Harrisonburg Public Utilities (HPU)
Sanitary Sewer Management Plan
(SSMP)

January 31, 2018
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I. **Introduction; SSMP Balanced Scorecard:**

Harrisonburg Public Utilities (HPU) has crafted a Sanitary Sewer Management Program (SSMP) to guide operation and maintenance of its sewer system infrastructure as it increases 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.

This SSMP includes 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 term goals. **Figure 1** shows the SSMP Balance Scorecard.

![Harrisonburg SSMP Balance Scorecard](image)
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:

- **Establish an “Annual Plan” of activities that are compatible with the SSMP, Operating Budget and CIP Budget.**

- **Execute and monitor progress of the “Annual Plan”.**

- **Annually evaluate the SSMP goals and progress.**

**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.

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**Harrisonburg SSMP ORG Chart**

- **Executive Staff**
  - **Finances**
    - Rates
    - Liquidity
    - Debt Coverage
    - R & R
  - **Capacity**
    - HRRSA WWTP

- **Engineering Division**
  - **Demand–Capacity**
    - Flow Monitoring
    - Modeling

- **Field Utilities Division**
  - **Predictive**
    - CCTV Inspection
    - Smoke Testing
    - MH Inspections
  - **Preventive**
    - Flushing
  - **Corrective**
    - Flushing
    - Repair
    - R & R

- **Pump Division**
  - **Predictive**
    - Routine PS inspection
    - SCADA
  - **Preventive**
    - CMMS Pre-Schedule
  - **Corrective**
    - Repair
    - R & R

- **Benchmarks**
  - **Capacity**
    - Conveyance
    - I & I
  - **Asset Management**
    - COF
    - LOF
    - RUL
  - **Reliability**
    - Sewer System Integrity
    - Over Flow Rate

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**Figure 2**

R & R is Rehab and Replacement through CIP
II. **SSMP Objective #1: Forecasting Annual Average Daily BWF**

Objective #1 requires HPU to monitor “Base Wastewater Flow (BWF)”, or sales of sewer commodity, in terms of annual average daily (AAD) flows. Meeting the objective then requires forecasts for ultimate build-out conditions in the City.

- To recognize existing BWFs, data were obtained from sales records at the HPU Billing Office per the following customer groups:
  - City residential
  - City commercial
  - City institutional
  - City apartments
  - City municipal
  - Rural customer
  - Rockingham County as a Contract Customer

- To predict future growth in BWF, HPU carefully selected a dual approach that delivered both an aggressive growth forecast (AGF) and a conservative growth forecast (CGF); this provides a forecast envelope.

- Forecasted BWF is therefore the sum of existing BWF and growth BWF; the equation is:

  \[
  \text{Forecasted BWF} = \text{Current BWF} + \text{(undeveloped land} \times \text{rate per unit land area)}
  \]

  - For the AGF approach, rate per unit land area is based on maximum density and usage rates per design criteria.
  - For the CGF approach, rate per unit land area is based on historic records of sewer sales per unit of corresponding developed land type.

The aggressive approach hereafter has been used to make evaluations of capacity needed to treat and to convey the volumes and flow rates of sanitary sewer. The conservative approach has
been provided for comparison and understanding of the degree for margin of error (or safety margin) in planning.

The results of the forecasts are shown in Table 1. *Average annual demands have been forecasted to increase to between 6.7 and 9.4 MGD as determined by historic growth rate and maximum density growth rate, respectively. An additional 0.5 to 1.0 MGD is needed for 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

<table>
<thead>
<tr>
<th>Description</th>
<th>Existing MGD</th>
<th>Capacity MGD</th>
<th>% Maturity</th>
<th>Capacity MGD</th>
<th>% Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Residential</td>
<td>1,300,000</td>
<td>1,756,211</td>
<td>74%</td>
<td>2,584,300</td>
<td>50%</td>
</tr>
<tr>
<td>City Commercial</td>
<td>1,100,000</td>
<td>1,511,001</td>
<td>73%</td>
<td>1,647,452</td>
<td>67%</td>
</tr>
<tr>
<td>City Industrial</td>
<td>890,000</td>
<td>1,410,171</td>
<td>63%</td>
<td>2,654,000</td>
<td>34%</td>
</tr>
<tr>
<td>City Apartments</td>
<td>720,000</td>
<td>935,020</td>
<td>77%</td>
<td>1,506,051</td>
<td>48%</td>
</tr>
<tr>
<td>City Institutional</td>
<td>500,000</td>
<td>610,000</td>
<td>82%</td>
<td>610,000</td>
<td>82%</td>
</tr>
<tr>
<td>City Municipal</td>
<td>20,000</td>
<td>20,000</td>
<td>100%</td>
<td>20,000</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Subtotal City</strong></td>
<td><strong>4,530,000</strong></td>
<td><strong>6,242,402</strong></td>
<td><strong>73%</strong></td>
<td><strong>9,021,803</strong></td>
<td><strong>50%</strong></td>
</tr>
<tr>
<td>Rural</td>
<td>150,000</td>
<td>150,000</td>
<td>100%</td>
<td>150,000</td>
<td>100%</td>
</tr>
<tr>
<td>Rockingham County</td>
<td>140,000</td>
<td>500,000</td>
<td>28%</td>
<td>1,000,000</td>
<td>14%</td>
</tr>
<tr>
<td>Michaels</td>
<td>-</td>
<td>90,000</td>
<td>0%</td>
<td>90,000</td>
<td>0%</td>
</tr>
<tr>
<td>Daley</td>
<td>-</td>
<td>170,000</td>
<td>0%</td>
<td>170,000</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Total W/ ROCO</strong></td>
<td><strong>4,820,000</strong></td>
<td><strong>7,152,402</strong></td>
<td><strong>67%</strong></td>
<td><strong>10,431,803</strong></td>
<td><strong>46%</strong></td>
</tr>
<tr>
<td><strong>Total WO/ ROCO</strong></td>
<td><strong>4,680,000</strong></td>
<td><strong>6,652,402</strong></td>
<td><strong>70%</strong></td>
<td><strong>9,431,803</strong></td>
<td><strong>50%</strong></td>
</tr>
</tbody>
</table>

Institutional growth uses 5,000 students at 22 gpd.
Rockingham County not used against allocation at HRRSA.
III. SSMP Objective #2: Managing Treatment Capacity at HRRSA

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 definition. By indirect definition, a Maximum Allowable Head-Works Load (MAHL) for a given pollutant can support or supersede the hydraulic definition.

**Hydraulic Capacity:**

The HRRSA hydraulic allocation to each member is by million gallons per day (MGD). The HRRSA facility is rated at 22.0 MGD with Harrisonburg’s allocation at 12.8 MGD. The service agreement applies this capacity in terms of the maximum 2 consecutive months (M2CM) of flow.

The objective of this SSMP is to develop understanding regarding Harrisonburg’s hydraulic capacity at HRRSA and its needed capacity at the build-out of its undeveloped properties. In FY2017, Harrisonburg sold 4.7 MGD of sewer, thus leaving 8.1 MGD available for future growth. Objective #1 has forecasted the future annual average daily demand to range from 6.7 to 9.4 MGD. By escalating the annual forecast by 1.16 (as determined from historical records) to account for M2CM conditions; long term planning should recognize that Harrisonburg will need between 7.7 MGD and 10.9 MGD hydraulic capacity. Referencing sales forecasting only, Harrisonburg’s 12.8 MGD capacity is adequate with a surplus of 1.9 to 5.0 MGD; see Figure 3.
**Maximum Allowable Head-Works Loading (MAHL) Capacity:**

MAHL is the allowable pounds per day of a pollutant that can be assimilated into the treatment plant without causing adverse effects. MAHL is the product of volume of flow and the concentration of pollutant. The Pollutants of Concern (POC) that are most significant to the HRRSA facility and Harrisonburg are Biological Oxygen Demand ($\text{BOD}_5$), Total Suspended Solids (TSS), Total Kjeldahl Nitrogen (TKN) and Total Phosphorous (TP). Unlike designated hydraulic capacity, the HRRSA contract service agreement does not currently define the MAHL allocations to the members. Table 2A summarizes HRRSA’s FY2017 and maximum hydraulic and pollutant loadings; HRRSA operates between 21% and 63% capacity for the referenced loadings.
### Table 2A

Table 2B summarizes concentration rates for the pollutants referenced above:

<table>
<thead>
<tr>
<th>SIU (Significant Industrial User)</th>
<th>HYDRAULIC FLOW (MGD)</th>
<th>$\text{BOD}_5$ (#/DAY)</th>
<th>TSS (#/DAY)</th>
<th>N (#/DAY)</th>
<th>P (#/DAY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRRSA DESIGN LOADING</td>
<td>22.00</td>
<td>248</td>
<td>248</td>
<td>50</td>
<td>8</td>
</tr>
<tr>
<td>HRRSA EXISTING NON-SIU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>318</td>
<td>248</td>
<td>53</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HRRSA PROPOSED SIU LOADING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>70</td>
<td>14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2B

Table 3 summarizes forecasted City of Harrisonburg pollutant loadings at HRRSA based on the previously itemized aggressive growth forecast at proposed SIU loadings in Table 2B above.

Inclusive is 4.75 MGD of future sales; all 1.42 MGD of forecasted industrial grown is included at SIU POC levels.

<table>
<thead>
<tr>
<th>SIU SOURCE</th>
<th>BILLING (MGD)</th>
<th>HRRSA (MGD)</th>
<th>$\text{BOD}_5$ (#/DAY)</th>
<th>TSS (#/DAY)</th>
<th>N (#/DAY)</th>
<th>P (#/DAY)</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARIAKA</td>
<td>0.23</td>
<td>0.12</td>
<td>362</td>
<td>362</td>
<td>55</td>
<td>7</td>
<td>NOTE 3</td>
</tr>
<tr>
<td>GEORGES</td>
<td>0.60</td>
<td>0.53</td>
<td>1,556</td>
<td>1,556</td>
<td>236</td>
<td>28</td>
<td>NOTE 3</td>
</tr>
<tr>
<td>MONTIBELLO</td>
<td>0.21</td>
<td>0.20</td>
<td>578</td>
<td>578</td>
<td>88</td>
<td>10</td>
<td>NOTE 3</td>
</tr>
<tr>
<td>PACKAGING</td>
<td>0.11</td>
<td>0.03</td>
<td>88</td>
<td>88</td>
<td>13</td>
<td>2</td>
<td>NOTE 3</td>
</tr>
<tr>
<td>SVO</td>
<td>0.16</td>
<td>0.17</td>
<td>485</td>
<td>485</td>
<td>73</td>
<td>9</td>
<td>NOTE 3</td>
</tr>
<tr>
<td>NON SIU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.69</td>
<td>9,786</td>
<td>7,632</td>
<td>1,631</td>
<td>194</td>
<td></td>
<td>NOTE 1</td>
</tr>
<tr>
<td>SUBTOTAL SALES</td>
<td>4.68</td>
<td>4.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I&amp;I</td>
<td>1.94</td>
<td>1.94</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>NOTE 2</td>
</tr>
<tr>
<td>H'BURG FY2017</td>
<td>6.62</td>
<td>12,854</td>
<td>10,700</td>
<td>2,096</td>
<td>249</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HRRSA MAX</td>
<td>22.00</td>
<td>45,503</td>
<td>45,503</td>
<td>9,174</td>
<td>1,411</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H'BURG %</td>
<td>0.30</td>
<td>0.28</td>
<td>0.24</td>
<td>0.23</td>
<td>0.18</td>
<td></td>
<td>NOTE 5</td>
</tr>
<tr>
<td>SIU GROWTH</td>
<td>1.24</td>
<td>1.24</td>
<td>3,631</td>
<td>3,631</td>
<td>726</td>
<td>145</td>
<td>NOTE 3</td>
</tr>
<tr>
<td>NON SIU GROWTH</td>
<td>3.51</td>
<td>3.51</td>
<td>9,298</td>
<td>7,252</td>
<td>1,550</td>
<td>184</td>
<td>NOTE 1</td>
</tr>
<tr>
<td>I&amp;I ALLOWANCE</td>
<td>3.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H'BURG ULTIMATE</td>
<td>12.80</td>
<td>25,784</td>
<td>21,583</td>
<td>4,372</td>
<td>579</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H'BURG %</td>
<td>0.58</td>
<td>0.57</td>
<td>0.47</td>
<td>0.48</td>
<td>0.41</td>
<td></td>
<td>NOTE 4</td>
</tr>
<tr>
<td>H'BURG MAX</td>
<td>12.80</td>
<td>12.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NOTE 1: BOD$_5$=318, TSS=248, N=53, P=6.3
NOTE 2: BOD$_5$=0, TSS=0, N=0, P=0
NOTE 3: BOD$_5$=350, TSS=350, N=70, P=14
NOTE 4: HBRUG loading capacity limit is 0.58
NOTE 5: The highest value is the limited loading parameter

*Based on calculations in Table 3, hydraulic loading of 12.8 MGD continues to be the limiting parameter for growth within the City. The projected total SIU and NON-SIU growth under the HRRSA proposed loading rates aren’t anticipated to exceed the City’s allowable contribution to MAHL.*
IV. SSMP Objective #3: Leveraging Unused Treatment Capacity at HRRSA

Hydraulic Capacity:

AGF Objective #2 has suggested that Harrisonburg has available hydraulic capacity at HRRSA to meet future sales. However, exempted from this conclusion was the effect of capacity used by unbilled extraneous sewer that is caused by infiltration and inflow (I&I). Because I&I is significantly influenced by environmental variables that are inconsistent from year to year, forecasted sales growth has been added to the history of Harrisonburg flow (sales + I&I) to HRRSA over the recent 15 one year periods. By also displaying the City’s allocation of 12.8 MGD, a re-evaluation of available capacity was made; but with I&I included.

The results shown in Figure 4 indicate that available capacity of 12.8 MGD will not always support the future treatment requirement. Under conservative and aggressive forecasts, treatment requirements exceeded treatment capacity in 5 and 15 of the 15 annual periods, respectively. A period that repeats FY2011 conditions and adds aggressive growth would incur 3.28 MGD deficit capacity.

Figure 4
Harrisonburg has not exceeded hydraulic capacity in the past, 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 leveraged capacity.

Maximum Allowable Head-Works Loading (MAHL) Capacity:

HRRSA has evaluated the POC leverage concept in their 2016 and 2017 effort to update the “Local Limits” program that applies to SIUs. The “Original Local Limits” program set forth a 300 mg/l limit on BOD5 and TSS concentrations but had no limits upon TKN, TP and Nitrate + Nitrite. Under this past program, consistent performance in meeting the BOD5 and TSS limits would appear to support expectations that HRSSA is in position to leverage unused MAHL capacities. The other POCs as listed were not under control of the program so expectations would be null until further data is collected. A tabulation of HRRSA and Harrisonburg’s MAHL limits and their respective FY2017 usages are shown in Table 3.

\[
\begin{align*}
\text{BOD} &= 12,937 \text{ lb/day (25,784-12,854)} \\
\text{TSS} &= 10,883 \text{ lb/day (21,583-10,700)} \\
\text{TKN} &= 2,276 \text{ lb/day (4,372-2,096)} \\
\text{P} &= 330 \text{ lb/day (579-249)}
\end{align*}
\]

In contrast and in a Local Limits Technical Memorandum 2 dated November 4, 2016, HRSSA consultant Mangrum had identified some inconsistencies with expectations as stated earlier toward the existing “Local Limits” program. Compliance with Local Limits by SIUs as perceived under a self-reporting format is not supported by analysis at the head works of the HRRSA plant. Mass loadings and concentrations for POCs at the HRRSA head works were significantly variable.
and therefore carried a direct impact upon the opportunities to leverage unused MAHL capacities. The following Figure 5 has been taken from the referenced memorandum.

**Figure 5**

Mangrum notes that a reliable “base mass load” is necessary for the plant to establish a sustainable population in its three biological treatment processes but that any “added load” above the base cannot allow the total load to exceed 2 times the base load. The above graph shows that the current “Local Limits” program has not developed the needed practices among the SIUs. Both mass loadings and extreme concentrations (recorded to reach 1,000 to 2,000 mg/l) are evident at the head works. HRSSA’s future efforts in the proposed 2017 “Local Limits” program encompasses some strengths to control this variability issue but it is also constrained in some efforts.
• **Strengths:**

  HRRSA proposes a single maximum sample concentration and a more rigorous testing schedule. This will target reducing the release of high concentration wastes during periods of no sampling. This problem is most likely present from SIUs given the high concentrations detected at the head works.

• **Constraints:**

  Mass loadings are determined by not only concentration but also the volume of discharges. Under the current and proposed programs, there is no mechanism available to control the load discharge from SIUs by scheduling process discharges or equalizing sewer flows. This problem is inherent to the HRRSA-Member contract service agreement which makes no reference to allocation by MAHL. As such, there is no foundation to impose mass loadings on the HRRSA members or the SIUs without incurring much administrative difficulty.

  In conclusion, the current SIU group contributes significantly more in proportionate flow and in loading than would be ideal for HRRSA. They also practice in a much too uncontrolled pretreatment environment for HRRSA and its members to seize the opportunities to purposefully leverage unused MAHL capacity. As such, *the current program strategy is limited to revise and implement the Local Limits Program with emphasis to increase monitoring to gain control of the variable mass loading that occurs at the HRRSA headworks.* Opportunity may exist in the future as “Local Limits” programs should be reviewed every five years; however, the strengths of the proposed pretreatment program would need to overcome the referenced constraints such that SIU practices change significantly.
V. **SSMP Objective #4: Managing Interceptor Capacity**

Harrisonburg’s interest in the interceptor components of the sewer system are with those owned and operated by HRRSA and then again with those owned and operated by the City.

*Hydraulic Capacity in HRRSA Owned Interceptors:*

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 (*Figure 6*). In evaluation of capacity in the interceptors, 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.

From the referenced report, the HRRSA Black’s Run and Lower Cook’s Creek Interceptors were the subjects of interest to Harrisonburg. Meeting the desired LOS for the two interceptors will engage Harrisonburg into I&I reduction efforts and capital improvements; the latter forecasting a series of bond repayments that extend for 20 years as follows:

- 2023-2014: $84,000 per year
- 2027 -2047: $719,000 per year
- 2031-2051: $2,472,000 per year
- 2033-2053: $545,000 per year

With anticipation to meeting its obligations of approximately 83% of the referenced annual financial obligations, HPU has added this program to its Capital Improvement Plan.
Figure 6
Hydraulic Capacity in City Owned Interceptors:

In a similar study to the HRRSA LOS report, HPU forecasted the need for interceptor conveyance capacities through a study conducted by Wiley & Wilson in 1989. Since 1989, forecasted demand and capacity relationships from the study have guided capital investments into upgrading the interceptor system. The components of the interceptor and their respective Dry Weather Flow (DWF) design criteria from 1989 are shown below:

<table>
<thead>
<tr>
<th>INTERCEPTOR SYSTEM</th>
<th>Length</th>
<th>DWF design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper HRRSA</td>
<td>3,030</td>
<td>26.65 MGD</td>
</tr>
<tr>
<td>Lower West Interceptor</td>
<td>4,832</td>
<td>11.58 MGD</td>
</tr>
<tr>
<td>Upper West Interceptor</td>
<td>8,543</td>
<td>2.20 MGD</td>
</tr>
<tr>
<td>North Interceptor</td>
<td>14,124</td>
<td>8.36 MGD</td>
</tr>
<tr>
<td>West Spur Interceptor</td>
<td>1,975</td>
<td>3.71 MGD</td>
</tr>
<tr>
<td>East Interceptor</td>
<td>18,808</td>
<td>12.68 MGD</td>
</tr>
<tr>
<td>Blue Ridge Drive Interceptor</td>
<td>3,516</td>
<td>0.88 MGD</td>
</tr>
<tr>
<td>Country Club Road Interceptor</td>
<td>3,930</td>
<td>2.06 MGD</td>
</tr>
<tr>
<td>Total</td>
<td>58,758</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7 below is a schematic of the Harrisonburg Black’s Run Interceptor with DWF.
Objective #4 of this SSMP requires an update to the 1989 Black’s Run Interceptor Study in the HRRSA LOS format and to then replace the original CIP strategy to match the recommendations from the updated study. The steps to complete this objective are as follows:

- Update current and forecasted BWF (Objective #1) into the interceptor hydraulic model.
- Conduct flow monitoring at select locations along the interceptor to define the amounts and locations of I&I / RDII effects.
- Integrate BWF and I&I / RDII data into the interceptor hydraulic model process.
- Evaluate model outputs for the best combinations of interceptor capacity improvements versus I&I abatement priorities and projects.

Flow monitoring began in FY 2016. Flow monitoring will expand and continue so that flow data can be compared holistically and converted to useful information to abate I&I and capacity issues. HPU has also issued Task Orders to RJN Group for the requirements herein for the Black’s Run Interceptor Study. Results are forthcoming.
VI. **SSMP Objective #5: Asset Management**

HPU is actively developing an asset management plan that includes the sanitary sewer system assets inventory. The plan guides the systematic process of maintaining, upgrading, and operating physical assets in the most cost efficient manner.

**Decision Process Planning**

- The first key element of the asset management planning process is to inventory the assets in both database and geospatial (GIS) format. HPU has completed step 1 as shown in **Table 5**.

### FY 2017 Sewer System Asset Management Status

<table>
<thead>
<tr>
<th>Current Asset Replacement Value ($)</th>
<th>Net Book Value ($)</th>
<th>Annual Depreciation ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>201.9 Miles of Pipes $75,532,410</td>
<td>Pipes $ 31,829,758</td>
<td>Pipes $ 935,258</td>
</tr>
<tr>
<td>5,692 Manholes $7,275,000</td>
<td>Manholes $ 4,698,030</td>
<td>Manholes $ 42,900</td>
</tr>
</tbody>
</table>

**Table 5**

- The second key component is to establish the desired Level of Service (LOS) in terms of structural mortality, performance, capacity and efficiency / obsolescence. HPU has adopted the following LOS as shown in **Table 6**.
The third key element is to establish criticality of each asset should failure occur. The level of criticality is defined by financial, social and environmental impacts. Currently, HPU has established a first draft menu for criticality as shown in Figure 8.
**HPU’s immediate agenda in the third component is to finalize the criticality criteria and then establish rate values on a scale from 1 (best) to 5 (worst) for all assets in inventory.**

- The fourth key element of the asset management process is to evaluate the functional condition of each asset for each LOS and to then define the Likelihood Of Failure (LOF) for each asset on a scale from 1 (best) to 5 (worst).

**HPU’s immediate agenda in the fourth component is to establish asset LOF scores:**

- **a) Configure its CMMS technology to deliver condition assessment for CCTV records in hand;**
- **b) Configure its CMMS technology to deliver MTBF for sewer backups;**
- **c) Configure its CMMS technology to identify obsolescence of materials;**
- **d) Include LOS for capacity into the Black’s Run Interceptor Hydraulic Study**

- The fifth and final key element of the asset management process is to engage the COF and LOF of each asset into prioritizing predictive, preventive and corrective maintenance as well using Remaining Useful Life (RUL) for asset retirement planning. HPU will build upon the principle of COF=5, LOF=4 and COF=1, LOF=5 to establish retirement and maintenance priorities (**Figure 9**).

**HPU’s immediate agenda in the fifth component is to establish a decision tree that considers LOF, COF and life cycle analysis; evaluation of on market software may provide solutions.**
**Maintenance, Repair and R&R**

Whereas Asset Management strategies are relatively new in using the principles of risk planning with LOF and COF parameters, HPU has functioned in the past to complete many preventive, predictive, repair and retirement activities. Previous SSMP maintenance goals were to enhance the presence of significant planned maintenance (predictive + preventive + corrective) and to facilitate the absence of unplanned (corrective) disruptive maintenance that is accompanied with high ancillary costs in fiscal, social and environmental terms. AWWA benchmarks (2016) and Harrisonburg benchmarks (3rd Quartile Ranking) for maintenance are shown in Table 7:

<table>
<thead>
<tr>
<th>BENCHMARK</th>
<th>TOP QUARTILE</th>
<th>MEDIAN</th>
<th>BOTTOM QUARTILE</th>
<th>HARRISONBURG FY2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLANNED Hrs. MAINTENANCE</td>
<td>79%</td>
<td>69%</td>
<td>48%</td>
<td>62%</td>
</tr>
<tr>
<td>CORRECTIVE MAINTENANCE</td>
<td>381</td>
<td>1,257</td>
<td>2,665</td>
<td>1,780</td>
</tr>
<tr>
<td>HRS / 100 mi. pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 7**

Harrisonburg Planned maintenance = 1,443.41 hours / 2,325.22 = 62%

Harrisonburg Corrective maintenance = 881.81 hours *(201.9 miles / 100 miles) = 1,780 hours per 100 miles.
The following Table 8 is in raw data form as extracted from the HPU CMMS program. Preventive and planned repair comprise planned maintenance in the above benchmark calculation. Repair is the sole component of unplanned maintenance.

<table>
<thead>
<tr>
<th>Sewer Assets Program Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>From: 7/1/2016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maintenance Type</th>
<th>TOTAL HOURS</th>
<th>LABOR COST</th>
<th>EQUIPMENT COST</th>
<th>MATERIAL COST</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billable Services</td>
<td>907.10</td>
<td>$20,360.15</td>
<td>$9,745.74</td>
<td>$12,384.86</td>
<td>$42,490.75</td>
</tr>
<tr>
<td>New Installation</td>
<td>355.00</td>
<td>$8,036.81</td>
<td>$4,436.54</td>
<td>$3,915.78</td>
<td>$16,389.13</td>
</tr>
<tr>
<td>Other</td>
<td>69.50</td>
<td>$1,499.99</td>
<td>$451.54</td>
<td>$475.37</td>
<td>$2,426.90</td>
</tr>
<tr>
<td>Preventative Maintenance (Pf)</td>
<td>1,412.41</td>
<td>$32,271.92</td>
<td>$3,716.71</td>
<td>$1,663.30</td>
<td>$37,651.94</td>
</tr>
<tr>
<td>Rehab &amp; Replace (CIP)</td>
<td>389.50</td>
<td>$43,991.00</td>
<td>$59,498.37</td>
<td>$42,109.64</td>
<td>$145,599.01</td>
</tr>
<tr>
<td>Remove</td>
<td>3.00</td>
<td>$82.84</td>
<td>$0.00</td>
<td>$0.00</td>
<td>$82.84</td>
</tr>
<tr>
<td>Repair</td>
<td>881.81</td>
<td>$56,179.94</td>
<td>$44,132.21</td>
<td>$40,534.50</td>
<td>$140,846.65</td>
</tr>
<tr>
<td>Scheduled Repair</td>
<td>31.00</td>
<td>$718.02</td>
<td>$0.00</td>
<td>$247.34</td>
<td>$965.36</td>
</tr>
<tr>
<td>Program Totals:</td>
<td>4,049.32</td>
<td>$163,140.66</td>
<td>$121,981.11</td>
<td>$101,330.79</td>
<td>$386,452.57</td>
</tr>
</tbody>
</table>

Listed below is a summary of maintenance activity types and individual activities that HPU has previously engaged to perform its asset management work:

- **Predictive Maintenance:**
  - COF & LOF Analysis of Assets
  - CCTV Inspection of Pipe
  - Three Phase I&I Inspection of Manholes
  - Structural Inspection of Manholes
  - Flow Monitoring
Preventive Maintenance: Planned Sewer Flushing
Oil & Grease Run Flushing
Root Cutting Bimonthly

Corrective Maintenance: Planned (without impact to LOS)
Unplanned (negative impact to LOS)

Predictive Maintenance: Flow monitoring, inspections and LOF/COF analysis are discussed elsewhere in this document. Sewer pipe CCTV inspection has been the single most important predictive maintenance activity in HPU’s Linear “Asset Management”. As shown in Figure 10, since 2008 HPU has inspected 70 miles of sanitary sewer main, or 35% of system inventory of 201.9 miles. All pipes were evaluated in the Ques 1-100 scoring system.

Figure 10

Preventive Maintenance: Sewer Flushing activities are discussed elsewhere in this document.
Repair Maintenance: Figure 11 as shown below recaptures sewer line repairs completed since 2011.

Rehab and Rehabilitation: Figure 12 as shown below recaptures past replacement and rehab (R&R) projects completed using CIP funding. HPU progress for pipe R&R between 2008 and 2017 included:

- Total R&R = 29,754 feet
- R&R by trenchless technology methods = 16,357 feet (55%)
- R&R by conventional open cut technology = 7,606 feet (45%)
Funding

The total sewer budget for FY2017 is summarized below in terms of rate impact.

- Direct Operating = $0.60 / 1,000 gallons
- Management = $0.66 / 1,000 gallons
- Transfers = $0.54 / 1,000 gallons
- HRRSA Operating = $1.92 / 1,000 gallons
- Total Operating = $3.72 / 1,000 gallons
- Operating & Debt = $2.24 / 1,000 gallons
- Total = $5.96 / 1,000 gallons

Direct operating expenses include many fixed, semi-fixed and variable costs; for linear assets costs were funded under 2012-432061 budget line item. Fiscal Year 2017 expenses are shown at $881,643 shown in Figure 13:

Rehab and replacement (R&R) funding for Harrisonburg sewer is shown in Figure 14. During FY2017, $1,200,000 were appropriated after years of limited funding. Funding was previously directed to treatment expansion and enhancement.
Figure 14
SSMP Objective #6: Mitigating I&I Induced Effects

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.

EPA has set a benchmark of 2,500 gpd per inch mile of pipe as the maximum threshold for total I&I in sewer collection pipe. In Figure 15 below; Harrisonburg holistically meets the benchmark on an annual perspective, however, when displaying the Maximum 2 Consecutive Month benchmark as applicable to HRRSA capacity, the performance frequently exceeded the 2,500 benchmark. Local peaks, when monitored, will most likely be much greater.

Figure 15
The key component in recent HPU I&I abatement efforts has been smoke testing of 405,157 feet of pipe shown in Figure 16. This work has been scheduled in a progressive sweep approach and achieved some unquantified success with identification and remediation of private sources.

![Sewer Line Smoke Testing](image)

In moving forward, HPU has reformatted its I&I program.

- The initial step is to use the Black’s Run Interceptor flow monitoring to prioritize the area of investigation.
- The successive steps are to locate and relocate additional flow monitors into the collection pipe network with each rain event and with purpose to rank assets for LOF(I&I). This will be performed in a triage type agenda
- High LOF assets will be visually inspected, dye tested, CCTV inspected or smoke tested as determined appropriate to provide closure for LOF ranking.
- High COF / LOF assets will be remediated. Private source remediation will be enforced
HPU has advanced in FY2017 as follows:

Interceptor Flow Monitoring: 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.

Figure 17

HPU top priority of this SSMP is to eliminate the Sanitary Sewer Overflow (SSO) that occurs in the West Spur Interceptor; at this location baseline flow and peak flow were observed at 0.5 MGD and 14.0 MGD, respectively.
HPU future priorities

*HPU shall progressively flow monitor, dye test, smoke test and CCTV inspect pipes and manholes in the West Spur contributing sewer pipe network. These work goals shall be scheduled and monitored through CMMS technology.*

*HPU shall engage with Public works to facilitate a sanitary sewer & storm water program that interfaces with the private ownership in a cooperative arrangement.*
SSMP Objective #7: Collection System Integrity

The integrity of a sewer system 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 = \[100 \times \left(\frac{\text{# public failures}}{\text{Total Miles of Pipe}}\right)\]

Table 9 AWWA Published Benchmarks

<table>
<thead>
<tr>
<th></th>
<th>Top Quartile</th>
<th>Median</th>
<th>Bottom Quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stoppages per 100 miles pipe</td>
<td>2.9</td>
<td>5.0</td>
<td>8.7</td>
</tr>
</tbody>
</table>

Figure 18 below shows that since 2011 Harrisonburg has performed near the bottom quartile.

HPU identifies the sewer system integrity benchmark as an area of preferred improvement with an initial target to move from bottom quartile (14.1 to 18.8 f/100mi.) performance to midrange performance (9.6 f/100mi.). Asset management will address this issue.
Figure 19 as shown below recaptures HPU progress for preventive cleaning that was completed between 2008 and 2017 by progressive sweep planning. Since 2008 HPU has cleaned 204 miles of sanitary sewer main, or 100.7% of system inventory of 201.4 miles. HPU will continue to perform flushing preventive maintenance and focus upon troubled areas that our CMMS system has identified as high probability for blockage.
VII. **SSMP Objective #8: Financial Benchmark**

Objective #8 required HPU to monitor its sewer enterprise fund financial indicators; reference is made to Fitch’s 2013 publication for:

- “% Household Median Income”
- “Debt Coverage Ratio”
- “Liquidity”
- “R&R Ratio”

- The ratio of Harrisonburg 5000 gallon per month of water plus sewer to the Draper Aden statewide residential average is: 0.58 ($42.23 /mo. City rates vs. $71.61/mo. state average)

- The ratio of Harrisonburg 5000 gallon per month of sewer only to the Draper Aden statewide residential average is: 0.67 ($27.60 /mo. City rates vs. $41.47/mo. state average)

- **Residential Rates = 1.07% (Household Median Income) HMI**; where FY2017 annual water plus sewer = $42.23/yr.; HMI = $47,420 / yr.:

  - Fitch rating “Stronger” 1.2% HMI
  - Fitch rating “Midrange” 1.5% HMI
  - Fitch rating “Weaker” 2.0% HMI

- The ratio of Harrisonburg 1 MGD gallon per month (industrial) of water plus sewer to the Draper Aden statewide average is: 0.63 ($8,162 /mo. City rates vs. $13,054/mo. state average)

- The ratio of Harrisonburg 1 MGD gallon per month (industrial) of sewer only to the Draper Aden statewide residential average is: 0.73 ($5,450 /mo. City rates vs. $7,490/mo. state average)

- **Sanitary Sewer Liquidity = 40%;** where Fund Balance = $4,381,747 to Cash Revenue = $10,823,395:

  - Upper Limit “Stronger” 50%
  - Liquidity Target “Midrange” 37%
  - Lower Limit “Weaker” 25%


• Debt coverage Ratio = 1.47 including HRRSA debt and infinity excluding HRRSA debt; where revenue less operating = $4,201,733. HRRSA debt = $2,851,982 and there was no City debt

  Fitch rating “Stronger”  2.00
  Fitch rating “Midrange”  1.50
  Fitch rating “Weaker”  1.25

• % CARV Ratio = 2.5%; where EOY CIP balances = $2,563,286; asset replacement value = $100,694,722

  Fitch rating “Stronger”  5.00%
  Fitch rating “Midrange”  3.50%
  Fitch rating “Weak”  2.00%

• Sewer Capital To Depreciation Ratio = 1.31; where Sewer Capital (no city debt) = $1,575,000; Sewer Asset Depreciation $1,205,906. Target ratio = 1.0. In FY 2017 HPU provided capital funding that exceeded the annual depreciation of its sewer assets; however, this pattern is not sustainable due to the one time use of unappropriated balance. (HPU favored capital funding over liquidity in the FY 2017 budget)

In summary, the City of Harrisonburg residential and industrial water and sanitary rates can be categorized as very strong and below the Draper Aden state averages for all benchmarks referenced above. With this knowledge consideration must be given to possible rate increases in the future to support balancing sanitary sewer capital to asset depreciation ratio. Rehabilitation and replacement of the City’s sanitary sewer infrastructure at a minimum should be performed at the same rate of depreciation. Rate increases would also positively influence the City’s standing for liquidity, debt coverage ratio and % CARV ratio. Having stable and strong benchmarks discussed above also improves bond fund availability if those funds are being perused for capital improvement projects.