# DRAFT PRE-DESIGN OF THE SRWA WATER TREATMENT PLANT

***Prepared for: Stanislaus Regional Water Authority***
**July 2018**

SRWA STANISLAUS REGIONAL WATER AUTHORITY

Trussell TECHNOLOGIES INC

WEST YOST ASSOCIATES Consulting Engineers

# TECHNICAL MEMORANDUM

**Stanislaus Regional Water Authority Water Treatment Project**
**Prepared for West Yost Associates**

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**APPENDICES:**

# ABBREVIATIONS

ANSI – American National Standards Institute

BSHB – Backwash Solids Handling Basins

BAC – Biologically Active Carbon

$CO_2$ – Carbon Dioxide

DB – Design Build

DBP – Disinfection By-Product

DDW – Division of Drinking Water

DOC – Dissolved Organic Carbon

EBCT – Empty Bed Contact Time

EPA – Environmental Protection Agency

GAC – Granular Activated Carbon

GPM – Gallons per Minute

HAA5 – Five Haloacetic Acids

HRT – Hydraulic Residence Time

LOX – Liquid Oxygen

LRAAs – Locational Running Annual Averages

LRV – Log Removal Values

LSI – Langelier Saturation Index

MCL – Maximum Contaminant Level

MG – Million Gallons

MGD – Million Gallons per Day

MRL – Method Reporting Limit

NL – Notification Level

NSF – National Science Foundation

PFD – Process Flow Diagram

PFR – Pipeline Flash Reactor

PSU – Power Supply Unit

SBC – Sand Ballasted Clarification

SF – Square Feet

SLR – Surface Loading Rate

SRWA – Stanislaus Regional Water Authority

sMCL – Secondary Maximum Contaminant Level

SWTR – Surface Water Treatment Rule

TAC – Technical Advisory Committee

TBD – To Be Determined

TDS – Total Dissolved Solids

TOC – Total Organic Carbon

TSS – Total Suspended Solids

TID – Turlock Irrigation District

TM – Technical Memorandum

TTHM – Total Trihalomethanes

VFD – Variable Frequency Drive

WTP – Water Treatment Plant

# 1 INTRODUCTION AND BACKGROUND

The Stanislaus Regional Water Authority (SRWA) is preparing to construct a new surface water treatment plant (WTP) as part of a Surface Water Supply Project (Project) to provide a new, supplemental drinking water supply to the Cities of Ceres and Turlock (Cities). The sole drinking water supply for both cities has historically been groundwater. The source water for SRWA's new treatment plant will be the Tuolumne River, at a location near the City of Hughson, as indicated in Figure 1.1. Raw water will be withdrawn from an existing infiltration gallery (constructed and owned by Turlock Irrigation District [TID]) located four to five feet below the river bottom and pumped to the WTP from a new raw water pump station adjacent to the infiltration gallery via a new raw water pipeline. Treated water from the new WTP will be pumped to the Cities in new finished water transmission mains. Together, these facilities will comprise the Project's "regional facilities" operated by SRWA. SRWA intends to design and construct the regional facilities utilizing a Design-Build (DB) procurement method.

The purpose of this technical memorandum (TM) is to establish preliminary design criteria for a "Reference WTP" reflecting SRWA's previously established, preferred treatment train. Design criteria presented in this TM are expected to inform the development of technical requirements for the DB contract that will govern the design and construction of the new WTP.

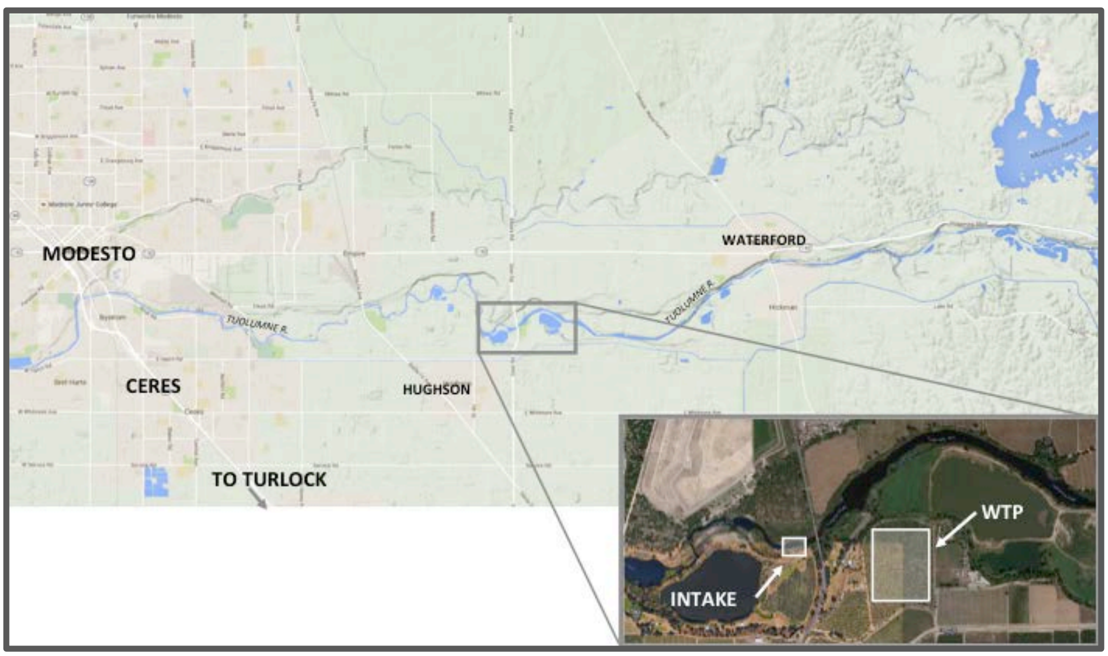


**Figure 1.1 - Location of SRWA's Future WTP near the Tuolumne River**

As part of the process of selecting the preferred treatment train for SRWA's WTP, a wide array of treatment alternatives were considered, seasonal bench-scale studies were conducted, and a number of reports were prepared. The studies and reports prepared in support of this technical memorandum (TM) are summarized in Table 1.1.

**Table 1.1 - Summary of studies and reports supporting reference WTP pre-design**

| Subject | Report Title | Author & Date |
|---|---|---|
| Tech Memo of treatment performance goals for the WTP | *Treatment Performance Goals* | Trussell Technologies July 2016 |
| Assessment of historical water quality Tech Memo | *Tuolumne River Historical Water Quality Assessment* | Trussell Technologies Sept. 2016 |
| Tech memo of treatment alternatives | *Treatment Process Alternatives, TM1, Part 1* | Trussell Technologies Sept. 2016 |
| Tech Memo of treatment alternatives | *Treatment Process Alternatives Technical Memorandum, No. 2* | West Yost and Trussell Technologies July 2017 |
| Coagulation performance evaluation Tech Memo | *Stanislaus Regional Water Authority Water Supply Project, Bench Test Results – TM1, November 2016 through February 2017* | Trussell Technologies Oct. 2017 |
| Source water monitoring Tech Memo | *Source Water Quality Assessment, Oct 2016 to Oct 2017* | Trussell Technologies Feb. 2018 |
| Ozone demand testing Tech Memo | *Bench Test Results – TM2, Seasonal Ozone* | Trussell Technologies *Draft in preparation* |
| Manganese removal testing | *Bench Test Results – TM3, Seasonal Manganese Removal* | Trussell Technologies *Draft in preparation* |

The above studies and reports, in conjunction with a number of focused workshops with the SRWA Technical Advisory Committee (TAC), resulted in the selection of the preferred treatment train for the new WTP. This preferred treatment train includes clarification (i.e., coagulation, flocculation, and sedimentation) using an aluminum-based coagulant, intermediate ozonation, dual-media filtration through granular activated carbon (GAC)/sand biologically active filters, final disinfection with free chlorine, and finished water stabilization.


**Figure 1.2 – Preferred treatment train**

# 2 HYDRAULIC DESIGN CAPACITY AND FUTURE EXPANSIONS

The initial treatment plant capacity is expected to be 15 mgd (estimated maximum daily demand). The plant is expected to expand over time to a buildout capacity of 45 mgd (future estimated maximum daily demand). Expansion is expected to occur in 15 mgd increments. Design criteria in this TM are provided for the initial 15 mgd facility and an intermediate, expanded 30 mgd facility. In general, each of two 15 mgd expansions are expected to replicate the initial 15 mgd facility design.

**Table 2.1 – Plant capacity**

| Parameter | Units | Value |
|---|---|---|
| Initial Production Capacity | mgd | 15 |
| Intermediate Production Capacity | mgd | 30 |
| Buildout Production Capacity | mgd | 45 |
| Plant Recycle Flow Rate (maximum) | % | 10 |

# 3 SOURCE WATER QUALITY AS BASIS OF DESIGN

Two reports have been prepared to characterize the water quality of the Tuolumne River in the vicinity of the existing TID infiltration gallery. The first report considers historical water quality data collected along the Tuolumne River at locations between La Grange Dam and the confluence of Dry Creek at Modesto for the period of 2005 to 2015 (Trussell Technologies, September 2016). This document also discusses potential contamination sources in the Lower Tuolumne River watershed along the same reach of the Tuolumne River.

The second report is a summary of the year-long source water monitoring program initiated by SRWA (Trussell Technologies, March 2018). This report discusses seasonal changes in water quality based on samples collected at the infiltration gallery location between October 2016 and October 2017, as well as comparison with the historical data. This 2016-2017 year-long monitoring program is referred to as the “Phase 1” monitoring program. A “Phase 2” extended monitoring program began in April 2018 and will continue until the start of construction of the new WTP.

The historical data collected at the infiltration gallery location (by TID) were combined with the more recent 2016-2017 data collected by SRWA and used as the basis for treatment train selection and as the basis of design for this TM. Statistics for this combined dataset are provided in Table 3.1, which includes (a) general water quality parameters, (b) inorganic contaminants with a regulatory primary maximum contaminant level (MCL) and were measured at least once above their method reporting limit (MRL), (c) organic contaminants with a primary MCL and detected at least once, and (d) microbial parameters. A similar summary is provided for the two individual datasets in Appendix A at the end of this TM.

**Table 3.1 - Statistical Summary of Tuolumne River Water Quality Parameters at the Infiltration Gallery Location**

| Parameter | Units | Regulatory List [5] | MCL/NL[1] | Combined Data [2] | | | |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | Avg [3] | Median [4] |
| **General Water Characteristics (Physical and Chemical)** | | | | | | | |
| Alkalinity, total | mg/l as $CaCO_3$ | - | - | 11 | 80 | 32.8 | 33.0 |
| Ammonia | mg/l as N | - | - | <0.050 | <0.1 | <0.1 | <0.1 |
| Bromide | mg/l | - | - | <0.005 | <0.1 | <0.1 | <0.1 |
| Calcium | mg/l | - | - | 2.7 | 11 | 8.7 | 9.1 |
| Calcium Hardness | mg/l as $CaCO_3$ | - | - | 6.8 | 27.5 | 21.8 | 22.8 |
| Chloride | mg/l | sMCL | 250 | <1.0 | 11 | 3.5 | 2.9 |
| Color | Color Units | sMCL | 15 | <1 | 20 | 5.4 | 5.0 |
| Dissolved Oxygen[2] (Field Meas.) | mg/l | - | - | 7.9 | 14.5 | 10.5 | 10.4 |
| Iron, Total | mg/l | sMCL | 0.3 | 0.032 | 6.5 | 0.2 | 0.1 |
| Iron, Dissolved | mg/l | - | - | <0.020 | 0.098 | 0.049 | 0.037 |
| Magnesium | mg/l | - | - | 0.97 | 5.6 | 4.1 | 4.3 |
| Manganese, Total | mg/l | sMCL/NL | 0.05/0.5 | <0.010 | 0.85 | 0.022 | 0.016 |
| Manganese, Dissolved | mg/l | - | - | <0.0020 | 0.013 | 0.0039 | <0.0020 |
| Nitrate | mg/l as N | pMCL | 10 | <0.10 | 0.86 | 0.41 | 0.36 |
| Nitrite | mg/l as N | pMCL | 1 | <0.050 | <0.1 | <0.1 | <0.1 |
| Odor – Threshold | Odor units | sMCL | 3 | <1 | 4 | 1.4 | 1.0 |
| Organic Carbon, Dissolved (DOC) | mg/l | - | - | 1.3 | 4.4 | 2.4 | 2.2 |
| Organic Carbon, Total (TOC) | mg/l | - | - | 1.4 | 6.5 | 3.1 | 2.8 |
| pH (Field Measurement) | pH units | - | - | 6.7 | 8.3 | 7.5 | 7.4 |
| Specific Conductance (Field Meas.) | µS/cm | sMCL | 900 | 20.8 | 201 | 78.4 | 69.0 |
| Sulfate | mg/l | sMCL | 250 | 1 | 6.5 | 3.1 | 2.7 |
| Temperature | ºC | - | - | 4.4 | 27.7 | 15.1 | 14.8 |
| Total Dissolved Solids (TDS) | mg/l | sMCL | 500 | 25 | 150 | 60.4 | 63.0 |
| Total Suspended Solids (TSS) | mg/l | - | - | <5 | 62 | 6.8 | 5.0 |
| Turbidity, Field Measurement[6] | NTU | sMCL | 5 | 0.59 | 25.6 | 2.8 | 2.1 |
| **Inorganic Contaminants with MCL** | | | | | | | |
| Aluminum | mg/L | pMCL/sMCL | 1/0.2 | <0.020 | 0.53 | 0.146 | 0.056 |

| Parameter | Units | Regulatory List [5] | MCL/NL[1] | Combined Data [2] | | | |
|---|---|---|---|---|---|---|---|
| | | | | Min | Max | Avg [3] | Median [4] |
| Barium | mg/L | pMCL | 1 | 0.0078 | 0.1 | 0.030 | 0.02 |
| Chromium, VI | mg/L | pMCL | 0.01 | 0.000028 | 0.000038 | 0.000034 | 0.000035 |
| **Organic Contaminants with MCL** | | | | | | | |
| Bis(2-Ethylhexyl) Phthalate | mg/L | pMCL | 0.004 | 0.0037 | -- | -- | -- |
| Simazine | mg/L | pMCL | 0.004 | 0.000093 | 0.00069 | -- | -- |
| **Pesticides of Local Concern without Regulatory Limit** | | | | | | | |
| Diuron | mg/L | -- | -- | 9.1E-6 | 6.6E-5 | -- | -- |
| **Microbiological Parameters** | | | | | | | |
| Coliform, Total | MPN/100 mL | - | - | 4 | >2420 | 695 | 240 |
| *Cryptosporidium* | oocysts/L | - | - | 0 | 0.1 | 0.007 | 0 |
| *E. coli* | MPN/100 mL | - | - | 0 | 460 | 48.7 | 23.5 |
| *Giardia* | cysts/L | - | - | 0 | 2 | 0.34 | 0 |

1: MCL = Maximum Contaminant Level; NL = Notification Level
2: Results from the Tuolumne River intake location (2016-2107) and TID's historical water quality data from the same intake location (2006-2008) were combined for statistical analysis
3,4: Non-detectable concentrations were assumed to be equal to the reportable limit in average calculation
5: sMCL = Secondary Maximum Contaminant Level; pMCL = Primary Maximum Contaminant Level
6: The maximum turbidity was measured after conclusion of the SRWA Phase 1 sampling program. This maximum value was not included in the calculated average or median values. The maximum turbidity measured during the SRWA Phase 1 sampling program was 15.4 NTU.

# 4 FINISHED WATER QUALITY GOALS AS BASIS OF DESIGN

Treatment objectives for the WTP are to produce a finished water that is in compliance with all primary and secondary drinking water standards (i.e., maximum contaminant levels (MCLs)), all pathogen removal and inactivation regulations, all disinfection by-product regulations, and all notification level (NL) limits as established by the California State Water Resources Control Board Division of Drinking Water (DDW) and specified in Title 22 of the California Code of Regulations. For select contaminants, SRWA is requiring that the finished water meet more stringent limits than established by Title 22 regulations. These limits, termed “Additional Finished Water Quality Standards”, are listed in Table 4.1.

**Table 4.1 - Additional finished water quality standards**

| Parameter | Target Concentration | Point of Performance Measurement | Considerations for Target Concentration |
|---|---|---|---|
| Turbidity | ≤ 0.15 NTU 95% of the time in accordance with 40 C.F.R § 141.718 Treatment Performance Toolbox of LT2ESWTR | • Individual Filter Effluent<br>• Combined Filter Effluent | Provides additional *Cryptosporidium* treatment credit, if needed |
| Total Trihalomethanes (TTHMs)[1] | < 0.064 mg/L | Distribution System – All Locational Running Annual Averages (LRAAs) | 80% of MCL[2] |
| Five Haloacetic Acids (HAA5)[1] | < 0.048 mg/L | Distribution System – All LRAAs | 80% of MCL[2] |
| Bromate | < 0.008 mg/L | After ozonation, as required by DDW | 80% of MCL |
| Manganese, total | ≤ 0.015 mg/L | Finished Water leaving WTP | To protect against aesthetic issues and public complaints |
| Iron, total | ≤ 0.24 mg/L | Finished Water leaving WTP | 80% of sMCL |
| Aluminum, total | ≤ 0.16 mg/L | Finished Water leaving WTP | 80% of sMCL |
| Pathogen Treatment | *Cryptosporidium* = 2-log<br>*Giardia* = 4-log<br>Virus = 5-log | Summation of LRV[5] through treatment train. Compliance determined at the finished water. | Source water monitoring data indicates additional *Giardia* and virus treatment likely required |
| Total Chlorine Residual | Assumed 1.5 – 3.5[3] | TBD[4] | Integration study to be conducted |
| Finished Water pH | Assumed 7.5 – 8.5[3] | TBD[3] | Integration study to be conducted |
| Langelier Saturation Index (LSI) | -0.2 to +0.2[3] | TBD[3] | Integration study to be conducted |
| Corrosion Inhibitor | TBD[3] | TBD[3] | Integration study to be conducted |

[1] Compliance will be determined using the Simulated Distribution System test method, with a pre-determined holding time such as 48 hours, on samples of finished water collected at the WTP. The holding time will be based on estimated detention times in the Cities systems.

[2] These treatment goals apply after steady state TOC removal occurs through the BAC filters, which can take as long as 6 – 12 months. For Acceptance Testing of the WTP immediately after construction, the Additional Water Quality Standards for these parameters are 50% of the MCL since the GAC filters will contain virgin GAC which will readily adsorb TOC, resulting in lower than normal SDSDBP levels.

[3] These parameters will be determined as part of the Integration Studies to be conducted independently by each City. Assumed values in this table are placeholders for chemical type and dose selection in this pre-design report.

[4] TBD = To Be Determined

[5] LRV = Log Removal Values

# 5 INFILTRATION GALLERY, RAW WATER PUMP STATION AND RAW WATER PIPELINE

Background and preliminary design information for the existing TID infiltration gallery and the new Raw Water Pump Station are presented in the TM titled "Preliminary Design of SRWA Raw Water Pump Station" (West Yost Associates, May 2018a). Similarly, background and preliminary design information for the new Raw Water Pipeline are presented in the TM titled "Preliminary Design of SRWA Raw Water Transmission Main" (West Yost Associates, May 2018b).

# 6 OVERVIEW OF REFERENCE WATER TREATMENT PLANT

This section provides an overview of the full process train for SRWA's Reference WTP, including process flow diagrams, a preliminary site layout and a hydraulic profile.

## 6.1 Process Flow Diagrams

Process flow diagrams (PFDs) for both the water train and the solids train for the Reference WTP are shown in Appendix B. The PFDs also show locations of critical monitoring and control instruments (e.g., flow meters and analyzers). The water process train includes the following treatment processes:

- Permanganate addition (as needed) for "preoxidation" of reduced manganese
- Coagulation with alum
- Flocculation and sedimentation
- Intermediate ozonation
- Dual-media biological filtration
- Final disinfection with free chlorine
- Stabilization of the finished water prior to the finished water pump station to minimize corrosion related water quality issues.

At the in-plant finished water pump station, Ceres and Turlock will each have the ability to adjust the finished water chlorine residual, corrosion inhibitor concentration, and pH in order to tailor the finished water to meet the specific needs of each City. Both Cities are in the process of evaluating the preferred approach for finished water stabilization and corrosion control by conducting surface water integration studies to define the optimum finished water quality and treated surface water ramp-up schedule to meet their individual distribution system and demand needs. In the absence of detailed, City-specific finished water stabilization and corrosion control information, assumptions have been made, where appropriate, regarding finished water quality for the purpose of setting Reference WTP design criteria. These assumptions can be modified once the Cities complete their planned integration studies.

The solids process train (Appendix B) includes (1) redundant backwash solids handling basins (BSHB) which operate in batch mode, (2) gravity thickeners to increase the percent solids of the sludge from sedimentation and the BSHB before being sent to the sludge drying beds, (3) sludge drying beds that allow for storage and seasonal drying, and (4) a recycle equalization basin to regulate the flowrate of the return flow back to the head of the WTP. In accordance with DDW's Cryptosporidium Action Plan guidelines, the return flow will be 10 percent or less of the plant's design flow and will have a turbidity ≤ 2 NTU.

Flowrates at various points through the treatment train are summarized in Table 6.1, for both the 15 mgd facility and the expanded 30 mgd facility. The PFDs in Appendix B also include estimated inter-process flowrates throughout for the 15 mgd facility.

**Table 6.1 - Flowrates at various points in the treatment train for 15 mgd and 30 mgd production**

| Location | Flowrate in 15-mgd WTP (mgd) [a] | Flowrate in 30-mgd WTP (mgd) |
|---|---|---|
| **Water Stream** | | |
| **Raw Water** | 15.03 | 30.06 |
| Recycle Return Flow ahead of Flash Mix | 1.50 | 3.00 |
| Flash Mix/Floc/Sed Influent | 16.53 | 33.06 |
| Ozone Influent | 16.24 | 32.49 |
| Filter Influent | 16.24 | 32.49 |
| Filter Effluent | 15.00 | 30.00 |
| **Finished Water** | 15.00 | 30.00 |
| **Waste Streams** | | |
| Backwash Basin Influent | 0.91 | 1.81 |
| Backwash Basin Decant | 0.87 | 1.75 |
| Gravity Thickener Decant | 0.29 | 0.57 |
| Filter To Waste | 0.34 | 0.68 |
| Sludge from Sedimentation | 0.29 | 0.57 |
| Gravity Thickener Influent | 0.32 | 0.63 |
| Sludge Drying Bed Influent | 0.03 | 0.06 |
| a: The PFDs in Appendix B provide a visual presentation of each of the inter-process flows included in this table for the 15 mgd WTP. | | |

## 6.2 Site Layout

Appendix C presents a site layout for the Reference WTP. The layout of all unit processes is shown for the initial 15-mgd capacity, as well as the footprint for the first expansion to 30 mgd and the projected second expansion to 45 mgd. This layout also shows potential placement of the chemical metering and storage building, a maintenance building and an operations/laboratory building. The laboratory will initially be used for process control, but will be sized during initial design to become a certified lab, if desired, in the future. The WTP site is large enough for full expansion to 45 mgd of all processes except the sludge drying beds. As discussed in Section 16.3 of this TM, operating experience with the 15 mgd facility will allow SRWA to accurately evaluate the need for additional drying beds upon expansion, and whether or not to supplement available drying bed capacity with mechanical thickening and/or dewatering systems.

## 6.3 Hydraulic Profile

The hydraulic profile between the static mixer at the beginning of the 15-mgd Reference WTP and the end of the WTP is shown in Appendix D. As shown, the layout of the Reference WTP allows for gravity flow through the full treatment train to the finished water pump station, where the water is then pumped to each City.

## 6.4 Scheduled Plant Down-Time

The new SRWA WTP is intended to provide a “base load” of treated drinking water to the Cities, to be supplemented as needed with existing groundwater supplies. Prior to the expansion of the WTP from 15 to 30 mgd, for example, the amounts of groundwater needed to supplement surface water during peak demand months is expected to be greater than the total drinking water demand during minimum demand months (West Yost Associates, June 2016). By virtue of the continued availability of groundwater supplies, the Cities have indicated that the WTP may undergo periodic, partial shutdowns during low demand months (typically December through February) to facilitate planned maintenance. This assumption is reflected in a number of process train sizing criteria presented throughout this TM.

## 6.5 Process Design Criteria

The following sections of this TM (Section 7 to Section 16) provide detailed design information about each unit process in the Reference WTP, including (1) preliminary design criteria, (2) background information regarding treatment options considered and reasons for the presented approach, (3) a description of the redundancy incorporated into the 15 mgd facility and discussion of the expansion design for the 30 mgd facility, and (4) a summary of the chemicals used in the treatment process.

# 7 PRE-OXIDATION

Design criteria for the Reference WTP’s pre-oxidation process is presented in Table 7.1. Additional discussion below provides background information on the recommended treatment technology, chemical addition requirements, and proposed approaches to expansion and redundancy.

**Table 7.1 - Permanganate pre-oxidation design criteria**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Chemical addition point | -- | raw water ahead of coagulant addition | |
| Preferred chemical | -- | sodium permanganate | |
| Dosage, design | mg/L as $NaMnO_4$ | 0.2 | |
| Minimum required reaction time | min | 1 | |
| Mixer type | -- | low headloss static mixer | |

## Background Information

In order to minimize aesthetic issues related to manganese in the finished water (namely colored water or black water), the target finished water manganese concentration is less than 0.015 mg/L, based on the experience and recommendation of Brandhuber, et al., (2013). Manganese can exist in one of several possible oxidation states, but the form of manganese most problematic in water treatment is the manganous ion ($Mn^{2+}$) with an oxidation state of (II). $Mn^{2+}$ is generally measured as "dissolved" manganese in laboratory samples. Oxidation of the $Mn^{2+}$ to form particulate $MnO_2$ is the preferred treatment option, and this form of manganese is readily removed through clarification and filtration. However, with ozone in the process train, removal of manganese becomes more complex because the ozone forms colloidal-sized $MnO_2$, which SRWA's bench-scale testing showed to pass through clarification and filtration. Therefore, if $Mn^{2+}$ is present in the raw water, the preferred treatment—confirmed through bench testing—is to oxidize the $Mn^{2+}$ to particulate $MnO_2$ using permanganate, which is then readily removed through clarification prior to intermediate ozonation.

A summary of raw water total and dissolved manganese concentrations is provided in Table 3.1 and Appendix A. Raw water dissolved manganese concentrations were low during the SRWA Phase 1 monitoring program (Trussell Technologies, February 2018), with a maximum measured concentration of 0.013 mg/L. Total manganese concentrations, though, were higher than the finished water target (< 0.015 mg/L). Only total manganese—not the dissolved fraction—was measured during the historical sampling program (2006-2008), so long term trends in $Mn^{2+}$ concentrations in this source water are not known. However, based on 95 total manganese data points in the historical dataset, the source water total manganese concentration exceeded the SRWA proposed target limit more than 50% of the time. Additionally, the influence of the Infiltration Gallery on $Mn^{2+}$ concentration is not known at this time. As a result, it was concluded that there is potential for elevated $Mn^{2+}$ concentrations in the raw water, and pre-oxidation treatment with sodium permanganate is included in the Reference WTP treatment train.

## Chemical Addition

Permanganate, preferably in the form of sodium permanganate which is easier to work with at full-scale, will be fed to the single raw water pipeline ahead of the flash mix system, on an as-needed basis only. A minimum reaction time of 1 minute shall be provided between permanganate addition and coagulant addition at the flash mix facility. An assumed raw water $Mn^{2+}$ concentration of 0.10 mg/L is used to determine the design permanganate dosage.

## Redundancy & Expansion

Because permanganate will be used on an as-needed basis only, minimal redundancy is required. Only one duty metering pump will be needed, with a shelf spare in the event that maintenance is required on the duty pump.

Chemical metering pumps generally have a high turn-down ratio and can therefore accommodate a wide range of doses. The first few years of operating experience will indicate how often permanganate preoxidation is needed and what dose is typical. Expansion should be minimal and does not need to be addressed as part of the initial design. When the plant expands to 30 or even 45 mgd, a larger metering pump or pumphead may be required to deliver the appropriate dose, but the pump selected for the 15 mgd facility may be able to accommodate a wide enough range of doses such that no changes are necessary for expansion.

# 8 FLASH MIX

Design criteria for the Reference WTP's flash mix process is presented in Table 8.1. The Raw Water Pump Station and Raw Water Pipeline predesign TMs (West Yost Associates, May 2018a and May 2018b, respectively) discuss options for pigging the raw water pipeline and location of the pig retrieval station should the low water velocities through the pipeline prior to buildout expansion (i.e., 45 mgd) allow sediment to settle and accumulate in the pipeline. Other than this brief mention, pigging is not discussed in this predesign TM. Additional discussion below provides background information on the recommended treatment technology, chemical addition requirements, and proposed approaches to expansion and redundancy.

**Table 8.1 - Flash mix system design criteria**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| **General** | | | |
| Type | -- | Hydraulic Pump Diffusion, with target (diffuser) plate | |
| No. of Flash Mix Trains | no. | 2 | 4 |
| Flow per Train | mgd | 8.25 | 8.25 |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Water Temperature, Min | ˚C | 5 | 5 |
| Dynamic Viscosity at Min Temperature | Kg/m*sec | 1.52E-03 | 1.52E-03 |
| **Chemical Addition** | | | |
| Lime, design dose | mg/L as $Ca(OH)_2$ | 5.5 | |
| Cationic Polymer, design dose | mg/L as polymer | 0.5 | |
| Aluminum Sulfate, design dose | mg/L as $Al_2(SO_4)_3 \cdot 14H_2O$ | 15 | |
| **Flash Mix Design Criteria Per Train** | | | |
| Number of Flash Mix Systems (duty/standby) | no. | 1/0 | 1/0 |
| Nominal Pipe Size (Ductile Iron, Class 250), Raw Water Pipe | in | 24 | 24 |
| Pipe Diameter of Raw Water Pipe, ID | in | 25.06 | 25.06 |
| Velocity in Raw Water Pipe | fps | 3.73 | 3.73 |
| Mixing Provided by High Velocity Pumped Sidestream: | | | |
| Mixing Energy (G) | $sec^{-1}$ | 906 | 906 |
| Required Water Horsepower for Mixing | hp<br>kW | 0.49<br>0.37 | 0.49<br>0.37 |
| Percent of Flow through Pumped Sidestream | % | 3 | 3 |
| Flash Mix Pump Flowrate, per Pump | gpm<br>cfs | 171.9<br>0.38 | 171.9<br>0.38 |
| Orifice Diameter | in | 1.6 | 1.6 |
| Velocity of Mixing Jet through Orifice | m/s | 8.36 | 8.36 |
| Number of Mixing Pumps, per Flash Mix System (duty/standby) | no. | 1/0 | 1/0 |
| Number of Shelf Mixing Pumps, Total | no. | 2 | 2 |
| Type of Mixing Pump | -- | Horizontal End Suction | |
| Total Dynamic Head, per Pump | ft | 15 | 15 |
| Nominal Motor Size, per Pump | hp | 1.0 | 1.0 |

## Background Information

In conventional treatment, the clarification process includes three steps: coagulation, flocculation, and sedimentation. During coagulation, a coagulant (e.g., a metal salt) and possibly a coagulant aid (i.e., polymer) is rapidly mixed into the raw water to destabilize particles allowing them to aggregate, forming larger particles that will effectively settle—this is essentially the Flash Mix process. The flocculation process allows for the destabilized particles to aggregate into larger masses to improve their settling characteristics, and associated design criteria for this step of the clarification process is discussed in Section 9. Enhanced coagulation, where a higher coagulant dose and possibly lower pH is used than required for particle destabilization, allows dissolved species such as natural organic matter, or total organic carbon (TOC), (i.e., DBP precursor material) to adsorb to and/or become enmeshed in the metal hydroxide floc particles—providing enhanced TOC removal.

The coagulant should be very quickly dispersed (e.g., 10 sec or less) and mixed with the raw water. Although velocity gradient (G) can be used as a guide in flash mix design, other factors such as degree of short circuiting, type of mixing element, energy input, and effective mixing time also affect the rapid mixing and dispersion of coagulants (Kawamura, 2000).

There are several options for flash mixing, including mechanical mixing, in-line static mixers, and pump diffusion mixing. Advantages and disadvantages of the alternative flash mix systems are summarized in Table 8.2.

**Table 8.2 - Advantages and disadvantages of flash mix systems**

| Flash Mix System | Advantages | Disadvantages |
|---|---|---|
| Mechanical Mixing | | • Potential for flow short-circuiting and back-mixing<br>• Potential for long mixing times at reduced flows<br>• Maintenance requirements for mechanical components |
| In-Line Static Mixer | • No moving parts, so very low maintenance<br>• | • High headloss<br>• Potential for insufficient rapid mixing at reduced flows |
| Pump Diffusion Flash Mixing | • Effective mixing over a wide range of flows<br>• No moving parts in mixer<br>• No headloss<br>• Controllable mixing<br>• Lower power consumption than mechanical mixing | • Maintenance requirements for pumps<br>• Spare pumps required |

For the Reference WTP, a pump diffusion flash mix system was selected for flash mixing. Such a system includes a sidestream injection pump, coagulant addition piping and injection apparatus, and a target plate for rapid diffusion of the coagulant solution into the main raw water flow. A side stream of raw water—approximately 3% of the plant design flow—is pulled from and then pumped back into the main flow at a high velocity through small diameter piping. This high velocity water jet provides the mixing energy (G) needed to rapidly mix the coagulant with the raw water. The coagulant is added to the jet of water just before the water leaves the small diameter pipe to enter the main water flow. A schematic of the target plate assembly used for the pump diffusion flash mix system is shown in Figure 8.1.

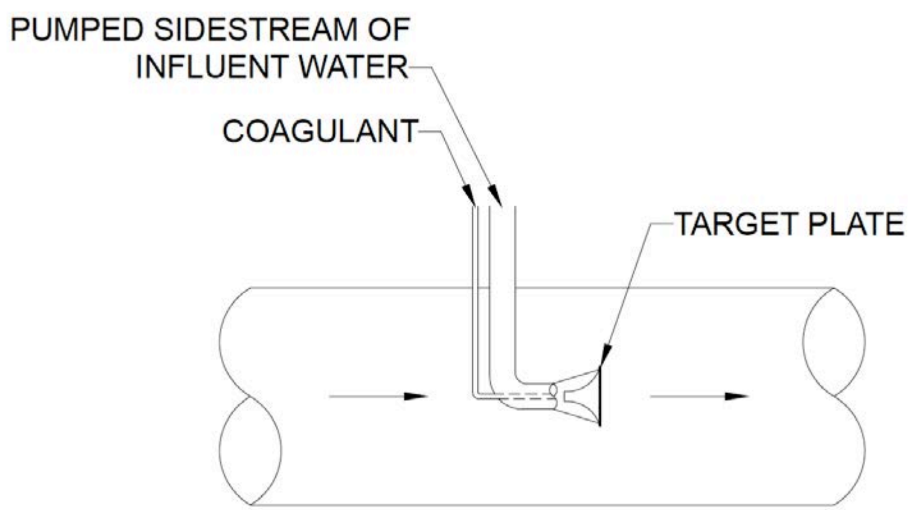


**Figure 8.1 - Pump diffusion flash mix target plate assembly**

For the initial 15 mgd Reference WTP, flow through the coagulation/flocculation/sedimentation process is split into two parallel trains, each designed to handle 50% of the plant flow. At this point in the process train the flow is greater than the finished water flow because recycle streams (e.g., filter-to-waste, coagulated/settled backwash waste) are returned to the head of the plant (i.e., ahead of coagulant addition and flash mixing).

## Chemical Addition

Chemicals added as part of the clarification process include (a) lime (as needed), (b) cationic polymer, and (c) an aluminum-based coagulant. Lime will be added as needed to adjust the pH and alkalinity of the raw water for effective coagulation. The optimum pH range for alum coagulation is between 5.5 and 7.7, but typically close to a pH of 6 under warm water conditions and close to a pH of 7 under cold water conditions (Crittenden, et al., 2012). Having sufficient alkalinity is important for maintaining an effective operating pH for alum coagulation and to prevent unacceptable aluminum residual post sedimentation. Cationic polymer addition is also added, as needed, to produce a stronger floc that is more amenable to settling. Aluminum-based coagulants were selected for the Reference WTP since iron-based coagulants are known to contain some percentage of reduced manganese contamination. As previously described, the reduced manganese can be oxidized in a plant utilizing ozone treatment to a colloidal manganese dioxide ($MnO_2$) which can pass through the treatment train and result in aesthetic issues in the distribution system. Aluminum sulfate (or alum) is the most common aluminum-based coagulant in water treatment.

For additional information about chemical selections, doses, storage requirements, and so on, refer to Section 15 of this TM.

### Redundancy & Expansion

Maintenance requirements for the pump diffusion flash mix system are expected to be low, but when required one of the two trains can be taken off-line. Because SRWA has indicated it is acceptable to reduce plant capacity by 50% for planned maintenance in the winter when demand is low, spare mixing pumps will be shelf items rather than installed redundant pumps. Likely, though, if a mixing pump is taken off-line for repair, it can be replaced rather quickly (less than one day) with the shelf spare pump; replacing the mixing pump should not prevent coagulant injection and the flocculation train should not have to be taken off-line during the time the mixing pump is replaced. Additionally, rather than providing redundant flash mix systems for each of the two trains, one shelf flash mix assembly and injection assembly is provided in case the injection tubing becomes plugged or other maintenance is required.

When expanding to 30 mgd, two additional parallel trains are proposed. The reason for two additional 8.25 mgd trains rather than one 16.5 mgd trains is so that spare mixing pumps and flash mix assemblies are the same size for all trains. This will minimize the number of shelf spare components that are needed.

## 9 FLOCCULATION/SEDIMENTATION

After Flash Mix, the Reference WTP flow is split into two trains for clarification via flocculation and sedimentation. Flow into the flocculation/sedimentation (floc/sed) basins is equally divided between each train using influent weirs with downward opening slide gates. At the initial 15 mgd WTP capacity, each train is sized for half the plant flow, or 8.25 mgd. The two flocculation-sedimentation trains are constructed side-by-side utilizing common-wall construction. Each train can be isolated for maintenance by closing the butterfly valve in the influent pipeline and by closing the sliding weir gate. The flow split described here is the same for all floc/sed alternatives.

Two flocculation/sedimentation treatment alternatives were considered for the Reference WTP, and are described in the following subsections:

- Section 9.1 – Conventional flocculation plus sedimentation with lamella plates

- Section 9.2 – Sand ballasted clarification (SBC) with a proprietary system such as the Actiflo® Turbo system by Kruger (a subsidiary of Veolia Water Solutions)
- Section 9.3 – Comparison of conventional flocculation/sedimentation and SBC treatment

The Reference WTP site layout (Appendix C) reflects the conventional flocculation/sedimentation alternative rather than the SBC alternative since the conventional system has a larger footprint and SRWA desires to identify the site-planning implications of the largest-footprint alternatives under consideration.

## 9.1 Conventional Flocculation and Sedimentation with Lamella Plates

This subsection describes the first of two flocculation/sedimentation alternatives considered for the Reference WTP, conventional flocculation and sedimentation with lamella plates. Individual elements of this alternative are described below in paragraphs 9.1.1 (Conventional Flocculation) and 9.1.2 (Conventional Sedimentation with Lamella Plates).

### 9.1.1 Conventional Flocculation

Design criteria for the Reference WTP's conventional flocculation process alternative is presented in Table 9.1. Additional discussion below provides background information on this treatment technology, chemical addition requirements, and proposed approaches to expansion and redundancy.

**Table 9.1 - Conventional flocculation design criteria**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| **General** | | | |
| Number of Trains | no. | 2 | 4 |
| Flow, per Train | mgd | 8.25 | 8.25 |
| **Chemicals** | | | |
| Anionic Polymer, design dose | mg/L as polymer | 0.05 - 0.1 mg/L as polymer | |
| **Flocculation Design Criteria** | | | |
| Number of Stages, per Train | no. | 4 | 4 |
| Number of Flocculators, per Stage | no. | 2 | 2 |
| Number of Flocculators, per Train | no. | 8 | 8 |
| Stage 1 Mixing Energy (G) | $sec^{-1}$ | 55 | 55 |
| Stage 2 Mixing Energy (G) | $sec^{-1}$ | 40 | 40 |
| Stage 3 Mixing Energy (G) | $sec^{-1}$ | 25 | 25 |
| Stage 4 Mixing Energy (G) | $sec^{-1}$ | 15 | 15 |
| Length of Stage | ft | 14.25 | 14.25 |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Width of Stage | ft | 28.5 | 28.5 |
| Type Wall Between Stages | -- | Durable, water resistant material planks with specially sized orifices. Number and size of orifices changes per stage. | |
| Length of Train | ft | 57 | 57 |
| Width of Train | ft | 28.5 | 28.5 |
| Water Depth, each Basin | ft | 14.25 | 14.25 |
| Tank Freeboard | ft | 2 | 2 |
| Volume, per Train (excluding freeboard) | gal | 173,179 | 173,179 |
| Hydraulic Residence Time, per Stage | min | 7.5 | 7.5 |
| Hydraulic Residence Time, per Train | min | 30.2 | 30.2 |
| Type of Flocculators | -- | Vertical Turbine | |
| Type of Impeller | -- | Hydrofoil, 3-blade | |
| Diameter of Impeller | in | 84 | 84 |
| Clearance between Impeller and Basin Floor | ft | 5 | 5 |
| Nominal Motor Size, per Flocculator | hp | 1 | 1 |
| Type of Motor | -- | Variable Speed | |

## Background Information

The purpose of flocculation is to gently increase the rate of particle collisions, thereby allowing the particles to aggregate, becoming larger and heavier so they will settle in the sedimentation basin. For the Reference WTP, four stages of tapered flocculation, with decreasing mixing energy in each stage, are employed to encourage large/heavy floc formation while maintaining low shearing forces that can break the floc apart. Plan and section views of a combined flocculation-sedimentation train is provided in Figure 9.1.The size and shape of each flocculation chamber is intended to provide sufficient eddies and turbulence for mixing while minimizing dead zones in the basin. Each stage of flocculation (in each train) includes two parallel square chambers. Vertical turbine flocculators with hydrofoil impellers have been selected to minimize trailing vortices that contribute to floc breakup. Variable speed motors for the flocculators are recommended so that mixing energy imparted in each stage of flocculation can be adjusted as needed to promote formation of large floc. Perforated baffle walls, made of water-resistant wood, are placed between each stage of flocculation and after the final stage to enable uniform hydraulic flow. The common wall between parallel flocculation chambers (within each train) is not a load bearing wall, and therefore can also be made of water-resistant wood or other NSF/ANSI 61[1] approved material.

Advantages of a conventional floc/sed design include:

- Proven process and widely used in water treatment plants in California and around the country.
- Not subject to the potentially higher costs of proprietary systems.

## Chemical Addition

Chemicals added as part of the clarification process include aluminum sulfate (i.e., alum), cationic polymer, and either anionic or nonionic polymer. Alum and cationic polymer are added during flash mix as discussed in Section 8. This Reference WTP predesign also includes the option for flocculant aid nonionic or anionic polymer addition partway through tapered flocculation, with the purpose being to strengthen and enlarge the floc to promote faster and more effective settling. Polymer addition is an integral part of the Actiflo® SBC system, and the system manufacturer generally recommends an anionic polymer. The choice of nonionic polymer or anionic polymer, though, is site-specific and may require bench testing to select the preferred chemical. For additional information about chemical selections, doses and storage requirements, refer to Section 15 of this TM.

## Redundancy & Expansion

For the 15 mgd WTP, there are two parallel floc/sed basins—a common wall between the two—with each train able to handle half the flow. When the plant is expanded to 30 mgd, two additional parallel floc/sed basins will be added. If maintenance on any basin is required, that train would have to be taken off-line while repairs are made. However, maintenance on the basin itself or any parts below the water surface should be infrequent at most. The only mechanical parts that may require maintenance are the flocculator motors, which are all housed on supports above the water and all the same horsepower. The WTP shall maintain a minimum of two shelf standby flocculator motors for each train, for both the 15 mgd and 30 mgd plant capacities.

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[1] The State of California's Title 22 Drinking Water Standard Section 64591 states: "after March 9, 2008 a water system shall not use any chemical, material, lubricant, or product in the production, treatment or distribution of drinking water that will result in its contact with drinking water... that has not been tested and certified as meeting the specifications of NSF International/American National Standard Institute (NSF/ANSI) 61-2005/ Addendum 1.0 - 2005 (Drinking Water System Components - Health Effects."

### 9.1.2 Conventional Sedimentation with Lamella Plates

Design criteria for the Reference WTP's conventional sedimentation with lamella plates process alternative is presented in Table 9.2. Additional discussion below provides background information on this treatment technology, chemical addition requirements, and proposed approaches to expansion and redundancy. Plan and section views of a combined flocculation-sedimentation train is provided in Figure 9.1.

**Table 9.2 – Design criteria for conventional sedimentation with lamella plates**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Type | -- | Rectangular with Plates | |
| Number of Trains | no. | 2 | 4 |
| Design Flow, per train | gpm | 5729 | 5729 |
| Length of Train | ft | 89 | 89 |
| Fraction of Basin with Plate Settlers | % | 75 | 75 |
| Length of Basin with Plate Settlers | ft | 66.8 | 66.8 |
| Width of Train | ft | 29.5 | 29.5 |
| Length to Width Ratio | -- | 3 | 3 |
| Water Depth | ft | 14.25 | 14.25 |
| Width to Water Depth Ratio | -- | 2.1 | 2.1 |
| Tank Freeboard | ft | 2 | 2 |
| Volume, per Train | gal | 279,889 | 279,889 |
| Footprint Equivalent Surface Loading Rate | gpm/sf | 2.2 | 2.2 |
| Surface Loading Rate of Area Covered by Plates | gpm/sf | 2.9 | 2.9 |
| Plate Settler Efficiency | % | 90 | 90 |
| Clearance below Plates | ft | 6 | 6 |
| Hydraulic Residence Time, per train | min | 48.9 | 48.9 |
| Hydraulic Residence Time through Plate Settlers, per train | min | 36.6 | 36.6 |
| Sludge Removal System | -- | Chain and Flight or Hoseless Collector | |

## Background Information

Sedimentation occurs after flocculation with gentle and continuous flow between the two processes. Lamella plate settlers are employed to minimize the footprint of the sedimentation process. A robust sludge removal system, such as a chain-and-flight collection system or a hoseless sludge collection system, that can operate continuously for long periods of time with minimal operator attention, is required to remove accumulated sludge from each sedimentation basin. Sludge from the sedimentation basin is pumped to the gravity thickeners, and from there to the sludge drying beds.

Including plate settlers in a conventional sedimentation basin significantly reduces the required footprint for particle settling. High-rate settlers, such as lamella plate settlers with inclined plates, improve settling efficiency and reduce the required footprint by reducing the distance particles must settle and increasing the surface area for particle capture. Surface loading rate[2] (SLR) for a conventional rectangular basin without tubes or inclined plates is 0.5 to 1 gpm/sf, while the SLR for high-rate settlers are generally 2 to 3.5 gpm/sf for the area of the basin covered by the plates (Kawamura, 2000) which translates to 1 to 2.5 gpm/sf based on basin footprint for alum floc (Crittenden, et al., 2012). Generally, the fraction of a rectangular basin covered by plates or tubes is 75% or less.

Design criteria for conventional sedimentation basins with lamella plates, for the 15 mgd SRWA WTP and 30 mgd expansion, are provided in Table 9.2. The SLRs for the sedimentation basin shown in Table 9.2 are within the guidelines provided by Kawamura (2000) and Crittenden, et al. (2012).

## Chemical Addition

No chemicals are added during sedimentation.

## Redundancy & Expansion

For the 15 mgd WTP, there are two parallel floc/sed basins—a common wall between the two—with each train able to handle half the flow. When the plant is expanded to 30 mgd, two additional parallel floc/sed basins will be added.

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[2] Surface loading rate = flowrate through the basin divided by surface area or footprint area.

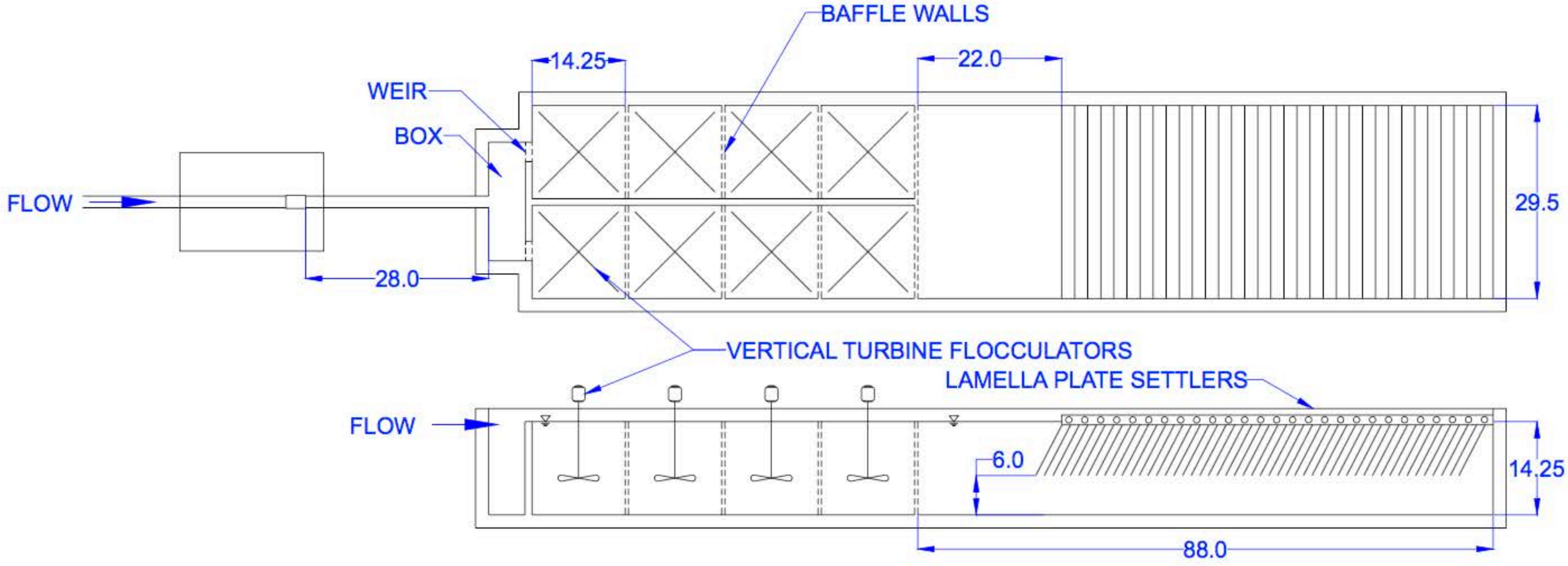


**Figure 9.1 - Plan and section view of conventional flocculation/sedimentation design for one train (dimensions in feet)**

## 9.2 Sand Ballasted Clarification (SBC)

This subsection describes the second of two flocculation/sedimentation alternatives considered for the Reference WTP, which is sand ballasted clarification (or SBC). Design criteria for the Reference WTP's SBC alternative is presented in Table 9.3. Additional discussion below provides background information on this treatment technology, chemical addition requirements, and proposed approaches to expansion and redundancy.

**Table 9.3 – Sand ballasted clarification design criteria**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| **General** | | | |
| Number of Trains | no. | 2 | 4 |
| Flow, per Train | mgd | 8.25 | 8.25 |
| Type | -- | SBC Actiflo® Turbo (Generation 2) | |
| Target HRT Through Settler | min | 6 – 8 | 6 – 8 |
| Rise Rate through Tube Settlers | gpm/sf | 25 | 25 |
| **Coagulation Tank** | | | |
| Coagulation Tank HRT, per train | min | 2 | 2 |
| Depth | ft | 15.0 | 15.0 |
| Length and Width, per train | ft | 10.17 | 10.17 |
| Freeboard Above Weir into Maturation Tank | ft | 2.5 | 2.5 |
| Mixing Energy, G | $sec^{-1}$ | Per SBC Supplier | |
| **Maturation Tank Depth** | | | |
| Maturation Tank HRT, per train | min | 4 | 4 |
| Depth | ft | 15.0 | 15.0 |
| Width, per train | ft | 18.17 | 18.17 |
| Length, per train | ft | 11.25 | 11.25 |
| Polymer Type | -- | Anionic | Anionic |
| Polymer Dose | mg/L | 0.1 – 0.5 | 0.1 – 0.5 |
| Mixing Energy, G | $sec^{-1}$ | Per SBC Supplier | |
| Sand Dose | g/L | 5 | 5 |
| **Sedimentation Tank** | | | |
| Target HRT Through Settler, per train | min | 6 – 8 | 6 – 8 |
| Design HRT Through Settler, per train | min | 6 | 6 |
| Depth | ft | 14 | 14 |
| Length and Width, per train | ft | 18.17 | 18.17 |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Length of Basin Covered by Tubes, per train | ft | 12.75 | 12.75 |
| Area of Basin Covered by Tubes, per train | sf | 231.7 | 231.7 |
| Percent of Basin Covered by Tubes | % | 70 | 70 |
| Target Rise Rate through Tube Settler (per Manufacturer) | gpm/sf | 25 - 33 | |
| Design Tube Settler Solids Loading Rate | gpm/sf | 24.7 | 24.7 |
| Settling Basin Solids Loading Rate | gpm/sf | 17.4 | 17.4 |

## Background Information

SBC is an alternative high-rate clarification process where micro-sand is added during the coagulation step. The microsand serves as nucleation sites for floc formation. The resultant floc is heavier than floc formed without micro-sand and therefore tends to increase the settling rate of the floc. The SBC supplier shall define the specifications for the microsand, but general information about the sand is that it is pure silica with a specific gravity between 2.6 and 2.7.

Due to the ballast provided by the micro-sand/floc, the SBC system operates at a higher rise rate (equivalent to surface loading rate) through the tube or plate settler than in the conventional sedimentation system with plates, and therefore has a much smaller footprint. Although the Tuolumne River is not known to experience "flashy" and variable conditions, SBC systems are known to provide robust treatment for rapidly changing and/or high turbidity source waters. Experience has shown that the SBC treatments are equally as effective for low turbidity waters, as seen on the Tuolumne River.

A schematic of the proprietary Actiflo® Turbo SBC system, manufacturered by Kruger (a subsidiary of Veolia Water Solutions) is provided in Figure 9.2. Veolia is not the only manufacturer of sand ballasted clarification systems, but design criteria presented in this Reference WTP predesign are for just this one system.

A plan view schematic of the Actiflo® Turbo (Generation 2) SBC system sized for the 15 mgd Reference WTP is shown in Figure 9.3

Advantages of an SBC system include:

- The SBC system has a shorter hydraulic residence time (HRT) through the coagulation and flocculation—12 minutes for SBC compared with 30 minutes for conventional—because of the floc nucleation sites provided by the added micro-sand.
- The SBC system has a faster rise rate (gpm/sf) through the tube settler than the rise rate through lamella plates in a conventional sedimentation

basin—25 to 33 gpm/sf for SBC compared with 2 to 3 gpm/sf for plates in a conventional basin. The sand used for ballast in the SBC unit produces floc that settled rapidly.
- The SBC system has a smaller footprint than a conventional floc/sed basin with plates.

One disadvantage of the SBC system may be its proprietary nature and the potential for higher cost. Encouraging competition by allowing at least two proprietary systems to participate in the bidding process, though, is expected to control capital costs.

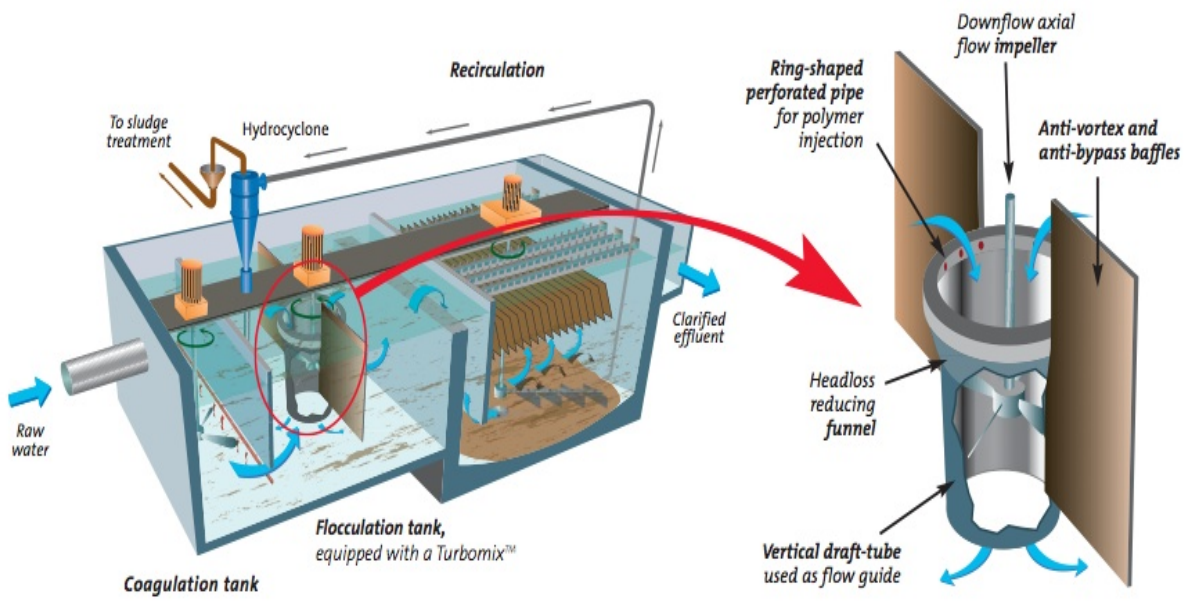


**Figure 9.2 - Schematic of Actiflo® Turbo sand ballasted clarification system**

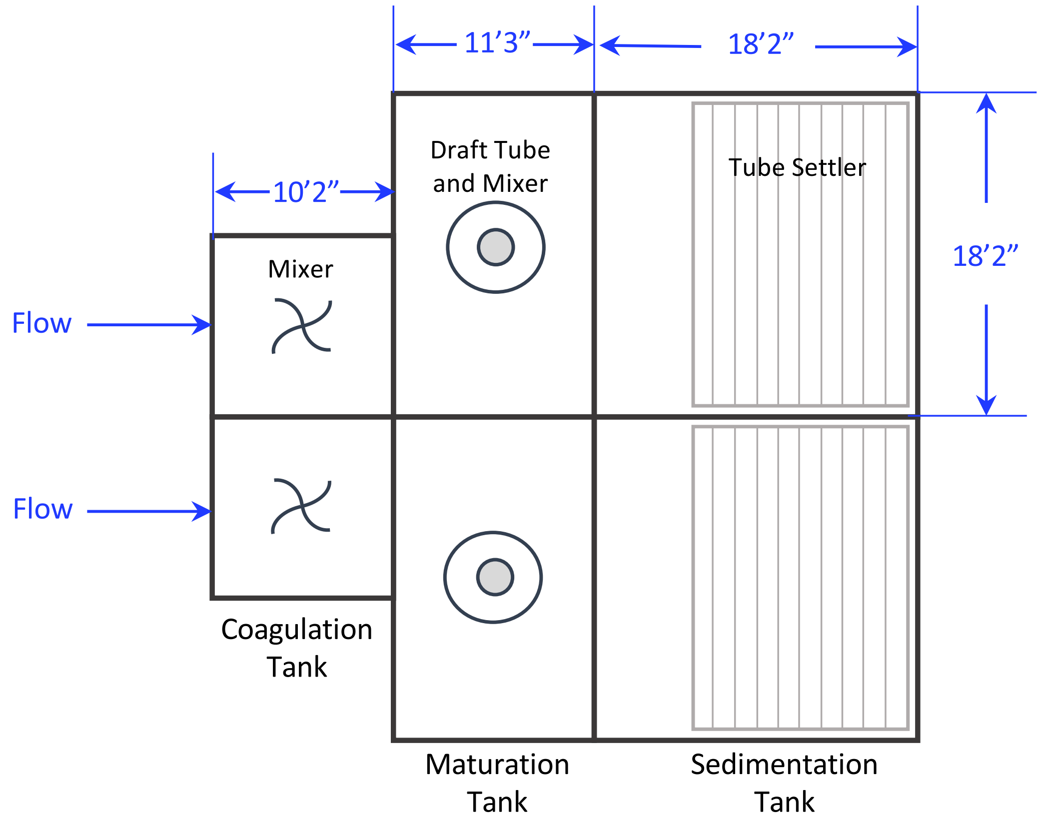


**Figure 9.3 - Plan View of Actiflo® Turbo SBC System**

## Chemical Addition

The same flash mix system discussed in Section 8 would be required for the SBC system, which means the same alum addition. However, because the SBC design relies heavily on the use of a anionic polymer in the "maturation, or flocculation, tank" of the SBC system, it is not known if the system manufacturer would also recommend concurrent cationic polymer addition (i.e., at Flash Mix). For design criteria presented in this Reference WTP predesign, however, it is assumed that cationic polymer would also be added at flash mix, ahead of the SBC system, just as done with conventional floc/sed.

For additional information about chemical selections, doses and storage requirements, refer to Section 15 of this TM.

## Redundancy & Expansion

For initial design of 15 mgd, there are two SBC trains—each sized to treat half the flow. If one of the SBC units is off-line for maintenance, the plant is able to produce only half the design capacity. When the WTP is expanded to 30 mgd, two additional parallel SBC trains will be added. At 30 mgd, if one unit is off-line, the plant capacity would decrease by only 25%, compared with 50% capacity reduction for the 15 mgd WTP.

## 9.3 Comparison of Conventional Flocculation/Sedimentation and Sand Ballasted Clarification

Jar tests were conducted in Trussell Tech's Pasadena lab to compare performance of conventional floc/sed with SBC, for both turbidity removal and TOC removal to meet the D/DBP Enhanced Coagulation treatment requirements. Comparison performance for turbidity removal is shown in Figure 9.4, and for percent TOC removal in Figure 9.5. Jar test procedures for each system are different from each other and representative of the flocculation times and settling times for each system. Performance of both systems was comparable and both exceeded the settled water turbidity goal and percent TOC removal goal.

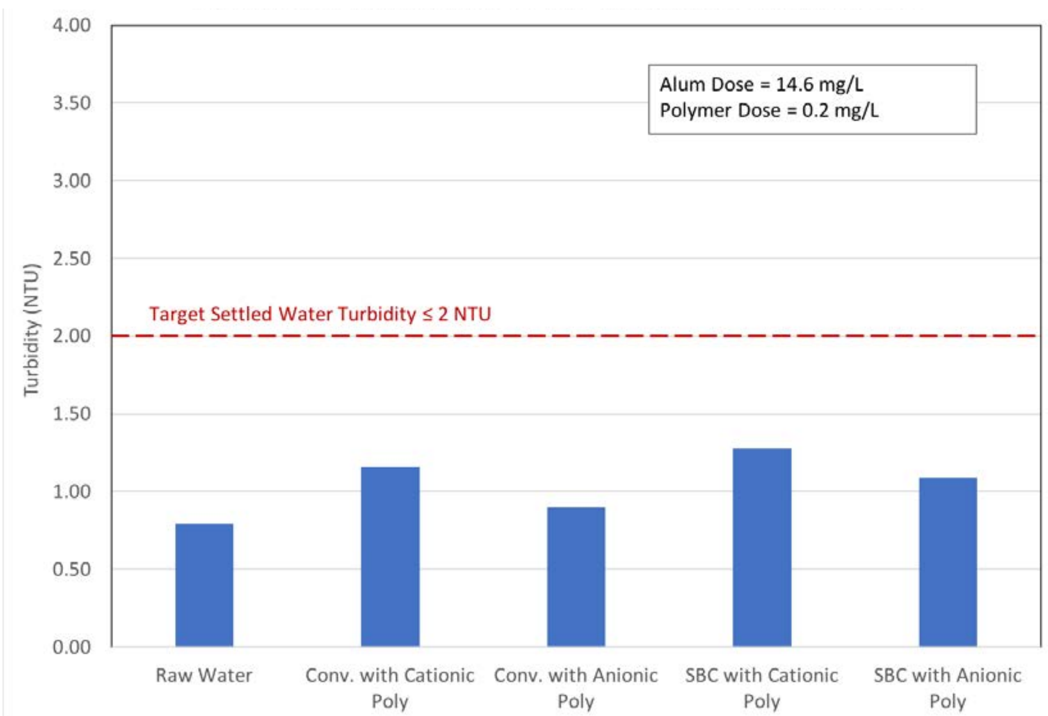


**Figure 9.4 - Comparison of Conventional Clarification vs SBC for Turbidity Removal**

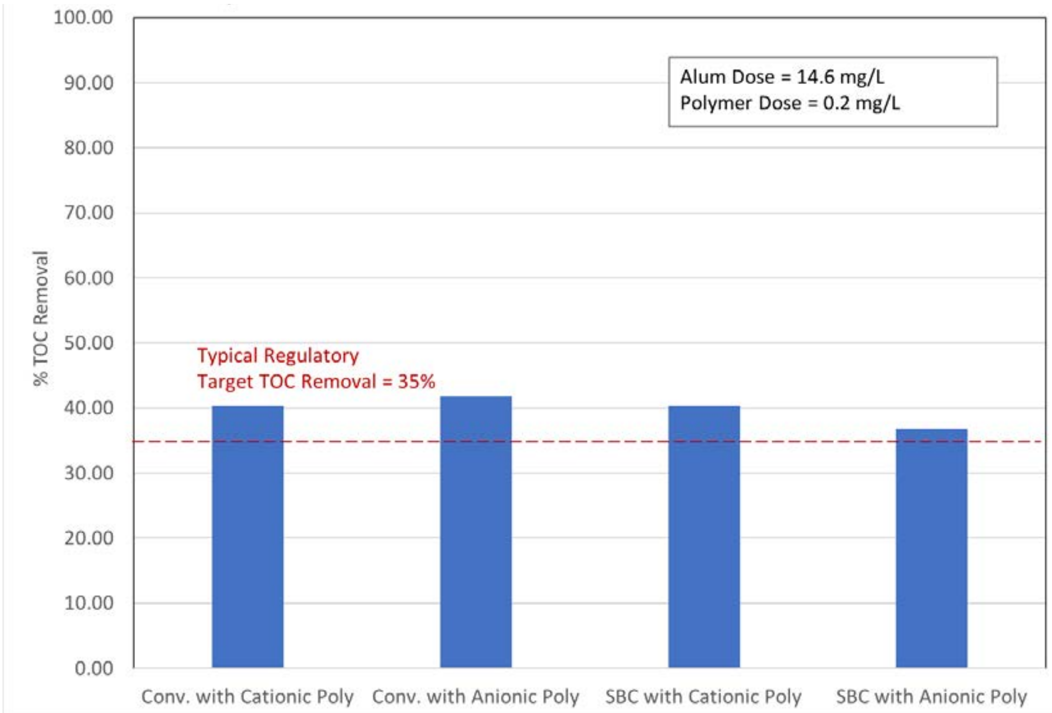


**Figure 9.5 - Comparison of Conventional Clarification vs SBC for Percent TOC Removal**

Both alternatives are robust and are expected to provide effective treatment of SRWA's source water, producing a settled water with turbidity less than the customary target of 2 NTU.

# 10 OZONE TREATMENT

Design criteria for the Reference WTP's ozone treatment process is presented in Table 10.1. Additional discussion below provides background information on the recommended treatment technology, chemical addition requirements, and proposed approaches to expansion and redundancy.

**Table 10.1 - Ozone System Design Criteria**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Number of Trains | no. | 1 | 2 |
| Minimum Pathogen Inactivation Goals: | | | |
| Giardia | log base 10 | 1.0 | 1.0 |
| Virus | log base 10 | 2.0 | 2.0 |
| Location of Ozonation | -- | Intermediate | |
| **Ozone generators** | | | |
| Number of Generators (duty/standby) | no. | 1/1 | 2/1 |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Design Ozone Dose | mg/L | 1.0 | 1.0 |
| Maximum Design Ozone Dose | mg/L | 2.0 | 2.0 |
| Design Ozone Concentration | % by wt. | 10 | 10 |
| Capacity at Maximum Design Ozone Dose | lbs/day | 270 | 541 |
| Generator Production Turndown, Maximum | % | 10 | 10 |
| Power Requirements[1] | kWh/lb $O_3$ | < 4.5 | < 4.5 |
| Cooling Water Source Water – Open Loop | -- | Contactor Influent | |
| Heat Exchanger Type | -- | Plate and Frame | |
| No. Heat Exchangers | no. | 2 | 3 |
| Closed Loop Cooling Water Pump Capacity | gpd | TBD[1] | TBD[1] |
| No. Closed Loop Cooling Water Pumps | no. | 2 | 3 |
| No. Open Loop Cooling Water Pumps (duty/standby) | no. | 1/1 | 2/1 |
| Maximum Cooling Water Temperature (Open Loop) | °C | 78 | 78 |
| Max Open Loop Cooling Water Temperature Rise | °C | 7.5 | 7.5 |
| Open Loop Cooling Water Pump Capacity | gpm | TBD[1] | TBD[1] |
| **LOX Storage and Feed** | | | |
| Oxygen Purity, Minimum | % | 99.5 | 99.5 |
| Required LOX Feed Gas Supply, Total | lb/day | 2700 | 5410 |
| Required LOX Feed Gas Supply, Total | gal/day | 284 | 567 |
| LOX Storage Required | days | 15 | 15 |
| Number of LOX Storage Tanks | no. | 1 | 2 |
| LOX Tank Configuration | | Horizontal | |
| LOX Storage Tank Volume, Minimum, per Tank | gal | 4300 | 4300 |
| LOX Consumption at Maximum Design Dose | gpd | 284 | 568 |
| Type of Vaporizer | -- | Aluminum Ambient Vaporizer | |
| Number of Vaporizers, per Tank (duty/standby) | no. | 1/1 | 1/1 |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Minimum Vaporizer Capacity, each (oxygen) | scfh | 4780 | 4780 |
| Length of LOX Pad | ft | 47 | 47 |
| Width of LOX Pad | ft | 39.5 | 39.5 |
| Nitrogen Boost Type | -- | Duplex Rotary Scroll | |
| Number of Nitrogen Compressors (duty/standby) | no. | 1/1 | 1/1 |
| Number of Dessicant Dryers (duty/standby) | no. | 1/1 | 1/1 |
| **Ozone Injection** | | | |
| Type of Ozone Injection | -- | Side Stream, Venturi | |
| Transfer Efficiency, Minimum | % | 95 | 95 |
| Number of Injectors (duty/standby) | no. | 2/2 | 4/3 |
| Number of Side Stream Pumps (duty/standby) | no. | 2/2 | 4/3 |
| Side Stream Pump Flow Rate | gpm | 223 | 223 |
| Max Side Stream Gas:Liquid Ratio | -- | 0.39 | 0.39 |
| Flash Reactor Type | -- | Inline | |
| Number of Flash Reactors | no. | 2 | 3 |
| Nozzles per Flash Reactor | no. | 2 | 2 |
| Length of Pad, Per Injection System | ft | 12 | 12 |
| Width of Pad, Per Injection System | ft | 8 | 8 |
| **Ozone Contactors** | | | |
| Type of Contactor | -- | Over-under | |
| Number of Contactors | no. | 2 | 4 |
| Design Flow, per Contactor | mgd | 8.12 | 8.12 |
| Design Hydraulic Residence Time for CT, per Contactor | min | 5 (Reactive Zone) | 5 (Reactive Zone) |
| Number of Ozone Contact Chambers, per Contactor | no. | 6 (Reactive Zone) | 6 (Reactive Zone) |
| Volume of Reactive Zone Contact Chambers, each Contactor | gal | 29,172 | 29,172 |
| Total Reactive Zone Contactor Volume | gal | 58,344 | 116,688 |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Length, per Contactor, including walls | ft | 49 | 49 |
| Width, per Contactor, including walls | ft | 16.5 | 16.5 |
| Height of Contactor | ft | 25 | 25 |
| Water Depth, per Contactor | ft | 20 | 20 |
| Depth of Headspace above Water Surface | ft | 5 | 5 |
| Length, per Ozone Contact Chamber, inside dimension | ft | 5.0 | 5.0 |
| Width, per Chamber, inside dimension | ft | 6.5 | 6.5 |
| Volume, per Chamber | cf | 650 | 650 |
| Minimum Baffle Factor ($T_{10}/T$) at Design Flow | -- | 0.6 | 0.6 |
| Height of Baffle Wall | ft | 16 | 16 |
| **Ozone Destruct Systems** | | | |
| Location of Destruct Systems | -- | On Top of Contactor | |
| Type of Destruct Units | -- | Thermal Catalytic | |
| Number of Destruct Systems (duty/standby) | no. | 1/1 | 2/2 |
| Ozone Limit after Destruct System | ppm | 0.1 | 0.1 |
| NA = not applicable | | | |

Footnotes:
[1] Operating at 10% by wt, maximum cooling water temperature, and design ozone production.
[2] Each chamber of the ozone contactor has the same dimensions.

## Background Information

The ozone system will provide primary disinfection for *Giardia* and viruses, treatment for pesticides and other synthetic organic chemicals, and taste and odor control. The minimum pathogen inactivation goals through ozone are 1.0-log treatment of *Giardia* and 2.0-log of virus, which require CTs (i.e., residual concentration x contact time) as specified in the Surface Water Treatment Rule (SWTR) Guidance Manual (USEPA, 1991), as a function of water temperature.

The ozone system has several major components, including liquid oxygen (LOX) storage and vaporization, ozone generation, ozone dissolution and contacting, and ozone off-gas destruction. The LOX storage and vaporization system will store LOX in a cryogenic tank and convert LOX into gaseous oxygen that will be used by the ozone generator to create ozone. The nitrogen boost system will add a small amount of nitrogen (approximately 2% by weight) to the ozone generator feed gas to improve the efficiency of the ozone generation process. Ozone generators will convert 10% of the oxygen to ozone, which will be added to the water flow for disinfection. Each ozone generator will receive power from a power supply unit (PSU), and a closed-loop cooling water system will transfer heat from the ozone generators and power supply units to the open-loop cooling water from the feed to the ozone contactor.

For ozone dissolution and contacting, the water flow will be split between two ozone contactors. Ozone dissolution will be accomplished between this split and the ozone contactors by side stream injection. The side stream injection skids will draw water from the main process pipe after the flow splits to the two contactors. After ozone gas is added to the side stream, the gas and water mixture will be blended with the main process flow in a pipeline flash reactor (PFR). The PFR will have two pairs of nozzles, one for each side stream injection skid. An example of a PFR is shown in Figure 10.1. The feed pipe to each contactor has its own PFR, which will be located immediately before the contactor. Minimizing the distance between the PFR and the contactor will minimize the size of the bubbles entering the contactor by limiting the time available for bubbles to coalesce at the crown of the pipe. Smaller bubbles will maximize the surface area-to-volume ratio and the ozone transfer efficiency. The DB team must consider ways of minimizing bubble size and maximizing ozone transfer efficiency in their ozone dissolution design.

**Figure 10.1 - An example of a PFR with two pairs of nozzles (Mazzei Injector Corp.)**

The ozonated water will enter an over-under contactor with an ozone dissolution chamber followed by 6 contact chambers to provide the required CT and ozone residual dissipation. A schematic of the ozone contactor for the Reference WTP, with side-stream ozone injection, is provided in Figure 10.2. The first chamber of the ozone contactor is the “dissolution chamber,” referred to as the “dissolution zone,” where the ozone is rapidly dissolving into solution and meeting the initial ozone demand of this source water. For the Reference WTP, the ozone concentration in the dissolution chamber is not stable due to bubbles and rapid reaction, and disinfection credit will not be considered for this chamber.

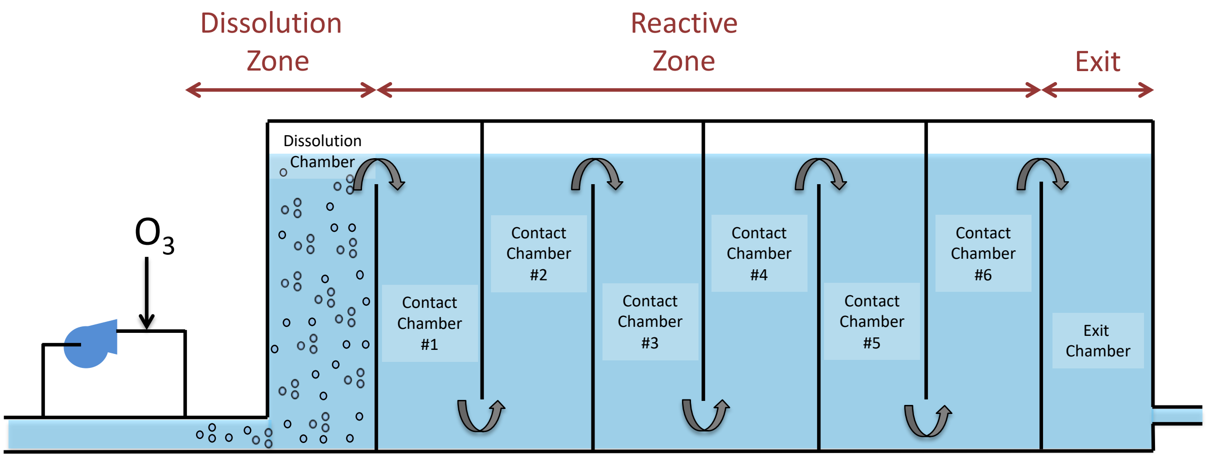


**Figure 10.2 - Zones within Ozone Contactor**

Following the dissolution zone is the “reactive zone,” which is comprised of six ozone contact chambers where disinfection, oxidation and ozone decay (i.e., after meeting the initial ozone demand of the water) occurs. *Giardia* and virus disinfection credit will be accounted for in the reactive zone, using a minimum of three residual ozone analyzers to measure residual ozone concentrations through the contactor. CT credit is calculated through continuous integration of the area under the ozone decay curve (i.e., the Extended Integration Method)—in accordance with the guidelines provided in the SWTR and the Long-Term 2 Enhanced Surface Water Treatment Rule (USEPA, 2006).

Calcium thiosulfate will be added (as needed) at the outlet of the last chamber—the “exit chamber”—to quench any remaining ozone in the water ahead of the biologically active carbon (BAC) dual-media filters. At least one ozone analyzer in the pipe leaving the contactor will confirm the absence of an ozone residual at that location. To address potential taste and odor events, the contactors will have the ability to add hydrogen peroxide to form hydroxyl radicals to help oxidize the chemicals that cause these events.

All chambers of the ozone contactor are the same dimension and volume. A dimensioned cross-section of the ozone contactor is provided in Figure 10.3.

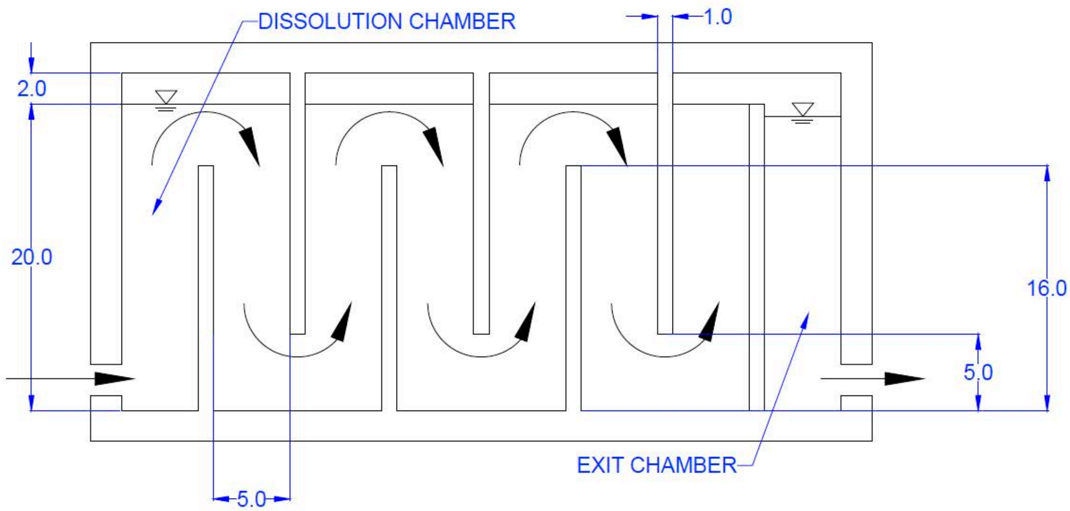


**Figure 10.3 - Cross section of ozone contactor (dimensions in feet)**

The ozone off-gas destruction system will be located on top of the ozone contactors and will draw off-gas from the headspace in the contactors. It will ensure the concentration of ozone in the off-gas does not exceed 0.10 ppm when it is vented to the atmosphere.

## Chemical Addition

LOX will generate the gaseous oxygen needed by the ozone generators to create ozone. Nitrogen gas from ambient air will be added to the ozone generator feed gas to increase the efficiency of the ozone generation process. Ozone will be added to the water between sedimentation and filtration to provide disinfection. Calcium thiosulfate can be added after the ozone contactor to quench residual ozone if it is present at that location.

Bench-scale testing was conducted monthly to determine the design ozone dose required to achieve the CT needed for the required pathogen treatment. This testing was used as the basis for establishing a design ozone dose of 1.0 mg/L and a maximum ozone dose of 2.0 mg/L for the ozone system. For more information on the bench-test results and analysis to establish the design ozone dose, refer to the Seasonal Ozone Demand TM (Trussell Technologies, in preparation).

For additional information about chemical selections, doses, storage requirements, and so on, refer to Section 15 of this TM.

## Redundancy & Expansion

The LOX system of the 15 mgd facility will include one LOX storage tank and two vaporizers. The LOX system will have a supplemental connection to allow a LOX tanker to feed the vaporizers in case there is a problem with the LOX storage tank. The vaporizers are sized for the expansion to 30 mgd, but an additional

LOX tank would need to be added to maintain 15 days of storage at the maximum rate of LOX consumption.

The ozone generation system includes 1 duty and 1 standby generator, with an additional duty generator added for the expansion. Each ozone generator has its own PSU. The nitrogen boost system will be sized for the expansion to 30 mgd. The closed-loop cooling water system will have two heat exchangers, two open-loop cooling water pumps, and two closed-loop cooling water pumps. An additional heat exchanger, open-loop cooling water pump, and closed-loop cooling water pump will be added for the expansion.

The 15 mgd facility will have two ozone contactors, and each contactor will have one duty side stream injection skid, one standby side stream injection skid, and one PFR. To accommodate the expansion, three side stream injection skids (two duty and one standby), one PFR with three pairs of nozzles, and two ozone contactors will be added. The ozone contactors will have the same dimensions as the first two contactors built for this facility.

The ozone destruct of the 15 mgd facility will include one duty ozone destruct unit and one standby ozone destruct unit. For the expansion, the new ozone contactors will require one duty ozone destruct unit and one standby ozone destruct unit. Ozone destruct units will be located on top of the contactors.

# 11 FILTERS

This subsection describes the filtration system for the Reference WTP, including BAC dual media filtration and the backwash water supply. A related element of the filtration system, backwash wastewater handling facilities, is described separately in Section 16.1 of this TM.

Design criteria for the Reference WTP's BAC dual media filtration process is presented in Table 11.1. Additional discussion below provides background information on the recommended treatment technology, chemical addition requirements, and proposed approaches to redundancy and expansion.

**Table 11.1 – Design criteria for dual-media BAC Filters**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Type of Filters | -- | Granular Media Filters with GAC over sand | |
| Number of Filters, Total | no. | 4 | 8 |
| Number of Filters Online | no. | 3 | 6 |
| Number of Filters Offline | no. | 1 | 2 |
| Flow, per Filter | gpm | 3747 | 3747 |
| Filter Rate | gpm/sf | 6.0 | 6.0 |
| Length, per Filter | ft | 37 | 37 |
| Width, per Filter | ft | 17 | 17 |
| Area, per Filter | sf | 629 | 629 |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Depth of GAC Media | in | 48 | 48 |
| GAC Media Effective Size | mm | 1.3 | 1.3 |
| GAC Media Uniformity Coefficient | -- | < 1.4 | < 1.4 |
| Depth of Sand Media | in | 12 | 12 |
| Sand Media Effective Size | mm | 0.5 | 0.5 |
| Sand Media Uniformity Coefficient | -- | 1.4 | 1.4 |
| Depth of Water Above Media | ft | 10.7 | 10.7 |
| Depth of Underdrain: Leopold Type S with IMS Cap or Equivalent | in | 13 | 13 |
| Tank Freeboard | ft | 2 | 2 |
| Overall Depth of Filter Structure | ft | 19 | 19 |
| EBCT for GAC | min | 5 | 5 |
| Minimum Filter Run Time | hr | 24 | 24 |
| **Filter Backwash** | | | |
| Type of Backwash System | -- | Concurrent Air-Scour Wash | |
| First Stage Backwash Rate | gpm/sf | 8 | 8 |
| First Stage Compressed Air Rate | cfm/sf | 3 | 3 |
| Second Stage Backwash Rate | gpm/sf | 22 | 22 |
| Volume per Backwash | gal/sf | 360 | 360 |
| **Filter to Waste** | | | |
| Filter to Waste Rate | gpm/sf | 4.5 | 4.5 |
| Filter to Waste Duration | min | 30 | 30 |
| Filter to Waste Volume, per Backwash | gal | 84297 | 84297 |

## Background Information

The Reference WTP filtration system is designed to remove particulates remaining in the water after sedimentation, as well as biodegradable organics remaining after ozonation. Ozonated water will be fed into the filtration system consisting of four filters for the initial 15 mgd capacity facility, oriented as shown in Figure 11.1. The filters will be designed for a maximum filtration rate of 6 gpm/ft$^2$, assuming one filter is offline for backwash. The filters will be dual-media consisting of granular activated carbon (GAC) over a layer of sand and will be operated as biological filters, with backwash water containing no chlorine residual. The GAC will be selected to meet the design criteria for effective size and uniformity coefficient as specified in Table 11.1. Figure 11.2 shows a section view of the filter design.

In addition to providing effective particulate removal, the combination of pre-ozonation followed by GAC has been shown to substantially reduce TOC concentrations through a combination of adsorption and biodegradation of organics that have been transformed by the ozone into readily biodegradable dissolved organic carbon (DOC) (Westerhoff, 2005). An empty bed contact time (EBCT) of five minutes (assuming the filter loading rate is 6 gpm/ft$^2$) will be achieved to allow for biodegradation of organic matter.

To maintain efficient and effective filtration, the filters will be periodically backwashed with chlorine-free filter effluent. This backwash water will be supplied from a basin that will be gravity fed with filter effluent. Water will exit the filters and flow into a subsequent filter head control basin (see Figure 11.1), with water level controlled by a weir to maintain the water height at or above the elevation of the filter media surface. After exiting the filter head control basin, a portion of the filter effluent will then flow into the backwash supply basin (see Figure 11.1) that will be designed to hold the volume for one filter backwash (assuming a volume per backwash of 360 gal/ft$^2$ ). When this basin is full, filter backwash water will bypass the backwash supply basin and flow directly to the chlorine contact basins. The filling cycle of this backwash supply basin is designed to be completed in 25 minutes (maximum), in time for the next backwash when considering the minimum time between each backwash (6 hours). A pipeline will also connect the clearwell and backwash basin, such that in the event that emergency backwash water is needed, water can be pulled from the clearwell. For information regarding backwash wastewater handling, see Section 16. Design criteria for the dual-media BAC filters is provided in Table 11.1.

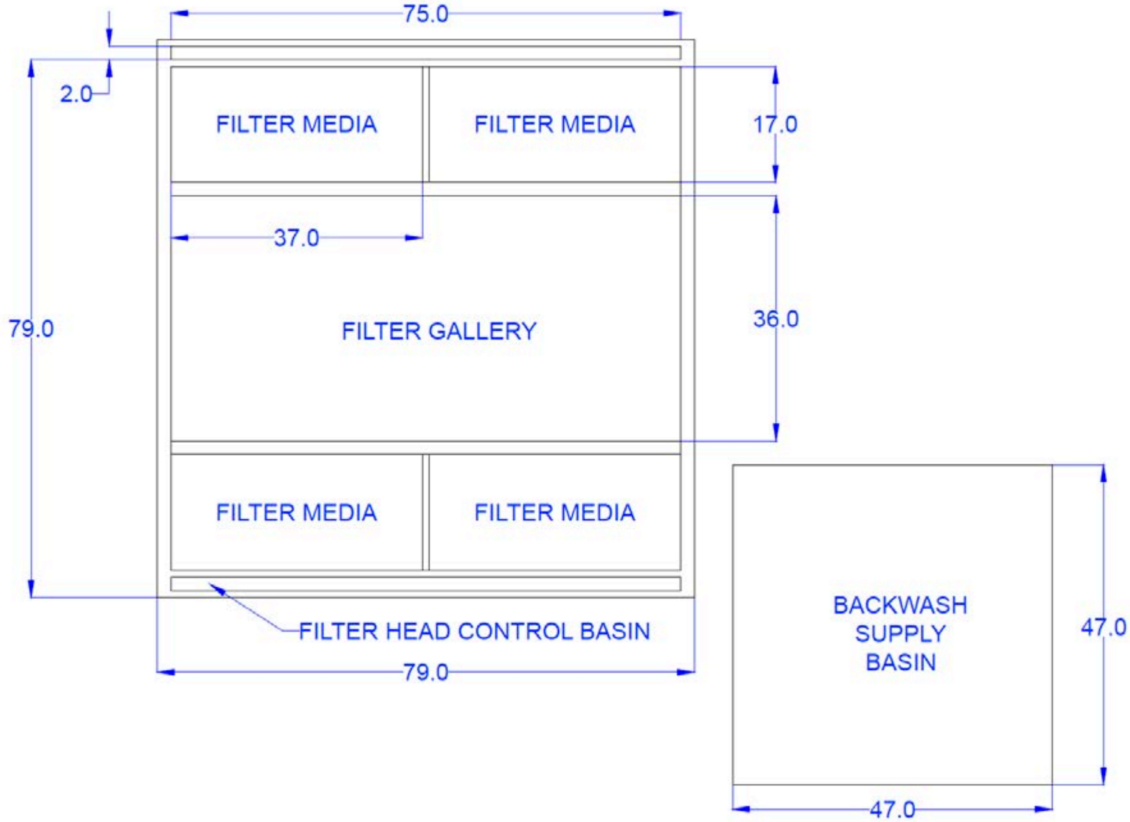


**Figure 11.1 - Plan view of biological active carbon filters and backwash supply basin (dimensions in feet)**

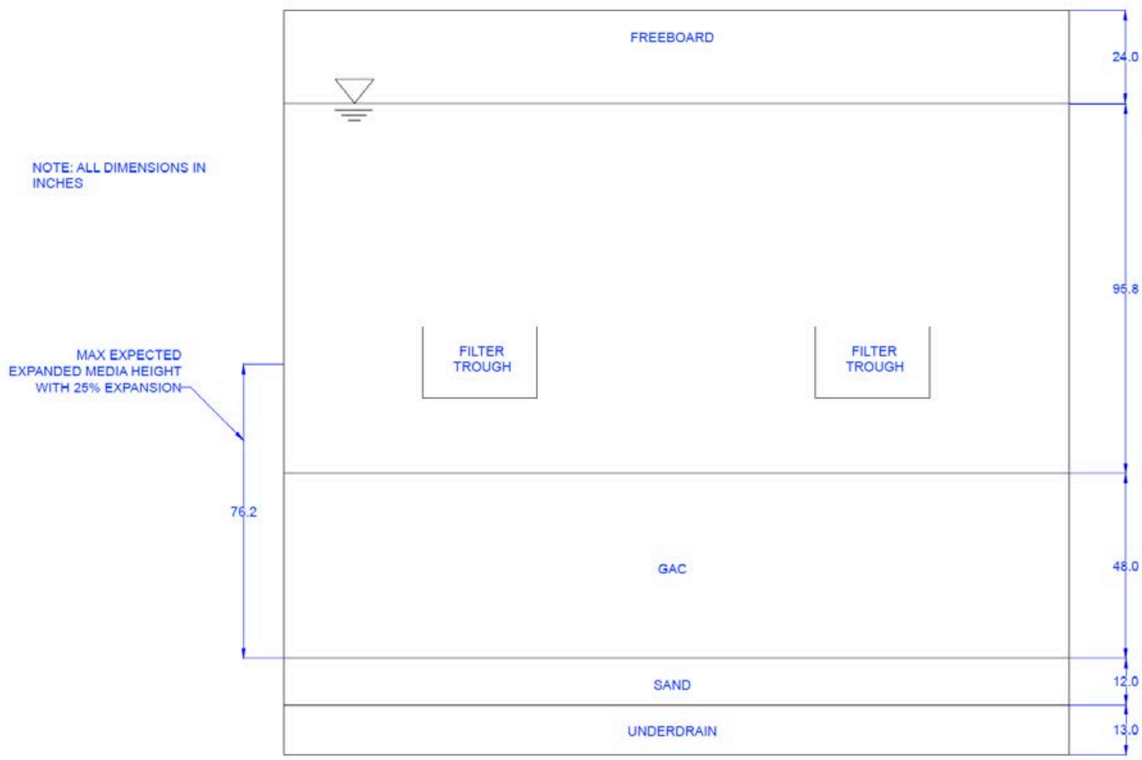


**Figure 11.2 - Section view of biological activated carbon filters (dimensions in inches)**

## Chemical Addition

Polymer will be added on an as-needed basis via a flow-paced dosing system prior to filtration to enhance turbidity removal. For additional information about chemical selections, doses, storage requirements, and so on, refer to Section 15 of this TM.

## Redundancy & Expansion

An additional four identical filters will be added to expand capacity of the WTP to 30 mgd. This design allows for two filters to be offline while still maintaining a filter loading rate of 6 gpm/ft$^2$. With this configuration, one filter can be offline for an extended period to allow for maintenance, while the plant still maintains production capacity at a maximum loading rate of 6 gpm/ft$^2$, with one filter off-line for backwashing. Another advantage to this configuration is that all filters remain the same size, allowing for simplified overall maintenance and backwash design. To expand the system to a capacity of 45 mgd, an additional four identical filters will be added. With a total of twelve filters, the system could operate at a loading rate of 6.0 gpm/ft$^2$ with two filters offline for maintenance and/or backwash.

# 12 CHLORINE CONTACT BASIN

Design criteria for the Reference WTP's chlorine contact basin is presented in Table 12.1. Additional discussion below provides background information on the recommended treatment technology, chemical addition requirements, and proposed approaches to redundancy and expansion.

**Table 12.1 – Chlorine Contact**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Type of Contact Basin | -- | Covered serpentine basin with diffuser walls | |
| Minimum Pathogen Inactivation Requirements: | | | |
| Giardia (Normal/Ozone Offline) | log base 10 | 0.5 / 1.5 | 0.5 / 1.5 |
| Virus (Normal/Ozone Offline) | log base 10 | 1 / 3 | 1 / 3 |
| CT Required for Pathogen Inactivation (Normal Conditions) | mg-min/L | 40.3 | 40.3 |
| CT Required for Pathogen Inactivation (Ozone Offline) | mg-min/L | 153.3 | 153.3 |
| Number of Basins | no. | 2 | 4 |
| Flow Rate per Basin | mgd | 7.5 | 7.5 |
| Water Depth | ft | 15 | 15 |
| Length (inside dimension) | ft | 76 | 76 |
| Width, per Channel (inside dimension) | ft | 7 | 7 |
| Number of Channels | no. | 5 | 5 |
| Number of Diffuser Walls per Basin | no. | 6 | 6 |
| Design Baffle Efficiency ($T_{10}$/T) | -- | 0.75 | 0.75 |
| Theoretical Hydraulic Residence Time | min | 54 | 54 |
| $T_{10}$ | min | 40 | 40 |
| Design Sodium Hypochlorite Residual (Normal Operation) | mg/L | 1 | 1 |
| Design Sodium Hypochlorite Residual (Ozone Offline) | mg/L | 3 | 3 |
| Length-to-Width Ratio | -- | 58 | 58 |

## Background Information

Per initial discussions with DDW, total required pathogen treatment credit for the Reference WTP is 2-log *Cryptosporidium*, 4-log *Giardia* and 5-log virus. Ozonation will provide 1-log *Giardia* and 2-log virus inactivation. By meeting regulatory filter effluent turbidity requirements, filtration will achieve 2-log *Cryptosporidium*, 2.5-log *Giardia*, and 2-log virus treatment credit. The target pathogen inactivation with free chlorine is 0.5-log for *Giardia* and 1-log for virus. The required 2-log *Cryptosporidium* removal is achieved through the filters, and no additional *Cryptosporidium* removal or inactivation is needed with either ozone or free chlorine, since the source water is assumed to fall in Bin 1 of the LT2ESWTR (based on initial source water monitoring data). Under normal operations, when the ozone system is operational, the required 0.5-log *Giardia* and 1-log virus inactivation with free chlorine will be achieved through the chlorine contact basins; no inactivation is accounted for through the clearwell (see Section 13 for design information for the clearwell), even though the water will still maintain a chlorine residual.

The chlorine contact basins will operate in parallel, each treating 7.5 mgd of filtered water. The basins will be identical, with four turns and diffuser walls at the start of each straight run as shown in Figure 12.1. An inlet weir will balance the amount of flow into each basin, and an outlet weir will help to maintain plug flow conditions. Additional design criteria are presented Table 12.1.

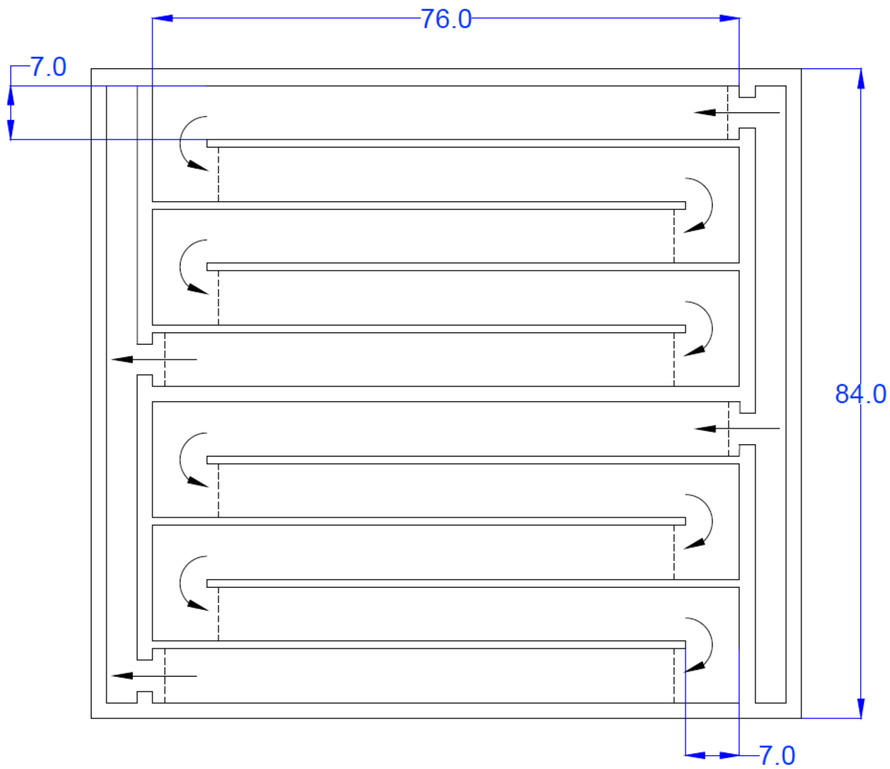


**Figure 12.1 Plan view of chlorine contact basins (dimensions in feet)**

An alternative option to a baffled chlorine contact basin followed by a clearwell is to instead omit the chlorine contact basin and design a baffled clearwell. The regulations currently allow a maximum baffle efficiency ($T_{10}/T$) of 0.1 for unbaffled clearwells, substantially increasing the required volume of the clearwell for CT (product of free chlorine concentration and contact time). If baffles are added to the clearwell, which provide flow structure to maintain more plug-flow hydraulics, the baffle efficiency can increase to > 0.5 (shown through tracer testing of the basin), allowing for a smaller clearwell volume to achieve the desired CT. If this option were selected, the clearwell would need to be designed to achieve the CT required when the ozone system is offline (153.3 mg-min/L).

The design criteria shown in Table 12.1 are associated with the disinfection option that includes a baffled chlorine contact basin followed by a clearwell. The design criteria to define a disinfection system with a baffled clearwell are not included, as a separate chlorine contact basin and clearwell offer the desired option of lime addition prior to the clearwell, as well as flow equalization within the clearwell.

### Chemical Addition

Sodium hypochlorite will be added just prior to the chlorine contact basin via a flow-paced dosing system for disinfection. For additional information about chemical selections, doses, storage requirements, and so on, refer to Section 15 of this TM.

### Redundancy & Expansion

Two parallel basins will be designed to handle half of the total flow (7.5 mgd) with no planned basin redundancy; therefore, in the event that a basin must be taken offline, the total plant flow rate must be reduced to 7.5 mgd. During infrequent periods when the ozone system is offline, the chlorine concentration will be increased to a target residual of 3 mg/L to achieve 1.5-log inactivation of *Giardia* and 3-log inactivation of virus[3]. When ozone is offline, the required pathogen treatment will be achieved through the chlorine contact basin and clearwell combined.

## 13 CLEARWELLS

Design criteria for the Reference WTP's clearwell storage system is presented in Table 13.1. Additional discussion below provides background information on the recommended design approach, chemical addition requirements, and proposed approaches to redundancy and expansion.

[3] A worst-case temperature of 6ºC and pH of 8.3 were used in these CT calculations.

**Table 13.1 – Clearwell Design Criteria**

| Parameter | Units | 15 mgd | Expansion Options | | |
|---|---|---|---|---|---|
| | | | Option 1 | | Option 2 |
| | | | 30 mgd | 45 mgd | 15 mgd to 45 mgd |
| **Storage Requirements** | | | | | |
| Facility Water Demands | MG | 0.8 | 1.5 | 2.3 | 2.3 |
| Reserve for Short-Term Facility Shutdown | MG | 0.6 | 1.3 | 1.9 | 1.9 |
| Operational Storage | MG | 1.9 | 3.8 | 5.6 | 5.6 |
| Emergency Chlorine CT Volume, Minimum Clearwell Volume | MG | 1.1 | 2.3 | 3.4 | 3.4 |
| **Sizing** | | | | | |
| Total Clearwell Volume | MG | 4.4 | 8.8 | 13.1 | 13.1 |
| Total No. of Clearwells | No. | 2 | 3 | 4 | 3 |
| Theoretical HRT through CT Storage Volume | min | 217 | 217 | 217 | 217 |
| Design Baffle Efficiency | -- | 0.1 | 0.1 | 0.1 | 0.1 |
| Diameter, per Clearwell | ft | 136 | 193 | 193 | 273 |
| Water Depth, Maximum, per Clearwell | ft | 20 | 20 | 20 | 20 |

## Background Information

The Reference WTP design for the initial production capacity of 15 mgd will include two clearwells, with 7.5 mgd flowing through each, with each clearwell capable of storing half of the desired finished water storage volume. The clearwells are sized to provide storage for (a) facility water demands, (b) reserve water in case of a short-term facility shutdown, (c) operational storage that is sufficient to balance facility production and pumping rates, and (d) additional pathogen disinfection with free chlorine in the event the plant's ozone system is off-line.  Assumptions used for each of these sizing categories are as follows:

- **Facility water demands** – Minimum of 5% of daily production capacity
- **Short-term facility shutdown** – Minimum of 60 minutes flow at treatment capacity
- **Operational Storage** – Minimum of 3 hours flow at treatment capacity
- **Emergency free chlorine disinfection** – Minimum storage volume to provide a HRT necessary to achieve the log credits for *Giardia* and virus inactivation that are normally provided by ozone.  A temperature of 6ºC, pH

of 8.3, and baffle efficiency of 0.1 were used to determine the required CT and associated storage volume.

During normal operation, the CT required to receive 0.5-log giardia and 1-log virus inactivation credit will be achieved in the chlorine contact basin; however, during infrequent periods of time when the ozone system is offline, additional inactivation of 1-log giardia and 2-log virus (normally achieved with ozone) must be achieved with free chlorine. Therefore, when the ozone system is offline 1.5-log giardia and 3-log virus inactivation will be achieved in the clearwell and chlorine contact basin combined. When CT is achieved in the clearwell, a minimum storage volume must be maintained in each clearwell (see Table 13.1 "Emergency Chlorine CT Volume"). The clearwells are sized such that this emergency volume of water is always available, and so the system can respond immediately and still achieve the full CT required for pathogen inactivation if the ozone system suddenly goes down. However, because the two clearwells each offer only half of the required storage, the flow would need to be reduced to 7.5 mgd if one clearwell was offline at the same time the ozone system is offline.

## Chemical Addition

Chemical addition points and mechanical mixing for carbon dioxide and lime are included after the chlorine contact basin but prior to the clearwells. Lime and carbon dioxide can be dosed at a level that is consistent with post-treatment stabilization (i.e., pH or LSI) required for both Ceres and Turlock. Additional corrosion inhibitor will be added after the clearwells and will be tailored to the specific needs of each City's distribution system (see Section 14.1 for additional information). A built-in control system will automatically reduce the lime dose in the event that ozone goes offline, in order to maintain the lower pH required to achieve CT for pathogen inactivation[4]. Finally, to make fine-tune adjustment of final pH before distribution, caustic can be metered to the finished water for each City.

If the disinfection design is modified to omit the chlorine contact basin and include a baffled clearwell, it is recommended that lime and carbon dioxide addition be moved to after the clearwell, to maintain an appropriate pH for disinfection. Otherwise, significantly more CT – meaning an increase in clearwell volume – will be required to achieve the desired CT for pathogen inactivation. For additional information about chemical selections, doses, storage requirements, and so on, refer to Section 15 of this TM.

## Redundancy & Expansion

The clearwells and connecting piping will also be designed to hydraulically accommodate the total 15 mgd flow if one clearwell must be taken off-line for

[4] Lime raises the pH of the water, resulting in a shift in hypochlorous acid (HOCl) / hypochlorite ($OCl^-$) speciation towards OCl- which is less effective for disinfection and leads to a lower CT for pathogen inactivation

maintenance; however, there will not be complete redundancy: when one tank is out of service, only half of the desired storage volume will be available.

Several alternatives exist for expanding clearwell capacity to 30 mgd. In the first alternative (Option 1), an additional clearwell capable of storing 4.4 MG could be constructed such that the total clearwell storage volume would be 8.8 MG (see Table 13.2). This would result in three separate clearwells, and the need for a fourth clearwell to be added when the facility is expanded to 45 mgd. To minimize the number of clearwells, an alternative design strategy (Option 2) would be to add one larger tank capable of storing 8.8 MG, such that the total clearwell volume for the 30-mgd plant would be equal to 13.1 MG, the same amount anticipated to be required for a 45-mgd facility. In this alternative, only three tanks would be required for the 45-mgd facility, with the added benefit of additional redundancy when the plant capacity is 30 mgd. In addition to Table 13.2, these expansion alternatives are also shown on the Site Layout (Appendix C).

**Table 13.2 – Clearwell expansion alternatives**

| Plant Capacity | Option 1 | Option 2 |
|---|---|---|
| 15 mgd | 2 tanks @ 2.2 MG each<br>**Total volume: 4.4 MG** | |
| 30 mgd | 2 tanks @ 2.2 MG each<br>1 tank @ 4.4 MG<br>**Total volume: 8.8 MG** | 2 tanks @ 2.2 MG each<br>1 tank @ 8.8 MG<br>**Total volume: 13.1 MG** |
| 45 mgd | 2 tanks @ 2.2 MG each<br>2 tanks @ 4.4 MG each<br>**Total volume: 13.1 MG** | 2 tanks @ 2.2 MG each<br>1 tank @ 8.8 MG each<br>**Total volume: 13.1 MG** |

## 14 FINISHED WATER

The following sections describe the final processes of the Reference WTP, including finished water stabilization to inhibit corrosion and the finished water pump station for distribution of the drinking water to cities of Ceres and Turlock.

## 14.1 Finished Water Stabilization

The purpose of finished water stabilization is to produce a finished water that will minimize the potential for corrosion-related aesthetic issues (i.e., red water associated with iron release and black water associated with manganese release and oxidation) and regulatory water quality issues (i.e., elevated lead and copper concentrations) at the consumer's tap. Two key tasks related to minimizing corrosion potential and delivering a high-quality drinking water to each City's consumers are (1) preparation of the existing groundwater distribution system ahead of surface water integration, and (2) producing a finished water that does not destabilize existing corrosion scale in the Cities' systems when the scale is re-equilibrating to new water quality conditions. The Reference WTP allows each City to independently select finished water pH, chlorine residual, and corrosion inhibitor doses to meet the specific needs of its distribution system.

The typical parameters that are considered for finished water stabilization are the pH, Langelier Saturation Index (LSI), alkalinity, and hardness. Accurate characterization of these parameters in the Reference WTP's finished water as well as the existing groundwater will be important to minimize corrosion potential. Chemicals typically used for stabilizing, and reducing the corrosion potential, of a soft water with low alkalinity are lime (for adjusting the hardness and alkalinity) and carbon dioxide (for pH adjustment). Other chemicals such as calcium chloride and caustic can be used, but the less expensive and easiest to control choices are lime with carbon dioxide.

The Cities are each currently conducting a surface water integration study to evaluate corrosion potential, optimum finished water stabilization and "ramp-up" schedule for their individual systems. Establishing finished water quality targets for each City, including whether phosphate-based corrosion inhibitors are required, and if so, the type(s) and dose(s) of corrosion inhibitor(s), has not yet been decided. Accordingly, selection of corrosion inhibitor(s) cannot be completed until the Integration Studies have been finished.

For the purposes of this TM, assumptions have been made regarding targets for finished water pH and LSI. Additionally, it has been assumed that lime and carbon dioxide will be used to adjust finished water pH and LSI, as this is a typical strategy for finished water stabilization; however, results from the integration studies may change these assumptions. The assumed target finished water quality conditions were presented in Table 4.1. The process flow diagram (PFD) (Appendix B) also shows the addition of a corrosion inhibitor to the finished water so that this chemical addition point is not overlooked; the doses and type of corrosion inhibitor will be decided during the integration study.

The following sections describe the design criteria and additional background information on the assumed finished water stabilization chemicals—lime and carbon dioxide addition.

### 14.1.1 Lime

Design criteria for the Reference WTP's lime addition for finished water stabilization are presented in Table 14.1. Additional discussion below provides background information on the recommended treatment technologies, chemical addition requirements, and proposed approaches to redundancy and expansion.

**Table 14.1 - Lime system design criteria**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Preferred Lime System | -- | Hydrated | Hydrated or Slaker - TBD |
| Total Number of Lime Silo(s) | No. | 1 | 2 |
| Type of Stored Lime | -- | $Ca(OH)_2$ | $Ca(OH)_2$ or CaO - TBD |
| Design Lime Dosage | mg/L as $Ca(OH)_2$ | 29 | 29 |
| Storage Duration for Design Dosage | Days | 30 | 30 |
| Storage Capacity, minimum | Tons, $Ca(OH)_2$ | 60 | 60 |
| Total Number of Slaker(s) / Slurry Prep Tank(s) (duty/standby) | No. | 1/0 | 2/0 |
| Total Number of Fine Grit Classifiers (duty/standby) | No. | 1/0 | 2/0 |
| Total Number of Slurry Aging Tanks (duty/standby) | No. | 1/0 | 2/0 |
| Total Number of Dosing Assemblies (duty/standby) | No. | 2/2 | 4/2 |
| Total Number of Slurry Loop Pumps (duty/standby) | No. | 1/1 | 2/2 |
| Total Number of Mixer Motors (duty/standby) | No. | 1/1 (shelf stdby) | 2/2 (shelf stdby) |

## Background Information

The water quality of the Reference WTP's filter effluent will have a pH and LSI much lower than the finished water targets defined in Table 4.1. Lime is therefore added to chlorine contact basin effluent to stabilize the water by increasing the alkalinity, calcium concentration, and pH, which also increases the LSI. LSI is calculated as:

$$LSI = pH - pH_s$$

Where: pH = measured pH
$pH_s$ = saturation pH, where alkalinity and calcium are at equilibrium with solid calcium carbonate

Because SRWA's source water has a very low buffering capacity (average alkalinity = 32.8 mg/L as $CaCO_3$), adding lime to increase the calcium concentration causes the pH to increase well above the upper limit of the target range defined in Table 4.1. To maintain pH within the target range, the preferred approach is to concurrently add carbon dioxide, which is discussed in Section 14.1.2, with additional discussion of carbon dioxide system options discussed in Appendix E.

## Chemical Addition

Working with lime at full-scale can be messy, potentially hazardous, and can increase the turbidity of the finished water, either due to the grit and inert particles the bulk chemical contains, or due to the formation of calcium carbonate if the chemistry of the process is not carefully controlled. Depending on the purity of the starting point lime (e.g., quick lime or hydrated lime) a lime saturator may be required for controlling finished water turbidity and for control of the metered dose.

Two proprietary systems that are known to minimize turbidity increases (e.g., increases ≤ 0.2 NTU) are (1) the Cal-Flo® liquid lime system by Burnett Lime Company, Inc. and (2) the RDP Tekkem Slaking system or RDP Tekkem Hydrated Lime system by RDP Technologies, Inc. The RDP Tekkem systems use precise weight control to prepare aged lime slurry that maintains an accurate and constant calcium concentration. The Burnett Cal-Flo® system meters a 30% lime slurry that is prepared from air classified hydrated lime to minimize particulates and maximize purity of the lime slurry. The 30% lime slurry is delivered to the site so that operators never have to deal with the dry lime.

With the RDP Tekkem system, the lime slurry is prepared in batches, with direct weight control operation to precisely control the amount of lime and water added to each batch. The RDP system operates either as (1) a lime slaker starting with dry quick lime (CaO) and ending with batches of hydrated 10% lime slurry, or (2) a precision hydrated lime system starting with dry hydrated lime ($Ca(OH)_2$) and ending at the same point with aged batches of hydrated 10% lime slurry. With both the RDP lime slaker system and the RDP hydrated lime system, the fine grit classifier is recommended to be used to remove grit and inert particulates from the hydrated lime. The lime slurry endpoint is the same with both RDP lime systems.

For the purpose of this Reference WTP predesign, the RDP Tekkem system is included in the design criteria table (Table 14.1). Because the hydrated lime system is cleaner and easier to work with, is it assumed that the SRWA WTP will start with the precision hydrated lime system, with the option of converting to a lime slaker system to increase storage capacity upon expansion to 30 mgd.

## Redundancy & Expansion

For the RDP Tekkem system, redundancy is required for the dosing assemblies and the pumps and motors, as indicated in Table 14.1. Redundancy is not required for the storage silo.

When the WTP expands from 15 mgd to 30 mgd, a duplicate lime storage, slaking and metering system is required, with a capacity identical to the lime system for the 15 mgd facility.

### 14.1.2 Carbon Dioxide

Design criteria for the Reference WTP's carbon dioxide ($CO_2$) addition for finished water stabilization are presented in Table 14.2. Additional discussion below provides background information on the recommended treatment technologies, chemical addition requirements, and proposed approaches to redundancy and expansion.

**Table 14.2 - Carbon dioxide system design criteria**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Total number of CO2 storage tanks | no. | 1 | 2 |
| Type System | -- | Direct CO2 injection | |
| Design dosage | mg/L as CO2 | 26 | 26 |
| Storage duration | days | 30 | 30 |
| Storage capacity | tons | 50 | 50 |
| Total number of vaporizers (duty/standby) | no. | 1/0 | 2/0 |
| Total number of refrigeration units (duty/standby) | no. | 1/0 | 2/0 |

## Background

Carbon dioxide is to be added prior to lime so that the pH of the water is low when lime is added to the flow, which minimizes calcium carbonate precipitation that can increase the turbidity. Dissolution of lime and $CO_2$ into water is not instantaneous, so adequate mixing distances must be provided.

## Chemical Addition

Two types of $CO_2$ injection systems are available: (1) a pressurized solution feed system as manufactured by TOMCO$_2$ Systems Company, where the $CO_2$ is added to a side stream of water which is then injected into the main process flow, and (2) direct $CO_2$ gas injection into the main process flow as manufactured by Burnett Lime Company, Inc.

For the purpose of site layout and design criteria for this pre-design report, the Burnett Company's direct $CO_2$ injection system is considered. Major system components of this system include $CO_2$ storage tank, vaporizer, refrigeration unit, PLC and Feed Control Panel. Note that Burnett Lime Company has patented the process of adding $CO_2$, followed by lime and then mixing (RE-MIN Process®). Design criteria are summarized in Table 14.2.

Chemical selections and dosages summarized in this section are estimates and are expected to be revisited and refined during and/or following completion of the Cities' planned surface water integration studies.

### Redundancy & Expansion

The carbon dioxide pressurized solution feed system does not require redundancy because there are few mechanical parts and no pumps that may break and need maintenance. With the type of system considered for this Reference WTP design, the two key parts of the system are the vaporizer and refrigeration units. The feed system can continue to operate and provide $CO_2$ even if one of these units is down for maintenance. If the refrigeration system goes offline, excess $CO_2$ can be released from pressure relief valves until the system can be fixed. The system is also designed to provide early warning in the event that the vaporizer is not working. This warning provides enough time to either fix the vaporizer with spare parts stored onsite or shipped overnight from the manufacturer. Therefore, neither the vaporizer or refrigeration units require redundancy.

When the WTP expands from 15 mgd to 30 mgd, an additional carbon dioxide system must be added.

## 14.2 Finished Water Pump Station

Design criteria for the Reference WTP's finished water pump station is presented in **Table 14.3**. Additional discussion below provides background information on the recommended design approach, chemical addition requirements, and proposed approaches to redundancy and expansion.

**Table 14.3 - Finished water pump station design criteria**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Total Number of Pump Stations | no. | 1 | 1 |
| **Ceres – Duty Pumps** | | | |
| Type of Pump | -- | Vertical turbine, in cans | |
| Speed | -- | Variable | |
| Number of Pumps (duty/standby) | no. | 1/1* | 2/1* |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Capacity, per Pump | gpm | 3472 | 3472 |
| Firm Capacity | mgd | 5.0 | 10.0 |
| Total Dynamic Head | ft | 92 | 116 |
| Water Horsepower, Total | hp | 82 | 209 |
| Wire-to-Water Horsepower**, per Pump | hp | 114 | 145 |
| Minimum Motor Size, per Pump | hp | 150 | 150 |
| **Turlock – Duty Pumps** | | | |
| Type of Pump | -- | Vertical turbine, in cans | |
| Speed | -- | Variable | |
| Number of Pumps (duty/standby) | no. | 2/1* | 4/1* |
| Capacity, per Pump | gpm | 3472 | 3472 |
| Firm Capacity | mgd | 10.0 | 20.0 |
| Total Dynamic Head | ft | 105 | 131 |
| Water Horsepower, Total | hp | 183 | 458 |
| Wire-to-Water Horsepower**, per Pump | hp | 127 | 159 |
| Minimum Motor Size, per Pump | hp | 175 | 175 |
| **Swing Standby Pump** | | | |
| Type of Pump | -- | Vertical turbine, in can | |
| Speed | -- | Variable | |
| Number of Pumps (duty/standby) | no. | 1/0 | 1/0 |
| Capacity, per Pump | gpm | 3472 | 3472 |
| | mgd | 5.0 | 5.0 |
| Total Dynamic Head | ft | 104 | 127 |
| Minimum Motor Size, per Pump | hp | 175 | 175 |

* Standby pumping capability provided by common "swing" standby pump
** Assumes pump and motor efficiencies of 80 and 90 percent, respectively

## Background Information

Each City will have separate pumping facilities for sending finished water to their respective finished water transmission mains and distribution systems. For the Reference WTP, a single pump station structure was selected to house each

City's pumps. Within the structure, a series of vertical turbine pumps would be installed in cans and would draw water from pipes connected to the clearwells. Each City would have a dedicated set of duty pumps but would share a single "swing" standby pump capable of providing backup pumping capacity to either City should a duty pump fail or be taken offline for planned maintenance. Each set of pumps would discharge into separate discharge headers leading to the respective finished water transmission mains. All finished water pumps would be equipped with variable frequency drives to facilitate pump turndown to meet a range of finished water demands.

### Chemical Addition

Several chemicals would be added to the finished water at the finished water pump station (i.e., suction side of pumps for effective chemical mixing), including sodium hypochlorite, sodium hydroxide and each City's selected corrosion inhibitor (e.g., phosphoric acid). The chemical injection locations would be chosen so that each City has the ability to adjust dosing independent of the other.

For additional information about chemical selections, doses, storage requirements, and so on, refer to Section 15 of this TM.

### Redundancy & Expansion

As described above, the Reference WTP's finished water pump station assumes the use of a single standby pump capable of servicing either City's finished water pumping needs in the event that a duty pump fails or is offline for planned maintenance. The "swing" standby pump would be identical in capacity to all of the duty pumps (i.e., 3,472 gpm or 5.0 mgd), but would be capable of meeting the higher TDH requirements associated with Turlock's longer transmission main.

As the Reference WTP expands beyond 15 mgd, additional duty pumps would be added. At the 30 mgd expansion, the number of duty pumps would double. Although the capacity of each pump would remain the same (3,472 gpm), the TDH experienced by each set of pumps would increase based on the higher head losses in the discharge piping and transmission main. While the number of pumps installed for the 15 mgd condition would only provide up to 15 mgd of flow capacity, it is assumed that the impellers and motors would be sized to handle the increased TDH requirements associated with the expansion to 30 mgd.

It is assumed that the finished water pump station structure would be initially sized to accommodate the number of pumps required for the 30 mgd condition, including installation of pump cans for future use. The pump station structure would need to be physically enlarged when the WTP expands to 45 mgd.

## 15 CHEMICALS

Design criteria for the Reference WTP's various chemicals, including assumed dosages, point(s) of application, and typical concentrations of bulk chemicals are presented in Table 15.1. Bulk chemical storage should be designed to provide 30 days of storage for all chemicals shown in Table 15.1, with the exception of sodium hypochlorite, which should be limited to 15 days of supply due to potential for degradation to chlorate, which is a regulated parameter with a California drinking water Notification Level of 0.8 mg/L.

Chemical feed locations throughout the treatment train are found on the PFDs shown in Appendix B.

**Table 15.1 – Design criteria for Reference WTP chemicals**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| **Lime ($Ca(OH)_2$)** | | | |
| **Purpose:** Finished water stabilization. Lime increases the alkalinity, calcium concentration, and pH, which also increases the LSI | | | |
| Point of Application #1 | Raw water, ahead of permanganate addition | | |
| Typical Chemical Form | -- | Hydrated Lime ($Ca(OH)_2$) Slurry | |
| Typical Chemical Concentration | % | 10% | |
| Type of Feed System | -- | RDP Tekkem Slaker or RDP Tekkem Hydrated Lime System | |
| Minimum Dosage | mg/L as $Ca(OH)_2$ | 1 | |
| Average Dosage | mg/L as $Ca(OH)_2$ | 7 | |
| Maximum Dosage | mg/L as $Ca(OH)_2$ | 13 | |
| Rationale for Dosages | -- | Lime dosages offset alkalinity consumed by alum coagulant | |
| Point of Application #2 | Finished Water Ahead of Clearwell | | |
| Minimum Dosage | mg/L as $Ca(OH)_2$ | 13 | |
| Average Dosage | mg/L as $Ca(OH)_2$ | 29 | |
| Maximum Dosage | mg/L as $Ca(OH)_2$ | 53 | |
| Rationale for Dosages | -- | Stabilization to provide LSI of -0.1 to +0.2 | |
| **Sodium Permanganate ($NaMnO_4$)** | | | |
| **Purpose:** Oxidation of reduced manganese. | | | |
| Point of Application | Raw water, ≥ 1 min ahead of coagulant addition | | |
| Typical Chemical Form | -- | Liquid | |
| Typical Chemical Concentration | % | 20 | |
| Type of Feed System | -- | Liquid Chemical Feed | |
| Minimum Dosage | mg/L as $NaMnO_4$ | 0 | |
| Average Dosage | mg/L as $NaMnO_4$ | 0.2 | |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| (assumes 0.1 mg/L $Mn^{2+}$) | | | |
| Maximum Dosage, (assumes 0.3 mg/L $Mn^{2+}$) | mg/L as $NaMnO_4$ | 0.5 | |
| Rationale for Dosages | -- | Avg = assumed 0.1 mg/L $Mn^{2+}$<br>Max = assumed 0.3 mg/L $Mn^{2+}$ | |
| **Aluminum Sulfate ($Al_2(SO_4)_3$)** | | | |
| **Purpose:** Primary coagulant for particulate removal. | | | |
| Point of Application | | Flash Mix | |
| Typical Chemical Form | -- | Liquid | |
| Typical Chemical Concentration | % | 35 - 45 | |
| Type of Feed System | -- | Liquid Chemical Feed | |
| Minimum Dosage | mg/L as $Al_2(SO_4)_3 \cdot 14H_2O$ | 10 | |
| Average Dosage[2] | mg/L as $Al_2(SO_4)_3 \cdot 14H_2O$ | 15 | |
| Maximum Dosage | mg/L as $Al_2(SO_4)_3 \cdot 14H_2O$ | 30 | |
| Rationale for Dosages | -- | See enhanced coagulation jar tests report[1] | |
| **Cationic Polymer** | | | |
| **Purpose:** Promotes larger floc formation and improves particulate settling and removal | | | |
| Typical Chemical Form | -- | Liquid | |
| Type of Feed System | -- | Liquid Chemical Feed | |
| Point of Application #1 | | Flash Mix | |
| Minimum Dosage | mg/L | 0.2 | |
| Average Dosage | mg/L | 0.5 | |
| Maximum Dosage | mg/L | 2.0 | |
| Rationale for Dosages | -- | Typical dosages | |
| Point of Application #2 | | Gravity Thickener Influent | |
| Minimum Dosage | mg/L | 0.5 | |
| Average Dosage | mg/L | 2.5 | |
| Maximum Dosage | mg/L | 5.0 | |
| Rationale for Dosages | -- | Typical dosages | |
| Point of Application #3 | Dewatering – Sludge Drying Bed (As Needed) | | |
| Minimum Dosage | mg/L | 0.1 | |
| Average Dosage | mg/L | 2.5 | |

| Parameter | Units | 15 mgd | 30 mgd |
| --- | --- | --- | --- |
| Maximum Dosage | mg/L | 5.0 | |
| Rationale for Dosages | -- | Typical dosages | |
| **Anionic or Nonionic Polymer** | | | |
| **Purpose:** Flocculant aid and particle destabilization | | | |
| Typical Chemical Form | -- | Dry or Liquid | |
| Type of Feed System | -- | Liquid Chemical Feed | |
| Point of Application #1 | -- | 3rd Stage of Flocculation | |
| Minimum Dosage | mg/L | 0.05 | |
| Average Dosage | mg/L | 0.1 | |
| Maximum Dosage | mg/L | 0.2 | |
| Rationale for Dosages | | Typical dosages | |
| Point of Application #2 | -- | Common Filter Influent | |
| Minimum Dosage | mg/L | 0.01 | |
| Average Dosage | mg/L | 0.02 | |
| Maximum Dosage | mg/L | 0.1 | |
| Rationale for Dosages | -- | Typical dosages | |
| Point of Application #3 | -- | Backwash Basin Influent | |
| Minimum Dosage | mg/L | 0.1 | |
| Average Dosage | mg/L | 0.2 | |
| Maximum Dosage | mg/L | 0.8 | |
| Rationale for Dosages | -- | Typical dosages | |
| **Ozone ($O_3$)** | | | |
| **Purpose:** Disinfection and break-down of total organic carbon (i.e., DBP precursors) and organic contaminants (e.g., pesticides) into more readily biodegradable material for removed via biological filtration | | | |
| Point of Application | -- | Immediately ahead of Ozone Contactor | |
| Typical Chemical Form | | Gas, On-Site Generation from Liquid Oxygen (LOX) | |
| Typical Chemical Concentration | % by wt. | 10 | |
| Type of Feed System | -- | Side Stream, Venturi, Injection | |
| Minimum Dosage | mg/L | 0.7 | |
| Average Dosage | mg/L | 1.0 | |
| Maximum Dosage | mg/L | 2.0 | |
| Rationale for Dosages | -- | Dose to achieve minimum of 1-log Giardia inactivation and 2-log virus inactivation[2]. | |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| **Liquid Oxygen ($O_2$)** | | | |
| **Purpose:** Source of oxygen for ozone generation | | | |
| Point of Application | -- | Ozone generators | |
| Oxygen Purity, Minimum | % | 99.5 | |
| Number of LOX Storage Tanks | No. | 1 LOX tank (15 mgd WTP)<br>2 LOX tanks (30 mgd WTP) | |
| Required LOX Feed Gas Supply | lbs/day | 2700 (15 mgd WTP)<br>5410 (30 mgd WTP) | |
| **Hydrogen Peroxide – If Needed ($H_2O_2$)** | | | |
| **Purpose:** Advanced oxidation for enhanced organic contaminant (e.g., pesticides) removal | | | |
| Point of Application | -- | Exit of 3rd Ozone Contactor Chamber | |
| Typical Chemical Form | -- | Liquid | |
| Typical Chemical Concentration | % | 30 - 50 | |
| Type of Feed System | -- | Liquid Chemical Feed | |
| Minimum Dosage | mg/L as $H_2O_2$ | 0.1 | |
| Average Dosage | mg/L as $H_2O_2$ | 0.5 | |
| Maximum Dosage | mg/L as $H_2O_2$ | 1.0 | |
| Rationale for Dosages | -- | Typical doses | |
| **Calcium Thiosulfate ($CaS_2O_3$)** | | | |
| **Purpose:** Quenches residual residual ozone prior to biological filtration | | | |
| Point of Application | -- | Exit of Ozone Contactor | |
| Typical Chemical Concentration | % | 24 | |
| Type of Feed System | -- | Liquid Chemical Feed | |
| Minimum Dosage | mg/L as $CaS_2O_3$ | 0 | |
| Average Dosage | mg/L as $CaS_2O_3$ | 0.16 | |
| Maximum Dosage | mg/L as $CaS_2O_3$ | 1.6 | |
| Rationale for Dosages | -- | Avg = Bench-Scale Ozone Demand Test results[2]<br>Max = Quench full max dose | |
| **Sodium Hypochlorite (NaOCl)** | | | |
| **Purpose:** Disinfection | | | |
| Typical Chemical Form | -- | Liquid | |
| Typical Chemical Concentration | % | 12.5 | |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Type of Feed System | -- | Liquid Chemical Feed | |
| Point of Application | -- | Chlorine Contact Basin Influent | |
| Minimum Dosage | mg/L as $Cl_2$ | 1.0 | |
| Average Dosage | mg/L as $Cl_2$ | 2.0 | |
| Maximum Dosage | mg/L as $Cl_2$ | 5.0 | |
| Point of Application | | Finished Water for Each City at the finished water pump station | |
| Minimum Dosage | mg/L as $Cl_2$ | 1.0 | |
| Average Dosage | mg/L as $Cl_2$ | TBD, depends on detention time in distribution system | |
| Maximum Dosage | mg/L as $Cl_2$ | 4.0 | |
| Rationale for Dosages | -- | Maintain chlorine residual through distribution system | |
| **Carbon Dioxide ($CO_2$)** | | | |
| **Purpose:** pH adjustment for finished water stabilization | | | |
| Point of Application | -- | Ahead of Clearwell and Prior to Lime Addition | |
| Type of Feed System | -- | Direct Gas Injection or Aqueous Solution Injection | |
| Storage Capacity | tons | 50 | |
| Storage Duration | Days | 30 days at average dose | |
| Minimum Dosage | mg/L as $CO_2$ | 8 | |
| Average Dosage | mg/L as $CO_2$ | 26 | |
| Maximum Dosage | mg/L as $CO_2$ | 45 | |
| Rationale for Dosages | -- | pH adjustment of finished water to achieve final pH or LSI targets | |
| **Sodium Hydroxide (Caustic - NaOH)** | | | |
| **Purpose:** pH adjustment to target specific pH for each City | | | |
| Typical Chemical Form | -- | Liquid | |
| Typical Chemical Concentration | % | 25 - 50 | |
| Type of Feed System | -- | Liquid Chemical Feed | |
| Point of Application | | Finished Water for Each City at the finished water pump station | |
| Minimum Dosage | mg/L as NaOH | TBD | |
| Average Dosage | mg/L as NaOH | TBD | |
| Maximum Dosage | mg/L as NaOH | TBD | |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Rationale for Dosages | -- | Target finished water pH for corrosion control in City's distribution system | |
| **Phosphoric Acid (Specific Corrosion Inhibitor TBD – $PO_4$)** | | | |
| **Purpose:** An option for corrosion control | | | |
| Point of Application | Finished Water for Each City at the finished water pump station | | |
| Typical Chemical Form | -- | Liquid | |
| Typical Chemical Concentration | % | 75 | |
| Type of Feed System | -- | Liquid Chemical Feed | |
| Minimum Dosage | mg/L as $PO_4$ | TBD | |
| Average Dosage | mg/L as $PO_4$ | TBD | |
| Maximum Dosage | mg/L as $PO_4$ | TBD | |
| Rationale for Dosages | | Doses will be selected as part of Cities' integration studies | |

**Footnotes:**
[1] *Stanislaus Regional Water Authority Water Supply Project Bench Test Results – TM1, November 2016 through February 2017*, Trussell Technologies, October 2017
[2] *Stanislaus Regional Water Authority Water Supply Project Bench Test Results – TM2, Seasonal Ozone Demand*, Trussell Technologies, March 2018

# 16 WASTE TREATMENT AND SOLIDS HANDLING

In accordance with anticipated provisions of SRWA's Domestic Water Supply Permit, the Reference WTP's waste treatment and solids handling systems must be designed to limit return streams to no more than 10% of the plant's finished water flow and must ensure that the turbidity of the return streams does not exceed 2 NTU. Individual elements of these systems are described below in sections 16.1 (Backwash Solids Handling Basins), 16.2 (Solids Thickening), 16.3 (Solids Drying Beds), and 16.4 (Recycle Equalization Basin).

The PFD for the Reference WTP's solids handling systems is shown in Appendix B.

## 16.1 Backwash Solids Handling Basins (BSHBs)

Design criteria for the Reference WTP's backwash solids handling process are presented in Table 16.1. The criteria presented are based on the design criteria for the filters described in Section 11, specifically that each filter will have a 24-hour run time and generate 360 gal/sf of BWW per backwash. Additional discussion below provides background information on the recommended treatment technology, chemical addition requirements, and proposed approaches to redundancy and expansion.

**Table 16.1 – Design Criteria for Filter Backwash Solids Handling Basins**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Number of In-Line Mechanical Mixers (with VFD) | No. | 1 | 2 |
| Polymer Type | -- | Nonionic | |
| Polymer Dose, Design | mg/L as polymer | 0.2 | |
| Number of Filter Backwash Basins | no. | 2 | 3 |
| Number of Backwashes Held per Basin | no. | 1.5 | 1.5 |
| Volume per Backwash | gal | 226,440 | 226,440 |
| Volume per Basin (Including sludge settling area plus 50%) | gal | 424,600 | 424,600 |
| Water Depth per Backwash Basin (Max) | ft | 20 | 20 |
| Water Depth per Backwash Basin (Min) | ft | 4 | 4 |
| Tank Freeboard | ft | 2 | 2 |
| Length per Backwash Basin | ft | 40 | 40 |
| Width per Backwash Basin | ft | 71 | 71 |
| Maximum Batch Time (Minimum Time Between Backwashes) | min | 360 | 360 |
| Basin Fill Time | min | 30 | 30 |
| Solids Settling Time | min | 180 | 180 |
| Sludge/Decant Pumping Time | min | 150 | 150 |
| Decant Pumping Rate (with VFD) | gpm | 1,456 | 1,456 |
| Number of Decant pumps (duty/standby) | No. | 4/1 | 6/1 |
| Minimum Decant Pump Capacity, per pump | gpm | 728 | 728 |
| Total Suspended Solids in Backwash Water | mg/L | 72 | 72 |
| % Volume as Settled Solids | % | 0.2 | 0.2 |

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Vol Sludge Produced per Backwash | gal | 8,117 | 8,117 |
| Number of Sludge Collectors Per Basin | No. | 2 | 2 |
| Sludge Collector Type | -- | Hoseless Sludge Collector | |
| Sludge Collector Drive Type | -- | VFD | |
| Sludge Pumping Rate (with VFD) | gpm | 55 | 55 |
| Number of Sludge Pumps (duty/standby) | No. | 2/1 | 3/1 |
| Minimum Sludge Pump Capacity, per pump | gpm | 55 | 55 |

## Background Information

During backwashing of the Reference WTP's filters, solids dislodged from the filter media will be carried away with the filter backwash water. The BSHBs allow settling of solids from the filter backwash water, with subsequent pumping of decant to the recycle equalization basin and sludge to the solids thickeners. The BSHBs will operate in batch mode, where the fill, settle, decant, and sludge removal steps occur prior to a new delivery of filter backwash water. Each basin is designed to finish a batch within six hours, which is the estimated worst-case time between backwashes. The BSHB is a rectangular basin with two hoseless sludge collectors in each basin that reach across the entire basin, and pump sludge to the solids thickeners. Decant water (supernatant) will drain from a pipe located 4 feet from the basin floor and will be pumped to the recycle equalization basin. For additional detail, see Figure 16.1.

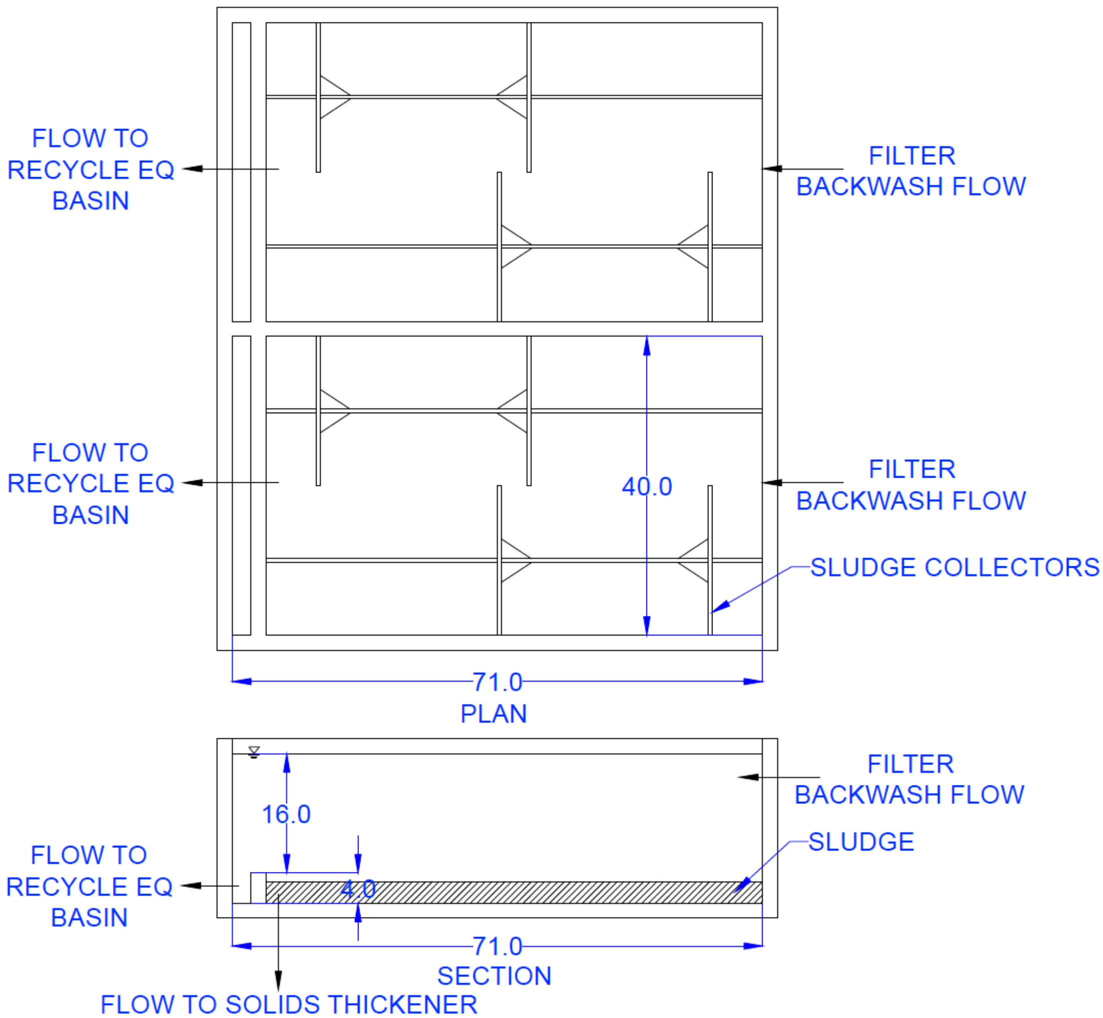


**Figure 16.1 - Plan and section view of the backwash solids handling basins (dimensions in feet)**

## Chemical Addition

A chemical metering pump will deliver a flow-paced dose of nonionic polymer to the backwash water prior to entering the BSHB. A variable speed in-line mechanical mixer will provide sufficient mixing of the polymer and the solids. For additional information about chemical selections, doses, storage requirements, and so on, refer to Section 15 of this TM.

## Expansion & Redundancy

The design of the BSHB offers 100% redundancy, as each basin will complete one cycle (fill, settle, decant, and sludge removal) within 6 hours, which is the minimum amount of time between backwashes assuming each filter has a 24-hour run time. Therefore, if one basin is taken offline for maintenance, the other basin could handle all backwashes so long as the minimum time between each backwash is 6 hours. This redundancy offers operational flexibility such that the filters could be backwashed out of sequence, or the plant could handle periods of degraded water quality that result in reduced filter run times (< 24 hours). Additionally, each basin is designed to handle 1.5 times the volume of a single backwash to allow for flexibility in the length of backwash time.

To expand the total capacity to 30 mgd, one additional basin will be added such that three basins could be operated in parallel. This design would maintain redundancy such that one basin could be taken offline for maintenance.

## 16.2 Solids Thickening

Design criteria for the Reference WTP's solids thickening process are presented in Table 16.2. These criteria are based on the design criteria for the Sedimentation Basins presented in Section 9. Additional discussion below provides background information on the recommended treatment technology, chemical addition requirements, and proposed approaches to redundancy and expansion.

**Table 16.2 - Gravity thickener design criteria**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Polymer Type | -- | Cationic | |
| Polymer Dose, Design | mg/L | 2.5 | |
| Total number of Gravity Thickeners | no. | 2 | 3 |
| Assumed Percent Solids of Un-Thickened Sludge | % | 0.2 | 0.2 |
| Assumed Percent Solids of Thickened Sludge | % | 2 | 2 |
| Hydraulic Loading Rate | gpm/sf | 0.10 | 0.06 |
| Solids Loading Rate | lb/sf/day | 4.2 | 4.2 |
| Diameter per Gravity Thickener | ft | 40 | 40 |
| Water Depth per Gravity Thickener | ft | 16.5 | 16.5 |
| Tank Freeboard | ft | 2 | 2 |
| Sludge Production Rate per Gravity Thickeners (at 2% solids) | gpd | 31,750 | 63,500 |
| Number of Sludge Pumps (duty/standby) | No. | 1/1 | 2/1 |
| Minimum Sludge Pump Capacity (per pump) | gpm | 11 | 11 |

### Background Information

The solids thickeners are 40-ft diameter gravity thickeners that will receive un-thickened solids from both the sedimentation basins (described in Section 9) and the BSHBs. The un-thickened solids will enter the gravity thickeners, settle and thicken in the bottom, and be scraped into a hopper. The thickened solids will be pumped to the solids drying beds. Decant water (i.e., supernatant) from the gravity thickeners will flow by gravity to the recycle equalization basin.

### Chemical Addition

Chemical metering pumps will deliver a flow-paced dose of cationic polymer to the backwash solids flow prior to entering the solids thickeners. To provide adequate mixing of the polymer with the sludge, a minimum of 100 pipe diameters must be provided between the polymer addition point and the entrance to the thickeners. Additionally, cationic polymer will be fed to the thickened sludge to aid in solids settling and subsequent dewatering in the drying beds. For more information about chemical selections, doses, storage requirements, and so on, refer to Section 15 of this TM.

### Redundancy & Expansion

Normal operations include two gravity thickeners operating in parallel at 50% capacity each, but each gravity thickener has the ability to accommodate 100% of the solids and flow while the other is offline. Solids are pumped from the gravity thickeners one at a time.

To expand the capacity to 30 mgd, one additional gravity thickener would be added to provide redundancy such that one thickener could be offline for maintenance.

## 16.3 Solids Drying

Design criteria for the Reference WTP's solids drying process are presented in Table 16.3. These criteria are based on the design criteria for the solids thickeners described previously. Additional discussion below provides background information on the recommended treatment technology and proposed approaches to redundancy and expansion.

**Table 16.3 - Solids drying bed design criteria**

| Parameter | Units | 15 mgd |
|---|---|---|
| No. of Drying Beds | no. | 4 |
| Fill Time per Bed | days | 120 |
| Drain and Dry Time per Bed | days | 365 |
| Spreading Depth per Fill | ft | 6 |
| Fill Volume per Bed | gal | 3,666,700 |
| Fill Area | sf | 81,700 |
| L:W ratio | -- | 2.25 |
| Width | ft | 190 |
| Length | ft | 430 |
| Solids Loading Rate | lb/sf | 7.0 |

| Parameter | Units | 15 mgd |
|---|---|---|
| Number of Decant Pump Stations | No. | 2 |
| Minimum Decant Pump Capacity | gpm | 5 |

## Background Information

The Reference WTP utilizes four solids drying beds for the initial 15-mgd plant capacity. The beds are sized assuming one duty and three standby solids drying beds. Each of the solids drying beds are designed to accept the amount of sludge produced in four months from the solids thickeners, assuming maximum solids loading (worst-case scenario). The solids drying beds have been sized to allow for a spreading depth of 6 feet and 2 feet of freeboard.

One bed will be filled for a period of four months, whereupon the thickened solids will be routed to the next bed while the first one dries. With sequential filling, the solids in the first bed will be allowed to dry for a full year prior to being removed and returning the bed to service. The drying beds will allow for passive drying of the solids. After a bed is full, decant will be drawn from the basins after an initial thickening period to speed drying time. This will be achieved by manually adjusting a downward opening slide gate leading to a decant pump station, and the stations will be placed such that one station can pump decant from two adjacent basins to the recycle equalization basin. The solids will be stored in the bottom of the drying bed until they are hauled to a landfill.

## Redundancy & Expansion

Based on the design criteria in Table 16.3, there is not enough available land on the WTP site to accommodate more than two additional solids drying beds for the WTP expansion to 30 mgd, whereas the above solids production estimates would require four additional beds when the plant expands to 30 mgd. If drying beds are ultimately selected for SRWA's WTP, it is suggested that SRWA monitor the performance of the solids drying beds during operation of the 15 mgd plant to assess solids dewatering requirements for the 30 mgd facility. If more than two additional beds will be required, supplemental mechanical dewatering capabilities would likely be required to provide adequate solids dewatering capacity. Appendix F of this TM summarizes the advantages and disadvantages of several mechanical dewatering options.

# 16.4 Recycle Equalization Basin

Design criteria for the Reference WTP's recycle equalization process are presented in Table 16.4. These criteria are based on the decant rates from the BSHB, solids thickeners, and solids drying beds described in previous sections. Additional discussion below provides background information on the recommended treatment technology and proposed approaches to redundancy and expansion.

**Table 16.4 - Recycle Equalization Basin Design Criteria**

| Parameter | Units | 15 mgd | 30 mgd |
|---|---|---|---|
| Number of Recycle Equalization Basins | no. | 1 | 1 |
| Design Capacity, per Basin | gal | 140,000 | 140,000 |
| Maximum Water Depth | ft | 20 | 20 |
| Minimum Water Depth | ft | 1 | 1 |
| Basin Diameter | ft | 42 | 42 |
| Basin Freeboard | ft | 2 | 2 |
| Minimum Number of Recycle Pumps (duty/standby) | no. | 1/1 | 2/1 |
| Minimum Pump Capacity, per Pump | gpm | 1040 | 1040 |

## Background Information

The recycle equalization basin will equalize water from the following WTP processes and procedures:

- Decant water from the BSHBs
- Filter to waste following filter backwashes
- Supernatant from the gravity thickeners
- Decant water from the solids drying bed

It is assumed that flushing and/or pigging of the raw water pipeline bringing water from the Tuolumne River to the WTP will not be needed because the source water has low turbidity year-round. Other miscellaneous facility flows, such as waste streams from water quality analyzers, will be returned to the head of the plant. However, any waste flows with chemicals or that are otherwise not appropriate for being returned to the head of the plant will be sent to the onsite septic systems.

Flows to the recycle equalization basin are pumped back to the head of the WTP prior to Pre-oxidation, targeting a return flow of less than 10% of the finished water flow. The recycle equalization basin is designed for continuous flow delivery. Emergency overflows from the recycle equalization basin would be discharged to one of the drying beds.

## Redundancy & Expansion

To expand this design to a capacity of 30 mgd, no additional equalization tank is required – all design waste flows for the 30 mgd facility can be equalized in one 42-foot diameter tank (the same is true for a 45 mgd capacity facility). Figure 16.2 shows the expected variance in the tank water level for the different facility sizes. The largest pulses of water that go through the waste handling processes and must be equalized in the recycle equalization basin are the filter backwash water and filter to waste streams. These flows also make up the majority of the total allowable return flow rate (> 80%), where the maximum return flow can be ≤ 10% of the plant capacity. The 15 mgd facility is expected to have the most variance in return flows because the system is designed to handle four backwashes per day, where each backwash sends a pulse to the equalization basin of ~ 20% of the total volume allowed to be recycled per day. With an increased capacity to 30 mgd (and associated increase of the allowable return flow rate), eight filters could be backwashed per day, with each backwash producing ~ 10% of the total volume recycled per day. Therefore, as the facility size increases and the volume of waste associated with one backwash decreases compared to the total allowable recycle volume, less volume is required in the recycle equalization basin.

The equalization basin is designed to handle a maximum water level of 20 feet, but during typical operation the water level is not expected to exceed 14 feet; however, infrequent flows from raw water flushing, raw water pigging, and miscellaneous facility overflows are not incorporated into this analysis. Therefore, the excess capacity provided by the equalization basin is designed to more than accommodate these additional flows.

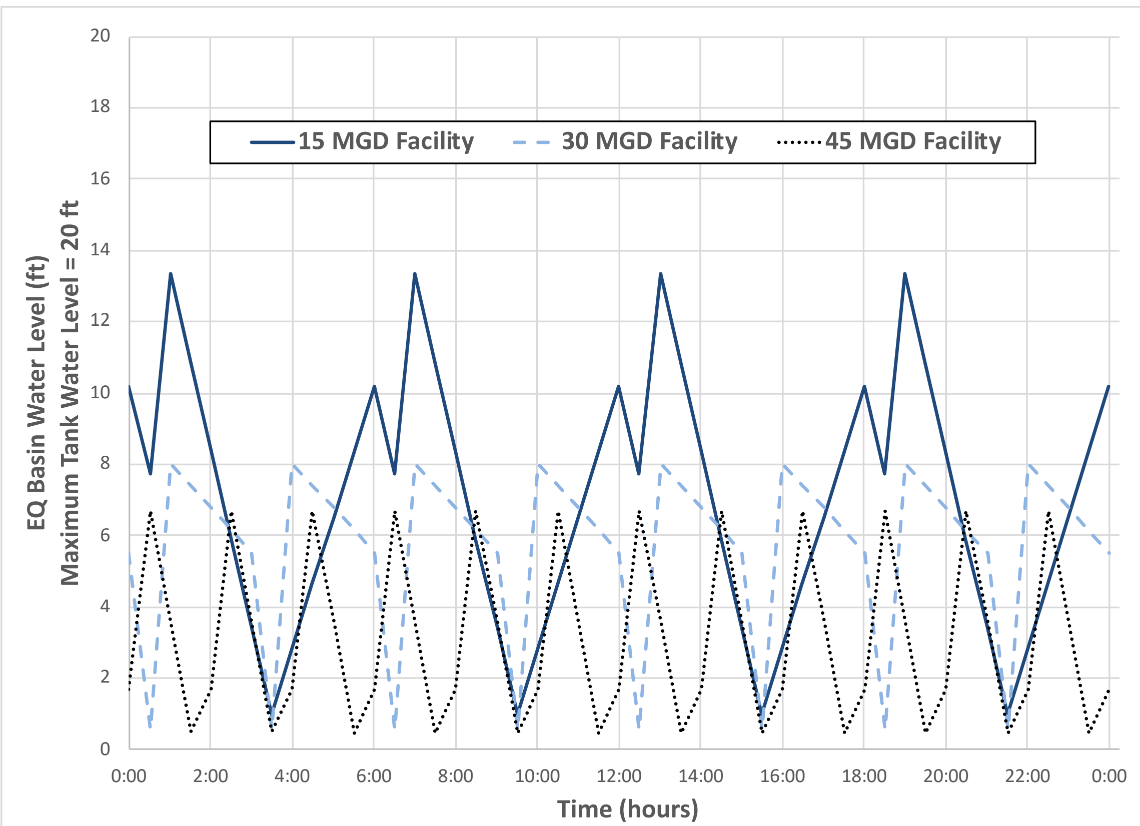


**Figure 16.2 - Equalization basin water level**

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## APPENDICES

- **Appendix A:** Statistical Summary of 2006-2008 and 2016-2017 Datasets for the Tuolumne River at the Infiltration Gallery Location
- **Appendix B:** Process flow diagrams for 15 mgd water treatment plant
- **Appendix C:** Site Layout
- **Appendix D:** Hydraulic profile for 15 mgd water treatment plant
- **Appendix E:** Discussion of lime system options for finished water stabilization
- **Appendix F:** Discussion of mechanical dewatering options

## Appendix A. Statistical Summary of 2006-2008 and 2016-2017 Datasets for the Tuolumne River at the Infiltration Gallery Location

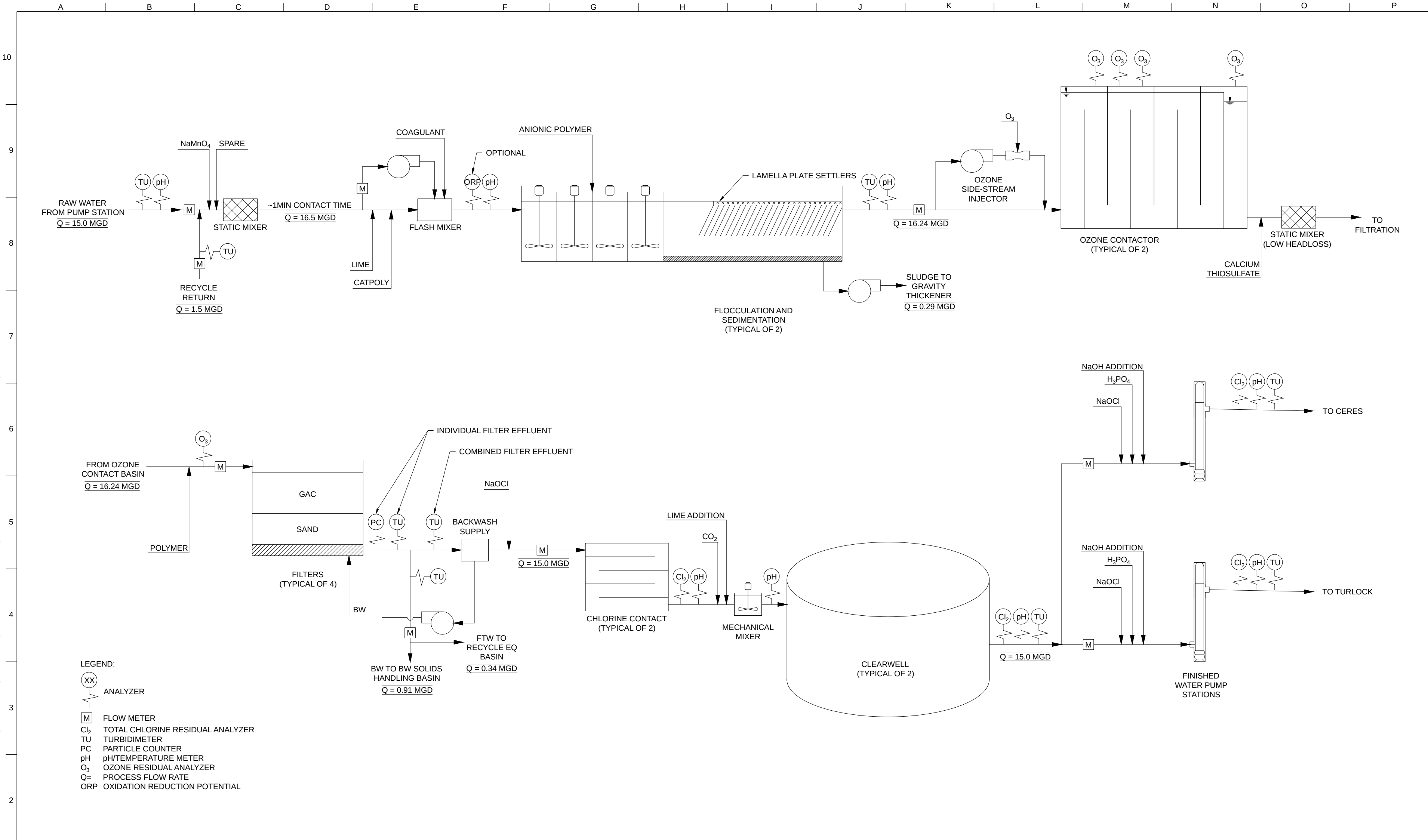
| Analyte | Units | 2006-2008 | | | | | 2016-2017 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Meadian | Avg | N | Min | Max | Median | Avg | N |
| **General Water Characteristics (Physical and Chemical)** | | | | | | | | | | | |
| Alkalinity, Total | mg/l as CaCO3 | 23 | 80 | 37 | 37 | 40 | 11 | 26 | 20 | 18.5 | 15 |
| Ammonia | mg/l as N | <0.1 | <0.1 | <0.1 | <0.1 | 11 | <0.050 | 0.059 | <0.050 | 0.051 | 12 |
| Bromide | mg/l | <0.1 | <0.1 | <0.1 | <0.1 | 30 | <0.005 | 0.0088 | <0.005 | 0.0061 | 12 |
| Calcium | mg/l | 5 | 11 | 9.2 | 9.2 | 23 | 2.7 | 5.9 | 4.6 | 4.5 | 4 |
| Chloride | mg/l | 2.1 | 11 | 4.8 | 5.1 | 5 | <1.0 | 2.9 | <1.0 | 1.5 | 4 |
| Color | Color Units (ACU) | <1 | 10 | 5 | 4 | 14 | 5 | 20 | 7.5 | 10 | 4 |
| Dissolved Oxygen | mg/l | 7.9 | 14.5 | 10.5 | 10.6 | 66 | 9.2 | 11.7 | 10.2 | 10.3 | 24 |
| Iron, Total | mg/l | <0.050 | 6.5 | <0.10 | 0.19 | 94 | 0.032 | 0.68 | 0.24 | 0.33 | 15 |
| Iron, Dissolved | mg/l | No Data | | | | | <0.020 | 0.098 | 0.037 | 0.049 | 15 |
| Magnesium | mg/l | 2.2 | 5.6 | 4.3 | 4.4 | 23 | 0.97 | 2.6 | 1.6 | 1.7 | 4 |
| Manganese, Total | mg/l | <0.010 | 0.85 | 0.017 | 0.029 | 95 | 0.01 | 0.21 | 0.015 | 0.03 | 15 |
| Manganese, Dissolved | mg/l | No Data | | | | | <0.0020 | 0.013 | <0.0020 | 0.0039 | 15 |
| Nitrate | mg/l as N | 0.29 | 0.86 | 0.43 | 0.47 | 19 | <0.10 | 0.53 | 0.13 | 0.22 | 12 |
| Nitrite | mg/l as N | <0.1 | <0.1 | <0.1 | <0.1 | 6 | <0.050 | <0.050 | <0.050 | <0.050 | 12 |
| Odor | Odor units | <1 | 4 | <1 | 1 | 13 | 2 | 2 | 2 | 2 | 4 |

| Analyte | Units | 2006-2008 | | | | | 2016-2017 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Meadian | Avg | N | Min | Max | Median | Avg | N |
| Organic carbon, Dissolved (DOC) | mg/l | 1.3 | 4 | 2.4 | 2.5 | 47 | 1.8 | 4.4 | 2.1 | 2.4 | 15 |
| Organic carbon, Total (TOC) | mg/l | 1.4 | 6.5 | 3 | 3.3 | 47 | 1.8 | 7.3 | 2.3 | 2.8 | 14 |
| pH (Field Measurement) | pH units | 6.7 | 8.3 | 7.4 | 7.4 | 68 | 7.2 | 8.2 | 7.7 | 7.6 | 19 |
| Specific Conductance (Field Measurement) | µS/cm | 33 | 201 | 77 | 90 | 67 | 20.8 | 68.2 | 44.8 | 46.4 | 24 |
| Sulfate | mg/l | 2.3 | 6.5 | 3 | 3.5 | 5 | 1 | 3.6 | 2.0 | 2.1 | 4 |
| Temperature | ºC | 4.4 | 27.7 | 15.2 | 16 | 70 | 7.6 | 16.6 | 12.1 | 12.7 | 24 |
| Total Solids, Dissolved (TDS) | mg/l | <30 | 150 | 64 | 61 | 54 | 25 | 54.0 | 37.5 | 38.5 | 4 |
| Total Solids, Suspended (TSS) | mg/l | <5 | 62 | <5 | 6.5 | 37 | <10 | <10 | <10 | <10 | 4 |
| Turbidity (Field Measurement) | NTU | 0.62 | 7.3 | 2 | 2.3 | 72 | 0.59 | 25.6 [A] | 2.9 | 4.4 | 24 |
| **Inorganic Contaminants** | | | | | | | | | | | |
| Aluminum | mg/L | <0.020 | 0.29 | 0.046 | 0.091 | 5 | 0.046 | 0.53 | 0.11 | 0.2 | 4 |
| Barium | mg/L | 0.02 | 0.1 | Not Reported | 0.04 | 4 | 0.0078 | 0.018 | 0.014 | 0.013 | 4 |
| Chromium, VI | mg/L | No Data | | | | | 2.8E-5 | 3.8E-5 | 3.5E-5 | 3.4E-5 | 4 |
| **Microbiological Parameters** | | | | | | | | | | | |

| Analyte | Units | 2006-2008 | | | | | 2016-2017 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Meadian | Avg | N | Min | Max | Median | Avg | N |
| Coliform, Total | MPN/100 mL | 4 | >1600 | 130 | 282 | 73 | 380 | >2420 | 2400 | 1953 | 24 |
| *Cryptosporidium* | oocysts/L | 0 | 0.09 | 0 | 0.004 | 24 | 0 | 0.1 | 0 | 0.008 | 12 |
| *E. coli* | MPN/100 mL | 0 | 160 | 12.7 | 24 | 24 | 6.3 | 460 | 40 | 73.4 | 24 |
| *Giardia* | cysts/L | 0 | 2 | 0.09 | 0.33 | 12 | 0 | 0.4 | 0 | 0.075 | 12 |

[A] The maximum turbidity was measured after conclusion of the SRWA Phase 1 sampling program. This maximum value was not included in the calculated average or median values. The maximum turbidity measured during the SRWA Phase 1 sampling program was 15.4 NTU.

## Appendix B. Process flow diagrams for 15 mgd water treatment plant

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IF NOT SCALE ACCORDINGLY

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DESIGNED BY :
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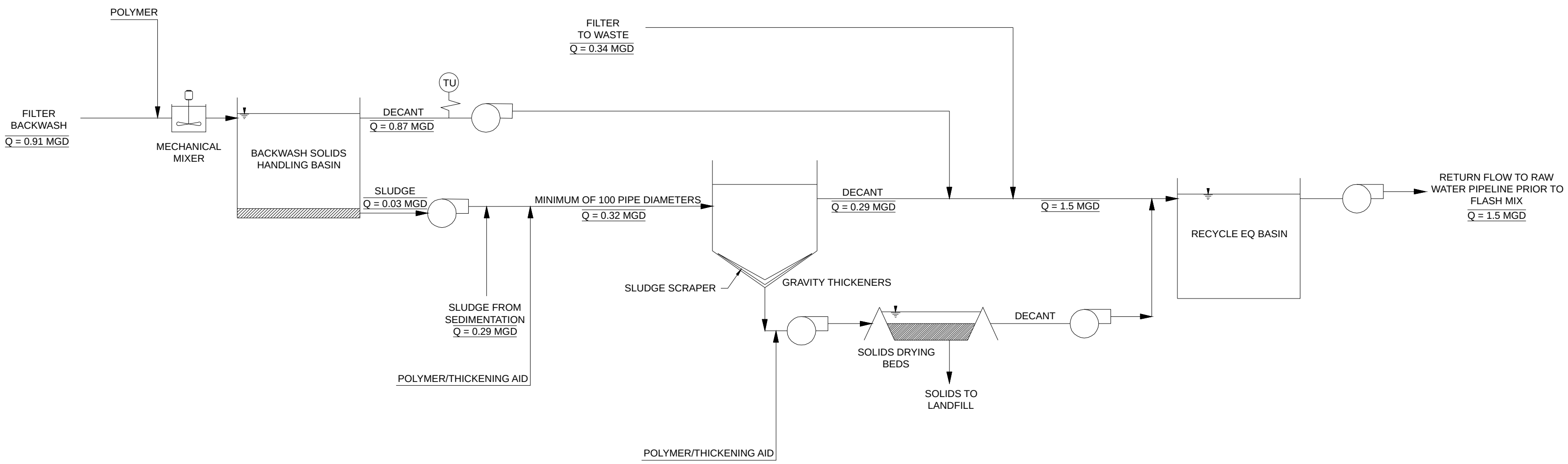
Trussell Technologies Inc

SRWA Stanislaus Regional Water Authority

**SURFACE WATER SUPPLY PROJECT**

JOB NUMBER
693-20-16-01
DRAWING NUMBER
SHEET NUMBER
OF __
REVISION




LEGEND:

- XX ANALYZER
- M FLOW METER
- $Cl_2$ TOTAL CHLORINE RESIDUAL ANALYZER
- TU TURBIDIMETER
- pH pH/TEMPERATURE METER
- $O_3$ OZONE RESIDUAL ANALYZER
- Q= PROCESS FLOW RATE

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# Appendix C. Site layout

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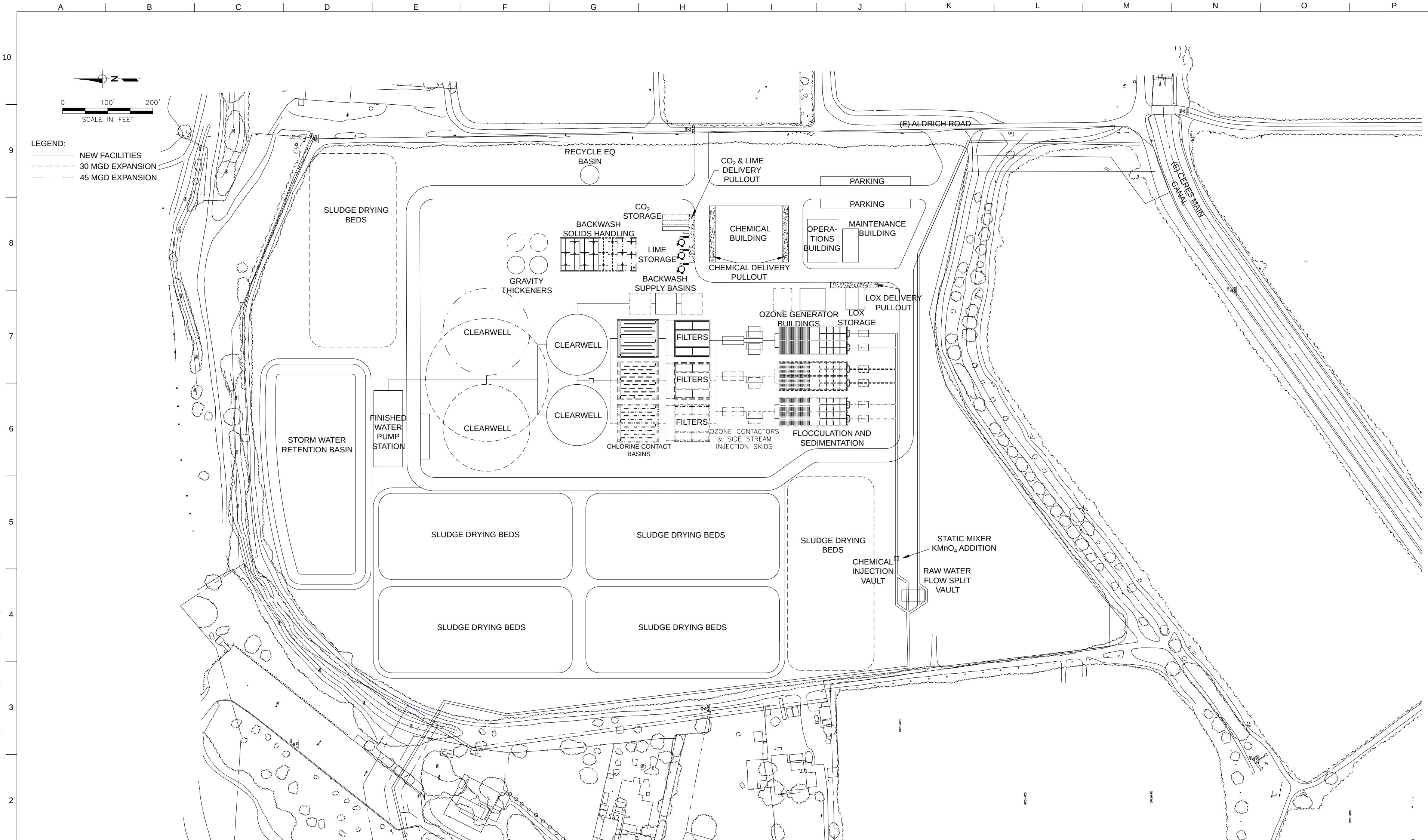


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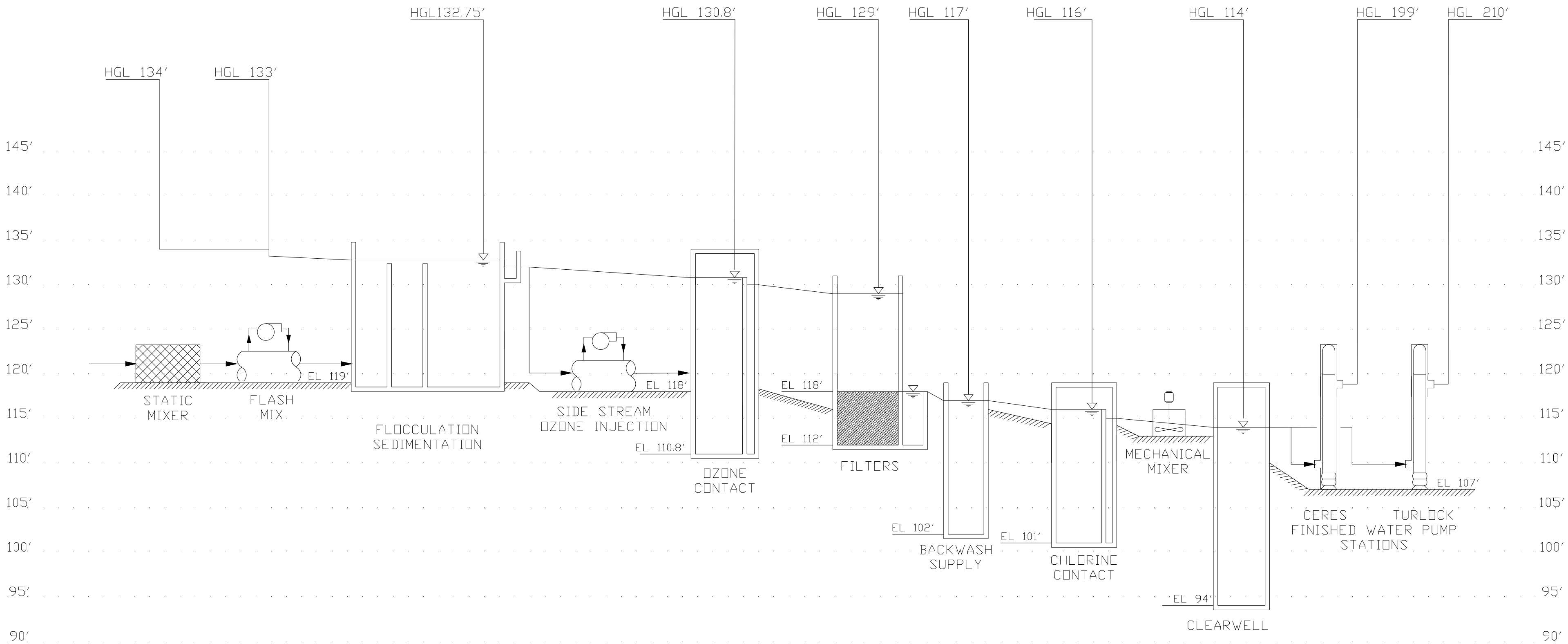
## Appendix D. Hydraulic profile for 15 mgd water treatment plant

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# Appendix E. Discussion of Lime System Options for Finished Water Stabilization

# Appendix E

# Discussion of Lime System Options for Finished Water Stabilization

The water quality of the Reference WTP's filter effluent will have a pH and Langelier Saturation Index (LSI) much lower than the finished water targets defined in Table 4.1 of the Predesign TM. Lime is therefore added to the chlorine contact basin effluent to stabilize the water by increasing the alkalinity, calcium concentration, and pH, which also increases the LSI. LSI is calculated as follows:

**$LSI = pH - pH_s$**

Where: pH = measured pH

$pH_s$ = saturation pH, where alkalinity and calcium are at equilibrium with solid calcium carbonate

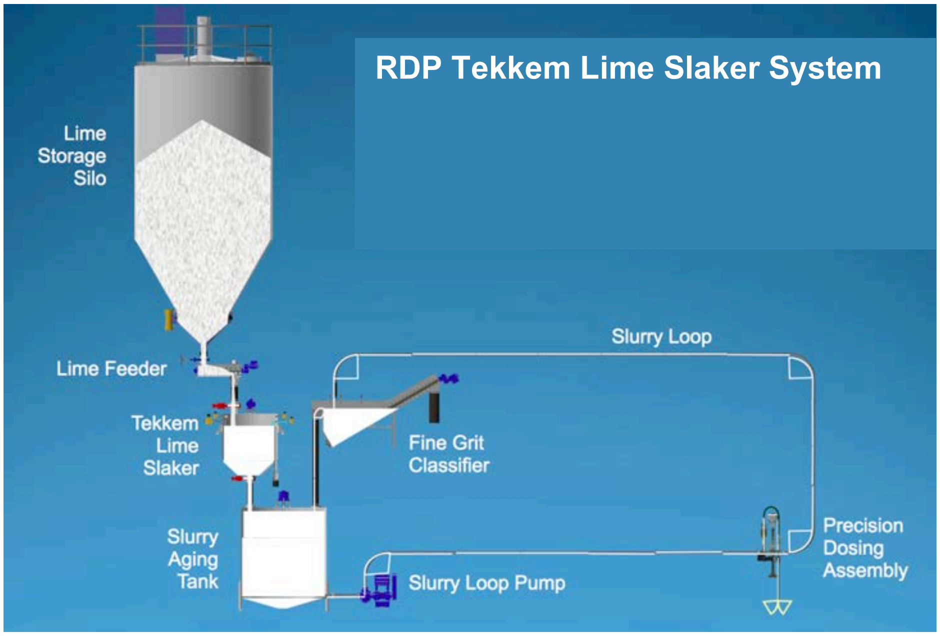
Because SRWA's source water has a very low buffering capacity with an average alkalinity of only 32.8 mg/L as $CaCO_3$, and because the addition of alum for coagulation will consume much of the raw water alkalinity (i.e., each mg/L alum consumes 0.5 mg/L alkalinity as $CaCO_3$), adding lime to increase the calcium concentration will cause the pH to increase well above the upper limit of the target range of 7.5 – 8.5. To maintain pH within the target range, the preferred approach is to concurrently add carbon dioxide.

## Lime System Options

Working with lime can be messy, hazardous (i.e., hydrating quick lime is a very exothermic process) and increases the turbidity of the finished water with impurities it contains and/or calcium carbonate formation if the chemistry is not controlled. Many treatment facilities using lime also require a lime saturator to reduce turbidity of the finished water and to provide a constant feed dose.

Two proprietary systems that are known to minimize turbidity of the finished water (e.g., turbidity increases ≤ 0.5 NTU) are (1) the Cal-Flo® liquid lime system by Burnett Lime Company, Inc. and (2) the RDP Tekkem Slaking system or RDP Tekkem Hydrated Lime system by RDP Technologies, Inc. The Burnett Cal-Flo® system meters a 30% lime slurry that is prepared from air classified hydrated lime to minimize particulates and maximize purity of the lime slurry. The 30% lime slurry is delivered to the site so that operators never have to deal with the dry lime.

The RDP Tekkem systems, shown in Figure 1, use precise weight control to prepare aged lime slurry that maintains an accurate and constant calcium concentration. The lime slurry is prepared in batches, with direct weight control operation to precisely control the amount of lime and water added to each batch. The RDP system operates either as (1) a lime slaker starting with dry quick lime (CaO) and ending with batches of hydrated 10% lime slurry, or (2) a precision hydrated lime system starting with dry hydrated lime ($Ca(OH)_2$) and ending at the same point with aged batches of hydrated 10% lime slurry. With either RDP lime system, the lime slurry endpoint is the same.



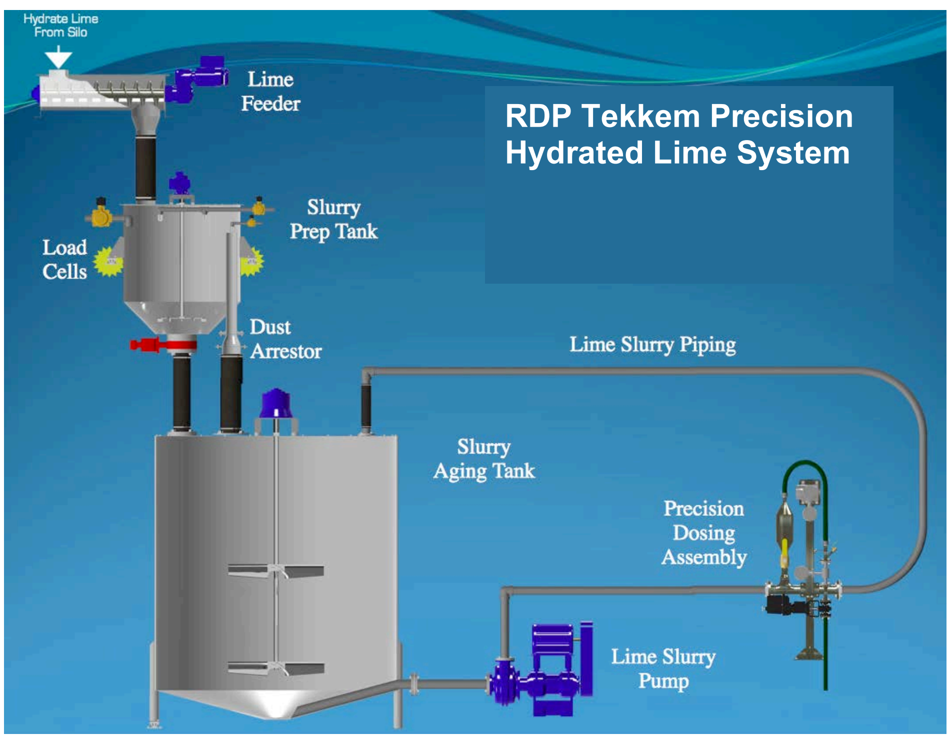




**Figure 1 - Simple schematics of slaked lime and hydrated lime systems**

The CalFlo liquid lime system uses a 30% lime slurry, prepared off-site from specially air-classified hydrated lime.  The 30% lime slurry delivered to the site can be diluted to a lower concentration when the slurry is pumped to the storage tank.  This system includes only a lime slurry storage tank, a chemical metering system, which includes chemical metering pumps, injection quills, and SCADA interfaced control system, and an in-line mechanical mixer to ensure fast and complete missing of the lime when added to the finished water.  Redundant metering pumps, lime injection points and lime slurry lines carrying the liquid lime to the injection point are recommended.  A photo of an example CalFlo system is provided in Figure 2.

**Figure 1.  CalFlo Liquid Lime System by Burnett Lime Company, Inc.**

Advantages and disadvantages of CalFlo liquid lime system, and the RDP Tekkem lime slaker system and precision hydrated lime system are summarized in Table 1.

The RDP Tekkem system can accommodate either quick lime or hydrated lime, and allows easy conversion from a hydrated lime system to a slaker system.  With both the RDP lime slaker system and the RDP hydrated lime system, the fine grit classifier is still used to remove grit and inert particulates from the hydrated lime. Because the fine grit classifier is not a critical component of slurry preparation with the hydrated lime system, it can be by-passed for short-term if maintenance is required.  It is recommended that the fine grit classifier be included with the system regardless of starting with quick lime or hydrated lime.  The only redundancy needed with the hydrated lime system are the slurry loop pumps, dosing assemblies, and mixers.  At expansion, the WTP will have full redundancy of the lime preparation and feed system—regardless of whether the plant sticks with the precision hydrated lime system or retrofits to the lime slaker system.

**Table 1 - Comparison of Burnett's CalFlo system with RDP lime slaker and hydrated lime system**

| Lime System | Starting Point Lime | Advantages | Disadvantages |
| --- | --- | --- | --- |
| Burnett Lime Co. CalFlo | $Ca(OH)_2$ slurry | • No bulk storage of $Ca(OH)_2$ since a 30% slurry is delivered<br>• Clean because slurry is delivered<br>• Air-classification process removed grit and inert particulates, to provide a high purity product<br>• Low turbidity in finished water | • Presently, only one supplier of the required air-classified hydrated lime slurry is available in California<br>• May be more expensive because the proprietary CalFlo system uses proprietary lime slurry. |
| RDP Lime Slaker | CaO | • Quicklime is less expensive than hydrated lime<br>• Lower tonnage of storage required; 1 lb CaO = 1.32 lb $Ca(OH)_2$ | • Messy and grit/solids disposal required<br>• Exothermic process that must be carefully controlled |
| RDP Hydrated Lime | $Ca(OH)_2$ | • Less grit to dispose of when starting with hydrated lime<br>• The fine grit classifier is recommended to provide low turbidity in the finished water.<br>• Less messy<br>• No exothermic reaction | • Starting lime is more expensive<br>• Lower tonnage storage available due to difference in molar mass between CaO and $Ca(OH)_2$ |

# Appendix F. Discussion of Mechanical Dewatering Options

# Appendix F - Discussion of Mechanical Dewatering Options

Various types of solids handling equipment and methods have been developed to manage sludge at drinking water and wastewater treatment plants. The proposed solids handling design for the Stanislaus Regional Water Authority (SRWA) Water Treatment Project includes polymer addition, gravity thickening, and multiple sludge drying beds. In this process, sludge is thickened by gravitational settling to 2-3% solids concentration and is then spread in a thin layer across the drying beds. Over time, the sludge dries by evaporation and draining of excess water through a filter material—typically a layer of sand. An underdrain system collects the filtrate and returns it to the Recycle Equalization Basin. Dried sludge builds up in the drying beds over a 12-month time period and must be removed. Figure 1 shows a schematic of sludge drying beds.

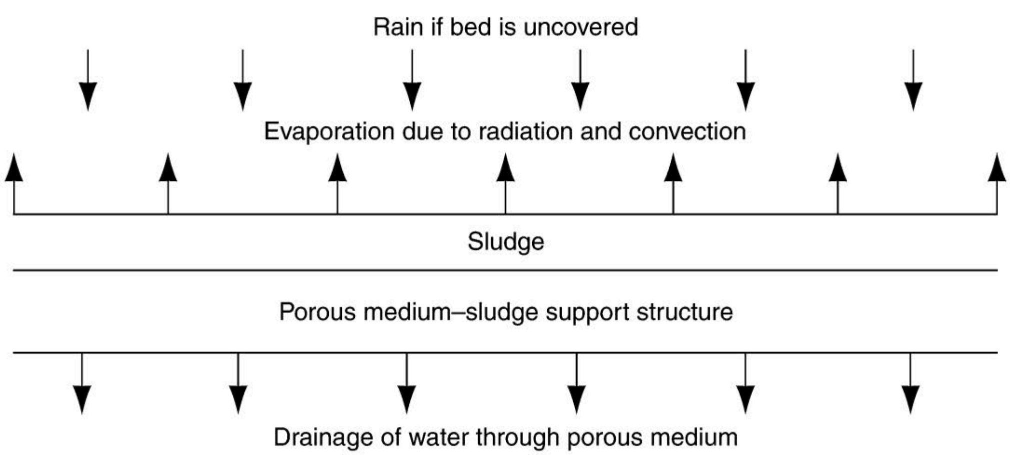



**Figure 1.** Schematic of sludge dewatering in drying bed system (Wang et al. 2007).

Mechanical dewatering is an alternative to sludge drying beds. Common methods include belt filter presses, centrifuges, and screw presses. Belt filter presses remove water in two principal ways: (1) gravity drainage and (2) mechanical application of pressure, through compressive and shear forces (see Figure 2). Centrifuges operate by rotating the liquid at high speeds to increase the gravitational forces applied on the sludge, thereby acting as a sedimentation device (see Figure 3). Screw presses operate by squeezing the sludge against a screen or filter, allowing the liquid to be collected on the other side; however, screw presses are not recommended for alum-containing sludge, and therefore not further evaluated in this writeup.

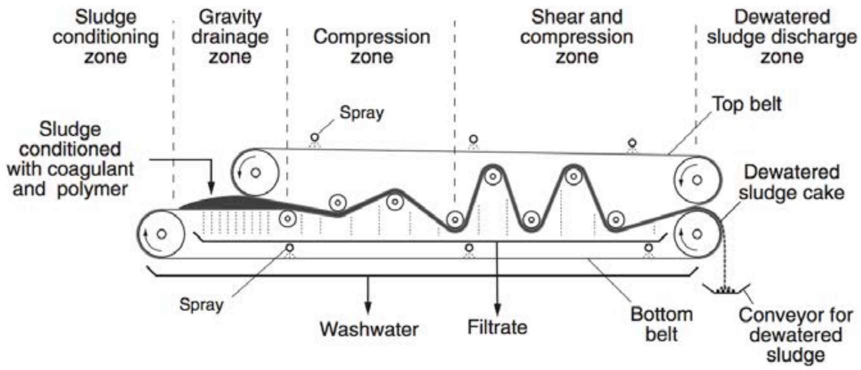



**Figure 2.** Schematic of belt filter press for dewatering sludge (Crittenden et al. 2005).

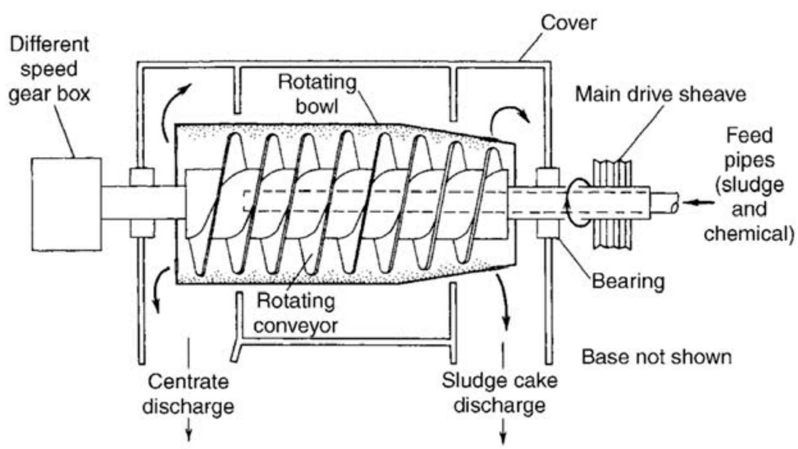



**Figure 3.** Schematic of centrifuge for dewatering sludge (Crittenden et al. 2005).

There are advantages and disadvantages to both sludge drying beds and mechanical dewatering systems. Sludge drying beds are the most common sludge dewatering method in the United States, treating 50% and 67% of drinking water and municipal wastewater treatment plant sludge, respectively (Wang 2007). Sludge drying beds are simple to operate and energy efficient. However, they require a large footprint and may be prone to odor and insect problems. Sludge drying beds require little operational oversight and can be operated continuously (24/7). In comparison, mechanical dewatering equipment requires some operational oversight and is typically operated ≤ 40 hours per week, especially at small facilities, thereby requiring a holding tank for thickened sludge.

Mechanical dewatering is advantageous for facilities with limited available land because the footprint is significantly smaller; however, capital and operating costs are higher because more frequent maintenance is required and replacement parts are typically expensive. Capital expenses for belt filter presses are more expensive than for centrifuges, while operating costs for centrifuges are higher. Footprints for centrifuges are typically slightly smaller than belt filter presses. Dewatered solids concentrations for sludge drying beds, centrifuges, and belt filter presses are relatively comparable. Table 1 presents a high-level comparison of sludge drying beds, centrifuges, and belt filter presses.

**Table 1. Comparison of dewatering methods.**

| Parameter | Dewatering Method | | |
|---|---|---|---|
| | Sludge Drying Bed | Centrifuge | Belt Filter Press |
| Operating Schedule | Continuous | ≤ 40 h per week | ≤ 40 h per week |
| Capital Cost | Low | Moderate | High |
| Operating Cost | Low | High | Moderate |
| Maintenance Frequency | Low | High | Moderate |
| Ease of Maintenance | Easy | Hard | Moderate |
| Footprint Requirements | High | Low | Low |
| Dewatered Solids Concentration | 20-40%[1] | 16-24%[2] | 16-20%[2] |
| Additional Considerations | Insects<br>Odor | Requires Operator Attention/Time | Requires Operator Attention/Time |

1 – Dependent on length of drying time
2 – Provided by equipment manufacturers for typical alum-based sludge dewatering

Trussell Technologies contacted two equipment manufacturers – Alfa Laval and Andritz – for information regarding the footprint of centrifuges and belt filter presses, assuming 40-hour per week operation (90 gpm) and 2-3% solids from the gravity thickener. Alfa Laval provided information for a centrifuge, the Aldec 75. Andritz provided information for a centrifuge, the D5L, and a belt filter press, the 1.5-meter SMX-Q. Brochures and a complete list of references for the recommended equipment are included at the end of this writeup.

A summary of the collected information is shown below in Table 2. Sludge drying beds have a significantly larger footprint than centrifuges and belt filter presses, and multiple beds are required to treat expected quantities of sludge. Centrifuge footprints are slightly smaller than belt filter press footprints. The Alfa Laval and

Andritz mechanical dewatering equipment has been used for alum-containing sludge in a number of drinking water and wastewater applications both in California and throughout the United States.

**Table 2. Footprint and references for centrifuge and belt filter press dewatering technologies, assuming 40 hour per week operation (90 gpm) with 2-3% solids.**

| Dewatering Method | Manufacturer | Model | Footprint[a] (L x W x H) | References |
|---|---|---|---|---|
| Sludge Drying Bed | -- | -- | 430 ft x 190 ft x 6 ft (per sludge drying bed) | -- |
| Centrifuge | Alfa Laval | Aldec 75 | 16 ft x 4 ft x 5 ft | • Havre De Grace WTP<br>• Forest Park WTP<br>• G Robert House Jr. WTP<br>• City of Houston, East Water Purification Plant<br>• City of Marlin, Texas WTP |
| | Andritz | D5L | 12 ft x 4 ft x 6 ft | • R.E. Badger Filtration WTP<br>• Union Sanitation District WWTP<br>• J.B. Laythem WWTP<br>• City of Riverside WWTP |
| Belt Filter Press | | 1.5-m SMX-Q | 18 ft x 11 ft x 5 ft | • Oceanside WWTP<br>• Hyperion WWTP<br>• Fiesta Island WWTP<br>• Burlingame WWTF |

## REFERENCES:

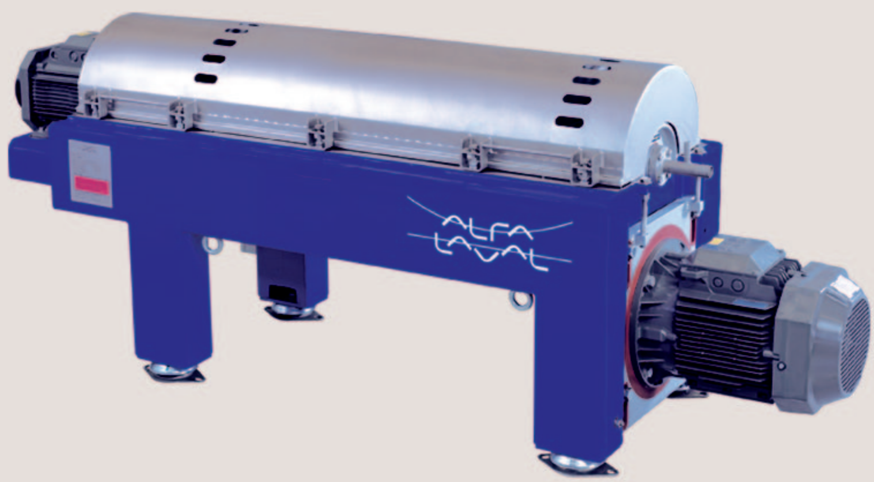

Crittenden, J. C., Trussell, R. R., Hand, D. W., Howe, K. J., Tchobanoglous, G. (2007) Water Treatment: Principles and Design. John Wiley & Sons.

Wang L.K., Li Y., Shammas N.K., Sakellaropoulos G.P. (2007) Drying Beds. In: Wang L.K., Shammas N.K., Hung YT. (eds) Biosolids Treatment Processes. Handbook of Environmental Engineering, vol 6. Humana Press.

# Appendix

# ALDEC

## High-performance decanter centrifuge




**Applications**

The ALDEC range of decanter centrifuges was developed with a focus on cost-efficiency, reliability and easy operation. The ALDEC design is used for sludge dewatering in a wide range of industrial wastewater treatment applications, as well as municipal wastewater treatment plants.

**Ideal for both small and medium-capacity installations**

ALDEC decanter centrifuges are designed to be efficient, simple to install, easy to maintain and straightforward to operate. Installation, operating and service life costs are minimal.

The ALDEC range features
- fully enclosed process sections
- critical parts made of wear-resistant material
- high performance combined with low energy consumption.

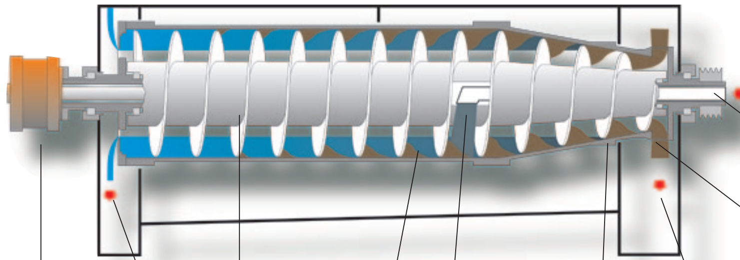
**Benefits**

The ALDEC decanter centrifuge design provides a series of concrete benefits
- reduces sludge volume, which cuts down on transport and disposal costs
- continuous operation
- compact, modular design saves space
- low installed power reduces electricity consumption.

**Working principle**

Separation takes place in a horizontal cylindrical bowl equipped with a screw conveyor (see drawing on page two). The feed enters the bowl through a stationary inlet tube and is accelerated smoothly by an inlet distributor. The centrifugal force that results from the rotation then causes sedimentation of the solids on the wall of the bowl.

The conveyor rotates in the same direction as the bowl, but slightly slower, thus moving the solids towards the conical end of the bowl. The cake leaves the bowl through the solids discharge openings into the casing. Separation takes place throughout the entire length of the cylindrical part of the bowl, and the clarified liquid leaves the bowl by flowing over adjustable plate dams into the casing.




### Process optimization

ALDEC decanter centrifuges can be adjusted to suit specific requirements by varying

- the bowl speed to obtain the G-force required for the most efficient separation
- the conveying speed for the most efficient balance between liquid clarity and solids dryness
- the pond depth in the bowl for the most efficient balance between liquid clarity and solids dryness
- the feed rate – ALDEC decanter centrifuges are designed to handle a wide range of different flow rates.

### Design

The rotating part of these decanter centrifuges is mounted on a compact, in-line frame, with main bearings at both ends. Vibration dampers are placed under the frame. The rotating part is enclosed in a casing with a cover and a bottom section with integrated outlets for both solids and the liquid being removed.

### Drive system

In all ALDEC decanter centrifuges, the bowl is driven by an electric motor and a V-belt transmission drive. Power is transferred to the conveyor via a planetary gearbox.

Operation can either be pre-set to a suitable set of parameters, or the difference between the speeds of the bowl and the conveyor can be controlled automatically, with no need for changing belts or pulleys.

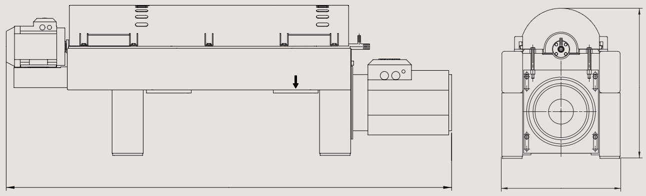
### Materials

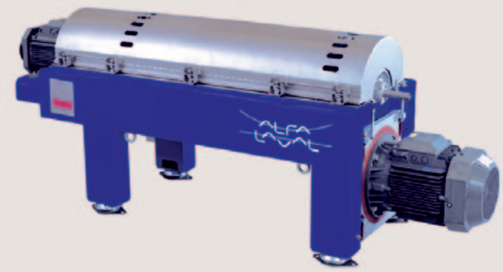
The bowl, conveyor, inlet tube, outlets, cover and other parts in direct contact with process media are all made of stainless steel. The discharge ports, conveyor flights and feed zone are protected with materials that are highly resistant to erosion. The frame is made of mild steel with an epoxy enamel finish.

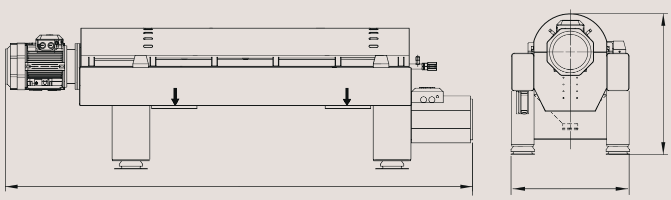
### The Basic Core Controller

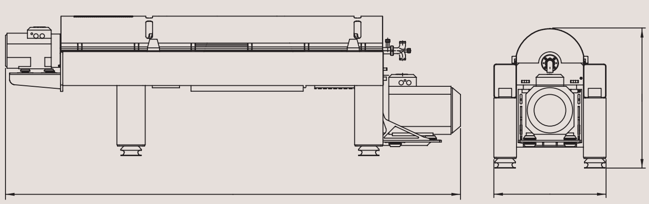
Each decanter centrifuge in the ALDEC range equipped with a variable frequency drive (VFD) as standard is delivered with the Basic Core Controller (BCC). This control package is capable of fully controlling the decanter operation, ensuring the most efficient performance and keeping costs for installation, commissioning, operation and maintenance to a minimum. The controller is also designed to measure the temperature of the bearings, and to monitor vibration levels.

## Dimensions









### Technical Data

| | | | | | | |
|---|---|---|---|---|---|---|
| ALDEC 10 | 375 kg (830 lbs) | AISI 316 | AISI 316 | 7.5 kW (10 HP) | 3 kW (4 HP) | Star-delta, VFD |
| ALDEC 20 | 1125 kg (2495 lbs) | AISI 316 | AISI 316 | 11 kW (15 HP) | 7.5 kW (10 HP) | Star-delta, VFD |
| ALDEC 30 | 1200 kg (2660 lbs) | AISI 316 | AISI 316 | 11 kW (15 HP) | 7.5 kW (10 HP) | Star-delta, VFD |
| ALDEC 45 | 2300 kg (5071 lbs) | AISI 316 | AISI 316 | 22 kW (30 HP) | 5.5 kW (7 HP) | Star-delta, VFD |
| ALDEC 75 | 3200 kg (7050 lbs) | DUPLEX | AISI 316 | 37 kW (50 HP) | 11 kW (15 HP) | Star-delta, VFD |
| ALDEC 95 | 4500 kg (9000 lbs) | DUPLEX | AISI 316 | 55 kW (75 HP) | 11 kW (15 HP) | VFD |
| ALDEC 105 | 5000 kg (11023 lbs) | DUPLEX | AISI 316 | 75 kW (100 HP) | 22 kW (30 HP) | VFD |

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**How to contact Alfa Laval**
Up-to-date Alfa Laval contact details for all countries are always available on our website at www.alfalaval.com

ANDRITZ

# Decanter centrifuge D
for the environment industry


ASK YOUR
SEPARATION
**SPECIALIST**

andritz.com/separation

# What is centrifugation?
## An efficient solution to solve your dewatering and thickening tasks

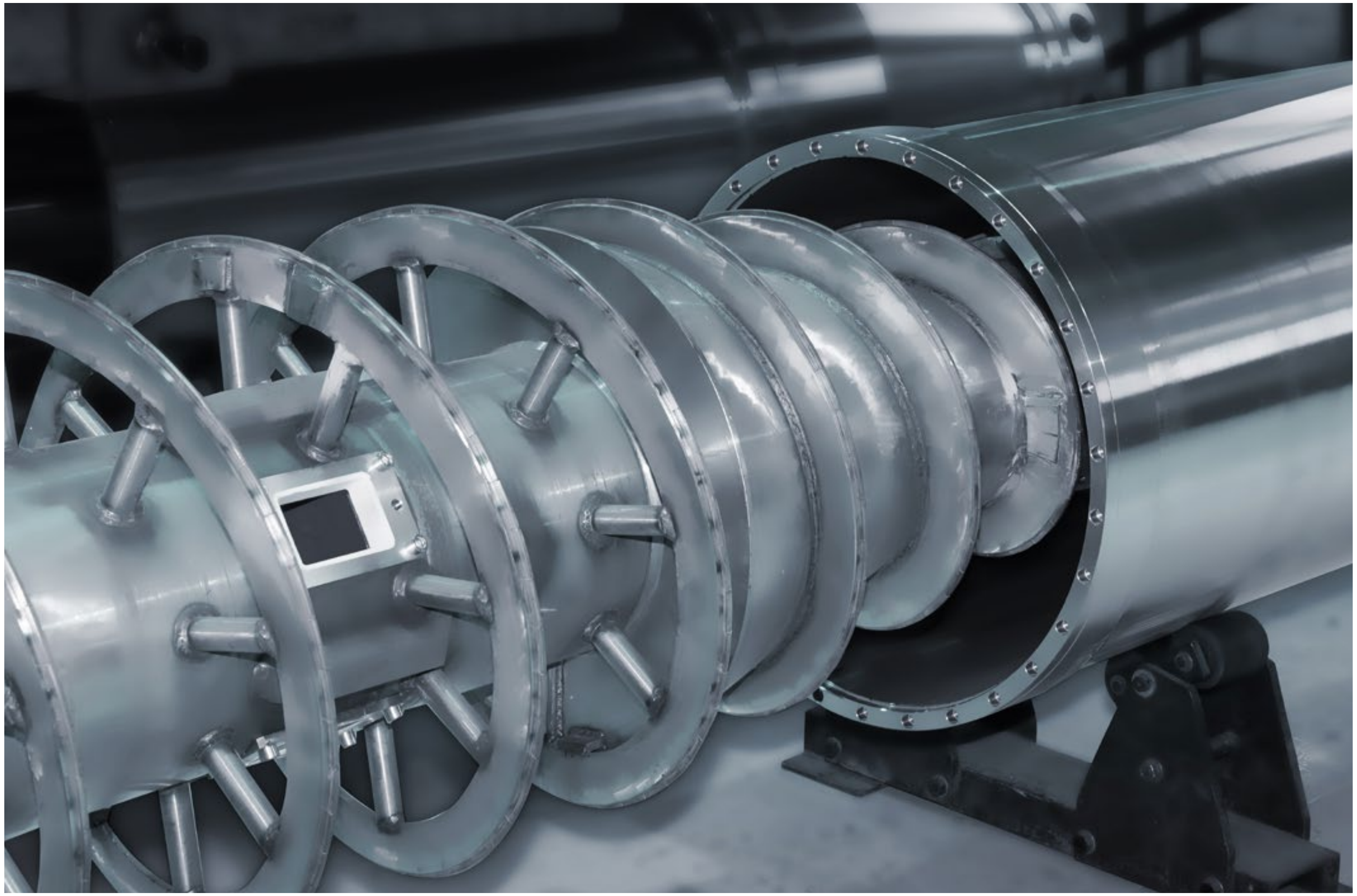
Centrifugation is a mechanical separation process in which two or more materials are separated using centrifugal forces. The demands of a centrifuge depend strongly on the specific application (e.g. flow rates and solids load), the material characteristics (e.g. particle size and abrasion behavior), and the operating environment (e.g. explosion-proof design).

Each machine in the ANDRITZ decanter centrifuge family benefits from an application-specific design. Whether your goal is to separate solids from liquids, two liquids from each other, or even to accomplish both tasks at the same time, our application specialists have an optimal design for you. Thanks to decades of experience with continuously evolving machine designs, our top-of-the-class decanter centrifuges ensure reliable and efficient performance.

**Filtration versus sedimentation**
Compared to filtration equipment, centrifugal sedimentation equipment can often achieve the same capacity at a lower investment cost. The sedimentation process can also reach higher flow rates in a continuous mode. Wide variations in feeding parameters can also be accepted.

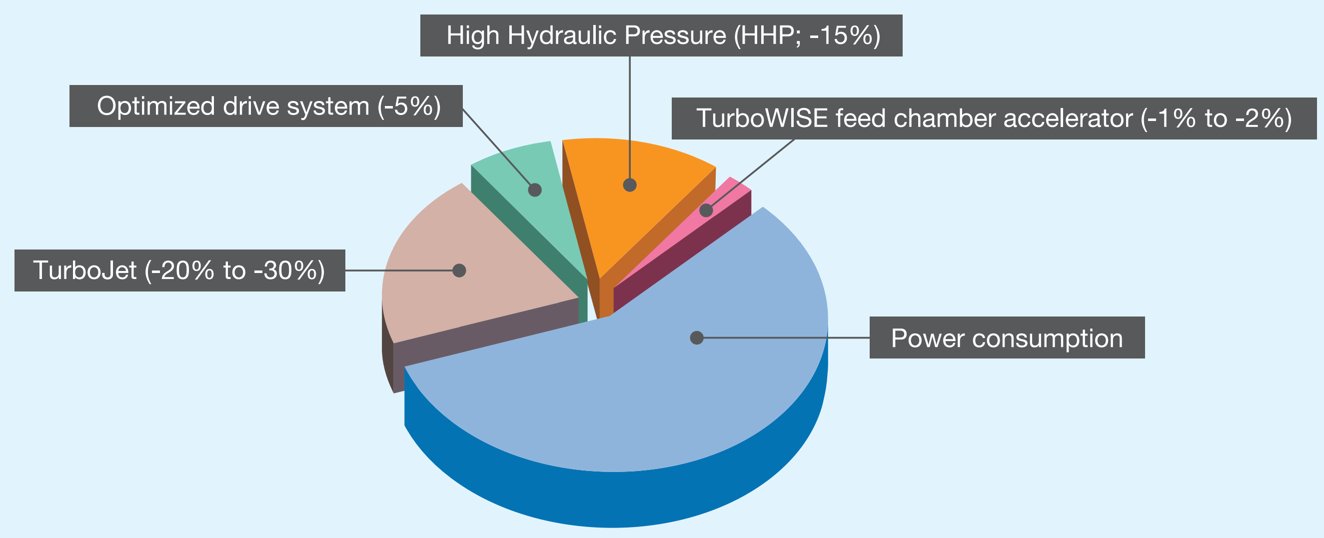
In sedimentation processes, consumables, such as filter media in filtration processes, are not used. Better capture rates can be achieved by centrifugal sedimentation as washing cycles in the filtration process could reduce the final product capture rate. Sedimentation processes are better able to handle complex products, especially compressible ones, which are difficult to separate in filtration processes.

Washing of sedimentation equipment is easier than with filtration equipment because the filtration equipment's wash water is under pressure, thus larger quantities are used.



# Get more results
with less energy

We put all our energy into delivering the best separation equipment so that you never have to waste energy in your decanter centrifuge.




ANDRITZ decanter centrifuge D has always been at the cutting edge of energy efficiency. We have shaped and improved today's industry standards through a number of technological innovations, including the following key energy-saving features:

- The High Hydraulic Pressure (HHP) design of the rotating assembly reduces the discharge radius of the clarified liquid (centrate). Besides improved separation characteristics, this design helps to recover the kinetic energy of the fluid to reduce energy consumption by up to 15%.
- Working the same way as a jet engine, the TurboJet weir plates recover the remaining kinetic energy of the clarified liquid. By creating liquid jets pointing in the opposite direction to the bowl rotation, the reaction force thus supports bowl rotation. The TurboJet weir plate reduces total power consumption by up to 30% as a stand-alone feature.
- As a standard feature, ANDRITZ SEPARATION offers two drive systems: a regenerative back drive and a direct drive. Whereas common back drive systems dissipate the braking energy of the scroll into heat, the regenerative back drive recovers this energy and feeds it back to the main motor. The direct drive system feeds the scrolling power directly to the scroll and therefore avoids recirculation losses, thus reducing total power consumption by another 5%.
- The unmatched TurboWISE solution is key to performance in the raw material feed chamber. The polyurethane liners of the TurboWISE system can be replaced easily on site and serve to accelerate the incoming slurry efficiently. The computational fluid dynamic optimization ensures lowest flocculant consumption, significantly reduced wear, and decreases the total power consumption again by up to 2%.

Decanter with low energy consumption features ▸

# What’s your
separation challenge?

ANDRITZ decanter centrifuges are suitable for different processes.

**Dewatering**

The ANDRITZ decanter centrifuge D is the most versatile of all existing solid/liquid separation technologies, and can be tailored to meet your target dry solids content. The decanter makes it possible to produce both thickened sludge and extremely dry cake from highly diluted sludge. Some Thermal Hydrolysis Process (THP) plant projects, for example, use it to achieve pre-dewatering (upstream thermal lysis step) and thickening during the same process stage. Others use this dual functionality to run the ANDRITZ decanter centrifuge D in thickening mode during the period in which liquid sludge can be spread on the fields, and in dewatering mode when it is forbidden to spread liquid sludge on the fields. Pig manure separation also falls into this category. The ANDRITZ decanter centrifuge D is capable of producing clarified liquid with a capture rate of more than 80% TSS, while at the same time producing dewatered solids with a very specific granularity necessary for efficient composting.

**Thickening**

As with all sludge dewatering and thickening technologies, performance of the ANDRITZ decanter centrifuge D is affected by the conditioning process, such as polymer type and dosage. But unlike other sludge separation technologies, the ANDRITZ decanter centrifuge D can still achieve a high solid/liquid separation rate in many applications without slurry preconditioning.

**Clarification**

The ANDRITZ decanter centrifuge D combines two significant advantages: high g-force capability and a specific HHP rotor design. The HHP rotor design helps to manage internal solids transportation, making it possible to utilize g-force capabilities to their fullest. All applications benefit from this approach, particularly food production processes such as juice clarification, which demand a high degree of separation at all times.

**Classification**

The ANDRITZ decanter centrifuge D can also be used in classification processes in all industries – from mining & minerals to food, chemical, and environmental applications. One such application is the classification of sand contained in sludge before being processed in a wet oxidation unit.

**3-phase separation**

The ANDRITZ decanter centrifuge D can also be used for 3-phase separation, in which the centrifugal force is used to separate liquids and solids with different densities, or to separate light liquid phase and heavy liquid phase from solids. Many ANDRITZ decanter centrifuges D in three phases design are used in applications ranging from slop oil and animal fat separation to olive oil and palm oil. Our machines are designed to support high-temperature processes, up to almost 100°C, to achieve the highest separation rate efficiency.

# Getting to know your ANDRITZ decanter centrifuge D

## A decanter with low energy consumption features

Design optimized to the very smallest detail to provide best results, while ensuring ease of maintenance and best results, while ensuring modularity for best fit to your needs.

### Scroll

The scroll of the ANDRITZ decanter centrifuge D is the most flexible scroll available on the market. Its specific open flight design reduces the torque created by the sludge and maximizes the clarification rate. The special cone design leads to high sludge compaction.

- Reduction of sludge conveying torque by 30%, which impacts the gear box lifetime and the scroll drive size positively.
- High cake dryness due to better sludge compaction.
- Excellent centrate quality due to minimized internal turbulences and maximized settling volume.

### Bowl

The bowl design is carefully selected to balance the various needs for integrity, stability, smooth operation, minimized windage, high durability, low wear, and easy maintenance, while ensuring the principle process functions. The design is modular to allow an easy fit to different basic process conditions by adjustment of diameter, length, and cone angle. The overall design is optimized to minimize the power consumption and provide the best possible stiffness. ANDRITZ decanter centrifuges are not only factory-tested before delivery to a customer's site, but also extensively type-tested according to international standards to meet all product safety requirements.


### Cover

Covers protect you against spillage and touching rotating parts, meet the noise radiation and thus are vital safety features. The shape is optimized for easy cleaning and handling. Different options are available to fit in with your needs, be it highest corrosion resistance, lowest noise radiation, or similar.

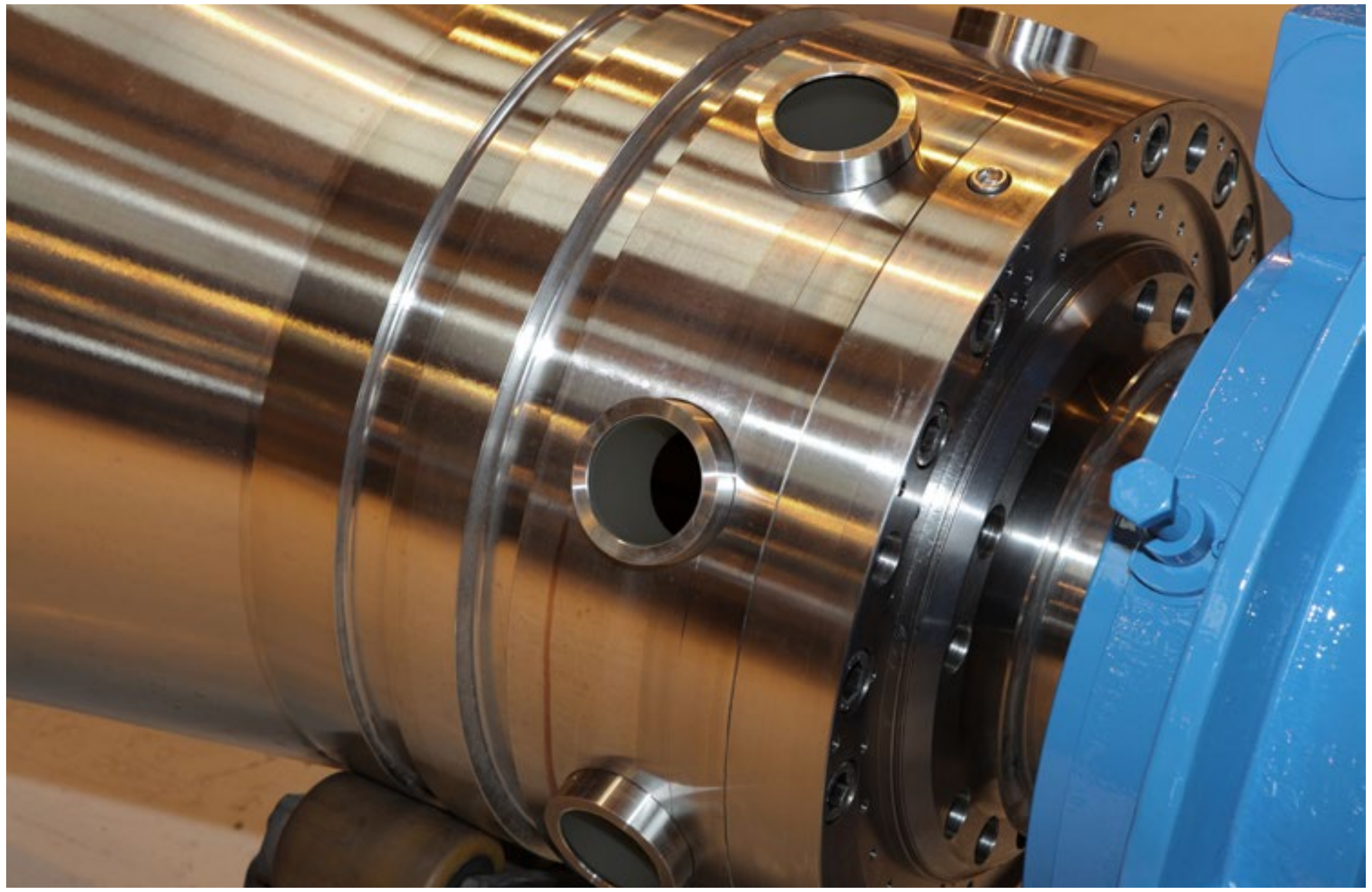
### Wear protection

The different zones and elements in a decanter that may be subject to higher wear are protected by a carefully composed selection of wear protection means. Depending on the extent of wear, different material compositions, ranging from polyurethane to sintered tungsten carbide elements, are used to protect scroll flights, feed chamber, feed pipe discharge ports, and discharge housing. Your ANDRITZ SEPARATION specialists are glad to offer their expertise in working towards the best combination of protection choice versus cost and selecting the best fit from the wide range of options.

### Machine instrumentation and machine protection

ANDRITZ decanter centrifuges will be as transparent in operation and for maintenance as you require. From the minimum machine protection to all levels of predictive maintenance information, including bearing conditioning sensors, the recommended minimum configuration depends on your operation and your application environment. It can be scaled to your needs in perfect combination with our addIQ control systems to support optimization of your operation. Our separation specialists seek to make operation and good care of your equipment, ensuring a long service life, blend seamlessly into your work schedule, and will provide fast and precise support should you need it.

# High-performance materials
## Best protection against wear for extended decanter life cycle



▲ Solid discharge ports with wear protection

The ANDRITZ decanter centrifuge D is manufactured with advanced wear-resistant materials for a long, continuous life cycle. A variety of materials ensures that your operations are able to withstand high temperatures, heavy-duty products, and corrosive products.

- To protect the bowl, the inner surface has strips or grooves, depending on machine size and application. Bowl outlets are protected with easily replaceable bushings.
- To protect the screw conveyor, the inside of the feed chamber is coated with tungsten carbide spray or protected with TurboWISE polyurethane inserts. Feed chamber outlets are equipped with replaceable bushings, and the screw conveyor blade has replaceable tiles made of tungsten carbide.
- Good wear protection is a strategic, long-term investment with a guaranteed return.
- To protect the solids casing, the receiving surface is a thick stainless steel plate with polyurethane or tungsten carbide spray coating, depending on the application.
- Exchangeable wear parts mean fewer repairs and less downtime, both of which lead directly to reduced maintenance costs.



# Metris addIQ control system for decanter centrifuges
## Decades of experience in one box


▲ Intuitive HMI

The addIQ centrifuge control system combines all of our extensive operational, troubleshooting, and start-up experience in one tailored automation solution. The heart of addIQ system is a modular, PLC-based control system that supports you in making the best use of your ANDRITZ equipment.

The addIQ product range is scalable from Eco, Pure up to Prime level and can be run in different operating modes to enhance the performance of your process:

- Optional remote access gives immediate support to your operation and maintenance team.
- Relative speed control allows the operator to enter the speed set points directly. If the feed product concentration is stable, this is the preferred and most efficient control mode.
- Torque control mode ensures constant dryness under varying process conditions. This automatic operation is achieved by a torque feedback algorithm.
- Maintenance and manual operation.
- CIP (Cleaning-In-Place) sequences and an optimized thickening control facilitate the operation of the machine and assure economical best return of the process.
- Alarms and support in troubleshooting.
- Built-in support for trending, documenting, and reporting efficiency is included. Multilanguage functionality is integrated in the operation interface to support communication.

# Municipal wastewater

## Reliability and performance guaranteed by experience

In cities all over the world, there is a rising need for efficient processing of wastewater and sludge, combined with increasingly tight regulatory standards and municipal budgets. To tackle these complex and conflicting challenges, you need a partner with the full perspective of your wastewater treatment needs, and an array of reliable solutions to fulfill them. Across all thickening, pre-thickening, and dewatering applications, ANDRITZ SEPARATION has the most experience worldwide with the largest installed base of equipment in operation.

**Flexible handling of all types of sludge**

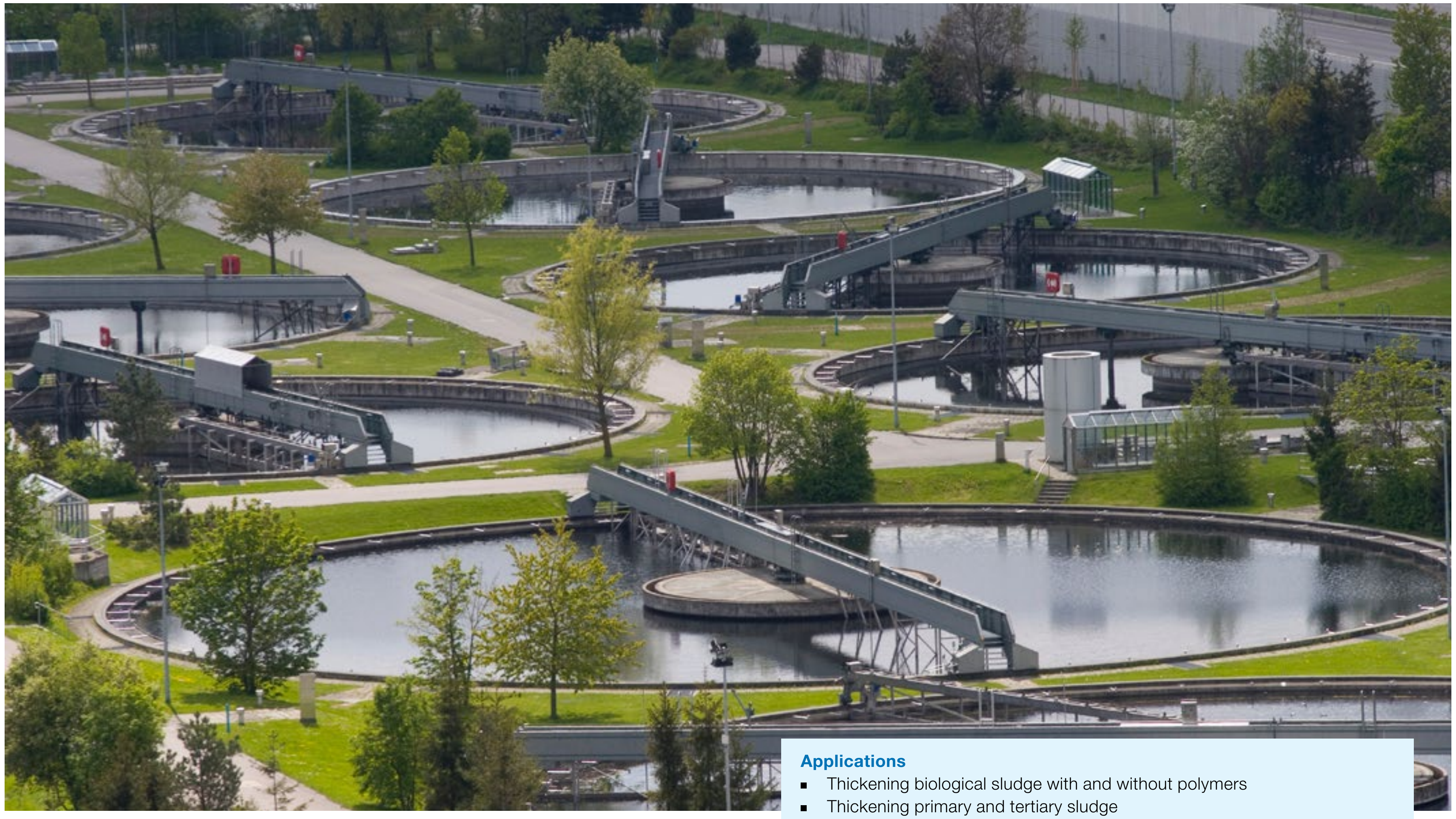
The ANDRITZ decanter centrifuge D is a high-performance solid bowl decanter centrifuge engineered for sludge treatment. It accepts any type of sludge, making the technology extremely suitable for centralized dewatering plants receiving different sludges from different regions. The centrifuge's unique design is the result of decades of engineering experience together with continuous feedback from our customers and service partners. ANDRITZ decanter centrifuges D provide a unique combination of robust design requirements, high-quality manufacturing, and enhanced maintenance-friendly features.

For municipal wastewater treatment plants of all sizes, the final step of sludge treatment is a critical one, accounting for a significant share of the plant's total operating costs. Since this is the last step before the sludge leaves the facility, the equipment must reliably produce stable dewatered sludge while minimizing downtime and maintenance requirements. Medium to large plants will also include a digestion treatment step using either standard aerobic, anaerobic, or more advanced methods such as pre-hydrolysis sludge treatment.

In each of these cases, the performance of the digester is directly linked to performance of the thickening equipment. ANDRITZ decanter centrifuge D technology is designed to ensure that both thickening and digestion are extremely reliable, flexible, and easily automated.

**Turnkey solutions for various applications**

Although each production line must be specially designed, a sludge dewatering line typically includes a sludge feeding system, a polymer preparation and feeding system, dewatered sludge conveying equipment, and a centrifuge. Over the years, we have gained extensive knowledge concerning all types of production facilities and machines to obtain the required final product characteristics. As a result, we offer comprehensive capabilities for the design, support, and supply of your plant's complete dewatering facility – all with one global partner to respond to your needs.



**Applications**

- Thickening biological sludge with and without polymers
- Thickening primary and tertiary sludge
- Dewatering membrane sludge
- Dewatering fresh, blended sludge
- Dewatering digested sludge
- Pre-thickening and dewatering of hydrolyzed sludge
- Classification of sludge
- Sand removal
- Potable water

# Industrial wastewater treatment
## All wastewater deserves the right solution

Industrial manufacturing processes generate specific wastewater and residual material flows. Systematic and efficient processing reduces water consumption, conserves raw materials, provides marketable residues, and improves overall efficiency.

### Versatile solutions for different types of wastewater

Organic or non-organic, greasy or oily, corrosive or abrasive, high- or low-solids – all types of content need to be recycled back into the process or discharged into the municipal sewage system. When it comes to industrial wastewater treatment, ANDRITZ SEPARATION provides expertise for each market-specific requirement with a wealth of references and a range of proven solutions.

### Water treatment and zero liquid discharge

Along with the recovery of raw materials, reduced water consumption has become a major topic for most industries. ANDRITZ SEPARATION provides a comprehensive selection of water-conserving and water-recycling solutions based on the unique design of screens, continuous sand filtration technologies, belt presses, centrifuges, and separators.

### Sludge management

The sewage sludge produced in organic production processes is often suitable for use as secondary fuel for on-site steam or electricity generation, or for supplying to buyers from energy-intensive industries. In many cases, waste heat can be used to dewater or dry the sewage sludge. Today, there are already large installations that process both their own sewage sludge as well as municipal sewage sludge to generate secondary fuel such as pellets.

### Solid/liquid separation

Every industrial site has to treat its wastewater – even if it does not have its own in-house treatment plant – and performs phase separation, thereby decreasing pollution levels in order to comply with discharge limits or decrease the size of its wastewater treatment plant. In some applications, the solid phase can be reutilized as fertilizer or even be recycled back into the production process. This phase separation process is applicable to mineral as well as organic streams. ANDRITZ SEPARATION offers complete technology packages requiring no further investments and with no environmental impact because no chemicals are used.

### Select the best technology for the toughest challenge

The ANDRITZ decanter centrifuge D is a high-performance solid bowl decanter centrifuge and one of the market's most versatile technology. Its compact and efficient design makes it possible to customize your solution with a wide range of advanced features. The most suitable configuration is chosen based on the specific industrial waste to be treated. Our vast experience includes the selection of specific construction materials, comprehensive abrasion protection, and 2- or 3-phase separation systems. The standardized design of the ANDRITZ decanter centrifuge D ensures that all configurations perform reliably and cost-efficiently.

**Applications**
- Manure and animal waste
- Dairy
- Food and beverage
- Pulp and paper
- Steel and stainless steel
- Power plants
- Slop oils and lagoons
- Drilling muds
- Sand and aggregates
- Mining effluents, etc.

# Staying ahead in innovation

## ANDRITZ develops test centers and puts extra focus on R&D activities

ANDRITZ SEPARATION with its competence center for decanter centrifuges D in France operates its own has its own on-site test center to speed up product innovation and reduce the time to release new products and features to customers in a systematic and well-controlled fashion.

With an available area of more than 250 m², this state-of-the-art facility is able to test all kinds of machines (screens, decanters, separators, filter presses, and similar, including mobile units), even at high flow rates exceeding today's market requirements for single units.

Modern instrumentation equipment is available to analyze mechanical and process elements such as effective power, vibration characteristics, noise rating, and more.

# A decanter centrifuge
## for every need

At ANDRITZ SEPARATION, we have one of the largest decanter centrifuge ranges on the market, from D2 centrifuges for small flow to the largest decanter either for municipal or industrial applications.


▲ Mobile unit

| Range | D2 to D 12 |
|---|---|
| Hydraulic capacity (m3/hr) | 0.2 to 400 |
| Installed power (kW) | 7.5 to 350 |

▲ D2

▲ D3

▲ D5

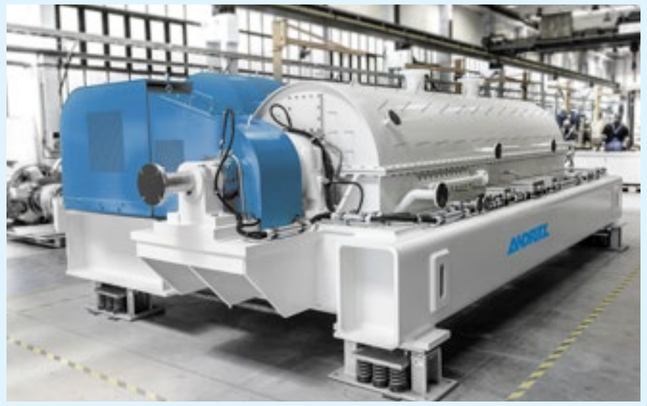
▲ D7

▲ D6 and D10

▲ Container

# ANDRITZ decanter centrifuges
## The best fit for the widest range of applications

The ANDRITZ decanter centrifuge D is a centrifuge optimized for lowest consumption and highest output to meet the demands of environmental processes. In addition to the environment market, ANDRITZ decanter centrifuges are versatile in order to fit several applications in various industries. For these specific applications, ANDRITZ SEPARATION specialists would recommend you the following units:



The **ANDRITZ decanter centrifuge A**, a heavy duty industry machine, rugged and robust, ideal for mining and minerals as well as the chemical Industry. The A-type range also includes special products such as the screen bowl decanter (AS machine) or Censor for plastics recycling.

### Applications

**Mining and minerals**

- Calcium carbonate
- Potash
- Clay
- Salt
- Coal and tailings
- Aluminum
- Iron and tailings
- Copper and tailings
- Phosphate

**Chemicals**

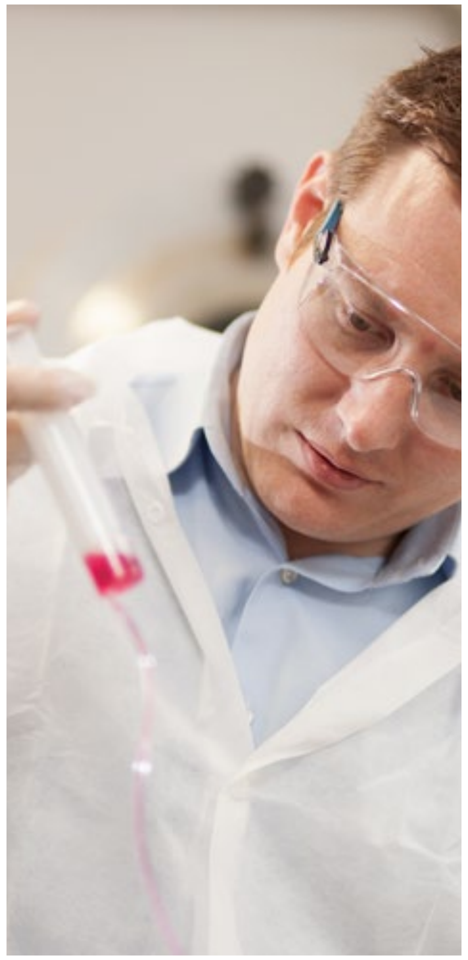
- Petrochemicals
- Soda ash
- Mineral and slop oil
- Pigments and dyes
- Agrochemicals
- Specialty chemicals
- Natural rubber and bioplastics
- Pharmaceuticals and cosmetics

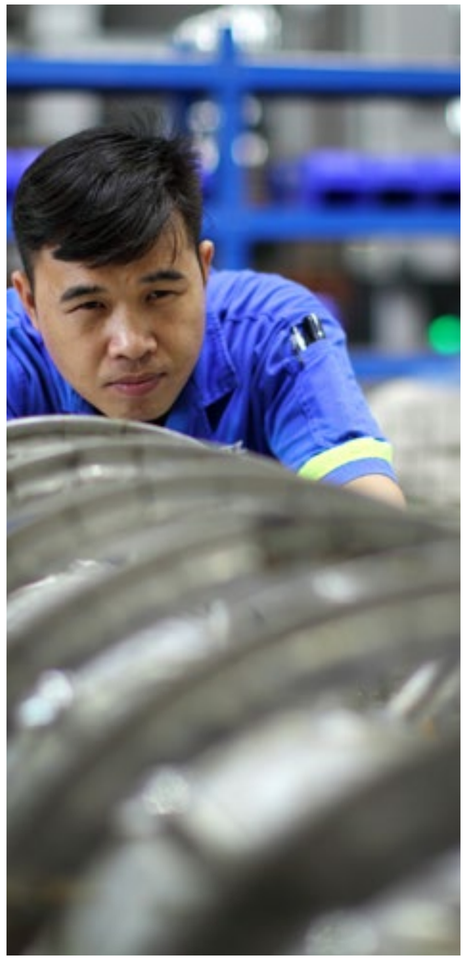
The **ANDRITZ decanter centrifuge F**, designed for the food industry, an optimized machine in three different finishes to meet the most stringent hygienic requirements, including CIP (Cleaning-In-Place) and pressure discharge.

### Applications

**Food**

- Beverages
- Dairy
- Vegetable oil
- Animal protein processing
- Functional ingredients
- Industrial fermentation
- Starches and proteins
- Sugar





# Process and product specialists
## Laboratory and trials to meet your needs

Could you get more from your existing equipment? Or do changing process conditions demand a completely new approach? At ANDRITZ SEPARATION, we have the knowledge and resources to help you find out. Whether you are looking to maximize efficiency, reduce filtration times, or explore new processes and products, our test facilities worldwide are always at your service. Helping you to optimize residual moisture levels, bulk density, particle size distribution, and more. Always with the latest application knowledge and an unmatched database of process performance analysis.

### Missions

- Define process warranty, design from experience
- Build sizing charts, specific sizing study
- Build process knowledge, process expertise
- Check technical feasibility of solid/liquid separation through lab tests
- Check performance by pilot tests on-site

### Goals

- Define and validate technical process warranties, separation performance
- Define technologies, sizing, design for projects according to process
- Technical support for various industries, with main focus on environment, mining and minerals, chemicals, and food

# Put our 150 years
## of OEM experience to work for you

Need to optimize your process? Boost availability? Ensure non-stop productivity? When you work with ANDRITZ SEPARATION, you gain access to one of the world's largest OEM manufacturers for solid/liquid separation. Put our in-depth knowledge of separation equipment and processing to work for you.

### Vast experience through large installed base

With an installed global base of more than 55,000 solid/liquid separation equipment and systems, you can imagine that we take service seriously. Wherever these customers are located, we work very closely with them to maximize uptime and boost efficiency.

### Well-known OEM brands

Some customers know us as the people with ANDRITZ SEPARATION on our overalls. Others have come to understand that we are the OEM behind former brand names like Bird, KHD, Guinard, and more – companies who all have been acquired by ANDRITZ. But frankly, we are capable of servicing and supplying spare parts for nearly all brands of solid/liquid separation equipment and systems on the market.

### Local support backed by global expertise

Our service philosophy is simple: One phone call, one contact person, one dedicated team that speaks your language and knows your equipment and process. This is not an empty promise. It is backed by a network of 550 service specialists for solid/liquid separation equipment and systems as well as service centers all around the world.

### A true full-service provider

Whether you need spare parts, rentals, local service, repairs, upgrades, or modernization of your equipment, ANDRITZ SEPARATION is your service specialist in all aspects of separation. From initial consulting through to service agreements, process optimization, and training programs, we are always looking for ways to minimize downtime and increase predictability in operations while raising your overall production efficiency. In short, we've got you covered.

**Local support**
Responsive local service centers and field service technicians

**Repairs & upgrades**
Optimization of machine and process performance, repair work, retrofitting, and modernization

**Second-hand & rentals**
Certified second-hand and rental machines

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Operator training and tailored seminars for operating and maintenance personnel

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Automation tools and process expertise to boost your profit

**Lab and on-site tests**
Lab and testing capabilities for process optimization and machine upgrades

# What's your biggest separation challenge?

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As the OEM for many of the world's leading brands, we have the solutions and services to transform your business to meet tomorrow's changing demands – wherever you are and whatever your separation challenge.

**Ask your separation specialist**


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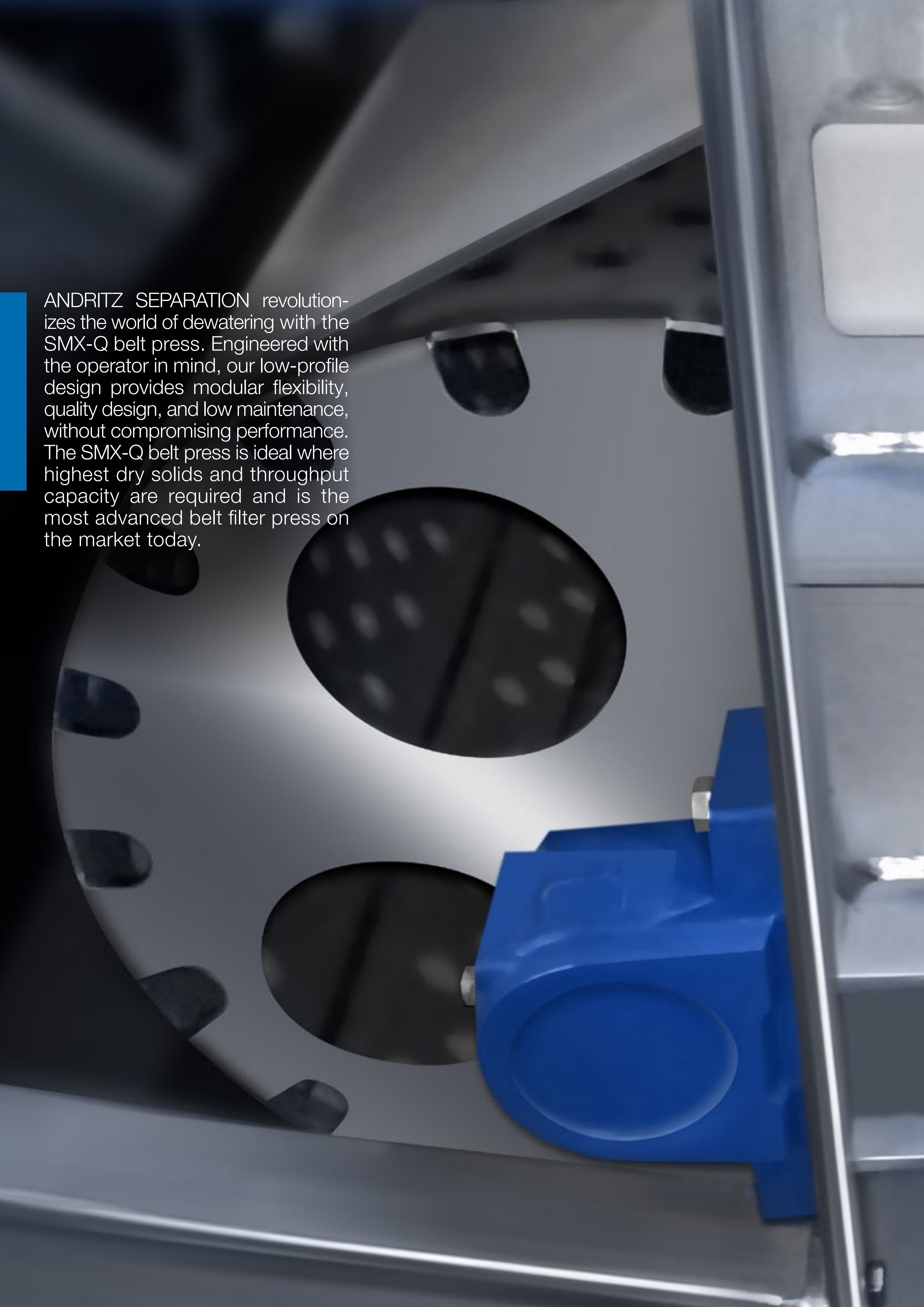
D-type decanter 1.0/09.2017 EN

# ANDRITZ belt press SMX-Q
## Low-profile dewatering belt press for the environment industry


ASK YOUR SEPARATION **SPECIALIST**

andritz.com/separation

ANDRITZ SEPARATION revolutionizes the world of dewatering with the SMX-Q belt press. Engineered with the operator in mind, our low-profile design provides modular flexibility, quality design, and low maintenance, without compromising performance. The SMX-Q belt press is ideal where highest dry solids and throughput capacity are required and is the most advanced belt filter press on the market today.



# Low-profile belt press
## Simplifies operation and maintenance significantly and lowers cost of ownership

### Low profile
The low-profile design eliminates the need for costly platforms. With an overall height of only 152 cm, the gravity zone is at a convenient height for operational and maintenance requirements. Access for maintenance has been improved, and by eliminating the need for platforms, the installation costs are dramatically reduced.

### Easy maintenance
With reduced installation costs, the low-profile architecture will also improve your accessibility for routine and planned maintenance. No more need for a platform or ladders to access the gravity zone. Every aspect of the SMX-Q belt press is at a convenient, low level, for the benefit of the operating staff and for more safety.

### Modular design
Using modularity to the optimum, the SMX-Q belt press allows a flexible number of rolls for the S-zone (either eight or twelve) without requiring any alteration to the frame. Furthermore, the simple addition of a third belt gravity zone enables feed material with low solids to be dewatered more easily and more effectively.

### Wide gravity zone and optimized camber wedge
An improved headbox will ensure perfect distribution of the sludge. Our wide gravity zone will allow efficiently process flow without having to utilize any additional thickening equipment. The optimized camber wedge will ensure gradually increasing pressure, minimizing the possibility of extrusion.

### Your benefits
- Low-profile  structure for a smaller machine footprint and ease of access for operator (no platform needed)
- Continuously increasing pressure for perfect dewatering
- Highest throughput of up to 50% more than comparable competitor machines
- Lowest residual moisture of final product thank to extended dewatering area (8 or 12 S-rolls)
- Flexibility increased by modular design
- Low energy requirement, reduction of polymer consumption, ease of maintenance, and hydraulic capacity increased for significant cost savings and best operator safety

▲ Camber wedge and low profile for ease of maintenance

# A revolution in the world of belt presses
thanks to a clever design

## Optimized gravity section
The gravity section design is optimized through a distribution header for optimal distribution of slurry, a longer thickening zone, and optimized plows for better efficiency. All these features result in the highest hydraulic capacity on the market and avoid the need for combined systems in some cases.

## Curved wedge and pre-dewatering section design
The specific design of the camber wedge section allows a smooth and gradual increase in pressure, which is usually a critical step. The perforated rolls with approximately 70% open area achieve highest drainage efficiency. Combining these features leads to highest hydraulic and filling capacity.

## Design of S-rolls in high-pressure section
The process data and roll geometry of the SMX-Q belt press allows the maximum possible pressure to be applied without squeezing out the slurry at the edge of the belt. The SMX-Q belt press is available with eight or twelve rolls to provide a long, final high-pressure stage to achieve highest dryness performance and lowest residual moisture.

## Belt tracking and regulating system
A pivoting regulating roll is provided for each filter belt in order to prevent the belt from running off center. The regulating rolls are pivoted automatically by a pneumatically or hydraulically operated regulating device. This device is separate for each belt and consists of a belt tracking device that controls the pivoting movement of the regulating rolls via two air spring bellows, an automatic control unit which regulates the amount of air in the air spring bellows, and a feeler plate, which transmits the position of the edge of the filter belt to the relevant automatic control unit.

## Belt tensioning system
Both filter belts are tensioned separately by one belt tensioning roll with pneumatic or hydraulic cylinders. The bearing housings of the tensioning rolls are moved horizontally on slide rods mounted on the machine frame.

▲ Optimized plows for better gravity efficiency

# The right technical solution
## for large municipal and industrial treatment plants

### Standard features
- Low-profile structure for a smaller footprint, operator convenience, simpler installation (no platform needed), ease of access for operator to any components and for maintenance purposes (1520 mm height)
- Modular design increases flexibiility, open frame design for easy access
- Spray pipes with cleaning brush for automatic cleaning in standard
- Reliable, non-stop operation and highest availability with stainless frame as standard
- Extended dewatering area (8 or 12 S-rolls) for lower residual moisture in final product
- Drive roll in Buna-N, other rolls available as stainless, cladded, and thermoplastic polymer-coated rolls
- Filtrate trays separated to re-use filtrate from thickening zone as wash water
- Simple wear strip replacement in the gravity and wedge sections
- Optimized plows for better gravity efficiency
- Extra-long thickening zone

### Options
- Optimized flocculant consumption and automatic control of the machine (e.g. with RheoScan system)
- Modular, third belt gravity zone for increased hydraulic capacity
- Hydraulic or electrical tensioning and tracking available
- Planetary gear high torque
- CE-compliant safety panels for a partial or fully enclosed machine
- Galvanized frame

▲ 8 or 12 rolls for lowest residual moisture of final product

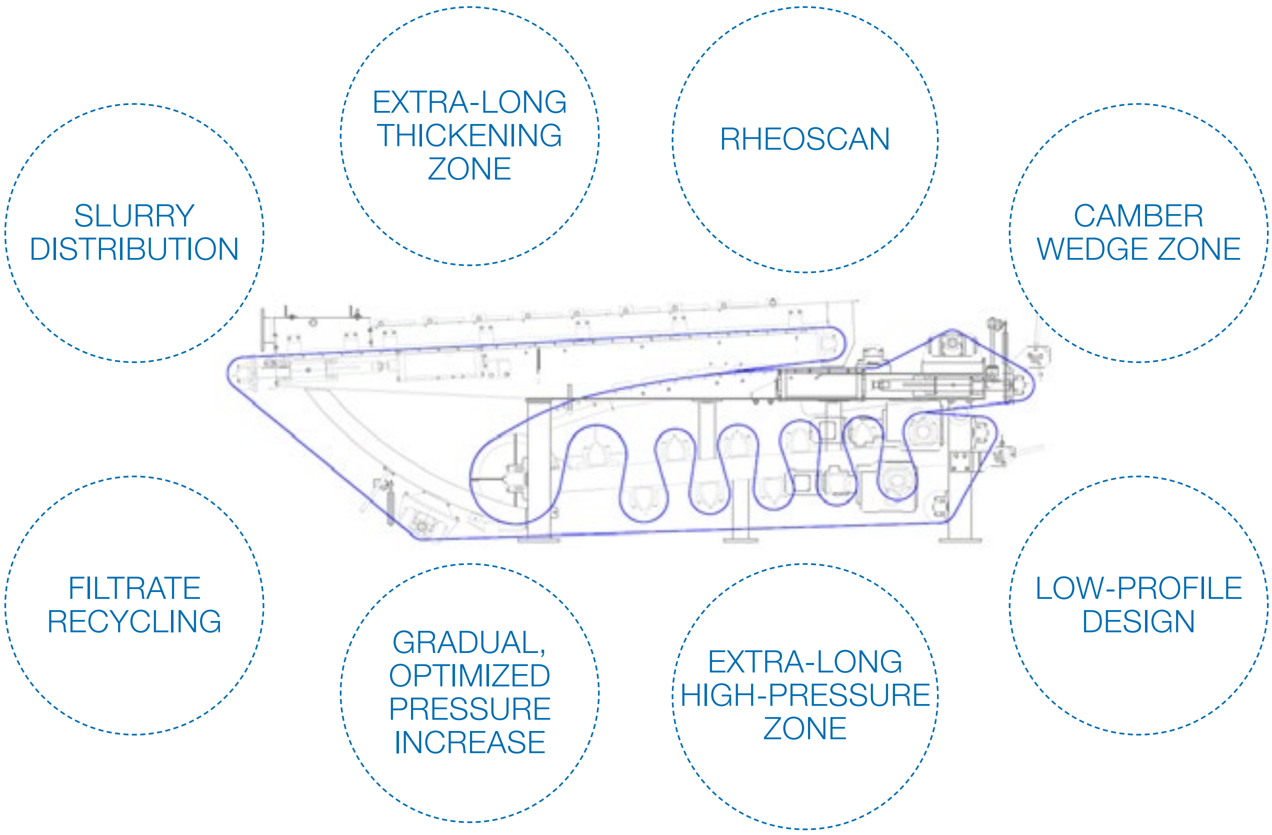
### Typical applications
- Thickening and dewatering in one stage (thank to efficient thickening zone or combined with gravity belt table)
- Municipal and industrial sludge
- High efficiency in specific applications: pulp & paper, manure, biogas, slaughterhouse, chemical sludge, etc.

| | SMX-Q 1000 | | SMX-Q 1500 | | SMX-Q 2000 | | SMX-Q 2500 | | SMX-Q 3000 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | S8 | S12 | S8 | S12 | S8 | S12 | S8 | S12 | S8 | S12 |
| Feed capacity up to (m³/hr)* | 22.5 | | 34 | | 45 | | 57 | | 67 | |
| Average dry solid throughput (kg/hr)* | 450 | | 750 | | 900 | | 1,125 | | 1,350 | |
| Length (mm) | 6,050 max. | | | | | | | | | |
| Width (mm) | 2,100 | | 2,600 | | 3,100 | | 3,625 | | 4,125 | |
| Height (mm) | 1,633 | | | | | | | | | |
| Motor drive (kW) | 1.5 | 2 x 1.5 | 1.5 | 2 x 1.5 | 2.2 | 2 x 1.5 | 2 x 1.5 | 2 x 2.2 | 2 x 2.2 | 2 x 2.2 |
| Average wash water consumption at 8 bar (g) (m³/hr) | 6.8 | | 10.2 | | 13.6 | | 17 | | 20.4 | |

* Based on specific feed solids – results will vary depending on sludge type

# Get more from your machine
## with full optimization of the dewatering process

As the world's leading separation specialist, we understand that no challenge starts or ends with a single machine. By taking a closer look at your entire process, we can apply the knowledge of more than 2,000 separation specialists and the technical capabilities of one of the world's broadest technology portfolios. Whether it's upstream or downstream, add-ons or automation, we have in-depth process know-how and resources around the world to further optimize your entire dewatering process.



# Your full-service provider

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Responsive local service centers and field service technicians

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SMX-Q 1.1/04.2017 EN

# References for WTP installations in CA (Alfa Laval Centrifuge)

| State | Project name | Type | # of units | Process | Flow Rate, gpm | Feed solids, TS% | Cake Solids, TS% | Polymer cons., lbs active/dT | Solids recovery, TS% |
|---|---|---|---|---|---|---|---|---|---|
| AZ | City of Phoenix, AZ 24th St. | ALDEC G2-120 | 2 | Ferric sludge | 250 | 4 | 25 | 8 | 95 |
| CA | IDE Carlsbad, CA | ALDEC G2 45 | 3 | Ferric sludge | 80 | 3 | 17 | 20 | 95 |
| DC | Dalecarlia | ALDEC G2-120 | 5 | Aluminium sludge | 250 | 6 | 28 | 12 | 95 |
| MA | Amesbury, MA | ALDEC G2 45 | 1 | Ferric sludge | 40 | 2 | 20 | 20 | 95 |
| MD | Harve De Grace WTP 08' | ALDEC G2-40 | 2 | Aluminium sludge | 60 | 3 | 19 | 20 | 95 |
| PA | Chalfont - Forest Park WTP | ALDEC G2-80 | 1 | Aluminium sludge | 110 | 1.2 | 22 | 13 | 95 |
| PA | Redbank Valley | ALDEC 30 | 1 | Aluminium sludge | 25 | 3 | 25 | 10 | 95 |
| PA | Lancaster, PA | ALDEC G2-100 | 2 | Aluminium sludge | 175 | 3 | 22 | 16 | 95 |
| TX | Midland, TX | ALDEC G2-80 | 2 | Ferric sludge | 130 | 4 | 30 | 15 | 95 |
| TX | Marlin, TX WTP | ALDEC G2-60 | 1 | Aluminium sludge | 75 | 3 | 25 | 14 | 95 |
| TX | City of Houston, East Water-Purification Plant | ALDEC G2-120 | 4 | Aluminium sludge | 400 | 3 | 18 | 18 | 96 |
| VA | G Robert House Jr WTP Phase III Expansion | ALDEC G2-75 | 2 | Aluminium sludge | 100 | 1.6 | 25 | 15 | 95 |

# Andritz Centrifuge References in California

| CUSTOMER | PLANT NAME (if different from customer name) | CITY | STATE | QTY | SIZE | SLUDGE TYPE |
|---|---|---|---|---|---|---|
| Union Sanitation District | Union Sanitation District WWTP | Union City | CA | 4 | D5LL | Anaerobically Digested |
| Industrial Design & Fabrication | | Stockton | CA | 1 | D5L 3 phase | Industrial Sludge |
| Hanford WWTP | | Hanford | CA | 1 | D6LL skid | Unknown |
| San Luis Obispo | | Oceana | CA | 1 | D4LL skid | Anaerobically Digested |
| Bell Carter Olive Co. | | Corning | CA | 1 | D5L | Other |
| Aliso Water Mgt. Assoc. | | Laguna Niguel | CA | 4 | D5L | Anaerobically Digested |
| Molton Niguel WWTP (SERRA, 3A) | | Molton Niguel | CA | 2 | D5L | WAS |
| South Orange County Wastewater Authority | J. B. Laythem WWTP | Dana Point | CA | 3 | (2) D5LL and (1) D5L | Anaerobically Digested |
| Escondido, CA (HARRF) | | Escondido | CA | 3 | D5L | Raw Undigested |
| Adelanto WWTP | | Temecula | CA | 1 | D4LL | WAS |
| Beaumont WWTP | City of Beaumont WWTP | Beaumont | CA | 1 | D4LL | WAS |
| R.E. Badger Filtration Plant WTP | R.E. Badger Filtration Plant WTP | Rancho Santa Fe | CA | 1 | D5LL | Water Treatment Plant Sludge |
| Selma-Kingsburg-Fowler | Selma-Kingsburg-Fowler | Kingsburg | CA | 1 | D5LL | Aerobically Digested |
| Inland Empire Energy Facility | Inland Empire Energy Facility | Chino | CA | 1 | D5LL | Other |
| Sacramento Regional WWTP | | Sacramento | CA | 2 | D7LL | Unknown |
| Table Mountain Rancheria WWTF | Table Mountain Rancheria WWTF | Fraint | CA | 1 | D4L | Aerobically Digested |
| Golden Cheese | Phoenix Bio Industries | Fallbrook | CA | 2 | D4L | Food Waste |
| LA County | | Los Angeles | CA | 1 | 3094 | Unknown |
| Selma-Kingsburg Fowler County Sanitation District | | Kingsburg | CA | 1 | D5LL | Aerobically Digested |
| City of Riverside WWTP | | Riverside | CA | 1 | D5LL | Unknown |
| Synagro | | Elk Grove | CA | 2 | D7LL | Unknown |
| Industrial Design & Fab | | Stockton | CA | 1 | D5L 3 Phase | Waste Water from Oil Tank Cleaning |
| Industrial Design III | | Stockton | CA | 1 | D5L 3 phase | Waste Water from Oil Tank Cleaning |
| Harry Tracy | | Fairfield | CA | 2 | D4LL | |

# Andritz Centrifuge References in California

| | | | | | | |
|---|---|---|---|---|---|---|
| San Francisco PUC | Harry Tracy WTP | San Mateo County | CA | 2 | D4L | Water Treatment Plant Sludge |
| Chino Basin Desalter | | Riverside | CA | 3 | D5LX | R/O Water Treatment |
| Sacramento Water | WTP | Sacramento | CA | 5 | D6LX | Alum WTP |
| Miner Ranch | WTP | Oroville | CA | 1 | D4L | Alum WTP |
| R.E. Badger Filtration Plant WTP | WTP | Rancho Santa Fe | CA | 1 | D5LL | Water Treatment Plant Sludge |

# Andritz Belt Filter Press References in California

ANDRITZ INSTALLATION LIST

CALIFORNIA

| CUSTOMER/CONSULTANT | LOCATION | STATE/ CTY | QTY. | EQUIPMENT | SIZE | APPLICATION | YEAR DELIVERED |
|---|---|---|---|---|---|---|---|
| Crown Zellerbach | Antioch | CA | 1 | S-C | 2000 | Primary/Secondary | 1977 |
| Vista Sanitary District | Encina | CA | 4 | SM | 2000 | Anaerobically Digested | 1983 |
| Aliso Water Mgmt. | Irvine | CA | 3 | SM | 1500 | Anaerobically Digested | 1983 |
| City of Thousand Oaks | Thousand Oaks | CA | 1 | SMX-S7-C | 2200 | Anaerobically Digested | 1983 |
| Proctor & Gamble | Oxnard | CA | 1 | P3-C | 1500 | Primary | 1984 |
| City of Riverside | Riverside | CA | 1 | SMX-S7-C | 2200 | Anaerobically Digested Primary/Waste | 1986 |
| Kimberly-Clark | Fullerton | CA | 2<br>2 | SMX-P3-C<br>RST | 1000<br>8x3 | Primary | 1986 |
| City of San Clemente | San Clemente | CA | 2 | SMX-S8 | 2000 | Primary/W.A.S. | 1987 |
| City of Riverside | Riverside | CA | 2 | SMX-S7-C | 2200 | Anaerobically Digested | 1988 |
| San Francisco | San Francisco | CA | 2 | SMX-S8 | 2000 | Anaerobically Digested Primary | 1989 |
| San Diego | San Diego | CA | 1 | SMX-S8 | 2000 | Anaerobically Digested | 1989 |
| Garden State Paper | Pomona | CA | 2<br>2 | Screw Presses<br>RST | 3630<br>8x3 | Primary | 1989 |
| City of San Francisco | San Francisco | CA | 1 | SMX-S8 | 2000 | Anaerobically Digested Primary Mobile Unit | 1989 |
| Foster Farms | Livingston | CA | 1 | SMX-S8 (SS) | 2000 | Clarifier Skimmage | 1990 |
| City of Millbrae | Millbrae | CA | 1 | SMX-S8 (SS) | 1500 | Primary Anaerobically Digested | 1990 |
| Foster Farms | Livingston | CA | 1 | SMX-S5 (SS) | 2000 | DAF/Poultry | 1990 |
| Zacky Farms | Fresno | CA | 1 | SMX-S5 (SS) | 1500 | DAF/Poultry | 1990 |
| Placer Co. WWTP | Auburn | CA | 1 | SMX-S8 (SS) | 1000 | Anaerobically Digested | 1990 |
| City of Burlingame | Burlingame | CA | 1 | SMX-S8 (SS) | 2000 | Aerobically Digested W.A.S. Activated | 1990 |
| Foster's Farms | Fresno | CA | 1 | SMX-S8 (SS) | 2000 | DAF/Poultry | 1990 |
| Oceanside WWTP | San Francisco | CA | 1 | SMX-S8 | 2000 | Anaerobically Digested | 1991 |
| Harcross Pigments | Emeryville | CA | 1 | SMX-S5-C | 2000 | Primary | 1991 |
| City of Placerville | Placerville | CA | 1 | SMX-S8 (SS) | 1200 | Aerobic/Anaerobic | 1991 |
| Mule Creek State Prison | Ione | CA | 1 | SMX-S8 (SS) | 1500 | Anaerobic Digested | 1992 |
| City of Vacaville | Vacaville | CA | 1 | SMX-S8 | 2000 | Waste Activated | 1993 |
| Hyperion | Playa Del Rey | CA | 1 | SMX-P3 (SS) | 1200 | Screenings | 1993 |
| Fiesta Island WWTP | San Diego | CA | 5 | SMX-S8 | 2000 | Blended Primary/W.A.S. | 1994 |
| Simpson Paper | Ripon | CA | 1 | SMX-S8P | 1000 | Primary | 1995 |

# Andritz Belt Filter Press References in California

| CUSTOMER/CONSULTANT | LOCATION | STATE/ CTY | QTY. | EQUIPMENT | SIZE | APPLICATION | YEAR DELIVERED |
|---|---|---|---|---|---|---|---|
| Corona, California | Corona | CA | 2 | SMX-S8 | 2000 | Biological W.A.S. | 1996 |
| San Francisco Airport | San Francisco | CA | 1 | SMX-S8 NGII (stock machine) | 2000 | N/A | 1998 |
| Tons Per Hour | Newcastle | CA | 2 | SMX-S4 (VA) | 2800 | Sludge from Aggregate Dewatering | 2008 |
| Tons Per Hour | Newcastle | CA | 2 | SMX-S4 (VA) | 2800 | Aggregate | 2008 |
| PW Gillibrand Co., Inc. | Simi Valley | CA | 2 | S4 | 2800 | Aggregate | 2006 |
| Hangtown Creek | Placerville | CA | 1 | 1200 EG8 | 1200 | Anaerobic digested blend | 2006 |
| Coachella Valley Water District | Palm Desert | CA | 2 | SMX-S14/4 | 2000 | WAS | 2005 |
| Tons Per Hour - Robertson Aggregate | Newcastle | CA | 1 | SMX-S4 | 2800 | Aggregate | 2005 |
| Burlingame WWTF | Burlingame | CA | 1 | SMX-S8 | 2000 | Aerobically Digested 40-50% Primary/WAS | 2004 |
| Tons Per Hour, CA | | CA | 1 | SMX-S8 VA | 2000 | Aggregate | 2004 |
| El Paso De Robles | Paso Robles | CA | 1 | SMX-S8 VA Skid | 2000 | Anaerobically Digested Sludge From Trickling | 2003 |

# Andritz Belt Filter Press References in the United States

Environment & Process

## ANDRITZ INSTALLATION LIST

## WATER TREATMENT PLANTS

| CUSTOMER/CONSULTANT | LOCATION | STATE/ CTY | QTY. | EQUIPMENT | SIZE | APPLICATION | YEAR DELIVERED |
|---|---|---|---|---|---|---|---|
| City of Tampa | Tampa | FL | 4 | SMX-S7-C | 2200 | Ferric Sulfate | 1986 |
| Ohio Dept. of Corrections | Columbus | OH | 2 | NF-C | 500 | Water Treatment Lime Sludge | 1988 |
| Northern Kentucky Water (formerly Kenton County) | Taylor Mill WTP | KY | 1 | SMX-S8 | 2000 | Alum/Primary | 1989 |
| Ed Love WTP | Birmingham | GA | 1 | SMX-S8 | 1000 | Alum Sludge | 1992 |
| Richmond County WTP | Richmond County | NC | 2 | SMX-S8 | 1000 | Alum Sludge | 1992 |
| Ullrich WTP | Austin | TX | 1 | SMX-S8 | 1000 | Water Treatment (lime) | 1993 |
| Perry WTP | Montgomery | AL | 2 | SMX-S8 | 2000 | Water Treatment (lime) | 1993 |
| City of Moline | Moline | IL | 2 | SMX-S8 | 2000 | Primary/Secondary/Lime | 1995 |
| A.B. Jewell WTP | Tulsa | OK | 3 | SMX-S8 | 2000 | Alum | 1994 |
| Mohawk WTP | Tulsa | OK | 2 | SMX-S8 | 2000 | Alum | 1994 |
| Fargo WTP | Fargo | ND | 1 | SMX-S8 | 2000 | Water Treatment Lime Softening | 1994 |
| Marston WTP | Denver | CO | 1 | SMX-S8 (SS) | 2000 | Alum Sludge | 1996 |
| Vicksburg, MS | Vicksburg | MS | 2 | SMX-S8 | 2000 | Lime Sludge | 1996 |
| T.L. Amiss WTP | Bossier City | LA | 1 | SMX-S8 | 2000 | Alum sludge | 1999 |

# Andritz Belt Filter Press References in the United States

| CUSTOMER/CONSULTANT | LOCATION | STATE/ CTY | QTY. | EQUIPMENT | SIZE | APPLICATION | YEAR DELIVERED |
|---|---|---|---|---|---|---|---|
| Ed Love WTP II | Tuscaloosa | AL | 1 | SMX-S8 | 1000 | Alum sludge | 1999 |
| Santee Cooper-Lake Moultrie WTP | Moncks Corner | SC | 1 | SMX-S8NGIII | | Alum sludge | 1999 |
| Jones Ferry | Carrboro | NC | 1 | SMX-S14 | 2000 | Alum Sludge | 2000 |
| Sanford WTP | Sanford | NC | 1 | SMX-S14/4 | 2000 | 100% Alum | 2004 |