

Clean Water 2020 Program

CONTINUING SEWER ASSESSMENT PROGRAM (CSAP)

June 2015

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We Are Columbia



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Section 1 Program Summary and Intent

1.1 Introduction and Objectives

The City of Columbia (City) has developed a continuing sewer assessment program (CSAP) to establish procedures and schedules for prioritizing and implementing the continual assessment of the City's wastewater collection and transmission system (WCTS). The CSAP also includes a description of the methods and standard procedures that are used for assessment of the WCTS and the systems used to manage information collected by the CSAP.

Results of the CSAP will be used under other programs required by the Consent Decree (CD) to identify and prioritize specific rehabilitation measures and projects to address infiltration and inflow (I/I) and other conditions causing sanitary sewer overflows (SSOs) within the WCTS.

This CSAP has been prepared in accordance with the requirements of Paragraph 14 of the Consent Decree entered by order dated May 21, 2014 in *The United States of America and State of South Carolina by and through the Department of Health and Environmental Control vs. The City of Columbia*, Civil Action No. 3:13-2429-TWL, DOJ Case Number 90-5-1-1-00954.

Below is a list of the CD requirements for the CSAP and the sections of this document that address each requirement.

- Subparagraph 14.a. - Establish procedures for setting priorities and schedules for undertaking the continual assessment of the WCTS. This is addressed in ***Section 2 Prioritization Procedures*** and ***Subsection 4.2 Performance Goals and Scheduling***.
- Subparagraph 14.a. – Notification to property owner that a private lateral is a source of I/I to the WCTS or is a source of a release. This is addressed in ***Subsection 3.7 Gravity System Defect Analysis*** and ***Appendix E – Example for Private Lateral Defect Notification***.
- Subparagraph 14.b.(i) - Standard procedures for evaluating the physical condition of the WCTS. This is addressed in ***Subsection 3.1 Physical Condition***.
- Subparagraph 14.b.(ii) - Standard procedures for conducting dyed water testing to locate sources of inflow and infiltration (I/I) to the WCTS. This is addressed in ***Subsection 3.2 Dyed Water Flooding*** and ***Appendix A – Dye Testing Procedures***.
- Subparagraph 14.b.(iii) - Standard procedures for inspecting and identifying sewer infrastructure that is either corroded or at risk of corrosion. This is addressed in ***Subsection 3.3 Corrosion Defect Identification***.
- Subparagraph 14.b.(iv) - Standard procedures and frequencies for routine inspection of manholes within the WCTS. This is addressed in ***Subsection 3.4 Routine Manhole Inspection*** and ***Appendix B – Routine Manhole Inspection Procedures***.
- Subparagraph 14.b.(v) - Standard procedures for routine flow monitoring during dry and wet-weather to support engineering analyses related to WCTS capacity and peak flow studies, including

an initial determination of the number and location of permanent and temporary flow meters, with a map showing such locations. This is addressed in **Subsection 3.5 Flow Monitoring** and **Appendix C – Flow Monitoring Location Map**.

- Subparagraph 14.b.(vi) - Standard procedures for routine use of closed circuit television and/or zoom camera video inspections to support sewer assessment activities. This is addressed in **Subsection 3.6 Video Inspection** and **Appendix D – Video Inspection Procedures**.
- Subparagraph 14.b.(vii) - Standard procedures for analysis of gravity sewer line defects. This is addressed in **Subsection 3.7 Gravity System Defect Analysis**.
- Subparagraph 14.b.(viii) - Standard procedures for smoke testing of gravity sewer lines to identify sources of I/I to the WCTS. This is addressed in **Subsection 3.8 Smoke Testing and Appendix F – Smoke Testing Procedures**.
- Subparagraph 14.b.(ix)(A) - Standard procedures for the evaluation of pump station performance and adequacy including the use of pump run time meters, pump start counters, computation of Nominal Average Pump Operating Time, root cause failure analysis protocols, and supervisory control and data acquisition. This is addressed in **Subsections 3.10.1 and 3.10.2**.
- Subparagraph 14.b.(ix)(B) - Standard procedures for the evaluation of pump station capacity. This is addressed in **Subsection 3.10.3 Evaluation of Pump Station Capacity**.
- Subparagraph 14.b.(ix)(C) - Standard procedures for the evaluation of pump station critical response time. This is addressed in **Subsection 3.10.4 Evaluation of Critical Response Time**.
- Subparagraph 14.b.(ix)(D) - Standard procedures for the evaluation of pump station conditions. This is addressed in **Subsection 3.10.5 Evaluation of Pump Station Condition**.
- Subparagraph 14.b.(ix)(E) - Standard procedures for the evaluation of pump station design and equipment. This is addressed in **Subsection 3.10.6 Evaluation of Pump Station Design and Equipment** and **Appendix G – Pump Station Design and Equipment Checklist**.
- Subparagraph 14.c - Standard procedures for a CSAP information management system and performance goals for each component of the CSAP. This is addressed in **Section 4 CSAP Information Management System and Performance Goals** and **Appendix H – Sewer Mapping Program Report**.

1.2 Acronyms

ARV – air release valve

BWWF – base wastewater flow

CAP – capacity assurance program

CCTV – closed circuit television

CD – consent decree

CMMS – Computerized Maintenance Management System

CSAP – continuing sewer assessment program

CW2020 – City’s program, Clean Water 2020, to manage the consent decree compliance

EPA – United States Environmental Protection Agency

FOG – fats, oils and grease

GIS – geographic information system

GPS – global positioning system

GWI – groundwater infiltration

I/I – inflow and infiltration

IMS – information management system

IR – infrastructure rehabilitation

MACP – Manhole Assessment and Certification Program

NAPOT – nominal average pump operating time

NASSCO – National Association of Sewer Service Company

PACP – Pipeline Assessment and Certification Program

RDI/I – rainfall dependent inflow and infiltration

RHR – run hour ratio

SCADA – supervisory control and data acquisition

SCDHEC – South Carolina Department of Health and Environmental Control

SMP – Sewer Mapping Program

SSO – sanitary sewer overflow

SSOAP – Sanitary Sewer Overflow Analysis and Planning Toolbox

WCTS – wastewater collection and transmission system

Section 2 Prioritization Procedures

This section describes the City of Columbia's procedures for setting priorities for the Continuing Sewer Assessment Program (CSAP) of the Wastewater Collection and Transmission System (WCTS), as required in Paragraph 14.a. of the Consent Decree (CD). These procedures are discussed in the following sections for each of the key WCTS elements (gravity sewers and manholes, force mains, and pump stations). In general, the procedures include prioritization of WCTS elements by two groups:

Major components of the WCTS – includes all pipes 15 inches in diameter or larger and their appurtenances, such as manholes and pump stations. Major components of the WCTS also includes Major Gravity Sewer Lines and Major Pump Stations as defined in the CD.

Minor components of the WCTS – includes all other City pipes, manholes, and pump stations that do not fall under the major WCTS elements category.

A map of the City of Columbia major and minor WCTS components is included in **Figure 2-1**.

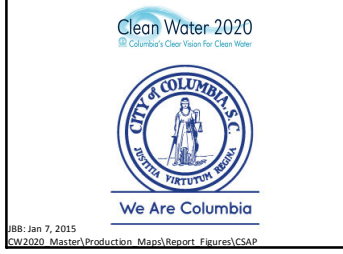
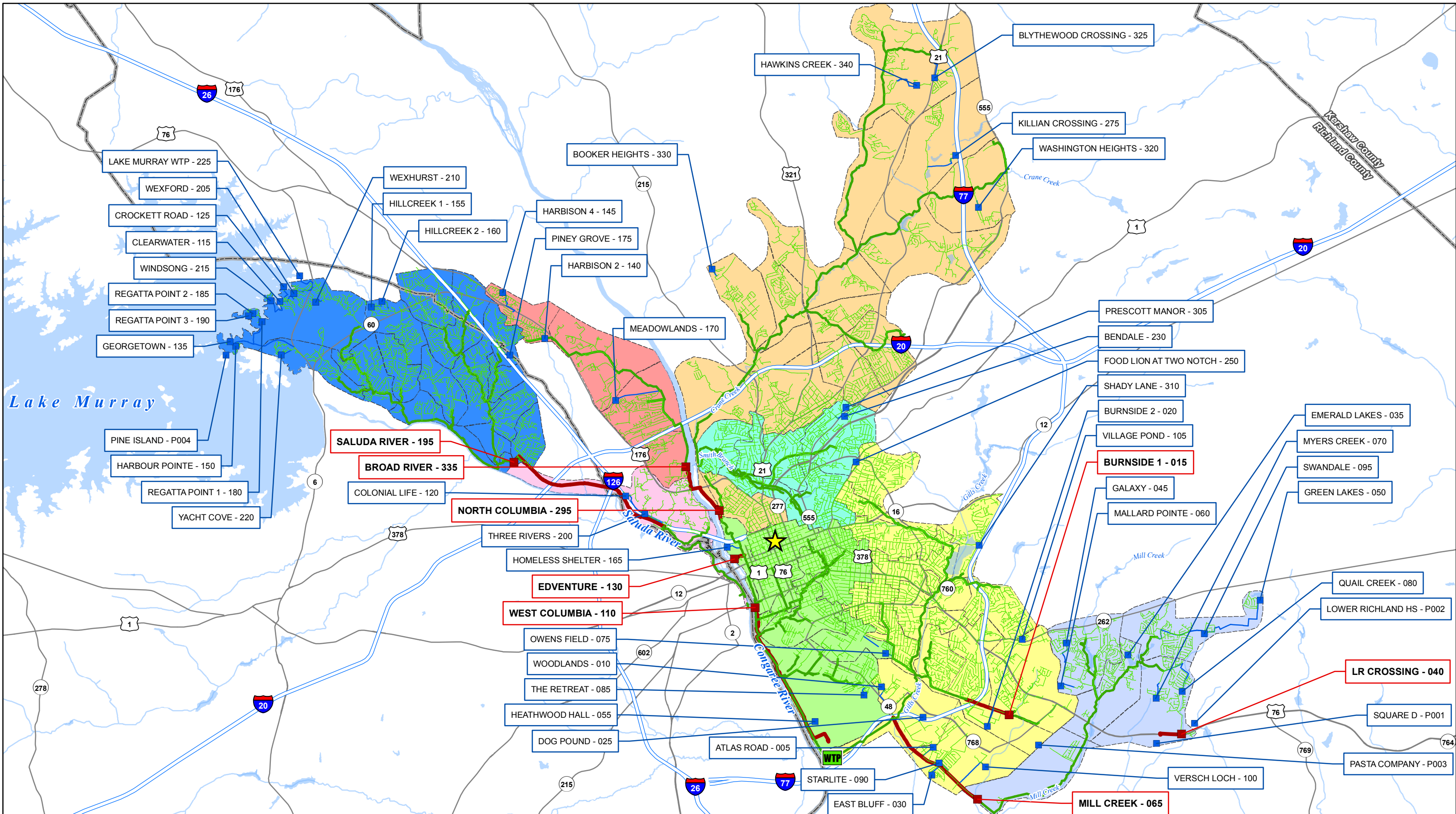
All system components (major and minor) will receive an initial prioritization and condition assessment and future continuing condition assessment. Sections 2.1 and 2.2 further describe the prioritization approach for the major and minor components.

2.1 Prioritization of Major WCTS Components

The City owns and operates a sanitary sewer collection system that consists of approximately 110 miles of Major Gravity Sewer Lines ranging from 15 inches diameter to 60 inches in diameter, which are located along the trunk sewer branches in each of the City's sewer basins as listed below.

- Broad River Basin
- Crane Creek Basin
- Gills Creek Basin
- Mill Creek Basin
- Rocky Branch Basin
- Saluda River Basin
- Smith Branch Basin

The WCTS also includes seven Major Pump Stations downstream of gravity sewers that are 15 inches in diameter and larger and approximately 13 miles of major force mains.



★ City Hall	— major force main	Broad River Basin	Rocky Branch Basin
WTP Metro WWTp	— minor force main	Crane Creek Basin	Saluda River Basin
■ Major Pump Station	— Major Gravity Sewer Line	Gills Creek Basin	Smith Branch Basin
■ minor pump station	— minor gravity sewer line	Mill Creek Basin	West Columbia Basin

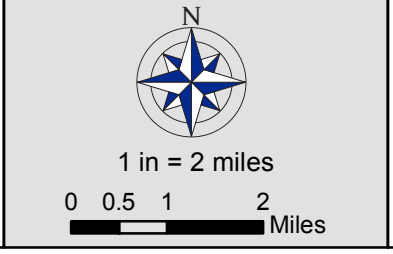


Figure 2 - 1
Wastewater Collection and Transmission System Components
 Prepared For: CleanWater 2020, CSAP

JBH: Jan 7, 2015
 CW2020 Master/Production Maps/Report Figures/CSAP

2.1.1 Initial Prioritization and Condition Assessment of Major Components

All pipes 15 inches in diameter or larger and associated manholes, Major Pump Stations, and Major Gravity Sewer Lines are considered high priority for initial condition assessment under the CSAP. Initial condition assessment of these major WCTS components will be completed within 24 months of the CSAP approval according to Paragraph 14.a. of the CD (as given in **Section 4.2** of this report) using methods described in **Section 3**.

At the time of this report, the following assessments have been initiated:

- Major Gravity Sewer Lines – Contracts for assessment of Major Gravity Sewer Lines, as identified in the SMP, have been started. Assessment will be performed using the video inspection procedure discussed in **Section 3.6** and **Appendix D** or potentially the multi-sensor inspection discussed in **Section 3.9.1**.
- Major Force Mains (force mains 15 inches in diameter or larger) – Assessment of the Major Force Mains has been initiated. Assessment will be performed using the desktop analysis approach discussed in **Section 3.11**.
- Associated major manholes (manholes associated with pipes 15 inches in diameter or larger) – Assessment of the major manholes, as identified in the Sewer Mapping Program (SMP) has been started. Assessment is being performed using the routine manhole inspection procedure discussed in **Section 3.4** and **Appendix B**.
- Major Pump Stations – Assessment of the Major Pump Stations has been started. Assessment is being performed using the field evaluation approach discussed in **Section 3.10.5**.

For a limited number of Major Gravity Sewer Lines or associated major manholes, an initial field condition assessment is not warranted in cases where the major component has been installed or rehabilitated within five years from start of the CSAP inspection period. These assets are in newly installed condition and thus the condition is already reasonably known. Also, inspections will not be performed on major components for which the City has already committed to funding a project that will lead to the abandonment of those major components. New or to be abandoned gravity sewer and manholes account for less than 3 percent of the Major Gravity Sewer Lines and less than 5 percent of the major manholes.

2.1.2 Continuing Condition Assessment of Major Components

Once the initial condition of a facility is determined from the initial assessment, the components will be reprioritized, as necessary, for further assessment. Continuing assessment of the major WCTS components will be prioritized by evaluating condition/probability of failure and criticality/consequence of failure as is described in **Section 2.2**. Continuing condition assessment will be performed using the methods described in **Section 3**.

2.2 Prioritization of Minor WCTS Components

The City's minor WCTS components include approximately 950 miles of gravity sewers and associated manholes, forty-eight pump stations downstream of minor gravity sewers, and approximately 25 miles of force mains that convey flow from minor pump stations.

The minor WCTS components are prioritized for condition assessment under the CSAP according to the procedures described in the following sections.

2.2.1 Initial Prioritization and Condition Assessment of Minor Gravity Sewers & Manholes

A prioritization procedure is used to prioritize the minor gravity sewers and manholes for condition assessment. The initial prioritization will be performed primarily on a sub-basin level. The steps in this procedure are outlined below. Initial condition assessment will be performed on the highest priority facilities using methods described in **Section 3**.

STEP 1: DATA COLLECTION

Existing data related to the condition of the gravity sewer system will be collected and compiled, as available. The data is categorized into different condition criteria. The criteria used in the prioritization will be determined based upon availability and quality of existing WCTS data. Condition criteria may include the following.

- **Age** – Age can be used as a surrogate for pipe and manhole condition for the purposes of setting initial priorities for further field condition assessment. It is assumed that newer pipes and manholes will be in better structural condition than those that are older. In addition, newer pipes typically reflect newer, more advanced technology in terms of materials and installation methods. Age of gravity sewers and manholes may be approximated using information available in the City's GIS, or garnered from other sources such as historical sewer maps. Age can also be assigned based on the age of the buildings on parcels adjacent to it, which can be obtained through GIS tax parcel data from Richland and Lexington Counties.
- **Material** – Material can be used as a surrogate for pipe and manhole condition for the purposes of setting initial priorities for further field condition assessment. Certain types of material, such as vitrified clay and concrete, are more prone to deterioration or corrosion over time. Pipe materials such as polyvinyl chloride (PVC) and high density polyethylene (HDPE) have come into use fairly recently and are corrosion resistant; therefore, it is generally assumed that these pipes would be in better condition. Pipe and manhole material may be determined using information available in the City's GIS or assumed based on age and knowledge of common materials used in the City during the time period when the pipe or manhole was installed.
- **Work Orders and Customer Service Requests** – The number of work orders, including the locations where frequent cleaning is required, and the number of customer service requests in a particular area can be used to evaluate the typical maintenance requirements. Those pipes with more frequent maintenance issues are assumed to have a higher probability of failure. Service

requests and work orders for the past two years that are available from the City's maintenance management system can be geocoded. Work orders can be categorized based on type (e.g. sewer stoppages, repairs, etc.). Statistics can be calculated, such as the number of service requests and work orders, by type, per mile of gravity sewer.

- **Flow Monitoring Data** – Data from temporary flow monitoring efforts can be used to identify areas that have high I/I into the wastewater collection system during wet weather storm events. Factors that are used to evaluate I/I can include the R value, which represents the fraction of rainfall entering the collection system as rainfall dependent inflow/infiltration (RDI/I); RDI/I volume per linear foot of sewer; and ratio of peak wet-weather to average dry-weather flow. These statistics can be obtained for each flow monitor basin and applied to the appropriate City sub-basins.
- **Sanitary Sewer Overflows (SSOs)** – The City tracks and records SSOs that occur within the WCTS, along with information categorizing the spill as either wet-weather related, structural defect, debris blockage, etc. Depending on the cause of the SSO, this information indicates areas with frequent maintenance or high I/I. SSO records can be obtained and mapped in GIS to calculate statistics including number of SSOs, by category, per mile of gravity sewer.
- **Ongoing Remediation Work** – Locations where remediation work is already ongoing, or has been recently completed, will be identified, as data is available, and can be factored into the prioritization process.
- **Preliminary Sewer Assessments, such as Midnight Flow Monitoring or Flow Isolation Studies** – The City does not have an ongoing midnight flow monitoring or flow isolation program and thus this information will not be used in prioritization. Data from temporary and permanent flow monitors installed in the system, including data from pump station records, may be used in lieu of this.
- **Maintenance Staff Observation of Field Conditions and Problem Areas** – In addition to the data categories listed above, the City's field maintenance staff have first-hand knowledge of condition of various portions of the WCTS. This information can be used to help verify and inform the prioritization.

STEP 2: ASSIGN LEVELS TO CONDITION CRITERIA

After the data is compiled, a numerical level of 1 through 5 is assigned for each of the condition criteria. A higher level is indicative of worse condition relative to the overall WCTS. For example, for age, increasing levels are assigned based on increasing age of the pipes, with level 5 pipes being the oldest in the system and level 1 being the newest. For each condition criteria, a weighted average level is computed.

STEP 3: CALCULATE CONDITION SCORE

After assigning levels, each condition criteria is considered to determine the overall score based on its relative importance, which is determined using professional judgment of the data quality and applicability to the goals of the CSAP. The final condition score may be a weighted average of several criteria or in some cases may be determined by the highest of the condition criteria to identify an immediate problem.

STEP 4: CALCULATE CRITICALITY SCORE

In addition to the condition score, a criticality score is assigned based on factors such as consequence of SSOs, location in relation to population density, need for additional system capacity, or others.

STEP 5: PRIORITIZE FOR CONDITION ASSESSMENT

Gravity sewer are ranked in order of condition and criticality scores and grouped into priority categories. Those with the highest condition and criticality scores will be prioritized the highest for condition assessment (**Figure 2-2**). The procedures used to assess the condition of the gravity system will be selected based on which criteria contributed to the high condition score and engineering judgment. A typical list of procedures that would be used based on condition criteria is shown in **Table 2-1**. Other procedures than shown in the table may be used based on engineering judgment. The procedures are further discussed in **Section 3**.

Figure 2-2. Prioritization Matrix

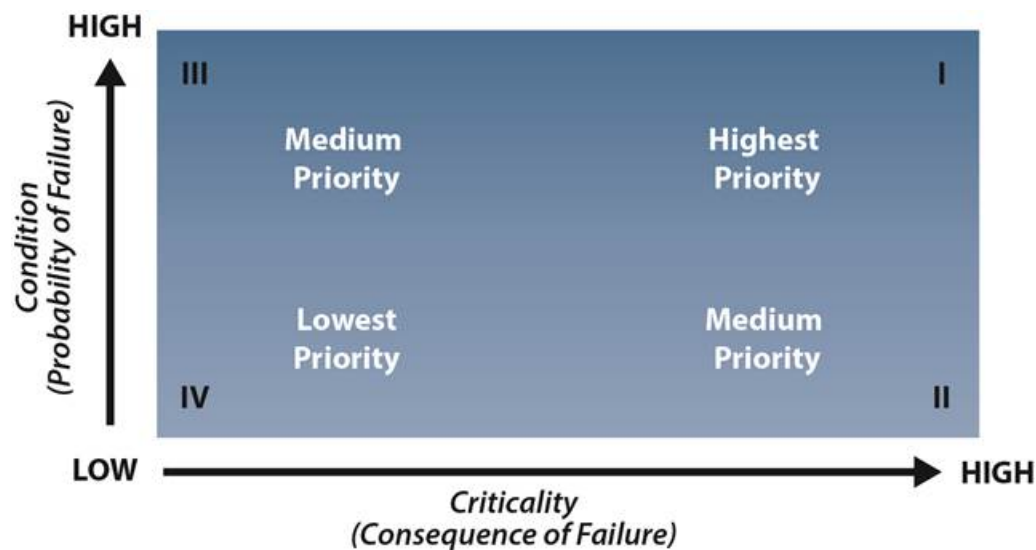


Table 2-1. Assessment Methods by Criteria

Condition Criteria	Assessment Methods	Description of Methods and Procedures
Inflow and Infiltration	Desktop Evaluation of Condition Data	Section 2.2.1
	Dyed Water Flooding	Section 3.2
	Routine Manhole Inspection	Section 3.4
	Flow Monitoring	Section 3.5
	Video Inspection – Zoom Camera	Section 3.6
	Video Inspection – CCTV	Section 3.6
	Gravity System Defect Analysis	Section 3.7 and 3.8
	Smoke Testing	Section 3.8
	Desktop Evaluation of Condition Data	Section 2.2.1

Condition Criteria	Assessment Methods	Description of Methods and Procedures
Work Orders, Customer Service Requests, SSOs, Maintenance Staff Observation of Field Conditions and Problem Areas	Dyed Water Flooding	Section 3.2
	Corrosion Defect Identification	Section 3.3
	Routine Manhole Inspection	Section 3.4
	Video Inspection – Zoom Camera	Section 3.6
	Video Inspection – CCTV	Section 3.6
	Gravity System Defect Analysis	Section 3.7
	Smoke Testing	Section 3.8
	Acoustic Inspection Tool	Section 3.9.2
Age or Material	Desktop Evaluation of Condition Data	Section 2.2.1
	Routine Manhole Inspection	Section 3.4
	Video Inspection – Zoom Camera	Section 3.6
	Video Inspection – CCTV	Section 3.6
	Gravity System Defect Analysis	Section 3.7
	Smoke Testing	Section 3.8
	Acoustic Inspection Tool	Section 3.9.2

2.2.2 Continuing Condition Assessment of Minor Gravity Sewers & Manholes

Continuing assessment of the minor gravity sewer and associated manholes will be prioritized by periodically evaluating condition/probability of failure and criticality/consequence of failure using the same approach as is described in **Section 2.2.1**. It is the intent to incorporate a pipe by pipe prioritization when appropriate in addition to a sub-basin prioritization. Condition assessment will be performed on the highest priority facilities using methods described in **Section 3**.

2.2.3 Initial Prioritization and Condition Assessment of Minor Pump Stations

The minor pump stations are prioritized for condition assessment using a procedure that considers the condition (probability of failure) and criticality (consequence of failure) for each pump station. The steps in this procedure are outlined below. Initial condition assessment will be performed on the highest priority facilities using methods described in **Section 3**.

STEP 1: DATA COLLECTION

Existing data related to the probability of failure and consequence of failure will be collected and compiled for each pump station, as available. The criteria used in the prioritization of pump stations will be determined based upon availability and quality of existing pump station data. Probability of failure and consequence of failure criteria may include the following.

- **Pump Station Age** – based on the installation date or the date of subsequent renovation or upgrade of the pump station based on record drawings or other City records.
- **Odor/Corrosion Control Issues** – based on knowledge of the City’s field maintenance staff and other data, such as customer odor complaints, as available. **Sanitary Sewer Overflows (SSOs)** – based on compilation of recent pump station related SSO records.
- **Reliability** – based on historical routine pump station maintenance inspections.
- **Redundancy** – based on the availability of backup power supply or reserve pumps.
- **Pump Run Times** – based on recent pump run time records; pump stations with variable frequency drives are considered separately.
- **Response Time/Time to Overflow** – based on the time between the trigger of the high wet well alarm and the point of overflow of the pump station compared with the time it takes maintenance crews from the Metro wastewater treatment plant to respond after a high wet well alarm is triggered.
- **Pump Station Firm Capacity** – based on pumping capacity with the largest pump out of service.
- **Proximity to Critical Areas** – based on the linear distance from the pump station to critical areas such as State water bodies, public water supply/reservoirs, hospitals, schools, parks, or other critical areas.
- **Potential for Pump Station Flooding during Wet Weather Events** – based on historical knowledge of flooding from City maintenance staff and 100-year floodplain data.
- **Difficulty of Repair at the Pump Station** – based on historical knowledge of difficult to repair assets located at the pump station.
- **Pump Station Accessibility** – based on City staff historical knowledge of pump stations that are difficult to access for maintenance.

STEP 2: CALCULATE PROBABILITY OF FAILURE SCORE

The probability of failure criteria represent the pump station condition, its performance capabilities, and the level of maintenance or inspection it receives. After the data are compiled, a numerical level is assigned for each of the probability of failure criteria for each pump station, depending on the availability of the data. A higher level is indicative of a higher probability of failure relative to the overall WCTS. The criteria are weighted according to relative importance, and an overall weighted probability of failure score is calculated for each pump station.

STEP 3: CALCULATE CONSEQUENCE OF FAILURE SCORE

The consequence of failure criteria indicate the impact when a pump station fails to perform as intended, under design conditions, in support of the system operation. Similar to **Step 2**, after the data are compiled, a numerical level is assigned for each of the consequence of failure criteria for each pump station. A higher level is indicative of a higher consequence of failure relative to the overall WCTS. The criteria are weighted

according to relative importance, and an overall weighted consequence of failure score is calculated for each pump station.

STEP 4: PRIORITIZE PUMP STATIONS FOR CONDITION ASSESSMENT

The relative risk of a pump station failure is calculated by multiplying the weighted consequence of failure score by the weighted probability of failure score. Pump stations are ranked in order of risk of failure and grouped into priority categories. Those pump stations with the highest risk of failure will be prioritized the highest for condition assessment.

2.2.4 Continuing Condition Assessment of Minor Pump Stations

Continuing assessment of the minor pump stations will be prioritized by periodically evaluating condition/probability of failure and criticality/consequence of failure using the same approach as is described in **Section 2.2.3**. Continuing condition assessment will be performed on the highest priority facilities using the methods described in **Section 3**.

2.2.5 Initial Prioritization and Condition Assessment of Minor Force Mains

The force mains may be divided into segments based on pipe diameter, material, age, junctions with other force mains, or other applicable criteria. Force mains are prioritized for condition assessment on a segment-by-segment basis to facilitate both the collection of condition information and implementation of any subsequent rehabilitation. Like the pump station prioritization procedure described in **Section 2.2.2**, this procedure considers the condition (probability of failure) and criticality (consequence of failure) for each force main to determine priority based on risk of failure. The steps in this procedure are outlined below. Initial condition assessment will be performed on the highest priority facilities using methods described in **Section 3**.

STEP 1: DATA COLLECTION

Data related to the probability of failure and consequence of failure will be collected and compiled for each force main segment, as available. The criteria used in the prioritization of force mains will be determined based upon availability and quality of existing WCTS data. Probability of failure and consequence of failure criteria may include age, material, SSOs, corrosion issues, or proximity to critical areas as described in previous subsections. In addition, the following criteria may be considered, depending upon data quality and availability.

- **Force Main Failure History** – based on number of recorded force main failures.
- **Aerial Crossings** – includes force mains that cross water bodies with an aerial crossing.
- **Soils** – based on whether the soil type in which the force main is installed is considered highly corrosive to concrete or ferrous pipe.
- **Force Main Taps** – based on the number of taps made in the force main.
- **Remaining Useful Life** – based on the estimated years of service remaining

- **Evidence of Internal Corrosion** – based on high points in the force main profile, sulfide modeling, or known odor issues
- **Pipe Size** – based on the diameter of the force main
- **Proximity to Critical Areas** – based on the distance from the force main to surface water, potable water supply, population centers, key transportation links, or other critical areas
- **Manifold force mains** – based on if more than one pump station is tied to a force main

STEP 2: CALCULATE PROBABILITY OF FAILURE SCORE

After the data are compiled, a numerical level is assigned for each of the probability of failure criteria for each force main segment. A higher level is indicative of a higher probability of failure relative to the overall WCTS. The criteria are weighted according to relative importance, and an overall weighted probability of failure score is calculated for each force main segment.

STEP 3: CALCULATE CONSEQUENCE OF FAILURE SCORE

After the data are compiled, a numerical level is assigned for each of the consequence of failure criteria for each force main segment. A higher level is indicative of a higher consequence of failure relative to the overall WCTS. The criteria are weighted according to relative importance, and an overall weighted consequence of failure score is calculated for each force main segment.

STEP 4: PRIORITIZE FORCE MAINS FOR CONDITION ASSESSMENT

The relative risk of a force main failure may be calculated by considering the weighted consequence of failure score by the weighted probability of failure score. Force main segments are ranked and grouped into priority categories based on weighted probability and consequence of failure scores. Those force main segments with high probability and high consequence of failure scores will be prioritized the highest for physical condition assessment.

2.2.6 Continuing Condition Assessment of Minor Force Mains

Continuing assessment of the minor force mains will be prioritized by periodically evaluating condition/probability of failure and criticality/consequence of failure using the same approach as is described in **Section 2.2.5**. Continuing condition assessment will be performed on the highest priority facilities using the methods described in **Section 3**.

Section 3 Assessment Methods and Procedures

This section includes methods and procedures that may be used by the City to assess the condition of the wastewater collection and transmission system during implementation of the continuing sewer assessment program. Several of these methods are often used in combination based on system size and needs, with some methods serving as a preliminary screening tool to target areas for more intensive inspection methods. For example, flow monitoring can be used to identify sub-basins with the highest infiltration and inflow issues. Smoke testing within that sub-basin can confirm the presence of I/I sources within a particular section of gravity sewer. Follow-up dye testing and video inspection can identify the location of defects in the pipeline. In some instances, a desktop or field screening method may be sufficient to determine that a portion of the WCTS is in adequate condition and not in need of more intensive inspection methods.

The City will employ a combination of assessment methods to evaluate the condition of the City of Columbia WCTS in order to identify rehabilitation needs and select appropriate rehabilitation approaches. Appropriate assessment methods for each portion of the WCTS will be selected based on the City's best professional judgment.

Table 3-1 lists the general methods available to assess physical condition by WCTS component. A description of the individual methods and procedures are provided in subsequent sections, as indicated in the table.

Table 3 -1. Assessment Methods

WCTS Component	Assessment Methods	Description of Methods and Procedures
Gravity Sewer	Desktop Evaluation of Condition Data	Section 2.2.1
	Dyed Water Flooding	Section 3.2
	Corrosion Defect Identification	Section 3.3
	Flow Monitoring	Section 3.5
	Video Inspection – Zoom Camera	Section 3.6
	Video Inspection – CCTV	Section 3.6
	Gravity System Defect Analysis	Section 3.7
	Smoke Testing	Section 3.8
	Multi-Sensor Inspection	Section 3.9.1
	Acoustic Inspection Tool	Section 3.9.2
Manholes	Desktop Evaluation of Condition Data	Section 2.2.1
	Corrosion Defect Identification	Section 3.3
	Routine Manhole Inspection	Section 3.4
	Gravity System Defect Analysis	Section 3.8
Pump Stations	Desktop Evaluation of Condition Data	Section 2.2.2
	Corrosion Defect Identification	Section 3.3
	Evaluation of Pump Station Operating Time	Section 3.10.1
	Root Cause Failure Analysis	Section 3.10.2
	Evaluation of Pump Station Capacity	Section 3.10.3
	Evaluation of Critical Response Time	Section 3.10.4
	Evaluation of Pump Station Conditions	Section 3.10.5
	Evaluation of Pump Station Design and Equipment	Section 3.10.6
Force Mains	Desktop Evaluation of Condition Data	Section 2.2.3
	Corrosion Defect Identification	Section 3.3
	Desktop Force Main Assessment	Section 3.11
	Air Release Valve Inspection	Section 3.11.1
	Hydrostatic Testing	Section 3.11.2
	Transient Pressure Analysis and Surge Modeling	Section 3.11.3
	Flow Conservation Checks	Section 3.11.4
	Coupon Extraction	Section 3.11.5
	Ultrasonic Thickness Testing	Section 3.11.6
	Acoustic Leak Detection	Section 3.11.7
	Broadband Electromagnetics	Section 3.11.8
	External Inspection	Section 3.11.9
Acoustic Monitoring for PCCP	Section 3.11.10	

3.1 Physical Condition

The existing physical condition of the WCTS is assessed using a variety of field inspection and desktop evaluation methods. Methods are selected based on applicability to the WCTS component, the type of information required to identify defects and prioritize rehabilitation, and the availability of equipment and manpower to perform the inspection method. The age and material of construction, as well as other condition factors, may be considered when prioritizing areas for field condition assessment, as discussed in **Section 2**. Where material of the WCTS components is unknown or assumed, field inspection methods may be used to confirm and document the actual materials of construction. In addition to observations of existing physical condition, WCTS components constructed of materials that are prone to corrosion or deterioration over time or suspected to be less durable will be factored into the prioritization process. For areas with no known problems and materials that are known to be in good condition, further field condition assessment will be given a low priority.

3.2 Dyed Water Flooding

Dyed water flooding, or dye testing, may be used to identify specific entry points of I/I into the WCTS, identify cross connections between the sanitary sewer and storm sewer, or confirm pipe connectivity. Used in conjunction with smoke testing, dye testing may also be used to confirm direct or indirect connections between the location of smoke exit point and the sewer system.

A non-toxic fluorescent dye is introduced into the suspected I/I sources, such as visible defects (cave-ins or open pipes), storm sewers, ditches, catch basins, low spots, or creeks/streams in close proximity to the sanitary sewer. After the dyed water is introduced, the downstream sanitary sewer manhole is checked for dyed water. The presence of dyed water indicates that an I/I source exists. Closed circuit television (CCTV) inspection is often used in conjunction with dye testing to record and document the entry point and type of leak into the sewer or manhole.

The findings and conclusions of dye testing activities are documented in a digital database of the inspection along with digital photographs and GPS locations.

The methods and procedures for dye testing are described in the City's specifications. The City periodically updates the specifications to provide clarification and maintain consistency with current industry practice. The most recent version of the following specifications related to dye testing are included in **Appendix A**:

- Specification 02761 – Dye Testing: Used for dye testing activities under the CSAP.
- Specification 02762 – Database Template Description for Dye Testing: Used to document and deliver the results of all work related to dye testing for integration with the City's CSAP information management system (IMS).

3.3 Corrosion Defect Identification

Corrosion in the WCTS can lead to material failures that may result structural failures and/or in excessive I/I entering the system. In addition, corrosion can result in catastrophic failures such as force main ruptures or sewer cave-ins that result in SSOs. Internal corrosion in sewers is typically a result of

hydrogen sulfide produced by biological reduction of sulfate to sulfide by anaerobic bacteria that reside in anoxic wastewater and on slime layers that accumulate on pipe, concrete structures, and sediment surfaces. The resulting sulfide is transformed into hydrogen sulfide (H₂S) gas, which is then converted to sulfuric acid (H₂SO₄) by aerobic bacteria that reside above the water line in the WCTS. The acid can result in severe corrosion of metals, reinforced concrete and mortar.

The City's corrosion defect identification process includes the following elements as applicable:

- Identification of WCTS components at risk of corrosion
- Prioritization and inspection as needed of at-risk WCTS components to identify corrosion defects
- Corrosion defect documentation and analysis
- Prioritization of repairs for corrosion defects

The elements of the corrosion defect identification process are described in detail in the following sections for the gravity system, force mains, and pump stations.

[STEP 1: IDENTIFY AREAS OF THE WCTS AT RISK OF CORROSION](#)

Corrosion problems in the gravity system (gravity sewers and manholes) often occur in the vicinity of pump station force main discharges. Residential wastewater contains sufficient quantities of sulfates to create a problem if they become anoxic, as they often do after initial wet well storage followed by force main residence time without opportunities for aeration. Hydrogen sulfide gas is released as soon as an air-water interface and turbulence occur at the discharge point of the force main into the gravity system. Other areas of the gravity system susceptible to internal corrosion may include areas of high turbulence (such as drop manholes), or flat, low velocity sections of sewer with long detention times that allow for solids to accumulate.

Corrosion potential in force mains is typically greatest at high points or down slopes where the pipe may be flowing partially full and where turbulence from connecting force mains may release hydrogen sulfide gas. High sulfides in wastewater, long detention times, low velocities, high strength wastewater, and pipe materials susceptible to hydrogen sulfide corrosion, such as concrete, steel, or iron, are all parameters indicating corrosion potential.

A desktop evaluation of available data is used to identify areas that meet the following criteria for corrosion potential:

- Manholes and gravity sewer segments directly downstream of a force main discharge, as determined from the city's geographic information system (GIS)
- Drop manholes or other manholes with excessive turbulence, as determined from review of GIS, existing inspection data, or maintenance personnel knowledge of the system
- Areas with a concentration of odor complaints, as determined from review of service requests, or areas with odor problems as documented by maintenance personnel

- Areas with low velocity/long detention times, as determined from the hydraulic model (as model results are available), velocity calculations from pump run time records, or maintenance personnel knowledge of the system
- High points in the force main and sections of down-sloping force main, as determined from record drawings or other available data sources
- Air release valve (ARV) locations as determined from record drawings, GIS, or other available data sources
- Force main pipe materials susceptible to hydrogen sulfide corrosion (concrete, metallic) as determined from GIS, or other available data sources
- Pump stations with known corrosion issues, as determined from maintenance records or maintenance personnel knowledge of the system

STEP 2: PRIORITIZE AND INSPECT AREAS AT RISK OF CORROSION

The gravity sewers, manholes, force mains, and pump stations at risk for corrosion, as identified in **Step 1**, are included as higher priority in the overall prioritization process for condition assessment by physical inspection.

- Manholes at risk of corrosion are inspected as necessary using routine manhole inspections, as described in **Section 3.4**.
- Gravity sewers at risk of corrosion are inspected as necessary using CCTV or zoom camera inspection, as described in **Section 3.6**, or multi-sensor inspection, as described in **Section 3.9**.
- Force main segments identified through desktop analysis as being at risk of corrosion and having a high probability and consequence of failure are inspected using one or a combination of the field inspection methods described in **Section 3.11**. The selection of the most effective inspection technology or combination of technologies will be on a case-by-case basis.
- Pump stations at risk of corrosion are visually inspected, as described in **Section 3.10.5**.
- Corrosion inspection may also include installation of continuous odor monitors, liquid phase wastewater sampling, wastewater temperature readings, or assessment of ventilation in pump stations.

STEP 3: DOCUMENT AND ANALYZE CORROSION DEFECTS

The corrosion defects identified through field inspections are documented in the City's CSAP information management system (IMS). Manhole and gravity sewer defects are coded using the National Association of Sewer Service Company's (NASSCO) Manhole Assessment and Certification Program (MACP) and Pipeline Assessment and Certification Program (PACP) standard codes for corrosion defects, referencing the City of Columbia manhole and pipe identification numbers. Force main and pump station defects are documented in standardized format with standard defect codes and condition ratings.

Defects are reviewed and analyzed to determine the source and cause of the corrosion. If necessary, additional investigation can be performed to determine the source of hydrogen sulfide gas or cause of

corrosion if no hydrogen sulfide is present. This information can be used to evaluate and implement corrosion reduction measures for corrosion prone areas of the WCTS, as appropriate. For example, operational changes can be evaluated to reduce the wastewater detention time and generation of hydrogen sulfide in the system. If corrosion is due to the nature of the wastewater, upstream industrial discharges can be investigated through the industrial pretreatment program.

STEP 4: PRIORITIZE DEFECTS FOR REPAIR OR CORRECTIVE ACTION

Corrosion defects identified through this process are incorporated into the overall repair and rehabilitation prioritization process under the infrastructure rehabilitation (IR) program.

For those sites where corrosion could result in a failure or where odors must be abated, the City may evaluate alternative control technologies, including but not limited to, chemical addition, aeration, and replacement or armoring of materials subject to corrosion damage. Any WCTS components that are found to be in imminent danger of failure will be addressed.

3.4 Routine Manhole Inspection

Manhole inspections are used to locate manholes, collect basic information on manhole dimensions, depth, number and size of pipeline connections, and pipeline cover (i.e., street, year, easement, etc.), and provide data on defects in the manhole that could cause structural failure or contribute to excessive I/I.

The Routine Manhole Inspection program includes visual inspection and/or video camera inspection of all manhole components including frame and cover, wall, steps, bench, invert/channel, service laterals, and pipe inlets and outlets, and documentation of conditions and defects with still photographs and digital video files. Inspections are performed and documented to meet the requirements of NASSCO MACP. The frequency of routine manhole inspections is discussed under performance goals in **Section 4.2** of this report.

The findings of manhole inspections are documented in an MACP-compliant digital database of the inspection along with digital photographs and videos, referencing the City of Columbia manhole identification numbers.

The methods and procedures for routine manhole inspection are described in the City's specifications. The City periodically updates the specifications to provide clarification and maintain consistency with current industry practice. The most recent version of the following specifications related to routine manhole inspection are included in **Appendix B**:

- Specification 02777 – Gravity Sewer System Manhole Inspections: Used for manhole inspections under the CSAP.
- Specification 02778 – Database Template Description for MACP: Used to document and deliver the results of all manhole inspections for integration with the City's CSAP Information Management System (IMS).

3.5 Flow Monitoring

Flow monitoring is used to analyze system performance and identify capacity issues in the WCTS. The data collected as part of a flow monitoring program is analyzed to characterize base wastewater flow and

rainfall dependent inflow and infiltration flow in portions of the WCTS, calibrate the hydraulic model, develop design wastewater flows for input in the hydraulic model, prioritize areas for CSAP assessment and rehabilitation, and/or evaluate the effectiveness of rehabilitation activities.

Flow monitoring can be performed on either a permanent or temporary basis. Permanent monitors are installed to track long-term base wastewater flow and RDI/I trends at a particular location over time, typically along a trunk sewer or upstream of a treatment facility.

Temporary flow monitoring programs include the installation of temporary meters over a sufficient period of time to collect the required data. The duration of a temporary flow monitoring program varies depending upon the program's objectives and rainfall conditions, but should typically be conducted for a minimum of eight weeks. Temporary monitoring may consist of an intensive system-wide monitoring effort to collect data for hydraulic modeling or identification of areas that are most susceptible to RDI/I. Temporary monitoring may also be focused on a particular area of the WCTS, such as for evaluation of the effectiveness of a rehabilitation program in a particular basin.

The following subsections describe the procedures for flow monitoring data collection and analysis and the City's strategies for flow monitoring under the CSAP.

3.5.1 Flow Data Collection Procedures

In order to measure the flow in the WCTS, on either a permanent or temporary basis, flow metering devices are installed in the sewer system to monitor the depth and velocity of wastewater flow at a selected location. Ultrasonic Doppler technology or equivalent is typically used for measuring velocity. Pressure transducer or ultrasonic technology or equivalent is typically used for depth measurements. The flow rate is calculated based on the depth and velocity measurements.

The flow meters are placed within gravity sewers to capture wastewater flow from the appropriate upstream sewer area, or sewer shed, depending on the objectives of the flow monitoring program. Flow meters are installed within the pipe, just upstream of a manhole. When considering locations for installation of flow meters, the following factors are typically taken into account:

- Ease of accessibility for meter maintenance
- Level of debris or sediment accumulation
- Volume and continuity of flow through the sewer
- Flow conditions near the site, avoid turbulent flow conditions
- Known surcharge conditions near the site

Meters are checked and maintained periodically to confirm that quality data is being collected. Routine maintenance includes verification of the monitor calibration, verification of proper data collection and recording, cleaning of velocity and depth sensors, and removal of accumulated sediment or debris in the vicinity of the flow monitor installation.

3.5.2 Rainfall Data Collection Procedures

Rainfall data are collected in conjunction with flow data to determine the relationship between rainfall volume and RDI/I volume. Continuous tipping-bucket type rain gauges or equivalent are typically used for rainfall data collection. In general, rain gauges are located to provide adequate coverage for spatial differences in rainfall over the monitored sewershed areas. Rain gauges are checked and maintained periodically to confirm that quality data is being collected.

3.5.3 Data Quality Review

During the flow monitoring program, data from the flow meters and rain gauges are regularly collected to perform quality review. The velocity and level data are used to make scatter plots. The cluster of data points in a scatter plot provides information regarding the site hydraulic behavior, data consistency, and reliability. Conditions such as turbulent flow, debris blockages or buildup, pipe surcharge conditions, and overflows can be identified in the scatter plots. In addition, the flow, depth, velocity and rainfall may be plotted over time and reviewed with respect to the following:

- Data gaps – missing data may occur due to equipment malfunction or debris fouling the equipment sensors.
- Consistency in dry-weather flow pattern – lack of a clear diurnal flow pattern or shifts and spikes in the level or velocity data could indicate turbulent flow conditions or debris buildup in the vicinity of the flow meter.
- Consistency in wet-weather response – inconsistent flow response during wet weather events, including the magnitude of peak flows and shape of hydrographs, may indicate debris or other unusual flow conditions at the meter.
- Flow balance – where meters are installed downstream of one another, the flow balance is checked by subtracting upstream flows from those downstream.

If necessary, the flow meters or rain gauges may be moved to another location in order to collect quality data. Missing or suspect data is excluded from flow monitoring data analysis.

3.5.4 Flow Monitoring Data Analysis Procedures

After collection and quality review of flow monitoring data, the data are analyzed, as necessary, to identify areas susceptible to RDI/I, prioritize areas for assessment and/or rehabilitation, and determine appropriate flows for input to the hydraulic model. The data analysis approach typically includes the following steps.

STEP 1: DECOMPOSITION OF FLOW DATA

In general, wastewater flows can be divided into three components that make up the total flow hydrograph showing the quantities of wastewater over a period of time:

- Base wastewater flow (BWFF) is domestic wastewater from residential, commercial, and institutional (schools, churches, hospitals, etc.) sources, as well as industrial wastewater sources.

- Groundwater infiltration (GWI) is defined as groundwater entering the collection system through defective pipes, pipe joints, and manhole walls. The magnitude of GWI depends on the depth of the groundwater table above the pipelines, the percentage of the system that is submerged, and the physical condition of the sewer system.
- Rainfall dependent inflow/infiltration (RDI/I) is stormwater that enters the sanitary sewer system in direct response to the intensity and duration of rainfall events.

Hydrograph decomposition is a method of estimating the different components of flow and may be used to analyze flow monitoring data to estimate BWWF, GWI, and RDI/I flow components. Hydrograph decomposition involves separating measured wastewater flows into base flow (including GWI) and RDI/I components. An average base flow hydrograph for a typical weekday and weekend day is developed from the recorded data for dry-weather conditions. To determine the RDI/I component for each storm event, the typical base flow hydrographs are then subtracted from a wet weather hydrograph.

STEP 2: DRY-WEATHER ANALYSIS

The base flow hydrographs determined from **Step 1** are used to calculate the average and peak daily dry-weather flow in each sewershed. GWI makes up a portion of the dry-weather flow and is typically measured by examining the minimum nighttime flows when most base wastewater flows would be very low. The average dry-weather infiltration rate, in gallons per day per inch-diameter mile, is determined for each sewershed as follows:

$$\text{Average dry-weather infiltration} = \frac{\text{GWI (gal/day)}}{\sum[\text{pipe length (miles)} * \text{diameter (inches)}]}$$

STEP 3: WET WEATHER ANALYSIS

In order to prioritize the sewersheds in terms of their RDI/I contribution, three factors may be considered: R value, peak wet-weather flow factor, and RDI/I per linear foot of sewer.

The R value of an area represents the fraction of rainfall entering the collection system as RDI/I. Once the hydrograph decomposition is completed for each monitor, the volume of RDI/I is compared to the volume of rainfall that fell on the area contributing flow to each monitor. The ratio of RDI/I volume to rainfall volume (the inches of rain over the sewershed area) is defined as the R value. The higher the R value, the more RDI/I a sewer system conveys.

The peak wet-weather flow factor is calculated as the ratio of peak wet-weather flow to average dry-weather flow for each sewershed. Even if the volume of infiltration is low, inflow could be producing high peaks that lead to overflows and surcharging. This would be reflected in a high peak wet-weather flow factor.

Another factor that may be considered when evaluating the amount of RDI/I entering each sewershed is the amount of RDI/I per foot of sewer. A higher volume of rainfall infiltration per linear foot of sewer can be a good indicator for future cost-effective rehabilitation. The amount of RDI/I per foot of sewer can be calculated by applying a given design storm to the R value for each sewershed. This allows all sewersheds to be compared on an equal basis, even if the measured rainfall varied over the service area during flow monitoring. Dividing this value by the footage of sewer gives the RDI/I volume per foot of sewer.

All three factors discussed above may be used to prioritize sewersheds for further assessment and/or rehabilitation. The flow monitoring data and analysis results will be stored in a centralized document control site as part of the City's CSAP IMS.

3.5.5 Temporary/Permanent Flow Monitoring Program

The City of Columbia initiated temporary flow monitoring programs in 2012 and 2014. For the 2012 temporary flow monitoring program, 65 meters and 10 rain gauges were installed in the collection system. Meters were installed by February 20, 2012 and the flow monitoring period ended June 20, 2012. The data was used to gain a better understanding of the relative I/I contributions of the system sub-basins. The general location of the temporary flow monitors are shown in **Appendix C**.

The City implemented the 2014 temporary flow monitoring program in the winter/spring season. Meters were installed in February 2014 and collected data for approximately 12 weeks. The data will be used to supplement hydraulic modeling and for future analysis of RDI/I removal following sewer system rehabilitation. A total of 27 flow monitors and ten rain gauges were identified for this program. The flow monitors were located primarily in the Saluda River, Rocky Branch, and Gills Creek basins. The general location of the temporary flow monitors and rain gauges for this temporary flow monitoring program are shown in **Appendix C**.

The City currently maintains seven permanent flow monitors within the WCTS. These monitors are generally located along the major trunk sewers in the Broad River, Rocky Branch, Gills Creek, and Crane Creek basins.

3.6 Video Inspection

Video inspections are completed using either zoom camera or closed circuit television equipment.

Zoom camera inspection is performed in conjunction with manhole inspection and uses a pole-mounted stabilized camera system with high-powered zoom lenses and high-intensity lighting to video the pipe condition while "moving" (zooming) upstream and downstream of a given manhole location. The zoom camera may inspect approximately 50 feet into each line from the manhole depending on the equipment and assuming debris, high-water levels, bends, or defects do not obstruct the camera's line of sight. The zoom camera allows a quick inspection of pipes to reveal defects, blockages, infiltration sources, etc. Examples of pipe defects that may potentially be seen with zoom camera inspection include cracks, holes, offset joints, active infiltration, roots, and debris.

CCTV inspection uses a color television camera mounted on a remotely controlled, self-propelled robotic device that is placed directly into the sewer through a manhole. The camera device moves through the sewer and allows the operator to examine the condition of the entire pipeline between manholes via a live video feed to the mobile survey unit, typically a truck or van. The CCTV operator can stop the camera and control the pan and tilt to investigate any defects or lateral connections in the sewer. The condition of the pipeline is documented using the NASSCO PACP standardized defect codes and data management practices. Digital video files and photographs of the inspection are also created.

CCTV inspection may be used to locate pipe defects, lateral connections, blockages (such as roots, grease, or debris), intrusions into the pipe, and infiltration/inflow sources. CCTV can be used as a follow-up to

provide a more detailed inspection of defects identified via zoom camera. CCTV may also be used in conjunction with dye testing to record and document the location of I/I and leaks into the sewer. Sewer cleaning is often required prior to CCTV inspection to get a clear view of pipeline defects.

The findings of video inspections are documented in a digital PACP-compliant database of the inspection along with digital photographs and videos, referencing the City of Columbia manhole identification numbers. Although the zoom camera inspections are documented using PACP standards, any PACP codes assigned using zoom camera results will be noted as preliminary since the NASSCO standards were developed for CCTV inspection work.

The methods and procedures for video inspection are described in the City's specifications. The City periodically updates the specifications to provide clarification and maintain consistency with current industry practice. The most recent version of the following specifications related to video inspection are included in **Appendix D**:

- Specification 02650 – Sanitary Sewer Line Cleaning: Used for cleaning prior to CCTV inspection.
- Specification 02731 – Sanitary Sewer Television Inspection: Used for CCTV inspections under the CSAP.
- Specification 02732 – Database Template Description for PACP: Used to document and deliver the results of all CCTV and zoom camera inspections for integration with the City's CSAP IMS.
- Specification 02777 (in **Appendix B**) – Gravity Sewer System Manhole Inspections: Includes specifications for zoom camera inspections under the CSAP.

3.7 Gravity System Defect Analysis

Data obtained through condition assessment of the gravity system is documented in a standard format and analyzed for use in prioritizing rehabilitation activities within the WCTS. Gravity sewer defects identified from the gravity sewer assessments and inspection activities described in **Section 3** are coded according to the NASSCO PACP and MACP standard defect codes by PACP/MACP certified personnel. Defect data is compiled in a standardized database, consistent with NASSCO PACP/MACP specifications. The database references the City of Columbia manhole and pipe identification numbers, which provide a linkage for integration within the City's IMS and GIS. Where the gravity system defect analysis results in a determination that a private lateral is a source of I/I to the WCTS or is a source of a release, the City will provide notification to the property owner, but will not be responsible for repairs. Attached at **Appendix E** is a sample letter which may be used to provide this notification to a property owner and may be revised as deemed appropriate necessary by the City.

The methods and procedures for documenting gravity system defects are described in the City's specifications. The City periodically updates the specifications to provide clarification and maintain consistency with current industry practice. The most recent version of the following specifications related to gravity system defect analysis are included in **Appendix B and D**:

- Specification 02778 (in **Appendix B**) – Database Template Description for MACP: Used to document and deliver the results of all manhole inspections for integration with the City’s CSAP IMS.
- Specification 02732 (in **Appendix D**) – Database Template Description for PACP: Used to document and deliver the results of condition inspections for integration with the City’s CSAP IMS.

3.8 Smoke Testing

Smoke testing is typically used to quickly identify and quantify sources of I/I entering the sewer collection system through cracks, breaks, and/or areas not intended to drain into the sewer system. Using a mechanical blower, a non-toxic, non-staining smoke is forced into the sewer collection system through a manhole. The smoke fills the sewer line and any connections and exits the system through the same points where inflow or RDI/I enter the system, such as a crack in a pipe, a cross-connection between a storm sewer and the sanitary sewer, a roof drain connected to the sanitary sewer, a broken cleanout cap/cover, or a defective or damaged manhole. Records of the location of each resulting smoke “leak” are located using GPS and/or street address and include type of defect and severity of the problem. Each defect is photographed using a digital camera with GPS location capability, and documented to show its location relative to the closest manhole or other easily identifiable feature.

The findings and conclusions of smoke testing activities are documented in a digital database of the inspection along with digital photographs and GPS locations.

The methods and procedures for smoke testing are described in the City’s specifications. The City periodically updates the specifications to provide clarification and maintain consistency with current industry practice. The most recent version of the following specifications related to smoke testing are included in **Appendix F**:

- Specification 02767 – Gravity Sewer System Smoke Testing: Used for smoke testing under the CSAP.
- Specification 02768 – Database Template Description for Gravity Sewer Smoke Testing: Used to document and deliver the results of all smoke testing for integration with the City’s CSAP IMS.

3.9 Other Gravity Sewer Assessments

The following gravity sewer assessment technologies may be also be used for condition assessment under the CSAP.

3.9.1 Multi-Sensor Inspection

Multi-sensor inspection utilizes traditional CCTV video inspection in combination with other sensor technologies to provide a comprehensive assessment of the pipeline condition both above and below the water surface that is more detailed than visual inspection alone. Multi-sensor inspection is used in large (36-inch diameter and larger) gravity sewers to identify structural defects, ovality, corrosion issues, sediment, and I/I sources. Multi-sensor inspection can consist of several or all of the following inspection methods:

- CCTV – video image capture or digital pipeline scanner image is used for the purpose of assessing existing conditions.
- Lidar Profiling/Laser Imaging – dimensional measurement to quantify section loss due to corrosion, fats, oils and grease (FOG) or other encrustation buildup, or geometric deformation.
- Sonar Profiling – measures the presence, location, and depth of sediment deposits for volumetric debris calculations, and for the assessment of geometric deformation, offset joints, fractures and other vertical displacement defects.
- Hydrogen Sulfide (H₂S) Measurement – provides gas concentrations to assess the potential for corrosion of pipe materials within the trunk sewer.
- Water temperature measurement – indicates conditions that may be indicative of inflow, infiltration or illicit connections to the sewer system.

Multi-sensor inspections are conducted by contractors that have the appropriate equipment and experience to perform such inspections. The findings of multi-sensor inspections are documented in report format and a PACP-compliant digital database along with digital photographs and videos, referencing the City of Columbia’s manhole identification numbers.

3.9.2 Acoustic Inspection

Acoustic inspection is used to quickly identify gravity sewer blockages. With this technology, the device transmits sound through the pipe and blockages are identified based on the sound received at the downstream manhole. This device can be used to focus sewer line cleaning and inspection efforts on pipes suspected to have blockages.

3.10 Pump Station Performance and Adequacy

The performance and adequacy of pump stations can be assessed through several methods. One or more of the standard procedures described in **Subsections 3.10.1 through 3.10.6** may be used to determine if a pump station is capable of providing reliable service for the operating conditions.

3.10.1 Evaluation of Pump Station Operating Time

Records from the City’s SCADA system, pump run time meters, and/or pump start counters may be used, depending on data availability, to evaluate pump operating time, which is an indicator of pump station performance and adequacy. This data may be compiled and reviewed for changes in trends over time. A significant increase in pump run times or pump cycling may indicate increased flows due to I/I, decreased pumping capacity due to pump wear, clogging of the pumps or pipes, or air binding in the force main.

For small pump stations with fixed speed pumps, cycle time is important because frequent motor starts can result in damage to the motor windings. In larger pump stations, variable speed pumps are often used and designed so that one pump operates continuously, or nearly continuously. Larger pump stations may also include pumps of different capacities. Therefore, a single criterion for establishing a threshold or comparing average daily pump operating time is not applicable to all pump stations.

For fixed speed pump stations with pumps of the same size, the nominal average pump operating time (NAPOT) can be calculated as an indicator of pump station adequacy. The NAPOT represents the daily average pump operating time and can be determined over one or more months. It is calculated by summing the total hours of pump operation over a given time period and dividing that value by the number of days included in the assessment period. The resulting number is then divided by one less than the total number of pumps installed at the station. Pump stations determined to have a NAPOT greater than a given threshold value may be targeted for further investigation, such as drawdown testing, to determine if the pumps are performing adequately or if maintenance activities or capacity upgrades are needed.

NAPOT, however, is not a suitable analysis technique for pump stations with pumps of different sizes or for pumps with variable speed drives. The adequacy of these stations can be determined through an evaluation of pump operating times.

3.10.2 Root Cause Failure Analysis

A root cause failure analysis is a problem-solving technique that attempts to identify and correct the root cause of the event instead of focusing on the event itself. This process recognizes that most failures involve a progression of events and consequences that lead to the failure. In many cases, it is not necessary to prevent the root cause from occurring; it is only necessary to prevent the chain of events that precede the failure from occurring. For example, if a pump station experiences chronic lift failures due to blockages by rags, it is not necessary to prevent rags from entering the sewer. Instead, redesign of the system to include a screen or grinder may be more appropriate, unless a single source of rags can be identified.

Available pump station failure data from maintenance records, SSO records, or SCADA is compiled as necessary to identify pump stations with a history of failures. For those stations with a history of failures, a root cause failure analysis may be conducted to determine the root cause of the failures. The root cause failure analysis process involves development of a classification system to assign failure codes. For example, pump or pump station failures may be classified under major categories such as electrical, controls, mechanical, wastewater contents, wastewater flow, operations, etc., and then further categorized under related sub-categories. Chronic failures of a particular pump or pump station may trigger further study to identify modifications or improvements to prevent future failures related to the same root cause.

3.10.3 Evaluation of Pump Station Capacity

As described in the CD, the capacity of each lift station may be evaluated relative to the guidance in the Pumping Systems chapter of WEF's Manual of Practice FD-4: *Design of Wastewater and Stormwater Pumping Stations*. Because this document primarily provides guidance for the design of new lift stations, the use of the guidance when evaluating existing stations needs to recognize that important distinction. The capacity criteria listed in that document include:

- The station should be designed to discharge the design peak flow, which is the maximum flow that the station will be required to discharge during the design life of the station. However, station design should consider approaches that allow the station to operate efficiently during initial, interim, and design year average flows.

- Pumps installed in a lift station should be capable of discharging the peak flow with the largest pump out of service, while accounting for age in the discharge force main.
- System curves, which are a combination of the system head-capacity curve and the pump curve, should be developed to understand how the system will operate under average and peak flow conditions. These curves also allow an assessment of the efficiency of the pump operation.

Capacity is evaluated by comparing the peak design flows conveyed to the pump station and the station’s capacity. Pump stations where the peak design flow is greater than the capacity will need further evaluation or improvements. The capacity of each pump station is determined based on pump station design documents, engineering evaluation, or drawdown testing.

For pump stations included in the hydraulic model, the capacity evaluation will be performed as part of the hydraulic model analysis. The pump stations listed in **Table 3-2** are included in the hydraulic model. For the remaining pump stations, the capacity evaluation will be performed as part of the Capacity Assurance Program (CAP).

Table 3-2. Pump Stations Included in the Hydraulic Model

Major Pump Stations in Hydraulic Model	Minor Pump Stations in Hydraulic Model
West Columbia	Burnside #2
Saluda River	Versch Lock
Mill Creek	East Bluff
North Columbia	Starlite
Broad River	Meadowlands
Garners Ferry Road (LR Crossing)	Heathwood Hall
	Homeless Shelter
	Atlas Road

3.10.4 Evaluation of Critical Response Time

The critical response time for a pump station is defined as the time between activation of the high wet well level alarm and the first SSO under peak flow conditions. This may be calculated, using the estimated peak flow rate into a station and the station’s wet well geometry, as the wet well fill time from the high wet well alarm to either the top of the wet well or the elevation of the upstream critical manhole as identified in the City’s Contingency and Emergency Response Plan (CERP), whichever is lower. The critical response time may then be evaluated in comparison with the time it takes maintenance crews from the City’s Metro Wastewater Treatment Plant to respond after a high wet well alarm is triggered.

3.10.5 Evaluation of Pump Station Conditions

The pump station condition assessment approach for the City of Columbia consists of a review of pump station operating history and visual inspection and assessment of the condition of pump station components to the extent possible without disrupting operations. From this data, the pump station is assigned an overall condition rating. The evaluation approach is outlined below.

- Review of Operating and Mechanical Failure History – The assets’ recent operating and mechanical failure history during the past five years is used, when available, as part of this inspection. Data to be reviewed may include pump run (hours) data, maintenance records, work order history, and SSO records of lift station related spills.

- Field Evaluation – Field evaluation consists of a site visit to the pump station and a non-invasive, visual inspection of the assets and discussions with pump station operations and maintenance staff. Pertinent information on the pump station components is collected and input into the CSAP IMS along with a condition rating for each component (**Table 3-3**). Components that are visually inspected during the field evaluation include the following, as applicable:
 - Control systems
 - Compressor
 - Communitor
 - Control Valves
 - Engine
 - Exterior lights
 - Generator
 - Mechanical meters
 - Motor
 - Pumps
 - Relief valves
 - System valves
 - Underground structures
 - Weight handling equipment
 - Transformer

Table 3-3. Pump Station Component Condition Index

Likelihood of Failure	Characteristics of Condition
Negligible = 1	No noticeable defects. Fully functional.
Not Likely = 2	Only minor deterioration or defects. Noticeable wear or aging is visible. Fully functional.
Possible = 3	Some deterioration or defects are evident. Significant aging or wear is visible. Function is not significantly affected.
Likely = 4	Serious deterioration or defects in at least some portion of the asset. Extensive aging or wear is visible. Function is significantly affected.
Failed = 5	General failure or complete failure or major functional component failure. No longer functions.

- Data Development – Based on the results of the field evaluation, the inspector develops an overall condition rating for the pump station.

- Data Validation – The inspector will meet with operations and maintenance staff to discuss and finalize the operational condition assessment findings. The condition ratings will be input into the City’s CSAP IMS.

-

3.10.6 Evaluation of Pump Station Design and Equipment

Pump station design and equipment, including redundancy of pumps and electrical power supply and other equipment installed, may be evaluated based on South Carolina Department of Health and Environmental Control (SCDHEC) regulation R.61-67 (Standards for Wastewater Facility Construction) and City of Columbia Utilities and Engineering Regulations Manual: Part 3 (Design of Sanitary Sewers).

The checklist included in **Appendix G** is derived from SCDHEC regulation R.61-67 (Standards for Wastewater Facility Construction). The checklist will be used in conjunction with the City's Pump Station Design Standards which are also included in **Appendix G**. The City periodically updates the design standards to provide clarification and maintain consistency with current industry practice. The most recent version of the pump station design standard is included in **Appendix G**. Because these documents primarily provide guidance for the design of new pump stations, the recommendations described therein may not be applicable to the evaluation of existing stations. For assessment of existing pump stations under the CSAP, the items in the **Appendix G** checklist may be considered, and deficiencies may be noted for consideration in subsequent evaluations/decisions.

3.11 Force Main Assessment

Force main assessment involves a desktop analysis which may be followed by one or a combination of field inspection methods in limited areas as prioritized by the desktop analysis. The desktop analysis is used to determine the most likely areas for corrosion or other failure modes. This is done by examining the profile of the force main and identifying locations where the pipe may be partially full and where turbulence from connecting force mains may release hydrogen sulfide gas. The desktop analysis may also include review of soil condition studies, investigation of groundwater levels, and investigation of surface conditions, as applicable.

Force main field inspection methods vary depending on the size and material of the pipe and whether or not the pipe can be taken out of service to complete the inspection. It is anticipated that few, if any, of the City's force mains could be taken out of service to perform investigative techniques due to the quantity of flow and lack of storage or redundancy. The inspection methods described in the following sub-sections can be performed while the pipe is in service. The selection of the most effective inspection technology or combination of technologies is made on a case-by-case basis using the City's best professional judgment.

Force main field inspections are conducted by personnel that have the appropriate equipment and experience to perform such inspections. The findings of force main inspections are documented in standardized format with standard defect codes and condition ratings.

3.11.1 Air Release Valve Inspection

Air release valve (ARV) inspection involves visual evaluation of the general conditions of the valves including flanges, valve body, and metal surfaces for corrosion, pitting, leakage, discoloration, stress cracks, and other abnormalities of use and age.

3.11.2 Hydrostatic Testing

Hydrostatic testing involves pressurizing a section of force main to determine if the pipe can maintain an allowable pressure over a specified duration. If the pipe cannot maintain pressure, this is an indication of a leakage.

3.11.3 Transient Pressure Analysis and Surge Modeling

Hydraulic transients, or pressure surges, are created when sudden changes in flow rates occur within a pumping or pipeline system. Transient pressure analysis determines the presence and severity of hydraulic transients and determines if they adversely affect the condition of the pipeline. Desktop surge modeling is performed to determine the anticipated and allowable pressures in the pipeline under various conditions. Model analysis also helps identify how operation of the pump station affects the pressure in the pipeline. If necessary, specialized high sample rate pressure monitoring equipment can also be installed in the pipeline to continuously monitor the pressure in the pipe for comparison with modeled pressures.

3.11.4 Flow Conservation Checks

Checking flow conservation involves comparing the flow pumped by the pump station with that exiting the force main. An external Mag meter is installed on the end of the force main to monitor the flow. This measurement is compared to the flow metered at the pump. A loss of flow indicates that the force main has leaks or cracks. This method is dependent on the accuracy of the meter installed and can only identify significant leaks given that there will always be some discrepancy between the meters.

3.11.5 Coupon Extraction

This inspection method involves extracting coupons (pipe samples) from selected locations of the force main to determine the amount of internal or external corrosion in any pipe material. The disadvantage to taking coupons is that it provides information only at the location where the coupon was taken, and often corrosion is not uniform. It also creates a permanent change in the condition of the force main at that specific location should be recorded.

3.11.6 Ultrasonic Thickness Testing

This inspection method uses an ultrasonic thickness device to determine the thickness of the pipe wall for ductile iron, cast iron, or pre-stressed concrete cylinder pipe (PCCP). A trench is dug so that the ultrasonic device can be applied around the circumference of the force main. This testing may also be performed at locations where the pipe is already exposed such as an air release valve manhole. Any exterior pipe coatings are removed before the device is applied. A coupon of the force main may be taken to calibrate the ultrasonic testing device.

3.11.7 Acoustic Leak Detection

Acoustic leak detection technology has been successfully used in water transmission main testing and has recently been adapted to work with wastewater force mains. Specialized acoustic leak detection equipment is used while the force main is in service to identify and pinpoint the location of leaks and air pockets in a force main. Where air pockets are identified, more focused inspection, such as coupon extraction or thickness testing, can be performed. The leak detection system is inserted into a live force

main through any tap larger than 2-inches. In operation, the probe is carried along the pipe by the flow of water. The system locates leaks through identification of the distinctive acoustic signals generated by leaks in the pipe wall, the joints, or steel welds. In addition to locating the leak, the technology can estimate the magnitude of the leak.

3.11.8 Broadband Electromagnetics

Broadband electromagnetics uses a range of electromagnetic frequencies to detect a variety of thicknesses in ductile and cast iron pipe. This technology can survey through ferrous pipe coatings and linings. A combination of investigation pits and keyhole excavations are used to scan the upper part of the exposed pipe in the keyhole. The whole exposed section of pipe is scanned for a full picture of pipe condition (loss of metal, cracks, etc.), not just a number of isolated points.

3.11.9 External Inspection

External inspection involves excavating to expose the force main. A visual inspection of the main is performed to identify coating deterioration, cracks, leaks, or other signs of distress. Any pipeline anomalies are photographed and documented. Soil and groundwater samples are taken for laboratory analysis of properties aggressive to pipe material.

3.11.10 Acoustic Monitoring for PCCP

This method relies on acoustic monitoring of the pipe to “hear” wire breaks in a PCCP force main. This technique accurately identifies wire breaks and their location. An array of sensors is installed at different locations on the outside of the pipe. The acoustic monitoring system is usually left in place for a period of months. During this time, all wire break activity is reported. Wire break information is then used to help establish the rate of deterioration and help predict the life remaining in individual pipe sections.

Section 4 CSAP Information Management System and Performance Goals

This section describes the Continuing Sewer Assessment Program Information Management System (CSAP IMS) that is used to store and maintain information collected through CSAP assessments as well as track and measure CSAP performance goals. The CSAP IMS incorporates several information tracking platforms under the City of Columbia's overall IMS Program.

4.1 CSAP Information Management

The procedures for documenting findings of the wastewater collection and transmission system (WCTS) inspections in standardized format are discussed in **Sections 3.2 through 3.11** of this report. Inspection databases and other assessment data are stored within the CSAP IMS under the following applications.

Computerized Maintenance Management System (CMMS) – The City is in the process of implementing a CMMS using Azteca Software's Cityworks® Server Asset Management System (Cityworks). Cityworks is seamlessly integrated with GIS and will serve as the City's single IMS repository for information related to corrective and preventive maintenance history, asset inventory and attributes. Information collected through CSAP assessments will be entered and maintained in the CMMS, as applicable. System maintenance data, including sanitary sewer overflow (SSO), service request, and work order frequency and location, will also be stored in the CMMS. This information will be periodically reviewed to update and inform the prioritization process for CSAP activities.

Microsoft SQL Server Database – This centralized database will be used to store, manage and distribute both spatial (GIS) and various datasets, including CSAP inspection databases that are not stored within the CMMS. Information in the inspection databases can be linked to GIS based on the City's previously defined and implemented unique asset identification number that exists on each asset in the GIS.

Document Control System – Other assessment data that are not specific to a single asset, such as flow monitoring data, will be stored within the CSAP IMS on a centralized document control site.

Data Integration

CSAP information will also be integrated with the following applications as available:

Hydraulic Model – Information collected through the CSAP will be used to update the hydraulic model of the WCTS as necessary.

Sewer Mapping Program – The Sewer Mapping Program Report, included in **Appendix H**, describes procedures that are used to integrate CSAP assessment data with the GIS, as well as standard operating procedures for incorporating and updating the data generated by the CSAP into thematic maps as part of the Sewer Mapping Program.

4.2 Performance Goals and Scheduling

The City will complete an initial condition assessment of all major and minor WCTS components according to the schedule set forth in Paragraph 14.a. of the CD. The initial assessment methods will be selected based upon the type and priority of the WCTS components. At a minimum, a desktop assessment will be completed. Those areas identified as high priority from the desktop assessment will be targeted for additional field assessment methods and/or rehabilitation. The schedule for initial assessment is summarized in **Table 4-1**.

Subsequent assessments will take place on a continuing basis, prioritized based upon results of the initial assessments, rehabilitation work completed, and other condition and criticality factors considered in the prioritization process discussed in **Section 2** of this report. High priority WCTS components, which are those that are both highly critical and suspected to be in poor condition, will receive the most frequent assessment. Other WCTS components that are highly critical, but not suspected to be in poor condition will receive a medium frequency assessment to determine their condition. Remaining WCTS components will be assessed with lower frequency to determine if field investigations are needed. The performance goals for continuing assessment of the WCTS are summarized in **Table 4-2**. In the future, it is the intent to incorporate a pipe by pipe prioritization when appropriate in addition to a sub-basin prioritization.

The prioritization of WCTS components will be tracked along with assessment scheduling and results of field investigation and rehabilitation activities.

TABLE 4-1. INITIAL CSAP ASSESSMENT SCHEDULE

	YEAR 1 <i>after approval of CSAP</i>				YEAR 2 <i>after approval of CSAP</i>				YEAR 3 <i>after approval of CSAP</i>				YEAR 4 <i>after approval of CSAP</i>				YEAR 5 <i>after approval of CSAP</i>			
	QTR 1	QTR 2	QTR 3	QTR 4	QTR 1	QTR 2	QTR 3	QTR 4	QTR 1	QTR 2	QTR 3	QTR 4	QTR 1	QTR 2	QTR 3	QTR 4	QTR 1	QTR 2	QTR 3	QTR 4
TASK 1.0 EPA APPROVAL OF CSAP	○																			
TASK 2.0 MAJOR COMPONENTS OF CSAP	■				■				■											
2.1 MAJOR GRAVITY SEWER - VIDEO INSPECTION OR MULTI-SENSOR INSPECTION	■				■				■											
2.2 MAJOR MANHOLES - MANHOLE INSPECTION	■				■				■											
2.3 MAJOR PUMP STATIONS - CONDITION ASSESSMENT USING ONE OR A COMBINATION OF THE METHODS LISTED IN TABLE 3.1, AS APPROPRIATE, BASED UPON PROFESSIONAL JUDGMENT	■				■				■											
2.4 MAJOR FORCE MAINS																				
2.4.1 Desktop Condition Assessment / Prioritization for all major force mains	■				■				■											
2.4.2 Field assessment for selected high priority areas using one or a combination of the methods listed in Table 3.1, as appropriate, based upon professional judgment					■				■											
TASK 3.0 MINOR COMPONENTS OF CSAP	■																			
3.1 CURRENT ANNUAL ASSESSMENT PROGRAM FOR MINOR COMPONENTS	■				■				■				■				■			
3.2 MINOR GRAVITY SEWER AND MANHOLES																				
3.2.1 Desktop Condition Assessment / Prioritization	■				■				■											
3.2.2 Condition assessment using one or a combination of the methods listed in Table 3.1, as appropriate, based upon professional judgment									■				■				■			
3.3 MINOR PUMP STATIONS																				
3.3.1 Desktop Condition Assessment / Prioritization	■				■				■											
3.3.2 Condition assessment using one or a combination of the methods listed in Table 3.1, as appropriate, based upon professional judgment									■				■				■			
3.4 MINOR FORCE MAINS																				
3.4.1 Desktop Condition Assessment / Prioritization for all minor force mains	■				■				■											
3.4.2 Field assessment for selected high priority areas using one or a combination of the methods listed in Table 3.1, as appropriate, based on professional judgment									■				■				■			

1) As part of the Continuing Sewer Assessment Program, the prioritization of the WCTS components will be updated annually as part of the Capital Improvements Planning Process

Table 4-2. Performance Goals for Continuing Assessment

Assessment Action	Category*	Performance Goal
Update Prioritization of WCTS Components	n/a	Periodically, as part of Capital Improvements Planning process
Assessment of Gravity Sewers and Manholes	High Priority	5 year frequency
	Highly Critical	10 year frequency
	Other	20 year frequency
Assessment of Pump Stations	Major Pump Stations	5 year frequency
	High Priority minor pump stations	5 year frequency
	Other minor pump stations	10 year frequency
Assessment of Force Mains	High Priority	5 year frequency
	Highly Critical	10 year frequency
	Other	20 year frequency

* Categories are based upon the prioritization of WCTS components to be reviewed periodically. High priority components are those that are both highly critical (high consequence of failure) and suspected to be in poor conditions. Highly critical components are highly critical (high consequence of failure) but not suspected to be in poor condition.

Appendix A
Dye Testing Procedures

SECTION 02761
DYE TESTING

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required to perform dye testing for the purpose of identifying cross connections between the storm water and sanitary sewer.
- B. CONTRACTOR as defined in this specification is presumed to be operating under a direct contract with ENGINEER to provide this scope of services. ENGINEER is responsible for CONTRACTOR's work and in some instances CONTRACTOR and ENGINEER may be the same entity.
- C. Document with digital photos and CCTV video as necessary to record the locations of positive and negative testing results. Data shall be collected related to the test and entered into the OWNER's Dye Testing database template with data entered into all fields. See Section 02762 for Dye Testing database guidance.

1.02 RELATED WORK

A. RELATED WORK

- 1. Sanitary Sewer Line Cleaning is specified in Section 02650.
- 2. Sanitary Sewer Television Inspection of sewers is specified in Section 02731.
- 3. PACP Database Template is specified in Section 02732.
- 4. Dye Testing Database Template is specified in Section 02762.
- 5. Gravity Sewer System Smoke Testing is specified in Section 02767.
- 6. Gravity Sewer System Smoke Testing Database Template is specified in Section 02768.
- 7. Gravity Sewer System Manhole Inspections is specified in Section 02777.
- 8. MACP Database Template is specified in Section 02778.
- 9. Sanitary Sewer Flow Control is specified in Section 02965

1.03 SUBMITTALS

- A. Submit a Traffic Control Plan to the OWNER's Representative, which includes the following items.
 - 1. Outline of permit acquisition procedure for lane closures.
 - 2. Methods for proper signing and barricades, which comply with local requirements and

the OWNER.

3. Site CONTRACTOR emergency phone numbers.
- B. Submit schedules of planned work on a weekly basis for the upcoming week, including a map in PDF format showing the area of work, and a map and list of streets being affected. Submittal should be provided by electronic mail to the OWNER. Provide 24-hour notice for deviations from the plan that are not caused by weather or natural causes.
- C. CONTRACTOR to submit confined space entry plan, certifications and hazardous atmosphere training certifications, if applicable.
- D. The work described in this Scope of Work, including any internal sewer or manhole inspections, shall meet the minimum requirements as presented in the OSHA Standard, Title 29 CFR 1910.146, Permit Required Confined Spaces. Upon commencement of the Work, copies of all confined space entry permits must be submitted to ENGINEER. CONTRACTOR shall notify the OWNER or delegated representative each day by phone, email or fax when it is necessary for CONTRACTOR to enter a manhole(s). CONTRACTOR shall identify all manholes that CONTRACTOR plans on entering that day by street location and manhole number.
- E. Final data shall be submitted in accordance with the requirements of this specification.

1.04 NOTIFICATIONS

- A. Notify OWNER:
 1. Submit schedules of planned work on a weekly basis for the upcoming week, including a map in PDF format showing the area of work, and a map and list of streets being affected. Submittal should be provided by electronic mail to the OWNER. Provide 24-hour notice for deviations from the plan that are not caused by weather or natural causes.
 2. Immediately, when a collapsed pipe or other pipe failure is identified.
 3. Immediately, if the conditions for inspection are found to be unsafe or impractical.
 4. Immediately, if a manhole is buried, cannot be found or cannot be accessed. Along with the manhole name, provide a map showing the location of the manhole and what procedures were used to attempt to locate the manhole.
 5. Inspection crews shall immediately notify the OWNER and/or on-site inspector of any defects posing imminent danger to the public (missing lids, covers broken during inspection, sink holes, etc.) and any observed pipe blockages, active surcharging, evidence of surcharging, or potential overflow conditions.
 6. If the pipe configuration in the field is different than shown in OWNER supplied GIS data. The notification shall include a diagram clearly indicating the location of structures in relation to immediately adjacent structures in PDF format via electronic mail. In addition, the information should be updated in the GIS database and will be provided to the OWNER at the time of submittal of the manhole inspection data relevant to that particular area or manhole structure in order to facilitate review and timely update of the

OWNER's GIS to match the manhole inspection database.

- B. Notify the public and coordinate with homeowners:
 - 1. A minimum of 48 hours prior to the inspection of any line segment, distribute door-to-door an OWNER approved Homeowner Notification door hanger describing the work to be performed.
 - 2. CONTRACTOR must use approved magnetic car signs affixed to vehicles at all times during the project to identify affiliation with the City of Columbia, SC.

PART 2 - PRODUCTS

- A. Dye shall be liquid, non-toxic and CONTRACTOR shall use multiple colors if simultaneous tests are being conducted to distinguish where the inflow source is originating.

PART 3 - EXECUTION

3.01 DYE TESTING

A minimum of 48 hours prior to the inspection of any line segment, distribute door-to-door an OWNER approved Homeowner Notification door hanger describing the work to be performed. On the day of inspection and prior to the inspection, knock on the doors of all properties that will require entering their private property to access the manholes which will potentially be impacted by the work and notify occupants of this inspection.

- A. As shown on the drawings or maps, the CONTRACTOR shall attempt to identify and document any transfers of water from storm sewers, ditches, catch basins, low spots, or creeks/streams that cross or parallel sanitary sewers and laterals within the public right of way, or within the existing sanitary sewer easement. CONTRACTOR shall perform these tests in the areas as determined by the ENGINEER.
- B. For storm sewer crossings, the CONTRACTOR shall plug or block the downstream storm water manhole and flood the storm sewer as necessary to recreate a full flowing or surcharged storm sewer. CONTRACTOR shall document any transfers of flow from the storm sewer to the sanitary sewer with CCTV video or manhole photos as approved by the ENGINEER. These areas may include sections of storm sewer that parallel or cross sanitary sewers. Storm sewer sections will be plugged and partially flooded with dyed water. Catch basins, stream sections, ditch sections, and ponding areas in close proximity to sanitary sewers will be included (if present) in the areas tested.
- C. In all instances of dyed water testing, the downstream manhole of the sanitary sewer system will be monitored for evidence of dyed water. The observed presence and concentration of dyed water is an indicator that an inflow/infiltration source exists. When positive results are observed, a CCTV camera will be inserted into the sanitary sewer and the leak will be recorded by the project team's CCTV equipment. The results of the television inspection report will be used to document the types of sources of inflow/infiltration sources, whether from joints, brickwork or from laterals. This inspection provides a basis for the appropriate sewer system rehabilitation techniques. CCTV video submissions must meet all requirements of specification Section 02731 (Sanitary Sewer Television Inspection).
- D. The ENGINEER'S RESPONSIBILITIES include:

- a. Furnish the necessary maps of the pipes and manholes to be investigated..

PART 4 - DELIVERABLES

4.01 DELIVERABLES

- A. ENGINEER to provide inspection data on a monthly basis with the database and data on an external hard drive. The ENGINEER to provide two hard drives on an alternating monthly basis. The submittals shall be cumulative (i.e. each successive database delivery will include previous deliveries as well). CONTRACTOR shall provide OWNER with a final external hard drive capable of storing all anticipated data for the project upon completion. The final hard drive shall be submitted on the first monthly submittal with the first month of data loaded and will become property of the OWNER upon project completion. Data to be submitted shall include: 1) NASSCO PACP Database and Dye Testing database files, 2) .jpg files (still photos), 3).mpg files (videos) 4) a PDF of any reports or additional data sheets.
- B. Each database submittal shall indicate the range of dates for which the database is being submitted as well as a list of new items as of the last submittal so that the OWNER may separate out and review the newly delivered records from previous submittals in an Excel format.

The databases shall be cumulative, with one database each for PACP CCTV inspections and one for Dye Testing. Each subsequent submittal shall be added into these databases.

Throughout the duration of the project, should ENGINEER discover inaccuracies in any of the videos, CONTRACTOR shall re-inspect those manholes and/or pipes at no additional cost to the ENGINEER or OWNER

- C. The results of each inspection must be delivered in a database formats using the dye testing and PACP template databases provided by the OWNER. The database filenames will use the following formats using upper case letters:

D_XYZ_BR02_SS7207_YYYYMMDD.MDB (where D=Dye testing database; XYZ=Contractor name; BR02 = Example Basin_ID, SS7207 = Example PO_Number+C7, YYYYMMDD=8-digit date)

P_XYZ_BR02_SS7207_YYYYMMDD.MDB (where P=PACP database; XYZ=Contractor name; BR02 = Example Basin_ID, SS7207 = Example PO_Number, YYYYMMDD=8-digit date)

- D. The dye test database records will include the unique test number, street address, date, time, weather conditions, etc. as documented within the template database provided by the OWNER. Unique test numbers for each test shall take the form of CONTRACTOR_ID (provided by the OWNER), the date of the test (YYYYMMDD format) and a sequential number denoting the test sequence performed on that date (i.e. 1, 2, 3, etc.). Each portion of the unique test number will be separated by an underscore. For example:

XYZ_20121211_3 (where XYZ=Contractor name; 20121211 = Example of 8-digit date; and 3 = Example indicating 3rd test on December 11, 2012)

- E. Digital photographs shall be in .JPG format and shall have a pixel resolution of at least 2 megapixels or 1920 x 1080 using a 16:9 format. Photos shall include a GPS coordinate location collected at the time the photo is taken utilizing GPS enabled digital camera or similar technology. Image files are managed in a PACP database. The dye test database shall include the name of the PACP database used to manage images specified in ImageVideo_DB_Name field of the Inspections table. The dye test database shall provide the PACP database's InspectionID associated with the images in the ImageVideo_InspectionID field of the Inspections table. Each photo shall be given a filename that consists of the unique dye test number followed by a number indicating the photograph sequence and using an underscore to separate the test number, photo sequence number (e.g., XYZ_20121211_3_1.JPG where XYZ=Contractor name; 20121211=example of 8-digit date; 3=test number; and 1=photo sequence number). No spaces or special characters will be allowed in the file names except dashes or underscores and the photograph test numbers must correlate exactly back to those entered in the digital database submission.
- F. Digital CCTV videos shall be recorded in .mpg format (unless otherwise approved by OWNER). The CCTV video shall be visually clear and have audio that clearly describes the result of the test. CCTV video submissions must meet all requirements of specification Section 02731 (Sanitary Sewer Television Inspection). Video files are managed in a PACP database. The dye test database shall include the name of the PACP database used to manage images specified in ImageVideo_DB_Name field of the Inspections table. The dye test database shall provide the PACP database's InspectionID associated with the images in the ImageVideo_InspectionID field of the Inspections table. Video obtained for dye testing shall have a "D_" as prefix. There may be situations that require CONTRACTOR to televise an individual pipe segment from more than one direction, i.e. the camera is only able to televise 75% of the segment heading downstream, and the remaining 25% is televised heading upstream. The name of additional database files etc. produced in these circumstances shall be that unique upstream structure ID followed by the unique downstream structure ID followed by 8-digit date and "_1", "_2" etc. For example:

Initial file name:

D_SS-SR02-01673:SS-SR02-01674_YYYYMMDD.MPG

Additional file name(s):

D_SS-SR02-01673:SS-SR02-01674_YYYYMMDD_1.MPG (where D=dye testing; SS-SR02-01673 is upstream structure ID; SS-SR02-01674=downstream structure ID, YYYYMMDD= 8 digit date; 1=additional attempt at CCTV of sewer reach)

Example file name for pipe segments associated with a relief sewer or multi-barreled sewer, facing downstream, between two identical structure IDs:

SS-SR02-01673: SS-SR02-01674_(1,2 or 3)_YYYYMMDD.MPG (where SS-SR02-1673 = upstream structure ID; SS-SR02-1674 = downstream structure ID; 1,2 or 3 represent the pipe segment from left to right (facing downstream), YYYYMMDD = 8 digit date.

The direction of camera pull versus the pipe flow must be noted in the inspection record in the database.

- G. For structural assets, with unknown ID, and constructed during or later than 2013, the contractor is required to obtain an ID from the GIS administrator.

PART 4 DELIVERABLES (NOT USED)

END OF SECTION

SECTION 02762
DATABASE TEMPLATE DESCRIPTION DYE TESTING

PART I GENERAL

1.01 DATABASE TEMPLATE

- A. The attached database template (version 2) and formatting as specified must be used to document and deliver the results of all work related to dye testing. A description is provided in this specification for each field, and formatting notes and examples for fields to provide additional guidance. Examples are provided for fields that are open that required additional clarity, and the lack of an example does not imply that the field can be left blank.
- B. All codes and descriptions must be used pursuant to Specification Section 02761 and the valid value tables within the attached database template.
- C. All database fields must be populated unless noted as optional in the Description field of the database table.

PART 2 TABLE FORMAT AND DESCRIPTION

- A. The following tables show available Field Names, the data type allowed, field size, a description of the Field, additional formatting notes if needed, and an example if provided.

2.01 INSPECTIONS TABLE

- A. This table shall be used to store the primary information regarding the inspection.

Field Name	Data Type	Field Size	Field Description	Field Formatting Notes	Field Example
Inspection_ID	Text	100	Unique identification code in the format specified in specification Section 02761	Unique test numbers for each test shall take the form of CONTRACTOR_ID (provided by the OWNER), the date of the test (YYYYMMDD format) and a sequential number denoting the test sequence performed on that date (i.e. 1, 2, 3, etc.). Each portion of the unique test number will be separated by an underscore. For example: XYZ_20121211_3 would be the third test performed by contractor XYZ staff on December 11, 2012	XYZ_20121211_3

Field Name	Data Type	Field Size	Field Description	Field Formatting Notes	Field Example
Contractor_ID	Text	25	Unique contractor identification code	Use consistent entry, all uppercase	XYZ
PO_Number	Text	15	Customer's Purchase Order Number	CIP number	SS7207
Inspection_Date	Date/Time	8	Date the inspection was performed	Any valid date entry allowed, displays as: yyyyymmdd	20130726
Inspection_Time	Date/Time	8	Time of day the inspection was performed	Any valid time entry allowed, displays as: h:mm	13:41
Owner	Text	30	Owner of collection system surveyed	Validated single-value entry; default populated	City of Columbia
City	Text	64	City name where sewer located using the codes in the Valid_City table	Validated entry list e.g., Irmo, Columbia, Lexington	Irmo
Basin_ID	Text	15	City of Columbia wastewater system basin identification code from the City's GIS	Validated entry list e.g., BR03, BR04, CC01	BR02
StreetNumber	Text	30	Street address number of the building or structure nearest to the inspection or that the inspection was performed on, if applicable		842

Field Name	Data Type	Field Size	Field Description	Field Formatting Notes	Field Example
StreetName	Text	200	Name of the street nearest to the inspection or that the inspection was performed on	Indicate street name when applicable i.e., if asset is in street or crosses the street or can be associated with an address. Use PREDIRECTIONAL STREET SUFFIX POSTDIRECTIONAL with no punctuation and all uppercase letters. Alleys or right-of-ways between two streets should remain unassigned. Fields, parks, other open areas should receive a positive entry of "OTHER".	N MAIN ST
Location_Code	Text	100	Location of the inspection using the codes in the Valid_Locations table	Validated entry list e.g., Alley, Building, Creek	Alley
Location_Details	Text	255	Free form text describing additional details of the location, if needed		
Pipe_Segment_ID	Text	100	Unique identification code from the City's GIS of the pipe segment or last pipe segment involved in the dye test	Upstream_structure_ID:downstream_structure_ID. See structure ID formatting details.	SS-SR02-01674:SS-SR02-01675

Field Name	Data Type	Field Size	Field Description	Field Formatting Notes	Field Example
Downstream_MH_ID	Text	25	Unique identification code from the City's GIS of the manhole or structure used to monitor the test for the presence of dye	Each manhole has been given unique structure identifications per OWNER guidelines, and the name of each database ID shall be that unique structure ID. If an unnamed structure is found, the letter "A" will be added to the end of the structure ID to form a new structure. If more than one unnamed manhole is found between two named manholes, subsequent new structure ID's will be formed using the letters "B", "C" etc. Spaces and special characters are not allowed in the unique ID codes. For example, SS-SR02-03123 or SS-SR02-03123A	SS-SR02-03123A
Weather	Text	30	Weather conditions at the time of the inspection using the codes in the Valid_Weather table	Validated entry list e.g., Light Rain, Saturated, Snow	Heavy Rain
Dye_Present	Yes / No	1	Yes/no indication of the presence of dye at the monitoring location		Yes
Dye_Intensity	Text	15	Intensity of the dye observed using the codes in the Valid_Intensity table	Validated entry list e.g., Dense, Medium, Trace	Trace

Field Name	Data Type	Field Size	Field Description	Field Formatting Notes	Field Example
ImageVideo_DB_Name	Text	100	Unique name of the PACP database used to manage the dye testing images and video	The database filename will following the following format using upper case numbers: P_CONTRACTORNAME_B ASINID_PONUMBER_YY YYMMDD.MDB (where P=PACP database;Contractor name; Basin ID, PO_Number, YYYYMMDD=8-digit date)	P_XYZ_BR02_SS72 07_YYYYMMDD.M DB
ImageVideo_InspectionID	Text	100	Unique PACP database InspectionID	InspectionID is autogenerated by PACP database	155

2.02 VALIDATED ENTRY TABLES

These tables shall be used to determine the valid entries allowed in certain fields as specified in the tables above. These tables are related to the above-mentioned tables within the database and provide predefined validated fields. The following tables are included in the database and should not be edited or modified:

1. Valid_Basin
2. Valid_City
3. Valid_Intensity
4. Valid_Locations
5. Valid_Weather

Appendix B
Routine Manhole Inspection Procedures

SECTION 02777
GRAVITY SEWER SYSTEM MANHOLE INSPECTIONS

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The Work covered by this section includes furnishing all labor, competent certified technicians, equipment, tools, accessories, and materials required to perform Level 2 MACP inspections and preliminary PACP inspections of pipelines connected to those manholes. It is anticipated that the CONTRACTOR will perform the manhole and connecting pipeline inspections using the zoom camera equipment specified herein.
- B. CONTRACTOR as defined in this specification is presumed to be operating under a direct contract with ENGINEER to provide this scope of services. ENGINEER is responsible for CONTRACTOR's work and in some instances CONTRACTOR and ENGINEER may be the same entity.
- C. All standard MACP forms shall be completed and all data must be entered into a MACP compliant database format, including but not limited to:
 - 1. Manhole Inspection Header Form
 - 2. Manhole Component Observation Form
 - 3. Manhole Connection Form
 - 4. Manhole Component Defect Form
- D. The standard PACP database shall be completed and all data must be entered into a PACP compliant database format based on the zoom camera inspections of all pipes entering or exiting manholes that are being inspected. See Section 02731 for PACP inspections and database guidance, as applicable, for the zoom camera inspections.
- E. Digital videos, data, and photos shall be delivered to the ENGINEER on an external hard drive which will become property of the OWNER. Data files shall be delivered in a NASSCO MACP/PACP Exchange Databases version 6. Please consult with the OWNER before proceeding if a more recent version is currently available.
- F. Video recordings shall be made of zoom camera inspections and copies of both the recordings, digital photographs of defects and inspection information shall be supplied to the ENGINEER in digital database format per the specifications described herein.
- G. Inspection and coding of pipeline and manhole conditions, determined based on zoom camera inspections, shall be performed by personnel trained and certified in the use of the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP©) and Manhole Assessment and Certification Program (MACP©).

1.02 RELATED WORK

1. Sanitary Sewer Line Cleaning is specified in Section 02650.
2. Sanitary Sewer Television Inspection of sewers is specified in Section 02731.
3. PACP Database Template is specified in Section 02732.
4. Dye Testing is specified in Section 02761.
5. Dye Testing Database Template is specified in Section 02762.
6. Gravity Sewer System Smoke Testing is specified in Section 02767.
7. Gravity Sewer System Smoke Testing Database Template is specified in Section 02768.
8. MACP Database Template is specified in Section 02778.
9. Sanitary Sewer Flow Control is specified in Section 02965

1.03 SUBMITTALS

- A. Submit a Traffic Control Plan to the OWNER's Representative, which includes the following items.
 1. Outline of permit acquisition procedure for lane closures.
 2. Methods for proper signing and barricades, which comply with local requirements and the OWNER.
 3. Site CONTRACTOR emergency phone numbers.
- B. Submit schedules of planned work on a weekly basis for the upcoming week, including a map in PDF format showing the area of work, and a map and list of streets being affected. Submittal should be provided by electronic mail to the OWNER. Provide 24-hour notice for deviations from the plan that are not caused by weather or natural causes.
- C. CONTRACTOR to submit confined space entry plan, certifications and hazardous atmosphere training certifications, if applicable.
- D. The work described in this Scope of Work, including any internal sewer or manhole inspections, shall meet the minimum requirements as presented in the OSHA Standard, Title 29 CFR 1910.146, Permit Required Confined Spaces. Upon commencement of the Work, copies of all confined space entry permits must be submitted to ENGINEER. CONTRACTOR shall notify the OWNER or delegated representative each day by phone, email or fax when it is necessary for CONTRACTOR to enter a manhole(s). CONTRACTOR shall identify all manholes that CONTRACTOR plans on entering that day by street location and manhole number.

- E. CONTRACTOR must submit to ENGINEER for OWNER's review and approval, sample videos and digital photographs at the beginning of the project that shows no less than 20 line segments and ten manholes. Submitted videos and digital photographs will be reviewed to determine expected quality of data. All data must be submitted following the pipe and manhole/structure identifier codes approved by the OWNER and described herein.
- F. Final sewer main and manhole inspection reports, digital video/photographs and data shall be submitted in accordance with the requirements specified in Section 3 of this specification.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. CONTRACTOR: Performed work successfully for at least three other projects, within last 5 years, with at least 500 manholes.
2. Crew Chief: Minimum of 5 years of experience on projects similar to this Project with at least 250 manholes and experience using proposed equipment for this Project.

1.05 NOTIFICATIONS

A. Notify OWNER:

1. Submit schedules of planned work on a weekly basis for the upcoming week, including a map in PDF format showing the area of work, and a map and list of streets being affected. Submittal should be provided by electronic mail to the OWNER. Provide 24-hour notice for deviations from the plan that are not caused by weather or natural causes.
2. Immediately, when a collapsed pipe or other pipe failure is identified.
3. Immediately, if the conditions for inspection are found to be unsafe or impractical.
4. Immediately, if a manhole is buried, cannot be found or cannot be accessed. Along with the manhole name, provide a map showing the location of the manhole and what procedures were used to attempt to locate the manhole.
5. Inspection crews shall immediately notify the OWNER and/or on-site inspector of any defects posing imminent danger to the public (missing lids, covers broken during inspection, sink holes, etc.) and any observed pipe blockages, active surcharging, evidence of surcharging, or potential overflow conditions.
6. If the pipe configuration in the field is different than shown in OWNER supplied GIS data. The notification shall include a diagram clearly indicating the location of structures in relation to immediately adjacent structures in PDF format via electronic mail. In addition, the information should be updated in the GIS database and will be provided to the OWNER at the time of submittal of the manhole inspection data relevant to that particular area or manhole structure in order to facilitate review and timely update of the OWNER's GIS to match the manhole inspection database.

B. Notify the public and coordinate with homeowners:

1. A minimum of 48 hours prior to the inspection of any line segment, distribute door-to-door an OWNER approved Homeowner Notification door hanger describing the work to be performed.
2. CONTRACTOR must use approved magnetic car signs affixed to vehicles at all times during the project to identify affiliation with the City of Columbia, SC.

PART 2 - PRODUCTS

2.01 ZOOM CAMERA EQUIPMENT

- A. Above ground photographs for Level 2 manhole inspections shall be performed using a digital camera (or the still photo function on the zoom camera). Zoom cameras shall be used for all manhole interior and connecting pipe video/photographs. The camera shall be operative in 100 percent humidity conditions and blowers shall be used if necessary to create a clear view of the pipe. Camera shall be operative in a hazardous and corrosive environment.
- B. The camera used for the inspection shall be one specifically designed and constructed for such inspection. Lighting for the camera shall be suitable to allow a clear video picture for the entire periphery of the pipe. The camera and other components shall be capable of producing a high resolution video picture and should also have a still photo function. Picture quality and definition shall be to the satisfaction of the ENGINEER and if unsatisfactory, inspection shall be performed again with the appropriate changes made as designated by the Inspector at no additional cost.
- C. The zoom camera shall be specifically designed and constructed for sewer inspection. The camera shall have an optical zoom range of 25X (minimum) and digital zoom range of 1X through 12X (minimum). The camera shall have a total zoom ratio of 300X. The camera shall have auto focus, auto exposure and manual override for focus and camera aperture.
- D. The camera light head shall include a high-intensity discharge lighting system to allow illumination of the pipe. Lighting for the camera shall illuminate the entire periphery of the sewer for a minimum distance of 75 feet. In the event sufficient site distance cannot be achieved, operator shall notify ENGINEER to determine if internal CCTV inspection is required.
- E. Zoom camera shall be capable of positioning the camera a minimum of 20 feet below grade.
- F. The camera equipment/software shall be capable of producing digitized images of all manhole defects and sewer line service connections in .jpeg format. The digital photographs (.jpegs) shall be at least 50 kilobytes in size. The digital photographs (.jpeg) shall have a minimum resolution of at least 1024x768 at a 4:3 aspect ratio or 1920 x 1080 at a 16:9 format. The digital photographs shall become the property of the OWNER.

PART 3 - EXECUTION

3.01 PREPARATION

- A. A minimum of 48 hours prior to the inspection of any line segment, distribute door-to-door an OWNER approved Homeowner Notification door hanger describing the work to be performed. On the day of inspection and prior to the inspection, knock on the doors of all properties that will require entering their private property to access the manholes which will potentially be impacted by the work and notify occupants of this inspection.

CONTRACTOR shall insert a measuring rod into the interior of the manhole to verify rim to invert distance measurements of the manhole, as well as the invert of each adjoining pipe.

- B. CONTRACTOR shall provide X, Y, and Z coordinates and elevations with survey grade accuracy as described below:
 - 1. All coordinates obtained will be provided in the latest edition of SC State Plane Coordinates and all elevations will be provided to the City in NAVD '88 and NGVD '29 datum.
 - 2. All coordinate data collected will be accurate to within 0.15' (fifteen-hundredths of a foot) to meet the now current Standards of Practice Manual for Land Surveying in South Carolina as published by SCLLR.
 - 3. At the completion of the field surveying activities, surveyor will prepare a surveyor's report containing quantity counts of the items surveyed and a narrative describing the survey procedures used. The final report will be signed and sealed by a licensed land surveyor in the state of South Carolina.

3.02 LEVEL 2 MANHOLE INSPECTION PROCEDURES

- A. Manhole inspections must meet all requirements of a NASSCO MACP Level 2 inspection. All required forms and photographs must be completed in accordance with the LEVEL 2 requirements. The Manhole Component Defect Form and all of its required fields must also be completed to meet the requirements of a LEVEL 2 inspection. All mandatory and available non-mandatory fields must be collected unless written approval of the ENGINEER is obtained.
- B. CONTRACTOR shall take digital still photographs of the manhole surface as follows:
 - 1. One close-up photograph of the manhole frame and cover to see overall condition. Photograph shall be taken of any indications of previous overflows such as water marks and paper or other debris typical of sewer overflows.
 - 2. Two "area" photographs of manhole frame and cover showing location within the roadway, shoulder or easement as appropriate. One photograph shall be oriented in the direction of the upstream pipe and shall show the pipeline cover and easement condition. One photograph shall be oriented in the direction of the downstream pipe and shall show the pipeline cover and easement condition. The area photographs should show the manhole visible in the foreground where possible.
- C. It is the intent of the Scope of Work to inspect the full height of sewer of each manhole. If, during the inspection operation, the camera will not pass through the entire manhole section, notify the OWNER or the OWNERs representative and remove the blockage. No additional payment shall be made for multiple set-ups required due to an obstruction.

1. OWNER makes no guarantee that all of the manholes proposed to be inspected are clear for the passage of the camera set-up. The equipment, tools and methods used for securing the passage of the camera are to be at the discretion of CONTRACTOR, with the approval of ENGINEER.
- D. CONTRACTOR shall take digital still images of each defect, construction features and service connections as specified.
- E. Adjust the camera such that the camera lens is always centered in the manhole being investigated.
- F. Adequate lighting must be provided for good quality pictures.
- G. Upon lowering the video camera into the manhole the camera should record video a full 360 degrees of the manhole to facilitate the inspection of the manhole and identification of all defects. CONTRACTOR shall start the video with the camera pointed due north and should continue in a clockwise direction.
- H. Video files (.mpg) must be submitted in one continuous video section for each manhole inspection, and not in multiple files, unless specifically approved by ENGINEER. The video files shall be named per section 3.07.
- I. Stop the camera at all connections and pan at such an angle that an internal view of each pipe can be seen. Separate video files (.mpg) should be recorded for the upstream and downstream connecting pipes. Additional requirements for pipeline inspections are detailed in Section 3.03.
- J. Photograph all significant defects and features of the manhole interior as follows:

Photos of any defects within the manhole shall be taken with the component and clock position identified (NOTE: 6 o'clock shall always reference the lowest pipe that is LEAVING the manhole. The clock location and approximate depth of the defect shall be recorded. The inspection crew shall determine the types of defects within the manhole, and take a photograph of each defect. The manhole chimney, cone, wall, bench and channel will be inspected for structural integrity, signs of I/I and the presence of roots. All documentation shall follow the latest version of the "current" NASSCO MACP Exchange format. Each manhole shall be coded in accordance with the current NASSCO MACP standards, and fields should utilize standard MACP codes and follow the examples and guidance provided in Section 02778.
- K. The pictures taken of the entire inside periphery of the manhole shall be clear and visible. Picture quality and definition shall be to the satisfaction of ENGINEER, and if unsatisfactory, the equipment shall be removed and no payment made for the unsatisfactory inspection.
- L. CONTRACTOR shall verify the X, Y coordinates that will be supplied in GIS format by the OWNER. The CONTRACTOR shall use GPS technology to collect accurate coordinates for each of the manholes in the study area to provide precise X, Y coordinates in accordance with MACP standards and in accordance with the Section 3.01.C of this specification document. A copy of the OWNER's GIS database shall be updated with the changes found in the field pursuant to the City's requirements.

3.03 PIPE INSPECTION WITH DIGITAL ZOOM POLE CAMERA

- A. Each pipe entering and exiting the manhole shall be photographed where possible and inspected to determine diameter, pipe material, debris levels and rim to invert measurements to within a 0.1 foot accuracy. Drop manholes shall have the drops inspected as well. All required NASSCO MACP inspection fields for pipe connections shall be populated and available additional inspection fields to be recorded, in addition to all required PACP inspection fields for pipes (see Section 02731 for further detail on the database requirements)including, but not limited to:
 - 1. The pipe diameter and verify the pipe material observations if differences are noted between upstream and downstream manholes.
 - 2. Debris depth.
 - 3. Connecting structure number of manhole or cleanout, service line clock position, stub-out clock position, etc.
 - 4. Pipe seal roots (using approved MACP codes).
 - 5. Observed pipe defects, obstructions, roots, etc. (using PACP codes).
- B. The camera shall be positioned in the manhole channel to provide maximum illumination of the pipeline. CONTRACTOR shall zoom down the pipe steadily, stopping at all defects for condition assessment. If additional zooming is required to visually inspect a defect, CONTRACTOR shall re-position camera to the centerline of the pipe prior to continuing inspections.
- C. CONTRACTOR shall collect a continuous video inspection of each sewer and document and visible defects. CONTRACTOR will supply the digital .mpg video files on external hard drives as approved by the ENGINEER. The CONTRACTOR will document the visible construction features and defects per NASSCO PACP standards and estimate the distance by counting the number of pipe joints as the zoom progresses down the pipe. The approximate clock position shall also be documented.
- D. CONTRACTOR shall re-measure the pipe diameter and verify the pipe material observations if differences are noted between upstream and downstream manholes.
- E. CONTRACTOR to denote in the PACP Inspections table under 'Additional_Info' that this is a by writing in 'ZOOM' in all capital letters in this field for all entries related to zoom camera inspections.

3.04 SEWER FLOW CONTROL

- A. In accordance with Sewer Flow Control specification Section 02965.

3.05 CLOSEOUT ACTIVITIES

- A. Once the inspection is complete the field crew shall make certain that the frame is clean and does not have any debris preventing a proper cover fit. The manhole lid shall be replaced and any displaced items moved back into place.
- B. CONTRACTOR shall submit in electronic format digital videos, photos, and inspection reports to ENGINEER in accordance with the data delivery requirements of this specification, Section 3.07.
- C. If digital videos are of such poor quality that ENGINEER is unable to evaluate the condition of the manhole, or locate the sewer connections, CONTRACTOR shall be required to re-inspect the manhole and provide new digital videos of good quality, at no additional cost to OWNER.

3.06 INSPECTION SOFTWARE

- A. All inspections shall use software that is capable of providing complete survey reports in compliance with current version of NASSCO MACP/PACP software. OWNER has no intent to specify which software the CONTRACTOR should use, but requires the submitted database to be fully compliant with MACP/PACP. No payment will be rendered for improperly formatted data.

PART 4 DELIVERABLES

4.01 MANHOLE AND PIPE INSPECTION REPORTS AND DATA REQUIREMENTS

- A. Manhole Inspection Reports shall include the manhole identification number, depths, construction material, total survey length, and a photo of all incoming and outgoing pipe diameters and depths. The inspection crew shall complete the manhole plan view noting all connecting pipes. Any special observations or notes may be added to the field form. Influent and effluent lines in each manhole shall be compared to the existing map and corrections noted in the field form. A sample template of a Manhole Inspection Report will be provided by the OWNER. Each inspection report shall be provided in PDF format to the OWNER with the monthly data submittals.
- B. All reports and/or submittals shall adhere to NASSCO MACP/PACP Standards.
- C. CONTRACTOR shall provide a rating of each pipe and manhole per the ENGINEER's recommendations.

- D. ENGINEER to provide inspection data on a monthly basis with the database and data on an external hard drive. The ENGINEER to provide two hard drives on an alternating monthly basis. The submittals shall be cumulative (i.e. each successive database delivery will include previous deliveries as well). CONTRACTOR shall provide OWNER with a final external hard drive capable of storing all anticipated data for the project upon completion. The final hard drive shall be submitted on the first monthly submittal with the first month of data loaded and will become property of the OWNER upon project completion. Data to be submitted shall include: 1) NASSCO MACP/PACP Database files, 2) .jpg files (still photos), 3).mpg files (videos) for each manhole and upstream/downstream pipe segment and 4) a PDF of each Manhole Inspection Report.
- E. Each database submittal shall indicate the range of dates for which the database is being submitted as well as a list of new items as of the last submittal so that the OWNER may separate out and review the newly delivered records from previous submittals in an Excel format.

The databases shall be cumulative, with one database each for MACP Level 2 inspections, one for PACP zoom camera inspections, and one for PACP CCTV inspections. Each subsequent submittal shall be added into these databases. Throughout the duration of the project, should ENGINEER discover inaccuracies in any of the videos, CONTRACTOR shall re-inspect those manholes and/or pipes at no additional cost to the ENGINEER or OWNER

- F. . Each manhole has been given unique manhole identifications (MH_Asset_ID) per OWNER guidelines, and the name of each database file shall be that unique MH_Asset_ID. If an unnamed manhole is found, the letter “A” will be added to the end of the MH_Asset_ID to form a new MH_Asset_ID. The data / video files shall then be re-named to include the new MH ID, and a new inspection shall be started from the new MH_Asset_ID. If more than one unnamed manhole is found between two named manholes, subsequent new MH_Asset_ID’s will be formed using the letters “B”, “C” etc. Spaces and special characters are not allowed in the unique ID codes. The newly located manholes must be added to the manhole inspection database using the same new identification codes.
- G. Zoom camera video files for connecting pipelines between inspected manholes should be given the nomenclature of Z_DIRECTION_UPSTREAM STRUCTURE:DOWNSTREAM STRUCTURE_YYYYMMDD.MPG. Subsequent files for the same reach shall include suffixes 1, 2, 3 etc. separated by underscore. If there exists more than one sewer between the upstream and downstream structures identified, the filename will include a path identifier indicating which sewer is referenced. This path identifier will be in sequence, as looking downstream, from left to right e.g., 1 is the first sewer on left and 2 is sewer on right, looking downstream in a two-sewer parallel reach. This identifier is added following the downstream structure ID and separate by underscores. For example:

Z_IN_SS-SR02-01674:SS-SR02-01675_20120103.MPG and Z_OUT_SS-SR02-01675:SS-SR02-01680_20120103_1.MPG (Z=zoom, IN or OUT = direction of pipe relative to access structure, SS-SR02-01674=upstream structure ID on first example, SS-SR02-01675=downstream structure ID on first example and upstream structure ID on second example, YYYYMMDD=8-digit date, 1= subsequent video taken for reach SS-SR02-01675:SS-SR02-01680_20120103

Example for outflow zoom file where two outflow pipes go to the same downstream structure:

Z_OUT_SS-SR02-01675:SS-SR02-01680_2_20120103.MPG (Z=zoom, OUT =

direction of pipe relative to access structure, SS-SR02-01675=upstream structure ID,SS-SR02-01680=downstream structure ID, 2=second pipe out having the same upstream and downstream structure IDs and being the second from left looking downstream; YYYYMMDD=8-digit date)

- H. The results of each inspection must be delivered in a database format using the MACP and PACP template databases provided by the OWNER. The database filename will use the following format using upper case letters:

M_XYZ_BR02_SS7207_YYYYMMDD.MDB (where M=MACP database; XYZ=Contractor name; BR02 = Example Basin_ID, SS7207 = Example PO_Number, YYYYMMDD=8-digit date)

- I. During inspections, structures shall be free of steam, fog, water vapor or other conditions that will impact the quality of photographs. Blowers shall be used if necessary. Photographs shall be named according to the photograph naming conventions as follows:

Area Photo (1): Structure ID, A, Date, Photo Number, JPG

Example: SS-SR02-01673-MHA_YYYYMMDD_0001.JPG (SS-SR02-01673 = structure ID; MH=manhole indicator; A=area indicator; YYYYMMDD=8-digit date; 0001= image index)

Upstream Photo (2): Structure ID, US, Date, Photo Number, JPG

Example: SS-SR02-01673-MHUS_YYYYMMDD_0001.JPG (SS-SR02-01673 = structureID; MH=manhole indicator;US=direction indicator; YYYYMMDD=8-digit date; 0001= image index)

Downstream Photo (3): Structure ID, DS, Date, Photo Number, JPG

Example: SS-SR02-01673-MHDS_YYYYMMDD_0001.JPG (SS-SR02-01673 = structure ID; MH=manhole indicator;DS=direction indicator; YYYYMMDD=8-digit date; 0001= image index)

Internal Photo: Structure ID, I, Date, Photo Number, JPG

Example: SS-SR02-01673-MHI_YYYYMMDD_0001.JPG (SS-SR02-01673 = structure ID; MH=manhole indicator;I=internal indicator; YYYYMMDD=8-digit date; 0001= image index)

Structure Defect Photo: Structure ID, M, Date, Photo Number, JPG

Example: SS-SR02-01673-MHM_YYYYMMDD_0015.JPG (SS-SR02-01673 = structure ID; MH=manhole indicator;M=defect indicator; YYYYMMDD=8-digit date; 0015= image index)

Pipe Photo: Structure ID, Date, Photo Number, JPG

Example: IN_SS-SR02-01673:SS-SR02-01674_YYYYMMDD_0002.JPG (IN (or OUT) = direction of pipe relative to access structure; SS-SR02-01673:SS-SR02-01674 = structure ID for pipe comprised of upstream structure ID:downstream structure ID; YYYYMMDD=8-digit date; 0001= image index) See Section 3.07 G for naming of parallel pipes between identical upstream and downstream structures.

- J. In all filenames, the image index allows multiple images to be taken sequentially from 0001, 0002, 0003, etc. If site is revisited for the same intended purpose (ie-pre-rehab manhole inspection), the indexing shall continue where previous visit's image indexing ended plus an index value of 1

- K. Digital files of all field data collection forms (if used by CONTRACTOR) should be delivered in PDF format and shall have file names that include the same unique identifier as the database submittal so that they can easily be related to the database and digital photograph/video submittals, if a naming convention is not specified.

- L. The contractor shall contact the Owner's GIS administrator to obtain an ID for any structural asset, with an unknown ID, constructed during or later than 2013.

END OF SECTION

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SECTION 02778
DATABASE TEMPLATE DESCRIPTION MACP

PART I GENERAL

1.01 DATABASE TEMPLATE

- A. The attached database template (version 6) and formatting as specified must be used to document and deliver the results of all work related to manhole inspections and related inspections. A description is provided in this specification for each field, and formatting notes and examples for fields to provide additional guidance. Examples are provided for fields that are open that required additional clarity, and the lack of an example does not imply that the field can be left blank.
- B. All codes and descriptions must be used pursuant to the applicable specifications and the valid value tables within the attached database template.
- C. All database fields must be populated unless noted as optional in the Description field of the database table.

PART 2 TABLE FORMAT AND DESCRIPTION

- A. The following tables show available Field Names, the data type allowed, field size, a description of the Field, additional formatting notes if needed, and an example if provided.

2.01 INSPECTIONS TABLE

- A. This table shall be used to store the primary information regarding the inspection.

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
InspectionID	Long Integer	4	This field is automatically populated when any inspection information is entered. The number generated must be entered in the InspectionID field of the Conditions table for all conditions recorded during the inspection		
Surveyed_By	Text	25	Name of individual conducting survey	Name of Contractor_Inspector's initials	Hydrostructures_A AA
Certificate_Number	Text	15	NASSCO PACP # of Surveyor		U-1211-1238
Owner	Text	30	Owner of collection system surveyed		City of Columbia
Customer	Text	30	Entity commissioning the survey		City of Columbia

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Drainage_Area	Text	15	Common name of drainage area	Basin Name	SR05
Sheet_Number	Long Integer	4	Number used to identify individual surveys done within a group	Leave blank unless applies	
PO_Number	Text	15	Customer's Purchase Order Number	CIP number	SS7207
Date	Date/Time	8	Inspection Date	yyyymmdd	20130620
Time	Date/Time	8	Time of inspection	hh:mm (24 hour clock, military time)	15:30 (i.e. 3:30 PM)
Street	Text	64	Street Number and Name	Indicate street name when applicable i.e., if asset is in street or crosses the street or can be associated with an address. Use NUMBER PREDIRECTIONAL STREET SUFFIX POSTDIRECTIONAL with no punctuation and all uppercase letters. Alleys or right-of-ways between two streets should remain unassigned. Fields, parks, other open areas should receive a positive entry of "OTHER".	321 MAIN ST
City	Text	64	City name where sewer located	Enter Columbia, Irmo, or Lexington	Irmo
Location_Details	Text	255	Descriptive explanation of sewer location		Manhole is located in railroad easment near...; Manhole is located at the zoo on the northwest corner of elephant cages...
Manhole_Number	Text	25	Client provided designation for upstream manhole	Each manhole has been given unique structure identifications per OWNER guidelines, and the name of each database ID shall be that unique structure ID. If an unnamed structure is found, the letter "A" will be added to the end of the structure ID to form a new structure. If more than one unnamed manhole is found between two named manholes, subsequent new structure ID's will be formed using the letters "B", "C" etc. Spaces and special characters are not allowed in the unique ID codes. For example, SS-SR02-03123 or SS-SR02-03123A	SS-SR02-03123A

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Rim_to_Invert	Single	4	Distance (ft to nearest tenths of ft) or (meters to 2 decimal places max) from rim to invert of outgoing pipe	Record value as feet to nearest tenth of a foot.	8.4
Grade_to_Invert	Single	4	Distance (ft to nearest tenths of ft) or (meters to 2 decimal places max) from average grade to invert of outgoing pipe	Record value as feet to nearest tenth of a foot.	10.2
Rim_to_Grade	Single	4	Distance (ft to nearest tenths of ft) or (meters to 2 decimal places max) from rim to lowest grade of manhole (can be negative number)	Record value as feet to nearest tenth of a foot.	1.2
MH_Use	Text	15	Purpose of sewer	Validated entry list e.g., Combined, Force Main, Other	Combined
Year_Built	Long Integer	4	Year sewer surveyed was constructed		
Year_Renewed	Long Integer	4	Year sewer surveyed was renewed		
Media_Label	Text	64	Unique identifier for tape/media		
Purpose	Text	64	Reason for conducting survey	Validated entry list e.g., Capital Improvement Program Assessment, Infiltration and Inflow investigation, Maintenance related	Capital Improvement Program Assessment
Category	Text	2	Importance of sewer, to be provided by client	Validated entry list e.g., A, B, or C	A
Pre-Cleaning	Text	15	Type of preparatory cleaning conducted prior to survey	Validated entry list e.g., Heavy Cleaning, Jetting, No Pre-Cleaning	Heavy Cleaning
Date_Cleaned	Date/Time	8	Date when sewer was cleaned prior to survey		
Weather	Text	12	Weather conditions when survey conducted [Ground Conditions]	Validated entry list e.g., Damp, Dry, Heavy Rain	Damp
Location_Code	Text	30	General description of ground cover of surveyed segment	Validated entry list e.g., Airport, Alley, Building	Airport
Additional_Info	Text	255	Supplemental info regarding survey or segment		
Surface_Type_Asphalt	Yes/No	1			
Surface_Type_ConcretePavement	Yes/No	1			
Surface_Type_ConcreteCollar	Yes/No	1			

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Surface_Type_GrassDirt	Yes/ No	1			
Surface_Type_Gravel	Yes/ No	1			
Surface_Type_Other	Yes/ No	1			
Potential_for_Runoff	Text	50		Validated entry list e.g., Inundated, None, Ponding	Inundated
Access_Type	Text	50		Validated entry list e.g., Catch Basin, Clean Out House, Clean Out Mainline	Catch Basin
Northing	Text	50		All coordinate data collected will be accurate to within 0.15' (fifteen-hundredths of a foot) to meet the now current Standards of Practice Manual for Land Surveying in South Carolina as published by SCLLR.	806354.16
Easting	Text	50		All coordinate data collected will be accurate to within 0.15' (fifteen-hundredths of a foot) to meet the now current Standards of Practice Manual for Land Surveying in South Carolina as published by SCLLR.	1946419.03
Elevation	Text	50			150.25
Coordinate_System	Text	50		All coordinates obtained will be provided in the latest edition of SC State Plane Coordinates and all elevations will be provided to the City in NAVD '88 and NGVD '29 datum.	
GPS_Accuracy	Text	50		Validated entry list e.g., Survey Level, Sub-Meter, Nearest Meter	Survey Level
Inspection_Status	Text	50		Validated entry list e.g., Buried or Marked, Descent Inspection, No Access	Buried or Marked
Evidence_Surcharge	Text	50		Validated entry list e.g., No, Not Known, Yes	No
IsImperial	Yes/ No	1		Use imperial units.	
Cover_Shape	Text	50		Validated entry list e.g., Circular, Other, Oval	Circular
Cover_Size	Single	4			
Cover_Size_Width	Single	4			
Cover_Material	Text	50		Validated entry list e.g., Cast Iron, Concrete (non-reinforced), Concrete (reinforced)	Cast Iron
Cover_Type_Solid	Yes/ No	1			
Cover_Type_Vented	Yes/ No	1			

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Cover_Type_Gasketed	Yes/ No	1			
Cover_Type_Bolted	Yes/ No	1			
Cover_Type_Inner_Cover	Yes/ No	1			
Cover_Type_Locking	Yes/ No	1			
Cover_Type_Hatch_Single	Yes/ No	1			
Cover_Type_Hatch_Double	Yes/ No	1			
Cover_Type_Lamphole	Yes/ No	1			
Hole_Diameter	Text	50		Validated entry list e.g., <= 1/2 inch (13mm), > 1 1/2 inch (38mm) <= 2 inch(50mm), > 1 inch (25mm) <= 1 1/2 inch (38mm)	<= 1/2 inch (13mm)
Hole_Number	Integer	2			
Cover_Bearing_Surface_Dia	Single	4			
Cover_Bearing_Surface_Dia_Width	Single	4			
Cover_Frame_Fit	Text	50		Validated entry list e.g., Good, Oversized, Rocks/Wobbles	Good
Cover_Condition_Sound	Yes/ No	1			
Cover_Condition_Cracked	Yes/ No	1			
Cover_Condition_Broken	Yes/ No	1			
Cover_Condition_Corroded	Yes/ No	1	Corroded/Pitted		
Cover_Condition_BoltsMissing	Yes/ No	1			
Cover_Condition_Missing	Yes/ No	1			
Cover_Condition_Restraint_Missing	Yes/ No	1			
Cover_Condition_Restraint_Defective	Yes/ No	1			
Cover_Insert_Type	Text	50		Validated entry list e.g., Metal, None, Other	Metal
Insert_Condition_Sound	Yes/ No	1			
Insert_Condition_PoorlyFitting	Yes/ No	1			
Insert_Condition_Cracked	Yes/ No	1	Cracked/Torn/Holes		
Insert_Condition_Leaking	Yes/ No	1			
Insert_Condition_InsertFell	Yes/ No	1			

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Insert_Condition_Corroded	Yes/No	1			
Adjustment_Ring_Type	Text	50		Validated entry list e.g., Adjustable, None, Solid	Adjustable
Adjustment_Ring_Material	Text	50		Validated entry list e.g., Cast Iron, Concrete (non-reinforced), Concrete (reinforced)	Cast Iron
Ring_Condition_Sound	Yes/No	1			
Ring_Condition_Cracked	Yes/No	1			
Ring_Condition_Broken	Yes/No	1			
Ring_Condition_Corroded	Yes/No	1	Corroded/Pitted/Worn		
Ring_Condition_Leaking	Yes/No	1			
Ring_Condition_PoorInstall	Yes/No	1	Poor Installation		
Adjustment_Ring_Height	Single	4			
Frame_Material	Text	50		Validated entry list e.g., Cast Iron, Concrete (non-reinforced), Concrete (reinforced)	Cast Iron
Frame_Bearing_Surface_Width	Single	4			
Frame_Bearing_Surface_Depth	Single	4			
Frame_Clear_Open_Diam	Single	4			
Frame_Condition_Sound	Yes/No	1			
Frame_Condition_Cracked	Yes/No	1			
Frame_Condition_Broken	Yes/No	1			
Frame_Condition_Missing	Yes/No	1			
Frame_Condition_Corroded	Yes/No	1	Corroded/Pitted/Worn		
Frame_Condition_Coated	Yes/No	1			
Seal_Condition_Sound	Yes/No	1			
Seal_Condition_Cracked	Yes/No	1			
Seal_Condition_Loose	Yes/No	1	Loose/Not Attached		
Seal_Condition_Offset	Yes/No	1			
Seal_Condition_Missing	Yes/No	1			
Frame_Offset_Distance	Single	4		inches to nearest tenth	

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Frame_Seal_Inflow	Text	50		Validated entry list e.g., Infil Dripper, Infil Gusher, Infil Runner	Infil Dripper
Frame_Depth	Single	4		inches to nearest tenth	
Chimney_Material1	Text	50		Validated entry list e.g., Asbestos Cement, Brick, Corrugated Metal	Asbestos Cement
Chimney_Material2	Text	50		Validated entry list e.g., Asbestos Cement, Brick, Corrugated Metal	Asbestos Cement
Chimney_InI	Text	50	Chimney I/I	Validated entry list e.g., Infil Dripper, Infil Gusher, Infil Runner	Infil Dripper
Chimney_Clear_Opening	Single	4			
Chimney_Depth	Single	4		feet to nearest tenth	
Chimney_Lining_Interior	Text	50		Validated entry list e.g., Bitumastic, Cementitious, Cured In Place	Bitumastic
Chimney_Lining_Exterior	Text	50		Validated entry list e.g., Bitumastic, Cementitious, Cured In Place	Bitumastic
Cone_Type	Text	50		Validated entry list e.g., Conical Centered, Conical off centered, Flattop	Conical Centered
Cone_Material	Text	50		Validated entry list e.g., Asbestos Cement, Brick, Corrugated Metal	Asbestos Cement
Cone_Depth	Single	4		feet to nearest tenth	
Cone_Lining_Interior	Text	50		Validated entry list e.g., Bitumastic, Cementitious, Cured In Place	Bitumastic
Cone_Lining_Exterior	Text	50		Validated entry list e.g., Bitumastic, Cementitious, Cured In Place	Bitumastic
Wall_Diam	Integer	2			
Wall_BySize	Integer	2			
Wall_Material	Text	50		Validated entry list e.g., Asbestos Cement, Brick, Corrugated Metal	Asbestos Cement
Wall_Depth	Single	4		feet to nearest tenth	
Wall_Lining_Interior	Text	50		Validated entry list e.g., Bitumastic, Cementitious, Cured In Place	Bitumastic
Wall_Lining_Exterior	Text	50		Validated entry list e.g., Bitumastic, Cementitious, Cured In Place	Bitumastic
Bench_Present	Text	50		Validated entry list e.g., None, Partial, Yes	None
Bench_Material	Text	50		Validated entry list e.g., Asbestos Cement, Brick, Corrugated Metal	Asbestos Cement

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Bench_Lining	Text	50		Validated entry list e.g., Bitumastic, Cementitious, Cured In Place	Bitumastic
Channel_Installed	Text	50		Validated entry list e.g., No, Not Known, Yes	No
Channel_Material	Text	50		Validated entry list e.g., Asbestos Cement, Brick, Corrugated Metal	Asbestos Cement
Channel_Type	Text	50		Validated entry list e.g., Formed, Insert, Pipe	Formed
Channel_Exposure	Text	50		Validated entry list e.g., Closed, Fully Opened, Partially Opened	Closed
Step_Number	Integer	2			
Step_Material	Text	50		Validated entry list e.g., Brick, Metal, Other	Brick
WorkOrder	Text	20	Work order or Project reference for Asset Management		
Project	Text	64	Project reference for Asset Management		
PressureValue	Single	4	Grouting pressure value		
AdditionalComponentInfo	Text	255	Additional information to record in the Manhole Component Observation section		
InspectionLevel	Text	50	Currently Level 1 or Level 2	Validated entry list e.g., Level 1, Level 2	Level 2

2.02 MH INSPECTIONS MEDIA TABLE

- A. This table shall be used to store information regarding the digital photographs and videos taken for inspections.
- B. This table should be completed along with the inspections table.

MH_Inspections_Media			
Field Name	Data Type	Field Size	Description
MediaID	Long Integer	4	
InspectionID	Long Integer	4	
Image_Name	Text	255	
Image_Location	Text	255	
Video_Name	Text	255	
Video_Location	Text	255	

2.03 MH CONDITIONS TABLE

- A. This table shall be used to store information regarding the conditions of manholes in the system.
- B. This table should be completed along with the inspections table.

MH_Conditions			
Field Name	Data Type	Field Size	Description
ConditionID	Long Integer	4	This field is automatically populated when any condition information is entered.
InspectionID	Long Integer	4	Software provided designation for this inspection (THIS FIELD USED TO JOIN TABLES)
Distance	Single	4	Distance is measured to one decimal place to feature location whether it is in feet or meters
Counter	Single	4	Time into the video of the identified condition, in seconds
MH_Component_ID	Text	50	
MACP_Code	Text	5	Combination of Group/Descriptor and Modifier/Severity in a single data field
Continuous	Text	3	Continuous defect number with start (S) and finish (F) matching to denote beginning and ending of defect
Value_1st_Dimension	Single	4	Dimensions of defects to nearest Inch or mm
Value_2nd_Dimension	Single	4	Used for intrusion of tap or width of non-circular connecting pipe to nearest inch or mm
Value_Percent	Long Integer	4	Used to express percentage value of defects
Joint	Yes/No	1	Indicates a defect located near a joint
Step	Yes/No	1	Indicates a defect located near a step
Clock_At_From	Integer	2	Clock At/From Position of defect/observation
Clock_To	Integer	2	Clock To Position of defect/observation
Remarks	Text	255	Additional info to describe defect/coding
VCR_Time	Text	6	Time into the video of the identified condition in HHMMSS format with 0 used as space holder.

2.04 MH CONDITIONS MEDIA TABLE

- A. This table shall be used to store information regarding the digital photographs and videos taken for inspections relating to manhole conditions.

B. This table should be completed along with the inspections table.

MH_Conditions_Media					
Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
MediaCondID	Long Integer	4	This field is automatically populated when any media (picture or movie file) is saved.		
ConditionID	Long Integer	4	Software provided designation for this inspection (THIS FIELD USED TO JOIN TABLES)		
Image_Reference	Text	255	If digital snapshots are taken, the name or number of the image file.	<p>Photographs shall be named according to the photograph naming conventions as follows: Area Photo (1): Structure ID, A, Photo Number, JPG Example: SS-SR02-01673-MHA_YYYYMMDD_0001.JPG (SS-SR02-01673 = structure ID; MH=manhole indicator; A=area indicator; YYYYMMDD=8-digit date; 0001= image index)</p> <p>Upstream Photo (2): Structure ID, US, Photo Number, JPG Example: SS-SR02-01673-MHUS_YYYYMMDD_0001.JPG (SS-SR02-01673 = structure ID; MH=manhole indicator; US=direction indicator; YYYYMMDD=8-digit date; 0001= image index)</p> <p>Downstream Photo (3): Structure ID, DS, Photo Number, JPG Example: SS-SR02-01673-MHDS_YYYYMMDD_0001.JPG (SS-SR02-01673 = structure ID; MH=manhole indicator; DS=direction indicator; YYYYMMDD=8-digit date; 0001= image index)</p> <p>Internal Photo: Structure ID, I, Photo Number, JPG Example: SS-SR02-01673-MHI_YYYYMMDD_0001.JPG (SS-SR02-01673 = structure ID; MH=manhole indicator; I=internal indicator; YYYYMMDD=8-digit date; 0001= image index)</p>	SS-SR02-01673-MHDS_YYYYMMDD_0001.JPG

				<p>Structure Defect Photo: Structure ID, M, Photo Number, JPG Example: SS-SR02-01673-MHM_YYYYMMDD_0015.JPG (SS-SR02-01673 = structure ID; MH=manhole indicator;M=defect indicator; YYYYMMDD=8-digit date; 0015= image index)</p> <p>Pipe Photo: Structure ID, Photo Number, JPG Example: IN_SS-SR02-01673:SS-SR02-01674_YYYYMMDD_0002.JPG (IN (or OUT) = direction of pipe relative to access structure; SS-SR02-01673:SS-SR02-01674 = structure ID for pipe comprised of upstream structure ID:downstream structure ID; YYYYMMDD=8-digit date; 0001= image index) See Section 3.07 G for naming of parallel pipes between identical upstream and downstream structures.</p> <p>In all filenames, the image index allows multiple images to be taken sequentially from 0001, 0002, 0003, etc. If site is revisited, the indexing shall continue where previous visit's image indexing ended plus an index value of 1.</p>	
Image_Path	Text	255	Path to digital image reference file	Path neutral	
Video_File_Path	Text	255	For digital recordings, path of the video file associated with this condition relative to the data file	Path neutral	

Video_File	Text	255	For digital recordings, name of the video file associated with this condition relative to the data file	<p>Zoom camera video files for connecting pipelines between inspected manholes should be given the nomenclature of Z_DIRECTION_UPSTREAM STRUCTURE:DOWNSTREAM STRUCTURE_YYYYMMDD.M PG. Subsequent files for the same reach shall include suffixes 1, 2, 3 etc. separated by underscore. If there exists more than one sewer between the upstream and downstream structures identified, the filename will include a path identifier indicating which sewer is referenced. This path identifier will be in sequence, as looking downstream, from left to right e.g., 1 is the first sewer on left and 2 is sewer on right, looking downstream in a two-sewer parallel reach. This identifier is added following the downstream structure ID and separate by underscores. For example, Z_IN_SS-SR02-01674:SS-SR02-01675_20120103.MPG and Z_OUT_SS-SR02-01675:SS-SR02-01680_20120103_1.MPG (Z=zoom, IN or OUT = direction of pipe relative to access structure, SS-SR02-01674=upstream structure ID on first example, SS-SR02-01675=downstream structure ID on first example and upstream structure ID on second example, YYYYMMDD=8-digit date, 1=subsequent video taken for reach SS-SR02-01675:SS-SR02-01680_20120103)</p> <p>Example for outflow zoom file where two outflow pipes go to the same downstream structure: Z_OUT_SS-SR02-01675:SS-SR02-01680_2_20120103.MPG (Z=zoom, OUT = direction of pipe relative to access structure, SS-SR02-01675=upstream structure ID,SS-SR02-01680=downstream structure ID, 2=second pipe out having the same upstream and downstream structure IDs and being the second from left looking downstream; YYYYMMDD=8-digit date)</p>	Z_IN_SS-SR02-01674:SS-SR02-01675_20120103.MPG
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2.05 MH CONNECTIONS TABLE

- A. This table shall be used to store information regarding manhole connections identified during inspections.
- B. This table should be completed along with the inspections table.

MH_Connections			
Field Name	Data Type	Field Size	Description
ConnectionID	Long Integer	4	
InspectionID	Long Integer	4	
Pipe_Number	Long Integer	4	
Clock_Position	Integer	2	
Rim_To_Invert	Single	4	
Direction	Text	50	
Material	Text	50	
Shape	Text	50	
Diam_1	Integer	2	
Diam_2	Integer	2	Only required if shape is non-circular
Pipe_Condition	Text	50	
Seal_Condition	Text	50	
Special_Condition	Text	50	
Structure_ID	Text	26	
Comments	Text	255	

2.06 MH CONNECTIONS MEDIA TABLE

- A. This table shall be used to store information regarding the digital photographs and videos taken for inspections related to manhole connections.
- B. This table should be completed along with the inspections table.

MH_Connections_Media			
Field Name	Data Type	Field Size	Description
MediaCondID	Long Integer	4	This field is automatically populated when any media (picture or movie file) is saved.
ConnectionID	Long Integer	4	Software provided designation for this inspection (THIS FIELD USED TO JOIN TABLES)
Image_Reference	Text	255	If digital snapshots are taken, the name or number of the image file.
Image_Path	Text	255	Path to digital image reference file
Video_File	Text	255	For digital recordings, name of the video file associated with this condition relative to the data file
Video_File_Path	Text	255	For digital recordings, path of the video file associated with this condition relative to the data file

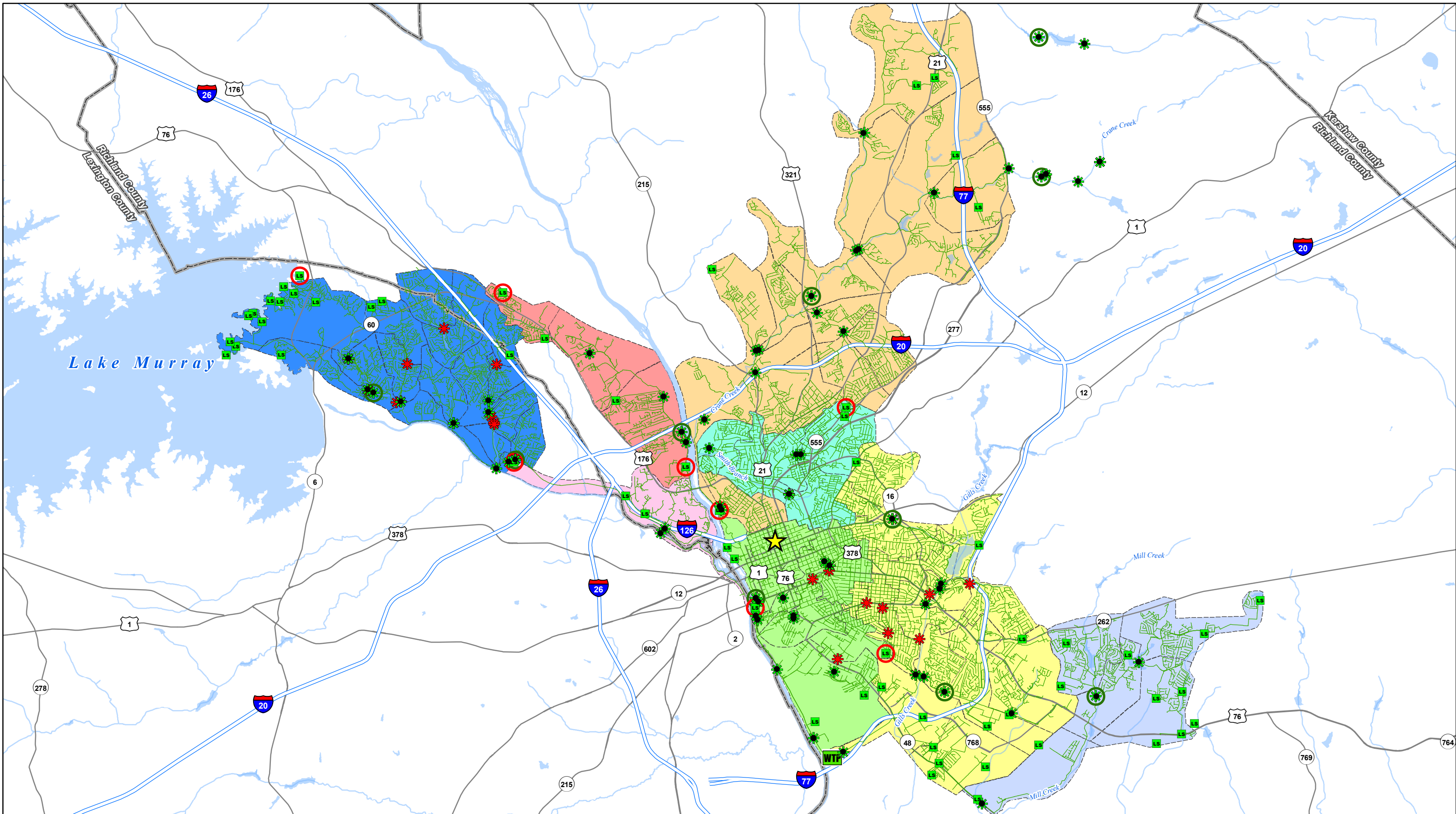
2.07 VALIDATED ENTRY TABLES

These tables shall be used to determine the valid entries allowed in certain fields as specified in the tables above. These tables are related to the above-mentioned tables within the database and provide predefined validated fields. The following tables are included in the database and should not be edited or modified:

1. Valid_CI_EOS
2. Valid_CNWABECH_Materials
3. Valid_Cover_Shapes
4. Valid_CVARFR_Materials
5. Valid_Inspection_Level
6. Valid_Locations
7. Valid_Materials
8. Valid_MH_Access_Points
9. Valid_MH_Accuracy_of_GPS
10. Valid_MH_Adjustment_Ring_Types
11. Valid_MH_Bench_Present
12. Valid_MH_Channel_Exposures
13. Valid_MH_Channel_Types
14. Valid_MH_Codes
15. Valid_MH_Components
16. Valid_MH_Cone_Types
17. Valid_MH_Cover_Frame_Fit
18. Valid_MH_Cover_Hole_Diameter
19. Valid_MH_Cover_Insert_Types
20. Valid_MH_Inflow_Infiltration
21. Valid_MH_Inspection_Status
22. Valid_MH_MH_Linings
23. Valid_MH_Pipe_Direction
24. Valid_MH_Pipe_Seal_Conditions
25. Valid_MH_Pipe_Special_Conditions
26. Valid_MH_Potential_Runoff
27. Valid_MH_Purposes
28. Valid_MH_Step_Materials
29. Valid_Pre-Cleaning
30. Valid_Sewer_Uses
31. Valid_Shapes
32. Valid_Weather

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Appendix C
Flow Monitoring Location Map



Clean Water 2020
 © Columbia's Clear Vision For Clean Water

We Are Columbia

JBH: September 8, 2014
 CW2020 Master/Production Maps/Report Figures/CSAP

City Hall	Permanent Flow Meter	Temp. (2014) Rain Gauge	Broad River Basin	Rocky Branch Basin
Metro WWTW	Temp. (2014) Flow Meter	Permanent Rain Gauge	Crane Creek Basin	Saluda River Basin
SS Lift Station	2012 Flow Meter		Gills Creek Basin	Smith Branch Basin
Sewer Line			Mill Creek Basin	West Columbia Basin

1 in = 2 miles
 0 0.5 1 2 Miles

Appendix C
Location of
Flow Monitors
and Rain Gauges

Prepared For: CleanWater 2020, CSAP

Appendix D
Video Inspection Procedures

SECTION 02650
SANITARY SEWER LINE CLEANING

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required to clean all sewer pipe as required and directed by ENGINEER.
- B. CONTRACTOR as defined in this specification is presumed to be operating under a direct contract with ENGINEER to provide this scope of services. ENGINEER is responsible for CONTRACTOR's work and in some instances CONTRACTOR and ENGINEER may be the same entity.
- C. Cleaning shall include the proper high pressure water jetting, rodding, bucketing, brushing and flushing of sewers and manholes prior to inspection by closed circuit television, pipeline rehabilitation or replacement, point repairs, manhole preparation, and testing operations. It shall also include water, debris dewatering, removal and proper disposal.
- D. The goal of the cleaning is to remove all debris, roots, intruding services, deposits and other blockages to a minimum of 95% open area. On all sewers, CONTRACTOR shall perform sewer cleaning work to an acceptable level as necessary to perform a thorough television inspection of the sewer. If the pipe condition is such that cleaning may cause a potential collapse, then the pipe shall be televised without attempting to clean it to the 95 percent condition, pending approval by ENGINEER.
- E. Cleaning may involve preparatory or light sewer cleaning (small amounts of debris and/or light root growth existing within the sewer line) or heavy sewer cleaning (large amounts of debris, grease, large size stones and bricks and/or heavy root growth existing within the sewer line). Cleaning shall dislodge, transport and remove all sludge, mud, sand, gravel, rocks, bricks, grease, roots, sticks, and all other debris from the interior of the sewer pipe and manholes.
- F. Root cutting or sawing may be deemed necessary and is included in this work.

1.02 RELATED WORK

- 1. Sanitary Sewer Television Inspection is specified in Section 02731
- 2. PACP Database Template is specified in Section 02732.
- 3. Dye Testing is specified in Section 02761.
- 4. Dye Testing Database Template is specified in Section 02762.
- 5. Gravity Sewer System Smoke Testing is specified in Section 02767.
- 6. Gravity Sewer System Smoke Testing Database Template is specified in Section 02768
- 7. Gravity Sewer System Manhole Inspections is specified in Section 02777.
- 8. MACP Database Template is specified in Section 02778.
- 9. Sanitary Sewer Flow Control is specified in Section 02965

1.03 SUBMITTALS

- A. Submit a Traffic Control Plan to the OWNER's Representative (ENGINEER), which includes the following items.
 - 1. Outline of permit acquisition procedure for lane closures.
 - 2. Methods for proper signing and barricades, which comply with local requirements and the OWNER.
 - 3. Site contractor emergency phone numbers.
- B. Confined space entry plan, certifications and hazardous atmosphere training certifications, if applicable.
- C. The work described in this Scope of Work, including any internal sewer or manhole inspections, shall meet the minimum requirements as presented in the OSHA Standard, Title 29 CFR 1910.146, Permit Required Confined Spaces. Upon commencement of the Work, copies of all confined space entry permits must be submitted to ENGINEER. CONTRACTOR shall notify the OWNER or delegated representative each day by phone, email or fax when it is necessary for CONTRACTOR to enter a manhole(s). CONTRACTOR shall identify all manholes that CONTRACTOR plans on entering that day by street location and manhole number.

1.04 NOTIFICATIONS

- A. Notify the ENGINEER:
 - 1. On a weekly basis of scheduled work for the upcoming week, including a map showing the area of work, and a map and list of fire hydrants that will be utilized for a water source, and a list of streets being affected. Submittal should be provided by electronic mail in PDF format. Provide 24-hour notice for deviations from the plan that are not caused by weather or natural causes.
 - 2. Immediately, when a collapsed pipe or other pipe failure is identified.
 - 3. Immediately, if the conditions for cleaning are found to be unsafe or impractical.
 - 4. Immediately, if a manhole is buried, cannot be found or cannot be accessed. Along with the manhole identification number, provide a map (in PDF format) showing the location of the manhole and what procedures were used to attempt to locate the manhole.
 - 5. Inspection crews shall immediately notify the OWNER and/or on-site inspector of any defects posing imminent danger to the public (missing lids, covers broken during inspection, sink holes, etc.) and any observed pipe blockages, surcharging, or potential overflow conditions.

6. If the pipe configuration in the field is different than shown in OWNER supplied GIS data. The notification shall include a diagram clearly indicating the location of structures in relation to immediately adjacent structures in PDF format via electronic mail. In addition, the information should be updated in the GIS database and will be provided to the OWNER at the time of submittal of the CCTV data relevant to that particular area or reach of piping in order to facilitate review and timely update of the OWNER's GIS to match the CCTV database.

B. Notify the public and coordinate with homeowners:

1. A minimum of 48 hours prior to the cleaning or inspection of any line segment, distribute door-to-door an OWNER approved Homeowner Notification door hanger describing the work to be performed.
2. CONTRACTOR must use approved magnetic car signs affixed to vehicles at all times during the project to identify affiliation with the City of Columbia, SC.

PART 2 PRODUCTS

2.01 CLEANING MATERIALS AND EQUIPMENT

A. Hydraulically propelled Sewer Cleaning Equipment.

1. Hydraulically propelled sewer cleaning equipment shall be the movable dam type constructed such that a portion of the dam may be collapsed during cleaning to prevent flooding of the sewer.
2. The movable dam shall be the same diameter as the pipe being cleaned and shall provide a flexible scraper around the outer periphery to ensure total removal of grease.
3. CONTRACTOR shall take precautions against flooding prior to using sewer cleaning balls or other such equipment that cannot be collapsed instantly.

B. High Velocity Hydro-Cleaning Equipment shall have the following:

1. A minimum of 500-ft of high pressure hose.
2. Two or more high velocity nozzles capable of producing a scouring action from 15 to 45 degrees in all size lines to be cleaned.
3. A high velocity gun for washing and scouring manhole walls and floor.
4. Capability of producing flows from a fine spray to a long distance solid stream.
5. A water tank, auxiliary engines and pumps and a hydraulically driven hose reel.
6. Equipment operating controls located above ground.

C. Mechanical cleaning equipment shall be either power buckets or power rodders by the Flexible Tool Division of Rockwell Manufacturing Co. or equal. Mechanical equipment can only be

utilized with approval of OWNER or his representative and after the structural condition of the pipe has been verified and CONTRACTOR has indicated that jetting will not be sufficient to perform the cleaning and mechanical cleaning will not further damage the pipe.

1. Bucket machines shall:
 - a. Be furnished with buckets in pairs and with sufficient dragging power to perform the work efficiently.
 - b. Use V-belts for power transmission or have an overload device. No direct drive machines will be permitted.
 - c. Be equipped with a take up drum and a minimum of 500-ft of cable.
2. Power rodding machine shall:
 - a. Be either sectional or continuous.
 - b. Hold a minimum of 750-ft of rod.
 - c. Have rods made of treated steel.
 - d. Be fully enclosed and have an automatic safety throw out clutch.

PART 3 EXECUTION

3.01 PERFORMANCE

- A. Cleaning Precautions: During sewer cleaning operations, satisfactory precautions shall be taken in the use of cleaning equipment. When hydraulically propelled cleaning tools (which depend upon water pressure to provide their cleaning force) or tools which retard the flow in the sewer line are used, precautions shall be taken to ensure that the water pressure created does not damage or cause flooding of public or private property being served by the sewer. When possible, the flow of sewage in the sewer shall be utilized to provide the necessary pressure for hydraulic cleaning devices. When additional water from fire hydrants is necessary to avoid delay in normal work procedures, the CONTRACTOR shall apply for a temporary meter and service at the City and pay all associated costs. An approved backflow preventer will be required to be used at all times. No fire hydrant shall be obstructed in case of a fire in the area served by the hydrant.
- B. Sewer Cleaning: The designated sewer manhole and sewer main sections shall be cleaned using hydraulically propelled, high velocity jet, or mechanically powered equipment. Selection of the equipment used shall be based on the conditions of lines at the time the work commences. The equipment and methods selected shall be satisfactory to the OWNER's Representative. The equipment shall be capable of removing dirt, grease, rocks, sand, roots and other materials and obstructions from the sewer lines and manholes. If cleaning of an entire section cannot be successfully performed from one manhole, the equipment shall be set up on the other manhole and cleaning again attempted. If, again, successful cleaning cannot be performed or the equipment fails to traverse the entire manhole section, it will be assumed that a major blockage exists and the cleaning effort shall be repeated with other types of equipment. The goal of the cleaning is to remove all debris, roots, intruding services, deposits and other

blockages to a minimum of 95% open area. On all sewers, CONTRACTOR shall perform sewer cleaning work to an acceptable level as necessary to perform a thorough television inspection of the sewer. If the pipe condition is such that cleaning may cause a potential collapse, then the pipe shall be televised without attempting to clean it to the 95 percent condition, pending approval by ENGINEER.

- C. Selection of cleaning equipment shall be based on the conditions of the manholes and sewer lines at the time the work commences based on the CCTV inspection to be conducted by the CONTRACTOR. All pipe segments cleaned must be noted as such in the CCTV inspection database submittal provided to the OWNER (see specification Section 02731- Sanitary Sewer Television Inspection).
1. Light cleaning (small amounts of debris existing within the sewer line): Use balls, scooters, high pressure water jetting equipment, brushes and swabs. "Light Cleaning" will be defined and managed as follows: Sewer reaches that do not require heavy cleaning, as defined below, and all cleaning up to and including 3 passes of high pressure water jetting. If, after three passes of high pressure water jetting, the sewer is still not clean, the CONTRACTOR shall inform the ENGINEER of the condition and the reason(s) for the failure to fully clear the line. The ENGINEER may then direct the CONTRACTOR to perform heavy cleaning of the problem section of sewer. Costs related to the cleaning of such sewers shall be included in CONTRACTOR's unit prices for CCTV and Light Cleaning.
 2. Heavy cleaning (large deposits of debris or heavy root growth existing within the sewer line): Use bucket machines, scrapers and augers. Cleaning which requires more than 3 passes with hydraulic cleaning equipment to achieve acceptance results shall be considered heavy cleaning. Heavy cleaning will be conducted only upon the approval and direction of the ENGINEER. "Heavy Cleaning" will be defined and managed as follows: Sewer reaches that require debris removal of depths up to 25 percent of the pipe height and requires more than 3 passes with the jetter to sufficiently remove the debris. Costs related to the cleaning of such sewers shall be included in CONTRACTOR's unit prices for Heavy Cleaning. Costs related to the televising of such sewers following Heavy Cleaning shall be included in CONTRACTOR's unit prices for CCTV and Light Cleaning. Compensation for Heavy Cleaning of a particular line will only be paid if at least one of the following apply:
 - a) The heavy cleaning was authorized by the OWNER or his designated representative and prior to CONTRACTOR performance of the work, The CONTRACTOR shall obtain a written signature from the OWNER or his representative agreeing to the terms, prices and lengths of the heavy cleaning.
 - b) CONTRACTOR proves that both significant time AND effort was necessary to clean the line. The time required to clean and inspect the line must have been at least twice the average time required to clean and inspect other previous sewer segments on the project of comparable length /diameter in the project area, and adequate video proof of the blockage, debris, grit or grease build-up, or other condition is provided by CONTRACTOR. Video proof of heavy cleaning must be obtained by acquiring a "before" video of all accessible portions of the obstructed reach and submitting that to ENGINEER along with the completed inspection. A submerged camera does not justify a need for heavy cleaning; proof that the submergence was due to a blockage and/or heavy debris and not a sag in the line

will be required.

CONTRACTOR shall clean these pipes to the standards listed above. Upon completion of the cleaning, each sewer line shall be televised to assess the condition of the sewer pipe and to confirm that it meets the standards of cleanliness listed above. Heavy Cleaning will be paid for on a linear foot basis only for the length required to be cleaned unless otherwise agreed to be paid for before performing the work in writing.

3. Time and Material Cleaning: Pipes that contain roots and/or debris depths greater than 25 percent of the pipe height may be paid on a time and material basis, upon approval by OWNER or his designated representative. OWNER or his representative may determine if any individual pipe should be cleaned on a time and material basis. Payment shall be made for the time and cost per hour in the contract.
- D. CONTRACTOR shall provide appropriate screening to stop passing of materials into downstream sewers. All solid or semisolid materials dislodged during cleaning operations shall be removed from the sewer by CONTRACTOR at the downstream manhole of the sewer section being cleaned. These materials shall become the property of the CONTRACTOR, shall be removed from the site at the end of each workday, and shall be disposed of in a lawful manner by CONTRACTOR. The passing of dislodged materials downstream of the sewer segment being cleaned shall not be permitted. In such an event, as observed or detected by the OWNER, ENGINEER or any third party, CONTRACTOR shall be responsible for cleaning the affected downstream sewers in their entirety, at no additional cost to ENGINEER or OWNER.
 - E. Use properly selected equipment to remove all dirt, grease, rock and other deleterious materials and obstructions.
 - F. Protect existing sewer lines from damage caused by improper use of cleaning equipment. CONTRACTOR is solely responsible for the operations and for preventing sewer backups into area homes and causing sewage overflow.
 - G. Take precautions to avoid damage or flooding to public or private property being served by the line being cleaned.
 - H. Use sewage flow in the sewer lines to provide necessary pressures for hydraulic cleaning devices whenever possible.
 - I. Removal of Materials.
 1. Remove all solids and semi-solids at the downstream manhole of the section being cleaned.
 2. Passing material from one section of a line to another will not be permitted.
 - J. Disposal of Material. Remove from the site and properly dispose of all solids or semi-solids recovered during the cleaning operation. The CONTRACTOR shall be responsible for the proper disposal of all collected material. Waste material removed from the sewer during the cleaning process may be disposed of by hauling it to an appropriate disposal facility. Specifics regarding the scheduling, monitoring, disposal fees (if any) and approved methods and procedures for disposal are the contractor's responsibility and must comply with all County, State and Federal regulations.

- K. No sewer cleaning shall take place in a particular sewer segment until all upstream pipe segments have been cleaned. If cleaning is done in a downstream pipe segment in order to facilitate overall cleaning operations, the segment shall be re-cleaned at no additional cost, after all pipes upstream of that segment have been cleaned.

3.02 FIELD QUALITY CONTROL

- A. Acceptance of this portion of the work shall be dependent upon the results of the television inspection. The goal of the cleaning is to remove debris, roots and deposits sufficiently to inspect the pipeline and provide at least 95% capacity of the pipeline. Sewers that are not sufficiently clean as to permit television inspection shall be re-cleaned and re-inspected at no additional cost to the OWNER.

PART 4 DELIVERABLES (NOT USED)

END OF SECTION

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SECTION 02731
SANITARY SEWER TELEVISION INSPECTION

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The Work covered by this section includes furnishing all labor, competent certified technicians, equipment, tools, accessories, and materials required to clean and inspect the designated sanitary sewer lines specified.
- B. CONTRACTOR as defined in this specification is presumed to be operating under a direct contract with ENGINEER to provide this scope of services. ENGINEER is responsible for CONTRACTOR's work and in some instances CONTRACTOR and ENGINEER may be the same entity.
- C. Closed-circuit television (CCTV) inspection of sanitary sewers as follows:
 - 1. CCTV on all lines proposed for television inspection.
 - 2. CONTRACTOR shall use a NASSCO Pipeline and Assessment Certification Program (PACP) certified software form and coding. Data files shall be formatted to facilitate upload into a NASSCO certified CCTV software package.

1.02 RELATED WORK

- 1. Sanitary Sewer Line Cleaning is specified in Section 02650.
- 2. PACP Database Template is specified in Section 02732.
- 3. Dye Testing is specified in Section 02761.
- 4. Dye Testing Database Template is specified in Section 02762.
- 5. Gravity Sewer System Smoke Testing is specified in Section 02767.
- 6. Gravity Sewer System Smoke Testing Database Template is specified in Section 02768
- 7. Gravity Sewer System Manhole Inspections is specified in Section 02777.
- 8. MACP Database Template is specified in Section 02778.
- 9. Sanitary Sewer Flow Control is specified in Section 02965

1.03 SUBMITTALS

- A. Submit a Traffic Control Plan to the OWNER's Representative (ENGINEER), which includes the following items.
 - 1. Outline of permit acquisition procedure for lane closures.
 - 2. Methods for proper signing and barricades, which comply with local requirements and the OWNER.
 - 3. Site contractor emergency phone numbers.
- B. Confined space entry plan, certifications and hazardous atmosphere training certifications for

- all staff engaged in activities within or near the open structures, if applicable.
- C. Prior to beginning work, submit to the ENGINEER certification of the NASSCO PACP Program for all CCTV operators that will be working and performing this inspection work on the project. CONTRACTOR shall not commence work until such certification is provided. Submit 2 copies of the NASSCO issued identification card and PACP certification number.
 - D. The work described in this Scope of Work, including any internal sewer or manhole inspections, shall meet the minimum requirements as presented in the OSHA Standard, Title 29 CFR 1910.146, Permit Required Confined Spaces. Upon commencement of the Work, copies of all confined space entry permits must be submitted to ENGINEER. CONTRACTOR shall notify the OWNER or delegated representative each day by phone, email or fax when it is necessary for CONTRACTOR to enter a manhole(s). CONTRACTOR shall identify all manholes that CONTRACTOR plans on entering that day by street location and manhole number.
 - E. CONTRACTOR must submit to ENGINEER for OWNER's review and approval, sample videos and photographs at the beginning of the project that shows no less than 20 line segments. Submitted videos will be reviewed to determine expected quality of data. All data must be submitted referencing the pipe and manhole structure identifier codes approved by the OWNER and described herein.
 - F. Final sewer inspection reports, digital videos/photographs and data shall be submitted in accordance with the requirements specified in Section 3 of this specification.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. CONTRACTOR: Performed work successfully for at least three other projects, within last 5 years, with at least 500,000 linear feet and the CCTV operator must have at least 250,000 linear feet of CCTV experience in NASSCO PACP format.
2. Crew Chief: Minimum of 5 years experience on projects similar to this Project and experienced using proposed equipment for this Project.

1.05 NOTIFICATIONS

A. Notify the ENGINEER:

1. On a weekly basis of scheduled work for the upcoming week, including a map showing the area of work, and a map and list of fire hydrants that will be utilized for a water source, and a list of streets being affected. Submittal should be provided by electronic mail in PDF format. Provide 24-hour notice for deviations from the plan that are not caused by weather or natural causes.
2. Immediately, when a collapsed pipe or other pipe failure is identified.
3. Immediately, if the conditions for CCTV inspection are found to be unsafe or impractical.
4. Immediately, if a manhole is buried, cannot be found or cannot be accessed. Along with the manhole identification number, provide a map (in PDF format) showing the location

of the manhole and what procedures were used to attempt to locate the manhole.

5. Inspection crews shall immediately notify the OWNER and/or on-site inspector of any defects posing imminent danger to the public (missing lids, covers broken during inspection, sink holes, etc.) and any observed pipe blockages, surcharging, or potential overflow conditions.
6. If the pipe configuration in the field is different than shown in OWNER supplied GIS data. The notification shall include a diagram clearly indicating the location of structures in relation to immediately adjacent structures in PDF format via electronic mail. In addition, the information should be updated in the GIS database and will be provided to the OWNER at the time of submittal of the CCTV data relevant to that particular area or reach of piping in order to facilitate review and timely update of the OWNER's GIS to match the CCTV database.

B. Notify the public and coordinate with homeowners:

1. A minimum of 48 hours prior to the inspection of any line segment, distribute door-to-door an OWNER approved Homeowner Notification door hanger describing the work to be performed.
2. CONTRACTOR must use approved magnetic car signs affixed to vehicles at all times during the project to identify affiliation with the City of Columbia, SC.

PART 2: PRODUCTS AND EQUIPMENT

2.01 TELEVISION INSPECTION AND CLEANING EQUIPMENT

- A. CONTRACTOR shall furnish all labor, materials, machinery, equipment and incidentals required to perform the thorough cleaning and CCTV of the assigned sewers within the study area.
- B. Provide a mobile vehicle with video monitoring equipment specifically compatible with the camera equipment being used. The vehicle shall be large enough to accommodate at least three people at any time for viewing of the monitor. OWNER and ENGINEER shall have unrestricted access to observe the television screen and all other operations at all times.
- C. The television camera used for the inspection shall be one specifically designed and constructed for such inspection. Adjustable light source to allow an even distribution of lighting for the camera shall be suitable to allow a clear color picture of the entire periphery of the pipe. The camera shall be capable panning 360° and tilting 270° to facilitate the inspection of all laterals and defects, with optimum picture quality provided by focus and iris adjustment. The camera, television monitor, and other components of the video system shall be capable of producing a minimum 600-line resolution picture. A backup camera shall be available on the Project Site. The camera shall be operative in 100 percent humidity conditions. Camera shall be operative in a hazardous and corrosive environment. The camera shall be capable of zooming at least 10:1 for looking further down the pipe or up into the laterals.
- D. The camera, television monitor, and other components of the video system shall be capable of producing picture quality to the satisfaction of ENGINEER and/or OWNER.

- E. The television inspection equipment shall have an accurate footage counter that shall display on the monitor the exact distance of the camera from the centerline of the starting manhole. CONTRACTOR shall, in the presence of inspector, calibrate the camera footage every week with above ground tape measure and simultaneous CCTV footage counter.
- F. The CCTV equipment must include the most current version PACP compliant application and database referenced in these specifications, or as approved by the OWNER.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Prior to the inspection, CONTRACTOR shall use CCTV or other means to identify any significant blockages. If the upstream manhole is full of water due to a blockage, a reverse setup shall be done to locate the blockage if possible. Then the cleaning and CCTV inspection shall be performed.
- B. The CONTRACTOR shall thoroughly clean the pipelines of debris, grease, roots, sediment, broken pipe, or other obstructions that could retard the movement of the television camera. Precautions shall be taken to protect the sewer lines being cleaned from damage by the cleaning equipment. CONTRACTOR should perform cleaning in accordance with Specification Section 02650.
- C. CONTRACTOR shall in the presence of OWNER's inspector, calibrate the camera footage every week with above ground tape measure and simultaneous CCTV footage counter.
- D. Immediately after cleaning, the sewer line section shall be visually inspected by means of closed-circuit television to determine the condition of the line and to locate existing service connections. The inspection will be done one manhole section at a time and the flow in the section being inspected will be suitably controlled as specified in Section 2.04.
- E. Do not float the camera unless permitted by the OWNER or their designated representative.

3.02 CCTV INSPECTION

- A. Perform all CCTV inspection using personnel who are trained and certified (current standing) in the use of NASSCO's Pipeline and Assessment Certification Program (PACP).
- B. Move the camera through the line in either direction (direction versus flow must however be noted) at less than or equal to 30 feet per minute rate, stopping when necessary to permit proper documentation of the construction features and pipe condition. Manual winches, power winches, TV cable, and powered rewinds or other devices that do not obstruct the camera view or interfere with proper documentation of the sewer conditions shall be used to move the camera through the sewer line.
- C. When manually operated winches are used to pull the television camera through the line, use telephones or other suitable means of communication set up between the two manholes of the section being inspected to ensure good communications between members of the crew.
- D. Obstructions that cause a stuck camera are the responsibility of the CONTRACTOR, and the

retrieval of equipment or cameras is the responsibility of the CONTRACTOR and will be performed at the CONTRACTOR's expense.

- E. Adjust the camera height such that the camera lens is always centered in the pipe being televised.
- F. Provide lighting system adequate for good quality pictures. A reflector in front of the camera may be required to enhance lighting in black pipe.

3.03 PASSAGE OF TV CAMERA

- A. It is the intent of the Scope of Work to inspect the full length of sewer between each manhole, but there may be occasions during the CCTV inspection of a sewer line section when the camera will be unable to pass an obstruction even though flow is continuing. If, during the inspection operation, the television camera will not pass through the entire pipe section, set up the CCTV equipment so that the inspection can be performed from the opposite manhole. No additional payment shall be made for reverse set-ups required due to an obstruction. Reverse setups must be noted in the CCTV database submittal in a separate database field to indicate that the inspection was performed in the reverse direction of flow.
- B. CCTV videos shall be submitted in one continuous video section from manhole to manhole, and not in multiple files, unless specifically approved by ENGINEER. See Section 2.07 for file naming convention details.
- C. Roots shall be removed to approximately 95% clear by cross sectional area. Special precautions should be exercised during the cleaning operation to assure complete removal of visible roots from the joint area. Fine roots are allowed if the CCTV camera has made 3 attempts to remove roots with proper root removal nozzle or with approval from the OWNER or their representative. Any visible roots that may impact rehabilitation efforts shall be removed. Procedures may include the use of mechanical devices such as rodding machines, expanding root cutters and porcupines, and hydraulic procedures such as high-pressure jet cleaners. See Specification 02650 for complete sewer cleaning specifications.
- D. The television camera shall travel through the lines using its own power. The digital pictures taken of the entire inside periphery of the pipe shall be clear and visible. Picture quality and definition shall be to the satisfaction of ENGINEER, and if unsatisfactory, the equipment shall be removed and no payment made for the unsatisfactory inspection.
- E. The camera must be stopped at all service laterals and pan such an angle that an internal view of the service lateral is available to determine if the lateral is active or dead or plugged. Digital photographs must be made of any service lateral or deficiency observed in the sewer line and the photograph itself must contain a brief description of the issue. The descriptions must also be noted in the inspection condition record within the database. Where other pipe deficiencies are noted, stop the camera to observe the condition, record information and take digital photographs. All digital photos must be cataloged in the CCTV database and linked to the specific length along the inspection via linkage to the defect record in the database.
- F. Note in the PACP database the status of identified laterals as active or inactive, and other PACP database information required including location of each service lateral based on television inspection logs, accurate distance measured from the centerline of the starting manhole as well as the notation of where on the circumference of the pipe the service lateral connects,

etc. See Section 02732 for additional PACP Database Template information

3.04 SANITARY SEWER FLOW CONTROL

- A. CCTV inspection shall be done one sewer line section (i.e. manhole structure to manhole structure) at a time, and the flow in the section shall be suitably controlled. The depth of wastewater flow shall not exceed that shown below:

6" – 10" Pipe:	20% of pipe's diameter
12" – 24" Pipe:	25% of pipe's diameter
Over 24" Pipe:	30% of pipe's diameter

- B. When the depth of flow in the section being worked is above the maximum allowable for the television inspection, the flow shall be reduced to allowable levels by: performing the inspection during minimum flows hours, with diversion pumping, jet nozzles or a flow-through plug.
- C. When flow in a sewer line is plugged, blocked, or bypassed, sufficient precautions must be taken to protect the sewer lines from damage that might result from sewer surcharging. Further, precautions must be taken to insure that sewer flow control operations do not cause flooding or damage to public or private property being served by the sewers involved.
- D. Sewer flow control procedures shall be performed in accordance with specification Section 02965.

3.05 SEWER INSPECTION SOFTWARE

- A. All inspections shall use software that is capable of providing complete survey reports in compliance with current version of NASSCO PACP software. OWNER has no intent to specify which software the CONTRACTOR should use, but requires the submitted database to be fully compliant with PACP. No payment will be rendered for improperly formatted data.

A

- B. All NASSCO PACP mandatory fields and any additional available fields requested by the OWNER or his representative shall be populated during the inspections. All reports and/or submittals shall adhere to NASSCO MACP/PACP Standards.
- C. The software shall maintain a database of underground pipe and manhole assets referencing the pipe and manhole structure asset identifier codes provided in GIS format by the OWNER. The pipe segment information shall be entered prior to the actual survey based on the numbering convention provided by the OWNER. Surveys for pipes found not to be included in the OWNER's GIS database will be numbered per Section 2.07. The software shall also have the capability to import and export survey results in the current NASSCO PACP Exchange digital format and to manage the database to meet the specifications in Section 2.07 herein.

CONTRACTOR to denote in the PACP Inspections table under 'Additional_Info' that this is a by writing in 'CCTV' in all capital letters in this field for all entries related to CCTV inspections.

PART 4: DELIVERABLES

4.01 DIGITAL DATA DELIVERY

- A. CONTRACTOR shall submit in electronic format digital videos, digital photographs, evaluation reports, and databases in NASSCO PACP Exchange format version 6 to ENGINEER . Please consult with the OWNER before proceeding if a more recent version is currently available.
- B. If digital videos are of such poor quality that ENGINEER is unable to evaluate the condition of the sanitary sewer main, locate the sewer service connections, or verify the cleaning CONTRACTOR shall be required to re-televiser the sanitary sewer and provide new digital videos of good quality, at no additional cost to OWNER.
- C. All digital videos will become the property of OWNER.

4.02 DATA DELIVERY REQUIREMENTS

- A. All reports and/or submittals shall adhere to NASSCO PACP Standards.
- B. CONTRACTOR shall provide a rating of each pipe per the ENGINEER's recommendations.
- C. ENGINEER to provide inspection data on a monthly basis with the database and data on an external hard drive. The ENGINEER to provide two hard drives on an alternating monthly basis. The submittals shall be cumulative (i.e. each successive database delivery will include previous deliveries as well). CONTRACTOR shall provide OWNER with a final external hard drive capable of storing all anticipated data for the project upon completion. The final hard drive shall be submitted on the first monthly submittal with the first month of data loaded and will become property of the OWNER upon project completion. Data to be submitted shall include: 1) NASSCO PACP Database files, 2) .jpg files (still photos), 3).mpg files (videos) for each pipe segment and 4) a PDF of any separate inspection reports.
- D. Each database submittal shall indicate the range of dates for which the database is being submitted as well as a list of new items as of the last submittal so that the OWNER may separate out and review the newly delivered records from previous submittals in an Excel format.
- E. The databases shall be cumulative, with one database each for MACP Level 2 inspections, one for PACP zoom camera inspections, and one for PACP CCTV inspections. Each subsequent submittal shall be added into these databases. Throughout the duration of the project, should ENGINEER discover inaccuracies in any of the videos, CONTRACTOR shall re-inspect those manholes and/or pipes at no additional cost to the ENGINEER or OWNER. The CCTV equipment/software shall be capable of producing digital still images of all sewer line defects, and sewer line service connections in .jpg image format. CONTRACTOR shall take digital still images of each defect, construction features and service connections to clearly depict it. More images may be necessary depending upon the condition of the pipe. The digital images shall have a minimum size/resolution of 1024x768 at a 4:3 aspect ratio. The screen captures or digital images shall include an onscreen display with date, sewer main reach number, footage, and type of defect/PACP Code. The filename of each .jpg shall be in accordance with these

specifications.

- F. A final, compiled version of the inspection database in a PACP Exchange format must be delivered at the end of the project to the OWNER. The final database must include all inspection records previously delivered in the individual inspections as well as incorporate all requested changes by the ENGINEER.
- G. All database inspection records must be linked to the OWNER's unique pipe numbering system which is based on the upstream and downstream structure numbers for the pipe end structures (manhole, outfall, cleanout, etc.). The unique pipe identifier must take the form of UPSTREAM ASSET ID and DOWNSTREAM ASSET ID separated by a colon (:). For example: SS-SR02-01673:SS-SR02-01674 would be the pipe between manhole number SS-SR02-01673 and SS-SR02-01674. These values will be provided within the OWNER's GIS database however, if additional intermediate structures are located in the field, the naming convention described below must be used.
- H. During the inspection work, if a previously unknown manhole not shown in the GIS is found, the letter "A" will be added to the end of the upstream manhole ID (no spaces or special characters allowed) to form a new manhole ID in the inspection records. The data / video files shall then be re-named to include the new manhole ID, and a new CCTV inspection shall be started from the new manhole ID. If more than one unnamed manhole is found between two named manholes, subsequent new manhole IDs will be formed using the letters "B", "C" etc. A copy of the OWNER's GIS database shall be updated with the changes found in the field per the OWNER's requirements. Individual and final deliverables must include database records that link to the OWNER'S GIS database using unique manhole identification numbers per the OWNER'S standard manhole identification number (MH_Asset_ID field in the OWNER's GIS) format. The newly located manholes must be added to the manhole inspection database using the same new identification codes.
- I. The contractor shall contact the Owner's GIS administrator to obtain an ID for any structural asset, with an unknown ID, constructed during or later than 2013.
- J. There may be situations that require CONTRACTOR to televise an individual pipe segment from more than one direction, i.e. the camera is only able to televise 75% of the segment heading downstream, and the remaining 25% is televised heading upstream. The name of additional database files etc. produced in these circumstances shall be that unique upstream manhole ID followed by the unique downstream manhole ID followed by "_1", "_2" etc.

Initial file name: SS-SR02-01673:SS-SR02-01674.MPG

Additional file name(s): SS-SR02-01673:SS-SR02-01674.MPG

Where SS-SR02-1673 = upstream asset ID, SS-SR02-1674 = downstream asset ID, YYYYMMDD = 8 digit date, 1 = a subsequent video of the same sewer ID)

The direction of camera pull versus the pipe flow must be noted in the inspection record in the database.

- K. The name of each digital still image shall be based on the video / data file name of the sewer reach in which the image was taken. The name shall be recorded as follows:

Examples: SS-SR02-01673:SS-SR02-01674_HSV-37_2.jpg

SS-SR02-01673:SS-SR02-01674_1_MCU-113_7.jpg

Where SS-SR02-01673:SS-SR02-01674 is the pipe identification number, HSV and MCU are PACP defect codes, 37 and 113 are the footage counts for the defect locations along the pipe and 2 and 7 are the sequential defect photo numbers along the pipe.

- L. Digital files of all field data collection forms (if used by CONTRACTOR) should be delivered in PDF format and shall have file names that include the same unique identifier as the database submittal so that they can easily be related to the database and digital photograph/video submittals, if a naming convention is not specified.

END OF SECTION

SECTION 02732
DATABASE TEMPLATE DESCRIPTION PACP

PART I GENERAL

1.01 DATABASE TEMPLATE

- A. The attached database template (version 6) and formatting as specified must be used to document and deliver the results of all work related to pipe and related inspections. A description is provided in this specification for each field, and formatting notes and examples for fields to provide additional guidance. Examples are provided for fields that are open that required additional clarity, and the lack of an example does not imply that the field can be left blank.
- B. All codes and descriptions must be used pursuant to the applicable specifications and the valid value tables within the attached database template.
- C. All database fields must be populated unless noted as optional in the Description field of the database table.

PART 2 TABLE FORMAT AND DESCRIPTION

- A. The following tables show available Field Names, the data type allowed, field size, a description of the Field, additional formatting notes if needed, and an example if provided.

2.01 INSPECTIONS TABLE

- A. This table shall be used to store the primary information regarding the inspection.

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
InspectionID	Long Integer	4	This field is automatically populated when any inspection information is entered. The number generated must be entered in the InspectionID field of the Conditions table for all conditions recorded during the inspection		
Surveyed_By	Text	25	Name of individual conducting survey		Allen S.
Certificate_Number	Text	15	NASSCO PACP # of Surveyor		04-6134
Owner	Text	30	Owner of collection system surveyed		City of Columbia
Customer	Text	30	Entity commissioning the survey		City of Columbia
Drainage_Area	Text	15	Common name of drainage area	Basin Name	SR05
PO_Number	Text	15	Customer's Purchase Order Number	CIP number	SS7207

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Pipe_Segment_Reference	Text	25	Client provided segment number	Upstream_structure_ID:downstream_structure_ID. See structure ID formatting details.	SS-SR02-01674:SS-SR02-01675
Date	Date/Time	8	Inspection Date		20101214
Time	Date/Time	8	Time of inspection		13:25
Street	Text	64	Street Number and Name	Indicate street name when applicable i.e., if asset is in street or crosses the street or can be associated with an address. Use NUMBER PREDIRECTIONAL STREET SUFFIX POSTDIRECTIONAL with no punctuation and all uppercase letters. Alleys or right-of-ways between two streets should remain unassigned. Fields, parks, other open areas should receive a positive entry of "OTHER".	321 MAIN ST
City	Text	64	City name where sewer located	Enter Columbia, Irmo, or Lexington	Irmo
Location_Details	Text	255	Descriptive explanation of sewer location		
Upstream_MH	Text	25	Client provided designation for upstream manhole	Each manhole has been given unique structure identifications per OWNER guidelines, and the name of each database ID shall be that unique structure ID. If an unnamed structure is found, the letter "A" will be added to the end of the structure ID to form a new structure. If more than one unnamed manhole is found between two named manholes, subsequent new structure ID's will be formed using the letters "B", "C" etc. Spaces and special characters are not allowed in the unique ID codes. For example, SS-SR02-03123 or SS-SR02-03123A	SS-SR02-03123A
Up_Rim_to_Invert	Single	4	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from rim to invert of upstream manhole	Record value as feet to nearest tenth of a foot.	8.4
Up_Grade_to_Invert	Single	4	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from average grade to invert of upstream manhole	Record value as feet to nearest tenth of a foot.	10.2
Up_Rim_to_Grade	Single	4	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from rim to average grade of upstream manhole	Record value as feet to nearest tenth of a foot.	1.2

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Downstream_MH	Text	25	Client provided designation for downstream manhole	Each manhole has been given unique manhole identifications (MH_Asset_ID) per OWNER guidelines, and the name of each database ID shall be that unique MH_Asset_ID. If an unnamed manhole is found, the letter "A" will be added to the end of the MH_Asset_ID to form a new MH_Asset_ID. If more than one unnamed manhole is found between two named manholes, subsequent new MH_Asset_ID's will be formed using the letters "B", "C" etc. Spaces and special characters are not allowed in the unique ID codes. For example, SS-SR02-03123 or SS-SR02-03123A	SS-SR02-03123A
Down_Rim_to_Invert	Single	4	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from rim to invert of downstream manhole	Record value as feet to nearest tenth of a foot.	8.4
Down_Grade_to_Invert	Single	4	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from average grade to invert of downstream manhole	Record value as feet to nearest tenth of a foot.	10.2
Down_Rim_to_Grade	Single	4	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from rim to average grade of downstream manhole	Record value as feet to nearest tenth of a foot.	1.2
Sewer_Use	Text	15	Purpose of sewer	Validated entry list e.g., Combined, Force Main, Processes	Combined
Direction	Text	10	Direction of survey, Upstream or Downstream	Validated entry list e.g., Downstream, Upstream	Downstream
Flow_Control	Text	25	Type restriction of flow used	Validated entry list e.g., Bypassed, De-watered using jetter, Lift Station	Bypassed
Height	Long Integer	4	Diameter of sewer (or height if non-circular) to nearest inch(999) or nearest mm(99999)		
Width	Long Integer	4	Width of non-circular sewer to nearest inch(999) or nearest mm(99999)		
Shape	Text	15	Sewer shape	Validated entry list e.g., Arched, Barrel, Circular	Arched
Material	Text	64	Type of pipe material	Validated entry list e.g., Asbestos Cement, Brick, Cast Iron	Asbestos Cement
Lining_Method	Text	30	Type of process used to line the host pipe	Validated entry list e.g., Cured in Place, Fold and Form or Deform/Reform, Other	Cured in Place
Pipe_Joint_Length	Single	4	Length of pipe joint sections measured to one decimal place whether in feet or meters		

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Total_Length	Single	4	Distance between the exit of the start manhole and the entrance of the finish measured to one decimal place whether it is feet or meters		
Length_Surveyed	Single	4	If the survey is abandoned, enter the actual length surveyed to one decimal place whether it is feet or meters		
Year_Laid	Long Integer	4	Year sewer surveyed was constructed		
Year_Renewed	Long Integer	4	Year sewer surveyed was renewed		
Media_Label	Text	64	Unique identifier for tape/media		
Purpose	Text	64	Reason for conducting survey	Validated entry list e.g., Capital Improvement Program Assessment, Infiltration/Inflow Investigation, Maintenance Related	Capital Improvement Program Assessment
Sewer_Category	Text	2	Importance of sewer, to be provided by client	Validated entry list e.g., A, B, C	A
Pre-Cleaning	Text	15	Type of preparatory cleaning conducted prior to survey	Validated entry list e.g., Heavy Cleaning, Jetting, No Pre-Cleaning	Heavy Cleaning
Date_Cleaned	Date/Time	8	Date when sewer was cleaned prior to survey		
Weather	Text	12	Weather conditions when survey conducted		
Location_Code	Text	30	General description of ground cover of surveyed segment	Validated entry list e.g., Airport, Alley, Building	Airport
Additional_Info	Text	255	Supplemental info regarding survey or segment		
Reverse_Setup	Long Integer	4	Specifies that a second survey has been done on the pipe segment--use inspection ID from matching survey		
Sheet_Number	Long Integer	4	Number used to identify individual surveys done within a group		
IsImperial	Yes/No	1	Used to identify whether units are metric or imperial. Defaults to imperial.		Yes
PressureValue	Single	4	Grouting pressure value		
WorkOrder	Text	20	Work order or Project reference for Asset Management		
Project	Text	64	Project Title or reference for Asset Management		

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Northing	Text	50	Y Coordinate - Latitude at the center point of the Starting Access Point - If value exists, Easting and Coordinate System are also required	All coordinate data collected will be accurate to within 0.15' (fifteen-hundredths of a foot) to meet the now current Standards of Practice Manual for Land Surveying in South Carolina as published by SCLLR. For dye testing related work, accuracy is relaxed to sub-meter where coordinates are to be obtained.	806354.16
Easting	Text	50	X Coordinate - Longitude at the center point of the Starting Access Point- If value exists, Northing and Coordinate System are also required	All coordinate data collected will be accurate to within 0.15' (fifteen-hundredths of a foot) to meet the now current Standards of Practice Manual for Land Surveying in South Carolina as published by SCLLR. For dye testing related work, accuracy is relaxed to sub-meter where coordinates are to be obtained.	1946419.03
Elevation	Text	50	Z Coordinate - Height at the center point of the Starting Access Point		
Coordinate_System	Text	50	Datum or reference system used for the gps coordinates - If value exists, Northing and Easting are also required	All coordinates obtained will be provided in the latest edition of SC State Plane Coordinates and all elevations will be provided to the City in NAVD '88 and NGVD '29 datum.	
GPS_Accuracy	Text	50	Describes degree of accuracy obtained from coordinates	Validated entry list e.g., Survey Level, Sub-Meter, Nearest Meter	Survey Level

2.02 INSPECTIONS MEDIA TABLE

- A. This table shall be used to store information regarding the digital photographs and videos taken for inspections.
- B. This table should be completed along with the inspections table.

Media_Inspections					
Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
MediaID	Long Integer	4	This field is automatically populated when any media (picture or movie file) is saved.		

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
InspectionID	Long Integer	4	Software provided designation for this inspection (THIS FIELD USED TO JOIN TABLES)		
Video_Name	Text	255	The name of the video file corresponding to data file	<p>DYE TEST: Video obtained for dye testing shall have a "D_" as prefix. There may be situations that require CONTRACTOR to televise an individual pipe segment from more than one direction, i.e. the camera is only able to televise 75% of the segment heading downstream, and the remaining 25% is televised heading upstream. The name of additional database files etc. produced in these circumstances shall be that unique upstream structure ID followed by the unique downstream structure ID followed by 8-digit date and "_1", "_2" etc. For example:</p> <p>Initial file name: D_SS-SR02-01673:SS-SR02-01674_YYYYMMDD.MPG Additional file name(s): D_SS-SR02-01673:SS-SR02-01674_YYYYMMDD_1.MPG (where D=dye testing; SS-SR02-01673 is upstream structure ID;SS-SR02-01674=downstream structure ID, YYYYMMDD=8-digit date; 1=additional attempt at CCTV of sewer reach)</p> <p>Example file name for pipe segments associated with a relief sewer or multi-barreled sewer, facing downstream, between two identical structure IDs:</p> <p>SS-SR02-01673: SS-SR02-01674_(1,2 or 3)_YYYYMMDD.MPG (where SS-SR02-1673 = upstream structure ID; SS-SR02-1674 = downstream structure ID; 1,2 or 3 represent the pipe segment from left to right (facing downstream), YYYYMMDD = 8 digit date.</p>	<p>DYE TEST: D_SS-SR02-01673:SS-SR02-01674_YYYYMDD.MPG</p> <p>INSPECTION: SS-SR02-01673:SS-SR02-01674_YYYYMDD.MPG</p>

				<p>INSPECTION: There may be situations that require CONTRACTOR to televise an individual pipe segment from more than one direction, i.e. the camera is only able to televise 75% of the segment heading downstream, and the remaining 25% is televised heading upstream. The name of additional database files etc. produced in these circumstances shall be that unique upstream structure ID followed by the unique downstream structure ID followed by “_1”, “_2” etc.</p> <p>Examples: Initial file name: SS-SR02-01673:SS-SR02-01674_YYYYMMDD.MPG Additional file name(s): SS-SR02-01673:SS-SR02-01674_YYYYMMDD_1.MPG (SS-SR02-01673=upstream structure ID, SS-SR02-01674=downstream structure ID, YYYYMMDD=8-digit date, 1 equals a subsequent video of the same sewer structure ID)</p> <p>Example file name for pipe segments associated with a relief sewer or multi-barreled sewer, facing downstream, between two identical structure IDs: SS-SR02-01673: SS-SR02-01674_(1,2 or 3)_YYYYMMDD.MPG (where SS-SR02-1673 = upstream structure ID; SS-SR02-1674 = downstream structure ID; 1,2 or 3 represent the pipe segment from left to right (facing downstream), YYYYMMDD = 8 digit date.</p> <p>The direction of camera pull versus the pipe flow must be noted in the inspection record in the database.</p>	
Video_Location	Text	255	For digital recordings, path of video file relative to corresponding data file	Path neutral	

2.03 CONDITIONS TABLE

- A. This table shall be used to store information regarding the conditions of pipes in the system.
- B. This table should be completed along with the inspections table.

Conditions			
Field Name	Data Type	Field Size	Description
ConditionID	Long Integer	4	This field is automatically populated when any condition information is entered.
InspectionID	Long Integer	4	Software provided designation for this inspection (THIS FIELD USED TO JOIN TABLES)
Distance	Single	4	Distance is measured to one decimal place to feature location whether it is in feet or meters
Counter	Single	4	Time into the video of the identified condition, in seconds
PACP_Code	Text	5	Combination of Group/Descriptor and Modifier/Severity in a single data field
Continuous	Text	3	Continuous defect number with start (S) and finish (F) matching to denote beginning and ending of defect
Value_1st_Dimension	Single	4	Dimensions of defects to nearest Inch or mm
Value_2nd_Dimension	Single	4	Used for intrusion of tap or width of non-circular connecting pipe to nearest inch or mm
Value_Percent	Long Integer	4	Used to express percentage value of defects
Joint	Yes/No	1	Indicates a defect located near a joint
Clock_At_From	Integer	2	Clock At/From Position of defect/observation
Clock_To	Integer	2	Clock To Position of defect/observation
Remarks	Text	255	Additional info to describe defect/coding
VCR_Time	Text	6	Time into the video of the identified condition in HHMMSS format with 0 used as space holder.

2.04 MH CONDITIONS MEDIA TABLE

- A. This table shall be used to store information regarding the digital photographs and videos taken for inspections relating to pipe conditions.
- B. This table should be completed along with the inspections table.

Media_Conditions					
Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
MediaCondID	Long Integer	4	This field is automatically populated when any media (picture or movie file) is saved.		
ConditionID	Long Integer	4	Software provided designation for this inspection (THIS FIELD USED TO JOIN TABLES)		

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Image_Reference	Text	255	If digital snapshots are taken, the name or number of the image file.	<p>DYE TEST: Each photo shall be given a filename that consists of the unique dye test number followed by a number indicating the photograph sequence and using an underscore to separate the test number, photo sequence number (e.g., XYZ_20121211_3_1.JPG where XYZ=Contractor name; 20121211=example of 8-digit date; 3=test number; and 1=photo sequence number). No spaces or special characters will be allowed in the file names except dashes or underscores and the photograph test numbers must correlate exactly back to those entered in the digital database submission.</p> <p>INSPECTION: The name of each digital still image shall be based on the video / data file name of the sewer reach in which the image was taken. The name shall be recorded as follows: Examples: SS-SR02-01673:SS-SR02-01674_HSV-37_YYYYMMDD_2.JPG SS-SR02-01673:SS-SR02-01674_1_MCU-113_YYYYMMDD_7.JPG Where SS-SR02-01673:SS-SR02-01674 is the pipe structure ID, HSV and MCU are PACP defect codes, 37 and 113 are the footage counts for the defect locations along the pipe, YYYYMMDD=8-digit date, and 2 and 7 are the sequential defect photo numbers along the pipe.</p>	<p>DYE TEST: XYZ_20121211_3_1.JPG</p> <p>INSPECTION: SS-SR02-01673:SS-SR02-01674_1_MCU-113_YYYYMMDD_7.JPG</p>
Image_Path	Text	255	Path to digital image reference file	Path neutral	

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Video_File	Text	255	For digital recordings, name of the video file associated with this condition relative to the data file	<p>DYE TEST: Video obtained for dye testing shall have a "D_" as prefix. There may be situations that require CONTRACTOR to televise an individual pipe segment from more than one direction, i.e. the camera is only able to televise 75% of the segment heading downstream, and the remaining 25% is televised heading upstream. The name of additional database files etc. produced in these circumstances shall be that unique upstream structure ID followed by the unique downstream structure ID followed by 8-digit date and "_1", "_2" etc. For example:</p> <p>Initial file name: D_SS-SR02-01673:SS-SR02-01674_YYYYMMDD.MPG Additional file name(s): D_SS-SR02-01673:SS-SR02-01674_YYYYMMDD_1.MPG (where D=dye testing; SS-SR02-01673 is upstream structure ID;SS-SR02-01674=downstream structure ID, YYYYMMDD=8-digit date; 1=additional attempt at CCTV of sewer reach)</p> <p>Example file name for pipe segments associated with a relief sewer or multi-barreled sewer, facing downstream, between two identical structure IDs:</p> <p>SS-SR02-01673: SS-SR02-01674_(1,2 or 3)_YYYYMMDD.MPG (where SS-SR02-1673 = upstream structure ID; SS-SR02-1674 = downstream structure ID; 1,2 or 3 represent the pipe segment from left to right (facing downstream), YYYYMMDD = 8 digit date.</p>	<p>DYE TEST: D_SS-SR02-01673:SS-SR02-01674_YYYYMMDD.MPG</p> <p>INSPECTION: SS-SR02-01673:SS-SR02-01674_YYYYMMDD.MPG</p>

				<p>INSPECTION: There may be situations that require CONTRACTOR to televise an individual pipe segment from more than one direction, i.e. the camera is only able to televise 75% of the segment heading downstream, and the remaining 25% is televised heading upstream. The name of additional database files etc. produced in these circumstances shall be that unique upstream structure ID followed by the unique downstream structure ID followed by “_1”, “_2” etc. Examples: Initial file name: SS-SR02-01673:SS-SR02-01674_YYYYMMDD.MPG Additional file name(s): SS-SR02-01673:SS-SR02-01674_YYYYMMDD_1.MPG (SS-SR02-01673=upstream structure ID, SS-SR02-01674=downstream structure ID, YYYYMMDD=8-digit date, 1 equals a subsequent video of the same sewer structure ID)</p> <p>Example file name for pipe segments associated with a relief sewer or multi-barreled sewer, facing downstream, between two identical structure IDs: SS-SR02-01673: SS-SR02-01674_(1,2 or 3)_YYYYMMDD.MPG (where SS-SR02-1673 = upstream structure ID; SS-SR02-1674 = downstream structure ID; 1,2 or 3 represent the pipe segment from left to right (facing downstream), YYYYMMDD = 8 digit date.</p> <p>The direction of camera pull versus the pipe flow must be noted in the inspection record in the database.</p>	
Video_File_Path	Text	255	For digital recordings, path of the video file associated with this condition relative to the data file	Path neutral	

2.05 VALIDATED ENTRY TABLES

These tables shall be used to determine the valid entries allowed in certain fields as specified in the tables above. These tables are related to the above-mentioned tables within the database and provide predefined validated fields. The following tables are included in the database and should not be edited or modified:

1. Valid_AccuracyOfGPS
2. Valid_Codes
3. Valid_Flow_Controls
4. Valid_Lining_Methods
5. Valid_Locations
6. Valid_Materials
7. Valid_Pre-Cleaning
8. Valid_Purposes
9. Valid_Sewer_Uses
10. Valid_Shapes
11. Valid_Start_Manhole
12. Valid_Survey_Directions
13. Valid_Weather

END OF SECTION

Appendix E
Sample Letter – Private Lateral Defect Notification

SAMPLE LETTER - NOTICE OF DEFECTIVE PRIVATE SANITARY SEWER LATERAL

Date

Name

Address

City, State Zip Code

Subject: Defective Private Sanitary Sewer Lateral
Work Order Number
Located at <<location>>

Dear Sir/Madam:

We have determined through field investigation that the private sanitary sewer lateral serving your property at <<location>> requires repair. The private sanitary sewer lateral is a pipe that conveys wastewater from your residence to the connection to the public sanitary sewer system. The defect(s) we detected indicate rainwater, groundwater, and/or drainage from your property may be entering the public sanitary sewer system through your lateral. This extraneous flow, known as infiltration and inflow (I/I), contributes to sanitary sewer overflows, backups into buildings, lost sewer capacity, and creates the unnecessary expense of transporting and treating storm water. This extraneous flow is a prohibited discharge under Section 23-102 of the City Code of Ordinances. As the property owner, you are required to correct the defects identified and thereby eliminate the prohibited discharge.

The City has various methods for investigation of the private lateral. One method is to force smoke into the sanitary sewer system and identify if it exits the lateral. The exiting smoke indicates a leak in the lateral. Laterals with roots, cracks, separated joints, deteriorated walls allow I/I to enter the system. Direct visual inspection of storm water flowing from the lateral during a rain event is another method of identifying lateral defects. Attached is information resulting from one of the inspection methods above that shows the lateral on your property is defective.

As the property owner, you are solely responsible for making the required repairs. We appreciate your attention to this important matter. If you have any questions, please call <<phone number>>.

Sincerely,

<<NAME>>

<<TITLE>>

Attachment

Appendix F
Smoke Testing Procedures

SECTION 02767
GRAVITY SEWER SYSTEM SMOKE TESTING

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required, smoke test those sewers designated and submit all required digital data identifying potential sources of inflow discovered as a result of smoke testing.
- B. CONTRACTOR as defined in this specification is presumed to be operating under a direct contract with ENGINEER to provide this scope of services. ENGINEER is responsible for CONTRACTOR's work and in some instances CONTRACTOR and ENGINEER may be the same entity.
- C. Document with digital photos video as necessary to record the locations of positive and negative testing results. Data shall be collected related to the test and entered into the OWNER's Smoke Testing database template with data entered into all fields. See Section 02768 for Smoke Testing database guidance.

1.02 RELATED WORK

- 1. Sanitary Sewer Line Cleaning is specified in Section 02650.
- 2. Sanitary Sewer Television Inspection of sewers is specified in Section 02731.
- 3. PACP Database Template is specified in Section 02732.
- 4. Dye Testing is specified in Section 02761.
- 5. Dye Testing Database Template is specified in Section 02762.
- 6. Gravity Sewer System Smoke Testing Database Template is specified in Section 02768.
- 7. Gravity Sewer System Manhole Inspections is specified in Section 02777.
- 8. MACP Database Template is specified in Section 02778.
- 9. Sanitary Sewer Flow Control is specified in Section 02965

1.03 SUBMITTALS

- A. Submit the following:
 - 1.
 - 2. Manufacturers data sheets on the smoke and the blower to be used on the project.

3. Proposed field data gathering and observation methodologies prior to the start of the work.
- B. Submit a Traffic Control Plan to the OWNER's Representative, which includes the following items.
1. Outline of permit acquisition procedure for lane closures.
 2. Methods for proper signing and barricades, which comply with local requirements and the OWNER.
 3. Site CONTRACTOR emergency phone numbers.
- C. Submit schedules of planned work on a weekly basis for the upcoming week, including a map in PDF format showing the area of work, and a map and list of streets being affected. Submittal should be provided by electronic mail to the OWNER. Provide 24-hour notice for deviations from the plan that are not caused by weather or natural causes.
- D. CONTRACTOR to submit confined space entry plan, certifications and hazardous atmosphere training certifications, if applicable.
- E. The work described in this Scope of Work, including any internal sewer or manhole inspections, shall meet the minimum requirements as presented in the OSHA Standard, Title 29 CFR 1910.146, Permit Required Confined Spaces. Upon commencement of the Work, copies of all confined space entry permits must be submitted to ENGINEER. CONTRACTOR shall notify the OWNER or delegated representative each day by phone, email or fax when it is necessary for CONTRACTOR to enter a manhole(s). CONTRACTOR shall identify all manholes that CONTRACTOR plans on entering that day by street location and manhole number.
- F. Final data shall be submitted in accordance with the requirements of this specification.

1.04 NOTIFICATIONS

A. Notify OWNER:

1. Submit schedules of planned work on a weekly basis for the upcoming week, including a map in PDF format showing the area of work, and a map and list of streets being affected. Submittal should be provided by electronic mail to the OWNER. Provide 24-hour notice for deviations from the plan that are not caused by weather or natural causes.
2. Immediately, when a collapsed pipe or other pipe failure is identified.
3. Immediately, if the conditions for inspection are found to be unsafe or impractical.
4. Immediately, if a manhole is buried, cannot be found or cannot be accessed. Along with the manhole name, provide a map showing the location of the manhole and what procedures were used to attempt to locate the manhole.

5. Inspection crews shall immediately notify the OWNER and/or on-site inspector of any defects posing imminent danger to the public (missing lids, covers broken during inspection, sink holes, etc.) and any observed pipe blockages, active surcharging, evidence of surcharging, or potential overflow conditions.
 6. If the pipe configuration in the field is different than shown in OWNER supplied GIS data. The notification shall include a diagram clearly indicating the location of structures in relation to immediately adjacent structures in PDF format via electronic mail. In addition, the information should be updated in the GIS database and will be provided to the OWNER at the time of submittal of the manhole inspection data relevant to that particular area or manhole structure in order to facilitate review and timely update of the OWNER's GIS to match the manhole inspection database.
- B. Notify the public and coordinate with homeowners:
1. A minimum of 4 days prior to the inspection of any line segment, distribute door-to-door an OWNER approved Homeowner Notification door hanger describing the work to be performed.
 2. CONTRACTOR must use approved magnetic car signs affixed to vehicles at all times during the project to identify affiliation with the City of Columbia, SC.

PART 2 PRODUCTS

2.01 MATERIALS

- A. The smoke used in smoke testing shall be acceptable for both indoor and outdoor use, shall be non-contaminating and shall leave no residue to stain clothing or the interior of buildings. Smoke shall be non-hazardous smoke by PlantPro Smoke Fluid (or equal) and shall be utilized to provide a continuous supply of smoke during the test and provide enough time for defects to be found and identified.

2.02 EQUIPMENT

- A. The air blower used to force smoke into the sewer pipe shall have a minimum capacity rating of 4000 cfm.

PART 3 EXECUTION

3.01 TESTING

- A. A minimum of 4 days prior to the inspection of any line segment, distribute door-to-door an OWNER approved Homeowner Notification door hanger describing the work to be performed. On the day of inspection and prior to the inspection, knock on the doors of all properties that will require entering their private property to access the manholes which will potentially be impacted by the work and notify occupants of this inspection.

- B. Smoke shall be blown into the sanitary sewer system at the manholes using a high-volume, gasoline- fueled smoke blower. Non-hazardous smoke shall be utilized to provide a continuous supply of smoke during the test and provide enough time for defects to be found and identified.
- C. Sewer sections shall be smoke tested by setting the blower at the up-stream manhole and blowing the smoke to the down-stream manhole.
- D. Testing shall not be done during rainy weather or when the ground is saturated from a recent rain event and testing shall be closely monitored on windy days. If smoke coming out of the ground is blown away so quickly as to escape accurate detection, testing will cease until such time that conditions permit.
- E. CONTRACTOR is solely responsible for the safety of their crews.
- F. The ENGINEER or his/her project representative reserves the right to observe field crews and evaluate effectiveness of identifying defects.
- G. CONTRACTOR shall not test more than 800 linear feet of sewer per setup unless approved by the ENGINEER. Adequate control shall be provided to prevent migration of smoke into upstream and downstream pipe segments through the use barriers or plugs. Bypass pumping is not required but flow-through plugs can be utilized.

PART 4 - DELIVERABLES

4.01 DELIVERABLES

- A. Documentation regarding each smoke leak identified in the field must be collected and delivered in the digital format described herein. The locations where smoke is observed shall be recorded with handheld, sub-meter GPS data collectors. Information regarding the characteristics of the defect and its surrounding area shall also be recorded and delivered in the OWNER's Smoke Testing database. The information collected shall include:
 - 1. Manhole identification numbers of all manholes/structures used to define the limits of the smoke test (i.e. both where blocked and where smoke was blown into the system) from the OWNER'S GIS (MH_Asset_ID database field).
 - 2. Pipe identification numbers of all the pipes involved in the smoke test (from the OWNER'S GIS (Pipe_Asset_ID database field).
 - 3. Direction of sewer flow (if different from that shown in the OWNER'S GIS).
 - 4. Direction of smoke.
 - 5. Date of smoke test (each test must be completed in a single day).
 - 6. System basin identifier as defined by the OWNER.
 - 7. Unique test number defined by the CONTRACTOR (however no spaces or special characters may be used in the name).
 - 8. Crew number defined by the CONTRACTOR.

9. Weather condition.
 10. Wind condition.
 11. Smoke intensity (high, medium or low).
 12. A code defining the potential cause of the smoke leak.
 13. Street address (where applicable) for the properties found to have smoke leaks.
 14. Unique identification numbers for sewer pipe and manholes found to have smoke leaks (from the OWNER'S GIS).
 15. Digital photographs of the smoke leaks in the format specified.
 16. Point locations (using GPS derived coordinates) in Esri geodatabase GIS identifying the location of each identified defect including the unique test number and sequential defect number described herein.
- B. CONTRACTOR shall take two digital photographs showing each defect located and the surrounding area. One photograph shall be taken to identify the general area of the defect and a second photograph shall be taken of the defect at closer range to provide context+D1 and smoke intensity. The precise location of the defect will be identified using sub-meter GPS equipment. The photographs shall show the smoke escaping, at the source, in the foreground with the reference structure in the background. The photographs shall be taken with a GPS enabled camera and be taken using JPG format and shall have a pixel resolution of at least 2 megapixels and the digital images shall have a minimum size/resolution of at least 1024x768 at a 4:3 aspect ratio or 1920 x 1080 at a 16:9 format. Each photo shall be given a filename that consists of the unique smoke test number (smoke test number is comprised of contractor, 8-digit date and number indicating test performed on that date) followed by a number indicating the photograph sequence and using an underscore to separate the test number, issue/defect location number and photo sequence number (for example:XYZ_20121211_3_2.JPG and XYZ_20121211_3_3.JPG are taken by contractor XYZ on 8-digit date 20121211 for the 3rd test on that date and represent the second and third images taken for the 3rd test). No spaces or special characters will be allowed in the file names except dashes or underscores and the photograph test numbers must correlate exactly back to those entered in the digital database submission.
- The address or house number shall be recorded for the locations of each smoke leak found on private property. A description of the leak and possible cause shall be recorded in the database submittal using the codes and guidance provided in Section 02768 for the Smoke Testing Database template provided. The City shall be notified of all issues identified on private property so that the Property Owner can be notified by the City. The Engineer shall provide the City with documentation to support the findings so that the City can communicate with the property owner.
- C. The contractor shall contact the Owner's GIS administrator to obtain an ID for any structural asset, with an unknown ID, constructed during or later than 2013.

- D. The results of each inspection must be delivered in a database formats using the smoke testing template database provided by the OWNER. The database filename will use the following format using upper case letters:

S_XYZ_BR02_SS7207_YYYYMMDD.MDB (where S=Smoke testing database; XYZ=Contractor name; BR02 = Example Basin_ID, SS7207 = Example PO_Number, YYYYMMDD=8-digit date)

- E. ENGINEER to provide inspection data on a monthly basis with the database and data on an external hard drive. The ENGINEER to provide two hard drives on an alternating monthly basis. The submittals shall be cumulative (i.e. each successive database delivery will include previous deliveries as well). CONTRACTOR shall provide OWNER with a final external hard drive capable of storing all anticipated data for the project upon completion. The final hard drive shall be submitted on the first monthly submittal with the first month of data loaded and will become property of the OWNER upon project completion. Data to be submitted shall include: 1) Smoke Testing database files, 2) .jpg files (still photos), 3).mpg files (videos) 4) a PDF of any reports or additional data sheets.
- F. Each database submittal shall indicate the range of dates for which the database is being submitted as well as a list of new items as of the last submittal so that the OWNER may separate out and review the newly delivered records from previous submittals in an Excel format.

The databases shall be cumulative, with one database for Smoke Testing. Each subsequent submittal shall be added into this database.

Throughout the duration of the project, should ENGINEER discover inaccuracies in any of the videos, CONTRACTOR shall re-inspect those manholes and/or pipes at no additional cost to the ENGINEER or OWNER

- G. The results of each inspection must be delivered in a database formats using the Smoke Testing database provided by the OWNER. GIS geodatabase data for the point locations collected shall be cumulative (i.e. each successive database delivery will include previous deliveries as well) and each point must include the unique test and defect number (i.e. TESTXYZ_1, TESTXYZ_2 where _1 and _2 are the sequential defects found for TESTXYZ) and must be delivered in the database template format provided by the OWNER, such as:

(02767_Gravity_Sewer_Smoke_Testing_Template_GPS_Geodatabase.mdb)

Unique test numbers for each test shall take the form of CONTRACTOR_ID (provided by the owner), the date of the test (YYYYMMDD format) and a sequential number denoting the test sequence performed on that date (i.e. 1, 2, 3, etc.). Each portion of the unique test number will be separated by an underscore. For example:

XYZ_20121211_3 would be the third test performed by contractor XYZ staff on December 11, 2012.

- H. Digital photocopies of all field data collection forms (if used by CONTRACTOR) should be delivered in PDF format and shall have file names that include the same unique smoke test number as the database submittal so that they can be easily related to the database and digital photograph submittals.
- I. For structural assets, with unknown ID, and constructed during or later than 2013, the contractor is required to obtain an ID from the GIS administrator.

END OF SECTION

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SECTION 02768
 DATABASE TEMPLATE DESCRIPTION GRAVITY SEWER SMOKE TESTING

PART I GENERAL

1.01 DATABASE TEMPLATE

- A. The attached database template (version 2) and formatting as specified must be used to document and deliver the results of all work related to smoke testing. A description is provided in this specification for each field, and formatting notes and examples for fields to provide additional guidance. Examples are provided for fields that are open that required additional clarity, and the lack of an example does not imply that the field can be left blank.
- B. All codes and descriptions must be used pursuant to Specification Section 02767 and the valid value tables within the attached database template.
- C. All database fields must be populated unless noted as optional in the Description field of the database table.

PART 2 TABLE FORMAT AND DESCRIPTION

- A. The following tables show available Field Names, the data type allowed, field size, a description of the Field, additional formatting notes if needed, and an example if provided.

2.01 INSPECTIONS TABLE

- A. This table shall be used to store the primary information regarding the inspection.

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Inspection_ID	Text	100	Unique inspection identification code in the format specified in specification Section 02767	Unique test numbers for each test shall take the form of CONTRACTOR_ID (provided by the OWNER), the date of the test (YYYYMMDD format) and a sequential number denoting the test sequence performed on that date (i.e. 1, 2, 3, etc.). Each portion of the unique test number will be separated by an underscore. For example: XYZ_20121211_3 would be the third test performed by contractor XYZ staff on December 11, 2012	XYZ_20121211_3

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Contractor_ID	Text	25	Unique contractor identification code	Use consistent entry, all uppercase	XYZ
ContractorCrew_ID	Text	25	Unique contractor crew identification code or number for the crew performing the test	Use consistent entry, all uppercase	BOB MARKLEY
PO_Number	Text	15	Customer's Purchase Order Number	CIP number	SS7207
Inspection_Date	Date/Time	8	Date the inspection was performed	Any valid date entry allowed, displays as: yyyyymmdd	20130726
Inspection_Time	Date/Time	8	Time of day the inspection was performed	Any valid time entry allowed, displays as: h:mm	13:41
Owner	Text	30	Owner of collection system surveyed	Validated single-value entry; default populated	City of Columbia
City	Text	64	City name where sewer located	Validated entry list e.g., Irmo, Columbia, Lexington	Irmo
Basin_ID	Text	15	City of Columbia wastewater system basin identification code from the City's GIS	Validated entry list e.g., BR03, BR04, CC01	BR02
Weather	Text	30	Weather conditions at the time of the inspection using the codes in the Valid_Weather table	Validated entry list e.g., Light Rain, Saturated, Snow	Heavy Rain
Wind	Text	50	Wind conditions at the time of the inspection using the codes in the Valid_Wind table	Validated entry list e.g., High, Low, Medium	Medium

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
StreetNumber	Text	30	Street address number of the building or structure nearest to the inspection or that the inspection was performed on, if applicable		312
StreetName	Text	200	Name of the street nearest to the inspection or that the inspection was performed on	Indicate street name when applicable i.e., if asset is in street or crosses the street or can be associated with an address. Use PREDIRECTIONAL STREET SUFFIX POSTDIRECTIONAL with no punctuation and all uppercase letters. Alleys or right-of-ways between two streets should remain unassigned. Fields, parks, other open areas should receive a positive entry of "OTHER".	N MAIN ST
Smoke_Direction	Text	50	The direction of the smoke flow - with pipe fluid flow or against pipe fluid flow as defined by the Valid_Direction table	Validated entry list e.g., Against, With	Against

2.02 CONTROL STRUCTURES TABLE

- A. This table shall be used to store information regarding the manholes in the system that define the limits of the smoke test and the smoke insertion point. These manholes shall be the manholes that are blocked and that are used to insert smoke for each test. This table shall have a one to many relationship to the Inspections table based on the Inspection_ID field and will relate to the City's GIS database via the MH_Asset_ID field.
- B. This table should be completed along with the inspections table.

Control_Structures					
Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Inspection_ID	Text	100	Unique inspection identification code in the format specified in specification Section 02767	Unique test numbers for each test shall take the form of CONTRACTOR_ID (provided by the OWNER), the date of the test (YYYYMMDD format) and a sequential number denoting the test sequence performed on that date (i.e. 1, 2, 3, etc.). Each portion of the unique test number will be separated by an underscore. For example: XYZ_20121211_3 would be the third test performed by contractor XYZ staff on December 11, 2012	XYZ_20121211_3
MH_Asset_ID	Text	100	Unique identification code from the City's GIS of the manhole that define the limits of the inspection (i.e. many manholes to one inspection)	Each manhole has been given unique structure identifications per OWNER guidelines, and the name of each database ID shall be that unique structure ID. If an unnamed structure is found, the letter "A" will be added to the end of the structure ID to form a new structure. If more than one unnamed manhole is found between two named manholes, subsequent new structure ID's will be formed using the letters "B", "C" etc. Spaces and special characters are not allowed in the unique ID codes. For example, SS-SR02-03123 or SS-SR02-03123A	SS-SR02-03123A
Smoke_Test_Use	Text	50	Code describing the use of the manhole during the test (i.e. blocked or used to insert smoke)	Validated entry list e.g., Blocked, Smoke Inserted	Smoke Inserted

2.03 MEDIA SMOKE TABLE

- A. This table shall be used to store information regarding the digital photographs taken for each smoke defect identified. Note that there will be many photograph records for each smoke defect location. Therefore there will be a one to many relationship between this table and the Smoke_Issues table based on the Smoke_Defect_ID

B. This table should be completed along with the inspections table.

Media_Smoke					
Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Media_ID	Auto-Number	4	Unique auto-generated ID		
Smoke_Defect_ID	Text	255	Unique, sequential smoke defect identification code for the defect photographed in the format specified in specification Section 02767	Integer values in sequential order of defects found e.g., 1, 2, 3 etc.	3
Image_Reference	Text	255	Unique image file name in the format specified in specification Section 02767	Each photo shall be given a filename that consists of the unique smoke test number (smoke test number is comprised of contractor, 8-digit date and number indicating test performed on that date) followed by a number indicating the photograph sequence and using an underscore to separate the test number, issue/defect location number and photo sequence number (for example: XYZ_20121211_3_2.JPG and XYZ_20121211_3_3.JPG are taken by contractor XYZ on 8-digit date 20121211 for the 3rd test on that date and represent the second and third images taken for the 3rd test). No spaces or special characters will be allowed in the file names except dashes or underscores and the photograph test numbers must correlate exactly back to those entered in the digital database submission. XYZ_20121211_3_1_2.JPG would be the Inspection_ID (XYZ_20121211_3), deflection location would be 1 (_1_) and this would be the second (_2.) photo at the defect location.	XYZ_20121211_3_1_2.JPG

2.04 PIPES INSPECTED TABLE

- A. This table shall be used to store information regarding pipes within the system that are isolated and tested as part of the inspection. This table shall have a one to many relationship to the Inspections table based on the Inspection_ID field and will relate to the City’s GIS database via the Pipe_Asset_ID field.
- B. This table should be completed along with the inspections table.

Pipes_Inspected					
Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Inspection_ID	Text	100	Unique inspection identification code in the format specified in specification Section 02767	Unique test numbers for each test shall take the form of CONTRACTOR_ID (provided by the OWNER), the date of the test (YYYYMMDD format) and a sequential number denoting the test sequence performed on that date (i.e. 1, 2, 3, etc.). Each portion of the unique test number will be separated by an underscore. For example: XYZ_20121211_3 would be the third test performed by contractor XYZ staff on December 11, 2012	XYZ_20121211_3
Pipe_Asset_ID	Text	100	Unique identification code from the City's GIS of each pipe that was inspected as part of each inspection (i.e. many pipes to one inspection)	Upstream_structure_ID:downstream_structure_ID. See structure ID formatting details.	SS-SR02-01674:SS-SR02-01675
Reverse_Flow	Yes/No	1	Notation that the direction of flow within the pipe feature is found in the field to be counter that shown in the City's GIS		

2.05 SMOKE ISSUES TABLE

- A. This table shall be used to store information regarding the defects identified by the smoke during the smoke test (i.e. pipe and manhole defects, roof drains, etc.). There will be a one to many relationship between this table and the Smoke_Media table based on the Smoke_Defect_ID.
- B. This table should be completed along with the inspections table.

Smoke_Issues					
Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Inspection_ID	Text	100	Unique inspection identification code in the format specified in specification Section 02767	Unique test numbers for each test shall take the form of CONTRACTOR_ID (provided by the OWNER), the date of the test (YYYYMMDD format) and a sequential number denoting the test sequence performed on that date (i.e. 1, 2, 3, etc.). Each portion of the unique test number will be separated by an underscore. For example: XYZ_20121211_3 would be the third test performed by contractor XYZ staff on December 11, 2012	XYZ_20121211_3
Smoke_Defect_ID	Text	100	Unique, sequential smoke defect identification code in the format specified in specification Section 02767	Integer values in sequential order of defects found e.g., 1, 2, 3 etc.	3
Smoke_Intensity	Text	15	Intensity of the smoke observed using the codes in the Valid_Intensity table	Validated entry list e.g., High, Medium, Low	Low

Field Name	Data Type	Field Size	Description	Additional Formatting Notes	Example
Smoke_Cause	Text	200	Potential cause for the smoke observed using the codes in the Valid_Cause table	Validated entry list e.g., Pipe Defect, Roof Drain, Yard Drain	Illicit Connection
Smoke_Street_Num	Text	30	Street address number of the building or structure where the smoke issue was found, if found on private property		312
Smoke_Street_Name	Text	200	Street name of the address of the building or structure where the smoke issue was found, if found on private property	Indicate street name when applicable i.e., if asset is in street or crosses the street or can be associated with an address. Use PREDIRECTIONAL STREET SUFFIX POSTDIRECTIONAL with no punctuation and all uppercase letters. Alleys or right-of-ways between two streets should remain unassigned. Fields, parks, other open areas should receive a positive entry of "OTHER".	N MAIN ST
Pipe_Asset_ID	Text	100	Unique identification code from the City's GIS for the pipe that was found to have a smoke issue (i.e. defect) - not only one pipe ID per issue record - not all defects will involve a pipe	Upstream_structure_ID:downstream_structure_ID. See structure ID formatting details.	SS-SR02-01674:SS-SR02-01675

X_Coordinate	Double	8	The horizontal geographic location coordinate of the inspection image location using the NAD_1983_H ARN_StatePlane_South_Carolina_FIPS_3900_Feet_Intl coordinate system	The locations where smoke is observed shall be recorded with handheld, sub-meter GPS data collectors. 02767 indicates submeter accuracy	1946419
Y_Coordinate	Double	8	The vertical geographic location coordinate of the inspection image location using the NAD_1983_H ARN_StatePlane_South_Carolina_FIPS_3900_Feet_Intl coordinate system	The locations where smoke is observed shall be recorded with handheld, sub-meter GPS data collectors. 02767 indicates submeter accuracy	806354
Notes	Text	255	Free-form text field to be used to add notes regarding details about the defect identified		

2.06 VALIDATED ENTRY TABLES

These tables shall be used to determine the valid entries allowed in certain fields as specified in the tables above. These tables are related to the above-mentioned tables within the database and provide predefined validated fields. The following tables are included in the database and should not be edited or modified:

1. Valid_Cause
2. Valid_Direction
3. Valid_Intensity
4. Valid_MH_Use
5. Valid_Weather
6. Valid_Wind
7. Valid_Basin
8. Valid_City

End of Section.

Appendix G
Pump Station Design and Equipment Checklist

City of Columbia Cleanwater 2020

CSAP - Evaluation of Pump Station Design and Equipment per SCDHEC regulation R.61-67

Checklist Item	(Yes/No/NA)
General	
Pump station located in restricted access area (fenced or locked building/enclosure).	
Weather-durable signage provided on fence or structure, with emergency contact telephone number.	
All-weather access road provided to the pump station.	
Pump station fully operational with flooding to the 25-year flood elevation.	
Pump station structures and equipment protected from physical damage by flooding to the 100-year flood elevation.	
Wet Well/Dry Well	
Ventilated wet well and dry well. Vent constructed of a weather-durable material.	
Common walls between wet well and valve pit or dry well are gas tight.	
Pumps	
Minimum of two (2) pumps.	
When two (2) pumps are provided, pumps are of the same capacity and are capable of handling the expected peak flow.	
When three (3) or more pumps are provided, pumps are of such capacity that with one (1) unit out of service the remaining units can handle the expected peak flow.	
Pump openings capable of passing spheres of at least 3-inches in diameter.	
Suction and discharge piping at least 4-inches in diameter.	
Duplex pumps operate in a lead lag sequence and on alternating cycles.	
Suction lift pumps are of the self-priming type.	
Valves and Valve Pit	
Shutoff and check valves located on the discharge line from each pump.	
Check valve located between shutoff valve and pump.	
Shutoff valve located outside of the wet well in a separate valve pit	
Check valves located outside of the wet well in a separate valve pit or dry well	
Electrical	
Electrical junction boxes located outside of the wet well unless box and components are made of a material suitable for use under corrosive conditions.	
Alarms	
Pump station includes an audible and visible high water alarm and/or a centralized automated alarm system.	
Alarm system functions if power is not available for any pump.	
Emergency Operations	
Emergency Operation Plan (EOP) provided. EOP includes method of maintaining continuous operability/power supply in the event of a power failure. Acceptable methods:	
<ul style="list-style-type: none"> a. Onsite standby generator with capability to operate automatically. b. Connection of pump station to two (2) separate utility substations with an automatic switching feature. c. Sufficient wet well capacity, above the Pump On level, to contain wastewater generated during the longest recorded power outage of the last five (5) years. d. Bypass pumping around the pumps and control panel and into the downstream force main. e. Transfer switch for portable generator. 	

PART 3A: SPECIFICATION FOR DESIGN OF PUMP STATIONS
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CITY OF COLUMBIA REGULATIONS
PART 3A
DESIGN OF PUMP STATIONS

City of Columbia
Pump Station Design Standards

The standards in this section are applicable to all pump stations that the City will own and maintain. This section is intended for pump stations with reliable design capacities of less than 1000 gpm serving domestic wastewater. For pump stations with larger reliable design capacities, or stations serving wastewater other than domestic, please contact the City Engineer for additional requirements and design standards.

All sewage pumping stations that will be turned over to the City for ownership and maintenance shall be reviewed during design before being bid for construction, and after completion of construction to ensure compliance with these standards. Failure to meet these requirements may result in denial of taking ownership of the pumping station, force main, and appurtenances until the requirements are met.

The standards listed below are minimum City of Columbia design standards. The written standards in combination with the standard details and referenced documents are all included as a part of the standard. These should be adhered to, with good Engineering practice. If a variation or exception is needed to maintain good Engineering practices, please provide an explanation supporting the type of variation, and the reason for the variation for review by the City for acceptance. A submittal of a variance request does not guarantee approval.

The developer is responsible for securing and paying all application and permit fees and costs associated with and incurred for the pump station before final acceptance. The City will take ownership of the pump station upon final acceptance, at which time future billing will be transferred to the City of Columbia.

GENERAL

1. In general pumping stations will only be approved where gravity service is not possible.
2. Sewage pumping stations shall not be subject to flooding. Temporary facilities expected to be in service from five to ten years shall be protected from the 25 year frequency storm in accordance with the Columbia Drainage Ordinance. Permanent facilities which have a life expectancy of more than ten years shall be 2 feet above the 100 year flood plain or one foot above the base flood elevation, whichever is more stringent. A suitable superstructure, preferably located off the right-of-way of streets and alleys, should be provided. It is important that the station be readily accessible.
3. All pump stations and force mains shall be the requirements of SCDHEC Standards for Wastewater Facility Construction R.61-67 and Ten State Standards, latest edition.
4. Pump Station sites, collection system, force main, access road, and any other appurtenances that are to be owned and maintained by the City are to be deeded over to the City per the City property requirements for Pump Stations.
5. All paints and coatings to be applied to meet or exceed manufacturer's recommendations for the specific application.

6. Provide flood elevation on drawings and record drawings. List surveyor information-date, by whom, and datum.

PUMP STATION SITE AND EQUIPMENT

1. The size of the site provided for the pumping station must be a minimum of 60 feet by 60 feet. The pumping station site must be fenced with an access gate. The fence shall be a 6 foot tall standard galvanized fence with eight gauge wire (not coated) with 3 strand barbed wire. Wooden fences are not allowed as a substitution. However, a wooden fence is allowed outside of the galvanized fence for screening and aesthetic purposes, but must be located outside of the City's pump station property and be maintained by the property owner.
2. A double swing gate shall be provided at the pump station site access. The gate shall consist of two eight-foot gates with self-holding latches and a center post.
3. The fence shall have a City standard weather durable emergency contact sign attached with hardware at a location visible from the access road.
4. An all-weather surface road a minimum of 12 feet wide shall be provided for access to the pump station site. The road shall consist of a minimum of 6-inches of crusher run stone, AND must be capable of supporting 36,000 pound vehicles. A permanent easement, a minimum of 20 feet wide, must be furnished centered along the access road.
5. Pump stations shall be designed to be submersible type stations.
6. Pump station wet wells shall be round. Wet wells shall be sized for sewershed basin build-out utilizing sound Engineering practice and standards and shall include available information such as Metcalf and Eddy land use flow projections, topographic maps, land use maps, zoning, population projections, the study of available land for development, and other available City or County planning studies which may include the sewershed area.
7. The wet well shall be positioned inside the fence so as to allow easy access with a vacuum or boom truck.
8. A by-pass pumping connection utilizing Bauer fittings shall be provided close to the entrance and easily accessible with a truck.
9. Pump station wet well and vaults to be sized for build-out conditions and shall be large enough to accommodate future pump sizes.
10. Valve Vaults shall be of sufficient inside depth to house valves and appurtenances with enough clearance, but shall be shallow enough to not be defined as a confined space.
11. Wet well access hatch to be stainless steel and sized to provide the ability to remove existing and future pumps, as well as access to guide rails and float hangars. Access hatch to be a minimum 4-foot by 4-foot.

12. Wet well shall be provided with a ductile iron vent with a 90-degree elbow on the end with a slotted screen. The entire vent shall be coated with Light Grey 32GR Tenemec paint or approved equal.
13. Pumps to be submersible Flygt pumps. A minimum of two identical pumps are to be installed. In addition to the pumps installed, an additional identical spare pump shall be provided and delivered to the City Metro Wastewater Treatment Plant. Pumps are to be designed with a design capacity that will be able to handle maximum flows with any one pump out of service.
14. The design of the pumping station shall include the evaluation of the downstream receiving collection system to ensure that there is adequate capacity to handle the proposed flows and pumping rates. The extent of the downstream collection system requiring evaluation, as well as the criteria for evaluation, shall be determined by the City.
15. One pump in the pumping station shall have a Flygt mix flush valve installed by the manufacturer's representative.
16. Pumps to be provided with Flygt standard guide rails with spacing that will also accommodate build-out condition pumps. Guide rails may be welded for wet wells up to 23 feet deep as long as the piece added to the 20 foot section is no longer than 3 feet in length. An internal spline piece made of smaller pipe to fit the inside diameter of the guide rail should extend at least 3 inches into each pipe being welded together. The finished weld should be smooth with the exterior of the welded sections so as not to interfere with the pump guide rail bracket when removing or installing the pumps. Any wet well requiring more than three feet additional guide bar length shall use an intermediate guide rail bracket attached to the discharge pipe.
17. All hardware shall be stainless steel including, but not limited to, lifting chains, bolts, nuts, guide rails, anchors, bolts, nuts, washers, screws, etc.
18. Each pump to include a 3/8-inch PC 316 stainless steel lifting chain.
19. Provide two Flygt or approved equal flat bolted stainless steel plates with 4 hooks minimum on each on opposite sides of the wet well access.
20. Level sensors shall be provided to include Pumps Off, Lead On, Lag On, Pumps Off, and Alarm at a minimum. Levels to be read using a Birdcage level transducer for wet wells over 20 feet deep (with a minimum 30 foot range capability if less than 30 feet is required, or greater if needed), and either Birdcage level transmitter or Ultrasonic level sensors for wet wells 20 feet deep or less (with a minimum 30 foot range capability). All pump stations shall have a float switch backup system that is in place and operates in case of level sensor failure as further defined in the SCADA specifications. Pneumatic bubbler systems are not acceptable.
21. Wet well interior (excluding the bottom) and all exposed piping in the wet well shall be coated with Raven 405 coating.
22. The wet well floor shall have a minimum slope of one to one to the hopper bottom. The horizontal area of the hopper bottom shall be no greater than necessary for proper installation and function of the inlet.
23. Valve vault shall be less than 4 feet deep and a minimum 4-foot by 4-foot size for a 4-inch discharge and 4-foot by 6-foot for a 6-inch discharge. The size shall be increased as needed.

24. Valve vault to have an access hatch that opens to expose the entire vault, matching the size of the vault interior. The hatch shall be a traffic rated aluminum access hatch.
25. A drain from the valve vault to the wet well shall be provided with a minimum 4-inch drain at a minimum 1 percent slope. A Tideflex Series 35 Flanged Check Valve or approved equal shall be used on the interior of the wet well on the end of the drain line from the valve vault. The valve shall be positioned as to not interfere with pump removal, and be visible and readily accessible from the wet well hatch opening (ie-not behind guide rails, etc). A removable screen shall be installed on the intake side of the drain to prevent debris from entering the drain.
26. Safety grating shall be provided in the wet well.
27. All exposed piping, fittings, and valves shall be painted with 095F Spearmint Green/Safety Tenemec paint or approved equal.
28. No check valves shall be installed inside of the wet well. Check valves shall be located within the valve vault between the pump and the shut-off valve.
29. A water supply with a minimum 4-inch service shall be installed to the site with a Mueller or approved equal post hydrant and a yard hydrant. The hydrants shall be frost and freeze proof, and shall be anti-siphon. All fees must be paid by the developer.
30. A testable backflow preventer and meter shall be provided for the water service to the site. The meter and backflow preventer shall be located in separate meter boxes.
31. Two hoses shall be provided at the site. A 25-foot industrial 2-inch hose with an adjustable brass spray nozzle and a 25-foot .75-inch hose with an adjustable brass spray nozzle shall be provided. A hose rack shall be provided for each hose.
32. Check valves 12-inches and smaller shall be Mueller A-2606-6-01B1 flanged end with rubber disc facing swing type lever and weight.
33. Pressure gauges shall be quick disconnect Ashcroft or Wika that are accurate within 0.5 percent of the total scale range. The gauges shall have type 316L stainless steel housing and components, and shall provide a top limit above the pump shutoff head. Pressure gauges to be installed with an Apollo stainless steel shut-off ball valve with handle.
34. Stainless steel ball valves 3-inches and smaller shall be full port with a lever handle operator, and a three piece body that is in-line serviceable without removing the valve from the line. Acceptable manufacturers include Series 60 as manufactured by Whitey or Apollo Series 86R-200 as manufactured by Conbraco, CF Ball Valve Series F12 as manufactured by CF Fluid Controls, or V3P-1000 as manufactured by Velan. Stainless steel ball valves 3 to 4 inches shall be regular port stainless steel ball valves with an oval handle operator, top entry design, fully serviceable without removing the valve body from the line, Seal body cover to body section with fully closed spiral wound graphite gasket, and adjustable two-piece packing gland and pre-compressed solid packing rings. Acceptable manufacturers include Series "TE-150/300/600" as manufactured by Velan.
35. Surge relief valves shall be provided if required in the valve vault.

36. Plug valves shall be Dezurik.
37. Air release valves shall be ARI D-025 and shall be housed in a manhole with an open bedded bottom.
38. Anchor bolts for the pump discharge stand must be J-type stainless steel cast in place in the wet well floor.
39. Two level indicators shall be marked on the inside of the wet well at a pre-measured distance for the use of draw-down tests. The markings should be clearly visible without entering the wet well, and shall be resistant to fading or reduced visibility over time due to debris or build-up. The pre-measured distance and diameter of the wet well shall be written clearly above the higher of the two levels and readable from outside of the wet well. The markings shall not be such to void the warranty of the Raven coating on the interior of the wet well.
40. A canopy shall be provided on the pump station site that covers the panels. See the standard canopy detail. The canopy shall be painted Tenemec medium bronze 85BR, and shall be on a minimum 6-inch pad that spans the extents of the canopy. Engineer is responsible for reviewing the standard canopy detail and making modifications to ensure the canopy is structurally sound, and making adjustments as needed to increase the requirements. The standard detail shown is a minimum requirement and may not be sufficient for all sites.
41. Wet well shall be sized for build-out conditions. All conditions listed below shall be met for current design and future build-out design conditions by simple adjustments in level controls or changing of pumps.
42. Pumps shall not run less than 1 minute (or more if recommended by the pump manufacturer) with no flow entering the wet well.
43. The reliable pumping capacity (defined as one pump on in a duplex station) shall be higher than the peak inflow rate in gpm into the pump station.
44. The pump station shall be designed to run no more than 6 cumulative hours a day.
45. Pumps should be selected that have an operating point at or near peak efficiency.
46. Pumps shall be capable of passing spheres of at least three inches in diameter. Pump suction and discharge openings shall be at least four (4) inches in diameter.
47. Pump stations shall have screening mechanisms before the pumps if larger solids will be received by the station, or if wastewater received is determined to be more than typical household wastewater.
48. Force mains shall be adequately sized to handle the design peak flow of the sewershed drainage basin.
49. The force main should enter the gravity sewer system at a point not more than two feet above the flow line of the receiving manhole.
50. An automatic air release valve for sewage application shall be placed at high points in the force main to prevent air locking.

51. At design average flow, a cleaning velocity of at least two feet per second shall be maintained in the force main.
52. Pump Station Drawings Shall include a chart showing pump conditions and ranges such as the one below:

Condition	Flow Per Pump	TDH	Total Pump Station Flow
(Pumps On)	GPM	Feet	GPM
One Pump	XX	XX	XX
Two Pumps	XX	XX	XX

BACK-UP POWER

1. Natural gas generator shall be provided on all pump station sites and shall be capable of running all equipment as a secondary power source in case of a power failure. Generator shall meet a minimum of the standards in the City’s Natural Gas Fueled Engine Driven Generator Specification as outlined in Section 16216.
2. Generator shall be silenced and meet local sound ordinances and in strict accordance with Section 16216.
3. Generator shall be provided with an automatic transfer switch (ATS) per the requirements of Section 16216.
4. All generator support structures, concrete pads, site layout, etc. shall be designed accordingly for a complete standby power system at each location.

SCADA

1. Provide equipment, services, and associated components to meet the City’s standard Remote Telemetry Unit, Instrumentation and SCADA System Interface Specification Section X and associated Standard Construction Details.

ELECTRICAL

1. Provide equipment, services, and associated components to meet the City’s standard Lift Station Electrical Requirements Specification Section 16000 and associated Standard Construction Details.

OTHER REQUIREMENTS

1. Authorized supplier of check valves shall be present on site during installation to set valve weight and make adjustments as necessary to meet design conditions as intended by the design engineer.
2. Contractor responsible for the design, installation, and operation of by-pass pumping operations or pumping and hauling operations needed to complete the work for the construction of the pump station and its appurtenances, including the force main. Contractor to submit a plan to the Engineer for review of operations, which should include any requests and supporting reasoning for creating surcharge conditions within the sewer system that will need to be considered and reviewed by the City as well as the design engineer. The City’s review of the proposed conditions does not relieve the

Contractor of any responsibility and liability of these operations, including overflows, damage to property or the sewer system, and meeting the requirements of other regulatory agencies.

3. Contractor to submit to the design engineer written certification from the coating manufacturer demonstrating the persons applying the Raven 405 coating are certified in the application. The application shall have a standard manufacturer's warranty from defects.
4. A preconstruction conference of Wastewater Maintenance Division personnel with the Contractor and design engineer will be held at the pump station site.
5. A full set up Operations and Maintenance Manuals shall be provided for the SCADA system, pumps, motors, control panel, generator, ATS, and any other appurtenances provided on the site. 2 hard copies and 1 electronic PDF copy shall be provided to the City before ownership transfer. The manuals shall include, but not be limited to, operational instructions, emergency procedures, maintenance schedules, pump curves, parts lists, tools, spare parts, etc. Contractor to coordinate with the City to determine what asset information is to be provided by the Contractor necessary for City Works before the completion of the project.
6. A training session shall be conducted covering all O&M aspects of the pump station including, but not limited to operational instructions, emergency procedures, maintenance schedules etc. for City staff. The training shall be recorded on video and a copy of the video shall be provided in electronic format.
7. The following spare parts are to be delivered to the City before close-out:
 - a. 3 sets of o-rings and seals for each pump
 - b. 1 spare pump and cable
 - c. 1 spare pressure transmitter/level control
 - d. All recommended spare parts as listed in the SCADA/Electrical/Stand-By Power Specifications
8. All spare parts shall be delivered to the Metro Wastewater Treatment Plant. A clear record of the items delivered, the date, and who they were delivered to, and a signed notification acknowledging the receipt of each part shall be documented and included in project close-out documentation.

STANDARD DETAILS

1. Typical Pump Station Site Layout
2. Typical Cross section of Wet Well and Valve Vault
3. Emergency Contact Sign
4. Typical Fence and Gate Detail
5. Typical Pump Controls Canopy
6. Typical Electrical/RTU/Instrumentation/SCADA Details (standard details provided by MR Systems)
7. By-pass pumping Connection Detail
8. Air release valve detail

Appendix H
Sewer Mapping Program Report

Clean Water 2020 Program

SEWER MAPPING PROGRAM

July 2014



Submitted to EPA-SCDHEC
July 17, 2014



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Program Summary and Intent

The City of Columbia (City) has designed this Sewer Mapping Program (SMP) to establish the City's current wastewater collection system (WCTS) asset data and electronic systems to be used in connection with other programs required under the Consent Decree (CD Programs). The SMP is part of the larger Information Management System (IMS) required by the Consent Decree (CD) and forms the basis for supporting, storing and distributing location, connectivity, and other data regarding the physical wastewater system assets (gravity pipes, manholes, valves, pump stations, force mains and other associated components).

Below is a list of the CD requirements for the SMP and the sections of this document that address each requirement. The SMP for the City shall:

- Subparagraph 12.f.(i) – *“enable Columbia to produce maps of the WCTS using GIS technology.”* This is addressed in **Section 4 Map Standards and Products.**
- Subparagraph 12.f.(ii) – *“be designed in such a manner so as to allow electronic integration with Columbia’s computer-based collection system model and computer-based operations and maintenance information management system.”* This is addressed in **Section 2 Mapping Plan Computer Systems and Integration.**
- Subparagraph 12.f.(iii) – *“enable Columbia to produce maps showing the location of all manholes, Gravity Sewer Lines, Pump Stations, Force Mains, valves, inverted siphons and the WWTPs.”* This is addressed in **Section 4 Map Standards and Products.**
- Subparagraph 12.f.(iv) – *“enable Columbia to produce maps capable of integrating electronically the locations of sewer service connections on lines that are televised.”* This is addressed in **Subsection 3.1.2. Data collection methods.**
- Subparagraph 12.f.(v) – *“enable Columbia to produce maps that include attribute data for Columbia’s WCTS including, but not limited to, size, material, estimated age or age range, slope, invert elevation, and rim elevation.”* This is addressed in **Subsection 3.1.3. Data to be collected** and **Section 4 Map Standards and Products.**
- Subparagraph 12.f.(vi) – *“enable Columbia to produce maps that delineate the spatial boundaries of all Sewerbasins and Subbasins.”* This is addressed in **Subsection 3.3. Basin boundary modifications** and **Section 4 Map Standards and Products.**
- Subparagraph 12.f.(vii) – *“enable Columbia to produce maps that can integrate electronically available maps that show the location of surface streets and street addresses, permitted FOG customers, surface water bodies and political boundaries.”* This is addressed in **Subsection 2.2.5. Fats Oils and Grease (FOG) program data management** and **Section 4 Map Standards and Products.**
- Subparagraph 12.f.(viii) – *“enable Columbia to produce maps in a manner that will allow use by all*

*Sewer System operation and maintenance crew leaders in the field.” This is addressed in **Section 4 Map Standards and Products.***

- Subparagraph 12.f.(ix) – *“allow entry and mapping of work orders to identify and track problems geographically such as stoppages, service interruptions, and SSOs, and to assist in the planning and scheduling of maintenance.” This is addressed in **Subsection 2.2.1. Cityworks®** and **Section 4 Map Standards and Products.***
- Subparagraph 12.f.(x) – *“include written standard operating procedures for use of the program, the acquisition and entry of updated mapping data for new assets or changes to existing assets, and updates to system software.” This is addressed in **Section 5 Standard Operating Procedures (SOPs)***
- Subparagraph 12.f.(xi) – *“include locations of each permitted FOG establishment.” This is addressed in **Subsection 2.2.5. Fats, Oils and Grease (FOG) program data management.***
- Subparagraph 12.f.(xii) – *“include a schedule for the completion of the electronic mapping of each Sewerbasin in Columbia’s WCTS.” This is addressed in **Section 6 Sewer System Mapping Program Implementation.***

Acronyms

ARV - Air Release Valve

CAP - Capacity Assurance Program

CCTV - Closed-Circuit Television

CD – Consent Decree

CERP - Contingency and Emergency Response Plan

CMMS - Computerized Maintenance Management System

CMOM - Capacity, Management, Operations, and Maintenance

CSAP - Continuing Sewer Assessment Program

CW2020 – City’s program to manage the Consent Decree compliance

Esri – Environmental Systems Research Institute

FOG - Fats, Oils and Grease

IMS - Information Management System

IRP - Infrastructure Rehabilitation Program

MOM - Management, Operations and Maintenance

PMO - Program Management Office

PMP - Project Management Plan

SOP - Standard Operating Procedure

SSES - Sewer System Evaluation Survey

SSO - Sanitary Sewer Overflow

WCTS - Wastewater Collection and Transmission System

WWTP - Wastewater Treatment Plant

Section 1. Sewer Mapping Program Objectives

1.1. Introduction and Objectives of the Plan

The City of Columbia (City) has continually maintained records regarding the City's wastewater collection and transmission system (WCTS) both in paper format and, more recently, in digital format within the City's centralized geographic information system (GIS). The City is constantly working to maintain and upgrade the database of information regarding the WCTS assets. The City, under the Information Management System (IMS) Development task of the Consent Decree (CD) and the resulting City Program, is developing and implementing an overall information management system to be used by staff to review, store, manage, and integrate the data generated throughout both on-going CW2020 Program and future City projects. The final IMS will include, but may not be limited to, the following items, many of which will require the support of accurate and complete sewer system mapping:

- A description of information to be managed under this sewer mapping plan and entered into the system, how it is entered, and by what means it is recorded
- A description of the types of work reports prepared and submitted, including example
- A description of the management reports generated using the data gathered (i.e., work reports, location maps, performance reports, etc.)
- Standard data collection formats used by both field personnel and management
- A detailed description of how the records are maintained
- A description of the software used with cited references for software training and procedures for utilizing the software
- Procedures for periodic quality assurance/quality control checks of the system
- Standard operating procedures
- Standard map templates for distribution of information from the system

Efficient, accurate, and complete information regarding the sewer system, its assets, attributes, and condition is critical to the management of the sewer system and the resulting reduction in sewer system overflow (SSO) events. The Sewer Mapping Program (SMP) will provide the documentation of the planned activities to support the development of the mapping components of the IMS and the resulting upgrades to the City's database of information regarding the assets that make up City's wastewater collection and transmission system. This SMP outlines the activities that will be undertaken to collect, review, integrate and distribute information regarding the City's sewer system as required pursuant to Paragraph 12.f. of the Consent Decree entered by order dated May 21, 2014 in *The United States of America and State of South Carolina by and through the Department of Health and Environmental Control vs. The City of Columbia*, Civil Action No. 3:13-2429-TLW, DOJ Case Number 90-5-1-1-00954. The SMP includes activities to address the following key objectives.

1.1.1. Integration with Other Systems

The City of Columbia has invested in many computerized systems to manage the day-to-day operations of the WCTS. These include the Cityworks® computerized maintenance management system (CMMS), hydraulic modeling applications, capital projects tracking databases and other continuously evolving applications to more efficiently manage the WCTS, performance, operations, and maintenance. A key objective of the SMP will be to facilitate the integration of WCTS data between the various systems and

to put in place operating procedures to promote the continued linkage and flow of data throughout the program into the future. Section 2 of this document further describes the planned integration of the existing and future applications.

1.1.2. Data Collection

A number of the other City activities will be collecting large amounts of information that can be used to upgrade and augment the existing City of Columbia WCTS GIS data set. The SMP will include data collection specifications to be used to accurately collect information regarding the WCTS assets in the field and deliver them to the City in such a way as to allow efficient, electronic integration of the collected data into the City's WCTS GIS data sets and other databases. Section 3 of this document describes the activities to facilitate data collection and integration efforts.

1.1.3. Informational Map Products

The collection of updated information regarding the WCTS, while important, will not provide benefit if stakeholders and those working on the system do not have clear, timely and accurate information regarding the location and key attributes about the system to reference. Therefore, map documents, both paper and digital, will be a key component of the SMP and will provide information to guide work and report on progress and systems issues as the overall program continues into future phases of work. The planned mapping standards and products are described herein in Section 4.

1.1.4. Standard Operating Procedures

A critical objective of the SMP will be to develop standard operation procedures (SOP) to be used by staff for the implementation of a sustainable mapping program. The procedures will provide staff with both step-by-step procedures to be used to perform mapping tasks (data updates, quality checking, etc.) and documented software tools to be used by staff to increase efficiency in processing the large amount of data generated by the on-going activities of consultants, contractors, and daily City work activities. The SOPs are documented within Section 5 of this document.

Section 2. Mapping Plan Computer Systems and Integration

The City maintains many computerized systems to support the day-to-day staff work activities including a GIS database that includes layers for both basemap data (streets, buildings, etc.) and the WCTS assets such as sewer pipes and manhole locations. The goal of the SMP is to increase the completeness and accuracy of the City's WCTS GIS data sets while integrating the updated mapping layers with additional system data. This section describes the current state of the City's WCTS GIS data and the planned integration of these data with other City computer applications.

2.1. GIS Mapping System Computer Components

The City currently has a GIS department with full-time, dedicated GIS professionals that are charged with maintaining the GIS data and assisting City staff in using the GIS and its outputs. The following is a description of the planned SMP GIS components that will be used during the implementation of the sewer mapping plan.

2.1.1. Esri ArcGIS Desktop GIS

Esri ArcGIS software will be used as the primary mapping and GIS data management software platform for the SMP. The application version to be used will be the version currently in use by the City, or the version that is required to maintain compatibility with other software being used, such as hydraulic modeling software.

2.1.1.1. Desktop Software Tools

As part of the SMP, a number of software tools will be implemented. Customized tools from Esri will be used to support network flow tracing, streamline data entry and perform quality control checking of the data. These applications and the software codes required to operate them will be developed under the direction of the City GIS staff.

2.1.1.2. Quality Control Software Used

Esri's Data Reviewer extension for the ArcGIS desktop application will be used to perform, manage and track the review of the data developed as part of the SMP, as it is integrated into the City's database. This will include both spatial data (i.e., GIS data) and non-spatial data (i.e., manhole inspection data, etc.) and will provide an on-going, centralized database regarding the number, type and status of issues identified during the quality control reviews. See Section 5.1.3 for more description of the planned quality control checking to be performed.

2.1.2. Esri ArcGIS Server Components

The SMP data will be accessed by many users and applications. This will require a multi-user, centralized database to store, manage and distribute the GIS and other data during the program lifecycle. This will require both spatial (GIS) and non-spatial databases as described below.

2.1.2.1. ArcSDE Multi-user Database

The sewer network and basemap GIS data within the IMS will be stored in a multi-user Esri ArcSDE

(spatial database engine) geodatabase. This form of database allows for multiple users to both edit and view the data at the same time allowing for maximum flexibility. As edits can be made by multiple staff at the same time, the ArcSDE database will provide the most efficient method of continuously updating the sewer network data for use in the SMP. The geodatabase will be stored on a centralized computer server on the same Microsoft SQL Server database that will store other key datasets such as the manhole and pipe inspection databases and video files. The ArcSDE database will also feed the Program web-portal with GIS data for the web-map portion of the portal.

2.1.2.2. Microsoft SQL Server Database

Due to the large volume of data that will be collected, a centralized 'enterprise' level database will be needed to store and distribute the data. The IMS will therefore use a Microsoft SQL Server database to store both the spatial (GIS) data as well as the various datasets collected during the early phases of the SMP. (See Section 3)

2.1.2.2. ArcServer Website

The City will develop a web-based portal which will contain information and documentation pertaining to its sewer system. The portal will contain an interactive GIS-based map which will display selected information from the City's GIS database.

The web-map will be fed with data directly from the master SMP GIS database stored in ArcSDE as described above. This will provide users of the system with the most up-to-date and complete information regarding the sewer system and data that is continually generated.

2.1.3. User Control Levels

Users will have access to the SMP data and components based on a set of login credentials that will provide them with the appropriate access (read only or edit) to the various datasets and applications within the SMP. Sensitive data will be limited to only those individuals with the appropriate need to have access including printed paper map sets.

2.2. Integration with Other Applications

2.2.1. CMMS

The City has implemented Azteca Software's Cityworks® Server AMS (Cityworks®) for its CMMS. Cityworks® is a web-based, GIS-centric application that tracks all maintenance-related activities for the WCTS. Since Cityworks® is seamlessly integrated with GIS, work orders generated and managed by the system are linked to the corresponding GIS asset and can be displayed geographically. The asset registry for all assets within Cityworks® is the ArcSDE geodatabase. Therefore, as long as an asset is created within the GIS, that asset can be accessible to Cityworks®. In addition, Cityworks® also tracks corrective and preventive maintenance work histories through work orders, inspections, service requests, and inventory. On-going work by consultants, contractors, and City staff will continue to ensure new assets are added as Program work moves forward.

The SMP will take advantage of the GIS-centric nature of Cityworks® to map work order data and generate status maps and other ad-hoc reporting/mapping needs. See Section 4 for more detail regarding the planned work order mapping products.

2.2.2. Hydraulic Model

A hydraulic model of the large diameter (15 inches and greater) sewer pipe “trunk” network will be developed and is scheduled for completion in accordance with Consent Decree requirements. The hydraulic model will provide information regarding sewer flow volumes and pipe network capacities to City and program staff once completed. Data from the GIS will be used to populate the hydraulic model, and outputs from the model will be available to the IMS through the sewer system network data in the GIS.

2.2.2.1. Integration Methodology

The hydraulic model will have a one-to-one correspondence to the City’s GIS sewer trunk pipe network where the pipes and pipe end structures, such as manholes, will have the same spatial location in the model as the GIS data layers and will have the same unique identifier codes (UICs). This will allow analysis results from the model to be viewed and mapped within the SMP GIS both on-screen and as mapping products for reports, etc. The GIS and model databases will be maintained separately but each system will be updated with data from the other at regular intervals as part of regularly scheduled maintenance procedures.

2.2.3. Inspection Data

Section 3.1 describes in detail the anticipated sewer pipe and manhole inspections that contractors and City staff will be performing. Ultimately, inspections will be conducted on a subset of the system as determined by the City based on needs. These inspections will result in both database tables and digital video/photographs of the sewer assets that will be stored within the IMS. The results will be utilized within the SMP to update sewer connectivity and condition mapping. These data will provide important information for future operations and maintenance as well as asset condition tracking within the Program and by City staff in the future.

2.2.3.1. Integration Methodology

The integration of the various inspection databases are described below.

2.2.3.1.1. Closed-Circuit Television (CCTV) and Manhole Inspections

The same City GIS UICs are required to be used within the inspection databases by contractors and City staff. These identifiers will provide the link between the GIS assets and the inspection databases and video/photograph files. An asset naming convention will be developed which will describe the structure of these identifiers. The Continuing Sewer Assessment Program (CSAP) and Sewer System Evaluation Survey (SSES) data collection specifications and PACP/MACP requirements will result in standard databases for each of the inspections.

City staff will combine the various inspection database deliveries, once quality-control checked and approved, into single, master inspection databases (one each for CCTV and manhole inspections) within the IMS inside the City’s existing Microsoft SQL Server centralized database. The linkage to the GIS based on the unique identifier codes will allow City staff to query and map inspection results from the database and highlight specific pipes and manhole features in the GIS.

2.2.3.1.2. Smoke and Dye Testing

As part of the CSAP, a number of sewer pipe assets will undergo smoke and dye testing to answer questions concerning the connectivity and condition of the sewer system pipes and structures as well as identify potential sources of inflow. The results of these inspections will be provided to the Program in a standard, specified format that, once approved by the City, will be combined into single, master inspection databases (one each for smoke and dye inspections) within the IMS inside the Microsoft SQL Server centralized database. Using the unique identifier codes to connect the GIS to the database will allow City staff to query and map inspection results from the database and highlight specific pipes and manhole features in the GIS.

2.2.4. Capital Projects

The City anticipates a major expansion of sewer rehabilitation projects over the next 10 years. This effort will result in a large number of capital projects that will require accurate tracking of status, location, budget, and type. Status reports for on-going projects in a given area will be important for both City staff as well as for residents. The City is currently tracking capital improvement projects (CIP) within a tabular database.

2.2.4.1. Project Tracking Methodology

City GIS and capital project management staff will maintain GIS point and polygon data layers that identify the boundaries of on-going projects with a unique project identification number that links the GIS layer to the CIP database. The CIP database contains information regarding the projects including cost, schedule, and contractor information. As the projects progress, the database is updated with information regarding the project status. As projects are created, City GIS staff identify the sewer system pipes and structures that will be affected by the project and populate a separate “asset” table with the unique GIS identifiers for those assets. This information will be used to develop CIP location maps as described in Section 4.

2.2.4.2. Integration Methodology

The SMP will contain a copy of the City’s CIP database and GIS data layers that will be updated regularly for use in mapping the status of the projects. The CIP project identifier within the CIP database will be used to link the CIP database to the project point and polygon GIS data layers. SMP users will also be able to identify the exact sewer system assets involved in a project through the association to the sewer system GIS data layers based on the unique GIS asset identifier stored in the ‘asset’ table. These connections will be used to develop color-coded thematic mapping products and data layers that can be viewed in the Program web-portal map. Examples of potential web-based products include project status maps and maps highlighting assets impacted by specific projects.

2.2.5. Fats, Oils and Grease (FOG) Program Data Management

The City maintains a fats, oils, and grease (FOG) reduction program aimed at educating commercial and private establishments regarding the need to properly dispose of the fatty or oily cooking byproducts

rather than allowing them to enter the sewer system. The FOG program currently tracks over 800 permitted locations for their compliance with City ordinance requirements. The IMS will include a database for tracking the locations linked to a GIS data layer (points) showing the location of each establishment being tracked.

The sewer connection location for each permitted FOG contributor will be identified in the GIS and the status of downstream presence of oils and grease within the sewer network will be monitored and tracked to verify compliance with the Program and document the reduction in blockages in the sewer system. The Cityworks® work order system linked to the GIS will be used to track blockage occurrences and GIS network tracing will allow SMP users the ability to identify potential upstream contributors.

Section 3. Sewer System Mapping Data Collection

As the City continues to inspect, rehabilitate, expand and maintain its sewer assets, additional data will be collected regarding portions of the sewer system asset locations, connectivity and condition. The existing City GIS database will be updated periodically based on the information collected. This section documents the methods that will be used to collect system asset data and integrate it into the GIS data layers. In addition to the data being collected by consultants and contractors, additional data regarding changes and additions to the sewer system resulting from newly constructed areas and daily City of Columbia staff operations (point repairs, etc.) will also be integrated into the GIS database in a coordinated effort so that at any given time during the Program system mapping is as up-to-date as possible.

3.1. CSAP and SSES-Driven Activities

The implementation of the SSES and rehabilitation activities will require the collection and verification of sewer system data for a subset of the sewer network. This will result in a large number of changes and additions to the sewer system. The following describes the planned activities, resulting data and methods that will be used to integrate the data into the City's records. This work will be performed by contractors and internal City staff under on-going annual contracts, City operations and maintenance activities and as part of specific CSAP and SSES contracts.

3.1.1. Supporting Continuing Sewer Assessment Program (CSAP) Activities

CSAP activities will require detailed assessments of manhole and sewer pipe assets within specific sewer area basins in the City of Columbia system. The investigations are intended to identify structural, operations and maintenance, and infiltration and inflow (I/I) related problems. The GIS and sewer mapping tools will provide support to the CSAP by assisting in the prioritization of locations for condition assessment through the use of risk-based priority criteria (such as sanitary sewer overflow (SSO) locations and proximity to other critical assets such as highways). CSAP will provide data to support subsequent sewer system rehabilitation design and implementation within the system. GIS and sewer mapping tools will provide a geographically-based database to store system condition assessment and rehabilitation information. The following condition assessment data collection activities will be performed as part of the CSAP:

- Gravity Sewer System Manhole Inspections
- Zoom Camera Television Inspection
- Sanitary Sewer Closed-Circuit Television Inspection
- Gravity Sewer System Smoke Testing
- Dye Testing

3.1.2. Data Collection Methods

The data collection methods to be used during the CSAP are outlined in a set of detailed specifications that describe the methods and the data delivery format to be used for each. The specifications require

digital data submissions and were developed with the intent of providing the most efficient and streamlined methods of integrating collected data into the IMS for use in the SMP functions. A brief description of each of the activities and required data submittal formats is provided below.

Gravity Sewer System Manhole Inspections - Manhole inspections will be performed in some locations to verify the accuracy of the available mapping/locations and make updates to the GIS to reflect the actual field conditions. This will allow field crews performing rehabilitation and/or replacement work to begin working more quickly and eliminate confusion regarding system connectivity, identification numbers, etc. The manhole inspections will also evaluate the general condition of the system, identify specific defects or problems, and determine manhole rehabilitation recommendations.

Inspection crews will locate, open, and visually inspect a set of specified manhole features within a given project area. The condition of the manholes will be assessed and an inspection report will be completed addressing all reporting requirements, filling out all reporting forms as listed in the NASSCO (National Association of Sewer Service Companies) *Manhole Assessment and Certification Program (MACP) Handbook for Level 2 Inspections*. This work requires that a digital database of the inspection results referencing the City of Columbia manhole identification numbers be delivered.

Zoom Camera Television Inspection - In conjunction with the manhole inspections, CSAP field crews will conduct an initial screening of all adjacent pipes less than 15 inches in diameter using a pole-mounted, stabilized “zoom” camera system. This will allow a quick inspection of the pipes to reveal defects, blockages, infiltration sources, etc. The inspector will “assess” each pipe utilizing the zoom feature to inspect the interior of the pipe. The digital imaging and storage unit included with the camera will be used to record the results of each pipe survey.

Using this preliminary pipe survey information, pipes will be prioritized using the NASSCO Pipeline Assessment and Certification Program (PACP) system. Any PACP codes assigned using zoom camera results will be noted as preliminary as the NASSCO standards were developed for CCTV inspection work. The work will require that a digital PACP-compliant database of the inspection results referencing the City of Columbia manhole identification numbers be delivered.

Sanitary Sewer Closed-Circuit Television (CCTV) Inspection - Pipes needing further inspection will be inspected via CCTV. CCTV inspection work will consist of digital video recordings, digital photos and a NASSCO PACP database. The work will require that a digital PACP compliant database of the inspection results referencing the City of Columbia manhole identification numbers be delivered. Sewer pipes that undergo CCTV work will identify sewer lateral locations that will be incorporated into the GIS as point features along the sewer lines showing the lateral connection locations.

Gravity Sewer System Smoke Testing - Smoke testing will be performed to enable field inspection staff to quickly identify and quantify sources of inflow and rain-derived infiltration (RDII) entering the sewer collection system. Using a mechanical blower, smoke is forced into the sewer collection system through a manhole. The smoke exits the system through the same points where inflow or RDII enter the system. Records on the location of each resulting smoke “leak” will be accessed by inputting sub-meter mapping grade GPS coordinates and/or street address. Records will include type of defect and severity of the problem for use in future repair. Each defect will be photographed using a digital camera, with GPS location capability, and documented to show its location relative to the closest manhole or other easily identifiable feature.

All applicable information regarding the test will be collected and entered into a digital database format

using the City’s GIS manhole and pipe identification codes and detailed specifications. The GIS will be able to generate maps and reports of tests by plotting the point locations and listing the addresses/coordinates of leaks, respectively on base map features with street names, building footprints, etc., see Section 4 describing map templates.

Dye Testing - Dye water testing will be used to assist in locating cross-connections between storm water and sanitary sewer systems or to confirm connections from an identified smoke lead to the sanitary sewer where the connection is not known from the smoke test alone. Storm sewer cross-connections and area drains that are suspected of being connected to the sanitary sewer will be positively identified using the dye tracer procedure. Field documentation, including sketches showing the location of all tests conducted and digital photographs with GPS locations, where feasible, will be used to record findings. Internal pipeline inspection will determine the exact source of the suspected interconnection and establish the best abatement option. The findings and conclusions will be documented in a digital database of the inspection and will be delivered along with the digital photographs and GPS locations.

3.1.3. Data to be Collected

The primary data to be collected as part of the CSAP activities is listed below. These data will be integrated into the City sewer system GIS and centralized databases as described in Section 2.2.3 and Section 5.

Data will be collected for sewer pipe end structures (i.e., manholes, cleanouts, vaults, etc.), sewer pipe features and sewer pumping structures (pump stations, lift stations, etc.). The primary attributes that will be collected for each of these sewer system assets is listed in the following tables. The asset condition data to be collected as part of CSAP will be linked to GIS assets by the City’s UIC and will be stored within the IMS database/warehouse and available for mapping as needed:

Sewer Manhole or Pipe End Structures
Structure type (manhole, etc.)
Horizontal and vertical (elevation) of the structure rim (X and Y) location in South Carolina State Plane coordinate system
Depth to bottom (lowest point)
Depth to shelf
Shape of structure (round, etc.)
Wall material
Presence of rehabilitation
Cover and rim condition
Wall condition
Evidence of surcharging
Access issues
Required internal and external photographs
Additional attributes required by NASSCO MACP Level 2 inspections

Sewer Pipes

Flow type (gravity or force main)
Diameter
Material
Shape of pipe
Upstream invert elevation
Downstream invert elevation
Slope
Flow direction (GIS digitized direction)
Upstream and downstream system network connectivity (as defined by GIS network)
Condition of pipe (from zoom camera and CCTV work in NASSCO PACP format)
Siphon (yes/no - the pipe functions as a siphon)
Presence of air valves or other gas relief
Photographs and videos as required by PACP and the inspection specifications

Pumping Features
Type of pump feature
Type of pumps
Number of pumps
Size of pumps
Control system
Location (coordinates and description)
Total capacity
General operating capacity
Condition of pumps
Condition of structure
Stand-by power type
Inlet elevation
Discharge elevation
Installation date of the structure
Wet well size and capacity
Photographs as required during the inspections

All data collected will undergo the quality control checking process described in Section 5.1.3 prior to being accepted into the final GIS and data repository.

3.2. City Driven Activities

In addition to the CSAP-related data collection efforts that will occur and be managed by the SMP, day-to-day updates to the sewer system GIS data will occur based on new portions of the system that have recently been constructed. Minor repairs to the system performed by City (or contractor) staff as part of on-going maintenance activities can also be expected.

3.2.1. Internal City Data Flows and Collection Methods

Pipe Network GIS Updates

Documentation regarding newly constructed portions of the sewer system due to new home construction, etc. are documented with as-built plan sets that are required to be delivered to the City at the completion of the construction. Documents are received by City engineering document storage staff

and are scanned into digital format and stored in the City’s document management system software and computer servers.

The City GIS department is then notified that a new document has been received and the documents are used by City GIS staff to update the sewer system GIS data set. As part of the on-going development of the SMP this process will be reviewed and modified as needed to ensure the timely transfer of data. The City’s documentation standards will also be reviewed and updated as needed to require contractors to provide the required documentation in a timely fashion.

City Maintenance Crew CCTV Work

City sewer maintenance staff regularly uses CCTV technology to investigate issues within the sewer system such as SSOs and blockages. The staff is NASSCO PACP trained and utilizes in-truck CCTV software that is compatible with the same formats required by the contractors performing CSAP work described in Section 3.1.2. As City staff collects these data, the CCTV inspection databases and resulting video files will be integrated with the CSAP inspection data within the IMS to provide a single repository for inspection results within the system.

3.2.2. Data to be Collected

Similar types of data collected during the CSAP regarding the physical system features will be collected for sewer pipe end structures (i.e., manholes, cleanouts, vaults, etc.), sewer pipe features and sewer pumping structures (pump stations, lift stations, etc.). However, as the record documentation does not provide any condition data, condition information will be limited to only those pipe assets that the City performs CCTV inspections on. The primary attributes that will be collected for each of these sewer system assets is listed in the following tables:

Sewer Pipe End Structures
Structure type (manhole, etc.)
Horizontal and vertical (elevation) of the structure rim (X and Y) location in South Carolina State Plane coordinate system
Depth to bottom (lowest point)
Depth to shelf
Shape of structure (round, etc.)
Wall material
Installation date

Sewer Pipes
Flow type (gravity or force main)
Diameter
Material
Shape of pipe
Upstream invert elevation
Downstream invert elevation
Slope
Flow direction (GIS digitized direction)
Upstream and downstream system network connectivity (as defined by GIS network)
Siphon (yes/no that the pipe functions as a siphon)

Presence of air valves or other gas relief
Installation date
Photographs and videos from CCTV inspections

Pumping Features
Type of pump feature
Type of pumps
Number of pumps
Size of pumps
Control system
Location (coordinates and description)
Total capacity
General operating capacity
Stand-by power type
Inlet elevation
Discharge elevation
Installation date of the structure
Wet well size and capacity

All data collected will undergo the quality control checking process described in Section 5.1.3 herein prior to being accepted into the final GIS.

3.3. Basin Boundary Modifications

The City maintains a GIS layer showing the boundaries of land areas that serve as “catchments” for the sewer system where flow within the collector pipe network inside the basin flows to a single connection point along the trunk sewer network. As new data are collected regarding the sewer system it will most likely be necessary to expand or modify the boundaries of the existing sewer basins. The following steps will be followed when modifying the boundaries:

- Changes to the basin boundaries will be performed by City of Columbia engineering staff to validate the changes.
- The manhole and pipe identification codes used to link data to the assets and reference individual assets are based on the basin identifiers. Any changes to the boundaries that result in the need to change identification codes will be performed on the master database. The old and newly updated codes will be tracked in a database for future reference and distributed to all contractors working with the basin areas so that the correct identification codes are used within their data submittals.

Section 4. Map Standards and Products

4.1. Map Standards

In order to satisfy the mapping requirements as identified in this SMP and to support all reporting obligations, a set of mapping standards will be developed. These standards will provide consistency with respect to the content and formatting of all map products generated for internal and external Program needs. The result will be a streamlined map production process, informative maps, and enhanced communication among Program participants.

The map products will be used for various purposes including field work, official reporting, website information, and on-going analyses. Products may be generated in a variety of formats (digital and hardcopy) and sizes depending upon the need. In order to provide content in a more useable format, particularly for field visits, some maps may be generated as map books or map sets. The map templates and standards will expand upon the existing standards developed by City GIS staff previously to augment the existing mapping.

Maps will be generated from data stored in the centralized Program GIS database integrated with the City's existing GIS, Cityworks® asset management system, and other systems or databases. Once data have been entered into the system and have passed through the QA/QC process (see Section 5.1.1.2 regarding the Standard Operating Procedures for the Program) they will be available for map generation.

4.1.1. Map Templates

Program participants have been interviewed and have identified a variety of map products which correspond to key elements in the Program. A general template will be designed for all map products which will standardize certain visual elements of the maps, such as titles, logos, and background data layers. Individual templates for each map product will define standardized map content, such as specific thematic data layers and symbology.

The following map templates have been identified and will be developed to support the Program:

- **System-wide asset map series** - These maps will show the inventory of all the City's sewer system-related assets and therefore will be used by nearly all participants throughout the SMP. They will provide the basis for the geographic tracking of issues, system status monitoring, inspection status monitoring, analyses, field crew support, as well as the supporting day-to-day activities and analyses. The attributes associated with the assets will enable the production of standardized and ad-hoc thematic maps. In addition, the maps will support EPA reporting requirements and other deliverables.
- **Capital planning maps** -The capital planning maps will display the locations of current City CIPs, maintenance contracts and work contracts. These maps will be primarily used by the Program Controls manager for tracking the status of City CIPs. Initially only wastewater CIPs will be included in the maps, but other CIP types may be included in

the future.

- **Work order maps** - These maps will be used for tracking work orders issued throughout the SMP. Work orders may be mapped by type (stoppages, service interruptions, SSOs, infiltration, etc.), status, contractor, etc. and will be primarily used for Maintenance and Operations Management activities.
- **Condition assessment results maps** - These maps will be used to track all condition assessment efforts, including CCTV, smoke testing, etc. Maps will show the extents (distances from manholes) of CCTV sewer line inspections, as well as type, condition and relevant notes. Primary use will be for Maintenance and Operations Management activities such as inspection monitoring, scheduling and EPA reporting.
- **FOG program maps** - Maps will show the locations of approximately 800 permitted food establishments in the SMP area which need to be identified and monitored for FOG management. The maps will be used for scheduling and monitoring of inspection and cleaning efforts as part of the Maintenance Operations Program.
- **ROW and Easement maintenance maps** - These maps will show the locations of Rights-Of-Way and easements relative to the sewer system assets in support of access maintenance (defoliation, trimming, etc.) by City staff.
- **Elevated Stream crossings and Bridge crossing maintenance maps** - These maps will show the locations of elevated stream and bridge crossings within the WCTS for use by City staff in operations and maintenance of the sewer system assets.
- **Satellite systems** - These maps will identify the locations and ownership of 47 satellite systems for general reference as part of the Maintenance Operations Program.
- **Sanitary Sewer Overflow (SSO) Maps** - These maps will show the locations of the sewer system by type and status. They will be used by City staff and Program managers to geographically track issues, monitor and audit inspection and maintenance efforts.
- **Sub-Basin Boundaries** - Maps will show the basin and sub-basin boundaries for the sewer system, and will be used for analyses, cataloging assets, and general reference by City management personnel.

4.1.2. Map Contents by Template

The specific map products that will be needed for the SMP have been identified and are discussed below. The actual map templates will be created upon the start of the SMP. The following is a list of the map products that will be developed, along with brief descriptions of their content. It is expected that other map products may be added to this list as additional needs are identified. In addition to the standard maps listed below, the mapping system will also be able to generate other non-standard, ad-hoc maps as necessary using the template standards as the basis. Should the ad-hoc maps become routinely

requested, they will be added to the standard set of map templates.

4.1.2.1. System-wide Asset Map Series

Contents:

Thematic Content

Locations of assets with some potential asset information (size, material, age, slope, invert elevation, rim elevation, etc.) The assets to be mapped include, but are not limited to:

- Sewer Lines and Manholes
- Pump Stations
- Force Mains
- Valves
- Waste Water Treatment Plants
- Flow monitors (Permanent, Temporary, and Billing Meters)
- Rain Gauges (Permanent, Temporary)

Background Content

- Basins and Sub-basins
- Roads and Highways
- Water Features
- Property Lines
- Administrative Boundaries (city & county lines)

Data Source: Program GIS, Cityworks® asset management software, field data

Recurrence: As needed

Coordinate System: South Carolina State Plane Coordinate System, NAD83, Int'l Feet, NAVD88

Delivery Formats: Digital (PDF and web-based), Hardcopy (Report and poster size)

4.1.2.2. Capital Planning Maps

Contents:

Thematic Content

Locations of appropriate active City wastewater CIPs

Background Content

- Basins and Sub-basins
- Roads and Highways
- Water Features
- Administrative Boundaries (city & county lines)

Recurrence: As needed

Coordinate System: South Carolina State Plane Coordinate System, NAD83, Int'l Feet, NAVD88

Delivery Formats: Digital (PDF and web-based), Hardcopy (Report and poster size)

4.1.2.3. Work Order Maps

Contents:

Thematic Content

Work order locations, status, contractor, etc.

Background Content

Sewer Lines and other assets

Roads and Highways

Water Features

Administrative Boundaries (city & county lines)

Recurrence: As needed

Coordinate System: South Carolina State Plane Coordinate System, NAD83, Int'l Feet, NAVD88

Delivery Formats: Digital (PDF), Hardcopy (Report size)

4.1.2.4. Condition Assessment Results Maps

Contents:

Thematic Content

Sewer lines, coded by condition assessment status

Sewer lines, coded by CCTV data collection status

Inspection results (condition, smoke leak locations, etc.)

Background Content

Manholes with IDs

Sewer basins

Roads and Highways

Water Features

Administrative Boundaries (city & county lines)

Recurrence: As needed

Coordinate System: South Carolina State Plane Coordinate System, NAD83, Int'l Feet, NAVD88

Delivery Formats: Digital (PDF and web-based), Hardcopy (Report and poster size)

4.1.2.5. FOG Maps

Contents:

Thematic Content

Point locations of food establishments monitored for FOG
Time since last inspection

Background Content

Roads and Highways
Water Features
Administrative Boundaries (city & county lines)

Data Sources: Internal sources, Cityworks® database

Recurrence: As needed

Coordinate System: South Carolina State Plane Coordinate System, NAD83, Int'l Feet. NAVD88

Delivery Formats: Digital (PDF and web-based), Hardcopy (Report and poster size)

4.1.2.6. ROW and Easement Maintenance Maps

Contents:

Thematic Content

Right-of-Way and easement locations, color-coded and/or annotated with
maintenance status

Background Content

Sewer basins
Roads and Highways
Water Features
Administrative Boundaries (city & county lines)

Data Sources: City GIS parcel data, easement & ROW data (if available)

Recurrence: As needed

Coordinate System: South Carolina State Plane Coordinate System, NAD83, Int'l Feet. NAVD88

Delivery Formats: Digital (PDF and web-based), Hardcopy (Report and poster size)

4.1.2.7. Elevated Stream Crossings and Bridge Crossing Maintenance Maps

Contents:

Thematic Content

Elevated stream crossings and bridge crossings, color-coded and/or annotated with maintenance status

Background Content

Sewer basins
Roads and Highways
Water Features
Administrative Boundaries (city & county lines)

Data Sources: City GIS elevated stream crossing data and bridge crossings data (if available); data derived from desktop analyses and field work.

Recurrence: Semi-annually

Coordinate System: South Carolina State Plane Coordinate System, NAD83, Int'l Feet. NAVD88

Delivery Formats: Digital (PDF and web-based), Hardcopy (Report and poster size)

4.1.2.8. Satellite System Maps

Contents:

Thematic Content

Locations of satellite systems, color-coded by ownership, and labels

Background Content

Sewer basins
Roads and Highways
Water Features
Administrative Boundaries (city & county lines)

Data Sources: List of satellite systems

Recurrence: As needed

Coordinate System: South Carolina State Plane Coordinate System, NAD83, Int'l Feet. NAVD88

Delivery Formats: Digital (PDF and web-based), Hardcopy (Report and poster size)

4.1.2.9. SSO Maps

Contents:

Thematic Content

SSOs (by cause, by number of gallons, number of spills per location)
Sewer Lines (by diameter)

Background Content

Sewer Lines, Pump Stations, and other assets
Sewer basins
Roads and Highways
Water Features
Administrative Boundaries (city & county lines)

Data Sources: Field inspections, Cityworks®

Recurrence: Monthly

Coordinate System: South Carolina State Plane Coordinate System, NAD83, Int'l Feet. NAVD88

Delivery Formats: Digital (PDF and web-based), Hardcopy (Report and poster size)

4.1.2.10. Sub-basin Boundary Maps

Contents:

Thematic Content

Sewer basins, sub-basins and labels

Background Content

Roads and Highways
Water Features
Administrative Boundaries (city & county lines)

Recurrence: As needed

Coordinate System: South Carolina State Plane Coordinate System, NAD83, Int'l Feet. NAVD88

Delivery Formats: Digital (PDF and web-based), Hardcopy (Report and poster size)

Section 5. Standard Operating Procedures (SOPs)

5.1. System Operations

In order to satisfy the mapping requirements as outlined in this plan, and to ensure that all reporting obligations are met, specific standards and procedures must be established which will promote the efficient operation of mapping efforts. This section briefly describes the procedures that are relevant to GIS data maintenance and mapping.

A detailed operations manual will be produced which will describe all mapping-related tasks and SOPs in greater detail as the SMP is implemented

5.1.1. Operations Manual and Standard Operating Procedures

The following describes the general outline of the planned SOPs that will be followed for regularly occurring tasks within the SMP. These SOPs will be further developed as the SMP and the Program components involved (CSAP, hydraulic model, etc.) are developed. The number of SOPs is expected to increase as the SMP is implemented and additional needs are identified.

Integration of CSAP Data

As noted in Sections 2 and 3, the CSAP will generate a large amount of digital data that will be linked to the GIS and available for mapping purposes. Section 2 describes the ways in which these data will be tied to the City GIS data. The anticipated SOPs for performing the connection and integrating the data into the SMP master database are described below in further detail.

CCTV Inspection Data

CSAP contractors are required to deliver four items as part of their inspection submittals:

1. A CCTV database in PACP format consisting only of inspection results for the appropriate area
2. Digital video files for the submitted inspection records
3. Inspection reports in PDF format for the submitted inspection records
4. Digital photographs for the submitted inspection records, if applicable

These items will be delivered electronically to SMP Data Management staff who will review the submittal for completeness. If the submittal fulfills the requirements, it will then be recorded in a tracking database and transferred to an SMP GIS technician.

The designated GIS technician will use the unique asset identification code to locate the appropriate GIS features and then update the attributes with the inspection results contained in the submitted database using database queries to efficiently transfer the data. The video files, inspection reports, and photographs will be moved to their corresponding repositories on the SMP data server. The technician will then link these files to the appropriate sewer network features by updating the paths to the files in the image linking database. In addition, fields containing the name of the contractor which provided the

data, the initials of the technician and the date of update will be populated.

Once the sewer network has been updated with all of the inspection results for a particular deliverable, a series of quality control checks will be conducted. These will ensure that all of the appropriate features were updated and that the data are appropriate. The tracking database will be updated to record the successful integration of updates into the GIS database.

Zoom Camera Inspection Data

CSAP contractors are required to deliver four items as part of the inspection submittals:

1. A Microsoft Access database (using PACP conventions) consisting of construction features, defects, distances and clock positions for features in the appropriate area
2. Digital video files for the submitted inspection records
3. Inspection reports in PDF format for the submitted inspection records
4. Digital photographs of conditions and defects for the submitted inspection records, using specified file naming conventions

These items will be delivered electronically to SMP Data Management staff, who will review the submittal for completeness. If the submittal fulfills the requirements, it will then be recorded in a tracking database and transferred to an SMP GIS technician.

The GIS technician will update the attributes of the sewer network features within the submitted condition data. The technician will use the provided distances to determine the locations of defects along the lengths of the sewer lines, and will create point features at these locations, coded with the City GIS asset UICs and/or defect codes. Digital photographs will be linked to the appropriate network features using the asset ID and file names.

A quality control review will be conducted to ensure that all submitted data were recorded accurately and that links to photographs reference the correct images.

Gravity Sewer System Manhole Inspection Data

CSAP contractors are required to deliver the following items as part of the manhole inspection submittals:

1. A database file containing the manhole inspection data
2. Photographs
3. Video files in MPG-1 format
4. Summary reports in PDF format

These items will be delivered electronically to SMP Data Management staff, who will review the submittal for completeness. If the submittal fulfills the requirements, it will then be recorded in a

tracking database and be transferred to an SMP GIS technician. The GIS technician will update the attributes (depths, materials, diameters, etc.) of the manhole features on the sewer network with the submitted inspection data. Photographs, video files, and summary reports will be linked to the appropriate manhole features within the GIS by using the manhole asset ID UICs and file names.

A quality control review will be conducted to ensure that all submitted data were recorded accurately and that photographs, videos, and reports link correctly to the GIS and reference the right files.

Gravity Sewer System Smoke Testing Data

CSAP contractors are required to deliver the following items as part of their smoke testing submittals:

1. GIS point locations (from addresses or GPS) containing current and previous inspection locations
2. Digital photographs for the current inspection only
3. Field data collection forms in PDF format

These items will be delivered electronically to SMP Data Management staff, who will review the submittal for completeness. If the submittal fulfills the requirements, it will then be recorded in a tracking database and transferred to an SMP GIS technician.

The existing GIS smoke testing feature class will be updated by integrating the locations within the submittal. The submitted points will employ a unique identification code which uniquely identifies each test and contractor. This ID will be used for linking the photographs and data collection forms to the point locations in the GIS.

A quality control review will be conducted to ensure that all submitted data were recorded logically, and that photographs and reports/database records link correctly to the GIS and reference the correct files.

Gravity Sewer System Dye Testing Data

Contractors are required to deliver the following items as part of their dye testing submittals:

1. Database containing dye testing results
2. Digital photographs for the current inspection only
3. CCTV video files

These items will be delivered electronically to SMP Data Management staff, who will review the submittal for completeness. If the submittal fulfills the requirements, it will then be recorded in a tracking database and transferred to an SMP GIS technician.

The dye testing table within the SMP master database will be updated with the submitted dye testing results. The submitted inspection records will utilize the unique GIS UIC codes to link the results records to the City of Columbia GIS assets (pipes and/or manholes).

A quality control review will be conducted to ensure that all submitted data were recorded logically, and that photographs and reports/database records link correctly to the GIS and reference the correct files.

CSAP Map Production SOP

Inspection maps will be generated on a regular basis. These thematic maps will show, for the subset of the network to be inspected, the overall status of the inspection work by each contractor, as well as those inspections conducted during the period since the previous map was generated. The maps will be produced as PDF files from a standard template by the GIS technician. The file name for each map will contain the map type code (for example, "CCTV"), the year and date of content (for example, "2013_Aug"), plot size, and a flag identifying the map as "draft" or "final". An example of a typical inspection map filename is: "CCTV_2013_Aug_D_DRAFT.pdf".

The draft map will be reviewed by the SMP Data Manager. Once approved, the GIS technician will change the map status flag to "FINAL", move the map to the map files folder on the server, and upload it to the CW2020 SharePoint site. Users of the site will then receive notification that the map is available.

Other maps may be generated to support SMP activities and analyses. Requests for such maps will be handled by the GIS technician. As with all maps generated for the SMP, these maps will be created as PDF files and stored on the SMP server and loaded onto SharePoint and tracked within the map versioning database.

It is anticipated that as the SMP expands, a version of many of the status mapping products will be implemented on the CW2020 internal web-portal described in Section 2 so that staff can interactively look at specific areas of the system to gather project status, etc.

Integration of City-generated Work SOP

A GIS database will be maintained by the GIS technician in order to track City-generated work, such as repairs, CCTV inspections, etc. Work will be tracked by the City staff using the Cityworks® work order management software currently being implemented. Work orders that result in physical changes to the system, such as repairs, will be documented in an electronic format (PDF or scanned field notes) linked to the work orders. SMP GIS staff will have access to the work order database and will be included in the work-flows developed within the Cityworks® software that will route or notify SMP staff that work affecting the sewer assets has occurred in the system and should be replicated in the GIS by the SMP GIS technician(s).

A detailed SOP will be developed which will discuss the specific steps for transferring work data to the GIS staff, as well as the specific data items to be included and coordinated with the staff/contractors implementing the Cityworks® software.

Hydraulic Model SOP

Any updates and changes made to the sewer network or associated features have the potential to impact the hydraulic model. In order to keep the hydraulic model up-to-date and maintain its integrity, it will be necessary to communicate any changes to the modeling staff so that they can conduct any necessary updates. To this end, a summary of changes will be submitted to the hydraulic modeling staff periodically. This summary will consist of a map and report highlighting the relevant changes in the sewer network for the previous period, showing only the changes since the previous summary. In

addition, the latest digital network will be submitted to facilitate updates to the model. The updates to the actual model database will be conducted by the modeling staff directly in the modeling software using the updated GIS data provided by the SMP staff.

Capital Improvements Program Projects SOP

The Capital Improvements Program projects database will contain data for existing and proposed CIP projects to upgrade or expand the sewer system. The interim CIP database is currently being developed and will be initially maintained by an SMP GIS technician with assistance from the City's GIS manager and CIP management staff. As projects are added and updated, City staff will forward the data to the City's GIS manager for review. The manager will then submit the data to the GIS technician, who will update the database.

The CIP database will include links to a GIS layer showing the general project limits and location. The CIP GIS layer will be updated by the SMP GIS technician and will be used for status mapping both in PDF format and on the web-portal.

FOG SOP

The FOG database will consist of over 800 food establishments which will require inspection and monitoring. The database will be part of the master SMP database and will be maintained by an SMP GIS technician. As inspections are conducted as part of the maintenance operations program the results will be submitted to the SMP Data Manager. The GIS technician will then update the FOG database with the new inspection data and conduct quality checks to validate the locations identified are correct and that the inspection data are complete and generally accurate (i.e., dates appear correct, etc.). This will facilitate mapping and tracking of the FOG related issues within the system.

5.1.2. GIS Data Update Procedures

Most GIS data editing, updating, and mapping operations will be conducted using Esri ArcGIS geographic information system software. As noted in Section 2, the master SMP GIS database will store geographic and attribute data in an Esri multi-user ArcSDE centralized database. However, in some cases it may be necessary to generate maps from other software. For example, some modeling software may be used to generate maps of modeling outputs utilizing desktop GIS software using the sewer model database.

In order to maintain the integrity of the GIS database, various procedures will be established to ensure that any additions or changes meet the quality standards required to support SMP needs. Because the data will originate from numerous sources (departments, contractors, etc.) it will be important to follow the procedures in order to maintain data quality and consistency. In addition, having a standard set of processes enables data updates to be performed by various technical staff while maintaining a consistent workflow. Contractors and City staff will also have a more thorough appreciation and understanding of the way in which the data they create are used within the program, resulting in higher quality data.

Data From Consultants & Contractors

Initial Data Receipt

Required GIS data received from contractors will be placed in a dedicated “Data Received” folder on the SMP server and reviewed within three days of receipt to verify that the delivery meets agreed-upon requirements with respect to file formats, coordinate system, etc. A record of the data received will be logged in a tracking table in the master SMP GIS database to record the date received, contractor, format, contents, etc. Data that do not meet the basic requirements will be returned to the contractor with a document describing the deficiencies and a record of the issue will be logged in the database. Contractors will be asked to remedy the issue and resubmit the data within one week pending the severity of the issue.

Non-spatial data that are associated with submitted geographic data will also be logged and given a cursory review to verify that they are generally complete and meet the minimum submittal requirements.

Data Review

The data received will then be imported into a “review” geodatabase for a more thorough review. Data will be examined for the following qualities:

- **Completeness (geographic):** Does the data cover the expected geographic extents (area or network extents)?
- **Completeness (attribute):** Are the required attribute fields fully populated?
- **Spatial Accuracy:** Are locations within specified requirements and does the pipe network flow electronically in a manner that would be expected from an engineering perspective?
- **Attribute Accuracy:** Are attributes correct (to the extent that this can be determined)?

GIS technical staff will review the data by visual inspection (on-screen), data review tools such as ArcGIS Data Reviewer, and topology checks and queries. Due to the different types of data to be reviewed, standardized data checks will be developed for each type and format of data being delivered. See Section 5.1.3. below for a description of some of the anticipated quality control checks to be developed and used in the SMP.

Once a data set has been reviewed its status will be recorded in the tracking database. Data that have passed the review with no issues will be flagged as ‘clean’ and moved to the ‘staging’ geodatabase. Those with errors or inconsistencies will be flagged with a code describing the type of issue. A summary report will be generated for each layer and reviewed by the SMP Data Manager.

Data layers or sets with errors may be returned to the contractor or corrected in-house depending on the nature and severity of the errors. Data returned to contractors will be subject to the process outlined above upon resubmittal once the issues have been corrected.

Non-geographic ancillary data such as photographs and video files will be checked to ensure that identifiers are correct to allow the files to be linked with the corresponding geographic features and that the correct number of photographs and naming conventions were provided by the contractors.

Data from City and Other Sources

Data obtained from the City, from the Cityworks® database, or from other (non-contractor) sources will

undergo quality checks similar to those described above, including visual inspection, use of data review tools, and topology checks and queries. While it is expected that data from the City and Cityworks® have previously undergone quality checks by the staff managing those systems, it is in the best interest of the SMP for all data to pass the same quality checks.

Data from non CSAP contractor sources (such as newly constructed subdivision pipe networks) will also be documented in the tracking database. Any errors detected in the data will be relayed to the original sources. However, due to staffing concerns at the City or availability of the original contractor to perform the edits, it may be necessary for internal SMP staff to correct any errors.

Integration with Existing Data and Further Review

As mentioned above, once a GIS data layer has cleared the quality checks it will be moved to the “staging” geodatabase. At this stage the data will be integrated with existing sewer pipe network data and subjected to additional checks. There are two possible scenarios:

1. Update existing features – Existing features are updated with geometry or values from the new data layers. Conflation tools, such as Esri’s Spatial Adjustment tools, will be used to transfer geometry or attributes from one feature to another and therefore update the map features. For example, the diameter of an existing line may be updated by transferring the value from one feature to another.
2. Add new features – Adding new features will require merging the new data with existing data and building the correct pipe network connectivity where appropriate.

5.1.3. GIS Data Quality Control

Various quality control mechanisms will be established to ensure the quality of the sewer network data within the SMP master database. The database will be designed with topology and connectivity rules and attribute domains to minimize the possibilities of errors when entering and updating network data. However, additional procedures are required to verify the data and ensure the physical and logical integrity of the network.

Quality control tools, customized to the City GIS database design, will be utilizing Esri software tools such as the GIS Data Reviewer extension to verify the attributes, connectivity and logic of the network. The following is a list of some of the data checks that are planned to be performed for gravity and forcemain pipes in the network. As the final quality control check suite is developed a complete list and description of each test will be documented in a separate SMP quality control procedures document.

Gravity Sewer Pipes:

- Compare pipe shape to diameter values
- Compare pipe up invert to down invert
- Compare structure invert to pipe invert
- Compare upstream pipe diameter to downstream pipe diameter
- Compare upstream pipe inverts to downstream pipe inverts
- Compare manhole rim to pipe invert
- Compare pipe invert value and diameter to manhole rim

Gravity and Forcemain Systems:

- Check for invalid GIS geometry
- Check for duplicate geometry
- Compare pipe to pipe install date/diameter to material and shape
- Check pipes flowing in but none flowing out
- Check for features not connected to another feature
- Verify that pipe features have structures at each end
- Compare rim/fitting and pipe invert values to topography
- Compare pipe invert value and diameter to topography
- Compare middle pipes values
- Compare slope to length
- Compare record slope to calculated slope

In addition, large format hardcopy plots will be used for visual inspection of the network and attributes. Other procedures will include attribute and domain checks to ensure that feature attributes are correct and within standards.

Where appropriate, errors will be documented and corrected by the GIS technicians. A summary of the issues will be submitted to the SMP Data Manager for review. Any systematic or procedural errors will result in a review of the processes and in appropriate changes with the contractor involved. Errors found in data submitted from contractors will be relayed to the appropriate parties for correction. The updates tracking database will then be updated to reflect the completion of data integration and quality checks.

A comprehensive quality control SOP will be developed which describes each quality check in detail as well as the exact procedures SMP staff will use to review the data and track issues.

5.1.4. Map Storage and Versioning

Numerous map products will be generated during the life of the SMP. Because these products will often be distributed to various users and because so many versions will be generated, it is imperative to devise a system for managing these maps.

In order to facilitate the tracking of maps all (non web-based) map products will be generated in digital Adobe PDF file format. These maps will be stored on the SMP server in dedicated folders located in the appropriate map storage folders. For example, FOG maps may be located in a subfolder named "Map Documents" within the FOG program file location. As PDF map files are generated, they will be entered into a master tracking database table on the SMP server containing the path, date of generation, version of the map (using a logical series number) and staff requesting the map.

Using the Esri ArcGIS software's Dynamic Text features, each map layout and PDF will be annotated in the lower margin with the date and time the map was produced and the path and name of the source ArcMap SMP file (.mxd).

PDF maps and ArcGIS MXD GIS SMP files will follow a naming convention in order to facilitate identification of contents and version. This convention will consist of a category, content, date, and plot size, similar to the following:

SSO_Status_20130822_E.PDF

For cases in which maps are generated from software other than ArcGIS, the above naming conventions will still be followed for any SMP and output files to the extent possible.

Section 6. Sewer System Mapping Program Implementation

The following section provides an implementation plan for the SMP components described in Sections 2 through 5 of this document. The implementation plan provides the following:

- A list of implementation tasks for each of the SMP components described within Sections 2 through 5
- An anticipated schedule for the implementation of the SMP

Each of these parts of the implementation plan is described in further detail.

6.1 Anticipated Implementation Tasks

This subsection provides brief descriptions of the actions to be taken to implement the various aspects of the SMP. The action items are listed in the tables below and indicate the Consent Decree requirement they will address as well as the SMP document section describing the need and task in detail. The actions for each of the SMP Sections 2 through 5 are divided into separate tables listing each action item.

6.1.1 Section 2 - GIS Mapping System Computer Components

CD Task Number	SMP Section	SMP Task	Action/Description
	2.1	GIS Mapping System computer components	
12.f.ii	2.1.1.1	Desktop Software Tools	Develop custom tools to support data entry and analytical operations
12.f.ii	2.1.1.2	Quality Control Software Used	Configure Esri's Data Reviewer extension with comprehensive spatial and non-spatial data checks.
		Esri ArcGIS server components	
12.f.ii	2.1.2.1	ArcSDE Multi-user Database	a) Develop data model b) Configure, optimize and test ArcSDE geodatabase for storage and editing of spatial data and for web mapping support.
12.f.ii	2.1.2.2	Microsoft SQL Server Database	a) Develop data model b) Configure, optimize and test SQL Server database for storage/retrieval of project data and for reporting support.
12.f.ii	2.1.2.3	ArcGIS Server Web-site	Develop web-based project portal for sewer system information, including web mapping component to retrieve data from sewer system GIS database.
12.f.ii	2.1.3	User Control Levels	Configure user accounts and credentials for accessing and editing program data and applications

CD Task Number	SMP Section	SMP Task	Action/Description
	2.2	Integration with Other Applications	
12.f.ii	2.2.1	CMMS	<ul style="list-style-type: none"> a) Set up, optimize and test CMMS (Cityworks®) integration with project geodatabase b) Establish asset links c) Configure tracking of work orders, maintenance requests, inspections, etc., and mapping functions.
12.f.ii	2.2.2	Hydraulic Model	
12.f.ii	2.2.2.1	Integration Methodology	Establish and verify (QA/QC) spatial and UIC relationships between hydraulic model and GIS sewer network
	2.2.3	Inspection Data	
12.f.ii	2.2.3.1	Integration Methodology	
12.f.ii	2.2.3.1.1	Closed-Circuit Television (CCTV) and Manhole Inspections	<ul style="list-style-type: none"> a) Develop asset naming convention and provide to contractors. b) Perform quality checks on inspection data deliveries c) Import into inspection SQL Server databases.
12.f.ii	2.2.3.1.2	Smoke and Dye Testing	<ul style="list-style-type: none"> a) Perform quality checks on inspection data deliveries b) Import into inspection SQL Server databases.
	2.2.4	Capital Projects	
12.f.ii	2.2.4.1	Project Tracking Methodology	<ul style="list-style-type: none"> a) Develop GIS CIP database b) Populate database with projects and code with unique CIP identifier.
12.f.ii	2.2.4.2	Integration Methodology	Establish and test linkage between GIS CIP database and sewer system assets to enable identification of assets involved in each project.
12.f.ii	2.2.5	Fats, Oils and Grease (FOG) Program Data Management	<ul style="list-style-type: none"> a) Develop and test GIS point database for FOG businesses. b) Establish linkage to Cityworks® for blockage tracking. c) Develop/configure network tracing function for identifying upstream contributors.

Table 1 - Mapping system components.

6.1.2 Section 3 - Sewer System Mapping Data Collection

CD Task Number	SMP Section	SMP Task	Action/Description
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CD Task Number	SMP Section	SMP Task	Action/Description
	3.1	CSAP and SSES-Driven Activities	
12.f.v	3.1.1	Supporting the Continuing Sewer Assessment Program (CSAP) activities	
12.f.v	3.1.2	Data Collection Methods	<p>Gravity Sewer System Manhole Inspections Conduct quality control on contractor data submittals:</p> <ul style="list-style-type: none"> a) Review submitted databases for completeness, adherence to specifications b) Review submitted photos for naming, quality c) Review submitted videos naming, quality d) Review submitted summary reports e) Create memo summarizing results of reviews
12.f.v	3.1.2		<p>Zoom Camera Television Inspection Conduct quality control on contractor data submittals:</p> <ul style="list-style-type: none"> a) Review submitted databases for completeness, adherence to specifications, accuracy of manhole ID references b) Review submitted photos for naming, quality c) Review submitted videos naming, quality d) Review submitted summary reports e) Create memo summarizing results of reviews
12.f.v	3.1.2		<p>Sanitary Sewer Closed Circuit Television (CCTV) Inspection Conduct quality control on contractor data submittals:</p> <ul style="list-style-type: none"> a) Import submitted data b) Review submitted data for completeness, PACP compliance c) Review submitted photos (naming, quality, all required angles, features, etc.) d) Review submitted videos (naming, quality, all required angles, features, etc.) e) Enter GIS features (laterals) into master sewer geodatabase, code with proper ID and verify f) Write memo
12.f.v	3.1.2		<p>Gravity Sewer System Smoke Testing Conduct quality control on contractor data submittals:</p> <ul style="list-style-type: none"> a) Extract new inspection records b) Review records for completeness, locations (addresses/coordinates) c) Review submitted photos (naming, quality, etc.) d) Review submitted videos (naming, quality, etc.) e) Enter features into master geodatabase, code with manhole & pipe IDs, verify f) Load photographs and videos into database and link to GIS features g) Write memo

CD Task Number	SMP Section	SMP Task	Action/Description
12.f.v	3.1.2		Dye Testing Conduct quality control on contractor data submittals: a) Review submitted records (attributes) for completeness b) Review GPS locations c) Review photographs (naming, quality, etc.) d) Review submitted videos (naming, quality, etc.) e) Enter features from GPS locations into master geodatabase f) Load photographs and videos into database and link to GIS features g) Write memo
12.f.v	3.1.3	Data to be Collected	a) Integrate CSAP spatial and attribute data (sewer pipes, features & structures, sewer pumping structures) into geodatabase and SQL Server databases. b) Conduct quality control on master geodatabase and UICs c) Test linkages between GIS assets and condition data.
	3.2	City Driven Activities	
12.f.v	3.2.1	Internal City Data Flows and Collection Methods	Pipe network GIS updates a) Add new sewer features from as-builts into master GIS sewer database. b) Perform quality control checks (connectivity, attributes, etc.) on updated network. c) Create memo describing updates.
12.f.v	3.2.1		City maintenance crew CCTV work Conduct quality control on contractor data submittals: a) Import submitted data b) Review submitted data c) Review submitted photos (naming, quality, all required angles, features, etc.) d) Review submitted videos (naming, quality, all required angles, features, etc.) e) Merge GIS features into master geodatabase f) Perform quality control on master geodatabase g) Validate links to Cityworks® h) Create memo describing updates
12.f.v	3.3	Basin Boundary Modifications	a) Update basin boundary in GIS database and verify boundary accuracy b) Add/Update sewer features in GIS database c) Update IDs on relevant manhole and pipe features in GIS sewer database d) Conduct quality control checks on updated features e) Revise Basin Boundary map f) Prepare & distribute updated boundaries and codes to contractors g) Prepare memo describing basin updates h) Verify boundary accuracy i) Check network ID changes

Table 2 - Sewer system mapping data collection.

6.1.3 Section 4 - Map Standards and Products

CD Task Number	SMP Section	SMP Task	Action/Description
	4.1	Map Standards	
	4.1.1	Map Templates	For each required map (4.1.2.1 – 4.1.2.10): <ul style="list-style-type: none"> a) Identify data requirements for each map template b) Develop standardized content c) Design templates for each map size and format (online, PDF, report, etc.)

Table 3 – Map standards and products.

6.1.4 Section 5 - Standard Operating Procedures (SOPs)

CD Task Number	SMP Section	Task Number	Action/Description
	5.1	System Operations	
12.f.x	5.1.1	Operations Manual and Standard Operating Procedures	SOP Development Task Details (apply to 5.1.1 thru 5.1.3 below): a) Review EPA, Cityworks® & GIS requirements b) Meet w/appropriate staff to discuss existing & desired workflows & procedures c) Create draft SOPs d) Send draft SOPs for comments e) Conduct SOP testing f) Finalize SOPs (create hardcopy & digital documents)
12.f.x	5.1.2	GIS Data Update Procedures	For each GIS and SQL dataset: a) Review requirements and specifications b) Evaluate existing data update workflows c) Determine best workflow for updating data d) Identify required/desired software tools e) Develop workflow process model f) Create draft SOP g) Test SOP and modify if necessary h) Finalize SOPs and create hardcopy & digital documents
12.f.x	5.1.3	GIS Data Quality Control	For GIS sewer data: a) Review requirements and specifications, including topology and connectivity requirements, attribute domains, etc. b) Evaluate existing quality control workflows c) Determine best workflow for updating data d) Identify required data checks e) Develop topology rules, logic and attribute checks in Esri Data Reviewer extension. f) Create database for testing of data checks g) Conduct testing of Data Reviewer extension h) Modify, retest, and finalize rules in Data Reviewer i) Develop workflow process model j) Create draft SOP k) Test SOP and modify if necessary l) Finalize SOPs and create hardcopy & digital documents

CD Task Number	SMP Section	Task Number	Action/Description
12.f.x	5.1.4	Map Storage and Versioning	One SOP for all required maps: a) Develop map naming/versioning convention b) Develop storage & tracking/recording procedure for map documents c) Finalize SOP (create hardcopy & digital document)

Table 4 - Standard Operating Procedures.

6.2 Sewerbasin Electronic Mapping Schedule

Basin	Mapping Completion
West Columbia Basin	
Major WCTS Mapping	12 months after CSAP approval
Minor WCTS Mapping	5 years after Sewer Mapping Program Approval
Smith Branch Basin	
Major WCTS Mapping	12 months after CSAP approval
Minor WCTS Mapping	6 years after Sewer Mapping Program Approval
Saluda River Basin	
Major WCTS Mapping	18 months after CSAP approval
Minor WCTS Mapping	6 years after Sewer Mapping Program Approval
Rocky Branch Basin	
Major WCTS Mapping	18 months after CSAP approval
Minor WCTS Mapping	6 years after Sewer Mapping Program Approval
Mill Creek Basin	
Major WCTS Mapping	24 months after CSAP approval
Minor WCTS Mapping	8 years after Sewer Mapping Program Approval
Gills Creek Basin	
Major WCTS Mapping	24 months after CSAP approval
Minor WCTS Mapping	8 years after Sewer Mapping Program Approval

Crane Creek Basin	
Major WCTS Mapping	24 months after CSAP approval
Minor WCTS Mapping	8 years after Sewer Mapping Program Approval
Broad River Basin	
Major WCTS Mapping	24 months after CSAP approval
Minor WCTS Mapping	8 years after Sewer Mapping Program Approval