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**Project name:**
MSD Odor Control Master Plan

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**FINAL**

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# Memo

**Subject:** Technical Memorandum #7B- Collection System Current Odor Technologies Performance Evaluation

# 1. Introduction

## 1.1 Background

In response to receiving a Notice of Violation (NOV) in November 2019 for failure to control odors from the Morris Forman Water Quality Treatment Center (MFWQTC) and its collection system, the Louisville Metropolitan Sewer District (MSD) entered into an agreed order with the Louisville Metro Air Pollution Control District (APCD) to develop and implement a phased district-wide Odor Control Master Plan. MSD has contracted AECOM to provide MSD with professional engineering services for the development of Phase I of the Odor Control Master Plan which is focused on the Morris Forman Service Area. MSD also contracted a public relations firm to increase public engagement and communications during the development and implementation of the phased Odor Control Master Plan.

The Morris Forman combined sewer collection system serves approximately 134 square miles across Jefferson County, Kentucky. Wastewater throughout the service area is collected and conveyed by approximately 1,910 miles of sewer to the MFWQTC for subsequent treatment. There are currently thirteen (13) main gravity trunk sewers, (2) major force mains, and 139 pump stations in the MFWQTC service area. Figure 1 shows an overview of the MFWQTC collection system including service area boundaries, pump stations, major gravity trunk sewers, force mains, and the location of MFWQTC.

MSD has made several odor control improvements within the collection system. Beginning in April 2014, MSD contracted a third-party firm to perform routine chemical dosing at various locations. To assess the odor removal efficiency of chemical dosing, gaseous hydrogen sulfide ($H_2S$) and liquid nitrate sampling were also performed each quarter. MSD has continued chemical dosing and monitoring within the collection system as outlined in the MSD Collection System Calcium Nitrate Solution Supply and Odor Control Service Bid.

In March 2018, MSD contracted a Consultant to perform an odor evaluation on the Ohio River Force Main (ORFM) air relief valve (ARV) locations in the northeast portion of the Morris Forman Service Area. Multiple improvements were implemented as a result of this study which were shown to significantly reduce $H_2S$ levels in the ORFM area. These improvements included:

1. Installation of biofilter system at an air release valve (ARV) (2018)
2. Closure of the smaller diameter barrel on a portion of the ORFM (2018)
3. Construction of an oxygen injection system at a Pump Station (PS) (2021)

These odor control systems were shown to significantly reduce $H_2S$ levels in the ORFM area. However, the systems are designed to only improve the force main area they are directly treating. Odor issues in other portions of the Morris Forman service area are not impacted by these odor control systems. Other areas within the Morris Forman service area will be evaluated for odor control improvements as part of the odor control master plan.

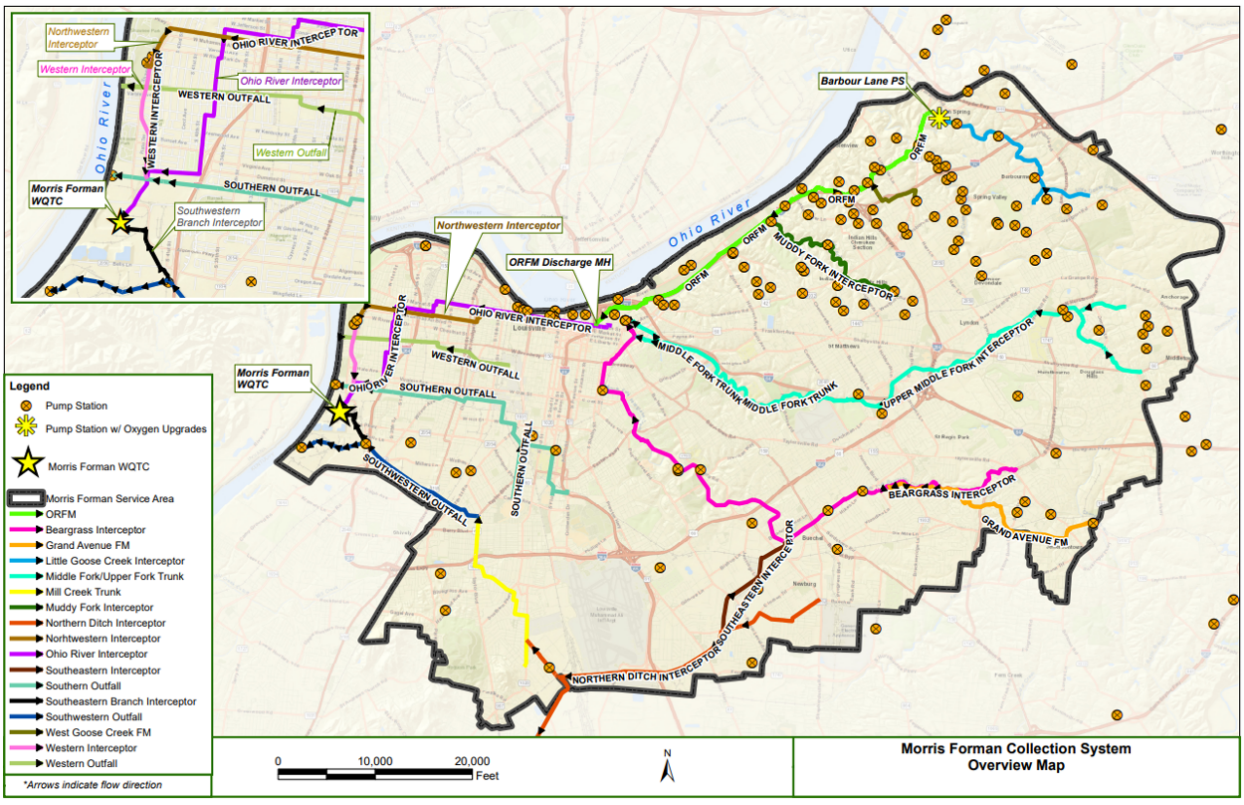


**Figure 1: MFWQTC Collection System Overview**

## 1.2 Purpose

During the previous phases of the Odor Control Master Plan, AECOM compiled and examined the existing odor control reports and data pertaining to the collection system. This memorandum is intended to review historical sampling data and new data collected during the 2021 and 2022 sampling campaigns to evaluate the performance of odor control systems and technologies within the collection system. The main objectives of this report are to:

1. Summarize the effectiveness of calcium nitrate (Bioxide) injections, the ARV Biofilter, and the oxygenation system located within the collection system
2. Determine if additional odor control technologies and systems are required within the collection system
3. Incorporate findings from this TM#7B, Collection System Current Odor Control Technologies Performance Evaluation into TM#8, New Odor Control Technologies Performance Evaluation, and TM#9, Odor Control Conceptual Design

## 1.3 Previous Documentation and Implementation Schedule

In accordance with the agreed order, MSD has submitted several documents to APCD to demonstrate ongoing odor control efforts. Table 2 shows MSD's completed and ongoing efforts towards the APCD agreed order.

**Table 1: Phase I Master Plan Implementation Schedule**

| Title | | Due Date | Status |
|---|---|---|---|
| TM#1 | Morris Forman WQTC Background Document Review | Q1 2021 | Completed |
| TM#2 | Collection System Background Document Review | Q2 2021 | Completed |
| TM#3 | Pump Stations Background Document Review | Q2 2021 | Completed |
| TM#4 | WQTC, Pump Stations and Combined Sewer System Planned Process Modifications | Q1 2021 | Completed |
| TM#5 | Current WQTC, Pumping Stations and Combined Sewer System Odor Impact Evaluation | Q2 2021 | Completed |
| TM#6A, TM#6B, TM #6C | Morris Forman WQTC (TM#6A), Collection System (TM #6B), and Pump Stations (TM #6C) Sampling Phase Results Analysis | Q4 2022 | Completed |
| TM#7A<br>TM#7B<br>TM#7C | Morris Forman WQTC Current Odor Technologies Performance Evaluation<br>Collection System Current Odor Technologies Performance Evaluation<br>Pump Stations Current Odor Technologies Performance Evaluation | Q4 2022 | Completed |

| | | | |
|---|---|---|---|
| **TM#8** | **New Odor Control Technologies Recommendation** | **Q4 2022** | **Ongoing*** |
| **TM#9** | **Odor Control Conceptual Design** | **Q4 2022** | **Ongoing*** |
| **Odor Control Master Plan Phase I Final Report** | | **Q4 2022** | **Ongoing**** |

**- TM#8 and TM#9 will be submitted following the completion of TM #7.*
***- The Final Odor Control Master Plan Phase I Final Report will be a comprehensive document which includes information about the Morris Forman Collection System, WQTC, and selected pump stations.*

Please refer to TM#2, TM#5, and TM#6B for details relating to the data review, odor impact evaluation, and sampling results prior to the development of this report.

# 2. Design and Operational Performance Review

## 2.1 Previous Odor Control System Review

Prior to the development of this report, a detailed review of existing documentation was performed in relation to odor control within the Morris Forman Collection System. Background documentation included previous studies, reports, and field sampling data to gain an understanding of MSD's odor control efforts to date and to investigate current odor conditions in specific areas of the collection system. Key findings from the background documentation review process for the Morris Forman Collection System can be found in TM#2.

### 2.1.1 Bioxide Injections and Gaseous $H_2S$ Sampling

Beginning in April 2014, MSD contracted with a third-party firm to perform routine chemical dosing and $H_2S$ monitoring at target locations in the wastewater collection system, with the overarching goal of improving odor emissions at the ORFM ARVs and force main terminus. According to the July 2020 Invitation to Bid (ITB), a total of nine (9) chemical feed systems were installed within the Morris Forman service area. These feed systems are operated seasonally when H2S is elevated within the system. In addition to chemical dosing, $H_2S$ monitoring at locations downstream of the Bioxide injections was performed to evaluate the effectiveness of the injections on removing odorous compounds within the distribution system.

Most of the Bioxide feed and sampling locations are located outside of the Morris Forman service area and therefore are outside of the study area for this TM. Within the study area, the majority of Bioxide feed and sampling sites are located towards the northeast. Dosing rates for each Bioxide dosing site were provided to MSD quarterly – in March, May, July, and October of each calendar year.

Monitoring locations were selected by MSD / third-party firm to assess the efficiency of $H_2S$ reduction with Bioxide. Each of these $H_2S$ monitoring sites were related to the associated upstream chemical dosing site(s) based on flow path, and a summary of the $H_2S$ monitoring results is presented for each monitoring location in Table 2. A 10 ppm maximum $H_2S$ concentration, defined in the "Ohio River Force Main Odor Study" by Consultant was used to highlight locations with elevated $H_2S$ concentrations. This threshold is higher than the concentration when corrosion begins (5 ppm) and is higher than the odor threshold for $H_2S$ (10 ppb). However, MSD is only required to meet the APCD $H_2S$ threshold of 161 ppm at the odor source. Therefore the 10 ppm maximum concentration is only used for the third-party firm Bioxide injection study and the Ohio River Force Main Odor Study, and the APCD standard of 161 ppm was used for the 2021-2022 sampling study. It is also important to note

that the $H_2S$ monitoring was not performed during periods without Bioxide injection. As a result, the $H_2S$ removal efficiency of Bioxide is not easily observable.

**Table 2: MFWQTC Collection System $H_2S$ Sampling From 2018-2020**

| Location Number | $H_2S$ Monitoring Period | Average $H_2S$ Concentration (ppm) | | | |
|---|---|---|---|---|---|
| | | 2018 | 2019 | 2020 | 2018-2020 |
| 1 | Oct 2019 – Current | N/A | Low | Low | Low |
| 2 | Jan 2018 – Current | Low | Low | Low | Low |
| 3 | June 2018 – Current | Low | High | Low | Low |
| 4 | Sept 2019 – Current | N/A | High | High | High |
| 5 | Sept 2019 – May 2020 | N/A | Low | Low | Low |

Consistent with average monthly $H_2S$ concentrations, the highest peak $H_2S$ concentration was reported at the ORFM monitoring locations, with a maximum $H_2S$ reading at Location #4 ARV and at Location #3 Discharge Manhole. When ORFM chemical dosing rates were at their highest in the summer of 2018, the Location #3 still showed peak $H_2S$ readings in July and in October. High peak $H_2S$ concentrations were observed at these locations multiple times each month. The monitoring location associated with one of the dosing locations (Pump Station #2) also showed significant peak $H_2S$ levels, with a maximum concentration in July 2018, and additional spikes in June 2019, September 2019, June 2020, July 2020, and October 2020. The monitoring location downstream of another dosing site also consistently showed relatively high $H_2S$ concentrations, with a maximum reading of in September 2020. These results suggested a low $H_2S$ reduction efficiency at the Bioxide injection locations, particularly at the ORFM and Pump Station #2 dosing locations.

### 2.1.2 Ohio River Force Main Odor Study $H_2S$ Sampling

In response to odor complaints at odor hotspots along the ORFM, gaseous $H_2S$ concentrations were monitored at nine (9) locations as a part of the Ohio River Force Main Odor Study (CH2M, 2018). Four (4) of the locations were at ARVs, and the remaining five (5) were located at critical manholes or connection points. The monitoring period was continuous from April 26, 2017 through May 9, 2017.

Peak and average vapor $H_2S$ concentrations obtained during this sampling campaign are shown in Table 3. Three ARVs and the ORFM Discharge Manhole all had peak $H_2S$ concentrations exceed the maximum acceptable threshold of 10 ppm. These results prompted the testing and future implementation of a biofilter at an ARV and an oxygenation system at an MSD Pump Station.

**Table 3: ORFM/ORI $H_2S$ Monitoring Summary, April-May 2017**

| Location Number | Location Description | Peak $H_2S$ Conc. (ppm) | Average $H_2S$ Conc. (ppm) |
|---|---|---|---|
| 1 | ARV | Low | Low |
| 2 | ARV | High | Low |
| 3 | ARV | High | Low |
| 4 | ARV | High | High |
| 5 | ORFM Discharge Manhole | High | High |

| Location Number | Location Description | Peak $H_2S$ Conc. (ppm) | Average $H_2S$ Conc. (ppm) |
|---|---|---|---|
| 6 | Force Main Discharge Manhole | Low | Low |
| 7 | Ohio River Interceptor (ORI) | Low | Low |
| 8 | ORI | Low | Low |
| 9 | ORI | Low | Low |

### 2.1.3 ARV Biofilter

A biofilter pilot was installed at  an ARV as a part of the Ohio River Force Main Odor Study (2018). The biofilter system consisted of two stages; the first stage involved a 4-ft by 8-ft precast tank with 3 feet of biofilter media (Bohn brand), and the second stage included a 4-ft by 8- ft precast tank with 3 feet of activated carbon media. This field test was initiated to evaluate the $H_2S$ reduction efficiency of the proposed ARV biofilter system and its potential implementation across the ORFM. The biofilter system was monitored for inlet and outlet $H_2S$ concentrations from August to October 2017, and removal efficiency is summarized in Table 4.

**Table 4: Biofilter $H_2S$ Removal Efficiency, August-October 2017**

| $H_2S$ Monitoring Period | Average $H_2S$ Removal Efficiency (%) | Peak $H_2S$ Removal Efficiency (%) |
|---|---|---|
| 8/11-8/24 | 79.50% | 91.40% |
| 8/24-9/5 | 84.00% | 63.60% |
| 9/5-9/19 | 99.70% | 95.50% |
| 9/19-10/4 | 99.60% | 76.50% |
| 10/4-10/21 | 99.90% | 94.50% |

On average the biofilter $H_2S$ removal was considered acceptable with a minimum efficiency of 79.5% during the first monitoring phase and a maximum efficiency of 99.9% during the final monitoring phase. However, the biofilter performance was less efficient for peak inlet $H_2S$ loadings, with peak $H_2S$ removal efficiencies ranging from 63.6% to 95.5%. Based on the average $H_2S$ removal efficiency results, Consultant concluded that the biofilter system was an effective tool in this application and therefore included the ARV biofilter system as part of the future ORFM odor control alternatives. However, peak $H_2S$ outlet concentrations were extremely high, exceeding the 10 ppm threshold. Therefore, additional modifications to the ORFM were required to reduce $H_2S$ peak loadings.

### 2.1.4 Pump Station Oxygen System

Recent improvements were made to reduce odor emissions in the ORFM area which include the closing of the smaller diameter barrel on a portion of the ORFM and the installation of an oxygenation system at an MSD Pump Station in 2021.  MSD monitored $H_2S$ levels at key areas along the ORFM before and after start-up of the Pump Station oxygen feed to evaluate its performance. $H_2S$ monitoring results from April 2021 at two ARV's and the ORFM Discharge Manhole indicate that $H_2S$ levels were significantly reduced as a result of the oxygen system operation.  It should also be noted that the oxygen system was down for an extended period of time (May 19 through June 11, 2021) which resulted in a spike in $H_2S$ levels in downstream monitoring locations.  These results suggest that recent improvements in the ORFM area have been able to reduce the $H_2S$ levels. However other odor-

causing compounds (RSCs, VOCs, etc.) were not monitored during this study, and the abundance of these chemical compounds is unknown.

## 2.2 2021 and 2022 Collection System Sampling

Although MSD has implemented several odor control systems and monitoring programs in the northeast portion of the collection system along the ORFM and the southeast portion downstream of Pump Station #2, there is a lack of odor control systems in the central downtown areas, towards the northwest and southwest portions of the MFWQTC collection system. Subsequently, high quantities of customer odor complaints have been filed for these locations, particularly between 2019 and 2020. These complaints prompted a new sampling campaign in 2021 and 2022, and an overview map of the sampling locations is shown in Figure 2. Table 5 and Table 6 summarize the vapor and liquid sampling results, respectively, measured during these campaigns for each of the locations. Additional information on the sampling campaign including sampling methods, all measured parameters, and recommendations can be found in TM#6B. Summarized results and conclusions will be presented here for clarity. It is important to note that MSD is only required to meet the liquid discharge regulations and the APCD standard for gaseous $H_2S$ concentrations at the source. Additional workplace and environmental standards were used to identify elevated concentrations of other odorous compounds, but these were used as a reference for comparison only.

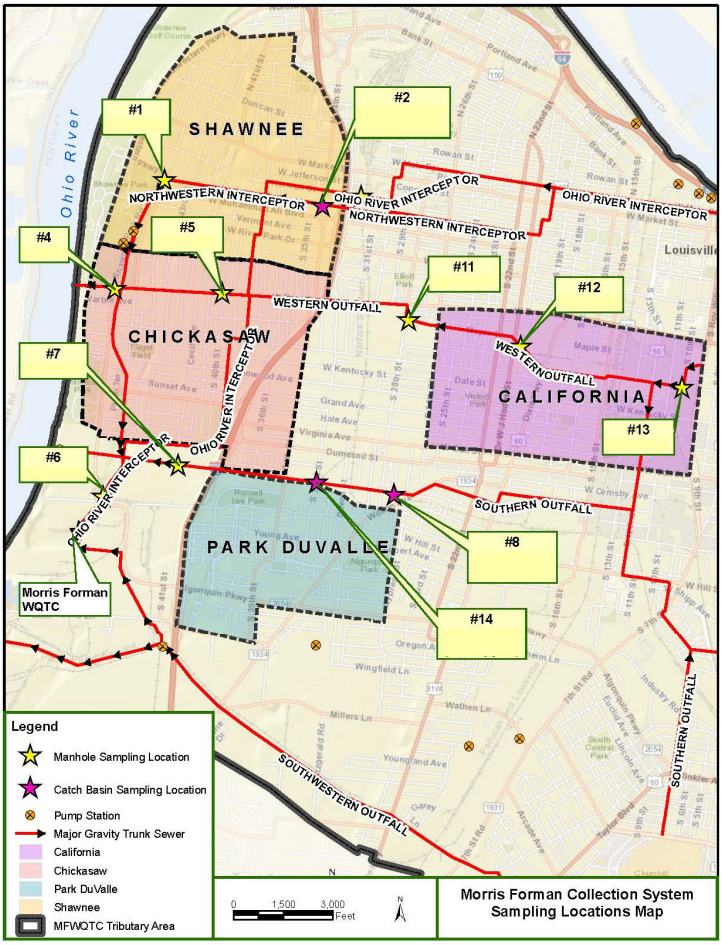


**Figure 2: 2021 and 2022 Collection System Sampling Locations Map**

## Table 5: Collection System Liquid Sampling Summarized Results

| | Liquid Concentrations | | | | | |
|---|---|---|---|---|---|---|
| Sample ID | Sulfide (mg/L) | $BOD_5$ (mg/L) | TSS (mg/L) | Ammonia (mg/L) | pH | DO (mg/L) |
| 1 | ND | High | Low | Low | Low | Low |
| 2 | - | - | - | - | - | - |
| 3 | ND | Low | Low | Low | Low | Low |
| 4 | Low | High | High | High | Low | Low |
| 5 | Low | Low | Low | Low | Low | Low |
| 6 | ND | High | Low | Low | Low | ND |
| 7 | ND | Low | Low | Low | Low | ND |
| 8 | - | - | - | - | - | - |
| 11 | ND | High | Low | Low | Low | Low |
| 12 | NL | NL | NL | NL | NL | NL |
| 13 | ND | ND | Low | ND | Low | Low |
| 14 | - | - | - | - | - | - |

Note:
Values in red signify exceedances of the parameter thresholds at the odor source (see TM 6B for more information)
$BOD_5$= 5-Day Biological Oxygen Demand
TSS= Total Suspended Solids
DO = Dissolved Oxygen
- = Substance was not sampled for or has not been analyzed by the appropriate laboratory
NL=No Liquid – no liquid was present at sample location
ND= Non-Detect – Compound was analyzed for, but not detected above the method detection limit

## Table 6: Collection System Vapor Sampling Summarized Results

| | Vapor Concentrations | | | | |
|---|---|---|---|---|---|
| Sample ID | Odor (D/T) | $H_2S$ (ppm) | Butyraldehyde (ppm) | Max Pressure (In H2O) | Temp. (°F) |
| 1 | High | Low | ND | High | Low |
| 2 | High | ND | ND | - | - |
| 3 | High | Low | Low | High | Low |
| 4 | High | SL | High | Low | Low |
| 5 | High | Low | ND | High | Low |
| 6 | High | Low | High | High | Low |
| 7 | High | Low | ND | Low | Low |
| 8 | High | Low | ND | - | - |
| 11 | High | Low | Low | Low | Low |
| 12 | High | Low | ND | - | Low |

| Sample ID | Vapor Concentrations | | | | |
|---|---|---|---|---|---|
| | Odor (D/T) | $H_2S$ (ppm) | Butyraldehyde (ppm) | Max Pressure (In H2O) | Temp. (°F) |
| 13 | High | Low | ND | High | Low |
| 14 | High | SL | ND | - | - |

Note:
Values in red signify exceedances of the parameter thresholds at the odor sources (see TM 6B for more information)
D/T = Dilution to threshold
H2S= Hydrogen Sulfide
Temp. = Temperature
- = Substance was not sampled for or has not been analyzed by the appropriate laboratory
ND= Non-Detect – Compound was analyzed for, but not detected above the method detection limit
SL= Sample Loss – Air sample was damaged during shipment to laboratory
ppm= parts per million
ppb= parts per billion

The liquid and vapor sampling results in Table 5 and Table 6 indicate a correlation between high $BOD_5$ concentrations and elevated odor D/T values and a correlation between lower pH readings ($H_2S$ more likely to be present) and high $BOD_5$ concentrations. Liquid Sample ID #11 had a high $BOD_5$ measurement and the lowest pH value that was measured, which created conditions favorable for odor generation. Samples taken along the Western Outfall (Broadway St.) also show that ammonia concentrations were above the threshold.

The air sampling results indicate elevated odor parameters at several source locations. The pressure monitoring results also indicate that most of the manholes operated at positive pressure compared with the atmospheric pressure which caused the release of pipe headspace air into the surrounding environment. All sampling locations were observed to exceed MSD's odor target of 20 D/T, so additional odor control systems are recommended.

After the sampling campaign was completed, water traps were added to the previously untrapped catch basins in the Southern Outfall in the Park DuValle neighborhood which included the basin at liquid and vapor sampling ID #14.

Sample IDs 1-3 were located along the Ohio River Interceptor downstream of the Bioxide and oxygen injections in the ORFM. These locations were also observed to have high odor measurements which suggests that additional odor control systems are needed in the Shawnee neighborhood. Other odor control upgrades to the Ohio River Interceptor and the Western Outfall are recommended in TM#6B.

# 3. Conclusions

Available data and reports were evaluated to understand the performance of existing odor control methods within the MFWQTC wastewater collection system and to identify target areas for further evaluation as part of the Odor Control Master Plan Update.

MSD has made significant efforts to reduce odor emissions and mitigate customer complaints across the MFWQTC collection system. Beginning in March 2014, MSD contracted a third-party firm to inject calcium nitrate (Bioxide) at specific locations in the collection system. In July 2020, MSD extended the Bioxide dosing and monitoring services with the third-party firm by an additional three (3) years which is documented in the Invitation to Bid (ITB). Nine (9) injection locations fall within the MFWQTC collection system, five (5) of which are actively performing Bioxide injection as of December 2020.

MSD also closed the smaller diameter barrel from a portion of the ORFM, installed an oxygen injection system at a Pump Station, and continues to operate the biofilter system installed at an ARV.

Table 7 summarizes the status of the existing odor control technologies within the MFWQTC wastewater collection system.

**Table 7: Current Odor Control Technologies Summary**

| Number | Odor Control System | Status* |
|---|---|---|
| 1 | Bioxide injection | Inactive |
| 2 | Oxygen injection (Bioxide injection backup) | Active |
| 3 | Bioxide injection | Inactive |
| 4 | Bioxide injection | Active |
| 5 | Bioxide injection | Inactive |
| 6 | Bioxide injection | Active |
| 7 | Bioxide injection | Active |
| 8 | Bioxide injection | Inactive |
| 9 | Bioxide injection | Active |
| 10 | Biofilter | Active |

Performance data for the Bioxide injections suggested a low $H_2S$ reduction efficiency with both average and peak $H_2S$ concentrations exceeding 10 ppm. On average the $H_2S$ removal of the biofilter at the ARV was considered acceptable with a minimum efficiency of 79.5% during the first monitoring phase and a maximum efficiency of 99.9% during the final monitoring phase. However, the biofilter's $H_2S$ removal was not sufficient under high $H_2S$ loadings. Following the completion of the oxygen dosing system improvements at the PS, $H_2S$ concentrations significantly decreased within the ORFM

# 4. Recommendations

The findings from the 2021 and 2022 sampling events in the Morris Forman collection system indicate that odor control improvements are necessary for areas of the gravity sewer system and force mains that discharge into the gravity sewer system.

The chemical injection system was evaluated for the $H_2S$ reduction only, and other chemical compounds are present in the gravity sewer headspace, drop-structures, and diversion chambers. Chemical injections will not control the headspace pressure, so any odor residue will escape into the surrounding environment.

We recommend pilot testing a portable odor control unit within the collection system combined with air quality monitoring to evaluate the emissions mitigation and operating costs. This unit would maintain the pipe headspace under slightly negative pressure and would convey the air to the treatment unit.

TM#8 - New Odor Control Technologies Performance Evaluation, and TM#9 - Odor Control Conceptual Design will focus on the design approach for reducing the odors in these sewers.