City of Cleveland Heights Partial Consent Decree

Integrated Overflow Control Master Plan

Prepared For

June 2021

WADE TRIM

Acknowledgements

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Water Resources & Coastal Engineering and R2O

Integrated Overflow Control Master Plan

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Acronyms

AACE	American Association of Cost Engineers
BBU	Basement Backup
CCTV	Closed-circuit (Sewer) Television
CD	Consent Decree
CIPP	Cured in Place Pipe
CMOM	Capacity, Management, Operations and Maintenance
CSO	Combined Sewer Overflow
DVI	Doan Valley Interceptor
EWWTP	Easterly Wastewater Treatment Plan
FBRS	Fairmount Boulevard Relief Sewer
FBSRS	Fairmount Boulevard Sanitary Relief Sewer
FCA	Financial Capability Analysis
FCI	Financial Capability Indicators
FOG	Fats, Oils and Grease
GI	Green Infrastructure
GIS	Geographical Information System
HGL	Hydraulic Grade Line
HHI-LSSES	Heights Hilltop Interceptor-Local Sewer System Evaluation Study
I/I	Infiltration/Inflow
IMS	Information Management System
IOCMP	Integrated Overflow Control Master Plan
IT	Information Technology
LF	Linear Feet
LQI	Lowest Quintile Income
LQRI	Lowest Quintile Residential Indicator
MG	Million Gallons
MGD	Million Gallons per Day
MHI	Median Household Income
MS4	Municipal Separate Storm Sewer System
NASSCO	National Association of Sewer Service Companies
NEORSD	Northeast Ohio Regional Sewer District
NOACA	Northeast Ohio Areawide Coordinating Agency
OM&R	Operation, Maintenance and Repair
PACP	Pipeline Assessment and Certification Program

PI	Poverty Indicator
RI	Residential Indicator
ROW	Right of Way
SCS	Society for Modeling and Simulation
SORP	Sewer Overflow Response Plan
SSES	Sewer System Evaluation Study
SSO	Sanitary Sewer Overflow
TY	Typical Year
USEPA	United States Environmental Protection Agency

Executive Summary

In 2017, the City of Cleveland Heights executed a Partial Consent Decree with the U.S. Environmental Protection Agency (USEPA) and the U.S. Department of Justice (DOJ). The Consent Decree (CD) requires Cleveland Heights to submit an Integrated Overflow Control Master Plan (Master Plan – this Report) as described in the CD Main Text Section V.F. Paragraphs 30 – 34, and the associated Consent Decree Appendix A: Integrated Overflow Control Master Plan Development Process.

This Report fulfills the Consent Decree requirements for the Master Plan and comports with the USEPA's Integrated Planning Framework, now part of the Clean Water Act, 33 U.S.C. Section 1412(s). More detailed discussion regarding the specific Consent Decree requirements is provided in **Section 2 - Legal Compliance**.

In 2021, Cleveland Heights is celebrating its centennial year. A fundamental challenge for the City's second century is to renew and update much of its century-old infrastructure. This Master Plan outlines a mammoth $565 million (2020 dollars) of sewer improvements. The estimated cost is directly related to the unique combination of sewer types in the Cleveland Heights' collection system.

Common Trench Sewers

Peculiar to Northeast Ohio is the concentration of "common trench" sewers, a prevailing design in Cleveland's inner-ring suburbs at the time of their rapid growth in the early 20th century. The design was an early evolution from the single-pipe combined sewers in Cleveland proper. Common trench sewers have sanitary and storm sewers in the same trench. These sewers include the "over-under" variety, where the two pipes were constructed with the storm sewer directly over the sanitary sewer. The sewers share a common manhole and are separated by a removable invert plate to allow access to the lower sanitary sewer for maintenance. The common trench design had the benefit of constructing a single trench, often excavated in rock. The entire common trench system in Cleveland Heights, however, was not designed to remain separated in all wet weather conditions. For example, houses built before WWII very frequently connected a back downspout directly to the sanitary lateral to serve as a 'flusher."

The design of the common trench system and the private infrastructure that it serves presents an enormous technical and financial challenge to the long-term renewal of the City's infrastructure. As discussed in great detail, the $428 million cost for only the Tier 2 over/under and dividing wall sewer systems retrofit represents 76% of the total estimated cost of this Master Plan. The challenge will require decades of adaptive management to find the cost-effective approaches necessary to meet performance goals and remain affordable.

Financial Capability and Affordability

This Master Plan includes a detailed review of the City of Cleveland Heights' financial capability and ratepayer affordability, consistent with the USEPA guidance and Integrated Planning Framework.

Consistent with the priorities of the Consent Decree, and recognizing the extreme affordability constraints, the Master Plan focuses first on controlling and ultimately eliminating the identified sanitary sewer overflows (SSOs). Prioritizing SSO control achieves the goals of the Consent Decree. The prioritization process for the Consent Decree measures, articulated in Section V. F., resulted in three Tiers of projects. The Master Plan includes a schedule for the Tier 1 SSO control projects that will start in 2021 and conclude in 2036. **Figures ES-1** and **ES-2** summarize the proposed Tier 1 improvements and proposed schedule. This 15-year duration is critical to maintain ratepayer affordability and utility financial capability, and to remain in position to sustain system improvement in the subsequent years.

Recognizing that the ratepayers of Cleveland Heights are also ratepayers for the Northeast Ohio Regional Sewer District (NEORSD) is vital to the financial capability analysis. For many decades, these ratepayers have contributed significant funds to the excellent human health and environmental improvements made by NEORSD. These obligations include NEORSD fees that support NEORSD's regional stormwater program and regional sewage interceptors and treatment system, including its $3 billion federal CSO consent decree. As explained in Section 7, NEORSD fees account for approximately 75% of the financial capability of the Cleveland Heights' ratepayers. NEORSD's consent decree is expected to be complete in 2036, when Tier 1 of the Master Plan is completed. This will offer a much clearer picture of ongoing affordability to schedule future Master Plan work.

Approved by City Council, with input from the public, this Master Plan charts the City's sustainable path toward Clean Water Act compliance consistent with the Consent Decree. The City, in this Master Plan, formally adopts two guiding principles for implementation: 1) Ratepayer Affordability and 2) Adaptive Management. Only by observing both principles will Cleveland Heights be able to sustain its infrastructure renewal across the 21st Century. The high burden facing the City and its ratepayers cannot be overcome in a short time or by over-extending households. The City must adapt to evolving technologies and methods, locally and globally, that can cost-effectively make its collection system perform to standards.

Figure ES-1. Proposed Tier 1 SSO Control Improvements (10-year, 1-hour Rainfall)

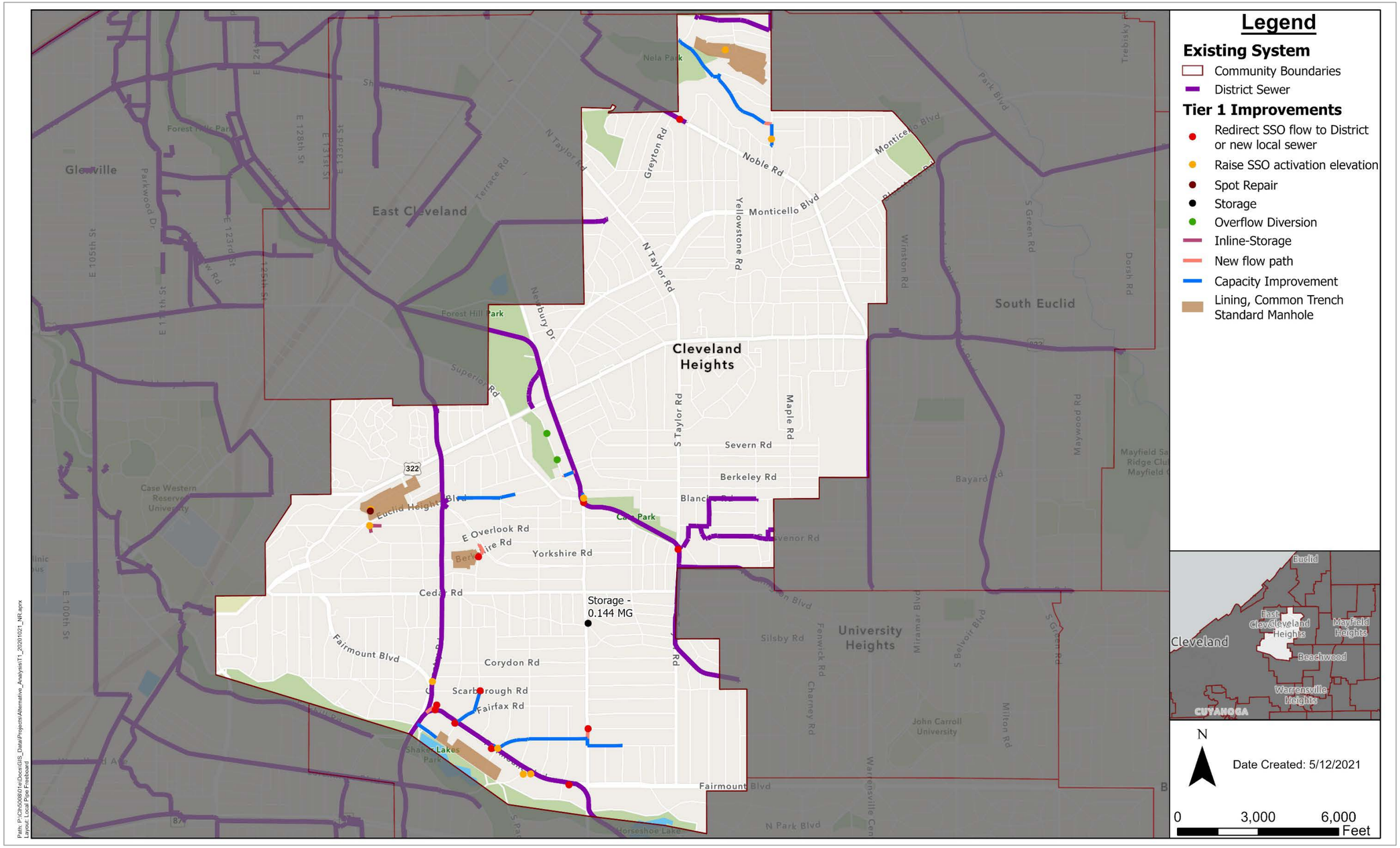
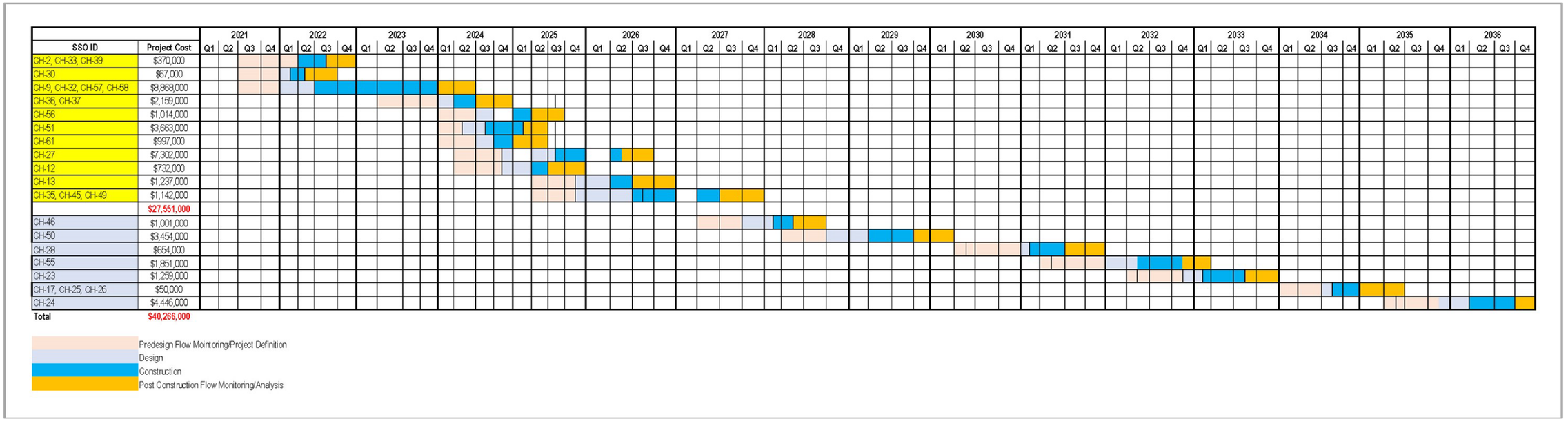


Figure ES-2. Cleveland Heights Tier 1 SSO Control Improvements Proposed Schedule



Report Overview

This Report integrates findings from the Partial Consent Decree tasks completed to date to summarize the analysis, findings and proposed remedial measures for the City of Cleveland Heights sanitary sewer system. **Section 1** provides an overview of the Cleveland Heights sewer system. **Section 2** discusses legal compliance issues, completion status of the Partial CD and how Cleveland Heights is using USEPA's Integrated Planning Framework as a basis for the program. **Section 3** summarizes the Cleveland Heights Sewer System Evaluation Survey (SSES) activities and results, including cleaning, televising and assessment of the entire sanitary sewer system. **Section 4** describes the flow monitoring, sewer system computer modeling and capacity assessment process and results that formed the basis for alternatives analysis and proposed improvements.

Section 5 summarizes how planning level improvement alternatives were developed and optimized and the resulting planning-level improvements proposed to control SSOs, remediate common trench over/under and dividing wall sewer systems, and reduce the risk of basement backups in projected problem areas. This section also provides the associated planning level project costs and describes how the associated construction and project costs were developed. **Section 6** describes the prioritization criteria and integrated planning considerations used to break the proposed improvements into three tiers and to prioritize work within the tiers.

Section 7 details the financial capability and affordability analysis and results used to establish a feasible program timeline. **Section 8** summarizes engagement with City Council and public participation that has accompanied development of the proposed program. **Section 9** provides the proposed program schedule and summarizes implementation considerations and outlines implementation of the typical project phases including project definition investigations, pre-design flow monitoring, design/bidding, construction, post-construction flow monitoring, and performance assessment.

Appendices A - G

This Report includes seven appendices containing additional information not previously submitted, as follows:

- **Appendix A** contains mapping showing high-frequency cleaning locations.
- **Appendix B** provides capacity assessment results for Consent Decree Rainfalls.
- **Appendix C** provides the *HHI-LSSES Project Cost Opinion Development Technical Memorandum, September 2018*
- **Appendix D** provides maps of Tier 1, 2 and 3 improvements for Consent Decree rainfalls.
- **Appendix E** provides the Tier 1 projects prioritization spreadsheet.
- **Appendix F** contains the Black and Veatch Report *Sewer Rate Study and Affordability Analysis, May 21, 2021*.
- **Appendix G** provides the City Council resolution approving the Master Plan and includes slides from Cleveland City Council and other public meetings and webinars.

1.0 BACKGROUND AND SEWER SYSTEM OVERVIEW

The City of Cleveland Heights is served by a separate sanitary sewer system that discharges to NEORSD's Easterly Wastewater Treatment Plant (EWWTP) on Lake Erie via the Heights Hilltop Interceptor (HHI) and Doan Valley Interceptor (DVI) systems. NEORSD owns and operates the interceptor system that serves Cleveland Heights and all or parts of 14 other communities as shown in **Figure 1-1**. The HHI system was constructed between 1985 and 2000 using a 5-year, 1-hour rainfall as the basis of design and ranges in size from 15 to 120 inches in diameter.

1.1 HEIGHTS HILLTOP INTERCEPTOR SYSTEM BENEFITS

The HHI system has provided two critical benefits. The first was to route separate sanitary sewage flows away from downstream combined sewer areas and the Doan Valley Interceptor (DVI) system and convey the sewage directly to the EWWTP for treatment prior to discharge to Lake Erie. This reduces the volume and sewage loading in the downstream combined sewer overflows (CSOs). The second, perhaps more important benefit for the tributary Heights communities, was to provide critical wet weather conveyance capacity to reduce basement backups (BBUs) and control SSOs present in the local community sewer systems. The HHI system has resulted in significant environmental and human health benefits for the region and the local tributary communities. The sewer system improvements proposed in this Report will continue to improve system performance in Cleveland Heights by optimizing use of the available NEORSD HHI system capacity per NEORSD guidelines and by remediating the existing local sewers to reduce peak wet weather flows and improve the local system structural conditions and serviceability.

1.2 CLEVELAND HEIGHTS SEWER SYSTEM

The Cleveland Heights sanitary sewer system is composed of 87% common trench and 13% separate trench sewers, with a total sanitary sewer length of 698,000 linear feet (LF). The common trench sewers include dividing wall, modified dividing wall, over/under (invert plate), over/under (piped access) and common standard manhole configurations. The Cleveland Heights sewer system serves a population of approximately 46,000 in a total area of 4,540 acres. **Table 1-1** summarizes the sewer system service area and primary system components. Sewer system trench types and lengths are summarized in **Table 1-2**. The *City of Cleveland Heights Partial Consent Decree Capacity Assessment Report, Revised February 2021* and the City of *Cleveland Heights Phase 1 Sewer System Evaluation Survey Report, February 2020 updated April 2021* discuss the sewer system and common trench sewers in detail. **Figure 1-2** shows the Cleveland Heights sewer system and sewer trench type locations.

Figure 1-1. Heights Hilltop Interceptor Service Area

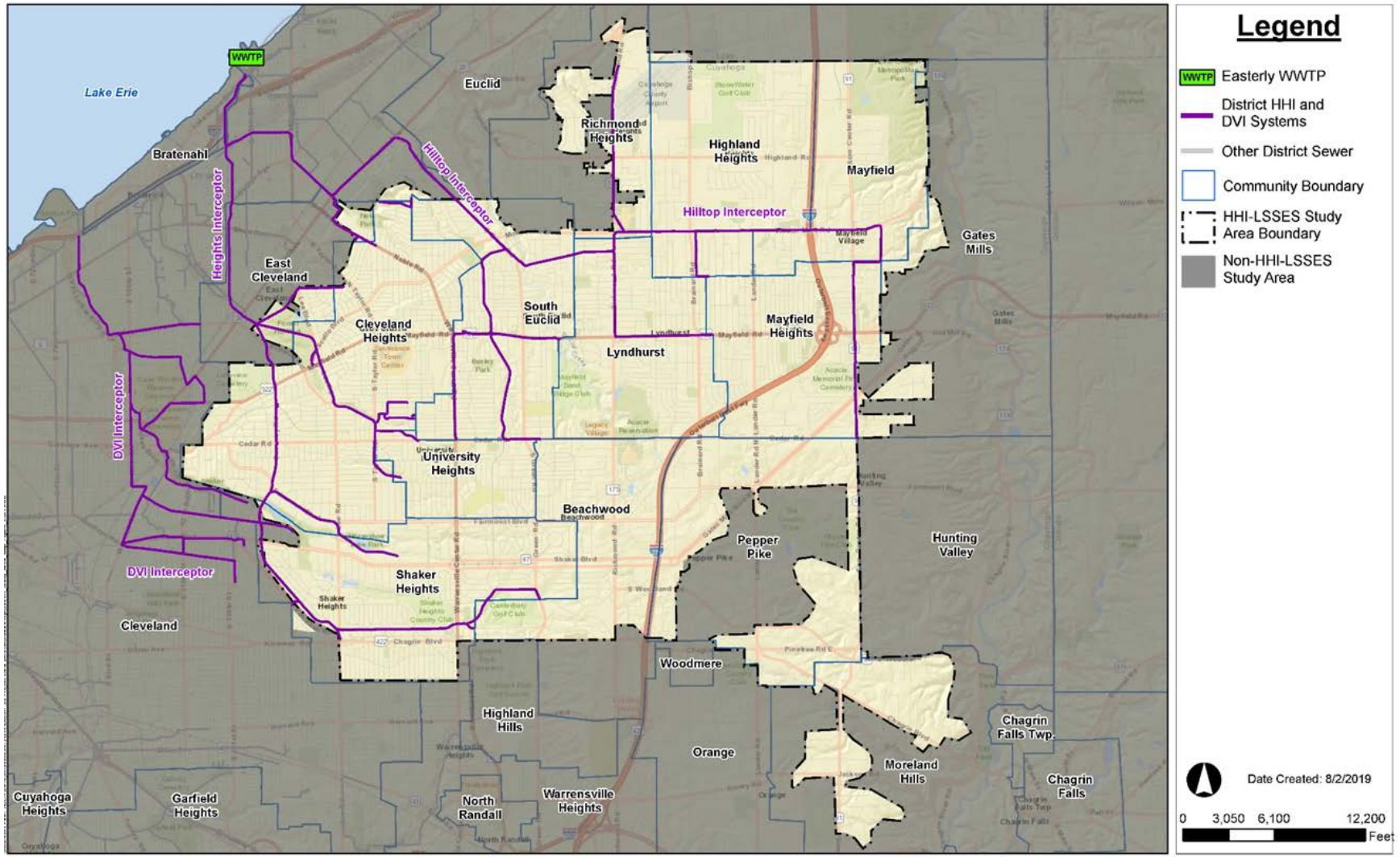
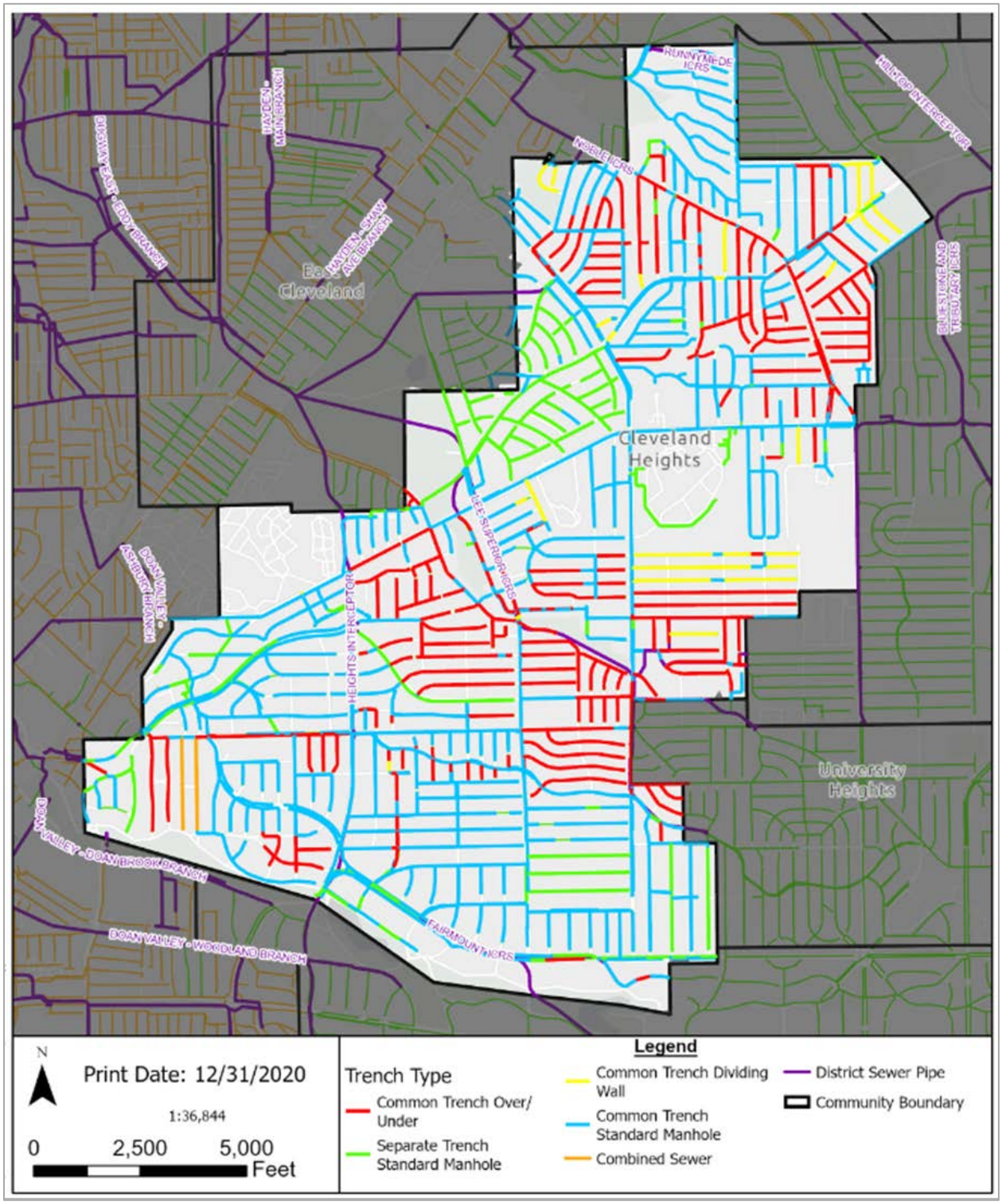


Table 1-1. Cleveland Heights Sewer System Information	
Service Area (square miles)	8.1
Population Served	46,000
Phase 1 SSES Gravity Sanitary Length (miles)	75
Phase 2 SSES Gravity Sanitary Length (miles)	49
Total Length of Gravity Sanitary (miles)	124
Combined Sewer (miles)	1.4
Number of Pump Stations	2
Number of Parcels Served by Pump Stations	12
Total Length of Force Main (miles)	0.03
Number of Sewer System Subareas	32

Table 1-2. Sanitary Sewer System Trench Types Summary		
Trench Type	Length, LF	Proportion
Separate Trench	88,614	13%
Common Standard	357,252	54%
Dividing Wall	24,558	4%
Over/Under (Invert Plate)	183,123	27.5%
Over/Under (Vertical Access)	3,927	0.5%
Combined Sewer	7,400	1%
Total	**664,874**	**100%**

Figure 1-2. Sanitary Sewer Trench Type Locations



1.2.1 Common Trench Sewers

Common trench sewer systems were primarily constructed prior to 1960 and represent the largest single cause of problems in the HHI area. Common trench sewers are an unusual sewer system configuration found primarily in northeast Ohio. The common trench configuration was developed to reduce construction cost, disruption, and duration by constructing both the sanitary and storm sewers in a single trench. Many of the Heights communities are in areas where rock is relatively shallow, so construction of the common trench sewers was likely viewed as an optimal solution at the time. Common trench systems are known to include some homes with a "flusher" downspout connected directly to the sanitary service lateral to help flush accumulated solids from the service laterals and downstream sewers during rainfall. These connections introduce significant inflow to the system during wet weather.

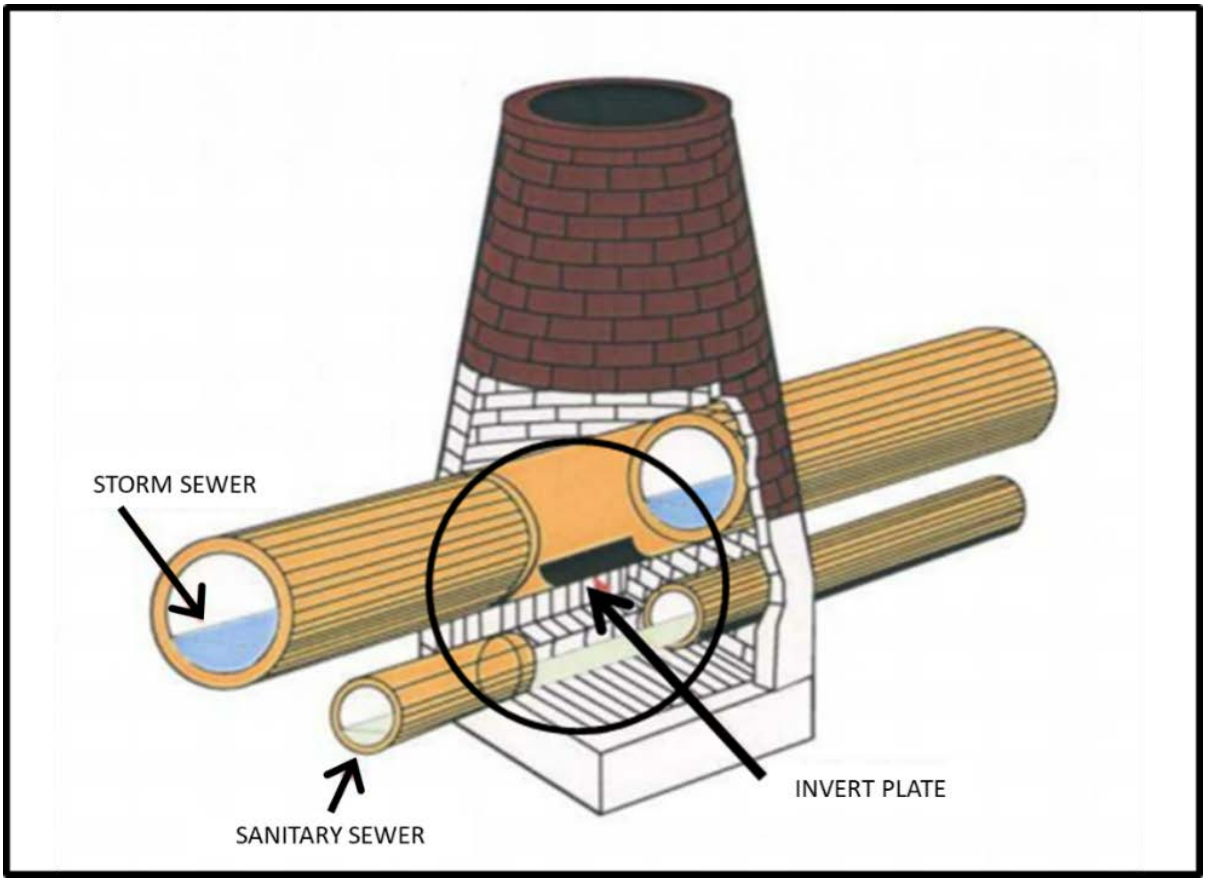
Additionally, as the sanitary and storm sewer systems have aged and developed defects, the common trench configuration has resulted in high wet weather flows in the lower sanitary sewers, and potential sewage contamination of stormwater under some hydraulic conditions. **Figures 1-3** through **1-8** show the four primary common trench manhole configurations including over/under (invert plate), over/under (piped access), dividing wall and common standard manholes. Leaky common trench sewers can:

- Contribute large amounts of sanitary sewer stormwater infiltration and inflow (I/I) leading to SSOs and BBUs.
- Allow crossflow of sanitary sewage and storm sewer flows, leading to contaminated stormwater.
- Contribute to solids deposition in sanitary sewers and allow undetected dry weather overflows.
- Make sewer system operation, maintenance, and repairs (OM&R) more difficult.

Common Trench Over/Under (Invert Plate) Sewers

Over/under sewer systems were constructed with the sanitary sewer located directly below the storm sewer as shown in **Figure 1-3**. A common manhole provides access to both storm and sanitary sewers. The two sewers are typically separated by a metal plate covering a large maintenance opening in the invert of the storm sewer. This configuration is particularly problematic because displaced or missing invert plates essentially create a two-pipe system that allows sewage and stormwater to mix and introduces excessive solids into the lower sanitary sewer. If the plates are permanently grouted in place to prevent crossflows, the sanitary sewer system cannot be maintained properly. This close configuration also complicates repairs to both sewers and typically produces the highest crossflows of all separate sewer systems even when the plates are in place.

Figure 1-3. Over/Under (Invert Plate) Sewer



Common Trench Over/Under (Piped Access) Sewers

The second less frequently encountered over/under sewer configuration includes a piped access constructed through the bench of the storm sewer manhole to provide access to the sanitary sewer below. **Figure 1-4** shows a sketch of this sewer configuration. **Figure 1-5** shows a piped access over/under sewer manhole from the surface. The City placed temporary wooden discs on the access pipes and checked status of these pipes after rain events. After several rain events there was no evidence of activation, so the disks have been cemented in place. When access to these pipes is needed, the cement will be broken out and the disk removed and replaced after maintenance has been completed. **Figure 1-6** shows a piped access manhole with the wooden disk grouted in place. Purchase of mechanical plugs is not being pursued at this time because of the non-standard size of the openings. No additional problems have been reported since the access pipes have been sealed.

Figure 1-4. Common Trench Over/Under Piped Access Sewer

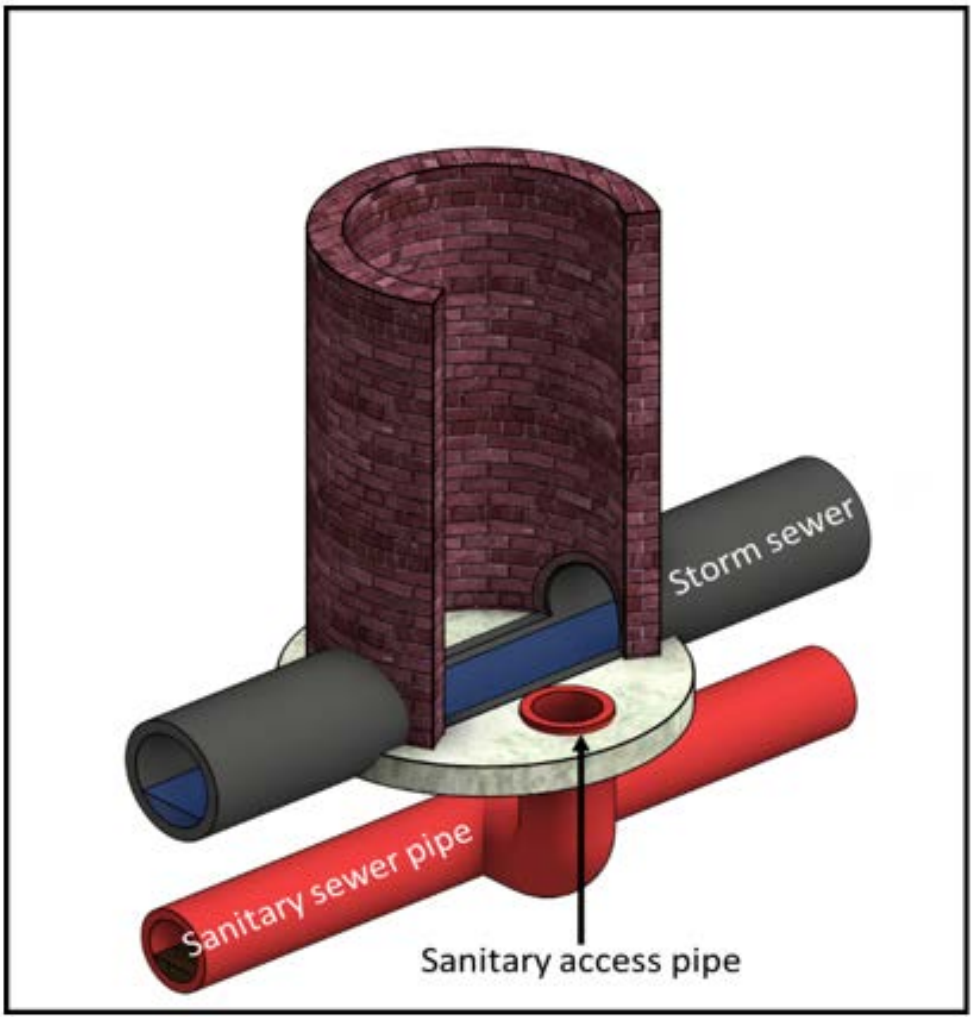


Figure 1-5. Topside Photo of Piped Access Sewer

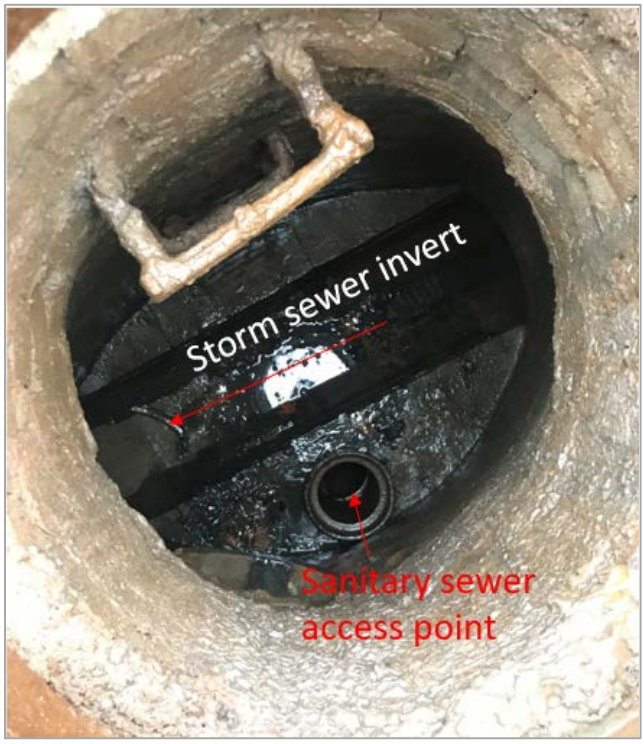
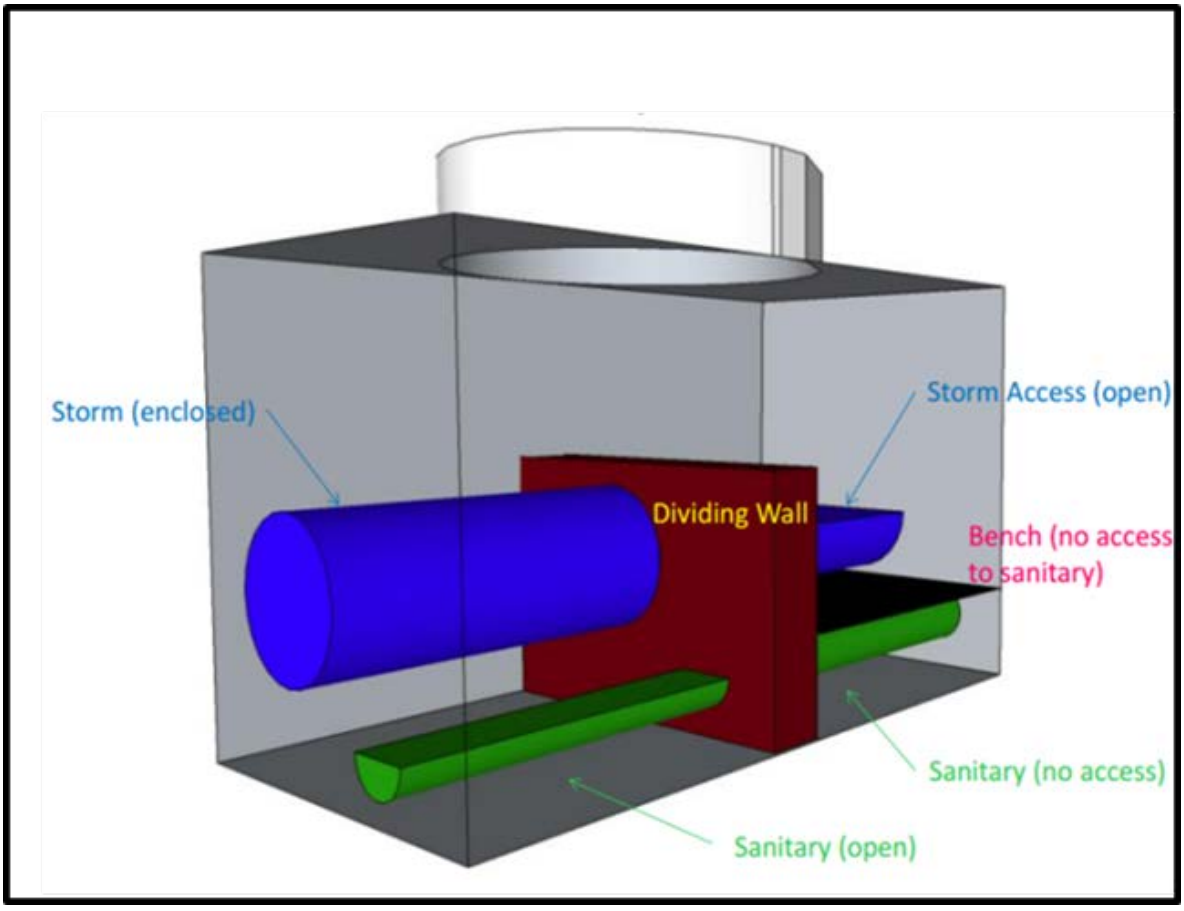


Figure 1-6. Piped Access Sewer with Wooden Disk Grouted in Place

Common Trench Dividing Wall Systems

In the dividing wall sewer configuration, the storm sewer is aligned above and is offset laterally from the sanitary sewer as shown in **Figure 1-7**. A common manhole allows access to the storm and sanitary sewers. In the manhole, a weir wall was typically constructed perpendicular to the flow path to separate flows in the two systems. An elevated water level in either system can cause an overflow of the weir wall into the other sewer. In some HHI communities, dividing wall systems have been modified to seal off the hydraulic connection in the manholes. These are referred to in this study as modified dividing wall manholes. In some cases, this connection was later reinstated, perhaps for maintenance access, or potentially to relieve surcharging. These are referred to as remodified dividing wall manholes.

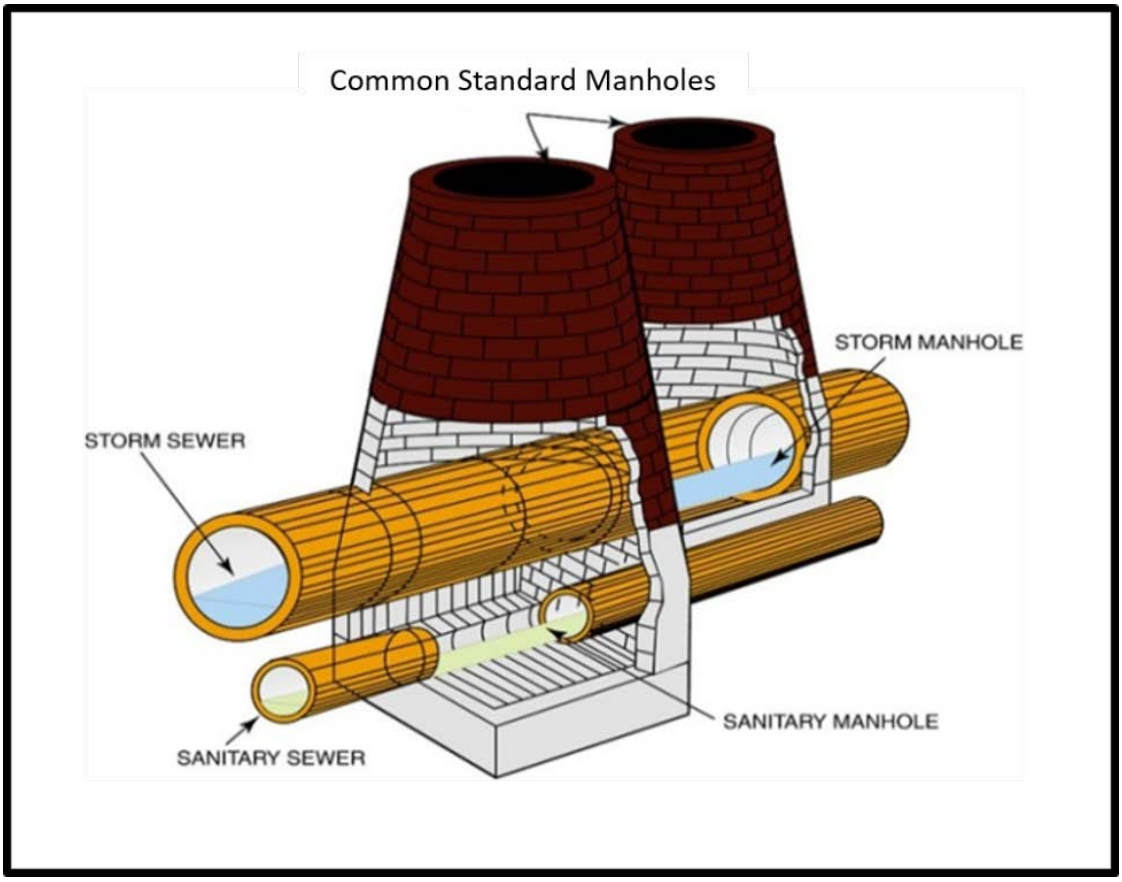
Figure 1-7. Common Trench Dividing Wall Manhole



Common Trench Standard Manhole Systems

The common standard sewer configuration constructed the storm sewer above and offset laterally from the sanitary sewer in the same trench as shown in **Figure 1-8**. Two separate manholes provide independent access to the storm and sanitary sewers. Although there is no direct hydraulic connection in the common standard system, there is an increased potential for stormwater exfiltration entering the sanitary sewer due to the proximity of the sewers.

Figure 1-8. Common Trench Standard Manholes



1.2.2 Recent and Continuing Improvements

Since 2016, Cleveland Heights has implemented several sewer system projects, some in partnership with NEORSD, to control SSOs and BBUs. The projects are summarized in **Table 1-3** and the project locations are shown in **Figure 1-9**.

Figure 1-9. Locations of Completed and Ongoing Sewer System Improvement Projects

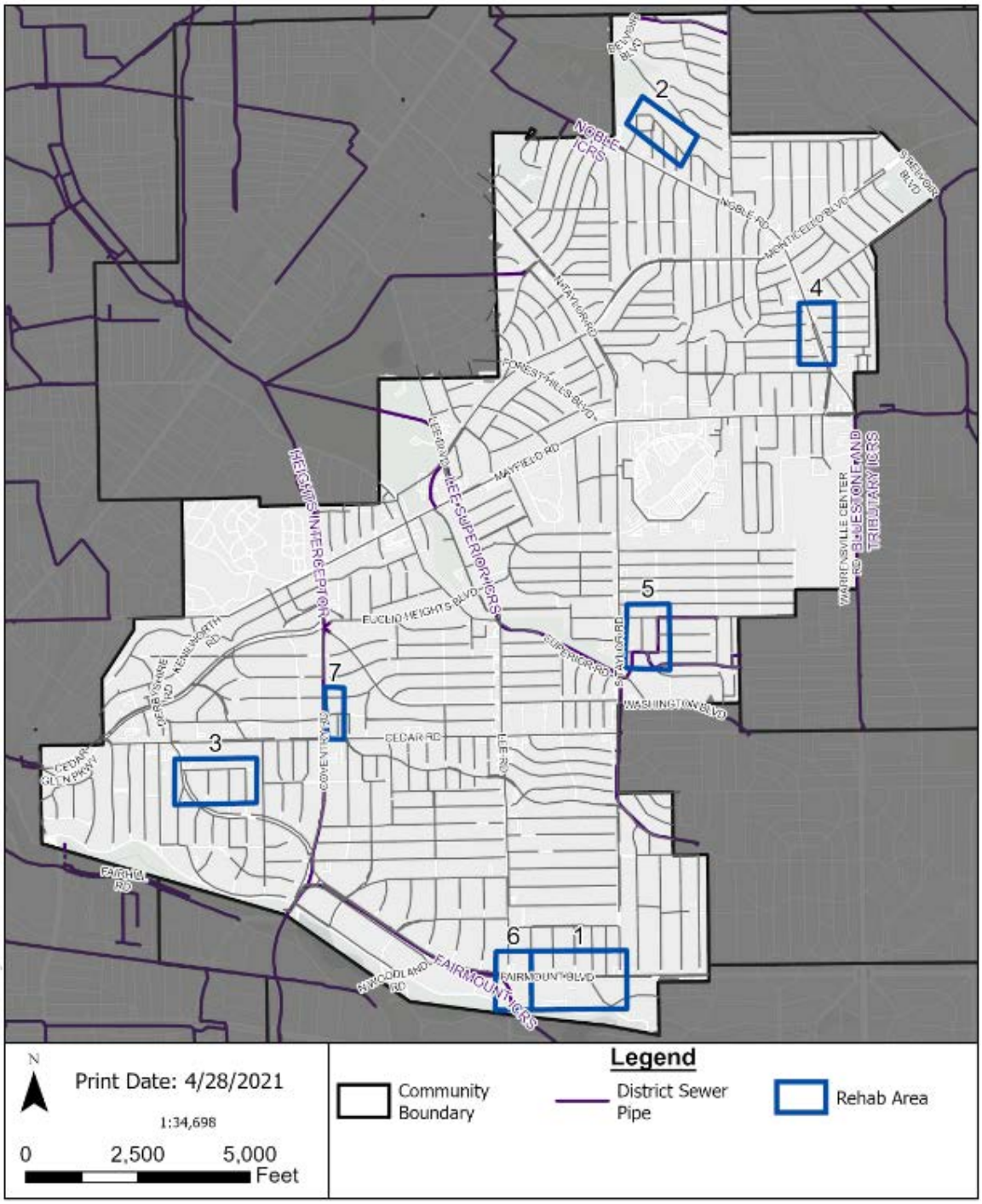
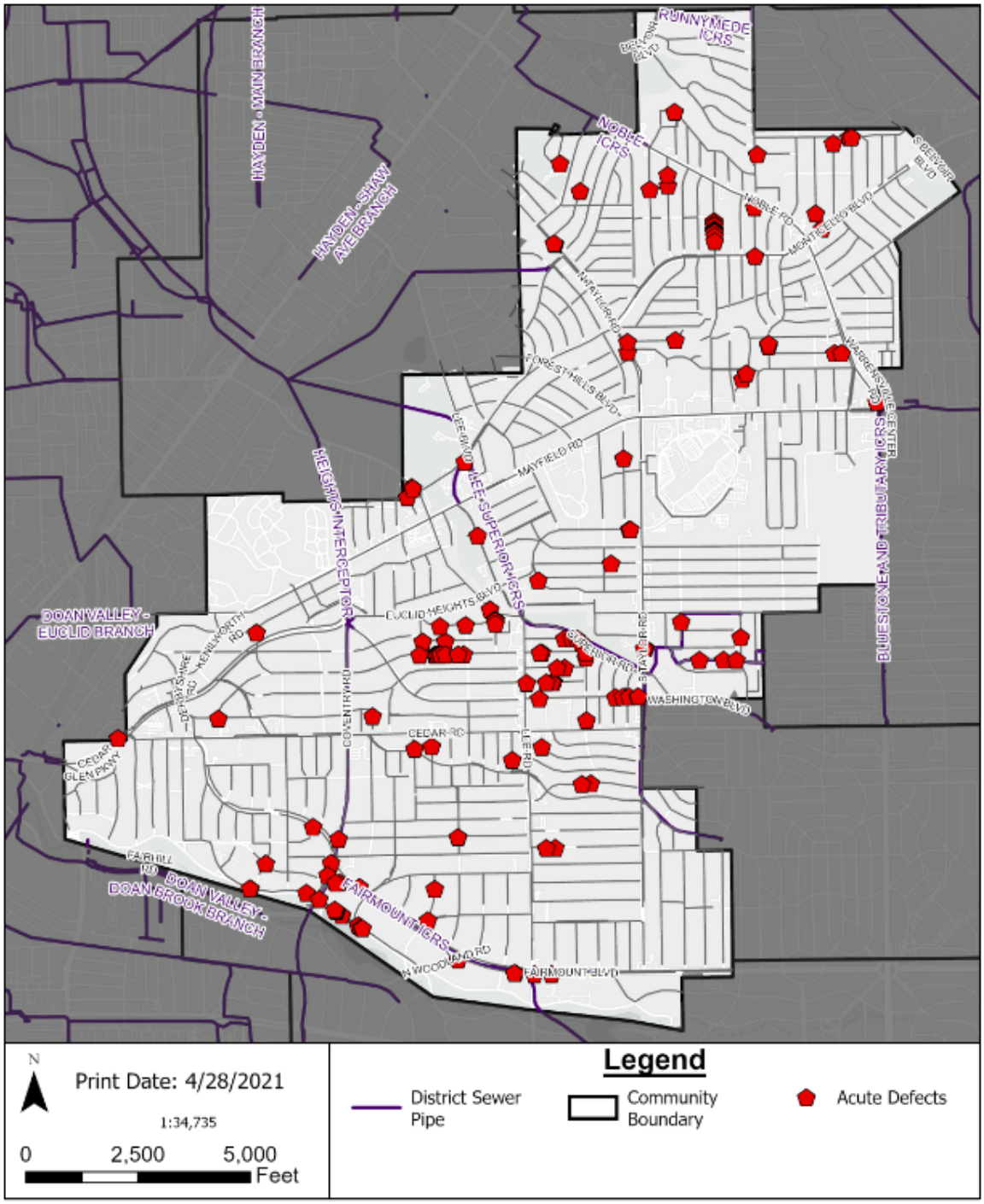


Table 1-3 Completed and Ongoing Sewer System Improvement Projects				
Reference # in Figure 1-9	Improvement Project	Purpose	Cost, $	Status
1	Fairmount Blvd Sanitary Relief Sewer	Sanitary relief sewer constructed to control four SSOs and eliminate two SSOs identified during design	2.3M	Completed 2018
2	Randolph Rd Sewer Improvements	Sewer system and service lateral rehab to improve performance and reduce I/I	300,000	Completed 2016
3	Delamere Dr Sewer Improvements	Sewer system improvements and inline storage to reduce risk of basement backups and replace aging sewers	1.4M	Construction Ongoing
4	Noble Rd Sewer Repair	Repair of collapsed sewer	20,000	Completed 2019
5	Janette Ave Sewer Replacement	Replacement of 115 LF of collapsed over/under sewer on Janette Avenue.	73,000	Completed 2019
6	Manhole Replacement 3176 Fairmount Blvd	Rebuilding of collapsing sanitary sewer manhole and pipe at 3176 Fairmount Blvd	16,000	Completed 2020
7	Renrock Road Sewer Replacement	Replacement of 268 LF of poor conditioned sanitary sewer on Renrock Road	100,000	Completed 2020
Figure 1-12	Invert plate replacements	19 invert plates found either missing or in disrepair have been replaced	19,000	Completed 2021
		Total	4.2M	

1.2.3 Remediation of SSES Phases 1 and 2 Critical Condition Sewers

Cleveland Heights is continuing sewer system rehabilitation, repairs, and replacements to remediate critical condition sewer system components identified in the recent SSES closed-circuit television (CCTV) inspections and associated investigations. **Figure 1-10** shows locations of critical sewer system defects requiring near-term rehabilitation or replacement. The proposed system rehabilitation is included in the financial analysis and integrated planning for the proposed Master Plan work described in this Report.

Figure 1-10. Acute Defects for Critical Condition Sewers

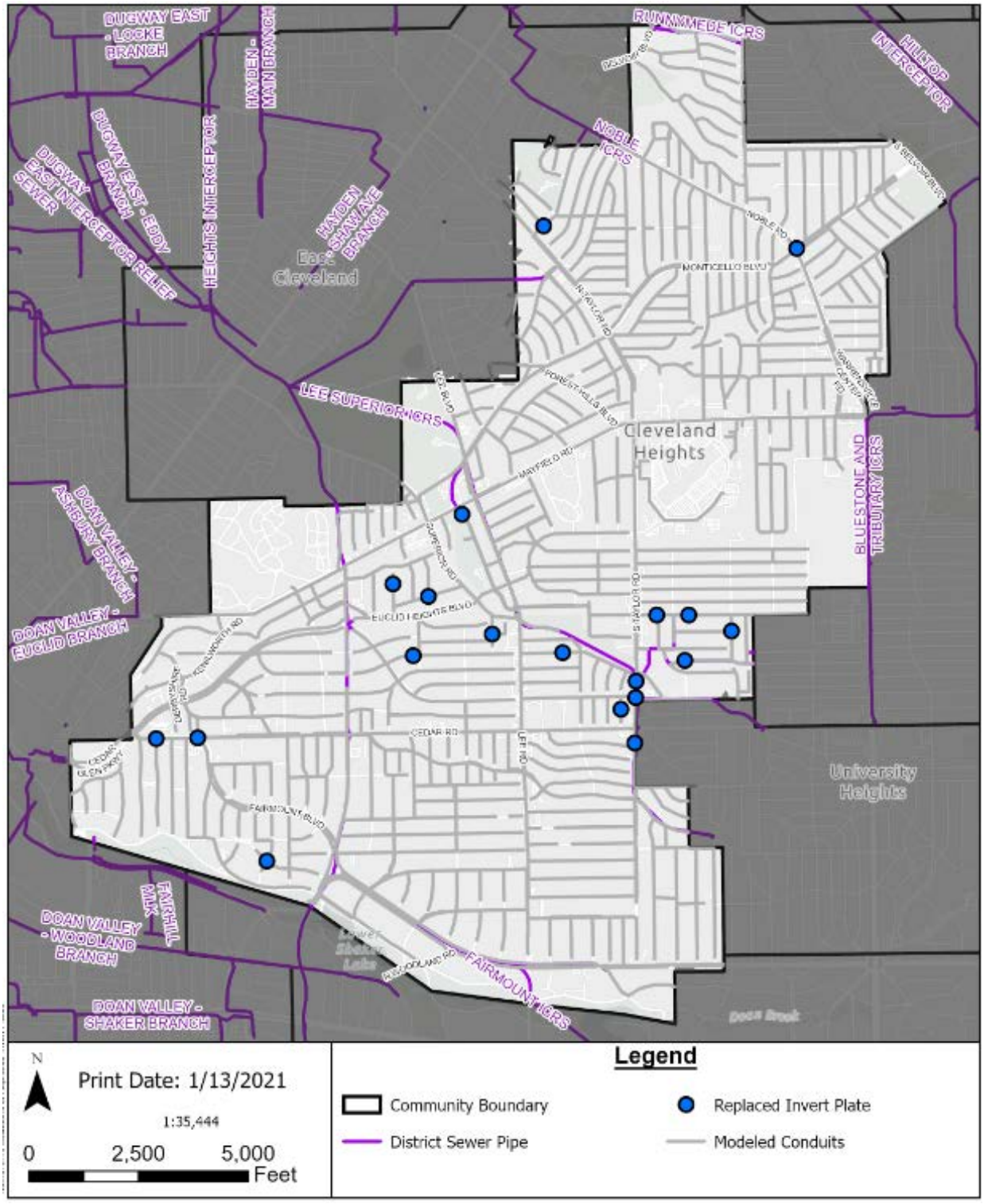


1.2.4 Over/Under Invert Plate Replacement

In 2018, the City of Cleveland Heights identified a supplier of new invert plates to replace broken and missing plates. The City replaced plates as they were identified during the sewer investigations. **Figure 1-11** shows an invert plate manhole before and after installation of the new plate. To date, the City has replaced 19 invert plates at locations shown in **Figure 1-12**. Status checks have been performed after significant rainfall events to confirm the performance of the new invert plates and the plates will continue to be checked and adjustments/replacements made as needed.

Figure 1-11. Missing and Replaced Invert Plate

Figure 1-12. Locations of Invert Plate Replacement



1.2.5 Sanitary Sewer System Cleaning

Since 2018 the City has cleaned 95% of the sanitary sewer system and will have completed cleaning of the entire system by June 30, 2021. Thereafter, the City will clean all sewer reaches in the sanitary sewer system at least once every 10 years. The City also has a High Frequency Cleaning Program that maintains a list of 31 “hot spots” for increased cleaning and/or inspections. The list includes locations of known recurring issues, the nature of the previous issue and the appropriate action (i.e., check, flush, root cut, grease control). The list is updated periodically as new issues arise and projects are completed to address the root cause of maintenance issues. The current high frequency cleaning locations are summarized in **Appendix A** of this Report. Hot spots are inspected and addressed twice annually or as determined by the Utilities Commissioner. Hot spot areas may be prioritized by the Utilities Commissioner if needed to optimize the High Frequency Cleaning Program.

2.0 LEGAL COMPLIANCE

This Report fulfills the Consent Decree requirements for the Master Plan and comports with the USEPA's Integrated Planning Framework, now part of the Clean Water Act, 33 U.S.C. Section 1412(s) as summarized below. The Master Plan will be submitted by June 1, 2021 for USEPA review and approval.

2.1 CONSENT DECREE REQUIREMENTS FOR THE MASTER PLAN

- Incorporate the results of the SSES, Capacity Assessment Report, Real Time Monitoring Plan, and System Characterization Monitoring Plan.
- Use a screening process to identify technically practical controls to meet the requirements of the Consent Decree.
- Identify the sizes of such practical controls required to provide adequate capacity for 2-year, 1-hour; 5-year, 1-hour; 10-year, 1-hour; 10-year, 6-hour; and 25-year, 1-hour rainfall events.
- Provide estimates of the (1) capital, operation and maintenance, and present-value costs and (2) time required for design, construction, and implementation for each remedial measure identified as a technically practical control measure as sized for each of the storms included above. The estimated costs are provided in consistent, year-specific dollars.
- Identify the site-specific remedial measures the City will undertake that will (1) eliminate SSOs; (2) ensure that there is adequate capacity in the sanitary sewer system to collect and convey anticipated peak flows under current and projected future conditions; and (3) eliminate illicit discharges, cross connections, and non-stormwater discharges into the MS4.
- Identify a proposed implementation schedule for the selected remedial measures that includes dates for the notice to proceed, beginning of construction, completion of construction, and placement in operation.
- Identify a plan for monitoring and modeling to evaluate the success of the remedial measures.
- Remedial measures proposed by Cleveland Heights in its Master Plan to address capacity limitations may include but are not limited to:
    - Removing I/I sources, including footing drains and other sources of private I/I, and/or using innovative approaches such as green infrastructure.
    - Removing cross connections between the sanitary sewer system and the MS4.
    - Increasing the capacity of gravity sewer lines.
    - Constructing storage or equalization basin facilities.
    - Hiring additional personnel or purchasing additional equipment.
- The remedial measures in the Master Plan shall achieve the goal of ensuring adequate capacity in the sanitary sewer system and eliminating SSOs as expeditiously as practicable.
- In proposing the timing and order of remedial measures, Cleveland Heights shall set priorities based upon potential for harm to human health or the environment, frequency, and volume of SSOs, the location of SSOs in low-income census tract areas, and technical engineering judgment.

2.1.1 Consent Decree Status

The Consent Decree *Appendix D: Schedule of Consent Decree Requirements* lists the requirements and due dates. All requirements have been achieved/submitted by the required dates as shown in **Table 2-1**.

Table 2-1. Partial Consent Decree Completion Overview

	Requirement	Consent Decree Citation	Submit for Review and Approval (all submittal requirements have been met to date)
1	Have an operable, discoverable website dedicated to posting Consent Decree Deliverables	CD Main Text Section VII Paragraph 44.	Within 1 month after CD lodged
2	Install information management system (IMS) on city computers	Appendix B Section A Paragraph 4.a.	Within 4 months after CD lodged
3	Hire IT professional to implement IMS	Appendix B Section A Paragraph 4.b.	July 1, 2017
4	Provide USEPA a report that analyzes FOG and root problems	Appendix B Section A Paragraph 4.c.	August 1, 2017
5	Carry out complete review of sewer maintenance spare parts inventory	Appendix B Section A Paragraph 4.e.	September 1, 2017
6	Have at least 2 staff complete training provided by IMS software provider	Appendix B Section A Paragraph 4.d.	Within 7 months after CD lodged
7	Develop and implement public information program for Sewer System	Appendix B Section A Paragraph 4.f.	December 1, 2017
8	Have at least 7 employees complete training for assessment and certification of pipelines and manholes	Appendix B Section A Paragraph 4.h.	December 1, 2017
9	Submit CMOM that satisfies Appendix B	CD Main Text Section V.C Paragraph 21.	December 1, 2017
10	Submit SSES work plan for 2 phased approach	CD Main Text Section V.B Paragraph 17.	December 4, 2017
11	Submit System Characterization Monitoring Plan that satisfies Appendix A	CD Main Text Section V.D Paragraph 25.	March 2, 2018
12	Submit System Modeling Plan that satisfies Section E and IV in Appendix A	CD Main Text Section V.E Paragraph 26.	March 30, 2018
13	Fully implement and develop IMS system	Appendix B Section I Paragraph 28.	December 1, 2018
14	Develop System Model of Sanitary Sewer that satisfies Section E and IV of Appendix A	CD Main Text Section V.E. Paragraph 27.	April 1, 2019

Table 2-1. Partial Consent Decree Completion Overview			
Requirement		Consent Decree Citation	Submit for Review and Approval (all submittal requirements have been met to date)
15	Complete Phase 1 SSES, satisfying Section II of Appendix A	CD Main Text Section V.B. Paragraph 18.	November 1, 2019
16	Submit Phase 1 SSES Report to USEPA	CD Main Text Section V.B. Paragraph 18.	February 3, 2020
17	Develop and submit Capacity Assessment Report	CD Main Text Section V.E. Paragraph 28.	March 2, 2020
18	Submit Integrated Overflow Control Master Plan	CD Main Text Section V.F. Paragraph 30.	June 1, 2021

On May 24, 2021, Cleveland Heights City Council voted to adopt a resolution supporting the Master Plan. This resolution is included in **Appendix G**. The following items remain to be completed as of this Report submittal:

- Complete Phase 2 of the SSES – June 30, 2021
- Submit Phase 2 SSES Report to USEPA – September 30, 2021

2.2 INTEGRATED PLANNING FRAMEWORK

The City of Cleveland Heights developed its Integrated Overflow Control Master Plan in accordance with the principles and elements of USEPA's Integrated Planning Framework (IPF), now codified at 33 U.S.C. Section 1412(s). The Master Plan exemplifies the principles articulated in the IPF, with particular emphasis on the principle of "address[ing] the most pressing public health and environmental issues first." For Cleveland Heights, these most pressing issues are the identified SSOs and risk of basement backups. The Master Plan also relies on evolving innovation in how to best and most cost-effectively update its common trench sewer system in the years ahead after the immediate phase of work.

Each of the six elements in the IPF is fully addressed in this Master Plan. Elements 1 and 2 require, respectively, descriptions of the regulatory issues to be addressed and of the current system and its performance. These elements are thoroughly addressed in Sections 1, 3 and 4 and their underlying studies. Element 3 requires a process for public communication. As set forth in Section 8, the City has maintained open communication on this issue for several years, as reflected in the materials and comment opportunity that it maintains on its website and in conducting public webinars under COVID restrictions. Element 4 requires presentation of alternatives analysis, including the relevant financial strategy. Section 7 and its associated appendix provide the required, detailed financial analysis that explains the extremely high burden facing Cleveland Heights. Alternatives analysis is captured in many

sections but most completely in Sections 5 and 6. Element 5 requires a plan for measurement of success, which as discussed herein includes compliance with the Partial Consent Decree, elimination of identified SSOs and reduction of the risk of basement backups. See, among other discussions, Section 2. Element 6 specifies that a plan have an ability to make improvements to the Integrated Plan. This Master Plan purposefully is set forth in a phased approach so that improvements can be made. Further, City Council, in this Master Plan, has adopted the principle of Adaptive Management precisely for the reason of incorporating improvements based on lessons learned as the Master Plan is implemented, a vital approach to addressing the task of affordably retrofitting common trench sewers.

3.0 SUMMARY OF SSES

The Cleveland Heights SSES was divided into two phases. The Phase 1 area included more than 50% of the collection system and focused on the worst performing portions of the system including all known SSOs and their associated tributary areas, over/under sewer areas, community identified problem areas, and portions of the system projected to have the highest inflow and infiltration (I/I) rates. The Phase 1 SSES was completed on November 1, 2019, and the Phase 1 SSES Report was submitted on January 31, 2020. The remaining Cleveland Heights sewer system areas will be included in the Phase 2 SSES to be completed by June 30, 2021. **Figure 3-1** shows the Phase 1 and Phase 2 areas for the SSES.

The City received two sets of follow up questions from USEPA on the Phase 1 SSES Report submittal. The City provided two SSES Phase 1 Report updates to USEPA. A virtual meeting with the City and USEPA occurred on November 24, 2020 to discuss questions and comments, and formal written responses. The City submitted a final updated Phase 1 Report to USEPA in April 2021. Inspection in the Phase 2 area is concluding in May or June 2021 with the Phase 2 Report due for submittal to USEPA on or before September 1, 2021.

3.1 SSES FIELD INVESTIGATION AND CLEANING ACTIVITIES

Field investigations and other efforts completed for the HHI-LSSES and Phase 1 SSES projects included model calibration flow monitoring, micromonitoring, real-time SSO monitoring, manhole inspections, dyed water testing in public sewers and on private property, sewer system cleaning, CCTV investigations, and identification of interconnections between the sanitary sewer system and MS4. The City detailed these efforts and results in previously submitted reports. The SSES has provided updates of system connectivity that supported model extension and the ArcGIS online (AGOL) representation of the system. Dye flood testing and smoke testing have yielded an understanding of expected I/I in the different trench types and manhole configurations. Primary findings are summarized in this section.

3.1.1 Cleaning, Condition Assessment, and Other Maintenance

The SSES cleaned and televised the entire Cleveland Heights sewer system. Heavy cleaning was required in approximately 50% of the system, as shown in **Figure 3-2**. This extensive effort has significantly improved system performance under both dry and wet weather conditions and has identified several locations where sewer repairs or replacement are needed. The SSES assessment has also supported development of SSO control (Tier 1) and Tier 2 and Tier 3 improvements and prioritization. A map showing locations with NASSCO PACP[1] defect scores 4 and 5 defects identified during the SSES through 2020 is provided in **Figure 3-3**. The final Phase 2 SSES Report will provide updated condition information for the entire system.

[1] NASSCO PACP: National Association of Sewer Service Companies Pipeline Assessment and Certification Program

Figure 3-1. SSES Phase 1 and Phase 2 Areas

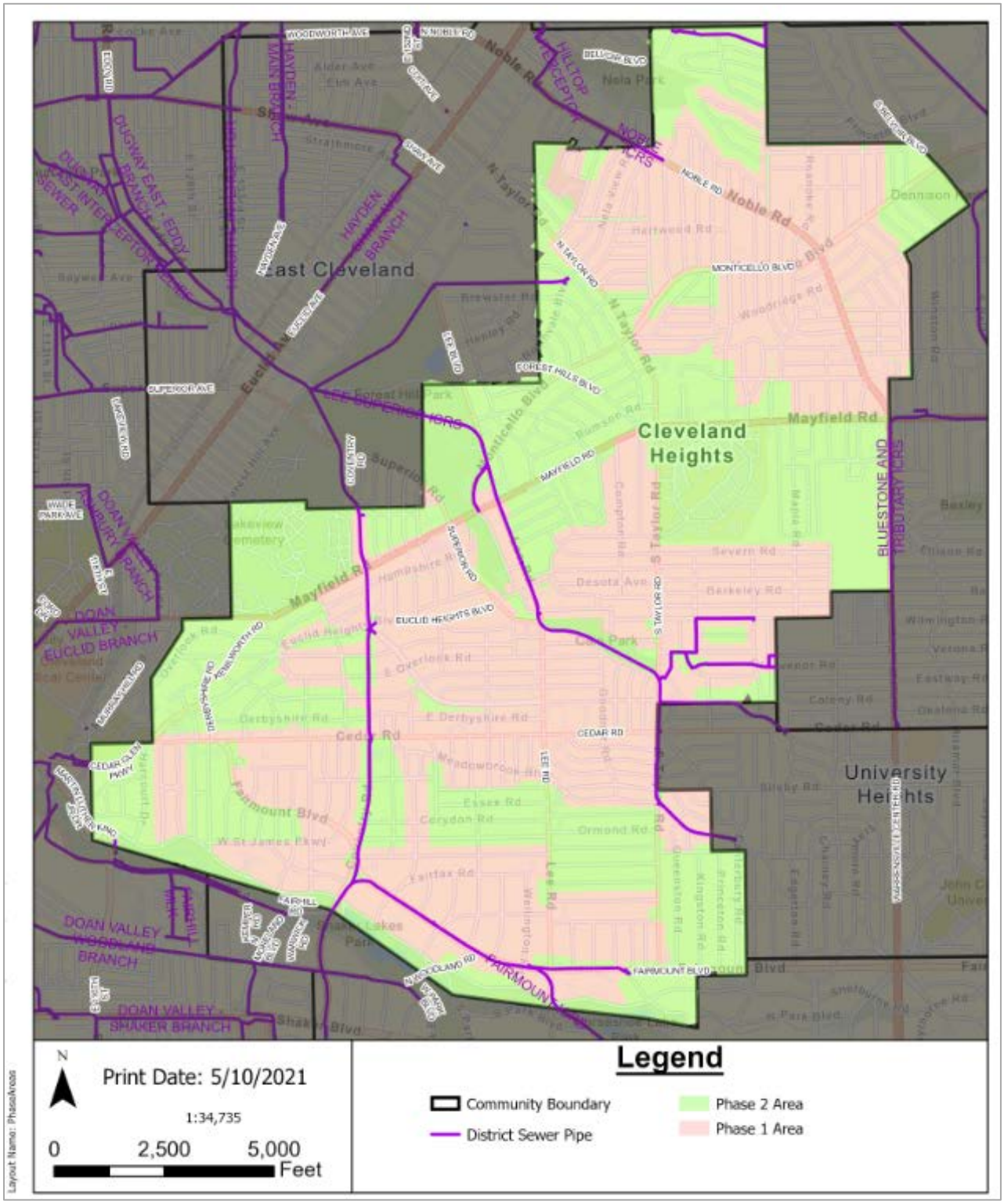


Figure 3-2. Locations of Heavy Cleaning Performed During SSES

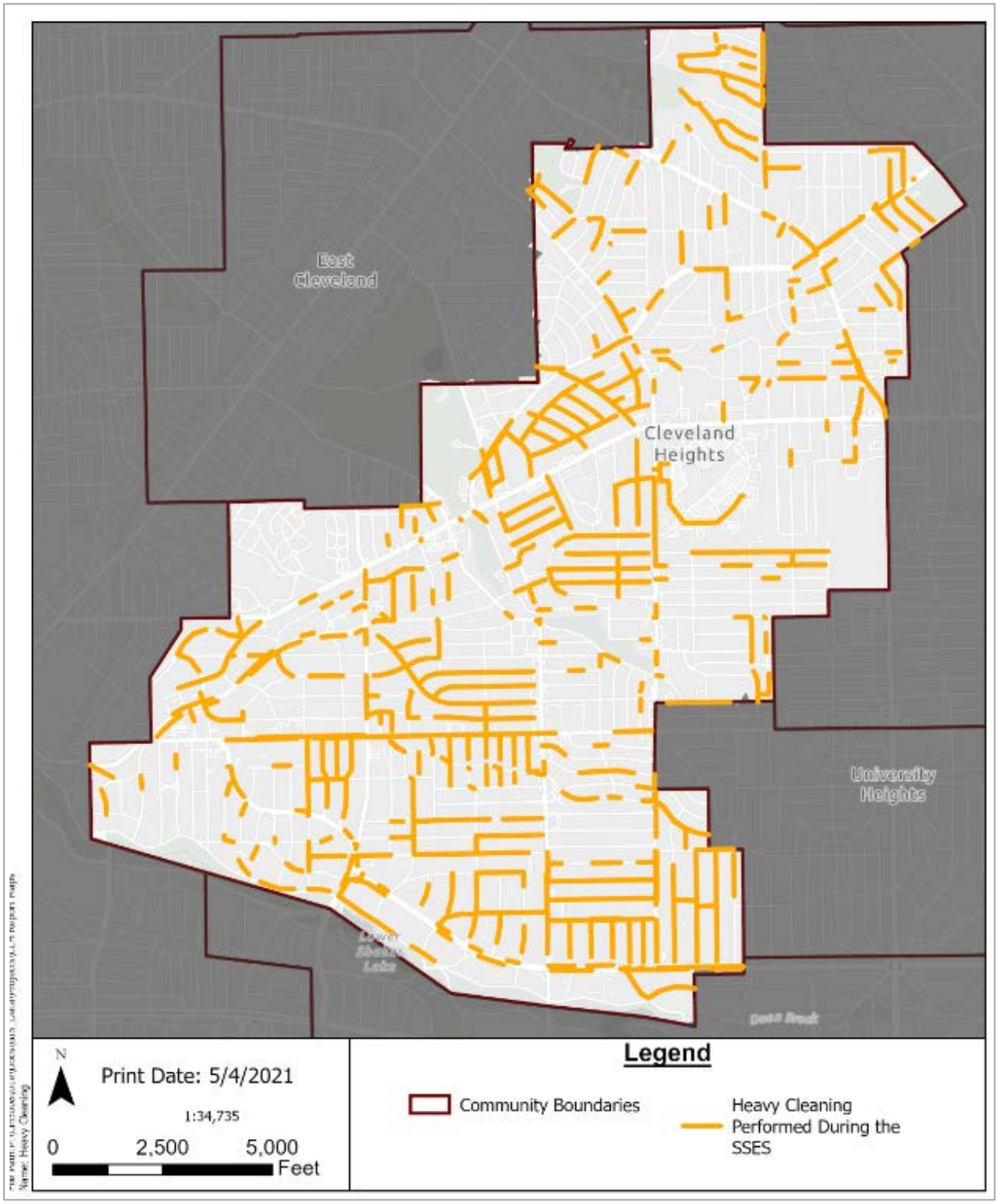
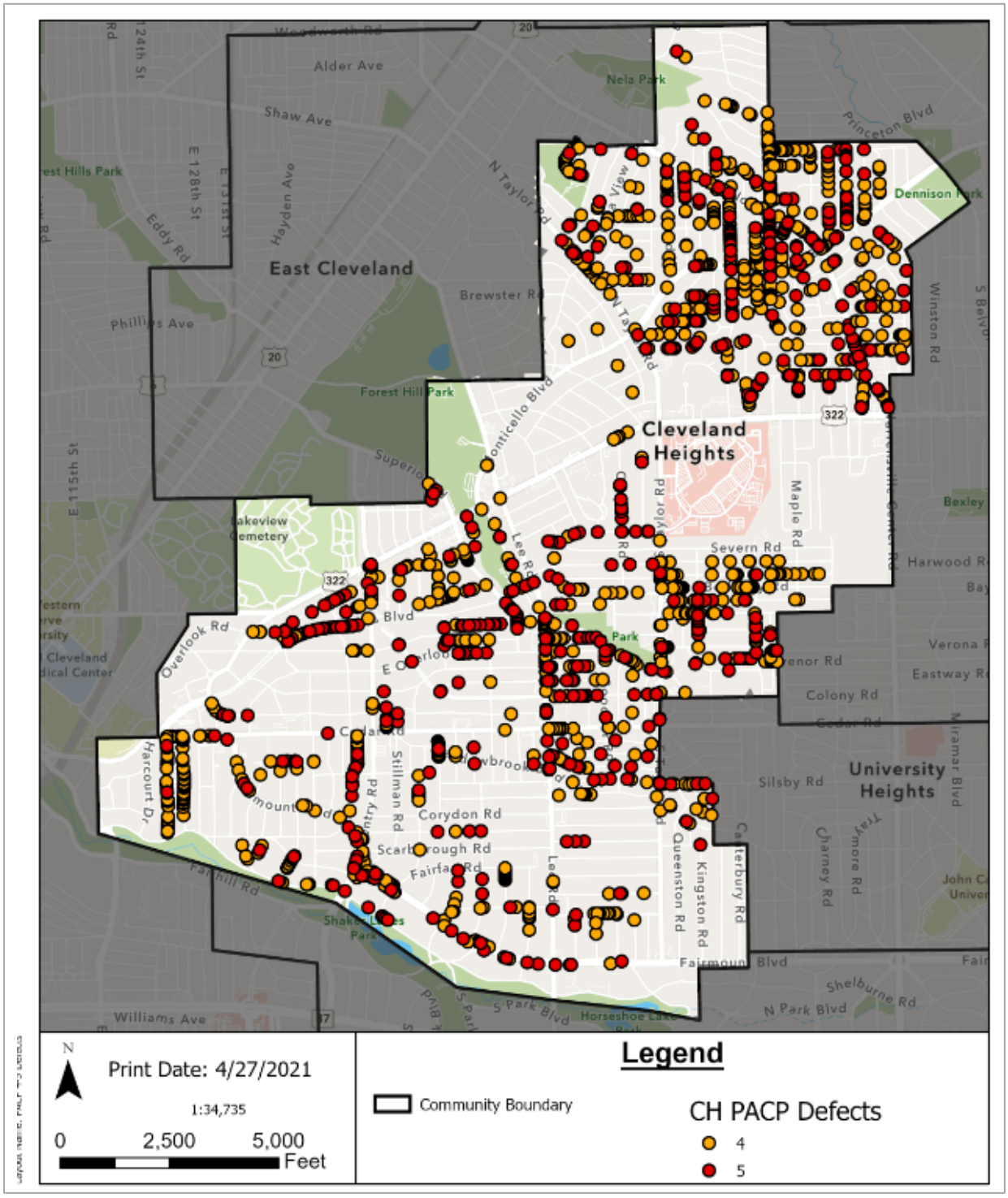


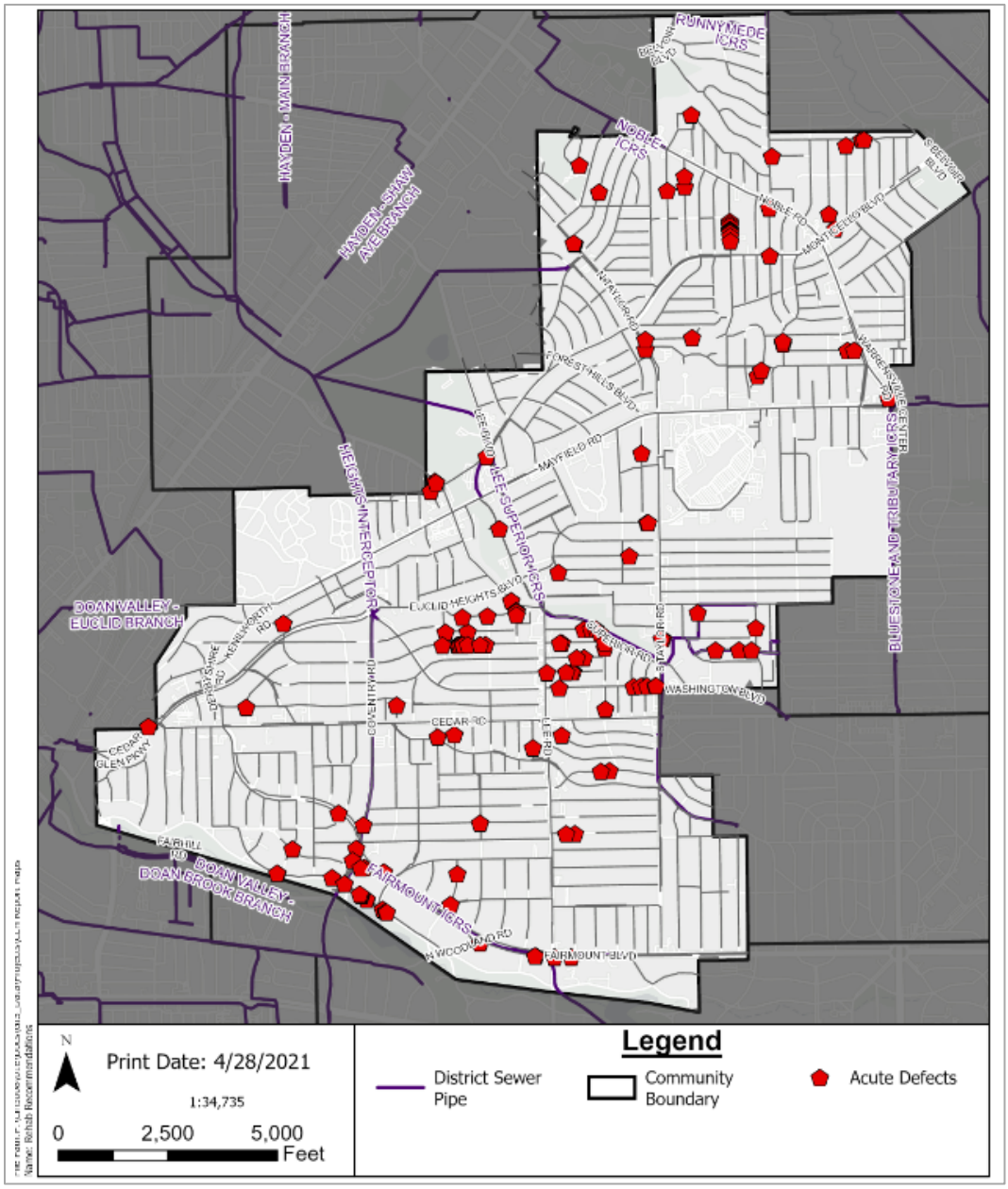
Figure 3-3. Locations of NASSCO PACP 4 and 5 Defects



Acute Sewer System Defects

The most severe defects found include hinge fractures, holes in pipe with void visible, and broken pipe that are recommended for repair or replacement as soon as possible. Locations of acute defects are shown in **Figure 3-4.** Repair of acute defects will be completed in parallel with the Tier 1 SSO control projects. In cases where acute defects are close to active SSOs, the defect(s) may be rehabilitated as part of the Tier 1 projects. The Phase 2 SSES Report, due September 30, 2021, will address the findings from the rest of the investigation in the collection system and address outstanding comments made by USEPA. Acute defects found in the remaining investigation will be added to the current list.

Figure 3-4. Locations of Acute Defects Found During SSES



Over/Under Sewers Inspection and Remediation

The City completed other maintenance activities, including invert plate inspection, and reseating and replacing invert plates where needed in over/under sewer areas. A total of 146 invert plates were reseated in place after manhole inspection showed the plates to be unseated or seated improperly. An example of an unseated plate that has been reseated can be seen in **Figure 3-5**. To date, 19 missing or broken invert plates have also been replaced as shown in **Figure 3-6**.

Figure 3-5. Unseated Invert Plate that has been Seated Properly

Figure 3-6. Over/Under Sewer Before/After Invert Plate Installation

The City identified over/under piped access manholes at 18 locations. The open pipes were plugged and grouted with wooden disks to prevent cross flows at these manholes. An example sealed pipe access is shown in **Figure 3-7**. These disks can be removed if required to perform maintenance or relieve the system.

Figure 3-7. Sealed Pipe Access Manhole

3.1.2 Resident Flooding Survey

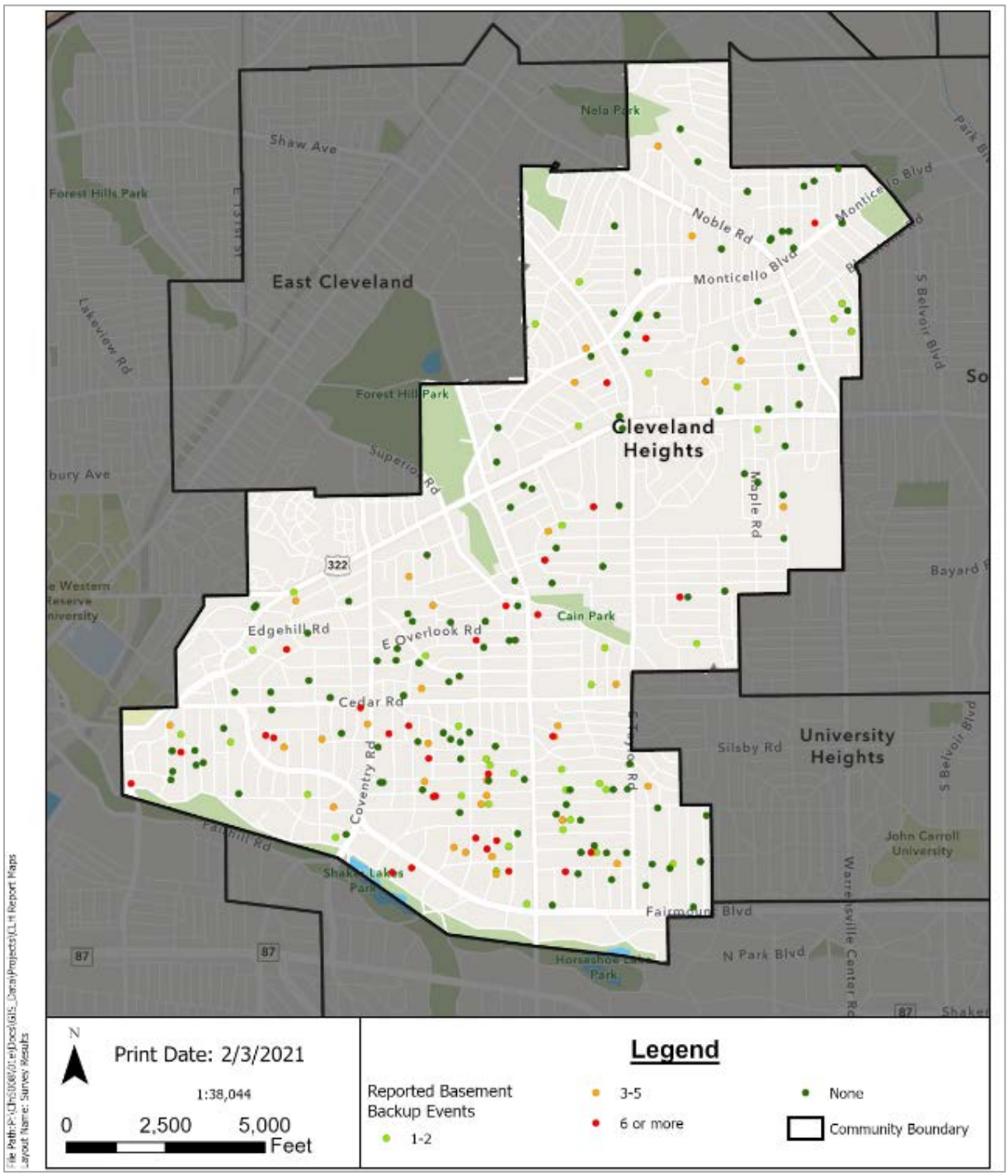
In August 2020, the City initiated a Stormwater Management Survey to better understand flooding locations and surface flooding versus basement backups. The survey requested occurrences of basement backups and other flooding issues in the past 10 years. The survey included questions relevant to basement and property flooding such as the following:

- Has flooding or drainage been a problem in your home or on your property?
- How many times in the last ten years have you had water in your basement?
- What is the usual depth?
- How did water end up in your basement?
- What was the character of the water?

The survey information to date has indicated, particularly in common trench areas, that actual performance is often better than that projected using the system model. This is believed to result from both the storm sewer system capacity and the storage volume available in the sewer trench for flows that exceed sanitary and storm sewer system capacities. Cleveland Heights is considering conducting a more detailed survey that may be sent to all residents. There is also preliminary planning by NEORSD to potentially deploy a common complaint questionnaire and AGOL tracking system for member communities that would help make the information collected more uniform and would display via AGOL. **Figure 3-8** shows reported basement flooding locations based on survey responses. Colored dots

represent the number of recorded basement flooding occurrences in the last 10 years. Existing and future survey information will be considered to better define and prioritize sewer system improvement projects.

Figure 3-8. Resident Flooding Survey Responses – Basement Backups in Past 10 Years



4.0 SYSTEM MONITORING, MODELING AND CAPACITY ASSESSMENT

NEORSD HHI-LSSES project conducted extensive sewer system monitoring, modeling, and capacity assessment from 2016 through 2019 for 14 communities served by the HHI system. The HHI-LSSES monitoring program in Cleveland Heights in the spring/summer of 2016 included 46 sanitary sewer model calibration meters, 4 storm sewer system meters, and 53 sanitary sewer micromonitoring locations to help target field investigations in areas of highest wet weather flow response.

Following NEORSD HHI-LSSES project, Cleveland Heights conducted additional sewer system monitoring, modeling and assessment of system capacity and potential problems to develop a more detailed model of the local collection and trunk sewer system discharging to NEORSD interceptors. The sewer system models developed under both efforts are summarized in **Figure 4-1**. As shown in the figure, the updated and expanded model included nearly all local sewers. Additional flow monitoring was also conducted at 55 locations to support expansion and updated calibration of the model. **Figure 4-2** shows the new locations added for the Cleveland Heights SSES model expansion.

The flow monitoring and modeling planning and capacity assessment efforts and results are described in more detail in the following documents previously submitted to USEPA.

- *Cleveland Heights System Characterization Monitoring Plan, March 2, 2018*
- *Cleveland Heights System Modeling Plan, Revision Per EPA Comment, November 2018*
- *Cleveland Heights Capacity Assessment Report, Final, February 2021*

Figure 4-1. Cleveland Heights Modeled Sanitary Sewer System

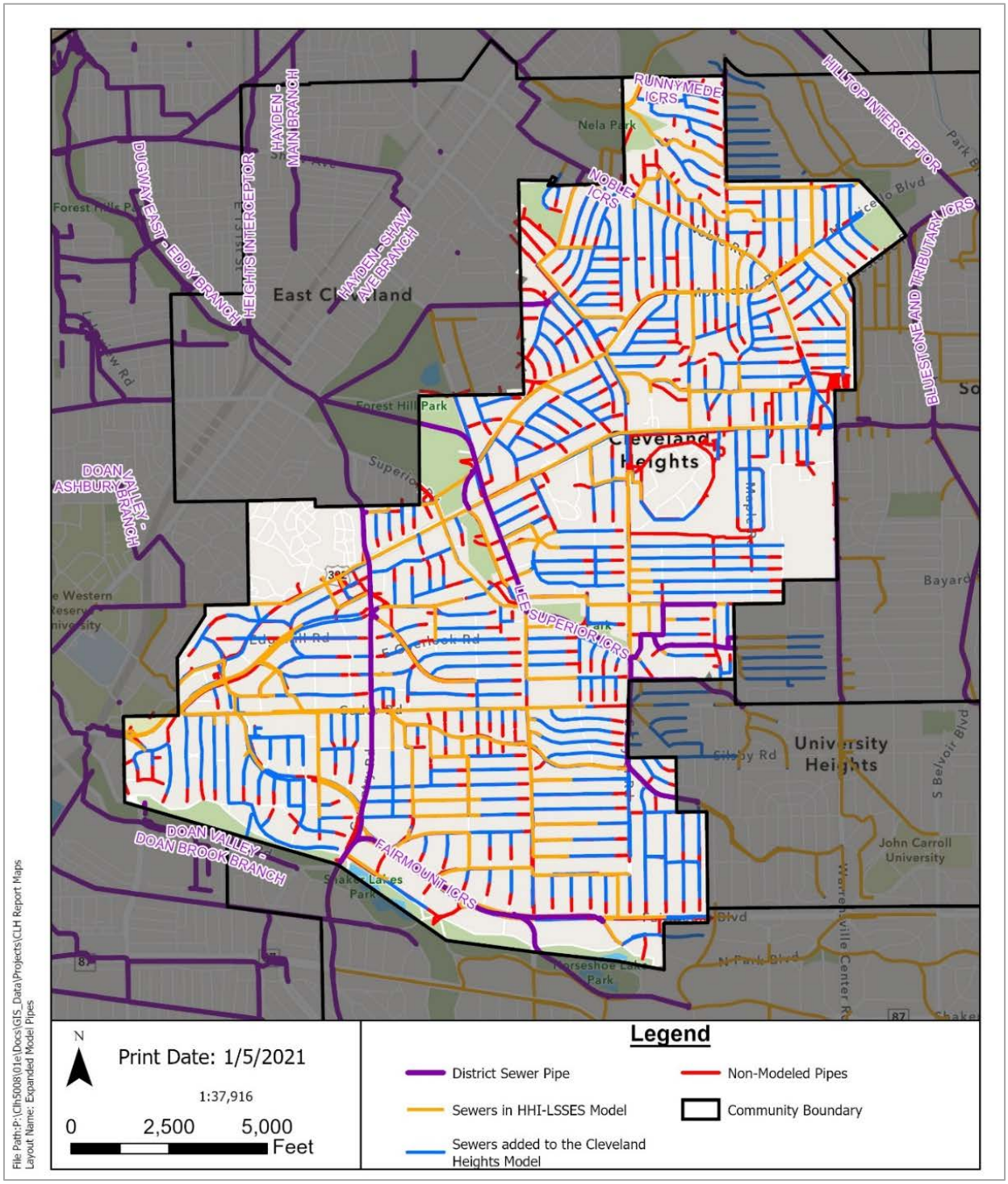
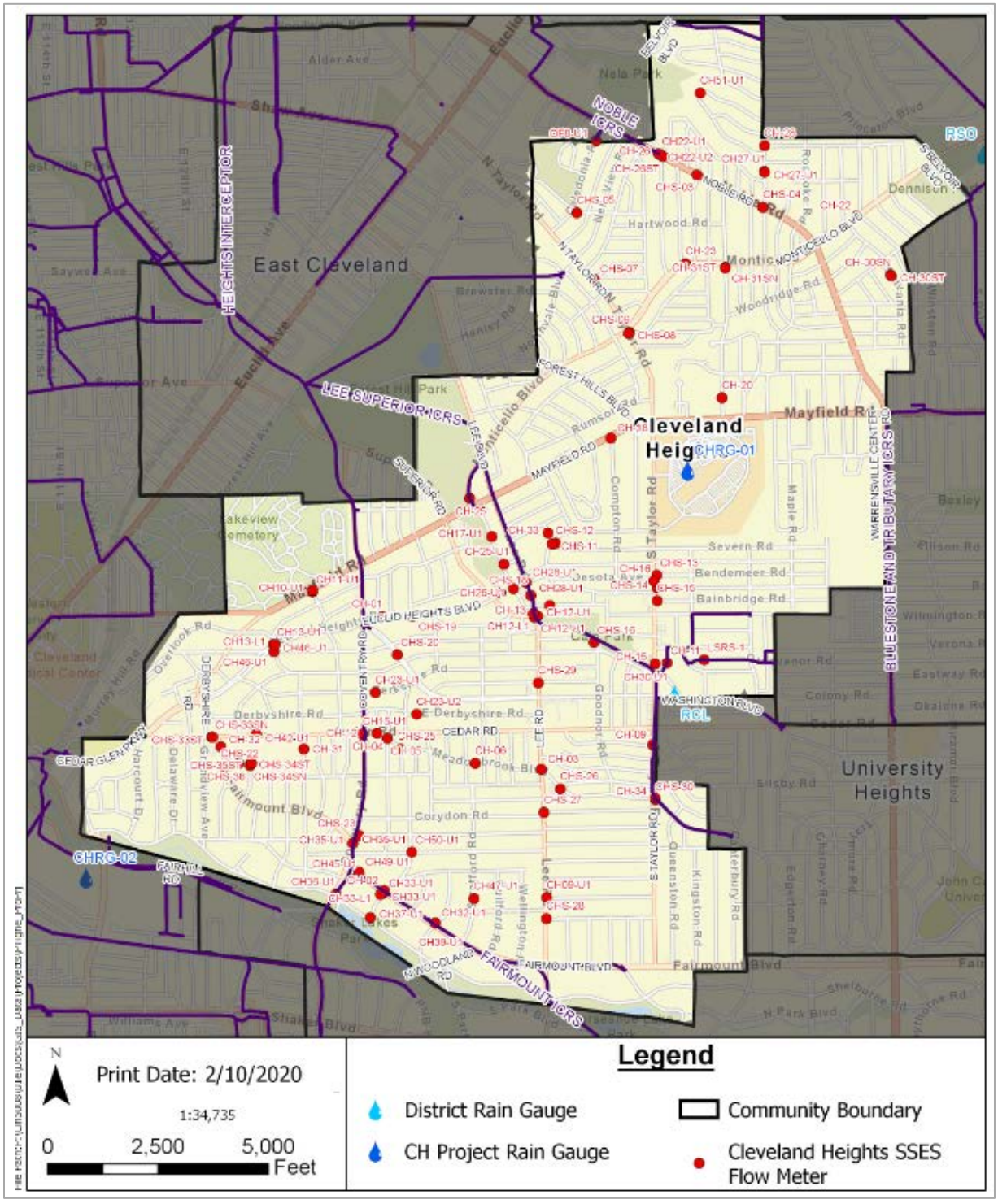


Figure 4-2. Calibration Flow Monitoring Locations, July 14 – October 15, 2018



4.1 OTHER SEWER SYSTEM MONITORING

The HHI-LSSES and ongoing Cleveland Heights SSES projects have also conducted tethered block monitoring at all known SSOs and annual real-time electronic monitoring at selected active SSOs to better characterize SSO activity and support calibration of the model and potential need for sewer system O&M response. These are described in detail in the *Phase 1 Sewer System Evaluation Survey Final Report, April 2021*.

Project Definition/Preliminary Design Monitoring

Cleveland Heights is proposing to conduct project definition monitoring and/or preliminary design monitoring in conjunction with upcoming Master Plan project implementation to further define the individual project areas and scopes, consider alternatives optimization opportunities and to provide information for detailed design of improvements.

Dividing Wall Monitoring

Starting in 2021, Cleveland Heights is performing tethered block monitoring at all dividing wall manholes. The dividing wall blocks will be checked for activations after significant rainfalls. An example tethered block installed at a dividing wall manhole is shown in **Figure 4-3**. If dividing wall locations are found to activate due to rainfalls, electronic monitoring will be deployed to assess activations with respect to rainfall and flow direction. This information may then be used to update model calibration and develop potential remediation improvements to prevent rainwater inflow and/or sewage overflows.

Figure 4-3. Example Dividing Wall Tethered Block Installation

4.2 CAPACITY ASSESSMENT AND PERFORMANCE SUMMARY

The *Capacity Assessment Report, February 2021* describes the approach and results of the sewer system monitoring, model update and calibration, capacity evaluation and analysis results. The modeling and analysis considered existing and future dry weather flows and wet weather flows associated with the five rainfall events as required in the Consent Decree. The Capacity Assessment was completed in March 2020. The City reviewed follow-up questions from USEPA regarding the Capacity Assessment submitted on December 22, 2020, and formal written responses and a revised Report were submitted to USEPA on February 22, 2021.

Projected SSOs

Sanitary sewer system capacity and performance were evaluated primarily based on model projected SSO activations and basements backups. The HHI-LSSES and initial Cleveland Heights SSES capacity assessment assumed that projected SSOs of less than 0.01 MG were smaller than the likely model accuracy and were ignored. Based on discussion with USEPA, all non-zero SSO projections are now included in the results and proposed improvements. The assessment focused on projected SSOs, sewer system surcharging and basement backups. The analysis found that 29 of 45 known SSOs are projected to overflow for the 10-year, 1-hour rainfall and that one additional SSO is projected to overflow for the 10-year, 6-hour, and 25-year, 1-hour rainfalls as shown in **Table 4-1. Figure 4-4** shows the projected active SSO locations.

Projected BBUs

For this study, basements are considered at risk of flooding due to sanitary sewer surcharging if the model projected sanitary sewer hydraulic grade line (HGL) is within 1 foot of the estimated basement floor elevations. Basement floor elevation estimates are based on the county digital elevation model and basement depths are assumed to be 8 feet below the first-floor elevation. **Figure 4-4** shows the capacity assessment results based on the 10-yr, 1-hr rainfall. Capacity assessment results figures for the other rainfall events considered for this project are provided in **Appendix B**. The figure shows pipes with projected surcharge above the sewer crown in blue or red. Blue indicates a projected backwater condition. Red indicates that the local sewer capacity is projected to be deficient. Green indicates no surcharge, or adequate capacity.

Figure 4-5 shows model projected BBUs and results of the recent basement backup questionnaire completed during the SSES for comparison. While there is reasonable agreement between the two data sets, the model projected BBUs are more numerous and extend in areas without survey responses. This is likely due to the model being conservative (indicates worse performance) compared to actual performance and potentially due to incomplete survey response. Cleveland Heights is considering using a new NEORSD complaint survey form and response tracking system under development by NEORSD for future system performance surveys to guide future improvements and Capacity, Management, Operations and Maintenance (CMOM) efforts.

The actual system performance is also likely better than the model-projected performance due to the sewer trench storage volume and potential basement storage volume in flooded basements, neither of which are represented in the planning-level InfoWorks sewer system model. This unaccounted-for volume reduces the system hydraulic grade line (HGL) in the actual system as compared to the modeled system.

Dividing Wall Manholes

Table 4-2 summarizes the model projected overflows at 19 dividing wall manholes projected to activate for Consent Decree rainfall events. The volumes are relatively small compared to most of the projected SSO volumes, but like the SSOs, the ultimate proposed solution will be to separate the two systems up to grade to prevent stormwater inflows and sewage overflows that may occur. **Figure 4-4** also shows the projected active dividing wall locations.

Figure 4-4. Sanitary Sewer Capacity Evaluation for 10-Year, 1-Hour Rainfall

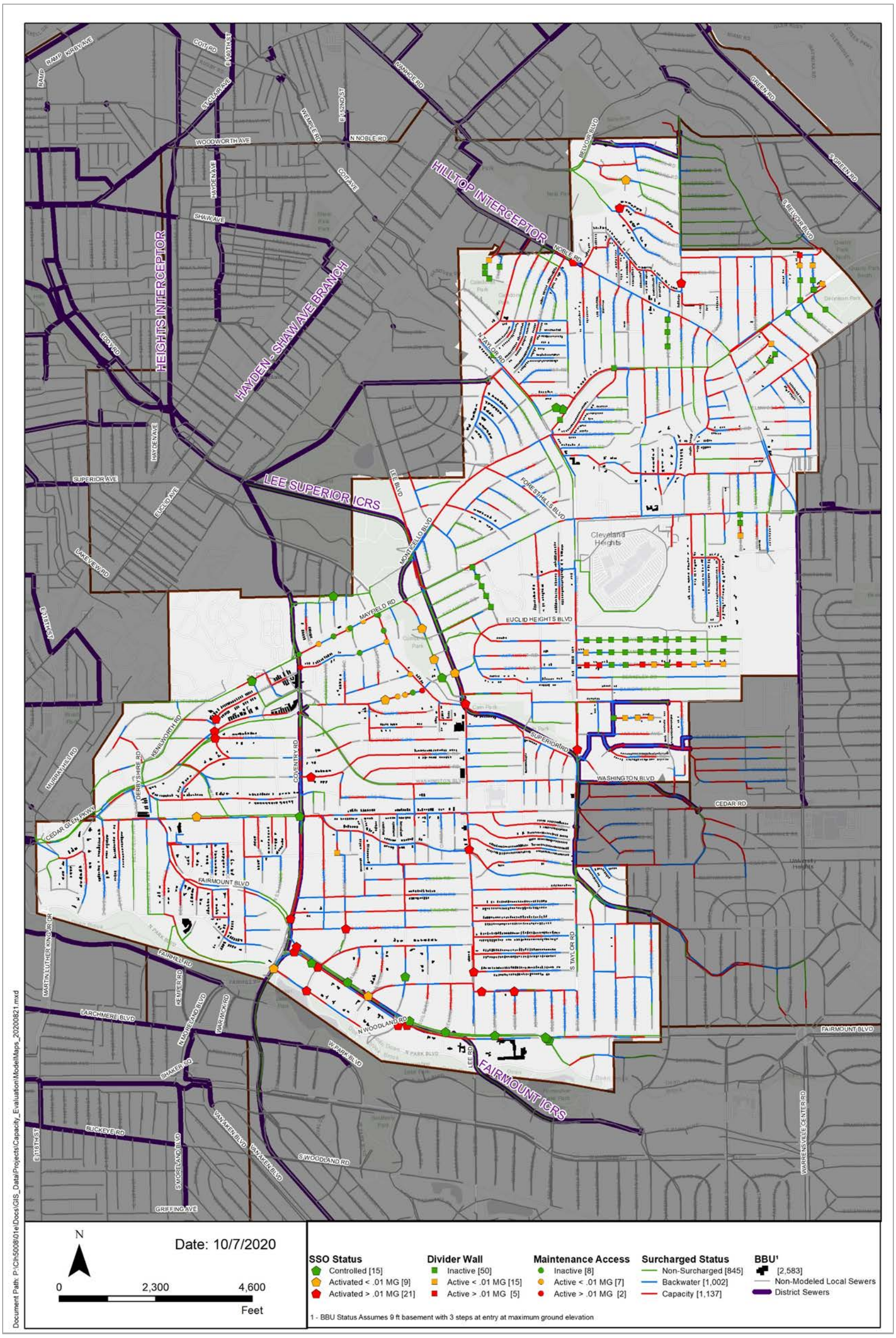


Figure 4-5. Comparison of Basement Backup Survey and Model Projected BBUs (10-yr, 1-hr rainfall)

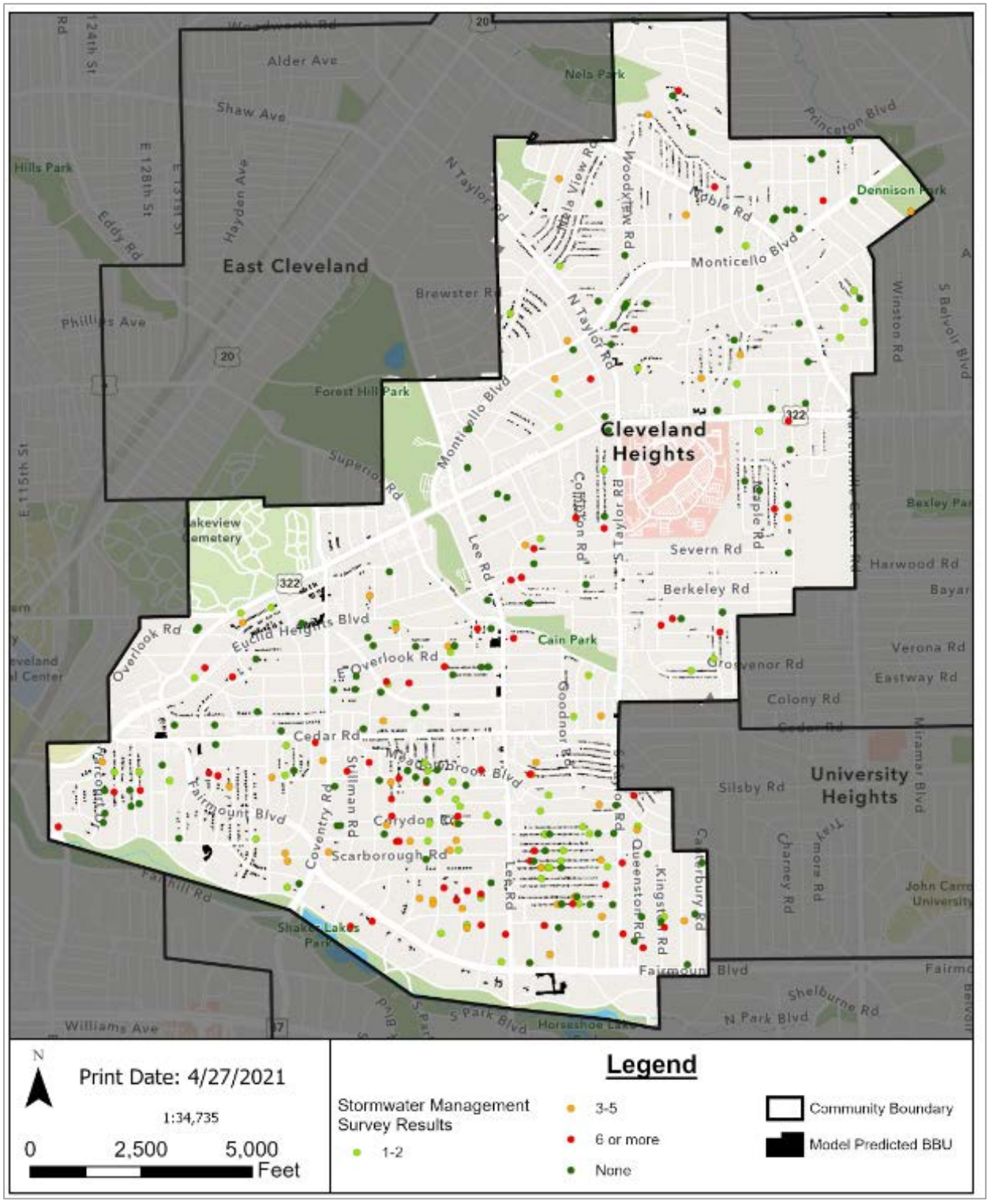


Table 4-1. Individual SSO Statistics based on Rainfall (Model Projected)

SSO ID	2-yr, 1-hr Overflow Volume (MG)	5-yr, 1-hr Overflow Volume (MG)	10-yr, 1-hr Overflow Volume (MG)	10-yr, 6-hr Overflow Volume (MG)	25-yr, 1-hr Overflow Volume (MG)	Typical Overflow Volume (MG)	Typical Year Overflow Frequency (# Overflows)
CH-1	0	0	0	0	0	0	0
CH-2	0.005	0.012	0.018	0.036	0.028	0.000	1
CH-3	0	0	0	0	0	0	0
CH-4	0	0	0	0	0	0	0
CH-5	0	0	0	0	0	0	0
CH-6	0	0	0	0	0	0	0
CH-7	0	0	0	0	0	0	0
CH-9	0.087	0.106	0.127	0.222	0.158	0.908	26
CH-10	0	0	0.004	0.006	0.02	0	0
CH-11	0	0	0	0	0	0	0
CH-12	0.033	0.038	0.041	0.106	0.047	0.696	25
CH-13	0.028	0.039	0.048	0.067	0.065	0.028	5
CH-15	0	0	0	0	0	0	0
CH-17	0	0.002	0.003	0.005	0.011	0	0
CH-22	0.023	0.028	0.031	0.048	0.035	0.103	9
CH-23	0.009	0.015	0.022	0.035	0.035	0.005	4
CH-24	0.003	0.003	0.004	0.005	0.005	0.001	1
CH-25	0	0	0.003	0.007	0.009	0	0
CH-26	0	0	0	0	0	0	0
CH-27	0.05	0.08	0.106	0.136	0.148	0.029	5
CH-28	0	0.002	0.004	0.005	0.007	0	0
CH-30	0.065	0.075	0.08	0.155	0.086	0.783	13
CH-32	0	0.002	0.005	0.009	0.011	0	0
CH-33	0.036	0.045	0.062	0.217	0.112	0.643	23
CH-35	0.026	0.037	0.047	0.094	0.066	0.123	9
CH-36	0.002	0.004	0.005	0.01	0.008	0.001	1
CH-37	0.0028	0.039	0.05	0.079	0.068	0.123	19
CH-38	0	0	0	0	0	0	0
CH-39	0.035	0.051	0.066	0.118	0.088	0.117	8

Table 4-1. Individual SSO Statistics based on Rainfall (Model Projected)

SSO ID	2-yr, 1-hr Overflow Volume (MG)	5-yr, 1-hr Overflow Volume (MG)	10-yr, 1-hr Overflow Volume (MG)	10-yr, 6-hr Overflow Volume (MG)	25-yr, 1-hr Overflow Volume (MG)	Typical Overflow Volume (MG)	Typical Year Overflow Frequency (# Overflows)
CH-42	0	0	0	0.001	0.005	0	0
CH-45	0.018	0.024	0.032	0.058	0.043	0.060	6
CH-46	0.024	0.038	0.048	0.06	0.066	0.017	5
CH-47	0	0	0	0	0	0	0
CH-49	0.006	0.01	0.015	0.023	0.022	0.002	4
CH-50	0.027	0.037	0.044	0.071	0.058	0.091	13
CH-51	0.176	0.206	0.231	0.475	0.272	4.162	47
CH-52	0	0	0	0	0	0	0
CH-54	0	0	0	0	0	0	0
CH-55	0.002	0.005	0.008	0.01	0.014	0	0
CH-56	0.114	0.13	0.144	0.282	0.168	1.891	33
CH-57	0.037	0.044	0.049	0.108	0.058	0.421	13
CH-58	0.03	0.036	0.041	0.067	0.048	0.158	10
CH-59	0	0	0	0	0	0	0
CH-60	0	0	0	0	0	0	0
CH-61	0.015	0.024	0.034	0.065	0.049	0.047	11
Totals	**0.879**	**1.13**	**1.372**	**2.58**	**1.81**	**10.409**	**291**

Table 4-2. Active Dividing Wall Manholes (Model Projected)

Asset ID	Street Name	2-yr, 1-hr (15min) Overflow Volume (MG)	5-yr, 1-hr (15min) Overflow Volume (MG)	10-yr, 1-hr (15min) Overflow Volume (MG)	10-yr, 6-hr (15min) Overflow Volume (MG)	25-yr, 1-hr (15min) Overflow Volume (MG)
SA16AJPK0	Bendemeer Road	0.01	0.02	0.02	0.03	0.03
SA16AJPC0	Bendemeer Road	0.01	0.02	0.02	0.03	0.03
SA16AOEG0	Northampton Road	0.01	0.02	0.02	0.04	0.03
SA16AJPB0	Bendemeer Road	0.01	0.01	0.02	0.03	0.02
SA16AJPF0	Bendemeer Road	0.004	0.01	0.01	0.01	0.02
SA16AOFA0	Quarry Road	0.002	0.004	0.01	0.01	0.01
SA16AJPP0	Bendemeer Road	0.002	0.004	0.01	0.01	0.01
SA16ABQC0	Lamberton Road	0	0.001	0.003	0.005	0.01
SA16AJDB0	Harvey Road	0	0	0.002	0.003	0.01
SA16AJDD0	Harvey Road	0	0	0.001	0.002	0.004
SA16APUC0	Ravine Drive	0	0	0.001	0.002	0.003
SA16AJOA0	Shannon Road	0	0	0	0.002	0.003
SA16ANSA0	Hillstone Road	0	0.001	0.001	0.001	0.002
SA16AKUC0	Middleton Road	0	0	0	0	0.001
SA16AOFE0	Monticello Boulevard	0	0	0.001	0.001	0.001
SA16AOEH0	Keystone Drive	0	0	0	0	0.001
SA16AJDC0	Harvey Road	0	0	0	0	0.001
SA16AJPG0	Bendemeer Road	0	0	0.00047	0.001	0.001
SA16ANTB0	Orchard Road	0	0	0	0	0.001
SA16AJPN0	Bendemeer Road	0	0	0	0	0.001

4.2.1 Capacity and Performance Discussion

This section summarizes observations and conclusions from the capacity assessment analysis. The Cleveland Heights sewer system and most other predominantly common trench systems in NEORSD service area have proven challenging to model for existing conditions. This is primarily due to the often-numerous distributed infiltration sources that allow water to pass from the higher storm sewers to the lower sanitary sewers in the common trench areas. This is further compounded by a similar configuration along the private property storm and sanitary service laterals.

Counteracting the leaky systems to varying extent are the annular sewer trench volumes along the sewers and on private property that are believed to provide significant temporary storage volume for wet weather flows that may exceed the sanitary and storm sewer system capacities. This appears to dampen the peak flow response and lower the peak HGL elevation during larger rainfalls.

The stormwater drainage system analysis indicates that much of the local storm sewer system likely provides less than a 5-year rainfall capacity, so to the extent the system defects allow sanitary sewer infiltration from the storm sewers, the relatively low stormwater drainage system capacities would tend to increase the storm sewer exfiltration and sanitary sewer infiltration rates.

SSOs and basement backups are the two primary concerns for Cleveland Heights. Each improvement project will also consider localized stormwater drainage problems and potential improvements needed during project definition investigations and preliminary design, but a generalized stormwater drainage capacity increase to provide control for 10- or 25-year rainfalls is not being considered because it would be extremely costly and disruptive. In most, if not all cases, however, the SSOs, all of which have relatively small flows and volumes, can likely be controlled via diversion to NEORSD sewers.

Where improvements are proposed to address basement backups, a combination of I/I reduction and additional capacity and/or inline storage may be considered. The projects will be designed to accommodate the agreed upon design event based on the calibrated model, and successive post-construction monitoring and analysis will determine if more aggressive I/I control is needed and where it should be applied. A key factor over the course of the Master Plan improvements will be to monitor and adapt the successive designs to optimize performance and minimize cost, while meeting the agreed upon design level of service and SSO control performance.

Nevertheless, remarkably few basement backup complaints have been registered with the City, particularly since starting the CMOM and SSES cleaning and televising efforts. A proposed survey to check on sewer system performance problems should help confirm this performance.
The capacity evaluation figures for the 2-year to 25-year rainfalls (Appendix B of this Report) indicate that while the number of BBUs and SSOs and SSO volumes increase for the larger rainfalls, they tend to remain primarily in the same areas.

The capacity assessment and associated model adequately define the projected overflows and potential capacity problem areas to allow development and comparison of potential remedial measures. However, projection of system performance for the larger 10-year and 25-year rainfall events may be significantly less accurate because neither the local sanitary nor storm sewer system has been calibrated to the larger rainfalls.

Because much of the local storm and sanitary sewer systems do not have capacity for the 10- to 25-year rainfalls, the actual sanitary sewer system performance may be significantly worse than projected for

larger events, particularly in common trench areas. This implies that sewer separation and/or significant sewer system rehabilitation and increased sanitary sewer and stormwater drainage capacity would likely be needed in the public right-of-way (ROW) and on private property in many areas to significantly improve performance for larger rainfalls. These conditions will be considered during the alternatives development, costing, and comparison as part of the Master Plan development and during project definition and preliminary design phases of each project. As noted elsewhere, the Master Plan program and successive projects will benefit from performance information learned from each completed project.

It has also been observed that inadequate maintenance of private property stormwater and sanitary service laterals may contribute significantly to high I/I rates and performance problems. Local plumbing contractors have observed that stormwater service laterals are often not adequately maintained, leading to obstructions caused by leaves and other materials washed from roofs and yard drains. The aged, plugged stormwater laterals then tend to discharge impounded stormwater to the common trench and into leaky sanitary service laterals.

Based on NEORSD and Cleveland Heights project analyses to date, identification, and prioritization of potential remedial measures as part of the Master Plan will likely include consideration of reported versus projected problems, SSO frequency/activation rainfall and volume, sewer system physical condition, and known operations and maintenance issues.

5.0 REMEDIAL MEASURES ALTERNATIVES ANALYSIS

NEORSD's HHI-LSSES project (2016-2020) developed the local sewer system model and analyzed and prioritized potential solutions for Cleveland Heights and the other communities with separate sanitary sewers tributary to the HHI system. Development of the Cleveland Heights Master Plan used the HHI-LSSES project as a foundation and extended the model and completed extensive additional field work, alternatives analysis and optimization to update the proposed planning-level improvements.

5.1 ALTERNATIVES DEVELOPMENT AND OPTIMIZATION APPROACH

The analysis approach and breakdown of the proposed improvements is based on and remains similar to that developed under the HHI-LSSES project, which is summarized below.

- Hydraulic performance parameters including peak flow rates and HGL levels were used with costs to compare effectiveness of various system improvement options described in the following section.
- Potential nearby existing spare capacity in local and/or NEORSD sewers was considered to minimize need for/length of relief sewers. For example, SSOs may be routed to nearby NEORSD or other local sewers with spare capacity where feasible.
- Opportunities were considered to combine neighboring improvements in a common solution to reduce cost and/or disruption.
- Over/under sewer systems were identified for sewer separation, and other common trench systems including dividing wall and common standard systems were considered for rehabilitation. Both alternatives also consider the need for capacity improvements in conjunction with system separation/rehabilitation.
- Areas of excessive I/I were considered for private property I/I reduction, particularly if the area tested positive, or is suspected to have high private I/I flows based on anecdotal information and/or building age.
- Private I/I reduction is also considered in areas where common trench rehabilitation/separation area available may not provide adequate performance improvement.
- Planned community projects to add or redistribute flows to NEORSD sewers were included to account for future flow changes.
- Feasible alternatives were developed starting with the HHI-LSSES analysis to provide acceptable performance during the 10-year, 1-hour rainfall and were then adjusted to adapt the solutions as needed for the other Consent Decree storm events (e.g., 2-year, 1-hour, 5-year, 1-hour, 10-year, 6-hour, and 25-year, 1-hour rainfalls).

Figure 5-1 provides an overview of the process used to analyze and optimize proposed improvements. The system improvement options considered are summarized in the following section**. Figure 5-2** shows locations of the sewer trench types.

Figure 5-1. Cleveland Heights Improvement Alternatives Analysis

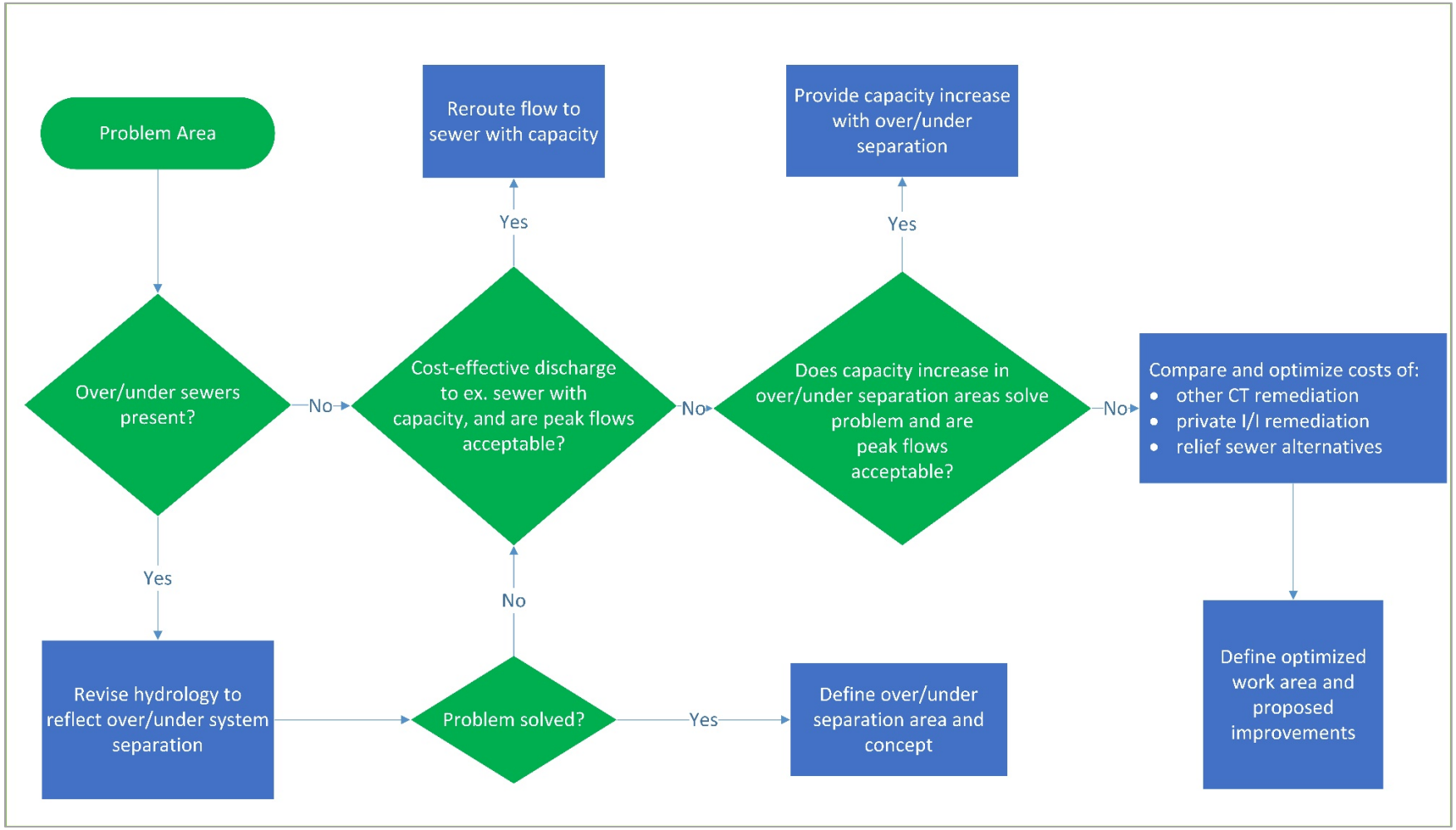
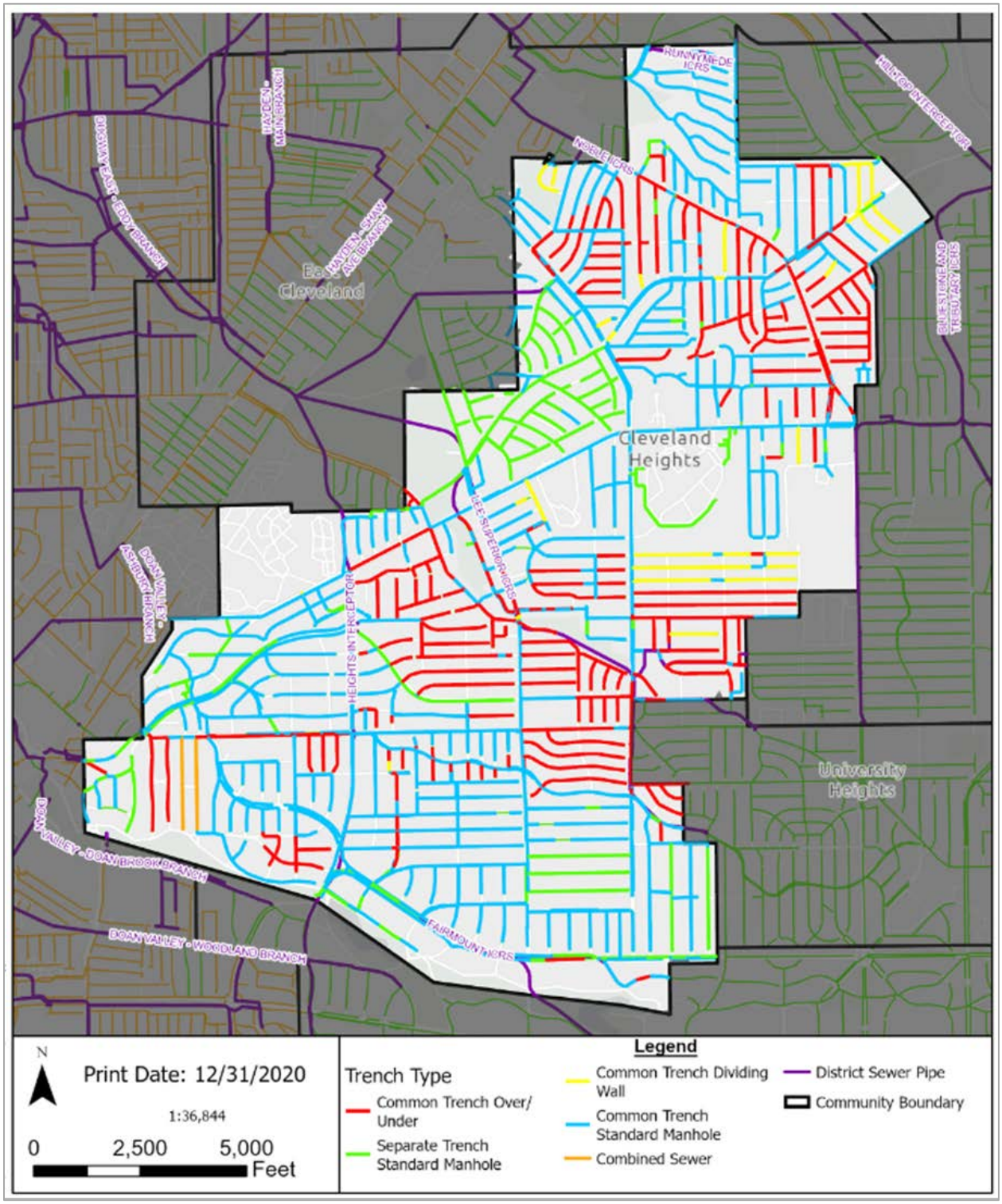


Figure 5-2. Sanitary Sewer Trench Type Locations



5.2 SYSTEM IMPROVEMENT OPTIONS CONSIDERED

A range of system improvement options was considered to provide adequate capacity and/or reduce peak wet weather flows during the design rainfall, thereby controlling BBUs and SSOs. The Master Plan calls for eventual elimination of SSOs, separation of invert plate sewers and addressing capacity limitations. This guidance will help eliminate sewage and stormwater crossflows and excessive I/I and provide a serviceable sanitary sewer system that can be adequately and safely maintained using modern sewer cleaning and inspection equipment.

Existing System Optimization

Optimization of the existing system looked for simple, low-cost improvements that control SSOs and/or BBUs and reduce pollution by either maximizing use of existing available capacity, or perhaps removing a localized bottleneck. Examples may include:

- O&M activities to remove roots or other obstructions or debris.
- Repair of system structural problems to improve reliability.
- Removal of isolated system bottlenecks such as poorly constructed manholes and short reaches of deficient system capacity.
- Modifying an existing diversion structure to divert excess wet weather flow from a problem area to a portion of the system with available capacity.
- Raising SSO weir or activation pipe elevations to control activations during the 10-year, 1-hour rainfall while maintaining acceptable system HGL elevation. This can include modifying weir heights, offset pipes, or other diversion features, including at SSOs. These modifications are relatively simple and inexpensive and take advantage of available system hydraulic capacity.

Over/Under Common Trench Separation

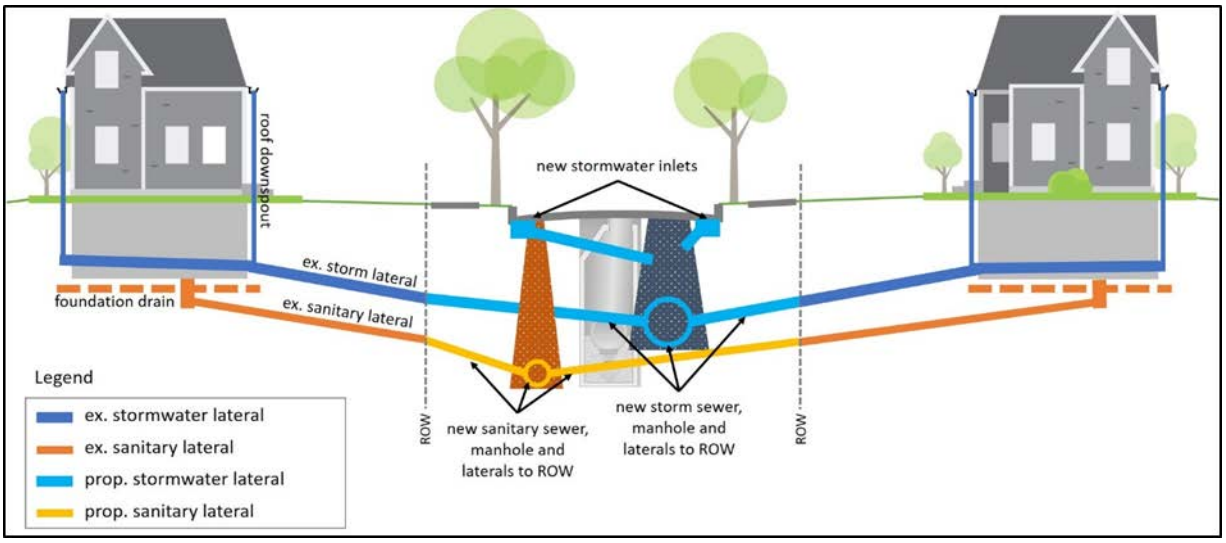
Separation of common trench sewers reduces sanitary sewer I/I and seeks to eliminate crossflow of sewage into adjacent storm sewers originally constructed in the same trench. Separation constructs a new sanitary sewer or storm sewer or both to eliminate the common trench configuration. Over/under common trench separation is expected to fully control known and projected problems. In common standard and dividing wall manhole systems, common trench separation may be indicated if either the storm or sanitary sewer is in poor structural condition, and common trench sewer rehabilitation is impractical.

Two options have been identified for over/under common trench separation and may be feasible with any type of common trench configuration.

Option 1- Replacement of Storm and Sanitary Sewers

The option to replace both storm and sanitary sewers and all service laterals in the public ROW has been implemented in several areas with mixed success, presumably because a significant portion of sanitary sewer I/I is generated on private property. **Figure 5-3** shows the over/under separation concept to replace all sanitary sewage and stormwater piping in the ROW. This option would be most applicable when the storm and/or sanitary sewers and service laterals are in poor condition and nearing the end of their useful life. This option would also be applicable in other common standard and dividing wall systems where the sewers and service laterals are in poor condition, and not suitable for rehabilitation.

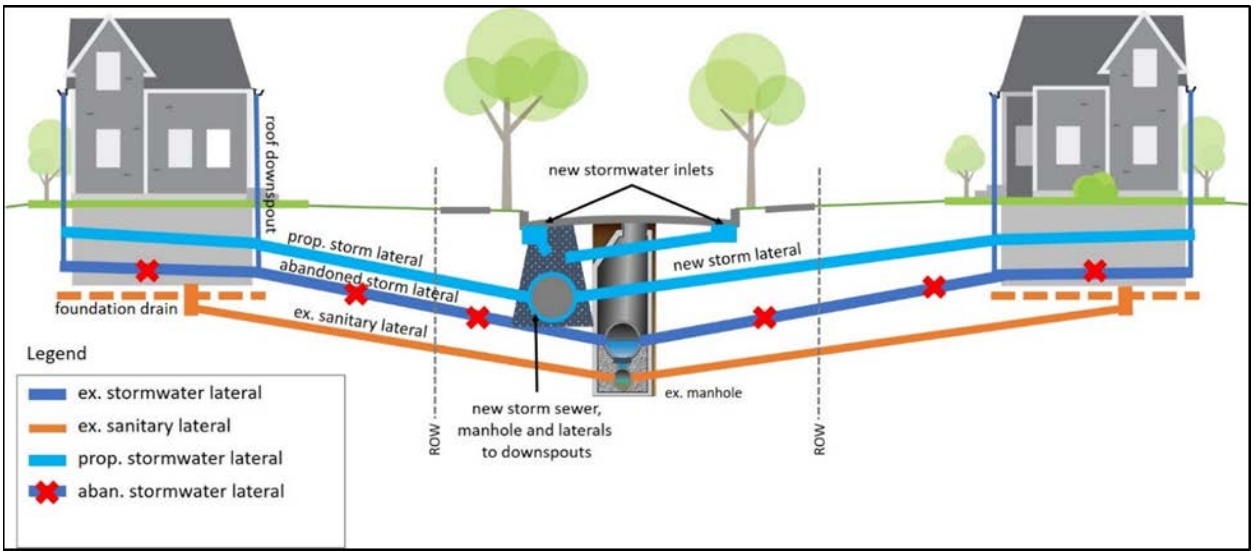
Figure 5-3. Replacement of Common Trench Sewers and Service Laterals



Option 2 – Stormwater Separation

Stormwater separation would construct a new storm sewer in the public ROW, and new stormwater service laterals in the public ROW and on private property to collect water from all roof downspouts as may be feasible. This option seeks to collect and transport stormwater without crossflow to the sanitary sewer system and to maintain new construction as shallow as feasible. The existing common trench system would remain as the sanitary sewer system. **Figure 5-4** shows the stormwater separation concept. This option would be applicable for over/under and other common trench systems where the existing piping is in good structural condition, and where private property I/I is significant. It would also be appropriate in areas where stormwater drainage capacity is inadequate and would allow for construction of increased capacity where needed.

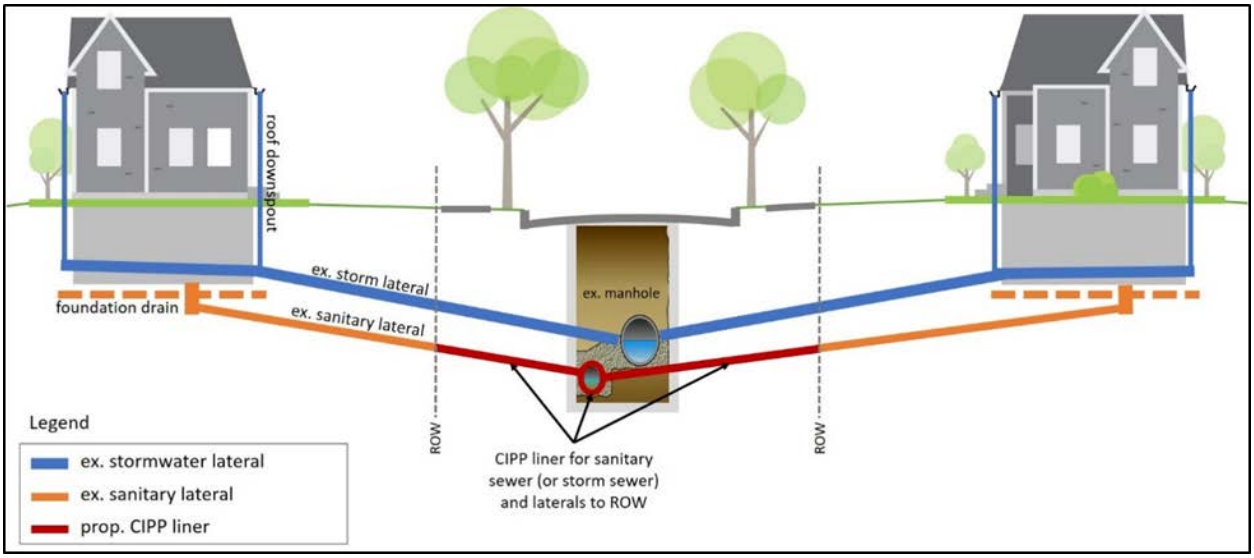
Figure 5-4. Stormwater Separation Concept for Common Trench Areas



Dividing Wall and Common Standard Manhole Trench Rehabilitation (Public ROW)

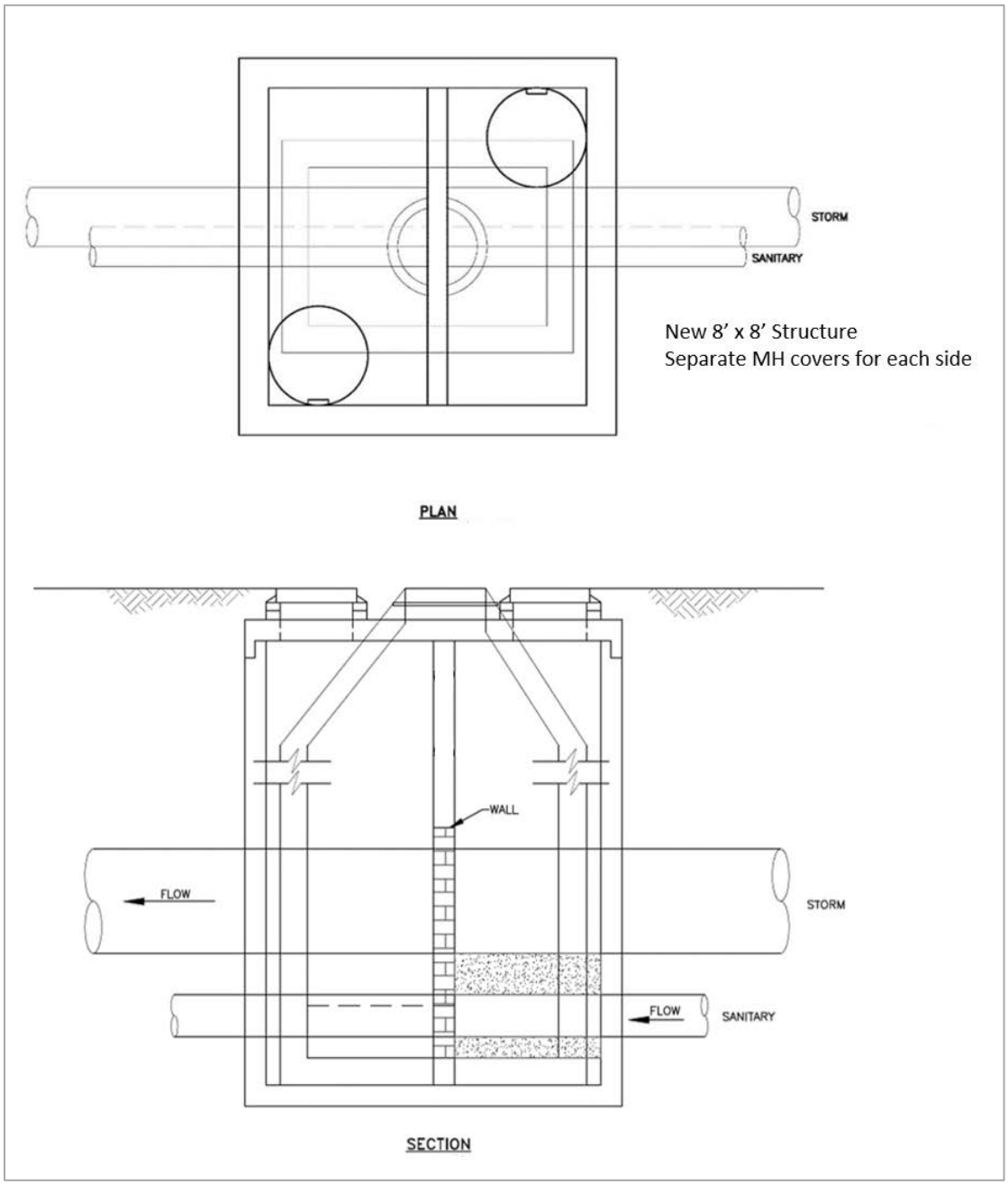
In dividing wall and high I/I common standard manhole systems in good structural condition, sewer system and service lateral rehabilitation using Cured-in-Place-Pipe (CIPP) lining may be a feasible improvement option to reduce I/I in the public ROW. Rehabilitation may potentially target the sanitary or storm sewer system. If pre-design investigations determine that most of the I/I is originating in the public ROW, this may be the preferred option in these systems. This may be an important consideration, because if significant I/I is originating upstream of the pipe/service lead rehabilitation areas, making the system more watertight in the public ROW could potentially worsen any existing surcharging problem. This is because the existing system likely allows flows to exfiltrate, and the improved system would not. **Figure 5-5** shows a common trench sanitary sewer rehabilitation concept.

Figure 5-5. Common Trench Rehabilitation (Dividing Wall and Common Standard Manholes)



In dividing wall systems, manholes may also be replaced to eliminate SSO/inflow potential and support system O&M. **Figure 5-6** shows a replacement concept for a dividing wall manhole reconstruction. This type of structure may not be needed at every existing dividing wall manhole but may be placed at selected routine maintenance locations and where storm and sanitary sewers may be influent to the common manhole from multiple directions.

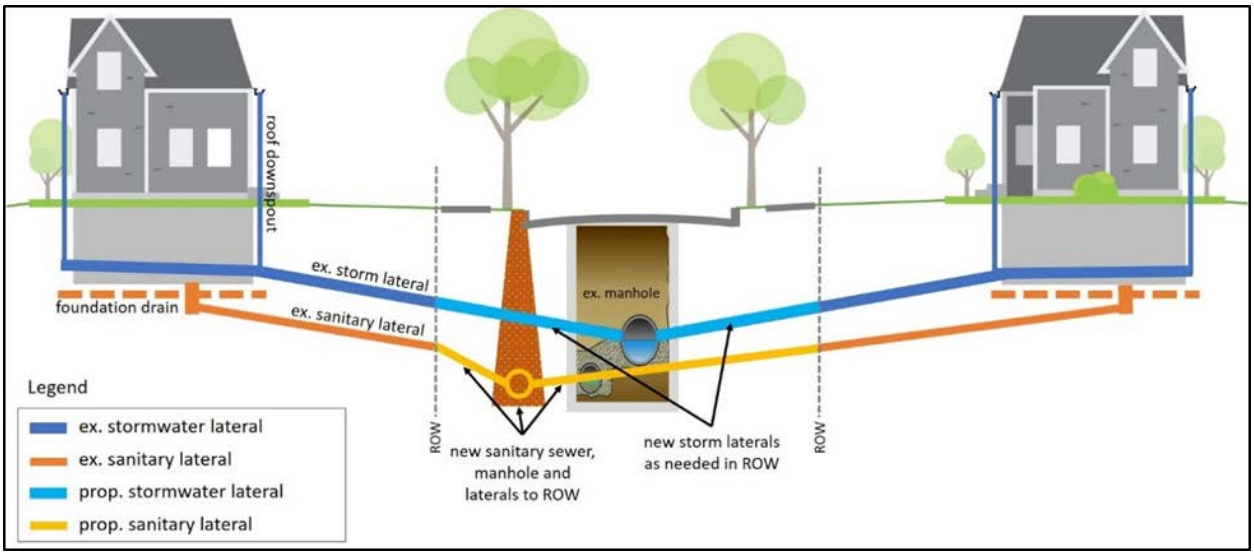
Figure 5-6. Dividing Wall Manhole Reconstruction Concept Plan and Section Views



Hydraulic Capacity Increase and/or New Flow Connection

Additional sanitary sewer capacity may be needed to prevent sewer system backups and/or SSOs even if common trench rehabilitation is completed. This may be most likely in areas where high private property I/I is infeasible to remove. New sanitary sewers may also be indicated to reroute some or all the flow from one system that is overloaded to another with spare capacity. Increased sewer capacity can be constructed in conjunction with common trench remediation or on its own to relieve overloaded systems. **Figure 5-7** shows a new sanitary sewer improvement concept.

Figure 5-7. New Sanitary Sewer to Increase Capacity and/or Reroute Flow



Private Property I/I Remediation

Areas with high flows likely have significant I/I originating on private property. In these areas, the most cost-effective solution may involve reducing I/I on private property.

Conditions at each parcel may vary widely due to construction quality, piping connectivity, materials, presence of a p-trap on the stormwater lateral, and owner maintenance. Private property dyed water testing and service lateral CCTV inspection are typically required at each property to assess presence and likely quantity of I/I, and to determine the cost-effective I/I control approach. Typical methods for reducing private property I/I include the following:

- New sanitary and/or stormwater service laterals.
- New shallower stormwater piping may help reduce cost and disruption.
- Trenchless construction methods, such as pilot tube microtunneling, may be effective to install new service laterals with minimal disruption. Extensive information is available online:
    - https://trenchlesstechnology.com/pilot-tube-microtunneling-catching-on-in-the-united-states/

  - https://www.ncpi.org/assets/PTMT%20D%20Gill-%20Rocky%20Mountain%20Trenchless%20Journal%202010.pdf
  - http://www.nadapacific.com/guided-boring.html
- Re-pitching eaves troughs may help redirect roof water to minimize trenching in heavily landscaped areas.
- CIPP lining of sanitary and/or stormwater laterals if in acceptable condition – include removal of stormwater lateral p-traps if present to reduce potential plugging with debris.
- Discharge of roof water to engineered rain gardens with shallow overflow piping or swales for larger events may be desirable on some parcels where space allows, and homeowners are agreeable. See further discussion of green infrastructure later in this Section.

Groundwater I/I

Anecdotal information from local engineers and plumbing contractors suggests that local groundwater levels are not typically problematic. This implies that foundation drain water may not pose a significant I/I problem in the study area. This should be considered, however, in areas where prevailing groundwater levels are known to reach local sewer system and foundation drain elevations during wet weather conditions.

Defects in the downspout stormwater service laterals that collect roof water may allow rainwater to seep through the soil into the lower foundation drains. In these instances, the stormwater lateral would be rehabilitated or replaced as indicated by onsite inspection to eliminate the I/I sources.

Separate Sewer System I/I Remediation

Mitigation of high I/I flows and/or sewer system surcharge and BBU problems in separate trench areas may involve improvements like those previously discussed. Cleveland Heights is served primarily by common trench sewers and limited separate sewers (13%).

Storage of Peak Wet Weather Flows

Inline or offline flow detention storage facilities may be considered where other alternatives, such as I/I reduction and/or capacity improvements, are infeasible or not cost-effective, or to provide increased level of service. Inline systems that are self-cleaning would typically be preferred over offline systems that may require pumping of influent or effluent flows and significant maintenance after wet weather events.

In some cases where new piping is already proposed either to provide adequate capacity or repair failing infrastructure, inline storage in oversized pipes can provide a significant level of service improvement to attenuate peak flows during larger rainfall events. This concept typically requires additional grade flexibility and some added depth to allow use of the pipe storage volume without raising the local system design HGL.

Green Infrastructure (GI)

For local projects that construct sewer system improvements in the ROW and/or on private property, stormwater control measures, such as rain gardens and ROW bioretention, may be considered with the project where feasible to reduce stormwater runoff and improve runoff water quality. If local GI improvements are included, the designer should consider siting location and overflow connections to the storm sewer system to direct stormwater away from the sanitary sewer system.

For large projects that involve significant new stormwater drainage improvements, or in cases where existing stormwater capacity is low, larger stormwater detention facilities may be constructed in conjunction with the sanitary sewer system improvements to improve performance in both systems.

5.3 PLANNING LEVEL PROJECT COST DEVELOPMENT

Project cost opinions were developed for the potential improvement options at an AACE Class 5 planning level using guidance from the *Project Cost Opinion Development for LSSES Improvement Alternatives Analysis, Technical Memorandum, Revision 2, September 2018* created under the HHI-LSSES project. This memorandum is provided in **Appendix C** of this Report. The project costs include construction and design and construction engineering costs and a 30% contingency as follows:

- Project definition (PD) cost for additional investigations in common trench areas prior to preliminary design are included at approximately $10,000 per acre (this is included separate from the contingency multiplier below).
- Design engineering: 15% of construction cost including the contingency.
- Construction resident engineering and administration: 10% of construction cost including the contingency.
- Contingency: 30% of engineering and construction costs.

This results in a project cost multiplier of 1.625 times the construction cost, e.g.

Project Cost = Construction cost*1.3*(1.0+0.15+0.10) + PD = 1.625*Construction cost + PD cost

5.4 MODELING OF SEWER SYSTEM IMPROVEMENT OPTIONS

In a typical sanitary sewer system I/I analysis, a percent reduction and/or explicit modeling of inflow sources to be removed are used to simulate the improved conditions after I/I control/capacity improvement projects. Based on HHI and Cleveland Heights system conditions and on a review of sewer system rehabilitation projects completed in the HHI study area, that type of analysis was determined to be infeasible in the HHI tributary areas. This is because I/I sources were found to be numerous and widely distributed, and because pre- and post-construction flow monitoring information was generally not available for completed sewer system rehabilitation and separation projects. The approach used instead is based on the actual residual I/I responses observed in sewer system rehabilitation and common trench separation projects completed in the HHI-LSSES area.

Based on the HHI-LSSES analysis and on the broader calibration monitoring and micromonitoring completed for the project, the following peak runoff assumptions were made to simulate the system improvements in each community for the 5-year design rainfall:

- Existing separate trench sewers in primarily common trench areas generate an existing peak flow response of 20,000 GPAD.
- Common trench rehabilitation and/or separation in the public ROW reduces peak flows to 35,000 GPAD. For example, in an area with 100% common trench sewers, the peak flow rate is reduced to 35,000 GPAD.
- In areas with mixed common and separate trench sewers, the peak flow rate is reduced based on trench type percentages. For example, after rehabilitation in the public ROW, an area with 70% separate trench (assumed response of 20,000 GPAD) and 30% common trench (assumed response of 35,000 GPAD) would have a remaining peak flow of 24,500 GPAD. Conversely, an area with 30% separate trench and 70% common trench would have a remaining peak flow of 30,500 GPAD.
- Common trench areas with private property I/I remediation in addition to public system rehabilitation, or private property remediation in separate trench areas would reduce peak flows to 10,000 GPAD. The private property response rates did not need to vary between separate and common trench types since the value applied to both.

Figure 5-8 and **Table 5-1** summarize the hydrologic responses assumed for modeling of common trench and private I/I remediation based on monitoring of several completed projects in the HHI study area. In the InfoWorks model, the hydrologic runoff parameters were adjusted to achieve the target runoff values summarized in the preceding list. Only the parameters impacting flow magnitude were adjusted so the shape of the runoff hydrograph was maintained. The changes were typically only applied to the shorter-term runoff parameters, impacting the peak of the event and not the long-term infiltration.

Figure 5-8. Hydrologic Responses Assumed for Modeling of HHI Proposed Improvements

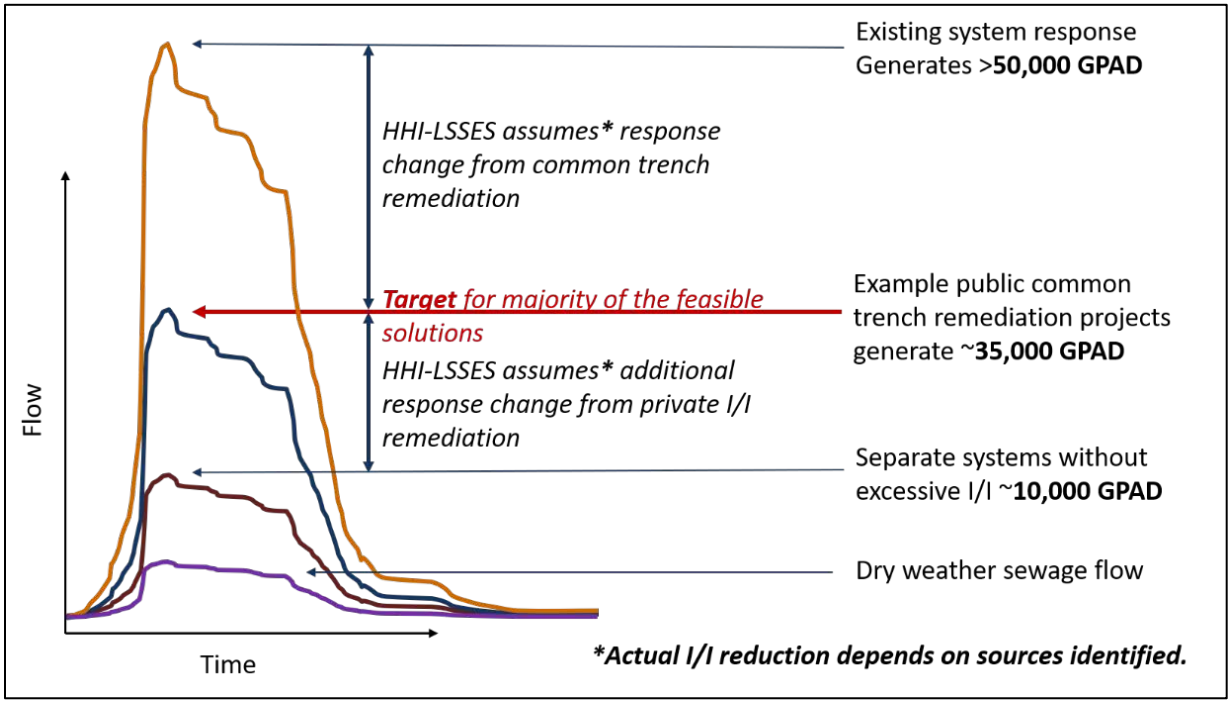


Table 5-1. Modeling Assumptions for Sewer System Improvements

System Condition	Common Trench Flow Response (GPAD)	Separate Trench Flow Response in CT Areas (GPAD)	Notes
Existing	Variable to over 500,000	20,000	Based on calibration flow monitoring
CT sewer rehabilitation or separation	35,000	20,000	Modeled catchment area weighted by trench type
Private Property I/I Remediation	10,000	10,000	Modeled catchment area weighted by trench type

5.5 BASIS OF DESIGN RAINFALLS

The rainfalls used for capacity assessment and improvement alternatives analysis are prescribed in the Consent Decree. All are based on current NEORSD standards and SCS Type 2 distributions with 15-minute rainfall increments.

- 2-Year/1-Hour rainfall (1.13 in)
- 5-Year/1-Hour rainfall (1.40 in)
- 10-Year/1-Hour rainfall (1.63 in)
- 10-Year/6-Hour rainfall (2.55 in total, 1.63 in peak hour)
- 25-Year/1-Hour rainfall (1.98 in)

Tier 1 SSO Control

The 10-year, 1-hour rainfall (1.63 inches) is proposed as the basis of design rainfall for initial SSO control improvements in Cleveland Heights. The long-term objective is SSO elimination, but elimination may require additional time to implement I/I reduction upstream of some SSOs as discussed in the following section summarizing Tier 1 improvements. I/I flows originating on private property may be significant in some areas. If residual I/I flows are excessive, leading to an unacceptable level of service, or producing peak wet weather flows exceeding NEORSD guidelines, remedial work to reduce private property I/I may be indicated. As preliminary design investigations and post-construction flow monitoring and performance assessments are performed, successive projects will adapt to optimize the basis of design rainfall and system improvement approaches versus cost to provide Cleveland Heights residents the best possible performance versus cost.

Tier 2 Over/Under and Dividing Wall Sewers Remediation

Tier 2 over/under and dividing wall remediation projects are also proposed to use the 10-year, 1-hour rainfall as the basis of design. Both systems have cross connections between the storm and sanitary sewer systems that will be abandoned, so designing improvements for the 10-year rainfall rather than the 5-year rainfall is suggested to provide a slightly more conservative solution. The over/under system is proposed for long-term replacement or other means of effective separation of the storm and sanitary sewer systems, while providing safe and efficient access to both sewer systems. Because so much of the existing system is expected to be replaced, the cost increase to provide acceptable 10-year rainfall performance is expected to be only marginally higher than for the 5-year rainfall. The marginal cost increase is also projected to be true for the dividing wall system.

Tier 2 dividing wall system remediation is proposed to include complete sewer system rehabilitation in the ROW and reconstruction/modification of the dividing wall manholes to eliminate the hydraulic connection between the storm and sanitary sewers. The extensive replacement and rehabilitation of both over/under and dividing wall systems is expected to provide a relatively watertight system within the public ROW. This will help the improvement areas achieve acceptable performance and meet NEORSD peak flow guidelines. Further performance improvements for larger rainfalls may follow over

time in conjunction with private property infrastructure rehabilitation completed by property owners and/or the City if financially feasible.

Tier 3 Projected Problem Area Improvements

Longer-term Tier 3 sewer system problem area improvements are proposed to include sewer system rehabilitation, private I/I remediation and capacity improvements where needed to reduce the risk of BBUs. The projected costs for these areas are more sensitive to the design rainfall because more piping is identified for capacity increase and/or extensive private I/I remediation is required for larger rainfalls. Cleveland Heights is proposing to use the 5-year, 1-hour rainfall (1.40 inches) as the initial basis of design rainfall for the dividing wall and Tier 3 common trench problem areas to reduce the risk of BBUs. Further performance improvements for larger rainfalls may follow over time in conjunction with private property infrastructure rehabilitation completed by property owners and/or the City as financially feasible.

In locations where capacity improvements are required to convey peak 5-year flows, design of the proposed improvements will consider the cost effectiveness of providing capacity in the new piping for peak flows associated with the 10-year rainfall, which can often be provided at a marginal cost increase.

5.6 REMEDIAL MEASURES IDENTIFIED FOR CONSENT DECREE STORM EVENTS

Planning-level improvements have been developed to control the known SSOs and solve other known and projected performance problems and have been optimized and prioritized using cost and non-cost criteria. Improvements have been separated into three tiers:

- Tier 1 – Control active SSOs and reduce the risk of BBUs in associated chronic problem areas
- Tier 2 - Separate or otherwise remediate over/under sewers and dividing wall sewers; reduce peak flows in high flow areas in accordance with future NEORSD guidance
- Tier 3 – Improve performance in other model projected areas at increased risk of BBUs

5.6.1 Tier 1 – Address Active SSOs and Associated BBU Problem Areas

Active SSOs and associated BBU problem areas are proposed to be addressed first. The recent capacity assessment analysis projected 30 of 45 known SSOs to be active during the 10-year, 6-hour, and 25-year, 1-hour rainfalls. All active SSOs are proposed to be addressed. Several of the SSO control areas exhibit a higher risk of BBUs that can also be reduced in conjunction with the SSO control improvements.

SSO Elimination

Cleveland Heights' ultimate objective is to physically eliminate all known SSOs. Once the SSOs are controlled such that overflow frequencies are low, eventual elimination may require additional I/I reduction to allow physical abandonment without increasing risk of basement backups. In some instances, project definition investigations and pre-design flow monitoring may indicate stormwater inflow at SSO locations rather than SSOs for larger rainfalls. In these cases, physical abandonment may accompany the Tier 1 improvements. In other cases where the SSO may need to be retained to reduce

the risk of basement flooding for larger rainfalls, I/I reduction may be required after initial SSO control improvements to allow eventual abandonment and still meet NEORSD peak flow guidelines. Post-construction flow monitoring will be conducted to determine the need for I/I reduction work. If I/I reduction is needed, additional project definition investigations would be required to determine the proposed improvements in the public ROW and/or on private property.

Basement Backup Problem Areas

The proposed SSO control improvements and other ongoing work such as the Delamere sewer improvement project and completed projects such as the Randolph Road sewer rehabilitation project are beginning to address several chronic problem areas. Other areas identified going forward based on subsequent resident survey and/or project definition investigation efforts will be considered for addition to Tier 1 improvements.

Figure 5-9 summarizes the proposed Tier 1 SSO control improvements for the 10-year, 1-hour rainfall. Similar Tier 1 SSO control improvement overview maps for the other Consent Decree design rainfalls are provided in **Appendix D**. The remainder of this Section describes the proposed Tier 1 improvements in more detail using the 10-year, 1-hour rainfall improvements for example.

SSO Control Improvement Detail Figures

Following the Figure 5-9 overview of the Tier 1 SSO control improvements are detail **Figures 5-10** through **5-26**. These figures show the proposed SSO control improvements associated with the 10-year, 1-hour rainfall event in more detail. Each figure includes notes and callout describing the proposed work. The proposed capacity improvements and new flow path pipe sizes are documented in the model and will be confirmed during design based on updated detailed flow monitoring for each project. The proposed pipe sizes may also vary slightly by design event, but for Tier 1 projects, this has little impact on cost.

Other Potential Tier 1 Improvements

Other improvements that may be included as feasible under Tier 1 include the following:

- Mitigation of recurrent BBU problems
- Control of any new SSOs
- Mitigation of significant I/I sources
- Replacement of missing or damaged invert plates
- Correction of illicit discharges to storm sewers
- Critical O&M activities outside planned improvements

Figure 5-9. Proposed Tier 1 SSO Control Improvements (10-year, 1-hour Rainfall)

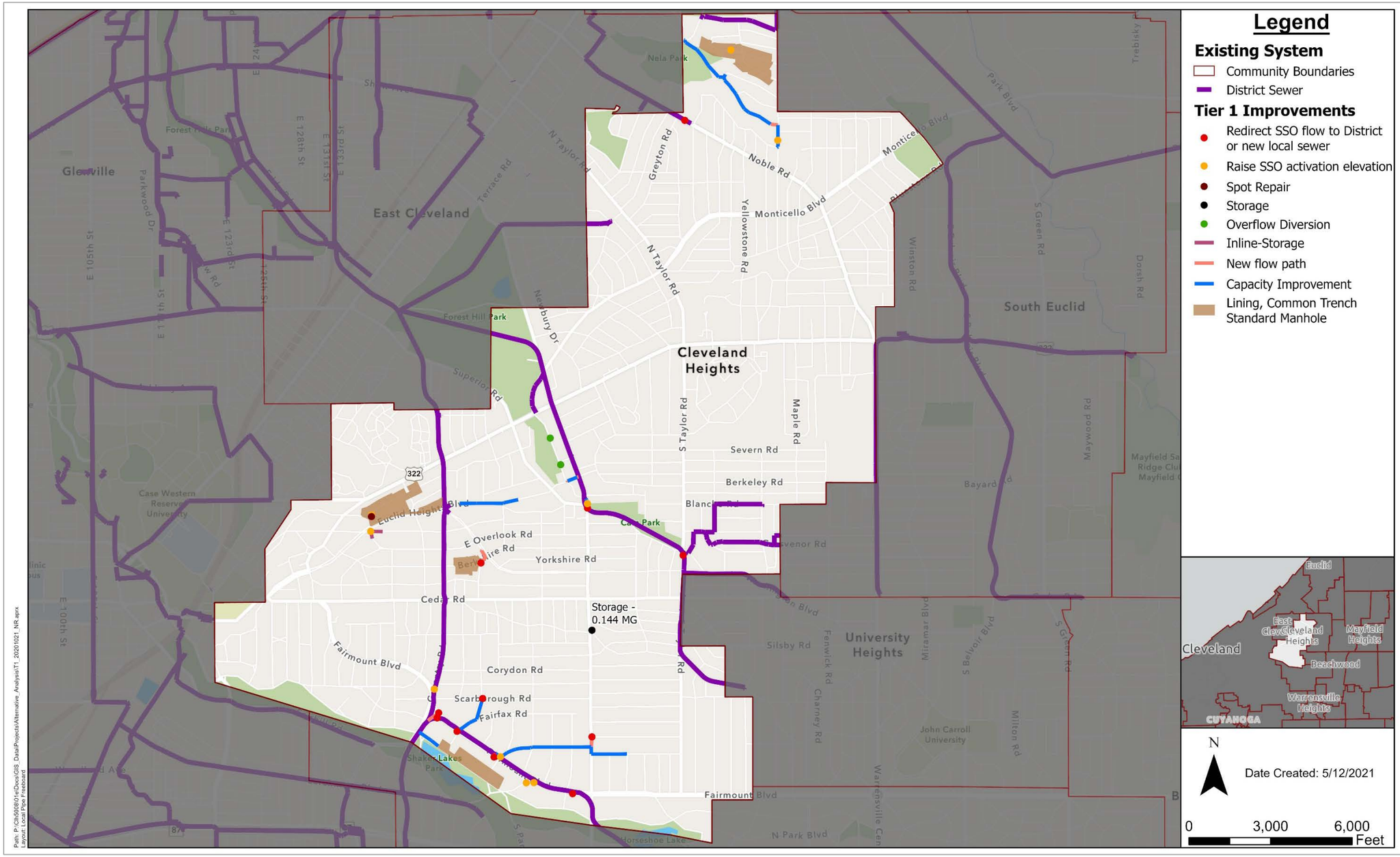


Figure 5-10. Control SSOs CH-2, CH-33, and CH-39 (Fairmount Blvd)

Project Description: Redirect local sewer flows to existing NEORSD sewer manholes along Fairmount Boulevard. The flow diversions will control the local SSOs CH-2, CH-33, and CH-39 for the 10-year, 1-hour rainfall and reduce flows to downstream SSOs at Fairfax and Coventry roads. The improvements will also reduce the risk of BBUs projected along Fairmount Boulevard. Rehabilitate 1,200 LF of sanitary sewer upstream of SSO CH-39 found during the SSES to be in poor condition. **Project Status:** Project is being submitted in 2021 for potential grant funding support under NEORSD's 2022 MCIP program.

Figure 5-11. Control SSOs CH-35, CH-45, and CH-49 (Fairmount Blvd and Coventry Rd)

Project Description: Divert flow from local sewers at SSOs CH-45 and CH-49 to the existing NEORSD sewer shaft at Colchester and Coventry Roads. The flow diversions will also control SSO CH-35 and will reduce the risk of BBUs in the tributary sewer areas. **Project Status:** Project is scheduled for design in 2021 to integrate construction with paving on Coventry Road scheduled for 2022.

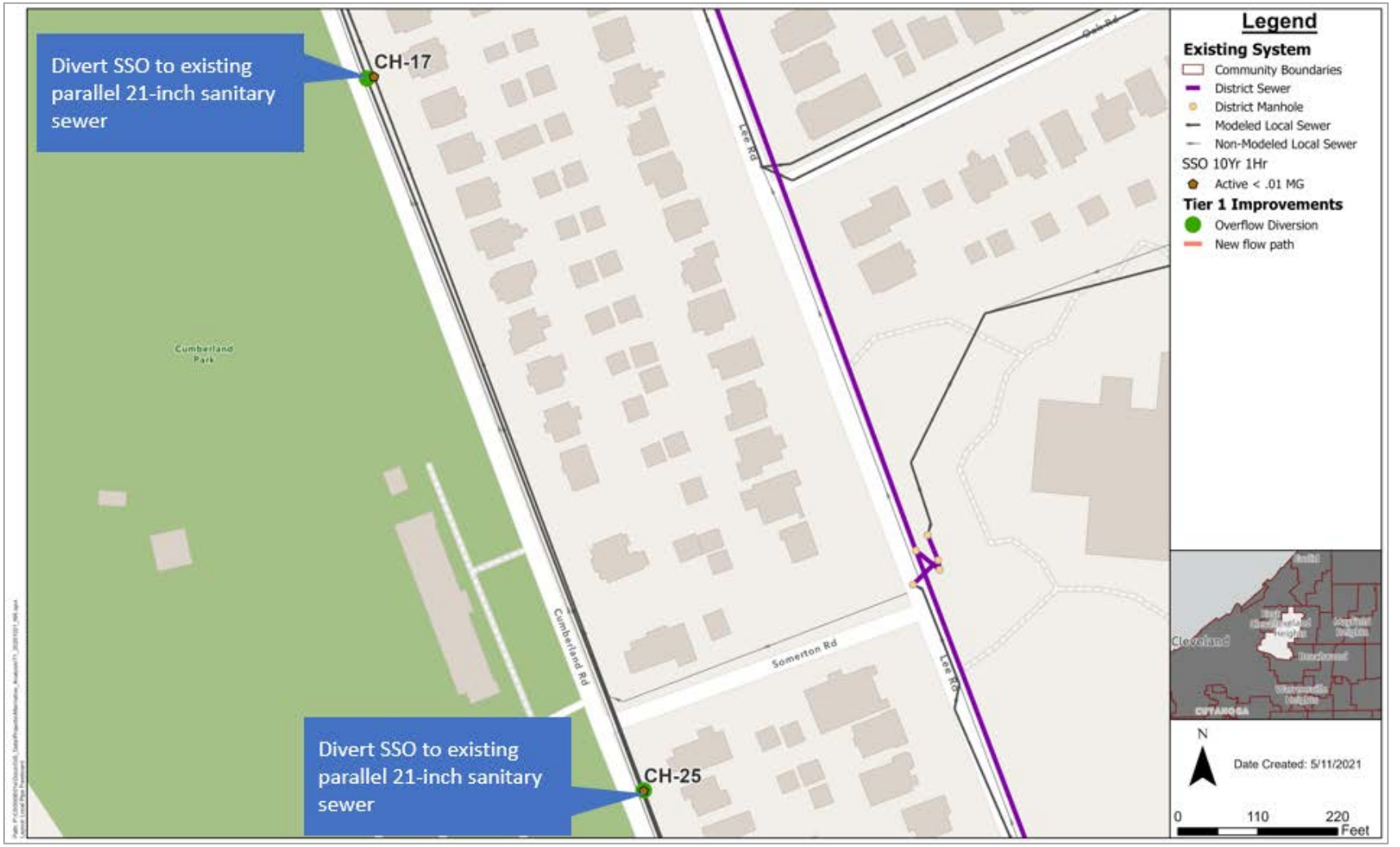
Figure 5-12. Control SSOs CH-36 and CH-37 (N. Park Blvd)

Project Description: Replace downstream in poor condition and rehabilitate upstream 1,800 LF of common trench sewers. Sewer rehabilitation may precede replacement to confirm required replacement sewer size. **Investigation**: Project definition field investigations may also be completed to confirm sources of excessive I/I along this reach.

Figure 5-13. Control SSOs CH-9, CH-32, CH-57, and CH-58 (Monmouth and Lee roads)

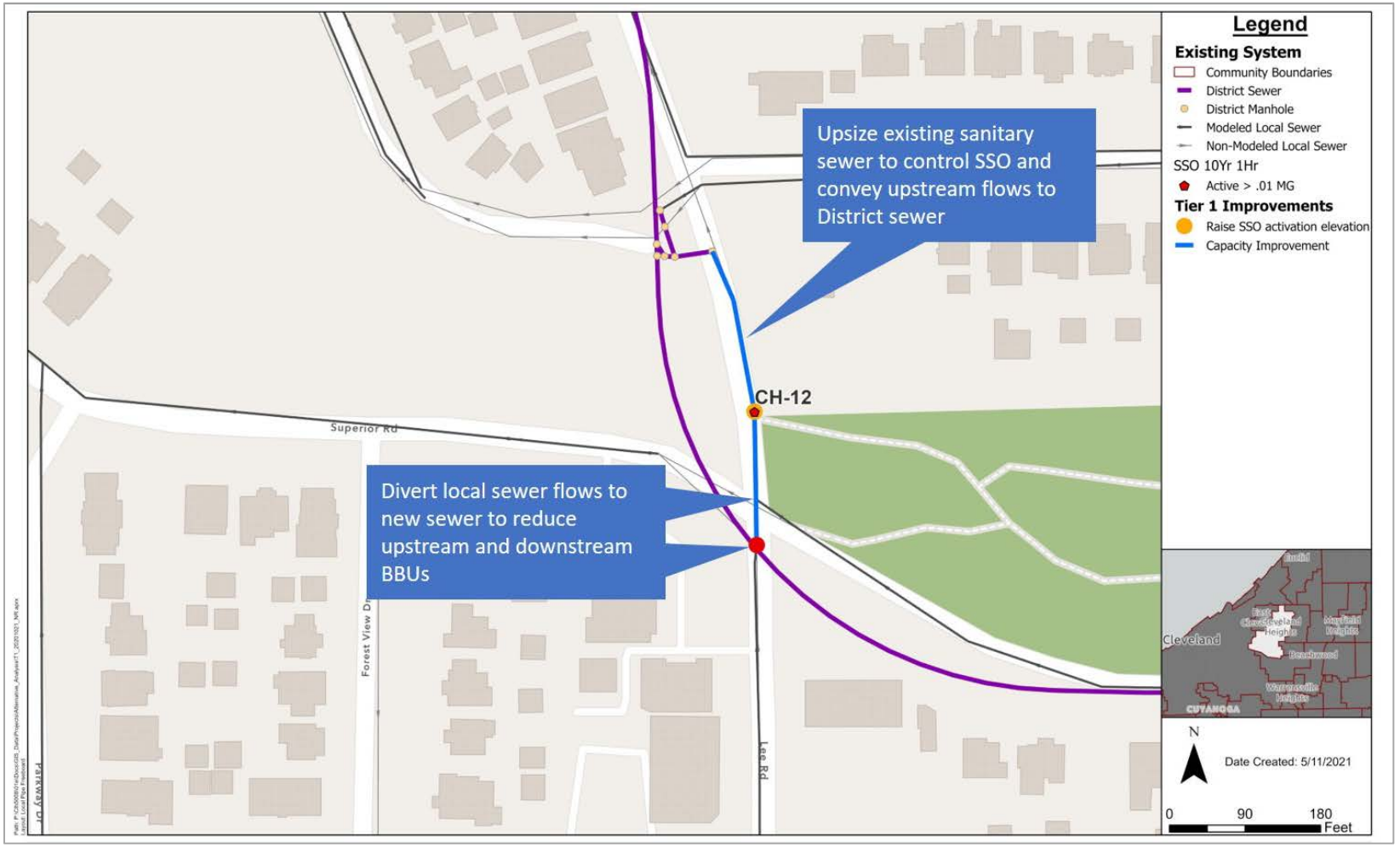
Project Description: Upsize approximately 3,850 LF of sanitary sewer along Monmouth/East Monmouth Roads and make connection to existing NEORSD sewer manhole in Fairmount Boulevard. Redirect flow from SSO CH-9 south to the new sanitary sewer in Monmouth Road. The improvements will control the four SSOs and reduce the risk of BBUs in tributary sewers. Preliminary design will consider alternative sewer route in Lee Road to existing NEORSD at Lee Road and Fairmount Boulevard. **Project Status**: Project investigation and design is being submitted in 2021 for potential grant funding under NEORSD's 2022 MCIP program.

Figure 5-14. Control SSOs CH-17 and CH-25 (Cumberland Road)



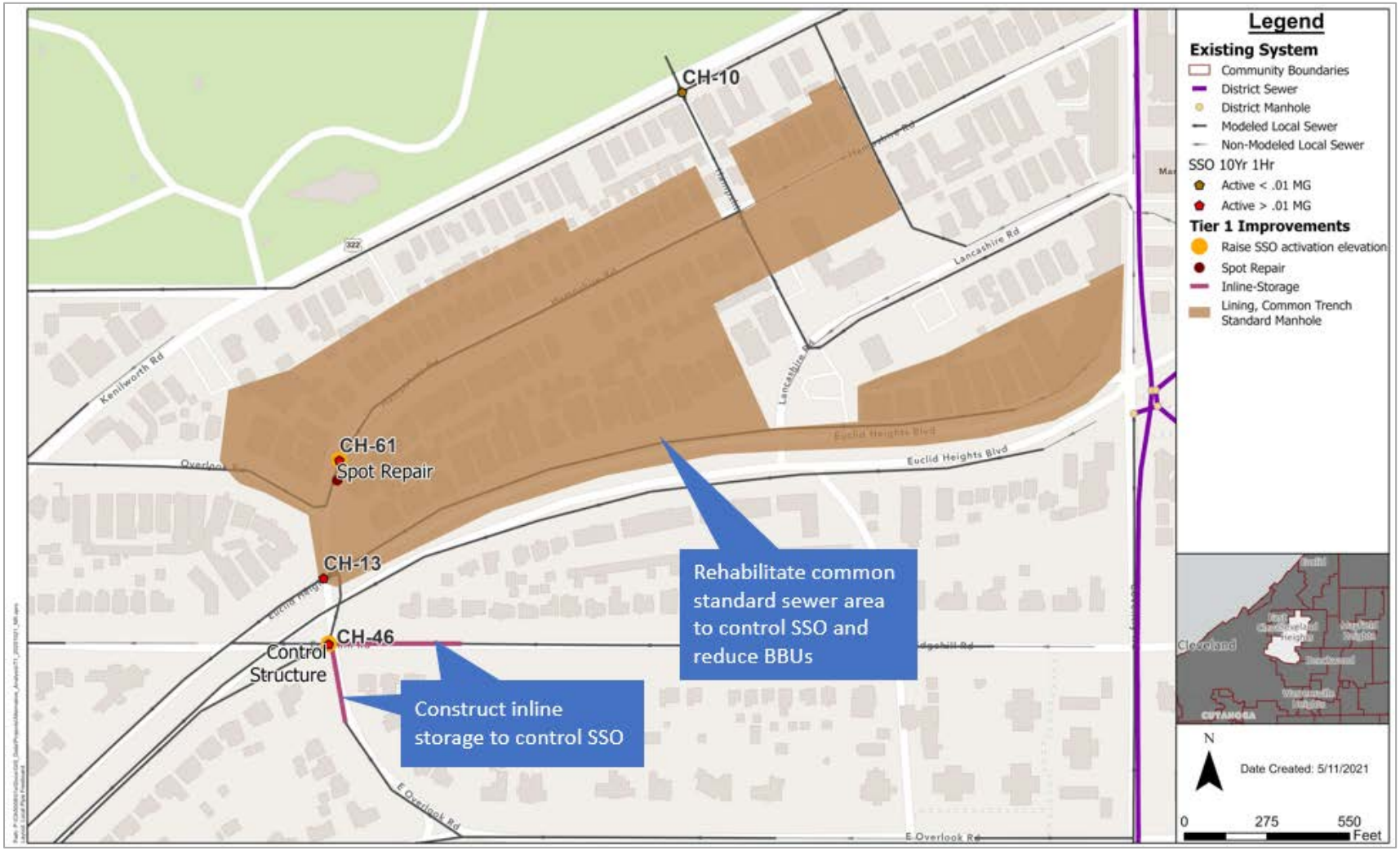
Project Description: Divert flow from SSOs CH-17 and CH-25 to parallel 21-inch local sanitary sewer. **Future Considerations:** Over/under sewer on Cumberland Road proposed for separation in Tier 2.

Figure 5-15. Control SSO CH-12 (Lee and Superior roads)



Project Description: Direct upstream flows from Lee and Superior roads to upsized sewer in Lee Road and discharge new sanitary sewer to ex. NEORSD sewer connection at Lee Road near Cumberland Road. Proposed work will control SSO CH-12 and reduce upstream BBUs. **Project Status:** This project is proposed for 2021 design and is being submitted for funding under NEORSD's 2022 MCIP grant program.

Figure 5-16. Control SSOs CH-13, CH-46, and CH-61 (Hampshire Rd and Euclid Heights Blvd)

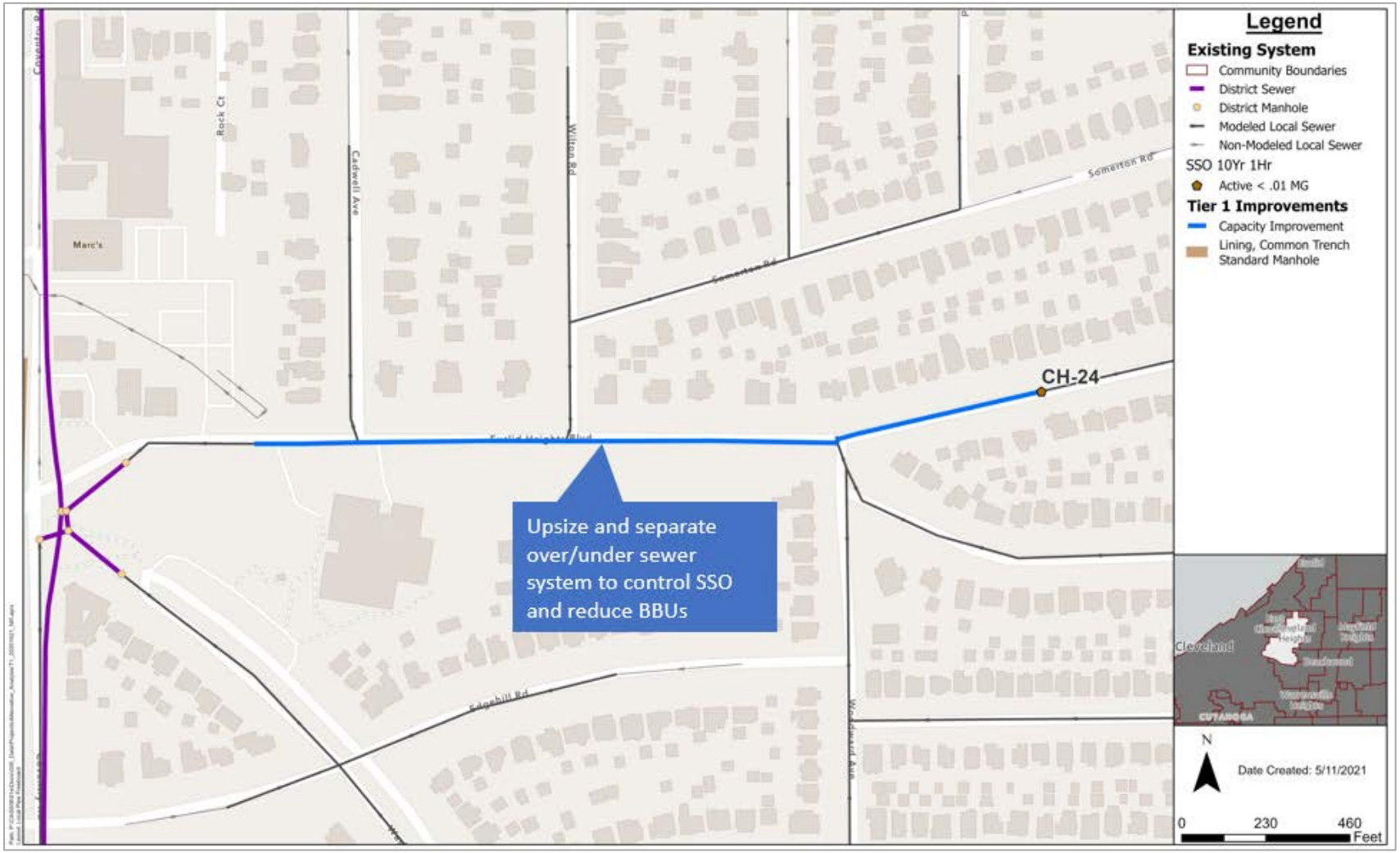


Project Description: Common trench sewer rehabilitation is proposed to control SSOs CH-13 and CH-61 and reduce the risk of BBUs in the tributary sewers. Inline storage is proposed to control SSO CH-46. **Investigation:** Further I/I investigation is proposed to determine if there is significant I/I from private property that may require remediation.

Figure 5-17. Control SSO CH-23 (Berkshire Rd)

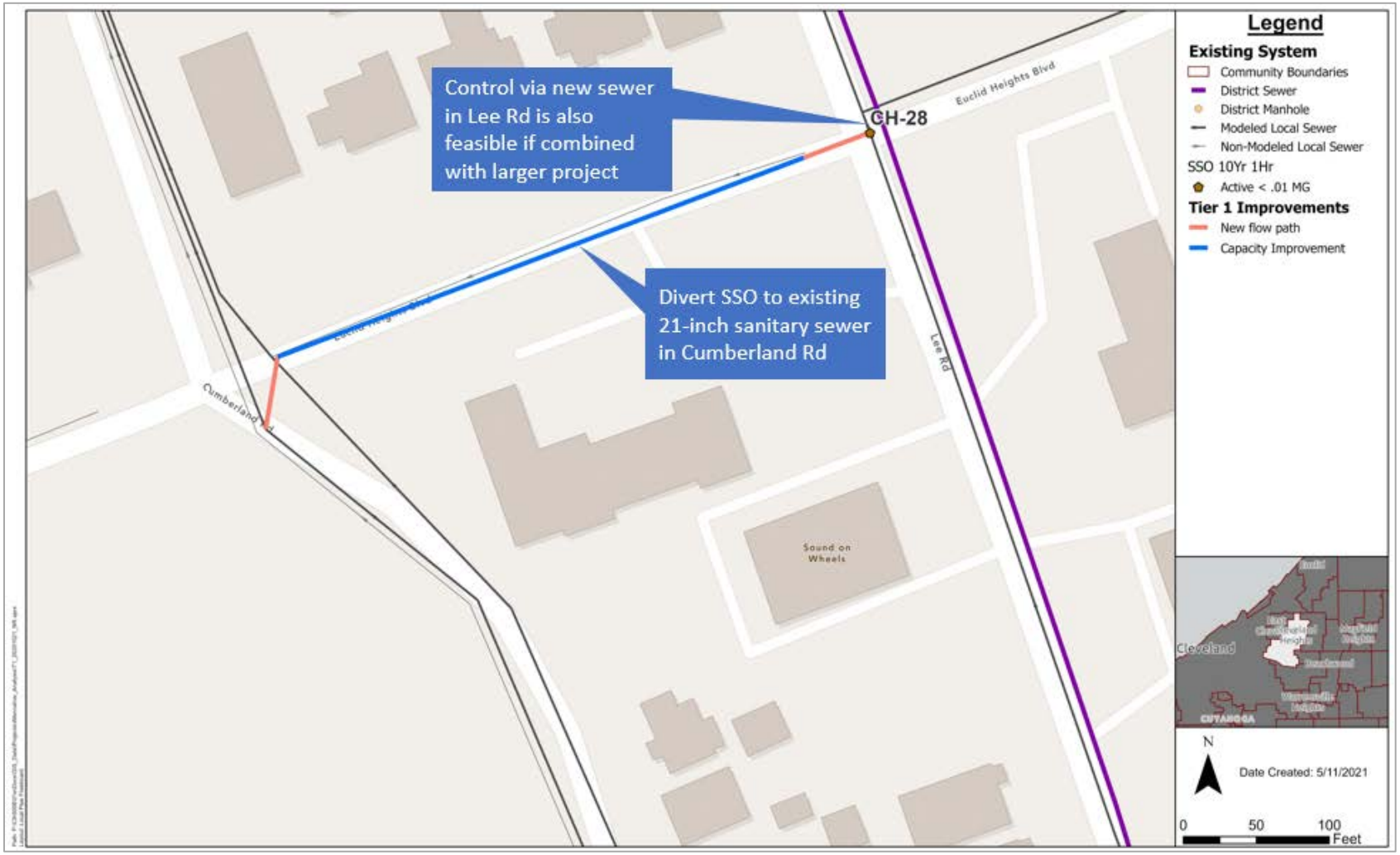
Project Description: Rehabilitate upstream common trench sewers to control SSO CH-23 and mitigate BBUs. Further I/I investigations are suggested to define predominant sources of wet weather flow increases. If necessary, after sewer system rehabilitation, divert upstream flow at Berkshire and Lamberton to local sanitary sewer in Washington Boulevard that has spare capacity.

Figure 5-18. Control SSO CH-24 (Euclid Heights Blvd)



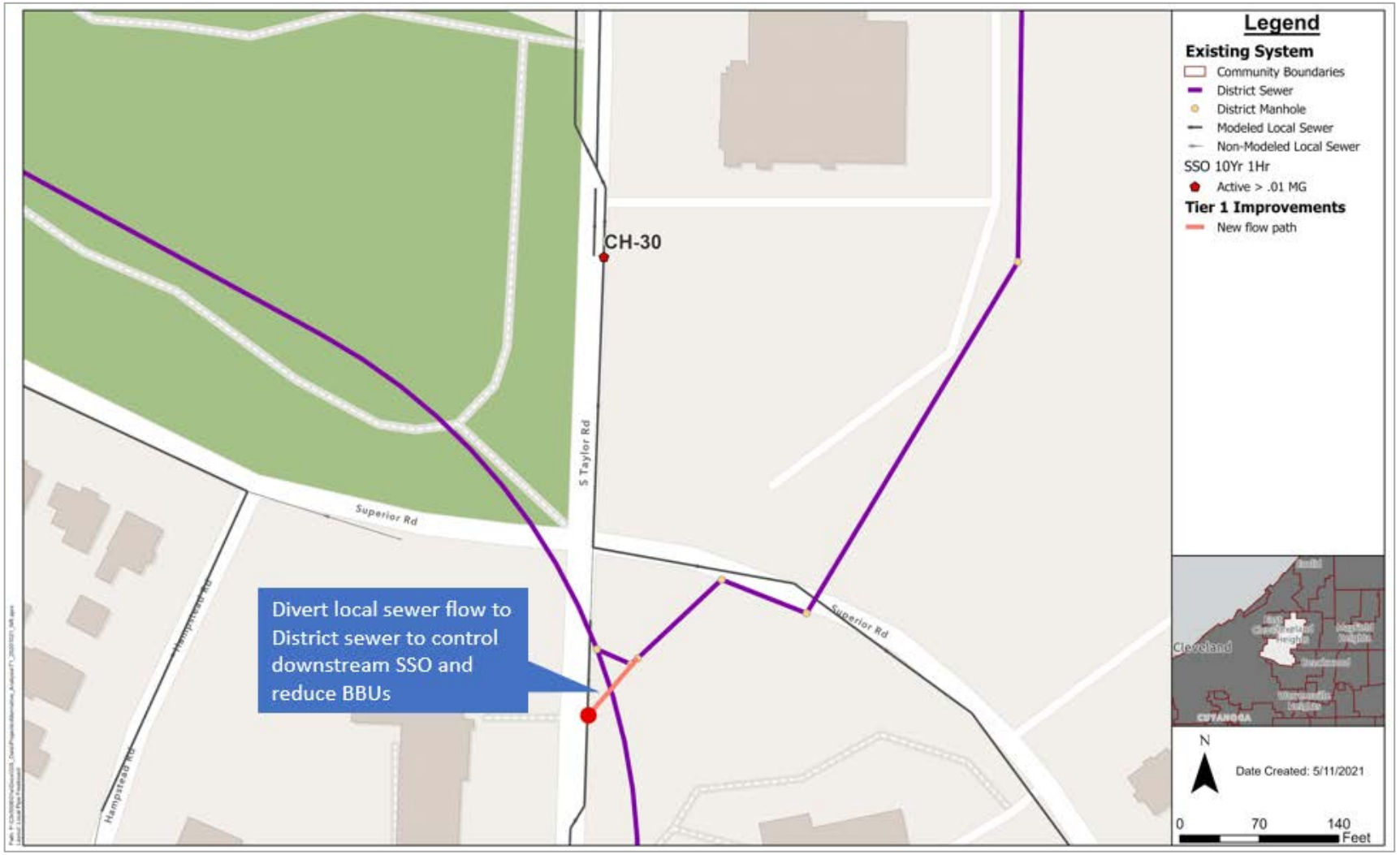
Project Description: Upsize 1,650 LF of over/under sanitary sewer to control SSO CH-24 and mitigate upstream BBUs. Project definition investigation and preliminary design will consider proposed subsequent upstream over/under sewer system replacement/separation.

Figure 5-19. Control SSO CH-28 (Euclid Heights Blvd at Lee Rd)



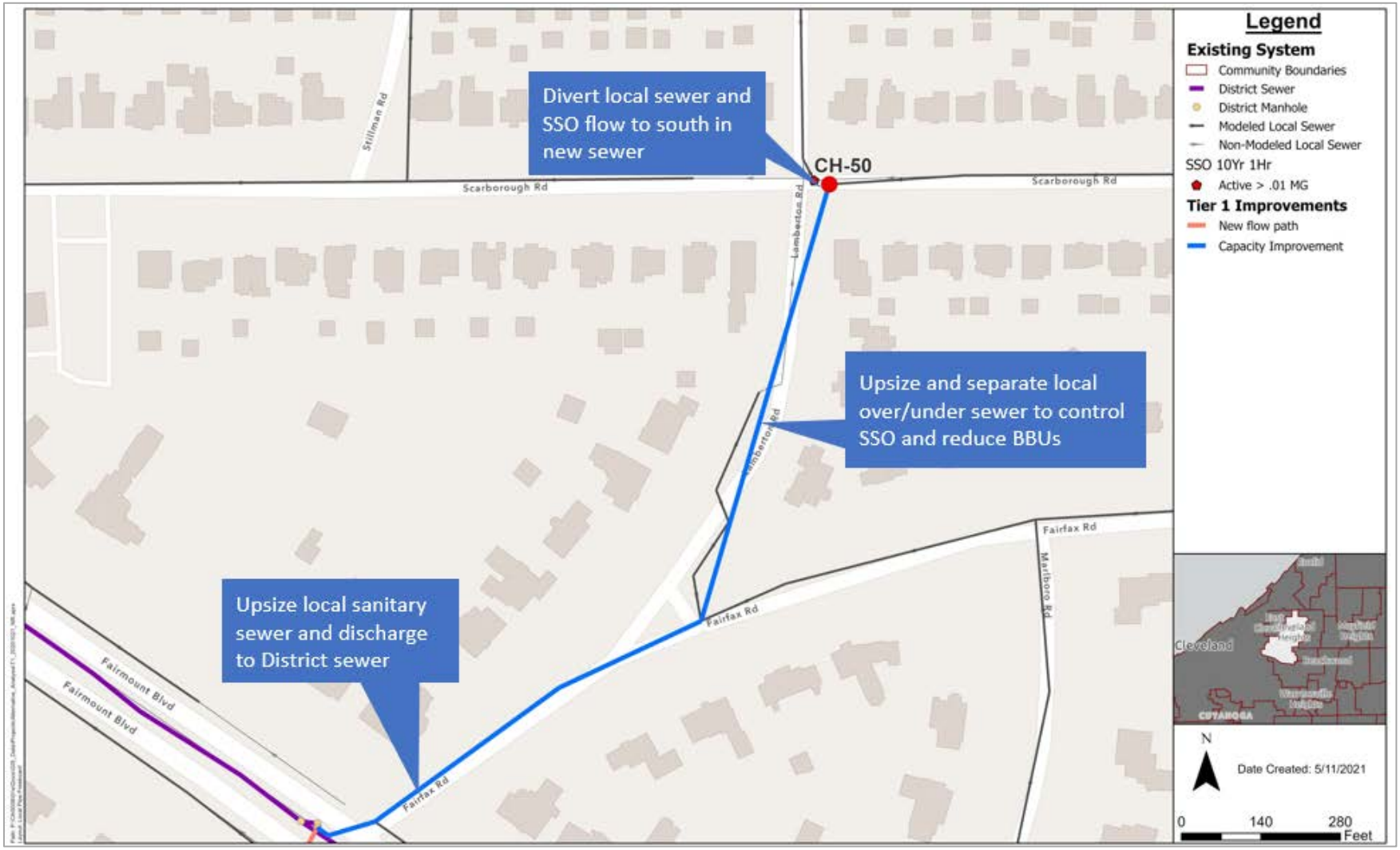
Project Description: Control SSO CH-28 via new sanitary sewer in Euclid Heights Boulevard and discharge to existing 21-inch sanitary sewer Cumberland Road. Project definition and preliminary design should consider feasibility of integrating SSO CH-28 control with larger upstream over/under/dividing wall project from Desota Ave and Bendemeer Road.

Figure 5-20. Control SSO CH-30 (South Taylor Rd at Superior Rd)



Project Description: Divert upstream sanitary sewer flow to NEORSD sewer to control downstream SSO CH-30 and mitigate upstream BBUs. Alternative flow diversion one block south near Washington Boulevard may also be feasible. **Project Status:** This project is proposed for 2021 design and is being submitted for funding under NEORSD's 2022 MCIP grant program.

Figure 5-21. Control SSO CH-50 (Scarborough, Lamberton and Fairfax roads)



Project Description: Divert local sewer and SSO flow at Scarborough Road south in new sanitary sewer along Lamberton and Fairfax roads and discharge to existing NEORSD sewer manhole in Fairmount Boulevard to control SSO CH-50 and mitigate local sewer BBUs.

Figure 5-22. Control SSO CH-55 (Fenley Rd)

Project Description: Rehabilitate common trench sewers and raise the SSO activation elevation to control SSO CH-55. **Investigation** – Project definition investigation is suggested prior to design to identify predominant sources of wet weather I/I.

Figure 5-23. Control SSOs CH-27 and CH-51 (Quilliams and Atherstone roads)

Project Description: Construct new sanitary sewers in Quilliams and Atherstone Roads from Randolph Road to 30-inch trunk sewer with spare capacity in Belvoir Boulevard to control SSOs CH-27 and CH-51 and mitigate local sewer BBUs and downstream BBUs in Randolph Road area. Project may be phased to manage cost.

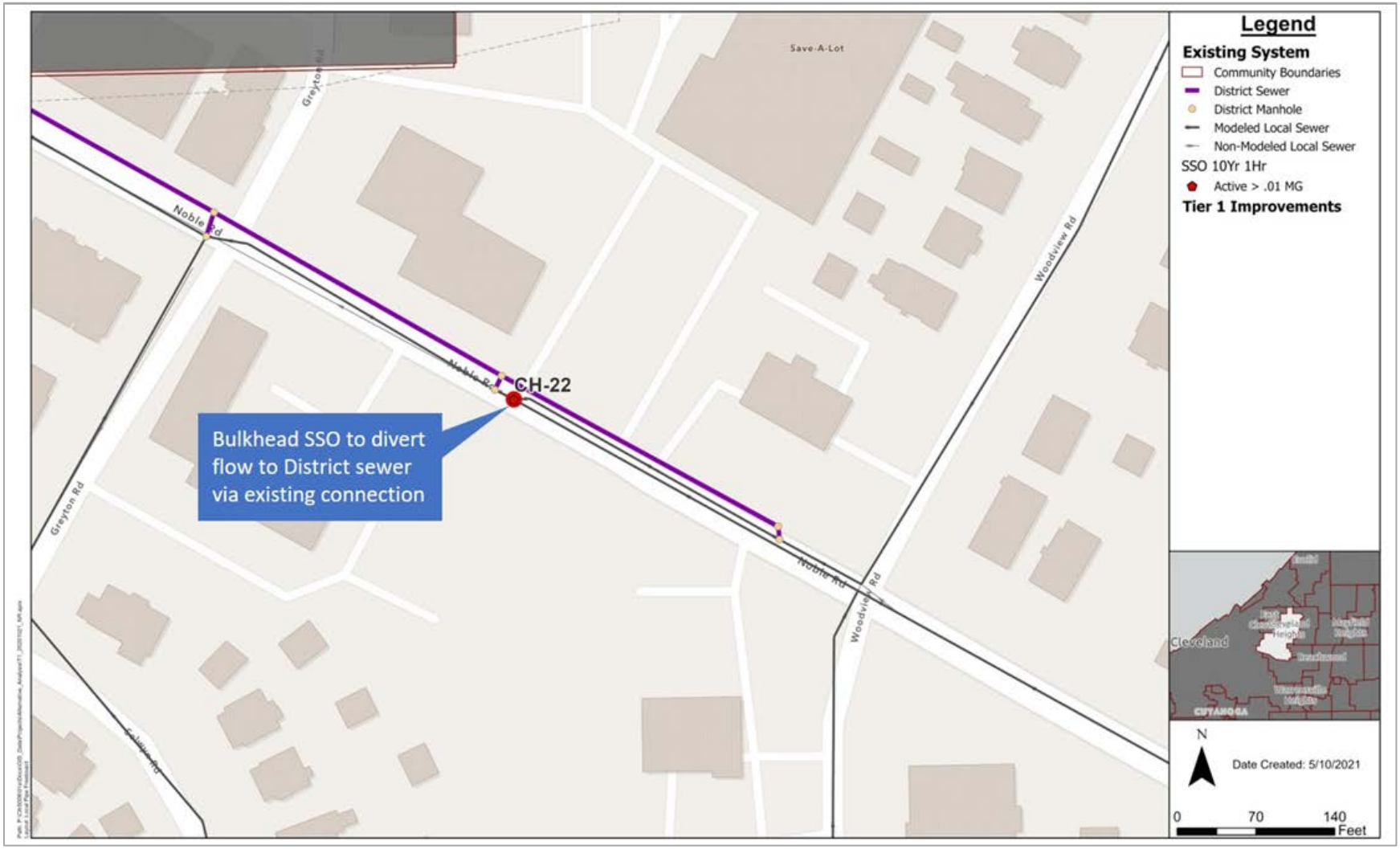
Figure 5-24. Control SSO CH-56 (Lee Road at Meadowbrook Blvd)

Project Description: Construct inline or offline storage to control SSO CH-56. Determine configuration and location of storage piping based on future development of nearby parcel(s). Proposed future sanitary sewer construction in Lee Road and common trench remediation in upstream and downstream tributary areas will provide further SSO control and BBU mitigation.

Figure 5-25. Control SSO CH-10 (Mayfield Road)

Project Description: Remove heavy debris from downstream sanitary sewer and confirm control of SSO CH-10. Proposed future over/under common trench remediation will provide additional control.

Figure 5-26. Control SSO CH-22 (Noble Road)



Project Description: Bulkhead SSO to divert flow to existing NEORSD sewer connection.

5.6.2 Tier 2 – Separation of Over/Under and Dividing Wall Sewers

The HHI-LSSES project found that over/under common trench sewer systems often produce excessive I/I, BBUs and stormwater crossflow contamination. Over/under systems are also more difficult and sometimes unsafe to maintain using normal sewer maintenance procedures. Study results indicate that over/under systems should ultimately be replaced to provide a long-term, serviceable system to adequately convey sewage and stormwater flows. This separation is projected to be very costly, however, and will need to be implemented with the proposed integrated planning approach to combine the work with other development and infrastructure renewal projects to minimize total costs and disruption.

Remediation of the relatively small areas of dividing wall sewers in Cleveland Heights has also been proposed for completion in Tier 2. These systems are not observed or projected to be highly problematic but should ultimately be separated to grade to allow for normal maintenance and prevent potential sanitary sewer system stormwater inflow and/or overflows of sewage to storm sewers.

Figure 5-27 identifies locations of over/under sewers that are high priority based on poor condition, proximity to SSOs and reported basement backups, and require high frequency O&M. Other over/under sewers were classified as lower priority. Quantities for each category are summarized in **Table 5-2.** All proposed Tier 2 improvements based on the 10-year, 1-hour rainfall are shown in **Figure 5-28**. Tier 2 improvements were also identified for the other Consent Decree design rainfall events. Tier 2 improvements identified for all Consent Decree design rainfalls are summarized in **Appendix D**.

Table 5-2 Over/Under Sewers Separation Categories

Color in Figure 5-27	Tier 2 Priority Categories	LF
Red	Pipe has at least one Level 4 or 5 defect, based on PACP ratings.	54,950
Yellow	Pipe has been identified as a high frequency cleaning location.	11,496
Purple	Pipe is immediately upstream or downstream of an active SSO.	6,429
Orange	Residents have reported multiple basement backup events in the last 10 years.	10,445
	Total High Priority	**83,320**
Green	Lower Priority	102,528
	Total Tier 2	**185,848**

Figure 5-27. Over/Under Priority Categorization Map

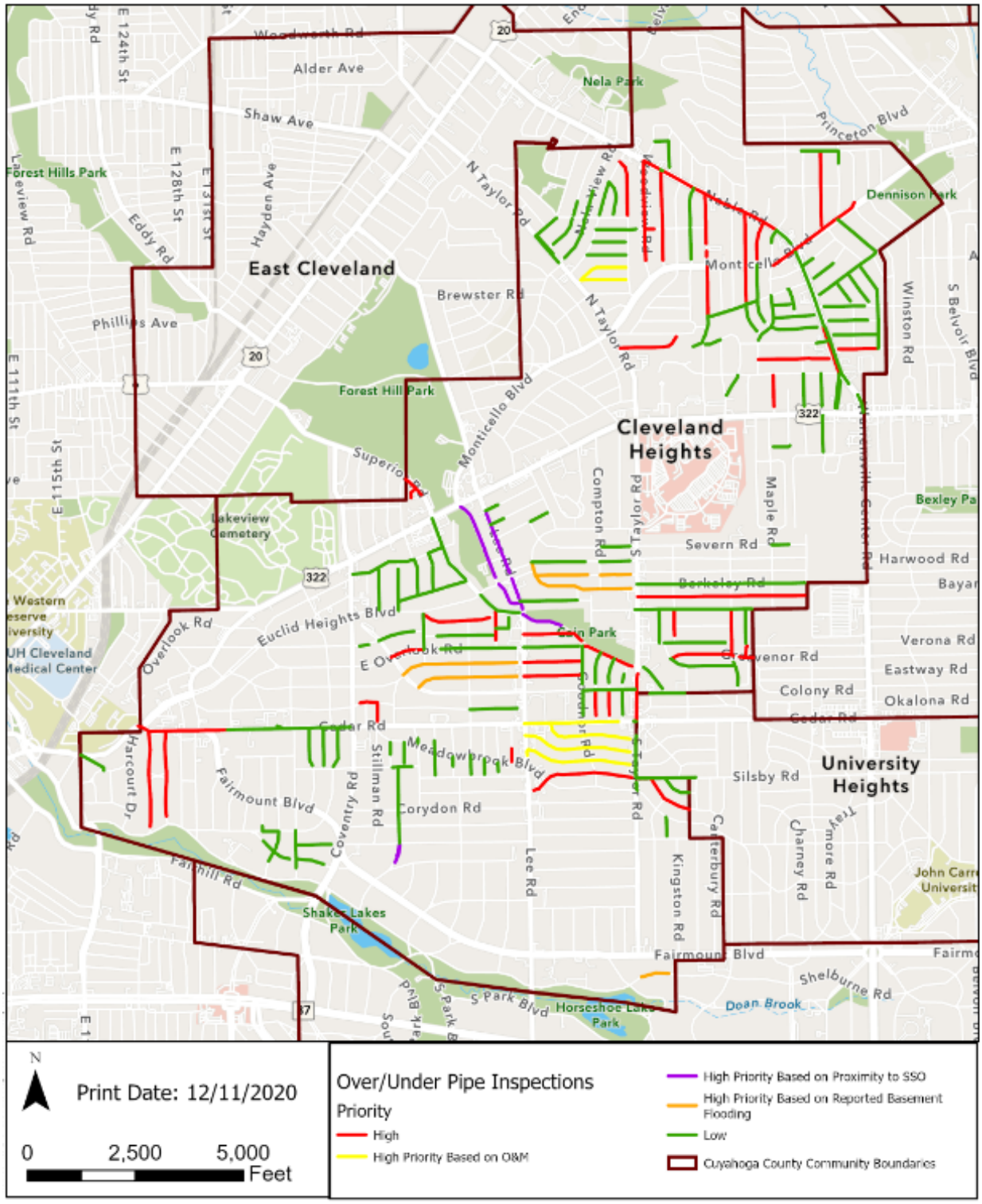
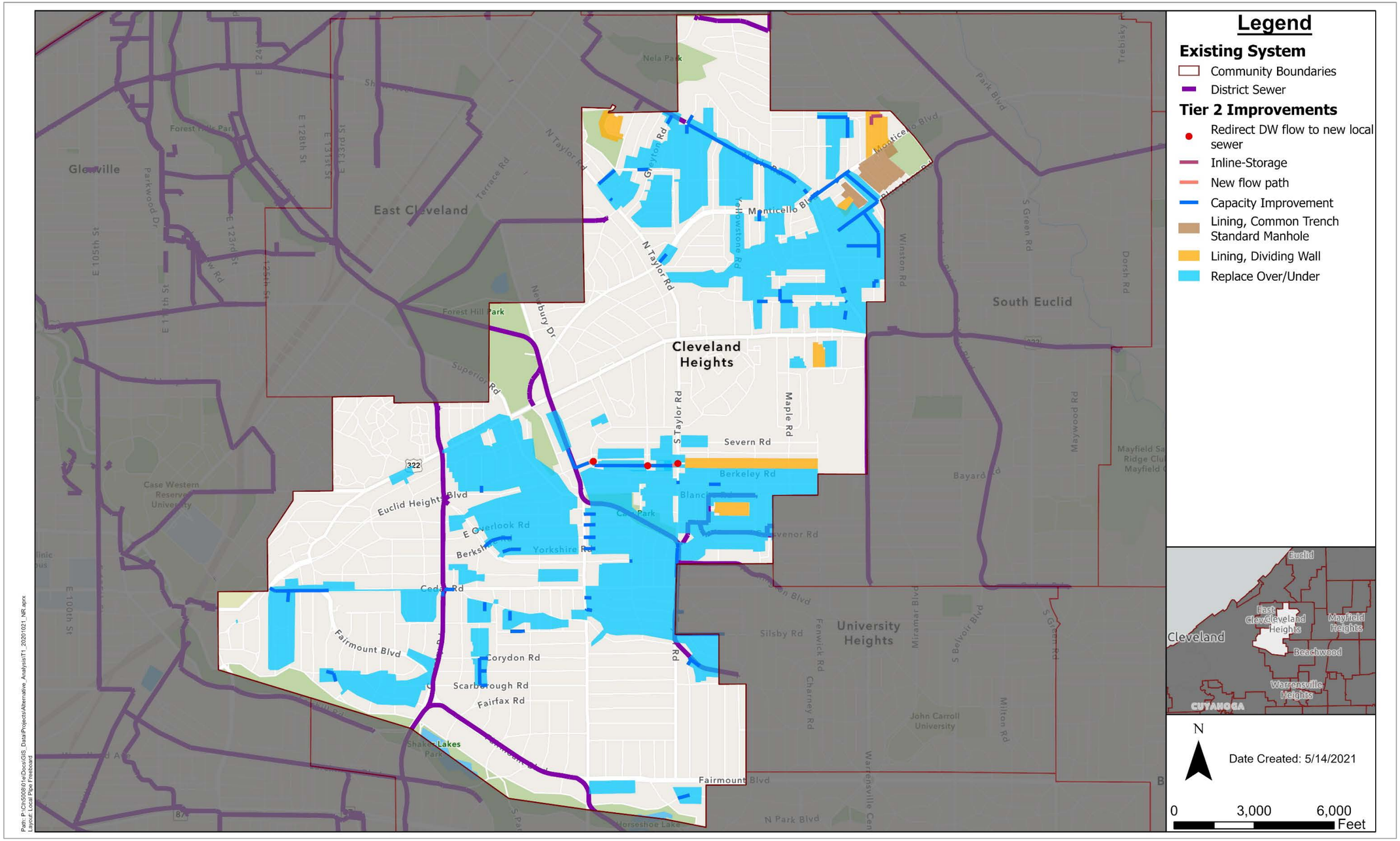


Figure 5-28. Tier 2 Over/Under and Dividing Wall Improvements for 10-year, 1-hour Rainfall



5.6.3 Tier 3 – Address Other Projected Problems

Tier 3 projects address remaining projected BBU areas not addressed by Tier 1 and 2 improvements. Tier 3 improvements, including common trench remediation, private property I/I reduction and capacity increases, have been identified in portions of the system that are projected to experience surcharging and BBU problems in response to the 5-year, 1-hour rainfall, but where there have been no problems reported by the community. Such improvements may be included in long-term master planning, private property redevelopment, time-of-sale improvements and/or roadway reconstruction projects. **Figure 5-29** shows locations of potential Tier 3 improvements. **Figure 5-30** summarizes overall potential improvements in Cleveland Heights.

Tier 3 improvements were also identified for the other Consent Decree design rainfall events. Tier 3 improvements identified for all Consent Decree design rainfalls are summarized in **Appendix D**.

Figure 5-29. Tier 3 Proposed Improvements in Other Projected BBU Problem Areas

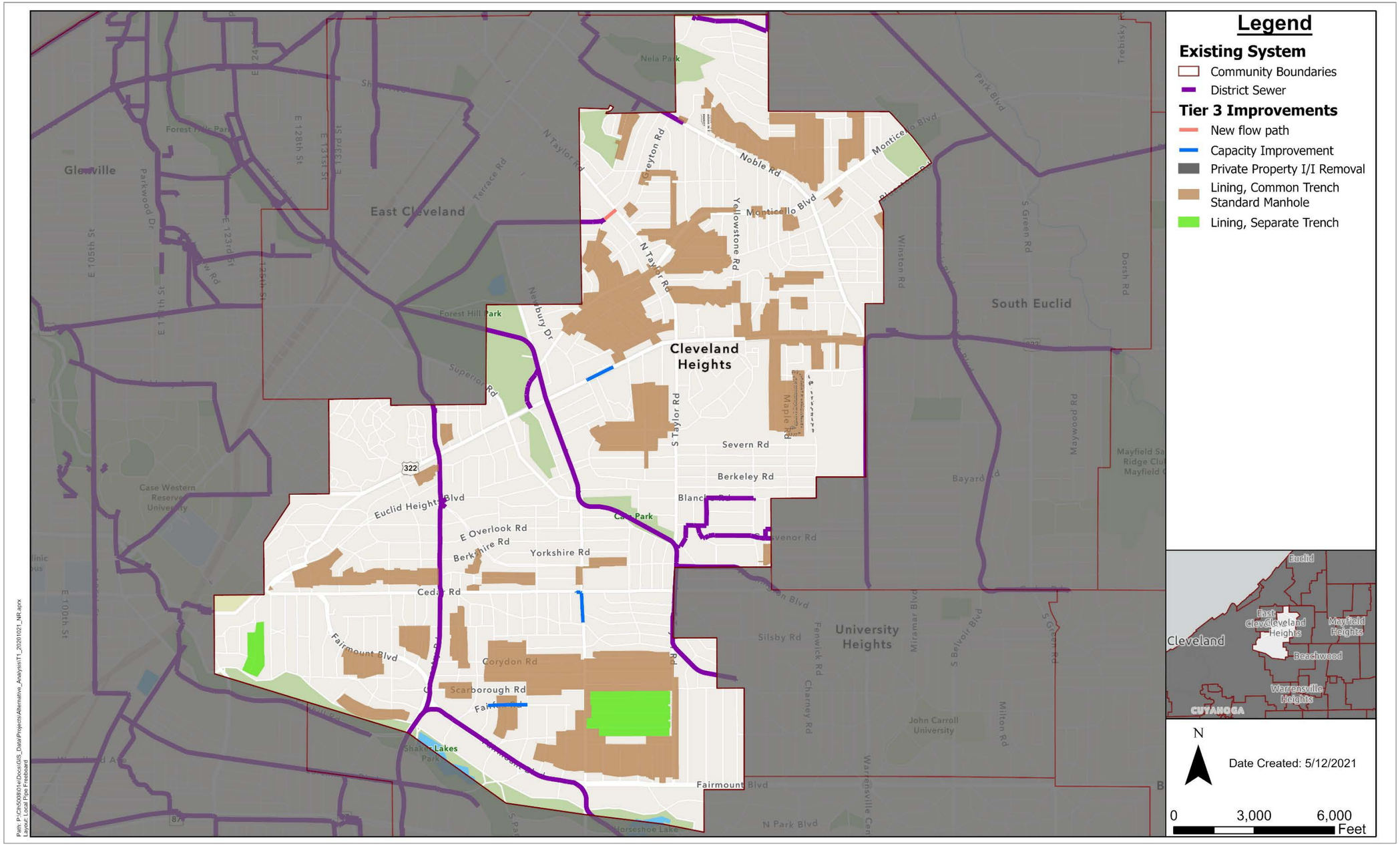
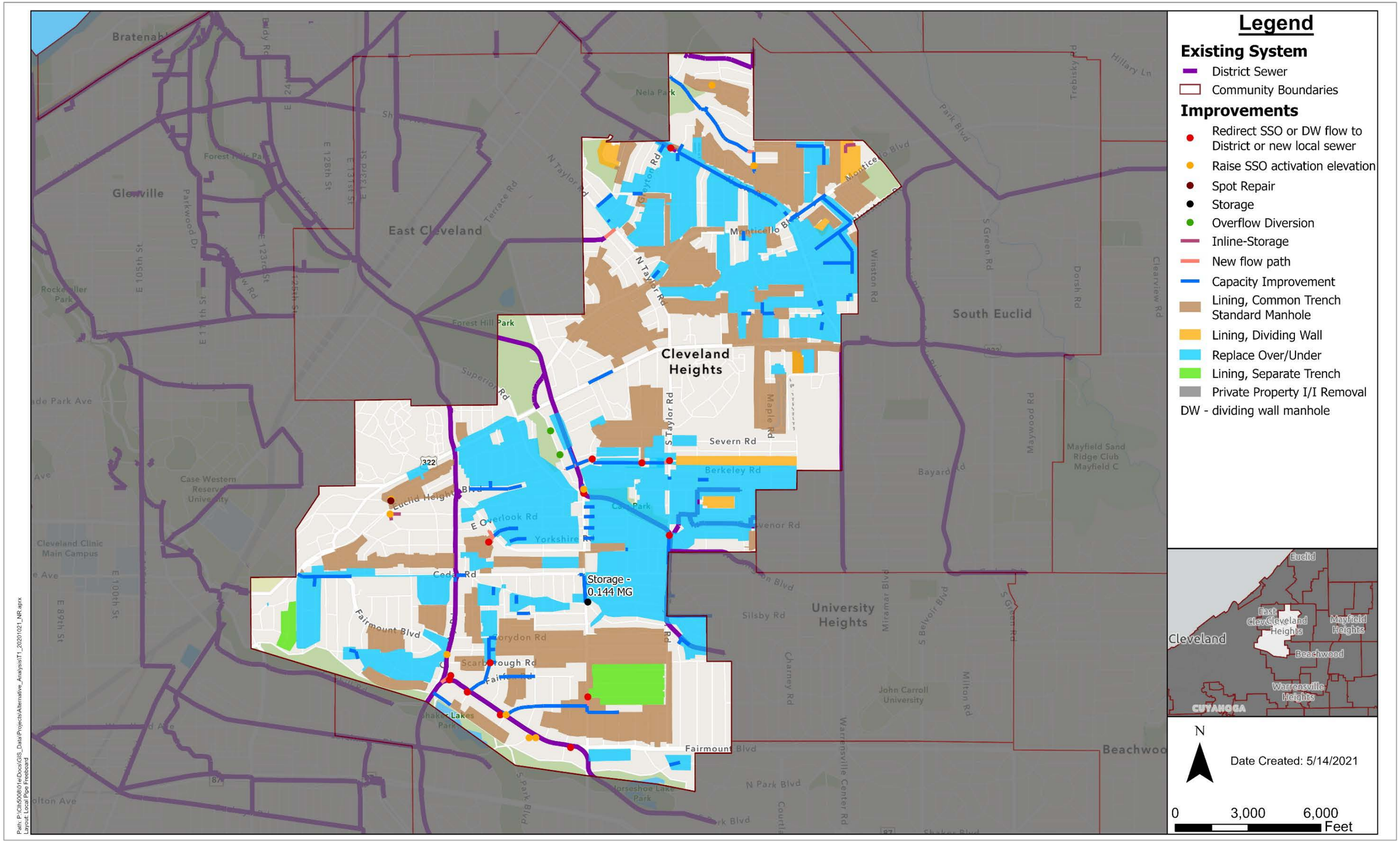


Figure 5-30. All Proposed Improvements for Tiers 1, 2 and 3



5.7 COST INFORMATION FOR PROPOSED REMEDIAL MEASURES

This section summarizes the projected costs of the remedial measures considered to control SSOs and provide adequate capacity for the five Consent Decree design rainfall events. For Tier 1, project costs are developed for each project group as shown in the detail figures in **Section 5.6.1**. For Tier 2 improvements, an approximate cost breakdown is provided for the over/under sewer priority categories and dividing wall improvements. Total costs are provided for Tier 3. **Table 5-3** summarizes project costs for the five Consent Decree design rainfalls.

The costs include design and construction, engineering, contingencies, and a project definition cost for additional pre-design investigations in common trench sewer areas to confirm problem causes and extent of each project area. This is explained in **Section 5.3 - Planning Level Project Cost Development**. **Table 5-3** shows that proposed Tier 1 and Tier 2 improvement costs are not projected to be sensitive to design rainfall, but that long-term Tier 3 improvement costs are significantly affected by design rainfall. This is explained in **Section 5.5 - Basis of Design Rainfalls**.

Table 5-3. Summary of Project Costs by Rainfall Event (AACE Class 5)

SSO Control Projects	Current Year Total Project Cost ($)				
	2-yr	5-yr	10-yr	10-yr, 6-hr	25-yr
CH-2, 33, 39	366,000	367,000	371,000	1,820,000	1,820,000
CH-35, 45, 49	1,136,000	1,142,000	1,142,000	1,649,000	1,649,000
CH-36, CH-37	2,160,000	2,160,000	2,160,000	2,160,000	2,160,000
CH-9, 32, 57, 58	8,868,000	8,868,000	8,868,000	8,868,000	8,868,000
CH-10	6,500	6,500	6,500	6,500	6,500
CH-12	732,000	732,000	732,000	732,000	732,000
CH-13	1,237,000	1,237,000	1,237,000	1,237,000	1,237,000
CH-17, 25, 26	NA	28,000	50,000	50,000	50,000
CH-22	16,250	16,250	16,250	16,250	16,250
CH-23	650,000	1,259,000	1,259,000	1,259,000	1,259,000
CH-24	4,311,000	4,311,000	4,446,000	4,446,000	4,446,000
CH-27	6,985,000	7,302,000	7,302,000	7,302,000	7,302,000
CH-28	654,000	654,000	654,000	654,000	654,000
CH-30	66,500	66,500	66,500	66,500	66,500
CH-46	932,000	1,001,000	1,001,000	2,014,000	2,014,000
CH-50	3,454,000	3,454,000	3,454,000	3,454,000	3,454,000
CH-51	3,663,000	3,663,000	3,663,000	3,663,000	3,663,000
CH-55	1,835,000	1,851,000	1,851,000	3,135,000	3,135,000
CH-56	762,000	865,000	1,014,000	1,859,000	1,096,000
CH-61	997,000	997,000	997,000	997,000	997,000
Tier 1 SSO Control Total	**38,831,000**	**39,980,000**	**40,288,000**	**45,387,000**	**44,624,000**
Tier 2 High Priority O/U	182,021,000	181,730,000	181,894,000	181,935,000	182,067,000
Tier 2 Lower Priority O/U	223,983,000	223,625,000	223,827,000	223,877,000	224,039,000
Tier 2 Dividing Wall (DW)	17,076,000	21,196,000	22,197,000	22,197,000	22,433,000
Tier 2 – Total O/U & DW	423,079,000	426,551,000	**427,918,000**	428,010,000	428,538,000
Tier 3 – Other Areas at Risk	76,500,000	**96,306,000**	122,517,000	130,938,000	150,784,000
System Total	**538,410,000**	**562,837,000**	**590,723,000**	**604,334,000**	**623,946,000**
System Total as Proposed	**565,000,000**				

Operation and Maintenance (O&M) Costs

O&M costs have been reviewed and adapted for the activities required to meet Consent Decree requirements as summarized **Table 5-4**. The estimated annual cost for the listed activities is $1 million.

Table 5-4. CMOM Requirements

CMOM and Other Operation Tasks	Units
Acute defects repair/rehabilitation	138 Locations - to be prioritized
25 Miles (132,000 LF) of Cleaning per Year	132,000 LF
Inspect all pipes with at least a 3 PACP defect every 5 years	300,000 LF
Inspect entire system every 10 years	665,000 LF
Real time monitoring	10 Locations/Yearly
Consent Decree Annual Report	Yearly
MS4 illicit connection repair	Estimated 1 Yearly
FOG Control Program	10 Years
CMOM Program and SORP Update	Update every 5 years
HFC inspect/clean twice a year	31 Locations

Because the proposed remedial measures are essentially all sewer system rehabilitation or replacement improvements, the resulting improved sewer system useful lives, O&M requirements, and costs are expected to be similar to those the City currently incurs. Based on this, project alternatives analysis and selection did not consider specific project O&M costs in detail. The complexity of maintaining over/under common trench systems did, however, contribute significantly to the proposed replacement/separation concepts for over/under sewer areas.

6.0 REMEDIAL MEASURES PRIORITIZATION

Prioritization of the proposed improvements varies by tier. Tier 1 SSO control projects and mitigation of associated BBUs have been prioritized using a ranking system and integrated planning concepts based on the following criteria some of which are suggested in the Consent Decree:

- Associated local system basement backups – actual and model projected
- SSO projected activation frequencies based on NEORSD's Typical Year of rainfall
- SSO volumes based on the Typical Year of rainfall
- SSO volumes for Consent Decree Rainfalls
- Upstream/downstream system benefits to reduce risk of BBUs and SSOs
- Local open stream exposure downstream of SSO outfall
- Northeast Ohio Areawide Coordinating Agency (NOACA) environmental justice areas
- Sanitary and/or storm sewer significant O&M issues
- Sewer system structural condition
- Other planned projects in or near the SSO project area

A spreadsheet was developed to score and prioritize the SSO control projects based on the criteria above. A copy of the Tier 1 prioritization spreadsheet with all criteria is provided in **Appendix E**. **Figure 6-1** shows Tier 1 SSO locations and 5-year paving plan locations also considered for project prioritization. The locations of paving that overlap with Tier 1 projects have made it necessary to expedite the Tier 1 projects so that construction work could be performed in conjunction with the scheduled paving even if the prioritization ranking was lower than other projects. Two Tier 1 projects scheduled for design in conjunction with planned road resurfacing include control of SSO CH-12 near Lee and Superior roads, and control of SSOs CH-35, CH-45, and CH-49 near Coventry Road and Fairmount Boulevard.

The proposed project to control SSO CH-56 at Meadowbrook Boulevard and Lee Road would use local storage to temporarily store peak flows. One of the potential locations identified for this storage is an area along the east side of Lee Road that may be undergoing redevelopment. The City will consider opportunities to incorporate the SSO control project into the redevelopment project.

The Tier 2 over/under (invert plate) sewer systems are proposed to be replaced or otherwise effectively separated in 10-year segments as a second priority behind Tier 1 work. Dividing wall sewers are also proposed for remediation in Tier 2. A preliminary prioritization of the over/under sewer areas has been completed based on related criteria including structural condition, O&M issues, proximity to existing SSOs, and proximity to related BBUs. **Figure 6-2** identifies locations of over/under sewers that are high priority based on poor condition, proximity to SSOs and reported basement backups, and high frequency O&M locations. Other over/under sewers were classified as lower priority. Quantities for each category are summarized in **Table 5-2.**

Tier 3 improvements to mitigate other projected BBU problem areas will be prioritized over time based on similar criteria. Some current Tier 3 project areas may be advanced for earlier completion under the integrated planning framework based on new development projects, sewer system performance issues and other infrastructure improvements.

Figure 6-1. Tier 1 SSO Control Projects and 5-year Paving Plan Project Areas

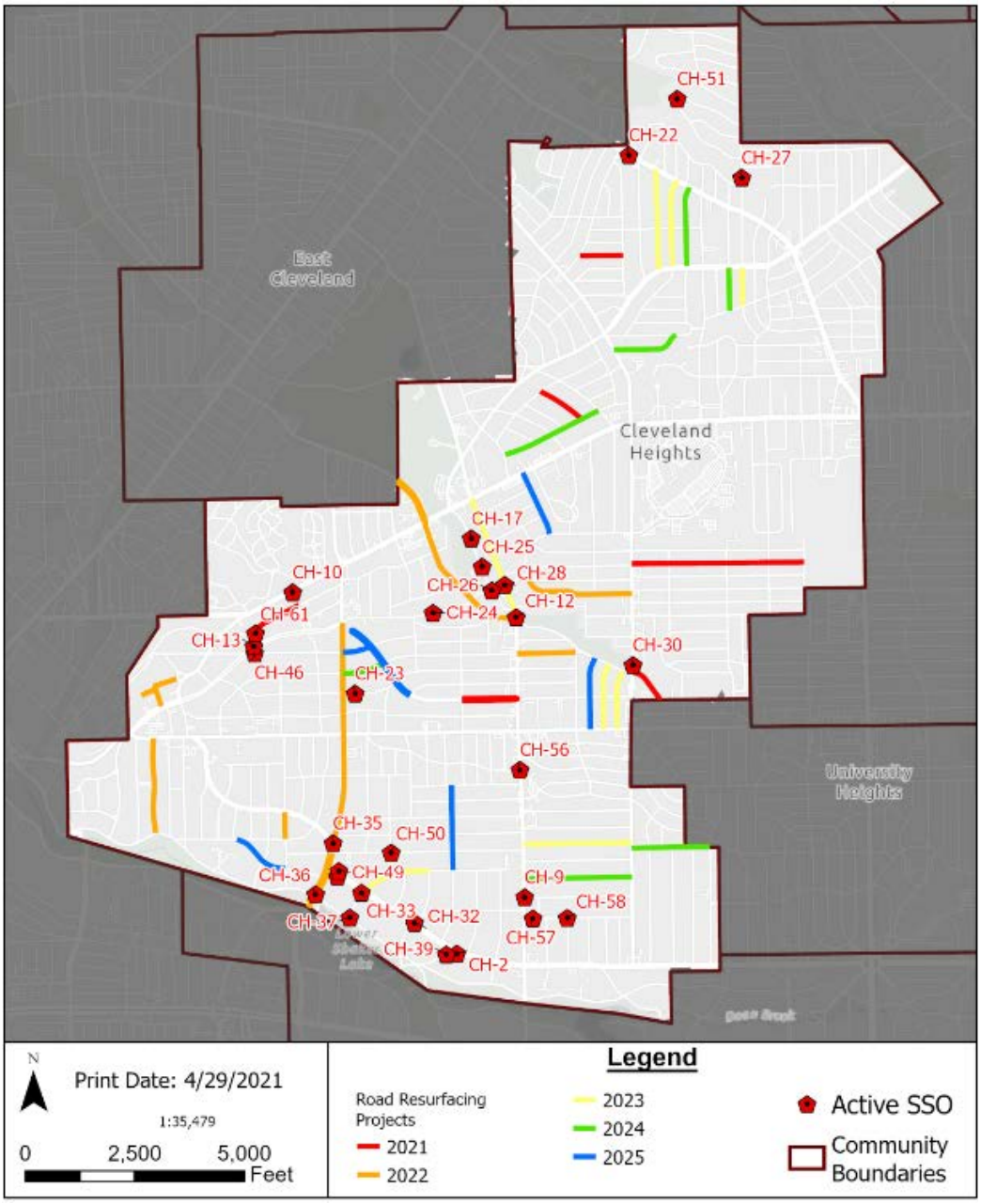
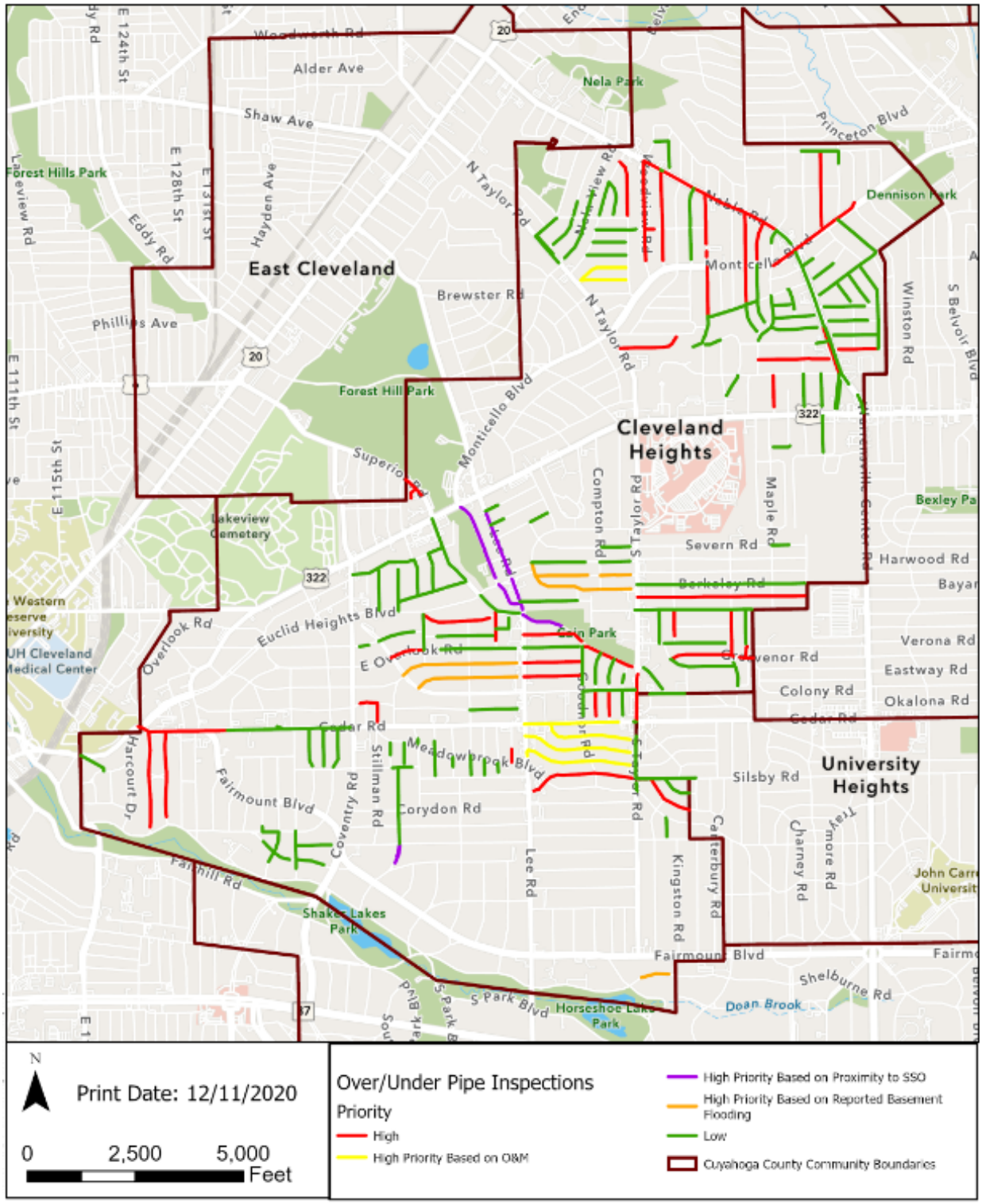


Figure 6-2. Over/Under Sewers Priority Categorization Map



7.0 FINANCIAL CAPABILITY AND AFFORDABILITY ASSESSMENT

Financial capability and customer affordability are the principal considerations in the development of the Master Plan Tier 1 schedule. The City has undertaken a comprehensive financial capability and affordability assessment to determine the overall level of capital spending possible. Local economic and demographic trends, customer affordability, and the City's Sewer Utility (Utility) financial capacity were evaluated. In addition to completion of USEPA's Financial Capability Assessment (FCA), as outlined in its 1997 Guidance[2] and revised/expanded in its proposed 2021 Guidance[3], the City developed a comprehensive long-range financial plan to evaluate the impact of the Master Plan Tier 1 schedule. A summary of the City's Financial Capability and Affordability Assessment follows. A more detailed discussion is provided in the report included in **Appendix F**.

7.1 LOCAL ECONOMIC CONDITIONS

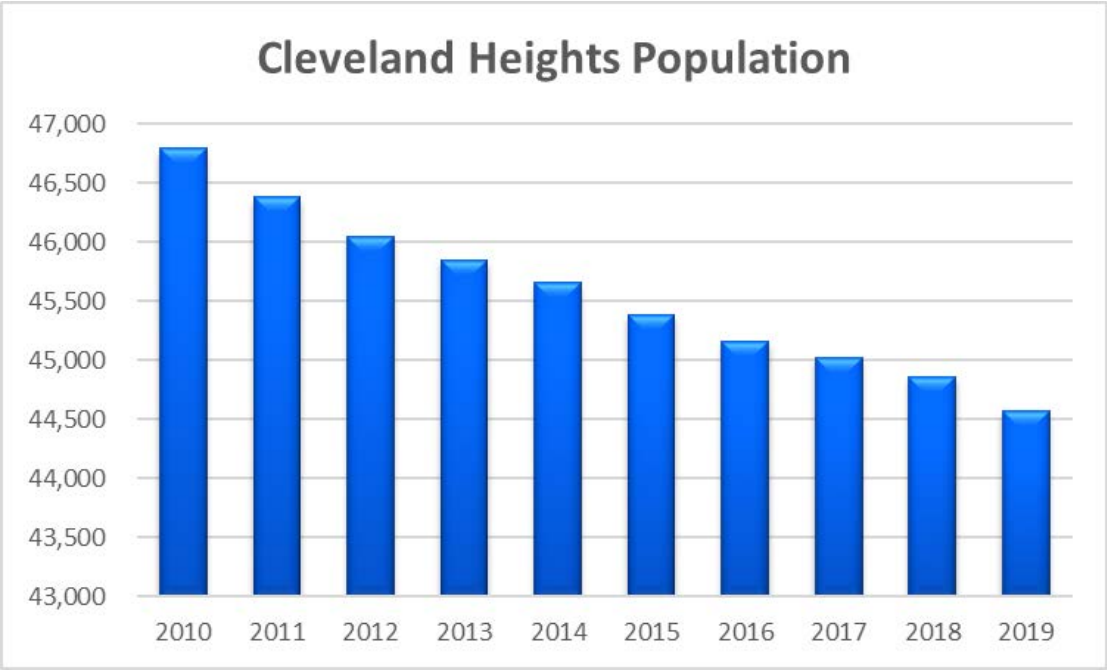
The City of Cleveland Heights is the 26th largest city in Ohio, with a population of 44,571[4]. The City is primarily residential, with associated commercial businesses supporting the community. As an inner ring suburb, the City is "built out," however, redevelopment activities are underway. The City has experienced a continued decline in population, with fewer occupied households and smaller average household size. In their February 26, 2020 Summary Report on Cleveland Heights' general obligation bonds, S&P Global Ratings stated: *"We consider Cleveland Heights' economy weak."* This was prior to the onset of the pandemic. While the City continues to manage both its General Fund and Sewer Utility enterprise fund well, concerns regarding continued population decline and increasing costs, most notably the City's high pension liability, present challenges to the City's financial capability to complete the Master Plan.

7.1.1 Population

The City's population has been consistently declining for at least two decades, and in the past 10 years, population has declined at a rate of approximately 0.5% annually (see **Figure 7-1**). Cuyahoga County has shown a similar, although slightly less drastic decline in population. These declines are in stark contrast to the population trend for the state of Ohio and for the U.S. as a whole, as shown in **Figure 7-2**.

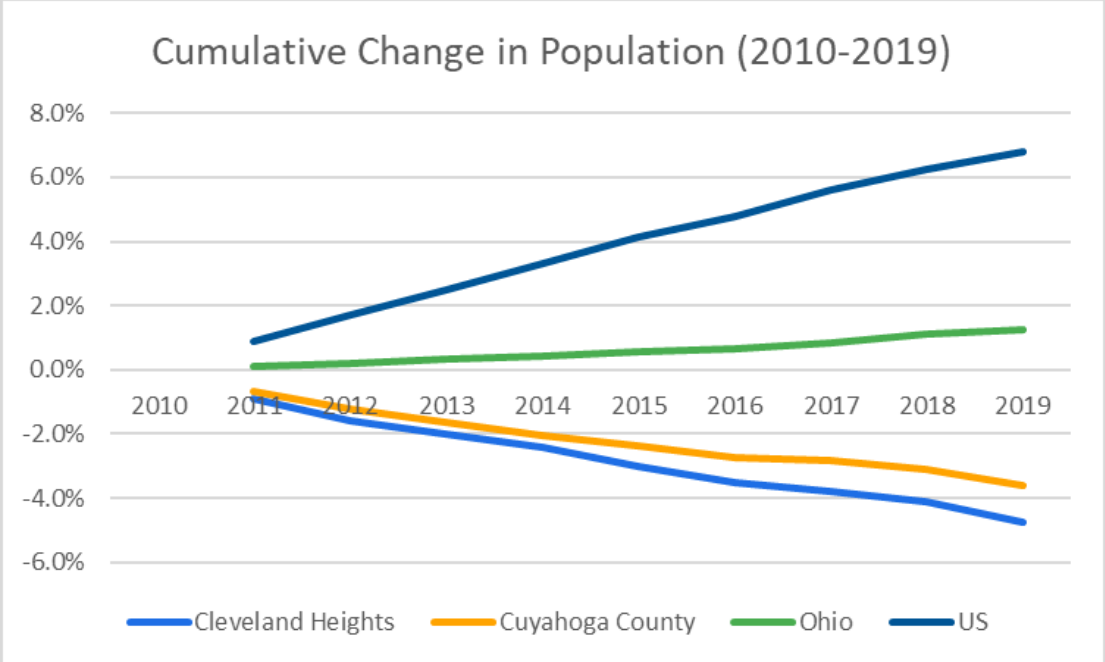
[2] "Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development," EPA 832-B-97-004.
[3] USEPA "2021 Financial Capability Assessment Guidance," January 2021 (prepublication).
[4] American Community Survey, 2019 5-year average.

Figure 7-1. Cleveland Heights' Population, 2010-2019



American Community Survey, 5-year estimates

Figure 7-2. Population Growth Trends, 2010-2019

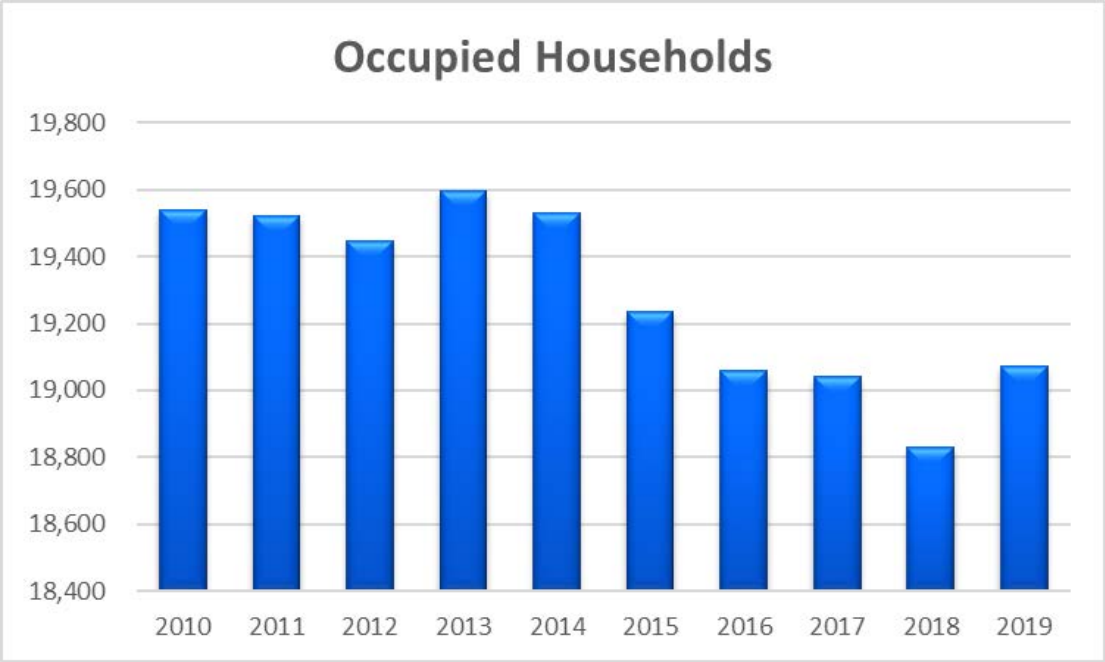


American Community Survey, 5-year estimates

The decline in population is related to both a decline in the number of occupied households as well as a decline in the size of households. The number of occupied households has been declining steadily with

an average annual decline rate of 0.3% and an overall decline rate of 2.4% from 2010 to 2019, reaching 19,074[5] occupied households as of 2019 (see **Figure 7-3**).

Figure 7-3. Cleveland Heights' Occupied Households, 2010-2019

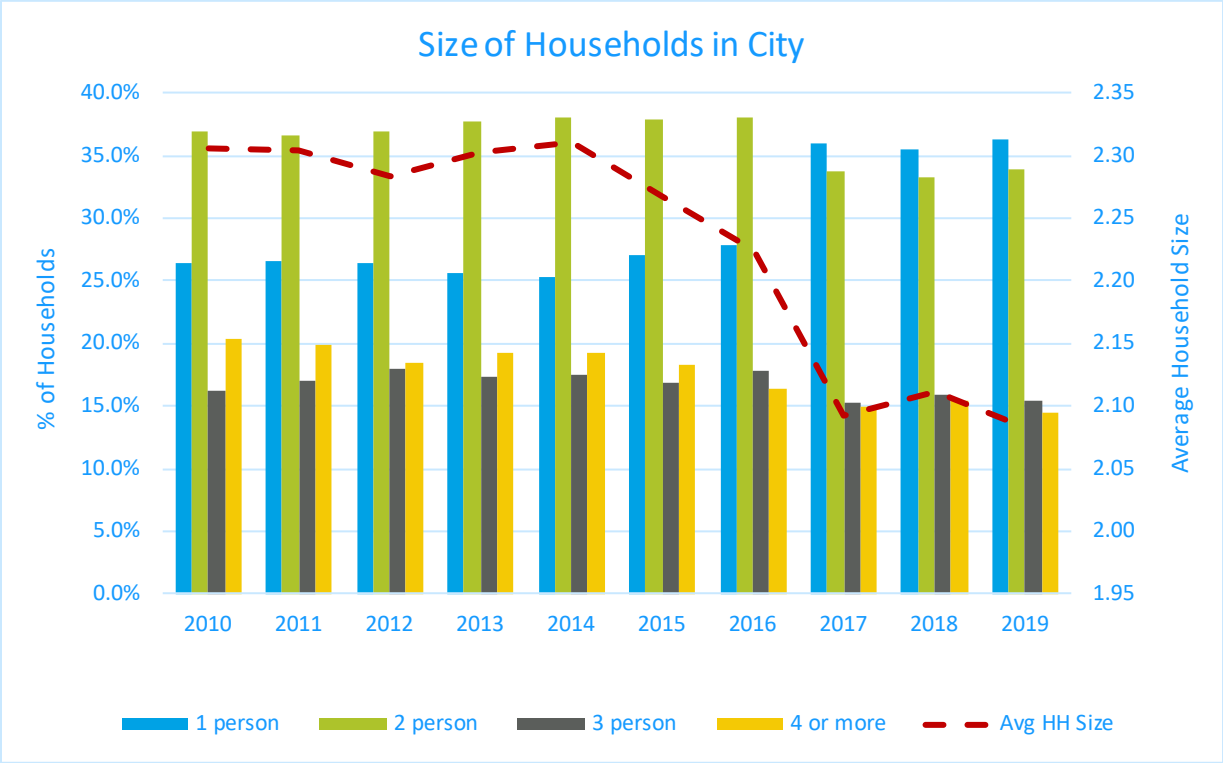


American Community Survey, 5-year estimates

As shown in **Figure 7-4**, currently over 36% of the City's households represent one person households, with the percentage of single person households growing significantly over the past 3 years. An additional 34% of households are two-person households. Overall, the average size of households in the City as of 2019 is 2.08 people, a decline of almost 10% from 2.31 in 2010.

[5] American Community Survey, 2019 5-year estimates.

Figure 7-4. Cleveland Heights' Household Size, 2010-2019



American Community Survey, 5-year estimates

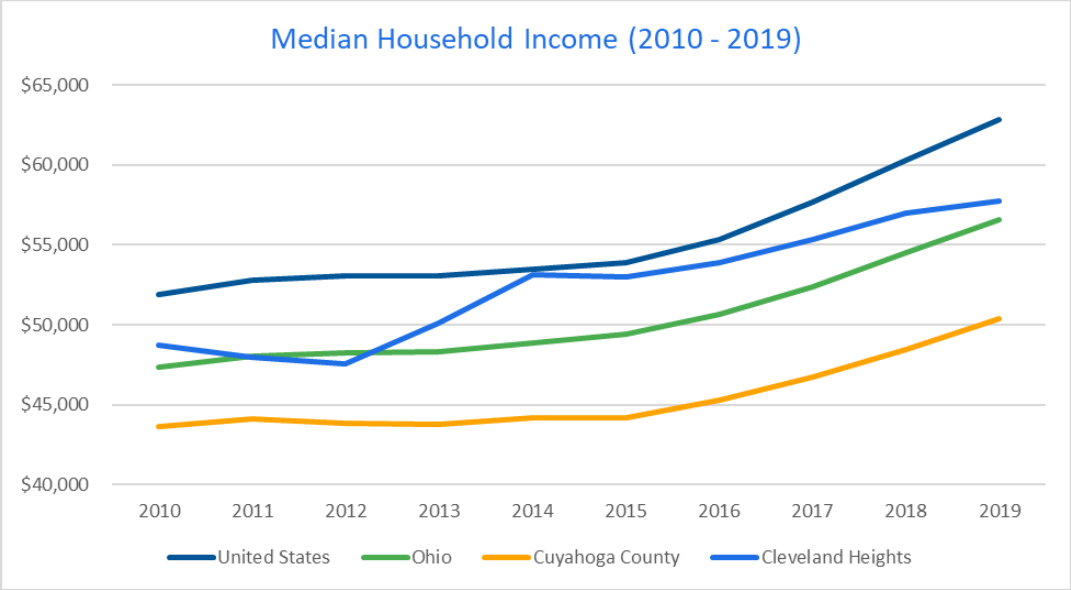
The combined trends of a declining number of occupied households as well as smaller household size has a significant impact on Utility revenues, that reduces the number of residential customers and volume per residential customer. There is no indication that these trends will reverse in the near-term, and as such, they need to be taken into consideration when evaluating the Utility's projected revenues.

7.1.2 Household Income

The median household income (MHI) for the City as of 2019 was $57,768[6], increasing approximately 18.6% from 2010 to 2019 (cumulative increase). While this level of income growth is slightly less than MHI growth for the U.S. over the same period of 21.1%, Cleveland Height's MHI remains lower than that for the U.S. as a whole, with the gap actually growing from 6% in 2010 to 8% in 2019. The City's MHI has consistently remained below that for the U.S. over the past 10 years, with the gap widening over the past 5 years (**Figure 7-5**).

[6] American Community Survey, 2019 5-year Average.

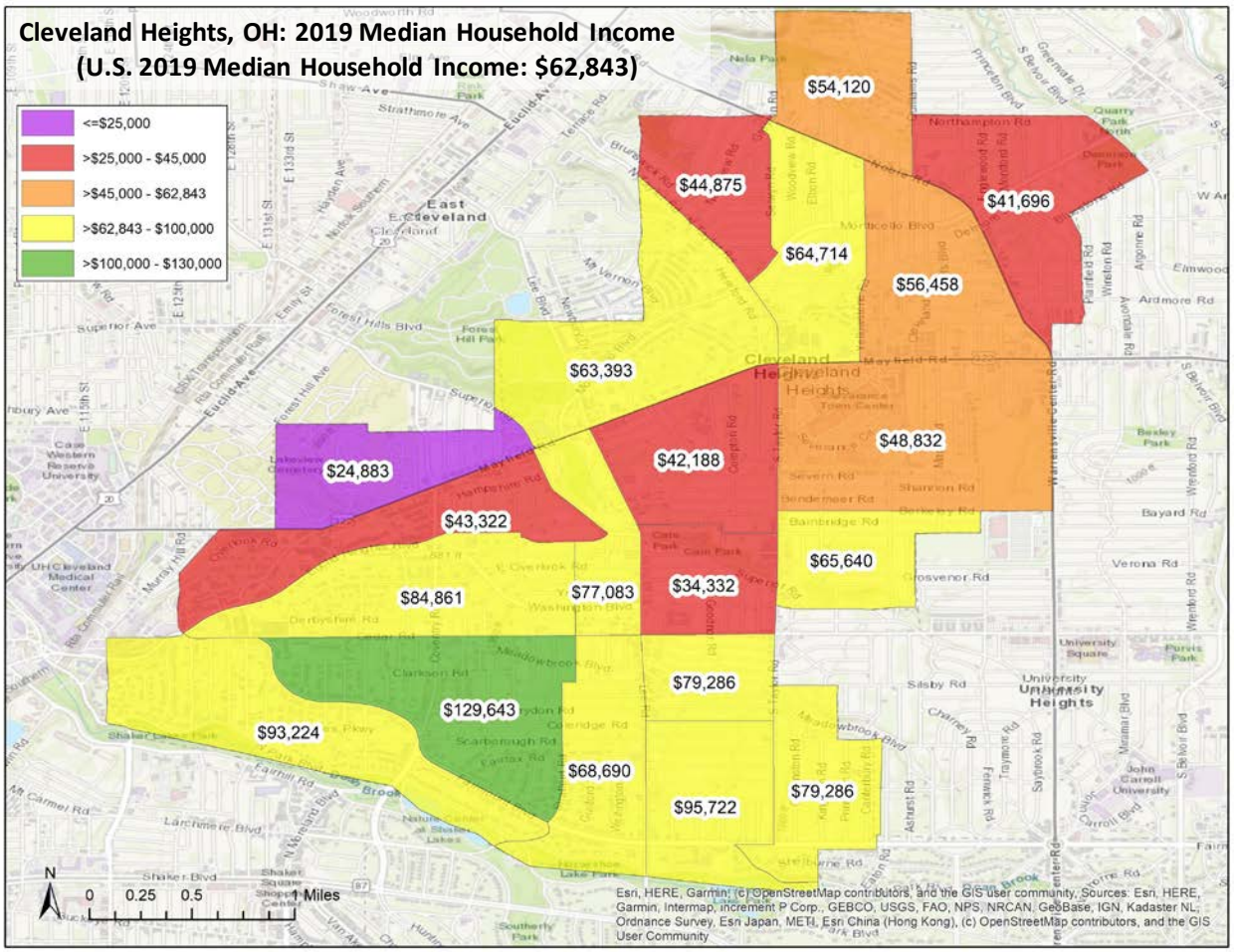
Figure 7-5. Comparison of Median Household Income, 2010-2019



American Community Survey, 5-year estimates

While the overall MHI for a community is commonly used as an initial indication of a community's "wealth," it is a high-level indicator at best. Within the City, income varies significantly, as shown in **Figure 7-6**. The map shows MHI at the census tract level. As shown, MHI ranges from $24,883 to $129,643. Census tracts with an MHI below the U.S. MHI of $62,843 are shown in orange, red or purple. Nearly half of the census tracts have an MHI below that of the U.S.

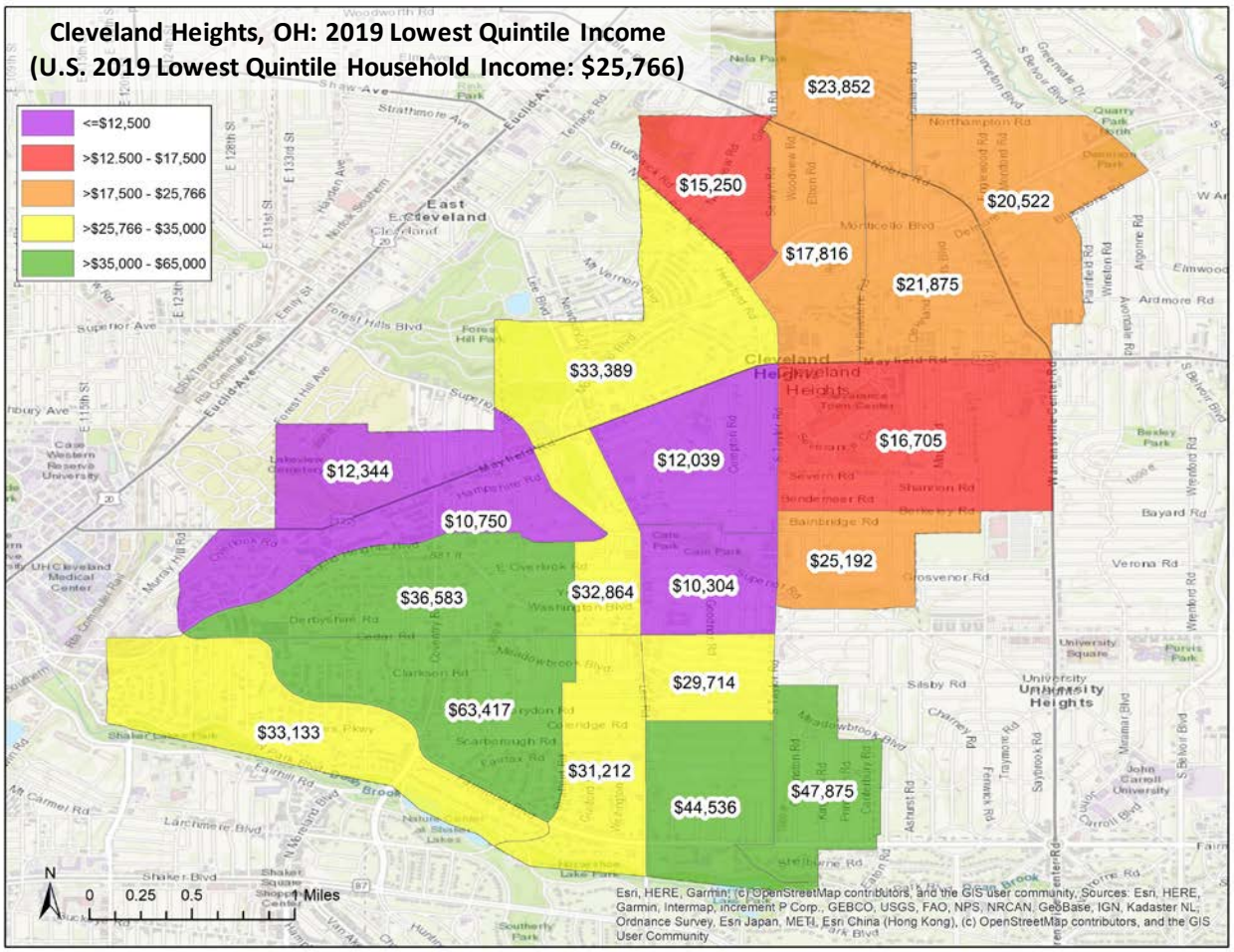
Figure 7-6. Cleveland Heights' Median Household Income



American Community Survey, 2019 5-year estimate

Within the City, there is also wide disparity in income at the lowest quintile, similar to the analysis of MHI at the census tract level. **Figure 7-7** illustrates the variation in Lowest Quintile (Upper Limit) throughout the City, as represented by Lowest Quintile by census tract. More than half of Cleveland Heights's census tracts (those in purple, red and orange) have a Lowest Quintile Income (LQI) below the U.S. LQI of $25,766.

Figure 7-7. Cleveland Heights' Lowest Quintile Income



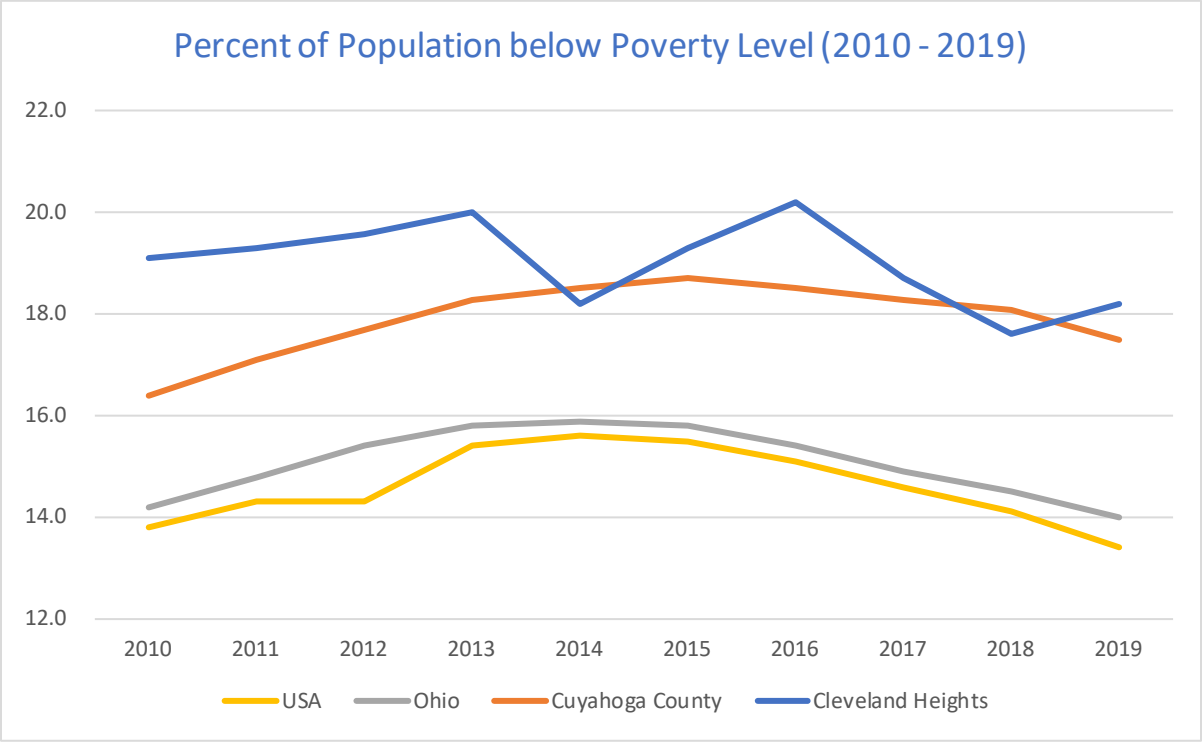
American Community Survey, 2019 5-year estimate

7.1.3 Poverty Rate

While the City's MHI is only slightly below that for the U.S., the City's poverty rate (18.2%[7]) exceeds the overall national rate of 13.4%[8] by 35.8%. As shown in **Figure 7-8**, over the past 10 years, the City's poverty rate has consistently remained higher than that of the nation and Ohio, ranging from 16.7% to 38.4% higher, averaging 30.4% over the 10-year period.

[7] American Community Survey, 2019 5-year estimates.
[8] American Community Survey, 2019 5-year estimates.

Figure 7-8. Cleveland Heights' Poverty Rate, 2010-2019



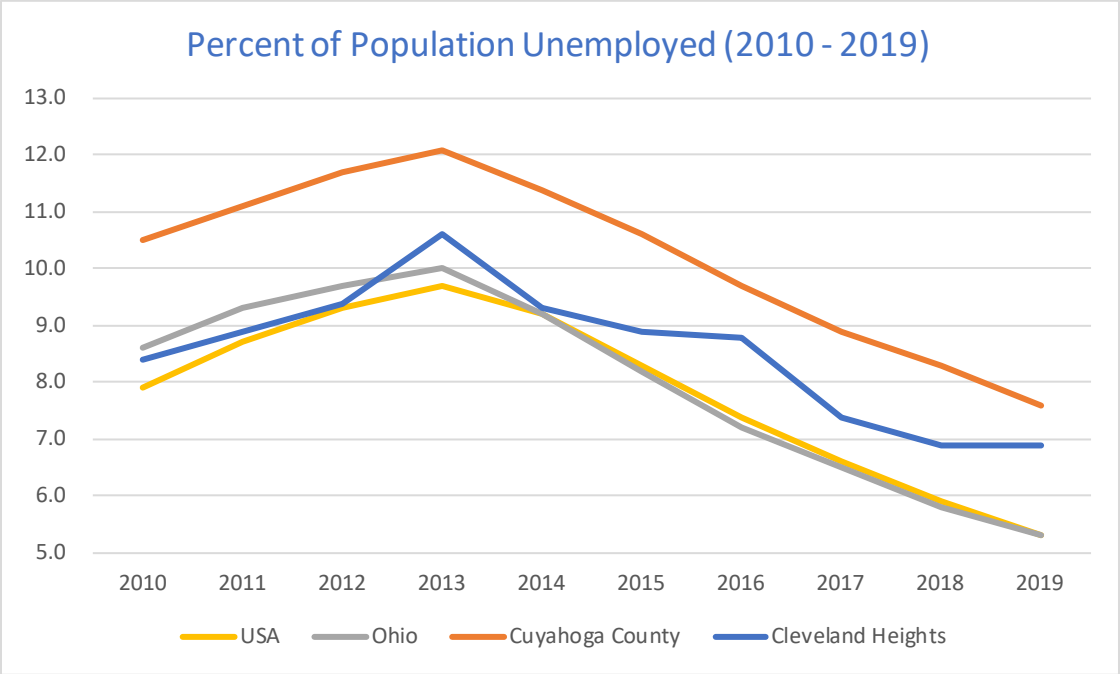
American Community Survey, 5-year estimates

7.1.4 Unemployment Rate

Unemployment is an important factor in USEPA guidance for determining a community's financial capability to complete the requirements of a consent decree. The unemployment rate reflects the community's economic condition as well as a significant segment of the population who face difficult economic conditions and thus would be expected to have difficulty in paying increased sewer costs. As shown in **Figure 7-9**, in the past 10 years, the City's unemployment rate has exceeded that of the U.S. as a whole, with the most recent data indicating the City's unemployment at 6.9%[9], 30.2% higher than the U.S. unemployment rate of 5.3%[10]. The analysis of data for the City and the U.S. over the past 10 years illustrates that the City's unemployment rate has consistently remained higher than that of the U.S., ***averaging 10.5% higher over the 10 years***.

[9] American Community Survey, 2019 5-year estimates.
[10] American Community Survey, 2019 5-year estimates.

Figure 7-9. Cleveland Heights' Unemployment Rate, 2010-2019



7.1.5 Conclusion of Economic and Demographic Analysis

While at first review of the City's MHI it may appear that the City is in good shape economically, a closer evaluation of the City's economic condition and demographics reflects that the City has had continual decline in population, number of occupied households, and household size. Furthermore, compared to the U.S., the City has consistently experienced higher poverty and unemployment rates compared to the U.S. Rating agencies have recognized the City's economic condition, as noted in S&P Global Ratings' 2020 report on the City's general obligation bonds, indicating that they consider the City's economy "weak." For the City's Sewer Utility, this means declining billed volume, as the City has experienced, which has decreased revenue under existing rates.

7.2 FINANCIAL CAPABILITY ANALYSIS – 1997 GUIDANCE

The Financial Capability Analysis (FCA), as outlined in the USEPA's "Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development" (1997 Guidance) results in a Residential Indicator (RI) and score for Financial Capability Indicators (FCI) that USEPA uses to make an initial determination of the level of burden a program may place on the community. A summary of the City's FCA follows.

7.2.1 Residential Indicator

The City has calculated the Residential Indicator (RI) for the full Program, as required under the 1997 Guidance. **Table 7-1** summarizes the calculation of the RI for the full program, estimated at $565 million. As discussed throughout this Report, the cost of the full program, at $565 million, is well beyond the financial capability of the community for the foreseeable future. Therefore, it is impossible to estimate the number of years required to complete all work, and, therefore, it is not possible to incorporate associated asset management capital projects for the appropriate time period. Therefore, this analysis underestimates the RI, with the total impact dependent upon the number of years required to complete all Master Plan projects. Likewise, it is not possible to determine a projected mix of cash and debt for completion of the Master Plan projects, or project the burden of future NEORSD costs beyond that assumed in the calculation of the Tier 1 RI. Therefore, the average annual cash financed capital projected for the analysis of the Tier 1 RI is used in this analysis, and NEORSD cost per household is that assumed for the Tier 1 RI. Nonetheless, as shown in **Table 7-1**, the calculated RI for the entire Program, is 5.55%, with the actual calculated RI expected to be even higher, as discussed. This level of impact is nearing three times the 2% threshold used by USEPA to determine high burden.

Table 7-1. Residential Indicator (All Costs)

Worksheet 1 COST PER HOUSEHOLD (2019 dollars) - All IOCMP Costs			
Line No.			
	Current Costs		
100	Annual Operations and Maintenance Expenses (excluding Depreciation)	$	4,649,617
100a	Cash Financed Capital	$	-
101	Annual Debt Service (Principal and Interest)	$	1,618,952
102	* Subtotal * (Line 100 + Line 100a + Line 101)	$	6,268,569
	Projected LTCP Costs (Current Dollars)		
103	Estimated Additional Annual Operations and Maintenance Expenses (Excluding Depreciation)	$	374,000
103a	Cash Financed Capital	$	2,078,765
104	Annual Debt Service (Principal and Interest)	$	34,795,000
105	* Subtotal * (Line 103 + Line 104)	$	37,247,765
106	Total Current and Projected WWT and CSO Costs (Line 102 + Line 105)	$	43,516,334
107	Residential Share of Total WWT and CSO Costs	$	35,340,038
107a	Residential Share		81.2%
108	Total Number of Households in Service Area		19,074
109	Cost Per Household (Line 107 / Line 108)	$	1,852.79

Worksheet 2 RESIDENTIAL INDICATOR - All IOCMP Costs			
Line No.			
	Median Household Income (MHI)		
201	Census Year MHI	$	57,768
202	MHI Adjustment Factor		0.00%
203	Adjusted MHI (Line 201 x Line 202)	$	57,768
204	Annual WWT and CSO Control Cost Per Household (CPH) (Line 109)	$	1,853
204a	NEORSD Est. Cost per HH	$	1,353
204b	Total Cost per Household	$	3,206
	Residential Indicator		
205	Annual Wastewater and CSO Control Costs per Household as a percent of Adjusted Median Household Income (CPH as % MHI) (Line 204 / Line 203 x 100)		5.55%

As the total cost of the entire Master Plan is well beyond the financial capability of the City, as discussed in this Report, the City recommends completing all Tier 1 projects over a 15-year schedule, by the end of 2036. **Tables 7-2** and **7-3** summarize the calculation of the RI for the City's Recommended Tier 1 schedule. As indicated, even completion of the Tier 1 projects will result in an RI of 3.17%. This level of burden is well beyond that used by USEPA in determining high burden.

Table 7-2. Cost per Household – Tier 1 Projects (Worksheet 1)

Worksheet 1 COST PER HOUSEHOLD (2019 dollars) - Tier 1 Projects Only			
Line No.			
	Current Costs		
100	Annual Operations and Maintenance Expenses (excluding Depreciation)	$	4,649,617
100a	Cash Financed Capital [2]	$	-
101	Annual Debt Service (Principal and Interest) [3]	$	1,618,952
102	* Subtotal * (Line 100 + Line 100a + Line 101)	$	6,268,569
	Projected LTCP Costs (Current Dollars)		
103	Estimated Additional Annual Operations and Maintenance Expenses (Excluding Depreciation) [4]	$	374,000
103a	Cash Financed Capital	$	2,078,765
104	Annual Debt Service (Principal and Interest) [5]	$	2,580,000
105	* Subtotal * (Line 103 + Line 104)	$	5,032,765
106	Total Current and Projected WWT and CSO Costs (Line 102 + Line 105)	$	11,301,334
107	Residential Share of Total WWT and CSO Costs [6]	$	9,177,923
107a	Residential Share [7]		81.2%
108	Total Number of Households in Service Area [8]		19,074
109	Cost Per Household (Line 107 / Line 108)	$	481.17

(1) 2019 Audited Financial Statement.

(2) Cash financed capital shown in Line 103a.

(3) 2019 Audited Financial Statement.

(4) Estimated additional O&M required, per City, beginning 2022.

(5) Debt financed portion of program, assuming 30 year revenue bonds, equal annual principal and interest payments at 4.5% interest rate, 1.0% issuance expenses.

(6) Line 106 times Line 107a.

(7) Percentage is based on 2019 billing data and is the portion of billable volume attributed to residential customers (Residential, Homestead, Affordability). Excludes any large master metered apartment buildings that are billed as commercial, due to inability to identify such customers in billing data. Therefore, this calculation underestimates the true Residential Share.

(8) American Community Survey, 2019 5-Year Survey, total occupied households, Cleveland Heights City

Table 7-3. Residential Indicator – Tier 1 Projects (Worksheet 2)

Worksheet 2 RESIDENTIAL INDICATOR - Tier 1 Projects Only			
Line No.			
	Median Household Income (MHI)		
201	Census Year MHI [1]	$	57,768
202	MHI Adjustment Factor [2]		0.00%
203	Adjusted MHI (Line 201 x Line 202)	$	57,768
204	Annual WWT and CSO Control Cost Per Household (CPH) (Line 109)	$	481
204a	NEORSD Est. Cost per HH [3]	$	1,353
204b	Total Cost per Household	$	1,834
	Residential Indicator		
205	Annual Wastewater and CSO Control Costs per Household as a percent of Adjusted Median Household Income (CPH as % MHI) (Line 204 / Line 203 x 100)		3.17%

(1) American Community Survey, 2019 5-Year Survey.

(2) None.

(3) Estimated annual residential bill in 2036, last year of NEORSD consent decree.

7.2.2 Financial Capability Indicators

The second part of the FCA is the calculation of six Financial Capability Indicators (FCIs), and their scoring of ranking and average ranking. The six factors outlined in USEPA's Guidance include:

Debt Indicators:

1. Bond rating
2. Overall net debt

Socioeconomic Indicators:

3. Unemployment rate
4. Median Household Income (MHI)

Financial Management Indicators:

5. Property Tax Revenue Collection Rate
6. Property Tax Revenues as a % of Full market property value

Each indicator is scored as "Weak," "Mid-range," or "Strong" and assigned a value of 1, 2 or 3, respectively. The FCIs have been calculated based on the 2019 and 2020 data (most recent data available) at the time of the analysis. This assessment is based on available and appropriate audited financial data and data obtained from City official statements. **Table 7-4** summarizes the FCIs and average score. A full discussion of each FCI can be found in the full Report in **Appendix F**. The average score of 1.83 places the City on the lower end of the range for "Mid-Range."

Table 7-4. Financial Capability Indicators (Worksheet 9)

Worksheet 9 SUMMARY OF PERMITTEE FINANCIAL CAPABILITY INDICATORS			
Line No.	Indicator	Actual Value	Score
901	Bond Rating (Line 303)	N/A	3
902	Overall Net Debt as a Percent of Full Market Property Value (Line 405)	8.0%	1
903	Unemployment Rate (Line 501)	6.9%	1
904	Median Household Income (Line 601)	$56,993	2
905	Property Tax Revenues as a Percent of Full Market Property Value (Line 703)	0.42%	3
906	Property Tax Revenue Collection Rate (Line 803)	76.1%	1
907	Permittee Indicators Score (Sum of Column B / Number of Entries)		1.83

7.2.3 Level of Burden

Under the 1997 Guidance, the comparison of the RI calculation in Phase 1 and the FCI score in Phase 2 result in a financial capability matrix that USEPA uses to determine the level of burden imposed on a community in the implementation of mandated consent decree projects. As discussed, the two phases of the FCA come together to result in a matrix rating of "Low Burden," "Medium Burden," or "High Burden." The FCA indicates the City is at "High Burden." Furthermore, while in the past, per the original 1997 CSO Guidance, a permittee's rating as "Low Burden," "Medium Burden," or "High Burden" determined the schedule allowed for the completion of Long-Term Control Plan (LTCP) requirements, the 2014 FCA Framework rightfully acknowledged that financial capability is on a continuum, and not discretely described by three alternative conclusions. Rather than being viewed according to the chart as outlined in the 1997 Guidance, the USEPA is, in effect, characterizing its application of the Financial Capability Matrix as being more along the lines of the chart shown in **Figure 7-10**.

Figure 7-10. Determination of "Level of Burden" – 1997 Guidance

Financial Capability Indicator	Residential Indicator		
	Low Impact (Below 1%)	Mid-Range (1 -2%)	High Impact (Above 2%)
Strong (Above 2.5)	Low Burden	Low Burden	Medium Burden
Mid-Range (1.5-2.5)	Low Burden	Medium Burden	High Burden
Weak (Below 1.5)	Medium Burden	High Burden	High Burden

7.3 FINANCIAL CAPABILITY ANALYSIS – PROPOSED 2021 GUIDANCE

In January 2021, USEPA posted the pre-publication "2021 Financial Capability Assessment Guidance" (2021 Guidance). The 2021 Guidance further clarifies the flexibility USEPA provided in the 2014 Financial Capability Assessment Framework memorandum, including options for analysis that will be considered. The expanded FCA includes the calculation of a Low-Income Residential Indicator (LQRI) and a Poverty Indicator (PI), which combined with the original FCA provides a new FCA determination of burden. While recognizing that the 2021 Guidance has not been published in the Federal Register and is not yet adopted, the City has calculated a level of burden indicated by the proposed guidance. As shown, in **Figure 7-11**, the Tier 1 program results in the City being at the upper range of ***"high burden."***

Figure 7-11. Determination of "Level of Burden" – Proposed 2021 Guidance

FCA Burden (RI and FCI)	LQ Burden (LQRI and PI)		
	Low Burden	Medium Burden	High Burden
Low Burden	Low Burden	Low Burden	Medium Burden
Medium Burden	Low Burden	Medium Burden	High Burden
High Burden	Medium Burden	High Burden	High Burden

7.4 SEWER UTILITY FINANCIAL CAPABILITY

While the FCA is required by the USEPA, the analysis is limited in really understanding the Utility's ability to finance the Program and what the resulting impact will be on customers. As such, as USEPA is proposing in the 2021 Guidance, a detailed long-term financial plan should be developed to understand how the Master Plan may be financed, and the resulting revenue increases that could be required in completing the Master Plan. The City has undertaken a comprehensive analysis of the Utility's revenues and revenue requirements and developed a long-range financial plan that projects the required revenue

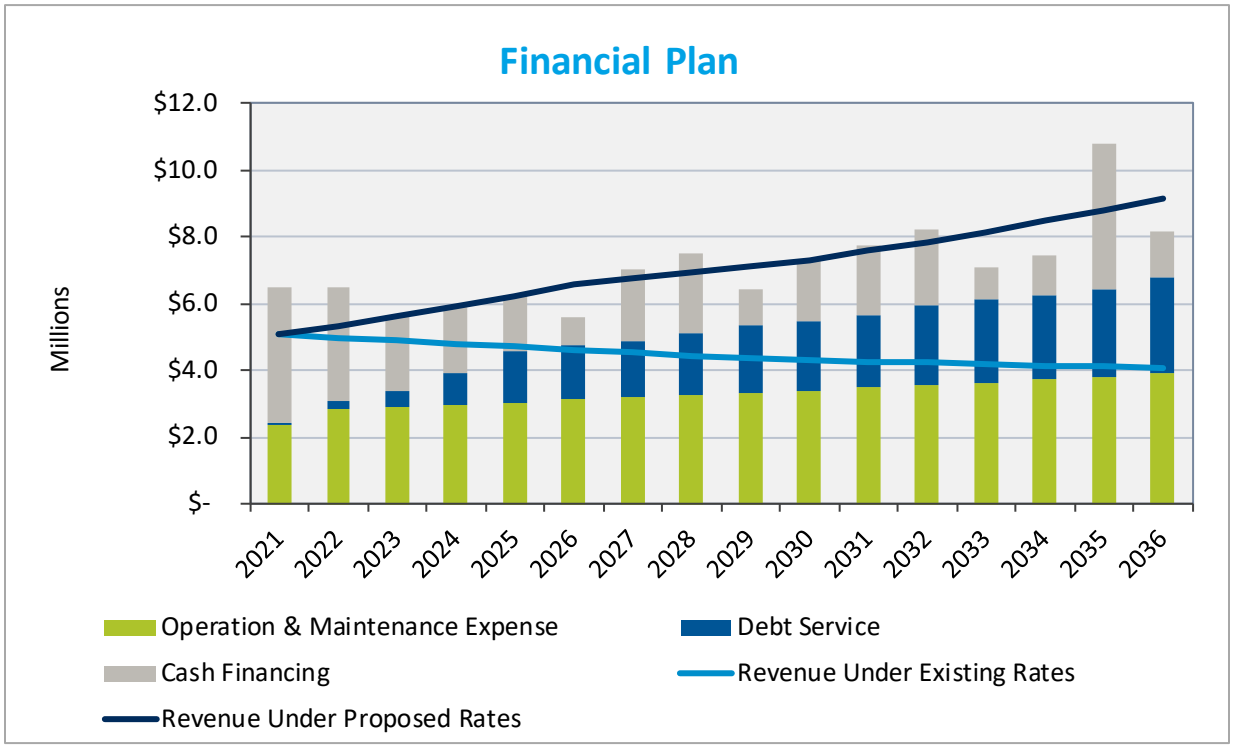
increases and capital financing requirements through 2036 for completion of the Tier 1 Program. A detailed discussion of the development of the long-range financial plan can be found in Appendix F.

Figure 7-12 illustrates the Utility revenues under existing rates and with projected revenue increases, compared with the projected revenue requirements of the Utility. The analysis indicates the following projected revenue increases:

- 2022 – 2026: 6.4%/year
- 2027 – 2036: 3.8%/year

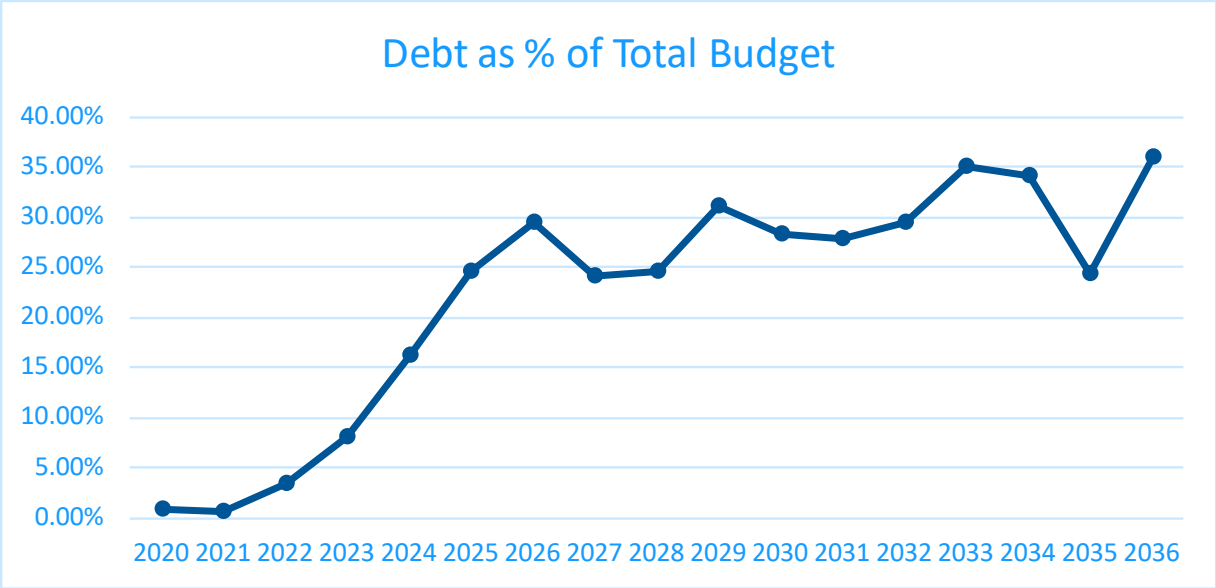
The cumulative revenue increase required over the 15-year period is therefore 98.0%, or nearly a doubling of revenue over the 15-year period.

Figure 7-12. Projected Financial Plan



The Utility currently does not have any significant outstanding debt. During the completion of the Tier 1 Program, however, the Utility will incur substantial debt, with total outstanding debt exceeding 35% of the Utility budget by 2036, as shown in **Figure 7-13**.

Figure 7-13. Debt as a Percent of Total Budget



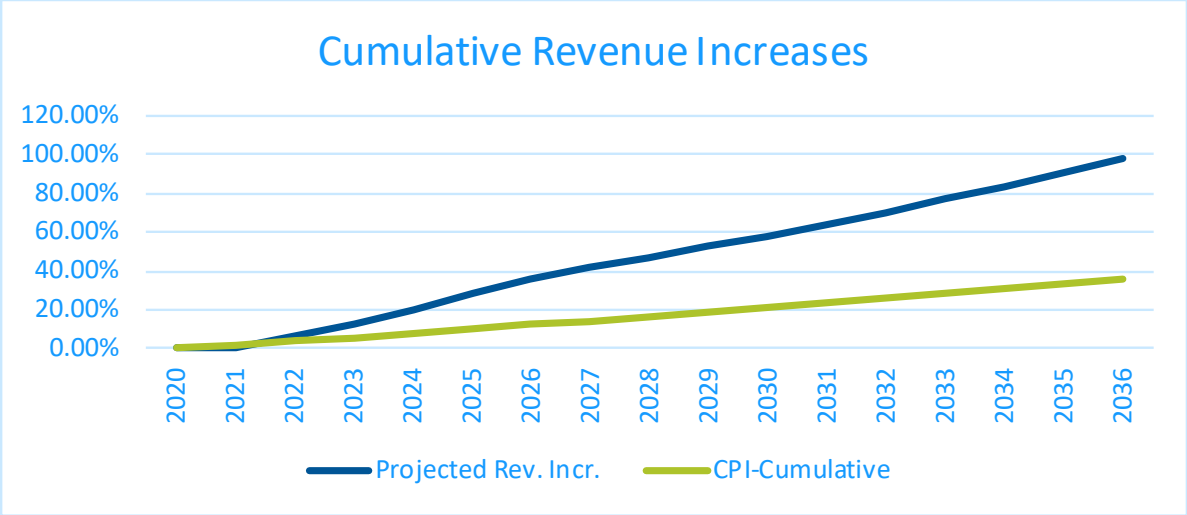
7.5 CUSTOMER AFFORDABILITY

To understand the impact the long-range financial plan may have on ratepayers, it is necessary to compare the projected average annual bill for residential ratepayers, as a percent of household income. The following discussion summarizes the impact of all CWA costs on residential ratepayers.

7.5.1 Impact of the City's Tier 1 Program

As discussed in the previous section, completion of the Tier 1 Program will require annual revenue increases well beyond that projected for inflation. **Figure 7-14** illustrates the cumulative impact of the annual revenue increases projected through 2036, compared to the average annual historical impact of CPI.

Figure 7-14. Cumulative Revenue Increases



The projected revenue increases are in addition to substantial revenue increases the City has implemented previously to provide the funding necessary to accomplish the many requirements outlined in the Partial Consent Decree.

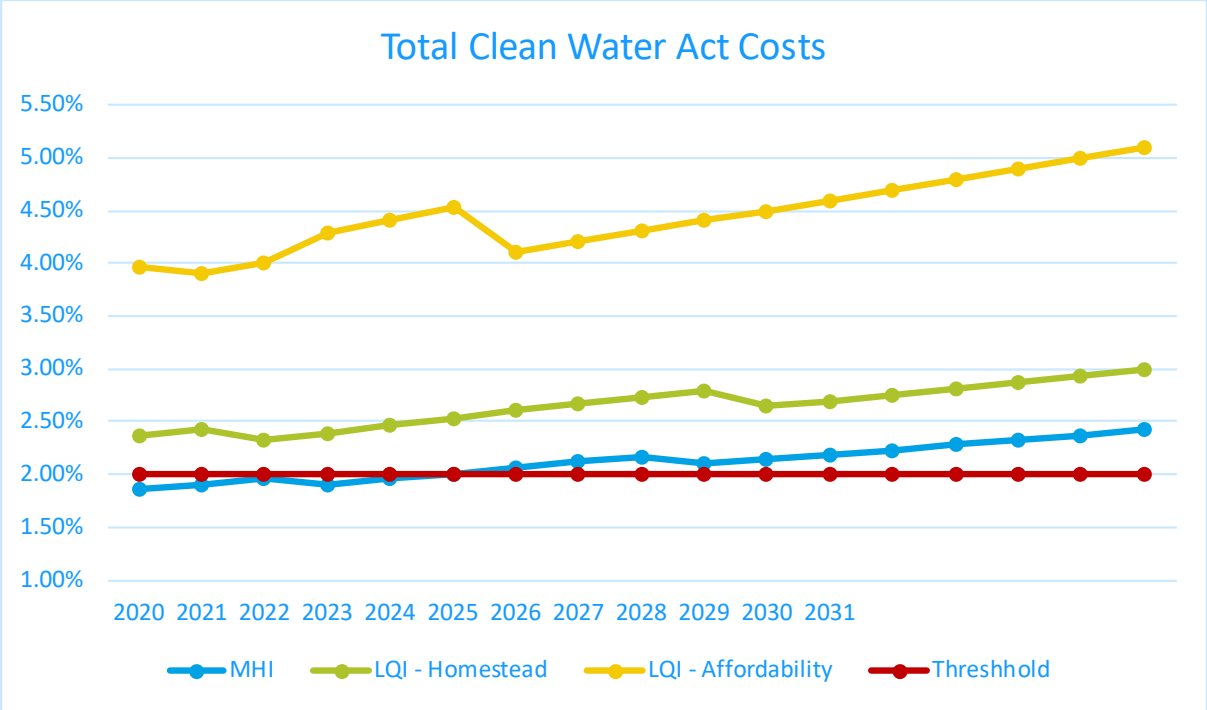
7.5.2 Impact of NEORSD Costs on Customers

In addition, ratepayers pay NEORSD on a monthly basis, for the conveyance and treatment services provided by NEORSD. Currently, nearly 75% of the average residential ratepayer's cost for all CWA costs is for NEORSD bill. As NEORSD is also under a consent decree, its rates have increased substantially, and are projected to continue to increase through the end of its consent decree (2036), at a rate more than double the rate of inflation. Therefore, to understand the full impact of CWA compliance on ratepayers, projected NEORSD bills must also be included in the determination of potential "burden."

7.5.3 Calculated "Burden" on Customers – All Clean Water Act Costs

The evaluation of total burden on customers for all CWA costs includes the calculation of average annual bills compared to projected household income. **Figure 7-15** presents the results of the analysis. The annual cost calculated for the Residential, Homestead, and Affordability classes is based on the average billed volume for each. As shown, under 2021 rates, the average residential ratepayer's annual bill is just under 2% of MHI, while ratepayers in the Homestead and Affordability programs are above 2%, even with the 40% discount afforded to them. The average annual cost for all ratepayers, as a percent of income, is expected to increase throughout the study period, and by 2036, will exceed 2% for all ratepayers, with lower income ratepayers well above the threshold for high burden.

Figure 7-15. Customer Burden – All Clean Water Act Costs



7.6 SUMMARY OF FINANCIAL CAPABILITY AND AFFORDABILITY ANALYSIS

As demonstrated throughout this Report, due to the City's current and anticipated economic condition and the high cost of the Master Plan, along with the burden customers already are experiencing due to the obligations NEORSD has in completing its own consent decree requirements, it is clear that the Program presented in this Report stretches the limits of the City's financial capability. Any program that requires increased funding, or a shorter schedule, would result in an unacceptable burden on customers, and would push the Utility beyond its capability to remain financially sound.

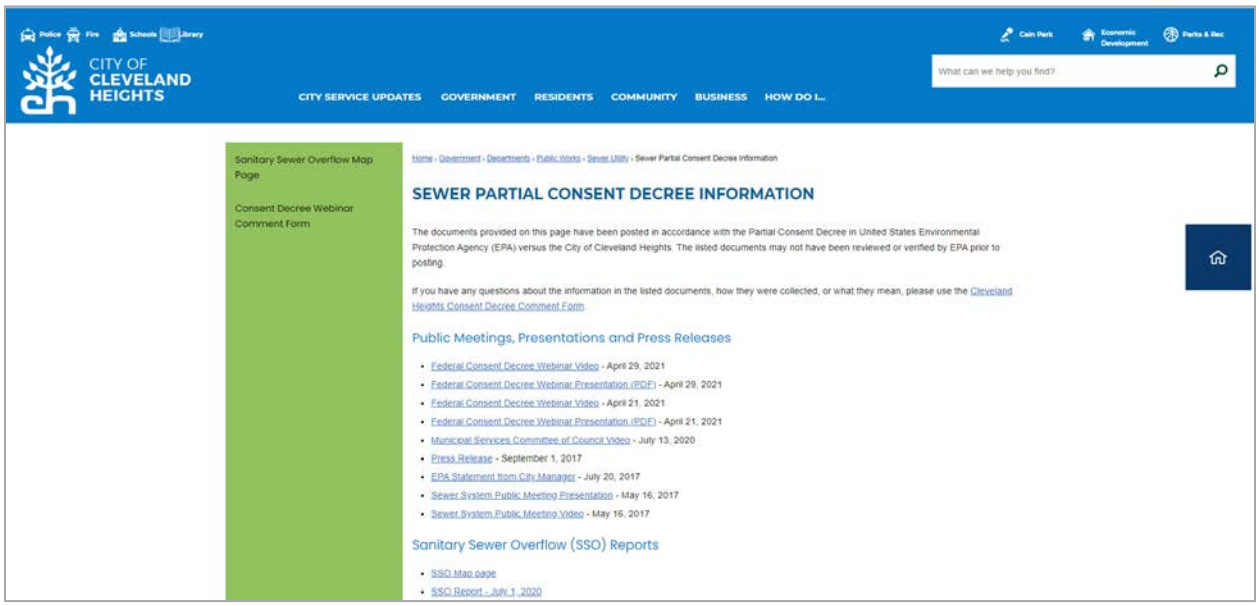
While not presented in this Report, based on preliminary evaluation of the first several years after completion of the Master Plan Tier 1 projects, the City will need to continue to increase rates to maintain the minimum financial metrics recommended by the City's Financial Advisor and expected by rating agencies. This is without any additional consent decree funding. Given the uncertainty of future conditions, the City will continue to monitor financial conditions to determine what, if any, additional spending may be possible in 2037 and beyond.

Additional detail is provided in the full report in **Appendix F**.

8.0 CITY COUNCIL AND PUBLIC PARTICIPATION

The City of Cleveland Heights maintains a Consent Decree information website as shown in **Figure 8-1** to provide updates and document public meetings and presentations. The City also uses social media to update its citizens.

Figure 8-1. Cleveland Heights Consent Decree Information Website



(https://www.clevelandheights.com/556/Sewer-Partial-Consent-Decree-Information).

Public Meetings

The first public meeting was held in May 2017 with USEPA and provided a broad overview of the Cleveland Heights system, the problems to be solved and activities to meet the Consent Decree requirements.

A public information webinar was livestreamed and recorded for viewing on April 21, 2021. The webinar provided an overview of the Cleveland Heights system and Consent Decree development and of the Tier 1 proposed work and schedule and a summary of proposed future work in Tiers 2 and 3. The public was given an opportunity to comment and ask questions on the presentation via the Cleveland Heights website.

A second public hearing was then held on April 29, 2021 to answer questions and address comments received after the April 21 webinar. All presentation materials and a summary of public comments received to date can be viewed in **Appendix G**.

Since 2017, the City has held the following public meetings:

- Sewer System/Consent Decree Public Meeting, May 16, 2017, including meeting slides and video
- City Council Municipal Services Committee meeting, July 13, 2020, including video
- Consent Decree information webinar, April 21, 2021, including webinar slides and video
- Consent Decree follow-up webinar responding to questions and comments, April 29, 2021, including slides and video

Cleveland Heights City Council adopted this Master Plan at a meeting on May 24, 2021. The executed resolution is included in **Appendix G**.

Future Public Engagement

Cleveland Heights will continue to maintain its Consent Decree website in a similar manner as program implementation proceeds and will conduct public meetings to update the community on significant developments and achievements of the Master Plan implementation. The City is also proposing to conduct sewer system performance surveys and is considering using NEORSD's Report a Flood Tool (RAFT) system to track results when it becomes available.

9.0 PROPOSED SCHEDULE AND IMPLEMENTATION

9.1 SCHEDULE

Based on the financial analysis and other non-cost criteria, projects in Tier 1 have been prioritized and are proposed to be completed by December 31, 2036. The proposed schedule summarizes approximate predesign/project definition, design, construction, and post-construction monitoring periods. **Figure 9-1** shows the proposed schedule for Tier 1 projects.

The City is applying annually for highly competitive grant funding through NEORSD's Member Community Infrastructure Program (MCIP). The applications will target projects that are expected to score well based on the program criteria. Proposed applications for the 2022 MCIP include design and construction for control of SSOs CH-12, CH-30, CH-2, CH-33, and CH-39 and for design only for control of SSOs CH-9, CH-32, CH-57, and CH-58. If funding is awarded, these projects would likely be advanced. The City will continue applying for NEORSD MCIP funding to optimize and advance control of SSOs as feasible.

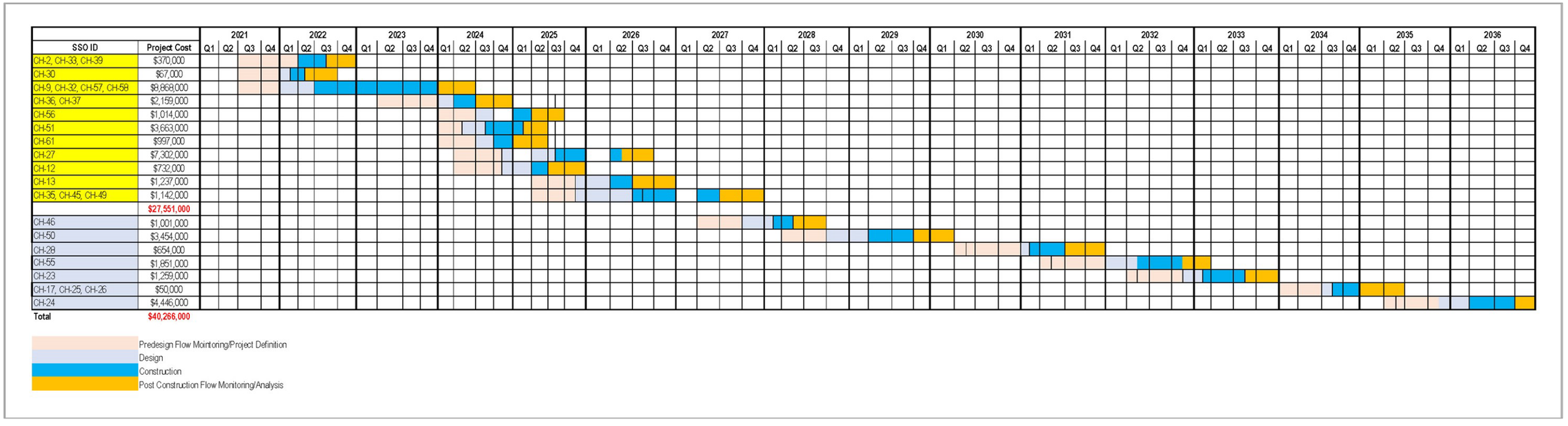
Tier 2 and Tier 3 Improvements

Because Tiers 2 and 3 are so costly, the improvements are proposed for construction in 10-year segments after completion of Tier 1 work. Similar prioritization guidelines to be updated for each 10-year work segment will be used to guide scheduling of individual projects. A preliminary prioritization for the over/under areas is summarized in **Section 4**. More detailed scheduling for Tier 2 improvements would begin in the second half of the Tier 1 projects period and would consider updated technical and financial information available at that time. The program will adapt, optimize, and prioritize the work in each 10-year segment based on the following factors that may vary as new information becomes available during program implementation:

- Cleveland Heights updated financial capability
- Other proposed infrastructure and/or related development/redevelopment in proposed work areas
- Low-income census areas
- Cost and performance of completed projects
- Remaining sewer system performance/problem frequency/severity and potential new problems to be addressed
- Operations and maintenance issues
- New construction and/or other smart sewer system technologies that may become available to further optimize proposed improvements performance versus cost.

Tier 3 improvements are proposed for long-term implementation after or during Tier 2 to renew aging sewers and improve performance in other areas projected to be at risk of system surcharging and BBUs. These portions of the system may ultimately be improved by reducing I/I in the public sewer system and on private property, and by providing increased capacity where needed.

Figure 9-1. Cleveland Heights Tier 1 SSO Control Improvements Proposed Schedule

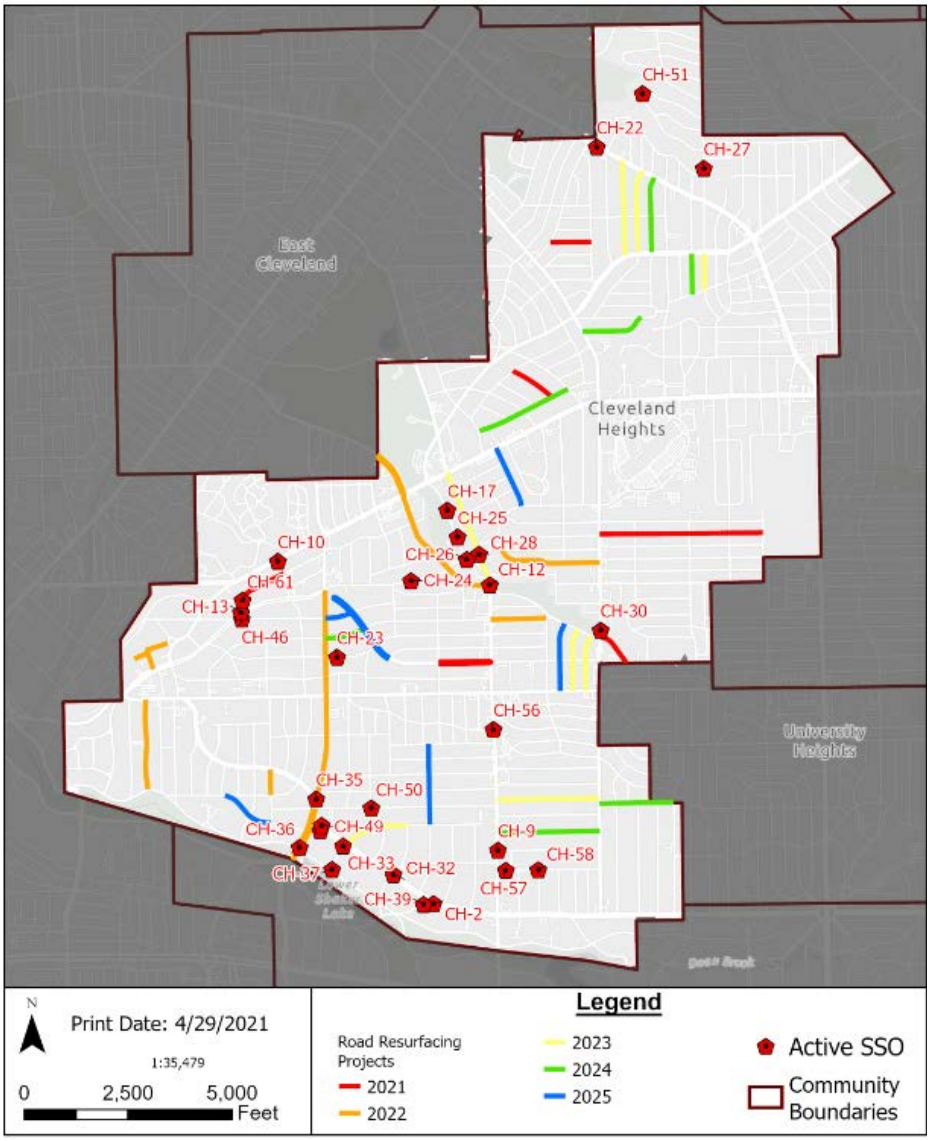


9.2 INTEGRATED PLANNING AND IMPLEMENTATION

The City is proposing to allow for flexibility in the Master Plan to adjust to future opportunities that may reduce cost and/or disruption. Other factors such as stormwater management, road resurfacing, future development, and NEORSD requirements or funding opportunities may affect project planning and prioritization.

The analysis considered upcoming paving projects included in the City's 5-year paving plan to prioritize schedule. **Figure 9-2** shows the 5-year paving locations in conjunction with the active SSOs. This type of coordination with other proposed infrastructure and development projects will be used to adapt and optimize the work going forward.

Figure 9-2. 5-Year Paving Locations with Tier 1 SSOs



9.2.1 Future NEORSD Guidelines

NEORSD has indicated that updates to its Community Discharge Permit Program and Title 3 Sanitary Sewer Code will be available in the near future. These updates may potentially affect the proposed work but are not likely to affect the Tier 1 schedule. The updates may require communities to focus additional efforts on reducing peak wet weather flows to reduce the risk of problems to downstream communities and NEORSD infrastructure. Cleveland Heights will review the updates when available and assess potential adjustments to program implementation.

9.2.2 Project Definition, Design and Post-Construction Activities

The HHI-LSSES and Cleveland Heights SSES conducted extensive sewer system investigations to identify system problems and develop proposed improvements at a planning level. Each project, however, particularly in common trench areas, is expected to benefit from project definition investigations to define the project scope and extents. Post-construction activities will also be helpful to confirm project success and optimize future projects. Potential activities include the following:

- Conduct preliminary design investigations to refine prioritization and proposed work.
    - Inspect sewer system to identify and reposition/replace displaced/missing invert plates.
    - Use micromonitoring, dyed water testing and/or smoke testing and CCTV to isolate high I/I areas and identify failing infrastructure in the public ROW and on private property. Check for plugged stormwater lateral traps and other obstructions. Stormwater laterals must be maintained in a clean condition to avoid crossflows and surcharging problems on private property.
    - Use stormwater sampling to identify illicit discharges and rank common trench areas based on stormwater pollutant loading.
    - Define specific project areas and work locations in the public ROW and the private parcels requiring work.
- Conduct pre- and post-construction flow monitoring for performance verification and confirmation of design flow rates. Conduct post-construction stormwater quality sampling to verify adequate capacity and separation of sewage and stormwater flows.
    - Post-construction flow monitoring data may be used to compare to pre-construction data using rainfall capture percentage and peak flow rate projected to the design event rainfall.
    - Projected design event flows should also be compared to the project design capacities as appropriate to determine need for follow-up I/I mitigation.
    - Pre- and post-construction flow monitoring may be affected by seasonal precipitation variations and antecedent moisture effects. These may be considered for the improvement projects by using control basin monitoring in conjunction with the pre- and post-construction monitoring in a nearby area of similar system type that does not undergo improvements. This information allows more accurate estimation of the pre/post-construction flow changes and the benefits attributable to the infrastructure improvements.

- Develop a summary report and suggestions for future project improvement and/or continued remediation in the project area, if needed.
- Determine best method(s) for improvements in each project area.
    - CIPP and other system rehabilitation for common standard and dividing wall systems in good structural condition
    - Sewer separation – new piping
    - Stormwater separation – allow CT system to remain for sewage conveyance
    - Private property I/I reduction – remove stormwater lateral traps if feasible to provide adequate drainage. Reroute directly connected downspouts and other significant inflow sources away from the sanitary service lateral. Rehab or replace leaky/failing service laterals.
    - Capacity improvements and flow rerouting
- Document conditions and lessons learned during design and construction.
    - Varying conditions
    - High groundwater areas, poor soils, etc.
    - Unusual piping configurations
    - Preferred construction methods
- Prepare accurate construction record drawings, and update AGOL. Consider developing record drawings in GIS-compatible format to streamline updating of GIS information.
- The sewer system model will be updated periodically to reflect completed projects and resulting wet weather flow responses. The updated model will then be used to adjust subsequent design parameters to provide the desired performance.

APPENDIX A – HIGH FREQUENCY CLEANING MAPBOOK

APPENDIX B – CAPACITY ASSESSMENT RESULTS FOR CD RAINFALLS

APPENDIX C – COST OPINION DEVELOPMENT TM

APPENDIX D – TIER 1, 2 & 3 IMPROVEMENTS FOR CD RAINFALLS

APPENDIX E – TIER 1 PROJECTS PRIORITIZATION SPREADSHEET

APPENDIX F – FINANCIAL CAPABILITY AND AFFORDABILITY ASSESSMENT

APPENDIX G – RESOLUTION AND PUBLIC ENGAGEMENT INFORMATION