MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

STATEWIDE WASTEWATER TREATMENT PLANT AND BIOSOLIDS PFAS STUDY

Field Reports Summary

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EGLE, WATER RESOURCES DIVISION
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CONTENTS

BACKGROUND

The United States Environmental Protection Agency (USEPA) has classified per- and polyfluoroalkyl substances (PFAS) as emerging contaminants that are regulated by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) under Part 201, Environmental Remediation, and Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, Act 451 of 1994, as amended (NREPA); and their respective administrative rules, specifically Rule 299.44-299.50 (Generic Cleanup Criteria) and Rule 323.1057 (Rule 57, Toxic Substances) of the Michigan Administrative Code. PFAS are a complex family of more than 4,750 human-made fluorinated organic chemicals. Due to their unique chemical properties, PFAS have been used in many industries and consumer products since the late 1950s. The widespread use of PFAS in conjunction with extreme resistance to degradation has resulted in the presence of PFAS in the environment and at Wastewater Treatment Plants (WWTPs). While WWTPs are not the source of PFAS, they are a central point of collection and could serve as a key location to control and potentially mitigate the release of PFAS into the environment. Effluents (i.e., the treated wastewater) discharged from WWTPs and the biosolids applied to agricultural land for beneficial reuse have been identified as potential PFAS release pathways into the environment by the Interstate Technology and Regulatory Council (ITRC).

Biosolids are the nutrient-rich organic materials resulting from the treatment of domestic sewage in a WWTP and contain essential plant nutrient and organic matter. When treated and processed, biosolids can be recycled and applied to crops as fertilizer to improve and maintain productive soils and stimulate plant growth. In Michigan, biosolids are beneficially used under requirements set forth in Michigan's Part 24 Administrative Rules, Land Application of Biosolids, promulgated under Part 31 of the NREPA; and the federal requirements contained in Title 40 of the Code of Federal Regulations (40 CFR), Part 503, Standards for the Use or Disposal of Sewage Sludge. Under these laws, biosolids must meet strict standards, including how much metal they contain, and where and how they can be applied to land. In contrast, sludge from WWTPs that does not need to meet these quality standards is typically disposed of in a landfill or incinerated. Sludges from industrial processes and residential septic systems are not considered "biosolids," but under certain circumstances these wastes can be applied to land.

In June 2017, EGLE identified that the Lapeer WWTP was passing through perfluorooctanesulfonic acid (PFOS) received from an industrial user (i.e., a chrome plater) discharging into their sanitary collection system. The effluent from the Lapeer WWTP discharged to the Flint River was at concentrations far exceeding Michigan's Rule 57 Water Quality Standard (WQS) for PFOS of 12 nanograms per liter (ng/L) for a nondrinking water source and 11 ng/L for a drinking water source. As a result, EGLE sampled the Lapeer WWTP's sludge, which showed elevated levels of PFOS, and prohibited the sludge from being spread on land. In response to these results, in late 2017/early 2018, the Michigan Action PFAS Response Team (MPART) contracted with AECOM Technical Services Inc. (AECOM) to investigate PFAS issues related to Lapeer's biosolids. MPART was established to address the threat of PFAS contamination, protect public health, and ensure the safety of Michigan's land, air, and water. This unique multiagency approach brings together seven state departments responsible for environmental and natural resources protection, agriculture, public health, military installations, airports, and fire departments for a coordinated response. A PFAS Land Application Workgroup consisting of department staff from EGLE, the Michigan Department of Agriculture and Rural Development (MDARD), and the Michigan Department of Health and Human Services (MDHHS) was formed under MPART in 2018. While EGLE's Water Resources Division (WRD) has regulatory oversight of the Michigan Biosolids Program and is the lead, the MPART Land Application Workgroup has been consulted in the development of the investigations summarized below.

The Lapeer Biosolids PFAS Investigation included sampling surficial soils, nearby surface water bodies, tile drains, and groundwater at four Land Application Sites (LASs) that received industrially-impacted biosolids from the Lapeer WWTP. The four LASs had received biosolids over multiple years, received relatively high application rates (dry tons per acre [dT/acre]), and received high total tonnage of biosolids when compared to other LASs used by the Lapeer WWTP. These criteria were used to select LASs due to the increased likelihood of impact associated with consistent LAS use and heavy application of biosolids. Three of the sites (i.e., 08N11E16-TG01, 08N11E16-TG02, and 08N11E33-SK01) are privately owned, while the fourth site (i.e., 08N10E33-CL01) is owned by the City of Lapeer. PFAS was detected in the soil on all four LASs, with the highest soil PFOS concentration of 172 micrograms per kilogram (µg/kg) or parts per billion (ppb) detected at Site 08N10E33-CL01. Surface water and tile drain samples exceeded the WQS for PFOS (12 ng/L) at two of the LASs and groundwater samples exceeded the Part 201 residential and nonresidential drinking water generic cleanup criteria (Part 201 criteria) for PFOS of 16 parts per trillion (ppt) at one LAS and for perfluorooctanoic acid (PFOA) of 8 ppt at two of the LASs. The elevated surface water PFAS concentrations are likely related to a combination of surface runoff and discharge of shallow groundwater into the tile drains and nearby surface water bodies. The elevated groundwater PFAS concentrations were detected in shallow wells, two of which are likely screened in perched groundwater zones (i.e., screened from 6 to 11 ft below ground surface [bgs] and 4 to 9 ft bgs). Based on the groundwater flow directions, site geology, and location of adjacent residential wells, there is no indication that the residential wells near these two LASs would be at risk of PFAS contamination. The detailed investigation reports can be found on the MPART Land Application Workgroup webpage and as **Attachment G.**

Additionally, in February 2018, EGLE WRD launched the Industrial Pretreatment Program (IPP) PFAS Initiative, which mandated all municipal WWTPs required to implement IPPs (97 statewide) to determine if they were passing through PFOS and/or PFOA to surface waters and groundwater and, if found, to reduce and eliminate any sources. As of 2020, 46 percent did not identify any significant industrial sources of PFOS or PFOA to their system, 23 percent identified significant industrial sources but the WWTP discharge still met WQS, and 31 percent identified significant industrial sources and the WWTP discharge exceeded WQS. As a part of the initiative, EGLE WRD developed numerous documents, including Frequently Asked Questions (FAQs), Wastewater PFAS Sampling Guidance, and Recommended PFAS Screening and Evaluation Guidance, which can be found on the EGLE IPP PFAS Initiative webpage.

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STATEWIDE WWTP AND BIOSOLIDS PFAS STUDY

Based on the results of the Lapeer Biosolids PFAS Investigation and the IPP PFAS Initiative, EGLE WRD launched a second initiative, the Statewide WWTP and Biosolids PFAS Study, in the fall of 2018. The study objectives were to 1) further understand the prevalence of PFAS in municipal WWTPs in Michigan and 2) better understand the fate and transport of PFAS from biosolids in associated soils, groundwater, and surface waters once the biosolids were spread on land.

To accomplish the first objective, 42 municipally-owned WWTPs were selected for sample collection based on the following criteria:

- The 20 largest WWTPs in Michigan, based on daily flows in million gallons per day (MGD).
- Twenty-two medium and small WWTPs selected from three main groups based on flows of 0.2 to 0.4 MGD, 0.5 to 3 MGD, and 3 to 9 MGD.
- A variety of secondary treatment processes.
- The presence/absence of significant industrial users.
- Geographic location.

The influent, effluent, and associated residuals (i.e., final treated solids such as sludge or biosolids) were sampled at each WWTP. The results are presented in **Table 1** (Appendix A)of this document and discussed in the detailed investigation report.

To accomplish the second objective, EGLE WRD reviewed results from the 42 WWTPs and selected 8 WWTPs for LAS screening to 1) evaluate LASs that received PFAS industrially-impacted biosolids to ensure protection of public health and the environment and 2) evaluate LASs that received biosolids with lower or more “typical” levels of PFAS, to assist with the development of future land application guidance. Due to the prolific use of PFAS in household, commercial, and industrial applications and products, as well as its presence in our blood (see Basic Information on PFAS), it is expected that some anthropogenic background levels of PFAS, including PFOS and PFOA, will be found in municipal wastewater and the associated solids. Understanding and evaluating the fate and transport of PFAS from biosolids at these lower levels is important as we move forward with a land application program where anthropogenic background levels of PFAS in biosolids will continue even as significant industrial sources are removed.

WWTP SELECTION FOR LAS SCREENING

Three WWTPs (Wixom WWTP, Ionia WWTP, and Bronson WWTP) with high concentrations of PFOS in their biosolids/sludge, were selected for LAS screening. All three of these WWTPs were identified through implementation of the IPP PFAS Initiative as having an industrial user (i.e., a chrome plater) with very high concentrations of PFOS in their process wastewater that was then discharged to the WWTP. All three WWTPs had pass through of PFOS at the WWTP that exceeded the WQS of 12 ng/L and PFOS concentrations in their biosolids/sludge that exceeded 900 ppb. For perspective, the median level of PFOS in biosolids/sludge sampled as part of the 42 WWTPs in the Statewide Study was 13 ppb.

Note, similar to the Lapeer WWTP, EGLE WRD suspended land application approval for two of the three WWTPs in this group based on these results. The third WWTP was already disposing of their sludge at a landfill for reasons unrelated to PFAS.

An additional five WWTPs (Delhi Township WWTP, South Huron Valley Utility Authority WWTP [SHVUA WWTP], Midland WWTP, Gaylord WWTP, and Jackson WWTP) were selected that had PFOS concentrations considered to be lower or more “typical,” ranging from 3 to 90 ppb. This group of WWTPs included both anaerobic and aerobic treatment processes and varied in size and the presence of known PFAS sources. All five WWTPs had effluents that were below the WQS of 12 ng/L for PFOS at the time of selection. Note, EGLE WRD also selected one of the Port Huron WWTP LASs to include in the Statewide WWTP and Biosolids PFAS Study after EGLE WRD began investigating PFAS in Fort Gratiot Township in late 2018, near the closed Fort Gratiot Landfill. EGLE WRD conducted PFAS sampling in nearby streams and drains and found elevated levels of PFAS that warranted further investigation. The Port Huron WWTP has several LASs in this region that may be potential sources of PFAS to the surface waters.

A summary of size (i.e., flow), PFOS concentrations, biosolids treatment, and whether the WWTP had known significant sources of PFAS are provided in **Table 2.** **Figure 1** shows the range of the WWTPs selected based on sludge/biosolids PFOS concentrations.

TABLE 2. WWTP SELECTION SUMMARY

Table 2.1 WWTPs Without Industrially Impacted Biosolids

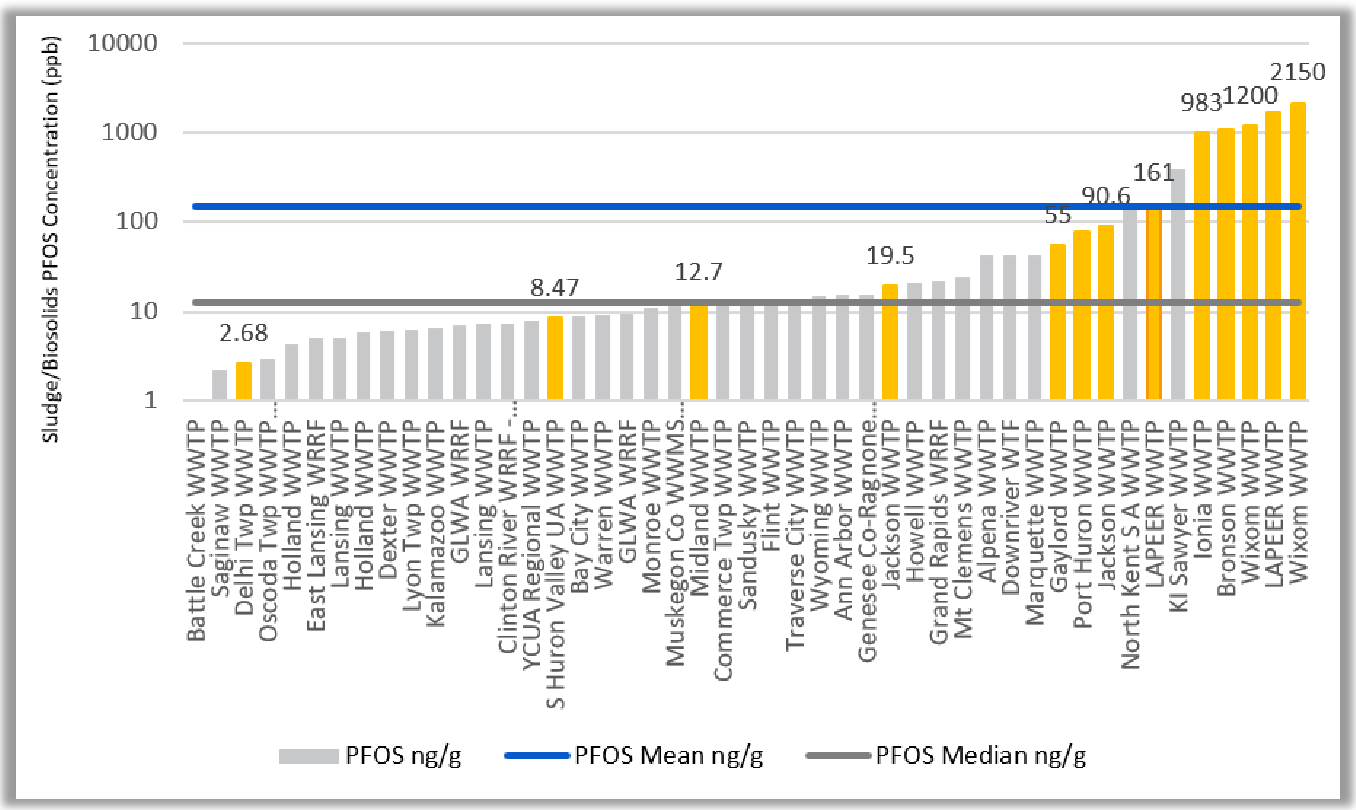
WWTP	Flow (MGD)	IPP	Significant Sources	Influent PFOS (ppt)	Effluent PFOS (ppt)	Biosolids PFOS (ppb)	Treatment Type
Delhi Twp.	2.28	Yes	No	< 2	2	3	Anaerobic
SHVUA	9.42	Yes	Yes	< 2	5	8	Alkaline Stabilization
Midland	8.5	No	No	3	4	13	Anaerobic
Jackson	9.97	Yes	Yes	6	3	20/91	Anaerobic
Gaylord	0.35	No	No	< 2	4	55	Aerobic
Port Huron	10.63	Yes	Yes	20	13	78	Alkaline Stabilization

Table 2.2 WWTPs With Industrially Impacted Biosolids

WWTP	Flow (MGD)	IPP	Significant Sources	Influent PFOS (ppt)	Effluent PFOS (ppt)	Biosolids PFOS (ppb)	Treatment Type
Wixom	1.92	Yes	Yes	128	269	2150/1200	Aerobic
Bronson	0.41	Yes	Yes	843	169	1060	Anaerobic
Ionia	2.06	Yes	Yes	213	635	983	Anaerobic
Lapeer	1.78	Yes	Yes	NS	29	1680	Aerobic

NS = Not Sampled

FIGURE 1. WWTPS SELECTED FOR FIELD SCREENING



Note: Yellow indicates a selected WWTP. Several WWTPs are plotted more than once due to more than one sample result. Nanograms per gram (ng/g) is equivalent to ppb.

SPECIFIC LAS SELECTION FOR SCREENING

Many of the WWTPs selected for LAS screening had land application programs approved under EGLE WRD that dated back over 20 years. Further, some of the WWTPs had applied biosolids to as many as 75 LASs over the course of their program. Therefore, using the criteria from the Lapeer Biosolids PFAS Investigation, EGLE WRD developed guidance on site selection criteria to select and prioritize LASs for investigation. EGLE WRD targeted the most heavily used LASs for each WWTP to identify a worst-case scenario. The selection process included locating available records from the WWTPs to identify each WWTP's LAS that received biosolids during the applicable timeframe. Each Biosolids Annual Report (AR) submitted to EGLE WRD was reviewed to collect the following data for each LAS:

- AR Year
- Site Identification Number
- Dry Tons (dT) Land Applied
- The Application Rate (dT/acre)
- Acres Used
- Acres Approved
- Dates of Land Application

This data was then analyzed to identify the most likely impacted LASs. The parameters considered were:

- LASs that received multiple applications
- High application rates
- Total tonnage a LAS received
- Consistency of LAS use
- Downgradient receptors
- Recreational surface waters
- Soil type
- Geology
- Environmentally sensitive areas
- LASs located in watersheds receiving fish consumption advisories

LASs that received biosolids over multiple years are of interest due to the increased likelihood of impact, as are LASs that received relatively high application rates (dT/acre). Total tonnage that a site receives is also thought to be relevant to the impact on the LAS. EGLE WRD created a weighted use ratio to encompass all the parameters mentioned above and generate a score that identifies the most likely impacted LASs. The weighted use ratio is the total tonnage of biosolids (accounting for years of use and high application rates) that a LAS received, divided by the total approved acreage (accounting for use consistency) of the LAS.

$$\textbf{Weighted Use Ratio} = \frac{\sum \textbf{Site Tonnage}}{\sum \textbf{Site Acreage}}$$

The most likely impacted LASs identified by a comparison of weighted use ratios were then considered for LAS screening. Two to six LASs were selected for each WWTP. The farmers and landowners for each of the LASs were contacted jointly by EGLE WRD and MDARD to discuss the proposed screening, answer any questions, and obtain access agreements to perform the sampling. All landowner/farmers contacted, except two, agreed to allow access for the screening. Both landowners that refused had accepted biosolids from the Ionia WWTP. **Table 3** summarizes the LASs selected for each WWTP and the associated screening parameters.

It should be noted that many factors, including soil type and slope/gradient, likely influence PFAS concentrations in the LASs, and when looking at sites with historical applications, there are many unknowns, such as the actual concentrations of PFAS in the biosolids during past applications. Further, information that EGLE WRD has is limited by the accuracy of the reports received. In some cases, LASs that were sampled may have been used for land application of municipal solids prior to 1997 under a different program and records for those applications are difficult to locate as they have exceeded their record retention schedule.

TABLE 3. LASs SELECTED FOR SCREENING

Table 3.1 WWTPs Without Industrially Impacted Biosolids

		WWTP Concentrations		LAS Data		
WWTP	LAS	Effluent PFOS (ppt)	Biosolids PFOS (ppb)	Total Dry Tons (dT)	Application Timeframe	Weighted Use Ratio (Total dT/ Site Acres)
Delhi Twp.	DT01	2	3	266	2001 – 2018	12.65
	DT02			385	2003 – 2018	18.35
SHVUA	VG02	5	8	177	2010 – 2013	11.79
	JU02			389	2009 – 2015	22.92
Midland	RG02	4	13	220	2014 – 2015	6.67
	RG03			255	2011 – 2018	6.22
Jackson	MC01	3	20 – 91	649	2016	10.3
	FC01			678	2002 – 2016	7.2
	MT01			928	2007 – 2018	12.05
Gaylord	RW01	4	55	397	2002 – 2015	7.2
	JW01			433	2004 – 2016	14.4
Port Huron	East Parcel 1007-01 (CK02)	13	78	24	1983	1.76
	West Parcel 1007-01 (CK01, CK1A, CK2A)			93	1982 – 1983	5.9

Table 3.2 WWTPs With Industrially Impacted Biosolids

		WWTP Concentrations		LAS Data		
WWTP	LAS	Effluent PFOS (ppt)	Biosolids PFOS (ppb)	Total Dry Tons (dT)	Application Timeframe	Weighted Use Ratio (Total dT/ Site Acres)
Bronson	CA03	169	1060	204	2003 – 2014	9.26
	CA04			39+	2000 – 2017	4.35
	CA05			441	2005 – 2017	9.79
Wixom	JW01	Application Prior to Significant Industrial User Discharge	Application Prior to Significant Industrial User Discharge	243	1995 – 2000	10.1
	JW05			188	1995 – 2001	14.44
	E01-BC01	269	1200 – 2150	521	2010 – 2015	14.89
	E01-BC02			184	2010 – 2015	9.22
	E02-BC01			167	2010 – 2013	4.41
	AG01			488	2010 – 2015	4.07
Ionia	RW01	635	983	1773	2003 – 2017	28.60
	RW02			943	2004 – 2011	13.10
	RW03			312	2009 – 2015	12.03
	GH01			518	1999 – 2002	9.14
Lapeer	TG01	29	1680	469	2014 – 2017	6.69
	TG02			79.2	2015 – 2016	3.3
	SK01			700	1997 – 2006	9.34
	CL01			1423	1999 – 2014	28.54

Overview of LAS Screening Process and Results

Various environmental media were sampled at the LASs to evaluate potential PFAS impacts from the land application of biosolids. Surface water grab samples were collected at all LASs and analyzed for PFAS using EGLE's recommended PFAS minimum analyte list. Note, the recommended minimum analyte list was revised from 24 to 28 analytes over the course of the study. The types of surface waters sampled included ponds and streams located on or adjacent to the LASs and tile drains, as well as perched water (i.e., standing water) on the agricultural fields.

Surficial soil samples were also collected at all LASs and were analyzed for PFAS and Total Organic Carbon (TOC). The locations of soil samples were selected based on soil types, topography, and surface water flow paths, and were generally biased with the intent of obtaining the highest possible concentrations as a worst-case scenario. The soil sampling methods evolved over the course of the study. In the Lapeer Biosolids PFAS Investigation, soil samples were collected during two different events. In May 2018, soil samples were collected in accordance with EGLE's Incremental Sampling Methodology (ISM) and Applications guidance document, which is based on the ITRC 2012 ISM. A total of three, one-acre decision units (DUs) were selected for each LAS. Fifty incremental sampling locations were sampled within each DU and composited into one ISM soil sample for that DU. A total of three ISM soil samples were collected per DU. Soil samples were collected at a depth of six to eight inches bgs, since the spreading of the biosolids was assumed to have been applied consistently at a depth of eight inches across the LAS, based on information provided by EGLE WRD. Further, the various soil types identified in the soil survey could influence the adsorption of PFAS. To evaluate potential changes in PFAS impacts with soil type, the soil samples were taken from areas with various soil types that covered at least 50 percent of the entire LAS.

However, ISM can be expensive and time consuming, potentially limiting the extent of sampling that can be done. Therefore, in December 2018, EGLE WRD collected additional soil samples from Site 08N10E33-CL01 to evaluate if using composite sampling methods in smaller DUs would yield similar results to the May 2018 ISM sampling. A total of 12 50-by-50 ft DUs were identified for composite soil sampling across the LAS. Each composite sample was composed of nine aliquots, from a depth of six to eight inches bgs within the DU. All nine aliquots from each DU were homogenized into one composite sample for that DU. Results from the May and December 2018 events were similar.

Based on the results from the Lapeer Biosolids PFAS Investigation, EGLE WRD decided to continue using the composite sampling method in the Statewide WWTP and Biosolids PFAS Study. Soils at all LASs from the Bronson WWTP, Delhi Township WWTP, Gaylord WWTP, Jackson WWTP, Midland WWTP, and SHVUA WWTP were sampled using the same composite sampling method from the December 2018 event at Lapeer. Note, the number of DUs varied by LAS. After these initial LASs were sampled, EGLE WRD began receiving questions on whether the soil samples collected using this method were representative of the entire LAS (i.e., full area of the agricultural field that received biosolids) as well as the upper soil horizon, which reflects near surface soil conditions and is where lots of plant roots grow. As a result, EGLE WRD adjusted the soil sampling methods at some of the LASs associated with the Wixom WWTP and Port Huron WWTP (i.e., Fort Gratiot Parcel 1007-01) to attempt to address these concerns.

For the Wixom WWTP, Sites E01-BC01, E01-BC02, JW01, and JW05 were sampled using the same composite sampling method described above. However, at Site E02-BC01, EGLE WRD investigated using different soil sampling and analytical processing methods. To evaluate potential differences in PFAS concentrations with depth, EGLE WRD collected co-located composite samples within two 50-by-50 ft DUs at Site E02-BC01 from a depth of six to eight inches bgs (Method A) and from a depth of 0 to 12 inches bgs (Method B) within each DU. Each composite sample consisted of nine homogenized aliquots. Secondly, EGLE WRD also collected a third co-located composite sample in each DU from a depth of 0 to 12 inches bgs that was processed by the analytical laboratory using ISM, which includes prescribed procedures on how the sample is homogenized and sub-sampled prior to analysis (Method C). The third group of samples were used to evaluate the need for ISM processing by the analytical lab. Sampling Method B was also used at Site AG01.

In doing so, EGLE WRD demonstrated that the top 12 inches of soil are generally well homogenized. As a result, EGLE WRD chose to collect all soil samples from a depth of 0 to 12 inches bgs at the LAS associated with the Port Huron WWTP. For the Port Huron WWTP, EGLE WRD collected ISM samples from two DUs (i.e., DU1 and DU2), each composed of 52 aliquots. DU1 and DU2 were significantly larger than past DUs used in the study and covered the entirety of the LAS (i.e., DU1 covered the eastern portion, DU2 covered the western portion). To evaluate any differences in results between using ISM to sample an entire LAS versus using composite sampling to sample a smaller area of the same LAS, EGLE WRD collected composite soil samples from two 50-by-50 ft DUs (i.e., DU3 and DU4) within DU2. Each composite sample was composed of nine homogenized aliquots. Note, EGLE WRD also identified and sampled several dredge spoils from a nearby culvert replacement stockpiled on the Port Huron WWTP LAS.

In addition to surface waters and soils, groundwater was sampled and analyzed for PFAS at select LASs where the geology suggested that PFAS impacts to groundwater were more likely to occur. These included LASs associated with the Bronson WWTP, Delhi Township WWTP, and Wixom WWTP. Monitoring wells were installed at each LAS to assess the fate and transport of PFAS in groundwater and determine local groundwater flow direction. The location of monitoring wells was selected based on LAS topography, soil type/geology, and surface water features. Nested wells (i.e., shallow and deep wells) were installed at several locations to also assess the vertical movement of PFAS in the groundwater.

At sites where the geology, groundwater flow direction, and residential well locations suggested that residential wells may be susceptible to PFAS impacts, EGLE WRD also sampled the residential wells of most concern. This included residential wells near the LASs associated with the Port Huron WWTP and Wixom WWTP. Residential wells were also sampled near the LASs associated with the Ionia WWTP, as EGLE WRD had been unable to gain access to sample the fields. In addition, a livestock well was also sampled at one of the Wixom WWTP LASs.

Lastly, a limited number of crop samples were collected for MPART from some of the Wixom WWTP LASs and one of the Lapeer WWTP LASs to evaluate the potential uptake of PFAS in crops. Sample results are pending. A summary of the environmental media sampled per LAS for each WWTP is provided in **Table 4** and a summary of the LAS screening results for PFAS are provided in **Table 5**. For a detailed description of the LAS screening and associated results for each WWTP, see **Attachments A - G.**

TABLE 4. ENVIRONMENTAL MEDIA SAMPLED PER LAS FOR EACH WWTP

Table 4.1 WWTPs Without Industrially Impacted Biosolids

		Environmental Media							
WWTP	LAS	Soil DUs	Spoils Piles	Surface Water Body (Pond or Stream)	Tile Drain	Perched Water	Groundwater Monitoring Well	Residential Well	Livestock Well	Crops
Delhi Twp.	DT01	2	NS	3	NS	NS	4	NS	NS	NS
	DT02	2	NS	3	NS	NS	4	NS	NS	NS
SHVUA	VG02	2	NS	4	NS	NS	NS	NS	NS	NS
	JU02	2	NS	5	NS	1	NS	NS	NS	NS
Midland	RG02	2	NS	3	1	NS	NS	NS	NS	NS
	RG03	3	NS	4	7	1	NS	NS	NS	NS
Jackson	MC01	3	NS	2	NS	NS	NS	NS	NS	NS
	FC01	3	NS	4	NS	NS	NS	NS	NS	NS
	MT01	2	NS	NS	NS	NS	NS	NS	NS	NS
Gaylord	RW01	2	NS	NS	NS	NS	NS	NS	NS	NS
	JW01	2	NS	NS	NS	1	NS	NS	NS	NS
Port Huron	Parcel 1007-01	4	3	7	NS	NS	NS	3	NS	NS

NS = Not Sampled

Table 4.2 WWTPs With Industrially Impacted Biosolids

		Environmental Media								
WWTP	LAS	Soil DUs	Spoils Piles	Surface Water Body (Pond or Stream)	Tile Drain	Perched Water	Groundwater Monitoring Well	Residential Well	Livestock Well	Crops
Bronson	CA03	4	NS	7	NS	NS	2	NS	NS	NS
	CA04	2	NS	1	1	NS	2	NS	NS	NS
	CA05	2	NS	1	1	NS	4	NS	NS	NS
Wixom	AG01	1	NS	1	NS	2	NS	4	1	10
	JW01	2	NS	1	1	2	NS			NS
	JW05	2	NS	1	NS	NS	NS			NS
	E01-BC01	3	NS	2	NS	3	4			NS
	E01-BC02	2	NS	NS	NS	2	2			2
	E02-BC01	2	NS	2	NS	NS	NS			3
Ionia	RW01	NS	NS	NS	NS	NS	NS	37	NS	NS
	RW02	NS	NS	NS	NS	NS	NS		NS	NS
	RW03	NS	NS	NS	NS	NS	NS		NS	NS
Lapeer	TG01	1	NS	3	NS	NS	1 on TG01, plus 5 saturated soil samples	NS	NS	NS
	TG02	2	NS		NS	NS		NS	NS	NS
	SK01	3	NS	3	5	NS	6	NS	NS	NS
	CL01	3	NS	5	3	NS	6	NS	NS	30

NS = Not sampled

TABLE 5: LAS SCREENING PFAS RESULTS

Table 5.1 WWTPs Without Industrially Impacted Biosolids

		Field Results								
WWTP	LAS	Soils Total PFAS Range (ppb)	Soils PFOS Range (ppb)	Surface Water/Tile Drain/ Perched Water Total PFAS Range (ppt)	Surface Water/Tile Drain/ Perched Water PFOS Range (ppt)	Groundwater Total PFAS Range (ppt)	Groundwater PFOS Range (ppt)	Groundwater PFOA Range (ppt)	# of Residential Wells Sampled	# of Residential Wells Above MCLs
Delhi Twp.	DT01	2–15	2–9	4–18	ND	ND–21	ND–2	ND–3	NS	NS
	DT02	3–8	3–5	4–18	ND	3–97	ND	ND–6	NS	NS
SHVUA	VG02	ND	ND	9–46	ND–5	NS	NS	NS	NS	NS
	JU02	4–5	1–3	2–346	ND–2	NS	NS	NS	NS	NS
Midland	RG02	ND–9	ND–4	ND–7	ND	NS	NS	NS	NS	NS
	RG03	ND	ND	ND–58	ND–3	NS	NS	NS	NS	NS
Jackson	MC01	ND	ND	2–30	ND	NS	NS	NS	NS	NS
	FC01	3–11	3–8	2–25	ND	NS	NS	NS	NS	NS
	MT01	2	1	NS	NS	NS	NS	NS	NS	NS
Gaylord	RW01	ND–1	ND–1	NS	NS	NS	NS	NS	NS	NS
	JW01	1–2	ND–1	13	2	NS	NS	NS	NS	NS
Port Huron	Parcel 1007-01	1–191	1–150	10–1012	ND–813*	NS	NS	NS	3	0

*indicates exceedances of applicable Rule 57 WQS and/or Part 201 criteria.

All concentrations rounded to the nearest whole number. MCL = Maximum Contaminant Limits

ND = Non-Detect

NS = Not Sampled

Table 5.2 WWTPs With Industrially Impacted Biosolids

		Field Results								
WWTP	LAS	Soils Total PFAS Range (ppb)	Soils PFOS Range (ppb)	Surface Water/Tile Drain/ Perched Water Total PFAS Range (ppt)	Surface Water/Tile Drain/ Perched Water PFOS Range (ppt)	Groundwater Total PFAS Range (ppt)	Groundwater PFOS Range (ppt)	Groundwater PFOA Range (ppt)	# of Residential Wells Sampled	# of Residential Wells Above MCLs
Bronson	CA03	1–17	1–16	1–10	ND–3	ND–220	ND	ND–10*	NS	NS
	CA04	4–13	4–13	13–14	4–5	6–1	ND	ND	NS	NS
	CA05	6–7	6–7	7 – 9	1	ND–3	ND	ND	NS	NS
Wixom	AG01	8–15	8–14	12–551	2–159*	NS	NS	NS	4	0
	JW01	6–11	3 – 6	9–59	ND–18*	NS	NS	NS		
	JW05	2–4	2 – 3	4	ND	NS	NS	NS		
	E01-BC01	20– 7	20 – 27	86–968	38 – 533*	ND – 188	ND	ND		
	E01-BC02	31–36	28–34	37–86	16 – 57*	ND–9	ND	ND		
	E02-BC01	68–101	64 – 97	226–297	60– 191*	NS	NS	NS		
Ionia	RW01	NS	NS	NS	NS	NS	NS	NS	37	6*
	RW02	NS	NS	NS	NS	NS	NS	NS		
	RW03	NS	NS	NS	NS	NS	NS	NS		
Lapeer	TG01	3–22	2–14	7–15	ND–2	5	1	2	NS	NS
	TG02								NS	NS
	SK01	3– 14	2 – 12	9–2163	ND–2080*	2–169	ND–15	ND–9*	NS	NS
	CL01	21–183	21–172	7–2542	ND–2060*	ND–41823	ND–35300*	ND–1930*	NS	NS

*indicates exceedances of applicable Rule 57 WQS and/or Part 201 criteria.

All concentrations rounded to the nearest whole number. MCL = Maximum Contaminant Limits

ND = Non-Detect

NS = Not Sampled

Summary and Conclusions

PFAS such as PFBA, PFPeA, PFHxA, PFHpA, PFBS, and PFPeS have a shorter carbon chain length and are referred to as short-chain PFAS. PFAS such as PFHxS, PFOA, and PFOS have longer fluorinated carbon chain lengths and are referred to as long-chain PFAS. For example, the carbon chain length for PFBA and PFBS is four and eight for PFOA and PFOS. The shorter the carbon chain length for PFAS, the more mobile they are in the environment. As a result, long-chain PFAS are expected to concentrate and be present in the biosolids and soils at higher concentrations, while short-chain PFAS are expected to be more frequently detected in aqueous phases, such as surface water, tile drains, and groundwater.

Review of the LAS screening results showed that PFAS was detected to some extent in environmental media at all LASs studied. The six WWTPs that had biosolids PFOS concentrations considered to be lower or more "typical," exhibited non-detectable to low concentrations of PFAS in soils, surface waters, and groundwater at all LASs, except for the Port Huron WWTP LAS (**Table 5**). No exceedances of Rule 57 WQS for PFOA were observed and the only exceedance of Rule 57 WQS for PFOS was observed at the Port Huron WWTP LAS. There were no exceedances of the Part 201 criteria for PFAS in groundwater. Overall, a low environmental PFAS impact was observed at LASs that received biosolids from WWTPs with low to "typical" PFOS concentrations. EGLE WRD that the Port Huron WWTP biosolids were industrially-impacted at the time of application based on PFAS concentrations detected in the soils and a known significant source to the WWTP at the time of application. The source no longer discharges to the Port Huron WWTP so current biosolids PFOS concentrations likely do not reflect historical concentrations.

The LASs that received industrially-impacted biosolids (i.e., high concentrations of PFOS in the biosolids/ sludge) showed higher concentrations of PFAS in the soils. Again, note that EGLE WRD suspended land application approval for all four WWTPs (Wixom WWTP, Ionia WWTP, Bronson WWTP, and Lapeer WWTP) associated with these LASs. The highest soil total PFAS concentration was detected at the Lapeer WWTP Site CL01, which also had the highest biosolids PFOS concentration and weighted use ratio (**Table 2**). The soil results indicate that the total tonnage of biosolids that a LAS receives, the amount of acreage used, and the PFOS concentrations in the biosolids are good criteria to use when evaluating potential PFAS impacts. However, it is worth noting that PFOA and PFOS were much more widely used in the past. As a result, PFAS concentrations in all environmental media found at LASs where biosolids were land applied in the past may not be closely correlated to current concentrations found within the WWTP (e.g., see Port Huron WWTP discussion above). Further, the soil results indicated that PFOS was generally the PFAS detected at the highest concentrations, which supports the expectation above that long-chain PFAS will concentrate in the soils.

In addition to PFAS, the soil samples were also analyzed for TOC. PFAS, especially the long-chain compounds, are known to adsorb more strongly to fine particles such as silt and clay, which contain more TOC. Therefore, it was expected that soils with higher TOC concentrations would also have higher PFAS concentrations than other areas of the LAS. Results showed that on LASs with low PFAS concentrations (e.g., Delhi Twp. WWTP LASs), PFAS and TOC did not show a strong correlation, while on LASs with higher PFAS concentrations (e.g., Wixom WWTP LASs), the areas with the highest TOC concentrations were generally the areas with the highest total PFAS concentrations. However, at Bronson WWTP Site CA03, which also received industrially-impacted biosolids, there was no clear relationship between TOC and PFAS, likely due to the variation in PFAS concentration in the biosolids over time and the amount of land-applied biosolids. These results indicate that site-specific environmental conditions could play a significant role in environmental PFAS impacts.

The LAS screening process also evaluated several soil sampling methods at LASs associated with the Lapeer WWTP, Port Huron WWTP, and Wixom WWTP. The results showed that ISM and composite sampling methods could produce comparable results when used for screening of potential PFAS impacts from land applications of biosolids with properly selected decision units. Further, sample results indicated that ISM processing in the lab may not be necessary to obtain representative PFAS results if the mixing of the soil samples in the field can be done appropriately. Lastly, the results also indicated that biosolids are well mixed in the top 12 inches of soil, and that based on this limited dataset, sampling six to eight inches bgs or the top 12 inches of the soil horizon should be comparable. Based on these findings, ISM has unique benefits and is recommended when evaluating a large area but is not needed for proper screening of PFAS impacts to all soils from land application of biosolids.

Further, the LASs that received industrially-impacted biosolids also showed higher concentrations of PFAS in the surface waters and groundwater. Exceedances of the Rule 57 WQS for PFOS was observed at several locations around LASs associated with the Wixom WWTP and Lapeer WWTP. Elevated PFAS surface water concentrations are likely related to a combination of surface runoff and discharge of shallow groundwater into the tile drains and nearby surface water bodies. Exceedances of the Part 201 criteria for PFOS and/or PFOA were observed in several groundwater monitoring wells at LASs associated with the Bronson WWTP and Lapeer WWTP. While PFAS was detected in both shallow and deep monitoring wells, higher PFAS concentrations were generally detected in the shallow monitoring wells, often located in perched groundwater zones. Note, short-chain PFAS were detected at higher frequencies and concentrations in groundwater than long-chain PFAS at most of the LASs, likely due to their higher mobility. In addition, Delhi Twp. WWTP LAS boring logs show intervals of deep clay throughout Sites DT01 and DT02. The only PFAS detected in deep wells at the Delhi Twp. WWTP LASs were short-chain PFAS, such as PFBA and PFBS, which are more mobile in the environment, suggesting that deep clay may prevent the migration of long-chain PFAS such as PFOA and PFOS. Based on the groundwater flow direction, location of residential wells, and/or low PFAS concentrations observed in the groundwater at the LASs included in this study, there does not appear to be a potential risk to the nearby drinking water wells from PFAS in the biosolids applied to these LASs, except for those associated with the Ionia WWTP.

Since access to the selected Ionia WWTP LASs was denied, EGLE WRD decided that in the absence of the information, a limited sampling of residential wells would be conducted to ensure the protection of public health. EGLE WRD contracted with the Michigan Geological Survey, who provided a hydrogeologic triage package that summarized information on soils, groundwater, and surface water flows for the area in question. This information, as well as any available well logs for the area, were reviewed and wells were selected for sampling based on location, depth, and geology. To date, 37 residential wells have been sampled adjacent to LASs RW01, RW02, and RW03, as well as in the nearby town of Palo.

Of the 37 wells, 6 have detected concentrations of PFOS and/or PFOA above the Part 201 criteria and have been offered point-of-use filters in the interim. Based on the information available to EGLE WRD from the 37 residential wells sampled, PFAS contamination in the groundwater in this area appears to be limited to the east side of Palo and the northern edge of LAS RW01 at this itme. Since EGLE WRD did not directly sample the soils, surface waters, and groundwater at LASs RW01, RW02, and RW03, it is unclear if the land application of biosolids from the Ionia WWTP is the source of PFAS contamination in this area. Further investigations are needed to identify the source and determine the extent of PFAS.

Findings from the Statewide WWTP and Biosolids PFAS Study were used to develop an Interim Biosolids Land Application PFAS Strategy, which in conjunction with the IPP PFAS Initiative efforts, works to allow the majority of WWTPs to maintain the option to land apply biosolids, while protecting public health and the environment. EGLE WRD, working with MPART, will continue to build upon and expand knowledge on PFAS in municipal biosolids and at LASs.

ATTACHMENTS

Attachment A – Delhi Twp. WWTP Field Report

Attachment B – Gaylord, Jackson, Midland, and SHVU WWTPs Field Report

Attachment C – Port Huron WWTP (Ft Gratiot) Field Report

Attachment D – Bronson WWTP Field Report

Attachment E – Ionia WWTP Field Report

Attachment F – Wixom WWTP Field Report

Attachment G – Lapeer WWTP Field Report

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MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

APPENDIX A

Table 1: Summary of PFAS Results from the Statewide WWTP and Biosolids PFAS Study

No.	Facility Name	Influent PFOA (ng/l)	Influent PFOS (ng/l)	Influent Total PFAS (ng/l)	Effluent PFOA (ng/l)	Effluent PFOS (ng/l)	Effluent Total PFAS (ng/l)	Sludge/ Biosolids PFOA (µg/Kg)	Sludge/ Biosolids PFOS (µg/Kg)	Sludge/ Biosolids Total PFAS (µg/Kg)	Sludge/ Biosolids Final Treated Solids Sample Location	Sample Date	Comments
1	Alpena WWTP	5.94	5.44	51.05	7.49	5.07	73.39	1.36	42.1	136	Anaerobic Digestor	11/9/18	
2	Ann Arbor WWTP	2.91	16.5	88.76	4.42	14.8	112.85	<0.801	15.2	27.47	Lime Stabilized Solids*	11/2/18	*2 days after stabilization
3	Battle Creek WWTP	7.25	3.28	46.78	8.43	5.14	72.10	<0.97	<0.97	8.37	Lime Stabilized Solids*	10/31/18	*2 hours of stabilization
4	Bay City WWTP	4.87	18.20	69.19	5.39*	15.80*	76*	<0.93[1]	8.951	17.781	Inclined Screw Press Effluent (Primary & Secondary)	11/19/18	* Effluent after GAC tank, before UV | [1]Dewatered solids after polymer
5	Bronson WWTP	<2.22	843	2,219	2.4	169	290	3.86	1,060	1,173	Anaerobic Digestor	10/31/18	
6	Commerce Twp. WWTP	17.9	6.38	104	15.5	1.92	146	14.10	12.70	102	Belt Filter Press*	11/14/18	*Primary and Secondary Treatment
7	Delhi Twp. WWTP	<2.13	<2.13	5.12	2.33	1.76	20.57	<1.00	2.68	34.09	Anaerobic Digestor	11/1/18	
8	Dexter WWTP	<2.11	<2.11	11.53	7.97	1.51	105	<0.94	5.95	59.00	Anaerobic Digestor	11/2/18	
9	Downriver WTF	7.20	22.20	83.58	12.70	7.93	87.81	3.94	42.50	82.46	Belt Filter Press*	11/20/18	
10	East Lansing WRRF	2.21	<2.16	17.95	3.28	2.01	37.53	0.89	4.94	20.95	Belt Filter Press*	11/1/18	*Primary and Secondary Treatment

TABLE 1. CONTINUED

No.	Facility Name	Influent PFOA (ng/l)	Influent PFOS (ng/l)	Influent Total PFAS (ng/l)	Effluent PFOA (ng/l)	Effluent PFOS (ng/l)	Effluent Total PFAS (ng/l)	Sludge/ Biosolids PFOA (µg/Kg)	Sludge/ Biosolids PFOS (µg/Kg)	Sludge/ Biosolids Total PFAS (µg/Kg)	Sludge/ Biosolids Final Treated Solids Sample Location	Sample Date	Comments
11	Flint WWTP	4.83/ 6.35[1]	26.6/ 34.8[1]	77.44/ 97.24[1]	4.50	14.80	96.25	<0.98	13.50	44.45	Belt Filter Press[2]	11/5/18	[1]Without/with return flow | [2]Primary and Secondary Treatment
12	Fowlerville WWTP	<2.03	<2.03	6.78	7.6	1.47	62.11	*	*	*	*	11/5/18	*Did not collect solids
13	Gaylord WWTP	<2.02	<2.02	16.83	8.72	4.26	161	17.70	55.00	214	Aerobic Digestor	11/13/18	
14	GLWA WRRF	6.02[1]/9.1[2]/4.64[3]	7.54[1]/ 15.6[2]/ 10.7[3]	71.24[1]/ 117[2]/ 53.13[3]	6.74[4]/ 7.18[5]	9.68[4]/ 9.31[5]	119[4]/ 125[5]	<0.87[6]/ 1.12[7]/ <0.96[8]	<0.87[6]/9.44[7]/ 7.07[8]	ND[6]/18.56[7]/ 14.2[8]	see notes	11/16/18	[1]NIEA, [2]Oakwood, [3]Jefferson, [4]049B in Plant, [5]049F Zug Island, [6]Ash from Incinerator, [7]Pellets, [8]Cake from Belt Filter Press - primary and secondary
15	Grand Rapids WRRF	5.06	12.70	72.14	11.40	35.60	403	0.92	21.80	74.10	Dewatered Solids*	11/16/18	*Primary and Secondary Treatment
16	Holland WWTP	5.73/ 3.20[1]	3.79/ <2.19[1]	36.85/ 15.73[1]	4.67	2.41	42.71	< 0.98	5.89	22.16	Lime Stabilized Solids[2]	10/30/18	[1]North Influent/South Influent | [2]Collected from the sludge tank
17	Howell WWTP	4.42	<2.07	12.89	7.39	4.87	70.61	1.67	21.00	52.27	Belt Filter Press*	11/13/18	*Primary and Secondary Treatment

TABLE 1. CONTINUED

No.	Facility Name	Influent PFOA (ng/l)	Influent PFOS (ng/l)	Influent Total PFAS (ng/l)	Effluent PFOA (ng/l)	Effluent PFOS (ng/l)	Effluent Total PFAS (ng/l)	Sludge/ Biosolids PFOA (µg/Kg)	Sludge/ Biosolids PFOS (µg/Kg)	Sludge/ Biosolids Total PFAS (µg/Kg)	Sludge/ Biosolids Final Treated Solids Sample Location	Sample Date	Comments
18	S. Huron Valley UA WWTP	3.76	<2.14	17.72	6.69	5.33	102	2.46/ 0.913[1]	<0.987/ 8.47[1]	75.27/ 32.37[1]	Lime Stabilized Solids	11/20/18	[1]One(1) day of stabilization/Sludge cell (15 ft total depth)
19	Ionia WWTP	<2.23	213	8,667	<2.15	635	143,360	<0.99	983	1,006	Anaerobic Digestor	10/31/18	
20	Jackson WWTP	<2.28	5.98	15.80	3.38	3.17	60.38	0.80/ 4.41[1]	19.50/ 90.60[1]	87.83/ 155[1]	Anaerobic Digestor/ Drying Bed[1]	11/5/18	[1]One (1) week old constantly blend/No land application in the last 2 years
21	Kalamazoo WWTP	8.43	26	88.06	9.81	5.79	85.93	<1.00	6.49	17.68	Belt Filter Press*	10/30/18	*Primary and Secondary Treatment
22	KI Sawyer WWTP	<2.04/ <2.09[1]	5.77/ 81.00[1]	23.27/ 156[1]	10.20	62.00	132.64	25.40	387	662	Aerobic Stabilized - Storage Tank[2]	11/7/18	[1]Residential/Industrial | [2]Estimated to be 2 weeks old
23	Lansing WWTP	4.98	<2.16	35.09	7.58	5.51	107	<1.00/ <1.00[1]	5.08/ 7.18[1]	27.75/ 40.18[1]	Lime Stabilized Solids/ Belt Filter Press[1]	11/1/18	[1]Estimated to be 2-6 months old/Primary and secondary treatment
24	Lapeer	*	*	*	5.03	28.70	374	<5.58	1680.00	2358.00	Drying Beds[1]	5/9/18	*Not sampled during initial sampling period [1]Dewatered biosolids collected from drying beds.
25	Lyon Twp. WWTP	<2.28	<2.28	7.50	15.40	<2.01	111	25.10	6.35	133	Biosolids Storage Tank	11/13/18	

TABLE 1. CONTINUED

No.	Facility Name	Influent PFOA (ng/l)	Influent PFOS (ng/l)	Influent Total PFAS (ng/l)	Effluent PFOA (ng/l)	Effluent PFOS (ng/l)	Effluent Total PFAS (ng/l)	Sludge/ Biosolids PFOA (µg/Kg)	Sludge/ Biosolids PFOS (µg/Kg)	Sludge/ Biosolids Total PFAS (µg/Kg)	Sludge/ Biosolids Final Treated Solids Sample Location	Sample Date	Comments
26	Marquette WWTP	3.27	10.30	38.63	6.56	10.70	86.17	2.72	43.00	104	Belt Filter Press*	11/7/18	*Anaerobic stabilized biosolids cake from BFP.
27	Midland WWTP	10.30	2.72	69.92	10.50	4.03	79.02	1.93	12.70	91.61	Storage Tank*	11/19/18	*Anaerobic stabilized sludge
28	Monroe WWTP	2.89	5.50	33.17	5.35	5.46	50.31	<0.958	10.90	33.54	Screw Press*	11/20/18	*Primary and Secondary Treatment
29	Mt. Clemens WWTP	4.60	5.02	40.62	9.03	3.40	92.21	6.43	24.70	93.21	Storage Tank*	11/15/18	*Biosolids were 1 week old
30	Muskegon Co WWMS Metro WWTP	11.7	10.5	48.82	31.70	16.20	124	8.42	11.30	86.63	Drying Beds*	10/30/18	*Biosolids stabilized using lagoons
31	North Kent S A WWTP	11.2	31.1	80.41	21.2	12.5	389	11.00	160	332	Screw Press*	11/29/18	*Aerobic digested solids
32	Oscoda Twp. WWTP Wurtsmith	4.42	38.20	62.21	12.40	75.80	153	*	*	*	*	11/9/18	*Did not collect treated solids only soil
33	Pontiac WWTP - Oakland Co.	4.94	7.68	42.43	38.10	20.00	169	<1.00	7.31	29.35	Belt Filter Press*	11/14/18	*Dewatered biosolids after anaerobic digestion
34	Port Huron WWTP	64.60	19.50	361	44.80	13.10	336	4.42	77.60	196	Lime Stabilized Solids*	11/15/18	*Storage tank about 2 months old

TABLE 1. CONTINUED

No.	Facility Name	Influent PFOA (ng/l)	Influent PFOS (ng/l)	Influent Total PFAS (ng/l)	Effluent PFOA (ng/l)	Effluent PFOS (ng/l)	Effluent Total PFAS (ng/l)	Sludge/ Biosolids PFOA (µg/Kg)	Sludge/ Biosolids PFOS (µg/Kg)	Sludge/ Biosolids Total PFAS (µg/Kg)	Sludge/ Biosolids Final Treated Solids Sample Location	Sample Date	Comments
35	Genesee Co-Ragnone WWTP	4.00	5.22	45.88	7.23	4.72	73.64	1.66	15.70	83.39	Lime Stabilized Solids*	11/5/18	*Sampled before transfer into truck
36	Saginaw WWTP	2.56	4.19	25.93	4.58	4.13	42.42	< 1.72	2.18	12.50	Anaerobic Stabilized Solids*	11/19/18	*Sampled from storage tank 6 months old
37	Sandusky WWTP	12.2	7.98	138	8.39	5.26	154	0.90	12.80	93.58	Anaerobic Digester	11/16/18	
38	Traverse City WWTP	6.17	4.73	38.45	20.70	2.90	154	4.16	13.60	77.61	Anaerobic Digester	11/8/18	
39	Warren WWTP	4.61	7.31	59.04	7.19/ 7.21[1]	7.48/ 7.64[1]	73.54/ 75.62[1]	<0.997/ <0.992	9.19/ <0.992	22.49/ ND	Belt Filter Press/Ash[2]	11/15/18	[1]Effluent after UV/Effluent after sand filter | [2]Primary and Secondary Treatment / Incinerator ash lagoon
40	Wixom WWTP	3.07	128	2,329	9.89	269	4,950	1.73/ 4.58*	2,150/ 1,200*	2,324/ 1,510*	Aerobic Stabilized Biosolids/ Screw Press*	11/14/18	*Storage tank 6 months old/ Dewatered final treated solids
41	Wyoming WWTP	5.08	26.6	1,208	8.74	12.00	113	<1.00	15.00	32.10	Lime Stabilized Solids*	10/29/18	*Sampled from the storage tank
42	YCUA Regional WWTP	7.39	7.51	60.95	12.6	6.12	109	1.41	7.75	32.68	Belt Filter Press*	11/2/18	*Primary & Secondary Treatment

Note: ND = Non-detect with detection limits typical about 1 µg/Kg or parts per billion (ppb)