Metropolitan Sewer District of Greater Cincinnati

10142910 Ludlow Run Sustainable Source Control

Task 5.1 Capacity Analysis Technical Memorandum

May 2024

FINAL

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1 Project Background and Objectives

1.1 Background

The Ludlow Run Sustainable Control project includes planning, design and construction phase services for a Wet Weather Improvement Plan (WWIP) project (or projects) to reduce the volume of the combined sewer overflows (CSOs) in the Ludlow Run watershed (CSOs 151, 109, 110, 111, 112, 162 and 024). The project will also identify asset management needs within the Ludlow Run watershed.

As seen in Figure 1, the Ludlow Run sub-watershed, located in King's Run watershed, includes portions of Cincinnati neighborhoods: Northside, College Hill, Winton Hills, and Winton Place. CSO 024, referred to as the Ludlow Run Regulator is located on the west bank of Mill Creek at the three-way intersection of Spring Grove Avenue, Dooley Bypass, and Dana Avenue. Six CSOs are nested within CSO 024 sub-watershed. Listed from north to south within the sub-watershed, CSOs 151, 109, 110, 111, 112, and 162 overflow into Ludlow Run, which then enters the combined sewer system and contributes to overflow at CSO 024 to the Mill Creek.

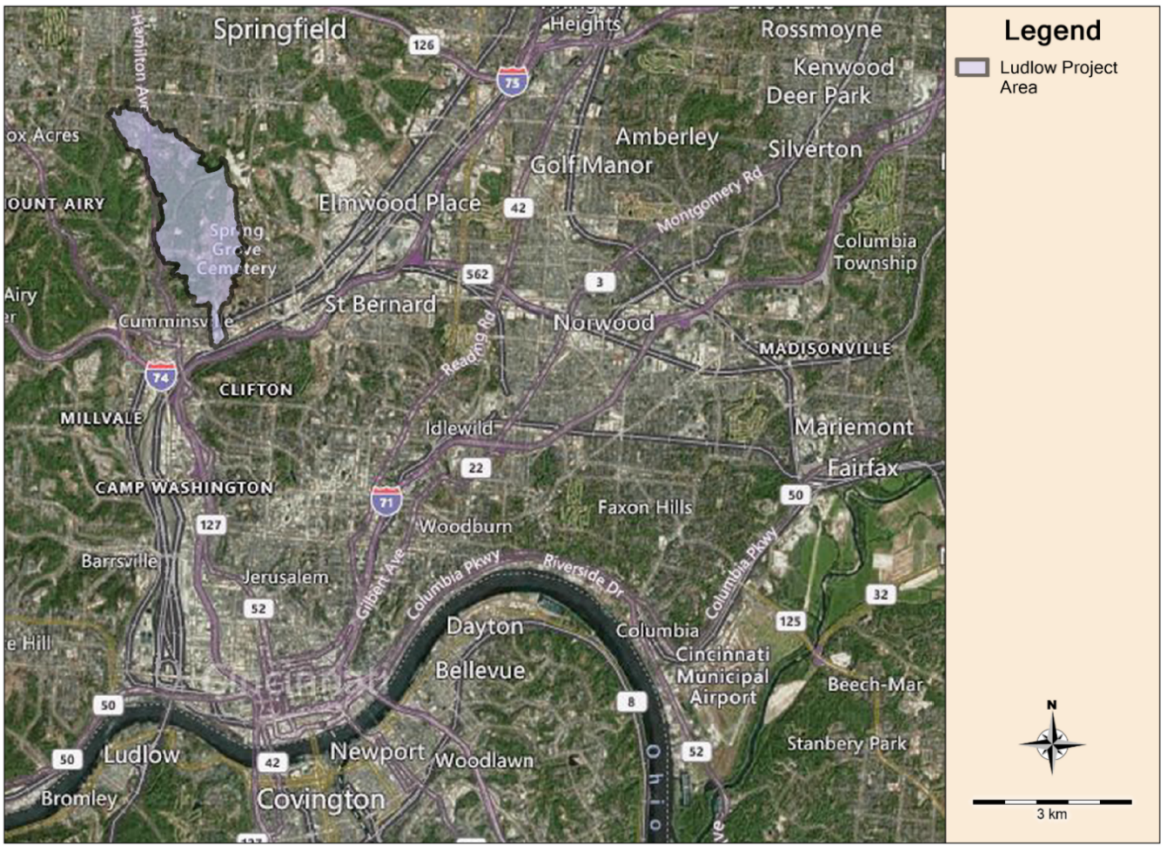

Figure 1 – Ludlow Project Area Map

In 2021, a model review was performed based on monitors installed for the Ludlow Run Watershed CSO 024 Strategic Separation project performed by AMEC. At that time the comparison of the observed data to the model

data for the period of 2010-2011 indicated that the current model did not consistently predict observed dry weather or wet weather flows and in a few locations there was not a sufficient dataset available for calibration (less than two months). The monitors installed for project performed by AMEC provided the most coverage in the project area between 2008 to 2011. However, the monitoring locations for that project did not include monitoring of the influent sewers of the diversion structures for CSOs 110, 111 and 112. Based on that model and data review, Arcadis recommended the installation of 10 flow monitors for a period of 12 months to obtain the data needed for a model calibration. Please refer to the Task 3.1 Model Review Technical Memorandum and Flow Monitoring Plan for more detailed information on the model review.

1.2 Objectives

A primary objective of this project is to determine compliance of the nested CSO's with WWIP Plan Remaining CSO volume requirements using an updated calibrated model. If compliance is not met, the second objective of the project is to develop a watershed plan to address the CSOs in the Ludlow Run sub-watershed.

Table 1 presents the current Wet Weather Improvement Plan (WWIP) requirements for the CSOs in the Ludlow Run watershed. The table includes the requirement as well as the source of the data for reference. CSO 109 and CSO 162 were not included in the Final 2010 WWIP, as they were addressed with the completion of the Ludlow Run project (Project ID 10144900) and comply with MSDGC's CSO Permit. Figure 2 provides locations of the CSOs within the Ludlow Project Area.

Table 1 – WWIP Requirements for the Ludlow Run Watershed CSOs

CSO	Index	Project ID	Name	Description/Design	Plan Remaining CSO (MG/yr)	Source
024	New Line 453	NA	Phase 2 Default Lower Mill Creek Final Remedy (LMCFR)	Default tunnel/conveyance	LMCFR	Attachment 2, USEPA Approval of LMCPR dated May 30, 2013
151	38	10144900	Ludlow Run	Collector Upgrade CIP 83-10 Exhibit 1	16.8	Attachment 1, Final 2010 WWIP
110	444	10143360	4710 Howard Grating	Regulator Improvements, 2.00 cfs	0.3	Attachment 2, Final 2010 WWIP
111	445	10143400	Springlawn Grating	Partial Separation	4.1	Attachment 2, Final 2010 WWIP
112	446	10143420	1547 Springlawn Grating	Partial Separation	0.7	Attachment 2, Final 2010 WWIP

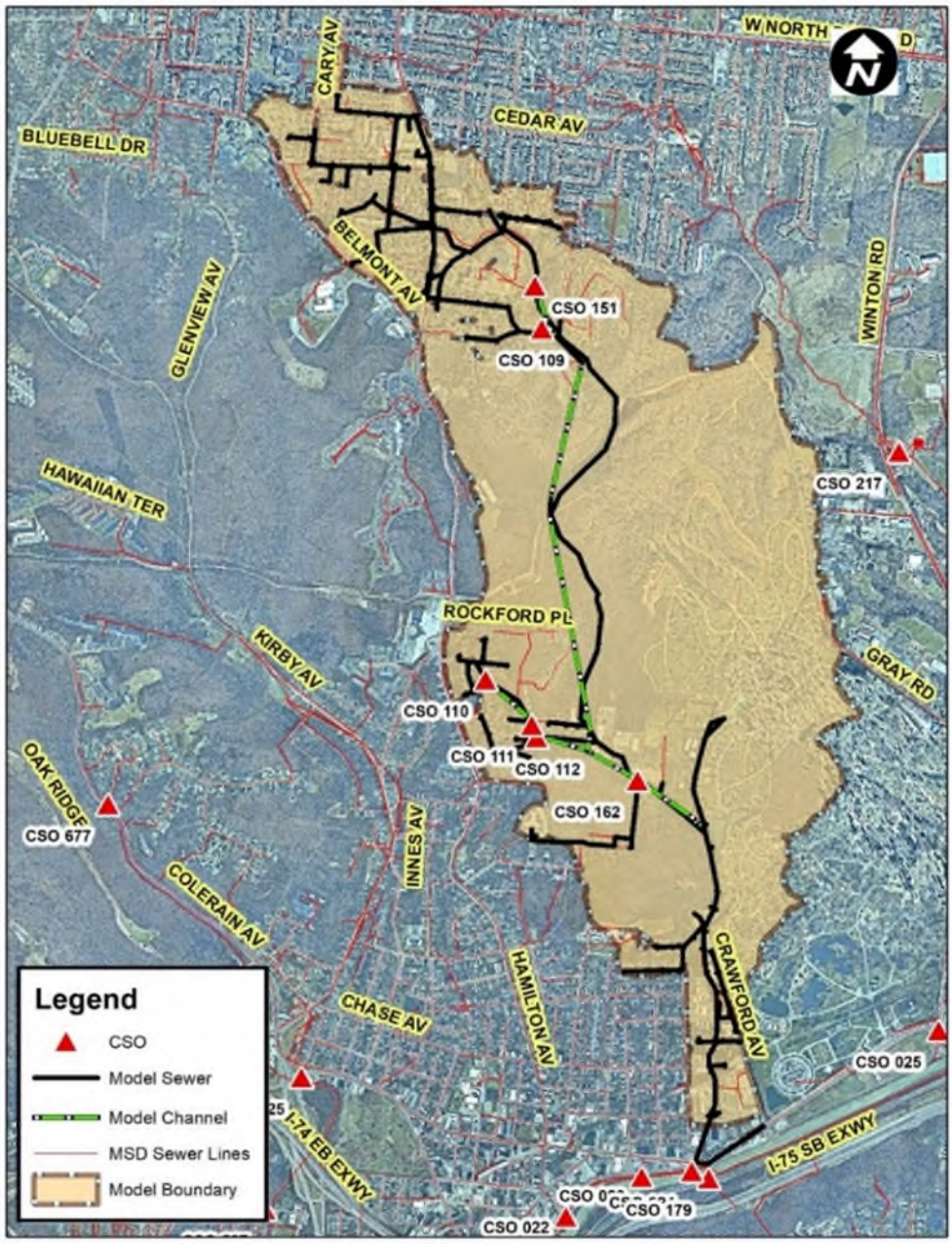

Figure 2 – Ludlow CSOs Location Map

2 Model Updates and Calibration

In March 2021, twelve monitors were installed in the Ludlow Run Project Area for a period of 14 months to collect flow and or level data to update and calibration the hydrologic and hydraulic model in the Ludlow Project Area. Arcadis was tasked with calibrating the model from flow monitoring data collected at the following meters: MC-KR-

007, MC-KR-008, MC-KR-009, MC-KR-010, MC-KR-011, MC-KR-012, MC-KR-017, MC-KR-019, MC-KR-025, MC-KR-074, MC-KR075, MC-KR-076.

Figures 3 and Figure 4 show the project monitor locations with tributary areas relative to the existing system and a schematic of interconnecting elements within the project area. Flow monitoring began on March 17, 2021, and ended on May 27, 2022. In general, between 60 to 80 rain events were identified for use during calibration depending on the monitor. There were no significant flow data trends among excluded events. A majority of events were excluded due to the rainfall event being too small or general issues with data quality unrelated to magnitude of storm or season.

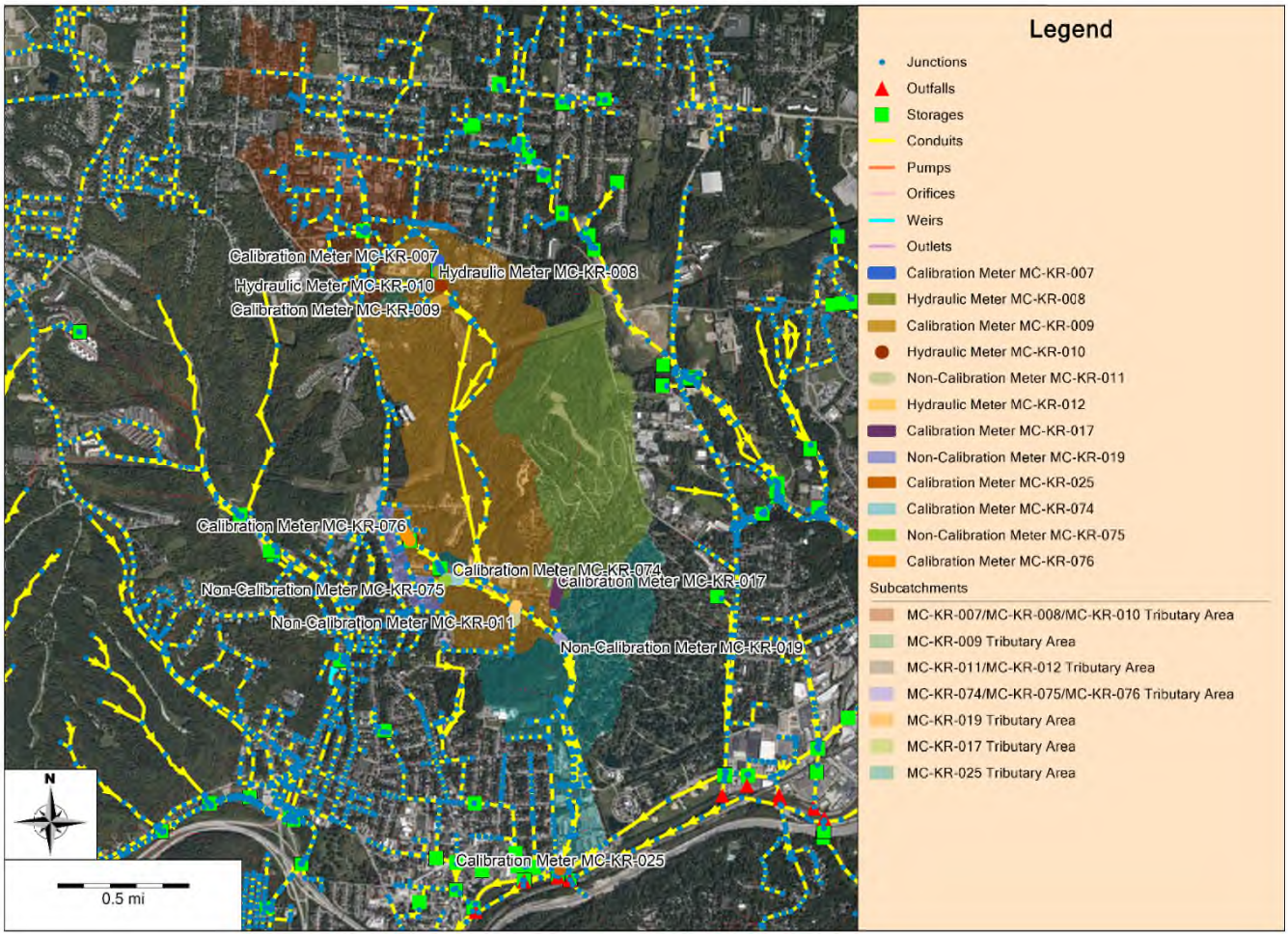

Figure 1 – Ludlow Flow Monitor Location Overview

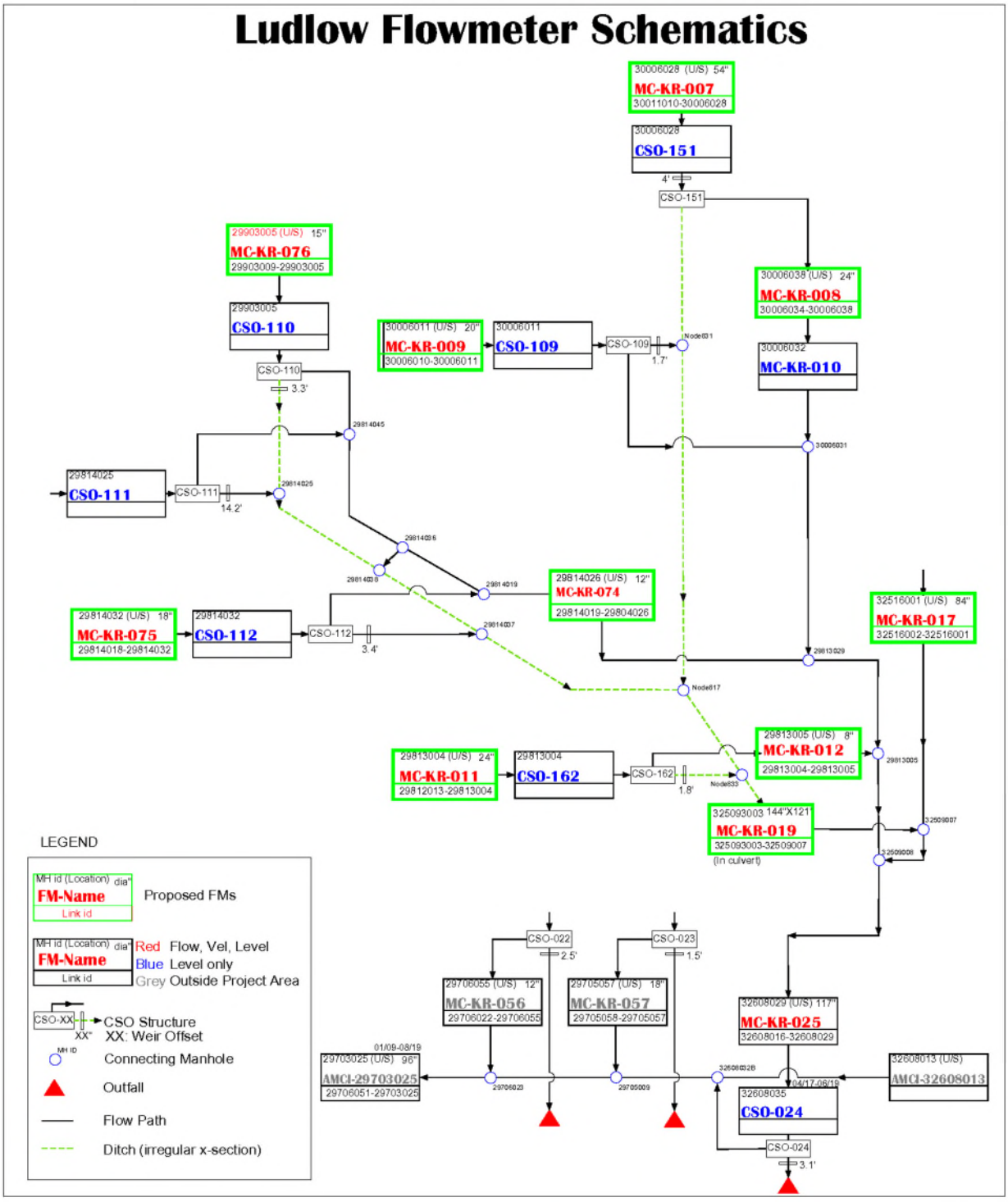

Figure 2 – Ludlow Flow Monitor Connection Schematic

During the calibration process, the flow meters were categorized based on their use in the project. The six flow monitors used for calibration are summarized in Table 2. Two meters were use for hydraulic purpose and four meters were not used for calibration of hydrology.

Table 2 – Overview of Flow Monitors used for Calibration

Monitors	Tributary Metershed		Installation	
	Type	Acres	Pipe Size (in)	Location Description
MC-KR-007	Combined	228	54	Inflow to CSO 151
MC-KR-009	Combined	11	20	Inflow to CSO 109
MC-KR-017	Combined	250	84	Downstream of Spring Grove Cemetery
MC-KR-025	Combined	1248	117	Inflow to CSO 024
MC-KR-074	Combined	21	12	Underflow downstream of CSOs 110, 111 and 112
MC-KR-076	Combined	7	15	Inflow to CSO 110

The model was calibrated following the MSDGC Modeling Guidelines Revision 5.0 dated June 2023 with limited deviations. Some parameters, which were outside of the MSDGC Modeling Guidelines, were approved. The calibration was marked as follows for each location:

- MC-KR-007: Calibration Meter – Conditional Pass
- MC-KR-008: Hydraulic Meter – Pass
- MC-KR-009: Calibration Meter – Conditional Pass
- MC-KR-010: Hydraulic Meter – Pass
- MC-KR-011: Non-Calibration Meter – Not Used for Calibration of Hydrology
- MC-KR-012: Hydraulic Meter – Pass
- MC-KR-017: Calibration Meter – Pass
- MC-KR-019: Non-Calibration Meter – Not Used for Calibration of Hydrology
- MC-KR-025: Calibration Meter – Pass
- MC-KR-074: Calibration Meter – Pass
- MC-KR-075: Non-Calibration Meter – Not Used for Calibration of Hydrology
- MC-KR-076: Calibration Meter – Conditional Pass

With completion of the calibration and submittal approvals from MSDGC, this model is well-suited for its intended planning purpose and can be further utilized to identify system capacity constraints including CSO remaining overflow volume in the typical year. For additional details on the Ludlow Run hydrologic and hydraulic model calibration, refer to the Model Calibration Report submitted as required by the MSDGC Modeling Guidelines.

3 Typical Year Results

After successful calibration of the Ludlow Run Project Model, the model was vaulted into MSDGC's Mill Creek System Wide Model in 2024Q1. As part of the model vaulting process the system wide model is run for the 1970

Typical Year to determine the modeled remaining overflow volumes at each CSO location in the Mill Creek System. Table 3 indicates the overflow volume in million gallons per the typical year for the six CSOs located in the Ludlow Run project area. These values are compared to the WWIP Plan Remaining CSO volume targets.

Table 3 – Ludlow Run CSO Typical Year Model Results

CSO	Plan Remaining CSO from 2010 Final WWIP (MG/yr)	Typical Year Overflow Volume MC_Exist2024Q1_TY.inp (MG/yr)
151	16.8	3.2
109	NA	0.1
110	0.3	0.2
111	4.1	0.0, No Activation
112	0.7	0.3
162	NA	0.01

NA = Not Applicable.

Typical Year results indicate that modeled CSO volumes calculated in the 2024Q1 vaulted model, which includes the Ludlow Run project calibration model, for the CSO locations nested within the Ludlow Run project area meet the WWIP remaining CSO volume target.

4 Ludlow Run CSO Locations

Based on the results of the Typical Year run, the CSOs within the Ludlow Run project area meet the targets set in the 2010 Final WWIP. To verify the CSO volume results, each CSO was evaluated based on number of activations per the calibration period (March 2021 to May 2022) and compared to the reported CSO activations. CSOs within the MSDGC are monitored for level only, therefore they are not able to be used for hydrological model calibration. The hydraulics of the CSO were checked against survey data of the regulator and were adjusted as needed to match the surveyed setup. This section of the report provides a more detailed review of each of the CSO locations within the project area and the improvements and efforts since the beginning of the WWIP to reduce CSO volumes in the Ludlow Run watershed.

4.1 CSOs 109 and 162

CSO 109 is in the northern section of the project area, on the southern end of College Hill. There are about 11 acres tributary to CSO 109 and it was calibrated using meter MC-KR-009 which was installed in the inflow pipe upstream of the CSO regulator. CSO 162 is in the southern half of the project area and includes about 3.5 acres of tributary area. The monitor installed in the inflow pipe for CSO 162 did not have usable data, so this small area was calibrated using hydrologic parameters from the calibration of monitor MC-KR-025. Figures 5 and 6 show the locations of CSO 109 and CSO 162, respectively.

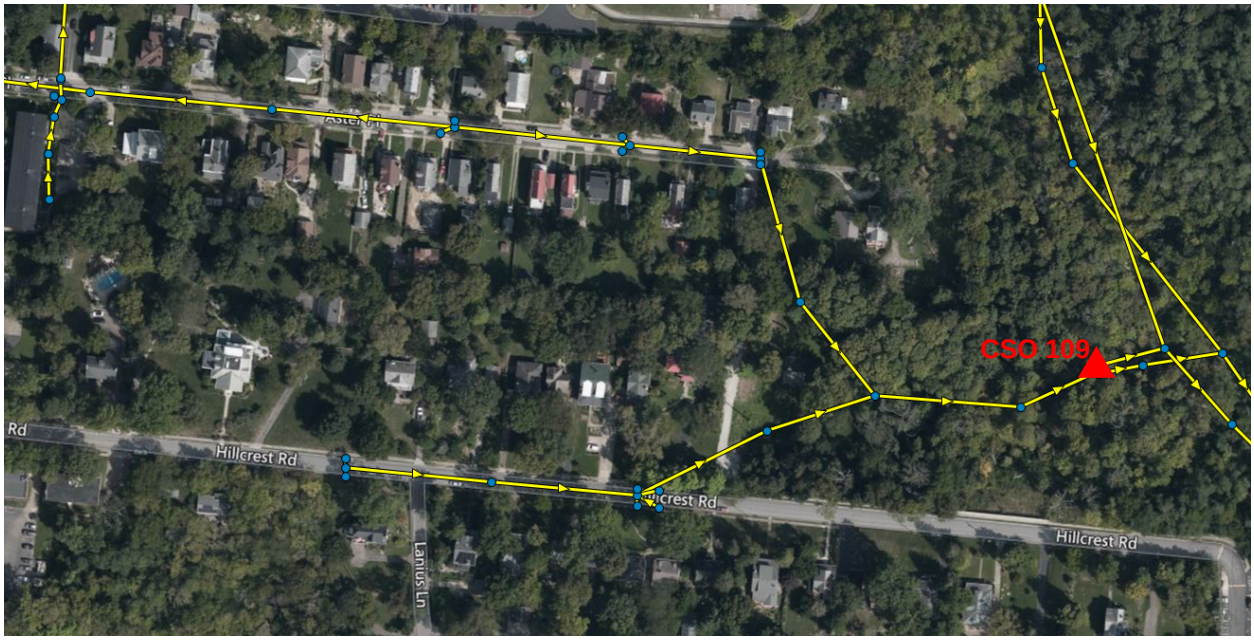

Figure 5 – CSO 109 Location

Figure 6 – CSO 162 Location

At CSO 109, during the calibration period of 442 days, MSDGC reported 32 days of CSO activations based on level monitoring data collected in the CSO regulator. The calibrated model reports 28 overflow activation days at CSO 109. The model represents the overflow activations well as compared to the reported data. At CSO 162, during the calibration period MSDGC reported 14 overflow activation days and the model reported 10. Again, the

calibrated model represents the overflow activations at CSO 162 well as compared to the reported data. Tables 4 and 5 provide summaries of the CSO activation comparison for the calibration period at CSO 109 and CSO 162, respectively.

Table 4 – CSO 109 Model vs Reported Activation Summary

CSO 109	Total Number of Days
Observed Data Period	442
Reported Overflow Activation Days	32
Modeled Overflow Activation Days	28
Reported and Modeled Activation Days (both)	22
Modeled Activations and Site Unavailable Days	0
Reported Activations without Modeled Activations	10
Modeled Activations without Reported Activations	6
No Reported or Modeled Activation Days	403
Site Unavailable	0

Table 5 – CSO 162 Model vs Reported Activation Summary

CSO 162	Total Number of Days
Observed Data Period	442
Reported Overflow Activation Days	14
Modeled Overflow Activation Days	10
Reported and Modeled Activation Days (both)	7
Modeled Activations and Site Unavailable Days	0
Reported Activations without Modeled Activations	7
Modeled Activations without Reported Activations	3
No Reported or Modeled Activation Days	425
Site Unavailable	6

4.2 CSO 110

CSO 110 is located south of Rockford Place and includes a tributary area of about 7 acres. CSO 110 was calibrated using meter MC-KR-076 which was installed in the inflow pipe upstream of the CSO regulator. Meter data at Meter MC-KR-076 was not optimal for calibration but was used in conjunction with a downstream meter

(MC-KR-074) in order to calibrate the hydrologic parameters for the area tributary to CSO 110. Figure 7 shows the location of CSO 110.

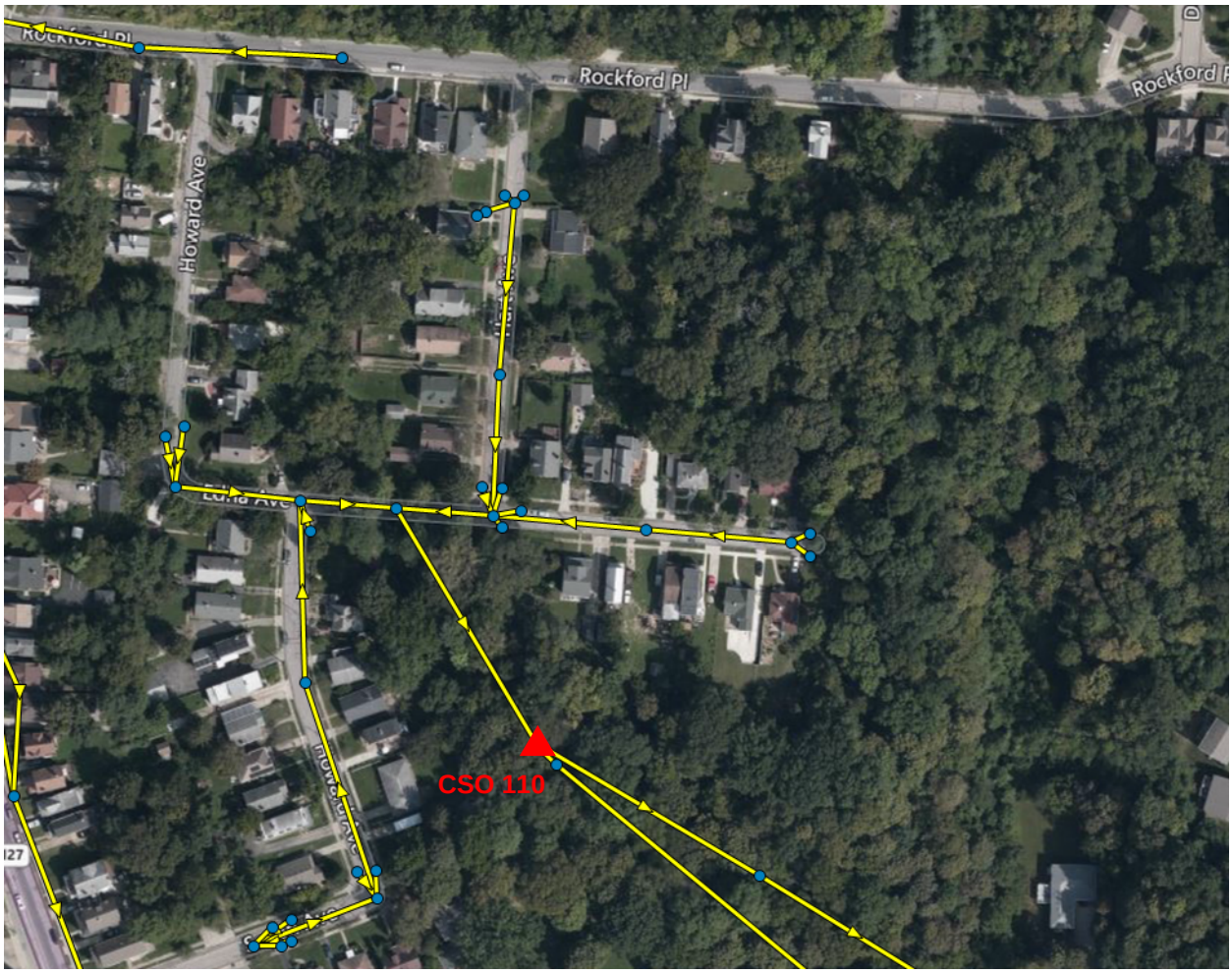

Figure 7 – CSO 110 Location

CSO 110 has a remaining overflow volume target of 0.3 MG in the typical year event. The calibrated model resulted in an overflow volume of 0.21 MG in the typical year event. During the calibration period, CSO 110 had 45 reported overflow activation days, whereas the calibrated model only resulted in 8 overflow activation days. Table 6 provides a summary of the CSO activation comparison for the calibration period at CSO 110.

Table 6 – CSO 110 Model vs Reported Activation Summary

CSO 110	Total Number of Days
Observed Data Period	442
Reported Overflow Activation Days	45

CSO 110	Total Number of Days
Modeled Overflow Activation Days	8
Reported and Modeled Activation Days (both)	8
Modeled Activations and Site Unavailable Days	0
Reported Activations without Modeled Activations	37
Modeled Activations without Reported Activations	0
No Reported or Modeled Activation Days	397
Site Unavailable	0

CSO 110 was reviewed closer due to the discrepancy of reported and modeled activation days during the calibration period. In many cases, the CSO 110 reported activation days were occurring multiple days after an event or during dry weather. This may indicate that the grate leading to the underflow within the regulator structure may be getting clogged and creating additional overflow days. The flow monitoring maintenance work orders were reviewed to determine maintenance frequency during the calibration period. Based on these records, CSO 110 mostly had maintenance concerning battery replacement for the monitoring equipment. The records do indicate that at one point during the monitoring period the battery compartment was knocked down and slightly damaged. Pictures from the maintenance logs show the general setup of the regulator at CSO 110. As seen in Figure 8, it would not take much for the grate to the underflow to get clogged and the flow to continue over the weir. The weir is measured as 3.25 feet above the invert of the underflow, but it is only 1.12 feet above the elevation of the grate. The model does not take into account flow reduction to the underflow that may occur at the grate due to storm debris.

Figure 8 – CSO 110 Diversion Weir Photo

MSDGC records also indicate that the diversion weir at CSO 110 was raised in spring of 2014. This dam raise is evident from the photograph in Figure 8, as bricks were added within the 15-inch outfall pipe.

4.3 CSO 111

CSO 111 is in Spring Lawn Avenue adjacent to the storm culvert that lies beneath road. CSO 111 was calibrated using meter MC-KR-076 which was installed in the inflow pipe upstream of the CSO 110 regulator and meter MC-

KR-074 which is located downstream in the underflow. Meter data at Meter MC-KR-076 was not optimal for calibration but was used in conjunction with MC-KR-074 in order to calibrate the hydrologic parameters for the area tributary to CSO 111. Figure 9 shows the location of CSO 111.

Figure 9 – CSO 111 Location

CSO 111 has no reported overflow activation days during the calibration period and does not have any modeled overflow activation days. In early 2010, this CSO was moved out of the stream bed just south of Spring Lawn Avenue and was relocated in the street and adjacent street catch basins were separated The new regulator located in the street has a diversion weir that is 14 feet above the underflow. This CSO has not had any reported activations for many years.

4.4 CSO 112

CSO 112 is located in the stream bed just south of Spring Lawn Avenue and the location of CSO 111. The meter installed upstream of CSO 112 (MC-KR-075) did not have usable data and was not chosen for hydrologic calibration. The CSO 112 tributary area was calibrated utilizing the parameters for the meters adjacent to this tributary area, including meters MC-KR-074 and MC-KR-076. Figure 10 shows the location of CSO 112.

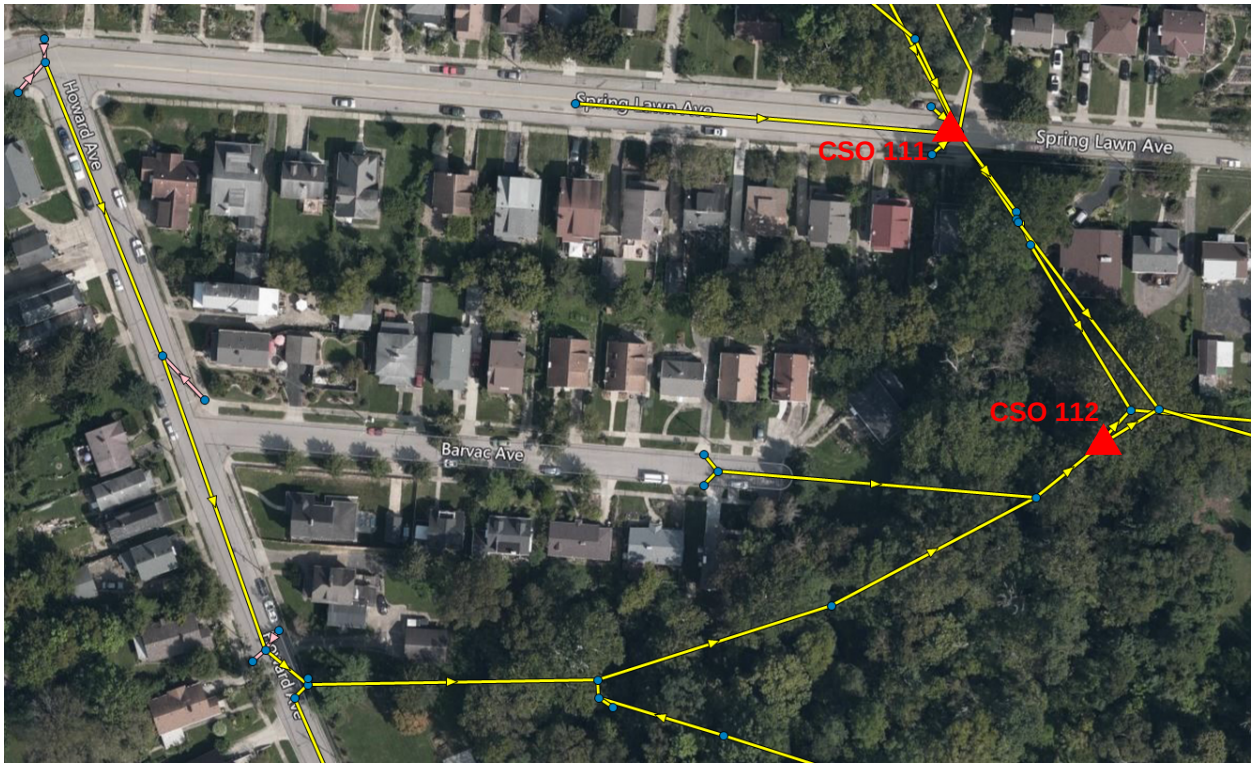

Figure 10 – CSO 112 Location

CSO 112 has 23 reported overflow activation days and 18 modeled activation days during the model calibration period. The model represents the overflow activations well as compared to the reported data. Table 7 provides a summary of comparison of reported versus modeled overflow activation days for the calibration period after July 23, 2024, when the installation of inlet restrictions tributary to CSO occurred, as described below.

Table 7 – CSO 112 Model vs Reported Activation Summary

CSO 112	Total Number of Days
Observed Data Period	313
Reported Overflow Activation Days	14
Modeled Overflow Activation Days	10
Reported and Modeled Activation Days (both)	7
Modeled Activations and Site Unavailable Days	0
Reported Activations without Modeled Activations	7
Modeled Activations without Reported Activations	3
No Reported or Modeled Activation Days	296
Site Unavailable	1

The sewer network in the area tributary to CSO 112 had some updates that occurred during the monitoring period. As part of a program to reduce stormwater flow into the combined system and to prevent sewer backups, flow restriction doors were installed at a handful of storm inlets on Howard Avenue, upstream of CSO 112. The installation occurred during the calibration period. After discussions with MSDGC, it was decided that these restrictions should be added to the calibrated model and that the area be calibrated only to the period after the inlet restrictions were installed. Figure 11 shows an example of an inlet restriction that is placed inside the manhole and restricts the flow coming to the manhole from the catch basin. Figure 12 indicates the locations of the inlet restrictions. The inclusion of the inlet restrictions has reduced the volume of stormwater entering the system upstream of CSO 112 and has had a positive effect for the CSO volume reduction at CSO 112.

Figure 11 – Inlet Restriction

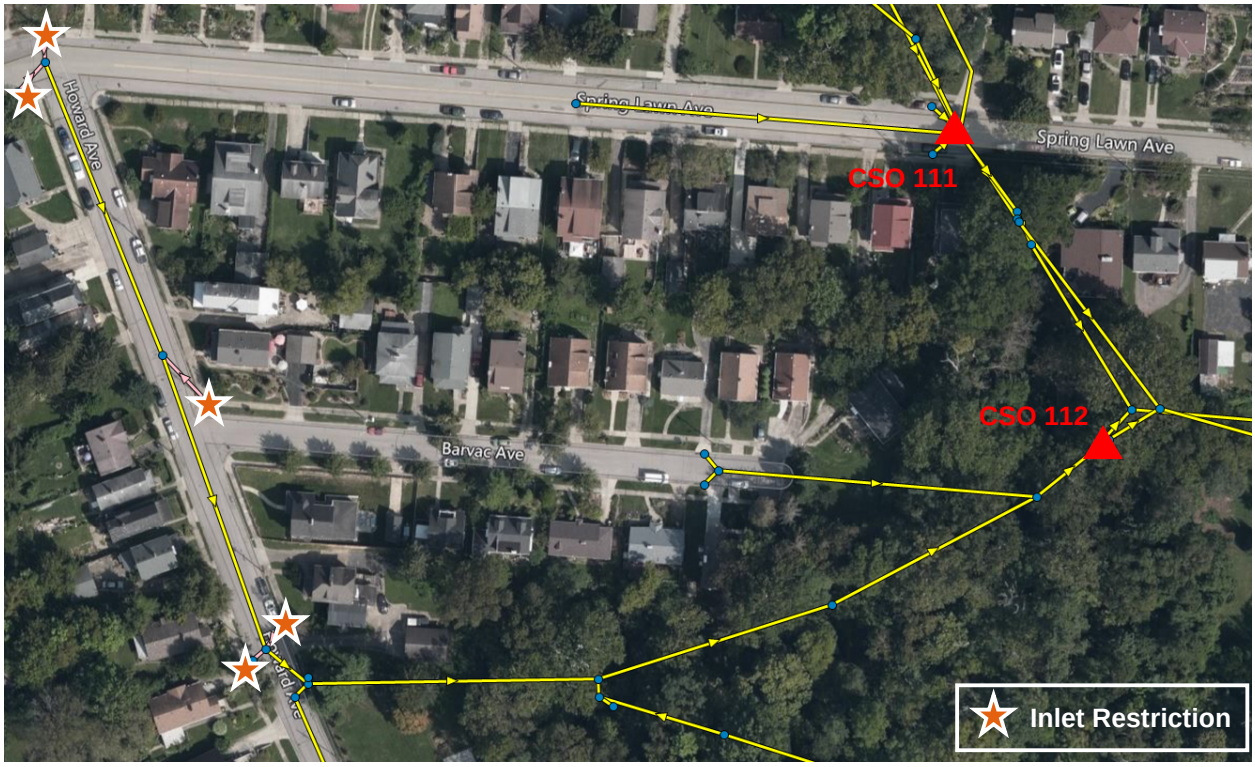

Figure 12 – CSO 112 Storm Inlet Restriction Installations

4.5 CSO 151

CSO 151 is located the furthest north in the Ludlow Run project area and includes about 230 acres of tributary area. CSO 151 was calibrated using meter MC-KR-007 which was installed in the inflow pipe upstream of the CSO regulator. Figure 13 shows the location of CSO 151 in the project area.

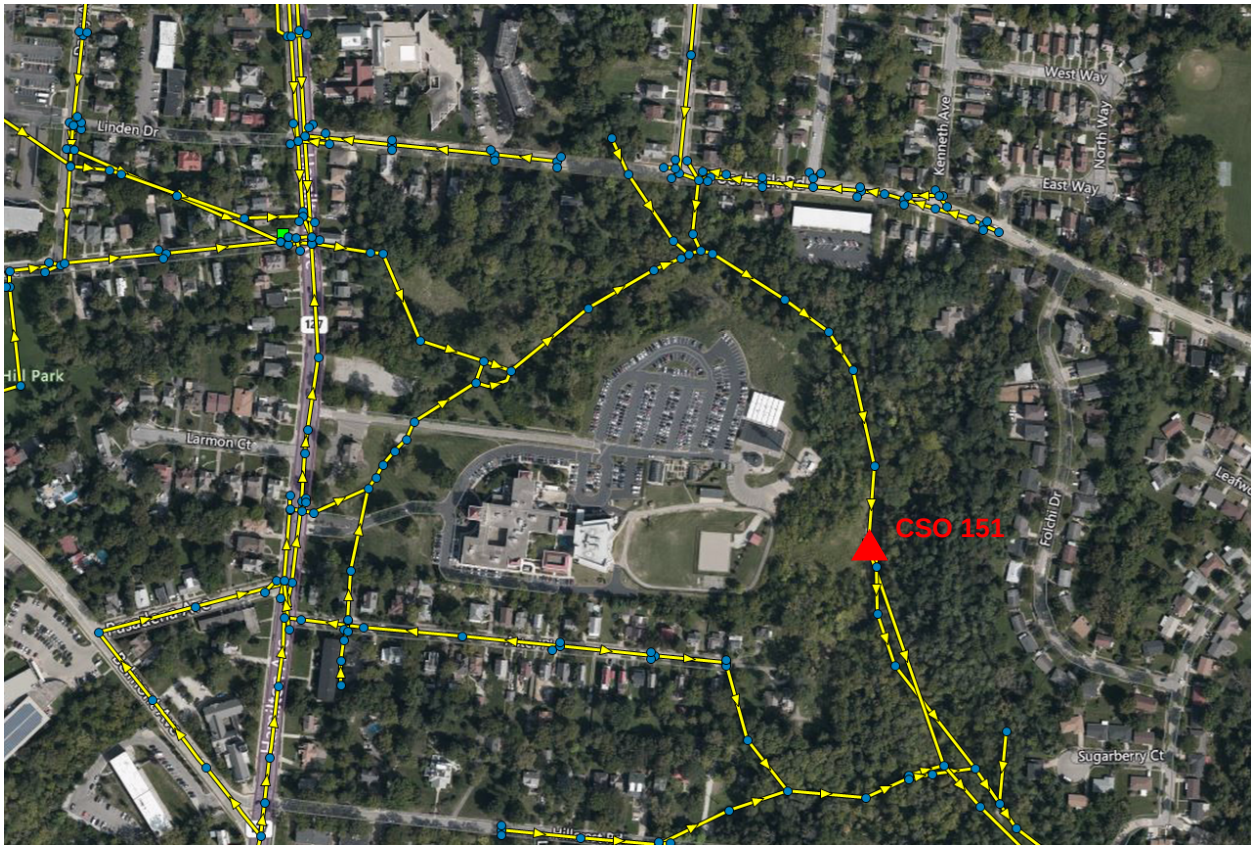

Figure 13 – CSO 151 Location

During the calibration period, CSO 151 had 55 reported overflow activation days and 53 modeled overflow activation days. The model represents the overflow activations well as compared to the reported data. Table 8 provides a summary of comparison of reported versus modeled overflow activation days for CSO 151.

Table 8 – CSO 151 Model vs Reported Activation Summary

CSO 151	Total Number of Days
Observed Data Period	442
Reported Overflow Activation Days	55
Modeled Overflow Activation Days	53
Reported and Modeled Activation Days (both)	40
Modeled Activations and Site Unavailable Days	0
Reported Activations without Modeled Activations	15
Modeled Activations without Reported Activations	13
No Reported or Modeled Activation Days	374
Site Unavailable	0

4.6 CSO 024

CSO 024 is the furthest downstream CSO in the Ludlow Run subwatershed and is located on the Mill Creek. All the other CSOs in the Ludlow Run project area are upstream and are considered nested above CSO 024. The tributary area for CSO 024 includes the entire Ludlow Run project area of approximately 1250 acres. The calibration for CSO 024 includes all the hydrology calibration meters upstream of CSO 024, as well as MC-KR-025 which was installed in the inflow pipe upstream of the regulator.

CSO 024 has by far the largest annual CSO volume in the project area. It is included in the Phase 2 Lower Mill Creek Final Remedy and has a WWIP requirement with the other CSOs identified for the Lower Mill Creek Final Remedy. Figure 14 shows the location of CSO 024 and its tributary area.

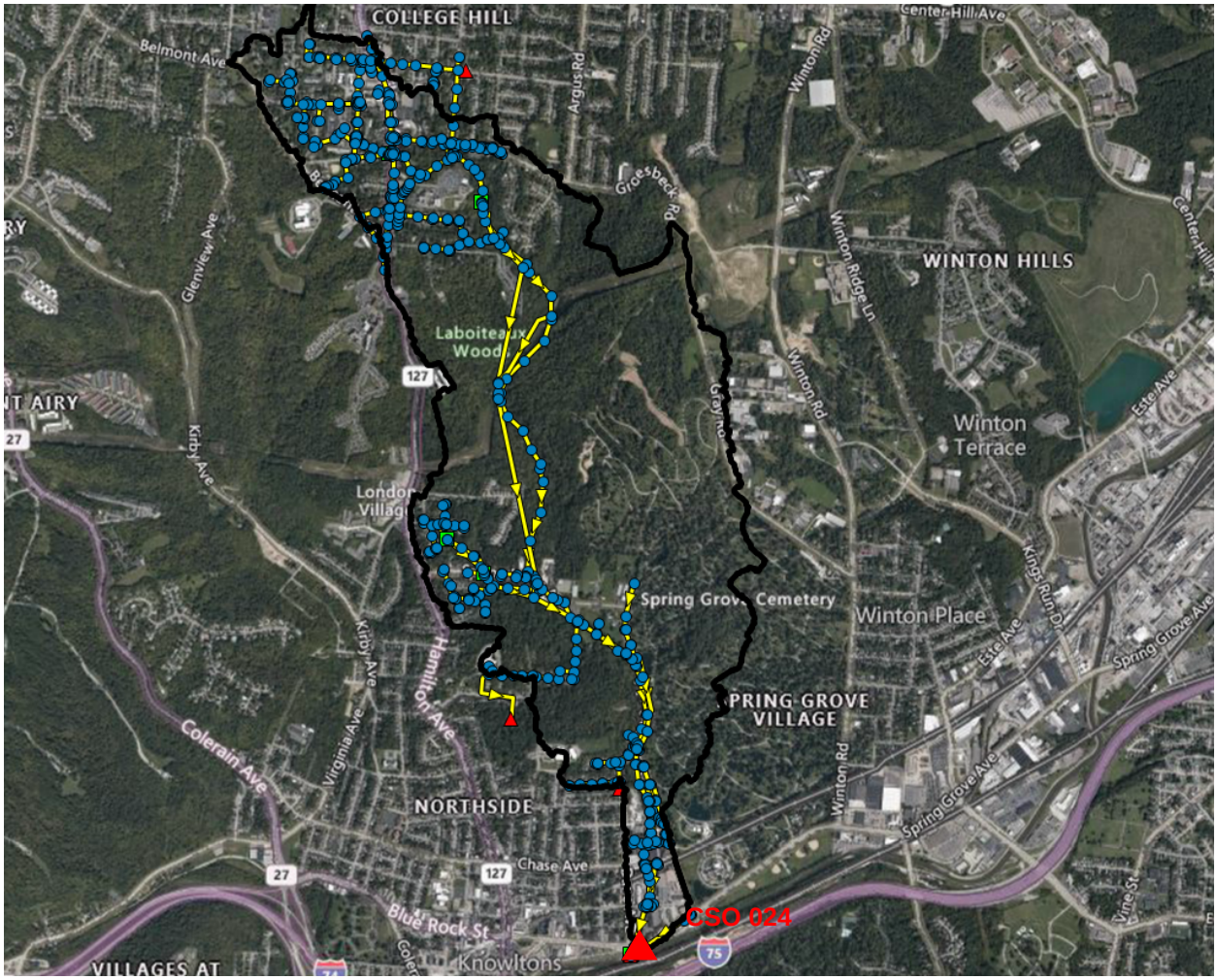

Figure 14 – CSO 024 Location

During the monitoring period for calibration, CSO 024 had 152 reported overflow activation days and 120 modeled activation days. Table 9 provides a summary of comparison of reported versus modeled overflow activation days for CSO 024 during the calibration period.

Table 9 – CSO 024 Model vs Reported Activation Summary

CSO 024	Total Number of Days
Observed Data Period	442
Reported Overflow Activation Days	152
Modeled Overflow Activation Days	120
Reported and Modeled Activation Days (both)	101
Modeled Activations and Site Unavailable Days	0
Reported Activations without Modeled Activations	51
Modeled Activations without Reported Activations	19
No Reported or Modeled Activation Days	271
Site Unavailable	32
River Above Diversion Dam	4

5 Conclusions

The Ludlow Run model has been calibrated based on flow meter data collected between March 2021 and May 2022 for over 60 storm events and meets MSDGC Modeling Guidelines Revision 5.0 dated June 2023. The typical year simulation results were compared to Plan Remaining Volume requirements in the 2010 Final WWIP at each of the CSO locations within the Ludlow Run project area. CSOs 110, 111, 112, and 151 meet the WWIP requirements, and CSOs 109 and 162 were less than 0.1 MG per typical year. Improvements in the Ludlow watershed, including CSO 110 weir raising, inlet restrictions tributary to CSO 112, and relocation of the CSO 111 diversion structure are now part of the calibrated model and are included in this capacity analysis. CSO 24 will be evaluated regionally in the future with the other Lower Mill Creek Final Remedy CSOs.

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