**GLOSSARY:**

**ACTIVATED SLUDGE -** Are the solids that are formed when microorganisms are used to treat wastewater during the process referred to as activated sludge treatment. It includes organisms, accumulated food materials and waste products from the aerobic decomposition process.

**ADVANCED WASTE TREATMENT -** A treatment technology used to produce an extremely high-quality discharge.

**AEROBIC -** A condition in which atmospheric or dissolved molecular oxygen is present in the aquatic (water) environment.

**AIR TEST** - A method of inspecting a sewer pipe for leaks. Inflatable or similar plugs are placed in the line, and the space between these plugs is pressurized with air. A drop in pressure indicates the line or run being tested has leaks.

**ANAEROBIC** - A condition in which atmospheric or dissolved molecular oxygen is NOT present in the aquatic (water) environment.

**ANAEROBIC DECOMPOSITION -** The decay or breaking down of organic material in an environment containing no “free” or dissolved oxygen.

**ANOXIC** - Oxygen deficient or lacking sufficient oxygen.

**ASPHYXIATION -** An extreme condition often resulting in death due to a lack of oxygen and excess carbon dioxide in the blood from any cause.

**AVERAGE MONTHLY DISCHARGE LIMITATION** - The highest allowable discharge over a calendar month

**AVERAGE WEEKLY DISCHARGE LIMITATION** - The highest allowable discharge over a calendar week.

**BOD -** Biochemical Oxygen Demand. The rate at which organisms use the oxygen in water or wastewater while stabilizing decomposable organic matter under aerobic conditions. In decomposition, organic matter serves as food for the bacteria and energy results from its oxidation. BOD measurements are used as a measure of the organic strength of wastes in water.

**BACKFILL -** (1) Material used to full in a trench or excavation. (2) The act of filling a trench or excavation, usually after a pipe or some type of structure has been placed in the trench or excavation.

**BACKFILL COMPACTION -** (1) Tamping, rolling or otherwise mechanically compressing material used as backfill for a trench of excavation. Backfill is compressed to increase its density so that it will support the weight of machinery or other loads after the material is in place in the 222

excavation. (2) Compaction of a backfill material can be expressed as a percentage of the maximum compatibility, density or load capacity of the material being used.

**BACKFLUSHING -** A procedure used to wash settled waste matter off upstream to prevent odors from developing after a main line stoppage has been cleared.

**BACTERIA** - Bacteria are living organisms, microscopic in size, which usually consist of a single cell. Most bacteria use organic matter for their food and produce waste products as a result of their life processes.

**BALLING -** A method of hydraulically cleaning a sewer or storm drain by using the pressure of a water head to create a high cleansing velocity of water around the ball. In normal operation, the ball is restrained by a cable while water washes past the ball at high velocity. Special sewer cleaning balls have an outside tread that causes them to spin or rotate, resulting in a “scrubbing” action of the flowing water along the pipe wall.

**BAR RACK -** A screen composed of parallel bars, either vertical or inclined, placed in a sewer or other waterway to catch debris. The screenings may be raked from it.

**BARREL -** (1) The cylindrical part of a pipe that may have a bell on one end. (2) The cylindrical part of a manhole between the cone at the top and the shelf at the bottom.

**BEDDING -** The prepared base or bottom of a trench or excavation on which a pipe or other underground structure is supported.

**BEDDING COMPACTION -** (1) Tamping, rolling or otherwise mechanically compressing material used as bedding for a pipe or other underground structure to a density that will support expected loads. (2) Bedding compaction can be expressed as a percentage of the maximum load capacity of the bedding material. (3) Bedding compaction also can be expressed in load capacity or pounds per square foot.

**BEDDING GRADE** - (1) In a gravity-flow sewer system, pipe bedding is constructed and compacted to the design grade of the pipe. This is usually expressed in a percentage. A 0.5 percent grade would be a drop of one-half of foot per hundred feet of pipe. (2) Bedding grade for a gravity-flow sewer pipe can also be specified as elevation above mean sea level at specific points.

**BELL -** (1) In pipe fitting, the enlarged female end of a pipe into which the male end fits. (2) In plumbing, the expanded female end of a wiped joint.

**BELL-AND-SPIGOT JOINT -** A form of joint used on pipes which have an enlarged diameter or bell at one end, and a spigot at the other which fits into and is laid in the bell. The joint is then made tight by lead, cement, rubber O-ring, or other jointing compounds or materials.

**BIOCHEMICAL OXYGEN DEMAND see (BOD)** 223

**BIOSOLIDS** - Organic matter recovered from a sewage treatment process.

**BIOSOLIDS CAKE -** Solid discharge from a dewatering apparatus.

**BIT -** (1) Cutting blade used in rodding (pipe cleaning) operations. (2) Cutting teeth on the auger head of a sewer boring tool.

**BLOCKAGE -** (1) Partial or complete interruption of flow as a result of some obstruction in a sewer. (2) When a collection system becomes plugged and the flow backs up, “blockage.”

**BRANCH MANHOLE** - A sewer or drain manhole which has more than one pipe feeding into it. A standard manhole will have one outlet and one inlet. A branch manhole will have one outlet and two or more inlets.

**BRANCH SEWER -** A sewer that receives wastewater from a relatively small area and discharges into a main sewer servicing more than one branch sewer area.

**BUCKET** - (1) A special device designed to be pulled along a sewer for the removal of debris from the sewer. The bucket has one end open with the opposite end having a set of jaws. When pulled from the jaw end, the jaws are automatically opened. When pulled from the other end, the jaws close. In operation, the bucket is pulled into the debris from the jaw end and to a point where some of the debris has been forced into the bucket. The bucket is then pulled out of the sewer from the other end, causing the jaws to close and retain the debris. Once removed from the manhole, the bucket is emptied and the process repeated. (2) A conventional pail or bucket used in BUCKETING OUT and also for lowering and raising tools and materials from manholes and excavations.

**BUCKET BAIL -** The pulling handle on a bucket machine.

**BUCKET MACHINE -**A powered winch machine designed for operation over a manhole. The machine controls the travel of buckets used to clean sewers.

**BUCKETING OUT -** An expression used to describe removal of debris from a manhole with a pail on a rope. In balling or high-velocity cleaning of sewers, debris is washed into the downstream manhole. Removal of this debris by scooping it into pails and hauling debris out is called “bucketing out.”

**BUFFER** - A substance or solution that resists changes in pH.

**BYPASS** - A pipe, valve, gate, weir, trench or other device designed to permit all or part of a wastewater flow to be diverted from usual channels or flow. Sometimes refers to a special line which carries the flow around a facility or device that needs maintenance or repair.

**BYPASSING -** The act of causing all or part of a flow to be diverted from its usual channels. In a wastewater treatment plant, overload flows should be bypassed into a holding pond for future treatment. 224

**CAKE SOLID DISCHARGE RATE** – The dry solids cake discharge from a centrifuge, which is expressed as: dry cake solids discharge rate = (dry solids feed rate) x (solids recovery).

**CATCH BASIN** - A chamber or well used with storm or combined sewers as a means of removing grit which might otherwise enter and be deposited in sewers.

**CHEMICAL GROUT** - Two chemical solutions that form a solid when combined. Solidification time is controlled by the strength of the mixtures used and the temperature.

**CHEMICAL OXYGEN DEMAND (COD)** – The amount of chemically oxidizable material present in wastewater.

**CLARIFIER**- Is a structure designed to permit solids to settle or rise for the purpose of separation from the flow.

**CLEANOUT -** An opening (usually covered or capped) in a wastewater collection system used for inserting tools, rods or snakes while cleaning a pipeline or clearing a stoppage.

**COLIFORM BACTERIA** – Live in everyone’s intestinal track. They are considered non-pathogenic.

**COLLECTION SYSTEM** - A network of pipes, manholes, cleanouts, traps, siphons, lift stations and other structures used to collect all wastewater and wastewater-carried wastes of an area and transport them to a treatment plant or disposal system. The collection system includes land, wastewater lines and appurtenances, pumping stations and general property.

**COMMUNITY WASTEWATER SYSTEM** – A public wastewater system which has at least 15 service connection or treats 5,000 gallons or more of wastewater per day. The term “community wastewater system” is used only to identify the public wastewater systems which must be operated by certified operators.

**COMPOSITE SAMPLE** – A combination of individual samples taken in proportion to flow.

**COMPUTED PER CAPITA CONTRIBUTION**

-The computed wastewater contribution from a domestic area, based on the population of the area. In the United States, the daily average wastewater contribution is considered to be 100 gallons per capita per day (100GPCD).

**COMPUTED TOTAL CONTRIBUTION -** The total anticipated load on a wastewater treatment plant or the total anticipated flow in any collection system area based on the combined computed contributions of all connections to the system.

**CONCRETE CRADLE -** A device made of concrete that is designed to support sewer pipe. 225

**CONFINED SPACE**

Confined space means a space that:

**A**. Is large enough and so configured that an employee can bodily enter and perform assigned work; and

**B**. Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and

**C**. Is not designed for continuous employee occupancy. (Definition from the Code of Federal Regulations (CFR) Title 29 Part 1910.146).

**CORROSION** - The gradual decomposition or destruction of a material due to chemical action, often due to an electrochemical reaction. Corrosion starts at the surface of a material and moves inward, such as the chemical action upon manholes and sewer pipe materials.

**COUPLING** - (1) A threaded sleeve used to connect two pipes. (2) A device used to connect two adjacent parts, such as pipe coupling, hose coupling or drive coupling.

**COUPON -** A steel specimen inserted into wastewater to measure the corrosiveness of the wastewater. The rate of corrosion is measured as the loss of weight of the coupon or change in its physical characteristics. Measure the weight loss (in milligrams) per surface area (in square decimeters) exposed to the wastewater per day.

**CROSS CONNECTION** - A connection between a storm drain system and a sanitary collection system.

**DAILY DISHARGE** – The discharge of a pollutant measured during a calendar day or any 24 – hour period that reasonably represents a calendar day for the purposes of sampling.

**DAILY MAXIUM DISCHARGE** – The highest allowable value for a daily discharge.

**DEQ** - Department of Environmental Quality.

**DEADEND MANHOLE** - A manhole located at the upstream end of a sewer and having no inlet pipe.

**DEBRIS -** Any material in wastewater found floating, suspended, settled, or moving along the bottom of a sewer. This material may cause stoppages by getting hung up on roots or settling out in a sewer. Debris includes grit, paper, rubber, silt, and all materials except liquid.

**DETENTION TIME** – The theoretical time water remains in a tank at a given discharge.

**DEWATER** - To drain or remove water from an enclosure. A structure may be dewatered so that it can be inspected or repaired. Dewater also means draining or removing water from sludge to increase the solids concentration. 226

**DIP -** A point in the sewer pipe where a drain grade defect results in a puddle of standing water when there is no flow.

**DICHARGE MONITORING REPORT (DMR)** – The monthly report required by the treatment plant’s NPDES / OPDES discharge permit.

**DIGESTER** – A tank in which sludge is placed to allow decomposition by microorganisms. Digestion may occur under anaerobic or aerobic conditions.

**DISINFECTION** - The process designed to kill or inactivate most microorganisms in water, including essentially all pathogenic (disease-causing) bacteria. There are several ways to disinfect, with chlorine being the most frequently used method in both water and wastewater systems.

**DISSOLVED OXYGEN (DO)** – Free or elemental oxygen that is dissolved in water.

**DRAGLINE** - A machine that drags a bucket down the intended line of a trench to dig or excavate the trench. Also used to dig holes and move soil or aggregate.

**DROP MANHOLE** - A main line or house service line lateral entering a manhole at a higher elevation than the main flow line or channel. If the higher elevation flow is routed to the main manhole channel outside of the manhole, it is called an “outside drop.” If the flow is routed down through the manhole barrel, the pipe down to the manhole channel is called an “inside drop.”

**DRY WELL -** A dry room or compartment in a lift station, near or below the water level, where the pumps are located.

**EPA** - United States Environmental Protection Agency.

**EASEMENT** - Legal right to use the property of others for a specific purpose. For example, a utility company may have a five-foot easement along the property line of a home. This gives the utility the legal right to install and maintain a sewer line within the easement.

**EFFLUENT** - Wastewater or other liquid—raw (untreated), partially, or completely treated—flowing FROM a reservoir, basin, treatment process, or treatment plant.

**ELEVATION** - The height to which something is elevated, such as the height above sea level.

**EXFILTRATION** - Liquid wastes and liquid-carried wastes which unintentionally leak out of a sewer pipe system and into the environment.

**FACULTATIVE ORGANISMS** - Organisms that can survive and function in the presence or absence of free, elemental oxygen. Basically organisms that can switch from aerobic or anaerobic depending on its environment. 227

**FACULTATIVE POND** (also known as a wastewater treatment pond or lagoon) – The most common type of treatment pond used for treating domestic wastewater. The upper portion is aerobic, while the bottom layer is anaerobic. Algae supply most of the oxygen in the aerobic layer.

**FAIR LEAD PULLEY** - A pulley that is placed in a manhole to guide TV camera electric cables and the pull cable into the sewer when inspecting pipelines.

**FECAL COLIFORM** – A type of bacteria found in the bodily discharges of warm-blooded animals. Used as an indicator organism.

**FLOAT LINE** - A length of rope or heavy twine attached to a float, plastic jug or parachute to be carried by the flow in a sewer from one manhole to the next. This is called “stringing the line” and is used for pulling through winch cables, such as for a bucket machine work or closed-circuit television work.

**FLOTATION -** (1) The stress or forces on a pipeline or manhole structure below a water table which tend to lift or float the pipeline or manhole structure. (2) The process of raising suspended matter to the surface of the liquid in a tank where it forms a scum layer that can be removed by skimming. The suspended matter is raised by aeration, the evolution of gas, the use of chemicals, electrolysis, heat or bacterial decomposition.

**FLOW -** The continuous movement of a liquid from one place to another.

**FLOW ISOLATION -** A procedure used to measure inflow and infiltration (I/I). A section of sewer is blocked off or isolated and the flow from the section is measured.

**FLUME** – (1) An open conduit of wood, masonry, metal, or plastic constructed on a grade and sometimes elevated. (2) A flow rate measurement device.

**FLUSHER BRANCH -** A line built specifically to allow the introduction of large quantities of water to the collection system so the lines can be “flushed out” with water. Also installed to provide access for equipment to clear stoppages in a sewer.

**FLUSHING -** The removal of deposits of material which have lodged in sewers because of inadequate velocity of flows. Water is discharged into the sewers at such rates that the larger flow and higher velocities are sufficient to remove the material.

**FOOD-TO-MASS RATIO (F/M)** – An activated sludge process-control calculation based upon the amount of food (BOD5 or COD) available per pound of mixed liquor volatile suspended solids.

**FORCE MAIN -** A pipe that carries wastewater under pressure from the discharge side of a pump to a point of gravity flow downstream. 228

**FRICTION LOSS -** The head lost by water flowing in a stream or conduit as the result of the disturbances set up by the contact between the moving water and its containing conduit and by intermolecular friction.

**GRAB SAMPLE** – An individual sample collected at a randomly selected time.

**GRADE** - (1) The elevation of the invert (or bottom) of a pipeline, canal, culvert, sewer, or similar conduit. (2) The inclination of slope of a pipeline, conduit, stream channel, or natural ground surface; usually expressed in terms of the ratio or percentage of number of units of vertical rise or fall per unit of horizontal distance. A 0.5 percent grade would be a drop of one-half foot per hundred feet of pipe.

**GRAVITY FLOW** - Water or wastewater flowing from a higher elevation to a lower elevation due to the force of gravity. The water does not flow due to energy provided by a pump. Wherever possible, wastewater collection systems are designed to use the force of gravity to convey waste liquids and solids.

**GREASE -** In a collection system, grease is considered to be the residues of fats, detergents, waxes, free fatty acids,

calcium and magnesium soaps, mineral oils, and certain other non-fatty material which tend to separate from water and coagulate as floatables or scums.

**GREASE BUILDUP -** Any point in a collection system where coagulated and solidified greases accumulate and build up. Many varieties of grease have high adhesive characteristics and collect other solids, forming restrictions and stoppages in collection systems.

**GREASE TRAP -** A receptacle designed to collect and retain grease and fatty substances usually found in kitchens or from similar wastes. It is installed in the drainage system between the kitchen or other point of production of the waste and the building wastewater collection line. Commonly used to control grease from restaurants.

**GRIT -** The heavy mineral material present in wastewater such as sand, coffee grounds, eggshells, gravel and cinders. Grit tends to settle out at flow velocities below 2 ft. /sec,

and accumulates in the invert or bottoms of the pipelines.

**GRIT CATCHER -** A chamber usually placed at the upper end of a depressed collection line or at other points on combined or storm water collection lines where wear from grit is possible. The chamber is sized and shaped to reduce the velocity of flow through it and thus permit the settling out of grit.

**GRIT TRAP** - A permanent structure built into a manhole (or other convenient location in a collection system) for the accumulation and easy removal of grit.

**INDUSTRIAL WASTEWATER** – Wastes associated with industrial manufacturing processes. 229

**INFILTRATION** - The seepage of groundwater into a sewer system, including service connections. Seepage frequently occurs through defective or cracked pipes, pipe joints, connections, or manhole walls.

**INFILTRATION HEAD -** The distance from a point of infiltration leaking into a collection system to the water table elevation. This is the pressure of the water being forced through the leak in the collection system.

**INFILTRATION/INFLOW -** The total quantity of water from both infiltration and inflow without distinguishing the source. Abbreviated I&I or I/I.

**INFLATABLE PIPE STOPPER -** An inflatable ball or bag used to form a plug to stop flows in a sewer pipe.

**INFLOW -** Water discharged into a sewer system and service connections from such sources as, but not limited to, roof leaders, cellars, yard and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, around manhole covers or through holes in the covers, cross connections from storm and combined sewer systems, catch basins, storm waters, surface runoff, street wash waters or drainage. Inflow differs from infiltration in that it is a direct discharge into the sewer rather than a leak in the sewer itself.

**INFLUENT -** Wastewater or other liquid—raw (untreated) or partially treated—flowing into a reservoir, basin, treatment process, or treatment plant.

**INLET -** (1) A surface connection to a drain pipe. (2) A chamber for collecting storm water with no well below the outlet pipe for collecting grit. Often connected to a CATCH BASIN or a “basin manhole” with a grit chamber.

**INORGANIC** - Material such as salts, metals, and all other substances of mineral origin.

**INSERTION PULLER -** A device used to pull long segments of flexible pipe material into a sewer line when sliplining to rehabilitate a deteriorated sewer.

**INSITUFORM -** A method of installing a new pipe within an old pipe without excavation. The process involves the use of a polyester-fiber felt tube, lined on one side with polyurethane and fully impregnated with a liquid thermal setting resin.

**INSPECTION TELEVISION EQUIPMENT -** Television equipment that is superior to standard commercial quality, providing 600 to 650 lines of resolution, and designed for industrial inspection applications.

**INVERT -** The lowest point of the channel inside a pipe or manhole.

**INVERTED SIPHON -** A pressure pipeline used to carry wastewater flowing in a gravity collection system under a depression such as a valley or roadway or under a structure such as a building. 230

**KEY MANHOLE -** In collection system evaluation, a key manhole is one from which reliable or specific data can be obtained.

**KITE -** A device for hydraulically cleaning sewer lines. Resembling an airport wind sock and constructed of canvas-type material, the kite increases the velocity of a flow at its outlet to wash debris ahead of it.

**LAMPING -** Using reflected sunlight or a powerful light beam to inspect a sewer between two adjacent manholes. The light is directed down the pipe from one manhole. If it can be seen from the next manhole, it indicates that the line is open and straight.

**LATERAL -** (See LATERAL SEWER)

**LATERAL CLEANOUT** - A capped opening in a building lateral, usually located on the property line, through which the pipelines can be cleaned.

**LATERAL SEWER -** A sewer that discharges into a branch or other sewer and has no other common sewer tributary to it. Sometimes called a “street sewer” because it collects wastewater from individual homes.

**LIFT STATION** - A wastewater pumping station that lifts the wastewater to a higher elevation when continuing the sewer at reasonable slopes would involve excessive depths of trench. Also, an installation of pumps that raise wastewater from areas too low to drain into available sewers. These stations may be equipped with air-operated ejectors or centrifugal pumps. Sometimes called a PUMP STATION, but this term is usually reserved for a similar type of facility that is discharging into a long FORCE MAIN, while a lift station has a discharge line or force main only up to the downstream gravity sewer.

**MAIN LINE** - Branch or lateral sewers that collect wastewater from building sewers and service lines.

**MAIN SEWER -** A sewer line that receives wastewater from many tributary branches and sewer lines and serves as an outlet for a large territory or is used to feed an intercepting sewer.

**MANDREL -** (1) A special tool used to push bearings in or to pull sleeves out. (2) A gage used to measure for excessive deflection in a flexible conduit.

**MANHOLE -** An opening in a sewer provided for the purpose of permitting operators or equipment to enter or leave a sewer.

**MANHOLE ELEVATION** - The height (elevation) of the invert or lowest point in the bottom of a manhole above mean sea level.

**MANHOLE FLOW -** (1) The depth or amount of wastewater flow in a manhole as observed at any selected time. (2) The total or the average flow through a manhole in gallons on any selected time interval. 231

**MANHOLE INFILTRATION –** Groundwater that seeps or leaks into a manhole structure.

**MANHOLE INFLOW -** Surface waters flowing into a manhole, usually through the vent holes in the manhole lid.

**MANHOLE INVERT -** The lowest point in a trough or flow channel in the bottom of a manhole.

**MANHOLE LID** - The heavy cast-iron or forged-steel cover of a manhole. The lid may or may not have vent holes.

**MANHOLE LID DUST PAN -** A sheet metal or cast-iron pan located under a manhole lid. This pan serves to catch and hold pebbles and other debris falling through vent holes, preventing them from getting into the pipe system.

**MANHOLE VENTS** - One or a series of one-inch diameter holes through a manhole lid for purposes of venting dangerous gases found in sewers.

**MEAN CELL RESIDENCE TIME (MCRT)** – The average length of time a mixed liquor suspended solids particle remains in the activated sludge process. May also be known as sludge retention time.

**MECHANICAL CLEANING** - Clearing pipe by using equipment that scrapes, cuts, pulls or pushes the material out of the pipe. Mechanical cleaning devices or machines include bucket machines, power rodders and hand rods.

**MECHANICAL PLUG -** A pipe plug used in sewer systems that is mechanically expanded to create a seal.

**MIXED LIQUOR –** The combination of return activated sludge and wastewater in the aeration tank.

**MIXED LIQUOR SUSPENDED SOLIDS (MLSS)** – The suspended solids concentration of the mixed liquor.

**MIXED LIQUOR VOLATILE SUSPENDED SOLIDS (MLSS)** – The concentration of organic matter in the mixed liquor suspended solids.

**MOISTURE CONTNET** – The amount of water per unit weight of bio solids.

**NONTRANSIENT NONCOMMUNITY (NTNC) WATER SYSTEM** - Means a public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year, including schools, day care centers, factories, restaurants and hospitals. 232

**NPDES** - National Pollutant Discharge Elimination System. NPDES permits are required by the Federal Water Pollution Control Act Amendments of 1972 with the intent of making the Nation’s water suitable for swimming and for fish and wildlife. The permits regulate discharges into navigable waters from all point sources of pollution, including industries, municipal treatment plants, large agricultural feed lots and return irrigation flows.

**NUTRIENTS** – Substances required to support living organisms. Usually refers to nitrogen, phosphorus, iron and other trace metals.

**OBSTRUCTION -** Any solid object in or protruding into a wastewater flow in a collection line that prevents a smooth or even passage of the wastewater.

**OFFSET** - (1) A combination of elbows or bends which brings one section of a line of pipe out of line with, but into a line parallel with, another section. (2) A pipe fitting in the approximate form of a reverse curve, made to accomplish the same purpose. (3) A pipe joint that has lost its bedding support and one of the pipe sections has dropped or slipped, thus creating a condition where the pipes no longer line up properly.

**ORGANIC** - Material which comes from mainly animal or plant sources and contains carbon.

**OPDES** - Oklahoma Pollutant Discharge Elimination System – A permit program established in accordance with Section 402 of the CWA and authorized in 27A O.S. Environment and Natural Resources. This program regulates discharges into Oklahoma’s waters from point sources, including municipal, industrial, commercial and certain agricultural sources.

**OUTFALL -** (1) The point, location or structure where wastewater or drainage discharges from a sewer, drain, or other conduit. (2) The conduit leading to the final disposal point or area.

**OUTFALL SEWER -** A sewer that receives wastewater from a collection system or from a wastewater treatment plant and carries it to a point of ultimate or final discharge in the environment.

**OUTLET -** Downstream opening or discharge end of a pipe, culvert, or canal.

**OVERFLOW MANHOLE -** A manhole which fills and allows raw wastewater to flow out onto the street or ground.

**OVERFLOW RELIEF LINE -** Where a system has overload conditions during peak flows, an outlet may be installed above the invert and leading to a less loaded manhole or part of the system. This is usually called an “overflow relief line.”

**PARACHUTE** - A device used to catch wastewater flow to pull a float line between manholes.

**PARSHALL FLUME -** A specially constructed flume or channel used to measure flows in open channels.

**PATHOGENIC ORGANISM** – An organism that is capable of causing illness. 233

**PEAKING FACTOR** - Ratio of a maximum flow to the average flow, such as maximum hourly flow or maximum daily flow to the average daily flow.

**PHOTOGRAPHIC INSPECTIONS -** A method of obtaining photographs of a pipeline by pulling a time-lapse motion picture camera through the line.

By moving the camera a specific distance at timed intervals, a sequence of photographs covering the full length of the line is obtained.

**PIG** - Refers to a poly pig which is a bullet-shaped device made of hard rubber or similar material.

**PIPE CAPACITY -** In a gravity-flow sewer system, pipe capacity is the total amount in gallons a pipe is able to pass in a specific time period.

**PIPE CLEANING -** Removing grease, grit, roots and other debris from a pipe run by means of one of the hydraulic cleaning methods.

**PIPE DIAMETER -** The nominal or commercially designated inside diameter of a pipe, unless otherwise stated.

**PIPE DISPLACEMENT -** The cubic inches of soil or water displaced by one foot or one section of pipe.

**PIPE GRADE -** The angle of a sewer or a single section of a sewer as installed. Usually expressed in a percentage figure to indicate the drop in feet or tenths of a foot per hundred feet. For example, 0.5 percent grade means a drop of one-half foot per 100 feet of length.

**PIPE JOINT** - A place where two sections of pipe are coupled or joined together.

**PIPE JOINT SEAL -** (1) The tightness or lack of leakage at a pipe joint. (2) The method of sealing a pipe coupling.

**PIPE LINER -** A plastic liner pulled or pushed into a pipe to eliminate excessive infiltration or exfiltration. Other solutions to the problem of infiltration/exfiltration

are the use of cement grouting or replacement of damaged pipe.

**PIPE PLUG -** (1) A temporary plug placed in a sewer pipe to stop a flow while repair work is being accomplished or other functions are performed. (2) In construction of a new sewer system, service saddles are sometimes installed before a building or a building lateral is in existence. Under such circumstances, a plug will be placed in the off-lead of the saddle of a “Y.”

**PIPE RODDING -** A method of opening a plugged or blocked pipe by pushing a steel rod or snake, or pulling same, through the pipe with a tool attached to the end of the rod or snake. Rotating the rod or snake with a tool attached increases effectiveness. 234

**PIPE RUN -** (1) The length of sewer pipe reaching from one manhole to the next. (2) Any length of pipe, generally assumed to be in a straight line.

**PIPE SECTION -** A single length of pipe between two joints or couplers.

**PLAN -** A drawing showing the TOP view of sewers, manholes and streets. Also means approved contract drawings, town standards, working drawings, detail sheets or exact reproductions thereof, which show the location, character, dimensions and details of the work to be done.

**PRELIMINARY TREATMENT** – The removal of rocks, rags, sand, eggshells, and similar materials which may hinder the operation of a treatment plant. Preliminary treatment is accomplished by using equipment such as bar screens and grit removal systems.

**PRIMARY TREATMENT** (also known as sedimentation) – A wastewater treatment process that takes place in a rectangular or circular tank and allows those substances in wastewater that readily settle or float o be separated from the water being treated.

**PNEUMATIC EJECTOR -** A device for raising wastewater, sludge or other liquid by compressed air. The liquid is alternately admitted through an inward-swinging check valve into the bottom of an airtight pot. When the pot is filled compressed air is applied to the top of the liquid. The compressed air forces the inlet valve closed and forces the liquid in the pot through an outward-swinging check valve, thus emptying the pot.

**POPULATION EQUIVALENT (HYDRAULIC) -** A flow of 100 gallons per day is the hydraulic or flow equivalent to the contribution or flow from one person. Population equivalent = 100 GPCD or gallons per capita per day.

**PORCUPINE -** A sewer cleaning tool the same diameter as the pipe being cleaned. The tool is a steel cylinder having solid ends with eyes cast in them to which a cable can be attached and pulled by a winch. Many short pieces of cable or bristles protrude from the cylinder to form a round brush.

**POWER RODDER** - A sewer cleaning machine fitted with auger rods which are inserted in a sewer line to dislodge and cut roots and debris.

**PRECIPITATION -** (1) The total measurable supply of water received directly from clouds as rain, snow, hail, or sleet; usually expressed as depth in a day, month, or year, and designated as daily, monthly, or annual precipitation. (2) The process by which atmospheric moisture is

discharged onto a land or water surfaces. (3) The separation (of a substance) out in solid form from a solution, as by the use of a reagent.

**PRE-CLEANING -** Sewer line cleaning, commonly done by high-velocity cleaners, that is done prior to the TV inspection of a pipeline to remove grease, slime, and grit to allow for a clearer and more accurate identification of defects and problems. 235

**PREVENTIVE MAINTENANCE** - Crews assigned the task of cleaning sewers (for example, balling or high-velocity cleaning crews) to prevent stoppages and odor complaints. Preventive maintenance is performing the most effective cleaning procedure, in the area where it is most needed, at the proper time in order to prevent failures and emergency situations.

**PRIMARY CONTAMINANTS** - The contaminants identified by the EPA as harmful to human health. In order to protect public health, the primary contaminants must not exceed certain specified levels known as Maximum Contaminant Levels (MCL).

**PROFILE -** A drawing showing the SIDE view of sewers and manholes.

**PUMP** - A mechanical device for causing flow, for raising or lifting water or other fluid, or for applying pressure to fluids.

**PUMP PIT -** A dry well, chamber or room below ground level in which a pump is located.

**PUMP STATION -** Installation of pumps to lift wastewater to a higher elevation in places where flat land would require excessively deep sewer trenches. Also used to raise wastewater from areas too low to drain into available collection lines. These stations may be equipped with

air-operated ejectors or centrifugal pumps.

**PUBLIC SEWER** - means a sewer in which all owners of abutting properties have equal rights and is controlled by acting as Sewer Commissioners, and maintained by the Public Works Superintendent.

**REGULATOR** - A device used in combined sewers to control or regulate the diversion of flow.

**RETENTION -** (1) That part of the precipitation falling on a drainage area which does not escape as surface stream flow during a given period. It is the difference between total precipitation and total runoff during the period, and represents evaporation, transpiration, subsurface leakage, infiltration, and when short periods are considered, temporary surface or underground storage on the area. (2) The delay or holding of the flow of water and water carried wastes in a pipe system. This can be due to a restriction in the pipe, a stoppage or a dip. Also, the time water is held or stored in a basin or wet well.

**RETURN ACTIVATED SLUDGE SOLIDS (RASS)** – The concentration of suspended solids in the sludge flow being returned from the settling tank to head of the aeration tank.

**ROD GUIDE** - A bent pipe inserted in a manhole to guide hand and power rods into collection lines so the rods can dislodge obstructions.

**ROD (SEWER) -** A light metal rod, three to five feet long with a coupling at each end. Rods are joined and pushed into a sewer to dislodge obstructions.

**RODDING MACHINE -** A machine designed to feed a rod into a pipe while rotating the rod. 236

**RODDING TOOLS -** Special tools attached to the end of a rod or snake to accomplish various results in pipe rodding.

**ROOF LEADER -** A downspout or pipe installed to drain a roof gutter to a storm drain or other means of disposal.

**ROOT SEWER -** Any part of a root system of a plant or tree that enters a collection system.

**ROOT MOP -** When roots from plant life enter a sewer system, the roots frequently branch to form a growth that resembles a string mop.

**SADDLE** - A fitting mounted on a pipe for attaching a new connection. This device makes a tight seal against the main pipe by use of a clamp, adhesive, or gasket and prevents the service pipe from protruding into the main.

**SADDLE CONNECTION -** A building service connection made to a sewer main

with a device called a saddle.

**SAND TRAP -** A device which can be placed in the outlet of a manhole to cause a settling pond to develop in the manhole invert, thus trapping sand, rocks and similar debris heavier than water. Also may be installed in outlets from car wash areas.

**SANITARY COLLECTION SYSTEM** - The pipe system for collecting and carrying liquid and liquid-carried wastes from domestic sources to a wastewater treatment plant.

**SANITARY SEWER -** A pipe or conduit (sewer) intended to carry wastewater or waterborne wastes from homes, businesses, and industries to the POTW. Storm water runoff or unpolluted water should be collected and transported in a separate system of pipes or conduits (storm sewers) to natural water courses.

**SCOOTER** - A sewer cleaning tool whose cleansing action depends on the development of high water velocity around the outside edge of a circular shield. The metal shield is rimmed with a rubber coating and is attached to a framework on wheels (like a child’s scooter). The angle of the shield is controlled by a chain-spring system which regulates the head of water behind the scooter and thus the cleansing velocity of the water flowing around the shield.

**SCUM -** (1) A layer or film of foreign matter (such as grease, oil) that has risen to the surface of water or wastewater. (2) A residue deposited on the ledge of a sewer, channel, or wet well at the water surface. (3) A mass of solid matter that floats on the surface.

**SECONDARY CONTAMINANTS** - Contaminants in drinking water that are not harmful to human health but are unpleasant. Secondary contaminants include substances that cause unpleasant tastes and odors or color the water. A Recommended Maximum Level (RCM) has been set for each of the secondary contaminants in order to make sure the water is pleasant to drink. 237

**SEDIMENT -** Solid material settled from suspension in a liquid.

**SEDIMENTATION -** The process of settling and depositing of suspended matter carried by wastewater. Sedimentation usually occurs by gravity when the velocity of the wastewater is reduced below the point at which it can transport the suspended material.

**SELECT BACKFILL -** Material used in backfilling of an excavation, selected for desirable compaction or other characteristics.

**SELECT BEDDING -** Material used to provide a bedding or foundation for pipes or other underground structures. This material is of specified quality for desirable bedding or other characteristics and is often imported from a different location.

**SEPTIC** – Wastewater that has no dissolved oxygen present it is generally characterized by black color and rotten egg (hydrogen sulfide) odors.

**SETTLEABILITY** – A process-control test used to evaluate the settling characteristics of activated sludge. Reading taken at 30 to 60 minutes are used to calculate the settled sludge volume (SSV) and the sludge volume index (SVI).

**SETTLED SLUDGE VOLUME (SSV)** – The volume in percent occupied by an activated sludge sample after 30 to 60 minutes of settling. Normally written as SSV with a subscript to indicate the time of the reading used for calculation (SSV60) or (SSV30).

**SERVICE ROOT** - A root entering the sewer system in a service line and growing down the pipe and into the sewer main.

**SEWAGE -** The used household water and water-carried solids that flow in sewers to a wastewater treatment plant.

**SEWER -** A pipe or conduit that carries wastewater or drainage water.

**SEWER BALL -** A spirally grooved, inflatable, semi-hard rubber ball designed for hydraulic cleaning of sewer pipes.

**SEWER CLEANOUT -** A capped opening in a sewer main that allows access to the pipes for rodding and cleaning. Usually such cleanouts are located at terminal pipe ends or beyond terminal manholes.

**SEWER GAS -** (1) Gas in collection lines (sewers) that results from the decomposition of organic matter in the wastewater. When testing for gases found in sewers, test for lack of oxygen and also for explosive and toxic gases. (2) Any gas present in the wastewater collection system, even though it is from such sources as gas mains, gasoline, and cleaning fluid.

**SEWER USE DISCHARGE PERMIT -** Permit required or issued jointly by the Authority and a Municipality for the discharge of industrial waste. 238

**SEWERAGE SYSTEM** - Any device, equipment or works used in the transportation, pumping, storage, treatment, recycling, and reclamation of Wastewater and Industrial Wastes.

**SEWER JACK -** A device placed in manholes which supports a yoke or pulley that keeps wires or cables from rubbing against the inlet or outlet of a sewer.

**SEWER MAIN -** A sewer pipe to which building laterals are connected.

**SEWERAGE -** System of piping with appurtenances for collecting, moving and treating wastewater from source to discharge.

**SHORING** - Material such as boards, planks or plates, and jacks used to hold back soil around trenches and to protect workers in a trench from cave-ins.

**SILTING -** Silting takes place when the pressure of infiltrating waters is great enough to carry silt, sand and other small particles from the soil into the sewer system. Where lower velocities are present in the sewer pipes, settling of these materials results in silting of the sewer system.

**SLEEVE** - A pipe fitting for joining two pipes of the same nominal diameter in a straight line.

**SLIPLINING** - A sewer rehabilitation technique accomplished by inserting flexible polyethylene pipe into an existing deteriorated sewer.

**SLOPE -** The slope or inclination of a sewer trench excavation is the ratio of the vertical distance to the horizontal distance or “rise over run.” The inclination of a trench bottom or a trench sidewall, expressed as a ratio of vertical distance to the horizontal distance. For example, a 3:1 slope shall rise or fall 3’ vertical feet in a distance of 1’ horizontal foot.

**SLUDGE** – The mixture of settleable solids and water that is removed from the bottom of the settling tank.

**SLUDGE LOADING RATE** – The weight of wet bio-solids fed to the reactor per square foot of reactor bed area per hour (lb./ft2/H).

**SLUDGE VOLUME INDES (SVI)** – A process-control calculation used to evaluate the settling quality of activated sludge. Requires SSV30 and mixed liquor suspended solids test results to calculate.

**SMOKE TEST -** A method of blowing smoke into a closed-off section of a sewer system to locate sources of surface inflow.

**SNAKE -** A stiff but flexible cable that is inserted into sewers to clear stoppages.

**SOAP CAKE or SOAP BUILDUP -** A combination of detergents and greases that accumulate in sewer systems, build up over a period of time, and may cause severe flow restrictions.

**SOLIDS FEED RATE** – The dry solids fed to a centrifuge. 239

**SOLIDS LOADING (BELT FILTER PRESS)** – The feed solids to the belt filter on a dry weight basis including chemicals per unit time.

**SOLIDS LOADING RATE (DRYING BEDS)** – The weight of solids on a dry weight basis applied annually per square foot of drying bed area.

**SOLIDS RECOVERY (CENTRIFUGE)** – The ratio of cake solids to feed solids for equal sampling times. It can be calculated with suspended solids and flow data or with only suspended solids data. The cenrate solids must be corrected if chemicals are fed to the centrifuge.

**SOIL POLLUTION** - The leakage (exfiltration) of raw wastewater into the soil or ground area around a sewer pipe.

**SOUNDING ROD -** A T-shaped tool or shaft that is pushed or driven down through the soil to locate underground pipes and utility conduits.

**SPOIL -** Excavated material such as soil from the trench of a sewer.

**STATION** - A point of reference or location in a pipeline is sometimes called a “station.” As an example, a building service is located 51 feet downstream from a manhole could be reported to be at “station 51.”

**STILLING WELL -** A well or chamber which is connected to the main flow channel by a small inlet. Waves and surges in the main flow stream will not appear in the well due to the small diameter inlet. The liquid surface in the well will be quiet, but will follow all of the steady fluctuations of the open channel. The liquid level in the well is measured to determine the flow in the main channel.

**STOPPAGE -** (1) Partial or complete interruption of flow as a result of some obstruction in a sewer. (2) When a sewer system becomes plugged and the flow backs up, it is said to have a “stoppage.”

**STORM COLLECTION SYSTEM -** A system of gutters, catch basins, yard drains, culverts and pipes for the purpose of conducting storm waters from an area, but intended to exclude domestic and industrial wastes.

**STORM SEWER** - A separate pipe, conduit or open channel (sewer) that carries runoff from storms, surface drainage, and street wash, but does not include domestic and industrial wastes. Storm sewers are often the recipients of hazardous or toxic substances due to the illegal dumping of hazardous wastes or spills created by accidents involving vehicles and trains transporting these substances.

**STRETCH** - Length of sewer from manhole to manhole. 240

**SUCKER RODS** - Rigid, coupled sewer rods of metal or wood used for clearing stoppages. Usually available in 3-ft, 39-in, 4-ft, 5-ft and 6-ft lengths.

**SUCTION HEAD -** The POSITIVE pressure (in feet or pounds per square inch (psi)) on the suction side of a pump. The pressure can be measured from the centerline of the pump UP TO the elevation of the hydraulic grade line on the suction side of the pump.

**SUCTION LIFT -** The NEGATIVE pressure (in feet or inches of mercury vacuum) on the suction side of the pump. The pressure can be measured from the centerline of the pump DOWN TO (lift) the elevation of the hydraulic grade line on the suction side of the pump.

**SUPERNATANT** – The amber-colored liquid above the sludge in a digester.

**SURCHARGE -** Sewers are surcharged when the supply of water to be carried is greater than the capacity of the pipes to carry the flow. The surface of the wastewater in manholes rises above the top of the sewer pipe, and the sewer is under pressure or a head, rather than at atmospheric pressure.

**SURCHARGED MANHOLE -** A manhole in which the rate of the water entering is greater than the capacity of the outlet under gravity flow conditions. When the water in the manhole rises above the top of the outlet pipe, the manhole is said to be “surcharged.”

**SUSPENDED SOLIDS** - (1) Solids that either float on the surface or are suspended in water, wastewater, or other liquids, and which are largely removable by laboratory filtering. (2) The quantity of material removed from wastewater in a laboratory test, as prescribed in STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, and referred to as Total Suspended Solids Dried at 103-105 ºC.

**SWAB -** A circular sewer cleaning tool almost the same diameter as the pipe being cleaned. As a final cleaning procedure after a sewer line has been cleaned with a porcupine, a swab is pulled through the sewer and the flushing action of water flowing around the tool cleans the line.

**TAG LINE -** A line, rope or cable that follows equipment through a sewer so that equipment can be pulled back out if it encounters an obstruction or becomes stuck. Equipment is pulled forward with a pull line.

**TAP -** A small hole in a sewer where a wastewater service line from a building is connected (tapped) into a lateral or branch sewer.

**TELEVISION INSPECTION** - An inspection of the inside of a sewer pipe made by pulling a closed-circuit television camera through the pipe.

**TERMINAL “LAMPHOLES” CLEANOUT** - When a manhole is not provided at the upstream end of a sewer main, a cleanout is usually provided. This is called a “terminal cleanout.”

241

# Preface

* + 1. \*\*\* 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. \*\*\* composite sample.

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

* + 1. \*\*\* dissolved oxygen (DO).

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

* + 1. \*\*\* effluent.

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

* + 1. \*\*\* eutrophication.

Eutrophication is the excessive growth of plant and algae in receiving waters due to dissolved nutrients and their decomposition.

* + 1. \*\*\* flume.

A flume is a restriction in an open channel used to measure flow.

* + 1. \*\*\* food to microorganism ratio (F:M or F/M).

F/M is the amount of food (BOD) provided to the microorganisms [mixed liquor volatile suspended solids (MLVSS) or mixed liquor suspended solids (MLSS)].

* + 1. \*\*\* gallons per day (gpd).

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

* + 1. \*\*\* gallons per hour (gph).

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

* + 1. \*\*\* gallons per minute (gpm).

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

* + 1. \*\*\* grab sample.

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

* + 1. \*\*\* hydraulic retention time (HRT).

HRT is a period of time that wastewater remains in a tank. This term is also known as detention time.

* + 1. \*\*\* influent.

Influent is the raw (or untreated) wastewater entering a treatment process.

* + 1. \*\*\* 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. \*\*\* 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. \*\*\* 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. \*\*\* septage.

Septage is the high strength waste pumped out of septic tanks, sometimes disposed at wastewater treatment plants.

* + 1. \*\*\* sludge age.

Sludge age is the theoretical length of time a particle of activated sludge stays in the treatment plant, measured in days. In an activated sludge plant, sludge age is the amount (lbs) of MLSS divided by the suspended solids or excess cell mass withdrawn from the system per day [lbs per day of waste activated sludge (WAS)].

* + 1. \*\*\* 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. \*\*\* weir.

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

### Section 1.2 - Sewer Systems

* + 1. \*\*\* combined sewer.

Combined sewers are pipe conveyances that carry both wastewater and storm water in a single pipe. During dry weather conditions, combined sewers discharge to a wastewater treatment plant. In the past, combined sewers discharged directly to a water body during wet weather conditions. Today, the extra wet weather volume is stored until it can be returned to the wastewater treatment plant.

* + 1. \*\*\* 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. \*\*\* lift 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. \*\*\* manhole.

A manhole is a structure that provides access to a collection system. It is typically a round opening with an iron lid.

* + 1. \*\*\* 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. \*\*\* 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. \*\*\* 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. \*\*\* treatment facility overflow (TFO).

A TFO is a release of wastewater, other than through permitted outfalls, from a wastewater facility into a water of the state or the land surface. All TFOs must be reported to the Department of Natural Resources within 24 hours of the occurrence.

* + 1. \*\*\* 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.

### Section 1.3 - Wastewater Processes

* + 1. \*\*\* aeration basin.

An aeration basin is a tank where wastewater is aerated to achieve biological treatment.

* + 1. \*\*\* aerobic (oxic) [O2].

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

* + 1. \*\*\* anaerobic (septic) [Ø].

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

* + 1. \*\*\* 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. \*\*\* biosolids.

Biosolids are the nutrient-rich, organic byproduct of a municipal wastewater treatment plant that is utilized as fertilizer.

* + 1. \*\*\* clarifier.

A clarifier is a circular or rectangular tank used to remove floatable and settleable solids in wastewater.

* + 1. \*\*\* disinfection.

Disinfection is a process used to destroy most pathogens to a safe level in the effluent. Disinfection does not destroy all microorganisms.

* + 1. \*\*\* grit.

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

* + 1. \*\*\* headworks.

Headworks is the beginning, or head, of a treatment plant where influent flow is measured and sampled and where preliminary treatment occurs.

* + 1. \*\*\* microorganism.

A microorganism is a living organism too small to be seen with the naked eye, but is visible under a microscope. They include: bacteria, viruses, fungi, or protozoa.

* + 1. \*\*\* primary treatment.

Primary treatment is a treatment process usually consisting of clarification by solid and liquid separation removing a substantial amount of suspended and floating matter.

* + 1. \*\*\* process control.

Process control is the tools and methods used to optimize treatment plant operations.

* + 1. \*\*\* return activated sludge (RAS).

RAS is the settled activated sludge (biomass) collected in a final clarifier and returned to the secondary treatment process to mix with incoming wastewater. This returns a concentrated population of microorganisms back into the aeration basin.

* + 1. \*\*\* screenings.

Screenings are the materials in wastewater removed with screens at the headworks of treatment plants. They include: sticks, stones, plastics, and personal hygiene products.

* + 1. \*\*\* secondary treatment.

Secondary treatment is a treatment process using biological processes that utilize bacteria to remove pollutants.

* + 1. \*\*\* selector.

A selector is part of the treatment system that selects for a specific type of microorganism by providing an environment (anaerobic, anoxic, or aerobic) that favors its growth.

* + 1. \*\*\* sidestreams.

Sidestreams are flows generated within the plant, usually from solids processing that has been recycled back through the plant.

* + 1. \*\*\* tertiary treatment.

Tertiary treatment is a treatment process using physical, chemical, or biological processes to remove suspended solids and nutrients in wastewater to accomplish a level of treatment greater than what can be achieved by secondary treatment.

* + 1. \*\*\* treatment process.

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

* + 1. \*\*\* 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. \*\*\* waste activated sludge (WAS).

WAS is the activated sludge (excess biomass or cell mass) removed from the secondary treatment process. For most treatment plants, this will be a portion of the RAS flow stream.

### Section 1.4 - Safety and Regulations

* + 1. \*\*\* 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.

* + 1. \*\*\* pathogens.

Pathogens are infectious microorganisms in wastewater that pose health risks.

* + 1. \*\*\* Wisconsin Pollutant Discharge Elimination System (WPDES) permit.

A WPDES permit is issued to wastewater facility owners and contains facility effluent, biosolids and sludge limitations, conditions, and reporting requirements.

* + 1. Discuss where a wastewater treatment plant operator would find information on conducting wastewater tests.

The most authoritative source for conducting wastewater testing can be found in ‘Standard Methods for the Examination of Water and Wastewater’, prepared and published jointly by the American Public Health Association, American Water Works Association, and Water Environment Federation. It is commonly referred to simply as ‘Standard Methods’. The first edition was published in 1905 and many editions have since been published as information is updated and instrumentation and methodologies change.

### Chapter 2 - Influent Wastewater Section 2.1 - Sources

* + 1. Discuss the early historical methods of dealing with wastewater.

Early on, human waste and wastewater was basically disposed of directly on the land surface. In urban communities, it was common to discharge human waste in gutters and ditches. This situation created sanitary problems (illnesses and diseases), nuisance odors, and unsightliness. Rains were counted on to flush the waste away. Later development of the pit toilet or outhouse facility continued until underground collection systems were developed.

The development of water supply systems increased the volume of wastewater generated. Early health concerns led to the building of pipe collection systems to convey this material away from human habitation, usually to a river, stream, or other body of water. Early systems received both wastewater and storm water. This improved public health concerns, but transferred the problem to receiving water streams.

* + 1. 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.

* + 1. Discuss the importance of treating wastewater. Wastewater is treated for two main reasons:
       1. Protect public health by destroying pathogens
       2. Protect the environment by removing pollutants

Pathogenic organisms are disease-causing microorganisms. They include various bacteria, viruses, and parasites. The discharge of waterborne human wastes will contain these organisms from ailing individuals and would be expected to be present in wastewater entering a wastewater treatment plant.

Although wastewater treatment is taken for granted in the United States, rivers and lakes are more polluted and waterborne diseases are more prevalent in countries that do not properly treat wastewater.

* + 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 to the wastewater treatment plant as septage, holding tank waste, leachate, and some high strength industrial wastewater. In addition, clearwater (rain, snow, and groundwater) from inflow and infiltration (I/I) can get into the collection system.

* + 1. List and \*\*\* common sources of I/I.

I/I is unwanted clearwater that gets into the collection system. Clearwater is classified by how fast it gets into the collection system and is determined by weather and groundwater conditions. If the flow increases as soon as there is significant rainfall and subsides soon after the rain stops, it is called inflow. If the flow goes up gradually after a rainfall and stays up as long as the groundwater remains high, it is called infiltration.

Common sources of clearwater (I/I) are:

* + - 1. Roof leaders connected to the sanitary sewer
      2. Storm and sanitary crossovers
      3. Low lying manholes in roads or ditches subject to flooding
      4. Uncapped lateral connections
      5. Sump pumps and foundation drains
      6. Cracks and offset joints in the sanitary sewer
      7. Manhole cracks and defects
      8. Buried manholes
      9. Cracks and leaks in building sewers

**Figure 2.1.5.1**

Diagram

Description automatically generated

* + 1. 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 and treatment problems. Too much flow going through aeration basins and clarifiers can wash out solids, creating a loss of treatment efficiency and

resulting in permit violations.

### Section 2.2 - Conveyance

* + 1. Trace the sequence of events from the time one flushes a toilet until treated wastewater reaches a receiving stream.

Potable water is provided by the water supply system into a building and is used to flush or drain wastes into the building’s sanitary sewer pipes and into the wastewater collection system. Wastewater is conveyed through gravity sewers, lift stations, and force mains until it makes its way into the headworks of a wastewater treatment plant. The wastewater is then treated by both physical and biological unit operations and processes and then clean water is discharged into a receiving water body.

* + 1. Explain the components of a sanitary sewer collection system.
       1. Private building lateral sewer

A private building lateral sewer is a 6-inch pipe that conveys sewage from the building to the

public sewer main, usually under the street.

* + - 1. Mainline sewer

Mainline sewers are pipes that collect sewage from buildings and flow by gravity to the treatment plant.

* + - 1. Force mains

Force main sewer pipes are where wastewater is pumped (forced) under pressure to a specific location. Force mains are used when sewage cannot flow by gravity.

* + - 1. Lift (pump) stations

A lift station is a location in the collection system where wastewater is collected (wet well) and then pumped to another location. The purpose of a lift station is to lift (pump) wastewater to a higher elevation where it can flow by gravity.

* + - 1. 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.

* + - 1. Manholes

A manhole is a structure, usually circular, at the surface that allows access to the sewer pipes buried below.

* + 1. 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 and motor being completely submerged in the wet well. The submersible centrifugal pump is watertight and normally controlled by float switches. They are made to be easily removed for cleaning and maintenance using a rail system.

* + 1. 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 submersed 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 reach 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.

* + 1. Describe sanitary sewer overflows (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.

* + 1. Discuss the operation and maintenance (O&M) of a collection system.

The primary activities of operating and maintaining a sanitary sewer collection system are:

* + - 1. Cleaning
      2. Root removal
      3. Televising
      4. Flow monitoring
      5. Smoke testing
      6. Manhole inspections
      7. Lift station maintenance
      8. Manhole rehabilitation
      9. Mainline rehabilitation
      10. Private sewer inspections
      11. Private sewer I/I removal
      12. Fat, oil and grease (FOG) control program

Operating and maintaining a sewer system will ensure the wastewater flows to the treatment plant, without any overflows or basement back-ups anywhere in the sewer system.

Regularly televising a certain percentage of the sewer system each year to assess pipe conditions is the most important inspection tool available to operators, as it is the only way to see the pipe.

### Section 2.3 - Wastewater Characterisitics

* + 1. Describe the characteristics of influent domestic wastewater.

Raw influent is less than 99% water and is gray in color with an earthy, musty odor. Typical influent wastewater concentrations are:

**Figure 2.3.1.1**

Table

Description automatically generated

* + 1. Discuss the potential impacts of industrial and commercial discharges.

Industrial discharges may vary in strength and volume. Slug loads are of special concern and can upset or pass through the treatment plant and out with the final effluent. High levels of BOD, TSS, phosphorus, ammonia, and FOG can effect treatment. High or low pH can also be a problem.

* + 1. Discuss the wastewater characteristics and problems with industrial discharges into a treatment plant.
       1. Dairy operations

Many different types of dairy and whey products are produced in Wisconsin. Some dairy operations have their own wastewater treatment plant, but many discharge to the treatment plant in the community in which they are located. Industrial wastes from dairy facilities consist of various dilutions of milk entering the municipal collection system. One of the largest sources of dairy wastewater come from the wash waters and rinse waters of dairy tanks, trucks, equipment, pipelines, and floors. Dairies use clean-in-place systems that alternate acidic and caustic cleaners and rinses in the cleaning of tanks, equipment, and pipes, raising or lowering pH. Milk and milk solids have a very high BOD, sometimes as high as 1,000 to 10,000 mg/L. Milk wastes also contain high amounts of nitrogen, phosphorus, and chlorides. The volume and BOD of dairy wastewater can vary greatly over a 24-hour period. Therefore the collection and equalization of dairy wastewater is very important so that the flow and BOD discharges to the collection system are more uniform. Sometimes dairy wastes have to be pretreated before discharge to a sanitary sewer. A treatment plant can be upset if it receives variable loads, high-strength wastes, high or low pH discharges, or slug loads from a dairy facility.

* + - 1. Food industry

Food (meats, canned foods, snacks, etc.) is processed in many different ways, and the wastes from them can vary in composition. Because food industry wastewaters can be variable and are usually high in BOD, suspended solids, nitrogen compounds, phosphorus, chlorides, and vary in pH, it is important for operators to be familiar with the wastewaters from food processors in their community. Sometimes these wastes have to be equalized or even pretreated before they can be discharged to a collection system.

* + - 1. Breweries

Wisconsin is known for its many breweries and microbreweries. Brewery wastewater typically has a high concentration of BOD from the carbohydrates and protein used in the brewing process and in the cleaning of brewery vessels, pipes, and equipment. Brewery wastewater can have a BOD of 1,000 to 4,000 mg/L; TSS from 200 to 1,000 mg/L; nitrogen 25 to 80 mg/L; phosphorus 1 to 50 mg/L; and a pH of 4 to 12. The volume and BOD of brewery wastewater can vary greatly over a 24-hour period. Therefore, the collection and equalization of brewery wastewater is very important so that the flow and BOD discharges to the collection system are relatively uniform.

* + - 1. Metal finishing

Wastewater from metal finishing has very little BOD associated with it, but has pollutants that can be toxic to fish and aquatic life and treatment plant microorganisms, even in small

concentrations. These pollutants are not always readily removed by conventional secondary biological treatment methods. Cleaning and coating operations can result in wastewater with a pH from 1 to 12 and wastewater can contain phosphates and toxic materials such as chromate, cyanide, and metals. Many metal-finishing industries have federal or state pretreatment requirements before they can discharge their waste to a collection system.

Metals can concentrate in treatment plant sludges, and, therefore, metals in sludges must be analyzed and reported to the Department of Natural Resources on sludge characteristic reports. Application of sludge with high metals concentrations is prohibited and/or restricted in rate due to potential toxicity and/or soil accumulation concerns.

* + 1. Discuss the impact cleaning agents and products can have on a treatment plant.

Cleaning products and sanitizers are used widely in communities and are important in ensuring public health. When used frequently and in large quantities at industries, businesses, schools, nursing homes, medical facilities, or restaurants, they have the potential to affect treatment. Many effective cleaners contain phosphates and thus can contribute a significant amount of phosphorus to wastewater. Wastewater treatment plants with phosphorus limits, especially those with stringent limits, will have to remove nearly all this phosphorus. While ammonia is a very effective cleaning agent, quaternary ammonium compounds (commonly known as quats) can have toxic effects on treatment. Ammonia- based cleaning products also contribute ammonia to the waste stream, which must in turn be removed since ammonia can be toxic to fish and aquatic life. Surfactants can interfere and keep solids from settling in clarifiers as well as create foam in aeration basins.

* + 1. Discuss the impact FOG can have on a collection system and a treatment facility.

FOGs are waste byproducts of cooking. They 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 or institutions. The most common cause of sanitary sewer overflows (SSO) from sewer pipes are blockages caused by grease. If grease makes its way to the treatment plant, it can plug valves, meters, and pipes. It floats to tank surfaces and can create settling problems. Grease can also favor the growth of filamentous organisms that create surface foam and scum. Grease can involve costly and unpleasant clean-ups.

The best practice for controlling grease is to keep it out of the collection system in the first place by having a Grease Control Program in a community. A Grease Control Program usually involves regular inspections of restaurant and institutional (nursing home, hospital, and school kitchens) grease traps or interceptors and an ongoing information and education program with residents and businesses.

* + 1. Discuss control measures necessary for industrial discharges.
       1. Enforce sewer use ordinances
       2. Effective communication with industries
       3. Grease Control Program
       4. Monitoring
    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.

* + - 1. Volatile organics, including gasoline or solvents, can cause an explosive atmosphere in the collection system or at the treatment plant.
      2. Heavy metals, including chromium, zinc, copper, nickel, and cadmium, are very toxic and can cause a treatment plant upset, pass through the plant, or accumulate in the sludge.
      3. 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.
      4. 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.
      5. 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.
      6. High temperature wastewaters can affect biological activity.
      7. Solid or viscous materials can cause sewer blockages.
      8. Any debris including rags or other materials can cause sewer blockages or pump clogging.
      9. Other toxic materials can impair or interfere with the treatment process.

### Section 2.4 - Flow Monitoring

* + 1. Discuss the importance of wastewater flow measurement.

It is very important to know how much influent is flowing and being treated in the plant. Treatment efficiency is dependent on loadings and detention time. It is also required to report how much final effluent flows into a receiving water body. To measure the influent entering a treatment plant from the community, flow measurements should be taken before sidestreams. To know the actual flow and loading to the treatment units, sidestreams need to be included in the flow measurements.

* + 1. List and describe the common types of flow measurement devices.
       1. 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.

* + - 1. 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 2.4.2.1**

Diagram

Description automatically generated

* + 1. List flow measuring applications in a wastewater treatment plant.

While flow monitoring is required in Wisconsin Pollution Discharge Elimination System (WPDES) permits for measuring influent and effluent flows, flow measurements are needed in many other places within the plant for proper process control. In an activated sludge plant, measuring return and waste activated sludge is extremely important as they are the key to successful operations. In-plant flow meters are used for measuring:

* + - 1. Return activated sludge (RAS)
      2. Waste activated sludge (WAS)
      3. Recycle or recirculation flows
      4. Sidestream flows
      5. Sludge flows to digesters
      6. Sludge feed rates to sludge dewatering equipment
      7. Sludge withdrawal volumes from storage tanks

### Section 2.5 - Sampling

* + 1. Discuss grab and composite influent sampling.

A grab sample is a sample collected at a single instant in time. A composite sample is a collection of samples taken over a longer period of time (usually 24 hours) and mixed and stored in a larger container. A composite sample represents the average wastewater quality being received into a wastewater treatment plant. If samples collected over 24 hours are stored in a composite sampling jug or container, the jug or container must be shaken and well mixed before pouring the actual sample to be used for testing. Some samples, such as pH, dissolved oxygen (DO), and chlorine residual, must be grab samples because compositing and holding such samples would change the test results.

**Figure 2.5.1.1**

A picture containing text, indoor, microwave, open

Description automatically generated

* + 1. Describe how flow-proportional sampling works.

Flow-proportional sampling is the most representative method of collecting wastewater samples for wastewater coming into and being discharged from a wastewater treatment plant on a continuous basis. For most treatment plants in Wisconsin, flow-proportional sampling is a permit requirement. The volume of each sample collected is based on the flow, and this is accomplished by having a flow meter send a signal to an automatic composite sampler. The sampler is programmed to collect a certain sample volume per

unit volume of flow (flow pulse interval). For instance, the sampler may take a 50 mL sample every 10,000 gals of flow.

It is more representative to take a small sample more often than it is to take a large sample less often. A sample should be collected at least every 10 to 15 mins (4 to 6 samples every hour) during the peak flow period of the day, such as in the morning of a normal work day.

For instance, if a peak hourly flow of 60,000 gals flows into the plant between 8 am and 9 am, the sampler should be programmed to take a sample every 10,000 to 15,000 gals of flow (60,000 gals/hr and 6 samples per hour = 10,000 gals/sample). Conversely, in the middle of the night when flows may drop to only 10,000 to 20,000 gals/hr, the flow- proportional sampler will only collect 1 to 2 samples in an hour. The volume of sample

collected each flow pulse interval should be adjusted, as a general rule, to fill at least 1/4 to 1/2 of the compositing container in 24 hours during average flows. This will allow the container to fill, without overfilling, during wet weather periods when daily flows increase 2 to 4 times the average flow. If peak flows are higher than this, then the sample volume will have to be reduced during wet weather so as to not overfill the container and cause the sampler to shut off, thereby not collecting a true 24-hour composite sample. A flow- proportional sample MUST sample during a full 24-hour period, even during wet weather peak flows.

* + 1. Discuss the difference between a time-proportional and flow-proportional composite sample.

Time-proportional composite samples are a collection of samples over time, usually after so many minutes. Flow-proportional composite samples are samples collected per unit of flow, after so many gallons. The frequency at which flow-proportional samples are collected is directly proportional to the flow, with more samples taken when flows are higher and less samples when flows are lower. Automatic flow-proportional composite samplers are required for almost all wastewater treatment plants, as they are the most representative means of collecting samples from continuous flowing treatment systems, especially for biochemical oxygen demand (BOD) and total suspended solids (TSS).

* + 1. Describe a good sampling location and procedure for collecting representative influent wastewater samples.

It is important that raw influent wastewater be sampled in a location where it is well mixed and represents the actual wastewater coming into the treatment plant. It is best to collect the sample after the headworks (after screenings and grit removal), as this is most representative of the BOD and TSS going into downstream treatment units.

* + 1. Discuss the information that must be recorded for influent wastewater samples.

Automatic composite samplers must be refrigerated and maintained at a temperature not to exceed 6°C (Celsius) and must never be frozen. A thermometer immersed in a small capped bottle of liquid is usually kept in the sampler to check and record temperatures on a daily basis. A 24-hour composite sample is the common requirement. For Discharge Monitoring Reporting (DMR), the date on which the majority of the composite sample was taken is the date of the sample. A sampling log must be maintained at the automatic composite sampler and the following information recorded:

* + - 1. Sample identification
      2. Date started
      3. Time started
      4. Date collected
      5. Time collected
      6. Sampler temperature
      7. Operator initials
      8. Comments

### Chapter 3 - Wastewater Treatment

**Section 3.1 - Preliminary Treatment**

* + 1. Discuss the preliminary treatment process.

The purpose of preliminary treatment is to remove larger materials (rags, sticks, stones, plastics, personal hygiene products, etc.) and grit from the waste stream before it flows to downstream treatment units. This is done to significantly reduce the plugging and clogging of pumps and pipes, the abrasive action of grit on equipment, and the settling of these materials in down streams tanks and basins.

Preliminary treatment usually consists of screening and grit-removal equipment. Sewage grinders and comminutors that shred larger materials into smaller pieces are not commonly used anymore. Newer preliminary treatment units now automatically clean, dewater, and bag or containerize these materials thus greatly reducing exposure to operators.

**Figure 3.1.1.1**

Diagram

Description automatically generated

* + 1. Describe common equipment used in preliminary treatment.

The purpose of preliminary treatment is to remove larger, inorganic materials (rags, sticks, stones, plastics, personal hygiene products, etc.) and grit from the waste stream before it flows to downstream treatment units.

Preliminary treatment equipment primarily consists of screening and grit removal systems. Septage handling, grinders, odor control, and flow equalization are also considered preliminary treatment.

* + - 1. Screening

Common screening systems are manually cleaned bar screens, mechanically cleaned bar screens, and rotary fine screens. These processes simply remove debris which is then land filled.

* + - 1. Grit removal

Common grit removal systems are aerated grit chambers and vortex-type (Pista®) unit. An aerated grit chamber uses air that separates light from heavier solids (grit). A vortex-type (Pista®) unit consists of a cylindrical tank creating a vortex flow in which the heavier grit settles to the bottom.

**Figure 3.1.2.1**

A picture containing text

Description automatically generated

**Figure 3.1.2.2**

Engineering drawing

Description automatically generated

**Figure 3.1.2.3**

A picture containing appliance, iron

Description automatically generated

* + 1. Discuss how an aerated grit chamber works.

Raw wastewater is introduced into the end of an aerated grit chamber, which is typically rectangular in shape. Injected air creates a spiral flow of wastewater as it moves through the chamber. As the flow velocity diminishes along the tank, heavier grit particles gradually settle from the water. The settled solids are typically gathered at the tank bottom by a rake mechanism and removed by pumping.

**Figure 3.1.3.1**

Diagram, engineering drawing

Description automatically generated

* + 1. Discuss how a vortex-type (Pista®) grit chamber works.

Raw wastewater is introduced along the side of a cylindrical tank designed for vortex flow. The water and grit combination rotates slowly around the vertical access of the tank. The flow spirals gradually down the tank perimeter, allowing the heavier solids to settle to the tank bottom where they are then removed.

**Figure 3.1.4.1**

Diagram

Description automatically generated

### Section 3.2 - Primary Treatment

* + 1. Discuss the primary treatment process.

The purpose of primary treatment is to settle wastewater solids and capture floatable substances [such as fats, oil, and grease (FOG)]. Some biochemical oxygen demand (BOD) is also removed in the settling of these solids. The solids that settle in primary clarifiers and the FOG skimmed off the surface are directly removed from the process.

Primary treatment commonly consists of circular or rectangular clarifiers. Sometimes dissolved air flotation (DAF) thickeners or other processes are used for primary treatment. Primary effluent containing soluble BOD and some suspended solids flows to a secondary biological treatment process for further treatment.

**Figure 3.2.1.1**

Diagram

Description automatically generated

* + 1. Describe common equipment used in primary treatment.

The purpose of primary treatment is to settle wastewater solids and capture floatable substances (such as FOG). Well-designed and operated primary facilities can expect removal efficiencies of 40% to 60% for suspended solids and 20% to 35% for BOD.

Common primary treatment units are rectangular clarifiers, circular clarifiers, and DAF.

**Figure 3.2.2.1**

Diagram

Description automatically generated

**Figure 3.2.2.2**

Diagram

Description automatically generated

**Figure 3.2.2.3**

Diagram

Description automatically generated

### Section 3.3 - Secondary (Biological) Treatment

* + 1. Discuss the secondary biological treatment process.

The purpose of secondary biological treatment is to remove dissolved and suspended organic material from wastewater to produce an environmentally safe treated effluent and biosolids or sludge.

A secondary treatment system can achieve overall biochemical oxygen demand (BOD) and suspended solids removal in the 85% to 95% range.

Secondary biological treatment consists of microorganisms (bacteria), either in mixed suspension in a basin or attached to a media of some type where the organic material is broken down and consumed by the microorganisms. Most secondary treatment processes require oxygen for the bacteria.

**Figure 3.3.1.1**

Diagram

Description automatically generated

* + 1. Discuss suspended growth systems (activated sludge).

Activated sludge is a suspension of wastewater and microorganisms in an aeration basin. The mixture of wastewater and microorganisms is referred to as mixed liquor suspended solids (MLSS). Aeration equipment provides dissolved oxygen (DO) to promote the growth of microorganisms that substantially remove organic material. Some common types of suspended growth processes are conventional and extended aeration activated sludge plants, oxidation ditches, and sequencing batch reactors (SBR). The reader is referred to the ‘Biological Treatment – Suspended Growth Process Study Guide’ for more detailed information about suspended growth processes.

* + 1. Describe common equipment used in suspended growth secondary (biological) treatment.

Common equipment used in suspended growth secondary biological treatment are aeration tanks, blowers, diffusers, final clarifiers, and sludge pumps.

* + - 1. Aeration tanks

Aeration tanks are usually square, rectangular, or circular. They contain aeration equipment for providing oxygen to the microorganisms that live and grow in the tanks. Aeration equipment also provides mixing in the tank. The mixed suspension of wastewater, solids, and microorganisms in the aeration tank is commonly referred to as activated sludge. The activated sludge is measured as MLSS in milligrams per liter (mg/L).

* + - 1. Blowers

Mechanical blowers provide the air to the aeration tanks.

* + - 1. Diffusers

Diffusers disperse the air into the aeration tank, providing oxygen and mixing in the tank.

* + - 1. Final clarifiers

Final clarifiers follow the aeration basins and settle the MLSS. Clear effluent is discharged over and through weirs in the clarifier.

* + - 1. Sludge pumps

The settled solids in the clarifier can be returned back to the aeration tank or wasted from

the treatment system by the pump(s). The pump(s) are known as the return activated sludge (RAS) or waste activated sludge (WAS) pump(s).

* + 1. Discuss attached growth systems (rotating biological contactor (RBC), trickling filter, and biotower).

An attached growth system (some times referred to as a fixed-film process) utilizes microorganisms that are fixed in place on a solid surface (attached). As wastewater passes through and around the solid surface, the microorganisms remove the food (organic content) from the wastewater. This attached growth type aerobic biological treatment process creates an environment that supports the growth of microorganisms. Some common types of fixed-film processes are trickling filters, biotowers, and RBCs. The reader is referred to the ‘Biological Treatment – Attached Growth Study Guide’ for more detailed information about attached growth processes.

* + 1. Describe common equipment used in attached growth secondary (biological) treatment.

Attached growth systems make use of microorganisms that attach themselves to a medium or substrate of some type. Common equipment used in attached growth systems such as trickling filters and biotowers are different types of media, pumps, distribution arm and piping, and underdrains. Common equipment used in attached growth systems such as RBCs are basins, shafts, circular plastic disks, motors, and drives and sometimes blowers and diffusers (for air driven shafts).

* + - 1. Pumps and distribution piping

After wastewater receives primary treatment, primary effluent is collected and pumps are used to convey the wastewater to a trickling filter or biotower distribution arm or to RBC basins for secondary biological treatment.

* + - 1. Media

The media is where biological organisms and bacteria attach themselves for treatment of the incoming wastewater. Trickling filter and biotower media most commonly consists of rock beds, gravel, or plastic (providing surface area for bacteria to grow) through which the wastewater flows. RBCs consist of closely spaced, circular plastic disks (providing surface area for bacteria to grow) that rotate on a shaft through the wastewater.

* + - 1. Underdrain system

After wastewater flows down through a trickling filter or biotower, it is collected in a drain where some of it is recirculated back through the media by pumps for further treatment. Because of temperature difference between outside air temperature and the temperature inside the filter, natural air drafts upward through the filter media providing oxygen.

* + - 1. RBC motors, drives, and shafts

The circular plastic disks of RBCs are on a shaft that is turned by a motor and drive system.

* + 1. List and discuss the process control equipment used for monitoring an activated sludge plant.
       1. DO meter

A DO meter is used to monitor aeration basin DO levels. Many plants have inline DO sensors to automatically control DO levels. If manual measurements are made, they should be taken in each aeration basin using a field DO probe.

* + - 1. Settleometer

A settleometer is used to monitor sludge settling characteristics in 30 minutes. A 1,000 mL beaker or cylinder is most commonly used. The MLSS sample for this test should be collected just before it goes to the final clarifier.

* + - 1. Sludge blanket finder

The sludge blanket finder is used to measure the depth of settled sludge in the bottom of a clarifier. A clear core sampler (Sludge Judge®) or an electronic device is most commonly used. Samples are usually collected before and after the scraper mechanism both near the well, midway, and near the sidewall. When and where the sludge depth is measured should be consistent each day.

* + - 1. Microscope

A microscope is used to observe the population and health of microorganisms living in an activated sludge system. The settled MLSS sample used for the 30-minute settling test can be used for the microscopic observation sample.

* + - 1. pH and temperature meter

A pH and temperature meter is used to measure pH and temperatures of wastewater entering the plant and the aeration basins.

* + - 1. Flow meters

Flow meters are used to measure influent, sidestream, RAS, WAS, and effluent flows.

* + 1. Describe the differences between nitrification and denitrification in wastewater treatment.

Nitrification is a biological process where nitrifying bacteria (nitrifiers) convert nitrogen in the form of ammonia (NH3) into nitrite (NO2-) and nitrate (NO3-) under aerobic conditions.

Treatment plants that have ammonia limits on their permit will use nitrification to remove ammonia. Many plants that discharge to surface waters have ammonia limits to protect fish and aquatic life from ammonia toxicity.

Denitrification is a biological process where bacteria convert nitrate (NO3-) and nitrite (NO2-) to nitrogen gas (N2) under anoxic conditions. Treatment plants that have total nitrogen limits will use denitrification to remove nitrogen.

Plants that discharge to groundwater have total nitrogen limits to protect groundwater from nitrates. Plants that remove phosphorus biologically will also employ denitrification to remove nitrates that interfere with enhanced biological phosphorus removal (EBPR).

**Figure 3.3.7.1**

Chart, pie chart

Description automatically generated

* + 1. Explain why some treatment plants have to meet ammonia nitrogen limits.

Ammonia is toxic to fish and aquatic life, and its toxicity is dependent on temperature and pH. The actual limits for ammonia nitrogen are calculated based on stream flow, stream temperature, stream pH, and the type of fishery classification.

* + 1. Explain why some treatment plants have total phosphorus limits.

Phosphorus is one of the key nutrients that contribute to eutrophication and excess algae and plant growth in rivers and lakes. The decomposition of excess plant matter reduces the level of DO in the receiving water which affects aquatic life.

* + 1. Describe the role microorganisms have in the activated sludge process.

The principle role microorganisms have in the activated sludge process is to convert dissolved and particulate organic matter, measured as BOD, into cell mass. In a conventional activated sludge process, microorganisms use oxygen to break down organic matter (food) for their growth and survival. Over time, and as wastewater moves through the aeration basin, food (BOD) decreases with a resultant increase in cell mass (MLSS concentration).

* + 1. Describe the environmental factors that influence the health and growth of microorganisms.

The activated sludge wastewater treatment process must operate under proper environmental conditions to support a healthy, growing population of microorganisms. The operator must monitor the activated sludge process to ensure the right environmental conditions are being provided for the microorganisms. Efficient wastewater treatment plant performance will then be achieved.

* + - 1. Food

Incoming wastewater to a treatment plant provides the food that microorganisms need for their growth and reproduction. This food is mostly organic material. The more soluble the organic material is, the more easily microorganisms can use it. Since the amount and type

of organic loading in the treatment plant affects the growth of the microorganisms, influent total BOD and soluble BOD are measurements an operator can make to determine the amount and type of incoming food for the microorganisms.

* + - 1. Flow

Incoming wastewater must flow through a treatment plant at a rate that allows the microorganisms sufficient time to consume the incoming food and to settle properly. High flows can shorten the time necessary for the full treatment of wastewater. Extremely high flows can wash microorganisms out of the plant through the final clarifier.

* + - 1. Oxygen

Conventional activated sludge is an aerobic process. Many bacteria in the activated sludge process need free oxygen (O2) to convert food into energy for their growth. For optimal performance, it is very important for an operator to be sure enough oxygen is being provided in the aeration tanks for the microorganisms (typically 1.0 to 3.0 mg/L). Aeration basin DO concentrations (mg/L) are measured continuously in many plants to ensure adequate oxygen is available.

* + - 1. Temperature

All biological and chemical reactions are affected by temperature. Microorganisms' growth and reaction rates are slow at cold temperatures and much faster at warmer temperatures. Most microorganisms do best under moderate temperatures (10 to 25°C). Aeration basin temperatures should be routinely measured and recorded.

* + - 1. pH

Biological and chemical reactions are affected by pH. Most microorganisms do well in a pH environment between 6.0 and 9.0. Acidic (low pH) or alkaline (high pH) conditions can adversely affect microorganisms' growth and survival. Operators measure both influent pH and aeration basin pH to ensure proper plant pH conditions.

* + - 1. Nutrients

Microorganisms need trace nutrients such as nitrogen, phosphorus, and some metals for their metabolism. Most incoming wastewater to a treatment plant, especially domestic sewage, contains an abundance of these trace nutrients. The ratio of BOD to nitrogen to phosphorus should be 100:5:1. Influent wastewater is measured to determine this nutrient ratio.

* + - 1. Toxicity

Incoming wastewater to a treatment plant may, at times, contain materials or compounds that are toxic to microorganisms. Depending on the concentration of toxic material, microorganisms could be destroyed or their metabolic rates affected, thus impairing the wastewater treatment plant efficiency.

* + 1. Discuss the possible impacts of sidestreams or recycle flows back to the secondary process.

Sidestreams or recycle flows usually come from solids handling treatment or dewatering

processes, such as decanting digesters or sludge storage tanks. Sidestreams may be high in BOD, suspended solids, ammonia, phosphorus, and sulfides or very low in temperature.

It is best to return sidestreams slowly and regularly so microorganisms adjust and acclimate to this loading. If the permit limits phosphorus or ammonia, it is critical to know the loading from sidestreams. Sidestreams can upset a treatment plant or result in a pass-through of pollutants to the effluent, resulting in permit violations. If the permit limits phosphorus or ammonia, sometimes it is necessary to separately treat the sidestream.

* + 1. List common sidestreams within a treatment plant. The most common recycle streams are from:
       1. Thickening and dewatering process
          1. Gravity belt thickening filtrate
          2. Centrifuge centrate
          3. Gravity thickening supernatant
          4. Dissolved air flotation (DAF) subnatant
          5. Rotary drum thickening filtrate
          6. Belt filter press filtrate
          7. Sludge drying bed underdrain
          8. Plate and frame filtrate
          9. Reed bed filtrate
       2. Stabilization and storage
          1. Aerobic digester decant
          2. Anaerobic digestion supernatant
          3. Biosolids storage decant
          4. Granular filter backwash

### Section 3.4 - Final Clarification

* + 1. Discuss the final clarification process.

The purpose of final clarification (consisting of final clarifiers) is to settle secondary biological treatment solids and discharge clear effluent. The settled solids can be returned [recycle activated sludge (RAS)] to the aeration tank or wasted [waste activated sludge (WAS)] for biosolids or sludge processing.

**Figure 3.4.1.1**

* + 1. Explain the function of a final clarifier.

The final clarifier is a large basin or tank designed to allow organic solids to settle from effluents discharged from an attached growth process and/or activated sludge process. Hydraulic overloads or operational problems in the secondary system can cause major problems in the efficiency of the final clarifier, because the biologic solids to be removed have a density very close to that of water.

* + 1. List the parts of a final clarifier.
       1. Motor and drive system
       2. Center stilling well
       3. Skimmer
       4. Scum skimmer
       5. Scum beach
       6. Baffles
       7. Weirs
       8. Effluent trough
       9. Sludge collection and removal mechanism
       10. RAS and WAS pumps

**Figure 3.4.3.1**

* + 1. Describe common equipment used in final clarification.
       1. Motor and drive system

The motor and drive system is the device used to turn the surface skimmer and sludge collector.

* + - 1. Center stilling well

The center stilling well is the suspended column in the center of a clarifier which provides an area for mixed liquor flow to slow down and spread out.

* + - 1. Scum skimmer

The scum skimmer is the flat device at the surface of the clarifier which is moved by the drive system, to remove floating scum.

* + - 1. Scum beach and trough

The scum beach and trough are the equipment used to receive the collected scum.

* + - 1. Scum baffles

The scum baffles are the ring or plate at the clarifier’s surface that prevents scum from entering the effluent trough.

* + - 1. Effluent weirs

Effluent weirs rest just below the clarifier surface allowing effluent to flow over and through into the trough.

* + - 1. Effluent trough

The effluent trough is the open channel on which the effluent weir is mounted and conveys the effluent.

* + - 1. Sludge collection and removal mechanism

The sludge collection and removal mechanism is an assembly and piping arrangement at the bottom of the clarifier moved by the drive system and used to gather and remove settled sludge.

* + - 1. RAS and WAS pumps

The RAS and WAS pumps return or waste the settled solids from the final clarifier.

### Section 3.5 - Tertiary Treatment

* + 1. Discuss the tertiary treatment process.

The purpose of tertiary treatment is to provide advanced wastewater treatment beyond secondary biological treatment. It results in a very high quality effluent, extremely low in biochemical oxygen demand (BOD), suspended solids, and nutrients. Wastewater treatment plants that have discharge limits less than 10 mg/L of BOD and total suspended solids (TSS) or have very low phosphorus limits, usually need to provide tertiary treatment.

Tertiary treatment usually consists of a type of physical and/or chemical process. Sand or mixed media filters, cloth discs, membranes, or other treatment units can remove TSS and/or phosphorus to very low levels. Chemicals can also be used to precipitate some pollutants in the wastewater. Air stripping or activated carbon is sometimes used to remove volatile organic chemicals from the wastewater.

**Figure 3.5.1.1**

* + 1. Describe common equipment used in tertiary treatment.

Currently, the most common method of tertiary treatment is granular filtration. The overall efficiency in removing pollutants by filtration could exceed 95% removal of suspended solids and phosphorus. Other less frequently used methods of tertiary treatment are carbon adsorption and physical chemical methods.

Common equipment used in filtration are:

* + - 1. Filtering system

Depending on the level of tertiary treatment needed, the filtering of very fine, suspended particles in the effluent is accomplished using mixed media (usually sand), cloth, or membranes. The filter captures fine particles from the wastewater as it passes, resulting in a very clear and high quality effluent.

* + - 1. Cleaning system

As fine particles are filtered from the wastewater, the particles eventually start to plug the filter media and cleaning becomes necessary. Backwashing effluent filters or cloth disks are done to re-open the filtering pore space to restore the performance of the filter.

Membranes are subject to fouling and are cleaned using one or a combination of backwashing, air sparging, relaxation, and chemical clean-in-place.

### Section 3.6 - Disinfection

* + 1. Discuss the disinfection process.

The purpose of disinfection of treated wastewater is to reduce the discharge of waterborne pathogenic organisms that cause illness. This is done to protect public health as related to surface drinking water supplies and recreational use of downstream areas. Seasonal disinfection provides disinfection during the months when recreational activities are using downstream areas.

Disinfection consists of either chlorination tanks or ultraviolet (UV) radiation units in Wisconsin.

**Figure 3.6.1.1**

* + 1. Describe common disinfection processes.
       1. Chlorination

The process of chlorination uses chlorine as a gas, solid, or as a liquid. Chlorine is added to the treated wastewater as the wastewater flows through the contact tank. The contact tank gives ample time for the chlorine to react with the wastewater, killing the pathogenic organisms. After the contact tanks, a chemical (usually sodium bisulfite or sulfur dioxide) is added to remove the excess chlorine. This removal is called dechlorination. Chemical feed pumps that are flow proportional are commonly used in feeding liquid chlorine (sodium hypochlorite, a stronger version of household bleach). When feeding chlorine as a gas, special equipment is used to create a vacuum which draws the gas into the treated wastewater.

* + - 1. UV radiation

The process of UV radiation uses ultraviolet light to destroy the pathogenic organisms’ ability to reproduce. Treated wastewater enters a channel where a stack of several ultraviolet lamps are placed either in horizontal or vertical banks. These lamps need cleaning when they become fouled (dirty).

**Figure 3.6.2.1**

**Figure 3.6.2.2**

### Section 3.7 - Ponds and Lagoons

* + 1. Discuss pond and lagoon systems.

Pond and lagoon systems are earthen basins with a clay or synthetic liner to prevent leakage to groundwater. These systems are classified as secondary biological treatment and are an economical way to accomplish biological treatment. Pond systems are typically used for biochemical oxygen demand (BOD) and total suspended solids (TSS) removal when limits are 30 mg/L; however, when limits are more restrictive or include nutrient limits, mechanical treatment is necessary. The flow often goes through more than one pond in a

series. Their large size provides a long detention time for the bacteria to break down the wastes. Due to their large size, pond systems are mostly used in small communities when land is available.

Wastewater is pumped into one end of the pond. On the other end, the flow exits through a control manhole, which may consist of stop logs or a telescopic valve, allowing the operator to control the pond depth. Most stabilization pond systems have a detention time of 150 days or greater and use more than one pond to effectively treat the wastewater.

* + 1. Describe a stabilization pond system.

Stabilization ponds are large, non-aerated, and normally less than 10 feet deep. Algae growing in the ponds provide most of the oxygen to the bacteria to remove pollutants. Solids settle to the bottom of the pond and are further stabilized by bacteria.

**Figure 3.7.2.1**

* + 1. Describe an aerated lagoon system.

Aerated lagoons can use surface aerators or subsurface diffusers to provide aeration and mix the wastewater. Aerated lagoons are usually deeper (more than 10 feet) and require shorter detention times (60 days) to effectively treat the wastewater. Aeration improves removal efficiency. Aerated lagoons are followed by non-aerated lagoons to allow settling of suspended solids before discharge.

* + 1. Discuss what photosynthesis is and how it aids the biological treatment of wastewater in stabilization ponds.

Photosynthesis is a natural, chemical process in which green plants (algae in ponds) containing chlorophyll use carbon dioxide in the presence of sunlight to produce carbohydrates for growth. In wastewater treatment ponds, photosynthesis releases oxygen as a byproduct, which is used to sustain the bacteria that stabilize the suspended organic material in wastewater.

Photosynthesis can be summarized by the equation:

Carbon dioxide + Water => Carbohydrate + Water + Oxygen CO2 + 2H2O => CH2O + H2O + O2

**Figure 3.7.3.1**

### Section 3.8 - Equipment

* + 1. Describe the types of pumps used in wastewater treatment.

**Figure 3.8.1.1**

Diagram, engineering drawing

Description automatically generated

**Figure 3.8.1.2**

Diagram

Description automatically generated

**Figure 3.8.1.3**

Diagram

Description automatically generated

**Figure 3.8.1.4**

Graphical user interface, diagram

Description automatically generated

**Figure 3.8.1.5**

Diagram

Description automatically generated

**Figure 3.8.1.6**

A picture containing text, weapon

Description automatically generated

**Figure 3.8.1.7**

Diagram, schematic

Description automatically generated

**Figure 3.8.1.8**

Diagram

Description automatically generated

**Figure 3.8.1.9**

Diagram

Description automatically generated

* + 1. Describe the valves used in a wastewater treatment plant.

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 3.8.2.1**

Diagram

Description automatically generated

**Figure 3.8.2.2**

Diagram

Description automatically generated

**Figure 3.8.2.3**

Diagram

Description automatically generated

* + 1. Describe wastewater treatment plant back-up power sources.

During power outages, treatment plants have generators to provide power to some or all of the plant. Generators are run by fuel and should be routinely operated to ensure their reliable operation during an actual emergency.

* + 1. Discuss energy usage in a wastewater treatment plant.

The aeration system of a wastewater treatment plant uses the largest percentage (over 60%) of the energy in the treatment process. Wastewater pumping is another large energy user (12%) at a wastewater plant. Energy usage can be reduced with cost savings by having energy-efficient aeration systems, blowers, motors, and pumps.

**Figure 3.8.4.1**

Chart, pie chart

Description automatically generated

* + 1. List the basic components of an activated sludge system.
       1. Aeration tanks
       2. Blowers and diffusers or mechanical aerators
       3. Clarifiers
       4. Recycle activated sludge (RAS) and waste activated sludge (WAS) pumps
    2. Describe the purpose of the aeration system.

The aeration system in the activated sludge process provides oxygen to the microorganisms and mixes the contents of the aeration basins. The mixing brings the wastewater pollutants into contact with the microorganisms to treat the wastewater and reduce the pollutants.

* + 1. Describe aeration equipment used in a wastewater treatment plant.
       1. Blowers

Blowers provide the air that is pumped through diffusers.

* + - * 1. Centrifugal

A blower consisting of an impeller fixed on a rotating shaft and enclosed in a casing having an inlet and a discharge connection.

* + - * 1. Positive displacement (PD)

A PD blower forces air to move by trapping a fixed amount, then displacing that trapped volume into the discharge pipe.

* + - 1. Diffusers
         1. Fine bubble

Fine bubble diffusers are devices through which air is pumped and divided into very

small bubbles and used to introduce dissolved oxygen (DO) into the liquid. Fine bubble diffusers are normally disks or tubes with membranes or ceramic materials to create the bubbles and gentle mixing action.

* + - * 1. Coarse bubble

Coarse bubble diffusers are devices through which air is pumped and divided into large bubbles transferred and dissolved into the liquid. Coarse bubble diffusers normally discharge air at a high rate and are installed to induce a spiral or cross roll mixing pattern.

* + - 1. Mechanical Aerators

The most common types of mechanical aerators utilize paddles or discs and spray or turbine mechanisms. By agitating the wastewater, air from the environment is introduced.

* + 1. Describe instrumentation and controls used in a wastewater treatment plant.
       1. Process probes and analyzers

Process probes, such as pH, total suspended solids (TSS), DO, turbidity, and temperature, are used throughout the treatment plant. Usually they are wired to an analyzer that sends data to a computer.

* + - 1. Supervisory control and data acquisition (SCADA)

SCADA is a computer program that is used solely for gathering the plant's operational data. The program shows different parts of the plant and what is happening in real time. An operator can see flows, DO levels, blowers, pumps, tank levels, probe readings, and other operational data. The data is stored within the program.

* + - 1. Programmable logic controller (PLC)

A PLC is a programmable electronic device that has inputs and outputs and is usually found in a control panel. For example, a PLC could control the liquid level of a tank by turning a pump on and off. An operator would program the PLC with set points to \*\*\* the levels that the pump turns on and off.

* + - 1. Flow meters

Flow meters are used to measure the flow of liquids. Some areas of measurement include: influent, effluent, recycle streams, sludge pumping, septic stations, lift stations, and chemical feed systems. Flow meters are usually wired to a SCADA system that displays and stores flow data.

* + - 1. Alarms

Alarms notify operators of operational problems and emergencies. Alarms could be during the working day or programmed to notify operators after hours. An alarm can be triggered by a high or low water level, a high or low DO level in the aeration process, a malfunctioning pump, a high temperature reading on a pump, a problem at a lift station, etc.

### Section 3.9 - Treatment Plant and Equipment Maintenance

* + 1. Discuss the importance of having a wastewater treatment plant preventative maintenance program.
       1. Minimize unanticipated breakdowns or emergency maintenance
       2. Maximize operational consistent performance
       3. Long-term cost savings
       4. Prevent violations
       5. Energy efficiencies
    2. Describe a preventative maintenance system for wastewater treatment equipment.
       1. Inventory and label all equipment
       2. Use O&M manuals for preventative maintenance tasks and frequencies
       3. Establish a preventative maintenance record keeping system for maintenance schedules and history of repairs and maintenance for each piece of equipment
       4. Establish a follow-up system to ensure maintenance is performed
       5. Have a spare parts inventory
    3. Explain how to prevent grease and grit build-up in lift station wet wells.

To prevent grease and grit, control it at its source. This means having stringent pretreatment requirements in the sewer use ordinance and through a Grease Control Program. Monitor commercial and industrial sources to ensure good maintenance is performed on grease traps, oil separators, and any solids removal system.

* + 1. Develope a routine lubrication maintenance schedule for all wastewater treatment equipment.

Lubrication is one of the most important preventative maintenance tasks at a treatment plant. The O&M manual specifies the type of lubricants and the frequencies of lubrication for each piece of equipment.

* + 1. Discuss the importance of routine preventative maintenance of aeration basins and clarifiers.

Aeration basins and clarifiers should be emptied on a regular basis to:

* + - 1. Perform a detailed inspection of the structure, valves, and control gates
      2. Clean out grit and settled solids
      3. Maintain equipment and piping

When emptying aeration basins and clarifiers, an operator should be aware of structural and operational effects. Notify the Department of Natural Resources of scheduled maintenance activities as given in the standard conditions of the Wisconsin Pollution Discharge Elimination System (WPDES) permit.

* + 1. List the items to include in a maintenance schedule for final clarifiers.

An operator should consult the O&M manual for the preventative maintenance schedule. Daily observations should be performed, including: checking for oil leaks, unusual vibrations or noises, scum collection, weirs, and floating solids. All maintenance and repairs should

be documented.

* + 1. List common critical maintenance tasks for pumps.
       1. Lubrication
       2. Amperage checks
       3. Packing if leaking
       4. Flushing water seals
       5. Check for clogging

Follow the O&M manual for all specific maintenance tasks.

* + 1. Discuss how to calibrate lift station pumps.

Calibrating pumps is a way to check on wear. Regular calibration also helps determine actual flow rates and whether any plugging or infiltration is occurring.

To calibrate pumps, first it is a must to find the drawdown distance, drawdown time, refill distance and refill time for each pump. Here is how:

* + - 1. Measure wet well length and width (for rectangular wells) or the diameter (for circular wells)
      2. Allow the pump to come on and then record distance between the wastewater surface and a fixed object and the time until the pump shuts off. The distance between when the pump comes on and shuts off is called the drawdown distance. The time it takes is called the drawdown time.
      3. Allow the pump to refill and then record the distance and time. The change in wastewater depth between when the pump shuts off and when it starts again is called the refill distance. The time elapsed is called the refill time.
      4. Repeat A, B, and C several times to ensure similar results
      5. Calculate the pump rate (see key knowledge 7.5.1)

For further information, refer to the ‘MPCA Math Workbook for Collection System Operators’.

* + 1. List common critical maintenance tasks for valves.
       1. Exercise
       2. Check for clogs (check valves)

Follow the O&M manual for all specific maintenance tasks.

* + 1. List common critical maintenance tasks for motors.
       1. Grease
       2. Check temperature
       3. Check amperage
       4. Inspect for noise and vibration

Follow the O&M manual for all specific maintenance tasks.

* + 1. List the informational content of a treatment plant O&M manual.

The Department of Natural Resources requires the following topics be in a treatment plant O&M manual:

* + - 1. General Information
      2. Staffing
      3. Records system
      4. Laboratory
      5. Safety
      6. Security and emergencies
      7. Utilities and electrical systems
      8. Appendices
      9. Process description, operation, and control (liquid and solids)
      10. Sludge management
      11. Maintenance
      12. Recommended reference materials (manuals, books, and codes)
    1. Explain cavitation, its cause, the sound, and how to handle it.

Cavitation occurs in wastewater systems when the vacuum pressure at any point in the system is lowered to the vapor pressure of the liquid. Under such conditions, vapor bubbles form and then collapse producing effects ranging from decreased efficiencies to equipment failure. Cavitation usually occurs in pumps, on impellers, or at restrictions in a flowing liquid and may occur as suction cavitation or discharge cavitation.

Cavitation can make a pump very noisy. This noise has been described as a popping sound, clattering, or similar to marbles rattling around in the pump. Operating the pump continuously under this condition can cause pitting of the impeller and corrosion. If cavitation is occurring, contact the consultant or pump service representative to determine the cause and corrective actions.

* + 1. Discuss wastewater financial budgets in the operation, management, and upgrading of a wastewater treatment plant.

In the operation and management of a wastewater system there are four major separate budgetary items needed: Operation and Maintenance Budget, Capital Improvement Budget, Replacement Fund, and Debt Retirement. Revenues come from sewer use charges to support the operation, upgrading, and management of the treatment system. Sewer use charges should be reviewed every two years and adjusted as needed. Financial management information about the treatment plant and sewer system is reported to the

Department of Natural Resources each year in the Compliance Maintenance Annual Report (CMAR).

* + - 1. Operation and maintenance budget

Sufficient funds must be available to cover the daily operational and maintenance expenses for the wastewater treatment plant and collection system, including salaries, electric bills for running all the equipment, lubricating pumps and drives, and cleaning sewer pipes.

* + - 1. Capital improvements budget or loan

Significant upgrading or improvement projects often require large expenditures of money. Utilities should establish a capital improvements budget to plan for future treatment plant needs. Sometimes it is not possible to save enough money for a project and in those cases there are a variety of funding methods available including grants, loans, and municipal bonds.

* + - 1. Replacement fund

Treatment plant equipment, such as pumps, motors, or aeration equipment, have projected lifespans and need to be replaced when reaching the end of their design life. A replacement fund with readily available funds allows an operator to replace old or worn out equipment during the useful life of the treatment works to maintain the capacity and performance for which the treatment works were designed and constructed.

* + - 1. Debt retirement

The large investment a community has to make in constructing and upgrading a wastewater treatment system often requires loans or bonds from a funding agency and/or financial institutions to be obtained and paid back over the terms of the loan.

### Chapter 4 - Biosolids/Sludge - Processing, Handling, and Land Application Section 4.1 - Thickening

* + 1. Compare the sources and characteristics of primary and secondary biosolids and sludges.

Primary sludges are the solids that settle out of the raw wastewater in the primary clarifiers. The primary sludges are usually fairly coarse with a specific gravity (density) significantly greater than water, allowing for rapid settling. Primary sludges are typical 60% to 80% volatile solids (organic) varying depending on the raw wastewater characteristics. Primary sludge is odorous and requires additional treatment prior to ultimate disposal.

Secondary sludges are those solids generated as a part of the secondary treatment process and settle out in the final clarifiers. These sludges are mainly composed of the microorganisms generated in the secondary process (activated sludge or fixed-film systems). Excess sludge amounts must be removed to keep the secondary system in balance. Secondary sludges are more flocculent with a specific gravity (density) very close to that of water making them more difficult to settle than primary sludges. Secondary sludges are 75% to 80% volatile solids and contain bound water in the cells of the microorganism, making them difficult to dewater or thicken. Chemical additions can be used to enhance dewatering. The higher the volatile solids (organics) content, the more difficult the sludge is to dewater.

Both primary and secondary sludges should be as concentrated as possible by proper

operation of clarifiers. At times, additional thickening is used to reduce the amount of water and volume loading on subsequent sludge treatment processes. Here, too, chemical additions can be used to enhance dewatering.

* + 1. Discuss the thickening of biosolids and sludges.

The purpose of sludge thickening is to further concentrate and thicken solids settled and wasted from treatment plant processes. In the treatment of wastewater, solids from the primary and secondary treatment processes can range from 0.5% (5,000 mg/L) to 5.0% (50,000 mg/L) suspended solids. Sludge thickening further concentrates these solids from 3.0% (30,000 mg/L) to 6.0% (60,000 mg/L) to allow for further handling and processing.

Sludge thickening most commonly consists of gravity thickeners (settling tanks) or dissolved air flotation (DAF). A polymer can be added and used to enhance thickening. Plants with aerobic digesters simply thicken their sludge by turning off the air for a short time, allow the sludge to settle, and thicken by decanting the clear liquid off the tank. Sludge drying beds can be used to thicken and store solids but are not as commonly used as they once were because of handling, odor issues, and space limitations at a treatment plant site.

**Figure 4.1.2.1**

* + 1. Describe common biosolids and sludge thickening unit processes and how they work.

Sludge is thickened prior to being pumped to the digester or sludge storage. Common sludge thickening unit processes are:

* + - 1. Gravity settling thickener

Gravity thickening consists of a circular tank (usually with a conical bottom) fitted with collectors or scrapers at the bottom. Primary and/or secondary solids are fed into the tank through a center well, which releases the solids at a low velocity near the surface of the tank. The solids settle to the bottom of the tank by gravity, and the scrapers slowly move the settled, thickened solids to a discharge pipe at the bottom of the tank.

* + - 1. DAF

DAF thickens sludge by adding dissolved air under pressure and then releasing the air at

atmospheric pressure in a flotation tank or basin. The released air forms tiny bubbles which adhere to the suspended matter causing the suspended matter to float to the surface where it is removed by a skimming device.

**Figure 4.1.3.1**

Diagram, engineering drawing

Description automatically generated

**Figure 4.1.3.2**

Diagram

Description automatically generated

### Section 4.2 - Treatment

* + 1. Discuss the treatment of biosolids and sludges.

The purpose of sludge treatment, sometimes also referred to as sludge stabilization, is to reduce the pathogens (fecal coliforms) in the sludge and the attraction of vectors (flies, mosquitos, vermin, birds, etc.) that transmit diseases. The Department of Natural Resources establishes pathogen control and vector attraction reduction criteria in Wisconsin Pollution Discharge Elimination System (WPDES) permits that must be met before the sludge can be landspread.

Sludge treatment most commonly consists of aerobic or anaerobic digesters. Digesters utilize bacteria in the treatment of the sludge. Heat and chemicals can be used to treat sludges as well.

* + 1. Discuss biosolids and sludge treatment processes used to significantly reduce fecal coliform bacteria and meet the pathogen control criteria.

Class B sludges are sludges that can be applied to agricultural lands. Adequate pathogen control for a Class B sludge is less than 2,000,000 colony forming units (cfu)/g or most probable number (mpn) fecal coliforms or by one of the following methods below. Certain sludge treatment processes are able to significantly reduce fecal coliform bacteria and meet these criteria in Wisconsin.

* + - 1. Anaerobic digestion

Sludge is treated in the absence of oxygen for a certain amount of time at a specific temperature. The time and temperature shall be between 15 days at 35°C to 55°C and 60 days at 20°C.

* + - 1. Air drying

Sludge is dried on sand beds or on paved or unpaved basins for a minimum of 3 months. During 2 of the 3 months, the average daily temperature has to be above 0°C.

* + - 1. Composting

Sludge is composted using a within-vessel, static-aerated pile, or windrow-composting method and the temperature of the sludge raised to 40°C or higher for 5 days. For 4 hours during the 5 days, the temperature in the compost pile has to exceed 55°C.

* + - 1. Alkaline stabilization

Lime is added to sludge to raise the pH to 12 for 2 hours of contact.

* + - 1. Process to significantly reduce pathogens (PSRP) equivalent

Sludge is treated in a process that is equivalent to a process to significantly reduce pathogens, as approved by the Department of Natural Resources. Many such processes are proprietary.

* + 1. Describe how aerobic digesters work.

Aerobic digesters utilize microorganisms and oxygen to digest the remaining organic material in wasted sludge from the primary and secondary treatment processes. The detention time in an aerobic digester is sufficiently long to allow for most of organic material to be consumed resulting in a stabilized sludge. Aerobic digesters are similar to the activated sludge process except well digested, stabilized sludge in the tanks is thicker and most of the time darker.

* + 1. Describe how anaerobic digesters work.

Anaerobic digesters utilize microorganisms without oxygen to digest the remaining organic material in wasted sludge from the primary and secondary treatment processes. Anaerobic digesters are heated and covered. The process generates methane gas that can be recovered and used as an energy source in the treatment plant.

### Section 4.3 - Dewatering

* + 1. Discuss the dewatering of biosolids and sludges.

The purpose of dewatering biosolids and sludges is to significantly concentrate the solids and reduce the liquid content of the sludge. Dewatering reduces the sludge volume to be stored, transported, and landspread. Large treatment plants that generate large liquid volumes of sludge often use some type of sludge dewatering.

Sludge dewatering is done mechanically and most often consists of presses (belt or plates), vacuum filters, and centrifuges. Sludge can also be dewatered in sludge drying beds, reed beds, and other ways. Dewatered sludges are typically 15% to 30% solids and referred to as cake sludge. Cake sludge handling, transport, and land application is different than liquid sludge. Dewatered sludge is drier, thicker, and more solid and thus can be shoveled, moved using belt conveyors, and transported in dump trucks rather than pumper trucks.

**Figure 4.3.1.1**

Shape

Description automatically generated with medium confidence

* + 1. Describe common mechanical biosolids and sludge dewatering units and how they work.

**Figure 4.3.2.1**

Diagram, schematic

Description automatically generated

**Figure 4.3.2.2**

Diagram

Description automatically generated

**Figure 4.3.2.3**

Diagram

Description automatically generated

### Section 4.4 - Land Application

* + 1. List the common methods of sludge disposal.

Federal and state regulations establish two levels of quality for municipal biosolids for final use or disposal. Class A biosolids or sludge receive a very high degree of treatment and can thus be used by the public in parks, gardens, and golf courses. Some biosolids are used in composting programs. Class B biosolids or sludge do not meet all the criteria of a Class A sludge and thus are land applied on agricultural lands or disposed of in a landfill. Land application is the most common method of sludge reuse in Wisconsin.

**Figure 4.4.1.1**

Diagram

Description automatically generated

* + 1. List the two Wisconsin Administrative Codes regulating municipal and industrial sludge.
       1. NR 204 Domestic sewage sludge management
       2. NR 214 Land treatment of industrial liquid wastes, by-product solids and sludges
    2. Discuss the importance of recycling biosolids and sludge through land application.

The Environmental Protection Agency (EPA) \*\*\*s biosolids as a “primarily organic solid product yielded by municipal wastewater treatment processes that can be beneficially

recycled” as soil amendments (fertilizer and conditioners). Recycling biosolids through land application is a sustainable management method to reuse nutrients and soil conditioners in place of commercial fertilizers and to avoid disposal in landfills.

### Section 4.5 - Sampling and Reporting

* + 1. Discuss sludge sampling and reporting prior to reuse or disposal.

Municipal sludge regulations require that sludge meet certain criteria before they can be re- used as a Class A or Class B sludge and to protect public health and the environment.

Industrial sludges must also meet certain criteria. The main parameters analyzed prior to the land application of a Class B sludge are:

* + - 1. Nutrients (nitrogen and phosphorus)

Nitrogen and phosphorus should be added to the cropland at the proper amount for the crop being grown (the agronomic rate). If more nutrients are added than the crop will use, the excess will leach down into the groundwater or run-off into rivers and streams.

* + - 1. Metals

Metals can be toxic and thus limits are set for their safe application on agricultural lands.

* + - 1. Pathogen densities

Fecal coliform bacteria must be below certain limits before the sludge can be landspread.

* + - 1. Vector attraction reduction

Sludge must be treated and stabilized to below an acceptable level so that when land applied, it does not attract flies, mosquitos, vermin, and birds that can carry and transmit diseases.

* + 1. Compare activated sludge solids results expressed as milligrams per liter (mg/L) and percent solids.

In activated sludge aeration basins, mixed liquor suspended solids (MLSS) is expressed in mg/L. As solids are thickened and the concentration gets to 10,000 mg/L or above, the solids are then often expressed as a percent. Every 10,000 mg/L is 1% and can be expressed as follows:

10,000 mg/L = 1.0% solids

15,000 mg/L = 1.5% solids

20,000 mg/L = 2.0% solids

25,000 mg/L = 2.5% solids

30,000 mg/L = 3.0% solids

* + 1. Discuss the records an operator must keep when biosolids and sludge are landspread.

A treatment plant operator has to maintain an application log for biosolids land applied each day when land application occurs. Minimum records must be kept, in addition to all analytical results for the biosolids land applied.

The daily log must include the following information:

* + - 1. Approved site used
      2. Number of acres applied with sludge on that day
      3. Amount of sludge applied that day and amount per acre
      4. Amount of nitrogen applied per acre
      5. Method of application of the sludge (injection, incorporation, or surface application)
    1. Discuss the pounds formula.

The purpose of the pounds formula is to convert mg/L of BOD, TSS, phosphorus, etc. into lbs/day. This formula is the most used formula in wastewater calculations.

The formula is:

lbs/day = flow (MGD) × concentration (mg/L) × 8.34

The number 8.34 is obtained by cancelling the units in the full formula using 1 mg/L for concentration and 1 MGD for flow (see figure below).

**Figure 4.5.4.1**

A picture containing timeline

Description automatically generated

### Chapter 5 - Effluent Discharge Section 5.1 - Flow Monitoring

* + 1. Explain effluent flow measurement.

Effluent flow measurement is required by the Wisconsin Pollution Discharge Elimination System (WPDES) permit at all wastewater treatment plants for measuring flows to the receiving water. It also is used for the operation of effluent flow-proportional composite

samplers and for the pacing of chemical addition equipment. Effluent flow measurement equipment should be close to the end of the treatment plant. Treatment plants are typically equipped with an open channel flow measurement structure, which is fitted with a (primary) V-notch weir or Parshall flume. See key knowledge 2.4.2 for more information on these flow measurement devices.

* + 1. Describe how daily flow measurements are recorded.

For Discharge Monitoring Reports (DMR), the day in which most of the flow is received is the date the flow should be recorded. For example, influent wastewater flow entering the plant is recorded and totaled from 7:00 am, July 14th to 7:00 am, July 15th. The total flow read the morning of July 15th is 475,000 gals. The operator would report this flow as the flow for July 14th. Flows should be recorded at about the same time each day. Flows are most commonly reported on DMRs in million gallons per day (MGD). In the example above, the flow would be recorded as 0.475 MGD.

### Section 5.2 - Sampling

* + 1. Describe a good sampling location and procedure for collecting representative effluent wastewater samples.

It is very important that the final effluent discharged from a wastewater treatment plant be sampled in a location where it is well mixed and represents the actual water being discharged to the receiving water. The sample should be collected using a flow- proportional composite sampler. Sample strainers or tubes should not lie on the bottom of a channel (where some solids may accumulate) or against any tank wall or in a corner (which may be stagnant zones). They should be suspended 1 to 2 feet below the water surface that has been well mixed or in a channel where it is mixed well, such as just before entering a flume or exiting a weir. The sampling strainer should be checked and cleaned regularly.

Often, an effluent sample is collected just prior to disinfection so the sample does not have to be seeded in the biochemical oxygen demand (BOD) test. If the sample is collected after disinfection, the BOD sample will have to be seeded with a very small amount of settled influent supernatant to reintroduce microorganisms to the BOD bottle.

* + 1. Discuss samples and lab testing when sending to certified labs. When sending samples to a certified lab one must make sure:
       1. The lab is certified to perform the test needed.
       2. The sample will get there in the appropriate time. For example: grab samples for pH cannot be sent out due to the holding time requirements and BOD samples must be tested at the certified lab no later than 48 hours after the last composite sample was taken.
       3. The paperwork is filled out completely. Certified labs will provide a chain of custody form that has all the necessary data.
       4. The samples are on ice when needed and that the temperature of the samples meets the specific requirements when they reach the certified lab.
    2. List the information that must be recorded for effluent wastewater samples.

Automatic composite samplers must be refrigerated and maintained at a temperature of less than 6°C at all times without freezing. A thermometer immersed in a small capped bottle of liquid is usually kept in the sampler to check and record temperatures. A 24-hour flow-proportional composite sample is the common requirement. For Discharge Monitoring Reporting (DMR), the day on which most of the composite sample was taken is the date of the sample. A sampling log must be maintained at the automatic composite sampler and the following information recorded:

* + - 1. Sample identification
      2. Date started
      3. Time started
      4. Date collected
      5. Time collected
      6. Sampler temperature
      7. Operator initials
      8. Comments
    1. Describe how to set an automatic sampler.

An automatic sampler takes a series of small samples throughout the day and stores it in a large container. The large container is in a refrigerator to preserve the sample while collecting it. At the end of 24 hours, a 24-hour composite sample will be collected.

The Department of Natural Resources usually specifies flow-proportional composite samples, which means the automatic sampler receives a signal from a flow meter and takes a sample every so many gallons of flow.

In order to set up an automatic sampler to take a 24-hour flow-proportional sample, two settings need to be adjusted. The first setting determines the sample size (aliquot) and the second setting determines how often the sampler takes a sample (interval). During normal flows, for example, set up the sampler to take 100 samples per day with the container about half full at the end of the 24-hour period.

EXAMPLE:

An operator wants to take a 24-hour flow-proportional sample. The flow is 500,000 gals per day (gpd) and the sample container holds 20 liters.

SOLUTION:

The operator wants to take 100 samples per day with the container about half full at the end of the 24-hour period. 10 liters = 10,000 mL, so:

10,000 mL ÷ 100 samples = 100 mL/sample

The operator can set the sample size (aliquot) to 100 mL. To determine the interval, divide

the daily flow by the number of samples:

500,000 gpd ÷ 100 samples/day = 5,000 gals/sample The operator can set the interval to 5,000 gals.

* + 1. Discuss the water pollution concerns related to the discharge of insufficiently treated

wastewater.

The discharge of insufficiently treated wastewater can affect fish and aquatic life in the receiving water course. These biological organisms are dependent on sufficient dissolved oxygen (DO) to live and the oxygen demand of the effluent can reduce or use up the oxygen present. Other concerns from wastewater discharges would include: toxics, deposition of suspended solids, and excessive growth of aquatic plants from the nutrients in the discharge.

### Section 5.3 - Permitting and Reporting

* + 1. List and describe what is in a Wisconsin Pollution Discharge Elimination System (WPDES) permit.

A WPDES permit allows you to discharge treated wastewater from a treatment plant to a specified receiving water or land area in accordance with the effluent limitations, monitoring requirements, and other conditions set forth in the permit. A WPDES permit contains the following sections:

* + - 1. Influent Requirements

The Influent Requirements section lists the specific influent sampling points and associated monitoring requirements at each point. It also provides how much flow and pollutants are coming into the plant.

* + - 1. Surface Water or Land Disposal Requirements

This section lists the specific effluent sampling points with associated monitoring requirements and effluent limitations at each point. This provides information on treatment efficiency and the amount and quality of the treated wastewater being discharged from the plant.

* + - 1. Groundwater Requirements (if applicable)

This section includes monitoring requirements and standards for a groundwater monitoring system.

* + - 1. Land Application Requirements

The Land Application Requirements section includes the specific sampling points and associated monitoring requirements and limitations at each point. It also provides information on the biosolids and sludge hauled from the plant and landspread.

* + - 1. Schedules of Compliance

The Schedules of Compliance section establishes a time schedule for any reports, upgrading construction requirements, or other actions to be met by the permittee.

* + - 1. Standard Requirements

The Standard Requirements section contains the more general requirements regarding wastewater reporting and monitoring, system operations, surface water discharge, and land application.

* + - 1. Summary of Reports Due

The end of the permit contains a table listing and summarizing all the reports that must be submitted and when they are due. Many operators copy this page and post it for ready reference.

* + 1. Describe how water quality standards and limits are established in WPDES permits.

Some effluent limitations listed in a WPDES permit are derived from water quality based standards which vary depending on the receiving water. These limits are set to protect the water quality of the receiving water.

Other limits found in a WPDES permit are established based on the type of wastewater treatment plant processes and the amount of treatment they are technologically able to provide.

* + 1. Describe a Discharge Monitoring Report (DMR).

A DMR is an electronic submittal required by the Department of Natural Resources, which includes routine monitoring data from a wastewater treatment plant primarily to determine compliance with permit limits. The monitored parameters and frequencies are outlined in the facility's WPDES permit. These reports are submitted electronically to the Department of Natural Resources on a monthly basis, although some facilities submit them quarterly. DMRs are due on the 15th of the following month.

**Figure 5.3.3.1**

A picture containing text, receipt, screenshot

Description automatically generated

* + 1. Describe other reports required in WPDES permits submitted to the Department of Natural Resources.

In addition to the DMR, there are several other required reports listed in the WPDES permit. These include: the Compliance Maintenance Annual Report (CMAR), Whole Effluent Toxicity (WET), General Sludge Management, Sludge Characteristics, and Land Application reports. Compliance schedules in a WPDES permit may require other reports.

* + 1. Discuss certifications needed at a wastewater treatment facility.
       1. Operator Certification

Each WWTP must have an operator-in-charge (OIC). The OIC must be a DNR Certified Wastewater Operator. Different size plants and different types of treatments determine the type of operator certification required for that plant.

* + - 1. Lab registration or certification

Wisconsin state law requires that sampling and testing shall be performed by a certified or registered lab. A Registered lab runs tests for only their plant. A certified lab generally performs tests for any treatment plant.

* + 1. Discuss the requirements for reporting a Sanitary Sewer Overflow (SSO).

Whenever there is an overflow occurrence at the treatment plant or from the collection system, the permittee must notify the Department of Natural Resources within 24 hours of initiation of the overflow occurrence by telephoning the wastewater staff in the regional office as soon as reasonably possible (by FAX, email, or voice mail, if staff are unavailable). In addition, the permittee shall within 5 days of conclusion of the overflow occurrence report pertinent SSO information in writing on a SSO reporting form provided by the Department of Natural Resources.

### Chapter 6 - Safety and Regulations Section 6.1 - Personal Safety

* + 1. List prevalent diseases that can be contracted through wastewater exposure.
       1. Gastroenteritis
       2. Dysentery
       3. Hepatitis B and C
       4. Giardiasis
       5. Upper respiratory illnesses
    2. Identify potential toxic gases at a wastewater treatment plant.
       1. Hydrogen sulfide
       2. Methane
       3. Carbon monoxide
       4. Chlorine
    3. \*\*\* personal protective equipment (PPE).

PPE is the protective clothing and other devices designed to protect an individual while in potentially hazardous areas or performing potentially hazardous operations. Examples of PPE include, but are not limited to: gloves, hard hat, steel-toed boots, safety glasses, and other appropriate clothing.

* + 1. \*\*\* lock-out/tag-out.

Lock-out/tag-out is used to protect the operator from serious injury by ensuring that machinery remains completely off. The lock is placed on the power source in a way that prohibits the machinery from receiving the power necessary to run and includes a tag with the operator’s name performing the maintenance. Without a lock-out/tag-out system, the possibility exists that a machine will unexpectedly start-up, either because of stored energy not correctly released, being triggered by the control system, or through someone starting it without realizing maintenance is being performed.

* + 1. Describe a potential safety hazard with anaerobic digesters.

A potential safety hazard with anaerobic digesters is the possibility of an explosive atmosphere being formed. If air is mixed with the methane gas from the digestion process, either in the digester or from any methane gas leak, any spark could cause a severe explosion.

* + 1. Discuss precautions for entering tanks, vessels, or other confines space areas.

Owners of wastewater treatment plants should clearly \*\*\* all confined spaces. Operators should know them and follow all confined space entry procedures. FOLLOW ALL CONFINES SPACE ENTRY PROCEDURES!

* + 1. Describe the applicable safety program and requirements municipal wastewater treatment plants must follow.

Wisconsin Department of Safety and Professional Services SPS 332 Public Employee Safety and Health must be followed. Some of the important safety requirements are: confined space, excavation, hearing conservation, blood-borne pathogens, CPR-First Aid, Safety Data Sheets (SDS), electrical, fall protection, hazardous materials, as well as others. Non-public entities follow OSHA CFR 29 part 1910.

* + 1. Discuss the importance of floatation devices at a wastewater treatment plant.

Sampling from basins, channels, and other treatment processes puts an operator at risk of falling into the wastewater. Basins that are aerated can be the most dangerous because the aeration process makes it extremely difficult to stay afloat in waters saturated with high concentrations of air. For this reason, an operator should never extend beyond the protection of the guardrails. OSHA highly recommends ring buoys with at least 90 ft of line be provided and readily available for emergencies and strategically placed around all process basins. OSHA also recommends any operator working over or near water where a risk of drowning is present be provided with a life jacket or buoyant work vest.

### Section 6.2 - Chemical Safety

* + 1. Discuss the importance of maintaining chemical delivery, storage, and usage records.

Some chemicals used in wastewater treatment plants are hazardous materials and must be identified. Safety Data Sheets (SDS) for each chemical are required to be kept onsite and readily available. In the event of a spill, the Department of Natural Resources must be contacted.

* + 1. Discuss what should be done in the event of a chemical spill.

Any spill of hazardous material should be reported to the Department of Natural Resources within 24 hours and to the local emergency response agencies.

### Section 6.3 - Management of Wastewater Treatment Plants

6.3.1 Discuss preventative spill measures and procedures when handling hazardous chemicals.

Storage tanks must have secondary containment that equals the volume of the storage tank.

Place containment pails under potential leak points during unloading of delivery vehicles and when uncoupling fill lines. Inspect and maintain fill lines and valves. Inspect storage tanks and hardware for integrity. Pay attention to what is being done!

Provide onsite containment equipment such as absorbent booms, sandbags, etc. and seal the yard and storm drains to prevent offsite loss of chemical.

### Chapter 7 - Calculations

**Section 7.1 - Sampling**

7.1.1 Given the average daily plant flow, calculate the programming of a flow-proportional sampler to collect the correct number and volume (mL) of samples.

GIVEN:

Average daily flow = 850,000 gals

24-hour composite volume desired = 5,000 mL Sample container size = 10 L

Samples per day = 100

FORMULAS AND SOLUTION:

gpd = gallons per day

Flow interval (gals/sample) = average flow (gpd) ÷ # of samples/day

= 850,000 gpd ÷ 100 samples/day

= 8,500 gals/sample

Sample volume (mL) = 24-hour composite volume (mL) ÷ # of samples/day

= 5,000 mL ÷ 100 samples/day

= 50 mL

### Section 7.2 - Flow Conversions and Flow Rate

* + 1. Given a flow rate (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

* + 1. Given a flow rate (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 7.3 - Tank Areas and Volumes

* + 1. Given the dimensions of a rectangular basin, calculate the volume (gallons). GIVEN:

Basin length = 60 ft Basin width = 20 ft Basin depth = 10 ft

1 cubic foot = 7.48 gals FORMULA AND SOLUTION:

Basin volume (gals) = [length (ft) × width (ft) × depth (ft)] × 7.48 gals/ft³

= [60 ft × 20 ft × 10 ft] × 7.48 gals/ft³

= 89,760 gals

* + 1. Given the dimensions of a circular basin, calculate the volume (gals). GIVEN:

Basin diameter = 30 ft Basin depth = 10 ft

1 cubic foot = 7.48 gals FORMULA AND SOLUTION:

Basin volume (gal) = [3.14 × (radius (ft))² × depth (ft)] × 7.48 gals/ft³

= [3.14 × (15 ft × 15 ft) × 10 ft] × 7.48 gals/ft³

= 52,846 gals

* + 1. Given data, determine if an unused circular tank at a treatment plant can be used for 180 day sludge storage. The volume of sludge generated is 2,500 gallons per day (gpd) and the tank is 20 ft deep with a diameter of 50 ft.

GIVEN:

Tank depth = 20 ft Tank diameter = 50 ft

Sludge wasted = 2,500 gpd FORMULAS AND SOLUTION:

Sludge volume needed = sludge wasted (gpd) × sludge storage (days)

= 2,500 gpd × 180 days

= 450,000 gals

Tank volume = [3.14 × (radius (ft))² × depth (ft)] × 7.48 gals/ft³

= [3.14 × (25 ft)² × 20 ft] × 7.48 gals/ft³

= 293,590 gals

Since the sludge wasted is 450,000 gals and the tank is only 293,560 gals, the tank by itself is too small to be used for 180 days of storage.

* + 1. Given data during wet weather, determine if a chlorine contact tank 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 gals/hr Detention time needed = 30 minutes

FORMULAS AND SOLUTION:

Tank volume (gals) = [length (ft) × width (ft) × depth (ft)] × 7.48 gals/ft³

= [20 ft × 15 ft × 15 ft] × 7.48 gals/ft³

= 33,660 gals

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

= [33,660 gals ÷ 35,000 gals/hr] × 60 mins/hr

= 0.96 hrs × 60 mins/hr

= 57 minutes

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

### Section 7.4 - Pounds Formula

* + 1. The pounds formula is one of the most commonly used formulas by operators. Given data, convert a pollutant concentration and flow to pounds per day.

GIVEN:

Influent biochemical oxygen demand (BOD) = 200 mg/L Flow = 1.0 million gallons per day (MGD)

FORMULA AND SOLUTION:

Influent BOD (lbs/day) = influent flow (MGD) × influent BOD (mg/L) × 8.34

= 200 mg/L × 1.0 MGD × 8.34

= 1,668 lbs/day

* + 1. Given data, calculate the BOD (lbs) entering the treatment plant each day. GIVEN:

Influent flow = 0.845 MGD Influent BOD = 320 mg/L

FORMULA AND SOLUTION:

Influent BOD (lbs/day) = influent flow (MGD) × influent BOD (mg/L) × 8.34

= 0.845 MGD × 320 mg/L × 8.34

= 2,255 lbs/day

* + 1. Given data, determine the food to microorganism ratio (F/M) in the aeration basin of an activated sludge treatment plant.

In an activated sludge plant, the F/M ratio is the amount of food (BOD in lbs) relative to the amount of biomass (mixed liquor suspended solids (MLSS) in lbs) in the aeration basin.

GIVEN:

Influent flow = 0.125 MGD Influent BOD = 280 mg/L

Aeration basin volume = 0.200 million gallons (MG) Aeration basin MLSS = 2,100 mg/L

FORMULAS AND SOLUTION:

Incoming BOD (lbs) = influent flow (MGD) × influent BOD (mg/L) × 8.34

= 0.125 MGD × 280 mg/L × 8.34

= 292 lbs BOD

MLSS under aeration (lbs) = aeration basin volume (MG) × MLSS (mg/L) × 8.34

= 0.200 MG × 2,100 mg/L × 8.34

= 3,503 lbs MLSS

F/M ratio = incoming BOD (lbs) ÷ MLSS under aeration (lbs)

= 292 lbs ÷ 3,503 lbs

= 0.08 lbs

### Section 7.5 - Pump Rate

* + 1. Given the dimensions of a rectangular sewage wet well (ft), calculate the pump rate (gallons per minute (gpm)) for the given pumping drawdown. Assume influent flow is shut-off.

GIVEN:

Wet well length = 16 ft Wet well width = 13 ft

Pumping drawdown = 1.75 ft Pumping time = 6 mins

1 cubic foot = 7.48 gals

FORMULA AND SOLUTION:

Pump rate (gpm) = [length (ft) × width (ft) × drawdown (ft) × 7.48 gals/ft³] ÷ pumping time (mins)

= [16 ft × 13 ft × 1.75 ft × 7.48 gals/ft³] ÷ 6 min

= 454 gpm

* + 1. Given the dimensions of a circular sewage wet well, calculate the pump rate (gpm) for the given pumping drawdown. Assume influent flow is shut-off.

GIVEN:

Wet well diameter = 8 ft Pumping drawdown = 4.25 ft Pumping time = 5 mins

1 cubic foot = 7.48 gals FORMULA AND SOLUTION:

Pump rate (gpm) = [3.14 × (radius (ft))² × drawdown (ft) × 7.48 gals/ft³] ÷ pumping time (min)

= [3.14 × (4 ft)² × 4.25 ft × 7.48 gals/ft³] ÷ 5 min

= 319 gpm

* + 1. Given data, calculate the size of an emergency (trash) pump needed to pump to a downstream manhole during a power outage at a lift station wet well to avoid a sanitary sewage overflow (SSO) or basement backup.

GIVEN:

Lift station wet well size = 10 ft × 10 ft Wet well depth = 15 ft

Wet well fill time during storm = 10 mins 1 cubic foot = 7.48 gals

FORMULAS AND SOLUTION:

Wet well volume (gals) = [length (ft) × width (ft) × depth (ft)] × 7.48 gals/ft³

= 10 ft × 10 ft × 15 ft × 7.48 gals/ft³

= 11,220 gals

Sewage flow (gpm) = wet well volume (gals) ÷ fill time (mins)

= 11,200 gals ÷ 10 mins

= 1,120 gpm

Size slightly larger, so use at least a 1,500 gpm pump will need to be used to prevent a SSO or basement backup.

* + 1. Given data, calculate the pump rate (gpm) of the lift station pump. GIVEN:

Wet well diameter = 7 ft Drawdown time = 250 secs Drawdown distance = 1.33 ft Refill time = 400 secs

Refill distance = 1.25 ft 1 cubic foot = 7.48 gals

60 secs = 1 min

FORMULAS AND SOLUTION:

Drawdown volume (gals) = 3.14 × (radius (ft))² × draw down (ft) × 7.48 gals/ft³

= 3.14 × (3.5 ft)² × 1.33 ft × 7.48 gals/ft³

= 383 gals

Refill vol. (gals) = 3.14 × (radius (ft))² × refill (ft) × 7.48 gals/ft³

= 3.14 × (3.5 ft)² × 1.25 ft × 7.48 gals/ft³

= 360 gals

Pump rate (gpm) = [drawdown vol. (gal) ÷ time (min)] + [refill vol. (gal) ÷ time (min)]

= [383 gals ÷ (250 secs ÷ 60 secs/min)] + [360 gals ÷ (400 secs ÷ 60 secs/min)]

= [383 gals ÷ 4.2 mins] + [360 gals ÷ 6.7 mins]

= 91 gpm + 54 gpm

= 145 gpm

### Section 7.6 - Detention Time

* + 1. Given data, calculate the detention time (hrs) for a clarifier. GIVEN:

Volume of clarifier = 95,000 gals

Flow rate = 540,000 gallons per day (gpd) FORMULAS AND SOLUTION:

Flow (gals/hr) = flow rate (gpd) ÷ 24 hrs/day

= 540,000 gpd ÷ 24 hr/day

= 22,500 gals/hr

Detention time (hrs) = volume (gals) ÷ flow (gals/hr)

= 95,000 gals ÷ 22,500 gals/hr

= 4.22 hrs

* + 1. Given data, calculate detention time (hrs) for multiple clarifiers operating in parallel.

GIVEN:

Primary clarifiers = 2 Clarifier diameter = 80 ft Clarifier depth = 12 ft

Average daily flow = 7.2 million gallons per day (MGD) 1 cubic foot = 7.48 gals

[NOTE: Both clarifiers receive equal flows] FORMULAS AND SOLUTION:

Volume (gals) = # of clarifiers × [3.14 × (radius (ft))² × depth (ft) × 7.48 gals/ft³]

= 2 clarifiers × 3.14 × (40 ft)² × 12 ft × 7.48 gals/ft³

= 901,908 gals

Detention time (hrs) = tank volume (gals) ÷ flow rate (gals/hr)

= 901,908 gals ÷ (7,200,000 gpd ÷ 24 hrs/day)

= 901,908 gals ÷ 300,000 gals/hr

= 3 hrs

[NOTE: This can also be calculated by using the volume (gals) of 1 clarifier and dividing the flow by 2]

### Section 7.7 - Percent Removal

7.7.1 Given data, calculate the percent removal of biochemical oxygen demand (BOD) in a wastewater treatment plant.

Wisconsin Pollution Discharge Elimination System (WPDES) permits require wastewater treatment plants remove at least 85% of the influent BOD and suspended solids. The intent of this permit condition is to ensure "the solution to pollution is NOT dilution".

GIVEN:

Influent BOD = 250 mg/L Effluent BOD = 10 mg/L

FORMULA AND SOLUTION:

Percent (%) removal = [(infl. BOD (mg/L) - eff. BOD (mg/L)) ÷ infl. BOD (mg/L)] × 100

= [(250 mg/L - 10 mg/L) ÷ 250 mg/L] × 100

= (240 mg/L ÷ 250 mg/L) × 100

= 96%

# References and Resources

## 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’.

[www.aqua.wisc.edu/waterlibrary](http://www.aqua.wisc.edu/waterlibrary)

## OPERATION OF MUNICIPAL WASTEWATER TREATMENT PLANTS

Water Environmental Federation (WEF). (2008). Operation of Municipal Wastewater Treatment Plants: Manual of Practice No. 11 (6th ed., Vols. I, II, III). New York, New York: McGraw-Hill.

[www.wef.org](http://www.wef.org/)

## OPERATION OF WASTEWATER TREATMENT PLANTS

Office of Water Programs, California State University, Sacramento. (2008). Operation of Wastewater Treatment Plants (7th ed.). Sacramento, CA: University Enterprises, Inc., California State University.

[www.owp.csus.edu](http://www.owp.csus.edu/)

## WASTEWATER MICROBIOLOGY: A HANDBOOK FOR OPERATORS

Glymph, T. (2005). Wastewater Microbiology: A Handbook for Operators. Denver, CO: American Water Woks Association.

[www.awwa.org](http://www.awwa.org/)

## BASIC ACTIVATED SLUDGE PROCESS CONTROL: PROBLEM-RELATED OPERATIONS-BASED EDUCATION (PROBE)

Water Environment Federation (WEF). (1994). Basic Activated Sludge Process Control: Problem-Related Operations-Based Education (PROBE). Alexandria, VA: Water Environment Federation.

[www.wef.org](http://www.wef.org/)

## AERATION: A WASTEWATER TREATMENT PROCESS

Water Pollution Control Federation, American Society of Civil Engineers. (1988). Aeration: A Wastewater Treatment Process. Alexandria, VA: Water Pollution Control Federation.

[www.wef.org](http://www.wef.org/)

## A DROP OF KNOWLEDGE: THE NON-OPERATOR’S GUIDE TO WASTEWATER SYSTEMS

National Environmental Services Center on behalf of Rural Community Assistance Partnership, Inc. (2011). A Drop of Knowledge: The Non-operator's Guide to Wastewater Systems. Washington, DC: Rural Community Assistance Partnership, Inc (RCAP).

[www.rcap.org](http://www.rcap.org/)

## 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.

[www.pca.state.mn.us](http://www.pca.state.mn.us/)

## STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER

United States Environmental Protection Agency (USEPA). (2012). Standard Methods for the Examination of Water and Wastewater (22nd ed.). Washington, DC: American Water Works Association.

[www.standardmethods.org](http://www.standardmethods.org/)

## OSHA CFR 29 PART 1910

Occupational Safety & Health Administration (OSHA). (2012). Regulations (Standards-29 CFR 1910.1200)

[www.osha.gov](http://www.osha.gov/)

## WISCONSIN ADMINISTRATIVE CODE SPS 332 PUBLIC EMPOLYEE SAFETY AND HEALTH

Wisconsin Administrative Code SPS 332 Public Employee Safety and Health (2014) [http://docs.legis.wisconsin.gov](http://docs.legis.wisconsin.gov/)

**TERMINAL MANHOLE -** A manhole located at the upstream end of a sewer and having no inlet pipe.

**TOTAL CONTRIBUTION** - All water and wastewater entering a sewer system from a specific facility, subsystem or area. This includes domestic and industrial wastewaters, inflow and infiltration reaching the main collection system.

**TOTAL DYNAMIC HEAD (TDH) -** When a pump is lifting or pumping water, the vertical distance (in feet) from the elevation of the energy grade line on the suction side of the pump to the elevation of the energy grade line on the discharge side of the pump.

**TOTAL FLOW -** The total flow passing a selected point of measurement in the collection system during a specified period of time.

**TRAP -** (1) In the wastewater collection system of a building, plumbing codes require every drain connection from an appliance or fixture to have a trap. The trap in this case is a gooseneck that holds water to prevent vapors or gases in a collection system from entering the building. (2) Various other types of special traps are used in collection systems such as a grit trap or sand trap.

**TRUNK SEWER** - A sewer that receives wastewater from many tributary branches or sewers and serves a large territory and contributing population.

**TRUNK SYSTEM -** A system of major sewers serving as transporting lines and not as local or lateral sewers.

**TWO-WAY CLEANOUT** - An opening in pipes or sewers designed for rodding or working a snake into the pipe in either direction. Two way cleanouts are most often found in building lateral pipes at or near a property line.

**VAC-ALL -** Equipment that removes solids from a manhole as they enter the manhole from a hydraulic cleaning operation. Most of the wastewater removed from the manhole by the operation is separated from the solids and returned to the sewer.

**VELOCITY HEAD -** The energy in flowing water as determined by a vertical height (in feet or meters) equal to the square of the velocity of flowing water divided by twice the acceleration due to gravity (V2/2g).

**VERTICAL OFFSET -** A pipe joint in which one section is connected to another at a different elevation.

**WASTELINE CLEANOUT** - An opening or point of access in a building wastewater pipe system for rodding or snake operation.

**WASTELINE VENT -** Most plumbing codes require a vent pipe connection of adequate size and located downstream of a trap in a building wastewater system. This vent prevents the accumulation of gases or odors and is usually piped through the roof and out of doors. 242

**WASTEWATER -** A community’s used water and water-carried solids that flow to a treatment plant. Storm water, surface water, and groundwater infiltration also may be included in the wastewater that enters a wastewater treatment plant. The term “sewage” usually refers to household wastes, but this word is being replaced by the term “wastewater.”

**WASTE ACTIVATED SLUDGE SOLIDS (WASS)** – The concentration of suspended solids in sludge that is being removed from the activated sludge process.

**WASTEWATER COLLECTION SYSTEM -** The pipe system for collecting and carrying water and water-carried wastes from domestic and industrial sources to a wastewater treatment plant.

**WASTEWATER FACILITIES -** The pipes, conduits, structures, equipment, and processes required to collect, convey, and treat domestic and industrial wastes, and dispose of the effluent and sludge.

**WASTEWATER TREATMENT PLANT -** (1) An arrangement of pipes, equipment, devices, tanks and structures for treating wastewater and industrial wastes. (2) A water pollution control plant.

**WATER POLLUTION** - Any change in the natural state of water which interferes with its beneficial reuse or causes failure to meet water quality requirements.

The average **wastewater production per person per day** in most communities is between 70 and 100 gallons, depending upon a variety of factors including time of the year and water rates.

**WAYNE BALL** - A spirally grooved, inflatable, semi-hard rubber ball designed for hydraulic cleaning of sewer pipes.

**WEIR** - A device used to measure wastewater flow.

**WET WELL** - A compartment or tank in which wastewater is collected. The suction pipe of a pump may be connected to the wet well or a submersible pump may be located in the wet well.

**WETTED PERIMETER -** The length of the wetted portion of a pipe covered by flowing wastewater.

**ZOOGLEAL SLIME** – The biological slime that forms on fixed film treatment devices. It contains a wide variety of organisms essential to the treatment process.