Clean Water 2020 Program

SEWER MAPPING PROGRAM

July 2014

We Are Columbia

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Table of Contents

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	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	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	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	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	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

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	**Gravity Sewer System Manhole Inspections** Conduct quality control on contractor data submittals: 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		**Zoom Camera Television Inspection** Conduct quality control on contractor data submittals: 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		**Sanitary Sewer Closed Circuit Television (CCTV) Inspection** Conduct quality control on contractor data submittals: 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		**Gravity Sewer System Smoke Testing** Conduct quality control on contractor data submittals: 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): 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