Memorandum

March 11, 2019

To:	Grant Trigger, RACER	Ref. No.:	017358
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cc:	Kristen Jenkins, Ryan Thomas, Allie Murphy, Daniel Beck-GHD		

Subject: **PFAS Treatment Methods Evaluation Summary**
Willow Run Powertrain
Ypsilanti, MI

This memorandum provides a high-level briefing of the per- and polyfluoroalkyl substances (PFAS) treatment methods currently being evaluated at the Willow Run Powertrain (Site).

The groundwater collection system, installed between 2017 and 2018 at the Site, has been sampled for the last year to establish baseline influent characteristics for final treatment system design. During this groundwater quality analysis, PFAS was discovered. The treatment system that had been preliminarily designed is ineffective in removing PFAS, requiring a re-evaluation of remedial alternatives.

The PFAS sampling data from the French drain discharge is very consistent, as expected with a steady state groundwater collection system. With updated influent definition, additional sampling and evaluations have been initiated to assess alternative treatment options, effectiveness and cost.

Moreover, inconsistencies in some of the data suggested potential multiple sources of PFAS might be involved. Consequently, specific sampling was focused on evaluating the collection system components installed in the French drain for PFAS contributions. The flow meters, level sensors and pumps were evaluated (tested) to determine if these components that included Teflon, Tefzel, etc. are significantly contributing to the total PFAS detected in the groundwater. Although low levels of PFAS were detected, the components are not significantly/materially contributing to the PFAS concentrations observed in the French drain discharge compared to Site groundwater samples.

To evaluate treatment options, specialized laboratory testing, bench scale and pilot scale tests are underway. This memorandum provides a brief summary of these tests, the results obtained to date, questions that have arisen from the results and next steps in evaluating the results.

1. Pilot Test

RACER assembled a team to conduct a pilot test to assess the potential for advanced oxidation to destroy PFAS in a flow-through system. The team consists of A2 Innovation Group, LLC (designer, fabricator and operator of the pilot system [protected intellectual property]), Merit Laboratories, Inc. (analytical laboratory),

and GHD Services Inc. (provide water for treatment, pretreatment of water and sample collection and assessment of system performance). The team, along with RACER are evaluating the data collected.

The first round of pilot testing was completed in late December 2018. Data was received and evaluated in early January 2019. To evaluate the effectiveness of the pilot system (combining UV, hydrogen peroxide, and ozone) water samples were collected at regular intervals up to 60 minutes of total exposure time. The resulting data showed a significant increase in four of the 24 PFAS compounds analyzed for over the exposure time. The initial total PFAS concentration was 1,200 ppt. Following 60 minutes of exposure the total PFAS concentration was 8,200 ppt. Attachment 1 presents graphed results of the first round data.

The test results show a much larger increase (7,000 ppt) in PFAS concentrations following advanced oxidation than the results obtained from a coincident Total Oxidizable Precursor (TOP) assay analysis on the initial water sample, which showed a 170 ppt increase. It is possible that PFAS precursors (not analyzed in the standard 24 compound PFAS analyte list) are being converted by advanced oxidation using UV/peroxide/Ozone into PFAS compounds that can be measured using the 24 PFAS compound analyte list. It was postulated after the first round that a source of PFAS is present in the pilot system components or a reagent used in the treatment process.

The second round of pilot testing was completed in early February 2019. This round of testing included system blank testing and doubling the exposure time (to about 2 hours) to determine if a greater exposure time could complete the destruction of the PFAS. Attachment 1 presents graphed results of the system blank and pretreated water results from the second round of pilot testing.

As with the first round of sampling, total PFAS increased dramatically over the duration of the test from about 800 ppt to over 9,500 ppt after 135 minutes of exposure. The bulk of the increase was made up of increased levels of PFHpA, PFHxA, PFPeA and PFBA. The most significant increases occurred with PFHpA (40 to 3,250 ppt) and PFHxA (120 to 4,280ppt). At the same time, the PFOA and PFOS (and PFHxS) remained essentially unchanged. The source of the increase in total PFAS is not clear yet but could be attributable to:

- Groundwater from the site containing precursors that are degraded by the oxidation process
- Distilled water used to test the system (system blank) containing precursors that are degraded by the oxidation process
- The treatment train containing precursors that are “leached” and degraded by the oxidation process
- The treatment train as a source of PFAS “leached out" by the oxidation process

In addition, the hydrochloric acid used to adjust the pH in one of the tests contained PFAS, but not likely materially impacting the results.

Laboratory results for additional samples are expected over the next two weeks and a follow up assessment of the likely source of the increased PFAS will continue.

Outreach to the research community (Oregon, Indiana and Texas) is underway seeking a method to analyze for more than the standard 24 or so PFAS substances that could aid in identifying, at least from a qualitative perspective, the presence of potential precursors.

2. Bench Scale

The GHD Innovative Technology Group (ITG) located in Niagara Falls, New York is in the process of conducting bench scale studies in the laboratory to evaluate PFAS removal using granular activated carbon (GAC) and ion exchange resins (IX). This includes estimating the GAC and IX usage, which can be used to evaluate the economics of GAC/IX and compare it to AOP costs (if proven effective) based on the pilot test results. As part of the bench scale studies, jar testing using an iron coagulant was performed to evaluate phosphorus removal, which is needed in the treatment train design to meet discharge standards for release to a surface water body.

Initial results showed that all the detectable levels of PFAS were removed from pretreated water (after removal of iron and solids) using activated carbon and IX resin. To evaluate usage rates, additional water has been collected and has been shipped to the laboratory to the evaluate breakthrough times of the activated carbon and IX columns. There are significantly different usage rates provided by carbon vendors and published USEPA documents. These next tests will evaluate the low-end usage rates and determine if they are realistic.

3. Specialized Laboratory Testing

Following review of the first round of pilot test data and the hypothesis that there is a mass of PFAS compounds present that cannot be measured with the current standard 24 compound PFAS analyte list, academic laboratories were contacted to assist in additional specialized testing. Dr. Graham Peaslee's laboratory at Notre Dame University will be analyzing total organoflourine in samples collected during the pilot study. This analysis is focused on measuring the fluorine still bound to the PFAS molecule and not free fluoride in the water. GHD was unable to locate a commercial laboratory to do this type of sampling.

Water samples may also be sent to Dr. Jennifer Field at Oregon State University whose laboratory is developing a process to analyze water samples for a list of approximately 400 PFAS compounds, referred to as suspects. These suspects do not have analytical laboratory standards to calibrate against; therefore, the results are a qualitative analysis with a quantitative estimate. If this process is initiated by Dr. Field, the results could help evaluate the hypothesis that there are PFAS compounds present that cannot be seen by the current standard 24 compound list and that are being converted by advanced oxidation to compounds that can be seen by the standard analysis. This analytical method may also assist in assessing potential precursors at any location.

The Research and Development Laboratory of Heritage Environmental Services is looking into new laboratory methods for PFAS analysis. RACER is supporting this research by sending split samples of water from the Site.

4. Next Steps

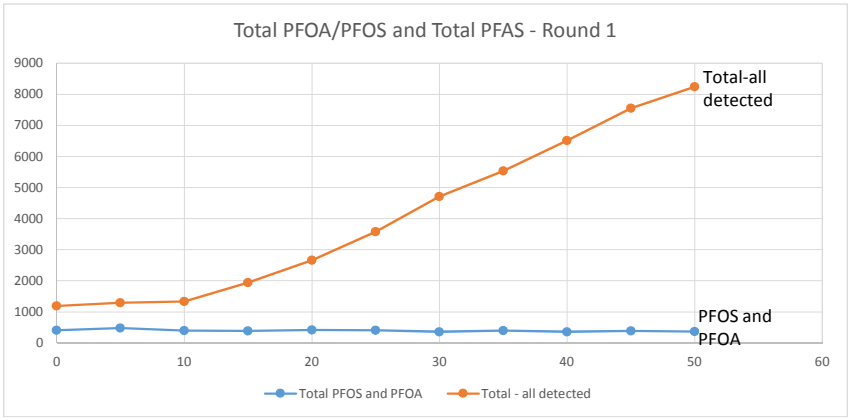
In addition to the evaluations described above, several additional vendors are being consulted to conduct high-level evaluation of other PFAS treatment options considering the nature of the raw water and the likely

need for pretreatment of phosphorus and/or iron as part of any treatment train. Possible further modifications of the pilot system are being considered.

Results have not been received from split samples submitted for total organoflourine and possible expanded precursor analysis. Those results and further bench scale test results will need to be gathered and assessed to determine the viability and cost-effectiveness of all alternative remedial options.

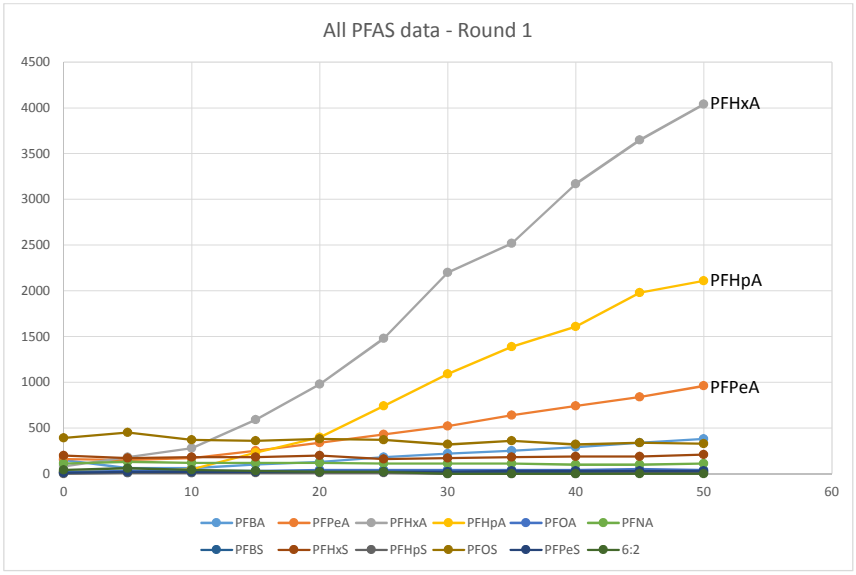
Because the discovery of PFAS rendered the original designed system ineffective - a full remedial alternatives analysis update is anticipated once all pilot system information, bench scale tests and analytical results are collected and considered.

Round 1 test run with peroxide dosed pretreated water exposed to UV and ozone.



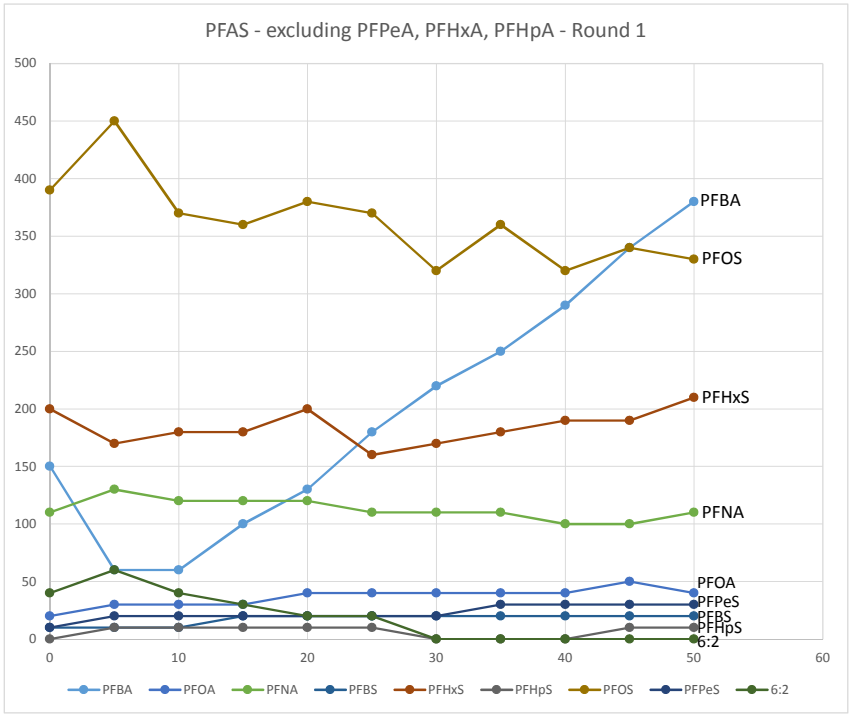
This graph shows the concentrations in total PFOS and PFOA compared to the total of all PFAS compounds detected over the exposure period

X axis - exposure time in minutes
Y axis - concentrations in PPT



This graph shows the concentrations individual PFAS compounds detected over the exposure period

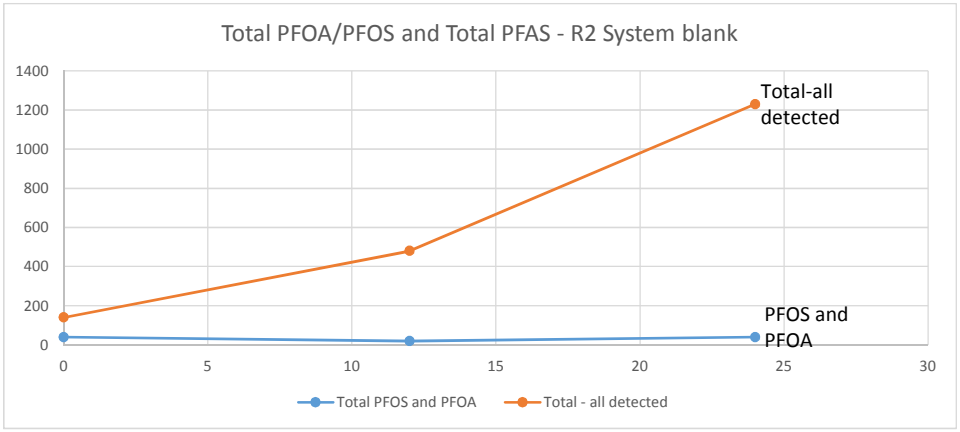
X axis - exposure time in minutes
Y axis - concentrations in PPT



This graph shows the concentrations of individual PFAS compounds at lower concentrations detected over the exposure period

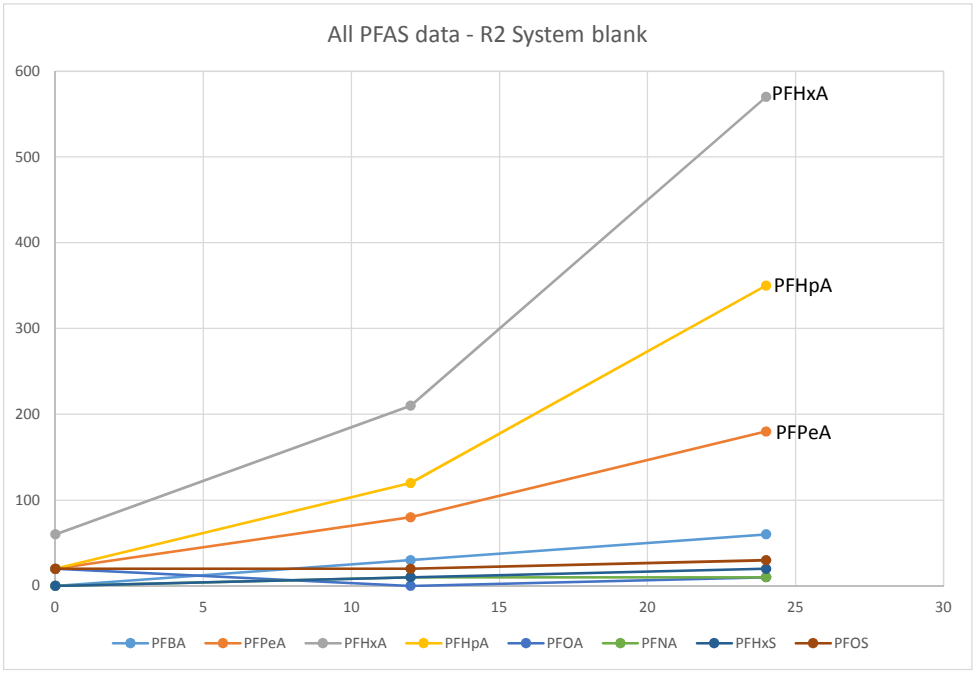
X axis - exposure time in minutes
Y axis - concentrations in PPT

System blank run similarily to first round of pilot test (including peroxide dosing) using distilled water instead of pretreated water.



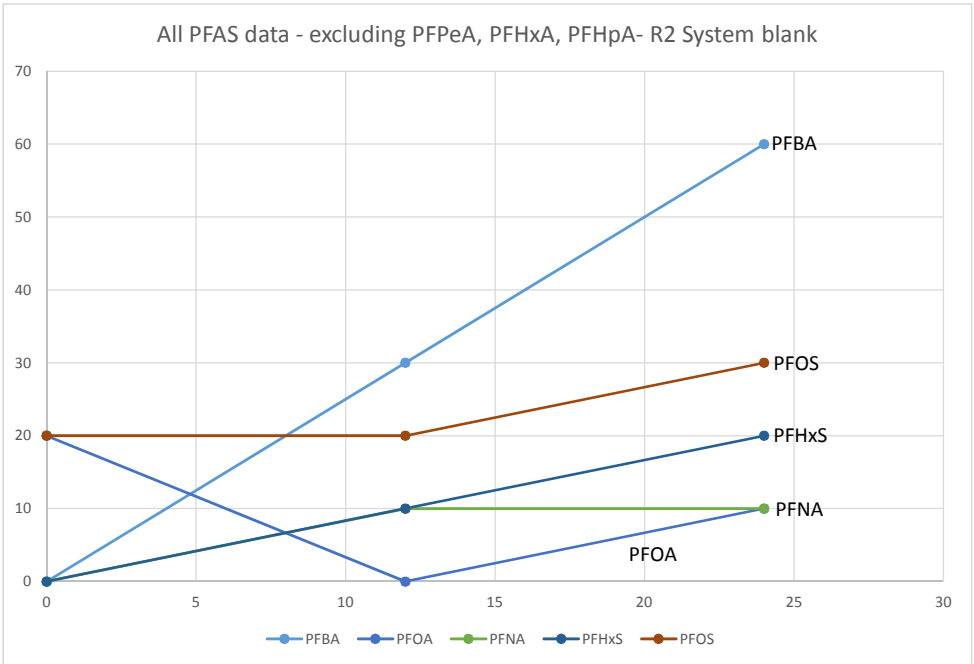
This graph shows the concentrations in total PFOS and PFOA compared to the total of all PFAS compounds detected over the exposure period

X axis - exposure time in minutes
Y axis - concentrations in PPT



This graph shows the concentrations individual PFAS compounds detected over the exposure period

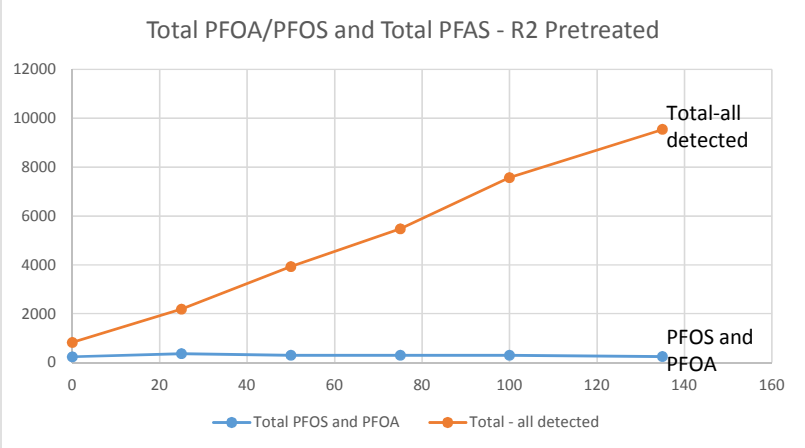
X axis - exposure time in minutes
Y axis - concentrations in PPT



This graph shows the concentrations of individual PFAS compounds at lower concentrations detected over the exposure

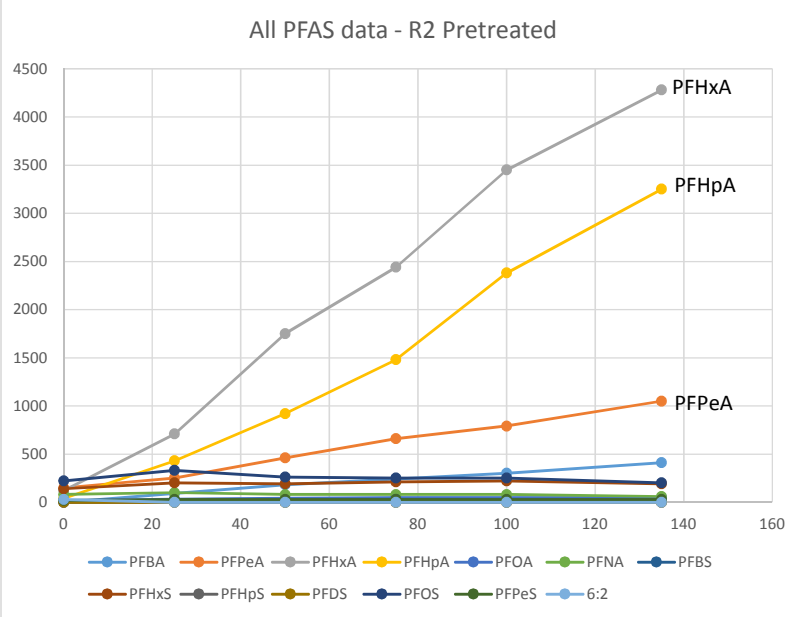
X axis - exposure time in minutes
Y axis - concentrations in PPT

Second Round Test - run similarily to first round with pretreated water and peroxide dosing but increased exposure time.



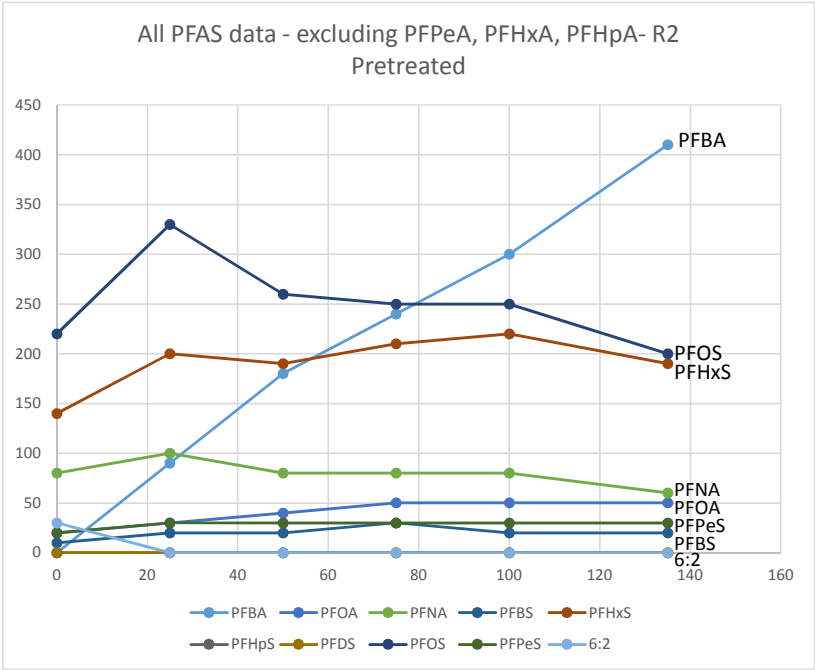
This graph shows the concentrations in total PFOS and PFOA compared to the total of all PFAS compounds detected over the exposure period

X axis - exposure time in minutes
Y axis - concentrations in PPT



This graph shows the concentrations individual PFAS compounds detected over the exposure period

X axis - exposure time in minutes
Y axis - concentrations in PPT



This graph shows the concentrations of individual PFAS compounds at lower concentrations detected over

X axis - exposure time in minutes
Y axis - concentrations in PPT