South Platte Water Renewal Partners
Full Process Description

Contents

Headworks 2
Primary Treatment 3
Dissolved Air Flotation Tanks (DAFT) 4
Anaerobic Digestion 5
Beneficial Use 6
The Farm 7
Trickling Filters 7
Odor Control 8
Solids Contact Tanks 8
Final Clarifiers 9
Nitrifying Trickling Filters 10
Denitrification Filters 11
Contact Tanks 13
Final Effluent .... **Error! Bookmark not defined.**
Administration 13

Headworks

The existing Headworks, placed into service in 1977, provides influent flow measurement, screening, influent pumping, and grit removal. This building was renovated in 1991 during the Phase 1A project to upgrade the existing treatment systems, improve ventilation, and provide odor control facilities. The influent flow metering equipment was updated during the Phase 2 Expansion project in 2009.

An average of 23 million gallons per day (mgd) of wastewater from the cities of Littleton and Englewood enters the plant separately through two interceptor pipes. The Englewood interceptor is 60-inches in diameter and the Littleton interceptor is 66-inches in diameter. Two Parshall flumes located at the entrance to the Headworks building measure the incoming flows; one flume is dedicated to measuring City of Englewood flows and the other flume measures City of Littleton flows. Each flume has a rated free-flow capacity of 80 mgd.

After screening, raw sewage pumps lift the flow approximately 30 feet into two grit basins or two grit concentrators. Raw sewage pumping is provided by six dry well, vertical shaft, centrifugal pumps. Each pump has a rated capacity of 20.1 mgd and discharges individually just above the water level of the grit basin distribution channel. An air gap of several inches precludes reverse flow when the pumps are shut down, eliminating any need for check valves on the pump discharge piping.

The raw sewage pumps are each equipped with electronic pulse-width modulation (PWM) type variable speed drives. Pump speed is varied to maintain a constant level in the Headworks wetwell. The pumps start and stop automatically in an operator selectable sequence. Operation with a constant wetwell level achieves several purposes including:

1. Reduces the drop downstream of the influent flumes minimizing turbulence and air entrainment. Minimal turbulence reduces stripping of H_2S and other odorous compounds to the air.
2. Eliminates frequent pump cycling associated with a variable level control strategy.
3. Minimizes static lift on the existing pumps to achieve the rated capacity of the existing units.
4. Increases submergence of existing pumps to minimize potential for vortex and air entrainment.

The wetwell water surface level is set as high as possible while maintaining scouring velocities at low flow. The barscreen rake mechanism operates frequently enough to avoid high head-loss or breakthrough of rags and debris at high flow. The diurnal flow peaking factor of 1.5 does not cause excessive velocities through the bar screens.

Screened raw sewage is pumped to the grit influent channel by the raw sewage pumps. Flow from the filter influent pump station is combined with the raw sewage flow in the grit influent channel. From the influent channel, the sewage/nitrified effluent can flow to either Grit Tank 1, Grit Tank

2, Grit Concentrator 1 and/or Grit Concentrator 2. Normally, the grit tanks are isolated and the grit concentrators are used for grit removal.

The grit concentrators are hydraulically-driven separation devices that utilize boundary layer effects to create a concentrated grit slurry and a de-gritted sewage stream. The de-gritted sewage flows out of the concentrator, over a weir, to the grit effluent channel. The grit slurry is pumped from the bottom of the concentrator to grit classifiers for further processing. A water (3W) supply is delivered to the concentrator as an underflow stream during operation to assist in the separation process.

The grit pumps draw the grit slurry from the bottom of the concentrators and pump the slurry to the grit classifiers. The grit pumps are recessed impeller pumps with variable speed drive. Grit classifiers are hydraulically-driven separation devices that utilize centrifugal force to separate grit from the sewage stream. A 3W supply is delivered to the classifier during operation to assist in the separation process. After separation, the sewage and supply water are returned to the raw sewage wet well. The grit falls from the classifier directly into an associated grit dewaterer.

In the grit dewaterers, the grit from the classifiers is dewatered prior to being deposited in a truck for off-site removal. Rinse water is added to the dewaterers to prevent against dewaterer run-dry conditions. Dewatering is accomplished by transporting the grit up an inclined cleated belt. The grit then falls out of the discharge chute at the end of the belt into the screenings/grit hopper or disposal vehicle. The excess rinse water drains from the dewaterer and is returned to the raw sewage wet well. Grit and screening that are discharged to the screenings/grit discharge hopper normally fall through the hopper and are deposited in a truck for off-site disposal. When a truck is not available, a slide gate at the bottom of the hopper is closed and the grit/screenings are temporarily collected in the hopper.

The ventilation system provides approximately 30 air changes per hour through the Headworks building. This exchange rate scours odorous gases out of the building and maintains a good working environment for operations staff. The exhaust air from the Headworks building is used to supply oxygen to the biological treatment process in the nearby Trickling Filters. The combined exhaust from Headworks and Trickling Filters is chemically treated to remove odorous compounds. The foul air is brought into contact with a mixture of sodium hypochlorite, sodium hydroxide, and softened water and is sprayed over a plastic media. Softened water is required to ensure that scale (mineral precipitants) does not buildup. The pH and oxygen reduction potential (ORP) are monitored constantly to ensure that the dosing of the chemicals is correct. As the air is forced through the media, hydrogen sulfide is stripped from the air. The treated air is discharged to the atmosphere through the tower and the spent solution is returned for reuse.

Primary Treatment

The wastewater flows from the grit removal process into two junction boxes and is distributed equally to the primary clarifiers. Primary sedimentation occurs in six open 105-feet diameter primary clarifiers. Four have a side wall depth of 8 feet. Two have a side wall depth of 12 feet.

The primary clarifiers are center feed, peripheral overflow type. The primary clarifiers provide quiescent conditions where solids are removed from the liquid stream. The clarified or primary effluent travels from the primary clarifiers through a series of pipes and junction boxes to the trickling filter/solids contact process.

Sludge settling to the bottom of the primary clarifiers is collected by a rotating rake mechanism which carries the sludge to a center hopper. The settled solids are continuously withdrawn at a low concentration by recessed impeller type centrifugal pumps. An in-line grinder upstream of each sludge pump shreds large solids and stringy materials into small fragments to ensure a uniform sludge consistency for downstream processes. Primary sludge is pumped to the dissolved air flotation process (DAFT) for thickening prior to anaerobic digestion.

Each primary clarifier has a scum baffle and rotating scum skimmer which traps floating materials such as grease from the water surface. Skimmings are removed periodically by the same pumps used to remove primary sludge. A 3-way valve on the suction piping of each centrifugal pump alternates on a timed cycle between the clarifier center hopper piping and the skimmings hopper. A below grade scum and sludge pumping station is located between the six primary clarifiers.

Dissolved Air Flotation Tanks (DAFT)

Waste primary and secondary sludges are combined into a homogeneous mixture and thickened in three 45-foot diameter dissolved air flotation tanks. The DAFT tanks abut against an integral equipment gallery which houses mechanical support systems. Mixed sludge is distributed to the DAFTs through a system of overflow weirs. As the sludge enters the DAFT center column it contacts air bubbles less than 100 µm in diameter released from a pressurized recycled effluent stream. The resulting air/solids aggregate floats to the surface of the tank. Concentrated float is skimmed from the DAFT water surface and pumped to the anaerobic digestion process. The DAFT system removes about 90 percent of the water in the waste sludge, increasing the float concentration to approximately 5 percent solids.

The thickener liquid effluent (subnatant) flows out of the tank via a submerged orifice collection system. This feature, coupled with a level controlled modulating valve, allows the liquid level within the thickener to be adjusted. By varying the liquid level, the float depth and concentration can be optimized before skimming into the collection troughs. A portion of the subnatant is recycled through the pressurization system.

Using the recycle pressurization method, a portion of the subnatant is mixed with air under pressure in the saturation vessels. The pressurization system drives the air into solution in the recycle flow. As the air saturated recycle is mixed with the un-thickened sludge inside the DAFT tank center column, a decrease in pressure releases fine bubbles into the sludge flow. The bubbles contact and adhere to the solid particles creating a buoyant solid-gas complex which floats to the liquid surface. The float particles accumulate and concentrate until they are removed from the DAFT tank by surface skimmers. The DAFT tanks are covered to contain odorous foul air emissions. The exhaust air is discharged to the NTF process for biological foul air treatment prior to release to the atmosphere.

Anaerobic Digestion

Stabilization of thickened sludge at is currently achieved through anaerobic digestion. The five anaerobic digestion units are each approximately 80 feet in diameter and 30 feet deep with a sludge volume of approximately 145,800 cubic feet each.

Anaerobic digestion is a residual solids treatment process. Solids removed from raw wastewater, known as primary sludge, and solids removed from the biological treatment processes, known as secondary sludge, are treated, after thickening in Dissolved Air Floatation Tanks, in the anaerobic digestion process. The anaerobic digestion process stabilizes the biodegradable solids concentrated from wastewater which in turn, provides the following benefits:

1. Protects public health and the environment
2. Makes sludge relatively inert
3. Reduces odor generation from undigested sludge
4. Reduces bacteria and pathogenic organisms
5. Reduces possibility of becoming food source for vectors
6. Reduces the volume and weight of sludge
7. Reduces the cost of sludge handling and ultimate disposal

The anaerobic digestion process itself is a multistage biological process that occurs in the absence of oxygen. Complex organic substances are solubilized and fermented to methane, carbon dioxide, trace gases, cells, and stabilized sludge solids. Anaerobic digestion at the Littleton/Englewood Wastewater Treatment Plant (WWTP) is accomplished in five conventionally shaped anaerobic digesters. The total facility is comprised of five major components:

1. Thickened sludge loop and dedicated digester mixing and circulated sludge pumps
2. Five fixed cover anaerobic digesters
3. Boilers, heat exchangers, cogeneration and a heat reservoir system to maintain a warm environment for the digestion process
4. Digested sludge recirculation pumps for continual heating and foam suppression and mixing pumps to distribute feed sludge and toxic digestion products
5. Associated gas handling equipment, including a waste gas burner

Fixed submerged cover digesters operate as a constant liquid level system. Digested sludge is removed by displacement of the digester contents by feeding new sludge into the digester through the DAFT loop feed pumps that discharges into the center of the digester dome. The center digester mixer combines the fresh sludge with the digester contents. This causes hydraulic displacement of sludge from the bottom of the digester up and over the sludge transfer overflow weir and into the sludge withdrawal line. This overflow line carries the digested sludge into a 24-inch diameter standpipe. The level of sludge in the standpipe is measured, which controls the operation of the sludge transfer pumps. On a high level in the standpipe, the pump is turned on until the sludge reaches a predetermined low level, where the pump ceases operation. The digested sludge is transferred into either Digester No. 1 or No. 2 where it is held until it can be dewatered. Since all of the solids are sent through grinders prior to thickening in the DAFTs, material accumulation in the digesters such as grit, rags, and plastic is minimized.

The anaerobic digestion process is a single unit process in the overall treatment of wastewater sludges. Gas produced by the digestion process is used to fire boilers and cogeneration units to produce both heat and electrical power. The heat source provides hot water that is used to heat the facility as well as maintain the temperature in the digesters. These units will burn methane or natural gas.

Mixing is currently provided by 25 horsepower sludge circulation pumps. This system circulates digested sludge continuously to the DAFT gallery, returning through the heat exchangers to the digester tanks. Thickened sludge from the DAFTs is pumped into the circulating sludge loop to be transported into the digester system.

Beneficial Use

Three scroll centrifuges, each with a maximum capacity of 200 gpm, provide consistent sludge dewatering to approximately 18 to 20 percent solids. Currently, the plant dewaters approximately 140,000 gallons of digested sludge per day. One centrifuge operates at approximately 185 gpm for 13 hours per day on a 5-day per week schedule. The other units provides backup capability in the event of breakdown of the operating unit. Each centrifuge requires a major overhaul annually. Major overhauls usually require 3 to 4 weeks to complete.

The goals of the Beneficial Use program are to:

- Promote public relations and local ordinance involvement necessary for the operation and maintenance of a safe, effective and beneficial land application program.
- Provide a long term Beneficial Use program in order to ensure an environmentally safe and cost efficient method of domestic biosolids utilization.

The objectives of the Beneficial Use program are to:

- Continue long term monitoring and testing programs at the Littleton/Englewood Kiowa farm and Colorado State University testing sites.
- Continue the development and implementation of a permanent biosolids application site into a long term, biosolids application program.
- Maintain biosolids quality to comply with Colorado state biosolids regulations and EPA Part 503 regulations.
- Operate an accident-free biosolids application program with no motor vehicle or DOT violations.
- Develop and implement a computer database program for recording and reporting requirements, as well as historical site documentation.

Biosolids recycling is regulated according to 40 CFR (Code of Federal Regulations) Part 503, Standards for the Use or Disposal of Sewage Sludge. These standards, commonly known as the "503" regulations, are promulgated by the US Environmental Protection Agency (US EPA). The regulations recognize that biosolids, by nature of their origin, have the potential to contain appreciable concentrations of contaminants that may adversely affect human health and/or the environment. The three categories of potential contaminants identified by the regulations are (1) pathogens, or disease organisms, (2) organic compounds, and (3) trace metal content. Federal, state, and local agencies regulate the production, application and marketing of biosolids. There are two classifications of biosolids based on pathogen content: Class A biosolids have been treated to reduce pathogens to a level where access to application sites does not need to be limited, and Class B biosolids have been treated to reduce pathogens to a level that is safe for application on land with an initial period of limited public access. Treatments to produce Class A biosolids do not affect the metals or organic chemicals in the biosolids; odor may or may not be affected. Federal regulations also set maximum limits on trace metal content in biosolids. The state and county health departments may impose stricter standards. We treat our biosolids to meet the Class B standards. The federal regulations on biosolids processing and use and the corresponding state regulations mandate that biosolids be applied at agronomic rates to balance uptake of nitrogen by crops with the potential for nitrate leaching to ground water. The maximum rate and the cumulative amount of biosolids that can be applied to a particular parcel of land are intended to limit the concentrations of contaminants in soil, crops, and receiving waters. These regulations limit the accumulation of contaminants in biosolids-amended soil to levels that are not harmful to the health of humans and other biota. When biosolids are applied in compliance with federal, state and local regulations and permitting requirements, there are no probable significant adverse environmental impacts associated with this practice.

The Farm

Trickling Filters

The secondary treatment process has three 105-foot diameter trickling filters each containing 16 vertical feet of plastic cross-flow media. A rotary 4-arm distributor sprays primary effluent over the media at a rate of approximately 1.7 gpm/sf. The trickling filters are elevated above the plant hydraulic gradient to allow the effluent to flow to the solids contact tanks by gravity.

The filters are covered with aluminum domes to contain foul air. A forced air ventilation system transfers foul air exhausted from the headworks building into the space below the dome enclosures. Air moves downward, concurrent with the wastewater flow through the trickling filter media to provide oxygen for the biological process. Foul air collected from the plenum area below the media is discharged to a chemical scrubber system to remove odorous compounds prior to discharge to the atmosphere.

Five variable speed 24 mgd vertical column pumps are available to lift primary effluent to the top of the trickling filter. Trickling filter effluent is recycled through the pump station to maintain minimum wetting for the fixed-film process. Electric variable speed drives and motor control centers for the trickling filter pumps are housed inside the Trickle Filter Service Building.

Odor Control

Odorous air is withdrawn from the Trickling Filters by an odorous air fan and into an odor control scrubber tower. Two towers (one standby) service Trickling Filters 1 & 2. One tower services Trickling Filter 3. The foul air is brought into contact with a mixture of Sodium Hypochlorite, Sodium Hydroxide and softened water and is sprayed over a media made of plastic pieces. Softened water is required to ensure that scale does not buildup. The pH and ORP are monitored constantly to ensure that the dosing of the chemicals is correct. As the air is forced through the media, Hydrogen Sulfide is stripped from the air. The treated air is discharged to the atmosphere through the tower. The spent solution is returned for reuse.

Solids Contact Tanks

The Return Aeration/Solids Contact Tanks (RA/SCT) is an integral part of the Trickling Filter/Solids Contact (TF/SC) biological treatment process. In this process the Trickling Filter Effluent (TFE) is mixed with activated sludge in the SCTs to improve sludge settleability and to oxidize any Carbonaceous Biochemical Oxygen Demand (cBOD5) remaining in the TFE or in any Primary Effluent (PE) that is sent to the system. The RA Tank serves to reaerate the Return Secondary Sludge (RSS) coming from the final clarifiers before it is mixed with the TFE in the SCT tanks.

There are six tanks in the system; RA1, RA/SCT2, SCT 3-6. Each of the six tanks measures 108 feet long by 49 feet wide by 12.8 feet deep and has an approximate volume of 500,000 gallons. Reaeration Tanks RA1 and RA/SCT2 are designed as the reaeration tanks. Only one of these tanks will be in service as an RA tank at any given time. The Reaeration tank receives all of the RSS from the final clarifiers. The tank is equipped with fine bubble diffusers and an automatic air control valve. This tank is designed to provide retention time for reaeration of the solids from the seven final clarifiers. The Hydraulic Retention Time (HRT) for this tank will vary with flow from about 29 minutes at 25 MGD RSS flow to about 14 minutes at 50 MGD RSS flow. RA/SCT2 serves as a backup RA tank for use when RA1 is out of service or as a SCT.

The SCTs receive the reaerated RSS from the RA tank plus TFE and PE. These tanks are equipped with fine bubble diffusers and automatic air control valves. These tanks are designed to condition the solids to improve settling in the final clarifiers and to oxidize any cBOD5 remaining in the influent.

The HRT for the SCT tanks is designed to be about 29 minutes at the maximum design flow of 100 MGD (50 MGD TFE+PE + 50 MGD RSS) with four SCT on line. At lower flows fewer SCTs may be in service. To maintain the 29 minute HRT at 50 MGD (25 MGD TFE+PE + 25 MGD RSS) only two SCT are needed.

As bacteria begin growing, they generally develop into small chains or clumps. They are very active and motile and it is difficult for them to settle. They have not yet developed the slime layer which aids in their sticking together. So, when mixing occurs, the small chains or clumps are broken up and the bugs are dispersed, and they will not flocculate or settle. As the sludge is allowed to age, the bugs lose their motility and accumulate more slime. Then the clumps and chains are better able to stick together. The clumps grow bigger and bigger until they form a floc. If the organisms are allowed to develop properly, under the right conditions, the floc get large and compact and begin to settle. The mixing in the aeration tank tends to keep the floc small since, even though the bugs are sticky, the bond formed holding the organisms together is not very strong. This is good because it allows the cells, food, and oxygen to contact each other.

The growth curve characteristics of bacteria:

- Lag-phase - During this phase bacteria become acclimated to their new surroundings. They are digesting food, developing enzymes and other things required for growth.
- Accelerated Growth phase - The bacteria are growing as fast as they can, since there is an excess of food. The cells are mostly dispersed, not sticking together.
- Declining Growth phase - Reproduction slows down because there is not an excess of food. A lot of food has been eaten and there are now a large number of bacteria to compete for remaining food, so the bacteria do not have enough remaining food to keep the growth rate at a maximum.
- Stationary phase - The number of bacteria is the highest possible, but not much food is left, so the bacteria cannot increase in number. There is some reproduction, but some cells are also dying, so the number of bacteria remain relatively constant. The bacteria have now lost their flagella and have a sticky substance covering the outside of the cell, allowing them to agglomerate into floc. In fact, the floc get big enough that if aeration and mixing were stopped, the floc could settle to the bottom.
- Death-phase - The death rate increases with very little if any growth occurring. Therefore, the total number of living bacteria keeps reducing. The bacteria are just trying to keep alive.

Final Clarifiers

There are seven final clarifiers for sedimentation of the biological solids previously conditioned in the RA/SCT process. The primary function of the final clarifiers is to aid in the separation of settleable solids from the mixed liquor and collect the settled biological solids for re-routing back to the RA/SCT process. The final clarifier effluent or supernatant that is separated from the mixed liquor is then routed to the nitrifying trickling filter (NTF) pump station for additional treatment. The settled solids or return activated sludge (RAS) flows through a 24" pipe to the return secondary sludge wetwell which pumps the RAS into the reaeration basin(s).

The settled solids form a sludge "blanket" on the bottom of the clarifier that is collected using a rotating suction header which is connected to the 24" line that travels to the secondary sludge wetwell. The suction in the 24" clarifier-RSS wetwell pipe is created by the pumping of RAS from the return secondary sludge wetwell to the reaeration basin. The suction header spans the diameter of the bottom of the clarifier and has holes on the bottom which then collect the settled sludge as it is rotating and from the siphon created in line from the RSS pumping activities. If the RAS pumps are not running, the siphon is not created thus the sludge blanket can build up to high levels which could possibly jeopardize water quality.

Less dense and colloidal solids that do not settle and accumulate on the surface of the clarifiers are skimmed by a traveling arm. These skimmed solids are collected in the scum box and flow by gravity to the headworks of the facility. Clarifiers 1 - 5 hold a volume of 200,394 cubic feet (135' diameter, 14' SWD) and a surface area of 14,314 square feet. Clarifiers 6 and 7 hold a volume of 286,278 cubic feet (135' diameter, 20' SWD) with the surface area being the same as the other clarifiers.

The RSS pump station returns solids to the re-aeration tank from the final clarifiers. There is a dedicated 50 hp variable-speed Vertical Turbine Mixed Flow RSS pump to remove solids from each of the seven final clarifiers the tank. There is also one standby pump, RSS-8, configured for backup of any of the other pumps. This is accomplished with the transfer channel. The transfer channel is equipped with gates that can be configured to direct flow from any clarifier to any of the RSS pumps, including the backup pump, RSS-8. Each of the RSS pumps is rated at 5,000 gpm (7.2 MGD) and the entire station has a firm capacity of 35,000 gpm (50.4 MGD).

Station flow is monitored by a flow meter located in the common discharge pipe located in the gallery in the basement of the Secondary Sludge Pump Station. Individual pump speed is automatically regulated by SCADA programming. There is a high level override that will limit flow when a high level is detected in the RA tank. Four variable-speed 30 hp Waste Secondary Sludge (WSS) pumps, three duty one standby, remove solids from the Secondary Treatment process via withdrawal lines from the re-aeration tanks (normal mode of operation). Solids can also be wasted from the effluent channel (know as Mixed Liquor, or ML wasting). The waste sludge is transferred to the DAFT complex, where it is thickened prior to digestion. The wasting rate is optimized to maintain the appropriate mass of solids in the system.

The WSS system relies on sludge inventory calculations for monitoring and control of sludge wasting. The inventory of the RA and SCT tanks is calculated by multiplying the suspended solids concentration by the number of online tanks and by the tank volume. SCT tanks are calculated using the concentration in the effluent channel, while RA tanks are calculated using the WSS line (pulled from the RA tank). Total solids in the system is calculated by adding the SCT and RA solids. Staff determines and inputs the setpoint value for desired SRT within the system. The PLC will modulate the WSS pump(s) speed to maintain the setpoint.

Five large multi-stage centrifugal blowers and one small blower, discharging into a common header are staged to provide airflow to the RA/SCTs for mixing and oxygenation. The inlet valves to the blowers can be adjusted to maintain pressure on the air header. A modulating blow-off valve will prevent the blowers from entering a surge condition and provide additional capacity adjustment. Total blower capacity for the five blowers is 40,500 scfm, 8,100 each. The capacity of the smaller blower is 3,210 scfm. The average air flow demand is expected to be 15,600 scfm (two blowers) and the peak air flow demand is expected to be 34,500 scfm (4 blowers). Each blower is equipped with an equipment protective package to provide shutdown and alarming for surge, vibration, and temperature.

Oxygen is required by these bugs to metabolize food for cell maintenance and growth. Although the bugs need oxygen, some bugs can get along with less oxygen than others. Each bug must have a dissolved oxygen of at least from 0.1-0.3 mg/L to function properly. So, it is important to maintain about 2 mg/L of D.O. in the activated sludge so that the bacteria that are contained in the floc can get oxygen. If the DO is less than 2 mg/L, the bugs on the outside of the floc use the DO before it can get to the center of the floc. If this happens, the bugs in the center may die causing the floc to break up.

Mixing is required to bring organisms, oxygen, and nutrients together, and to remove metabolic waste products. If there is not enough mixing, proper treatment will not take place because of lack of contact between the bugs, their food and oxygen. If too much mixing is provided, it can cause break up of floc or formation of unstable floc particles.

Nitrifying Trickling Filters

Three nitrifying trickling filters (NTF's) provide ammonia removal to meet monthly variable effluent limitations. Each NTF is 105-feet in diameter and contains 24 vertical feet of plastic cross-flow media. The filters rest on a base of fill approximately 6 feet above grade to allow gravity flow from the NTF's to the Denitrification Filters Influent Pump Station. NTF structural design allows routine flooding and backwashing of the units to control nuisance organisms associated with the nitrification process. Sodium hydroxide can be applied to raise the pH during flooding for snail control. Secondary effluent is applied over the media surface by a 4-arm, hydraulically driven rotary distributor.

The three covered nitrifying trickling filters serve a dual function, oxidizing ammonia to meet effluent water quality standards and biologically treating odorous sulfur compounds in the exhaust air from the dissolved air flotation thickeners, the centrate return tank and the solids handling building. Forced air ventilation systems transfer foul air from three dissolved air flotation thickeners, the solids handling building and a centrate equalization tank to the three NTF's. Geodesic dome covers enclose the NTF tanks, ensuring uniform distribution of foul air over the biofilm surface, preventing short-circuiting and enhancing odor treatment. The combined foul air from both sources discharges into the top of the NTF enclosure, moving downward through the media with the wastewater flow. Treated air drawn from underneath the NTF media is discharged to the atmosphere through a centrifugal fan. Foul air flow to each NTF unit is approximately 9,900 cfm. Use of the nitrifying biofilm for foul air treatment avoids the cost for another expensive chemical scrubbing system.

Four variable speed, 24-mgd, vertical column pumps lift secondary effluent to the NTF distributors. The pump station can recycle nitrified effluent to increase wetting rates. Two pumps allow bypass of a controlled portion of the secondary effluent to the disinfection complex in order to provide the required amount of ammonia necessary for efficient disinfection of the wastewater. Electric variable speed drives and other support equipment are housed in a separate support building.

The nitrifying trickling filters serve a dual function, oxidizing ammonia to meet effluent water quality standards and biologically treating odorous sulfur compounds in the exhaust air from the dissolved air flotation thickeners, the centrate return tank and the solids handling building. Forced air ventilation systems transfer foul air from three dissolved air flotation thickeners, and a centrate equalization tank to three NTFs. Geodesic dome covers enclose the NTF tanks, ensuring uniform distribution of foul air over the biofilm surface, preventing short-circuiting and enhancing odor treatment. The combined foul air from both sources discharges into the top of the NTF enclosures, moving downward through the media concurrent with the wastewater flow. Treated air drawn from underneath the NTF media is discharged to the atmosphere through a centrifugal fan. Foul air flow to each NTF unit is approximately 9,900 cfm. Use of the nitrifying biofilm for foul air treatment avoids the cost for another expensive chemical scrubbing system.

Denitrification Filters

Nitrate-nitrogen is reduced in the wastewater stream in the Denitrification Filters. The nitrate-nitrogen is converted to nitrogen gas through a biological reaction known as denitrification. This takes place in the absence of dissolved oxygen and the presence of a readily biodegradable carbon source. This is known as an anoxic environment. There are numerous organisms capable of the facultative process of denitrification. The presence of these organisms should not be an issue. The presence of nitrate/nitrite-nitrogen is dependent on the level of nitrification occurring in the nitrifying trickling filters (NTF). Most of the biodegradable carbon is removed in trickling filter/solids contact and NTF processes. A supplemental carbon source must be added to accomplish denitrification. In this process, the carbon source is added in the form of 99%

methanol. There is a ratio of 3:1 of methanol (mg/L) required for every mg/L of nitrate-nitrogen. However, care is taken not to overdose methanol as every 1.0 mg/L of residual methanol adds 1.5 mg/L of biochemical oxygen demand (BOD) to the effluent.

The effluent from the NTF flows to a pump station that feeds the denitrification filters through an influent channel. The eight filters are operated in a parallel configuration with each filter having the option of running in a dual operation of denitrification/deep bed filtration or solely as a deep bed filter. Each filter has two separate inlet channels with Cutthroat flumes to standardize flow rates. One of the flumes has a methanol feed diffuser for carbon addition prior to filter. For the filter to maintain a proper flow rate in denitrification mode, the gate is closed to the channel without the methanol feed and is open to the channel with the methanol feed. Both gates are opened when the filter is in the high rate filtration only mode. Only one gate is open for low rate filtration mode.

There are eight, deep bed denitrification filters at the facility which serve two purposes:

1. Removal of nitrate-nitrogen
2. Removal of suspended solids

Each filter is layered with specially sized and shaped granular media. The primary layer being composed of high grade silica sand, which promotes a fixed-film growth of the biomass for denitrification. In addition to denitrification the filter also acts as a deep bed sand filter for suspended solids removal. The layering of the filters is composed of 8' sand media on the top with five, 4" additional layers below, which increase in particle size to the bottom which is a coarse gravel. The filter media is supported from the bottom of the filter by a T- Block configuration. It is specially designed to prevent the media from passing through while allowing air and water to be pumped through in the opposite direction during backwash and bump cycles.

The bump cycle is specifically designed to release nitrogen gas that accumulates in the media, which decreases the capillary action of the filter and increases head-loss. The bump is an operation where the filtered effluent is pumped back through the media at a rate of 6 gpm/sq. ft. This shifts the media slightly which releases entrained nitrogen gas bubbles. A bump cycle is initiated by time and occurs once every two hours except during low flows of less than 10 MGD. The time between bump cycles is adjustable.

During normal filter operation, head-loss builds up as solids accumulate in the media from the filtration function and the growth of biomass. To mitigate this, the filter is designed to pump water in the reverse direction as is done in a bump cycle as well as aerate the filter at a rate of 5 CFM/sq. ft. This backwash and aeration stirs up the accumulated solids which rise to the top from the aeration. A motorized valve opens during this process and the waste stream flows by gravity to the mudwell. As the mudwell is filled solids are then pumped to the plant headworks. The backwash cycle can be initiated by four methods:

1. Flow Controlled
2. Level Controlled
3. Time Controlled
4. Manual

The backwash frequency must be carefully selected as too frequent backwashes causes a waste of methanol due to the fact that it is the methanol that reduces the dissolved oxygen after a backwash thus the fewer backwash cycles the less methanol is wasted. If the backwash cycles are not frequent enough, it will have an effect of the volume of water that is filtered and could impact water quality. The backwash water supply is derived from the stored filter effluent in the clearwell.

Contact Tanks

Treated water from the Denitrification Filters flows to the chlorine Contact Tanks where disinfection takes place. Once disinfected, residual chlorine is removed and the water is discharged to the South Platte River.

In 1992, the Littleton/Englewood WWTP converted existing gas disinfection system to an alternative liquid chemical method. The liquid chemical disinfection system consists of low pressure storage tanks, peristaltic pumps, and an oxidation reduction potential (ORP) control system. The process uses a 10 to 12 percent solution of sodium hypochlorite for disinfection and a 34 percent solution of sodium bisulfite for effluent dechlorination.

The chemical and pumping systems are housed in separate buildings. Four 4,500 gallon hypochlorite storage tanks are located within a secondary containment area sized to hold the volume from at least one full storage tank. Two tanks are always kept empty. In the event of a spill, provisions allow the chemical to be recycled from the secondary containment area back into the empty or a partially filled tank or allow wasting to the plant headworks. A peristaltic pump is plumbed from each tank. Pump revolution totalizers indicate when pump hoses should be changed.

The two 6,000 gallon sodium bisulfite tanks are equipped with bottom heaters which maintain tank temperatures at 20 degrees C to prevent crystallization in the metering and distribution equipment. Tanks vent outdoors and overflow piping has water traps to eliminate fumes from entering the storage room. There is also a peristaltic pump provided for each bisulfite tank with revolution totalizers to indicate when pump hoses need changed.

The Strantrol 900 ORP (oxidation reduction potential) system monitors the ORP value of the chlorine contact tank influent. The system adjusts pump speed in response to plant flow changes and variance from the ORP setpoint. The dechlorination ORP monitors the chlorine contact tank effluent and adjusts the bisulfite pumps to maintain the setpoint. Five identical chlorine contact tanks provide adequate detention time for disinfection. Each tank is drained and cleaned four times a year.

An automatic sampler is programmed to collect a sample for every 500,000 gallons of final effluent.
Four plant water pumps pull water from the chlorine contact tanks and supply water for pump seals, the headworks sluice system and irrigation water. The water flows through strainers to remove particles.

Administration

The Administration Building houses offices for plant administration, laboratory services, a central operations control center, training facilities, conference rooms, plant maintenance functions, and locker rooms for plant staff. The location of all of these activities within one building promotes frequent contact between plant personnel and enhances communication, and interdepartmental coordination.

The Service and Support building includes approximately 2,800 square feet of general office space for plant administrative functions. Specific functions served by this facility include a reception area open to the public; general office functions including word processing, file maintenance, and reproduction; drafting equipment and construction drawing record maintenance; plant process analysis and discharge permit compliance; industrial pretreatment program; plant safety program;

cost accounting; budgeting; planning; and administration of service and ongoing construction contracts. The facilities include several personal computers with data and file exchange capability via a local area network.

The plant Operations Control Center (OCC) serves as a central monitoring point for all plant operations. It contains a central control room with wall-mounted graphic display of major process equipment status and alarm annunciators. In addition, two personal computers provide access to a supervisory control and data acquisition (SCADA) system and a display of all current plant alarms. All alarms automatically annunciate and print out on the video display of the second monitor. Alarms can be broadcast throughout the plant or to specific process areas via the plant intercom system.

The SCADA system receives status indication and process variables from five separate local area control centers (ACCs) located in the different process buildings throughout the plant site. Operations staff may access any data or equipment status by calling up a graphic display of the appropriate process system on the video monitor.

The OCC serves as a muster room for operations staff to meet and exchange information between shift changes. In addition to the central control room, the OCC includes offices for the operations superintendent and two shift supervisors. A boot wash room located adjacent to the plant staff entrance to the building provides space to wash and store boots, raincoats, and other field gear. A storage room adjacent to the OCC provides a convenient place to keep sampling devices, manual valve keys, portable instruments, safety equipment, and other operations equipment.

The plant control system is primarily manual. Individual system components may have automatically controlled functions within the component but are started or stopped by the operator. The plant has been divided into five separate areas for control and equipment status monitoring. Power and equipment control and status is provided at these local Area Control Centers (ACC). The ACCs contain Motor Control Centers (MCC), Programmable Logic Controllers (PLC), and annunciators for alarms and other manual controls for equipment within the area it serves. Control of equipment can be performed to various degrees at the ACCs, but the OCC is only a central monitoring point. Operating status of the individual pieces of equipment in a sub-area are transmitted to the ACC and then from the ACC to the OCC. Locations of the various Area Control Centers are listed in Table 5-3.

Each piece of equipment can also be controlled from its actual location using Local Control Panels (LCP). The LCPs may have additional control not available at the ACC. Alarms are always annunciated or indicated by status lights at the LCPs, ACCs and the OCC. In some cases, a general trouble alarm covering a variety of alarm conditions will annunciate at the ACC and OCC locations. Operations staff must then consult the LCP specific to the alarmed equipment to ascertain the specific cause of the general alarm.

The laboratory provides analytical support for a variety of functions including plant self-monitoring for the monthly DMR report; process data for operations control; periodic special studies to assist the CDH, DRCOG, and other regulatory and planning agencies in developing environmental data; monitoring of agricultural sites used for beneficial utilization of plant biosolids (digested sludge). The laboratory is equipped with several standard analytical instruments including gas chromatography, mass spectroscopy, atomic absorption, auto-analyzer for nutrients, automated BOD, and has facilities to support wet chemistry, solids analysis, bacteriology, and bioassay functions.

The 8,600 square foot maintenance center provides equipment and facilities for both routine and emergency repairs of virtually all the equipment at the plant. Maintenance center facilities include office space on the second floor overlooking the shop floor. A three-bay service area with overhead bridge crane provides space for multiple repair operations to proceed simultaneously in an orderly and logical sequence. An automatic storage and retrieval (ASAR) system provides compact and secure storage and control of small parts inventory. A walk-in paint booth accommodates virtually all of the mechanical equipment on the plant site, allowing high quality coatings for corrosion protection to be applied. A welding fabrication area is equipped with local jib crane and articulated fume hoods to facilitate equipment repair and fabrication activities. Service air to drive air-powered tools is provided from a central air compressor system located in the dewatering building adjacent to the maintenance shop.

The maintenance shop has an H-4 occupancy classification which requires segregation from the rest of the Service and Support Building in the event of a fire. All doors and windows between the maintenance area and the rest of the building are therefore equipped with automatic fire doors or louvers which shut when a fusible link in each device is actuated by smoke or heat.

To promote health and hygiene, plant staff are encouraged to wash frequently and shower at the end of each shift. Locker rooms provide two lockers for each person so that clean street clothes and uniforms may be segregated from work boots, and soiled plant uniforms. All lockers are ventilated by forced draft to maintain fresh, dry conditions. All floors in the area are ceramic tile and all exposed walls are glazed masonry block to minimize daily cleaning and maintenance.

Heating and cooling for the Service and Support Facilities is provided by a central hydronic system located in mechanical equipment room 720 on the second floor of the building. Hot water supplied by boilers BLR 9050 and BLR 9051 is circulated by four heating water pumps in a continuous constant rate circulation loop through heating coils inside the four air handling units (AHUs) which supply various portions of the building. The amount of heat transferred to the supply air is controlled by a bypass damper located in front of each heating coil. The intake air stream is split by directing part of the air flow around the heating coil with the bypass damper. The heated fraction of air passing over the coil is then blended with the bypass air to achieve the desired supply air temperature. The constant rate flow of hot water through the heating coil prevents the coil from freezing during extreme cold weather. The cooling system is analogous to the heating system with an evaporative chiller providing cold water to cooling coils in the three AHU units which supply air to the office, laboratory, and locker room areas of the building.

The Service and Support Building is segregated into four discrete air supply zones served by separate air handling units (AHUs). Two AHUs serve office space located in the administration, operations control, and maintenance areas of the building. These units are connected to return air ducts to recirculate air through the system and minimize building heating and cooling energy demand. The other two supply air units provide 100 percent fresh outside air to the laboratory and maintenance shop areas. Chemical and exhaust fumes and other air contaminants generated in these locations make use of the return air undesirable. By means of heating and cooling coils inside the AHUs, supply air temperature to the whole building is maintained at year round set point of approximately 65 degrees F.

In addition to the heating and cooling coils located inside the AHUs, most of rooms in the building are equipped with an additional hot water heating coil located in a reheat box in the supply air duct above the ceiling. Hot water from the boilers is circulated through these reheat boxes at a variable rate controlled by a throttling valve. The control valve adjusts the amount of hot water flowing through the reheat coil to raise the supply air temperature to match the temperature set on a thermostat located in the heated space. The individual room thermostats allow the temperature in each room to be independently adjusted to accommodate the needs of individual occupants.

This area includes a room dedicated to ongoing staff training. It is used to house reference materials, O&M manuals, and audio/visual equipment both to record training sessions and play back prerecorded or commercially produced training video tapes. A combination conference and lunch room provides sufficient space to allow group meetings with virtually all of the plant staff in attendance at the same time. This space is also used for public education purposes during plant tours and similar functions. The conference room may be separated from the lunch room by means of a folding partition wall. A kitchen has also been provided for staff use.

The existing maintenance facilities located in the service and support building provide space for offices, equipment breakdown and assembly areas, paint booth, welding area, tool storage, and small parts storage. In addition to these facilities, warehouse space is needed for large parts, spare equipment subassemblies, chemicals, piping and valves, spare motors, other electrical equipment, and other materials used for routine maintenance of the plant.

These large parts and materials are currently kept in temporary storage in the former cryogenic system compressor building and several other temporary locations throughout the plant. This building has three existing overhead garage doors and sufficient space to house several vehicles and mobile equipment which currently are left outside.