Technical Memorandum

Flow Meter Operation and Maintenance

Annual Billing Look Back: 2022

South Huron Valley Utility Authority

February 9, 2023

CDM Smith

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Section 1

Introduction and Approach

1.1 Purpose

This report documents the work and results of the 2022 Data Review performed under the South Huron Valley Utility Authority (SHVUA) Flow Metering Operation and Maintenance project. This project is being performed for SHVUA by the consulting engineering firm CDM Smith Michigan Inc. (CDM Smith) from January 2019 to December 2023, under the current contract. The purpose of the 2022 Data Review was to review raw flow meter data, make corrections or estimates of poor quality or missing data, review accuracy for the sanitary sewer flow meters, and apply the estimated inflow and infiltration (I/I) volumes in the SHVUA interceptor system to provide data for billing purposes.

1.2 Background

The SHVUA provides wastewater service to seven member communities and one customer community including:

- Charter Township of Brownstown
- City of Flat Rock
- City of Gibraltar
- Huron Charter Township
- City of Romulus (non-voting customer)
- Village of South Rockwood
- Van Buren Charter Township
- City of Woodhaven

Each community owns and operates its own local sanitary sewer systems. Flows from the local systems discharge to the SHVUA regional interceptor system and are transported to a 24 million gallons per day (mgd) advanced secondary wastewater treatment plant. The SHVUA interceptors, pump stations, and wastewater treatment plant (WWTP) are currently operated by Jacobs Engineering Group Inc. The sewer billing meters and two meters located at the WWTP are maintained under SHVUA's current contract with CDM Smith.

Communities are billed for their flows based on SHVUA flow meter data. For some communities, flows are directly metered at their connection to the interceptor system. For other communities, billable flows are calculated incrementally by subtracting flows from the upstream community and/or subtracting estimated I/I flows of the regional system. The interceptor I/I estimate is removed from the total billable community flows shared by each community. However, all flow from the collection system, including interceptor I/I, is still treated at the WWTP and is included in the total operating costs of the system. In this way, interceptor I/I is considered a shared cost to all communities. The formulas used to calculate billable flows for each community are given in

Table 1-1. **Figure 1-1** is a schematic of the SHVUA flow meter and interceptor system. Included are the SHVUA interceptor I/I and other un-metered inputs related to the billing calculations.

Table 1-1 Current Meter Calculations

Community	Meter System Calculations	
	Meter Math	Interceptor I/I (thousand gallon)
Brownstown Central	(5 + 6)	(note 1)
Brownstown South	(1 + 3)	(note 1)
Flat Rock	(8 - 12 - 17) - I/I	3,258 (note 2)
Gibraltar	4 + QW (note 4)	(note 1)
Huron Township	(12 + 17 - 16) - I/I	12,609 (note 2, 3)
South Rockwood	7	(note 1)
Van Buren Township	16 - I/I	1,863 (note 2)
Woodhaven	(14 - 5 - 6) - I/I	5,557 (note 2)

Notes:

1. The measured wastewater flows are not currently adjusted for I/I within the interceptor system. Any I/I included in the measured flow rates for these communities are recognized as originating in the community's collection system rather than the interceptor system, and hence not considered a shared cost.
2. Measured wastewater flows are adjusted for I/I within the interceptor system. Review of the I/I allowance may be appropriate to determine if adjustments are necessary to reflect existing interceptor conditions.
3. Beginning with the 2012 Look Back the monthly I/I allowance for Huron Township increased from 9,931 to 12,609 thousand gallon (kgal) based on SHVUA assuming ownership of Sections II and III of the 1986 Wayne County interceptor pipes.
4. Quala Wash, an industrial discharger within Gibraltar, re-routed its sewer discharge directly into the 60-inch diameter SHVUA interceptor on Vreeland Road downstream of SH-14 and upstream of Trenton Arm Lift Station starting 4/17/17. Its discharge was previously routed through SH-04. Quala Wash's discharge is added to Gibraltar for billing purpose. The discharge volume is the sum of its process volume and estimated sanitary discharge (340 gallons per day) during work days.

Table 1-2 lists the SHVUA sanitary flow meters used for billing and system operations. Prior to 2020, most flow meters in the interceptors were Accusonic transit-time meters that were installed in 2001. A meter replacement program has been in place to prioritize and install new meters on an as-needed basis. SH-02, SH-04, SH-08, SH-16, and SH-17 were replaced upon failure in 2014-2019. Meter sites SH-03 and SH-05 also had new meters installed in 2020. In 2022, new meters were installed at SH-01, SH-06, SH-07, SH-12, and SH-14 under the SHVUA Priority 1 & 2 Improvements Project.

Meters SH-01, SH-07, and SH-12 at the three collection system pump stations are magmeters. The WWTP has a main influent flume (SH-10), and a meter to measure recycle flows (SH-02). The recycle flows are pumped back to upstream of the main influent meter. These two meters are not used for billing, but they are maintained under the CDM Smith's contract as they are used as an important check against the sum of the upstream meters. There is also an effluent meter at the WWTP that is maintained by Jacobs and not under CDM Smith's contract.

Figure 1-1 Schematic of SHVUA Interceptor and Flow Meters

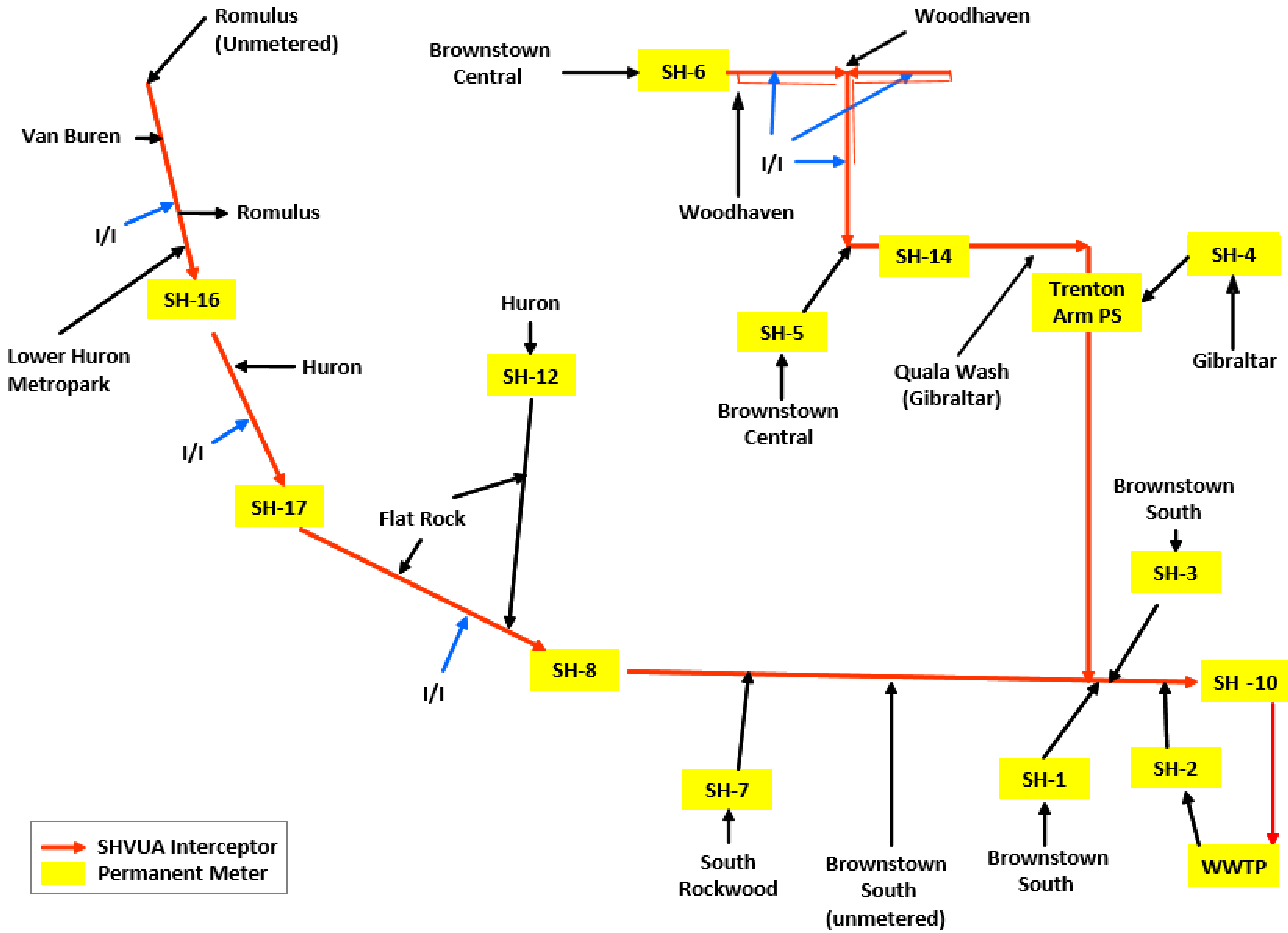

Table 1-2 SHVUA Flow Meters

Meter	Community	General Location Information for Meter	Meter Description	Year Installed
SH-01	Brownstown Township	Lee Road Pump Station	Magmeter (replaced 10/18/22), manhole access	2022
SH-02	SHVUA WWTP	Recycle Manhole #1 adjacent to WWTP Raw Sewage P.S.	Transit-time meter replaced by two ISCO 2150 continuous Doppler meters, manhole access	2019
SH-03	Brownstown Township	Manhole adjacent to the interceptor junction chamber at the WWTP entrance on W. Jefferson	Transit-time meter replaced by 2160 LaserFlow module with redundant 350 area-velocity sensor, manhole access	2020
SH-04	Gibraltar	Manhole at SE intersection of Jefferson and former N. Gibraltar Road- across from steel plant	ISCO Signature meter w/LaserFlow velocity sensor and redundant 350 area-velocity sensor, manhole access	2014
SH-05	Brownstown Township	Manhole at SW intersection of Steven Drive and Allen Road	Transit-time meter replaced by ISCO 2160 EX LaserFlow in 2020, temporary 2150 meter was installed on 5/11/22, manhole access	2020/2022
SH-06	Brownstown Township	Manhole at Van Horn Road 425 feet east of Gregory Drive	Transit-time meter replaced by NivuFlow Meter (installed 1/29/22), manhole access	2022
SH-07	South Rockwood	Labo Park Pump Station	Magmeter (replaced 9/19/22), manhole access	2022
SH-08	Flat Rock	Backyard area along Huron River between 25303 and 25317 Huron River Drive	Transit-time meter replaced by ISCO pulse Doppler meter and ISCO 2150 continuous Doppler meter, manhole access.	2019/ 2020
SH-10	SHVUA WWTP	WWTP Influent Meter at Raw Sewage P.S.	Parshall flume & level sensor (replaced 2020)	
SH-12	Huron Township	Odette Pump Station	Magmeter (replaced 2022 during pump station re-construction), manhole access	2022
SH-14	Gibraltar	Manhole at SE intersection of Fort Street and Vreeland Road	Transit-time meter replaced by NivuFlow Meter (installed 2/11/22), manhole access	2022
SH-16	Huron Township	Lower Huron Metro Park - South Metropolitan Parkway at Park Office Road	ISCO Signature meter w/LaserFlow module and redundant 350 area-velocity sensor, manhole access	2017
SH-17	Flat Rock	Backyard area behind residential address 26730 Will Carleton Road	Transit-time meter replaced by ISCO meter 2160 LaserFlow module and redundant 350 area-velocity sensor, manhole access	2020

1.3 Task Approach

The data review, correction, and estimation approach consisted of the following steps, which are performed during the monthly review and then reviewed and revised as needed for the annual Look Back:

- Reviewed raw data to identify missing or poor-quality data and significant recorder clock errors
- Applied adjustments for meter accuracy, including flow recalculation and clock corrections where necessary
- Applied data replacement methods based on the acceptable and historical meter data
- Reviewed data after preceding recalculations, clock corrections, and replacement methods completed to verify implementation was as expected
- Applied adjustment factors (AFs) for meter bias based on dye dilution test results
- Applied I/I credits

Specialized tools and procedures were applied to facilitate data review efforts. The raw 5-minute averaged flow data was reviewed graphically. Each date was classified as either acceptable quality to be kept, or classified as needing replacement of all, or a portion of the day when missing and/or poor-quality data occurred. Since November 2006, when CDM Smith started providing monthly flow data analysis, data has undergone this review process monthly.

Maintenance records and accuracy testing information were reviewed to assess the relative accuracy of the existing data. During the year, corrective maintenance was performed when needed. From time to time, corrective maintenance occurred at a site shortly after the monthly volume report. The yearly data review allowed for reassessment of operational issues affecting the metered flow volumes, with corrections made to the data to account for inaccuracy as needed. In some cases, it was determined that flows could be recalculated: e.g., if the primary level sensor fails to perform adequately, flows could be recalculated using the secondary level sensor. For periods with poor or missing velocity data, but with acceptable quality level data, site-specific rating curve or best-fit polynomial equations may be used to calculate flow based on level data only.

These equations were calibrated against acceptable quality flow data during periods of acceptable quality level and velocity data.

Clock shift error corrections were made as needed. These are identified by comparison to an accurate clock, or by evaluating timing of historic diurnal patterns. For the latter, time shifting was performed for errors of approximately five hours or more. Since the inception of routine quarterly maintenance in November 2006, significant clock errors have become rare and affect much shorter periods of time than clock errors prior to November 2006. Some time differences of about 1-hour were accounted for this year as the meter data collection transitioned to SCADA. The internal meter clocks were on standard time (not observing daylight savings time shifts),7hile the SCADA logged data was on daylight savings time. Going forward the meter clocks will also be adjusted to local, daylight time.

After data review and classification was completed, the acceptable data was processed to calculate average trends, such as an average diurnal by weekday (also referred to as the 'greenline'). Depending on the amount of data classified for replacement, different protocols and methods are used. When acceptable data exists for part of the day, the missing or poor data is estimated based on the typical average diurnal flow for that day of the week (scaled up or down as needed to match the acceptable data for that day). This is referred to as "partial-date estimation". If the entire day has been classified for replacement, the data is estimated based on correlation to another meter; this is "full-date estimation". Relationships to other meters are determined through statistical comparison of historical behavior of a given meter to all other meters in the system. The best correlated meter having available acceptable quality data is used.

Finally, I/I credits (determined by the Flow Metering and Analysis project in 2005 and updated in 2012 for Huron Township to account for SHVUA ownership of an abandoned interceptor parallel to the active interceptor) are applied to provide the percentage flow distribution for each community.

1.4 Exceedance of Contract Capacity Approach

In August 2012 CDM Smith was asked by Hinshon Environmental Consulting to perform an analysis of the billing meter data for July 2009 – July 2012 to identify instances where a community's flow exceeded its Interceptor or Treatment Plant Purchase Capacity. The process for examining the community flow data and criteria used to determine if a purchase capacity was exceeded are described below. The exceedances identified in the initial historical review were presented and discussed with the SHVUA Technical Committee at the October 9, 2012, meeting. As described in the meeting summary, the proposed criteria would be applied as a useful tool for identifying potential problems. The Board would retain discretion to review each case of an exceedance, consider the history of past exceedances, circumstances relating to an individual event, and the impact of the excess flows on the system's ability to treat or convey flows from all communities during the event. The exceedance criteria are included in Exhibit M to the ***Consolidated Service Agreement*** (dated December 3, 2014). By establishing the exceedance criteria as an Exhibit, the criteria can be adjusted in the future if needed without modifying the Consolidated Service Agreement itself (see Section V.2 of the service agreement).

The Interceptor and Treatment Plant Purchase Capacities for each community are provided in **Table 1-3** in units of mgd. Note that in other references of the SHVUA Interceptor Purchase Capacities, the value is often listed in units of cubic feet per second (cfs). The units were changed for this evaluation for consistency with the units of flow measurement utilized by the billing meter data.

Table 1-3 Purchase Capacities for Each Community

Community	Interceptor Capacity (mgd)	Treatment Capacity (mgd)
Brownstown Township – South	2.94	6.66
Brownstown Township – Central	11.01	
Flat Rock	9.65	3.47
Gibraltar	7.11	1.97
Huron Township	7.97	3.67
South Rockwood	0.83	0.40
Van Buren Township	5.30	5.43
Woodhaven	17.47	2.40
TOTAL	62.28	24.00

The initial data compilation and review of the exceedances found that the criteria proposed by Mr. Hinshon were reasonable for identifying community flows above the contract capacities. The exceedance criteria are:

- Community flow (or subarea flow for Brownstown Township) exceeds interceptor purchase capacity by 20% or more for at least 1 hour
- Community flow (or subarea flow for Brownstown Township) exceeds interceptor purchase capacity by 10% or more for at least 4 hours
- Community flow exceeds treatment plant purchase capacity by 20% or more for at least 24 hours
- Community flow exceeds treatment plant purchase capacity by 10% or more for at least 72 hours

The data compilation approach to compile total flow for each community consisted of the following steps:

- Utilize finalized data from Look Back or monthly data processing with adjustment factors (AFs) applied as needed to each meter.
- Calculate a 1-hour moving average to reduce impact of very brief spikes or fluctuating flows from pump stations. This step maintains a flow rate for every 5-minute time interval, but that flow rate represents the average of the flows 30 minutes before and after the particular timestamp.
- Calculate total flow for each community utilizing the moving average data for each meter and applying the metering addition or subtractions and I/I allowances shown in **Table 1-1** (converted to mgd). An adjustment for time of travel between meter locations is made for communities where the total flow is determined by subtraction to better account for the timing of the peak flows.
- Flag community flows that exceed any relevant capacity criterion.

- Identify exceedances by counting sequential records that exceed a flow criterion to determine if the duration criterion is also exceeded.

The results and exceedances identified for the initial data review are summarized in the October 9, 2012, Technical Committee meeting summary. The Technical Committee recommended that CDM Smith provide a summary of exceedances occurring in 2012 as part of the annual Look Back and on a monthly basis beginning with the January 2013 monthly data report. The 2022 exceedance summary is provided in **Section 3**.

Section 2

Meter Accuracy Assessment

2.1 Introduction

This section describes how the accuracy of existing flow meters used for sanitary sewer billing was assessed. The work included review of the flow meter data collection and maintenance records, verification of accuracy using dye dilution testing at the meters, and physical inspections of each metering site performed during preventive or corrective maintenance visits.

Table 1-2 in **Section 1** lists descriptions of the existing billing meters that were reviewed. The reviewed billing meters include all the meters in **Table 1-2** except SH-02 and SH-10, which are not used for billing. **Figure 1-1** shows a schematic of the SHVUA system.

2.2 Meter Data and Maintenance Reports Review

The project team reviewed available raw data from 2022 to identify missing or poor-quality data. The team also reviewed each day's 5-minute averaged data using weekly and monthly plots of the data generated for each meter. Data was reviewed and compared to typical diurnal patterns determined for each day of the week to identify anomalies. Based on these reviews, the data for each date and for each meter was classified as "Acceptable" or "Unacceptable". Dates classified as unacceptable may be due to a wide variety of problems such as power failure, sensor failure or error (level and/or velocity), etc.

Long-term plots of the flow, level, and velocity data were used to identify changes in meter operation not evident in weekly plots. These reviews helped corroborate initial data classifications and identify gradual problems with data indicated by dye dilution test results or data collected during quarterly preventative maintenance visits.

Table 2-1 summarizes data quality for the billing meters. The third column shows the percent of raw data identified as "acceptable", which are used without any recalculation or estimation. However, this data may also have a bias correction or adjustment factor (AF) that is applied based on dye dilution test results, before being used to calculate community volume. The fourth to seventh columns list the percent of data "recalculated" to correct for errors in depth measurement or velocities. Based on review of long-term plots of flow, level, and velocity data, these errors include drifting of the primary level sensor and velocity sensor failures/errors. Recalculated flows use secondary level sensor data and/or corrected level offsets. Other missing or poor-quality data is estimated using the "partial-date" or "full-date" estimation methods, described in **Section 1**. "Other methods" are used as appropriate, such as polynomial equation-estimated flow based on level data and a calibrated depth to flow relationship (rating curve) developed during periods of acceptable operation. The percentages are based on a total of 365 days in 2022.

Overall, 85% of the flow data was acceptable in its raw state in 2022, compared to historical range of 82% to 94% between 2008 and 2021. Data corrections for each meter are summarized in the following pages.

Table 2-1 Summary of Raw Data Compilation Methods

Meter ID	Percent of Look Back Data				
	Acceptable	Recalculated	Partial-date Estimation	Full-date Estimation	Other Method (Rating Curve, etc.)
SH-01	95.8	0.0	0.0	3.8	0.3
SH-03	82.3	0.0	1.0	16.4	0.2
SH-04	95.0	0.0	2.3	0.0	2.7
SH-05	98.9	0.0	1.1	0.0	0.0
SH-06	97.8	0.5	0.5	0.3	0.8
SH-07	97.0	0.0	0.0	2.5	0.5
SH-08	81.8	0.0	0.0	0.0	18.2
SH-12	53.6	0.0	0.0	45.8	0.6
SH-14	52.8	0.0	0.4	0.0	46.7
SH-16	95.9	0.0	1.6	2.2	0.3
SH-17	85.0	0.0	4.3	0.0	10.7

Routine maintenance of the meters is performed quarterly, including checking and potentially correcting level sensor accuracy, cleaning and verifying operation of meter components, and collecting real-time meter data readings and site information. Corrective maintenance was performed as needed during the routine maintenance visits and during several visits specifically for corrective purposes. Additional information on corrective maintenance issues can be found in the monthly reports to the SHVUA Board. Routine and corrective meter maintenance is performed by a subcontractor, HESCO.

The key meter operations and maintenance that influenced recalculations for the 2022 data included:

- **SH-01**: During the transition to connecting the meter to the SHVUA SCADA system, no meter data was recorded/available for the period of 10/18 – 11/2. Full date estimation was used for flow data for this period.

- **SH-02**: No meter data was available for the period of 3/1 – 3/8. During the 3/1 data download, HESCO found the primary ("blue") 2150 module had stopped working but secondary ("red") 2150 module data was available. During the March PM visit, HESCO cycled power to the system to resolve the issue, but a portion of data was lost. During the transition to the SHVUA SCADA system, no meter data was recorded/available for the period of 10/18 – 11/1. Full date estimation was used for flow data from 10/18 – 11/1.

- **SH-03**: No meter data was available for the period of 11/1 through 12/31 because the primary (2160 Laser) and secondary (350 AV Doppler) meters were both found to be not functioning correctly during the 12/2 site visit and needed to be removed and evaluated for repair. Lease equipment was ordered, but not received before the end of the calendar year. Full date estimation was used for flow data for this period.

- **SH-04**: Beginning in October and through December, velocity measurements tended to drop out during low flow periods (i.e., night-time low flow). There was very minimal rainfall during the second half of 2022, and flow rates at all meters tended to be historically low during these months.

- **SH-06:** For a couple days in January, flows from the Accusonic meter were recalculated with secondary level when the primary level data differed from secondary level by more than 3%. The new Nivus meter was installed on 1/19. During the transition to the SHVUA SCADA system, no meter data was recorded/available for the period of 10/4 – 10/6. Additional details regarding meter accuracy and adjustments to the new meter are summarized in Section 2.3.

- **SH-07**: During the transition to the SHVUA SCADA system, no meter data was recorded/available for the period of 10/4 – 10/12. Full date estimation was used for flow data for this period.

- **SH-08**: Significant debris caught on the meter mounting band in the sewer impacted velocity readings for the primary (accQmin, pulse Doppler) and secondary (2150, continuous wave Doppler) meters. During quarterly PM visits (3/22, 6/15, 9/19, and 12/2) and on 10/17, HESCO removed significant debris caught on the accQmin mounting band. For several days from September through December, flows were estimated using depth measurements and a depth to flow correlation that was developed for the 2022 Look Back based on the 2150 meter data during periods of acceptable operation from 1/1/22 to 11/30/22.

- **SH-12**: The meter was offline during the construction at Odette Pump Station from 3/24 through 8/31. The new magmeter installation was completed on 8/31, however no meter data was recorded/available for the period of 8/31-9/7, during the transition to the SHVUA SCADA system. Full date estimation was used for flow data from 3/24 through 9/7/22.

- **SH-14**: Flows were estimated with correlation to level due to high velocity measurements in the Accusonic meter in January and February. The new Nivus meter was installed on 2/11. Several velocity sensor and pressure level sensor parameter adjustments were made to the Nivus meter following installation and prior to dye testing. Flows from 2/11 through 6/17 were estimated using adjusted radar level sensor data and a depth to flow correlation developed from data after 10/17/22. Flows from 9/28 through 10/17 were also estimated by correlation to level. More details on parameter adjustments and correlations for these periods are described in the 2022 dye dilution test report for SH-14 and summarized in Section 2.3.

- **SH-16**: The meter occasionally reported unreasonably high velocities (exceeding 2 feet per second) during dry weather for short periods (5 – 15 minutes). Data were corrected using simple interpolation with acceptable data immediately before and after the period. Also, on 12/13, the primary meter (360 Laser) began recording erroneous velocity data and upon investigation it was found that the existing meter needed to be removed for repairs and a temporary replacement meter was installed on 12/22. There was no available data for the period 12/13-12/22 and full-date estimation was used.
- **SH-17**: Debris/moisture accumulation on Laser window impacted velocity and flow measurements. Flows were estimated based on correlation to level for 10/1-11/7 and 11/28-29.

2.3 Dye Dilution Accuracy Verification Review

Since 2001, dye dilution testing has been performed on most of the SHVUA billing meters to assess their accuracy. The dye dilution method is a means for estimating flow in systems to verify meter flow. A dye dilution test is performed by adding dye to the sewage stream at a constant rate, allowing it to mix completely, and measuring concentration at a downstream location. A mass balance on all fluorescing materials in the system can then be used to estimate sewage flow based on the degree of dilution observed at the downstream sampling point. While any non-reactive tracer could be used for estimating flow by this method, the use of fluorescent dye is particularly convenient because simple and accurate fluorometric methods are available for on-site continuous analysis of concentrations.

The dye dilution testing method used for these tests is based on the protocol developed under the Greater Detroit Regional Sewer System (GDRSS) Technical Committee and Flow Metering Task Force in 1997 for the Detroit Water and Sewerage Department. The full protocol and error analysis are detailed in GDRSS ***Technical Memorandum 4-2 Dye Dilution Testing Protocol*** **and** ***Technical Memorandum 4-4 Meter Uncertainty Analysis***.

Dye dilution tests are performed once for each billing meter (except SH-03) on an annual basis. If the test result was inconsistent with previous test results and showed that the meter was operating outside 5% error, a second test would be performed at that meter. Details for each test can be found in the individual test reports provided to the SHVUA Technical Committee. Current and previous test results are summarized in **Table 2-2**. Additional dye test meter flow adjustment history is provided in previous annual Look Back reports and the individual test reports. In 2022, the dye tests attempted for meters SH-01, SH-07, and SH-12, did not yield usable results. High suspended solids and other operational issues were encountered during attempted tests at SH-01 and SH-07. The configuration of dye injection and withdrawal at the newly constructed Odette pump station resulted in incomplete mixing of the dye and dye test results at SH-12 were not considered representative of meter accuracy.

The project goal and accepted meter accuracy is +/-5%. However, for communities where volume is calculated by subtraction, the overall accuracy may be outside of 5% due to compounding errors for multiple meters.

Based on the results of the 2022 dye dilution tests, the following findings and adjustments to data were incorporated for each meter:

- **SH-01 (Brownstown Township)** and **SH-07 (South Rockwood):** These magmeters that were replaced in October and September 2022, respectively. Tests of the new meters were not completed due to high suspended solids and other field conditions that prevented good test results. Comparison of meter flows from 2021 to 2022 and before and after meter replacement indicate consistent accuracy between the old and new meters, therefore no bias adjustment was applied for 2022.

- **SH-03 (Brownstown Township):** This meter is not tested due to the relatively small volume of flow metered and the difficulty of testing this meter due to rapid changes in flow from the tributary area pump station. An adjustment factor of 0.8 was applied to all Look Back data based on the previous comparison of the new meter data with 2019 data.

- **SH-04 (Gibraltar):** Dye dilution tests in 2022 indicated the meter is accurate to within 5% error. No adjustments were applied to the Look Back data.

- **SH-05 (Brownstown Township):** The test indicated that ISCO LaserFlow meter was accurate to within 5%. Following the initial test on the meter in 2020, the velocity coefficient was adjusted on 10/16/20 to 0.79 (from the default coefficient of 0.90), to internalize the measurement bias. No bias adjustment was applied for 2022.

- **SH-06** (**Brownstown Township**): Initial tests on the new NivuFlow meter installed on 1/19/22, indicated that the meter was overestimating flow. Changes were made to the meter operating parameters on 6/13/22 to attempt to improve meter accuracy but appeared to have increased the meter flow instead. A bias adjustment factor of 0.91 was applied from 1/19 to 6/13 based on the 5/12/22 dye test, and a bias adjustment factor of 0.79 was applied from 6/13 to 11/29 based on the 7/13/22 dye test results. The meter velocity sensor parameters that describe the sensor position in the pipe were adjusted and a -0.4-in level adjustment were made on 11/29. A subsequent dye test, on 12/2/22, indicated the adjustments improved meter accuracy to within 5% and no bias adjustment was applied for 11/29 to 12/31.

- **SH-08 (Flat Rock):** Both the primary (AccQmin) and secondary (ISCO 2150 continuous wave Doppler) meters were in operation during the 2022 test. However, after review of the meter data it was determined that meter velocity readings were affected by the debris buildup during the 2022 dye test. The level data was concluded to be accurate and used to recalculate flow based on previously derived depth v. flow correlation. Results indicate this meter is within 5% accuracy. The ISCO 2150 meter is being used during periods of good operation, but flows are recalculated or estimated when data, particularly velocity data, is inconsistent.

- **SH-12 (Huron Township):** The Odette pump station was reconstructed in 2022, and the flow meter (magmeter) was replaced in Aug-Sep, prior to the 2022 tests. The new dye injection point on the submersible pump discharge pipe within valve vault has short distance from the injection point to the dye withdrawal and results in incomplete mixing.

Based on data review, the dye test does not appear to be representative of meter accuracy. An attempt was also made to inject dye near the pump intake within the wet well but this also resulted in incomplete mixing (high fluctuations in dye concentration/fluorescence).

- **SH-14 (Woodhaven):** The new NivuFlow meter was installed on 2/11/22 The first two tests performed on the meter had consistent results indicating the meter was overestimating flows. The resulting AF was applied between 6/17 and 9/28 when there was consistent operation between sensor adjustments. A level sensor correction was made on 9/28 and additional level adjustment was made on 10/17. Dye testing following the 10/17 adjustment indicated the meter was within 5% accuracy. Recommended recalculation and bias adjustments are detailed in SH-14 dye test report. A bias adjustment factor of 0.79 was applied from 6/17 to 9/28 when there was consistent meter operation. Flows were recalculated based on depth for periods from 2/11 to 6/17 and 9/28 to 10/17. No bias adjustment was needed after 10/17.
- **SH-16 (Van Buren Township):** The dye dilution test performed in 2022 indicated the meter is accurate to within 5% error. Following two tests on the meter in 2020, the velocity coefficient was adjusted on 10/15/20 from 0.85 to 0.75, to internalize the measurement bias. No bias adjustment was applied for 2022.
- **SH-17 (Huron Township):** The dye dilution test in 2022 indicated the meter is accurate to within 5% error, accounting for the overall accuracy of the dye test (+/-1.7%). Following the initial tests on the meter in 2020, the velocity coefficient was adjusted on 10/14/20 to 0.8, to internalize the measurement bias. No bias adjustment was applied for 2022.

Table 2-2 Summary of Dye Dilution Test
(Previous test results provided for reference.
Refer to individual meter testing reports for additional information on each test)

Meter	2018	2019	2020	2021	2022	Avg. of all relevant tests	Notes
SH-01	2.7%	2.0%	2.9%	2.9%	**NA**	*0.7%*	Magmeter replacement completed on 10/18/22, before 2022 test. Test of the new meter not completed due to high solids. Comparison of 2021 to 2022 flows and before/after replacement indicate consistent accuracy between old and new meter. No bias adjustment applied. Average includes 2017-2021 tests.
SH-04	1.8%	2.9%	-3.8%	-1.7%	**-1.2%**	*0.4%*	Meter accurate within 5%. No bias adjustment applied. Average includes 2017-2022 tests.
SH-05 (Isco)			14.4%	-2.8%	**5.0%**	*1.1%*	Test shows the ISCO LaserFlow meter is within/at 5% accuracy. Following the initial test on the meter, the velocity coefficient was adjusted on 10/16/20 to 0.79, to internalize the measurement bias. No bias adjustment applied. Average includes 2021-2022 tests.
SH-06	- 18.2%, 3.7%	-1.0%	-0.9%		**10.1% 26.4% 1.8%**	*N/A*	Initial tests on NivuFlow meter installed on 1/19/22 indicated meter was overestimating flow. Changes to meter operating parameters on 6/13/22 to improve meter accuracy but increased the meter flow instead. Recommended to apply a bias adjustment factor of *0.91 from 1/19 to 6/13 and a bias adjustment of *0.79 from 6/13 to 11/29. Meter velocity sensor parameters adjusted and a -0.4-in level adjustment on 11/29 improved meter accuracy to within 5%. No bias adjustment applied 11/29 to 12/31.
SH-07	3.7%	-2.2%	-	2.9%	18.7%	*N/A*	Magmeter replacement completed on 9/19/22, before 2022 test. New test results affected by field conditions were not representative of meter accuracy. Comparison of 2021 to 2022 flows and flows before/after meter replacement indicate consistent accuracy between old and new meter. No bias adjustment applied.

Meter	2018	2019	2020	2021	2022	Avg. of all relevant tests	Notes
SH-08 (ISCO AccQPulse and AccQmin)		-1.8%	6.3% 9.9%	4.4%	56.3%	*(see report)*	The AccQmin meter operation affected by debris caught on sensor mounting band. Sensor was cleaned 1-2 weeks before test but debris accumulated again. The dye test not representative of overall meter accuracy. Meter had other operational issues before and after the dye test date. Recommend to use 2150 meter data and calculated or estimated data for 2022.
SH-08 (ISCO 2150, temp. meter)			-1.9% -2.4%	-1.9%	**-3.9%**	*-2.5%*	An ISCO 2150 continuous wave Doppler meter was installed in parallel to the AccQpulse in 2020. The meter velocity readings were affected by the debris buildup during the 2022 dye test, but the level data was accurate and used to recalculate flow based on previous data, depth v. flow correlation. Results indicate this meter is within 5% accuracy. The meter is being used during periods of good operation, but flows are recalculated or estimated when data is inconsistent. Average includes 2020-2022 tests.
SH-12	-2.7%	-3.2%	0.2%	1.9%	-9.1%	*-0.9%*	Pump station reconstructed and flow meter replaced prior to 2022 test. New dye injection point on submersible pump discharge pipe within valve vault has short distance from inject to dye withdrawal and results in incomplete mixing. Based on data review, dye test does not appear to be representative of meter accuracy. An attempt was made to inject dye near the pump intake within the wet well but this also resulted in incomplete mixing (high fluctuations in dye concentration/ fluorescence). Average includes 2017-2021 tests.

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Meter	2018	2019	2020	2021	2022	Avg. of all relevant tests	Notes
SH-14	8.2%	15.2%, 11.9%	8.1%	--	***25.7%*** ***27.2%*** ***-3.9%***	*N/A*	2022 tests performed on new NivuFlow meter installed in Feb 2022. The first two dye tests apply between 6/17 and 9/28 when there was consistent operation between sensor adjustments. Since the level sensor correction on 9/28 and level adjustment on 10/17 the meter has been within 5% accuracy. Recommend recalculation and bias adjustments were detailed in SH-14 dye test report. Adjustment factor of *0.79 applied 6/17 to 9/28. For 2/11 to 6/17 & 9/28 to 10/17, depth adjusted for level sensor error and flow recalculated based on depth. No bias adjustment needed after 10/17.
SH-16	2.5%, 6.6%	2.6%	16.2%, 10.3%	-4.3%	**4.6%**	*0.2%*	2022 test shows meter accuracy within 5%. The meter programmed velocity coefficient was adjusted on 10/15/20 from 0.85 to 0.75 to internalize the measurement bias (after the 2020 dye tests). No bias adjustment needed for 2022 data. Average includes 2021-2022 tests.
SH-17			18.9%, 12.9%	4.9%	**5.2%**	*5.0%*	Test shows the ISCO LaserFlow meter is within 5% accuracy, accounting for the overall accuracy of the dye test (+/-1.7%). Following the initial tests on the meter in 2020, the velocity coefficient was adjusted on 10/14/20 to 0.8, to internalize the measurement bias. No bias adjustment recommended for 2022. Average includes 2021-2022 tests.

Note: Negative meter error indicates meter is under-reporting flow.

Section 3

Community Contribution

3.1 Introduction

This section describes how each community's contribution to the total community flows is evaluated. This review and compilation of flow data utilizes the work performed for the 2005 report for estimation of the interceptor I/I volumes. The volumes and percentage community contributions represent the Look Back flow data compiled as described in **Section 2**.

3.2 Total Flows

The SHUVA interceptor system displays different flow patterns between dormant (winter and early spring) and growth (summer and early fall) seasons. Dormant season is characterized by higher base flow because of higher groundwater table levels and larger response to precipitation because of lower evapotranspiration and, in some periods, frozen ground. Coupled with spring melt, March through May is usually the period with the highest recorded flow. Base flows then recede into the summer months as groundwater and soil moisture levels are reduced through evapotranspiration in growth seasons. For individual communities, their system's response to precipitation is affected by sewer condition and its proximity to local groundwater/river level. In 2019-2020 amid increasing Detroit River level, Brownstown South and Gibraltar's base flow patterns aligned with the Detroit River's seasonal cycle (high in summer, low in winter). However, in 2022 the river level has decreased and these areas have returned to following a seasonal pattern that is similar to other SHVUA communities.

Figure 3-1 and **Figure 3-3** illustrate the percent share by community of the total community flow for 2022. Interceptor I/I is excluded in these calculations. The interceptor I/I uses values from the 2005 four-month flow balance, and as updated in 2012 for Huron Township to account for SHVUA ownership of an abandoned interceptor parallel to the active interceptor. **Table 3-1** and **Figure 3-2** show the monthly average daily flow for each meter, the estimated I/I, and the total flow and percentage by community. **Figure 3-4** shows the monthly precipitation in 2022 compared to the 2005 – 2021 average.

Figure 3-1 Community Share of Total Flow 2022

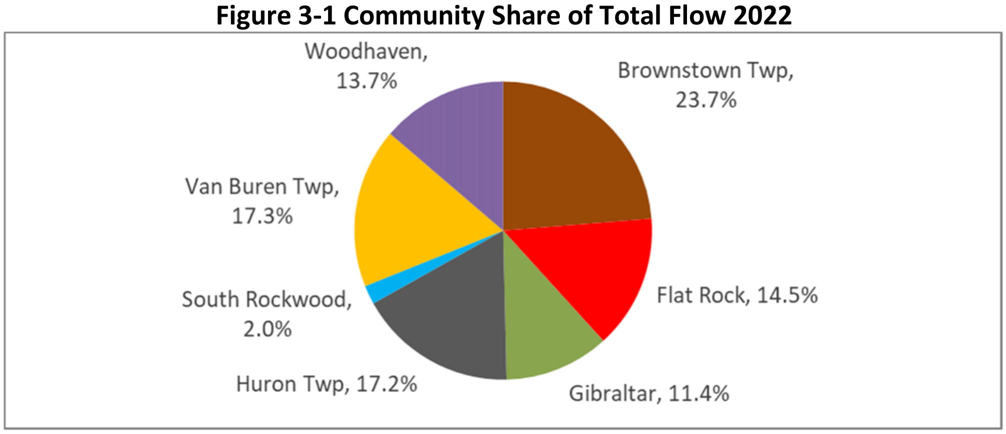


Table 3-1 Monthly Average Total Flows for 2022

Flow Component	Average Total Flow (mgd)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
SH-01	0.09	0.14	0.14	0.14	0.17	0.11	0.08	0.07	0.06	0.05	0.05	0.06	0.10
SH-03	0.29	0.38	0.41	0.41	0.43	0.29	0.24	0.23	0.21	0.21	0.22	0.28	0.30
SH-04	0.82	0.99	1.03	1.05	1.24	1.00	0.87	0.84	0.69	0.53	0.51	0.70	0.85
SH-05	0.46	0.64	0.58	0.54	0.68	0.56	0.42	0.45	0.39	0.38	0.41	0.47	0.50
SH-06	0.99	1.09	1.15	1.12	1.10	0.86	0.76	0.76	0.72	0.73	0.76	0.89	0.91
SH-07	0.16	0.24	0.26	0.22	0.24	0.15	0.10	0.10	0.09	0.09	0.09	0.11	0.16
SH-08	4.73	5.46	5.81	5.84	5.91	4.25	3.43	3.56	3.33	2.94	3.03	3.59	4.32
SH-12	0.38	0.43	0.49	0.47	0.47	0.34	0.28	0.29	0.32	0.30	0.30	0.31	0.36
SH-14	2.98	3.49	3.38	3.28	3.34	2.58	2.03	2.05	1.98	2.01	2.13	2.42	2.63
SH-16	1.43	1.59	1.70	1.78	1.68	1.34	1.23	1.24	1.19	1.15	1.14	1.11	1.38
SH-17	3.01	3.49	3.72	3.64	3.52	2.75	2.33	2.26	2.09	2.01	1.99	2.14	2.74
Quala Wash	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Romulus_in	0.01												
Romulus_out	0.01												
Van Buren Interceptor I/I	0.06												
Huron Interceptor I/I	0.41												
Flat Rock Interceptor I/I	0.11												
Woodhaven Interceptor I/I	0.18												
Community Flow Based on Billing Meters													
Brownstown	1.84	2.25	2.28	2.21	2.38	1.82	1.49	1.52	1.39	1.37	1.44	1.68	1.80
Flat Rock	1.23	1.43	1.50	1.63	1.81	1.06	0.72	0.90	0.81	0.53	0.63	1.03	1.10
Gibraltar	0.83	1.00	1.04	1.06	1.25	1.02	0.88	0.86	0.70	0.54	0.52	0.71	0.87
Huron Twp	1.55	1.92	2.09	1.92	1.89	1.33	0.96	0.90	0.81	0.75	0.74	0.93	1.31
South Rockwood	0.16	0.24	0.26	0.22	0.24	0.15	0.10	0.10	0.09	0.09	0.09	0.11	0.16
Van Buren Twp	1.37	1.53	1.64	1.72	1.62	1.28	1.17	1.18	1.13	1.09	1.08	1.05	1.32
Woodhaven	1.35	1.58	1.47	1.44	1.38	0.98	0.67	0.66	0.69	0.71	0.77	0.89	1.04
Total	8.32	9.96	10.27	10.19	10.57	7.63	5.99	6.11	5.62	5.07	5.28	6.40	7.60
Percent Contribution													
Brownstown	22.1%	22.6%	22.2%	21.7%	22.5%	23.8%	24.8%	24.8%	24.7%	27.0%	27.4%	26.3%	23.7%
Flat Rock	14.8%	14.4%	14.6%	16.0%	17.2%	13.9%	12.0%	14.8%	14.5%	10.4%	12.0%	16.1%	14.5%
Gibraltar	10.0%	10.1%	10.1%	10.4%	11.8%	13.3%	14.7%	14.0%	12.5%	10.6%	9.8%	11.1%	11.4%
Huron Twp	18.6%	19.3%	20.3%	18.8%	17.9%	17.4%	16.0%	14.7%	14.4%	14.8%	14.0%	14.5%	17.2%
South Rockwood	1.9%	2.4%	2.5%	2.2%	2.3%	2.0%	1.7%	1.7%	1.7%	1.7%	1.8%	1.8%	2.0%
Van Buren Twp	16.4%	15.3%	15.9%	16.9%	15.3%	16.8%	19.6%	19.3%	20.1%	21.5%	20.5%	16.4%	17.3%
Woodhaven	16.2%	15.8%	14.3%	14.1%	13.0%	12.8%	11.2%	10.7%	12.2%	14.1%	14.6%	13.9%	13.7%

Note: Flows listed are rounded to 2 decimal places. Percentages shown are rounded to 1 decimal place and may not add up to 100.

Figure 3-2 Average Monthly Community Flows and Monthly Precipitation for 2022

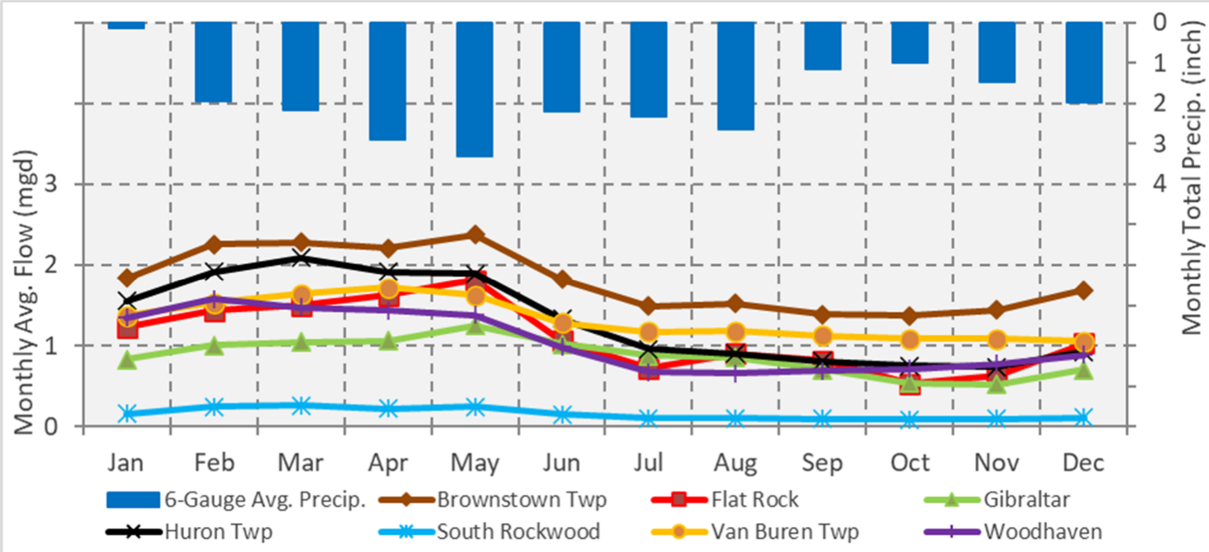


Figure 3-3 Monthly Community Contribution of Total Flow in 2022

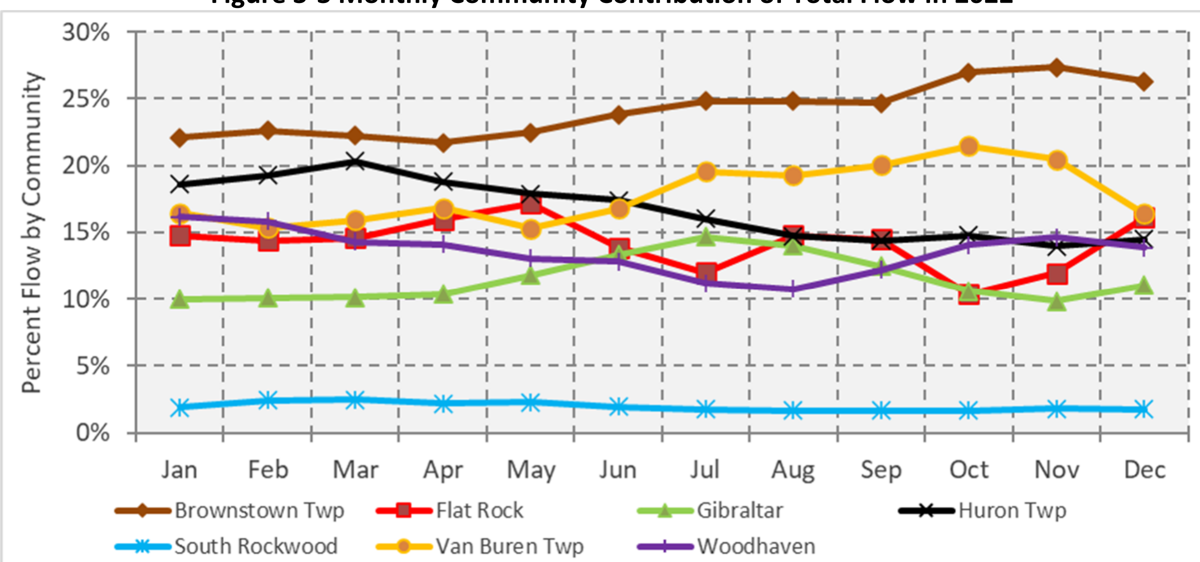
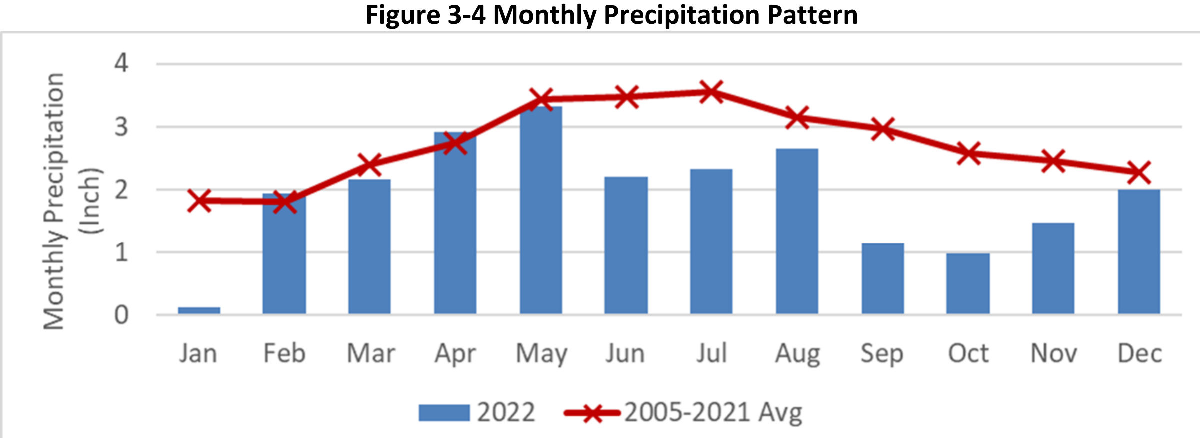


Figure 3-4 Monthly Precipitation Pattern



3.3 Comparison to Previous Year(s)

Table 3-2 and **Figure 3-5** summarize the volumes and percent contribution by community in the last five years. The total precipitation in 2022 was 23.2 inches, on average, across six rain gauges in the SHVUA tributary area and is the lowest total annual precipitation recorded for the area based on data going back to 2005. This follows one year of slightly higher than average rainfall in 2021 and is about 9 inches less than the 2005-2021 average (32.6 inches). The year began with a very dry January with nearly zero recorded rainfall followed by four months of average precipitation totals in February through May. From June through December, monthly rainfall totals remained well below average with deviations ranging from -1.8 inches in September to -0.29 inches in December. Overall, there was a deficit of approximately 7.7 inches of rainfall compared to average from June through December. Total community volume was 2,775 MG in 2022, a nearly 18% decrease from 3,373 MG in 2021.

Due to the historically low precipitation total for 2022, flow volumes in all communities decreased significantly compared to 2021. However, the percentage decreases were quite variable. The largest year over year flow volume percentage decrease was seen at South Rockwood (-28%). There was a greater than 20% flow volume decrease for Brownstown (-21%), Gibraltar (-22%) and Woodhaven (-24%). There were similar flow volume decreases in Flat Rock (-16%) and Huron Township (-15%). The smallest year over year flow volume decrease occurred for Van Buren Township (-6%). While the entire SHVUA service area experienced significantly lower precipitation in 2022, the variability in year over year change in flow volume can be attributed, in part, to each community's sewer system's typical response to precipitation (wet weather flows). For example, there is typically a significant wet weather response at meter SH-14 (Woodhaven) during precipitation events, but much smaller wet weather response at meter SH-17 (Huron Township) and a minimal response at meter SH-16 (Van Buren Township). Given that precipitation in 2022 was much lower than average, it makes sense that there was a greater year over year reduction in relative flow volume for Woodhaven (and other communities) than for Huron Township and Van Buren Township.

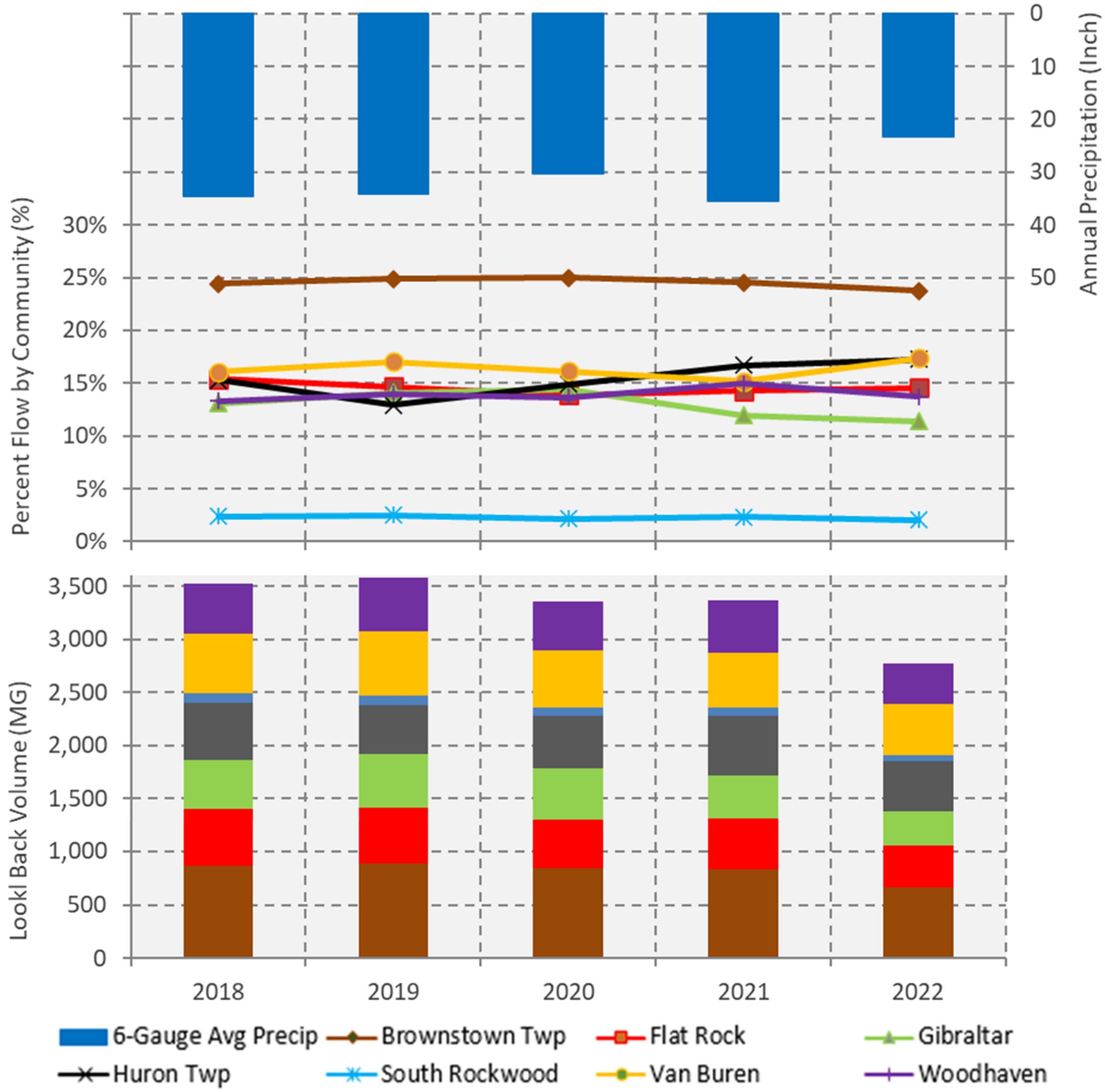
While all communities had lower year over year flow volumes, due to the variability in the magnitude of the reduction, some community's percentage of total volume decreased from 2021, while others increased. The largest decrease in percentage of total flow volume occurred at Woodhaven (-1.2%), followed by Brownstown (-0.8%), Gibraltar (-0.6%), and South Rockwood (-0.3%). There was an increase in the percentage of total flow volume at Flat Rock (+0.3%), Huron Township (+0.5%) and Van Buren Township (+2.1%).

Table 3-2 Look Back Volume and Community's Percent Contribution in Past 5 Years

	2018		2019		2020		2021		2022		5-Year Total	
	Flow (MG)	%	Flow (MG)	%	Flow (MG)	%	Flow (MG)	%	Flow (MG)	%	Flow (MG)	%
Brownstown Twp.	861	24.4%	889	24.9%	838	25.0%	828	24.6%	658	23.7%	4,073	24.5%
Central	662		669		628		633		514		3,105	
South	199		220		210		195		144		968	
Flat Rock	542	15.4%	524	14.7%	465	13.9%	482	14.3%	403	14.5%	2,416	14.6%
Gibraltar	460	13.1%	504	14.1%	482	14.4%	404	12.0%	316	11.4%	2,167	13.1%
Huron Twp.	539	15.3%	462	12.9%	499	14.9%	563	16.7%	478	17.2%	2,542	15.3%
South Rockwood	84	2.4%	89	2.5%	72	2.1%	79	2.3%	57	2.0%	380	2.3%
Van Buren Twp.	567	16.1%	610	17.0%	540	16.1%	513	15.2%	481	17.3%	2,711	16.3%
Woodhaven	470	13.3%	500	14.0%	457	13.6%	504	14.9%	381	13.7%	2,312	13.9%
TOTAL VOLUME	3,524	100%	3,577	100%	3,353	100%	3,373	100%	2,775	100%	16,602	100%
Precip. (Inch)	34.6		34.0		30.2		35.5		23.2		32.1 (2005-2022 avg)	

Note: Percentages shown are rounded to one decimal place and may not add up to 100.

Figure 3-5 Community Contribution of Total Flow 2018 – 2022



3.4 Exceedance of Contract Capacity

The Look Back data was examined as described in **Section 1.4** to identify instances where a community's flow exceeded its Interceptor or Treatment Plant Purchase Capacity. This information is summarized in **Table 3-3** and **Table 3-4**.

Interceptor capacity exceedances were observed for South Rockwood in February and May 2022. There were no treatment capacity exceedances in 2022.

Table 3-3 2022 Interceptor Capacity Exceedance Summary

Customer Name	Interceptor +20% 1-hour			Interceptor +10% 4-hour			Interceptor Contract Capacity (mgd)
	Start Date/Time (Eastern Standard Time)	Avg Exceedance Duration (hours)	Avg Exceedance Flow (mgd)	Start Date/Time (Eastern Standard Time)	Avg Exceedance Duration (hours)	Avg Exceedance Flow (mgd)	
South Rockwood	no exceedance			2/17/22 7:05	9.7	0.94	0.83
	no exceedance			5/3/22 14:55	8.1	0.97	

Table 3-4 2022 Treatment Capacity Exceedance Summary

Customer Name	Treatment +20% 24-hour			Treatment +10% 72-hour			Treatment Contract Capacity (mgd)
	Start Date/Time (Eastern Standard Time)	Avg Exceedance Duration (hours)	Avg Exceedance Flow (mgd)	Start Date/Time (Eastern Standard Time)	Avg Exceedance Duration (hours)	Avg Exceedance Flow (mgd)	
N/A	no exceedance			no exceedance			N/A

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