Chapter 1
Understanding Wastewater Collection System Problems and Needs

1.1 Purpose of a Wastewater Collection System 2

1.2 Problems 2

1.3 O&M Programs 4

1.3.1 Types of Maintenance 5

1.3.2 Benefits of Effective O&M Programs 6

1.3.2.1 Asset Management 7

1.3.2.2 Service to Customers 7

1.3.2.3 Regulatory Compliance 8

1.3.2.4 Public Health and Safety 8

1.3.2.5 Environmental Protection 9

1.3.2.6 Cost-Effective Use of Agency Resources 9

1.4 Performance Indicators 9

1.5 Additional Resources 11

Chapter Review 13

Chapter 2
Researching Trends in Collection System Performance

2.1 Literature Review 16

2.2 Site Visits and Interviews 17

2.3 Developing the Survey 17

2.3.1 Identifying O&M Categories 17

2.3.2 Identifying Significant Activities or Events 17

2.3.3 Defining Metrics 18

2.3.4 Refining Survey Questions 18

2.3.5 Arranging Data in a Matrix 18

2.3.6 Reviewing Performance Indicators 18

2.4 Survey Matrix 19

2.4.1 Sewer Maintenance (Stoppages and Overflows) 19

2.4.2 Pump Station and Force Main Maintenance 19

2.4.3 Emergency Response (Sewers and Pump Stations) 21

2.4.4 Planning, Scheduling, and Work Order Control 22

2.4.5 Level of Service Provided to Users 23

2.4.6 Control of Infiltration/Inflow and SSOs 23

2.4.7 Equipment 25

2.4.8 Finance 25

2.4.9 Personnel 26

2.4.10 Safety 27

2.4.11 Regulatory Compliance 27

Chapter Review 28

Chapter 3
Developing Benchmark Data

3.1 Profile of 1998 Survey Respondents 30

3.1.1 Population Served, System Size, and Major System Components 31

3.1.2 Flow Characteristics and Precipitation 31

3.1.3 Local Conditions Affecting Design, Construction, and Inspection 31

3.1.3.1 Precipitation 32

3.1.3.2 Terrain 33

3.1.3.3 Soils 33

3.1.3.4 Temperature 33

3.1.3.5 Groundwater 33

3.1.3.6 Geology 33

Chapter Review 28
Table of Contents

5.4 Cleaning 78

5.4.1 Methods 80

5.4.1.1 Hydraulic Cleaning 80
5.4.1.2 Mechanical Cleaning 81
5.4.1.3 Chemical Cleaning 83
5.4.1.4 Summary 84

5.5 Pump Station and Force Main O&M Program 86

5.5.1 Inspection 86
5.5.2 Electrical/Mechanical Preventive Maintenance 87
5.5.3 Emergency Response 88

5.6 Controlling Infiltration/Inflow Sources 89

5.6.1 Investigating Infiltration/Inflow Sources 90

5.6.1.1 Sewer System Evaluation Survey 92
5.6.1.2 Flow Monitoring 93
5.6.1.3 Physical Survey 93
5.6.1.4 Internal Pipe Inspection 94
5.6.2 Reducing or Eliminating Infiltration/Inflow Sources 95
5.6.3 Protecting the System from Infiltration/Inflow Sources 95

5.7 Underground Repair 96

5.7.1 Connections 97
5.7.2 Main Line Sewer 97
5.7.3 Selecting a Rehabilitation Method 98

5.7.3.1 Nonstructural Repairs 98
5.7.3.2 Structural Repairs 99
5.7.3.3 Selecting Structural Rehabilitation/Reconstruction Methods 102
5.7.3.4 Preparing the Scope of Work 102
5.7.4 Prioritizing Pipe Rehabilitation Backlogs 103

5.8 Emergency Response 104

5.8.1 Emergency Management and Response Plans 105

5.9 Data Management 107

5.10 Additional Resources 108

Chapter Review 109

Chapter 6
Case Histories and Benchmarking Surveys

6.1 Introduction 112

6.2 Summary of Case Histories 112

6.2.1 Sacramento County 113
6.2.2 Central Contra Costa Sanitary District 115
6.2.3 City of Bloomington 117
6.2.4 Denver Metro Wastewater Reclamation District 127

6.2.4.1 Planner Performance Report 128
6.2.4.2 Overtime and Work Backlog Report 129
6.2.4.3 Maintenance Performance Report 130
6.2.4.4 Open Work Order Report 130
6.2.4.5 Equipment Maintenance History Tracking 131
6.2.5 County Sanitation Districts of Orange County 131
6.2.6 Union Sanitary District 133

6.3 Benchmarking Surveys 140

6.4 Performance Indicator Categories 146

6.5 Additional Resources 147

Chapter Review 148

Chapter 7
How Has Performance Improved?

7.1 Comparing Performance Data 150

7.2 Performance Survey Objectives 151

7.3 Data Collection Procedures 151

7.4 Survey Data Analysis 152

7.4.1 Explanations and Trends 153
7.4.2 Identifying Factors for Improvement 168

7.5 Factors Influencing Changes in System Performance 170
Table of Contents

7.5.1 Discussion of Most Influential Factors 171
7.5.2 Regulatory Compliance and Enforcement 171
   7.5.2.1 Adopting CMOM 172
7.5.3 New Technologies 173
7.5.4 Staff 174
7.5.5 O&M Business Practices 174
7.5.6 Replacement, Rehabilitation, and Capital Improvement Plan 174
7.5.7 Training and Certification 175
7.5.8 Attitudes and Public Education 175
7.5.9 Remaining Factors 175

7.6 Characteristics of High-Performing Agencies 176
   7.6.1 Leadership 176
   7.6.2 Financial 176
   7.6.3 Operation and Maintenance Programs 176
   7.6.4 Performance Indicators 177
   7.6.5 Technology 177

7.6.6 Training 177
7.6.7 Community Support 178

7.7 Additional Resources 178

Chapter Review 179

Appendix A
Literature Review

Appendix B
Data Collection Forms

Appendix C
Benchmarking Worksheets

Answer Key 219
Glossary 221
Index 225
A

Acceptance, collection systems, 4
Acceptance test, 158
Access
poor or no physical access as a design-related problem, 32
requiring easement, 31
Accidents, 177
Accountability, 58
Additional Resources, 11–12, 54, 108, 147
Administrative orders, 8
Agency averages and standard deviations, 152–153
Agency characteristics, 176–178
Agency responsibility, 2
Aging of system, 170, 171, 175
Air relief valves, 21, 31, 45
Air testing, 75
Air/vacuum relief valves, 21, 30, 45
Analysis of survey data, 69, 152–170
Annual O&M cost
per capita, 64, 153, 160, 162–163
per mile of sewer, 65, 153, 163, 164
Annual rate for residential users, 65, 153, 164, 165, 168, 169
Annual stoppage caused SSO, trend, 151
Applied Science and Technology Index, 16
As-builts, 74
Assessment, condition, 158
Asset management, 7, 25, 156, 158, 170, 171, 177
Assets, collection system, 47–48
Attitudes of community, management, and policy makers, 170, 171, 175
Availability of facilities and equipment, 6
Average annual rate for residential users, 65, 153, 164, 165, 168, 169
Averages, survey data, 152–170

B

Backfill, 33
Backup power, pump stations, 42
Backups, 3, 23, 75
Bags, cleaning, 81
Balanced scorecard, 177
Balls, cleaning, 81
Bedding, 33
Benchmark data
additional resources, 54
age, size, and pipe materials, 35
certification, 50–51
compliance, regulatory, 53
corrosion, 34

C

Cable machines, 83
Calibration, pump stations, 42, 43
Capacity, collection system, 2
Capacity Assurance, Management, Operation, and Maintenance (CMOM), 162, 172–173, 175
Capacity redundancy, 42

finance, 47–50
flow characteristics, 31–32
geology, 32, 33
grease, 34
groundwater, 33
information management, 54
level of service, 52
local conditions affecting design, construction, and inspection, 31–34
major system components, 31
odors, 34
O&M policies and procedures, 53–54
operation and maintenance data, 36–46
population served, 32
precipitation, 32–33
profile of 1998 survey respondents, 30–35
regulatory compliance, 53
roots, 34
safety, 51–52
soils, 33
system components, 31
system size, 31
temperature, 32, 33
terrain, 32, 33
training, 50–51
Benchmarking
performance indicators, 10, 59
process, 60–67
surveys, 140–145
worksheets, 209–218
Bloomington (Minnesota), City of, 117–126
Bonds, 176
Breaks, force mains, 44
Bucket machines, 83
Budget
performance indicators, 59
process, 25
system performance, 170, 171, 175
Bursting, pipe, 100, 102
Business practices, 156, 162, 170, 171, 172, 174, 176
Bypasses, 2
Capita, annual O&M cost per, 64, 153, 160, 162
Capital costs, funding, 176
Capital improvement plan (CIP), 4, 38, 50, 59, 67, 75, 170, 174–176
Case histories, 112–140
Categories of performance indicators, 146–147
CCTV (closed-circuit television)
    inspection, 37, 75, 172
    percent inspected, 63, 153, 156–158, 169, 170
Central Contra Costa Sanitary District (CCCSD), 115–117
Certification, 26, 50–51, 170, 171, 175, 177
Changes to enhance performance, 67–69
Characteristics of agencies, 176–178
Charlotte-Mecklenberg Utilities Department, 3, 142
Chemical cleaning methods, 84
Cholera, 2
CIP (capital improvement plan), 4, 38, 59, 67, 170, 171, 174–176
CIPP (cured-in-place pipe), 98, 100, 101
City of Bloomington, Minnesota, 117–126
City of Portland, Oregon, 3
Claims, 23
Cleaned, percent of system, 63, 153, 158–160
Cleaning
    costs, 50
    equipment, 25
    frequency, 79–80
    schedule, 156
    sewers, 36, 80–86
Clean Water Act (CWA), 8, 172
Closed-circuit television (CCTV) inspection, 37, 75, 182
CMMSs (computerized maintenance management systems), 76, 177
CMOM (Capacity Assurance, Management, Operation, and Maintenance), 162, 172–173, 175
Collection of data, 61
Collection system performance indicators, 152
Collection system performance standards, 152
Communication, 178
Community support, 178
Compaction, 33
Comparing agencies, 61–64
Comparing performance data, 150–151
Complaints, 23, 52
Complaints per 100,000 population, 66, 153, 164, 166
Compliance, regulatory, 8, 27, 53, 171–173, 176
Components
    core, program, 17
    system, 32
Computerized maintenance management systems (CMMSs), 76, 177
Computerized management program, 177, 184
Condition assessment, 158
Condition of system, 6
Confined spaces, 168
Connections, 30
Consent agreements, 8
Construction, collection systems, 4
Contracted services, 25
Controlling infiltration/inflow sources, 89–96
Conventional point repair, 100
Core components, program, 17
Corrective maintenance, 5, 166, 176
Corrosion, 34
Cost-effective use of resources, 9, 178, 183
Costs
    claims, 23, 52
    cleaning, 50
    inspection, 50
    O&M, 49–50
    regulatory fines, 53
    rehabilitation, 49
    repair, 49–50
    replacement, 50
    safety, 27
    service, 7
County Sanitation Districts of Orange County, 131–133
Crews
    inspection, pump stations, 41
    performance, 26
    size, 37
Criticality, pump stations, 41
Criticality of pump failure, 89
Cryptosporidiosis, 2
Cryptosporidium, 8
Cured-in-place pipe (CIPP), 98, 100, 101
Customer service, 7–8
CWA (Clean Water Act), 172

D
Data collection
    forms, 200–206
    performance survey, 151
    procedures, 151–152
Data management, 107–108, 162, 170, 171, 174
Debris, 78, 82, 83
Defects
    nonstructural, 97
    rehabilitation, 98–103
    repairs, 98–103
    structural, 78, 99
Denver Metro Wastewater Reclamation District, 127–131
Design, collection systems, 5, 31–34, 74
Design life, 6
Deterioration, 170, 171, 175
Developing, analyzing, and interpreting performance, 58–70
Disease-causing organisms, 8
Diseases transmitted, 2
Drop manhole, 33
Dry weather capacity, pump stations, 42, 44
Dyed water flooding, 76, 94
Dye testing, 22

E
Easement required for access, 31
Economies of scale, 164
Effectiveness of sewer cleaning methods, 86
Efficiency of managing O&M resources, 170, 171
Electrical maintenance, pump stations, 43, 87–88
Emergency maintenance, 5, 176
Emergency response, 21, 38, 44, 88–89, 104–107
Emergency stoppages, 86
Enforcement, regulatory, 170–173
Enterprise basis, 176
Environmental Periodicals Bibliography, 16
Environmental protection, 9
Equipment, cleaning, 25
Examples, performance indicators, 61–64
Explanations, survey data, 153–168
Extraordinary emergencies, 5

F
Factors influencing performance, 170–175
Failure
  air, vacuum, and air/vacuum relief valves, 45
  criticality of pump, 89
  force mains, 44–45
  pump stations, 44
Failure analysis, 158
Fats, oils, and greases (FOG) programs, 156, 160, 174
Fee-for-service basis, 176
Finance
  asset management, 25
  assets, 47–49
  budget process, 25
  cleaning, 49, 50
  contracted services, 25
  difficulties, 47
  information, 47–49
  inspection, 49, 50
  O&M, 25, 49–50
  personnel, 25
  rates, 47
  rehabilitation, 49–50
  repairs, 49–50
  replacement, 49–50
  revenue, 47
  spot repairs, 50
  value, 48
Financial management strategies, 176
Fines, regulatory, 27, 55
Flow characteristics, 31–32
Flow monitoring
  effective O&M business practices, 176–177
  pump stations, 42, 43
  sewers, 92–93
Flow velocity, 79
FOG (fats, oils, and greases) programs, 156, 160, 174
Fold-and-formed lining, 98, 101
Force mains
  age, 35
  breaks, 44–45
  corrosion, 34
  failures, 44–45
  inspection, 44
  maintenance, 19–20
  material, 35
  monitoring, 44
  O&M program, 86–89
  size, 35
Frequency
  cleaning, 79
  inspections, pump stations, 41, 43

G
Geographic Information System (GIS), 177
Geology, 32, 33
Giardia, 8
Giardiasis, 2, 9
GIS (Geographic Information System), 177
Global positioning satellite (GPS), 173
Gravity systems
  age, 35
  corrosion, 34
  inspections, 23, 24
  material, 35
  planning and scheduling, 22–23
  size, 35
  work order control, 22–23
Grease, 34, 78, 83, 84
Greater Houston Wastewater Program Survey, 144–145
Grit, 85, 86
Groundwater, 32, 33

H
Hazard awareness, 167
Health of the public, 8–9
Health warnings, 23, 52
Hepatitis, 2
High-performing agencies
  community support, 178
  financial, 176
  leadership, 176
  operation and maintenance programs, 176–177
  performance indicators, 177
  technology, 177
  training, 177
High-velocity cleaners, 80–81
Hot spot, 156
House service lines, responsibilities, 30
Houston Program Survey, 144–145
Hydraulic capacity, 170
Hydraulic cleaning methods, 80–81
Hydraulic continuity, 100, 101
Hydrogen sulfide
  corrosion, 34
  odors, 34

I
Improving collection system performance
  cleaning, 78–86
  controlling infiltration/inflow sources, 89–96
Improving collection system performance (Continued)
data management, 107–108
emergency response, 104–107
force mains, O&M program, 86–89
infiltration, 89–96
inflow, 89–96
management, data, 107–108
performance indicators, 59
physical inspection, 74–77
pump stations, O&M program, 86–89
references, 108
repair, underground, 96–104
response, emergency, 104–107
solving problems, 77–78
underground repair, 96–104
Indicators, performance
See Performance indicators
Infiltration/inflow (I/I), 23, 24, 89–96, 170, 174
Information management, 54, 170, 171, 174
Injuries, frequency, 27
Injuries, lost time, 51, 52, 66, 165, 167, 177
Inspection
air, vacuum, and air/vacuum relief valves, 45, 46
CCTV, 37, 63, 75, 157, 158, 172, 182
collection systems, 5, 21, 23, 34
costs, 50
crews, pump stations, 41
force mains, 44–45, 86–87
gravity systems, 22
internal pipe, 94–95
pump stations, 41, 86–87
relief valves, 45
staff per 10 pump stations, 64, 153, 160, 161
system, 85
Internal pipe inspection, 94–95
Interpreting data, 69
Interviews and site visits, 17
Investment, 6
ISO environmental standards, 177

J
Joint sealing, 98–99

K
Kites, cleaning, 80

L
Lateral Sealing System (LSS), 97
Leadership, 176
Level of service, 7, 17, 23, 153, 154, 162, 170, 171, 176, 178
categories, 23, 52–53
performance indicators, 58, 59, 61
Life cycle costs, 156
Lines of best fit, 152
Lining, 101

Literature review (Appendix A), 182–197
Local conditions affecting design, construction, and inspection, 31–34
Lost time injuries, 51, 52, 66, 165–167, 177

M
Main line rehabilitation, 40
Main line repairs, 39
Main line stoppage caused SSO, trend, 150
Maintenance
access structures, 30
air relief valves, 21
computerized maintenance management systems (CMMs), 76, 177
electrical and mechanical, 43
force mains, 19–21
programs, 182
pump station, 19–21
sewer, 17
tasks, 166
types, 5–6
vacuum relief valves, 21
Major system components, 31
Management
assets, 7
data, 107–108, 162, 170, 171, 174
information, 54, 170, 171, 174
O&M resources, 170, 171, 174
Mandrel testing, 75
Manhole rehabilitation, 40
Manholes, 31
Matrix, survey, 19–27
Mechanical cleaning methods, 81–83
Mechanical maintenance, pump stations, 43, 86
Monitoring
flows
effective O&M business practices, 174
pump stations, 42–43
sewers, 92–93
force mains, 44
pump stations, 42, 43
Monthly stoppage caused SSO, trend, 150

N
National Conference on Sanitary Sewer Overflows, 3
National Pollutant Discharge Elimination System (NPDES), 8, 172, 173
Needs of collection system, 9
New technologies, 173
Nonstructural defects, 97
NPDES (National Pollutant Discharge Elimination System), 8, 172, 173

O
O&M
See Operation and maintenance (O&M)
Objectives, performance survey, 151
Odors, 34, 86
Operation and maintenance (O&M)
  benefits, 6
  budget, 25
  business practices, 156, 162, 170, 171, 172, 174, 176
  cost per capita, 64, 153, 160, 162
  cost per mile of sewer, 65, 153, 163
  costs, 49–50
  data
    breaks, main line, 39
    cleaning, 36
    closed-circuit television (CCTV) inspection, 37
    crew size, cleaning, 37
    emergency response, 38
    equipment, 37
    inspection, 36
    main line rehabilitation, 40
    main line repairs, 39
    manhole inspection, 36
    manhole rehabilitation, 40
    proactive repairs, rehabilitation, and replacement, 38–40
    rehabilitation, 38–40
    repairs, 38–40
    replacement, 38–40
    spot repairs, 39
    SSOs, 37–38
    stoppages, 37–38
    visual inspection, 36
  expenditures, 25
  performance indicators
    See Performance indicators
  performance standards, 10
  policies and procedures, 53
  programs
    acceptance, 4
    administrative orders, 8
    asset management, 7
    availability of facilities and equipment, 6
    benchmarking, 10
    benefits, O&M, 6
    benefits, preventive maintenance, 5
    capital improvement plan (CIP), 4
    characteristics, 176
    compliance regulatory, 8
    condition of system, 6
    consent agreements, 8
    construction, 4
    core components, 17
    corrective maintenance, 5
    cost-effective use of resources, 9
    cost of service, 7
    customer service, 7–8
    data and information, 6
    design, 4
    design life, 6
    disease-causing organisms, 8
    emergency maintenance, 5
    environmental protection, 9
    essential elements, 4
    health of the public, 8–9
  inspection, 4
  investment, 6
  level of service, 7
  maintenance, types, 5
  management of assets, 7
  performance indicators, 7, 9–11
  problems, 2
  public health and safety, 8–9
  regulatory compliance, 8
  reliability, 6
  scheduled maintenance, 5
  startup, 4
  system performance, 6
  training, 9
  Operator training, 167
  Orange County Sanitation Districts, 131–133
  Outreach, public, 175
  Overflows, 19, 77, 173

P
Parachutes, cleaning, 81
Percent of system cleaned annually, 63, 153, 158, 159
Percent of system inspected annually by CCTV, 63, 153, 156–158, 169, 170
Performance, system
  aging of system, 170, 171, 175
  attitudes of community, management, and policy makers, 170, 171, 175
  budget, 170, 171, 175
  business practices, 156, 162, 170, 171, 172, 174, 176
  capital improvement plan (CIP), 170, 171, 174, 176
  certification, 170, 171, 175
  compliance, 170, 171, 176
  deterioration of system, 170, 171, 175
  enforcement, 170, 171
  factors, 170–175
  new technologies, 173
  O&M business practices, 156, 162, 170, 171, 172, 174, 176
  population served, 170, 171, 175
  public education, 170, 171, 175
  regulatory compliance/enforcement, 170, 171, 172, 176
  rehabilitation, 170, 171, 174, 176
  repair, 176
  replacement, 170, 171, 174, 176
  size of system, 170, 171, 175
  staff, 173
  technologies, 173
  training, 170, 171, 175
Performance data, comparing, 150
Performance deterioration, 170
Performance goal, 2
Performance indicators
  accountability, 58
  analyzing data, 69
  annual O&M cost per capita, 64, 153, 160, 162
  annual O&M cost per mile of sewer, 65, 153, 163, 164
  annual rate for residential users, 65, 153, 164, 165, 168, 169
Performance indicators (Continued)
benchmarking, 10, 58
benchmarking process, 60–67
budget, 59
capital improvement plan (CIP), 59
categories, 146–147
changes to enhance performance, 67
characteristics of high-performing agencies, 177
CIP (capital improvement plan), 59
collection of data, 60
comparing agencies, 60
complaints per 100,000 population, 66, 153, 164, 166
cost, 58
data collection, 151
developing, analyzing, and interpreting, 57–70
enhancing performance, 67
elements, 61–64
improving performance, 58
inspection staff per 10 pump stations, 64, 153, 160, 161
interpreting data, 69
level of service, 58, 59, 61
lost time injuries, 66, 153, 165–167
O&M cost per capita, 64, 153, 160, 162
O&M cost per mile of sewer, 65, 153, 163, 164
O&M programs, 7, 9–11
percent of system cleaned annually, 63, 153, 158, 159
percent of system inspected annually by CCTV, 63, 153, 156–158, 169, 170
production indicators, 59
production rates, 58
rate for residential users, 65, 153, 164, 165, 168, 169
recommendations, 69
SSOs per 100 miles of gravity sewer, 61, 153, 154, 169, 170
stakeholders meetings, 58
stoppages per 100 miles of gravity sewer, 62, 153, 154, 155
target performance levels, 67
trends, 11, 59, 61
using, 59
Performance standards, 152
Performance survey, data collection procedures, 151
Personnel
certification, 26
crew performance, 26
finance, 25
training, 26
Physical inspection, 74–77
Physical survey, 93–94
Pipe bursting, 100, 102
Pipe inspection, 94
Pipes, corrosion, 34
Planning and scheduling
gravity systems, 22
pump stations, 22
PLC (programmable logic controller) controls, 173
Policies and procedures, O&M, 53
Policymakers, 175
Polio, 2
Population served, 31, 170, 171, 175
Portland (Oregon), City of, 3
Power, backup, pump stations, 42
Precipitation, 31, 32–33
Predictive maintenance, 5, 87, 160, 176
Pretreatment inspector, 174
Preventive maintenance, 5, 87–88, 160, 176
Priority codes, 103
Proactive maintenance, 4, 75, 79, 88, 176
Proactive repairs, rehabilitation, and replacement, 38
Problems, collection systems, 2
Production indicators, 59
Production rates, 58
Professional organizations, 177
Profile of 1998 survey respondents
air relief valves, 30
air/vacuum relief valves, 30
area, 30
components, system, 31
connections, 30
force mains, 30
gravity sewer length, 30
length, gravity sewer, 30
maintenance access structures, 30
major system components, 31
manholes, 31
population served, 31
pump stations, 30
siphons, 30
system components, 31
system size, 31
vacuum relief valves, 30
Program, safety, 27
Protruding tap, 78, 97
Public advisory council, 175
Public education, 170, 171, 175
Public health warnings, 23, 52
Public outreach, 175
Pump stations
age, 35
backup power, 42
calibration, 42, 43
capacity redundancy, 42
crews, inspection, 41
criticality, 40
dry weather capacity, 42
electrical maintenance, 43
emergency response, 21, 44
failures, 44
flow monitoring, 42, 43
frequency, inspections, 41
inspection, 41
inspection crews, 41
maintenance, electrical and mechanical, 42
maintenance programs, 19–20, 176
mechanical maintenance, 42
O&M program, 86–89
power, backup, 42
redundancy, capacity, 42
running time meters, 42
SCADA systems, 41

Profile of 1998 survey respondents
air relief valves, 30
air/vacuum relief valves, 30
area, 30
components, system, 31
connections, 30
force mains, 30
gravity sewer length, 30
length, gravity sewer, 30
maintenance access structures, 30
major system components, 31
manholes, 31
population served, 31
pump stations, 30
siphons, 30
system components, 31
system size, 31
vacuum relief valves, 30
Program, safety, 27
Protruding tap, 78, 97
Public advisory council, 175
Public education, 170, 171, 175
Public health warnings, 23, 52
Public outreach, 175
Pump stations
age, 35
backup power, 42
calibration, 42, 43
capacity redundancy, 42
crews, inspection, 41
criticality, 40
dry weather capacity, 42
electrical maintenance, 43
emergency response, 21, 44
failures, 44
flow monitoring, 42, 43
frequency, inspections, 41
inspection, 41
inspection crews, 41
maintenance, electrical and mechanical, 42
maintenance programs, 19–20, 176
mechanical maintenance, 42
O&M program, 86–89
power, backup, 42
redundancy, capacity, 42
running time meters, 42
SCADA systems, 41
Index

staff, electrical and mechanical, 42
tasks performed, inspection, 41
wet weather capacity, 42

Purpose
collection systems, 2
O&M programs, 4

R

Rates
level of service categories, 23
residential users, 65, 153, 164, 165, 168, 169

Reactive maintenance, 5

Recommendations, performance indicators, 69

Record drawings, 74

Recordkeeping, 173

Redundancy, capacity, 42

Regulatory compliance/enforcement, 8, 27, 53, 170, 171, 172, 176

Rehabilitation
considerations, 97
costs, 49
defects, 98–104
inflow/infiltration, 24
manhole, 40
methods, 98
sewers, 38, 40
SSOs, 24
system performance, 170, 171, 174, 176

Reliability, 6

Repairs
costs, 49
defects, 98–104
inflow/infiltration, 24
sewers, 38, 39
SSOs, 24
system performance, 176
underground, 96–104

Replacement
sewers, 38
system performance, 170, 171, 174, 176

Researching trends in collection system performance, 15–27

Residential user rates, 65, 153, 164, 165, 169

Response, emergency, 21, 38, 44, 88–89, 104–107

Responsibility for repairs, 2, 30

Revenue, 47

Review of literature, 16, 181–197

Rodders, 81–82

Root cause failure analysis, 78

Roots, 34, 78, 85, 86

Running time meters, pump stations, 42, 43

S

Sacramento Area Sewer District (SASD), 150
Sacramento County, 113–115

Safety
cost, 27
hazards, 168

injuries, 27, 51
lost time, 51–52
program, 27, 51–52, 167, 177
public, 8

Sand, 78, 85, 86
Sanitary Sewer Overflow Federal Advisory Committee, 3
Sanitary sewer overflows (SSOs), 3, 23, 24, 37–38

SASD (Sacramento Area Sewer District), 150
Satellite collection systems, 173

SCADA (supervisory control and data acquisition) systems, 41, 86, 88, 160, 177

Scheduled maintenance, 5

Scooters, cleaning, 81

Scorecard, balanced, 177

Service, level of, 7, 17, 23, 153, 154, 162, 170, 171, 176, 178
categories, 23, 52–53

Service area, 170, 171

Sewer cleaning methods, effectiveness of, 86

Sewer maintenance, 19

Sewers, emergency response, 21

Sewer System Evaluation Surveys (SSEs), 49, 92

Silt, 78

Siphons, 30, 32

Site visits and interviews, 17

Size of system, 31, 170, 171, 175

Slip-lining, 102

Smoke testing, 24, 75, 93

Soils
bench mark data, 32, 33
corrosive, 33

Solving collection system problems, 77–78

Spot repairs, 39, 50

SSEs (Sewer System Evaluation Surveys), 49, 92

SSO reporting, 171

SSOs (sanitary sewer overflows), 3, 23, 24, 37–38

SSOs per 100 miles of gravity sewer, 61, 153, 154, 169, 170

Staff
electrical and mechanical, 42
inspection, 64, 153, 160, 161
system performance, 173
utilization, 45–46

Stakeholders meetings, 58

Standards, collection system performance, 152

Startup, collection systems, 4

Stoppages, 3, 19, 37, 38, 77, 85, 86

Stoppages per 100 miles of gravity sewer, 62, 153, 154, 155

Strategic plans, 177

Structural defects, 78, 97

Supervisory control and data acquisition (SCADA) systems, 41, 86, 88, 160, 177

Surcharging, 77

Survey respondents, profile
See Profile of 1998 survey respondents

Surveys
data analysis, 152–170
development, 17
forms, 151
matrix, 19–27
physical, 93–94

Sydney Water, Australia, performance indicators, 146–147
System components, 31
System inspection, 85
System performance
   aging of system, 170, 171, 175
   attitudes of community, management, and policy makers, 170, 171, 175
   budget, 170, 171, 175
   business practices, 156, 162, 170, 171, 172, 174, 176
   capital improvement plan (CIP), 170, 171, 174, 176
   certification, 170, 171, 175
   compliance, 170, 171, 176
   deterioration of system, 170, 171, 175
   enforcement, 170, 171
   factors influencing, 170–175
   new technologies, 173
   O&M business practices, 156, 162, 170, 171, 172, 174, 176
   O&M programs, 6
   population served, 170, 171, 175
   public education, 170, 171, 175
   regulatory compliance/enforcement, 170, 171, 172, 176
   rehabilitation, 170, 171, 174, 176
   repair, 176
   replacement, 170, 171, 174, 176
   size of system, 170, 171, 175
   staff, 173
   technologies, 173
   training, 170, 171, 175
T
   Tap, protruding, 78, 97
   Tap cutting, 99
   Target levels of performance, 67
   Tasks performed, pump station inspection, 41
   Technology
      high-performing agencies, 177
      system performance, 173
   Temperature, 32, 33
   Terrain, 32, 33
   Testing
      air, 75
      dye, 24, 76
      mandrel, 75
      smoke, 24, 75
      vacuum, 75, 173
   Tetanus, 2
   Third party notice, 172
   Tracking, 11
   Training, 9, 26, 50–51, 167, 170, 171, 175, 177
   Trench fatalities, 168
   Trenchless point repair, 99
Trends
   main line stoppage caused SSO, 150
   performance indicators, 11, 59, 61
   survey data, 152–170
   Tuberculosis, 2
   Turbulence as a design-related problem, 32
   Types of maintenance, 5
   Typhoid, 2
U
   Underground repair, 96–104
   Union Sanitary District (USD), 133–134
   Using performance indicators, 59
   Utilization, staff, 45–46
V
   Vacuum relief valves, 21, 30, 45
   Vacuum testing, 75, 173
   Value, collection system, 47
   Velocity of flow, 79
   Violations, regulatory, 27, 53
   Visual inspection, 36, 75, 76
W
   Washington Suburban Sanitary Commission (WSSC), 3
   Wastewater collection systems
      agency responsibility, 2
      backups, 3
      benchmarking, 10
      bypasses, 2
      capacity, 2
      diseases transmitted, 2
      needs, 9
      operation and maintenance (O&M) program, 3, 4
      performance goal, 2
      performance indicators, 9
      problems, 2
      purpose, 2
      sanitary sewer overflows (SSOs), 3
      stoppages, 3
   Water Environment Federation's Annual Literature Review, 16
   Weil's disease, 2
   Wet weather capacity
      limitations, 160
      pump stations, 42
   Work order control
      gravity systems, 22
      pump stations, 22
   Worksheets, benchmarking, 209–218