Appendix C
Data Validation Review, Third Quarter 2020

AECOM
Memorandum

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To	Renee Knecht, Project Manager	Info	FINAL
Subject	Summary Data Quality Review Phillips 66 – D Street Terminal, Tacoma Washington 2020 Third Quarter Groundwater Sampling		
From	Lucy Panteleeff, Chemist Jennifer B. Garner, Chemist		
Date	May 19, 2021		

The summary data quality review of 34 groundwater samples and 3 trip blanks collected between September 21 and September 23, 2020, has been completed. The samples were analyzed at Eurofins TestAmerica Laboratories, Incorporated (TA) located in Spokane and Seattle, Washington for benzene, toluene, ethylbenzene, and total xylenes (BTEX) by EPA Method 8260D; total petroleum hydrocarbons (TPHs) by Washington State Department of Ecology (Ecology) Methods NWTPH-Gx (gasoline-range TPH) and NWTPH-Dx (diesel-range and heavy oil-range TPH); naphthalenes by EPA Method 8270E modified by selected ion monitoring (SIM); metals by EPA Method 6020B (total and dissolved lead and dissolved manganese); anions by EPA Method 300.0 (sulfate and nitrate as nitrogen); and/or total alkalinity by EPA Method 310.1. The laboratory provided summary reports containing sample results and associated quality assurance (QA) and quality control (QC) data for all samples. The following samples are associated with TA laboratory groups 590-13912-1, 590-13920-1, and 590-13928-1:

Sample ID	Laboratory Group	Laboratory ID	Requested Analyses
FW-5R	590-13912-1	590-13912-1	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity, Naphthalenes
T-3		590-13912-2	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
DMW-4		590-13912-3	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
E-21		590-13912-4	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
E-21-DUP (field duplicate of E-21)		590-13912-5	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
RR-3		590-13912-6	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity, Naphthalenes
B-31		590-13912-7	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
RR-4		590-13912-8	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
RR-2		590-13912-9	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity, Naphthalenes
RR-1		590-13912-10	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
Trip Blank		590-13912-11	BTEX
T-2	590-13920-1	590-13920-1	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
FW-3		590-13920-2	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
G-8		590-13920-3	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
RW-5R		590-13920-4	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
FW-4		590-13920-5	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity, Naphthalenes
DMW-1		590-13920-6	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
FW-13		590-13920-7	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
RW-8		590-13920-8	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
HC-111		590-13920-9	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
RW-2		590-13920-10	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
E-22		590-13920-11	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity

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Summary Data Quality Review
Phillips 66 - D Street Terminal, Tacoma, Washington
2020 Third Quarter Groundwater Sampling
Laboratory Groups: 590-13912-1, 590-13920-1, and 590-13928-1

Sample ID	Laboratory Group	Laboratory ID	Requested Analyses
DMW-3	590-13920-1 (continued)	590-13920-12	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
B-17B		590-13920-13	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
B-19		590-13920-14	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
B-19-Dup (field duplicate of B-19)		590-13920-15	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
B-34		590-13920-16	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
RR-5		590-13920-17	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
Trip Blank		590-13920-18	BTEX
DMW-2	590-13928-1	590-13928-1	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
FW-14		590-13928-2	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity, Naphthalenes
FW-15		590-13928-3	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
G-18		590-13928-4	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
G-16		590-13928-5	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
B-30		590-13928-6	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
B-25		590-13928-7	BTEX, TPH-Gx, TPH-Dx, Metals, Anions, Alkalinity
Trip Blank		590-13928-8	BTEX

Data were evaluated based on validation criteria established in the *National Functional Guidelines for Organic Superfund Methods Data Review*, dated January 2017, and *National Functional Guidelines for Inorganic Superfund Methods Data Review*, January 2017, as applied to the reported methodology.

The following data components were reviewed during the limited data validation procedure for compliance with method specific or laboratory control charted criteria where appropriate: chain of custody forms, holding times, field/method/trip/instrument blanks, surrogate recoveries, matrix spike/matrix spike duplicate recoveries, laboratory and field duplicate results, laboratory control sample/laboratory control sample duplicate recoveries, reporting limits, and electronic data deliverables.

A summary of qualifiers that may be assigned to results in these laboratory groups are included in Table 1. Qualifiers that may be assigned to results include:

- U - The analyte was analyzed for but was not detected above the reported sample quantitation limit.
- J - The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
- UJ - The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
- R - The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

- DNR - Do Not Report. Another result is available that is more reliable or appropriate.

Sample Receipt

Upon receipt by the laboratories, the sample jar information was compared to the associated chain-of-custody (COC) and the cooler temperatures were recorded. No discrepancies related to sample identifications were noted by the laboratory and the coolers were received at temperatures within the EPA recommended temperature limits of greater than 0°C and less than or equal to 6°C.

Organic Analyses

Samples were analyzed for BTEX, TPHs, and/or naphthalenes by the methods identified in the introduction of this report.

1. Holding Times – Acceptable

2. Blanks – Acceptable

3. Surrogates – Acceptable except as noted below:

   Naphthalenes by Method 8270E-SIM – The percent recovery for the surrogate nitrobenzene-d5 (184%) was outside the control limits of 44-121% in the diluted analysis (x100) of FW-5R. The percent recovery for nitrobenzene-d5 in the initial analysis (x1) of FW-5R was acceptable; therefore, data were not qualified based on the dilution surrogate recovery.

4. Laboratory Control Sample/Laboratory Control Sample Duplicate (LCS/LCSD) – Acceptable

5. Matrix Spike/Matrix Spike Duplicate (MS/MSD) – Acceptable

   BTEX by Method 8260D – An MS/MSD was performed in using G-8. Results were acceptable.

   NWTPH-Gx – An MS/MSD was performed in using G-8. Results were acceptable.

   NWTPH-Dx – An MS/MSD was performed in using G-8. Results were acceptable.

   Naphthalenes by Method 8270E-SIM – An MS/MSD was not performed in association with this analysis. Precision and accuracy were assessed using the LCS/LCSD and field duplicate results.

6. Field Duplicate (applicable to BTEX and TPH analyses only) – Acceptable

   General – Field duplicates were submitted for E-21 and B-19 and identified as E-21-DUP and B-19-Dup, respectively. Results were comparable for all analytes reported at concentrations greater than five times the reporting limits.

7. Reporting Limits – Acceptable except as noted below:

   General – One or more results in multiple samples were flagged 'J' by the laboratory to indicate a concentration that was less than the reporting limit, but above the method detection limit (MDL). Laboratory 'J'-flagged results are considered estimated. As the result is between the MDL and the reporting limit, there is a greater level of uncertainty associated with the numerical result.

8. Other Items of Note:

   NWTPH-Dx – The laboratory noted the following:

   - Detected hydrocarbons in diesel range appeared to be due to gasoline overlap as well as heavily weathered diesel in RW-8, HC-111, RW-2, DMW-3, B-19, B-19-Dup, T-3, and B-31.
   - Detected hydrocarbons in the diesel range appeared to be due to heavily weathered diesel in DMW-4, E-21, E-21-DUP, DMW-2, FW-15, G-18, G-16, FW-4, DMW-1, FW-13, and B-34.
   - Detected hydrocarbons in the diesel range appeared to be due to heavily weathered diesel and/or biogenic interference in T-2, G-8 and RR-5.
   - Detected hydrocarbons in the diesel range appeared to be due gasoline overlap in B-25 and RW-5R.
   - Detected hydrocarbons in the diesel range appeared to be due to a complex mixture of heavy gas/light diesel range components in FW-5R.

Metals

Samples were analyzed for total and/or dissolved metals by EPA Method 6020A.

1. Holding Times – Acceptable

2. Blanks – Acceptable

3. Laboratory Control Sample/Laboratory Control Sample Duplicate (LCS/LCSD) – Acceptable

4. Matrix Spike/Matrix Spike Duplicate (MS/MSD) – Acceptable

   MS/MSDs for total and dissolved metals were performed using G-8 and FW-5R. Results were acceptable.

5. Laboratory Duplicate – Acceptable

   Laboratory duplicates for total and dissolved metals were performed using G-8 and FW-5R. Results were comparable.

6. Field Duplicates – Acceptable

   Field duplicates were submitted for E-21 and B-19 and identified as E-21-DUP and B-19-Dup, respectively. Results were comparable for all analytes reported at concentrations more than five times the reporting limits.

7. Reporting Limits – Acceptable

   One or more results were flagged 'J' by the laboratory to indicate a concentration that was less than the reporting limit, but above the MDL. Laboratory 'J'-flagged results are considered estimated. As noted above, there is a greater level of uncertainty associated with the numerical result.

   The reporting limits for total lead, dissolved lead, and/or dissolved manganese reported as not detected were elevated in multiple samples due to dilutions for matrix interferences. The elevated reporting limits do not impact the use of the data.

Conventional Analyses

Samples were analyzed for sulfate, nitrate, and alkalinity by the methods identified in the introduction of this report.

1. Holding Times – Acceptable

2. Blanks – Acceptable (where applicable)

3. Laboratory Control Sample (LCS) – Acceptable

4. Matrix Spike/Matrix Spike Duplicate (MS/MSD) – Acceptable (where applicable)

   Anions by EPA Method 300.0 – MS/MSDs were performed using B-25, G-8, and FW-5R. The following recoveries were outside the control limit of 80-120%.

Sample ID	Analyte	MS	MSD
G-8	Sulfate	2,102%	2,104%

   The sample concentration for sulfate in G-8 was more than four times the spike concentration; therefore, data were not qualified based on these MS/MSD recoveries.

   Alkalinity by EPA Method 310.1 – An MS/MSD was not performed in association with this analysis. Accuracy was assessed using the LCS results. Precision was assessed using the laboratory and field duplicate results.

5. Laboratory Duplicate – Acceptable

   Anions by EPA Method 300.0 – Laboratory duplicates were performed using B-25, G-8, and FW-5R. Results were comparable.

   Alkalinity by EPA Method 310.1 – Laboratory duplicates were performed using B-30, T-3,

RR-3, and RR-1. Results were comparable.

6. Field Duplicates - Acceptable

General – Field duplicates were submitted for E-21 and B-19 and identified as E-21-DUP and B-19-Dup, respectively. Results were comparable for all analytes reported at concentrations more than five times the reporting limits.

7. Reporting Limits – Acceptable

Anions by EPA Method 300.0 – One or more results were flagged 'J' by the laboratory to indicate a concentration that was less than the reporting limit, but above the MDL. Laboratory 'J'-flagged results are considered estimated. As noted above, there is a greater level of uncertainty associated with the numerical result.

The reporting limits for nitrate reported as not detected in T-2 and G-8 were slightly elevated due to dilutions made for high concentrations of non-target analytes. The elevated reporting limits do not affect the use of the data.

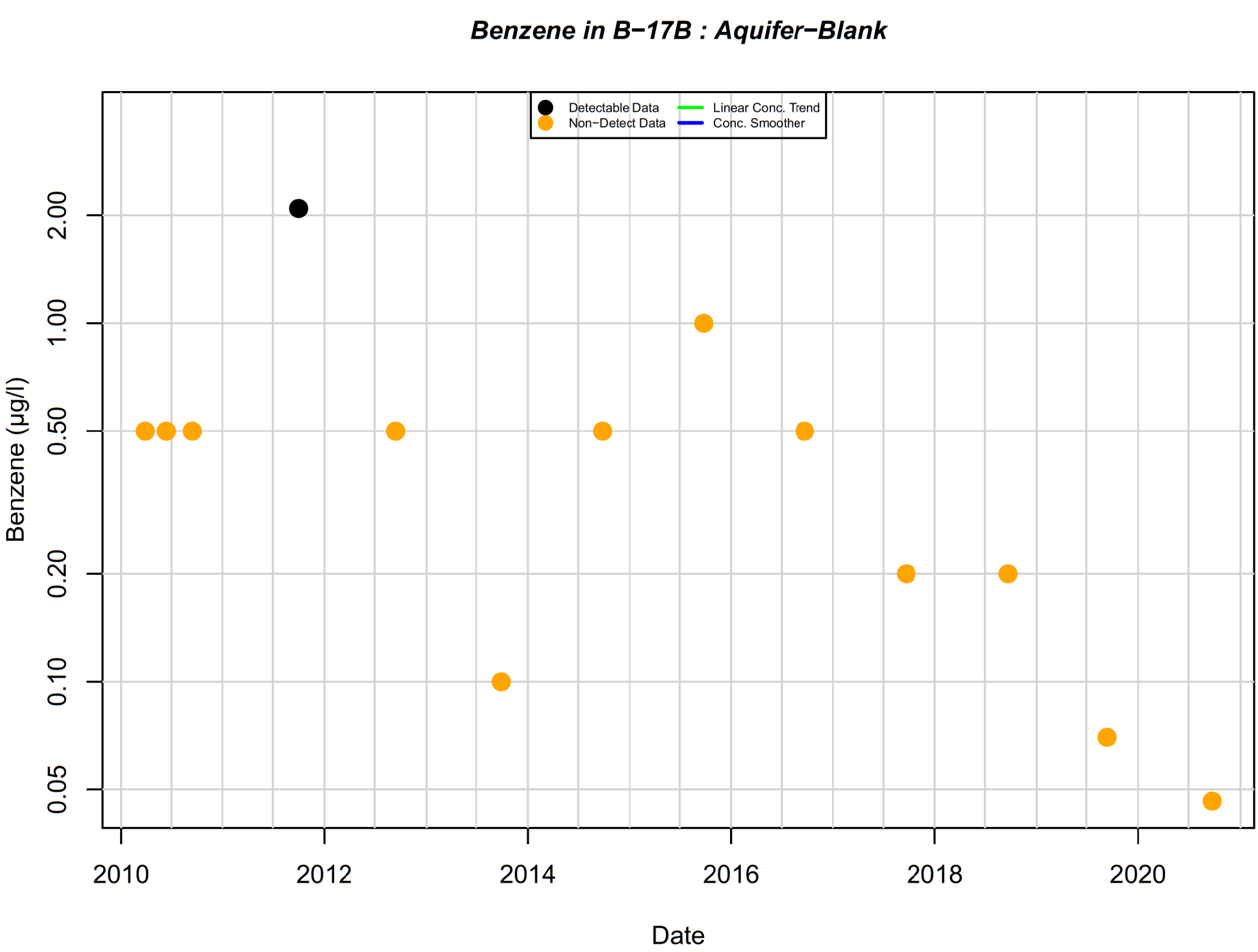
Overall Assessment of Data

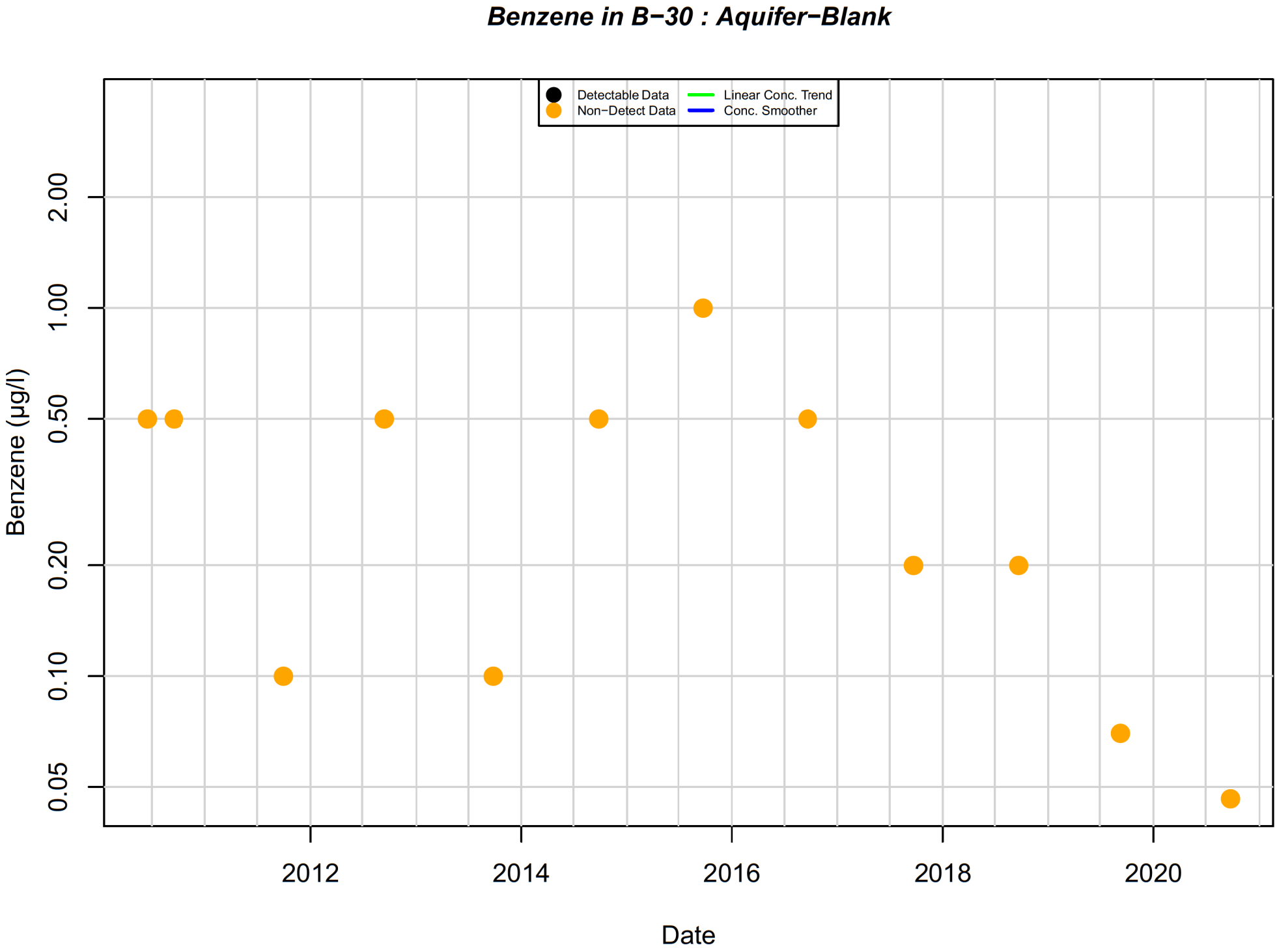
The data reported in these laboratory groups, as qualified, are considered to be usable for meeting project objectives. The completeness for TestAmerica laboratory groups 590-13912-1, 590-13920-1, and 590-13928-1 is 100%.

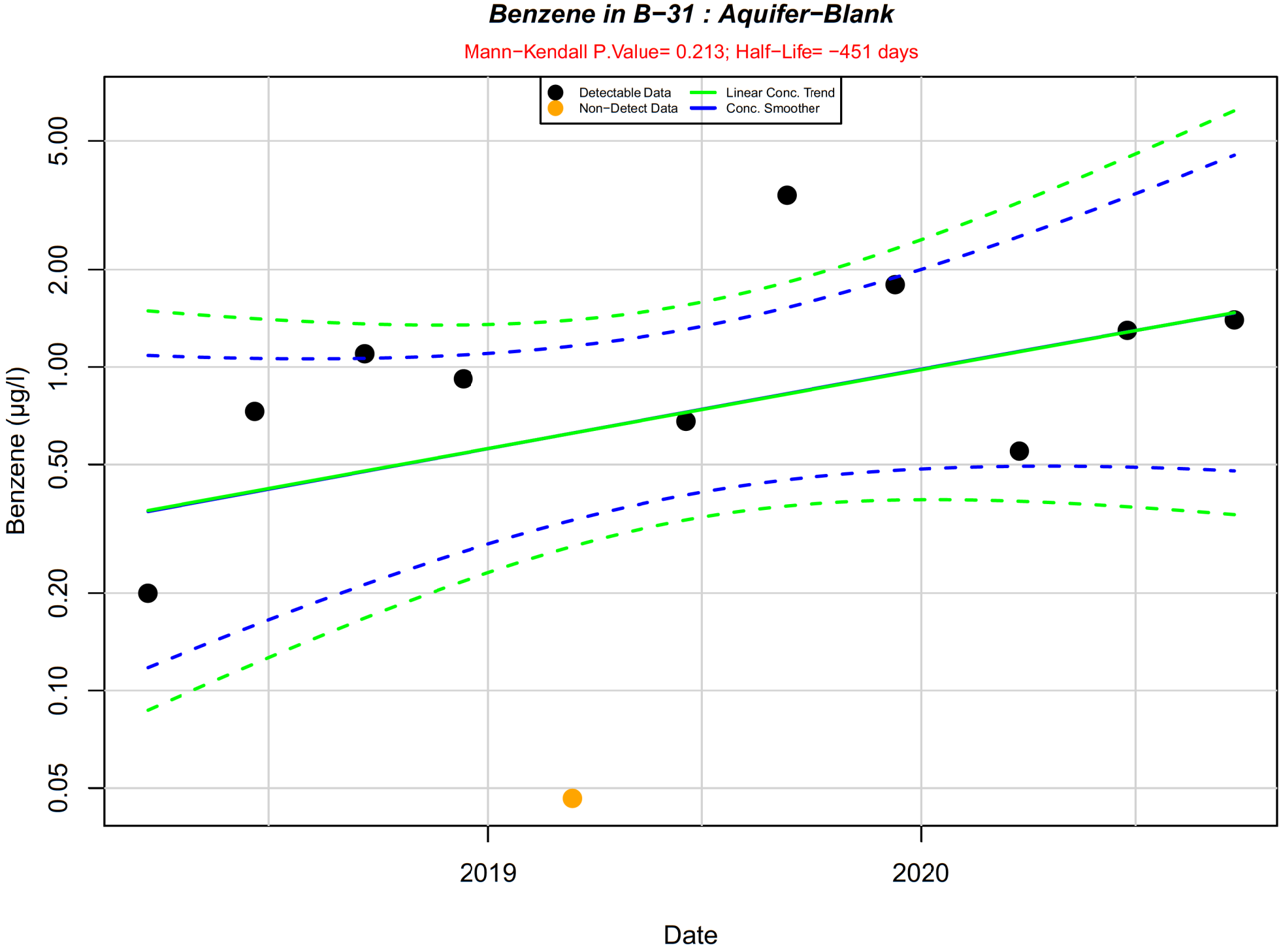
Table 1 - Summary of Qualified Data

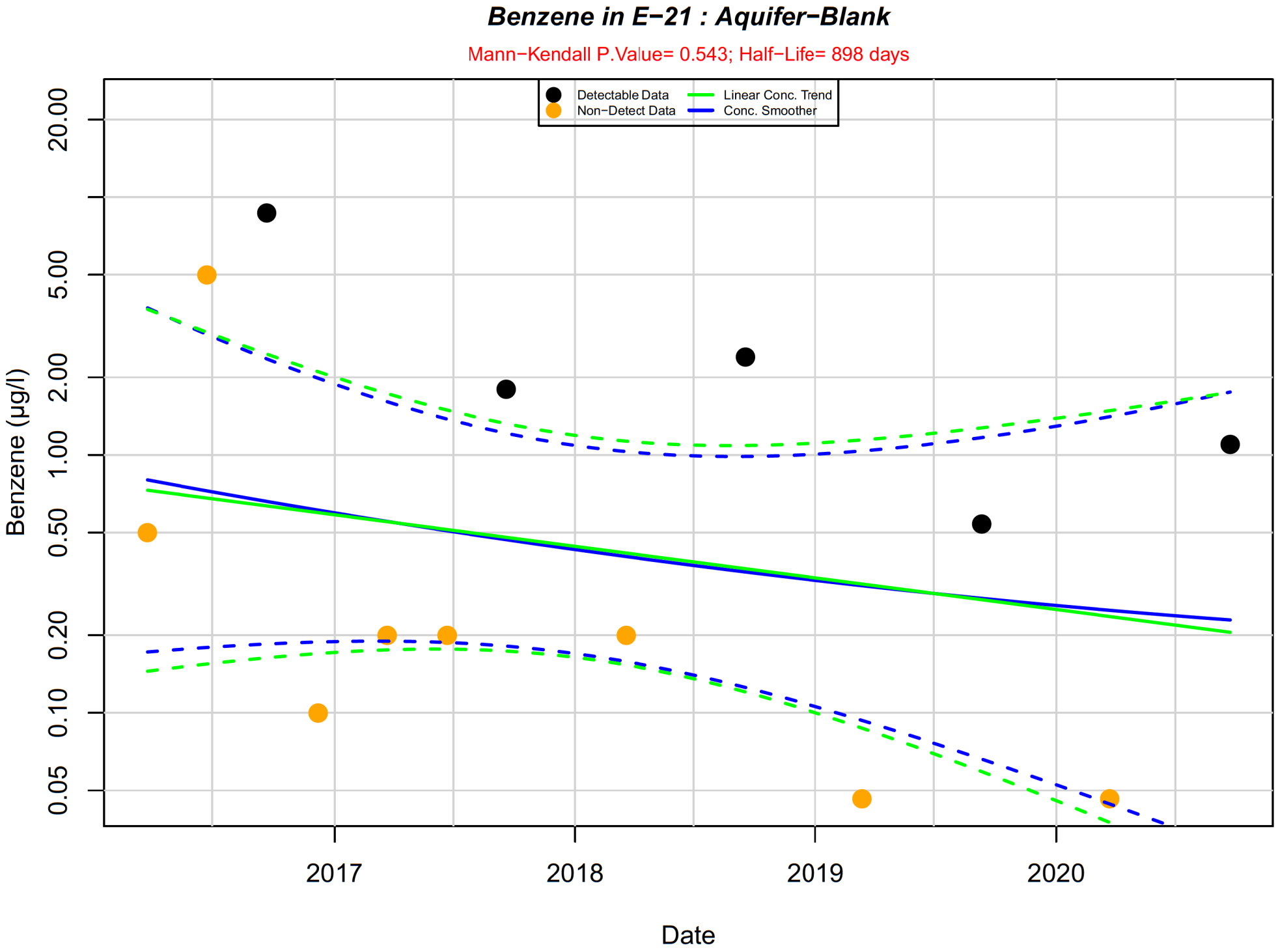
Sample ID	Laboratory ID	Analyte	Laboratory Result	Units	Final Result	Reason
No data qualifiers were assigned based on the validation of these laboratory groups.						

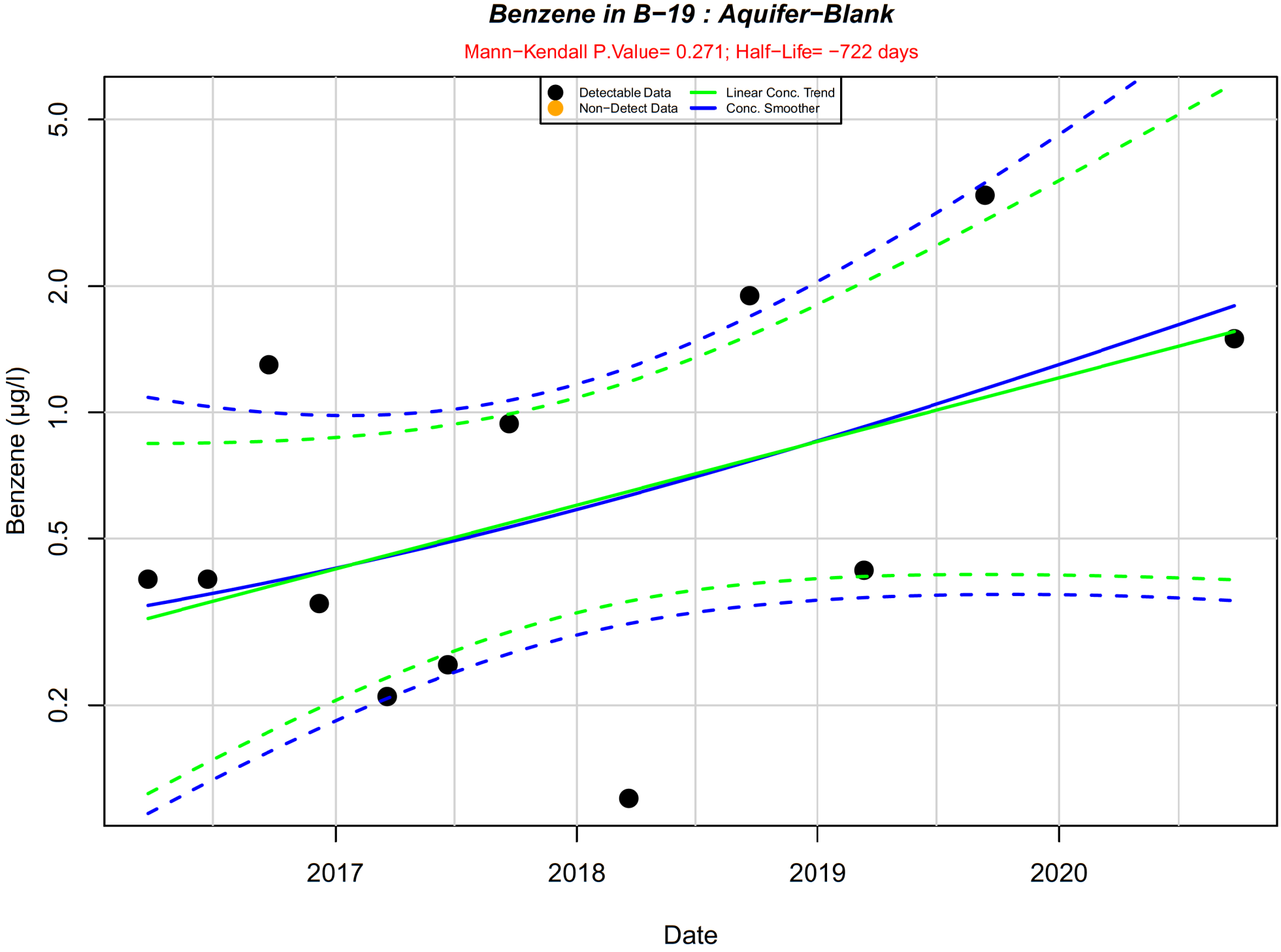
Appendix D
GWSDAT Plots: Time vs. Concentration with Mann-Kendall

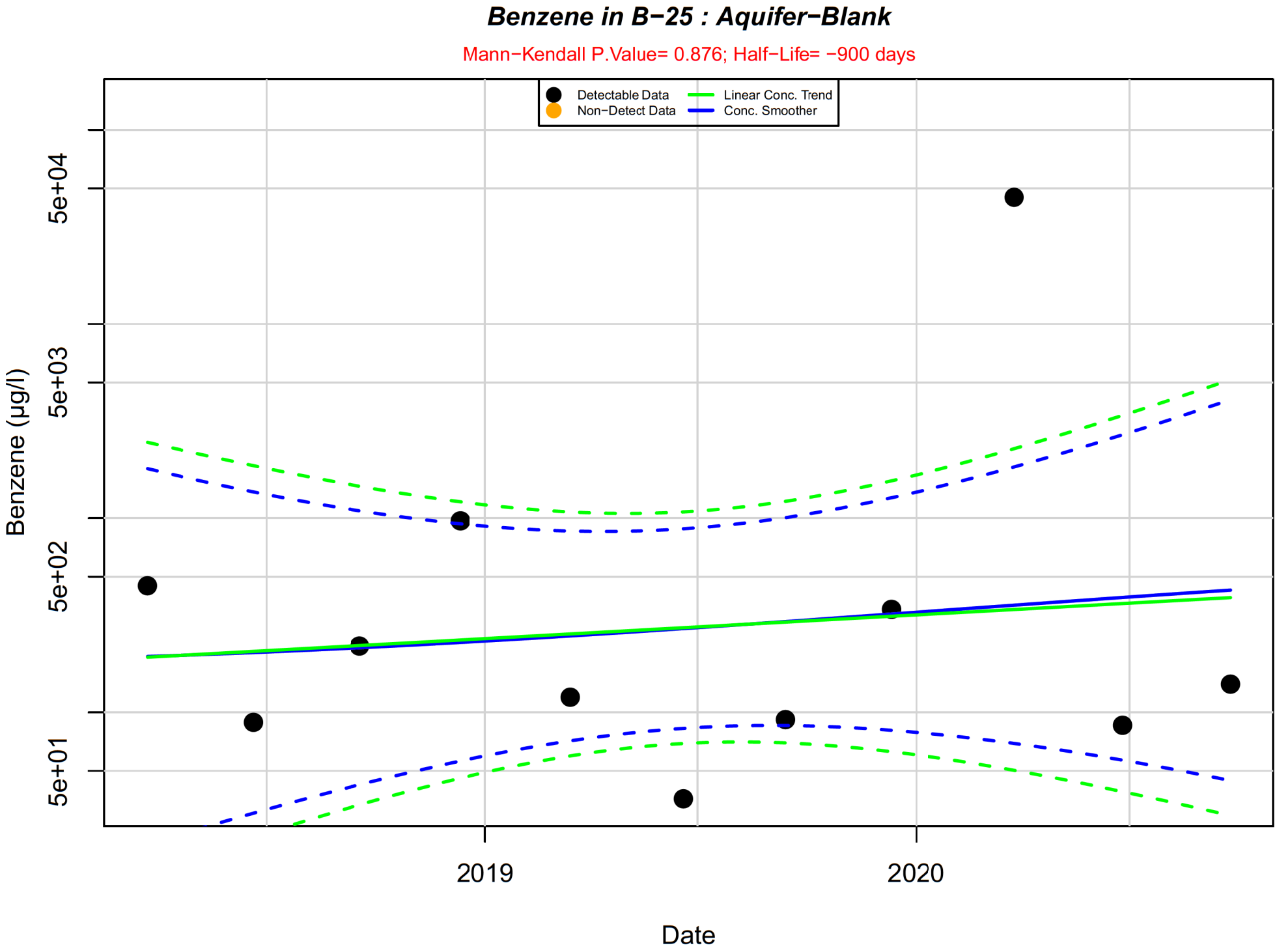

Benzene in B-17B : Aquifer-Blank
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
2.00
1.00
0.50
0.20
0.10
0.05
2010
2012
2014
2016
2018
2020
Date

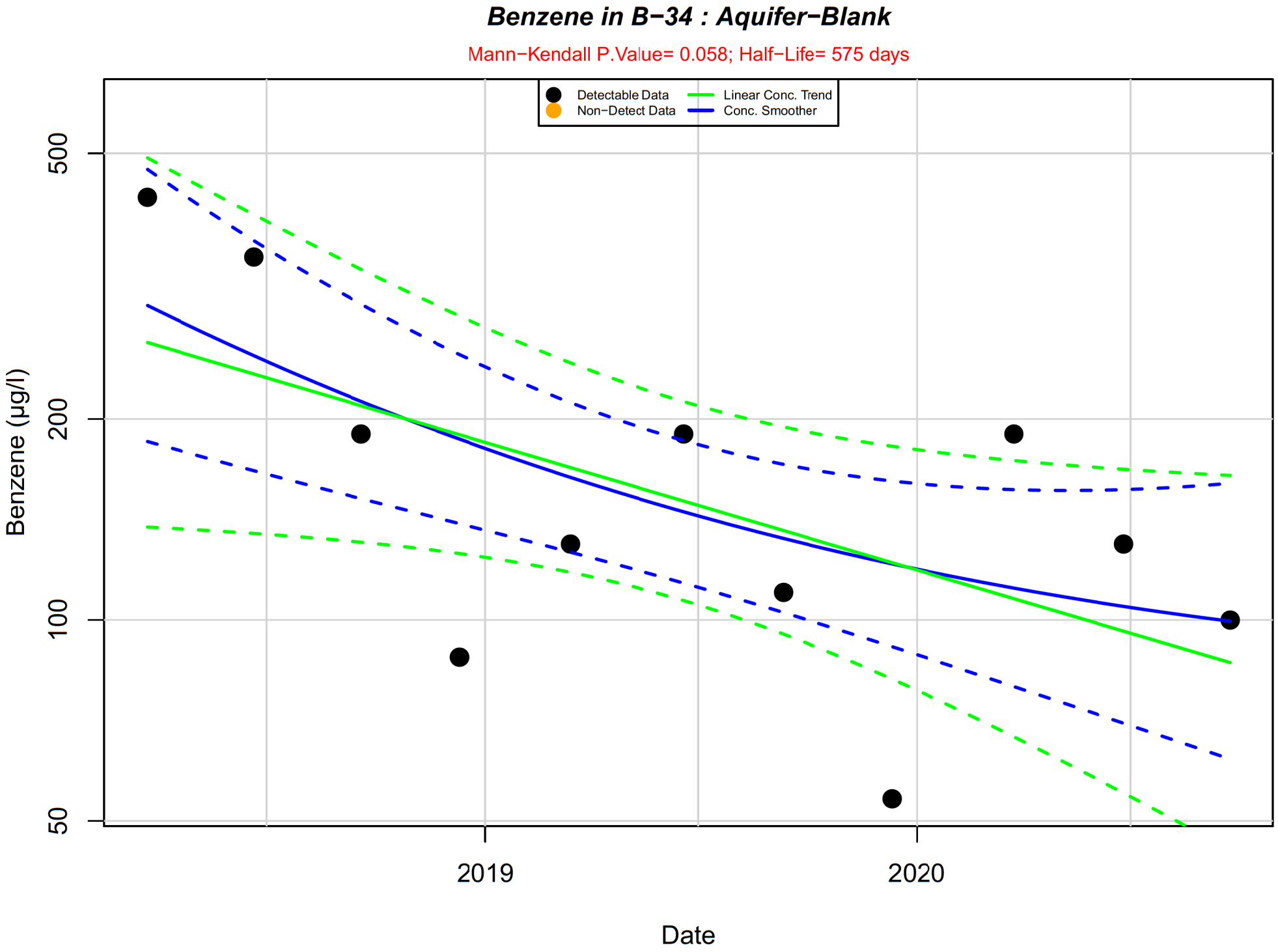

Benzene in B-30 : Aquifer-Blank
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
2.00
1.00
0.50
0.20
0.10
0.05
2012
2014
2016
2018
2020
Date

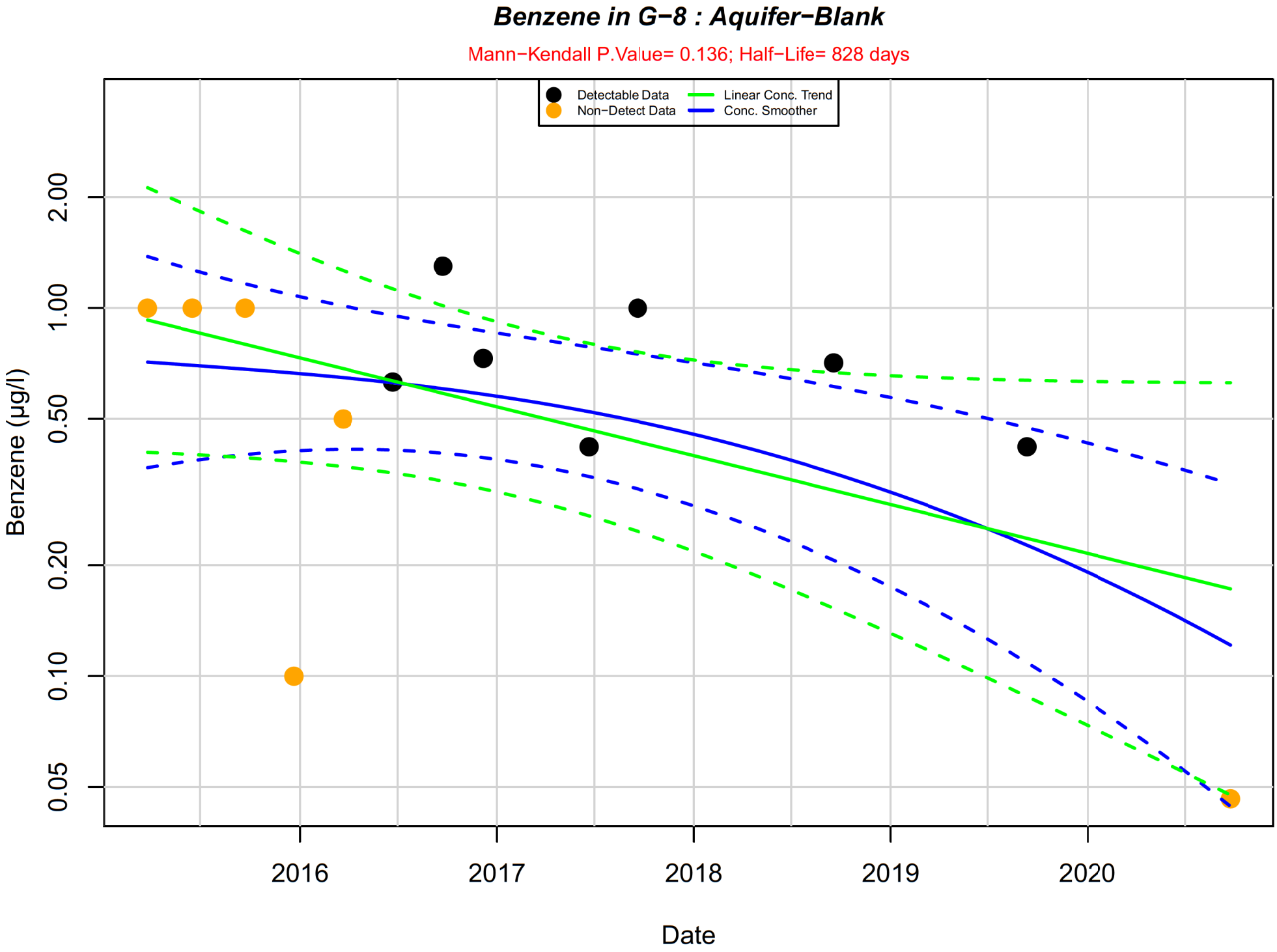

Benzene in B-31 : Aquifer-Blank
Mann-Kendall P.Value= 0.213; Half-Life= -451 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
5.00
2.00
1.00
0.50
0.20
0.10
0.05
2019
2020
Date

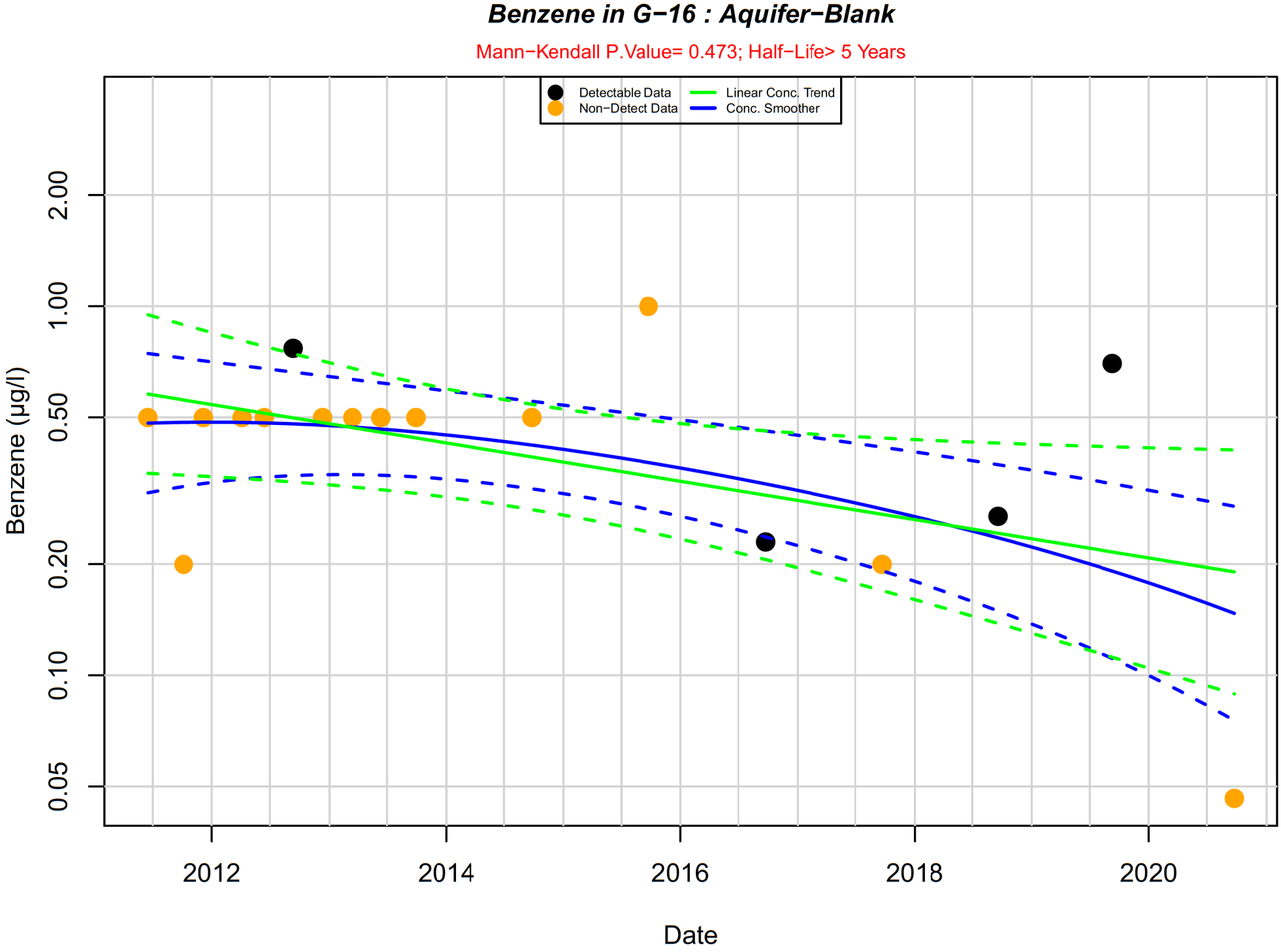

Benzene in E-21 : Aquifer-Blank
Mann-Kendall P.Value= 0.543; Half-Life= 898 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
20.00
5.00
2.00
1.00
0.50
0.20
0.10
0.05
2017
2018
2019
2020
Date

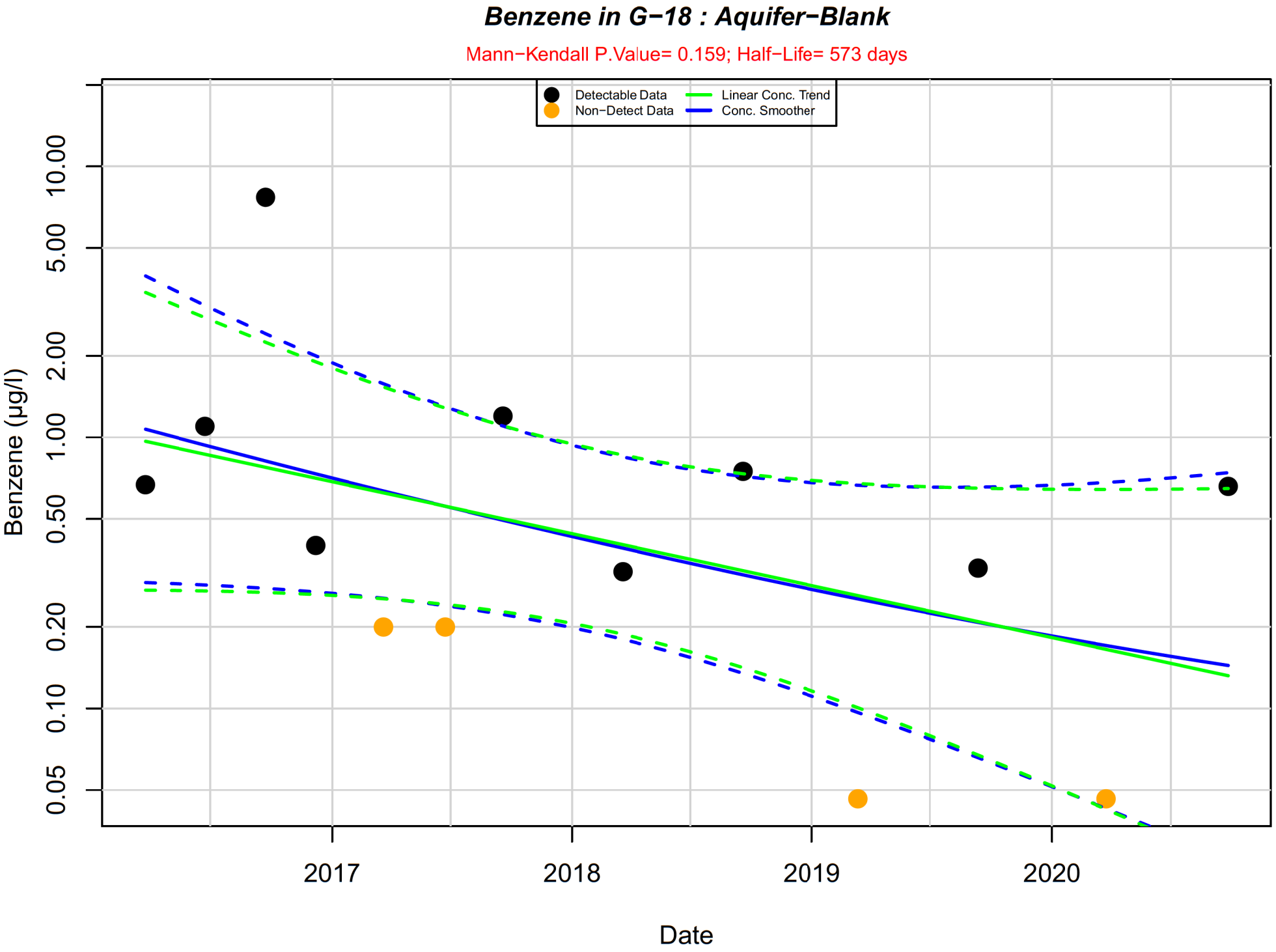

Benzene in B−19 : Aquifer−Blank
Mann−Kendall P.Value= 0.271; Half−Life= −722 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
0.2
0.5
1.0
2.0
5.0
2017
2018
2019
2020
Date

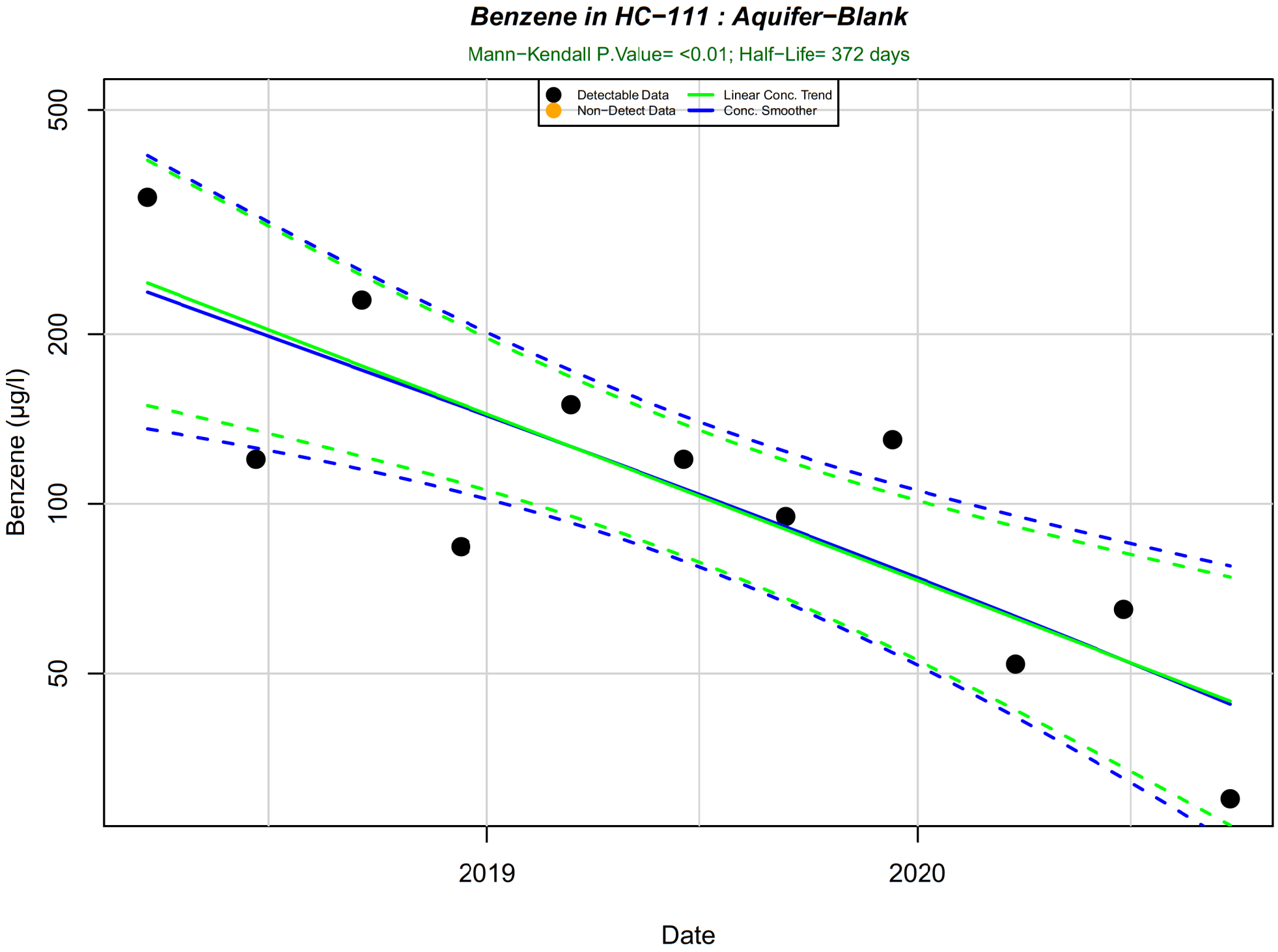

Benzene in B−25 : Aquifer−Blank
Mann−Kendall P.Value= 0.876; Half−Life= −900 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
5e+04
5e+03
5e+02
5e+01
2019
2020
Date

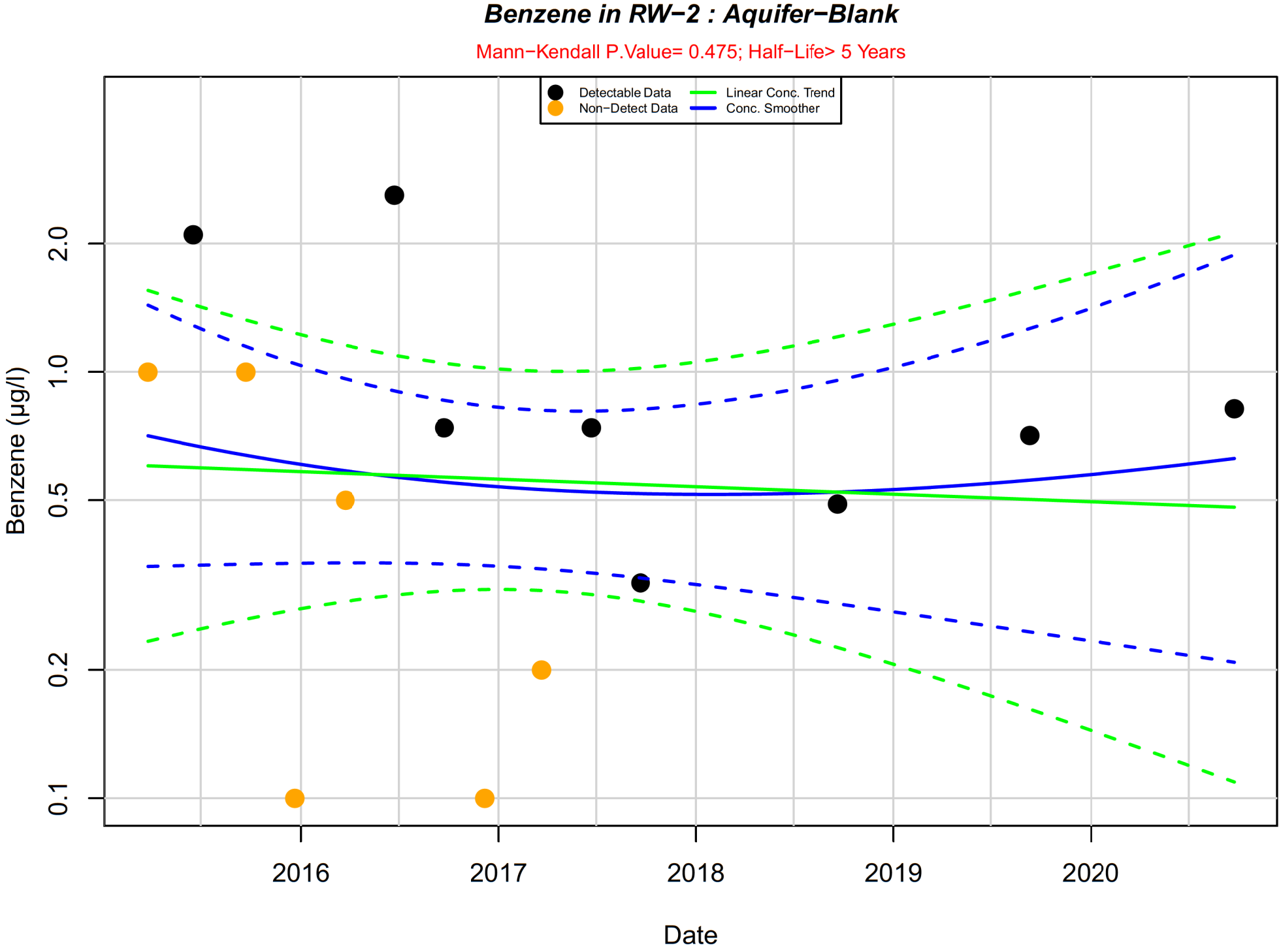

Benzene in B-34 : Aquifer-Blank
Mann-Kendall P.Value= 0.058; Half-Life= 575 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
500
200
100
50
2019
2020
Date

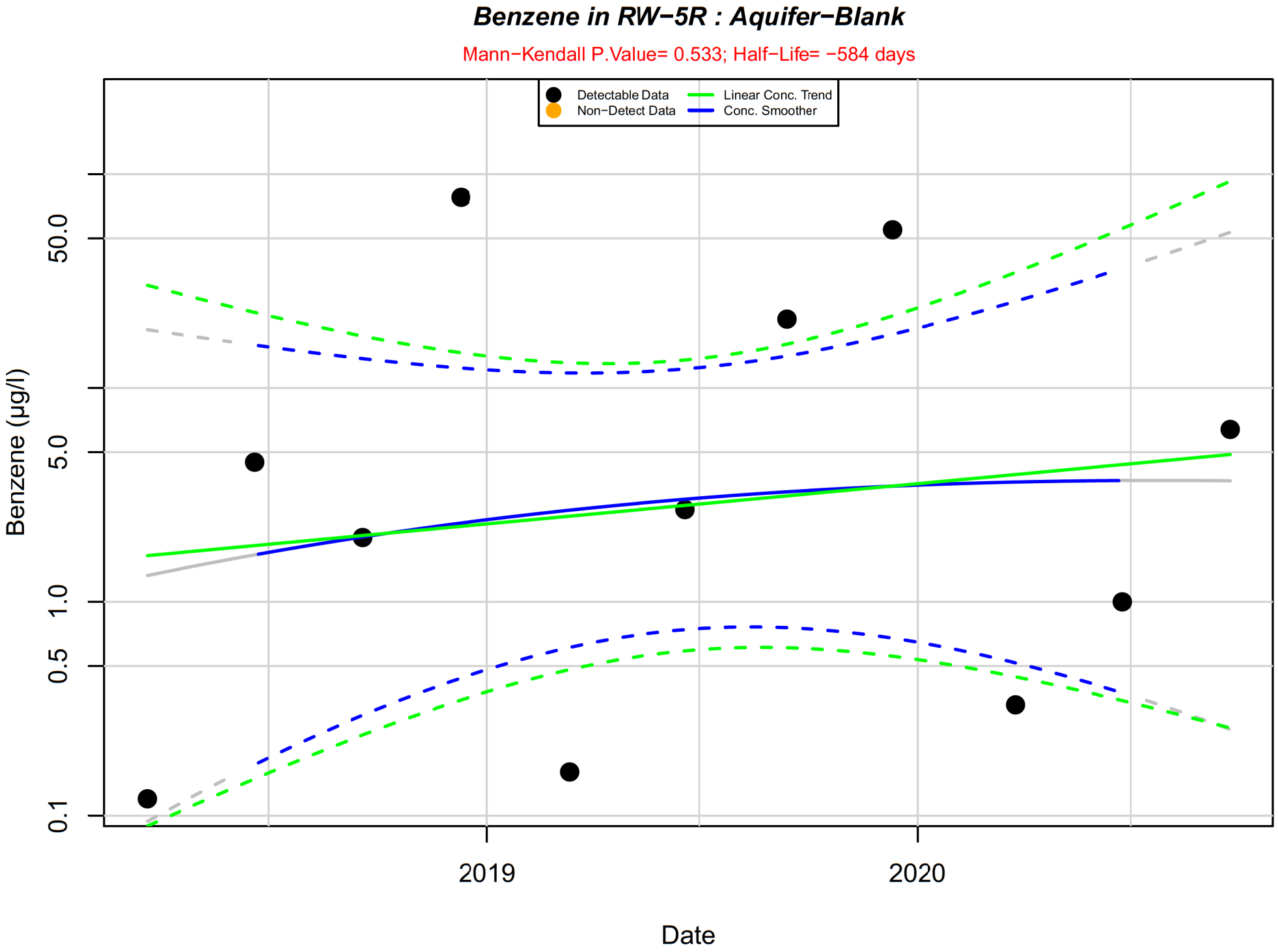

Benzene in G-8 : Aquifer-Blank
Mann-Kendall P.Value= 0.136; Half-Life= 828 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
2.00
1.00
0.50
0.20
0.10
0.05
2016
2017
2018
2019
2020
Date

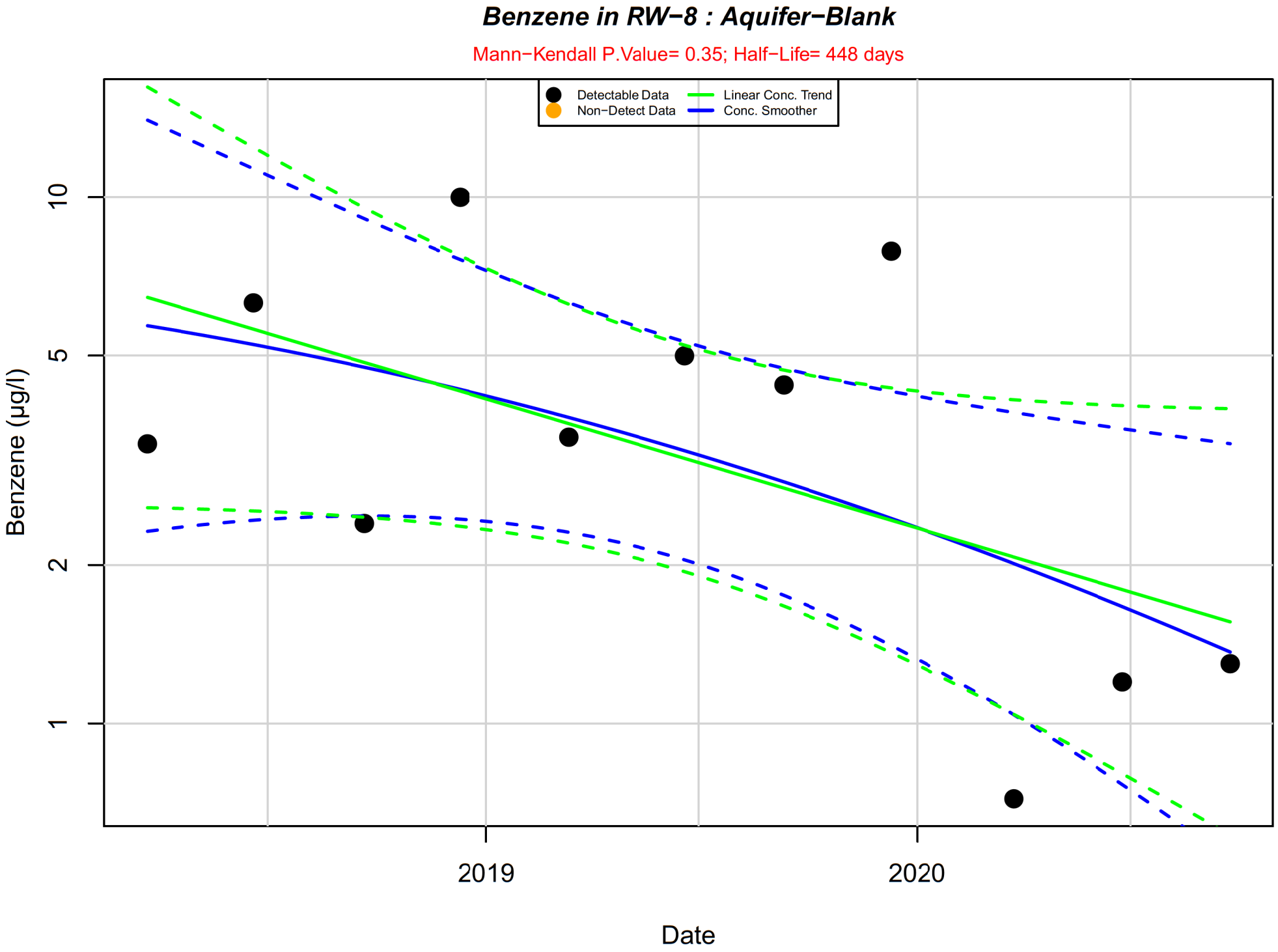

Benzene in G-16 : Aquifer-Blank
Mann-Kendall P.Value= 0.473; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
2.00
1.00
0.50
0.20
0.10
0.05
2012
2014
2016
2018
2020
Date

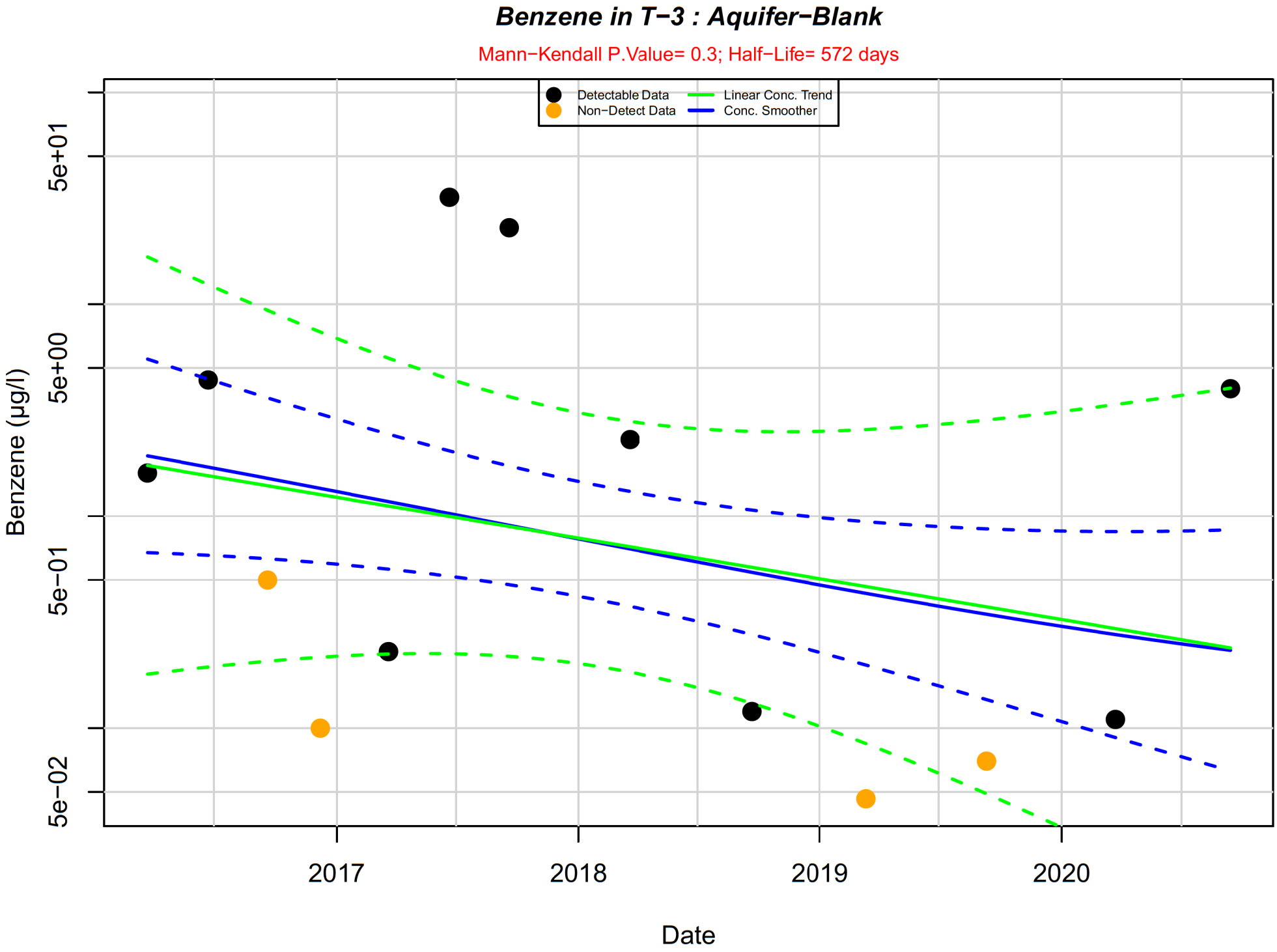

Benzene in G−18 : Aquifer−Blank
Mann−Kendall P.Value= 0.159; Half−Life= 573 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
0.05
0.10
0.20
0.50
1.00
2.00
5.00
10.00
2017
2018
2019
2020
Date

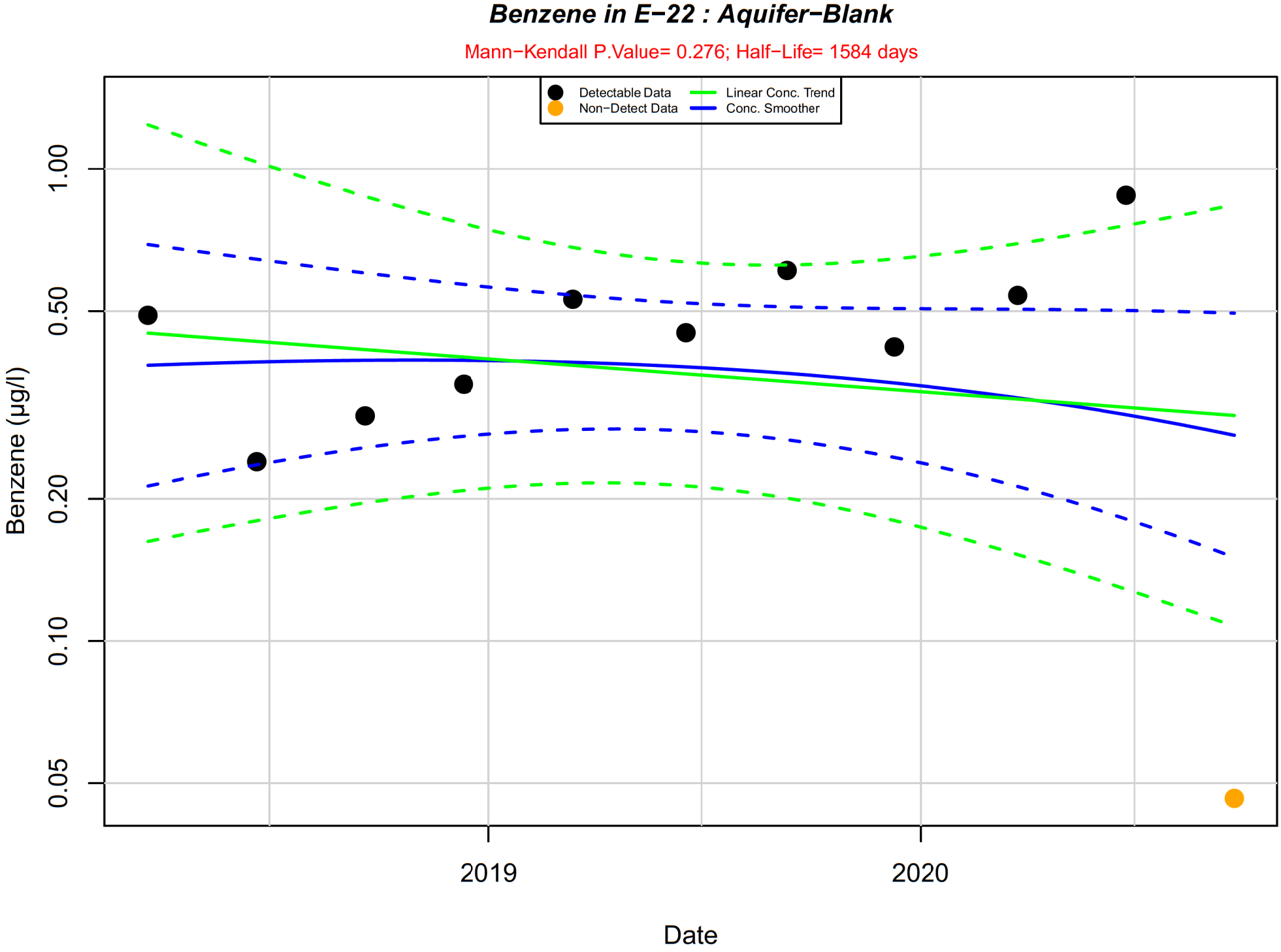

Benzene in HC−111 : Aquifer−Blank
Mann−Kendall P.Value= <0.01; Half−Life= 372 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
500
200
100
50
2019
2020
Date

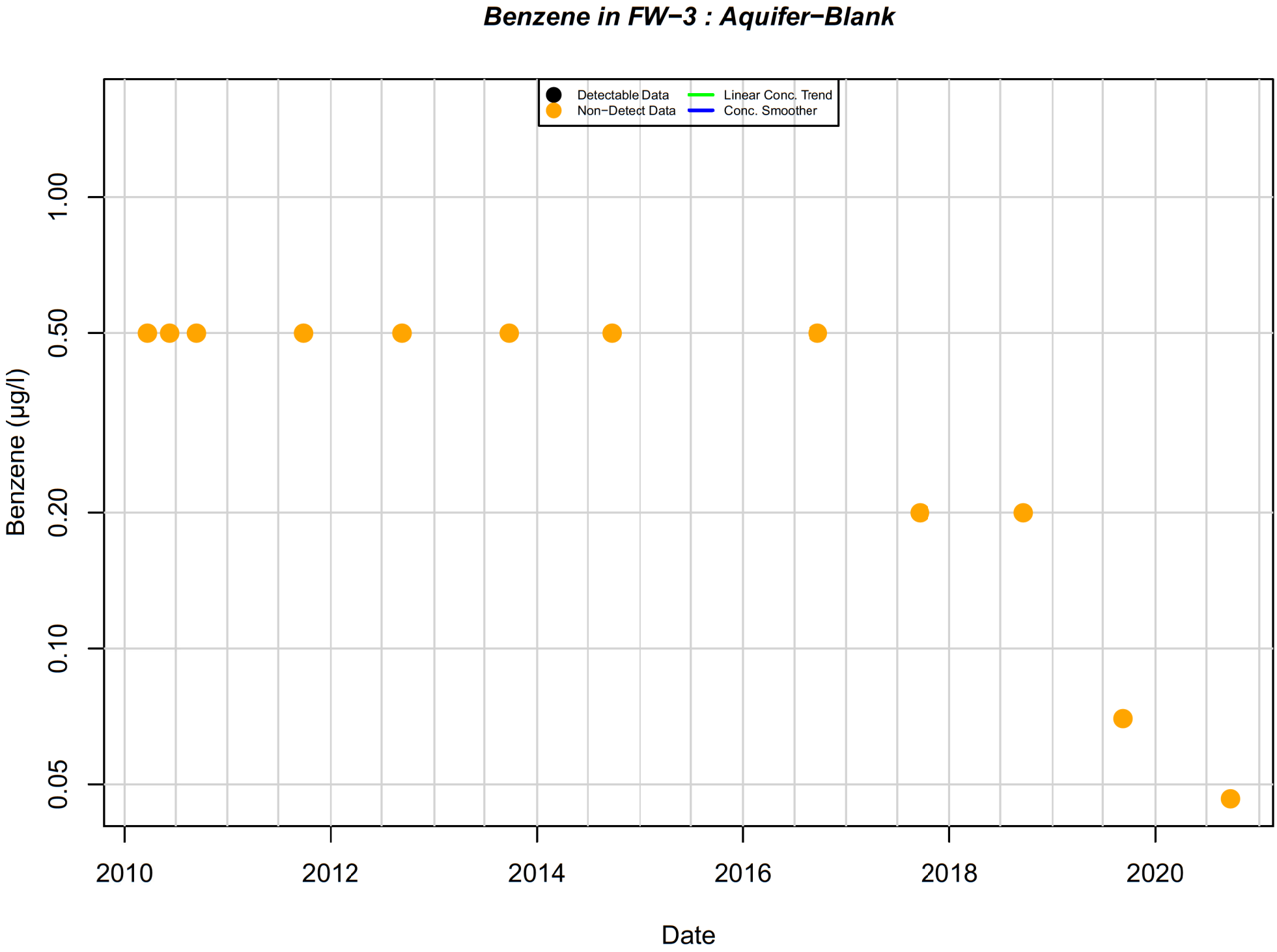

Benzene in RW−2 : Aquifer−Blank
Mann−Kendall P.Value= 0.475; Half−Life> 5 Years
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
0.1
0.2
0.5
1.0
2.0
2016
2017
2018
2019
2020
Date

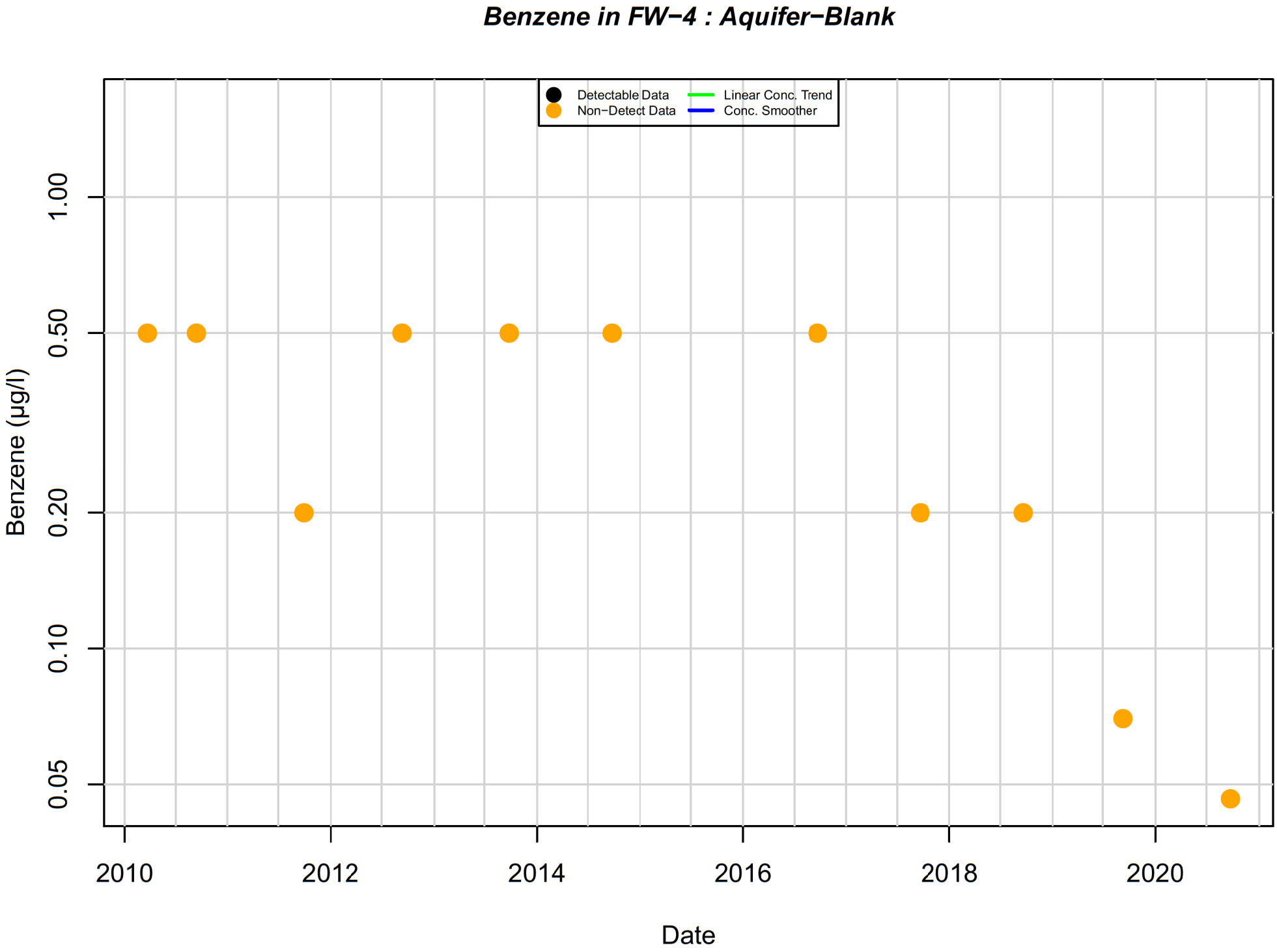

Benzene in RW−5R : Aquifer−Blank
Mann−Kendall P.Value= 0.533; Half−Life= −584 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
50.0
5.0
1.0
0.5
0.1
2019
2020
Date

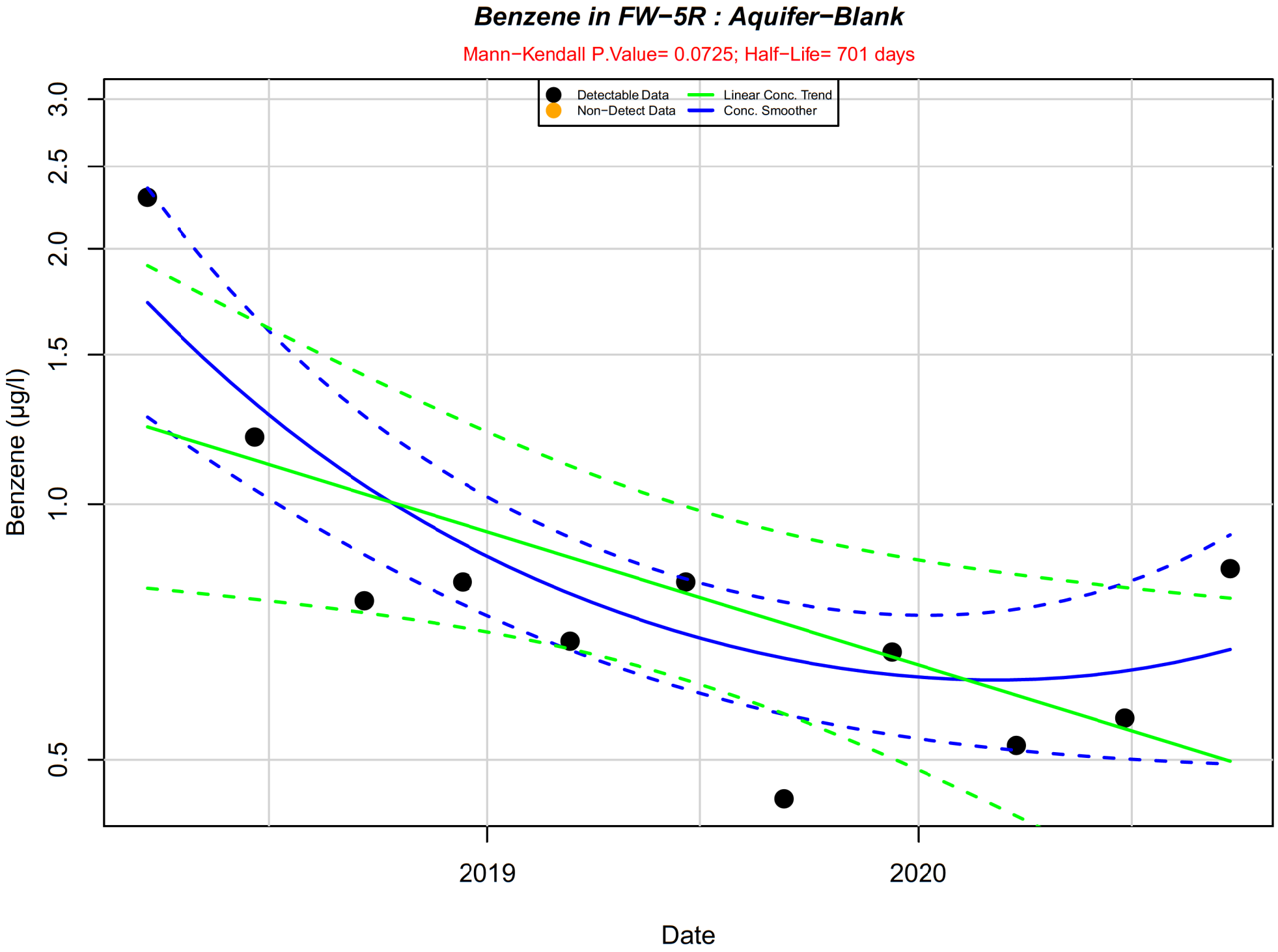

Benzene in RW-8 : Aquifer-Blank
Mann-Kendall P.Value= 0.35; Half-Life= 448 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
10
5
2
1
2019
2020
Date

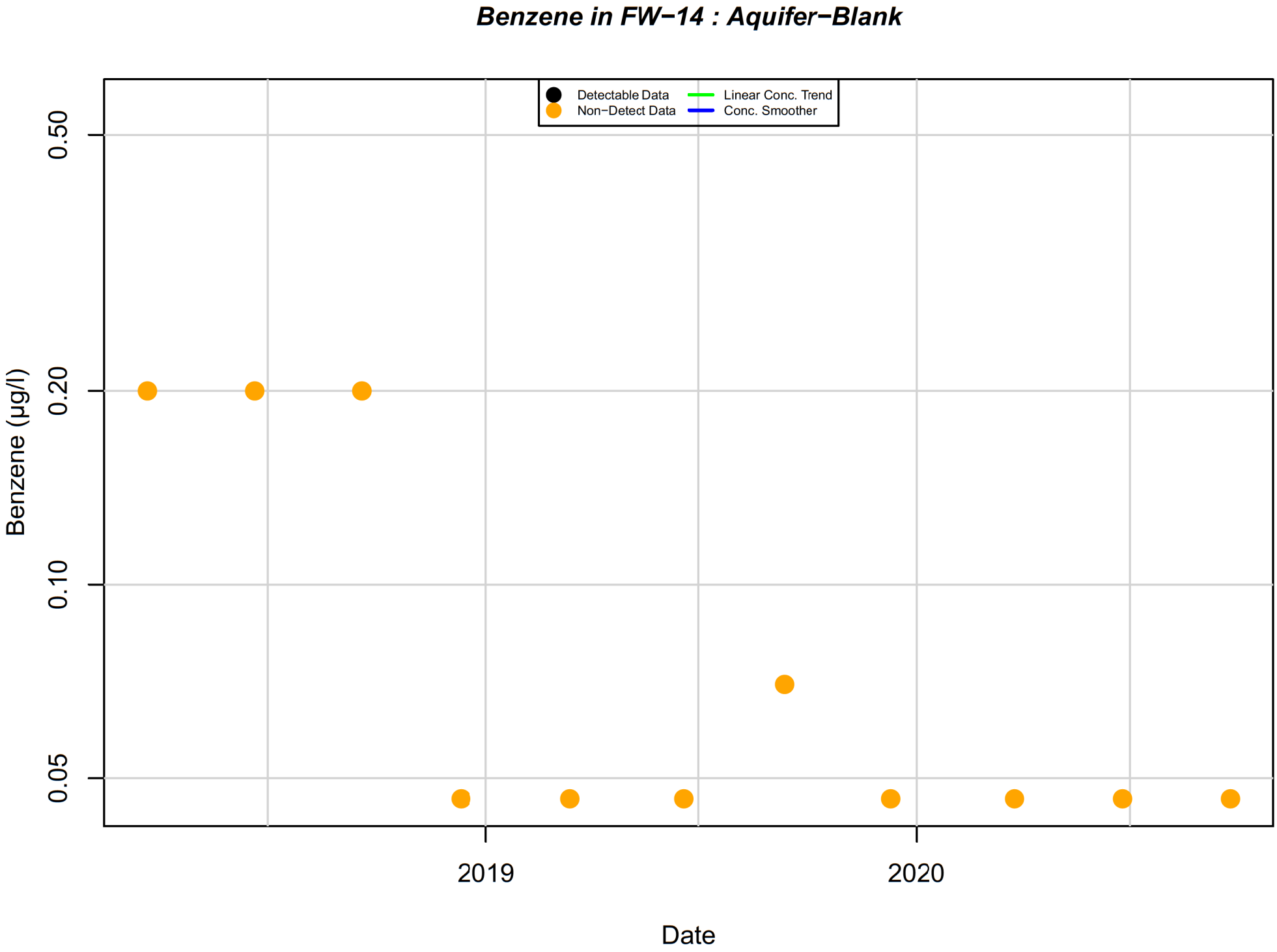

Benzene in T−3 : Aquifer−Blank
Mann−Kendall P.Value= 0.3; Half−Life= 572 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
5e+01
5e+00
5e−01
5e−02
2017
2018
2019
2020
Date

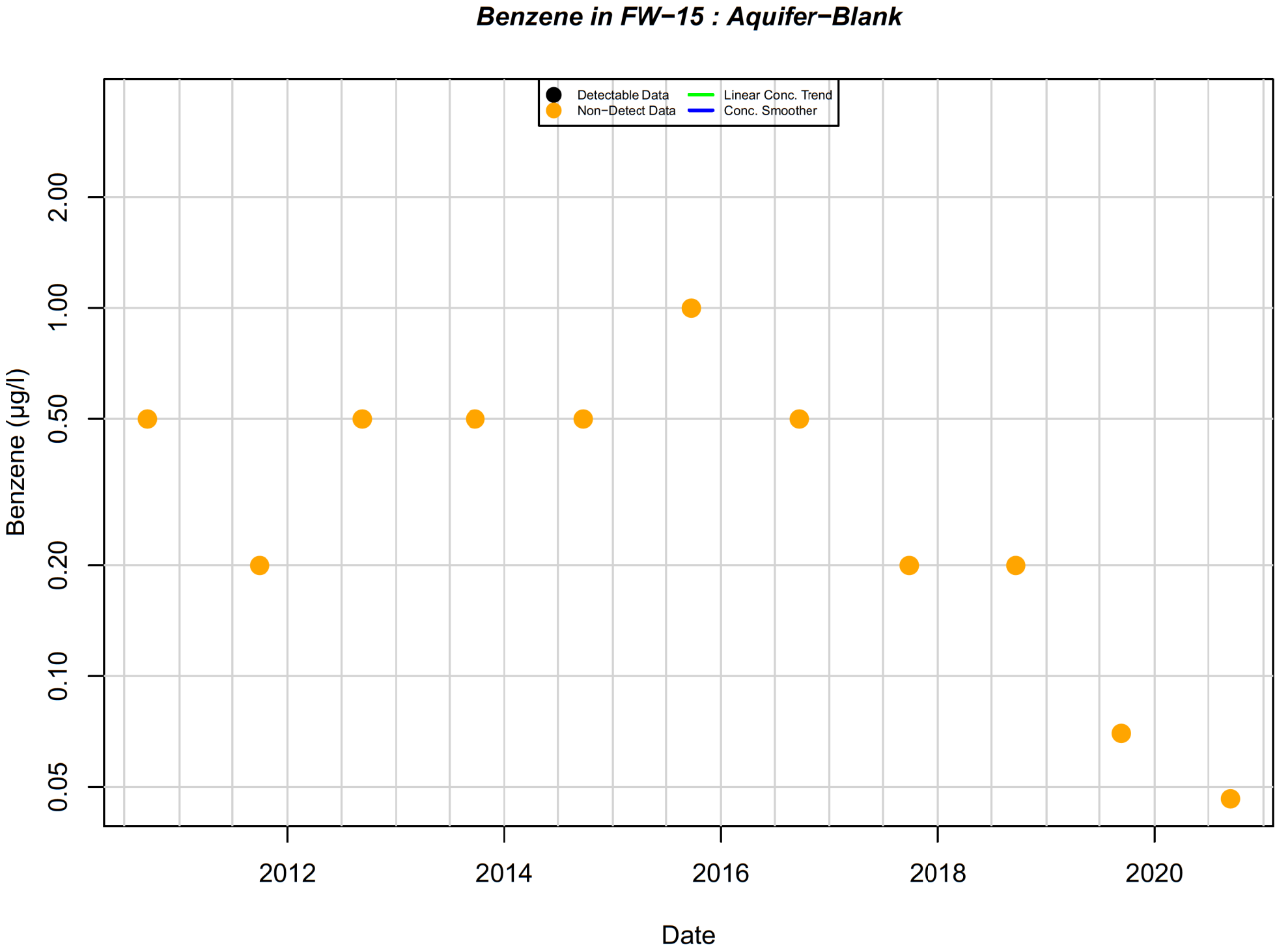

Benzene in E-22 : Aquifer-Blank
Mann-Kendall P.Value= 0.276; Half-Life= 1584 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
1.00
0.50
0.20
0.10
0.05
2019
2020
Date

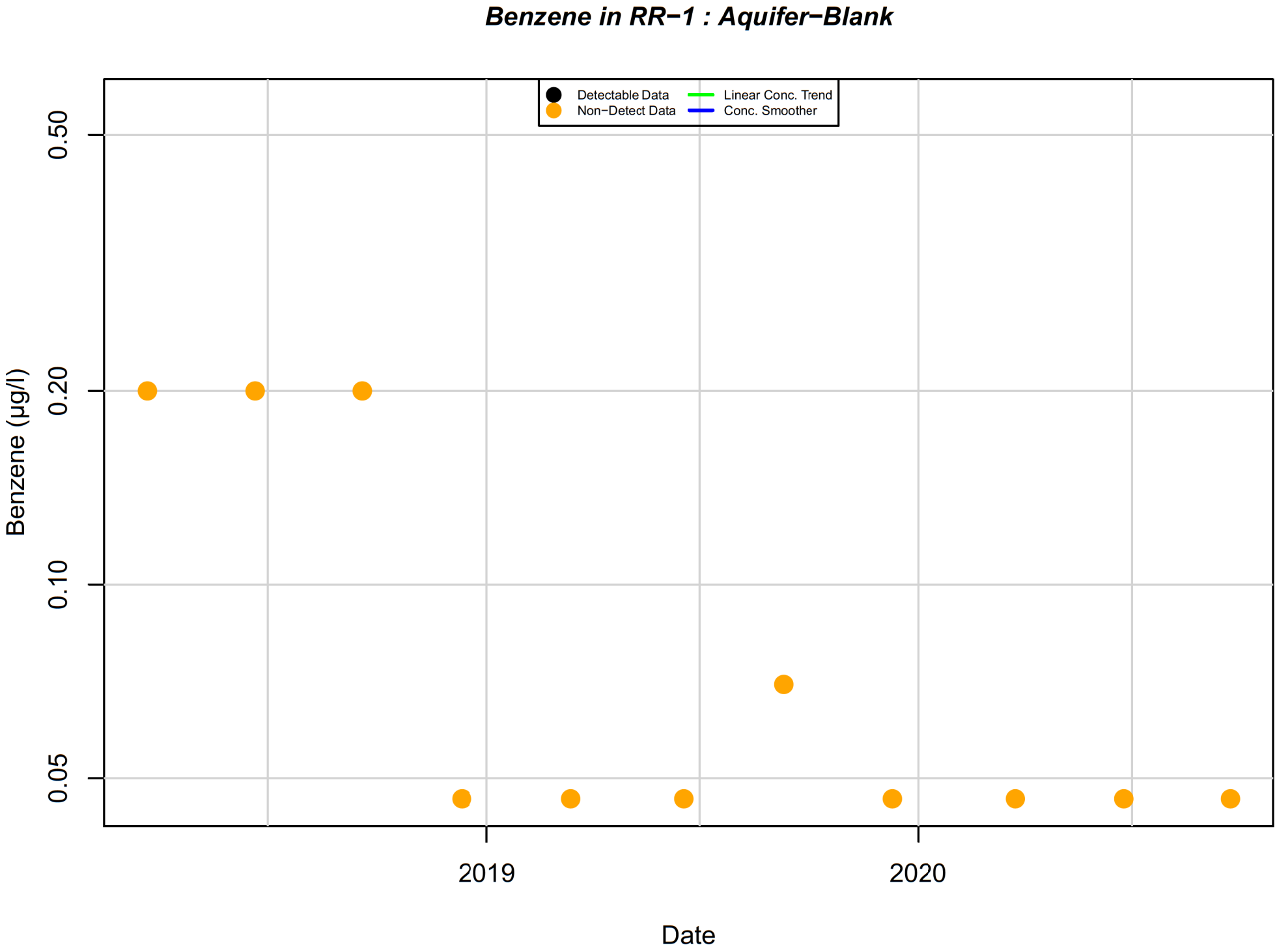

Benzene in FW-3 : Aquifer-Blank
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
1.00
0.50
0.20
0.10
0.05
2010
2012
2014
2016
2018
2020
Date

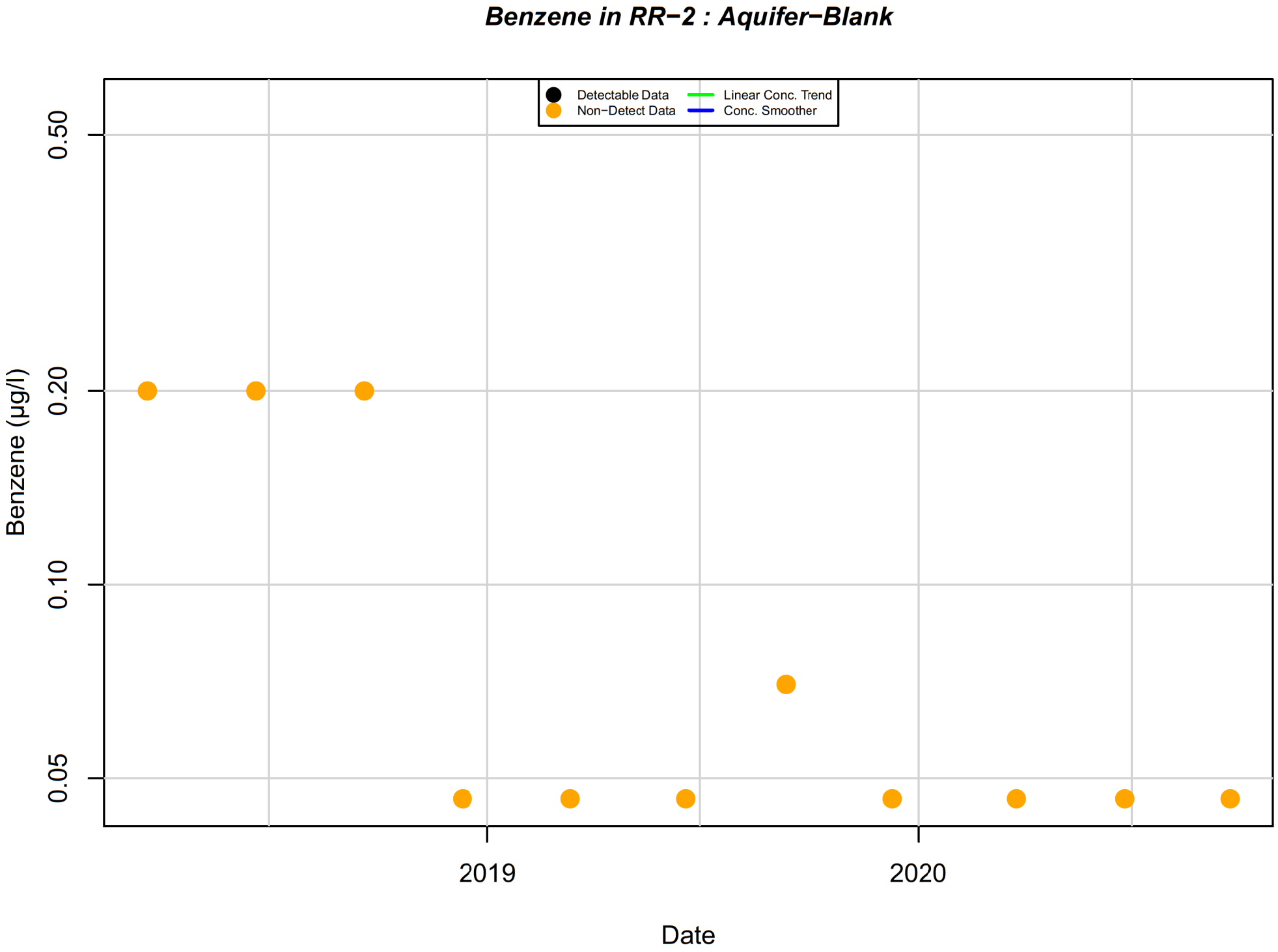

Benzene in FW-4 : Aquifer-Blank
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
1.00
0.50
0.20
0.10
0.05
2010
2012
2014
2016
2018
2020
Date

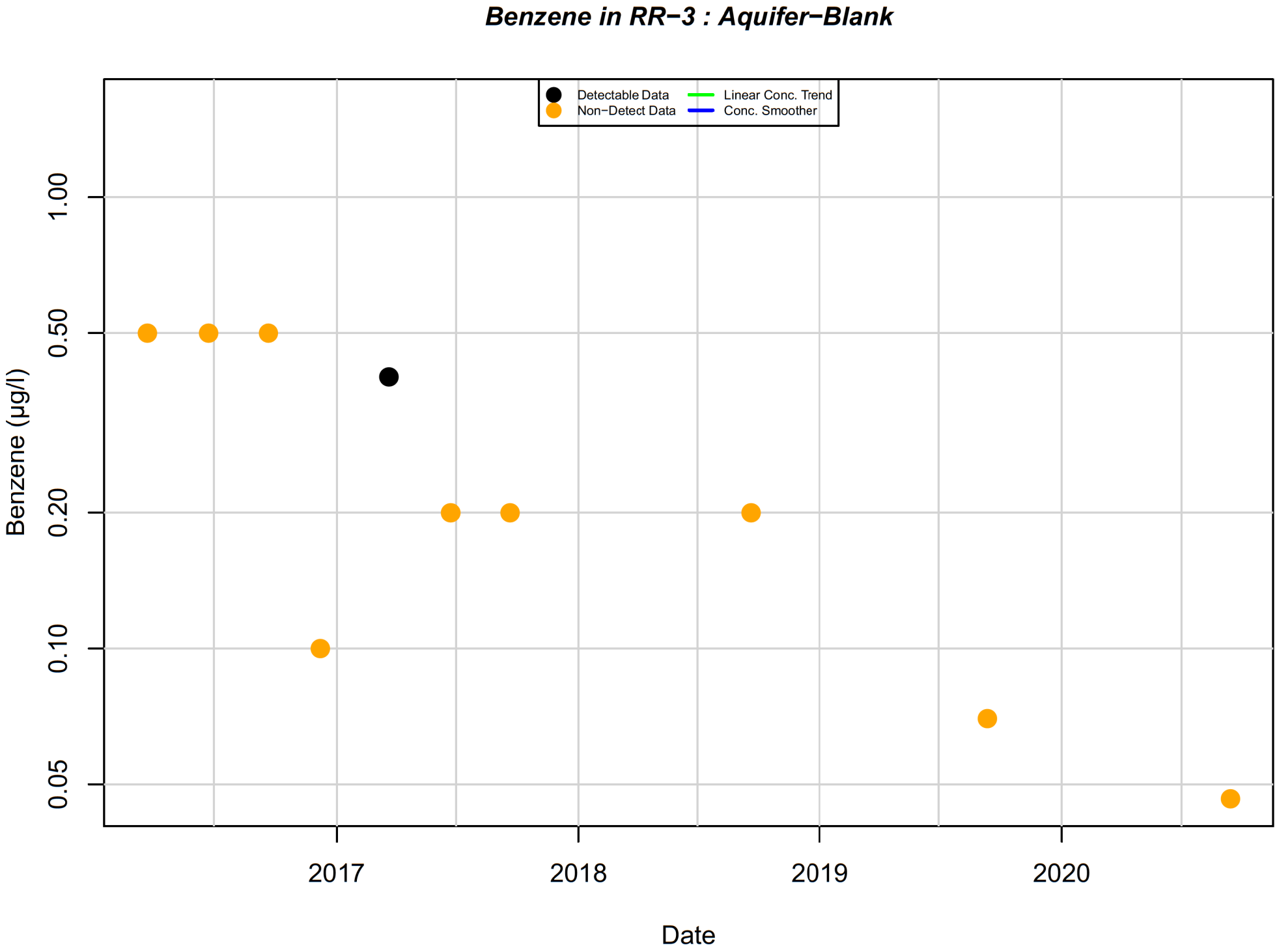

Benzene in FW-5R : Aquifer-Blank
Mann-Kendall P.Value= 0.0725; Half-Life= 701 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
3.0
2.5
2.0
1.5
1.0
0.5
2019
2020
Date

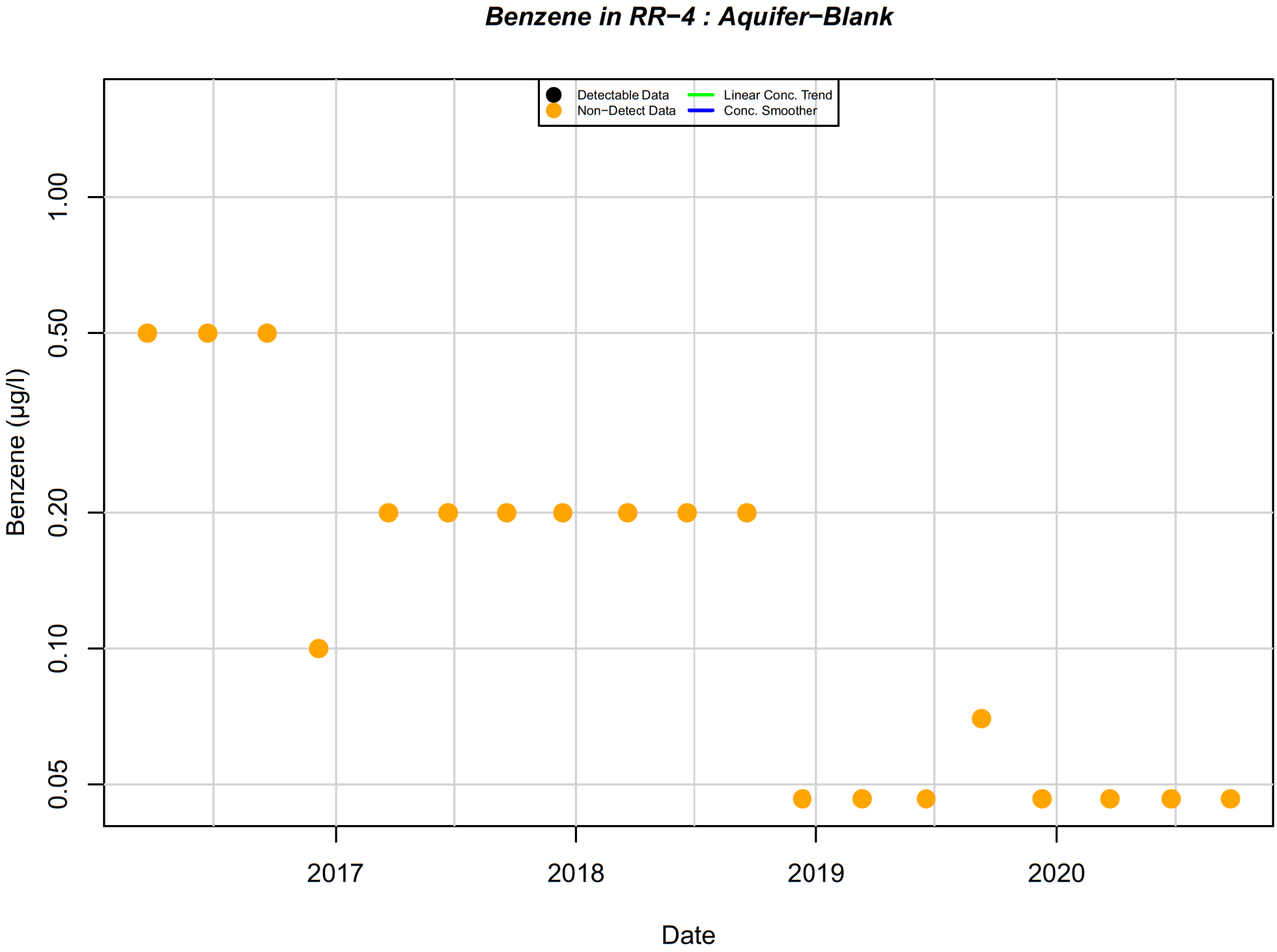

Benzene in FW−14 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
0.50
0.20
0.10
0.05
Benzene (µg/l)
2019
2020
Date

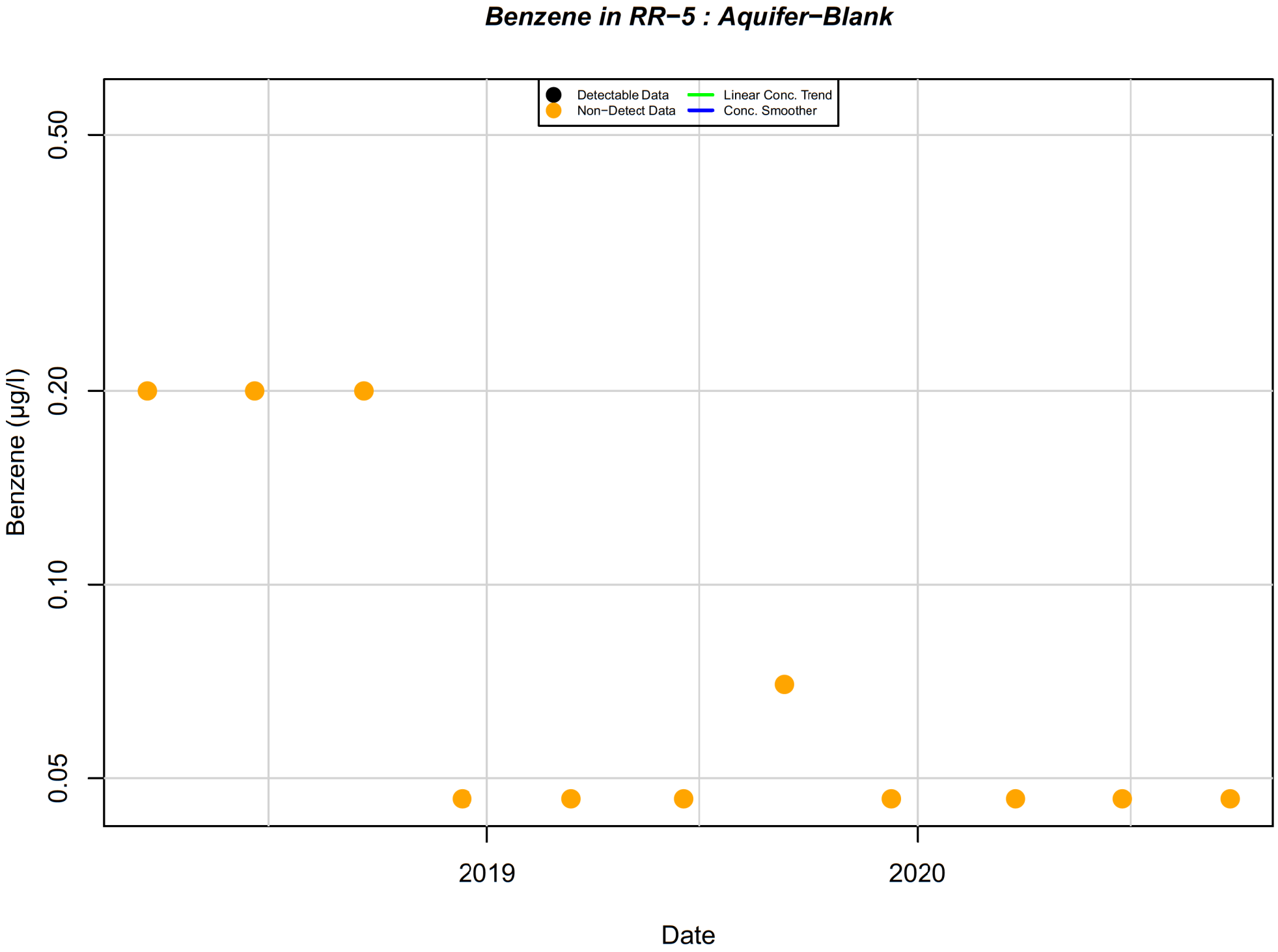

Benzene in FW-15 : Aquifer-Blank
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
2.00
1.00
0.50
0.20
0.10
0.05
2012
2014
2016
2018
2020
Date

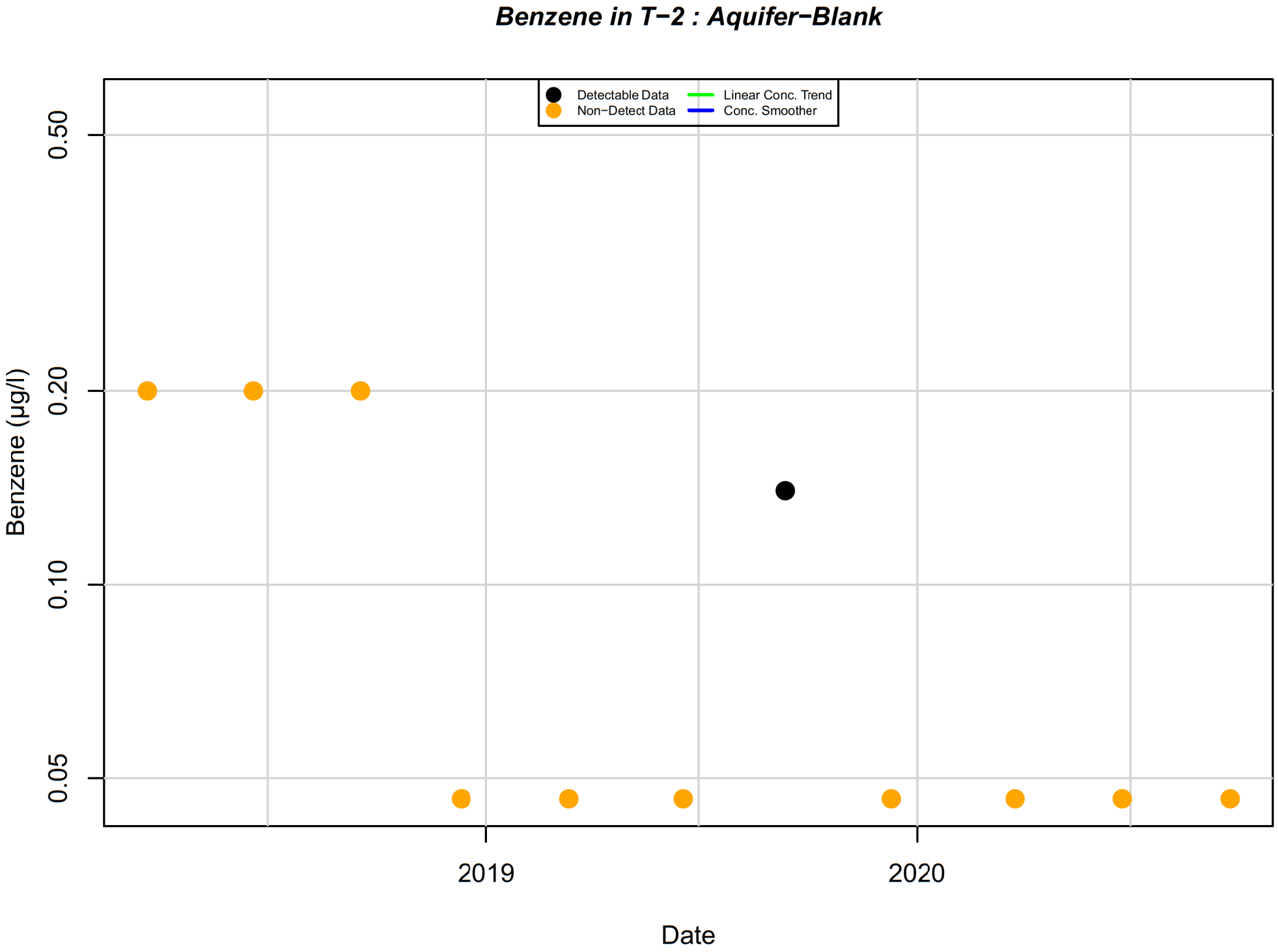

Benzene in RR−1 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
0.50
0.20
0.10
0.05
Benzene (µg/l)
2019
2020
Date

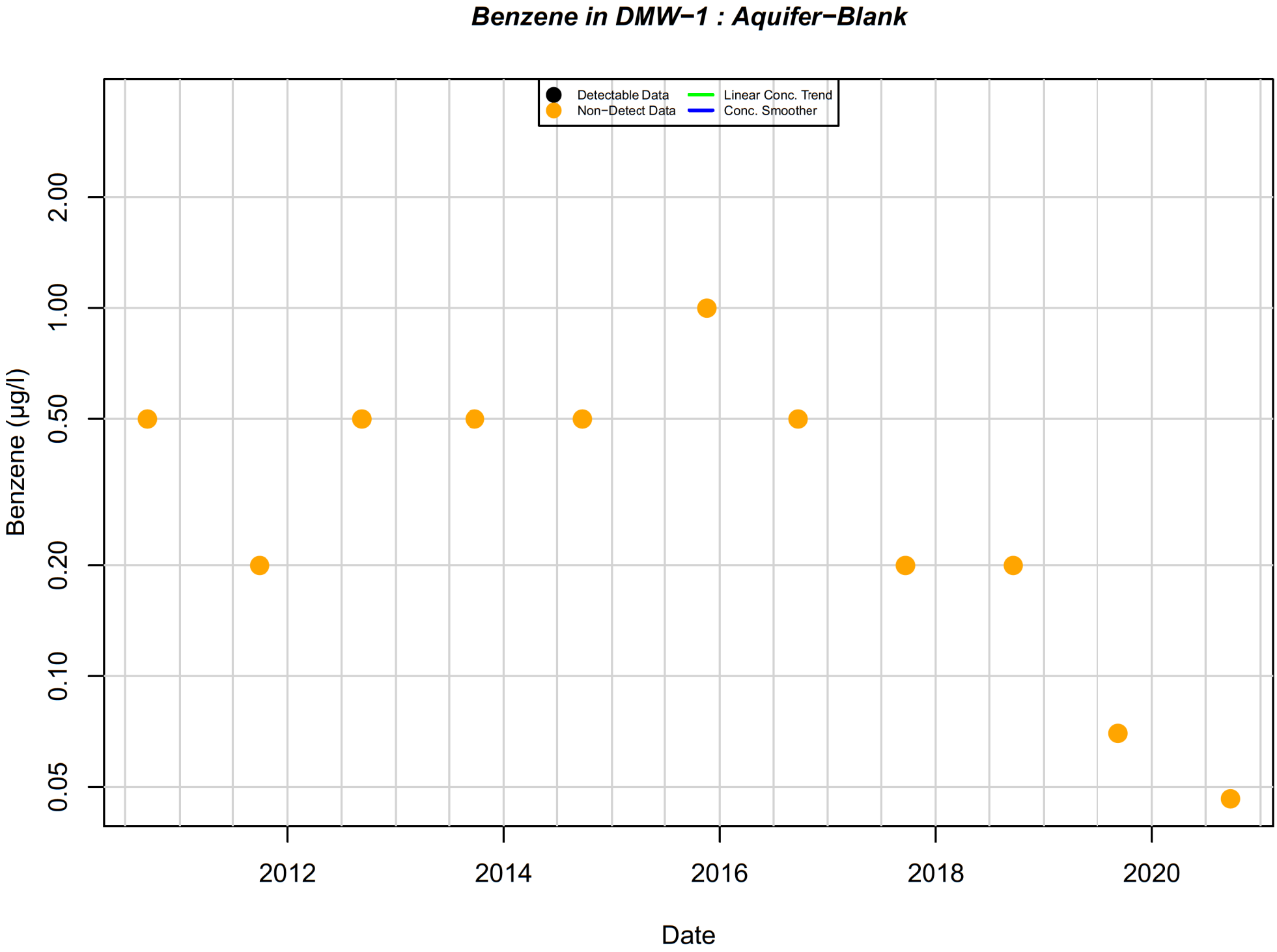

Benzene in RR−2 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
0.50
0.20
0.10
0.05
Benzene (µg/l)
2019
2020
Date

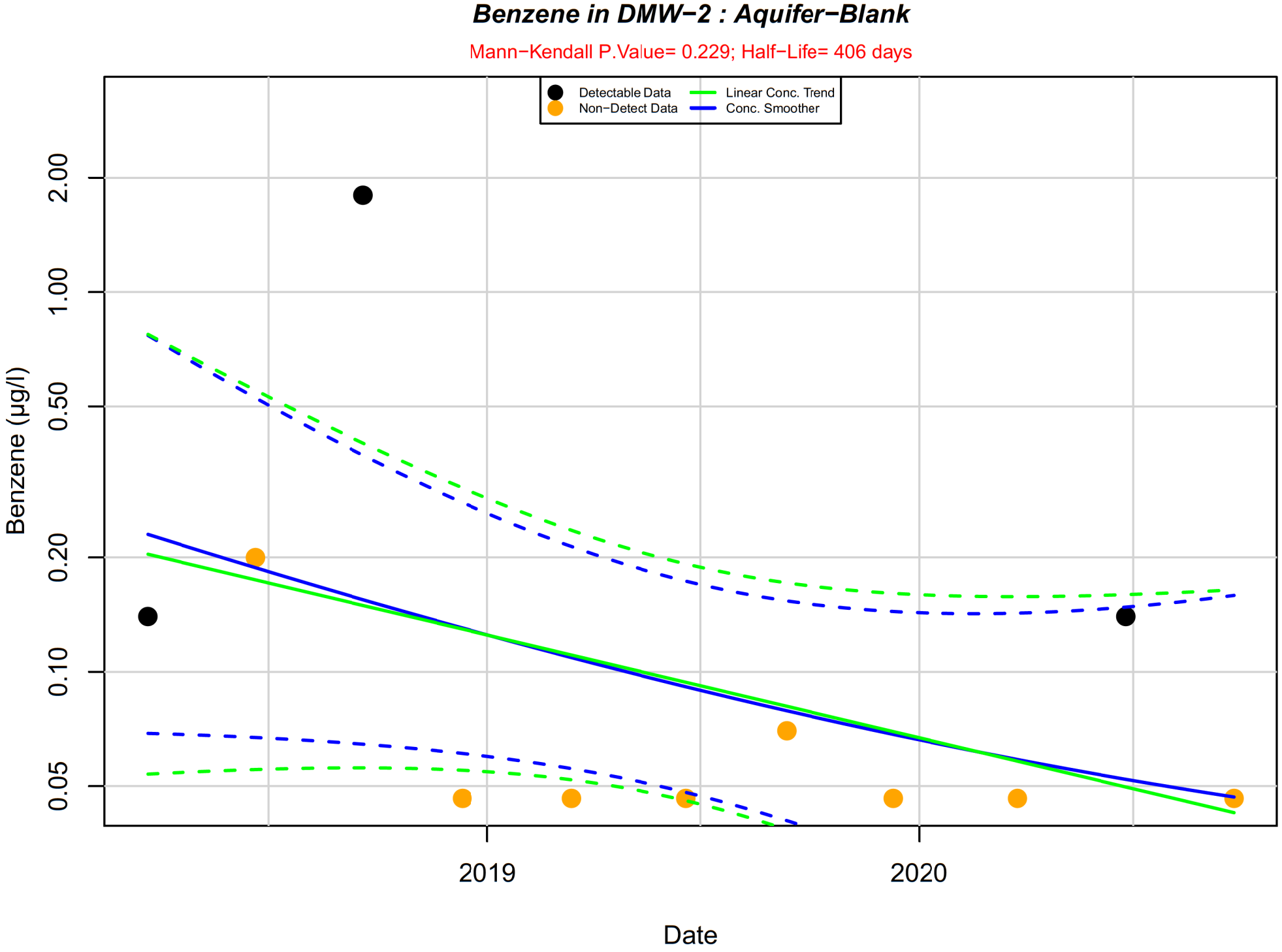

Benzene in RR−3 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
1.00
0.50
0.20
0.10
0.05
2017
2018
2019
2020
Date

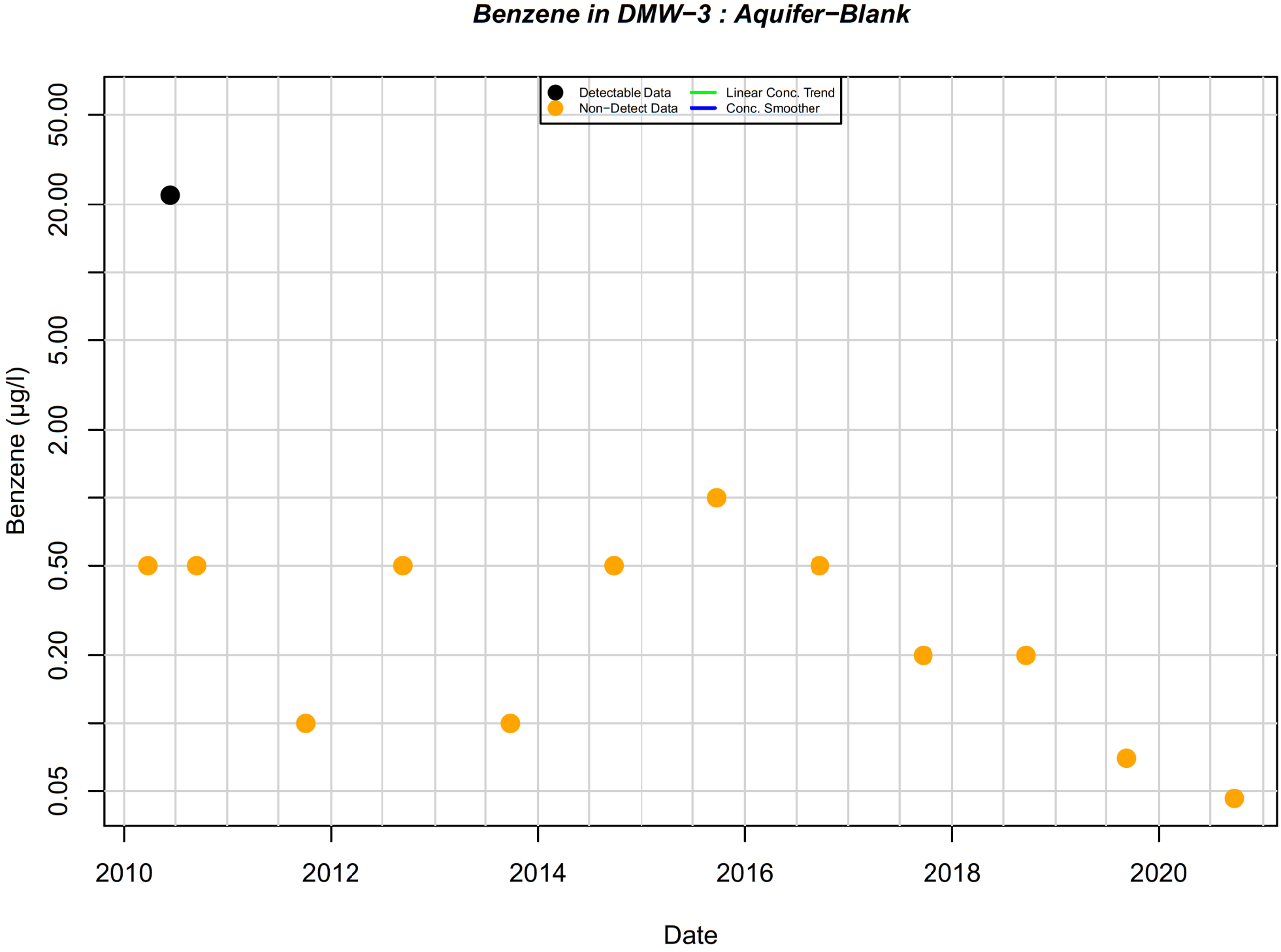

Benzene in RR−4 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
1.00
0.50
0.20
0.10
0.05
2017
2018
2019
2020
Date

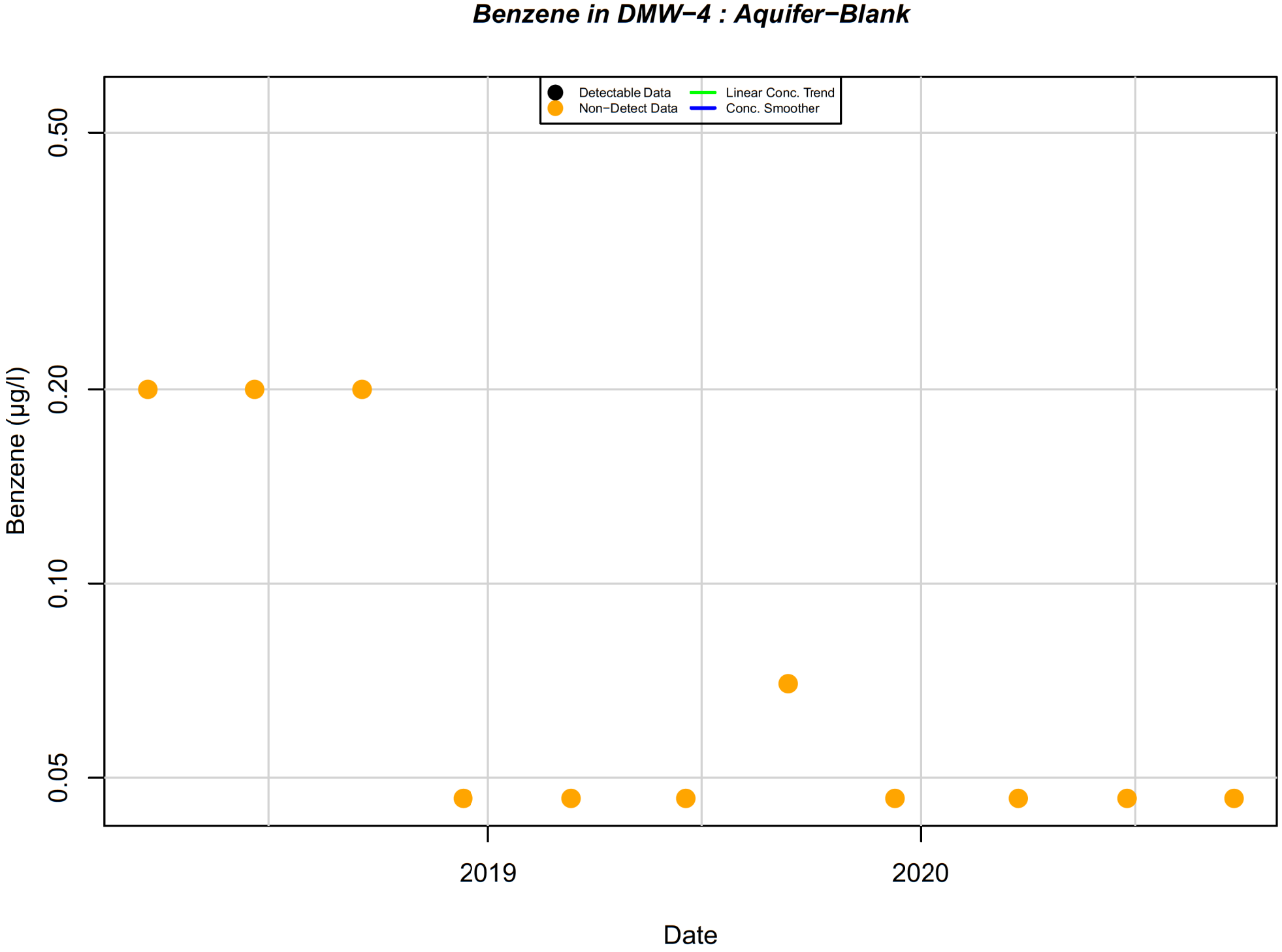

Benzene in RR-5 : Aquifer-Blank
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
0.50
0.20
0.10
0.05
Benzene (µg/l)
2019
2020
Date

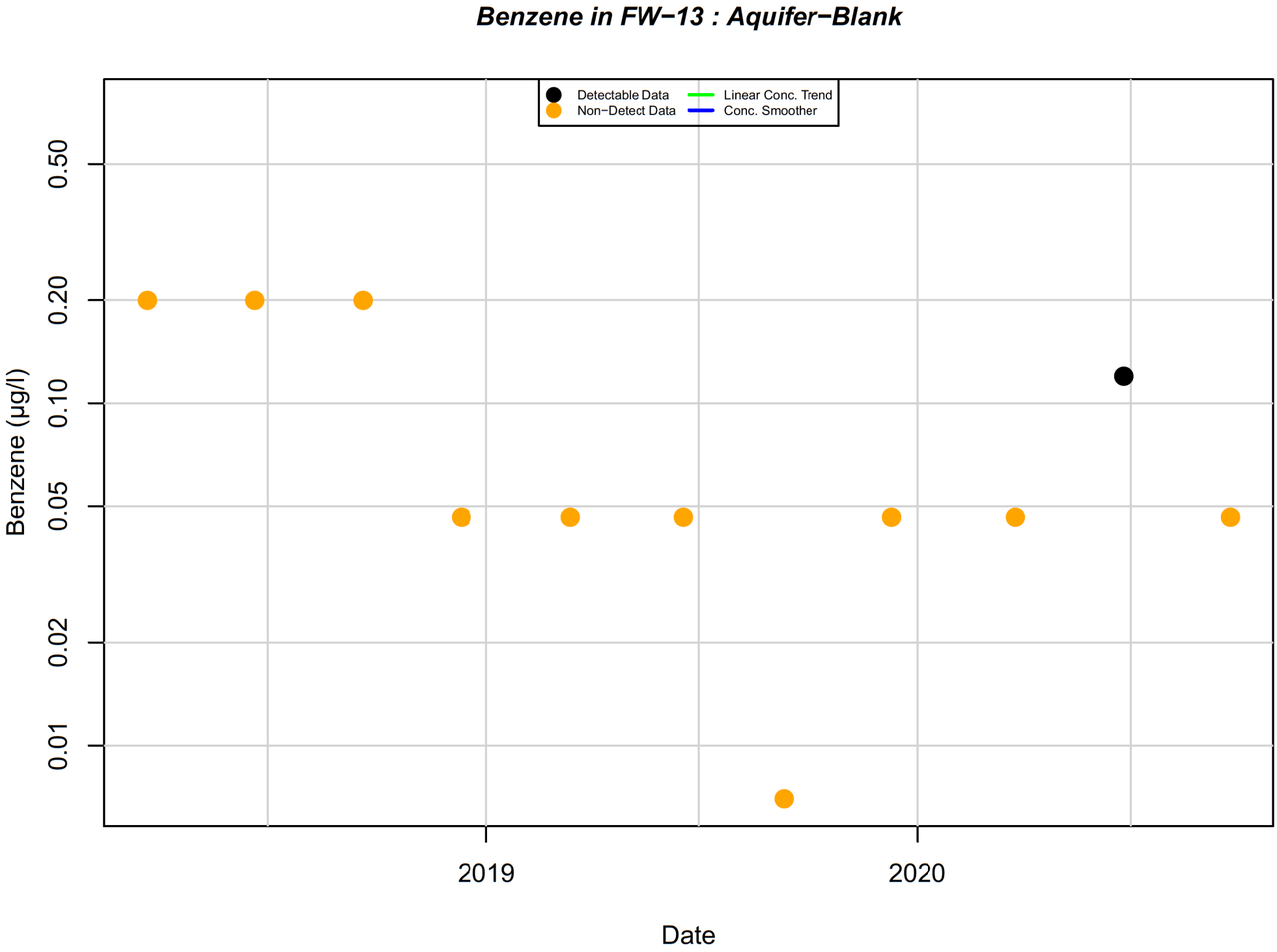

Benzene in T−2 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
0.50
0.20
0.10
0.05
Benzene (µg/l)
2019
2020
Date

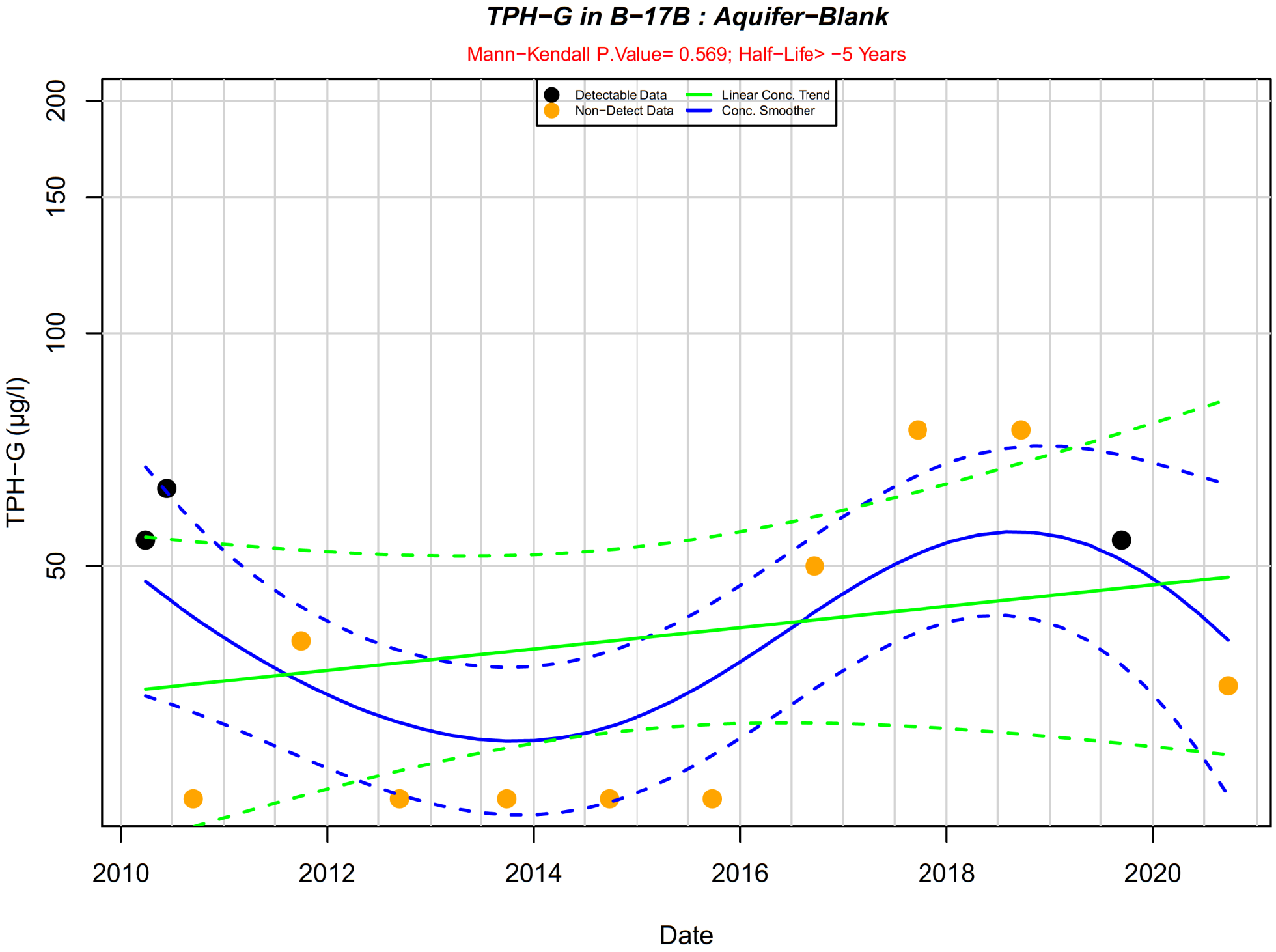

Benzene in DMW−1 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
2.00
1.00
0.50
0.20
0.10
0.05
2012
2014
2016
2018
2020
Date

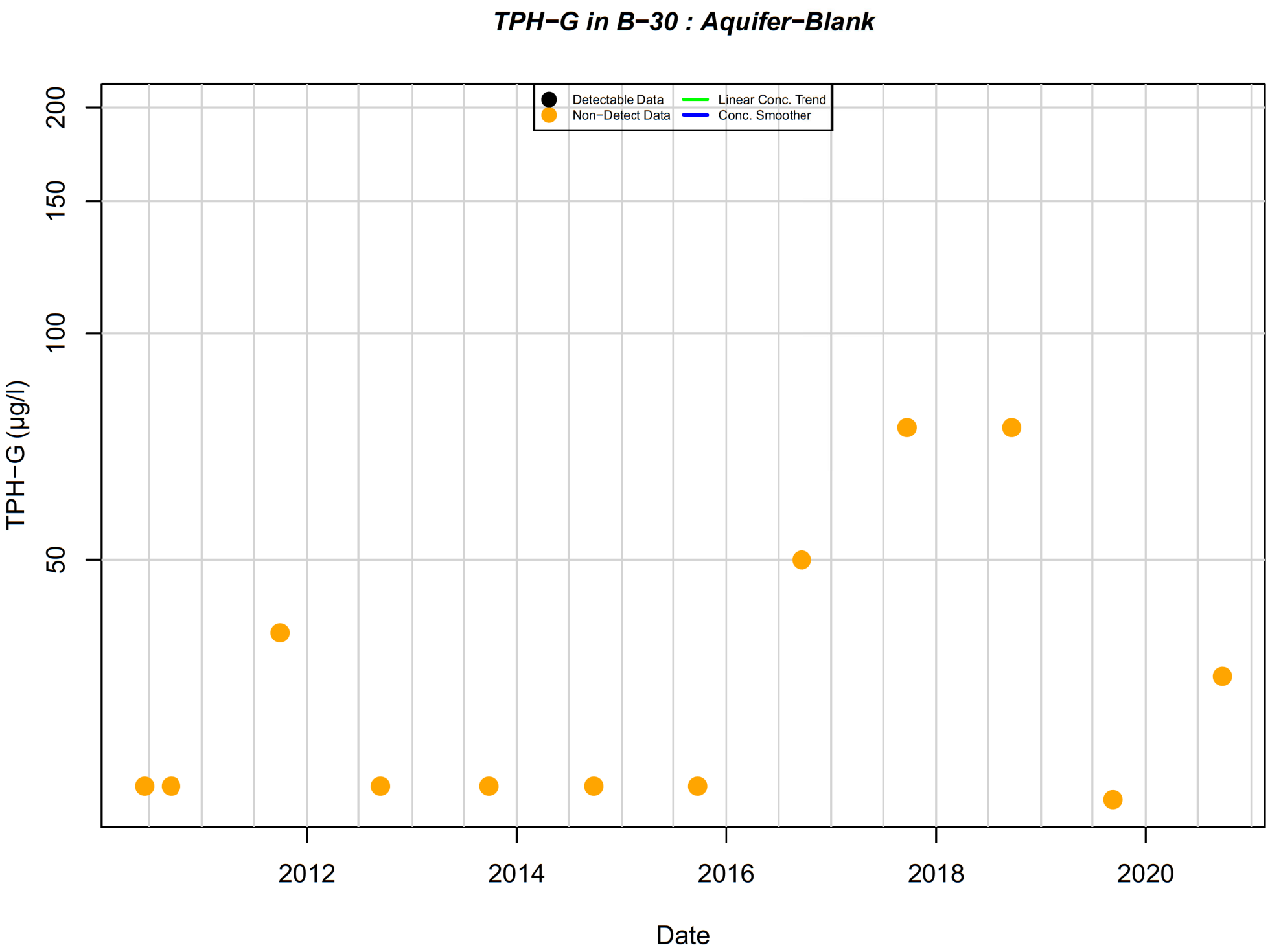

Benzene in DMW−2 : Aquifer−Blank
Mann−Kendall P.Value= 0.229; Half−Life= 406 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
2.00
1.00
0.50
0.20
0.10
0.05
2019
2020
Date

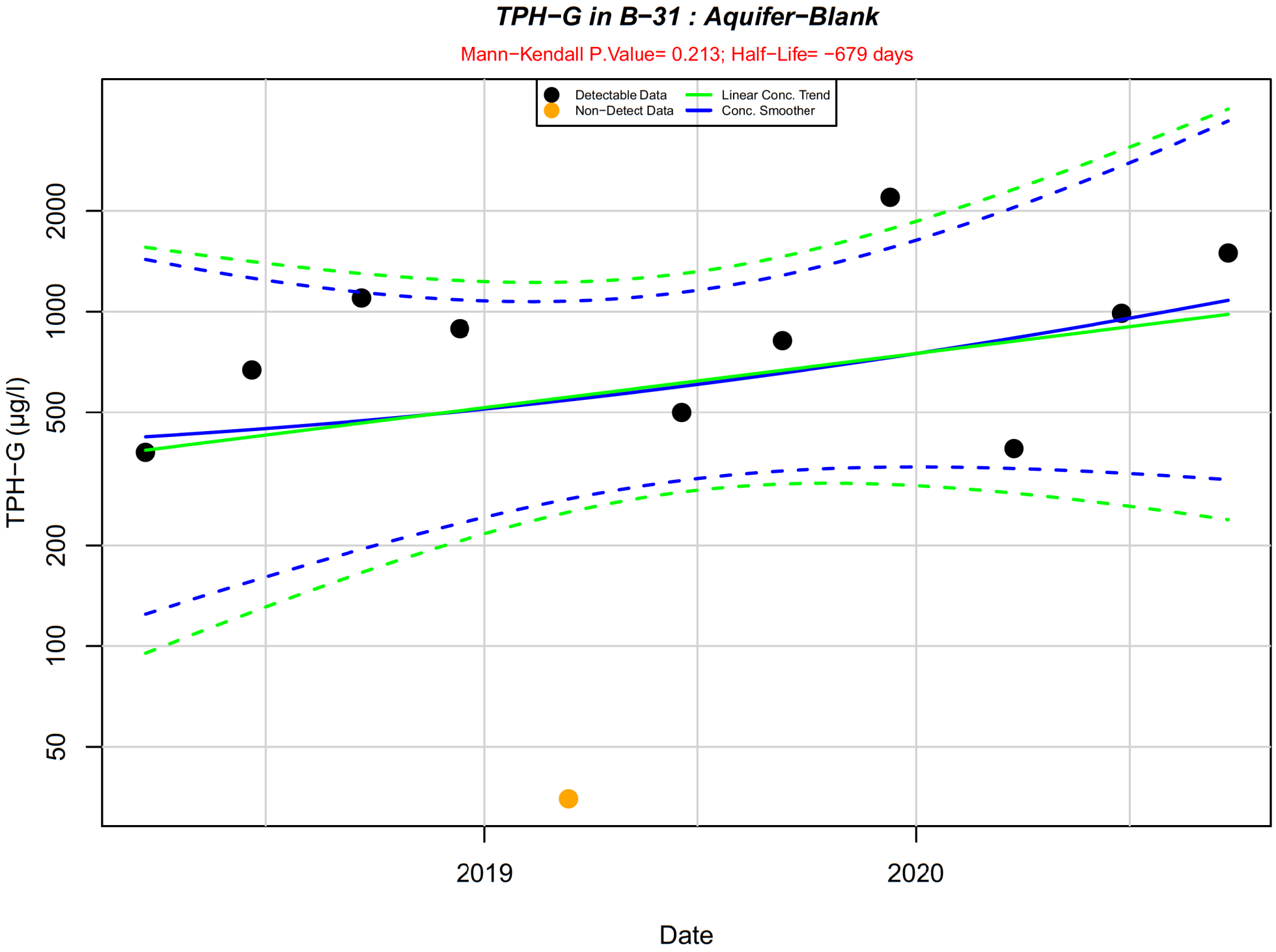

Benzene in DMW−3 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
50.00
20.00
5.00
2.00
0.50
0.20
0.05
2010
2012
2014
2016
2018
2020
Date

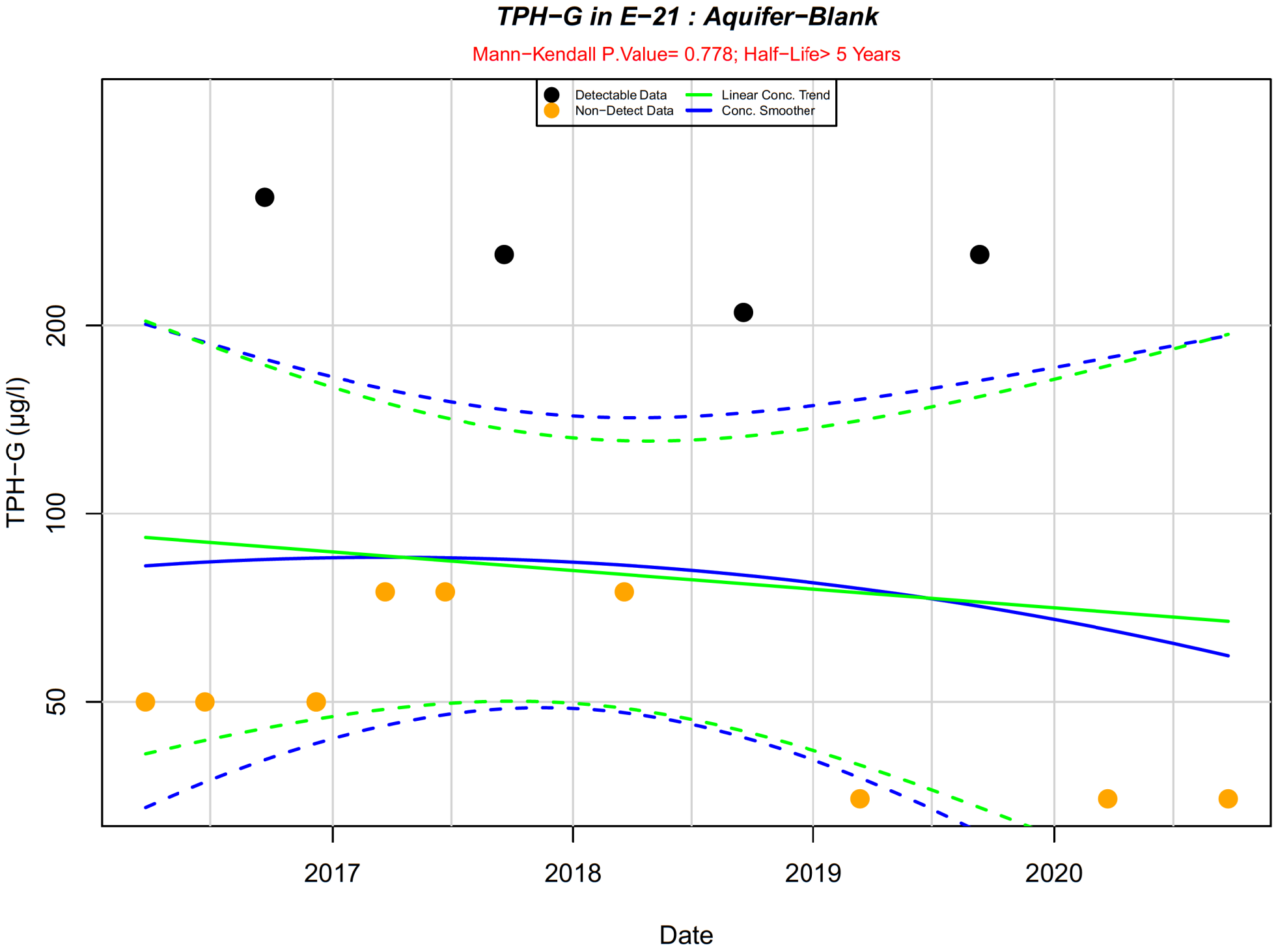

Benzene in DMW−4 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
0.50
0.20
0.10
0.05
Benzene (µg/l)
2019
2020
Date

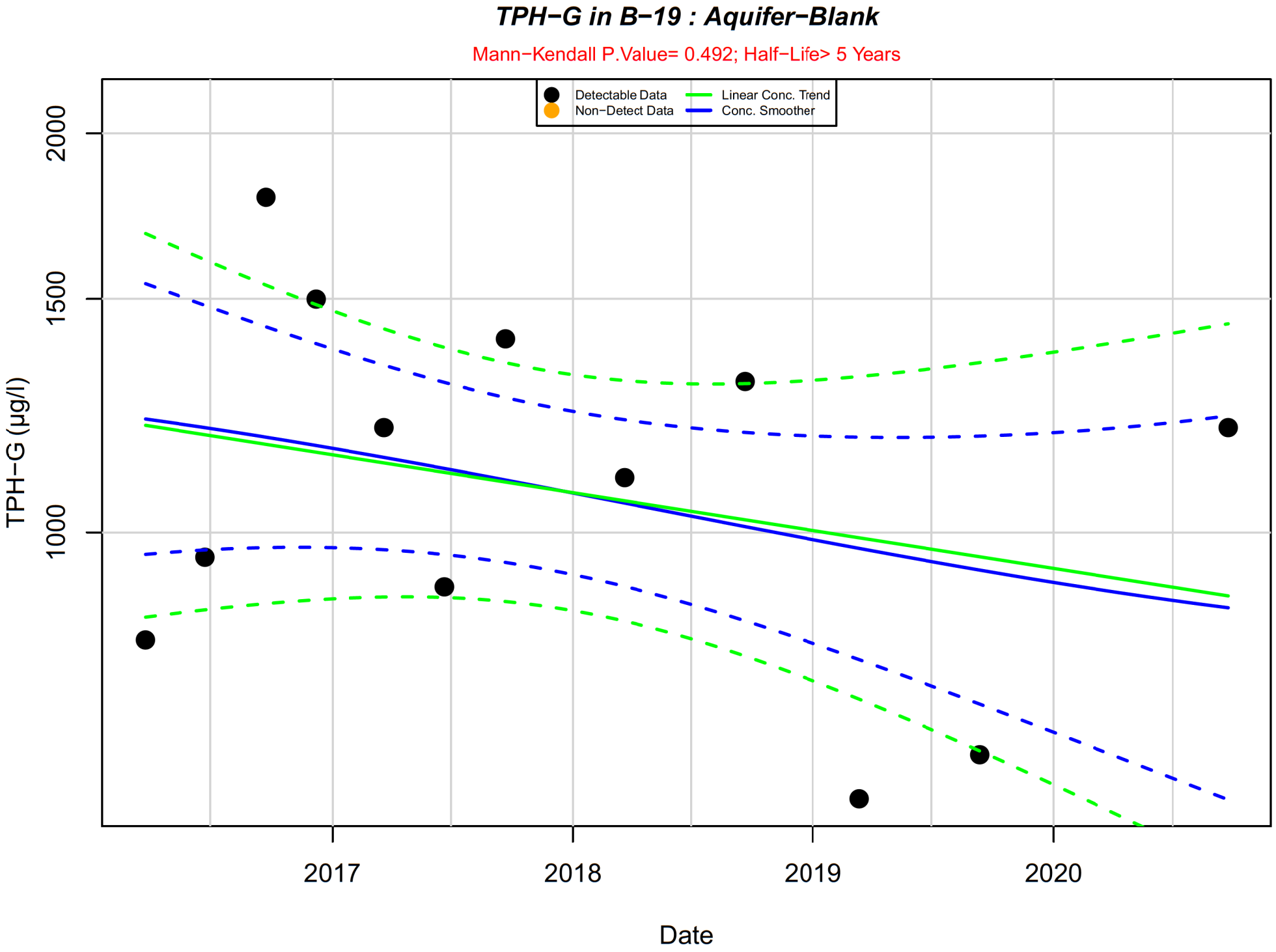

Benzene in FW−13 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
Benzene (µg/l)
0.50
0.20
0.10
0.05
0.02
0.01
2019
2020
Date

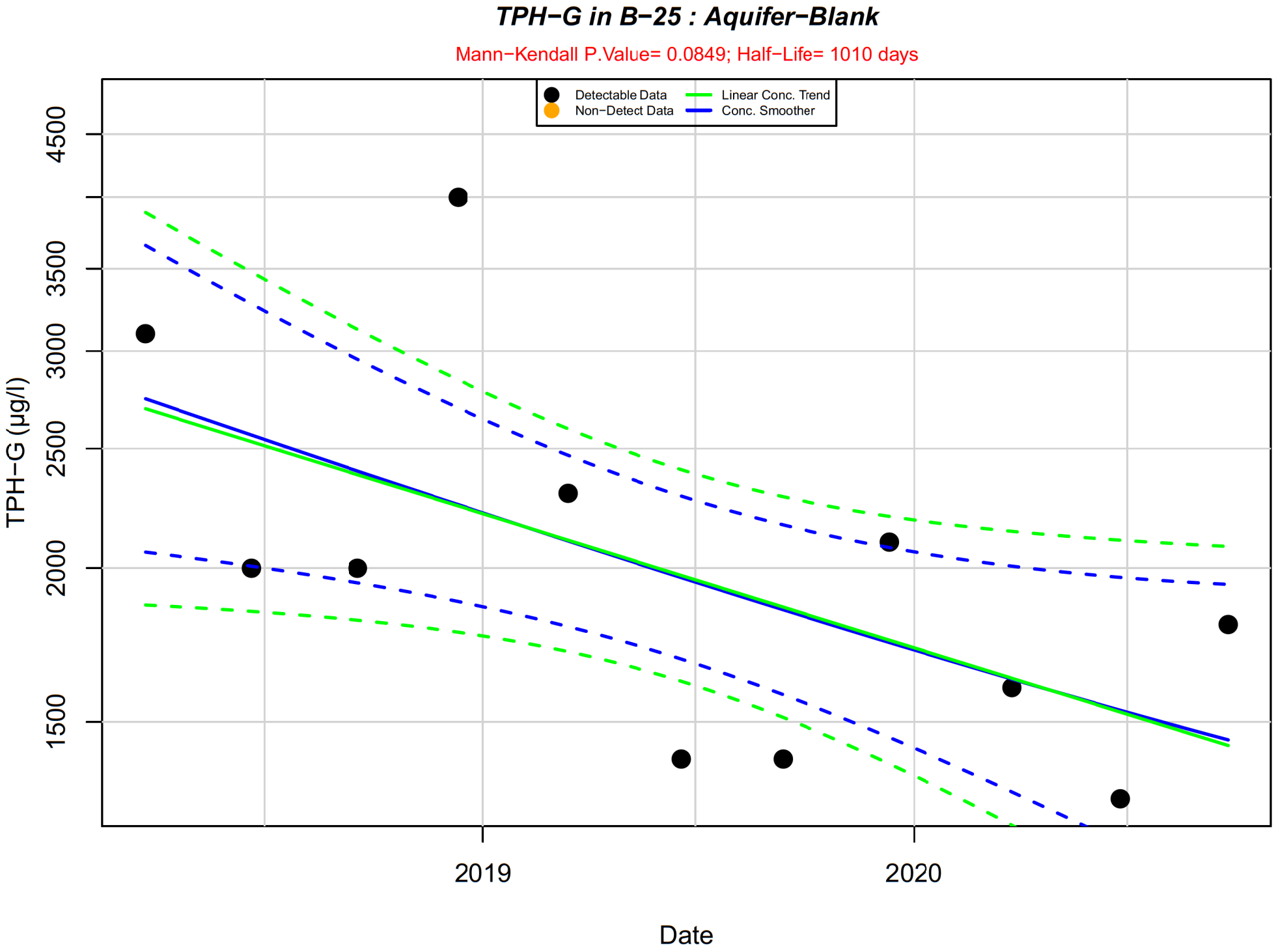

TPH-G in B-17B : Aquifer-Blank
Mann-Kendall P.Value= 0.569; Half-Life> -5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
200
150
100
50
2010
2012
2014
2016
2018
2020
Date

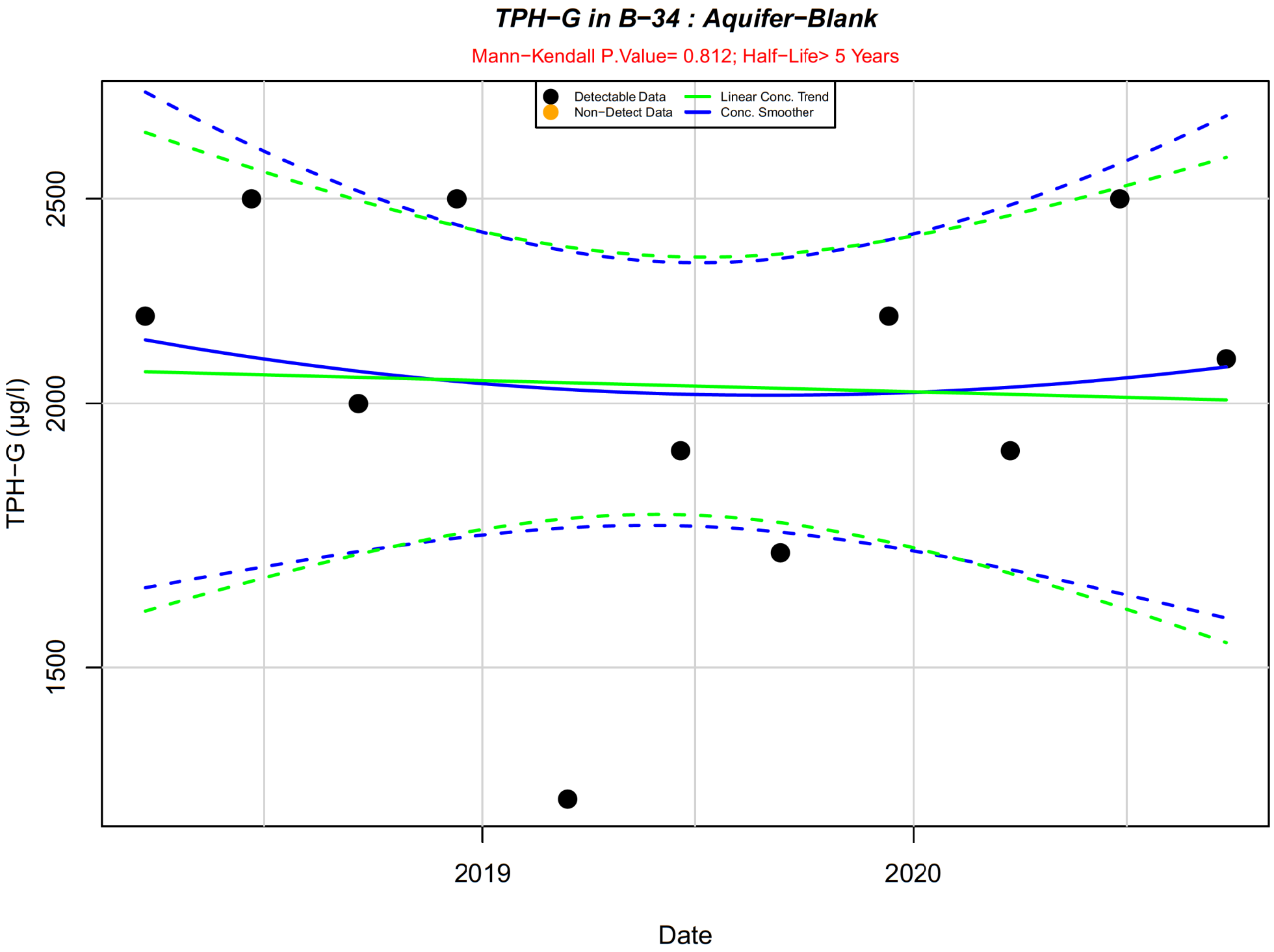

TPH−G in B−30 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
200
150
100
50
2012
2014
2016
2018
2020
Date

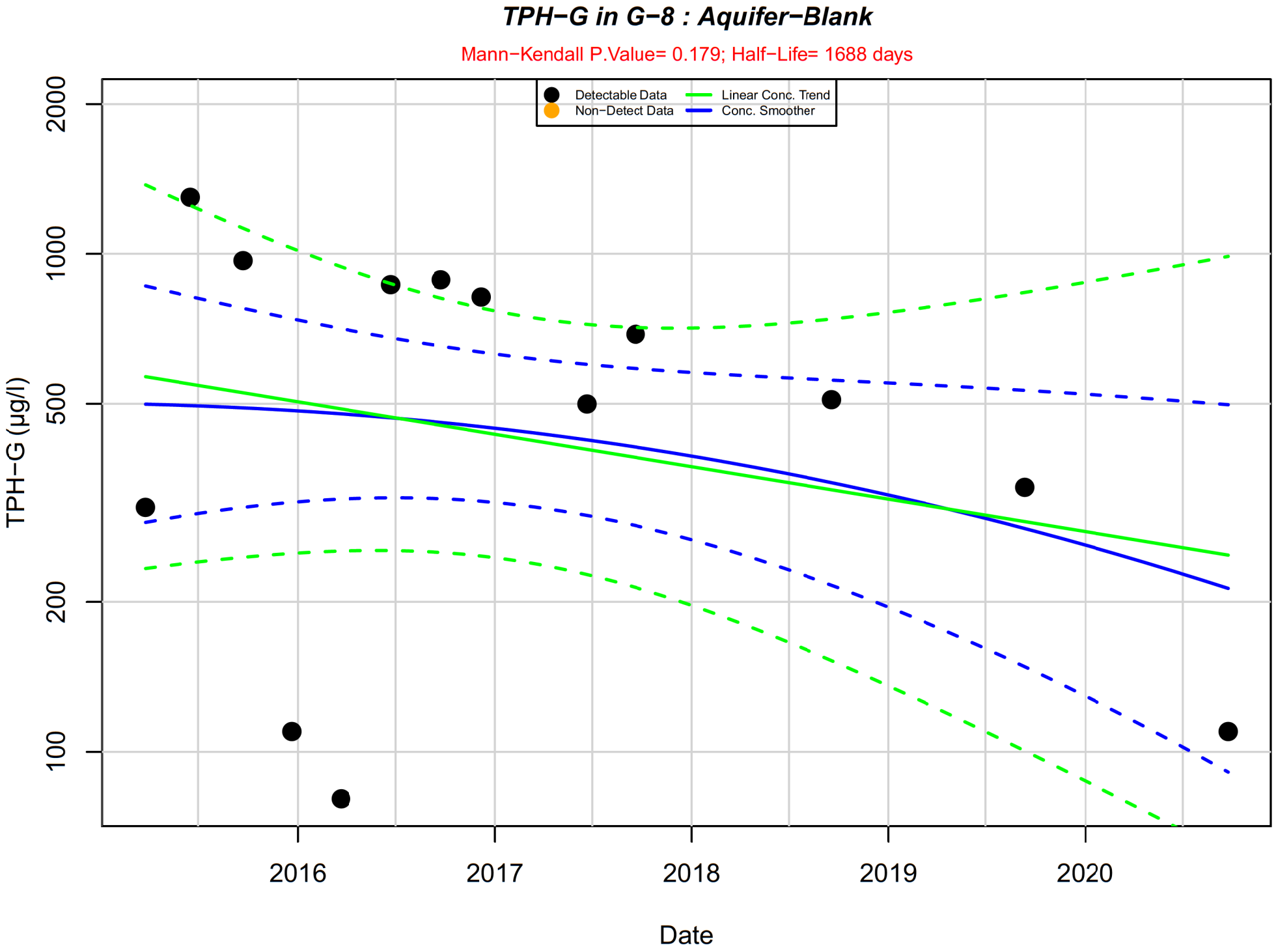

TPH-G in B-31 : Aquifer-Blank
Mann-Kendall P.Value= 0.213; Half-Life= -679 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
50
100
200
500
1000
2000
2019
2020
Date

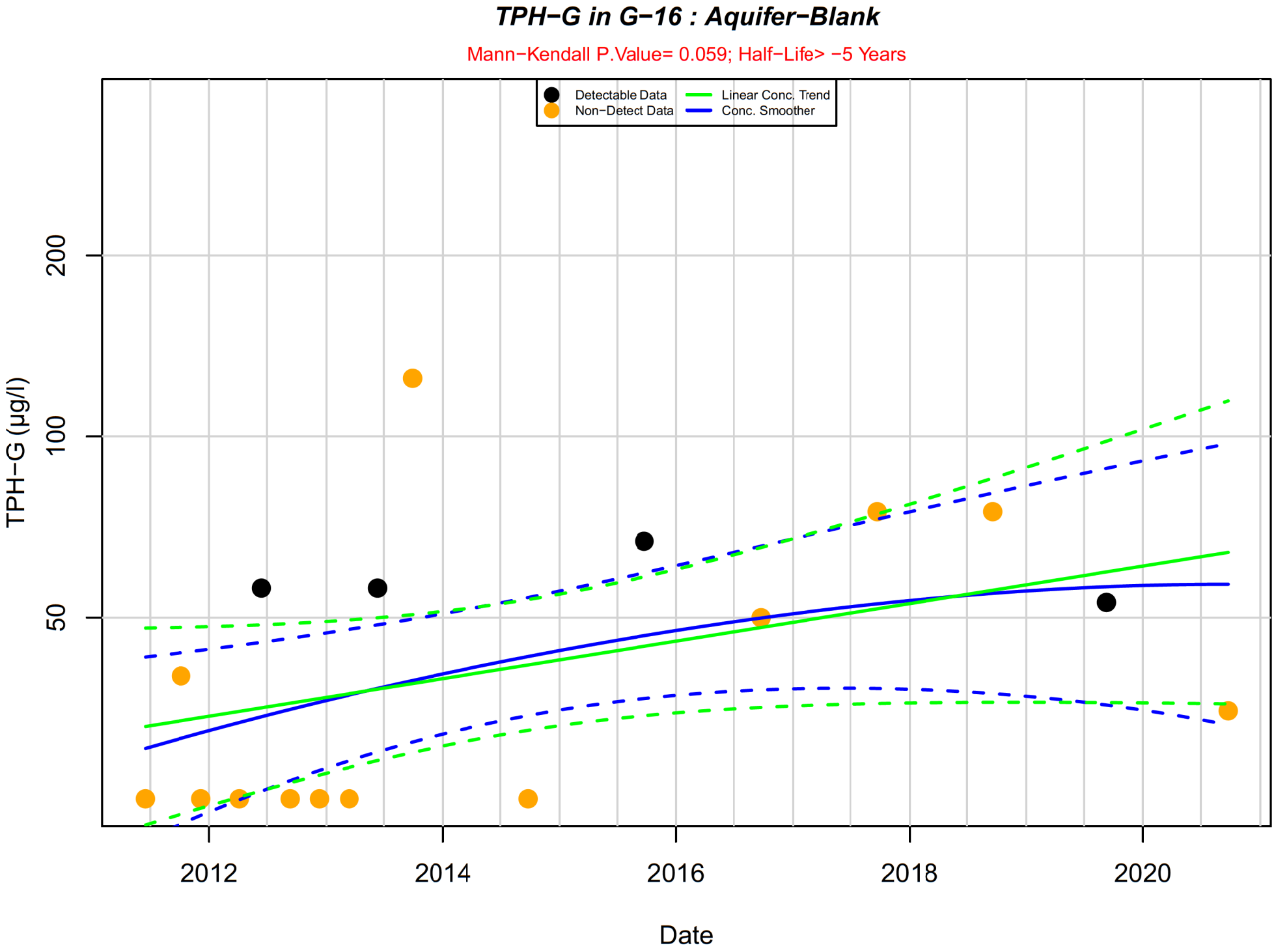

TPH-G in E-21 : Aquifer-Blank
Mann-Kendall P.Value= 0.778; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
200
100
50
2017
2018
2019
2020
Date

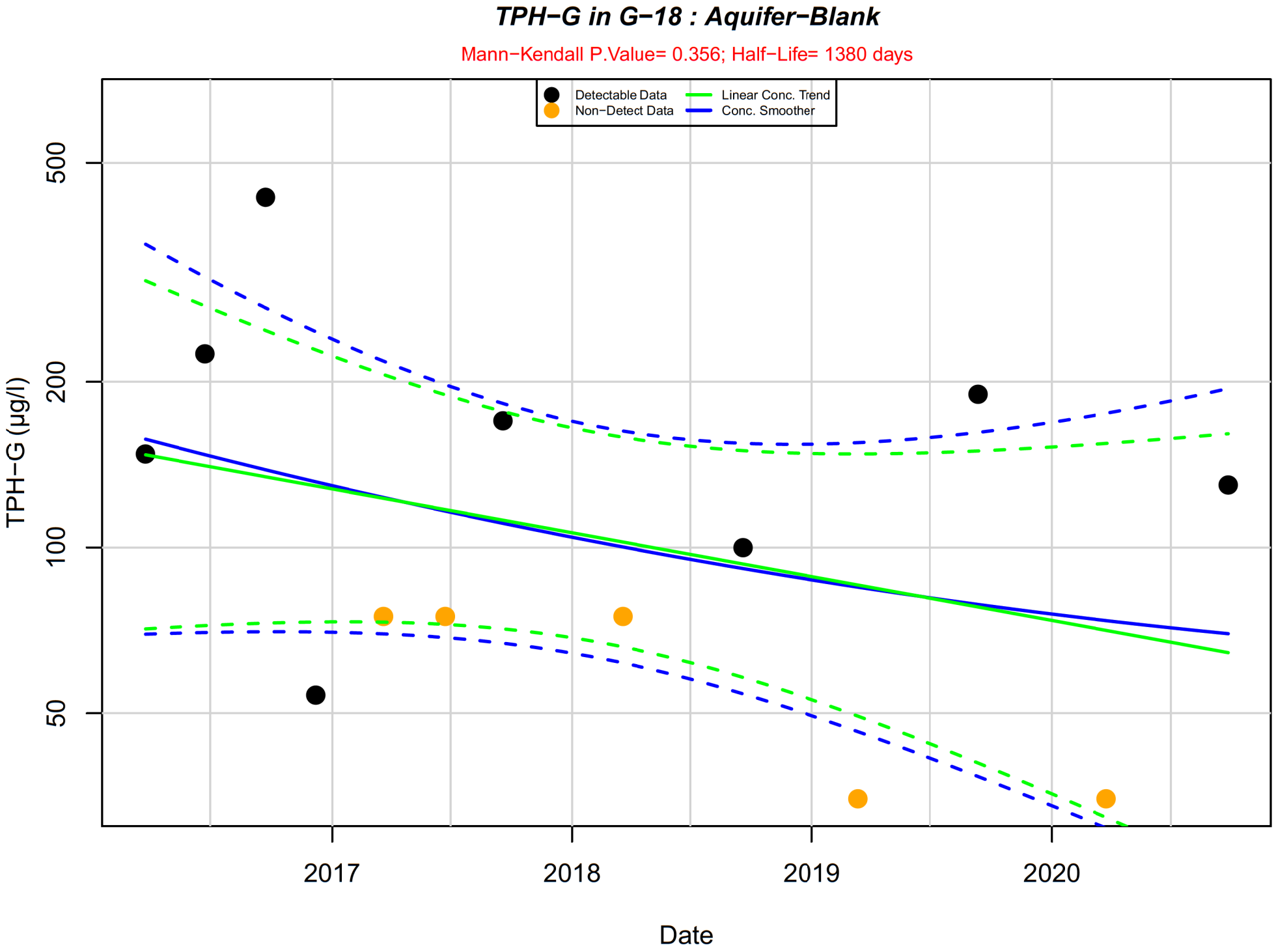

TPH-G in B-19 : Aquifer-Blank
Mann-Kendall P.Value= 0.492; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
2000
1500
1000
2017
2018
2019
2020
Date

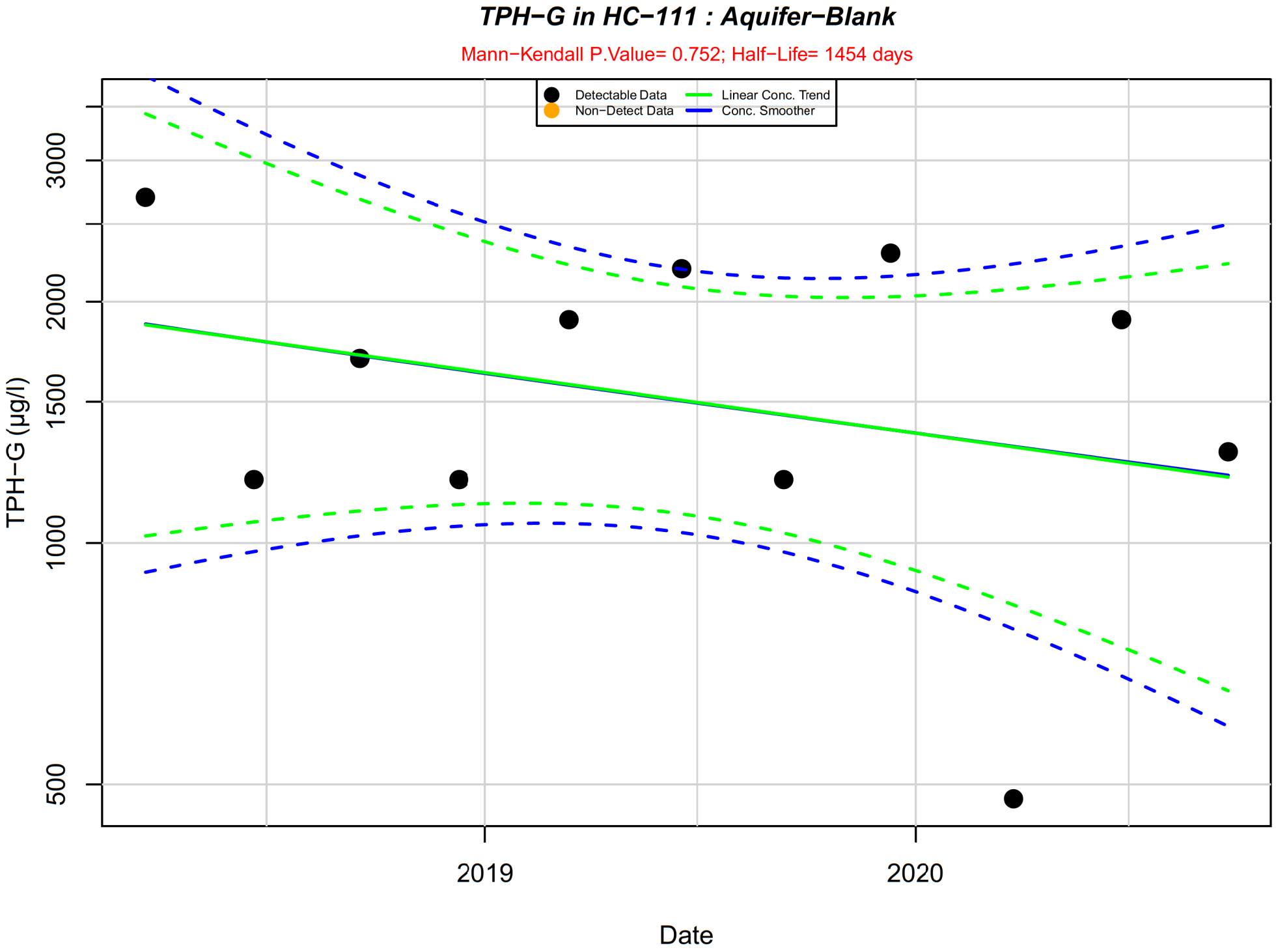

TPH-G in B-25 : Aquifer-Blank
Mann-Kendall P.Value= 0.0849; Half-Life= 1010 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
4500
3500
3000
2500
2000
1500
2019
2020
Date

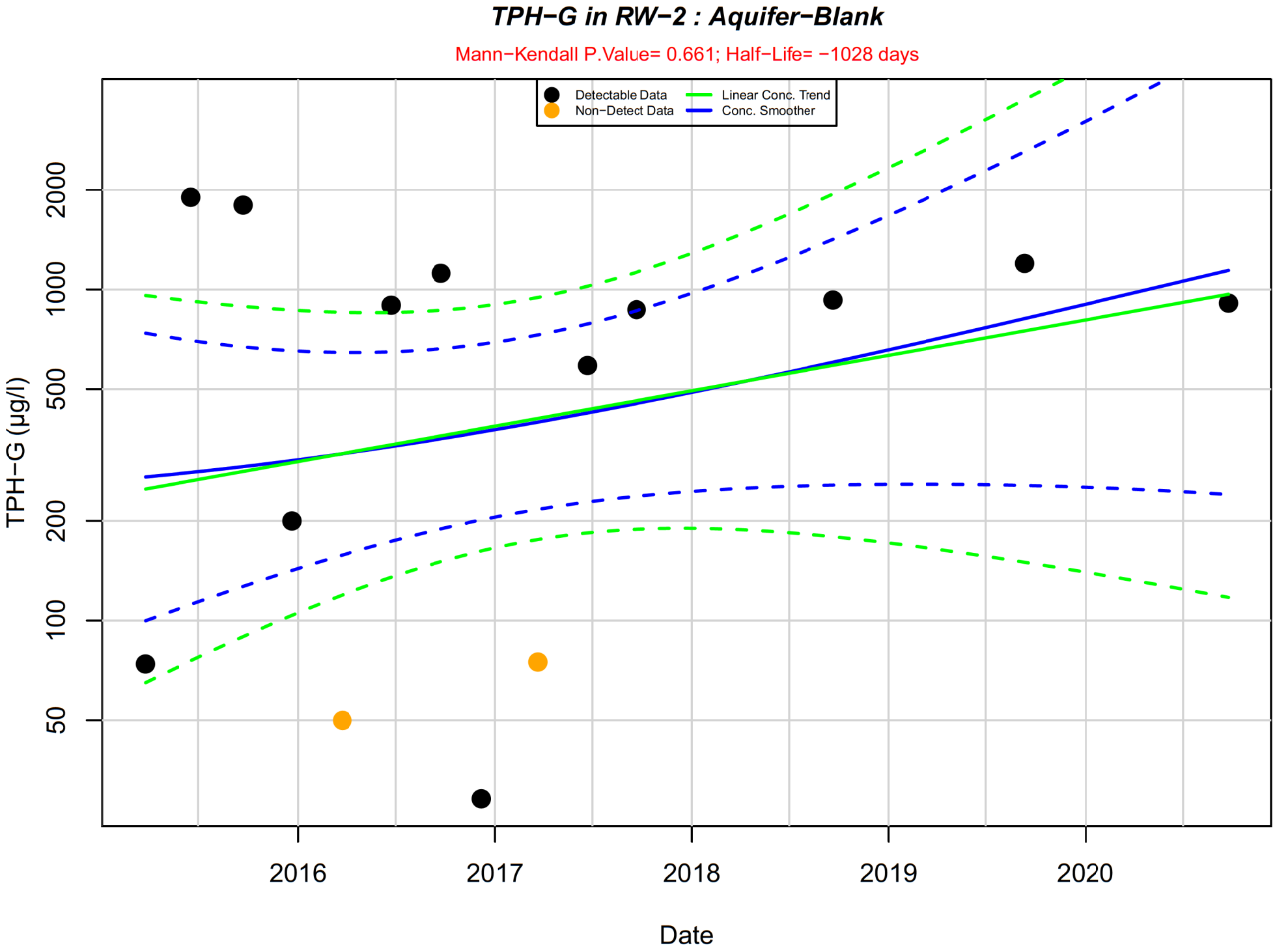

TPH-G in B-34 : Aquifer-Blank
Mann-Kendall P.Value= 0.812; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
2500
2000
1500
2019
2020
Date

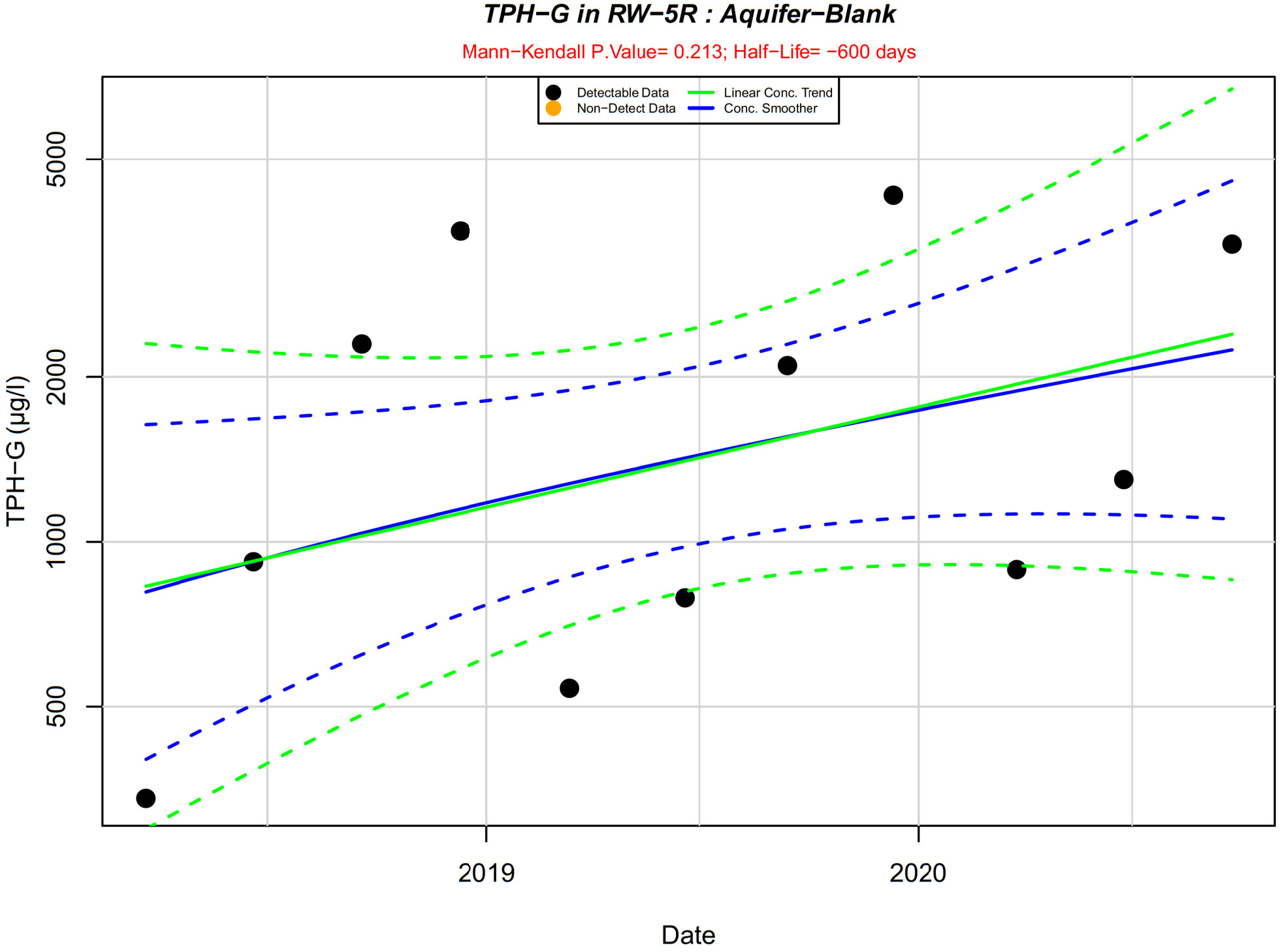

TPH−G in G−8 : Aquifer−Blank
Mann−Kendall P.Value= 0.179; Half−Life= 1688 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
2000
1000
500
200
100
2016
2017
2018
2019
2020
Date

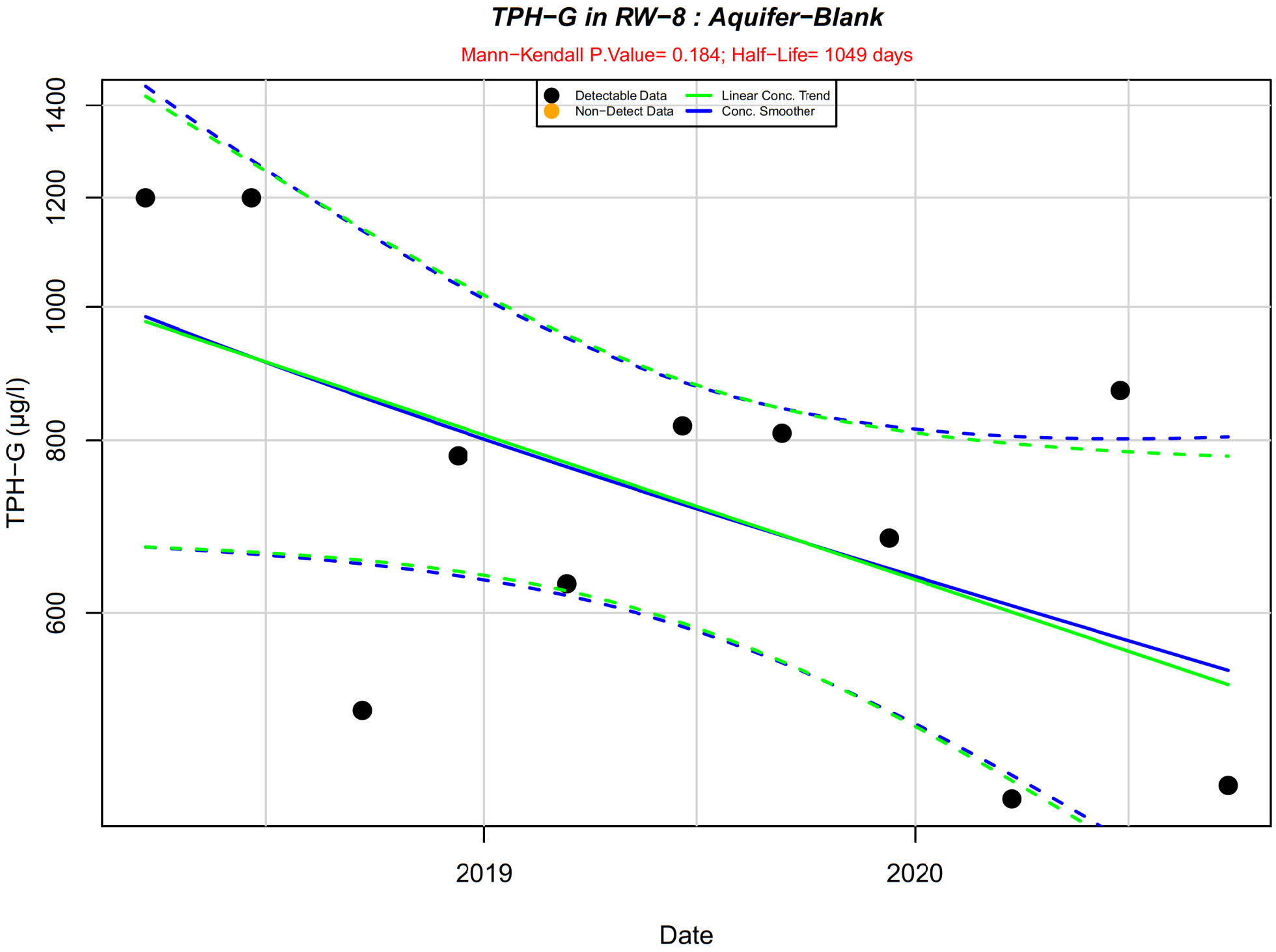

TPH-G in G-16 : Aquifer-Blank
Mann-Kendall P.Value= 0.059; Half-Life> -5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
50
100
200
2012
2014
2016
2018
2020
Date

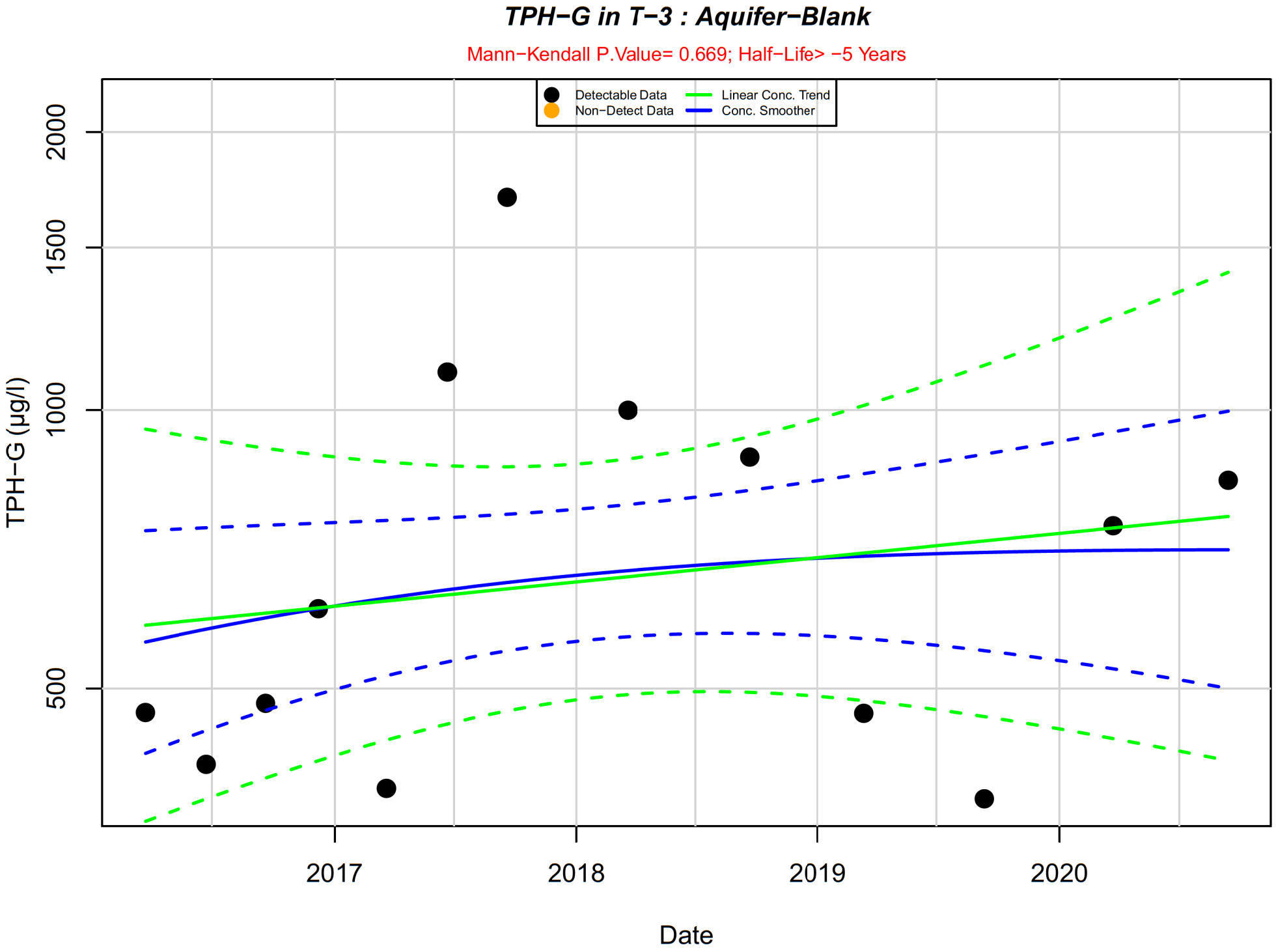

TPH−G in G−18 : Aquifer−Blank
Mann−Kendall P.Value= 0.356; Half−Life= 1380 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
500
200
100
50
2017
2018
2019
2020
Date

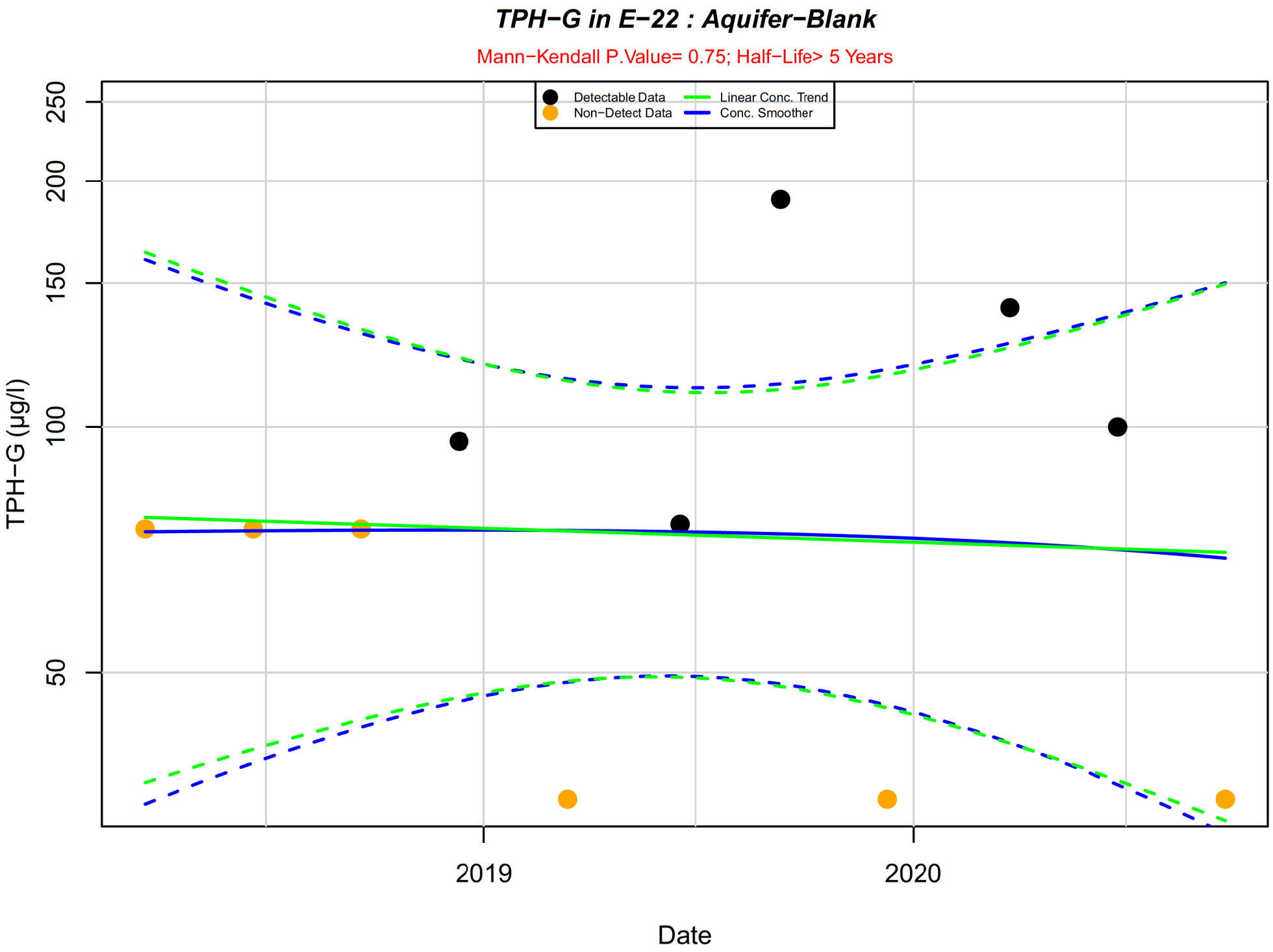

TPH−G in HC−111 : Aquifer−Blank
Mann−Kendall P.Value= 0.752; Half−Life= 1454 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
3000
2000
1500
1000
500
2019
2020
Date

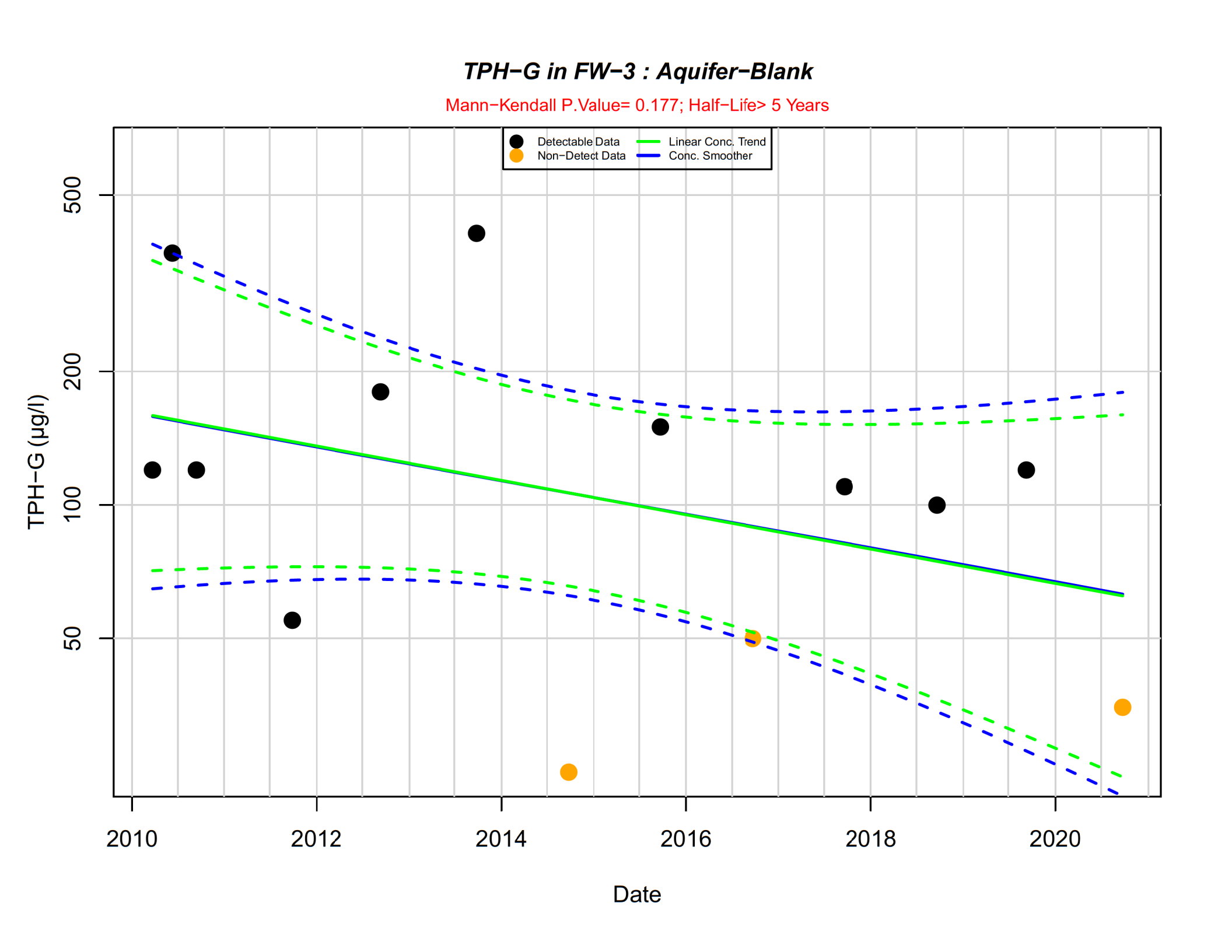

TPH-G in RW-2 : Aquifer-Blank
Mann-Kendall P.Value= 0.661; Half-Life= -1028 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
50
100
200
500
1000
2000
2016
2017
2018
2019
2020
Date

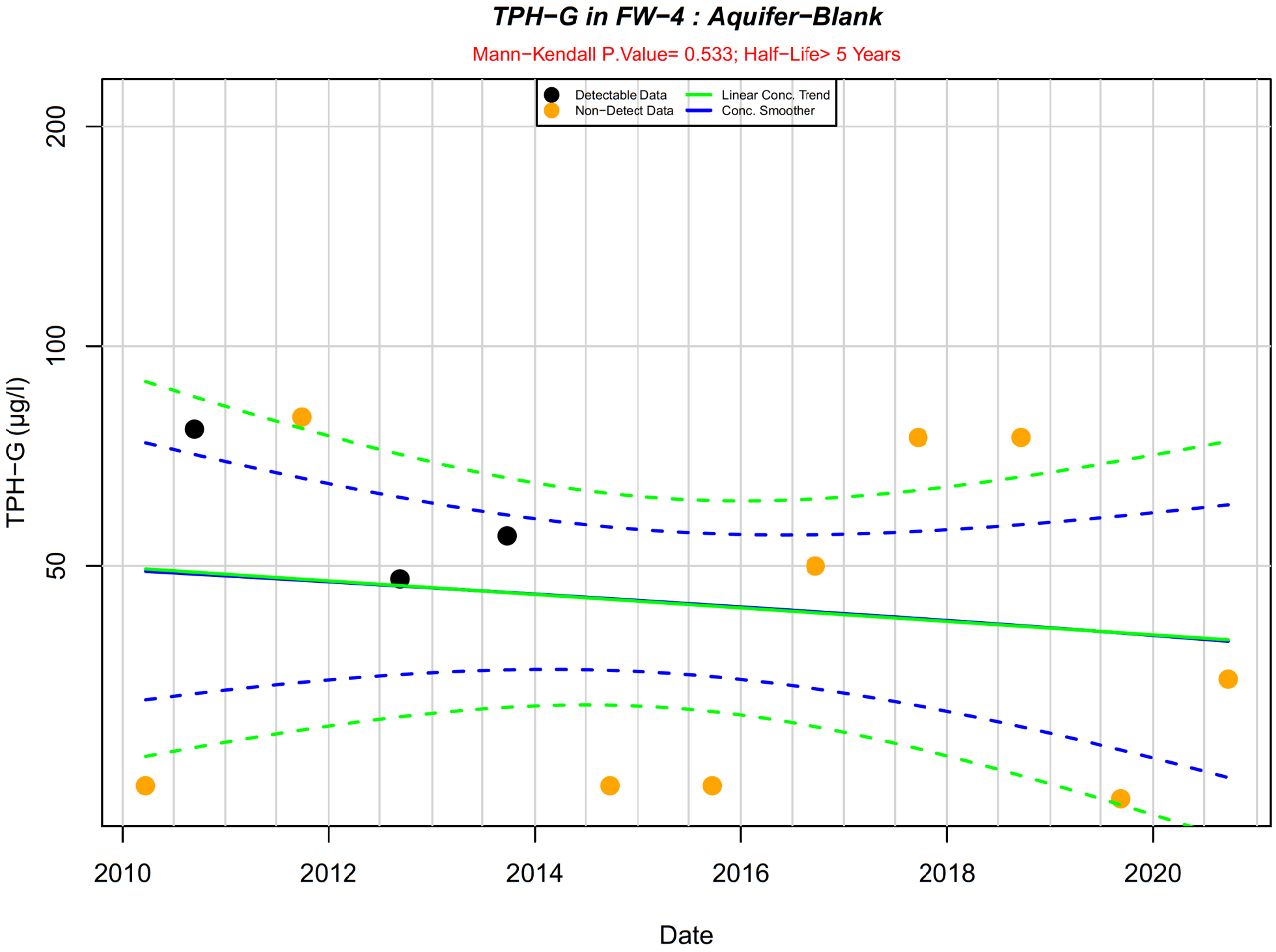

TPH−G in RW−5R : Aquifer−Blank
Mann−Kendall P.Value= 0.213; Half−Life= −600 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
5000
2000
1000
500
2019
2020
Date

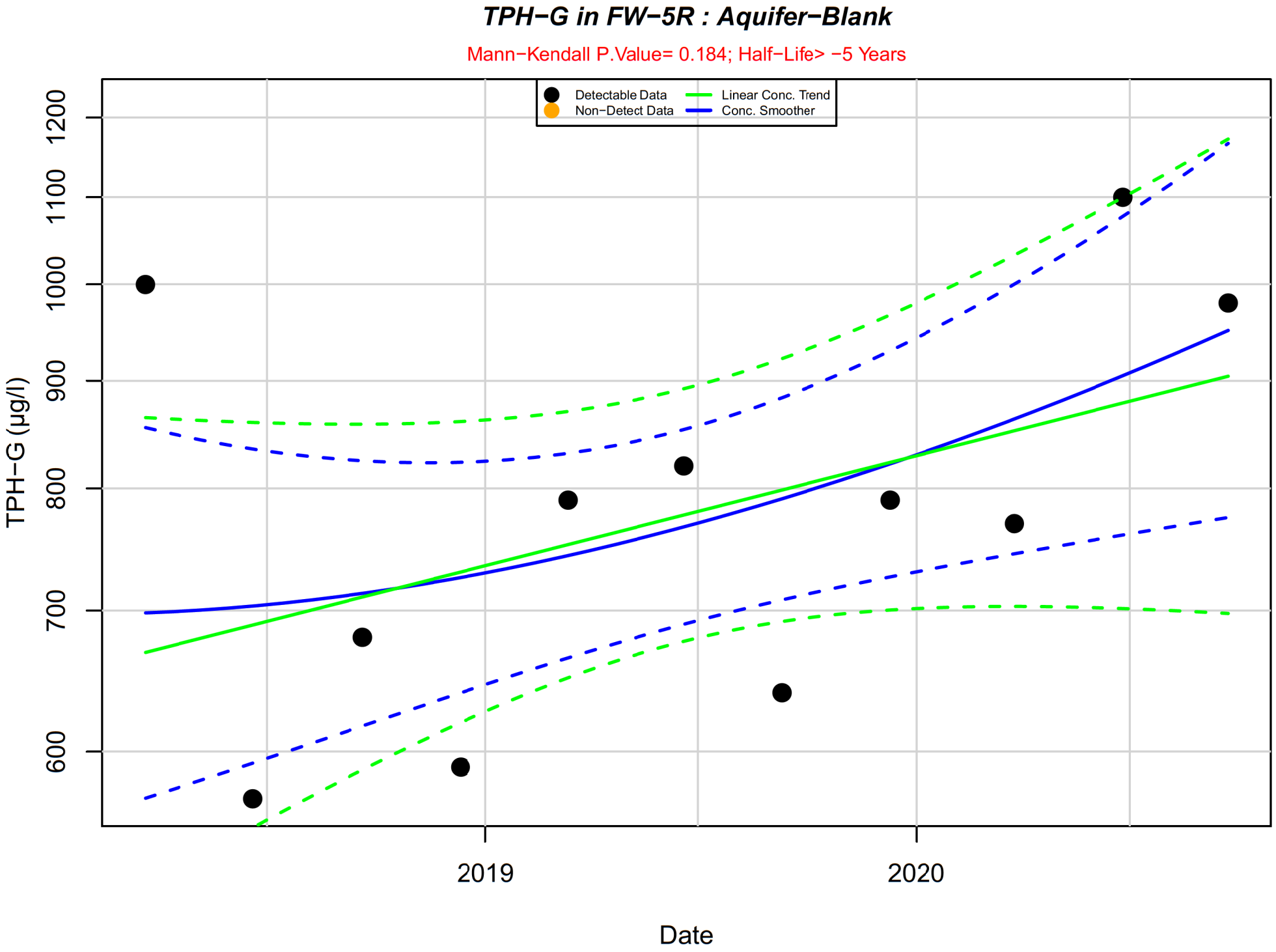

TPH-G in RW-8 : Aquifer-Blank
Mann-Kendall P.Value= 0.184; Half-Life= 1049 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
1400
1200
1000
800
600
2019
2020
Date

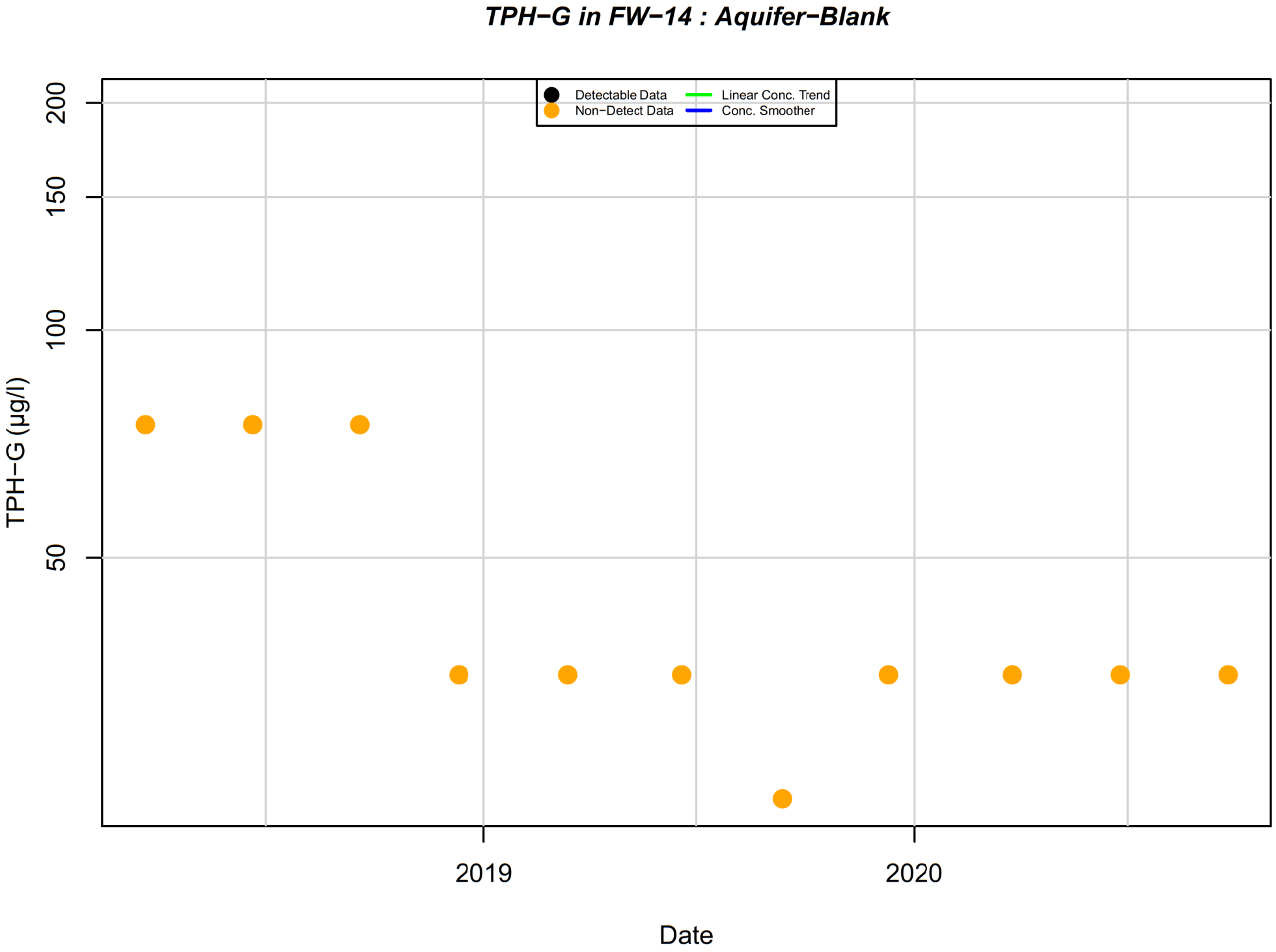

TPH-G in T-3 : Aquifer-Blank
Mann-Kendall P.Value= 0.669; Half-Life> -5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
500
1000
1500
2000
2017
2018
2019
2020
Date

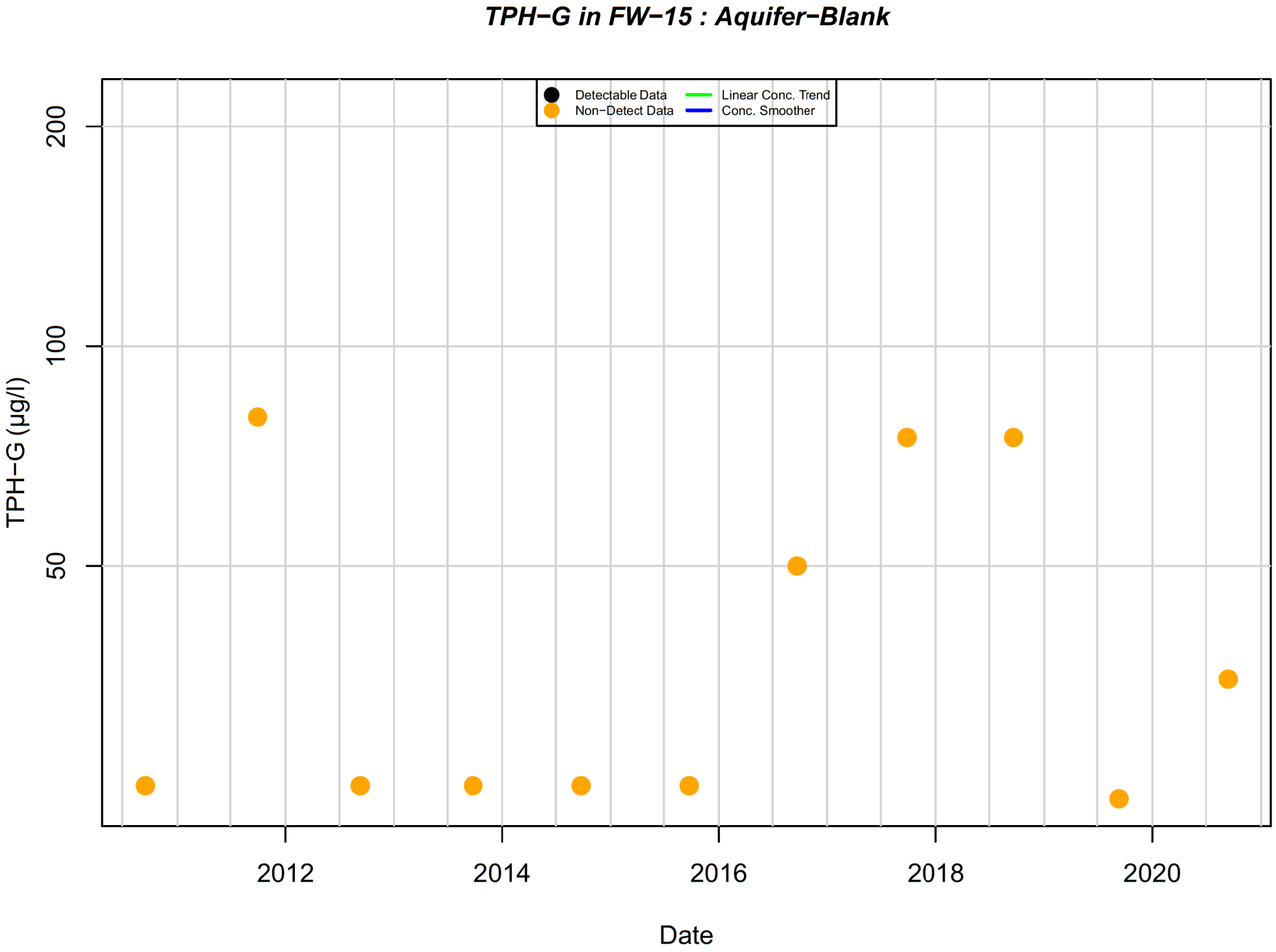

TPH-G in E-22 : Aquifer-Blank
Mann-Kendall P.Value= 0.75; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
250
200
150
100
50
2019
2020
Date

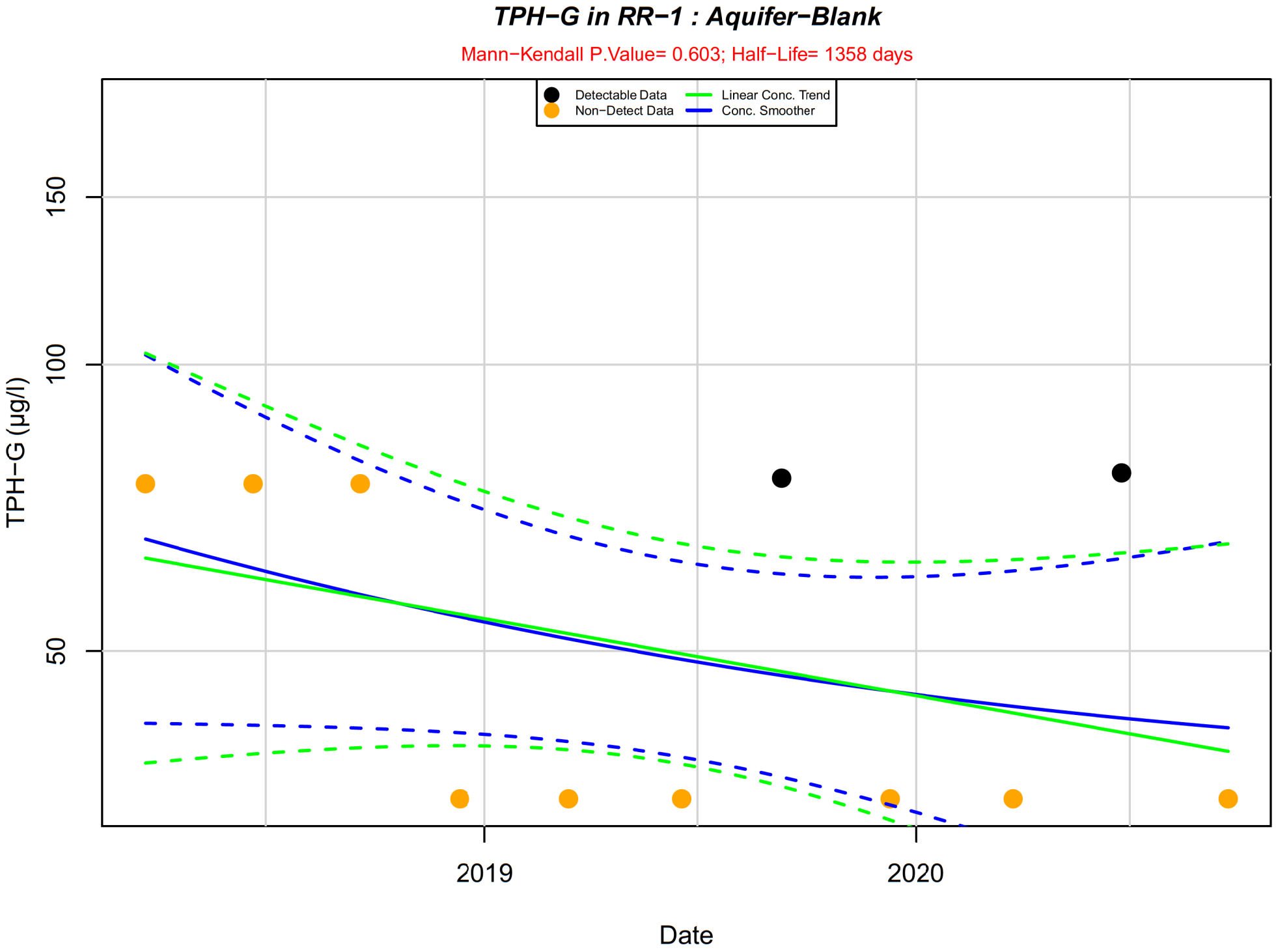

TPH-G in FW-3 : Aquifer-Blank
Mann-Kendall P.Value= 0.177; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
500
200
100
50
2010
2012
2014
2016
2018
2020
Date

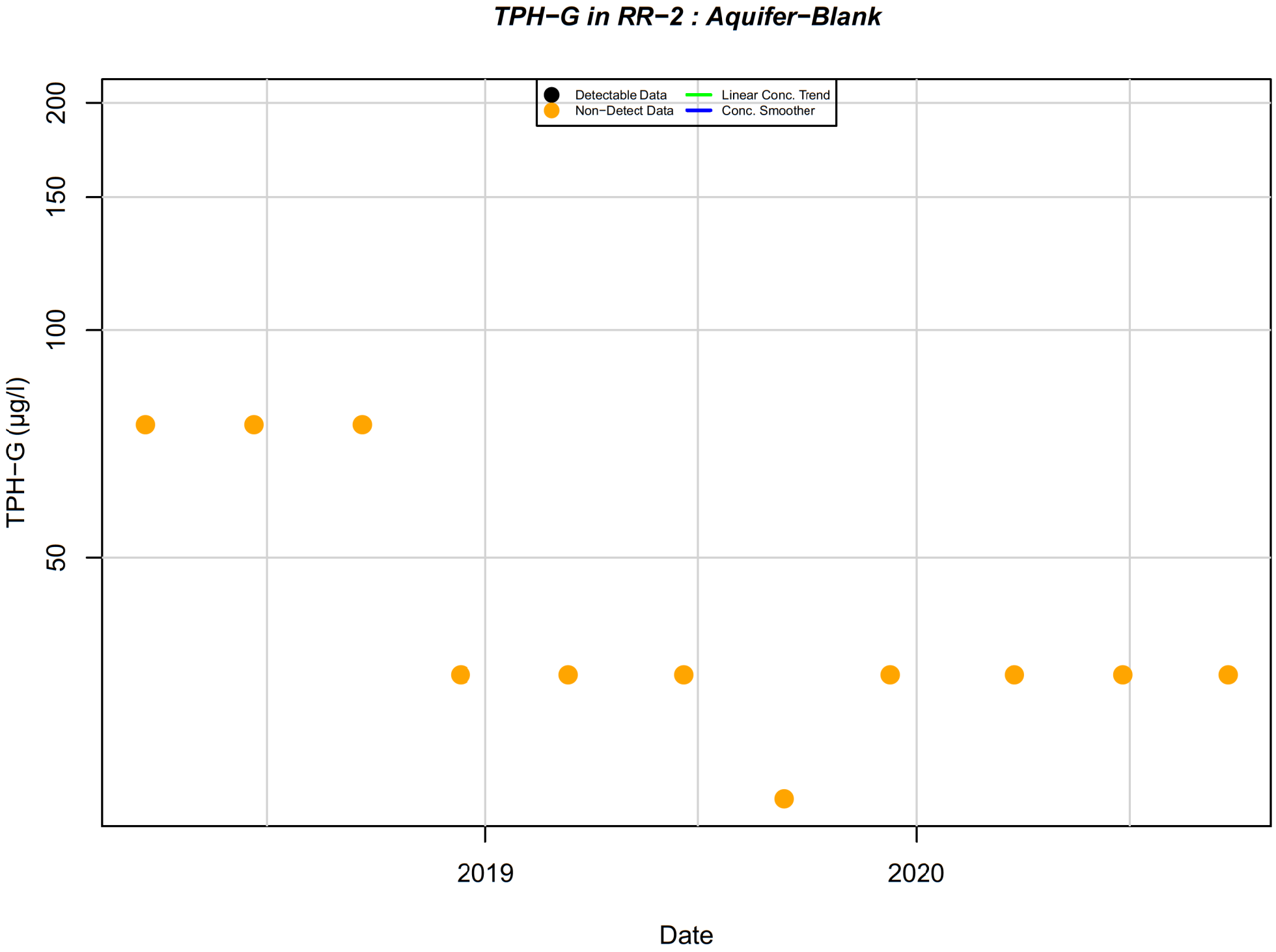

TPH−G in FW−4 : Aquifer−Blank
Mann−Kendall P.Value= 0.533; Half−Life> 5 Years
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
200
100
50
2010
2012
2014
2016
2018
2020
Date

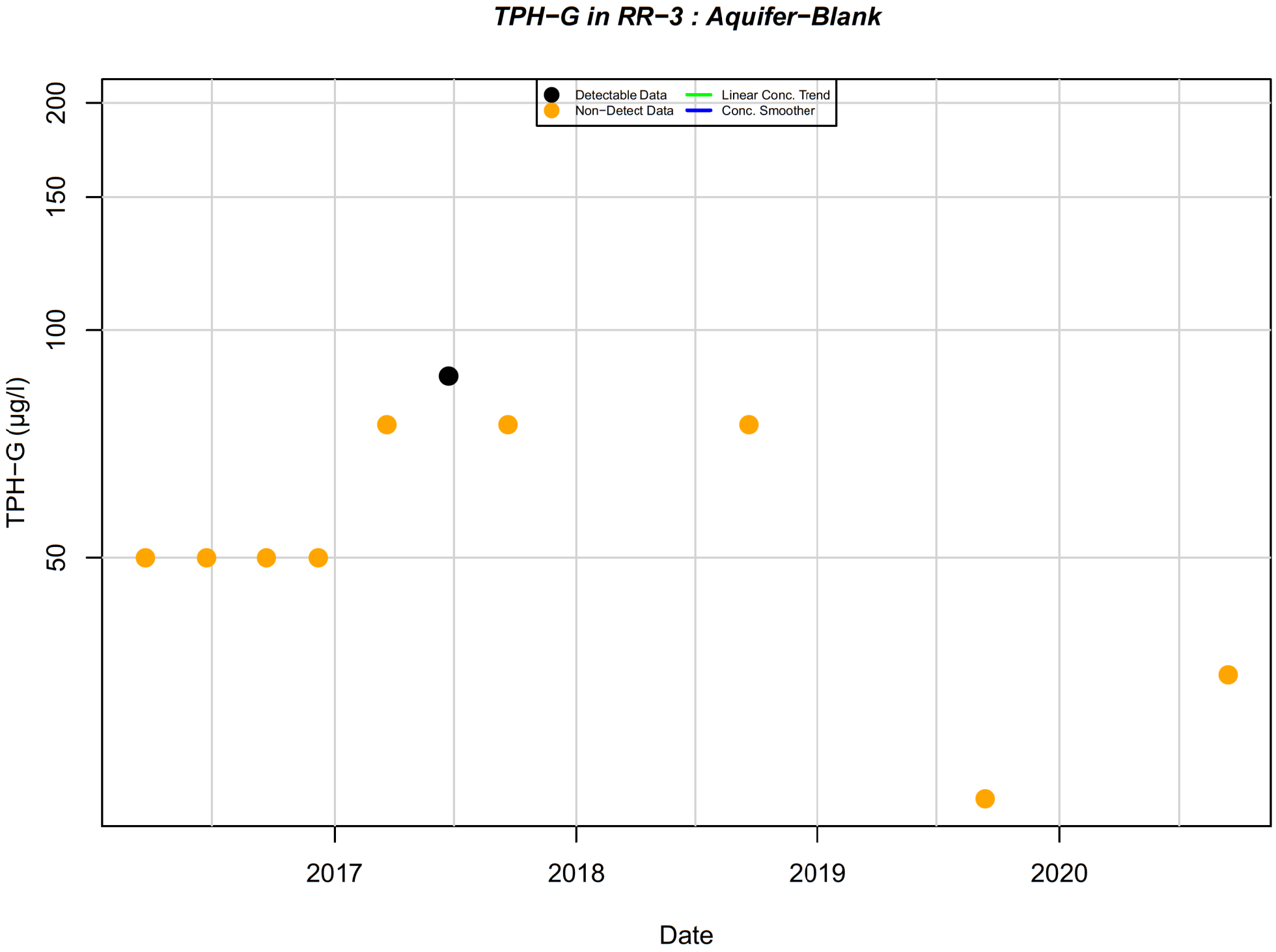

TPH−G in FW−5R : Aquifer−Blank
Mann−Kendall P.Value= 0.184; Half−Life> −5 Years
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
600
700
800
900
1000
1100
1200
2019
2020
Date

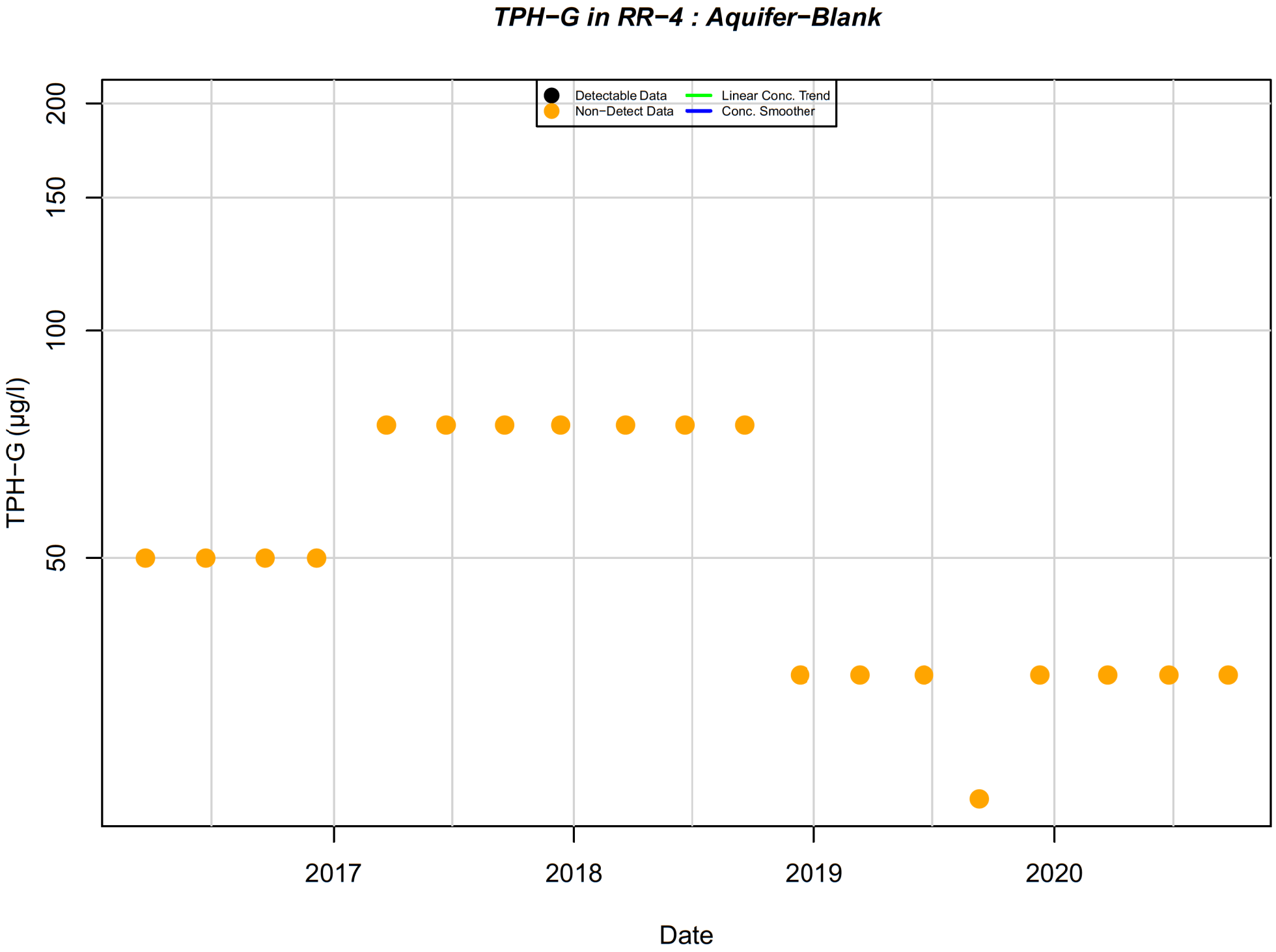

TPH-G in FW-14 : Aquifer-Blank
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
200
150
100
50
2019
2020
Date

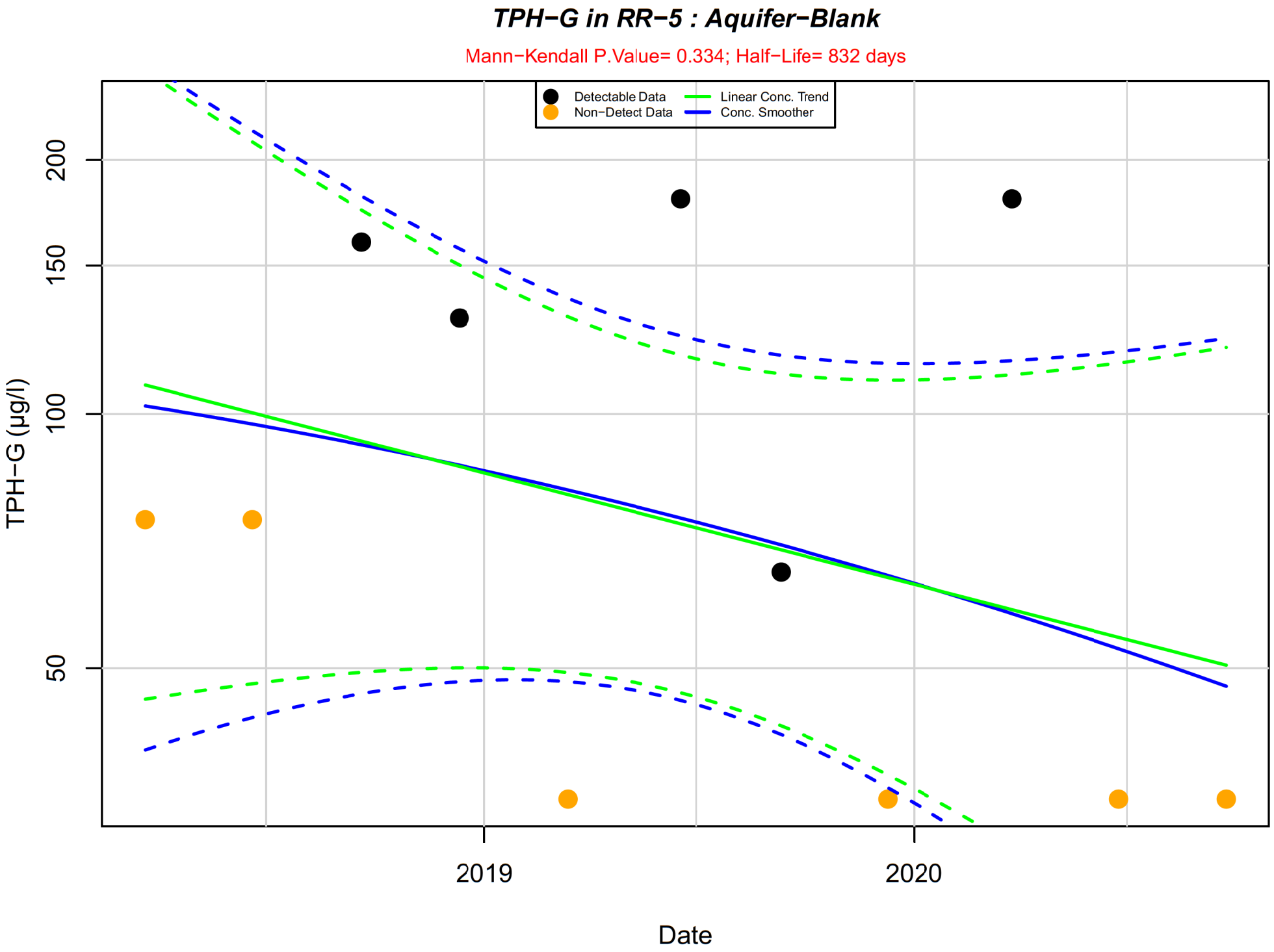

TPH−G in FW−15 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
200
100
50
2012
2014
2016
2018
2020
Date

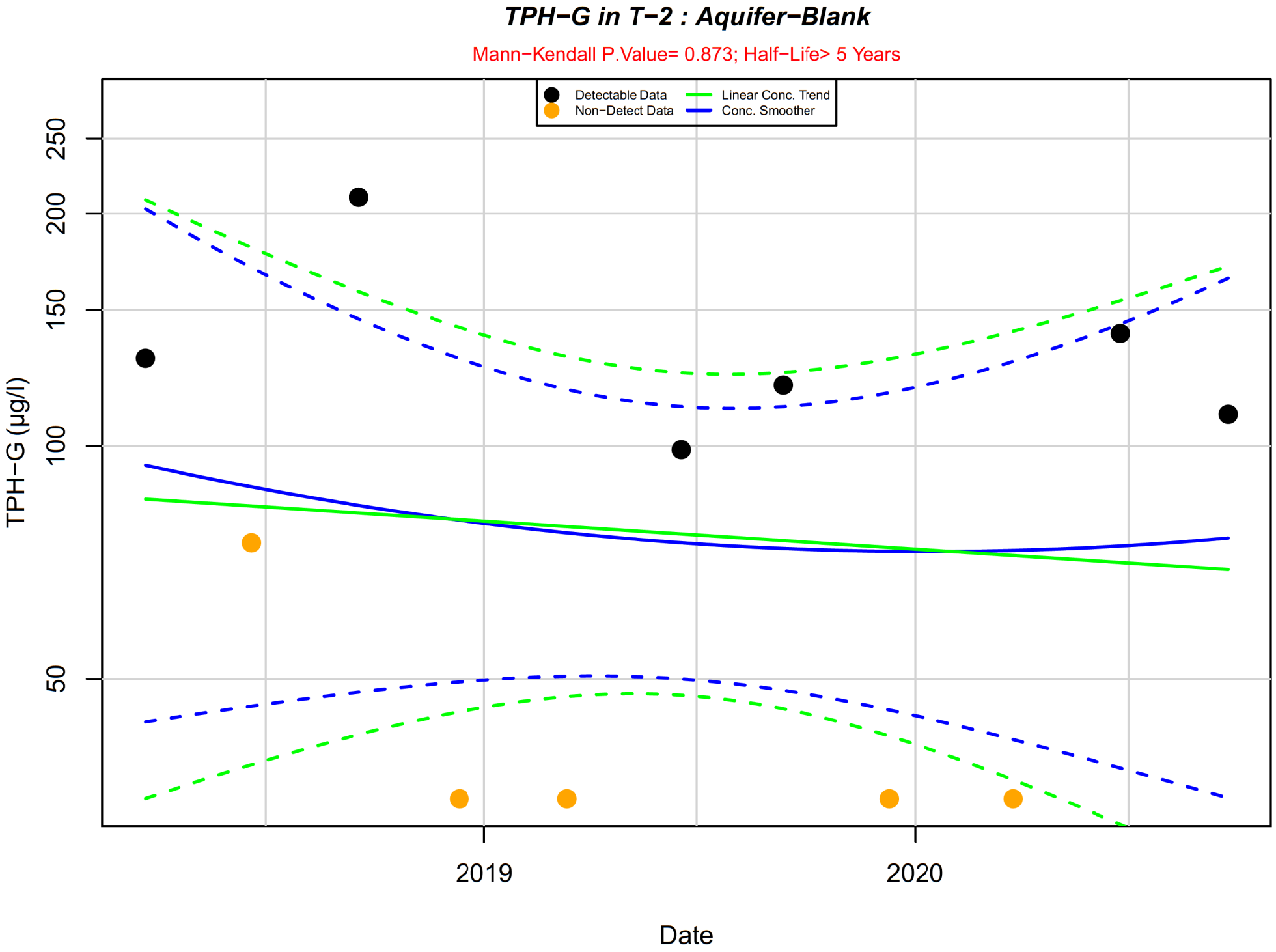

TPH-G in RR-1 : Aquifer-Blank
Mann-Kendall P.Value= 0.603; Half-Life= 1358 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
150
100
50
TPH-G (µg/l)
2019
2020
Date

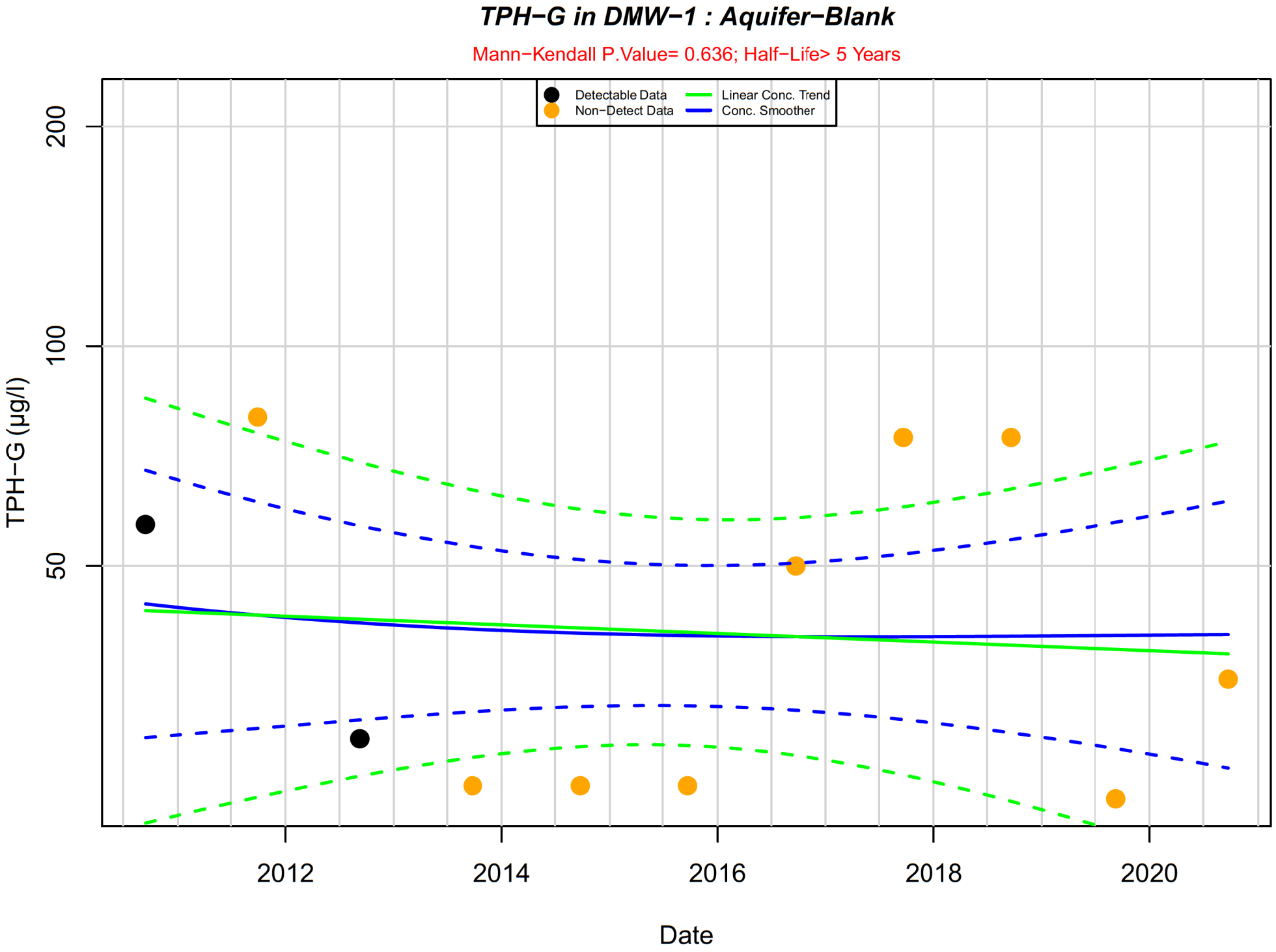

TPH−G in RR−2 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
200
150
100
50
2019
2020
Date

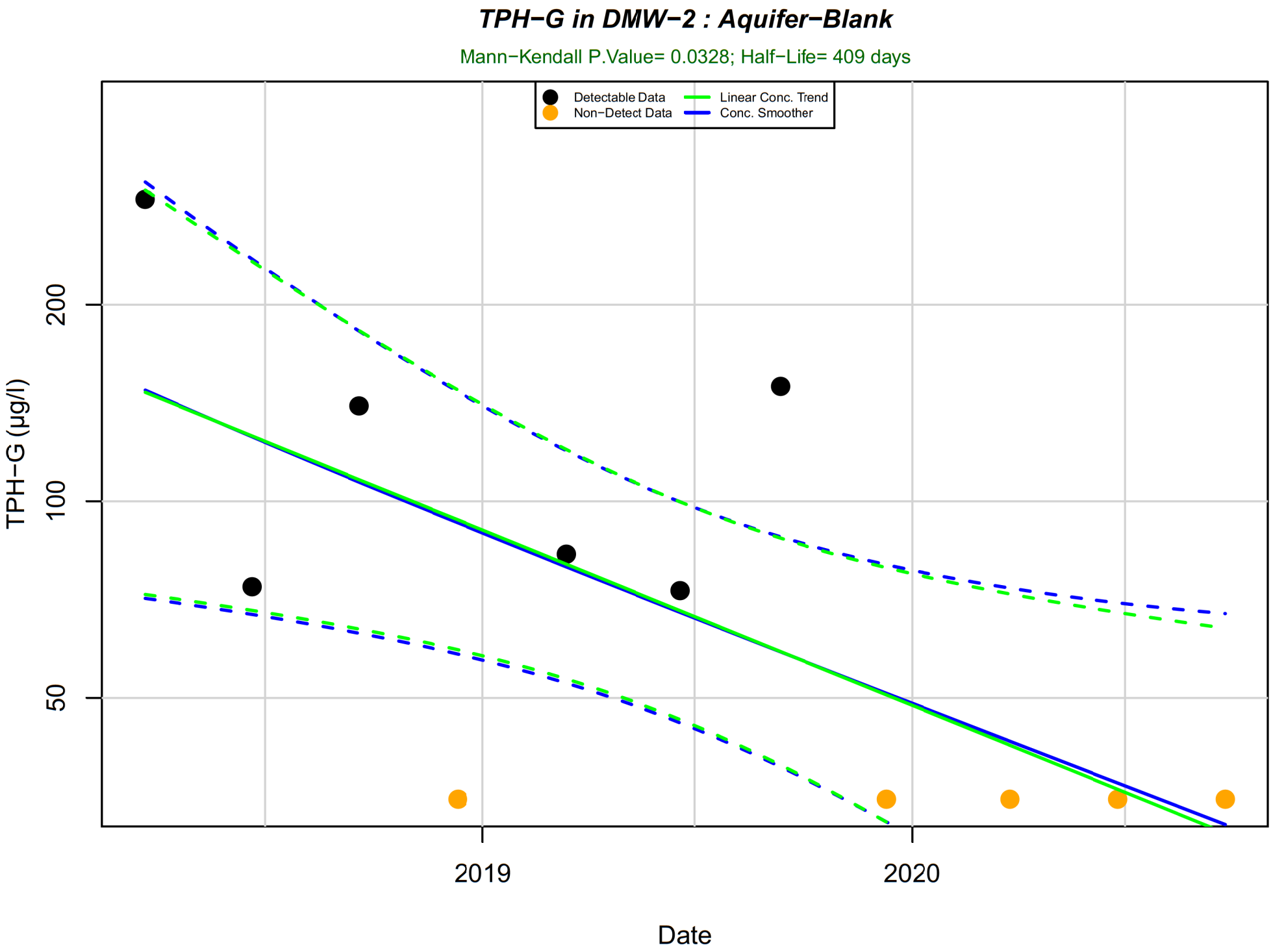

TPH−G in RR−3 : Aquifer−Blank
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
200
150
100
50
2017
2018
2019
2020
Date

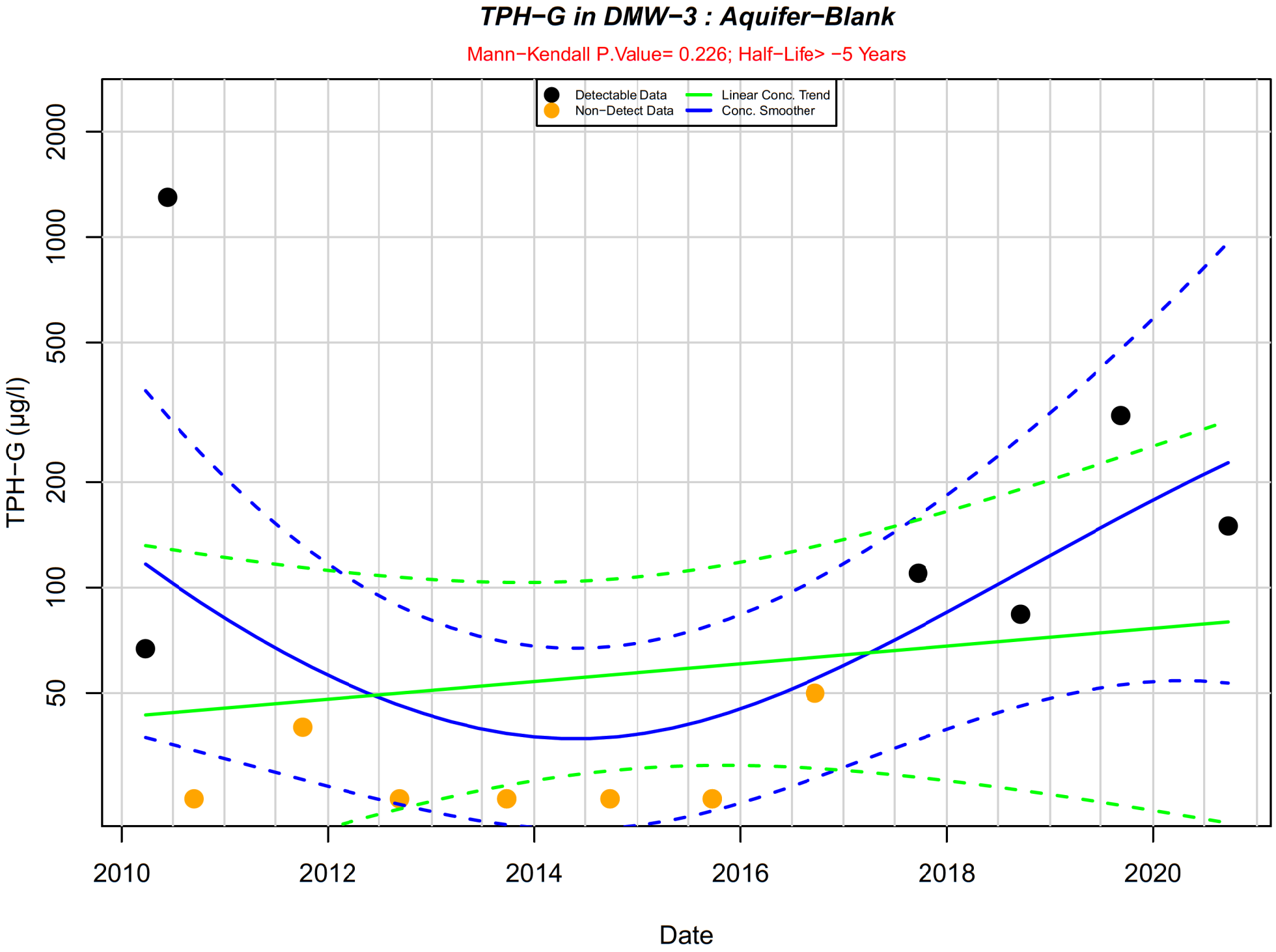

TPH-G in RR-4 : Aquifer-Blank
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
200
150
100
50
2017
2018
2019
2020
Date

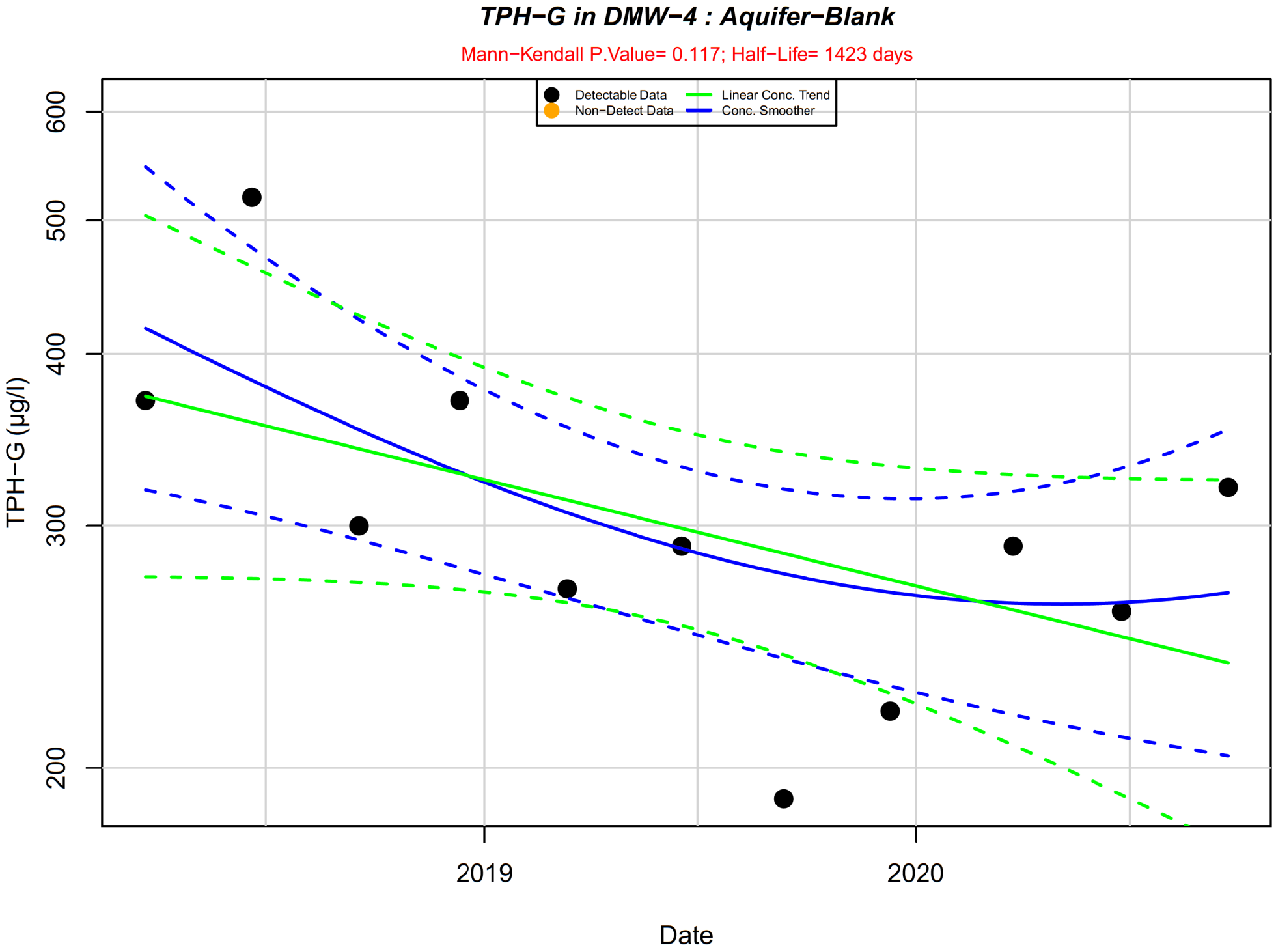

TPH-G in RR-5 : Aquifer-Blank
Mann-Kendall P.Value= 0.334; Half-Life= 832 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
200
150
100
50
2019
2020
Date

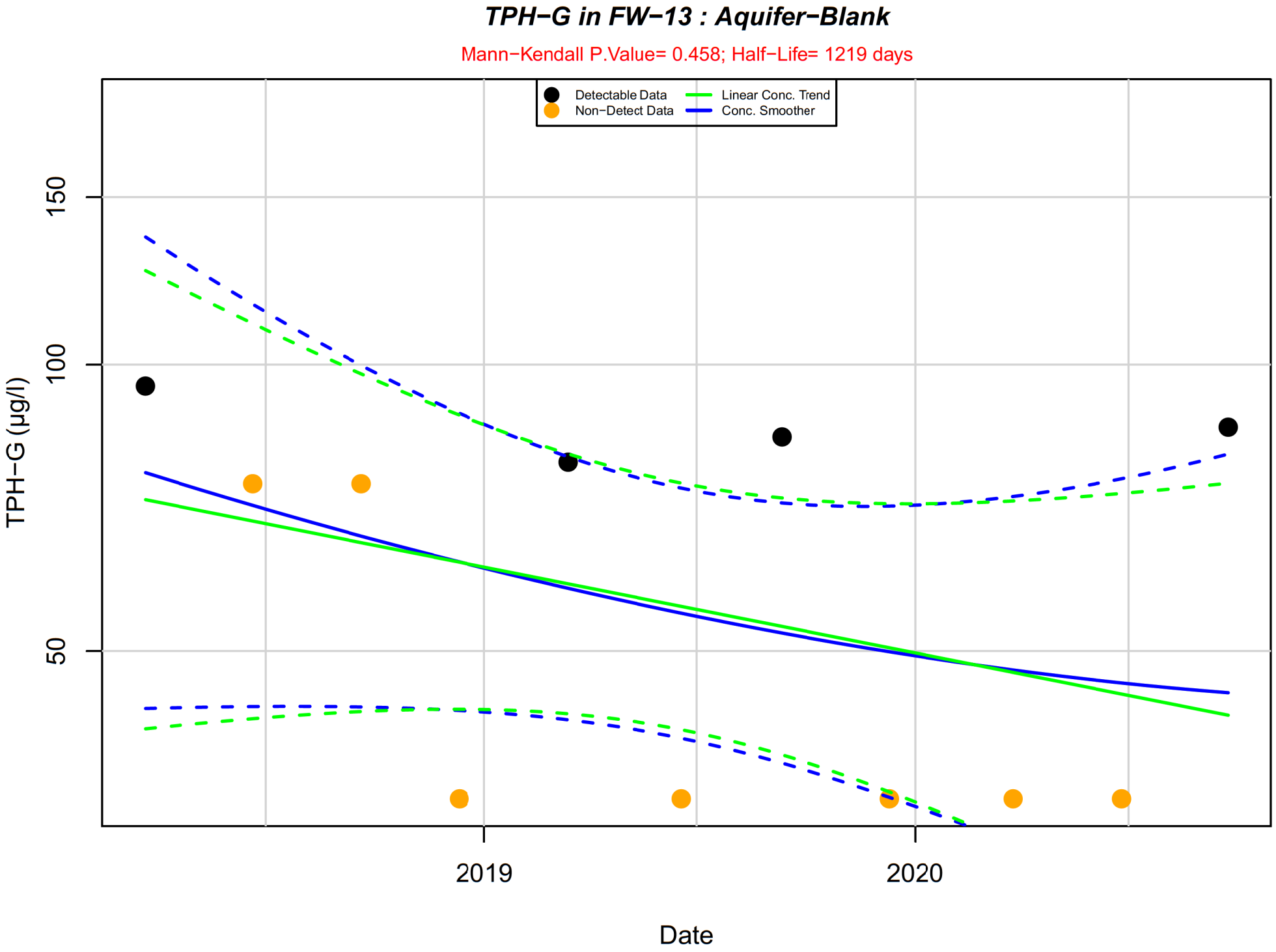

TPH−G in T−2 : Aquifer−Blank
Mann−Kendall P.Value= 0.873; Half−Life> 5 Years
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
250
200
150
100
50
2019
2020
Date

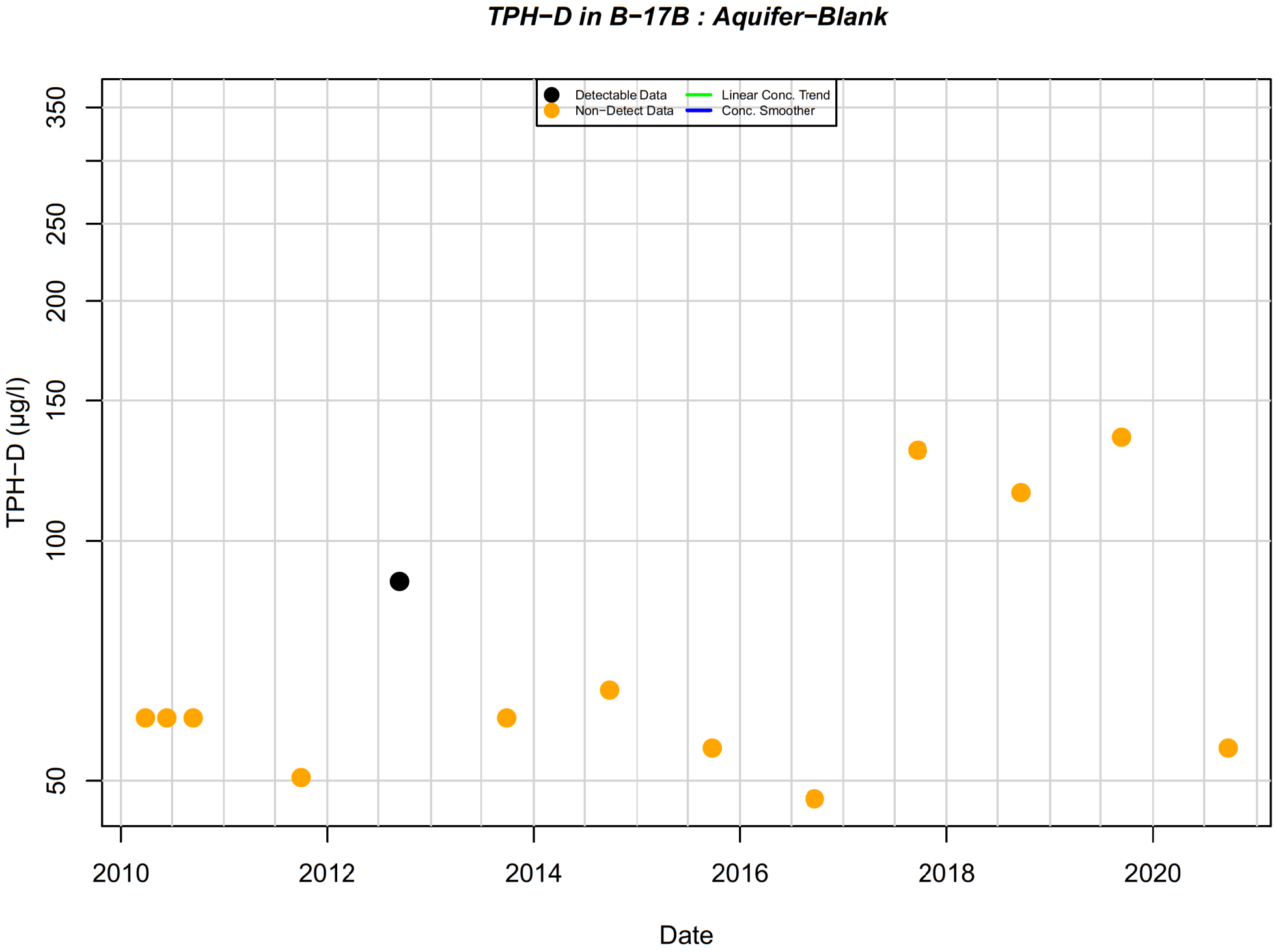

TPH−G in DMW−1 : Aquifer−Blank
Mann−Kendall P.Value= 0.636; Half−Life> 5 Years
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
200
100
50
2012
2014
2016
2018
2020
Date

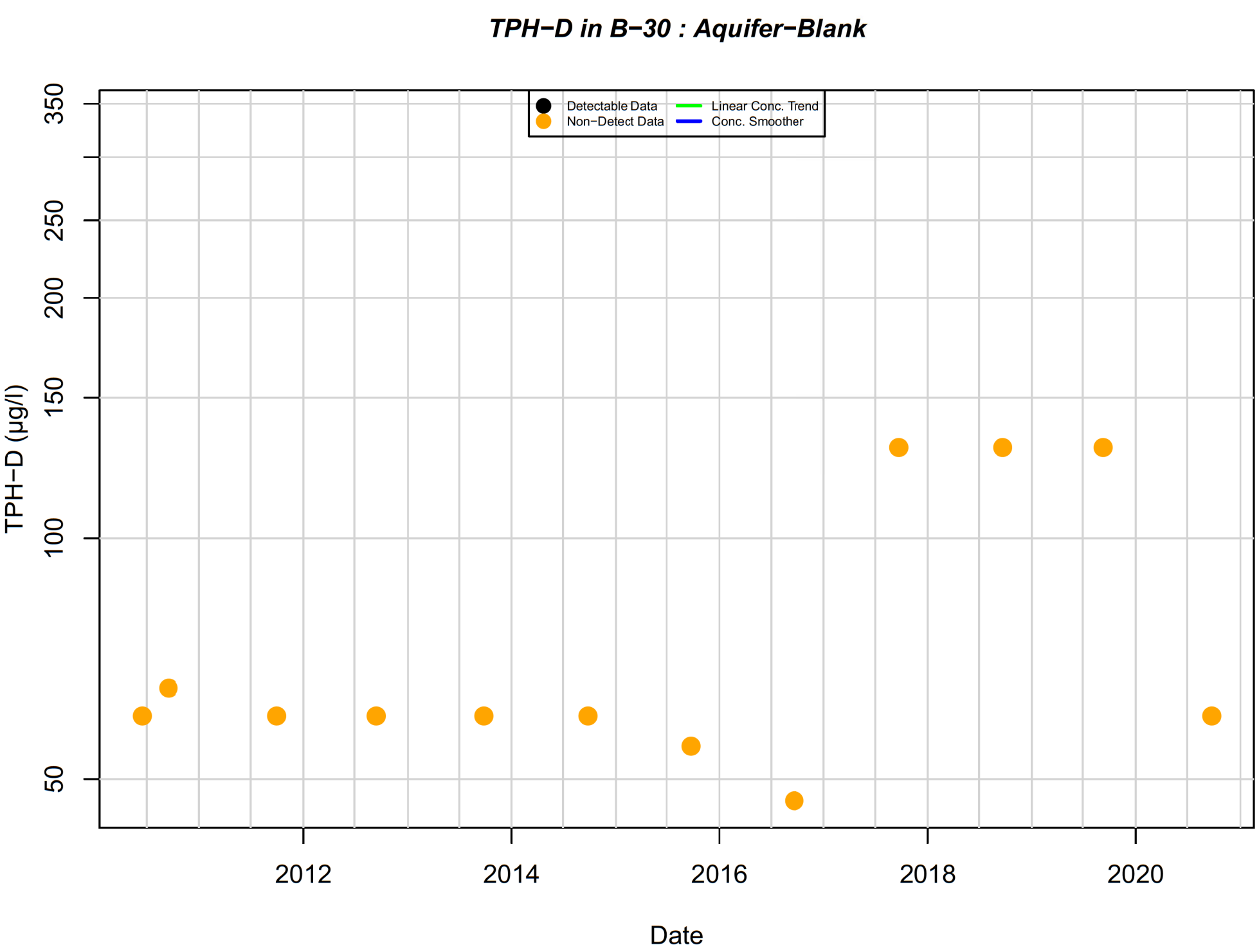

TPH−G in DMW−2 : Aquifer−Blank
Mann−Kendall P.Value= 0.0328; Half−Life= 409 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
200
100
50
2019
2020
Date

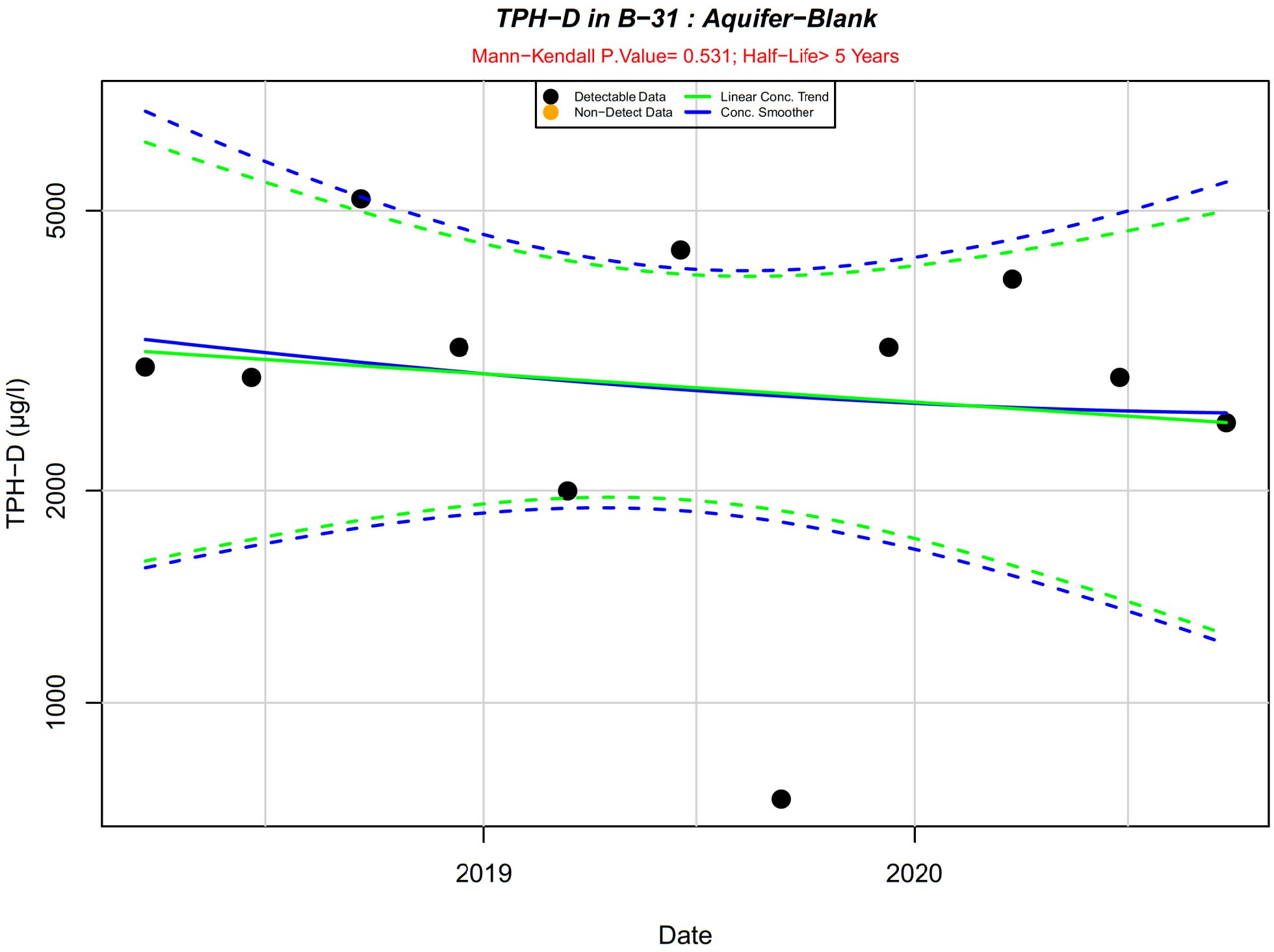

TPH-G in DMW-3 : Aquifer-Blank
Mann-Kendall P.Value= 0.226; Half-Life> -5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
50
100
200
500
1000
2000
2010
2012
2014
2016
2018
2020
Date

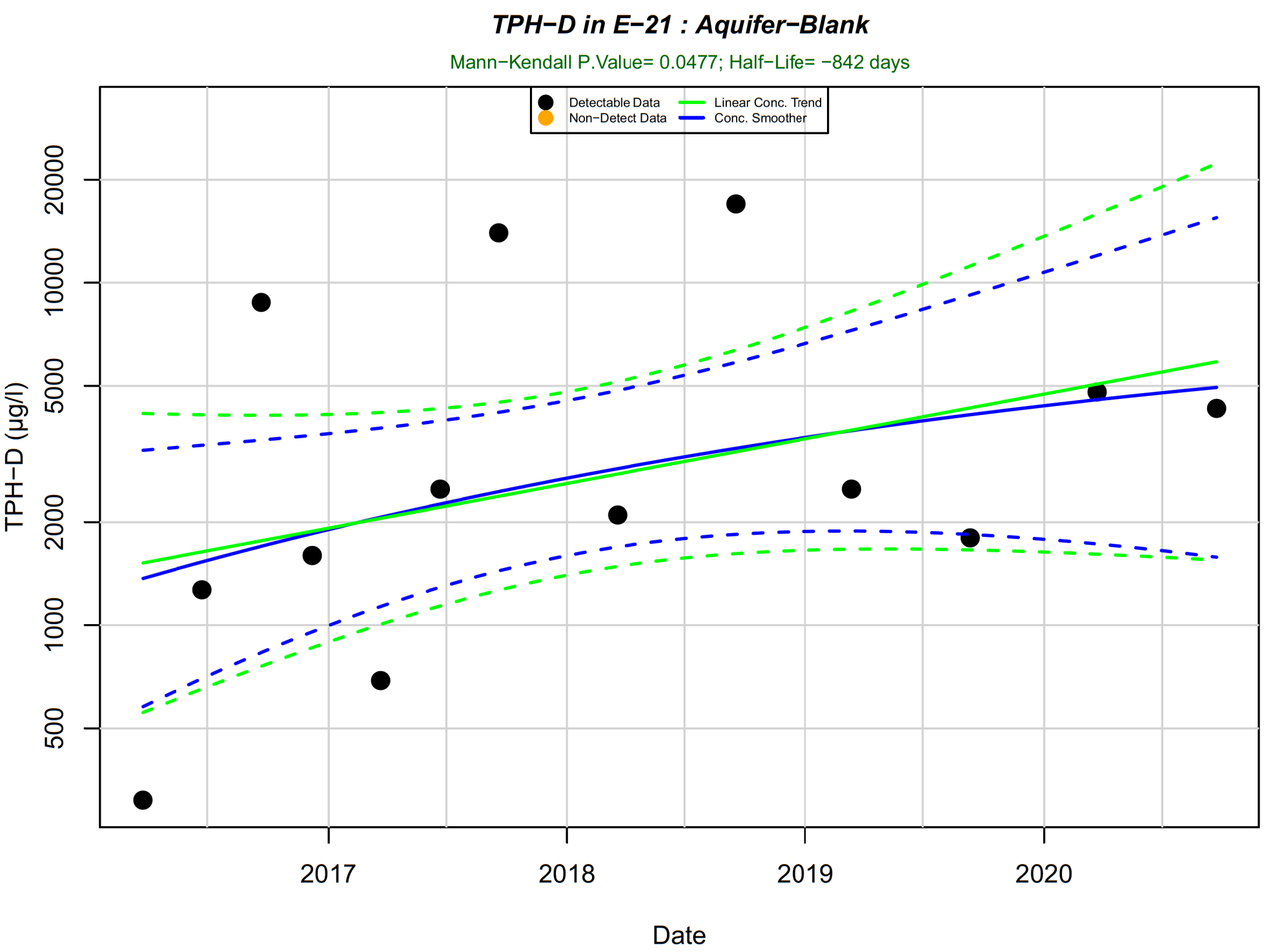

TPH−G in DMW−4 : Aquifer−Blank
Mann−Kendall P.Value= 0.117; Half−Life= 1423 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−G (µg/l)
600
500
400
300
200
2019
2020
Date

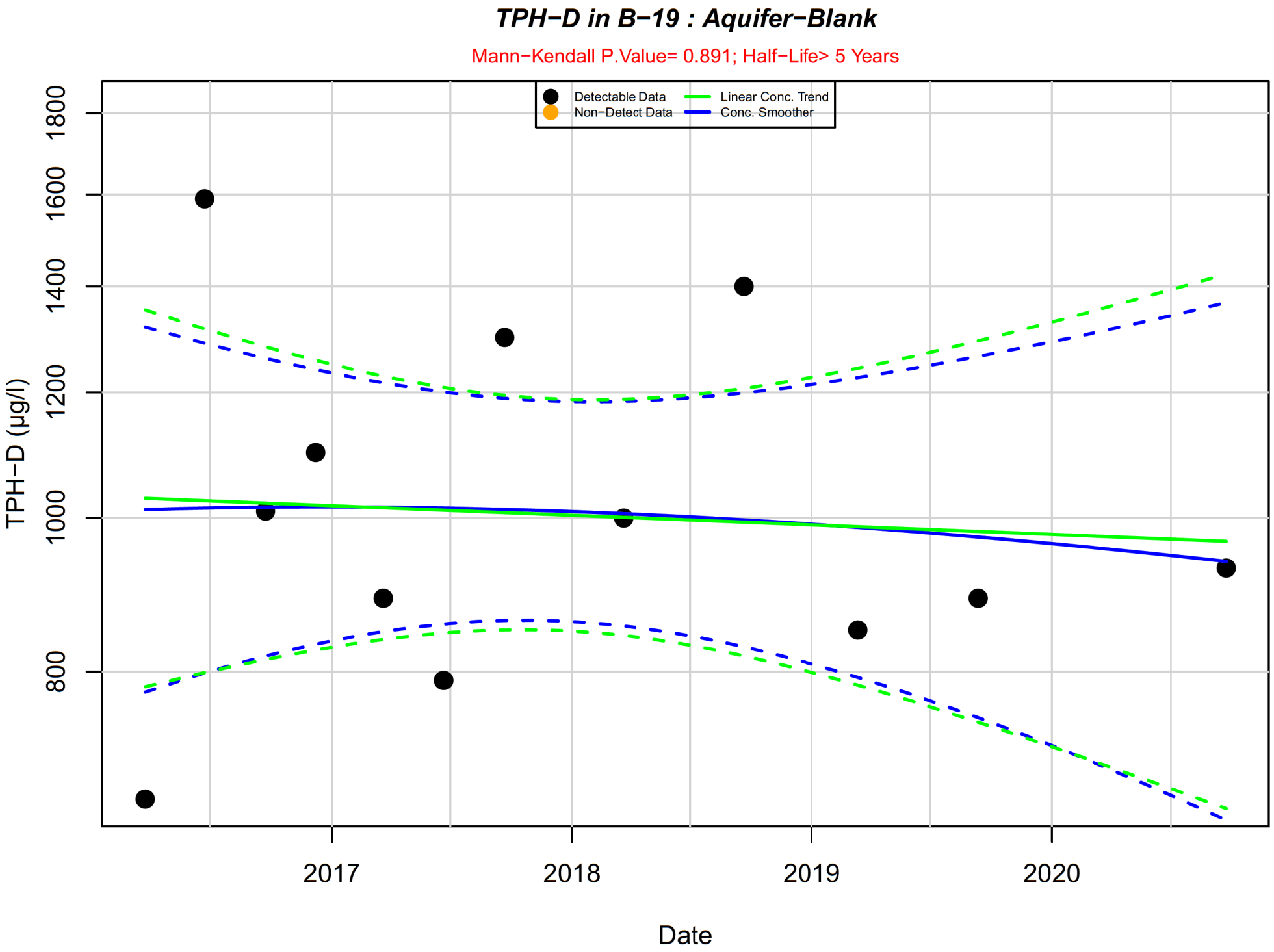

TPH-G in FW-13 : Aquifer-Blank
Mann-Kendall P.Value= 0.458; Half-Life= 1219 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-G (µg/l)
150
100
50
2019
2020
Date

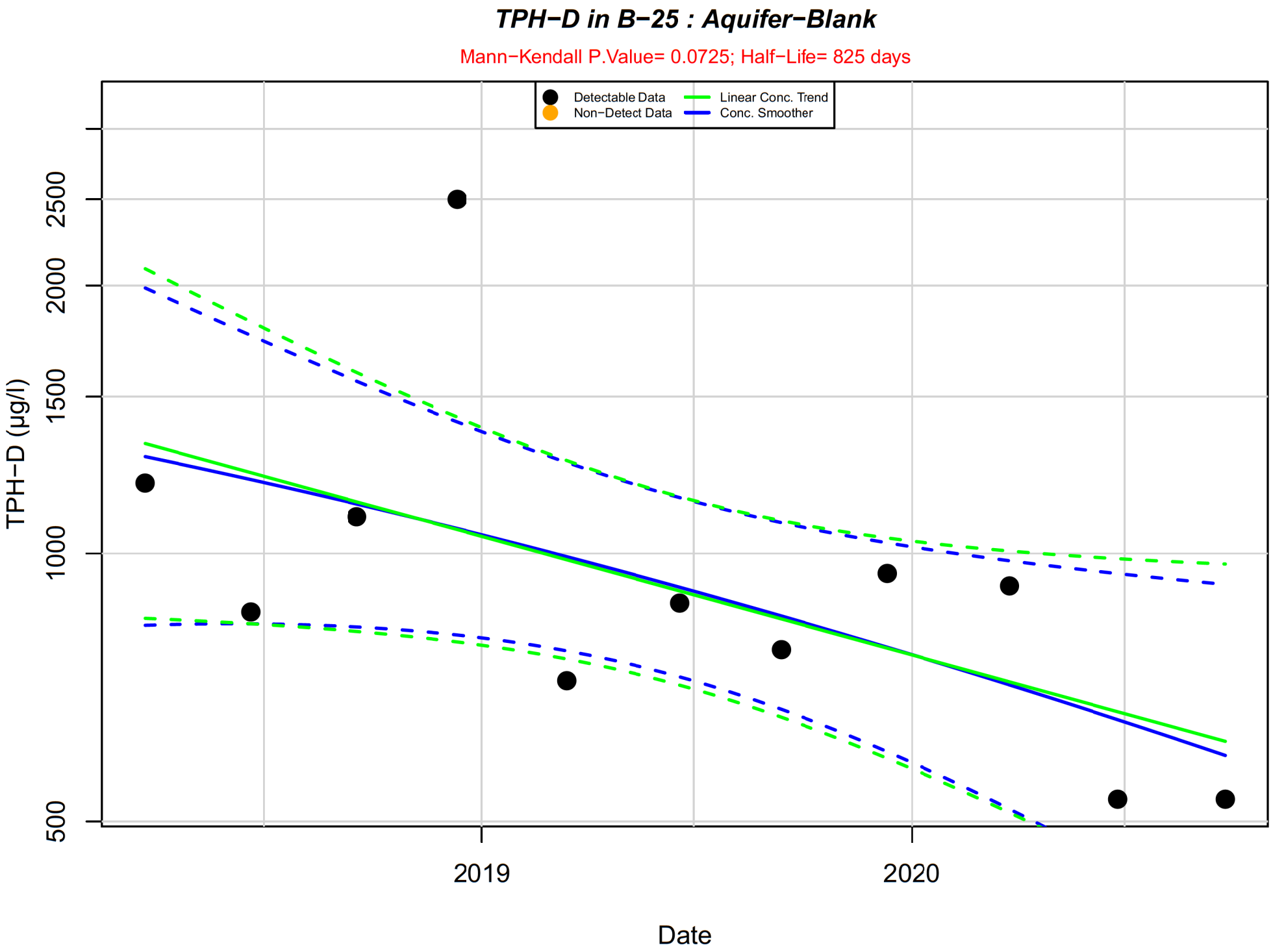

TPH-D in B-17B : Aquifer-Blank
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
350
250
200
150
100
50
2010
2012
2014
2016
2018
2020
Date

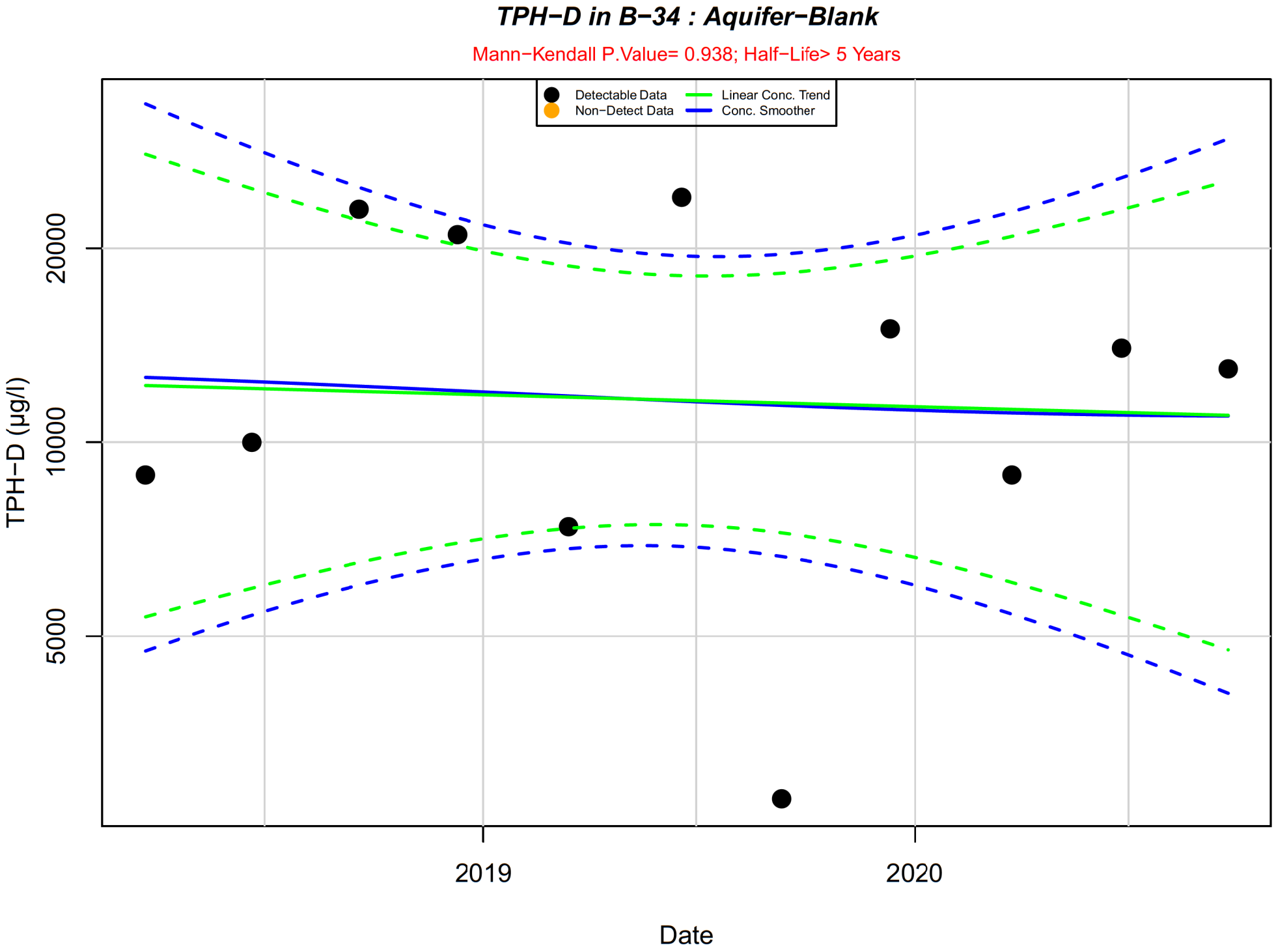

TPH-D in B-30 : Aquifer-Blank
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
350
250
200
150
100
50
2012
2014
2016
2018
2020
Date

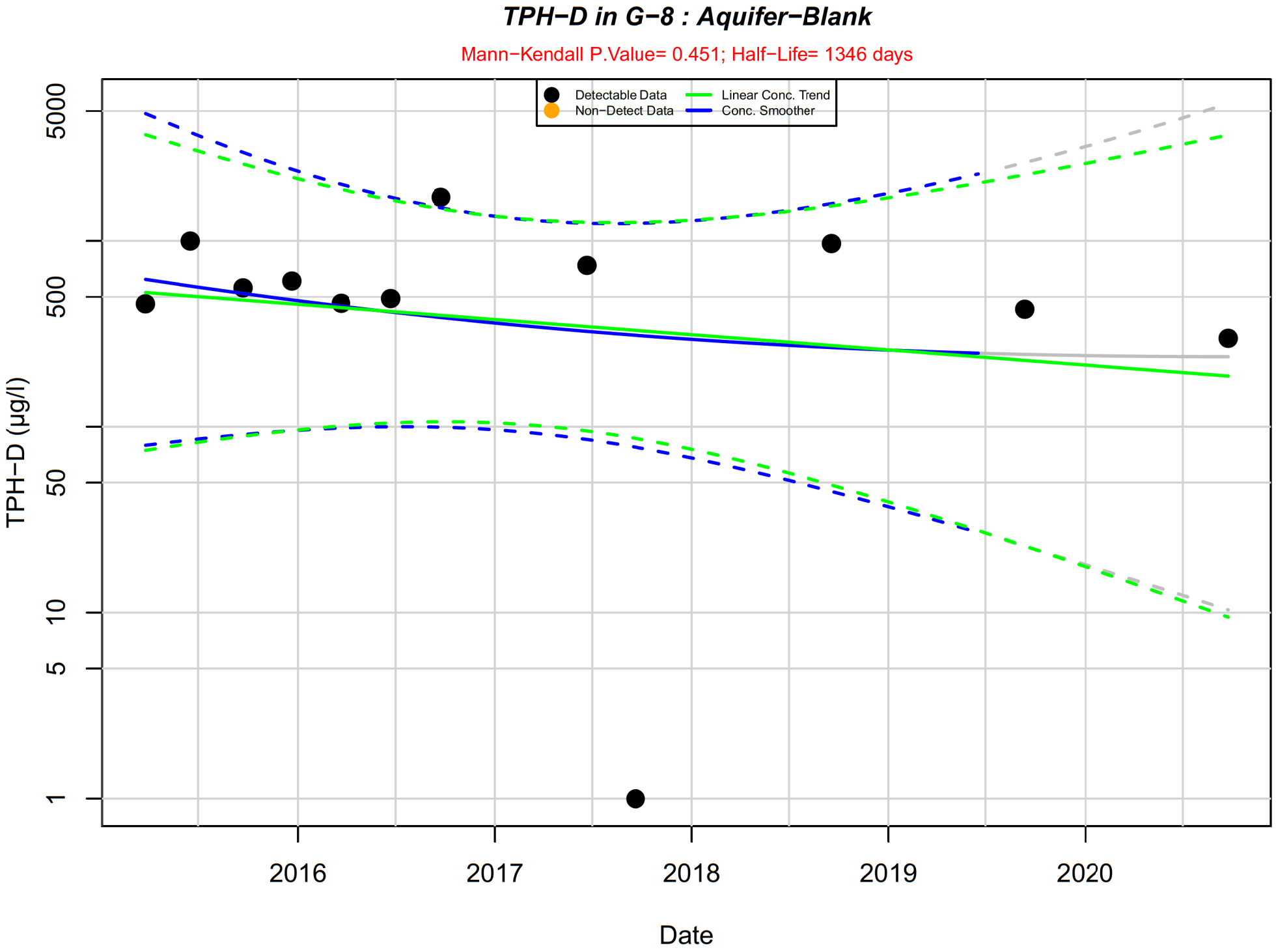

TPH-D in B-31 : Aquifer-Blank
Mann-Kendall P.Value= 0.531; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
5000
2000
1000
2019
2020
Date

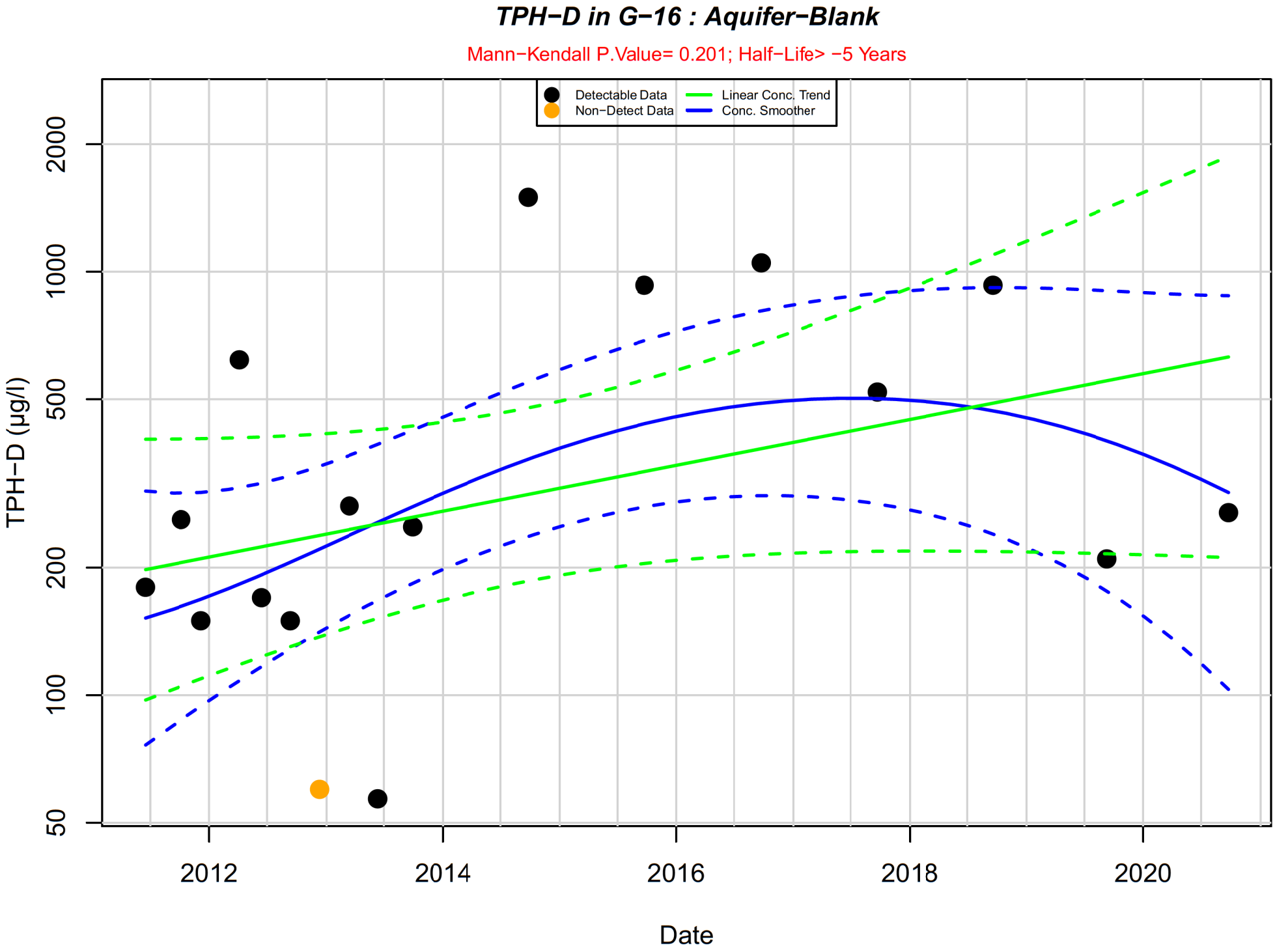

TPH−D in E−21 : Aquifer−Blank
Mann−Kendall P.Value= 0.0477; Half−Life= −842 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−D (µg/l)
500
1000
2000
5000
10000
20000
2017
2018
2019
2020
Date

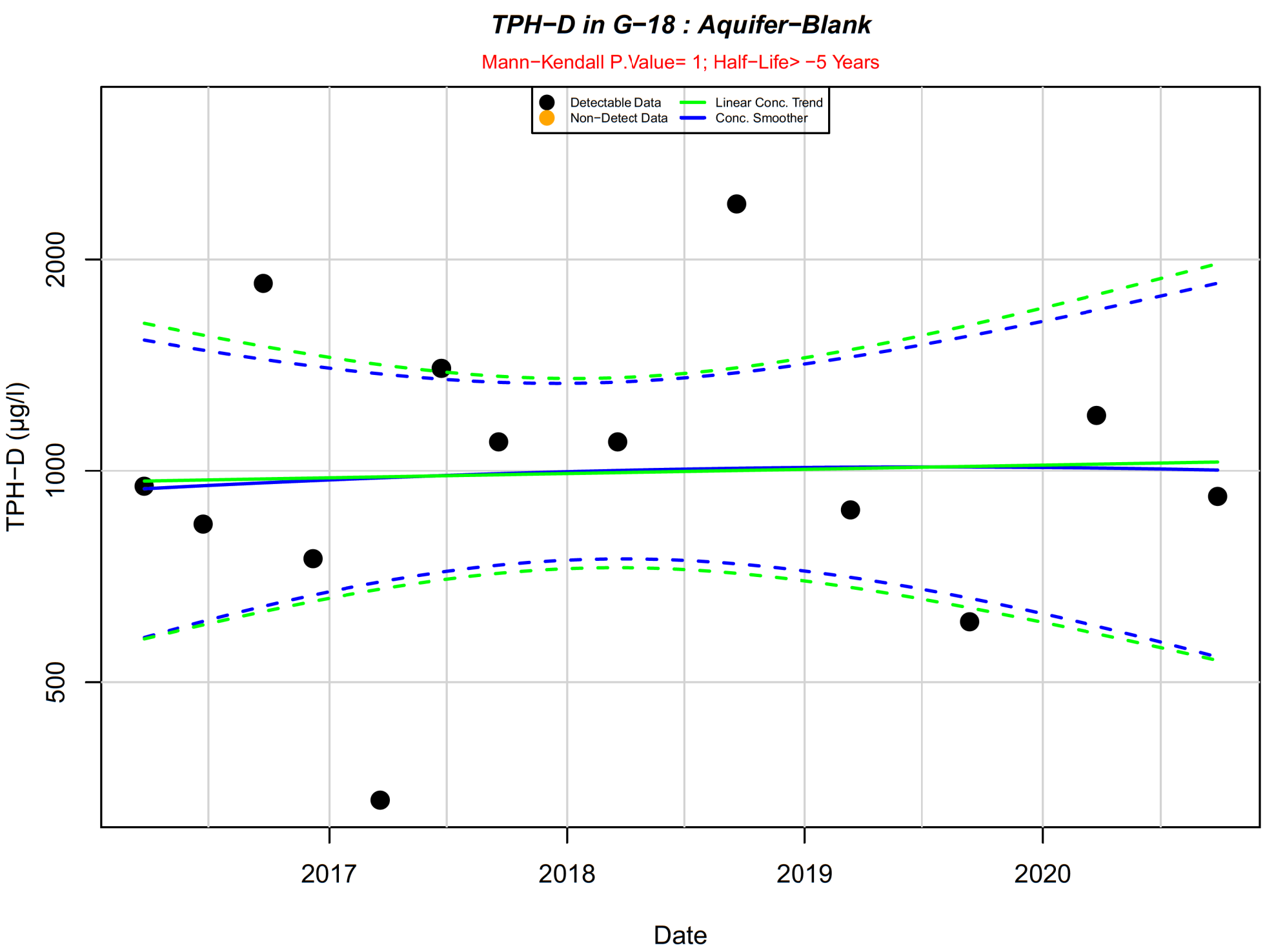

TPH-D in B-19 : Aquifer-Blank
Mann-Kendall P.Value= 0.891; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
800
1000
1200
1400
1600
1800
2017
2018
2019
2020
Date

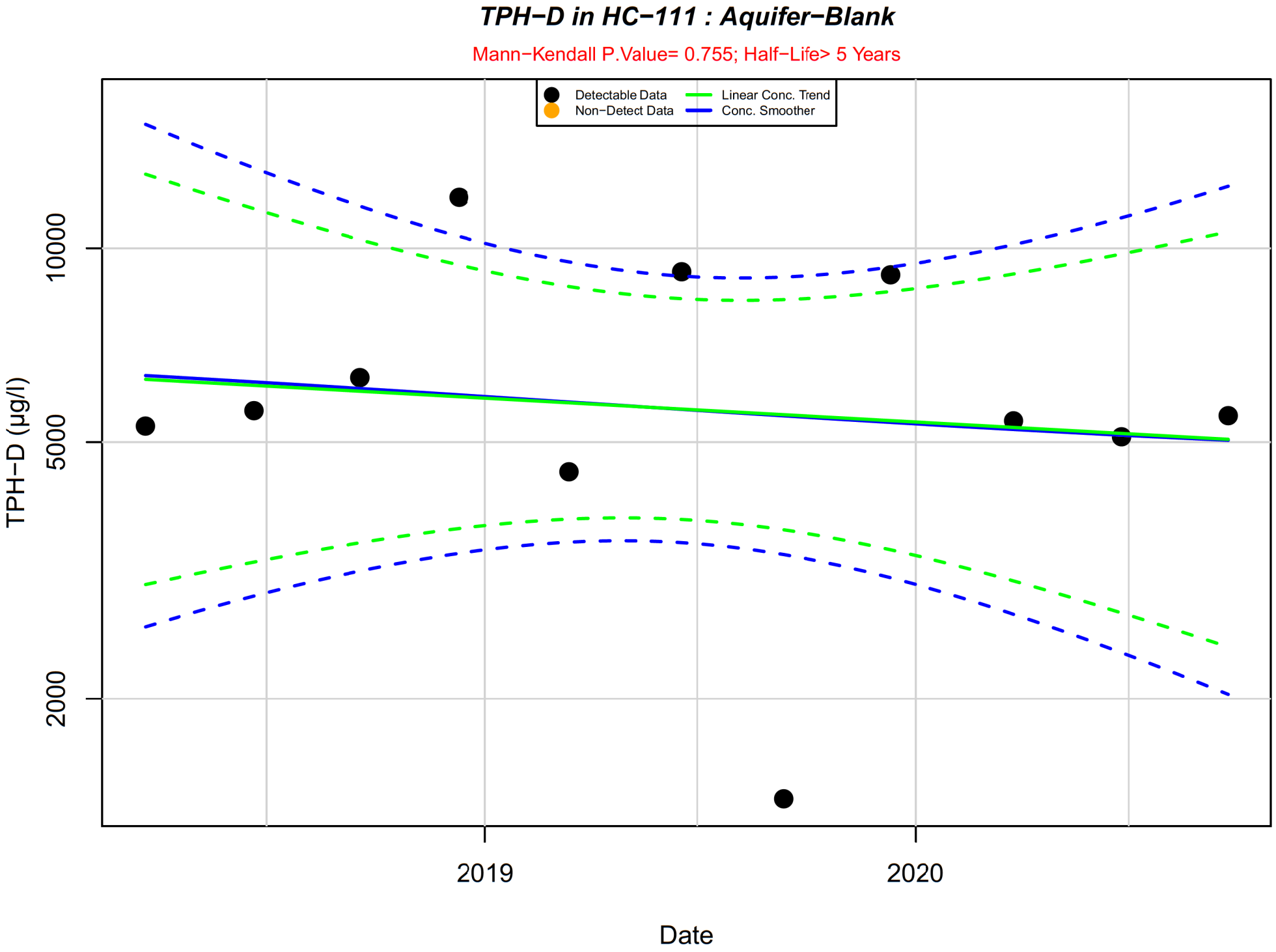

TPH-D in B-25 : Aquifer-Blank
Mann-Kendall P.Value= 0.0725; Half-Life= 825 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
500
1000
1500
2000
2500
2019
2020
Date

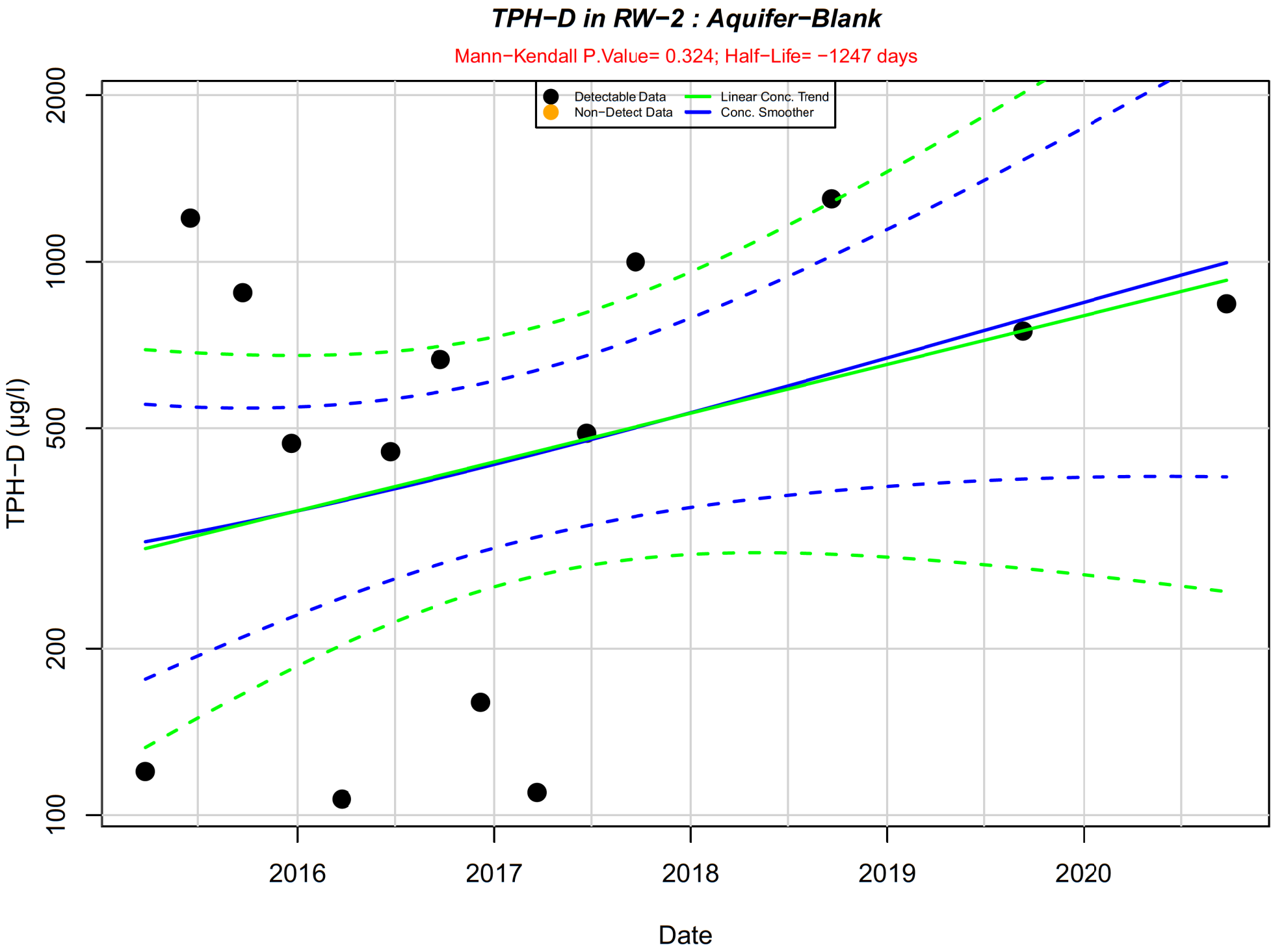

TPH-D in B-34 : Aquifer-Blank
Mann-Kendall P.Value= 0.938; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
20000
10000
5000
2019
2020
Date

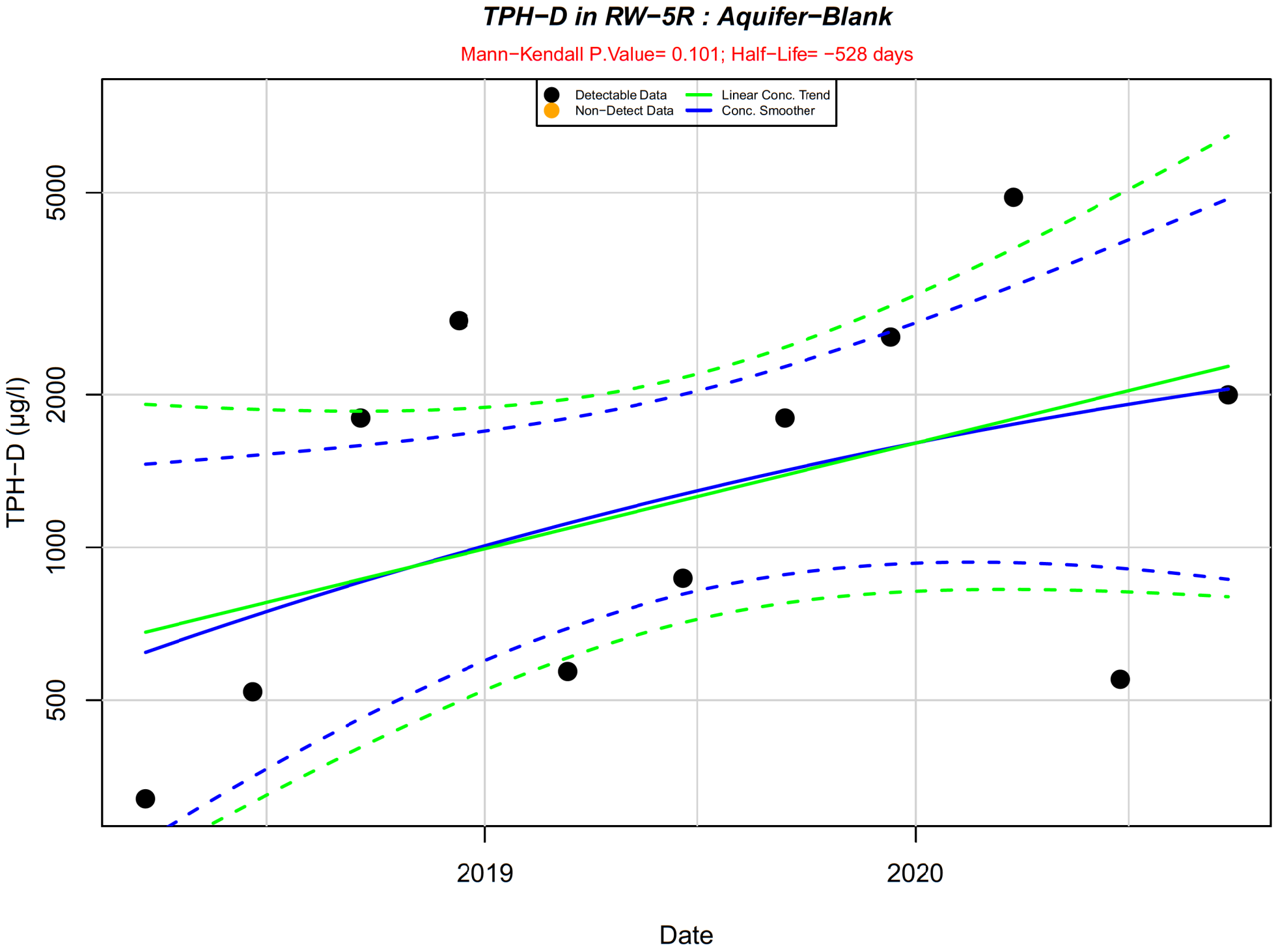

TPH-D in G-8 : Aquifer-Blank
Mann-Kendall P.Value= 0.451; Half-Life= 1346 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
5000
500
50
10
5
1
2016
2017
2018
2019
2020
Date

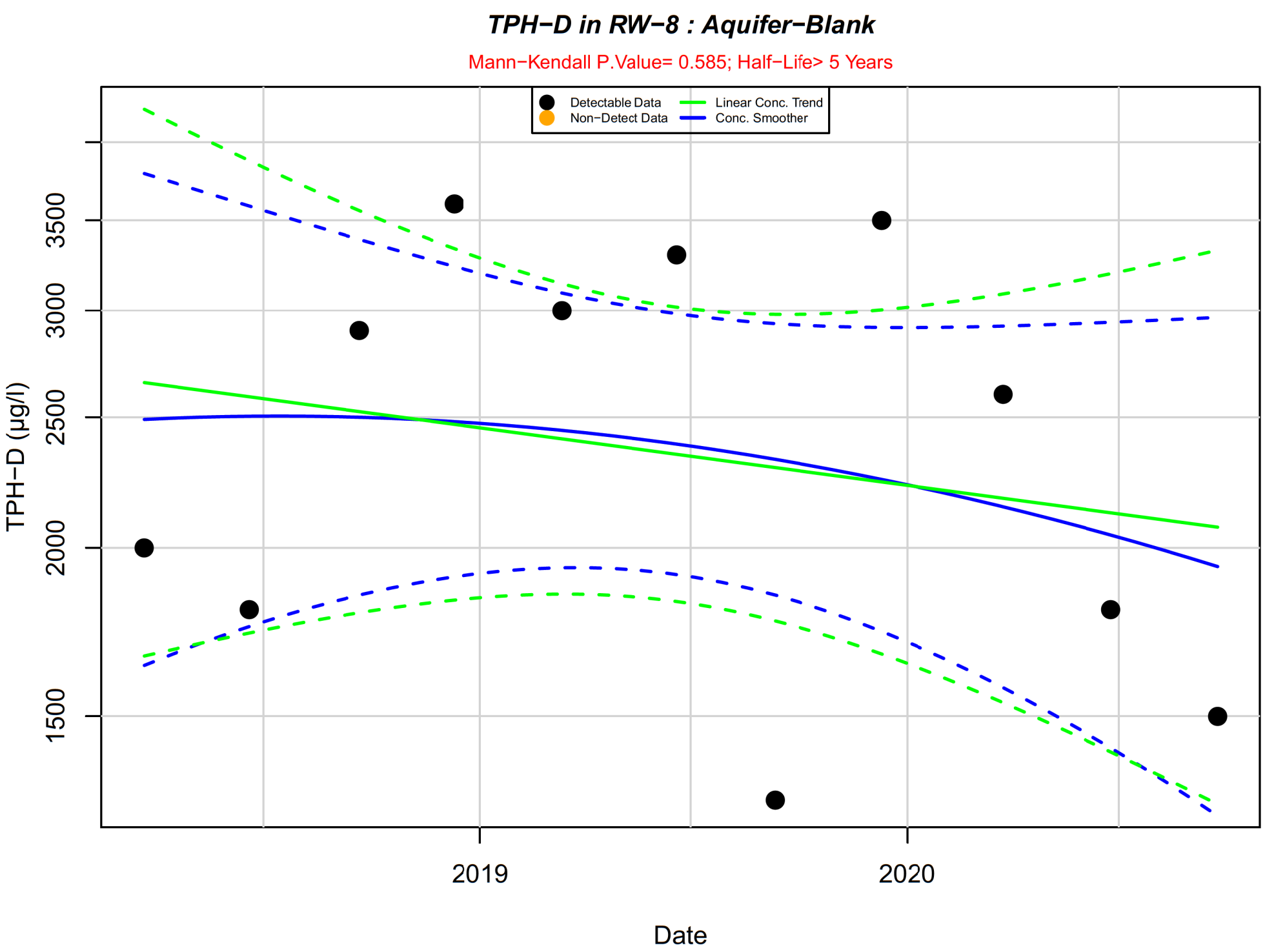

TPH-D in G-16 : Aquifer-Blank
Mann-Kendall P.Value= 0.201; Half-Life> -5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
50
100
200
500
1000
2000
2012
2014
2016
2018
2020
Date

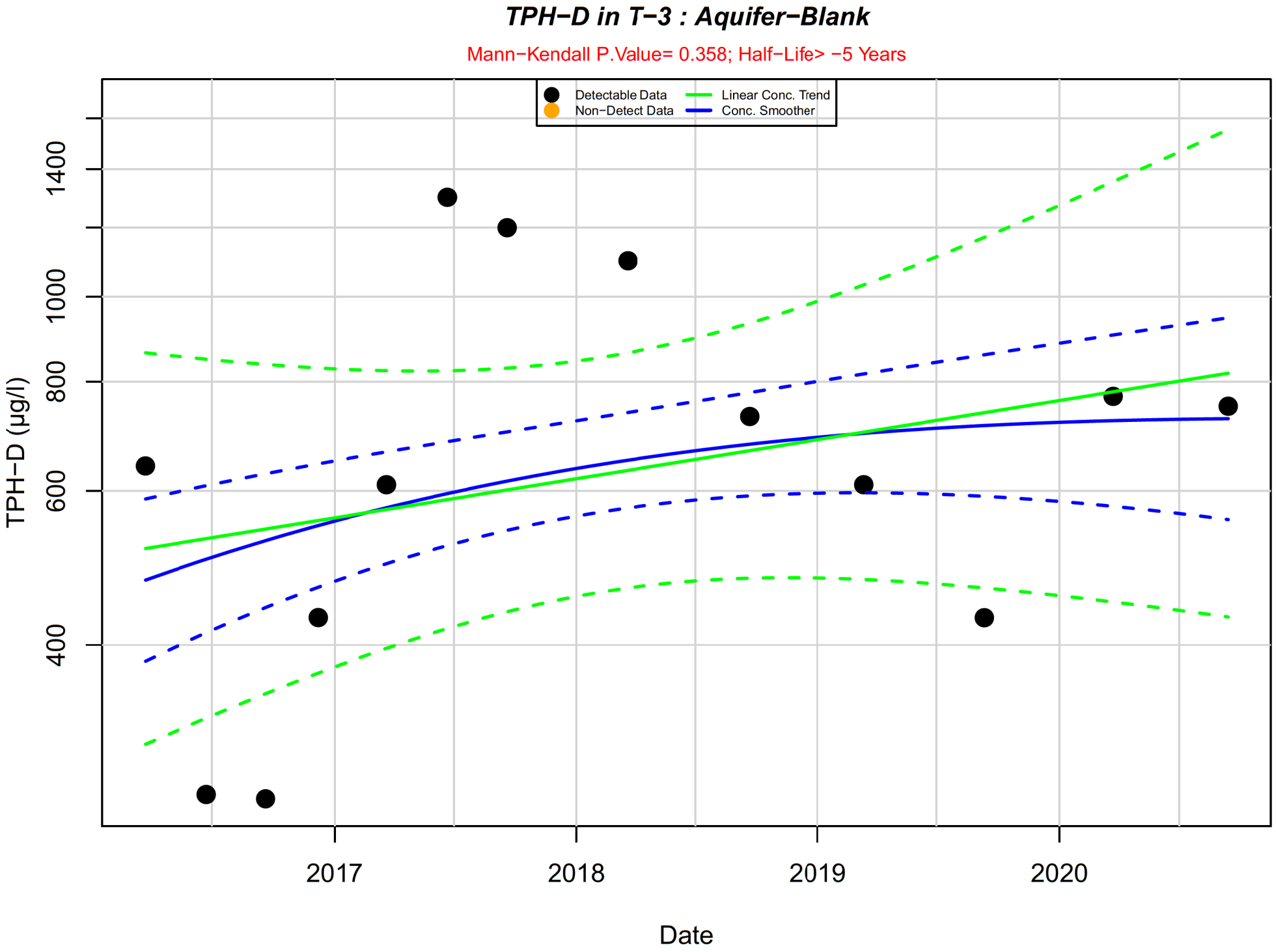

TPH-D in G-18 : Aquifer-Blank
Mann-Kendall P.Value= 1; Half-Life> -5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
2000
1000
500
2017
2018
2019
2020
Date

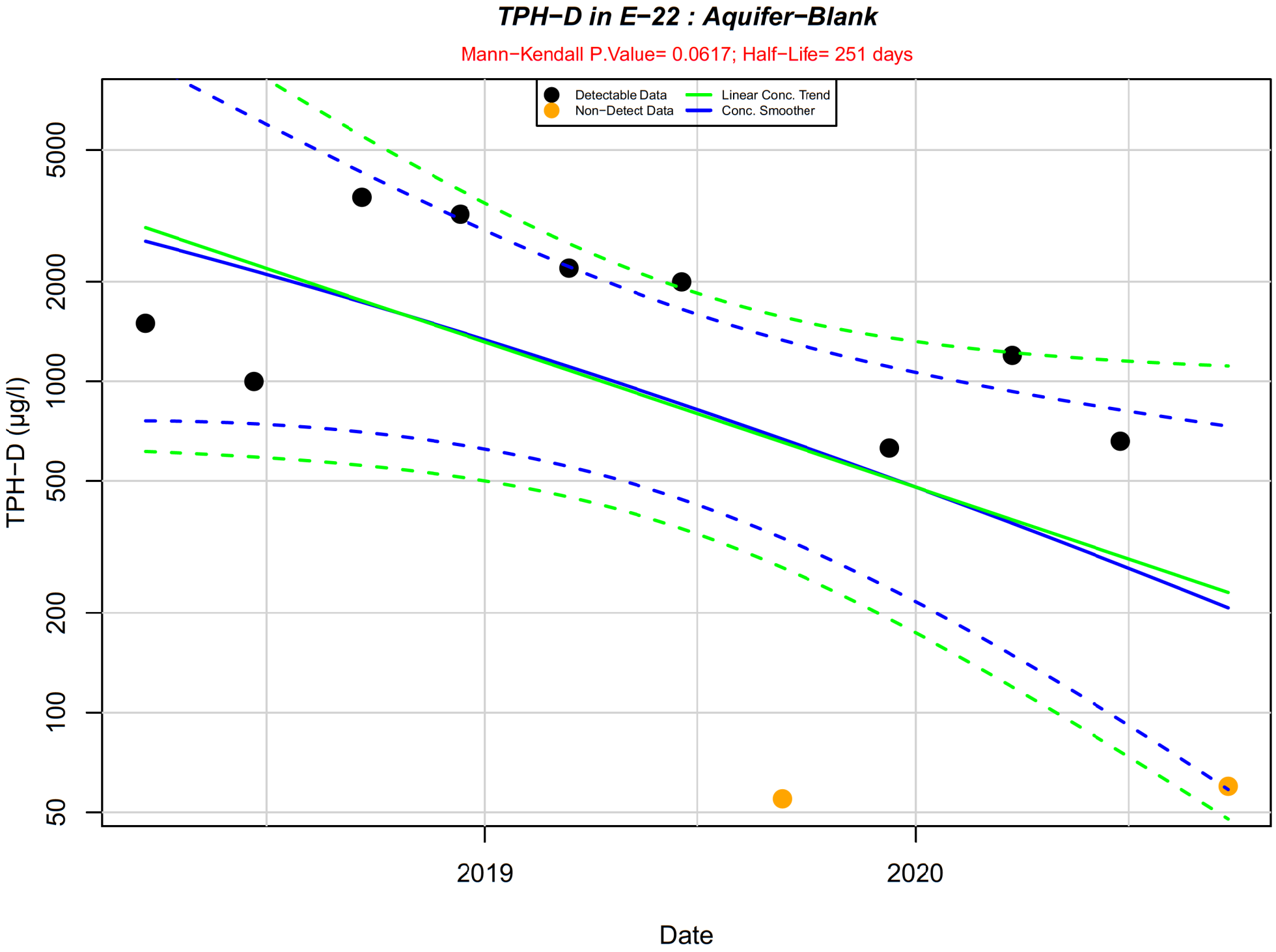

TPH-D in HC-111 : Aquifer-Blank
Mann-Kendall P.Value= 0.755; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
10000
5000
2000
2019
2020
Date

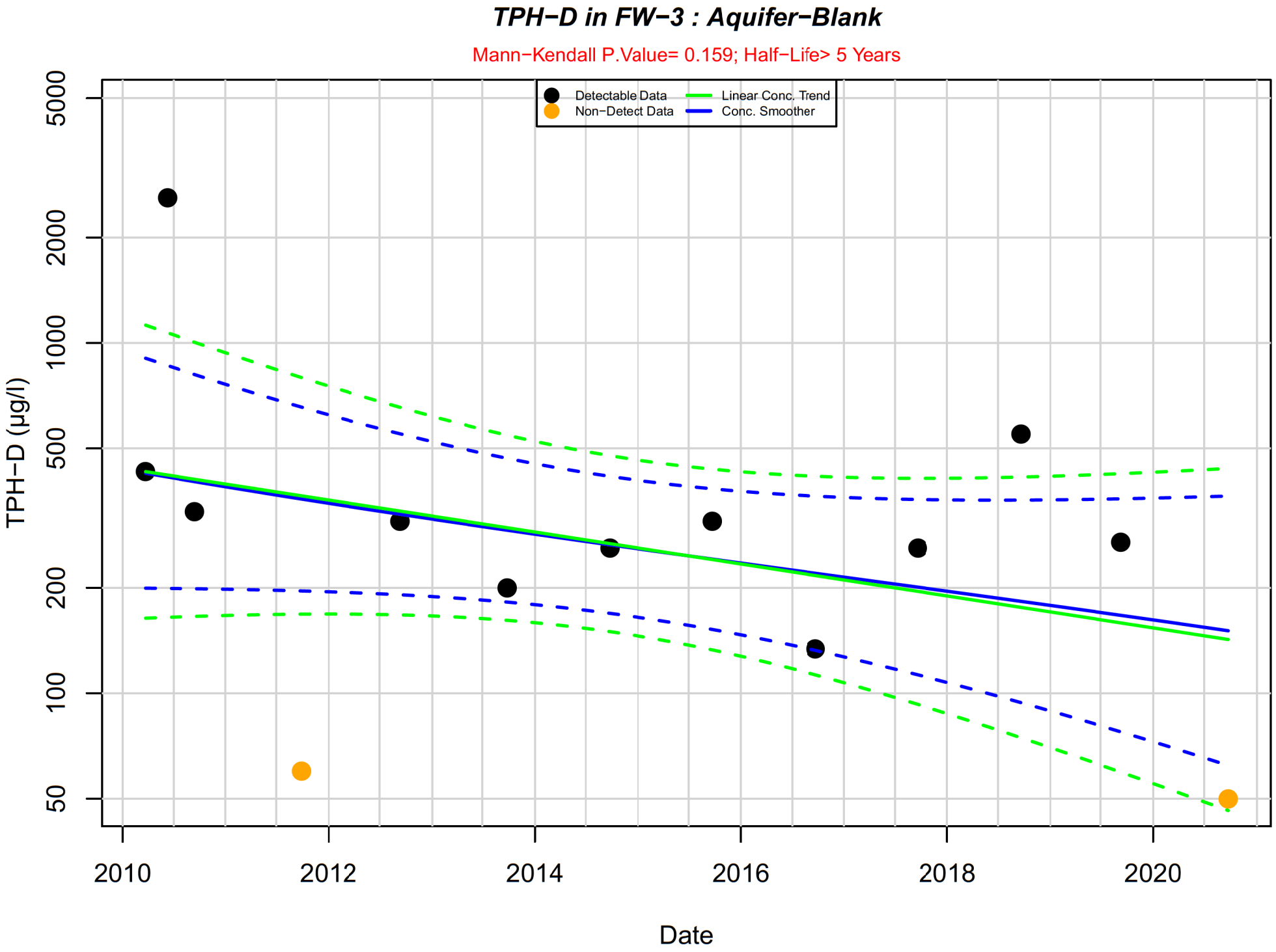

TPH-D in RW-2 : Aquifer-Blank
Mann-Kendall P.Value= 0.324; Half-Life= -1247 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
2000
1000
500
200
100
2016
2017
2018
2019
2020
Date

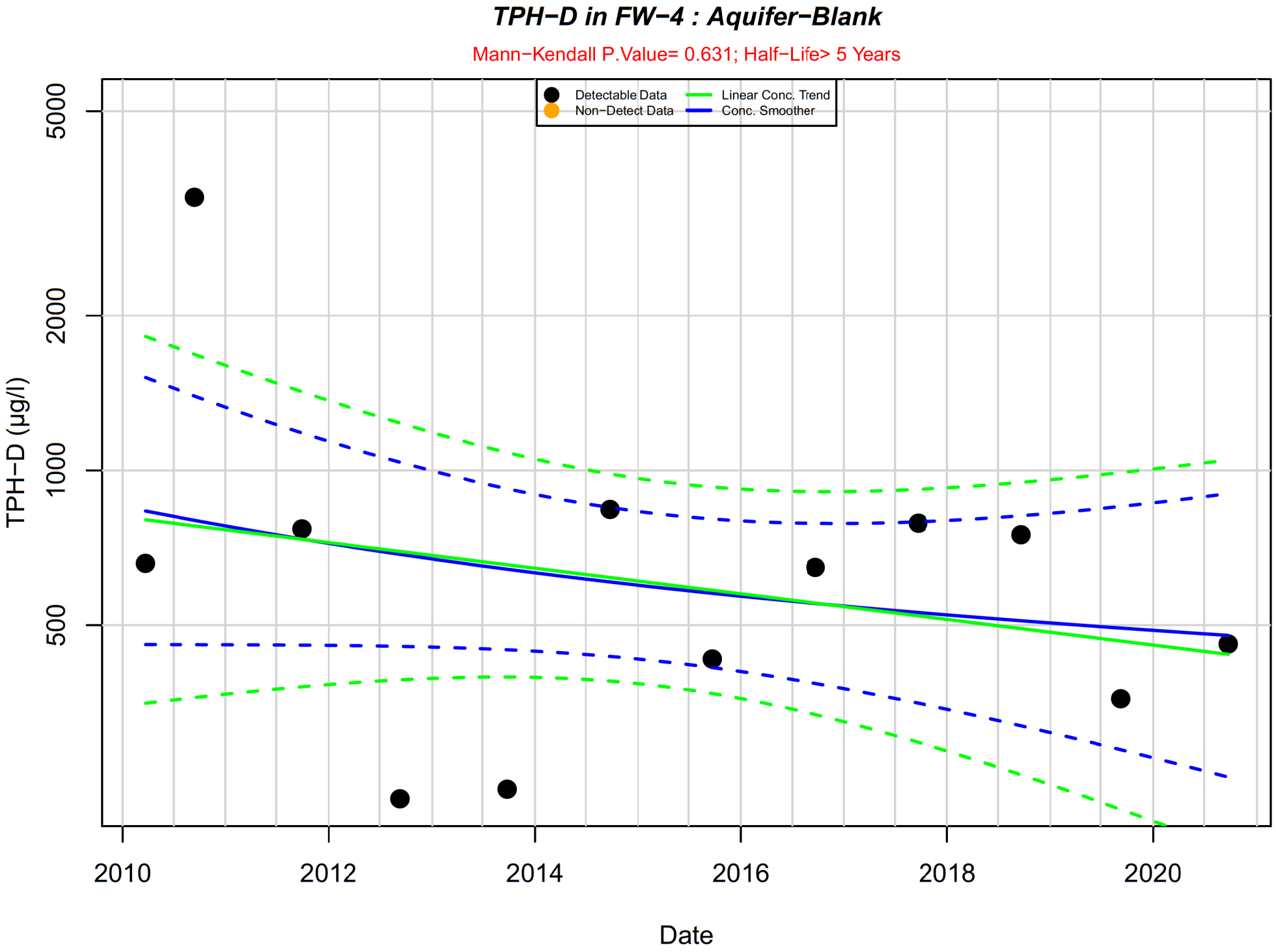

TPH−D in RW−5R : Aquifer−Blank
Mann−Kendall P.Value= 0.101; Half−Life= −528 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−D (µg/l)
500
1000
2000
5000
2019
2020
Date

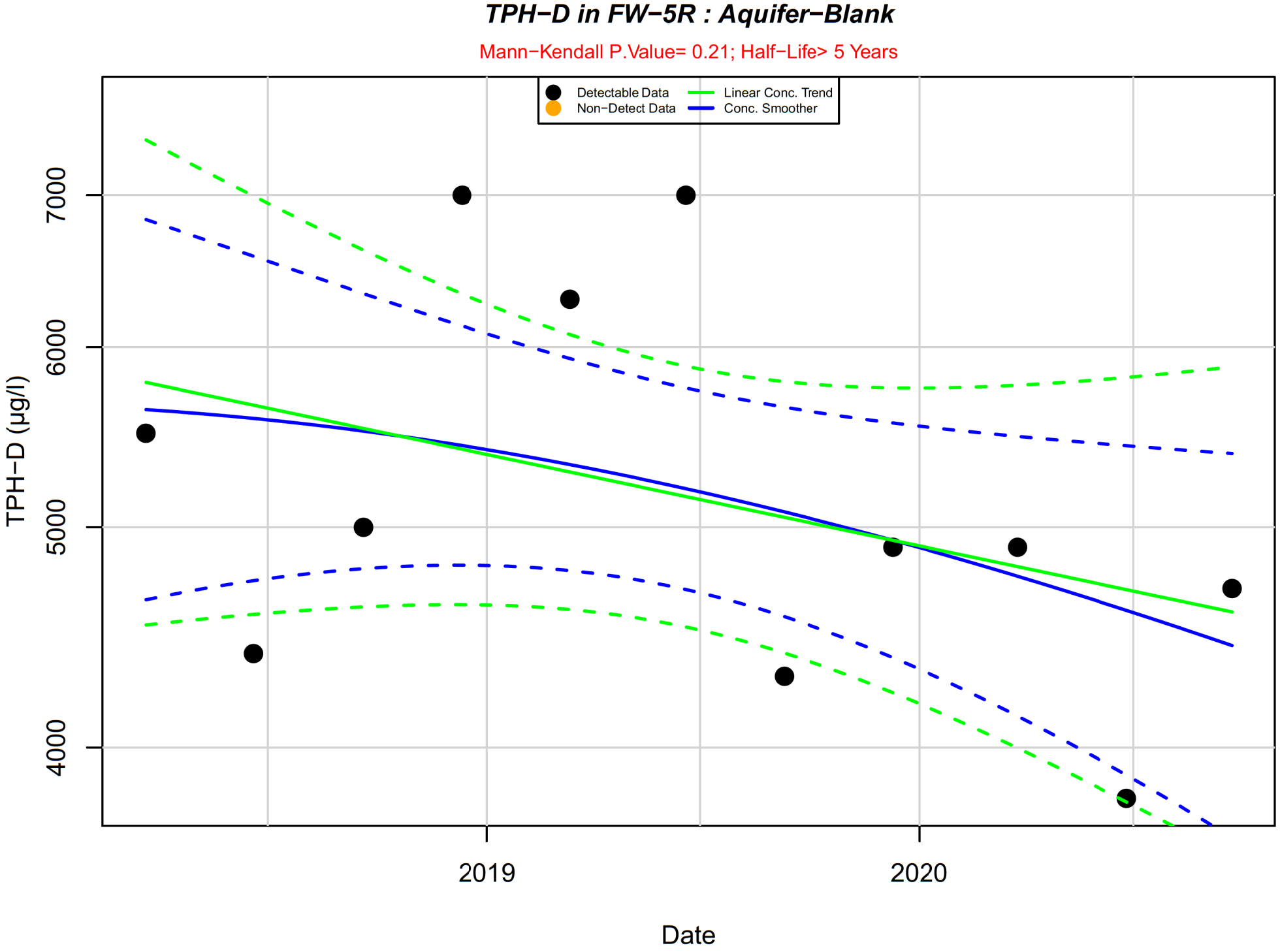

TPH-D in RW-8 : Aquifer-Blank
Mann-Kendall P.Value= 0.585; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
1500
2000
2500
3000
3500
2019
2020
Date

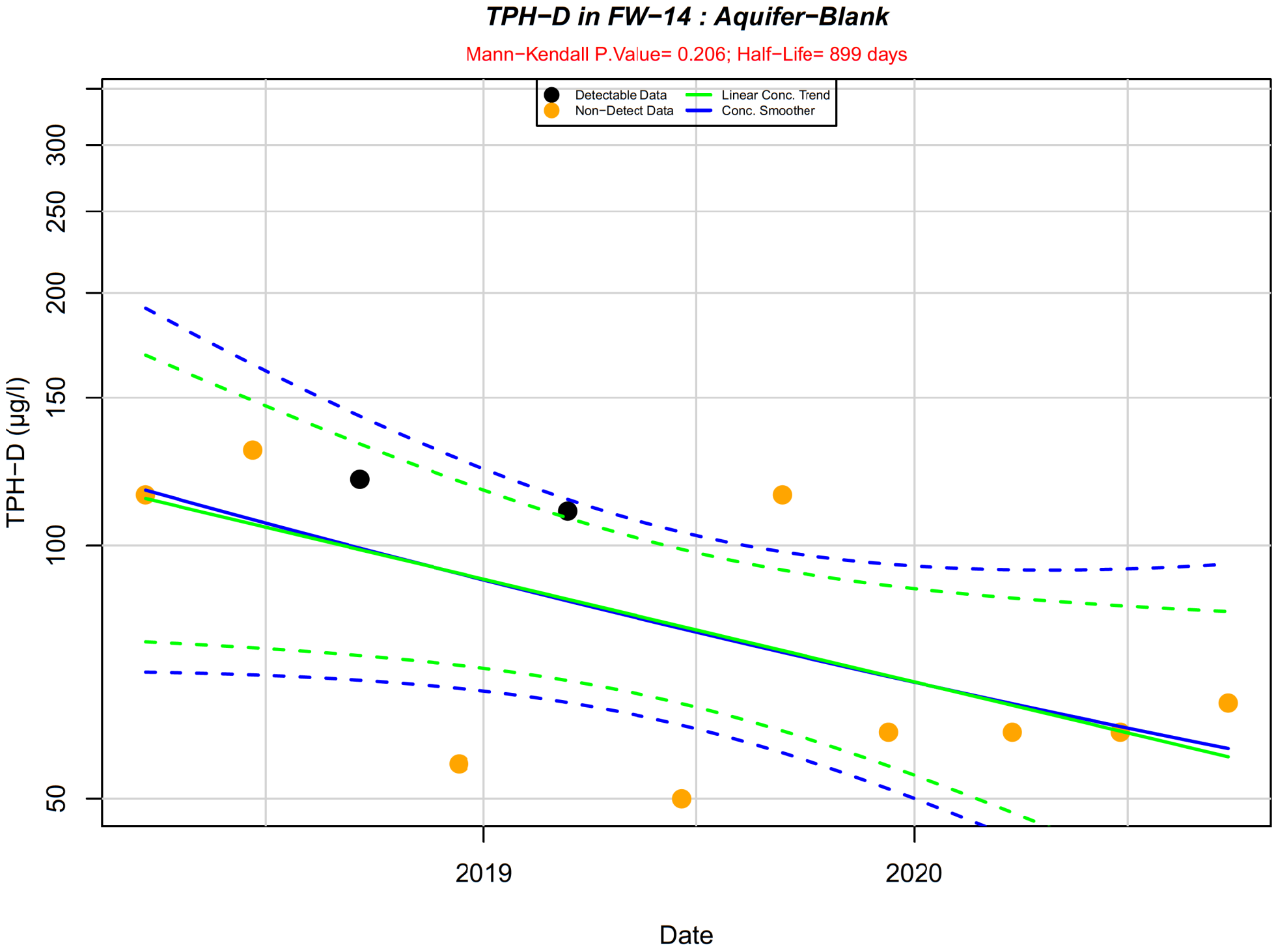

TPH-D in T-3 : Aquifer-Blank
Mann-Kendall P.Value= 0.358; Half-Life> -5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
400
600
800
1000
1400
2017
2018
2019
2020
Date

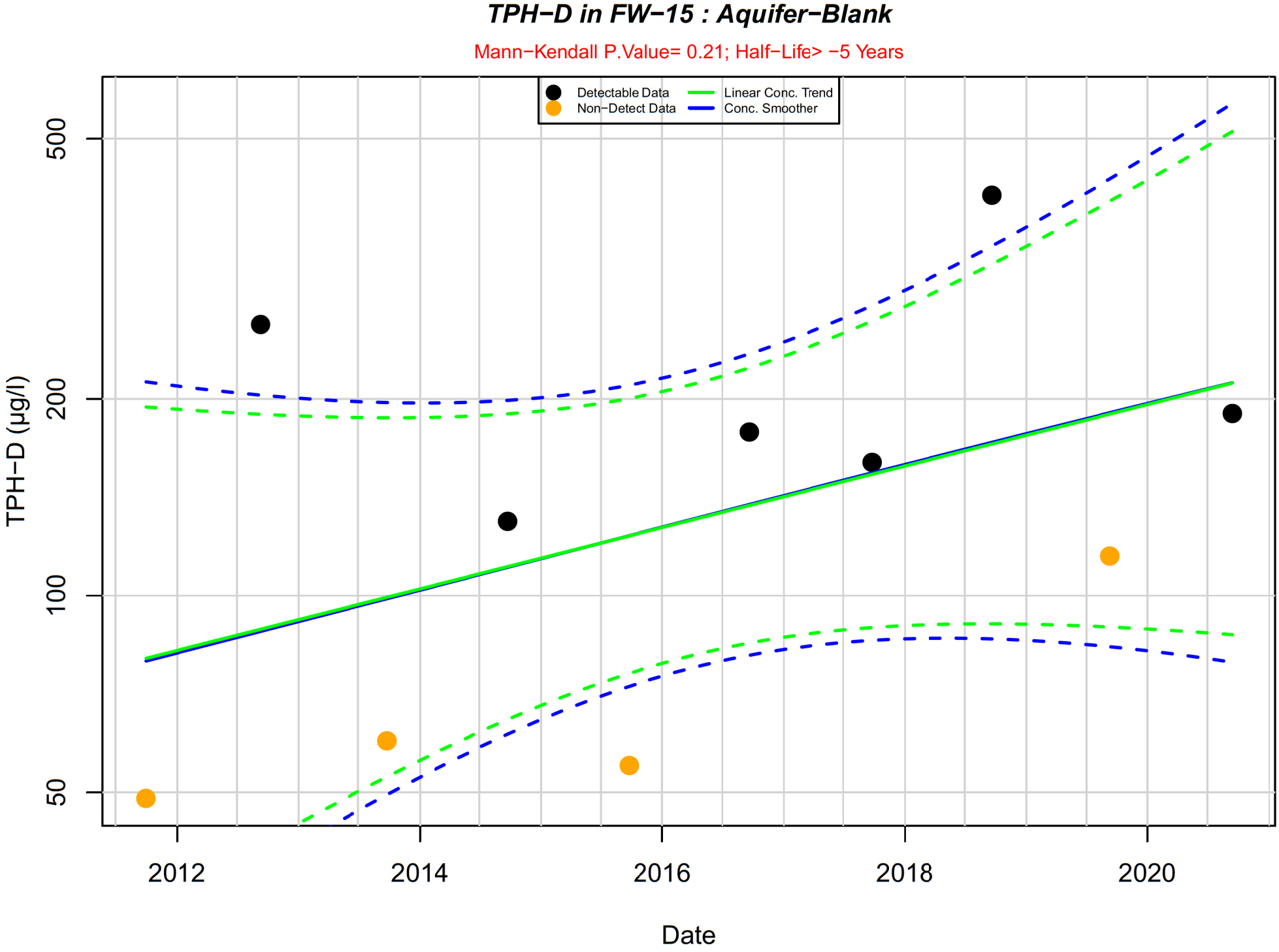

TPH-D in E-22 : Aquifer-Blank
Mann-Kendall P.Value= 0.0617; Half-Life= 251 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
5000
2000
1000
500
200
100
50
2019
2020
Date

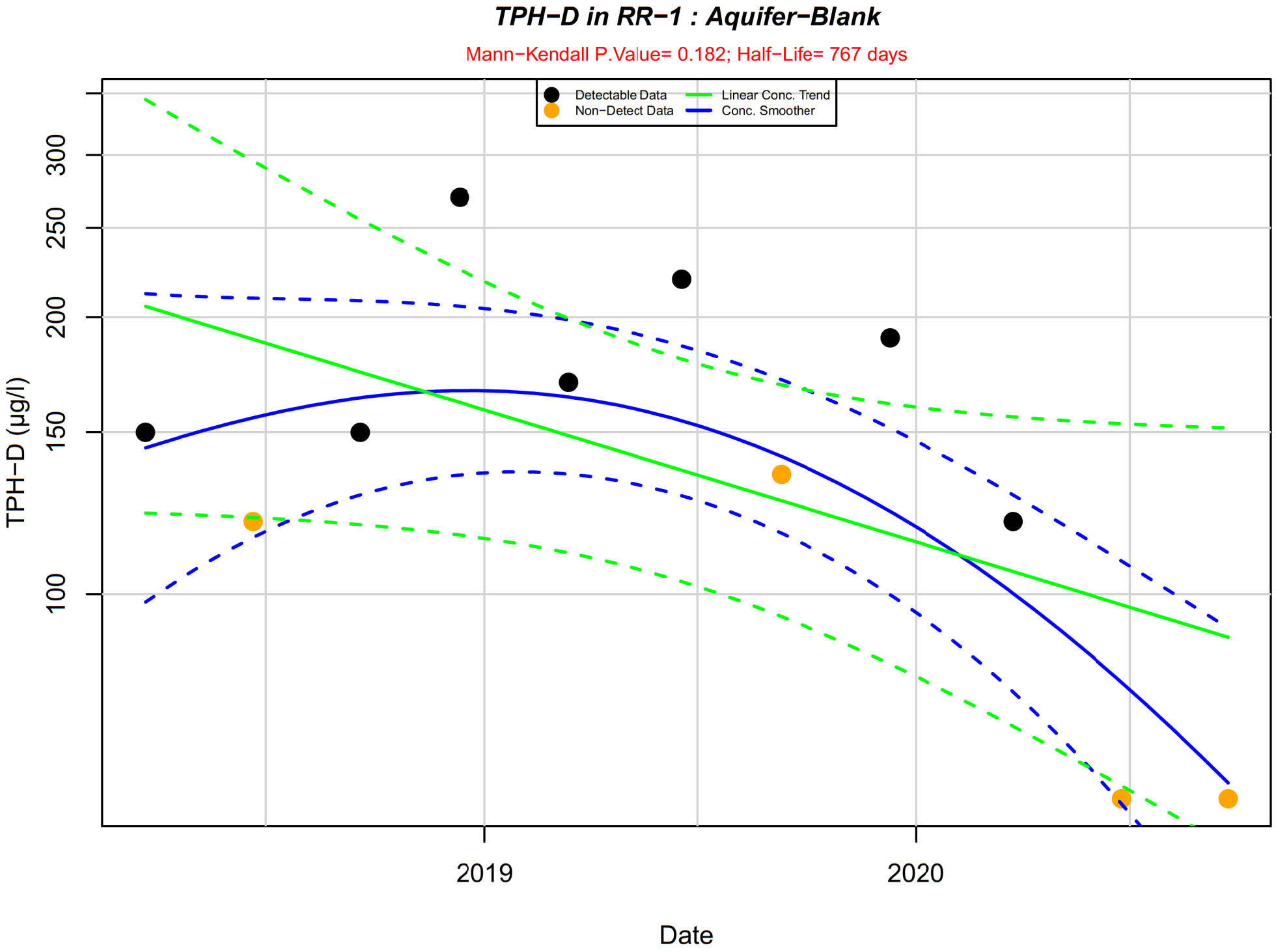

TPH-D in FW-3 : Aquifer-Blank
Mann-Kendall P.Value= 0.159; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
5000
2000
1000
500
200
100
50
2010
2012
2014
2016
2018
2020
Date

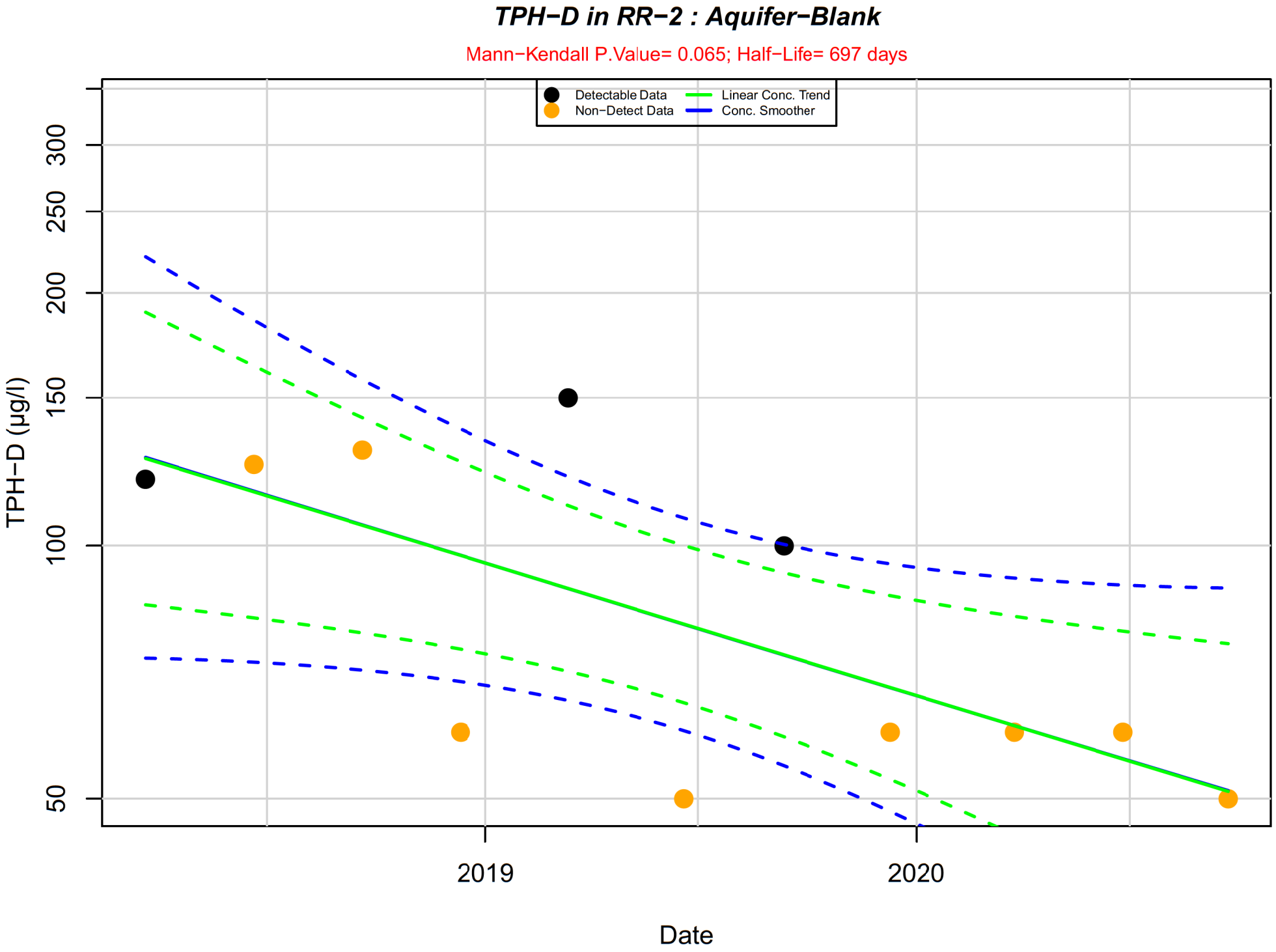

TPH-D in FW-4 : Aquifer-Blank
Mann-Kendall P.Value= 0.631; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
5000
2000
1000
500
2010
2012
2014
2016
2018
2020
Date

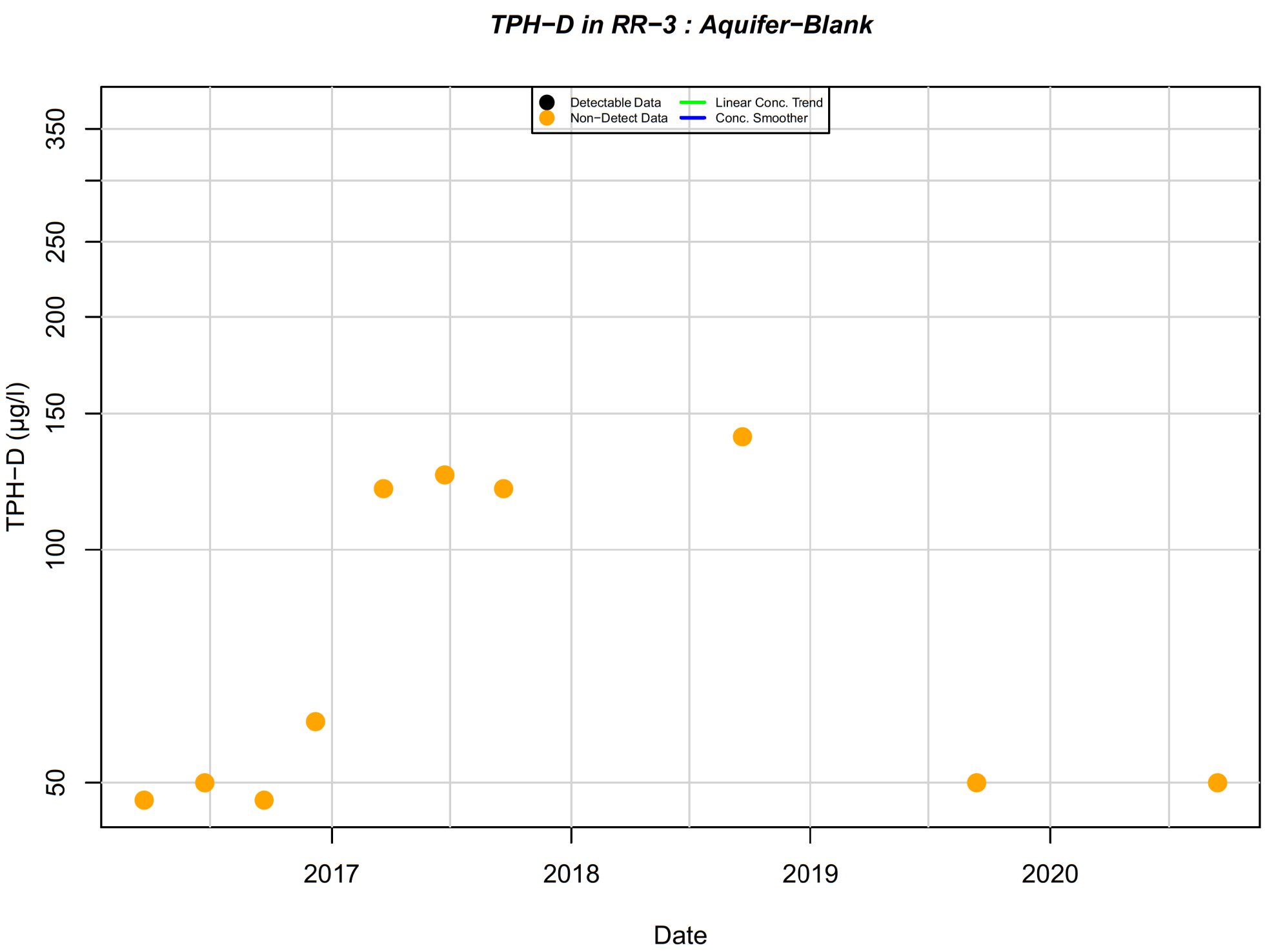

TPH-D in FW-5R : Aquifer-Blank
Mann-Kendall P.Value= 0.21; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
7000
6000
5000
4000
2019
2020
Date

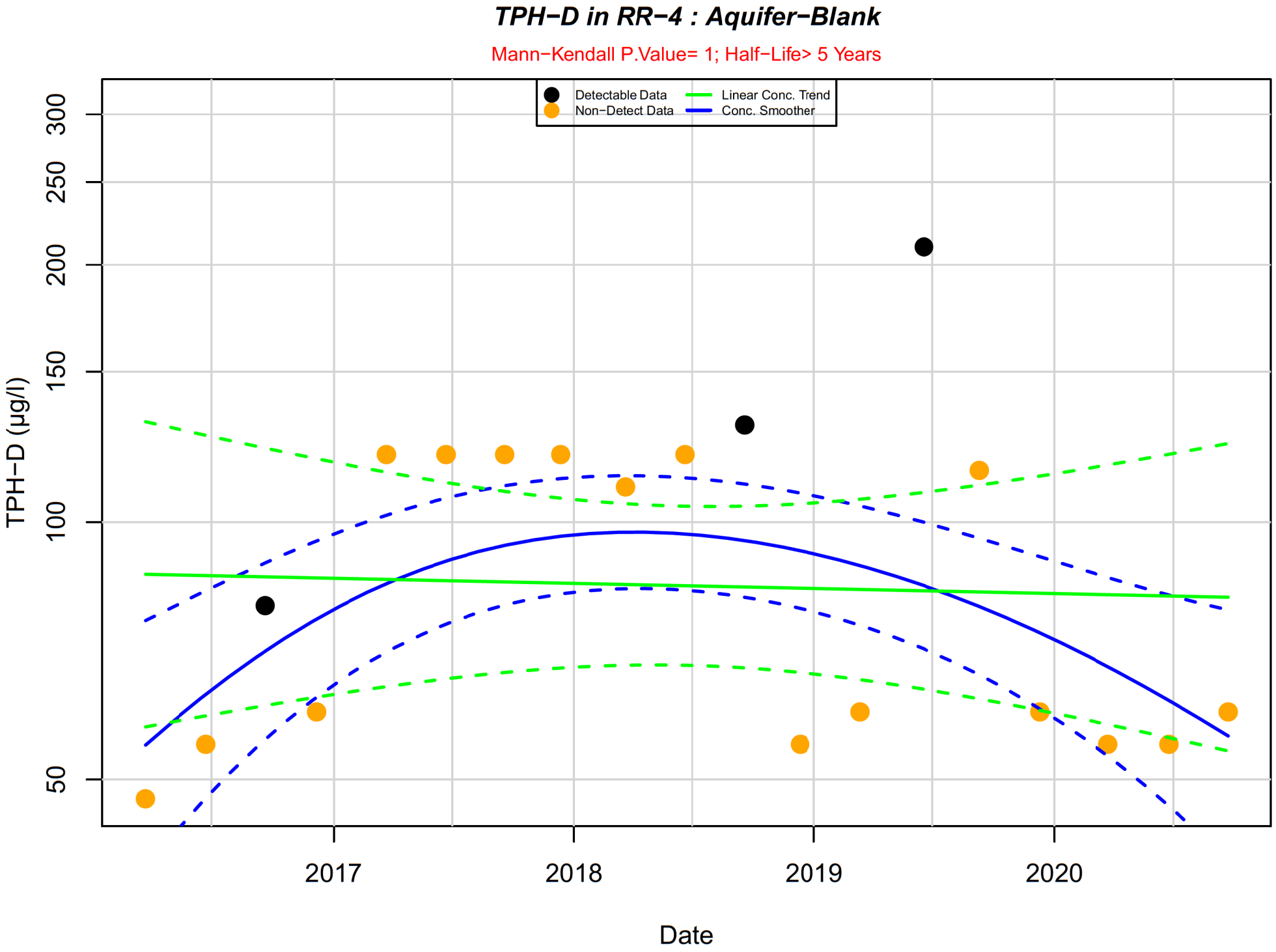

TPH-D in FW-14 : Aquifer-Blank
Mann-Kendall P.Value= 0.206; Half-Life= 899 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
300
250
200
150
100
50
2019
2020
Date

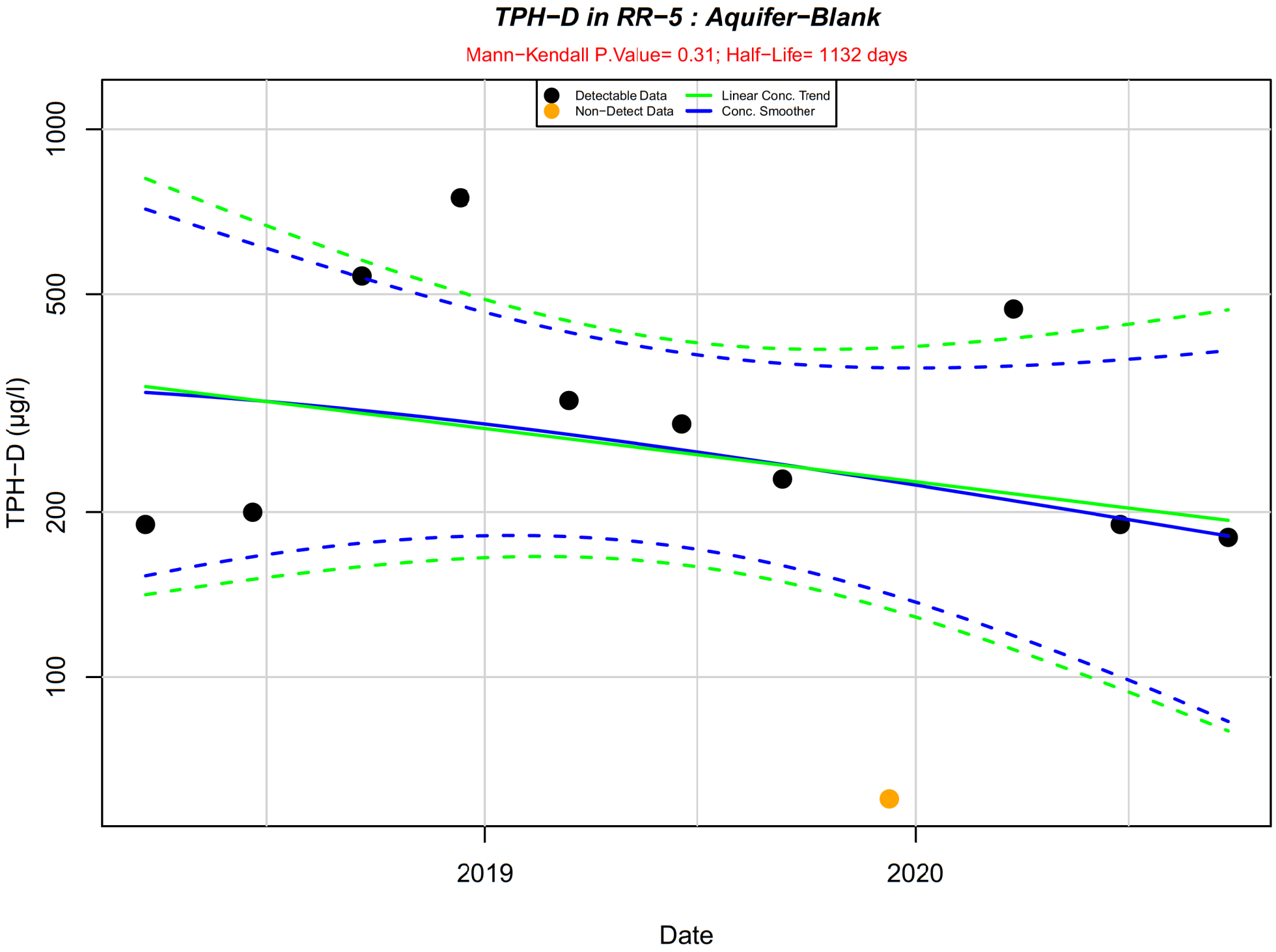

TPH−D in FW−15 : Aquifer−Blank
Mann−Kendall P.Value= 0.21; Half−Life> −5 Years
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−D (µg/l)
500
200
100
50
2012
2014
2016
2018
2020
Date

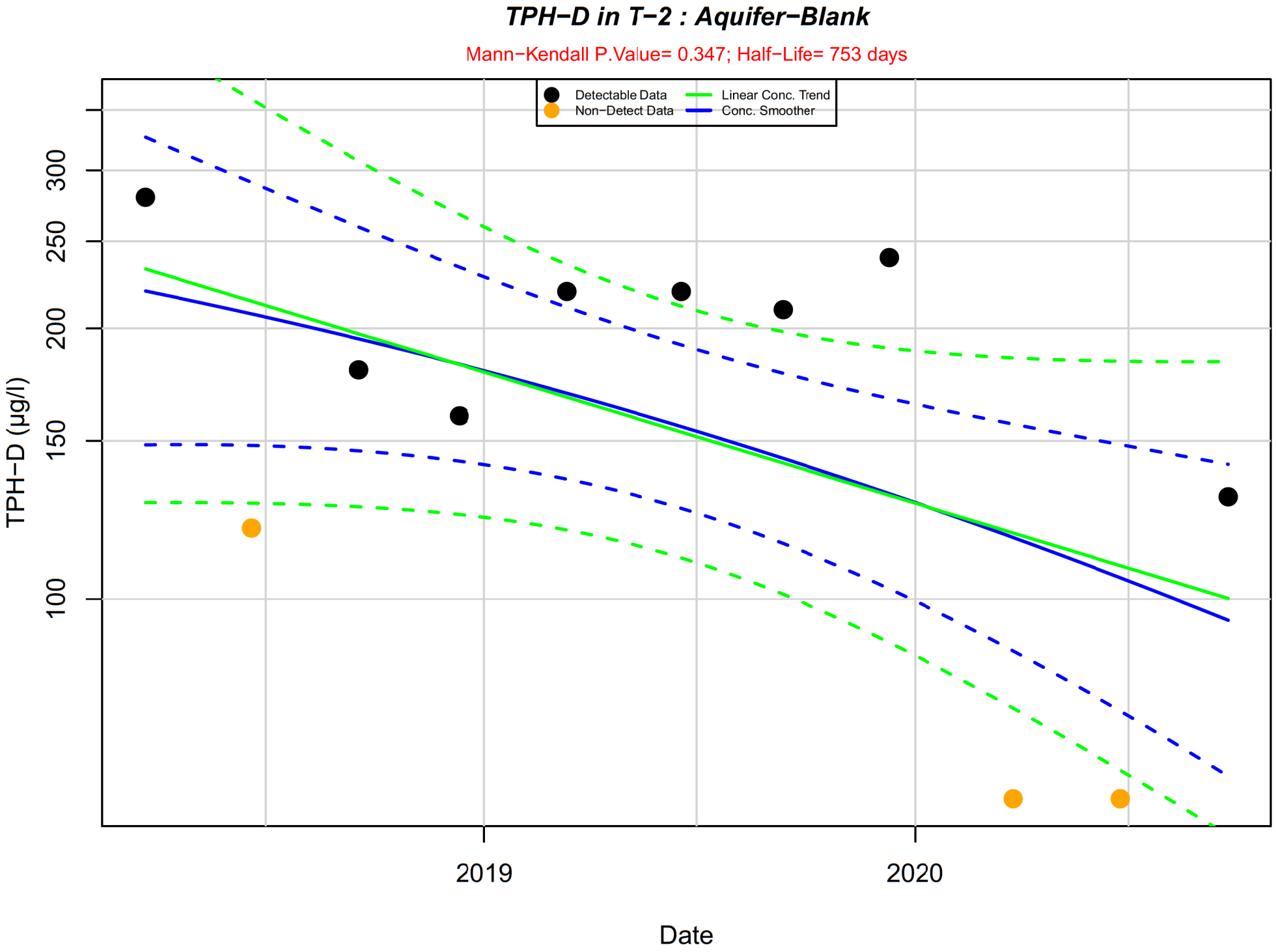

TPH-D in RR-1 : Aquifer-Blank
Mann-Kendall P.Value= 0.182; Half-Life= 767 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
100
150
200
250
300
2019
2020
Date

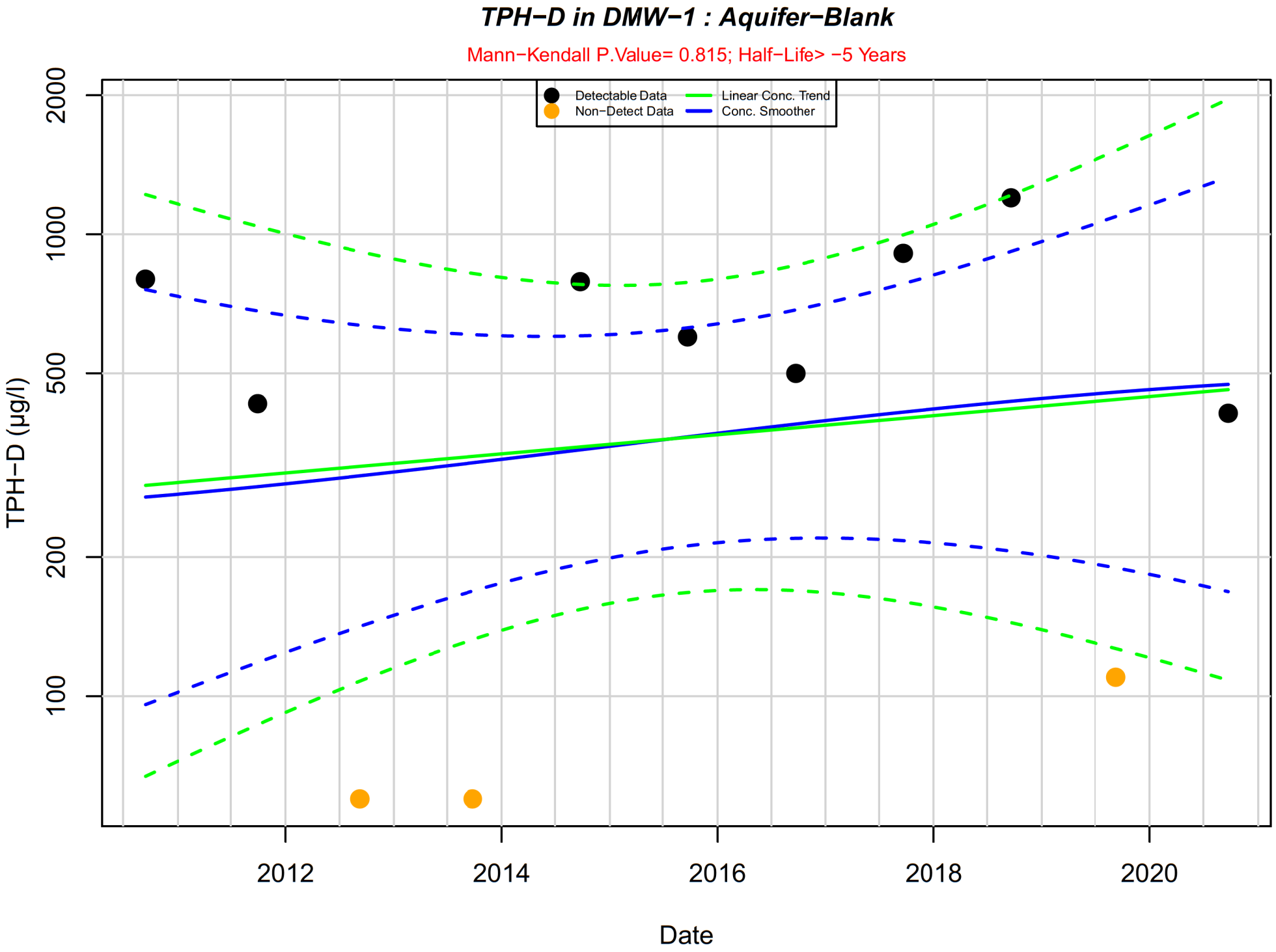

TPH−D in RR−2 : Aquifer−Blank
Mann−Kendall P.Value= 0.065; Half−Life= 697 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−D (µg/l)
300
250
200
150
100
50
2019
2020
Date

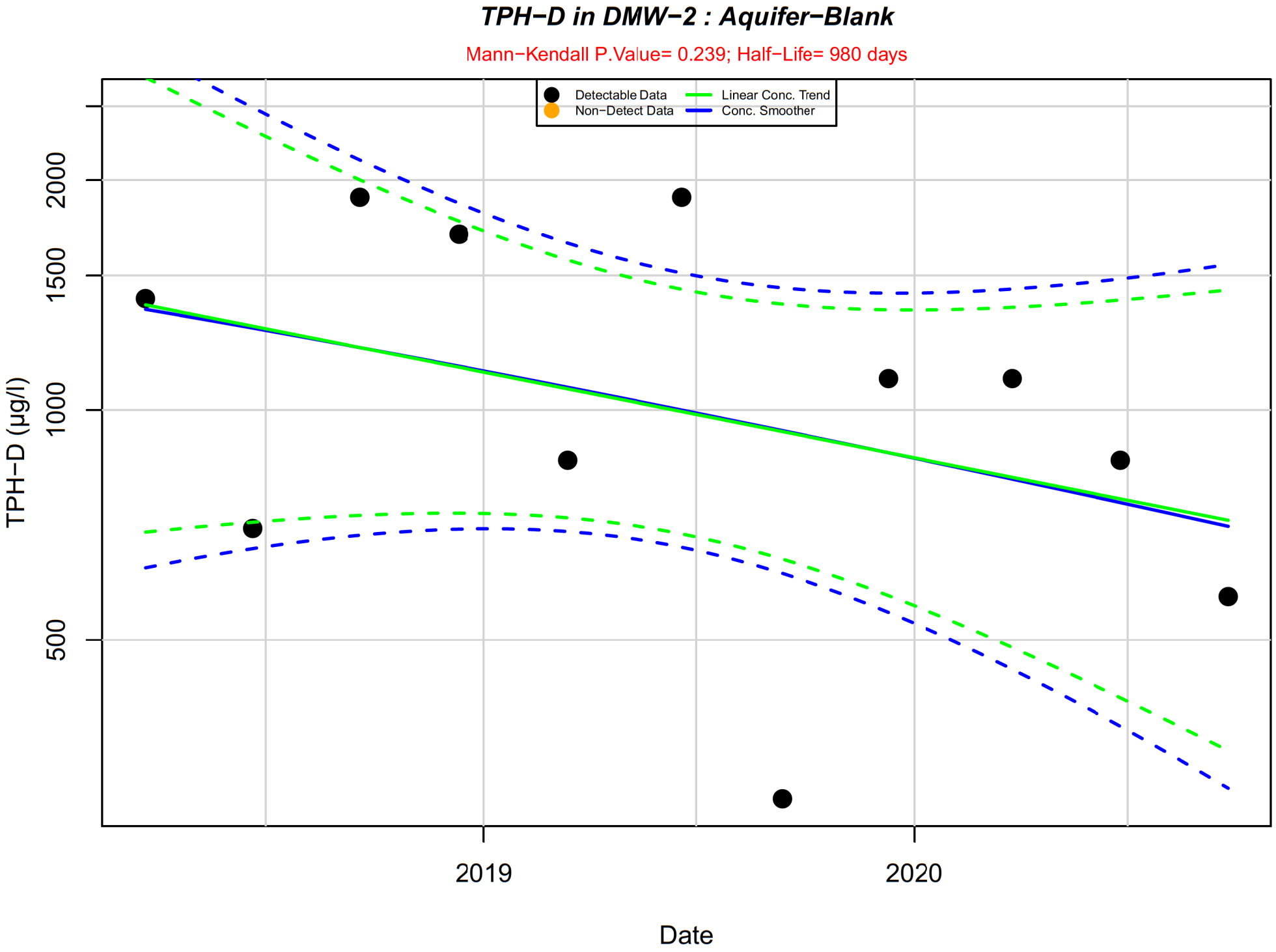

TPH-D in RR-3 : Aquifer-Blank
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
350
250
200
150
100
50
2017
2018
2019
2020
Date

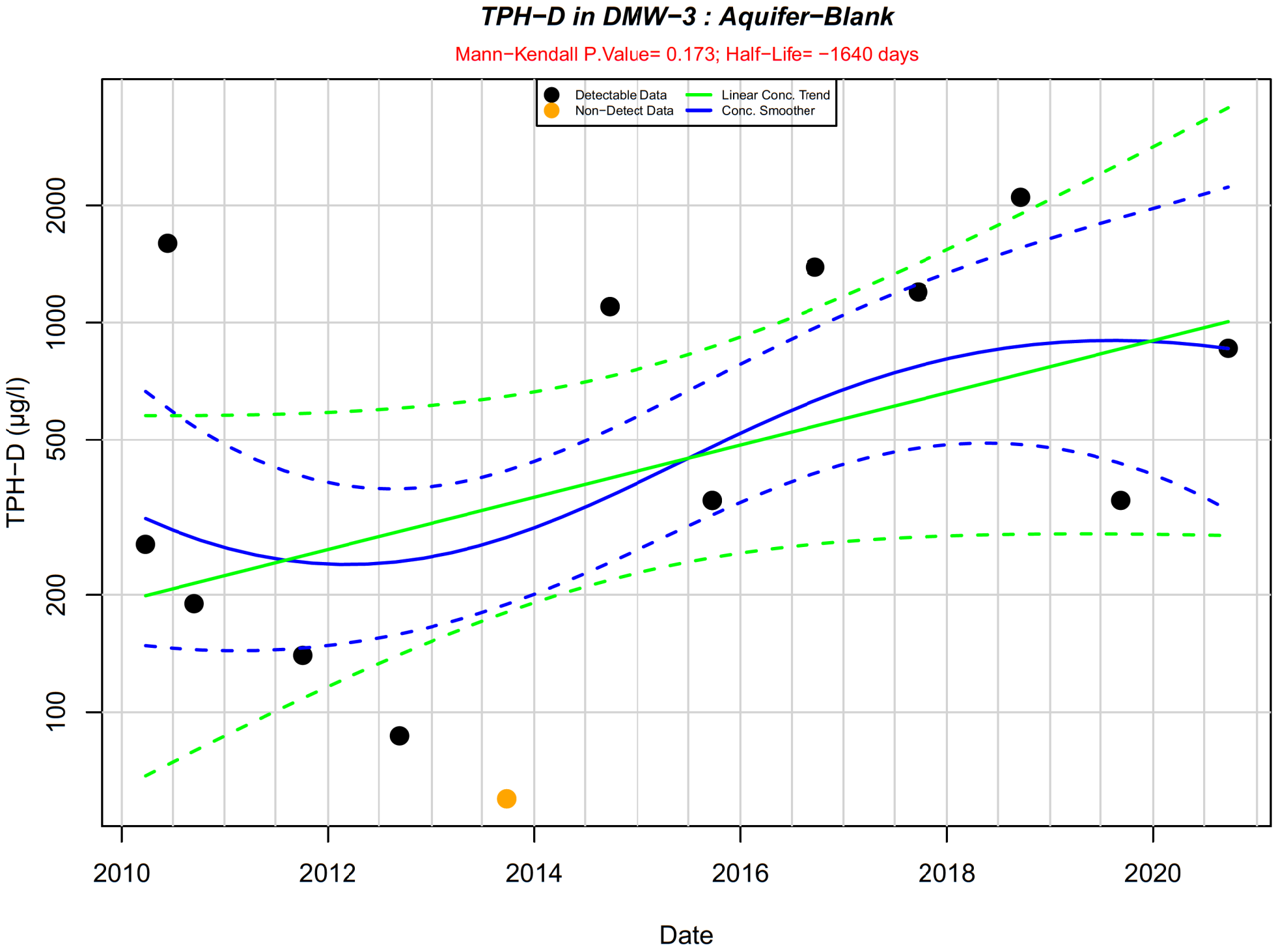

TPH−D in RR−4 : Aquifer−Blank
Mann−Kendall P.Value= 1; Half−Life> 5 Years
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−D (µg/l)
300
250
200
150
100
50
2017
2018
2019
2020
Date

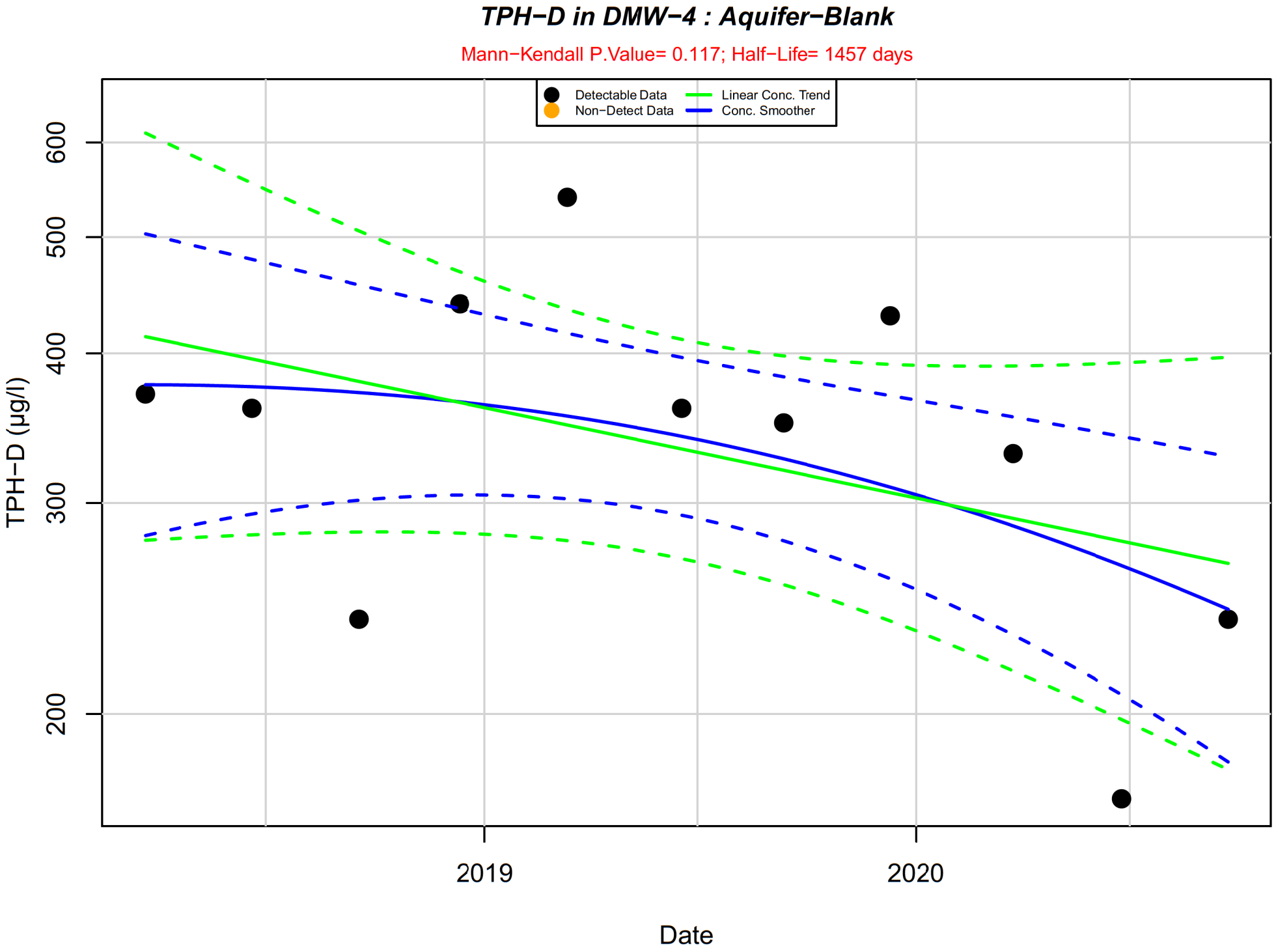

TPH-D in RR-5 : Aquifer-Blank
Mann-Kendall P.Value= 0.31; Half-Life= 1132 days
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
1000
500
200
100
2019
2020
Date

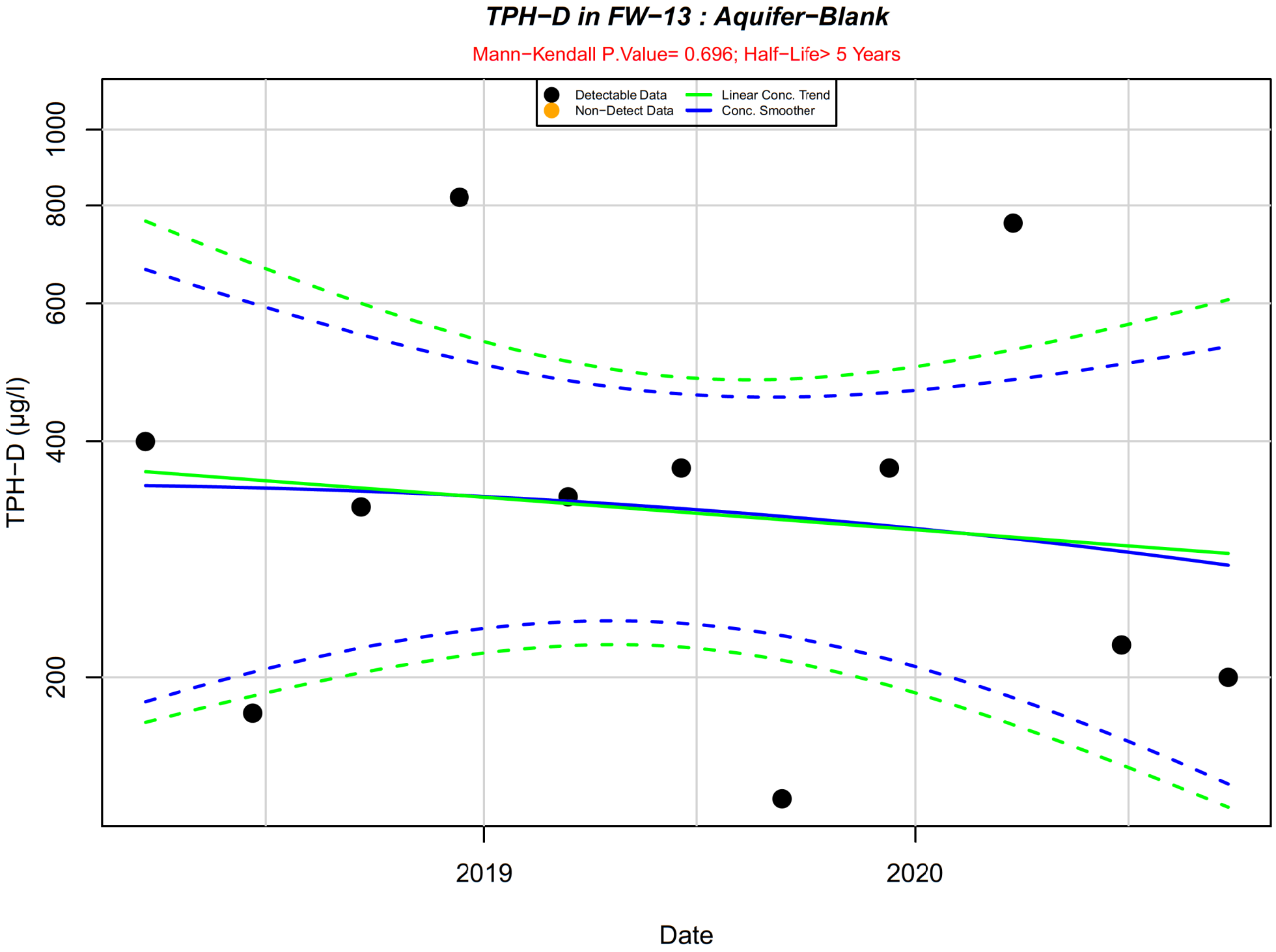

TPH−D in T−2 : Aquifer−Blank
Mann−Kendall P.Value= 0.347; Half−Life= 753 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−D (µg/l)
100
150
200
250
300
2019
2020
Date


TPH−D in DMW−1 : Aquifer−Blank
Mann−Kendall P.Value= 0.815; Half−Life> −5 Years
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−D (µg/l)
2000
1000
500
200
100
2012
2014
2016
2018
2020
Date


TPH−D in DMW−2 : Aquifer−Blank
Mann−Kendall P.Value= 0.239; Half−Life= 980 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−D (µg/l)
2000
1500
1000
500
2019
2020
Date


TPH−D in DMW−3 : Aquifer−Blank
Mann−Kendall P.Value= 0.173; Half−Life= −1640 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−D (µg/l)
100
200
500
1000
2000
2010
2012
2014
2016
2018
2020
Date


TPH−D in DMW−4 : Aquifer−Blank
Mann−Kendall P.Value= 0.117; Half−Life= 1457 days
Detectable Data
Non−Detect Data
Linear Conc. Trend
Conc. Smoother
TPH−D (µg/l)
600
500
400
300
200
2019
2020
Date


TPH-D in FW-13 : Aquifer-Blank
Mann-Kendall P.Value= 0.696; Half-Life> 5 Years
Detectable Data
Non-Detect Data
Linear Conc. Trend
Conc. Smoother
TPH-D (µg/l)
200
400
600
800
1000
2019
2020
Date

Appendix E
Restoration Time Frame Results

Module 2: Temporal Analysis: Concentration of contaminant vs. time (Regression Analysis at each well)

Site Name: *D Street Petroleum Site*
Site Address: *Tacoma, WA*
Additional Description: *0*
Hazardous Substance *Benzene*

1. Level of Confidence (Decision Criteria)? **85%**

2. Prediction: Calculation of Restoration Time and Predicted Concentration at Wells

Well Location		**HC-111**	**G-18**	**B-34**	**RR-2**	**RR-3**	**B-25**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
A. Cleanup Level (Criterion) to be achieved?	ug/L	160	160	160	40	40	160										
A.1 Average (@50% CL[1] best-fitting values)																	
Time to reach the criterion	yr	2.71	-9.60	NA	-8.28	-9.39	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Date when the Criterion to be achieved	date	3/3/18	11/11/05	NA	3/8/07	1/28/06	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
A.2 Boundary (@85% CL)																	
Time to reach the criterion[2]	yr	4.68	-15.71	NA	-9.81	-13.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Date when the Criterion to be achieved	date	2/17/20	10/6/99	NA	8/25/05	5/25/02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B Date of Prediction?	date	7/22/20	7/22/20	7/22/20													
B.1 Average conc predicted (@50% CL)	ug/L	78.45	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B.2 Boundary conc predicted (@85% CL)	ug/L	148.61	0.39	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

3. Log-Linear Regression Results

Coefficient of Determination	r^2	0.276	0.371	0.035	0.721	0.574	0.009	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Correlation Coefficient	r	-0.525	-0.609	0.188	-0.849	-0.757	-0.094	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Number of data points	n	19	15	20	20	13	19	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

4. Statistical Inference on the Slope of the Log-Linear Regression Line with t-statistics

One-tailed Confidence Level calculated, %		97.905%	98.406%	57.297%	100.000%	99.728%	29.777%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sufficient evidence to support that the slope of the regression line is significantly different from zero?		YES!	YES!	**NO!**	YES!	YES!	**NO!**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Coefficient of Variation?		NA	NA	0.970	NA	NA	0.992	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Plume Stability?		Shrinking	Shrinking	Stable	Shrinking	Shrinking	Stable	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

5. Calculation of Point Decay Rate Constant (k_{point})

Slope: Point decay rate constant (k_{point})	@50% CL	yr^{-1}	0.299	0.474	0.235	0.514	0.456	0.044	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	@85% CL	yr^{-1}	0.173	0.290	NA	0.433	0.327	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Half Life for (k_{point})	@50% CL	yr	2.321	1.463	2.944	1.350	1.521	15.898	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	@85% CL	yr	3.998	2.392	NA	1.600	2.117	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Note: 1. CL : Confidence Level; UD= Undetermined

2. The length of time that will actually be required is estimated to be no more than years calculated (@ 85% of confidence level.)