CITY of HARRISONBURG

Sanitary Sewer

Management Plan

FY2019

December 31, 2018

Revised February 28, 2020

CITY OF HARRISONBURG
PUBLIC
UTILITIES

Table of Contents

I. Executive Summary Score Card

II. Introduction and Level of Service

III. SSMP Balanced Strategy

IV. Capacity Mode: Annual Average Daily Sales and Treatment

V. Capacity Mode: Annual Average Daily Demand and Treatment

VI. Capacity Mode: HRRSA Interceptors

VII. Capacity Mode: City Owned Interceptors

VIII. Performance Mode: Integrity and MTBF

IX. Mortality Mode: RUL by MASL and RISK

X. Obsolescence Mode:

XI. Asset Management at HPU

XII. Financial Benchmarking

XIII. Appendix A: Sewer Pipe Asset Management Plan (AMP)

XIV. Appendix B: Sewer Manhole Asset Management Plan (AMP)

XV. Appendix C: Interceptor hydrographs

XVI. Appendix D: Blacks Run Interceptor Improvements

I. EXECUTIVE SUMMARY SCORECARD:

Harrisonburg's Sanitary Sewer Management Plan (SSMP) has purpose to guide in the effective and efficient providing of services and in the managing of sewer assets. ***The following is an executive scorecard summary of the SSMP objectives and respective status at the end of FY2019***:

SSMP Framework

SSMP Objective #1	Status - FY 2019
Objective #1 requires HPU to monitor and update the SSMP annually.	**Objective #1 has been met for FY2019 with the February 28, 2020 publication of the SSMP.**

Capacity Mode: Annual Average Sales and Treatment

SSMP Objective #2	Status - FY 2019
Objective #2 requires HPU to monitor and forecast sales of sewer commodity in terms of annual average daily (AAD) flows.	**Objective #2 has been completed through FY2019: A*t 12.8 MGD capacity at HRRSA, Harrisonburg has ample allocation to accommodate its current and future sewer sales*.**

Capacity Mode: Annual Average Sales and Treatment

SSMP Objective #3	Status - FY 2019
Objective #3 requires HPU to monitor and forecast sewer demand in terms of annual average daily (AAD) flows versus allocated treatment capacity at HRRSA.	**Objective #3 has been completed through FY2019. Considering the effect of I&I upon forecasted future sales, treatment requirements would exceed allocated treatment capacity in 5 of the 10 annual periods that were studied. Prior to FY2019, Harrisonburg has not exceeded hydraulic capacity, however; it is undesirably leveraging available unused hydraulic capacity to accommodate I&I. Therefore, I&I reduction is an SSMP goal that must keep pace with sales growth such to release currently leveraged capacity.**

Capacity Mode: HRRSA Interceptors

SSMP Objective #4	Status - FY 2019
Objective #4 requires HPU to be consistent with HRRSA in planning HRRSA interceptor capacities and to place emphasis upon the Blacks Run Interceptor.	For ILOS = 10 years, Harrisonburg is currently at 50% capacity in the HRRSA EBRI and at 100% capacity in the HRRSA UBRI. Additional flow monitoring is needed to quantify Harrisonburg's status into the lower HRRSA BRI and into the HRRSA UCCI. Harrisonburg's future capacity status in HRRSA's EUBRI, UBRI, and LBRI requires HPU to delineate the forecasted future demand into the respective interceptors and then to complete comparison against the proposed upgrade capacities. Harrisonburg's future capacity status in LBRI and UCCI requires completion of flow monitoring, flow delineation and comparison against proposed capacities.

Capacity Mode: City Owned Interceptors

SSMP Objective #5	Status - FY 2019
Objective #5 of this SSMP requires an update to the 1989 Black's Run Interceptor Study in ILOS format and to then replace the original CIP strategy to match the recommendations from the updated study.	Work authorized to RJN by Tasks to deliver current ILOS is expected to be available March 2020. Follow up Tasks to identify needed I&I reduction or CIP investments will be scheduled for completion end of 2021.

Performance Mode: Integrity and MTBF

SSMP Objective #6	Status - FY 2019
Objective #6 requires continuous monitoring of system integrity and MTBF sensitivity and to use these benchmarks as drivers for asset management.	Referring to AWWA industry benchmark, Harrisonburg Sanitary Sewer System integrity rating has performed most frequently in the third and fourth quartiles since 2011 but at the upper second quartile in FY2019. For FY2019, 29 pipes did not meet HPU's 10 years ILOS benchmark for MTBF.

Mortality Mode: RUL by MASL and RISK

SSMP Objective #7	Status - FY 2019
Objective #7 of this SSMP requires HPU to forecast the retirement date and value of its asset inventory.	Harrisonburg's asset retirement schedule by MASL that underlies the FY2019 LTFM includes an Annual Sustainable Cost of Service (ACSO) of $1.89M per year to retire $36.3M of assets over the next 20 years. Advancing maturity into RISK methodology will improve accuracy.

Capacity Mode: Obsolescence

SSMP Objective #8	Status - FY 2019
Objective #8 requires HPU to maintain a pipe inventory for materials types.	HPU has met objective #8 for FY2019; data cleanup is needed for older pipes, but pipe type is a driver for asset management decisions.

Asset Management Implementation at HPU

SSMP Objective #9	Status - FY 2019
Objective #9 requires the development of a Long-Term Financial Model (LTFM) to identify funding and expenses as necessary to minimize the total cost of owning and operating assets while delivering the desired service levels.	The Harrisonburg–Econics LTFM model delivered a recommendation for a 2.5% annual increase in rates from 2020 through 2031.

Asset Management Implementation at HPU

SSMP Objective #10	Status - FY 2019
Objective #10 requires the development of individual Asset Management Plans (AMPS) for sewer pipes and manholes to guide the use of all identified drivers in making asset management decisions.	**Asset managers are currently drafting AMPS for sewer pipes and manholes but many of the maintenance activities have been in progress for years. AMPS recognize 12 driving forces for asset management decisions.** **A project is currently active to optimize the HPU computer maintenance management system (CMMS) to better schedule activities and to formulate data into useful information in the asset management decision processes.** **Asset Registers: FY 2019 sewer asset inventory value was reported as $84.6M.** **Predictive Maintenance: FY2019 CCTV added 15 miles of condition assessments for sewer pipe.** **Preventive Maintenance: FY2019 sewer flushing completed 15% of the sewer asset inventory.** **Repair Maintenance: FY2019, 64% of manhours and 59% of cost (vs. AWWA benchmark for median @ 69%) was directed to planned maintenance.**

	CIP (R&R): During FY2019 HPU allocated $1.14M to CIP and conducted 9,358 feet of pipe R&R. **Flow Monitoring (I&I): During FY2019 baseline flow monitoring was nearly completed for ILOS status. The data will provide a baseline for five years interval comparisons.** **Smoke Testing (I&I): Due to unrelenting ground saturation during FY2019, smoke testing didn't occur until fall of 2019 which will be reported for FY2020.**

Benchmarking HPU Management

SSMP Objective #11	Status - FY 2019
Objective #11 requires monitoring selected sewer enterprise fund financial benchmarks	**Harrisonburg residential monthly bills for water plus sewer are 55% of the statewide survey benchmark for 5000 gallons** **Residential households with greater than $26,880 annual household median income (HMI) can adequately absorb the monthly water plus sewer bill of $44.80.** **Liquidity (53%): Sewer Fund Balance at $6,173,303 meets criteria of 25% cash revenue for a Moody's Aaa bond rating.**

	Debt coverage at 1.57 meets a moderate level benchmark per Fitch's recommendations (1.25-2.00). **ASCO is the average annual funding target that is needed for the retirement of assets over the next 20 years. The benchmark ratio of 0.71 (vs. 1.0) suggested a shortfall in funds. Rates do not support funding at the required level.** **HPU uses the EOY balance in CIP funds for purposes generally intended for "Capital Reserves". The Capital Reserves is an amount of funds that are appropriated and could be readily used in the event of a significant failure of assets. For end of Fy2019, unspent allocations in the CIP funds were a healthy 6.1% of CARV (Current Asset Replacement Value); this was made available by delay of active target projects.**

II. Introduction and Level of Service (LOS):

Harrisonburg Public Utilities (HPU) has crafted a Sanitary Sewer Management Plan (SSMP) to guide operation and maintenance of its sewer system infrastructure as it expands and ages. This strategy underlies the effort to deliver the level of services expected today and to safeguard this level of service into the future.

A key foundation to developing an SSMP is to understand and identify the Level of Service (LOS) that a utility's customers want and are willing to pay for. HPU has adopted the following LOS goals in terms of the four failure modes that are common to asset management practices within the industry. The modes of failure are capacity, performance, mortality and obsolescence.

HPU Level of Service Summary

	Capacity`	Efficiency through Structural Mortality	Functionality	Obsolescence
Benchmark	**Overflow ILOS @ 10 years and greater**	**Remaining Useful Life**	**Overall System Integrity = AWWA median frequency** **Mean Time Between Failure on Sewer Backups = 10 years**	**Brick Manholes**
Implementation tool	**Flow Monitoring & Hydraulic Modelling**	**Ques scoring**	**CMMS Level 3 & 4**	**Material Approval Protocol**

1) Capacity: Capacity is a failure mode that benchmarks hydraulic induced sewer overflows that are evaluated in terms of return frequency. The goal for each location of overflow in the Harrisonburg Sewer System is less than one event every ten years.

2) Functionality: The functionality performance failure mode is termed as "System Integrity"; it provides a benchmark for uninterrupted service to the customer. The "Integrity" goal for the Harrisonburg Sewer System is less than 5.0 backups per year 100 miles of pipe. The Mean Time Between Failure (MTBF) goal for each pipe asset in the Harrisonburg Sewer System is one backup at less than once every ten years.

3) Mortality: Developing the retirement and replacement (R&R) schedule is an analysis of remaining useful asset life (RUL) of the collection of system assets. Current practices at HPU have used the "Manufacturer's Anticipated Service Life" (MASL) to forecast long term financial funding requirements through the Capital Improvement Program (CIP). HPU is continuously moving deeper into condition assessment to refine RUL when applying asset management principles to routine decisions for rehabbing or retiring an asset.

4) Obsolescence: Obsolescence is a failure mode that identifies materials that do not support goals of the SSMP.

III. SSMP Balanced Strategy:

This SSMP includes measures for strategic, tactical, and operational performance. It was organized around a balanced strategy that emphasized financial and nonfinancial measures with short term and long terms goals. **Figure 1** shows the SSMP Balance Strategy.

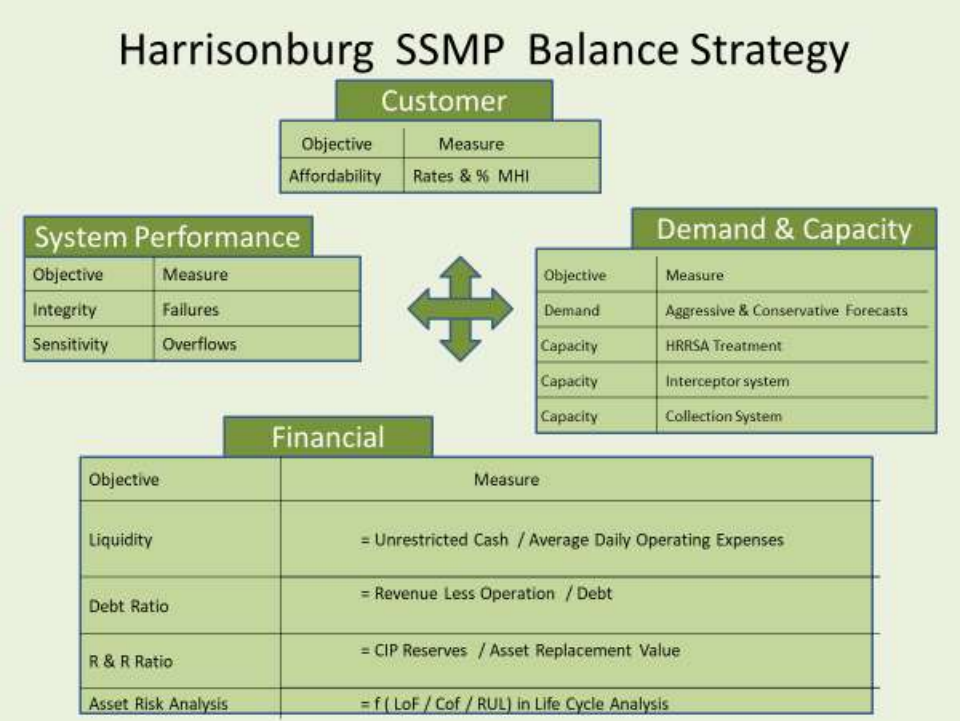


Figure 1

Objective #1 requires HPU to monitor and update the SSMP annually.

Objective #1 has been met for FY2019 with the February 28, 2020 publication of the SSMP

Figure 2 below shows the HPU SSMP framework including responsible entities and their objectives; the latter are defined in greater detail in this document. This document omits the vertical assets managed under the Pump Division but will be added later.

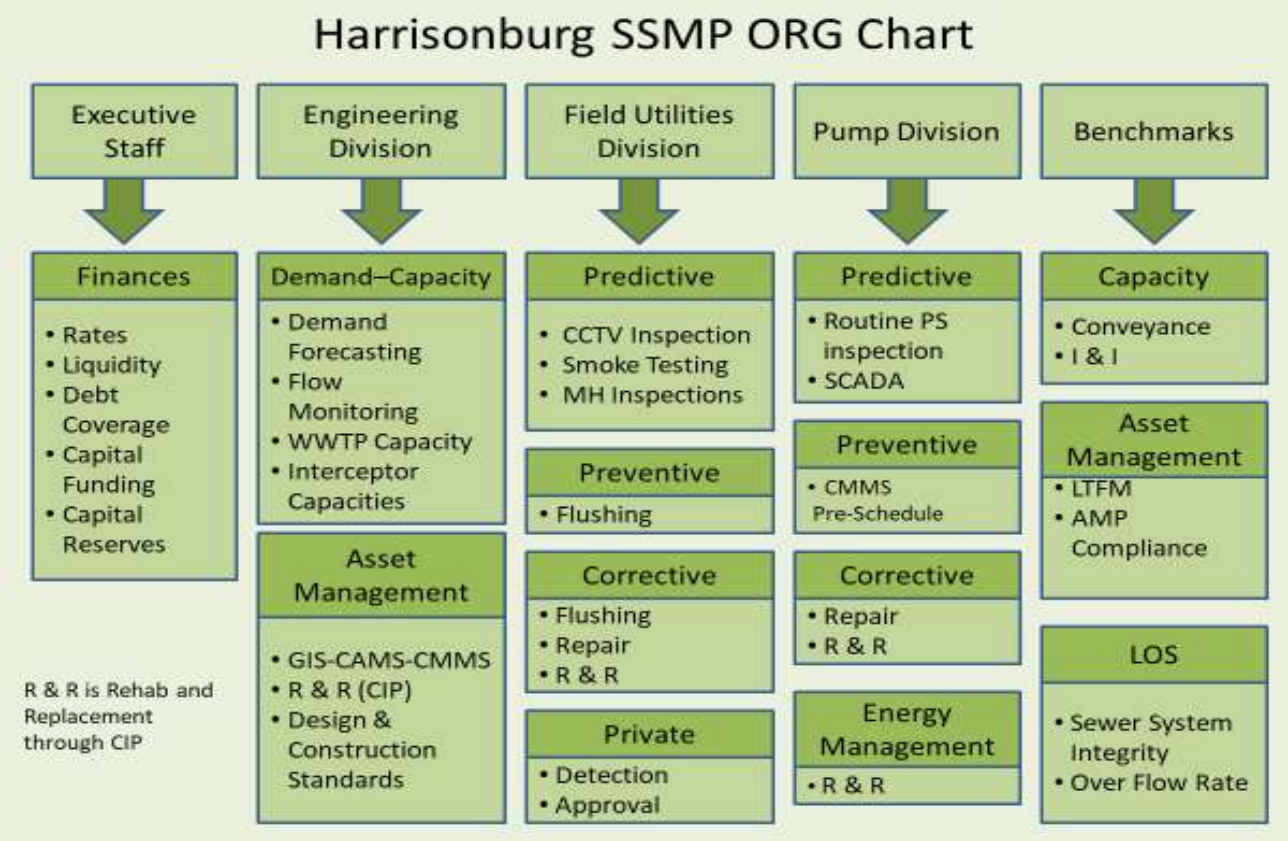


Figure 2

IV. Capacity Mode: Annual Average Sales and Treatment Capacity

Objective #2 requires HPU to monitor and forecast sales of sewer commodity in terms of annual average daily (AAD) flows.

Historic Analysis of Sales

Shown in the **Figure 3** below is a comparison of sewer sales by the Harrisonburg Department of Billing. Growth rates for the most recent 18 years period, 10 years period, 5 years period and one-year period were +0.0%, +1.4%, +1.6%, and -2.9%, respectively.

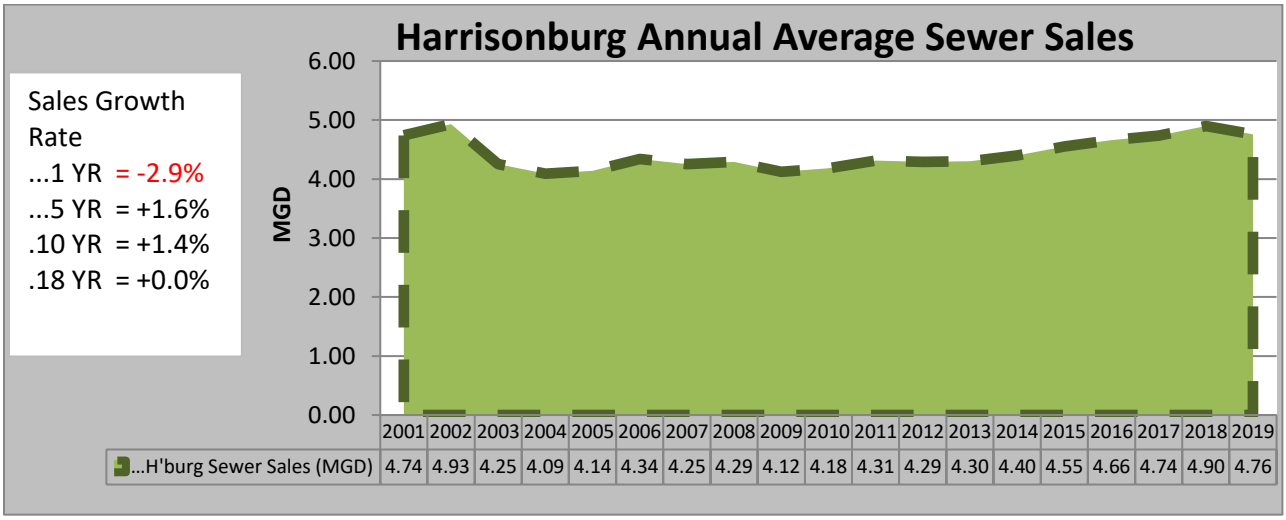


Figure 3

Forecast Analysis of Sales

A team of Harrisonburg City Departments have optimized the methodology and enhanced the use of GIS capabilities to better evaluate existing city water demands. *(Note that water sales were analyzed and are presumed to have generated 10%-20% higher estimates as compared to sewer sales. This is an acceptable level of safety for this analysis.)* Using most recent sales and land use data from FY2019, the City departments of Economic Development, Community Development, IT & GIS, City Manager and Public Utilities have determined the existing consumption per acre rates for all zoning types in the City.

Developed Lands, Existing Land Use *includes lawn and irrigation meter use*	**Consumption per acre**	**Consumption per unit (million gal/day)**	**Total Consumption**
COMMERCIAL - LODGING	0.001831	0.003901	0.117
COMMERCIAL - OFFICE	0.000335	0.000212	0.066
COMMERCIAL - RETAIL SERVICE	0.000428	0.000496	0.429
GOLF COURSES	0.000011	0.000514	0.004
INDUSTRIAL	0.002102	0.007798	1.279
INSTITUTIONAL	0.000616	0.000286	0.127
MIXED USE	0.003150	0.000116	0.051
PARKS AND RECREATION	0.000041	0.000657	0.017
PUBLIC FACILITIES	0.000076	0.000280	0.019
RESIDENTIAL - MULTI-FAMILY	0.001241	0.000118	0.784
RESIDENTIAL - SINGLE FAMILY ATTACHED	0.000644	0.000105	0.279
RESIDENTIAL - SINGLE FAMILY DETACHED	0.000350	0.000120	0.634
RESIDENTIAL SINGLE FAMILY GREATER THAN 2 ACRES	0.000027	0.000128	0.003
ROW	0.000000	0.000000	0.000
SCHOOLS, COLLEGES, AND UNIVERSITIES	0.000918	0.005273	0.933
VACANT	0.000009	0.000016	0.002
BASELINE TOTAL			**4.742**

The team then applied the consumption per acre rates to respective vacant lands to forecast future internal City water sales. The forecast was for an additional 3.119 MGD in growth based on desired future land uses as shown:

Vacant Lands, Land Use Guide	gal/day per unit	Number of units per ac	Multiplier value (mgd/ac)	Apply to ac from LUG	Growth Factor	Projected Use (mgd)
Conservation, Recreation, Open Space	-	-	0.000041	15.9	-	0.001
Low density residential	-	-	0.000350	143.7	-	0.050
Low density mixed residential	104	10	0.000001	618.2	-	0.643
Neighborhood residential	-	-	0.000420	60.6	-	0.025
Medium Density Residential	114	15	0.000001	77.0	-	0.132
Medium Density Mixed residential	114	20	0.000001	151.4	-	0.345
High density Residential	118	24	0.000001	5.7	-	0.016
Mixed Use	-	-	0.001418	317.0	-	0.449
Limited Commercial	-	-	0.000513	42.9	-	0.022
Commercial	-	-	0.000513	208.1	-	0.107
General Industrial	-	-	0.002102	567.6	-	1.193
Governmental/Quasi-Governmental	-	-	0.000798	140.3	1.2	0.134
Institutional	-	-	0.000546	2.0	1.2	0.001
USE BY FUTURE LAND USE GUIDE MULTIPLIERS TOTAL						3.119

Sales Versus Treatment

Harrisonburg treats its sewer as a member at the Harrisonburg Rockingham Regional Sewer Authority (HRRSA). The contract service agreement between HRRSA and its five members (Bridgewater, Dayton, Harrisonburg, Mount Crawford and Rockingham County) directly defines member allocation by hydraulic capacity in million gallons per day (MGD). The HRRSA facility is rated at 22.0 MGD with Harrisonburg's allocation at 12.8 MGD (58%).

An initial analysis is to compare current and future sewer sales against allocated capacity at HRRSA. Preliminary discussions suggest an expansion at HRRSA may increase its total capacity to 28.0 MGD; Harrisonburg would have opportunity to purchase additional capacity to 16.2 MGD (58%).

	FLOW	CAPACITY MGD
Existing Sewer Sales	4.3 MGD	
Future Sewer Sales	3.2 MGD	
Max Sewer Sales	7.5 MGD	12.8 MGD
		16.2 MGD

Objective #2 has been completed through FY2019: At 12.8 MGD capacity at HRRSA, Harrisonburg has ample allocation to accommodate its current and future sewer sales.

V. Capacity Mode: Annual average Daily Demand and Treatment

Objective #3 requires HPU to monitor and forecast sewer demand in terms of annual average daily (AAD) flows versus allocated treatment capacity at HRRSA.

Utilization of allocated capacity for each member jurisdiction is set forth under the HRRSA service agreement and refers to the maximum 3 consecutive months (M3CM) flow. The use of allocated flow is the sales of sewer as detailed in the preceding section of this plan; however, infiltration and inflow (I&I) is an undesirable component that must be included in the evaluation.

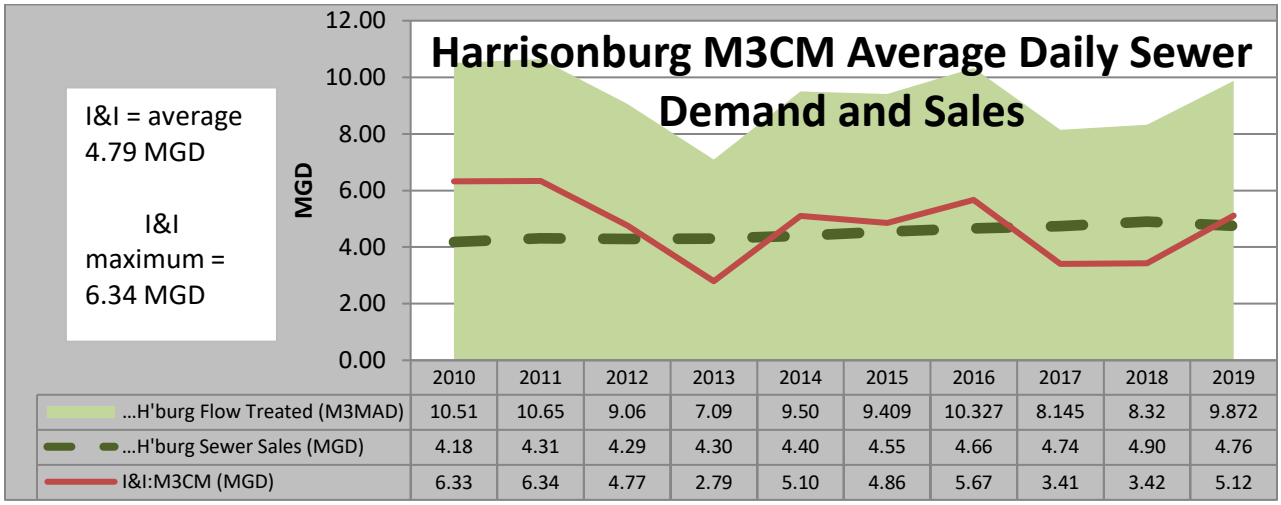
Rainfall-derived "infiltration" refers to rainfall runoff that filters through the soil before entering a sanitary sewer system through damaged pipe sections, leaky joints, or poor manhole connections; duration is generally longer than experienced with inflow.

Rainfall-derived "Inflow" is the water that enters a sanitary sewer system directly by way of depressed manhole lids and frames, downspouts, sump pumps, foundation drains, areaway drains, and cross connections with storm sewers. Inflow occurs and peaks shortly after rainfall and then tapers quickly.

Historic Analysis of Demand

Demand is sales plus I&I. Shown in the table below for the period of 2010 through 2019 is a historic comparison of sewer sales by the Harrisonburg Department of Billing versus Harrisonburg's demand at the HRRSA sewer treatment plant. The latter is the larger; the difference is largely caused by infiltration & inflow (I&I). This extraneous source of water

is driven by unfavorable sewer system configuration and asset condition as well as incurred weather conditions. The maximum recorded maximum daily three months average for I&I was 6.34 MGD and the average was 4.79 MGD.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
…H'burg Flow Treated (M3MAD)	10.51	10.65	9.06	7.09	9.50	9.409	10.327	8.145	8.32	9.872
…H'burg Sewer Sales (MGD)	4.18	4.31	4.29	4.30	4.40	4.55	4.66	4.74	4.90	4.76
I&I:M3CM (MGD)	6.33	6.34	4.77	2.79	5.10	4.86	5.67	3.41	3.42	5.12

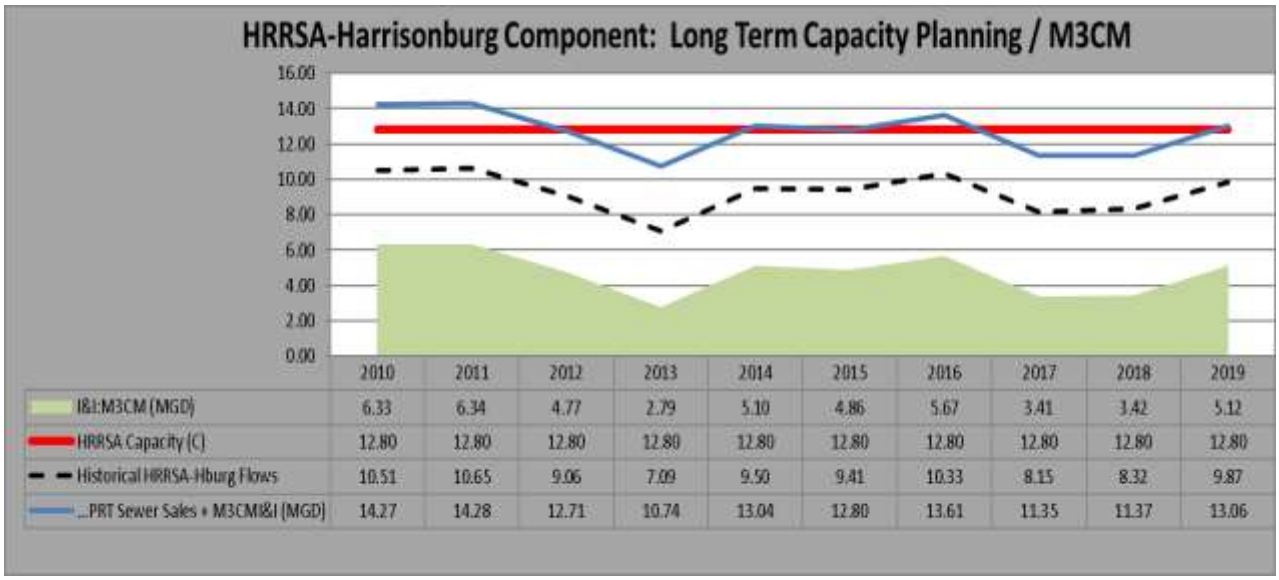
Figure 4

Forecast Analysis of Demand

Forecasting future demand is somewhat difficult because the I&I component is not a constant (as compared to sales) but more related to incurred weather. Therefore, the future demand and needed treatment capacity can be estimated by displaying future demands added upon previous trends. The following are components of future demands:

- Future growth in City sales:
  3.2 MGD as determined in the previous section
- Reserved sales for Michaels and Daley
  0.26 MGD
- Future I&I effect: The analysis assumed zero reduction in existing system and zero addition with future growth. Other allowances can provide opportunities for additional sensitivity analysis.

The results shown in **Figure 5** indicate that available capacity of 12.8 MGD will not always support the future treatment requirement.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
I&I:M3CM (MGD)	6.33	6.34	4.77	2.79	5.10	4.86	5.67	3.41	3.42	5.12
HRRSA Capacity (C)	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80
Historical HRRSA-Hburg Flows	10.51	10.65	9.06	7.09	9.50	9.41	10.33	8.15	8.32	9.87
PRT Sewer Sales + M3CM&I (MGD)	14.27	14.28	12.71	10.74	13.04	12.80	13.61	11.35	11.37	13.06

Figure 5

Objective #3 has been completed through FY2019: Considering the effect of I&I upon forecasted future sales, treatment requirements would exceed allocated treatment capacity in 5 of the 10 annual periods that were studied. Prior to FY2019, Harrisonburg has not exceeded hydraulic capacity, however; it is undesirably leveraging available unused hydraulic capacity to accommodate I&I. Therefore, I&I reduction is an SSMP goal that must keep pace with sales growth such to release currently leveraged capacity.

VI. Capacity Mode: HRRSA Interceptors

Objective #4 requires HPU to be consistent with HRRSA in planning HRRSA interceptor capacities and to place emphasis upon the Blacks Run Interceptor.

HRRSA owns and operates interceptor sewer pipes that extend through certain sections of the City and then southward beyond the City limits to the treatment facility in Mount Crawford. HRRSA has defined and named its interceptor system into three divisions. Two divisions are geographically located in the upper system and they are named Upper Cooks Creek Interceptor (UCCI) and Blacks Run Interceptor (BRI). The lower section has been named Lower Cooks Creek Interceptor (LCCI); it receives flow from UCCI plus BRI and then conveys the combined flow to the HRRSA treatment plant.

.

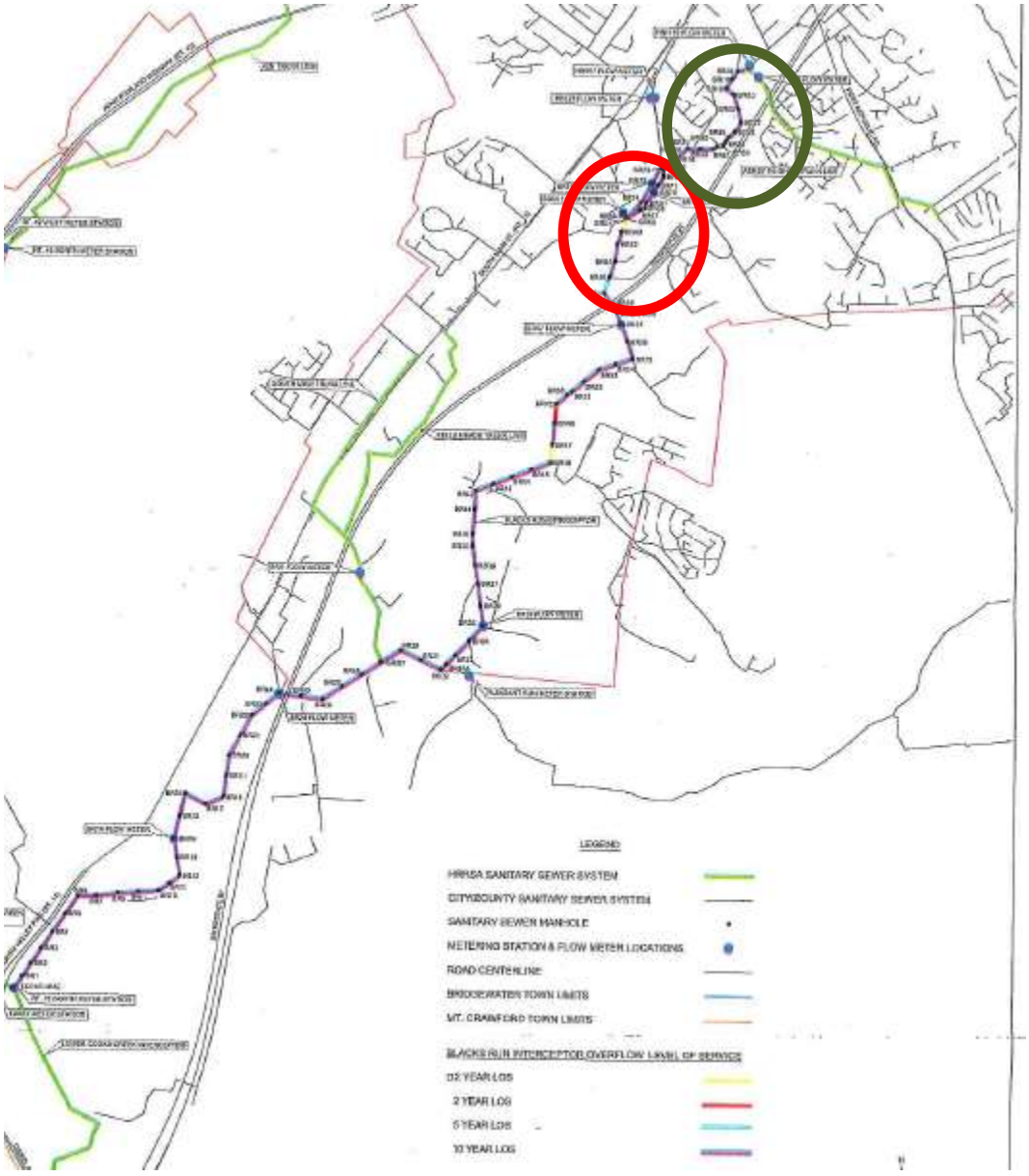
Current Capacity Analysis: HRRSA finalized a report entitled "Level of Service Master Plan Report" and dated July 10, 2017. The report identified a desired Level of Service (LOS) of 10 years where LOS was defined as the peak flow reoccurrence that the sanitary sewer can convey without resulting in a capacity related SSO. The report evaluated existing capacities against current flow monitoring data. The capacities were based on the pipe in the lowest segment of the interceptor to convey flow without surcharging.

Future Capacity Analysis: Using selected assumptions, the HRRSA study then extended to forecast future flows and corresponding needed sewer capacities if the treatment facility is expanded from 22 MGD to 28 MGD. A capital improvement master plan for the interceptor system was included in the study.

Ancillary Analysis: Flow monitoring completed by Harrisonburg throughout 2018 and 2019 for analysis of its own interceptors provided additional flow data that has value to understanding current and future conditions in the upper section of the BRI, now referred to as Upper Blacks Run Interceptor (UBRI).

Existing Conditions:

UBRI: Shown in **Figure 6** below is the HRRSA BRI. The mid-section of UBRI is shown inscribed in red and the East Interceptor (EBRI) is inscribed in green.

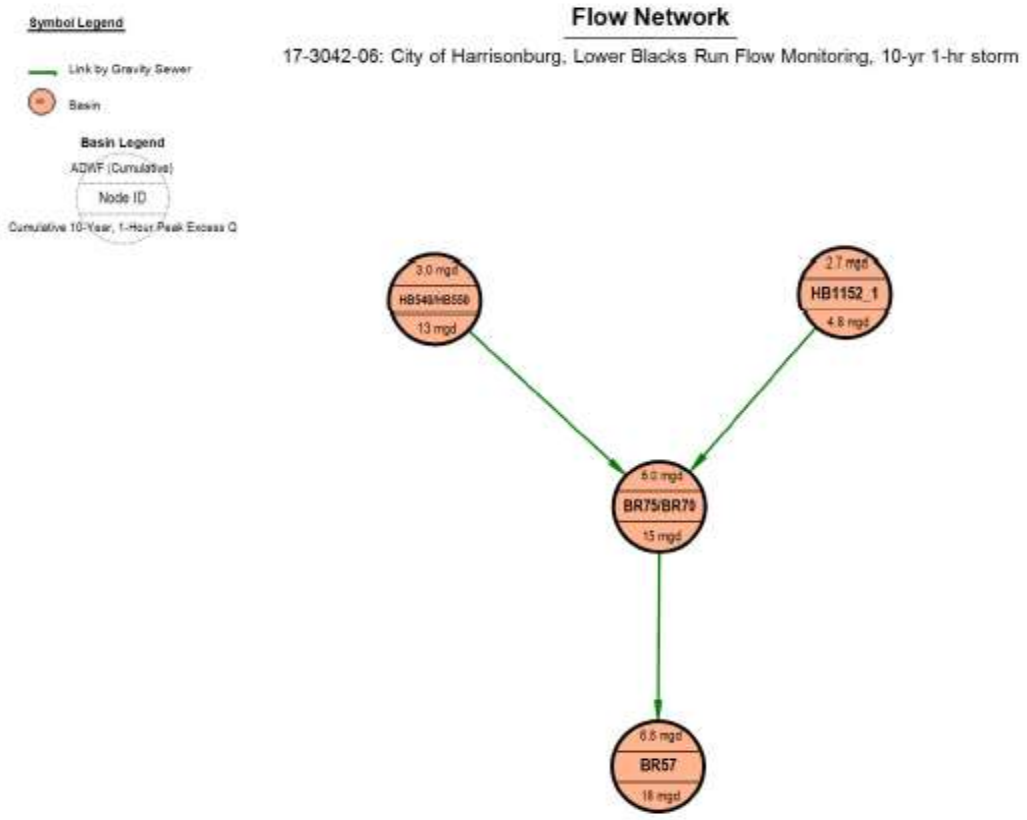


The HRRSA study shows nearly all sections in UBI and the EBRI to meet current ILOS = 10 years. Exception is noted for sections that are downstream of the mid-section where observed SSOs have been recorded.

Additional flow monitoring by Harrisonburg showed further understanding of the EBRI and UBRI positions at the 10 years storm frequency (See Appendix C for metering hydrographs). In summary, the existing demand and capacity relationship is summarized:

- East Interceptor: 8 MGD total flow; 17 MGD pipe capacity
  *7 MGD H'burg flow; 14 MGD allocated pipe capacity
- UBRI: 24 MGD total flow; 24 MGD pipe capacity
  *20 MGD H'burg flow; 20 MGD allocated pipe capacity

*Following the HRRSA ILOS assumption, calculations assume the 83% to 17% split of flow between Harrisonburg and Rockingham County for both demand and pipe capacity; this is most likely subject to re-evaluation. County average flows 2019 = 0.07 MGD from Ashby Heights and 0.11 MGD from Smithland Road for a total of 0.2 MGD; this was a 93% to 7% split of annual flows. Delineation of 10 years storm frequency flows is not available.



Fugure7

BRI, UCCI and LCCI: The capacity of each existing HRRSA interceptor division as shown below are listed in table 3-3 on page 7 of the HRRSA report.

EXISTING INTERCEPTOR CAPACITIES @ 22MGD PLANT RATING

LCCI Capacity = 44 MGD	LBRI Capacity = 29 MGD	UCCI Capacity = 22 MGD
H'burg = 25.6 MGD @ 58%	H'burg = 24.1 MGD @ 83%	H'burg = 2.6 MGD @ 12%

Interceptor Capacity was based on the ratio of the Locality's NRWWWTF allocation and the total NRWWTF allocations specific to each interceptor and on calendar year 2016 billings records. Harrisonburg's allocation was 83% assigned to BRI; this allocation formula is not recognized by the HRRSA Service Agreement and is subject to future review.

For ILOS = 10 years, Harrisonburg is currently at 50% capacity in the HRRSA EBRI and at 100% capacity in the HRRSA UBRI. Additional flow monitoring is needed to quantify Harrisonburg's status into the lower HRRSA BRI and into the HRRSA UCCI.

Future Capacities:

BRI, UCCI and LCCI: The HRRSA ILOS study recommended a master plan for capital improvements to the HRRSA owned interceptors. The improvements will provide interceptor capacities to meet the forecasted 10-year ILOS goals at an expanded 28MGD plant capacity. Project goals are shown below:

MASTERPLAN INTERCEPTOR CAPACITIES @ 28MGD PLANT RATING

LCCI Capacity = 95 MGD	LBRI Capacity = 75 MGD	UCCI Capacity = 22 MGD
H'burg = 55 MGD @ 58%	H'burg = 60 MGD @ 83%	H'burg = 2.6 MGD @ 12%

Interceptor Capacity was based on the ratio of the Locality's NRWWWTF allocation and the total NRWWTF allocations specific to each interceptor and on calendar year 2016 billings records. Harrisonburg's allocation was 83% assigned to BRI; this allocation formula is not recognized by the HRRSA Service Agreement and is subject to future review.

Meeting the future ILOS for the interceptors will engage Harrisonburg into I&I reduction efforts and shared capital funding that will be undertaken by HRRSA. Below is the debt schedule for HRRSA.

- 2023-2042 Div. 1 Bond $ 847,519 per year
- 2027 -2046: Div. 2 Bond $ 718,516 per year
- 2031-2050: Div. 3 Bond $2,471,766 per year
- 2033-2052: Div. 4 Bond $ 544,836 per year

Division 1 improvements are currently under design with modifications to the original masterplan. The post improvement capacity as recommended for UBRI and the Harrisonburg East Interceptor was 75 MGD with 60 MGD allocated to Harrisonburg. After further evaluation, upper sections of UBRI have been retained in capacity at 17 MGD at the option of slip lining existing pipe. The future demand and capacity relationship is summarized:

- East Interceptor: 8+ MGD total flow; 17 MGD pipe capacity
  7+ MGD H'burg flow; 14 MGD allocated pipe capacity

- UBRI: 24+ MGD total flow; 75 MGD pipe capacity
  *20+ MGD H'burg flow; 60 MGD allocated pipe capacity

+ future flow will be calculated by adding the proportion of 3.2 MGD forecasted increase in sales that will be generated in the East Interceptor or BRI drainage area. Allowable I&I will be included
*Following the HRRSA ILOS assumption, calculations assume the 83% to 17% split of flow between Harrisonburg and Rockingham County for both demand and pipe capacity; this is most likely subject to re-evaluation. Maximum Rockingham County flow from Smithland Road is 0.3 MGD average and 0.75 MGD peak; growth from Ashby Heights is unknown.

Harrisonburg's future capacity status in HRRSA's EUBRI, UBRI, and LBRI requires HPU to delineate the forecasted future demand into the respective interceptors and then complete comparison against the proposed upgrade capacities.

Harrisonburg's future capacity status in LBRI and UCCI requires flow monitoring and then delineation of forecasted future flows and comparison against proposed capacities.

VII. Capacity Mode: City Owned Interceptors

Harrisonburg owns and operates its own interceptor sewer pipes that extend through certain sections of the City. The Western Blacks Run Interceptor (WBRI) and the Eastern Blacks Run Interceptor (EBRI) are the two City divisions.

The Harrisonburg WBRI has several component subsystems that included the "Lower West Interceptor (LWI)", "Upper West Interceptor (UWI)", "North Interceptor (NI)" and the "West Spur Interceptor (WSI)". The LWI delivers flow into the HRRSA UBRI.

The Harrisonburg EBRI is an extension of the HRRSA UBBI and includes the "Blue Ridge Drive Interceptor (BDI). It also delivers flow into the HRRSA UBRI.

A study conducted by Wiley & Wilson in 1989 has guided HPU in its CIP investments into the Blacks Run Interceptor Program. The study is outdated and was not framed in the format of LOS that was performed under the HRRSA capacity studies. The study provided a 22 years plan to upgrade interceptor capacities to meet future growth forecasts. Most recommendations have been completed; refer to Appendix D for a status update. The components of the interceptor and their respective Dry Weather Flow (DWF) design criteria from 1989 are shown below:

INTERCEPTOR SYSTEM	Length (ft)	DWF design
Upper HRRSA	3,030	26.65 MGD
Lower West Interceptor	4,832	11.58 MGD
Upper West Interceptor	8,543	2.20 MGD
North Interceptor	14,124	8.36 MGD
West Spur Interceptor	1,975	3.71 MGD
East Interceptor	18,808	12.68 MGD
Blue Ridge Drive Interceptor	3,516	0.88 MGD
Country Club Road Interceptor	3,930	2.06 MGD
Total	58,758	

Figure 8 below is a schematic of the Harrisonburg Black's Run Interceptor with DWF.

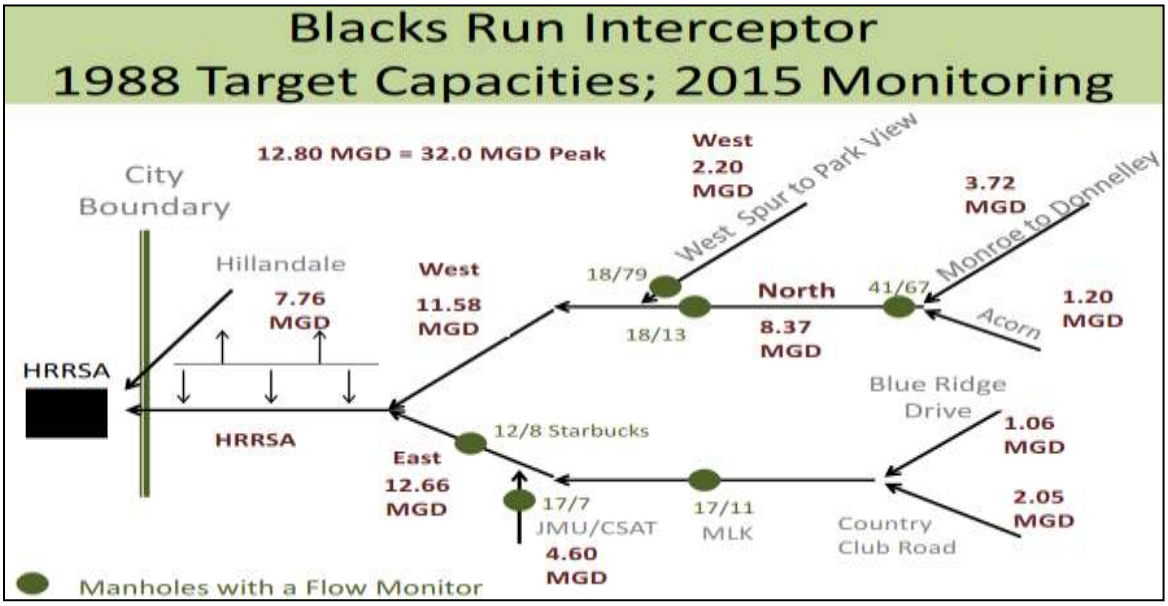


Figure 8

Objective #5 of this SSMP requires an update to the 1989 Black's Run Interceptor Study in ILOS format and to then replace the original CIP strategy to match the recommendations from the updated study.

HPU is actively moving to complete Objective #4 under consultant arrangements with RJN Group, Inc. CIP projects #501-15-16 Blacks Run Interceptor Study & #509-16-17 West Spur Interceptor have the following engineering task orders with RJN.

- T.O. #1 – RJN consulted with HPU to define and clarify Owner's requirements for the Specific Project, including design objectives and constraints, space, capacity and performance requirements, flexibility, and expandability, and any budgetary limitations, and identify available data,

information, reports, facilities and plans. RJN attended several meetings at HPU throughout 2017 to satisfy this task order.

- T.O. #2 - Under CIP project #509-16-17, RJN Group, Inc. performed flow monitoring services to characterize the West Spur section of the upper Blacks Run Interceptor (WSI) sub shed for known I&I loads placed on the sanitary sewer collection system during significant rain events. The report covers the results of temporary flow and rainfall monitoring and analysis services at four RJN-maintained meter locations within the City of Harrisonburg as well as two City-maintained meters to assist with addressing Objective 4. The purpose of the flow monitoring was twofold. The first objective aided the City in determining where storm water inflow and groundwater infiltration occurs in the West Spur sub shed. This assisted in developing a PPM plan to mitigate I&I in this area. Additionally, it provided data to develop a model which will provide hydraulic analysis to plan and monitor system improvements. The RJN flow monitoring report for WSI was delivered in February 2018.

- T.O. #3 – Meter Data Collection, Processing and Analysis to Support an Interceptor Hydraulic Model Update. Under CIP project #501-15-16 RJN Group Inc. performed professional engineering services consisting of flow meter data collection, review, and evaluation to support the hydraulic model update. This review/evaluation will determine existing data adequacy and identify gaps and/or locations that require further metering. The technical memorandum for TO #3 documented data review, analysis, editing process and metering recommendations. Harrisonburg Meter Data Adequacy Review Technical Memorandum was delivered on July 12, 2018.

- T.O. #3.1 - Interceptor Flow Monitoring for Model Development. The primary objective of this TO is to identify and ultimately rehabilitate I&I sources within the City's sanitary sewer collection system. The flow monitoring exercise identified dry-weather flow conditions and I&I amounts in the upper reaches of Blacks Run Interceptor, namely the East and North branches. Metered basins were prioritized relative to I&I contributions.

These prioritized basins are currently being used to allocate manhours and dollars in our annual PPM plan for mitigation of I&I. In addition, flow distributions for model updates were verified, which will be a tool to evaluation capacity upgrades. This report is titled Flow Monitoring Report Blacks Run Interceptor Monitoring for Model Development and was delivered in November 2018.

- T.O. #3.2 - Flow Analysis, Model Calibration, and Capacity Evaluation Hydraulic Model Update. The overall goal of this task is to identify and rehabilitate I&I sources and/or provide needed capacity upgrades that restore City interceptors to a desired Level of Service. Flow and rainfall data analysis will be done to determine both dry and wet-weather peaking factors. Model Calibration involves consolidation of an existing Sewer-CAD model into a complete Sewer-GEMS model, then calibrated for dry-and wet-weather conditions. Lastly, capacity evaluations will be performed in Sewer-GEMS by running several simulations to evaluate a range of storm return intervals (expressed as a Level of Service) under the City's growth projections. Simulations for wet-weather 2-year, 5-year and 10-year storm Level of Service will be performed utilizing current flows and forecasted future flows. RJN's anticipated completion date for this task order is March 1, 2020.

- T.O. #3.3 – Lower Blacks Run Interceptor Monitoring for Model Development. The primary objective of this TO was to utilize flow monitoring to quantify dry-weather flow and I&I amounts in the lower reaches of Blacks Run Interceptor. This TO was needed to fill data gap identified in TO #3.2. Gaps occurred because flows could not be balanced with similar field work completed by HRRSA. Metered basins were prioritized relative to I&I contributions. These prioritized basins are currently being used to allocate manhours and dollars in our annual PPM plan for mitigation of I&I. In addition, flow distributions for model updates were verified, which will be a tool to evaluation capacity upgrades. This report is titled Flow Monitoring Report Lower Blacks Run Interceptor Monitoring for Model Development and was delivered in November 2019.

A future Phase 2 may be necessary to expand this effort for analysis of alternatives for interceptor improvements based on updated flow monitoring, updated land use data and growth projections.

Work authorized to RJN by Tasks to deliver current ILOS is expected to be available March 2020. Follow up Task Work to identify needed I&I reduction or CIP investments will be scheduled completion end of 2021.

VIII. Performance Mode; Integrity and MTBF

Objective #6 requires continuous monitoring of system integrity and MTBF sensitivity and to use these benchmarks as drivers for asset management.

System Integrity:

The integrity of a sewer system measures the frequency of collection system failures per 100 miles of collection piping= [100 * [(# public failures) / Total Miles of Pipe]]. Failure means a loss of capacity resulting from a flow restriction in gravity or pressurized wastewater systems. Examples include blockages from debris inappropriately deposited by users or blockages caused by substandard pipe structural condition. Integrity analysis is a driver for maintenance decisions.

AWWA Published Benchmarks

Top Quartile pipe	2.9 stoppages per 100 miles
Median pipe	5.0 stoppages per 100 miles
Bottom Quartile pipe	8.7 stoppages per 100 miles

Referring to AWWA industry benchmark, Harrisonburg Sanitary Sewer System integrity rating has performed most frequently in the third and fourth quartiles since 2011 but at the upper second quartile in FY2019.

The above trend is shown in **Figure 9** below:

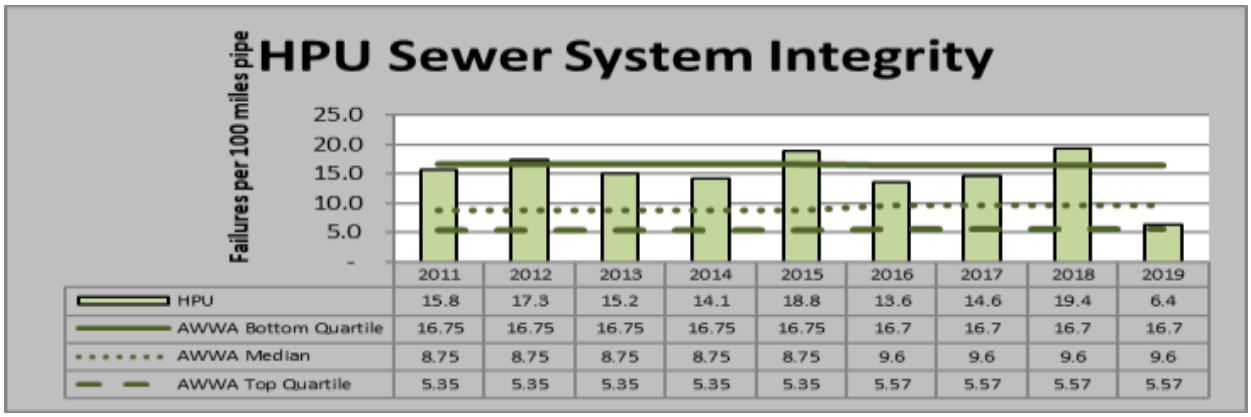


Figure 9

Functionality-Customer Sensitivity:

HPU desires to deliver a LOS of ten years to its customers; it expects to have a backup failure occur to a customer habitat no more than once per ten years. Shown below is the distribution of Mean Time Between Failure (MTBF) frequency in the Harrisonburg Sanitary Sewer System. ***For FY2019, 29 pipes did not meet the Harrisonburg 10 years ILOS benchmark for MTBF.*** MTBF analysis is a driver for maintenance decisions

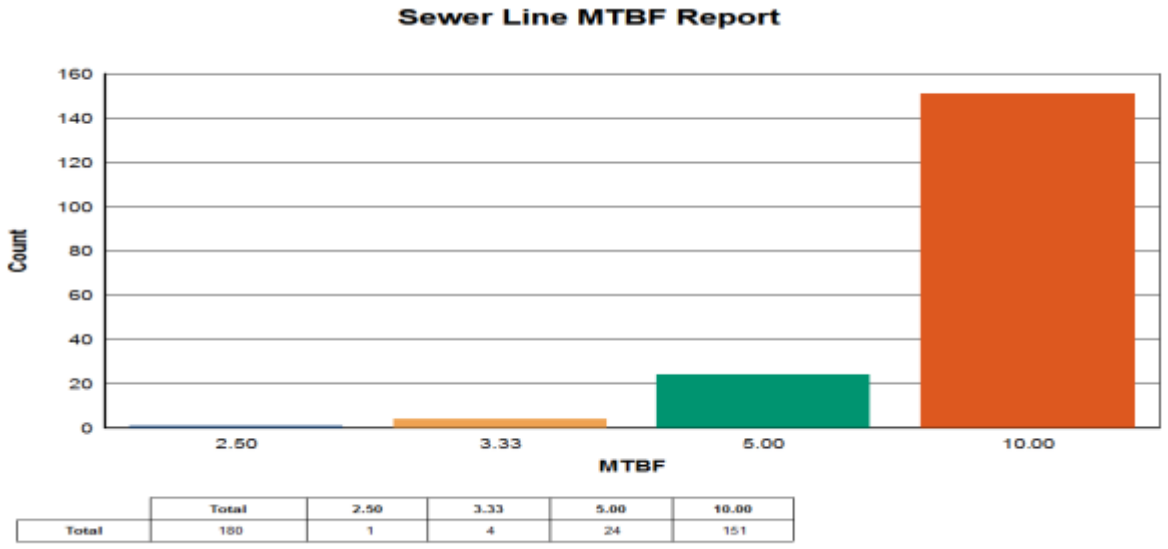


Figure 10

IX. Mortality Mode: RUL by MASL and RISK

Objective #7 of this SSMP requires HPU to forecast the retirement date and value of its asset inventory.

The first key decision process in asset management is to determine when the individual assets may need rehabilitated or replaced. For funding purposes in the LTFM, retirement requirements are forecasted using the Manufacturer's Anticipated Service Life (MASL) for each asset type (sewer pipes, manholes, etc.). As HPU moves forward in maturing asset management implementation by means of staffing, technology, experience and training, more efficient RISK principles will replace MASL principles.

Harrisonburg's asset retirement schedule by MASL that underlies the FY2019 LTFM includes an Annual Sustainable Cost of Service (ACSO) of $1.89M per year to retire $36.3M of assets over the next 20 years. Advancing maturity into RISK methodology will improve accuracy.

The FY2019 LTFM retirement schedule is shown below.

Fund 911161-	Total CARV	20 Yr. CARV	ACSO $	20 Yr. Sum $	Starting Balance	Adjusted ACSO $
48735	$84.6M	$28.4M	$1.61M	$32.2M	$1.48M	$1.54M
48736	$ 1.6M	$ 0.9M	$0.06M	$ 1.2M	$0.37M	$0.04M
48641	$14.4M	$ 6.8M	$0.63M	$ 7.6M	$1.47M	$0.30M
48757	$ 1.4M	$ 0.2M	$0.007M	$ 0.2M	$0.00M	$0.007M
Total	$102.0M	$36.3M				$1.89M

econics

3

Figure 11

X. Obsolescence Mode

Obsolescence:

Objective #8 requires HPU to maintain a pipe inventory for materials types. HPU has met objective #8 for FY2019; data cleanup is needed for older pipes, but pipe type is a driver for asset management decisions.

Cohort Groups	Inventory (feet)	% of System
Iron	33,499	3.14
PVC	376,602	35.31
Clay	25,277	2.37
Concrete	631,190	59.18
Total	1,066,568	100

XI. Asset Management at HPU

Asset management is the practice of managing infrastructure capital assets to minimize the total cost of owning and operating these assets while delivering the desired service levels through the following formal tools:

Objective #9 requires the development of a Long-Term Financial Model (LTFM) to identify funding and expenses as necessary to minimize the total cost of owning and operating assets while delivering the desired service levels.

Long Term Financial Model (LTFM):

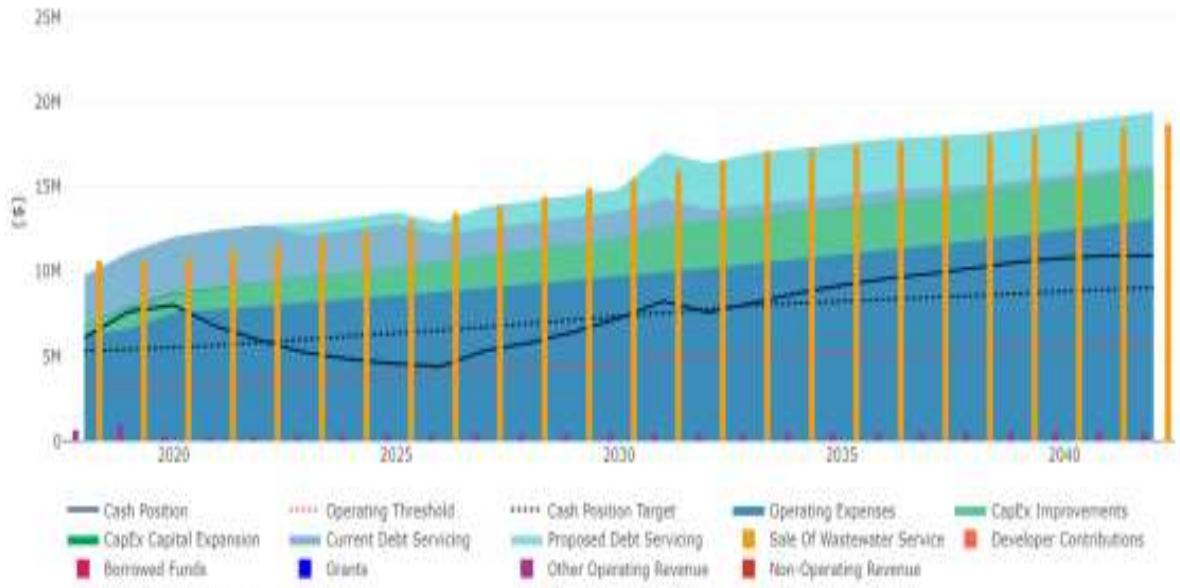
Financial evaluations for the Harrisonburg sewer system extended beyond the annual budget process. HPU has partnered with Econics Corporation to use "Water-Worth" software in developing its LTFM. The LTFM for FY2019 was evaluated simultaneously with preparation of the CIP FY2021-2025.

In addition to forecasts for operating, transfers and debt expenses, the 2021-2015 Capital Improvement Plan (CIP) expenditure schedule was a key input into the "HPU / Water-Worth" Sewer Enterprise model. Approximately $36M in retirement spending over the next 20 years were recognized. Whereas rates could not sustain an average ACSO of $1.9M per year, adjustments were input for capital expenditures as they were backloaded but still delivered the full funding requirements over the 20 years period. ***The Harrisonburg-Econics LTFM model delivered a recommendation for a 2.5% annual increase in rates from 2020 through 2031.*** The model is available with the 2021- 2015 Sewer Enterprise CIP document.

Harrisonburg - Harrisonburg Wastewater - Base Scenario SCIP 2021-2025 Model

Figure No. 1: Long Term Financial Model

LFM - Base Scenario



- **Requirements**
  - **1.0% annual growth in sewer volume billing;**
  - **2.5% annual rate increase 2021 through 2033;**
  - **"Work around" deficit capital reserves until satisfactory rate schedule obtained in 2030.**

- **Outcomes**
  - **Cash position target = liquidity @ 30% cash revenues (Aaa bond rating) plus capital reserves =2% CARV**
  - **CIP funding (Slide 4) which included full asset retirement funding 2021-2040 @ 2.5% APR (Slide 3)**
  - **Full funding of operating budget @ 2.5% APR plus existing debt schedule (Slide 5)**

econics

2

Figure 12

Shown in the graph is the residential benchmark comparison that gives strong indication that Harrisonburg is well positioned to adjust rates as recommended under the LTFM. Under the LTFM, Harrisonburg residential

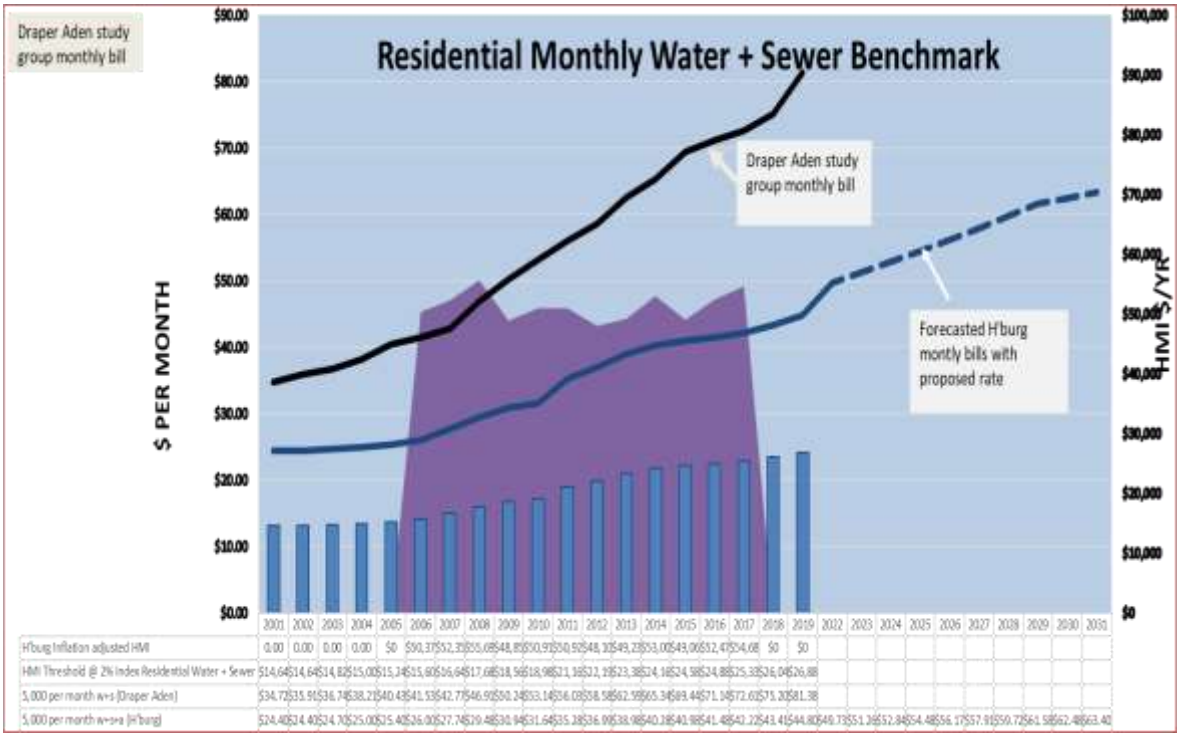


Figure 13

Asset Management Plans (AMPS):

Objective #10 requires the development of individual Asset Management Plans (AMPS) for sewer pipes and manholes to guide the use of all identified drivers in making asset management decisions.

Asset managers are currently drafting AMPS for sewer pipes and manholes but many of the maintenance activities have been in progress for many years. Inclusive to the AMPS are topics for inventory management, Level of Service (LOS) functionality standards, predictive & preventive & repair maintenance targets, R&R goals, financial benchmarks and resources commitment requirements.

- Appendix A: Sewer Pipe AMP
- Appendix B: Sewer Manhole AMP

Each year HPU prioritizes activities using procedures and protocol set forth in the AMPS (see Appendices). ***AMPS recognize 12 driving forces for making asset management decisions.*** The driving forces are summarized below:

WHAT DRIVES HPU TO PROVIDE MAINTENANCE A SEWER MAIN?		
1	Age:	Age is an initial indicator but not generally the decisive factor.
2	Material Type	Material type is the general foundation for identfying obsolescence.
3	Immediate Service Failure	Sewer backup response requires immediate action; multilple require CCTV.
4	CCTV or visual inspection	Priority repair is initiated from known significant default.
5	MTBF:	CMMS outputs failue rate in the past 10 years where failure = unplanned repair.
6	CCTV: Structural Score	CCTV scores have an unquantified relationship to physical "Remaining Useful Life".
7	CCTV: I&I Score	CCTV scores have an unquantified relationship to I&I".
8	Capacity:	SSO's or hydraulic model alerts identify capacity problems; interceptor priority.
9	CIP Projects:	Non-sewer driven projects can prioritize sewer asset management decisions.
10	Paving Schedule:	Paving maintenance can prioritize sewer asset management decisions.
11	Visual Observation	Harnessing employee knowledge is extremely valuable.
12	Other	Unlisted at this time

These driving forces establish priority in terms of condition assessment and criticality in the process below.

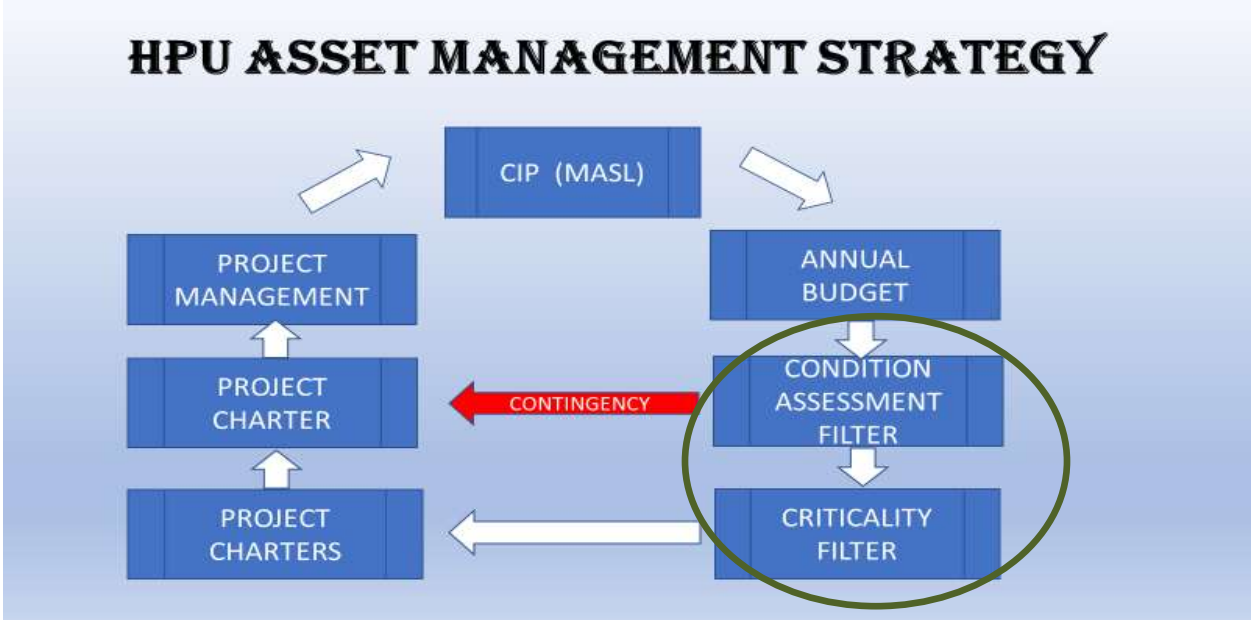


Figure 14

A project is currently active to optimize the HPU computer maintenance management system (CMMS) to better schedule activities and to formulate data into useful information in the asset management decision processes.

Asset Register / Inventory: FY209 sewer asset inventory was 84.6M. The breakout among assets is shown below:

.

FY 2019 Sewer System Asset Management Inventory

Current Asset Replacement Value ($)	Net Book Value ($)	Annual Depreciation ($)
202 Miles of Pipes $77,237,880	Pipes $ 30,666,939	Pipes $ 935,245
5,698 Manholes $7,314,000	Manholes $ 4,661,410	Manholes $ 41,900

Assets are field located by GPS coordinates and retained in GIS asset registers

Predictive Maintenance: Strategies for scheduling predictive maintenance and for using retrieved data are being summarized in AMPS as discussed earlier. Sewer pipe CCTV inspection has been the single most important predictive maintenance activity in HPU's Linear "Asset Management". ***FY2019 CCTV added 15 miles of condition assessments for sewer pipe.*** *As* shown below, *s*ince 2008 HPU has inspected 96 miles of sanitary sewer main, or 47% of system inventory of 202 miles. All pipes were evaluated in the Ques 1-100 scoring system (1 best to 100 worst)

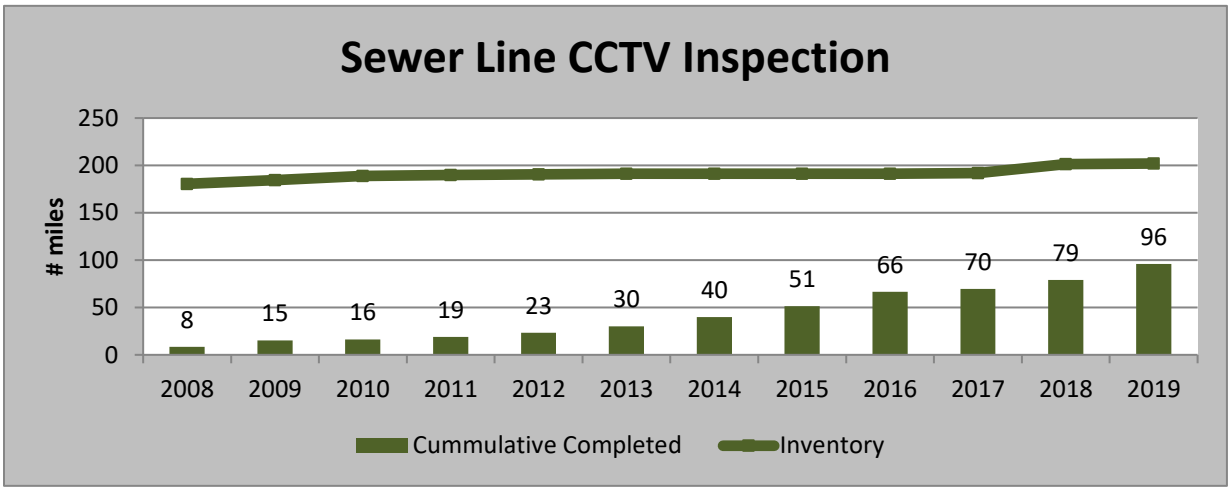


Figure 15

Scores for structural condition assessment that were output from the CCTV inspections above are discussed under structure mortality.

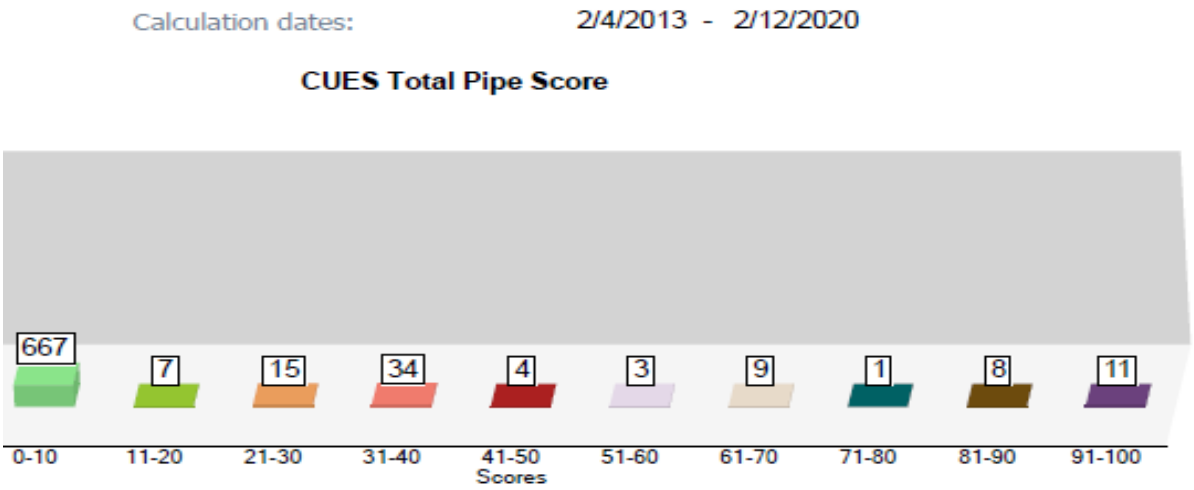


Figure 16

Preventive Maintenance: Strategies for scheduling preventive maintenance and for using retrieved data are being summarized in AMPS as discussed earlier. ***FY2019 sewer flushing completed 15% of the sewer asset inventory.*** Sewer pipe flushing has been the single most important preventive maintenance activity in HPU's Linear "Asset Management". HPU progress for preventive cleaning is shown below. Since 2008 HPU has cleaned 251 miles of sanitary sewer main with purpose to improve system integrity. HPU will continue to perform flushing preventive maintenance and focus upon troubled areas that our CMMS system has identified as high probability for blockage.

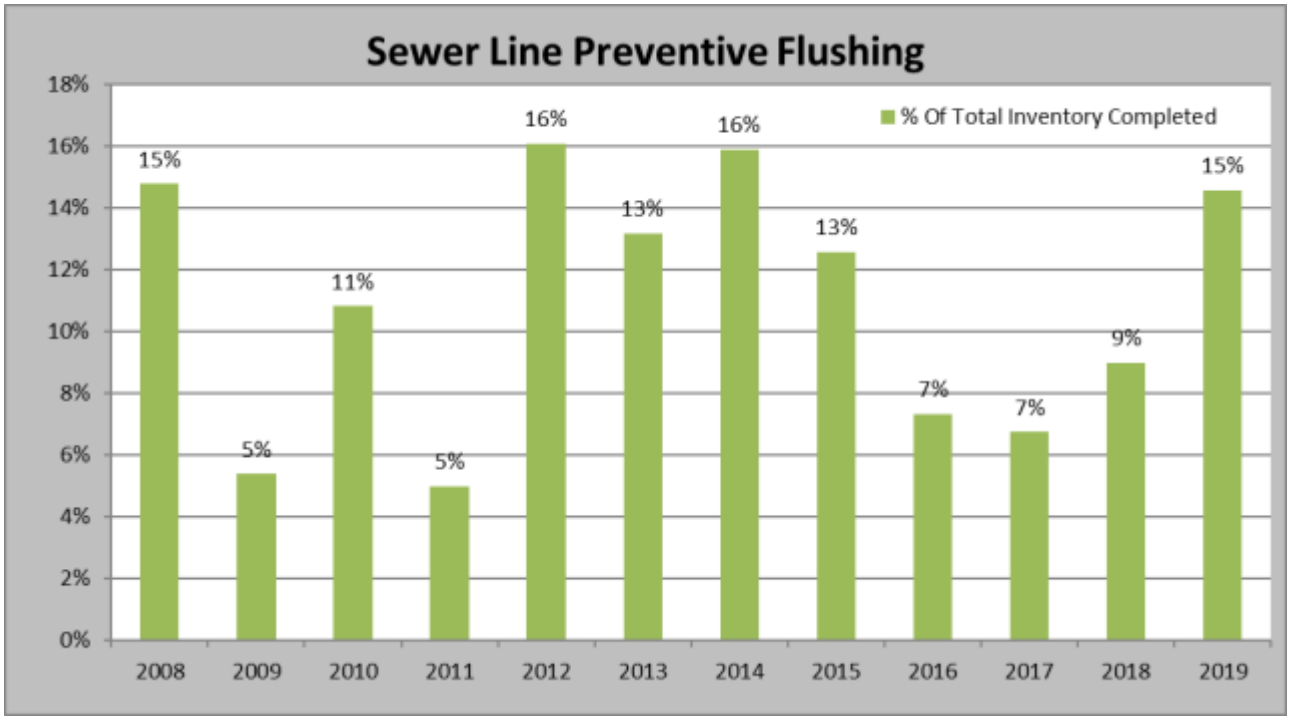


Figure 17

Repair Maintenance:

Unplanned (corrective) maintenance is disruptive and is accompanied with high ancillary costs in fiscal, social and environmental terms. AMPS are drafted to provide continuous improvement by enhancing the presence of planned maintenance (predictive + preventive + corrective) and to facilitate the absence of unplanned (corrective) disruptive maintenance. Shown below is output from the HPU CMMS system. ***For FY2019, 64% of manhours and 59% of cost (vs. AWWA benchmark for median @ 69%) was directed to planned maintenance.***

BENCHMARK	TOP QUARTILE	MEDIAN	BOTTOM QUARTILE	HARRISONBURG FY2019
PLANNED Hrs. MAINTENANCE	79%	69%	48%	64%
CORRECTIVE MAINTENANCE HRS / 100 mi. pipe	381	1,257	2,665	1,883

==========

Sewer Assets Program Summary

From: 7/1/2018 To: 6/30/2019

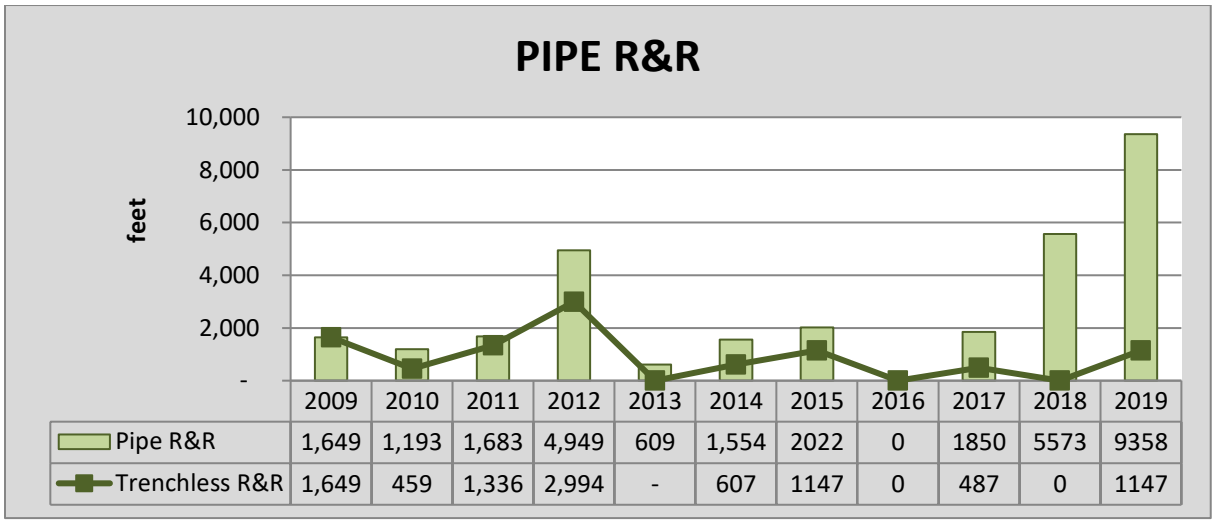
Harrisonburg VIRGINIA

	TOTALHOURS	LABORCOST	EQUIPMENTCOST	MATERIALCOST	TOTAL COST
Billable Services	339.27	$8,662.82	$2,495.34	$2,716.34	$13,874.50
New Installation	1,093.00	$28,046.28	$8,718.42	$12,452.33	$49,217.02
Other	91.50	$2,687.30	$1,382.65	$200.07	$4,270.02
Preventative Maintenance (PM)	3,328.90	$90,369.61	$27,461.30	$244.31	$118,075.22
Rehab & Replace (CIP)	656.50	$62,942.56	$12,345.78	$12,630.47	$87,918.81
Repair	1,883.26	$49,428.25	$16,657.36	$15,126.25	$81,211.86
Scheduled Repair	108.00	$2,808.91	$987.00	$593.37	$4,389.28
Program Totals:	7,500.43	$244,945.73	$70,047.84	$43,963.13	$358,956.71

…Harrisonburg Planned maintenance = 3,437 hours / 5,320 = 64%
…Harrisonburg Corrective maintenance = 1,883 hours *(202 miles / 100 miles) = 3,804 hours per 100 miles.

Rehab & Replacement (R&R) through CIP: With funding available to rehab and retire assets, the application of project selection and then project management is paramount into effective and efficient results. HPU encourages PMI endorsed project management principles to plan and complete effective and efficient projects. ***During FY2019 HPU allocated $1.14M to CIP and conducted 9,358 feet of pipe R&R.*** Shown below is past rehab and retirement (R&R) projects completed using CIP funding between 2009 and 2019 included:

Total R&R = 30,440 feet
R&R by trenchless technology methods = 9,826 feet (32%)
R&R by conventional open cut technology = 20,614 feet (68%)



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Pipe R&R	1,649	1,193	1,683	4,949	609	1,554	2022	0	1850	5573	9358
Trenchless R&R	1,649	459	1,336	2,994	-	607	1147	0	487	0	1147

Figure 18

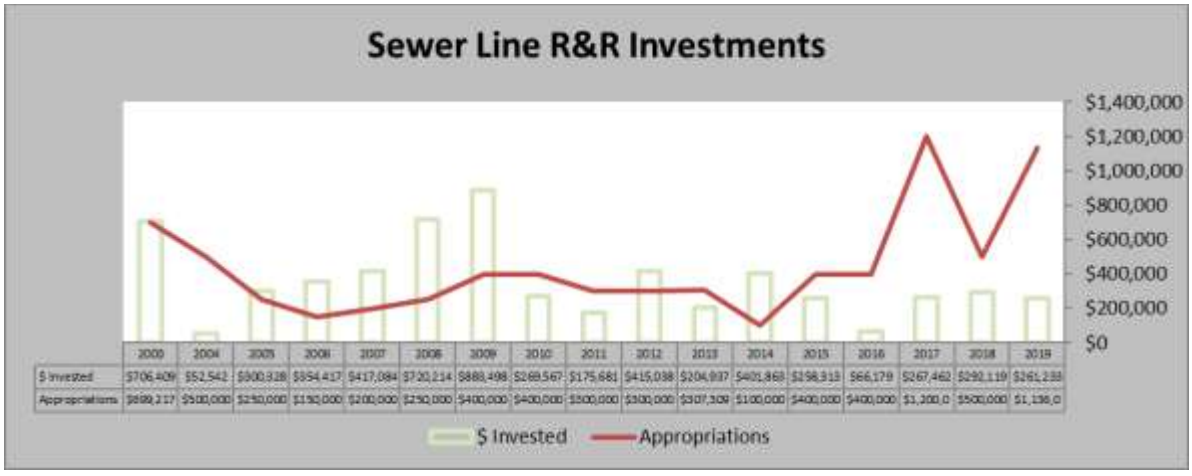


Figure 19

Flow Monitoring

During FY2019 baseline flow monitoring was nearly completed for ILOS status. The data will provide a baseline for five years interval comparisons.

Two sites of I&I hydraulic induced overflows have been identified. The first location is in the HRRSA Interceptor system which collects flow from Harrisonburg's Black's Run Interceptor (BRI). This location is immediately downstream of the confluence of the East and the West sections of the BRI. The second overflow location in the lower downstream section of Harrisonburg's West Spur Interceptor which begins at Maryland Avenue and continues into Park View. This second overflow is also located at MH18/79 which is upstream from the first overflow.

I&I Abatement

The HPU I&I program is designed with recognition to publications that have generalized that fifty five percent (55%) of all I&I comes from the private sector. Without I&I abatement in the private sector little more than 5-10% I&I reduction will be achieved.

CCTV for scoring structural conditions of sewer pipes also included scoring for I&I conditions. I&I scores are another driver for maintenance decisions. The second component for I&I abatement has been smoke testing of 431,407 feet of pipe since 2009. ***Due to unrelenting ground saturation during FY2019, smoke testing didn't occur until fall of 2019 which will be reported for FY2020.*** Shown below is the completed activity schedule.

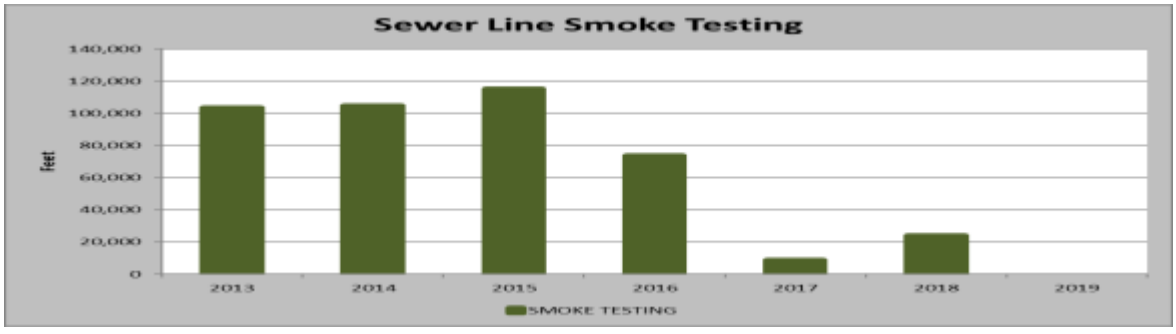


Figure 20

VII Financial Benchmarks

Objective #11 requires monitoring selected sewer enterprise fund financial benchmarks; the objective is complete as shown below:

RATES: RESIDENTIAL BENCHMARK		18-19
10	**Virginia Statewide Residential Index Water + Sewer**	**0.55**
11	5,000 per month water + sewer + authority in Harrisonburg)	$44.80
12	**5,000 per month water +sewer (Draper Aden Survey)**	**$81.38**
20	**Virginia Statewide Residential Index Water**	**0.47**
21	5,000 per month water in Harrisonburg	$16.50
22	**5,000 per month water (Draper Aden Survey)**	**$35.39**
30	**Virginia Statewide Residential Index Sewer**	**0.62**
31	5,000 per month sewer + authority	$28.30
32	**5,000 per month sewer Draper Aden**	**$45.99**
40	**HMI Threshold @ 2% Index Residential Water + Sewer**	**$26,880**

Harrisonburg residential monthly bills for water plus sewer are 55% of the statewide survey benchmark for 5000 gallons

Residential households with greater than $26,880 annual household median income (HMI) can adequately absorb the monthly water plus sewer bill of $44.80.

LIQUIDITY INDEX (% CASH REVENUE)		18-19
250	**Sewer Index**	**53%**
251	Sewer Fund Balance $	$6,173,303
252	Sewer Cash Revenue	$11,688,668
253	Moody AAA Bond Rating	30%
254	Moody AA Bond Rating	15%
255	Moody A Bond Rating	5%

Sewer Fund Balance at $6,173,303 meets criteria of 25% cash revenue for a Moody's Aaa bond rating.

DEBT COVERAGE BENCHARK		18-19
305	**Sewer Index**	**1.57**
306	Income less Operating (includes transfers)	$5,009,595
307	Debt	$3,200,000
308	Lower Limit Stronger	2.00
309	Upper Limit Weaker	1.25

Debt coverage at 1.57 meets a moderate level benchmark per Fitch's recommendations (1.25-2.00).

CAPITAL FUNDING BENCHMARK		18-19
420	**Sewer CIP to ASCO Ratio**	**0.71**
421	Sewer Capital Funding	$1,336,000
422	Water ASCO	$1,890,000
423	Target Ratio	1.0

ASCO is the average annual funding target that t is needed for retirement of assets over the next 20 years. The benchmark ratio of 0.71 (vs. 1.0) suggested a shortfall in funds. Rates do not support funding at the required level.

CAPITAL RESERVE BENCHMARK		18-19
430	**% CARV in Sewer Capital Reserves**	**6.1%**
431	911161 CARV value	$60,068,799
432	Sewer Capital Balance	$3,678,614
433	Target Ratio	1.5%

HPU uses the EOY balance in CIP funds for purposes generally intended for "Capital Reserves". The Capital Reserves is an amount of funds that are appropriated and could be readily used in the event of a significant failure of assets. For end of Fy2019, unspent allocations in the CIP funds were a healthy 6.1% of CARV (Current Asset Replacement Value); this was made available by delay of active target projects.

The graph below recaptures budget expenses; the five years period shown below has incurred a 5.7% increase in O&M expenses.

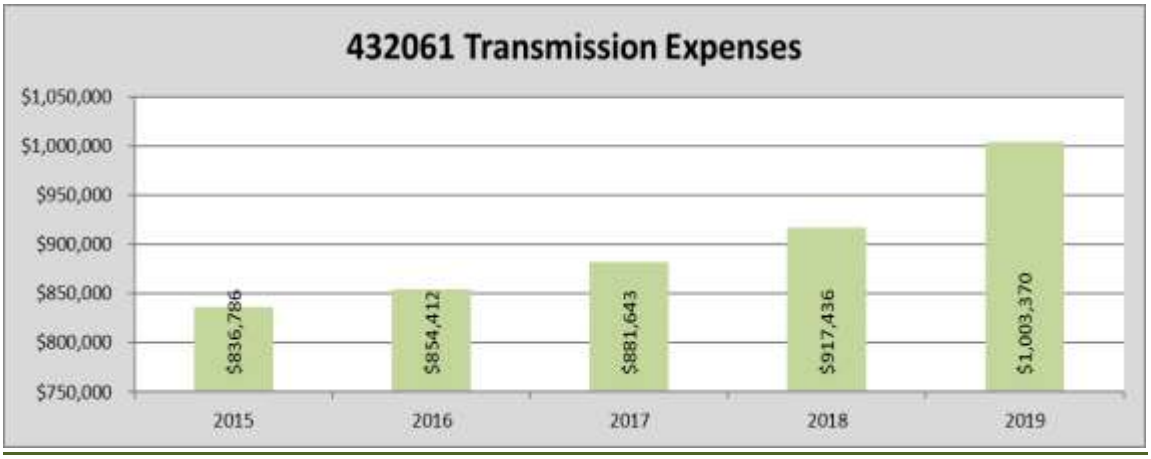


Figure 21

CITY OF HARRISONBURG
PUBLIC
UTILITIES
2155 BEERY ROAD, HARRISONBURG, VA 22801
OFFICE (540) 434-9959 • FAX (540) 434-9769

Harrisonburg Public Utilities

Asset Management Plan

For Sewer Pipes

Revision Date: February 14, 2020

Under Construction

CITY OF HARRISONBURG
PUBLIC
UTILITIES
2155 BEERY ROAD, HARRISONBURG,
OFFICE (540) 434-9959 • FAX (540)

Harrisonburg Public Utilities Asset Management Plan For Sewer Manholes

Revision Date: February 14, 2020

Under Construction

CITY OF HARRISONBURG
PUBLIC
UTILITIES
2155 BEERY ROAD, HARRISONBURG,
OFFICE (540) 434-9959 • FAX (540)

Harrisonburg Public Utilities

Interceptor Flow Monitoring Hydrographs

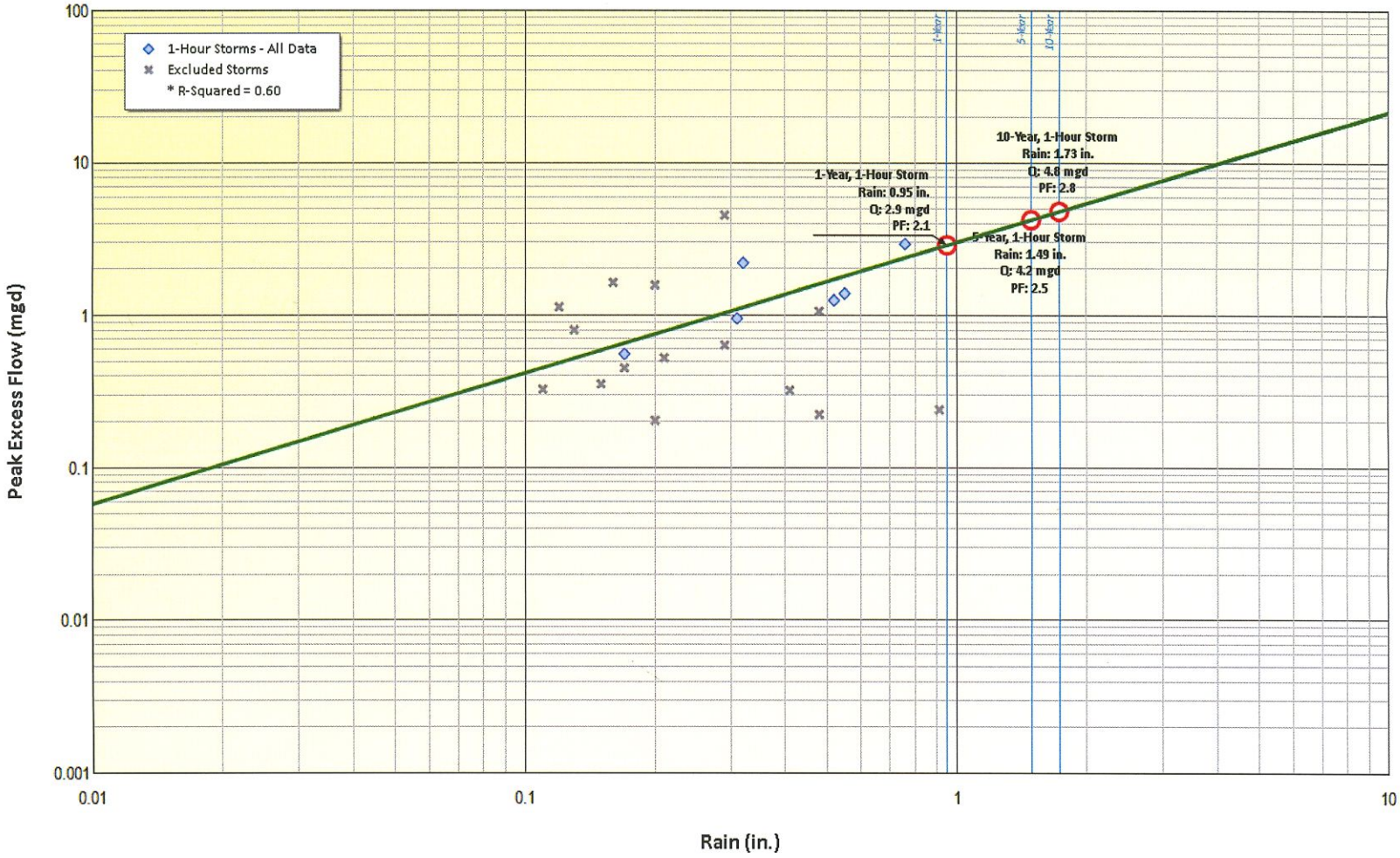
CITY OF HARRISONBURG
PUBLIC
UTILITIES
2155 BEERY ROAD, HARRISONBURG,
OFFICE (540) 434-9959 • FAX (540)

Harrisonburg Public Utilities

Backs Run Interceptor 1989 Master Plan Update

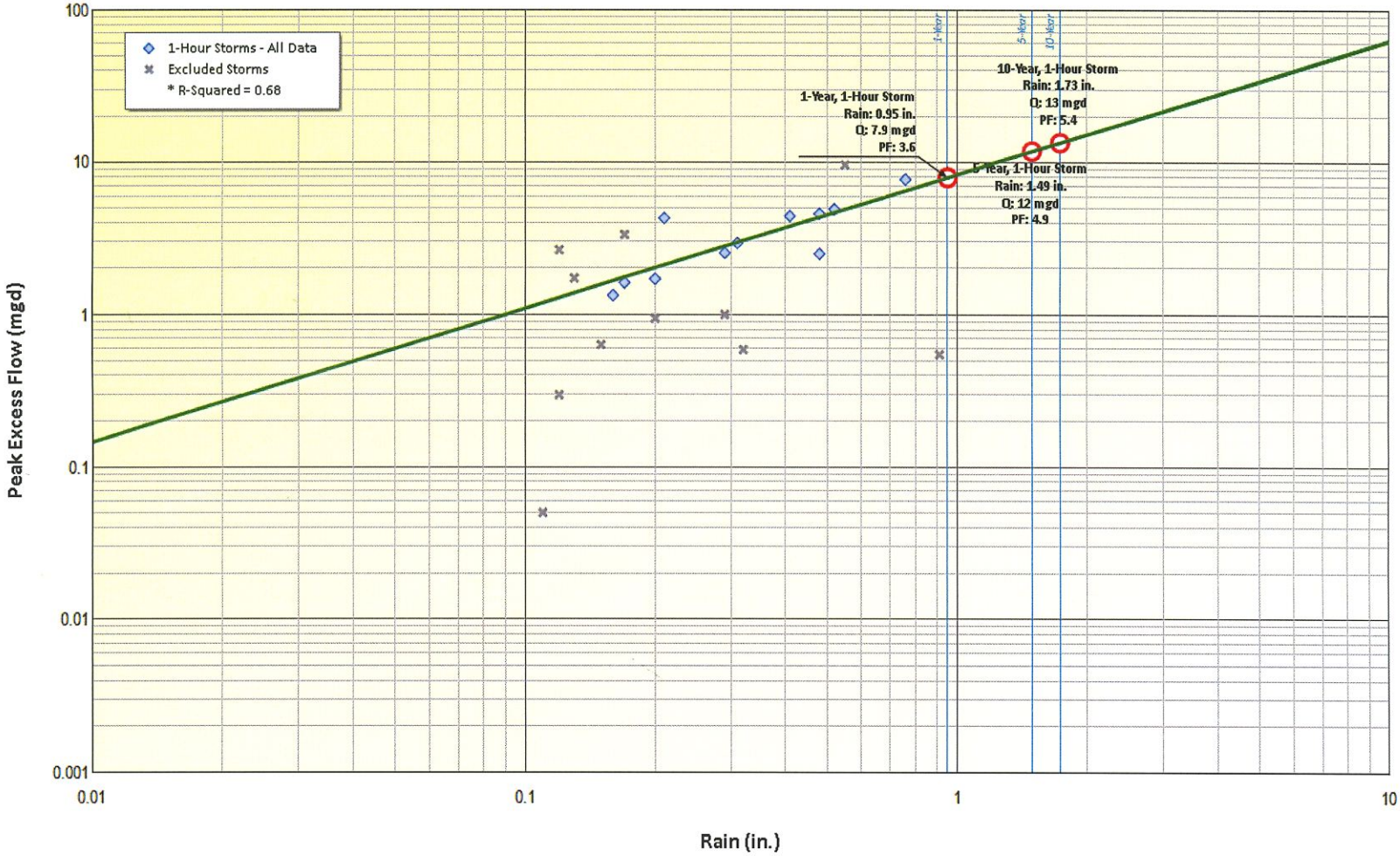
1-Hour Flow vs. Rainfall Regression

Basin HB1152_1



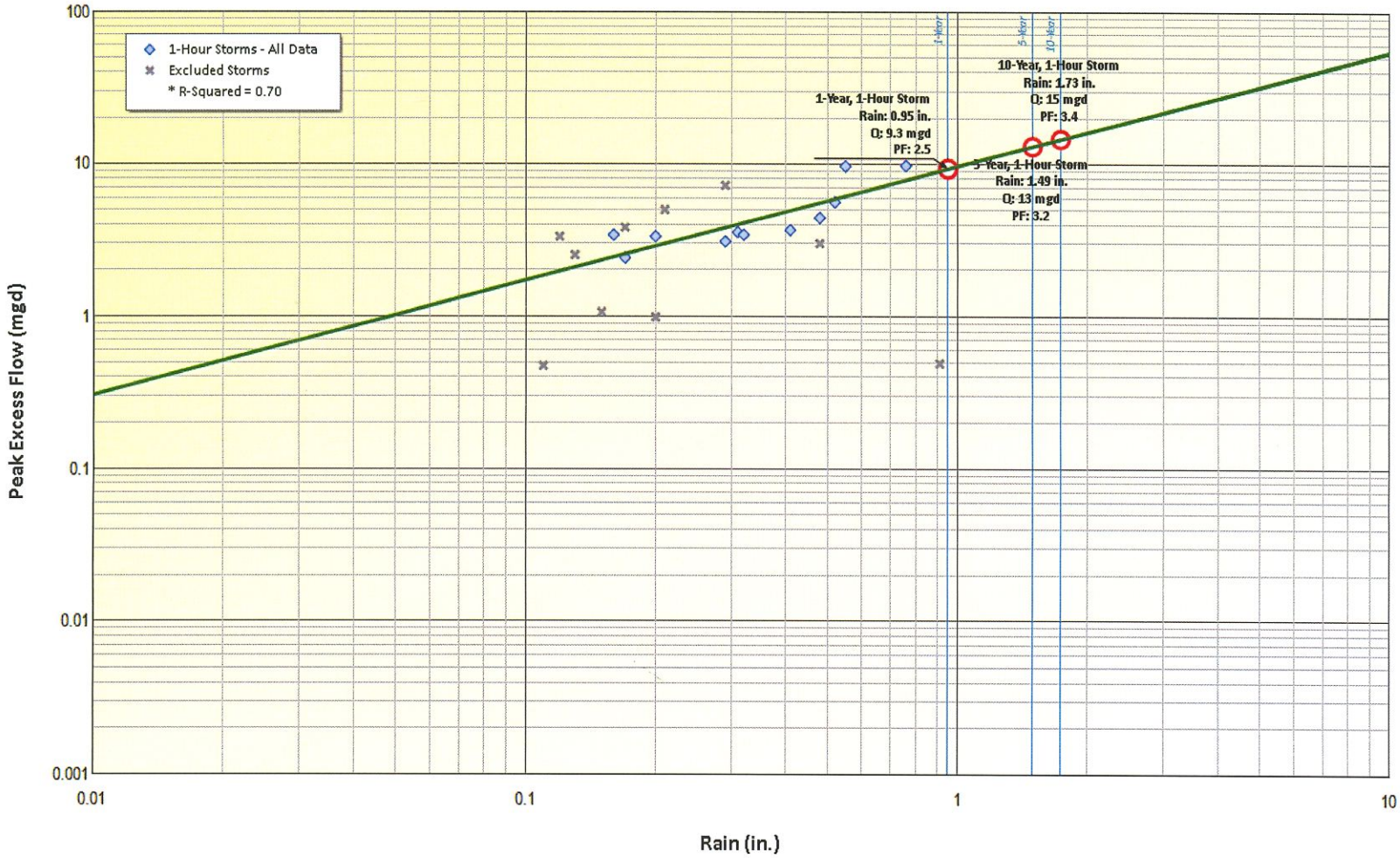
1-Hour Flow vs. Rainfall Regression

Basin HB540/HB550



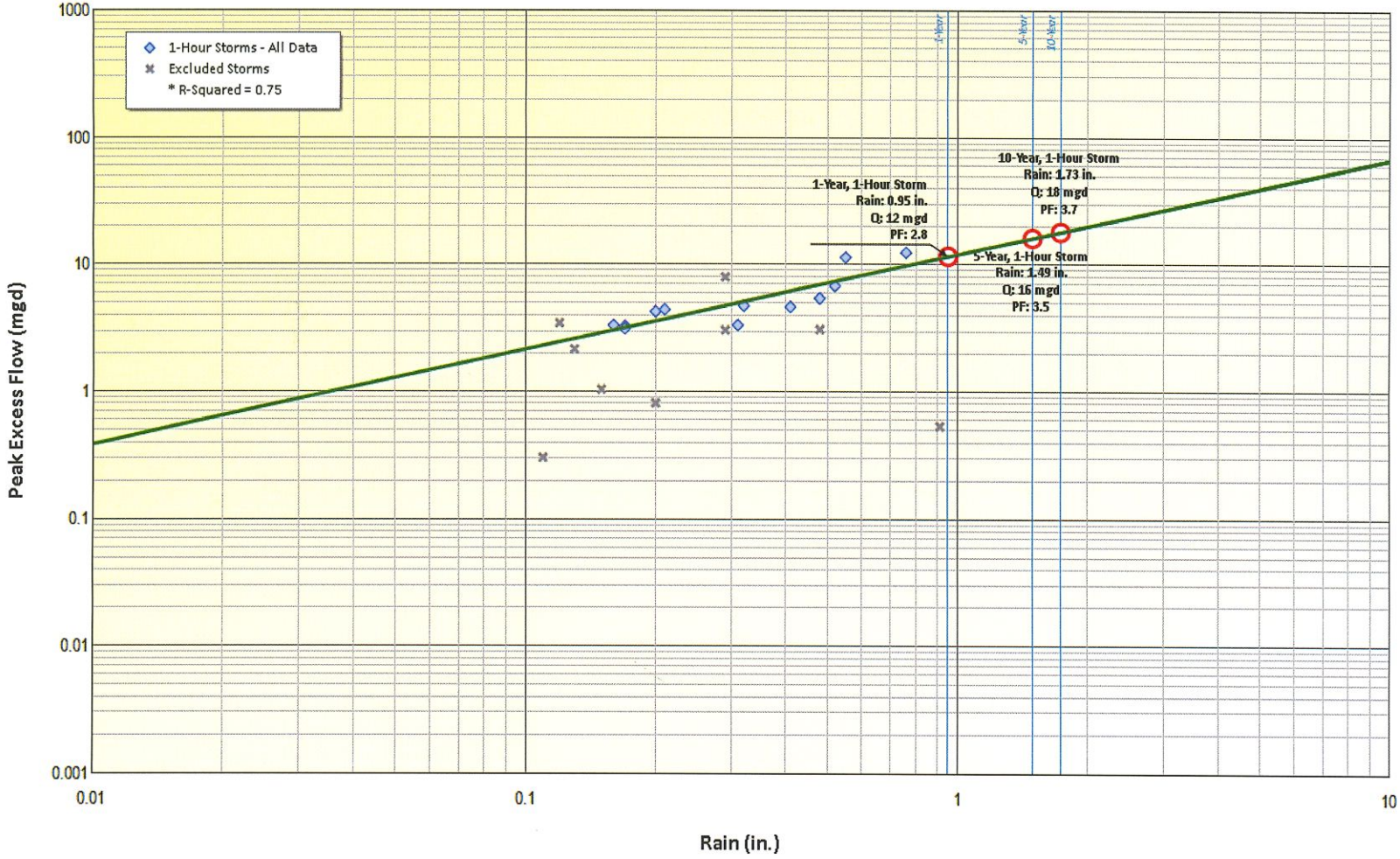
1-Hour Flow vs. Rainfall Regression

Basin BR75/BR70



1-Hour Flow vs. Rainfall Regression

Basin BR57



CITY OF HARRISONBURG
PUBLIC
UTILITIES
2155 BEERY ROAD, HARRISONBURG,
OFFICE (540) 434-9959 • FAX (540)