Nine Mile Run
Operations and Maintenance Plan

Prepared for:

The Borough of Edgewood

Administered by:

Wilkinsburg-Penn Joint Water Authority

Funded by:

3 Rivers Wet Weather Demonstration Program

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1.0 INTRODUCTION

The purpose of this Operation and Maintenance (O&M) Plan is to provide a planning/programming document to initiate scheduled maintenance on the Borough of Edgewood (the "Borough") sanitary sewer system. The development of the O&M plan for an established / aging system is an ongoing process that starts with current conditions and resolution of known/identified problems, and evolves to a proactive plan into the future.

This O&M Plan is an Addendum to a Report entitled "Urban Sewershed Wet Weather Plan A Demonstration Project" prepared by 3 Rivers Wet Weather. Section 5 of the final Report presents a broad overview of the relationship of proactive maintenance programs, asset management, GIS data management systems, cMOM, and Hydrologic and Hydraulic modeling. This Plan develops specific guidance to planning and implementing a Borough specific O&M plan based on information developed under the Demonstration Project.

Sections 1 and 2 of this document identify program elements necessary to fully develop an effective O&M Program.

Section 3 discusses and identifies segments of the sewer system that require maintenance on a regular basis in order to keep the system operational and techniques can be used to implement repairs. The Plan also presents a routine inspection program to proactively identify potential defects and maintain the assets of the sewer system.

Section 4 presents the routine operation and maintenance techniques the Borough should employ to maintain the sewer system in a proactive mode of operation.

1.1 Discussion of Types of Maintenance Activities

The purpose of developing O&M program is to maintain the original design functionality (capacity and integrity) of the system. The ability to effectively operate and maintain a sewer collection system so it performs as intended depends on development and implementation of a routine inspection and repair program. Appropriate rehabilitation including selection of rehabilitation materials and equipment, construction and inspection, and testing and acceptance all play an important role.

Sewer system maintenance can be performed by either a proactive or reactive approach. Effective O&M programs are based on knowledge of the system inventory, capacity and actual day-to-day operation. With the information gathered during preparation of the Demonstration Plan, a proactive maintenance plan can be developed and scheduled, rehabilitation needs identified, and long-term Capital Improvement Programs (CIPs) planned and budgeted. Implementation and tracking of a proactive maintenance program can be substantially enhanced using the GIS database/mapping linked software tools (currently populated with know system information) discussed later in this document.

Commonly accepted types of maintenance include preventive maintenance, and predictive maintenance.

1.1.1 Preventive Maintenance

Preventative maintenance, which is a proactive response, is defined by a pre-programmed, systematic approach to maintenance activities. This type of maintenance will always result in improved system performance except in the case where major chronic problems are the result of design, capacity exceedance associated with unregulated system growth, construction, or structural flaws that cannot be completely corrected by O&M activities. Preventive maintenance can be scheduled on the basis of specific criteria such as known problem areas (including grit and grease buildups and root infestation) or the passage of a certain amount of time (calendar period

The preventative maintenance program will allow the Borough to plan routine maintenance and schedule repair work. By doing so, the Borough will be able to track currently identified backlog and additional resources that may be able to support that backlog, such as outside contractors. Scheduling also requires the Borough to plan and identify personnel and material requirements on a regular basis, which will assist in budget determination.

1.1.2 Predictive Maintenance

The second type of maintenance is predictive. Predictive maintenance (also proactive) is a method of establishing baseline performance data, monitoring performance criteria over a period of time, and observing changes in performance so that failure can be predicted and maintenance can be performed on a planned, scheduled basis.

The goals of a successful predictive maintenance operation are to manage personnel and material resources effectively. By achieving these goals, it is possible to effectively deliver a high level of service to the customer base while maximizing the investment of labor and materials. Organization of these elements in a populated relational database is the key to success.

The benefits of an effective operation and maintenance program are as follows:

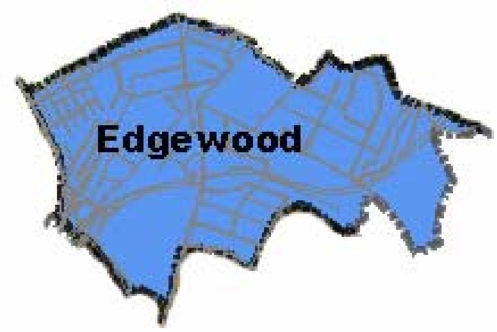
- Ensuring the availability of facilities and equipment as intended.
- Equipment and facilities are less likely to fail when properly maintained.

- The equipment and facilities maintain their value, thus maintaining the Borough's major capital assets.
- Obtaining full use of the system throughout its useful life.
- Collecting accurate information and data on which to base the operation and maintenance of the system and justify requests for the financial resources necessary to support it.
- Planned maintenance and repairs are much more cost effective both in the long and short term because the work can be done with the proper materials during normal working hours and under preferred working conditions thus reducing the overall costs for such repair.

An American Society of Civil Engineers (ASCE) / US EPA cooperative research paper has equated system maintenance ("re-investment") to system capacity.[1] Assuming a design life of 100 years and a salvage value of 25% the ASCE/ EPA theory holds that reinvestment rates of 2%, 4% and 10% yield "minimum system capacity performance " of 65%, 80% and 93% respectively.

[1] "Optimization of Collection System Maintenance Frequencies and System Performance" ASCE ; EPA Cooperative Agreement # CX824902-01-0 (February 1999)

SECTION 2.0 ADMINISTRATIVE OPTIMIZATION



3 Rivers Wet Weather Demonstration Program

2.0 ADMINISTRATIVE OPTIMIZATION

Administration of an O&M program involves communication and understanding between all personnel. To achieve a high level of success, the O&M program must be well defined, standardized to the point of being routine, and clearly communicated. All personnel must understand the goals of the program and have a clearly written set of procedures to accomplish these goals. Organizational charts listing personnel responsibilities and duties are required to assist in the management of operations and dealing with emergency responses. A complete inventory of equipment and materials is required to effectively schedule maintenance.

2.1 Standards, Policies and Procedures

Standardization of O&M operations insures that all personnel are trained and capable of performing their responsibilities maintaining the system. Program administrators utilize written standards to manage the process. Issues pertaining to health and safety, repair procedures and purchasing policies should all be well understood by the staff in order to make the program work effectively and efficiently. A documented staffing plan will allow personnel to understand their role in the program.

A well organized O&M program will allow the Borough to achieve the following goals:

- Standardize maintenance procedures and material and spare parts purchasing policies.
- Utilize funding effectively and efficiently to maximize the asset value of the system.
- Provide the highest level of service to the customer base.
- Perform all work on the system safely through personnel training.
- Protect the public health by continually maintaining the system.

2.2 Budgeting

Appropriating adequate operational funds to facilitate proper levels of operation and maintenance is prerequisite to implementation of a successful preventive maintenance program. Lack of funding is a primary cause of neglect and resultant deterioration. Annual line item budget development by the administrative staff, engineer and operations superintendent is recommended. A key element of the operation budget program is the tracking of costs in order to have accurate records each time the annual operating budget is developed. The Borough can utilize available modules in the software database to develop the budget by tracking maintenance and capital costs. Having an annual baseline provides documentation for future budget considerations and provides justification for future rate increases and other sources of funding. Some basic budgeting items to consider are as follows:

- **Administration**
  - Management Staff Labor
  - Insurances
  - Training
  - Telephone / Office equipment
- **Legal**
- **Engineering**
- **Force Account**
  - **System Maintenance**
    - O&M Training
    - Labor
      - Regular
      - OT
      - Benefits (Health, Pension, Vacation/Sick, SS etc)
    - Equipment
      - Depreciation /Acquisition
      - Maintenance /Repairs
      - Rentals
    - Subcontract
      - Repairs/ Excavation
      - Cleaning
      - Pavement / Restoration
    - Materials and Supplies
      - Pipe, Manholes and Appurtenances
      - Stone / Asphalt
      - Fuel
      - Chemical / Cementitious Grouts
      - Root Control Chemicals
      - Safety Equipment
    - **Defect Repairs**
      - Labor
      - Regular
      - OT
      - Benefits (Health, Pension, Vacation/Sick, SS etc)
    - Equipment
      - Depreciation /Acquisition
      - Maintenance /Repairs
      - Rentals
    - Subcontract
      - Repairs/ Excavation
      - Cleaning
      - Pavement / Restoration
    - Materials and Supplies
      - Pipe, Manholes and Appurtenances
      - Stone / Asphalt
      - Fuel
      - Chemical / Cementitious Grouts
      - Root Control Chemicals
      - Safety Equipment
  - **Operations**
    - Labor
      - Regular
      - OT
      - Benefits (Health, Pension, Vacation/Sick, SS etc)
    - Equipment
      - Depreciation /Acquisition
      - Maintenance /Repairs
      - Rentals
    - Subcontract
      - Repairs/ Excavation
      - Cleaning
      - Pavement / Restoration
    - Materials and Supplies
      - Pipe, Manholes and Appurtenances
      - Stone / Asphalt
      - Fuel
      - Chemical / Cementitious Grouts
    - Root Control Chemicals
  - **Subcontract Work**
    - Dye Testing
    - CCTV
    - Smoke Testing
    - Clean
    - Root removal
    - Flow Monitoring
    - [2]Defect Repairs

2.3 Asset Management

Generally speaking, sanitary sewer systems are one of the largest capital assets a Municipality owns and operates. However, historically these systems have not been operated as an asset. Recent changes in national accounting standards require municipal governments to treat systems as an asset (GASB 34). Failure to meet the standard may have an adverse effect on bonding capacity and ability to incur indebtedness. Asset management is essentially managing infrastructure capital asset to minimize the total cost of owning and operating it while delivering the service level customers desire. This can be achieved through utilization of the tools acquired under the Demonstration Plan and provided to the Borough (i.e. GBA Master Series™ database). A focus on asset management ensures that the Borough will utilize life cycle costing and value engineering when considering budgets and capital improvements, which in turn can justify rate increases and financing requirements.

The key elements of asset management are:

- Management Information Systems.
- Asset identification and valuation.
- Failure impact evaluation and risk management.
- Condition assessment.
- Rehabilitation and replacement planning.
- Capacity assessment and assurance.
- Maintenance analysis and planning.
- Financial management.
- Continuous improvement.

2.3.1 GIS System

In order to organize, maintain and manage the Borough sewer assets, one seat of GBA Master Series™ SewerMaster was purchased and populated with data available for the Borough system. Acquisition and population of this software module is the first step toward a comprehensive asset management based system in the Borough. The currently populated information can be used to;

1. Keep permanent records of Maintenance activities
2. Report completed and remaining defect repairs
3. Track and Plan segment specific Cleaning and defect repair programs
4. Maintain a complete system inventory
5. Track Customer Complaints

Lennon, Smith, Souleret Engineering, Inc. (LSSE) provided setup and database development of a GIS Information system describing the following characteristics of the Edgewood system;

- **Customer Information**
  - Address Information
    - Residential/Commercial
    - Address number and street
    - Apartment number
    - City/State/Zip
  - Building Connection Point
    - Upstream Manhole
    - Downstream Manhole
- **System Inventory Modules**
  - Sewer Manhole Inventory ;
    - Material of Construction
    - Number of connective sewer lines
    - Depth
    - Condition
    - Manhole lid and pipe invert survey information
  - Sewer Pipe Inventory;
    - Material
    - Dimensional Data
    - Shape
    - Line and Flow Type
    - Upstream and Downstream manhole
- **Sewer System Inspection Modules**
  - Sewer Television Inspection
    - Date of inspection
    - Cleaning information
    - Defect information
      - Distance to defect
      - NASSCO grade for defect
      - Video information
    - Type of lateral connection
    - Tape ID/start/stop information
  - Manhole Inspections
    - Inspection Crew
    - Date of inspection
    - Ladder bar condition
    - Bottom and Barrel characteristics
    - Flow depth
  - Sewer Building Inspections
    - Inspection Crew
    - Date of inspection
    - Upstream and downstream manholes
    - Illegal connection (dye and smoke test) information

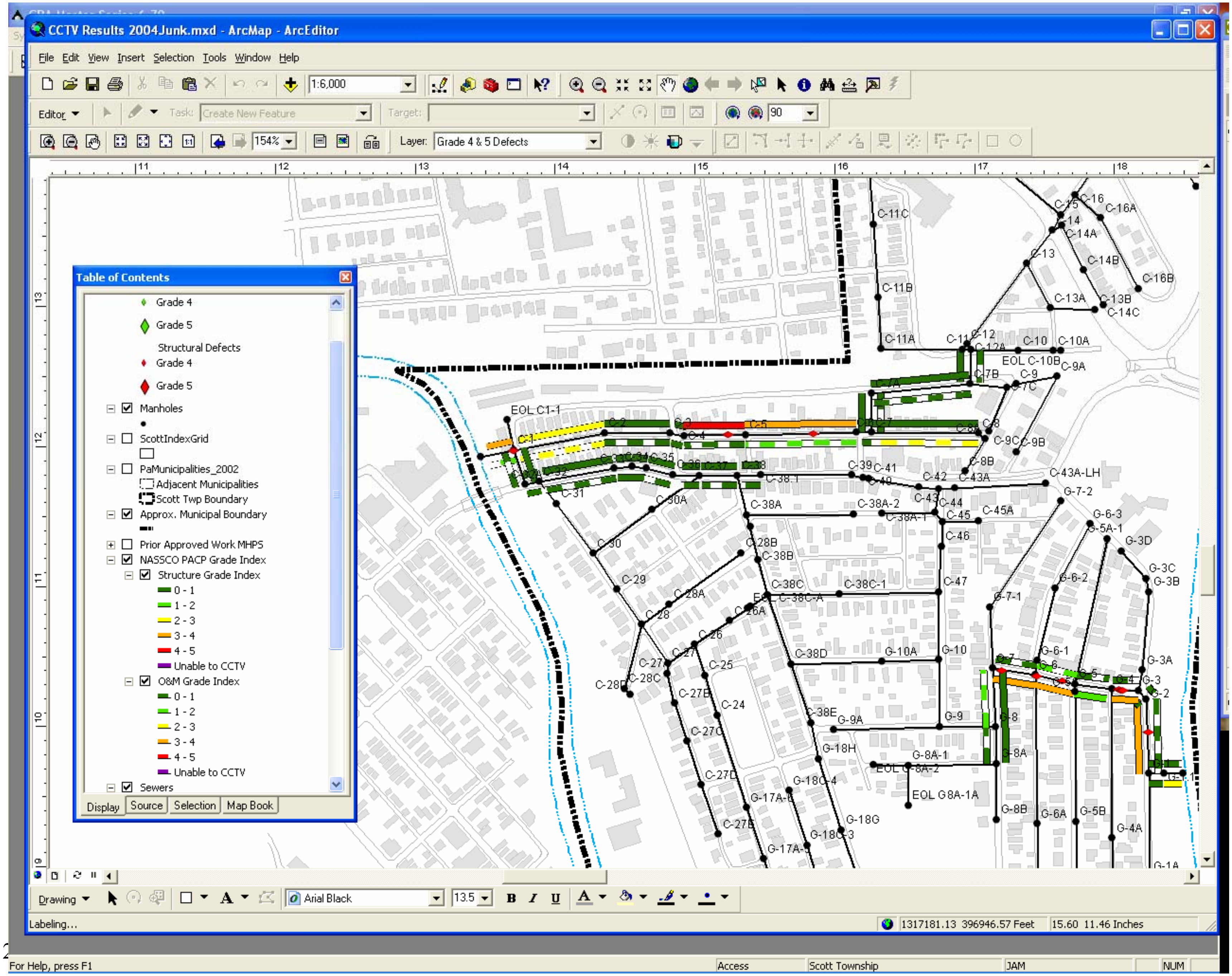
This data is directly linked to a digital map (see Figure 2-1) of the Borough (Allegheny County 1992 GIS base mapping) to show actual location and connectivity of sanitary sewers in the Borough. The Borough can utilize GBA linking with other GIS software to efficiently organize the maintenance program by providing the rehabilitation crew maps of the localized system.

Additional data that can be input includes:

- customer data including street address and ID numbers,
- type of customer,
- EDUs,
- service line diameter and length and point of connection (sub-unit and stationing),
- dye test status,
- dye test findings and sources of illegal flow,
- floor drain and or foundation drain connections,
- site tee status etc.;
- mainline data including; end manhole id's, length, slope, type, size,
- cleaning and root intrusion data,
- date of last CCTV and findings,
- CCTV findings including noted O&M as well as structural problems,
- number of taps by type (fitting or break-in), etc.

Appendix H presents a compilation of available screen shots to demonstrate the amount of information that can be stored in the database. The Borough can expand the software capabilities by adding modules to achieve additional goals required for a successful O&M Plan such as;

1. Development of maintenance scheduling and planning tools (work orders, schedules, etc.)
2. Development of a parts and equipment inventory
3. Tracking actual maintenance costs including Force Account items
4. Maintaining a real time asset management valuation


CCTV Results 2004Junk.mxd - ArcMap - ArcEditor
File Edit View Insert Selection Tools Window Help
1:6,000
Editor
Task: Create New Feature
Target:
Layer: Grade 4 & 5 Defects
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Grade 4
Grade 5
Structural Defects
Grade 4
Grade 5
Manholes
ScottIndexGrid
PaMunicipalities_2002
Adjacent Municipalities
Scott Twp Boundary
Approx. Municipal Boundary
Prior Approved Work MHPS
NASSCO PACP Grade Index
Structure Grade Index
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
Unable to CCTV
O&M Grade Index
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
Unable to CCTV
Sewers
Display
Source
Selection
Map Book
Drawing
Arial Black
13.5
Labeling...
1317181.13 396946.57 Feet
15.60 11.46 Inches
For Help, press F1
Access
Scott Township
JAM
NUM

FIGURE 2

2.4 SSO Response Plan

Planning for emergencies, such as Sanitary Sewer Overflows, and developing reaction plans to protect the public health and safety, and provide for environmental protection is a key component to an O&M plan. The development of a response plan and procedure will also allow the Borough to inventory the necessary resources to respond to those emergencies, and create a staffing plan accordingly.

The plan should contain a mechanism to keep the customers notified of impacts to them, such as outages (including projected lengths of time), road closings, etc. A representative from management should be given the role of dealing with the media to address public concerns. All other employees should refer inquiries to this designated spokesperson.

Included in Appendix A is an SSO Response Plan (SSORP) developed by 3 Rivers Wet Weather. This SSORP should be considered for adoption by the Borough. This document lists the responsibilities and procedures necessary to effectively respond to an SSO event. The plan includes a procedural form that allows standardization of the reporting of the event in order to document the occurrence and report to the appropriate agencies.

2.5 Maintenance

Initial preventive maintenance program for the Borough system will be based on the manhole physical surveys, dye testing program, flow isolation studies, and CCTV information acquired during the study period from 2001 through 2003. Utilizing the CCTV tape documentation, NASSCO grading of the defects observed in the Borough has been completed. The NASSCO ratings are a standardized numerical rating system that assigns a specific numerical value to observed “Structural” and “O&M” defects. The ratings range from 1 to 5 with 5 representing a very severe condition requiring immediate attention. The Borough will need to cross correlate the “Structural” and “O&M” defects when determining annual budgets as sewer line segments may have both types of defects.

2.6 Frequency of Maintenance Activities

As noted a good preventive maintenance O&M program is based on a routine operating procedure that assures that each component of the system is inspected and necessary maintenance performed at appropriate intervals. Newer systems or systems that have exhibited no operating problems such as backups, surcharges, odors etc. will require less frequent inspection while those with chronic problems will require more frequent inspection and maintenance activities. The frequency of maintenance activities will depend on the nature of the problem. For instance mainlines with chronic root problems may require semi-annual root cutting or chemical treatment. Surcharging manholes (i.e. bypassing manhole lids) should be inspected either during or immediately after any significant precipitation event.

To provide a frame of reference, Chapter 4 of the ASCE Report "Optimization of Collection System Maintenance Frequencies and System Performance" ASCE ; EPA Cooperative Agreement # CX824902-01-0 (February 1999) (Appended) presents typical ranges of frequencies for cleaning, root removal, mainline and house "stoppage" repairs, inspections etc.

2.7 Manhole Accessibility Field Review Schedule

Accessibility to the sewer system is required in order to evaluate and maintain the system. A primary initial objective of the O&M program will be to evaluate the accessibility of each manhole in the system. Follow up accessibility reviews are suggested as part of annual road paving programs and review/issuance of grading and building permits as these activities are significant contributors to inaccessibility problems. The Borough should visit each of the 255 manhole structures located in the system to verify the following:

- The manholes are accessible
- The tops of the manholes are not buried or paved over.
- The manhole lids have not been displaced, removed or damaged.

Each visitation to a manhole should be recorded on the "Accessibility Field Review Form" (see Appendix B) and filed. Any change in status of the manhole accessibility should be noted and a photograph of the manhole location should be taken. If corrective action is required, the Public Works foreman should schedule the field maintenance personnel to correct the issue.

2.8 Manhole Physical Survey Schedule

The Borough should internally inspect each manhole in the system every two years. A physical inspection of each manhole will assist in proactively identifying defects in the system before they deteriorate to the point of failure. It is recommended that at least 10% of manholes be inspected each year.[1] The goals of the physical survey are to:

- Prevent the premature failure of the structures.
- Identify collection system maintenance needs.
- Identify any system surcharging/bypassing.
- Maintain each manhole structure in a proactive manner.

Personnel working on the survey program should be properly trained regarding confined space entry. Each manhole inspection should be recorded on the "Manhole Physical Survey" form (see Appendix C). This form should be filled out by the personnel completing the inspection and submitted to the Public Works foreman for cataloging when the survey is complete. The inspector should take photographs of any areas that require repair. All deficiencies should be noted and ranked for repair scheduling.

Each survey form should be considered as the initiation of a work order. The form should describe in some level of detail the nature of the repairs required. If the repairs are within the capabilities of the Public Works department the form should include as an attachment a listing of materials needed to complete the repair. If the repairs are beyond the capabilities of the crew and require outside contract the form should include a brief scope description. Site access or traffic concerns that may be present should be identified.

The Borough should initiate repairs using the Project Tracking form in Appendix D. The foreman should complete the basic information prior to assigning the work to a crew. The crew foreman should complete this document after the repair work is complete. This document should also be used during routine maintenance repairs. The Borough should catalog these forms for future reference in their maintenance database.

2.9 Defect Repair

The Borough will need to implement an effective defect repair program to handle the structural defect findings as determined by the CCTV work performed in 2001 through 2003. The Borough will need to review the findings and determine if a capital improvement project should be initiated, or if a scheduled maintenance program can be implemented for the necessary repairs. The categorization and quantification of defects is necessary to develop a budget sufficient to account for the identified repair scope and timeline of repair.

2.10 Standardized Defect Identification; NASSCO Methodology Overview

Implementation of a comprehensive rehabilitation program requires development of a standardized method of identifying and rating pipeline defects in a manner that facilitates proactive remediation planning. This section discusses a method that has gained increasing use in the region. The National Association of Sewer Service Companies (NASSCO) with assistance from the Water Research Centre (WRc) developed Pipeline Assessment and Certification Program (PACP©) grading codes for sewer defects to promote the consistency in grading/evaluating the condition of sewers across a single authority, a municipality, a region and across the country. These uniform codes were developed in part to standardize pipeline conditions rating to better prioritize and plan wastewater collection system repairs. The consistency of PACP can be translated into such issues as infrastructure value and bonding relating to GASB 34 requirements, repair and/or replacement prioritization of a system's components and studies of the degradation of collection systems over time.

NASSCO has two distinct "families" of defects in which a defect grade (e.g. severity rating) is applied. These include:

- Structural Defects, and
- Operational and Maintenance (O&M) Defects.

These defects are also further classified as "continuous defects" or "non-continuous"/ localized. Brief descriptions follow.

2.10.1 NASSCO Structural Defects Overview

The Structural Family of defects describes various types of defects where the pipe has been damaged or otherwise defective.[3] The following 11 groups comprise the Structural family of defects. Certain examples provided in the NASSCO PACP Manual are provided as exhibits in Appendix G.

a. Crack – Longitudinal (CL) – refer to Exhibit 3-1
b. Fracture – Longitudinal (FL) – refer to Exhibit 3-2
c. Broken (B) – refer to Exhibit 3-3
d. Hole (H) – refer to Exhibit 3-4
e. Deformation (D) – refer to Exhibit 3-5
f. Collapse Pipe (XP) – refer to Exhibit 3-6
g. Joint
h. Surface Damage
i. Weld Failure
j. Point Repair
k. Brickwork

2.10.2 NASSCO Operational and Maintenance (O&M) Defects Overview

The O&M Family of defects describes various types of conditions that are found in sewers that may interfere with the operation of the conveyance system.[4] The following 5 groups comprise the O&M family of defects. Certain examples provided in the NASSCO PACP Manual are provided.

[3] NASSCO PACP Manual, © NASSCO 2001, Page 5-1
[4] NASSCO PACP Manual, © NASSCO 2001, Page 6-1

a. Deposits
b. Roots – Medium (RM) – refer to Exhibit 3-7
c. Infiltration Gusher (IG)– refer to Exhibit 3-8
d. Other Obstacles (OBZ) – refer to Exhibit 3-9
e. Vermin

There are also two additional "Families" of observations, Construction related (e.g. taps, intruding seal material, line/bends, access points/cleanouts etc.) and Other (miscellaneous observations including camera underwater/sag, water level observations etc.), which are given O&M grades for Pipe Rating Index computations.

2.10.3 NASSCO Continuous Defect Overview

A "continuous defect" is any defect which extends (or is repeated) beyond the first three feet from the camera position.[5] Continuous defects fall into one of two categories, either truly continuous (defects that extend along the sewer without any interruption over more that three feet) or repeated continuous defects (which occur at regular intervals along the pipe).

The PACP Code Matrix published by NASSCO is provided as Exhibit 3-10.

2.10.4 NASSCO Defect Condition Grading

Using the PACP Code Matrix, each sewer line observation is labeled with a PACP code then, based on this code, is assigned a condition grade from 1 to 5. Grades were assigned as specified by NASSCO criteria based on potential for further deterioration or pipe failure. Pipe failure is defined by NASSCO as when the pipe can no longer convey the pipe design capacity, and does not necessarily refer to the structural failure of the pipe. An overview of the five NASSCO grades is summarized in Table 3-A. (Note the time frames associated with the Codes.)

[5] NASSCO PACP Manual, © NASSCO 2001, Page 4-1

Table 3-A NASSCO Grade Summary			
Pipeline Grade	**NASSCO Classification**	**NASSCO General Description**	**NASSCO Guidelines Relating to Pipeline Failure**
5	Immediate Attention	Defects requiring immediate attention	Pipe has failed or will likely fail within the next five years
4	Poor	Severe defects that will become Grade 5 defects within the foreseeable future	Pipe will probably fail in 5 to 10 years
3	Fair	Moderate defects that will continue to deteriorate	Pipe may fail in 10 to 20 years
2	Good	Defects that have not begun to deteriorate	Pipe unlikely to fail for at least 20 years
1	Excellent	Minor defects	Failure unlikely in the foreseeable future

2.11 Sewer Line Cleaning and CCTV Schedule

Based on current sanitary sewer system record information; there are approximately 67,265 linear feet of sanitary sewer and 255 manholes comprising the sewer system.

Recent CCTV information has provided a base datum for planning a future sewer line cleaning and televising schedule. GIS Mapping and graded O&M defects for the current televising are shown in Appendix E.

2.11.1 Cleaning and Root Removal Program

The Borough should implement an annual cleaning and root removal program. Initial cleaning/root removal and re-televising efforts should focus on those portions of the system (i.e. manhole to manhole segments) that exhibit NASSCO Level 4 and 5 O&M defects. Each manhole to manhole segment should be rated based on average defect Grade value (i.e. Total Grade value of defects divided by total defects observed). These sites should be revisited at least annually until the defects are stabilized, eliminated or reduced to a Level 3 or less. The following Table 3-B presents a summary of initial prioritization and scheduling for cleaning and root removal activities. The footages presented are based on the recent system wide CCTV findings. The Minimum Recommended Frequency guideline should be applied to all line segments exhibiting chronic, or persistent, maintenance problems such as basement flooding. Recommended Annual Total Footage is based on the average Recommended Frequency

Table 3-B				
Sanitary Sewer Cleaning Priority			Recommended Frequency	
NASSCO PACP O&M Grade[1]	2004 System Footage	Recommended Annual Total Footage	Minimum (months)	Maximum (months)
4.1 to 5	-	-	6	9
3.1 to 4	-	-	9	15
2.1 to 3	698	430	15	24
1.1 to 2	2,033	813	24	36
< 1	6,065	1,735	36	48
Total	8,796	2,978		

(1) National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP©) grading

For initial planning and budget purposes it is recommended that the borough schedule 2,978 (based on the average recommended frequency) lineal feet of cleaning each year. This is about 18% of the system footage as compared to the ACCE Report (Appended) which suggests a range of 34% to 45% (clean and root removal combined.)

As part of the cleaning work, the Borough should regularly analyze the residual material for any pipe fragments so that future structural defects can be efficiently located.

2.11.2 CCTV Program

In addition to the cleaning activities the Borough should implement a proactive CCTV program to monitor the status of existing defects and identify accelerated deterioration to schedule repairs. An annual CCTV program targeted to monitor existing and identify new NASCO PACP Structural Grade 4 and 5 defects is recommended. Initial re-televising efforts should focus on those portions of the system (i.e. manhole to manhole segments) that exhibit NASSCO Level 4 and 5 Structural defects. Each manhole to manhole segment should be rated based on average defect Grade value (i.e. Total Grade value of defects divided by total defects observed). These sites should be revisited at least annually until the defects are stabilized, eliminated or reduced to a Level 3 or less. A map of the NASSCO Level 1 through 5 should be developed by the Borough Engineer. Recommended Annual Total Footage in Table 3-C should be based on the maximum Recommended Frequency. Table 3-C will need to be completed by the Borough Engineer as the information was not available at the time of this writing. The values determined by the table will allow the Borough to develop an annual CCTV program.

Table 3-C				
Sanitary Sewer CCTV Priority			Recommended Frequency	
NASSCO PACP Structural Grade	2004 System Footage	Recommended Annual Total Footage	Minimum (months)	Maximum (months)
4.1 to 5	1,443	1,443	-	12
3.1 to 4	6,418	3,209	-	24
2.1 to 3	26,315	8,772	-	36
1.1 to 2	9,980	2,495	-	48
< 1	120	24	-	60
Total	44,276	15,943		

The sewer line CCTV schedule will need to be adjusted on an annual basis as the condition of the sewer system will change over time. CCTV information should be cataloged in the Borough GIS database for pre and post cleaning results. Review of CCTV comparative information will allow the Borough to track their success and make adjustments to the maintenance schedules as necessary.

The annual CCTV contract should include provision of National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP$^{©}$) grading. The NASSCO PACP grading system will assist in determining what system defects are more serious than others, allowing the Borough to set maintenance priorities to higher level defects.

2.12 Illegal Storm Drain Connections: Smoke Testing and Post Real Estate Transfer Dye Testing and Inspection

The identification of illegal direct storm inlet connections through dye testing has been performed by the Borough. The dye testing program consisted of residential and commercial structures and catch basins/storm inlets. Approximately 1,220 residential structures, which represent 100% of the Borough, were tested. There were 306 residences noted as non-compliant. Approximately 77 commercial structures, which represented 100% of those types of structures located in the Borough, were tested. There were 9 commercial units noted as non-compliant. Approximately 239 catch basins/storm inlets, which represented 100% of the system, were also tested. There were 2 catch basins that were noted as potential sources of direct connection to the sanitary sewer system that were subsequently found to be false positive findings based on follow-up CCTV efforts. In terms of structures/ buildings tested, a net positive finding rate of 26% (315 / 1,197) was computed.

As of April 2005, 282 of the 315 positive findings (90%) are reported to have been removed from the sanitary sewer system based on Borough Code Enforcement records.

The removal of illegal connections is an important step in reducing the amount of direct inflow into the sewer system. Direct inflow from roof leaders, driveway drains, and other connections increases the amount of flow to the sewer system. This additional flow increases the cost of treatment and reduces the capacity of the sewer system during wet weather events.

To assist in the permanent removal of these connections, the Borough has adopted an ordinance requiring all real estate title transfers be contingent upon dye test and defect inspection results. One purpose of the ordinance is to insure that these disconnections are permanent. This program also assists in the identification of any connections that have not previously been identified.

Failure of the dye test or inspection during a real estate transfer should prevent the purchaser from completing the transaction until the illegal connection is removed and or defects repaired. The Borough should inspect the property after the dye testing results are submitted to insure that the purchaser has permanently removed the connection or repaired the defect. The Borough should also inspect and confirm the accessibility of any manhole located on the property. After compliance with the removal of the connection, the Borough should release the title to the purchaser.

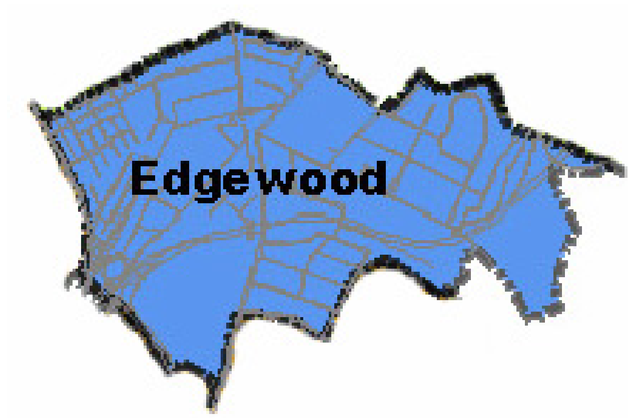
In addition to the follow up dye testing it is recommended that the Borough initiate an annual smoke testing program. Twenty five percent of the system should be smoke tested each year.

2.13 O&M Plan Progress Evaluation

In addition to implementing an O&M plan, the Borough will need to continually develop and refine the plan through self evaluation. The Environmental Protection Agency (EPA) has published a cMOM Program Self Assessment Checklist (Appendix I) designed to assist municipalities in identifying their strengths and areas needing improvement regarding compliance. It is recommended that the Borough complete this checklist prior to implementation of the O&M plan in order to track improvements.

The Borough should revisit the findings of this assessment at the end of each year, and perform a more detailed evaluation to identify specific actions required to improve the plan. Additional resources designed to assist the Borough with evaluating system performance relating to O&M (Optimization of Collection System Maintenance Frequencies and System Performance; American Society of Civil Engineers – EPA Cooperative Agreement #CX 824902-01-0) can be found in Appendix J. Sections 4, 5, 4.6 and 4.7 present methodologies to refine maintenance activity frequency and to "rate" the system maintenance. This information may be useful in tracking and monitoring progress after a comprehensive O&M Plan is implemented.

SECTION 3.0 OPERATIONS AND MAINTENANCE RESOURCES



3 Rivers Wet Weather
Demonstration Program

3.0 OPERATIONS AND MAINTENANCE RESOURCES

A systematic approach to an Operation and Maintenance program is essential to proper operation. The methods and techniques available are wide ranging and there are a number of resources that are available to provide a comprehensive presentation on sanitary sewer collection systems O&M. A partial listing of available publications and training follows;

3.1 Publications

The following publications are recommended as comprehensive guidance documents;

WASTEWATER COLLECTION SYSTEMS MAINTENANCE, Parcher, Michael J., Scranton Gillette Publications

WASTEWATER COLLECTIONS SYSTEM MANAGEMENT Manual of Practice 11 (MOP11) Water Environment Federation (WEF), Alexandria VA

EXISTING SEWER EVALUATION & REHABILITATION Manual of Practice FD-6 (MOP FD-6) Water Environment Federation (WEF), Alexandria VA and ASCE Manual and Report on Engineering Practice No. 62, American Society of Civil Engineers (ASCE) New York NY

GUIDANCE FOR CAPACITY, MANAGEMENT, OPERATION, AND MAINTENANCE (CMOM) PROGRAMS AT SANITARY SEWER COLLECTION SYSTEMS (127 PAGES) Appendix K.

OPTIMIZATION OF COLLECTION SYSTEM MAINTENANCE FREQUENCIES AND SYSTEM PERFORMANCE, American Society of Civil Engineers EPA Cooperative Agreement #CX 824902-01-0 (146 Pages) Appendix J.

3.2 Training

Comprehensive Operator Training and Certification (aka Sacramento Training) is available through distance education through the California State University, Sacramento CA. Two certificate courses are offered;

Operation & Maintenance of Wastewater Collection Systems Vol. I And

Operation & Maintenance of Wastewater Collection Systems Vol. II

PaDEP web site link and course information is as follows;
http://www.dep.state.pa.us/waterops_apps/etpmain/ApprTraining/Public/CourseDetail.asp?CourseIDNum=87

Course ID:	86
Title:	Operation & Maintenance of Wastewater Collection Systems Vol. I and Volume II
Industry:	Wastewater
Contact Hours:	90
Background:	Volume I provides operators with the information needed to operate and maintain collection systems efficiently and effectively. Certification boards throughout the United States and Canada recognize this course as a means of preparing and qualifying to be a successful collection system operator.
Content:	* The wastewater collection system operator * Why collection system operation and maintenance * Wastewater collection systems * Safe procedures * Inspection and testing collection systems * Pipeline cleaning and maintenance methods * Underground repair
Audience:	The target audience for this course is the person interested in working in the wastewater collection field and wishing to prepare for certification license exams, to learn how to do the job safely and effectively, and/or to meet educational needs for promotion.
Course Format:	Distance Education

Training Provider Details:

Training Provider ID:	20
Name:	California State University, Sacramento
Address:	Office of Water Programs 6000 J St Sacramento, CA - 958196025
Contact Person:	Ramzi J Mahmood
Telephone:	916-278-6142
Fax:	916-278-5959
E-Mail:	wateroffice@csus.edu
Web site:	http://www.owp.csus.edu

Additional training is available at;
Water Environment Federation Sponsored Programs at:
http://www.wef.org/ConferencesTraining/Conferences/SpecialtyConference/Collection_Systems06.htm

SECTION 4.0
OVERVIEW
METHODS

3 Rivers
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4.0 OVERVIEW METHODS

4.1 Physical Inspection

Physical inspection is essential to quantify the maintenance characteristics of the sewer system. As part of a preventative maintenance routine, the Borough should employ both visual and equipment based techniques. Physical inspection of the system will provide the Borough with:

- A system inventory.
- A means of identifying and quantifying the rehabilitation and maintenance requirements.
- A preventative maintenance plan.
- An assessment of the current conditions in the system
- A means of preparing an inventory of spare parts for emergency situations.

As discussed in Section 2.8, the Borough will need to institute a regular manhole physical survey and CCTV program. Additional physical inspection techniques that should be employed on rehabilitated line segments are:

- Mandrel testing
- Vacuum testing
- Air Testing

Mandrel testing should be performed to insure proper joint and pipe alignment which is essential for proper operation. Air and vacuum testing can test the integrity of the pipe, lateral and manhole structures to verify proper connections.

4.2 Cleaning

Blockages in sewer pipes are caused by either collapsed pipe or by accumulation of materials in the pipe. Accumulation typically occurs from sags, root intrusion, protruding taps or broken pipes. Prevention of material buildup requires systematic cleaning of the system to insure against system failure. As part of the maintenance program, the Borough will need to implement a cleaning program as discussed in Section 2.11.

Cleaning a sewer minimizes the potential for system blockages and keeps the system operational. Cleaning also removes grit material, such as sand and stones, and prevents such objects from reaching pump stations where it could cause detrimental effects.

There are various hydraulic and mechanical methods used to clean a sewer system. Hydraulic methods employ high velocity water to clean the inverts of pipes and manholes. Mechanical methods are used to remove encrustation and root intrusions. Several cleaning methods are described below.

4.2.1 Hydraulic

Hydraulic cleaning of a sewer system is an efficient and effective means of removing debris. High velocity water is used to pull debris along the bottom of the pipe invert until it can be recovered at the manhole. A vacuum unit is then used to lift the debris out of the manhole for disposal.

These types of units are typically truck mounted, and are self sufficient machines. A two man crew can effectively operate the machinery. These units can carry all of the equipment necessary to remove manhole covers, route traffic, and all other necessary equipment.

4.2.2 Rodders

A rodder is used to remove build-up or cut intruding roots in a pipe. This is an effective tool in removing material that is stuck to or intruding into the sewer pipe. Rodders are very effective in removing this type of debris, but they must be used in conjunction with a hydraulic cleaning devise as they are not designed to pull the material to a removal location.

The use of a rodder should be monitored as they can cause damage to older pipe. This equipment can also damage protruding connections in the pipe. The Borough should review all CCTV tapes prior to using rodders to determine if repairs to the line should be performed prior to employing the equipment.

4.2.3 Bucket Machines

Bucket machines are ideal for removing large amounts of debris from a sewer pipe. They are effective at removing roots, grease build-up, and sediments. The equipment uses a specialized set of winches and a specially designed bucket that is pulled through the pipe. The bucket captures the debris and physically removes the material.

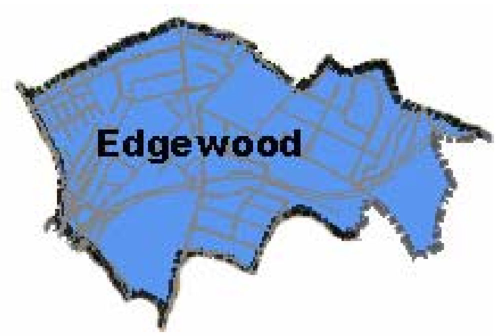
The bucket is sized for the pipe, which increases the capture efficiency. Special brushes and cutters can be added to the bucket to completely scrape the inside of the pipe, leaving very little residual material.

4.2.4 Chemical Cleaning

Sewers can be cleaned with a variety of chemicals by using mechanical equipment to apply foaming, dusting or spray on agents. Chemical compounds are a very cost-effective method to retard root growth. Various chemical agents such as enzymes, caustics, hydroxides and biocides can be applied for specific purposes, such as grease build-ups.

Chemical cleaning for grease build-up should only be considered after a grease trap ordinance has been initiated. The use of chemicals to remove grease deposition can become a costly routine maintenance routine.

APPENDIX A



3 Rivers Wet Weather Demonstration Program

SANITARY SEWER OVERFLOW RESPONSE PLAN
BOROUGH OF EDGEWOOD

I. PURPOSE

The Borough of Edgewood (Borough) has structured this Sanitary Sewer Overflow Response Plan to satisfy requirements for such plan, as laid forth within the Administrative Consent Order by and between the Allegheny County Health Department.

II. GENERAL

The Sanitary Sewer Overflow Response Plan (SSORP) is designed to define appropriate actions by the Borough upon notification of a possible sanitary sewage overflow caused by problems within the Borough owned sewer system. The Borough shall dispatch the appropriate crews to investigate the possible overflow, identify the responsible party(ies), and provide appropriate customer service to minimize the effects of the overflow on public health and quality of surface waters. The SSORP further includes provisions to ensure safety pursuant to the directions provided by the Allegheny County Health Department (ACHD), Pennsylvania Department of Environmental Protection (DEP) and that notification and reporting is made to the appropriate local and state agencies. For purposes of this SSORP, “confirmed sewage spill” is also sometimes referred to as “sewer overflow,” “overflow,” or “SO.” The effective date of this plan will be referred to as “date.”

A. Objectives

The primary objectives of the SSORP are to:

- protect public health and the environment, and
- satisfy the requirements of regulatory agencies and waste discharge permits which address procedures for managing sanitary sewer overflows.

Additional objectives of the SSORP are to:

- provide appropriate customer service,
- protect the wastewater treatment plants and collection
- protect the wastewater treatment plants and collection systems including all related appurtenances and personnel, and
- protect property from overflows resulting from problems within a publicly owned sanitary sewage system.

B. Organization of Plan

The key elements of the SSORP are addressed individually as follows:

Section I Purpose
Section II General
Section III Overflow Response Procedure

Section IV Regulatory Agency Notification Procedure
Section V Distribution and Maintenance of SSORP

III. OVERFLOW RESPONSE PROCEDURE

The Sanitary Sewer Overflow Response Procedure presents a strategy for the Borough to mobilize labor, materials, tools and equipment to correct or repair any condition, which may cause or contribute to an un-permitted discharge from a publicly owned sanitary system. A wide range of potential system failures is considered by the plan. Being prepared to respond to system failures could lessen the effect of overflows to surface waters, land, or buildings.

A. Receipt of Information Regarding an SSO

System employees or the public may detect an overflow. The Borough is primarily responsible for receiving phone calls from the public notifying the Borough of possible overflows from the wastewater conveyance and system. The Borough is then responsible for forwarding the possible overflow information to the appropriate party within the Borough.

The emergency response shall be available 24 hours per day, 365 days of the year.

1. The person at the Borough receiving the call from the public will obtain all relevant information available regarding the possible overflow including:
    a. Time and date call was received;
    b. Specific location and/or address of possible overflow;
    c. Description of problem; and
    d. Caller's name and call back phone number.
2. Pump station failures are monitored and received by the Borough. The operator on duty shall convey all information regarding alarms to the Borough to initiate the investigation.
3. Sanitary sewer overflows detected by any personnel in the course of their normal duties shall be reported to the Borough. Dispatched personnel should record all relevant overflow information and report back information to the Borough. The Borough shall dispatch additional response crews, equipment or contracted services as necessary.
4. It is the responsibility of the appropriate Borough personnel or the response crew to gather all spill response data and communicate this data back to the Borough as soon as possible. Until verified, the report of a possible spill will be referred to as a "sewer inspection" (SI), not a "sanitary sewer overflow" (SSO).
5. A sewer inspection or sewer overflow report should be completed by the maintenance division of the Borough within 24 hours of the responding crews confirmation of an overflow. The Borough is

responsible for reviewing, updating, signing, and submitting the final sewer inspection or overflow report form to the proper agency, including but not limited to the ACHD (and/or DEP).

B. Dispatch of Appropriate Crews to Site of Sewer

Failure of any element within the Borough owned and operated wastewater conveyance system that threatens to cause or causes a sanitary sewage overflow will trigger a response to isolate and correct the problem. Crews and equipment shall be available to respond to any SI/SO locations. Crews will be dispatched to any site of a reported SO as soon as possible.

1. Dispatching Crews

- Upon receipt of a report of a sewage overflow, all response crew members shall proceed to the Borough maintenance facility where they will gather all necessary equipment and resources before proceeding to the site of the SI/SO. Delays or conflicts in assignments and issues regarding equipment and resources should be reported to the Borough supervisor for resolution.
- The response crew leader should report his/her findings, including possible damage to public system and if assessable to a private party, to the Borough supervisor. If the Borough has not received findings from the response crew leader within an appropriate time frame then they should contact the response crew leader to determine the status of the investigation.

2. Additional Resources

- Requests for additional personnel, material, supplies, and equipment from response crews shall be received by the response crew leader and conveyed to the Borough.

3. Preliminary Assessment of Damage to Private and Public Property

- The response crews should use discretion in assisting property owners/occupants who are affected by a SSO. Be aware that the Borough could face increased liability for any further damages inflicted to private property during such assistance. Appropriate photographs and video footage, if possible, should be taken of the area of the SSO and impacted area, allowing for thorough documentation of the nature and extent of the impact. Photographs or video tape are to be forwarded to the Borough for filing with the inspection/overflow report.

4. Coordination with Hazardous Material Response

- Upon arrival at the scene of a SSO, should a suspicious substance (e.g., oil sheen, foamy residue) be found on the ground surface, or should a suspicious odor (e.g., gasoline) not common to the sewer system be detected, response crew leader should contact the Borough for guidance before taking further action.
- The Borough will alert the local fire department if necessary. The response crew leader shall await the arrival of the local fire department.
- After arrival of the local fire department, response crew members will take direction from the commanding officer of the local fire department. Only when the commanding officer determines it is safe and appropriate for the response crew members to proceed can containment, clean-up, and corrective activities be performed in accordance with the SSORP.
- Vehicle engines, portable pumps, or open flames (e.g., cigarette lighters) can provide the ignition for an explosion or fire should flammable vapors or fluids be present at the site. Maintain a safe distance and observe caution until and after assistance arrives.

5. Post-Cleanup Activities

- The appropriate Borough should conduct a follow up visit the site of the overflow, if possible, to ensure the provisions of the SSORP and other directives were properly followed.
- The response crew leader is responsible for confirming that the SI/SO Report was provided to the Borough.

C. Overflow Correction, Containment, and Clean-Up

Blocked sewers, pipe failures, or mechanical malfunctions can cause sanitary sewage overflows. Other natural and man-made disturbances are also possible causes of sanitary sewer overflows.

This section describes specific actions to be performed by response crews during an SSO. The objectives of these actions are to:

- Determine the apparent cause of the overflow, for example whether the cause lies in the publicly owned sewer or a private lateral,
- protect public health, the environment, and property by minimizing SSO impacts as soon as possible;
- establish perimeters with appropriate barricades and control zones with vehicles or natural topography (e.g., hills, berms);
- communicate preliminary overflow information and potential impacts as soon as practical to the regulatory agency, and

- contain the SSO to the maximum extent possible including preventing the discharge of sanitary sewage into surface waters.

Circumstances may arise when The Borough could benefit from the support of private-sector construction assistance.

1. Responsibilities of Response Crew Upon Arrival

   It is the responsibility of the first personnel who arrive at the site of a sanitary sewer overflow to protect the health and safety of the public by mitigating the impact of the overflow to the extent possible. Should the overflow not be the responsibility of the Borough, but there is imminent danger to public health, public or private property, or to the waters of the U. S., then prudent action should be taken until the responsible party assumes control and provides remedial actions.

   Upon arrival at a SSO the response crew should do the following:

   - Determine the cause of the sanitary sewer overflow,
   - If necessary, identify and request additional resources to correct the overflow or to determine its cause,
   - Determine if private property is impacted. If it is, the Borough should inform the ACHD (or DEP if appropriate) by faxing the standardized reporting form to:

     Allegheny County Health Department
     Chief of Public Drinking Water & Waste Management
     Phone: 412.578.8040
     Fax: 412.578.8053
     24-hour phone number: 412.687.2243

     Pennsylvania Department of Environmental Protection
     24-hour phone number: 412.442.4000
     Fax: 412.442.4194 or 412.442.4303

   - Appropriate personnel, materials, supplies, and/or equipment which can be dispatched to minimize the impact of the overflow.

1. Initial Measures for Containment

   Initiate measures to contain the SSO, thereby minimizing impact to public health or the environment.

2. Additional Measures Under Potentially Prolonged Overflow Conditions.

In the event of a prolonged sewer line blockage or a sewer line collapse, a determination should be made to set up a portable by-pass pumping operation around the obstruction.

- Appropriate measures shall be taken to effectively handle the sewage flow.
- Continuous or periodic monitoring shall be implemented as required.
- Regulatory agency issues shall be addressed in conjunction with emergency repairs.

4. Cleanup

Sewer overflow sites are to be promptly cleaned to the highest degree possible after an overflow. No readily identifiable residue is to remain in the area of the SSO.

- The SSO site is to be secured to prevent access to the site by the public until the site has been thoroughly cleaned.
- Where practical, the area is to be thoroughly flushed and cleaned of any sewage or wash-down water. Solids and debris are to be transported for proper disposal.
- Where appropriate, the overflow site is to be disinfected and ponds formed by the SSO will be pumped dry and the residue will be disposed of properly.

D. Overflow Report

An overflow report shall be completed by the response personnel, who shall promptly notify the Supervisor within the Borough when the overflow is eliminated.

To properly complete an overflow report:

- Determine if the SSO may have impacted the surface waters.
- Characterize the SSO by evaluating the following:
  a. Sewage overflows to stormwater system,
  b. Preplanned or emergency maintenance jobs involving bypass pumping,
  c. Overflows where observation or on-site evidence clearly indicates all sanitary sewage was retained on land and did not reach surface water and where cleanup occurs, and
  d. Any other pertinent information relating to each individual SSO.

- Use one of the following criteria to estimate the start date/time of the SSO:

a. Information reported to The Borough and later substantiated by a sewer investigator (or response crew, or
b. Visual observation.

• Use one of the following criteria to estimate the end date/time of the SSO:

a. When the blockage is cleared or flow is controlled or contained; or (When the flow of the sanitary sewer is controlled or contained by removing the blockage)
b. The arrival time of the sewer investigator or response crew, if the overflow stopped between the time it was reported and the time of arrival.

• Estimate the flow rate of the SSO in gallons per minute (GPM) by:

a. Direct observations of the overflow or;
b. Estimated measurement of actual overflow.

- Estimate the volume of the sanitary sewer overflow when rate of overflow is known by:

  a. Multiplying the duration of the overflow by the overflow rate.

- Photograph the event.

- Describe any damage to the exterior areas of public/private property.

IV. REGULATORY AGENCY NOTIFICATION PLAN

The Regulatory Agency Notification Plan establishes procedures that the Borough shall follow to provide formal notice to the ACHD as necessary in the event of SSOs. The following reporting criteria explain to whom various forms of notification should be sent, and lists agencies/individuals to be contacted.

Notification Procedure:

The Borough should notify the county regulatory agency representatives as soon as possible and keep them abreast of response actions and final corrective actions.

Notification will be by telephone or by fax no later than twenty-four (24) hours or the next working day after an overflow is confirmed. The initial and overflow report should be faxed on the standardized reporting form to:

Allegheny County Health Department
Chief of Public Drinking Water & Waste Management
Phone: 412-578-8040
Fax: 412-578-8053
24-hour phone number: 412.687.2243

Pennsylvania Department of Environmental Protection
Phone: 412.442.4000
Fax: 412.442.4194 or 412.442.4303

V. DISTRIBUTION AND MAINTENANCE OF SSORP

Annual updates to the SSORP should be made to reflect all changes in policies and procedures as may be required to achieve its objectives.

A. Submittal and Availability of SSORP

Copies of the SSORP and any amendments should be distributed to the following departments and functional positions:

Executive Office Complex – one copy.
Maintenance Division – One copy per operations management personnel.
Plants – one copy per location.

All other personnel who may become incidentally involved in responding to overflows should be familiar with the SSORP. Appended to the SSORP should be a sign off sheet that states that they have read and completely understand the SSORP.

B. Review and Update of SSORP

The SORP should be reviewed and amended as appropriate. The Borough should:

- Up-date the SSORP with the issuance of a revised or new NPDES permit or state waste discharge permit.
- Review and up-date, as needed the various contact person lists included in the SSORP.

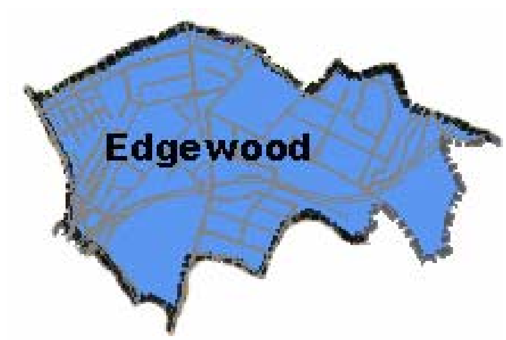
Sanitary Sewer Overflow Inspection/Verification Report
Borough of Edgewood

Assignment Information:					
Inspector Name:			Date of Inspection:		
			Time of arrival for Inspection:		a.m./p.m.
Initial Contact Information:					
Time of Call:		a.m./p.m.	Date of Call:		
Caller's name:			Caller's Phone Number		
Caller's address:					
Caller's Description of Problem:					
Initial Response Information (to be completed by the Inspector)					
Arrival time at the scene		a.m. / p.m.			
Is there any immediate evidence of hazardous materials present at the scene?	☐	YES	☐	NO	
If YES, then the Inspector is required to contact the local fire department and take direction from them. Note that vehicle engines, portable pumps or open flames can provide the ignition for an explosion. Maintain a safe distance and observe caution until and after assistance arrives. Refer to the SSORP for further initial response coordination.					

Field Investigation Information:						
1.	Has the event caused impact on the local surface waters? (If yes, include specific information below)		☐	YES	☐	NO
2.	Characterize the event by evaluating the following:					
	a.	The sewage overflowed to the stormwater system.	☐	YES	☐	NO
	b.	This event was caused due to a failure in a pre-planned or an emergency maintenance issue involving bypass pumping.	☐	YES	☐	NO
	c.	Observation or on-site evidence clearly indicates that sanitary sewage was retained on land and did not reach surface waters.	☐	YES	☐	NO
	d.	Characterize other additional pertinent information below:				
3.	Identify or estimate the time the event started based on visual information or the Caller's understanding of the event start time.				a.m./p.m.	
4.	Estimate the end date and time of the event using the following:					
	a.	When the blockage is cleared or flow is controlled or contained; or when the flow of the sanitary sewer is controlled or contained by removing the blockage.	Date:			
					a.m./p.m.	
	b.	The arrival time of the inspector or response crew, if the overflow stopped between the time it was reported and the time of arrival.	Date:			
					a.m./p.m.	
5.	Estimate the flow rate of the event in gallons per minute by:					
	a.	Direct observations of the overflow			GPM	
	b.	Estimated measurement of actual overflow			GPM	
6.	Estimate the volume in million gallons of the event flow by multiplying the duration of the overflow by the overflow rate calculated above.				MG	
7.	Describe any damage to the exterior areas of public and private property observed (use the back of this form to provide additional detail as required):					
NOTE: The Inspector is required to photograph the event and damages described above.						

Additional Notes:

APPENDIX B



3 Rivers Wet Weather Demonstration Program

Accessibility Field Review Form
Borough of Edgewood

Inspector Name:		Date of Field Review:	

	Manhole Structure Number	Manhole Status		Photograph Taken	Description of Accessibility Problem
		No Action Required	Corrective Action Required		
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

APPENDIX C

3 Rivers Wet Weather Demonstration Program

Manhole Physical Survey Form
Borough of Edgewood

Inspector Name:		Date of Physical Survey:	

Manhole Number:		Location Description:	
Weather Conditions:			

Casting / Lid:

Type:	☐	Vented	☐	Solid		Buried:	☐	Yes	☐	No	How Deep?	FT

Ladder Bars:

Type:	☐	Steel	☐	PVC	☐	Cast Iron	☐	None

Condition:	☐	Good (no repair necessary)	☐	Fair (some repair required)	☐	Poor (extensive repair required)	☐	Replace
	Description of Repair Work							

Barrel:

Construction:	☐	Brick	☐	Precast:	☐	Other:	

Condition:	☐	Good (no repair necessary)	☐	Fair (some repair required)	☐	Poor (extensive repair required)	☐	Replace
	Description of Repair Work							

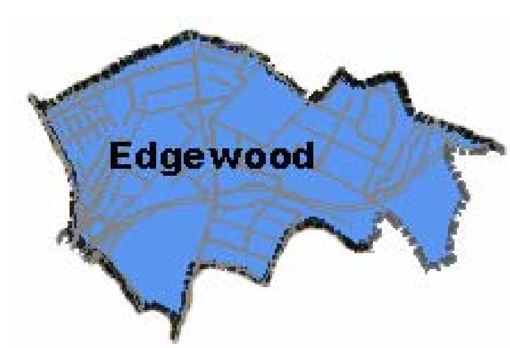
Bottom:

Construction:	☐	Brick	☐	Precast	☐	Cast-in-place

Condition:	☐	Good (no repair necessary)	☐	Fair (some repair required)	☐	Poor (extensive repair required)	☐	Replace
	Description of Repair Work							
Debris:								

Additional Observations: (include a description of materials needed for repair, access, traffic, and other issues that the repair crew will need to know prior to arriving at the site.)

APPENDIX D



3 Rivers Wet Weather Demonstration Program

Project Tracking Form
Borough of Edgewood

Project Number:			
Date of complaint (if any) or Work Order:		Name of complainant (if any):	
Address:			
Location Description:			
Complaint Tracking Number (if any):			
Description of reported condition or Maintenance Request:			
Manhole from:		Manhole to:	
Charge to:		Project Classification:	
Contractor:			
Project Engineer:			

Project Inspector:					**Work Type:**
Crew Foreman:				☐	Main Line New Installation
Project Summary Information				☐	Main Line Replacement
Start Date:				☐	Min Line Repair
Completion Date:				☐	Main Line Bulk Head
Estimated Days to completion:				☐	Main Line Fill, Seal Abandon
Cut Size (feet):	Length		Width		
	Average Depth			☐	Manhole New Installation
Permit Number:				☐	Manhole Replacement
Utilities Phone Numbers:	Gas			☐	Manhole Repair
	Electric			☐	Manhole Rehabilitation
	Phone			☐	Manhole Raise
	Cable				
	Water			☐	Encasement Installation
Project Notes (include description of equipment used, number of personnel required and any difficulties encountered):				☐	Encasement Repair
				☐	Force Main Replacement
				☐	Force Main Repair
				☐	Force Main Valve Replacement
				☐	Force Main Valve Repair
				☐	Low Pressure Force Main Replacement
				☐	Low Pressure Force Main Repair
				☐	Low Pressure Force Main Valve Replacement
				☐	Low Pressure Force Main Valve Repair
One Call Serial Numbers and Dates:					
				☐	Building Lateral New Installation
				☐	Building Lateral Replacement
				☐	Building Lateral Repair
				☐	Building Lateral Relocate
Project Difficulty Rating:				☐	Other (describe):
(Easy, Moderate, Difficult)					

Soil Conditions:	☐	Rock	☐	Clay	☐	Silt/Sand	☐	Other:	
Surface Conditions:	☐	Asphalt	☐	Concrete	☐	Sidewalk	☐	Driveway	
	☐	Unimproved	☐	Off Road/Creek	☐	Other:			
Utilities:	☐	None	☐	Water	☐	Electric			
	☐	Gas	☐	Phone/Cable	☐	Other			
	Utilities Concentration:		☐	Light	☐	Medium	☐	Heavy	
Pumping Required:	☐	Dewatering	☐	Bypass					
Excavation:	☐	No Shoring	☐	Trench Box	☐	Tunnel Liner	☐	Open Sheeting	
	☐	Closed Sheeting	☐	Soldier/Pile Lagging	☐	Horizontal Tunneling	☐	Horizontal Boring	
	☐	Sheet Piling	☐	Other:					
Backfill:	☐	Excavated Soil	☐	Controlled Density	☐	Compacted Granular	☐	Flash Fill	

Pipe Materials:

Item	Material	Type	Size	Length	Quantity

Notes:

Concrete Encasement			Fill, Seal and Abandon		Tunneling / Boring	
Height (FT)	Length (FT)	Width (FT)	Pipe Diameter (IN)	Pipe Length (FT)	Casing / Liner Plate Diameter (IN)	Length (FT)

APPENDIX E

3 Rivers
Wet Weather
Demonstration Program

Table E-1
Edgewood O&M Defects - Summary of NAASCO Grades
Sorted by Grade

Upstream MH	Downstream MH	Line Length (feet)	NAASCO O&M Grade
21-6	21-5.1	92.4	1.00
24-8A	24-8.2	164.2	1.12
24-6O	24-6N	324.2	1.14
24-6N	24-6M	194.7	1.22
20-10A	20-10.1	110.3	1.33
20-12J.3	20-12J.2	60.0	1.40
24-8B	24-8A	289.6	1.40
21-4.1	21-3	455.3	1.44
22	21	91.5	1.50
20-4E	20-4D	300.4	1.50
23-4	23-3	102.1	1.50
24-6H-5	24-6H-4B	261.0	1.50
27-D1	27-D	177.9	1.50
20.1-D3	20.1-D	95.2	1.56
14	13	207.0	1.57
27-5A	27-5	262.8	1.63
21-5.1	21-4.1	308.3	1.65
21-1B	21-1A	284.9	1.66
20-12J-1	20-12J	250.9	1.67
20-1I-1	20-1I	367.3	1.70
24-6H	24-6GA	288.1	1.71
21-1D	21-1C	260.9	1.72
20-4F	20-4E	149.5	1.73
End 1	20.1-D4	363.0	1.75
24-6A	24-6	212.6	1.79
20-14	20-13	129.0	1.80
20-1I-3	20-1I-2	284.1	1.80
20-12L-3	20-12L-2	341.1	1.81
24-6D-2A	24-6D-2	449.8	1.82
24	23	538.7	1.83
24-6H-3	24-6H-2	103.5	1.83
27-2	27	65.2	1.86
20-16	20-15	232.1	1.86
24-6D	24-6C	501.1	1.86
20.1-I-A	20.1-I	187.9	1.87
20.1-B	20.1-A	173.7	1.88
20-14B	20-14	121.3	1.88
24-6B-1	24-6B.1	310.8	1.88
20.1-I-B	20.1-I-A	274.7	1.91
20-1I-6	20-1I-5	226.5	1.92
24-6C	24-6B	499.5	1.94
End 8	24-6B-1	50.0	1.94
20-14D	20-14C	579.0	1.95
20-7B-1	20-7B	263.0	1.95
20-14C	20-14B	340.0	1.96
20	19	33.4	1.97
20-1I-4	20-1I-3	249.3	1.97
	Total Line Length - Grade 1 to 2	11,627.80	

Table E-1
Edgewood O&M Defects - Summary of NAASCO Grades
Sorted by Grade

Upstream MH	Downstream MH	Line Length (feet)	NAASCO O&M Grade
27	26	340.3	2.00
20-11A	20-11	203.9	2.00
20-11-3	20-11-2	303.9	2.00
20-12J	20-12I	209.7	2.00
20-1E-2	20-1E-1	220.4	2.00
20-1E-2A	20-1E-2	103.8	2.00
20-1H-1	20-1H	306.7	2.00
20-1I	20-1H-A	116.7	2.00
20-6	20-5	120.7	2.00
23-2	23-1	44.6	2.00
23-3	23-2	299.8	2.00
End 2	23-4	158.0	2.00
24.1B	24.1A	371.9	2.00
24-6	24-5	82.2	2.00
24-6D-4B	24-6D-4A	198.6	2.00
24-6G-7	24-6G-3	512.9	2.00
24-6H-6	24-6H-5	365.4	2.00
24-6J-1	24-6I	271.9	2.00
20-1H	BC 2	125.0	2.00
20.1-C	20.1-B	400.3	2.04
20-1I-5	20-1I-4	418.6	2.04
24-6H-3.1	24-6H-3	321.0	2.04
20-12K	20-12J.3	120.0	2.05
21-1-4	21-1-3	312.1	2.06
27-7	27-6	260.8	2.08
20-1I-1C	20-1I-1B	277.5	2.10
20-12F	20-12E	312.3	2.12
20-15	20-14-1	143.9	2.12
10	9	163.4	2.13
12	11	336.3	2.13
21-2	21-1	399.4	2.14
21-3	21-2	125.6	2.14
End 6	24-6H-3A	145.0	2.14
27-5	27-4	311.3	2.17
20-2C	20-2B	547.9	2.19
20-12B	20-12A	115.5	2.20
20-4D	20-4B	283.9	2.20
27-4	27-2	351.1	2.20
20-1A.2	20-1A.1	275.2	2.23
20-2B	20-2A	438.8	2.23
20-12L-2	20-12K	156.5	2.25
21-1-1	21-1.1	238.3	2.25
24-5	24-4	37.2	2.25
24-6M	24-6L	54.3	2.25
27-H	27-G	253.4	2.25
20-11B	20-11A	349.5	2.26
20-10.1	20-10	198.5	2.27
24-6D-2	24-6D-1	288.5	2.28

Table E-1
Edgewood O&M Defects - Summary of NAASCO Grades
Sorted by Grade

Upstream MH	Downstream MH	Line Length (feet)	NAASCO O&M Grade
24-6D-2A	24-6H	242.3	2.29
27-E1	27-E	389.9	2.29
27-G	27-F	367.2	2.29
20.1-H	20.1-G	457.0	2.30
24-6B	24-6A	143.7	2.30
24-6D-4A	24-6D-4	213.1	2.30
20-10C	20-10A	94.7	2.33
20-12J-2	20-12J-1	125.1	2.33
24.1C	24.1B	459.4	2.33
21-1C	21-1B	454.1	2.34
20.1-D4	20.1-D3	85.6	2.35
20-2A	20-2.1	511.5	2.39
20-12I	20-12H	240.6	2.40
20-12J.2	20-12J.1	400.0	2.42
20-1G.1A	20-1G.1	242.2	2.45
20-1M	20-1L	432.9	2.45
24-6G-2	24-6G-1	466.0	2.46
24-6B-2	20-10C	249.1	2.50
20-7	20-6.1	104.2	2.50
20-9	20-8	87.9	2.50
21-8	21-7.1	157.7	2.50
24-4	24-3	133.9	2.50
24-6D-4B.1	24-6D-4B	228.9	2.50
24-6L	24-6K	47.1	2.50
27-E2	27-E1	198.0	2.50
27-J	27-I	281.7	2.50
20-1A	20-1	340.3	2.54
24-6D-1	24-6D	274.8	2.55
20-12G-1A	20-12G	300.0	2.56
20-7B	20-7	186.8	2.56
20-1I-2	20-1I-1	350.3	2.58
20-1I-1B	20-1I-1A	400.6	2.60
20-4	20-3	294.2	2.60
20-2D	20-2C	264.0	2.62
BC 1	22	595.0	2.64
20.1-D	20.1-C	34.1	2.67
27-D	27-C	171.9	2.67
26-6B.1	27-J	331.7	2.67
21-9	21-8	259.1	2.68
24-8.2	24-8	181.6	2.70
20-1L	20-1J	290.5	2.71
20-11-2	20-11-1	307.6	2.72
20-12D-1	20-12D	90.0	2.75
20-12G-1	20-12G-1A	180.0	2.80
16	15	336.8	2.83
24-6H-4A	24-6H-4	373.9	2.83
BC 4	20	844.0	2.85
24-2	24	481.7	2.85
13	12	257.6	2.87

Table E-1
Edgewood O&M Defects - Summary of NAASCO Grades
Sorted by Grade

Upstream MH	Downstream MH	Line Length (feet)	NAASCO O&M Grade
21	BC 3	281.0	2.87
20-1E-4	20-1E-3	285.4	2.89
24-6G	24-6E	420.8	2.91
24-6GA	24-6G	252.1	2.91
18	17	300.0	2.92
19	18	185.0	2.94
End 9	20-1A.2	139.7	2.96
	Total Line Length - Grade 2 to 3	27,816.80	
9	8	1062.9	3.00
20-12J-3	20-12J-2	43.0	3.00
End 10	20-1A	60.0	3.00
20-5	20-4A	343.5	3.00
20-6.1	20-6	113.7	3.00
20-10	20-9	135.1	3.00
27-C	27-A	296.4	3.00
27-E	27-D1	140.6	3.00
23-1	BC 1	101.0	3.00
17	16	301.8	3.13
20-12E	20-12D-1	435.0	3.23
24-6G-3	24-6G-2	105.8	3.23
20-12C	20-12B	291.3	3.25
BC 2	20-1GA	230.0	3.25
11	10	573.0	3.33
20.1-H-A	20.1-H	145.0	3.33
20-4.1	20-4	456.4	3.33
27-I	27-H	173.8	3.33
21-1-3	21-1-1	351.1	3.38
20-11C	20-11B	199.1	3.50
24-3	24-2	79.8	3.50
15	14	566.0	3.61
20-1E-1	20-1E	123.4	3.75
20-12A	20-12	115.5	4.00
24-6H-4B	24-6H-4A	120.0	4.00
	Total Line Length - Grade 3 to 4	6,563.20	
	Total Line Length - Grade 4 to 5	0.00	

Edgewood Borough

2001 to 2003 CCTV Findings

O & M Defect Characterization

LENNON, SMITH, SOULERET ENGINEERING, INC.
846 4th Avenue • Coraopolis, PA 15108
(412) 264-4400 Fax No. (412) 264-1200
E-Mail Address: Admin@LSSE.com

0 187.5 375 750 1,125 1,500 Feet

Legend

Sewerlines
- Debris
- Encrustation
- Grease
- Obstruction
- Roots
- Sagging
- Manholes
- EDGEWOOD

NO.	DATE	REVISION DESCRIPTION
1	11/15/05	Issued for O & M Refinement Field Work

Printed 11/15/05

Edgewood Borough

2001 to 2003 CCTV Findings

O & M Defect Characterization

LENNON, SMITH, SOULERET ENGINEERING, INC.
846 4th Avenue • Coraopolis, PA 15108
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E-Mail Address: Admin@LSSE.com

0 187.5 375 750 1,125 1,500 Feet

Legend

Severity

- 1
- 2
- 3
- 4
- 5
- Manholes
- EDGEWOOD

NO.	DATE	REVISION DESCRIPTION
1	11/15/05	Issued for O & M Refinement Field Work

Printed 11/15/05

APPENDIX F

3 Rivers
Wet Weather
Demonstration Program

Table F-1
Edgewood Structural Defects - of NAASCO Grades
Sorted by Grade

Upstream MH	Downstream MH	Line Length (feet)	NAASCO Structural Grade
14	13	207.00	1.92
18	17	300.00	1.92
20	19	33.40	1.50
20.1-C	20.1-B	400.30	1.89
20.1-I-A	20.1-I	187.90	1.67
20.1-I-B	20.1-I-A	274.70	1.82
20-10A	20-10.1	110.30	1.60
20-10C	20-10A	94.70	1.93
20-11-3	20-11-2	303.90	1.25
20-12A	20-12	115.50	1.67
20-12J-2	20-12J-1	125.10	1.50
20-14B	20-14	121.30	1.85
20-14C	20-14B	340.00	1.18
20-1G.2	20-1G.1	118.70	1.00
20-1I-3	20-1I-2	284.10	1.50
20-4D	20-4B	283.90	1.83
23-2	23-1	44.60	1.57
24-6D	24-6C	501.10	1.95
24-6E	24-6D	439.80	1.77
24-6H	24-6GA	288.10	1.71
24-6H-3A	24-6H-3	260.80	1.84
24-6J-1	24-6I	271.90	1.67
24-6M	24-6L	54.30	1.67
24-8B	24-8A	289.60	1.85
27-6	27-5	308.60	1.81
	Total Line Length - Grade 1 to 2	5,759.60	
13	12	257.60	2.00
9	8	1,062.90	2.95
16	15	336.80	2.40
17	16	301.80	2.80
19	18	185.00	2.42
21	BC 3	281.00	2.06
24	23	538.70	2.15
27	26	340.30	2.69
20.1-D	20.1-C	34.10	2.00
20.1-D4	20.1-D3	85.60	2.69
20.1-G	20.1-D	364.60	2.39
20.1-H	20.1-G	457.00	2.10
20-11-2	20-11-1	307.60	2.50
20-11A	20-11	203.90	2.38
20-11B	20-11A	349.50	2.50
20-12C	20-12B	291.30	2.69
20-12G	20-12F	251.00	2.00
20-12J	20-12I	209.70	2.95
20-12J.3	20-12J.2	60.00	2.00
20-12J-1	20-12J	250.90	2.87
20-12K	20-12J.3	120.00	2.20
20-12L-2	20-12K	156.50	2.13
20-12L-3	20-12L-2	341.10	2.69
20-14	20-13	129.00	2.42

Table F-1
Edgewood Structural Defects - of NAASCO Grades
Sorted by Grade

Upstream MH	Downstream MH	Line Length (feet)	NAASCO Structural Grade
20-15	20-14-1	143.90	2.74
20-1A	20-1	340.30	2.22
20-1E-1	20-1E	123.40	2.00
20-1E-2	20-1E-1	220.40	2.00
20-1I-1B	20-1I-1A	400.60	2.94
20-1I-2	20-1I-1	350.30	2.20
20-1I-5	20-1I-4	418.60	2.00
20-1I-6	20-1I-5	226.50	2.60
20-1J	20-1I	348.60	2.81
20-1L	20-1J	290.50	2.65
20-1M	20-1L	432.90	2.57
20-2C	20-2B	547.90	2.27
20-4A.2	20-4A.1	150.00	2.68
20-4E	20-4D	300.40	2.86
20-4F	20-4E	149.50	2.00
20-7B	20-7	186.80	2.00
20-7C	20-7B	101.90	2.50
21-1.1	21	123.90	2.75
21-1-1	21-1.1	238.30	2.79
21-1-3	21-1-1	351.10	2.86
21-1-4	21-1-3	312.10	2.17
21-1B	21-1A	284.90	2.71
21-1C	21-1B	454.10	2.57
21-1D	21-1C	260.90	2.64
21-2	21-1	399.40	2.90
21-3	21-2	125.60	2.33
21-4.1	21-3	455.30	2.89
21-5.1	21-4.1	308.30	2.56
21-6	21-5.1	92.40	2.50
21-7.1	21-6	244.10	2.00
21-8	21-7.1	157.70	2.00
21-9	21-8	259.10	2.50
23-3	23-2	299.80	2.84
23-4	23-3	102.10	2.00
24.1B	24.1A	371.90	2.37
24-3	24-2	79.80	2.90
24-5	24-4	37.20	2.75
24-6	24-5	82.20	2.94
24-6B	24-6A	143.70	2.45
24-6B-1	24-6B.1	310.80	2.97
24-6B-2	20-10C	249.10	2.80
24-6C	24-6B	499.50	2.59
24-6D-2	24-6D-1	288.50	2.33
24-6D-3	24-6D-2	423.70	2.00
24-6D-4	24-6D-3	141.30	2.60
24-6G	24-6E	420.80	2.38
24-6G-2	24-6G-1	466.00	2.36
24-6G-7	24-6G-3	512.90	2.40
24-6GA	24-6G	252.10	2.00
24-6H-3	24-6H-2	103.50	2.67
24-6H-4	24-6G-7	138.80	2.00
24-6H-4A	24-6H-4	373.90	2.50

Table F-1
Edgewood Structural Defects - of NAASCO Grades
Sorted by Grade

Upstream MH	Downstream MH	Line Length (feet)	NAASCO Structural Grade
24-6H-5	24-6H-4B	261.00	2.60
24-6H-6	24-6H-5	365.40	2.00
24-6I	24-6H	356.30	2.71
24-6N	24-6M	194.70	2.22
24-6O	24-6N	324.20	2.00
24-8.1	24-6	199.80	2.69
24-8A	24-8.2	164.20	2.50
24-9	24-8	237.30	2.49
26-6B.1	27-J	331.70	2.75
27-2	27	65.20	2.62
27-5	27-4	311.30	2.55
27-7	27-6	260.80	2.00
27-A	27-2	298.10	2.31
27-C	27-A	296.40	2.40
27-D	27-C	171.90	2.83
27-D1	27-D	177.90	2.45
27-E	27-D1	140.60	2.80
27-F	27-E	192.50	2.34
27-G	27-F	367.20	2.00
27-H	27-G	253.40	2.80
27-J	27-I	281.70	2.25
BC 1	22	595.00	2.71
End 1	20.1-D4	363.00	2.42
End 2	23-4	158.00	2.18
End 6	24-6H-3A	145.00	2.12
End 7	20-14C	100.00	2.21
	Total Line Length - Grade 2 to 3	27,625.80	

11	10	573.00	3.00
10	9	163.40	3.20
12	11	336.30	3.33
15	14	566.00	3.00
20.1-B	20.1-A	173.70	3.50
20-10.1	20-10	198.50	3.83
20-12B	20-12A	115.50	3.00
20-12D-1	20-12D	90.00	3.00
20-12G-1	20-12G-1A	180.00	3.64
20-12G-1A	20-12G	300.00	3.02
20-12I	20-12H	240.60	3.83
20-12J.2	20-12J.1	400.00	3.00
20-12J-3	20-12J-2	43.00	3.00
20-16	20-15	232.10	3.81
20-1A.2	20-1A.1	275.20	3.04
20-1H-A	20-1H	50.10	3.00
20-1I	20-1H-A	116.70	3.50
20-1I-1C	20-1I-1B	277.50	3.67
20-1I-4	20-1I-3	249.30	3.00
20-2A	20-2.1	511.50	3.06
20-2B	20-2A	438.80	3.43
20-2D	20-2C	264.00	3.00
20-4B	20-4A.2	33.00	3.00

Table F-1
Edgewood Structural Defects - of NAASCO Grades
Sorted by Grade

Upstream MH	Downstream MH	Line Length (feet)	NAASCO Structural Grade
20-5	20-4A	343.50	3.00
20-6.1	20-6	113.70	3.30
23-1	BC 1	101.00	3.00
24.1C	24.1B	459.40	3.58
24-2	24	481.70	3.01
24-4	24-3	133.90	3.08
24-6D-4B	24-6D-4A	198.60	3.20
24-6D-5	24-6D-4	230.10	3.40
27-E2	27-E1	198.00	3.00
27-I	27-H	173.80	3.67
BC 4	20	844.00	3.25
End 10	20-1A	60.00	3.83
End 8	24-6B-1	50.00	3.33
	Total Line Length - Grade 3 to 4	9,215.90	

24-6D-4B.1	24-6D-4B	228.90	4.00
20-11C	20-11B	199.10	5.00
20-12H	20-12G.1	250.00	4.81
20-4	20-3	294.20	4.10
20-4.1	20-4	456.40	5.00
20-7	20-6.1	104.20	4.32
End 9	20-1A.2	139.70	4.13
	Total Line Length - Grade 4 to 5	1,672.50	

Edgewood Borough

2001 to 2003 CCTV Findings

Structural Defect Characterization

LENNON, SMITH, SOULERET ENGINEERING, INC.
846 4th Avenue • Coraopolis, PA 15108
(412) 264-4400 Fax No. (412) 264-1200
E-Mail Address: Admin@LSSE.com

Feet
0 187.5 375 750 1,125 1,500

Legend

Structure Grade

- 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- 3.01 - 4.00
- 4.01 - 5.00
- Unable to CCTV
- • Manholes
- EDGEWOOD

NO.	DATE	REVISION DESCRIPTION
1	11/15/05	Issued for O & M Refinement Field Work

Printed 11/15/05

APPENDIX G

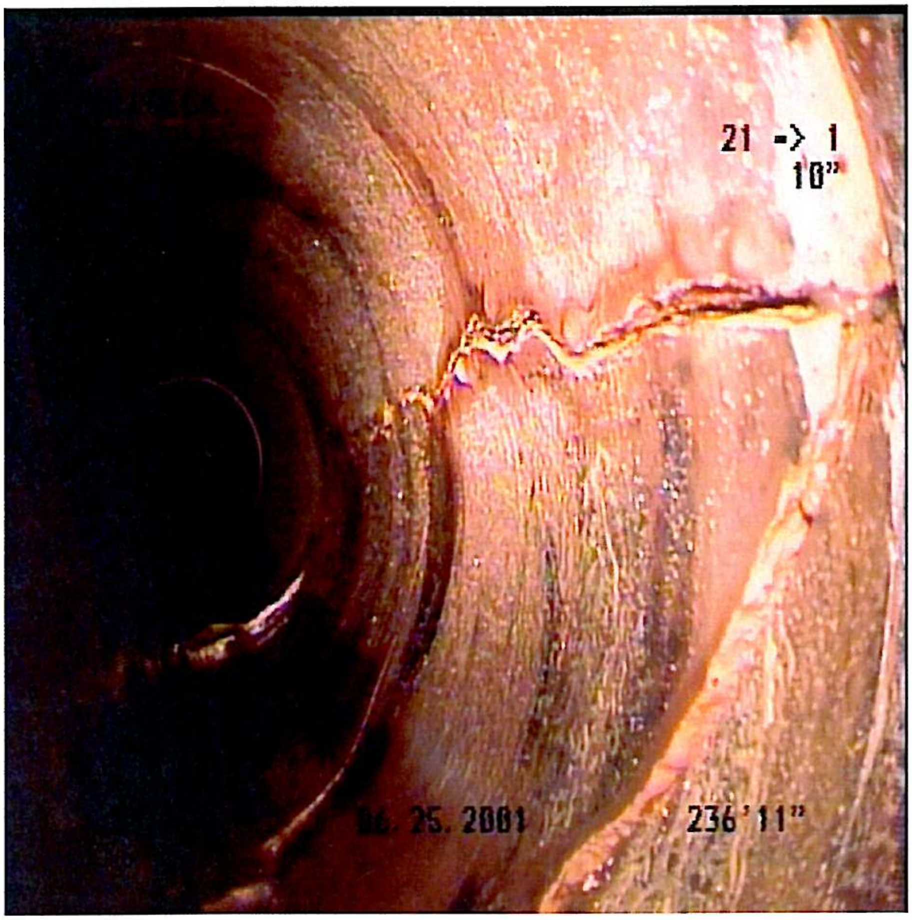
3 Rivers
Wet Weather
Demonstration Program

Crack - Longitudinal (CL)

Distance (Feet)	Video Ref.	Code		Continuous defect	Value				Joint	Circumferential Location	
		Group/ Descriptor	Modifier/ severity		S/M/L	Inches		%		At/ From	To
						1st	2nd				
1.5		CL		S01						03	
1.5		CL		S02						09	

EXHIBIT 3-1

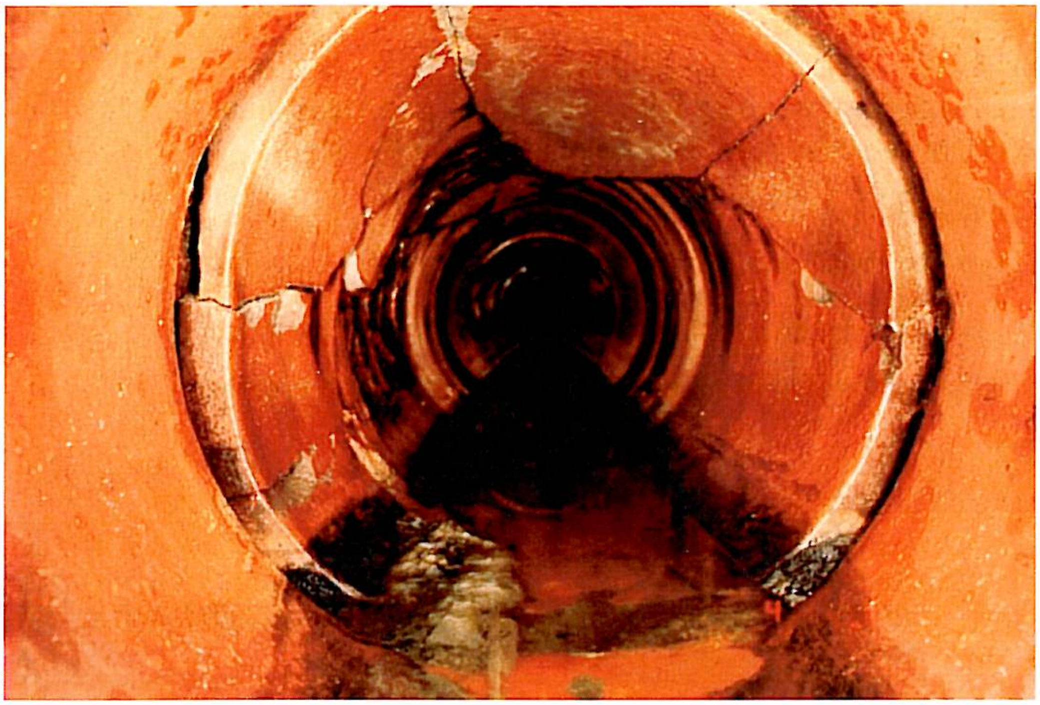
Fracture - Longitudinal (FL)



Distance (Feet)	Video Ref.	Code		Continuous defect	Value				Joint	Circumferential Location	
		Group/ Descriptor	Modifier/ severity		S/M/L	Inches		%		At/ From	To
						1st	2nd				
236.9		FL								03	

EXHIBIT 3-2

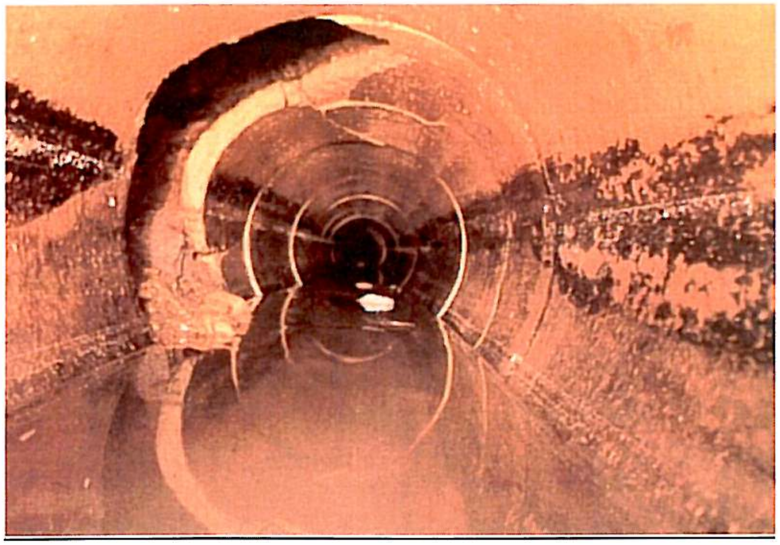
Broken (B)



Distance (Feet)	Video Ref.	Code		Continuous defect	Value				Joint	Circumferential Location	
		Group/ Descriptor	Modifier/ severity		S/M/L	Inches		%		At/ From	To
						1st	2nd				
3.4		B		S01						07	03

EXHIBIT 3-3

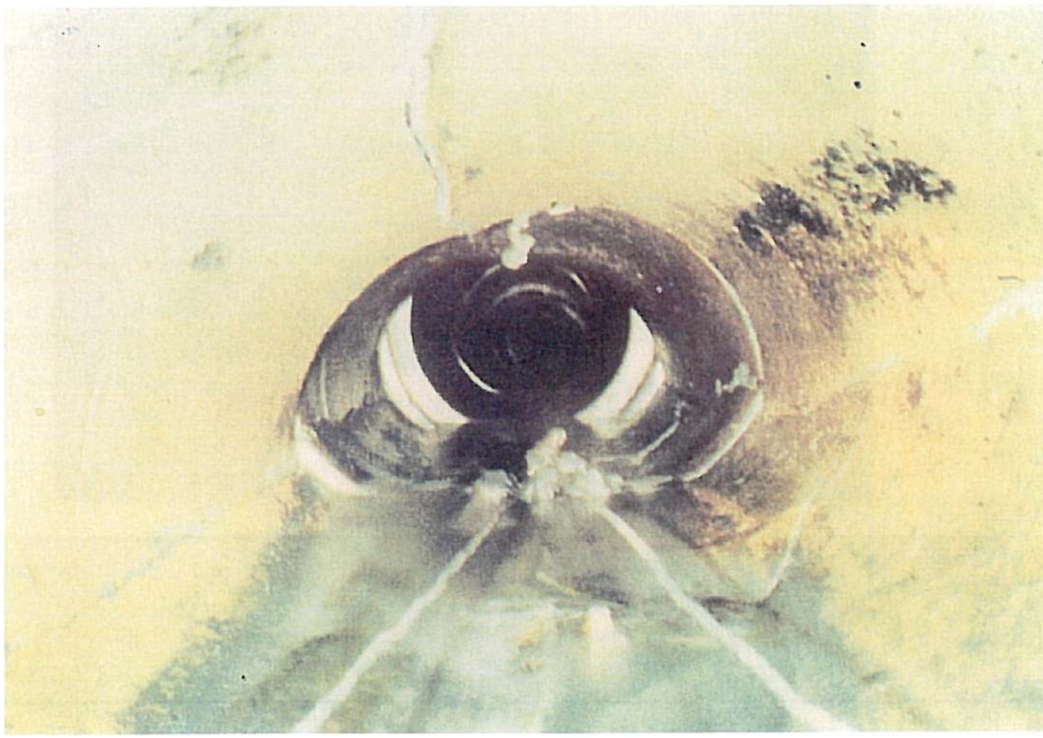
Hole (H)



Distance (Feet)	Video Ref.	Code		Continuous defect	Value				Joint	Circumferential Location	
		Group/ Descriptor	Modifier/ severity		S/M/L	Inches		%		At/ From	To
						1st	2nd				
309.4		H	SV							07	12

EXHIBIT 3-4

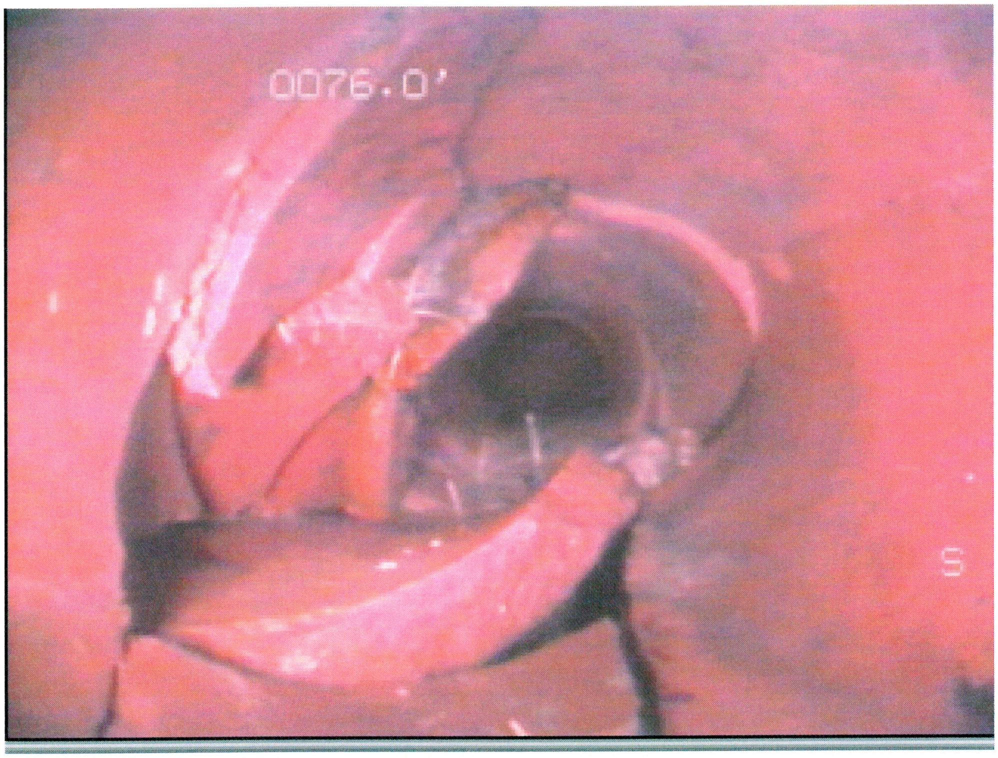
Deformation (D)



Distance (Feet)	Video Ref.	Code		Continuous defect	Value				Joint	Circumferential Location	
		Group/ Descriptor	Modifier/ severity		S/M/L	Inches		%		At/ From	To
						1st	2nd				
3.0		D						20			

EXHIBIT 3-5

Collapse Pipe (XP)

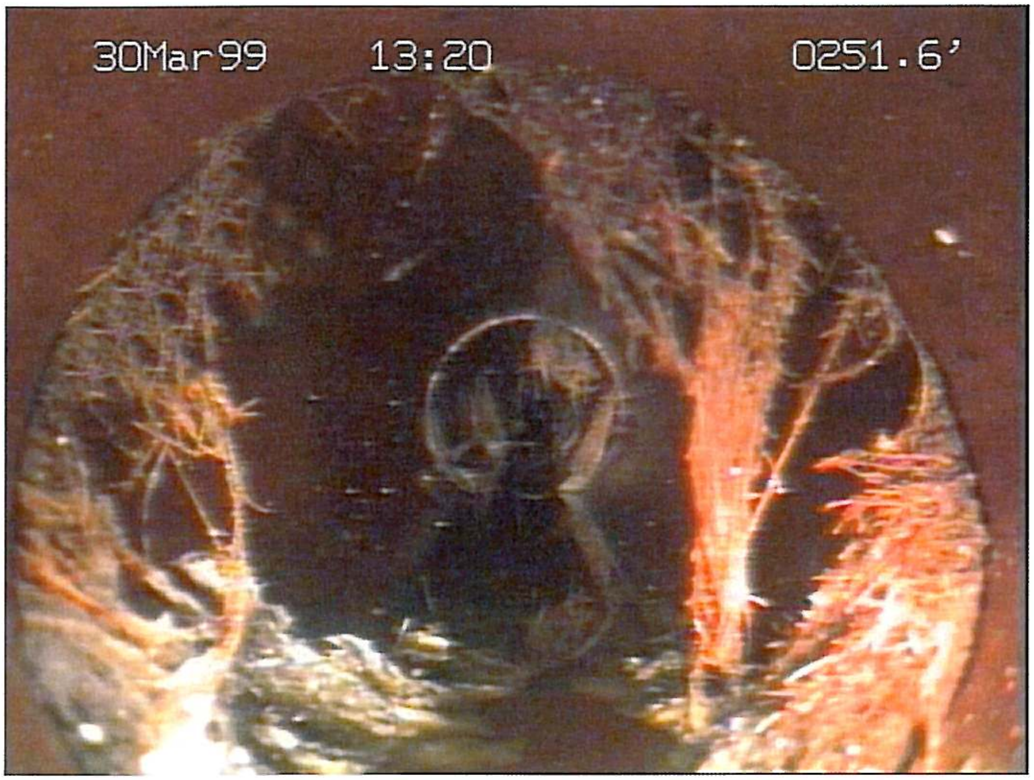


Distance (Feet)	Video Ref.	Code		Continuous defect	Value				Joint	Circumferential Location	
		Group/ Descriptor	Modifier/ severity		S/M/L	Inches		%		At/ From	To
						1st	2nd				
76.0		XP						75			
76.0		MSA									

Note: By definition Collapse means the camera is blocked and the survey abandoned. The survey abandoned code (MSA) will also be used (See Section 8)

EXHIBIT 3-6

Roots - Medium (RM)



Distance (Feet)	Video Ref.	Code		Continuous defect	Value				Joint	Circumferential Location	
		Group/ Descriptor	Modifier/ severity		S/M/L	Inches		%		At/ From	To
						1st	2 nd				
251.6		RM		S01				20	J	07	05

Note: Joint column used as modifier. 50% or less cross sectional area loss means Roots Medium used for coding.

EXHIBIT 3-7

Infiltration Gusher (IG)

Distance (Feet)	Video Ref.	Code		Continuous defect	Value				Joint	Circumferential Location	
		Group/ Descriptor	Modifier/ severity		S/M/L	Inches		%		At/ From	To
						1st	2 nd				
3.1		IG								08	09

Note: Infiltration from 08 to 09 are coded "Gushers"

EXHIBIT 3-8

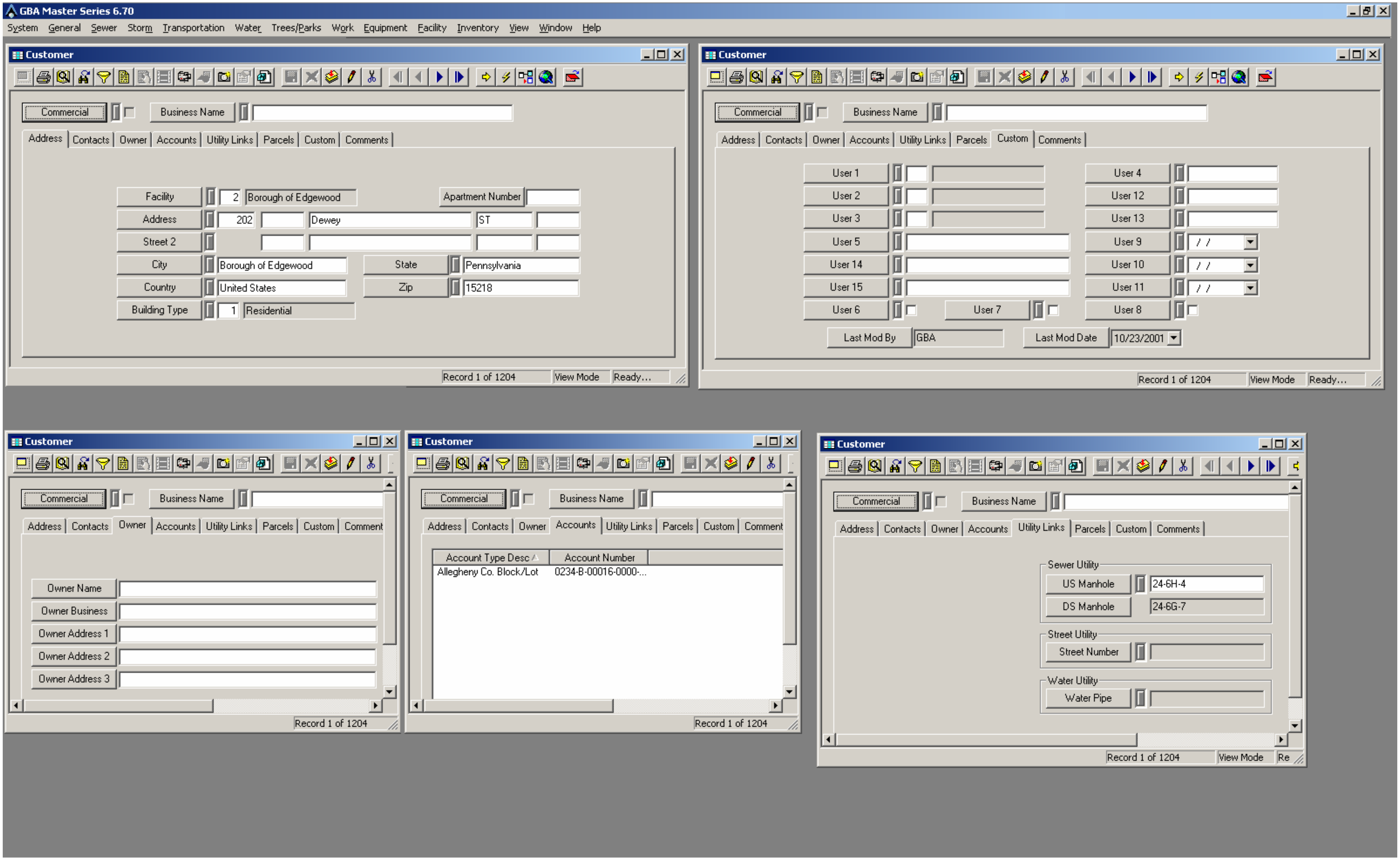
Other Obstacles (OBZ)

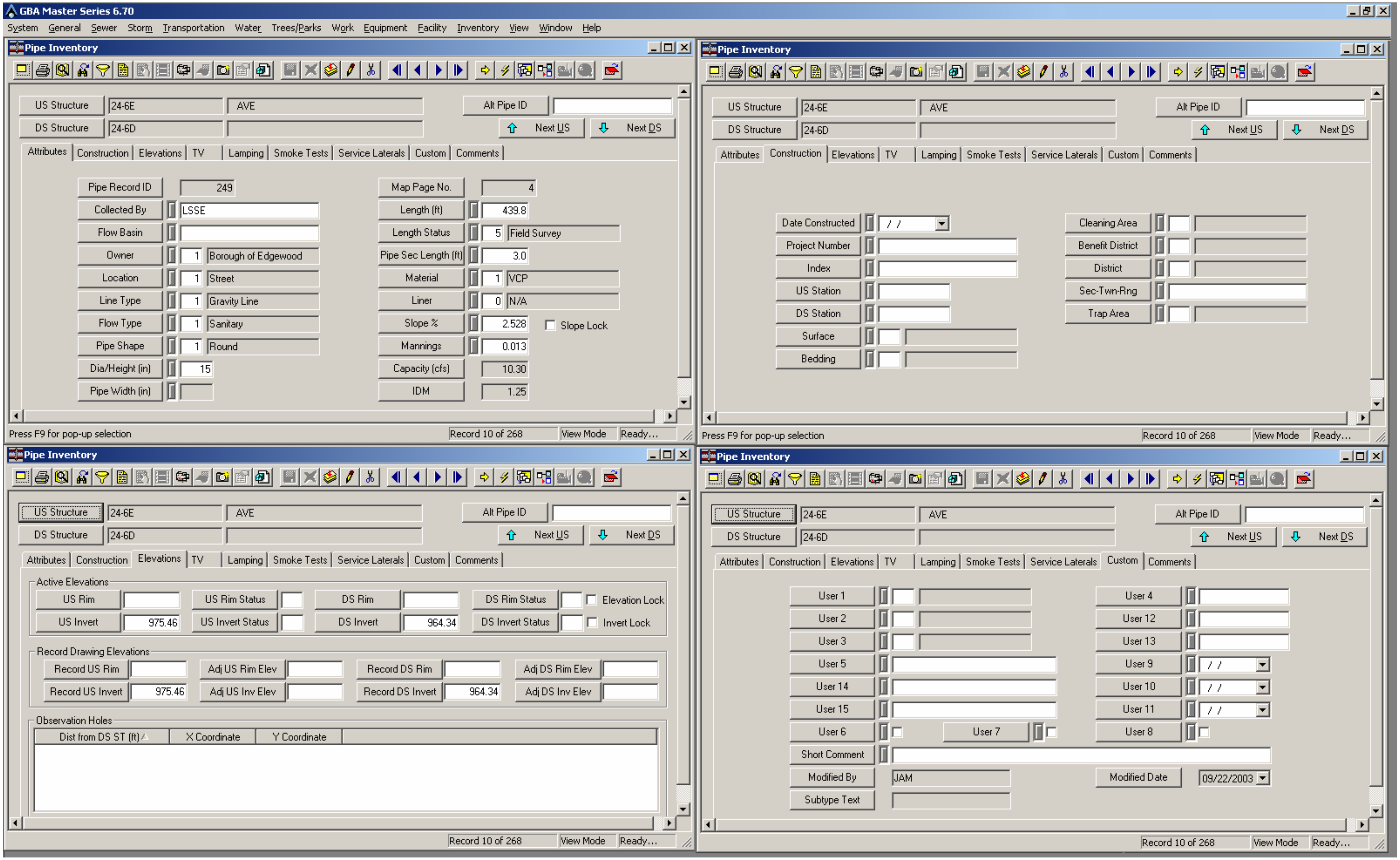
Distance (Feet)	Video Ref.	Code		Continuous defect	Value				Joint	Circumferential Location	
		Group/ Descriptor	Modifier/ severity		S/M/L	Inches		%		At/ From	To
						1st	2 nd				
99.3		OBZ						45		03	09

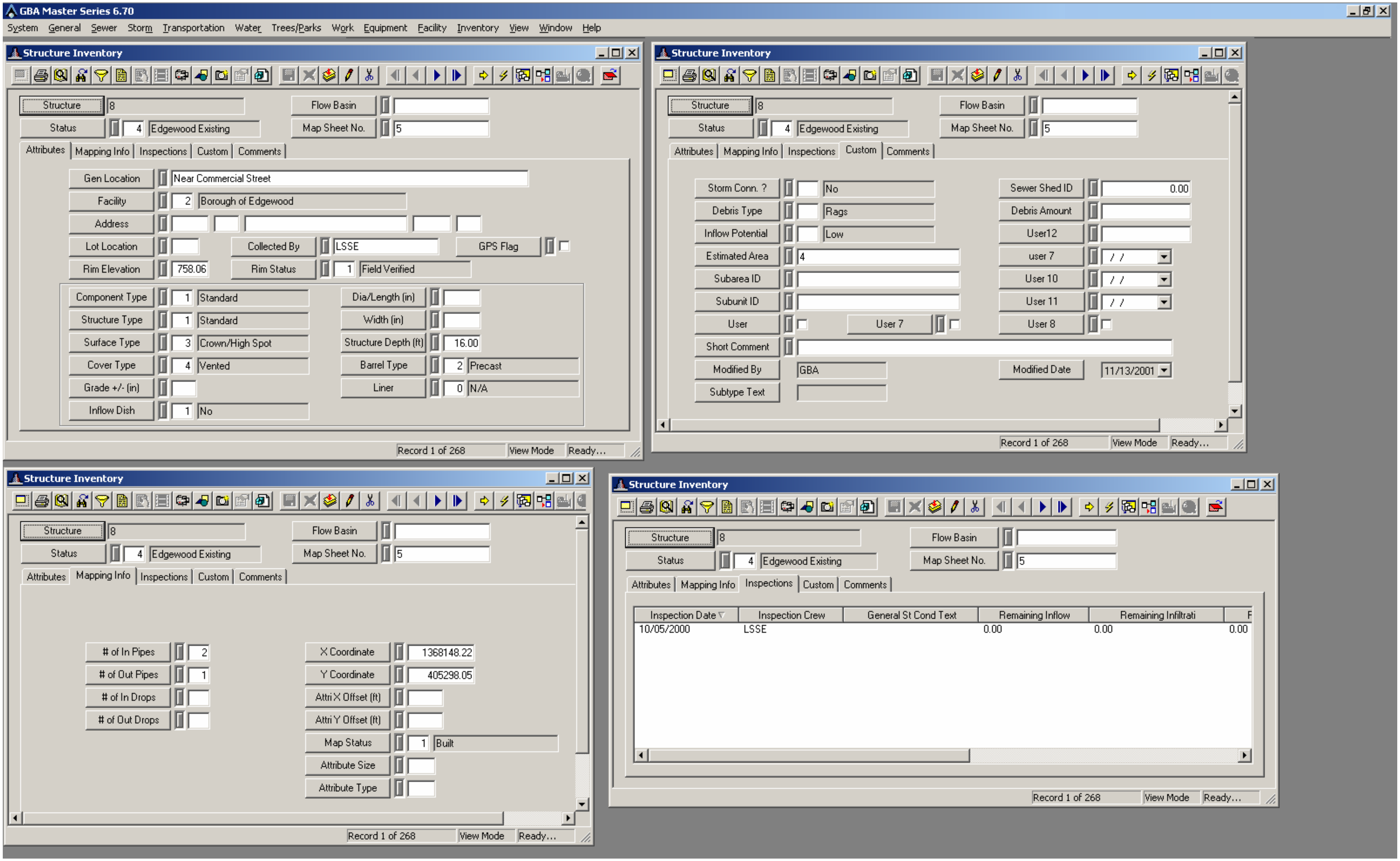
EXHIBIT 3-9

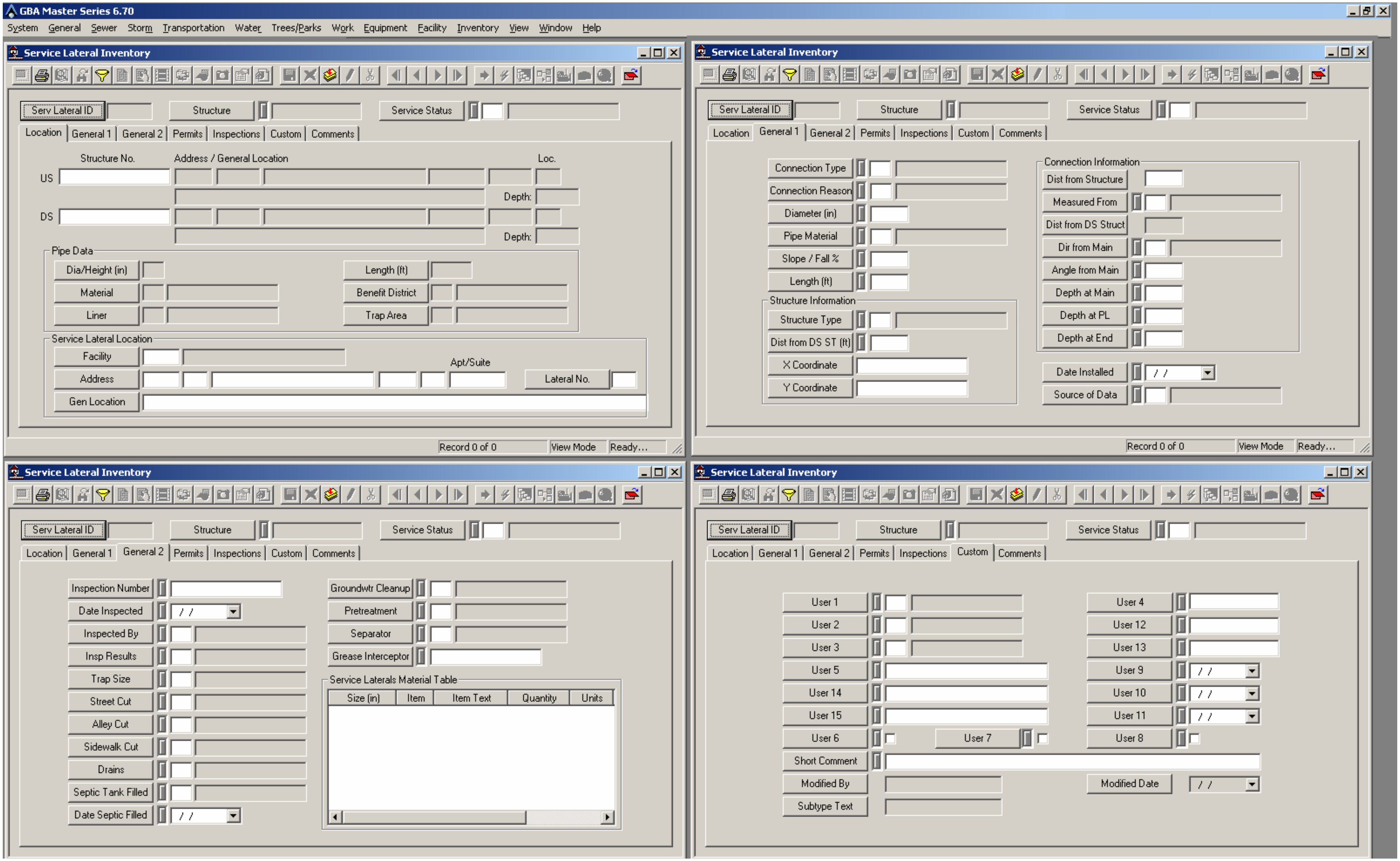
APPENDIX H

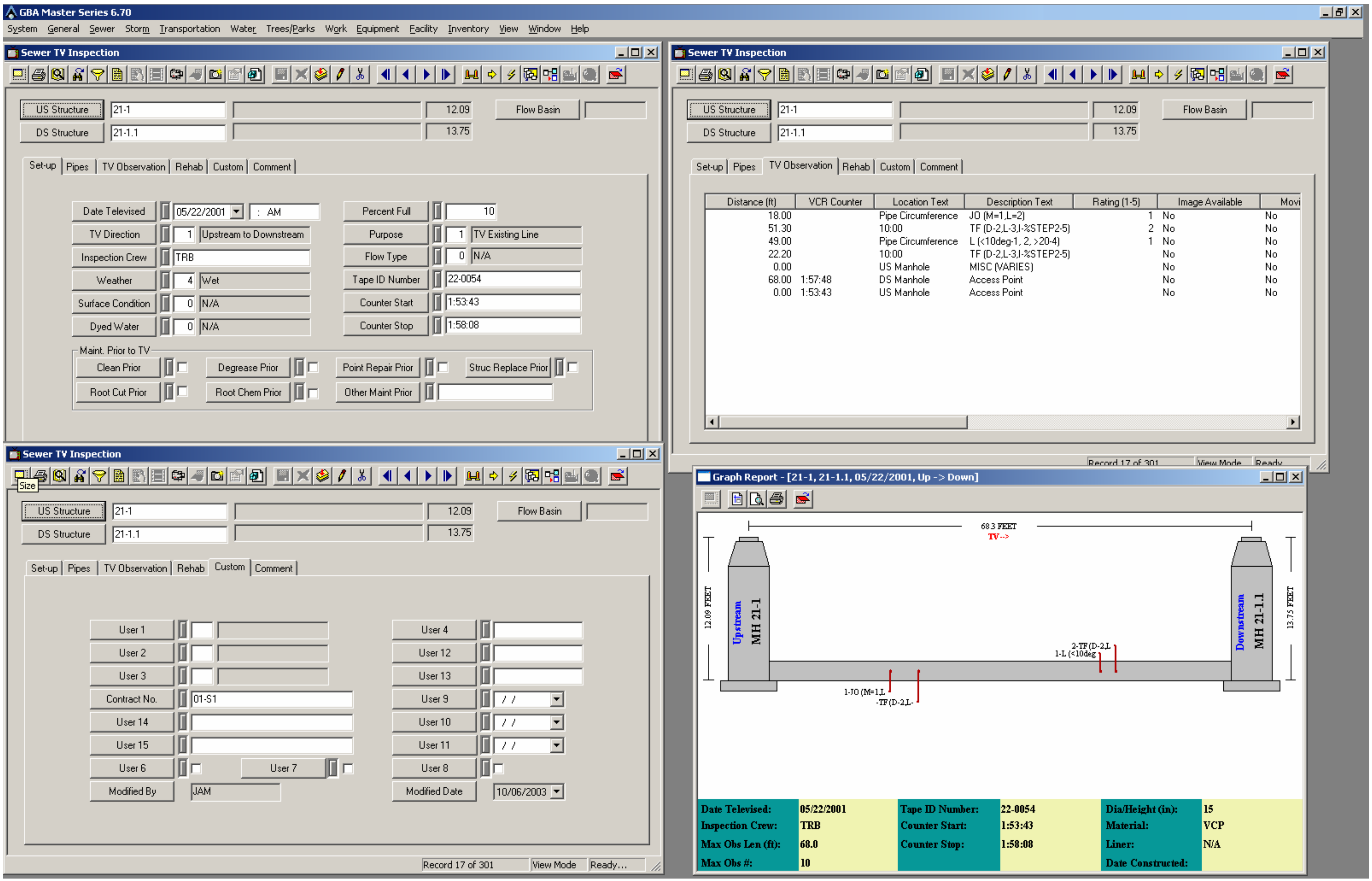
3 Rivers
Wet Weather
Demonstration Program


GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Customer
Commercial
Business Name
Address Contacts Owner Accounts Utility Links Parcels Custom Comments
Facility 2 Borough of Edgewood
Apartment Number
Address 202 Dewey ST
Street 2
City Borough of Edgewood
State Pennsylvania
Country United States
Zip 15218
Building Type 1 Residential
Record 1 of 1204
View Mode
Ready...
Customer
User 1
User 2
User 3
User 5
User 14
User 15
User 6
User 7
User 4
User 12
User 13
User 9
User 10
User 11
User 8
Last Mod By GBA
Last Mod Date 10/23/2001
Record 1 of 1204
View Mode
Ready...
Customer
Owner Name
Owner Business
Owner Address 1
Owner Address 2
Owner Address 3
Record 1 of 1204
Customer
Account Type Desc
Account Number
Allegheny Co. Block/Lot
0234-B-00016-0000-...
Record 1 of 1204
Customer
Sewer Utility
US Manhole 24-6H-4
DS Manhole 24-6G-7
Street Utility
Street Number
Water Utility
Water Pipe
Record 1 of 1204
View Mode

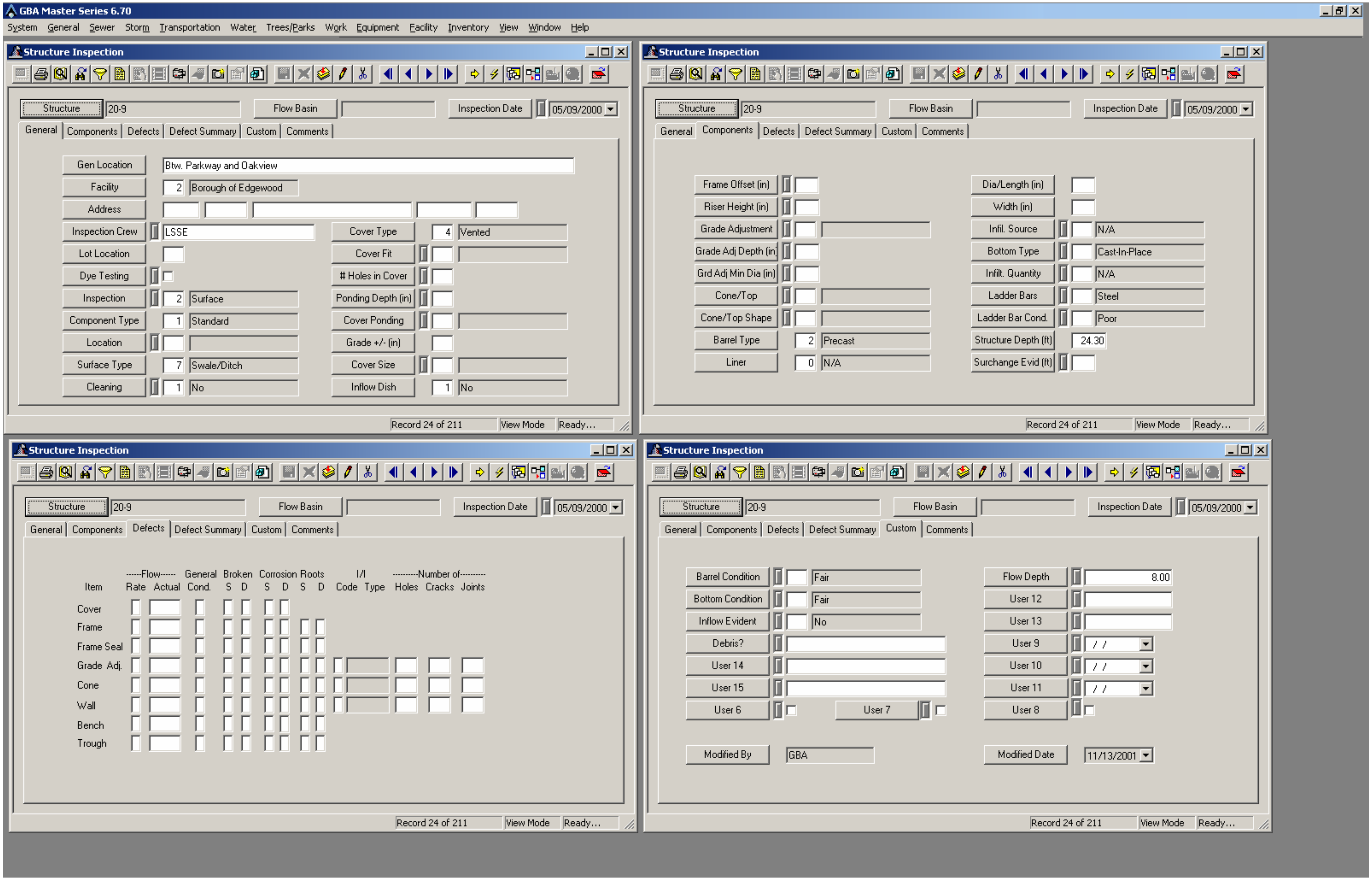

GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Pipe Inventory
US Structure 24-6E AVE
DS Structure 24-6D
Alt Pipe ID
Next US Next DS
Attributes Construction Elevations TV Lamping Smoke Tests Service Laterals Custom Comments
Pipe Record ID 249
Collected By LSSE
Flow Basin
Owner 1 Borough of Edgewood
Location 1 Street
Line Type 1 Gravity Line
Flow Type 1 Sanitary
Pipe Shape 1 Round
Dia/Height (in) 15
Pipe Width (in)
Map Page No. 4
Length (ft) 439.8
Length Status 5 Field Survey
Pipe Sec Length (ft) 3.0
Material 1 VCP
Liner 0 N/A
Slope % 2.528
Slope Lock
Mannings 0.013
Capacity (cfs) 10.30
IDM 1.25
Press F9 for pop-up selection
Record 10 of 268
View Mode
Ready...
Date Constructed / /
Project Number
Index
US Station
DS Station
Surface
Bedding
Cleaning Area
Benefit District
District
Sec-Twn-Rng
Trap Area
Active Elevations
US Rim
US Rim Status
DS Rim
DS Rim Status
Elevation Lock
US Invert 975.46
US Invert Status
DS Invert 964.34
DS Invert Status
Invert Lock
Record Drawing Elevations
Record US Rim
Adj US Rim Elev
Record DS Rim
Adj DS Rim Elev
Record US Invert 975.46
Adj US Inv Elev
Record DS Invert 964.34
Adj DS Inv Elev
Observation Holes
Dist from DS ST (ft)
X Coordinate
Y Coordinate
User 1
User 2
User 3
User 5
User 14
User 15
User 6
User 7
User 4
User 12
User 13
User 9 / /
User 10 / /
User 11 / /
User 8
Short Comment
Modified By JAM
Modified Date 09/22/2003
Subtype Text

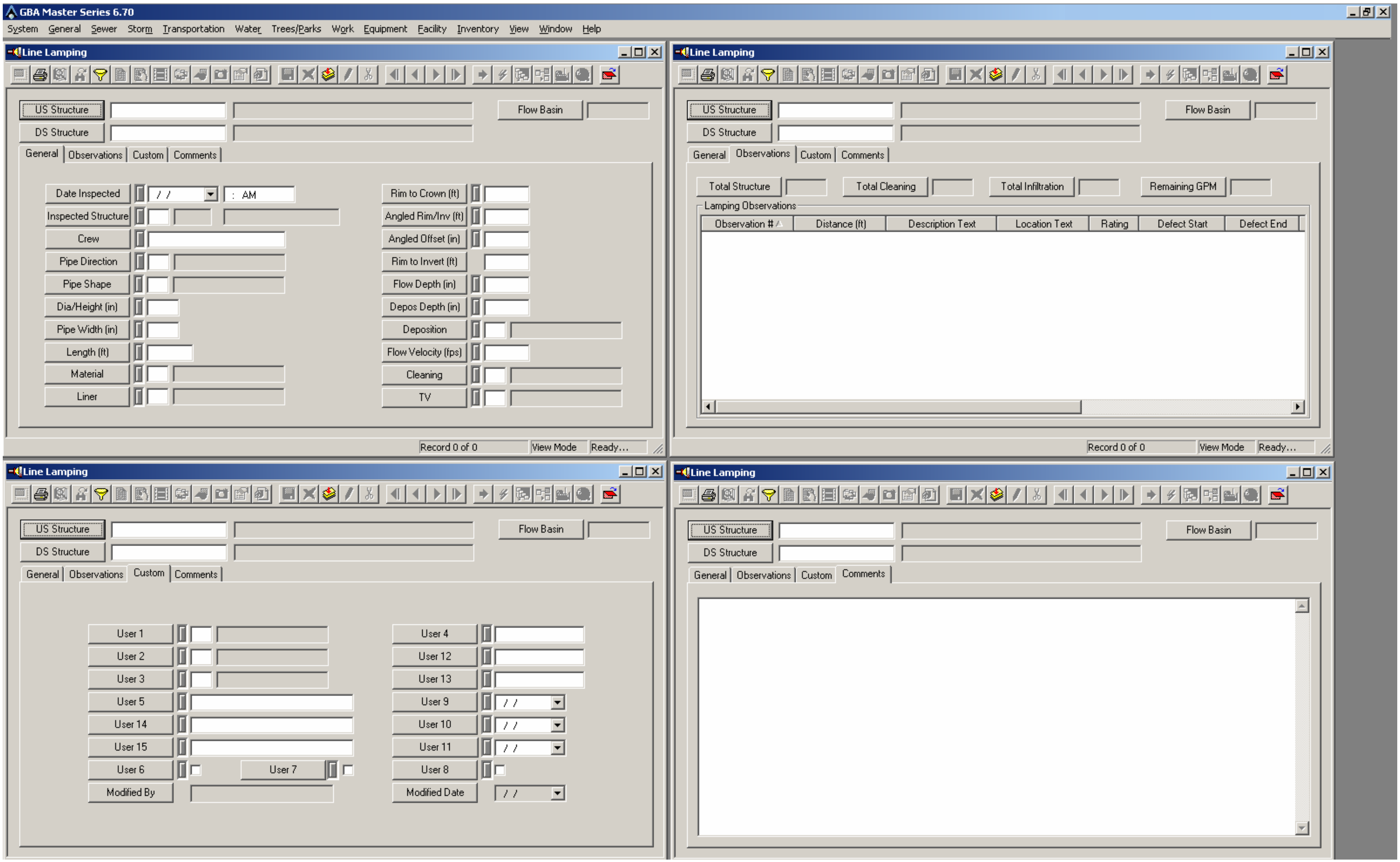

GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Structure Inventory
Structure 8
Flow Basin
Status 4 Edgewood Existing
Map Sheet No. 5
Attributes Mapping Info Inspections Custom Comments
Gen Location Near Commercial Street
Facility 2 Borough of Edgewood
Address
Lot Location
Collected By LSSE
GPS Flag
Rim Elevation 758.06
Rim Status 1 Field Verified
Component Type 1 Standard
Structure Type 1 Standard
Surface Type 3 Crown/High Spot
Cover Type 4 Vented
Grade +/- (in)
Inflow Dish 1 No
Dia/Length (in)
Width (in)
Structure Depth (ft) 16.00
Barrel Type 2 Precast
Liner 0 N/A
Record 1 of 268 View Mode Ready...
Storm Conn. ? No
Debris Type Rags
Inflow Potential Low
Estimated Area 4
Subarea ID
Subunit ID
User
User 7
Short Comment
Modified By GBA
Subtype Text
Sewer Shed ID 0.00
Debris Amount
User12
user 7 / /
User 10 / /
User 11 / /
User 8
Modified Date 11/13/2001
# of In Pipes 2
# of Out Pipes 1
# of In Drops
# of Out Drops
X Coordinate 1368148.22
Y Coordinate 405298.05
Attri X Offset (ft)
Attri Y Offset (ft)
Map Status 1 Built
Attribute Size
Attribute Type
Inspection Date Inspection Crew General St Cond Text Remaining Inflow Remaining Infiltrati F
10/05/2000 LSSE 0.00 0.00 0.00

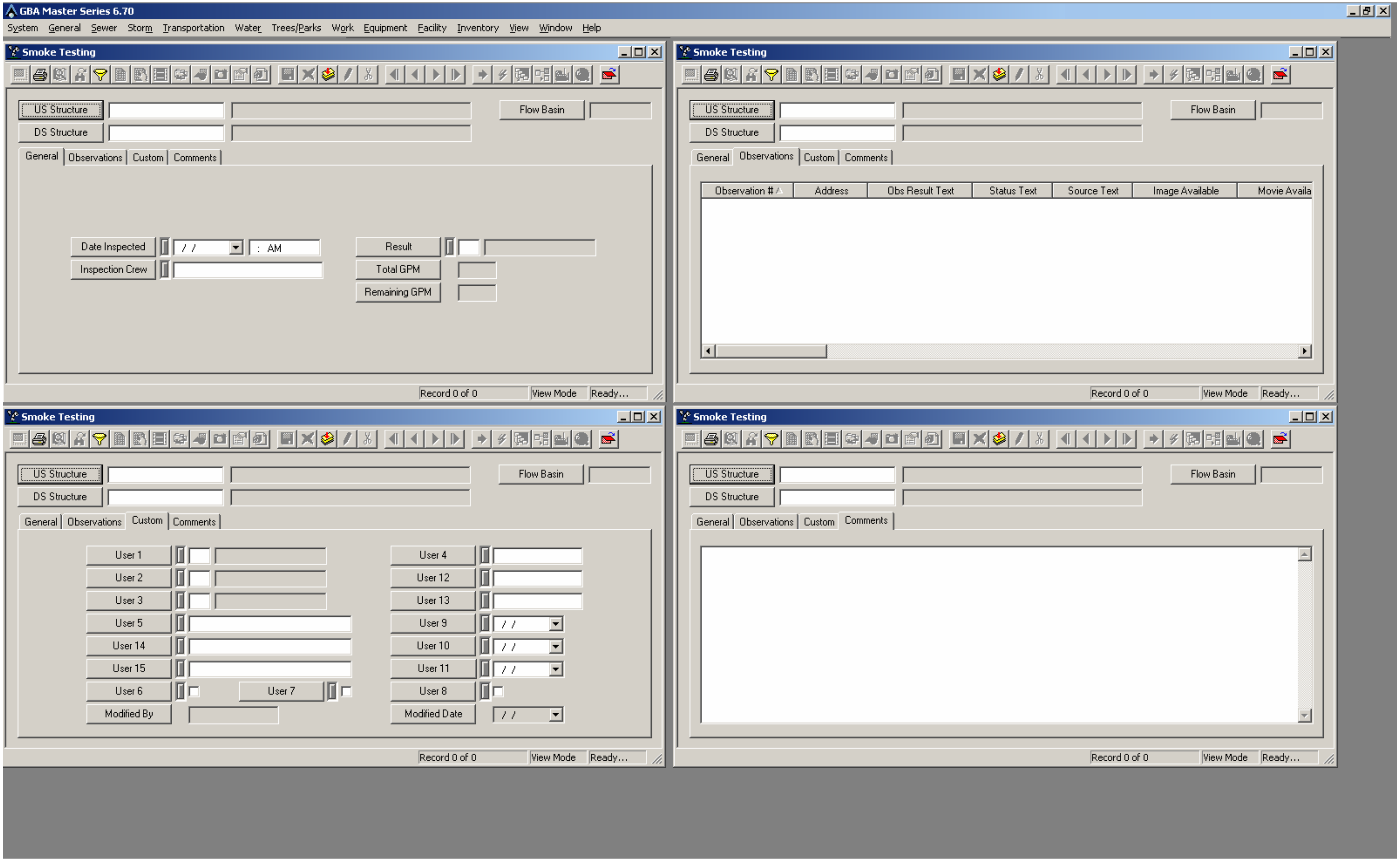

GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Service Lateral Inventory
Serv Lateral ID
Structure
Service Status
Location General 1 General 2 Permits Inspections Custom Comments
Structure No.
Address / General Location
Loc.
US
DS
Depth:
Pipe Data
Dia/Height (in)
Material
Liner
Length (ft)
Benefit District
Trap Area
Service Lateral Location
Facility
Address
Gen Location
Apt/Suite
Lateral No.
Record 0 of 0
View Mode
Ready...
Connection Type
Connection Reason
Diameter (in)
Pipe Material
Slope / Fall %
Length (ft)
Structure Information
Structure Type
Dist from DS ST (ft)
X Coordinate
Y Coordinate
Connection Information
Dist from Structure
Measured From
Dist from DS Struct
Dir from Main
Angle from Main
Depth at Main
Depth at PL
Depth at End
Date Installed
Source of Data
Inspection Number
Date Inspected
Inspected By
Insp Results
Trap Size
Street Cut
Alley Cut
Sidewalk Cut
Drains
Septic Tank Filled
Date Septic Filled
Groundwtr Cleanup
Pretreatment
Separator
Grease Interceptor
Service Laterals Material Table
Size (in) Item Item Text Quantity Units
User 1
User 2
User 3
User 5
User 14
User 15
User 6
User 7
User 4
User 12
User 13
User 9
User 10
User 11
User 8
Short Comment
Modified By
Modified Date
Subtype Text

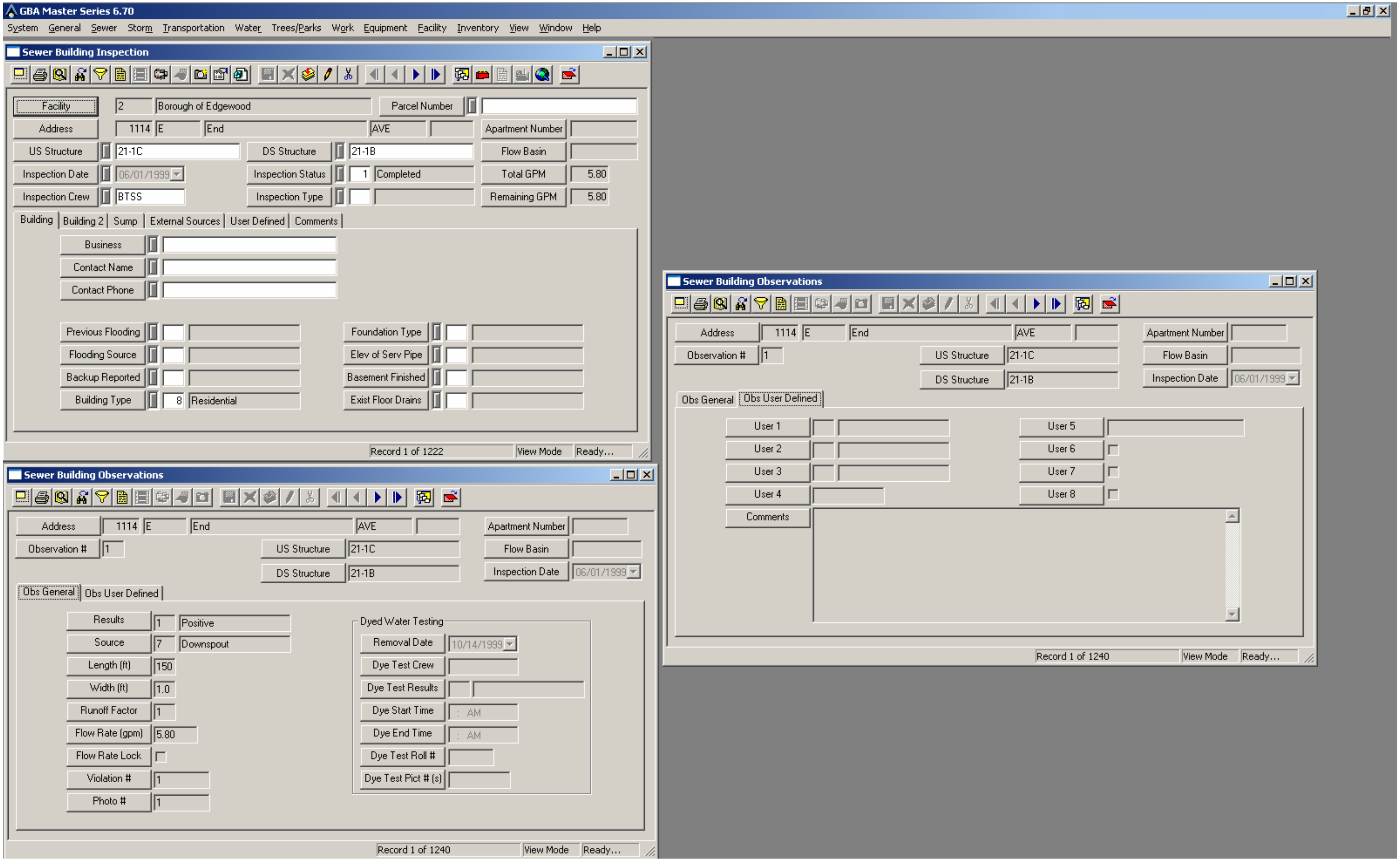


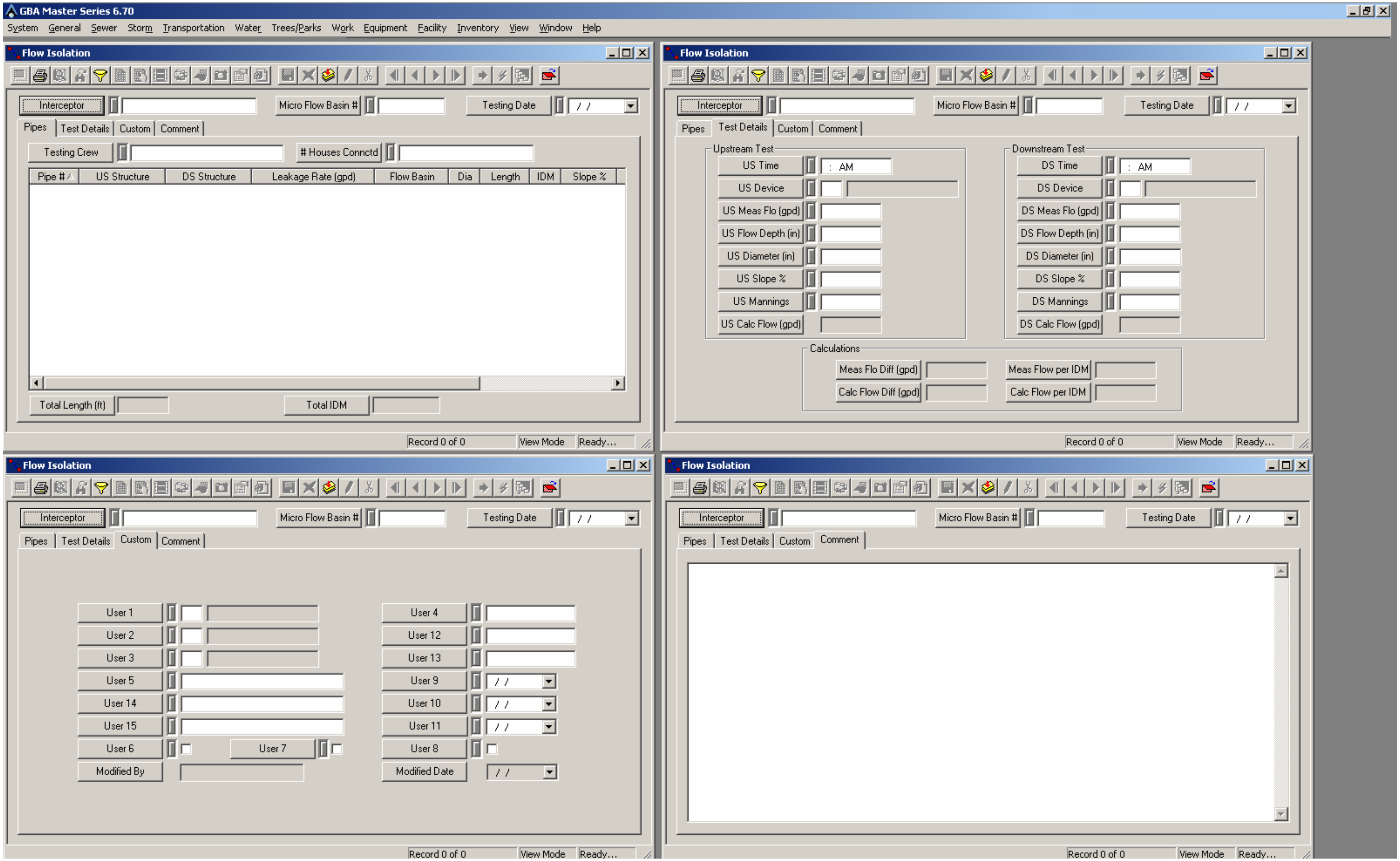
GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Sewer TV Inspection
US Structure 21-1 12.09 Flow Basin
DS Structure 21-1.1 13.75
Set-up Pipes TV Observation Rehab Custom Comment
Date Televised 05/22/2001 : AM
TV Direction 1 Upstream to Downstream
Inspection Crew TRB
Weather 4 Wet
Surface Condition 0 N/A
Dyed Water 0 N/A
Percent Full 10
Purpose 1 TV Existing Line
Flow Type 0 N/A
Tape ID Number 22-0054
Counter Start 1:53:43
Counter Stop 1:58:08
Maint. Prior to TV
Clean Prior
Degrease Prior
Point Repair Prior
Struc Replace Prior
Root Cut Prior
Root Chem Prior
Other Maint Prior
Distance (ft) VCR Counter Location Text Description Text Rating (1-5) Image Available Movi
18.00 Pipe Circumference JO (M=1,L=2) 1 No No
51.30 10:00 TF (D-2,L-3,I-%STEP2-5) 2 No No
49.00 Pipe Circumference L (<10deg-1, 2, >20-4) 1 No No
22.20 10:00 TF (D-2,L-3,I-%STEP2-5) No No
0.00 US Manhole MISC (VARIES) No No
68.00 1:57:48 DS Manhole Access Point No No
0.00 1:53:43 US Manhole Access Point No No
Record 17 of 301 View Mode Ready
Size
User 1
User 2
User 3
Contract No. 01-S1
User 14
User 15
User 6
User 7
Modified By JAM
User 4
User 12
User 13
User 9 / /
User 10 / /
User 11 / /
User 8
Modified Date 10/06/2003
Record 17 of 301 View Mode Ready...
Graph Report - [21-1, 21-1.1, 05/22/2001, Up -> Down]
68.3 FEET
TV-->
12.09 FEET
Upstream
MH 21-1
Downstream
MH 21-1.1
13.75 FEET
2-TF (D-2,L-
1-L (<10deg
1-JO (M=1,L
-TF (D-2,L-
Date Televised: 05/22/2001
Inspection Crew: TRB
Max Obs Len (ft): 68.0
Max Obs #: 10
Tape ID Number: 22-0054
Counter Start: 1:53:43
Counter Stop: 1:58:08
Dia/Height (in): 15
Material: VCP
Liner: N/A
Date Constructed:

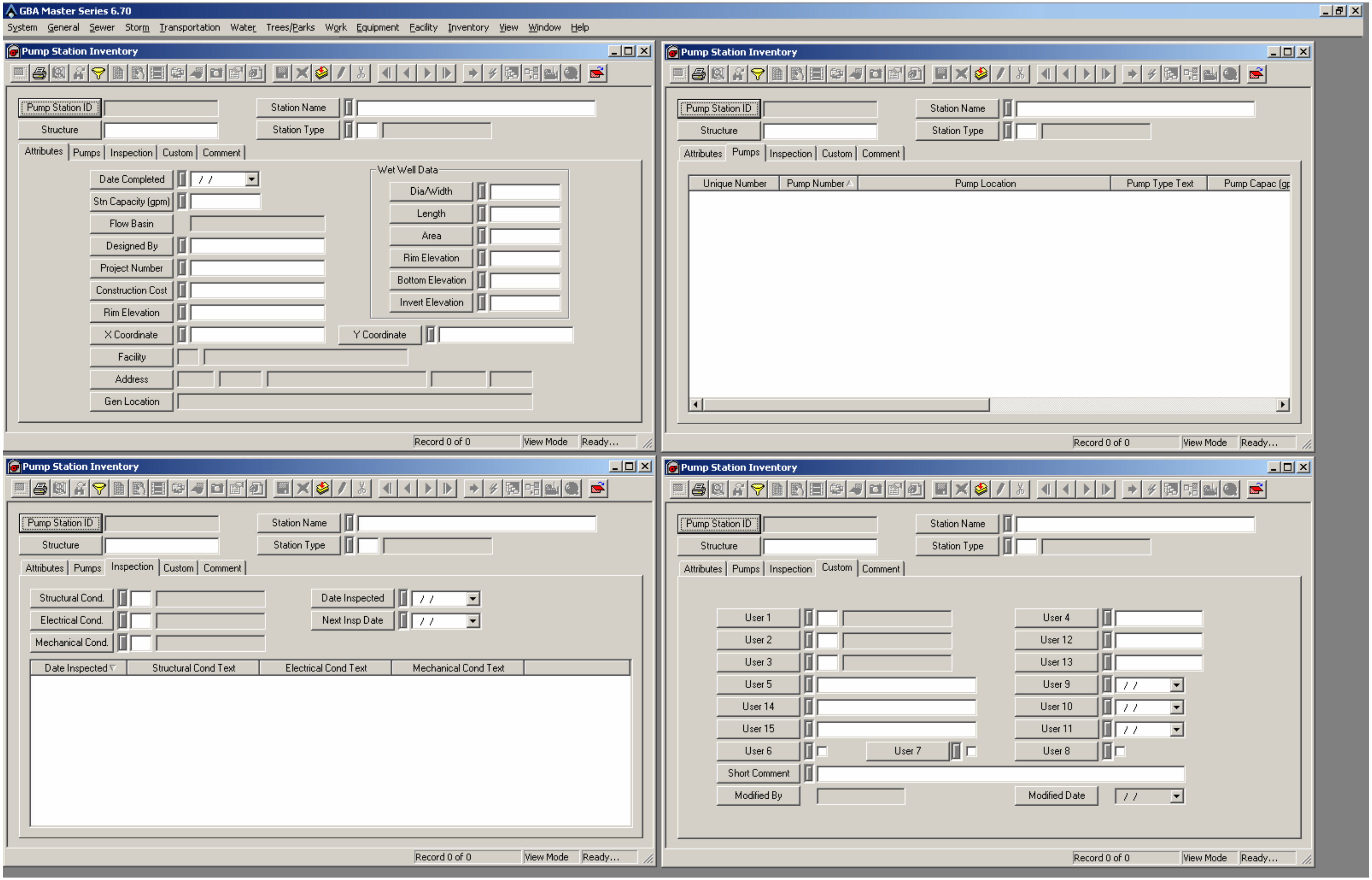

GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Structure Inspection
Structure 20-9 Flow Basin Inspection Date 05/09/2000
General Components Defects Defect Summary Custom Comments
Gen Location Btw. Parkway and Oakview
Facility 2 Borough of Edgewood
Address
Inspection Crew LSSE
Cover Type 4 Vented
Lot Location
Cover Fit
Dye Testing
Holes in Cover
Inspection 2 Surface
Ponding Depth (in)
Component Type 1 Standard
Cover Ponding
Location
Grade +/- (in)
Surface Type 7 Swale/Ditch
Cover Size
Cleaning 1 No
Inflow Dish 1 No
Record 24 of 211 View Mode Ready...
Structure Inspection
Structure 20-9 Flow Basin Inspection Date 05/09/2000
General Components Defects Defect Summary Custom Comments
Frame Offset (in)
Dia/Length (in)
Riser Height (in)
Width (in)
Grade Adjustment
Infil. Source N/A
Grade Adj Depth (in)
Bottom Type Cast-In-Place
Grd Adj Min Dia (in)
Infilt. Quantity N/A
Cone/Top
Ladder Bars Steel
Cone/Top Shape
Ladder Bar Cond. Poor
Barrel Type 2 Precast
Structure Depth (ft) 24.30
Liner 0 N/A
Surchange Evid (ft)
Record 24 of 211 View Mode Ready...
Structure Inspection
Structure 20-9 Flow Basin Inspection Date 05/09/2000
General Components Defects Defect Summary Custom Comments
-----Flow----- General Broken Corrosion Roots I/I ---------Number of---------
Item Rate Actual Cond. S D S D S D Code Type Holes Cracks Joints
Cover
Frame
Frame Seal
Grade Adj.
Cone
Wall
Bench
Trough
Record 24 of 211 View Mode Ready...
Structure Inspection
Structure 20-9 Flow Basin Inspection Date 05/09/2000
General Components Defects Defect Summary Custom Comments
Barrel Condition Fair
Flow Depth 8.00
Bottom Condition Fair
User 12
Inflow Evident No
User 13
Debris?
User 9 / /
User 14
User 10 / /
User 15
User 11 / /
User 6
User 7
User 8
Modified By GBA
Modified Date 11/13/2001
Record 24 of 211 View Mode Ready...

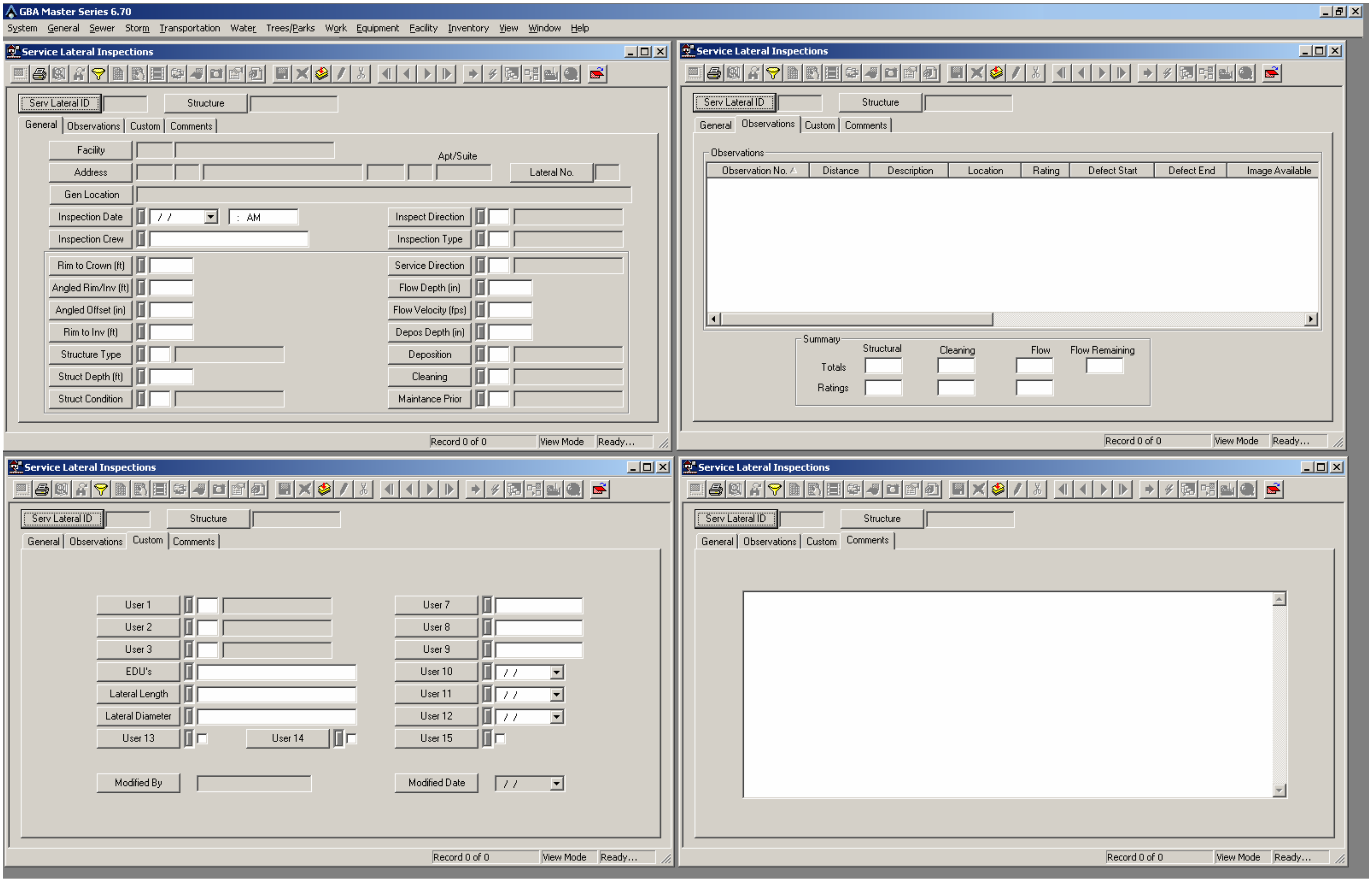

GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Line Lamping
US Structure
DS Structure
Flow Basin
General
Observations
Custom
Comments
Date Inspected
Inspected Structure
Crew
Pipe Direction
Pipe Shape
Dia/Height (in)
Pipe Width (in)
Length (ft)
Material
Liner
Rim to Crown (ft)
Angled Rim/Inv (ft)
Angled Offset (in)
Rim to Invert (ft)
Flow Depth (in)
Depos Depth (in)
Deposition
Flow Velocity (fps)
Cleaning
TV
Record 0 of 0
View Mode
Ready...
Total Structure
Total Cleaning
Total Infiltration
Remaining GPM
Lamping Observations
Observation #
Distance (ft)
Description Text
Location Text
Rating
Defect Start
Defect End
User 1
User 2
User 3
User 5
User 14
User 15
User 6
User 7
Modified By
User 4
User 12
User 13
User 9
User 10
User 11
User 8
Modified Date


GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Smoke Testing
US Structure
DS Structure
Flow Basin
General
Observations
Custom
Comments
Date Inspected
/ /
: AM
Inspection Crew
Result
Total GPM
Remaining GPM
Record 0 of 0
View Mode
Ready...
Observation #
Address
Obs Result Text
Status Text
Source Text
Image Available
Movie Availa
User 1
User 2
User 3
User 5
User 14
User 15
User 6
User 7
Modified By
User 4
User 12
User 13
User 9
User 10
User 11
User 8
Modified Date

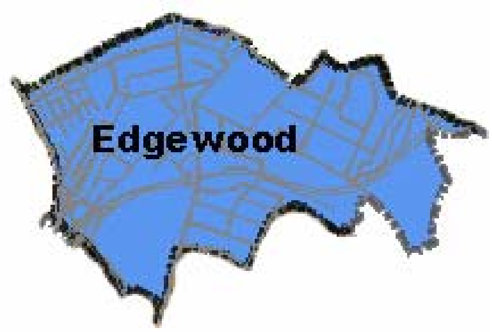

GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Sewer Building Inspection
Facility 2 Borough of Edgewood
Parcel Number
Address 1114 E End AVE
Apartment Number
US Structure 21-1C
DS Structure 21-1B
Flow Basin
Inspection Date 06/01/1999
Inspection Status 1 Completed
Total GPM 5.80
Inspection Crew BTSS
Inspection Type
Remaining GPM 5.80
Building
Building 2
Sump
External Sources
User Defined
Comments
Business
Contact Name
Contact Phone
Previous Flooding
Flooding Source
Backup Reported
Building Type 8 Residential
Foundation Type
Elev of Serv Pipe
Basement Finished
Exist Floor Drains
Record 1 of 1222
View Mode
Ready...
Sewer Building Observations
Address 1114 E End AVE
Apartment Number
Observation # 1
US Structure 21-1C
Flow Basin
DS Structure 21-1B
Inspection Date 06/01/1999
Obs General
Obs User Defined
Results 1 Positive
Source 7 Downspout
Length (ft) 150
Width (ft) 1.0
Runoff Factor 1
Flow Rate (gpm) 5.80
Flow Rate Lock
Violation # 1
Photo # 1
Dyed Water Testing
Removal Date 10/14/1999
Dye Test Crew
Dye Test Results
Dye Start Time : AM
Dye End Time : AM
Dye Test Roll #
Dye Test Pict # (s)
Record 1 of 1240
View Mode
Ready...
Sewer Building Observations
Address 1114 E End AVE
Apartment Number
Observation # 1
US Structure 21-1C
Flow Basin
DS Structure 21-1B
Inspection Date 06/01/1999
Obs General
Obs User Defined
User 1
User 2
User 3
User 4
User 5
User 6
User 7
User 8
Comments
Record 1 of 1240
View Mode
Ready...


GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Flow Isolation
Interceptor
Micro Flow Basin #
Testing Date
Pipes
Test Details
Custom
Comment
Testing Crew
Houses Conncted
Pipe #
US Structure
DS Structure
Leakage Rate (gpd)
Flow Basin
Dia
Length
IDM
Slope %
Total Length (ft)
Total IDM
Record 0 of 0
View Mode
Ready...
Upstream Test
US Time
US Device
US Meas Flo (gpd)
US Flow Depth (in)
US Diameter (in)
US Slope %
US Mannings
US Calc Flow (gpd)
Downstream Test
DS Time
DS Device
DS Meas Flo (gpd)
DS Flow Depth (in)
DS Diameter (in)
DS Slope %
DS Mannings
DS Calc Flow (gpd)
Calculations
Meas Flo Diff (gpd)
Meas Flow per IDM
Calc Flow Diff (gpd)
Calc Flow per IDM
User 1
User 2
User 3
User 5
User 14
User 15
User 6
User 7
Modified By
User 4
User 12
User 13
User 9
User 10
User 11
User 8
Modified Date


GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Pump Station Inventory
Pump Station ID
Station Name
Structure
Station Type
Attributes Pumps Inspection Custom Comment
Date Completed
Stn Capacity (gpm)
Flow Basin
Designed By
Project Number
Construction Cost
Rim Elevation
X Coordinate
Y Coordinate
Facility
Address
Gen Location
Wet Well Data
Dia/Width
Length
Area
Rim Elevation
Bottom Elevation
Invert Elevation
Record 0 of 0
View Mode
Ready...
Unique Number
Pump Number
Pump Location
Pump Type Text
Pump Capac (gp
Structural Cond.
Electrical Cond.
Mechanical Cond.
Date Inspected
Next Insp Date
Structural Cond Text
Electrical Cond Text
Mechanical Cond Text
User 1
User 2
User 3
User 5
User 14
User 15
User 6
User 7
User 4
User 12
User 13
User 9
User 10
User 11
User 8
Short Comment
Modified By
Modified Date


GBA Master Series 6.70
System General Sewer Storm Transportation Water Trees/Parks Work Equipment Facility Inventory View Window Help
Service Lateral Inspections
Serv Lateral ID
Structure
General
Observations
Custom
Comments
Facility
Address
Apt/Suite
Lateral No.
Gen Location
Inspection Date
Inspect Direction
Inspection Crew
Inspection Type
Rim to Crown (ft)
Service Direction
Angled Rim/Inv (ft)
Flow Depth (in)
Angled Offset (in)
Flow Velocity (fps)
Rim to Inv (ft)
Depos Depth (in)
Structure Type
Deposition
Struct Depth (ft)
Cleaning
Struct Condition
Maintance Prior
Record 0 of 0
View Mode
Ready...
Observation No.
Distance
Description
Location
Rating
Defect Start
Defect End
Image Available
Summary
Structural
Cleaning
Flow
Flow Remaining
Totals
Ratings
User 1
User 2
User 3
EDU's
Lateral Length
Lateral Diameter
User 13
User 14
User 7
User 8
User 9
User 10
User 11
User 12
User 15
Modified By
Modified Date

APPENDIX I



3 Rivers
Wet Weather
Demonstration Program

About the CMOM Program Self Assessment Checklist

Introduction

A sanitary sewer collection system is a vital element of any community's infrastructure and a critical component of the wastewater treatment process. The nation's sanitary sewer infrastructure has been built over the last 100 years or more using a variety of materials, design standards, installation techniques, and maintenance practices. As this valuable infrastructure ages, the importance of preventive and predictive maintenance increases.

What is CMOM?

CMOM stands for "capacity, management, operations, and maintenance." It is a flexible, dynamic framework for municipalities to identify and incorporate widely-accepted wastewater industry practices to:

- Better manage, operate, and maintain collection systems
- Investigate capacity constrained areas of the collection system
- Respond to sanitary sewer overflow (SSO) events

The CMOM approach helps municipal wastewater utility operators provide a high level of service to customers and reduce regulatory noncompliance. CMOM can help utilities optimize use of human and material resources by shifting maintenance activities from "reactive" to "predictive"–often leading to cost savings through avoided overtime, emergency construction costs, increased insurance premiums, and the possibility of lawsuits. CMOM information and documentation can also help improve communications with the public, other municipal works and regional planning organizations, and regulators.

In CMOM planning, the utility selects performance goal targets, and designs CMOM activities to meet the goals. The CMOM planning framework covers operation and maintenance (O&M) planning, capacity assessment and assurance, capital improvement planning, and financial management planning. Information collection and management practices are used to track how well each CMOM activity is meeting the performance goals, and whether overall system efficiency is improving. On an ongoing basis, activities are reviewed and adjusted to better meet the performance goals. As the CMOM program progresses, performance goals can change. For instance, an initial goal may be to develop a geographic information system (GIS) of the system. Once the GIS is complete, a new goal might be to use the GIS to track emergency calls and use the information to improve maintenance planning.

An important component of a successful CMOM program is to periodically collect information on current systems and activities and develop a "snapshot-in-time" analysis. From this analysis, the utility establishes its performance goals and plans its CMOM program activities.

Additional information describing CMOM can be found at: www.epa.gov/npdes/sso or www.epa.gov/region4/water/wpeb/pdfs/self-audit_review2-3.pdf.

What is the purpose of the CMOM program checklist?

This document is a screening-level tool that can help utilities evaluate CMOM programs and identify general areas of strength and weakness. Completing this CMOM assessment will allow the utility to flag CMOM program areas that need improvement and establish priorities for additional, more detailed assessments. In addition, the checklist will allow the utility to compare annual performance (e.g., percent of employees meeting training standards).

This document is not intended to be all-inclusive. It addresses the types of practices EPA believes should be considered by most utilities when implementing a CMOM program. However, the ways in which utilities use the information gathered through the checklist will depend on the complexity and site-specific issues facing individual collection systems. When reviewing the questions, utilities should use their judgment to determine if the question is reasonable for their collection system size and design.

How do I use this checklist?

The questions on the checklist will request answers in three different formats:

- Check yes, no, or not applicable (NA),
- Fill in the blank, and
- Check all that apply.

At the end of each section, additional space is provided to allow for comments on or explanations of the answers recorded (information that will be useful to the utility in follow-on planning). Each utility should make an effort to answer all the questions that are applicable to its system. If a particular question takes a significant amount of time to answer, this could be an indication of an area of weakness. Utilities should plan to invest approximately one day to complete the checklist.

This document is designed to help utilities perform an initial evaluation of CMOM activities. **It is not intended to serve as an absolute indicator of a successful CMOM program, nor will all of the questions apply to every utility.** By working through these questions, utilities will be able to identify strengths and areas for improvements in their CMOM programs. If a utility has a significant number of “no” answers or very few items selected in the checklist, this could indicate an area of weakness. The utility manager then can make a more detailed evaluation, including identifying specific actions needed to address areas for improvement.

General Information

CHECKLIST COMPLETED BY:

Name ______________________ Date ______________

Daytime Telephone Number ______________________

UTILITY CONTACT INFORMATION

Utility Name ______________________

LOCATION

Street Address ______________________

Street Address (continued) ______________________

City State Zip ______________________

STAFF

Name ______________________

Title ______________________

Email ______________________

Phone ( ) - Fax ( ) -

PERMITTED TREATMENT & COLLECTION FACILIITES

NPDES or STATE PERMIT #	PERMITTEE/CO-PERMITTEE/JURISDICTIONS	PERMIT COVERAGE: WWTP Effluent	PERMIT COVERAGE: Collection System	PERMIT COVERAGE: Wet-Weather Facility
		☐	☐	☐
		☐	☐	☐
		☐	☐	☐
		☐	☐	☐
		☐	☐	☐

Collection System Description

SYSTEM INVENTORY

Treatment Facilities

Item	Value	Unit
# of Treatment facilities		NUMBER
WWTP design capacity		MGD
Average daily flow		MGD
Average dry weather fow		MGD

Access & Maintenance

Item	Value	Unit
Manholes		NUMBER
Number of air vacuum relief valves		NUMBER

Conveyance & Pumping

	Gravity Sewers	Force Mains	Pump Stations
Pipes and pumps Length/quantity	MILES	MILES	NUMBER
Age of system 0 - 25 years old	% PERCENT	% PERCENT	% NUMBER
26 - 50 years old	% PERCENT	% PERCENT	% NUMBER
51 - 75 years old	% PERCENT	% PERCENT	% NUMBER
>76 years old	% PERCENT	% PERCENT	% NUMBER

Number of inverted siphons ____________

SERVICE AREA CHARACTERISTICS

Item	Value	Unit
Service area		ACRES
Service population		PEOPLE
Annual precipitation		INCHES

Number of Service Connections

Residential		Commercial		Industrial		TOTAL
NUMBER	+	NUMBER	+	NUMBER	=	NUMBER

Collection system service lateral responsibility *(check one)*

- ☐ At main line connection only
- ☐ From main line to property line or easement/cleanout
- ☐ Beyond property line/clean out
- ☐ Other: ____________

Combined Sewer Systems

What percent of sewer system is served by combined sewers (i.e., sanitary sewage and storm water in the same pipe)? ____ % PERCENT

Collection System Description

PIPE DIAMETER	Gravity Sewers	Force Mains
8 inches or less	% PERCENT	% PERCENT
9 - 18 inches	% PERCENT	% PERCENT
19 - 36 inches	% PERCENT	% PERCENT
>36 inches	% PERCENT	% PERCENT

PIPE MATERIALS	Gravity Sewers	Force Mains
Prestressed concrete cylinder pipe (PCCP)	% PERCENT	% PERCENT
High density polyethylene (HDPE)	% PERCENT	% PERCENT
Reinforced concrete pipe (RCP)	% PERCENT	% PERCENT
Polyvinyl chloride (PVC)	% PERCENT	N/A PERCENT
Vitrified clay pipe (VCP)	% PERCENT	N/A PERCENT
Ductile iron	% PERCENT	% PERCENT
Non-reinforced concrete pipe	% PERCENT	% PERCENT
Asbestos cement pipe	% PERCENT	% PERCENT
Cast iron	% PERCENT	% PERCENT
Brick	% PERCENT	% PERCENT
Fiberglass	% PERCENT	% PERCENT
Other (*Explain*)____________________	% PERCENT	% PERCENT

Engineering Design (ED)

ED-01	Is there a document which includes design criteria and standard construction details?	YES	NO
ED-02	Is there a document that describes the procedures that the utility follows in construction design review?	YES	NO
ED-03	Are WWTP and O&M staff involved in the design review process?	YES	NO
ED-04	Is there a procedure for testing and inspecting new or rehabilitated system elements both during and after the construction is completed?	YES	NO
ED-05	Are construction sites supervised by qualified personnel (such as professional engineers or certified engineering technicians) to ascertain that the construction is taking place in accordance with the agreed upon plans and specifications?	YES	NO
ED-06	Are new manholes tested for inflow and infiltration?	YES	NO
ED-07	Are new gravity sewers checked using closed circuit TV inspection?	YES	NO
ED-08	Does the utility have documentation on private service lateral design and inspection standards?	YES	NO
ED-09	Does the utility attempt to standardize equipment and sewer system components?	YES	NO

Satellite Communities and Sewer Use Ordinance (SUO)

SUO-01	Does the utility receive flow from satellite communities? IF NO, GO TO PAGE 6	YES	NO
SUO-02	What is the total area from satellite communities that contribute flow to the collection system? *(Acres or square miles)*	______	
SUO-03	Does the utility require satellite communities to enter into an agreement? IF NO, GO TO QUESTION SUO-06.	YES	NO
SUO-04	Does the agreement include the requirements listed in the sewer use ordinance (SUO)?	YES	NO
SUO-05	Do the agreements have a date of termination and allow for renewal under different terms?	YES	NO
SUO-06	Does the utility maintain the legal authority to control the maximum flow introduced into the collection system from satellite communities?	YES	NO
SUO-07	Are standards, inspections, and approval for new connections clearly documented in a SUO?	YES	NO
SUO-08	Does the SUO require satellite communities to adopt the same industrial and commercial regulator discharge limits as the utility?	YES	NO
SUO-09	Does the SUO require satellite communities to adopt the same inspection and sampling schedules as required by the pretreatment ordinance?	YES	NO
SUO-10	Does the SUO require that satellite communities or the utility to issue control permits for significant industrial users?	YES	NO
SUO-11	Does the SUO contain provisions for addressing overstrength wastewater from satellite communities?	YES	NO

SUO-12 Does the SUO contain procedures for the following? *(Check all that apply)*

- ☐ Inspection standards
- ☐ Pretreatment requirements
- ☐ Building/sewer permit issues

SUO-13 Does the SUO contain general prohibitions of the following materials? *(Check all that apply)*

- ☐ Fire and explosions hazards
- ☐ Corrosive materials
- ☐ Obstructive materials
- ☐ Oils or petroleum
- ☐ Material which may cause interference at the wastewater treatment plant

SUO-14 Does the SUO contain procedures and enforcement actions for the following? *(Check all that apply)*

- ☐ Fats, oils, and grease (FOG)
- ☐ Infiltration and inflow
- ☐ Building structures over the sewer lines
- ☐ Storm water connections to sanitary lines (downspouts)
- ☐ Defects in service laterals located on private property
- ☐ Sump pumps, air conditioner connections

Organizational Structure (OC)

OC-01 Is an organizational chart available that shows the overall personnel structure for the utility, including operation and maintenance staff? YES NO

OC- 02 Are up-to-date job descriptions available that delineate responsibilities and authority for each position? YES NO

OC-03 Are the following items discussed in the job descriptions? *(Check all that apply)*

- ☐ Nature of work to be performed
- ☐ Examples of the types of work
- ☐ Minimum requirements for the position
- ☐ List of licenses required for the position
- ☐ Necessary special qualifications or certifications
- ☐ Performance measures or promotion potential

OC-04 What percent of staff positions are currently vacant? ______ %

OC-05 On average how long do positions remain vacant? *(months)* ______

OC-06 What percent of utility work is contracted out? ______ %

Internal Communications (IC)

IC-01 Which of the following methods are used to communicate with utility staff? *(Check all that apply)*

☐ Regular meetings ☐ Bulletin boards ☐ E-mail ☐ Other (walkie talkie/pager)

IC-02 How often are staff meetings held? *(e.g., Daily, Weekly, Monthly, etc.)* ________

IC-03 Are incentives offered to employees for performance improvements? YES NO

IC-04 Does the utility have an "Employee of the Month/Quarter/Year" program? YES NO

IC-05 How often are performance reviews conducted? *(e.g. Semi-annually, Annually, etc.)* ________

IC-06 Does the utility regularly communicate/coordinate with other municipal departments? YES NO

Budgeting (BUD)

BUD-01	What is the average annual fee for residential users?	$ ______
BUD-02	How often are user charges evaluated and adjusted? *(e.g. annually, biannually, etc.)*	______
BUD-03	Are utility-generated funds used for non-utility programs?	YES / NO
BUD-04	Are costs for collection system operation and maintenance (O&M) separated from other utility services such as water, storm water, and treatment plants? IF NO, GO TO QUESTION BUD-07.	YES / NO
BUD-05	What is your average annual (O&M) budget?	$ ______
BUD-06	What percentage of the utility's overall budget is allocated to maintenance of the collection system?	______ %
BUD-07	Does the utility have a Capital Improvement Plan (CIP) that provides for system repairs/replacements on a prioritized basis?	YES / NO
BUD-08	What is your average annual CIP budget?	$ ______
BUD-09	What percentage of the maintenance budget is allotted to the following maintenance?	
	Predictive maintenance (tracking design, life span, and scheduled parts replacements)	______ %
	Preventive maintenance (identifying and fixing system weaknesses which, if left unaddressed, could lead to overflows)	______ %
	Corrective maintenance (fixing system components that are functioning but not at 100% capacity/efficiency; for example partially blocked lines)	______ %
	Emergency maintenance (reactive maintenance, overflows, equipment breakdowns)	______ %
BUD-10	Does the utility have a budgeted program for the replacement of under-capacity pipes?	YES / NO
BUD-11	Does the utility have a budgeted program for the replacement of over-capacity pipes?	YES / NO

Training (TR)

TR-01 Does the utility have a formal job knowledge, skills, and abilities (KSA) training program? YES NO

TR-02 Does the training program address the fundamental mission, goals, and policies of the utility? YES NO

TR-03 Does the utility have mandatory training requirements identified for key employees? YES NO

TR-04 What percentage of employees met or exceeded their annual training goals during the past year? ______ %

TR-05 Does the utility provide training in the following areas? *(Check all that apply)*

- ☐ Safety
- ☐ Traffic control
- ☐ Public relations
- ☐ Routine line maintenance
- ☐ Record keeping
- ☐ SSO/Emergency response
- ☐ Confined space entry
- ☐ Electrical and instrumentation
- ☐ Pump station operations and maintenance
- ☐ Other
- ☐ Pipe repair
- ☐ CCTV and trench/shoring
- ☐ Bursting CIPP

TR-06 Are operator and maintenance certification programs used? IF NO, GO TO QUESTION TR-08 YES NO

TR-07 Are operator and maintenance certification programs required? YES NO

TR-08 Is on-the-job training progress and performance measured? YES NO

TR-09 Which of the following methods are used to assess the effectiveness of the training? *(Check all that apply)*

☐ None ☐ Periodic testing ☐ Drills ☐ Demonstrations

TR-10 What percentage of the training offered by the utility is in the form of the following?

Manufacturer training ______ %

In-house classroom training ______ %

On-the-job training ______ %

Industry-wide training ______ %

Safety (SAF)

SAF-01 Does the utility have a written safety policy? YES NO

SAF-02 How often are safety procedures reviewed and revised? *(e.g. Semiannually, Annually, etc.)* YES NO

SAF-03 Does the utility have a safety committee? YES NO

SAF-04 Are regular safety meetings held with the utility employees? YES NO

SAF-05 Does the utility have a safety training program? YES NO

SAF-06 Are records of employee safety training kept up to date? YES NO

SAF-07 Does the utility have written procedures for the following? *(Check all that apply)*

- ☐ Lockout/tagout
- ☐ Material safety date sheets (MSDS)
- ☐ Chemical handling
- ☐ Confined spaces permit program
- ☐ Trenching and excavations safety
- ☐ Biological hazards in wastewater
- ☐ Traffic control and work site safety
- ☐ Electrical and mechanical systems
- ☐ Pneumatic and hydraulic systems safety

SAF-08 What is your agency's lost-time injury rate? ________% or __________ hours

SAF-09 Are the following equipment items available and in adequate supply? *(Check all that apply)*

- ☐ Rubber/disposable gloves
- ☐ Confined space ventilation equipment
- ☐ Hard hats, safety glasses, rubber boots
- ☐ Antibacterial soap and first aid kit
- ☐ Tripods or non-entry rescue equipment
- ☐ Fire extinguishers
- ☐ Equipment to enter manholes
- ☐ Portable crane/hoist
- ☐ Atmospheric testing equipment and gas detectors
- ☐ Oxygen sensors
- ☐ H_2S Monitors
- ☐ Full body harness
- ☐ Protective clothing
- ☐ Traffic/public access control equipment
- ☐ 5-minute escape breathing devices
- ☐ Life preservers for lagoons
- ☐ Safety buoy at activated sludge plants
- ☐ Fiberglass or wooden ladders for electrical work
- ☐ Respirators and/or self contained breathing apparatus
- ☐ Methane gas or optical vector (OVA) analyzer
- ☐ Lower explosion limit (LEL) metering

SAF-10 Are safety monitors clearly identified? YES NO

Customer Service (CS)

CS-01 Does the utility have a customer service and public relations program? IF NO GO TO QUESTION CS-03 — YES / NO

CS-02 Does the customer service program include giving formal presentations on the wastewater field to the following? *(Check all that apply)*

- ☐ Schools and universities
- ☐ Local officials
- ☐ Media
- ☐ Building Inspector(s)
- ☐ Community gatherings
- ☐ Businesses
- ☐ Citizens
- ☐ Public utility officials

CS-03 Are employees of the utility specifically trained in customer service? — YES / NO

CS-04 Are there sample correspondence, Q/A's, or "scripts" to help guide staff through written or oral responses to customers? — YES / NO

CS-05 What methods are used to notify the public of major construction or maintenance work? *(Check all that apply)*

- ☐ Door hangers
- ☐ Newspaper
- ☐ Fliers
- ☐ Signs
- ☐ Other
- ☐ None
- ☐ Public radio or T.V. announcements

CS-06 Is a homeowner notified prior to construction that his/her property may be affected? — YES / NO

CS-07 Do you provide information to residents on cleanup and safety procedures following basement backups and overflows from manholes when they occur? — YES / NO

CS-08 Does the utility have a customer service evaluation program to obtain feedback from the community? — YES / NO

CS-09 Do customer service records include the following information? *(Check all that apply)*

- ☐ Personnel who received the complaint or request
- ☐ Name, address, and telephone number of customer
- ☐ Nature of the complaint or request
- ☐ Location of the problem
- ☐ To whom the follow-up action was assigned
- ☐ Date the follow up action was assigned
- ☐ Date of the complaint or request
- ☐ Cause of the problem
- ☐ Date the complaint or request was resolved
- ☐ Feedback to customer
- ☐ Total days to end the problem

CS-10 Does the utility have a goal for how quickly customer complaints (or ermergency calls) are resolved? IF NO, GO TO THE NEXT PAGE. — YES / NO

CS-11 What percentage of customer complaints (or emergency calls) are resolved within the timeline goals? ______ %

Equipment and Collection System Maintenance (ESM)

ESM-01 Is a maintenance card or record kept for each piece of mechanical equipment within the collection system? IF NO, GO TO QUESTION ESM-03. YES NO

ESM-02 Do equipment maintenance records include the following information? *(Check all that apply)*

- ☐ Maintenance recommendations
- ☐ Maintenance schedule
- ☐ Instructions on conducting the specific maintenance activity
- ☐ A record of maintenance on the equipment to date
- ☐ Other observations on the equipment

ESM-03 Are dated tags used to show out-of-service equipment? YES NO

ESM-04 Is there an established system for prioritizing equipment maintenance needs? YES NO

ESM-05 What percent of repair funds are spent on emergency repairs? ______ %

ESM-06 Are corrective repair work orders backlogged more than six months? YES NO

ESM-07 Do collection system personnel coordinate with state, county, and local personnel on repairs, before the street is paved? YES NO

Equipment Parts Inventory (EPI)

EPI-01	Have critical spare parts been identified?	YES	NO
EPI-02	Are adequate supplies on hand to allow for two point repairs in any part of the system?	YES	NO
EPI-03	Is there a parts standardization policy in place?	YES	NO
EPI-04	Does the utility have a central location for storing spare parts?	YES	NO
EPI-05	Does the utility maintain a stock of spare parts on its maintenance vehicles?	YES	NO
EPI-06	Does the utility have a system in place to track and maintain an accurate inventory of spare parts?	YES	NO
EPI-07	For those parts which are not kept in inventory, does the utility have a readily available source or supplier?	YES	NO

Management Information System (MIS)

MIS-01 Does the utility have a management information system (MIS) in place for tracking maintenance activities? *(Either electronic or good paper files)* IF NO, GO TO PAGE 15. ☐ YES ☐ NO

MIS-02 Are the MIS records maintained for a period of at least three years? ☐ YES ☐ NO

MIS-03 Is the MIS able to distinguish activities taken in response to an overflow event? ☐ YES ☐ NO

MIS-04 Are there written instructions for managing and tracking the following information? *(Check all that apply)*

- ☐ Complaint work orders
- ☐ Scheduled work orders
- ☐ Customer service
- ☐ Scheduled preventive maintenance
- ☐ Scheduled inspections
- ☐ Sewer system inventory
- ☐ Safety incidents
- ☐ Scheduled monitoring/ sampling
- ☐ Compliance/overflow tracking
- ☐ Equipment/tools tracking
- ☐ Parts inventory

MIS-05 Do the written instructions for tracking procedures include the following information? *(Check all that apply)*

- ☐ Accessing data and information
- ☐ Instructions for using the tracking system
- ☐ Updating the MIS
- ☐ Developing and printing reports

MIS-06 How often is the management information system updated? *(Check one)*

- ☐ Immediately
- ☐ Monthly
- ☐ Within one week of the "incident"
- ☐ As time permits

System Mapping (MAP)

MAP-01 Are "as built" plans (record drawings) or maps available for use by field crews in the office and in the field? YES NO

MAP-02 Is there a procedure for field crews to record changes or inaccuracies in the maps and update the mapping system? YES NO

MAP-03 Do the maps show the date the map was drafted and the date of the last revision? YES NO

MAP-04 Do the sewer line maps include the following? *(Check all that apply)*

- ☐ Scale
- ☐ North arrow
- ☐ Date the map was drafted
- ☐ Date of last revision
- ☐ Service area boundaries
- ☐ Property lines
- ☐ Other landmarks (Roads, water bodies, etc.)
- ☐ Manhole and other access points
- ☐ Location of building laterals
- ☐ Street names
- ☐ SSOs occurrences/CSOs outfalls
- ☐ Flow monitors
- ☐ Force mains
- ☐ Pump stations
- ☐ Lined sewers
- ☐ Main, trunk, and interceptor sewers
- ☐ Easement lines and dimensions
- ☐ Pipe material
- ☐ Pipe diameter
- ☐ Installation date
- ☐ Slope
- ☐ Manhole rim elevation
- ☐ Manhole coordinates
- ☐ Manhole invert elevation
- ☐ Distance between manholes

MAP-05 Are the following sewer attributes recorded? *(Check all that apply)*

- ☐ Size
- ☐ Shape
- ☐ Invert elevation
- ☐ Material
- ☐ Separate/combined sewer
- ☐ Installation Date

MAP-06 Are the following manhole attributes recorded? *(Check all that apply)*

- ☐ Shape
- ☐ Depth
- ☐ Age
- ☐ Type (e.g., precast, cast in place, etc.)
- ☐ Material

MAP-07 Is there a systematic numbering and identification method/system established to identify sewer system manhole, sewer lines, and other items (pump stations, etc.)? YES NO

Internal TV Inspection (TVI)

TVI-01 Does the utility have a standardized pipeline condition assessment program? YES NO

TVI-02 Is internal TV inspection used to perform condition assessment? IF NO, GO TO PAGE 17. YES NO

TVI-03 Are there written operation procedures and guidelines for the internal TV inspection program? YES NO

TVI-04 Do the internal TV record logs include the following? *(Check all that apply)*

- ☐ Pipe size, type, length, and joint spacing
- ☐ Distance recorded by internal TV
- ☐ Results of the internal TV inspection (including a structural rating)
- ☐ Internal TV operator name
- ☐ Cleanliness of the line
- ☐ Location and identification of line being televised by manholes

TVI-05 Is a rating system used to determine the severity of the defects found during the inspection process? YES NO

TVI-06 Is there documentation explaining the codes used for internal TV results reporting? YES NO

TVI-07 Approximately what percent of the total defects determined by TV inspection during the past 5 years were the following?

Failed coatings or linings	____ %	Line deflection	____ %
House connection leaks	____ %	Joint separation	____ %
Illegal connections	____ %	Crushed pipes	____ %
Pipe corrosion (H_2S)	____ %	Collapsed pipes	____ %
Fats, oil, and grease	____ %	Offset joints	____ %
Broken pipes	____ %	Root intrusions	____ %
Debris	____ %	Minor cracks	____ %
Other	____ %		

TVI-08 Are main line and lateral repairs checked by internal TV inspection after the repair(s) have been made? YES NO

Sewer Cleaning (CLN)

CLN-01	What is the system cleaning frequency? (the entire system is cleaned every "X" years)	________
CLN-02	What is the utility's plan for system cleaning (% or frequency in years)?	________
CLN-03	What percent of the sewer lines are cleaned, even high/repeat cleaning trouble spots, during the past year?	________ %
CLN-04	Is there a program to identify sewer line segments, with chronic problems, that should be cleaned on a more frequent schedule?	☐ YES ☐ NO
CLN-05	Does the utility have a root control program?	☐ YES ☐ NO
CLN-06	Does the utility have a fats, oils, and grease (FOG) program?	☐ YES ☐ NO
CLN-07	What is the average number of stoppages experienced per mile of sewer pipe per year?	________ %
CLN-08	Has the number of stoppages increased, decreased, or stayed the same over the past 5 years? ☐ Increased ☐ Decreased ☐ Stayed the same	
CLN-09	Are stoppages plotted on maps and correlated with other data such as pipe size and material or location?	☐ YES ☐ NO
CLN-10	Do the sewer cleaning records include the following information? *(Check all that apply)* ☐ Date and time ☐ Method of cleaning ☐ Identity of cleaning crew ☐ Cause of stoppage ☐ Location of stoppage or routine cleaning activity ☐ Further actions necessary/initiated	
CLN-11	If sewer cleaning is done by a contractor are videos taken of before and after cleaning?	☐ YES ☐ NO

Manhole Inspection and Assessment (MAN)

MAN-01 Does the utility have a routine manhole inspection and assessment program? IF NO, GO TO QUESTION MAN-06. YES NO

MAN-02 Are the results and observations from the routine manhole inspections recorded? YES NO

MAN-03 Does the utility have a goal for the number of manholes inspected annually? YES NO

MAN-04 How many manholes were inspected during the past year? ________

MAN-05 Do the records for manhole/pipe inspection include the following? *(Check all that apply)*

- ☐ Conditions of the frame and cover
- ☐ Evidence of surcharge
- ☐ Offsets or misalignments
- ☐ Atmospheric hazards measurements (especially hydrogen sulfide)
- ☐ Details on the root cause of cracks or breaks in the manhole or pipe including blockages
- ☐ Recording conditions of (corbel, walls, bench, trough, and pipe seals)
- ☐ Presence of corrosion
- ☐ If repair is necessary
- ☐ Manhole identifying number/location
- ☐ Wastewater flow characteristics (flowing freely or backed up)
- ☐ Accumulations of grease, debris, or grit
- ☐ Presence of infiltration, location, and estimated quantity
- ☐ Inflow from manhole covers

MAN-06 Does the utility have a grouting program? YES NO

Pump Stations (PS)

PS-01 Are Standard Operation Procedures (SOPs) and Standard Maintenance Procedures (SMPs) used for each pump station? YES NO

PS-02 Are there enough trained personnel to properly maintain all pump stations? YES NO

PS-03 Is there an emergency operating procedure for each pump station? YES NO

PS-04 Is there an alarm system to notify personnel of pump station failures and overflow? YES NO

PS-05 Percent of pump stations with back up power sources ______ %

PS-06 Does the utility use the following methods when loss of power ocurs? *(Check all that apply)*

☐ On-site electrical generators ☐ Portable electric generators ☐ Alternate power source ☐ Other
☐ Vacuum trucks to bypass pump station

PS-07 Is there a procedure for manipulating pump operations (manually or automatically) during wet weather to increase in-line storage of wet weather flows? YES NO

PS-08 Are wet well operating levels set to limit pump start/stops? YES NO

PS-09 Are the lead, lag, and backup pumps rotated regularly? YES NO

PS-10 Are operation logs maintained for all pump stations? YES NO

PS-11 Are the original manuals that contain the manufacturers recommended maintenance schedules for all pump station equipment easily available? YES NO

PS-12 On average, how often were pump stations inspected during the past year? YES NO

PS-13 Are records maintained for each inspection? YES NO

PS-14 Average annual labor hours spent on pump station inspection ______

PS-15 Percent of pump stations with pump capacity redundancy ______ %

PS-16 Percent of pump stations with dry weather capacity limitations ______ %

PS-17 Percent of pump stations with wet weather capacity limitations ______ %

PS-18 Percent of pump stations calibrated annually ______ %

PS-19 Percent of pump stations with permanent flow meters ______ %

Capacity Assessment (CA)

CA-01 Does the utility have a flow monitoring program? YES NO

CA-02 Does the utility have a comprehensive capacity assessment and planning program? YES NO

CA-03 Are flows measured prior to allowing new connections? YES NO

CA-04 Do you have a tool (hydraulic model, spreadsheet, etc.) for assessing whether adequate capacity exists in the sewer system? IF NO, GO TO QUESTION CA-06. YES NO

CA-05 Does your capacity assessment tool produce results consistent with conditions observed in the system? YES NO

CA-06 What is the ratio of peak wet weather flow to average dry weather flow at the wastewater treatment plant? ___________

CA-07 How many permanent flow meters are currently in the system? *(Include meters at pump stations and wastewater treatment plants)* ___________

CA-08 How frequently are the flow meters checked? *(e.g. Daily, Weekly, Monthly, etc.)* ___________

CA-09 Do the flow meter checks include the following? *(Check all that apply)*

- ☐ Independent water level
- ☐ Velocity reading
- ☐ Downloading data
- ☐ Checking the desiccant
- ☐ Cleaning away debris
- ☐ Battery condition

CA-10 Are records maintained for each inspection? IF NO, GO TO QUESTION CA-12. YES NO

CA-11 Do the flow monitoring records include the following? *(Check all that apply)*

- ☐ Descriptive location of flow meter
- ☐ Frequency of flow meter inspection
- ☐ Type of flow meter
- ☐ Frequency of flow meter calibration

CA-12 Does the utility maintain any rain gauges or have access to local rainfall data? YES NO

CA-13 Does the utility have any wet weather capacity problems? YES NO

CA-14 Are low points or flood-plain areas monitored during rain events? YES NO

CA-15 Does the utility have any dry weather capacity problems? YES NO

CA-16 Is flow monitoring used for billing purposes, capacity analysis, and/or inflow and infiltration investigations? YES NO

Tracking SSOs (TRK)

TRK-01 How many SSO events have been reported in the past 5 years? ________

TRK-02 What percent of the SSOs were less than 1,000 gallons in the past 5 years ? ________ %

TRK-03 Does the utility document and report all SSOs regardless of size? YES NO

TRK-04 Does the utility document basement backups? YES NO

TRK-05 Are there areas that experience frequent basement or street flooding? YES NO

TRK-06 Approximately what percent of SSOs discharges were from each of the following in the last 5 years?

Manholes ________ %
Main and trunk sewers ________ %
Structural bypasses ________ %
Pump stations ________ %
Lateral and branch sewers ________ %

TRK-07 Approximately what percent of SSOs discharges were caused by the following in the last 5 years?

Debris buildup ________ %
Root intrusion ________ %
Excessive infiltration and inflow ________ %
Collapsed pipe ________ %
Capacity limitations ________ %
Fats, oil, and grease ________ %
Vandalism ________ %

TRK-07A What percentage of SSOs were released to:

Soil ________ %
Basements ________ %
Paved area ________ %
Surface water (rivers/lakes/streams) ________ %
Coastal, ocean, beaches ________ %

TRK-07B For surface water releases, what percent are to areas that could affect:

Contact recreation (beaches, swimming, areas) ________ %
Drinking water sources ________ %
Shellfish growing areas ________ %

TRK-08 How many chronic SSO locations are in the collection system? ________

TRK-09 Are pipes with chronic SSOs being monitored for sufficient capacity and/or structural condition? YES NO

TRK-10 Prior to collapse, are structurally deteriorating pipelines being monitored for renewal or replacement? YES NO

Overflow Emergency Response Plan (OERP)

OERP-01	Does the utility have a documented OERP available for utility staff to use? IF NO, GO TO QUESTION OERP-04.	YES	NO
OERP-02	How often is the OERP reviewed and updated? *(Annually, Biannually, etc.)*	______	
OERP-03	Are specific responsibilities detailed in the OERP for personnel who respond to emergencies?	YES	NO
OERP-04	Are staff continuously trained and drilled to respond to emergency situations?	YES	NO
OERP-05	Do work crews have immediate access to tools and equipment during emergencies?	YES	NO
OERP-06	Does the utility have standard procedures for notifying state agencies, local health departments, the NPDES authority, the public, and drinking water authorities of significant overflow events?	YES	NO
OERP-07	Does the procedure include a current list of the names, titles, phone numbers, and responsibilities of all personnel involved?	YES	NO
OERP-08	Does the utility have a public notification plan?	YES	NO
OERP-09	Does the utility have procedures to limit public access to and contact with areas affected with SSOs? *(Procedure can be delegated to another authority)*	YES	NO
OERP-10	Does the utility use containment techniques to protect the storm drainage systems?	YES	NO

OERP-11 Do the overflow records include the following information? *(Check all that apply)*

- ☐ Date and time
- ☐ Location
- ☐ Any remediation efforts
- ☐ Cause s)
- ☐ How it was stopped
- ☐ Estimated flow/volume discharged
- ☐ Names of affected receiving water(s)
- ☐ Duration of overflow

OERP-12	Does the utility have signage to keep public from effected area?	YES	NO

Smoke and Dye Testing (SDT)

SDT-01	Does the utility have a smoke testing program to identify sources of inflow and infiltration?	YES	NO
SDT-01A	Does the utility have a smoke testing program to identify sources of inflow and infiltration in illegal connectors?	YES	NO
SDT-01B	Does the utility have a smoke testing program to identify sources of inflow and infiltration in house laterals (private service laterals)?	YES	NO
SDT-02	Are there written procedures for the frequency and schedule of smoke testing?	YES	NO
SDT-03	Is there a documented procedure for isolating line segments?	YES	NO
SDT-04	Is there a documented procedure for notifying local residents that smoke testing will be conducted in their area?	YES	NO
SDT-05	What is the guideline for the maximum amount of the line to be tested at one time? *(Feet or Miles)*	______	
SDT-06	Are there guidelines for the weather conditions under which smoke testing should be conducted?	YES	NO
SDT-07	Does the utility have a goal for the percent of the system smoke tested each year?	YES	NO
SDT-08	What percent of the system has been smoke tested over the past year?	______ %	
SDT-09	Do the written records contain location, address, and description of the smoking element that produced a positive result?	YES	NO
SDT-10	Does the utility have a dye testing program?	YES	NO
SDT-11	Are there written procedures for dye testing?	YES	NO
SDT-12	Does the utility have a goal for the percent of the system dye tested each year?	YES	NO
SDT-13	What percent of the main collection system has been dye tested over the past year?	______ %	
SDT-14	Does the utility share smoke and dye testing equipment with another utility?	YES	NO

Hydrogen Sulfide Monitoring and Control (HSMC)

HSMC-01 How would you rate the systems vulnerability for hydrogen sulfide corrosion? *(Check only one)*

☐ Not a problem ☐ Only in a few isolated areas ☐ A major problem

HSCM-02 Does the utility have a corrosion control program? YES NO

HSCM-03 Does the utility take hydrogen sulfide corrosion into consideration when designing new or replacement sewers? YES NO

HSCM-04 Does the utility have written procedures for the application of chemical dosages? YES NO

HSCM-05 Are the chemical dosages, dates, and locations documented? YES NO

HSCM-06 Does the utility document where odor is a continual problem in the system? YES NO

HSCM-07 Does the utility have a program in place for renewing or replacing severely corroded sewer lines to prevent collapse? YES NO

HSCM-08 Are the following methods used for hydrogen sulfide control? *(Check all that apply)*

☐ Aeration ☐ Chlorine ☐ Potassium permanganate

☐ Iron salts ☐ Sodium hydroxide ☐ Biofiltration

☐ Enzymes ☐ Hydrogen peroxide ☐ Other

☐ Activated charcoal canisters

HSCM-09 Does the system contain air relief valves at the high points of the force main system? YES NO

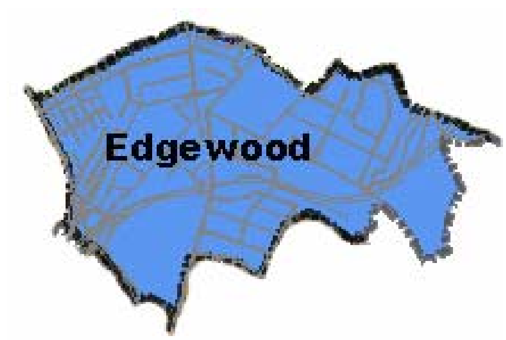
HSCM-10 How often are the valves maintained and inspected? *(Weekly, Monthly, etc.)* ____________

HSMC-11 Does the utility enforce pretreatment requirements? YES NO

Infrastructure Security

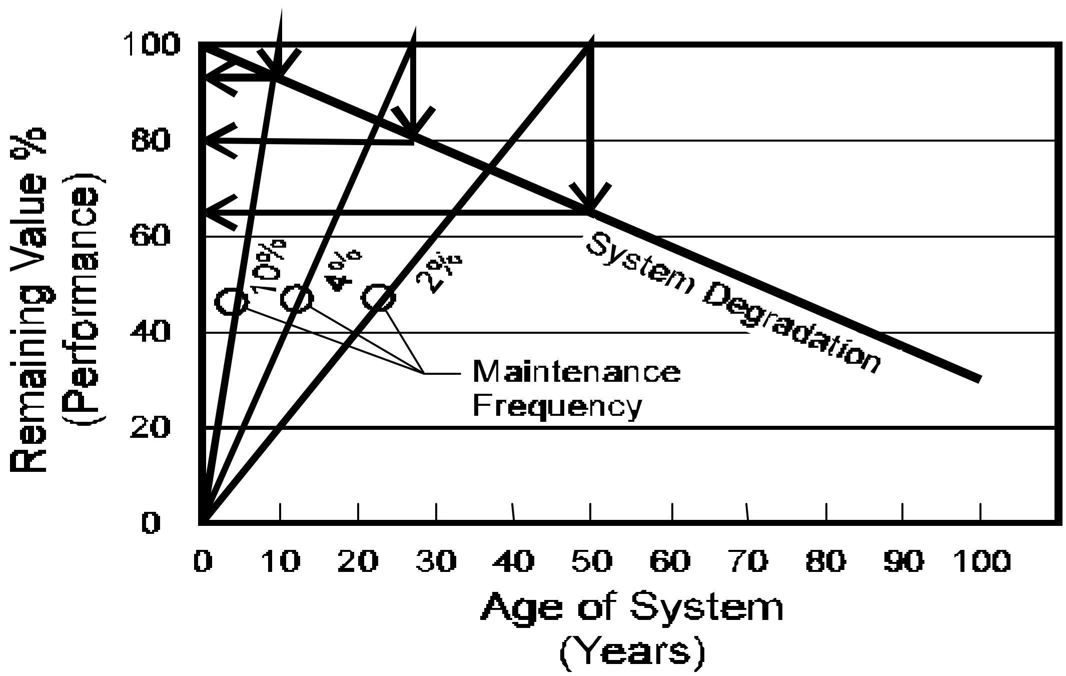
Although outside the scope of a CMOM program, municipal wastewater utilities should also consider security vulnerabilities. To reduce the threat of both intentional and natural disasters, the utility should take steps to implement appropriate countermeasures and develop or update emergency response plans.

APPENDIX J



3 Rivers Wet Weather Demonstration Program

OPTIMIZATION OF COLLECTION SYSTEM MAINTENANCE FREQUENCIES AND SYSTEM PERFORMANCE



American Society of Civil Engineers
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February 1999

Optimization of Collection System Maintenance Frequencies and System Performance

Prepared

by

Black & Veatch LLP

for

American Society of Civil Engineers

Under

Cooperative Agreement

with

U.S. Environmental Protection Agency
Office of Wastewater Management
Washington, DC

EPA Cooperative Agreement #CX 824902-01-0
February 1999

NOTICE

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Acknowledgments

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Participating wastewater utilities and agencies provided needed information for this project are listed below. Only those agencies granting permission to do so are listed by name.

Carpinteria Sanitary District
Carpinteria, CA

Charlotte-Mecklenburg Utilities, Wastewater Collection
Charlotte, NC

City of Albuquerque
Albuquerque, NM

City of Columbus, Division of Sewerage and Drainage
Columbus, OH

City of Council Bluffs, Department of Public Works
Council Bluffs, IA

City of Dallas, Water Department, Wastewater Collection Division
Dallas, TX

City of Durham
Durham, NC

City of Fresno
Fresno, CA

City of Glendale
Utilities Department
Glendale, AZ

City of Tulsa
Tulsa, Oklahoma

City of Wichita, Water and Sewer Department
Wichita, KS

Clark County Sanitation District
Las Vegas, NV

Columbia Sanitary Sewer Utility
Columbia, MO

Columbus Water Works
Columbus, GA

County Sanitation Districts of Los Angeles County
Compton, CA

County of Sacramento, Public Works Agency, Water Quality Division, County Sanitation District No.1
Sacramento, CA

Little Rock, Wastewater Utility
Little Rock, AR

Madison Metropolitan Sewerage District
Madison, WI

City of Houston
Houston, TX

City of Indianapolis, Department of Capital Asset Management
Indianapolis, IN

City of Kansas City, Water Service Department
Kansas City, MO

City of Las Vegas
Las Vegas, NV

City of McMinnville
McMinnville, OR

City of Modesto
Modesto, CA

City of Phoenix
Phoenix, AZ

City of Rochester, Department of Public Works
Rochester, MN

City of Scottsdale
Water Operations
Scottsdale, AZ

City of Shreveport, Department of Water and Sewerage
Shreveport,, LA

City of Springfield
Department of Public Works
Springfield, MO

Louisville & Jefferson County Metropolitan Sewer District
Louisville, KY

Metropolitan Sewer District of Greater Cincinnati
Cincinnati, OH

Metropolitan Council Environmental Services,
Regional Maintenance Facility
Eagan , OH

Metropolitan St. Louis Sewer District
St. Louis, MO

Miami-Dade Water and Sewer Department
Coral Gables, FL

Oklahoma City Water and Wastewater Utilities Department
Oklahoma City, OK

Pima County Wastewater Management Department
Tucson, AZ

Portland Water District
Portland, ME

Reedy Creek Energy Services, Inc.
Reedy Creek Improvement District
Lake Buena Vista, FL

Unified Sewerage Agency
Hillsboro, OR

Washington Suburban Sanitary Commission
Laurel, MD

Wastewater Management - City and County of Denver, CO

Executive Summary

The objective of this project was to develop an optimized approach for maintenance of separate collection systems. Maintenance has a broad definition as defined in this report, and includes any reinvestment in an existing collection system in the form of cleaning, monitoring, inspection, rehabilitation and relief. Hopefully, this project will benefit the general public, state and local decision makers, and other potentially affected groups by reducing the failure rate of collection systems. The reduction in the failure rate of collection systems will improve public health by preventing sewer backups, and will also benefit the environment by minimizing discharge of untreated sewage to surface waters. Specific objectives accomplished are as follows:

C the effectiveness of maintenance programs of agencies surveyed was evaluated by reviewing their maintenance activities and their frequency,

C a review of how maintenance and rehabilitation dollars spent are being spent,

C an overview of typical values for maintenance frequencies and system reinvestment expense amounts was performed to serve as benchmarks for local governments and agencies in evaluating their own programs, and

C guidelines and methods were developed to help agencies evaluate and Ameasure@ their own maintenance frequency and performance rating by developing a single number or Ayardstick@ which can be determined based on commonly collected data.

The wastewater collection system is a major capital investment, and agencies must ensure they are providing safe and efficient service to their customers. The level of service, or system performance, is difficult to quantify because of the many variables in collection systems. Nevertheless, system performance can be improved and maintained at an acceptable level with proper maintenance. This report provides guidance to answer the following questions: "How much maintenance is enough?", AIs the performance of my system adequate and is it improving or getting worse@ and "How do I determine the level of maintenance required?" Currently, there is no rational approach for determining the frequencies of various maintenance procedures except through experience and judgement.

Quality collection system maintenance consists of the optimum use of labor, equipment, and materials to keep the system in good repair, so that it can efficiently accomplish its intended purpose of collection and transportation of wastewater to the treatment plant. Serious health hazards and extensive property damage can result from sanitary sewer backups and overflows. There should be some reasonable balance between the cost of maintenance and the benefits derived.

The scope of work for this project included the following major task groups:

- $ Task 1. Literature Search
- $ Task 2. Data Collection
- $ Task 3. Follow up and Data Compilation
- $ Task 4. Data Analysis
- $ Task 5. Report and Presentation

Very little data was identified in the literature search with respect to establishing maintenance frequencies or performance ratings. This report then is a preliminary effort to develop a rational approach to evaluating maintenance (reinvestment) and system performance. It is expected that future studies will enhance and result in modifications to the approach presented herein.

The data collection effort was somewhat protracted due to the amount of information agencies were requested to provide and the difficulty of collecting the data needed. Most agencies do not keep detailed records for all information requested and therefore the Abest guess@ was provided in some instances. It is believed that the lack of quality data by many of the agencies resulted in much of the scatter and broad range of data responses received. Nevertheless, it is also believed that the data received support the hypothesis that performance and reinvestment are related and that system performance and maintenance can be quantitatively evaluated to optimize the system reinvestment for selected levels of system performance.

Based on the agency responses received cleaning, root removal, and pump station service are the most important routine maintenance activities; although a total of 12 key maintenance activities are still necessary for a balanced routine maintenance program. Using a statistical method to develop a routine maintenance Ayard stick@, an average maintenance frequency, considering all routine maintenance activities of 6.6% was derived with a range of 2.4% to 12.6%. The relationship of maintenance and performance was explored and it was found that a strong relationship exists between the maintenance frequency and system historical performance. Independent variables related to maintenance frequency include customer complaints, manhole overflows, pipe failures, system sizes, number of pump stations, regional location, and pump station failures.

The agency responses received also identified pipe failures, SSOs, and customer complaints as the most important performance measures. Using the same statistical method used for establishing the maintenance yard stick, a performance yard stick was developed. Considering all performance measures, an average performance rating of 71.1% was derived with a range of 53.1% to 97.2%. In addition to this performance rating, the amount of reinvestment was reviewed and analyzed. It was found that the annual reinvestment has been increasing and for the period 1980 to 1996 has averaged $9,328/mi$yr or $1.77/ft$yr. The annual reinvestment for the life of the systems as reported was about $1.00/ft$yr. These reinvestment rates support the theory of reinvestment required presented in Chapter 1. The relationship between the performance rating and reinvestment was explored and it was found that a strong relationship exists between these two parameters.

Based on the methods developed for determining maintenance frequencies and performance ratings, a method or approach for optimizing collection system maintenance is presented with general guidance for the desirable envelope for performance and maintenance. Collection system maintenance can be optimized by creating a better balance of maintenance activities, increasing or decreasing budgets as appropriate, and evaluating performance of the system against the maintenance frequency being implemented. In time, by monitoring both maintenance and performance, agencies will be able to strike the right balance for their system and maintain acceptable performance and the least reinvestment cost.

Because of the importance of system maintenance (reinvestment) and system performance, it is recommended that ongoing research be performed to enhance and improve the work presented in the report. Specific recommendations are as follows:

1. Review and refine the maintenance, performance, and reinvestment measures used in this report. Develop detailed definitions of each.

2. Develop either an information collection guideline which would request agencies to collect data consistent with Step 1 or have a study with a core group of agencies to provide data that can be used to refine these analyses and to generate a AGuideline Report for Collection System Maintenance.@

3. Implement the information collection process and use the data to develop cost estimates, maintenance guidelines, and performance measures similar to those presented in this study.
4. Repeat the analysis on a regular basis every 2 to 5 years as the output will improve with the improved data collection.

1.0 Introduction and Background

Collection system maintenance and rehabilitation is being performed to meet regulatory requirements and to improve sewerage service to customers. Maintenance as defined in this report includes any reinvestment in an existing collection system in the form of cleaning, monitoring, inspection, rehabilitation, and relief. Rehabilitation is performed to correct the deficiencies identified from maintenance activities. With more emphasis being placed on maintenance, it is becoming increasingly important to determine Ahow much maintenance is enough?@ According to the Water Pollution Control Federation (WPCF) Manual of Practice No. 7, (1985), AThere should be some reasonable balance between cost of preventive maintenance and benefit derived.@ This need is demonstrated by a survey of 20 cities which showed a 1000-to-1 spread on main breaks and a 150-to-1 spread on stoppages per 1000 miles of sewer per year. Age and neglect were noted as the primary reasons for these differences. (WEF 1994)

This study was undertaken to evaluate collection system maintenance and rehabilitation needs based on information from a questionnaire completed by selected cities and agencies, hereinafter referred to collectively as agencies. Specifically, the objectives were to evaluate the effectiveness of maintenance programs by reviewing the inspection activities and their frequency; to review how reinvestment dollars were spent; and to provide an overview of typical values to serve as guidance for local governments and agencies in evaluating their own programs. It should be noted that this study pertains to Aseparate@ collection systems only and does not include data for combined sewer systems.

This project was performed by the American Society of Civil Engineers (ASCE) and Black & Veatch LLP under a cooperative agreement with the U.S. Environmental Protection Agency (USEPA).

1.1 Project Significance and Objectives

The objective of this project is to develop an approach for optimizing maintenance of wastewater collection systems. The project will help wastewater agencies plan for maintenance based on specific performance measures and will provide guidance on the total reinvestment required to meet selected levels of system performance. Improved performance of collection systems will benefit public health, and will also benefit the environment. This project presents a decision making model which can be used by agencies in evaluating the cost of maintenance, as it relates to maintenance frequency and system performance.

1.2 Background

Collection system maintenance is performed to meet regulatory requirements and to improve sewerage service to customers. A collection system corrodes, erodes, collapses, clogs, and ultimately deteriorates. Collection system capacity can be reduced by root growth; by the accumulation of obstructions discharged to the system, such as grease, garbage, rags, paper towels, and by structural failures such as line breaks and collapses. Maintenance, in the broad sense used for this study, includes any reinvestment in an existing collection system in the form of cleaning, monitoring, inspection activities, rehabilitation, and relief. Relief can be in the form of relief sewers, additional pumping capacity or equalization facilities.

Wastewater collection systems are a major capital investment which agencies must properly maintain to ensure safe and efficient service to their customers. The level of service, or system performance, is difficult to quantify because of the many variables involved. Nevertheless, this study attempts to develop an approach to measure system performance so that it can be monitored and improved if necessary by proper maintenance procedures.

Many agencies have not provided the collection system maintenance necessary for an adequate level of customer service and to protect the sizable investment in their facilities. We have all heard the adage Aout of sight, out of mind@ as this relates to collection systems. Collection system maintenance functions are frequently treated as a necessary evil, to be given attention only as emergencies arise. Getting adequate maintenance budgets is dependent on justifying the level of maintenance required. Currently, there is no rational approach to estimating the frequency of the various maintenance procedures required, except through experience and judgment.

Quality collection system maintenance consists of the optimum use of labor, equipment, and materials to keep the system in good condition so that it can efficiently accomplish its intended purpose of collecting and transporting wastewater to the treatment plant. Serious health hazards and extensive property damage can result from sanitary sewer backups and overflows. There should be some reasonable balance between the cost of maintenance and the benefits derived.

1.3 Review of Literature

The authors of this project conducted an extensive literature search (see Appendix E, Literature Review) to obtain nationwide information on current trends in collection system maintenance planning. Very few publications were found that dealt with optimizing maintenance and no publications were found that specifically addressed system maintenance frequency determination or system performance rating evaluation. The literature contained very few papers on the subject of collection system operation and maintenance. Most papers focused on engineering design or sanitary sewer evaluation studies (SSES).

Details of the Literature review are contained in Appendix E.

1.4 Relationship of System Performance and Reinvestment

Collection system performance depends on regular and effective reinvestment. This study explores the relationships between system performance, maintenance frequency, and reinvestment. Without reinvestment and effective maintenance, collection systems will eventually fail.

1.5 Theory

The theoretical basis for establishing a relationship between system performance and maintenance (reinvestment) is the hypothesis that collection systems deteriorate over time, with consequent loss of system performance. To maintain system performance, ongoing reinvestment is required. For purposes of discussion, let us assume that the life of a sewer is 100 years, with 25 percent salvage value remaining at the end of the 100 years as shown on Figure 1-1. Furthermore, we will assume an average system value of $100 per foot, or $528,000 per mile. Given these assumptions, the rate of degradation would be $0.75 per year per foot of sewer system.

Next, let us assume that the life of a system can be extended past the 100 years through system reinvestment in the form of rehabilitation, capital improvements, and routine maintenance. A hypothetical cycle of degradation and maintenance is shown on Figure 1-2.

Figure 1-1 System Value and System Age
(No Rehabilitation)

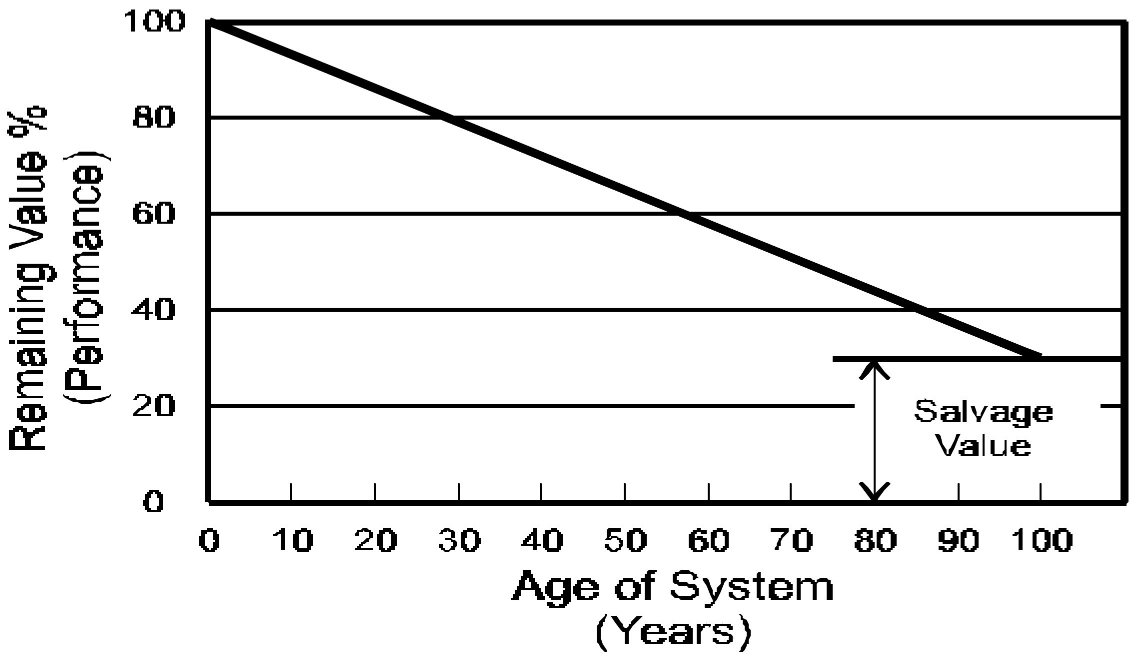
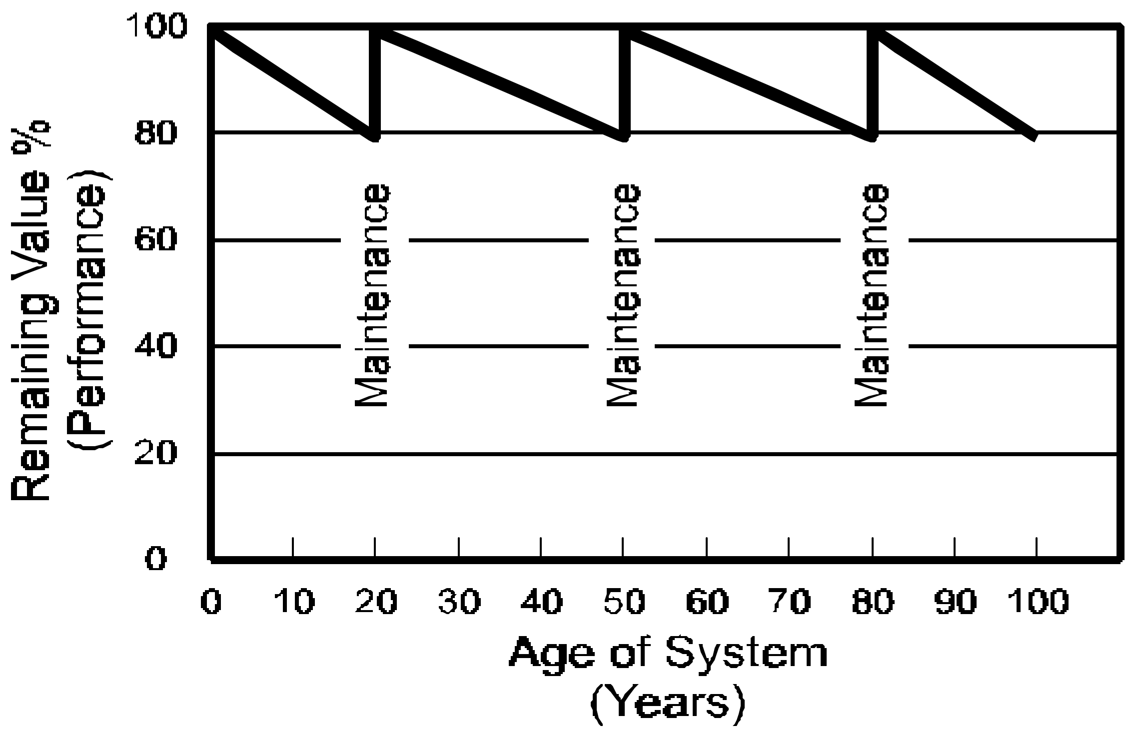
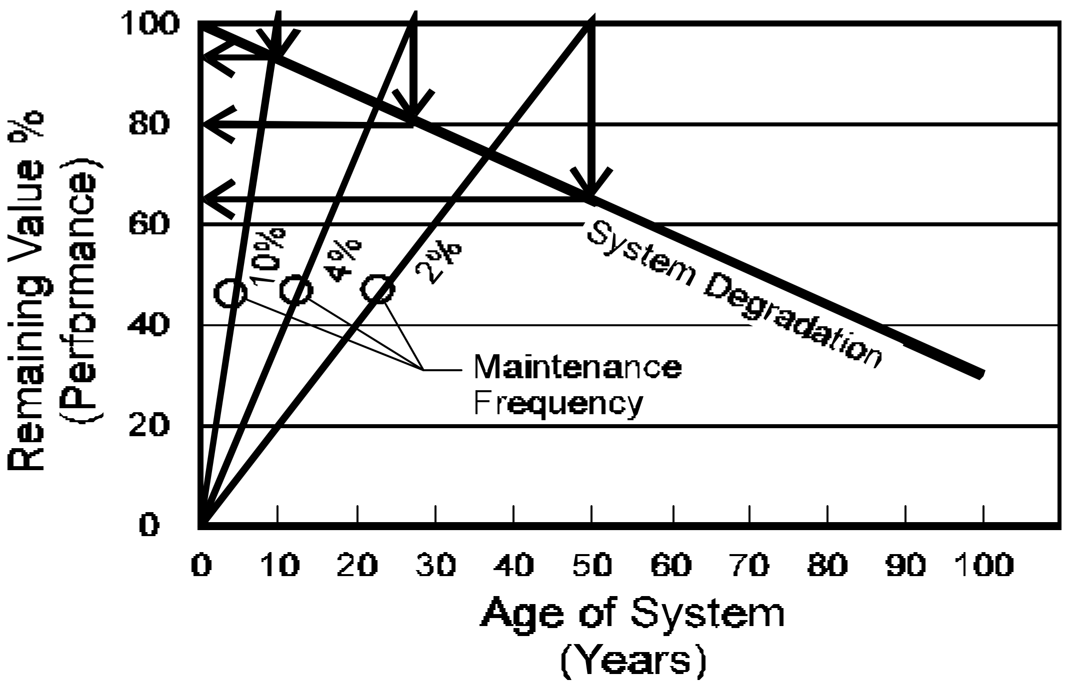


Figure 1-2 System Value and System Age
(With Rehabilitation)



If complete maintenance (reinvestment) is performed each year, the system will operate at 100 percent efficiency all the time. If maintenance (reinvestment) is never performed, then the system will degrade and perform at 25 percent of the efficiency of a new system after 100 years. If maintenance (reinvestment) is performed at a rate of 2 percent per year, the system performance will decrease to about 65 percent of a new system's performance. If maintenance is performed at 4 percent per year, the minimum system performance would be about 80 percent; with maintenance at 10 percent per year, the minimum performance would be about 93 percent of new system performance. These scenarios are shown on Figure 1-3.

Figure 1-3 System Performance and Maintenance Frequency



This study researches relationships between system performance, maintenance rates, and reinvestment. The objective, in concept, was to develop an approach similar to that depicted on Figure 1-3, so that a desired maintenance frequency could be selected based on a minimum acceptable performance rating for the system.

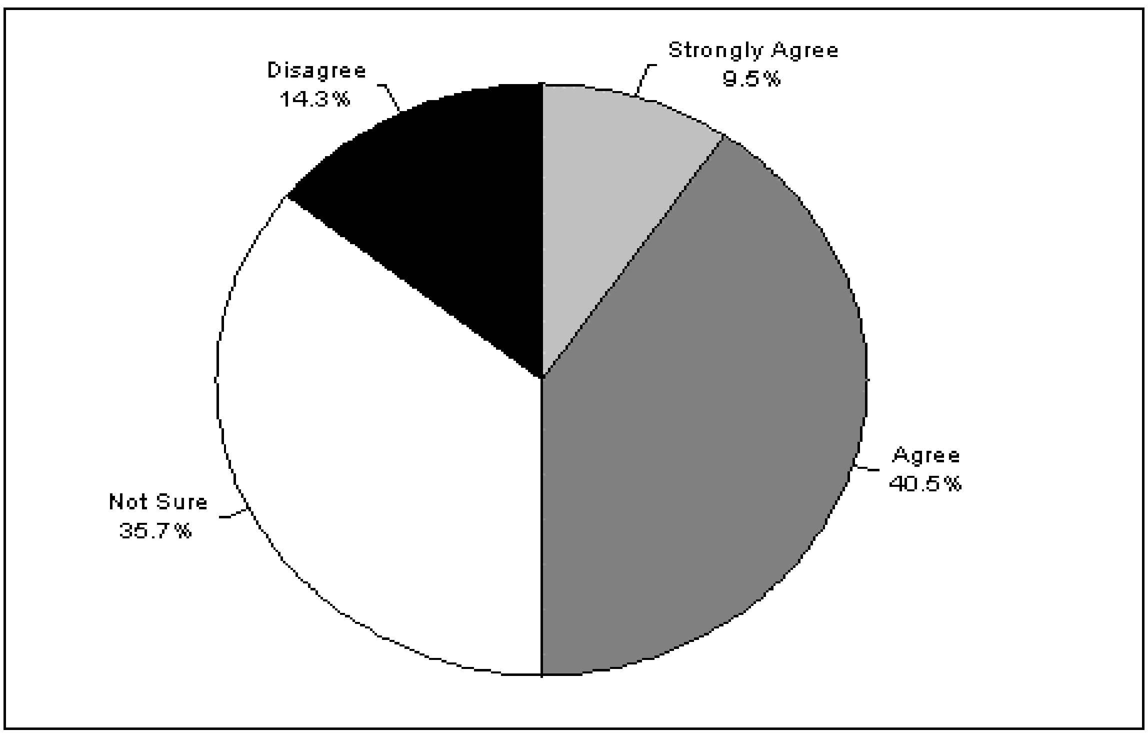
1.6 Perceived Effectiveness of Existing Maintenance Programs

Based on the survey responses obtained during this study, the effectiveness of existing maintenance programs was evaluated. Each agency surveyed was asked the question, AAre you satisfied with your system maintenance (total reinvestment) program?@ Each agency was requested to respond with one of the following answers:

1. Strongly Agree - system performance is as required, and budget is sufficient.
2. Agree - system performance is generally as required, and budget is adequate.
3. Not sure - system performance is not defined, and budget may be adequate.
4. Disagree - system performance generally not as required, budget is not adequate.
5. Strongly Disagree - system performance and budget unacceptable.

Of the 42 respondents 4 strongly agreed, 17 agreed, 15 were not sure, 6 disagreed, and 0 strongly disagreed, as shown on Figure 1-4. The need for improved maintenance and performance measures is evidenced by the high percentage of agencies that are not sure of how effective they are.

Figure 1-4 Perceived Satisfaction with Existing Maintenance Program



1.7 Statistical Analyses Performed

Statistical analyses were performed to evaluate data and data relationships. The analytical methods include functions of random variables such as mean, variance, and standard deviations as well as methods to evaluate relationships among independent variables in the form of linear regression and multiple linear regression analyses. The SPSS 6.0 statistical software package for Windows was employed for this purpose. The SPSS is a world leading statistical analysis software package.

1.8 Benefits

The benefits derived from this report include guidance for measuring system maintenance, system performance, and developing guidelines for reinvestment dollars. The methods developed will help agencies evaluate the effectiveness of their current maintenance programs and establish target performance goals. This study will also assist regulatory agencies in reviewing the effectiveness of collection system maintenance programs and the adequacy of collection system budgets which may result in environmental, economic, social, and public health improvements.

1.9 Report Organization

Chapter 1 describes the significance, objectives, background information on, and methods used to evaluate collection systems performance. Chapter 2 introduces the criteria and measures to be used in the evaluation of a collection system. Chapter 3 describes system characteristic data. Chapter 4 describes the system performance data. The measures associated with each criterion, the determination of maintenance frequency and performance rating are discussed in Chapters 5 and 6. Comprehensive performance evaluations are also discussed. Chapter 7 presents the use of these tools for optimizing collection system maintenance. Supplemental data , overview of relevant literature regarding collection system performance and maintenance, and the survey form are presented in the appendices.

1.10 Abbreviations and Definitions

Abbreviations

#ps/mi	number of pump stations per mile of sewer
$/mi$yr	cost per mile of sewer per year
$/ft$yr	cost per foot of sewer per year
%/system$yr	percent of sewer system per year
ADF	average annual daily flow
ASCE	American Society of Civil Engineers
avg	average (mean)
CCTV	closed circuit TV
fm/ps	miles of forcemain per pump station
fps	feet per second
gpcd	gallons per capita per day
hp	horsepower
hp/mi	horsepower per mile of sewer
I/I	inflow/infiltration
kWh	kilowatts per hour
ps/mi	pump stations per mile
max	maximum value
mgd	million gallons per day
min	minimum value
no/ps$yr	number per pump station per year
no/mi$yr	number per mile of sewer per year
O & M	operations and maintenance
PH/ADF	peak hourly flow to average daily flow ratio
PM/ADF	peak monthly flow to average daily flows ratio
sd	standard deviation
SSES	Sewer System Evaluation Survey
SSO	sanitary sewer overflow
USEPA	United States Environmental Protection Agency
WWTP	wastewater treatment plant
WEF	Water Environmental Federation

Codes for Use in Regression Equations

SIZE CODE

1 = small
2 = medium
3 = large

REGIONAL CODE

1 = central
2 = northeast
3 = northwest
4 = southeast
5 = southwest

Definitions

Backup: The backup of wastewater in a sewer, as a result of a stoppage, until the wastewater floods a basement or other lower portion of a residence or commercial facility.

Capital Improvement: A sewer line, manhole, pump station, forcemain, or other special structure added to collection system.

Complaints: A customer complaint related to the performance of the collection system, including issues such as overflows, odors, and loose manhole covers.

Equalization (Basin): A facility to store peak flows in excess of the hydraulic capacity of downstream facilities.

Linear Regression: A procedure of estimating a linear relationship between a dependent variable and one or more independent variables.

Maintenance: Any reinvestment in an existing collection system in the form of cleaning, monitoring, inspection, rehabilitation, and relief.

Normal Distribution: A continuous distribution of a random variable with its mean, median, and node equal.

Optimization of Maintenance: An effective balance of maintenance activities which results in an acceptable level of system performance.

Overflow: An incident where any measurable or observable quantity of wastewater exists in the sanitary sewer system.

Peak Hour/ADF Ratio: The ratio of peak hour flow at a selected design condition to the average annual daily flow. This calculation may require extrapolation of monitored storm events.

Peak Month/ADF Ratio: The ratio of the peak monthly flow at the WWTP to the average annual daily flow.

Performance of Collection System: The ability of the system to function as desired.

Performance Indicator: A measure of the level of service provided by a collection system agency, such as stoppages per 100 miles of sewer, number of complaints per 100,000 population, or time to respond to a service request.

Pipe Failures: A pipe which has lost its structural integrity as evidenced by total or partial collapse (loss of 50% of pipe area or 25% of pipe wall around any circumference).

Pump Station Failure: A condition that results in station overflows or an unacceptable surcharge of the system.

Rehabilitation: The upgrading and improving of existing facilities.

Reinvestment: The spending of money on the collection system.

Relief: Facilities to provide additional hydraulic capacity.

Sanitary Sewer Overflow (SSO): A discharge of wastewater from the collection system with the potential to enter surface water courses.

SSES: Sewer System Evaluation Survey. A key step in identifying specific sources of infiltration/inflow (I/I).

Stoppages: Any incident where a sanitary sewer is partially or completely blocked causing a backup, a service interruption, or an overflow.

2.0 Data Collection

2.1 Development of Questionnaire

To obtain the data needed for analyzing maintenance frequencies and performance measures, a questionnaire was developed for distribution to collection system agencies. The questionnaire was developed based on the following:

- Previous form used in a 1992 Sewer System Evaluation Survey (SSES) in Kansas (Nelson, p. 25).
- Review of literature.
- Input from the Technical Advisory Committee.

The steps taken to develop the questionnaire are described below.

Step 1

A Sewer System Evaluation Survey form developed by Nelson (25) was the basic guideline to develop the format of the questionnaire. Modifications to this form were based on data from the literature review and input from the Technical Advisory Committee. The questionnaire was structured to collect both system performance data and system maintenance data.

Step 2

The next step in developing the questionnaire was to identify the types of significant activities or events which could be used as possible performance indicators and maintenance frequency. System performance, for example, could be related to pipe failures, manhole overflows, treatment overflows, basement backups, customer complaints, and pump station failures. Maintenance frequency could be related to tasks such as cleaning, pump station servicing, and other maintenance activities.

Step 3

Once the activities or events were identified, it was necessary to define how each activity would be measured. To have meaning as an indicator of performance or maintenance, each activity or event was expressed as a ratio to allow comparisons between systems. Pipe failure, for example, was expressed as failures per mile per year. This ratio provides an indicator of performance that can be tracked over time and can be compared with other agencies' performance data.

Step 4

The next step in constructing the questionnaire was specifying the information that respondents would be asked to provide. The questionnaire also allowed respondents to indicate the quality of data being provided as “very good,” “good,” “fair,” and “a guess.”

Step 5

The next step involved arranging the questions for data needed in an easy-to-use matrix as shown in Table 2-1.

Step 6

The final step was a review of the questionnaire by the Technical Advisory Committee. Comments were received and incorporated and the questionnaire was finalized. A copy of the final questionnaire sent to each agency surveyed is included in Appendix A.

Table 2-1
Questionnaire Matrix

Category	Data Requested	Data Needed
Service Area Information	Miles of Public Sewer Number of Manholes Number of Connections Area Served (sq mi) Population Served Age of System (Age Distribution)	General collection system information.
Flow Information	Average Annual Daily Flow Maximum Daily Flow Peak Hourly Flow Maximum Month/Average Daily Flow Minimum Month/Average Daily Flow Percentage of System below the Groundwater Table	General flow information representing collection system.
System Characteristic Information	Percentage of System > 24-inches in Diameter Number of Pump Stations Total Installed Horsepower Total Energy Consumed Total Length of Forcemains, Miles Number of Equalization Basins Volume of Equalization Percentage of System Which is Industrial/Commercial Typical Velocity of Flow	General characteristic information related to the collection system.
Systems Performance Data	Pipe Failures Manhole Overflows Treatment Overflows Basement Backups Others Customers Complaints Pump Station Failures	Cumulative number of events in last 1 yr, 5 yrs, 10 yrs, and 20 yrs.
Routine Maintenance Frequencies	Cleaning, Miles of Sewer Root Removal/Treatment, Miles of	Total completed each year from 1992 to 1996.

Table 2-1 Questionnaire Matrix		
Category	Data Requested	Data Needed
	Sewer Main Line Stoppages Cleared, Number House Services Stoppages Cleared, Number Inspections and Services Pump Stations	
Inspection Method and Status	Flow Monitoring/Capacity Evaluation Manhole Smoke/Dye Test Television Inspection (Internal Inspection) Private Sector Building Inspection	Cumulative percent of system quality inspected in last 1yr, 5 yrs, 10 yrs, and 20 yrs.
System Maintenance Costs	Relief Equalization Rehabilitation/Replacement O&M Budget (Collection System Only) Equipment Replacement Other Costs	Total dollars spent in different time periods: 1990 - 1996 1980 - 1989 1970 - 1979 Pre - 1970
System Performance Importance (Weight)	Pipe Failures Sanitary Sewer Overflows (SSOs) Customer Complaints Pump Station Failures Peak Hourly/ADF Ratio Peak Month/ADF Ratio	Percentage of weight for each item, total weight should be 100%.
Maintenance Activity Importance (Weight)	Percentage of system Cleaned/yr Percentage of system Root/yr Pump Station Service Flow Monitoring/Capacity Evaluation Manhole Inspection Smoke/Dye Testing CCTV Inspections Private Sector Inspections Manhole Rehabilitation Main Line Rehabilitation Relief Sewer Construction Private Sector I/I Source Removal	Percentage of weight for each items, total weight should be 100%.
Effectiveness of Program	Strongly Agree Agree Not Sure Disagree Strongly Disagree	

2.2 Identification of Participants

During project startup, the Technical Advisory Committee members helped to define the collection system sizes and geographic boundaries for selection of agencies to be included in the survey. Three system size categories, shown in Table 2-2, were defined, based on the population. Agencies with populations less than 100,000 were classified as small, agencies with populations equal to or greater than 100,000 and less or equal to 500,000 were classified as medium, and agencies with populations greater than 500,000 were classified as large. The geographic regions defined were Northeast, Southeast, Central, Northwest and Southwest. The boundaries of these regions are shown on Figure 2-1

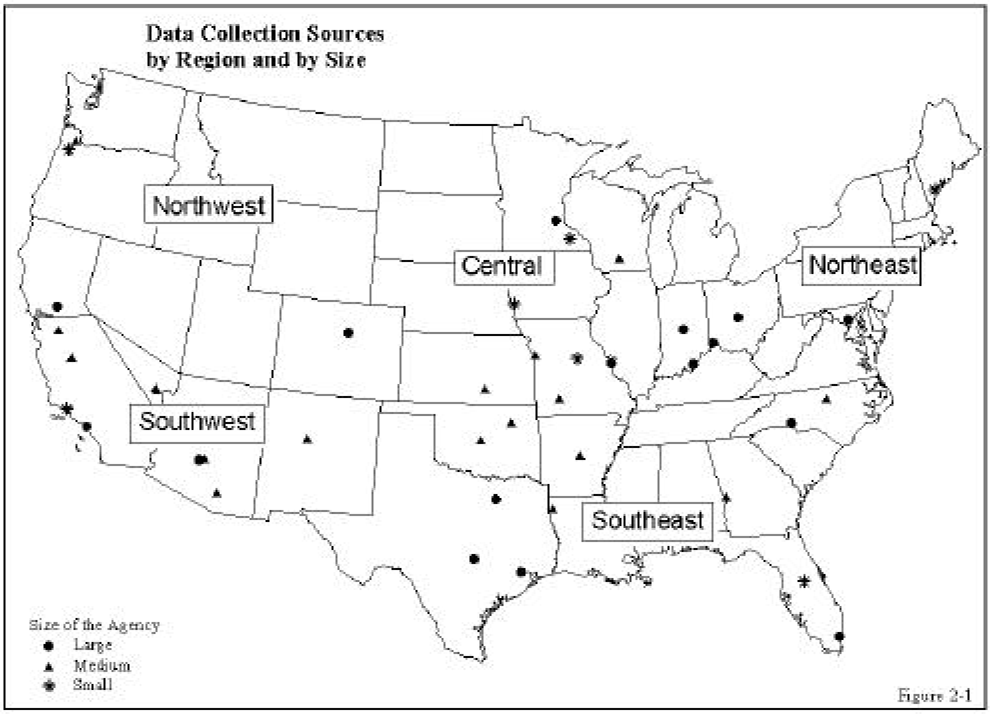
Table 2-2
System Size and Population Classification

System Size Category	Population
Large	> 500,000
Medium	100,000 - 500,000
Small	< 100,000

The initial listing of potential participating agencies was screened by contacts through the authors and Technical Advisory Committee. A list of more than 100 potential participants was developed. From this list, and in consultation with the Technical Advisory Committee, the authors selected 75 agencies to contact with a goal of ultimately receiving 50 completed questionnaires.

2.3 Data Collection

Initial telephone calls were made to get tentative commitments from the agencies. A 10-page questionnaire was mailed out to those agencies which agreed to participate. Follow-up calls were made every two weeks to every participating agency that had not returned a completed questionnaire to remind the participants to return the completed questionnaire.



Several difficulties were encountered during the data collection. Many agencies had limited time and staff to complete the questionnaire. Some agencies were apprehensive about providing performance data. Some of the agencies could not provide adequate data, as the requested data were unavailable. The reasons cited for this included data lost in natural disasters, such as flooding, limited storage spaces (e.g. keep only the last 10 years of data); or not having a good record tracking system to maintain any kind of record related to their collection system. In some cases, personnel initially involved in completing the questionnaire were reassigned and it was therefore necessary to reinitiate the process with new staff. Due to a variety of reasons, several cities and agencies canceled their commitment.

The questionnaire was mailed to more than 75 agencies across the continental United States. A total of 42 agencies fulfilled their commitment to complete the questionnaire. The summary of the number of respondents by size and region is shown in Table 2-3 and on Figure 2-1.

Table 2-3 Summary of Agencies by Size and Region				
Region	Large Size System	Medium Size System	Small Size System	Number of Responses
Northeast	2	1	1	4
Southeast	1	2	0	3
Central	9	8	3	20
Northwest	2	1	1	4
Southwest	2	8	1	11
Total	16	20	6	42

The data supplied by the 42 agencies are listed in Appendix B. Each respondent was assigned a unique identification number.

3.0 Agency Data

3.1 Introduction

All collection systems included in the survey were designed as separate sanitary sewers. This chapter summarizes the data supplied by the 42 respondents. The majority of the respondents thought the quality of data in each section was either "very good," "good," or "fair."

3.2 Service Area Characteristics

3.2.1 Summary of Service Area Information

Each agency was requested to provide information on, among other things, the total sewer miles, total number of manholes, total number of connections, service area size, served population, and the age of the system. The system characteristic data for each agency is presented in Table 3-1.

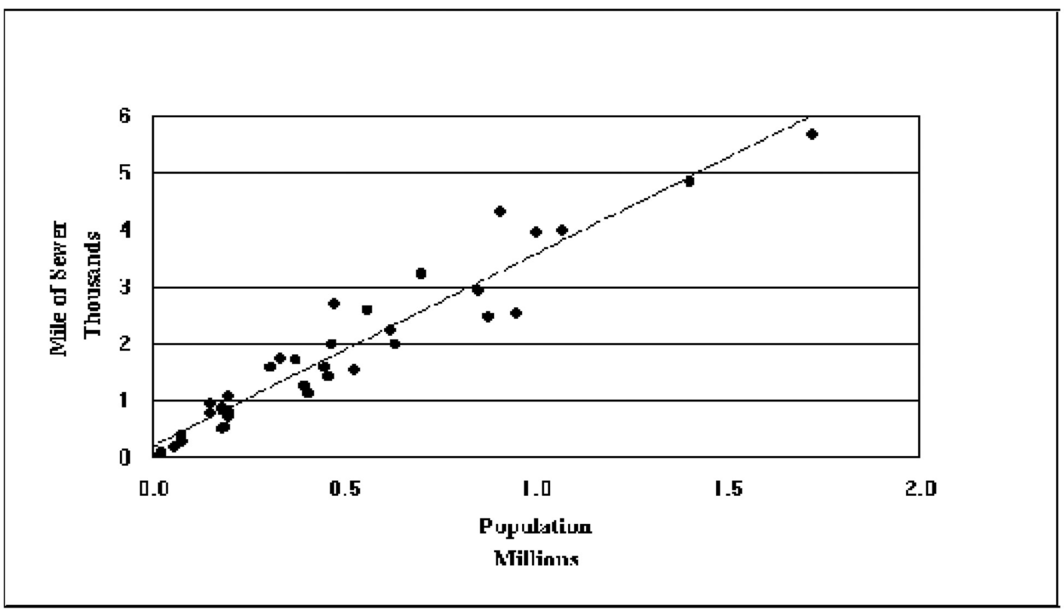
The agencies varied widely in terms of size and population served, number of manholes, and number of connections, with the smallest agency having a service area of 7 square miles and a population of 14,000, and the largest having a service area of 1,650 square miles and a population served of 4,770,000. The number of connections ranged from 390 to 1,143,980. The number of manholes ranged from 160 to 128,691. The miles of sewer ranged from 32 to 5,700. Some of the data reported indicates a mismatch between people served and miles of sewer. It is believed that some of these data are for regional systems where the smaller collection sewers serving the population are not included in the length of sewer reported. In addition, the same data for several agencies are suspect. As expected, sewer length is proportional to population. Eliminating these suspect agencies (agencies 4, 5, 7, 14, 21, and 32) results in an average sewer length density of 1 mile for every 245 people or 21.5 feet of sewer per person. Table 3-2 summarizes the population area, and sewer length by region, size, and average. Figure 3-1 shows a relationship between miles of sewer and population.

Table 3-1
Summary of System Characteristics

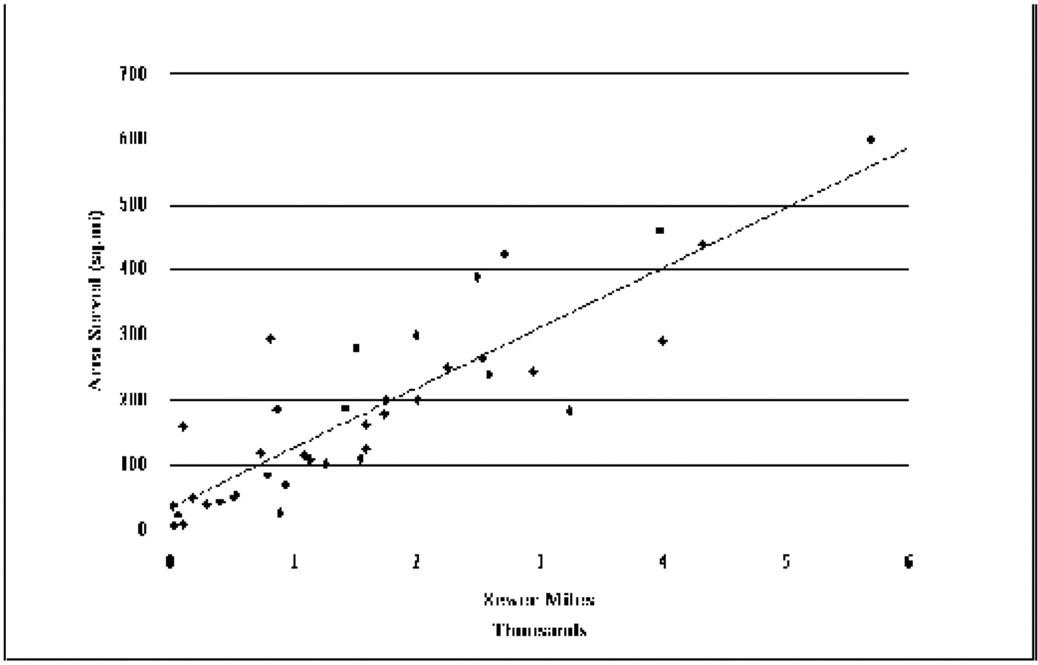
City/ Agency	Size	Region	Population Served	Miles of Sewer	Number of Manholes	Number of Connections	Area Served (sq mi)	Average Age	Average Annual Daily Flow (mgd)	System in Groundwater (%)	System > 24" (%)	Number of Pump Stations	Total Installed (hp)	Energy Per Year (kWh)	Miles of Force Mains	Industrial/ Commercial (%)	Typical Velocity (fps)
1	Large	Northeast	1,400,000	4,891	128,691	388,238	1,000	28.0	192.0	30	5.5	43	22,925	22,362,361	40.1	19	2.0
2	Small	Central	75,561	418	8,129	29,144	44	38.1	14.6	10.0	6.0	11	495	500,000	4.0	5.0	3.0
3	Small	Central	56,000	190	3,855	18,000	50	40.0	7.7	30.0	12.9	16	3,000	45,000	12.9	15.0	15.0
4	Large	Central	2,500,000	511	6,535	n/a	1,650	44.2	213.3	n/a	68.0	61	11,660	n/a	95.1	n/a	n/a
5	Large	Central	900,000	1,520	32,108	300,000	280	30.7	88.6	75.0	8.0	214	30,000	n/a	40.0	20.0	n/a
6	Medium	Central	180,000	900	27,000	60,000	26	39.2	34.6	n/a	8.0	23	5,700	4,000,000	20.0	n/a	2.5
7	Medium	Central	280,000	119	1,200	n/a	161	39.0	39.6	50.0	70.0	17	9,350	7,413,000	31.0	0.0	3.0
8	Medium	Central	465,000	2,000	35,000	160,000	300	42.0	70.5	15.0	20.0	60	n/a	n/a	n/a	10.0	4.0
9	Small	Central	78,000	300	7,243	24,000	39	31.1	12.1	n/a	7.0	4	305	n/a	1.0	59.0	n/a
10	Large	Central	850,000	2,953	82,900	220,000	244	63.0	216.0	n/a	n/a	131	4,593	5,800,000	n/a	40.0	n/a
11	Large	Central	632,958	2,017	60,000	176,004	201	34.8	160.6	n/a	12.0	11	1,210	1,421,500	6.5	15.0	4.0
12	Large	Central	875,000	2,500	44,000	212,000	390	51.0	113.0	n/a	n/a	202	14,472	14,700,000	140.0	n/a	n/a
13	Large	Northwest	700,000	3,250	43,500	182,386	183	18.5	160.5	10.0	3.0	71	2,654	2,834,228	12.4	9.0	2.0
14	Large	Southwest	4,770,000	1,250	20,400	1,143,980	770	47.9	520.0	n/a	38.0	48	7,388	1,280,000	20.0	20.0	3.0
15	Large	Northwest	525,000	1,550	36,000	136,814	110	59.5	50.0	5.0	4.0	4	n/a	n/a	3.0	n/a	3.0
16	Large	Central	619,320	2,255	35,000	138,975	250	21.0	76.9	n/a	8.7	82	n/a	8,275,000	1.8	n/a	3.0
17	Large	Central	1,070,168	4,010	30,493	285,000	290	24.5	177.0	25.0	21.5	16	477	122,500	2.0	10.0	3.5
18	Medium	Southeast	200,000	1,100	18,000	66,000	115	42.0	28.0	50.0	20.0	90	1,800	15,000	50.0	10.0	2.1
19	Medium	Central	180,000	800	18,000	57,000	85	31.0	31.0	25.0	12.0	35	1,700	2,100,000	15.0	30.0	2.0
20	Large	Southeast	950,000	2,543	59,150	258,152	266	19.2	307.0	75.0	1.2	930	90,000	100,000,000	735.0	20.0	2.0
21	Medium	Southeast	136,500	32	160	390	38	17.0	9.6	90.0	26.0	27	2,900	n/a	22.0	99.0	2.0
22	Medium	Southwest	456,445	1,435	19,346	127,578	187	11.4	68.3	10.0	4.0	32	1,125	1,586,836	12.4	1.0	4.0
23	Large	Southwest	1,000,000	3,986	63,837	348,973	460	26.0	59.2	n/a	5.6	19	1,840	n/a	12.8	20.0	2.0
24	Medium	Central	373,644	1750	51,042	121,880	180	30.0	55.0	n/a	5.0	57	n/a	n/a	32.0	n/a	n/a
25	Medium	Central	310,000	1,600	40,000	125,000	125	49.0	42.0	20.0	n/a	40	n/a	n/a	n/a	25.0	n/a
26	Medium	Southwest	183,000	875	13,000	60,000	185	22.5	15.1	0.0	5.0	27	700	40,000	43.8	6.7	2.5
27	Medium	Central	335,000	1,766	29,026	93,060	200	42.1	98.0	70.0	15.0	35	12,000	n/a	128.0	15.0	2.5
28	Medium	Southwest	405,517	1,141	23,281	114,857	108	20.3	49.3	0.0	6.3	2	140	n/a	0.7	6.6	n/a
29	Medium	Northeast	200,000	820	17,300	60,000	296	30.0	18.2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2.0
30	Medium	Southwest	475,000	2,729	45,626	187,000	425	25.7	60.0	0.0	3.5	36	1,553	550,000	23.0	12.5	2.5
31	Large	Southeast	560,000	2,600	55,000	140,000	240	25.1	64.5	20.0	20.0	50	3,500	6,000,000	n/a	25.0	3.0
32	Small	Northeast	86,900	72	1,500	2,500	25	12.5	19.2	n/a	20.0	55	4,760	n/a	17.3	10.0	2.5
33	Large	Central	906,885	4,332	91,365	301,545	440	48.2	55.9	n/a	n/a	220	22,387	n/a	73.1	6.0	n/a
34	Large	Central	1,720,000	5,700	100,000	368,000	600	22.0	236.0	30.0	5.0	377	n/a	n/a	n/a	n/a	n/a
35	Medium	Southwest	191,000	548	10,863	41,650	54	17.9	15.0	n/a	2.7	5	450	n/a	2.0	20.0	2.0
36	Medium	Central	150,000	949	21,100	67,693	70	29.4	40.7	25.0	11.0	32	1,020	2,750,000	33.0	53.0	4.0
37	Medium	Southwest	450,000	1,600	29,000	141,000	162	29.0	57.1	5.0	6.0	14	n/a	5,504,196	8.0	20.0	3.0
38	Small	Southwest	14,000	40	836	4,022	7	42.7	1.6	70.0	0.0	5	212	24	1.4	2.0	3.0
39	Medium	Northwest	200,000	747	6,333	62,000	120	26.7	63.6	60.0	12.0	36	2,096	n/a	n/a	n/a	n/a
40	Small	Northwest	23,485	120	1,590	11,150	10	29.7	6.0	90.0	4.0	10	2,240	585,471	5.3	25.0	n/a
41	Medium	Southwest	396,011	1,274	18,190	104,000	102	34.6	63.0	n/a	19.0	16	372	158,000	2.6	7.0	n/a
42	Medium	Southwest	180,000	525	10,000	52,000	50	50.5	24.0	0.0	14.0	55	800	n/a	0.3	30.0	2.0
Total			26,030,394	69,718	1,345,599	6,389,991	10,536	1,387.0	3,464.0	860.0	509.9	3,220	242,898	177,200,755	164.7	646.8	89.0
Average			619,771	1,660	32,038	159,750	251	33.0	82.0	33.1	13.8	79	7,361	7,704,381	47	20.2	3.0
Maximum			4,770,000	5,700	128,691	1,143,980	1,650	63.0	520.0	90.0	70.0	930	90,000	100,000,000	735	99.0	15.0
Minimum			14,000	32	160	390	7	11.4	1.6	0.0	0.0	2	140	24	0	0.0	2.0

Region	Number of Respondents	Feet of Sewer/Capita	Feet of Sewer/sq. mi.
Central	17	23	58,184
Northeast	2	20	20,226
Northwest	4	22	66,100
Southeast	3	23	52,727
Southwest	10	19	45,805
Size			
Large	13	19	35,457
Medium	18	23	54,725
Small	5	22	40,844
Overall Average	36	21	53,062

Figure 3-1 Sewer Miles vs. Population



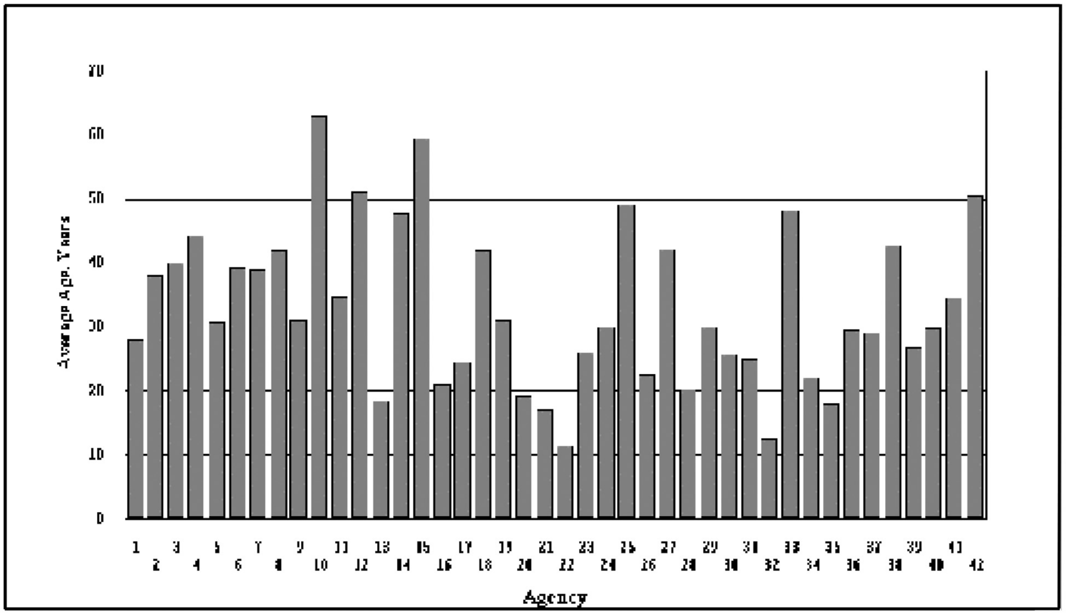
The overall average sewer density in this survey is 21 feet of sewer per capita, or 53,062 feet per square mile. Large systems have the average sewer density of 19 feet per capita, medium-sized systems have 23 feet per capita, and small systems, 22 feet per capita.



The age distribution of sewers in a system will vary depending on when development occurred. Age is an important factor in assessing system needs since systems deteriorate over time. The oldest collection system in this survey was constructed in 1880. The system age for each agency was estimated based on the reported percentage of their system within the following age categories:

- 0 - 10 years (use 5 years as midpoint)
- 11 - 20 years (use 15 years as midpoint)
- 21 - 50 years (use 35 years as midpoint)
- 51- 100 years (use 75 years as midpoint)
- > 100 years (use 125 years as midpoint)

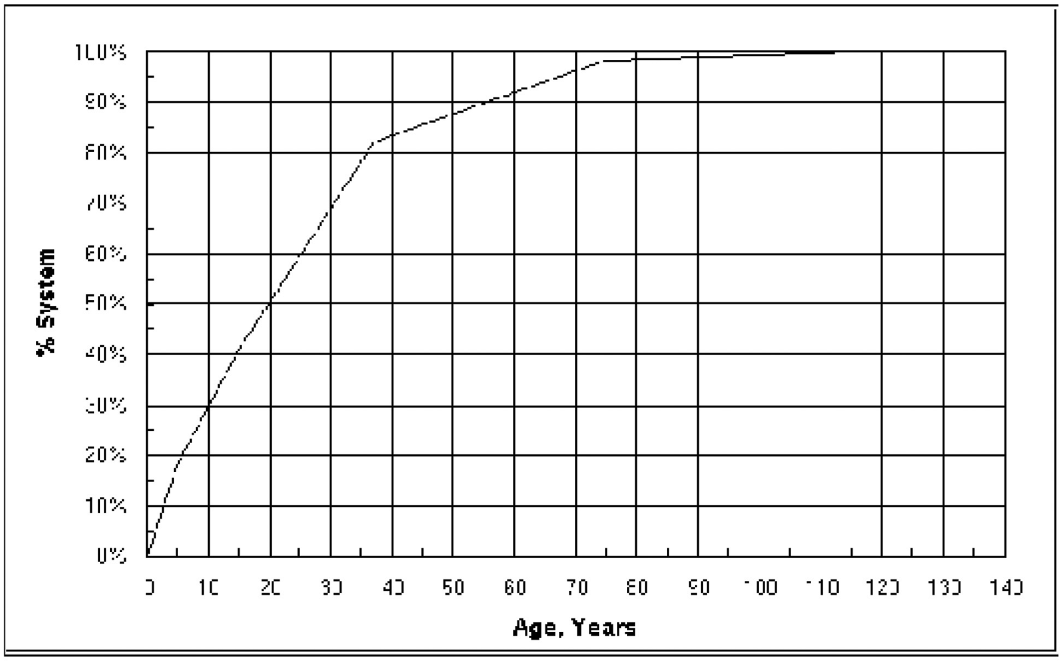
The average system age ranged from 11.4 to 63 years. The overall average was 33 years. Average system age for each agency is shown on Figure 3-3



Averaging the cumulative percentages within each class of the age distribution shows that about 18 percent of sewers were built in the last 10 years, 41 percent in the last 20 years, 82 percent in the last 50 years, and 98 percent in the last 100 years as summarized on Table 3-3 and shown on Figure 3-4. The average rate of system growth, based upon the age distribution, is estimated to be about 2.1% per year.

Table 3-3
Percentage of System vs. Average Age

Region	Number of Respondents	0-10 Years (%)	11-20 Years (%)	21-50 Years (%)	51-100 Years (%)	>100 Years (%)
Central	20	13.4	19.7	43.5	21.2	2.2
Northeast	3	21.5	40.4	30.4	7.6	0.0
Northwest	4	19.5	19.0	45.3	12.8	3.5
Southeast	4	27.5	27.3	34.3	10.8	0.3
Southwest	11	21.9	23.4	40.5	13.3	0.9
Size						
Large	16	16.3	22.9	39.2	19.5	2.1
Medium	20	20.3	21.5	43.0	13.7	1.5
Small	6	16.0	26.7	39.7	16.8	0.8
Overall	42	18.2	22.8	41.1	16.4	1.6
Cumulative		18.2	40.9	82.0	98.4	100.0



3.3 Flow Information

3.3.1 Summary of Flow Information

Each agency was requested to provide flow information, such as average annual daily flow, maximum daily flow, peak hourly flow, and maximum and minimum month daily flow.

Average annual daily flows (ADF) reported in the survey ranged from 1.6 to 520 mgd. The ADF listed in Table 3-4 vary widely, reflecting the differences in the industrial component and the I/I of flow of each system. Generally, ADF increases with increasing population although the data shows that ADF cannot be accurately predicted by population estimates alone. The average per capita ADF is 140 gpcd. Figure 3-5 shows the relationship between ADF and population.

Region	Number of Respondents	Average ADF (mgd)	Average Population	Average (gpcd)
Central	20	89.2	626,377	142
Northeast	3	76.5	562,300	136
Northwest	4	70.0	362,121	193
Southeast	4	102.3	461,625	222
Southwest	11	84.8	774,634	109
Size				
Large	16	168.2	1,248,708	135
Medium	20	44.1	285,856	170
Small	6	10.2	55,658	183
Overall Average	42	86.5	619,771	140

Figure 3-5 ADF vs. Population

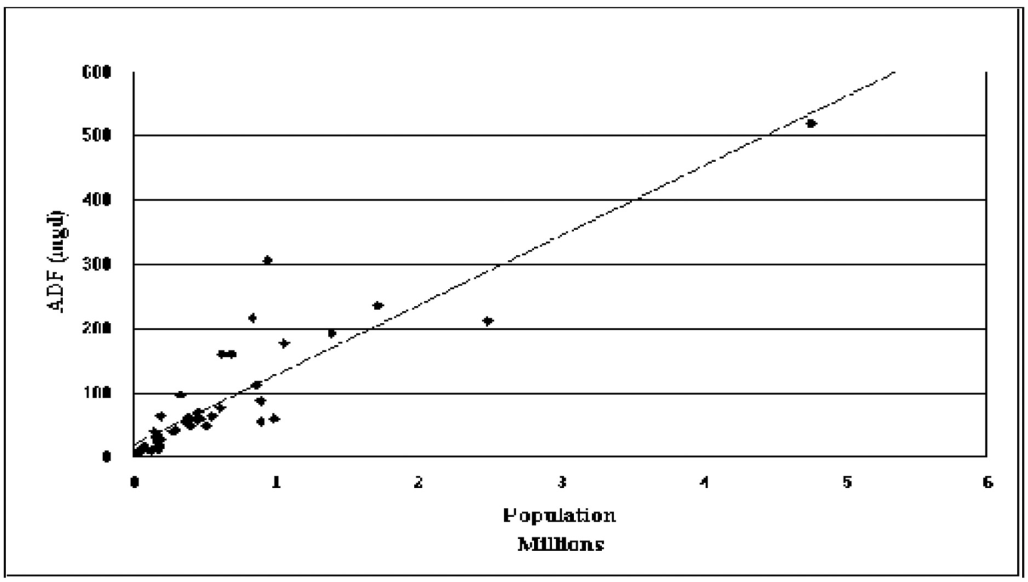


Table 3-5 summarizes the peak hourly/ADF flow ratio by region and by size. The overall average peaking factor is 2.24. The Northwest region has the highest ratio of 3.81 as expected, since this region has a wetter climate than other parts of the country. The Southwest region has the lowest peaking factor of 1.77, also as expected, since this region has a drier climate than rest of the country.

Region	Number of Respondents	Average Peak Hourly Flow/ADF
Central	18	2.47
Northeast	2	2.27
Northwest	2	3.81
Southeast	3	2.05
Southwest	10	1.77
Size		
Large	12	2.20
Medium	17	2.34
Small	6	2.95
Overall Average	35	2.24

3.4 Information on System Characteristics

Characteristic information includes the number of pump stations, total installed horsepower of pumps in the pump stations, total energy consumed by all pump stations, total length of force mains, typical velocity of flow, etc.

3.4.1 Summary of Characteristic Information

The percentage of larger than 24-inch diameter sewers in each system ranged from 0 to 70%. Total number of pump stations in each agency's system ranged from 2 to 930. The total installed horsepower for all regions ranged from 140 to 90,000 hp, the total energy consumed per year ranged from 24 kWh to 100 million kWh. The percentage of industrial/commercial flow ranged from 0 to 99% of the system. The typical flow velocity in the system ranged from 2 to 15 fps.

Table 3-6 summarizes the percentage of greater than 24-inch diameter sewers in each system by region and by system size. The overall average is 13.8%.

Table 3-6 Percentage of System Greater than 24 Inches in Diameter		
Region	Number of Respondents	Percentage of System
Central	16	18.1
Northeast	2	12.8
Northwest	4	5.8
Southeast	4	16.8
Southwest	11	9.5
Size		
Large	13	15.4
Medium	18	14.4
Small	6	8.3
Overall Average	37	13.8

All 42 agencies have pump stations. The number of pump stations ranged from 2 to 930. Table 3-7 summarizes the number of pump stations per mile of sewer by region and by system size. The overall average is 0.09 pump stations per mile of sewer. As expected, the Southeast region has the highest number of pump station rates of 0.33 per mile of sewer. Small systems have the highest pump station rate of 0.18 per mile of sewer, medium-sized systems have 0.08 pump stations per mile of sewer, and large systems, 0.06 pump stations per mile of sewer.

Table 3-7 Number of Pump Stations		
Region	Number of Respondents	Number of Pump Stations/ Miles of Sewer
Central	20	0.05
Northeast	2	0.26
Northwest	4	0.04
Southeast	4	0.33
Southwest	11	0.03
Size		
Large	16	0.06
Medium	19	0.08
Small	6	0.18
Overall Average	41	0.09

Each agency was requested to provide information on the total horsepower of the pump stations. Although all 42 agencies reported having pump station installed, only 34 agencies reported total horsepower of the pump stations.

Table 3-8 summarizes the total installed horsepower per pump station by region and by system size. The Northeast region has the largest horsepower installed. The Southwest has the smallest horsepower installed. Small systems have larger horsepower installed than large and medium-seized systems.

Table 3-8 Total Installed Horsepower of Pump Stations		
Region	Number of Respondents	Horsepower/Pump Station
Central	15	110
Northeast	2`	310
Northwest	3	80
Southeast	4	74
Southwest	10	54
Size		
Large	13	104
Medium	15	90
Small	6	110
Overall Average	34	98

The average of the total length of force main per pump station is 0.56 miles as summarized in Table 3-9. The Central region has the highest rates of 0.67 miles of force main per pump station, and the Northwest region has the lowest rate of 0.36 miles of force main per pump station. Medium-sized systems have the highest rate of 0.69 miles of force main per pump station, large systems have 0.45 miles of force main per pump station, and small systems, 0.42 miles of force main per pump station.

Table 3-9 Ration-Force Main Length/Pump Station		
Region	Number of Respondents	miles/ps
Central	16	0.67
Northeast	2	0.42
Northwest	3	0.36
Southeast	3	0.54
Southwest	11	0.50
Size		
Large	13	0.45
Medium	16	0.69
Small	6	0.42
Overall Average	35	0.56

Table 3-10 summarizes the percentages of systems in industrial/commercial flows. The overall average is 20.2%. The Southeast region has the highest percentage, 38.5%, the Central region has 21.6%, the Northwest region 17%, the Northeast region 14.5%, and the Southwest region 13.3%. The medium-sized systems, 21.6%, the small systems 13.3% and, large systems 18.6%.

Table 3-10
Percentage of System Industrial/Commercial Flow

Region	Number of Respondents	Percentage of System
Central	14	21.6
Northeast	2	14.5
Northwest	2	17.0
Southeast	4	38.5
Southwest	11	13.3
Size		
Large	11	18.6
Medium	16	21.6
Small	6	19.3
Overall Average	33	20.2

Table 3-11 summarizes the minimum, maximum, and typical velocities by regions and system sizes. The overall average in minimum velocity is 1.4 ft/s, maximum velocity is 8.4 ft/s.

Table 3-11
Typical Velocity of Flow

Region	Min (ft/s)	Max (ft/s)	Typical (ft/s)
Central	1.7	8.4	4.2
Northeast	0.3	7.5	2.2
Northwest	1.5	7.5	2.5
Southeast	1.2	4.7	2.3
Southwest	1.4	10.1	2.7
Size			
Large	1.3	7.3	2.8
Medium	1.5	9.3	2.7
Small	1.3	8.3	5.9
Overall Average	1.4	8.4	3.1

4.0 Maintenance Data

4.1 Introduction

Maintenance typically refers to the specific procedures, tasks, instructions, personnel, qualifications, equipment, and resources needed to satisfy the maintainability requirement within a specific use environment. AMaintenance is that set of activities required to keep a component, system, infrastructure asset, or facility functioning as it was originally designed and constructed to function.@[1] For our purpose, any reinvestment in the system, including routine maintenance, capital improvements for repair or rehabilitation, inspection activities, and monitoring activities are classified as maintenance. Capital improvements for system expansion are not classified as maintenance reinvestment.

4.2 Routine Maintenance

Routine maintenance includes sewer cleaning, root removal/treatment, cleaning of mainline stoppages, cleaning of house service stoppages, and inspections and servicing of pump stations. Each agency was requested to provide 5 years of data (from 1992 to 1996) to establish routine maintenance rates. These routine maintenance rates by region and by size are presented in Table 4-1 through 4-5.

Forty-one out of 42 agencies reported having a cleaning maintenance program. Table 4-1 summarizes the sewer maintenance for each year from 1992 to 1996 by region and system size. The cleaning rates represented the reported total miles cleaned annually compared to the total miles in the agency=s system. Overall, the Northwest region has the highest cleaning rates in miles per mile per year, and the Northeast has the lowest rate in miles per mile per year. Small systems have the highest cleaning rate, followed by medium and large systems. Overall, the annual cleaning rate varied from about 0.29 miles per mile per year to about 0.32 miles per mile per year. The overall average cleaning rate is 0.30 miles per mile per year.

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[1] Ronald Hudson, *Infrastructure Management*.

Table 4-1 Routine Maintenance - Average Sewer 5-Year Cleaning (miles cleaned/mile of system$yr)							
Region	Number of Respondent s	1992	1993	1994	1995	1996	5-Year Average miles cleaned/ mile of system$yr
Central	20	0.23	0.23	0.22	0.22	0.21	0.22
Northeast	2	0.08	0.09	0.09	0.09	0.08	0.09
Northwest	4	0.76	0.57	0.56	0.58	0.56	0.61
Southeast	4	0.32	0.37	0.26	0.26	0.24	0.29
Southwest	11	0.35	0.36	0.37	0.42	0.41	0.38
Size							
Large	16	0.27	0.31	0.27	0.27	0.24	0.27
Medium	20	0.27	0.28	0.29	0.33	0.32	0.30
Small	5	0.51	0.34	0.35	0.42	0.37	0.40
Overall Average	41	0.30	0.30	0.29	0.32	0.29	0.30

Thirty-six out of 42 agencies reported having a root removal maintenance program. Table 4-2 summarizes miles of root removal by region and by system size. The Central region shows a decrease in root removal from 1992 to 1995, followed by a huge increase in 1996. The Southeast region has shown a slight increase between 1992 and 1993, then a significant decrease from 1993 to 1996. The overall average root removal during this 5-year period was 0.04 miles per mile of systems per year.

Table 4-2 Routine Maintenance - Average Root Removal (miles/mile of system$yr)							
Region	Number of Respondent s	1992	1993	1994	1995	1996	5-Year Average mile/mile of system$yr
Central	18	0.02	0.02	0.02	0.02	0.03	0.02
Northeast	2	0.01	0.01	0.01	0.01	0.01	0.01
Northwest	4			0.02	0.02	0.02	0.01
Southeast	4	0.22	0.24	0.10	0.11	0.07	0.15
Southwest	8	0.08	0.06	0.06	0.06	0.05	0.06
Size							
Large	13	0.06	0.05	0.03	0.03	0.02	0.04
Medium	17	0.05	0.05	0.04	0.05	0.06	0.05
Small	6	0.00	0.07	0.02	0.03	0.03	0.03
Overall Average	36	0.05	0.05	0.03	0.04	0.04	0.04
Note: Blank cells indicate that data were unreported or required data to convert values to rates was unreported.							

Thirty-eight out of 42 agencies reported main line stoppages cleaned data. Only 27 agencies provided house service stoppages cleared data between 1992 and 1996. Tables 4-3 and 4-4 summarize the main line stoppages and house service stoppages cleared per sewer mile between 1992 and 1996. Both large and medium systems show an increase of main line stoppages cleared annually. In general, as shown in Table 4-3, main line stoppages in both large and medium systems have been increasing annually and have decreased in small systems. Large systems reported a 35% increase of stoppages cleared between 1994 and 1995. The Central, Northeast, Northwest and Southwest areas reported an average increase of 10% to 20% each year, while the Southeast reported more than a 62% increase between 1995 and 1996. The overall rate of mainline stoppages cleared is about 0.23 per mile per year.

Table 4-3
Routine Maintenance - Average Main Line Stoppages Cleared
(stoppages/mi)

Region	Number of Respondents	1992	1993	1994	1995	1996	5-Year Average stoppages/mile
Central	18	0.30	0.31	0.30	0.28	0.25	0.29
Northeast	3	0.19	0.17	0.19	0.24	0.23	0.20
Northwest	4	0.19	0.13	0.11	0.07	0.07	0.11
Southeast	4	0.26	0.28	0.26	0.39	0.63	0.36
Southwest	9	0.09	0.09	0.16	0.15	0.15	0.13
Size							
Large	13	0.17	0.18	0.17	0.23	0.23	0.20
Medium	19	0.27	0.28	0.31	0.26	0.31	0.29
Small	6	0.16	0.13	0.14	0.12	0.10	0.13
Overall Average	38	0.22	0.21	0.23	0.23	0.25	0.23

As shown in Table 4-4, large systems reported an increase in house service stoppages cleared annually, while medium and small systems reported a decrease each year. Overall, the rate of stoppages cleared increased by an average 10 to 20% each year. Increasing numbers of stoppages indicate decreasing performance of the systems. The overall average for house service stoppages cleared is 0.29 stoppages per mile per year.

Table 4-4 Routine Maintenance - Average House Service Stoppages Cleared (stoppages/mi$yr)							
Region	Number of Respondents	1992	1993	1994	1995	1996	5-Year Average stoppage/mi$yr
Central	13	0.47	0.46	0.49	0.48	0.40	0.46
Northeast	3	0.20	0.20	0.17	0.19	0.24	0.20
Northwest	3	0.22	0.26	0.25	0.14	0.14	0.20
Southeast	2	0.26	0.33	0.35	0.63	0.68	0.45
Southwest	6	0.06	0.05	0.05	0.02	0.04	0.04
Size							
Large	13	0.21	0.22	0.25	0.30	0.32	0.26
Medium	10	0.35	0.35	0.35	0.31	0.26	0.32
Small	4	0.38	0.35	0.33	0.27	0.29	0.32
Overall Average	27	0.29	0.29	0.30	0.30	0.29	0.29

Thirty-one agencies reported having routine inspection and service on pump stations between 1992 and 1996. Table 4-5 summarizes the inspections and servicing of pump stations by region and by size. Although the Southeast region has the largest number of pump stations installed, it has the lowest number of inspections between 1994 and 1996. The small systems have the highest inspection and servicing rate.

Table 4-5 Routine Maintenance - Average Inspections & Service of Pump Stations (inspection/pump stations$yr)							
Region	Number of Respondents	1992	1993	1994	1995	1996	5-Year Average inspection/ps$yr
Central	13	140	155	143	144	125	141
Northeast	1	331	340	340	340	365	353
Northwest	4	18	18	18	14	14	16
Southeast	4	1	1	41	44	28	23
Southwest	9	140	74	75	72	73	87
Size							
Large	11	92	87	92	93	90	91
Medium	15	72	84	78	71	65	74
Small	5	30	220	328	184	184	229
Overall Average	31	122	107	106	98	92	105

4.3 Inspection Maintenance

An inspection program is vital to proper maintenance of a wastewater collection system. Without inspections, a maintenance program is difficult to define, since problems cannot be solved if they are not identified. The elements of an inspection program include flow monitoring, manhole inspections, smoke/dye testing, closed circuit television inspection, and private sector inspections. Inspections provide the data necessary for managers to make informed decisions on all maintenance, repair, and rehabilitation actions.

Information regarding the inspection methods and status for the most recent 1-year, 5-year, 10-year, and 20-year time intervals was obtained for each agency. Cumulative numbers of inspections completed for each type of activity were obtained. The inspection maintenance methods by region and by size are summarized in Tables 4-6 through 4-10.

The frequency and types of inspections vary widely from agency to agency.

Table 4-6 summarizes the flow evaluations performed by region and by size in the last 1 year, 5 years, 10 years, and 20 years. The Northwest and Southwest regions reported greater flow monitoring activities than the other regions. Large systems reported more flow monitoring than medium or small systems. Overall, flow monitoring has increased from 8% per year 20 years ago to 33% per year today. Some areas have been monitored more than once and therefore, have been reported as being flow monitored more than once resulting in reported values exceeding 100%.

Table 4-6
Inspection Methods - Flow Evaluation
(cumulative % of system)

Region	Number of Respondents	1-Year	5-Year	10-Year	20-Year
Central	15	26%	53%	74%	83%
Northeast	3	63%	67%	67%	67%
Northwest	3	67%	367%	533%	733%
Southeast	4	15%	43%	43%	43%
Southwest	8	32%	67%	106%	170%
Size					
Large	10	53%	143%	220%	331%
Medium	17	33%	68%	76%	77%
Small	6	2%	35%	74%	91%
Overall Average	33	33%	85%	119%	157%
Average %/Year		33%	17%	12%	8%

Table 4-7 summarizes the manhole inspections status. The Northeast and Southwest regions reported relatively high manhole inspection rates over the past 20 years. The Central region is below the average manhole inspection rate. Large, medium and small systems all reported an average inspection rate greater than 100% over the past ten years. Most regions reported more than 100% manhole inspections during last 5 years. Reported values that exceed 100% indicated that manhole inspections have been conducted more than once in the same area. The overall average reported shows that manhole inspection activity has increased from 10%, 20 years ago, to 26%, 1 year ago.

Table 4-7
Inspection Methods - Manhole Inspection
(cumulative % of system)

Region	Number of Respondents	1-Year	5-Year	10-Year	20-Year
Central	17	17%	48%	73%	76%
Northeast	3	35%	88%	125%	163%
Northwest	4	34%	55%	61%	67%
Southeast	4	19%	144%	144%	145%
Southwest	7	44%	186%	334%	598%
Size					
Large	13	27%	115%	177%	289%
Medium	16	27%	80%	113%	142%
Small	6	24%	70%	109%	130%
Overall Average	35	26%	91%	136%	195%
Average/Year		26%	18%	14%	10%

Table 4-8 summarizes the smoke/dye test by region and by system size. The Southeast region reported the greatest average percentage system smoke/dye testes. Small systems reported the greatest overall smoke/dye testing over the past 20 years but the lowest activity in the past year. The smoke/dye test activity has been increased from 2% per year, 20 years ago, to 8%, 1 year ago.

Table 4-8 Inspection Methods - Smoke/Dye Testing (cumulative % of system)					
Region	Number of Respondents	1-Year	5-Year	10-Year	20-Year
Central	18	12%	21%	31%	38%
Northeast	3	1%	3%	3%	5%
Northwest	4	2%	8%	15%	21%
Southeast	4	13%	123%	123%	123%
Southwest	9	1%	17%	23%	34%
Size					
Large	14	10%	33%	35%	37%
Medium	18	7%	20%	27%	33%
Small	6		33%	42%	60%
Overall Average	38	8%	26%	32%	39%
Average/Year		8%	5%	3%	2%

Note: Blank cells indicate that data were unreported or required data to convert values to rates was unreported.

Table 4-9 summarizes TV inspection activity. Overall, TV inspection has increased from 2% per year 20 years ago to 7% per year a year ago. The Southeast region has shown the highest percentage of TV inspection within the past 5 years.

Table 4-9 Inspection Methods - Television Inspection (cumulative % of system)					
Region	Number of Respondents	1-Year	5-Year	10-Year	20-Year
Central	19	6%	19%	29%	32%
Northeast	3	8%	15%	17%	24%
Northwest	4	7%	36%	45%	55%
Southeast	4	9%	105%	107%	111%
Southwest	9	10%	27%	35%	43%
Size					
Large	15	7%	41%	47%	54%
Medium	18	6%	25%	30%	34%
Small	6	11%	25%	48%	54%
Overall Average	39	7%	31%	39%	44%
Average %/Year		7%	6%	4%	2%

The private sector building inspection activities include area drains, downspouts, cleanouts, sump discharges and other private sector inflow sources into the system. Only twenty-two out of 42 agencies provided private sector building inspection data. Table 4-10 summarizes the cumulative percentage of private sector building inspection. The overall average activity for the private sector building inspection has been increased from 1 percent per year, 20 years ago, to 5 percent, 1 year ago.

Table 4-10
Inspection Methods - Private Sector Building Inspection
(cumulative % of system)

Region	Number of Respondents	1-Year	5-Year	10-Year	20-Year
Central	12	7%	17%	27%	27%
Northeast	1	0%	0.5%	1%	1%
Northwest	2	0%	0%	0%	0%
Southeast	2	12%	50%	50%	50%
Southwest	5	0.2%	20%	20%	20%
Size					
Large	9	4%	15%	16%	17%
Medium	9	8%	18%	18%	18%
Small	4	0.3%	25%	50%	50%
Overall Average	22	5%	18%	24%	24%
Average %/Year		5%	4%	2%	1%

Note: Blank cells indicate that data were unreported or required data to convert values to rates was unreported.

4.4 Rehabilitation Maintenance

A rehabilitation maintenance program is essential to maintaining a wastewater collection system. The percentage of system manholes, sewer lines, relief sewers, and private sector defects which have been rehabilitated (rehabilitation maintenance and status) was summarized. The rehabilitation maintenance status by region and by size is shown in Table 4-11.

Thirty-eight out of 42 agencies reported the rehabilitation maintenance status. The national average for manhole rehabilitation is 42% from this survey. Both large and medium-sized systems are above the average. Central and Northwest region are below the national average in manhole rehabilitation maintenance. The national average for main line or public service connection repairs is 38%. Northeast region has shown a high percentage of repairing rate in main line or public service connection. The national average relief sewer rehabilitation maintenance is 47%. The small systems have the highest maintenance rate of 81%. The national average for private sector maintenance is 28%. Southwest region and small systems have the highest maintenance rate.

Table 4-11
Rehabilitation Maintenance Status

Region	Number of Respondents	Manhole	Main Line or Public Service Connection Repairs	Relief/Equalization	Private Sector
Central	18	35%	33%	42%	21%
Northeast	2	83%	73%	80%	0 %
Northwest	4	35%	28%	50%	34%
Southeast	4	51%	41%	32%	32%
Southwest	10	45%	40%	55%	49%
Size					
Large	14	46%	36%	44%	26%
Medium	18	43%	39%	44%	26%
Small	6	32%	39%	81%	44%
Overall Average	38	42%	38%	47%	28%

Note: Blank cells indicate that data were unreported or required data to convert values to rates was unreported.

4.5 System Maintenance Costs

System maintenance costs were reported by the following categories: relief, equalization, rehabilitation/replacement, routine O&M, equipment replacement, and other costs. Information regarding the total dollars reinvested on system maintenance was obtained for the following time periods:

- 1990 - 1996
- 1980 - 1989
- 1970 - 1979
- pre - 1970

The dollar values listed are as reported and are not adjusted for inflation.

The average cumulative dollars spent on system maintenance is listed in Tables 4-12 through 4-15. The data show a large increase in spending in the 1990s. The rate of spending has increased from $5 per mile per year in pre-1970s to $8,000 per mile per year in the 1990s as indicated in Table 4-16.

Table 4-12
Relief Maintenance Costs by Period

Region	Number of Respondents	Pre-1970 ($/mi·yr)	Number of Respondents	1970-1979 ($/mi·yr)	Number of Respondents	1980-1989 ($/mi·yr)	Number of Respondents	1990-1996 ($/mi·yr)
Central	3	3	5	6,206	9	1,906	17	1,467
Northeast	1	0	1	0	1	0	2	1,730
Northwest	1	0	1	0	1	0	3	907
Southeast	1	0	2	1,057	2	1,216	4	0
Southwest	1	0	2	1,648	7	476	7	1,640
Size								
Large	4	0	4	7,597	6	2,480	13	1,980
Medium	2	5	5	1,093	12	577	15	572
Small	1	0	2	294	2	554	5	1,656
Overall Average		1		3,313		1,146		1,291

Note: Blank cells indicate that data were unreported or required data to convert values to rates was unreported.

Table 4-13
Equalization Costs

Region	Number of Respondents	Pre-1970 ($/mi·yr)	Number of Respondents	1970-1979 ($/mi·yr)	Number of Respondents	1980-1989 ($/mi·yr)	Number of Respondents	1990-1996 ($/mi·yr)
Central	7	0	8	0	8	17	10	257
Northeast								
Northwest								
Southeast	2	0	2	0	2	0	2	1,325
Southwest	4	0	7	130	6	68	6	97
Size								
Large	3	0	4	0	4	0	4	1
Medium	8	0	11	82	10	53	12	482
Small	2	0	2	0	2	6	2	7
Overall Average		0		53		34		322

Note: Blank cells indicate that data were unreported or required data to convert values to rates was unreported.

Table 4-14
Rehabilitation/Replacement Costs by Period

Region	Number of Respondents	Pre-1970 ($/mi·yr)	Number of Respondents	1970-1979 ($/mi·yr)	Number of Respondents	1980-1989 ($/mi·yr)	Number of Respondents	1990-1996 ($/mi·yr)
Central	3	2	6	1,209	9	1,176	14	3,583
Northeast	1	3	1	143	1	1,718	1	1,270
Northwest	1	0	1	0	1	0	2	2,517
Southeast	2	0	3	106	3	65	3	1,098
Southwest	2	0	2	0	8	516	8	2,456
Size								
Large	2	0	5	593	6	1,269	9	3,229
Medium	5	1	6	39	13	260	15	1,317
Small	1	0	2	2,205	3	1,876	4	7,650
Overall Average		1		585		756		2,836

Note: Blank cells indicate that data were unreported or required data to convert values to rates was unreported.

Table 4-15
O&M Budget by Period

Region	Number of Respondents	Pre-1970 ($/mi yr)	Number of Respondents	1970-1979 ($/mi$yr)	Number of Respondents	1980-1989 ($/mi$yr)	Number of Respondents	1990-1996 ($/mi$yr)
Central	3	7	7	766	11	2,063	18	2,260
Northeast	1	0	1	0	1	488	2	7,350
Northwest			1	0	1	0	3	2,960
Southeast	1	0	1	0	2	0	3	2,988
Southwest			1	1,329	6	1,247	9	2,657
Size								
Large	2	0	5	695	10	1,481	13	3,945
Medium	3	4	5	302	9	1,273	17	1,548
Small			1	941	2	1,163	5	4,051
Overall Average		3		539		1,362		2,796

Note: Blank cells indicate that data were unreported or required data to convert values to rates was unreported.

Table 4-16
Rate of Spending

Reinvestment Category	Number of Respondents	Pre-1970 ($/mi yr)	Number of Respondents	1970-1979 ($/mi$yr)	Number of Respondents	1980-1989 ($/mi$yr)	Number of Respondents	1990-1996 ($/mi$yr)
Relief	7	1	11	3,313	20	1,146	33	1,291
Equalization	13	0	17	53	16	34	18	322
Rehabilitation	8	1	13	585	22	756	28	2,836
O&M	5	3	11	539	21	1,362	35	2,796
Equipment	5	0	6	9	8	34	15	117
Other	2	0	2	0	5	512	5	647
Total		5		4,499		3,844		8,009

Note: Blank cells indicate that data were unreported or required data to convert values to rates was unreported.

5.0 System Maintenance Frequency Determination

5.1 Introduction

Maintenance, as defined in the broad sense used in this study, includes any collection system reinvestment in the form of capital improvements, rehabilitation, inspection, and what is typically considered routine maintenance. All maintenance activities are not equally effective. Therefore, when evaluating how much maintenance an agency is doing, what is of real interest is how much *effective* maintenance it is doing. For example, if an agency was performing only CCTV inspections and nothing else, even though considerable time and effort may be going into the CCTV inspection, little system improvement would result. The CCTV is effective only if it is done in concert with other activities such as removing blockages and debris or repairing defects. In other words, an effective maintenance program requires a balance of activities. This chapter presents an evaluation of maintenance and a determination of a maintenance frequency for the agencies surveyed.

5.2 Weighting of Maintenance Activities

In order to evaluate the relative importance of activities necessary to develop a system maintenance frequency, each agency was requested to provide an opinion of the relative importance of twelve common maintenance activities. The most important maintenance activity, as selected by the agencies surveyed, is line cleaning, which averaged almost 18% of the total maintenance weight assigned. The next three activities, listed in descending order of importance, are pump station servicing (14.1%), main line rehabilitation (12.6%), and closed circuit television inspection (10.5%). The three least important activities, as selected by the agencies surveyed, are manhole rehabilitation (5.6%), smoke testing (3.3%), and private sector inspections (2.0%). These maintenance activities and their average weight of importance are listed in Table 5-1. Average percentages were adjusted proportionately, so that the total of all maintenance items was equal to 100 percent.

Table 5-1 Average Weight of Maintenance Activity		
Activity	Relative Importance (Weight)	Number of Responses
1. Cleaning	17.7%	36
2. Root removal	8.4%	36
3. Pump station service	14.1%	36
4. Flow monitoring	7.0%	33
5. Manhole inspection	6.4%	35
6. Smoke testing	3.3%	31
7. CCTV	10.5%	34
8. Private sector inspections	2.0%	32
9. Manhole rehabilitation	5.6%	37
10. Main line rehabilitation	12.6%	36
11. Relief construction	6.3%	35
12. Private sector I/I removal	6.1%	34
Total	100%	

The variations in weights by region and by size category are presented in Appendix C. The relative importance by region and size was similar for all regions except for the Southeast region which placed a higher importance on pump station servicing than other regions, and for the Central region which placed a higher importance on main line rehabilitation. Because of the small sample within each category (region and size), the overall average weights of maintenance activities were used in the analysis reported herein.

5.3 Development of Maintenance Frequency

The system maintenance frequency for each agency was developed using the maintenance activity weight (importance) as discussed in Section 5.2, a calculated standard rating based on a normal distribution of maintenance rates, and the assigned maintenance frequencies.

5.3.1 Determining Maintenance Rates

All maintenance activity quantities were converted into unit rates. For example, miles of sewer cleaned was converted into miles of sewer cleaned per year. For annual maintenance activities, data for the past five years were used as a basis for the analysis, since this period was considered representative of the best data. For Aone-time@ maintenance activities such as rehabilitation, an estimate of the needed rehabilitation completed was used. For example, if over the life a system, 50% of the manholes were identified as needing rehabilitation and no repairs had been made, 0% of manhole rehabilitation would have been completed. Likewise, if 25% of the total number of manholes in this same system had been repaired (50% of manholes needing rehabilitation), then 50% of manhole rehabilitation would have been completed, and so on. The time interval during which rehabilitation was done was assumed to be the most recent 25 years, which approximates the life expectancy of many rehabilitation methods. The maintenance done by the agencies surveyed is presented in Table 5-2 and the maintenance rates are given in Table 5-3. To determine maintenance rates, the average miles of sewer installed were estimated over the maintenance period, based on the age information provided by each agency.

5.3.2 Developing the Standard Rating

A standardized table was developed using the maintenance data collected and a normal distribution. The mean, standard deviation, range, and number of responses for each maintenance activity are listed in Table 5-4. The rate of each maintenance activity was normalized using the normal distribution to develop a standard by which any maintenance rate, or group of maintenance rates from various maintenance activities, could be compared. The frequency of individual maintenance activities can be easily determined; however, the overall system maintenance frequency, considering all maintenance activities, requires a method to standardize and weight all maintenance activities. Once the maintenance data was normalized, a frequency was assigned to correspond to selected standard deviations from the mean. The assignment of the standard maintenance frequency was somewhat arbitrary; however, based on previous reports (Nelson) a 5 to 10 percent overall average frequency goal was assumed to be reasonable. Through trial and error, an average maintenance frequency of 6.7% for all agencies was chosen. This is discussed in more detail in Section 5.4. The selected frequencies corresponding to the normalized data are listed in Table 5-5.

Table 5-2
Maintenance Performed

Utility No.	Cleaning 1992 -1996, miles	Root Removal 1992 - 1996, miles	Lift Station Inspections 1992 - 1996	% Flow Monitoring Last 5 Yr	% Manhole Inspections Last 5 Yr.	% Smoke/Dye Test Last 5 Yr.	% CCTV Last 5 Yr.	% Private Sector Last 5 YR.	% Manhole Rehabbed	% Main Line Rehabbed	% Relief/ Equal Completed	% Private Sector Completed
1	1,282	280	75,900	100%	10%	5%	15%	1%	75%	50%	80%	
2	780	103	1,148		80%		10%		20%	50%		10%
3	204	0	45,500	10%	10%		15%		33%	29%	62%	69%
4	50	9	75,000	200%	40%	2%	20%		90%			
5			16,770		50%		5%		75%	75%		
6	2,280	0		17%	50%	17%	23%		20%	20%	5%	
7	42	0	9,000	100%	47%		47%		100%	100%	100%	100%
8				30%	20%	20%	10%		30%	40%	50%	
9	828		1,000	5%	4%	5%	48%		25%	50%		
10			29,912									
11	1,869			200%		3%	6%		10%	2%		1%
12	269	108			50%	3%	7%					
13	4,123		4,176	500%	1%	1%	15%		0%	1%		
14				250%	500%		37%		56%	56%	67%	
15	9,984	0	500		100%	1%	45%		100%	100%	100%	100%
16	953			20%	50%	50%	50%		5%	10%		5%
17	4,258	284	3,328	20%	20%	20%	18%	20%	40%	50%	80%	90%
18					18%	50%	8%		2%	2%	20%	
19	145	21	3,851	25%	32%	26%	25%		40%	30%	60%	
20			135,220	100%	100%	100%	100%	100%	96%	70%	25%	95%
21	50	0		30%	90%		90%		100%	90%		
22	1,111		14,104	100%	250%	50%	8%		100%	100%	100%	100%
23	5,417	2	9,360		200%	1%	65%		1%	1%		
24	3,851	29	39,182	45%	211%	84%	27%	70%	30%	30%	60%	30%
25									5%	1%		1%
26	991	118	970	100%	50%		75%			25%	10%	n/a
27	935	480	52,610	75%	50%	15%	8%	3%	20%	20%	10%	5%
28	3,565	5	676									
29	486			80%	54%		11%					
30	6,000			5%			6%		5%	5%	10%	
31	3,760	2,564			368%	218%	222%		5%	3%	50%	
32		0		20%	200%				90%	95%		
33												
34									40%	44%	35%	17%
35	739		260		100%		7%		25%	25%	50%	
36	1,075	30	20,800	55%	95%	60%	17%	85%	20%	15%		
37	2,814	39				3%	7%			31%		
38	124	0	8,700	75%	105%	101%	33%	101%	20%	2%	100%	95%
39	880			500%	100%		60%			5%		3%
40	75			100%	20%	25%	25%		5%	5%		
41	3,539	1,783							99%	100%	100%	100%
42	844	20		2%	100%		5%		95%	60%		
	32	23	22	27	33	23	35	7	34	36	21	17
	count	count	count	count	count	count	count	count	count	count	count	count
	1979	255	24908	102%	96%	37%	33%	54%	43%	39%	56%	48%
	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg
	2209	614	33367	1.29	1.07	0.50	0.41	0.42	0.37	0.33	0.33	0.44
	sd	sd	sd	sd	sd	sd	sd	sd	sd	sd	sd	sd

Note: Blank cells indicate that data was unreported.

Table 5-3
Reported Maintenance Rates

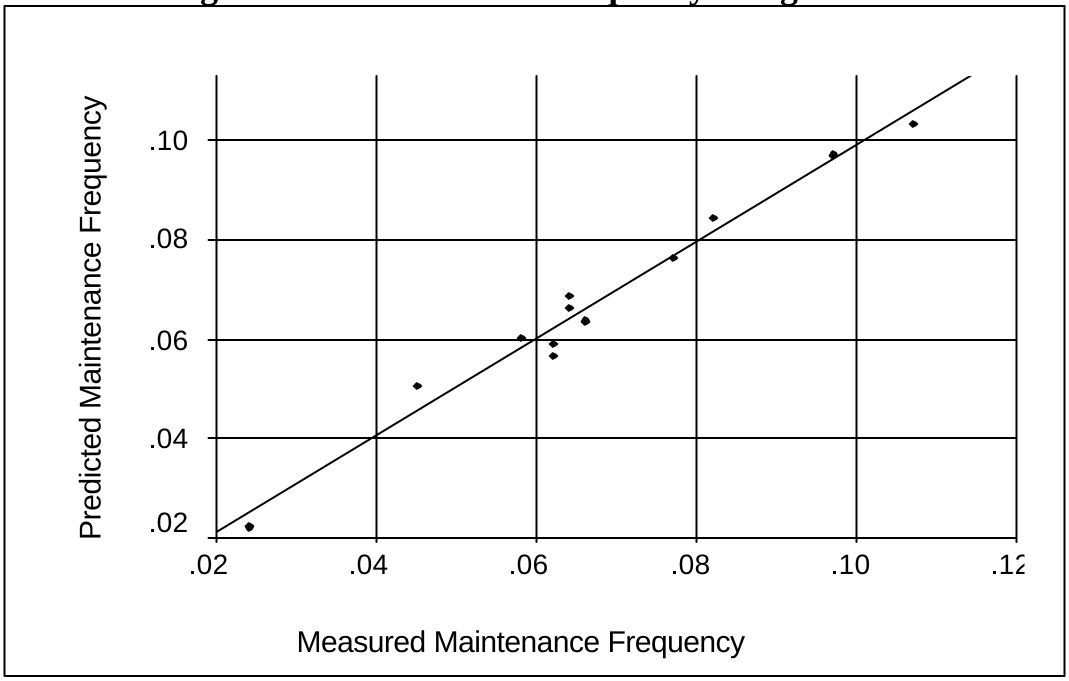
Utility	Cleaning Rate, % system/year	Root Cutting, % System/yr	Lift Station Rate, no/ls/yr	Flow Monitoring Rate,% System/yr	Manhole Inspect. % System/yr	Smoke/dye Rate, % System/yr	CCTV Rate, % System/yr	Private Sector Inspection Rate, % System/yr	Manhole Rehab Status	Main Line Rehab Status	Sewer Relief Status	Private I/I Removal Rating
1	0.052	0.011	353	0.200	0.020	0.010	0.030	0.001	0.750	0.500	0.800	
2	0.373	0.049	21		0.160		0.020		0.200	0.500		0.100
3	0.214	0.000	569	0.020	0.020		0.030		0.330	0.290	0.620	0.690
4	0.020	0.003	246	0.400	0.080	0.004	0.040		0.900			
5			16		0.100		0.010		0.750	0.750		
6	0.507	0.000		0.034	0.100	0.034	0.046		0.200	0.200	0.050	
7	0.070	0.000	106	0.200	0.094		0.094		1.000	1.000	1.000	1.000
8				0.060	0.040	0.040	0.020		0.300	0.400	0.500	
9	0.552		50	0.010	0.008	0.010	0.096		0.250	0.500		
10			46									
11	0.185			0.400		0.006	0.012		0.100	0.020		0.010
12	0.022	0.009			0.100	0.006	0.014					
13	0.254		12	1.000	0.001	0.001	0.030		0.001	0.010		
14				0.500	1.000		0.074		0.560	0.560	0.670	
15	1.288	0.000	25		0.200	0.002	0.090		1.000	1.000	1.000	1.000
16	0.085			0.040	0.100	0.100	0.100		0.050	0.100		0.050
17	0.212	0.014	42	0.040	0.040	0.040	0.036	0.040	0.400	0.500	0.800	0.900
18					0.036	0.100	0.017		0.020	0.020	0.200	
19	0.036	0.005	22	0.050	0.064	0.052	0.050		0.400	0.300	0.600	
20			29	0.200	0.200	0.200	0.200	0.200	0.960	0.700	0.250	0.950
21	0.313	0.000		0.060	0.180		0.180		1.000	0.900		
22	0.155		88	0.200	0.500	0.100	0.016		0.999	1.000	1.000	1.000
23	0.272	0.000	99		0.400	0.002	0.130		0.010	0.010		
24	0.440	0.003	137	0.090	0.422	0.168	0.054	0.140	0.300	0.300	0.600	0.300
25									0.050	0.010		0.010
26	0.227	0.027	7	0.200	0.100		0.150			0.250	0.100	
27	0.106	0.054	301	0.150	0.100	0.030	0.016	0.006	0.200	0.200	0.100	0.050
28	0.625	0.001	68									
29	0.119			0.160	0.108		0.022					
30	0.440			0.010			0.012		0.050	0.050	0.100	
31	0.289	0.197			0.736	0.436	0.444		0.050	0.030	0.500	
32		0.000		0.040	0.400				0.900	0.950		
33												
34									0.400	0.440	0.350	0.170
35	0.270		10		0.200		0.014		0.250	0.250	0.500	
36	0.227	0.006	130	0.110	0.190	0.120	0.034	0.170	0.200	0.150		
37	0.352	0.005				0.007	0.014			0.310		
38	0.623	0.000	348	0.150	0.210	0.202	0.066	0.202	0.200	0.020	1.000	0.950
39	0.236			1.000	0.200		0.120			0.050		0.030
40	0.125			0.200	0.040	0.050	0.050		0.050	0.050		
41	0.556	0.280							0.990	0.999	1.000	1.000
42	0.322	0.008		0.004	0.200		0.010		0.950	0.600		
	29.9%	2.9%	123.781	0.205	0.192	0.075	0.067	0.108	0.434	0.387	0.559	0.513
	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg
	32	23	22	27	33	23	35	7	34	36	21	16
	count	count	count	count	count	count	count	count	count	count	count	count
	24.8%	6.7%	144.801	0.257	0.213	0.099	0.082	0.083	0.366	0.334	0.329	0.434
	sd	sd	sd	sd	sd	sd	sd	sd	sd	sd	sd	sd
	129%	28%	568.750	1.000	1.000	0.436	0.444	0.202	1.000	1.000	1.000	1.000
	max	max	max	max	max	max	max	max	max	max	max	max
	2%	0%	7.185	0.004	0.001	0.001	0.010	0.001	0.001	0.010	0.050	0.010
	min	min	min	min	min	min	min	min	min	min	min	min

Table 5-4 Maintenance Activity Statistics				
Activity	Mean	Standard Deviation	Range	Number of Responses
1. Cleaning, % system/yr	29.9%	24.8%	2% - 129%	32
2. Root removal, % system/yr	2.9%	6.7%	0% - 28%	23
3. Pump station service, no/ps/yr	123.8	144.8	7.2-569	22
4. Flow monitoring, % system/yr	20.5%	25.7%	0.4% - 100%	27
5. Manhole inspection, %system/yr	19.2%	21.3%	0.1% - 100%	33
6. Smoke testing, %system/yr	7.5%	9.9%	0.1% - 43.6%	23
7. CCTV, % system/yr	6.7%	8.2%	1.0% - 44.4%	35
8. Private sector inspections, % system/yr	10.8%	8.3%	0.1% - 20.2%	7
9. Manhole rehabilitation, % complete	43.4%	36.6%	0.1% - 100%	34
10. Main line rehabilitation, % complete	38.7%	33.4%	0.1% - 100%	36
11. Relief construction, % complete	55.9%	32.9%	5% - 100%	21
12. Private sector I/I removal, % complete	51.3%	43.3%	0.1% - 100%	16

The relationship between maintenance activity rate and maintenance frequency was determined by setting a maintenance frequency of 10 percent equal to the mean value for each maintenance activity and assigning corresponding maintenance frequencies on either side of the mean based on the area under the normal curve. The selection of 10 percent maintenance frequency association with the mean maintenance rate assumes that on average, most systems will perform 100 percent of maintenance activities in a 10 year period. The maintenance frequencies assigned to each deviation from the mean are shown on Figure 5-1.

Table 6.5 Standardized Maintenance Frequency Table by Maintenance Rate																			
Activity	No. Reporting	Avg.	sd	-2sd -2	-1.5sd -1.5	-1.0sd -1	-0.75sd -0.75	-0.50sd -0.5	-0.25sd -0.25	x 0	+0.25sd 0.25	+0.50sd 0.5	+0.75sd 0.75	+1.00sd 1	+1.25sd 1.25	+1.50sd 1.5	+1.75sd 1.75	+2.0sd 2	+3.00sd 3
Cleaning	32	0.299	0.248	-0.20	-0.07	0.05	0.11	0.18	0.24	0.30	0.36	0.42	0.48	0.55	0.61	0.67	0.73	0.79	1.04
Root Removal	23	0.029	0.067	-0.11	-0.07	-0.04	-0.02	-0.00	0.01	0.03	0.05	0.06	0.08	0.10	0.11	0.13	0.15	0.16	0.23
LS Service	22	123.781	144.801	-165.82	-93.42	-21.02	15.18	51.38	87.58	123.78	159.98	196.18	232.38	268.58	304.78	340.98	377.18	413.38	558.18
Flow Monitoring	27	0.205	0.257	-0.31	-0.18	-0.05	0.01	0.08	0.14	0.20	0.27	0.33	0.40	0.46	0.53	0.59	0.65	0.72	0.98
Manhole Inspection	33	0.192	0.213	-0.23	-0.13	-0.02	0.03	0.09	0.14	0.19	0.25	0.30	0.35	0.41	0.46	0.51	0.57	0.62	0.83
Smoke/Dye Test	23	0.075	0.099	-0.12	-0.07	-0.02	0.00	0.03	0.05	0.07	0.10	0.12	0.15	0.17	0.20	0.22	0.25	0.27	0.37
CCTV	35	0.067	0.082	-0.10	-0.06	-0.01	0.01	0.03	0.05	0.07	0.09	0.11	0.13	0.15	0.17	0.19	0.21	0.23	0.31
Private Sector Inspections	7	0.108	0.083	-0.06	-0.02	0.03	0.05	0.07	0.09	0.11	0.13	0.15	0.17	0.19	0.21	0.23	0.25	0.28	0.36
Manhole Rehabilitation	34	0.434	0.366	-0.30	-0.12	0.07	0.16	0.25	0.34	0.43	0.53	0.62	0.71	0.80	0.89	0.98	1.08	1.17	1.53
Main Line Rehabilitation	36	0.387	0.334	-0.28	-0.11	0.05	0.14	0.22	0.30	0.39	0.47	0.55	0.64	0.72	0.80	0.89	0.97	1.05	1.39
Sewer Relief	21	0.559	0.329	-0.10	0.07	0.23	0.31	0.39	0.48	0.56	0.64	0.72	0.81	0.89	0.97	1.05	1.14	1.22	1.55
Private I/I Removal	16	0.513	0.434	-0.35	-0.14	0.08	0.19	0.30	0.40	0.51	0.62	0.73	0.84	0.95	1.06	1.16	1.27	1.38	1.82
Standardized Maintenance Frequency:				0%	1%	3%	5%	6%	8%	10%	12%	14%	15%	17%	18%	19%	19%	20%	20%
Areas Under Normal Curve (=1.00):				0.0228	0.0668	0.1587	0.2266	0.3085	0.4013	0.5	0.5987	0.6915	0.7734	0.8413	0.8944	0.9332	0.9599	0.9772	0.9987
sd = standard deviation																			
x = mean																			

Figure 5-1 Maintenance Frequency Assignments



5.4 Determination of Maintenance Frequency

An overall maintenance frequency for each agency was determined by applying the actual maintenance rates reported from Table 5-3, the relative weight for each maintenance activity from Table 5-1, and the corresponding standard activity maintenance frequency using Table 5-5. Average maintenance activity rates were used for missing data to estimate the maintenance frequency for each agency. The range and mean of the maintenance frequencies derived is presented in Table 5-6 and shown on the distribution curve on

Figure 5-2. The system maintenance frequency determined for each agency is presented in Table 5-7.

Table 5-6 Calculated Maintenance Frequencies

Utility No. 5	Cleaning Rating	Root Cutting Rating	Lift Station Rating	Flow Monitoring Rating	Manhole Inspect Rating	Smoke/dye Rating	CCTV Rating	Private Sector Inspection Rating	Manhole Rehab Rating	Main Line Rehab Rating	Sewer Relief Rating	Private I/I Removal Rating	Total Maintenance Frequency Rating
	17.7%	8.4%	14.1%	7.0%	6.4%	3.3%	10.5%	2.0%	5.6%	12.6%	6.3%	6.1%	100.0%
1	0.6%	0.5%	2.6%	0.6%	0.2%	0.1%	0.6%	0.0%	0.9%	1.5%	0.9%	0.1%	8.6%
2	2.1%	1.0%	0.6%	0.2%	0.5%	0.1%	0.5%	0.0%	0.3%	1.5%	0.0%	0.2%	7.1%
3	1.1%	0.5%	2.8%	0.3%	0.2%	0.1%	0.6%	0.0%	0.3%	0.8%	0.6%	0.7%	8.2%
4	0.2%	0.5%	2.2%	1.1%	0.3%	0.1%	0.6%	0.0%	1.0%	0.2%	0.0%	0.1%	6.4%
5	0.2%	0.5%	0.6%	0.2%	0.4%	0.1%	0.5%	0.0%	0.9%	2.1%	0.0%	0.1%	5.7%
6	2.7%	0.5%	0.4%	0.3%	0.4%	0.2%	0.6%	0.0%	0.3%	0.6%	0.0%	0.1%	6.2%
7	0.6%	0.5%	1.1%	0.6%	0.4%	0.1%	1.3%	0.0%	1.0%	2.4%	1.1%	1.0%	10.2%
8	0.2%	0.5%	0.4%	0.3%	0.3%	0.2%	0.5%	0.0%	0.3%	1.3%	0.5%	0.1%	4.7%
9	3.0%	0.5%	0.6%	0.2%	0.2%	0.1%	1.3%	0.0%	0.3%	1.5%	0.0%	0.1%	7.9%
10	0.2%	0.5%	0.6%	0.2%	0.2%	0.1%	0.3%	0.0%	0.1%	0.2%	0.0%	0.1%	2.6%
11	1.1%	0.5%	0.4%	1.1%	0.2%	0.1%	0.5%	0.0%	0.2%	0.2%	0.0%	0.1%	4.5%
12	0.2%	0.5%	0.4%	0.2%	0.4%	0.1%	0.5%	0.0%	0.1%	0.2%	0.0%	0.1%	2.8%
13	1.4%	0.5%	0.4%	1.4%	0.2%	0.1%	0.6%	0.0%	0.1%	0.2%	0.0%	0.1%	5.2%
14	0.2%	0.5%	0.4%	1.2%	1.3%	0.1%	1.1%	0.0%	0.7%	1.7%	0.8%	0.1%	8.1%
15	3.5%	0.5%	0.6%	0.2%	0.6%	0.1%	1.3%	0.0%	1.0%	2.4%	1.1%	1.0%	12.6%
16	0.6%	0.5%	0.4%	0.3%	0.4%	0.4%	1.3%	0.0%	0.1%	0.4%	0.0%	0.1%	4.5%
17	1.1%	0.7%	0.6%	0.3%	0.3%	0.2%	0.6%	0.1%	0.4%	1.5%	0.9%	0.9%	7.7%
18	0.2%	0.5%	0.4%	0.2%	0.3%	0.4%	0.5%	0.0%	0.1%	0.2%	0.1%	0.1%	3.0%
19	0.2%	0.5%	0.6%	0.3%	0.3%	0.3%	0.8%	0.0%	0.4%	0.8%	0.6%	0.1%	5.1%
20	0.2%	0.5%	0.6%	0.6%	0.6%	0.6%	2.0%	0.3%	1.0%	1.9%	0.2%	1.0%	9.7%
21	1.8%	0.5%	0.4%	0.3%	0.5%	0.1%	1.9%	0.0%	1.0%	2.4%	0.0%	0.1%	9.1%
22	0.8%	0.5%	1.1%	0.6%	1.1%	0.4%	0.5%	0.0%	1.0%	2.4%	1.1%	1.0%	10.7%
23	1.4%	0.5%	1.1%	0.2%	1.0%	0.1%	1.6%	0.0%	0.1%	0.2%	0.0%	0.1%	6.4%
24	2.4%	0.5%	1.4%	0.4%	1.1%	0.5%	0.8%	0.2%	0.3%	0.8%	0.6%	0.4%	9.6%
25	0.2%	0.5%	0.4%	0.2%	0.2%	0.1%	0.3%	0.0%	0.1%	0.2%	0.0%	0.1%	2.4%
26	1.1%	0.7%	0.4%	0.6%	0.4%	0.1%	1.8%	0.0%	0.1%	0.8%	0.1%	0.1%	6.1%
27	0.6%	1.0%	2.4%	0.6%	0.4%	0.2%	0.5%	0.0%	0.3%	0.6%	0.1%	0.1%	6.6%
28	3.2%	0.5%	0.9%	0.2%	0.2%	0.1%	0.3%	0.0%	0.1%	0.2%	0.0%	0.1%	5.8%
29	0.8%	0.5%	0.4%	0.6%	0.4%	0.1%	0.5%	0.0%	0.1%	0.2%	0.0%	0.1%	3.7%
30	2.4%	0.5%	0.4%	0.2%	0.2%	0.1%	0.5%	0.0%	0.1%	0.2%	0.1%	0.1%	4.9%
31	1.4%	1.6%	0.4%	0.2%	1.3%	0.7%	2.1%	0.0%	0.1%	0.2%	0.5%	0.1%	8.6%
32	0.2%	0.5%	0.4%	0.3%	1.0%	0.1%	0.3%	0.0%	1.0%	2.4%	0.0%	0.1%	6.4%
33	0.2%	0.5%	0.4%	0.2%	0.2%	0.1%	0.3%	0.0%	0.1%	0.2%	0.0%	0.1%	2.4%
34	0.2%	0.5%	0.4%	0.2%	0.2%	0.1%	0.3%	0.0%	0.4%	1.3%	0.3%	0.2%	4.3%
35	1.4%	0.5%	0.4%	0.2%	0.6%	0.1%	0.5%	0.0%	0.3%	0.8%	0.5%	0.1%	5.5%
36	1.1%	0.5%	1.4%	0.4%	0.5%	0.4%	0.6%	0.3%	0.3%	0.6%	0.0%	0.1%	6.2%
37	1.8%	0.5%	0.4%	0.2%	0.2%	0.1%	0.5%	0.0%	0.1%	1.0%	0.0%	0.1%	5.0%
38	3.2%	0.5%	2.6%	0.6%	0.6%	0.6%	0.8%	0.3%	0.3%	0.2%	1.1%	1.0%	11.9%
39	1.1%	0.5%	0.4%	1.4%	0.6%	0.1%	1.5%	0.0%	0.1%	0.2%	0.0%	0.1%	6.0%
40	0.8%	0.5%	0.4%	0.6%	0.3%	0.3%	0.8%	0.0%	0.1%	0.2%	0.0%	0.1%	4.1%
41	3.0%	1.7%	0.4%	0.2%	0.2%	0.1%	0.3%	0.0%	1.0%	2.4%	1.1%	1.0%	11.6%
42	1.8%	0.5%	0.4%	0.2%	0.6%	0.1%	0.5%	0.0%	1.0%	1.7%	0.0%	0.1%	7.1%
	1.2%	0.6%	0.8%	0.4%	0.5%	0.2%	0.8%	0.1%	0.4%	1.0%	0.3%	0.3%	6.6%
	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg
	42	42	42	42	42	42	42	42	42	42	42	42	42
	count	count	count	count	count	count	count	count	count	count	count	count	count
	1.0%	0.3%	0.7%	0.3%	0.3%	0.2%	0.5%	0.1%	0.4%	0.8%	0.4%	0.4%	2.6%
	sd	sd	sd	sd	sd	sd	sd	sd	sd	sd	sd	sd	Sd
													2.4%
													min
													12.6%
													max

Figure 5-2 Collection System Maintenance Frequency Distribution

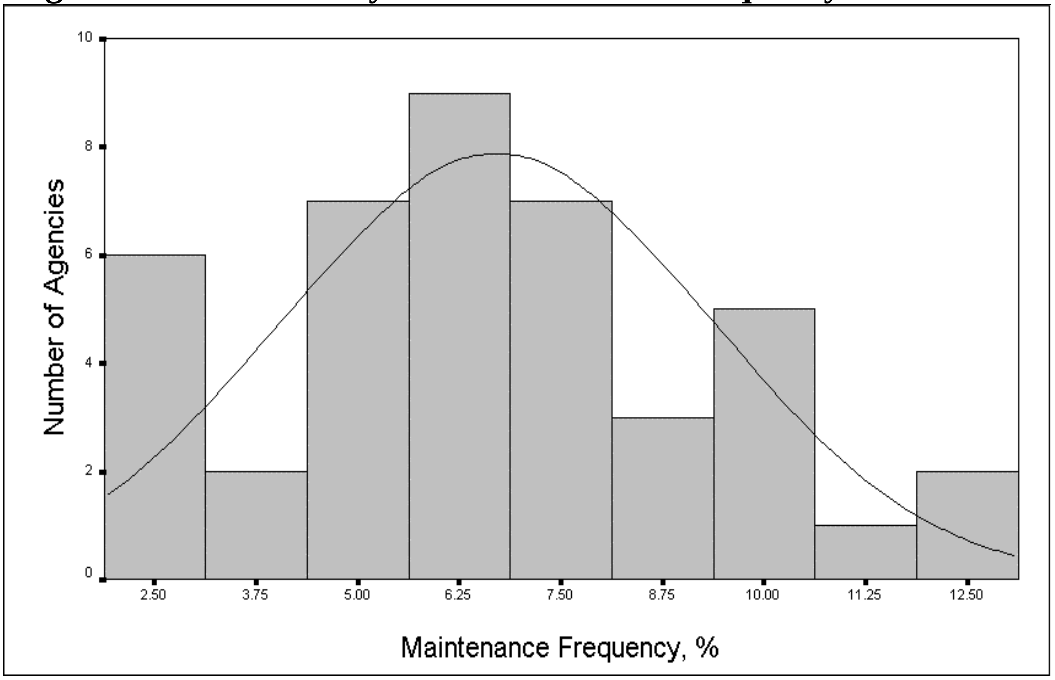


Table 5-7 **Range and Mean of System Maintenance Frequencies**	
Estimate	Value
Mean	.6%
Minimum	2.4%
Maximum	12.6%

5.5 Performance Indicators

The objective of system maintenance is to provide a properly operating collection system. The effectiveness of maintenance can be evaluated by improvement in system performance. Performance measures considered in this study include customer complaints, manhole overflows, pipe failures, pump station failures, and the ratio of peak hourly flow to average daily flow (ADF), and peak monthly flow to ADF. The relationship between system maintenance frequency and performance is explored in the next section.

5.6 Regression Analysis for Maintenance Frequency

Multiple linear regression analysis involves determining and measuring the relationship between three or more variables. In this respect, regression deals with determining a quantitative expression to describe the relationship, while correlation deals with the measurement of the extent of the relationship. Linear regression is a procedure of estimating a linear relationship between a dependent variable, and one or more independent variables. The general form of a multiple regression equation is:

$$Y= B1 + B2X1 + ...BnXn\text{-}1 +e$$

Where:

Y = dependent variable

Xi = ith independent variable for I=1...n

Bi = ith coefficient for Xi

e = random error

The variable Ae@ is a random error parameter and is assumed to have a normal distribution with a mean of zero and a constant variance for all values of independent variables. The multiple regression used in the model building process uses the least square method to estimate the coefficients. All regression analyses were performed using the SPSS statistical software package for Windows Release 6.0 .

Regression analyses were performed using the derived maintenance frequency as the dependent variable and various sets of independent variables. The purpose of this analysis was to explore the relationship, if any, between calculated maintenance frequency and key independent variables, including performance measures, the number of pump stations, the size of the agency, and the regional location of the agency, which may tend to result in the need for maintenance. The independent variables considered for analysis, were selected from the list of data requested from the agencies and are summarized in Table 5-8.

Table 5-8

Potential Independent Variables Related to Maintenance Frequency

Variable	Unit	Code
Customer Complaints - last 5 years	Complaints/mile$year	CUSTC_5
Manhole and Treatment Overflows last 5 years	Overflows/mile$year	MHOF_5
Pipe Failures - last 5 years	Failures/mile$year	PIPEF_5
Pump Station Failures - last 5 years	Failures/pump station$year	PSF_5
Pump Station Number	Number of pump stations	PS_NO
Size of Agency	Based on size designation - small, medium, large	SIZE_CD
Location of Agency	Based on regional codes established for this project	REG_CD
Ratio of Peak Hourly Flow to Annual Average Flow	Ratio	PH_ADF
Ratio of Peak Monthly Flow to Annual Average Flow	Ratio	PM_ADF

Note: The code is used in the SPSS statistical software package and is listed here for reference.

A number of regression analyses were performed to evaluate possible relationships. Out of the many analyses performed, nine are documented in this report. The coefficients of determination (R^2) for the nine documented analyses are presented in Table 5-9. The analyses show that the best R^2 is obtained when all nine independent variables are considered. The R^2 values show that the estimate of the maintenance frequency is highly dependent on customer complaints, manhole overflows, size characteristics, regional characteristics, peak hour/ADF ratio, and pump station failure rates. The Size Code is 1 = small, 2 = medium, 3 = large, and the Regional Code is 1 = central, 2 = northeast, 3 = northwest, 4 = southeast, and 5 = southwest. The regression equation coefficients for the four best relationships (R^2 greater than 0.80) are presented in Table 5-10. These regression coefficients were used to estimate the maintenance frequency from those agencies that provided complete information. Only 12 agencies provided all the data necessary for the regression analysis. The results presented on Figure 5-3 show good agreement between the calculated (from Table 5-7) and the predicted maintenance frequency using Equation MF1 in Table 5-10. The results on Figure 5-3 indicate that system performance measures and system maintenance frequencies may be related.

Table 5-9
Regression Analysis for Maintenance Frequency

No. Var	Independent Variables									Coefficient of Determination		Selected Regression Analyses R^2>0.80	Equation Name
	Customer Complaints	Manhole Overflows	Pipe Failures	Size Code	Region Code	Peak Hour/ADF	Peak Month/ADF	Pump Station Failure	Pump Station Quantity	R^2	Adjusted R^2 (1)		
9	X	X	X	X	X	X	X	X	X	0.975	0.863	X	MF1
8	X	X	X	X	X	X		X	X	0.896	0.619	X	MF2
7	X	X	X	X	X	X		X		0.827	0.523	X	MF3
7	X	X	X	X	X	X			X	0.495	0.053		
6	X	X	X	X	X			X		0.593	0.276		
6	X	X	X	X		X		X		0.609	0.140		
6		X	X	X	X	X		X		0.318	-0.054		
6	X		X	X	X	X		X		0.639	0.422		
6	X	X		X	X	X		X		0.826	0.618	X	MF5

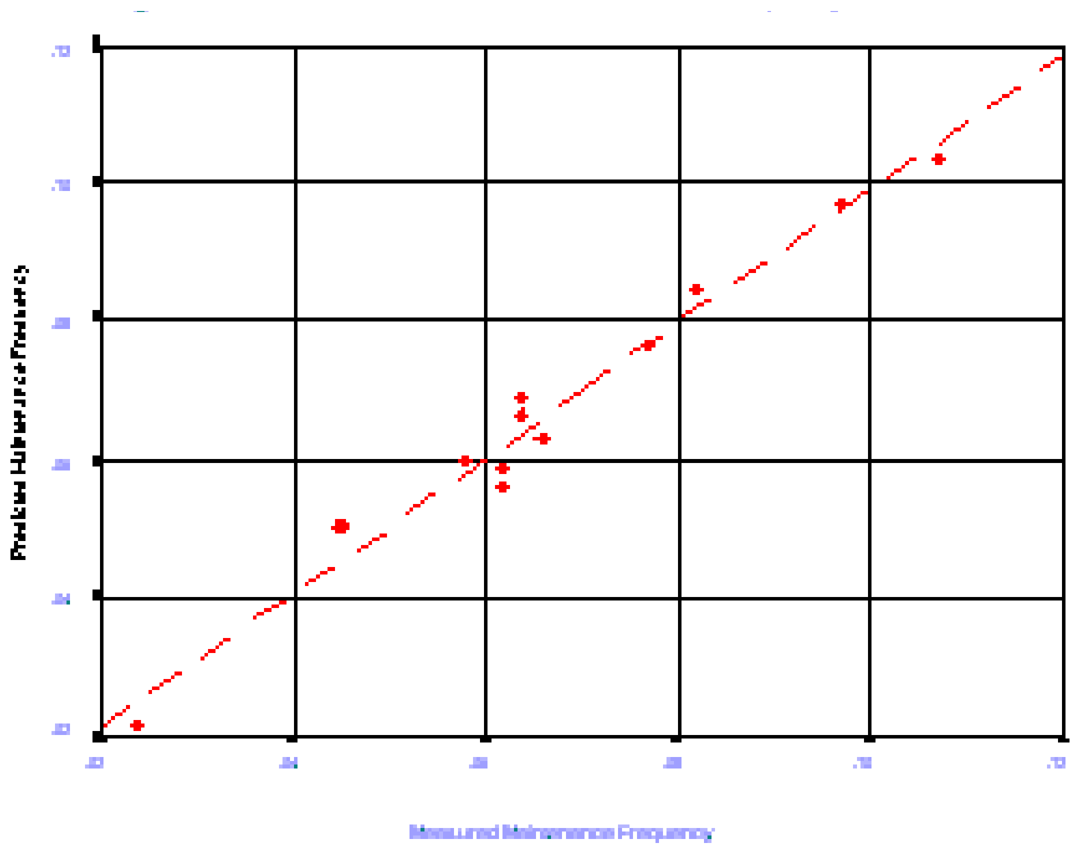
(1) The adjusted R^2 statistic attempts to model R^2 to more closely reflect the goodness of fit of the model in the population. (pg. 318 SPSS Manual)

$$R^2 = R^2 - \frac{P(1-R^2)}{N-P-1}$$

Table 5-10
Regression Coefficients for Maintenance Frequencies

Item	Linear Regression Equation Coefficients			
	Equation MF1	Equation MF2	Equation MF3	Equation MF4
Constant	-0.107	-0.123	0.0796	0.0804
Customer Complaints	-0.0484	-.00041	-0.00156	0.00152
Manhole Overflows	-0.340	-0.139	-0.190	-0.189
Pipe Failures	-0.422	-0.0760	-0.00359	----
Size Code	-0.00978	-0.0103	-0.00658	-0.0065
Region Code	-0.0129	0.0031	0.00849	0.00841
Peak Hour/ADF	-0.0920	-0.0093	-0.000785	-0.001
Peak Month/ADF	0.430	----	----	---
Pump Station Failure	0.344	-0.839	-0.826	-0.828
Pump Station Number	0.00004	0.000038	----	----

Figure 5-3 Calculated vs. Predicted Maintenance Frequency



5.7 Conclusions

The maintenance frequency for a system can be expressed as a single measurement using a standard rating frequency and weighting factor for each activity. The maintenance frequency appears to be related to a number of independent variables, including customer complaints, manhole overflows, pipe failures, system size, number of pump stations, system size, regional locations, peak hour/ADF ratio, peak month/ADF ratio, and pump station failures. These independent variables can be used to derive a suggested system maintenance frequency using one of the equations in Table 5-10.

6.0 Determination of System Performance Rating

6.1 Introduction

System performance measurements should indicate how well or how poorly a collection system is providing the intended service. The measurement of system performance is crucial to the optimization of maintenance, for without a proper Ayardstick@, it is not possible to tell how effective the maintenance program is. All performance measures are not necessarily equal in importance. Therefore, when evaluating an agency=s performance, the most important question is how the system as a whole is performing based on a number of significant factors. It does little good for an agency to have zero pipe failures and yet have a large number of complaints about sewage backing up into homes. Just as with maintenance activities, an effective performance evaluation requires consideration of a number of factors. This chapter presents the evaluation of performance, the determination of a performance rating for the agencies surveyed, and the procedures to follow in determining the performance rating.

6.2 Performance Data Weighting

In order to develop an overall performance rating, each agency was requested to provide its opinion of the relative importance of six commonly used collection system performance measures as described below:

> Pipe Failure - a pipe which has lost its structural integrity as evidenced by total or partial collapse (loss of 50% of pipe area or 25% of pipe wall around any circumference. Measured by failures per mile per year.
>
> Sanitary Sewer Overflow (SSO) - a discharge of wastewater from the collection system with the potential to enter surface water courses occurring either in the collection system or in the headworks of the wastewater treatment plant.
>
> Complaints - a customer complaint related to the performance of the collection system, including issues such as overflows, odors, and loose manhole covers.

Pump Station Failure - a condition that results in station overflows or an unacceptable surcharge of the system.

Peak Hour/ADF Ratio - The ratio of peak hour flow at a selected design condition to the average annual daily flow. This calculation may require extrapolation of monitored storm events.

Peak Month/ADF Ratio - The ratio of the peak monthly flow at the WWTP to the average annual daily flow.

The performance measures described above and the average weight assigned by the surveyed agencies are presented in Table 6-1. Average percentages were adjusted proportionately so the total of all maintenance items was equal to 100 percent.

Table 6-1
Performance Measure Weight

Measure	Relative Importance (Weight)
1. Pipe failure	22.6%
2. Sanitary sewer overflow (SSO=s) (Manhole and Treatment Overflows)	23.6%
3. Complaints (basement backups and customer complaints)	20.8%
4. Pump station failure	17.8%
5. Peak Hour/ADF ratio	9.7%
6. Peak Month/ADF ratio	5.5%
Total	100.0%

The most important performance measures, according to the agencies surveyed, is pipe failure, SSO=s, customer complaints, and pump station failures, which account for approximately 88 percent of the performance importance. The average performance weights of all agencies are used for the analysis presented herein.

6.3 Development of Performance Rating

Overall performance ratings for each agency were developed using an approach similar to that used to standardize maintenance frequencies. Standard performance ratings were developed based on normal distribution of performance measures, assigned performance rating, and the importance of the performance measure.

6.3.1 Determining Performance Rating

All performance measures were converted into unit rates, such as pipe failures per mile per year. Performance measures over the past 5 years were used as the basis for the analysis, since this data period provided more complete information than longer periods. Performance data for each agency is presented in Table 6-2. Blank cells indicate that the data was not provided by the agency. Performance rates for each agency were determined using the performance data and appropriate measures, such as miles of sewer. To determine performance, adjustments to miles of sewer were made based on the age information provided by each agency to more accurately estimate the true rate of each performance data. The performance rates for each agency are presented in Table 6-3.

6.3.2 Developing the Standard Rating

The mean, standard deviation, range, and number of responses for each performance measure are listed in Table 6-4. The rate of each performance measure was then normalized using the normal distribution to develop a standard by which any performance rate, or group of performance rates from various performance measures could be compared. Once the performance data was normalized, a standard performance rating was assigned to selected deviations from the mean. The assignment of the standard performance rating was somewhat arbitrary; however, based on the initial hypothesis, an average rating of 65 to 75% for the age of the systems investigated was assumed to be reasonable. Through trial and error, an average performance rating of 71.1% was determined, as discussed in more detail in Section 6.4. The standardized performance ratings assigned to each deviation from the mean for each performance measured data are given in Table 6-5. The weights used for analysis are also given in Table 6-5. It should be noted that the performance weight suggested by agencies for complaints was split 50/50 between basement backups and customer complaints.

Table 6-2 Utility Performance Data						
Utility No.	**Pipe Failures Last 5 Yrs.**	**SSOs Last 5 Yr. (1)**	**Complaints Last 5 years (2)**	**Pump Station Failures Last 5 Yrs.**	**Peak Hr/ADF**	**Peak Mo/ADF**
1	270	1,102	2,860	123	2.08	1.13
2					2.05	1.25
3	20	2	1,675	3	1.83	1.10
4	15	20	60	1	2.81	1.11
5					2.26	1.58
6					3.36	1.29
7	0	13	22	4	3.36	1.24
8					2.55	1.77
9	1	5	110	0	2.31	1.08
10					2.70	1.83
11	986				1.80	1.16
12	562	345	21,705	623	2.21	1.19
13	2	924	30,284	0		1.24
14	11	27	105	1	1.81	1.02
15	1,000		4,150			1.32
16	846	651	34,901	36		1.00
17	27	72	44,955	28	2.15	1.25
18	500	250		3	3.21	2.14
19	500		100	25	2.29	1.32
20	1,200	251	23,000	70	1.95	1.33
21	7	5	1	0	1.69	1.11
22	1	184	2,999	5	1.39	1.05
23					1.32	1.03
24	761	1,486	13,656	20		1.28
25					2.80	1.03
26	5	20	1,500	2		1.22
27	2,200	560	7,970	35	1.28	1.12
28	5	640	3,375	100	1.83	1.10
29						1.15
30	12		2,215	30	2.05	1.03
31						1.12
32	2	25	20	5	4.16	1.41
33					2.95	1.38
34					2.75	
35	1	9	4	0	2.27	
36	5	9	6,510	5	3.44	1.35
37	355	275	161	1	1.27	1.03
38	2	13	1		1.97	1.07
39						
40	5	100	120	5	4.26	2.43
41						1.02
42	3	76	3,805	60	3.00	2.50
	9,304	7,064	206,264	1,185	2.40	1.30
	sum	sum	sum	sum	avg.	avg.
	29	26	28	26	33	39
	Count	Count	Count	Count	Count	Count

(1) Includes manhole and treatment headworks SSOs.
(2) Includes Complaints, basement backups, and "other" category on questionnaire.
Note: Blank cells indicate that data is unreported or required data to convert values to rates was unreported.

Table 6-3 Performance Rates

Utility No.	Pipe Failure Rate Last 5 yrs, no/yr/mi	SSO Rate Last 5 Yrs., no/mi/yr (1)	Complaints Last 5 Yrs., no/mi/yr (2)	Pump St. Failures Last 5 Yrs., no/mi/yr	Peak Hr/ADF	Peak Mo/ ADF
1	0.012	0.047	0.114	0.005	2.08	1.13
2					2.05	1.25
3	0.021	0.002	0.294	0.003	1.83	1.10
4	0.006	0.008	0.005	0.000	2.81	1.11
5			0.179		2.26	1.58
6			1.001		3.36	1.29
7	0.000	0.022	1.027	0.007	3.36	1.24
8			0.116		2.55	1.77
9	0.001	0.003	0.043	0.000	2.31	1.08
10			0.962		2.70	1.83
11	0.102		0.518		1.80	1.16
12	0.046	0.028	69.107	0.051	2.21	1.19
13	0.000	0.061	0.027	0.000		1.24
14	0.002	0.004	0.963	0.000	1.81	1.02
15	0.130		0.019			1.32
16	0.080	0.062	1.000	0.003		1.00
17	0.001	0.004	0.460	0.001	2.15	1.25
18	0.093	0.046		0.001	3.21	2.14
19	0.132			0.007	2.29	1.32
20	0.101	0.021	0.200	0.006	1.95	1.33
21	0.047	0.033	0.011	0.000	1.69	1.11
22	0.000	0.028	1.005	0.001	1.39	1.05
23					1.32	1.03
24	0.091	0.177	0.034	0.002		1.28
25			2.079		2.80	1.03
26	0.001	0.005	0.750	0.000		1.22
27	0.257	0.066	25.394	0.004	1.28	1.12
28	0.001	0.119	0.357	0.019	1.83	1.10
29						1.15
30	0.001		0.074	0.002	2.05	1.03
31						1.12
32	0.006	0.077	1.615	0.015	4.16	1.41
33			9.821		2.95	1.38
34					2.75	
35	0.000	0.004	0.202	0.000	2.27	
36	0.001	0.002	0.059	0.001	3.44	1.35
37	0.046	0.035	0.022	0.000	1.27	1.03
38	0.010	0.067	0.106		1.97	1.07
39			0.051			
40	0.009	0.174	17.182	0.009	4.26	2.43
41						1.02
42	0.001	0.030	1.552	0.023	3.00	2.50
	0.041	0.045	4.010	0.006	2.399	1.302
	avg	avg	avg	avg	avg	avg
	29	25	34	26	33	39
	count	count	count	count	count	count
	0.059	0.048	12.464	0.011	0.756	0.360
	sd	sd	sd	sd	sd	sd
	0	0.00197989	0.00542603	0	1.27081507	0.99890744
	min	min	min	min	min	min
	0.257	0.177	69.107	0.051	4.257	2.500
	max	max	max	max	max	max

(1) Includes manhole and treatment headworks SSOs.
(2) Includes complaints, basement backups and "other" category on questionnaire.
Note: Blank cells indicate that data was unreported or required data to convert values to rates was unreported.

Table 6-4

Performance Data Statistics

(Last 5 years)

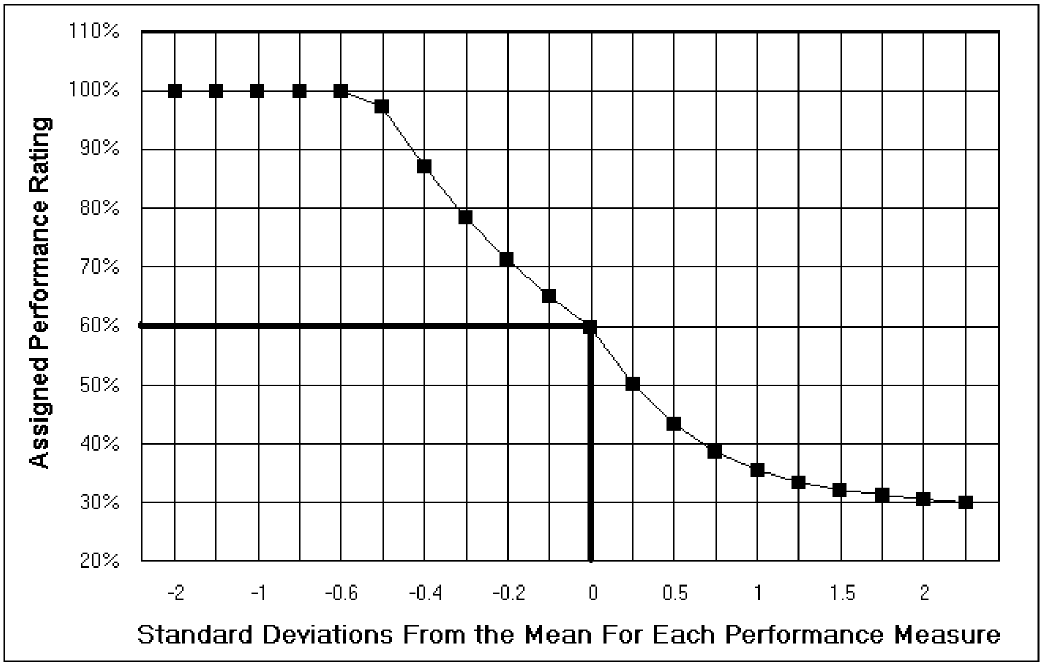
Performance Measure	Mean	Standard Deviation	Range	Number of Responses
1. Pipe failures, number/mi$yr	0.041	0.059	0.025	29
2. Sanitary Sewer Overflows (SSOs,) number/mi$yr	0.045	0.048	0.002-0.17	25
3. Complaints, number/mi$yr	4.010	12.464	0.005-69.1	34
4. Pump station failure, number/ps$yr	0.006	0.011	0-0.051	26
5. Peak hour flow/ADF Ratio	2.409	.756	1.27 - 4.26	33
6. Peak month flow/ ADF Ratio	1.30	0.360	1.0 - 2.50	39

The relationship between measured performance and assigned performance rating was determined by setting a performance rating of 50 percent equal to the mean value of each performance measure, and assigning corresponding performance ratings on either side of the mean based on the area under the normal curve. The selection of 50 percent association with the mean performance measure was by trial and error, so that the average performance rate of all agencies was between 65 and 75%. The performance rating assigned to each deviation from the performance mean is shown on Figure 6-1.

Table 6-5 Standardized Performance Rating Table by Performance Measure

Performance Measure	Weight	No.	Avg.	sd	-2sd	-1.5sd	-1sd	-0.75sd	-0.6sd	-0.5sd	-0.4sd	-0.3sd	-0.2sd	-.1sd	**x**	+.25sd	+0.50sd	+.75sd	+1sd	+1.25sd	+1.50sd	+1.75sd	+2sd	+3.0sd
					-2	-1.5	-1	-0.75	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.25	0.5	0.75	1	1.25	1.5	1.75	2	3
Pipe Failures	22.6%	29	0.0413	0.0593	-0.077	-0.048	-0.018	-0.003	0.006	0.012	0.018	0.024	0.029	0.035	0.041	0.056	0.071	0.086	0.101	0.115	0.130	0.145	0.160	0.219
SSO's	23.6%	25	0.0450	0.0480	-0.051	-0.027	-0.003	0.009	0.016	0.021	0.026	0.031	0.035	0.040	0.045	0.057	0.069	0.081	0.093	0.105	0.117	0.129	0.141	0.189
Customer Complaints	20.8%	34	4.0103	12.4642	-20.918	-14.686	-8.454	-5.338	-3.468	-2.222	-0.975	0.271	1.517	2.764	4.010	7.126	10.242	13.358	16.475	19.591	22.707	25.823	28.939	41.403
PS Failures	17.8%	26	0.0062	0.0107	-0.015	-0.010	-0.004	-0.002	-0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.009	0.012	0.014	0.017	0.020	0.022	0.025	0.028	0.038
PH/ADF	9.7%	33	2.3992	0.3598	1.000	1.859	2.039	2.129	2.183	2.219	2.255	2.291	2.327	2.363	2.399	2.489	2.579	2.669	2.759	2.849	2.939	3.029	3.119	3.479
PM/ADF	5.5%	39	1.3023	0.3598	0.583	0.763	0.942	1.032	1.086	1.122	1.158	1.194	1.230	1.266	1.302	1.392	1.482	1.572	1.662	1.752	1.842	1.932	2.022	2.382
Standardized Performance Rating:					100%	100%	100%	100%	109%	97%	87%	79%	71%	65%	60%	50%	43%	39%	36%	34%	32%	31%	31%	30%
Areas Under the Normal curve (+1.00): X = mean					0.0228	0.0668	0.1587	0.2266	0.2743	0.3085	0.3446	0.3821	0.4207	0.4602	0.5	0.5987	0.6915	0.7734	0.8413	0.8944	0.9332	0.9599	0.9772	0.9987

Figure 6-1 Assignment of Performance Rating



6.4 Determination of Performance Rating

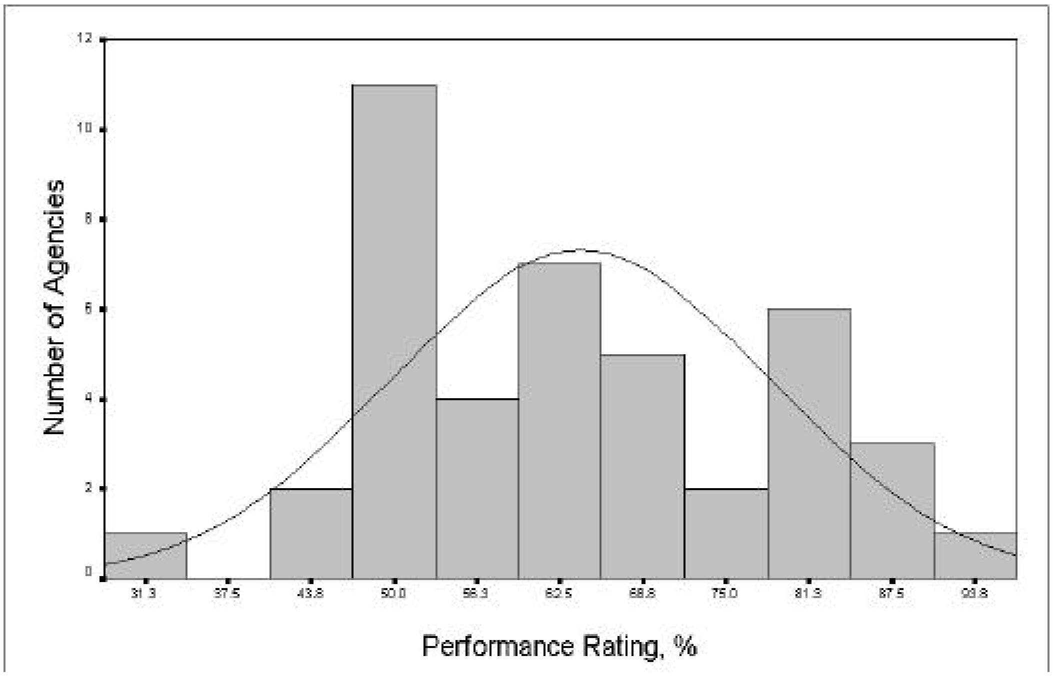
An overall performance rating for each agency, presented in Table 6-6, was determined by applying the actual performance measures reported, the relative weight for each performance measure, and the standard performance rating. A summary of the performance ratings derived is presented in Table 6-7 and shown on the distribution curve on Figure 6-2. For missing data points, where a performance measure was not provided, the average overall rating was used to calculate a performance rating.

Table 6-6 Calculated Performance Ratings

Utility No.	Pipe Failure Rating	SSO Rating	Complaint Rating	Pump St. Failure Rating	Peak Hr/ADF Rating	Peak Mo/ ADF Rating	System Performance Rating
(Weighting-->)	22.6%	23.6%	20.8%	17.8%	9.7%	5.5%	1.000
1	24.7%	14.2%	18.1%	11.6%	9.7%	5.4%	0.837
2	13.6%	14.2%	12.5%	10.7%	9.7%	3.9%	0.645
3	19.7%	23.6%	16.3%	13.9%	9.7%	6.1%	0.893
4	24.7%	23.6%	18.1%	10.7%	3.5%	6.1%	0.866
5	13.6%	14.2%	18.1%	10.7%	8.5%	2.1%	0.671
6	13.6%	14.2%	16.3%	10.7%	3.0%	3.6%	0.613
7	13.6%	22.9%	16.3%	10.7%	3.0%	3.9%	0.704
8	13.6%	14.2%	18.1%	10.7%	4.9%	1.9%	0.632
9	22.6%	23.6%	18.1%	10.7%	7.6%	5.5%	0.881
10	13.6%	14.2%	16.3%	10.7%	3.8%	1.9%	0.603
11	8.1%	14.2%	16.3%	10.7%	9.7%	4.8%	0.637
12	13.6%	20.5%	6.2%	5.3%	10.6%	4.3%	0.607
13	22.6%	11.8%	18.1%	10.7%	5.8%	3.9%	0.730
14	22.6%	23.6%	16.3%	19.4%	9.7%	5.5%	0.972
15	7.6%	14.2%	18.1%	10.7%	5.8%	3.3%	0.597
16	9.8%	11.8%	16.3%	13.9%	5.8%	5.5%	0.633
17	22.6%	23.6%	16.3%	17.3%	9.7%	3.9%	0.935
18	8.8%	14.2%	12.5%	19.4%	3.0%	1.7%	0.595
19	7.3%	14.2%	12.5%	10.7%	8.5%	3.3%	0.563
20	8.1%	22.9%	18.1%	11.6%	9.7%	3.3%	0.737
21	13.6%	18.5%	18.1%	10.7%	9.7%	6.1%	0.766
22	22.6%	20.5%	16.3%	19.4%	9.7%	5.5%	0.942
23	13.6%	14.2%	12.5%	10.7%	9.7%	5.5%	0.661
24	8.8%	7.2%	18.1%	15.5%	5.8%	3.6%	0.590
25	13.6%	14.2%	14.8%	10.7%	3.5%	5.5%	0.622
26	22.6%	23.6%	16.3%	19.4%	5.8%	4.3%	0.921
27	6.8%	11.8%	6.7%	12.7%	9.7%	5.4%	0.531
28	22.6%	7.6%	16.3%	6.3%	9.7%	6.1%	0.686
29	13.6%	14.2%	12.5%	10.7%	5.8%	5.4%	0.621
30	22.6%	14.2%	18.1%	15.5%	9.7%	5.5%	0.856
31	13.6%	14.2%	12.5%	10.7%	5.8%	6.1%	0.627
32	24.7%	10.2%	14.8%	6.9%	2.9%	2.8%	0.624
33	13.6%	14.2%	10.4%	10.7%	3.1%	3.3%	0.553
34	13.6%	14.2%	12.5%	10.7%	3.8%	3.3%	0.580
35	22.6%	23.6%	18.1%	10.7%	8.5%	3.3%	0.868
36	22.6%	23.6%	18.1%	17.3%	3.0%	3.3%	0.879
37	13.6%	18.5%	18.1%	19.4%	9.7%	5.5%	0.849
38	24.7%	11.8%	18.1%	10.7%	9.7%	5.5%	0.806
39	13.6%	14.2%	18.1%	10.7%	5.8%	3.3%	0.656
40	24.7%	7.2%	7.4%	10.7%	2.9%	1.7%	0.546
41	13.6%	14.2%	12.5%	10.7%	5.8%	5.5%	0.622
42	22.6%	20.5%	14.8%	5.7%	3.1%	1.7%	0.685
	0.164	0.162	0.153	0.121	0.068	0.042	71.1%
	avg	avg	avg	avg	avg	avg	avg
	42	42	42	42	42	42	42
	count	count	count	count	count	count	count
	0.059	0.049	0.033	0.036	0.028	0.014	0.128
	sd	sd	sd	sd	sd	sd	sd
	0.068	0.072	0.062	0.053	0.029	0.017	0.531
	min	min	min	min	min	min	min
	0.247	0.236	0.181	0.194	0.106	0.061	0.972
	max	max	max	max	max	max	max

Table 6-7 **Summary of Performance Rating Derived**	
Estimate	Value
Mean	0.640
Minimum	0.339
Maximum	0.910

Figure 6-2 Collection System Weighted Performance Rating



6.4.1 Annual Reinvestment

It was suspected that performance would be strongly linked to the annual system reinvestment in terms of dollars per mile per year ($/mi$yr). The annual investment for each agency was based on the reinvestment reported and the estimated miles of pipeline for the following time periods:

Before 1970
1970-1979
1980-1989
1990-1996

The reinvestment amount considers relief sewers, equalization, rehabilitation, operation and maintenance, equipment, and other reported costs. The reinvestment amount by agency over the life of the system is presented in Table 6-8. The average reinvestment for all years reported at $2,594 per mile per year in 1996 costs would be $5,252 per mile per year based on an average age of 37 years and adjusting costs using the Engineering News Record Construction Cost Index.

The reinvestment data shows that the reinvestment for 1980 to 1996 increased to $9,328 per mile per year.

6.4.2 Regression Analysis for Performance Rating

Multiple linear regression analyses were performed using the derived performance rating as the dependent variable and various sets of independent variables. The purpose of this analysis was to explore the relationship, if any, between performance and key independent variables which may influence system performance. The independent variables considered for analysis, their units, and a code for use in the statistical program, were selected from the list of data requested from the agencies, and are summarized in Table 6-9. Note that the overall maintenance frequency determined in Chapter 5 is a component of this relationship, and is a surrogate for all maintenance activities included in the determination of the overall maintenance frequency. It was hypothesized that the reinvestment amount in terms of $/mi$yr and the maintenance frequency influences system performance.

A number of regression analyses were performed to evaluate possible relationships. Of the many analyses performed, the five best relationships are reported here. The coefficient of determinations (R^2) for the five documented analyses are presented in Table 6-10. The analyses show that the best R^2 is obtained when all the independent variables are considered. The R^2 values indicate that the estimated performance rating is highly dependent on maintenance frequency and reinvestment. Only reinvestments during or after 1980 were considered. The regression equation coefficients for the one equation with an R^2 greater than 0.70 is presented in Table 6-11. These regression coefficients were used to estimate the performance rating from those agencies that provided the information required to use the equation. The results, showing the predicted performance rating and the calculated performance ratio using Equation PR1, are presented on Figure 6-3. This figure shows fairly good agreement between measured and predicted performance ratings.

Table 6-8 Agency Reinvestment Data				
Utility No.	Total Spent $/mi•yr (All Years Reported)	Total Spent $/ft•yr (All Years Reported)	Total Spent $/mi•/yr (1980 –1996)	Total Spent $/ft•yr (1980 – 1996)
1	$1,484	$0.28	$2,753	$0.52
2				
3	$9,436	$1.79	$20,053	$3.80
4			$31,863	$6.03
5	$3,000	$0.57		
6	$1,145	$0.22		
7	$5,387	$1.02	$10,069	$1.91
8	$3,905	$0.74		
9	$675	$0.13	$1,430	$0.27
10	$484	$0.09		
11	$1,833	$0.35	$10,434	$1.98
12				
13	$3,066	$0.58		
14	$5,902	$1.12	$16,961	$3.21
15	$645	$0.12		
16				
17	$3,267	$0.62		
18	$1,926	$0.36	$3,832	$0.73
19	$1,734	$0.33	$3,776	$0.72
20	$3,657	$0.69		
21	$701	$0.13		
22	$7,381	$1.40	$5,585	$1.06
23				
24	$1,686	$0.32	$8,304	$1.57
25	$1,089	$0.21		
26	$513	$0.10	$1,969	$0.37
27	$258	$0.05		
28				
29				
30	$1,035	$0.20	$1,820	$0.34
31				
32	$8,180	$1.55	$21,641	$4.10
33	$406	$0.08		
34				
35	$579	$0.11		
36	$2,663	$0.50	$3,158	$0.60
37	$1,977	$0.37		
38				
39				
40	$1,828	$0.35		
41				
42	$1,988	$0.38	$5,596	$1.06
	$2,594 avg	$0.49 avg	$9,328 avg	$1.77 avg
	30 count	30 count	16 count	16 count
	$2,377 sd	$0.45 sd	$8,583 sd	$1.63 sd

Table 6-9
Potential Independent Variables Related to Performance Rating

Variable	Unit	Code
Size code	none	Size_cd
Region code	none	Region_cd
Peak month/ADF	ratio	PM_ADF
Peak hour/ADF	ratio	PH_ADF
Maintenance frequency	none	Maintfq
Reinvestment	$/mi$yr	$_mi_yr
Pump station density	ps/mi	Ps_mi

Table 6-10

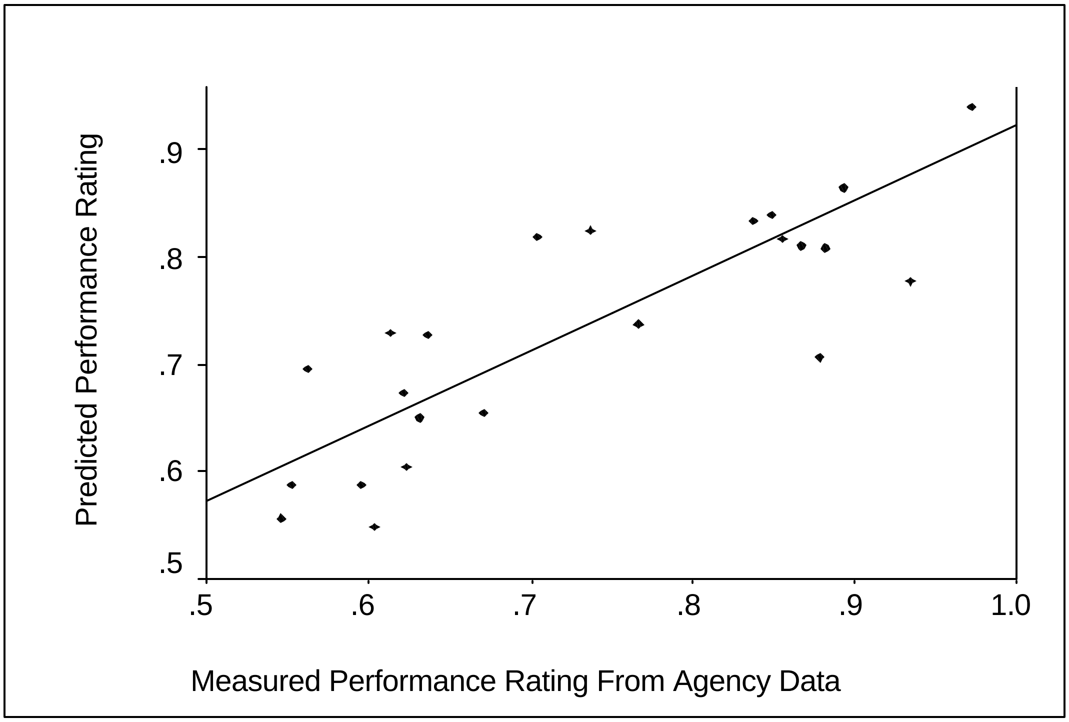
Regression Analysis for Performance Ratios

Independent Variables							Coefficient of Determination		Selected Regression Analysis	Equation Name
Reinvestment, $/mi$yr	Regional Code	Size Code	Peak Month/ADF	Peak Hour/ADF	Pump Stations/M*i*	Maintenance Frequency	R^2	Adjusted R^2	$R^2 > 0.70$	
	X	X				X	0.34380	0.11820		
	X	X			X	X	0.35678	0.12730		
	X	X		X	X	X	0.57434	0.32987		
	X	X	X	X	X	X	0.71141	0.50611		
X	X	X	X	X	X	X	0.84710	0.71757	X	PR1

Table 6-11
Regression Coefficients for
Performance Rating

Item	Line Regression Equation Coefficients Eq PR1 B_i
Constant	0.751
$/mi**$**yr	3.342×10^{-6}
Regional Code	2.179×10^{-2}
Size Code	-1.114×10^{-2}
Peak Month/ADF	-0.117
Peak Hour/ADF	-1.487×10^{-2}
Pump Stations/mi	-0.252
Maintenance Frequency	2.614

Figure 6-3 Predicted Versus Measured Performance Rating



6.5 Estimates of Reinvestment

Because the reinvestment amount is such an important independent factor related to system performance and because it is a very important consideration for agencies, regression analyses were performed to evaluate the system performance rating and reinvestment amount based on reinvestments since 1980. A summary of regression equations is presented in Table 6-12.

The analyses show that reinvestment is related to a number of independent variables but most strongly with regional location, pump stations per mile, maintenance frequency, percent of system greater than 20 years old, and performance rating. Equation RE1 has an R^2 value of 0.473. The relationship between predicted reinvestment, which included performance rating as an independent variable in Equation RE1 and calculated historical reinvestment performance rating is shown in Figure 6-4 which supports the hypothesis of improved performance with increased reinvestment.

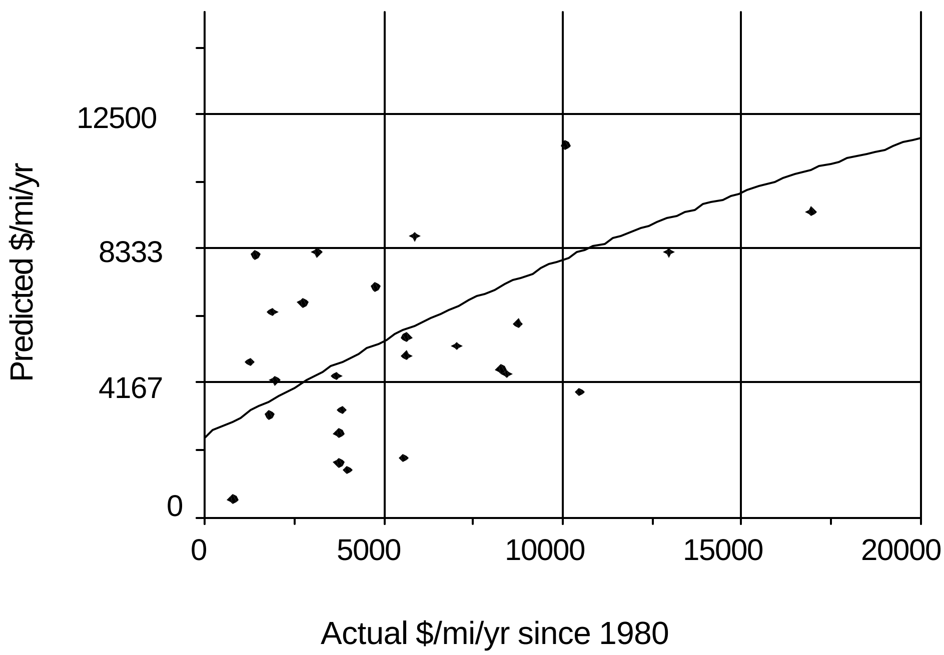
Table 6-12
Regression Analysis for Reinvestment
($/mi yr - Since 1980)

Independent Variables					Coefficient of Determination		Equation Name
Regional Code	Pump Stations/Mile	Maintenance Frequency	% System>20 Yrs Old	Performance Rating	R^2	Adjusted R^2	
X	X	X	X	X	0.473	0.363	RE1
X	X	X		X	0.375	0.275	RE2

Table 6-13
Regression Coefficients for Reinvestment

Item	Linear Regression Equation RE1	Equation Coefficients Equation RE2
Constant	-13,665.9	-3,256.9
Regional Code	-1,151.7	-1,393.2
Pump Station/Mile	24,994.3	18,958.1
Maintenance Frequency	22,968.5	27,770.9
% System > 20 Yrs Old	10,772.1	----
Performance Rating	18,368.9	14,445.8

Figure 6-4 Predicted Versus Actual $/mi$yr



6.6 Conclusion

System performance can be expressed as a single performance rating based on standard performance measures. The performance ratings are strongly related to maintenance frequencies and to reinvestment amounts. The average reinvestment of all agencies surveyed during 1980 to 1996 was $9,328 per mile per year ($1.77 feet per mile per year) which corresponds to an average performance rating of 71%. The average reinvestment of all agencies surveyed during the life of the system was about $5,252 per mile per year ($0.99 per foot per year) when costs are adjusted for inflation.

7.0 Optimizing Collection System Maintenance

7.1 Introduction

This chapter presents maintenance frequencies, performance ratings, and reinvestment rates for optimizing collection system maintenance activities. Optimization should provide a system which performs satisfactorily with a reasonable level of maintenance (reinvestment). It should be remembered that each collection system has its own unique characteristics and requirements and that the information presented in this study is intended to provide guidance for improving system performance through a more balanced maintenance program and appropriate levels of reinvestment. The guidelines presented herein relative to system performance, maintenance levels, and reinvestment will help agencies determine how much maintenance is enough. In order to optimize collection system maintenance, it is necessary to establish the existing system maintenance frequency, performance rating, and reinvestment rate as discussed in the following sections.

7.2 Collection System Maintenance Frequency

The following sections present the methods to determine the maintenance frequency of a given system.

7.2.1 Establish Existing Maintenance Frequency

All maintenance activities should be expressed as rates, such as percentage of system cleaned per year. The procedure presented in Chapter 5 can be used to develop the overall maintenance frequency. The maintenance activities listed in Table 7-1 should be considered when developing the system maintenance frequency.

Table 7-1 Activities for Determination of Maintenance Frequencies	
Maintenance Activity	Suggested Rate Expression
Cleaning of sewer lines	Percentage of system/yr
Root removal	Percentage of system/yr
Pump Station Inspections	number/pump station$yr
Flow monitoring	Percentage of system/yr
Manhole inspection	Percentage of system/yr
Smoke/dye testing	Percentage of system/yr
CCTV	Percentage of system/yr
Private sector Inspections	Percentage of system/yr
Manholes rehabilitated	Percentage of manholes requiring rehabilitation actually rehabilitated
Sewer line rehabilitated	Percentage of sewer lines requiring rehabilitation actually rehabilitated
Relief/equalization	Percentage of relief/equalization facilities needed actually constructed
Private sectors rehabilitated	Percentage of private sector needs actually addressed

The following steps describe the determination of system maintenance frequency:

(1) Determine Maintenance Activity Rate

For each maintenance activity, a rate is calculated. For most routine maintenance activities, such as line cleaning, the maintenance activity rate is expressed as the percentage of system cleaned per unit time (%/yr). For example, an agency which has 1,500 miles of sewer and has cleaned 825 miles of sewers over a 5-year period, has a cleaning maintenance rate of 11%/yr determined as follows:

825 miles / (5 years x 1500 miles) = 0.11 = 11% per year

(2) Assign Normalized Frequency to Each Maintenance Activity

Using the data presented in Chapter 5, a normalized frequency rate is assigned to each maintenance activity. This allows the overall maintenance frequency to be determined considering multiple maintenance activities. The normalized frequency for each maintenance activity and the activity rate from Chapter 5 are summarized in Table 7-2. For example, an agency which has a line cleaning frequency of 11%/yr (0.11) will have a normalized maintenance frequency of 5% for this activity.

Table 7-2

Normalized Maintenance Frequency for Given Maintenance Activity Rate

Normalized Frequency	0%	1%	3%	5%	6%	8%	10%	12%	14%	15%	17%	18%	19%	19%	20%	20%
Activity																
Cleaning	-0.20	-0.07	0.05	0.11	0.18	0.24	0.30	0.36	0.42	0.48	0.55	0.61	0.67	0.73	0.79	1.04
Root Removal	-0.11	-0.07	-0.04	-0.02	0.00	0.01	0.03	0.05	0.06	0.08	0.10	0.11	0.13	0.15	0.16	0.23
Pump Station Service	-165.82	-93.42	-21.02	15.18	51.38	87.58	123.78	159.98	196.18	232.38	268.58	304.78	340.98	377.18	413.38	558.18
Flow Monitoring	-0.31	-0.18	-0.05	0.01	0.08	0.14	0.20	0.27	0.33	0.40	0.46	0.53	0.59	0.65	0.72	0.98
Manhole Inspection	-0.23	-0.13	-0.02	0.03	0.09	0.14	0.19	0.25	0.30	0.35	0.41	0.46	0.51	0.57	0.62	0.84
Smoke/Dye Testing	-0.12	-0.07	-0.02	0.00	0.03	0.05	0.07	0.10	0.12	0.15	0.17	0.20	0.22	0.25	0.27	0.37
CCTV	-0.10	-0.06	-0.01	0.01	0.03	0.05	0.07	0.09	0.11	0.13	0.15	0.17	0.19	0.21	0.23	0.31
Private Sector Inspections	-0.06	-0.02	0.03	0.05	0.07	0.09	0.11	0.13	0.15	0.17	0.19	0.21	0.23	0.25	0.28	0.36
Manhole Rehabilitation	-0.30	-0.12	0.07	0.16	0.25	0.34	0.43	0.53	0.62	0.71	0.80	0.89	0.98	1.08	1.17	1.53
Main Line Rehabilitation	-0.28	-0.11	0.05	0.14	0.22	0.30	0.39	0.47	0.55	0.64	0.72	0.80	0.89	0.97	1.05	1.39
Sewer Relief	-0.10	0.07	0.23	0.31	0.39	0.48	0.56	0.64	0.72	0.81	0.89	0.97	1.05	1.14	1.22	1.55
Private I/I Removal	-0.35	-0.14	0.08	0.19	0.30	0.40	0.51	0.62	0.73	0.84	0.95	1.06	1.16	1.27	1.38	1.82

(3) Assign Activity Weighting Factor

The normalized maintenance frequency is then adjusted by the product of itself and the maintenance activity weighting factor presented in Chapter 5. The maintenance activity weighting factors are based on the results of the agency survey in this study and are presented in Table 7-3. The activity weighting factor is an indicator of the importance of the maintenance activity in maintaining collection system performance. For example, in the opinion of the agencies surveyed, sewer cleaning is the most important maintenance activity, representing 16.9% of the total value of all maintenance activities.

Table 7-3
Activity Weighting Factor

Maintenance Activity	Activity Weighting Factor (%)
Cleaning	17.7
Root Removal	8.4
Pump Station Service	14.1
Flow Monitoring	7.0
Manhole Inspection	6.4
Smoke Testing	3.3
CCTV	10.5
Private Sector Inspections	2.0
Manhole Rehabilitation	5.6
Mainline Rehabilitation	12.6
Relief Construction	6.3
Private Sector I/I Removal	6.1

(4) Determine Weighted Normalized Maintenance Activity Frequency

The product of the normalized maintenance activity frequency and the assigned maintenance weight calculates the weighted maintenance activity frequency rate. For example, the weighted normalized maintenance activity frequency for sewer cleaning for an agency with a normalized maintenance activity frequency of 5% for cleaning is:

$$0.05 \times 0.177 = 0.00885 = 0.885\%$$

(5) Determine System Maintenance Frequency

The system maintenance frequency rate is determined by adding the weighted normalized maintenance activity frequencies for all maintenance activities. The system maintenance frequencies for the agencies that responded to the questionnaire ranged from 2.7 to 12.8%, with an average of 8.7%. It is helpful to think of the maintenance frequency in terms of a 100 year period. A 10%

maintenance frequency would mean that, on average, maintenance activities would be performed 10 times in a 100 year period, or every 10 years. A maintenance frequency of 2% would mean that, on average, maintenance activities would be performed twice in a 100 year period, or every 50 years. The system maintenance frequency is an indication of the level of effective maintenance activity. For example, an agency with a system maintenance frequency of 2% could have an inadequate maintenance program, while an agency with a system maintenance frequency of 15% could have an excessive maintenance program. This indicator, however, does not provide any information on whether or not the maintenance program is effective. The effectiveness of the maintenance program may be measured by performance indicators which are discussed in the next section.

7.3 Performance Rating

The second step in optimizing system performance is to establish the existing system performance rating as discussed in the following sections.

7.3.1 Establish Performance Rating

All performance data should be converted to rates. For example, pipe failures can be expressed as pipe failures per mile per year. These performance rates can then be converted to a performance rating using the procedures presented in Chapter 6. The performance indicators listed in Table 7-4 should be considered.

Table 7-4

Performance Measure and Units

Performance Measure	Units
Complaints	complaints/mi$yr
Sanitary Sewer Overflows (SSOs)	overflows/mi$yr
Pipe Failures	pipe failures/mi$yr
Pump Station Failures	failures/ps$yr
Peak Hourly Flow/ADF	ratio
Peak Monthly Flow/ADF	ratio

The following steps should be taken to calculate the performance rating:

(1) Determine Performance Measure Rate

For each performance measure, a performance rate is calculated. The performance rate in most cases is defined as the number of occurrences divided by the number of years for which the performance indicator is reported and by the total miles of sewer in the system. For example, the pipe failure performance rate for an agency which has 1,500 miles of sewer and has experienced 370 pipe failures over a 5-year period can be calculated as follows:

370 pipe failures / (5 years x 1500 miles) = 0.049 failures/mi$year

The performance rate for pump station failures is calculated by dividing the number of pump station failures per year by the number of pump stations. The flow performance indicators, peak hour and peak month to average daily flow are expressed as a ratio.

(2) Assign Normalized Performance Rating to Each Performance Measure

Using the data presented in Chapter 6, a normalized performance rating is assigned to each performance measurement. The normalized performance rating for each performance measure is presented in Table 7-5. For example, an agency which has a performance measure of 0.049 failures/mi$yr for pipe failure, will have a normalized performance rating of 50% for this item.

(3) Assign Performance Weighting Factor

The normalized performance rating is then adjusted by multiplying it by the activity weighting factor presented in Chapter 6. The performance activity weighting factors for each performance measure are presented in Table 7-6. The performance weighing factor is a measure of the importance of the performance measure as perceived by the agencies that participated in this survey. For example, the largest weighting factor of 23.6% was assigned to SSO=s.

Table 7-5

Normalized Performance Rates for Given Performance Measure Values

Measure/Performance Rates	30%	31%	32%	34%	36%	39%	50%	60%	65%	71%	79%	97%	100%	100%	100%	100%
Pipe Failures	0.219	0.160	0.130	0.115	0.101	0.086	0.056	0.041	0.035	0.029	0.024	0.012	0.006	-0.003	-0.018	-0.077
SSO=s	0.189	0.141	0.117	0.105	0.093	0.081	0.057	0.045	0.040	0.035	0.031	0.021	0.016	0.009	-0.003	-0.051
Customer Complaints	41.403	28.939	22.707	19.591	16.475	13.358	7.126	4.010	2.764	1.517	0.271	-2.222	-3.468	-5.338	-8.454	-20.918
Pump Station Failures	0.038	0.028	0.022	0.020	0.017	0.014	0.009	0.006	0.005	0.004	0.003	0.001	0.000	-0.002	-0.004	-0.015
PH/ADF	3.749	3.119	2.939	2.849	2.759	2.669	2.489	2.399	2.363	2.327	2.291	2.219	2.183	2.129	2.039	1.000
PM/ADF	2.382	2.022	1.842	1.752	1.662	1.572	1.392	1.302	1.266	1.230	1.194	1.122	1.086	1.032	0.942	0.583

Table 7-6 Performance Weighting Factor	
Performance Measure	Weighting Factor (%)
Customer Complaints	22.6
Sanitary Sewer Overflows (SSO=s)	23.6
Pipe Failures	20.8
Pump Station Failures	17.8
Peak Hourly/ADF Ratio	9.7
Peak Monthly/ADF Ratio	5.5

(4) Calculate Weighted Normalized Performance Rating

The weighted normalized performance rating is calculated by the product of the weighting factor and the normalized performance rate. For example, the weighted normalized performance rating of pipe failure for an agency with a normalized performance rating of 50% is:

$$0.50 \times 0.208 = 0.104 = 10.4\%$$

(5) Determine Overall System Performance Rating

The overall system performance rating is calculated by summing the weighted normalized performance ratings of the six performance measures. The weighted performance rating for the agencies that responded to the questionnaire varied from 33.9 to 91.0%, with an average of 64%. The performance rating is an indication of the level of system performance. For example, an agency with a performance rating of 30% probably is not providing effective service to its customers while an agency with a performance rating of 80% is likely providing safe and effective service.

7.4 Determine Historical Reinvestment Rate

The historical reinvestment rate should be determined based on the information in Table 7-7. If cost data for the life of the system is not available, then the longest period for which data is available should be used. Only costs related to the collection system should be included. The costs of facilities such as wastewater treatment plants should not be included. The reinvestment rate will provide a basis for comparison with other agencies regarding the adequacy of the budget for system maintenance, and can also be compared with predicted reinvestment amounts which may be estimated from system operating characteristics as discussed in this section.

Table 7-7 Determination of Reinvestment	
Reinvestment Item	Unit
Relief construction	\$/mi\$yr, over the life of the system

Table 7-7

Determination of Reinvestment

Equalization basin construction	$/mi$yr, over the life of the system
Rehabilitation costs	$/mi$yr, over the life of the system
Operation and maintenance costs	$/mi$yr, over the life of the system
Equipment costs	Total $, over the life of the system
Other costs	Other costs over the life of the system

The average reinvestment rate for all agencies surveyed was about $5,252/mi$yr ($2,594/mi$yr adjusted for inflation) for the costs considered over the life of each system. Many agencies did not report, or had poor data, for years prior to 1980. For this reason the $5,252/mi$yr reinvestment rate is probably lower than the actual reinvestment amount. The average reinvestment rate for all agencies surveyed for the period 1980 to 1996 was $9,328/mi$yr ($1.77/ft$yr). The rate of reinvestment appears to be increasing, which may be due to agencies trying to Acatch-up@ with system needs and to comply with Environmental Protection Agency requirements. For these reasons, the $9,328/mi$yr may be higher than the average reinvestment rate needed to properly maintain a collection system. Poor correlations were observed between reinvestment (single independent variable) and system performance (dependent variable) using linear regression. This may be due to the complex mix of the drivers for reinvestment. Another factor for this poor correlation may be that much of the reinvestment reported has been relatively recent (in the last 10 years) and that performance data is not yet reflecting any improvement that may have occurred. Accurate performance data for a longer period will be required to properly evaluate this relationship. While exploring other relationships, a high correlation ($R^2 > 0.98$) for both reinvestment time periods (life of system and 1990-1996) was observed between the reinvestment amount ($/mi$yr) and the following independent variables:

$ average age
$ pipe failure rate
$ SSO rate
$ pump station failure rate
$ peak hour/average daily flow rate
$ customer complaint rate
$ pump stations per mile of system
$ regional code

The regression coefficients for the reinvestment rates based on survey data are presented in Table 7-8.

Table 7-8
Reinvestment Regression Coefficients

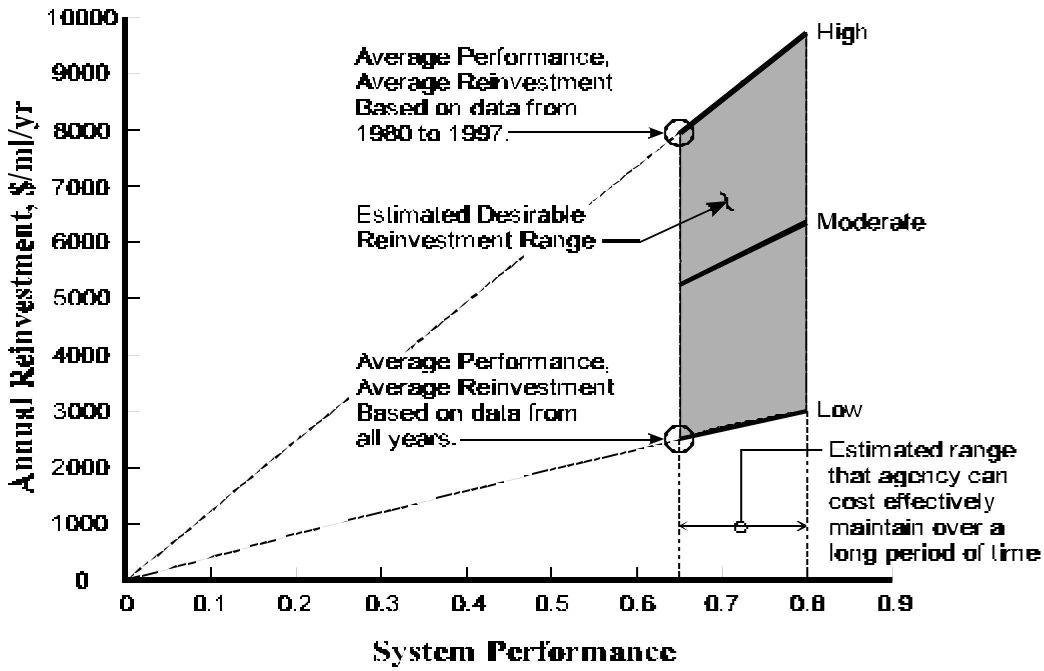
Dependent Variable: $/mi$yr Reinvestment

Independent Variable	Equation RE-3 Based on All Reinvestment Data	Equation RE-4 Based on 1980 to 1996 Data
Customer Complaint Rate(1)	-2836.49	-6114.06
SSO=s (1)	-63550.25	-101100.93
Pipe Failure Rate(1)	-42308.86	-19817.16
Pump Station Failure Rate(1)	-131572.22	-251085.23
Regional Code	-56.04	-942.45
Pump Stations Per Mile	17055.97	46788.79
Peak Hour/ADF Ratio	-3616.08	-6915.00
Average Age	191.08	642.09
Constant	13288.45	17776.14
R^2	0.998	0.984
Adjusted R^2	0.980	0.860

(1) Five years of data ending 1996.

It must be remembered that the sample used for this study is relatively small and that some of the agencies likely have very good maintenance programs while the programs of others are deficient. If all agencies had optimized maintenance activities and high quality data, a stronger correlation between reinvestment and performance would be expected. Nevertheless, the reinvestment trends provide some insight into the adequacy of the total reinvestment. In order to develop a better perspective of the relationship between performance and reinvestment, an estimated performance/reinvestment envelope was constructed using the average performance ratios and the reinvestment rates previously presented. For a performance rating of 0.65 to 0.80 cost ranges of $2,500/mi$yr to $8,000/mi$yr and $3,000/mi$yr to $9,700/mi$yr, respectively, appear to form a reasonable envelope of values. The estimated envelope showing reinvestment and desired performance is shown on Figure 7-1. Based on data from the agencies surveyed it was assumed that a desirable range of system performance would be from about 0.65 to 0.80. The data show that a moderate reinvestment level of $5,200/mi$yr to $6,500/mi$yr would be required to achieve this performance. Reinvestment rates higher than the moderate value may indicate that too much money is being spent for the benefit derived, and that some program adjustment is warranted. Reinvestment rates lower than the moderate values indicate a very effective reinvestment program. These values are only guidelines and must be evaluated carefully for each agency.

Figure 7-1
Estimated Desirable System Performance and Reinvestment Envelope



The regression equations presented in Table 7-8 can also be used to estimate the annual reinvestment rate. It is suggested that the results of Equations RE3 and RE4 be used as the limits of the reinvestment rates. Averaging the results of the two equations is a suggested best estimate or starting point for establishing the optimum reinvestment. The actual and predicted reinvestment rates for the agencies surveyed which provided sufficient data to apply Equations RE3 and RE4 are listed in Table 7-9. The data show excellent agreement between predicted and actual values for a wide range of performance ratings and maintenance frequencies.

Table 7-9
Actual and Predicted Reinvestment Rates

Performance Maintenance			Actual Reinvestment [1] $/mi$yr		Predicted Reinvestment [1] $/mi$yr		Average [2] $/mi$yr
Agency No.	Rating	Frequency	All Years	›80-96	All Years	›80-96	
3	85%	8.5%	$9,436	$20,053	$9,391	$21,956	$15,671
4	91%	7.0%	N/A	$31,863	$12,746	$30,344	$21,545
6	73%	6.8%	$1,145	$7,030	$1,170	$7,006	$4,088
11	58%	3.0%	$1,833	$10,434	$2,224	$10,907	$6,566
17	82%	7.7%	$3,267	$4,737	$3,088	$2,858	$2,973
20	57%	9.4%	$3,657	$12,983	$3,624	$12,260	$7,942
22	89%	10.5%	$7,381	$5,585	$7,400	$6,046	$6,723
25	68%	2.7%	$1,089	$8,445	$1,056	$8,306	$4,681
32	65%	6.4%	$8,180	$21,641	$8,024	$21,965	$14,994
36	80%	6.8%	$2,663	$3,158	$2,629	$4,284	$3,456

(1) AAll years@ indicates that all reinvestment data over the life of the system was used. As noted, many agencies have missing data for the early years of their system. A›80-96" indicates that only the reinvestment data from 1980 to 1996 was used.

(2) Average of predicted values.

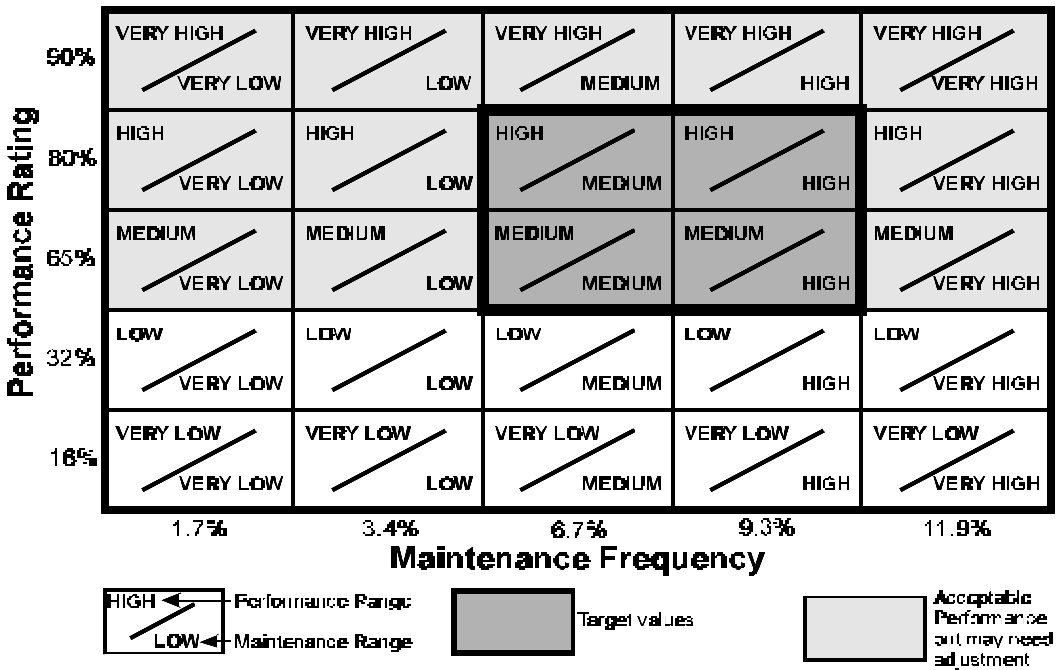
7.5 Optimizing Collection System Maintenance

Once the existing maintenance frequency, performance rating, and reinvestment rate are determined, optimization of maintenance can be evaluated. Optimization is an iterative process requiring judgment and the use of the tools presented in this study. An example of the optimization procedure is presented in the next section using Agency 42 as an example.

7.5.1 Optimization Of Maintenance For an Agency

Optimizing collection system maintenance involves a review and judgment of the system performance, the maintenance frequency, and the reinvestment amount. A target envelope for reinvestment amount and performance, based on results of the survey, is given on Figure 7-1. Reinvestment amounts can also be estimated using the regression equation in Table 7-8. A target envelope for performance rating and maintenance frequency is on Figure 7-2.

Figure 7-2
Estimated Target Envelope for
Performance Rating and Maintenance Frequency



The target values should result in good system performance with a well balanced maintenance program at an acceptable cost. Values to the left and upper left indicate high performance, but the maintenance frequency would be low. Long-term system performance may suffer if maintenance is kept at a low level. Values to the right and upper right may result in high reinvestment amounts. Values with low or very low performance levels represent unacceptable service.

7.5.2 Optimizing Maintenance for Agency No. 42

The maintenance frequency for Agency No. 42 is given in Table 7-10. The maintenance frequency of 7.6% is within the target values of moderate to high range. The performance rating of 62.6% and the reinvestment amount, determined in Table 7-11, would be classified as slightly low. The reinvestment amount of $1,988/mi$yr (shown in Table 7-12) based on all year=s reinvestment also is outside the desirable range on Figure 7-1. The more recent reinvestment of $5,596/mi$yr is within the lower portion of the desirable envelope.

Review of the individual performance measures shows that customer complaints, pump station failures, peak hour/ADF ratio, and maximum month/ADF ratio are all below desirable performance levels. A strategy to improve system performance would be to address maintenance items that are most likely to improve the performance deficiencies. The number of pump station failures could be reduced by increasing the number of inspections per year, and customer complaints may be reduced by increasing relief sewer improvements and/or reducing flows. Implementation of these measures will require increased reinvestment in the form of relief, and possible adjustment of priorities and budget.

Table 7-10
Determination of Maintenance Frequency for Agency No. 42

Characteristic Data:	Value		
Miles of Sewer - No.42	525		
Number of Pump Stations	55		
Data			
Activity	Quantity	Years	Rate
Cleaning 1992 -1996, miles	844	5	32.2%
Root Removal 1992 - 1996, miles	20	5	0.8%
Pump Station Inspections 1992 - 1996	1,1876	5	43.2%
Percentage of Flow Monitoring Last 5 Years	2%	5	0.4%
Percentage of Manhole Inspections Last 5 Years	100%	5	20.0%
Percentage of Smoke/Dye Test Last 5 Years	0%	5	0.0%
Percentage of CCTV Last 5 Years	5%	5	1.0%
Percentage of Private Sector Last 5 Years	0%	5	0.0%
Percentage of Manhole Rehabed	95%	n/a	95.0%
Percentage of Main Line Rehabed	60%	n/a	60.0%
Percentage of Relief/ Equal	0%	n/a	0.0%
Percentage of Private Sector	0%	n/a	0.0%
Maintenance Activity Frequency			
Item	Rate		
Cleaning Rate, % system/year	32.2%		
Root Cutting, % System/yr	0.8%		
Pump Station Rate, no/ps$yr	43.2		
Flow Monitoring Rate,% System/yr	0.4%		
Manhole Inspect. % System/yr	20.0%		
Smoke/dye Rate, % System/yr	0.0%		
CCTV Rate, % System/yr	1.0%		
Maintenance Activity Frequency			
Item	Rate		
Private Sector Inspection Rate, % System/yr	0.0%		
Manhole Rehab Status	95%		
Main Line Rehab Status	60%		
Sewer Relief Status	0%		
Private I/I Removal Rating	0%		

Table 7-10 Determination of Maintenance Frequency for Agency No. 42			
Weighted Normalized Maintenance Activity Frequency			
Rating	Weight	Unadjusted Frequency	Weighted Frequency
Cleaning Rating	17.7%	10%	1.77%
Root Cutting Rating	8.4%	6%	0.50%
Pump Station Rating	14.1%	5%	0.71%
Flow Monitoring Rating	7.0%	3%	0.21%
Manhole Inspect Rating	6.4%	10%	0.64%
Smoke/dye Rating	3.3%	3%	0.10%
CCTV Rating	10.5%	5%	0.53%
Private Sector Inspection Rating	2.0%	1%	0.02%
Manhole Rehab Rating	5.6%	18%	1.01%
Main Line Rehab Rating	12.6%	14%	1.76%
Sewer Relief Rating	6.3%	0%	0.00%
Private I/I Removal Rating	6.1%	1%	0.06%
Total Maintenance Frequency Rating	100.0%	76.0%	7.30%

Table 7-11 Determination of Performance Rating for Agency No. 42			
Data			
Performance Measure	Value		
Pipe Failure Rate Last 5 Years, no/yr$mi	0.001		
SSO Rate Last 5 Years, no/yr$mi	0.029		
Customer Complaints Last 5 Years., no/mi$yr	1.552		
Pump Station Failures Last 5 Years., no/mi$yr	0.023		
Peak Hourly/ADF	3.000		
Peak Month/ADF	2.500		
Weighted Normalized Performance Activity Rating			
Performance Rating	Weight	Unadjusted Rating	Weighted Rating
Pipe Failure Rating	22.6%	100%	22.6%
SSO Rate Rating	23.6%	87.1%	20.5%
Customer Complaints Rating	20.8%	71.3%	14.8%
Pump Station Failures Rating	17.8%	32.1%	5.7%
Peak Hourly/ADF Rating	9.7%	32.1%	3.1%
Peak Month/ADF Rating	5.5%	30.0%	1.7%
Total	100%		68.5 %

Table 7-12 Determination of Reinvestment		
Reinvestment	All Years	'80-'96
Relief $ Total,$/mi$yr	$136	$431
Equal. $ Total, $/mi$yr	$155	$491
Rehab $ Total, $/mi$yr	$490	$1,558
O&M $ Total, $/mi$yr	$1,207	$3,116
Equipment $ Total	$0	$0
Other $ Total	$0	$0
Total Spent, $/mi$yr	$1,988	$5,596
Total Spent, $/ft$yr	$0.38	

Figure 7-1 and the reinvestment regression equations (Table 7-8) can be used to estimate the annual reinvestment needed to achieve a higher performance rating. As indicated on Figure 7-1, a moderate reinvestment amount at a performance rating of 80% would be about $6,500 per mile per year, an increase from the current $5,596 per mile per year. This would result in an increase of about $475,000 per year for the 525 mile system. Using the average result from Equations RE3 and RE4 (Table 7-8) the estimated reinvestment amount is about $8,300 per mile per year, or an increase of about $1.4 million per year. For purposes of discussion, an increase of $1.4 million per year is assumed, which is still within the envelope on Figure 7-1. By focusing cleaning efforts to problem areas, the cleaning rate of 32 percent of the system per year can be reduced to around 20 percent per year. This will help offset some of the cost increase and may not significantly affect performance. This will need to be evaluated only one time. Over a typical planning cycle of 5 to 10 years, the increased reinvestment will result in significant improvements for large capital expenditures such as relief sewers. Agency No. 42 indicated that none of the required relief sewers had been constructed at the time of this survey. In actual practice, cost analyses need to be performed to determine the cost of each activity for the revised maintenance plan to check the plan's validity. Such an evaluation will not be performed for this example. The costs are unique for each agency and must be evaluated on the basis of local prices, personnel resources, equipment, and production rates. Nevertheless, a brief example of the impact of the reinvestment adjustment is as follows:

(1) Reinvestment increase - $1.4 million.

(2) Reduction due to change in cleaning frequency - ($340,000)
(68 miles x $5,000/mile).

(3) Increase due to more frequent pump station inspections - $424,000
(77 inspections/yr x 55 ps x $100/inspection).

(4) Increased relief reinvestment - $1.3 million.

The resulting plan will be a first step towards achieving a system with a maintenance frequency of about 7.5%, a performance rating of 80%, and a reinvestment of $8,300 per mile per year.

Refining the maintenance and reinvestment will be an iterative process which will require judgment to properly address performance deficiencies. The above example provides an approach to using maintenance frequencies, performance ratings, and system reinvestment amounts in adjusting a maintenance plan and evaluating its adequacy.

7.6 Conclusion

The data collected during this study and the methods used to develop maintenance frequencies, performance ratings, and reinvestment rates can be useful in evaluating the adequacy of existing maintenance programs (including routine maintenance and total reinvestment), and for making modification and adjustments to these programs. By expressing collection system maintenance in terms of overall frequency and performance as an overall rating, it is hoped that the relationship between maintenance (total reinvestment) and system performance will be better understood. This will also help regulators and agencies evaluate acceptable levels of system performance and reinvestment.

7.7 Recommendations

This study is a first effort to evaluate the relationship between collection system performance and maintenance (reinvestment), using an overall rating approach. The data for this study were difficult to collect, were guessed in some cases, and were not readily available from many of the agencies surveyed. It is probable that many agencies across the country also lack good data. It is recommended that agencies compile and keep records of performance and maintenance (total reinvestment) in a standardized format. The information presented in this study includes standard formats for collecting and summarizing data. The definitions and guidelines developed during this study for maintenance, and performance measures should be used by agencies to ensure uniform interpretation and collection of data.

Specific steps to improve the optimization of collection system maintenance are as follows:

1. Review and refine the maintenance, performance, and reinvestment measures used in this report. Develop detailed definitions of each.

2. Develop either an information collection guideline which would request that agencies collect data consistent with results of Step 1 or have a study with a core group of agencies to provide data that can be used to refine these analyses and to generate a AGuideline Report for Collection System Maintenance@.

3. Implement the information collection process and analyze the data to develop cost estimates, maintenance guidelines, and performance measures similar to those presented in this study.

4. Repeat the analysis on a regular basis every 2-5 years as the output will improve with the improved data collection.

Appendix A

Questionnaire

Optimization of Collection System Maintenance Frequencies
American Society of Civil Engineers and Black & Veatch
EPA Cooperative Agreement #CX 826097-01-0

The following questionnaire pertains to *separate collection systems only* and should not include data for combined sewers or wastewater treatment facilities. Please answer as many questions as possible. For data which are not available, simply enter An/a.@ Use judgment, if necessary, since exact figures may not always be available. Finally, please indicate the quality of the data where indicated in each section.

Definitions

1. **Collection System Maintenance:** Any reinvestment in the collection system infrastructure to improve and/or maintain wastewater service. "Maintenance", for purposes of this survey, includes what is traditionally considered maintenance, such as cleaning and lift station service, as well as capital improvements and rehabilitation to "maintain" the system..

2. **Quality of Data.**

a. Very Good. Data based on operational records or recent studies and is fully documented.

b. Good. Mostly based on operational records and recent studies supplemented by personnel knowledgeable of the data requested.

c. Fair. Based mostly on approximations with some supporting documentation but primarily data provided by memory from personnel knowledgeable of the data requested.

d. A Guess. Written records not available to verify but the best guess representing what is reasonably thought to be true by a person somewhat knowledgeable of the data requested.

Please FAX or Mail your completed Questionnaire to:

Richard E. (Rick) Nelson, P.E.
Principal Investigator
Black & Veatch
8400 Ward Parkway
Kansas City, MO 64114
Telephone: 913/458-3510
Fax: 913/458-3730
e-mail: nelsonre@bv.com

Thank You

I. General Information

1. City/Agency: ______________________
2. Address: ______________________
3. City/Zip Code: ______________________
4. Telephone No.: ______________________
5. Fax No.: ______________________
6. E-mail: ______________________
7. Completed By/Title: ______________________
8. Date: ______________________

II. Service Area Information

Quality of data for this section: G *Very Good (1)* G *Good (2)* G *Fair (3)* G *A Guess (4)*

1. Data is for: City Wide or Total Regional System G (1) or Individual Drainage Area G (2)
2. Service Area Name: ______________________
3. Miles of Public Sewer: ______________________
4. Number of Manholes: ______________________
5. Number of Connections: ______________________
6. Area Served (sq mi.): ______________________
7. Population Served: ______________________
8. Age of System: ______________________

a. Date of original collection system constructed: ______________________
b. Date of latest collection system improvement: ______________________
c. Age distribution: ______________________

AGE (YRS)	PERCENT OF SYSTEM
1. 0-10 Years	
2. 11-20 Years	
3. 21-50 Years	
4. 50 – 100 Years	
5. >100 Years	
6. Total	100%

III. Flow Information (all values are MGD unless otherwise indicated)

(Select year within last 3 years of data which best represents your system)

Quality of data for this section: G *Very Good (1)* G *Good (2)* G *Fair (3)* G *A Guess* (4)

1. Data is for: City Wide or Total Regional System G (1) or Individual Drainage Area G (2)
2. Year of data: ______________________
3. Average annual daily flow: ______________________
4. Maximum daily flow observed:* ______________________
5. Peak hourly flow observed:* ______________________
6. Indicate basis for peak hourly flow reported in item #III.4 (ie. Measured annual, estimated, weather and other related condition upon which estimate was made.

____

____

7. Maximum month average daily flow:
8. Minimum month average daily flow:
9. Percent of system below the average groundwater table:

*Indicates basis for flows reported (i.e., measured annual, estimated, weather and other related condition upon which estimate was made):

IV. System Characteristic Information

Quality of data for this section: **G** *Very Good (1)* **G** *Good (2)* **G** *Fair (3)* **G** *A Guess* (4)

1. Percent of system greater than 24 inches in diameter: ____________________
2. Number of pumping (lift) stations: ____________________
3. Total installed horsepower of lift stations: ____________________
4. Total energy consumed by all lift stations, kwh/yr: ____________________
5. Total length of force mains, miles: ____________________
6. Number of equalization basins upstream of WWTP: ____________________
7. Total volume of equalization basins, mg: ____________________
8. Percent of system which is industrial/commercial: ____________________
9. Typical velocity of flow, ft/s (min/max/typical): ____________________

V. System Performance Rates

Estimate numbers of storm events that exceeded the capacity of your system and caused SSOs.
Quality of data for this section: **G** *Very Good (1)* **G** *Good (2)* **G** *Fair (3)* **G** *A Guess (4)*

CUMULATIVE NUMBER OF EVENTS IN LAS ...				
ITEM	**1 Yr**	**5 Yr**	**10 Yr**	**20 Yr**
1. Pipe Failures (1)				
2. Manhole Overflows				
3. Treatment Overflows				
4. Basement Backups				
5. Other				
6. Customer Complaints (2)				
7. Pump Station Failures (3)				

(1) Pipe failure is defined as a pipe which has lost its structural integrity as evidenced by total or partial collapse (lost of 50% of pipe area or 25% of pipe wall along any circumference).
(2) Number of customer complaints related to the performance of the collection system. Based on customer complaint records.
(3) Number o pump station failures that result in station overflows. Based on operational records

VI. Routine Maintenance Frequencies

Quality of data for this section: **G** *Very Good (1)* **G** *Good (2)* **G** *Fair (3)* **G** *A Guess (4)*

TOTAL COMPLETED EACH YEAR					
ITEM	**1996**	**1995**	**1994**	**1993**	**1992**
1. Cleaning, miles of sewer					
2. Root Removal/Treatment, miles of sewer					
3. Main Line Stoppages Cleared, number					
4. House Service Stoppages Cleared, number					
5. Inspections and Services of Lift Stations, number					

VII. Inspection Methods Used and Status

Quality of data for this section: **G** *Very Good (1)* **G** *Good (2)* **G** *Fair (3)* **G** *A Guess (4)*

INSPECTIONS METHOD AND STATUS (1)				
	CUMULATIVE PERCENT OF SYSTEM QUANTITY INSPECTED IN LAST ...			
INSPECTION TASK	**1 YR**	**5 YR**	**10 YR**	**20 YR**
1. Flow Monitoring/Capacity Evaluation (2)				
2. Manhole (3)				
3. Smoke/Dye Test				
5. Private Sector Building Inspection (4)				

(1) Inspection % may exceed 100% of actives have been performed more than once. Percentage should be base on total quantity of task completed divided by total system. For example, in a system with 100 manholes, if 50 manholes were inspected twice each in the last year, the 100% of the system quantity would have been inspected in the last 1 year; not 50%. This data will help establish the frequency of inspection activities.

(2) Percent of subsystem (basins) monitored and evaluated.

(3) Surface or internal inspections.

(4) Inspections for area drains, downspouts, cleanouts, sump discharges and other private sector inflow sources into the sewer system.

VIII. Approximate Rehabilitation Status Percent Complete:

Quality of data for this section: **G** *Very Good (1)* **G** *Good (2)* **G** *Fair (3)* **G** *A Guess (4)*

REHABILITATION TASK	**PERCENT COMPLETE** (1)
1. Manhole	
2. Main line/public service connection repairs	
3. Relief/equalization	
4. Private Sector (lateral and illegal disconnect program)	

(1) Indicate the completion status of total estimated rehabilitation required to bring each item to a new or like new condition. For example: (a) if a system requires not rehabilitation (a like new system) then all rehabilitation tasks would be 100% complete; (b) in a 100 manhole system, if a total of 50 manholes require rehabilitation and 25 manholes have already been rehabilitated, then the rehabilitation status would be 50% complete; not 25% (i.e. 25/50 – 0.50).

XI. Estimated System Maintenance Costs:

Quality of data for this section: **G** *Very Good (1)* **G** *Good (2)* **G** *Fair (3)* **G** *A Guess (4)*

TOTAL DOLLARS SPENT (1)				
ITEM	**1990-1996 (7 yrs)**	**1980-1989 (10 yrs)**	**1970-1970 (10 yrs)**	**PRE-1970 (variable – list # of yrs.) (____ yrs.)**
1. Relief (Increased capacity) (2)				
2. Equalization (2)				
3. Rehabilitation/replacement				
4. O&M Budget (collection system only)				
5. Equipment Replacement (if not included in O&M above)				
6. Other Costs (4)				

(1) Includes engineering, construction and legal costs. Cost values should not be adjusted for infiltration.

(2) Does not include sewer extensions to serve growth. Only costs required to upgrade the existing collection system should be included.

(3) Differentiate whether it is in-system storage or if it is storage at the WWTP which is used to equalize wet weather flows.

(4) Description of "other costs" ____

X. Estimated Importance of Performance and Maintenance Activities

Based on your opinion, enter the relative importance of the various system **performance** indicators. The total should be up to 100%

1. System Performance Importance (Weight)	
Performance Indicator	**(Importance %)**
1. Pipe Failures	
2. Sanitary Sewer Overflows (SSOs)	
3. Customer Complaints	
4. Pump Station Failures	
5. Peak Hourly/ADF Ratio	
6. Peak Month/ADF Ratio	
Total	**100%**

X. Estimated Importance of Performance and Maintenance Activities

Based on your opinion, enter the relative importance of the various system performance indicators. The total should be up to 100%

2. Maintenance Activity Importance (Weight)	
Maintenance Activity	**(Importance %)**
1. % System Cleaned/Yr	
2. % System Root Removal/Yr	
3. Lift Station Service	
4. Flow Monitoring/Capacity Evaluation	
5. Manhole Inspection	
6. Smoke/Dye Testing	
7. CCTV Inspections	
8. Private Sector Inspections	
9. Manhole Rehabilitation	
10. Main Line Rehabilitation	
11. Relief Sewer Construction	
12. Private Sector I/I Source Removal	
Total	**100%**

XI. Effectiveness of Program:

1. Are you satisfied with your system maintenance (total reinvestment) program:

   a. Strongly Agree _____ (system performance is as required, cost effective budget)

   b. Agree _____ (system performance is generally as required, budget adequate)

   c. Not Sure _____ (system performance not defined, budget may be adequate)

   d. Disagree _____ (system performance generally not as required, budget not adequate)

   e. Strongly Disagree _____ (system performance and budget unacceptable)

2. What would you do different, if anything?

____
____
______
____
____
______
____
____
______

Thank You

Appendix B

Data Provided by Respondents

	Size	Region	Date	Quality of Data II	Data For	Miles of Sewer	Number of Manholes	Number of Connection	Area Served	Population Served	Date of Original System	Date of Most Recent	Age 0 - 10 Yrs.	Age 11 - 20 Yrs.	Age 21 - 50 Yrs.	Age 51 - 100 Yrs.	Age > 100 Yrs.
Item	**2**	**3**	**11**	**12**	**13**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
Form No.			**1.8**	**II**	**II.1**	**II.3**	**II.4**	**II.5**	**II.6**	**II.7**	**II.8.a**	**II.8.b**	**II.8.c.1**	**II.8.c.2**	**II.8.c.3**	**II.8.c.4**	**II.8.c.5**
No.	**size**	**region**	**date**	**Qual_II**	**datafor**	**milessew**	**nummh**	**numconn**	**area**	**pop**	**dateorg**	**datelast**	**age10**	**age20**	**age50**	**age100**	**ageold**
1	Large	NE	07/03/97			4891	128,691	388,238	1000	1,400,000	**1880**		19.6%	21.2%	51.3%	7.9%	0.0%
2	Small	CENTRAL	07/11/97	1	1	418	8,129	29,144	44	75,561	1900	1997	17.0%	19.0%	34.0%	30.0%	0.0%
3	Small	CENTRAL	04/11/97	2	1	190	3,855	18,000	50	56,000	1880	1997	5.0%	10.0%	70.0%	10.0%	5.0%
4	Large	CENTRAL	05/02/97	2	1	511	6,535		1650	2,500,000	1886	1996	1.0%	13.0%	67.0%	10.0%	9.0%
5	Large	CENTRAL	06/10/97	2		1520	32,108	300,000	280	900,000	1900	1997	6.0%	19.0%	73.0%	1.0%	1.0%
6	Medium	CENTRAL	04/07/97	2	1	900	27,000	60,000	26	180,000	1885	1997	10.0%	17.0%	49.0%	22.0%	2.0%
7	Medium	CENTRAL	05/27/97	2	1	119	1,200		161	280,000	1890	1997	2.0%	7.0%	76.0%	15.0%	0.0%
8	Medium	CENTRAL	06/11/97	3	1	2000	35,000	160,000	300	465,000	1910	1997	10.0%	10.0%	50.0%	30.0%	0.0%
9	Small	CENTRAL	04/17/97	1	1	300	7,243	24,000	39	78,000	1890	1996	19.0%	23.0%	42.0%	16.0%	0.0%
10	Large	CENTRAL	05/19/97	1	1	2953	82,900	220,000	244	850,000	1830	1997	5.0%	5.0%	20.0%	65.0%	5.0%
11	Large	CENTRAL	05/09/97			2017	60,000	176,004	201	632,958	1850	1997	20.0%	19.0%	37.0%	24.0%	0.0%
12	Large	CENTRAL	06/10/97	1		2500	44,000	212,000	390	875,000	1854	1997	4.0%	12.0%	40.0%	40.0%	4.0%
13	Large	NW	07/14/97	2	2	3250	43,500	182,386	183	700,000	1950	1983	35.0%	30.0%	35.0%	0.0%	0.0%
14	Large	SW	06/20/97	1	1	1250	20,400	1,143,980	770	4,770,000	1927	1997	3.0%	3.0%	58.0%	36.0%	0.0%
15	Large	NW	02/27/97	2	1	1550	36,000	136,814	110	525,000	1876	1997	1.0%	7.0%	44.0%	34.0%	14.0%
16	Large	CENTRAL	07/28/97	2	1	2255	35,000	138,975	250	619,320	1917	1997	30.0%	35.0%	30.0%	5.0%	0.0%
17	Large	CENTRAL	04/05/97	1		4010	30,493	285,000	290	1,070,168	1881	1997	25.0%	35.0%	30.0%	10.0%	0.0%
18	Medium	SE	04/16/97	3	1	1100	18,000	66,000	115	200,000	1910	1997	10.0%	10.0%	50.0%	30.0%	0.0%
19	Medium	CENTRAL		2	1	800	18,000	57,000	85	150,000	1945	1997	20.0%	30.0%	30.0%	20.0%	0.0%
20	Large	SE	02/27/97	1	1	2543	59,150	258,152	266	950,000	1919	1997	30.0%	40.0%	27.0%	3.0%	0.0%
21	Medium	SE	07/21/97	1	1	32	160	390	38	136,500	1969	1997	50.0%	15.0%	35.0%	0.0%	0.0%
22	Medium	SW		1		1435	19,346	127,578	187	456,445	1954	1997	60.0%	28.0%	12.0%	0.0%	0.0%
23	Large	SW	06/20/97	1	1	3986	63,837	348,973	460	1,000,000	1890	1997	20.0%	35.0%	35.0%	10.0%	0.0%
24	Medium	CENTRAL	08/29/97	1	1	1750	51,042	121,880	180	373,644	1909	1997	10.0%	30.0%	50.0%	10.0%	0.0%
25	Medium	CENTRAL	09/04/97	2		1600	40,000	125,000	125	310,000	1890	1997	10.0%	20.0%	30.0%	30.0%	10.0%
26	Medium	SW	08/25/97	3	1	875	13,000	60,000	185	183,000	1955	1997	25.0%	25.0%	50.0%	0.0%	0.0%
27	Medium	CENTRAL		1	1	1766	29,026	93,060	200	335,000	1850	1997	12.0%	20.0%	40.0%	21.0%	7.0%
28	Medium	SW	08/27/97	1	1	1141	23,281	114,857	108	405,517	1950	1997	51.0%	9.0%	34.0%	6.0%	0.0%
29	Medium	NE	08/26/97	3	1	820	17,300	60,000	296	200,000	1900	1997	**20.0%**	**25.0%**	**40.0%**	**15.0%**	**0.0%**
30	Medium	SW	05/02/97	1		2729	45,626	187,000	425	475,000	1901	1997	16.9%	26.8%	53.6%	2.7%	0.0%
31	Large	SE	08/26/97	2		2600	55,000	140,000	240	560,000	1800	1997	20.0%	44.0%	25.0%	10.0%	1.0%
32	Small	NE	05/05/97	2	1	72	1,500	2,500	25	86,900	1978	1997	25.0%	75.0%	0.0%	0.0%	0.0%
33	Large	CENTRAL	05/30/97	2		4332	91,365	301,545	440	906,885	1930	1997	11.6%	8.0%	34.6%	45.8%	0.0%
34	Large	CENTRAL		2		5700	100,000	368,000	600	1,720,000	**1900**		30.0%	40.0%	20.0%	10.0%	0.0%
35	Medium	SW	09/25/97	2	1	548	10,863	41,650	54	191,000	1917	1997	25.0%	50.0%	24.0%	1.0%	0.0%
36	Medium	CENTRAL	10/06/97	1	1	949	21,100	67,693	70	150,000	1894	1997	21.0%	21.0%	47.0%	10.0%	1.0%
37	Medium	SW	11/05/97	2		1600	29,000	141,000	162	450,000	**1900**	1997	8.0%	20.0%	71.0%	1.0%	0.0%
38	Small	SW	11/14/97	1	1	40	836	4,022	7	14,000	1931	1997	3.0%	17.0%	50.0%	30.0%	0.0%
39	Medium	NW	10/28/97	2	1	747	6,333	62,000	120	200,000	1911		15.0%	23.0%	60.0%	2.0%	0.0%
40	Small	NW	12/09/97	1	1	120	1,590	11,150	10	23,485	1900	1997	27.0%	16.0%	42.0%	15.0%	0.0%
41	Medium	SW	12/15/97	1		1274	18,190	104,000	102	396,011	1800	1997	24.0%	29.0%	28.0%	9.0%	10.0%
42	Medium	SW	12/30/97	2	1	525	10,000	52,000	50	180,000	1880	1997	5.0%	15.0%	30.0%	50.0%	0.0%

	Size	Region	Total %	Average Age	Quality of Data III	Data For	Year of Flow Data	Avg Annual Daily	Max. Daily Flow	Peak Hourly Flow	Peak Hourly Basis	Max. Month Daily	Min. Month Daily	% System in Groundwater	Quality of Data IV.	% System > 24"	Number of Pumping Sta.
Item ->	2	3	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Form No. ->			II.8.c.6	Calc	III	III.1	III.2	III.3	III.4	III.5	III.6	III.7	III.8	III.9	IV	IV.1	IV.2
No.	size	region	agetot	avgage	qual_III	dif_III	yrdta	adf	mdf	phf	flwbas	mxmadf	mnmadf	grdwtr	qual_IV	per24	nops
1	Large	NE	100.0%	28.0			1996	192.0	350.0	400.0	Metered	216.0	177.0	30.0%		5.5%	43
2	Small	CENTRAL	100.0%	38.1	1		1996	14.6	26.9	30.0	Flow Meters	18.2	13.6	10.0%	1	6.0%	11
3	Small	CENTRAL	100.0%	40.0	2	1	1988	7.7	15.0	14.0	Est -peak wet	8.4	6.6	30.0%	3	12.9%	16
4	Large	CENTRAL	100.0%	44.2	3	2	1996	213.3	288.0	599.0	Measured	237.6	197.0		2	68.0%	61
5	Large	CENTRAL	100.0%	30.7	2	1	1996	88.6	179.6	200.0	Est -Pump	140.4	33.9	75.0%	2	8.0%	214
6	Medium	CENTRAL	100.0%	39.2		1	1993	34.6	116.4	116.4	Max Capacity	44.5	20.1			8.0%	23
7	Medium	CENTRAL	100.0%	39.0	1	1	1996	39.6	97.7	132.9	Measured	49.2	36.5	50.0%		70.0%	17
8	Medium	CENTRAL	100.0%	42.0	1		1996	70.5	150.0	180.0	Measured	125.0	63.0	15.0%	2	20.0%	60
9	Small	CENTRAL	100.0%	31.1	1	1	1995	12.1	20.0	28.0	Est	13.1	11.1		1	7.0%	4
10	Large	CENTRAL	100.0%	63.0	1	1	1996	216.0	475.0	583.0	Metered Flow	395.0	140.0		1		131
11	Large	CENTRAL	100.0%	34.8	1	1	1995	160.6	252.8	289.0	Metered	186.9	132.6			12.0%	11
12	Large	CENTRAL	100.0%	51.0			1997	113.0	250.0	250.0	Metered	135.0	90.0		3		202
13	Large	NW	100.0%	18.5	2	1	1996	160.5	316.4		Metered	198.3	148.7	10.0%	2	3.0%	71
14	Large	SW	100.0%	47.9	1	1	1996	520.0	684.0	942.0	Measured	532.0	507.0		1	38.0%	48
15	Large	NW	100.0%	59.5	2	1	1996	50.0	74.6			66.1		5.0%	2	4.0%	4
16	Large	CENTRAL	100.0%	21.0	2		1996	76.9	110.5			76.8			2	8.7%	82
17	Large	CENTRAL	100.0%	24.5	1	1	1996	177.0	343.7	380.4	Measured	221.0	164.0	25.0%	2	21.5%	16
18	Medium	SE	100.0%	42.0	1		1997	28.0	90.0	90.0	Measured	60.0	25.0	50.0%	3	20.0%	90
19	Medium	CENTRAL	100.0%	31.0	2	1	1996	31.0	67.0	71.0	Measured	41.0	23.0	25.0%	2	12.0%	35
20	Large	SE	100.0%	19.2		1	1996	307.0	500.0	600.0	Measured	408.0	290.0	75.0%	2	1.2%	930
21	Medium	SE	100.0%	17.0	1	1	1996	9.6	11.8	16.2	Measured	10.6	8.2	90.0%	1	26.0%	27
22	Medium	SW	100.0%	11.4	1	2	1996	68.3	74.8	95.0	Measured	72.0	64.0	10.0%	1	4.0%	32
23	Large	SW	100.0%	26.0	2	2	1996	59.2	63.4	78.0	Measured	61.1	56.7		2	5.6%	19
24	Medium	CENTRAL	100.0%	30.0	1	1	1996	55.0			Estimated	70.6	42.8		1	5.0%	57
25	Medium	CENTRAL	100.0%	49.0	2	1	1996	42.0	57.0	117.6	Weather	43.2	35.7	20.0%	3		40
26	Medium	SW	100.0%	22.5	1	1	1997	15.1	19.3	30.0	Estimated	18.4	13.4	0.0%	3	5.0%	27
27	Medium	CENTRAL	100.0%	42.1	4		1996	98.0	115.0	125.0	Estimated	110.0	93.3	70.0%	3	15.0%	35
28	Medium	SW	100.0%	20.3	1		1997	49.3	55.9	90.0	Measured	54.1	45.9	0.0%		6.3%	2
29	Medium	NE	100.0%	30.0	2		1996	18.2				20.9	16.0				
30	Medium	SW	100.0%	25.7	2	2	1996	60.0	79.0	123.0	Measured	62.0	56.0	0.0%	1	3.5%	36
31	Large	SE	100.0%	25.1	3		1996	64.5	72.0		Measured	72.0	57.9	20.0%	2	20.0%	50
32	Small	NE	100.0%	12.5		1	1996	19.2	73.7	80.0	Measured	27.2	11.8		3	20.0%	55
33	Large	CENTRAL	100.0%	48.2	2	2	1996	55.9	112.4	164.9	Metered Flow	77.2	45.5		2		220
34	Large	CENTRAL	100.0%	22.0	2			236.0	536.0	650.0				30.0%	3	5.0%	377
35	Medium	SW	100.0%	17.9	3		1997	15.0		34.0	Estimated				2	2.7%	5
36	Medium	CENTRAL	100.0%	29.4	1	1	1997	40.7	115.0	140.0	Measured	55.0	31.0	25.0%	2	11.0%	32
37	Medium	SW	100.0%	29.0	1		1997	57.1	69.5	72.5	Estimated	58.5	46.5	5.0%	3	6.0%	14
38	Small	SW	100.0%	42.7	1	1	1996	1.6	3.2	3.1	Estimated	1.7	1.3	70.0%	1	0.0%	5
39	Medium	NW	100.0%	26.7				63.6	244.1	240.0	Measured	83.6	57.9	60.0%		12.0%	36
40	Small	NW	100.0%	29.7	1	1	1996	6.0	25.0	25.5	Measured	14.5	2.9	90.0%	2	4.0%	10
41	Medium	SW	100.0%	34.6			1995	63.0	94.0		Measured	64.4	60.9		2	19.0%	16
42	Medium	SW	100.0%	50.5	3	1	1996	24.0	60.0	72.0	Measured	60.0	21.0	0.0%	3	14.0%	55

	Size	Region	Manhole Overflows Last 5 Yr.	Manhole Overflows Last 10 Yr.	Manhole Overflows Last 20 Yr.	Treatment Overflows Last 1 Yr.	Treatment Overflows Last 5 Yr.	Treatment Overflows Last 10 Yr.	Treatment Overflows Last 20 Yr.	Basement Backups Last 1 Yr.	Basement Backups Last 5 Yr.	Basement Backups Last 10 Yr.	Basement Backups Last 20 Yr.	Other Last 1 Yr.	Other Last 5 Yr.	Other Last 10 Yr.	Other Last 20 Yr.
Item ->	2	3	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Form No. ->			V.2.2	V.2.3	V.2.4	V.3.1	V.3.2	V.3.3	V.3.4	V.4.1	V.4.2	V.4.3	V.4.4	V.5.1	V.5.2	V.5.3	V.5.4
No.	size	region	mho5	mho10	mho20	tro1	tro5	tro10	tro20	bmb1	bmb5	bmb10	bmb20	otr1	otr5	otr10	otr20
1	Large	NE	1,102	2,051	3,398					430	2,860	5,460	8,000				
2	Small	CENTRAL	120	293	765					9	44	108	283				
3	Small	CENTRAL	2	20	50	0	0	0	0	12	75	250	1,000				
4	Large	CENTRAL	20	30	60	0	0	0	0	4	20	30	50				
5	Large	CENTRAL								25				200			
6	Medium	CENTRAL				1				1							
7	Medium	CENTRAL	7	9		2	6	10		11	22	30					
8	Medium	CENTRAL				0	0	0	0	200							
9	Small	CENTRAL	5	7		0	0	0	0	15	55	91					
10	Large	CENTRAL								2,642							
11	Large	CENTRAL								759							
12	Large	CENTRAL				147	345			2,376	2,714						
13	Large	NW	924	1,848		0	0	0	0	53	275	505					
14	Large	SW	27	57	70	0	0	6	19					1	105	135	316
15	Large	NW								17	150						
16	Large	CENTRAL	646			3	5	10	20								
17	Large	CENTRAL	70			0	2			118	783			0	0		
18	Medium	SE	250	500	1,000	0	0	0	0								
19	Medium	CENTRAL				0	0	0	0								
20	Large	SE	250			0	1			0	0	0	0				
21	Medium	SE	5			0	0	0	0	0	1						
22	Medium	SW	179	406	1,326	1	5	10	20	0	3	5	10	4	15	25	40
23	Large	SW	1,000	2,500						0	0	0	0				
24	Medium	CENTRAL	1,486							37	227			17	27		
25	Medium	CENTRAL				2				100							
26	Medium	SW	15			0	5	10	15	0	0	0	0	0	0	0	0
27	Medium		400	750	1,200	30	160	300	500	283	1,650	4,230	10,790				
28	Medium	SW	640	1,280	2,560					1	5	10	20	235	1,175	2,350	4,700
29	Medium	NE															
30	Medium	SW							1	30	215	500	900				
31	Large	SE	1,656	3,280						70	298			410	3,265	6,118	
32	Small	NE	15	35	50	2	10	20	30	3	10	30	50				
33	Large	CENTRAL				9				3,039				28			
34	Large	CENTRAL															
35	Medium	SW	8			0	1			2	4						
36	Medium	CENTRAL	9							3	10	400					
37	Medium	SW	275			0	0	0	0	22	161						
38	Small	SW	13			0	0	1		0	1						
39	Medium	NW								20				5			
40	Small	NW	0			20	100			15	60			10	35		
41	Medium	SW	761											64	100		
42	Medium	SW	70			1	6			2	5						

	Size	Region	Customer Complaints Last 1 Yr.	Customer Complaints Last 5 Yrs.	Customer Complaints Last 10 Yrs.	Customer Complaints Last 20 Yrs.	Pump Station Failures Last 1 Yr.	Pump Station Failures Last 5 Yrs.	Pump Station Failures Last 10 Yrs.	Pump Station Failures Last 20 Yrs.	Quality of Data VI.	Cleaning in 1992, miles	Cleaning in 1993, miles	Cleaning in 1994, miles	Cleaning in 1995, miles	Cleaning in 1996, miles	Cleaning 1992 - 1996, miles
Item ->	2	3	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Form No. ->			V.6.1	V.6.2	V.6.3	V.6.4	V.7.1	V.7.2	V.7.3	V.7.4	VI	VI.1.1	VI.1.2	VI.1.3	VI.1.4	VI.1.5	VI.1.6
No.	size	region	cust1	cust5	cust10	cust20	psfail1	psfail5	psfail10	psfail20	qual_VI	micln92	micln93	micln94	micln95	micln96	miclntot
1	Large	NE	6,241				10	123	223		1	216	238	268	262	298	1,282
2	Small	CENTRAL	216	1,032	2,151	4,501	1	2	2		1	177	135	168	162	138	780
3	Small	CENTRAL	284	1,600	4,000	10,000	0	3	5	10	3	30	35	40	46	53	204
4	Large	CENTRAL	20	40	80	120	1	1	2	4	2	10	10	10	10	10	50
5	Large	CENTRAL	150								3			359	359	359	1,077
6	Medium	CENTRAL	251				3				1	511	452	437	478	402	2,280
7	Medium	CENTRAL					3	4	7		2	7	8	9	7	11	42
8	Medium	CENTRAL					0	0	0	0	3					200	200
9	Small	CENTRAL	15	55	91		0	0	0		1	180	151	152	168	177	828
10	Large	CENTRAL	7,823				65	346			1					95	95
11	Large	CENTRAL	3,555				14				1	422	341	407	318	381	1,869
12	Large	CENTRAL	5,457	18,991			281	623	747	840	1	39	41	42	46	101	269
13	Large	NW	6,616	30,009	51,484		0	0	0		1	760	844	854	813	852	4,123
14	Large	SW					0	1	15	32	1				400	449	849
15	Large	NW	800	4,000							2	2,000	2,000	2,000	2,045	1,939	9,984
16	Large	CENTRAL	5,668	34,901	86,924			36			1	245	174	225	172	137	953
17	Large	CENTRAL	11,975	44,172			3	28			1	912	887	678	781	1,000	4,258
18	Medium	SE					1	3	8	10	3					204	204
19	Medium		25	100	250	500	2	25	100	500	2	10	10	10	15	100	145
20	Large	SE	4,600	23,000			14	70			1			600	600	600	1,800
21	Medium	SE					0	0	0	0	3	10	10	10	10	10	50
22	Medium	SW	640	2,981	4,998	8,625	1	5	10	15	2	206	228	218	227	232	1,111
23	Large	SW					0	0	5	10	2	821	1,016	1,141	1,239	1,200	5,417
24	Medium	CENTRAL	2,593	13,402	21,095		0	20			2	974	651	752	623	851	3,851
25	Medium	CENTRAL	1,200				100				2					400	400
26	Medium	SW	250	1,500	3,000	6,000	0	2			1	183	190	197	202	219	991
27	Medium		900	6,320	16,000	45,000	4	35	75	120	2	200	180	170	190	195	935
28	Medium	SW	439	2,195	4,390	8,780	20	100	200	400	1	481	634	783	863	804	3,565
29	Medium	NE									2	92	108	99	101	86	486
30	Medium	SW	300	2,000	5,000		4	30	80	160	2	1,000	1,100	1,200	1,300	1,400	6,000
31	Large	SE	4,700	18,700			2	5	7		1	843	1,090	619	579	629	3,760
32	Small	NE	4	10	40	60	2	5	7	14							0
33	Large	CENTRAL					26				2					637	637
34	Large										2		3,420	2,280	1,710	1,140	8,550
35	Medium	SW	55				0	0	0		2	141	157	132	128	182	739
36	Medium	CENTRAL	1,100	6,500	10,200		0	5	10		3	200	200	225	225	225	1,075
37	Medium	SW						1	2		2	481	494	544	717	578	2,814
38	Small	SW	24				0	0	0	0	3	34	20	20	30	20	124
39	Medium	NW	150				1								451	429	880
40	Small	NW	8	25			2	5			2		20	15	20	20	75
41	Medium	SW	749	1,347							2	590	751	668	737	793	3,539
42	Medium	SW	800	3,800			10	60			2	150	165	150	184	195	844

	Size	Region	Root Removal 1992, miles	Root Removal 1993, miles	Root Removal 1994, miles	Root Removal 1995, miles	Root Removal 1996, miles	Root Removal 1992 - 1996, miles	ML Stoppages Fixed 1992	ML Stoppages Fixed 1993	ML Stoppages Fixed 1994	ML Stoppages Fixed1995	ML Stoppages Fixed 1996	ML Stoppages Fixed 1992 - 1996	Service Stoppages Fixed 1992	Service Stoppages Fixed 1993	Service Stoppages Fixed 1994
Item ->	**2**	**3**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**	**101**
Form No. ->			**VI.2.1**	**VI.2.2**	**VI.2.3**	**VI.2.4**	**VI.2.5**	**VI.2.6**	**VI.3.1**	**VI.3.2**	**VI.3.3**	**VI.3.4**	**VI.3.5**	**VI.3.6**	**VI.4.1**	**VI.4.2**	**VI.4.3**
No.	**size**	**region**	**mirt92**	**mirt93**	**mirt94**	**mirt95**	**mirt96**	**mirttot**	**nostop92**	**nostop93**	**nostop94**	**nostop95**	**nostop96**	**nostopto**	**nohou92**	**nohou93**	**nohou94**
1	Large	NE	45.9	59.7	47.5	66.7	59.7	279.6	872	852	828	1,381	853	4,786	854	862	630
2	Small	CENTRAL	1.0	27.0	18.0	31.0	26.0	103.0	36	40	22	32	34	164	0	0	0
3	Small	CENTRAL	0.0	0.0	0.0	0.0	0.0	0.0	100	90	80	70	59	399	215	205	195
4	Large	CENTRAL	2.0	2.0	2.0	2.0	0.5	8.5	1	1	1	0	2	5	0	0	0
5	Large	CENTRAL			70.0	70.0	70.0	210.0			260	260	260	780			
6	Medium	CENTRAL	0.0	0.0	0.0	0.0	0.0	0.0	304	311	282	260	251	1,408			
7	Medium	CENTRAL	0.0	0.0	0.0	0.0	0.0	0.0	1	0	0	0	1	2			
8	Medium	CENTRAL					200.0	200.0					400	400			
9	Small	CENTRAL			1.0	1.1	2.0	4.1			46	40	15	101			
10	Large	CENTRAL					17.0	17.0						0			
11	Large	CENTRAL			16.0	14.5	16.4	46.8						0	0	0	0
12	Large	CENTRAL	75.1	7.1	6.8	12.7	6.4	108.1	54	31	46	48	54	233	923	711	584
13	Large	NW					4.3	4.3	618	764	598	557	512	3,049	1,418	1,663	1,634
14	Large	SW						0.0						0			
15	Large	NW	0.0	0.0	0.0	0.0	0.0	0.0				12	15	27	0	0	0
16	Large	CENTRAL		0.4	1.1	0.8	0.2	2.5	401	330	274	268	255	1,528	580	694	886
17	Large	CENTRAL	108.0	89.0	48.0	27.0	12.0	284.0	1,827	1,916	1,997	2,017	2,040	9,797	3,393	3,473	3,969
18	Medium	SE					100.0	100.0					744	744			
19	Medium	CENTRAL		3.0	5.0	5.0	5.0	21.0	1,500	1,500	1,500	1,350	1,600	7,450	1,500	1,500	1,500
20	Large	SE			25.0	25.0	25.0	75.0				2,400	3,827	6,227			
21	Medium	SE	0.0	0.0	0.0	0.0	0.0	0.0				2	4	6			
22	Medium	SW						0.0	63	48	47	53	47	258			
23	Large	SW	0.0	0.0	0.0	1.0	1.0	2.0	315	305	252	264	250	1,386	0	0	0
24	Medium	CENTRAL	12.0	10.5	4.0	1.0	1.0	28.5	365	495	536	488	531	2,415			
25	Medium	CENTRAL					200.0	200.0					490	490			
26	Medium	SW	17.0	20.0	24.0	27.0	30.0	118.0	42	45	49	55	53	244	0	0	0
27	Medium	CENTRAL		100.0	75.0	85.0	110.0	480.0	260	280	210	230	175	1,155	310	350	305
28	Medium	SW	1.0	1.0	1.0	1.0	1.0	5.0	134	132	135	130	128	659	2	2	2
29	Medium	NE						0.0	319	279	338	368	418	1,722	343	336	322
30	Medium	SW						0.0	590	540	480	410	372	2,392	0	0	0
31	Large	SE	581.0	615.0	506.0	551.0	311.0	2,564.0	664	723	676	410	519	2,992	685	851	899
32	Small	NE	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	1	1	0	0	0
33	Large	CENTRAL						0.0				746	470	1,216			
34	Large	CENTRAL						0.0				2,120	2,000	4,120			981
35	Medium	SW					0.0	0.0	28	25	30	22	24	129			
36	Medium	CENTRAL	0.0	0.0	30.0	0.0	0.0	30.0	100	120	100	90	80	490			
37	Medium	SW	11.0	9.0	4.0	7.0	8.0	39.0	2	6	4	4	8	24			
38	Small	SW	0.0	0.0	0.0	0.0	0.1	0.1	7	7	6	5	4	29	15	12	12
39	Medium	NW				5.0	6.0	11.0				40	40	80			
40	Small	NW			2.0	3.0	5.0	10.0		3	4	4	6	17			
41	Medium	SW	360.0	336.0	313.0	394.0	380.0	1,783.0						0			
42	Medium	SW	0.0	5.0	5.0	5.0	5.0	20.0			400	380	414	1,194	0	0	0

	Size	Region	Service Stoppages Fixed 1995	Service Stoppages Fixed 1996	Service Stoppages Fixed 1992 - 1996	Lift Station Inspections 1992	Lift Station Inspections 1993	Lift Station Inspections 1994	Lift Station Inspections 1995	Lift Station Inspections 1996	Lift Station Inspections 1992 - 1996	Quality of Data VII.	% Flow Monitoring Last 1 Yr	% Flow Monitoring Last 5 Yr	% Flow Monitoring Last 10 Yr	% Flow Monitoring Last 20 Yr	% Manhole Inspections Last 1 Yr.
Item ->	2	3	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
Form No. ->			VI.4.4	VI.4.5	VI.4.6	VI.5.1	VI.5.2	VI.5.3	VI.5.4	VI.5.5	VI.5.6	VII	VII.1.1	VII.1.2	VII.1.3	VII.1.4	VII.2.1
No.	size	region	nohou95	nohou96	nohouto	nolsin92	nolsin93	nolsin94	nolsin95	nolsin96	nolsinto	qual_VII	fm1	fm5	fm10	fm20	mh1
1	Large	NE	619	740	3,705	16,400	14,600	14,600	14,600	15,700	75,900		100.0%	100.0%	100.0%	100.0%	4.0%
2	Small	CENTRAL	0	0	0	0	0	380	380	388	1,148	2	0.0%	0.0%	0.0%	0.0%	30.0%
3	Small	CENTRAL	185	173	973	9,100	9,100	9,100	9,100	9,100	45,500	3	1.0%	10.0%	95.0%	95.0%	3.0%
4	Large	CENTRAL	0	0	0	15,000	15,000	15,000	15,000	15,000	75,000	2	100.0%	200.0%	300.0%	400.0%	20.0%
5	Large	CENTRAL			0			5,590	5,590	5,590	16,770	3					50.0%
6	Medium	CENTRAL			0						0	3	8.0%	17.0%	25.0%	25.0%	4.0%
7	Medium	CENTRAL			0	1,800	1,800	1,800	1,800	1,800	9,000	1	12.0%	100.0%	100.0%	100.0%	12.0%
8	Medium	CENTRAL		0	0					365	365		1.0%	30.0%	70.0%	80.0%	5.0%
9	Small	CENTRAL			0	200	200	200	200	200	1,000	2	0.0%	5.0%	5.0%	5.0%	2.1%
10	Large	CENTRAL		179	179	5,000	5,000	6,300	6,800	6,812	29,912	1					
11	Large	CENTRAL	0	0	0						0	3	100.0%	200.0%			
12	Large	CENTRAL	589	514	3,321						0	2					0.0%
13	Large	NW	1,301	1,317	7,333	828	828	828	840	852	4,176	3	100.0%	500.0%	900.0%	1400.0%	0.1%
14	Large	SW			0	48	48	48	48	48	240	1	50.0%	250.0%	500.0%	1000.0%	100.0%
15	Large	NW	0	0	0	100	100	100	100	100	500	2					60.0%
16	Large	CENTRAL	933	1,021	4,114						0	3	10.0%	20.0%	25.0%	35.0%	10.0%
17	Large	CENTRAL	3,952	5,270	20,057	416	416	832	832	832	3,328	3	7.0%	20.0%	30.0%	35.0%	7.0%
18	Medium	SE			0	86	88	89	90	94	447	4	0.0%	0.0%	0.0%	0.0%	17.0%
19	Medium	CENTRAL		1,500	7,500	25	38	38	1,850	1,900	3,851	2	5.0%	25.0%	26.0%	26.0%	7.0%
20	Large	SE	2,400	2,346	4,746	0	0	45,000	45,000	45,220	135,220	1	20.0%	100.0%	100.0%		30.0%
21	Medium	SE			0	50	53	55	55	57	270	2	0.0%	30.0%			0.0%
22	Medium	SW			0	2,750	2,800	2,800	2,850	2,904	14,104	3	100.0%	100.0%	100.0%		60.0%
23	Large	SW	0	0	0	1,872	1,872	1,872	1,872	1,872	9,360	2	0.0%	0.0%	0.0%	0.0%	30.0%
24	Medium	CENTRAL			0	6,055	7,733	7,886	8,316	9,192	39,182	2	45.0%	45.0%	100.0%		59.0%
25	Medium	CENTRAL		0	0					365	365	4	5.0%	0.0%	0.0%	0.0%	5.0%
26	Medium	SW	0	0	0	145	150	200	225	250	970	3	100.0%	100.0%	100.0%	100.0%	50.0%
27	Medium	CENTRAL		300	1,585	9,200	13,960	11,100	9,250	9,100	52,610	2	70.0%	75.0%	76.0%	77.0%	35.0%
28	Medium	SW	2	2	10	156	156	156	104	104	676						
29	Medium	NE	368	472	1,841						0	2	80.0%	80.0%	80.0%		2.0%
30	Medium	SW	0	0	0				2,533	2,946	5,479		1.0%	5.0%	10.0%	20.0%	
31	Large	SE	829	1,132	4,396			5,720	6,188	3,000	14,908	3	40.0%				29.0%
32	Small	NE	0	0	0						0	3	10.0%	20.0%			100.0%
33	Large	CENTRAL			0												7.3%
34	Large	CENTRAL		850	2,831						0	3					
35	Medium	SW			0	52	52	52	52	52	260	2	0.0%	0.0%	10.0%		45.6%
36	Medium	CENTRAL			0	4,160	4,160	4,160	4,160	4,160	20,800	2	30.0%	55.0%	60.0%	65.0%	40.0%
37	Medium	SW			0						0	2					
38	Small	SW	5	10	54	3,500	1,300	1,300	1,300	1,300	8,700	2	0.0%	75.0%	125.0%	125.0%	5.0%
39	Medium	NW	5	5	10				432	432	864		100.0%	500.0%			70.0%
40	Small	NW			0				75	50	125	2	0.0%	100.0%	200.0%	300.0%	5.0%
41	Medium	SW			0						0						
42	Medium	SW	0	0	0		2,800	3,023	3,105	2,948	11,876	4	1.0%	2.0%			20.0%

	Size	Region	% Manhole Inspections Last 5 Yr.	% Manhole Inspections Last 10 Yr.	% Manhole Inspections Last 20 Yr.	% Smoke/Dye Test Last 1 Yr.	% Smoke/Dye Test Last 5 Yr.	% Smoke/Dye Test Last 10 Yr.	% Smoke/Dye Test Last 20 Yr.	% CCTV Last 1 Yr.	% CCTV Last 5 Yr.	% CCTV Last 10 Yr.	% CCTV Last 20 Yr.	% Private Sector Last 1 YR.	% Private Sector Last 5 YR.	% Private Sector Last 10 YR.	% Private Sector Last 20 YR.
Item ->	**2**	**3**	**117**	**118**	**119**	**120**	**121**	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**	**131**
Form No. ->			**VII.2.2**	**VII.2.3**	**VII.2.4**	**VII.3.1**	**VII.3.2**	**VII.3.3**	**VII.3.4**	**VII.4.1**	**VII.4.2**	**VII.4.3**	**VII.4.4**	**VII.5.1**	**VII.5.2**	**VII.5.3**	**VII.5.4**
No.	**size**	**region**	**mh5**	**mh10**	**mh20**	**smk1**	**smk5**	**smk10**	**smk20**	**tv1**	**tv5**	**tv10**	**tv20**	**psi1**	**psi5**	**psi10**	**psi20**
1	Large	NE	10.0%	20.0%	35.0%	2.0%	5.0%	8.0%	15.0%	4.0%	15.0%	20.0%	40.0%	0.0%	0.5%	1.0%	1.0%
2	Small	CENTRAL	80.0%	80.0%	80.0%	0.0%	0.0%	0.0%	80.0%	2.0%	10.0%	25.0%	30.0%	0.0%	0.0%	0.0%	0.0%
3	Small	CENTRAL	10.0%	95.0%	100.0%			95.0%	100.0%	5.0%	15.0%	30.0%	35.0%	0.0%	0.0%	100.0%	100.0%
4	Large	CENTRAL	40.0%	60.0%	80.0%	1.0%	2.0%	2.0%	2.0%	10.0%	20.0%	30.0%	40.0%	0.0%	0.0%	0.0%	0.0%
5	Large	CENTRAL	50.0%			50.0%				5.0%	5.0%			0.0%			
6	Medium	CENTRAL	50.0%	60.0%	60.0%	8.0%	17.0%	25.0%	25.0%	12.0%	23.0%	40.0%	40.0%				
7	Medium	CENTRAL	47.0%	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	12.0%	47.0%	53.0%	53.0%	0.0%	0.0%	0.0%	0.0%
8	Medium	CENTRAL	20.0%	50.0%	60.0%	5.0%	20.0%	40.0%	50.0%	2.0%	10.0%	30.0%	50.0%				
9	Small	CENTRAL	4.1%	6.2%		0.0%	5.0%	5.0%	5.0%	3.0%	48.0%	100.0%					
10	Large	CENTRAL								1.0%							
11	Large	CENTRAL				1.0%	3.0%	4.2%		0.7%	6.0%	13.6%					
12	Large	CENTRAL	50.0%	100.0%		1.0%	3.0%			4.0%	7.2%			0.0%	0.0%	0.0%	0.0%
13	Large	NW	0.7%	2.1%	7.0%	0.1%	0.5%	2.0%	4.0%	3.0%	15.0%	23.0%	38.0%	0.0%	0.0%	0.0%	0.0%
14	Large	SW	500.0%	1000.0%	2000.0%	0.0%	0.0%	0.0%	0.0%	15.0%	37.0%	40.0%	50.0%				
15	Large	NW	100.0%	100.0%	100.0%	1.0%	1.0%	1.0%	1.0%	13.0%	45.0%						
16	Large	CENTRAL	50.0%	70.0%	70.0%	25.0%	50.0%	70.0%	85.0%	10.0%	50.0%	70.0%	70.0%				
17	Large	CENTRAL	20.0%	30.0%	35.0%	7.0%	20.0%	30.0%	35.0%	3.0%	18.0%	30.0%	40.0%	7.0%	20.0%	30.0%	35.0%
18	Medium	SE	18.0%	19.0%	22.0%	5.0%	50.0%	50.0%	50.0%	1.7%	8.3%	16.7%	33.3%				
19	Medium	CENTRAL		32.0%	32.0%	25.0%	26.0%	26.0%	26.0%	2.0%	25.0%	26.0%	26.0%	0.0%	0.0%	0.0%	0.0%
20	Large	SE	100.0%	100.0%		30.0%	100.0%	100.0%		30.0%	100.0%	100.0%		30.0%	100.0%	100.0%	
21	Medium	SE	90.0%			0.0%				0.0%	90.0%			5.0%			
22	Medium	SW	250.0%	450.0%	800.0%	10.0%	50.0%	100.0%	200.0%	2.3%	7.9%	14.7%	26.0%	0.0%	0.0%	0.0%	0.0%
23	Large	SW	200.0%	400.0%	800.0%	1.0%	1.0%	1.0%	1.0%	7.8%	65.0%	90.0%	130.0%	0.0%	0.0%	0.0%	0.0%
24	Medium	CENTRAL	211.0%	336.0%		31.0%	84.0%	126.0%		7.0%	27.0%	40.0%		30.0%	70.0%		
25	Medium	CENTRAL				5.0%				15.0%				5.0%	0.0%	0.0%	0.0%
26	Medium	SW	50.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	20.0%	75.0%	75.0%	75.0%	0.0%	0.0%	0.0%	0.0%
27	Medium	CENTRAL		60.0%	70.0%	10.0%	15.0%	17.0%	18.0%	5.0%	8.0%	11.0%	15.0%	2.0%	3.0%	4.0%	5.0%
28	Medium	SW															
29	Medium	NE	54.0%			0.0%	0.0%	0.0%	0.0%	1.0%	11.0%						
30	Medium	SW				0.0%	0.0%	0.0%	0.0%	2.0%	6.0%			0.0%	0.0%	0.0%	0.0%
31	Large	SE	368.0%			17.0%	218.0%			2.5%	222.0%			0.0%	0.0%	0.0%	0.0%
32	Small	NE	200.0%	300.0%	400.0%			1.0%		20.0%							
33	Large	CENTRAL				2.0%				2.4%							
34	Large	CENTRAL															
35	Medium	SW	100.0%			0.0%	0.0%	1.0%		3.0%	7.0%	8.0%					
36	Medium	CENTRAL	95.0%	100.0%	100.0%	30.0%	60.0%	60.0%	60.0%	10.0%	17.0%	24.0%	32.0%	40.0%	85.0%	85.0%	85.0%
37	Medium	SW				0.6%	3.3%			3.0%	7.0%						
38	Small	SW	105.0%	135.0%	135.0%	1.0%	101.0%	101.0%	101.0%	33.0%	33.0%	63.0%	63.0%	1.0%	101.0%	101.0%	101.0%
39	Medium	NW	100.0%			5.0%				12.0%	60.0%						
40	Small	NW	20.0%	40.0%	60.0%	0.0%	25.0%	50.0%	75.0%	0.0%	25.0%	50.0%	75.0%	0.0%	0.0%	0.0%	0.0%
41	Medium	SW															
42	Medium	SW	100.0%	200.0%	300.0%	0.0%	0.0%	0.0%	0.0%	2.0%	5.0%	10.0%	20.0%				

	Size	Region	Data Quality VIII	% Manhole Rehabed	% Main Line Rehabed	% Relief/ Equal	% Private Sector	Data Quality IX	Relief $ < 1970	Relief $ '70 - '79	Relief $ "80 - '89	Relief $ '90 - 96	Relief $ Total	Equal. $ < 1970	Equal. $ '70 - '79
Item ->	2	3	132	133	134	135	136	137	138	139	140	141	142	143	144
Form No. ->			VIII	VIII.1	VIII.2	VIII.3	VIII.4	IX	IX.1.1	IX.1.2	IX.1.3	IX.1.4	IX.1.5	IX.2.1	IX.2.2
No.	size	region	qual_VIII	mhrehab	lnrehab	rerehab	prireh	qual_IX	rel70	rel79	rel89	rel96	reltot	eq70	eq79
1	Large	NE		75.0%	50.0%	80.0%	0.0%		$0	$0	$0	$48,800,000	$48,800,000		
2	Small	CENTRAL	4	20.0%	50.0%		10.0%	1				$0	$0		
3	Small	CENTRAL	3	33.0%	29.0%	62.0%	69.0%	4		$1,000,000	$2,000,000	$5,000,000	$8,000,000	$0	$0
4	Large	CENTRAL	2	90.0%	0.0%	0.0%	0.0%	2		$140,000,000	$72,000,000	$60,000,000	$272,000,000	$0	$0
5	Large	CENTRAL	4	75.0%	75.0%		0.0%	4	$0				$0		
6	Medium	CENTRAL	4	20.0%	20.0%	5.0%	0.0%	2				$10,000,000	$10,000,000		
7	Medium	CENTRAL		100.0%	100.0%	100.0%	100.0%	2	$1,303,000	$126,000	$1,216,000	$586,000	$3,231,000	$0	$0
8	Medium	CENTRAL	2	30.0%	40.0%	50.0%		2				$7,000,000	$7,000,000		
9	Small	CENTRAL	3	25.0%	50.0%			1					$0		
10	Large	CENTRAL											$0		
11	Large	CENTRAL	4	10.0%	2.0%		1.0%						$0		
12	Large	CENTRAL											$0		
13	Large	NW	3	0.1%	1.0%	0.0%		1					$0		
14	Large	SW	1	56.0%	56.0%	67.0%		1			$1,400,000	$43,000,000	$44,400,000		
15	Large	NW	2	100.0%	100.0%	100.0%	100.0%	3				$2,500,000	$2,500,000		
16	Large	CENTRAL	4	5.0%	10.0%		5.0%	1					$0		
17	Large	CENTRAL	1	40.0%	50.0%	80.0%	90.0%					$54,320,000	$54,320,000		$1,025,000
18	Medium	SE	3	2.0%	2.0%	20.0%	0.0%	4		$20,000,000	$25,000,000	$0	$45,000,000	$0	$0
19	Medium	CENTRAL		40.0%	30.0%	60.0%	0.0%	3			$1,000,000	$2,000,000	$3,000,000	$0	$0
20	Large	SE	1	96.0%	70.0%	25.0%	95.0%		$0	$0	$0	$0	$0	$0	$0
21	Medium	SE	2	100.0%	90.0%			2				$0	$0		
22	Medium	SW	1	99.9%	100.0%	100.0%	100.0%	2		$18,157,229	$24,570,187	$42,391,582	$85,118,998		$5,000,000
23	Large	SW	2	1.0%	1.0%	0.0%	0.0%	2	$0	$0	$0	$0	$0	$0	$0
24	Medium	CENTRAL	2	30.0%	30.0%	60.0%	30.0%	2				$9,500,000	$9,500,000		
25	Medium	CENTRAL	4	5.0%	1.0%		1.0%	4				$14,000,000	$14,000,000		
26	Medium	SW	3	0.0%	25.0%	10.0%	0.0%	3			$1,000,000	$5,450,000	$6,450,000	$0	$0
27	Medium	CENTRAL		20.0%	20.0%	10.0%	5.0%	2	$1,100,000	$800,000	$1,200,000	$1,800,000	$4,900,000	$0	$0
28	Medium	SW											$0		
29	Medium	NE											$0		
30	Medium	SW	4	5.0%	5.0%	10.0%	0.0%	2			$8,900,000	$4,000,000	$12,900,000	$0	$0
31	Large	SE	2	5.0%	3.0%	50.0%	0.0%	3				$4,000,000	$4,000,000		
32	Small	NE		90.0%	95.0%			3				$900,000	$900,000		
33	Large	CENTRAL					0.0%	3			$25,425,145	$44,638,800	$70,063,945		
34	Large	CENTRAL		40.0%	44.0%	35.0%	17.0%						$0		
35	Medium	SW	4	25.0%	25.0%	50.0%		3			$2,800,000	$600,000	$3,400,000	$0	$0
36	Medium	CENTRAL	2	20.0%	15.0%	0.0%	0.0%	3		$0	$0	$0	$0	$0	$5,000,000
37	Medium	SW	3		31.0%								$0		
38	Small	SW	1	20.0%	2.0%	100.0%	95.0%						$0		
39	Medium	NW			5.0%		3.0%						$0		
40	Small	NW	2	5.0%	5.0%		0.0%	3	$0	$0	$0	$2,000,000	$2,000,000	$0	$0
41	Medium	SW	3	99.0%	99.9%	100.0%	100.0%						$0		
42	Medium	SW	4	95.0%	60.0%			3			$1,500,000	$2,100,000	$3,600,000		

	Size	Region	Equal. $ '80 - '89	Equal. $ '90 - '96	Equal. $ Total	Rehab $ < 1970	Rehab $ '70 - '79	Rehab $ '80 - '89	Rehab $ '90 - '96	Rehab $ Total	O&M $ <1970	O&M $ "70 - '79	O&M $ "80 - '89	O&M $ "90 - '96
Item ->	2	3	145	146	147	148	149	150	151	152	153	154	155	156
Form No. ->			IX.2.3	IX.2.4	IX.2.5	IX.3.1	IX.3.2	IX.3.3	IX.3.4	IX.3.5	IX.4.1	IX.4.2	IX.4.3	IX.4.4
No.	size	region	eq89	eq96	eqtot	rehab70	rehab79	rehab89	rehab96	rehabto	om70	om79	om89	om96
1	Large	NE			$0	$0	$5,000,000	$72,900,000	$41,700,000	$119,600,000	$0	$0	$20,700,000	$14,500,000
2	Small	CENTRAL			$0				$900,000	$900,000				$3,908,000
3	Small	CENTRAL	$0	$0	$0		$7,500,000	$10,000,000	$35,000,000	$52,500,000		$1,600,000	$2,500,000	$3,500,000
4	Large	CENTRAL	$0	$0	$0		$13,000,000	$18,000,000	$31,900,000	$62,900,000		$16,000,000	$39,200,000	$43,000,000
5	Large	CENTRAL			$0					$0			$75,000,000	$65,000,000
6	Medium	CENTRAL			$0				$13,600,000	$13,600,000				$14,000,000
7	Medium	CENTRAL	$0	$0	$0	$201,000	$0	$1,152,000	$5,719,000	$7,072,000		$3,600,000	$5,500,000	$5,600,000
8	Medium	CENTRAL		$0	$0		$50,000,000	$75,000,000	$105,000,000	$230,000,000				$84,000,000
9	Small	CENTRAL	$32,000	$28,000	$60,000			$245,000	$300,000	$545,000			$2,444,000	$2,895,000
10	Large	CENTRAL		$0	$0					$0				$90,000,000
11	Large	CENTRAL			$0				$10,800,000	$10,800,000			$48,883,527	$68,959,300
12	Large	CENTRAL			$0					$0				
13	Large	NW			$0					$0		$9,000,000	$75,981,000	$99,353,000
14	Large	SW			$0			$27,000,000	$109,000,000	$136,000,000			$43,000,000	$130,000,000
15	Large	NW			$0				$14,000,000	$14,000,000				$25,000,000
16	Large	CENTRAL			$0					$0				$4,377,371
17	Large	CENTRAL	$5,270,000	$63,000	$6,358,000				$56,490,000	$56,490,000		$60,000,000	$77,400,000	$66,400,000
18	Medium	SE	$0	$20,000,000	$20,000,000		$2,000,000	$2,000,000	$10,000,000	$14,000,000	$0	$0	$0	$10,000,000
19	Medium	CENTRAL		$0	$0			$1,000,000	$15,000,000	$16,000,000			$2,000,000	$3,044,000
20	Large	SE	$0	$0	$0	$0	$0	$0	$32,609,198	$32,609,198	$0	$0	$0	$145,803,513
21	Medium	SE		$0	$0				$0	$0				$381,200
22	Medium	SW			$5,000,000		$0	$6,500,000	$0	$6,500,000			$8,498,154	$12,071,921
23	Large	SW	$0	$0	$0		$1,000,000	$2,500,000	$2,100,000	$5,600,000			$35,000,000	$55,000,000
24	Medium	CENTRAL		$30,000,000	$30,000,000				$15,000,000	$15,000,000				$34,000,000
25	Medium	CENTRAL			$0				$14,000,000	$14,000,000				$22,400,000
26	Medium	SW	$0	$0	$0	$0	$0	$0	$500,000	$500,000				$3,000,000
27	Medium	CENTRAL		$0	$0	$600,000	$300,000	$300,000	$1,200,000	$2,400,000	$1,600,000	$2,500,000	$3,600,000	$4,200,000
28	Medium	SW			$0					$0				
29	Medium	NE			$0					$0				
30	Medium	SW	$0	$0	$0			$6,400,000	$11,400,000	$17,800,000			$16,400,000	$22,979,496
31	Large	SE		$12,000,000	$12,000,000					$0			$35,301,161	$34,956,049
32	Small	NE			$0					$0				$6,500,000
33	Large	CENTRAL			$0			$9,700,285	$5,144,520	$14,844,805				
34	Large	CENTRAL			$0					$0				
35	Medium	SW	$0	$0	$0			$500,000	$1,200,000	$1,700,000				$575,296
36	Medium	CENTRAL	$1,000,000	$0	$6,000,000	$100,000	$200,000	$800,000	$1,200,000	$2,300,000	$1,000,000	$15,000,000	$18,000,000	$23,000,000
37	Medium	SW			$0			$12,500,000	$41,845,000	$54,345,000			$17,500,000	$19,870,000
38	Small	SW			$0					$0				
39	Medium	NW			$0					$0				
40	Small	NW	$0	$0	$0	$0	$0	$0	$3,000,000	$3,000,000				$1,515,000
41	Medium	SW			$0					$0				$4,000,000
42	Medium	SW	$2,000,000	$2,100,000	$4,100,000			$5,000,000	$8,000,000	$13,000,000		$6,000,000	$12,000,000	$14,000,000

	Size	Region	O&M $ Total	Equipment $ < 1970	Equipment $ '70 - '79	Equipment $ '80 - '89	Equipment $ '90 - '96	Equipment $ Total	Other $ <1970	Other $ '70 - '79	Other $ '80 - '89	Other $ '90 - '96	Other $ Total	Total $ (all years)
Item ->	2	3	157	158	159	160	161	162	163	164	165	166	167	
Form No. ->			IX.4.5	IX.5.1	IX.5.2	IX.5.3	IX.5.4	IX.5.5	IX.6.1	IX.6.2	IX.6.3	IX.6.4	IX.6.5	
No.	size	region	omtot	omeq70	omeq79	omeq89	omeq96	omeqto	oth70	oth79	oth89	oth96	othtot	
1	Large	NE	$35,200,000	$0	$0	$0	$0	$0					$0	$203,600,000
2	Small	CENTRAL	$3,908,000					$0					$0	$4,808,000
3	Small	CENTRAL	$7,600,000	$0	$0	$0	$1,400,000	$1,400,000			$2,214,000		$2,214,000	$71,714,000
4	Large	CENTRAL	$98,200,000					$0					$0	$433,100,000
5	Large	CENTRAL	$140,000,000					$0					$0	$140,000,000
6	Medium	CENTRAL	$14,000,000				$2,800,000	$2,800,000					$0	$40,400,000
7	Medium	CENTRAL	$14,700,000	$0	$0	$0	$0	$0					$0	$25,003,000
8	Medium	CENTRAL	$84,000,000				$7,000,000	$7,000,000					$0	$328,000,000
9	Small	CENTRAL	$5,339,000				$351,650	$351,650					$0	$6,295,650
10	Large	CENTRAL	$90,000,000					$0					$0	$90,000,000
11	Large	CENTRAL	$117,842,827					$0					$0	$128,642,827
12	Large	CENTRAL	$0					$0					$0	$0
13	Large	NW	$184,334,000					$0					$0	$184,334,000
14	Large	SW	$173,000,000					$0					$0	$353,400,000
15	Large	NW	$25,000,000					$0				$18,000,000	$18,000,000	$59,500,000
16	Large	CENTRAL	$4,377,371					$0					$0	$4,377,371
17	Large	CENTRAL	$203,800,000					$0					$0	$320,968,000
18	Medium	SE	$10,000,000	$0	$0	$0	$0	$0					$0	$89,000,000
19	Medium	CENTRAL				$607,000	$1,155,000	$1,762,000			$8,939,900	$8,264,800	$17,204,700	$43,010,700
20	Large	SE	$145,803,513	$0	$0	$0	$0	$0	$0	$0	$0	$126,000	$126,000	$178,538,711
21	Medium	SE	$381,200				$0	$0					$0	$381,200
22	Medium	SW	$20,570,075		$300,000	$1,100,000	$2,150,000	$3,550,000					$0	$120,739,073
23	Large	SW	$90,000,000					$0					$0	$95,600,000
24	Medium	CENTRAL	$34,000,000					$0					$0	$88,500,000
25	Medium	CENTRAL	$22,400,000				$35,000,000	$35,000,000					$0	$85,400,000
26	Medium	SW	$3,000,000				$150,000	$150,000					$0	$10,100,000
27	Medium	CENTRAL						$0					$0	$19,200,000
28	Medium	SW	$0					$0					$0	$0
29	Medium	NE	$0					$0					$0	$0
30	Medium	SW	$39,379,496			$1,700,000	$645,135	$2,345,135					$0	$72,424,631
31	Large	SE	$70,257,210				$1,651,887	$1,651,887					$0	$87,909,097
32	Small	NE	$6,500,000					$0					$0	$7,400,000
33	Large	CENTRAL	$0					$0					$0	$84,908,750
34	Large	CENTRAL						$0					$0	$0
35	Medium	SW	$575,296					$0			$0	$0	$0	$5,675,296
36	Medium	CENTRAL	$66,000,000					$0					$0	$74,300,000
37	Medium	SW	$37,370,000					$0					$0	$91,715,000
38	Small	SW	$0					$0					$0	$0
39	Medium	NW	$0					$0					$0	$0
40	Small	NW	$1,515,000					$0	$0	$0	$0	$0	$0	$6,515,000
41	Medium	SW	$4,000,000					$0					$0	$4,000,000
42	Medium	SW	$32,000,000					$0					$0	$52,700,000

	Size	Region	Perf. Weight - Pipe Failure	Perf. Weight - SSOs	Perf. Weight - Complaints	Perf. Weight - PS Failures	Perf. Weight - Pk Hr/ ADF	Perf. Weight - Pk Mo/ ADF	Perf. Weight - Total	Maint. Weight - % Cleaned	Maint. Weight - % Root Cleaned	Maint. Weight - Lift Station Service	Maint. Weight - Flow/Capacity	Maint. Weight - Manhole	Maint. Weight - Smoke	Maint. Weight - CCTV	Maint. Weight - Private
Item ->	2	3	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182
Form No. ->			X.1.1	X.1.2	X.1.3	X.1.4	X.1.5	X.1.6	X.1.7	X.2.1	X.2.2	X.2.3	X.2.4	X.2.5	X.2.6	X.2.7	X.2.8
No.	size	region	perpf	perfsso	perfcomp	perfps	perfpkhr	perfpkmo	perktot	maintcl	maintrt	maintls	maintfm	maintmh	maintsmk	mainttv	maintpri
1	Large	NE															
2	Small	CENTRAL	27.0%	32.0%	32.0%	9.0%	0.0%	0.0%	100%	25.0%	10.0%	5.0%	1.0%	1.0%	1.0%	10.0%	5.0%
3	Small	CENTRAL	35.0%	35.0%	20.0%	0.0%	5.0%	5.0%	100%	15.0%	0.0%	5.0%	5.0%	2.0%		3.0%	0.0%
4	Large	CENTRAL	25.0%	25.0%	25.0%	25.0%			100%	6.0%	0.0%	35.0%	18.0%	12.0%	0.0%	13.0%	0.0%
5	Large	CENTRAL	18.0%	18.0%	14.0%	27.0%	14.0%	9.0%	100%	15.0%	15.0%	15.0%	8.0%	5.0%	5.0%	10.0%	3.0%
6	Medium	CENTRAL	25.0%	25.0%	40.0%	10.0%	0.0%	0.0%	100%	10.0%	10.0%	10.0%					
7	Medium	CENTRAL	16.7%	25.0%	25.0%	16.7%	16.6%	0.0%	100%	10.0%	0.0%	10.0%	20.0%	10.0%	0.0%	10.0%	0.0%
8	Medium	CENTRAL	80.0%	5.0%	10.0%	5.0%			100%								
9	Small	CENTRAL	35.0%	15.0%	20.0%	20.0%	7.0%	3.0%	100%	40.0%	5.0%	20.0%		15.0%			
10	Large	CENTRAL	20.0%	20.0%	40.0%	10.0%	5.0%	5.0%	100%	20.0%	10.0%	0.0%	5.0%	4.0%	10.0%	20.0%	10.0%
11	Large	CENTRAL	15.0%	30.0%	30.0%	15.0%	5.0%	5.0%	100%	12.0%	10.0%	10.0%	4.0%	8.0%	6.0%	12.0%	4.0%
12	Large	CENTRAL								22.0%	10.0%	22.0%	2.0%	3.0%	2.0%	10.0%	1.0%
13	Large	NW	5.0%	30.0%	30.0%	35.0%	0.0%	0.0%	100%	25.0%	5.0%	35.0%	10.0%	5.0%	0.0%	10.0%	0.0%
14	Large	SW	25.0%	25.0%	15.0%	25.0%	8.0%	2.0%	100%	15.0%	15.0%	15.0%	5.0%	5.0%		10.0%	
15	Large	NW	80.0%	5.0%	10.0%	2.0%	2.0%	1.0%	100%	60.0%	5.0%	5.0%	5.0%	1.0%	1.0%	12.0%	3.0%
16	Large	CENTRAL	20.0%	20.0%	20.0%	20.0%	10.0%	10.0%	100%	13.6%	9.1%	31.9%		0.9%		2.7%	0.9%
17	Large	CENTRAL	25.0%	39.0%	25.0%	3.0%	5.0%	3.0%	100%	15.0%	12.0%	2.0%	10.0%	10.0%	2.0%	10.0%	2.0%
18	Medium	SE	20.0%	20.0%	20.0%	20.0%	5.0%	15.0%	100%	4.8%	19.0%	9.5%	9.5%	4.8%	9.5%	4.8%	4.8%
19	Medium	CENTRAL		20.0%	10.0%	20.0%	15.0%	15.0%	100%	8.0%	5.0%	20.0%	15.0%	5.0%	5.0%	5.0%	1.0%
20	Large	SE	20.0%	20.0%	10.0%	10.0%	20.0%	20.0%	100%	5.0%	5.0%	5.0%	10.0%	10.0%	10.0%	10.0%	10.0%
21	Medium	SE	30.0%	25.0%	10.0%	25.0%	0.0%	10.0%	100%	20.0%	0.0%	50.0%	0.0%	5.0%	0.0%	15.0%	0.0%
22	Medium	SW	12.0%	40.0%	20.0%	25.0%	2.0%	1.0%	100%	34.0%	1.0%	20.0%	10.0%	9.0%	1.0%	15.0%	0.0%
23	Large	SW	50.0%	10.0%	20.0%	20.0%	0.0%	0.0%	100%	35.0%	0.0%	15.0%	0.0%	20.0%	3.0%	15.0%	0.0%
24	Medium	CENTRAL	15.0%	10.0%	20.0%	50.0%	2.0%	3.0%	100%	0.0%	30.0%	10.0%	2.0%	2.0%	2.0%	7.0%	1.0%
25	Medium	CENTRAL	30.0%	30.0%	20.0%	10.0%	5.0%	5.0%	100%								
26	Medium	SW	10.0%	25.0%	25.0%	20.0%	10.0%	10.0%	100%	10.0%	10.0%	10.0%	20.0%	10.0%	0.0%	10.0%	0.0%
27	Medium	CENTRAL		30.0%	20.0%	10.0%	10.0%	10.0%	100%	10.0%	10.0%	10.0%	6.0%	15.0%	6.0%	6.0%	3.0%
28	Medium	SW															
29	Medium	NE															
30	Medium	SW	10.0%	20.0%	60.0%	10.0%	0.0%	0.0%	100%	20.0%	15.0%	5.0%	10.0%	5.0%	0.0%	8.0%	1.0%
31	Large	SE	15.0%	25.0%	25.0%	25.0%	5.0%	5.0%	100%	20.0%	20.0%	30.0%	1.0%	1.0%	2.0%	4.0%	0.0%
32	Small	NE	5.0%	20.0%	5.0%	70.0%	0.0%	0.0%	100%	15.0%	0.0%	30.0%	5.0%	20.0%	0.0%	25.0%	
33	Large	CENTRAL	22.0%	27.0%	20.0%	20.0%	8.0%	3.0%	100%	13.0%	8.0%	11.0%	7.0%	7.0%	5.0%	5.0%	2.0%
34	Large	CENTRAL		25.0%	35.0%	15.0%	3.0%	2.0%	100%								
35	Medium	SW	20.0%	20.0%	10.0%	25.0%	13.0%	12.0%	100%	12.0%	5.0%	14.0%	10.0%	7.0%	5.0%	14.0%	5.0%
36	Medium	CENTRAL	15.0%	20.0%	30.0%	5.0%	20.0%	10.0%	100%	5.0%	5.0%	5.0%	5.0%	10.0%	10.0%	10.0%	5.0%
37	Medium	SW	30.0%	40.0%	10.0%	20.0%			100%	27.0%	17.0%	3.0%	4.0%	2.0%	7.0%	14.0%	0.0%
38	Small	SW	12.0%	48.0%	20.0%	15.0%	1.0%	4.0%	100%	18.0%	10.0%	17.0%	6.0%	4.0%	5.0%	10.0%	3.0%
39	Medium	NW	10.0%	20.0%	30.0%	5.0%	25.0%	10.0%	100%	30.0%	2.0%	12.0%	2.0%	2.0%	1.0%	12.0%	1.0%
40	Small	NW	20.0%	25.0%	20.0%	15.0%	10.0%	10.0%	100%	20.0%	10.0%	15.0%	5.0%	10.0%	5.0%	10.0%	0.0%
41	Medium	SW	25.0%	15.0%	15.0%	25.0%	10.0%	10.0%	100%	50.0%	20.0%	13.0%	1.0%	1.0%	4.0%	5.0%	1.0%
42	Medium	SW	10.0%	50.0%	10.0%	20.0%	5.0%	5.0%	100%	10.0%	10.0%	10.0%	20.0%	5.0%	0.0%	40.0%	0.0%

	Size	Region	Maint. Weight - Manhole Rehab	Maint. Weight - Main Rehab	Maint. Weight - Relief	Maint. Weight - Private I/I	Maint. Weight - Total	Satisfaction	What Different
Item ->	2	3	183	184	185	186	187	188	189
Form No. ->			X.2.9	X.2.10	X.2.11	X.2.12		X.1	X.2
No.	size	region	maintmhr	maintmn	maintre	maintpr	maintot	satis	diff
1	Large	NE							
2	Small	CENTRAL	1.0%	35.0%	5.0%	1.0%	100.0%	b	
3	Small	CENTRAL	5.0%	35.0%	15.0%	15.0%	100.0%	b	
4	Large	CENTRAL	8.0%	8.0%	0.0%	0.0%	100.0%	a	
5	Large	CENTRAL	5.0%	5.0%	4.0%	10.0%	100.0%	c	
6	Medium	CENTRAL	10.0%	10.0%	10.0%	40.0%	100.0%	c	
7	Medium	CENTRAL	0.0%	20.0%	10.0%	10.0%	100.0%	b	
8	Medium	CENTRAL	10.0%	70.0%	20.0%	0.0%	100.0%	b	
9	Small	CENTRAL	10.0%	10.0%			100.0%	c	
10	Large	CENTRAL	1.0%	5.0%	5.0%	10.0%	100.0%	b	
11	Large	CENTRAL	10.0%	12.0%	6.0%	6.0%	100.0%	c	
12	Large	CENTRAL	8.0%	10.0%	5.0%	5.0%	100.0%		
13	Large	NW	5.0%	5.0%	0.0%	0.0%	100.0%	b	
14	Large	SW	5.0%	15.0%	15.0%		100.0%	a	
15	Large	NW	1.0%	4.0%	2.0%	1.0%	100.0%	b	
16	Large	CENTRAL	4.5%	27.3%		9.1%	100.0%	d	
17	Large	CENTRAL	10.0%	10.0%	10.0%	7.0%	100.0%	b	
18	Medium	SE	9.5%	14.2%	4.8%	4.8%	100.0%	c	
19	Medium	CENTRAL		20.0%	2.0%	4.0%	100.0%	c	
20	Large	SE	5.0%	10.0%	10.0%	10.0%	100.0%	a	
21	Medium	SE	5.0%	5.0%	0.0%	0.0%	100.0%	c	
22	Medium	SW	2.0%	2.0%	5.0%	1.0%	100.0%	a	
23	Large	SW	2.0%	10.0%	0.0%	0.0%	100.0%	b	
24	Medium	CENTRAL	4.0%	10.0%	2.0%	30.0%	100.0%	b	
25	Medium	CENTRAL						c&d	
26	Medium	SW	10.0%	10.0%	10.0%	0.0%	100.0%	b	
27	Medium	CENTRAL		11.0%	6.0%	2.0%	100.0%	d	
28	Medium	SW						b	
29	Medium	NE							
30	Medium	SW	5.0%	10.0%	20.0%	1.0%	100.0%	b	
31	Large	SE	1.0%	5.0%	15.0%	1.0%	100.0%	d	
32	Small	NE	5.0%		0.0%		100.0%	b	
33	Large	CENTRAL	6.0%	13.0%	18.0%	5.0%	100.0%	d	
34	Large	CENTRAL							
35	Medium	SW	8.0%	8.0%	7.0%	5.0%	100.0%	d	
36	Medium	CENTRAL	15.0%	10.0%	5.0%	15.0%	100.0%	c	
37	Medium	SW	1.0%	20.0%	5.0%	0.0%	100.0%	d	
38	Small	SW	5.0%	10.0%	2.0%	10.0%	100.0%	b	
39	Medium	NW	4.0%	12.0%	12.0%	10.0%	100.0%	b	
40	Small	NW	10.0%	10.0%	0.0%	5.0%	100.0%	c	
41	Medium	SW	1.0%	2.0%	1.0%	1.0%	100.0%	b	
42	Medium	SW	0.0%	5.0%	0.0%	0.0%	100.0%	c	

Appendix C

Maintenance Activities Weighting

Collection System Maintenance Weighting

Maintenance Weighting - % System Cleaned

Crosstab Table For Average maintcl by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	13.0%	5.4%	26.7%	15.0%	
NE	0.0%	0.0%	15.0%	5.0%	
NW	42.5%	30.0%	20.0%	30.8%	
SE	12.5%	12.4%		12.5%	
SW	25.0%	20.4%	18.0%	21.1%	
	18.6%	13.6%	19.9%	16.9%	17.7%
				Count->	36

Maintenance Weighting - % System Root Cleaned

Crosstab Table For Average maintrt by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	8.2%	7.5%	5.0%	6.9%	
NE	0.0%	0.0%	0.0%	0.0%	
NW	5.0%	2.0%	10.0%	5.7%	
SE	12.5%	9.5%		11.0%	
SW	7.5%	9.8%	10.0%	9.1%	
	6.6%	5.8%	6.3%	6.5%	8.4%
				Count->	36

Maintenance Weighting - Lift Station Service

Crosstab Table For Average maintls by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	14.1%	8.1%	10.0%	10.7%	
NE	0.0%	0.0%	30.0%	10.0%	
NW	20.0%	12.0%	15.0%	15.7%	
SE	17.5%	29.8%		23.6%	
SW	15.0%	9.4%	17.0%	13.8%	
	13.3%	11.9%	18.0%	14.8%	14.2%
				Count->	36

Maintenance Weighting - Flow Monitoring

Crosstab Table For Average maintfm by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	6.0%	6.0%	2.0%	4.7%	
NE	0.0%	0.0%	5.0%	1.7%	
NW	7.5%	2.0%	5.0%	4.8%	
SE	5.5%	4.8%		5.1%	
SW	2.5%	9.4%	6.0%	6.0%	
	4.3%	4.4%	4.5%	4.5%	6.9%
				Count->	33

Maintenance Weighing - Manhole Inspection

Crosstab Table For Average maintmh by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	5.5%	5.3%	6.0%	5.6%	
NE	0.0%	0.0%	20.0%	6.7%	
NW	3.0%	2.0%	10.0%	5.0%	
SE	5.5%	4.9%		5.2%	
SW	12.5%	4.9%	4.0%	7.1%	
	5.3%	3.4%	10.0%	5.9%	6.5%
				Count->	35

Maintenance Weighing - Smoke Testing

Crosstab Table For Average maintsmk by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	3.3%	2.9%	0.3%	2.2%	
NE	0.0%	0.0%	0.0%	0.0%	
NW	0.5%	1.0%	5.0%	2.2%	
SE	6.0%	4.8%		5.4%	
SW	1.5%	2.1%	5.0%	2.9%	
	2.3%	2.2%	2.6%	2.5%	3.3%
				Count->	31

Maintenance Weighting - CCTV

Crosstab Table For Average maintty by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	9.2%	4.8%	4.3%	6.1%	
NE	0.0%	0.0%	25.0%	8.3%	
NW	11.0%	12.0%	10.0%	11.0%	
SE	7.0%	9.9%		8.5%	
SW	12.5%	13.3%	10.0%	11.9%	
	7.9%	8.0%	12.3%	9.2%	10.5%
				Count->	34

Maintenance Weighting - Private Sector Inspections

Crosstab Table For Average maintpri by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	2.5%	1.3%	1.7%	1.8%	
NE	0.0%	0.0%	0.0%	0.0%	
NW	1.5%	1.0%	0.0%	0.8%	
SE	5.0%	2.4%		3.7%	
SW	0.0%	0.9%	3.0%	1.3%	
	1.8%	1.1%	1.2%	1.5%	2.0%
				Count->	32

Maintenance Weighting - Manhole Rehab

Crosstab Table For Average maintmhr by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	5.8%	8.0%	5.3%	6.4%	
NE	0.0%	0.0%	5.0%	1.7%	
NW	3.0%	4.0%	10.0%	5.7%	
SE	3.0%	7.3%		5.1%	
SW	3.5%	3.4%	5.0%	4.0%	
	3.1%	4.5%	6.3%	4.6%	5.6%
				Count->	37

Maintenance Weighing - Main Rehabilitation

Crosstab Table For Average maintmn by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	10.0%	18.9%	26.7%	18.5%	
NE	0.0%	0.0%	0.0%	0.0%	
NW	4.5%	12.0%	10.0%	8.8%	
SE	7.5%	9.6%		8.6%	
SW	12.5%	7.1%	10.0%	9.9%	
	6.9%	9.5%	11.7%	9.2%	12.6%
				Count->	36

Maintenance Weighting - Relief

Crosstab Table For Average maintre by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	5.3%	6.9%	6.7%	6.3%	
NE	0.0%	0.0%	0.0%	0.0%	
NW	1.0%	12.0%	0.0%	4.3%	
SE	12.5%	2.4%		7.5%	
SW	7.5%	6.0%	2.0%	5.2%	
	5.3%	5.5%	2.2%	4.6%	6.3%
				Count->	35

Maintenance Weighting - Private Sector I/I Removal

Crosstab Table For Average maintpr by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	5.8%	12.6%	5.3%	7.9%	
NE	0.0%	0.0%	0.0%	0.0%	
NW	0.5%	10.0%	5.0%	5.2%	
SE	5.5%	2.4%		4.0%	
SW	0.0%	1.0%	10.0%	3.7%	
	2.4%	5.2%	5.1%	4.1%	6.1%
				Count->	34

Appendix D

Collection System Performance Weighting

Collection System Performance Weighting

Performance Weighting - Pipe Failure

Crosstab Table For Average perpf by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	18.3%	27.7%	32.3%	26.1%	
NE	0.0%	0.0%	5.0%	1.7%	
NW	42.5%	10.0%	20.0%	24.2%	
SE	17.5%	25.0%		21.3%	
SW	37.5%	14.6%	12.0%	21.4%	
	23.2%	15.5%	17.3%	18.9%	23.3%
				count->	38

Performance Weighting - SSO

Crosstab Table For Average perfsso by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	22.7%	20.6%	27.3%	23.5%	
NE	0.0%	0.0%	20.0%	6.7%	
NW	17.5%	20.0%	25.0%	20.8%	
SE	22.5%	22.5%		22.5%	
SW	17.5%	26.3%	48.0%	30.6%	
	16.0%	17.9%	30.1%	20.8%	24.4%
				count->	38

Performance Weighting - Complaints

Crosstab Table For Average perfcomp by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	23.2%	21.9%	24.0%	23.0%	
NE	0.0%	0.0%	5.0%	1.7%	
NW	20.0%	30.0%	20.0%	23.3%	
SE	17.5%	15.0%		16.3%	
SW	17.5%	18.8%	20.0%	18.8%	
	15.6%	17.1%	17.3%	16.6%	21.4%
				count->	38

Performance Weighting - Pump Station Failure

Crosstab Table For Average perfps by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	15.0%	15.8%	9.7%	13.5%	
NE	0.0%	0.0%	70.0%	23.3%	
NW	18.5%	5.0%	15.0%	12.8%	
SE	17.5%	22.5%		20.0%	
SW	22.5%	18.1%	15.0%	18.5%	
	14.7%	12.3%	27.4%	17.6%	18.3%
				count->	38

Performance Weighting - Peak Hour Flow/ADF

Crosstab Table For Average perfpkhr by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	5.6%	8.6%	4.0%	6.0%	
NE	0.0%	0.0%	0.0%	0.0%	
NW	1.0%	25.0%	10.0%	12.0%	
SE	12.5%	2.5%		7.5%	
SW	4.0%	5.0%	1.0%	3.3%	
	4.6%	8.2%	3.8%	5.8%	6.9%
				count->	35

Performance Weighting Peak Month Flows/ADF

Crosstab Table For Average perfpkmo by region and size

	Large	Medium	Small	Avg- Reg.	Avg - All
CENTRAL	4.1%	5.4%	2.7%	4.1%	
NE	0.0%	0.0%	0.0%	0.0%	
NW	0.5%	10.0%	10.0%	6.8%	
SE	12.5%	12.5%		12.5%	
SW	1.0%	4.8%	4.0%	3.3%	
	3.6%	6.5%	4.2%	5.3%	5.7%
				count->	35

Appendix E

Literature Review

Appendix E Literature Review

Review of the Literature

The authors of this project conducted an extensive literature search to obtain nationwide information on current trends in maintenance of wastewater collection systems.

The literature review included a search of the 1990-1997 publications listed below:

- $ Beton werk und Fertigtel - Technik
- $ Civil Engineering
- $ Engineering News Record
- $ Journal of Infrastructure System
- $ Journal of Professional Issues in Engineering
- $ Journal of Urban Planning and Development
- $ Optimizing the Resources for Water Management - Proceedings of the ASCE 17th Annual National Conference (1990)
- $ Proceedings of the International Conference on Pipeline Infrastructure II (1993)
- $ Proceedings of the 1995 Construction Congress
- $ Proceedings of the 1991 Specialty Conference on Environmental Engineering
- $ Public Works
- $ Urban Drainage Rehabilitation Programs and Techniques (1994)
- $ Water Engineering and Management
- $ Water Resources Infrastructure: Needs, Economic, and Financing (1990)
- $ Water Resources Planning and Management and Urban Water Resources (1991) - Proceedings of the 18th Annual Conference and Symposium
- $ Water Resources Planning and Management and Urban Water Resources (1993) - Proceedings of the 20th Anniversary Conference on Water Management in the 90s
- $ Water Resources Planning and Management: Saving a Threatened Resource - In Search of Solutions, Proceedings of the Water Resources Sessions at Water Forum (1992)
- $ 1992 Nation Conference on Water Resources Planning and Management (Water Forum 92)

Summary of Findings

Information from the following papers was used, in part, in the development of the survey form used for this study.

Anonymous (1994) Districts expand sewer rehabilitation program. *Public Works*, v125, n 9, 34-35.

The article describes system reinvestment through installation of a pipe liner in 40,000 linear feet of large diameter sewer (48 inches and larger) in 1993. The systems oldest sewers were constructed in 1926.

Burgess, Edward H. (1990) Planning model for sewer system rehabilitation. Proceedings of ASCE's Conference on Water Resources Infrastructure: Needs, Economics, and Financing, Fort Worth, TX, April 18-20, 1990.

A probabilistic model is developed to simulate long-term variation in the structural condition of wastewater collection systems. The effect of both deterioration and rehabilitation strategies as an extension of current sewer system planning and management practices was discussed.

Bergman, William (1991) 1991 Update on sanitary sewer rehabilitation metropolitan Chicago. *Water Resources Planning and Management and Urban Water Resources*, 825-829.

The following data for the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) was reported:

- Provided collection for 875 square miles, 5,100,000 people plus commercial/industrial population equivalent to 4,500,000 people.
- 520 miles of interceptor sewer, seven water reclamation plants.
- 125 communities own and operate separate sanitary sewers with a total discharge population equivalent of 2,000,000 people.
- MWRDGC required each community to do comprehensive sewer rehabilitation in 1973.
- 1973-1985 - $100,000,000 was spent by tributary communities, but was not successful in reducing I/I.
- 1986 - I/I Corrective Action Program (ICAP).
- 1987-1991 - estimated that an additional $140,000,000 (to the previous $100,000,000) would be needed to complete cost-effective rehabilitation.

The reinvestment needs for the I/I corrective program were identified at $240,000,000.

Dillard, Wayne C. (1993) Management of sewer system rehabilitation for the overflow abatement program in Nashville, Tennessee. Proceedings of the International Conference on Pipeline Infrastructure II, San Antonio, TX, August 16-17, 1993.

To comply with state order to abate overflows of wastewater from sanitary sewers:

- Metropolitan Department of Water and Sewer Services (MWS) owns and operates:
  - 472,700 acre service area.
  - three treatment facilities permitted to treat dry flow of 148.5 mgd plus a wet flow of 100 mgd.
- Phase I project to provide replacement or rehab of deteriorated sewers and overloaded pumping stations. Limited flow monitoring and TV inspection data for these early projects. Because of inadequate data and data interpretation on a system-wide basis, a defect classification system was developed which would consistently categorize common defects and provide criteria for assigning degrees of severity and rehabilitation techniques.
- A two- and five-year recurrent interval design was used based on how environmentally "sensitive" an area is.

Erdos, Lawrence I. (1991) Rehabilitation of urban pipelines. Proceedings of the 18th Annual Conference and Symposium, New Orleans, LA, May 20-22, 1991.

An article for the City of Los Angeles which projected a year 2000 budget of $4.9 billion for rehabilitation of the 6,000 miles of mainline sanitary sewers (8 inches to 14 feet in diameter). This is in addition to the $1 billion spent over the past 10 years.

Galeziewski, Thomas M. (1996) Plumbing the quality of a sewer system. *Civil Engineering* (New York) 66, 1 January 1996.

Phoenix, AZ

- Sewers in this study were installed in mid-1960s.
- Corrosion problems in unlined sewers.

Condition Assessment Program - $570,000. The assessment was to locate defective pipes and prioritize them for rehabilitation. Also, recommended a method of rehabilitation or replacement.

Estimated cost of rehab/replacement was $8.47 million.

Phoenix wastewater collection system size:

- 3,700 miles (8 to 90-inch in diameter).
- 7,200 manholes.

Unlined pipe: 116,347 ft (24 to 60-inch diameter) 258 manholes.

Gray, William R. (1990) Sanitary sewer bypass reduction program. *Water/Engineering and Management*, v 137, n 5, May 1990.

Elmhurst, Illinois, has a population of 44,000. The area is served by approximately 77,000 linear feet of gravity sewer and 10 lift stations.

Elmhurst implemented a program to reduce the incidence of sanitary sewer backups into basements and bypassing of wastewater into receiving streams following moderate to intense storm events.

Upgrading of system included 59,000 linear feet of sanitary relief sewers and force mains along with upgrading of lift stations.

Gregory, Henry N. Jr. (1990) New technologies help Houston inspect its sewers. *Public Works, v 121, n 2, February 1990.*

The City of Houston, Texas, conducted a physical inspection program on its 4,500 mile sewer system using laptop computers and image storage software and hardware. Cost of the program was estimated at $100 million.

Harman, Duane G. (1990) Evaluation plus history equals sewer renovation. Proceedings of ASCE's Conference on Water Resources Infrastructure: Needs, Economics, and Financing, Fort Worth, TX, April 18-20, 1990.

Fort Worth Zoo
477 manholes, 194,000 feet of sewer
3,952 residential units and 18 acres of commercial.

Intensive survey activities including flow monitoring, computer modeling, and analysis for cost-effective I/I removal. Key data are as follows:

- 2060 I/I sources identified (849 infiltration sources, 1,211 inflow sources).
- The I/I costs are for treatment and transport of the I/I flow rate. Treatment cost is for increasing treatment capacity, plus the present worth of increased cost of plant

operation for 20 years at 8.78 percent interest. Treatment cost for Fort Worth is $10.115/gpd of I/I. Transport cost is for constructing relief sewers to carry the I/I. The "present worth" of the renovation work is the construction cost for eliminating specific I/I sources, to accomplish a level of I/I reduction, plus the treatment and transport cost for the remaining I/I.

Cost-effective levels	Repair Cost
23% infiltration removal	<$1.05/gpd
68.5% inflow removal	<$1.70/gpd

Summary of Recommend Plan		
	Capital Cost (Million $)	Estimated Maintenance & Savings ($/20 Years)
I/I Removal	0.802	$0
New Sewers	0.775	$84,620
Maintenance	0.758	$770,620
Total	2.335	$855,240

- Maintenance includes TV lines and review of historical records. Historical records for all pipes were reviewed. Those with maintenance cost projected over 20 years that exceeded replacement costs were included for replacement.
- Reduced I/I by 60%.
- Effective cost of recommended plan: $2.335 million - $0.855 million = $1.480 million.

Kerri, Ken; Arbour, Rick (1998) Collection systems. *Methods for Evaluating and Improving Performance.*

Nationwide public awareness of collection system performance has increased in recent years because of the frequency and severity of sanitary sewer overflows (SSOs). The occurrence of SSOs indicates that a growing number of wastewater collection system agencies are failing to meet their primary responsibility, which is to convey the community=s wastewater in a manner that protects the public=s safety and health, and the environment.

The ability to effectively operate and maintain a collection system so it performs as intended depends greatly on proper design, construction and inspection, acceptance, and system start-up. The benefits of an effectively operated and maintained collection system include management and protection of the community=s assets (investment in the system), service to customers, regulatory compliance, protection of the safety and health of the public, environmental protection, and cost-effective use of agency resources.

This manual includes:

- Information on how to establish an effective collection system O&M program that will maintain the functional and structural integrity of the collection system,

- Information regarding how to evaluate the adequacy and effectiveness of existing O&M programs through the use of performance indicators, and

- Information on how to improve the performance of collection systems.

Steps in the evaluation process include:

- Verifying and validating what is being done right,

- Identifying areas of the O&M program that affect system performance,

- Identifying areas of opportunity for more cost-effective O&M of the system,

- Identifying areas of potential liability, and

- Adapting successful ideas and solutions from other agencies nationwide to improve performance.

This manual provides a detailed analysis of the data provided by 13 agencies whose systems consist of sanitary sewers only. The benchmark data are organized by both population served and miles of gravity sewer. Agencies can compare their system characteristics with other systems and also their level of production, performance, and budget with other similar agencies. Subjects for comparison include operation and maintenance data, finance, training and certification, safety, level of service, regulatory compliance, O&M policies and procedures, and information management. Critical performance indicators include stoppages per 100 miles of gravity sewer, complaints per 100,000 population served, and response time for service requests

.

Macaitis, William (1993) Collection system inspection and rehabilitation program. W*ater Resources Planning and Management and Urban Water Resources*.

Metropolitan Water Reclamation District of Greater Chicago:

- Serves area of 875 square miles.
- 535 mile collection system.
- The first sewer was constructed in 1906. Present worth of sewers is $3.8 billion. Sewers 50 years or older have a total length of 170 miles and a present worth of $1.5 billion.
- Spent approximately $3 million in last 10 years on emergency repairs.

Macaitis, William; Kuhl, Robert (1994) Local Sewer Rehabilitation - Metro Chicago. *Urban Drainage Rehabilitation Programs and Techniques*, 111-122

The Metropolitan Water Reclamation District of Greater Chicago is a regional wastewater agency encompassing an area of 875 sq. miles in Cook County, Illinois. The city of Chicago and 124 neighboring municipalities are served by the Water Reclamation District. The purpose of the study was to reduce overloading of the conveyance system and to alleviate the widespread occurrence of home and basement flooding.

The Water Reclamation District formulated and adopted a rehabilitation program in the 1970s and revised the program in 1985, which was patterned after the US EPA cost-effective methodology. The agencies were given two options: Either reduce the average wet-weather flow to 150 gpcpd under the old (1970s) program or implement a sewer rehabilitation program based upon the US EPA Corrective Action Program

(ICAP). Details of the ICAP option were defined in the "Sewer Summit Agreement," developed jointly by the IEPA, the Water Reclamation District, and local agencies.

The main features of the ICAP program included a Sewer System Evaluation Study (SSES) which consisted of a data collection and flow monitoring program, sewer system investigations, plans for corrective action in both public and private sectors, and construction of projects.

Based on the submitted SSES reports, the Water Reclamation District estimated that the total cost for local sanitary sewer systems rehabilitation would be $240 million (1985 dollars). Of this total, $100 million of work was completed prior to the 1985 Sewer Summit Agreement. The ICAP program represents a savings of $1.16 billion to the local agencies compared to the estimated $1.4 billion needed to complete the Sewer Rehabilitation, 150 option program. As a result of a 1993 Water Reclamation District survey, with 90 percent of the public sector and 80 percent of the private sector work completed, a revised estimate of $195 million (from the original $240 million estimate) was projected to be spent by the local agencies on sanitary sewer system rehabilitation as a result of the Sewer Summit Agreement.

Of the corrective work performed in the public sector, all identified I/I sources associated with manholes were found to be cost-effective to repair. In general, sewer grouting was determined to be a cost-effective repair. Sewer lining, sewer replacement, and interconnection repairs were usually found not to be cost-effective. In the private sector, down spouts and foundation sumps were found to be cost-effective repair items. Gravity foundation drain disconnections were generally found not to be cost-effective.

All agencies are required by the Sewer Summit Agreement to establish a long-term Operation & Maintenance (O&M) program. The three core elements of an acceptable O&M program are:

1. A five-year inspection cycle of all sewers and appurtenances.
2. TV inspection of any problem areas.
3. A program funded by annual budget appropriations or user fees.

The Water Reclamation District's treatment plants and interceptor system were designed and sized nominally for 150 gpcpd. The ICAP program reduced flows from 764 to 370 gpcpd, but the residual flow would have to be accommodated to prevent backups and overflows. It was determined that storing peak flows at remote sites for treatment at off-peak hours and providing additional regional treatment plant capacity as required would be the most cost-effective plan. The flow equalization was estimated to cost $0.6 billion.

Macaitis, William; Paintal, Amreek (1994) Interceptor inspection and rehabilitation program. *Urban Drainage Rehabilitation Programs and Techniques*, 123-142.

Description of methods conducted in inspection and rehabilitation for program: physical inspection, CCTV inspection, void defect inspection, flow monitoring, computerized mapping, documentation, and underground advisory committee.

Metropolitan Water Reclamation District of Greater Chicago: One third of the system is more than 50 years old; with cave-ins being a common occurrence.

- $ Based on costs experienced during last 10 years, average annual cost of unscheduled emergency repair has been $300,000.
- $ A program cost $1.4 million per year not including cost of rehabilitating sewers

Nelson, Richard E., *ASSES Experience in Kansas,@* presented at the Kansas Water Pollution Control Association, Lawrence, KS, April 1993, 20 pages.

Sewer System Evaluation Survey (SSES) are being performed or being considered throughout Kansas in an effort to meet regulator requirements and to improve sewerage service to customers. Following completion of the SSES, rehabilitation work is performed to correct identified deficiencies. A survey was conducted encompassing 10 cities and agencies, which include 12 service areas. The cities/agencies surveyed ranged in area from 9 to 150 square miles, with 55 to 1,500 miles of sewer line and an average daily flow

(ADF) from 1.2 MGD to 60 MGD, with populations ranging from 10,500 to 285,000 persons. The average age of the cities/agencies ranged from 20 to 63 years. Conclusions based on collected information include: (1) routine inspection activities include manhole inspections, line inspections and testing, and private sector work, (2) sewer systems degrade continuously and a plan is required to effectively manage this degradation, (3) rehabilitation is effective in improving system performance, (4) rehabilitation costs are typically about $25 per foot of sewer, but vary widely and are system-dependent, and (5) annual inspection frequency of about 6 to 10 percent of the system per year can be a cost-effective way to manage system performance.

Malik, Omesh; Pumphery, Jr., Norman D.; Roberts, Freddy L., ASanitary Sewers: State-of-the-Practice@. *ASCE Infrastructure condition Assessment,* 297-306.

Researchers are developing the framework of a sanitary sewer management system (SSMS). Too often and predominantly, a Aworst first@ or Acrisis management@ system exists, causing inefficient use of the meager resources available for maintaining and upgrading the sanitary sewer system. Of those who have a systematic management procedure in place, little compatibility exists so that the municipalities have difficulty in sharing information. As a first step in development of the SSMS, a state-of-practice survey was mailed to over 450 cities and sanitation districts across the United States. A survey was conducted through 121 cities and agencies, with population ranging from 40,000 to 832,750 persons. Cities with populations less than 20,000 or with less than 50 miles of sewer have been excluded from this study. The average age of the cities/agencies ranged from 29 to 42 years. An average city or sanitation district has 1,075 kilometers (667 miles) of sewer, a population of 221,199, and an annual budget of almost $3 million. On the average each city spent an average of about $14 per person and $2,790 per kilometer ($4,497 per mile) of sewer in the 1995. Each kilometer of sewer serves 228 people. According the survey, only 48% of the cities have some established procedures set down for planned maintenance, consisting mostly of the cleaning the lines, and only 45% of the respondents use some kind of subjective criteria for repairing sewers which are in poor conditions. Only 21% of the cities have any kind of historical data upon which to base decisions for the future, with only 26% of the cities making an attempt to predict the future condition of the different sections of the system. Several steps are involved to establish the state-of-practice for sanitary sewer management and for condition assessment.

Wright, Andrew G. (1996) Miami looks for alternatives to blue-chip sewer overhaul. *Engineering News Record*, McGraw-Hill, Inc., 22-25.

Program started - 1988
Target end date - 2002
Estimated expense - $1.1 billion

- System Characteristics
  - 400 sq. miles.
  - 2,400 miles of gravity sewers.
  - 640 miles of force mains.
  - 874 pump stations.
  - average flow = 320 mgd.
  - peak flow = >700 mgd.
  - three treatment plants.
- US EPA brought a federal lawsuit against Miami and to settle, Miami agreed to the $1.1 billion program.
- They believe the program should be much less than $1.1 billion when completed.
- Between 1985 and 1994 system-wide overflows were between 2,200 and 2,600.

Zimmerman, Robert A; Martin, Robert D., AFrom Prevention to Prediction,@ *Water Environment & Technology*, August, 1993.

- A model to predict sewer system rehabilitation needs has enabled the city of Moorhead, Minnesota, to preserve its gravity sewer system and minimize costly repairs. The city used information from an existing preventive maintenance program and expanded it into a predictive maintenance program. Information from a routine preventive maintenance program, including sewer cleaning reports, sewer service connection records, sewer inspections, and video inspection reports, was used to develop the predictive model. Data collected included:
  - pipe location
  - pipe diameter
  - pipe length
  - pipe age
  - video inspection status
  - pipe condition
  - type of rehabilitation required
  - length of pipe in need of rehabilitation

The statistical relationship between the percent of sewer lengths needing rehabilitation and sewer pipe age can be expressed as:

$$\boldsymbol{Y = 0.00183^{0.070x}}$$

where Y = the percent of the total length of sewer lines requiring rehabilitation, and x = the age of sewer pipe in years.

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Appendix F

Optimization of Collection System Maintenance Frequencies and System Performance (with sample diskette)

11/23/98

Title: Optimization of Collection System Maintenance Frequencies and System Performance

By:American Society of Civil Engineers

For: EPA, Cooperative Agreement # CX 824902-01-0

Author: Black & Veatch
Contact: Rick Nelson, Principal Investigator
Telephone: 913.458.3510
email: nelsonre@bv.com

Characteristic Data

No.	Characteristic Data	Qty	
1	Miles of Sewer	525	
2	Number of Pump Stations	55	
3	Size Code	2	
4	Regional Code	5	
5	System Reinvestment, $/mi/yr	$1,988	life of system
6	System Reinvestment, $/mi/yr	$5,596	1980-1996
7	Pump Stations/ mile	0.105	
8	Average System Age	50.0	

Size Code	
1 Small	<100,000
2 Medium	100,000-500,000
3 Large	> 500,000

Regional Code
1 Central
2 Northeast
3 Northwest
4 Southeast
5 Southwest

Determination of Maintenance Frequency

No.	Maintenance Activity	Qty	Unit	Years	Rate	Unit	Relative Importance	Standardized Frequency	Weighted Frequency
1	Cleaning of Sewer Lines	844	miles	5	32.2%	% system/yr	17.7%	10.0%	1.77%
2	Root Removal	20	miles	5	0.8%	% system/yr	8.4%	6.0%	0.50%
3	Pumping Station Inspection	11876	number	5	43.2	no/ps/yr	14.1%	5.0%	0.71%
4	Flow Monitoring	2%	% system	5	0.4%	% system/yr	7.0%	3.0%	0.21%
5	Manhole Inspection	100%	% system	5	20.0%	% system/yr	6.4%	10.0%	0.64%
6	Smoke/Dye Testing	0%	% system	5	0.0%	% system/yr	3.3%	3.0%	0.10%
7	CCTV	5%	% system	5	1.0%	% system/yr	10.5%	5.0%	0.53%
8	Private Sector Inspections	0%	% system	5	0.0%	% system/yr	2.0%	1.0%	0.02%
9	Manhole Rehabilitated	95%	% complete	n/a	95%	% complete	5.6%	18.0%	1.01%
10	Sewer Line Rehabilitated	60%	% complete	n/a	60%	% complete	12.6%	14.0%	1.76%
11	Relief/Equalization	0%	% complete	n/a	0%	% complete	6.3%	0.0%	0.00%
12	Private Sectors Rehabilitated	0%	% complete	n/a	0%	% complete	6.1%	1.0%	0.06%
						sum	100.0%		**7.3%** *Maintenance Frequency*

Determination of Performance Rating

No.	Performance Measure	Qty	Unit	Years	Rate	Unit	Relative Importance	Standardized Frequency	Weighted Frequency
1	Pipe Failures	3	number	5	0.001	no/mi/yr	22.6%	100.0%	22.6%
2	SSOs	76	number	5	0.029	no/mi/yr	23.6%	87.1%	20.5%
3	Customer Complaints(1)	4074	number	5	1.552	no/mi/yr	20.8%	71.3%	14.8%
4	Pump Station Failures	60	number	5	0.023	no/mi/yr	17.8%	32.1%	5.7%
5	Peak Hourly/ ADF Ratio	3	ratio	n/a	3	ratio	9.7%	32.1%	3.1%
6	Peak Month/ ADF Ratio	2.5	ratio	n/a	2.5	ratio	5.5%	30.0%	1.7%
						sum	100.0%		**68.5%** *Performance Rating*

(1) Includes complaints, basement backups and "other".

Equation Results:

Equation Name	Result
PR1	47.0%
RE1	($10,247)
RE2	$2,502
RE3	$4,203
RE4	$11,087

APPENDIX K

3 Rivers Wet Weather Demonstration Program

Guide for Evaluating Capacity, Management, Operation, and Maintenance (CMOM) Programs at Sanitary Sewer Collection Systems

United States
Environmental Protection
Agency

Office of Enforcement and
Compliance Assurance (2224A)

EPA 305-B-05-002

www.epa.gov

January 2005

TABLE OF CONTENTS

CHAPTER 1. INTRODUCTION

1.1 Purpose of this Guide

This guide identifies some of the criteria used by EPA to evaluate a collection system's management, operation, and maintenance (CMOM) program activities. The guide is intended for use by EPA and state inspectors as well as the regulated community – owners or operators of sewer systems collecting domestic sewage as well as consultants or other third-party evaluators or compliance assistance providers. Collection system owners or operators can review their own systems by following the checklist in Chapter 3 to reduce the occurrence of sewer overflows and improve or maintain compliance. The guidance herein may also be taken a step further. If a federal or state reviewer observes a practice that does not effectively meet the elements of a CMOM program, he or she may make recommendations to educate the operator, inspector, case developer, or those involved in a settlement agreement. Additionally, having key board members (policy makers) read this guide will also allow them to better understand the benefits of investing in good CMOM programs.

The guide is applicable to small, medium, and large systems; both publicly and privately owned systems; and both regional and satellite collection systems. Regardless of size, each owner or operator will have an organization and practices unique to its collection system. While these specific characteristics will vary among systems, the CMOM concepts and best management practices are likely to apply to all types of systems. Where appropriate, this document provides guidance on the differences.

This document does not, however, substitute for the CWA or EPA's regulations, nor is it a regulation itself. Thus, the document does not and cannot impose legally binding requirements upon these circumstances. EPA and state decision-makers retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance where appropriate. EPA may change this guidance in the future.

Individuals reviewing a collection system are strongly encouraged to read the guidance portion of this document prior to conducting a review. Reviewers should use the checklist in Chapter 3 as the primary tool for questions during the paperwork and/or onsite review of the collection system.

While some sections or topics may not appear to relate directly to environmental performance, taken as a whole, they provide an indication of how well the utility is run.

1.2 Terminology

To provide a more user-friendly guidance and for clarification, the terminology for several terms has been modified. The following paragraphs list these terms and reasoning for the modifications.

Frequently, the term "COLLECTION SYSTEM OWNER OR OPERATOR", abbreviated as "OWNER OR OPERATOR," is used in this guide and refers to the entities responsible for the administration and oversight of the sewer system and its associated staff (in either a municipal or industrial context); capacity evaluation, management, operation, and maintenance programs; equipment; and facilities. The owner and operator may be two different entities. For example, the owner may own the infrastructure and be responsible for its maintenance while it designates responsibility for the day to day operation of

the system to the operator. It should be noted that the term used in EPA's CMOM Program Self Assessment Checklist is "MUNICIPAL WASTEWATER UTILITY OPERATORS" or "UTILITY" rather than "collection system owner or operator." Both refer to the same individual(s).
The term "REVIEW" is used in this document in place of "INSPECTION" or "AUDIT." Because "inspection" often refers to an evaluation conducted by the regulatory authority and "audit" has been used to refer to an evaluation with very specific requirements, "review" is more appropriately used to capture the wider universe of evaluations (e.g., those conducted by a regulatory authority, the system itself, and/or by a third-party).

Similarly, the term used to describe the person conducting the CMOM review is the "REVIEWER" – this could be either an inspector, a third party reviewer hired by the owner or operator, or personnel of the owner or operator performing a self-evaluation of the collection system.

The term "FACILITY" is used in this document to refer to the components of the collection system (e.g., pump stations, sewer lines).

1.3 How to Use the Guide

The guide and checklist provide a three-tiered approach to the CMOM review:

- Evaluation of the CMOM program, based on interviews with management and field personnel, as well as observation of routine activities and functions
- Review of pertinent records and information management systems
- Evaluation based on field/site review

Chapter 2 provides a breakdown and overview of each CMOM concept and what to look for when reviewing the system, defines the CMOM elements for the reviewer, and follows through with a discussion of the indicators or other clues about which the reviewer should be aware. Chapters 2 and 3 present detailed information on conducting reviews of collection systems. Chapter 3 contains the comprehensive reviewer checklist, supported by the information in Chapter 2. Appendix A presents a Collection System Performance Indicator Data Collection Form which provides examples of the types of information a reviewer should attempt to obtain while on-site.

The "one size does not fit all" approach to reviewing CMOM programs cannot be overstated. The principles covered in this guide are applicable to all wastewater collection systems, however, these principles may be implemented through different means depending on the system. Larger systems may have the resources and the need to implement more costly and complex means of meeting the CMOM program elements. In occasional cases a CMOM feature may not be implemented at all, due to characteristics of the system. A reviewer should be able to look at the system as a whole and determine whether certain key elements are present or should be present and to what extent the system incorporates the CMOM principles.

Reviewers will also find that the location or names of some documents, logs, or reports may vary from system to system. This guide tries to provide a general description of the materials the reviewer should request.

Although use of this guide cannot guarantee a collection system will avoid permit violations or discharge violations, generally, when owners or operators adequately practice the principles laid out in the guide, they should experience fewer problems and, therefore, fewer instances of noncompliance.

1.4 Overview of the Underlying Issues

Sanitary sewer collection systems are designed to remove wastewater from homes and other buildings and convey it to a wastewater treatment plant. The collection system is a critical element in the successful performance of the wastewater treatment process. EPA estimates that collection systems in the U.S. have a total replacement value between $1 to $2 trillion. Under certain conditions, poorly designed, built, managed, operated, and/or maintained systems can pose risks to public health, the environment, or both. These risks arise from sanitary sewer overflows (SSOs) from the collection system or by compromised performance of the wastewater treatment plant. Effective and continuous management, operation, and maintenance, as well as ensuring adequate capacity and rehabilitation when necessary, are critical to maintaining collection system capacity and performance while extending the life of the system.

EPA believes that every sanitary sewer system has the capacity to have an SSO. This may be due to a number of factors including, but not limited to:

- Blockages
- Structural, mechanical, or electrical failures
- Collapsed or broken sewer pipes
- Insufficient conveyance capacity
- Vandalism

SSOs include untreated discharges from sanitary sewer systems that reach waters of the United States (photo: US EPA).

Additionally, high levels of inflow and infiltration (I/I) during wet weather can cause SSOs. Many collection systems that were designed according to industry standards experience wet weather SSOs because levels of I/I may exceed levels originally expected; prevention of I/I has proven more difficult and costly than anticipated; or the capacity of the system has become inadequate due to an increase in service population without corresponding system upgrades (EPA 2004).

SSOs can cause or contribute to environmental and human health impacts (e.g., water quality standards violations, contamination of drinking water supplies, beach closures, etc.) which, in addition to flooded basements and overloaded wastewater treatment plants, are some symptoms of collection systems with inadequate capacity and improper management, operation, and maintenance. These problems create the need for both the owner or operator and the regulatory authority to conduct more thorough evaluations of sanitary sewer collection systems.

1.5 Purpose of CMOM Programs

CMOM programs incorporate many of the standard operation and maintenance activities that are routinely implemented by the owner or operator with a new set of information management requirements in order to:

- Better manage, operate, and maintain collection systems
- Investigate capacity constrained areas of the collection system
- Proactively prevent SSOs
- Respond to SSO events

The CMOM approach helps the owner or operator provide a high level of service to customers and reduce regulatory noncompliance. CMOM can help utilities optimize use of human and material resources by shifting maintenance activities from “reactive” to “proactive”–often leading to savings through avoided costs due to overtime, reduced emergency construction costs, lower insurance premiums, changes in financial performance goals, and fewer lawsuits. CMOM programs can also help improve communication relations with the public, other municipal works and regional planning organizations, and regulators.

It is important to note that the collection system board members or equivalent entity should ensure that the CMOM program is established as a matter of policy. The program should not be micro-managed, but an understanding of the resources required of the operating staff to implement and maintain the program is necessary.

In CMOM planning, the owner or operator selects performance goal targets, and designs CMOM activities to meet the goals. The CMOM planning framework covers operation and maintenance (O&M) planning, capacity assessment and assurance, capital improvement planning, and financial management planning. Information collection and management practices are used to track how the elements of the CMOM program are meeting performance goals, and whether overall system efficiency is improving.

On an periodic basis, utility activities should be reviewed and adjusted to better meet the performance goals. Once the long-term goal of the CMOM program is established, interim goals may be set. For instance, an initial goal may be to develop a geographic information system (GIS) of the system. Once the GIS is complete, a new goal might be to use the GIS to track emergency calls and use the information to improve maintenance planning.

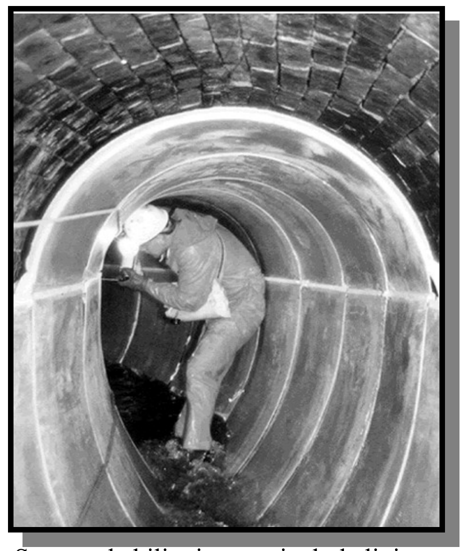
An important component of a successful CMOM program is periodically collecting information on current systems and activities to develop a “snapshot-in-time” analysis. From this analysis, the owner or operator evaluates its performance and plans its CMOM program activities.

Maintaining the value of the investment is also important. Collection systems represent major capital investments for communities and are one of the communities’ major capital assets. Equipment and facilities will deteriorate through normal use and age. Maintaining value of the capital asset is a major goal of the CMOM program. The infrastructure is what produces sales and service. Proper reinvestment in capital facilities maintains the ability to provide service and generate sales at the least cost possible and helps ensure compliance with environmental requirements. As a capital asset, this will result in the need for ongoing investment in the collection system and treatment plant to ensure design capacity while maintaining existing facilities and equipment as well as extending the life of the system.

The performance of wastewater collection systems is directly linked to the effectiveness of its CMOM program. Performance characteristics of a system with an inadequate CMOM program include frequent blockages resulting in overflows and backups. Other major performance indicators include pump station reliability, equipment availability, and avoidance of catastrophic system failures such as a collapsed pipe.

A CMOM program is what an owner or operator should use to manage its assets; in this case, the collection system itself. The CMOM program consists of a set of best management practices that have been developed by the industry and are applied over the entire life cycle of the collection system and treatment plant. These practices include:

- Designing and constructing for O&M
- Knowing what comprises the system (inventory and physical attributes)
- Knowing where the system is (maps and location)
- Knowing the condition of the system (assessment)
- Planning and scheduling work based on condition and performance
- Repairing, replacing, and rehabilitating system components based on condition and performance
- Managing timely, relevant information to establish and prioritize appropriate CMOM activities
- Training of personnel



Sewer rehabilitation can include lining aging sewers (photo: NJ Department of Environmental Protection).

1.6 National Pollutant Discharge Elimination System Regulatory Requirement

The National Pollutant Discharge Elimination System (NPDES) program prohibits discharges of pollutants from any point source into the nation's waters except as authorized under an NPDES permit. EPA and state NPDES inspectors evaluate collection systems and treatment plants to determine compliance with permit conditions including proper O&M. Among others, these permit conditions are based on regulation in 40 CFR 122.41(e): "The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit."

When violations occur, the collection system or wastewater treatment plant owner or operator can face fines and requirements to implement programs to compensate residents and restore the environment. For example, in June 2004, the U.S. District Court for the Southern District of Ohio entered a consent decree resolving CSO, SSO, and wastewater treatment plant violations at the Hamilton County sewer system in Cincinnati, Ohio. In addition to a $1.2 million civil penalty, the settlement included programs to clean up residents' basements, compensate residents, and implement measures to prevent further basement backups. The settlement also includes over $5.3 million in supplemental environmental projects.

1.7 EPA Region 4 MOM Programs Project

EPA Region 4 created the "Publicly Owned Treatment Works MOM Programs Project" under which the Region invites permitted owners or operators, and contributing satellite systems, in watersheds it selects to perform a detailed self-assessment of the management, operation, and maintenance (MOM) programs associated with their collection system. Participants provide a report which includes the results of the review, any improvements that should be made, and schedules to make those improvements. Participants that identify and report a history of unpermitted discharges from their collection system, and a schedule for the necessary improvements, can be eligible for smaller civil penalties while under a remediation schedule.

EPA's Office of Compliance coordinated with EPA Region 4 on the development of this CMOM Guide. This guide is based in part on material obtained from the Region 4 MOM Programs Project. Some of the more specific items of the Region 4 program have been omitted in order to provide a more streamlined review framework. The fundamental concepts behind CMOM have been maintained in this guide. By combining elements of the Region's program with existing NPDES inspection guidance, this CMOM Guide provides a comprehensive framework for reviewers and regulated communities to evaluate the effectiveness of O&M throughout the collection system.

CHAPTER 2. COLLECTION SYSTEM CAPACITY, MANAGEMENT, OPERATION, AND MAINTENANCE PROGRAMS

This chapter provides an overview of the CMOM program elements. The information will help evaluate wastewater collection system operation and maintenance (O&M) practices. The key elements of the CMOM program, which are presented in detail in the following sections, include:

- Collection System Management
- Collection System Operation
- Collection System Maintenance
- Collection System Capacity Evaluation

In addition to this overview, there are several areas (e.g., 2.1.3 Internal Communications, 2.1.4 Customer Service, etc.) in this guide that go into greater depth regarding the operation and maintenance of a collection system. The intent of this detail is not only to provide the owner or operator with suggestions as to what to look for in their own program, but to provide the reviewer a complete overview of good operations, in general, regardless of a particular item resulting in poor performance or a violation.

For EPA and state inspectors or other reviewers, conducting an evaluation of collection system CMOM programs shares many similarities with other types of compliance reviews. Overall, the reviewer would examine records, interview staff and conduct field investigations, generally in that order although tailored, if necessary, to meet site-specific needs. Prior to performing the on-site interviews and evaluations, preliminary information may be requested that will provide an overall understanding of the organization to allow for a more focused approach for the review. This information also provides a basis for more detailed data gathering during on site activities. The information typically requested prior to the review should include a schematic map of the collection system (could be as-built drawings) and any written operations or maintenance procedures. Depending on the volume of information, the collection system owner or operator may need ample lead time to gather and copy these documents. Alternatively, the reviewer may offer to examine the documents and bring them back when doing the on-site review so that extra copies are not necessary. No matter which method is used, the importance of up-front preparation cannot be overemphasized. With the exception of pump stations and manholes, much of the collection system is not visible. Therefore, the more complete the reviewer's understanding of the system is prior to the review, the more successful the assessment will be.

The reviewer would then proceed with the on-site activities. Guidance for conducting compliance reviews is provided in the *NPDES Compliance Inspection Manual* (EPA 2004). The manual provides the general procedures for performing compliance reviews and is a valuable source of information on such topics as entry, legal authority, and responsibilities of the reviewer. Although CMOM evaluations are not specifically addressed in the manual, the general review procedures can be applied to CMOM reviews. Another good reference for general review information is the *Multi-Media Investigations Manual, NEIC* (EPA 1992). Some issues with entry are specific to CMOM reviews. Some facilities may be on private property and the reviewer may need property owner consent for entry.

***Documents to Review On-site Include*:**

- Organization chart(s)
- Staffing plans
- Job descriptions
- Sewer use ordinance
- Overall map of system showing facilities such as pump stations, treatment plants, major gravity sewers, and force mains
- O&M budget with cost centers[1] for wastewater collection
- Performance measures for inspections, cleaning, repair, and rehabilitation
- Recent annual report, if available
- Routine reports regarding system O&M activities
- Collection system master plan
- Capital improvement projects (CIP) plan
- Flow records or monitoring
- Safety manual
- Emergency response plan
- Management policies and procedures
- Detailed maps/schematics of the collection system and pump stations
- Work order management system
- O&M manuals
- Materials management program
- Vehicle management and maintenance records
- Procurement process
- Training plan for employees
- Employee work schedules
- Public complaint log
- Rate ordinance or resolution
- Financial report ("notes" section)
- As built plans
- Discharge monitoring reports (DMRs)

The above list is not all inclusive nor will all utilities necessarily have formal, written documentation for each of the items listed. The *Collection System Performance Indicator Data Collection Form*, included as Appendix A, provides examples of the types of information a reviewer should attempt to obtain while on-site.

Reviewer - Point to Note
A schedule should be established by the reviewer for the staff interviews and field assessments.

Interviews are generally conducted with line managers and supervisors who are responsible for the various O&M activities

[1] A cost center is any unit of activity, group of employees, line of products, etc., isolated or arranged in order to allocate and assign costs more easily.

and support services staff from engineering, construction, human resources, and purchasing, where appropriate. Appendix B presents an example agenda and schedule that would be used for a large collection system owner or operator. The collection system's size and physical characteristics will determine the length of time needed for the review. A guideline for the time required, given a two person review team, would be two days for a small system, and a week or more for large systems.

Field reviews are typically conducted after interviews. The following is a list of typical field sites the team should visit:

- Mechanical and electrical maintenance shop(s)
- Fleet maintenance facilities (vehicles and other rolling stock)
- Materials management facilities (warehouse, outside storage yards)
- Field maintenance equipment storage locations (i.e., crew trucks, mechanical and hydraulic cleaning equipment, construction and repair equipment, and television inspection equipment)
- Safety equipment storage locations
- Pump stations
- Dispatch and supervisory control and data acquisition (SCADA) systems
- Crew and training facilities
- Chemical application equipment and chemical storage areas (use of chemicals for root and grease control, hydrogen sulfide control [odors, corrosion])
- Site of SSOs, if applicable
- A small, but representative, selection of manholes

Collection system operators typically assist with manhole cover removal and other physical activities. The inspector should refrain from entering confined spaces. A confined space is defined by the Occupational Safety and Health Administration (OSHA) as a space that: (1) is large enough and so configured that an employee can bodily enter and perform assigned work; and (2) has limited or restricted means for entry or exit; and (3) is not designed for continuous employee occupancy [29 CFR 1910.146(b)]. A "permit-required confined space (permit space)" is a confined space that has one or more of the following characteristics: (1) contains or has a potential to contain a hazardous atmosphere; (2) contains a material that has the potential for engulfing an entrant; (3) has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section; or (4) contains any other recognized serious safety or health hazard [29 CFR 1910.146(b)].

Though OSHA has promulgated standards for confined spaces, those standards do not apply directly to municipalities, except in those states that have approved plans and have asserted jurisdiction under Section 18 of the OSHA Act. Contract operators and private facilities do have to comply with the OSHA requirements and the inspector may find that some municipalities elect to do so voluntarily. In sewer collection systems, the two most common confined spaces are the underground pumping station and manholes. The underground pumping station is typically entered through a relatively narrow metal or concrete shaft via a fixed ladder. Inspectors conducting the field evaluation component of the CMOM audit should be able to identify and avoid permit-required confined spaces. Although most confined spaces are unmarked, confined spaces that may have signage posted near their entry containing the following language:

DANGER–PERMIT REQUIRED–CONFINED SPACE
AUTHORIZED PERSONNEL ONLY

If confined space entry is absolutely necessary, inspectors should consult with the collection system owner or operator first, have appropriate training on confined space entry, and use the proper hazard detection and personal safety equipment. More information on confined space entry can be found in *Operation and Maintenance of Wastewater Collection Systems Volumes I and II* (California State University (CSU) Sacramento 1996; CSU Sacramento 1998).

2.1 Collection System Management

Collection system management activities form the backbone for operation and effective maintenance activities. The goals of a management program should include:

- Protection of public health and prevention of unnecessary property damage
- Minimization of infiltration, inflow and exfiltration, and maximum conveyance of wastewater to the wastewater treatment plant
- Provision of prompt response to service interruptions
- Efficient use of allocated funds
- Identification of and remedy solutions to design, construction, and operational deficiencies
- Performance of all activities in a safe manner to avoid injuries

<u>Management Documents to Review</u>

- Organization chart(s)
- Staffing plans–Number of people and classifications
- Job descriptions for each classification
- Sewer use ordinance
- Safety manual
- Training program documentation
- Notes to financial reports

Without the proper procedures, management and training systems, O&M activities may lack organization and precision, resulting in a potential risk to human health and environmental contamination of surrounding water bodies, lands, dwellings, or groundwater. The following sections discuss the common elements of a robust collection system management program.

2.1.1 Organizational Structure

Well-established organizational structure, which delineates responsibilities and authority for each position, is an important component of a CMOM program for a collection system. This information may take the form of an organizational chart or narrative description of roles and responsibilities, or both. The organizational chart should show the overall personnel structure, including operation and maintenance staff. Additionally, up-to-date job descriptions should be available. Job descriptions should include the nature of the work performed, the minimum requirements for the position, the necessary special qualifications or certifications, examples of the types work, lists of licences required for the position, performance measures or promotion potential. Other items to note in regard to the organizational structure are the percent of staff positions currently vacant, on average, the length of time positions remain vacant, and the percent of collection system work that is contracted out.

> **Reviewer - Point to Note**
> The reviewer may want to note the turnover rate and current levels of staffing (i.e., how many vacant positions exist and for how long they have been vacant). This may provide some indication of potential understaffing, which can create response problems.

Reviewers should evaluate specific qualifications of personnel and determine if the tasks designated to individuals, crews, or teams match the job descriptions and training requirements spelled out in the organizational structure. From an evaluation standpoint, the reviewer might try to determine what type of work is performed by outside contractors and what specific work is reserved for collection system personnel. If much of the work is contracted, it is appropriate to review the contract and to look at the contractor's capabilities. If the contractor handles emergency response, the reviewer should examine the contract with the owner or operator to determine if the emergency response procedures and requirements are outlined.

The inclusion of job descriptions in the organizational structure ensures that all employees know their specific job responsibilities and have the proper credentials. Additionally, it is useful in the course of interviews to discuss staff management. The reviewer should note whether staff receive a satisfactory explanation of their job descriptions and responsibilities. In addition, when evaluating the CMOM program, job descriptions will help a reviewer determine who should be interviewed.

> **Reviewer - Point to Note**
> A reviewer should look for indications that responsibilities are understood by employees. Such indications may include training programs, meetings between management and staff, or policies and procedures.

When evaluating the organizational structure, the reviewer should look for the following:

- Except in very small systems, operation and maintenance personnel ideally should report to the same supervisor or director. The supervisor or director should have overall responsibility for the collection system.

- In some systems, maintenance may be carried out by a city-wide maintenance organization, which may also be responsible for such diverse activities as road repair and maintenance of the water distribution system. This can be an effective approach, but only if adequate lines of responsibility and communication are established.

- In general, one supervisor should manage a team of individuals small enough that is safe and effective. However, the individuals on the team may have additional employees reporting to them. This prevents the top supervisors from having to track too many individuals. The employee-supervisor ratio at individual collection systems will vary depending on their need for supervisors.

In a utility with well-established organizational structure, staff and management should be able to articulate their job and position responsibilities. Personnel should be trained to deal with constantly changing situations and requirements, both regulatory and operational.

The system's personnel requirements vary in relation to the overall size and complexity of the collection system. In very small systems, these responsibilities may include operation of the treatment plant as well as the collection system. In many systems, collection system personnel are responsible for the stormwater as well as wastewater collection system. References providing staff guidelines or recommendations are available to help the reviewer determine if staffing is adequate for the collection system being reviewed. Following is a list of available references:

- *Manpower Requirements for Wastewater Collection Systems in Cities of 150,000 to 500,000 Population* (EPA 1974)
- *Manpower Requirements for Wastewater Collection Systems in Cities and Towns of up to 150,000 Population* (EPA 1973)
- *Operation and Maintenance of Wastewater Collection Systems*, Volume II (California State University (CSU) Sacramento 1998)

Volumes I and II of *Operations and Maintenance of Wastewater Collection Systems* can be obtained through:

Office of Water Programs
California State University Sacramento
6000 J Street
Sacramento, CA 95819-6025
phone: 916/278-6142
www.owp.csus.edu

The following tables have been taken from the two EPA documents listed above to provide the reviewer with guidance. However, these documents may not take into account technological advances that have occurred since their publication date that might reduce staffing requirements. For instance, advances in remote data acquisition and telemetry have likely reduced the number of field inspection staff needed for systems with several pump stations. Other system-specific characteristics should also be accounted for when using these tables. An example of this might be collection systems that are not primarily constructed of brick will not require the masons the tables specify.

STAFF COMPLEMENTS FOR WASTEWATER COLLECTION SYSTEM MAINTENANCE
POPULATION SIZE
(Estimated Number of Personnel)

Occupational Title	5,000		10,000		25,000		50,000		100,000	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Superintendent	1	5	1	10	1	20	1	40	1	40
Assistant Superintendent										
Maintenance Supervisor							1	40	2	80
Foreman	1	15	1	20	1	20	1	40	1	40
Maintenance Man II	1	15	1	20	1	20	1	40	1	40
Maintenance Man I	1	15	1	20	2	60	3	120	5	200
Mason II							1	40	1	40
Mason I									1	40
Maint. Equipment Personnel					1	40	2	80	3	120
Construction Equipment Personnel	1	15	1	20	1	20	1	40	1	40
Auto. Equipment Personnel									1	40
Photo. Inspection Technician									1	40
Laborer	1	15	1	20	2	40	2	80	5	200
Dispatcher							1	40	2	80
Clerk Typist							1	20	1	20
Stock Clerk							1	40	1	40
Sewer Maint. Staff	6	80	6	110	9	220	16	620	27	1,060
Maintenance Mechanic II	see comment (c) below									
Maintenance Mechanic I	see comment (d) below									
Maintenance Mechanic Helper	see comment (d) below									
Construction Inspection Supervisor	see comments (e) and (f) below									
Total Staff										

(a) Estimated number of personnel.
(b) Estimated total man-hours per week.
(c) Multiply number of lift stations maintained by 8/3.
(d) Multiply number of lift station visits per week by 1.
(e) Multiply estimated construction site visits per week by 8/3.
(f) Determined by the number of Construction Inspectors employed and developed on a judgmental basis.

Unit processes included in this staffing table are:

1. Maintenance of sanitary sewer main lines & appurtenances (laterals not included).
2. Maintenance of storm sewer main lines.
3. Maintenance of lift stations.
4. Inspection of newly constructed sewer main lines and appurtenances.

(U.S. EPA 1973)

STAFF COMPLEMENTS FOR WASTEWATER COLLECTION SYSTEM MAINTENANCE
POPULATION SIZE
(Estimated Number of Personnel)

Occupational Title	**150,000**	**200,000**	**300,000**	**400,000**	**500,000**
Superintendent	1	1	1	1	1
Assistant Superintendent	1	1	1	1	1
Maintenance Supervisor II	1	1	1	1	1
Maintenance Supervisor I	1	2	2	3	3
Equipment Supervisor	1	1	1	1	1
TV Technician II	1	2	2	3	3
TV Technician I	1	2	2	3	3
Foreman	2	3	4	5	6
Maintenance Man II	3	5	6	8	9
Maintenance Man I	11	17	22	29	33
Mason II	1	2	2	3	3
Mason I	1	2	2	3	3
Maintenance Equipment Personnel	6	8	12	15	18
Construction Equipment Personnel	3	4	6	8	9
Auto. Equipment Personnel	2	3	4	5	6
Laborer	7	10	14	18	22
Dispatcher	2	2	2	3	3
Stock Clerk	1	2	2	3	3
Clerk Typist	2	2	2	3	3
Sewer Maintenance Staff	48	70	88	116	131
Maintenance Mechanic II	see comment (a) below				
Maintenance Mechanic I	see comment (b) below				
Maintenance Mechanic Helper	see comment (b) below				
Electrician	see comment (c) below				
Construction Inspector Supervisor	see comment (d) below				
Construction Inspector	see comment (e) below				
Total Staff					

(a) Divide number of lift stations maintained by 15.
(b) Divide number of lift station visits per week by 40
(c) Divide number of lift stations maintained by 15.
(d) Determined by the number of Construction Inspectors employed and developed on a judgmental basis.
(e) Divide estimated daily construction site visits by 2.

Unit processes included in this staffing table are:

1. Maintenance of sanitary sewer main lines & appurtenances (laterals not included).
2. Maintenance of storm sewer main lines.
3. Maintenance of lift stations.
4. Inspection of newly constructed main lines and appurtenances.

(U.S. EPA 1974)

2.1.2 Training

The commitment of management to training is key to a successful program. It is important to recognize training as a budget expense item. A guideline for the typical amount of funding for training is three to five percent of the gross budget for the collection system. However, in large collection systems or those undergoing extensive construction this percentage may be considerably lower, and, in systems with a high turnover, training costs may be higher due to orienting new employees. Other changes, such as incorporation of new technology, will have a short-term impact on training costs. Although training is not explicitly required under current regulations, a collection system with untrained or poorly trained collection system personnel runs a greater risk of experiencing noncompliance.

The following elements are essential for an effective training program:

- Fundamental mission, goals, and policies of the collection system are addressed
- Mandatory training requirements are identified for key employees
- On-the-job training progress and performance are measured
- Effectiveness of the training is assessed including periodic testing, drills, or demonstrations
- New employees receive training

The owner or operator should generally provide training in the following areas:

- Routine line maintenance (may be on-the-job training only)
- Safety during confined space entry (every system should also have a strict policy and permit program)
- Traffic control (where applicable)
- Record keeping
- Pump station O&M
- Electrical and instrumentation (may be a combination of formal and on-the-job training)
- Public relations and customer service
- SSO/Emergency response
- Pump station operations and maintenance
- Pipe repair; bursting or cured in place pipe (CIPP); or closed circuit TV and trench/shoring (where these activities are not outsourced)

Sources of Training

Training is required to safely perform inspections, follow replacement procedures, and lubricate and clean parts and equipment. Following are the many sources of maintenance training:

- Manufacturer
- In-house
- On-the-job (OJT)
- Industry-wide (e.g., consultants, regulatory authorities, professional associations, or educational institutions)

The training program should identify the types of training required and offered. Types of training vary, but may include general environmental awareness, specific equipment, policies and procedures, and conducting maintenance activities. If the owner or operator is carrying out its own training, the reviewer should evaluate one or more examples of training materials to answer the following questions: are the materials appropriate to the training topic and the level of those being trained; and are they likely to accomplish the intended goal?

> **Owner or Operator - Point to Note**
> The owner or operator should routinely assess the effectiveness of training through periodic testing, drills, demonstrations, or informal reviews, and improve training based on this assessment.

2.1.3 Internal Communication

Communication is essential to ensuring that collection systems run efficiently and effectively. It is especially important that an effective communication link exists between wastewater treatment plant operators and collection system crews as well as with other municipal departments.

Effective communication requires the top-down, bottom-up, and lateral exchange of information amongst staff. Examples of top-down communication are bulletin board posters, paycheck inserts, regular staff meetings, e-mail or informal brown-bag lunch discussions. Examples of bottom-up communication may include the establishing environmental committees, confidential hotlines, e-mail, or direct open discussions. Collection system owners or operators may also offer incentives to employees for performance, and encourage them to submit suggestions for ways to improve the performance of the collection system. "Front line" employees are often an excellent source of ideas, issues, and information about how to improve performance at the work site. In this context, the reviewer can check for morale-boosting activities or reward programs, such as "Employee of the Month" and "Employee of the Year."

The reviewer should attempt to determine lines of internal communication to ensure all employees receive information and have an appropriate forum to provide feedback. The reviewer should assess the level of communication by interviewing several levels of staff or by simply observing collection system teams on work assignments. The owner or operator should have procedures and be able to demonstrate internal communication between the various levels and functions of the collection system regarding its management, operation, and maintenance programs.

2.1.4 Customer Service

The community often knows very little about the wastewater treatment and collection services performed for them. The community may only be aware of the collection system and its owner or operator through articles in local newspapers, public radio and television announcements, or only when there is an SSO. Collection system representatives should talk to schools and universities, make presentations to local officials and businesses about the wastewater field. Formal presentations can also be given to citizens, building inspectors, public utility officials, and members of the media.

An effective customer service and public relations program ensures that the owner or operator addresses all incoming inquiries, requests, and complaints in a timely fashion. From this information, owners or operators may further develop or revise programs to better address areas of concern. The reviewer should examine customer service records for the following:

- Personnel who received the complaint or request
- Date and nature of the complaint or request
- Location of the problem
- Name, address, and telephone number of the customer
- Cause of the problem
- To whom the follow-up action was assigned
- The initial date of the follow-up action
- Date the complaint or request was resolved
- Total days to end the problem
- Feedback to the customer

Awareness of past issues, population served, compliance history, and other elements help a reviewer determine whether the amount and types of inquiries, requests, or complaints are increasing or decreasing. For example, there may have been many complaints during only a certain week. The reviewer can examine those records to determine if there were specific circumstances (e.g., a large precipitation event) that caused the increase in inquiries or complaints.

Reviewer - Point to Note
To fully understand the context of customer inquiries, requests, or complaints, a reviewer should understand the history, topography, boundaries, and demographics of the collection system's jurisdiction before site evaluations are conducted.

Employees who handle customer service should be specifically trained to handle complaints, requests, or inquiries. These employees should be provided with sample correspondence, Q/A's, or "scripts" to help guide them through written or oral responses to customers. The reviewer should look for procedures on how to answer the telephone, e-mail, and other communication used by personnel. A reviewer may evaluate staff telephone responses by evaluating:

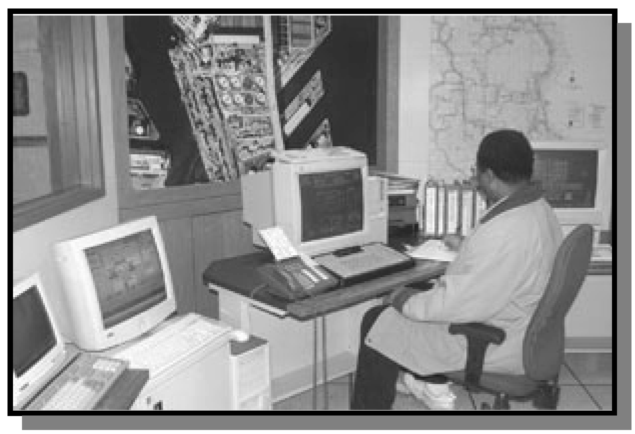
- The number of persons available to answer calls
- The number of repeat callers
- The average length of calls
- The volume of calls per day

Collection system field crews and their activities are the most visible segment of any wastewater treatment organization. Workers project a public image for their system on city and town streets. For this reason, personnel need to be trained in what to expect in public situations. For example, collection system supervisory staff should be familiar with the areas around public rights-of-way and easements to which their field crews must gain access to service facilities. Additionally, crew leaders should know how to deal with the public when approached.

Collection systems field crews influence the public's confidence in the collection system owner or operator. Reviewers should observe whether personnel wear uniforms or not, and if vehicles and equipment are identifiable as utility property and kept in good working order. Vehicles should be equipped with adequate emergency lighting and flashers, traffic control signs and barriers, etc. Before major construction or maintenance work begins, owners or operators should notify homeowners where properties may be affected. Methods of notification may include door hangers, newspaper notices, fliers, signs, or public radio or television announcements. Information should also be provided to residents on cleanup and safety procedures following basement backups and other overflows.

2.1.5 Management Information Systems

The ability of the owner or operator to effectively manage its collection system is directly related to its ability to maintain access to the most current information concerning the facilities. Maintenance of this current information is an effort involving all members of the collection system from the staff answering the telephone to the worker in the street. Operational information informs and clarifies financial information. This will make the financial information more useful for the policy makers, leading to better decisions. A satisfactory management information system should provide the owner or operator with the following advantages:



A growing number of sewer systems have shifted to computer-based collection system management [photo: Milwaukee Metropolitan Sewerage District (MMSD)].

- Maintain preventive maintenance and inspection schedules
- Offer budgetary justification
- Track repairs and work orders
- Organize capital replacement plans
- Manage tools and equipment inventories
- Create purchase orders
- Record customer service inquiries, complaints, or requests
- Provide measurement of effectiveness of program and O&M activities

Owners and operators have been shifting to computer-based systems to manage data. Only the smaller collection system owners or operators may still rely on paper management systems.

Computer-based Maintenance Management Systems (CMMSs) are designed to manage the data needed to track the collection system's O&M performance. Geographic Information Systems (GIS) are used to map and locate facilities and because of computer-based compatibility, can often easily be integrated with a CMMS. The computer-based system however, can only be as accurate as the data used to develop it, which was most likely paper files.

Types of Management Information Tracking

- Customer service
- Safety incident
- Emergency response
- Process change
- Inspection scheduling and tracking
- Monitoring and/or sampling schedules
- Compliance
- Planned maintenance (schedules and work orders)
- Parts inventory

Regardless of the information management style chosen, the collection system should have written instructions regarding the use of the management information systems. These procedures may include operating the system, upgrading the system, accessing data and information, and generating and printing reports. The system should be kept current with accurate information. Work reports from the field crews should be complete, accurate, and legible.

The reviewer may select some number of complaints and see how well they can be tracked through the system to an ultimate conclusion. Work reports generated by the field crew should be randomly chosen and scanned for legibility and completeness. The reviewer should do a random check of the timeliness and accuracy of data entry. Additionally, the reviewer should obtain selected original data sources (such as field reports) and compare them to the appropriate database output to determine how long entry takes. This will provide a check on how current the database is and what data entry backlog exists.

2.1.6 SSO Notification Program

The owner or operator should maintain a written procedure indicating the entities, (e.g., drinking water purveyors, the public, public health officials, and the regulatory authority) that should be notified in the event of an SSO. The procedure should clearly indicate the chain of communication used to notify the proper personnel of an SSO event for reporting and remediation. The procedure should include the names, titles, phone numbers, and responsibility of all personnel involved. The reviewer should verify that the personnel listed in the procedure are still in the position listed and are aware of their responsibilities.

Reviewer - Point to Note
To verify the effectiveness of the notification program, the reviewer should walk an overflow occurrence report through the chain of events that would occur from the time of initial notification.

The procedure may allow for different levels of response for different types of SSOs. For example, the regulatory authority may request that SSOs due to sewer line obstructions be reported on a monthly basis. Therefore, the procedure may simply be to gather this information from the maintenance information system and have the appropriate personnel put together a reporting form. A chronic SSO at a pump station that discharges when overloaded during wet weather may require a more complex notification procedure, including immediate telephone notification to specified authorities.

To verify the effectiveness of the notification program, the reviewer should walk an overflow occurrence report through the chain of events that would occur from the time of initial notification. This can be done by choosing several random overflow events from the complaint records and observing whether they are handled as procedures dictate. The minimum information that should be reported for an SSO includes the date, time, location, cause, volume of the overflow (which may be estimated), how it was stopped, and any remediation methods taken. The reviewer should not only verify that the SSO notification procedures are appropriate, but also verify that the owner or operator has reliable methods for the detection of overflows and a phone number or hotline for the public to report observed overflow events.

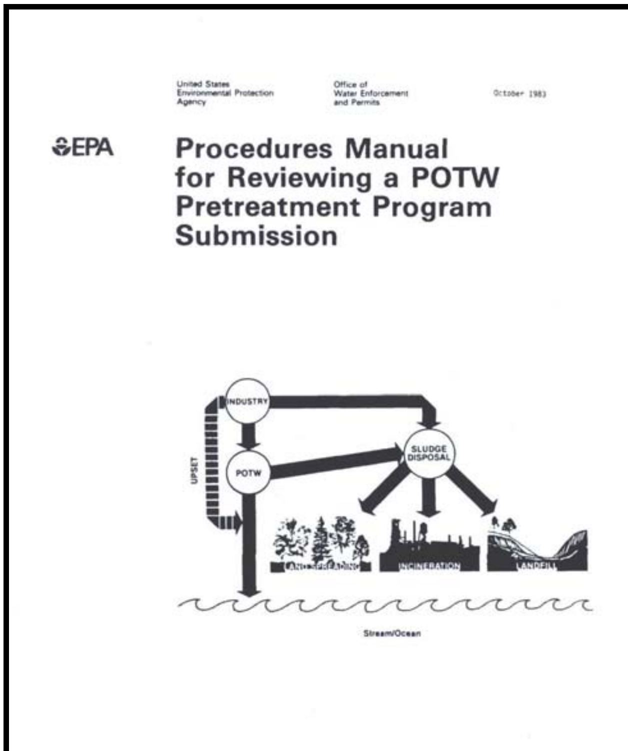
2.1.7 Legal Authority

The collection system owner or operator should select and enforce the legal authority necessary to regulate the volume of flow entering the collection system, including residential and commercial customers, satellite communities and industrial users. The legal authority may take the form of sewer use ordinances, contracts, service agreements, and other legally binding documents.

> A **satellite community** is a collection systems which does not own the treatment facility to which it discharges.

The pretreatment program seeks to prevent the discharge of materials into the sewer system (by non-domestic users) that interfere with proper operation of the wastewater treatment plant or may pass through the plant untreated. At the time the operator of a wastewater treatment plant submits its pretreatment program to the regulatory authority for approval, the plant operator must include a statement from the city solicitor or other legal authority that the plant has the authority to carry out the program [40 CFR 403.9(a)(1)]. The reviewer should verify the existence of this statement and inquire as to whether any significant changes have occurred in the program such that the legal authority may need further review. Additionally, some owners or operators may have a pretreatment program approved by the state, through which discharge permits are issued to industrial users and enforcement is conducted. Further information on legal authority under the pretreatment program may be found in *Procedures Manual for Reviewing a POTW Pretreatment Program Submission* (EPA 1983).

The owner or operator should have the authority to ensure that new and rehabilitated sewers and connections have been properly designed, constructed, and tested before being put into service. This authority could take the form of design and performance specifications in a sewer use ordinance or other legal document such as a statute or series of contracts or joint powers agreements. The ordinance or legal document should contain, at a minimum, general prohibitions, adequate grease control requirements and measures, prohibitions on stormwater inflow, infiltration from laterals, and new construction standards.



The grease control section of the document should contain the requirement to install grease traps at appropriate facilities (e.g., restaurants). Additionally, these facilities should be required to properly maintain the grease traps and pump them out on a regular basis. The document should also address periodic inspections of grease traps by collection system personnel and the ability to enforce (i.e., levy fines on persistent offenders).

General Prohibitions

- Fire and explosion hazards
- Corrosive and obstructive materials
- Material which may cause interference at the wastewater treatment plant
- Heat which may inhibit biological activity at the wastewater treatment plant
- Oils or petroleum products which may cause interference or pass through the wastewater treatment plant

The owner or operator should maintain strict control over the connection of private sewer laterals to sewer mains. These connections have significant potential as sources of infiltration. Standards for new connections should be clearly specified. The sewer use ordinance should contain provisions for inspection, approval of new connections, and a program to implement the requirements. A method to maintain control over existing connections is to require an inspection of the lateral prior to sale of a property. It is important to note that implementing this type of program may require a change to the local ordinance or code.

The owner or operator should also have the legal authority to prohibit stormwater connections to the sanitary sewer. Stormwater connections may include catch basins; roof, cellar and yard drains; sump pumps; direct connections between the storm and sanitary sewers; leaking manhole covers; uncapped cleanouts; and the direct entrance of streams into the collection system. This practice is now discouraged. Direct stormwater connections to a separate sanitary sewer system are known as inflow. Inflow can severely impact the ability of the collection system to transport flows to the treatment plant during wet weather, leading to overflows and noncompliance with the wastewater treatment plant's NPDES permit.

Sources of stormwater in the collection system may include building downspouts connected directly to the system (photo: MMSD).

Satellite communities should not be allowed to contribute excessive flows that cause or contribute to overflows, flooding, or noncompliance at the wastewater treatment plant. Should any of these situations exist, it is not sufficient for the owner or operator to charge the satellite community for the excess flow. The owner or operator must be able to prohibit the contribution of the excess flow. This may be done through a legal inter-jurisdictional agreement between the wastewater treatment plant owner or operator and the satellite community that addresses allowable flows and sets requirements. The reviewer should examine all contracts between systems and their satellites (unless too numerous, then select representative contracts). Contracts should have a date of termination and allow for renewal under renegotiated terms. Contracts should limit flow from satellite communities and limit peak wet weather flow rates.

Owner or Operator - Point to Note
The owner or operator should have a comprehensive program which addresses flows from satellite communities.

2.2 Collection System Operation

Collection systems have little of what is traditionally referred to as "operability" as compared to a wastewater treatment plant (i.e., the number of ways to route the wastewater is typically limited). However, the design of some collection systems does allow flow to be diverted or routed from one pipe to another or even to different treatment plants. This can be accomplished by redirecting flow at a pump station from one discharge point to another or opening and closing valves on gravity sewers and force mains.

Owner or Operator - Point to Note
There should be detailed, written procedures available to guide owners or operators through flow routing activities. Also, there should be operating procedures for mechanical equipment such as pump station pump on/off and service rotation settings or in-line grit removal (grit trap) operations.

There are many reasons why the owner or operator may want to divert flows; among them, to relieve overloading on a system of piping or the wastewater treatment plant or to add more flow to piping serving an area not yet fully developed to maintain a cleansing velocity.

2.2.1 Budgeting

The budget is one of the most important variables in the CMOM program. Although an adequate budget is not a guarantee of a well operated collection system, an inadequate budget will make attaining this goal difficult. Funding can come from a variety of sources, including user fees or appropriations from the state or local government.

> **Reviewer - Point to Note**
> Reviewers need to determine the source of the funding for the collection system and who controls it. Reviewers should also request budget documents, summaries, or pie charts to learn more about the systems' budget.

A key element of the operation budget program is the tracking of costs in order to have accurate records each time the annual operating budget is developed. Having an annual baseline provides documentation for future budget considerations and provides justification for future rate increases. Collection system management should be aware of the procedures for calculating user rates and for recommending and making user rate changes.

Collection system and wastewater treatment plant costs may be combined into one budget, or budget line items may be divided into each of two individual budgets. For example, electrical and mechanical maintenance work performed by plant staff on a pump station may be carried as an O&M cost in the treatment plant budget, although pumping stations are generally considered to be a collection system component.

The cost of preventive and corrective maintenance and major collection system repairs and alterations are key items in the annual operating budget. The collection system owner or operator should keep adequate records of all maintenance costs, both in-house and contracted, plus the costs for spare parts. This will assist in the preparation of the following year's budget. In general, there should be an annual (12-month cycle) budget of discretionary and non-discretionary items. There may also be a Capital Improvement Plan (CIP) which may encompass small projects (one to two year cycles) or larger projects (three to five year cycles). Larger projects may include items such as equipment, labor, training, or root cause failure analysis.

> **Examples of O&M Budget Items**
>
> - Labor (usually at least 50% of total budget)
> - Utilities
> - Capital
> - Maintenance materials and supplies
> - Chemicals
> - Motor vehicles
> - Contracted services

The major categories of operating costs are labor, utilities, and supplies. Cost accounting for these categories should include information on unit costs, total costs, and the amount and/or quantities used. The reviewer should evaluate the current and proposed budget, and current year balance sheets. In examining current and proposed expenditure levels, the reviewer should consider:

- Whether the budgets include contributions to capital reserve (sinking) funds. These funds are savings for replacement of system components once they reach their service life.
- Whether all income from water and sewer billings supports those functions, or if it goes into the general fund.
- Whether raising user fees is a feasible option to meet budget needs based on recent expenditure history.

2.2.2 Monitoring

The collection system owner or operator may be responsible for fulfilling some water quality or other monitoring requirements. Responsibilities may include:

- Monitoring discharges into the collection system from industrial users
- Monitoring to determine the effects of SSOs on receiving waters
- Monitoring required as part of an NPDES permit, a 308 letter, administrative order, or consent decree

The owner or operator should maintain written procedures to ensure that sampling is carried out in a safe, effective, and consistent manner. The procedures should specify, at a minimum the following:

- Sampling location(s)
- Sample volumes, preservatives, and holding times
- Instructions for the operation of any automatic sampling and/or field monitoring (e.g., pH or dissolved oxygen) equipment
- Sampling frequency
- Sampling and analytical methodologies
- Laboratory QA/QC

Records should be maintained of sampling events. These records should at a minimum include the following:

- Date, time, and location of sampling
- Sample parameters
- Date shipped or delivered to the laboratory

2.2.3 Hydrogen Sulfide Monitoring and Control

The collection system owner or operator should have a program under which they monitor areas of the collection system which may be vulnerable to the adverse effects of hydrogen sulfide. It may be possible to perform visual inspections of these areas. The records should note such items as the condition of metal components, the presence of exposed rebar (metal reinforcement in concrete), copper sulfate coating on copper pipes and electrical components, and loss of concrete from the pipe crown or walls.

Areas Subject to Generation of Hydrogen Sulfide:

- Sewers with low velocity conditions and/or long detention times
- Sewers subject to solids deposition
- Pump stations
- Turbulent areas, such as drop manholes or force main discharge points
- Inverted siphon discharges

As mentioned in Section 2.4.2, the collection system owner or operator should be carrying out routine manhole inspections. The hydrogen sulfide readings generated as a result of these inspections should be added to the records of potential areas of corrosion. A quick check of the pH of the pipe crown or structure enables early indication of potential hydrogen sulfide corrosion. A pH of less than four indicates further investigation is warranted. "Coupons" may be installed in structures or pipelines believed to be potentially subject to corrosion. Coupons are small pieces of steel inserted into the area and measured periodically to determine whether corrosion is occurring.

Reviewer - Point to Note
The reviewer should be aware that a system in which infiltration and inflow (I/I) has successfully been reduced may actually face an increased risk of corrosion. The reviewer should pay particular attention to the hydrogen sulfide monitoring program in these systems.

The reduction of flow through the pipes allows room for hydrogen sulfide gases to rise into the airway portion of the sewer pipe and react with the bacteria and moisture on the pipe walls to form sulfuric acid. Sulfuric acid corrodes ferrous metals and concrete.

There are several methods to prevent or control hydrogen sulfide corrosion. The first is proper design. Design considerations are beyond the scope of this manual but may be found in the *Design Manual: Odor and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants* (EPA 1985). The level of dissolved sulfide in the wastewater may also be reduced by chemical or physical means such as aeration, or the addition of chlorine, hydrogen peroxide, potassium permanganate, iron salts, or sodium hydroxide. Whenever chemical control agents are used, the owner or operator should have procedures for their application and maintain records of the dosages of the various chemicals. Alternatively, sewer cleaning to remove deposited solids reduces hydrogen sulfide generation. Also, air relief valves may be installed at the high points of the force main system. The valve allows air to exit thus avoiding air space at the crown of the pipe where acid can form. The reviewer should examine the records to see that these valves are receiving periodic maintenance.

Collection systems vary widely in their vulnerability to hydrogen sulfide corrosion. Vitrified clay and plastic pipes are very resistant to hydrogen sulfide corrosion while concrete, steel, and iron pipes are more susceptible. The physical aspects of the collection system are also important. Sewage in pipes on a decline that moves the wastewater at a higher velocity will have less hydrogen sulfide than sewage in pipes where the wastewater may experience longer detention times. Therefore, some systems may need a more comprehensive corrosion control program while some might limit observations to vulnerable points.

2.2.4 Safety

The reasons for development of a safety program should be obvious for any collection system owner or operator. The purpose of the program is to define the principles under which the work is to be accomplished, to make the employees aware of safe working procedures, and to establish and enforce specific regulations and procedures. The program should be in writing (e.g., procedures, policies, and training courses) and training should be well documented.

> **Point to Note**
> Although a safety program may not be explicitly required under current NPDES regulations, an excessive injury rate among personnel increases the likelihood of collection system noncompliance with other requirements. Furthermore, when good safety practices are not followed, there may be a risk to the public or to collection system workers.

The purpose of safety training is to stress the importance of safety to employees. Safety training can be accomplished through the use of manuals, meetings, posters, and a safety suggestion program. One of the most common reasons for injury and fatalities in wastewater collection systems is the failure of victims to recognize hazards. Safety training cuts across all job descriptions and should emphasize the need to recognize and address hazardous situations. Safety programs should be in place for the following areas:

- Confined spaces
- Chemical handling
- Trenching and excavations
- Material Safety Data Sheets (MSDS)
- Biological hazards in wastewater
- Traffic control and work site safety
- Lockout/Tagout
- Electrical and mechanical safety
- Pneumatic or hydraulic systems safety

The collection system owner or operator should have written procedures which address all of the above issues and are made available to employees. In addition to training, safety programs should incorporate procedures to enforce the program. For example, this could include periodic tests or "pop" quizzes to monitor performance and/or compliance and follow-up on safety related incidents.

Reviewer - Point to Note
The reviewer should, in the course of interviewing personnel, determine their familiarity with health and safety procedures according to their job description.

The owner or operator should maintain all of the safety equipment necessary for system staff to perform their daily activities and also undertake any emergency repairs. This equipment should include, at minimum:

- Atmospheric gas testing equipment
- Respirators and/or self-contained breathing apparatus
- Full body harness
- Tripods or non-entry rescue equipment
- Hard hats
- Safety glasses
- Rubber boots
- Rubber and/or disposable gloves
- Antibacterial soap
- First aid kit
- Protective clothing
- Confined space ventilation equipment
- Traffic and/or public access control equipment
- Hazardous gas meter

Each field crew vehicle should have adequate health and safety supplies. If the reviewer has access to the municipal vehicle storage area, he or she might choose to check actual vehicle stocks, not just supplies in storage.

2.2.5 Emergency Preparedness and Response

The collection system owner or operator should have a comprehensive plan in place for dealing with both routine and catastrophic emergencies. Routine emergencies include situations such as overflowing manholes, line breaks, localized electrical failure, and power outages at pump stations. Catastrophic emergencies include floods, tornados, earthquakes, other natural events, serious chemical spills, or widespread electrical

SSOs can include overflows out of manholes onto city streets, sidewalks, and surrounding areas (photo: U.S. EPA).

failure. Ideally, this plan is written, reviewed, and adjusted as needed at periodic intervals.

The reviewer should determine if the emergency response plan generally follows the guidelines described below. The location where the plan is housed may vary but, in general, such a document should be available in the yard office or other building commonly accessible to and frequented by collection system personnel. The emergency preparedness and response procedures may be contained in the collection system's O&M manual, or may be reflected in the descriptions of equipment and unit operations. Putting emergency procedures in a stand-alone document, rather than combining it with other information in the O&M manual, makes it easier for collection system personnel to find information.

The plan should utilize the most current information on the collection system. For larger systems, a structured analysis, or *risk assessment*, should be made of the collection system, treatment plant, and the community. The risk assessment should identify areas where the collection system is vulnerable to failure and determine the effect and relative severity to collection systems operations, equipment and public safety, and health of such a failure. The risk assessment should concentrate on such factors as topography, weather, sewer system size, and other site-specific factors which reflect the unique characteristics of the system. Once the areas of vulnerability are known, the collection system owner or operator should have appropriate plans in place to ensure collection system operations continue for the duration of the emergency.

The plans must clearly identify the steps staff should take in the event of emergency situations. Plans should include information on when it is appropriate to initiate and cease emergency operations. The plans should be very specific as to the collection system or repair equipment involved. Instructions should be available which explain how to operate equipment or systems during an emergency event when they are not functioning as intended but are not fully inoperable. The plan should also include specific procedures for reporting events that result in an overflow or other noncompliance event to the appropriate authorities.

The owner or operator should track emergency situations to become better prepared for future emergencies and to assist with reporting and maintaining compliance with emergency-related requirements. Typical components of an emergency program may include:

- General information regarding emergencies, such as telephone numbers of collection system personnel, fire department, and ambulance.
- Identification of hazards (e.g., chlorine storage areas) and use of universal classification system for hazards: combustible material, flammable liquids, energized electrical circuits, and hazardous materials.
- Vulnerability analysis that identifies the various types of emergencies that could occur, such as natural disasters, power outages, or equipment failures.
- Emergency response procedures.
- Methods to reduce risk of emergencies.
- Responsibilities of staff and management.

- Continuous training.

Procedures for emergency response plans should be understood and practiced by all personnel in order to ensure safety of the public and the collection system personnel responding. Procedures should be specific to the type of emergency that could occur. It is important to keep detailed records of all past emergencies in order to constantly improve response training, as well as the method and timing of future responses. The ability to deal with emergencies depends on the knowledge and skill of the responding crews, in addition to availability of equipment. The crew should be able to rapidly diagnose problems in the field under stress and select the right equipment needed to correct the problem. If resources are limited, consideration should be given to contracting other departments or private industries to respond to some emergency situations, for example, those rare emergencies that would exceed the capacity of staff.

2.2.6 Modeling

Computer programs (modeling programs) are available that are capable of simulating the different flows within the collection system. The purpose of modeling is to determine system capacity requirements with respect to sewer design and structural conditions. Therefore the input of accurate data on sizes, location, elevation, and condition of sewer system components such as pipes, manholes, and pump stations is necessary. When possible, flow monitoring data should be used to calibrate the model.

Reviewer - Point to Note
The reviewer should determine whether a model used by the owner or operator:

- Has user support
- Has adequate documentation such as a user's manual that describes data input requirements, output to be expected, model capabilities and limitations, and hardware

Modeling is also useful in examining effects before and after rehabilitation. For example, models can be applied to "before" and "after" scenarios to estimate the effects of repairs. If a collection system is not experiencing any capacity related issues (i.e., overflows, bypasses, basement backups, street flooding, hydraulic overload at the treatment plant, etc.) then maintenance of a model may be optional for that system, although most medium and large systems should maintain a model of the larger diameter portion of their system. If any of the mentioned conditions are occurring then development and maintenance of a model is essential to performing a capacity assessment in the problem areas.

Computer modeling is a specialized and complex subject. The reviewer may not have a comprehensive knowledge of modeling. If this is the case the he or she should obtain the following basic information:

- Is the owner or operator using a model?
- What areas of the collection system are being modeled and why?
- What model (including the version) is being used? Who developed the model and when?

- How are the modeling results being used?

2.2.7 Mapping

The importance of maintaining accurate, current maps of the collection system cannot be overstated. Efficient collection system maintenance and repairs are unlikely if mapping is not adequate. Collection system maps should clearly indicate the information that personnel need to carry out their assignments. The collection system maps should contain information on the following:

- Main, trunk and interceptor sewers
- Building/house laterals
- Manholes
- Cleanouts
- Force mains
- Pump stations
- Service area boundaries
- Other landmarks (roads, water bodies, etc.)

Collection system maps should have a numbering system which uniquely identifies all manholes and sewer cleanouts. The system should be simple and easy to understand. Manholes and sewer cleanouts should have permanently assigned numbers and never be renumbered. Maps should also indicate the property served and reference its cleanout.

Sewer line maps should indicate the diameter, the length between the centers of manholes, and the slope or direction of flow. The dimensions of easements and property lines should be included on the maps. Other information that should be included on maps are access and overflow points, a scale, and a north arrow. All maps should have the date the map was drafted and the date of the last revision. Although optional, maps often include materials of pipe construction. Maps may come in different sizes and scales to be used for different purposes. Detailed local maps may be used by maintenance or repair crews to perform the duties. However, these detailed local maps should be keyed to one overall map that shows the entire system.

Key Design Characteristics

- Line locations, grades, depths, and capacities
- Maximum manhole spacing and size
- Minimum pipe size
- Pumping Station dimensions and capacities
- Drop manholes
- Flow velocities and calculations (peak flow and low-flow)
- Accessibility features
- Other technical specifications (e.g., materials, equipment)

Geographic Information System (GIS) technology have made the mapping and map updating process considerably more efficient. GIS is a computerized mapping program capable of combining mapping with detailed information about the physical structures within the collection system. If a GIS program is being used by the owner or operator, the reviewer should ask if the program is capable of accepting information from the owner or operator's management program.

Specific procedures should be established for correction of errors and updating maps and drawings. Field personnel should be properly trained to recognize discrepancies between field conditions and map data and record changes necessary to correct the existing mapping system. Reviewers should check to see that maps and plans are available to the personnel in the office and to field personnel or contractors involved in all engineering endeavors.

2.2.8 New Construction

The owner or operator should maintain strict control over the introduction of flows into the system from new construction. New construction may be public (i.e., an expansion of the collection system) or private (i.e., a developer constructing sewers for a new development). Quality sanitary sewer designs keep costs and problems associated with operations, maintenance, and construction to a minimum. Design flaws are difficult to correct once construction is complete. The reviewer should be aware that this has historically not been adequately addressed in some collection systems. The owner or operator should have standards for new construction, procedures for reviewing designs and protocols for inspection, start-up, testing, and approval of new construction. The procedures should provide documentation of all activities, especially inspection. Reviewers should examine construction inspection records and be able to answer the following:

- Does the volume of records seem reasonable given system size?
- Do records reflect that the public works inspectors are complying with procedures?

The state or other regulatory authority may also maintain standards for new construction. The standards held by the owner or operator should be at least as stringent. Start-up and testing should be in accordance with the manufacturers' recommendation where applicable and with recognized industry practices. Each step of the review, start-up, testing, and approval procedures should be documented.

The owner or operator approval procedure should reflect future ease of maintenance concerns. After construction is complete, a procedure for construction testing and inspection should be used. Construction supervision should be provided by qualified personnel such as a registered professional engineer.

2.2.9 Pump Stations

Proper operation, maintenance, and repair of pump stations typically requires special electrical, hydraulic, and mechanical knowledge. Pump station failure may damage equipment, the environment, or endanger public health. Variation in equipment types, pump station configuration, and geographical factors determine pump station design and O&M requirements.

The reviewer should verify that the O&M manual contains procedures in writing for the following:

- Are pumps rotated manually or automatically? If manually, how frequently?
- Are wet well operating levels set to limit pump starts and stops?
- Is there a procedure for manipulating pump operations (manually or automatically) during wet weather to increase in-line storage of wet weather flows?
- Is flow monitoring provided? How is the data collected used?
- Does the pump station have capacity-related overflows? Maintenance related overflows? Is overflow monitoring provided?
- Is there a history of power outages? Is there a source of emergency power? If the emergency power source is a generator, is it regularly exercised under load?

2.3 Equipment and Collection System Maintenance

Every collection system owner or operator should have a well-planned, systematic, and comprehensive maintenance program. The goals of a maintenance program should include:

- Prevention of overflows
- Maximization of service and system reliability at minimum cost
- Assurance of infrastructure sustainability (i.e., ensure all components reach their service life)

There should then be procedures which describe the maintenance approach for various systems. In addition, there should be detailed instructions for the maintenance and repair of individual facilities. These instructions should provide a level of detail such that any qualified collection system personnel or repair technician could perform the repair or maintenance activity.

Maintenance may be planned or unplanned. There are essentially two types of planned maintenance; predictive and preventive. Predictive maintenance is a method that tries to look for early warning signs of equipment failure such that emergency maintenance is avoided. Preventive maintenance consists of scheduled maintenance activities performed on a regular basis. There are two types of unplanned maintenance, corrective and emergency. Corrective maintenance consists of scheduled repairs to problems identified under planned or predictive maintenance. Emergency maintenance are activities (typically repairs) performed in response to a serious equipment or line failure where action must be taken immediately. The goal of every owner or operator should be to reduce corrective and emergency maintenance through the use of planned and predictive maintenance. The reviewer should evaluate the progress of the owner or operator in achieving that goal. The goals of the reviewer in assessment of the maintenance program are:

- Identify SSOs caused by inadequate maintenance
- Determine maintenance trends (i.e., frequent emergency maintenance performed as opposed to predictive maintenance)
- Identify sustainability issues (i.e., inadequate maintenance to allow system components to reach service life and/or many components nearing or at service life)

2.3.1 Maintenance Budgeting

The cost of a maintenance program is a significant part of the annual operating budget. The collection system owner or operator should track all maintenance costs incurred throughout the year, both by internal staff and contractors, to ensure that the budget is based on representative costs from past years. Budgets should be developed from past cost records which usually are categorized according to preventive maintenance, corrective maintenance, and projected and actual major repair requirements. Annual costs should be compared to the budget periodically to control maintenance expenditures.

The reviewer should evaluate the maintenance budget keeping in mind the system's characteristics, such as age. Costs for emergency repairs should be a relatively small percentage of the budget; five to ten percent would not be considered excessive. The establishment of an "emergency reserve" may also be included as part of the maintenance budget. This is especially useful where full replacement is not funded. The budget should also be considered in light of maintenance work order backlog. The labor budget should be evaluated for consistency with local pay rates and staffing needs and the reviewer should compare local pay rates and staffing needs according to the tables in Section 2.1.1.

2.3.2 Planned and Unplanned Maintenance

A planned maintenance program is a systematic approach to performing maintenance activities so that equipment failure is avoided. Planned maintenance is composed of predictive and preventive maintenance. In the end, a good planned maintenance program should reduce material and capital repair and replacement costs, improve personnel utilization and morale, reduce SSOs, and sustain public confidence.

Examples of predictive maintenance includes monitoring equipment for early warning signs of impending failure, such as excess vibration, heat, dirty oil, and leakage. Assessment and inspection activities can be classified as predictive maintenance. Vibration and lubrication analyses, thermography, and ultrasonics are among the more common predictive maintenance tools. Predictive maintenance also takes into account historical information about the system as all systems will deteriorate over time. A predictive maintenance program strives to identify potential problem areas and

Reviewer - Point to Note
The reviewer should inquire as to whether tools such as vibration and lubrication analysis, thermography, or ultrasonics are used, and obtain information on the extent of the programs.

uncover trends that could affect equipment performance. Predictive maintenance offers an early warning. It allows collection system personnel to detect early signs of increasing rates of wear and therefore failure, and thus shift a "corrective" task into a "planned" task. To be truly effective predictive, however, maintenance should not spur personnel into doing the work too soon and wasting useful life and value of the equipment in question.

The basis of a good predictive maintenance program is recordkeeping. Only with accurate recordkeeping can baseline conditions be established, problem areas identified, and a proactive approach taken to repairs and replacement.

Effective preventive maintenance minimizes system costs and environmental impacts by reducing breakdowns and thus the need for corrective or emergency maintenance, improves reliability by minimizing the time equipment is out of service, increases the useful life of equipment thus avoiding costly premature replacement, and avoids potential noncompliance situations. An effective preventive maintenance program includes:

- Trained personnel
- Scheduling based on system specific knowledge
- Detailed instructions related to the maintenance of various pieces of equipment
- A system for recordkeeping
- System knowledge in the form of maps, historical knowledge and records

An effective preventive maintenance program builds on the inspection activities and predictive maintenance described in Sections 2.4.1 to 2.4.4, and includes a well thought-out schedule for these activities.

> **Lubrication**
>
> Lubrication is probably one of the most important maintenance activities for mechanical systems, such as pumps and motors. Frequency of lubrication, choice of lubricant and lubrication procedure are all important factors in this activity. These items should closely follow manufacturer instructions, but may be modified to fit site-specific conditions and particular equipment applications.

The basis of the schedule for mechanical equipment maintenance (i.e., pump station components) should be the manufacturers' recommended activities and frequencies. This schedule may then be augmented by the knowledge and experience of collection system personnel to reflect the site-specific requirements. The schedule for sewer line cleaning, inspection, root removal, and repair activities should be based on periodic inspection data. In most systems, uniform frequencies for sewer line cleaning, inspection, and root removal are not necessary and inefficient. In many systems, a relatively small percentage of the pipe generates most of the problems. Efficient use of inspection data allows the owner or operator to implement a schedule in the most constructive manner. In rare cases it may be appropriate to reduce maintenance frequency for a particular piece of equipment. An example of a scheduling code and maintenance schedule for a pump is shown below:

Rotary Pump Maintenance Schedule	
Frequency	**Maintenance Required**
D	Check packing gland assembly
D	Check discharge pressure
S	Inspect and lubricate bearings
A	Flush bearings and replace lubricant

D = Daily A = Annually
S = Semiannually

Typically, there is a maintenance card or record for each piece of equipment within the collection system. These records should contain maintenance recommendations, schedule, and instructions on conducting the specific maintenance activity. The records should include documentation regarding any maintenance activities conducted to date and other observations related to that piece of equipment or system. Maintenance records are generally kept where maintenance personnel have easy access to them. The reviewer should examine the full series of periodic work orders (i.e. weekly, monthly, semiannually, and annually) for a selection of system components (e.g., a few pump stations, several line segments). The reviewer should then compare the recommended maintenance frequency to that which is actually performed. He or she should also look at the backlog of work; not focusing solely on the number of backlogged work orders, but on what that number represents in time. A very large system can have a hundred orders backlogged and only be one week behind. In a computerized system, a listing of all open work orders is usually very simple for collection system personnel to generate. The owner or operator should be able to explain their system for prioritizing work orders.

The reviewer needs to clearly understand the following:

- How the maintenance data management system works
- How work orders are generated and distributed
- How field crews use the work orders
- How data from the field is collected and returned
- How and on whose authority work orders are closed out

The reviewer should check to see if data entry is timely and up to date.

Unplanned maintenance is that which takes place in response to equipment breakdowns or emergencies. Unplanned maintenance may be corrective or emergency maintenance. Corrective maintenance could occur as a result of preventive or predictive maintenance activities which identified a problem situation. A work order should be issued so that the request for corrective maintenance is directed to the proper personnel. An example of non-emergency corrective maintenance could be a broken belt on a belt driven pump. The worn belt was not detected and replaced through preventive maintenance and therefore the pump is out of service until corrective maintenance can be performed. Although the pump station may function with one pump out of service, should another pump fail, the situation may become critical during peak flow periods.

If the information can be easily generated the reviewer should select a sampling of work orders and compare them to the corrective maintenance database to determine if repairs are being made in a timely manner. Reviewers should note the current backlog of corrective maintenance work orders. A corrective maintenance backlog of two weeks or less would indicate an owner or operator in control of corrective maintenance. The owner or operator should be able to explain corrective maintenance work orders that have not been completed within six months.

Corrective maintenance takes resources away from predictive and preventive maintenance. When corrective maintenance becomes a predominant activity, personnel may not be able to perform planned maintenance, thus leading to more corrective maintenance and emergency situations. Emergency maintenance occurs when a piece of equipment or system fails, creating a threat to public health, the environment, or associated equipment. This type of maintenance involves repairs, on short notice, of malfunctioning equipment or sewers. A broken force main, totally non-functional pump station, and street cave-ins are all examples of emergency situations.

Types of Portable Emergency Equipment

- Bypass pumps
- Portable generator
- Air compressor, trailer-mounted
- Manhole lifters and gas testing equipment
- Sewer rodder and/or flushing machine
- Portable lights and hand tools
- Chemical spray units (for insects and rodent control)
- Truck (1-ton) and trailers
- Vacuum truck
- Repair equipment for excavation (backhoe, shoring equipment, concrete mixers, gasoline operated saws, traffic control equipment, etc.)
- Confined space entry gear

Emergency crews should be geared to a 24-hour-a-day, year-round operation. Most large systems have staffed 24-hour crews; many small systems have an "on-call" system. The owner or operator should be able to produce written procedures which spell out the type of action to take in a particular type of emergency and the equipment and personnel requirements necessary to carry out the action. The crews should have copies of these procedures and be familiar with them. Equipment must be located in an easily accessible area and be ready to move in a short period of time. Vehicles and equipment must be ready to perform, under extreme climatic conditions if necessary. The emergency crew

Reviewer - Point to Note
The reviewer should note the presence of supplies during the review of the yard where equipment and spare parts are maintained and personnel are dispatched.

may need materials such as piping, pipe fittings, bedding materials and concrete. The owner or operator should have supplies on hand to allow for two point (i.e. segment, fitting, or appurtenance) repairs of any part of its system.

Pump stations should be subject to inspection and preventive maintenance on a regular schedule. The frequency of inspection may vary from once a week, for a reliable pump station equipped with a telemetry system, to continuous staffing at a large pump station. The basic inspection should include verification that alarm systems are operating properly, wet well levels are properly set, all indicator lights and voltage readings are within acceptable limits, suction and discharge pressures are within normal limits, that the pumps are running without excessive heat or vibration and have the required amount of lubrication, and that the emergency generator is ready if needed. Less frequent inspections may include such items as vibration analysis and internal inspection of pump components.

> **Owner or Operator - Point to Note**
> Occasionally a supervisor should perform an unscheduled inspection to confirm that tasks have been performed as expected.

Observations and tasks performed should be recorded in a log book or on a checklist at the pump station. It is important to note how this data returns to the central maintenance data management system. At the time of the inspection, collection system personnel may perform minor repairs if necessary. If non-emergency repairs are required that are beyond the staff's training, it will probably be necessary to prepare a work order which routs a request though the proper channels to initiate the repair action. During the review the reviewer should check a random number of work orders to see how they move through the system. The reviewer should note whether repairs are being carried out promptly. In pump stations, for critical equipment (pumps, drives, power equipment, and control equipment), there should not be much backlog, unless the staff is waiting for parts.

During the review, the reviewer should also make on-site observations of a representative pump stations. The reviewer should plan at least half an hour to look at the simplest two-pump prefabricated station, and one to two hours to look at a larger station. In large systems, drive time between stations may be significant. The reviewer should strive to see a range of pump station sizes and types (i.e., the largest, smallest, most remote and any that review of work orders has indicated might be problematic).

Overall, the pump station should be clean, in good structural condition and exhibit minimal odor. The reviewer should note the settings of the pumps (i.e., which are operating, which are on stand-by, and which are not operating and why). The operating pumps should be observed for noise, heat, and excessive vibration. The settings in the wet well should be noted (as indicated on the controls, as direct observation of the reviewer in the wet well is not recommended) and the presence of any flashing alarm lights. The reviewer is reminded of the atmospheric hazards in a pump station (make sure ventilation has been running prior to arrival) and to avoid confined space entry. If the pump station has an overflow its outlet should be observed, if possible, for signs of any recent overflows such as floatable materials or toilet paper. The reviewer should check the log book and/or checklist kept at the pump station to ensure that records are current and all maintenance activities have been performed. Below is a listing of items that indicate inadequate maintenance:

- Overall poor housekeeping and cleanliness
- Excessive grease accumulation in wet well
- Excessive corrosion on railings, ladders, and other metal components
- Sagging, worn, improperly sized, or inadequate belts
- Excessive equipment out of service for repair or any equipment for which repair has not been ordered (i.e., a work order issued)
- Pumps running with excessive heat, vibration, or noise
- Peeling paint and/or dirty equipment (the care given to equipment's outer surfaces often, but not always, mirrors internal condition)
- Check valves not closing when pumps shut off
- Inoperative instrumentation, alarms, and recording equipment
- "Jury-rigged" repairs (i.e., "temporary" repairs using inappropriate materials)
- Leakage from pumps, piping, or valves (some types of pump seals are designed to "leak" seal water)
- Inadequate lighting or ineffective/inoperative ventilation equipment

2.3.3 Sewer Cleaning

The purpose of sewer cleaning is to remove accumulated material from the sewer. Cleaning helps to prevent blockages and is also used to prepare the sewer for inspections. Stoppages in gravity sewers are usually caused by a structural defect, poor design, poor construction, an accumulation of material in the pipe (especially grease), or root intrusion. Protruding traps (lateral sewer connections incorrectly installed so that they protrude into the main sewer) may catch debris which then causes a further buildup of solids that eventually block the sewer. If the flow is less than approximately 1.0 to 1.4 feet per second, grit and solids can accumulate leading to a potential blockage.

Results of Various Flow Velocities

Velocity	Result
2.0 ft/sec	Very little material buildup in pipe
1.4-2.0 ft/sec	Heavier grit (sand and gravel) begin to accumulate
1.0-1.4 ft/sec	Inorganic grit and solids accumulate
Below 1.0 ft/sec	Significant amounts of organic and inorganic solids accumulate

(EPA 1974)

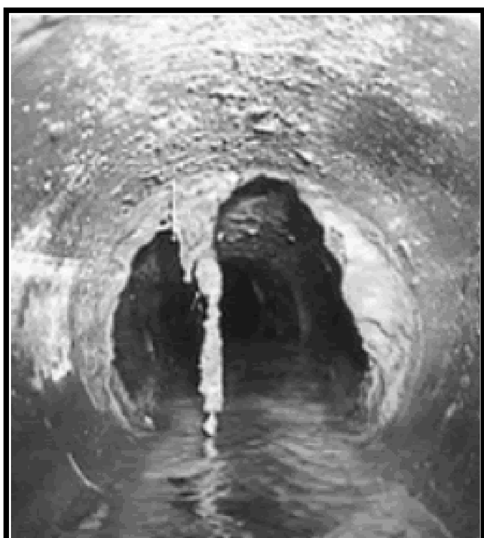
There are three major methods of sewer cleaning: hydraulic, mechanical, and chemical.

Hydraulic cleaning (also referred to as flushing) refers to any application of water to clean the pipe. Mechanical cleaning uses physical devices to scrape, cut, or pull material from the sewer. Chemical cleaning can facilitate the control of odors, grease buildup, root growth, corrosion, and insect and rodent infestation. For additional information on sewer cleaning methods refer to Volumes I and II of *Operation and Maintenance of Wastewater Collection Systems* (CSU Sacramento 1996 and 1998).

Sewer Cleaning Records

- Date, time, and location of stoppage or routine cleaning activity
- Method of cleaning used
- Cause of stoppage
- Identity of cleaning crew
- Further actions necessary and/or initiated
- Weather conditions

The backbone of an effective sewer cleaning program is accurate recordkeeping. Accurate recordkeeping provides the collection system owner or operator with information on the areas of the collection system susceptible to stoppages such that all portions of the system can be on an appropriate schedule. The reviewer should examine the records for legibility and completeness. He or she should then review the database to determine if entry of the field notes is current and accurate.



Root and grease buildup can cause blockages in a sewer system [photo: North Carolina Department of Natural Research (NCDNR)].

Sewers vary widely in their need for preventive cleaning. The collection system in a restaurant district may require cleaning every six months in order to prevent grease blockages. An area of the sewer system with new PVC piping and no significant grease contribution with reasonable and consistent slopes (i.e., no sags) may be able to go five years with no problems.

The owner or operator should be able to identify problem collection system areas, preferably on a map. Potential problem areas identified should include those due to grease or industrial discharges, hydraulic bottlenecks in the collection system, areas of poor design (e.g., insufficiently sloped sewers), areas prone to root intrusion, sags, and displacements. The connection between problem areas in the collection system and the preventive maintenance cleaning schedule should be clear. The owner or operator should also be able to identify the number of stoppages experienced per mile of sewer pipe. If the system is experiencing a steady increase in stoppages, the reviewer should try to determine the cause (i.e., lack of preventive maintenance funding, deterioration of the sewers due to age, an increase in grease producing activities, etc).

2.3.4 Parts and Equipment Inventory

An inventory of spare parts, equipment, and supplies should be maintained by the collection system owner or operator. The inventory should be based on equipment manufacturer's recommendations, supplemented by historical experience with maintenance and equipment problems. Without such an inventory, the collection system may experience long down times or periods of inefficient operation in the event of a breakdown or malfunction.

Files should be maintained on all pieces of equipment and major tools. The owner or operator should have a system to assure that each crew always has adequate tools. Tools should be subject to sign out procedures to provide accountability. Tools and equipment should be replaced at the end of their useful life. The reviewer should inquire as to how this is determined and how funds are made available to ensure this is the case. In addition, the reviewer should look at the tools and note their condition.

Basic Equipment Inventory

- Type, age, and description of the equipment
- Manufacturer
- Fuel type and other special requirements
- Operating costs and repair history

The owner or operator should maintain a yard where equipment, supplies, and spare parts are maintained and personnel are dispatched. Very large systems may maintain more than one yard. In this case, the reviewer should perform a visual survey at the main yard. In small to medium size systems, collection system operations may share the yard with the department of public works, water department, or other municipal agencies. In this case the reviewer should determine what percentage is being allotted for collection system items. The most important features of the yard are convenience and accessibility.

The reviewer should observe a random sampling of inspection and maintenance crew vehicles for equipment as described above. A review of the equipment and manufacturer's manuals aids in determining what spare parts should be maintained. The owner or operator should then consider the frequency of usage of the part, how critical the part is, and finally how difficult the part is to obtain when determining how many of the part to keep in stock. Spare parts should be kept in a clean, well-protected stock room. Critical parts are those which are essential to the operation of the collection system. Similar to equipment and tools management, a tracking system should be in place, including procedures on logging out materials, when maintenance personnel must use them. The owner or operator should be able to produce the spare parts inventory and clearly identify those parts deemed critical. The reviewer should evaluate the inventory and selected items in the stockroom to determine whether the specified number of these parts are being maintained.

Owner or Operator - Point to Note
The owner or operator should have a procedure for determining which spare parts are critical.

2.4 Sewer System Capacity Evaluation - Testing and Inspection

The collection system owner or operator should have a program in place to periodically evaluate the capacity of the sewer system in both wet and dry weather flows and ensure the capacity is maintained as it was designed. The capacity evaluation program builds upon ongoing activities and the everyday preventive maintenance that takes place in a system. The capacity evaluation begins with an inventory and characterization of the system components. The inventory should include the following basic information about the system:

- Population served
- Total system size (feet or miles)
- Inventory of pipe length, size, material and age, and interior and exterior condition as available
- Inventory of appurtenances such as bypasses, siphons, diversions, pump stations, tide or flood gates and manholes, etc., including size or capacity, material and age, and condition as available
- Force main locations, length, size and materials, and condition as available
- Pipe slopes and inverts
- Location of house laterals - both upper and lower

The system then undergoes general inspection (described below in Sections 2.4.1 to 2.4.4) which serves to continuously update and add to the inventory information.

The next step in the capacity evaluation is to identify the location of wet weather related SSOs, surcharged lines, basement backups, and any other areas of known capacity limitations. These areas warrant further investigation in the form of flow and rainfall monitoring and inspection procedures to identify and quantify the problem. The reviewer should determine that the capacity evaluation includes an estimate peak flows experienced in the system, an estimate of the capacity of key system components, and identifies the major sources of I/I that contribute to hydraulic overloading events. The capacity evaluation should also make use of a hydraulic model, if any, to identify areas with hydraulic limitations and evaluate alternatives to alleviate capacity limitations. Short and long term alternatives to address hydraulic deficiencies should be identified, prioritized, and scheduled for implementation.

A sewer inspection is an important part of a sewer system capacity evaluation (photo: N.J. Department of Environmental Protection).

2.4.1 Flow Monitoring

Fundamental information about the collection system is obtained by flow monitoring. Flow monitoring provides information on dry weather flows as well as areas of the collection system potentially affected by I/I. Flow measurement may also be performed for billing purposes, to assess the need for new sewers in a certain area, or to calibrate a model. There are three techniques commonly used for monitoring flow rates: (1) permanent and long-term, (2) temporary, and (3) instantaneous. Permanent installations are done at key points in the collection system such as the discharge point of a satellite collection system, pump stations, and key junctions. Temporary monitoring consists of flow meters typically installed for 30-90 days. Instantaneous flow metering is performed by collection system personnel, one reading is taken and then the measuring device is removed. The collection system owner or operator should have a flow monitoring plan that describes their flow monitoring strategy or should at least be able to provide the following information:

- Purpose of the flow monitoring
- Location of all flow meters
- Type of flow meters
- Flow meter inspection and calibration frequency

A flow monitoring plan should provide for routine inspection, service, and calibration checks (as opposed to actual calibration). In some cases, the data is calibrated rather than the flow meter. Checks should include taking independent water level (and ideally velocity readings), cleaning accumulated debris and silt from the flow meter area, downloading data (sometimes only once per month), and checking the desiccant and battery state. Records of each inspection should be maintained.

Flow measurements performed for the purpose of quantifying I/I are typically separated into three components: base flow, infiltration, and inflow. Base flow is generally taken to mean the wastewater generated without any I/I component. Infiltration is the seepage of groundwater into pipes or manholes through defects such as cracks, broken joints, etc. Inflow is the water which enters the sewer through direct connections such as roof leaders, direct connections from storm drains or yard, area, and foundation drains, the holes in and around the rim of manhole covers, etc. Many collection system owners or operators add a third classification: rainfall induced infiltration (RII). RII is stormwater that enters the collection system through defects that lie so close to the ground surface that they are easily reached. Although not from piped sources, RII tends to act more like inflow than infiltration.

In addition to the use of flow meters, which may be expensive for a small owner or operator, other methods of inspecting flows may be employed such as visually monitoring manholes during low-flow periods to determine areas with excessive I/I. For a very small system, this technique may be an effective and low-cost means of identifying problem areas in the system which require further investigation.

The owner or operator should have in place a program for the efficient identification of excessive I/I. The program should look at the wastewater treatment plant, pump stations, permanent meter flows, and rainfall data to characterize peaking factors for the whole system and major drainage basins. The reviewer should evaluate the program including procedures and records associated with the flow monitoring plan. Temporary meters should be used on a "roving" basis to identify areas with high wet weather flows. Areas with high wet weather flows should then be subject to inspection and rehabilitation activities.

2.4.2 Sewer System Testing

Sewer system testing techniques are often used to identify leaks which allow unwanted infiltration into the sewer system and determine the location of illicit connections and other sources of stormwater inflow. Two commonly implemented techniques include smoke testing and dyed water testing. Regardless of the program(s) implemented by the owner or operator, the reviewer should evaluate any procedures and records that have been established for these programs. The reviewer should also evaluate any public relations program and assess how the owner or operator communicates with the public during these tests (i.e., when there is a possibility of smoke entering a home or building).

Smoke testing is a relatively inexpensive and quick method of detecting sources of inflow in sewer systems, such as down spouts, or driveway and yard drains and works best suited for detecting cross connections and point source inflow leaks. Smoke testing is not typically used on a routine basis, but rather when evidence of excessive I/I already exists. With each end of the sewer of interest plugged, smoke is introduced into the test section, usually via a manhole. Sources of inflow can then be identified when smoke escapes through them.

Areas Usually Smoke Tested

- Drainage paths
- Ponding areas
- Roof leaders
- Cellars
- Yard and area drains
- Fountain drains
- Abandoned building sewers
- Faulty service connections

If the collection system owner or operator implements a regular program of smoke testing, the program should include a public notification procedure. The owner or operator should also have procedures to define:

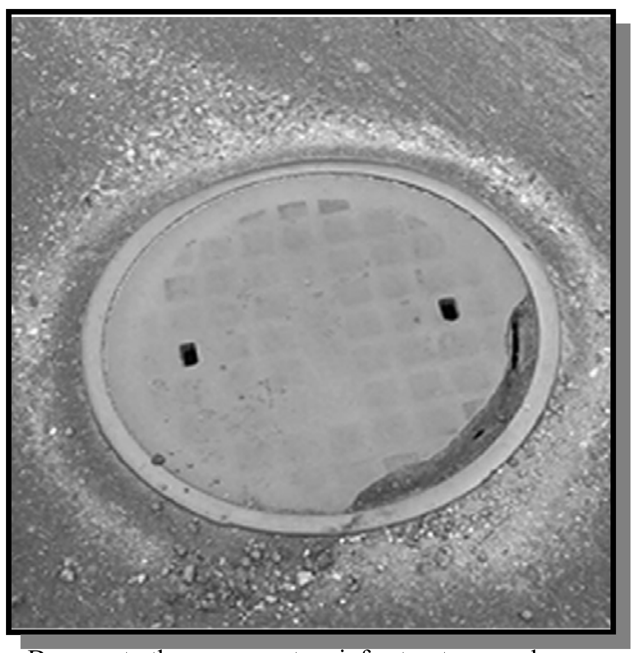
- How line segments are isolated
- The maximum amount of line to be smoked at one time
- The weather conditions in which smoke testing is conducted (i.e., no rain or snow, little wind and daylight only)

The results of positive smoke tests should be documented with carefully labeled photographs. Building inspections are sometimes conducted as part of a smoke testing program and, in some cases, may be the only way to find illegal connections. If properly connected to the sanitary sewer system, smoke should exit the vent stacks of the surrounding properties. If traces of the smoke or its odor enter the building, it is an indication that gases from the sewer system may also be entering. Building inspections can be labor intensive and require advanced preparation and communication with the public.

Dyed water testing may be used to establish the connection of a fixture or appurtenance to the sewer. It is often used to confirm smoke testing or to test fixtures that did not smoke. As is the case with smoke testing, it is not used on a routine basis but rather in areas that have displayed high wet weather flows. Dyed water testing can be used to identify structurally damaged manholes that might create potential I/I problems. This is accomplished by flooding the area close to the suspected manholes with dyed water and checking for entry of dyed water at the frame-chimney area, cone/corbel, and walls of the manhole.

2.4.3 Sewer System Inspection

Visual inspection of manholes and pipelines are the first line of defense in the identification of existing or potential problem areas. Visual inspections should take place on both a scheduled basis and as part of any preventive or corrective maintenance activity. Visual inspections provide additional information concerning the accuracy of system mapping, the presence and degree of I/I problems, and the physical state-of-repair of the system. By observing the manhole directly and the incoming and outgoing lines with a mirror, it is possible to determine structural condition, the presence of roots, condition of joints, depth of debris in the line, and depth of flow. The reviewer should examine the records of visual inspections to ensure that the following information is recorded:



Damage to the sewer system infrastructure, such as this broken manhole cover allows stormwater into the sewer system (photo: Limno-Tech, Inc.)

- Manhole identification number and location
- Cracks or breaks in the manhole or pipe (inspection sheets and/or logs should record details on defects)
- Accumulations of grease, debris, or grit
- Wastewater flow characteristics (e.g., flowing freely or backed up)
- Inflow
- Infiltration (presence of clear water in or flowing through the manhole)
- Presence of corrosion
- Offsets or misalignments
- Condition of the frame
- Evidence of surcharge
- Atmospheric hazard measurements (especially hydrogen sulfide)
- If repair is necessary, a notation as to whether a work order has been issued

Manholes should undergo routine inspection typically every one to five years. There should be a baseline for manhole inspections (e.g., once every two years) with problematic manholes being inspected more frequently. The reviewer should conduct visual observation at a small but representative number of manholes for the items listed above.

There are various pipeline inspection techniques, the most common include: lamping, camera inspection, sonar, and CCTV. These will be explained further in the following sections.

2.4.3.1 Sewer System Inspection Techniques

Sewer inspection is an important component of any maintenance program. There are a number of inspection techniques that may be employed to inspect a sewer system. The reviewer should determine if a inspection program includes frequency and schedule of inspections and procedures to record the results. Sewer system cleaning should always be considered before inspection is performed in order to provide adequate clearance and inspection results. Additionally, a reviewer should evaluate records maintained for inspection activities including if information is maintained on standardized logs and should include:

- Location and identification of line being inspected
- Pipe size and type
- Name of personnel performing inspection
- Distance inspected
- Cleanliness of the line
- Condition of the manhole with pipe defects identified by footage from the starting manhole
- Results of inspection, including estimates of I/I

Lamping involves lowering a still camera into a manhole. The camera is lined up with the centerline of the junction of the manhole frame and sewer. A picture is the taken down the pipe with a strobe-like flash. A disadvantage of this technique is that only the first 10-12 feet of the pipe can be inspected upstream and downstream of the access point. Additionally, it has limited use in small diameter sewers. The benefits of this technique include not requiring confined space entry and little equipment and set-up time is required.

Camera inspection is more comprehensive then lamping in that more of the sewer can be viewed. A still camera is mounted on a floatable raft and released into a pipe. The camera takes pictures with a strobe-like flash as it floats through the sewer pipe. This technique is often employed in larger lines where access points are far apart. Similarly to lamping, portions of the pipe may still be missed using this technique. Obviously, there also must be flow in the pipe for the raft to float. This technique also does not fully capture the invert of the pipe and its condition.

Sonar is a newer technology deployed similarly to CCTV cameras, described in more detail below. The sonar emits a pulse which bounces off the walls of the sewer. The time it takes for this pulse to bounce back provides data providing an image of the interior of the pipe including its structural condition. A benefit of this technique is that it can be used in flooded or inaccessible sections of the sewer. The drawback is that the technique requires heavy and expensive equipment.

Sewer scanner and evaluation is an experimental technology where a 360 degree scanner produces a full digital picture of the interior of the pipe. This technique is similar to sonar in that a more complete image of a pipe can be made than with CCTV, but not all types of sewer defects may be identified as readily (i.e., infiltration, corrosion).

Closed Circuit Television (CCTV) inspections are a helpful tool for early detection of potential problems. This technique involves a closed-circuit camera with a light which is self-propelled or pulled down the pipe. As it moves it records the interior of the pipe. CCTV inspections may be done on a routine basis as part of the preventive maintenance program as well as part of an investigation into the cause of I/I. CCTV, however, eliminates the hazards associated with confined space entry. The output is displayed on a monitor and videotaped. A benefit of CCTV inspection is that a permanent visual record is captured for subsequent reviews.

2.5 Sewer System Rehabilitation

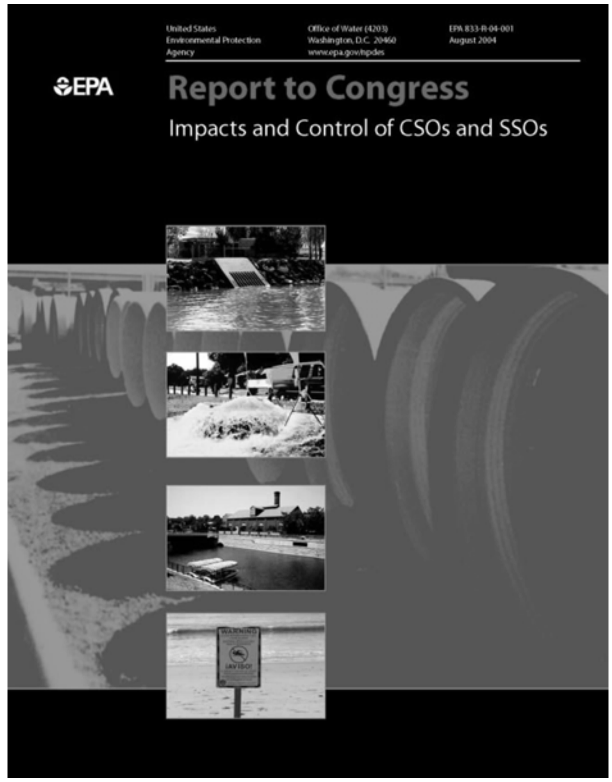
The collection system owner or operator should have a sewer rehabilitation program. The objective of sewer rehabilitation is to maintain the overall viability of a collection system. This is done in three ways: (1) ensuring its structural integrity; (2) limiting the loss of conveyance and wastewater treatment capacity due to excessive I/I; and (3) limiting the potential for groundwater contamination by controlling exfiltration from the pipe network. The rehabilitation program should build on information obtained as a result of all forms of maintenance and observations made as part of the capacity evaluation and asset inventory to assure the continued ability of the system to provide sales and service at the least cost. The reviewer should try to gain a sense of how rehabilitation is prioritorized. Priorities may be stated in the written program or may be determined through interviews with system personnel.

There are many rehabilitation methods. The choice of methods depends on pipe size, type, location, dimensional changes, sewer flow, material deposition, surface conditions, severity of I/I, and other physical factors. Non-structural repairs typically involve the sealing of leaking joints in otherwise sound pipe.

Structural repairs involve either the replacement of all or a portion of a sewer line, or the lining of the sewer. These repairs can be carried out by excavating usually for repairs limited to one or two pipe segments (these are known as point repairs) or by trenchless technologies (in which repair is carried out via existing manholes or a limited number of access excavations).

The rehabilitation program should identify the methods that have been used in the past, their success rating and methods to be used in the future. An reviewer who wants further guidance on methods of rehabilitation may consult:

- Technology Description from 2004 Report to Congress (EPA 2004)
- *Operation and Maintenance of Wastewater Collection Systems,* Volumes I and II (CSU Sacramento 1996 and 1998)
- *Existing Sewer Evaluation and Rehabilitation* (WEF 1994)



The reviewer should determine the owner's or operator's policies regarding service lateral rehabilitation since service laterals can constitute a serious source of I/I. Manholes should not be neglected in the rehabilitation program. Manhole covers can allow significant inflow to enter the system because they are often located in the path of surface runoff. Manholes themselves can also be a significant source of infiltration from cracks in the barrel of the manhole.

The owner or operator should be able to produce documentation on the location and methods used for sewer rehabilitation. The reviewer should compare the rehabilitation accomplished with that recommended by the capacity evaluation program. When examining the collection system rehabilitation program, the reviewer should be able to answer the following questions:

- Is rehabilitation taking place before it becomes emergency maintenance?
- Are recommendations made as a result of the previously described inspections?
- Does the rehabilitation program take into account the age and condition of the sewers?

CHAPTER 3. CHECKLIST FOR CONDUCTING EVALUATIONS OF WASTEWATER COLLECTION SYSTEM CAPACITY, MANAGEMENT, OPERATION, AND MAINTENANCE (CMOM) PROGRAMS

The following is a comprehensive checklist available for use in the review process. The checklist consists of a series of questions organized by major categories and sub-categories. The major category is followed by a brief statement describing the category. Following the sub-category is a brief clarifying statement. References are then given.

Questions are provided in a table format that includes the question, response, and documentation available.

Response is completed by using information and data acquired from the data and information request, onsite interviews, and site reviews. An alternative to this process is to transmit the entire checklist to the collection system owner or operator to complete and return electronically.

Table of Contents

I. General Information - Collection System Description

Question	Response	Documentation Available	
		Yes	No
Size of service area (acres).			
Population of service area.			
Number of pump stations.			
Feet (or miles) of sewer.			
Age of system (e.g., 30% over 30 years, 20% over 50 years, etc.).			

Comments:

II. Continuing Sewer Assessment Plan

Question	Response	Documentation Available	
		Yes	No
Does the collection system experience problems related to I/I? How do these problems manifest themselves? (Manhole overflows, basement flooding, structure, SSOs)			
How does the owner or operator prioritize investigation, repairs and rehabilitation related to I/I?			
What methods are considered to remedy hydraulic deficiencies?			
Does the plan include a schedule for investigative activities?			
Is the plan regularly updated?			

Comments:

III. A. Collection System Management: Organizational Structure

Question	Response	Documentation Available	
		Yes	No
Is an organizational chart available that shows the overall personnel structure for the collection system, including operation and maintenance staff?			
Are there organizational charts that show functional groups and classifications?			
Are up to date job descriptions available that delineate responsibilities and authority for each position?			
Are the following items discussed in the job descriptions: ☐ nature of work to be performed, ☐ minimum requirements for the position, ☐ necessary special qualifications or certifications, ☐ examples of the types of work, ☐ list of licences required for the position, ☐ performance measures or promotional potential?			
Does the organizational chart indicate how many positions are budgeted as opposed to actually filled?			
On average, how long do positions remain vacant?			
Are collection system staff responsible for any other duties, (e.g., road repair or maintenance, O&M of the storm water collection system)?			

Comments:

III. B. Collection System Management: Training

Question	Response	Documentation Available	
		Yes	No
Is there a documented formal training program?			
Does the training program address the fundamental mission, goals, and policies of the collection system owner or operator?			
Does the owner or operator provide training in the following areas: ☐ safety, ☐ routine line maintenance, ☐ confined space entry, ☐ traffic control, ☐ record keeping, ☐ electrical and instrumentation, ☐ pipe repair, ☐ bursting CIPP, ☐ public relations, ☐ SSO/emergency response, ☐ pump station operations and maintenance, ☐ CCTV and trench/shoring, ☐ other?			
Which of these programs have formal curriculums?			
Does On-the-Job (OJT) training use Standard Operating and Standard Maintenance Procedures (SOPs & SMPs)?			
Is OJT progress and performance measured?			
Does the owner or operator have mandatory training requirements identified for key employees?			
What percentage of employees met or exceeded their annual training goals during the past year?			
Which of the following methods are used to assess the effectiveness of the training: ☐ periodic testing, ☐ drills, ☐ demonstration, ☐ none?			
What percentage of the training offered by the owner or operator is in the form of the following: manufacturer training, on-the-job training, in-house classroom training, industry-wide training?			

Comments:

III. C. Collection System Management: Communication and Customer Service

Question	Response	Documentation Available	
		Yes	No
What type of public education/outreach programs does the owner or operator have about user rates?			
Do these programs include communication with groups such as local governments, community groups, the media, schools, youth organizations, senior citizens? List applicable groups.			
Is there a public relations program in place?			
Are the employees of the collection system trained in public relations?			
Are there sample correspondence or "scripts" to help guide staff through written or oral responses to customers?			
What methods are used to notify the public of major construction or maintenance work: ☐ door hangers, ☐ newspaper, ☐ fliers, ☐ signs, ☐ other, ☐ none?			
Is the homeowner notified prior to construction that his/her property may be affected?			
Is information provided to residents on cleanup procedures following basement backups and overflows from manholes when they occur?			
Which of the following methods are used to communicate with system staff: ☐ regular meetings, ☐ bulletin boards, ☐ e-mail, ☐ other?			
How often are staff meetings held (e.g., daily, weekly, monthly)?			
Are incentives offered to employees for performance improvements?			
Does the owner or operator have an "Employee of the Month/Quarter/Year" program?			

Question	Response	Documentation Available	
		Yes	No
How often are performance reviews conducted (e.g., semi-annually, annually, etc.)?			
Does the owner or operator regularly communicate with other municipal departments?			
Does the owner or operator have a formal procedure in place to evaluate and respond to complaints?			
What are the common complaints received?			
Does the owner or operator have a process for customer evaluation of the services provided?			
Do customer service records include the following information: ☐ personnel who received the complaint or request, ☐ nature of complaint or request, ☐ to whom the follow-up action was assigned, ☐ date of the complaint or request, ☐ date the complaint or request was resolved, ☐ customer contact information, ☐ location of the problem, ☐ date the follow-up action was assigned, ☐ cause of the problem, ☐ feedback to customer?			
Does the owner or operator have a goal for how quickly customer complaints (or emergency calls) are resolved?			
What percentage of customer complaints (or emergency calls) are resolved within the timeline goals?			
How are complaint records maintained? (i.e., computerized) Is this information used as the basis for other activities such as routine preventative maintenance?			

Comments:

III. D. Collection System Management: Management Information Systems

Question	Response	Documentation Available	
		Yes	No
What types of work reports are prepared by the O&M Staff?			
Do the work reports include enough information? (See example report forms)			
How are records kept?			
Are records maintained for a period of at least three years?			
Are the records able to distinguish activities taken in response to an overflow event?			
Does the owner or operator use computer technology for its management information system? (Computer Based Maintenance Management Systems, spreadsheets, data bases, SCADA, etc). If so, what type of system(s) is used?			
Are there written instructions for managing and tracking the following information: ☐ complaint work orders, ☐ scheduled work orders, ☐ customer service, ☐ scheduled preventative maintenance, ☐ scheduled inspections, ☐ sewer system inventory, ☐ safety incidents, ☐ scheduled monitoring/sampling, ☐ compliance/overflow tracking, ☐ equipment/tools tracking, ☐ parts inventory?			
Do the written instructions for tracking procedures include the following information: ☐ accessing data and information, ☐ instructions for using the tracking system, ☐ updating the MIS, ☐ developing and printing reports?			
How often is the management information system updated (immediately, within one week of the incident, monthly as time permits)?			

Comments:

III. E. Collection System Management: SSO Notification Program

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator have standard procedures for notifying state agencies, health agencies, the regulatory authority, and the drinking water purveyor of overflow events?			
Are above notification procedures dependent on the size or location of the overflow? If so, describe this procedure.			
Is there a Standard form for recording overflow events? Does it include location, type, receiving water, estimated volume, cause?			
Are chronic SSO locations posted?			

Comments:

III. F. Collection System Management: Legal Authority

Question	Response	Documentation Available	
		Yes	No
Does the collection system receive flow from satellite communities?			
What is the total area from satellite communities that contribute flow to the collection system (acres or square miles)?			
Does the owner or operator require satellite communities to enter into an agreement?			
Does the agreement include the requirements listed in the sewer use ordinance (SUO)?			
Do the agreements have a date of termination and allow for renewal under different terms?			
Does the owner or operator maintain the legal authority to control the maximum flow introduced into the collection system from satellite communities?			
Are standards, inspections, and approval for new connections clearly documented in a SUO?			
Does the SUO require satellite communities to adopt the same industrial and commercial regulator discharge limits as the owner or operator?			
Does the SUO require satellite communities to adopt the same inspection and sampling schedules as required by the pretreatment ordinance?			
Does the SUO require the satellite communities or the owner or operator to issue control permits for significant industrial users?			
Does the SUO contain provisions for addressing overstrength wastewater from satellite communities?			
Does the SUO contain procedures for the following: inspection standards, pretreatment requirements, building/sewer permit issues?			

Does the SUO contain general prohibitions of the following materials: ☐ fire and explosion hazards, ☐ oils or petroleum, ☐ corrosive materials, ☐ materials which may cause interference at the wastewater treatment plant, ☐ obstructive materials?			
Does the SUO contain procedures and enforcement actions for the following: ☐ fats, oils, and grease (FOG); ☐ I/I; building structures over the sewer lines; ☐ storm water connections to sanitary lines; ☐ defects in service laterals located on private property; ☐ sump pumps, air conditioner?			

Comments:

IV. A. Collection System Operation: Budgeting

Question	Response	Documentation Available	
		Yes	No
What are the owner or operator's current rates?			
What is the average annual fee for residential users?			
How are user rates calculated?			
How often are user charges evaluated and adjusted based on that evaluation?			
How many rate changes have there been in the last 10 years and what were they?			
Does the owner or operator receive sufficient funding from its revenues?			
Are collection system enterprise funds used for non-enterprise fund activities?			
Is there a budget for annual operating costs?			
Does the budget provide sufficient line item detail for labor, materials and equipment?			
Are costs for collection system O&M separated from other utility services, i.e., water, storm water and treatment plants?			
Do O&M managers have current O&M budget data?			
What is the collection system's average annual O&M budget?			
What percentage of the collection system's overall budget is allocated to maintenance of the collection system?			
Does the owner or operator have a Capital Improvement Plan (CIP) that provides for system repair/replacement on a prioritized basis?			
What is the collection system's average annual CIP budget?			

Question	Response	Documentation Available	
		Yes	No
What percentage of the maintenance budget is allotted to the following maintenance: Predictive maintenance (tracking design, life span, and scheduled parts replacement), preventative maintenance (identifying and fixing system weakness which, if left unaddressed, could lead to overflows), corrective maintenance (fixing system components that are functioning but not at 100% capacity/efficiency), emergency maintenance (reactive maintenance, overflows, equipment breakdowns).			
Does the owner or operator have a budgeted program for the replacement of under-capacity pipes?			
Does the owner or operator have a budgeted program for the replacement of over-capacity pipes?			
Are O&M staff involved in O&M budget preparation?			
How are priorities determined for budgeting for O&M during the budget process?			
Does the owner or operator maintain a fund for future equipment and infrastructure replacement?			
How is new work typically financed?			

Comments:

IV. B. Collection System Operation: Compliance

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator have inter-jurisdictional or inter-municipal agreements?	Already asked		
Is there a sewer-use and a grease ordinance?			
Is there a process in place for enforcing sewer and grease ordinances?			
Are all grease traps inspected regularly?			
How does the owner or operator learn of new or existing unknown grease traps?			
Who is responsible for enforcing the sewer ordinance and grease ordinance? Does this party communicate with the utility department on a regular basis?			
Are there any significant industrial dischargers to the system?			
Is there a pretreatment program in place? If so, please describe.			
Is there an ordinance dealing with private service laterals?			
Is there an ordinance dealing with storm water connections or requirements to remove storm water connections?			

Comments:

IV. C. Collection System Operation: Water Quality Monitoring

Question	Response	Documentation Available	
		Yes	No
Is there a water quality monitoring program in the service areas?			
If so, who performs the monitoring?			
How many locations are monitored?			
What parameters are monitored and how often?			
Is water quality monitored after an SSO event?			
Are there written standard sampling procedures available?			
Is analysis performed in-house or by a contract laboratory?			
Are chain-of-custody forms used?			

Comments:

IV. D. Collection System Operation: Hydrogen Sulfide Monitoring and Control

Question	Response	Documentation Available	
		Yes	No
Are odors a frequent source of complaints? How many?			
Are the locations of the frequent odor complaints documented?			
What is the typical sewer slope? Does the owner or operator take hydrogen sulfide corrosion into consideration when designing sewers?			
Does the collection system owner or operator have a hydrogen sulfide problem, and if so, does it have in place corrosion control programs? What are the major elements of the program?			
Does the owner or operator have written procedures for the application of chemical dosages?			
Are chemical dosages, dates, and locations documented?			
Does the owner or operator have a program in place for renewing or replacing severely corroded sewer lines to prevent collapse?			
Are the following methods used for hydrogen sulfide control: ☐ aeration, ☐ iron salts, ☐ enzymes, ☐ activated charcoal canisters, ☐ chlorine, ☐ sodium hydroxide, ☐ hydrogen peroxide, ☐ potassium permanganate, ☐ biofiltration, ☐ others?			
Does the system contain air relief valves at the high points of the force main system?			
How often are th valves maintained and inspected (weekly, monthly, etc.)?			
Does the owner or operator enforce pretreatment requirements?			

Comments:

IV. E. Collection System Operation: Safety

Question	Response	Documentation Available	
		Yes	No
Is there a documented safety program supported by the top administration official?			
Is there a Safety Department that provides training, equipment, and an evaluation of procedures?			
If not, who provides safety training?			
Does the owner or operator have written procedures for the following: ☐ lockout/tagout, ☐ MSDS, ☐ chemical handling, ☐ confined spaces permit program, ☐ trenching and excavations, ☐ biological hazards in wastewater, ☐ traffic control and work site safety, ☐ electrical and mechanical systems, ☐ pneumatic and hydraulic systems safety?			
What is the agency's lost-time injury rate(percent or in hours)?			
Is there a permit required confined space entry procedure for manholes, wetwells, etc.? Are confined spaces clearly marked?			
Are the following equipment items available and in adequate supply: ☐ rubber/disposable gloves; ☐ confined space ventilation equipment; ☐ hard hats, ☐ safety glasses, ☐ rubber boots; ☐ antibacterial soap and first aid kit; ☐ tripods or non-entry rescue equipment; ☐ fire extinguishers; ☐ equipment to enter manholes; ☐ portable crane/hoist; ☐ atmospheric testing equipment and gas detectors; ☐ oxygen sensors; ☐ H_2S monitors; ☐ full body harness; ☐ protective clothing; ☐ traffic/public access control equipment; ☐ 5-minute escape breathing devices; ☐ life preservers for lagoons; ☐ safety buoy at activated sludge plants; ☐ fiberglass or wooden ladders for electrical work; ☐ respirators and/or self-contained breathing apparatus; ☐ methane gas or OVA analyzer; ☐ LEL metering?			
Are safety monitors clearly identified?			
How often are safety procedures reviewed and revised?			

Question	Response	Documentation Available	
		Yes	No
Are workplace accidents investigated?			
How does the Administration communicate with field personnel on safety procedures; memo, direct communication, video, etc.?			
Is there a Safety Committee with participation by O&M staff? How often does it meet?			
Is there a formal Safety Training Program? Are records of training maintained?			

Comments:

IV. F. Collection System Operation: Emergency Preparedness and Response

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator have an emergency response plan? A contingency plan?			
How often is the plan reviewed and updated? What was the date it was last updated?			
Does the plan take into consideration vulnerable points in the system, severe natural events, failure of critical system components, vandalism or other third party events, and a root cause analysis protocol?			
Are staff trained and drilled to respond to emergency situations? Are responsibilities detailed for all personnel who respond to emergencies?			
Are there emergency operation procedures for equipment and processes?			
Does the owner or operator have standard procedures for notifying state agencies, local health departments, the regulatory authority, and drinking water authorities of significant overflow events?			
Does the procedure include an up-to-date list of the names, titles, phone numbers, and responsibilities of all personnel involved?			
Do work crews have immediate access to tools and equipment during emergencies?			
Is there a public notification plan? If so, does it cover both regular business hours and off-hours?			
Does the owner or operator have procedures to limit public access to and contact with areas affected with SSOs?			
Does the owner or operator use containment techniques to protect the storm drainage systems?			

Do the overflow records include the following information: ☐ date and time, ☐ cause(s), ☐ names of affected receiving water(s), ☐ location, ☐ how it was stopped, ☐ any remediation efforts, ☐ estimated flow/volume discharged, ☐ duration of overflow?			
Does the owner or operator have signage to keep public from affected area?			
Is there a hazard classification system? Where is it located?			
Does the owner or operator conduct vulnerability analyses?			
Are risk assessments performed? How often?			

Comments:

IV. G. Collection System Operation: Modeling

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator have a hydraulic model of the collection system including pump stations? What model is used?			
What uses does the model serve (predicting flow capacity, peak flows, force main pressures, etc.)?			
Does the model produce results consistent with observed conditions?			
Is the model kept up to date with respect to new construction and repairs that may affect hydraulic capacity?			

Comments:

IV. H. Collection System Operation: Engineering - System Mapping and As-built Plans (Record Drawings)

Question	Response	Documentation Available	
		Yes	No
What type of mapping/inventory system is used?			
Is the mapping tied to a GPS system?			
Are “as-built” plans (record drawings) or maps available for use by field crews in the office and in the field?			
Do field crews record changes or inaccuracies and is there a process in place to update “as built” plans (record drawings)?			
Do the maps show the date the map was drafted and the date of the last revision?			
Do the sewer line maps include the following: ☐ scale; ☐ north arrow; ☐ date the map was drafted; ☐ date of the last revision; ☐ service area boundaries; ☐ property lines; ☐ other landmarks; ☐ manhole and other access points; ☐ location of building laterals; ☐ street names; ☐ SSOs/CSOs; ☐ flow monitors; ☐ force mains; ☐ pump stations; ☐ lined sewers; ☐ main, trunk, and interceptor sewers; ☐ easement lines and dimensions; ☐ pipe material; ☐ pipe diameter; ☐ pipe diameter; ☐ installation date; ☐ slope; ☐ manhole rim elevation; ☐ manhole coordinates; ☐ manhole invert elevation; ☐ distance between manholes?			
Are the following sewer attributes recorded: ☐ size, ☐ shape, ☐ invert elevation, ☐ material, ☐ separate/combined sewer, ☐ installation date?			
Are the following manhole attributes recorded: ☐ shape, ☐ type, ☐ depth, ☐ age, ☐ material?			
Is there a systematic numbering and identification method/system established to identify sewer system manhole, sewer lines, and other items (pump stations, etc.)?			

Comments:

IV. I. Collection System Operation: Engineering - Design

Question	Response	Documentation Available	
		Yes	No
Is there a document which details design criteria and standard construction details?			
Is life cycle cost analysis performed as part of the design process?			
Is there a document that describes the procedures that the owner or operator follows in conducting design review? Are there any standard forms that are used as a guide?			
Are O&M staff involved in the design review process?			
Does the owner or operator have documentation on private service lateral design and inspection standards?			
Does the owner or operator attempt to standardize equipment and sewer system components?			

Comments:

IV. J. Collection System Operation: Engineering - Capacity

Question	Response	Documentation Available	
		Yes	No
What procedures are used in determining whether the capacity of existing gravity sewer system, pump stations and force mains are adequate for new connections?			
Is any metering of flow performed prior to allowing new connections?			
Is there a hydraulic model of the system used to predict the effects of new connections?			
Is there any certification as to the adequacy of the sewer system to carry additional flow from new connections required?			

Comments:

IV. K. Collection System Operation: Engineering - Construction

Question	Response	Documentation Available	
		Yes	No
Who constructs new sewers? If other than the owner or operator, does the owner or operator review and approve the design?			
Is there a document that describes the procedures that the owner or operator follows in conducting their construction inspection and testing program?			
Are there any standard forms that guide the owner or operator in conducting their construction inspection and testing program?			
Is new construction inspected by the owner or operator or others?			
What are the qualifications of the inspector(s)?			
What percentage of time is a construction inspector on site?			
Is inspection supervision provided by a registered professional engineer?			
How is the new gravity sewer construction tested? (Air, water, weirs, etc.)			
Are new manholes tested for inflow and infiltration?			
Are new gravity sewers televised?			
What tests are performed on pump stations?			
What tests are performed on force mains?			
Is new construction built to standard specifications established by the owner or operator and/or the State?			
Is there a warranty for new construction? If so, is there a warranty inspection done at the end of this period?			

Comments:

IV. L. Collection System Operation: Pump Station Operation

Question	Response	Documentation Available	
		Yes	No
How many pump stations are in the system? How many have backup power sources?			
Are enough trained personnel assigned to properly maintain pump stations?			
Are these personnel assigned full-time or part-time to pump station duties?			
Are there manned and un-manned pump stations in the system? How many of each?			
Is there a procedure for manipulating pump operations (manually or automatically during wet weather to increase in-line storage of wet weather flows?			
Are well-operating levels set to limit pump start/stops?			
Are the lead, lag, and backup pumps rotated regularly?			

Comments:

IV. L. 1. Collection System Operation: Pump Stations - Inspection

Question	Response	Documentation Available	
		Yes	No
How often are pump stations inspected?			
What work is accomplished during inspections?			
Is there a checklist?			
Are records maintained for each inspection?			
What are the average annual labor hours spent on pump station inspections?			
Are there Standard Operating Procedures (SOPs) and Standard Maintenance Procedures (SMPs) for each station?			
What are the critical operating characteristics maintained for each station? Are the stations maintained within these criteria?			

Comments:

IV. L. 2. Collection System Operation: Pump Stations - Emergencies

Question	Response	Documentation Available	
		Yes	No
Is there an Emergency Operating Procedure for each pump station?			
Is there sufficient redundancy of equipment in all pump stations?			
Who responds to lift station failures and overflows? How are they notified?			
How is loss of power at a station dealt with? (i.e. on-site electrical generators, alternate power source, portable electric generator(s))			
What equipment is available for pump station bypass?			
What process is used to investigate the cause of pump station failure and take necessary action to prevent future failures?			

Comments:

IV. L. 3. Collection System Operation: Pump Stations - Emergency Response and Monitoring

Question	Response	Documentation Available	
		Yes	No
How are lift stations monitored?			
If a SCADA system is used, what parameters are monitored?			

Comments:

IV. L. 4. Collection System Operation: Pump Stations - Recordkeeping

Question	Response	Documentation Available	
		Yes	No
Are operations logs maintained for all pump stations?			
Are manufacturer's specifications and equipment manuals available for all equipment?			
Are pump run times maintained for all pumps?			
Are elapsed time meters used to assess performance?			

Comments:

IV. L. 5. Collection System Operation: Pump Stations - Force Mains and Air/Vacuum Valves

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator regularly inspect the route of force mains?			
Does the owner or operator have a program to regularly assess force main condition?			
Is there a process in place to investigate the cause of force main failures?			
Does the owner or operator have a regular maintenance/inspection program for air/vacuum valves?			
Have force main failures been caused by water hammer?			

Comments:

V. A. Equipment and Collection System Maintenance: Maintenance Budgeting

Question	Response	Documentation Available	
		Yes	No
How does the collection system owner or operator track yearly maintenance costs?			
Is there a maintenance cost control system?			
Are maintenance costs developed from past cost records?			
How does the owner or operator categorize costs? Preventive? Corrective? Projected Costs? Projected Repair?			
How does the owner or operator control expenditures?			

Comments:

V. B. Equipment and Collection System Maintenance: Planned Maintenance

Question	Response	Documentation Available	
		Yes	No
Are preventive maintenance tasks and frequencies established for all pump stations and equipment?			
How were preventive maintenance frequencies established?			
What percentage of the operator's time is devoted to planned as opposed to unplanned maintenance?			
What predictive maintenance techniques are used as part of PM program?			
Is there a formal procedure to repair or replace pump stations and equipment when useful life is reached?			
Has an energy audit been performed on pump station electrical usage?			
Is an adequate parts inventory maintained for all equipment?			
Is there a sufficient number of trained personnel to properly maintain all stations?			
Who performs mechanical and electrical maintenance?			
Are there Standard Maintenance Procedures (SMPs) for each station?			

Comments:

V. C. Equipment and Collection System Maintenance: Maintenance Scheduling

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator plan and schedule preventive and corrective maintenance activities?			
Is there an established priority system? Who sets priorities for maintenance?			
Is a maintenance card or record kept for each piece of mechanical equipment within the collection system?			
Do equipment maintenance records include the following information: ☐ maintenance recommendations, ☐ instructions on conducting the specific maintenance activity, ☐ other observations on the equipment, ☐ maintenance schedule, ☐ a record of maintenance on the equipment to date.			
Are dated tags used to show out-of-service equipment?			
Is maintenance backlog tracked?			
How is O&M performance tracked and measured?			
What percent of repair finds are spent on emergency repairs?			
Are corrective repair work orders backlogged more than six months?			
Is maintenance performed for other public works divisions?			
How are priorities determined for this work?			
How is this work funded?			
Are maintenance logs maintained for all pump stations?			

Comments:

V. D. Equipment and Collection System Maintenance: Maintenance Right-of-Way

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator perform scheduled maintenance on Rights-of-Way and Easements?			
Does the owner or operator monitor street paving projects?			
Does the owner or operator have a program to locate and raise manholes (air valves, etc) as needed?			
How are priorities determined?			
How is the effectiveness of the maintenance schedule measured?			

Comments:

V. E. Equipment and Collection System Maintenance: Sewer Cleaning

Question	Response	Documentation Available	
		Yes	No
Is there a routine schedule for cleaning sewer lines on a system wide basis, *e.g.*, at the rate of once every seven to twelve years or a rate of between 8% and 14% per year?			
What is the owner or operator's goals for annual system cleaning?			
What percent of the sewer lines are cleaned, even high/repeat cleaning trouble spots, during the past year?			
Is there a program to identify sewer line segments that have chronic problems and should be cleaned on a more frequent schedule?			
What is the average number of stoppages experienced per mile of sewer pipe per year?			
Has the number of stoppages increased, decreased, or stayed the same over the past five years?			
Are stoppages diagnosed to determine the cause?			
Are stoppages plotted on maps and correlated with other data such as pipe size and material, or location?			
Do the sewer cleaning records include the following information: ☐ date and time, ☐ cause of stoppage, ☐ method of cleaning, location of stoppage or routine cleaning activity, ☐ identity of cleaning crew, ☐ further actions necessary/initiated?			
If sewer cleaning is done by a contractor are videos taken of before and after cleaning?			

Comments:

V. E. 1. Equipment and Collection System Maintenance: Sewer Cleaning - Cleaning Equipment

Question	Response	Documentation Available	
		Yes	No
What type of cleaning equipment does the owner or operator use?			
How many cleaning units of each type does the owner or operator have? What is the age of each?			
How many cleaning crews and shifts does the owner or operator employ?			
How many cleaning crews are dedicated to preventive maintenance cleaning?			
How many cleaning crews are dedicated to corrective maintenance cleaning?			
What has the owner or operator's experience been regarding pipe damage caused by mechanical equipment?			
Where is the equipment stationed?			

Comments:

V. E. 2. Equipment and Collection System Maintenance: Sewer Cleaning - Chemical Cleaning and Root Removal

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator have a root control program?			
Does the owner or operator have a FOG program?			
Are chemical cleaners used?			
What types of chemical cleaners are used?			
How often are they applied?			
How are the chemical cleaners applied?			
What results are achieved through the use of chemical cleaners?			

Comments:

V. F. Equipment and Collection System Maintenance: Parts Inventory

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator have a central location for the storage of spare parts?			
Have critical spare parts been identified?			
Are adequate supplies on hand to allow for two point repairs in any part if the system?			
Is there a parts standardization policy in place?			
Does the owner or operator maintain a stock of spare parts on its maintenance vehicles?			
What method(s) does the owner or operator employ to keep track of the location, usage, and ordering of spare parts? Are parts logged out when taken by maintenance personnel for use?			
Does the owner or operator salvage specific equipment parts when equipment is placed out-of-service and not replaced?			
How often does the owner or operator conduct a check of the inventory of parts to ensure that their tracking system is working?			
Who has the responsibility of tracking the inventory?			
For those parts which are not kept in inventory, does the owner or operator have a readily available source or supplier?			

Comments:

V. G. Equipment and Collection System Maintenance: Equipment and Tools Management

Question	Response	Documentation Available	
		Yes	No
Is there a list of equipment and tools used for operation and maintenance?			
Do personnel feel they have access to the necessary equipment and tools to do all aspects of operation and maintenance of the collection system?			
Is there access to suitable equipment if the owner or operator's equipment is down for repair?			
Does the owner or operator own or have access to portable generators?			
Where does the owner or operator store its equipment?			
Is a detailed equipment maintenance log kept?			
Are written equipment maintenance procedures available?			
What is the procedure for equipment replacement?			
Are the services of an in-house vehicle and equipment maintenance services used?			
What is the typical turnaround time for equipment and vehicle maintenance?			

Comments:

VI. Management Information Systems: Performance Indicators

Question	Response	Documentation Available	
		Yes	No
How many sanitary sewer overflows (SSOs) have occurred in the last 5 years? How many less than 1,000 gallons?			
Does the owner or operator document and report all SSOs regardless of size?			
Does the owner or operator document basement backups?			
Are there areas that experience basement or street flooding?			
How many SSOs have reached "Waters of the US"? Is there a record?			
Approximately, what percent of SSOs discharge were from each of the following in the last 5 years: manholes, pump stations, main and trunk sewers, lateral and branch sewers, structural bypasses?			
What is the per capita wastewater flow for the maximum month and maximum week or day?			
What is average annual influent BOD?			
What is the ratio of maximum wet weather flow to average dry weather flow?			
Approximately, what percent of SSO discharge were caused by the following in the last 5 years: debris buildup, collapsed pipe, root intrusion, capacity limitations, excessive infiltration and inflow, FOG, vandalism?			
What percent of SSOs were released to: soil; surface water; basements; paved areas; coastal, ocean, or beach areas; rivers, lakes or streams?			
For surface water releases, what percent are to surface waters that could affect: contact recreation, shellfish growing areas, drinking water sources?			
How many chronic SSO locations are in the collection system?			

Are pipes with chronic SSOs being monitored for sufficient capacity and/or structural condition?			
Prior to collapse, are structurally deteriorating pipelines being monitored for renewal or replacement?			
What is the annual number of mainline sewer cave-ins? What was the cause (i.e. pipe corrosion, leaks, etc.)			
What other types of performance indicators does the owner or operator use?			

Comments:

VII. A. Sewer System Capacity Evaluation (SSES): Internal TV Inspection

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator use internal T.V. inspection? If so please describe the program.			
Do the internal TV record logs include the following: ☐ pipe size, type, length, and joint spacing; ☐ distance recorded by internal TV; ☐ results of the internal TV inspection; ☐ internal TV operator name; ☐ cleanliness of the line; ☐ location and identification of line being televised by manholes?			
Is a rating system used to determine the severity of the defects found during the inspection process?			
Is there documentation explaining the codes used for internal TV results reporting?			
Approximately what percent of the total defects determined by TV inspection during the past 5 years were the following:			
Are main line and lateral repairs checked by internal TV inspection after the repair(s) have been made?			

Comments:

VII. B. SSES: Survey and Rehabilitation (general)

Question	Response	Documentation Available	
		Yes	No
Have SSES's been performed in the past? If so, is documentation available?			
Has any sewer rehabilitation work been done in the past 15 years? If so, please describe?			
Does the owner or operator have standard procedures for performing SSES work?			
Do the SSES reports include recommendations for rehabilitation, replacement, and repair?			
Were defects identified in the SSES repaired?			
Does the owner or operator have a multi-year Capital Improvements Program that includes rehabilitation, replacement, and repair?			
How are priorities established for rehabilitation, replacement, and repair?			
Has the owner or operator established schedules for performing recommended rehabilitation, both short term and long term?			
Has funding been approved for the recommended rehabilitation?			
Is post rehabilitation flow monitoring used to assess the success of the rehabilitation?			

Comments:

VII. C. SSES: Sewer Cleaning Related to I/I Reduction

Question	Response	Documentation Available	
		Yes	No
Are sewers cleaned prior to flow monitoring?			
Are sewers cleaned prior to internal T.V. inspection?			
When cleaning, is debris removed from the system?			

Comments:

VII. D. SSES: Flow Monitoring

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator have a flow monitoring program? If so, please describe.			
Does the owner or operator have a comprehensive capacity assessment and planning program?			
Are flows measured prior to allowing new connections?			
Number of permanent meters? Number of temporary meters?			
What type(s) of meters are used?			
Number of rain gauges?			
How frequently are flow meters checked?			
Do the flow meter checks include: ☐ independent water level, ☐ checking the desiccant, ☐ velocity reading, ☐ cleaning away debris, ☐ downloading data, ☐ battery condition?			
Are records maintained for each inspection?			
Do the flow monitoring records include: ☐ descriptive location of flow meter, ☐ type of flow meter, ☐ frequency of flow meter inspection, ☐ frequency of flow meter calibration?			
Are flow data used for billing, capacity analysis, and/or I/I investigations?			
What is the ratio of peak wet weather flow to average dry weather flow at the wastewater treatment plant?			
Does the owner or operator have any wet weather capacity problems?			
Are low points or flood-plain areas monitored during rain events?			
Does the owner or operator have any dry weather capacity problems?			

VII. E. SSES: Smoke Testing and Dyed Water Flooding

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator have a smoke testing program to identify sources of inflow and infiltration into the system including private service laterals and illegal connections? If so please describe.			
Are there written procedures for the frequency and schedule of smoke testing?			
Is there a documented procedure for isolating line segments?			
Is there a documented procedure for notifying local residents that smoke testing will be conducted in the area?			
What is the guideline for the maximum amount of line to be tested at one time?			
Are there guidelines for the weather conditions under which smoke testing should be conducted?			
Do the written records contain location, address, and description of the smoking element that produced a positive result?			
What follow-up occurs as a result of positive results for smoke or dye testing?			
Is there a goal for the percent of the system smoke tested each year?			
What percent of the system has been smoke tested over the past year?			
Does the owner or operator have a dyed water flooding program If so please describe.			
Is there a goal for the percent of the system dye tested each year?			
What percent of the system has been dye tested over the past year?			
Does the owner or operator share smoke and dye testing equipment with another owner or operator?			

Comments:

VII. F. SSES: Manhole Inspection

Question	Response	Documentation Available	
		Yes	No
Does the owner or operator have a routine manhole inspection and assessment program?			
What is the purpose of the inspection program?			
Does the owner or operator have a goal for the number of manholes inspected annually?			
How many manholes were inspected during the past year?			
Do the records for manhole/pipe inspection include the following: ☐ conditions of the frame and cover; ☐ evidence of surcharge; offsets or misalignments; ☐ atmospheric hazards measurements; ☐ details on the root cause of cracks or breaks in the manhole or pope including blockages; ☐ recording conditions of corbel, walls, bench, trough, and pipe seals; ☐ presence of corrosion, if repair is necessary; ☐ manhole identifying number/location; wastewater flow characteristics; ☐ accumulations of grease, debris, or grit; ☐ presence of infiltration, location, and estimated quantity; ☐ inflow from manhole covers?			
Are manholes susceptible to inflow identified and inspected on a regular frequency?			
Is there a data management system for tracking manhole inspection activities?			
What triggers whether a manhole needs rehabilitation?			
Does the owner or operator have a multi-year Capital Improvements Program that includes rehabilitation, replacement, and repair of manholes?			
How are priorities established for rehabilitation, replacement, and repair of manholes?			
Has the owner or operator established schedules for performing rehabilitation, both short term and long term of manholes?			

Question	Response	Documentation Available	
		Yes	No
Has funding been approved for the rehabilitation of manholes?			
Does the owner or operator have a grouting program?			

Comments:

VIII. A. Rehabilitation: Manhole Repairs

Question	Response	Documentation Available	
		Yes	No
What rehabilitation techniques are used for manhole repairs?			
How are priorities determined for manhole repairs?			
What type of documentation is kept?			
Does the owner or operator use manhole inserts?			
Are they used system wide or only on low lying manholes?			

Comments:

VIII. B. Rehabilitation: Mainline Sewers

Question	Response	Documentation Available	
		Yes	No
What type of main line repairs has the owner or operator used in the past?			
Does the owner or operator currently use any of above techniques for main line repairs? What other techniques is the owner or operator presently using?			
How are priorities established for main line repairs?			
What type of follow-up is performed after the repair (e.g., CCTV)?			

Comments:

Appendix A

EXAMPLE
COLLECTION SYSTEM PERFORMANCE
INDICATOR DATA
COLLECTION FORM

EXAMPLE
COLLECTION SYSTEM PERFORMANCE INDICATOR DATA COLLECTION FORM

I. General Information

A. Agency Name ____

B. Agency Address
Street ____
City ____________________ State __________________ Zip ________

C. Contact Person ____

D. Telephone: Voice ______________ Fax _____________ Email __________

E. Data provided for latest fiscal/calendar year, 20___

II. Collection System Description

A. Service Area ___________ Square miles

B. Population Served ________________

C. System Inventory

Miles of gravity sewer	Miles of force main	Number of maintenance access structures	Number of pump stations	Number of siphons	Number of air, vacuum, or air/vacuum relief valves

D. Number of Service Connections:
Residential ______ Commercial _______ Industrial _______ Total _______

E. Lateral Responsibility (check one)
1. At main line connection only _________
2. From main line to property line or easement/cleanout __________
3. Beyond property line/cleanout ___________
4. Other _________

F. System combined (storm and sanitary)? Yes ___ No ___ If yes, % combined ____

G. Average Annual Precipitation ___________ inches

H. System Flow Characteristics (total for service area)

Peak Dry Weather Flow (MGD)	Peak Wet Weather Flow (MGD)	Average Daily Flow (MGD)

III. Special Conditions

A. Indicate local conditions that are accounted for during design, construction, operation, and maintenance of the collection system.

1. Precipitation: Yes ____ No _____ If yes, provide brief explanation ______ ____ _________________
2. Terrain: Yes ____ No _____ If yes, provide brief explanation____________ ____
3. Soils: Yes ____ No _____ If yes, provide brief explanation _____________ ____
4. Temperature: Yes ____ No _____ If yes, provide brief explanation ______ ____
5. Groundwater: Yes _____ No _____ If yes, provide brief explanation ______ ____
6. Geology: Yes ____ No _____ If yes, provide brief explanation ___________ ____
7. Other: ____ ____

B. Is corrosion a significant problem? Yes ___ No ____
- Is there a corrosion control program in place? Yes ___ No ____

C. Is odor a significant problem? Yes ___ No ____
- Is there an odor control program in place? Yes ___ No ____

D. Is grease a significant problem? Yes ___ No ____
- Is there a grease control program in place? Yes ___ No ____

E. Are roots a significant problem? Yes ___ No ____
- Is there a root control program in place? Yes ___ No ____

IV. Age Distribution of Collection System

Age	Gravity Sewer, miles	Force Mains, miles or feet	Number of Pump Stations
0 - 25 years			
26 - 50 years			
51 - 75 years			
> 76 years			

V. Size Distribution of Collection System

Diameter in inches	Gravity Sewer, miles	Force Mains, miles or feet
8 inches or less		
9 - 18 inches		
19 - 36 inches		
> 36 inches		

VI. Distribution of Gravity Sewer By Material

A. Vitrified Clay Pipe (VCP) ___________ Miles
B. Reinforced Concrete Pipe (RCP) ___________ Miles
C. Unreinforced Concrete Pipe (CP) ___________ Miles
D. Plastic (all types) ___________ Miles
E. Brick ___________ Miles
F. Other ___________ Miles
G. Other ___________ Miles
H. Other ___________ Miles

VII. Distribution of Force Mains By Material

(circle one)

A. Reinforced Concrete Pipe (RCP) ___________ miles or feet
B. Prestressed Concrete Cylinder Pipe (PCCP) ___________ miles or feet
C. Asbestos Cement Pipe (ACP) ___________ miles or feet
D. Polyvinyl Chloride (PVC) ___________ miles or feet
E. Steel ___________ miles or feet
F. Ductile Iron ___________ miles or feet
G. Cast Iron ___________ miles or feet
H. Techite (RPMP) ___________ miles or feet
I. High Density Polyethylene (HDPE) ___________ miles or feet
J. Fiberglass Reinforced Plastic (FRP) ___________ miles or feet
K. Other ___________ miles or feet

VIII. Preventive Maintenance of System

A. Physical Inspection of Collection System, Preventive Maintenance

Inspection Activity	Total Annual Labor Hours Expended for This Activity	Total Completed (Miles of Pipe or Manholes Inspected Annually)	Crew Size (s)
CCTV			
Visual Manhole Inspection, Surface Only			
Visual Manhole Inspection, Remove Cover			
Visual Gravity Line Inspection, Surface Only			
Visual Force Main Inspection, Surface Only			
Other (Sonar, etc.)			

B. Mechanical and Hydraulic Cleaning, Preventive Maintenance

Cleaning Activity	Total Annual Labor Hours Expended for This Activity	Total Annual Labor Hours Expended for Scheduled PM	Total Miles Cleaned Annually	Crew Size (s)	Range of Pipe Diameters Cleaned
Hydraulic Jet					
Bails, Kites, Scooters					
Combination Machines					
Rod Machines					
Hand Rodding					
Bucket Machines					
Chemical Root Control					
Chemical or Biological Grease Control					

IX. Dry Weather Stoppages

A. Number of stoppages, annually ____________
B. Average time to clear stoppage ____________
C. Number of stoppages resulting in overflows and/or backups annually ____________
D. Total quantity of overflow(s) ____________
E. Is there an established procedure for problem diagnosis? Yes ____ No ____
F. Are future preventive measures initiated based on diagnosis? Yes ____ No ____
G. What equipment is available for emergency response? _________________________

X. Repairs and Rehabilitation, Proactive

A. Number of annual spot repairs identified __________
B. Number of annual spot repairs completed _________
C. Percent of spot repairs contracted ______________
D. Number of manholes identified for rehabilitation __________
E. Number of manholes rehabilitated annually ___________
F. Percent of manhole repairs contracted __________
G. Feet of main line needing rehabilitation __________
H. Feet of main line rehabilitated _______________
I. Percent of main line rehabilitation contracted ____________
J. Number of manholes scheduled for rehabilitation under Capital Improvement Program (s) _______
K. Feet of main line scheduled for rehabilitation under Capital Improvement Program (s) __________

XI. Repairs and Rehabilitation, Reactive

A. Number of annual line features ___________
B. Number of line repairs __________

XII. Pump Stations

A. Number of pump stations inspected ______
   - Frequency of inspections ___________ (daily, every other day, weekly)

B. Number of inpsection crews ___________
C. Crew size __________
D. Number of pump stations with pump capacity redundancy ___________
E. Number of pump stations with backup power sources ____________
F. Number of pump stations with dry weather capacity limitations __________
G. Number of pump stations with wet weather capacity limitations __________
H. Number of pump stations calibrated annually ______________
I. Number of pump stations with permanent flowmeters __________
J. Number of pump stations with remote status monitoring __________
K. Number of pump stations with running time meters ___________
L. Number of mechanical maintenance staff assigned to mechanical maintenance _______
M. Number of electrical maintenance staff assigned to electrical maintenance __________
N. Total labor hours scheduled annually for electrical and mechanical PM tasks ________
O. Total labor hours expended annually for electrical and mechanical PM tasks ________

XIII. Pump Station Failures, Dry Weather

A. Number of failures resulting in overflows/bypass or backup, annually ______________
B. Total quantity of overflow/bypass ______ Gallons or MG
C. Average time to restore operational capability ______ hours
D. Total labor hours expended for electrical and mechanical corrective maintenance tasks ________
E. Is failure mode and effect diagnosed? Yes ___ No ___
F. Are future preventive measures initiated based on diagnosis? Yes ___ No ___
G. What equipment is available for emergency response? _____________________________________

XIV. Force Mains

A. Force mains inspected annually ___________ miles or feet (visual surface inspection of alignment)

B. Force mains monitored annually __________ miles or feet (pressure profile, capacity)

C. Number of force main failures annually ___________

D. Cause(s) of force main failures ____
____

XV. Air Relief/Vacuum Valves

A. What is frequency of valve inspections? _____________________________

B. What is frequency of PM (backflushing, etc)? ____________________________

C. Number of annual valve failures ____________________

D. Cause(s) of valve failures ____
____

XVI. System Operation and Maintenance Efficiency

A. Total full time or full time equivalent staff assigned to O & M (excluding administration staff but including line managers, supervisors) ________________________

B. Total estimated labor hours actually expended for active O & M tasks (this is the total above less hours for sick, vacation, holidays, training, breaks, etc., not directly related to performing O & M tasks) ________________

XVII. Level of Service

A. Average annual rate for residential users __________________

B. Rate based on: water consumption __________ Flat rate ___________ Other ______________

C. Number of complaints annually ______________

D. Number of complaints that are agency responsibility _______________

E. Number of public health or other warnings issued annually _______________

F. Number of claims for damages due to backups annually ________________

G. Total cost of claims settled annually ______________

XVIII. Financial

A. Total annual revenue received from wastewater ___________________

   1. % of revenue for long-term debt __________________
   2. % of revenue for treatment and disposal ____________
   3. % of revenue for collection and conveyance _____________

B. Current value of collection system assets _______________________

C. Annual O & M expenditure ___________________

D. Annual CIP expenditure for repair, replacement, or rehabilitation _________________________

E. Annual O & M training budget _____________________________

F. Total number of O & M personnel (including administrative in O & M department) ____________

G. Number of personnel with collection system certification _______________

H. Number of personnel qualified for collection system certification _________________

I. Amount of O & M budget allocated for contracted services ___________________

J. Hydroflush cost per foot _______________________

K. Rodding cost per foot ___________________

L. Bucketing cost per foot __________________

M. CCTV cost per foot ______________________

N. Spot repairs, cost each _________________________

XIX. Safety

A. Total labor hours assigned to O & M _________________

B. Number of lost time injuries _________________

C. Total lost time days ______________

D. Total cost of lost time injuries ___________________

XX. Regulatory

A. Total number of violations issued annually ____________

B. Total cost of fines paid annually ______________

C. What is minimum reportable quantity in gallons? ______________

D. What is time reporting requirement? _________________

E. Number of annual WWTP upsets due to wet weather flow __________________

XXI. General

A. Has SSES been performed on system? Yes _____ No _____

B. Total O & M positions currently budgetd ________________

C. Total O & M positions currently filled ___________________

D. Is computerized maintenance management system (s) used for O & M managing? Yes ___ No __

E. Is GIS system used for O & M managing? Yes _____ No _____

XXII. Procedures or Other Documentation Available

A. Overflow, bypass and containment Yes _____ No _____

B. Problem evaluation and solution Yes _____ No _____

C. Cleanup procedure Yes _____ No _____

D. Failure mode and effect procedure Yes _____ No _____

E. O & M budget process Yes _____ No _____

F. O & M budget with line item detail Yes _____ No _____

G. Long-range CIP planning for system expansion, rehabilitation, and replacement Yes ____ No ___

H. Is there a written procedure for cleanup to mitigate effect of overflow? Yes _____ No _____

I. Is there a written procedure for containing overflows and bypasses? Yes _____ No _____

J. Is there an established procedure for containing overflows and bypasses? Yes _____ No _____

K. Is there an established procedure for problem evaluation and solution? Yes _____ No _____

L. Is there an established procedure for cleanup to mitigate effect of overflow? Yes _____ No ____

M. Is there a grease control program? Yes _____ No _____

N. Is there a pretreatment program? Yes _____ No _____

O. Is there a private source I/I reduction program? Yes _____ No _____

P. Do you have chronic O & M problems that are designed into your system? Yes _____ No _____
If yes, provide brief description ____
____

Q. Do you have chronic O & M problems that are constructed into your system? Yes _____ No ___
_ If yes, provide brief description ____
____

R. How would you rate your construction inspection program?
Very effective ________ Needs improvement ________ Poor _________

XXIII. Definitions/Clarifications

A. Maintenance access structures, most commonly manholes, in your system that are incorporated into your O & M program.

B. Pump capacity redundancy is the ability to maintain pumping at design capacity with the largest pump out of service.

C. Remote status monitoring is any remote monitoring system such as alarm telemetry or SCADA that provides remote pump station status information.

D. You will notice that in the section on stoppages and pump station failures, we are asking for dry weather incidents only. Dry weather system performance is a good indicator or effectiveness of O & M program. If you have wet weather information that you wish to provide also, please do.

E. Under the Special Conditions sections we are identifying conditions that are present in your system that require consideration during design, construction, and O & M of your system.

F. Any of the questions dealing with labor hours are designed to determine total labor hours irrespective of crew size or crews that are only assigned to cleaning, for example, less than full time.

G. Our goal is to obtain data that can be or are standardized and that are accurate. We also realize that some data may not be available; however, data can be accurately estimated. If you estimate data please follow with an (E).

H. If data is not available please indicate "NA." If data does not apply to your system, please indicate by "DNA."

I. Failure mode and effect refers to any established procedure you have to diagnose system failures to determine the cause and effect of the failure. This can apply to crews clearing stoppages or to pump station failures.

J. Pump station inspection (XII) means scheduled inspection by operators to verify station operation and perform PM. It excludes electrical or mechanical craft maintenance.

K. Stoppage in section IX refers only to stoppages other than pump stations. Pump stations are covered in Section XIII. Backup in this case refers to a basement or other structure backup as opposed to main line sewer backup.

XXIV. Additional Comments

____

____

____

Appendix B

EXAMPLE INTERVIEW SCHEDULE AND TOPICS

EXAMPLE INTERVIEW SCHEDULE AND TOPICS

Days 1 and 2 Interviews

Work Practice or Maintenance Function	Description	Examples of Discussion Topics and Supporting Documents	Name	Interview Date, Time, and Location
Senior Management	Discuss project expectations, report review and comment process. Overview of organizational structure and "culture". Identify sensitive issues and how to approach. Schedule			
Project Kick off Meeting	Overview and purpose of project. Interview and field assessment process. Report content and review process. Questions and answers	None		
Physical Inspection and Testing – Gravity sewer system	Visual Inspection, pipe alignment. CCTV Smoke and Dye Testing Other	Reports, inspection forms, performance data, inspection strategy, crew assignments and schedules, equipment available, current expenditures and budgeted amounts, area maps, Standard Operating Procedures, field maps.		

Work Practice or Maintenance Function	Description	Examples of Discussion Topics and Supporting Documents	Name	Interview Date, Time, and Location
Preventive Maintenance - Mechanical and hydraulic cleaning	High velocity jets and combination machines. Other hydraulic methods Rodding Machines Bucket Machines	Reports, performance data, preventive maintenance cleaning strategy, crew assignments and schedules, equipment available, current and budgeted, problem areas, Standard Operating Procedures, Standard Maintenance Procedures, problem diagnosis		
Chemical and biological cleaning	Root control Grease control Odor control Corrosion control	Grease control ordinance, enforcement, odor and corrosion control strategy, root control program, design for O&M considerations, materials used (MSDS), reports, performance data, preventive maintenance cleaning strategy, crew assignments and schedules, equipment available, current and budgeted, problem areas, Standard Operating Procedures, Standard Maintenance Procedures, problem diagnosis, public education, enforcement		
Pump Stations	Routine inspection Electrical and mechanical maintenance SCADA Standby/emergency systems Valves Forcemains	Logs, inspection sheets, Standard Maintenance Procedures, Standard Operating procedures, pump station inventory and attribute data base, spares inventory, Reports, performance data, preventive maintenance strategy, crew assignments and schedules, equipment available, current and budgeted, critical pump stations, Standard Operating Procedures, Standard Maintenance Procedures, problem diagnosis, preventive and predictive maintenance methods, maintenance tasks and frequencies, O&M manuals, capacity issues		

Work Practice or Maintenance Function	Description	Examples of Discussion Topics and Supporting Documents	Name	Interview Date, Time, and Location
Training and Certification	Training program, technical, supervisory and management. Certification program	Knowledge, skills and abilities, basic skills, career paths, minimum qualifications, certification, educational assistance program, internal and external training, OJT, training budget		
Work Management	Planning and scheduling work Materials management Priority Backlog management Procurement Manual or Computer Maintenance Management System (CMMS)	Complaints and emergencies normal hours and after hours. Corrective, preventive and predictive maintenance work orders, work backlog, labor utilization, reports,		

Work Practice or Maintenance Function	Description	Examples of Discussion Topics and Supporting Documents	Name	Interview Date, Time, and Location
Safety	Safety committee Safety meetings Safety enforcement Documentation of comprehensive safety training Compliance with safety regulations Documentation of effectiveness of safety program (e.g., reduction of accidents) Documentation of attendance and learning at safety training sessions	Policy and procedures for trenching, confined space, lockout tagout, PPE. Safety manual, formal training, tracking, accident investigation		
Financial	Annual O&M Budget Rates CIP for rehabilitation/rehab Non-enterprise fund allocations	O&M budget process, line item accounts, five year CIP plan, repair, rehabilitation, replacement strategy for pipes and pump stations		

Work Practice or Maintenance Function	Description	Examples of Discussion Topics and Supporting Documents	Name	Interview Date, Time, and Location
Construction and Repair	Emergency repair Spot repairs, gravity system Rehabilitation Lateral installation Inspection New Construction Testing	Reports, inspection forms, performance data, inspection strategy, crew assignments and schedules, equipment available, current and budgeted, area maps, Standard Operating Procedures, field maps,		
Fleet Management	Maintenance Replacement Availability Budgeting	Inventory, repair and replacement process, maintenance turn around time, preventive maintenance, Standard Operating Procedures, Standard Maintenance Procedures, CMMS,		

Day 3 - Field

Pump Stations

Work Practice or Maintenance Function	Description	Examples of Discussion Topics and Supporting Documents	Name	Interview Date, Time and Location
Pump Station Maintenance	Submersible Cast in place wet well dry well Prefabricated Grinder/Low Pressure System	Logs, O&M manuals, on-site procedures, vehicles and equipment, SCADA, Supervisory controls, electrical systems, flow meters, HVAC, variable speed systems, chronic problems, pumps and hydraulic systems.		

Day 4 – Field

Facilities and Crews

Work Practice or Maintenance Function	Description	Examples of Discussion Topics and Supporting Documents	Name	Interview Date, Time and Location
Facilities	Electrical and mechanical repair shops and equipment Warehouse and equipment storage areas Vehicle maintenance shops Crew areas; locker rooms, training areas, dispatch areas	Logs, O&M manuals, on-site procedures, vehicles and equipment, SCADA, Supervisory controls, electrical systems, flow meters, HVAC, variable speed systems, chronic problems, pumps and hydraulic systems,		
Crews Exit Interview	CCTV Cleaning Construction Repair Overview of findings for week	N/A None		

Appendix C

INFORMATION SOURCES

Information Sources
(Updated November 2004)

WEBSITES (water and/or wastewater-oriented; financial related)

EPA National Compliance Assistance Clearinghouse	www.epa.gov/clearinghouse
Compliance Assistance Centers	http://www.assistancecenters.net
Construction Industry Compliance Assistance Center	www.cicacenter.org
EPA NPDES website	http://www.epa.gov/npdes
EPA Operator On-Site Technical Assistance Program–104(g) (hands-on assistance to small municipal WWTP operators at no cost to community)	www.epa.gov/owm/mab/smcomm/104g/sstc.htm
EPA Office of Wastewater Management	www.epa.gov/owm
EPA Clean Water Tribal Grant Program	www.epa.gov/owm/mab/indian/cwisa.htm
EPA Colonias Program	www.epa.gov/owm/mab/mexican
EPA Clean Water State Revolving Loan Fund Program	www.epa.gov/owm/cwfinance/cwsrf
EPA Website (Headquarters & Regions)	www.epa.gov/
EPA Small Business Gateway	http://www.epa.gov/smallbusiness
Environmental Finance Center	http://sspa.boisestate.edu/efc
National Environmental Services Center/WV University	www.nesc.wvu.edu
Local Govt. Environmental Assistance Network	www.lgean.org
Rural Community Assistance Program (RCAP)	www.rcap.org
Water Environment Federation (WEF)	www.wef.org
AMSA	www.amsa-cleanwater.org/pubs/
American Water Works Assoc. (AWWA)	http://www.awwa.org/
National Association of Towns & Townships (NATAT)	http://www.natat.org/

PUBLICATIONS /TRAINING VIDEOS /NEWSLETTERS, etc.

EPA National Service Center For Environmental Publications (NSCEP)
USEPA/NSCEP
PO Box 42419
Cincinnati, OH 45242
Tele: 1-800-490-9198 or 513-489-8190 (fax: 513-489-8695)

EPA Office of Water Resource Center
Tele: 202-566-1729 (24 hours)
center.water-resources@epa.gov

National Environmental Services Center (formerly the National Small Flows Clearinghouse)
West Virginia University Small Business Gateway
P.O. Box 6064
Morgantown, WV 26506
Tele: 1-800-624-8301

California State University - Sacremento
Tele: 916-278-6142
(training videos, etc.)

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APPENDIX L

3 Rivers Wet Weather Demonstration Program

United States Environmental Protection Agency | Office of Water Washington, D.C. | EPA 832-F-99-039 September 1999

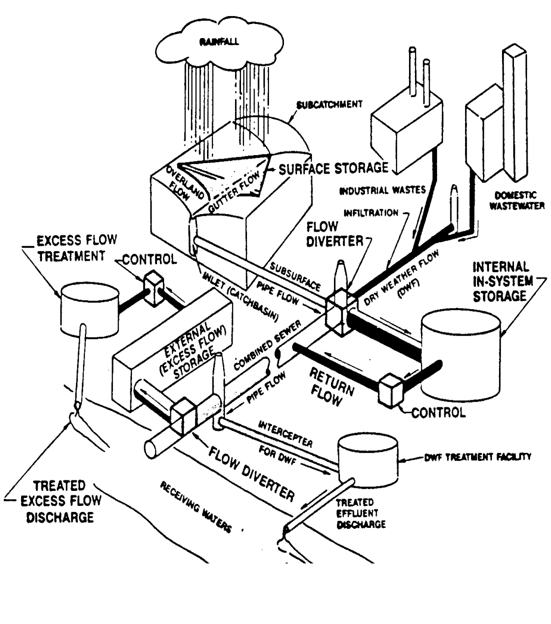
Combined Sewer Overflow O&M Fact Sheet
Proper Operation and Maintenance

DESCRIPTION

Combined sewer systems (CSSs), as shown in Figure 1, are single-pipe sewer systems that convey sanitary wastewaters (domestic, commercial and industrial) and storm water runoff to a publicly owned treatment works. During periods of heavy rainfall, however, the sanitary wastewaters and storm waters can overflow the conveyance system and discharge directly to surface water bodies. This is called a combined sewer overflow (CSO).

CSOs may contain high levels of suspended solids, biochemical oxygen demand (BOD), oil and grease, floatables, toxic pollutants, pathogenic microorganisms and other pollutants. These pollutants can exceed water quality standards and pose risks to human health, threaten aquatic species, and damage the waterways.

Because of the pollution potential from CSOs, EPA issued the CSO Control Policy on April 19, 1994. This policy states that permittees with CSSs that have CSOs should be able to provide, at a minimum, primary treatment and disinfection, when necessary, to 85 percent of the volume captured in a CSS on an annual average basis. The policy also includes nine minimum control requirements for inclusion in the CSO discharge permit. One of these minimum controls is proper operation and regular maintenance (O&M) programs for the sewer systems with CSOs.



Source: U.S. EPA, 1989.

FIGURE 1 COMBINED SEWER SYSTEM

KEY PROGRAM COMPONENTS

Proper O&M of combined sanitary sewers and overflows is not significantly different from that of sanitary sewer systems, with the objective being to maintain maximum flow to the wastewater treatment plant and to maximize either in-line storage capacity or detention upstream of the system inlets. There are several key components of an O&M program that a municipality/authority must provide to ensure proper O&M and to meet the minimum control requirement. These program components include:

- Scheduling routine inspections, maintenance and cleaning of the CSS, regulators and outfalls.
- Developing O&M reporting and record keeping systems with maintenance procedures and inspection reports.
- Providing training for O&M personnel.

- Reviewing the O&M program periodically to up-date and revise procedures as necessary.

These components are further described below.

Operational Review

Prior to developing an O&M program, the municipality should undertake an operational review of its system to inventory and assess existing facilities, operating conditions and maintenance practices. The municipality should have a complete plan of the collection system, showing all sewers and points where CSOs and outfalls are located. This plan should reference streets and other utilities to enable the maintenance crews to locate the structures and CSOs quickly. This plan may also aid in scheduling and planning the inspection and maintenance of the CSS system and overflows; for example, the regions or areas that are prone to flooding or premature overflows should be inspected first after a major storm.

The nine minimum CSO control requirements include conducting a characterization of the CSS. This characterization should include documentation of overflow occurrences and correlation of these events with rainfall patterns (e.g., volume, intensity, duration). The results of the CSS characterization are critical to designing an O&M program that is effective in optimizing system operations. As part of these studies, it is important to measure actual system flows and the response to various operating and wet weather conditions. This information will be critical during the development of specific operation and maintenance procedures that will be part of the O&M program.

Municipalities may eventually be able to use data from their Long-term CSO Control Plans to supplement their O&M programs. As part of these plans, a system may conduct modeling of the integrated system (sewers, regulators, and treatment plant) to analyze operational improvements. These modeling efforts typically identify operational modifications that maximize storage and transport, provide improved treatment in the existing system, and decrease untreated CSO discharges. Because many municipalities will implement their O&M programs before their Long-term CSO Control Plans are completed, the results of the CSS modeling may not be available during the early phase of the O&M program. However, the O&M program should be updated periodically to address this type of additional information.

Record Keeping System

The O&M program should include a record keeping component. The record keeping system should document maintenance procedures through inspection reports. These reports should include information about when the system was inspected, and, if applicable, what maintenance action was taken, including the equipment used and the personnel involved. Geographical information systems (GIS) and desktop mapping may be useful in storing O&M data on the CSO system, as well as in developing a database of problem areas.

System Operating Procedures

Each municipality should have written policies, procedures, or protocols for training O&M personnel and should conduct periodic reviews and revisions of the O&M program. Some municipalities have reported that alternating crews between O&M and other functions has proven beneficial because it reduces the tedium of the work by making it less routine, and it promotes the cross-training of employees. Other municipalities prefer devoting personnel strictly to O&M because it keeps the work assignments simple.

Training

The O&M Program should have established training goals, procedures, and schedules. Training should provide the maintenance personnel with an understanding of the CSS operations and system characteristics. Hands-on training illustrates the specific O&M procedure to those directly responsible for performing these activities. In addition, the nature of the O&M work may require employees to work in confined spaces or to be exposed to dangerous gases. Providing proper safety training, in accordance with Occupational Safety and Health Administration (OSHA) standards, is imperative. Safety programs should be reviewed, and, if necessary, updated periodically. Tide gates that require underwater inspection should only be inspected by a certified diver.

ROUTINE MAINTENANCE ACTIVITIES

Proper operation of the CSO system begins with proper operation and maintenance of the individual components - the regulators, tide gates, pump stations, sewer lines, and catch basins; and implementation of an organized plan that provides regular, consistent, and response-oriented O&M. In addition, operators must develop plans for determining where CSOs occur, and for conducting system-specific repairs to prevent future CSOs.

Regulator/Tide Gate Maintenance

Because of the debris normally present in combined sewage, regulators are particularly susceptible to the accumulation of materials that cause clogging and blockages. Trash blockages at the entrance to the orifice of the interceptor increase the headloss through the orifice and causes the majority of unnecessary overflows in passive regulators. Other causes of unnecessary diversions at regulators include weir plates or dams that are improperly set, damaged, or broken off. Similarly, tide gate failure can often be attributed to trash or debris becoming lodged in the gate, or corrosion of the gate or deterioration of the gate gaskets. Tide gate failure allows the receiving water to enter the CSS, reducing the storage and flow capacity. For more information on solids and floatables control, refer to the EPA's CSO Technology Fact Sheets on Screens (EPA 832-F-99-027) and Floatables Control (EPA 832-F-99-008).

Frequent inspection of CSO regulators and tide gates for the problems outlined above, and subsequent program to implement corrective measures (such as cleaning or repair of the regulator or tide gate) will ensure maximum storage or flow capacity. Inspection of tide gates is most easily performed during dry weather and at low tide, when most installations are above the water level of the receiving water. Tide valves that are below the level of the receiving water at all times may require a diver to perform the inspection. Regulators which have proven to be problematic should be inspected after every rainfall event.

There are many different ways of determining if an overflow has occurred at a regulator or tide gate, how long it lasted, and what volume was discharged. For instance, some municipalities have installed switches on their tide gates that sense when the gate is open; others have installed instrumentation in the discharge line upstream of the tide gate that senses when there is water in the line. In both cases, the signal from the instrumentation is sent to the operating municipality via telemetry to alert the operator of a possible overflow. This type of system may be especially useful if the tide gate is inaccessible or difficult to inspect. These types of systems should be regularly tested to ensure proper operation.

An inexpensive way of passively determining if an overflow occurred at the CSO is to place a small wooden block on the static weir; if the block is not present after a rainfall event, then it was carried off with the overflow. If the wooden block disappears after a period of dry weather flows, then the overflow structure needs to be recalibrated. Base sanitary flows can increase over time as a result of changes in the drainage basin, (e.g., more paved areas), higher sanitary flows, and increased I&I. An increase in base sanitary flow could cause dry weather overflows that need to be identified and eliminated. Another inexpensive method to determine overflows is to install a portable water level or depth gauge (e.g., sonic meter or bubbler) in the combined sewer line and to check dry weather head relative to overflow control structure elevation. This method can quickly determine if the overflow weir or other device needs to be adjusted.

Pump Station Maintenance

Pump stations should be maintained to operate at the design conditions. Wet wells should be routinely cleaned because grit and solids deposition in the wet well can damage or restrict the flow of wastewater into the pump.

Inadequate or improper pump station operation can lead to reduced storage and hydraulic capacity during wet weather, and, if the pumping capacity is severely restricted, dry weather overflows can result. In general, inadequate pumping capacity is caused by:

- Mechanical, electrical, or instrumentation problems.
- Changes in the upstream drainage area that cause storm runoff to exceed the original design basis.
- Changes in the discharge piping (e.g., tying-in or manifolding with another pressure system) that creates more headloss in the discharge system.

If conditions upstream of the pump station (such as development) increase the flow above the design values, steps should be taken to upgrade the station to meet the increased flowrate. Pump station upgrading may include such items as:

- Installing new pumps and motors.
- Changing out impellers.
- Upgrading/changing pump controls to maximize use of all pumps during wet weather.
- Modifying system piping to improve the system
- head curve.
- Installing additional force main piping for wet weather pumping.

Depending on the complexity of the system, changes to the downstream discharge conditions that may affect the system head curve may require extensive study and should be evaluated on a case-by-case basis.

Sewer Line Maintenance

Sewer line maintenance can be broken down into two main components, which include the use of diagnostic methods to identify potential trouble spots in the line; and actual physical inspections of the lines for cracks, breaks, or blockages.

The use of diagnostic methods allows system operators to predict where problems may occur in the lines, thus allowing a more efficient use of O&M resources. Proper maintenance of a sewer system requires a knowledge of the system, including information about the age of the system, the drainage areas served, the elevations of the drainage structures, and slopes of the sewer lines. Adequate knowledge of the age of the sewer system is crucial because many older systems are constructed of weaker materials (such as clay pipe) that are prone to cracking and collapsing. Cracked and collapsed sewers can pose significant problems, such as infiltration of the sewer flow into the groundwater and the introduction of sediment into the system. This may lead to hydraulic restrictions. Knowing which sections of the sewer system are the oldest or identifying sections that are made of less sturdy materials will allow the system operators to track the most likely trouble spots in the system.

Information regarding the elevations of the sewer system is important for determining the likelihood of sediment accumulation in the line. The slope of a sewer line is directly proportional to the line capacity and velocity. When the wastewater velocity in the line is below the self-cleaning velocity of 2 feet per second, solids tend to settle out, creating a flow restriction. Oversized sewers placed on very flat gradients are especially prone to conveying the wastewater at low velocities, and, as a result, filling with sediment. Small- and mid-sized storms are of significant concern because the flow velocity from these storms may be below the self-cleaning velocity. Therefore, areas that are prone to deposition should be inspected frequently. Sewer lines with a history of sediment deposition and blockages should be identified and scheduled for routine cleaning.

Modeling a sewer to evaluate the need for improvements can be especially beneficial in avoiding future problems. For instance, increasing the flow in an upstream sewer can create problems downstream if the downstream sewer does not have the capacity to handle the increased flow. Other problems, such as flow backing up into basements, may appear as a result. In cases where there is concern about back-ups into basements, a backflow preventor may be warranted. Modeling will help to determine how raising a weir will decrease CSOs. Methods of increasing the flow through sewers include increasing the pumping rate from the upstream pumping station and injecting polymer to reduce the sewer roughness coefficient (Field et al., 1994).

Determining whether an overflow occurred in a discharge sewer is important in understanding how the system works and for requirements on reporting. An inexpensive method for determining the maximum depth of flow in the discharge line is to draw a chalk line around the inner circumference of the discharge sewer. The overflow water will dissolve this substance to the maximum depth of flow. More advanced techniques include employing instrumentation that measures the flow in a discharge and relays this information via telemetry to the municipality.

The second part of a sewer line maintenance program is physical inspection of the lines. If possible, CSSs and CSOs should be inspected regularly to ensure peak performance. Sewers are commonly inspected by television cameras, but if the sewers are large enough and flow conditions are low enough, manual inspection may be possible. If manual inspection is the chosen method, the inspector must follow the OSHA confined space entry guidelines.

Inspections should be used to identify blockages, cracks, or other problems in the lines. Blockages are typically the result of sediment and grit accumulating in the sewer system, although dislodged vegetation and debris restrict flow as well. Another common cause of sewer blockages is tree roots, which can grow through cracked sewers. System blockages in sewer systems can decrease both the hydraulic capacity of the sewer and its effective storage capacity. This can cause flow to back up and overflow the sewer system.

Once these problems have been identified, maintenance crews must be dispatched to correct them. Crews should ensure that all lines are cleared of all lodged debris. They should check and empty any in-line grit chambers or flushing stations where sediment routinely causes blockages in the system. Cracked sewers should be repaired and collapsed sewers should be replaced to restore the system capacity and prevent infiltration.

Catch Basin and Grit Chamber Maintenance

Catch basins and grit chambers are inlet chambers that provide sumps for the retention of sediment, grit, and debris. These basins should be cleaned on a routine basis to prevent grit and sediment from filling the structure and passing untreated flow into the CSS. Cleaning methods include utilizing vacuum trucks, jet sprays, submersible pumps that can handle grit and slurry mixtures, and clamshell buckets.

Sediment Control

As sediment is a significant source of the problems in combined sewer systems, control of sediment from the source can prove beneficial. An example of source control includes implementing and maintaining effective erosion control practices for construction in the drainage area. These practices will prevent sediment from being transported to the sewer inlet during a rainfall event. Frequent street sweeping has also proven effective in decreasing the sediment load to the sewer system.

Infiltration & Inflow

Sewer system evaluation studies (SSES), such as smoke testing and television inspection, are effective methods of determining infiltration and inflow of groundwater into the sewer system. This is the result of structural failure of the piping system that allows groundwater into the piping system and is a common problem in older sewer systems. Often, tree roots will grow into the broken piping system, causing more blockage problems in the sewer. This problem is a serious one not only because it introduces additional flow into the sewer system which can lead to surcharges and overflows, but also because it can introduce sediment into the system, which can cause the problems outlined above.

COST

The cost of operating and maintaining CSOs and CSSs is especially difficult to determine because it is a function of many different factors, including the age of the system, the type(s) of overflow structure(s), the size of the system (both in linear footage and in the diameter of combined sewer), and the drainage areas. Cost data for key components of proper O&M of CSO systems is summarized in other EPA Fact Sheets, including "Sewer Cleaning and Inspection" (EPA 832-F-99-018) and "Catch Basin Cleaning" (EPA 832-F-99-011). For example, average costs for catch basin cleaning can range from $8-$16 per catch basin depending on whether the cleaning is done manually or with a vacuum sweeper. Table 1 summarizes average national cost data for cleaning and inspecting sewers, another key component of proper CSO system O&M..

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TABLE 1 NATIONAL SUMMARY OF MAINTENANCE COSTS

Identifier	Range of Costs	Average Cost
Total O&M cost/mile*year	$951-$46,973[1]	$2,823[3]
Labor (cost/mile/year)	$695 -$19,831[1]	$3,626[1]
Fringe Benefits (cost/mile/year)	$192 -$9,033[1]	$1,185[1]
Chemicals (cost/mile/year)	$0.3 -$7,616[1]	$512[1]
Hydroflush Cleaning (cost/mile)	$475 -5,230[2]	$1,700[1]
Television Inspection (cost/mile)	$1,000 -$11,450[2]	$4,600[1]
Preventive Maintenance	63% of Total Maintenance Costs (excludes depreciation)	

Source: 1 Water Environment Research Foundation, 1997.
2 Arbour and Kerri, 1997.
3 Black & Veatch/ASCE, 1998.

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