Harrisonburg Public Utilities (HPU)

Annual Report of Operations

FY 2015-2016

Sanitary Sewer Management Program Initiative (SSMP)

Table of Contents

I. Introduction; SSMP Balanced Scorecard

II. SSMP Objective #1: Forecasting Annual Average Daily BWF

III. SSMP Objective #2: Long Term Capacity at HRRSA

Hydraulic Loading

Organic Loading

IV. SSMP Objective #3: Optimum Use of Existing Capacity at HRRSA

Hydraulic Loading

Organic Loading

V. SSMP Objective #4: Interceptor Capacity

VI. SSMP Objective #5: System Collection and Transmission Performance

Collection System Integrity

Infiltration & Inflow

VII. SSMP Objective #6: Operation & Maintenance

Funding

Predictive Maintenance

Preventive Maintenance

Corrective Maintenance

VIII. SSMP Objective #7: Rehabilitation & Replacement (R&R)

Funding

Methodology

IX. SSMP Objective #8: Financial Benchmarking

Residential Rates : MHI Ratio

Liquidity

Debt Coverage Ratio

R & R Ratio

Appendix A: Sanitary Sewer Flow

Appendix B: Infiltration & Inflow Abatement SOP

Appendix C: FY 2016 SSMP Implementation Guide

I. Introduction; SSMP Balanced Scorecard:

Harrisonburg Public Utilities (HPU) has crafted a Sanitary Sewer Management Program (SSMP) to guide ownership and operation of the sewer system infrastructure as it increases with age. This document summarizes the SSMP strategy. The strategy underlies the effort to deliver the level of services expected today and to safeguard this level of service into the future.

The SSMP included measures for strategic, tactical, and operational performance. It was organized around a balanced scorecard that emphasized financial and nonfinancial measures with short term and long terms goals that must be part of the information system for all employees at all levels. **Figure 1** shows the SSMP Balance Scorecard.

Harrisonburg SSMP Balance Scorecard

Customer

Objective	Measure
Reliability	Sewer System Integrity
Affordability	% MHI

Demand

Objective	Measure
B W F	Existing & Projected
I & I	Monitored & Managed

Capacity

Objective	Measure
Treatment	BWF + I&I (max 2 month)
Interceptor	BWF + I&I (peak)
Collection	BWF + I&I (peak)
Assets	Risk

Financial

Objective	Measure
Liquidity	Unrestricted Cash $ / Average Daily Operating $
Debt Ratio	Revenue after Operation $ / Debt $
R & R Ratio	CIP Reserves $ / Asset Replacement Value $

Figure 1

With purpose that HPU plan and execute the SSMP in a consistent and sustained approach, the key element directives of the SSMP are as follows:

- Prior to the beginning of each fiscal year HPU shall establish an "Annual Plan" of activities that will be completed during the fiscal year. The activities shall be in alignment to achieving the goals of the SSMP. The activities shall be compatible with Operating and CIP budgets.

- During the fiscal year, HPU shall implement execution and monitor progress of the "Annual Plan".

- At the end of each fiscal year, HPU shall evaluate and update the SSMP with regard to approach, organization, progress, technology, data, and benchmarks with respect to the SMMP baseline goals.

Figure 2 below shows the HPU SSMP framework including responsible entities and their objectives which are defined in greater detail in this document. This document omits the vertical assets managed under the Pump Division.

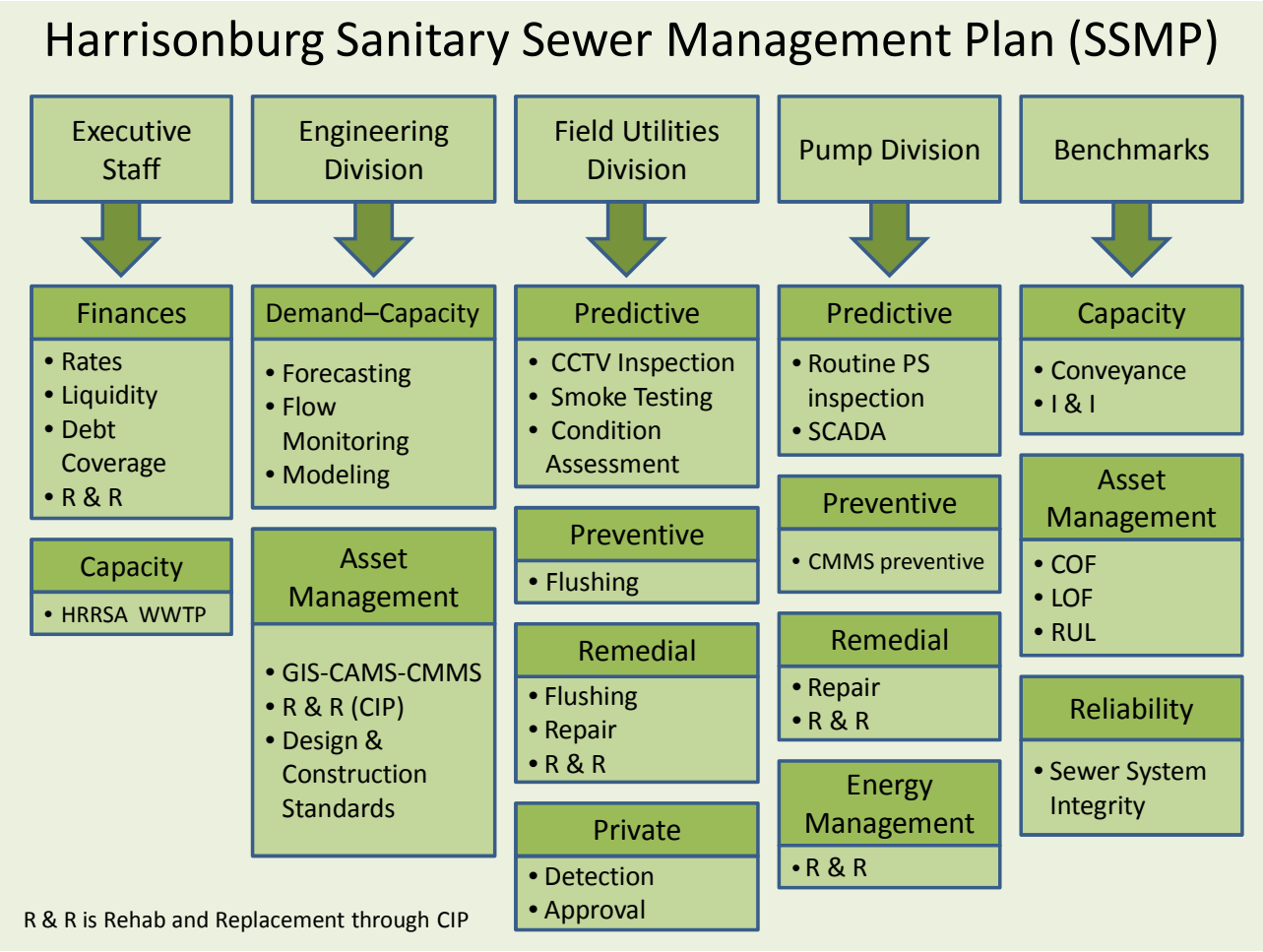


Figure2

II. SSMP Objective #1: Forecasting Annual Average Daily BWF

Objective #1 required HPU to monitor "Base Wastewater Flow" in terms of annual average daily (AAD) BWF and to then make projections for ultimate build-out conditions to the City system. This effort is with purpose to understand the demands that underlie the capacities needed to treat and to convey the volumes and flow rates of sanitary sewer. To recognize existing and historic BWFs, the data were obtained from sales records at the HPU Billing Office. The format identified and assigned BWF sources to customer groups listed below.

- City residential
- City commercial
- City institutional
- City apartments
- City municipal
- Rural customer
- Rockingham County as a Contract Customer

To predict future BWFs, HPU carefully selected a dual approach that delivered both an aggressive forecast and a conservative forecast; thus providing a forecast envelope. The aggressive approach was thereafter used to make evaluations of capacity. The conservative approach has been provided for comparison and understanding of the degree for margin of error (or safety margin) in planning.

- For the aggressive approach, build out BWF was forecasted as existing BWF plus future flow with the latter defined as the product of: 1) the area of undeveloped lands associated with each user group and 2) sewer BWF design criteria per unit area of specific land use type.

- For the conservative approach, future BWF was forecasted as existing BWF plus future flow with the latter defined as the product of: 1) the area of undeveloped lands associated with each user group and 2) historic sewer BWF unit rates as determined from generation of existing flows per unit area of specific developed land use type.

The results of the forecasts are shown in **Table 1**. Average annual demands have been projected to increase to between **6.3 and 9.0** MGD as determined by historic growth rate and maximum density growth rate, respectively. The forecast excluded wholesale services to Rockingham County which must be included in consideration of conveyance capacity but should not be included in capacity evaluation at HRRSA.

Table 1

Sanitary Sewer Projections for Harrisonburg : AAD FY2015

		Historical Criteria		Density Criteria	
Description	Existing MGD	Capacity MGD	% Maturity	Capacity MGD	% Maturity
City Residential	1,290,000	1,824,320	71%	2,642,181	49%
City Commercial	1,040,000	1,365,474	76%	1,587,452	66%
City Industrial	800,000	1,226,539	65%	2,327,243	34%
City Apartments	660,000	841,322	78%	1,396,018	47%
City Institutional	510,000	620,000	82%	620,000	82%
City Municipal	10,000	10,000	100%	10,000	100%
Subtotal City	**4,310,000**	**5,887,655**	**73%**	**8,582,894**	**50%**
Rural	150,000	150,000	100%	150,000	100%
Rockingham County	90,000	500,000	18%	1,000,000	9%
Michaels	-	90,000	0%	90,000	0%
Daley	-	170,000	0%	170,000	0%
Total W/ ROCO	**4,550,000**	**6,797,655**	**67%**	**9,992,894**	**46%**
Total WO/ ROCO	**4,460,000**	**6,297,655**	**71%**	**8,992,894**	**50%**

Institutional growth uses 5,000 students at 22 gps

Rockingham County not used against allocation at HRRSA

III. SSMP Objective #2: Long Term Capacity at HRRSA

Harrisonburg is a member jurisdiction at HRRSA with limited control over HRRSA policy and practices; however, Harrisonburg voting members should establish their positions as follows:

Hydraulic Loading:

By escalating the forecasted BWF from objective #1 by 1.16 (as determined from historical records) to account for maximum two month conditions; long term planning should recognize that Harrisonburg will need between 7.31 MGD and 10.43 MGD hydraulic capacity as HRRSA. Given its current allocation of 12.80 MGD, 5.50 to 2.38 MGD is available for assimilation of infiltration & inflow. See **Table 2**:

Table 2

Sanitary Sewer Projections for Harrisonburg : M2CM FY2015

Description	Existing	Forecasted per Historical Criteria	Forecasted per Max Density Criteria
City Residential	1,496,400	2,116,211	3,064,930
City Commercial	1,206,400	1,583,950	1,841,444
City Industrial	928,000	1,422,785	2,699,601
City Apartments	765,600	975,934	1,619,381
City Institutional	591,600	719,200	719,200
City Municipal	11,600	11,600	11,600
Subtotal City	**4,999,600**	**6,829,679**	**9,956,157**
Rural	174,000	174,000	174,000
Rockingham County			
Michaels	-	104,400	104,400
Daley	-	197,200	197,200
Total	**5,173,600**	**7,305,279**	**10,431,757**

Flows are shown in gallons per day

Organic Loading:

Organic Loading is a second design criterion for performance at HRRSA and is a function of hydraulic loading and organic concentration. Whereas hydraulic loading is expressed in MGD, organic loading is expressed in pounds per day. HRRSA member jurisdictions would be best served if the ratio of % hydraulic loading to % organic loading equals 1.0; otherwise, one loading will become the controlling criteria and will shortfall capacity per the other.

The HRRSA facility has been designed to accommodate 242 ppm of organic contents to it head works. At 22.0 MGD, the HRRSA maximum allowable loading is 44,402 pounds per day. In contrast, at

12.8 MGD allocated capacity, the maximum allowable loading for Harrisonburg is 25,098 pounds per day

For forecasting purposes, HRRSA has suggested that typical domestic sewerage is at 267 ppm and that Significant Industrial User (SIU) sewerage is regulated to a maximum of 300 ppm. The hydraulic projections for M2CM have been used in combination with the referenced 267 and 300 organic concentrations to forecast the Harrisonburg long term organic loading at HRRSA.

- **Table 3** itemizes and summarizes that Harrisonburg will max out between 16,659 (64%) to 23,972 (93%) pounds per day**.** Under the former, Harrisonburg may desire to increase SIU organic concentration limits for the purpose of leveraging existing capacity into a revenue stream.

Table 3

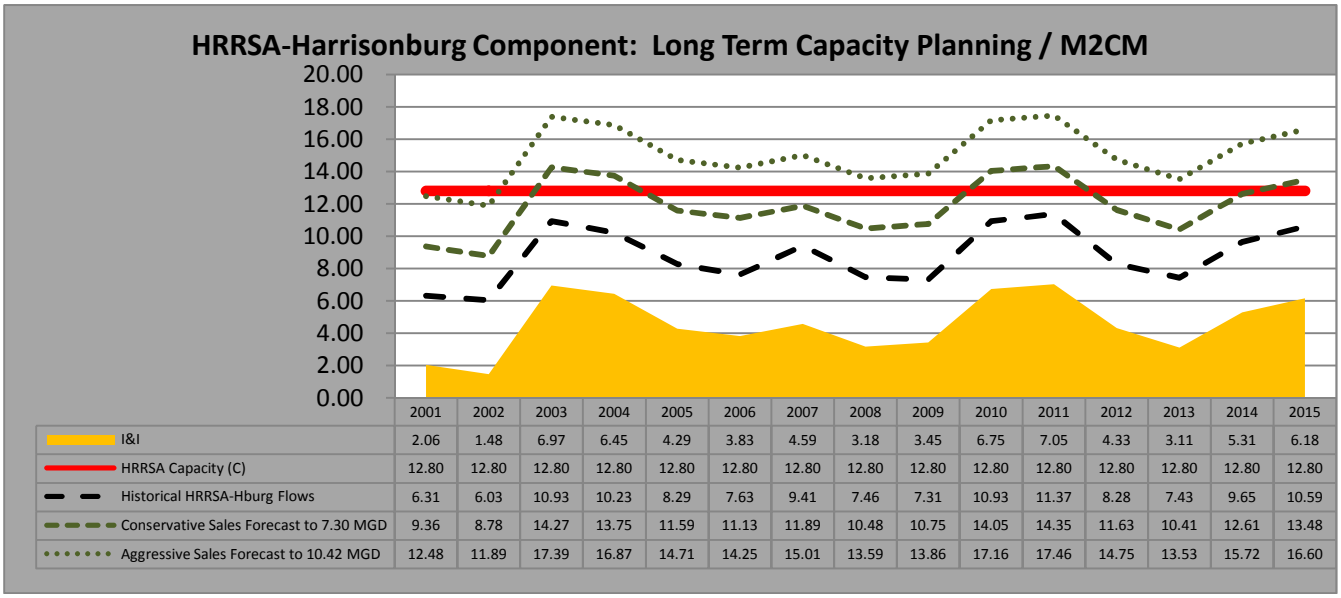
Sanitary Sewer Organic Loading for Harrisonburg : M2CM FY2015				
Description	BOD5	Historic Density BOD% Load	BOD5	Maximum Density BOD% Load
City Residential	267	4,712	267	6,825
City Commercial	267	3,527	267	4,100
City Industrial	300	3,560	300	6,754
City Apartments	267	2,173	267	3,606
City Institutional	267	1,602	267	1,602
City Municipal	267	26	267	26
Subtotal City		**15,600**		**22,913**
Rural	267	387	267	387
Rockingham County				-
Michaels	267	232	267	232
Daley	267	439	267	439
Total		**16,659**		**23,972**
		64%		93%

IV. SSMP Objective #3: Optimum Use of Existing Capacity at HRRSA

Hydraulic Loading:

Whereas Objective #2 has suggested that there is some hydraulic capacity for Infiltration and Inflow at HRRSA, an evaluation of past and most current conditions suggested that Harrisonburg has already leveraged available unused capacity.

In **Figure 3**, past sales as well as future or unrealized sales have been forecasted upon past incurred I&I conditions. The most recent 15 year period has been presented. The results show that available capacity at HRRSA (solid red line) will not always support the future treatment requirements for conservative and aggressive growth forecasts. Under conservative forecasts, treatment requirements exceed treatment capacity in 5 of the 15 annual periods. Under aggressive forecasts, treatment requirements exceed treatment capacity in 13 of the 15 annual periods. A period similar to FY2011 was most critical at 3.28 MGD. The SSMP has therefore adopted the goal to address a potential overleveraged I&I condition of approximately 3.3 MGD.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
I&I	2.06	1.48	6.97	6.45	4.29	3.83	4.59	3.18	3.45	6.75	7.05	4.33	3.11	5.31	6.18
HRRSA Capacity (C)	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80	12.80
Historical HRRSA-Hburg Flows	6.31	6.03	10.93	10.23	8.29	7.63	9.41	7.46	7.31	10.93	11.37	8.28	7.43	9.65	10.59
Conservative Sales Forecast to 7.30 MGD	9.36	8.78	14.27	13.75	11.59	11.13	11.89	10.48	10.75	14.05	14.35	11.63	10.41	12.61	13.48
Aggressive Sales Forecast to 10.42 MGD	12.48	11.89	17.39	16.87	14.71	14.25	15.01	13.59	13.86	17.16	17.46	14.75	13.53	15.72	16.60

Figure3

The required reduction is infiltration & inflow is better shown in **Figure 4.** Limits for allowable I&I for both the conservative and aggressive growth conditions are shown. Recorded I&I is also shown.

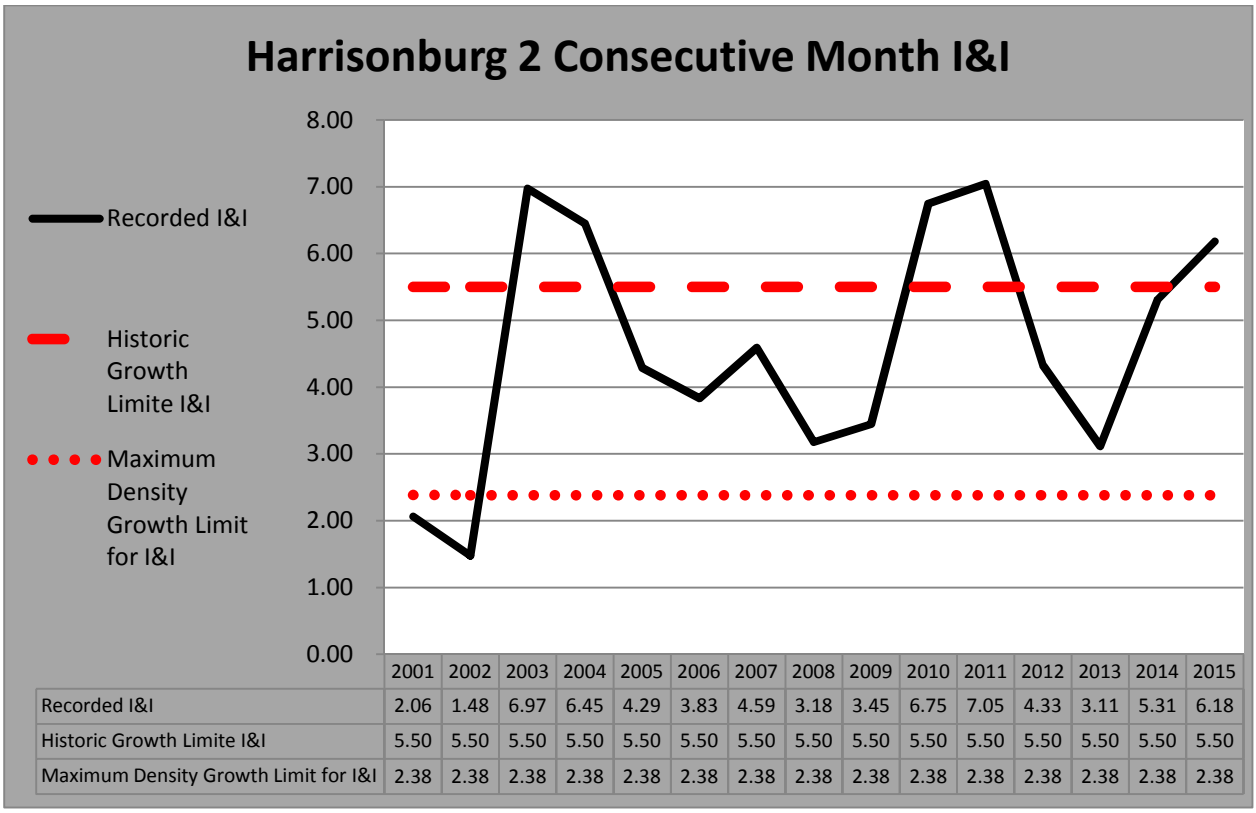


Figure 4

Existing Organic Loading:

A tabulation of organic load delivered by Harrisonburg to HRRSA in FY2015 is shown in **Table 4** below. Harrisonburg delivered 46% (11,776 #s/d) of its allowable 25,098 #s/d organic loading. This compared to 57% annual average daily hydraulic load. The ratio HL:OL =1.24; thus suggesting that there is significant opportunity to allow higher concentrations for a limited period of time with purpose to promote a revenue stream to HRRSA. An issue of discrepancy should be resolved with HRRSA referencing information that suggested that the total plant was at 55% hydraulic loading and 62% organic loading (ratio HL:OL =0.88)

Table 4

Sanitary Sewer Organic Loading for Harrisonburg : M2CM FY2015		
Description	BOD5	Existing BOD% Load
City Residential	267	3,332
City Commercial	267	2,686
City Industrial	300	2,322
City Apartments	267	1,705
City Institutional	267	1,317
City Municipal	267	26
Subtotal City		**11,388**
Rural	267	387
Rockingham County		
Michaels	267	-
Daley	267	-
Total		11,776
		46%

V. SSMP Objective #4: Interceptor Capacity

HPU forecasted the need for interceptor conveyance capacity through a study conducted by Wiley & Wilson in 1989. The components of the interceptor and their respective Dry Weather Flow (DWF) design criteria are shown below:

INTERCEPTOR SYSTEM	Length	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 5 below is a schematic of the Harrisonburg Black's Run Interceptor with system components and DWF shown on the configuration. Also shown on the schematic are the proposed locations of flow monitoring devices.

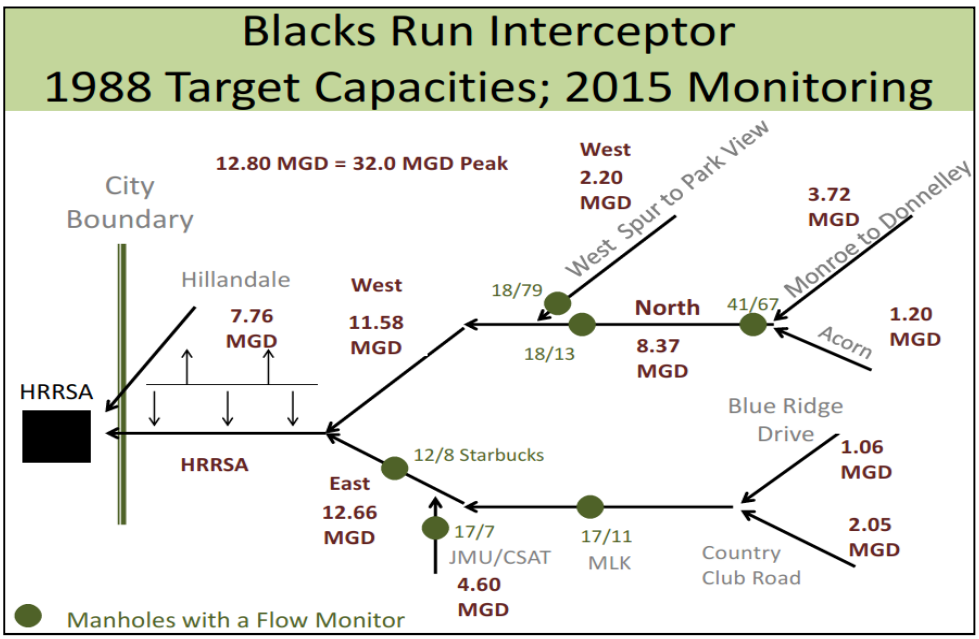


Figure 5

Not all flow monitors were installed in FY 2016 but early results indicated that the West Spur Interceptor beginning a Maryland Avenue and continuing to Park View has experienced the most significant peak flow rate when approaching 14.0 MGD; observed Sanitary Sewer Overflows (SSOs) have occurred in this area. Flow monitoring will continue so that flow data can be compared holistically and converted to useful information to abate I&I and capacity issues.

VI. SSMP Objective #5; System Collection and Transmission Performance:

Collection System Integrity

This indicator measures the frequency of collection system failures per 100 miles of collection piping. 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.

AWWA has defined System Integrity = [100 * [(# public failures) / Total Miles of Pipe]] and has published the following benchmark data in 2011 for Utilities serving 10,000 to 50,000 customers:

Top quarter percentile	5.35 stoppages per 100 miles pipe
Median	8.75 stoppages per 100 miles pipe
Bottom Quartile	16.75 stoppages per 100 miles pipe

Figure 6 below shows that Harrisonburg has performed since 2008 near the third quartile benchmark. Past activities to address this issue included preventive maintenance in the form of sewer flushing by sequential location. Objective #6 further elaborates upon these activities. HPU identifies this benchmark as an area of preferred improvement and in response may revise its preventive approach.

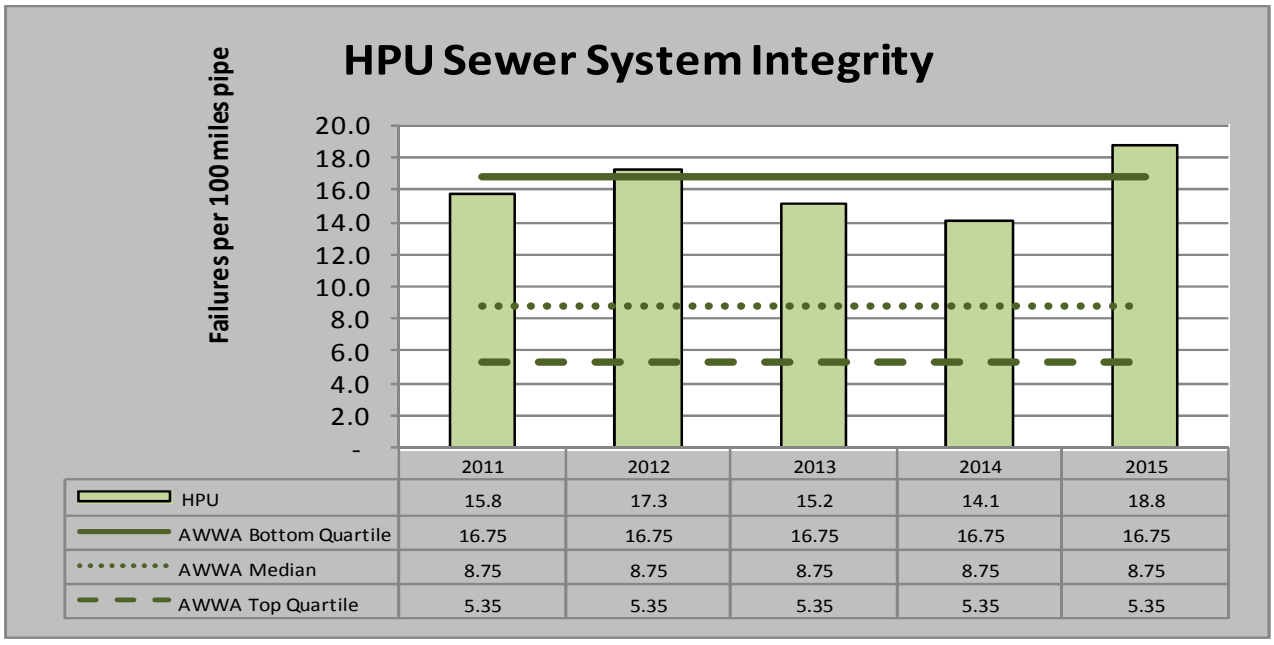


Figure 6

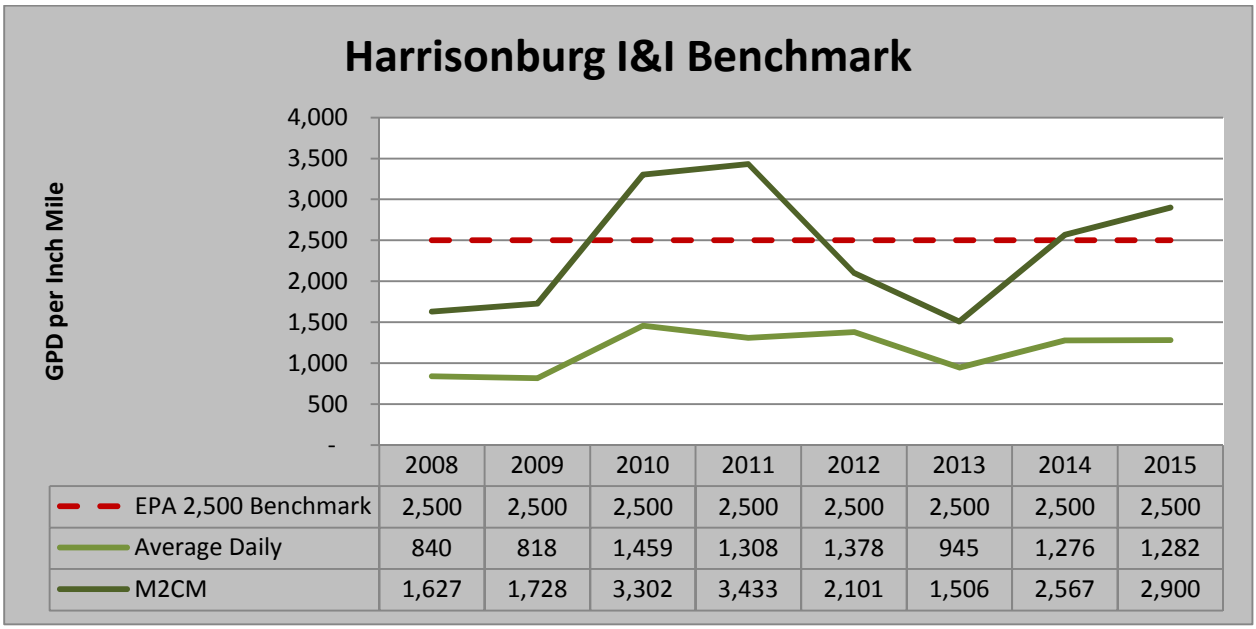
Infiltration & Inflow (I&I)

Appendix A includes additional information pertaining to the hydraulic composition of sewer flows. Appendix B is under construction and will provide a framework document under which HPU will conduct I&I abatement planning and implementation

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 typically occurs shortly after rainfall starts and then stops quickly once it stops.

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.

I&I effects have been mentioned in earlier objectives with respect to HRRSA capacity and interceptor capacity; its effects further penetrate into the local and remote sections of the collection system. EPA has set a benchmark of 2,500 gpd per inch mile of pipe as the maximum threshold for sewer collection pipe. In **Figure 7** below; Harrisonburg holistically meets the benchmark on an annual perspective. When benchmarking the Maximum 2 Consecutive Month benchmark the performance frequently exceeded the 2,500 benchmark; this is particularly relevant to HRRSA as noted earlier.



	2008	2009	2010	2011	2012	2013	2014	2015
EPA 2,500 Benchmark	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Average Daily	840	818	1,459	1,308	1,378	945	1,276	1,282
M2CM	1,627	1,728	3,302	3,433	2,101	1,506	2,567	2,900

Figure 7

Not shown in the figure, but relevant to conveyance capacity in the interceptor and collection pipe network, is this same benchmark for the local areas. A key element of Harrisonburg's SSMP will be flow monitoring; this information will allow for determination of general benchmarks as well as identification of instantaneous peaks; these with purpose to target priority I&I abatement projects.

VII. SSMP Objective #6: Operation & Maintenance

Funding

Harrisonburg's operations and maintenance for linear sewer system assets has been funded under budget code 2012- 432061 has been funded under budget code 2012-462061. The expended funds are shown in **Figures 8** below

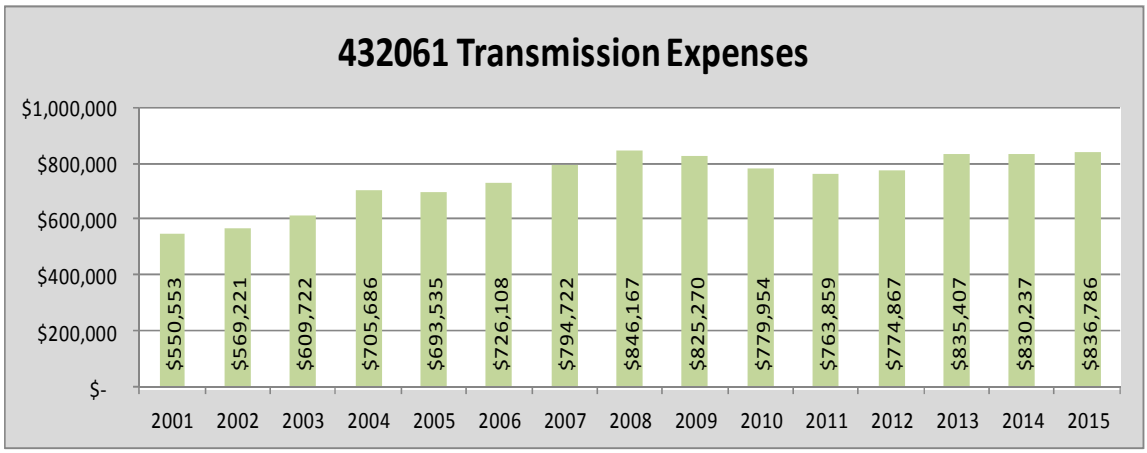


Figure 8

HPU has organized its maintenance efforts toward providing a balance of:

- Predictive Maintenance
- Preventive Maintenance
- Corrective Maintenance

AWWA benchmarks (2011) suggested the following for ratio between man-hours invested for planned maintenance versus man-hours invested for total maintenance.

- Top Quartile 73%
- Median 50%
- Bottom Quartile 37%

In Fiscal Year 2015, HPU's Linear invested 2,642 man-hours (34%) into planned maintenance and 7,684 man-hours into total sewer system care. The benchmark definition as presented may not fit HPU's reporting format. Going forward, a new CMMS system will be implemented in FY 2017 and will be configured to report this benchmark.

Predictive Maintenance:

Sewer pipe CCTV inspection is a most important component of HPU's Linear "Asset Management by Risk Methodology" (See HPU Asset Management Initiative). CCTV inspection scores are converted to "Likelihood of Failure" scores. *As* shown in **Figure 9**, *s*ince 2008 HPU has inspected 51 miles of sanitary sewer main, or 27% of system inventory of 191.2 miles. Not all CCTV scores have been converted to LOF scores; reporting on progress in this area will be added to the next SSMP update.

Sewer pipe "Consequence of Failure" analysis is also an important component of HPU's "Asset Management by Risk Methodology"; reporting on progress in this area will be added to the next SSMP update.

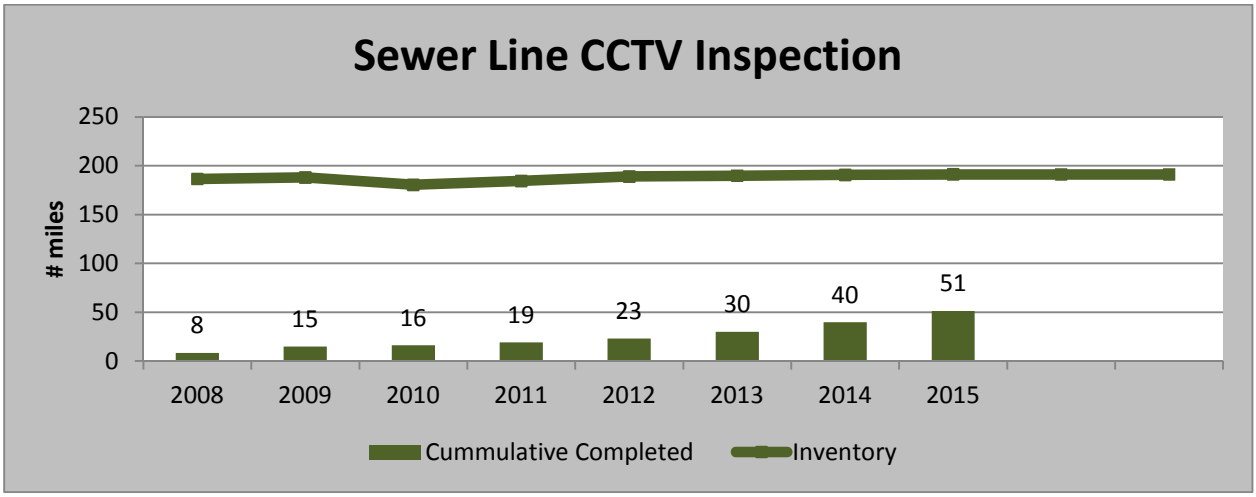


Figure 9

Sewer system smoke testing is a key activity to infiltration & inflow abatement; **Figure 10** as follows shows significant progress by HPU during the most recent 3 years. A total of 324,262 feet of sewer pipe has been tested.

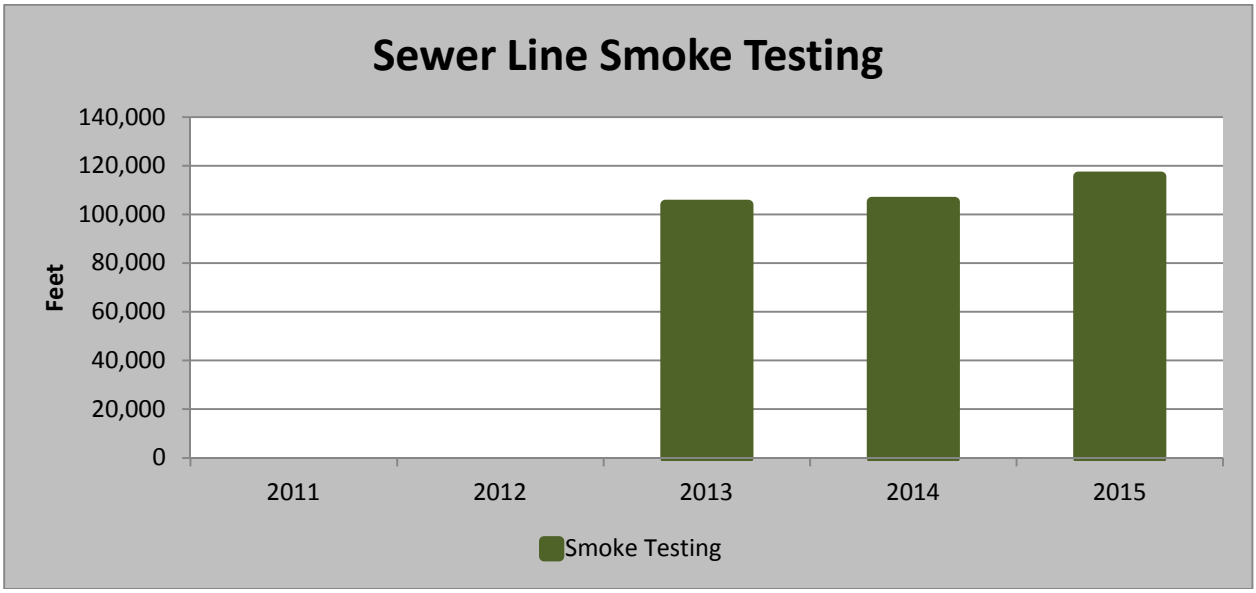


Figure 10

Preventive Maintenance:

Figure 11 as shown below recaptures HPU progress for preventive cleaning that was completed between 2008 and 2015. Since 2008 HPU has cleaned 177 miles of sanitary sewer main, or 93 % of system inventory of 191.2 miles. HPU is on schedule to complete the entire system by closure of the ten year period in 2016.

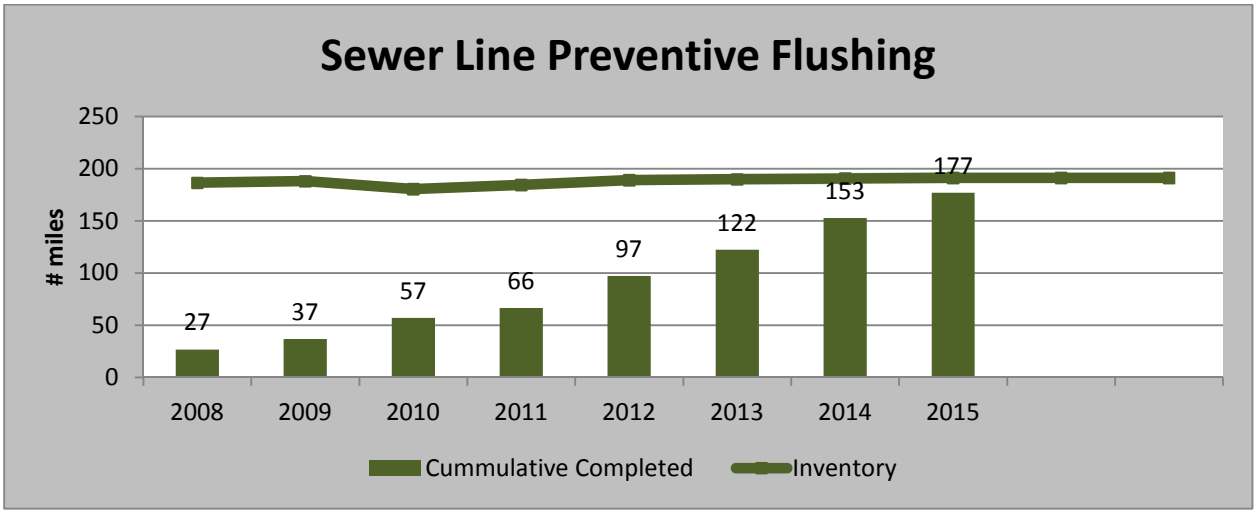


Figure 11

Corrective Maintenance:

Figure 12 as shown below recaptures sewer line repairs completed since 2010.

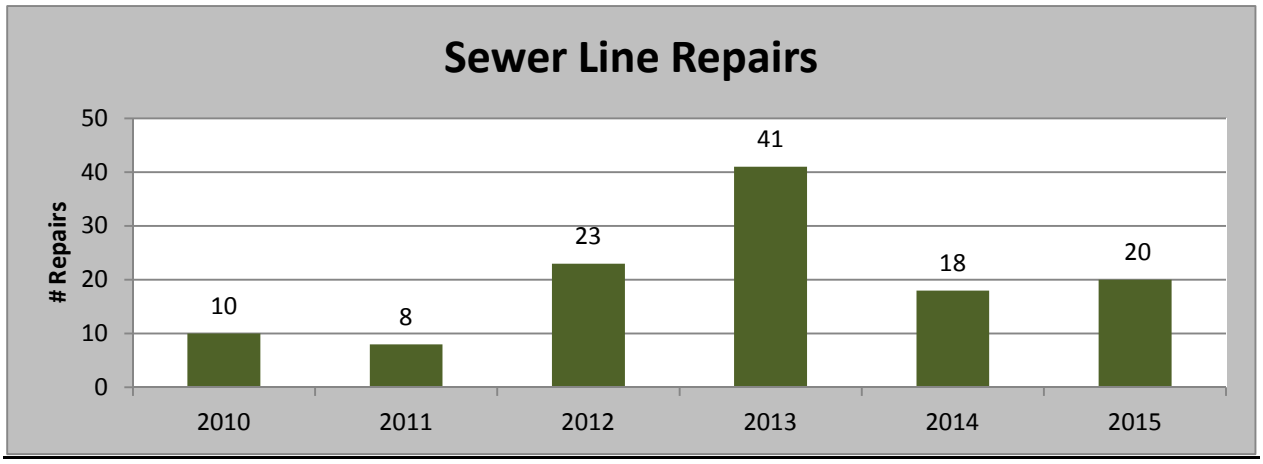
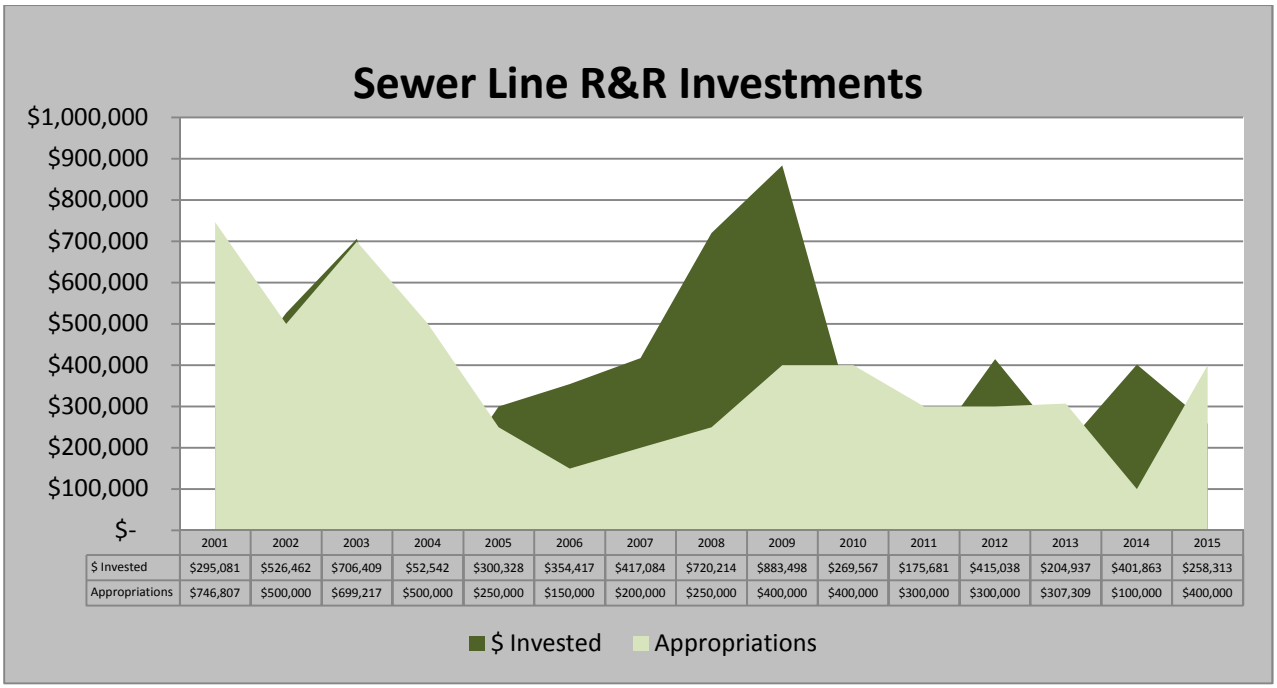


Figure 12

VIII. SSMP Objective #7: Rehabilitation & Replacement (R&R) Plan

Funding

Figure 13 as shown below shows HPU's reinvestment into asset replacement. During the most recent 5 year period the appropriation and expenditures for linear R&R have averaged $280,000 and $290,000, annually.

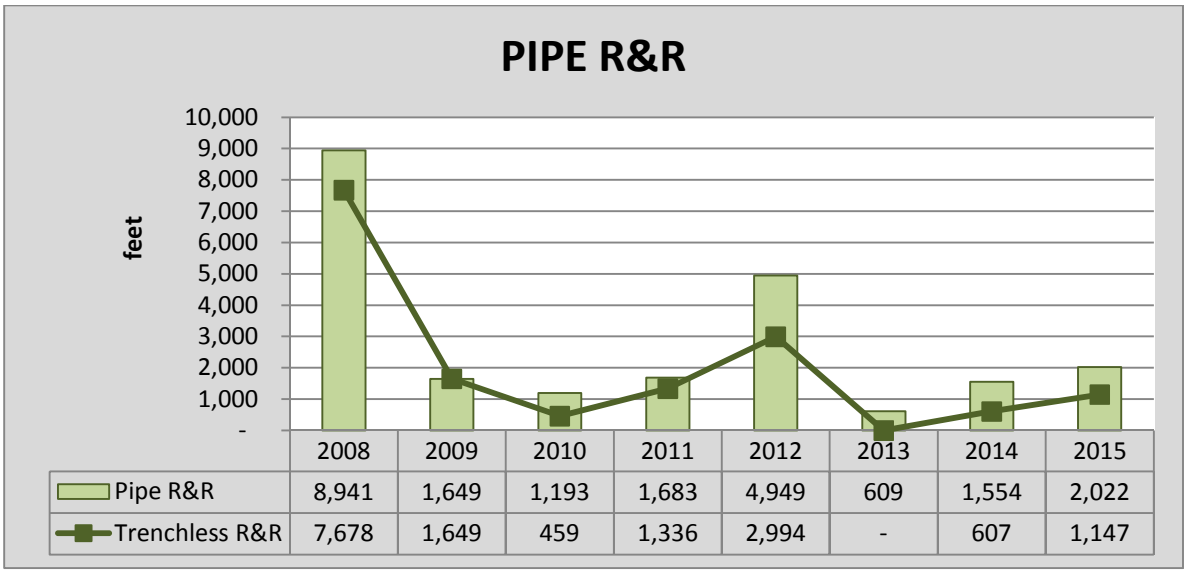


	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
$ Invested	$295,081	$526,462	$706,409	$52,542	$300,328	$354,417	$417,084	$720,214	$883,498	$269,567	$175,681	$415,038	$204,937	$401,863	$258,313
Appropriations	$746,807	$500,000	$699,217	$500,000	$250,000	$150,000	$200,000	$250,000	$400,000	$400,000	$300,000	$300,000	$307,309	$100,000	$400,000

Figure 13

Rehabilitation & Replacement

Figure 14 as shown below recaptures HPU progress for pipe rehab and replacement that was completed between 2008 and 2015. Since 2008 HPU has rehabbed or replaced 20,600 feet of pipe; 15,870 feet (77%) has been rehabbed with use of trenchless technology. The remaining pipe was replaced using conventional open cut technology. The underlying principle for R&R selection through CIP funding was the concept of "working within available funds". Beginning in FY 2017, selection of R&R project will use a new methodology of "Asset Management By Risk". This methodology is more fully defined in the HPU "Asset Management Initiative" document.



	2008	2009	2010	2011	2012	2013	2014	2015
Pipe R&R	8,941	1,649	1,193	1,683	4,949	609	1,554	2,022
Trenchless R&R	7,678	1,649	459	1,336	2,994	-	607	1,147

Figure 14

IX. SSMP Objective #8: Financial Benchmark

Objective #8 required HPU to monitor its sewer enterprise fund financial indicators and to strive for "Midrange" or "Stronger" designations. Fitch Ratings published its evaluation criteria in 2013; this information includes the following financial indicators.

"% Household Median Income"	"Debt Coverage Ratio"
"Liquidity"	"R&R Ratio"

The following indicators and benchmarks for FY2015 have been calculated:

- **Residential Rates = 0.96% HMI;** where annual water plus sewer = $491.96/yr; HMI = $51,136 / yr. (Reported for 2012 as most recent data available for HMI)

Fitch rating "Stronger"	1.2% HMI
Fitch rating "Midrange"	1.5% HMI
Fitch rating "Weaker"	2.0% HMI

- **Liquidity = 169 days including HRRSA debt and 524 excluding HRRSA debt;** where Fund Balance = $4,526,842; average daily expenses = $26,815 per day

Fitch rating "Stronger"	365 days
Fitch rating "Midrange"	180 days
Fitch rating "Weaker"	90 days

- **Debt coverage Ratio = 1.36 including HRRSA debt and infinity excluding HRRSA debt;** where revenue less operating = $3,742,108. HRRSA debt = $2,742,164 and there was no City debt

Fitch rating "Stronger"	2.00
Fitch rating "Midrange"	1.50
Fitch rating "Weaker"	1.25

- **R&R Ratio = 1.10;** where EOY CIP balances = $947,096; asset replacement value = $86,263,318

Fitch rating "Stronger"	5.00%
Fitch rating "Midrange"	3.50%
Fitch rating "Weaker"	2.00%

X. Conclusion:

The following are areas of strength in the SSMP:

1) Base Wastewater Flow (BWF):

   BWF was forecasted for City build out conditions using both conservative and aggressive growth approach. Forecasts were based on existing flows plus future growth from undeveloped properties.

2) Hydraulic Capacity at HRRSA

   Current purchased allocation at HRRSA is 12.80 MGD which exceeds BWF forecasts and allows for assimilation of infiltration & inflow at 2.38 MGD to 5.50 MGD.

3) Organic Capacity at HRRSA

   Current purchased allocation at HRRSA is 25,098 pounds per day. Forecasts herein suggest that Harrisonburg will max out between 16,659 (64%) to 23,972 (93%) pounds per day.

4) Operation and maintenance

   Funding is adequate with respect to predictive, preventive and corrective maintenance. Improvements have begun with approaches that will use Asset Management Methodology by Risk to drive predictive/preventive/corrective maintenance and a Flow Monitor Strategy to drive I&I abatement maintenance.

1) Asset Management and Capital Improvements:

   Improvements have begun with approaches that will use Asset Management Methodology by Risk to drive predictive/preventive/corrective maintenance and a Flow Monitor Strategy to drive I&I abatement maintenance.

5) Financial
   - Residential Rates to HMI Ratio is strong
   - Liquidity is midrange to strong
   - Debt Coverage ratio is midrange to strong

The following are areas of targeted improvements:

2) Current Hydraulic Status at HRRSA

   Current recorded I&I rates have exceeds the 2.38 MGD allowance during 13 of the last 15 years and have exceeded the 5.50 MGD allowance during 5 of the last 15 years. Harrisonburg is currently leveraging future capacity for I&I and must address this issue to accommodate future growth

3) Current Organic Loading Status at HRRSA

Harrisonburg delivered 46% (11,776 #s/d) of its allowable 25,098 #s/d organic loading in FY 2015. HRRSA has provided minimal opportunities to leverage this available capacity. This effort is now active with HRRSA.

4) Sewer System Interceptors

HPU has initiated an upgrade of its 1989 Wiley & Wilson study for capacity. Flow monitoring will be used to determine existing BWF and I&I problems. The study will conclude over the next several years to identify the optimum interceptor conveyance capacity in combination with recommended I&I reduction targets.

5) Collection System Integrity:

HPU will target improvements in its collection system integrity benchmark through revisions to preventive maintenance and through public education

6) Infiltration & Inflow Abatement

HPU is formalizing its framework methodology to systematically analyze its collection system such to target I&I reductions that contribute toward HRRSA, interceptor and collection system priorities

7) Asset Management and Capital Improvements:

HPU may be facing a need for a larger CIP fund to accommodate asset management and I&I reduction.

8) Financial

- R&R ratio is weak

Appendix A: Sanitary Sewer Flow

The volumes and rate patterns of the sanitary sewer flow as it enters into the collection system and treatment plant are major topics to the SSMP. Much of the SSMP places attention to changing or accommodating these characteristics. For an understanding, there are three major components (BWF, GWI, and RDII) of wet-weather flow into a sanitary sewer system; they have been illustrated **in Figure 3** below and defined thereafter:

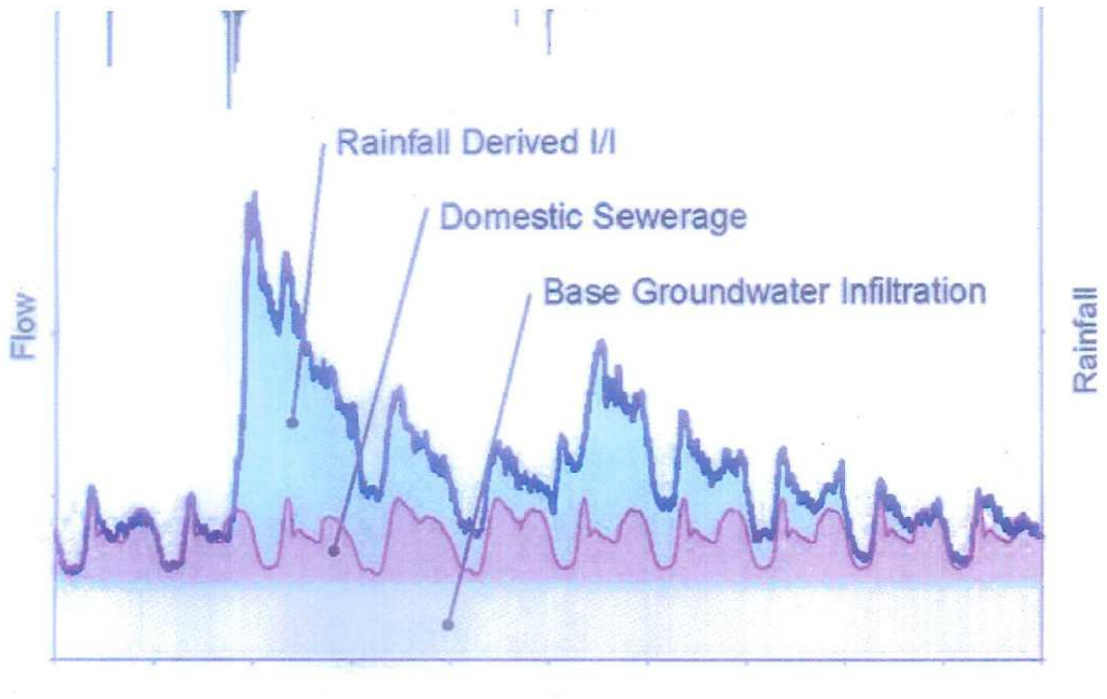


Figure3

BWF: Base Wastewater Flow is the residential, commercial, institutional, industrial and municipal flow that discharges to a sanitary sewer system for collection and treatment. BWFs are largely a function of population density, water consumption, and land uses. The flow rate varies both diurnally and seasonally. Rates for BWF per unit source have been published under many sanitary sewer design regulations; the City has published our rates in the "Harrisonburg Design and Construction Standards Manual".

GWI: Groundwater Infiltration represents the flow that enters a collection system through leaky pipes, pipe joints, and manhole walls. GWI is generally steady in the short term but varies throughout the year by trending higher when groundwater levels and soil moisture are higher. A design criterion of 1,000 to 2,000 gallons per acre per day is typical for GWI.

DWF is dry-weather flow and is the combination of BWF plus GWI.

RDII is that portion of a sewer flow hydrograph above the normal dry weather base flow pattern. It is a sewer flow response to rainfall or snowmelt in a sewer shed. RDII is typically responsible for

capacity related SSO problems and basement backups. Reported design criterion of less than 2,500 gallons per day per inch diameter mile of pipe is typical for RDII.

- 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 typically occurs shortly after rainfall starts and then stops quickly once it stops. Inflow is typically the major component of RDII peak flow.

- 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.

Appendix B: Infiltration & Inflow Abatement SOP

Under Construction

Appendix C: FY2016 SSMP Implementation

Sanitary Sewer Priority Planning Project

Project scope of work includes:

Sewer System planned management	input man-hour	**3,390**	
	Output (miles)		n/a
Planned: Root & Grease Runs	input man-hour	150	
	Outputs (miles)		6
Planned: Sewer Main Flushing (miles)	input man-hour	300	
	outputs (miles)		21
Planned: Sewer Smoke Testing (miles)	input man-hour	450	
	Outputs (miles)		30.62
Sweep	input man-hour	300	
	Outputs (miles)		20.00
BR65	input man-hour	150	
	Outputs (miles)		10.62
CATV Work total	input man-hour	1,472	
	Output (miles)		19.12
Age	input man-hour	297	
	Output (miles)		1.5
2015-2016 Priority Subshed	input man-hour	860	
	Output (miles)		4.1
Paving	input man-hour	315	
	Output (miles)		1.5

1) Perform field investigation of HRRSA priority (BR65-see below) and correlated to the 1980 PHR&A SSES study. Maps to be provided as follows:
   - A- 100 (Mosby Roads & City Shops Subsection)
   - A-200 (Lower Valley Blox Subsection)
   - A-300 (Pleasant Hill Subsection)
   - A-400 (Dealton Avenue & South Main Subsection)
   - B-200 (South Hampton Subsection)

Work to be performed:

- From previous interceptor flow monitoring, HRRSA has identified a collector sub-system known as BR65 (Mosby Road and Pleasant Hill) that contributes flows to the Upper HRRSA Interceptor. HRRSA has identified this section as having high probability of RDII contributions. HPU will repeat the flow

monitoring of the Upper HRRSA Interceptor and will complete the investigative activities for this sub-section before moving to another priority area.

- Complete a thorough re-smoke test of entire area; repeat as necessary in select locations per flow monitoring and inspections.
- Install flow monitors at Manholes A-2, A-100, B-200; correlate inflow induced peaking events with rainfall as incurred. Plan additional smoke testing, tv inspection, and wet weather investigation as necessary. Relocation of sensors may be required.
- Wet weather visual observations. Assign crews to field investigate the areas during rainfall events (schedule, field records, photographs to be formatted). Start with comprehensive approach and move to suspected high priority areas.

2) Perform field investigation of PHR&A line sections prioritized for Inflow as provided in Table 1-2 page 1-11 PHR&A Volume1. The table has been recreated with original data but also includes current day nomenclature to pipelines and manholes. The investigation should begin with smoke testing and then conclude with Catv inspection or manual inspection and possibly induced I&I.

3) Perform field investigation of all storm devices with possible connections to sanitary sewer per pages 5-18 through 5-23 PHR&A, Volume 1. Field maps are being provided for the following locations:

- West View & South Mason Streets
- South side of Franklin at Main Streets
- 3 inlets at Ash Tree and South Main Streets
- 3 inlets at Campbell and South Main Streets
- Storm lid between #120 and #130 Crescent Drive
- South side of First Street west of Lee Street
- Grate inlet on west side of Lee Street
- Intersection at 2nd and Colicello Streets
- Culvert back of Swift Company Parking Lot
- Behind curb @ 72 Weaver Street
- 12” storm pipe behind Meyers @ Creek Avenue

BR 65 / Old WWTP Site
JOHN WAYLAND HIGHWAY (RT. 42)
SOUTH MAIN ST. (RT. 11)
INTERSTATE 81
PORT REPUBLIC RD.
HB553 FLOW METER
HB1152 FLOW METER
AH3 FLOW METER
HB523 FLOW METER
BR65 FLOW METER
LEGEND
HRRSA SANITARY SEWER SYSTEM
CITY OF HARRISONBURG AND ROCKINGHAM COUNTY SEWER SYSTEM
METERING STATION & FLOW METER LOCATIONS
ROAD CENTERLINE
HARRISONBURG CITY LIMITS
BR65 FLOW METER SEWERSHED
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9