Technical Memorandum

EWPCF Aeration Basin Energy Efficiency Analysis

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Table of Contents

List of Figures

List of Tables

1 Introduction

In October 2015, the Encina Wastewater Authority (EWA) Board of Directors awarded a contract to Spiess Construction Co. for the construction of the Aeration Piping and Diffuser Replacement Project (Diffuser Project) in the amount of $584,000. The Diffuser Project was identified as Phase I of a multi-phased rehabilitation of the Encina Water Pollution Control Facility (EWPCF) Aeration Basins, and prioritized within the FY 2016 Comprehensive Asset Management Plan (E-CAMP).

The Diffuser Project was completed in August 2016, which included the removal and replacement of the existing diffusers as well as the PVC piping system within Aeration Basin Nos. 1, 2, and 3. The prior diffusers were 10 to 15 years old, with degraded permeability and reduced oxygen transfer efficiency. The existing diffuser system was replaced with a complete new membrane disk fine bubble diffused aeration system including diffuser manifolds, headers, laterals and pipe supports that deliver pressurized air into Basin Nos. 1, 2, and 3. Note that Aeration Basin No. 4 is currently operated primarily for equalization without air, and therefore did not warrant any changes.

The secondary treatment aeration systems represent one of the highest energy uses at the EWPCF. Thus, it is expected that the Diffuser Project's reconfiguration of the aeration system will reduce electricity use and operating costs, which in turn will help EWA advance toward its goal of becoming energy independent.

1.1 Background

The secondary treatment process with Aeration Basin Nos. 1 and 2 was implemented as part of the EWPCF Phase III expansion circa 1984. Aeration Basin Nos. 3 and 4 were added circa 1992 as part of the Phase IV Expansion. In 2001, EWA replaced the original 9-inch ceramic disc diffusers with Envirex® membrane-type fine bubble diffusers in Aeration Basin Nos. 1, 2 and 4. Aeration Basin No. 3 was converted to the membrane-type in 2006. The recommended service life for membrane-type diffusers is 7 to 10 years for optimal performance, but actual performance varies over time based on operational and other site characteristics.

As of Phase V, the EWPCF utilizes three 500-horsepower (hp) aeration blowers with 10,000 acfm air flow capacity each, and one 350-hp aeration blower with 6,000 acfm capacity. A significant portion of the energy consumption at the EWPCF is associated with operating these blowers, which are delivering compressed air to the Aeration Basins.

The diffusers were connected to submerged PVC pipes that supply the pressurized air. The PVC pipes were original construction and had become brittle over time, making them susceptible to cracking and breaking. The age of the system also made the piping difficult to repair. In addition, the configuration of the diffusers within each Aeration Basin was no longer optimal for delivery of air to the correct zones given the current mode of operation. It was decided that instead of just replacing the membranes, it was advantageous to replace and reconfigure all the piping given the age of the system and desire to optimize the layout.

1.2 Objectives

The purpose of this technical memorandum (TM) is to present an analysis of recent energy use data to document the changes in energy use and efficiency since the replacement of the diffuser system within Aeration Basin Nos. 1, 2 and 3. The Aeration Basins were put back into service with the new diffuser systems on the following dates:

- Aeration Basin No. 1: May 10, 2016
- Aeration Basin No. 2: June 7, 2016
- Aeration Basin No. 3: July 20, 2016

At current flows and loads, the EWPCF is typically operated with only two Aeration Basins online at a time. Therefore, the full energy savings resulting from the Diffuser Project would have begun after two basins were in service starting June 7th, 2016.

2 Analysis of Aeration Basin Energy Use and Cost

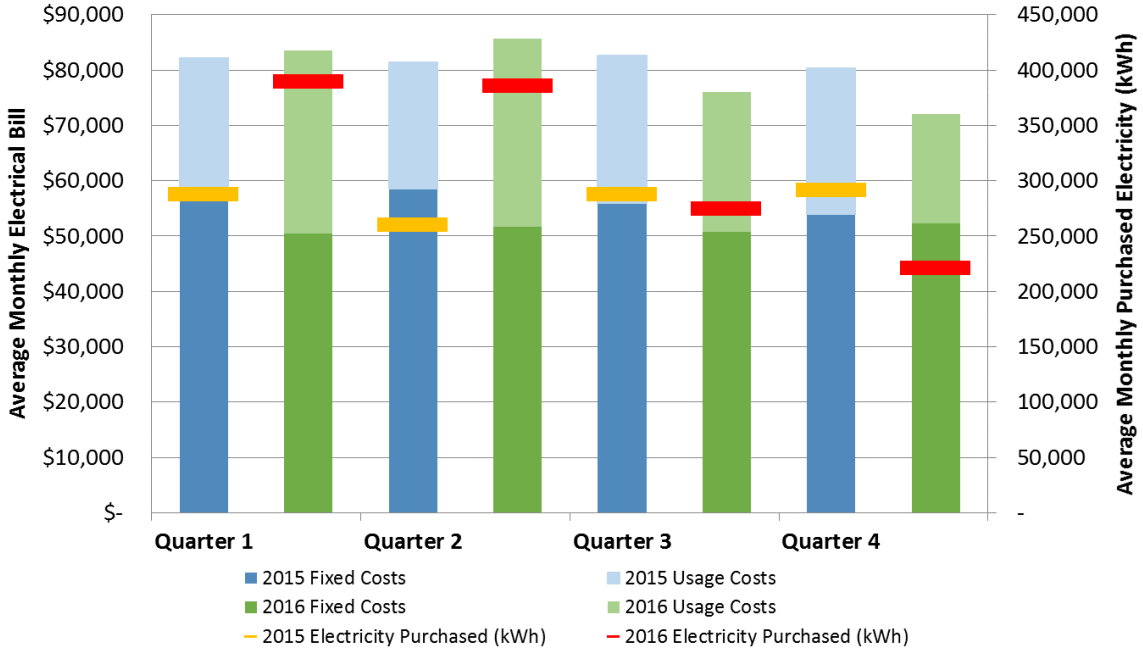
2.1 Local Utility Electricity Bill Analysis

Monthly utility bills from January 2015 through December 2016 (i.e., two years of bills) were reviewed to develop a baseline of electricity purchased from the local utility for use at the EWPCF and compare it to any changes associated with completion of the Project. It should be noted that the billing period runs from roughly mid-month to mid-month (for instance, the May 2016 bill was for usage during the April 13 – May 12 period). The utility bills show the total purchased electric energy (kWh) along with a detailed cost breakdown. The monthly energy cost was broken out into two categories as follows:

- Usage Costs: the portion of the bill that is proportional to the actual electricity consumed (kWh) during the billing period. This includes the utility's electricity delivery and generation charges for on-peak, semi-peak, and off-peak usage (as appropriate), as well as other charges that are applied on a per kWh basis (e.g., DWR bond charges, taxes, fees). These costs are affected by any rate changes implemented by the local utility, including seasonal changes between winter and summer periods.
- Fixed Costs: the remainder of the billed amount after subtracting the direct use costs. This includes the Time of Use Customer Charge, the Distance Adjustment Fee, Seasonal Non-Coincident Demands, and Standby Demand. Proportionally, these fixed costs account for roughly 60-70 percent of the typical electrical utility bill.

Figure 1 below presents the monthly utility bill average costs and energy usage by quarters to allow for comparison between 2015 and 2016. The cost is broken down into the usage and fixed cost components.

Figure 1: Monthly Average Electrical Utility Billing by Quarter, 2015 vs. 2016



With two Aeration Basins back online equipped with the new aeration piping and diffusers as of the third quarter of 2016, electricity purchases (as kWh) appear to have decreased significantly from the first two quarters of 2016, and with an especially notable decrease in Q4 of 2016 vs. 2015. For 2016, the fixed costs remained largely steady from quarter to quarter, while the usage cost portion decreased in Q3-Q4.

Additional analysis of the electrical energy bills was performed by comparing the first and second halves of 2015 and 2016, resulting in the following periods:

- Period 1: January-June 2015, prior to the Project
- Period 2: January-June 2016, during the Project
- Period 3: July- August 2015, prior to the Project
- Period 4: July- August 2016, after the Project (two Aeration Basins back online)

The average monthly electrical utility bill data for these periods is presented and compared in Table 1 below. By comparing equal 6-month periods from one year to the next, cost differences due to seasonal billing changes are mitigated.[1]

Table 1: EWPCF Monthly Average Imported Electrical Energy Cost by Period, 2015-2016

	Period 1: Jan-Jun 2015	Period 2: Jan-Jun 2016	Change (Period 2 vs. Period 1)		Period 3: Jul- Dec 2015	Period 4: Jul-Dec 2016	Change (Period 4 vs. Period 3)	
kWh Purchased	274,310	387,947	**113,637**	**41%**	290,033	248,573	**-41,460**	**-14%**
Usage Cost	$23,634	$33,491	**$9,857**	**42%**	$26,490	$22,543	**-$3,947**	**-15%**
Fixed Cost	$58,116	$51,087	**-$7,030**	**-12%**	$55,001	$51,488	**-$3,513**	**-6%**
Total Cost	$81,750	$84,577	**$2,827**	**3%**	$81,492	$74,031	**-$7,461**	**-9%**

Note: Negative values indicate decrease from 2015 to 2016 usage and costs.

By comparing Periods 3 and 4 from 2015 to 2016, the changes in energy used for aeration due to the Diffuser Project can be readily compared. For these periods, the energy purchased decreased by 14 percent. This resulted in an overall decrease of 9 percent in the total average electrical bill for a monthly savings of roughly $7,500.

2.2 Aeration Air Flow and Blower Energy Analysis

In addition to the local electrical utility bills, data were also reviewed for 2015-2016 for the EWPCF's aeration air flow, aeration blower energy usage, and electrical energy generated onsite by the cogeneration engines.

Table 2 below presents the aeration air flow, blower energy, energy purchased, and energy cost differences between Periods 1 and 2, and between Periods 3 and 4.

[1] Note that the electrical utility's annual rate changes had a minimal impact on the comparison between costs for 2015 and 2016 (i.e., the percent difference in kWh purchased closely matches the percent difference in usage cost).

Table 2: EWPCF Aeration Air, Blower Energy, and Total Energy Use by Period, 2015-2016

	Period 1: Jan-Jun 2015	Period 2: Jan-Jun 2016	Change (Period 2 vs. Period 1)		Period 3: Jul- Dec 2015	Period 4: Jul-Dec 2016	Change (Period 4 vs. Period 3)	
Aeration Air Flow avg. rate (acfm)	10,398	10,958	**560**	**5%**	10,667	9,659	**-1,008**	**-9%**
Blower Energy monthly avg. (kWh)	272,842	270,037	**-2,805**	**-1%**	326,132	197,538	**-128,594**	**-39%**
Total Energy Usage monthly avg. (kWh)	1,421,652	1,555,497	**133,845**	**9%**	1,474,964	1,346,493	**-128,471**	**-9%**

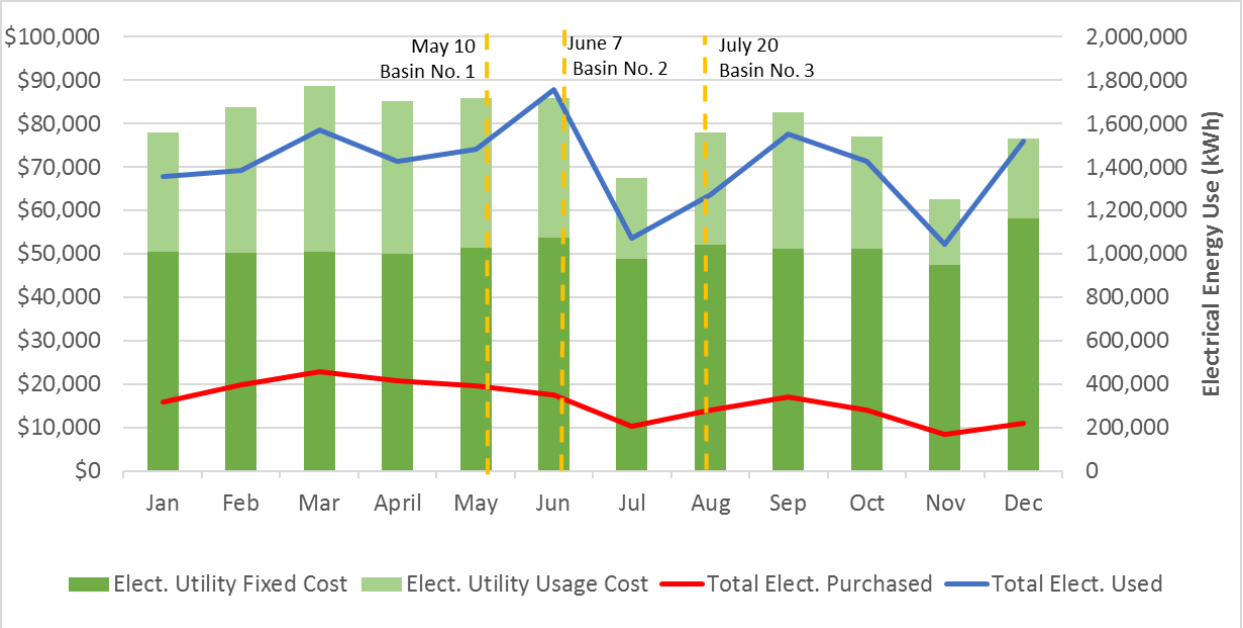
Note: Negative values indicate decrease from 2015 to 2016 usage.

The instantaneous average aeration air flow rate increased by 5 percent between Periods 1 and 2, while the blower energy usage remained nearly constant (within 1%). Thus, the 9 percent increase in energy demand is attributable to other uses at the EWPCF or increase in flow or strength of wastewater.

By comparing Periods 3 and 4 from 2015 to 2016, the changes in aeration air use due to the Diffuser Project can be readily compared. For these periods, a significant decrease is observed in the blower energy demand, with a reduction of 39 percent and absolute amount in kWh that essentially equates to the entire energy usage decline at the EWPCF of 9 percent.

Figure 2 below presents the electrical energy purchased, total electrical energy use (purchased and generated), and cost data by billing period for the 2016 bills. As previously discussed, a decreasing trend can be observed in EWPCF electrical energy use coinciding with the sequential replacement of the aeration basin diffuser systems.

Figure 2: Cost of Electrical Energy Purchases vs. Total Electricity Use by Billing Period, 2016



3 Conclusions

Based on the analysis of pre-Diffuser Project and post-Diffuser Project data for the months of July-December of 2015 and 2016, respectively, the Diffuser Project has resulted in a decrease of aeration blower energy usage of nearly 40 percent. The nearly 130,000 kWh/month saved represents the entire difference in the EWPCF energy usage between the two periods. This has contributed to a 9 percent savings in the EWPCF electrical bill between these two periods. Similarly, the overall EWPCF energy usage has declined between 9 and 14 percent, depending on how much of an increase was offset by the reduction in blower demand. At the estimated $7,500 per month savings, this equates to an annual savings of approximately $90,000 on the EWPCF electrical bill.