TECHNICAL MEMORANDUM

Flow Meter Operation and Maintenance

Annual Billing Look Back: 2021

SOUTH HURON VALLEY UTILITY AUTHORITY

February 7, 2022

CDM Smith

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Introduction and Approach

1.1 Purpose

This report documents the work and results of the 2021 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 Michigan Inc. (CDM Smith) from January 2019 to December 2023, under the current contract. The purpose of the 2021 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)

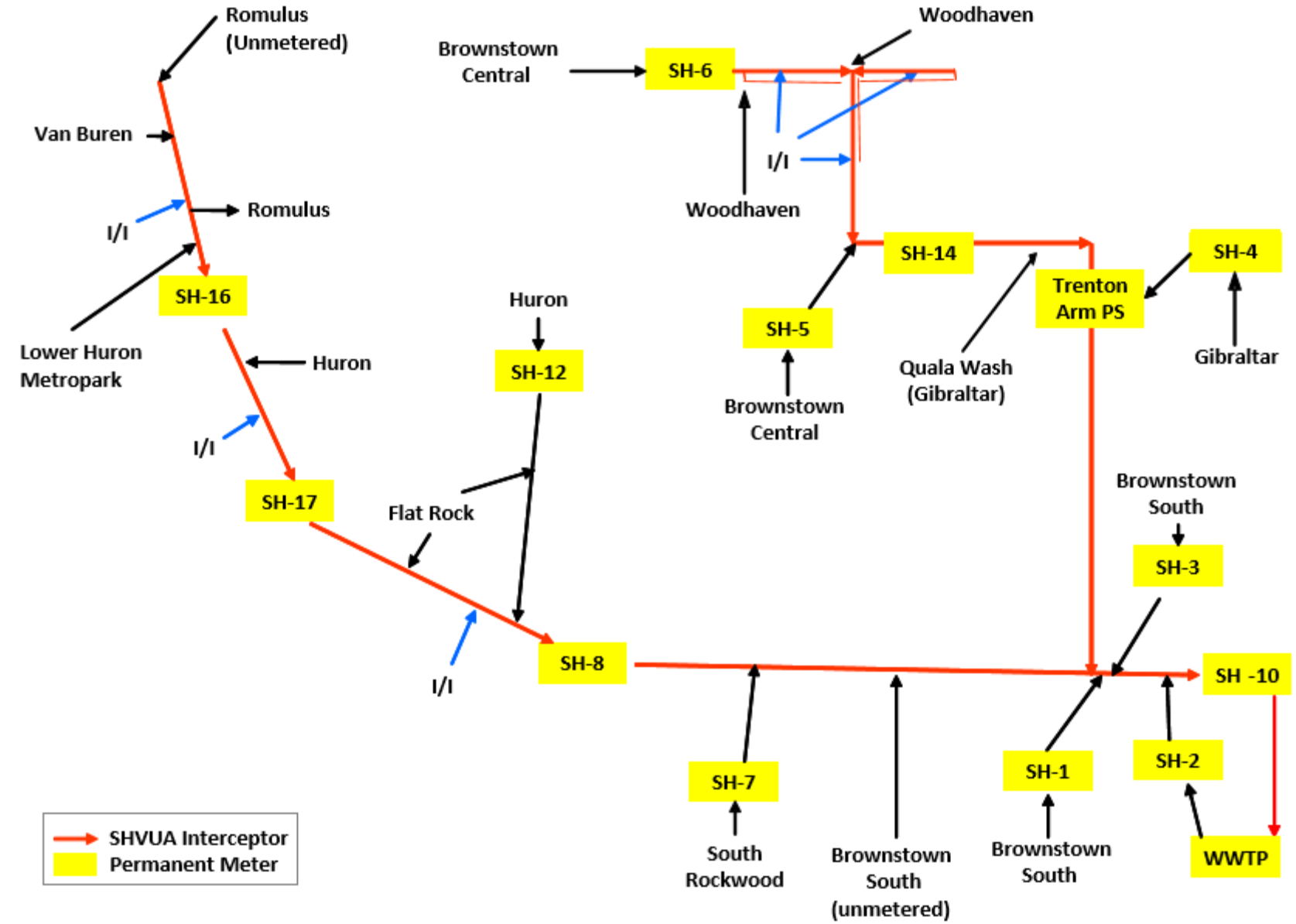
Notes:

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 recent years. SH-03 and SH-05, also had new meters installed in 2020 and the remaining meters are scheduled for replacement in 2022 under the SHVUA Priority 1 & 2 Improvements Project.

Meters at the three pump stations are Krohne 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

Figure 1-1 Schematic of SHVUA Interceptor and Flow Meters



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.

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, manhole access	2001
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, a new ISCO 2160 EX LaserFlow meter installed in parallel, manhole access	2001/ 2020
SH-06	Brownstown Township	Manhole at Van Horn Road 425 feet east of Gregory Drive	Transit-time meter, manhole access	2001
SH-07	South Rockwood	Labo Park Pump Station	Magmeter, manhole access	2001
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	
SH-12	Huron Township	Odette Pump Station	Magmeter, manhole access	2001
SH-14	Gibraltar	Manhole at SE intersection of Fort Street and Vreeland Road	Transit-time meter, manhole access	2001
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 date 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 Manning's equations 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. 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.

After data review and classification was complete, 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 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 2021 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 2021 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. 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, corrected level offsets, and/or use only the acceptable velocity paths. 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 Manning's equation or polynomial equation-estimated flow based on level data and a calibrated depth to flow relationship developed during periods of acceptable operation. The percentages are based on a total of 365 days in 2021.

Overall, 82% of the flow data was acceptable in its raw state in 2021, compared to historical range of 83% to 94% between 2008 and 2020. 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 (Manning's, etc.)
SH-01	100.0	0.0	0.0	0.0	0.0
SH-03	98.0	0.0	1.8	0.0	0.2
SH-04	99.8	0.0	0.2	0.0	0.0
SH-05	99.5	0.0	0.4	0.0	0.1
SH-06	34.3	64.5	0.8	0.0	0.4
SH-07	100.0	0.0	0.0	0.0	0.0
SH-08	66.5	0.0	0.1	0.0	33.4
SH-12	90.3	0.0	0.0	9.4	0.3
SH-14	62.1	0.0	0.0	0.0	37.8
SH-16	85.3	0.0	1.7	0.0	13.0
SH-17	61.2	35.9	0.2	2.7	0.0

Note: For SH-08, the periods using temporary flow meter data were also counted as "acceptable"

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 2021 data included:

- **SH-02 [non-billing, recycling flow at WWTP]:** The two ISCO continuous wave Doppler meters were providing reliable data in 2021. They were not impacted by the sewage condition and show improved operation compared to the Accusonic flow meter previously installed at this site.
- **SH-03:**
  - The meter occasionally reported primary level spikes during dry weather for short periods (5 – 15 minutes). Data were corrected using simple interpolation with "acceptable" data immediately before and after the period.
  - Different flow depths were measured between the primary level sensor (ultrasonic downlooker) and secondary level sensor (pressure transducer) due to flow hydraulics (rapid changes in flow and shallow depth over the secondary sensor measuring pressure depth and velocity via continuous wave Dopper). On 12/10/21, HESCO installed a 5-inch weir in the outlet pipe 53-inches downstream of the sensor

measurement point at SH-03. The weir was installed to improve hydraulics and reduce depth fluctuations at the flow meter. This problem did not affect meter flow accuracy in 2021.

- **SH-06:** Secondary level data were found more accurate than primary level data by dye test and maintenance visits. Flows were recalculated with secondary level when the primary level data differ from secondary level data by more than 3%. This meter is scheduled for replacement in early 2022.
- **SH-08:**
  - The primary meter (accQpulse) failed on June 24. The accQpulse meter is no longer supported by ISCO and was replaced with a spare accQmin meter on July 6. Both meters are the pulse Doppler meter technology. Data from a temporary 2150 (continuous wave Doppler meter technology) flow meter installed in March 2020 was determined to be more accurate for the entire year due to frequent ragging issues with the accQpulse that caused unreasonable velocity measurements.
  - The 2150 meter reported higher than normal velocity data in February through April and lower than normal velocities in July and November. Flows were estimated using correlation with level data for these periods. In May and June, 2150 meter velocity and level data were low and were considered not reasonable and flows were estimated using correlation with SH-17.
- **SH-12:** The meter failed during two periods (6/21-7/8 and 12/14-12/31) and no data could be retrieved. Flows were estimated for these periods using average trend ("greenline") data.
- **SH-14:** The meter reported higher than normal velocity data for several days in January through May and September through December. Flows were estimated by correlation with level data as these higher velocities were considered not reasonable. This meter is scheduled for replacement in early 2022.
- **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
- **SH-17:**
  - A level adjustment of -0.31-inch was required for the primary level sensor during the 4/30/21 PM visit. March and April flows were recalculated based on the adjusted level.
  - The meter reported higher than normal flow from 4/30/21 through 7/9/21 because an incorrect velocity coefficient was applied following the April 30 PM visit. Flow data were corrected by scaling to the correct velocity coefficient.
- **Serial-over-IP issue:** Extended periods of poor wireless signal occurred at **SH-02, SH-03, and SH-10**. HESCO collected the data on-site once a month. No data were lost.
- **Flow Recalculation with available velocity path(s) for Accusonic Meters:** Lowest velocity path (path 1) sensors were periodically affected by solids accumulating at meter

sections at **SH-06**. Flows for these periods were recalculated with other available velocity path(s) data.

- **Single-Velocity-Path Operation for Accusonic Meters:** Single-path operation often occurs at periods of lower flow (e.g. low part of diurnal) and average velocity can be significantly less accurate during those periods. Since the single-path operation also occurs at the lowest flows, the effect on the overall meter volume is less significant (see **Table 2-2** for individual meters).

Table 2-2 Percent of Time in Single-Path Operation for Accusonic Meters

Meter	Frequency of Occurrence
SH-05	4.8%
SH-06	16%
SH-14	5.7%

2.3 Dye Dilution Accuracy Verification Review

Since 2001, dye dilution testing has been performed on most of the SHVUA billing meters to verify 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 2-3**. Additional dye test meter flow adjustment history is provided in previous annual Look Back reports and the individual test reports. In 2021, no dye test was performed for meters SH-06 and SH-14 because the meters were scheduled to be replaced by the end of 2021; however, delivery delays extended the replacement schedule to early 2022.

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 2021 dye dilution tests, the following findings and adjustments to data were incorporated for each meter:

- **SH-01 (Brownstown Township), SH-04 (Gibraltar), SH-07 (South Rockwood),** and **SH-12 (Huron Township):** Dye dilution tests in 2021 indicated these meters are accurate to within 5% error. No adjustments were applied to the Look Back data.
- **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 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-05 (Brownstown Township):** Both Accusonic and ISCO meters were in operation during the 2021 dye test. The test indicated that both the Accusonic and ISCO meters were accurate to within 5%. The ISCO meter data were used for the entire year. 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 2021.
- **SH-06** (**Brownstown Township):** No test performed in 2021 pending meter replacement.
- **SH-08 (Flat Rock):** Both the AccQpulse and ISCO 2150 continuous wave Doppler meters were in operation during the 2021 test. However, the AccQpulse meter malfunctioned 1-2 days after the dye test and the recorded data could not be retrieved. Therefore, dye test results were compared to real-time meter readings only. The test indicated that both the AccQpulse and 2150 were accurate within 5%. However, due to other operational issues with the AccQpulse meter before and after the dye test date, CDM Smith recommended using the 2150 meter data for 2021 analyses.
- **SH-14 (Woodhaven):** No test performed in 2021 pending meter replacement.
- **SH-16 (Van Buren Township):** The dye dilution test performed in 2021 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 2021.
- **SH-17 (Huron Township):** The dye dilution test in 2021 indicated the meter is accurate to within 5% error. Following two tests on the meter previous year, the velocity coefficient was adjusted on 10/14/20 to 0.8, to internalize the measurement bias. No bias adjustment was applied for 2021.

Table 2-3 Summary of Dye Dilution Test
(Previous test results provided for reference.
Refer to individual meter testing reports for additional information on each test)

Meter	2017	2018	2019	2020	2021	Avg. of all relevant tests	Notes
SH-01	-2.6%	2.7%	2.0%	2.9%	**2.9%**	*0.6%*	Meter accuracy within 5%. No bias adjustment applied. Average includes 2008-2021 tests.
SH-04	-1.7%	1.8%	2.9%	-3.8%	**-1.7%**	*0.6%*	Meter accurate within 5%. No bias adjustment applied. Average includes 2011-2021 tests.
SH-05 (Accusonic)	0.6%	3.8%	0.5%	2.2%	**-1.8%**	*-0.5%*	Test shows the Accusonic meter accuracy is within 5%. No bias adjustment applied.
SH-05 (Isco)				14.4%	**-2.8%**	*-2.8%*	Test shows the ISCO LaserFlow meter within 5% accuracy. Following initial test in 2020, the velocity coefficient was adjusted on 10/16/20 to 0.79, to internalize the measurement bias. No bias adjustment applied in 2021.
SH-06	-2.6%	-18.2%, 3.7%	-1.0%	-0.9%		*-1.4%*	Test on hold pending meter replacement.
SH-07	4.2%	3.7%	-2.2%	-	**2.9%**	*1.1%*	Test shows meter accuracy within 5%. New pump station and piping configuration in 2019. No bias adjustment applied. Average includes 2011-2021 tests.
SH-08 (ISCO AccQPulse)			-1.8%	6.3%, 9.9%	**4.4%**	*(see report)*	AccQpulse meter malfunctioned after the dye test and recorded data could not be retrieved. Dye test results were compared to real-time readings. Test suggests AccQpulse meter operating within 5% accuracy; however, due to other operational issues before and after test, recommend use of 2150 meter data and calculated or estimated data for 2021.
SH-08 (ISCO 2150, temp. meter)				-1.9% 2.4%	**-1.9%**	*-2.1%*	ISCO 2150 continuous wave Doppler meter was installed in 2020. Dye test results indicate meter within 5%. Meter can be used to fill in poor quality or missing data from the AccQpulse with no bias adjustment.
SH-12	-0.4%	-2.7%	-3.2%	0.2%	**1.9%**	*-1.2%*	Meter accuracy within 5%. No bias adjustment applied. Average includes 2010-2021 tests.
SH-14	7.7%	8.2%	15.2%, 11.9%	8.1%		*10.1%*	Test on hold pending meter replacement.
SH-16	35.9%, 38.3%	2.5%, 6.6%	2.6%	16.2%, 10.3%	**-4.3%**	*13.5%*	2021 test shows meter within 5% accuracy. Following test 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 applied in 2021.
SH-17				18.9%, 12.9%	**4.9%**	*12.9%*	Test shows the ISCO LaserFlow meter within 5% accuracy. Following initial test in 2020, the velocity coefficient was adjusted on 10/14/20 to 0.8, to internalize the measurement bias. No bias adjustment applied in 2021.

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 recent years amid increasing Detroit River level, Brownstown South and Gibraltar's base flow patterns align with Detroit River's seasonal cycle (high in summer, low in winter).

Figure 3-1 and **Figure 3-3** illustrate the percent share by community of the total community flow for 2021. Interceptor I/I is excluded in these calculations. The interceptor I/I uses values from the 2005 four-month flow balance, 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 2021 compared to the 2005 – 2020 average.

Figure 3-1 Community Share of Total Flow 2021

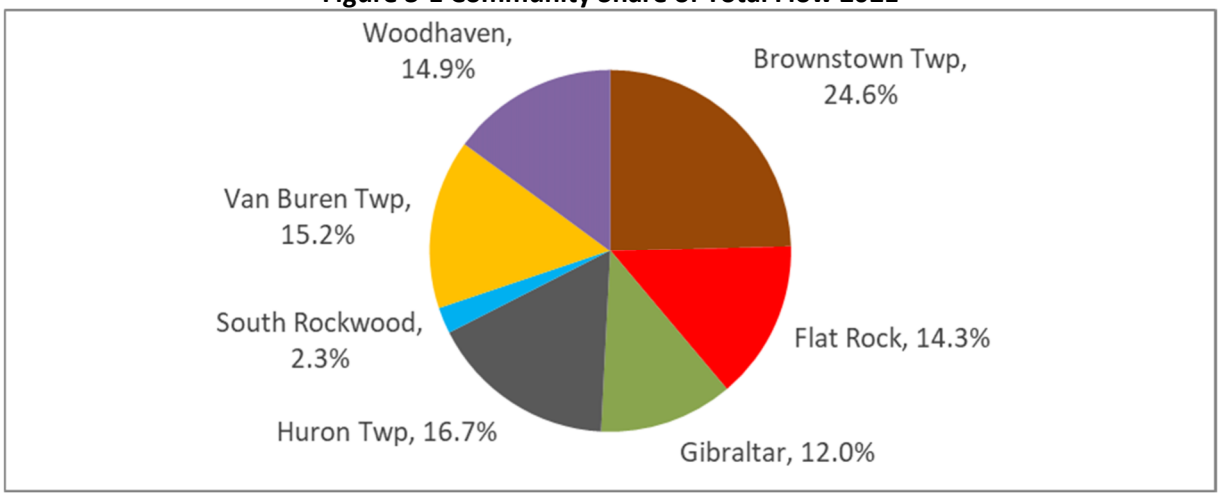


Table 3-1 Average Monthly Total Flows for 2021

Flow Component	Average Total Flow (mgd)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
SH-01	0.12	0.10	0.13	0.14	0.17	0.19	0.20	0.11	0.12	0.20	0.13	0.19	0.15
SH-03	0.34	0.31	0.37	0.35	0.45	0.51	0.47	0.27	0.26	0.44	0.35	0.48	0.38
SH-04	0.94	0.77	0.82	0.85	1.01	1.28	1.49	1.20	1.10	1.49	0.95	1.22	1.10
SH-05	0.53	0.49	0.55	0.56	0.56	0.67	0.61	0.49	0.57	0.87	0.57	0.78	0.61
SH-06	1.02	0.95	1.01	1.02	0.96	1.10	1.03	1.00	1.19	1.55	1.27	1.43	1.13
SH-07	0.17	0.15	0.20	0.19	0.23	0.26	0.21	0.13	0.17	0.32	0.22	0.32	0.22
SH-08	4.16	3.80	4.38	4.56	3.68	4.73	4.93	4.38	4.75	6.26	5.73	6.77	4.85
SH-12	0.32	0.29	0.33	0.36	0.31	0.37	0.35	0.30	0.34	0.47	0.43	0.53	0.37
SH-14	3.15	2.91	3.05	2.96	2.88	3.19	3.21	2.93	3.32	4.40	3.30	4.21	3.30
SH-16	1.31	1.23	1.38	1.46	1.27	1.59	1.68	1.45	1.42	1.56	1.51	1.72	1.47
SH-17	2.68	2.49	2.82	3.06	2.42	2.91	3.27	2.91	2.98	3.72	3.36	3.97	3.07
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	2.01	1.85	2.07	2.06	2.14	2.47	2.30	1.88	2.14	3.06	2.32	2.88	2.27
Flat Rock	1.05	0.90	1.12	1.03	0.84	1.34	1.20	1.06	1.32	1.97	1.82	2.15	1.31
Gibraltar	0.95	0.78	0.83	0.86	1.02	1.29	1.51	1.21	1.11	1.51	0.96	1.23	1.11
Huron Twp	1.28	1.14	1.36	1.55	1.05	1.28	1.53	1.35	1.49	2.21	1.88	2.37	1.56
South Rockwood	0.17	0.15	0.20	0.19	0.23	0.26	0.21	0.13	0.17	0.32	0.22	0.32	0.22
Van Buren Twp	1.25	1.17	1.32	1.40	1.21	1.53	1.62	1.39	1.36	1.50	1.44	1.66	1.40
Woodhaven	1.42	1.29	1.30	1.19	1.18	1.24	1.39	1.25	1.38	1.80	1.28	1.82	1.38
Total	8.13	7.28	8.19	8.28	7.66	9.41	9.76	8.27	8.97	12.36	9.93	12.44	9.24
Percent Contribution													
Brownstown	24.8%	25.4%	25.2%	24.9%	27.9%	26.3%	23.6%	22.7%	23.8%	24.7%	23.4%	23.2%	24.6%
Flat Rock	12.9%	12.4%	13.6%	12.4%	11.0%	14.2%	12.3%	12.8%	14.7%	15.9%	18.4%	17.3%	14.1%
Gibraltar	11.6%	10.7%	10.1%	10.4%	13.3%	13.7%	15.4%	14.7%	12.4%	12.2%	9.7%	9.9%	12.0%
Huron Twp	15.8%	15.7%	16.6%	18.7%	13.7%	13.6%	15.6%	16.3%	16.6%	17.9%	18.9%	19.0%	16.9%
South Rockwood	2.1%	2.1%	2.4%	2.3%	3.0%	2.8%	2.2%	1.5%	1.9%	2.6%	2.3%	2.6%	2.3%
Van Buren Twp	15.3%	16.0%	16.1%	16.9%	15.7%	16.3%	16.6%	16.8%	15.2%	12.1%	14.5%	13.3%	15.2%
Woodhaven	17.5%	17.7%	15.9%	14.4%	15.4%	13.1%	14.2%	15.2%	15.4%	14.6%	12.9%	14.6%	14.9%

Note: Flow 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 2021

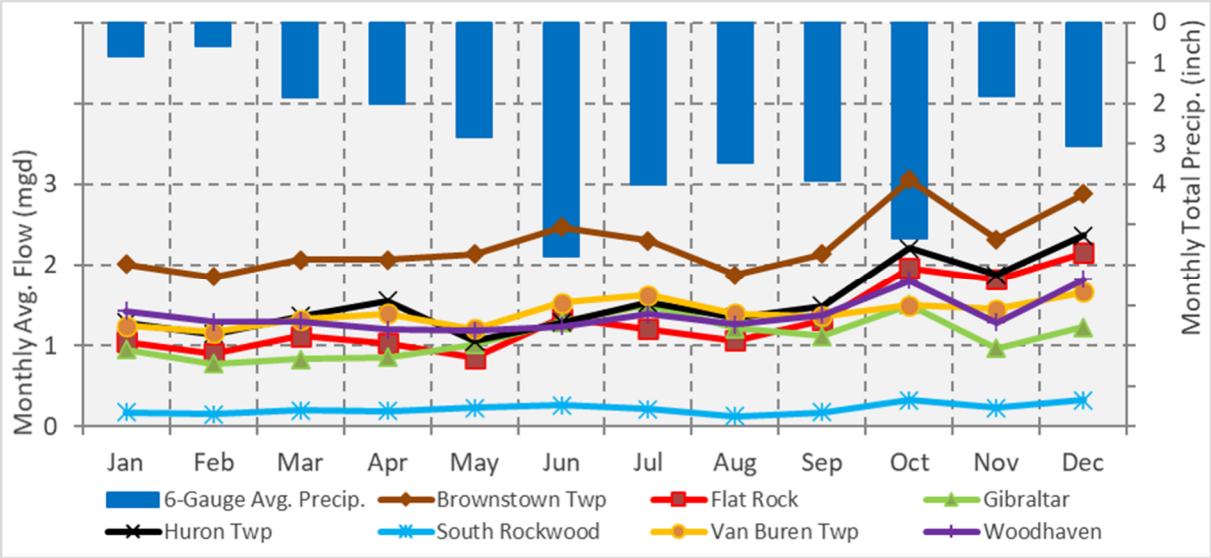


Figure 3-3 Monthly Community Contribution of Total Flow in 2021

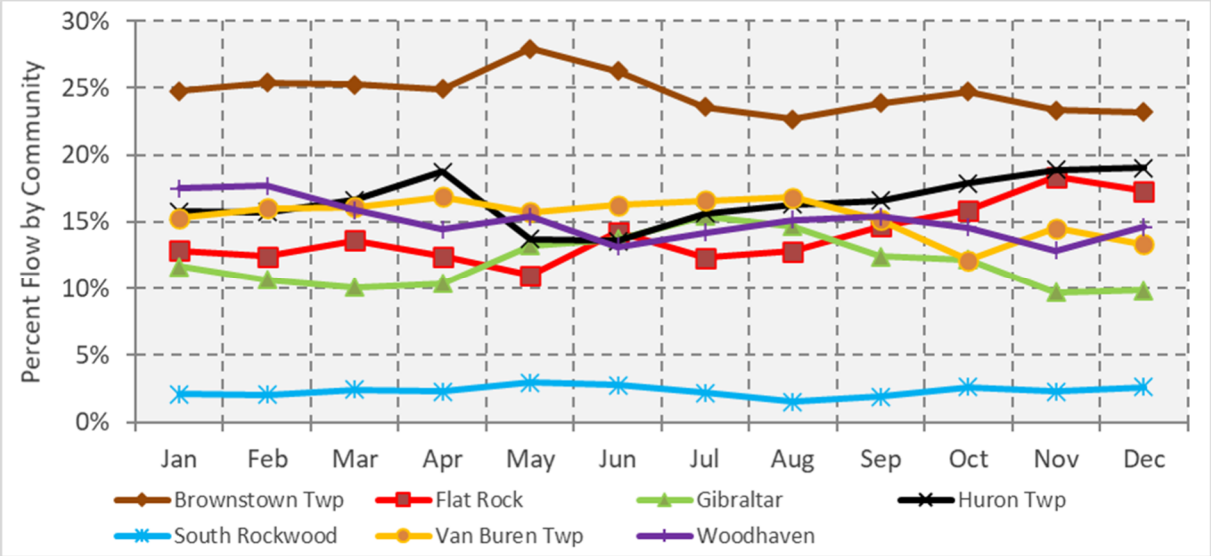
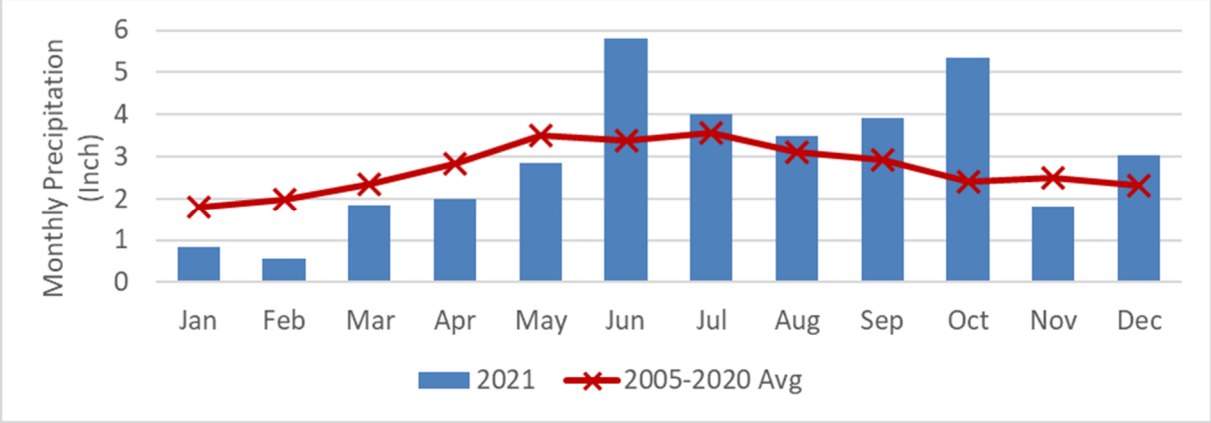


Figure 3-4 Monthly Precipitation Pattern



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 2021 averaged 35.5 inches across six rain gauges in the SHVUA tributary area. This follows one year of slightly lower than average rainfall in 2020 and is about 3 inches more than the 2005-2020 average (32.5 inches). In 2021, monthly precipitation total for January through May were all below average and monthly rainfall totals for the rest of the year, with the exception of November, were all above or significantly above (~2+ inches above) historical average monthly values. Total community volume was 3,373 MG in 2021, a <1% increase from 3,353 MG in 2020.

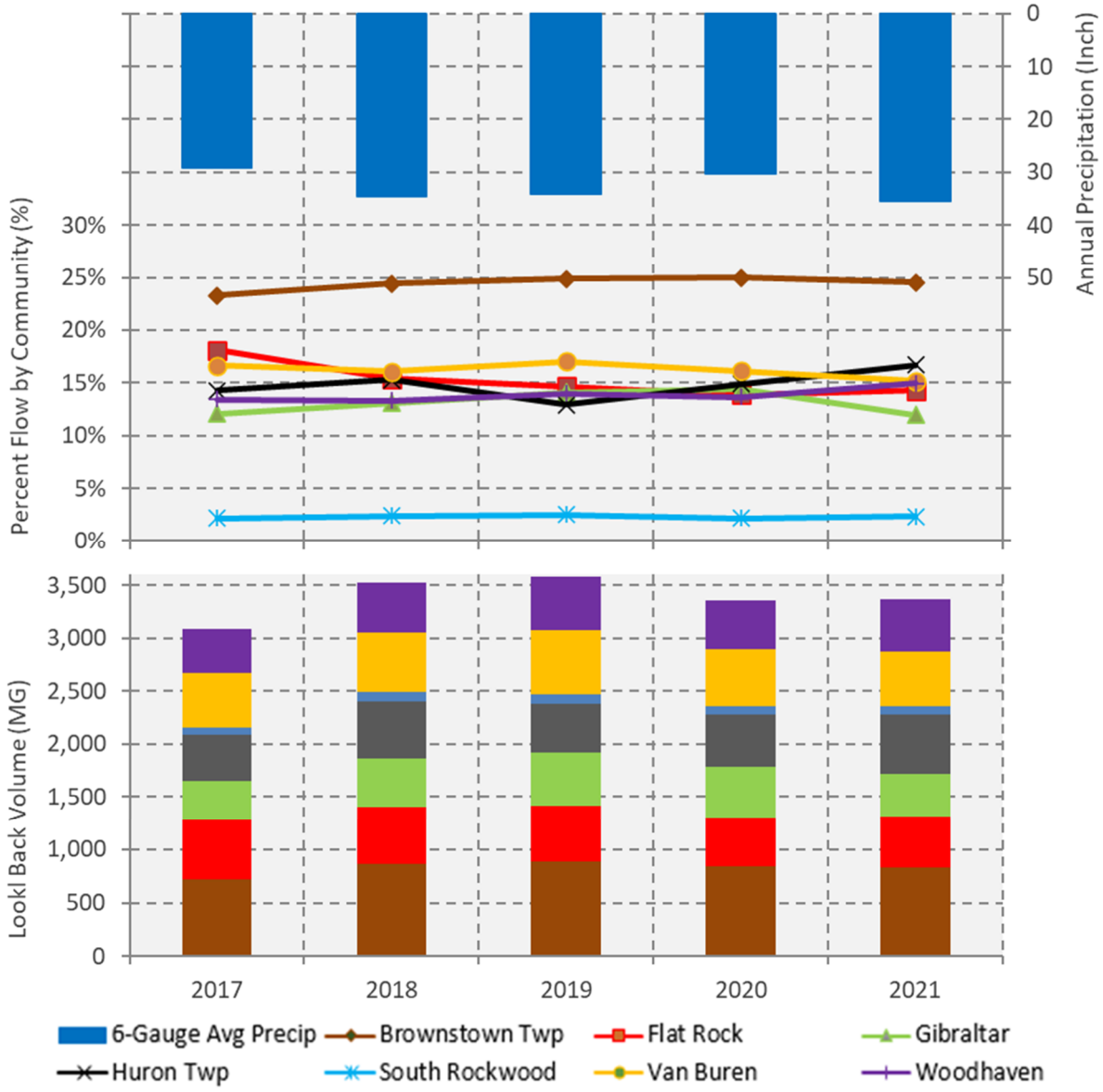
While flow volumes increased in Flat Rock, Huron Twp., South Rockwood, and Woodhaven from 2020 to 2021, there were decreased volumes in Gibraltar and Brownstown. Though there was a higher rainfall total in 2021 than 2020, Detroit River levels have dropped below the peak levels that occurred in 2019 and 2020. From 2020 to 2021, Gibraltar's and Brownstown's percent contributions dropped from 25.0% to 24.6% and 14.4% to 12.0%, respectively. The percentages are similar to those in 2017, before the historically high Detroit River levels in 2019 and 2020.

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

	2017		2018		2019		2020		2021		5-Year Total	
	Flow (MG)	%	Flow (MG)	%	Flow (MG)	%	Flow (MG)	%	Flow (MG)	%	Flow (MG)	%
Brownstown Twp.	719	23.3%	861	24.4%	889	24.9%	838	25.0%	828	24.6%	4,135	24.4%
Central	566		662		669		628		633		3,158	
South	153		199		220		210		195		977	
Flat Rock	559	18.1%	542	15.4%	524	14.7%	465	13.9%	482	14.3%	2,572	15.2%
Gibraltar	372	12.1%	460	13.1%	504	14.1%	482	14.4%	404	12.0%	2,223	13.1%
Huron Twp.	440	14.3%	539	15.3%	462	12.9%	499	14.9%	563	16.7%	2,504	14.8%
South Rockwood	68	2.2%	84	2.4%	89	2.5%	72	2.1%	79	2.3%	391	2.3%
Van Buren Twp.	515	16.7%	567	16.1%	610	17.0%	540	16.1%	513	15.2%	2,745	16.2%
Woodhaven	416	13.5%	470	13.3%	500	14.0%	457	13.6%	504	14.9%	2,346	13.9%
TOTAL VOLUME	3,089	100%	3,524	100%	3,577	100%	3,353	100%	3,373	100%	16,916	100%
Precip. (Inch)	29.1		34.6		34.0		30.2		35.5		32.6 (2005-2021 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 2017 – 2021



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**.

Exceedances were observed for Gibraltar, South Rockwood, and Woodhaven.

Table 3-3 2021 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)	
Gibraltar	6/21/21 5:15	1.1	9.0	no exceedance			7.11
South Rockwood	no exceedance			5/23/21 19:35	7.2	1.0	0.83
	6/21/21 0:50	24.6	1.1	6/20/21 23:40	28.3	1.1	
	7/16/21 17:45	5.8	1.0	7/16/21 12:05	25.2	1.0	
	9/22/21 8:30	1.2	1.0	9/22/21 14:35	4.2	0.9	
	no exceedance			9/23/21 0:00	8.8	1.0	
	10/15/21 14:35	6.9	1.1	10/15/21 14:25	7.3	1.1	
	10/25/21 0:20	2.3	1.0	10/25/21 5:30	21.1	1.0	
	10/25/21 6:10	8.6	1.1				
	10/29/21 18:10	10.7	1.0	10/29/21 10:30	22.8	1.0	
	no exceedance			12/11/21 4:20	8.5	1.0	

Table 3-4 2021 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)	
Gibraltar	6/20/21 21:35	25.9	4.6	no exceedance			2.0
	7/16/21 10:10	40.4	3.9				
	10/24/21 22:55	28.8	3.6				
	10/29/21 8:05	33.3	3.2				
South Rockwood	6/20/21 21:45	31.7	1.0	no exceedance			0.4
	7/16/21 9:55	35.9	0.9				
	9/21/21 23:10	46.7	0.8				
	10/15/21 13:35	28.8	0.8				
	10/24/21 22:30	37.7	0.9				
	10/29/21 4:35	42.7	0.8				
Woodhaven	7/16/21 10:00	30.3	5.5	no exceedance			2.4
	9/21/21 22:25	48.5	4.8				
	10/24/21 22:55	25.9	5.5				
	10/29/21 7:45	29.8	4.7				

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