Cleveland Heights

System Characterization Monitoring Plan

Submitted

March 2, 2018

Approved by EPA

April 20, 2018

WADE TRIM

1.0 Introduction

In 2017, the City of Cleveland Heights entered into a Partial Consent Decree (CD) with the U.S. Environmental Protection Agency (USEPA) and the U.S. Department of Justice (DOJ) to define and control sewer system overflows. The CD requires Cleveland Heights to complete a System Characterization Monitoring Plan as described in Section V, Paragraph 25 of the CD. Paragraphs 16, 17 and 18 of Section III (Monitoring) of *Appendix A: Integrated Overflow Control Master Plan (IOCMP) Development Process* describe the requirements for the System Characterization Monitoring Plan in conjunction with a Sewer System Evaluation Survey (SSES). The Cleveland Heights SSES will be completed in two phases between spring 2018 and June 30, 2021 to maximize Cleveland Heights' ability to complete the fieldwork using City crews as opposed to hiring outside contractors.

A flow and rainfall monitoring program will be conducted to provide data to support wet weather flow characterization of the entire Cleveland Heights sanitary sewer system. Flow meters will be installed within the sanitary sewer system at strategic locations during the Spring/Summer of 2018. A rainfall monitoring program will be conducted simultaneously to support characterization of the sewer system.

The monitoring will follow the Northeast Ohio Regional Sewer District's (NEORSD, or District) Flow and Rainfall Monitoring for Engineering and Construction Projects Standards and Protocols (Version 2.0) unless otherwise noted.

1.1 Purpose of Plan

The flow and rainfall monitoring program will produce data necessary to characterize the sanitary sewer system flow response to precipitation. This plan describes:

- How the flow and rainfall monitoring program will be developed and implemented
- Criteria to select the locations for installation of flow meters in the sanitary sewer system
- Flow and rainfall monitoring data previously collected during the District's Heights-Hilltop Interceptor Local SSES (HHI-LSSES) project and how it will be utilized
- Use of flow data collected under the City's Real Time Monitoring program

- Data collection and QA/QC procedures and how data will be stored for project and subsequent use
- Reporting requirements and how the information gathered during the SSES will support the upcoming System Characterization, Capacity Assessment and Integrated Overflow Control Master Plan (IOCMP).

2.0 Flow and Rainfall Monitoring Program Overview

The City of Cleveland Heights is conducting three types of flow monitoring to support the IOCMP development: real time monitoring of "known" sanitary sewer overflow (SSO) structures, calibration monitoring, and micromonitoring. Calibration monitoring and micromonitoring will be conducted throughout the Cleveland Heights system to support both SSES Phases 1 and 2. Flow meters used will electronically measure and log depth and velocity information. Rainfall monitoring will be conducted simultaneously with the flow monitoring program. Temporary rain gauges will be installed to supplement data from the District's existing permanent rain gauge network in and around Cleveland Heights.

Real Time Monitoring

Cleveland Heights is required to conduct real time monitoring of at least 10 active SSOs for a period of three months annually between May and September. This monitoring provides real time information to City staff regarding potential dry and wet weather overflows, and also provides data to support model calibration and verification.

Calibration Monitoring

Calibration monitoring will be conducted in the spring and summer of 2018 for at least 90 days to support further calibration and verification of the hydrologic/hydraulic model developed by NEORSD. The model will be extended into selected portions of the local sewer system to provide added detail for capacity assessment and development of overflow control alternatives. Proposed model extension and calibration is discussed in the System Modeling Plan. The calibration flow monitoring program is proposed to consist of approximately 53 temporary flow monitoring sites based on existing understanding of the system. The proposed calibration monitoring will also check performance of the Fairmount Boulevard Sanitary Relief Sewer

project that was completed in 2016 to control overflows along Fairmount Boulevard, between Lee and Shelburne Roads.

Micromonitoring

Micromonitoring is short term flow monitoring used to quickly check wet weather flow response and screen suspected problem and high I/I areas to help target inflow/infiltration (I/I) field investigations. Micromonitoring installations are typically in place for one or two significant rainfalls, and are effective for use in very leaky sewer systems such as common trench areas, where smoke testing is infeasible due to excessive smoke transfer. Up to 80 micromonitoring locations are proposed to help target I/I field investigations. All micrometers will be installed in 2018 and the collected data will support both phases of the SSES plan as identified in the *Cleveland Heights Sanitary Sewer Evaluation Survey (SSES) Work Plan, February 3, 2018*.

Rainfall Monitoring

Two temporary rain gauges are proposed to augment the existing District gauges in the area. The gauges will provide data to the NEORSD radar rainfall project consultant to refine the information available for model calibration.

2.1 Model Calibration Flow Monitoring Locations

The proposed model calibration flow monitoring locations will extend and refine the flow monitoring and modeling results from the District's HHI-LSSES project. Preliminary locations have been selected based on the following:

- SSO locations - SSOs that are active during the 5-year rainfall based on the HHI-LSSES model results will be the focus of SSO monitoring. SSO structures located in series with small tributary areas in between will be monitored using a single flow meter at the most downstream SSO structure. The performance of the upstream SSOs will be related using the calibrated model. SSOs with relatively small tributary areas will be calibrated using the closest downstream flow meter. Ten of the SSO monitoring locations will also function as real time monitoring locations, and will alarm the consultant and Cleveland Heights teams if overflows occur.
- Reported/suspected basement flooding areas

- Primary discharges to NEORSD sewers
- Locations of significant discharge to/from other communities
- Other areas of suspected hydraulic problems or other performance issues
- Locations to limit model subcatchment area size

Exhibit A in **Section 7 – Exhibits** provides a map of the preliminary proposed calibration and SSO real time flow monitoring locations described above. Previous calibration monitoring locations used for the HHI-LSSES project are also shown.

2.2 Micromonitoring Locations

Preliminary micromonitoring locations are proposed based on known and projected problem areas across the City to support both phases of the SSES Work Plan. Presence of SSOs, basement flooding and other known system problems are targeted first, while specific sewer and manhole configurations, including common trench systems, are proposed for follow-up micromonitoring locations. Micromonitoring locations will also be determined using results of the calibration monitoring and model results. Portions of the system that were adequately micromonitored during the HHI-LSSES study may be excluded from additional micromonitoring. Some micrometers will be placed at key locations in the adjacent storm system of the common trench system where micrometers are also installed in the sanitary system to improve understanding of the interaction between the two sewer systems and support better model calibration. The storm system micrometers are referred to as coupled meters.

The micrometers will measure and record depth and velocity, and will remain in service long enough to capture one or two significant rainfall events (>0.5 inches total rainfall) before being moved to the next location. In areas where significant inflow is observed at calibration meters, micrometers will be used to further break down the area tributary to the calibration meter to help zero in on specific problem areas. Areas tributary to the micrometers are targeted to include approximately 2,500 linear feet (LF) of pipe. **Exhibit B** provides the preliminary proposed micromonitoring locations for both phases of the SSES work plan. Previous micromonitoring locations used for the HHI-LSSES project are also shown.

2.3 Rainfall

Rainfall monitoring will be conducted throughout the flow monitoring period to characterize the hydraulic and hydrologic response of the sanitary sewer system to rainfall. The rainfall data will be used by NEORSD's radar rainfall consultant to provide spatially calibrated radar rainfall information in a grid of 1-kilometer squares. Two temporary, continuously-recording, electronic rain gauges will be installed during the flow monitoring period to supplement data from two existing District rain gauges in or near the Cleveland Heights area. The additional, temporary ground rain gauges will be continuously-recording, tipping-bucket gauges. The City will confirm with the District that their existing rain gauges in the Cleveland Heights area are operating correctly and will be maintained to provide rainfall data for the flow monitoring period.

The monitoring program will be conducted for at least 90 days starting in spring/summer 2018. The program is intended to capture at least 6 rainfall events with a peak hourly rainfall intensity greater than or equal to 0.25 in/hr at two of the three rain gauge sites.

Exhibit C shows the locations of the existing District rain gauges in and near the Cleveland Heights area and the proposed approximate locations for two additional temporary rain gauge sites. The rain gauges will provide a continuous time series of 5-minute interval rainfall data which will be used to calibrate the radar-rainfall data to support the sewer system model verification/calibration efforts.

2.4 Preliminary Monitoring Schedule

A preliminary flow and rainfall monitoring schedule is proposed as follows:

- Site selection and reconnaissance: spring 2018
- Calibration and SSO real time monitoring: spring/summer 2018
- Micromonitoring: spring – fall 2018

The schedule and success of the project depend on adequate rainfall to allow analysis of the system. If rainfall is inadequate during the proposed monitoring period, additional monitoring and/or other options will be considered to complete the analysis.

3.0 Site Selection and Reconnaissance

Calibration Monitoring

Preliminary site selection and reconnaissance will be performed using the District's flow monitoring standards and protocols as guidance before flow monitoring equipment is installed as summarized below:

- A preliminary flow monitoring plan map will be provided to the City for approval.
- The preliminary monitoring sites will be investigated to confirm site suitability. Observed conditions, potential issues, and/or recommendation for an alternative site/approach will be documented for each site. Photographs will be taken to support observations and recommendations.
- The City will be notified, as soon as practical, of debris or other issues that may impact data collection and require cleaning and/or removal.
- The City will perform any necessary cleaning or repairs. An alternative monitoring location or approach will be considered if system issues cannot be resolved to meet the flow monitoring schedule.
- Monitoring Site Reports will be submitted prior to the monitoring effort. **Exhibit D** provides an example form used to conduct field visits to evaluate the hydraulic suitability of the proposed sites.

Micromonitoring

Preliminary site selection and reconnaissance will be performed using a similar approach to the HHI-LSSES micromonitoring program before flow monitoring equipment is installed. **Exhibit E** provides an example micrometer location report. Criteria for locating the meters are summarized below:

- Areas of high I/I identified in the HHI-LSSES project will be considered for dividing into smaller areas to better identify areas contributing high I/I
- Over/under common trench systems will be targeted to help prioritize the more leaky parts of the system

- Problem areas that may not have been investigated during the HHI-LSSES project will be included as they are identified with City input.

4.0 Installation and Maintenance

Installation and maintenance of the calibration flow meters will be performed in accordance with the District's flow monitoring standards and protocols. A flow monitoring subconsultant will provide state-of-the-art electronic, logging flow meters at all flow monitoring locations for this project. **Figure 1** shows an ADS Triton+ flow logger. Similar equipment manufactured by ISCO and others may also be used.

Figure 1. ADS TRITON+ Flow Meter for Calibration/SSO Monitoring and Micromonitoring

The official start date is defined as the date on which all programmed monitors are installed and their initial performance verified by the project engineer and approved by the City. Monitoring data collected prior to this official start date is of interest to the City as well. The steps performed under this subtask are summarized below.

Installation

- Flow monitoring subconsultant to install the temporary flow monitors and rain gauges.
- Flow monitoring subconsultant to coordinate with the project engineer to identify an alternative monitoring site/approach if a pre-approved site was determined unsuitable.
- The project engineer will approve all alternative locations/approaches before monitoring equipment is installed at the respective site(s).

- Flow monitoring subconsultant to develop installation reports for calibration and micromonitoring sites and will submit to the project engineer for review/approval.
- The project engineer will submit the installation reports to the City as confirmation that the flow monitoring plan is operational and has started on schedule.

Micrometer installations may include a non-contact sensor attached to the crown of the pipe (See **Figure 2**). The sensor measures surface velocity and flow depth using ultrasonic technology. Pressure will only be measured during surcharge conditions when flow contacts the pressure sensor.

Figure 2. ADS Non-contact Micrometer Installation

Maintenance

- The flow monitoring subconsultant will be responsible for maintaining the temporary flow and rainfall monitoring equipment during the monitoring period.
- The flow monitoring subconsultant will perform at least monthly site visits (once every 4 weeks) for each calibration monitoring site supported by cellular communication. Weekly site visits will be required for monitoring sites not equipped with cellular communication.
- The flow monitoring subconsultant will monitor raw data from the micrometers on a regular basis. Routine maintenance visits will not be performed on the micrometers. Problems detected by raw data review will trigger a service site visit by the flow monitoring subconsultant. Common service issues may include sensor scrubs, battery changes and internal board replacements.

- The flow monitoring subconsultant will remotely review monitoring data on a daily basis to identify potential sensor fouling or equipment malfunctions. Issues are to be remedied by the flow monitoring subconsultant within 48 hours of identification, if possible, to minimize lost or inaccurate data.
- The flow monitoring subconsultant will perform routine meter confirmations (interrogations) during every site visit for each calibration flow monitor. Confirmations are to be performed and documented over the course of the calibration flow monitoring program per site for different times of day and weather conditions to obtain field data points over a wide range of flow depths. Confirmation points may not be available for calibration meter locations at common trench over/under pipe configurations.
- Confirmations will typically be performed for the micromonitoring locations only at the time of installation.
- The flow monitoring subconsultant will keep maintenance and confirmation logs per the NEORSD's standards and protocols and provide to the project engineer for review. A minimum of three confirmations, including initial meter calibration, are to be performed for each calibration meter over the 3-month calibration monitoring program, but before the final two weeks of the program.
- The project engineer will review confirmations for completeness and maintain electronic filing of the results.

5.0 Data Collection and Analysis

Flow monitoring data will be collected and analyzed in accordance with the District's flow monitoring standards and protocols as summarized below:

- Flow monitors will be configured to record depth and velocity readings at 5-minute intervals.
- Temporary rain gauges will be configured to record rainfall in 0.01-inch increments and report data at 5-minute intervals.
- The flow monitoring vendor will provide raw data for each calibration monitor sensor (ultrasonic depth, pressure depth, and Doppler velocity sensors) on a weekly basis to the project engineer. Raw data will be made available within one business day after

the end of the previous week. The flow monitoring vendor will be responsible for providing QA/QC of the raw data prior to posting. Potential issues identified during QA/QC of raw data will be communicated to the project engineer when first encountered.

- The flow monitoring vendor will make available raw data for each micrometer sensor (ultrasonic depth, velocity and pressure when pipe is surcharging) on a weekly basis in digital format. Raw data for micrometer locations will not have QA/QC performed prior to final posting.
- The flow monitoring vendor will make flow and rainfall data available to project team members and District employees as requested. A preliminary list of project team members will be provided to the vendor for providing access to the data.
- The project engineer will review the raw data in digital format to identify potential meter problems.
- The flow monitoring vendor will provide final depth, velocity, and flow data for each calibration monitor on a monthly basis to the project engineer. The final data from all calibration flow monitors will be provided by the vendor within three weeks from end of month.
- The District will provide rainfall data from their two permanent rain gauges in the Cleveland Heights area to support the flow monitoring program.
- The project engineer will download rainfall data from the District's Telog site on a regular basis.
- The flow monitoring vendor will provide the rainfall data collected from their temporary rain gauges to the project engineer on a weekly basis.
- The project engineer will analyze the rainfall data from the temporary and permanent rain gauges and maintain documentation summarizing observed rainfall events. A rain event summary will be submitted to the City on a regular basis.

6.0 Closeout

A draft flow monitoring report will be submitted to the City for review and approval within approximately eight weeks of the end of the calibration flow monitoring period. Typical closeout steps are summarized below:

- With assistance from the flow monitoring vendor, a calibration flow monitoring report will be drafted and submitted to the City for review.
- The project engineer will submit a final draft to the City for comments and approval.
- The flow monitoring vendor will remove all temporary flow and rainfall monitoring equipment at the completion of the flow monitoring program.
- After calibration monitoring activities are complete, a Flow Monitoring Report summarizing the monitoring effort will be provided and consist of the following:
    - Calibration meter installation reports
    - Print outs of flow/depth/velocity time series of each calibration meter for full flow monitoring period
    - Electronic scatter graphs for each calibration meter for full flow monitoring period with calibration and confirmation measurements overlain
    - Summary by rainfall events including total rainfall depth, duration, peak 5-minute and 1-hour intensities
    - Summary of calibration and confirmation measurement, including field measurements from actual calibrations and confirmations
    - Raw and final calibration meter data in standard electronic format (.csv)
- Micromonitoring data will be provided electronically as a separate deliverable at the end of the micromonitoring period. Selected plots/tables of the micromonitoring data used to support the area prioritization analysis and direct field activities will be presented in the corresponding technical memorandums.

References:

1. Flow and Rainfall Monitoring for Engineering and Construction Projects – Standards and Protocols (Version 2.0). Northeast Ohio Regional Sewer District.
2. Hydrologic and Hydraulic Modeling for Combined Sewer Systems – Standards and Protocols (Version 3.1). Northeast Ohio Regional Sewer District.

7.0 Exhibits

Exhibit A. Preliminary Proposed Calibration Flow Monitoring Locations

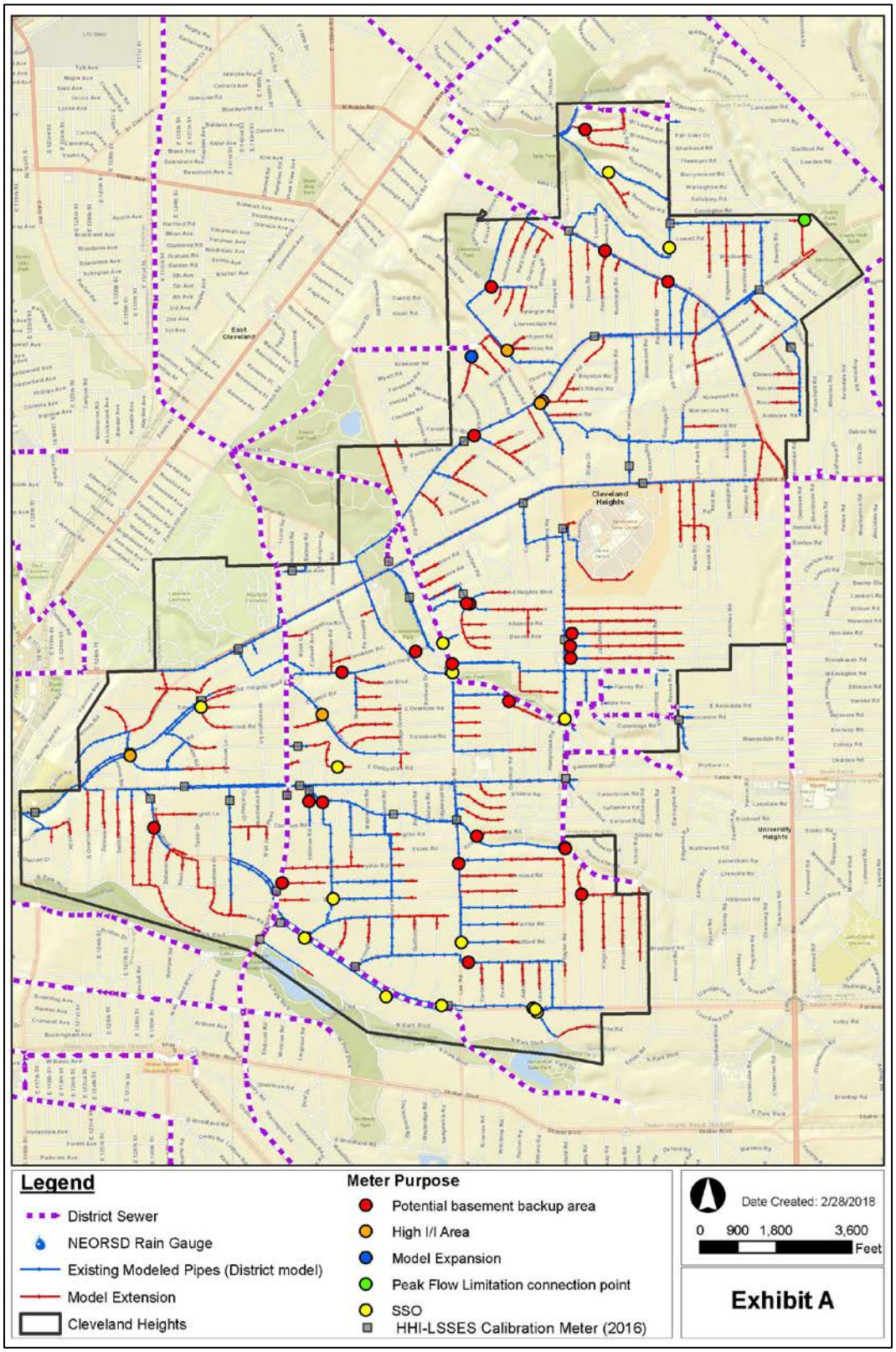


Exhibit B. Preliminary Proposed Micrometer Locations

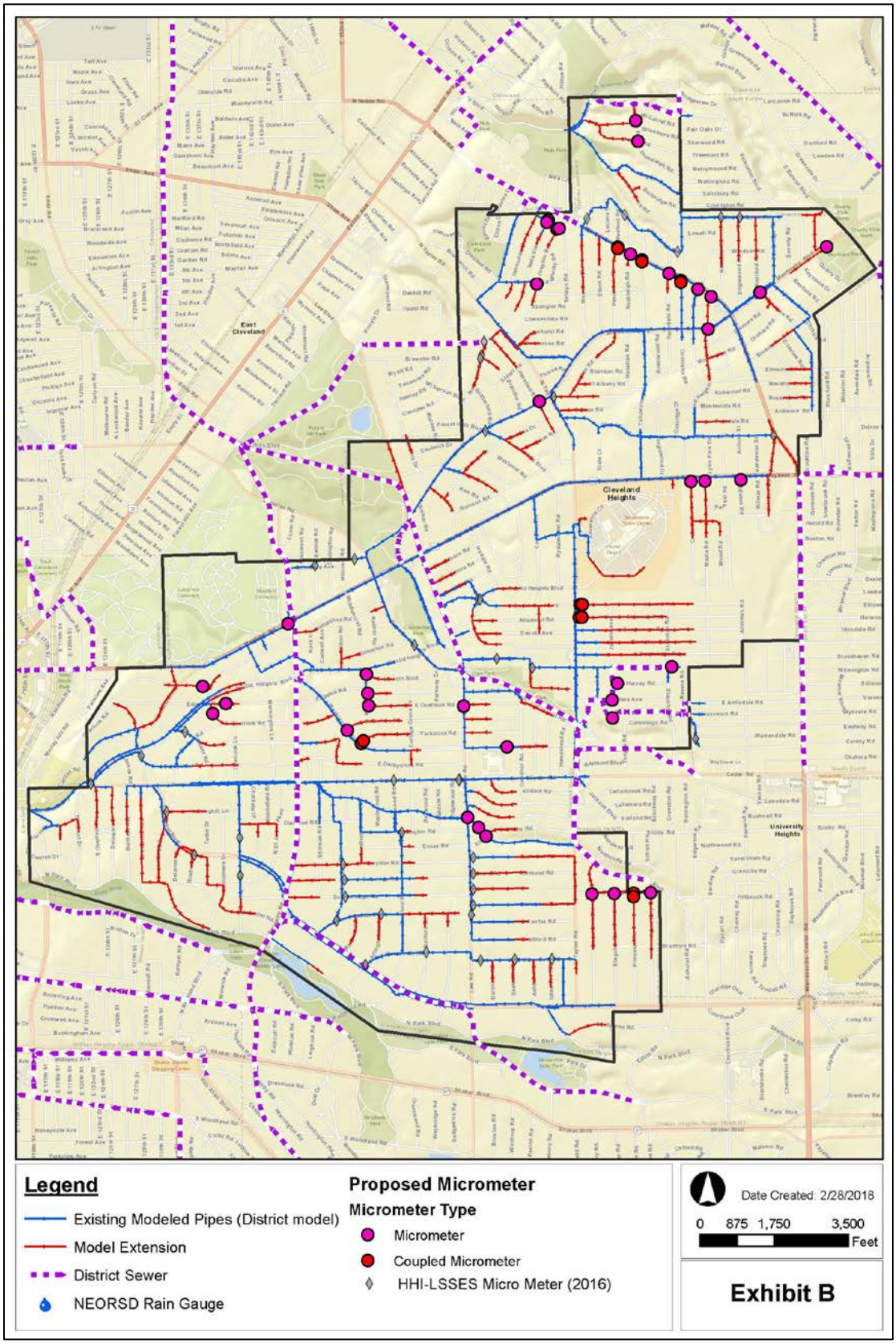


Exhibit C. Location of District Permanent and Proposed Temporary Rain Gauges

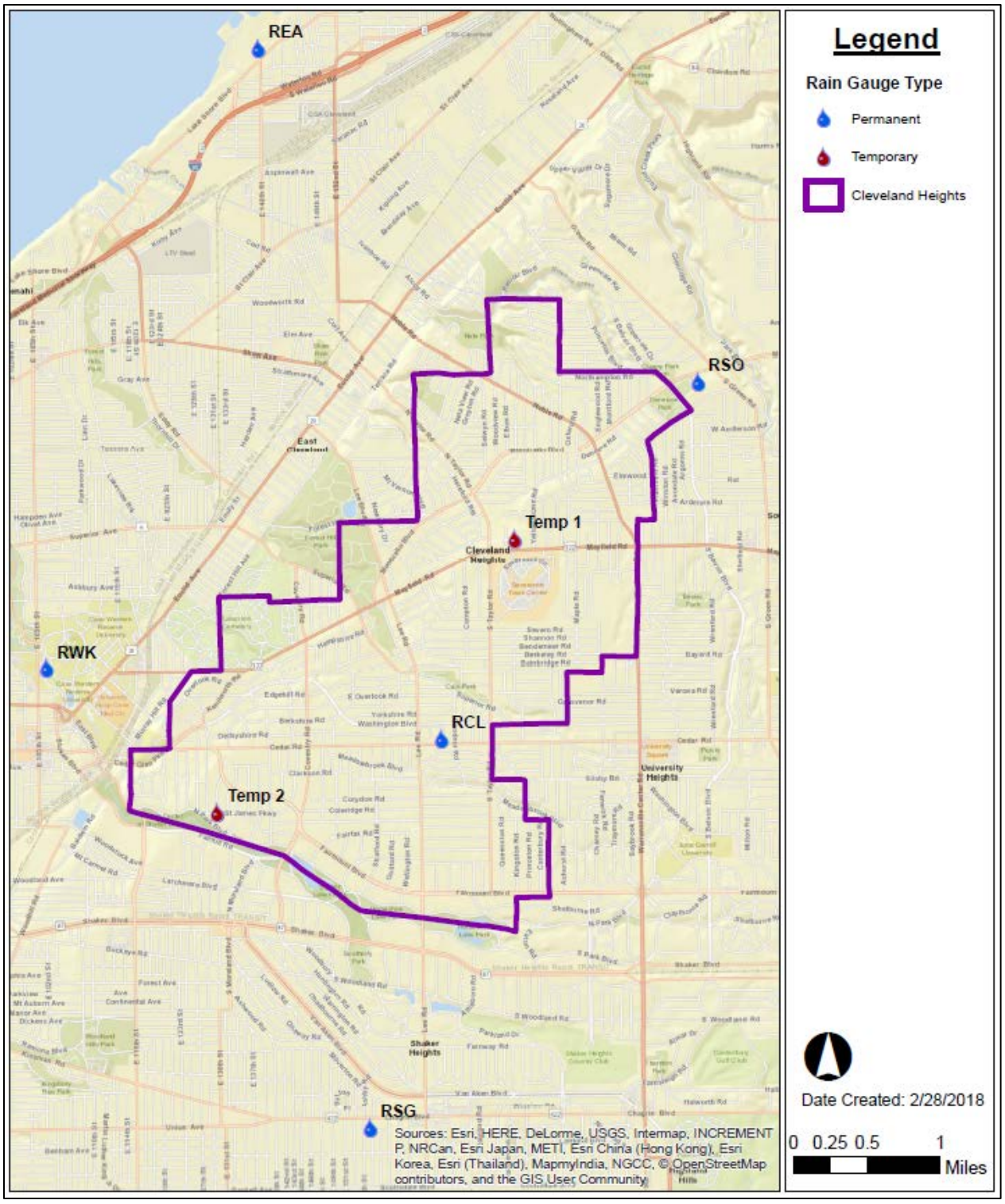
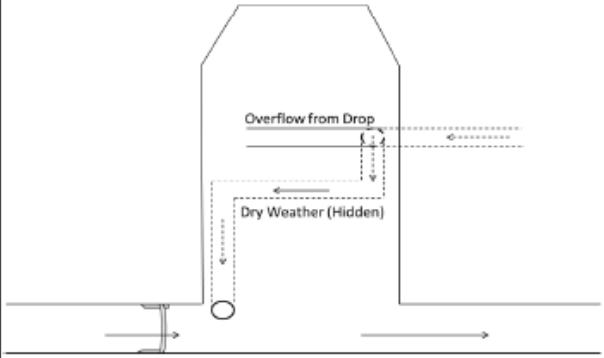


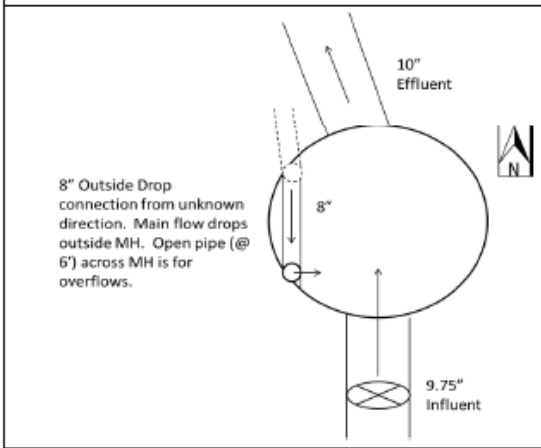
Exhibit D. Flow Monitor Site Installation Example Report

NEORSD HHI		Site I.D.
Flow Monitoring Site Installation Report	ADS ENVIRONMENTAL SERVICES®	BW-01

Site Address / Location:	Intersection at Richmond Rd. and Shaker Blvd.
Site Access:	Drive

Monitor Series	Location Type
TRITON+	Temporary
Pipe Size (H x W)	Pipe Shape
9.75" x 9.88"	Circular
Manhole #	System Characteristics
SA02ABBF0	Residential
Access	Traffic
Drive	Medium





ADS Project Name:	NEORSD.WRCE-HHI.TFM.OH16
ADS Project Number:	35035.11.100

Installation Information	
Installation Date:	Installation Type:
Friday, April 22, 2016	Doppler Standard Ring and Crank
Monitoring Location (Sensors):	Monitor Location:
Upstream 0-5 FT	Manhole
Sensors / Devices:	Pressure Sensor Range (psi)
Peak Combo (CS4), Smart Depth (CS5)	0 -5 psi
Installation Confirmation:	
Confirmation Time:	Pipe Size (HxW)
10:57:00 AM	9.75" x 9.88"
Depth of Flow (Wet DOF) (in)	Range (Air DOF) (in)
3.63	4.88
Downlooker Physical Offset (in)	Measurement Confidence (in)
1.38	0.38"
Peak Velocity (fps)	Velocity Sensor Offset (in)
1.2	0
Silt (in)	Silt Type
0	N/A
Hydraulic Comments:	
Slow, smooth flow	
Manhole / Pipe Information:	
Manhole Depth (Approx. FT):	Manhole Configuration
20	Separate Trench
Manhole Material:	Manhole Condition:
Brick	Good
Manhole Opening Diameter (in)	Manhole Diameter (Approx.):
24	36
Manhole Cover	Manhole Frame
Vented	Normal
Active Drop Connections	Air Quality:
No	20.9, 0, 0
Pipe Material	Pipe Condition:
Vitrified Clay Pipe	Good
Communication Information:	
Communication Type	Antenna Location
Wireless	Manhole Pick / Vent Hole
Additional Site Info. / Comments:	

Exhibit D. Flow Monitor Site Installation Example Report, cont'd

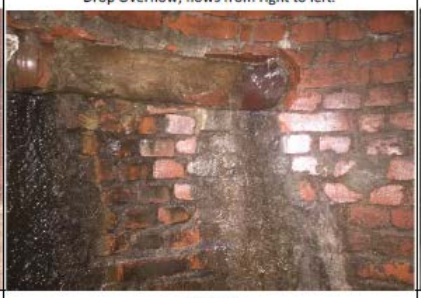
Upstream	Downstream	Down Manhole
		
Looking upstream from overflow, spills to MH on right	Drop Overflow, flows from right to left.	U/S with end of 8" drop
		
8" Drop at invert, near incoming line with flow meter	Location	Location
		

Exhibit E. Micrometer Example Location Report

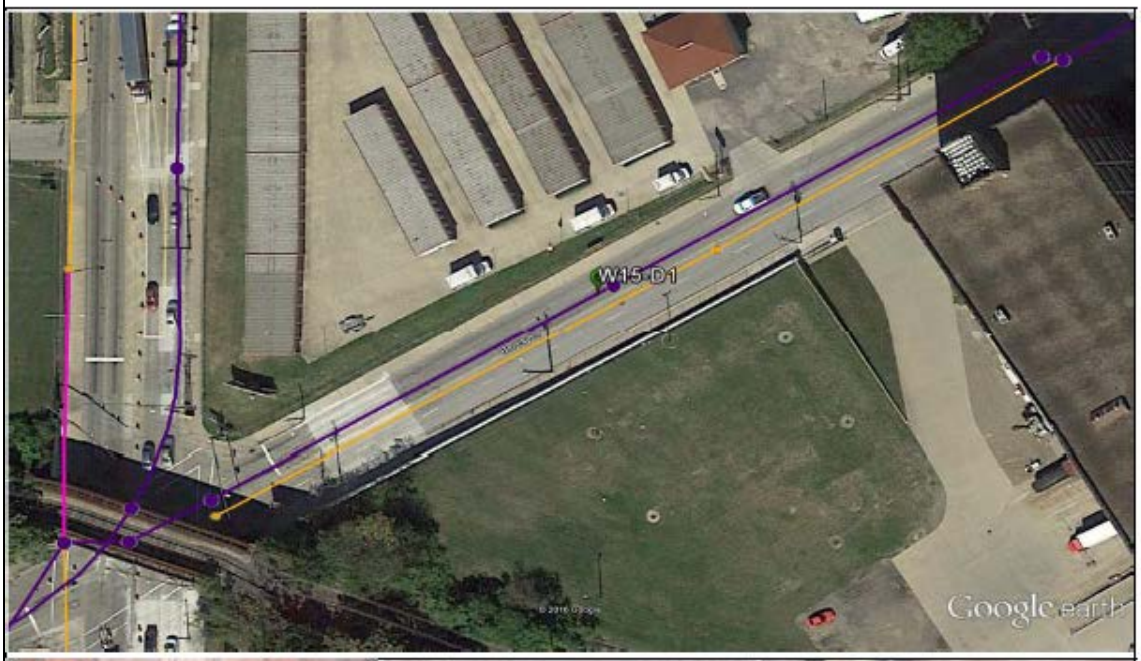
ADS ENVIRONMENTAL SERVICES®

Micro-Meter Location Report

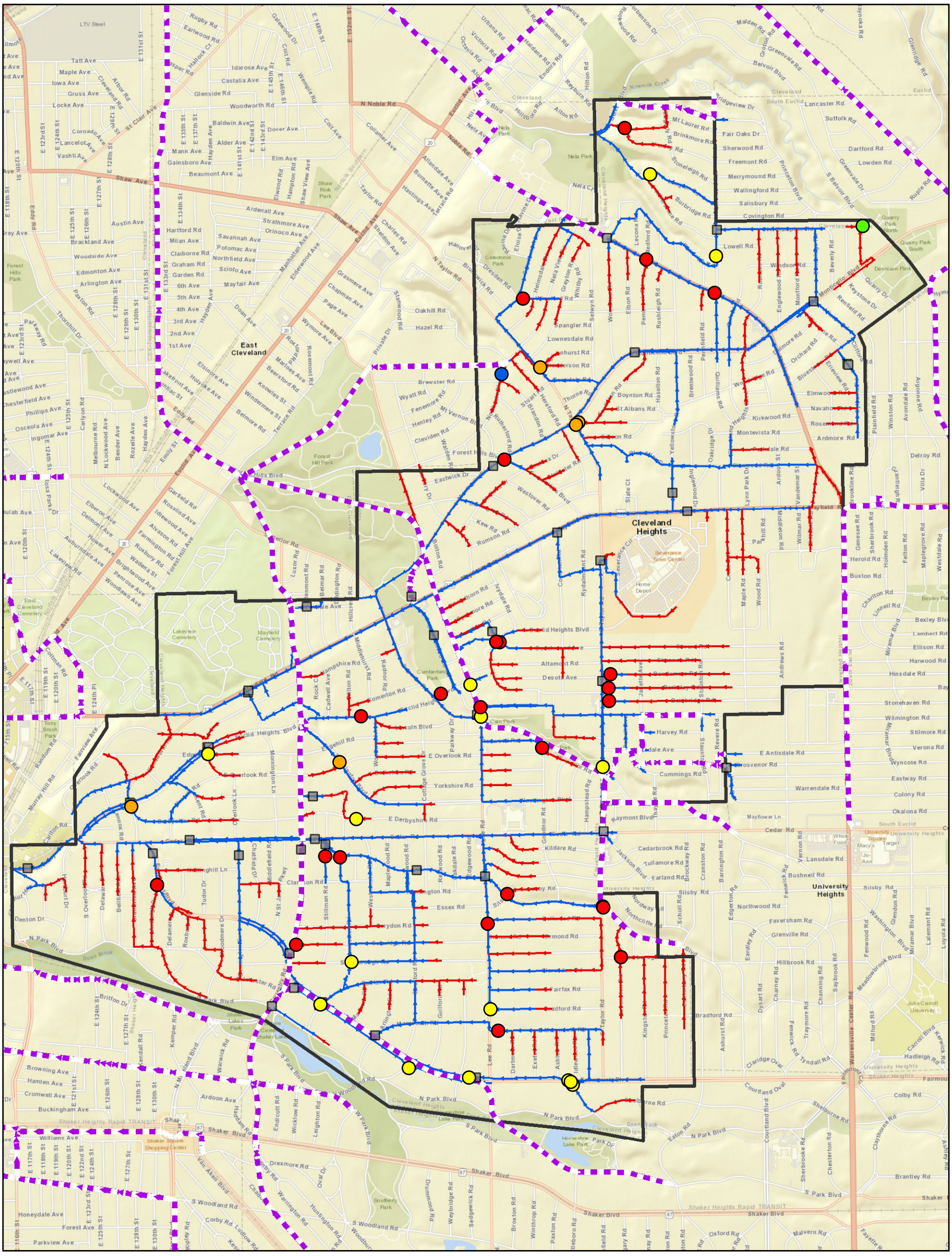
Project Name: NEORSD Edgewater

Site Name: W15-D1 Pipe Size: 30" Intallation Date: 3/15/2016 Project Number: 31992.11

Address / Location: Berea road, east of W177th St, in left, west-bound lane. In front of storage facility.



Cleveland Heights: Proposed Model Calibration
Flow Monitor Locations



Legend

- District Sewer
- NEORSD Rain Gauge
- Existing Modeled Pipes (District model)
- Model Extension
- Cleveland Heights

Meter Purpose

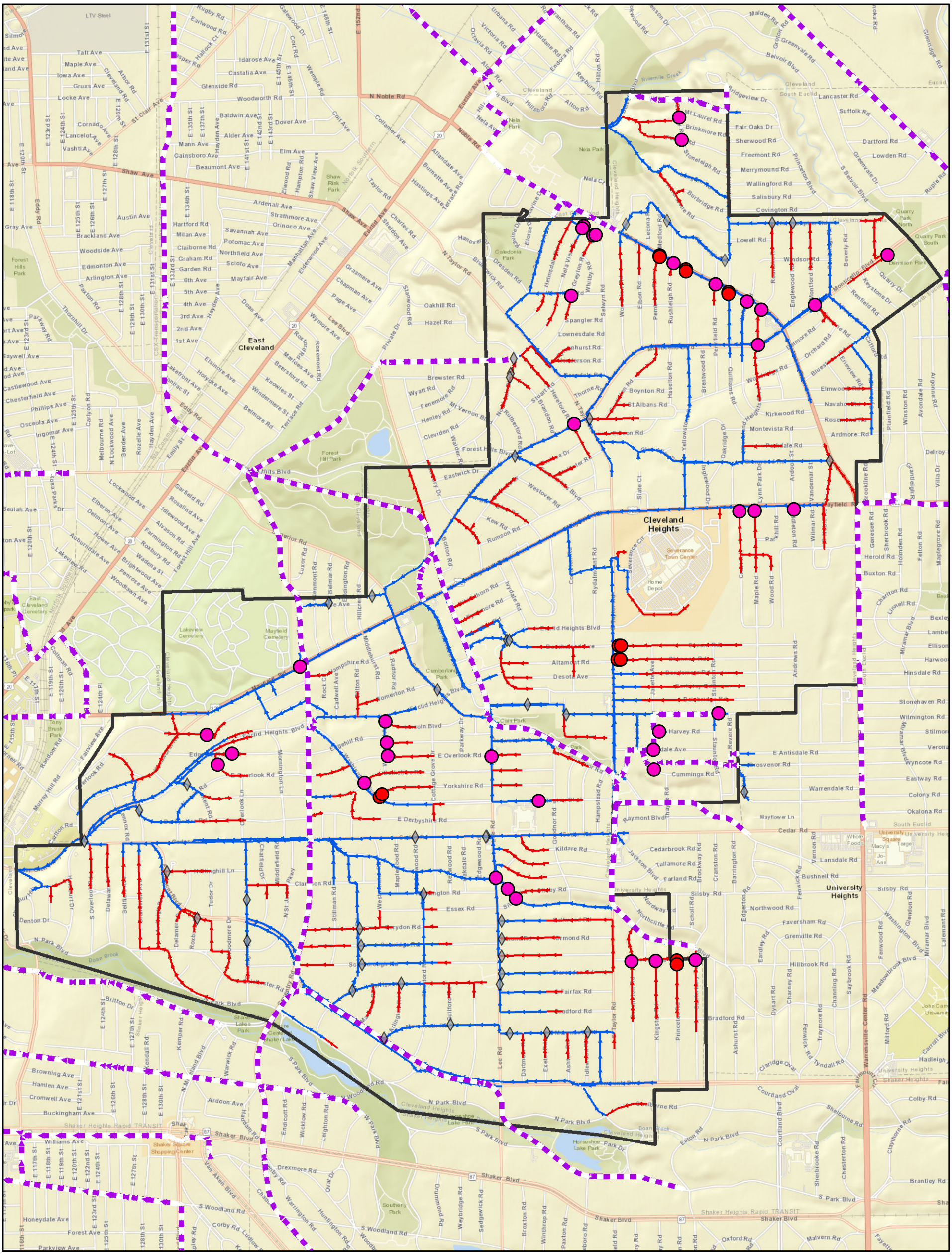
- Potential basement backup area
- High I/I Area
- Model Expansion
- Peak Flow Limitation connection point
- SSO
- HHI-LSSES Calibration Meter (2016)

Date Created: 2/28/2018

0 900 1,800 3,600 Feet

Exhibit A

Cleveland Heights: Proposed Model Calibration
Micro Monitor Locations



Legend

- Existing Modeled Pipes (District model)
- Model Extension
- District Sewer
- NEORSD Rain Gauge

Proposed Micrometer

Micrometer Type

- Micrometer
- Coupled Micrometer
- HHI-LSSES Micro Meter (2016)

Date Created: 2/28/2018

0 875 1,750 3,500 Feet

Exhibit B