	1	8.3	2.2	2.5	<1.0	5.2	-	-	5.3	12.62
MKTF-24	12/18/20	<0.005	ND	ND	0.0393	-	ND	0.0332	5.02	0.223	ND	ND	5.243	-	2.47	0.0989	893	0.248	7.25	2.39	2.84	ND	21.8	6.25	211.5	7.0	10.8
	09/19/20	<0.02	ND	ND	0.041	<0.02	0.0061	0.037	6.1	0.24	0.024	ND	6.364	15	0.38	0.12	950	0.26	32	1.9	4.4	-	35	2.65	238.9	7.6	12.35
	02/25/20	ND	ND	ND	0.038	-	0.02	0.028	2.9	0.083	0.011	ND	2.994	7.2	0.71	0.11	940	0.08	1.9	1.9	2.2	0.12	27	1.52	81	9.5	12.87
	10/23/19	<0.01	<0.01	<0.02	0.033	0.0093	0.011	0.037	5	0.31	0.024	<0.03	5.334	17	<0.4	0.11	660	0.59	0.9	2.4	2.3	<0.5	20	2.27	189.4	7.4	13.0
	08/23/19	<0.01	<0.02	0.0086	0.053	<0.02	0.019	0.038	4.1	0.24	0.022	0.012	4.374	15	0.94	0.11	800	1.6	5.3	2.2	2.1	<0.5	34	-	-	7.3	14.0
	05/06/19	<0.01	<0.01	<0.02	0.047	0.0066	0.014	0.022	3	0.12	0.014	<0.03	3.134	8.6	0.65	0.11	1000	5.7	8.3	2.3	2.6	<0.5	42	2.12	-81.9	6.7	14.32
	02/25/19	<0.01	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	NM	NM
	11/18/18	<0.01	<0.01	0.0093	0.076	<0.02	0.019	0.028	4.8	0.2	0.021	<0.03	5.021	16	1.5	0.12	520	0.1	0.7	1.8	2	<0.5	27	-	-	7.3	12.68
	08/20/18	<0.1	<0.02	0.011	0.074	0.0082	0.022	0.032	4.8	0.32	0.025	<0.03	5.145	23	1.4	0.12	560	0.33	1.2	1.8	1.8	<0.5	30	-	-	7.1	12.9
	05/01/18	<0.05	<0.02	0.022	0.066	0.0083	0.016	0.031	5.5	0.3	0.029	0.0065	5.8355	23	1.4	0.13	500	0.26	1.3	1.9	2.1	0.17	29	-	-	7.1	12.3
	02/06/18	<0.1	<0.02	0.017	0.082	<0.02	0.027	0.037	6.3	0.41	0.03	0.015	6.755	21	1.1	0.17	430	0.24	0.78	2.2	2.2	<1.0	30	-	-	8.3	12.43
MKTF-25	12/18/20	ND	0.0097	0.0149	0.0918	-	0.0613	ND	0.629	ND	ND	ND	0.629	-	1.86	0.795	844	ND	4.07	2.98	3.2	ND	68	4.8	165	7.1	11.9
	02/27/20	ND	0.012	0.027	0.1	-	0.063	0.0042	0.42	ND	ND	ND	0.42	2.5	0.32	0.62	980	0.13	5.6	3.2	3.4	-	76	6.28	91.5	8.4	9.86
	10/23/19	<0.005	0.011	0.027	0.11	0.0091	0.059	0.0033	0.37	0.00081	<0.005	<0.0075	0.37081	3	<0.4	0.88	1400	0.28	10	5.4	5.8	<0.5	73	2.66	179.1	7.3	12.8
	08/27/19	0.0016	0.013	0.025	0.13	0.01	0.052	<0.005	0.13	<0.005	<0.005	<0.0075	0.13	1.7	<1.0	0.85	1100	0.25	1.8	3.6	3.9	<0.5	68	-	-	6.8	14.93
	05/06/19	<0.01	0.012	0.035	0.14	0.0061	0.05	0.007	0.37	<0.01	<0.01	<0.015	0.37	3.6	0.4	0.29	860	0.21	4.7	1.8	2.2	<0.5	52	1.6	50.1	6.6	10.81
	02/14/19	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	NM	NM
	11/15/18	<0.01	0.0068	0.029	0.13	<0.01	0.027	<0.01	1.7	0.0029	0.0059	<0.015	1.7088	5	<1.0	0.2	630	0.048	2.9	2.9	3.1	<0.5	50	-	-	7.3	12.28
	08/17/18	<0.01	0.006	0.052	0.14	0.0085	0.049	<0.01	4.5	0.026	0.017	<0.015	4.543	17	1	0.25	540	0.97	12	2.4	3	<0.5	23	-	-	7.1	14.5
	05/06/18	0.0027	0.026	0.053	0.23	<0.005	0.11	0.04	3.4	0.15	0.015	0.009	3.574	12	1.1	0.26	500	0.75	2.6	2.4	2.7	<1.0	28	-	-	7.1	10.5
	02/05/18	0.0023	0.025	0.05	0.22	0.01	0.11	0.003	2	0.11	0.01	0.003	2.123	16	0.58	0.25	520	0.7	4.3	2.6	3.2	<1.0	27	-	-	6.9	10.70

Notes:
- = not sampled
BTEX = benzene, toluene, ethylbenzene, xylene
C = centigrade
DCA = dichloroethane
DCE = dichloroethene
DO = dissolved oxygen
Fe = iron
ID = identification
mg/L = milligrams per liter
Mn = manganese

MTBE = methyl tert-butyl ether
mV = millivolts
ND = non-detect
NM = not measured
ORP - oxidation reduction potential measured using an silver/silver chloride reference cell
PCE = tetrachloroethene
T = temperature
TCE = trichloroethene
TPH-DRO = total petroleum hydrocarbons - diesel range organics
TPH-GRO = total petroleum hydrocarbons - gasoline range organics

- pH, ORP, and temperature were measured during well purging prior to the sampling date

TABLE 2. MONITORED NATURAL ATTENUATION ASSESSMENT EPA SCORING SYSTEM
MARATHON GALLUP REFINERY, GALLUP NEW MEXICO

Analysis	Concentration in Most Contaminated Zone	Significance	Applicability to the Existing Data Set	Scoring Value
Oxygen	<0.5 mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	DO data collected in a bucket during well purging. Not as accurate as a flow-through cell	3
Oxygen	>5 mg/L	Not tolerated; however, VC may be oxidized aerobically	DO data collected in a bucket during well purging. Not as accurate as a flow-through cell	-3
Nitrate	<1 mg/L	At higher concentrations may compete with reductive pathway	In data set	2
Iron II	>1 mg/L	Reductive pathway possible; VC may be oxidized under Fe(III)-reducing conditions	Ferrous iron not sampled for; dissolved (field filtered) is used	3
Sulfate	<20 mg/L	At higher concentrations may compete with reductive pathway	In data set	2
Sulfide	>1 mg/L	Reductive pathway possible	Not currently analyzed.	3
Methane	<0.5 mg/L >0.5 mg/L	VC oxidizes Ultimate reductive daughter product, VC Accumulates	Not currently analyzed.	0 3
ORP	<50 millivolts (mV) <-100mV	Reductive pathway possible Reductive pathway likely	ORP data collected in a bucket during well purging. Not as accurate as a flow-through cell	1 2
pH	5 < pH < 9 5 > pH >9	Optimal range for reductive pathway Outside optimal range for reductive pathway	In data set	0 -2
TOC	> 20 mg/L	Carbon and energy source; drives dechlorination; can be natural or anthropogenic	Not currently analyzed; inferred from total BTEX and TPH	2
Temperature	> 20 C	At T >20 C biochemical process is accelerated	In data set	1
CO2	>2x background	Ultimate oxidative daughter product	Not currently analyzed.	1
Alkalinity	>2x background	Results from interaction between CO2 and aquifer minerals	Not currently analyzed.	1
Chloride	>2x background	Daughter product of organic chlorine	In data set, but very high background in shallow water at the refinery due to other releases.	2
Hydrogen	>1 nM/L	Reductive pathway possible, VC may accumulate	Not currently analyzed	3
Hydrogen	<1 nM/L	VC oxidized	Not currently analyzed.	0
Volatile Fatty Acids	> 0.1 mg/L	Intermediates resulting from biodegradation of more complex compounds; carbon and energy source	Not currently analyzed.	2
BTEX	> 0.1 mg/L	Carbon and energy source; drives dechlorination	In data set	2
PCE	Present	Material released	Not included in MNA due to low/infrequent concentrations.	0
TCE	Present	Material released Daughter product of PCE	In data set	0 2

TABLE 2. MONITORED NATURAL ATTENUATION ASSESSMENT EPA SCORING SYSTEM
MARATHON GALLUP REFINERY, GALLUP NEW MEXICO

Analysis	Concentration in Most Contaminated Zone	Significance	Applicability to the Existing Data Set	Scoring Value
DCE	Present	Material released Daughter product of TCE If cis is > 80% of total DCE it is likely a daughter product 1,1-DCE can be chemical reaction product of TCA	In data set	0 2
VC	Present	Material released Daughter product of DCE	In data set	0 2
1,1,1-TCA	Present	Material released	Not included in MNA due to low/infrequent concentrations.	0
DCA	Present	Daughter product of TCA under reducing conditions	1,1,1-TCA not in MNA analysis (not released)	2
Ethene /Ethane	>0.01mg/L >0.1 mg/L	Daughter product of VC/ethene	Not currently analyzed.	2 3

Notes:
BTEX = sum of benzene, toluene, ethylbenzene and xylene concentrations
C = centigrade
CO_2 = carbon dioxide
DCA = dichloroethane
DCE = dichloroethene
DO -dissolved oxygen
mg/L = milligram/liter
mV = millivolts
nM/L = nanomoles/liter
ORP = oxidation reduction potential
PCE = tetrachloroethene
TCA = trichloroethane
TCE = trichloroethene
TOC = total organic carbon

Source : EPA 1998

TABLE 3. MONITORED NATURAL ATTENUATION EPA SCORING RESULTS
MARATHON GALLUP REFINERY, GALLUP NEW MEXICO

Well	DO, mg/L		Nitrate, mg/L		Iron II, mg/L		Sulfate, mg/L		ORP, mV		pH		TOC, mg/L		T, C		BTEX, mg/L		TCE, mg/L		DCE, mg/L		VC, mg/L		Total Score	Evaluation
	Average	Score	Average	Score	Average	Score	Average	Score	Average	Score	Average	Score	Average	Score	Average	Score	Average	Score	Average	Score	Average	Score	Average	Score		
MKTF-2	3.34	0	<1	2	0.73	0	95.78	0	85.6	0	7.54	0	12.63	0	12.7	0	2.33	2	0.0024	0	0.02	2	0.016	2	8	Limited
MKTF-9	1.84	0	<1	2	2.13	3	21.23	0	-13.3	1	7.28	0	14.76	0	13.4	0	3.38	2	0.00305	0	0.04	2	ND	0	10	Limited
MKTF-10	1.76	0	<1	2	8.36	3	0.40	2	22.1	1	7.19	0	77.00	2	13.6	0	18.99	2	ND	0	0.05	2	0.017	2	16	Adequate
MKTF-13	0.85	0	<1	2	17.50	3	0.91	2	-8.4	1	7.18	0	50.98	2	14.0	0	6.75	2	ND	0	0.00	2	ND	0	14	Limited
MKTF-16	1.35	0	<1	2	6.47	3	10.22	2	-26.4	1	6.89	0	52.67	2	17.8	0	16.29	2	ND	0	ND	0	0.006	2	14	Limited
MKTF-17	2.34	0	<1	2	0.29	0	60.40	0	26.3	1	7.20	0	23.26	2	13.7	0	5.69	2	ND	0	ND	0	ND	0	7	Limited
MKTF-19	1.04	0	<1	2	9.98	3	0.59	2	-22.1	1	7.16	0	30.17	2	12.8	0	3.08	2	ND	0	0.00	2	ND	0	14	Limited
MKTF-22	1.95	0	<1	2	3.75	3	6.10	2	-24.5	1	6.84	0	15.64	0	12.8	0	3.03	2	ND	0	0.02	2	ND	0	12	Limited
MKTF-24	2.96	0	<1	2	0.94	0	29.58	0	127.8	0	7.52	0	21.94	2	12.8	0	4.56	2	ND	0	0.02	2	0.032	2	10	Limited
MKTF-25	3.84	0	<1	2	0.42	0	51.67	0	121.4	0	7.15	0	9.86	0	12.0	0	1.39	2	0.0135	0	0.10	2	0.012	2	8	Limited

Notes:

Scoring ranges for evidence of anaerobic biodegradation (EPA 1998):

Score	**Interpretation**
0 to 5	Inadequate
6 to 14	Limited
15 to 20	Adequate
>20	Strong

BTEX = benzene, toluene, ethylbenzene, xylene
C = centigrade
DCA = dichloroethane
DCE = dichloroethene
DO = dissolved oxygen
mg/L = milligrams per liter
mV = millivolts

ND = not detected; values set at half the detection limit for averaging
ORP = oxidation reduction potential measured using an silver/silver chloride reference cell
T = temperature
TOC - total organic carbon
TCE = trichloroethene
VC = vinyl chloride

TABLE 4. SUMMARY OF MANN-KENDALL CVOCs TREND ANALYSIS 2014-2020
MARATHON GALLUP REFINERY, GALLUP NEW MEXICO

				Descriptive Analysis											Mann-Kendall Trend Analysis				
Analyte	**Location**	**First Sample Date**	**Last Sample Date**	**Sample Size**	**Number of Detects**	**% Detects**	**Sample Mean**	**Sample Median**	**Sample Std. Dev.**	**Minimum Detected**	**Maximum Detected**	**Minimum MDL**	**Maximum MDL**	**Number of Outliers**	**Serial Correlation**	**Seasonality**	***p* -value**	**τ**	**Trend**
1,1-Dichloroethane	MKTF-02	4/8/2014	12/18/2020	26	26	100.00%	0.0453	0.0455	0.021	0.0065	0.098	1.100E-04	4.000E-03	0	YES	NO	0.0000	-0.637	Decreasing
1,1-Dichloroethane	MKTF-09	4/14/2014	3/3/2020	24	24	100.00%	0.0222	0.0230	0.008	0.0068	0.035	1.100E-04	8.000E-03	0	YES	NO	0.0000	-0.493	Decreasing
1,1-Dichloroethane	MKTF-10	4/11/2014	12/18/2020	25	13	52.00%	0.0357	0.0390	0.021	0.027	0.078	1.409E-03	4.000E-02	0	YES	NO	0.4080	-0.127	None
1,1-Dichloroethane	MKTF-16	4/10/2014	12/23/2020	25	12	48.00%	0.0360	0.0400	0.022	0.0062	0.081	2.200E-03	5.000E-02	0	NO	NO	0.1803	0.209	None
1,1-Dichloroethane	MKTF-22	4/10/2014	10/24/2019	21	6	28.57%	0.0060	0.0040	0.004	0.0017	0.015	1.000E-03	8.000E-03	0	NO	NO	0.1010	0.298	None
1,1-Dichloroethane	MKTF-24	4/8/2014	12/18/2020	26	26	100.00%	0.0864	0.0810	0.038	0.033	0.2	4.000E-04	1.250E-02	0	YES	NO	0.0000	-0.812	Decreasing
1,1-Dichloroethane	MKTF-25	4/8/2014	12/18/2020	24	24	100.00%	0.2230	0.2200	0.110	0.0918	0.61	5.200E-04	2.000E-02	0	NO	NO	0.0000	-0.659	Decreasing
1,1-Dichloroethene	MKTF-02	4/8/2014	12/18/2020	26	24	92.31%	0.0254	0.0210	0.025	0.0014	0.11	9.900E-05	4.108E-03	0	YES	NO	0.0000	-0.625	Decreasing
1,1-Dichloroethene	MKTF-09	4/14/2014	3/3/2020	24	24	100.00%	0.0337	0.0310	0.017	0.0063	0.074	9.900E-05	4.108E-03	0	YES	NO	0.0000	-0.547	Decreasing
1,1-Dichloroethene	*MKTF-10*	*4/11/2014*	*12/18/2020*	*25*	*6*	*24.00%*	*0.0074*	*0.0075*	*0.003*	*0.0059*	*0.013*	*1.300E-03*	*1.250E-02*	*0*	*YES*	*NO*	*0.0450*	*0.257*	*Increasing*
1,1-Dichloroethene	*MKTF-16*	*4/10/2014*	*12/23/2020*	*25*	*0*	*0.00%*	*0.0112*	*0.0099*	*0.010*	--	--	*8.100E-04*	*5.000E-02*	*0*	--	--	--	--	--
1,1-Dichloroethene	MKTF-22	4/10/2014	10/24/2019	21	13	61.90%	0.0065	0.0068	0.005	0.0051	0.017	8.100E-04	4.108E-03	0	YES	YES	0.0425	0.650	Increasing
1,1-Dichloroethene	MKTF-24	4/8/2014	12/18/2020	26	24	92.31%	0.0351	0.0350	0.021	0.0061	0.088	1.200E-04	1.250E-02	0	YES	NO	0.0000	-0.849	Decreasing
1,1-Dichloroethene	MKTF-25	4/8/2014	12/18/2020	24	24	100.00%	0.0978	0.0960	0.046	0.027	0.24	3.800E-04	2.500E-03	0	NO	NO	0.0016	-0.467	Decreasing
1,2-Dichloroethane	MKTF-02	4/8/2014	12/18/2020	26	21	80.77%	0.0068	0.0048	0.007	0.002	0.034	1.200E-04	4.000E-03	0	NO	NO	0.2981	-0.150	None
1,2-Dichloroethane	*MKTF-09*	*4/14/2014*	*3/3/2020*	*24*	*0*	*0.00%*	*0.0025*	*0.0023*	*0.002*	--	--	*1.200E-04*	*8.000E-03*	*0*	--	--	--	--	--
1,2-Dichloroethane	*MKTF-10*	*4/11/2014*	*12/18/2020*	*25*	*0*	*0.00%*	*0.0130*	*0.0097*	*0.012*	--	--	*1.946E-03*	*4.000E-02*	*0*	--	--	--	--	--
1,2-Dichloroethane	*MKTF-16*	*4/10/2014*	*12/23/2020*	*25*	*0*	*0.00%*	*0.0185*	*0.0130*	*0.013*	--	--	*2.300E-03*	*5.000E-02*	*0*	--	--	--	--	--
1,2-Dichloroethane	*MKTF-22*	*4/10/2014*	*10/24/2019*	*21*	*0*	*0.00%*	*0.0033*	*0.0035*	*0.002*	--	--	*1.100E-03*	*8.000E-03*	*0*	--	--	--	--	--
1,2-Dichloroethane	MKTF-24	4/8/2014	12/18/2020	26	16	61.54%	0.0128	0.0080	0.031	0.0056	0.163	2.600E-04	1.250E-02	0	NO	NO	0.8555	-0.030	None
1,2-Dichloroethane	MKTF-25	4/8/2014	12/18/2020	24	19	79.17%	0.0089	0.0090	0.006	0.0057	0.0321	2.600E-04	4.000E-03	0	NO	NO	0.5157	-0.101	None
cis-1,2-Dichloroethene	MKTF-02	4/8/2014	12/18/2020	26	20	76.92%	0.0104	0.0100	0.007	0.0019	0.03	8.100E-05	3.802E-03	0	YES	NO	0.0053	-0.289	Decreasing
cis-1,2-Dichloroethene	MKTF-09	4/14/2014	3/3/2020	24	22	91.67%	0.0205	0.0210	0.009	0.0096	0.036	8.100E-05	7.800E-03	0	YES	NO	0.0008	-0.308	Decreasing
cis-1,2-Dichloroethene	MKTF-10	4/11/2014	12/18/2020	25	17	68.00%	0.0333	0.0340	0.021	0.023	0.066	1.200E-03	2.000E-02	0	NO	NO	0.1164	0.235	None
cis-1,2-Dichloroethene	*MKTF-16*	*4/10/2014*	*12/23/2020*	*25*	*1*	*4.00%*	*0.0159*	*0.0120*	*0.013*	*0.0084*	*0.0084*	*2.000E-03*	*5.000E-02*	*0*	*NO*	*NO*	*0.7288*	*-0.071*	*None*
cis-1,2-Dichloroethene	MKTF-22	4/10/2014	10/24/2019	21	13	61.90%	0.0064	0.0078	0.004	0.0061	0.012	1.200E-03	7.500E-03	0	NO	NO	0.1424	0.248	None
cis-1,2-Dichloroethene	MKTF-24	4/8/2014	12/18/2020	26	19	73.08%	0.0225	0.0220	0.014	0.0086	0.057	1.200E-04	1.250E-02	0	YES	NO	0.0000	-0.791	Decreasing
cis-1,2-Dichloroethene	MKTF-25	4/8/2014	12/18/2020	24	24	100.00%	0.0427	0.0445	0.017	0.0149	0.1	2.000E-04	3.800E-03	0	NO	NO	0.0237	-0.337	Decreasing
Trichloroethene	MKTF-02	4/8/2014	12/18/2020	26	15	57.69%	0.0029	0.0026	0.002	0.0018	0.0073	1.600E-04	3.325E-03	0	YES	NO	0.0000	-0.532	Decreasing
Trichloroethene	MKTF-09	4/14/2014	3/3/2020	24	14	58.33%	0.0046	0.0043	0.003	0.0027	0.011	1.600E-04	5.200E-03	0	NO	NO	0.0007	-0.527	Decreasing
Trichloroethene	*MKTF-10*	*4/11/2014*	*12/18/2020*	*25*	*0*	*0.00%*	*0.0089*	*0.0082*	*0.005*	--	--	*1.663E-03*	*1.800E-02*	*0*	--	--	--	--	--
Trichloroethene	*MKTF-16*	*4/10/2014*	*12/23/2020*	*25*	*0*	*0.00%*	*0.0147*	*0.0110*	*0.010*	--	--	*1.100E-03*	*5.000E-02*	*0*	--	--	--	--	--
Trichloroethene	*MKTF-22*	*4/10/2014*	*10/24/2019*	*21*	*0*	*0.00%*	*0.0026*	*0.0033*	*0.001*	--	--	*1.100E-03*	*5.200E-03*	*0*	--	--	--	--	--
Trichloroethene	*MKTF-24*	*4/8/2014*	*12/18/2020*	*26*	*5*	*19.23%*	*0.0037*	*0.0034*	*0.002*	*0.0023*	*0.0052*	*1.900E-04*	*1.250E-02*	*0*	*YES*	*NO*	*0.0453*	*-0.237*	*Decreasing*
Trichloroethene	MKTF-25	4/8/2014	12/18/2020	24	23	95.83%	0.0224	0.0225	0.013	0.006	0.064	1.100E-04	2.600E-03	0	NO	NO	0.0008	-0.496	Decreasing
Vinyl Chloride	MKTF-02	4/8/2014	12/18/2020	26	19	73.08%	0.0082	0.0045	0.009	0.001	0.028	1.300E-04	3.582E-03	0	YES	NO	0.0000	0.542	Increasing
Vinyl Chloride	*MKTF-09*	*4/14/2014*	*3/3/2020*	*24*	*0*	*0.00%*	*0.0021*	*0.0018*	*0.001*	--	--	*1.300E-04*	*4.600E-03*	*0*	--	--	--	--	--
Vinyl Chloride	*MKTF-10*	*4/11/2014*	*12/18/2020*	*25*	*6*	*24.00%*	*0.0128*	*0.0100*	*0.007*	*0.0089*	*0.023*	*1.791E-03*	*2.300E-02*	*0*	*YES*	*NO*	*0.0373*	*0.290*	*Increasing*
Vinyl Chloride	*MKTF-16*	*4/10/2014*	*12/23/2020*	*25*	*1*	*4.00%*	*0.0147*	*0.0130*	*0.010*	*0.0058*	*0.0058*	*1.800E-03*	*5.000E-02*	*0*	*NO*	*NO*	*0.6274*	*0.094*	*None*
Vinyl Chloride	*MKTF-22*	*4/10/2014*	*10/24/2019*	*21*	*0*	*0.00%*	*0.0024*	*0.0022*	*0.001*	--	--	*1.100E-03*	*4.600E-03*	*0*	--	--	--	--	--
Vinyl Chloride	MKTF-24	4/8/2014	12/18/2020	26	17	65.38%	0.0178	0.0170	0.014	0.0049	0.038	1.100E-04	1.250E-02	0	YES	NO	0.0000	0.609	Increasing
Vinyl Chloride	MKTF-25	4/8/2014	12/18/2020	24	11	45.83%	0.0043	0.0023	0.009	0.00096	0.046	1.800E-04	4.600E-03	1	NO	NO	0.1009	0.271	None

Abbreviations:
MDL: Method Detection Limit
Std. Dev.: Standard Deviation

Notes:
All results are reported in mg/L.
Outlier and trend analyses were performed for all analyte-well pairs with sample size 4 or larger and at least one detected results above the MDL.
Italics : Trend analysis results based on data with less 25% detection rate should be considered with caution.
MDL = method detection limit
τ = test statistic, range -1 to 1
p = probability of no trend; trend present if $p < 0.05$,

TABLE 5. SUMMARY OF MANN-KENDALL MTBE TREND ANALYSIS 2014-2020
MARATHON GALLUP REFINERY, GALLUP NEW MEXICO

				Descriptive Analysis											Mann-Kendall Trend Analysis				
Analyte	Location	First Sample Date	Last Sample Date	Sample Size	Number of Detects	% Detects	Sample Mean	Sample Median	Sample Std. Dev.	Minimum Detected	Maximum Detected	Minimum MDL	Maximum MDL	Number of Outliers	Serial Correlation	Seasonality	*p* -value	τ	Trend
MTBE	MKTF-04	4/11/2014	3/3/2020	24	24	100.00%	1.8958	1.9000	0.393	1.2	2.5	1.700E-03	2.400E-02	0	YES	NO	0.1071	0.159	None
MTBE	MKTF-09	4/14/2014	3/3/2020	24	24	100.00%	0.6013	0.5300	0.214	0.31	1.2	8.700E-04	1.300E-02	0	YES	NO	0.0000	-0.522	Decreasing
MTBE	MKTF-16	4/10/2014	12/23/2020	25	25	100.00%	1.0636	0.8200	0.621	0.04	2.1	2.400E-03	7.400E-02	2	YES	NO	0.0000	-0.787	Decreasing
MTBE	MKTF-17	4/9/2014	10/29/2019	23	23	100.00%	1.9800	0.7700	2.153	0.28	7.4	8.700E-04	2.500E-02	0	YES	NO	0.1555	0.257	None
MTBE	MKTF-19	4/9/2014	10/29/2019	22	22	100.00%	9.4773	9.7000	1.131	7.8	12	8.700E-03	1.300E-01	0	YES	NO	0.4721	-0.074	None
MTBE	MKTF-20	4/11/2014	2/5/2020	21	20	95.24%	0.1241	0.1300	0.090	0.0057	0.38	2.100E-03	3.200E-02	0	NO	NO	0.2758	-0.178	None
MTBE	MKTF-21	4/11/2014	2/5/2020	20	20	100.00%	0.4887	0.5200	0.289	0.015	1.2	1.700E-03	1.300E-02	0	YES	NO	0.0000	-0.563	Decreasing
MTBE	MKTF-22	4/10/2014	10/24/2019	21	21	100.00%	5.4333	5.7000	1.593	2.6	8.8	9.122E-03	9.100E-02	0	YES	NO	0.5057	-0.095	None
MTBE	MKTF-23	9/23/2014	10/29/2019	9	9	100.00%	1.0200	1.1000	0.453	0.33	1.6	1.700E-03	4.561E-02	0	NO	NO	0.1138	0.457	None
MTBE	MKTF-24	4/8/2014	12/18/2020	26	26	100.00%	0.1543	0.1650	0.043	0.063	0.23	2.500E-04	1.850E-02	0	YES	NO	0.0000	-0.498	Decreasing
MTBE	MKTF-25	4/8/2014	12/18/2020	24	24	100.00%	0.3223	0.2450	0.227	0.12	0.88	5.000E-04	4.600E-03	0	YES	NO	0.0880	0.286	None

Abbreviations:
MDL: Method Detection Limit
Std. Dev.: Standard Deviation

Notes:
All results are reported in mg/L.
Outlier and trend analyses were performed for all analyte-well pairs with sample size 4 or larger and at least one detected results above the MDL.
MTBE = methyl tert-butyl ether
MDL = method detection limit
τ = test statistic, range -1 to 1
p = probability of no trend; trend present if $p < 0.05$,

TABLE 6. PROPOSED MNA GROUNDWATER QUARTERLY SAMPLING ANALYSES
MARATHON GALLUP REFINERY, GALLUP, NEW MEXICO

Analyte	Method of Analysis	Significance for MNA	Analyte Used in CVOC or MTBE Evaluation	Utility for MNA Analyses
BTEX	Laboratory	Source of organics for reducing conditions	CVOC, MTBE	Monitor trends
MTBE	Laboratory	Decreasing trends indicate natural attenuation	MTBE	Monitor trends
TBA	Laboratory	Decreasing trends indicate natural attenuation	MTBE	Monitor trends, degradation product of MTBE
PCE	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends
TCE	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of PCE
cis-1,2-DCE	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of TCE
1,1-DCE	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of TCE
1,1-DCA	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends
1,2-DCA	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends
Vinyl chloride	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of cis-1,2-DCE and 1,1-DCE
Ethene [1]	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of vinyl chloride
Ethane [1]	Laboratory	Decreasing trends indicate natural attenuation	CVOC	Monitor trends, degradation product of vinyl chloride
Methane [1]	Laboratory	Decreasing trends indicate natural attenuation	CVOC, MTBE	Monitor trends, indicator for CVOC and MTBE degradation
Chloride	Laboratory	End product of 1,1-DCA and 1,2-DCA degradation	CVOC	Monitor trends, but dissolved salts may mask trends
Nitrate	Laboratory	Potential electron receptor for biodegradation	CVOC, MTBE	Presence indicates potential for biodegradation
Nitrite	Laboratory	Form of nitrate reduced by biodegradation	CVOC, MTBE	Presence indicates possible biodegradation
Sulfate/sulfide	Laboratory	Potential electron receptor for biodegradation	CVOC, MTBE	Monitor trends
Iron (ferric/ferrous)	Laboratory	Potential electron receptor for biodegradation	CVOC, MTBE	Monitor trends
Manganese	Laboratory	Potential electron receptor for biodegradation	CVOC, MTBE	Monitor trends
Temperature	Field	Rate of natural attenuation	CVOC, MTBE	Monitor trends
pH	Field	Neutral range 6-8 required for biodegradation	CVOC, MTBE	Monitor level and trends
DO	Field	Presence required for aerobic biodegradation	CVOC, MTBE	Monitor level and trends
ORP	Field	Indicates redox state for biodegradation	CVOC, MTBE	Monitor level and trends

[1] Compound will be analyzed in monitoring wells MKTF-2, MKTF-10, MKTF-24, and MKTF-25 only.

Notes:

BTEX = benzene, toluene, ethylenzene, xylene
CVOC = chlorinated volatile organic compound
DCA = dichloroethane
DCE = dichloroethene
DO = dissolved oxygen
MNA = monitored natural attenuation
MTBE = methyl tert-butyl ether
ORP - oxidation reduction potential measured using an silver/silver chloride reference cell
PCE = tetrachloroethene
TCE = trichloroethene
TBA = tert-butyl alcohol

Figures

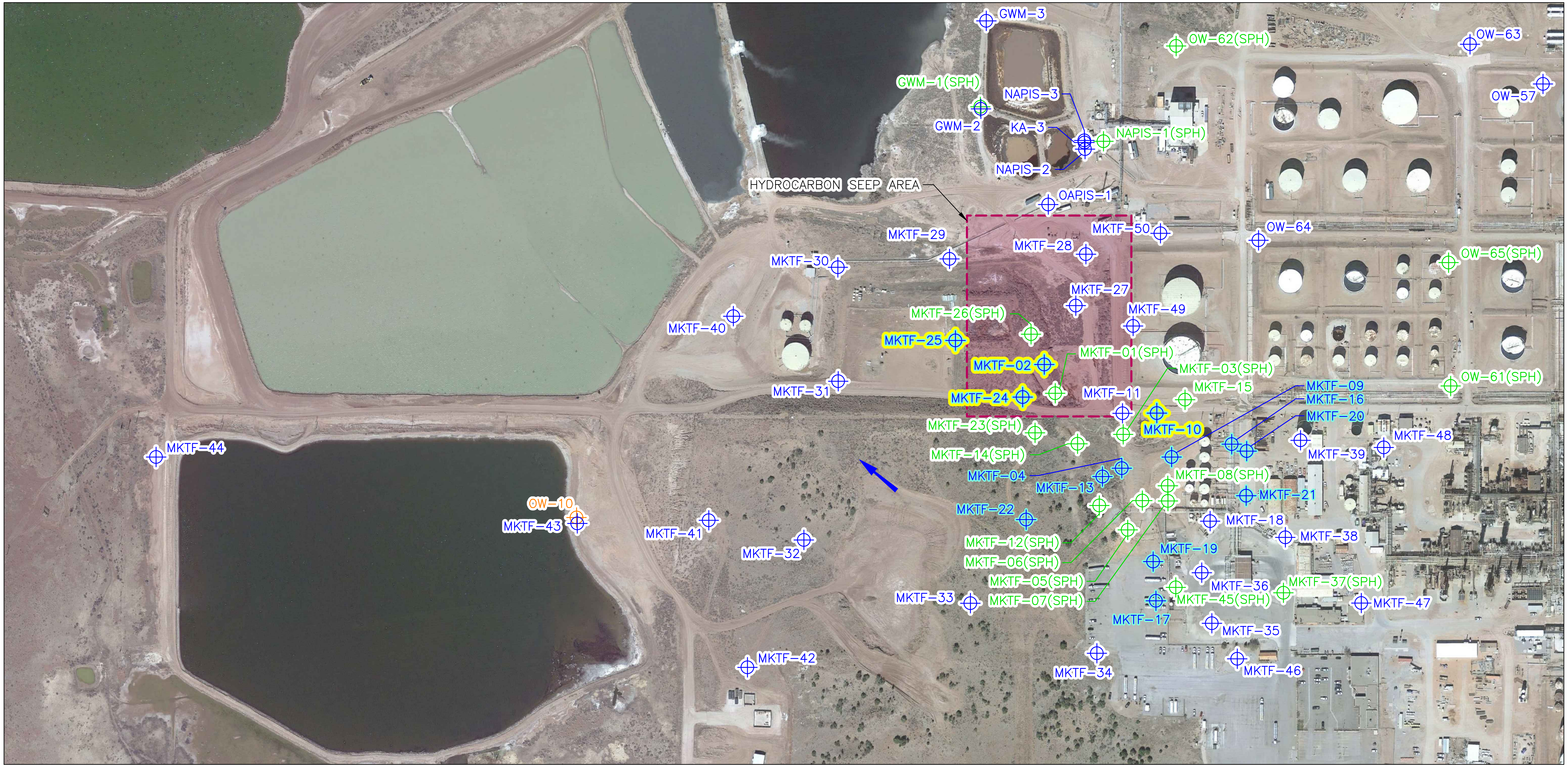
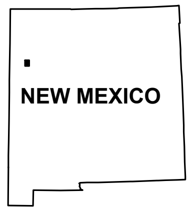


Image Citation: Google Earth Pro Imagery, Publication: March 2016.



QUADRANGLE LOCATION

NOTE:

SITE LEGAL DESCRIPTION -
TOWNSHIP 15 NORTH,
RANGE 15 WEST, SECTION 33

EXPLANATION

⌖ OW–10	SONSELA WELL AND DESIGNATION
⌖ MKTF–42	CHINLE/ALLUVIUM INTERFACE WELL AND DESIGNATION
⌖ MKTF–45	SPH MONITORING WELL AND DESIGNATION
⌖ MKTF–17	MKTF MNA WELL
⌖ MKTF–10	MONITORING WELL WITH CONSISTENT DETECTION OF VINYL CHLORIDE
←	GENERAL GROUNDWATER FLOW DIRECTION
▭	HYDROCARBON SEEP AREA

MKTF	MARKETING TANK FARM
MNA	MONITORED NATURAL ATTENUATION
SPH	SINGLE-PHASE HYDROCARBON (DETECTED DURING THIRD QUARTER 2020 SAMPLING EVENT)

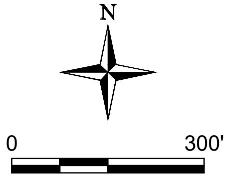


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FIGURE 1.A

HYDROCARBON SEEP AREA AND MNA WELL SET

MARATHON PETROLEUM CORP.
GALLUP REFINING DIVISION
GALLUP, NEW MEXICO

Drawn By: REP	Checked By: MS	Scale: 1" = 300'	Date: 11/12/21	File: 697-MNA-SITE1-202111

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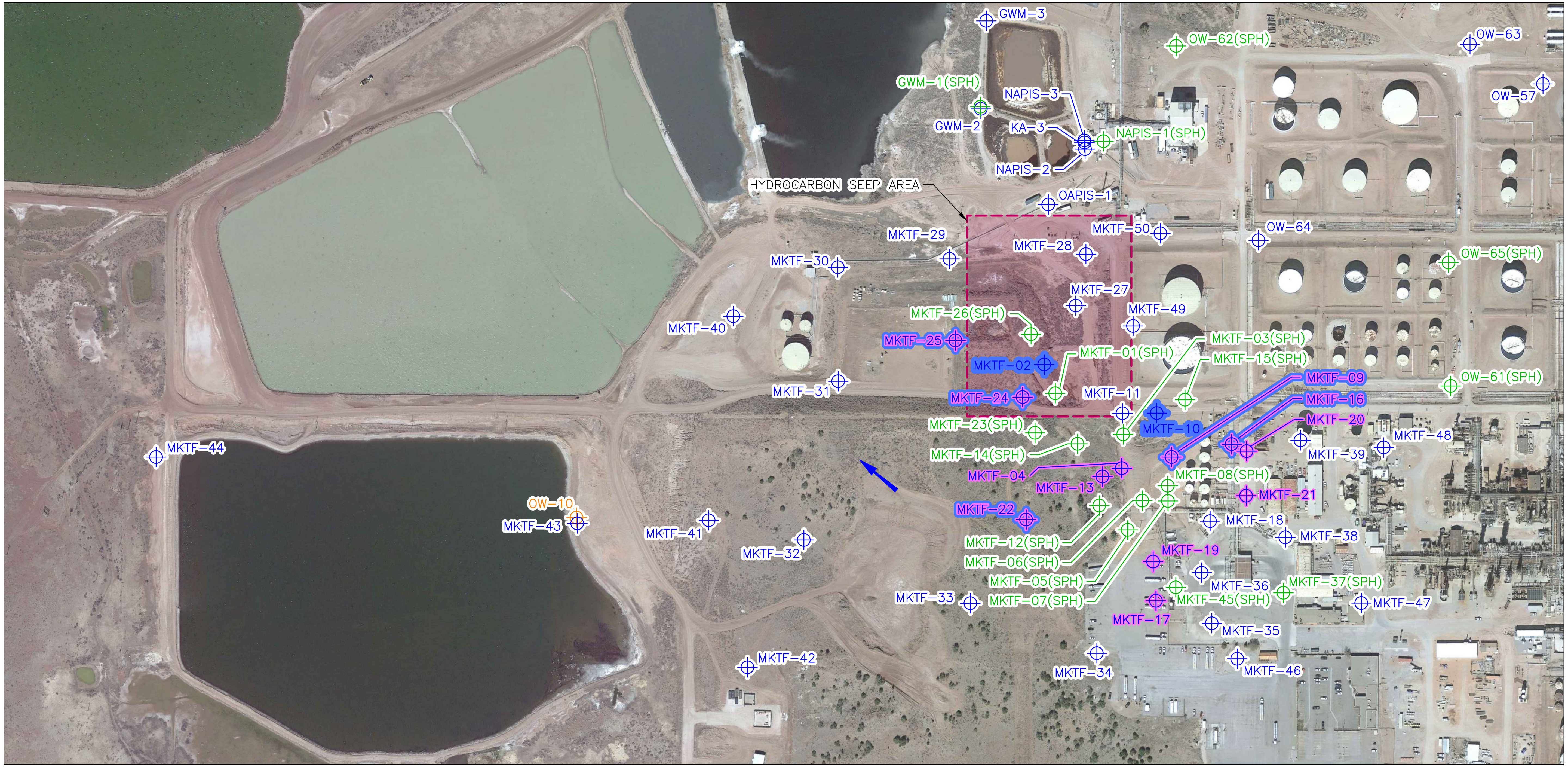

Image Citation: Google Earth Pro Imagery, Publication: March 2016.

NEW MEXICO

QUADRANGLE LOCATION

NOTE:

SITE LEGAL DESCRIPTION -
TOWNSHIP 15 NORTH,
RANGE 15 WEST, SECTION 33

EXPLANATION

OW-10	SONSELA WELL AND DESIGNATION
MKTF-42	CHINLE/ALLUVIUM INTERFACE WELL AND DESIGNATION
MKTF-45	SPH MONITORING WELL AND DESIGNATION
MKTF-17	MKTF MNA WELL
MKTF-04	MONITORING WELL WITH CONSISTENT DETECTION OF MTBE
MKTF-09	MONITORING WELL WITH CONSISTENT DETECTION OF CHLORINATED COMPOUNDS
MKTF-09	MONITORING WELL WITH CONSISTENT DETECTION OF MTBE AND CHLORINATED COMPOUNDS

←	GENERAL GROUNDWATER FLOW DIRECTION
▨	HYDROCARBON SEEP AREA
CVOC	CHLORINATED VOLATILE ORGANIC COMPOUND
MKTF	MARKETING TANK FARM
MNA	MONITORED NATURAL ATTENUATION
MTBE	METHYL TERT-BUTYL ETHER
SPH	SINGLE-PHASE HYDROCARBON (DETECTED DURING THIRD QUARTER 2020 SAMPLING EVENT)

N

0 300'

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FIGURE 1.B

MNA WELLS WITH CVOC AND MTBE DETECTIONS

MARATHON PETROLEUM CORP.
GALLUP REFINING DIVISION
GALLUP, NEW MEXICO

Drawn By: REP | Checked By: MS | Scale: 1" = 300' | Date: 11/12/21 | File: 697-MNA-SITE2-202111

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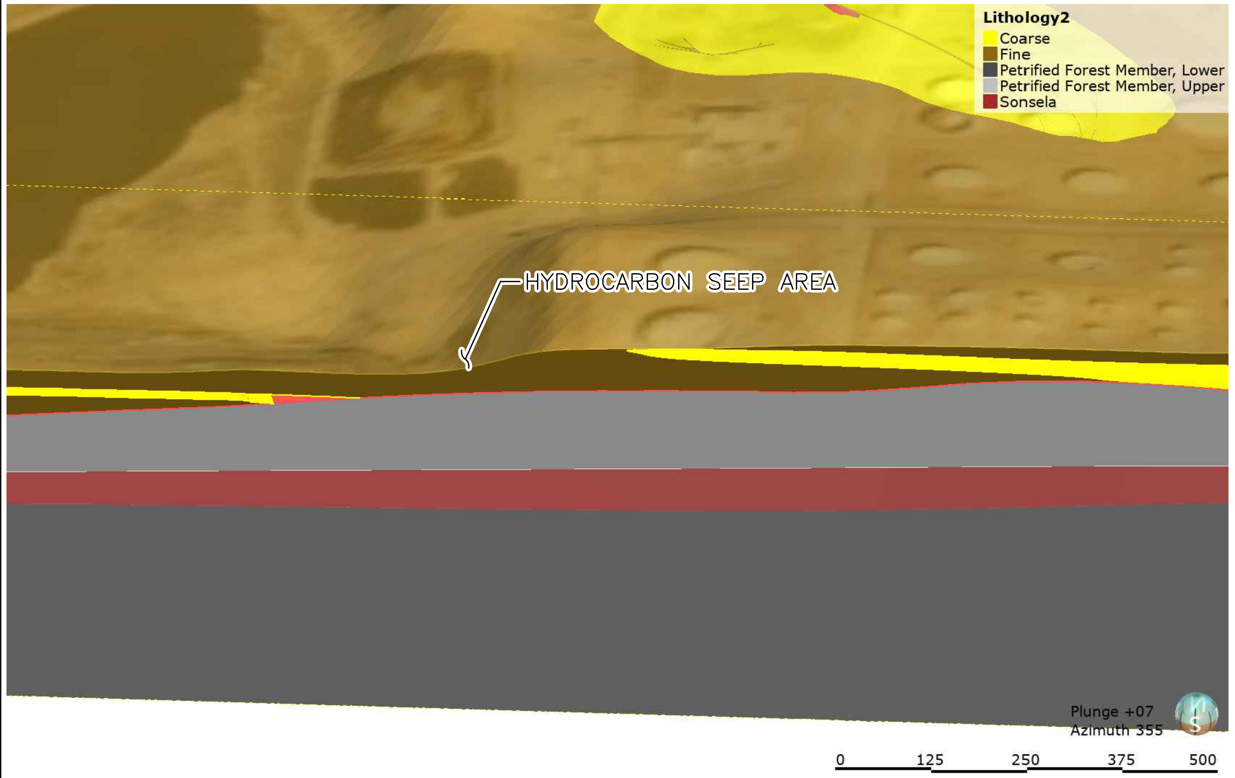
LOCAL SURFACE TOPOGRAPHY SHOWING SWALE IN THE HYDROCARBON SEEP AREA NORTH VIEW, X5 VERTICAL EXAGGERATION



GEOLOGICAL MODEL CROSS-SECTION OF THE HYDROCARBON SEEP AREA EAST VIEW, X5 VERTICAL EXAGGERATION

EXPLANATION

← GENERAL GROUNDWATER FLOW DIRECTION

N

0 ~250'

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FIGURE 2

3D MODELING OF LOCAL GEOLOGY IN THE HYDROCARBON SEEP AREA

MARATHON PETROLEUM CORP.
GALLUP REFINING DIVISION
GALLUP, NEW MEXICO

Drawn By: REP	Checked By: JP	Scale: 1" = ~250'	Date: 6/16/21	File: 697-MNA-3DMODEL-202011

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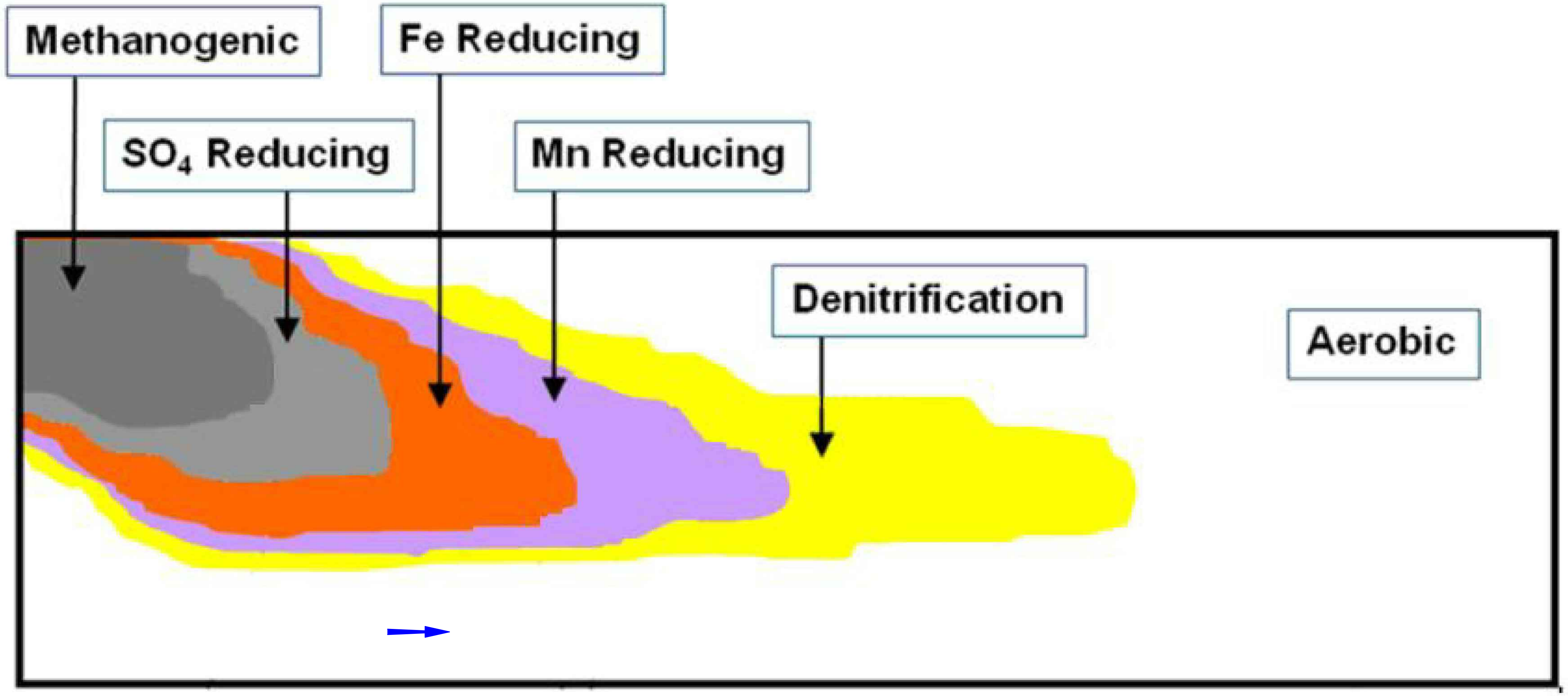

EXPLANATION

⬅	GENERAL GROUNDWATER FLOW DIRECTION
FE	IRON
MN	MANGANESE
SO4	SULFATE

Source: After ITRC 2010

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FIGURE 3

REDUCING REGIMES IN A TYPICAL HYDROCARBON GROUNDWATER PLUME

MARATHON PETROLEUM CORP.
GALLUP REFINING DIVISION
GALLUP, NEW MEXICO

Drawn By: REP	Checked By: CF	Scale: NONE	Date: 11/23/20	File: 697-MNA-REDREGIME-202011

Reactions

Contaminant	RD	DC	ACM	ANCM	ADM	ANDM	DHC	AH
PCE	●							
TCE	●							
1,2-DCE	●					○		
VC	●					○		
1,1,2,2-TeCA	●	●					●	
1,1,2-TCA	●	●					◒	
1,2-DCA	●	●					◒	◒
1,1-DCA	●						◒	

Key:

●	Highly Likely to occur
◒	Highly likely to occur, but a slow rate
○	May occur under specific conditions
☐	Highly Unlikely to occur

DCA - DICHLOROETHANE
DCE - DICHLOROETHENE
PCE - PERCHLOROETHENE
TCE - TRICHLOROETHENE
TeCA - TETRACHLOROETHANE
VC - VINYL CHLORIDE

REACTIONS

ACM	Aerobic Co-Metabolism
ANCM	Anaerobic Co-Metabolism
ADM	Aerobic Direct Metabolism
ANDM	Anaerobic Direct Metabolism
DHC	Dehydrochlorination (abiotic)
AH	Abiotic Hydrolysis
DC	Dichloroelimination (biotic)
RD	Reductive Dechlorination (hydrogenolysis)

Source: Adopted from TRUEX, ET AL 2007

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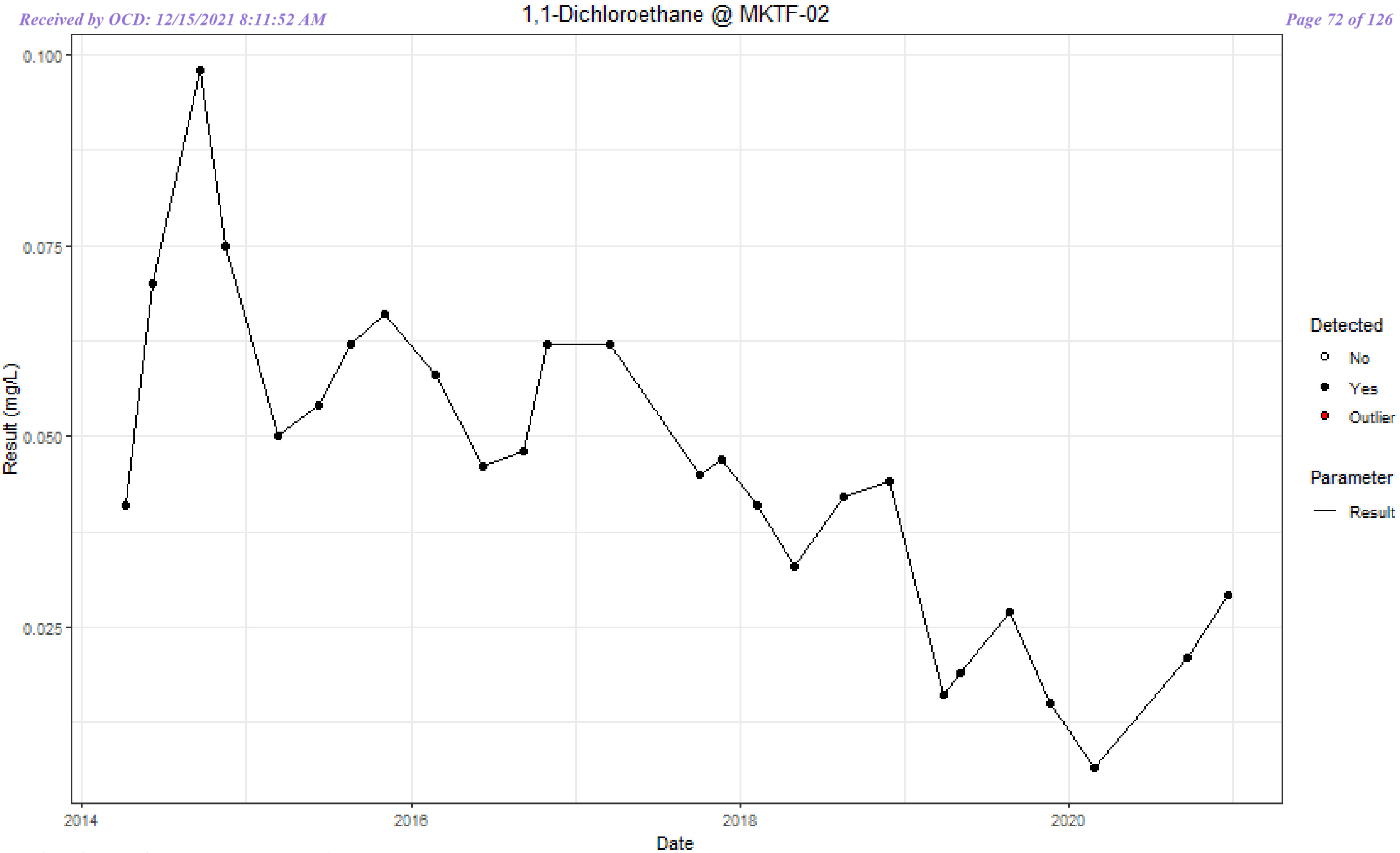
FIGURE 4

DEGRADATION REACTIONS IN ANAEROBIC CONDITIONS

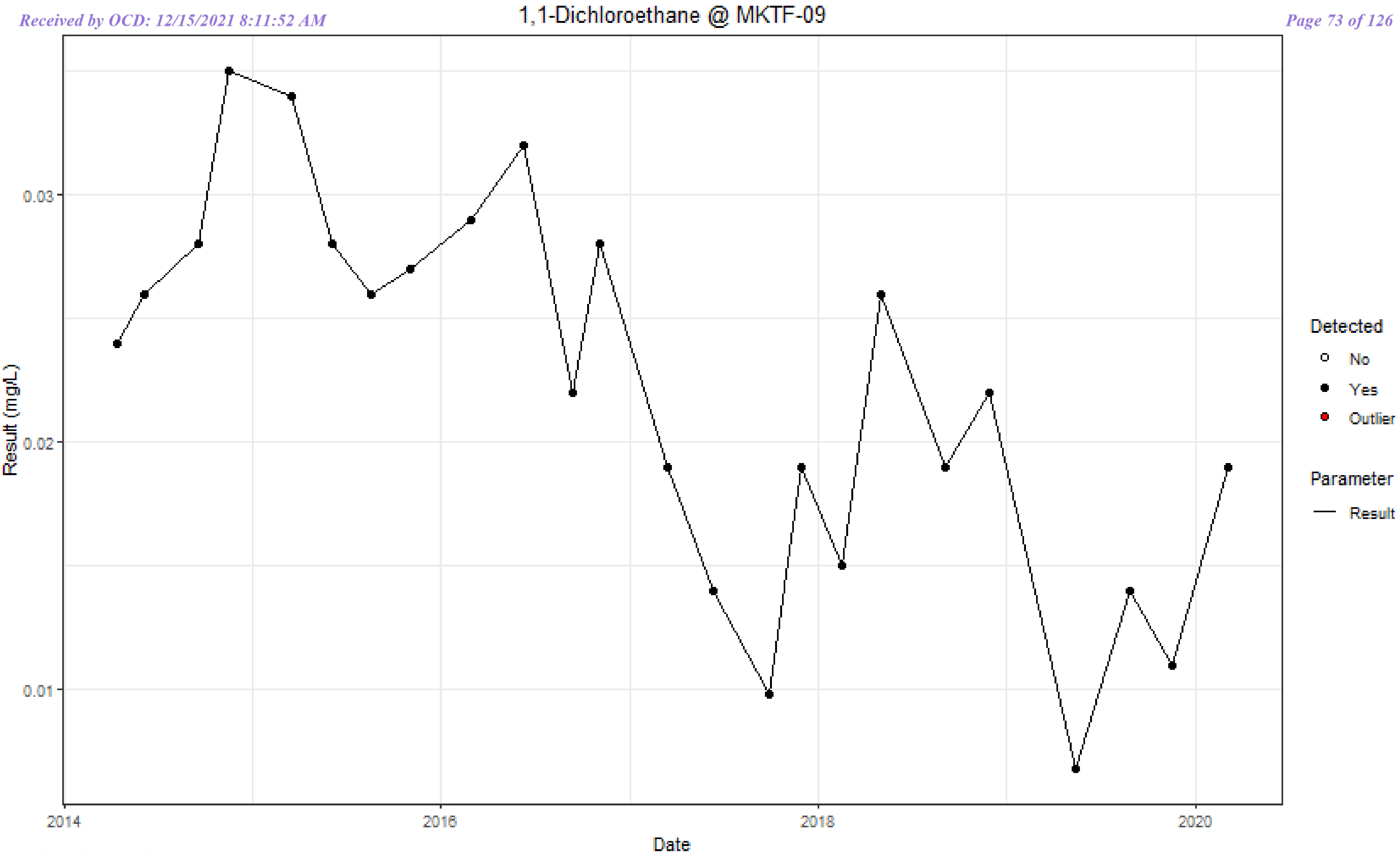
MARATHON PETROLEUM CORP.
GALLUP REFINING DIVISION
GALLUP, NEW MEXICO

Drawn By: REP | Checked By: CF | Scale: NONE | Date: 11/23/20 | File: 697-MNA-DEGRADATION-202011

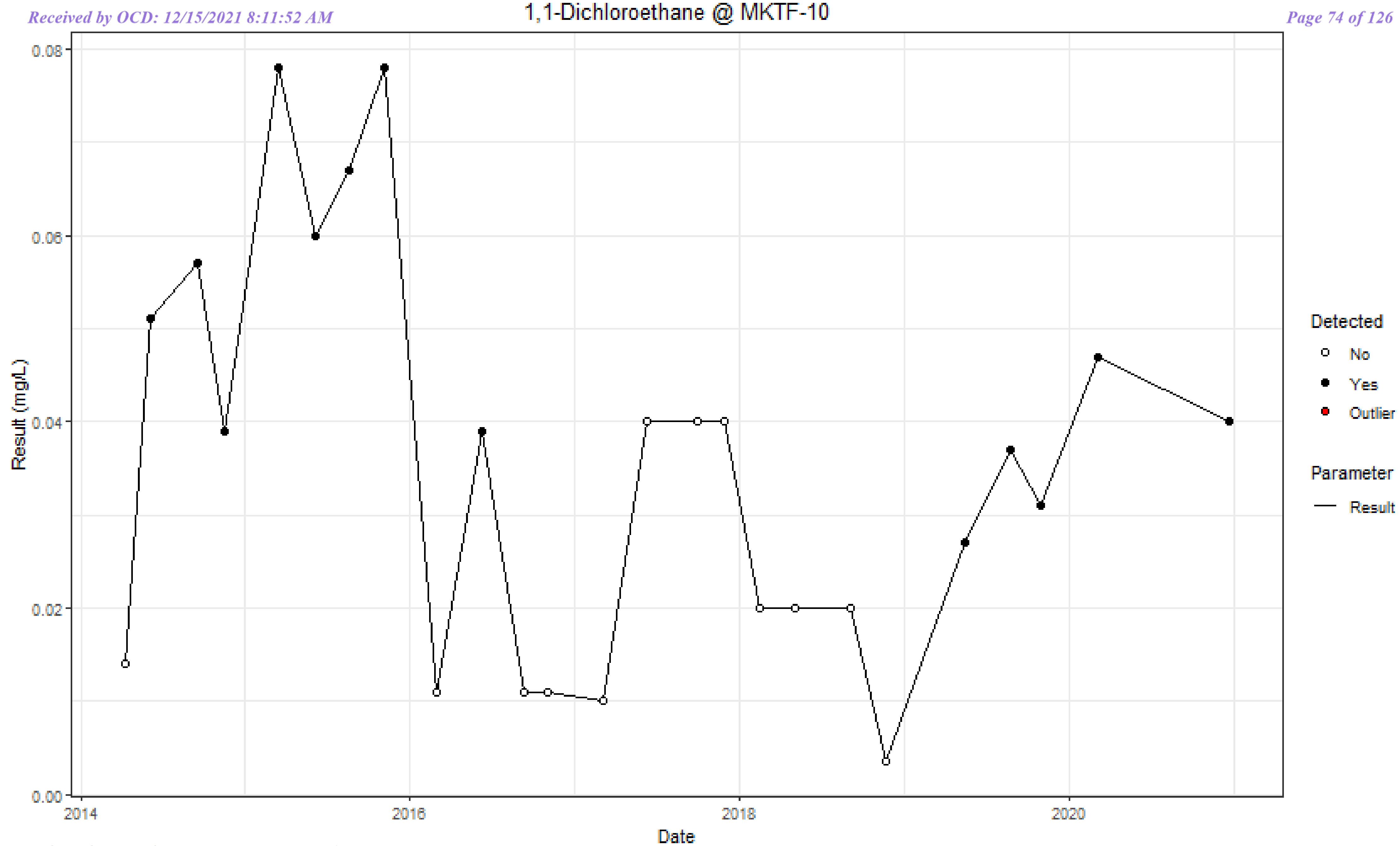
Attachment A – CVOC Time Series Plots



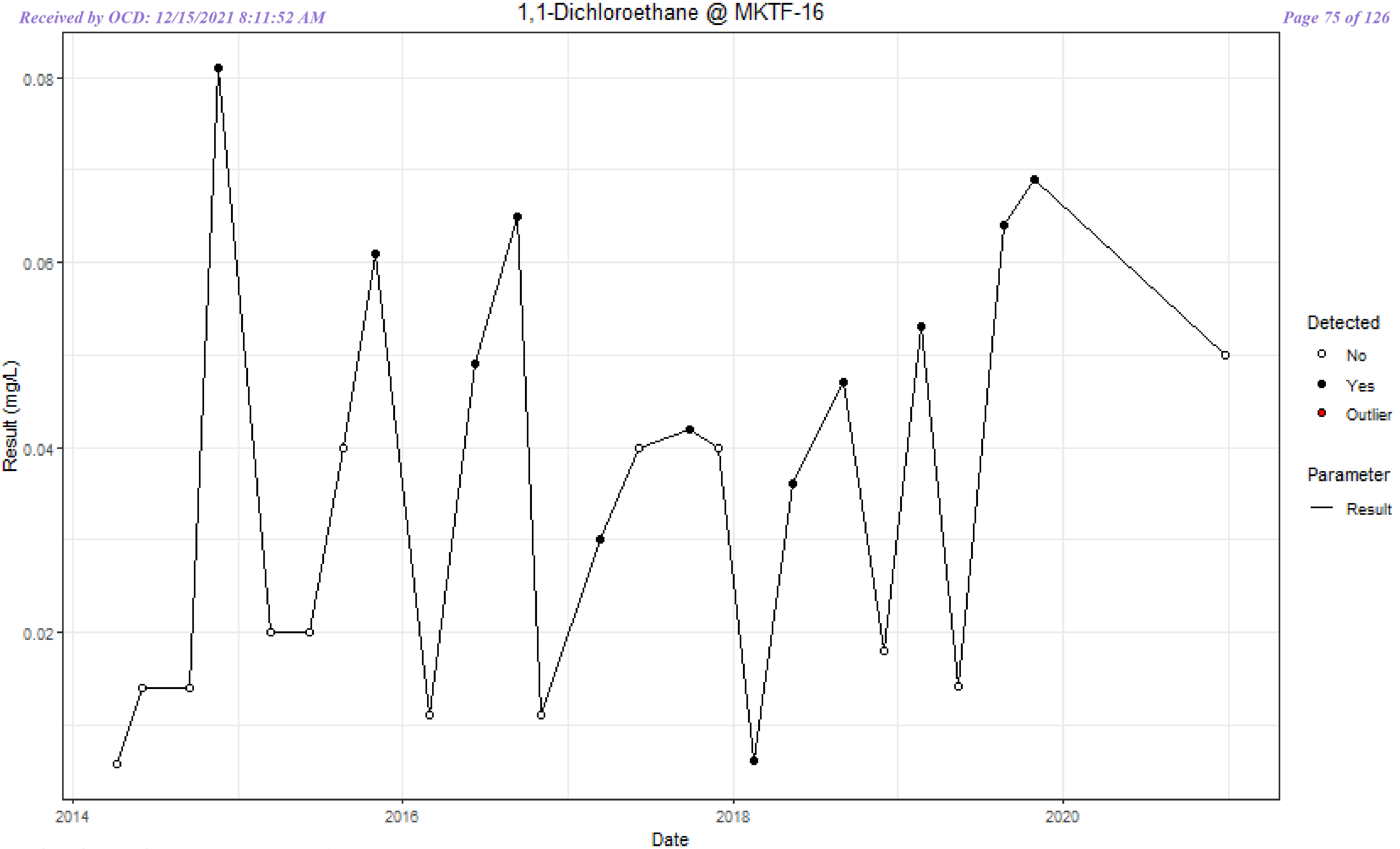
Method detection limit reported for ND results.



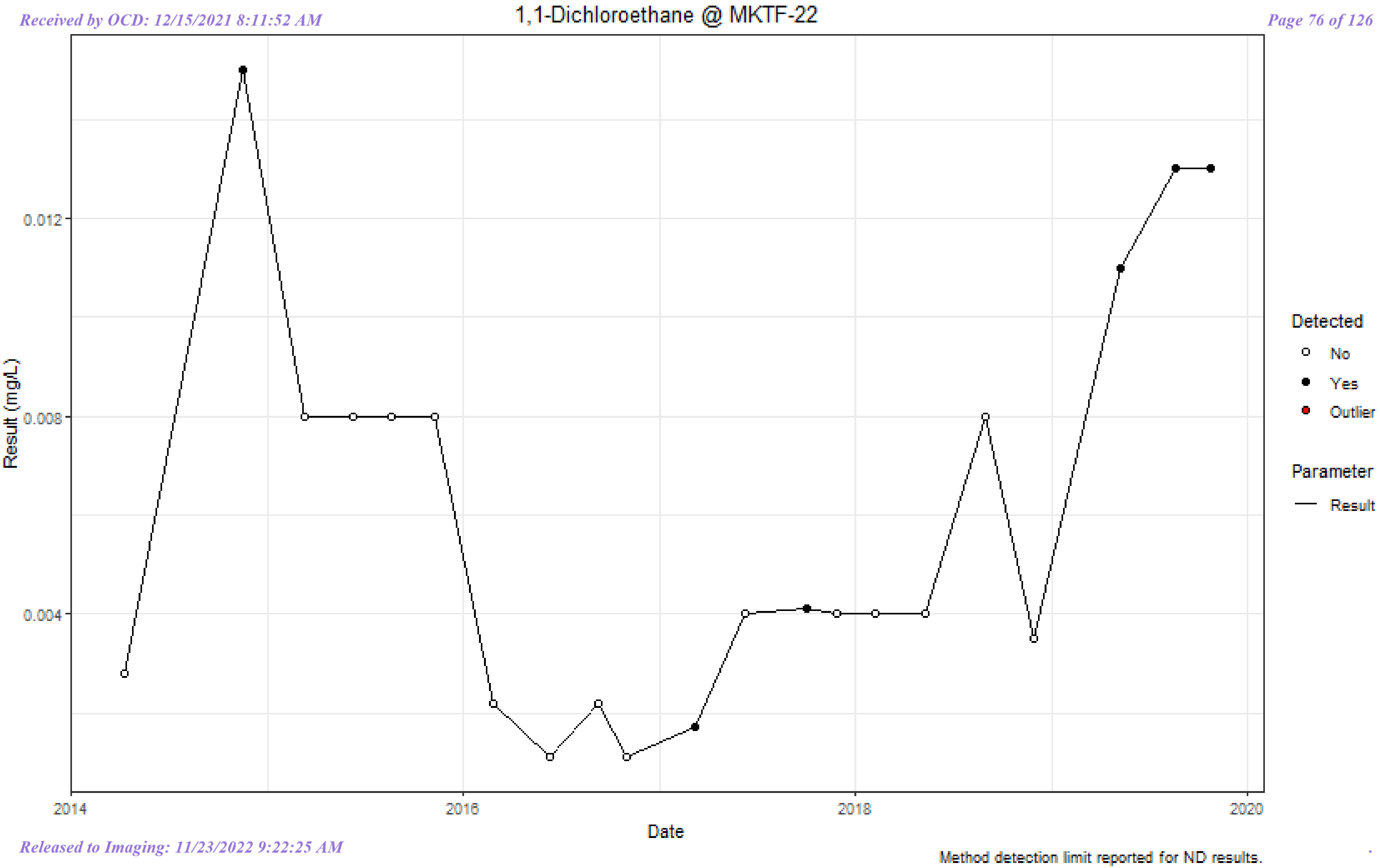
Method detection limit reported for ND results.



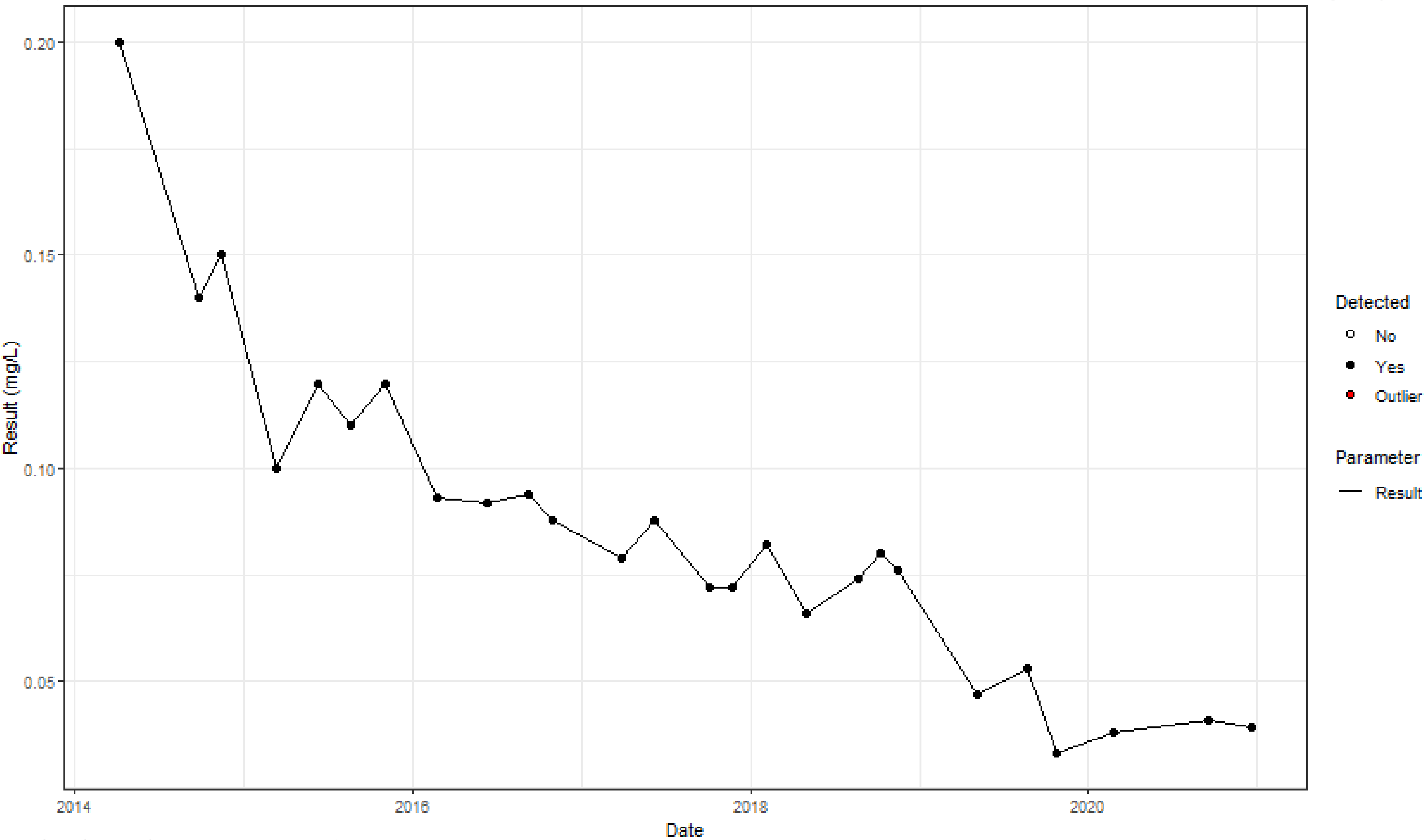
Method detection limit reported for ND results.



Method detection limit reported for ND results.

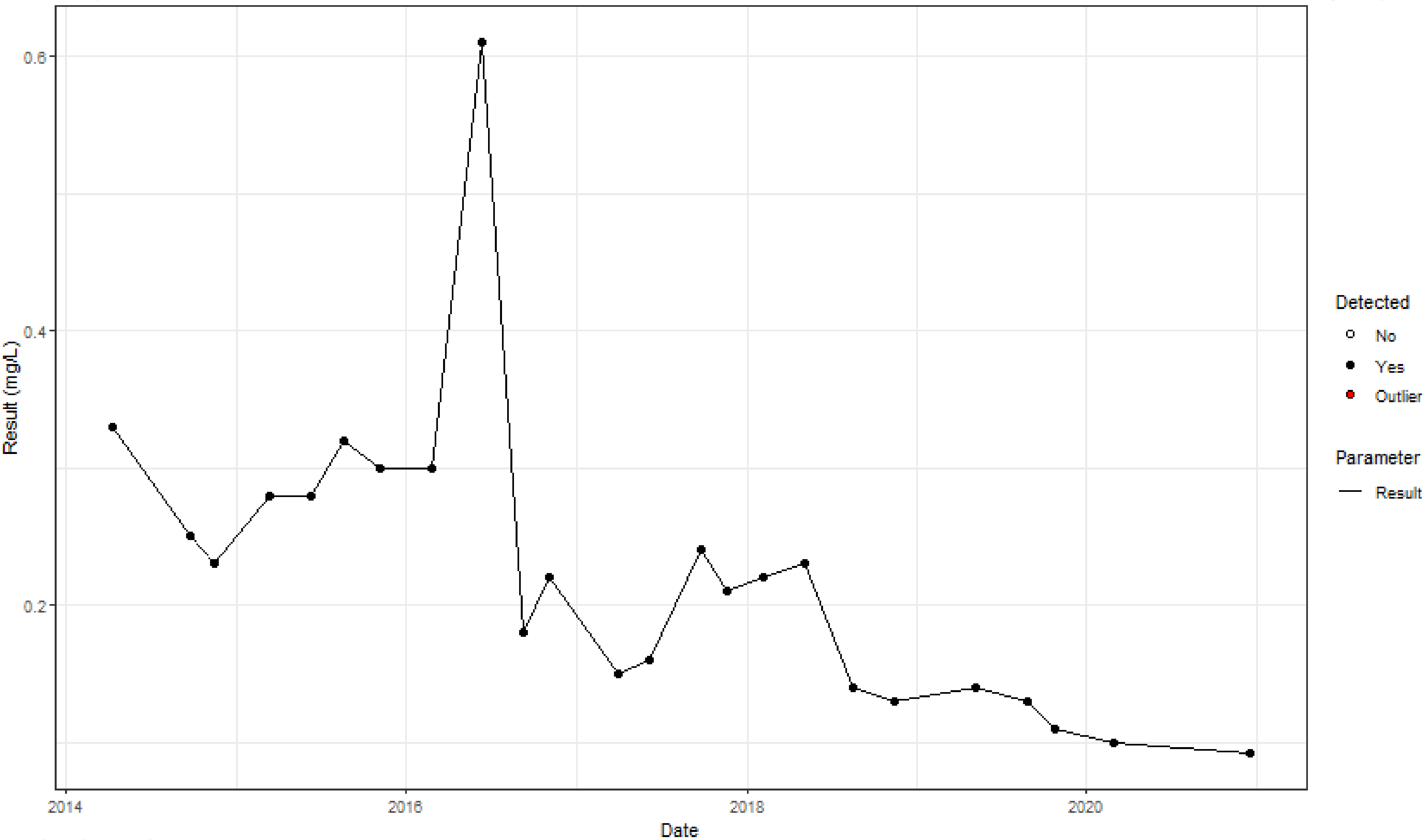

1,1-Dichloroethane @ MKTF-22
Result (mg/L)
0.012
0.008
0.004
Date
2014
2016
2018
2020
Detected
No
Yes
Outlier
Parameter
Result
Method detection limit reported for ND results.

1,1-Dichloroethane @ MKTF-24



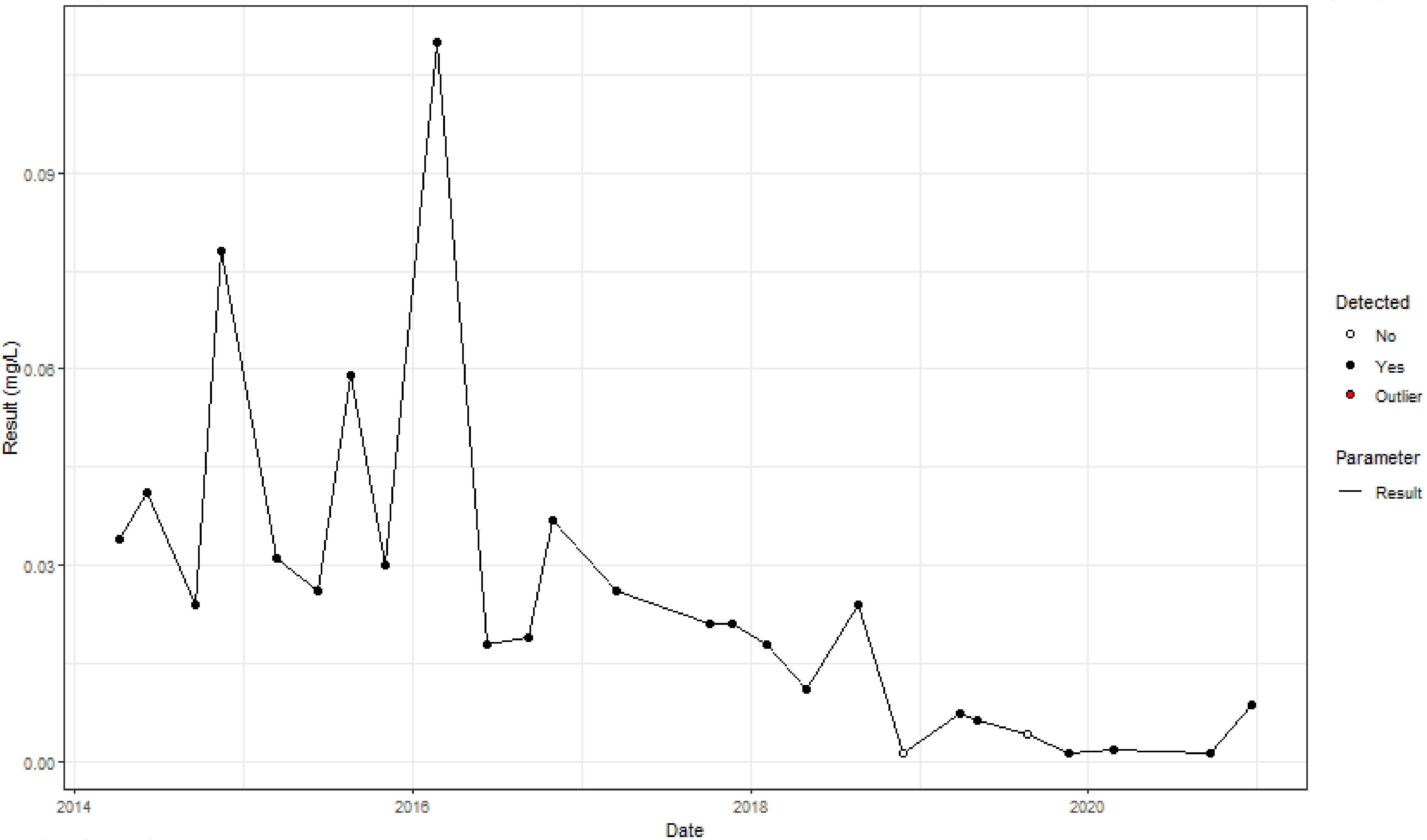
Method detection limit reported for ND results.

1,1-Dichloroethane @ MKTF-25



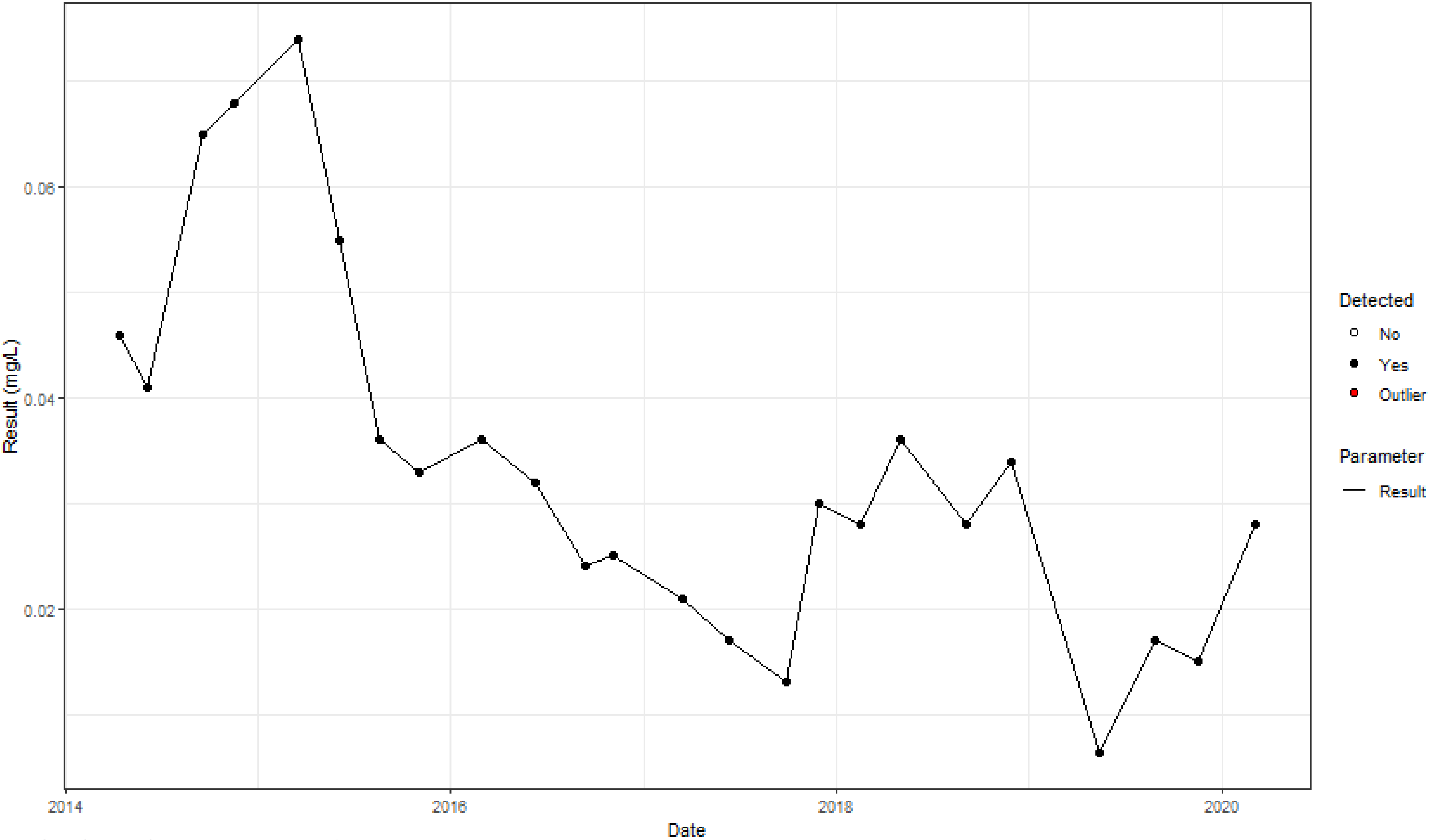
Method detection limit reported for ND results.

1,1-Dichloroethene @ MKTF-02

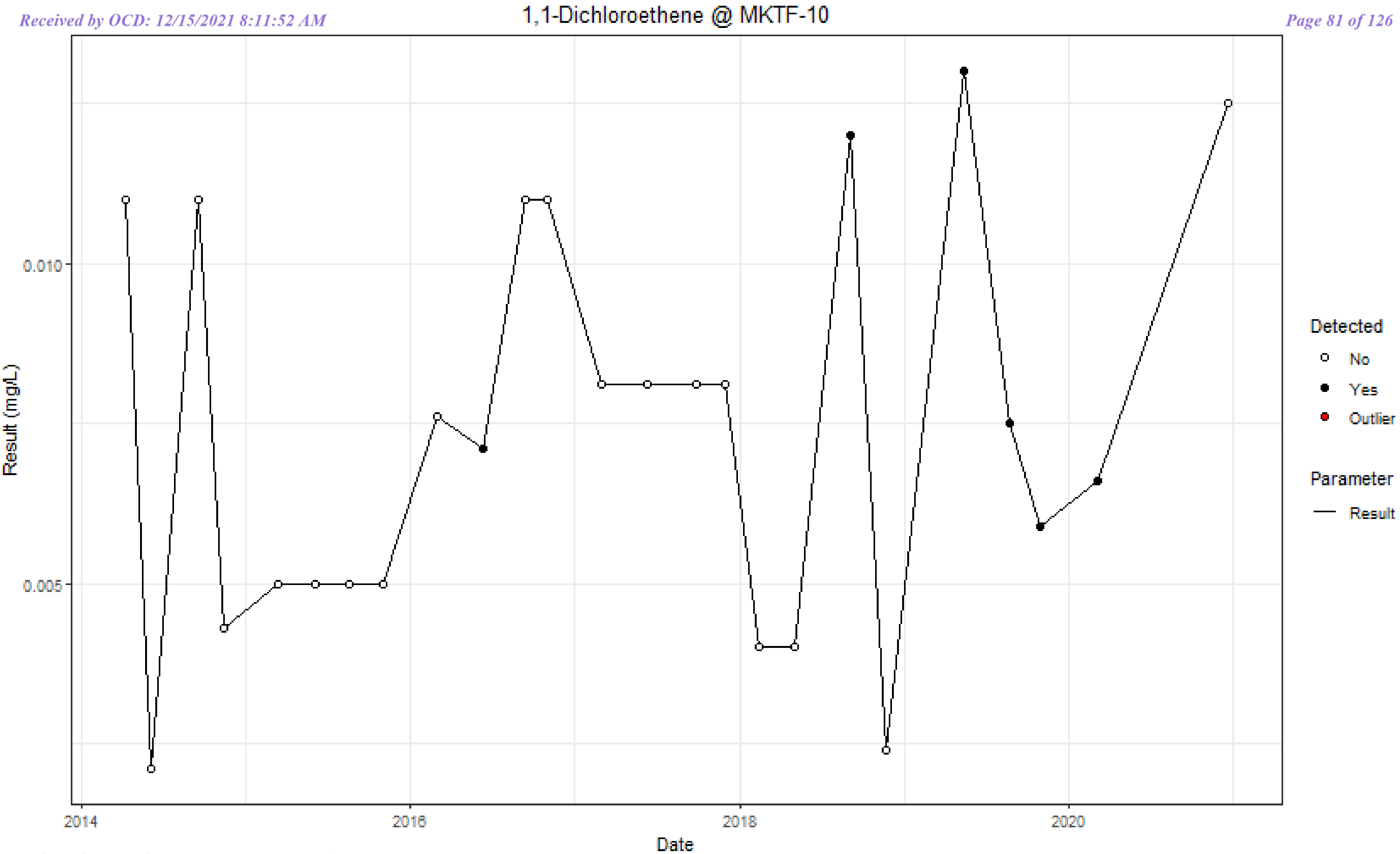


Method detection limit reported for ND results.

1,1-Dichloroethene @ MKTF-09



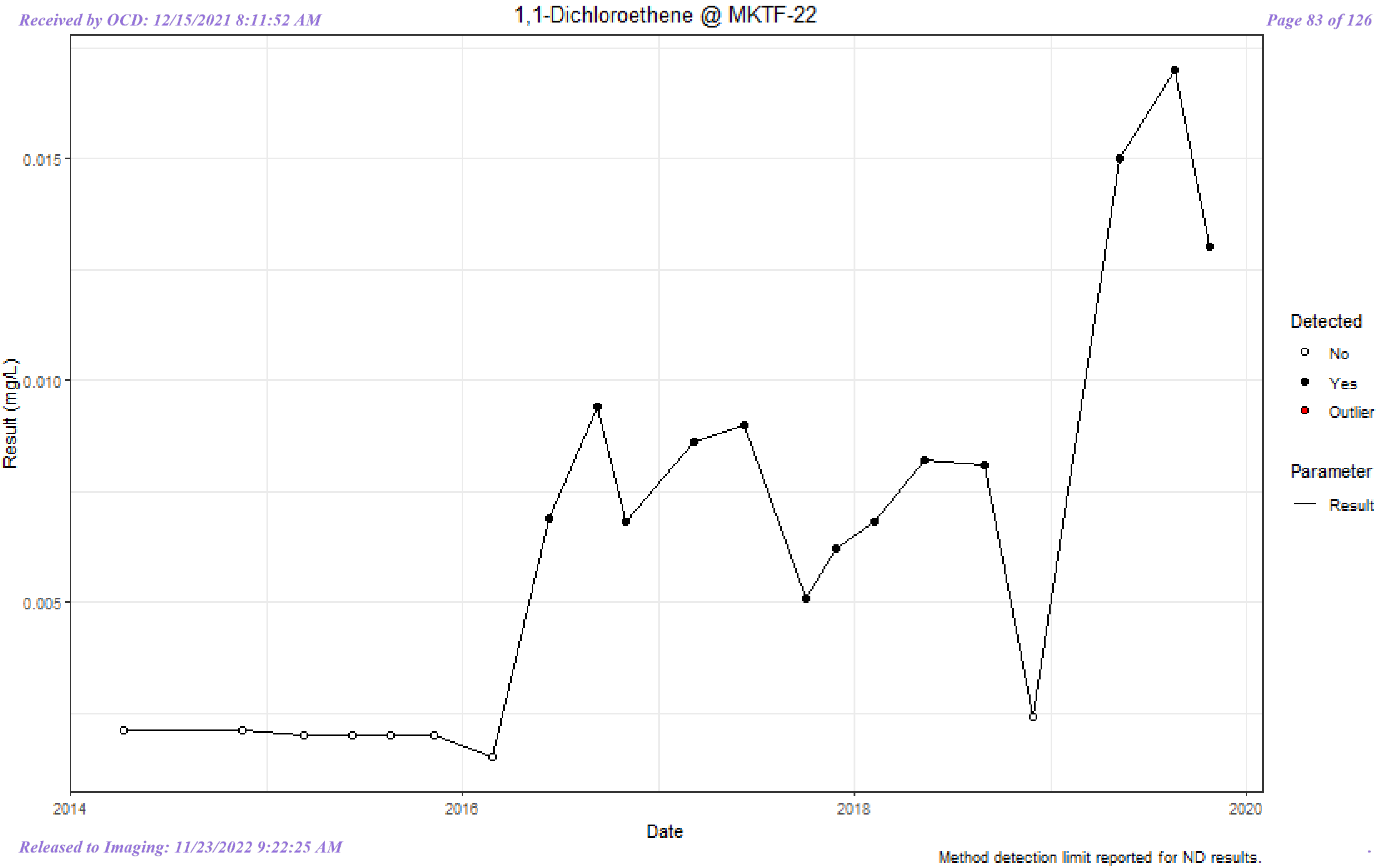
Method detection limit reported for ND results.

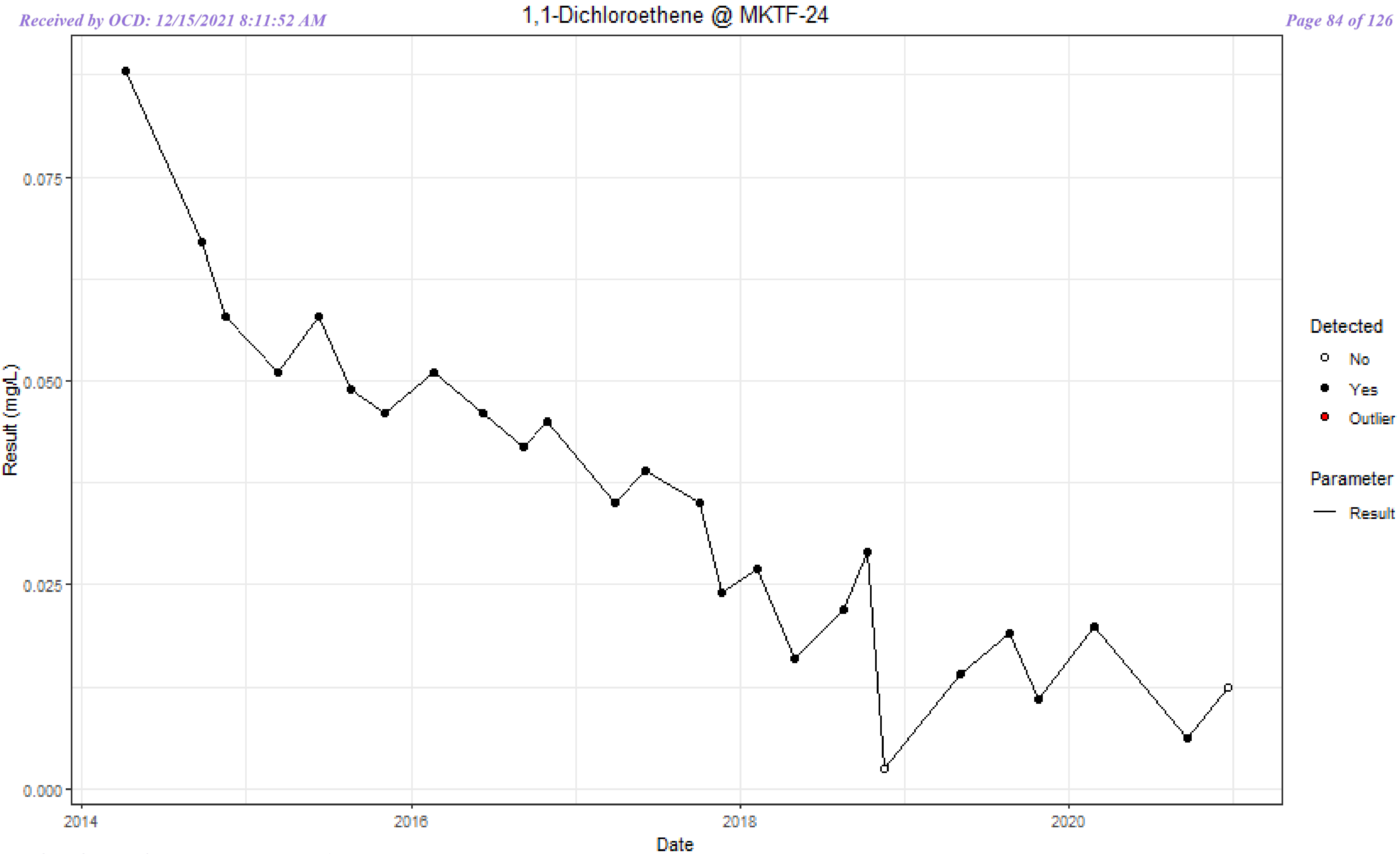


Method detection limit reported for ND results.

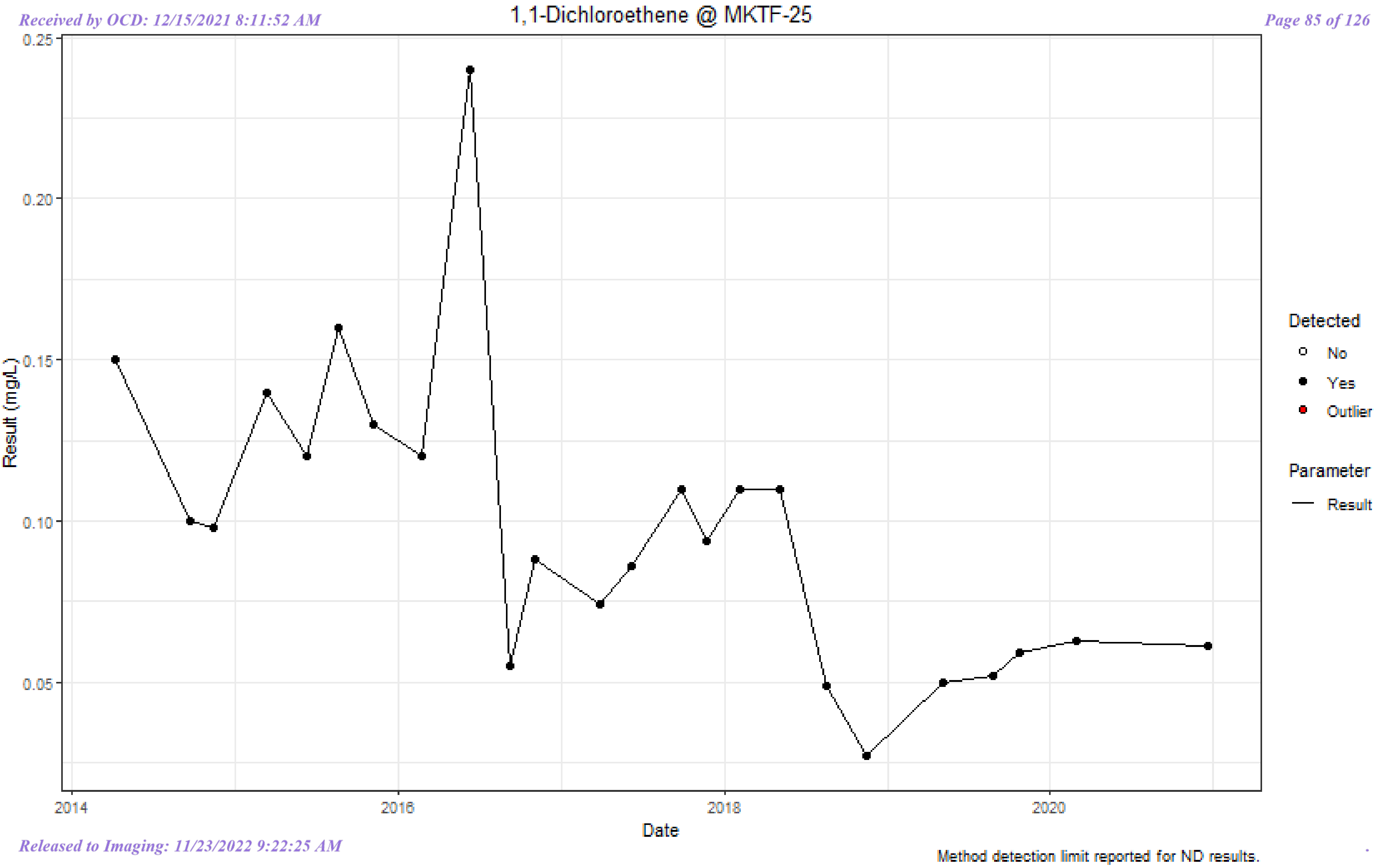
1,1-Dichloroethene @ MKTF-16

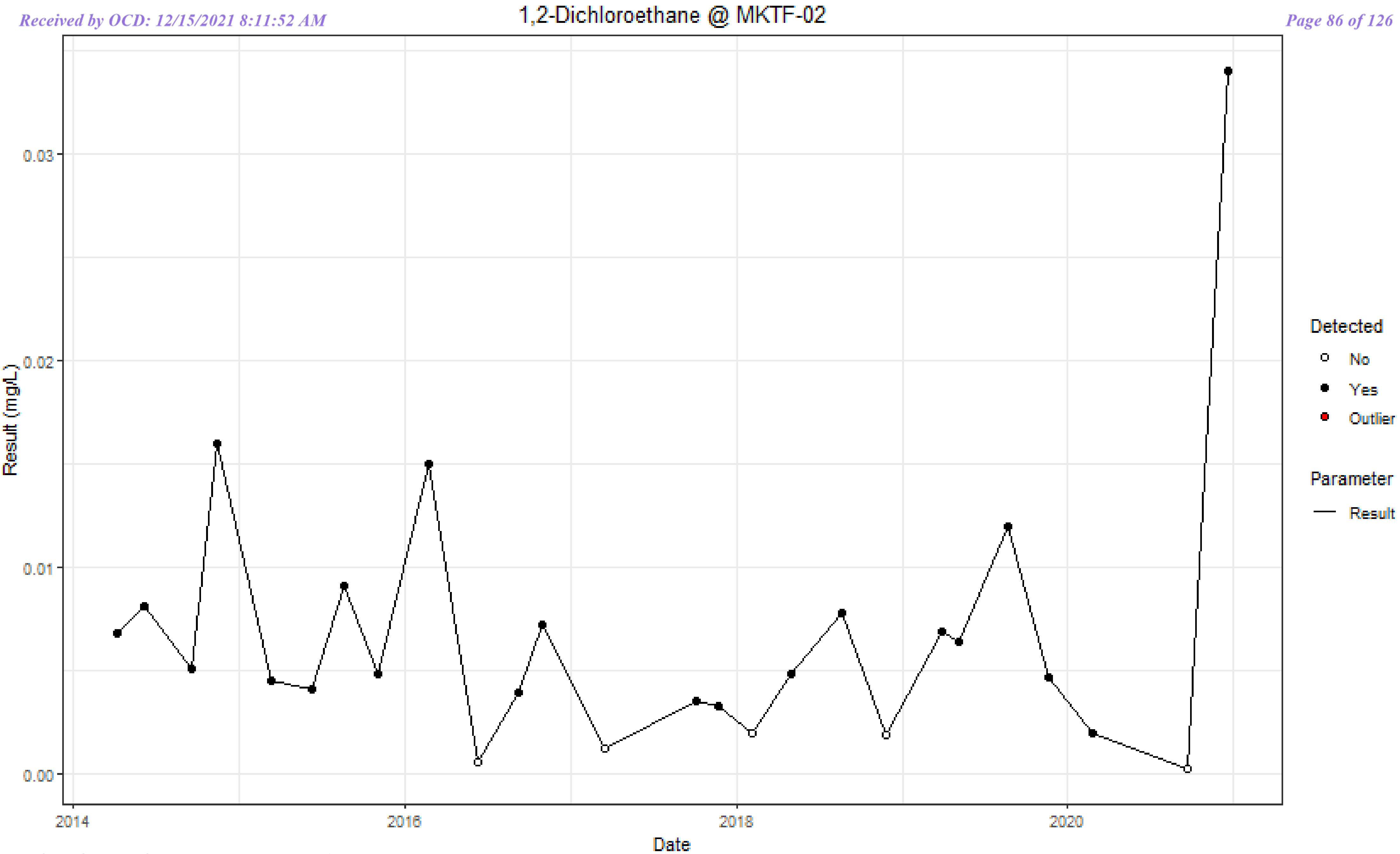
Method detection limit reported for ND results.


1,1-Dichloroethene @ MKTF-22
Result (mg/L)
0.015
0.010
0.005
Date
2014
2016
2018
2020
Detected
○ No
● Yes
● Outlier
Parameter
Result
Method detection limit reported for ND results.

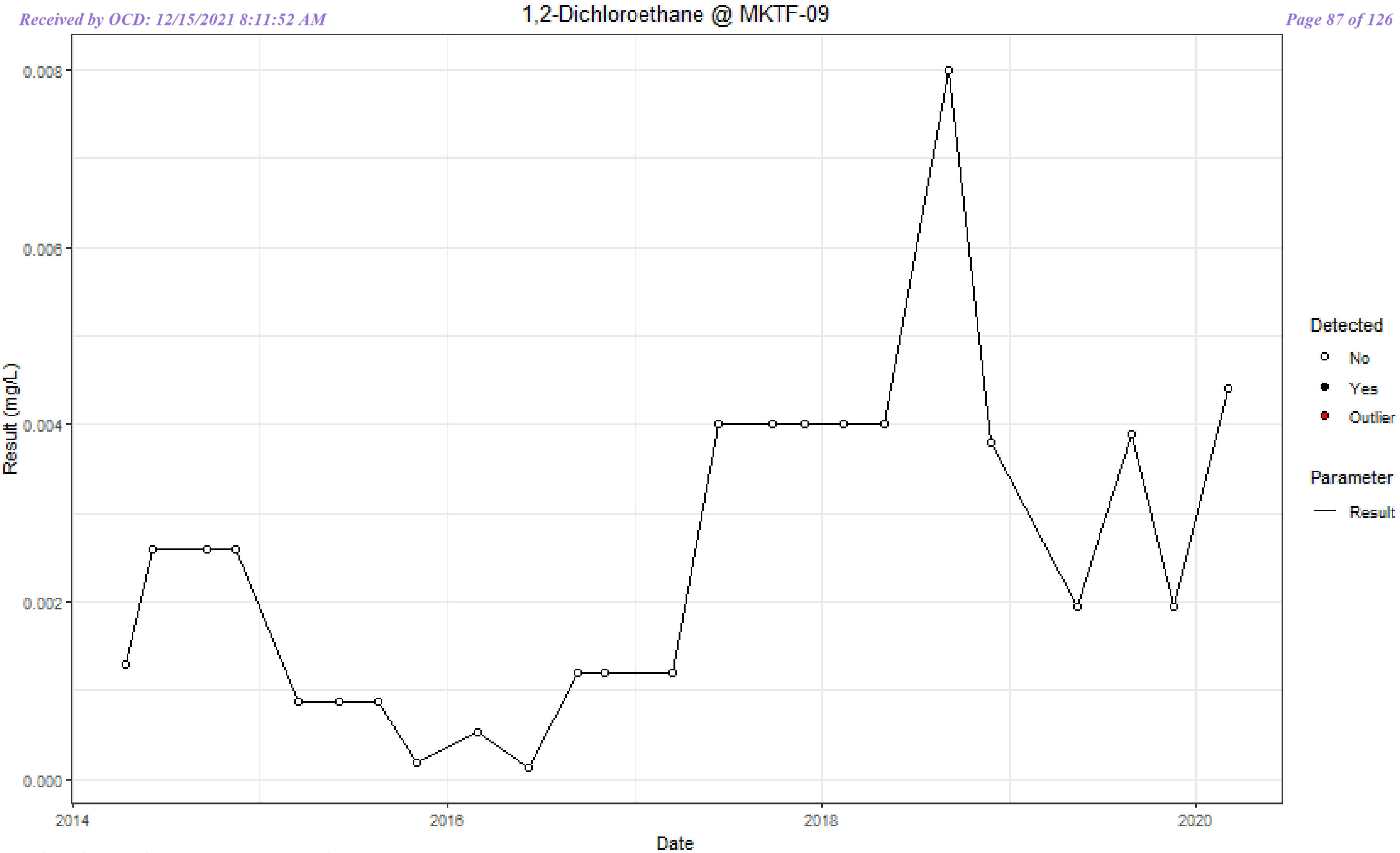


Method detection limit reported for ND results.

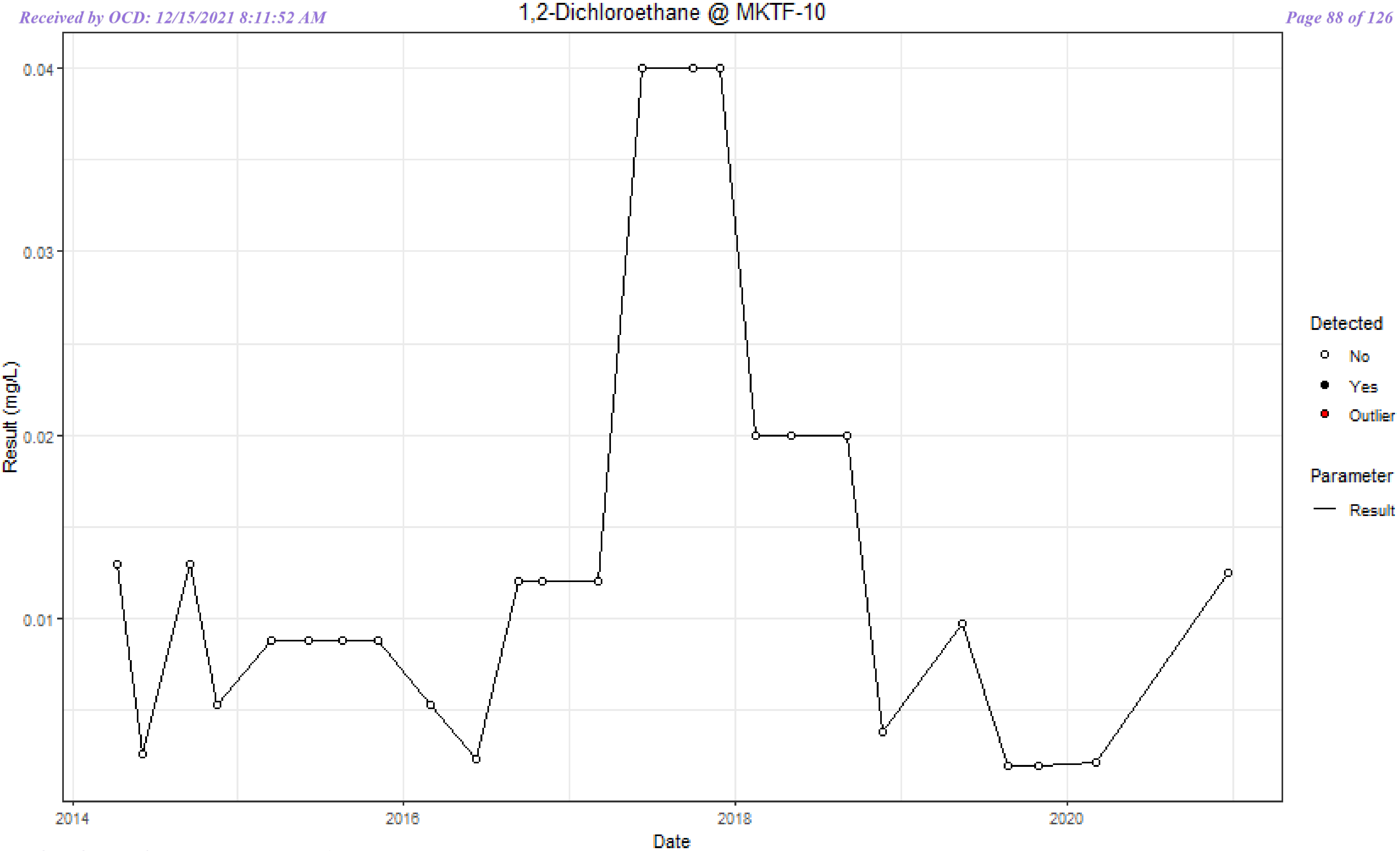

1,1-Dichloroethene @ MKTF-25
Result (mg/L)
0.25
0.20
0.15
0.10
0.05
2014
2016
2018
2020
Date
Detected
No
Yes
Outlier
Parameter
Result
Method detection limit reported for ND results.



Method detection limit reported for ND results.

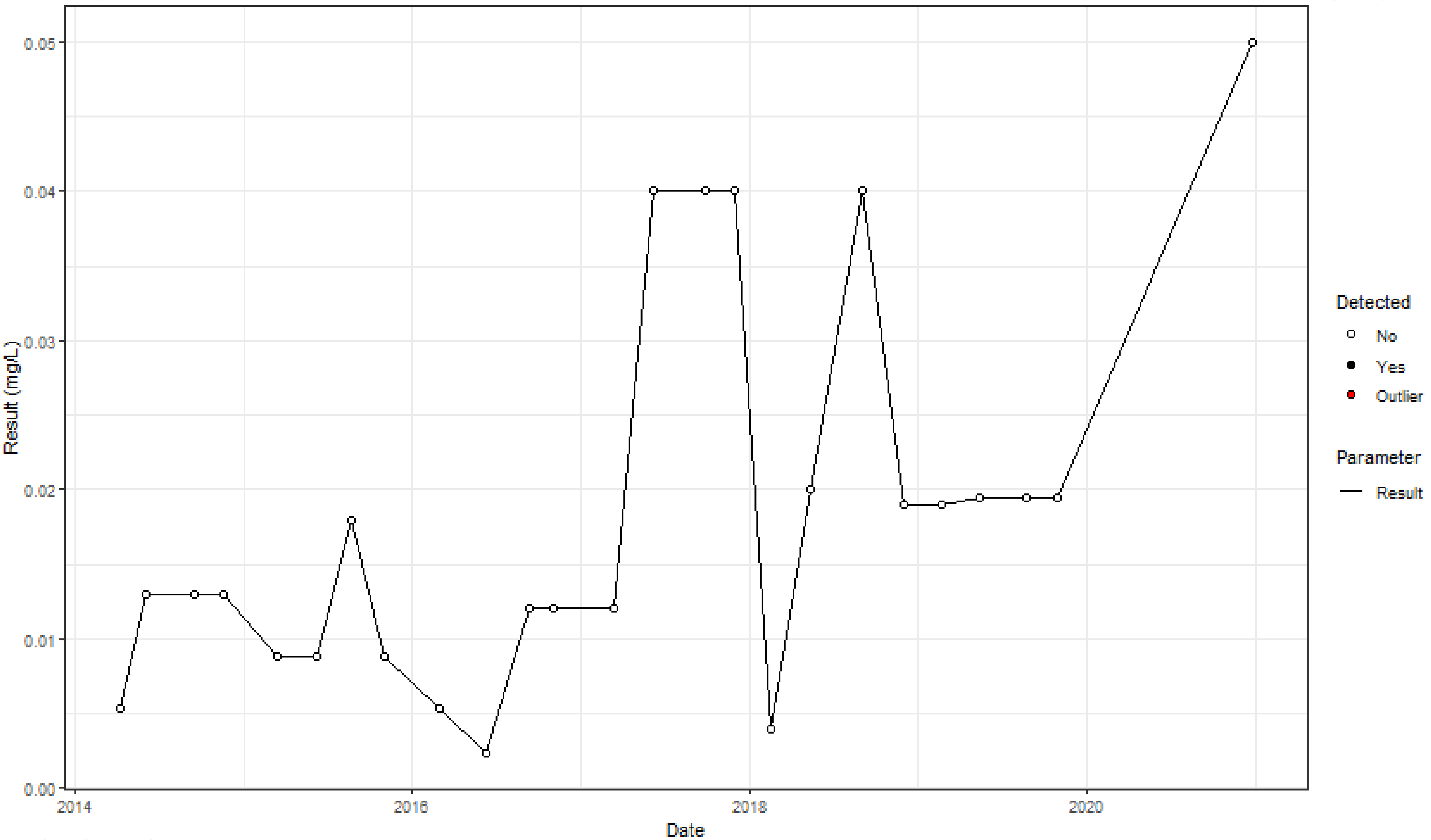


Method detection limit reported for ND results.

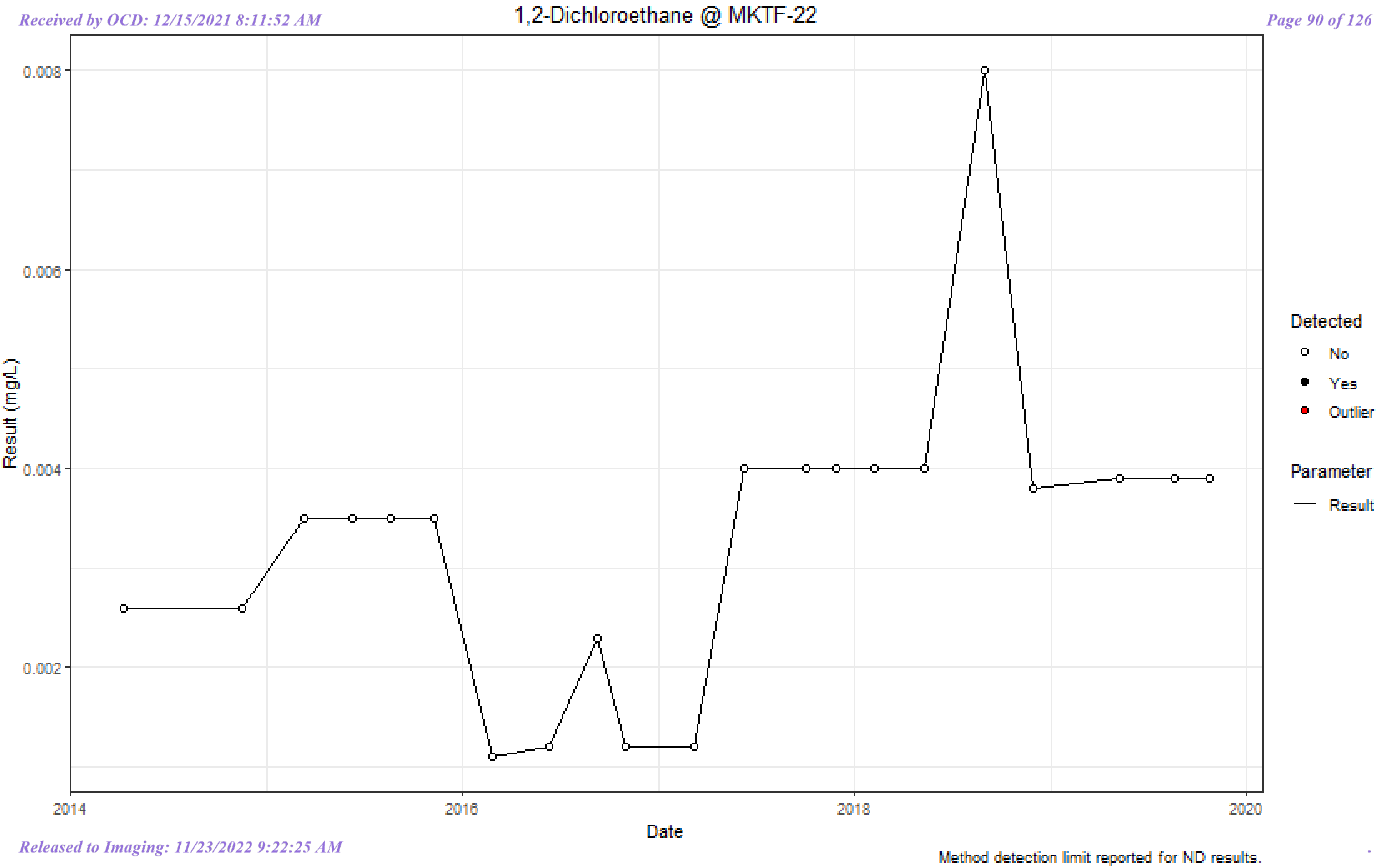


Method detection limit reported for ND results.

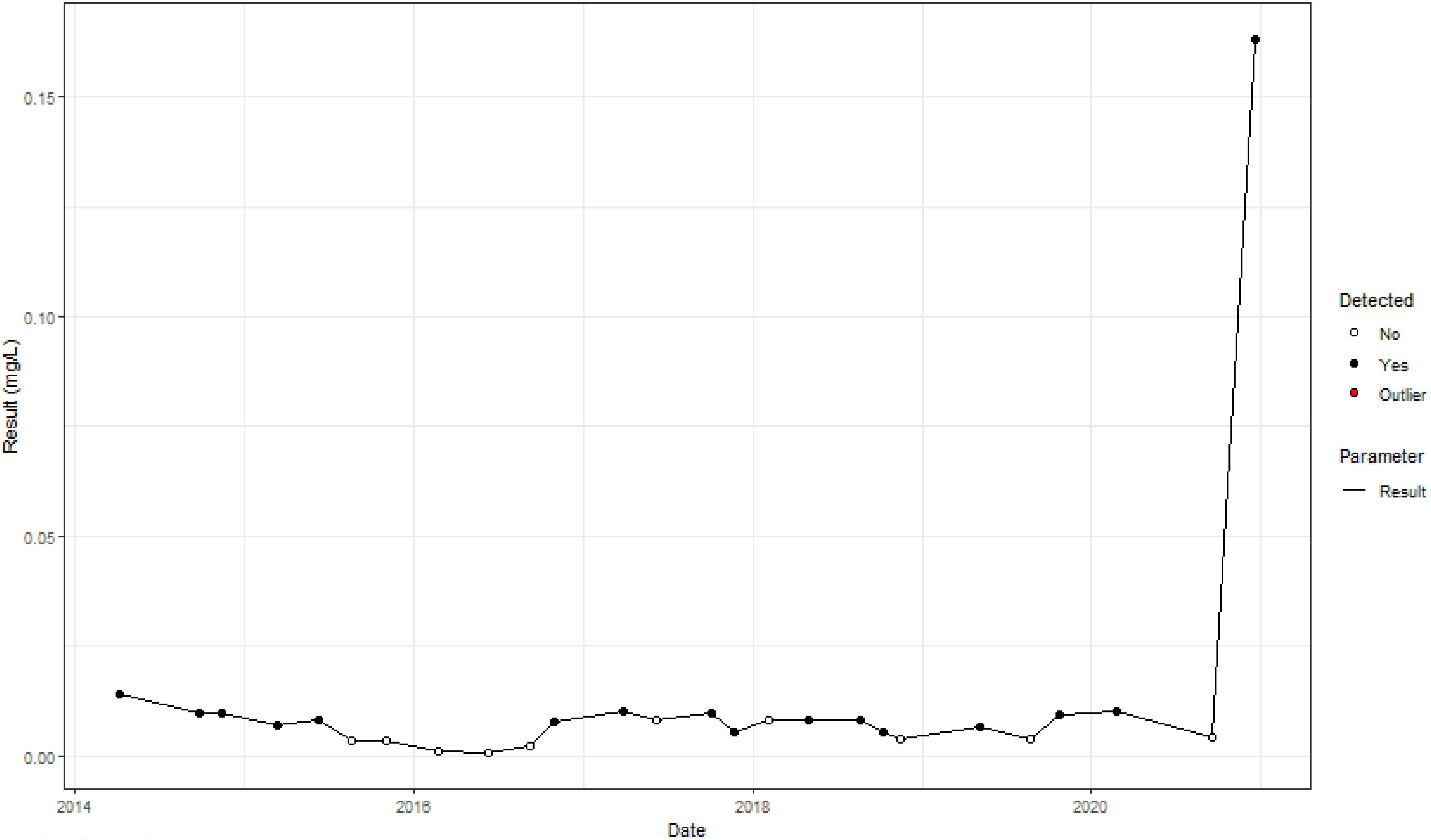
1,2-Dichloroethane @ MKTF-16



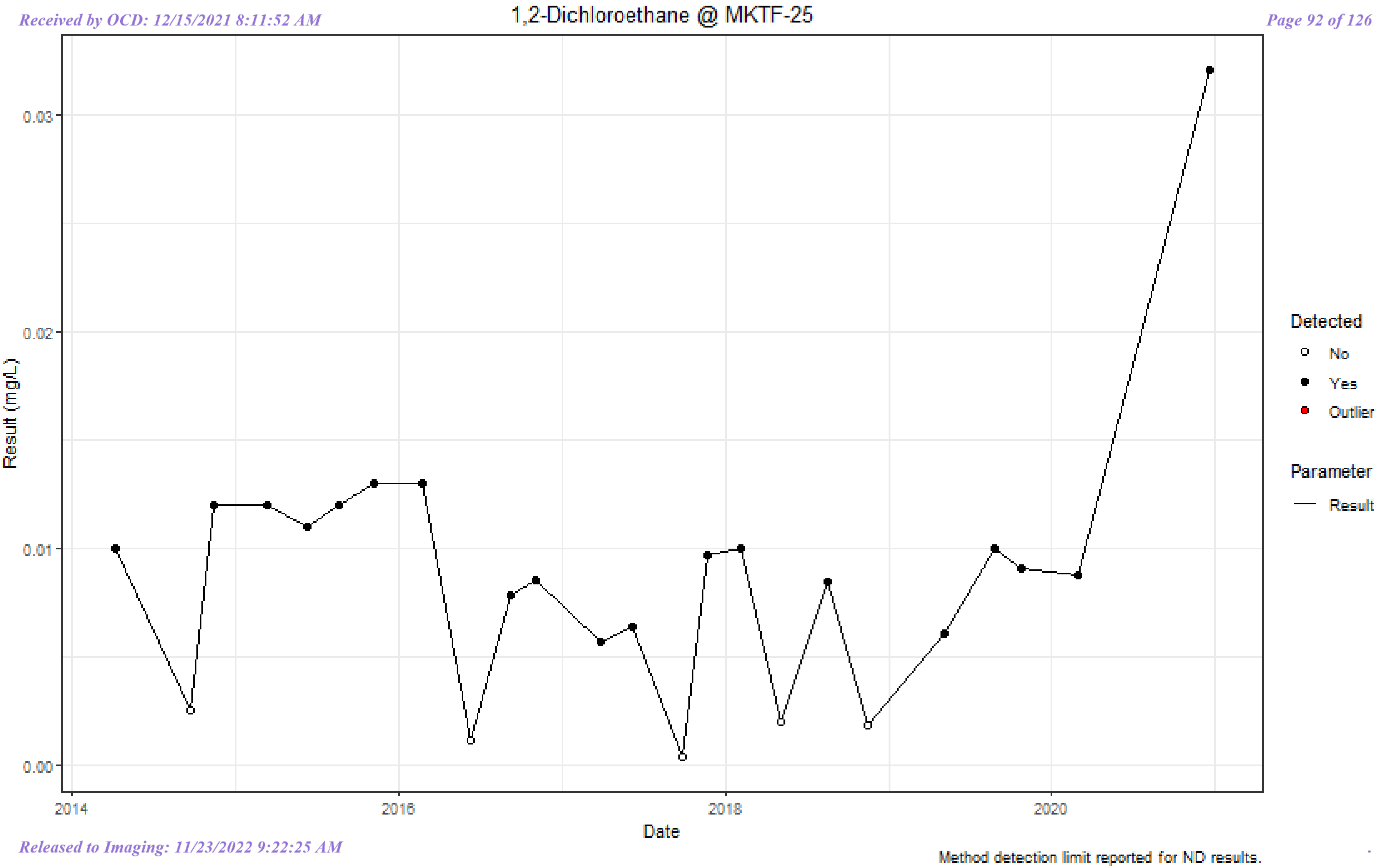
Method detection limit reported for ND results.


1,2-Dichloroethane @ MKTF-22
Result (mg/L)
0.008
0.006
0.004
0.002
2014
2016
2018
2020
Date
Detected
No
Yes
Outlier
Parameter
Result
Method detection limit reported for ND results.

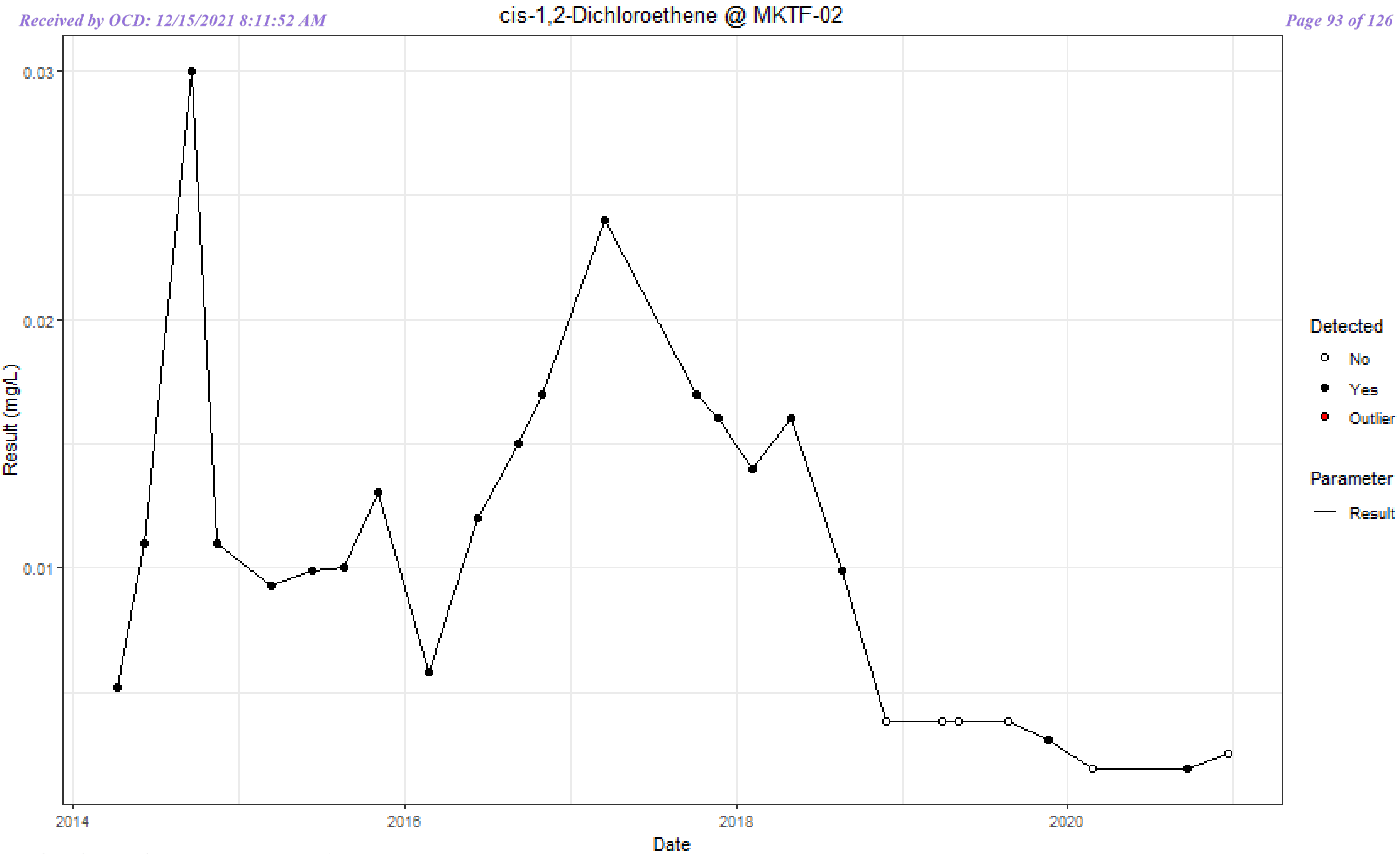
1,2-Dichloroethane @ MKTF-24



Method detection limit reported for ND results.

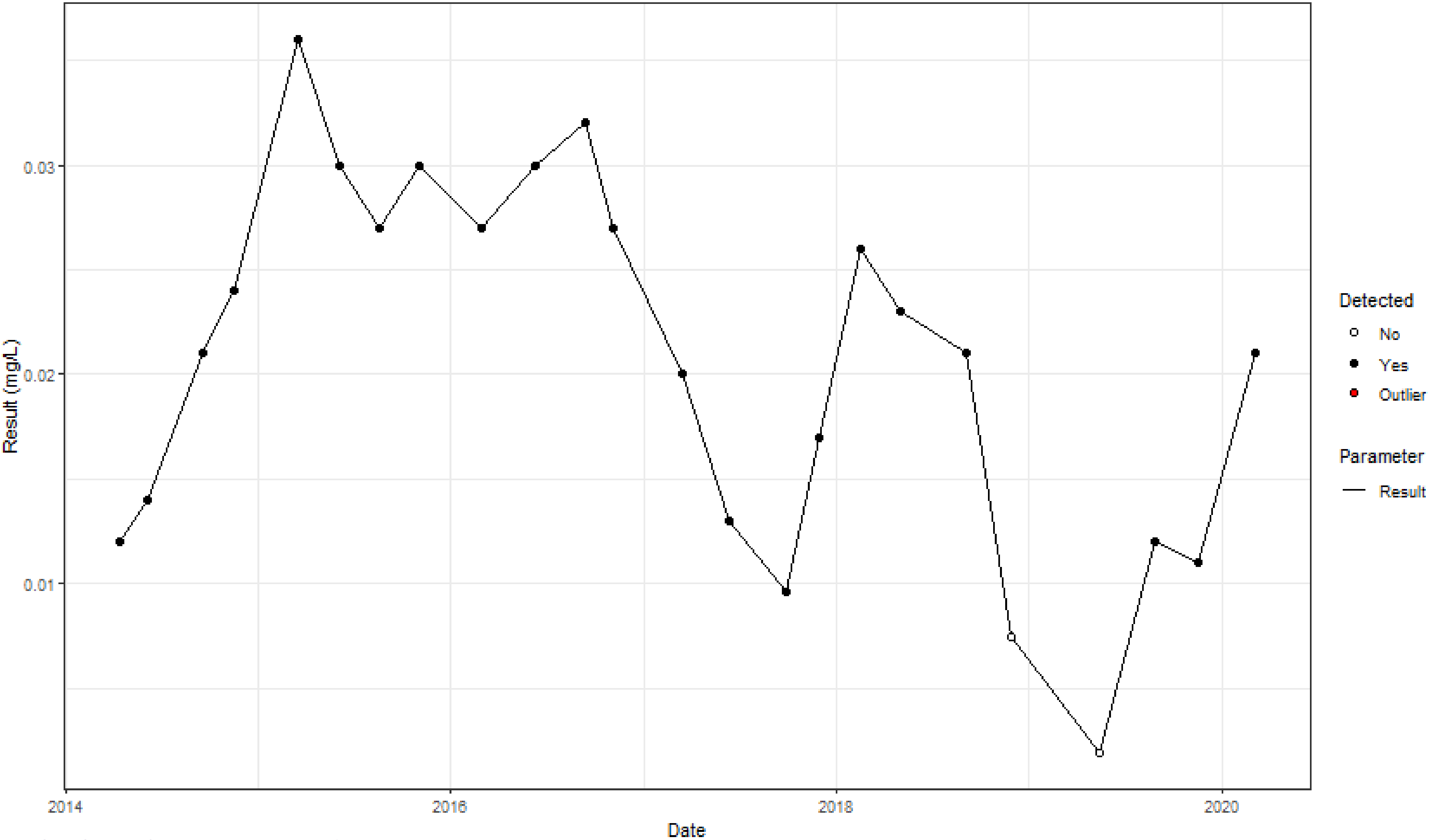


Method detection limit reported for ND results.

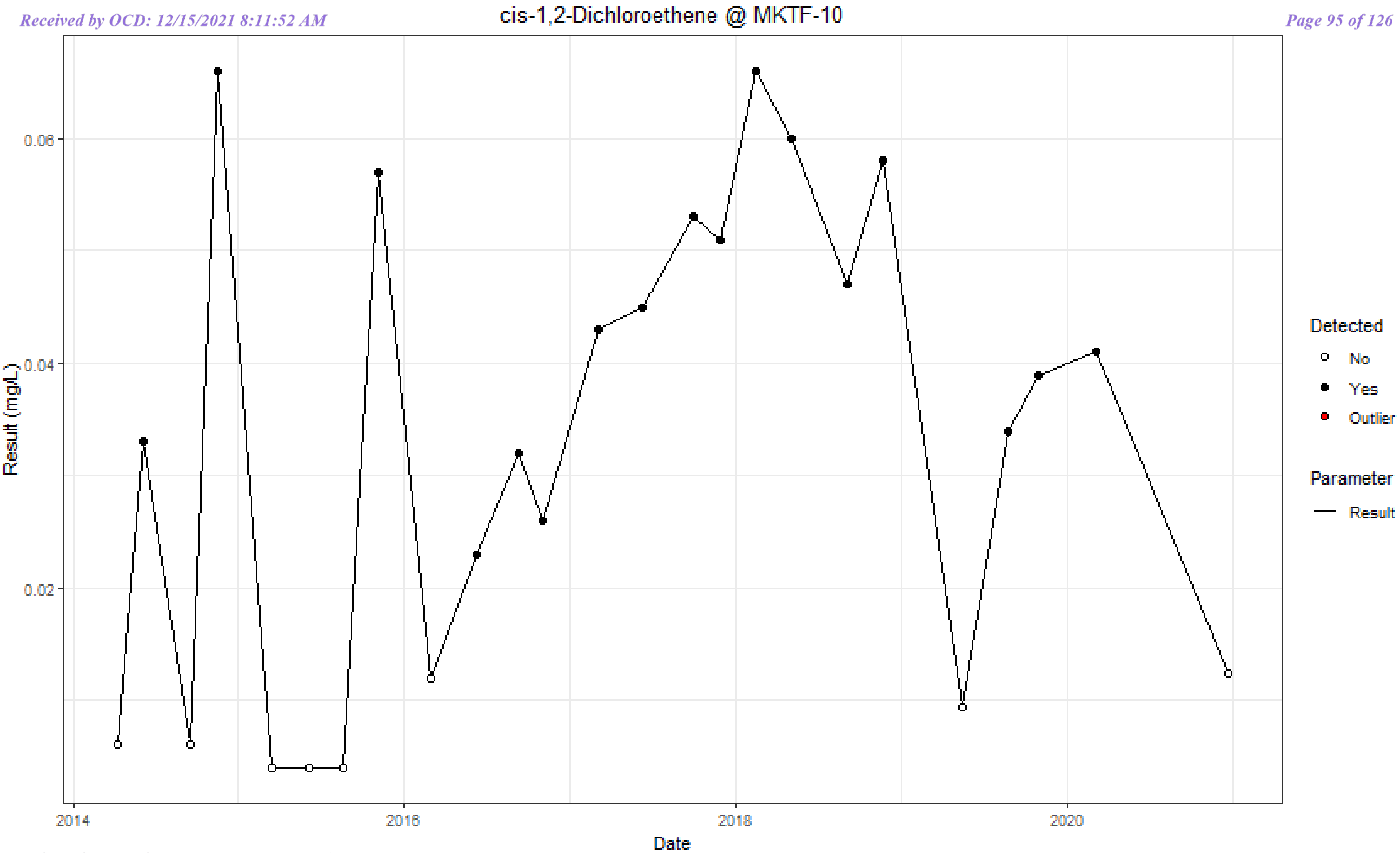


Method detection limit reported for ND results.

cis-1,2-Dichloroethene @ MKTF-09

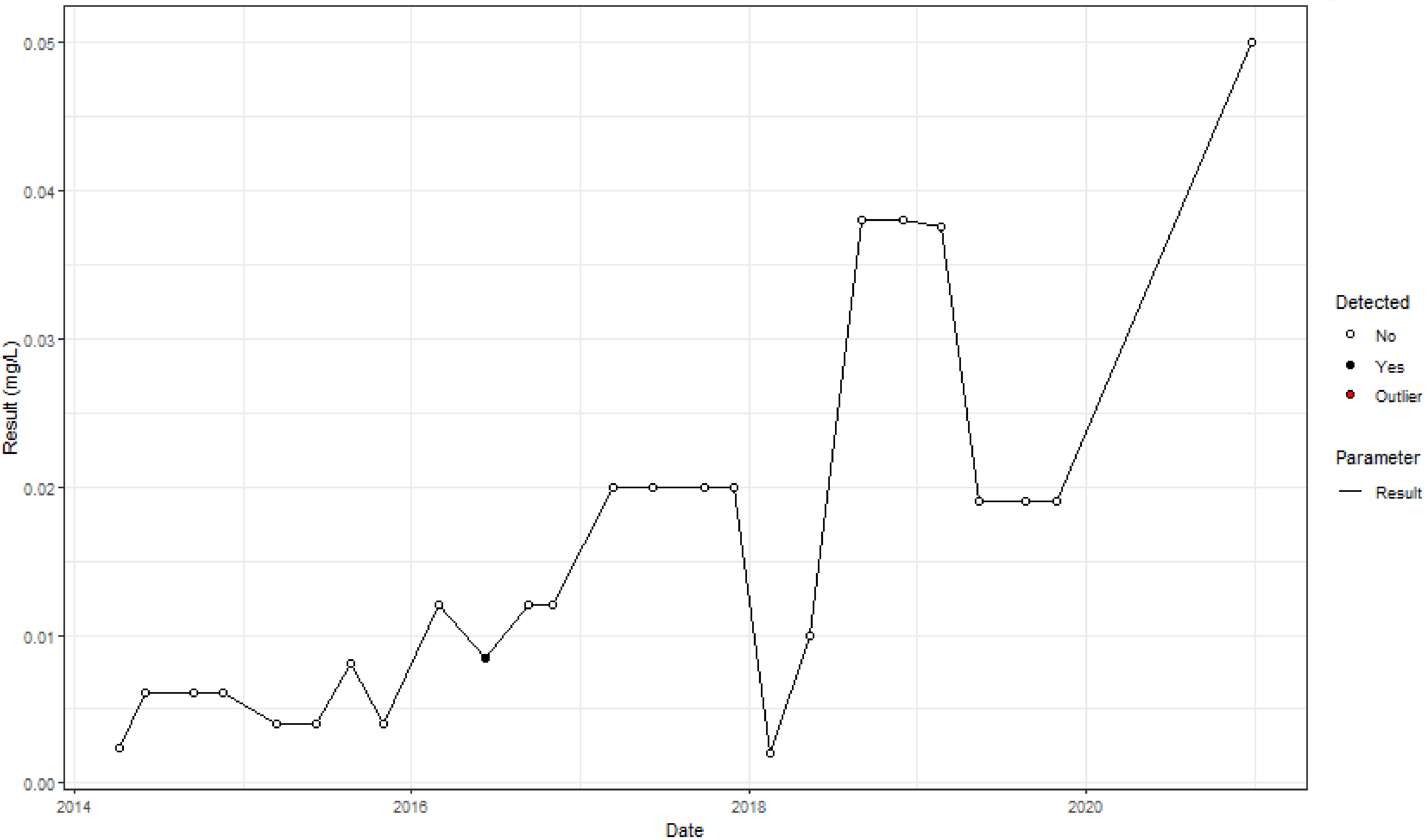


Method detection limit reported for ND results.



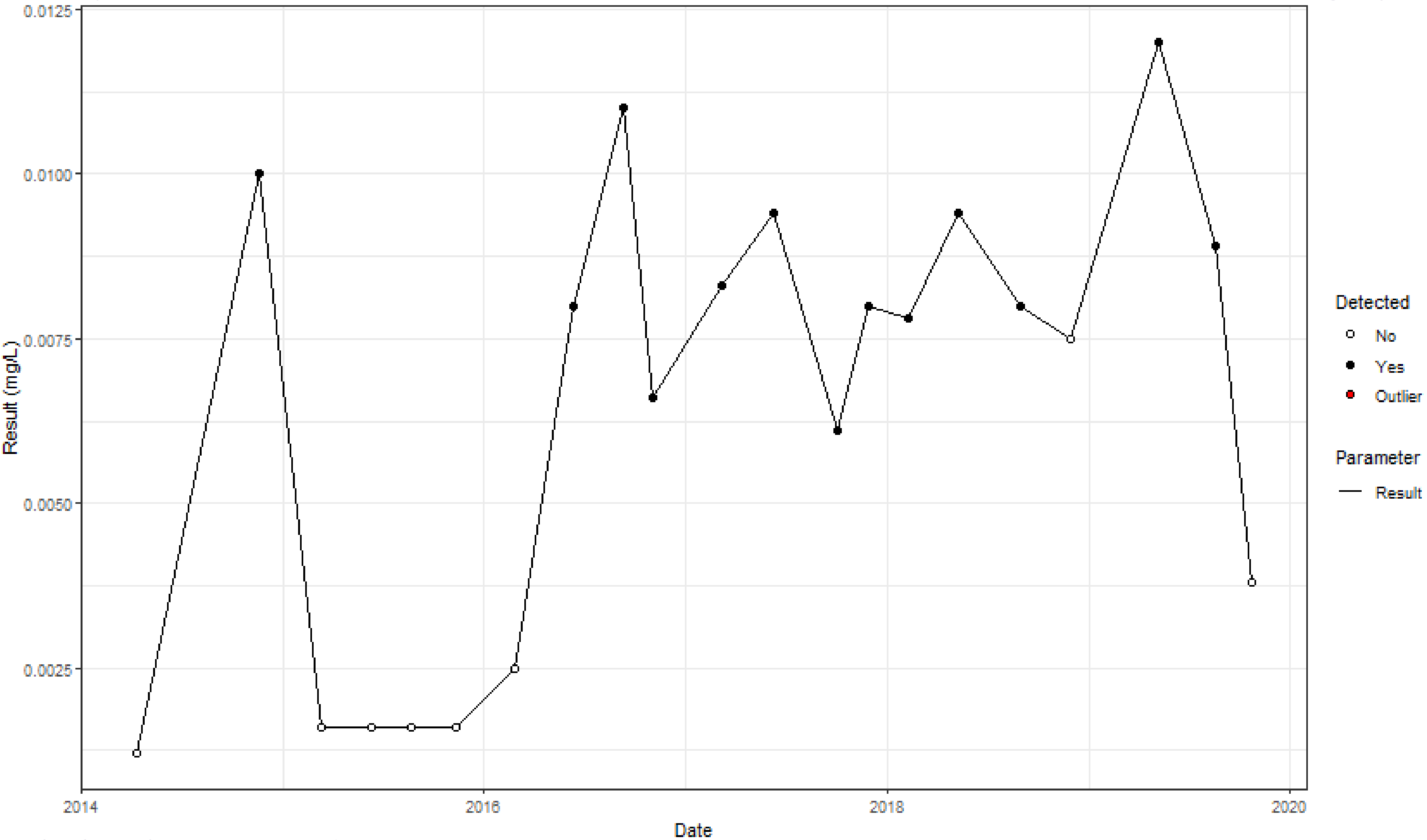
Method detection limit reported for ND results.

cis-1,2-Dichloroethene @ MKTF-16



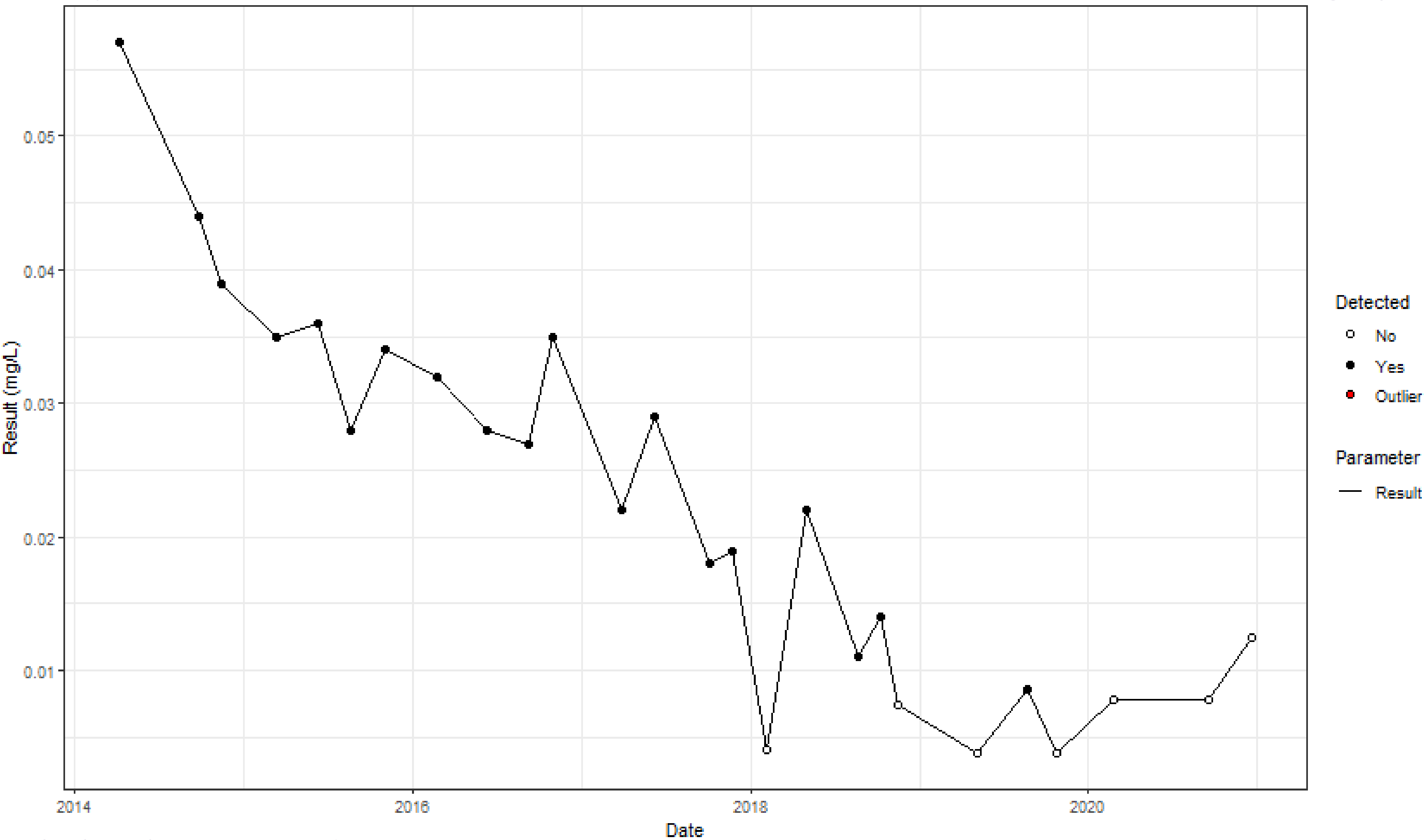
Method detection limit reported for ND results.

cis-1,2-Dichloroethene @ MKTF-22

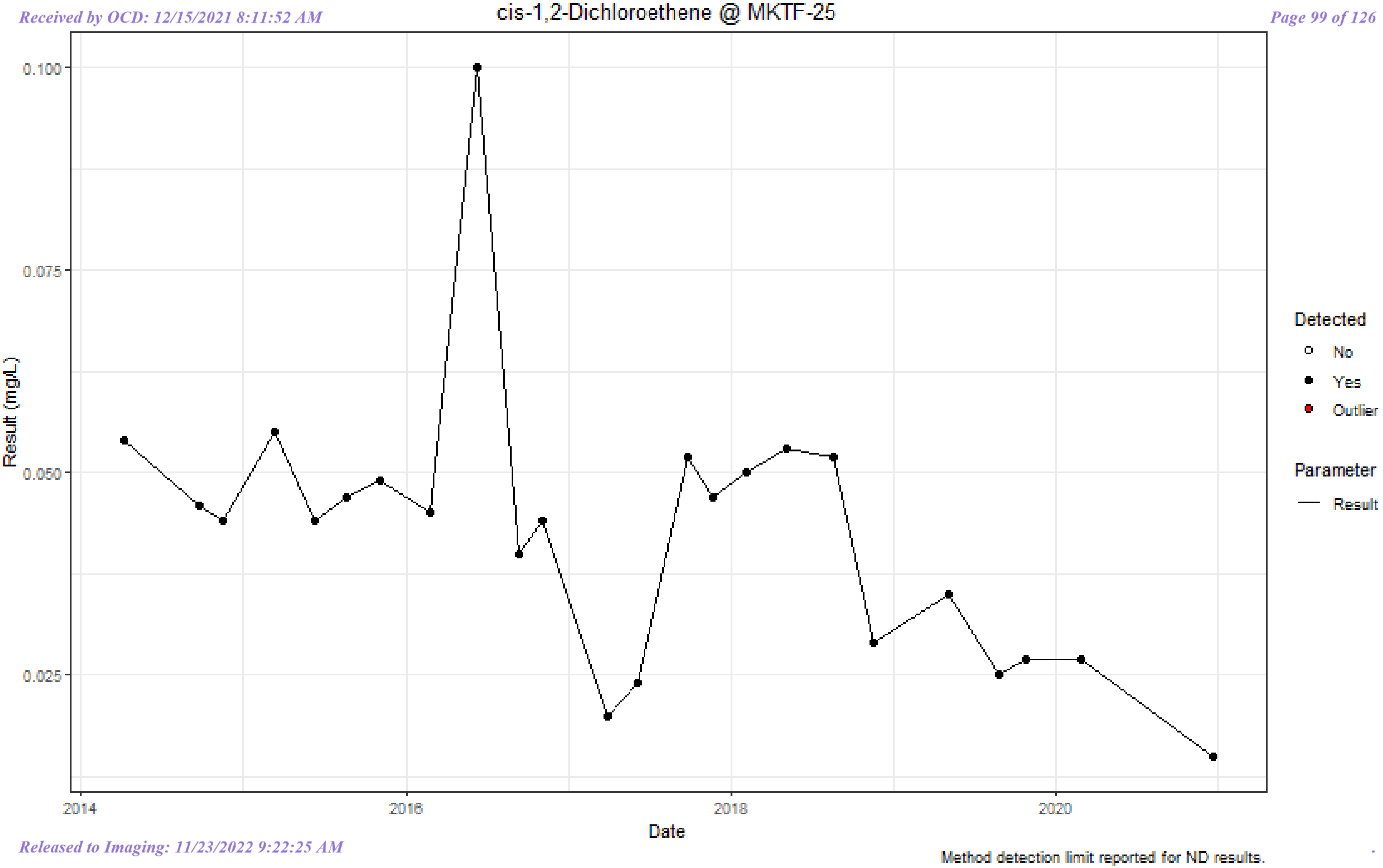


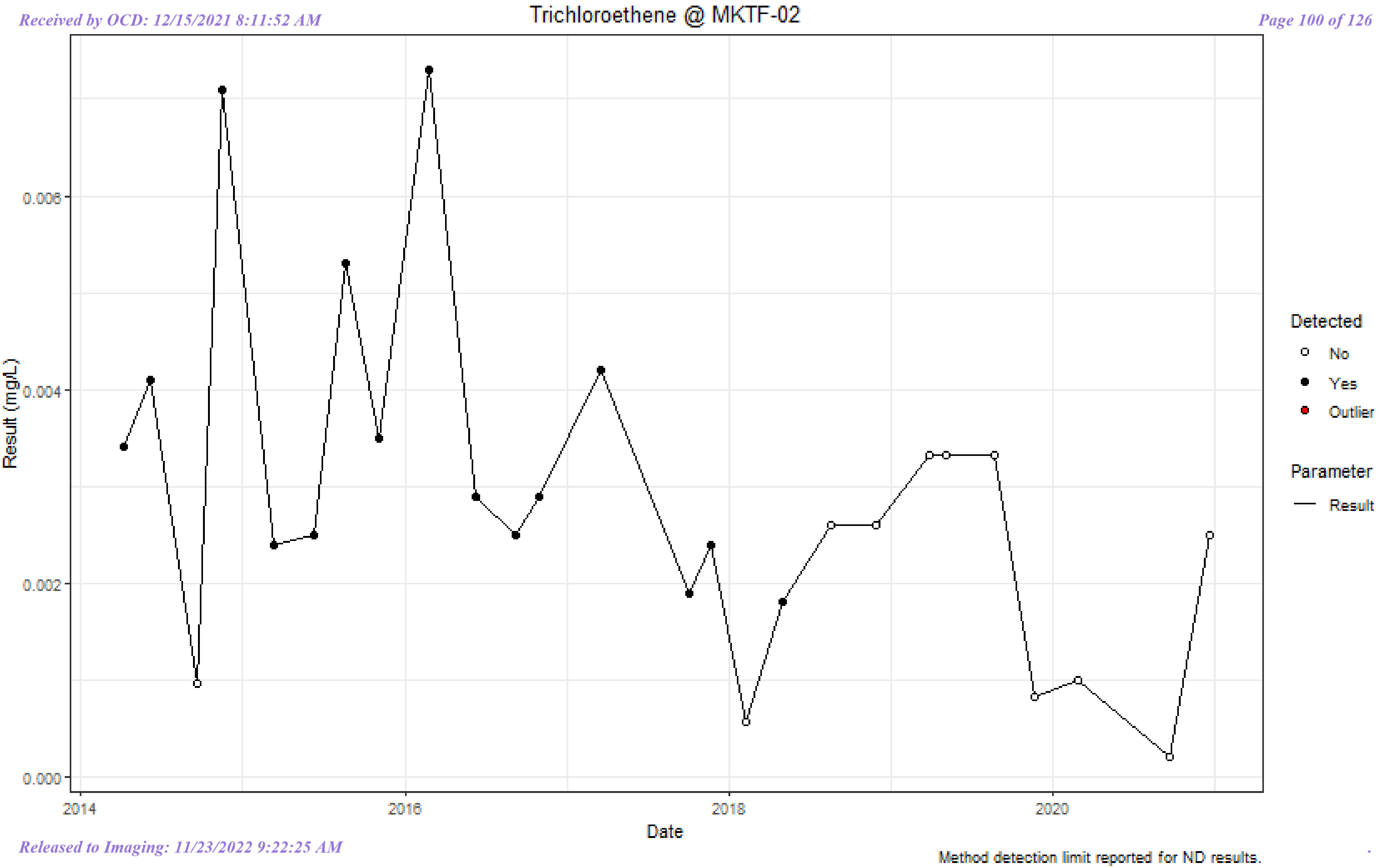
Method detection limit reported for ND results.

cis-1,2-Dichloroethene @ MKTF-24

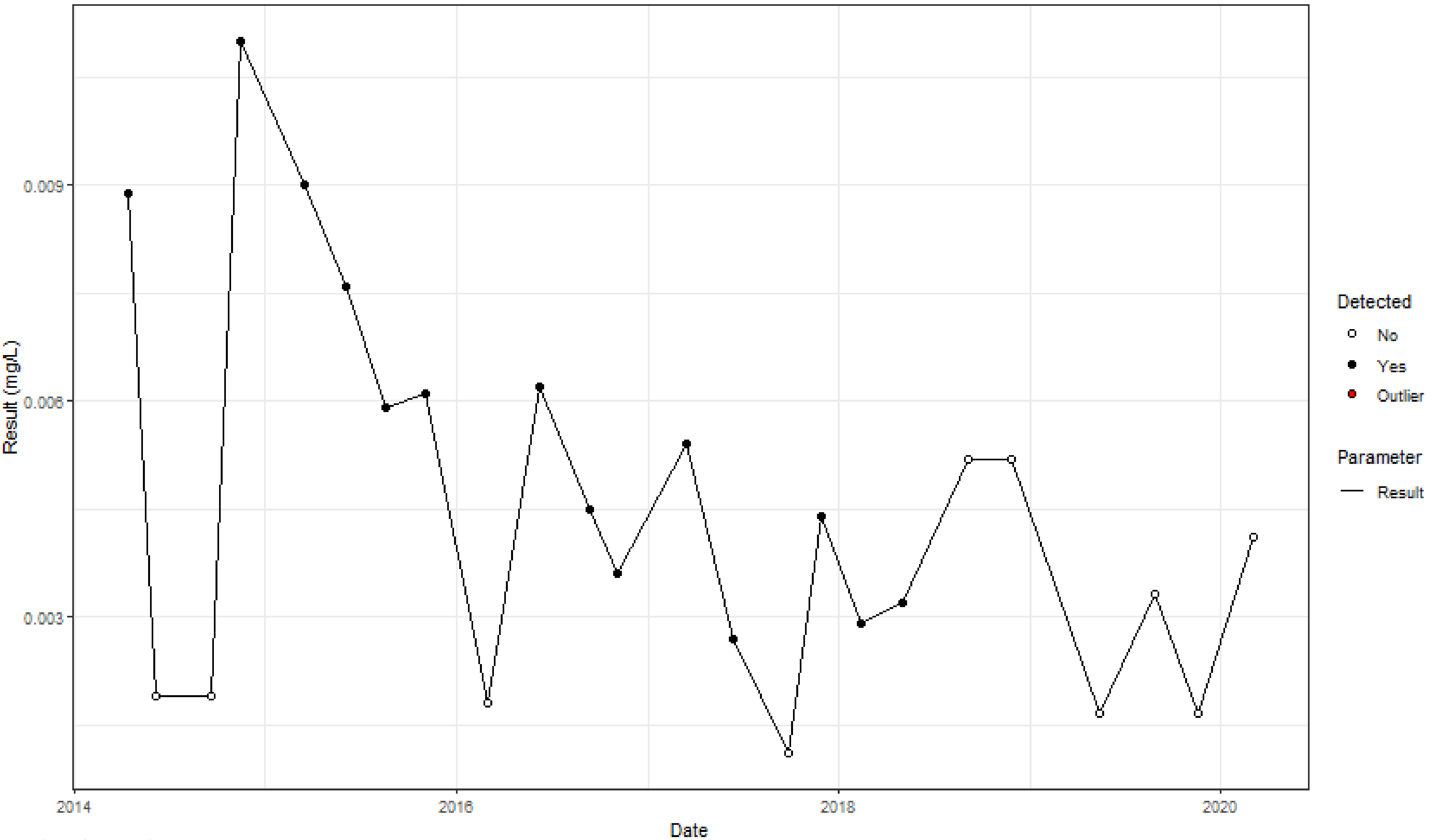


Method detection limit reported for ND results.

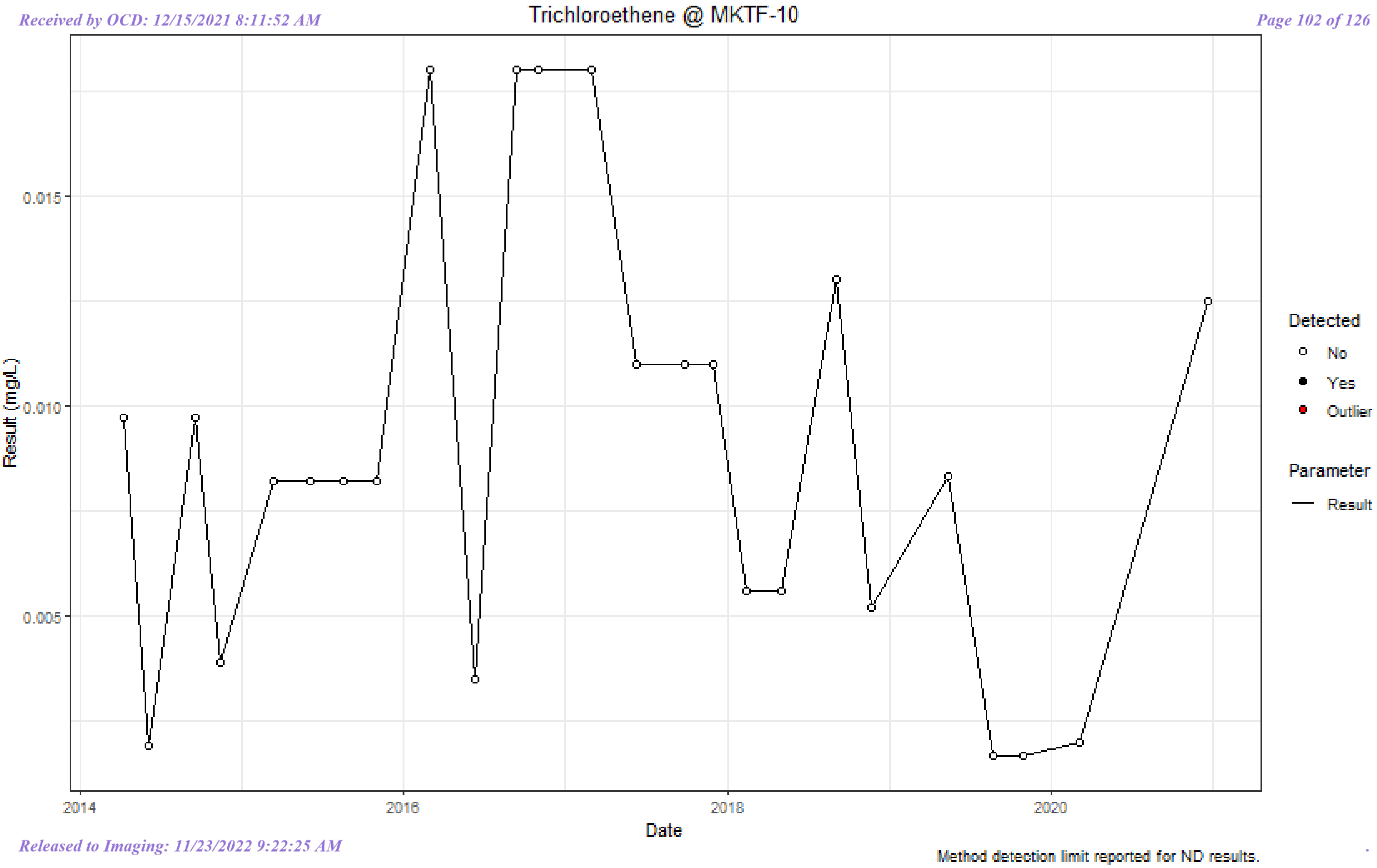

cis-1,2-Dichloroethene @ MKTF-25
Result (mg/L)
0.100
0.075
0.050
0.025
2014
2016
2018
2020
Date
Detected
No
Yes
Outlier
Parameter
Result
Method detection limit reported for ND results.

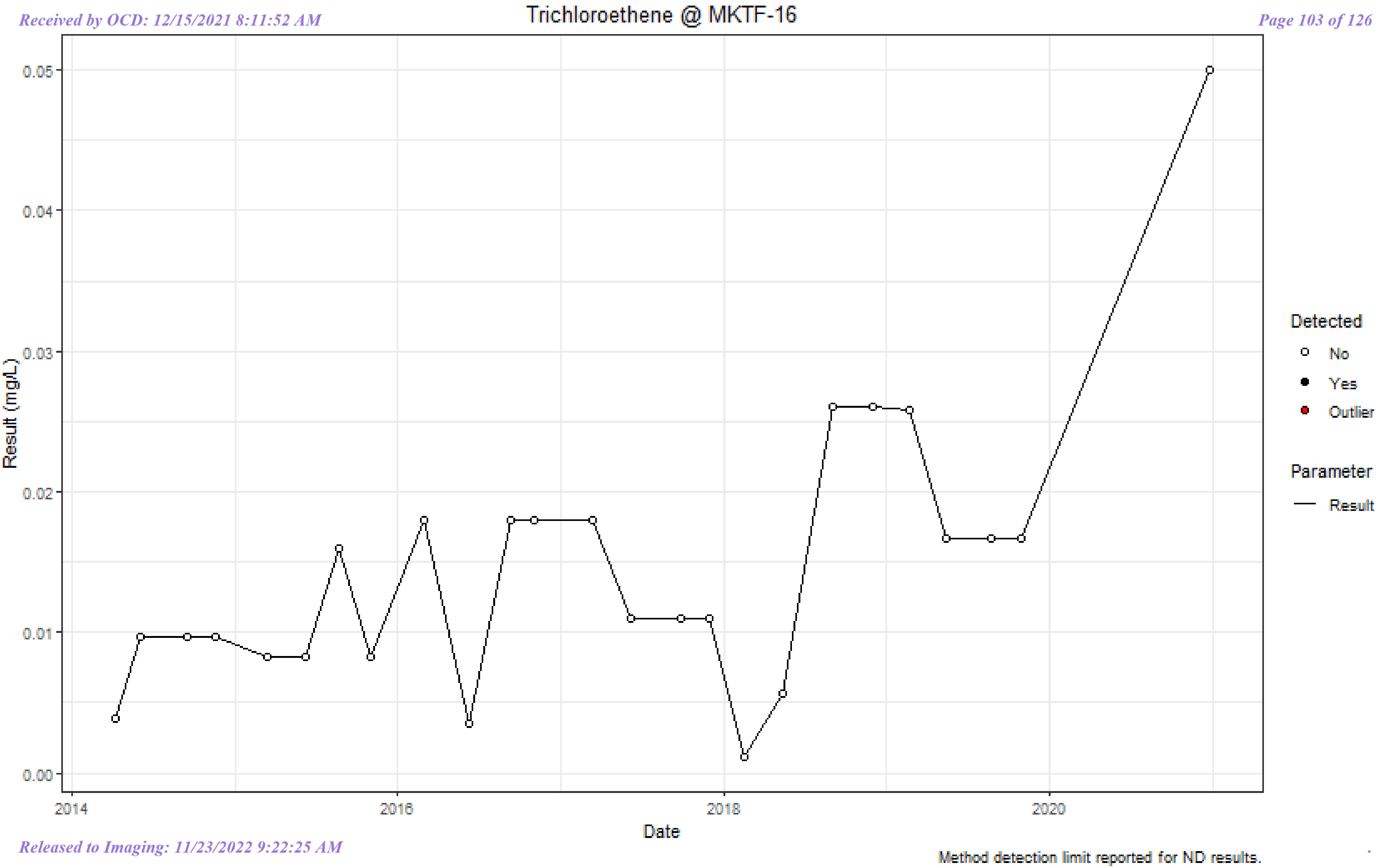

Trichloroethene @ MKTF-02
Result (mg/L)
0.000
0.002
0.004
0.006
2014
2016
2018
2020
Date
Detected
No
Yes
Outlier
Parameter
Result
Method detection limit reported for ND results.

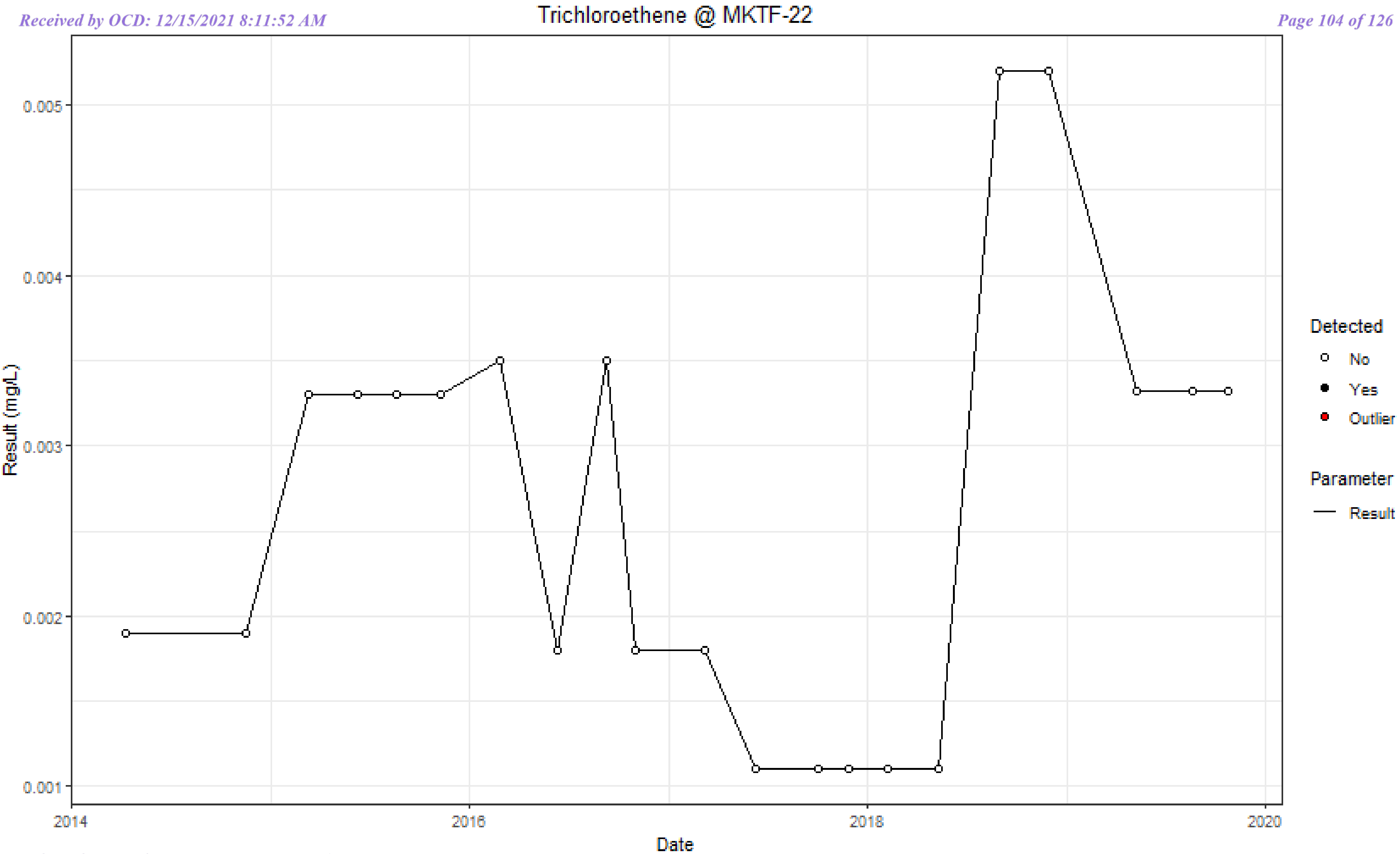
Trichloroethene @ MKTF-09



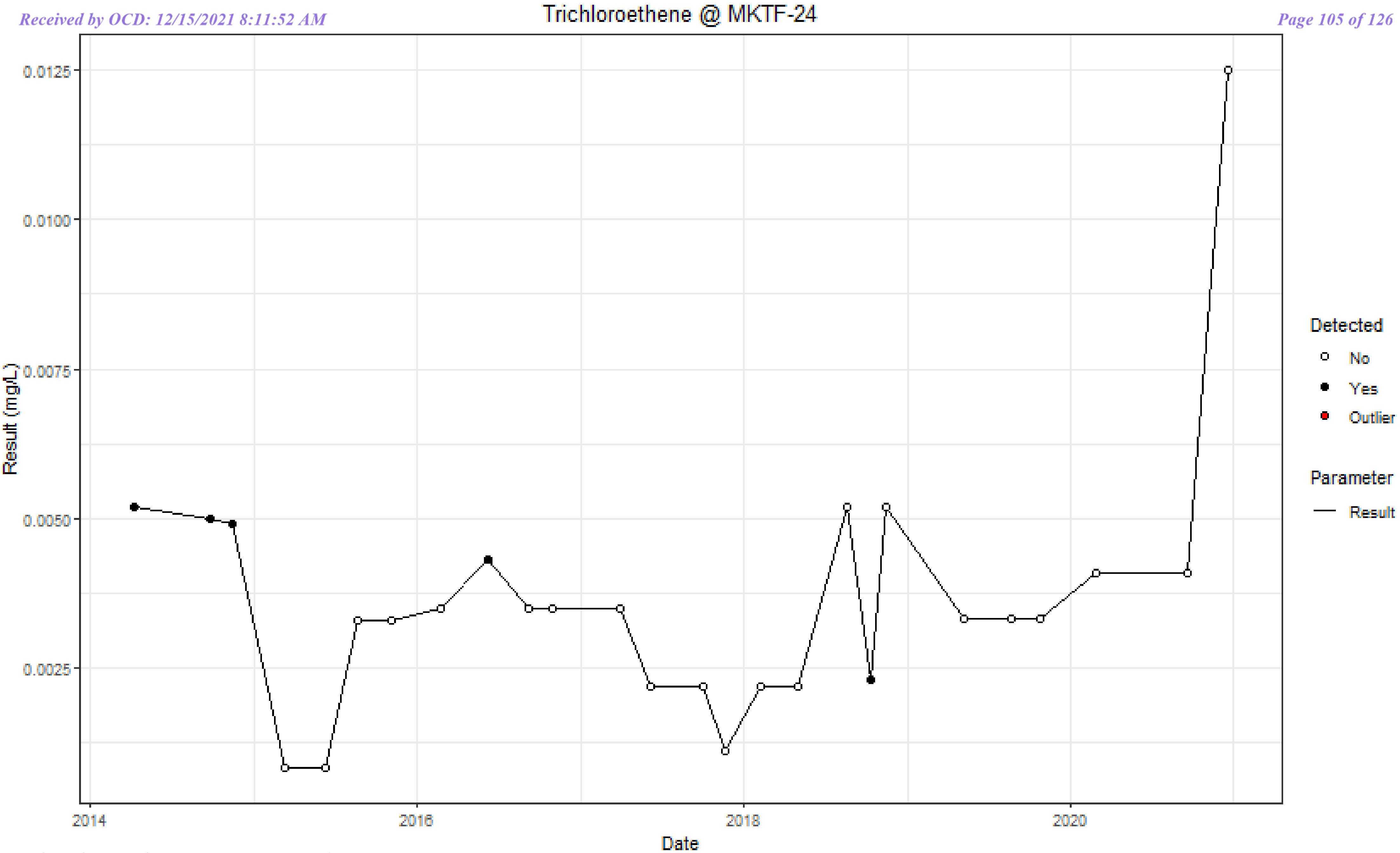
Method detection limit reported for ND results.


Trichloroethene @ MKTF-10
Result (mg/L)
0.015
0.010
0.005
2014
2016
2018
2020
Date
Detected
No
Yes
Outlier
Parameter
Result
Method detection limit reported for ND results.

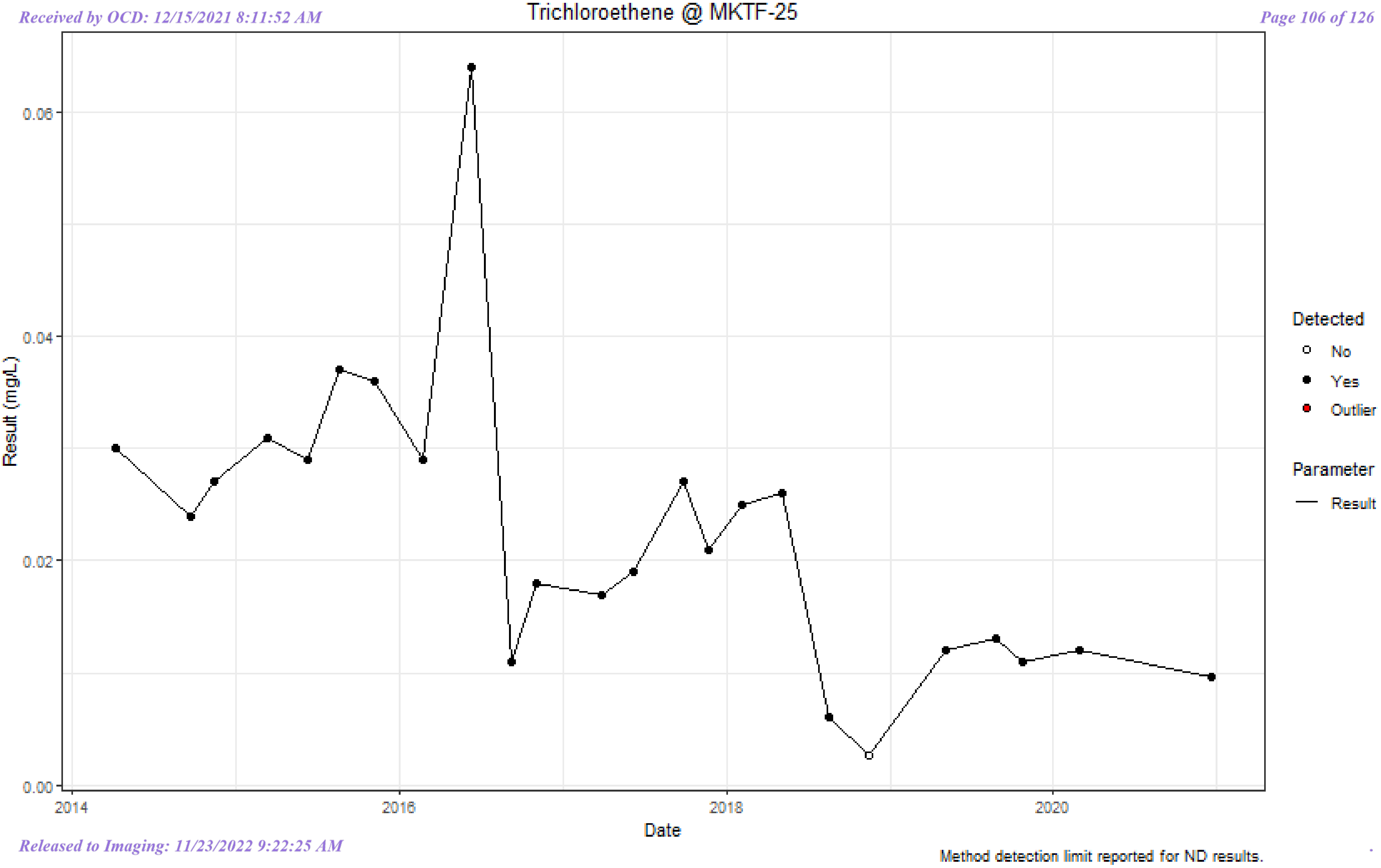

Trichloroethene @ MKTF-16
Result (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
2014
2016
2018
2020
Date
Detected
○ No
● Yes
● Outlier
Parameter
— Result
Method detection limit reported for ND results.



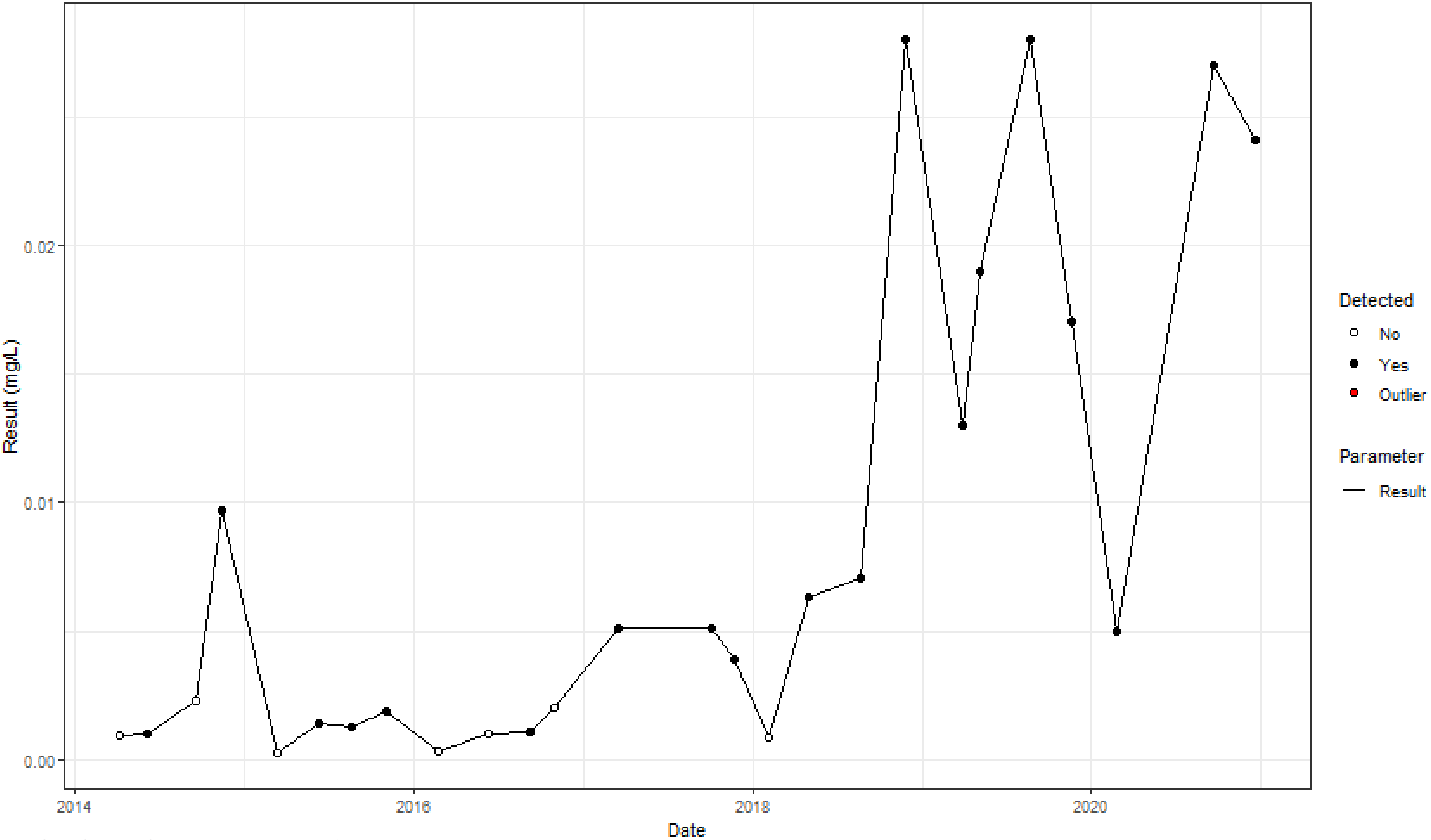
Method detection limit reported for ND results.



Method detection limit reported for ND results.

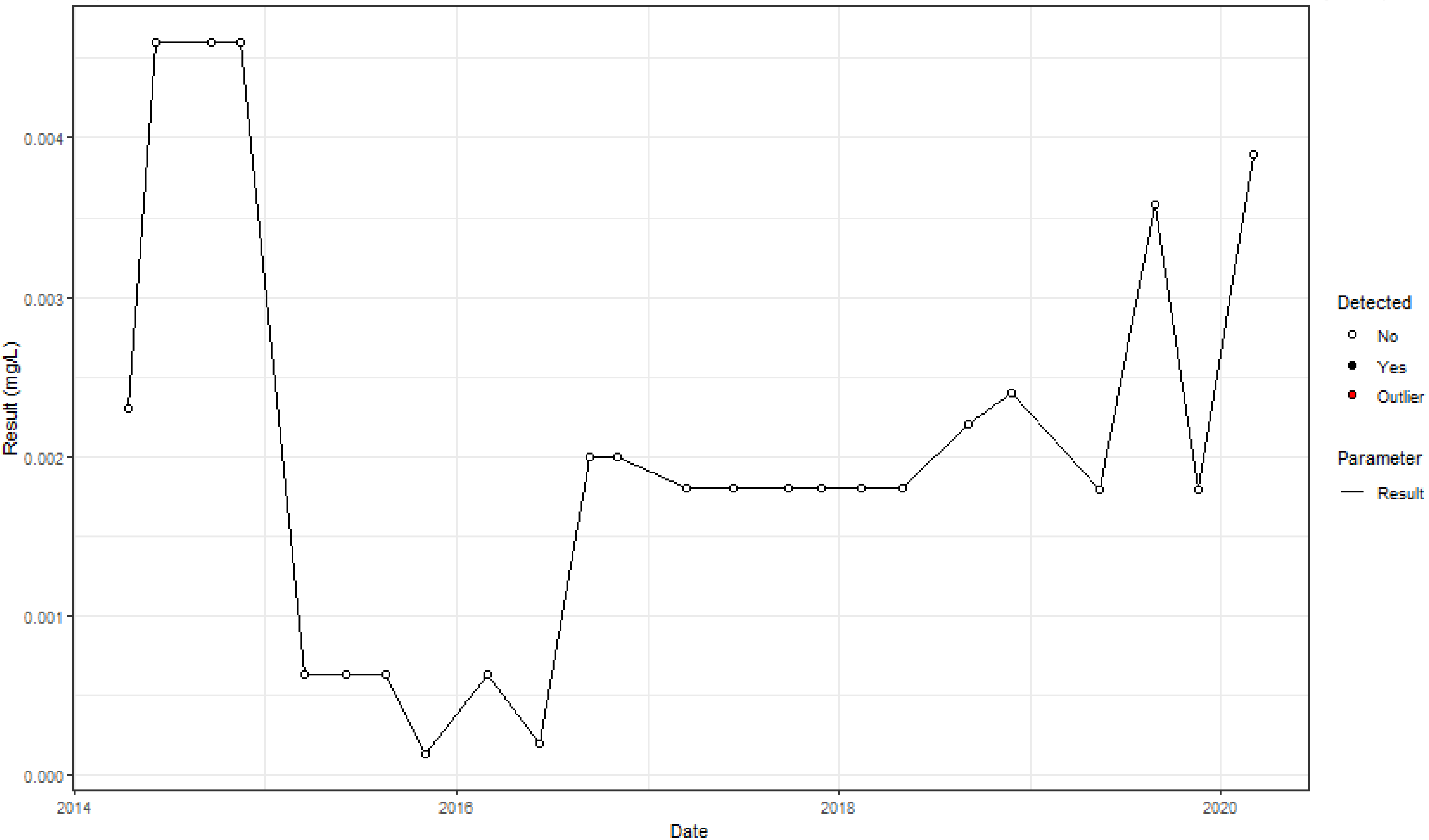

Trichloroethene @ MKTF-25
Result (mg/L)
0.06
0.04
0.02
0.00
2014
2016
2018
2020
Date
Detected
No
Yes
Outlier
Parameter
Result
Method detection limit reported for ND results.

Vinyl Chloride @ MKTF-02



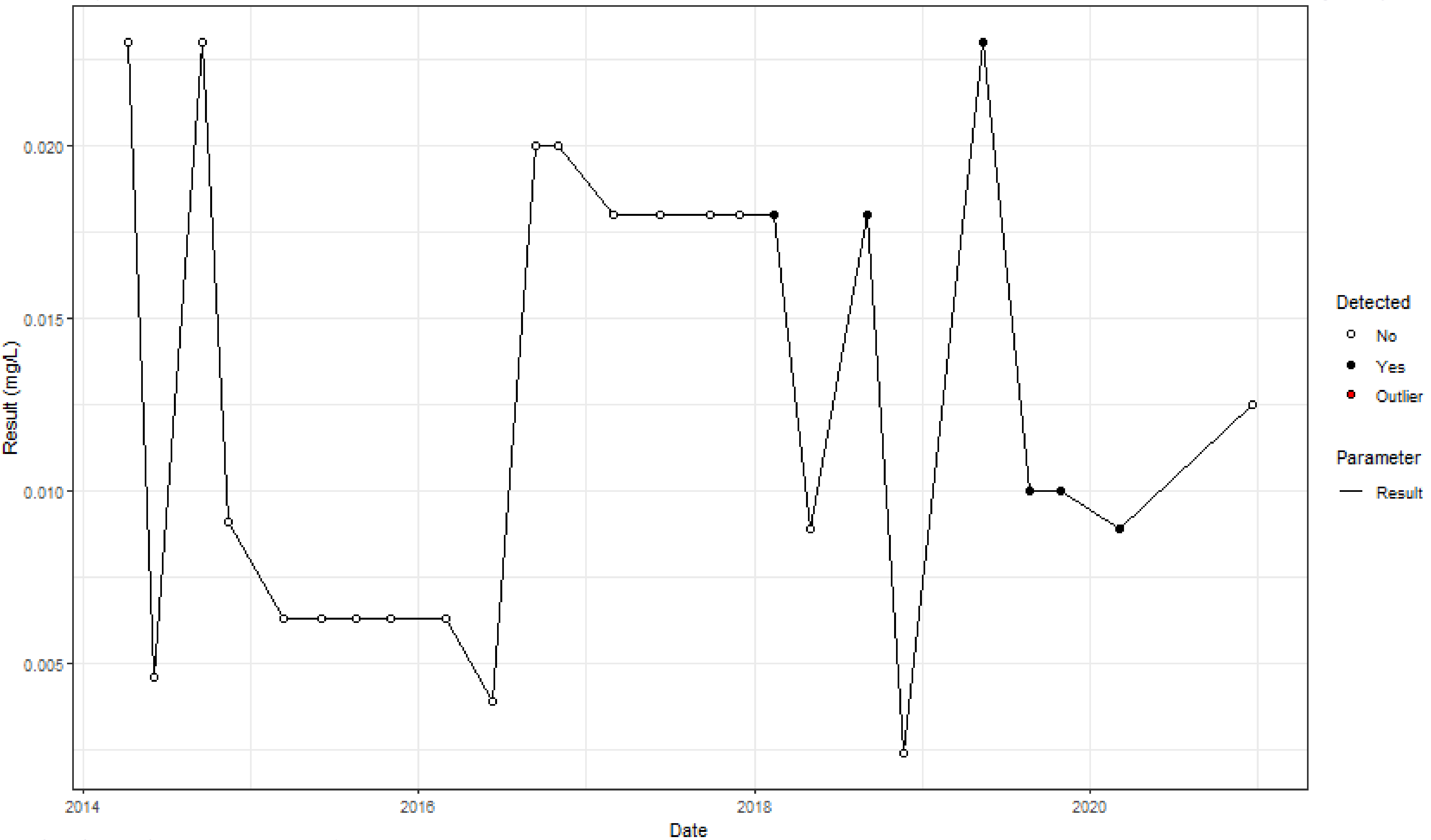
Method detection limit reported for ND results.

Vinyl Chloride @ MKTF-09



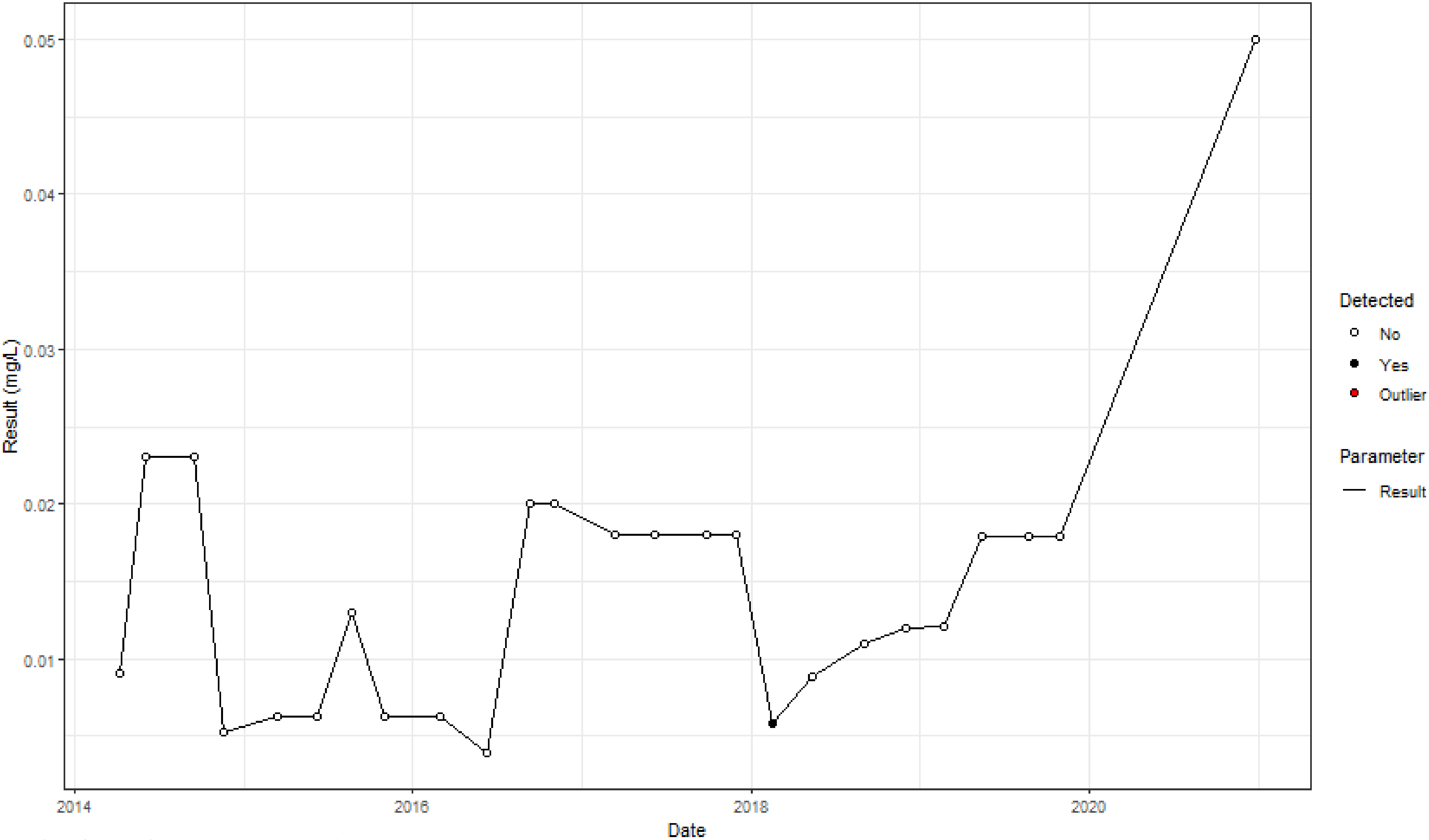
Method detection limit reported for ND results.

Vinyl Chloride @ MKTF-10

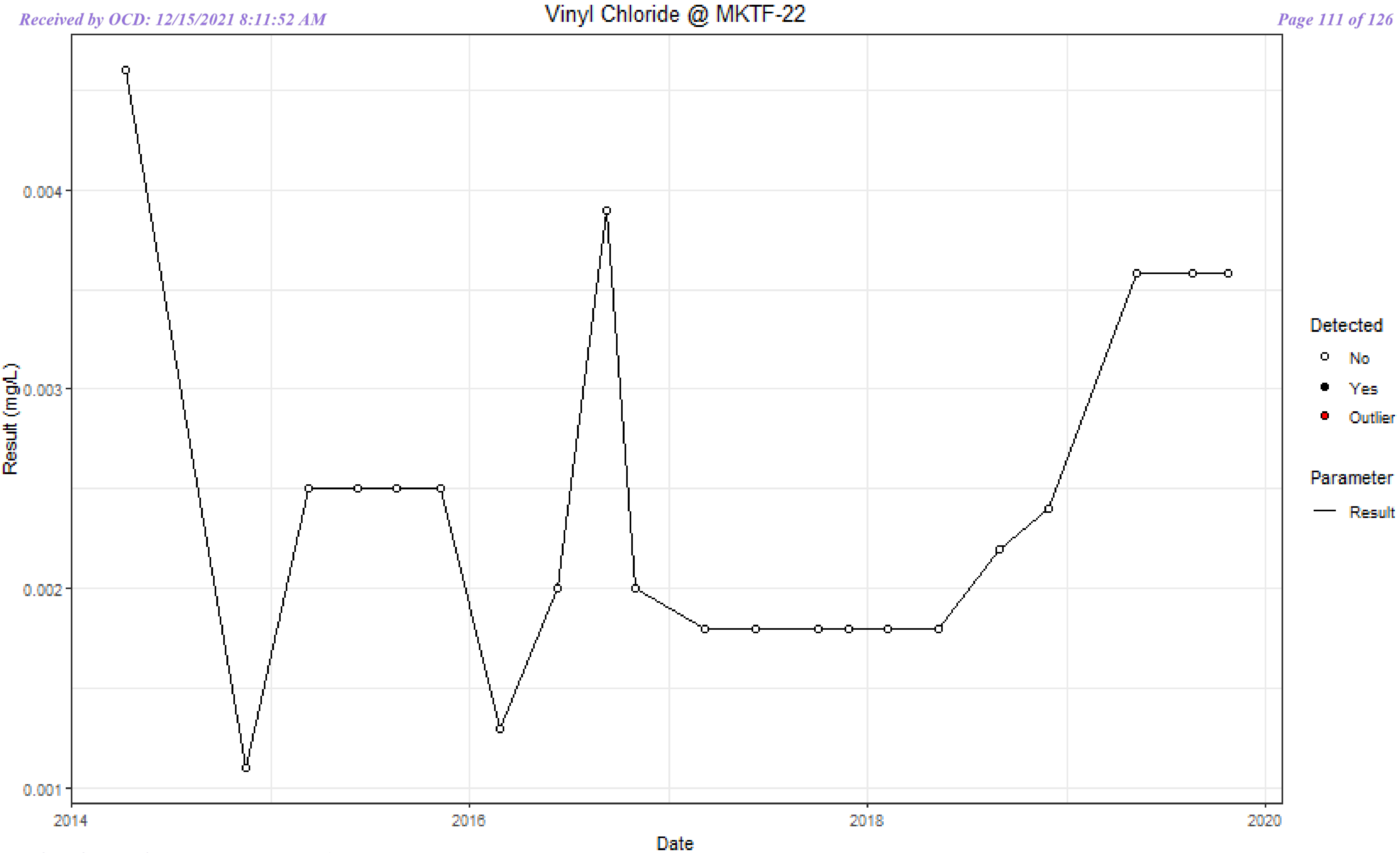


Method detection limit reported for ND results.

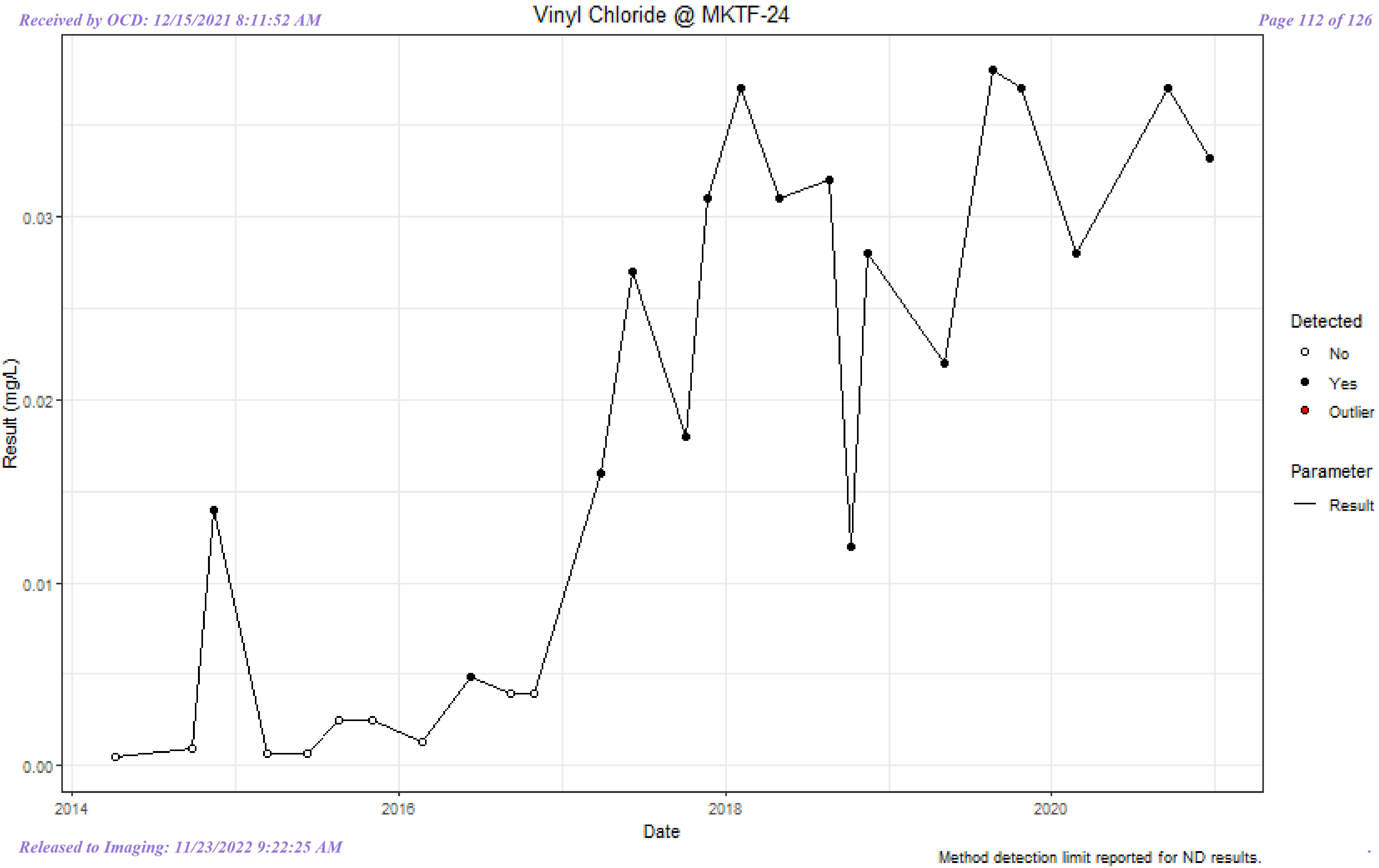
Vinyl Chloride @ MKTF-16

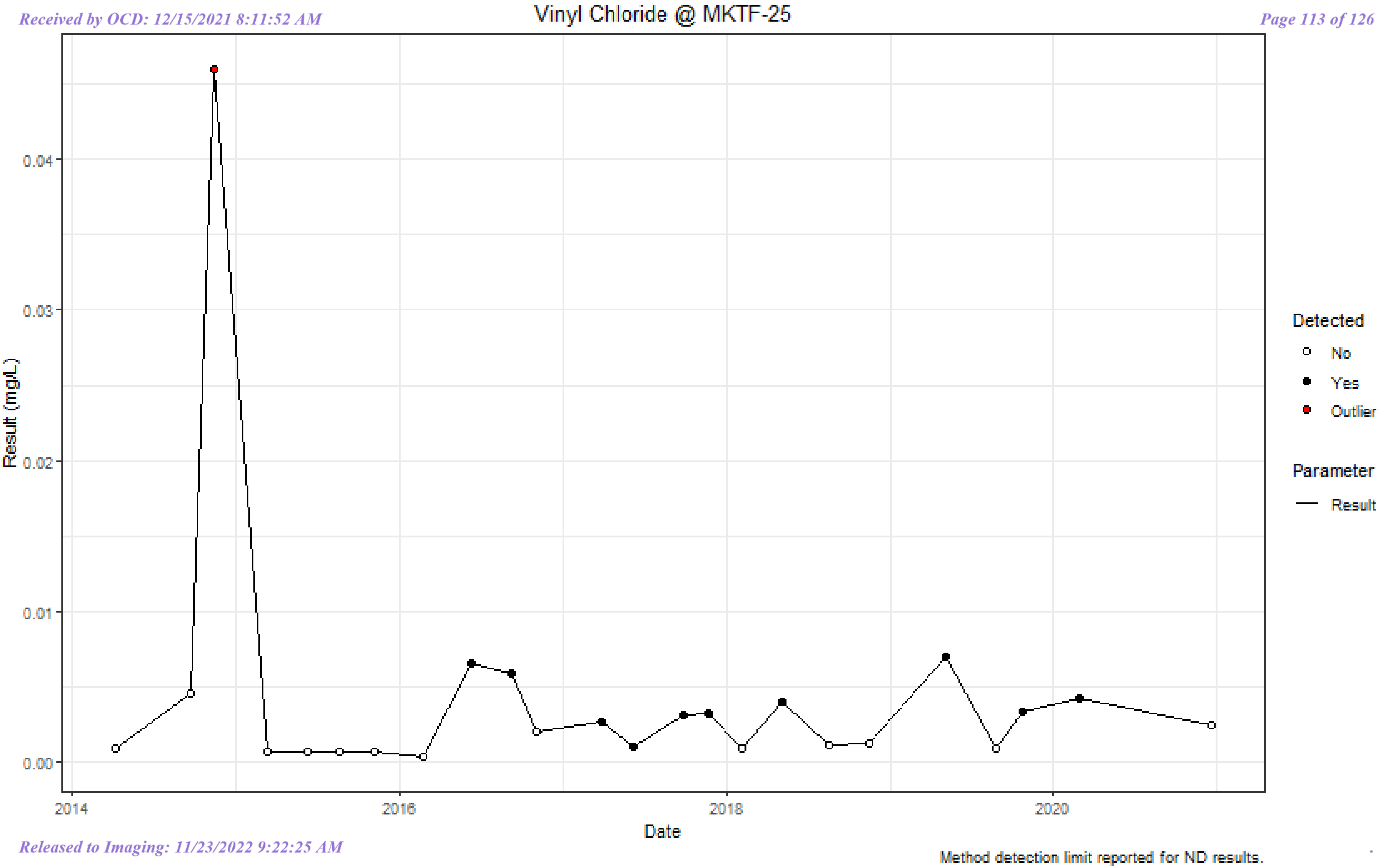


Method detection limit reported for ND results.



Method detection limit reported for ND results.

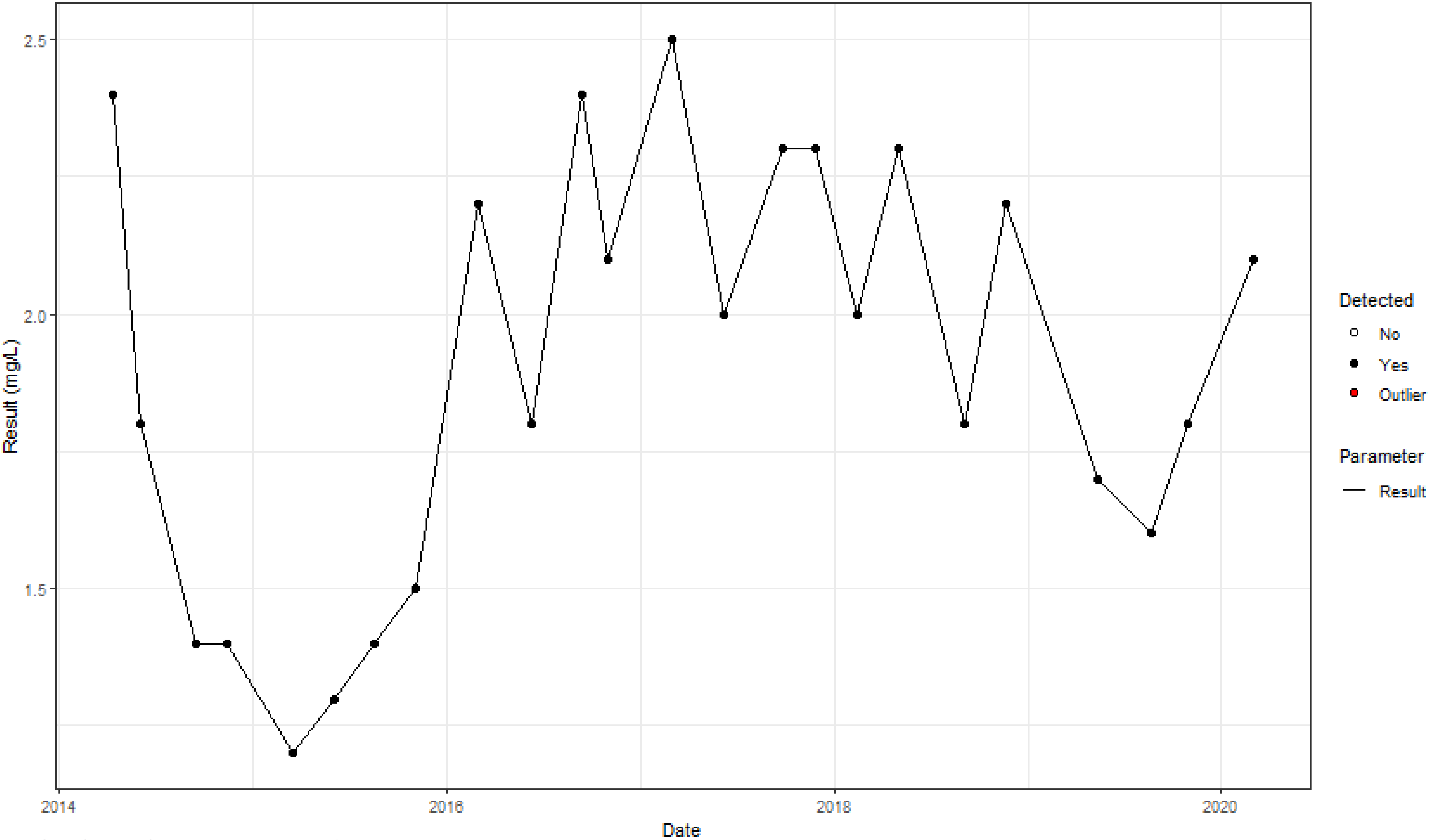

Vinyl Chloride @ MKTF-24
Result (mg/L)
0.00
0.01
0.02
0.03
2014
2016
2018
2020
Date
Detected
No
Yes
Outlier
Parameter
Result
Method detection limit reported for ND results.



Method detection limit reported for ND results.

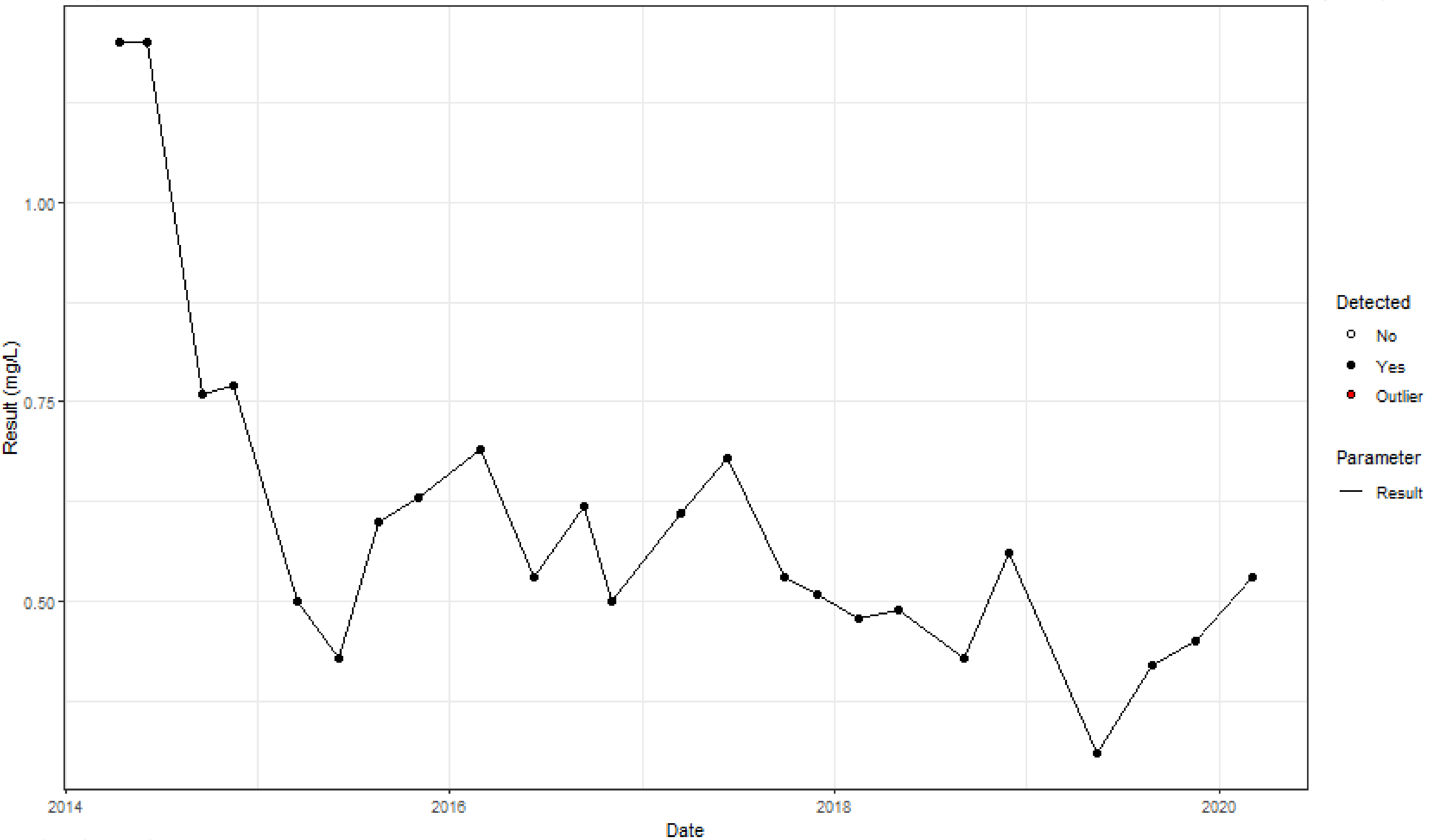
Attachment B – MTBE Time Series Plots

MTBE @ MKTF-04

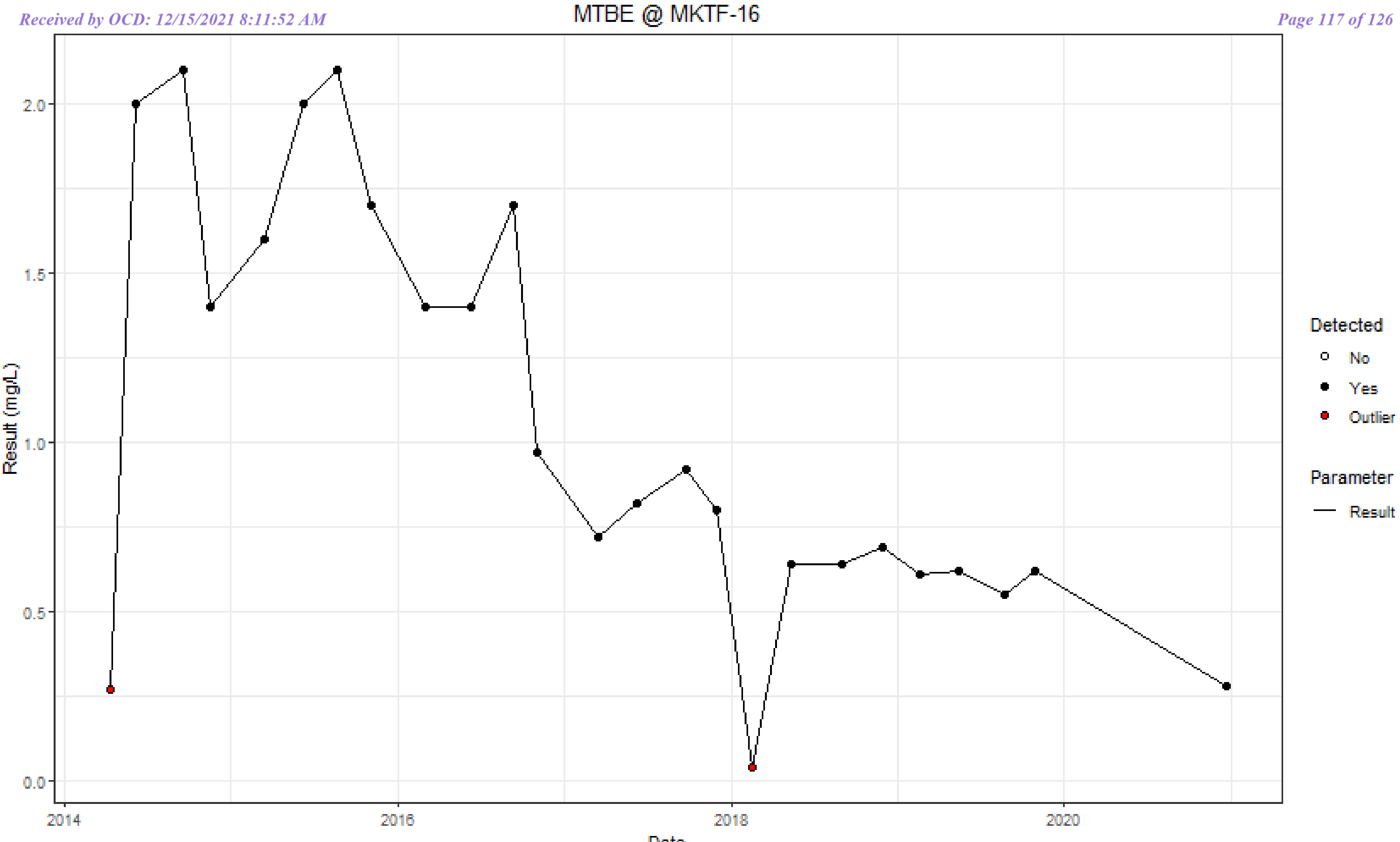


Method detection limit reported for ND results.

MTBE @ MKTF-09

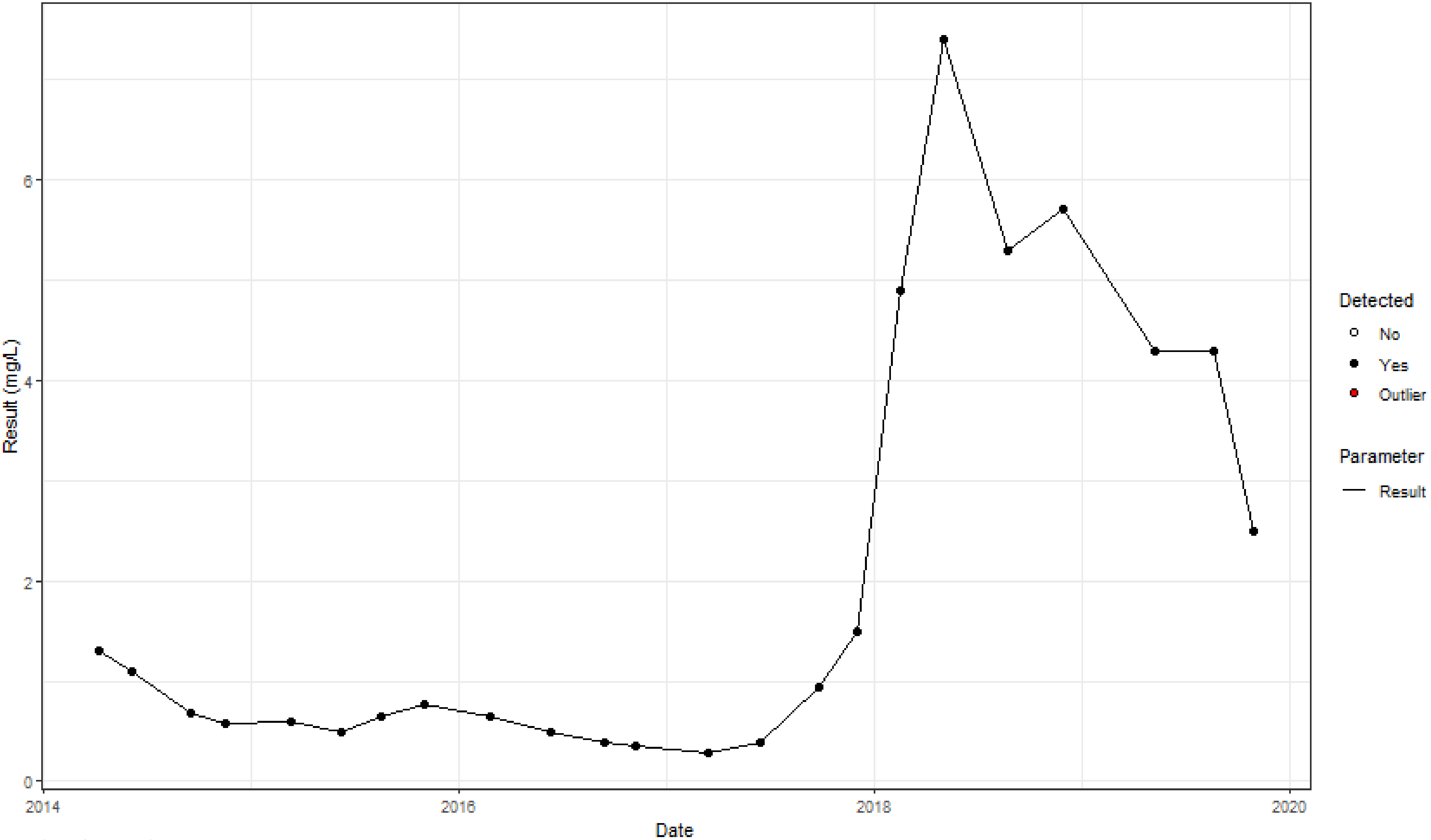


Method detection limit reported for ND results.



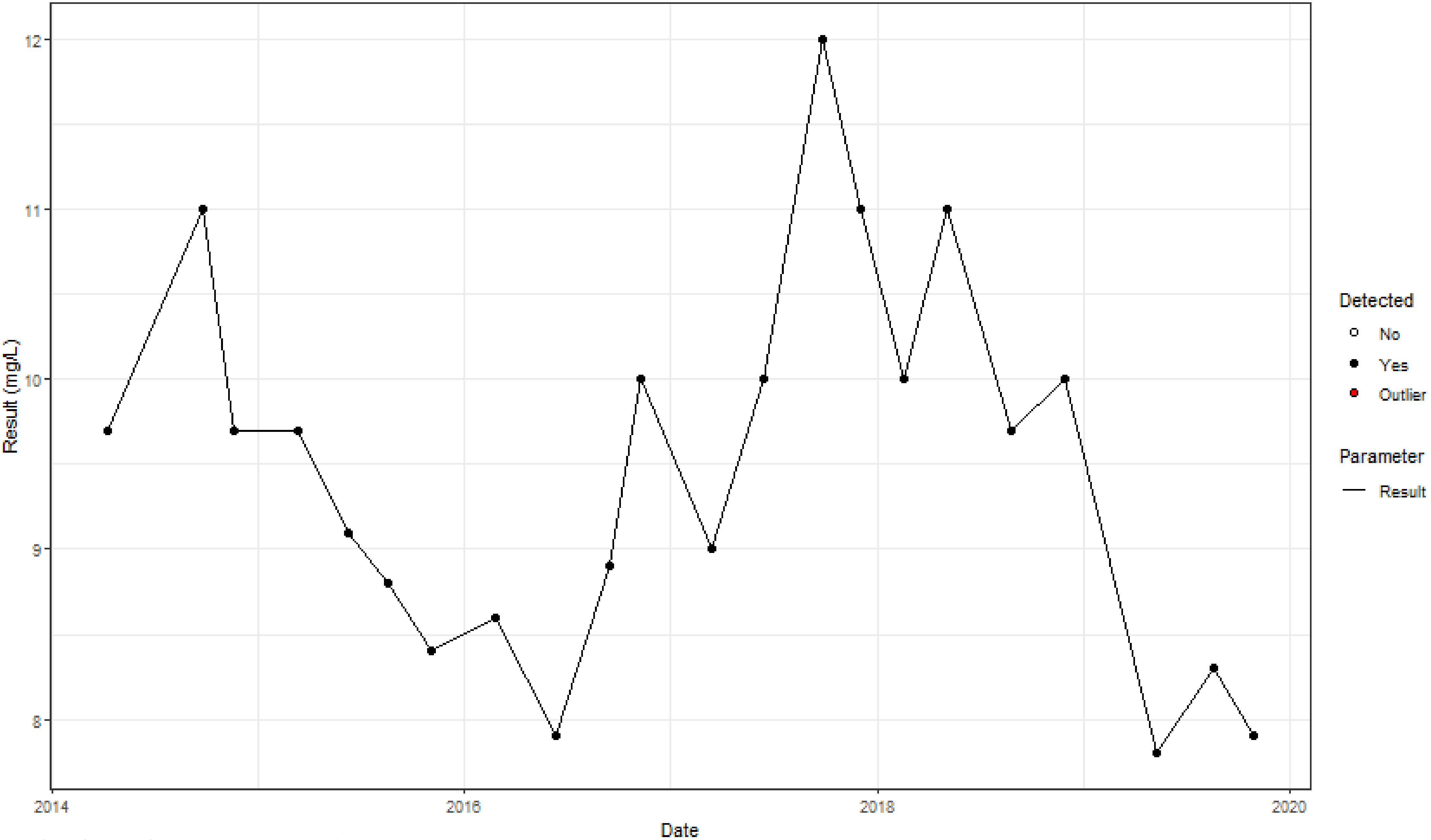
Method detection limit reported for ND results.

MTBE @ MKTF-17

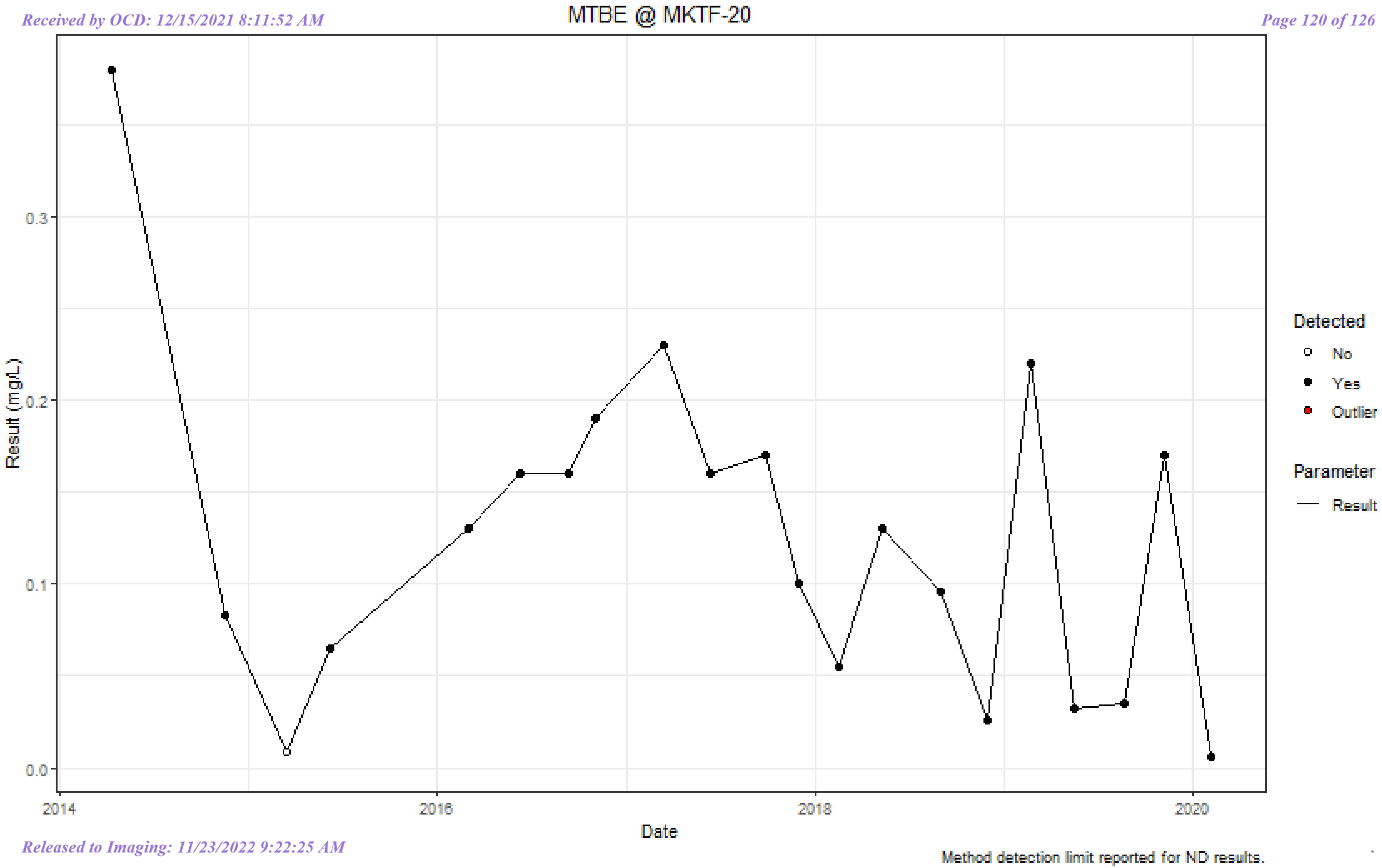


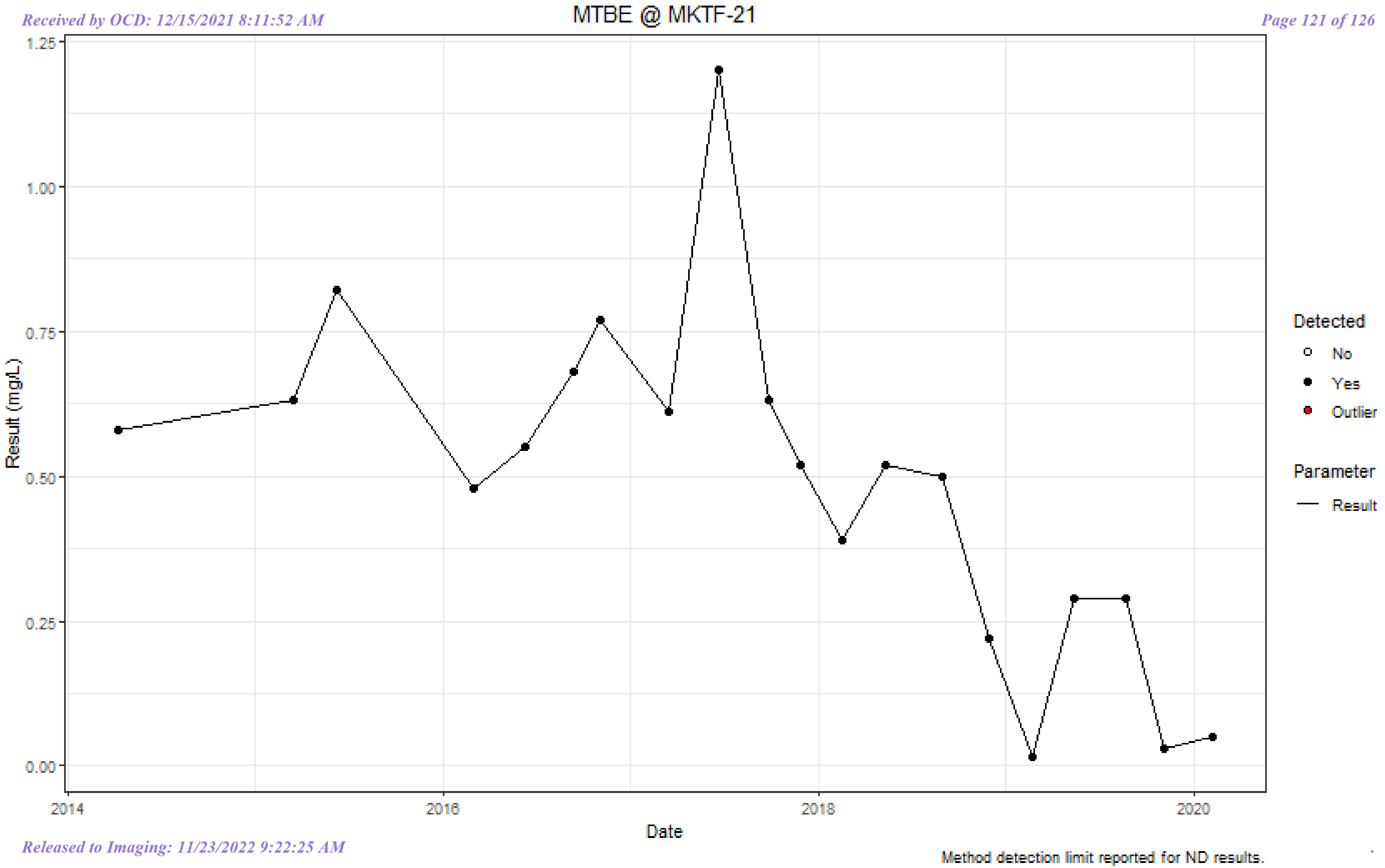
Method detection limit reported for ND results.

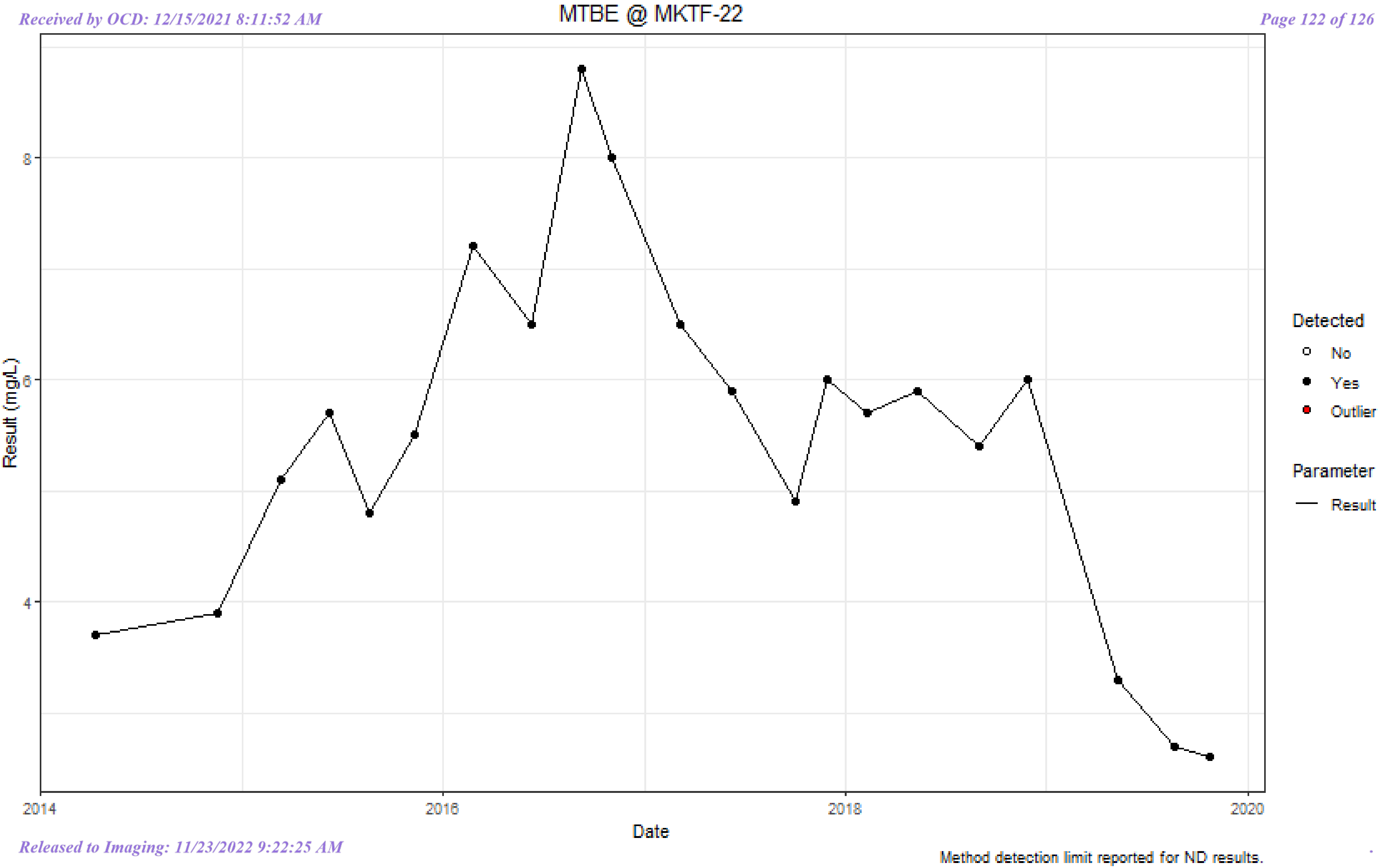
MTBE @ MKTF-19



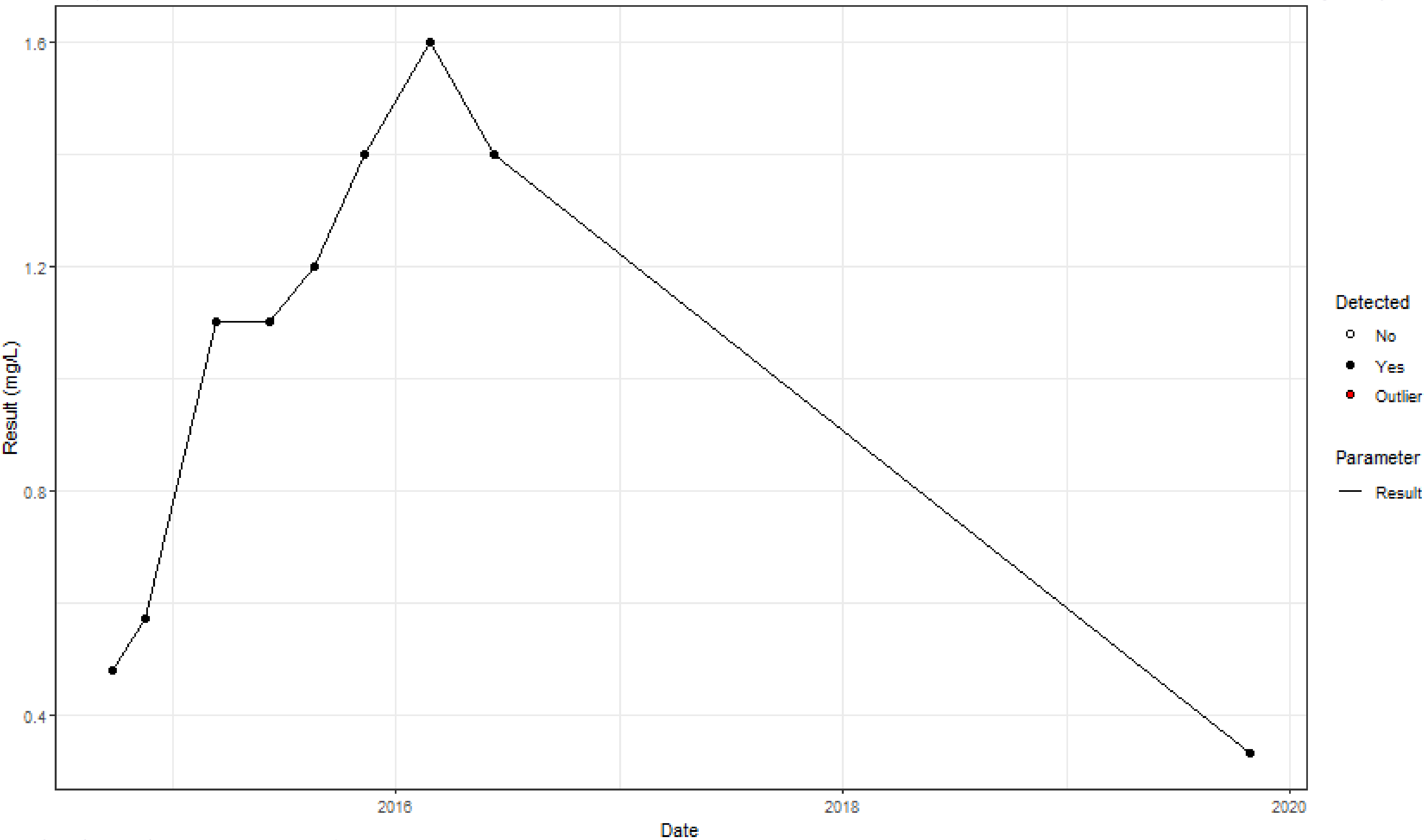
Method detection limit reported for ND results.


MTBE @ MKTF-20
Result (mg/L)
0.0
0.1
0.2
0.3
Date
2014
2016
2018
2020
Detected
○ No
● Yes
● Outlier
Parameter
— Result
Method detection limit reported for ND results.


MTBE @ MKTF-21
Result (mg/L)
1.25
1.00
0.75
0.50
0.25
0.00
2014
2016
2018
2020
Date
Detected
○ No
● Yes
● Outlier
Parameter
— Result
Method detection limit reported for ND results.

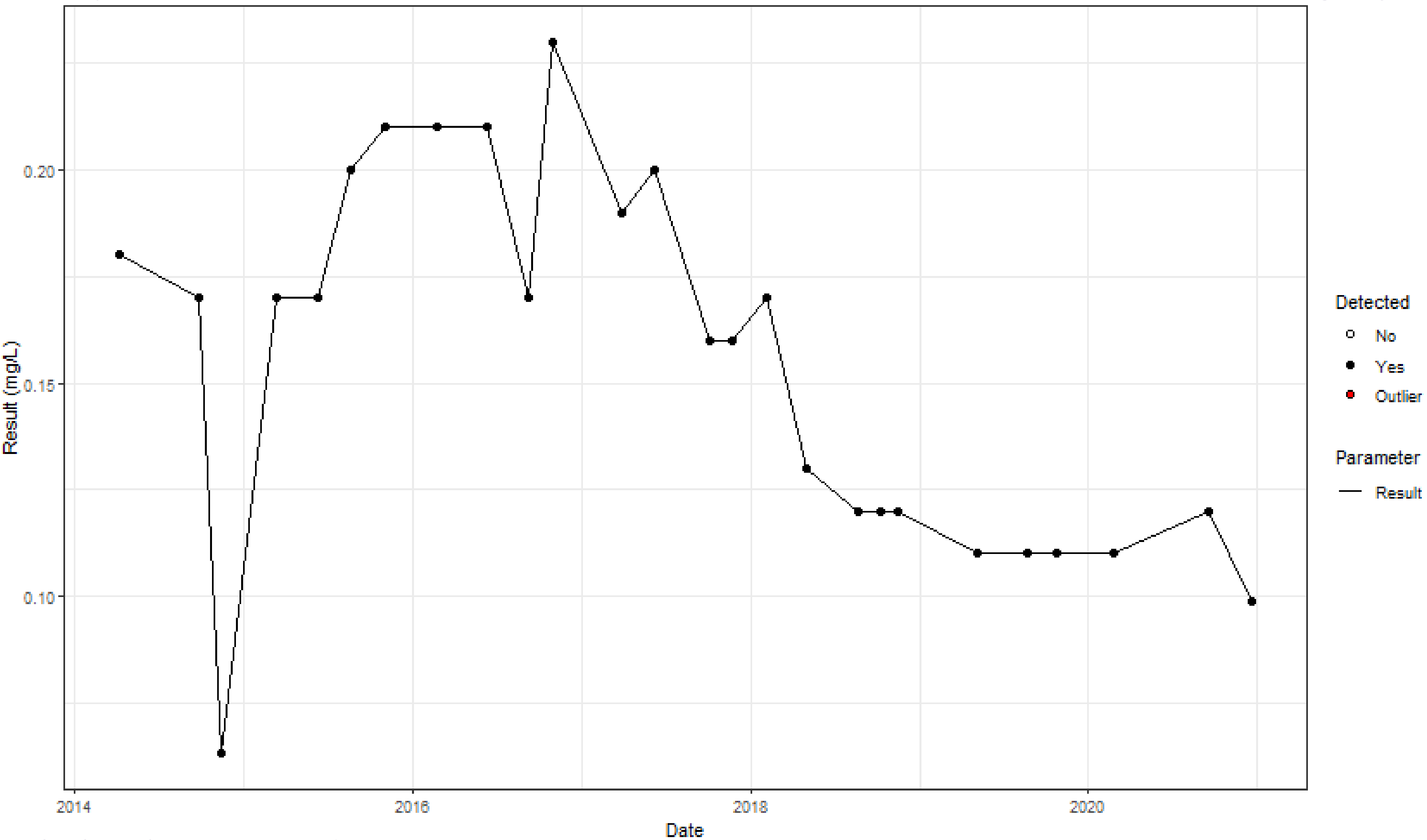

MTBE @ MKTF-22
Result (mg/L)
8
6
4
2014
2016
2018
2020
Date
Detected
○ No
● Yes
● Outlier
Parameter
Result
Method detection limit reported for ND results.

MTBE @ MKTF-23



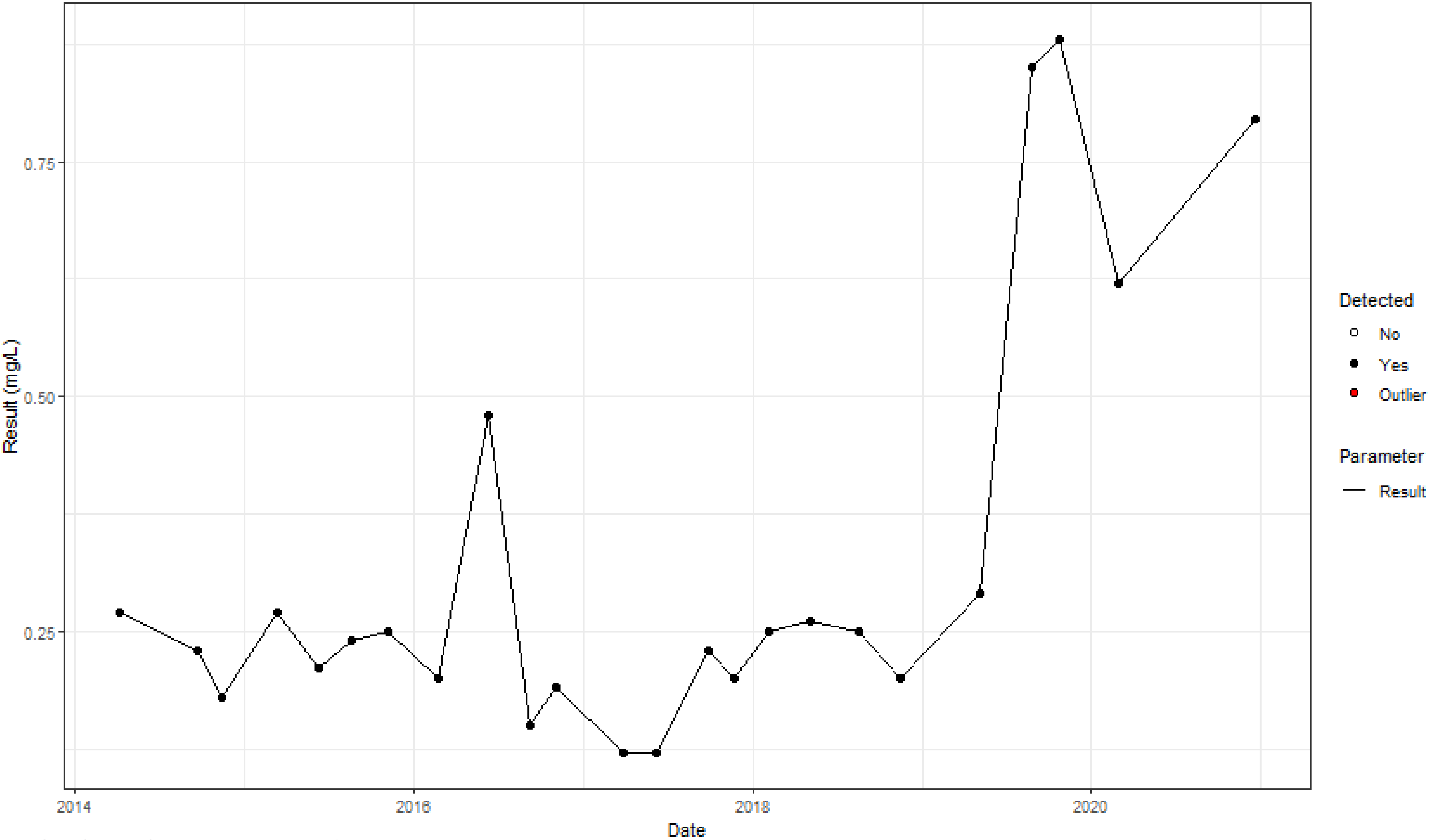
Method detection limit reported for ND results.

MTBE @ MKTF-24



Method detection limit reported for ND results.

MTBE @ MKTF-25



Method detection limit reported for ND results.

District I
1625 N. French Dr., Hobbs, NM 88240
Phone:(575) 393-6161 Fax:(575) 393-0720
District II
811 S. First St., Artesia, NM 88210
Phone:(575) 748-1283 Fax:(575) 748-9720
District III
1000 Rio Brazos Rd., Aztec, NM 87410
Phone:(505) 334-6178 Fax:(505) 334-6170
District IV
1220 S. St Francis Dr., Santa Fe, NM 87505
Phone:(505) 476-3470 Fax:(505) 476-3462

State of New Mexico
Energy, Minerals and Natural Resources
Oil Conservation Division
1220 S. St Francis Dr.
Santa Fe, NM 87505

CONDITIONS

Action 67134

CONDITIONS

Operator: Western Refining Southwest LLC 539 South Main Street Findlay, OH 45840	OGRID: 267595
	Action Number: 67134
	Action Type: [UF-DP] Discharge Permit (DISCHARGE PERMIT)

CONDITIONS

Created By	Condition	Condition Date
jburdine	Accepted for Record Retention Purposes-Only	11/23/2022