GLWA Sewer Shares Sampling Work Plan

Draft 8.10.17

1. Objectives

On June 7, 2017, the GLWA Board of Directors approved a resolution directing GLWA to prepare within 90 days a *preliminary strength of flow sampling plan that provides a meaningful basis for the allocation of strength of flow in each of the next three years with the expectation that, in part, the strength of flow could be used in determining sewer shares for the period of FY-2021 through FY-2023.* The objective of the sampling program is for all customers to feel comfortable that the water quality estimates used to determine the Shares are reasonable.

2. Background

In 2016, GLWA (through the Sewer Shares Project Team (Team), a joint GLWA-customer work group) implemented a water quality sampling program and included the results in the FY-2018 sewer share formulation. The sampling program focused on the largest customers and analyzed samples for the same parameters that are used in the industrial surcharge program: BOD (Biochemical oxygen demand), TSS (Total suspended solids), P (Phosphorous), and FOG (Fats, oil, and grease). Although the program was conducted from May through September, the samples per customer varied based on timing of getting specific sampling site issues resolved and the equipment installed. Initially, it was expected that the sampling data could provide an estimate of the relative pollutant load for each customer based on their own specific sampling data. During the process, difficulties were identified with the individual customer approach. An alternative approach of identifying a uniform concentration for each distinct type of flow (i.e. sanitary, dry weather infiltration and inflow, and wet weather infiltration and inflow) was developed and accepted by the Team.

Although the Team was able to develop recommended values to use for the Share calculations, a number of suggestions were provided on how to improve the process for the next Share determination. For example, additional data from the GLWA service area was desired for establishing the water quality of each flow component, rather than relying as strongly on national published data. Also, having a consistent period of time when all customer sampling is conducted to minimize climatological influence was also suggested. The suggestions are generally being implemented in this Work Plan.

In late 2016 use of grit as an additional pollutant was raised, since the customer contribution is expected to vary significantly and there are costs that can be identified at the WRRF for grit removal. It was raised relatively late in the process in 2016, but there was significant interest be several customers. Therefore, the subject of grit contributions is planned to be addressed in this Work Plan.

3. Approach

The suggested approach is to utilize three distinct methodologies as noted below:

A. Research the approach used by other major metropolitan areas with similar circumstances for addressing water quality variations amongst wholesale customers. Evaluate the results and compare them to the previously estimated values. Evaluate the practices and the results to identify what the customers would consider as best practices for GLWA.

B. Obtain data within the GLWA service area, if possible, to define the relative strength of flow for each component used in the analyses (i.e. flow components – sanitary, dry weather I/I, wet weather I/I). Identify any significant refinements to the prior methodology (e.g. sampling of wet weather I/I quality for separated areas, which is likely mostly groundwater flow, distinctly from combined areas, which is mostly surface runoff).

C. Conduct sampling to determine the relative magnitude of the contribution from several representative sewer districts in the GLWA service area (including several smaller districts, such as Allen Park and Melvindale). The sampling would occur during a consistent time period for all sites to minimize seasonal climatological variations and during a period that the deposition and resuspension dynamics are relatively low (e.g. daily composite samples for a two week period in late spring, after system is likely at minimum deposition/resuspension due to sustained higher flows). Since it would be very difficult to obtain this type of data from each customer, particularly the D+ area, it is expected that this would primarily be used to determine if the results from the component work are reasonable when applying it to sample customers.

4. Analyses

Each approach will help to provide guidance on the Shares determination. A brief description of how the data is expected to be utilized is described below:

A. It is expected that other metropolitan areas may have already gone through a similar strength of flow sampling and analytical process. Learning from the experience of others can be beneficial. It is also beneficial to compare the results of any similar analyses. If similar communities are finding similar results, confidence in the results usually increases. On the other hand, if results are dissimilar, it may indicate the need for greater understanding of what factors are contributing to the differences. It may also indicate a need for additional data to support or modify the estimates.

B. In the 2016 Sewer Share determination process, a limited number of sampling locations were identified to determine the component water quality. As data was collected and reviewed, it was determined that adjustments to the location and number of sampling sites would be desirable. However, the remaining schedule was limited and only a small number of adjustments could be made. Therefore, more reliance was placed on the literature values. Obtaining good component water quality data in the GLWA service area could significantly increase confidence in the results.

C. Obtaining good data for every customer creates practical difficulties particularly in the D+ area. However, obtaining data for a few representative customers would be desirable. This data could be used to make a limited comparison of relative mass flow balance calculations to the component methodology results. The categories of customers might include a. large, primarily separate system customers, b. large, primarily combined system customers, and c. small customers. The proposed strategy allows for sampling a limited number of customers in the first year. Sampling could potentially be expanded to all remaining customers in the second year if it is found there would be significant benefit to doing so.

5. Schedule

The adoption of the new Shares is expected to be completed by January, 2020. Therefore, the period available for execution of the sampling work plan is just over 2 years. By starting data collection soon, it will be feasible to have a phased approach, starting with a modest program for new data collection in the initial phase. If that proves insufficient, an additional, more extensive phase can be conducted.

Preliminary Thoughts for Sampling Locations

A. The research on other metropolitan areas can begin right away, since it is not dependent on climatological conditions.
B. Ideas for component flow sampling locations were discussed in 2016, but schedule limited the number of locations sampled. Preliminary ideas of sampling locations:
    a. Sanitary – Village of Franklin (pressure system with very low I/I), areas with very low DWII based on past studies, WWTPs outside GLWA that serve newer areas with very low DWII.
    b. DWII – manholes that have “gushers” or “runners” that have not yet been rehabilitated, footing drains, direct DWII in pipes such as sewers in abandoned areas that no longer have sanitary flow, storm sewers in dry weather.
    c. Wet weather I/I- similar to DWII for separate areas, storm sewers with soils similar to Detroit and Dearborn for combined areas, separate detention basin influent sampling data.

Large, primarily separate sanitary areas – OMID, EFSDS, RVSDS (or subarea, like Novi), large combined areas (RTB influent?) – Hubbell-Southfield, GWK, Dearborn Prospect, small areas – Allen Park, Melvindale, Center Line. Figure 1 shows a Map of Proposed Sampling Locations.

6. Parameters

The parameters included are consistent with those covered in the 2016 study: BOD, TSS, P, and FOG. Grit is one additional component added in this evaluation. “Grit consists of Sand, gravel, cinders, or other heavy materials that have specific gravities or settling velocities considerably greater than those of organic putrescible solids. In addition to these materials, grit includes eggshells, bone chips, seeds, coffee grounds, and large organic particles such as food wastes. (Metcalf & Eddy, 1991).”

Grit quantities are often highly variable, particularly in large sewers that exhibit tendencies for deposition during low flows and resuspension during high flows. Therefore, it is suggested that the initial grit analyses be based on available data in the literature and in wastewater facilities operating reports. The surface runoff in combined areas is likely the largest factor that will create a differential in loading from customers. The fraction of the treatment cost related to grit removal is likely relatively small, so it is anticipated that the differential cost allocation amongst customers will be small in comparison to other costs.

7. Protocols

The sampling protocols used in the analyses were determined to be acceptable in 2016. It is expected to continue the same process, but a review will be conducted to determine if any adjustments are desirable. Results are expected to be expressed as a percentage of sanitary flow strength.

A detailed description of the previous sampling plan, proposed sampling locations, a strategy to manage and understand sample variability and calculations are available in Appendix A through C (see below).

Two sampling protocols do need to be addressed by the technical committee.

A. Inflow at the WWRF is sampled on a time composite basis. It may be desirable to use time-weighted sampling in the other locations. This would enable consistent comparisons between collection system data and WWRF data. An alternative approach would be to collect flow-weighted samples to more accurately capture loading from individual components of the collection system. Assumptions would be required to compare the flow-weighted results from the collection system to time-weighted results from the WWRF. However, the GLWA is extensive and combines flows from many sub-systems, so the loading peaks are attenuated and time composite samples may be sufficiently representative.
B. The conditions that indicate wet weather events need to be clearly identified and protocols for collecting wet weather samples need to be explored in more detail.

8. Roles and Responsibilities

It is anticipated that GLWA will execute the Sampling Work Plan. Periodic meetings will be held with the stakeholders to provide input and to review results. GLWA will also develop the report and recommendations.

9. Appendixes

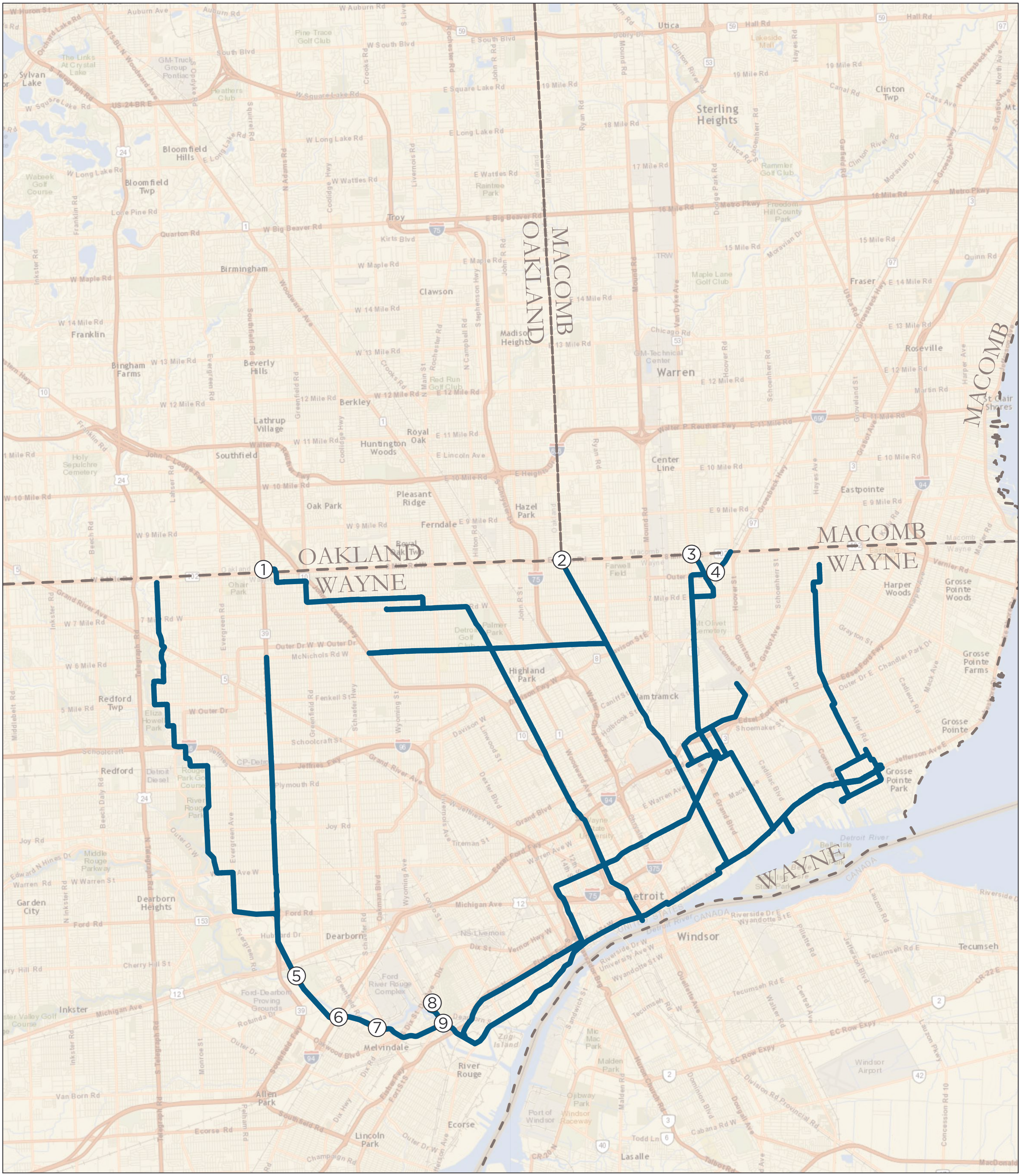
Appendix A: GLWA 2016 Strength of Flow Assessment

Appendix B: Confidence in Sampling Results

Appendix C: Calculations

10. References

Metcalf & Eddy. (1991). Wastewater Engineering. Burr Ridge, Illinois: Irwing McGraw-Hill.



① EFSDS
② GWK
③ Centerline
④ OMID
⑤ Hubbell - Southfield
⑥ Allen Park
⑦ Melvindale
⑧ Dearborn Prospect
⑨ RVSDS

Interceptor
County Boundary

Figure 1

Proposed Sampling Locations
GLWA Sewer Shares
Sampling Work Plan

N

0 3 6
Miles
1 inch = 3 miles

Source: Data provided by GLWA, the State of Michigan, and ESRI. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 HARN StatePlane Michigan South FIPS 2113 Feet Intl

Map Published: August 25, 2017

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Appendix A:
GLWA Strength of Flow Assessment

Strength of flow assessment study has been initiated as part of the Sewer Share Assessment. This study mainly consist of major-community sample collection, testing for certain pollutants, and analysis of the results.

1 Sample Collection

Both dry and wet-weather samples will be collected during the study period for strength of flow assessment. A few samples will also be collected to assess the DWII.

1.1 Sampling Criteria

1.1.1 Dry-Weather Sampling

Dry weather sampling will be performed whenever possible during the study. The following are the criteria for dry-weather day selection:

- Total rain for previous 4 days> 1 inch? Today not DW day
- Total rain for previous 3 days> 0.6 inch? Today not DW day
- Total rain for previous 2 days> 0.3 inch? Today not DW day
- Total rain for previous 1 day> 0.15 inch? Today not DW day
- Total rain today > 0.1 inch? Today not DW day
- Total Plant flow > 700 MGD? Today not DW day (To account for the possible impact of snow melt)

Note: Weather permitting 5 events/month/site.

1.1.2 Wet-Weather Sampling

High-intensity short duration events as well as long duration low-intensity events will be collected. These events during daytime hours, 7 days will be monitored and sampled. The following are the criteria for wet-weather day;

- The precipitation must be 0.1 inches or higher
- The storm must be preceded by at least 72 hours of dry weather (<0.1 inch rain)

Note: As many wet-weather samples as possible will be collected.

1.1.3 DWII Sampling

Samples will be collected from the communities as well as from the City of Detroit during hours of minimum sanitary flow to assess the DWII.

1.2 Weather Tracking and Team Mobilization

This section describes the weather tracking and team mobilization procedures for sample collection.

1.2.1 Dry-Weather Events

Potential days for dry-weather sampling events can be identified approximately five days in advance based on the predicted forecast and prior antecedent dry conditions. Weather tracking and monitoring will be performed on a daily basis by Systems Control Center (SCC) to identify the potential dry-weather events. SCC will notify the Field Program Coordinator. The Field Program Coordinator will confirm the event 24 hours in advance and inform the field crew. The Field Program Coordinator will also document the weather conditions approaching the day of the dry-weather sampling event to confirm that the dry-weather sampling criteria are met. Once the dry-weather sampling event has been identified, the Field Program Coordinator and the sampling crew are responsible for ensuring the proper collection of samples.

1.2.2 Wet-Weather Events

Potential days for wet-weather sampling events can be identified approximately five days in advance based on the predicted forecast from National Weather Services of NOAA. Weather tracking and monitoring will be performed on a daily basis by SCC to identify the potential wet-weather events. SCC will notify the Field Program Coordinator approximately 48 hours prior to the event. SCC and the Field Program Coordinator will continue to monitor the event and keep the team members informed of the potential event status. After a potential event is identified the Field Program Coordinator will issue a stand by notice to all sampling crew. As the storm is tracked SCC and Field Program Coordinator will issue a “go”/ “no-go” decision as to whether sampling will proceed, and participants will be informed accordingly. If a “go” decision is made the Field Program Coordinator will inform the sampling crew and the sampling will be mobilized. Weather “go”/”no-go” the Field Program Coordinator will also document the weather conditions. Once the wet-weather sampling event has been identified, the Field Program Coordinator and the sampling crew are responsible for ensuring the proper sample collection.

1.2.3 False Starts and Aborted Events

False starts may occur during wet-weather sampling due to the unpredictable nature of the wet-weather event. The Field Program Coordinator and SCC will determine whether an event will be aborted following the mobilization of sampling crew to the field. The Field Program Coordinator will document the situation. The sampling crew will be responsible for reporting the weather conditions in their respective area to the Field Program Coordinator.

1.3 Sampling Locations

The communities selected for the study are OMID, Evergreen-Farmington, Southeast Oakland, Wayne, Wayne-Macomb, Dearborn, and Detroit. The existing sewer meter locations are the dry and wet-weather sampling sites for all communities except Detroit. Specifics of the sampling locations are:

Community	Meters
Oakland Macomb Interceptor Drainage District (OMID)	Northeast Sewer Pump Station Meters
Evergreen-Farmington	OC-S-1 Meter
Southeast Oakland	SE-S-1
Wayne County	WC-S-1* WC-S-2 WC-S-3

Dearborn	DN-S-2 DN-S-8
Wayne-Macomb	WM-S-1
City of Detroit	DT-S-10 DT-S-12 Rest of them to be provided by the DWSD

*At WCS-1 site the wet-weather sampling will be conducted when the WWTP wet well levels are below 85 ft. When the WWTP wet well levels are above 85 ft. the wet-weather sampling will be from WCS-2 and WCS-3 sites.

1.4 Sampling Methods

Composite samples will be collected for TSS, TP and CBOD analyses, and grab samples will be collected for FOG from all sites.

1.4.1 Dry-Weather

Flow paced, 24-Hr. composite samples will be collected at all sites that has a flow meter (WMS-1 flow meter is out of order). Cleaned, pre-labeled bottles will be provided to the sampling team. Collected sample will be placed in a cooler for transportation to the laboratory.

1.4.2 Wet-Weather

The Field Program Coordinator monitors the flow meter flow, and start the collection of the wet-weather sample when the base flow increases by 15-20%. This is to account for the time delay of the storm flow to arrive at the sampling point. Flow paced samples will be collected for up to 6-8 hours. WMS-1 flow meter is out of service, so time paced hourly samples will be collected from the beginning of the storm. Cleaned pre-labeled bottles will be provided to the sampling team. Collected sample will be placed in a cooler for transportation to the laboratory.

1.4.3 DWII

Selected communities like Wayne, Macomb and Oakland will collect samples during the time periods when minimum amount of sanitary flow is possible. In the City of Detroit residential areas with maximum occupants and minimum occupants will be sampled. These areas will be sampled during different times of the day to assess the sanitary flow and DWII.

1.5 Field Documentation

The Field Program Coordinator will provide Field Data Collection Forms as well as Field Logbooks to the sampling crew.

1.6 Sample Designation, Handling and Custody

The Field Program Coordinator will collect clean bottles from the laboratory, and ensure that the bottles are properly labeled for sample collection. Samples will be preserved as required and will be placed in a cooler to transport to the laboratory. Sample chain of custody protocol shall be maintained during sample collection, transfer, transportation, and final disposal of the samples.

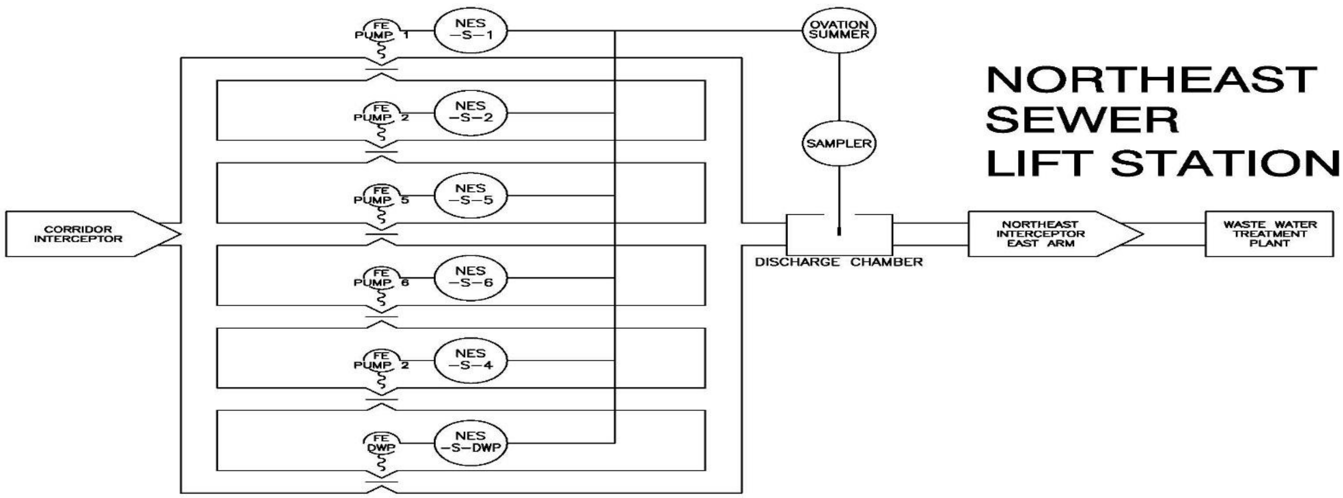
2 Sample Testing

The pollutants that are being investigated for the Strength of Flow Assessment study are Total Suspended Solids (TSS), Fat, Oil, and Grease (FOG), Total Phosphorus (TP), and C-Biological Oxygen Demand (CBOD). The collected samples will be analyzed by RTI Laboratories, 31628 Glendale St, Livonia, MI.

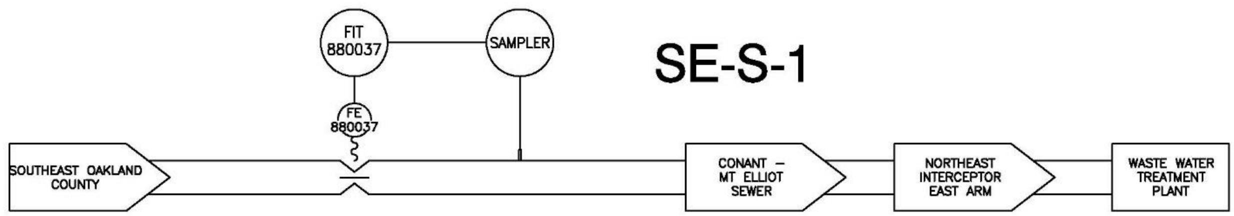
3 Analysis of the Results

The results of the Laboratory testing will be analyzed and presented to the Sewer Share Assessment Team.

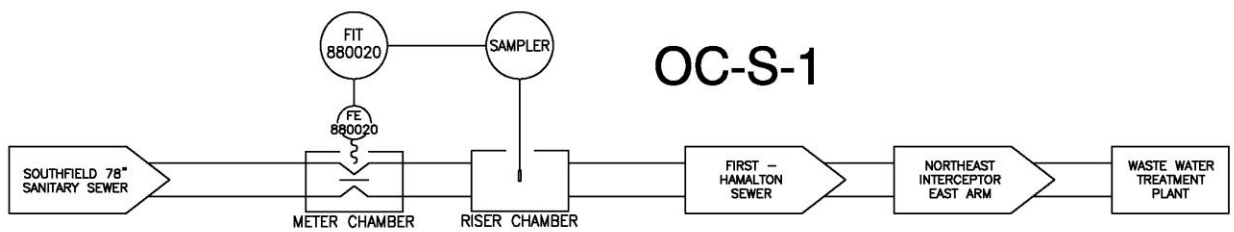
Sampler Flow Diagrams



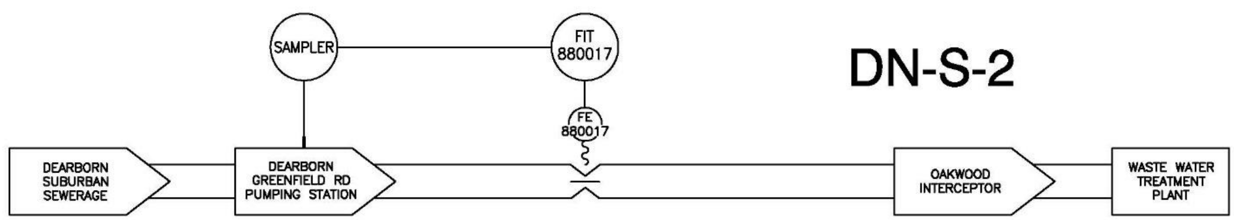
Sampler installed at the discharge chamber. Flow paced 24 Hr. composite sample collection



Sampler installation on 3/15/2016 at the meter chamber underground, Flow paced 24 Hr. composite sample collection

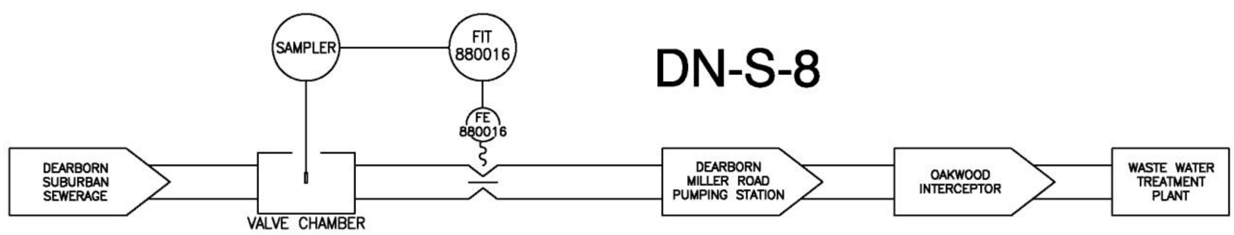


Sampler installation today at the meter riser chamber, Flow paced 24 Hr. composite sample collection



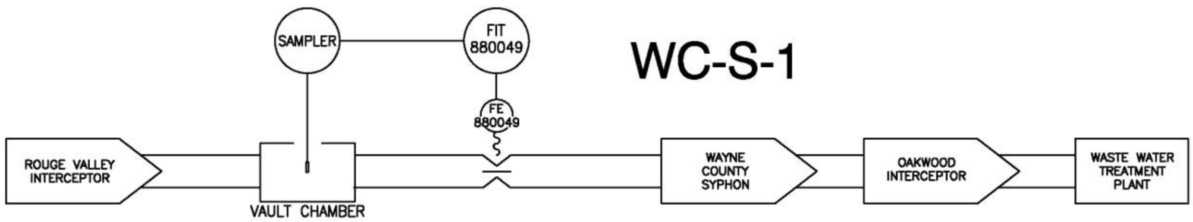
Possible installation at the Greenfield PS wet well. Flow paced 24 Hr. composite sample collection

Need permission from City of Dearborn



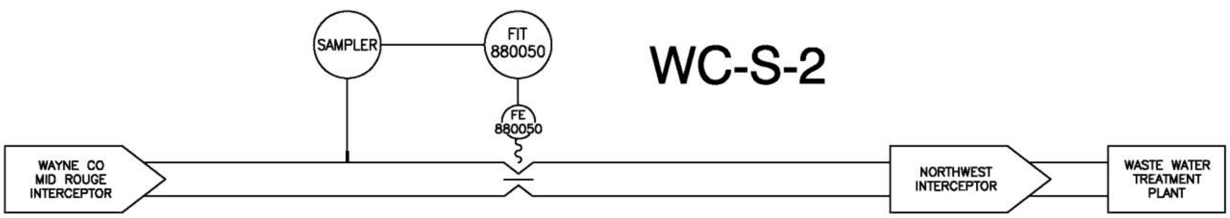
Possible installation at the Miller Rd. PS. Flow paced 24 Hr. composite sample collection

Need permission from City of Dearborn

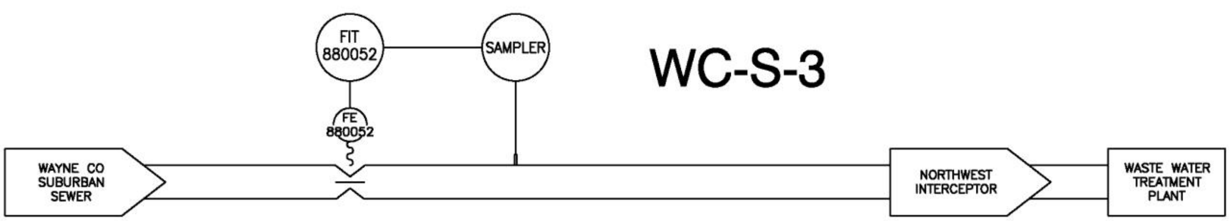


Possible installation at the Siphon's inlet chamber. Flow paced 24 Hr. composite sample collection

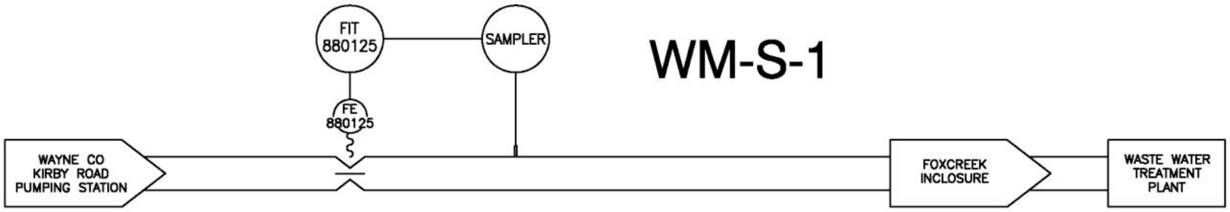
Need construction permit from Wayne County



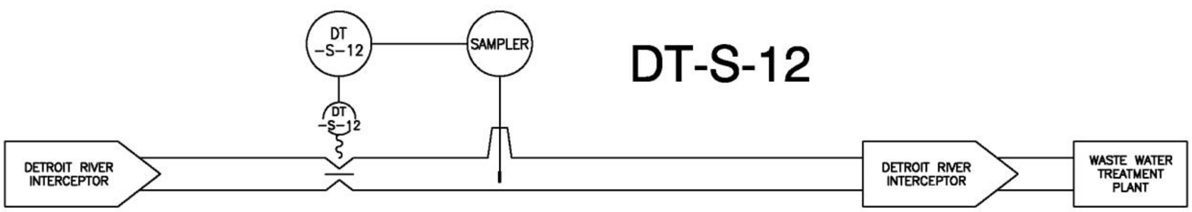
Possible installation at a manhole 20 yds. away from the meter. No power. Has to be battery powered. Flow paced 24 Hr. composite sample collection.



Possible installation from an existing port at the meter site. Has power. Flow paced 24 Hr. composite sample collection.



Possible installation at the Kerby Rd. PS. Flow meter out of service. 24 Hr. time paced composite sample collection



Sampler installed. Flow paced 24 Hr. composite sample collection

Appendix B: Confidence in Sampling Results

1. Background: Results from Previous Sampling Effort

The 2016 GLWA Strength of Flow Assessment evaluated wastewater strength of flow as a component of the cost allocation for the member communities. This analysis evaluated BOD (biochemical oxygen demand), TSS (Total suspended solids), TP (Total Phosphorous), and FOG (Fats, oil, and grease). The report established strength of flow recommendations for sanitary flow, dry weather inflow and infiltration (DW II), and wet weather flow.

The 2016 GLWA Strength of Flow Assessment collected samples from 20 different locations across the GLWA area. The BOD, TP, TSS and FOG data was highly variable across sample locations and at a single location over the duration of the sampling program. The time series data for select locations is shown in **Figure 1** through **Figure 4**.

Figure 1. Total Suspended Solids Concentrations at Four Sample Locations

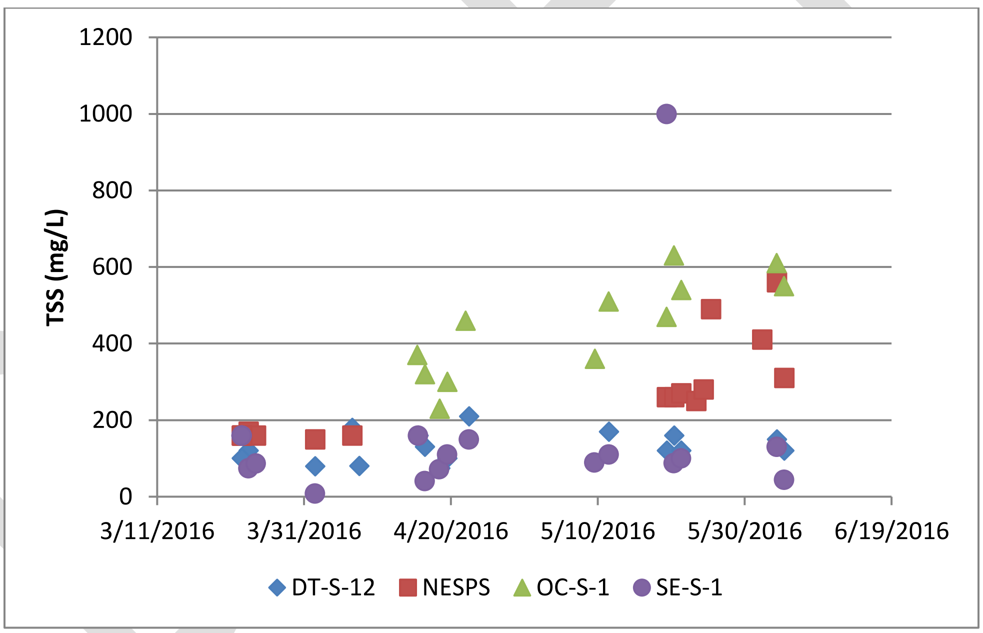


Figure 2. Total Phosphorus Concentrations at Four Sample Locations

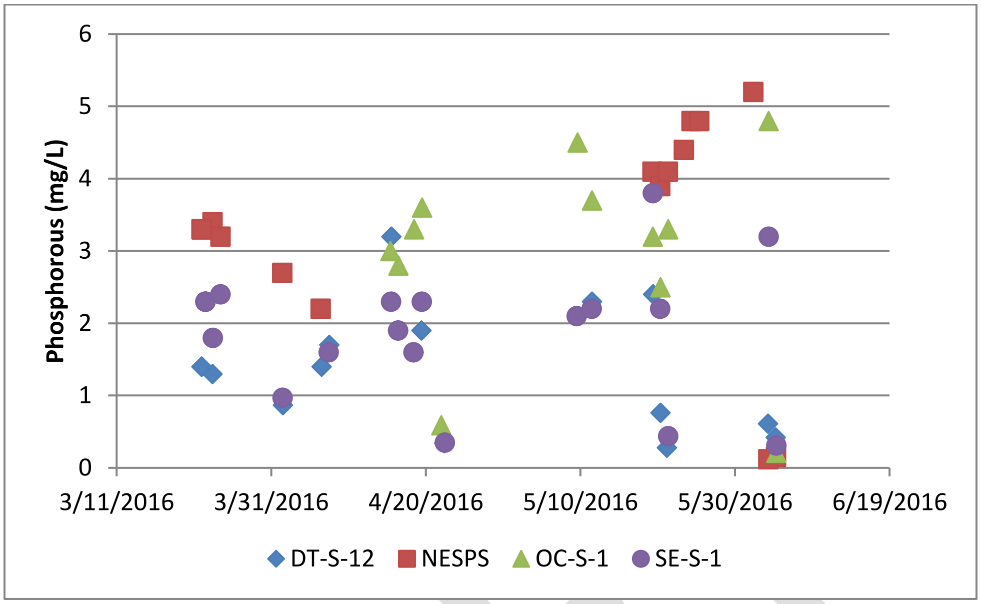


Figure 3. Oil and Grease Concentrations at Four Sample Locations

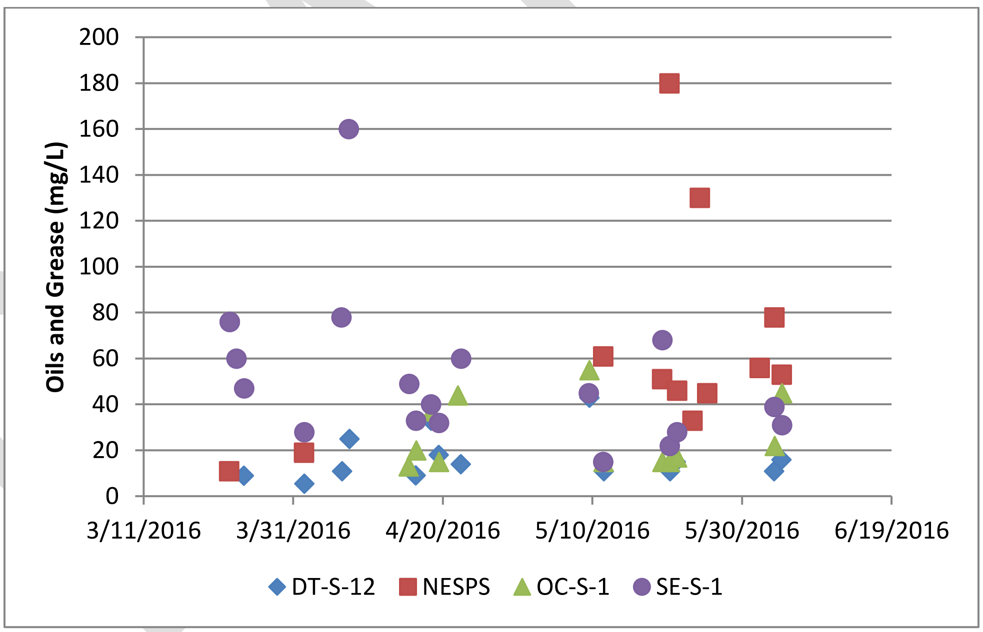
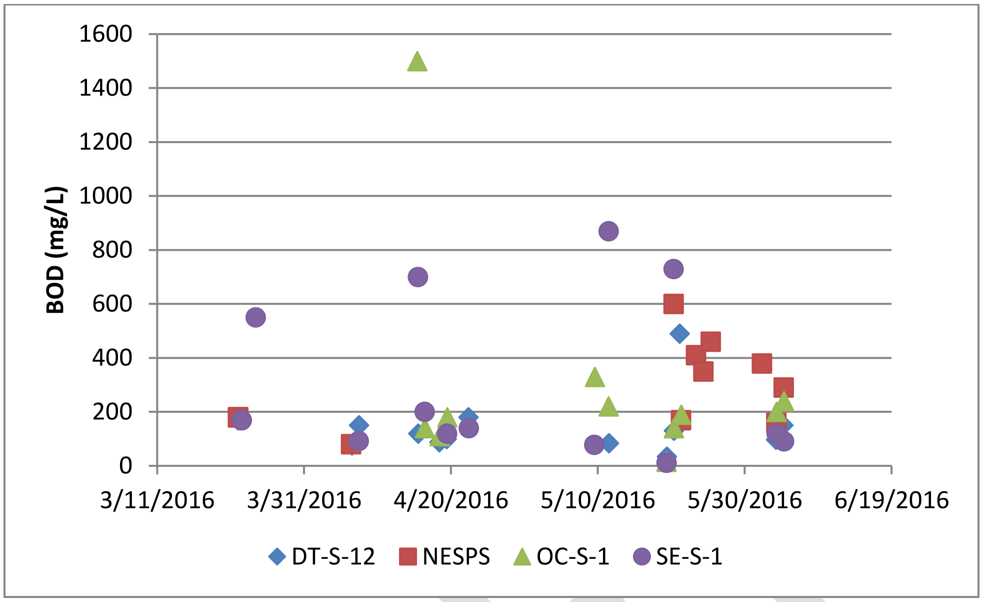


Figure 4. Biological Oxygen Demand at Four Sample Locations



Several possible phenomenon could explain the variability in the time series data.

A. Deposition and Resuspension: Deposits accumulate in sewers during periods of low flow and are scoured and transported during high flow events. Michigan rainfall is concentrated in the spring months when this sampling event took place. The time series data may be documenting a shift in flow regime from low to high flow and the tendency for high flow events to mobilize sediment and scums that would have higher TSS, TP, BOD and FOG concentrations.
B. Input of Different Sources: Higher rainfall events are also associated with more storm water flowing in combined sewers, and more groundwater infiltration. Both of these sources have lower concentration of TSS, TP, BOD and FOG relative to sanitary flow in dry weather and would dilute the overall concentrations. The sampling period may have captured variability due to the differences between dry weather, first flush during storms and dilution from precipitation after the storms purge the system.

2. Goal: Control and Quantify Uncertainty

The goal of this study is to control and quantify uncertainty in the sampling process thereby building confidence that the data are reasonable. Several strategies are built into this sampling plan to quantify and minimize data variability.

A. Avoid Periods of Settling and Resuspension: The sampling event is planned for late spring. Early spring storms are expected to flush accumulated sediment and scums. By sampling in late spring, we hope to capture the time period when deposition and resuspension are at a minimum and sampling conditions are more stable.
B. Isolate Types of Flow: Undiluted sanitary flow, dry weather II and wet weather flow have distinctly different concentration profiles. The plan is to locate sampling sites where each of these parameters can be quantified independently. For example: separated sewer systems

with low II provide an opportunity to sample the concentration of undiluted sewage. Similarly, locations that represent dry weather II and wet weather flow will be selected.

C. Obtain Sufficient Samples: We can use statistics as a tool to determine our level of confidence in our sample results and to determine the number of samples needed to establish an acceptable level of confidence in the results.
   a. Guidance from other applications: The typical industry standard to set sewer rates for industrial customers is two weeks of 24-hour composite samples (a total of 14). This approach is applicable to a single industrial customer with only one site. Additional complexity is added when examining a large project area that contains a mix of combined and separated sewers of varying ages and conditions. Still, 14 samples offers us a reference for the minimum number of samples that could be acceptable. The 2016 Strength of Flow Assessment exceeded the 14 sample minimum and collected 20 or more, 24-hour composite samples per site. The data still demonstrated a high degree of sample variance within each site and when comparing sites across the GLWA service area. One approach to managing sample variance is by selecting a sufficiently large sample size.
   b. Guidance from statistical analyses: We need to consider a number of variables to choose an appropriate sample size based on statistics:
      i. **Standard Deviation**: How much variance can we expect in the data? This information is available from the previous sampling event and can be calculated by the following equation (n=the number of samples, $\bar{x}$ is the sample mean and x_i is the value of the sample):

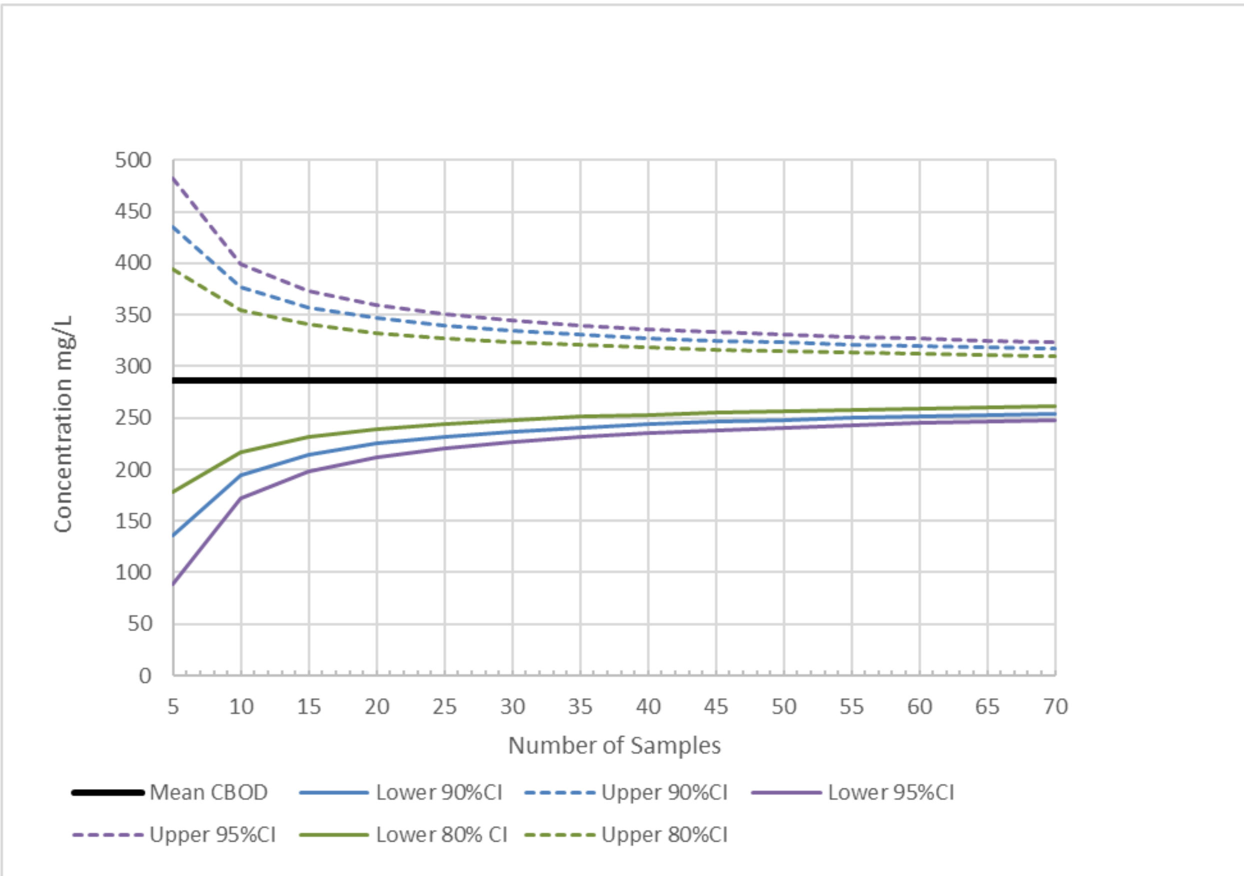
$$Standard\ Deviation = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$$

      ii. **Confidence Level**: The confidence level tells us how sure we can be that the answer is correct. It is expressed as a percentage and represents how often the true value of the sample population lies within the confidence interval. A 90% confidence level means we can be 90% certain; the 95% confidence level means we can be 95% certain. The confidence level enters the calculation in the form of the Critical Value and can be looked up from a compilation of values for the Student's-T statistical test for small sample sizes. See: http://www.itl.nist.gov/div898/handbook/eda/section3/eda3672.htm
      iii. **Confidence Interval:** No sample will be perfect, so we need to decide how much error to allow. The confidence interval determines how much higher or lower than the population mean we are willing to let our sample mean fall. We will examine how the confidence interval decreases as the number of samples increases in the following example. We can generate a confidence interval around a mean using the following formula:

$$\bar{x} \pm (\text{Critical Value}) * \frac{\text{Standard Deviation}}{\sqrt{\text{Sample Size}}}$$

A 95% confidence interval is the most commonly selected. In this analysis we compared the size of the 95% 90% and 80% confidence interval to see if there is a significant difference in the number of samples required. COBD data from the sample NESPS collected during the dry weather interval of 3-21-16 to 9-6-16 was used for this evaluation (see **Figure 5**).

Figure 5. Comparison of 80%, 90% and 95% Confidence Intervals as a Function of Sample Number. Sample Location NESPS. Parameter CBOD.



From **Figure 5** we can see that there is an advantage to collecting more samples. As the number of samples increases the width of the confidence intervals decreases and we can say with more certainty that the sampling mean value results represent the true value. However, as the number of samples increases, there is a point of diminishing return. Spending more money on additional samples does not result in more confidence in the data. For the 95% confidence interval, this point occurs at approximately 50 samples. If 50 samples per site is impractical, the GLWA could opt to collect 30 samples and accept 90% confidence in the data. Collecting 20 samples would result in an 80% confidence interval. Similar results can be observed with the data for FOG, TSS and TP (see **Figure 6** through **Figure 8**).

Figure 6. 95% Confidence Interval as a Function of Sample Number. Sample Location NESPS. Parameter FOG.

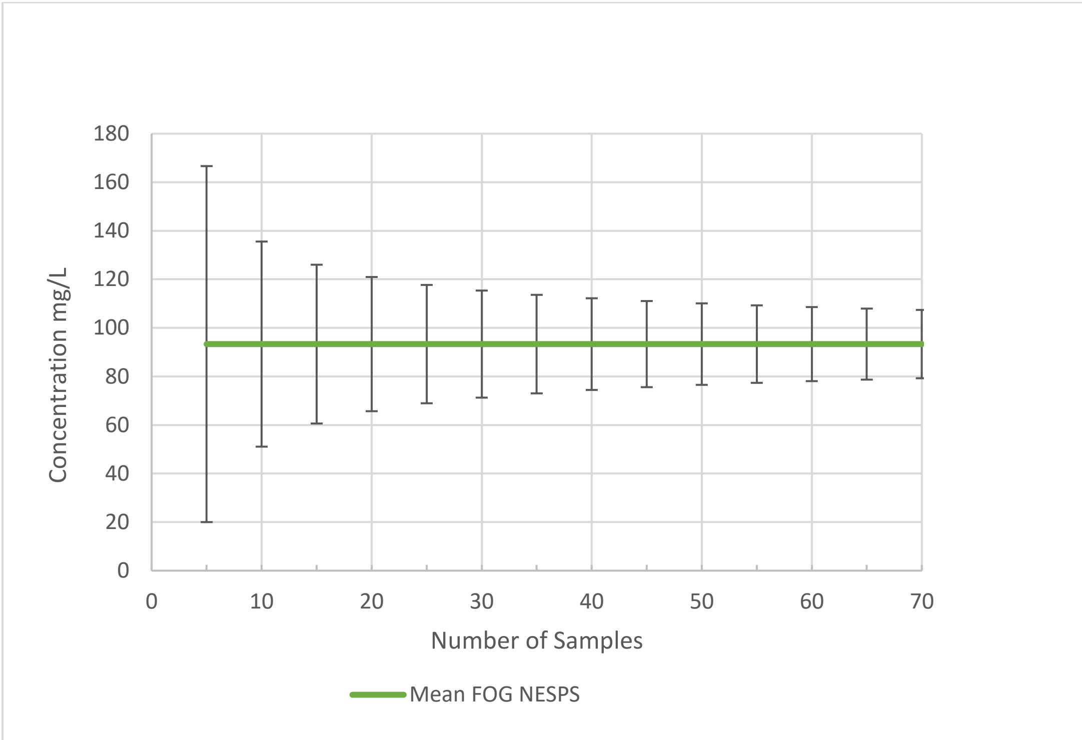


Figure 7. 95% Confidence Interval as a Function of Sample Number. Sample Location NESPS. Parameter TP.

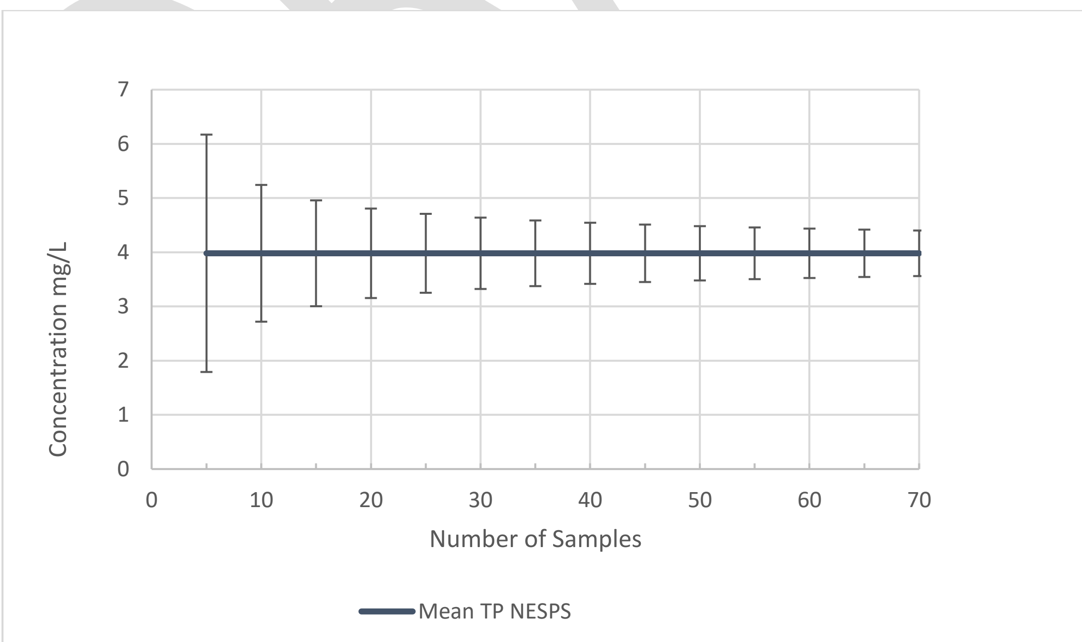
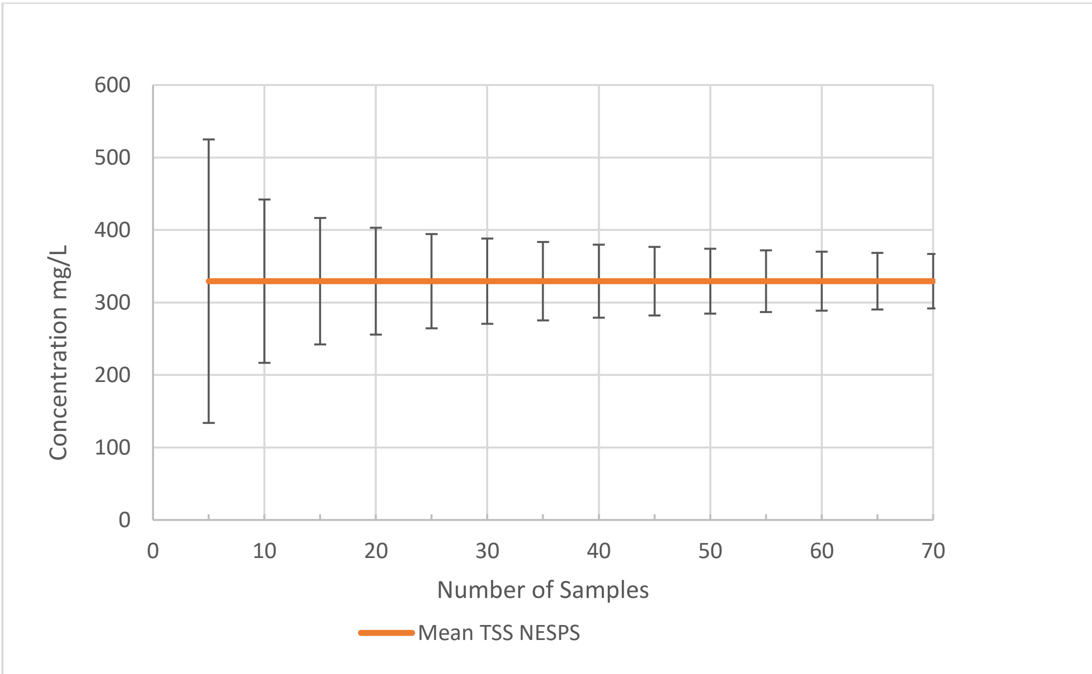


Figure 8. 95% Confidence Interval as a Function of Sample Number. Sample Location NESPS. Parameter TSS.



We are aware that the 2016 Strength of Flow Assessment choose to use the population median as a representative of sample characteristics. This approach is logical for highly variable samples because it reduces the importance of outliers. However, the sample mean is required to calculate confidence intervals, and confidence intervals demonstrate the relationship between sample variance and sample size. Therefore, this approach used the sample mean.

3. Conclusion

Working with highly variable data requires an understanding of the factors that contribute to the complexity. It may not be possible to obtain perfect data. However, we can make conscious choices to reduce the sample variability and making trade-offs between the cost of collecting samples and the confidence in the data. In doing so we can arrive at a data set that has an agreed upon level of confidence so all of the participating communities can have an acceptable level of comfort with the results.

Appendix C: Calculations

1. Development of Strength of Flow Ratios

One goal of this sampling plan is to develop strength ratios for each of the parameters (BOD, TP, TSS, FOG) in sanitary, DWII and wet weather flow scenarios. Development of the strength ratios is described below.

Flow meter data is utilized to establish the flow volumes.

$$V_t=V_s+V_{I/I}+V_{st}$$

- V_t=volume total
- V_s=volume sewage
- $V_{I/I}$ =volume I/I
- V_{st}=volume stormwater

Sample load combines flow volume and concentration in the following equation.

$$C_tV_t=C_sV_s + C_{I/I}V_{I/I} +C_{st}V_{st}$$

- C_t=concentration total (measured value)
- C_s=concentration sewage
- $C_{I/I}$=concentration I/I
- C_{st}=concentration stormwater

The strength ratios are calculated by assuming that the sanitary sewer strength C_s =100% and the other flow components are dilutions of C_s

$$R_s= 1$$

$$R_{I/I} = C_{I/I/}\ C_s$$

$$R_{st\ t}=C_{St/}\ C_s$$