APPENDIX E: EXISTING FACILITIES DESCRIPTIONS AND DESIGN CRITERIA

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APPENDIX E - EXISTING FACILITIES DESCRIPTION AND DESIGN CRITERIA

The Napa Sanitation District (District) was formed in 1945 as a special district under the California Health and Safety Code. The main District facilities originally consisted of the now decommissioned Imola wastewater treatment plant (WWTP), the Soscol Oxidation Ponds and the Soscol Physical/Chemical Plant.

In 1947, the District constructed the Imola WWTP as a two-stage trickling filter facility with both primary and secondary sedimentation to provide wastewater treatment prior to river discharge. Subsequently, the effluent was conveyed to the more recently constructed oxidation pond system off Soscol Ferry Road. It was recommissioned in 1981 as a primary treatment / trickling filter system, which treated a portion of the City of Napa (City) flows prior to discharge to the pond system. The Imola WWTP was decommissioned after the Soscol WWTP was upgraded in 2001.

In the mid 1960s, the District constructed the Soscol Oxidation Ponds to treat untreated wastewater from a portion of the District service area and effluent from the Imola WWTP prior to river discharge. In 1983, the California Regional Water Quality Control Board, San Francisco Bay Region, modified the National Pollutant Discharge Elimination System (NPDES) discharge permit to restrict river discharge to the winter higher flow periods. The ponds then also provided storage during the non-discharge season.

In 1975, the District constructed the Soscol Physical/Chemical Plant to treat District oxidation pond effluent and effluent from the City of American Canyon oxidation ponds. Its main function was to remove algae produced in the oxidation ponds. The original Soscol facilities were modified in two major upgrades in the last 15 years. The first upgrade, Phase 1, was completed in 1994 and included improvements to provide tertiary treatment. The second upgrade, Phase 2, was completed in 2001 and included the addition of secondary treatment including aeration basins and secondary clarifiers. Solids treatment, including an egg-shaped digester and dewatering, were also added.

SECTION 1- TREATMENT FACILITIES OVERVIEW

The existing WWTP has operated in its current configuration since Phase 2 modifications were constructed in 2001. The WWTP has two seasonal operations modes: dry-weather reclamation mode and wet-weather river discharge mode. The original WWTP design accommodated these two operational modes, which are required by the NPDES discharge permit. The discharge permit does not allow discharge to the river during the dry weather from May 1st through October 31st except under emergency conditions. During dry weather, a portion of the influent wastewater is treated for reclamation while the remainder is stored in the oxidation ponds. During wet weather, the permit allows discharge to the river, and the oxidation ponds are gradually emptied in preparation for the next summer. These modes are discussed for the main unit processes outlined below and illustrated in Figures E-1 and E-2.

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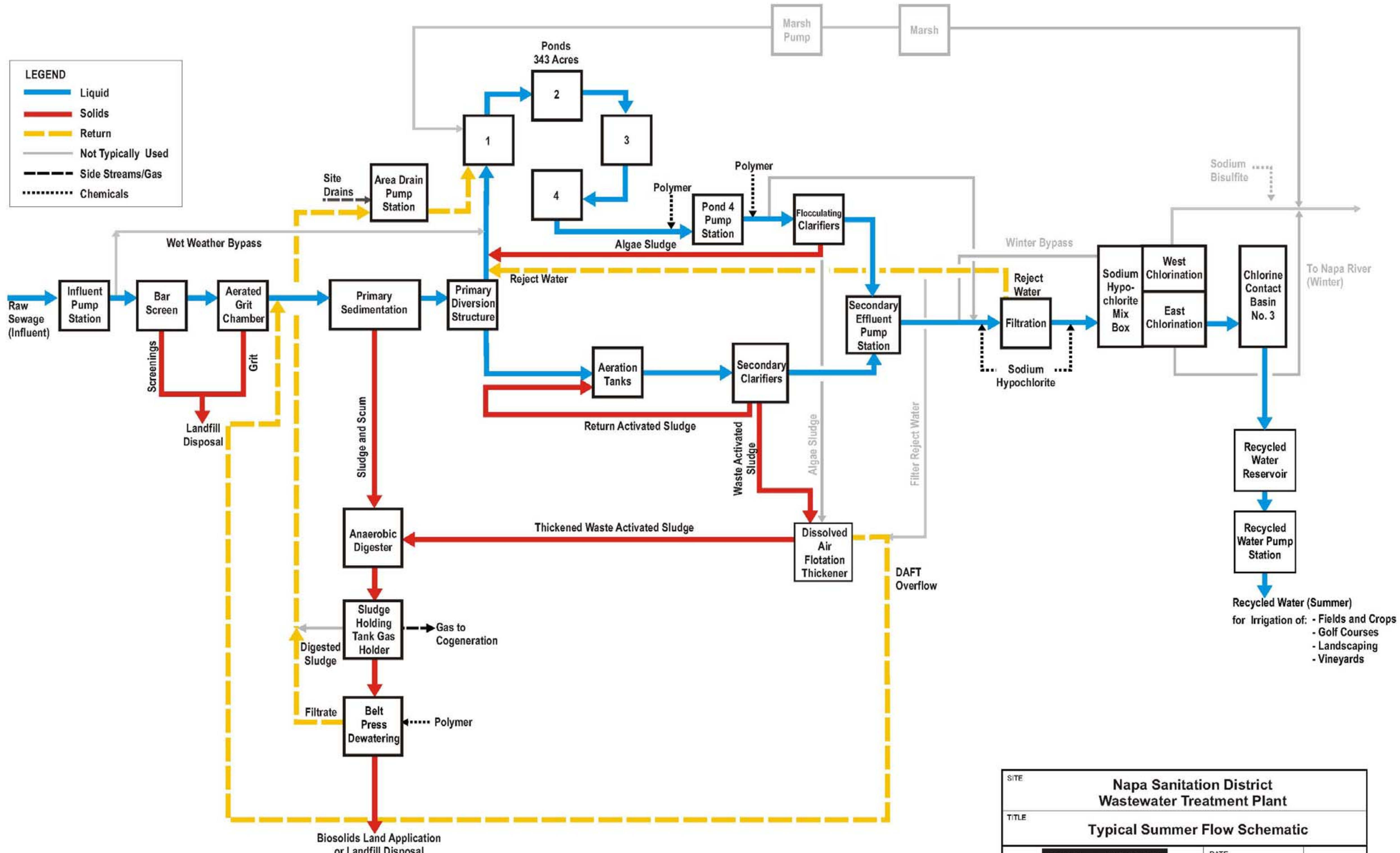

SITE	Napa Sanitation District Wastewater Treatment Plant
TITLE	Typical Summer Flow Schematic
BROWN AND CALDWELL / carollo Engineers...Working Wonders With Water	DATE August 2009; PROJECT 137280-011-113; Figure E-1

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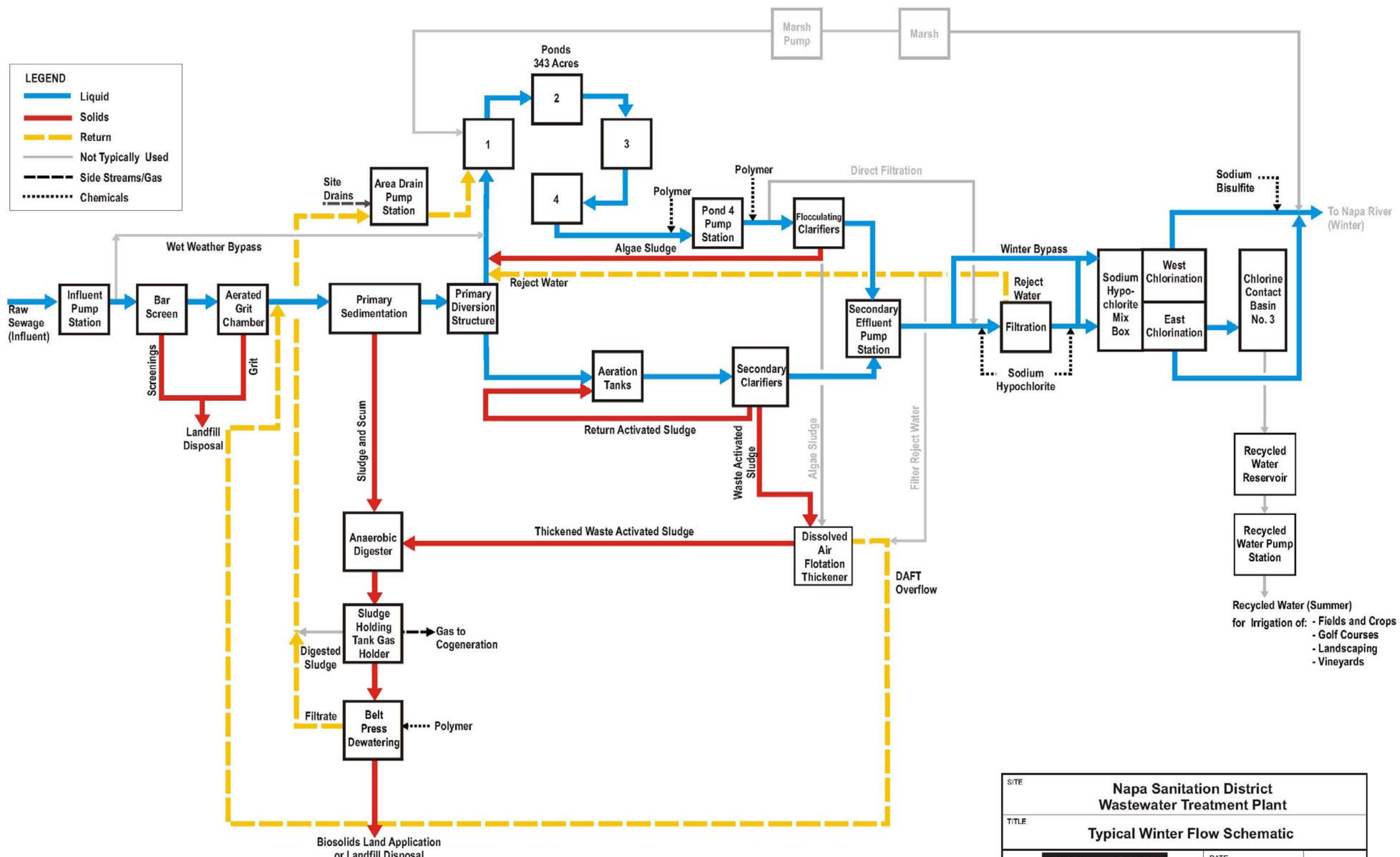

SITE	Napa Sanitation District Wastewater Treatment Plant	
TITLE	Typical Winter Flow Schematic	
BROWN AND CALDWELL / carollo Engineers...Working Wonders With Water	DATE August 2009 / PROJECT 137280-011-113	Figure E-2

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1.1 Liquid Process

The liquid process includes influent pumping, preliminary treatment (headworks), primary treatment, activated sludge treatment and oxidation pond secondary treatment, tertiary treatment and disinfection. Basic design criteria for each area are outlined below. Attachment E-1 summarizes the original design criteria for each unit process.

1.1.1 Influent Pump Station

The influent pump station (IPS) lifts sewage from the District's collection system and discharges to Manhole 9 (MH-9). From MH-9, sewage flows by gravity to the WWTP headworks. Wet weather flows above the hydraulic capacity of the preliminary and primary facilities can be diverted from MH-9 directly to the oxidation ponds with a modulating gate. The IPS consists of three vertical dry-pit pumps with variable speed drives, each with a rated capacity of 14.1 mgd at a design head of 64.5 feet. The pump station was constructed in 1966, and the existing pumps have been in operation since the original construction. During wet weather events, flows into the IPS have exceeded the pumping capacity, which results in surcharge of the collection system and high wet well levels. During wet weather periods with high wet well levels and all pumps in service at maximum capacity, pumped flows of up to 58 mgd have been recorded. Supplemental diesel-driven pumps provide additional pumping capacity.

1.1.2 Preliminary Treatment

Preliminary treatment includes screening and grit removal that remove solid material (i.e., rags, rocks, grit and other debris) from the influent wastewater. Effective preliminary treatment also reduces the accumulation of grit in downstream process tanks such as aeration basins and digesters.

The headworks was constructed during the Phase 2 improvements in 2001. Influent wastewater to the headworks can flow through three channels, two of which have mechanical fine screens. The screens are traveling-filter-type with ¼-inch x 1-inch openings, and each unit is rated for a maximum capacity of 10 mgd. An overflow weir in the headworks can be used to bypass excess influent wastewater through the primary diversion structure to the oxidation ponds. The third channel has a manually cleaned bar rack with 1.5-inch bar spacing. Screenings are washed and compacted before being transported with a belt conveyor to a screenings hopper.

Screened wastewater flows to two aerated grit tanks. Each grit tank has a dedicated recessed impeller grit pump with a rated capacity of 250 gallons per minute (gpm) at 15 pounds per square inch gage (psig) TDH. The grit slurry is washed and dewatered with a decanter and spiral flight grit classifiers before being discharged in the grit hopper. Odors are controlled in the headworks building by a ventilation system that discharges to an exhaust/odor control system.

The headworks includes a septage receiving station with two 1,375-gallon wet wells. The wet wells minimize the impact of shock loads to the biological process by holding the septage and allowing the pumping system to pump it gradually into the process over time. Septage can be pumped to the influent pipe, upstream of the WWTP flow meter, when the WWTP is required to totalize all of the influent flow. Normally, septage is pumped to the influent channel, and septage flow totals are kept and reported separately from normal influent flows. There are two recessed impeller septage pumps, identical to the grit pumps, with a pump capacity of 250 gpm at 15 psig TDH, each. The WWTP receives approximately five to six septage loads per day, on average, based on 2005 to 2008 data.

1.1.3 Primary Clarifiers

Two primary clarifiers remove readily settleable solids and organic material in the influent wastewater. Removing settleable and organic material reduces the loading on the downstream secondary treatment process and the quantity of solids settling in the oxidation ponds.

The existing two primary clarifiers were originally solids contact flocculating clarifiers, but were converted into primary clarifiers during the Phase 2 improvements. The units are 80 feet in diameter (75.3 feet to the inside effluent weirs) with a 14.5-foot side water depth.

The clarifiers have a center feed peripheral withdrawal configuration. In each tank a spiral scraper mechanism directs primary sludge to the sludge hopper at the tank bottom. Progressing cavity (PC) pumps remove sludge from the hoppers. Each clarifier has two dedicated PC pumps, each, with a capacity of 100 gpm at 35 psig.

Scum is collected from the water surface into a sump and is pumped to the anaerobic digesters. There are two PC scum pumps total, one per clarifier. The scum pumps have a capacity of 100 gpm each at 35 psig.

The original design included provisions for ferric chloride addition to primary clarifier influent for sulfide control in the digesters. . District staff has experimented with chemically enhanced primary treatment (CEPT) using ferric chloride, and has used it in the past to reduce organic loading to the secondary process. A dose of more than 25 mg/L is used to enhance primary treatment. The WWTP does not currently practice CEPT but does apply 10 to 12 mg/L of ferric chloride (as ferric chloride) to control sulfides in the digester gas.

The Phase 2 improvements also included aluminum geodesic dome covers for the primary clarifiers. Ventilation fans pull foul air from the enclosed clarifiers via air ducts connected to each covers. The withdrawn air exhausts to the odor control system.

Primary effluent (PE) flow is conveyed by gravity from the primary clarifiers to the primary diversion structure and then flows to the aeration basins. Flow above the secondary treatment flow setpoint overflows into a separate compartment within the primary diversion structure and then flows by gravity to the oxidation ponds.

1.1.4 Aeration Basins

The activated sludge process is used for secondary treatment at the WWTP for a portion of the flow. The oxidation pond secondary treatment system treats flow that bypasses the activated sludge system. The activated sludge facilities consist of two aeration basins, two secondary clarifiers, four return activated sludge (RAS) pumps and two waste activated sludge (WAS) pumps. Aeration basins remove soluble pollutants (soluble BOD_5) and further treat and remove particulate wastes not removed in the primary treatment processes. Nutrient removal is not required. The aeration basin design allows for year-round nitrification and can be expanded in the future for nutrient removal. During the wet season, both aeration basins operate to maximize river discharge capacity. During summer, only one aeration basin operates to minimize energy use and to produce a consistent feed to the tertiary filters. PE flow to the aeration basins is set at the secondary flow control valve and flow meter. The flow is split to the in-service aeration basins at the secondary flow split structure.

The existing aeration basins, constructed during the Phase 2 improvements, include two parallel basins, with six compartments each. The first pass is comprised of the first five compartments, 25 feet x 25 feet each, configured in series; the second pass is comprised of one long compartment, 35 feet x 133 feet; the side water depth is 19 feet, resulting in a total volume of 1.11 million gallons per basin.

Flow to the aeration basins is conveyed through the influent channel to the first compartment. The original design included flexibility to achieve biological nutrient removal by operating the first two compartments under anoxic conditions. The design provided for the ability to operate in step feed and/or mixed liquor recycle (MLR) modes with equipment additions including sluice gates for step feed to additional compartments and a MLR pump to recirculate ML. Originally the aeration basins operated in plug flow mode with every compartment under aeration for BOD_5 removal and nitrification. The current procedure is to operate the first and fifth compartments as anoxic selectors, with a portion of the influent flow diverted to compartment 5 in a step feed mode.

Aeration blower facilities include two recently installed high-speed turbo blowers, each with 300 HP drives, rated at up to 5,800 standard cubic feet per minute (scfm) at 10 psig and up to 4,200 scfm at 14 pounds per square inch gage (psig). One of the original 4,640-scfm multi-stage centrifugal blowers serves as a standby unit. Currently, both turbo blowers are operated when both aeration basins are in service; however, only one turbo blower is operated when one aeration basin is in service. Two dedicated 800 scfm; 25-HP rotary positive displacement channel air blowers provide air to both the aeration basin influent and effluent channels.

All of the aeration basin compartments are equipped with fine bubble diffuser panels, mounted about six inches above the aeration basin floor. The first two compartments also have coarse bubble diffusers for operating with an anoxic selector. The coarse bubble diffusers receive air from the same header as the fine bubble diffusers. The existing panels are the original Parkson membrane aeration panels, installed during the Phase 2 improvements; however, the membrane material was replaced in 2008. The first five compartments are each equipped with a single aeration drop leg and header pipe and ten 4-ft x 9-ft aeration panels. The sixth compartment has five drop legs and header pipes; 14 4-ft x 9-ft aeration panels; and 46 4-ft x 12-ft aeration panels. The drop legs are equipped with manual valves to control air flow rates, a fitting to install a flow measurement device, and a blow off valve to remove moisture from the header. The coarse bubble diffusers for the influent and effluent channels consist of drilled channel air piping.

Three dissolved oxygen (DO) meters are used for DO control on each aeration basin. They are located in compartment No. 3, and at the start and end of compartment No. 6.

1.1.5 Secondary Clarifiers and RAS/WAS Pumping

Two circular secondary clarifiers are provided to remove settleable flocs formed in the aeration basins. The return activated sludge (RAS) pumping system conveys settled sludge back to the aeration basins. To control sludge age in the secondary process, the waste activated sludge (WAS) pumping system conveys excess generated solids to the solids handling facilities. The existing secondary clarifiers and RAS/WAS pumping systems were part of the Phase 2 improvements.

The circular 100-foot-diameter secondary clarifiers (SC) have a sidewater depth of 14 feet and a center pier mounted sludge collector mechanism. Flow from the aeration basins is conveyed to a mixed liquor distribution structure, which splits flow between the secondary clarifiers. The clarifier configuration is a center-feed inlet with inboard effluent launders. A suction header at each clarifier's bottom removes and conveys sludge to the RAS/WAS wet wells.

The RAS pumping system consists of two submersible 20-HP pumps per secondary clarifier with a capacity of 2.2 mgd at 25 feet total dynamic head (TDH), each. The WAS pumping system consists of one submersible 10-HP pump per clarifier with a capacity of 0.28 mgd at 47 feet TDH, each. Variable frequency drives (VFDs) control the operation of both RAS and WAS pumps.

The RAS pipe from each secondary clarifier normally coveys RAS to a single aeration basin (i.e., RAS from Secondary Clarifier No.3 can only be conveyed to Aeration Basin No.4). A recently installed crossover line allows two clarifiers to be operated with a single aeration basin or allows maintenance on a clarifier without having to switch between aeration basins. WAS is conveyed to the DAFT for thickening prior to anaerobic digestion.

1.1.6 Oxidation Ponds

The WWTP facilities include four oxidation ponds that provide both storage and secondary treatment. The ponds range in surface area from 65 acres to 110 acres for a total of 343 acres, and provide more than 2,700 acre-feet of storage if no solids have accumulated in the ponds.

The ponds primarily receive a mixture of raw sewage during wet weather events and primary effluent. In addition, belt filter press (BFP) filtrate, storm water from the area drain pump station, filter backwash (filter reject), and flocculating clarifier sludge all flow from the WWTP to the ponds. All flows enter Pond No. 1 and are routed through the ponds serially. The ponds provide treatment through a combination of sedimentation and biological processes, including bacteria and algae growth.

In the past, the District has provided supplemental aeration using floating aerators in either Pond 1 or 2. The size and number of aerators is not documented in published reports. District staff reports that the existing aerators have reached the end of their useful life and should be replaced if the Master Plan indicates that future operation require supplemental pond aeration.

Currently, during the wet season the ponds are operated to reduce water to minimum levels (about 6 feet in Pond 1 and 2 to 2.5 feet in Ponds 2, 3, and 4 as flow is discharged from ponds through Pond 4 Pump Station to the flocculator clarifiers, and to river discharge. During the dry season, the ponds provide storage for flows in excess of the flow required to meet reclamation demand so that river discharges are avoided during the river discharge prohibition.

The oxidation pond effluent pump station, or Pond 4 Pump Station (formerly the Treatment Plant Influent System), pumps from Pond 4 to the flocculating clarifiers with three 75-HP, vertical suction centrifugal pumps. Each pump was rated for 7.7 mgd at 32 feet TDH and is operated with a 100-HP VFD but the current capacity with installed impellers is about 4 mgd per pump. It is operated at a constant rate based on the amount of flow to be discharged to the flocculating clarifiers. The Pond 4 Pump Station is equipped with three stainless steel removable mesh screens to keep fish and other debris out of the pump station wet well. Effluent from Pond 4 can also be bypassed around the flocculating clarifiers by pumping directly to the Secondary Effluent Pump Station (SEPS).

Pond operation has varied over the years based on the WWTP’s overall treatment objectives. The current strategy is to lower the pond water level throughout the wet season to provide sufficient storage for the dry season.

1.1.7 Flocculating Clarifiers

The flocculating clarifiers (old solids contact clarifiers) are used to remove algae solids and precipitated material from oxidation pond effluent for river discharge and for reclamation. Four 80-foot-diameter flocculating clarifiers, with a 15-foot side water depth, were originally constructed as part of the original WWTP in 1975, but two of the four flocculator clarifiers were converted to primary clarifiers during the Phase 2 improvements.

A high molecular weight polymer is added at the ponds and to the flocculating clarifier influent to aid in algae solids removal. Floating algae sludge is removed with a top skimmer mechanism and pumped back to the oxidation ponds. Bottom algae sludge is collected with a scraper mechanism and sent to the oxidation ponds. Pumps were installed to pump algae sludge to the DAFT but have not been used because of concerns with DAFT capacity and the unknown impact on digester operation.

The clarified water flows over radial effluent weirs and effluent weir launders located at the surface of the flocculator clarifiers. It then gravity flows to the secondary effluent pump station, to be directed to the filters during summer reclamation mode and to both the filters and the CCBs during winter river discharge mode.

1.1.8 Secondary Effluent Pump Station (SEPS)

Constructed as part of the Phase 1 improvements, the SEPS included three 100-HP pumps operating with VFDs. The pumps, each with a capacity of 10 mgd, originally conveyed flocculating clarifier effluent to the continuous backwash filters. The Phase 2 improvements included modifying the SEPS to convey both flocculating clarifier effluent and secondary clarifier effluent to either the filtration or disinfection processes.

Currently when required, the WWTP staff operates a portable diesel pump to transport secondary effluent to the ponds or marsh to more closely match secondary effluent production with filtration feed.

1.1.9 Continuous Backwash Filters

The continuous backwash filters are used to generate tertiary quality water for reclamation or sometimes to remove algae to meet secondary treatment requirements for river discharge. The filters were constructed during the Phase 1 improvements. The filtration system has a total surface area of 2,000 square feet (sf) and consists of four parallel filter cells, each with 10, 50-sf. modules.

Polymers (coagulants and/or flocculants are injected into filter influent at various locations upstream of the filters. Filter influent then passes through a manual bar screen prior to three-stage flocculation. Excess flow beyond the filters' capacity and filter to waste (FTW) flow over an overflow weir upstream of the manual bar screen and is conveyed through the primary diversion structure to the oxidation ponds. Each flocculation stage has a volume of 12,150 gallons and is equipped with one vertical-entry flocculator operating with a VFD. The flocculated filter influent flows from the flocculation chambers to the filter system.

Continuous backwash filters use a moving sand column as the filter medium. Influent enters the filter bottom, and the solids are removed as the water travels through the bed of sand. The sand laden with solids is pulled from the filter bed bottom through an airlift tube. A sand washer at the top of the unit uses a continuous stream of backwash, or filter reject, water to cleanse the media. The cleaned sand is deposited at the top of the bed and the filtered water and backwash water leave the filter cell through separate channels. The filter reject water flows through the primary diversion structure to the oxidation ponds in the same manner as the FTW flow.

The original design was to filter only pond effluent, either oxidation pond effluent directly from the Pond 4 Pump Station, or flocculating clarifier effluent, during the reclamation season. Since their construction, the filters have been operated primarily with a blend of activated sludge and pond or flocculating clarifier effluent.

The filter support facilities include polymer feed and storage and filter air supply.

1.1.10 Secondary and Tertiary Disinfection

Disinfection is provided using sodium hypochlorite injected at the beginning of the chlorine contact basins. The East and West Chlorine Contact Basins (CCB) were constructed during the 1975 project and have a volume of 320,000 gallons, each. The third basin, CCB No. 3, was constructed as part of the Phase 1 improvements and has a volume of 460,000 gallons. The first two basins, currently called the East and West CCBs, are identical and can be operated in parallel during wet season river discharge. The third basin was constructed during the Phase 1 improvements by converting the original dual-media filtration cells to CCB No. 3.

During winter river discharge mode, sodium hypochlorite is injected into secondary effluent (SE) pumped from the activated sludge system and oxidation ponds or flocculating clarifiers. The flow from the SEPS can be routed to the East and/or West CCBs using piping on the "H" pad south of the mix box.

CCB No. 3 is currently operated in series with the East CCB during the dry season to achieve a longer contact time sufficient for meeting Title 22 requirements for recycled water. Normally, flow is sent to the East CCB because the rapid mix system, used to improve mixing and disinfection, was only installed on the east side of the rapid mix box. The secondary effluent flow for river discharge is dechlorinated using sodium bisulfite (SB) at the East CCB exit.

1.1.11 Recycled Water Storage and Pumping

During dry season operations, tertiary-disinfected effluent is conveyed through a 36-inch-diameter pipe from CCB No. 3 to the recycled water storage reservoirs and is delivered via the recycled water pump station to various reclamation sites. Reclamation sites include the Somky Ranch, the Jameson Canyon Reclamation site, Kohnan Sake Factory, Chardonnay Golf Club, Kennedy Park, Napa College, and the Napa Corporate Park.

The recycled water storage and pumping system includes two recycled water reservoirs that provide approximately 6.5 MG/20 acre-feet of storage and three 600-HP (two duty and one standby) recycled water distribution system pumps. Each pump has a capacity of 5,700 gpm at 148 psig, operated with a VFD. Floating covers were added to the storage reservoirs to eliminate recycled water quality issues, including algae growth.

1.1.12 River Outfall

During winter operations, disinfected effluent from the East and/or West CCBs is conveyed through approximately 700 feet of 36-inch-diameter pipe to a diffuser structure located on the riverbank of the Napa River. The diffuser consists of three 24-inch-diameter pipes approximately 150 feet long extending from the riverbank out into the river. This outfall was installed in 1975 as part of the original WWTP construction.

1.2 Solids Handling and Treatment

The solids process includes a DAFT, one anaerobic digester, sludge storage tank/gas holder, and the BFP dewatering units.

1.2.1 Dissolved Air Flotation Thickener (DAFT)

The sludge thickening process at the WWTP consists of a single DAFT. The DAFT thickens WAS before its transfer to the anaerobic digester. The original design also included provisions to feed waste algae sludge from the flocculator clarifiers and filter reject water from the filter backwash. The WWTP currently does not send waste algae sludge or filter reject water to the DAFT. Polymer may be added to the DAFT to enhance thickening, but current operation does not include polymer use.

The 34-foot-diameter DAFT, with an 11.25-foot side water depth, was constructed by converting an existing gravity thickener to the present configuration. During thickening, the WAS solids are concentrated from 0.3 to 1 percent total solids (TS), to approximately 3.5 percent TS. The DAFT equipment dissolves air into a recycled flow stream under pressure. The influent feed is mixed with the recycle stream where the air bubbles attach to suspended solid particles and float to the surface of the tank for collection by a skimmer mechanism. Solids not captured by the rising air bubbles can settle to the DAFT’s bottom and be removed through a bottom sludge withdrawal. A portion of the DAFT underflow (liquid) is recycled to the thickener for air saturation, and the remainder is pumped with primary influent to the primary clarifiers.

Mechanical equipment associated with the DAFT operation includes: two centrifugal recycle pumps rated at 300 gpm and 500 gpm, respectively; two, 1,200-gpm centrifugal underflow pumps; two progressing cavity thickened waste activated sludge (TWAS) pumps, each with a rated capacity of 200 gpm at 60 psig; two air compressors each with a rated capacity of 50 scfm at 100 psig; one 3-gpm progressing cavity polymer feed pump; and a pressurization tank. This equipment is located in the solids handling building basement.

1.2.2 Anaerobic Digester

Primary sludge and scum, and TWAS, are stabilized in the anaerobic digestion process. The various feed streams are combined at the digester complex and introduced to the digester through one of 13 different feed configurations that provide flexibility to feed to the bottom, middle or top of the digester.

The process includes a single, 1.34-million-gallon steel vessel egg-shaped digester (ESD) that is mixed using a draft-tube-type mixer. The mixer provides an overall turnover time of approximately four hours. The draft tube mixer can be operated in a forward (upflow) or reverse (down flow) mode. The upflow mode circulates sludge and accumulated grit from the bottom of the tank to the top. The down flow mode circulates the sludge from the top and helps to break up any scum layers that form on the tank surface. The mixer is controlled to alternate the mixer direction daily.

Sludge is heated with two concentric tube heat exchangers to maintain digester temperature in a mesophilic range of 95 to 98 degrees F. Reject heat from the cogeneration system is the primary source of heat. A single-fuel boiler with a capacity of 2.34 million British thermal units (MBtu) per hour using natural gas is also available as a backup heat source. Two screw centrifugal heated sludge recirculation pumps, each with a rated capacity of 400 gpm at 12 psig, are available for pumping sludge from the bottom, middle or top of the digester through the heat exchangers. An identical screw centrifugal sludge recirculation pump is available for mixing the Digested Sludge Day Tank. The hot water system also includes two hot water supply pumps, each with a rated capacity of 300 gpm at 38 feet TDH.

The digested sludge flows by gravity to the sludge storage tank. In an emergency, digested sludge can also be sent to Pond 1.

1.2.3 Digested Sludge Day Tank/Gasholder

The original design included a second ESD deleted prior to construction. During the Phase 2 improvements, the District decided to build the lower half of a future anaerobic digester and use it for gas storage and sludge storage for dewatering. The half-egg digester has a sludge storage volume of 600,000 gallons and a flexible dual membrane digester cover with 62,500 cubic feet of gas-holding capacity. The cover installed during Phase 2 was replaced in 2008 because of a failure in the fabric cover during a severe storm event.

The gasholder is equipped with two blowers with a rated capacity of 350 cfm at 22 inches of water column. The gas holding cover system requires one blower in operation to control system gas pressure and keep the air membrane completely inflated. The sludge in the half-egg is mixed with one screw centrifugal pump with a rated capacity of 1,500 gpm at 12 psig.

1.2.4 Belt Filter Press Dewatering (BFP)

The belt filter presses (BFP) dewatering process reduces the digested sludge moisture content prior to disposal. Dewatered sludge reduces hauling costs, simplifies handling and transport, and reduces odors and pathogens.

Three (two duty and one standby units) 2-meter BFP dewatering units are used to dewater digested sludge. They are designed to dewater anaerobically digested sludge, increasing its solids content from approximately 3 percent TS to 16 to 20 percent TS. Three progressing cavity BFP feed pumps each with a rated capacity of 200 gpm at 35 psig deliver digested sludge to the BFPs. Polymer is mixed with the digested sludge feed upstream of the BFP to promote flocculation so that the solids release water and concentrate in cake form. The polymer system consists of two, 3 to 20 gallons per hour (gph), polymer blending units and three progressing cavity polymer feed pumps each with a rated capacity of 8 gpm at 30 psig. Dewatered sludge is conveyed to a sludge hopper that can store approximately two hours of cake production.

The dewatered sludge can go to land disposal for reuse or disposal to a sanitary landfill. Currently, the sludge from the cake hopper is discharged to a District-owned dump truck that transports the dewatered cake to on-site storage for land application on District ranch lands. The dewatered cake meets Class B biosolids criteria. On-site storage is provided using “ag”-bags, which provide some composting/stabilization benefits. BFP filtrate is returned to the ponds.

1.2.5 Cogeneration Facility

The cogeneration engine provides supplementary electricity to the WWTP by burning either digester or natural gas. Digester gas from the half-egg digester gas cover is compressed to 30 to 45 psig and cooled prior to use in power generation. The waste heat from the engine generator is used as the primary heat source for the anaerobic digester.

The cogeneration engine is a turbocharged, intercooled; lean-burn type designed for low fuel consumption and reduced exhaust emissions.

The digester gas compressor is a single-stage, two-cylinder, water-cooled type. The compressor package consists of an inlet gas filter, aftercooler, oil and moisture separator, and other accessories. The inlet gas filter removes moisture, dirt, scales, and other extraneous matter from the digester gas, and the after cooler and oil/moisture separator reduces the temperature and moisture content of the compressed gas. The aftercooler is capable of cooling 160 cfm of digester gas to within 15 degrees F of the cooling water temperature.

1.3 Other Support Facilities

Other support facilities include odor control, service and potable water systems, chemical feed systems, standby power and electrical distribution, and instrumentation and control systems.

1.3.1 Odor Control

Foul air from the headworks building and primary clarifiers is collected by air ducts and treated at a mist-type odor control scrubber system, consisting of an exhaust tower with high-pressure water sprayers and odor chemical treatment. Foul air is introduced to the bottom of the exhaust tower while water, pre-treated with odor control chemical, is sprayed downwards from the top of the exhaust tower. The District adds a proprietary chemical to assist in odor reduction. The system was constructed during the Phase 2 improvements and is sized for 5,300 cfm from the headworks building and 7,200 cfm from each primary clarifier.

1.3.2 Service Water and Potable Water System

The WWTP water system consists of potable water (1W), secondary-treated water (2W), and tertiary-treated water (3W). The City of Napa supplies potable water (1W) through backflow prevention devices. One potable water tap supplies water fixtures in the administration building and other various locations throughout the WWTP and support facilities building, such as emergency eyewash and shower fixtures in chemical feed areas. Another potable water tap is used as emergency reclaimed water supply, water supply for the 2W system, and fire water for the WWTP.

Plant 3W consists of disinfected secondary effluent during the wet season (river discharge mode) and tertiary effluent meeting Title 22 standards during the dry season. Service water pumps deliver 3W for washdown water at hose bibs and process sprays.

Plant 2W is City of Napa water supplied through another backflow preventer and is separate from the potable water system. However, the 2W system can be valved to deliver 3W. Plant 2W is primarily used for dilution water for the polymer feed systems and seal water for various pumps.

1.3.3 Compressed Air System

The compressed air system provides air for the diffusers located in the south half of the Primary Diversion Structure, the diffusers located in the filter flocculation chamber effluent channels, the laboratory, and the service area in the garage. The system is comprised of two 10-HP compressors rated for 40 scfm each at 100 psig, an 80-gallon air tank, and one refrigeration type moisture separator.

1.3.4 Chemical Feed Systems (Polymer, SH, SB)

Polymers (coagulants and/or flocculants) are injected into the feed of the flocculating clarifiers, BFP units, and continuous backwash filters. The WWTP was designed with polymer feed and storage systems for two different polymers (one for a coagulant and the other for a flocculant). One of the polymer feed systems consists of three 120-gph metering pumps with an available storage volume of 20,500 gallons. The other polymer feed system consists of two sets of metering pumps and chemical storage for delivering the same chemical to different locations: one set of two 24-gph metering pumps with a storage capacity of 4,000 gallons and a second set of two 24-gph metering pumps with a storage capacity of 375 gallons. The District has added an additional storage and feed system for filter feed treatment using a polyaluminum-chloride (PAC)-type coagulant.

Sodium Hypochlorite (SH) is used to disinfect effluent and can be added to the raw sewage, to filter influent, and to the discharge side of the recycled water pumps. There are four 45-gph SH feed pumps and two 16,400-gallon fiberglass SH storage tanks.

Sodium Bisulfite (SB) is used for dechlorination prior to river discharge. SB is pumped using two 24-gph variable-speed positive-displacement diaphragm pumps from one 9,200-gallon SB storage tank.

1.3.5 Electrical Distribution and Standby Power

Electrical power enters the WWTP through a metered 12 kilovolt (kV) distribution system. The main 12 (kV) overhead line passes through the main circuit breaker, and then distributes power to the following five locations that all have 480-V step-down transformers:

- Motor Control Center (MCC)-11 Influent Pump Station
- Recycled Water Pump Station
- Substation A, which supplies power to the aeration basin blowers, and MCC-7, which supplies power to other equipment for the aeration basin and secondary clarifier processes
- MCC-4 - Pond 4 Pump Station
- Switchboard SB-1, which distributes power to the remainder of the WWTP

The main bus in SB-1 receives power from the cogeneration system and two portable standby generators and distributes power to seven MCCs (MCC 1-A, 1-B, 2-A, 2-B, 5, 8, and 10) that power the remainder of the WWTP.

The standby, or emergency, power system is comprised of two diesel engine generator sets and one 3,200-gallon diesel fuel storage and feed system. The diesel engines each are rated at 1,200 HP. The standby generators are rated at 800 kW each. The combination of cogeneration system output and standby power can support all WWTP operations except for recycled water pumping.

1.3.6 Instrumentation and Controls (I&C)

The WWTP has a supervisory control and data acquisition (SCADA) system with operator-interface stations (OIS) and a distributed programmable logic controller (PLC) network system. The SCADA system provides connectivity to the Internet and is served by the Plant server. There are five OIS in the main operations building that provide access to the Plant server, several operator interfaces, PLC programming and network server computers, and software development computer. Other OIS are located near PLC’s throughout the WWTP. The PLC network was built using the Siemens S-5 but was later upgraded to S-7. There are eight PLCs distributed throughout the WWTP that control various process areas and route data through the SCADA system. Two main back-up PLCs located in the main operations building receive data from each individual PLC, in addition to receiving valve control information from the PAKSCAN control system and remote signals from the RUGID telemetry.

The SCADA and process control system is currently being upgraded as part of the SCADA Master Plan project. The project includes modifying the existing SCADA system.

REFERENCES

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ATTACHMENT E-1

Attachment E-1 Design Criteria

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Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Influent Pump Station	
Number of pumps	3 [1]
Pump Type	vertical dry pit [1]
Capacity, each, mgd	14.1 [1, 4]
Head, ft	64.5 [1]
Motor size, hp	200 [1]
Drive type	VFD [1]
Preliminary Treatment: Screening	
Type	traveling filter screen [1]
Number	2 [1]
Width, ft	3.5 [1]
Depth, ft	5.25 [1]
Total screening flow capacity, mgd	20 [1]
Bar spacing, in	0.25 [1]
Bar screen motor size, hp	1 [1]
Screenings compactors	
Number	2 [1]
Type	screw [1]
Drive	fixed speed [1]
Motor size, hp	2 [1]
Preliminary Treatment: Grit removal	
Type	aerated [1]
Number of chambers	2 [1]
Length, ft	20 [1]
Width, ft	11.75 [1]
Depth, ft	11.33 [1]
Total grit removal flow capacity, mgd	20 [1]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Preliminary Treatment: Grit removal (continued)	
Grit pumping	
Type	recessed impeller [9]
Number	2 [9]
Capacity, gpm	300 [9]
TDH, psi	12 [9]
Drive	fixed speed [1]
Motor size, hp	10 [1]
Air supply	
Type	rotary lobe blower [9]
Number	2 [9]
Capacity, scfm	320 [9]
Drive	fixed speed [1]
Motor size, hp	20 [1]
Grit classifier	
Type	spiral [1]
Number	1 [1]
Capacity, gpm	420 [1]
Drive	fixed speed [1]
Motor size, hp	0.5 [1]
Grit washer/classifier	
Type	spiral [1]
Number	1 [1]
Capacity, gpm	200 [1]
Drive	fixed speed [1]
Washer motor size, hp	0.75 [1]
Classifier motor size, hp	0.5 [1]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Primary Treatment	
Type	circular clarifier [1]
Number	2 [1]
Diameter, ft	80 [1]
Side water depth, ft	14.5 [1]
Total surface area, square ft	10,050 [1]
Weir length, total, ft	475 [1]
Primary sludge pumping	
Type	progressing cavity [1]
Number	2 [1]
Capacity, each, gpm	100 [1]
Discharge pressure, psi	35 [1]
Drive	fixed-speed [9]
Motor size, hp	10 [9]
Primary scum pumping	
Type	progressing cavity [1]
Number	1 [1]
Capacity, each, gpm	100 [1]
Discharge pressure, psi	35 [1]
Drive	fixed speed [9]
Motor size, hp	10 [9]
Odor Scrubber System	
Type	wet scrubber tower [9]
Number	1 [9]
Scrubber recirculation pumps	
Number	2 [7]
Drive	fixed-speed [7]
Motor size, hp	7.5 [7]
Headworks exhaust fan (to scrubber)	
Number	1 [1]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Capacity, scfm	15,000 [1]
Odor Scrubber System (continued)	
Primary clarifiers exhaust fans (no scrubber)	
Number	2 [1]
Capacity, scfm	7,000 [1]
Oxidation Pond Treatment	
Pond area, acres	
Pond 1	111 [5]
Pond 2	91 [5]
Pond 3	75 [5]
Pond 4	65 [5]
Maximum depth, ft	8 [4]
Pond volume at maximum depth, MG	
Pond 1	289 [6]
Pond 2	237 [6]
Pond 3	196 [6]
Pond 4	169 [6]
Total, MG	891 [6]
Pond 4 Pump Station	
Number of pumps	3 [3]
Pump type	vertical centrifugal
Capacity, each, mgd	6.25 [3]
TDH, ft	32 [9]
Drive	VFD [3]
Motor size, hp	100 [3]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Flocculating Clarifiers	
Type	circular [1]
Number	2 [1]
Diameter, ft	80 [1]
Side water depth, ft	14.5 [1]
Total surface area, square ft	10,050 [1]
Weir length, total, ft	975 [1]
Algae sludge pumping	
Type	progressing cavity [1]
Number	2 [1]
Capacity, each, gpm	100 [1]
Discharge pressure, psi	35 [1]
Drive	fixed-speed [9]
Motor size, hp	10 [9]
Scum pumping	
Type	progressing cavity [1]
Number	1 [1]
Capacity, each, gpm	100 [1]
Discharge pressure, psi	35 [1]
Drive	fixed-speed [9]
Motor size, hp	10 [9]
Activated Sludge Secondary Treatment	
Design flow, each, mgd	4.3 [1]
Aeration Basins	
Number	2 [1]
Side water depth, ft	19 [1]
Compartments per basin	6 [1]
Compartments 1 through 5	
Length, ft	25 [1]
Width, ft	25 [1]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Volume, each compartment, MG	0.09 [6]
Activated Sludge Secondary Treatment (continued)	
Compartment 6	
Length, ft	133 [1]
Width, ft	35 [1]
Volume, MG	0.66 [6]
Total Aeration Volume (Both Basins), MG	2.22 [6]
Aeration Diffusers	
Diffuser type	aeration panel [1]
Diffuser submergence, ft	18.5 [1]
Total Diffuser Surface Area, each basin, sq ft	4,500
Active Diffuser Surface Area, each basin, sq ft	3,800
Allowable Diffuser Loading, scfm/sq ft active area	0.3-1.25
Aeration Basin Blowers	
Type	high speed turbine [10]
Number	2 [10]
Capacity, each, scfm (Condition 1)	2,300-5,800 [10]
Discharge pressure, psig (Condition 1)	10 [10]
Capacity, each, scfm (Condition 2)	2,600-5,000 [10]
Discharge pressure, psig (Condition 2)	12 [10]
Capacity, each, scfm (Condition 3)	3,000-4,200 [10]
Discharge pressure, psig (Condition 3)	14 [10]
Motor size, hp	300 [10]
Type	multi-stage centrifugal [10]
Number	1 standby [10]
Capacity, each, scfm	4,640 [10]
Discharge pressure, psig	9.7 [11]
Motor size, hp	350 [10]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Activated Sludge Secondary Treatment (continued)	
Type (Channel Air Blowers)	rotary positive displacement
Number	2 [10]
Capacity, each, scfm	800 [10]
Capacity, each, cfm (under site conditions)	854 [10]
Discharge pressure, psig (under site conditions)	4.25 [10]
Motor size, hp	25 [10]
Secondary Clarifiers	
Number	2 [1]
Diameter, ft	100 [1]
Side water depth, ft	14 [1]
Total surface area, each, sq ft	7,850 [1]
RAS Pumping System	
Typical flows, % of influent	50-133 [1]
Type	submersible [1]
Number of Pumps	4 [1]
Capacity, each, mgd	2.2 [1]
Discharge pressure, ft	25 [1]
Drive	VFD [1]
Motor size, hp	20 [1]
Secondary Effluent Pump Station	
Number of pumps	3 [7]
Type	vertical turbine [7]
Capacity, each, mgd	10 [7]
TDH, each, ft	32,41 [7,8]
Drive	VFD [7]
Motor size, hp	100 [7]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Filtration	
Flocculation	
Number of stages	3 [7]
Length, each, ft	8.5 [7]
Width, each, ft	8.5 [7]
Depth, each, ft	22.5 [7]
Total volume, gal	36,450 [7]
Filter type	continuous backwash [7]
Number of filter cells	4 [7]
Modules per cell	10 [7]
Size of module, sq ft	50 [7]
Total surface area, sq ft	2,000 [7]
Filter compressed air system	
Air compressor motors	
Number	2 [9]
Capacity, each, scfm	243 [9]
Design pressure, psi	125 [9]
Motor size, hp	60 [9]
Moisture separator	
Type	refrigeration [9]
Number	1 [9]
Chlorine Contact Basins	
Basins 1 and 2 volume, each, gal	320,000 [7]
Basin 3 volume, gallons	460,000 [7]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Sodium Hypochlorite Disinfection System	
Pumps	
Type	diaphragm [7]
Number, large pumps	2 [7]
Capacity, large pumps, gph	200 [7]
Number, small pumps	4 [7]
Capacity, small pumps, gph	50 [7]
Drive	DC/Magnetic [7]
Storage tanks	
Number	2 [7]
Capacity, each, gal	16,400 [7]
Diameter, ft	12 [7]
Number of residual analyzers	2 [7]
Mixers	
Type	vertical entry turbine [7]
Number	1 [7]
Motor size, hp	15 [7]
Sodium Bisulfite - Dechlorination System	
Pumps	
Type	diaphragm [7]
Number	2 [7]
Capacity, gph	0.5-45 [7]
Drive	DC/Magnetic [7]
Storage tanks	
Number	1 [7]
Capacity, gal	9,200 [7]
Diameter, ft	12 [7]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Recycled Water System	
Recycled water storage reservoirs	
Number	2 [7]
Shape	semi-circular [7]
Size, ac-ft	20 [7]
Max water depth, ft	12 [7]
Pump station	
Pump type	vertical turbine [7]
Number	2 [7]
Capacity, each, gpm	5,709 [7]
TDH, ft	342 [7]
Drive	VFD [7]
Motor size, hp	600 [7]
Hydropneumatic tank	
Number	1 [7]
Volume, gal	1,900 [7]
Design pressure, psi	110 [7]
Motor size, hp	200 [7]
WAS Thickening	
Type	dissolved air flotation [1]
Number	1 [1]
Diameter, ft	34 [1]
Surface area, sq ft	900 [1]
Recycle pumps	
Type	centrifugal [1]
Number	2 [1]
Capacity, each, gpm	300/500 [1]
Pressure, psig	75 [1]
Drive	fixed-speed [1]
Motor size, hp	50 [1]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
WAS Thickening (continued)	
Overflow (liquid) pumps	
Type	centrifugal [1]
Number	2 [1]
Capacity, each, gpm	1200 [1]
Drive	VFD [1]
Motor size, hp	30 [1]
WAS Pumping System	
Typical flows per train, mgd	
Normal	0.12 [1]
Maximum	0.3 [1]
Type	submersible [1]
Number of Pumps	2 [1]
Capacity, each, mgd	0.28 [1]
Discharge pressure, ft	47 [1]
Drive	VFD [1]
Motor size, hp	10 [1]
TWAS pumps	
Type	progressing cavity [1]
Number	1 + 1 standby [1]
Capacity, each, gpm	200 [1]
Pressure, psig	60 [1]
Drive	fixed-speed [1]
Motor size, hp	20 [1]
Compressors	
Number	2 [1]
Capacity, scfm	50 [1]
Pressure, psig	100 [1]
Drive	fixed-speed [1]
Motor size, hp	15 [1]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
WAS Thickening (continued)	
DAFT polymer system	
No. of polymer blending units	1 [1]
Capacity, gph	4 to 20 [1]
Polymer feed pumps	
Type	progressing cavity [1]
Number	1 [1]
Capacity, gpm	3 [1]
Pressure, psig	90 [1]
Drive	VFD [1]
Motor size, hp	2 [1]
Anaerobic Digestion	
Type	egg shaped [1]
Number	1 [1]
Volume, each, gal	1,363,000 [1]
Hydraulic retention time, days	
Annual average flow	24.0 [1]
Digester mixing pumps	
Type	draft tube [1]
Number	1 [1]
Turnover time, hr	3.8 [1]
Capacity, each, gpm	6,000 [1]
Drive	fixed-speed [1]
Motor size, hp	20 [1]
Speed, rpm	720 [9]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Anaerobic Digestion (continued)	
Digester heating system	
Exchanger type	tube-in-tube [1]
Number	2 [1]
Net heat requirements, BTU/day	3.4 million [9]
Circulator pumps	
Number	2 [9]
Capacity, each, gpm	250 [9]
TDH, psi	22 [9]
Drive	fixed-speed [1]
Motor size, hp	5 [9]
Digester sludge circulation pump	
Type	screw centrifugal [1]
Number	3 [1]
Capacity, gpm	400 [1]
Pressure, psig	12 [1]
Drive	fixed-speed [1]
Motor size, hp	7.5 [1]
Hot water supply pumps	
Number	2 [9]
Capacity, each, gpm	300 [9]
TDH, ft	38 [9]
Drive	fixed-speed [1]
Motor size, hp	5 [1]
Auxiliary hot water supply pump	
Number	1 [1]
Drive	fixed-speed [1]
Motor size, hp	15 [1]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Anaerobic Digestion (continued)	
Boiler	
Capacity, MBTU/hr	2.34 [12]
Supply Boiler, hp	100 [9]
Circulation pump	
Number	1 [9]
Capacity, gpm	100 [9]
TDH, psi	4 [9]
Motor size, hp	5 [9]
Gasholder	
Type	flexible dual membrane [1]
Number	1 [1]
Capacity, cu ft	62,500 [1]
Air blowers for gas holder	
Number	2 [1]
Capacity, cfm	600 [1]
Maximum Pressure, inch W.C.	13.5 [1]
Drive	fixed-speed [1]
Motor size, hp	3 [1]
Sludge Storage Tank	
Type	half egg-shaped digester [1]
Number	1 [1]
Capacity, gallons	600,000 [1]
Mixing pump	
Type	screw centrifugal [1]
Number	1 [1]
Capacity, gpm	1,500 [1]
Pressure, psig	12 [1]
Drive	fixed-speed [1]
Motor size, hp	15 [1]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Sludge Dewatering	
Type	belt filter press [1]
Number	2 + 1 standby [1]
Belt size, m	2 [1]
Cake solids, percent	16 - 20 [1]
Percent capture, percent	90 [1]
BFP feed pumps	
Type	progressing cavity [1]
Number	3 [1]
Capacity, gpm	200 [1]
Pressure, psi	35 [1]
Drive	VFD [1]
Motor size, hp	20 [1]
Number of polymer blending units	1 [1]
Capacity, each, gph	3 to 20 [1]
Polymer feed pumps	
Type	progressing cavity [1]
Number	3 [1]
Capacity, gpm	3 [1]
Pressure, psi	90 [1]
Drive	VFD [1]
Motor size, hp	2 [1]
Sludge Storage Hopper	
Number	1 [1]
Capacity, cy	25 [1]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Cogeneration System	
Engine	
Number	1 [1]
Operating speed, rpm	1,200 [1]
Approximate output, HP	605 [1]
Cylinder configuration	straight 6 [1]
Piston displacement, ci	2,900 [1]
Aspiration	turbocharged intercooled [1]
Fuel mixture control	lean burn system [1]
Generator	
Number	1 [1]
Operating speed, rpm	1,200 [1]
Maximum rated output, kW	550 [1]
Approximate electrical output phase 2A, kW	415 [1]
Type	synchronous [1]
Volts/Phase/Hz	480/3/60 [1]
Standby Generators	
Number	2 [13]
Output, kW	800 [13]
Volts/Phase/Hz	480/3/60 [1]
Plant Water System	
Pumps	
Number	2 [7]
Capacity, each, gpm	1,900 [7]
Design pressure, psi	110 [7]
Motor size, hp	200 [7]

Attachment E-1 - Existing Facilities Design Criteria	
Parameter	**Design Value**
Plant Compressed Air System	
Air compressors	
Number	2 [9]
Capacity, each, scfm	40 [9]
Pressure, psi	100 [9]
Motor size, hp	10 [9]
Air tank size, gal	80 [9]
Moisture separator	
Type	refrigeration [9]
Number	1 [9]

Sources of Design Values:

[1]*Phase II drawings and specifications (Carollo 1998)*

[2]*Preliminary design report (Carollo 1992)*

[3]*1997 O&M manual (NSD 1997)*

[4]*With all 3 pumps in service, influent pump station pumped flows to 60 mgd during wet weather periods with higher than normal wet well levels*

[5]*1967 O&M manual (Oswald, 1967)*

[6]*Calculated*

[7]*Phase I drawings and specifications (Carollo 1994)*

[8]*1997 O&M manual shows both 41 ft TDH at 10 mgd and 32 ft at 10 mgd*

[9]*2002 Draft O&M manual (Carollo 2002)*

[10]*2008 Aeration blower replacement project drawings and submittals (Herwit Engineering 2008)*

[11]*2008 TM 2 Aeration panel evaluation long-term recommendations (Carollo 2008)*

[12]*1988 Sewer system evaluation survey - phase II and sewer system master plan (Carollo 1988)*

[13]*2002 Standby generator replacement/upgrade (Carollo 2002)*

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