

**SMALL WASTEWATER SYSTEM OPERATION
AND MAINTENANCE**

Volume I

Second Edition

Chapters		Page
1	The Small Wastewater System Operator.....	1
2	Small Collection, Treatment, and Discharge Systems.....	15
3	Safety.....	63
4	Septic Tanks and Pumping Systems.....	109
5	Wastewater Treatment and Effluent Discharge Methods.....	191
6	Collection Systems.....	245
7	Maintenance and Troubleshooting.....	349
8	Setting Rates for Small Wastewater Utilities	383

Appendix

Comprehensive Review Questions and Suggested Answers.....	407
How to Solve Wastewater System Arithmetic Problems	425
Wastewater Abbreviations	458
Wastewater Words	459
Subject Index	507

SUBJECT INDEX

A

AIDS, 31
 Absorbing odors, 212
 Absorption bed, soil, 270, 271
 Absorption field, 7, 8
 Absorption mound
 construction, 232–233
 description, 230–233
 dosing, 234
 inspection, 235–239
 leakage, 238
 location, 230
 maintenance, 235
 odors, 239
 operation and maintenance, 235
 percolation rates, 230
 ponding, 236
 seepage, 237
 septic odors, 239
 size and shape, 230–232
 soil surface preparation, 232
 spongy area, 238
 troubleshooting, 235–239
 Access, terminal, 313
 Activated carbon filters, 217, 218, 219
 Activated sludge, 8
 Activated sludge process, 51–53
 Acute health effect, 77
Ad valorem taxes, 401
 Additives, septic tanks, 127
 Administration, rate setting, 398
 Adsorbing odors, 212–213
 Adsorption, 131
 Aeration tank, 49
 Aerator, 50
 Aerobic bacteria, 30
 Aerobic condition, 203
 Aesthetic, 12, 309
 Agency responsibilities, vacuum sewer, 342
 Air binding, 172, 268, 290
 Air bubblers, 161, 162, 167
 Air pressure sensor, 161, 162, 166
 Air release assemblies, 42, 43
 Air release valves, 9, 172, 266, 270, 274, 286, 288, 289
 Alarms, 165, 166
 Algae, 29, 205
 Alignment, gravity sewer, 262

Allocation, cost, 391, 396
 Alternating current (AC), 367
 Alternative treatment and disposal methods, 203
 Also see Treatment alternatives, wastewater
 Ammeter, 371–373
 Amperage, 138, 163, 166, 172, 368
 Amplitude, 367
 Amps, 368
 Anaerobic bacteria, 31, 49
 Anaerobic condition, 131
 Anaerobic decomposition, 138
 Anaerobic digester, 121
 Antisiphon valves, 292, 294
 Appurtenance, 274
 Aquifer, 7
 As-built plans
 in O&M manual, 185, 186, 188
 SDGS, 273
 vacuum sewer, 314, 326
 Assistance, financial, 401
 Atmospheric alarm unit, 81
 Auger, 365
 Auxiliary vent, vacuum sewer, 307, 308

B

BOD (biochemical oxygen demand), 32, 52, 206
 Back pressure sensor, 161, 162, 167
 Backup, wastewater, 363–365
 Backwater valves, 154
 Bacteria cultures, septic tanks, 127
 Ball valves, 153, 154, 155
 Barminutor, 55
 Base, revenue, 391, 393–395
 Base-extra capacity method, 396
 Basic conversion factors
 English system, 453
 metric system, 456
 Biochemical oxygen demand (BOD), 32, 52, 206
 Bleeder valves, 172
 Block grants, 401
 Blockages, septic tanks, 131, 162
 Blue baby syndrome, 31, 222
 Bond, 393, 397
 Bubblers, air, 161, 162, 167
 Budgeting, 12, 400
 Buffer tank, 301, 302, 303
 Bugs, 76

Building sewer
 SDGS, 266
 STEP and grinder pump systems, 136
 vacuum sewer, 296, 298, 299
 Buried sand filter, 203, 204, 205, 210
 Butt connector, 171

C

CPR (cardiopulmonary resuscitation), 84, 91, 104
 Call date, 401
 Capillary action, 222
 Capital contributions, 397
 Capital costs, 392
 Capital improvements, 393, 401
 Carbon filter, 135, 164, 278
 Cardiopulmonary resuscitation (CPR), 84, 91, 104
 Carryover of solids, septic tanks, 132
 Cash basis, 391, 393, 395
 Cash flow, 392
 Cash reserve, 391, 392, 393, 395
 Cathodic protection, 124
 Cave-ins, 99–101
 Cavitation, 336
 Central vacuum station, 315–323
 Check valves, STEP system, 153–154, 168
 Checklist, grinder pump start-up, 141, 142, 143, 144
 Chemical rehabilitation, 223
 Chemicals
 hazardous, 92–98
 septic tanks, 127
CHEMTREC [(800) 424-9300], 92
 Chest harness, 82, 83
 Chlorination, 31, 50, 58
 Chlorine contact basin, 58
 Clarifier, primary, 121
 Classes, customer, 397
 Classification, soil, 220
 Cleanouts
 pressure sewer, 285, 286, 287
 SDGS, 269, 270
 vacuum sewer, 313
 Clothing, protective, 76, 84, 105
 Coliform, 32
 Collection main
 pressure sewer, 283–289
 SDGS, 268–269, 275
 vacuum sewer, 310–314
 Collection systems
 conventional gravity, 260–265
 gravity, 37
 pressure, 38, 39, 42
 pressure sewer, 281–294
 small-diameter gravity, 265–280
 vacuum collection systems, 44–46
 vacuum sewer, 295–342
 Comminutor, 55

Commodity-demand method, 396
 Communication, 10
 Components, pumping system, 136–162
 Compost, 59
 Computer uses, rates, 398
 Conductors, 369
 Confined space entry permit, 77, 79, 80
 Confined spaces, 77–84, 365
 Connection permit, 177, 180
 Conservation, water, 127, 183
 Construction
 absorption mound, 232–233
 gravity sewer, 265
 septic tanks, 124
 vacuum sewer, 337–338
 Construction cost index (CCI), 393
 Consumer price index (CPI), 393
 Contingencies, budgeting for, 392
 Control panels
 STEP system, 158, 159, 160, 172
 troubleshooting, 365, 377–382
 Controllers, liquid level, 158, 166
 Corporation stop, 283
 Corrosion
 SDGS, 275
 vacuum sewer, 338
 Cost allocation, 391, 396
 Cost distribution, 397
 Cost records, vacuum sewer, 339
 Counteracting odors, 211
 Coverage ratio, 399
 Cracks, septic tanks, 131
 Crossover connection, 309
 Current imbalance, 371
 Customer classes, 397
 Customer file, 188, 189
 Cycle, alternating current (AC), 367
 Cycle counter, 307, 308
 Cycle, natural purification, 7, 11

D

DWV pipe, 309, 311
 Dangerous air contamination, 77, 78
 Debt service, 391, 392, 393, 395, 399
 Decay, 127
 Dechlorination, 32, 58
 Decibel, 102
 Decomposition, 127
 Defensive driving, 85
 Depletion, oxygen, 30
 Depreciation, 395
 Depressed sewer, 38
 Depth
 effective soil, 7
 gravity sewer, 262
 Detention time, 50, 121

Developing rates, 391–392
 Dewater, 59
 Direct current (DC), 367
 Discharge of wastewater, 34–37, 58, 59, 60, 203
 Discharge pumps, vacuum sewer, 320–321, 322
 Discharges, waste, 27, 29–32
 Disinfection, 31, 57–58
 Disposal, sludge, septic tanks, 130–131
 Dissolved solids, 28
 Distance, stopping, 85
 Distances, minimum, disposal systems, 221
 Distribution box, 224, 225
 Distribution of costs, 397
 Ditch, oxidation, 8, 52, 55
 Division (isolation) valves, 274, 285, 312
 Docken, Lynita, 360
 Do's and don'ts, septic tanks, 181–184
 Dosing absorption mounds, 234
 Dosing methods, sand filter, 207–209
 Drains, effluent, 38
 Drawings, system, 185, 186, 188
 Driving and traffic, 84–88
 Drop box, 224, 226
 Dry well, 136, 137
 Dusts, safety, 102
 Duties, small system operator, 9, 12
 Dye test, 228, 260, 342

E

E. coli, 206
 EGL (energy grade line), 149
 Easement, 177, 178, 260
 Effective soil depth, 7
 Effects of wastes, 29–32
 Effluent, 8
 Effluent discharge, 58, 59, 60
 Effluent drains, 38
 Electrical troubleshooting, 171, 365–375
 Electricity, 88–92, 367–375
 Emergency calls
 maintenance, 164
 pressure sewer, 290
 SDGS, 275–278
 Emergency maintenance, 355
 records, 339
 vacuum sewer, 330, 339, 341
 Emergency pumping station, 277
 Emergency response, 326
 Emergency storage, 278, 279
 Employers, operators, 9
 Energy grade line (EGL), 149
 Entrain, 55, 316
 Entry license, 177, 179
 Enzymes, septic tanks, 127
 Equipment requirements, SDGS, 273
 Equipment service card, 356, 357

Equity, 395
 Evaporation pond, 59
 Evapotranspiration system, 35, 240
 Excavation, 99–101
 Exfiltration, 124
 Expenditures, 392
 Expenses, 393–395
 Explosive gases, 79
 Extended aeration, 55

F

FOG (fats, oils, and greases), 28
 Facultative pond, 50
 Failures, leach field, 7
 Fats, oils, and greases (FOG), 28
 Fault monitoring system, 315, 322–323
 Fiberglass reinforced polyester (FRP), 139
 Field maintenance
 emergency calls, 164
 information resources, 165
 preventive maintenance, 163
 private property, 163
 safety, 164
 staff requirements, 164
 troubleshooting, 165–173
 Filters, types, 203–205
 Filtration

See Sand filter; Gravel filter, recirculating
 Financial assistance, 401
 Financial stability, 399–402
 Fires, 101
 Fittings, vacuum sewer, 311
 Fixed costs, 391, 398
 Flies, septic tanks, 135
 Float tree, 362
 Floatable solids, 28
 Floats
 flow velocity, 260
 STEP system, 158, 161, 162, 163, 164, 166, 172
 Flopper, sludge and scum measurement, 128
 Flow monitoring, 162
 Flow patterns, 47, 48
 Flow velocity, sewer, 260
 Fluorescein dye, 228
 Force main, 38, 278, 295, 329, 335, 339
 Forecasting expenditures, 393
 Friction losses, 149, 311
 Full-body harness, 82, 83
 Fumes, safety, 102

G

GFCI (ground-fault circuit interrupter), 91, 171
 GP (grinder pump), 38, 40, 42, 136, 138–144, 172, 281, 283
 Garnet, 205
 Gases, safety, 79, 102

- Gauge, sludge and scum measuring device, 129
 General obligation bond, 401
 Gravel filter, recirculating, 47, 56, 57, 210–217, 218, 219
 Gravity collection systems, 37
Also see Gravity sewer
 Gravity discharge sand filter, 203, 204
 Gravity dosing siphon, 207–208, 209
 Gravity sewer
 alignment, 262
 components, 260
 construction, 265
 depth of sewer, 262
 design, 263, 265
 flow velocity, 260
 inspection, 265
 joints, pipe, 262
 layout, 261, 262
 location, 262
 manholes, 263, 264
 pipe joints, 262
 plan and profile, 263
 size of pipeline, 262
 slope of pipeline, 262
 testing, 265
 velocity, flow, 260
 Grease, vacuum sewer, 338
 Grinder pump (GP), 38, 40, 42, 136, 138–144, 172, 281, 283
 Ground-fault circuit interrupter (GFCI), 91, 171
 Groundwater, 37
 Groundwater table, 124
- H**
- HCS (Hazard Communication Standard), 92
 HGL (hydraulic grade line), 228
 HIV virus, 31
 HRT (hydraulic retention time), 124
 Harness, safety, 82, 83
 Hazard Communication Standard (HCS), 92
 Hazardous chemicals, 92–98
 Hazardous wastes, 183
 Hazards, safety
See Safety
 Head loss, 222
 Header, 211
 Health, human, 31
 Hearing protection devices, 102, 103
 Heat shrink, 171
 Homeowner's responsibility
 septic tanks, 126
 vacuum sewer, 342
 Horizontal pump, 320, 322
 Hot tap, 9, 155
 Hybrid SDGS O&M, 274
 Hydraulic grade line (HGL), 228
- Hydraulic jump, 279
 Hydraulic retention time (HRT), 124
 Hydrogen peroxide, 223
 Hydrogen sulfide gas, 77, 131, 164
 Hydrophobic soils, 238
 Hydrosplitter, 224, 225
 Hygiene, personal, 164
 Hypochlorite, 58
- I**
- I/I
See Infiltration/inflow (I/I)
 Imbalance
 current, 371
 voltage, 372
 Imhoff cone, 28, 170
 Immunization shots, 76
 Impeller, 320
 Incineration, 59
 Infections and infectious diseases, 75–76
 Infiltration/inflow (I/I)
 collection systems, 37
 SDGS, 280
 STEP and grinder pump systems, 136
 Information resources, maintenance, 165, 358
 Injuries, 73–74
 Inorganic solids, 28
 Inorganic waste, 27
 Insecticide, 76
 Insects
 safety, 76
 septic tanks, 135
 Inspection
 absorption mound, 235–239
 gravity sewer, 265
 septic tanks, 163, 188
 Installation
 septic tanks, 124, 125
 vacuum sewer, 313–314
 Insulators, 369
 Interceptor sewer, 260, 261, 262
 Interceptor, tank, 38, 41, 121, 186
 Interface surfaces, soil infiltration, 223
 Interface valves, 44, 45, 295
 Intermittent sand filter, 203, 204, 205, 210
 Interstice, 213
 Inventory, spare parts, 188
 Invert, 38, 263
 Inverted siphon, 38
 Iron sponge, 213
 Isolation valves
 pressure sewer, 185, 285
 SDGS, 274
 vacuum sewer, 312

J

Jack-of-all-trades, 12
 Job site protection, 85–88
 Joints, pipe, 262
 Junction boxes, 171

L

LEL (lower explosive limit), 79
 Label, warning, 92, 97, 98
 Lagoon, 50
 Land treatment, 59
 Landfill, sanitary, 59
Le Système International d'Unités (SI), 438
 Leach field, 7, 8, 35, 37, 203, 214, 216, 220–229
 Leakage, absorption mound, 238
 Legal considerations, 177–180
 Level control probes, 321, 323
 License, entry, 177, 179
 Lift, 272, 310, 311, 324, 325
 Lift stations, SDGS, 272, 275, 278, 279
 Liquid level controller, 158, 161, 162, 166
 Liquid-ring vacuum pump, 317, 318, 319
 Loading guidelines, sand filter, 207
 Location, gravity sewer, 262
 Lockout/tagout procedure, 74, 75
 Lower explosive limit (LEL), 79

M

MCC
See Motor control center (MCC)
 MSDS (Material Safety Data Sheet), 92, 93, 94, 95, 96
 Maintenance
 absorption mound, 235
 emergency, 355
 equipment service card, 356, 357
 information resources, 358
 need for program, 355
 operation and maintenance (O&M) manual, 356
 pressure sewer, 290–292
 preventive, 355
 recirculating gravel filter, 213–217
 records, 356
 SDGS, 274–275
 SWIS, 228–229
 safety, 358
 sand filter, 206
 seepage beds and pits, 230
 service record card, 356, 357
 tools, 358
 vacuum sewer, 324–330, 339, 340, 341
 Management, system, vacuum sewer, 342

Manholes, 263, 264
 Manifold, 211
 Manometer, 149, 188
 Masking odors, 211
 Material, pipe
See Pipe material
 Material Safety Data Sheet (MSDS), 92, 93, 94, 95, 96
 Measuring sludge and scum, 128–130
 Mechanical float, 162
 Megger, 374
 Megohm, 374
 Mercury float, 158, 162, 164, 172
 Meters, troubleshooting, 369
 Mil, 277
 Minimum distances, disposal systems, 221
 Mists, safety, 102
 Mixed liquor, 52, 55, 56
 Monitoring
 flow and pressure, 162
 septic tanks, 188
 Morrison bleeder valves, 172
 Motor control center (MCC)
 safety, 75
 vacuum sewer, 315, 321
 Motor starter, 164
 Motor windings, 172
 Mound troubleshooting, 360–365
 Mounds
See Absorption mound
 Multimeter, 369
 Multi-stage pump, 150

N

NPDES (National Pollutant Discharge Elimination System)
 permit, 32, 33, 206, 326
 NPSH (net positive suction head), 320, 336
 Nameplate, 367
 National Electrical Code (NEC), 79, 91
 National Environmental Services Center, 9, 14
 National Fire Protection Association (NFPA), 79, 92, 97
 National Onsite Wastewater Recycling Association, 9, 14
 National Pollutant Discharge Elimination System (NPDES)
 permit, 32, 33, 206, 326
 Natural cycles, 29
 Natural purification cycle, 7, 11
 Need for operators, 7–10, 13
 Net positive suction head (NPSH), 320, 336
 Nitrate, 31
 Nitrogen cycle, 29
 Noise, 102
 Nonclog pump, 320, 321, 322
 Nutrient cycle, 29
 Nutrients, 29

O**O&M manual**

- See* Operation and maintenance (O&M) manual
- OSHA (Occupational Safety and Health Act), 74
- Obstructions, SDGS, 276–278
- Occupational Safety and Health Act (OSHA), 74
- Odors
 - absorption mound, 239
 - in drinking water, 31
 - recirculating gravel filter, 211–213
 - SDGS, 278, 279
 - septic tanks, 131, 135, 163, 168
 - vacuum sewer, 338
- Offset joint, 275
- Ohmmeter, 375
- On-site services, 296–309
- Operating expenses, 392
- Operating ratio, 399
- Operation and maintenance
 - absorption mound, 235
 - recirculating gravel filter, 213–217
 - SDGS, 273–274
 - SWIS, 228–229
 - sand filter, 206
 - seepage beds and pits, 230
 - septic tanks, 185–189
 - vacuum sewer, 324–330
- Operation and maintenance (O&M) manual
 - maintenance, 356
 - operator, 9
 - SDGS, 273
 - septic tanks, 164, 165, 185–189
 - vacuum sewer, 325–327
- Operators, small system
 - budget preparation, 12
 - communication, 10
 - duties, 9, 12
 - employers, 9
 - location, 10
 - need, 7–10, 13
 - opportunities, 9
 - pay, 10
 - public relations, 12
 - qualifications, 12–13
 - recordkeeping, 12
 - requirements, 10
 - responsibilities, 9
 - safety, 13
 - staffing, 13
 - tasks, 9
 - training, 11, 14
- Opportunities, operator, 9
- Organic solids, 28, 206
- Organic waste, 27
- Orifice, 132

Outfall, 58

- Overflows, 164
- Oxidation, 30, 211
- Oxidation ditch, 8, 52, 55
- Oxidation pond, 8, 50
- Oxygen deficiency, 77
- Oxygen depletion, 30
- Ozonation, 211

P

- Package plant, 47, 54
- Panels, control, 158, 159, 160, 172, 365, 377–382
- Pathogenic organisms, 27, 31
- Pay for operators, 10
- Peaking factor, 266
- Percolation, 7, 35
- Percolation rate, 220, 230
- Permeability, 220
- Permits
 - confined space, 77, 79, 80
 - connection, 177, 180
 - NPDES, 32, 33, 206, 326
- Personal hygiene, 164
- pH, 31
- Photocell, 128
- Photosynthesis, 49
- Physical facilities, 47
- Physical injuries, 73–74
- Pig, 268, 269, 275, 285, 286
- Pig launch port
 - pressure sewer, 42, 44
 - SDGS, 269, 270, 275, 276
- Pipe joints, 262
- Pipe material
 - collection main, SDGS, 269
 - pressure sewer, 281
 - vacuum sewer, 309, 311
- Pipe saddle, 155, 157
- Plan view
 - in O&M manual, 185
 - sewer, 263, 284
- Plug valves, 312
- Point source, 32
- Pollution, 7, 8, 11, 12
- Ponding, absorption mound, 236
- Ponds, 49
- Pore, 213
- Power requirements
 - pump, 158
 - troubleshooting, 369
- Power supply, pump, 158, 159, 160
- Pressure collection systems, 38, 39, 42
 - Also see* Pressure sewer
- Pressure dosing, 208
- Pressure monitoring, STEP discharge, 162

Pressure sewer

- air release valves, 286, 288, 289
- cleanouts, 285, 286, 287
- collection main, 283–289
- description, 281
- emergency calls, 290
- grinder pump (GP) system, 281, 283
- isolation valves, 285
- maintenance, 290–292
- pipe material, 281
- preventive maintenance, 290
- STEP system, 281, 282
- safety, 290, 292
- service line, 283
- staff requirements, 292
- troubleshooting, 292, 293
- valves, air release, 286, 288, 289
- valves, isolation, 285

Pressurized collection system, 136, 281–294

Pressurized leach field, 224, 227

Preventive maintenance

- pressure sewer, 290
- purpose of program, 355
- SDGS, 274–275
- STEP system, 163, 188
- vacuum sewer, 328–330, 339, 341

Primary clarifier, 121

Primary treatment, 30, 203

Prime, 321

Private property, 163

Procedures, troubleshooting, 360–365

Also see Troubleshooting

Process description, septic tanks, 121

Profile view

- in O&M manual, 186
- sewer, 263, 284

Programmable timer (PT), 208

Progressive cavity pump, 140, 141

Protective clothing, 76, 84, 105

Protector, water quality, 11

Public relations, 12

Public safety, 105

Pump controls, 158, 159, 160

Pump curve, 150, 151

Pump discharge check valves, STEP system, 153–154

Pump discharge valves, STEP system, 154–155

Pump power supply, 158, 159, 160

Pump station, 38

Pumping frequency, septic tanks, 131, 163

Pumping system, 136–162

Pumps, STEP system, 145–150

Purification cycle, natural, 7, 11

Putrefaction, 31

Q

Qualifications, operator, 12–13

R

- RBC (rotating biological contactor), 8, 51
- RGF (recirculating gravel filter), 47, 56, 57, 210–217, 218, 219
- RSF (recirculating sand filter), 47, 56, 57, 203, 205
- Radioactive waste, 27
- Rate design, 397
- Rate of return, 395
- Rate setting
 - ad valorem* taxes, 401
 - administration, 398
 - allocation, costs, 391, 396
 - assistance, financial, 401
 - base, revenue, 391, 393–395
 - base-extra capacity method, 396
 - block grants, 401
 - bond, 393, 397
 - budgeting, 400
 - call date, 401
 - capital contributions, 397
 - capital costs, 392
 - capital improvements, 393, 401
 - cash basis, 391, 393, 395
 - cash flow, 392
 - cash reserve, 391, 392, 393, 395
 - commodity-demand method, 396
 - computer uses, 398
 - construction cost index (CCI), 393
 - consumer price index (CPI), 393
 - contingencies, 392
 - cost allocation, 391, 396
 - cost distribution, 397
 - coverage ratio, 399
 - customer classes, 397
 - debt service, 391, 392, 393, 395, 399
 - depreciation, 395
 - design of rates, 397
 - developing rates, 391–392
 - distribution of costs, 397
 - equity, 395
 - expenditures, 392
 - expenses, 393–395
 - financial assistance, 401
 - financial stability, 399–402
 - fixed costs, 391, 398
 - forecasting expenditures, 393
 - general obligation bond, 401
 - needs, revenue, 392
 - operating expenses, 392
 - operating ratio, 399
 - philosophy, 391
 - rate design, 397
 - rate of return, 395
 - ratepayers, 398
 - recordkeeping, 398
 - replacement costs, 391, 392
 - reserve fund, 391, 393

- Rate setting (continued)
 - revenue base, 391, 393–395
 - revenue bond, 401
 - revenue requirements, 392–395
 - SURF, computer software, 398
 - stability, financial, 399–402
 - state revolving fund (SRF), 401
 - user fees, 397, 399
 - utility basis, 391, 393, 395
 - variable costs, 391, 392, 398
- Ratepayers, 398
- Reactor, 51
- Receiving water, 8, 11, 12
- Recirculating gravel filter (RGF), 47, 56, 57, 210–217, 218, 219
- Recirculating sand filter (RSF), 47, 56, 57, 203, 205
- Record drawings
 - in O&M manual, 185, 186, 188
 - SDGS, 273
 - vacuum sewer, 314, 326
- Recordkeeping
 - importance, 12
 - maintenance, 356
 - rates, 398
 - SDGS, 274
 - septic tanks, 186, 188
 - vacuum sewer, 339–341
- Reduction, 35
- Rehabilitation, leach field, 223
- Removal, sludge, septic tanks, 130–131
- Replacement costs, 391, 392
- Reserve fund, 391, 393
- Resources, information, 165
- Respiratory protection, 103
- Responsibility
 - homeowner's, septic tanks, 126
 - operator, vacuum sewer, 324, 342
 - safety, 73, 105
- Revenue base, 391, 393–395
- Revenue bond, 401
- Revenue requirements, 392–395
- Right-To-Know laws, 92
- Rod, sewer, 363
- Rodents, 76
- Rotameter, 161, 167
- Rotating biological contactor (RBC), 8, 51
- Routing traffic, 85–88
- S**
- SCBA (self-contained breathing apparatus), 81, 103
- SDGS
 - See* Small-diameter gravity sewer (SDGS)
- SDR pipe
 - See* Standard dimension ratio (SDR) pipe
- SI (*Le Système International d'Unités*), 438
- SRF (state revolving fund), 401
- STEF (septic tank effluent filter) system, 132
- STEP system
 - See* Septic tank effluent pump (STEP) system
- SURF, computer software, 398
- SWIS (subsurface wastewater infiltration system), 220–229
- Saddle, pipe, 155, 157
- Safe work environment, 104–105
- Safety
 - acute health effect, 77
 - atmospheric alarm unit, 81
 - bugs, 76
 - CPR (cardiopulmonary resuscitation), 84, 91, 104
 - cave-ins, 99–101
 - chemicals, hazardous, 92–98
 - CHEMTREC* [(800) 424-9300], 92
 - chest harness, 82, 83
 - clothing, protective, 76, 84, 105
 - confined space entry permit, 77, 79, 80
 - confined spaces, 77–84
 - dangerous air contamination, 77, 78
 - decibel, 102
 - defensive driving, 85
 - distance, stopping, 85
 - driving and traffic, 84–88
 - dusts, 102
 - electricity, 88–92, 366
 - excavation, 99–101
 - explosive gases, 79
 - fires, 101
 - full-body harness, 82, 83
 - fumes, 102
 - gases, 79, 102
 - ground-fault circuit interrupter (GFCI), 91
 - harness, safety, 82, 83
 - Hazard Communication Standard (HCS), 92
 - hazardous chemicals, 92–98
 - hazards, 73
 - hearing protection devices, 102, 103
 - hydrogen sulfide gas, 77, 164
 - immunization shots, 76
 - infections and infectious diseases, 75–76
 - injuries, 73–74
 - insecticide, 76
 - insects, 76
 - job site protection, 85–88
 - label, warning, 92, 97, 98
 - lockout/tagout procedure, 74, 75
 - lower explosive level (LEL), 79
 - MSDS (Material Safety Data Sheet), 92, 93, 94, 95, 96
 - maintenance, 164, 358
 - Material Safety Data Sheet (MSDS), 92, 93, 94, 95, 96
 - mists, 102
 - National Electrical Code (NEC), 79, 91
 - National Fire Protection Association (NFPA), 79, 92, 97
 - noise, 102
 - OSHA (Occupational Safety and Health Act), 74
 - oxygen deficiency, 77
 - permit, confined space, 77, 79, 80

- Safety (continued)
- physical injuries, 73–74
 - pressure sewer, 290, 292
 - protective clothing, 76, 84, 105
 - public safety, 105
 - respiratory protection, 103
 - responsibility, 13, 73, 105
 - Right-To-Know laws, 92
 - rodents, 76
 - routing traffic, 85–88
 - SDGS, 274
 - STEP system, 91, 164
 - safe work environment, 104–105
 - self-contained breathing apparatus (SCBA), 81, 103
 - septic tanks, 127, 188
 - shielding, 100
 - shoring, 99–100
 - signs, traffic, 86, 87
 - snakes, 76
 - stopping distance, 85
 - strains and sprains, 74
 - tagout procedure, 75
 - temporary traffic control (TTC), 85–88
 - time-weighted average (TWA), 102
 - toxic gases, 79
 - traffic, 84–88
 - vapors, 79, 102
 - vehicles, driving, and traffic, 84–88
 - ventilation, 82
 - warning label, chemicals, 92, 97, 98
 - warning tag, 74
 - work environment, 104–105
- Sand filter
- components, 205
 - dosing methods, 207–209
 - gravity dosing siphon, 207–208, 209
 - intermittent sand filter, 203, 204, 205, 210
 - loading guidelines, 207
 - maintenance, 206
 - operation and maintenance, 206
 - pressure dosing, 208
 - recirculating sand filter (RSF), 47, 56, 57, 203, 205
 - troubleshooting, 210
 - types, 203–205
- Sanitary landfill, 59
- Sanitary sewer, 259
- Scouring velocity, 260
- Scum, 30
- Scum measuring device, 129
- Scum, measuring, septic tanks, 128–130
- Secondary clarifier, 121
- Secondary treatment, 30
- Sedimentation, 207
- Seepage, absorption mound, 237
- Seepage bed, 229
- Seepage pit, 7, 229
- Self-contained breathing apparatus (SCBA), 81, 103
- Septage, 59, 127, 131, 170
- Septic condition, 30
- Septic tank effluent filter (STEF) system, 132
- Septic tank effluent pump (STEP) system
- building sewer, 136
 - control panel, 158, 159, 160, 172
 - emergency calls, 164
 - field maintenance, 163–173
 - flow monitoring, 162
 - friction losses, 149
 - illustration, 41, 152
 - information resources, 165
 - internal pump vault, 145
 - liquid level controller, 161, 162, 166
 - maintenance staff requirements, 164
 - multiple-unit assembly, 148
 - O&M manual, 185–189
 - power supply, 158
 - pressure monitoring, 162
 - pressure sewer, 38, 281, 282
 - pump discharge check valves, 153–154
 - pump discharge valves, 154–155
 - pumping system, 136, 145–150
 - riser, septic tanks, 126
 - safety, 91, 164
 - service line, 155, 156
 - total dynamic head (TDH), 149
 - troubleshooting, 169–173
 - wiring diagram, 160
- Septic tanks
- additives, 127
 - appurtenance, 126
 - bacteria cultures, 127
 - blockages, 131, 162
 - building sewer, STEP system, 136
 - carryover, solids, 132
 - chemicals, 127
 - construction, 124
 - cracks, 131
 - disposal, sludge, 130–131
 - do's and don'ts, 181–184
 - drawing, 35, 36
 - enzymes, 127
 - flies, 135
 - flopper, 128
 - homeowner's responsibility, 126
 - insects, 135
 - inspection, 163, 188
 - installation, 124, 125
 - layout, 8
 - measuring sludge and scum, 128–130
 - odors, 131, 135, 163, 168
 - pressure system, 38
 - process description, 121
 - pumping frequency, 131, 163
 - purpose, 7, 35
 - records, 186, 188

- Septic tanks (continued)
 - removal, sludge, 130–131
 - responsibility, homeowner's, 126
 - SDGS, 266, 267, 268, 274
 - STEP system, 41, 126, 136, 145–150, 152, 169–173
 - safety, 127, 188
 - scum, measuring, 128–130
 - sludge disposal, 130–131
 - sludge, measuring, 128–130
 - sludge removal, 130–131
 - solids carryover, 132
 - supernatant, 121
 - toxic materials, 127
 - troubleshooting, 131–135, 165–173, 188
 - user guide, 181–184
- Service lateral
 - pressure sewer, 283
 - SDGS, 268
 - STEP system, 155, 156
 - vacuum sewer, 309
- Service record card, 356, 357
- Service record, grinder pump, 143
- Service request, 188, 189
- Set point, 164, 290
- Settleable solids, 28
- Sewers, gravity
 - See* Gravity sewer
- Shielding, 100
- Shoring, 99–100
- Short-circuiting, 58, 234
- Signs, traffic, 86, 87
- Single-stage pumps, 150
- Siphon
 - dosing tank, 224
 - gravity dosing, 207–208, 209
 - inverted, 38
 - troubleshooting, mound, 363
- Sliding-vane vacuum pump, 317, 320
- Slope
 - gravity sewer, 262
 - SWIS, 221
- Sludge, 30
 - Sludge disposal, septic tanks, 130–131
 - Sludge judge, 128
 - Sludge measuring device, 129
 - Sludge, measuring, septic tanks, 128–130
 - Sludge removal, septic tanks, 130–131
 - Slugs, 278
 - Slurry, 139, 314
 - Small-diameter gravity sewer (SDGS)
 - as-built plans, 273
 - building sewer, 266
 - cleanout, 269, 270
 - collection main, 268–269, 275
 - components, 266–272
 - description, 265
 - emergency calls, 275–278
- equipment requirements, 273
- hybrid SDGS O&M, 274
- infiltration/inflow (I/I) 280
- lift stations, 272, 275, 278, 279
- maintenance, 274–275
- obstructions, 276–278
- odors, 278, 279
- operation and maintenance, 273–274
- pig launch port, 269, 270, 275, 276
- preventive maintenance, 274–275
- record drawings, 273
- recordkeeping, 274
- safety, 274
- septic tanks, 266, 267, 268, 274
- service lateral, 268
- spare parts, 273
- staff requirements, 273
- troubleshooting, 279–280
- valves, 270
- Smoke testing, 342
- Snakes, 76
- Soil absorption bed, 270, 271
- Soil conditioner, 59
- Soil depth, effective, 7
- Soil surface preparation, absorption mound, 232
- Soil type, 220
- Solids carryover, 132
- Solids disposal, 59
- Solids, wastewater, 27–28
- Soluble BOD, 52
- Spare parts
 - inventory, 188
 - SDGS, 273
 - vacuum sewer, 327
- Specific gravity, 79
- Splice box, 379
- Splicing wires, 171
- Spongy area, absorption mound, 238
- Stability, financial, 399–402
- Stabilization, 30, 127, 206
- Stabilization pond, 50
- Staffing
 - need for operators, 13
 - requirements
 - maintenance, STEP system, 164
 - pressure sewer, 292
 - SDGS, 273
 - Standard dimension ratio (SDR) pipe
 - SDGS, 269
 - vacuum sewer, 309, 311
 - Standby generator, vacuum sewer, 315, 322
 - Starters, motor, 164
 - Start-up, grinder pump, 142, 143, 144
 - State revolving fund (SRF), 401
 - Static lift, 311
 - Static water head, 286
 - Sterilization, 57

Stopping distance, 85
 Strains and sprains, 74
 Submersible pump, 150, 320
 Substitute chemicals, 183
 Subsurface disposal field, 7, 8
 Subsurface leaching system, 35, 37
 Subsurface wastewater infiltration system (SWIS), 220–229
 Sulfur dioxide, 49, 58
 Supernatant, 121
 Surcharge, 270, 360
 Suspended solids, 27, 28, 131
 System drawings, 185, 186, 188
Système International d'Unités (SI), 438

T

TDH (total dynamic head), 149, 320
 TTC (temporary traffic control), 85–88
 TWA (time-weighted average), 102
 Tagout procedure, 75
 Telemetering equipment, 290
 Temporary traffic control (TTC), 85–88
 Terminal access, 313
 Testers, troubleshooting, 369
 Testing
 gravity sewer, 265
 septic tanks, 188
 Thermal waste, 27
 Threshold odor, 213
 Thrust block, 314
 Timer, 208, 216
 Time-weighted average (TWA), 102
 Toggle switch, 172
 Toning wire, 155, 273, 314
 Tools
 maintenance, 358
 troubleshooting, 369
 Topography, 37, 259
 Total dynamic head (TDH), 149, 320
 Total solids, 28
 Toxic gases, 79
 Toxic materials, septic tanks, 127
 Tracer dyes, 228, 260, 342
 Traffic, safety, 84–88
 Training, operator, 11, 14, 324
 Transpiration, 29
 Treatment alternatives, wastewater
 absorption mound, 230–239
 activated sludge, 51–53
 evapotranspiration system, 35, 240
 flow diagram of processes, 34, 48
 gravel filter, 47, 56, 57, 210–217, 218, 219
 oxidation ditch, 52
 pond, 49
 rotating biological contactor, 51
 sand filter, 47, 56, 57, 203–210
 seepage beds and pits, 229

subsurface wastewater infiltration system (SWIS), 220–229
 types of processes, 34–37, 47–57
 Trench, leach fields, 222
 Trickling filter, 49
 Troubleshooting
 absorption mound, 235–239
 alarm activation, 360–363
 ammeter, 371–373
 backup, wastewater, 363–365
 control panels, 365, 377–382
 electrical equipment, 171, 365–375
 grinder pumps, 172
 house service line, 169
 megger, 374
 meters, 369
 mound, 360–365
 odors, septic tanks, 131
 ohmmeter, 375
 operating problems, septic tanks, 188
 pressure sewer, 292, 293
 procedures, 360–365
 pumps, 169–170, 362, 363
 SDGS, 279–280
 STEP system, 134, 169–173
 sand filter, 210
 septic tanks, 131–135, 165–173, 188
 siphon, 363
 testers, 369
 tools, 369
 vacuum sewer, 330–339
 voltage testing, 369–371
 Turbine pump, 150, 167

U

Ultrasonics, 162
 Uniformity coefficient, 210
 User fees, 397, 399
 User guide, septic tanks, 181–184
 Utilities list, 188
 Utility basis, 391, 393, 395

V

Vacuum collection systems, 44–46
 Also see Vacuum sewer
 Vacuum collection tank, 316–317
 Vacuum interface valves, 44, 45, 295
 Vacuum pumps and gauges, 317–320
 Vacuum sewer
 agency responsibilities, 342
 as-built plans, 314, 326
 auxiliary vent, 307, 308
 building sewer, 296, 298, 299
 central vacuum station, 315–323
 cleanouts, 313
 collection main, 310–314

- Vacuum sewer (continued)
- components, 296–323
 - construction, 337–338
 - corrosion, 338
 - cost records, 339
 - description, 295
 - discharge pumps, 320–321, 322
 - emergency maintenance, 330, 339, 341
 - fault monitoring system, 315, 322–323
 - fittings, 311
 - grease, 338
 - homeowner responsibilities, 342
 - installation, 313–314
 - isolation valves, 312
 - layout, system, 296, 310–311
 - level control probes, 321, 323
 - maintenance, 324–330, 339, 340, 341
 - management, system, 342
 - motor control center (MCC), 315, 321
 - odors, 338
 - on-site services, 296–309
 - operation and maintenance, 324–330
 - pipe, 309, 311
 - preventive maintenance, 328–330, 339, 341
 - record plans, 314, 326
 - recordkeeping, 339–341
 - responsibilities, operator, 324, 342
 - service line, 309
 - spare parts, 327
 - standby generator, 315, 322
 - training, operator, 324
 - troubleshooting, 330–339
 - vacuum collection tank, 316–317
 - vacuum pumps and gauges, 317–320
 - vacuum station piping, 322
 - vacuum valves, 301, 304, 305, 306, 307, 331–334
 - valve pits and sumps, 299–301, 302, 303
 - valves, isolation, 312
 - Vacuum station piping, 322
 - Vacuum valves, 301, 304, 305, 306, 307, 331–334
 - Valve pits and sumps, 299–301, 302, 303
 - Valves
 - air release valves, 9, 172, 266, 270, 274, 286, 288, 289
 - interface valves, 44, 45, 295
 - isolation valves, 274, 285, 312
 - plug valves, 312
 - SDGS, 270
 - STEP system, 153–154
 - sizes and types, 188
 - vacuum interface valves, 44, 45, 295
 - vacuum valves, 301, 304, 305, 306, 307, 331–334
 - Vapors, safety, 79, 102
 - Variable costs, 391, 392, 398
 - Vault, grinder pump, 138
 - Vehicles, driving, and traffic, 84–88
 - Velocity, flow, gravity sewer, 260
 - Velocity, scouring, 260
 - Ventilation, 82
 - Vertical pump, 320, 321
 - Video, wastewater flow, 220
 - Void, 132
 - Volatile solids, 55
 - Voltage imbalance, 372
 - Voltage testing, 369–371
 - Volts, 367
 - Volute, 320

W

- Warning label, chemicals, 92, 97, 98
- Warning tag, 74
- Waste discharges, 27, 29–32
- Waste, organic and inorganic, 27
- Waste treatment pond, 49
- Wastewater characteristics, 27–28
- Wastewater pumping system, 136–162
- Wastewater, quantity, 259
- Wastewater solids, 27–28
- Water conservation, 127, 183
- Water quality protector, 11
- Waterlogging, 331
- Watts, 368
- Weir, 52
- Wet well, 136, 137
- Wetlands, 59, 60
- Windings, motor, 172
- Wiring diagram, 160
- Work environment, safety, 104–105