Microsand-Ballasted Clarification Technology Provides Recycled Water For Cooling Tower Make-up To Calpine's Delta Energy Center

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Summary: This paper presents a case study on the microsand-ballasted clarifiers installed at the Delta Diablo Sanitation District's recycled water facility in Antioch, CA., which is providing cooling tower water for Calpine Corporation's new Delta Energy Center (DEC) generating plant in Pittsburg, CA.

THE CHALLENGE

In February 1999, Calpine announced plans to build a new 880-megawatt (MW) gas-fired cogeneration plant in Pittsburg, CA, near San Francisco. This plant, known as the Delta Energy Center (DEC), would provide steam and electricity to the nearby Dow Chemical Company facility, with the excess electricity supplying the California power market. Before the plant could be built, however, the plant's developer and the California Energy Commission (CEC) had to make sure the facility complied with regulations protecting local water resources. They also had to evaluate the use of recycled water for cooling needs, to satisfy a water control policy established by the State Water Resources Control Board (SWRCB). In addition, they had to follow the specific language in the power plant siting regulations and the Waste Water Reuse Law on using recycled water for cooling.

The Delta Diablo Sanitation District, which operates the area's wastewater treatment plant, evaluated the cooling water make-up needs of Calpine's proposed plant, as well as those of the proposed Los Medanos Energy Center (LMEC). Owned and operated under Los Medanos Energy Center LLP, LMEC is a 550-MW combined-cycle, merchant cogeneration plant located about three miles from the District. In the application for certification, the two facilities proposed to use recycled water as the main cooling water source. DEC required a minimum of approximately 3.3 million gallons per day (MGD) of cooling water, and a maximum of approximately 6.9 MGD. LMEC required a minimum of about 2.8 MGD per day and a maximum of about 5.4. The District determined that a new recycled water facility was required to meet the needs of the two plants.

A public-private partnership between the District and a development team of representatives from Calpine Corporation and Bechtel Enterprises, Inc. (referred to as the Developers) was formed to build a new recycled water facility (RWF) at the District. The plan was for the Developers to design, construct and dedicate the RWF to the District to own, operate and deliver water to DEC, located adjacent to the District's wastewater treatment plant. The RWF had to meet the State of California Department of Health Services Title 22 standards for "disinfected tertiary," as required for cooling tower use. It also had to be completed in nine months so it could deliver water by the end of year 2000, in time for LMEC start-up in early 2001. The plant also needed to use proven technologies to avoid any permitting, start-up or operational delays.

THE SOLUTION

Construction of the RWF began in March 2000, with the goal that it would be delivering water by December. DEC construction began in the spring of 2000, with commercial operation starting in May 2002.

In order to meet stringent California State re-use water criteria, the treatment technologies chosen for the RWF consisted of primary and secondary pretreatment, microsand-ballasted clarifiers, tertiary filtration and disinfection (see Figure 1). The treated water is sent to a storage tank, then to DEC.

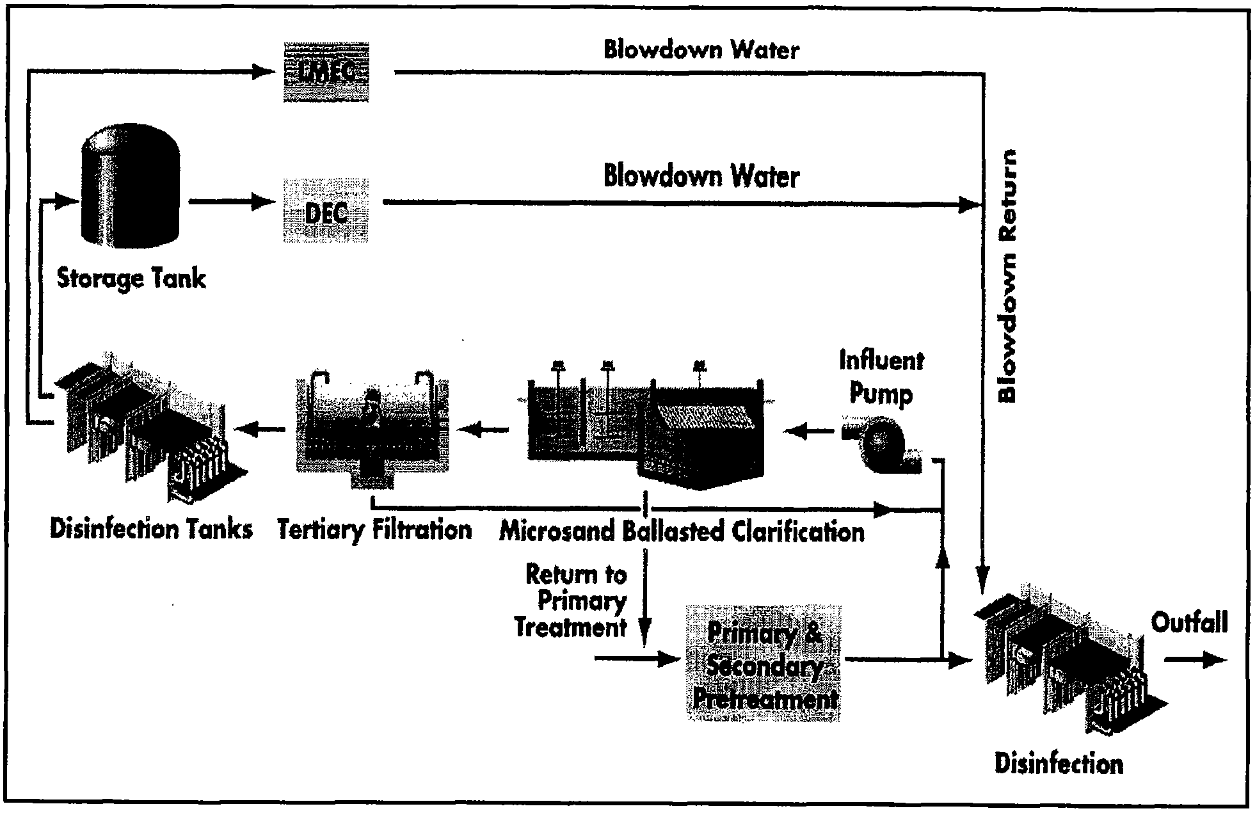

Figure 1 RWF Treatment Technology Flow Diagram

The feedwater to the continuous backwash tertiary filters must meet a certain quality so that the final disinfected tertiary effluent meets Title 22 standards for cooling tower use. This is accomplished with a combination of two 7 MGD microsand-ballasted clarifiers, followed by continuous backwash filters, and then chlorine contact disinfection.

Plant wastewater, which consists of cooling tower blowdown, RO reject and water from process drains, is returned to the District's chlorine contact equipment, where the flow combines with the secondary effluent and is dechlorinated before discharge to the District outfall.

Because of turbidity spikes, the feed water to the RWF would not have met the Title 22 specifications of 2.0 NTU without first undergoing microsand-ballasted clarification. The clarifiers are able to produce water with less than 1 NTU, even when there are spikes in raw water turbidity. This results in lower filter loading, and subsequently, less frequent backwashing, and also results in increased filter run times.

The microsand-ballasted clarifiers differ from conventional clarifiers in that they use microsand as a "seed" for floc formation (see Figure 2). The microsand provides increased surface area for floc attachment, and acts as a ballast or weight. The resulting sand-ballasted flocs have higher settling velocities than do flocs produced in conventional clarifiers. This allows much higher clarifier overflow rates, which translate directly into reduced clarification retention time, reduced system footprint, and reduced total cost. At maximum flow, the hydraulic retention time (HRT) for mixing and flocculation is less than nine minutes. Moreover, the concentration of recirculating microsand diminishes the effects of spikes in raw water quality on the settled water out of the clarifiers. The clarifier is capable of producing settled water with turbidity less than 1.0 NTU (suspended solids below 5 mg/l).

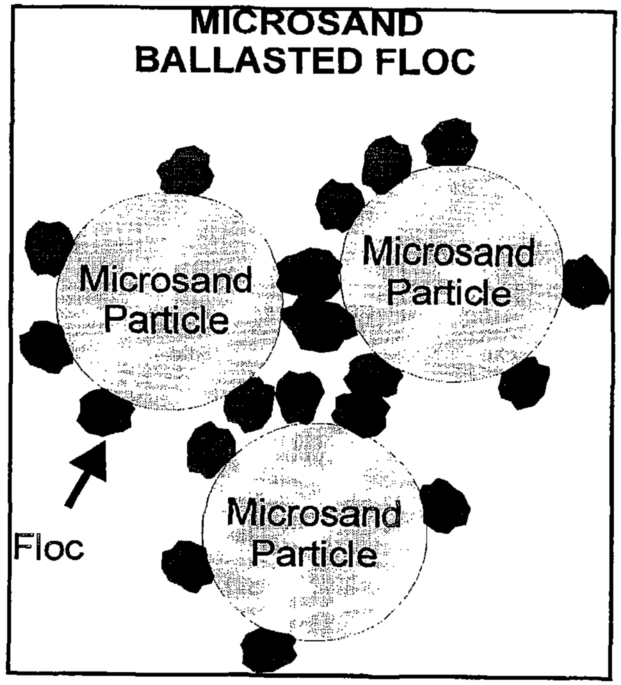

Figure 2

The clarifier works as follows (see Figure 3): raw water enters the coagulation tank, where chemical coagulant (alum or ferric, etc.) is added to destabilize suspended solids and colloidal matter in the influent stream. Mixing is provided in this step to thoroughly incorporate the coagulant into the raw water.

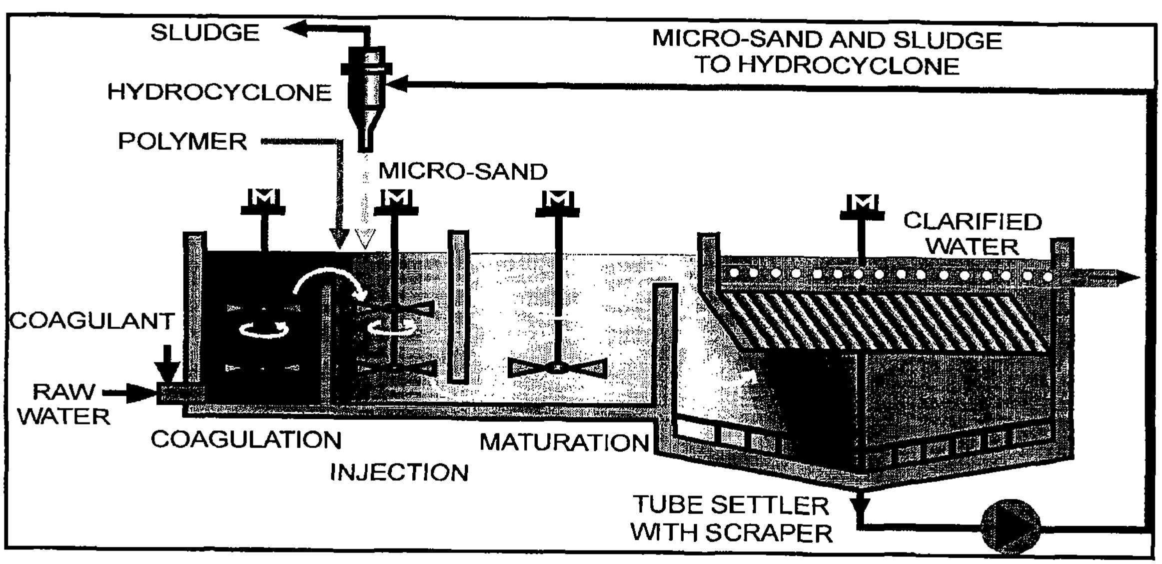

Figure 3 Microsand-Ballasted Clarifier Process

The coagulated water passes into the injection tank, where polymer and microsand are added to initiate floc formation. In this tank, the polymer acts as a bonding agent between the microsand grains and the coagulated matter, forming flocculated particles many times the size of the individual coagulated matter. At a nominal 100-micron diameter, the microsand is much larger and denser than the lighter coagulated particles, and the larger sand grains, covered with polymer chains, act as floc scavengers to collect and capture floc particles in the flow stream. The larger sand grains increase the occurrence of floc collision, resulting in higher water clarity.

Next, the water passes into the maturation tank, where gentler mixing provides ideal conditions for the formation of polymer bridges between the microsand and the destabilized suspended solids. The fully formed ballasted flocs leave the maturation tank and enter the settling tank, where the weighted flocs settle to the bottom of the clarifier. The clarified water flows upward through the lamella tubes in the clarifier zone, and exits the system via a series of collection troughs or weirs for subsequent filtration and disinfection.

The microsand with the floc attached settles to the bottom of the clarifier, where it is collected and recycled by a centrifugal pump to the injection hydrocyclone. The hydrocyclone separates the sand from the sludge, and the sand is re-injected into the process. Typical sand make-up is six to eight pounds per MGD of treated water.

The specifications of the clarifiers installed at the RWF are shown in Table 1.

Because of the reduced size of the microsand-ballasted clarifier, the installation cost is much less than that of very large conventional clarifiers, which often arrive primarily in rolled sheets of steel. Chemical costs associated with the clarifier may also be lower because of the microsand ballast and more efficient coagulation and flocculation mechanics.

Started up in February 2001, the clarifiers are meeting the Title 22 requirement for clarification pretreatment. The plant is being run to optimize total water quality, and although the clarifiers are able to produce water with significantly less than 1 NTU, the tertiary filters require water with some turbidity in order to produce good filtered water quality. As a result, the effluent from the clarifiers is generally kept between 1.5 and 2.0 NTU. The performance of the clarifiers is shown in Table 2 and also in Figure 4.

Table 1 Specification of Clarifiers at the RWF (per Train)

Flow Rate (per train)	4,860 gpm (7 MGD)
Coagulation HRT (at design flow)	1.5 minutes
Injection/Polymer Addition HRT (at design flow)	1.55 minutes
Maturation HRT (at design flow)	5.55 minutes
Total System HRT (at design flow)	14.6 minutes
Clarifier Section Rise Rate (at design flow)	21 gpm/sq ft
Footprint	41.5 ft L x 17.3 ft W x 13.8 ft D

Table 2 Clarifier Operating Data Summary

Clarifier Feed Rate	4 to 9 MGD
Clarifier Feed Water Turbidity	6 to 16 NTU
Clarifier Settled Water	1.5 to 2 NTU
Coagulant Type	Alum
Coagulant Dose	50 to 80 mg/l
Polymer Type	Cationic
Polymer Dose	1.4 to 2.0 mg/l
Filtered Water	0.5 to 1.2 NTU

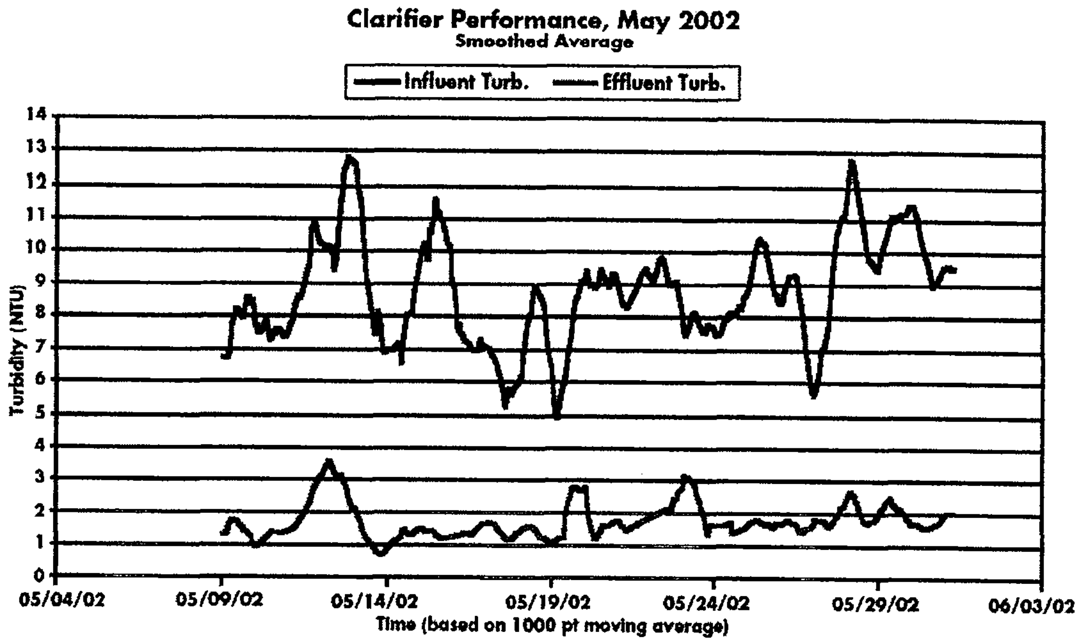

Figure 4 Clarifier Performance, May 2002

Clarifier startup went very well. The clarifier was producing water with less than 2 NTU within 24 hours after it was placed into operation. The entire system was operational in 10 days.

The system has performed well for the past 18 months. There have been few upsets even though influent quality varied quite a bit. Typically, the system runs unattended. Maintenance has been minimal, and daily operator attention is less than 4 hours even when sand is added. The plant has required on an average less than 100 pounds of non-proprietary sand per week, which is equal to approximately two pounds per MGD of treated water.