Prepared for: City of Middletown
Project Title: Collection System Pipeline Condition Assessment
Project No.: 152919

Technical Memorandum

Subject: Pipeline Condition Assessment Technical Memorandum
Date: July 2019
To: Scott Tadych, PE, Director of Public Works and Utilities
From: Nakita Lancaster

Prepared by: Nakita Lancaster, Project Manager

Reviewed by: Steve Donovan, Technical Advisor
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Background

The City of Middletown entered into a Consent Decree with the U.S. EPA and Ohio EPA (OEPA) in April 2018 to address Combined Sewer Overflows (CSO). This condition assessment is both a requirement of the Consent Decree and associated Long Term Control Plan (LTCP) [1], as well as the City’s National Pollutant Discharge Elimination System (NPDES) permit.

During the development of the City’s LTCP in 2013, Brown and Caldwell generated a Replacement Planning Model (RPM) for the entire collection system, including combined, sanitary, and storm sewer. This 2013 RPM was used to support an Affordability Analysis that is detailed in the City’s LTCP. The RPM was used to develop a high-level cost estimate of the probable City budget cost needs for asset repairs, rehabilitation, and replacement (renewal) over a 25-year period. The cost estimate was based on then current assumed remaining useful service life for systems assets. The RPM projected the City would need to expend a total of $142M in collection system renewal over the 25-year period, or an average of approximately $5.7M per year to address assets that have already exceeded or are approaching the end of their estimated remaining useful service life. The cost estimate is based in 2013 dollars and serves to provide an approximate order of magnitude for the required collection system investment.

The OEPA implements CSO controls through provisions included in the NPDES permit program. The OEPA issued the City a NPDES permit on March 30, 2016 (effective date – May 1, 2016) allowing for discharge from the wastewater treatment works. The City’s NPDES permit was issued in accordance with conditions including a requirement that the City develop and implement a Capacity, Management, Operation, and Maintenance (CMOM) Plan. This condition assessment plan is part of the City’s efforts to implement their CMOM Plan.

Improvements to the City’s combined and sanitary sewer systems are required to keep the systems functioning properly, provide a level of service acceptable to the community, and prevent unpermitted overflows. The objective of this project is to provide the City with an efficient and logical means to actively assess the condition of its aging sanitary and combined sewer infrastructure and make needed improvements on a prioritized basis. This will also assist in CMOM Plan implementation, abate costly emergency repairs, and comply with the requirements of the Consent Decree and NPDES permit.
Purpose
In accordance with the LTCP, the City needs to inspect its combined and sanitary sewer systems to perform a condition assessment and develop a plan for asset replacement and rehabilitation. As outlined in this document, a prioritized approach to inspection based on known data will be implemented so that the highest risk assets are inspected first. The objective of this project is to develop a four-year inspection plan and schedule that is prioritized by asset risk of failure.

Approach
The following sections detail the approach employed to assign each asset a consequence of failure (COF) score, probability of failure (POF) score, and risk of failure score, and describe how these scores were used to develop a prioritized inspection plan and schedule.

Data Collection and System Characterization
Data was collected and analyzed via GIS shapefiles of the collection system provided by the City. Assets analyzed included combined and sanitary sewer pipes; storm sewers were not part of this analysis. Sanitary and combined sewers marked as “abandoned” in GIS were also not included in the analysis. In addition, the North Interceptor was not included, as these pipes were already scheduled for inspection in 2018. This left a total of 5,869 gravity conduits and 28 force mains to be analyzed.

The GIS data were reviewed and where data was incomplete or missing, the following assumptions were made to characterize the City’s sanitary and combined sewer assets:

- 150 pipes were missing diameters. In these cases, the diameter of the nearest downstream pipe was used.
- 335 pipes were missing pipe material in both GIS and the RPM data. To populate this field, pipes missing material data were joined with spatially connected pipes and assigned the material provided in GIS. This method populated material data for 100 of the 335 pipes. The remaining 235 pipes were assigned materials using the assumptions found in Table 1, which are the same assumptions used to develop the RPM in 2013.

<table>
<thead>
<tr>
<th>System Type</th>
<th>Diameter (inches)</th>
<th>Installation Year</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined</td>
<td>&lt;=24</td>
<td>&lt;1950</td>
<td>VCP</td>
</tr>
<tr>
<td></td>
<td>&lt;=24</td>
<td>&gt;1950</td>
<td>RCP</td>
</tr>
<tr>
<td></td>
<td>&gt;24 and &lt;=48</td>
<td>Any</td>
<td>Brick</td>
</tr>
<tr>
<td></td>
<td>&gt;48</td>
<td>Any</td>
<td>CMP</td>
</tr>
<tr>
<td>Sanitary</td>
<td>Any</td>
<td>&lt;1975</td>
<td>VCP</td>
</tr>
<tr>
<td></td>
<td>&lt;=15</td>
<td>&gt;=1975</td>
<td>Truss</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>&gt;=1975</td>
<td>PVC</td>
</tr>
</tbody>
</table>
Consequence of Failure Analysis

Consequence of failure (COF) is defined as the impact that an asset would have on the surrounding community and environment upon failure, including inconvenience to the public, increased public health and safety risks, property damage, and environmental damage. COF also considers the costs of asset repair upon failure.

Conduits were assigned COF scores based on system type, size, and location. Depth was originally considered to be part of the COF scoring process, however, due to the amount of missing or unrealistic invert data, assigning each pipe an accurate depth was determined to be infeasible.

Each pipe was given a score from 1 to 5 for each of the COF categories, with 1 representing the lowest COF, and 5 representing the highest. Then, a weighted sum was used to determine the total COF score for each pipe.

The first factor considered for scoring the COF of each pipe was the system type. Sanitary sewers were assigned a COF score of 5, while combined sewer received a score of 1. Combined sewer was assigned a lower score than sanitary sewer due to the diluted nature of the sewage, resulting in less severe environmental and public health impacts upon failure. When calculating the total COF score for each pipe, the system type score was given a weight of 10%.

The next factor considered for scoring the COF was the pipe diameter. Larger pipes are typically costlier to repair than smaller pipes and tend to have a more significant environmental and public health impact upon failure due to the larger volume of conveyed flow. Pipes with a diameter greater than 33-inches were given a score of 5, pipes with a diameter between 10-inches and 33-inches were given a score of 3, and pipes with a diameter of 8-inches or less were given a score of 1. When calculating the total COF score for each pipe, the pipe diameter score was assigned a weight of 40%.

The final factor used in determining COF scores was the pipe location. Location scores were determined using spatial analysis methods in GIS and consider the effect of a pipe’s location on the resulting impacts to the public, the environment, and the replacement cost upon failure. Pipes in the following locations were considered to have a high COF and were assigned a score of 5:

- Intersecting a railroad
- Within 100’ of the “water body”, “pond”, or “lake” GIS shapefiles (not including drainage ditches)
- Within 10’ of a street centerline with the attribute “arterial” or “interstate”
- Within 15’ of a building
- Within 100’ of the Atrium Medical Center
- Within 100’ of a parcel owned by the Middletown Board of Education
- Within 100’ of 1 Donham Plaza, which houses City Hall, the Police Station, and the Fire Station
- Within 100’ of the wastewater treatment plant or water treatment plant

Pipes in the following locations were considered to have a moderate COF and assigned a score of 3:

- Within 10’ of a street centerline with the attribute “local” or “secondary”
- Within 10’ of a parcel with the attribute “commercial” (not including vacant commercial lots)

All other pipes were given a COF location score of 1. When calculating the total COF score for each pipe, the location score was given a weight of 50%. Each pipe’s weighted COF score was then rounded to the nearest whole number.

As an example, a 36-inch combined pipe within 10-ft of a secondary street would receive a system type score of 1, a pipe diameter score of 5, and a location score of 3. Applying the weights to each score yields an overall COF score of 1(0.1) + 5(0.4) + 3(0.5) = 3.6, which rounds up to a 4.

Table 2 summarizes the COF scores assigned to the analyzed combined and sanitary sewer pipe.
As shown in Table 2, less than 4% of the pipes were scored as having the highest COF of 5, with the majority of the pipes being assigned scores of 2 or 3. Figure 1 depicts the geographic distribution of COF scores across the City’s combined and sanitary sewer system.

![COF Score Map](image)

The figure shows that COF scores generally increase across the service area as flows are conveyed west towards the north interceptor, which is expected due to increasing pipe size and increased density of development. In addition, there are high COF scores along the east interceptor, which conveys flow directly to the WWTP.
wastewater treatment plant in the southwest. The lowest COF scores are generally located in the northeast, where pipe sizes and density of development are the lowest.

**Probability of Failure Analysis**

Probability of failure (POF) is defined as the likelihood of asset failure, based on an asset’s physical condition. The Replacement Planning Model (RPM) was used to assign an estimated year of replacement for each pipe, which was then used to assign POF scores. Replacement years are based on the remaining useful lives (RULs) of the assets at the current time. To calculate RULs, the RPM employs methodologies developed in New Zealand and documented in Version 1.1 of the New Zealand Infrastructure Management Manual [2], with certain modifications and additions by Brown and Caldwell.

The methodology used to estimate RUL is shown graphically in Figure 2. For this analysis, the “Adjust for Use” and “Modify for Performance” functions were not deemed appropriate for the level of detail needed for this model and due to the limited amount of data available for those functions.

![Figure 2. RPM Remaining Useful Life Logic](image)

Projecting the RUL of collection system assets was achieved by several adjustments in the RPM:

1. **Age**: Adjustment by a formula in the RPM. This is an actuarial calculation that will increase the total expected useful life if an asset has been in place for some time and survived early failure. If an asset has been in service for an appreciable portion of its class life, then its expected useful life is extended. This is based on the principle that early failures within that class will have already occurred, and surviving assets are members of a group of assets with average useful lives longer than the class life (which is the life expected when the asset is placed in service).

   **Example**: This example uses a hypothetical class life of 40 years for pumps. As of 2019, a pump has been in place for 25 years, 62.5 percent of its class life. The actuarial adjustment curve indicates that its expected total useful life is now 45.45 years, 4.45 years longer than its class life (that is, its life expectancy when installed).

2. **Material**: Each pipe material in the RPM is assigned an expected useful life and a condition rating to allow the RUL to be calculated. The expected useful lives were assigned based on experience from other projects, publication review, and web-based review. Since the actual condition of the pipes is mostly unknown, the material condition ratings were assigned based on conversations with the City. It is important to note that the expected useful life, along with the condition rating, is used to adjust the calculation of the remaining useful life for each pipe, and does not necessarily reflect the actual condition of the individual pipes in the system. Table 3 summarizes the expected useful lives and condition ratings assigned to each pipe material in the RPM.
The RPM identified estimated years of replacement ranging from 4 to 86 years for the analyzed pipes. Table 4 summarizes the resulting POF scores based on estimated year of replacement.

As shown in the table, approximately half of the pipes (by length) were determined to have an estimated year of replacement of 31 to 86 years by the RPM. Pipes in this range were assigned the lowest POF score of 1. To maintain objectivity in the scoring, the remainder of the POF scores (2-5) were assigned such that the distribution of pipe lengths was approximately equivalent for each score. Figure 3 depicts the geographic distribution of POF scores across the City’s combined and sanitary sewer system.
The figure shows that the highest concentration of POF scores occurs in the older, heavily developed business district just east of the north interceptor, which is expected as these pipes tend to have an older average age than the rest of the system. In addition, many of these pipes with POF scores of 5 are corrugated metal pipes, which have a low expected useful life of 50 years and a “poor” condition rating. This also explains why the majority of the east interceptor sewer received a POF score of 5, as it is mostly constructed of corrugated metal. Many of the other pipes scattered throughout the system with POF scores of 5 are ABS pipes, which also have a low expected useful life of 50 years.

**Risk Model**

The risk of failure score for a pipe is defined as the product of that pipe’s COF and POF scores. However, pipes with an estimated year of replacement greater than 30 years (POF score of 1) were automatically assigned a risk score of 1, regardless of the COF score. This was done to help better prioritize pipe inspections, which should be focused on pipes with an estimated year of replacement of less than 30 years based on the
City’s LTCP timeline for pipe replacement and rehabilitation. To maintain objectivity in the scoring, the remainder of the risk scores (2-5) were assigned such that the distribution of pipe lengths was approximately equivalent for each score. Table 5 summarizes the risk scores for the analyzed pipes.

<table>
<thead>
<tr>
<th>Score</th>
<th>COF * POF Range</th>
<th>Pipe Length (ft)</th>
<th>% of Total Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>595,715</td>
<td>48.9%</td>
</tr>
<tr>
<td>2</td>
<td>2-5</td>
<td>90,723</td>
<td>7.5%</td>
</tr>
<tr>
<td>3</td>
<td>6-8</td>
<td>208,426</td>
<td>17.1%</td>
</tr>
<tr>
<td>4</td>
<td>9-12</td>
<td>174,445</td>
<td>14.3%</td>
</tr>
<tr>
<td>5</td>
<td>15-25</td>
<td>148,609</td>
<td>12.2%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,217,956</td>
<td>100%</td>
</tr>
</tbody>
</table>

As shown in the table, approximately half of the analyzed pipes were assigned a risk score of 1 based on their POF scores of 1. Applying the approximately equivalent scoring distribution described above to the remainder of the pipes results in approximately 12% of the analyzed pipes receiving the highest risk score of 5.

Figure 4 depicts the geographic distribution of risk scores across the City’s combined and sanitary sewer system.
As expected based on the COF and POF scores, the figure clearly shows that the highest risk density occurs in the business district just east of the north interceptor. In addition, the east interceptor has a high risk of failure and should be prioritized for inspection.

**Inspection Plan**

Once a risk score was calculated for each pipe segment, a prioritized inspection plan could be developed. The objective of this inspection plan is to prioritize inspection of all pipes with an estimated replacement year prior to 2040 (POF >1). To facilitate ease of scheduling and budgeting, an attempt was made to evenly distribute the length of pipe to be inspected each year over the four years. The inspection plan consists of two separate inspection schedules – one to be completed by the City and one to be completed by a contractor. The City is assumed to inspect the majority of pipes with a diameter less than 20 inches, while it is assumed that the inspection of most pipes 20 inches or larger in diameter will be completed by a contractor. Based on these assumptions, it is anticipated that the City will, on average, inspect approximately 123,000 feet of pipe per year and that 52,000 feet of pipe will be contracted out per year to meet the four-year schedule.

To develop a prioritized inspection plan and to optimize deployment of resources, pipes of similar risk scores were grouped into “clusters” based on geographic area. The sewer network was divided into 92 clusters, with each cluster containing an average of 7,500 feet of pipe. Figure 5 depicts the clusters overlaying the sewer system.

![Figure 5. Clusters overlaying the Risk Score Map](image)
The clusters were then used to develop the two separate inspection schedules. Pipe segments in each cluster were designated as “city inspection” or “contractor inspection” based on pipe diameter and connectivity. The average risk score of city/contractor pipes in each cluster was used to prioritize clusters by year for each inspection schedule. It should be understood that the average risk score for each cluster includes high risk pipes, as well as low risk pipes. Figure 6 shows the anticipated inspection year for clusters to be inspected by the City, while Figure 7 shows the anticipated inspection year for clusters to be inspected by a contractor. The number depicted inside each cluster is the prioritization rank for that cluster, with a rank of 1 being the highest priority.

Figure 6. City Inspection Clusters

The figure shows that the majority of the clusters to be inspected by the City in the first two years are located in the highly developed business district, which is expected based on the assigned risk scores.
The figure shows that most of the clusters to be inspected by a contractor are located in the highly developed business district. In addition, the east interceptor should be prioritized for early inspection by a contractor due to its high risk score.

Table 6 provides a yearly breakdown of pipe length to be inspected by both the City and the contractor.

<table>
<thead>
<tr>
<th>Year</th>
<th>City Inspection (ft)</th>
<th>Contractor Inspection (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>123,916</td>
<td>56,654</td>
</tr>
<tr>
<td>2</td>
<td>131,484</td>
<td>52,117</td>
</tr>
<tr>
<td>3</td>
<td>119,296</td>
<td>53,276</td>
</tr>
<tr>
<td>4</td>
<td>123,158</td>
<td>46,910</td>
</tr>
<tr>
<td>Total</td>
<td>497,855</td>
<td>208,958</td>
</tr>
</tbody>
</table>
The table shows that 706,813 feet of pipe are scheduled for inspection. This is approximately 58% of the City’s combined and sanitary sewers. Assuming the City is able to inspect 1,000 feet of sewer a day, inspections are estimated to take 24 weeks a year to complete.

It should be noted that some pipe segments with a risk score of 1 were included for inspection due to their proximity to higher risk pipes. For example, a pipe with a risk score of 1 was included for inspection if located between two pipes that are scheduled for inspection (pipes with a risk score of 2 or higher).

In some cases, a pipe with an unknown material was assigned a material based on the assumptions described in Table 1, resulting in a much higher assigned risk score than adjacent pipes with a known, different material. In these cases, the pipe with the assumed material was removed from the inspection plan if the assigned risk differed significantly from the adjacent pipes with known materials.
References


Attachment A: Condition Assessment Maps
Sanitary Regulators

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Priority = 1
- L.F. Inspected = 9,005 Feet

FM Inspection Schedule
- Cluster ID = 112
- Total L.F. of Pipe to be Inspected by the City = 497,784 Feet (all clusters, all years)
### City Field Inspection Schedule

<table>
<thead>
<tr>
<th>Pipe Cluster</th>
<th>Sanitary Pipes</th>
<th>Gravity Pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year-1</td>
<td>Year-2</td>
<td>Year-3</td>
</tr>
<tr>
<td>Year-4</td>
<td>Year-4</td>
<td>Year-5</td>
</tr>
</tbody>
</table>

**Cluster ID = 70**

**Priority = 2**

**Total L.F. Inspected = 2,794 Feet**

**Total L.F. of Pipe to be Inspected by the City = 497,784 Feet**

(all clusters, all years)
City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor
- Inspected Pipe

Cluster ID = 38
Priority = 5
L.F. Inspected = 3,272
Total L.F. of Pipe to be Inspected by the City = 497,784 Feet (all clusters, all years)
Sanitary Regulators

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

BM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Pipe
- Inspected Pipe

Cluster ID = 109
Priority = 9
L.F. Inspected = 5,578

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet (all clusters, all years)

City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

BM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Pipe
- Inspected Pipe

Cluster ID = 109
Priority = 9
L.F. Inspected = 5,578

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet (all clusters, all years)
Cluster ID = 99
Priority = 12
L.F Inspected = 3,340
Total L.F. of Pipe to be Inspected by the City = 497,784 Feet (all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 102
Priority = 13
L.F. Inspected = 9,124

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)

City Field Inspection Schedule
City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor
- Inspected Pipe

Cluster ID = 65
Priority = 15
L.F. Inspected = 4,552

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Sanitary Regulators

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 12
Priority = 16
L.F. Inspected = 6,015

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor

Inspected Pipe

Cluster ID = 26
Priority = 17
L.F Inspected = 5,603

Total L.F. of Pipe to be Inspected by the City
= 497,784 Feet
(all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 62
Priority = 18
L.F Inspected = 2,311

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)

City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 62
Priority = 18
L.F Inspected = 2,311

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 118
Priority = 20
L.F Inspected = 8,257

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Sanitary Regulators

5675

C

37409

400

Inspected by the City

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)

Legend

- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

<table>
<thead>
<tr>
<th>Year-1</th>
<th>Year-2</th>
<th>Year-3</th>
<th>Year-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM Inspection Schedule</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contractor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year-3</td>
<td>Year-2</td>
<td>Year-1</td>
<td>Year-4</td>
</tr>
<tr>
<td>Inspected Pipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster ID = 91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Priority = 24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.F Inspected = 2,976 Feet</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

City Field Inspection Schedule
City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

<table>
<thead>
<tr>
<th>Year</th>
<th>Year-1</th>
<th>Year-2</th>
<th>Year-3</th>
<th>Year-4</th>
</tr>
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<tr>
<td>2019</td>
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</tr>
</tbody>
</table>

Pipe Cluster
Cluster ID = 49
Priority = 29
L.F. Inspected = 5,854

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor

Inspected Pipe

Cluster ID = 92
Priority = 35
L.F. Inspected = 6,543

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Inspected by the City

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 37
Priority = 37
L.F Inspected = 6,633

City Field Inspection Schedule
City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

Cluster ID = 1
Priority = 38
L.F Inspected = 24,641

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 80
Priority = 43
L.F Inspected = 9,006

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet (all clusters, all years)

City Field Inspection Schedule
City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule

- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 55
Priority = 48
L.F Inspected = 16,514

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Sanitary MHs

A

Sanitary Regulators
Sanitary MHs
Sanitary Pipes

Pipe Cluster

Gravity Pipe

Inspection Schedule

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Legend

- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

<table>
<thead>
<tr>
<th>Year-1</th>
<th>Year-2</th>
<th>Year-3</th>
<th>Year-4</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>FM Inspection Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year-1</td>
</tr>
</tbody>
</table>

Legend

- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

City Field Inspection Schedule

Cluster ID = 23
Priority = 50
L.F Inspected = 7,337

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet (all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

FM Inspection Schedule

Cluster ID = 94
Priority = 52
L.F Inspected = 12,545

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 6
Priority = 53
L.F Inspected = 5,582

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet (all clusters, all years)
City Field Inspection Schedule

- **Sanitary Regulators**
- **Sanitary MHs**
- **Sanitary Pipes**
- **Pipe Cluster**

**Gravity Pipe Inspection Schedule**

- **Year-1**
- **Year-2**
- **Year-3**
- **Year-4**
- **FM Inspection Schedule**

- **Cluster ID** = 64
- **Priority** = 55
- **L.F Inspected** = 9,360

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet (all clusters, all years)
<table>
<thead>
<tr>
<th>Pipe Cluster</th>
<th>Sanitary MHs</th>
<th>Gravity Pipe Inspection Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>L.F Inspected = 3,786 Priority = 56</td>
</tr>
<tr>
<td>FM Inspection Schedule</td>
<td>Year-1</td>
<td>Year-2</td>
</tr>
<tr>
<td>Cluster ID = 7</td>
<td>Total L.F. of Pipe to be Inspected by the City = 497,784 Feet (all clusters, all years)</td>
<td></td>
</tr>
</tbody>
</table>

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

City Field Inspection Schedule
City Field Inspection Schedule

FM Inspection Schedule

Gravity Pipe

Inspection Schedule

- Year-1
- Year-2
- Year-3
- Year-4

Pipe Cluster

Sanitary Pipes

Inspected by the City

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet

(all clusters, all years)

Legend

- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Cluster ID = 81
Priority = 60
L.F. Inspected = 9,743

Sanitary Pipes

Boylston St
Dickens Ave
98719

Vancouver St
Trafalgar Ct

Roosevelt Ave

Baker Ct

Dover Ave

Comerce Dr

Martha Dr
0 200 400 Feet

Legend

- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe

Inspection Schedule

- Year-1
- Year-2
- Year-3
- Year-4

Pipe Cluster

Sanitary Pipes

Inspected by the City

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet

(all clusters, all years)
City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

<table>
<thead>
<tr>
<th>Year-4</th>
<th>Year-3</th>
<th>Year-2</th>
<th>Year-1</th>
<th>Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend
- Inspected Pipe
- Gravity Pipe

FM Inspection Schedule

Cluster ID = 61
Priority = 61
L.F Inspected = 874

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster
Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe
Cluster ID = 84
Priority = 63
L.F. Inspected = 2,137
Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor
- Inspected Pipe

Cluster ID = 96
Priority = 64
L.F. Inspected = 18,756
Total L.F. of Pipe to be Inspected by the City = 497,784 Feet (all clusters, all years)
Sanitary Regulators
Sanitary MHs
D

Sanitary Pipes
Pipe Cluster

Gravity Pipe
Inspection Schedule

FM Inspection Schedule

Cluster ID = 132
Priority = 68
L.F Inspected = 4,719

Total L.F. of Pipe to be Inspected by the City
= 497,784 Feet
(all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4

Cluster ID = 93
Priority = 69
L.F. Inspected = 2,008

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule

- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 131
Priority = 73
L.F Inspected = 5,927

Total L.F of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Sanitary Regulators

Gravity Pipe Inspection Schedule

Year-1
Year-2
Year-3
Year-4

Sanitary Pipes

Legend

- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)

Cluster ID = 130
Priority = 74
L.F. Inspected = 2,801

City Field Inspection Schedule

[Map Image]
City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Pipe Cluster

Sanitary Regulators
Sanitary MHs
Sanitary Pipes
Pipe Cluster

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 72
Priority = 75
L F Inspected = 3,629

Total L F of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 72
Priority = 75
L F Inspected = 3,629

Total L F of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- Contractor Inspected Pipe

Cluster ID = 72
Priority = 75
L F Inspected = 3,629

Total L F of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
City Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

- Year-1
- Year-2
- Year-3
- Year-4

FM Inspection Schedule

Cluster ID = 123
Priority = 77
L.F. Inspected = 2,802

Total L.F. of Pipe to be Inspected by the City = 497,784 Feet
(all clusters, all years)
Cluster ID = 100
Priority = 2
L.F. Inspected = 10,761
Total L.F. of Pipe to be Inspected by the Contractor = 209,517 Feet
(all clusters, all years)
<table>
<thead>
<tr>
<th>Cluster ID</th>
<th>Priority</th>
<th>L.F. Inspected</th>
<th>Total L.F. of Pipe to be Inspected by the Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>3</td>
<td>6,724</td>
<td>209,517 Feet (all clusters, all years)</td>
</tr>
</tbody>
</table>

**Legend**
- **Sanitary Regulators**
- **Sanitary MHs**
- **Sanitary Pipes**
- **Pipe Cluster**
- **Gravity Pipe**
- **Inspection Schedule**
  - Year-1
  - Year-2
  - Year-3
  - Year-4
  - City Inspected Pipe

**Contractor Field Inspection Schedule**

City Inspected Pipe

Pipe Cluster

Gravity Pipe

[Map of Middletown, Ohio with marked locations and inspection data]

Legend: [Symbol for gravity pipes]
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary MHs
- Pipe Cluster

Gravity Pipe Inspection Schedule

- Year-1
- Year-2
- Year-3
- Year-4
- City Inspected Pipe

Cluster ID = 107
Priority = 4
L.F. Inspected = 4,319

Total L.F. of Pipe to be Inspected by the Contractor = 209,517 Feet
(all clusters, all years)
Sanitary Regulators

Sanitary MHs

Sanitary Pipes

Pipe Cluster

Legend

- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe
Inspection Schedule

- Year-1
- Year-2
- Year-3
- Year-4
- City Inspected Pipe

Cluster ID = 122
Priority = 13
L.F. Inspected = 6,642

Total L.F. of Pipe to be Inspected by the Contractor = 209,517 Feet
(all clusters, all years)
Sanitary Regulators

Gravity Pipe Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Cluster ID = 32
Priority = 23
L.F. Inspected = 7,689

Total L.F. of Pipe to be Inspected by the Contractor = 209,517 Feet
(all clusters, all years)

Contractor Field Inspection Schedule

0 200 400 Feet
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe
Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- City Inspected Pipe

Cluster ID = 33
Priority = 25
L.F. Inspected = 14,318

Total L.F. of Pipe to be Inspected by the Contractor = 209,517 Feet
(all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster
Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- City Inspected Pipe

Cluster ID = 120
Priority = 27
L.F. Inspected = 4,118
Total L.F. of Pipe to be Inspected by the Contractor = 209,517 Feet
(all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

<table>
<thead>
<tr>
<th>Year-1</th>
<th>Year-2</th>
<th>Year-3</th>
<th>Year-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Orange</td>
<td>Blue</td>
<td>Green</td>
</tr>
</tbody>
</table>

Cluster ID = 98
Priority = 28
L.F. Inspected = 10,016

Total L.F. of Pipe to be Inspected by the Contractor = 209,517 Feet
(all clusters, all years)
Sanitary Regulators

Gravity Pipe Inspection Schedule

<table>
<thead>
<tr>
<th>Year-1</th>
<th>Year-2</th>
<th>Year-3</th>
<th>Year-4</th>
<th>City Inspected Pipe</th>
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<tbody>
<tr>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
<td>Feet</td>
</tr>
<tr>
<td>3,103</td>
<td>3,103</td>
<td>3,103</td>
<td>3,103</td>
<td>3,103</td>
</tr>
</tbody>
</table>

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Cluster ID = 38
Priority = 30
L.F. Inspected = 3,103

Total L.F. of Pipe to be Inspected by the Contractor = 209,517 Feet
(all clusters, all years)
Sanitary MHs
400
863
2013
1878
A
1983
2032
1881
2001
Sanitary Regulators
1994
2035
2019
54439
1880
922
1978
918
88030
1875
2008
Image 18x18 to 1206x774

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe
Inspection Schedule

Inspected by the Contractor
Total L.F. of Pipe to be
Inspected = 10,104
Priority = 33
L.F. Inspected = 10,104

Cluster ID = 49

Total L.F. of Pipe to be
Inspected by the Contractor
= 209,517 Feet
(all clusters, all years)
Contractor Field Inspection Schedule

Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

Cluster ID = 121
Priority = 36
L.F. Inspected = 1,904

Total L.F. of Pipe to be Inspected by the Contractor = 209,517 Feet
(all clusters, all years)
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster

Gravity Pipe Inspection Schedule

<table>
<thead>
<tr>
<th>Year-1</th>
<th>Year-2</th>
<th>Year-3</th>
<th>Year-4</th>
<th>City Inspected Pipe</th>
</tr>
</thead>
</table>

Cluster ID = 28
Priority = 40
L.F. Inspected = 1,732

Total L.F. of Pipe to be Inspected by the Contractor = 209,517 Feet (all clusters, all years)

Contractor Field Inspection Schedule

City of MIDDLETOWN
OHIO
Legend
- Sanitary Regulators
- Sanitary MHs
- Sanitary Pipes
- Pipe Cluster
Gravity Pipe Inspection Schedule
- Year-1
- Year-2
- Year-3
- Year-4
- City Inspected Pipe

Cluster ID = 34
Priority = 42
L.F. Inspected = 913
Total L.F. of Pipe to be Inspected by the Contractor = 209,517 Feet
(all clusters, all years)