KEEPING A PLANT IN SERVICE DURING A $50 MILLION PROJECT - DESIGN AND CONSTRUCTION CHALLENGES DURING UPGRADE AND EXPANSION OF THE MANTECA WASTEWATER QUALITY CONTROL FACILITY

D. Richard, A.G. Calciano, R. Ait Lasri, P. Govea

Nolte Associates, Inc., 302 Cherry Lane, Manteca, California 95337

ABSTRACT

The Manteca Wastewater Quality Control Facility (WQCF) is a 7.5 million gallons per day (mgd) rated combined biofilter-activated sludge plant. The WQCF treats typical municipal wastewater generated in the City of Manteca, California and the neighboring City of Lathrop. The plant also receives seasonal discharges from a local food processor. Currently, the Manteca WQCF consists of an influent pump station with two mechanical screens, two aerated grit tanks, three primary sedimentation basins, a biotower feed pump station, two biotowers, five fine-bubble activated sludge aeration basins, three secondary clarifiers, and two chlorine contact tanks. Solid handling facilities include two dissolved air flotation units, two anaerobic digesters, one centrifugal dewatering system, and drying beds. Undisinfected secondary effluent is used to irrigate approximately 200 acres of City-owned land surrounding the plant. Flows in excess of crop demands are disinfected and discharged to the San Joaquin River. Anaerobically digested sludge is dewatered, dried, and stored on-site, and land applied during the spring and fall.

The capacity of the Manteca WQCF will increase from 6.95 mgd to 9.87 mgd following completion of the on-going expansion/upgrade project in 2006. The challenges and significant engineering issues encountered during the design and construction of the expansion/upgrade project is discussed in this paper.

KEYWORDS

Treatment plant expansion, Title 22, design challenges, alternative disposal routes

DESCRIPTION OF MANTECA WASTEWATER QUALITY CONTROL FACILITY

The Manteca Wastewater Quality Control Facility (WQCF) began operation in 1959. At that time the facility consisted solely of an oxidation pond. Pond effluent was discharged to the surrounding land. In 1970, the first major upgrade to the plant occurred. This upgrade included the construction of preliminary and primary treatment facilities and aerobic sludge digestion. Effluent continued to be discharged to the land for agricultural applications. In 1986-1988, as part of the Clean Water Grant Program, a major expansion to the plant was constructed. This Phase I Expansion Project included the construction of secondary treatment facilities, anaerobic sludge digesters, sludge drying beds, a chlorine disinfection system, and an outfall to the San Joaquin River. Design capacity of the plant

following the Phase I project was 5.45 mllion gallons per day (mgd). The Phase II Expansion Project in 1992-1993 added a primary sedimentation basin, secondary clarifier, and four sludge drying beds, increasing the facility capacity to 6.95 mgd.

Currently, the WQCF treats 7.5 mgd of municipal wastewater generated in the City of Manteca, California and the neighboring City of Lathrop. The plant also receives seasonal discharges from a local food processor. Today, the WQCF consists of an influent pump station with two mechanical screens, two aerated grit tanks, three primary sedimentation basins, a biotower feed pump station, two biotowers, five fine-bubble activated sludge aeration basins, three secondary clarifiers, and two chlorine contact tanks. Solids handling facilities include two dissolved air flotation units, two anaerobic digesters, one centrifugal dewatering system, and drying beds. Undisinfected secondary effluent is used to irrigate approximately 200 acres of City-owned land surrounding the plant. Flows in excess of crop demands are disinfected and discharged to the San Joaquin River. Anaerobically digested sludge is dewatered, dried, and hauled off-site to a landfill.

OVERVIEW OF PHASE III EXPANSION PROJECT

The Phase III Expansion Project at the Manteca WQCF will increase the capacity from 7.5 mgd to 9.87 mgd. The Project is divided into four Schedules: A, B, C, and D, respectively. Schedule A was completed in November 2003. The anticipated dates for design completion, commencement of construction, and completion of construction for Schedules B, C, and D are summarized in Table 1. A brief description of each of the four schedules is provided below.

TABLE 1
PROBABLE SCHEDULE OF EXPANSION/UPGRADE PROJECT
AT THE MANTECA WQCF

Project	Complete Design	Begin Construction	Complete Construction
Schedule B, Southside Facilities	Completed	January 2004	July 2005
Schedule C, Solids Handling	January 2004		
Schedule D, Effluent Filtration	June 2005	August 2005	August 2006

Schedule A Improvements - Northside Nitrification Facilities

Schedule A improvements included the construction of two new aeration basins, modifications to three existing secondary clarifier sludge collection mechanisms, and replacement of two existing centrifugal blowers with larger and more energy efficient units for the aeration basins. All aerations basins are equipped with high-efficiency panel diffusers. Schedule A improvements resulted in an increase in plant capacity from 6.95 to 7.5 mgd. The WQCF was also upgraded to a total nitrification plant with Schedule A improvements. Construction of Schedule A began in December 2001 and was completed in November 2003. As part of the Schedule A improvements, a skid-mounted centrifugal dewatering system was procured to dewater anaerobically digested primary and secondary sludges.

Schedule B Improvements – Southside Facilities and Influent Pump Station

Schedule B improvements include the construction of a new influent pump station, two aerated grit tanks, three primary sedimentation basins, five aeration basins, two secondary clarifiers, and an odor control biofilter (Southside Facilities). Schedule B improvements also includes the expansion of the existing laboratory and administration buildings. These improvements will increase the treatment capacity of the plant from 7.5 mgd to 9.87 mgd. The WQCF will also be upgraded to a total nitrogen removal plant at the completion of Schedule B. More specific information is as follows.

Influent Pump Station/Mechanical Screening: The influent pump station is sited on the eastern edge of the WQCF property to allow for easy tie-in with the new trunk sewers while minimizing disruption to existing facilities and structures. The station includes two fine mechanical screens (3/8 inch openings), a wet well, a dry well equipped with four centrifugal pumps, and a flow meter. Space is provided for a future third mechanical screen. The four screw centrifugal pumps equipped with variable frequency drive units will deliver screened raw wastewater to the northside and southside treatment systems, respectively. Discharge from two 100-hp pumps will be conveyed to the northside facilities. Discharge from one 200-hp pump will be conveyed to the southside facilities. Through the operation of valves, a standby 200-hp pump can discharge to either the northside or southside facilities. Space will be provided in the influent pump station to install four additional pumps to handle future flows. Screw centrifugal pumps were selected because of their ability to pass solids and their high efficiency. The influent pumps are designed to deliver a peak flow of 19.4 mgd.

Septage Receiving: To provide service to septage haulers, a new septage receiving station will be constructed as part of the Project. The septage receiving station will consist of two adjacent sumps that pumper trucks can back up to and discharge their load by gravity. The existing septage receiving station at the WQCF requires septage haulers to operate their vacuum pumps in reverse to fully discharge their load. Each sump will have an independent discharge point so that plant staff can sample septage quality prior to releasing material to the influent pump station.

Grit Removal/Primary Sedimentation: Two aerated grit tanks and three primary sedimentation basins are included in the southside facilities. Primary sludge and scum will be pumped to the plant solids handling facilities.

Southside Aeration Basins: Five new aeration basins will be constructed to provide secondary treatment at the southside facilities. The five southside aeration basins will be slightly larger than the five northside basins because biotowers for carbonaceous BOD removal will not be provided upstream of the southside basins. Biotowers were not selected for the southside because of historic problems WQCF staff have experienced with the northside units in producing an effluent of consistent quality. Similar to the northside aeration basins, the aeration basins will be divided into five zones separated by baffle walls. Three 200-hp multi-stage centrifugal blowers (two duty and one standby)

will supply this air to the diffusers. Each blower will be sized to provide up to 3,300 scfm at 9.5 psi. The same high efficiency air diffuser units are to be used on the southside that currently exist on the northside facilities.

Secondary Clarification: The three existing 85-ft diameter secondary clarifiers have sufficient capacity to handle projected northside flows. Two new 110-ft secondary clarifiers are proposed for the southside facilities.

Odor Control Biofilter: Current odor control practices at the WQCF consist of ferric chloride addition to the influent sewer upstream of the headworks facility. Because of the corrosive nature of ferric chloride, WQCF staff has speculated that it has contributed to the degradation of piping and equipment in the existing headworks facility. Based on the results of a life cycle cost analysis for three technologies, biofiltration was chosen for odor control. The biofilter will treat 32,000 scfm of foul air from the new influent pump station and future dewatering building.

Schedule C Improvements – Solids Handling Facilities

The improvements proposed under Schedule C primarily involve solids handling. Under Schedule C, a new anaerobic digester, sludge control building, and mechanical dewatering facility will be constructed. Additional improvements to occur under Schedule C include the construction of a shop maintenance building, expansion of the employee training area, and development of a paved biosolids stockpile area. These facilities are described below.

Anaerobic Digestion: Wastewater solids generated in the primary sedimentation basins and activated sludge process are anaerobically digested. New anaerobic digester facilities proposed as part of the Project include one digester, a sludge control building with a boiler and cogeneration room, a digested sludge transfer structure, and a waste gas burner. This new digestion complex was sized to handle the projected Phase III solids loading, however, space was included to facilitate expansion to the projected WQCF buildout flow of approximately 25 mgd. The existing facilities include two 510,000-gal fixed dome anaerobic digesters. As part of the Phase III expansion, a third 900,000-gal fixed dome digester will be built. A sludge control room will be constructed for mixing and heating the sludge. Two 50-hp pumps (one duty and one standby) will provide energy for mixing.

Dewatering Facilities: Anaerobically digested sludge used to be dewatered in 39 sludge drying beds located around the perimeter of the plant. Sludge was allowed to settle and dry in the beds and water decanted back to the headworks facility. Because expansion of the existing sludge drying beds is not considered feasible due to the loss of land area which would no longer be available for application of biosolids and treated effluent, the Project includes the construction of a mechanical sludge dewatering facility. Under Schedule A, one 100-hp skid-mounted mechanical centrifuge was installed at the plant. Under Schedule C, a second 100-hp centrifuge will be purchased and both centrifuges

will be mounted on a platform within a new building. The facility will have space for a third similar unit**.**

Schedule D Improvements – Tertiary Filtration and UV Disinfection Facilities

Proposed Schedule D improvements include the construction of a secondary effluent equalization pond, filter feed pump station, coagulation and flocculation facilities, tertiary filters, a chemical storage-metering facility, a UV disinfection system, and an effluent pumping station sized for total flow through the plant. In addition to flow attenuation, the secondary effluent equalization pond will store water during periods of reverse river flow due to tidal influence in the San Joaquin River. By operating the equalization pond in hold-back mode, the temperature impact of the discharge will be reduced. A cloth type disk filter and low pressure, high intensity UV disinfection system were selected to upgrade the WQCF to meet the California Title 22 wastewater reuse criteria.

Filter Feed Pump Station: A pump station will be used to deliver secondary effluent to the rapid mix tank, flocculation tanks and tertiary filters. Three vertical mixed flow impeller pumps (two duty and one standby) rated at 6,950 gpm (10 mgd) each at a TDH of 35 feet with 100 hp motors will be furnished. A smaller pump, rated at 3,500 gpm (5 mgd) at a TDH of 35 feet with a 50 hp motor will also be furnished for low flow conditions. Variable frequency drive (VFD) units and a magnetic flowmeter will be used to control the pumps to obtain the filter flow desired by the operator.

Coagulation, Flocculation, Tertiary Filtration: To reduce suspended solids and organic loading to the San Joaquin River and increase the reliability of the UV disinfection system, tertiary filtration will be added to the WQCF as part of Schedule D. Treatment facilities will include chemical addition, rapid mixing, flocculation, and filtration. Coagulant and polymer will be added to secondary effluent before filtration. Immediately after chemical addition, the water will be routed through a rapid mix tank, followed by a three-phase flocculation tank with mechanical mixers. Six units of the Cloth Disk Filter™ manufactured by Aqua Aerobic Systems will be used for tertiary filtration. Each filter unit will contain 12 cloth disks for a total filter area of 3874 ft^2. The filter will be sized for an average flow of 9.87 mgd and a maximum flow of 19.15 mgd.

UV Disinfection: Filtered effluent must be disinfected prior to discharge to the San Joaquin River or prior to reuse off-site. For reasons of worker safety, environmental protection, and operational flexibility, an ultraviolet light disinfection system will be used. The installation will be a low-pressure high-intensity UV system manufactured by Wedeco. Sizing of the UV system was based on guidelines published by NWRI as implemented by the Department of Health Services to ensure that the disinfected water complies with Title 22.

Effluent Pumping: Disinfected final effluent from the WQCF will be discharged to the San Joaquin River through an existing 36-in 14,300 ft long outfall. Under average conditions, discharge through the outfall can occur by gravity. However, when the water surface elevation in the San Joaquin River is high or peak flows occur at the plant or a

combination of the two, effluent pumping is required. The pump station will consist of two 100-hp vertical turbine pumps (one duty and one standby) each capable of pumping up to 6,700 gpm (9.65 mgd) at 45 ft TDH. The pumps will be automatically started via a water surface level sensor in the UV system effluent wet well.

Secondary Effluent Equalization Pond: An off-line secondary effluent equalization reservoir will be built to dampen diurnal peak and low flow conditions to the tertiary filters and UV disinfection system, and to store effluent when discharge to the San Joaquin River is unavailable due to temperature conditions. At an average daily flow of 9.87 mgd, the storage volume recommended to provide diurnal flow equalization is approximately 1.9 Mgal. Another 3.7 Mgal of storage will be needed when low flow conditions in the San Joaquin River at times of high tidal influence lead to a potential temperature increase greater than the 20º F allowed. Adding the storage associated with diurnal flow equalization (1.9 Mgal) and off-line storage (3.7 Mgal), while providing an additional 25 percent contingency for operational flexibility (1.4 Mgal), resulted in a recommended storage volume of 7.0 Mgal over an area of 4.8 acres. The pond will be both lined and covered to mitigate sedimentation and water quality issues.

DISCUSSION OF DESIGN/CONSTRUCTION CHALLENGES

Considering the Project scale and design objectives, a number of challenges were presented to the Engineer. These included: 1) Achieving significant improvements in effluent water quality; 2) Managing a four-year construction project under continuous regulatory scrutiny; 3) Providing maximum flexibility to operational staff; 4) Maintaining critical utility systems through the construction process; and, 5) Mitigating potential delays and construction change orders due to unforeseen conditions. Each of these challenges is discussed briefly below.

Effluent Water Quality Improvements

To satisfy more stringent effluent discharge requirements, significant water quality improvements at the Manteca WQCF are necessary. While the plant has operated effectively producing secondary effluent suitable for either discharge to the San Joaquin River or reuse through agricultural irrigation, the new plant NPDES permit will require tertiary treatment for any increases in flow. Specifically, wastewater must be fully nitrified and denitrified to reduce ammonia and nitrogen loadings to land application sites or to receiving waters. In addition, tertiary filtration and disinfection are required to produce essentially a pathogen-free wastewater suitable for unrestricted reuse as defined under Title 22, Wastewater Reclamation Criteria of the California Administrative Code. These requirements for nutrient and pathogen reductions necessitated an upgrade of the biological treatment process and the construction of secondary effluent filtration and enhanced disinfection systems. All of these advanced treatment systems must operate efficiently under varying influent loads to pass muster with the local regulatory agency.

Regulatory Scrutiny

Mandatory fines for permit violations eliminate any discretion or leeway by the regulatory agencies in resolving water quality issues during construction. Because of previous water quality violations and administrative penalties, Regional Water Quality Control Board (Regional Board) staff has focused upon enforcement actions with the City. This level of regulatory scrutiny creates additional pressure to design/implement temporary facilities or alternative disposal systems to avoid spills or poorly treated water. Where historically, a facility undergoing a major expansion or upgrade might be viewed sympathetically by the regulatory community, there is little room for error during the four-year construction period at the Manteca plant.

Operational Flexibility

A new process train will be constructed as part of the Phase III Expansion Project. Upon completion, the City can treat wastewater either through the existing process configuration known as the northside facilities or though the new high-rate activated sludge system within the proposed southside facilities. Disposal options to be maintained through either treatment system will include storage in a secondary effluent storage pond prior to land application or disinfection with discharge to the San Joaquin River. To maximize operational flexibility, provisions are desired to shunt water from either treatment system to either disposal option simultaneously. In other words, if water from the new southside facilities is superior to the northside facilities, southside secondary effluent would be routed to tertiary treatment facilities for river discharge while undisinfected secondary effluent from the northside facilities would be used for agricultural irrigation.

Critical Utility Systems

There are a number of vital utility systems within the plant that must remain operational throughout construction. These include the influent trunk sewer, electrical power system, process control system, and river outfall. Any potential outage must be strictly limited in nature or a temporary bypass system in place to allow for uninterrupted service.

Unforeseen Conditions

Unforeseen conditions encountered during construction can play havoc with a contractor’s schedule and lead to significant change orders and potential claims. Examples of unanticipated problems may include unknown utilities creating pipeline conflicts, underground obstructions, undocumented facility construction, and unpredicted electrical/control system failures. Because of the need to maintain plant operations throughout construction while satisfying all regulatory requirements, pre-construction activities designed to identify potential field problems along with mitigation strategies to avoid associated delays are critical to project success.

MITIGATING DESIGN/CONSTRUCTION CHALLENGES

To resolve design and potential construction challenges or issues, specific steps were undertaken by the Engineer including: 1) applying lessons learned from similar facilities; 2) undertaking pilot studies for key unit processes; 3) developing alternative routing for wastewater disposal; 4) identifying windows of opportunity for service interruptions with plant staff; 5) preparing a detailed construction sequence; 6) completing a comprehensive field investigation; and, 7) initiating a constructability review by the construction management team. Each step is discussed below along with the potential resolution of project issues.

Lessons Learned from Similar Projects

To validate the effectiveness of proposed advanced treatment systems, historical operating data from similar facilities were analyzed. Sites were selected considering facility size, effluent requirements, years in operation, and comparable mechanical/process equipment. For the combined nitrification-denitrification activated sludge process, wastewater treatment plants operated by the Los Angeles County Sanitation District served as a valuable resource for design criteria and desired facility features. Conversations with plant operators and process engineers provided a rationale for the recommended aeration basin design including sizing for oxic and anoxic zones, distribution of air within the aeration basins, and mixed liquor recycling. For the recommended wastewater filters at Manteca, the proposed design reflected operational experiences from four cloth disk filter facilities in the Phoenix/Tucson area, one reclamation plant in Orange County, and a San Joaquin County facility discharging to a local receiving water. Similarly, the proposed UV disinfection system design incorporated recommendations based on site visits to four low pressure-high intensity UV operational facilities in the United Kingdom and two large-scale plants in Northern California. The theme throughout the site visits was to identify from the operator and engineer’s perspectives, what worked well versus what should be changed in a future design. By capturing these lessons learned from similar projects, greater confidence in the proposed design features meeting the stricter effluent quality requirements at Manteca was achieved.

Pilot Studies for Key Unit Processes

Considering the critical nature of the wastewater filtration and UV disinfection process, pilot studies were undertaken to confirm process suitability, impacts from variations in influent quality, design criteria, ability to meet discharge requirements, and ancillary facilities. At Manteca, each unit process was piloted over a 4-6 week period to test equipment over a wide range of influent loads. As an example, secondary process upsets were simulated to stress test the filters and to determine the maximum hydraulic loading rate at which a 2 NTU turbidity could be achieved. Other criteria captured during the filter pilot test included backwash requirements, chemical dosage, and likely particle size distribution following filtration. For the low pressure-high intensity UV equipment, pilot studies provided data on transmittance, design dosage required to achieve the desired

coliform kill, and reactor hydraulic characteristics. In each case, the results of the pilot study were then folded into the full-scale treatment system design. This investment in pilot studies was viewed as another means to document the likelihood of satisfying stricter effluent quality requirements under the new plant permit.

Developing Alternate Disposal Routes

Maintaining effluent quality within the discharge limits during construction is the key to avoiding further regulatory scrutiny. Because the requirements for wastewater used for agricultural irrigation are significantly less than for a surface water discharge, land application can serve as an emergency disposal option for under-treated water. At the Manteca WQCF, wastewater destined for agricultural use can be routed directly to the irrigation network or to a 20 million gallon secondary effluent storage pond (SESP). Design of plant improvements has focused upon the development of multiple options to route water to the SESP. Specifically, each of the three major categories of facilities at the Manteca plant, northside facilities, southside facilities, and tertiary treatment facilities will be piped to the SESP. Both the northside and southside facilities will also have connections to the delivery system for agricultural irrigation. Within the tertiary treatment facilities, each unit process will be furnished with a dedicated dump line to the SESP. In this manner, both the operator's desire to maximize flexibility in shunting water through the plant and a goal of providing a regulatory fail-safe method for disposal are possible.

Identifying with Plant Staff Windows of Opportunity

To minimize potential unplanned interruptions to critical utility systems during construction, a systematic approach with plant staff was utilized to identify windows of opportunity for the construction contractors. The weekly construction meeting for Schedule A and Schedule B served as a forum to discuss impending utility outages and their impact to plant operations. Alternatives to contractor plans were suggested based on City convenience and ability to re-arrange or by-pass key systems. The use of the SESP and land application system played a key role in managing the construction process. The operation of off-site facilities was also considered with the goal of stream-lining subsequent contractor activities within the plant. Another example was the limited use of the existing plant emergency power system to accommodate interruptions to normal power systems such as a cut-over to a new plant-wide medium voltage system. The end-result of this collaborative process with plant staff was to create more frequent opportunities for utility system interruptions, albeit for much shorter durations.

Detailed Construction Sequence

As part of the construction documents for the respective improvement schedules, detailed construction sequences were developed. By preparing a construction sequence, the Engineer and plant staff can dictate where and when a contractor can work, thereby minimizing the potential for plant interruptions. Because much of the construction would occur within the developed plant core, a step by step procedure was outlined, including sequencing drawings and specifications. Special attention was devoted to the order of

work associated with the construction of new influent trunk sewers and the start-up of a large influent pump station. Similar detail was provided for the sequential conversion of the northside facilities from nitrification to denitrification. The theme of the construction sequence was to complete all work within an area prior to initiating connections or cut-overs to live systems. This process was particularly effective in establishing expectations for the contractors while providing opportunities for potential value engineering proposals designed to save time or money.

Comprehensive Field Investigation including Potholing

To the maximum extent possible, research, both in the office and in the field was conducted to confirm existing conditions and system status. Office research included review of historical record drawings for facilities and underground utilities and the development of base sheets for subsequent construction documents. Because the plant had undergone numerous renovations during the last forty years, the existence of utilities was traced from project to project to minimize the chance that a utility would be missed. Once the preliminary base sheets were prepared, on-site meetings were conducted with plant staff to review all background information and to confirm the completeness of the drawings. Meetings were conducted in the field and where questions could not be resolved, vaults and panels were opened and checked. For underground questions, potholing activities were scheduled. Ultimately, approximately 30 potholes were undertaken and surveyed to tie down the horizontal and vertical location of critical underground utilities. In this manner, the Engineer and City attempted to minimize the potential for unforeseen conditions particularly relating to underground construction.

Constructibility Review from Construction Management Team

Taking advantage of previous construction experiences both on-site and elsewhere represented another method to improve the design documents and avoid change orders on the Project. Specifically, constructability reviews were conducted by senior resident engineers who had recently completed similar projects. Reviews focused upon unclear or ambiguous design requirements, construction sequencing, and inter-disciplinary coordination. In addition, the construction management team working at the site provided valuable input for subsequent design documents. Their perspective emphasized design completeness, potential utility conflicts, and value-engineering proposals. This iterative-collaborative process served to further improve the design documents and to short-circuit issues in the field.

CONCLUSIONS

Expansion and upgrade of the 7.5 mgd Manteca WQCF creates a number of unique challenges for the Engineer and plant staff. Construction of the facility improvements must proceed without interruption to key plant operations while maintaining strict compliance with effluent discharge standards. New permit requirements dictate the construction of advanced treatment processes to produce an essentially pathogen-free recycled water. Additional pressure to perform is created by intense regulatory scrutiny.

These challenges can be overcome by applying lessons learned from similar projects, piloting key unit processes, developing alternative disposal methods, and identifying with plant staff windows of opportunity for specific construction activities. A collaborative approach between the Engineer and Owner is proving successful in delivering a $50 million program to a regional wastewater treatment plant.