Wisconsin Department of Natural Resources
Wastewater Operator Certification

Sanitary Sewage Collection System Study Guide

August 2018 Edition

Wisconsin Department of Natural Resources
Operator Certification Program PO Box 7921, Madison, WI 53707

http://dnr.wi.gov

Printed on 09/13/18

Preface

This Collection System Study Guide is an important resource for preparing for the SS certification exam and is arranged by chapters and sections. Each section consists of key knowledges of important concepts you need to know for the certification exam. While it is not a state requirement, operators of satellite sewerage collection systems are strongly encouraged to become certified in the SS subclass.

Other references include:
1. Section NR 210.23 Capacity, Management, Operation, and Maintenance Programs.

2. Chapter NR 110 Sewerage Systems

3. Chapter SPS 382 Design, Construction, Installation, Supervision, Maintenance And Inspection Of Plumbing (otherwise referred to as the Wisconsin plumbing code). Wisconsin Safety and Professional Services Published under s. 35.93 Wisconsin State Statutes

4. OSHA 1910.146 Confined Space Entry

5. Water Environment Federation (WEF) Collection Systems Operators’ Guide to Preparing for the Certification Examination 2014

In preparing for the exams:

1. Study the material! Read every key knowledge until the concept is fully understood and committed to memory.

2. Learn with others! Take classes in this type of wastewater operations to improve your understanding and knowledge of the subject.

3. Learn even more! For an even greater understanding and knowledge of the subjects, read and review the references listed above and at the end of the study guide.

4. Knowledge of the study guide material will be tested using a multiple choice format. Every test question and answer comes directly from one of the key knowledges.

Choosing a test date:

Before choosing a test date, consider the time you have to thoroughly study the guide and the training opportunities available. A listing of wastewater training opportunities and exam dates is available at http://dnr.wi.gov by searching for the keywords “Operator Certification”.

Acknowledgements

Dave Flowers, Natural Water Solutions, LLC
Gary Hanson, SEH, Inc.
Joan Hawley, Superior Engineering, LLC
Kevin Mraz, Algoma Sanitary District No. 1
Larry Claude, Energenecs, Inc.
Lyle Lutz, Village of Plover Wastewater Utility
Matt Schmidt, NEW Water

Sam Warp, Marshfield Wastewater Utilities
Tim Zimmerman, Village of Germantown
Bernie Robertson, Department of Natural Resources, Madison, WI
Jack Saltes, Department of Natural Resources, Madison, WI
Nathan Wells, Department of Natural Resources, Madison, WI
Taylor Steager, Department of Natural Resources, Madison, WI

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Chapter 1 - Collection System Terminology

Section 1.1 - Terminology

1.1.1 Acronyms

Common Collection System Acronyms

BOD	Biochemical Oxygen Demand
CCTV	Closed Circuit Television
CMAR	Compliance Maintenance Annual Report
CMMS	Computerized Maintenance Management System
CMOM	Capacity, Management, Operations and Maintenance
CIPP	Cured-in-place pipe
DO	Dissolved Oxygen
DOT	Department of Transportation
ERP	Emergency Overflow Response Plan
FOG	Fats, Oils & Grease
FPS	Feet per second
GPM	Gallons per minute
GPS	Global Positioning System
GIS	Geographic Information System
HRT	Hydraulic Retention Time
IDLH	Immediately Dangerous to Life or Health
I/I	Infiltration/Inflow
LEL	Lower Explosive Limit
LOTO	Lockout-Tagout
MGD	Million Gallons Per Day
MUTCD	Manual on Uniform Traffic Control Devices
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PIG	Pipeline Inspection Gauge
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
SCADA	Supervisory Control and Data Acquisition
SSO	Sanitary Sewer Overflow
STEP	Septic Tank Effluent Pump
TSS	Total Suspended Solids
VFD	Variable Frequency Drive
WDNR	Wisconsin Department of Natural Resources
WEF	Water Environment Federation
WPDES	Wisconsin Pollutant Discharge Elimination System
WWTP	Wastewater Treatment Plant

1.1.2 Define aerobic (oxic) [O2].

Aerobic is a condition under which free and dissolved oxygen (DO) is available in an aqueous environment.

1.1.3 Define anaerobic (septic) [Ø].

Anaerobic is a condition under which free, dissolved, and combined oxygen is unavailable in an aqueous environment.

1.1.4 Define anoxic.

Anoxic is a condition under which oxygen is only available in a combined form such as nitrate (NO3-), nitrite (NO2-), or sulfate (SO4-2) in an aqueous environment.

1.1.5 Define biochemical oxygen demand (BOD).

BOD, expressed in mg/L, is a measurement of the organic strength of a sample by measuring the amount of oxygen consumed over a given period of time.

1.1.6 Define bloodborne pathogens.

Bloodborne Pathogens means pathogenic microorganisms that are present in blood and other bodily fluids that can cause disease in humans. They have the ability to live outside of the human body.

1.1.7 Define combined sewer.

Combined sewers are pipe conveyances that carry both wastewater and storm water in a single pipe.

1.1.8 Define competent person.

A competent person is a trained individual who is responsible for identifying existing and predictable hazards of an excavation. A competent person also determines the soil types and protective systems to be used during an excavation. They are authorized to take prompt corrective measures to eliminate working conditions that are hazardous, unsanitary, or dangerous to workers.

1.1.9 Define composite sample.

A composite sample is a sample prepared by combining a number of grab samples, typically over a 24-hour period.

1.1.10 Define confined space.

A confined space is a space large enough for an operator to enter and perform assigned work. It has limited or restricted means for entry or exit and is not designed for continuous occupancy. It may contain a hazardous atmosphere or contain material with the potential to engulf someone who enters the space (storage bins).

1.1.11 Define dissolved oxygen (DO).

DO is the measure of the amount of oxygen dissolved in water and is expressed in mg/L.

1.1.12 Define dry well.

A dry well is the portion of a lift station which is isolated from the wastewater and typically contains the equipment for the lift station to operate.

1.1.13 Define effluent.

Effluent is the treated wastewater discharged from a treatment plant to the environment.

1.1.14 Define excavation.

An excavation is any man-made cut, cavity, trench, or depression that is formed by earth removal.

1.1.15 Define feet per second (fps).

The term fps is a common water velocity measurement expressed as the number of feet the water travels in a second.

1.1.16 Define flume.

A flume is a primary measuring device used in an open channel to measure flow.

1.1.17 Define four gas meter.

A four gas meter is a portable device that simultaneously measures up to four gases from specific sensors and will alarm when gas readings exceed preset limits. Four gas meters are commonly used for confined space atmospheric monitoring. It measures Oxygen (O_2), Carbon Monoxide (CO), Lower Explosive Limit (LEL), and Hydrogen Sulfide (H_2S) atmospheric concentrations.

1.1.18 Define gallons per day (gpd).

The term gpd is a common wastewater flow measurement expressed as the number of gallons flowing each day.

1.1.19 Define gallons per hour (gph).

The term gph is a common wastewater flow measurement expressed as the number of gallons flowing each hour.

1.1.20 Define gallons per minute (gpm).

The term gpm is a common wastewater flow measurement expressed as the number of gallons flowing each minute.

1.1.21 Define grab sample.

A grab sample is a single sample taken at a particular time and place that is representative of the current conditions.

1.1.22 Define grit.

Grit is the fine, abrasive particles removed from wastewater, such as sand and eggshells.

1.1.23 Define hydraulic retention time (HRT).

HRT is a period of time that liquid is in a system.

1.1.24 Define inflow and infiltration (I/I).

I/I is any unwanted clearwater that leaks into a collection system. Generally, it consists of groundwater, rainwater, or snowmelt.

1.1.25 Define influent.

Influent is the raw (or untreated) water entering a system.

1.1.26 Define lift pump station.

A lift station is an underground chamber with pumps that is used to elevate (lift) wastewater to a higher grade. Lift stations are located within a collection system.

1.1.27 Define manhole.

A manhole is a structure that provided access to a collection system. It is typically a round opening with a cast-iron cover.

1.1.28 Define milligrams per liter (mg/L).

The measurement mg/L is a concentration of a substance in a liquid expressed as a weight in milligrams per liter of volume (mg/L). Milligrams per liter is the same as parts per million (ppm). 1 mg/L = 1 ppm
(One liter of water weighs 1,000,000 mg)

1.1.29 Define million gallons per day (MGD).

MGD is a common wastewater flow measurement in a treatment plant, expressed as millions of gallons (MG) of wastewater flowing each day.

1.1.30 Define pathogenic organisms.

Pathogenic organisms are disease-causing microorganisms. They include various bacteria, viruses, and parasites. The discharge of waterborne human wastes contain these organisms and they will be present in the wastewater collection system.

1.1.31 Define pH.

pH is a measure of the acidity or alkalinity of a sample on a scale of 0 to 14 (acidic to alkaline). A pH of 7 is neutral.

1.1.32 Define sanitary sewer or collection system.

A sanitary sewer or collection system is an underground pipe system used to convey wastewater to a treatment facility.

1.1.33 Define sanitary sewer overflow (SSO).

A SSO is a release of wastewater from a sewage collection system or an interceptor sewer directly into a water of the state or to the land surface. All SSOs must be reported to the Department of Natural Resources within 24 hours of the occurrence.

1.1.34 Define screenings.

Screenings are the materials removed from wastewater with a screening mechanism. Screenings can include: sticks, rags, wipes, plastics, and personal hygiene products.

1.1.35 Define septage.

Septage means the wastewater or hauled contents of septic or holding tanks, dosing chambers, grease interceptors, seepage beds, seepage pits, seepage trenches, privies or portable restrooms, and landfill leachate waste.

1.1.36 Define storm sewer.

A storm sewer is an underground pipe system that collects rainwater from streets and conveys it to a place other than the wastewater treatment plant.

1.1.37 Define total suspended solids (TSS).

TSS is the measure of the total amount of solids suspended in a sample and is expressed in mg/L.

1.1.38 Define treatment facility overflow (TFO).

A TFO is a release of wastewater from a treatment process unit located within the wastewater treatment plant directly into a water of the state or to the land surface. All TFOs must be reported to the Department of Natural Resources within 24 hours of the occurrence.

1.1.39 Define treatment process.

A treatment process means a physical, biological, or chemical action that is applied to wastewater to remove or reduce pollutants.

1.1.40 Define treatment unit.

A treatment unit is an individual structure or equipment within a collection system or a wastewater treatment facility that is part of a treatment process.

1.1.41 Define trench.

A trench is a narrow excavation made below the surface of the ground. In general, the depth of a trench is greater than its width, and the width (measured at the bottom) is not greater than 15 ft.

1.1.42 Define variable frequency drive (VFD).

A VFD is a type of drive controller used to adjust the frequency and voltage supplied to an electric motor.

1.1.43 Define weir.

A weir is a level control structure used to provide uniform flow.

1.1.44 Define wet well.

A wet well is a tank where wastewater is collected. The wastewater is then pumped from the wet well. Wet wells are commonly found in lift stations and at the headworks of the wastewater treatment plant.

1.1.45 Define the Wisconsin Pollutant Discharge Elimination System (WPDES) permit.

Wisconsin Pollutant Discharge Elimination System (WPDES) permits contain all the monitoring requirements, special reports, and compliance schedules appropriate to a permit that covers a specific discharge or pollutants, such as a wastewater treatment plant or a municipal storm sewer system.

Chapter 2 - Safety

Section 2.1 - General

2.1.1 List the safety hazards that are present in the collection system.

Collection system operators are exposed to multiple safety hazards while performing work in the collection system. Typical collection system work may expose an operator to the following hazards:

A. Bloodborne pathogens
B. Confined spaces and atmospheric conditions
C. Electrical
D. Excavation
E. Fire
F. Hazardous chemicals
G. High noise conditions
H. Inclement weather
I. Mechanical equipment
J. Slips, trips, and falls (physical)
K. Traffic

Note that Wisconsin Department of Safety and Professional Services SPS 332 Public Employee Safety and Health must be followed. All operators must also follow OSHA CFR 29 part 1910.

Section 2.2 - Confined Space Entry and Atmospheric Conditions

2.2.1 Define confined space entry requirements.

Collection system operators must follow all confined space entry procedures required by their utility and OSHA 29 CFR part 1910.146. The following items are example requirements of a permit for a confined space entry:

A. Confined space entry permit
B. Proper PPE on entrant
C. Attendant and/or entry supervisor on standby
D. Communication plan reviewed
E. Rescue/entry equipment setup
F. Atmospheric monitoring before and during entry
G. Lockout-tagout applicable

H. Traffic control in place
I. Area is secure
J. Properly trained to enter the confined space
K. First Aid and CPR

Figure 2.2.1.1

Confined Space Entry

Courtesy of New Water

2.2.2 Discuss the importance of gas monitoring in the collection system.

Proper confined space entry procedures shall be followed and a four gas meter is required for any confined space entry into the collection system. The atmosphere in a sewer system is a complex mixture of toxic and nontoxic gases from bacteria or chemicals breaking down organic materials in collection system wastewater. Decomposition of wastewater produces sewer gases, which include carbon monoxide, methane, and hydrogen sulfide. Fuels, industrial solvents, and other gases may also be present in the collection system. The presence of these gases can create oxygen deficiency, toxic atmospheres, and explosive conditions. All of these gases and vapors require monitoring to provide early warning of life threatening conditions. Reference OSHA standard 1910.146 for current atmospheric exposure limits in confined spaces.

Figure 2.2.2.1

4 Gas Meter

City of Marshfield

2.2.3 Define and discuss carbon monoxide (CO).

Carbon monoxide is a poisonous, colorless, odorless, and tasteless gas. CO is harmful to human health since it displaces oxygen in the blood and deprives the brain, heart, and other critical organs of oxygen.

2.2.4 Define and discuss hydrogen sulfide (H2S).

Hydrogen sulfide is a flammable, colorless, and extremely hazardous gas with a “rotten egg” smell. Low concentrations of H2S can irritate the eyes, nose, throat, and respiratory system. Moderate concentrations can cause coughing, headaches, dizziness, nausea, vomiting, difficulty breathing, and loss of smell. High concentrations are immediately dangerous to life or health (IDLH) and can cause shock, convulsions, inability to breathe, unconsciousness, coma, and death.

2.2.5 Define and discuss methane (CH4).

Methane gas is explosive, tasteless, odorless, and is lighter than air. OSHA has no permissible exposure limit for methane, but the National Institute of Occupational Safety and Health (NIOSH) maximum methane exposure concentration during an 8-hour period is 1,000 ppm or 0.1 percent. Atmospheric levels above 50,000 ppm or 5 percent can be explosive and asphyxiation occurs at levels of 500,000 ppm or 50%.

Section 2.3 - Electrical Hazards

2.3.1 Discuss electrical dangers that are present in the collection system.

A collection system operator’s job involves the use of various electrical systems and tools. Operators are often exposed to hazardous wet and damp conditions. Injuries and deaths can occur from the unexpected energization of machinery and equipment along with electrical sources not being properly de-energized. It is critical that all collection system operators follow proper lockout-tagout procedures, manufacturer’s instructions, and are aware of their surroundings while working with electricity.

2.3.2 List the common sources of electrical hazards found in the collection system.

A. Power lines – overhead & underground
B. Control power feed sources
C. Electrical generators
D. Power tools
E. Exposed electrical parts
F. Inadequate wiring
G. Damaged electrical insulation
H. Damp/Wet conditions
I. Improper grounding

2.3.3 Describe the dangers of arc flash.

An arc flash is an event where a flashover of electric current leaves its intended path and travels through the air to the ground or from one conductor to another. When a human is in close proximity to an arc flash occurrence, serious injury and even death can occur. Proper PPE and training must be followed when working around electrical equipment and sources.

Dangers typically present from an arc flash can include:

A. Burns to the human body
B. Heat (temperatures can reach up to 35,000 ºF)
C. Fire
D. Flying debris
E. High blast sound (noise can reach 140 dB)

Section 2.4 - Excavating and Trenching

2.4.1 Describe the purpose of Diggers Hotline.

Diggers Hotline or one-call center is used to locate underground or overhead utility infrastructure. Knowing the location of the utility lines avoids hazards to workers or damage to existing utilities during construction or repair. State law requires that all projects that disrupt the ground surface require a locate request to be filed with Diggers Hotline. All utilities are marked with color coded flags and paint to indicate what type of utility is underground. Sewer is green, water is blue, electric is red, natural gas is yellow, communication is orange, and white is proposed (new) construction. Locating is for member utilities only.

Figure 2.4.1.1

Broken sanitary main from directional boring for utility line

Village of Germantown

2.4.2 Discuss trench safety measures.

OSHA standards require safe access and egress (exit) to trench depths greater than 4 feet. Ladders, steps, or ramps shall be located within 25 feet of the worker. All trench excavation materials, tools, and equipment must be located a minimum of 2 feet from the trench opening. All trenches shall be inspected at the start of each shift and after a rain event or water intrusion.

2.4.3 Describe excavation protective systems.

Protective systems provide the support for trench faces and prevent movement of soil and collapse of trench walls. There are several basic types of protective systems; sloping, benching, shoring, and shielding. Excavation depths 5 feet or greater require a protective system as determined by the competent person.

Figure 2.4.3.1

Protective shoring for utility work

Village of Germantown

Section 2.5 - Fire Safety

2.5.1 Discuss the common fire hazards in the collection system.

Vapors from flammable materials discharged or generated in a collection system can result in fires and explosions. These vapors can be ignited by electric sparks, friction, or heat generated by chemical reactions.

Section 2.6 - Hazardous Materials

2.6.1 Define and discuss hazardous materials in the collection system.

Hazardous materials in the collection system are any type of chemical, gas, or substance that creates a safety hazard to operators. Operators are often exposed to sewage, which can contain unknown substances, pharmaceuticals, and bloodborne pathogens. In addition, operators may use various chemicals, fuels, oils, herbicides and insecticides while performing work. Employers are responsible for providing Safety Data Sheets, training and information to employees regarding the hazards associated with using chemicals per OSHA's Hazard Communication Standard.

2.6.2 Discuss treatment system effects from using chemicals in the collection system.

Different chemicals are used to mitigate the effects of fats, oil and grease, roots, odor control, or hydrogen sulfide control in the collection system. These chemicals may impact the wastewater biology. The quantity and toxicity of the chemicals and additives should be reviewed with the wastewater treatment staff to ensure there are no detrimental impacts to the wastewater treatment plant.

Section 2.7 - Infectious Diseases

2.7.1 Discuss the hazards associated with bloodborne pathogens and infectious diseases.

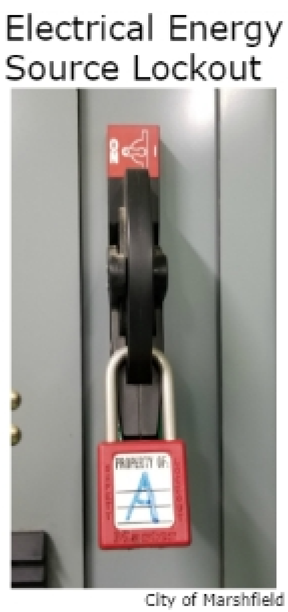
Collection system operators are susceptible to exposure to dangerous pathogens and infectious substances. The OSHA Bloodborne Pathogen Standard protects collection system operators from exposure to blood and other dangerous infectious materials. OSHA's Bloodborne Pathogen Standard requires all employers to have a written exposure control plan in place, provide training, and offer immunization (Hepatitis B). Operators should wear proper PPE, such as rubber gloves, safety glasses, and boots to help limit exposure.

Section 2.8 - Control of Hazardous Energy

2.8.1 Definition of hazardous energy.

The unexpected energy startup or release of stored energy that can result in serious injury or death. Energy sources include electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other sources within machines, pipes, and equipment. Hazardous energy is typically controlled by lockout-tagout procedures.

Figure 2.8.1.1



2.8.2 Define lockout-tagout (LOTO).

The term lockout-tagout (LOTO) refers to a safety procedure that ensures that dangerous machines and energy sources are isolated and do not unexpectedly release hazardous energy or start up before the completion of maintenance or servicing work. Without a LOTO system, the possibility exists that a system may unexpectedly start-up or release stored energy from a control system or by someone that does not realize maintenance is being performed.

2.8.3 Discuss the importance of lockout-tagout (LOTO).

LOTO is critical to the safety of collection system operators to prevent serious or fatal injuries from hazardous energy sources. OSHA requires all employers to establish an energy control program that defines LOTO procedures for equipment and machinery.

The program also requires training for all affected employees of the LOTO program. Employers shall review their procedures on an annual basis to ensure safe practices are being followed and procedures are current.

Section 2.9 - Manhole Hazards

2.9.1 Discuss the safety hazards when working in and/or around manholes.

Working near or in a manhole inherits potential dangers which may result in serious injury or death. Common manhole safety hazards are:

A. Falls/slips
B. Fire or explosion
C. Unsafe atmosphere
D. Drowning or engulfment
E. Falling objects

Physical hazards include:

A. Lifting
B. Pests
C. Weather
D. Traffic

Before working in or near a manhole, access the area and terrain around the manhole for potential safety hazards and take appropriate actions to mitigate the risks. Traffic control is an integral part of creating a safe access to manholes in the roadway. Proper confined space entry procedures are required when entering any type of manhole. Always use proper lifting techniques when lifting manhole covers.

Section 2.10 - Personal Protective Equipment (PPE)

2.10.1 List the different types of PPE available for collection system operators.

Operators are exposed to multiple safety hazards while performing work in the collection system. The use of proper PPE is critical to the protection and safety of operators. The following list is common PPE that operators use:

A. Eye protection – safety glasses, goggles, face shields
B. Hand protection – rubber, leather, insulated gloves
C. Hearing protection – ear plugs, muffs
D. Foot protection – safety shoes and boots
E. Clothing – high visibility, rain suits, winter clothing, hard hat, Tyvek
F. Fall protection – harness
G. Respiratory protection – respirators, four gas meter

2.10.2 List and explain the different safety classes of clothing for working in traffic.

All collection system operators who perform work within the road right-of-way and are subsequently exposed either to traffic and/or construction equipment within the traffic control zone shall wear high-visibility safety apparel that meet the Performance Class 2 or 3 requirements of ANSI/ISEA 107 which is located on the tag of the clothing. The following classes of safety clothing are available for collection system operators:

Class 1 Clothing – Operator exposure to traffic safety hazards are minimal and vehicle/equipment speeds are under 25 mph where work is being performed. Example of work areas include parking lots, sidewalks, fields, and terraces.

Class 2 Clothing – Operator is exposed to areas with traffic safety hazards. Work may position operators in close proximity of traffic where vehicle/equipment speeds are greater than 25 mph. Inclement weather and construction activities may obstruct driver's view of collection system operators. Examples of work areas include city/village roadways, county roadways, residential roadways, and roadway construction areas.

Class 3 Clothing – Operator is exposed to high speed traffic hazards and/or conditions reduce visibility of collection system operators especially night conditions. Class 3 clothing is required at all times for night time work and flagging operations per Wisconsin DOT. Per ANSI/ISEA 107, wearing high visibility pants along with a Class 2 vest meets the requirements for a Class 3 garment. Examples of work areas include federal highways/interstates, state roadways/highways, inclement weather (rain/snow), and night time work.

Figure 2.10.2.1

Section 2.11 - Traffic/Work Zone

2.11.1 Discuss the importance of traffic control while working in the collection system.

Collection system work is often in the road and right-of-way, exposing operators to traffic safety hazards. It is vital to the safety of collection system operators that they follow safe practices when working in and around traffic and evaluate their surroundings. Traffic control procedure and devices should be communicated and implemented before performing work in a particular traffic area using guidelines found in the Federal Manual on Uniform Traffic Control Devices (MUTCD).

Figure 2.11.1.1

Traffic control for large diameter CIPP installation

Village of Germantown

Chapter 3 - System Components

Section 3.1 - Pipes

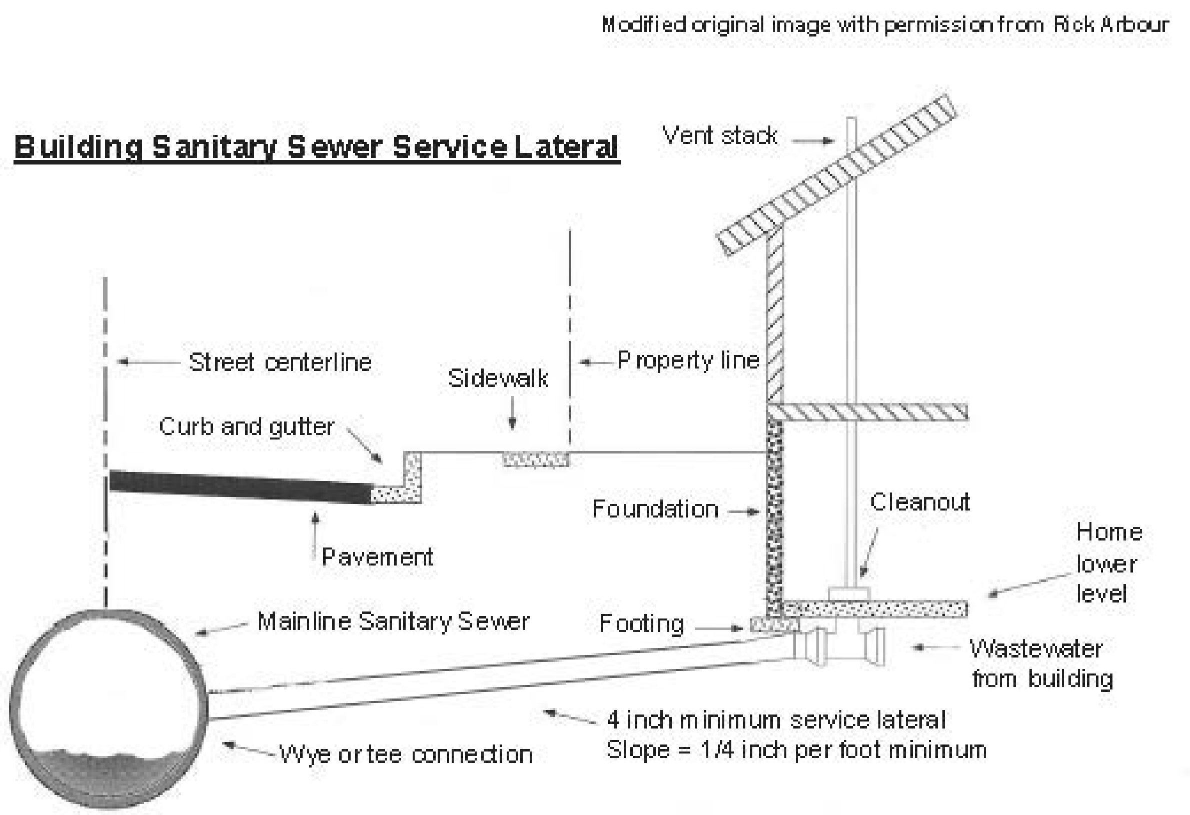
3.1.1 Describe gravity sewers.

Gravity sanitary sewers typically consist of circular pipe sizes from 8-inches to 144-inches with the majority of pipe sizes ranging from 8-inch to 12-inch in collection systems. Note in some older systems there are 6-inch sanitary sewers. Gravity sewers are designed with a slope to achieve minimum flow velocities of 2 feet per second to prevent solid settling and shall be laid with a consistent slope between manholes.

3.1.2 Discuss laterals (building sewers).

A building (lateral) sewer is a pipe that conveys sewage from the building plumbing to the public sewer main. The minimum size of a gravity flow sewer is 4-inch and is typically constructed of PVC pipe. Building sewer ownership and maintenance is regulated by local sewer use ordinance while lateral construction must meet state plumbing code standards.

Figure 3.1.2.1



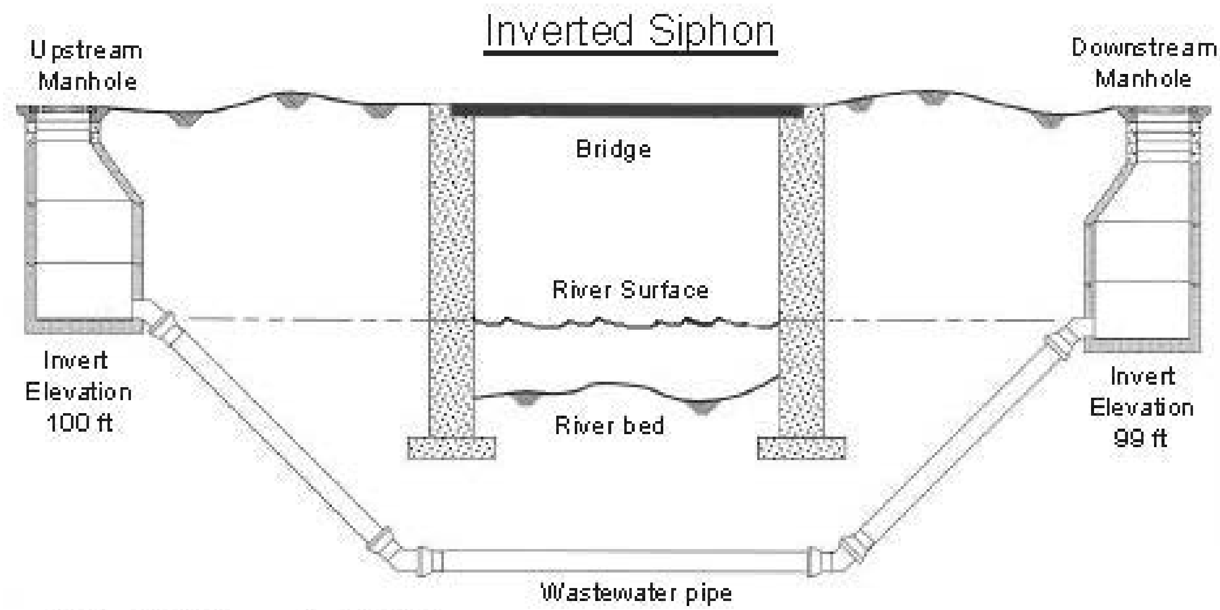
3.1.3 Describe the disadvantages of combined sewer systems.

Combined sewer volumes can reduce the efficiency and effectiveness of a treatment facility. When treatment plant or collection system capacity is exceeded, the water from combined sewers may cause backups or bypass infrastructure, discharging directly into a surface waterbody. Discharging raw (untreated) human sewage and other pollutants in the water is extremely dangerous to both aquatic ecosystems and humans.

3.1.4 Describe an inverted siphon.

An inverted siphon is a pipe that must dip below an obstruction and will normally form a U-shaped flow path. The liquid flowing in one end simply forces liquid up and out the other end. Inverted siphons are commonly used when a sewer pipe must be routed under a river or other deep obstructions.

Figure 3.1.4.1



3.1.5 Describe a force main.

Force main sewer pipes convey wastewater under pressure to a specific location. Force main design is dependent upon operating pressure and should be integrated into the pump or lift station design.

3.1.6 Describe the purpose of air relief valves on force mains.

Force mains typically include air release valves at the high elevation points to release trapped air. Relief valves may include blow offs to drain or flush the pipeline at the low elevation points. Routine inspection and cleaning of air relief valves prevents failure and SSOs.

3.1.7 Discuss pipe materials in the collection system.

The criteria used to determine the materials selected for construction of sanitary sewers are the pipes' resistance to deterioration from wastewater, strength to surface loads, resistance to root intrusion, ability to minimize leakage, ease of installation, and cost. Wastewater collection piping materials include:

A. Poly-vinyl chloride (PVC)
B. Cast iron (CI)
C. Ductile iron (DI)
D. Reinforced (RCP)
E. Non-reinforced concrete (CP)
F. Vitrified clay pipe (VCP)
G. Fiberglass reinforced pipe (FRP)
H. Acrylonitrile butadiene (ABS) pipe

I. High density polyethylene (HDPE) pipe

Currently, the most common pipe material installed for gravity sewers in Wisconsin is PVC. The most common material used for force main is DI and PVC.

Section 3.2 - Manholes

3.2.1 Discuss the function of manholes.

Manholes are typically installed every 300 to 400 feet to provide access to the pipe for inspection and cleaning. Manholes shall be installed at the end of each sanitary main, at all changes in slope (grade), size, alignment or offsets, and at all pipe intersections.

Figure 3.2.1.1

PVC sanitary mains of various diameters entering manhole

Village of Germantown

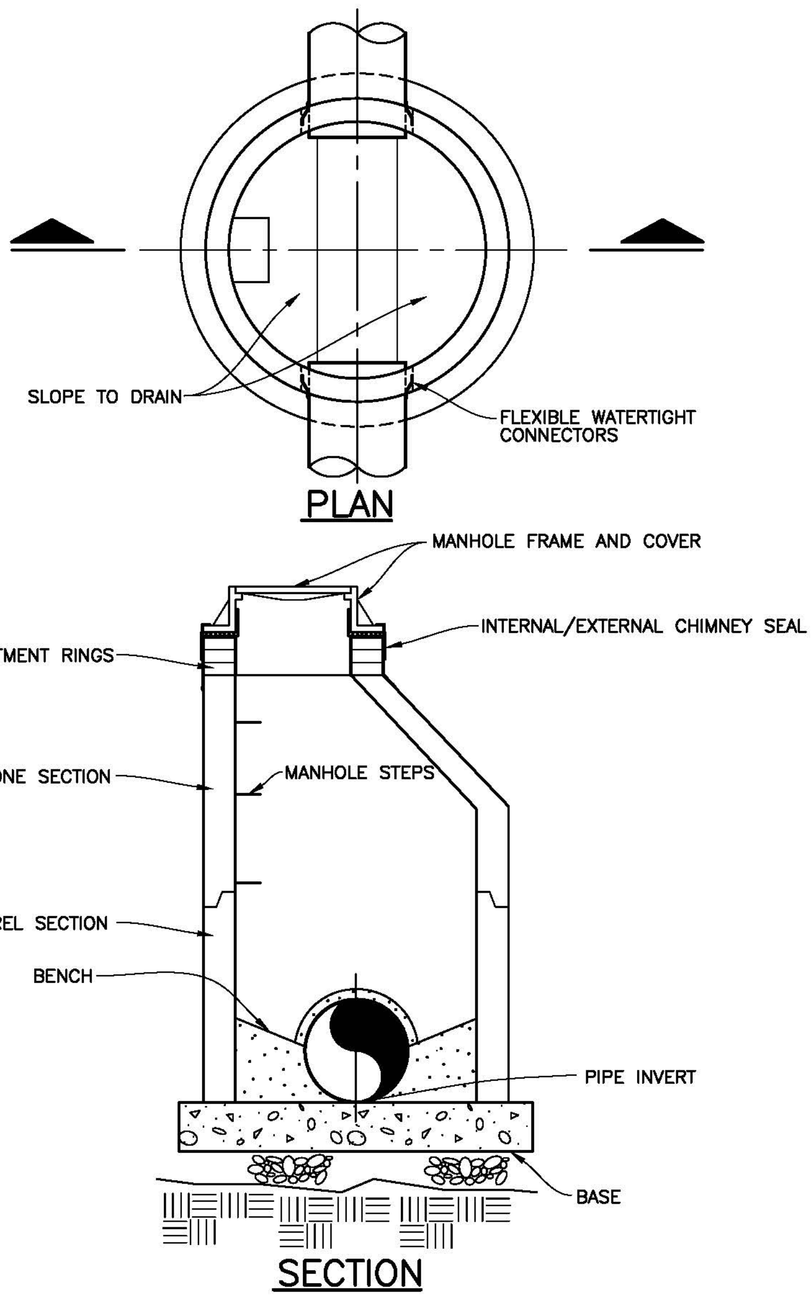
3.2.2 List manhole components.

Manhole design parameters may vary based on age and conveyance pipe diameters entering and exiting the manhole. The diagrams below show a typical manhole and its components. Currently, the majority of new construction manholes are pre-cast concrete or poured-in-place concrete. Drop manholes are used when the difference in the elevation of the incoming and outgoing sewer cannot be accommodated by a drop in the manhole channel without creating excessive turbulence and splashing of wastewater. The drop pipe has a tendency to clog and needs to be cleaned periodically. Manhole components are:

A. Base
B. Pipe invert and channel
C. Bench
D. Barrels
E. Cone

F. Adjusting rings
G. Frame and cover

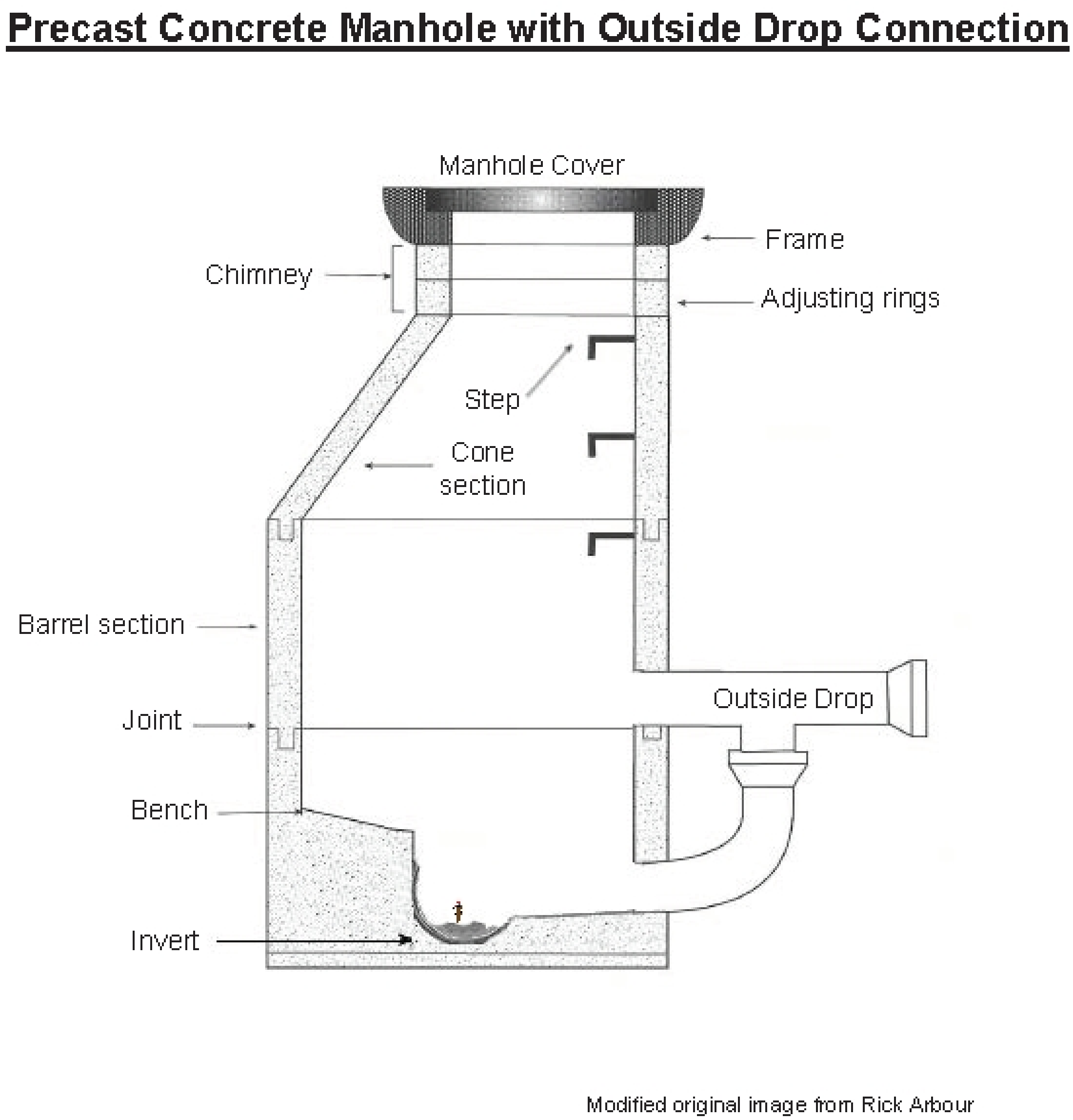
Figure 3.2.2.1



STANDARD SANITARY MANHOLE
NOT TO SCALE

Kathleen Hassing, P.E., Applied Technologies Inc.

Figure 3.2.2.2



Section 3.3 - Lift Stations

3.3.1 List types of lift stations.

Seven common types of lift stations include:

A. Wet well/dry well
B. Submersible
C. Suction lift
D. Screw pump
E. Pneumatic ejector
F. Grinder pump

G. Septic tank effluent pumping (STEP) system

In collection systems, the most commonly found are wet well/dry well combination and submersible lift stations.

Figure 3.3.1.1

Prefabricated "can" lift station

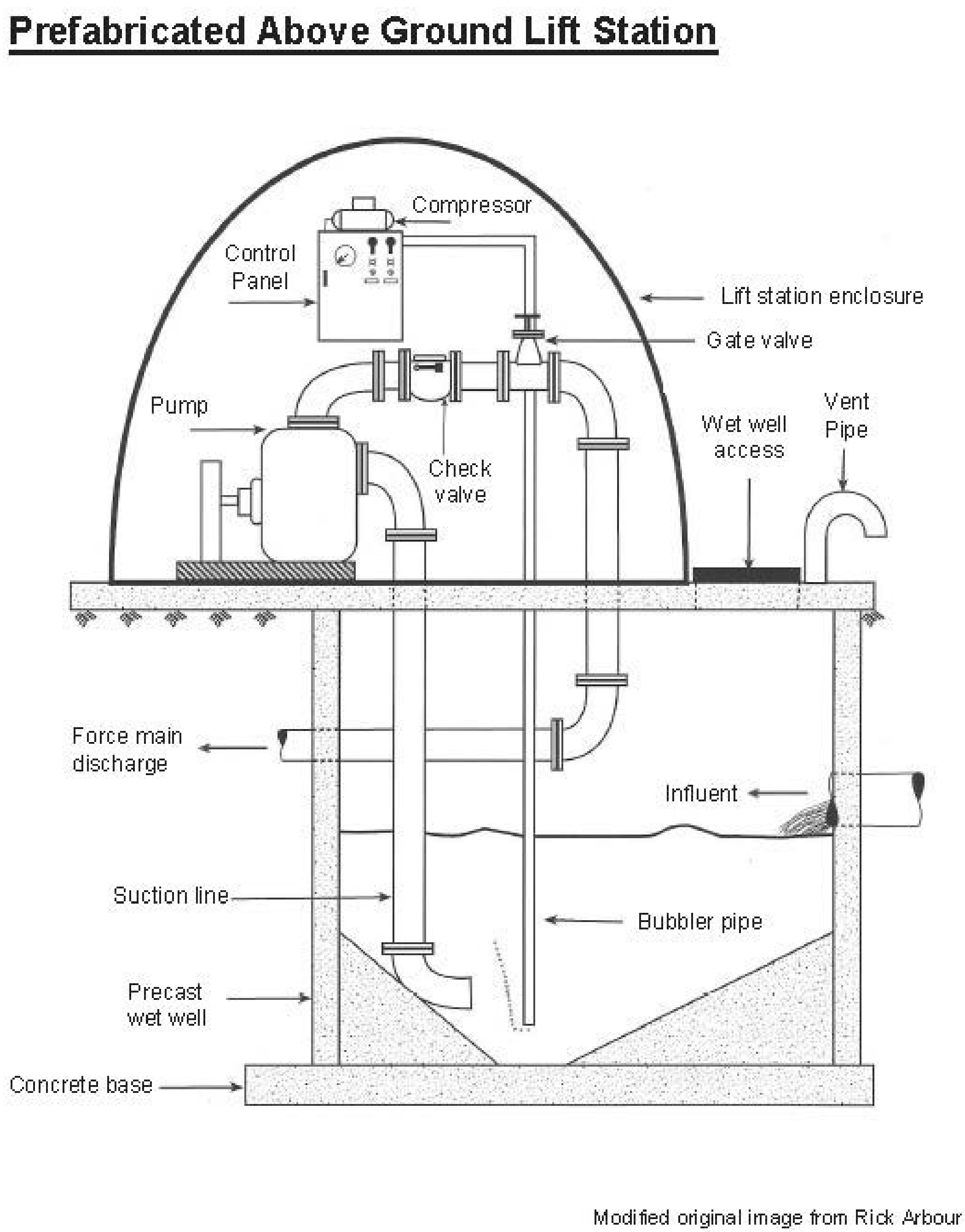
New Water

3.3.2 List lift station components.

A. Wet well and dry wells
B. Pumps
C. Motors
D. Instrumentation and Control including level control and control panels
E. Motor control center or main electric panel and electrical components including starter, fuses, relays for pumps and motors
F. Suction and discharge piping
G. Check valves/isolation valve
H. Mechanical ventilation

Auxiliary equipment can include a generator and transfer switch, a connection for a portable generator, and odor control and screening systems.

Figure 3.3.2.1



3.3.3 Describe a wet well lift station.

A wet well lift station is a single chamber that collects wastewater. This type of lift station is commonly called a submersible lift station due to the pump(s) being completely submerged in the wet well. Submersible centrifugal pumps are designed to be watertight. A slide rail system is generally used to remove pumps from a wet well to perform maintenance and cleaning.

3.3.4 Explain how a wet well and dry well pumping station works.

In wet well and dry well lift stations, the centrifugal pumps and other equipment are located in a separate chamber (dry well), with only the suction pipe being submerged in the wet well. The pump is turned on when the wastewater reaches a certain depth. If the wastewater continues to rise, more pumps will be turned on. The pumps are turned off when the wet well is empty or reaches the minimal set point. It is important that the dry well be well ventilated and dehumidified to protect the equipment and ensure the safety of the operator.

3.3.5 Describe a Septic Tank Effluent Pumping (STEP) system.

Wastewater flows into a conventional septic tank to capture floating and settled solids. The liquid septic tank effluent then flows to an added holding tank, commonly called a pump chamber, that contains a submersible pump and level control devices. The effluent from this holding tank pump chamber is then pumped and transferred to a collection system for treatment.

3.3.6 Discuss septage receiving station locations.

Septage receiving stations should be located at the wastewater treatment plant but can be at designated discharge points located in the collection system. It is important to note that hauled waste can contain large amounts of rags, debris, and grit. Receiving stations located in the collection system may require more cleaning and maintenance.

3.3.7 Discuss lift station motors.

An electric motor is an electrical machine that converts electrical energy into mechanical energy. The most common motor used in lift stations is the alternating current (AC) motor. Motors are sized to meet the requirements of the station design.

3.3.8 Discuss the purpose and use of variable frequency drives (VFDs) in sewer conveyance systems.

VFDs enable motors to accommodate fluctuating demands, adjusting motor speeds to draw less energy while still meeting operational needs. VFD’s are commonly used in the collection system lift stations.

3.3.9 List advantages and disadvantages of VFD use:

Advantages of VFD use are:
A. Reduces frequency of starting and stopping motors
B. Allows soft starting of equipment
C. Reduces motor and equipment wear
D. Optimizes electric consumption of motors which may lower electrical costs
E. VFDs can provide a steady feed rate of flow or allow for consistent wet well level range

Disadvantages of VFD use are:
A. High initial cost of equipment
B. Lower motor speeds may cause overheating concerns

C. Additional maintenance is required to ensure reliable operation
D. Not all motors are compatible with VFDs
E. VFD service life is typically less than the equipment

3.3.10 Discuss lift station mechanical ventilation.

All covered wet wells must be vented to the atmosphere and adequate ventilation must be provided for all dry wells. A permanent mechanical ventilation system must be provided in wet wells, submersible lift stations where routine entrance is required to inspect or maintain equipment, and when the dry well is below the ground surface. No interconnection is allowed between the wet well and dry well ventilation systems. For lift station entries, confined space protocols must be followed. Specific ventilation system requirements can be found in s. NR. 110.14 Wis. Adm. Code.

3.3.11 Describe liquid level measuring and control devices.

A. Ultrasonic/Radar Transducer
Ultrasonic and radar level sensors provide a continuous analog output by bouncing sound waves off the surface of the water. This is a non-contact measurement, so the sensor is mounted somewhere at the top of the well.

B. Submersible Pressure Transducer
Measures the hydrostatic pressure above the transducer to determine liquid level depth in the wet well.

C. Floats
Most commonly used is a ball float. The float hangs in the structure at an adjustable point. As the level rises or drops, the float will tip and will open or close a contact switch within the float. Floats can be used for fixed start/stop and lead/lag for pump control or to transmit if an alarm level condition is present.

D. Staff gauge
A rod installed in the water column with contacts at fixed increments. The contacts create continuity to determine liquid level.

E. Bubbler System
A bubbler system measures the hydrostatic pressure of a liquid level. Bubbler systems consist of a bubbler tube installed in the wet well, an air supply compressor, air flow meter, and a pressure switch or pressure transmitter. Pressurized air is used to create bubbles that are released from the end of tube at a fixed rate. The pressure required to create the air bubbles is proportional to the liquid level.

Figure 3.3.11.1

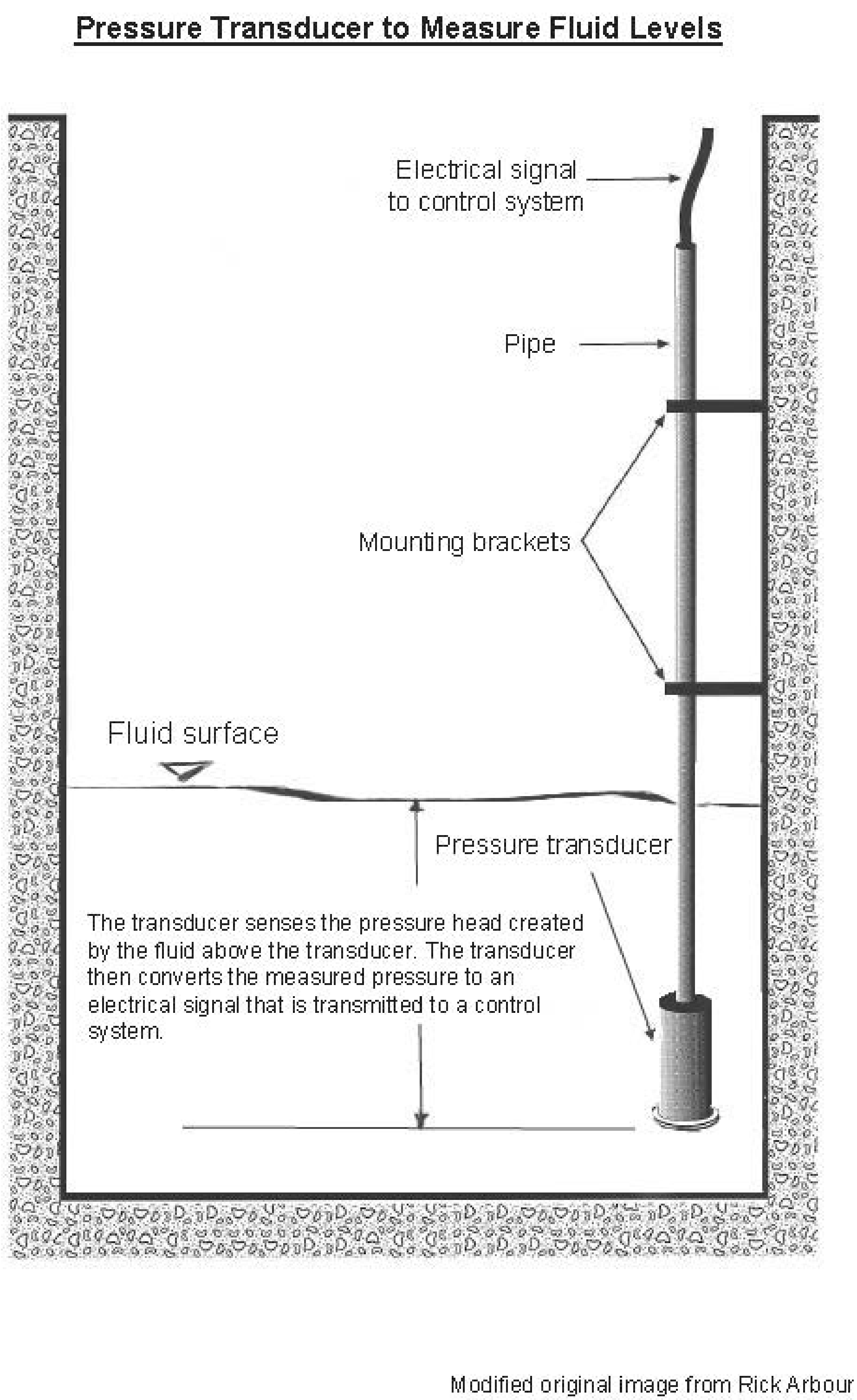
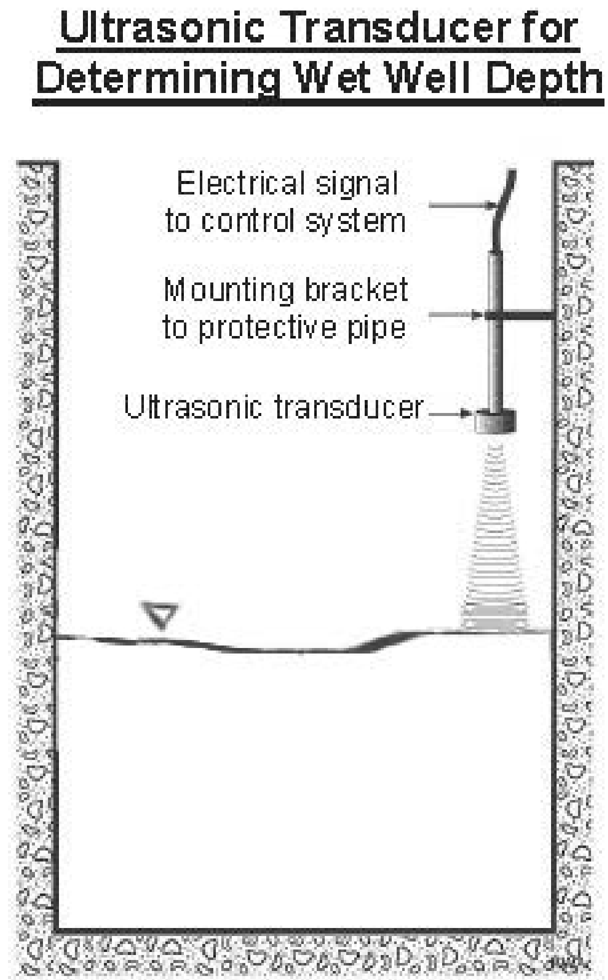
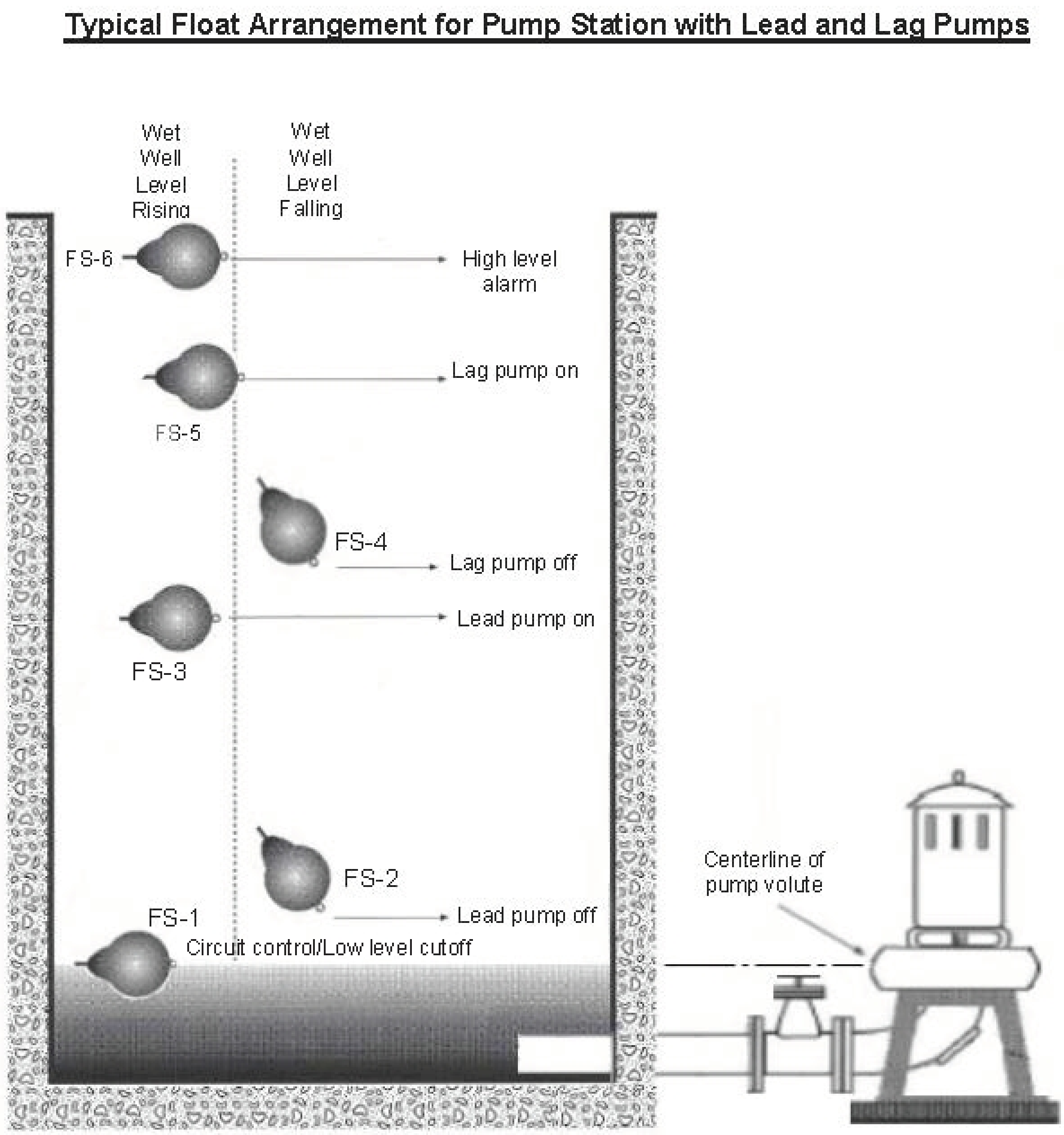


Figure 3.3.11.2



Modified original image from Rick Arbour

Figure 3.3.11.3



Modified original image from Rick Arbour

3.3.12 Discuss equipment and requirements for backup operation at lift stations.

Lift station emergency operations and equipment is required to prevent the discharge of wastewater to surface water, onto the ground, or backup into basements. Continuous operation of a lift station must be maintained with one of the following:

A. On-site generator or portable generator.
B. A redundant on-site pump or portable engine driven pump.
C. Capability of holding the average wastewater design flow for a minimum period of 24 hours.
D. Two independent electrical transmission routes from the same grid network.

3.3.13 Describe the difference between a flooded suction and a suction lift pump.

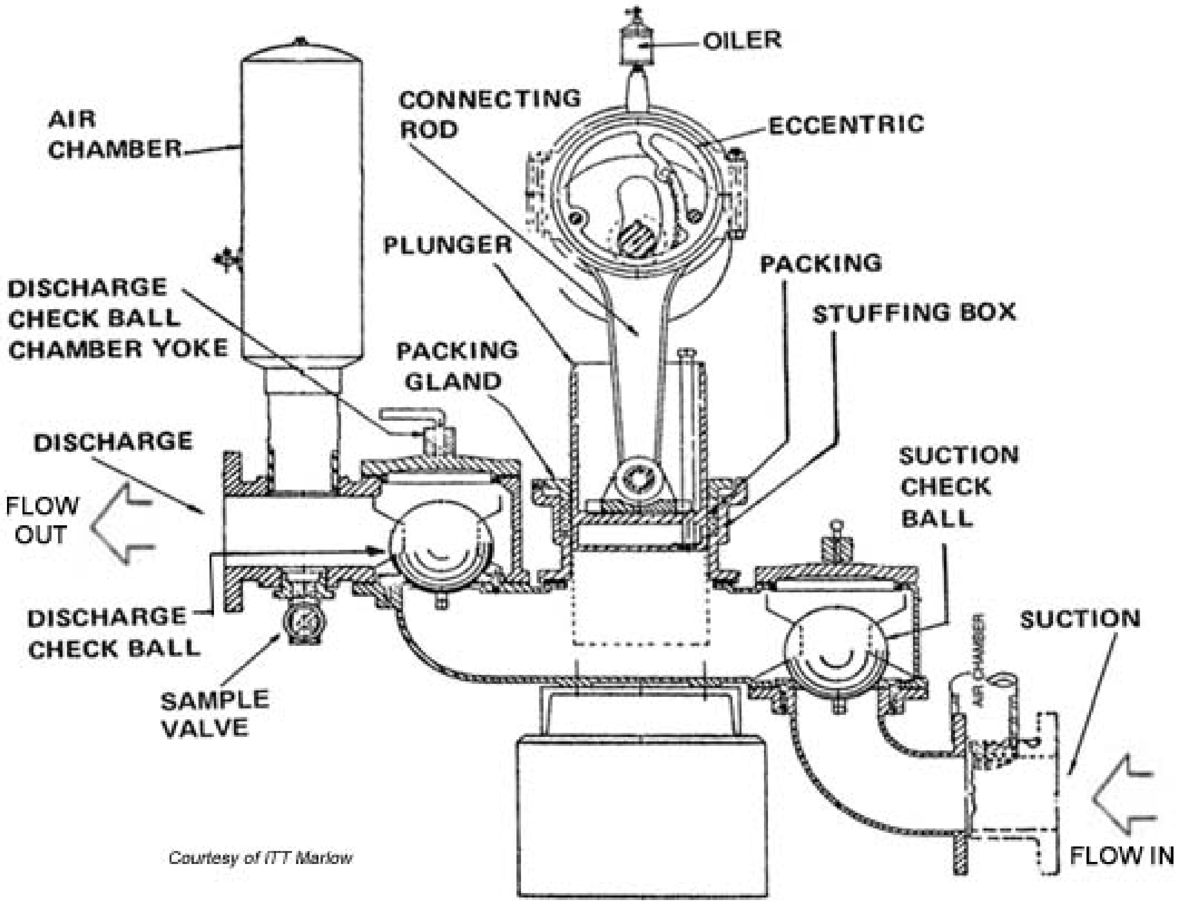
A pump system in which the elevation of the impeller (or volute) is above the wet well water level is a suction lift. The pump and system must be designed for vacuum assist or self-priming. When the minimum wet well water level is above the impeller (or volute) elevation, the unit is flooded suction.

3.3.14 Describe the types of pumps used in wastewater treatment.

Figure 3.3.14.1

Positive Displacement Piston Pump

This type of pump operates using a piston in a reciprocating motion to pump fluids (similar to piston in an automotive engine). These pumps are commonly used for pumping sludges.

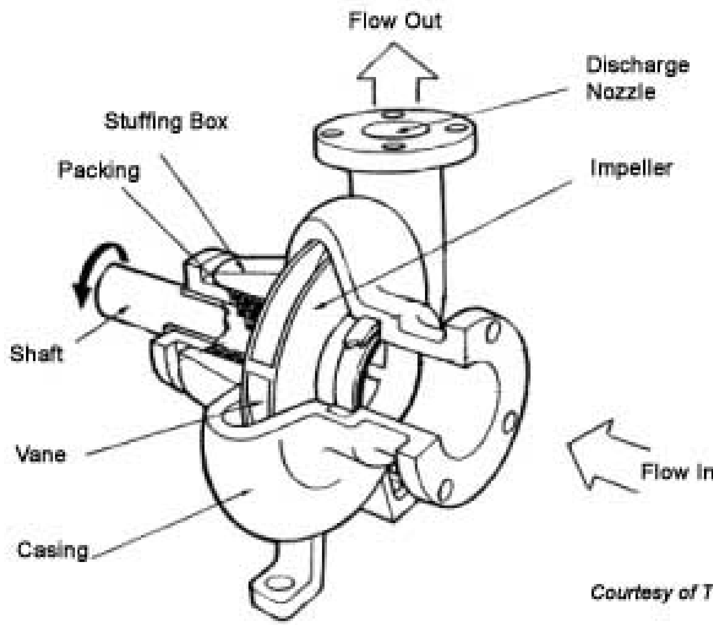


Courtesy of ITT Marlow

Figure 3.3.14.2

Centrifugal Pump

A pump with an impeller that rotates in a casing to pump large volumes of liquid through a pipe. A centrifugal pump is the most commonly used wastewater pump. They are used most commonly for raw wastewater pumping; at lift stations, recirculation flows, for return activated sludge, waste activated sludge, and final effluent pumping.



Courtesy of The McNally Institute

Figure 3.3.14.3

Courtesy of Megator & Gorger Company

Rotary Lobe Pump Cutaway

Rotary lobe pumps are used to pump both sewage and sludge. They are self-priming, valveless, positive displacement pumps. Two synchronized rotors rotating against each other create chambers between the lobes and pump casing. At the suction side the open chambers fill with the sewage or sludge. The sewage or sludge is displaced in the direction of the volume flow into the discharge side. When not operating, the rotors align and form a seal.

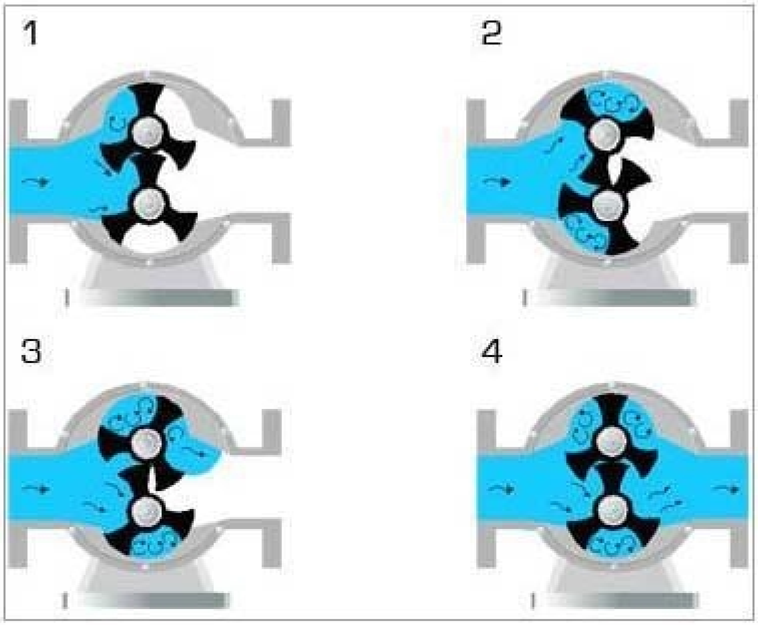


Figure 3.3.14.4

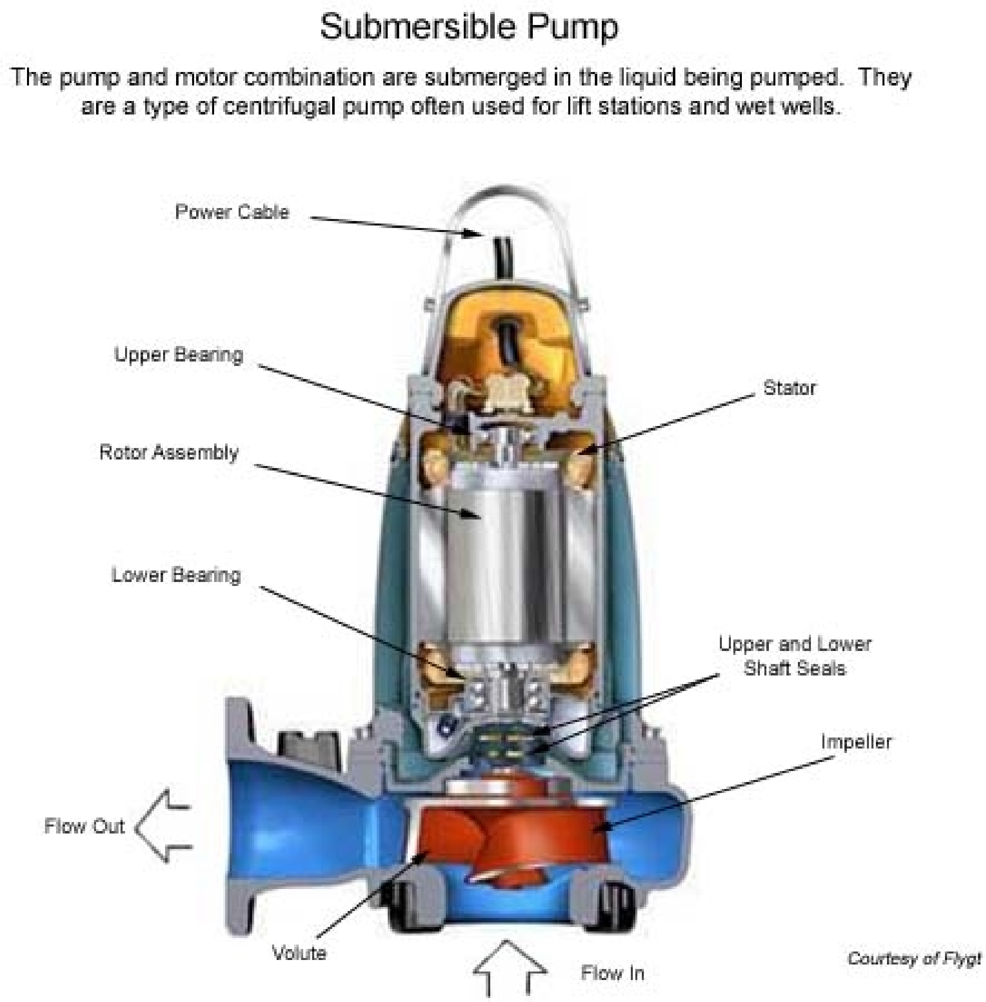


Figure 3.3.14.5

Peristaltic Pump

A small positive displacement pump commonly used for sampling and chemical addition.

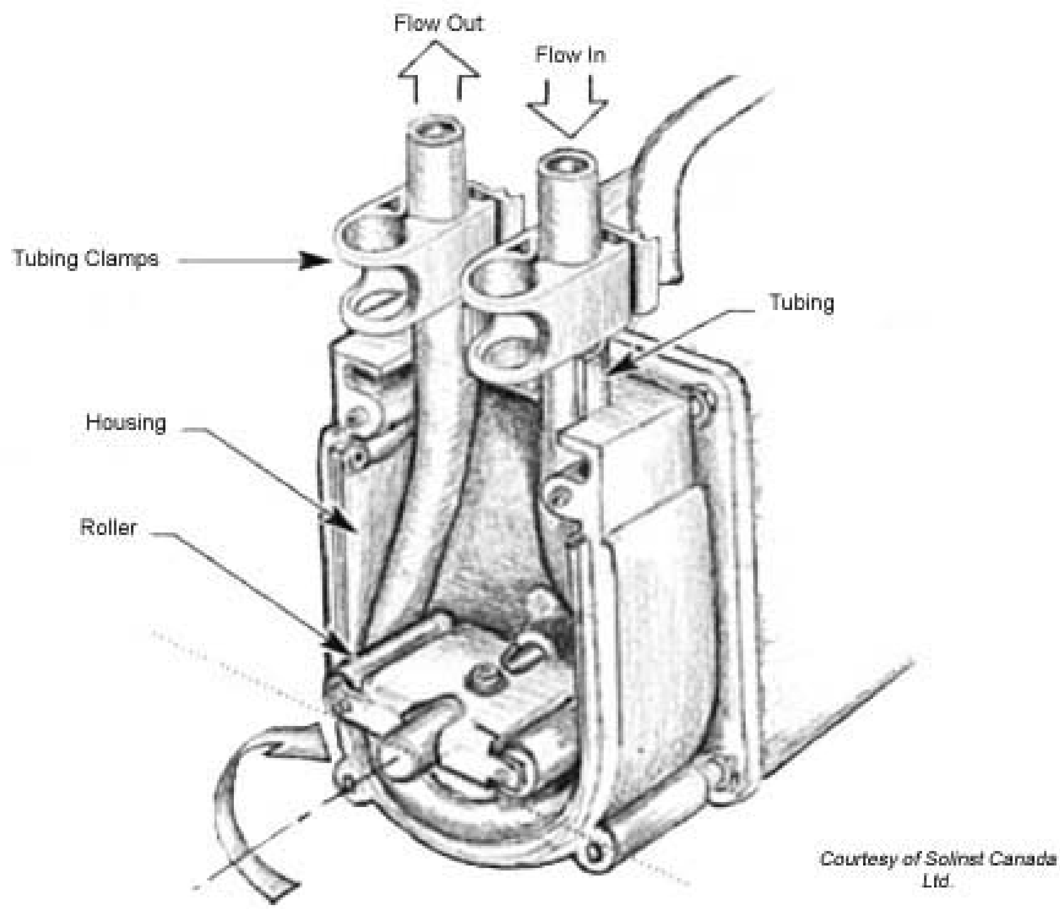


Figure 3.3.14.6

Progressive Cavity Pump

A fixed flow rate pump that turns a corkscrew shaped rotor inside a flexible rubber stator to transfer sludges. These pumps offer long life and reliable service as long as they don't run dry or with excessive grit.

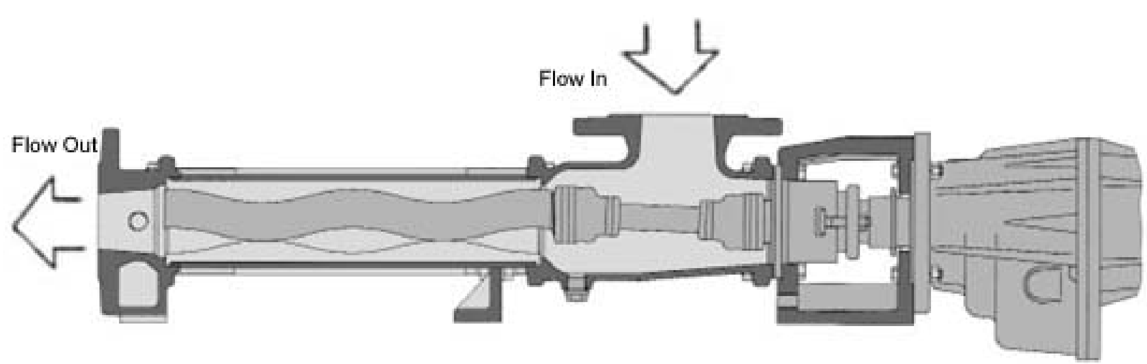
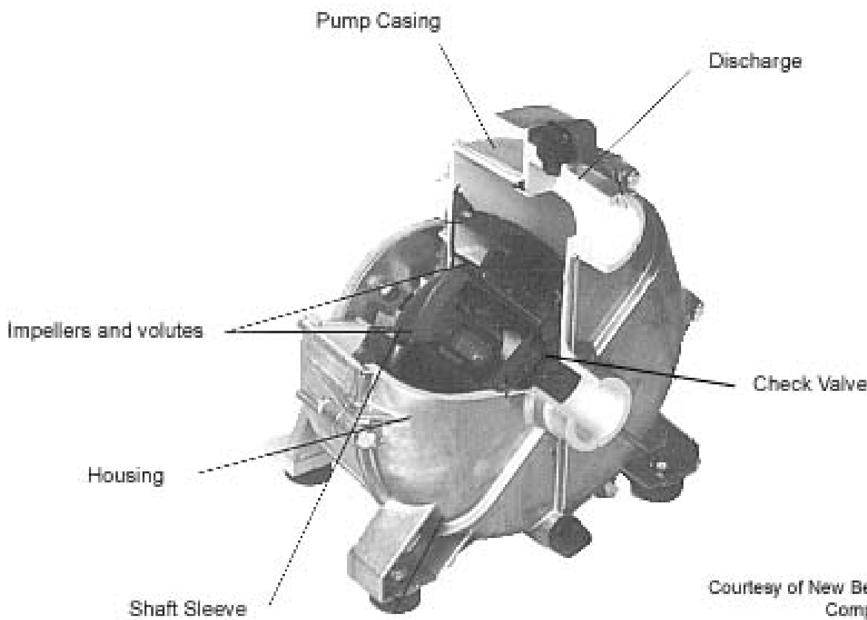


Figure 3.3.14.7

Trash Pump

They are usually gasoline or diesel operated positive displacement portable pumps with a suction hose and a discharge hose. They are non-clogging (can handle a 3 or 4 inch diameter object without clogging). They are used for moving large volumes of wastewater quickly such as, dewatering, bypassing, emptying treatment tanks, etc.



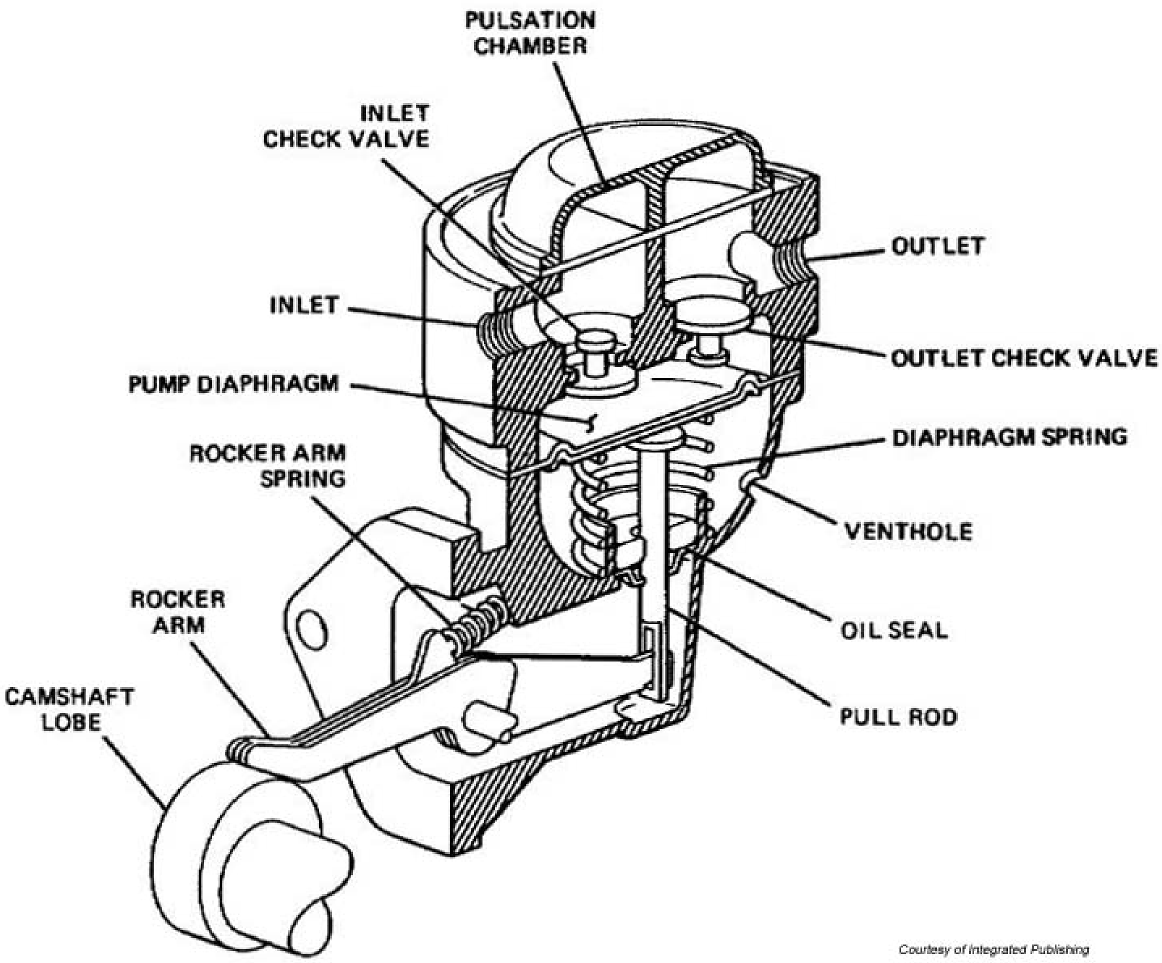
Courtesy of New Beginnings Management Company, Inc

Figure 3.3.14.8

Diaphragm Pump

A diaphragm pump is a type of positive displacement pump. They differ from other positive displacement pumps in that the pumping mechanism is protected from the material being pumped. They are often used for adding chemicals or polymers. Larger diaphragm pumps are used for pumping sludge.

Chemical Metering Diaphragm Pump

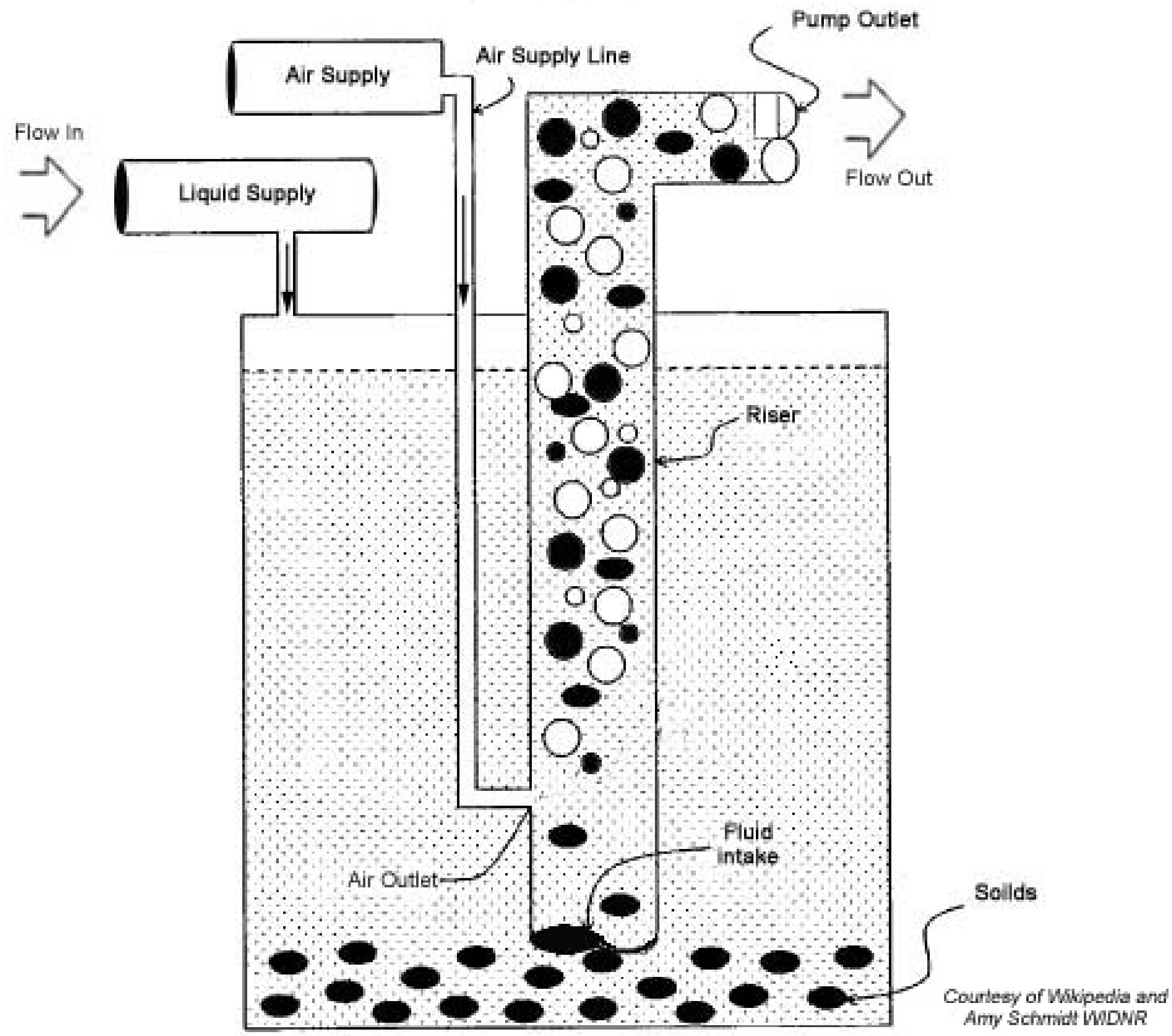


Courtesy of Integrated Publishing

Figure 3.3.14.9

Airlift Pump

Airlife pumps are mostly used in small activated sludge plants to return and waste sludge from the system. They operate on the principle of water/air displacement. Airlift pumps are prone to plugging, especially at low return flow rates. Operators should closely monitor these pumps often to ensure sludge is being returned at all times.



3.3.15 Describe the valves generally used in the collection system.

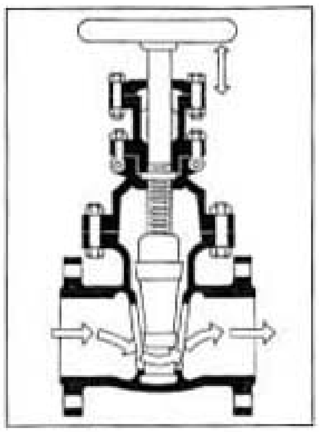
Valves are devices placed in piping systems to stop, regulate, divert, or change flow. Proper procedures for opening and closing valves must be followed to prevent personal injury and equipment damage. Valves used in wastewater treatment plants are:

Figure 3.3.15.1

MULTI TURN VALVES

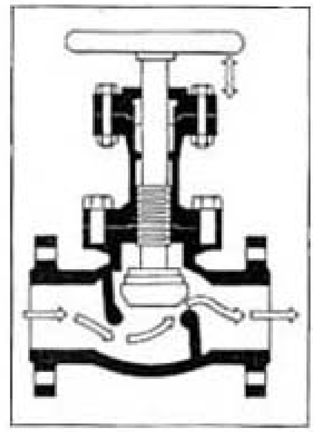
GATE VALVE

A gate valve is a general service valve used mostly for full open flow or no flow applications. This valve is closed using a gate or plate that slides the valve down to block the flow.



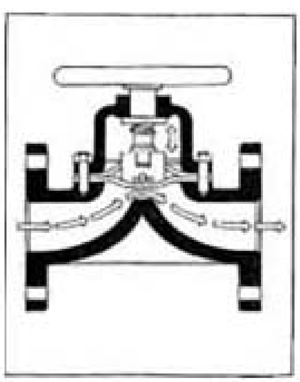
GLOBE VALVE

A globe valve is used for full flow or no flow applications as well as throttling clean water flows. This valve is closed by a flat or convex plug that is lowered onto a matching seat.



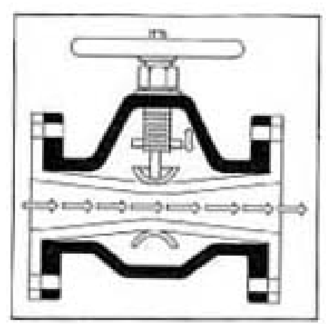
DIAPHRAGM VALVE

A diaphragm valve is often used for corrosive wastewaters. It is closed by a flexible diaphragm that is attached to a compressor. The diaphragm is lowered by the valve stem onto a weir, sealings, and shutting off the flow.



PINCH VALVE

A pinch valve is often used on sludge lines or wastewater with a high amount of suspended solids. The valve is closed by a flexible member in a valve that can be pinched close to shut off flow.



Courtesy of Water Engineering & Managment, Oct. 1988, Vol 135

Figure 3.3.15.2

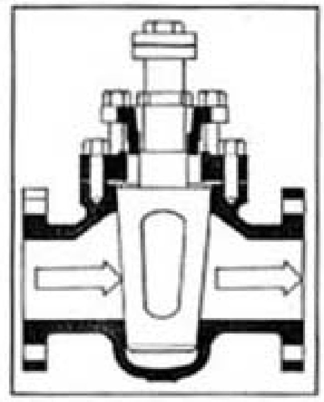
QUARTER TURN VALVES

NEEDLE VALVE

A needle valve is used for regulating flow in small lines, such as instrument air lines or fuel lines. A rod with a cone shaped tip is raised and lowered relative to a seat, thus creating a certain size opening for which flow to pass.

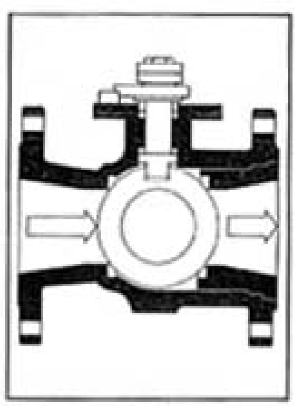
PLUG VALVE

A plug valve is used for on-off and some throttling application. It is closed by turning a cylindrical or tapered plug with a hole in the center. When open to allow full flow, the hole lines up directly with the flow path. A quarter turn in either direction blocks the flow.



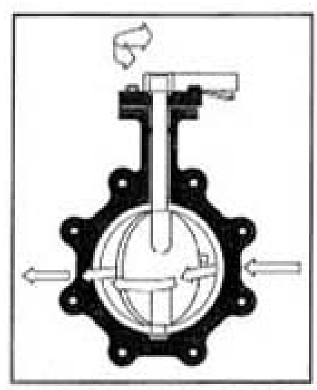
BALL VALVE

A ball valve is used for on-off and some throttling applications. It operates similarly to a plug valve but uses a rotating ball with a hole in the center. When open to allow full flow, the hole lines up directly with the flow path. When closed, the ball is rotated 90 degrees to block the flow.



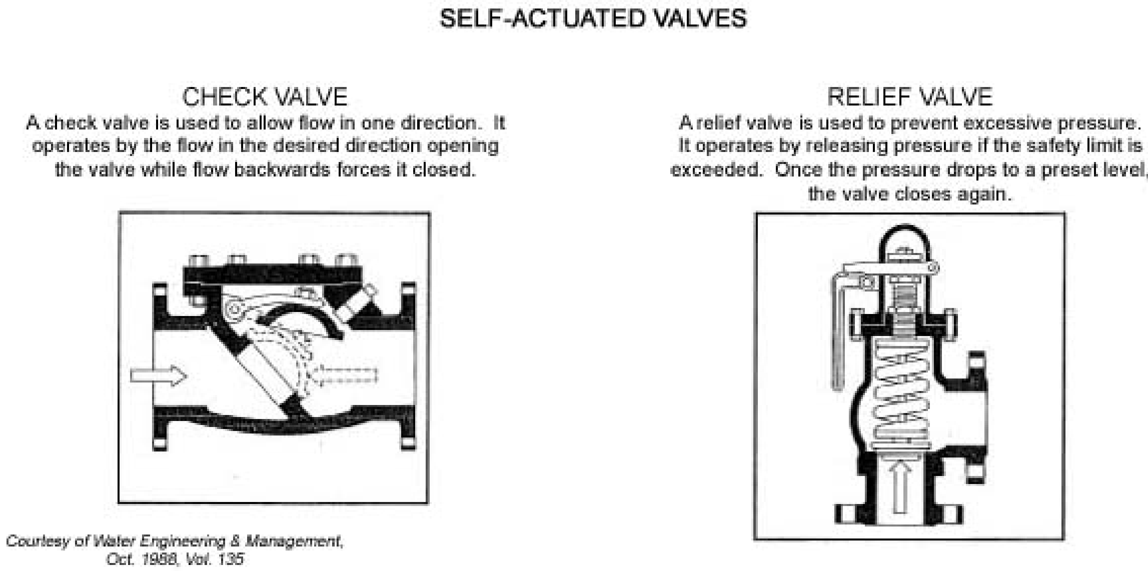
BUTTERFLY VALVE

A butterfly valve is used for on-off and good for throttling applications. A butterfly valve regulates flow by turning a circular disk or vane. When open to allow for full flow, the vane is directly parallel to the flow. when closed, the vane is perpendicular to block the flow.



Courtesy of Water Engineering & Managment, Oct. 1988, Vol 135

Figure 3.3.15.3



Section 3.4 - Flow Monitoring Stations

3.4.1 Discuss flow monitoring in the collection system.

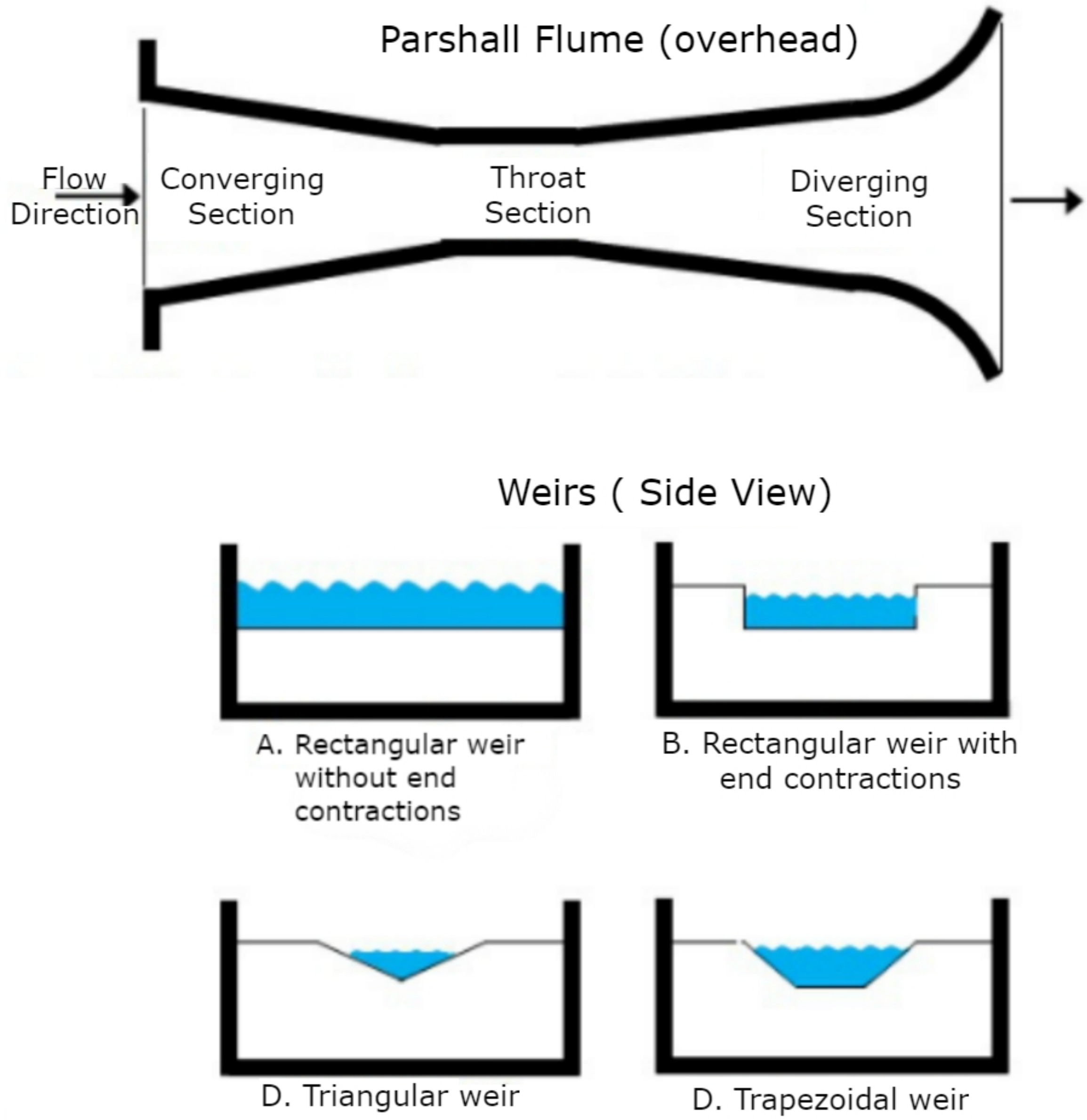
Flow monitoring is used in sanitary sewers or force mains to measure wastewater volumes. Monitoring stations (permanent and portable) may be used for billing purposes, analyzing flows within a sewer service area, or to identify high flows related to I/I.

3.4.2 List and describe the common types of flow measurement devices.

A. Open channel flow
Flow through an open channel can be measured by installing a structure in the channel. This structure is typically either a flume or weir. The most common type of flume is a Parshall Flume. The most common type of weir is either a 60° or 90° v-notch (triangular) weir. As water flows through a flume or weir, the level of water flowing through it is measured. The most common water level measurement device is an ultrasonic meter, but other devices such as pressure measurement, bubbler tubes, and staff gauges are also used. In order to get an accurate flow measurement, the weir or flume has to be sized correctly for the expected range of flows; the flow leading to it must be smooth and the water level measurement device must be properly located. The reader is referred to the 'ISCO Open Channel Handbook' for complete information about open channel flow monitoring equipment and tables.

B. Pipe flow meters
The most common way to measure the flow of wastewater through a pipe is a magnetic flow meter, commonly referred to as a magmeter. A magmeter operates on the principle of electromagnetic induction. Other devices, such as pressure or ultrasonic meters, are also used. As flows are metered, the flow data is recorded and stored in a computer or charted and totaled. This information is then used for operational and reporting purposes. All flow measurement devices must be calibrated annually according to the Wisconsin Administrative Code and records kept.

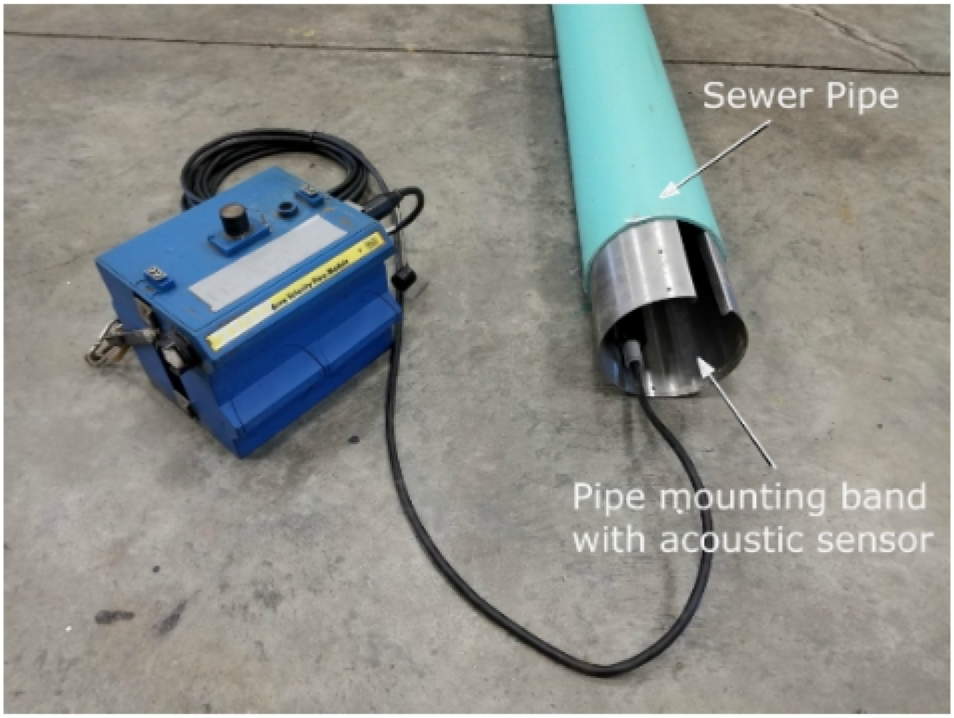
Figure 3.4.2.1



Source: ISCO Open Channel Flow Measurement Handbook 3rd ed.

Figure 3.4.2.2

Isco Portable Flow Monitoring System



City of Marshfield

Figure 3.4.2.3

Sensors for Flow Monitoring

Photo courtesy of Chris Skehan, ADS Environmental Services, LLC

Section 3.5 - Sampling

3.5.1 Discuss and describe collection system sampling applications.

Sampling can be conducted to determine areas of high loadings, illegal connections, and for industrial and municipal billing applications. Samples should be taken in a location where the water is well mixed and representative of the source. The sample could be collected using a flow proportional composite sampler, an automatic or manual timed series of grab samples, or an individual grab sample. To ensure a representative sample, strainers or tubes should not lie on the bottom of a channel or against any manhole wall or in a corner. Sample suction locations should be below the water surface that has been well mixed or in a channel that is mixed well, such as just before entering a flume or exiting a weir. Sampling strainers or tubing should be checked and cleaned regularly.

Section 3.6 - SCADA

3.6.1 Describe a Programmable Logic Controller (PLC).

A PLC is a programmable electronic device that has inputs and outputs and is generally found in a control panel. A PLC could control the liquid level of a tank by defining the set points a pump would be turned on and off.

3.6.2 Describe Supervisory Control and Data Acquisition (SCADA) systems.

SCADA is a process control system that uses PLCs, computers, networked data, and graphic interfaces to gather data in real time from on-site or remote locations to control equipment and monitor conditions. SCADA systems utilize hardware components to gather the data and software components to analyze and display data in a timely manner. Most SCADA systems are set to recognize an alarm condition and trigger a notification system.

Chapter 4 - Operation and Maintenance

Section 4.1 - Conveyance of Wastewater

4.1.1 Describe the sources of wastewater in a community.

Wastewater is “used” water that goes down the drain and flows to the wastewater treatment plant. Flows originate from domestic (household), industrial, and commercial sources. Some wastewater is trucked or hauled to a wastewater treatment facility (septage). In addition, clearwater from I/I can get into the collection system. Clearwater entry from rooftop drains to the sanitary sewer are typically illegal or non-compliant discharges.

4.1.2 Describe the types of materials prohibited from discharge into collection systems and the reasons they should not be discharged.

The materials with the characteristics listed below are generally prohibited from discharge to the sewer system. These prohibitions are included in local sewer use ordinances. Generally, materials that can interfere with wastewater treatment, pass through the treatment system and cause a water quality violation, or accumulate in sludges, making the sludges toxic or hazardous are prohibited. Many of the industrial materials can be handled with proper pretreatment or segregation of waste streams that cannot be pretreated.

A. Volatile organics, including gasoline or solvents, can cause an explosive atmosphere in the collection system or at the treatment plant.
B. Heavy metals, including chromium, zinc, copper, nickel, cadmium, and mercury are very toxic and can cause a treatment plant upset, pass through the plant, or accumulate in the sludge.
C. Acidic and alkaline wastes can damage the collection system or upset the treatment plant. Generally, a pH lower than 5.0 or greater than 10.0 should be neutralized prior to discharge to the collection system.
D. FOG must be controlled at industrial and commercial sources with oil separators and grease traps to prevent maintenance problems in wet wells and at the treatment plant.
E. High-strength loadings of BOD or suspended solids can organically overload the treatment plant. This can especially be a problem with batch dumping that causes large slug loads. Any batch type operation should be handled by flow equalization to prevent plant upsets.
F. High temperature wastewaters can affect biological activity.
G. Solid or viscous materials can cause sewer blockages.
H. Any debris including rags, wipes, or other materials can cause sewer blockages or pump clogging.
I. Other toxic materials can impair or interfere with the treatment process.

4.1.3 List and define common sources of I/I.

Infiltration is the entry of groundwater through defects of collection system components through soil or its surrounding bedding. Inflow is clearwater that enters directly into collection system components.

Common sources of clearwater (I/I) are:

A. Roof leaders connected to the sanitary sewer
B. Storm and sanitary cross connections
C. Low lying manholes in roads or ditches subject to flooding
D. Uncapped cleanouts
E. Uncapped lateral connections
F. Sump pumps and foundation drains
G. Cracks and offset joints in the collection system piping and private laterals
H. Manhole cracks and defects
I. Buried manholes

Figure 4.1.3.1

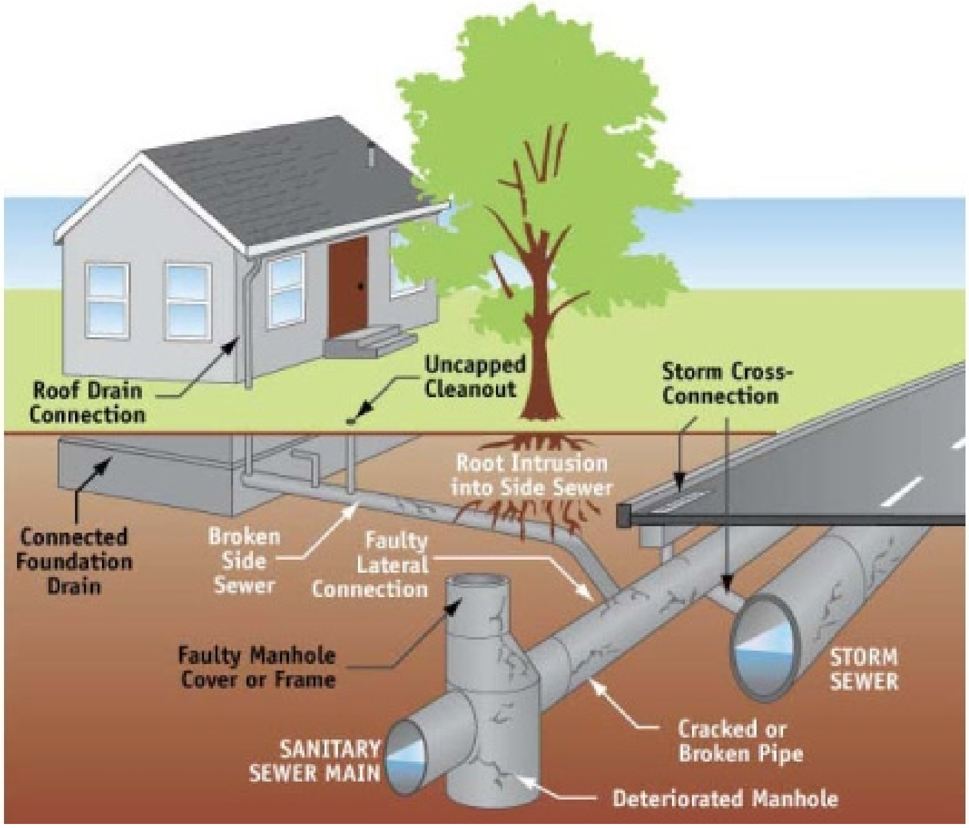


Figure 4.1.3.2

Inflow Source: MH Cover with Open Pick Holes and Vents

Gasketed Bolt Down MH Cover with Non-Penetrating Pick Holes

Photos from Joan Hawley, P.E., Superior Engineering, LLC

4.1.4 Discuss the effect of I/I on a collection system.

When I/I enters collection system pipes, it can exceed the flow capacity of the pipes and result in surcharging, basement backups, and sanitary sewer overflows (SSO). I/I in the collection system can also lead to very high flows entering the treatment facility and can lead to wastewater pumping, treatment problems, or treatment facility overflows (TFO).

Figure 4.1.4.1

4.1.5 Describe a Sanitary Sewer Overflow (SSO) and their causes.

SSOs occur for many different reasons. One of the main reasons sewers back-up and overflow is too much clearwater gets into the sewer pipes through infiltration or inflow (I/I) during wet weather events. Sewer pipes are designed for only a certain flow capacity and excessive I/I can exceed that capacity. As sewers age, sewer defects increase, allowing for more clearwater (I/I) to get into them. Other circumstances that can cause an overflow are power outages, plugged sewers due to grease or large objects, broken or collapsed pipes, equipment failure such as a lift station pump, or wide-scale flooding.

Section 4.2 - Cleaning

4.2.1 Discuss sewer line cleaning.

Sewer cleaning is routinely performed to prevent stoppages or blockages in the sewer. Blockages are caused by obstructions from roots, grease, debris, broken pipes or joint failures. When a blockage occurs, wastewater may backup and could cause an SSO. Streets, homes, businesses, surface waters, and groundwater can be damaged from SSOs. Sewer cleaning frequency varies depending upon the type of debris found and the data from the sewer inspection which is defined in each utilities CMOM program.

4.2.2 Discuss hydraulic and vacuum cleaning.

High velocity hydraulic cleaning machines such as a jetter or combination jetter and vacuum machines (combination trucks) use water pressure to propel a nozzle attached to a hose into a sewer line to loosen and move debris to keep collection systems' flow optimized. The trucks or trailers are equipped with a water supply tank, high pressure pump (typically positive displacement) and auxiliary engine for driving the pump. Hose length and diameter is dependent upon the size of the sewer being cleaned and the hose nozzle type being used.

Figure 4.2.2.1

Combination Jetter and Vacuum Machine

Joan Hawley, Superior Engineering, LLC

4.2.3 Describe nozzles used in hydraulic cleaning practices.

Nozzles are equipped with jets that scour debris loose and move it towards a manhole where the debris is intercepted and removed. Different types of nozzles are available for accomplishing different cleaning applications such as removing heavy debris, grit, grease, or blockages. Debris is manually removed from downstream manholes or by using the vacuum on a combination truck.

Figure 4.2.3.1

4.2.4 Describe rodding.

Rodding machines are effective with opening blockages and removing grease or root balls using a rotating steel rod to push or pull cleaning tools through sewers. Rodding machines are typically mounted on a separate trailer or truck. After the blockage has been cleared, the sewer should be cleaned with a jetter or combination truck to prevent additional blockages. The rods can be either sectional or continuous and a variety of tools are attached for clearing different types of blockages.

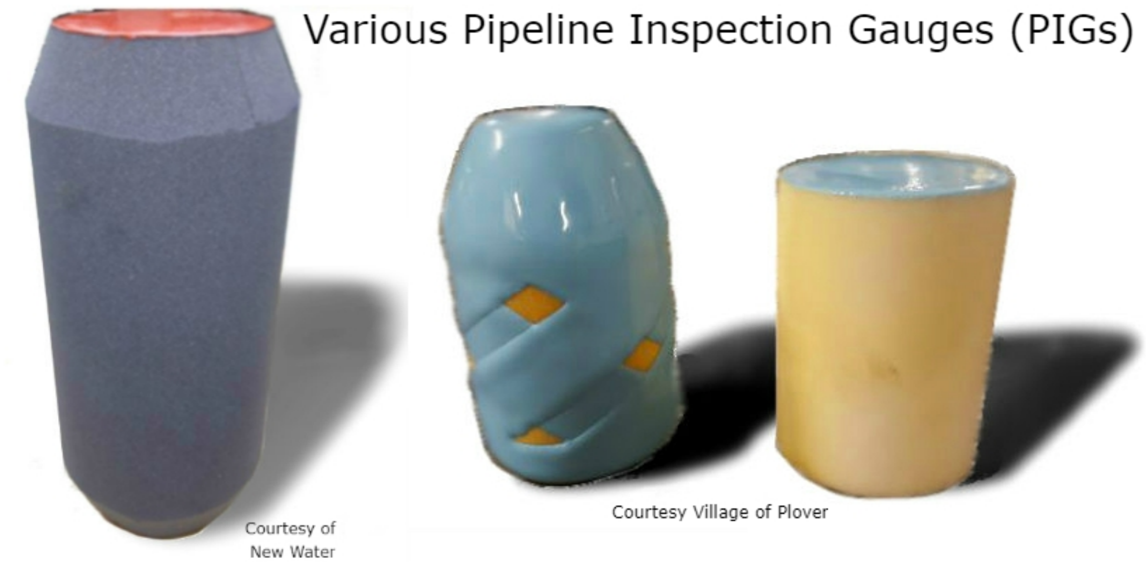
4.2.5 Describe a bucket machine.

Bucket machines are used to remove heavy debris from sewer pipes such as sand, gravel, bricks, and rocks. Materials are captured using a special bucket and removed from the pipe. Bucket machines are typically used in older large diameter collection systems.

4.2.6 Discuss pipeline inspection gauge (PIG) applications.

Pipeline inspection gauge (PIG) is typically used to clean out force mains using different size PIGs launched in the pipe to scour and clean it without stopping the flow. Typically the force main is designed to include a PIG launcher and a PIG catcher. PIG selection is dependent upon type and condition of the pipe and type of material being removed.

Figure 4.2.6.1



4.2.7 Describe ice pigging.

Ice pigging is the process in which water, as a frozen media, is generated and pumped into a pipe and forced through the inside in order to scour and remove sediment and other unwanted deposits.

4.2.8 Discuss force main chemical cleaning.

Chemicals can be used to clean force mains to remove materials. Disadvantages of chemical cleaning include cost, disposal of chemicals, and the potential of structural damage.

4.2.9 Discuss the importance of root control.

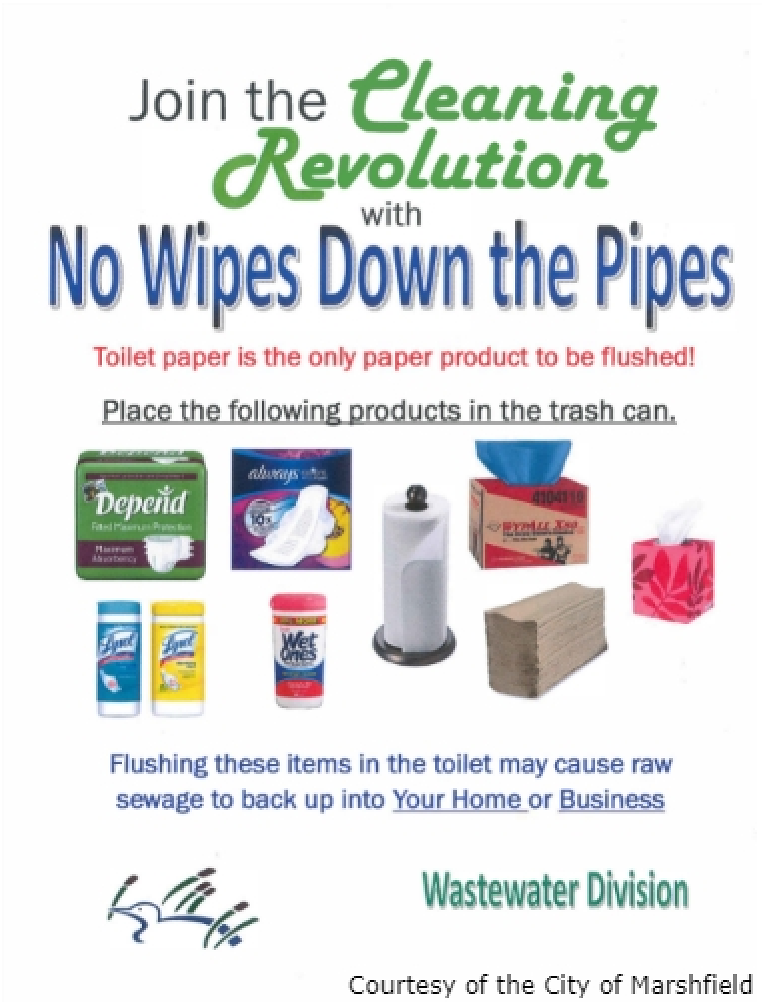
Roots are found in sewer joints, cracks, laterals, and manholes and need to be removed to prevent blockages. Roots can be removed with a root cutter or by the use of chemicals designed to kill roots. Specific root cutters are designed for different pipe materials and size.

Figure 4.2.9.1

4.2.10 Discuss the significance of flushable wipes in the collection system.

The term flushable would refer to a product that can be flushed because it breaks down quickly and causes no problems in a collection system. However, flushable and disposable wipes have been known to plug homeowner laterals and stop the flow in sanitary mains, manholes, as well as accumulate in lift station wet wells. Limited brands are designed to eventually break down after several minutes of constant agitation (sanitary collection systems are designed to minimize turbulent flow) but most brands are nonwoven and must be removed manually before reaching a treatment plant. If they reach a lift station pump that was not designed to pass them through an operator must use a LOTO procedure, remove the pump, and manually remove the wipe.

Figure 4.2.10.1



Section 4.3 - Fats, Oils, and Grease (FOG)

4.3.1 Discuss the importance of controlling fats, oils, and grease.

Fats, Oils, and Grease (FOG) are waste byproducts. FOG are found in meats, dairy products, cooking oils, shortenings, food scraps, and sauces. FOG collects and can form grease plugs in sewer pipes if washed down the drain or through unmaintained grease traps at restaurants, nursing homes, hospitals, churches, and school kitchens.

The most common cause of sanitary sewer overflows (SSO) from sewer pipes are blockages caused by grease. FOG can reduce pumping capacity and efficiency. If grease makes its way to the wastewater treatment facilities it can disrupt treatment processes as well as plug valves, meters, and pipes. Grease can involve costly and unpleasant clean-ups.

The best practice for controlling grease is to keep it out of the collection system by having a Grease Control Program in a community. A Grease Control Program usually involves regular inspections of grease traps or interceptors and an ongoing information and education program with residents and businesses.

Figure 4.3.1.1

4.3.2 Define and discuss the importance of grease traps.

A grease trap or interceptor, receives wastewater from food processing such as commercial food processors, restaurants, schools, hospitals, etc. Most commonly the grease trap takes the form of a rectangular or circular tank made of concrete or steel with inlet and outlet baffles. The purpose of the trap is to collect fats, oil, and grease (FOG) that would block or reduce the capacity of gravity collection systems.

4.3.3 Describe grease trap design and operation.

A grease trap is large enough to retain and cool the waste to allow FOG to solidify, float, and solid particles to settle. The tank is sized for storage and the size capacity requirements of grease interceptors as specified in the plumbing code SPS 382.

Each grease trap needs to be cleaned on a regular schedule to remove accumulated grease. The schedule is dependent upon the waste characteristics, temperature, and rate of FOG and settled solids accumulation. Tank contents are properly disposed at approved collecting facilities.

4.3.4 Describe a grease trap inspection.

Periodic inspections must be conducted to assure that the grease trap is functioning properly and all the components are present. Typically this is conducted by the owner's maintenance personnel or the licensed hauler that removes the tank contents. Clean on a regular scheduled basis, or in accordance with local ordinances and keep records on maintenance activities.

Typical operation and maintenance activities after pumping and cleaning include:

A. Inspect tank and fixtures for corrosion.
B. Inspect baffle(s) integrity.
C. Make sure baffles are fastened and clean.
D. Assure that inlet and outlets are clear of obstruction.
E. When operating, measure inlet and outlet temperature, record in log per established schedule.
F. Assure that recycled food oil is placed in marked containers.
G. Assure outdoor grease and oil storage containers are covered and show no signs of overflowing.
H. Assure that absorbent pads or other approved cleaning materials are available to clean up any spills or leakage.
I. Inspect nearby floor drains or storm drains for signs of FOG.

Section 4.4 - Inspections of Collection System Components

4.4.1 Discuss sewer, force main, and siphon inspections.

Sewer inspections are required to determine the condition of the sewer, presence of I/I, cleaning schedules, and the next inspection schedule. It is critical to get a baseline inspection of all the sewers to determine problem areas and to establish the frequency of the next sewer inspection. Sewer inspections are also needed to provide accurate data for sewer rehabilitation and replacement projects. Gravity sewers are typically inspected using a closed circuit television camera (CCTV).

Force mains are under pressure and the ability to inspect the sewer is more challenging. New technologies such as laser profiling, acoustic analysis and pipe wall thickness measurements are being used to provide force main conditions.

Siphons should be inspected more frequently than sewers because the siphons are typically located under critical infrastructure, railroad crossings, and sensitive ecosystems.

Figure 4.4.1.1

CCTV and Grout Truck

Visu-Sewer Inc.

Figure 4.4.1.2

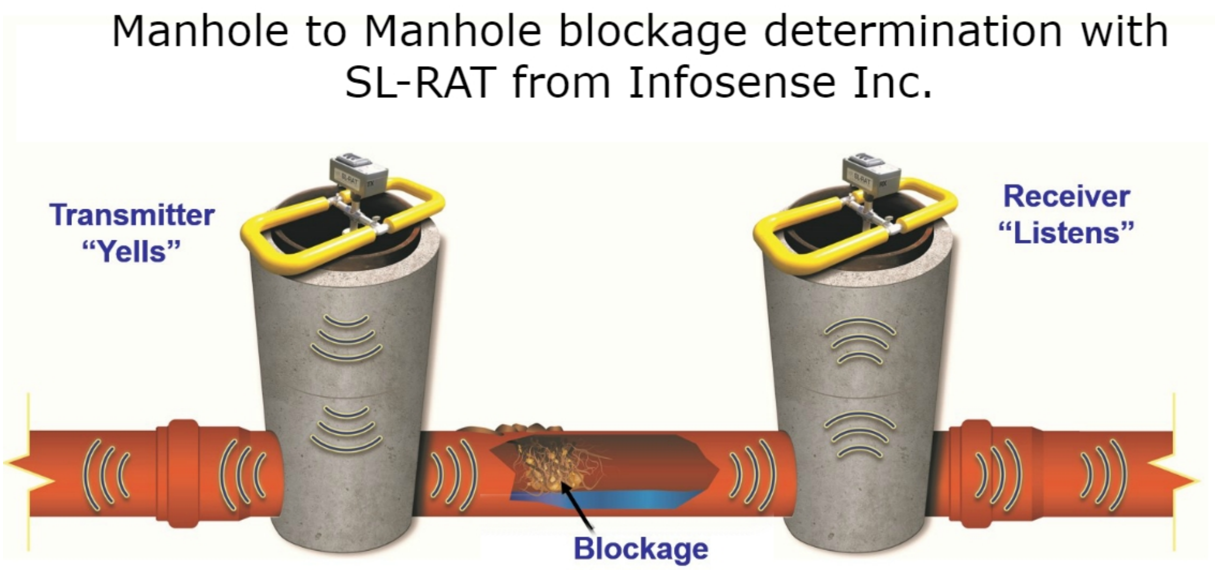
CCTV camera for sewer condition assessments

City of Marshfield

Figure 4.4.1.3

CCTV sanitary sewer inspection images

Figure 4.4.1.4



4.4.2 Discuss manhole inspections and their importance.

Manhole inspections should be performed routinely to verify flows, structural conditions, and evidence of backups. Inspection of the flow, benches, and invert can identify debris and grease buildup. Observations of walls, joints, steps, pipe connections, cover and castings, adjustment rings, root intrusions, and surrounding surface conditions should be noted and recorded.

Documentation of location, identification name or number, and measurements should be noted for future reference in collection system maintenance planning and repair. Pictures or videos should be referenced in the inspection report.

Figure 4.4.2.2

Panoramic Manhole Inspection Device

Visu-Sewer Inc.

4.4.3 Discuss easement inspections.

Sewers located in easements or within areas not located in streets or public right-of-ways should be inspected frequently to be able to access the manholes for cleaning, inspections and emergencies.

Figure 4.4.3.1

Figure 4.4.3.2

4.4.4 Discuss lateral inspections.

Laterals can be inspected via a lateral launch camera from the CCTV unit or a push camera to be launched from the lateral cleanout. Laterals can contribute I/I and typically are rarely inspected and maintained since the majority are privately owned, rather than by a municipality or utility.

Figure 4.4.4.1

4.4.5 Discuss the use of dye testing in the collection system.

Dye testing can be used to identify sources of I/I, perform flow studies or investigations in a collection system. For I/I studies, dye is introduced to a storm sewer or storm ditch. A sanitary sewer is then visually inspected to see if the dye is found in the sanitary sewer. This would indicate a cross-connection between the storm sewer and sanitary sewer.

Dye testing guidelines should include the following:

A. Notify the proper authorities prior to doing dye testing to let them know that the water will be colored in the event that it reaches navigable waters.
B. This testing should not to be performed when the ground is frozen as the frozen soil prevents the water from penetrating the soil and identifying leak.
C. Dye testing may be contracted out due to the resources and equipment necessary to successfully perform this task.
D. Dye must be non-toxic and biodegradable.

Figure 4.4.5.1

4.4.6 Discuss the use of smoke testing.

Smoke testing can be used to identify sources of I/I to a collection system. Smoke testing is done by installing a smoke blower on top of a manhole and visually observing the above ground area for smoke. Storm cross connections or defects are found by visually observing smoke at catch basins, uncapped clean-outs, and roof drains or drain tile illegally connected to the sanitary sewer. If smoke testing is performed, the utility will contact the fire department and provide notification to businesses and homeowners.

Figure 4.4.6.1

4.4.9 Discuss lift station inspections.

Lift stations should be manually inspected on a regularly scheduled basis. An inspection schedule is based on criticality of the lift station, maintenance program, and the condition of the equipment. Inspection checklists should include: pump operation, wet well level and debris, oil spills, visual and audible inspection for abnormal noises, and generator operation if applicable. As part of the inspection, the alarms should be checked to determine proper operation.

Figure 4.4.9.1

The following figure is an example lift station checklist:

LIFT STATION#: **STATION NAME:**

□ Confined Space Entry (This is a mandatory procedure if entry is required)

Ensure proper ventilation for confined space

Check confined space for hazardous atmosphere with gas detector

Follow required confined space entry procedures. Complete the required entry permit.

□ Run each pump for a short time and check for proper operation.

□ Record current amperage draw of each pump.

□ Check wet well to see if cleaning is required. (Grease & Debris) Clean the floats. Schedule cleaning ASAP if required.

□ Check pump on/off floats for proper operation.

□ Check high water float operation for alarm notification.

□ Exercise all lift station valves. Ensure proper functionality.

□ Record run time for each pump at the station. Also, enter all readings into your daily journal. Analyze the runtime minutes onsite to locate any issues. Ensure there are extra sheets in the log book.

□ Test backup pumps or generator under load at scheduled intervals.

□ Trim grass and weeds around station. Pick up litter around station.

LEAVING THE STATION

□ Ensure all pumps are on automatic. Ensure main disconnect is on.

□ Ensure that all control panels are secured and locked.

□ Perform final check to ensure entire station is secured.

4.4.10 Discuss the sulfur cycle within a sewer pipe.

Wastewater containing sulfates ($SO4-$) can cause problems in the collection system. Septic conditions, standing water, or wastewater with low oxygen levels can produce hydrogen sulfide ($H2S$). Hydrogen sulfide can then oxidize into sulfuric acid ($H2SO4$), which can corrode ductile iron and concrete structures, manholes, sampling and metering vaults, and lift station wet wells.

Figure 4.4.10.1

Hydrogen sulfide (H_2S) Spalling

Village of Germantown

4.4.11 Discuss the importance of structural inspection and maintenance within collection system.

There are numerous buildings, housings, and structures that are part and parcel of conveyance systems. Maintaining these systems is necessary for:

A. Personal safety
B. Public safety and comfort (being a good neighbor)
C. Security and protection of a public asset
D. Enhance the longevity of electrical, control, and mechanical systems, especially in harsh seasonal environments

The following are suggested items to review and include in periodic scheduled inspections. This section focuses on those structural components where personnel have visual access.

A. Inspect all structures for water leakage, especially in roofing systems and electrical/control housings.
B. Look for spalling of concrete or exposure/corrosion of steel reinforcing bars.
C. Look for and eliminate tripping hazards. Make sure that grating is secure and fastened down.
D. Secure doors and windows. Consider electronic systems that communicate if a door or window is ajar, when it shouldn't be.
E. Secure all covers when closed or open. Whenever an access cover is open, assure that a temporary barrier is placed around the opening and of adequate height to prevent someone from falling into the opening.
F. Assure that ventilation systems are working properly, and air changes are adequate.

Check for hydrogen sulfide generation using test strips or instrumentation, correct as necessary.
G. For metal structures - test cathodic protection systems where installed. Follow designer and manufacturer recommendations and test accordingly. Life expectancy depends on many factors; however, typical cathodic protection systems can last 20 years.
H. Visually look at overhead power lines and connections. Look for frayed insulation or poor connections.
I. Where installed, check four gas atmospheric analyzer(s) to assure proper operation and calibration.

Section 4.5 - Maintenance of Lift Stations

4.5.1 Discuss the importance of performing pump maintenance.

The key to a good pump maintenance program is preventive maintenance, which can help detect issues prior to pump failure. Proper pump maintenance maximizes a pump's lifespan, it can save money and improve efficiency, and decreased repair costs. Typical pump maintenance involves vibration testing and regular lubrication checks. Cooling system, amp draw, and bearing checks are also routinely performed. It is crucial to perform the proper maintenance at designated intervals dictated from equipment Operation and Maintenance (O&M) manuals.

4.5.2 Discuss the importance of valve maintenance and exercising.

Valve maintenance is important within any pumping system and valves should be kept in good working condition. The best way to keep valves and gates maintained is to exercise and grease them periodically. It may be necessary to carefully schedule this work as it may require shutting systems down during lower flow. If these periodic preventive maintenance activities are not conducted, there is a high probability that the valve will not work when called upon in an emergency.

4.5.3 Discuss the common critical maintenance tasks for motors.

Amperage and voltage readings should be taken at regular intervals as dictated in the motors O&M manual. If the readings do not meet the manufacturer's specifications, it is an indication that debris may be lodged in the pump propeller, possible internal motor issues, or that a bearing may be nearing failure. If the motor does not have sealed bearings, regular greasing of the internal bearings may be required.

4.5.4 Discuss the importance of maintenance of instrumentation and electrical systems at lift stations.

To ensure reliable operation, annual and preventative maintenance of instrumentation and control equipment at lift stations must be performed. Inspections of all electrical motor control equipment should be performed to find poor connections and worn parts. This inspection should include infrared testing and panel maintenance if warranted along with testing the cathodic protection system. Additional checks include testing and calibration of flow meters and level indicators.

4.5.5 Discuss lift station alarm systems.

Audible and visual alarm systems shall provide notification of a problem to prevent sanitary sewer overflows (SSOs) or potential backups into the collection system. Common lift station alarms could be activated by: power failure, high or low wet well water level, pump failure, communication failure, or a stuck float or switch. Alarm systems are often connected to SCADA or notification systems to notify an operator of an alarm condition.

4.5.6 Discuss typical lift station power maintenance activities.

Lift station pumps and control panels shall be periodically monitored for efficient and trouble free operation. Scheduled power monitoring, backup power system testing, and control system checks shall be completed and recorded for future reference to aid in troubleshooting electrical issues. Typical power maintenance activities can include checking source feed voltage, capacitor banks, surge protectors, and fuses.

4.5.7 Discuss the importance of proper maintenance for standby generators.

Back-up power supply from generators is crucial for meeting power demands of lift stations when electrical supply is lost from the main feed source. Generators must be regularly exercised and maintained properly to ensure reliable operation. It is important to follow proper maintenance tasks dictated in the generator's O&M manual. The fuel supply, battery, and charging system must also be maintained and serviced on regular intervals.

4.5.8 Discuss lift station wet well maintenance.

Wet wells should be cleaned on a regular basis to remove grease, debris, and objects. Typical wet well cleaning cycles are every 6 months to a year but may be increased based on conditions. Level devices, floats, and ventilation systems should all be checked during maintenance activities.

Chapter 5 - Rehabilitation and Replacement

Section 5.1 - Discuss Sewer Rehabilitation Techniques

5.1.1 Discuss sewer rehabilitation techniques.

Trenchless rehabilitation is done to restore the structural integrity of the sewer or reduce I/I without excavation, providing minimal disruption to surrounding infrastructure. The method of rehabilitation used is dependent upon: existing sewer materials; condition of the sewer; and existing sewer conditions such as the presence of hydrogen sulfide or I/I. The most common types of pipeline rehabilitation are: grout, slip-lining, pipe-bursting, and cured-in-place pipe (CIPP).

5.1.2 Discuss grouting rehabilitation.

For I/I reduction, a typical rehabilitation and generally less expensive method is to grout the joints of the sewer or lateral connections. Grout is a non-structural repair to be used on round pipe joints. The pipe must be in good structural condition with minimum soil moisture content and voids around the pipe.

Service life is typically 5-10 years but dependent on site conditions. Grout types are acrylamides and urethanes chemicals that are injected into a joint or at a lateral connection and pumped to specific pressures using a grout packer, filling a joint or void. The amount of grout pumped will depend upon the size of the void.

5.1.3 Discuss slip-lining rehabilitation.

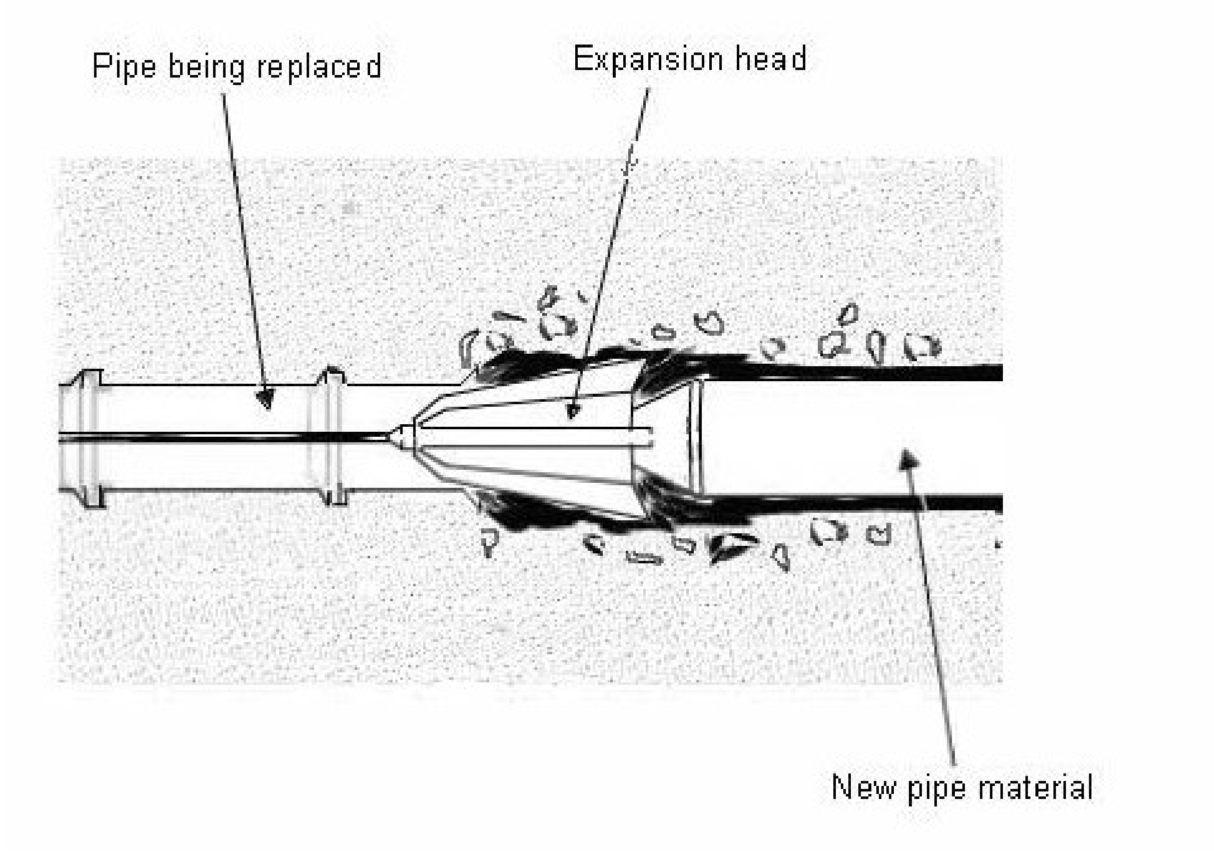
Sliplining is inserting a new smaller size diameter pipe into an existing sewer. Pipe materials for the new pipe are typically: polyvinyl chloride (PVC); high density polyethylene (HDPE); or fiberglass reinforced pipe (FRP) into an existing pipe. Sufficient hydraulic capacity must be maintained with this type of rehabilitation.

This type of rehabilitation is called a semi-trenchless rehabilitation method because trenches are required at the entry and exit points. The new pipe is pushed into existing pipe using the flow to push the pipe thus eliminating the need to bypass flows during installation. Lateral connections must be reinstated by open-cut at the connection.

5.1.4 Discussing pipebursting rehabilitation.

Pipebursting or inline expansion is a semi-trenchless rehabilitation method for replacing sanitary sewers using mechanical expansion to fracture and displace the existing pipe fragments outwards while a new pipe is drawn in to replace the old pipe. Laterals need to be reinstated by excavating.

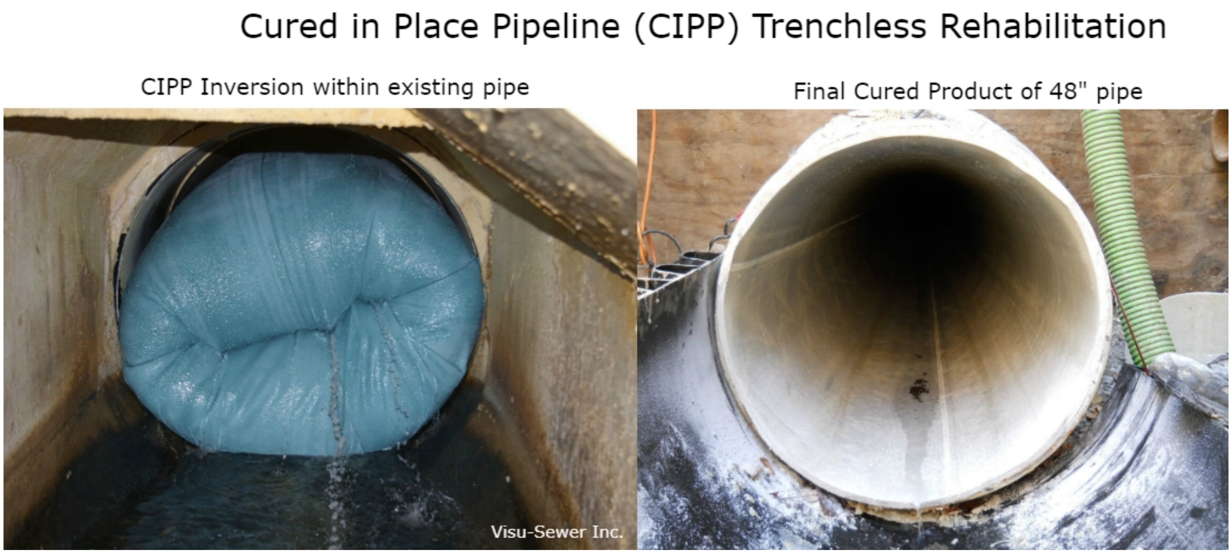
Figure 5.1.4.1



5.1.5 Discuss cured-in-place-pipe (CIPP) rehabilitation.

Cured-in-place pipe (CIPP) is a structural trenchless rehabilitation method for sanitary sewers. It can also be used to reduce I/I. Cured-in-place pipe is a method using a felt material saturated with resin that is installed in the pipe with an inversion method or pulled-in and “cured” using hot water, steam, or ultraviolet light. It is a method that requires bypassing existing flows. Though the diameter of the pipe is reduced, the flow capacity typically remains the same due to the reduced roughness of the pipe. Lateral connections are re-connected using a lateral cutter in the sewer that is operated remotely and verified using a CCTV camera.

Figure 5.1.5.1



5.1.6 Discuss manhole rehabilitation.

Manhole rehabilitation is performed to restore the integrity of the structure and to reduce or eliminate I/I. The method of rehabilitation used is dependent upon: existing manhole materials, condition of the manhole, and existing manhole conditions such as the presence of hydrogen sulfide or I/I.

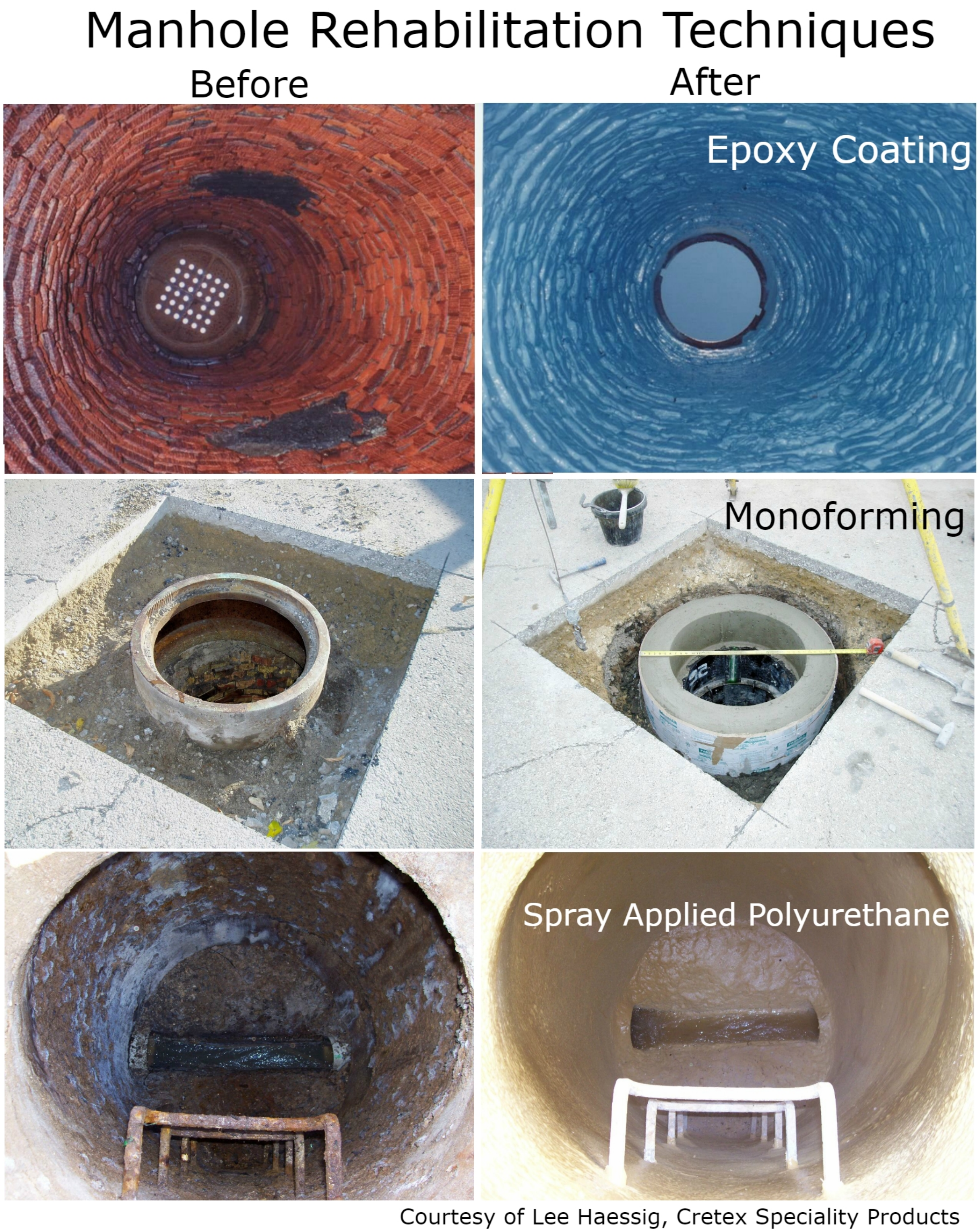
Typical rehabilitation for manholes include grouting the joints of the manhole cone and barrel sections and coating or lining the existing manhole using cured-in-place pipe (CIPP).

Important criteria for manhole rehabilitation is the selection of rehabilitation materials and preparation of the substrate for proper application of the material. Some materials are not acceptable if water is present.

Types of manhole rehabilitation can include:

A. Grout
B. Cementitious
C. Epoxy
D. Cured-in-place liner
E. Sprayed Urethane
F. Monoforming

Figure 5.1.6.1



Chapter 6 - Data and Records

Section 6.1 - Design Plans and Mapping

6.1.1 Describe the importance of collection system maps.

An accurate record of the location, size, depth, slope, material, and type of sanitary and storm sewer collection system components is essential for effective sewer operations and maintenance. Having accurate maps is critical for responding to emergencies (blockages, SSOs) and performing utility locates.

6.1.2 Describe the use and importance of collection system records.

Records provide a historical background of collection system assets including installation dates and work completed. Records help to determine the labor, maintenance, and repair costs to ensure a collection system is maintained. Records and associated documentation will help to identify and prioritize appropriate operation and maintenance (O&M) activities and identify structural defects. This can help to minimize costly corrective or reactive repairs caused by unmaintained or aging infrastructure.
Typical records include: engineering record drawings, videos, photographs, inspections, maintenance, and repair.

6.1.3 Describe the application of a Geographical Information System (GIS).

A geographic information system (GIS) is used to analyze, manage, and visualize assets of collection system infrastructure to identify, prioritize, and schedule appropriate operations and maintenance activities. When data is linked to global position system (GPS) coordinates, the mapped individual collection system components can be computerized and linked to photographs, videos, and databases that provide construction materials, elevations, as well as sewer main diameters, lengths, age, and structural conditions.

A GIS has the ability to document as-built plans, repair records, maintenance, inspections, photographs, and other pertinent collection system information.

6.1.4 Discuss the use of maintenance records in the collection system.

Maintenance records provide means of tracking and logging condition assessment and operational status of collection system components (sewers, manholes, pumps, etc). Maintenance records for collection systems typically fall in two categories - preventative maintenance and corrective maintenance. Preventative maintenance is routine scheduled maintenance performed to prevent a failure and corrective maintenance is performed after a failure or problem has occurred. The records document the work completed including labor, parts and materials, and work performed.

Maintenance records can be documented via a computerized maintenance management system (CMMS). Records can also be used to project upcoming maintenance, estimated service life, maintenance schedule, workload prioritization, and budgeting.

6.1.5 Discuss the importance of asset management in the collection system.

Equipment and infrastructure should be inspected on a regular basis for rehabilitation and/or replacement. Condition assessments are typically done on an annual or biannual basis to provide a long-term replacement schedule. Service life of rehabilitation costs need to be evaluated versus replacement costs.

Chapter 7 - Ordinances and Regulations

Section 7.1 - Definitions

7.1.1 Define satellite collection system.

Satellite sewage collection system means a municipally or a privately owned sewage collection system that conveys wastewater to another satellite sewage collection system or to a collection system that provides wastewater treatment.

7.1.2 Define the Capacity, Management, Operations and Maintenance (CMOM) program.

A program to efficiently operate and maintain collection system assets to minimize performance failures and prevent overflows.

7.1.3 Define municipal or local sanitary sewer ordinances.

Rules, regulations, or codes enacted into law by local or municipal government used to protect sanitary sewer assets, set fines, or create discharge limitations to prevent high strength waste, FOG, or illicit discharges from entering a municipal collection system. Ordinances may also be used to limit or prevent clearwater sources from roof and foundation drains as well as basement sump pumps.

Section 7.2 - Federal Regulations

7.2.1 Discuss the importance of collecting and treating wastewater.

Collecting and treating wastewater protects public health and the environment by destroying pathogens in the treatment process and also removes excessive nutrients and other pollutants.

7.2.2 Discuss the Clean Water Act.

The Clean Water Act is a federal law created in 1972 with the main objective of chemically, physically, and biologically restoring and maintaining the nation’s waters. It was created to stop the continuous dumping of pollutants, both point source and non-point source, into surface waters and wetlands.

Section 7.3 - State Regulations

7.3.1 Discuss the regulatory requirements of a CMOM program.

It is a utility specific document to properly operate and maintain collection systems that must be reviewed and updated on an annual basis. All CMOM plans must contain an overflow emergency response plan. This applies to municipal and non-municipal entities that own a sewage collection system that is treated by a regional wastewater treatment facility.

7.3.2 Describe the Satellite Sewage Collection Systems General Permit.

The Satellite Sewage Collection Systems General Permit applies to municipal and non-municipal entities that own a sewage collection system that is conveyed and treated at a regional wastewater treatment facility. The general permit includes reporting requirements for sanitary sewer overflows if they occur and the submittal of a compliance maintenance annual report (CMAR). Sewage collection system owners must also implement a capacity, management, operation and maintenance program (CMOM).

7.3.3 Discuss the purpose of an Emergency Response Plan (ERP).

An Emergency Response Plan (ERP) is a comprehensive document that accounts for actions that occur before, during, and after an emergency. The goal of an ERP is to prevent, minimize, and mitigate injury and damage resulting from natural or man-made emergencies or disasters.

7.3.4 Describe actions to limit SSO human health and environmental impacts.

If the release of wastewater from a sewage collection system or an interceptor sewer flows directly into a water of the state or infiltrates into the land surface the permittee shall take the following steps:

A. Control or limit the volume of wastewater and terminate the discharge as soon as possible.
B. Intercept or reroute wastewater flow around the collection system failure.
C. Create a berm or barrier to contain or direct flow away from public areas, waterways, storm drains, and ditches.
D. Use vacuum trucks or other mechanisms to recover as much of the wastewater discharged as possible.
E. Clean up debris at the overflow site.
F. Perform adequate sampling to determine amount, characteristics, and impact of overflow.
G. Perform remedial actions laid out in the emergency response plan to limit exposure to human health and the environment.

7.3.5 Describe reporting procedures of an SSO event.

Permittees must report all sanitary sewer overflows to the Wisconsin Department of Natural Resources (department). Within 24 hours from the time a permittee becomes aware of an SSO, it must be reported to the department by telephone, fax, or email. Within 5 days, submit the Sanitary Sewage Overflow Notification Summary Report (form 3400-184) to the department. Public notification of the SSO event shall occur promptly following any overflow event using the most effective and efficient communications available in the community. At minimum, a daily newspaper of general circulation in the county(s) and municipality whose waters may be affected by the overflow shall be notified by written or electronic communication.

Form 3400-184 contains the following:

A. The GPS location of the overflow.
B. The surface water the overflow reached, if any.
C. The duration and estimated volume of the overflow.
D. Description of the sewer system component the overflow occurred.
E. The estimated date and time when the overflow began and stopped or is expected to stop.
F. The cause or suspected cause of the overflow.
G. Steps taken or pan to reduce, eliminate, or prevent reoccurrence of the overflow with schedule of major milestones for those steps.
H. Description of actual or potential human exposure and contact with overflow

wastewater.
I. Planned schedule or steps taken to mitigate the impacts of the overflow.
J. Number of estimated building backups that occurred concurrently with the SSO.
K. Whether the overflow was unavoidable to prevent loss of life, personal injury, or severe property damage.

7.3.6 Discuss the purpose of the Compliance and Maintenance Annual Report (CMAR).

The CMAR is an annual self-evaluation tool submitted to the Department of Natural Resources that promotes the owner's awareness and responsibility for wastewater collection and treatment needs, measures the performance of a wastewater treatment and collection systems during a calendar year, and assesses its level of compliance with permit requirements.

Section 7.4 - Local Regulations

7.4.1 Describe an appropriate SSO ERP.

The ERP presents a strategy or procedures for staff to mobilize labor, materials, tools, and equipment to correct or repair any condition which may cause or contribute to an SSO. The utility is responsible for the following:

A. Compilation of information regarding an SSO.
B. Dispatching the appropriate personnel to address the SSO.
C. Protect collection system personnel.
D. SSO mitigation, containment and cleanup.
E. Protect private and public property beyond the collection system.
F. Proper notification and documentation to residents, regulatory agencies, and media.
G. Primary failure analysis and implement corrective action.

7.4.2 Describe capacity assurance.

The collection system must have sufficient capacity to convey average daily flows and peak flows attributed to wet weather. Collection systems that are experiencing SSOs caused by I/I, or have hydraulic deficiencies need to evaluate and determine I/I sources. As part of the capacity assurance evaluation it is critical to identify I/I sources, including private property roof drains, downspouts, and foundation drains, that contribute to peak flows.

Chapter 8 - Calculations

Section 8.1 - Sampling

8.1.1 Given the average industrial daily plant flow, calculate the programming of a flow-proportional sampler to determine the flow interval per sample and the correct volume (mL) of each sample.

GIVEN:

Average daily flow = 20,000 gpd
24-hour composite volume desired = 5,000 mL
Sample container size = 10 L

Samples per day = 100

FORMULAS AND SOLUTION:

Flow interval (gallons/sample) = average daily flow (gpd) ÷ # of samples/day
= 20,000 gpd ÷ 100 samples/day
= 200 gal/sample

Sample volume (mL) = 24-hour composite volume (mL/day) ÷ # of samples/day
= 5,000 mL/day ÷ 100 samples/day
= 50 mL samples

Section 8.2 - Flow Conversions and Flow Rate

8.2.1 Given a flow rate in gallons per day (gpd), convert the flow rate to million gallons per day (MGD).

GIVEN:

Flow rate = 600,000 gpd

FORMULA AND SOLUTION:

Flow rate (MGD) = flow rate (gpd) ÷ 1,000,000
= 600,000 gpd ÷ 1,000,000
= 0.600 MGD

8.2.2 Given a flow rate in gallons per minute (gpm), convert the flow rate to MGD.

GIVEN:

Flow rate = 500 gpm
1 day = 1,440 minutes

FORMULA AND SOLUTION:

Flow rate (MGD) = [flow rate (gpm) × 1,440 min/day] ÷ 1,000,000
= [500 gpm × 1,440 min/day] ÷ 1,000,000
= 0.720 MGD

Section 8.3 - Tank Areas and Volumes

8.3.1 Given the dimensions of a rectangular basin, calculate the volume in gallons.

GIVEN:

Basin length = 60 ft
Basin width = 20 ft
Basin depth = 10 ft
1 cubic foot = 7.48 gallons

FORMULA AND SOLUTION:

Basin volume (gal) = length (ft) × width (ft) × depth (ft) × 7.48 gal/ft^3
= 60 ft × 20 ft × 10 ft × 7.48 gal/ft^3
= 89,760 gallons

8.3.2 Given the dimensions of a circular basin, calculate the volume (gal).

GIVEN:

Basin diameter = 30 ft
Basin depth = 10 ft
1 cubic foot = 7.48 gallons
Radius = diameter/2

FORMULA AND SOLUTION:

Basin volume (gal) = 3.14 × (radius (ft))^2 × depth (ft) × 7.48 gal/ft^3
= 3.14 × (15 ft × 15 ft) × 10 ft × 7.48 gal/ft^3
= 52,846 gallons

8.3.3 Given data during wet weather, determine if a wet well is of sufficient volume to meet a 30-minute detention time at peak hourly flow.

GIVEN:

Tank depth = 15 ft
Tank length = 20 ft
Tank width = 15 ft
Peak hourly flow = 35,000 gal/hr
Detention time needed = 30 minutes
1 cubic foot = 7.48 gallons

FORMULAS AND SOLUTION:

Tank volume (gal) = length (ft) × width (ft) × depth (ft) × 7.48 gal/ft^3
= 15 ft × 20 ft × 15 ft × 7.48 gal/ft^3
= 33,660 gal

Detention time (minutes) = [tank volume (gal) ÷ flow rate (gal/hr)] × 60 mins/hr

= [33,660 gal ÷ 35,000 gal/hr] × 60 mins/hr
= 0.96 hr × 60 mins/hr
= 57 minutes

Yes; the wet well is just able to meet the 30-minute detention time during wet weather peak hourly flow.

Section 8.4 - Pounds Formula

8.4.1 The pounds formula may be used by collection system operators. Given the following data, convert a pollutant concentration and flow to pounds per day.

GIVEN:

Industrial effluent biochemical oxygen demand (BOD) = 200 mg/L
flowrate (gpd) = flowrate (MGD) ÷ 1,000,000

FORMULA AND SOLUTION:

BOD (lbs/day) = flowrate (MGD) × BOD (mg/L) × 8.34
= 200 mg/L × 1.0 MGD × 8.34
= 1,668 lbs/day

Section 8.5 - Pump Rate

8.5.1 Given the dimensions of a rectangular sewage wetwell, calculate the estimated pump rate in gallons per minute (gpm) for the given pumping drawdown. Assume no additional influent is flowing into the wetwell while pumping.

GIVEN:

Wet well length = 16 ft
Wet well width = 13 ft
Pumping drawdown depth = 1.75 ft
Pumping time = 6 mins
1 cubic foot = 7.48 gal

FORMULA AND SOLUTION:

Pump rate (gpm) = [length (ft) × width (ft) × drawdown (ft) × 7.48 gal/ft^3] ÷ pumping time (minutes)
= [16 ft × 13 ft × 1.75 ft × 7.48 gal/ft^3] ÷ 6 min
= 454 gpm

8.5.2 Given the dimensions of a circular sewage wet well, calculate the estimated pump rate in gallons per minute (gpm) for the given pumping drawdown. Assume there is no influent flow to the wet well.

GIVEN:

Wet well diameter = 8 ft
Pumping drawdown = 4.25 ft
1 cubic foot = 7.48 gal
Pumping time = 5 mins

FORMULA AND SOLUTION:

Pump rate (gpm) = [3.14 × $(\text{radius (ft)})^2$ × drawdown (ft) × 7.48 gal/ft^3] ÷ pumping time (min)

= [3.14 × (4 ft x 4 ft) × 4.25 ft × 7.48 gal/ft³] ÷ 5 min
= 319 gpm

8.5.3 During a lift station power outage, to avoid a sanitary sewage overflow (SSO) or basement backup, wastewater is pumped the wet well to a downstream manhole during a storm. Calculate the minimum pumping required in gallons per minute (gpm) needed to keep up with the wastewater flow.

GIVEN:

Wet well length = 10 ft
Wet well width = 10 ft
Wet well depth = 15 ft
1 ft³ = 7.48 gal
Wet well fill time during storm = 10 mins

FORMULAS AND SOLUTION:

Wet well volume (gal) = length (ft) × width (ft) × depth (ft) × 7.48 gal/ft³
= 10 ft × 10 ft × 15 ft × 7.48 gal/ft³
= 11,220 gal

Sewage flow (gpm) = wet well volume (gal) ÷ fill time (mins)
= 11,200 gal ÷ 10 mins
= 1,120 gpm

Due to uncertainty of rain intensity and flow characteristics a 1,500 gpm pump should be used to prevent a SSO or basement backup.

8.5.4 Assuming the water depth of a lift station wet well stays constant, calculate the approximate pump rate (gpm) of a lift station pump.

GIVEN:

Wet well diameter = 7 ft
Drawdown depth = 1.33 ft
Drawdown time = 250 secs
Refill time = 400 secs
Refill depth = 1.25 ft
1 cubic foot = 7.48 gal
60 secs = 1 min

FORMULAS AND SOLUTION:

Drawdown volume (gal) = 3.14 × (radius (ft))² × drawdown depth (ft) × 7.48 gal/ft³
= 3.14 × (3.5 ft × 3.5 ft) × 1.33 ft × 7.48 gal/ft³
= 383 gal

Refill volume (gal) = 3.14 × (radius (ft))² × refill depth (ft) × 7.48 gal/ft³
= 3.14 × (3.5 ft × 3.5 ft) × 1.25 ft × 7.48 gal/ft³

= 360 gal

Pump rate (gpm) = [drawdown volume (gal) ÷ time (min)] + [refill volume (gal) ÷ time (min)]
= [383 gal ÷ (250 secs ÷ 60 secs/min)] + [360 gal ÷ (400 secs ÷ 60 secs/min)]
= [383 gal ÷ 4.2 mins] + [360 gal ÷ 6.7 mins]
= 91 gpm + 54 gpm
= 145 gpm

Section 8.6 - Detention Time

8.6.1 Given data, calculate the detention time (hrs) for a wet well.

GIVEN:

Volume of wet well = 15,000 gal
Flow rate = 200,000 gallons per day (gpd)
1 day = 24 hrs

FORMULAS AND SOLUTION:

Flow (gal/hr) = flow rate (gpd) ÷ 24 hrs/day
= 200,000 gpd ÷ 24 hr/day
= 8,333 gal/hr

Detention time (hrs) = volume (gal) ÷ flow (gal/hr)
= 15,000 gal ÷ 8,333 gal/hr
= 1.80 hrs

Section 8.7 - Sewer Grading

8.7.1 What is the slope, in percent, of a sanitary main that is 400 ft long with a drop of 5 ft from manhole to manhole.

GIVEN:

Sewer main length between manholes = 400 feet
Upstream manhole to downstream manhole drop = 5 ft
Conversion to percentage = calculated value × 100

FORMULAS AND SOLUTION:

Slope = drop (ft) ÷ length (ft) of sewer
Slope = 5 ft ÷ 400 ft
= 0.0125

Convert to percentage
= 0.0125 × 100 = 1.25 %

References and Resources

1. **UW Water Library**

   Most of the resources listed on this page can be borrowed through the UW Water Library as part of a partnership between the UW Water Library, the Wisconsin Wastewater Operator Association (WWOA), Central States Water Environmental Association (CSWEA), and the Wisconsin Department of Natural Resources. Instructions for borrowing materials from the UW Water Library can be found by visiting the website provided below, clicking on 'WISCONSIN RESIDENTS', and then clicking on 'HOW TO BORROW MATERIALS'.

   https://waterlibrary.aqua.wisc.edu/

2. **A Drop of Knowledge, The Non-operator's Guide to Wastewater Systems**

   Washington, DC., National Environmental Services Center on behalf of Rural Community Assistance Partnership, Inc. (2011).

   https://rcap.org/

3. **ANSI/ISEA 107-2015**

   High-Visibility Safety Apparel & Accessories. The American National Standards Institute (2015).

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4. **Basic Wastewater Collection Systems**

   Rick Arbour. Minnesota Pollution Control Agency. 2nd Edition. (1995).

5. **Collection Systems Operators' Guide to Preparing for the Certification Examination**

   Water Environment Federation and Association of Boards of Certification. (2003).

6. **Design of Wastewater and Stormwater Pumping Stations**

   Manual of Practice FD4. Water Environment Federation. (1993).

7. **Jetter Code of Practice**

   National Association of Sewer Service Companies (NASSCO); 2nd Edition. (2006).

8. **Math Workbook for Collection System Operators**

   Duerre, S., Ellefson, N., & Minnesota Pollution Control Agency. (2008). Math Workbook for Collection System Operators. MN: Minnesota Pollution Control Agency.

9. **OSHA CFR 29 Part 1910**

   Occupational Safety & Health Administration (OSHA). Regulations (Standards-29 CFR 1910.1200)

   https://www.osha.gov

10. **Teledyne Isco Open Channel Flow Measurement Handbook**

    Teledyne Isco. 8th Edition. (2016).

11. WEF/ABC/C2EP Collection Systems Operators' Guide to Preparing for the Certification Examination

Water Environment Federation, Association of Boards of Certification and C2EP. Certification Commission for Environmental Professionals. (2014).

12. Wisconsin CMOM

Capacity, Management, Operation & Maintenance Booklet. PUB-WT-917-2009.

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