MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION FOR MONROE COUNTY DEPARTMENT OF ENVIRONMENTAL SERVICES FRANK E. VAN LARE WASTEWATER TREATMENT FACILITY

Agreement No. 7185

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THE NEW YORK STATE
ENERGY RESEARCH AND DEVELOPMENT AUTHORITY
ALBANY, NY

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Section 1
INTRODUCTION

1.1 OVERALL PROJECT DESCRIPTION

The New York State Energy Research and Development Authority (NYSERDA) is currently sponsoring a research program to evaluate submetering at wastewater treatment plants (WWTPs) throughout New York State. The purpose of the monitoring is to obtain detailed electric power use information through submetering various unit processes and equipment and to determine if that information is a cost-effective tool for identifying energy conservation measures. In addition to evaluating the usefulness of submetering, a secondary goal of the program is to identify and evaluate energy cost savings measures at WWTPs and make the findings available to other facilities in New York State.

Monroe County Department of Environmental Services (MCDES) has already implemented an extensive continuous submetering program at its Frank E. Van Lare (FEV) Wastewater Treatment Facility (WWTF). MCDES has also implemented various energy savings measures over the years, but energy savings and energy-related cost savings still exist at the FEV WWTF. As a result, MCDES agreed to participate in the submetering study, as conducted by the Research Team consisting of Malcolm Pirnie and Siemens Building Technologies.

1.2 FACILITY BACKGROUND

The MCDES operates the FEV WWTF, a secondary treatment facility permitted for an average dry weather flow of 135 million gallons per day (MGD). The FEV WWTF serves approximately 500,000 residents of Monroe County and is the largest of the two plants in the MCDES system. The FEV WWTF treats combined sewage primarily from the City of Rochester and older adjacent suburbs. Facility staff balance flow through the facility and subsurface storage tunnels to meet the capacity of the facility and minimize combined sewer overflows. Secondary treatment is provided for wet weather flows up to 225 MGD. For wet weather flows over 225 MGD and up to 630 MGD only primary treatment is provided.

Two incoming 34.5-kiloVolts (kV) feeds (Norton and Russell) supply electricity to both the FEV WWTF and the Cross Irondequoit Bay Pump Station (CIPS), which is located on the facility site and conveys flow from the eastern service area to the facility. Both feeds are metered and billed by Rochester Gas and Electric (RG&E) under Service Class 8, General Service.

The two incoming feeds are divided into six sub-feeds, four of which supply the WWTF and two of which supply the CIPS. The two CIPS sub-feeds are each metered by 34.5 kV circuit monitors. The four 34.5 kV

WWTF sub-feeds are reduced to 4.16 kV to supply various processes in the plant. Power is further reduced to 480 V as it reaches the process buildings.

The treatment processes at the FEV WWTF include the following:

- Preliminary treatment, including mechanically-cleaned bar screens and grit removal.
- Primary clarification.
- Secondary biological treatment with activated sludge followed by secondary clarification.
- Effluent chlorination.
- Solids handling consisting of sludge thickening, centrifugal dewatering, and on-site incineration.

MCDES is currently in the process of bringing a biosolids outload facility on-line. The biosolids outload facility will allow the loading and trucking of dewatered sludge for disposal at an off-site landfill. It is anticipated that the incinerators will be primarily off-line after the outload facility is fully operational. A more detailed description of the FEV WWTF treatment processes is presented in Section 2 of this report.

1.3 SCOPE AND OBJECTIVES

This study involved the following activities as part of the overall electric and natural gas usage assessment and electric submetering program:

1.3.1 Review of Historical Plant Performance and Energy Usage Data

Data were obtained from MCDES to establish a baseline for plant performance and energy usage at the FEV WWTF. The baseline seeks to separate improvements related to power savings from those that result from exogenous effects, such as changes in influent water quality, seasonal, and weekly cycles, and/or energy market changes.

Data obtained from MCDES for two years included:

- Average, minimum, and maximum daily influent flow.
- Influent, primary effluent, secondary effluent, and final effluent total suspended solids (TSS), biochemical oxygen demand (BOD_5), and Total Kjeldahl Nitrogen (TKN).
- Mixed liquor suspended solids (MLSS).
- Returned activated sludge (RAS) flow, TSS, and volatile suspended solids (VSS).

- Waste activated sludge (WAS), TSS, and VSS.
- Primary sludge quantities and TSS concentration; primary sludge pump operating records.
- Thickened sludge quantities and TSS concentration; thickened sludge pump operating records.
- Incinerator operating records (number of units in operation, operating hours, sludge quantities and solids percentage).
- Centrifuge operating records (number of units in operation, operating hours, sludge quantities and solids percentage).
- Plant water flows and pressures.
- Historical electric energy usage, including available time-of-use monitoring data, and any process changes recently undertaken or contemplated.
- Recent energy consumption data for non-electric accounts, including natural gas.

1.3.2 Electric Submetering

Continuous submetering and instantaneous power draw measurements were conducted to evaluate the typical electric energy usage of some of the larger motors [greater than 25 horsepower (hp)] at the FEV WWTF. The FEV WWTF already collects continuous submetering data at a number of key locations at the facility. Additional continuous submetering locations were selected based on information gathered during a site energy audit conducted on October 15, 2003. Submetering locations were selected such that the larger and more energy-intensive motors could be metered. Instantaneous power draw measurements were also obtained on additional motors, particularly those that operated on a set schedule at a constant speed.

The continuous submetering data were used to capture diurnal variations in electric energy demand for major pieces of equipment, as well as to provide a representative sample of electric energy usage, including electric energy demand as equipment cycles on and off. The following data were recorded at each location:

- Load Factor
- Power Factor
- Demand (kW)
- Usage (kWh)

Instantaneous submetering was conducted during a one-day site visit on September 30, 2004. The data were used to verify expected energy demand at the facility, as well as to monitor changes in electric energy demand as equipment is cycled on and off.

In addition, process data were collected for the duration of the submetering period including the following:

- Average, minimum, and maximum daily influent flow.
- Influent, primary effluent, and final effluent TSS and BOD_5.
- RAS, TSS, and VSS.
- WAS, TSS, and VSS.
- Centrifuge feed rate and percent solids.
- Incinerator feed rate and percent solids.
- Dissolved oxygen (DO) in aeration tanks.

The process data collected were correlated to electric energy usage to develop alternatives for energy savings as well as compare the FEV WWTF's energy performance to other WWTPs in New York State.

1.3.3 Identification of Energy Saving Opportunities through Equipment Replacement or Modification

Energy savings opportunities resulting from equipment replacement and/or process modifications were identified based on a review of the submetering data. Some of these opportunities, while they may consume more energy than existing processes, may also serve to improve treatment at the WWTF, thereby saving operational dollars in the facility's overall budget.

1.3.4 Identification of Energy Saving Opportunities through Operational Changes

The submetering data were further reviewed to evaluate the impact of demand throughout the course of the day and energy saving opportunities through load shifting and greater use of real-time data in energy-related decision making. Load shifting involves changing the time of use of certain loads to reduce the total facility electric energy demand during peak periods, the goal of which is to reduce electric energy demand charges.

This report summarizes the data evaluation and offers recommendations for opportunities to reduce energy usage, and thereby energy-related costs, at the FEV WWTF.

Section 2

CURRENT AND HISTORICAL OPERATIONS

2.1 EXISTING TREATMENT PROCESSES

FIGURES 2-1 and 2-2 present schematics for the wastewater treatment and solids handling processes respectively. Brief descriptions of the unit treatment processes that are currently implemented at the Frank E. Van Lare (FEV) Wastewater Treatment Facility (WWTF) are presented in this section.

2.1.1 Preliminary Treatment

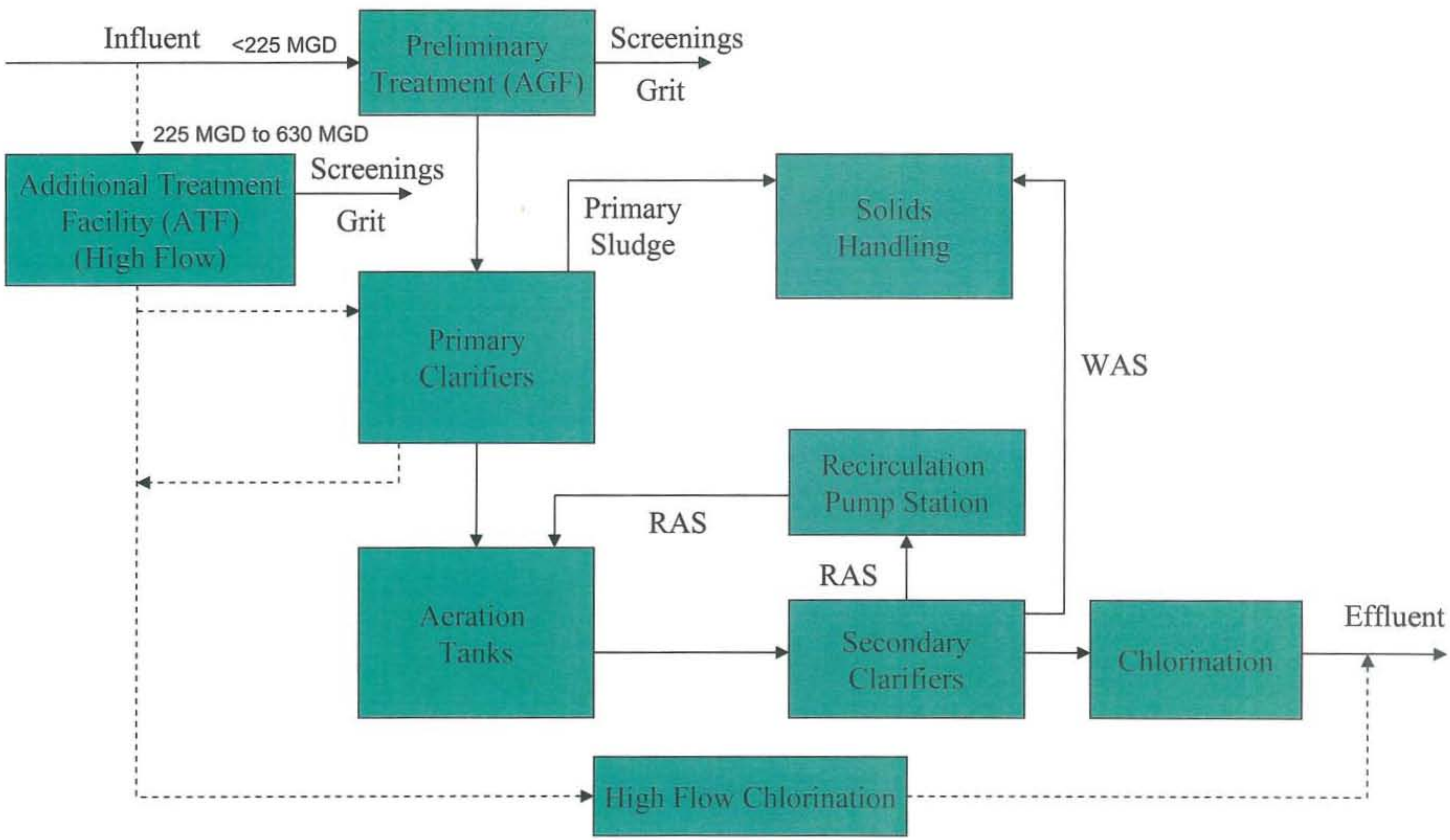
Preliminary treatment is accomplished through the use of two process trains, the aerated grit train and the additional treatment facility train. Control gates at the influent distribution structure direct flow to either the aerated grit facility (AGF) located to the north of the influent distribution structure at the head of the plant, or to the additional treatment facility (ATF), which includes the non-aerated grit facility (NAG) located to the north east of the influent distribution structure. The AGF is the main entry point to the primary and secondary treatment facilities for all dry weather flows and wet weather flows up to 225 million gallons per day (MGD). The ATF is part of the wet weather flow primary treatment train and removes grit associated with flows greater than 225 MGD. The AGF train consists of four mechanically-cleaned bar screens followed by two parallel horizontal flow aerated grit tanks. The excess flow (i.e. flow greater than 225 MGD) is diverted to the ATF train, which consists of three mechanically-cleaned bar screens followed by three parallel horizontal flow non-aerated grit chambers with traveling bridges.

2.1.2 Primary Treatment

Primary treatment is carried out in two banks of primary clarifiers (east and west). The west primary clarifiers were constructed in the 1950s and consist of 20 rectangular tanks with flight and chain mechanisms. The east primary clarifiers were constructed in the early 1970s and consist of three 150 foot (ft) diameter circular clarifiers. An average of 17% of the biochemical oxygen demand (BOD_5) and 20% of the total suspended solids (TSS) are removed during primary treatment. Settled solids are pumped from the tanks to the gravity thickeners.

2.1.3 Secondary Treatment

After passing through the primary clarifiers, flow is treated in 20 completely mixed activated sludge basins. Aeration is provided by three mechanical aerators per basin (total of 60). After aeration, final clarification is completed in six circular clarifiers. The aeration basins and secondary clarifiers were constructed in the 1970s. The sludge produced in the secondary clarifiers is either recycled to the head of the secondary treatment process (i.e., influent of the aeration basins) or wasted. A total of 85% to 89% of the BOD_5 and TSS remaining after primary



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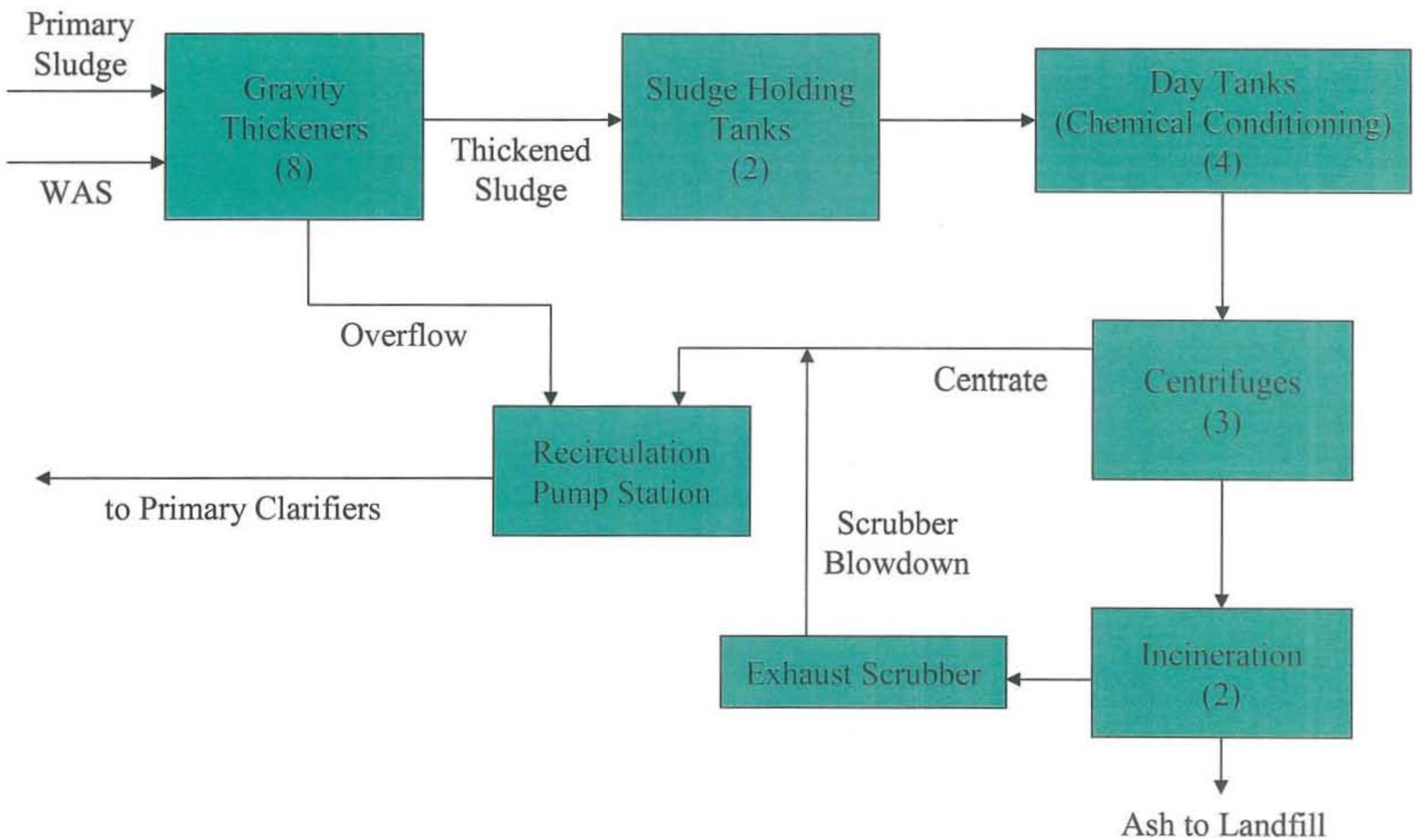
MONROE COUNTY DES – FRANK E. VAN LARE PLANT

FIGURE 2-1
WASTEWATER FLOW SCHEME



MALCOLM PIRNIE	NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION MONROE COUNTY DES – FRANK E. VAN LARE PLANT	FIGURE 2-2 SOLIDS HANDLING SCHEME

treatment are removed in the secondary processes. The overall removals through the plant are 89% and 91% for BOD_5 and TSS, respectively.

2.1.4 Disinfection

Disinfection is accomplished through sodium hypochlorite addition to the secondary clarifier effluent stream. The chemical is added to a series of channels at the effluent of the secondary clarifiers. Disinfection of the high flow bypass stream is carried out by adding hypochlorite directly to the 120-inch diameter bypass pipe before joining with the main plant outfall.

2.1.5 Solids Handling

Primary sludge is combined with waste activated sludge from the secondary clarifiers and thickened in eight circular gravity sludge thickeners to a solids concentration averaging from 3% to 5% with occasional peaks up to 11%. The thickened sludge is stored in two sludge holding tanks and then dewatered with centrifuges. Prior to dewatering, sludge is conditioned with lime slurry for pH adjustment and odor control and mixed in three 35,000 gallon (gal) day tanks. The Monroe County Department of Environmental Services (MCDES) is also considering the use of sodium hypochlorite for sludge conditioning and odor control. The centrifuges typically dewater the sludge to a solids content ranging from 26% to 33%.

Dewatered sludge is incinerated in two multiple hearth incinerators. Ash is slurried with water for transport to an ash lagoon for subsequent gravity dewatering. Dewatered ash is hauled to an off-site landfill for disposal. MCDES is currently in the process of transitioning from sludge incineration to landfilling as the primary means of sludge disposal. The incinerators will be operated on a part-time basis after the new biosolids outload facility is operational.

The facility is staffed 24 hours per day, 7 days per week, although the dewatering processes typically operate 5 days per week.

2.2 HISTORICAL ENERGY USAGE AND UTILITY BILLING

In the past decade, MCDES has performed a number of projects and studies with the goal of identifying and implementing energy-savings opportunities. Some of the notable efforts toward the implementation of energy saving measures are:

- Recirculation Pump Station Modifications (2000)

- Aeration Basin Automated Control Study (1996)
- Electric Feed Balancing (2003)

2.2.1 Recirculation Pump Station Modifications (2000)

The Recirculation Pump Station (RPS) is a critical component of the FEV WWTF liquid handling system and consists of the following pumping systems: return sludge (RS) – 14 pumps for transferring sludge from the secondary clarifiers to the aeration basins, return effluent (RE) – four pumps for transferring plant side streams (centrate, scrubber blowdown, etc.) to the primary clarifier influent chambers, and return dilution (RD) – four pumps for providing final clarifier effluent for elutriation of the gravity sludge thickening process.

The RPS was constructed in the early 1970s as part of the facility upgrade to secondary treatment. At the time, each of the RS, RE, and RD pumps consisted of a centrifugal line shaft pump, angled gear reducer, magnetic speed reducing coupling and constant speed motor. Although a state of the art means of controlling pump speed in the 1970s, the system became increasingly more maintenance intensive and inefficient as the equipment aged. MCDES implemented a project in 2000 to replace the entire drive system for each of the pumps with a slow speed premium efficiency motor driven by a variable frequency drive (VFD) and eliminated the need for gear reducers and magnetic drives. This new arrangement effectively increased the water to wire efficiency for the pumping systems from approximately 40% to 50% to over 65% for each of the pumps. The project also included rebuilding each of the pumps to like new condition and reducing the number of RS pumps from 18 to 14.

2.2.2 Aeration Basin Automated Control Study (1996)

MCDES conducted a study in the summer of 1996 to determine the potential savings in energy usage by varying the speed of the aeration basin aerators relative to the amount of DO in the mixed liquor. The evaluation was conducted in two basins ("test" and "control"), which were subjected to similar hydraulic and organic loadings. Two aerators in the test basin were outfitted with VFDs and paced to DO levels in the basin effluent and the second control basin with two dual speed aerators (existing units) was operated in manual mode with FEV operators controlling aerator speed (i.e. low or high speed) based on DO.

The results of the study indicated a potential to implement automated control on a large scale to reduce electric energy usage. Another finding of the test program was that any full scale installation should take into account proper DO meter selection and placement in the flow stream. However, due to the lack of reliable DO metering equipment at that time, the improvements were not implemented.

2.2.3 Electric Feed Balancing (2003)

There are two dedicated 34 kiloVolt (kV) feeds into the FEV facility: Russell and Norton. Each of these feeds serves various customers prior to FEV but terminate at the facility. Because there are two reliable independent feeds to the facility, MCDES does not have to supply facility-wide back up power in accordance with New York State Department of Environmental Conservation (NYSDEC) standards.

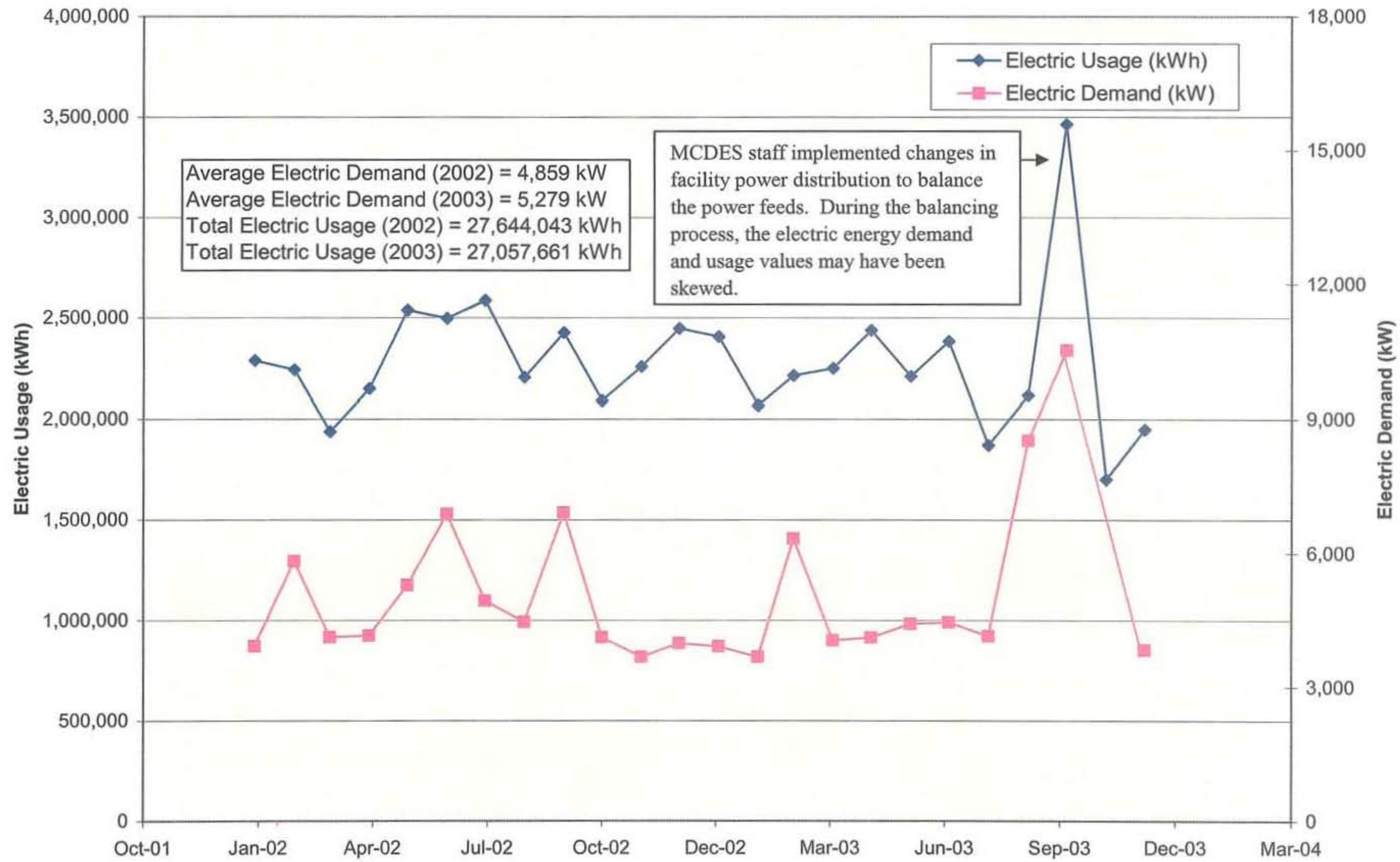
Each feed is considered to be a separate account by the utility (Rochester Gas & Electric) with demand and usage charges assessed on each. In 2003, MCDES implemented an internal program to monitor the electric energy demand on each feed and to balance the incoming loads to reduce demand charges. Before implementing this program, the loadings on each feed would range approximately from a 50/50 split (ideal) to an uneven split depending on the distribution of electric loads on various processes. Under this project, MCDES set up dedicated computer terminals in the FEV control room to constantly display the loading so that operators could make informed decisions regarding balancing electric energy usage on various MCCs and distribution systems.

2.2.4 Utility Summary

Monthly utility bills were attained from MCDES. The billing information for electric energy demand and usage and natural gas usage covered the period from January 2002 to December 2003.

Utility data were summarized and graphical representations of average monthly usages and demands were developed to evaluate trends in energy usage. Monthly electric energy usage and demand is presented on FIGURE 2-3. It should be noted that until the end of 2003, electric supply to the FEV WWTF was unbalanced between the two main electric feeds (approximately 90% vs.10%) resulting in unnecessarily high demand charges. MCDES staff subsequently implemented changes in facility power distribution to balance the power feeds. During the balancing process, the electric energy demand and usage values may have been skewed. The figures indicate that there was a significant increase in electric energy demand during the month October 2003 (155% increase from previous year). If this spike in electric energy demand were removed from the data set, the 2003 average electric energy demand would be closer to the 2002 average electric energy demand.

When comparing 2002 data with 2003 data, there is an overall increase in electric energy demand and a slight decrease in electric energy usage. Electric energy demand increased by 9% and usage decreased by 2%. The comparisons are presented graphically on FIGURES 2-4 and 2-5. The variations in electric energy demand and usage correlated to an average decrease in electricity charges of 1% (down from $1,877,977 in 2002 at $0.069 per kWh to $1,781,030 in 2003 at $0.062 per kWh).



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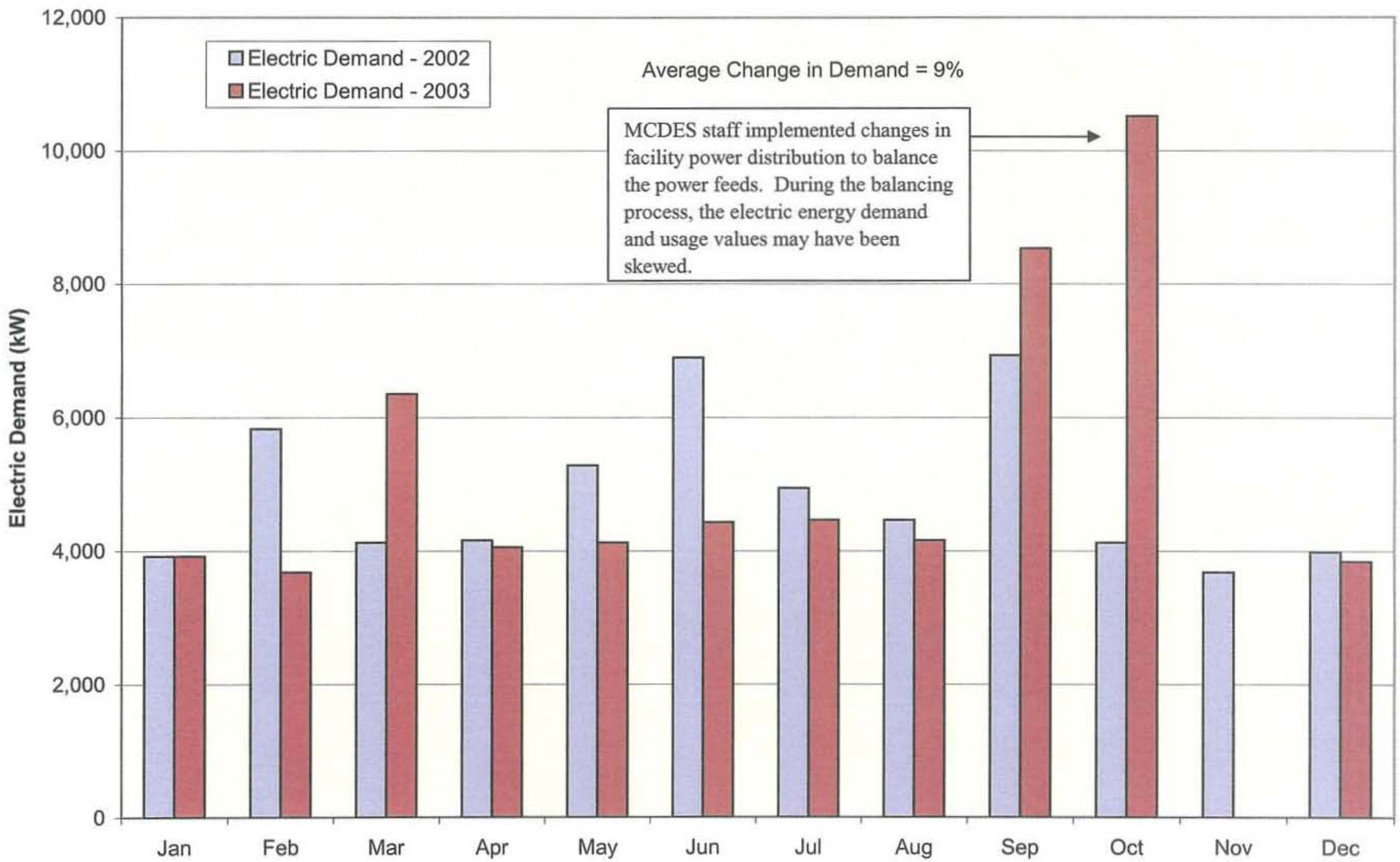
MONROE COUNTY DES - FRANK E. VAN LARE WWTF

FIGURE 2-3
ELECTRIC USAGE AND DEMAND
(2002 to 2003)



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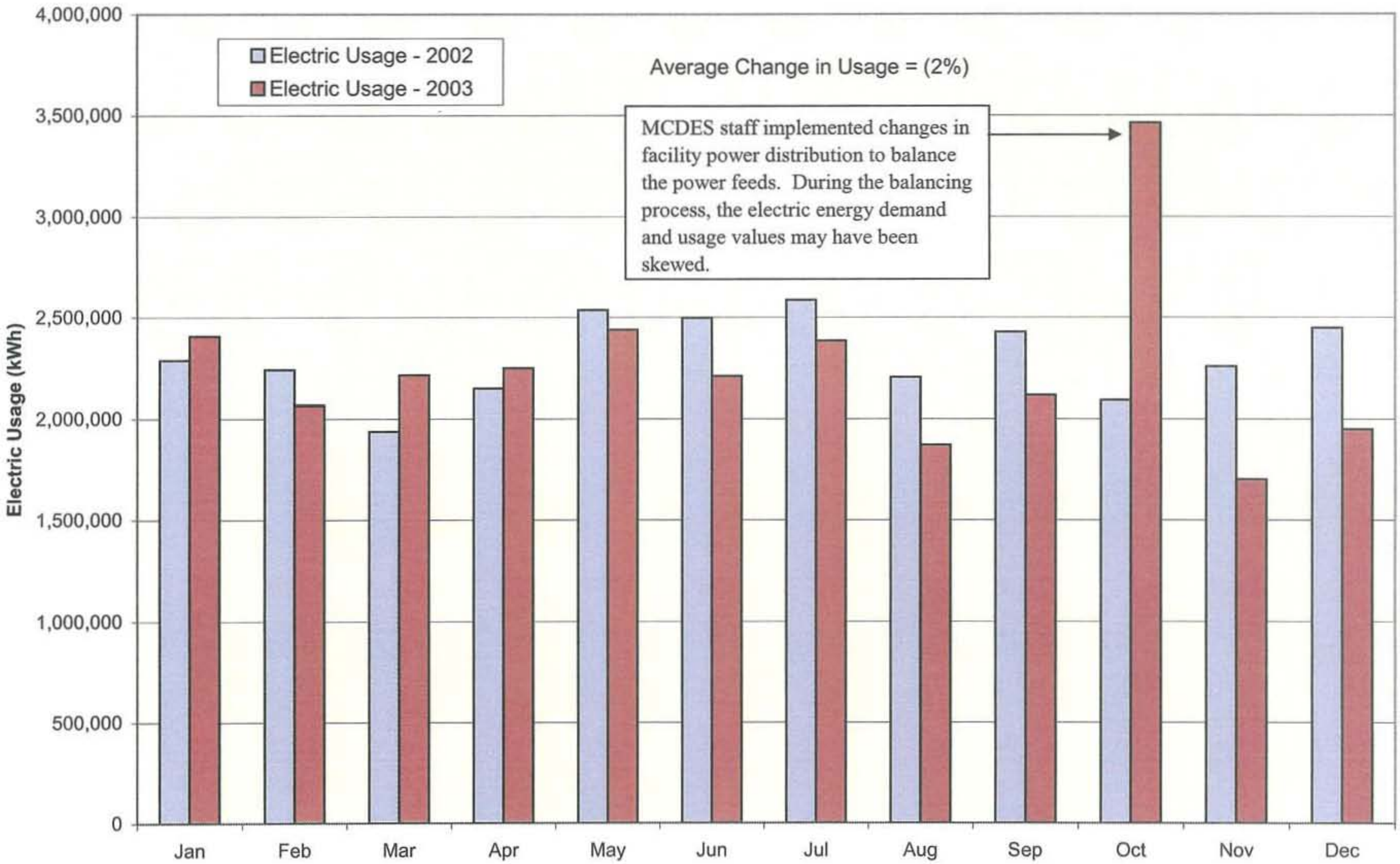
NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION
MONROE COUNTY DES - FRANK E. VAN LARE WWTF

FIGURE 2-4
CHANGE IN ELECTRIC DEMAND
(2002 TO 2003)



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MONROE COUNTY DES - FRANK E. VAN LARE WWTF

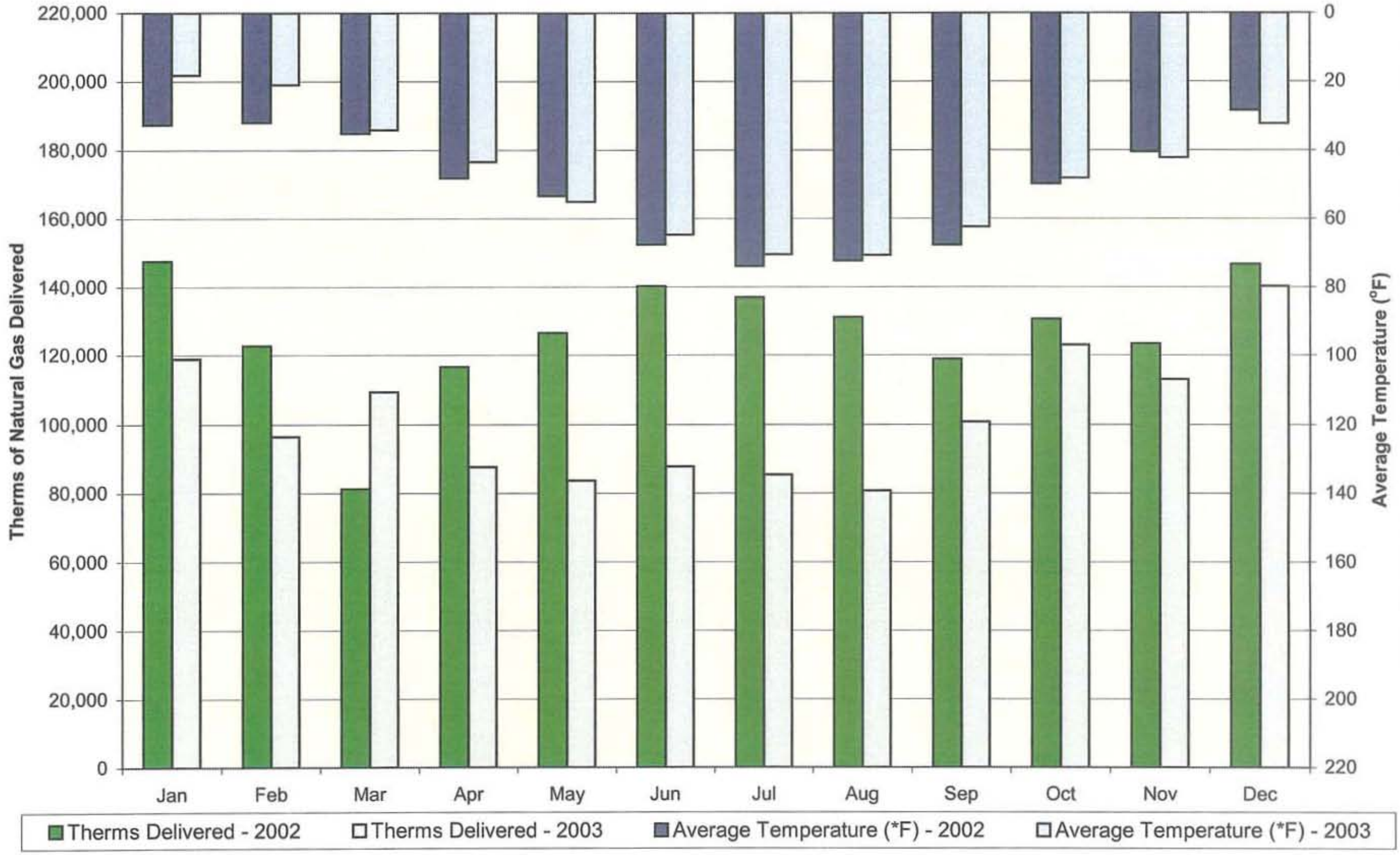
FIGURE 2-5
CHANGE IN ELECTRIC USAGE
(2002 TO 2003)

2.3 NATURAL GAS USAGE

The bulk of the natural gas used at the FEV WWTF is for the incineration process. Although natural gas usage typically peaks in the winter months due to elevated heating requirements and is at a minimum in the summer, these patterns are not as pronounced at facilities that use incineration due to possible variations in gas usage by the incinerators. The FEV WWTF operates two main boilers, the South boiler is operated year round and the North boiler is used as stand-by. There are also other miscellaneous direct fired heating units and hot water heaters. The relationship between natural gas usage and average monthly temperature for the years 2002 and 2003 is presented on FIGURE 2-6. The average temperature for 2002 was 50.1 degrees Fahrenheit (°F) with a total natural gas usage of 1,522,294 therms at a total cost of $845,726 (including transportation cost). The average temperature for 2003 was 46.9 °F with a total usage of 1,226,962 therms at a total cost of $862,816. Although the usage in 2002 was nearly 295,000 therms greater than 2003, the average cost per therm in 2002 was only $0.56, while it was $0.70 per therm in 2003.

Based on natural gas usage records, an average of 82% of the natural gas usage is associated with the incineration process. Therefore, the incineration process accounts for an average annual natural gas usage of 1,127,192 therms, resulting in an annual cost of $710,131 ($0.63 per therm).

Total WWTF natural gas usage on a square foot basis can be estimated as a benchmark performance parameter by dividing the annual gas usage by the rooftop square footage of the buildings. Based on a rooftop square footage of 118,000 square feet (sq. ft.) the FEV WWTF uses an average of approximately 11.6 therms of natural gas per square foot on an annual basis. Removing the incineration natural gas usage, the average natural gas usage per rooftop area is 2.1 therms per square foot. It should be noted that the new section of the Solids Handling Building is heated by waste heat from the incinerators, subtracting out the roof area of this section of the building yields an average natural gas usage per rooftop area of 2.4 therms per square foot.



MALCOLM PIRNIE	NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION MONROE COUNTY DES - FRANK E. VAN LARE WWTF	FIGURE 2-6 NATURAL GAS USAGE (2002 to 2003)

2.4 SUMMARY OF ENERGY COSTS

A summary of annual utility costs for 2002 and 2003 is presented in TABLE 2-1.

Table 2-1: Utility Cost Summary for 2002 and 2003

Year		2002	2003
Average Flow (MGD)		92.7	99.3
Electricity	Annual Usage (kWh)	27,644,043	27,057,661
	Rate ($/kWh)	0.068	0.062
	Annual Costs	$ 1,877,997	$ 1,709,129
	Average Usage (kWh per MGD)	817	747
	Average Cost ($/MGD)	$55.50	$47.15
Natural Gas	Annual Usage (therms)	1,522,294	1,226,962
	Rate ($/therm)	0.56	0.70
	Annual Costs	$845,726	$862,816
	Average Usage (therms per MGD)	45.0	33.9
	Average Cost ($/MGD)	$25.00	$23.81
Total Energy Cost of Electricity and Natural Gas		$2,723,723	$2,571,945
Total Energy Cost per MGD		$80.50	$70.96

* Electric rates determined by dividing annual electric cost by annual electric usage (in kWh)

The average energy usage per MGD, both electric and natural gas, decreased from 2002 to 2003 (9% and 25% respectively). This reduction in usage could be partially or in part attributed to lower BOD_5 loadings in 2003 as compared to 2002, as shown in FIGURE 2-7.

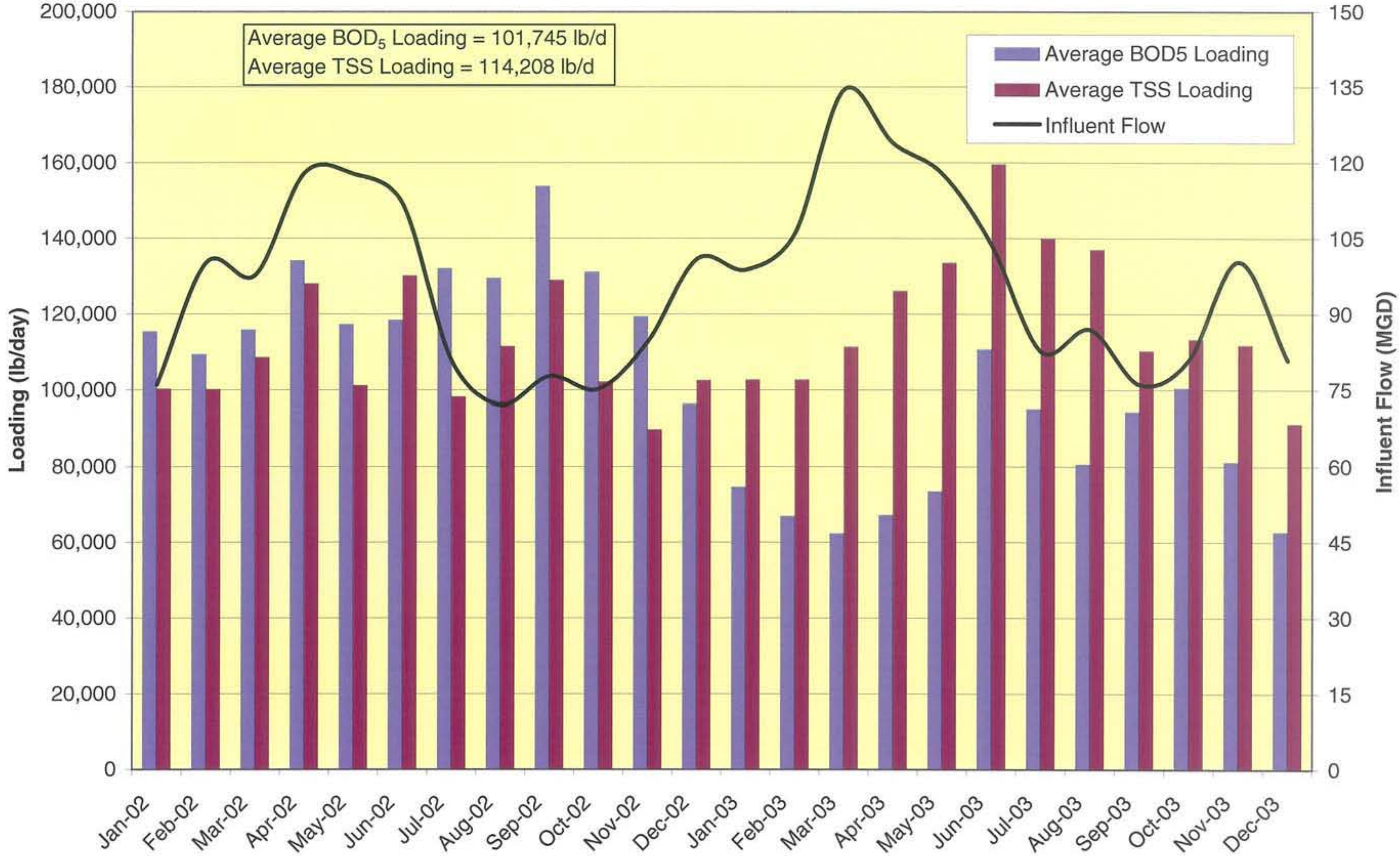


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FIGURE 2-7
INFLUENT BOD_5 AND TSS LOADING
(2002 to 2003)

2.5 SUMMARY OF HISTORICAL LOADINGS AND EFFLUENT QUALITY

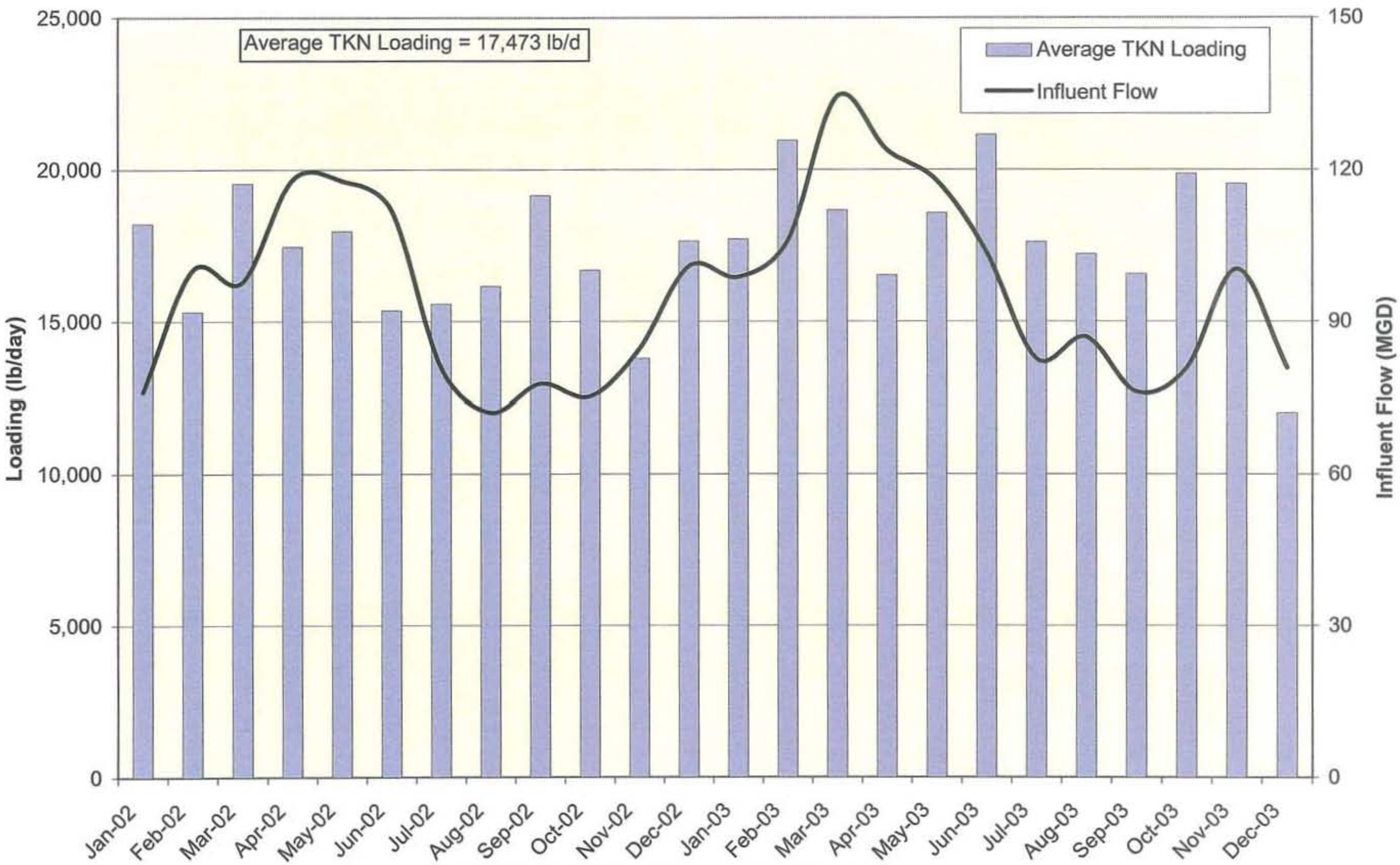
Monthly WWTF flow and process data that was provided by MCDES for 2002 and 2003 is tabulated in TABLE 2-2.

Table 2-2: Summary of FEV WWTF Performance

Wastewater Parameter	Average (2002 and 2003 data)
Influent WWTF Flow	96.0 MGD
Influent BOD_5 Concentration	133.6 mg/L
Influent BOD_5 Loading	101,745 lb/day
Average BOD_5 Removal	89%
Influent TSS Concentration	146.3 mg/L
Influent TSS Loading	114,208 lb/day
Average TSS Removal	91%
Influent TKN Concentration	22.4 mg/L
Influent TKN Loading	17,473 lb/day
Average TKN Removal	29%

FIGURE 2-7 shows the relationship of influent BOD_5 and TSS loadings versus influent flow to the WWTF. Typically, loadings should increase with increased influent flows. However, this may not be the case for plants that treat wastewater from combined sewers. The data shows that there are periods of high influent flows that correspond with relatively low loadings, which is evident with the BOD_5 loading in the spring of 2003 and could be attributed, in part, to dilution of the influent, as is often observed in combined collection systems. Also, during periods of high flow, wastewater and stormwater can be temporarily stored in a series of tunnels. Once flows begin to return to normal levels the stored wastewater can be fed to the facility. It is possible that a portion of the BOD_5 that would normally flow to the facility is stored in the tunnels during periods of high flow, thereby reducing the BOD_5 loading to the facility. FIGURE 2-8 presents the same relationship with TKN and influent flow. Overall, the loadings follow similar trends to those seen with BOD_5 and TSS.

Average overall plant BOD_5 and TSS removals are approximately 90% but can often vary by +/-5% depending upon the influent concentration. The BOD_5 and TSS removals are well above the 85% requirement of the facility State Pollutant Discharge Elimination System (SPDES) permit. Because the FEV WWTF handles combined sewer overflow (CSO) flows, the influent flow rate and BOD_5/TSS concentrations can vary significantly. WWTF effluent concentrations typically range between 8 milligrams per liter (mg/L) to 19 mg/L for BOD_5 and 12 mg/L to 21 mg/L for TSS, which are well below the seven day average SPDES discharge permit limits of 45 mg/L for BOD_5 and TSS as well as the 30 day average limit of 30 mg/L for BOD_5 and TSS.



MALCOLM PIRNIE	NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION MONROE COUNTY DES - FRANK E. VAN LARE WWTF	FIGURE 2-8 INFLUENT TKN LOADING (2002 to 2003)

In order to evaluate the energy usage at the FEV WWTF, the electric energy usage and demand data were compared to WWTP flows to establish the effects of varying influent flows on electric energy usage. FIGURE 2-9 presents the average monthly influent flow plotted with the average monthly electric energy usage. The figure shows that there is very little variation in electric energy usage throughout the year. An exception is the electric energy usage in October 2003, but this may be an anomaly due to efforts to balance the two main electric feeds.

Overall, the average influent flow rate does not appear to correlate with electric energy usage. The FEV WWTF does not have influent pumps on-site (there are pumps at the Cross Irondequiot Bay Pump Station, which is not included in this study). Influent flow pumps can account for a significant portion of a plants electric energy usage, which is directly related to influent flow. The overall electric energy usage at the FEV WWTP is driven by the aeration tank mechanical mixer motors. Although flow can affect the electric energy usage of the aeration mixers, other factors such as influent BOD_5 loading and biological activity play a primary role. Because the facility treats flow from a CSO, sharp increases in influent flow can occur during rain events, which can have a short-term effect on electric energy usage. The short-term effects are further discussed in Section 3.

The electric energy demand shows a similar trend. Average monthly electric energy demand is presented on FIGURE 2-10. The figure indicates that peak demand can occur at any time during the year regardless of flow.

FIGURE 2-11 shows the relationship between natural gas usage and influent wastewater flow. There does not appear to be a strong correlation between influent flow and natural gas usage. The largest consumer of natural gas at the facility is the incineration process, which is operated year round. As discussed earlier in this section, the solids quantities do not increase significantly with the plant influent flows at facilities serving combined sewer systems.

Based on the 2002 and 2003 data, approximately 92,406 lb/d BOD_5 are removed. Therefore, the estimated electric energy usage per pound of BOD_5 removed averages 0.81 kWh per lb of BOD_5. The natural gas usage is approximately 0.04 therms per lb BOD_5 removed.

TABLE 2-3 summarizes the performance of the solids handling process and incinerator performance, based on 2004 data.

Table 2-3: Summary of FEV WWTF Performance – Solids Handling Processes

Parameter	Average (2004 data)
Centrifuge Feed Sludge Quantities	87,520 wet tons per year, 26,046 dry tons per year
Average Cake Percent Solids	29.8%
Incinerator Natural Gas	987,230 therms per year
Gas Therms per Dry Ton	37.9 therms per dry ton
Average Dry Tons per Day	100.2 dry tons per day
Centrifuge Polymer Use	22.2 lbs per dry ton

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FIGURE 2-9
ELECTRIC USAGE vs. INFLUENT FLOW (2002 to 2003)

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FIGURE 2-11
NATURAL GAS USAGE vs.
INFLUENT FLOW (2002 to 2003)

Section 3

ELECTRIC SUBMETERING PROGRAM

3.1 DESCRIPTION OF SUBMETERING PROGRAM AND SUBMETER LOCATIONS

3.1.1 Description of Program

Continuous submetering was conducted using two methods. The Frank E. Van Lare (FEV) Wastewater Treatment Facility (WWTF) already has 18 submeters that are permanently in place. Facility staff wrote subroutines for the monitoring system to log the electric energy usage data for a period of six weeks from September 1, 2004 to October 15, 2004. Additional continuous recording electronic data loggers (CREDLs) were temporarily installed to monitor the process water pumps for a period of seven weeks from August 13, 2004 to September 30, 2004. The CREDLs had to be removed prior to October 15, 2004 for placement at another facility. A minimum of six weeks of data was collected at each of the submetering locations. For the purposes of this evaluation the submetering period refers to the period from September 1, 2004 to October 15, 2004, during which the bulk of the submetering occurred. The continuous submetering was used to capture diurnal variations in electric energy demand for major pieces of equipment, as well as to provide a representative sample of electric energy usage, including measuring electric energy demand as equipment cycles on and off.

In conjunction with the continuous submetering program, daily process data were collected for both the wet stream and solids handling processes. The summary of process data is further detailed in Section 4 of this report.

Instantaneous submetering was also conducted on representative pieces of equipment, usually those that operated at a constant speed according to a set schedule and driven by motors rated at 25 horsepower (hp) or greater. TABLE 3-1 summarizes the motors greater than 25 hp at the FEV WWTF. The submetering and instantaneous readings in conjunction with estimated operating hours were then used to estimate total electric energy usage for the particular pieces of equipment.

3.1.2 Submeter Locations

The FEV WWTF currently has a total of 18 submeters permanently installed throughout the facility. The submeters monitor the following locations:

- Two submeters on the main electric feeds to the WWTF – one meter for each feed.

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Table 3-1 List of Motors Over 25 hp[1]

Process	Use	MCC Location	Quantity	Size (HP)	Constant/ Variable Speed
Secondary Treatment	Aeration Motors	Aeration Tanks	60	150	V
Preliminary Treatment	Aerated Grit Blowers	AGF Building	3	100	C
Preliminary Treatment	Aerated Grit Pumps	AGF Building	4	25	C
Preliminary Treatment	Non-Aerated Grit Pumps	NAG Building	4	25	C
Solids Handling, Sludge Pumping	RS Pumps	Recirculation Pump Station	14	50	C
Plant Recycle	Dilution Water Pumps	Recirculation Pump Station	4	30	V
Plant Recycle	Return Effluent Pumps	Recirculation Pump Station	4	100	V
Plant Recycle	Process Water Pumps	Disinfection Building	4	100	C
Solids Handling, Thickening	Thickener Sludge Pumps	Odor Abatement Building	16	25	C
Solids Handling, Thickening	Holding Tank Pumps	Odor Abatement Building	3	25	C
Solids Handling, Dewatering	Centrifuge Bowl Motors	Solids Building	3	200	V
Solids Handling, Dewatering	Centrifuge Scroll Drive	Solids Building	3	30	V
Solids Handling, Incineration	Induced Draft Fans	Solids Building	2	100	V
Solids Handling, Incineration	Combustion Air Fans	Solids Building	2	30	C
Solids Handling, Incineration	Cooling Air Fans	Solids Building	2	25	C
Solids Handling, Incineration	Afterburner Turbos	Solids Building	2	25	C
Solids Handling, Incineration	Ash Pumps	Solids Building	3	40	V
Solids Handling, Incineration	Incineration Process Water Pumps	Solids Building	3	40	C
Solids Handling, Incineration	Incineration Wastewater Pumps	Solids Building	3	30	V
Solids Handling, Incineration	Instrument Air Compressor	Solids Building	2	25	C
Solids Handling, Incineration	Instrument Air Compressor	Odor Abatement Building	2	25	C
Solids Handling, Dewatering	Dewatered Sludge Pumps	Solids Building	3	125	C
Odor Control	Sludge Holding Tanks Scrubber Blower	Odor Abatement Building	1	25	C
Odor Control	Thickeners Scrubber Blower	Odor Abatement Building	2	25	C

Notes:

[1]All equipment Listed is 3-Phase, 480 Volts

- Two submeters on the portion routed to the Cross Irondequoit Bay Pump Station (CIPS) facility – one meter for each feed.
- Four submeters for the aeration process – one meter per circuit.
- Two submeters for the solids handling building – one meter per circuit.
- Four submeters for the recirculation pumps – one meter for the return dilution pumps, one meter for the return effluent pumps, and two meters for the return sludge pumps.
- One submeter for the odor abatement building.
- One submeter for the day tanks.
- Two submeters for the gravity thickeners – one meter for the north thickeners and one meter for the south thickeners.

A schematic of the electric feed system and submetering locations is presented on FIGURE 3-1.

Data from the permanent submeters were summarized for the period from September 1, 2004 to October 15, 2004.

Based on a facility walk-through and existing facility information, temporary continuously-recording submeters were also installed on the 100-hp process water pumps. A total of four submeters were installed, one submeter per pump. The temporary submeters were installed from August 13, 2004 to September 30, 2004.

3.2 SUMMARY OF SITE AUDIT

A one-day on-site survey was conducted on October 15, 2003 to:

- Document existing equipment, operations, and lighting.
- Finalize the list of opportunities for energy improvements.
- Finalize the submetering approach.

The temporary submetering locations listed in Section 3.1.2 were finalized as a result of the site audit. In addition, a list of existing equipment at the facility with motors 25-hp or greater was developed during the site survey As shown in TABLE 3-1, the motors that collectively have the potential for using the most energy are those on the mechanical aerators.

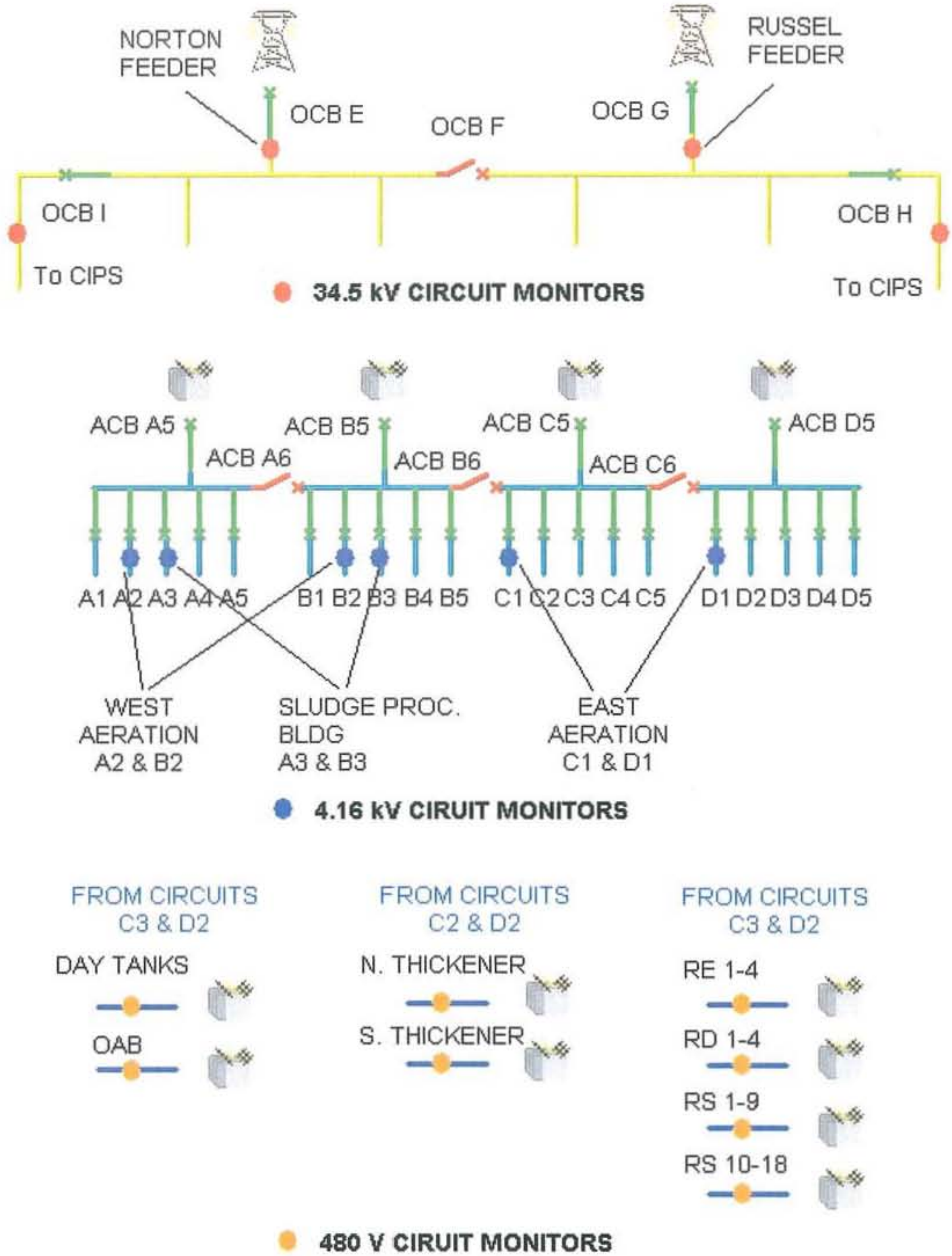

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FIGURE 3-1
ELECTRIC FEED SYSTEM AND SUBMETERING LOCATIONS

3.3 SUMMARY OF CONTINUOUS SUBMETERING

The following sections summarize the results from continuous submetering activities. The overall electric energy demand for the two feeds to the FEV WWTF is shown on FIGURE 3-2. Based on a visual comparison of the data, there appears to be a weekend/weekday trend in the electric energy demand due to the solids handling operation that is obscured due to the electric energy demand of the operations of the aeration system.

3.3.1 Process Water Pumps

Continuous submeters were installed on each of the four 100 hp constant speed process water pumps from August 13, 2004 to September 30, 2004. Pump number WP-2 was out of service for the duration of the period. One of the main purposes of the process water pumps is to supply treated effluent to the incineration process for the exhaust scrubber operation. The pumps also supply water for odor control scrubbers and wash water throughout the facility.

Each pump is sized to handle approximately 2,400 gallons per minute (gpm) at a total dynamic head (TDH) of 130 feet (ft).

The patterns of electric energy demand during the submetering period are shown on FIGURE 3-3. The data shows that pump WP-4 and WP-3 were operating for most of the submetering period (87% and 85% of the time respectively). Pump WP-1 only operated for a limited time at the beginning of September 2004. The regular drops in demand seen in the figure correspond to weekends when the incineration process was taken off-line. Additionally, facility staffing is limited during the weekend, which reduces the use of the water for maintenance, flushing, etc. The average electric energy demand during the week for the submetering period was 111 kiloWatt (kW) versus an average weekend demand of 56 kW. The electric energy demand was halved during weekends. The average power draw values for pumps WP-1, 3, and 4 (while in operation) were 55.1 kW, 86.5 kW, and 54.6 kW, respectively. Upon closer review of the data for WP-3, it appeared that the submetered data was suspect. A second set of instantaneous measurements were taken for the pumps and it was discovered that WP-3 and WP-4 have similar power draws. Therefore, for the purposes of the submetering evaluations, the data gathered for WP-3 was adjusted based on the average power draw at WP-4.

TABLE 3-2 summarizes the electric energy usage and estimated cost for each pump during the submetering period. Extrapolating to a full year, it is estimated that the total annual electric energy usage of the process water pumps would be 837,347 kiloWatt-hours (kWh), with a total estimated cost of $51,078, which is approximately 3.1% of the total annual electric cost.

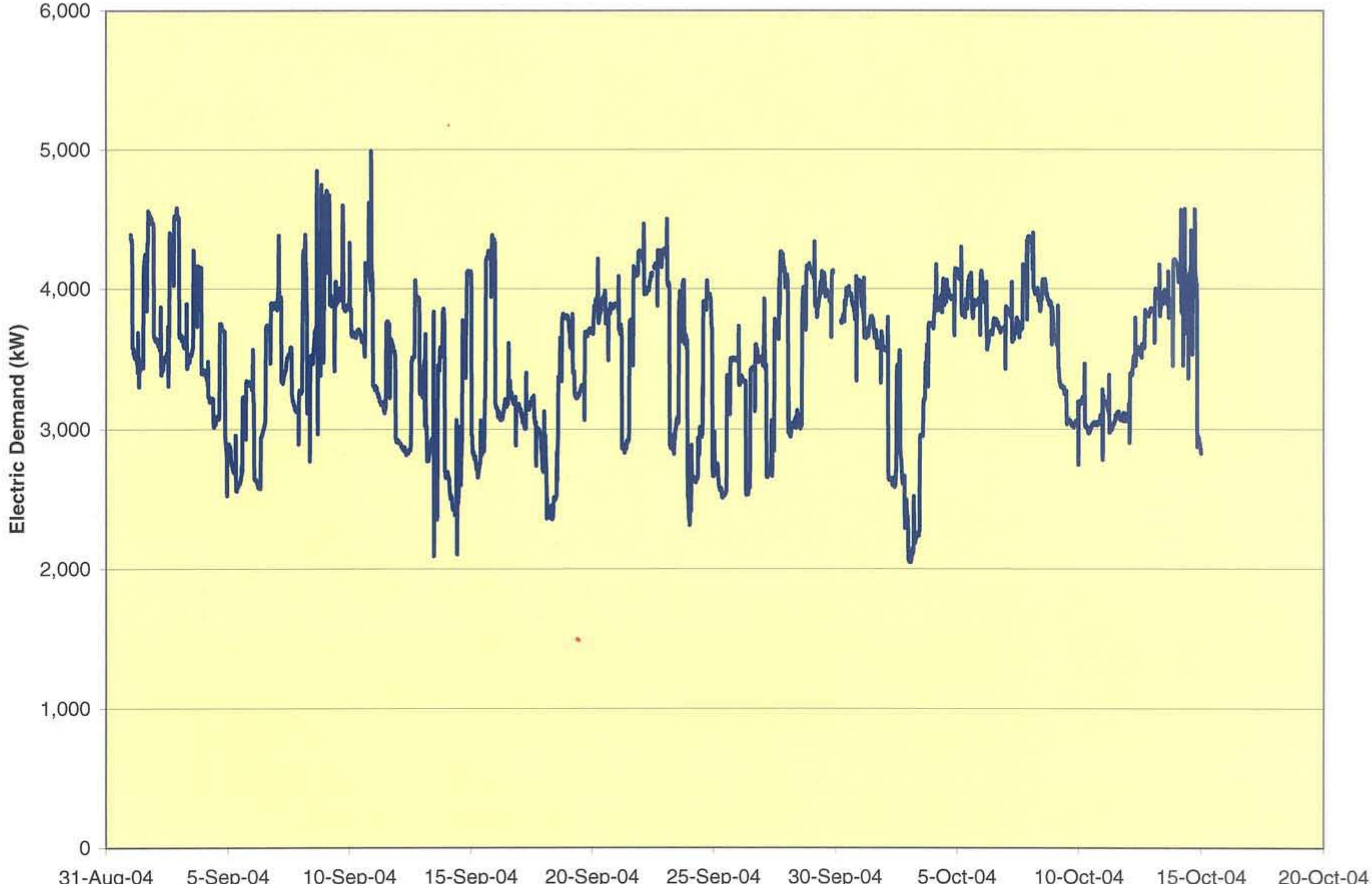

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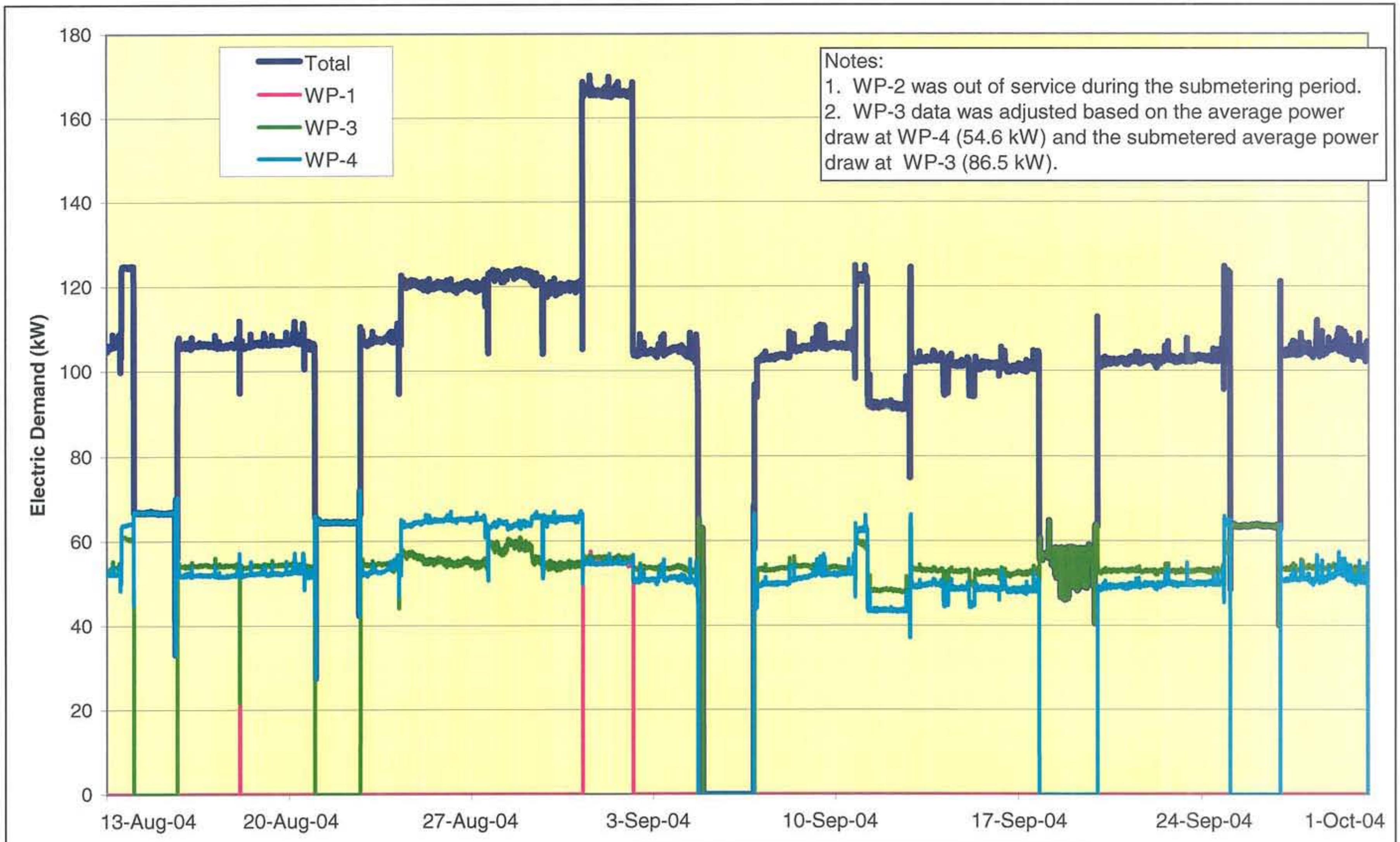
FIGURE 3-2
FACILITY WIDE ELECTRIC DEMAND



MALCOLM PIRNIE	NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION MONROE COUNTY DES - FRANK E. VAN LARE WWTF	FIGURE 3-3 SUBMETERING - PROCESS WATER PUMPS ELECTRIC DEMAND

Table 3-2: Summary of Process Water Pumps During the Submetering Period

Pump No.	Electric Energy Usage (kWh)	Estimated Cost*
WP-1	2,541	$ 155
WP-3	55,790	$ 3,403
WP-4	54,709	$ 3,337
TOTAL	**113,040**	**$ 6,895**

* Estimated using $0.061 per kWh, which was the average of 2004 data

3.3.2 Aeration Tanks

The energy usage associated with the aeration tanks is attributed to the 150 hp dual-speed mechanical aerators. There are a total of 20 tanks, of which 10 to 16 are on-line at any given time. An average of 10 to 12 tanks typically operate during the summer and more are operated in the winter due to a discharge of glycol from airplane de-icing operations. Each tank has three aerators that can be operated separately. Facility operators monitor the performance of the tanks and adjust the motor settings as needed. Each of the 60 aerators has three settings that are selected based on the dissolved oxygen (DO) levels:

- High Speed
- Low Speed
- Off

The total aerator horsepower for each tank ranges from approximately 85-hp (one aerator at low speed) to 450-hp (three aerators at high speed) depending upon the DO requirements. Monroe County Department of Environmental Services (MCDES) performed tests to evaluate the effectiveness of variable frequency drive use for the control of DO concentrations, but the investigation yielded mixed results presumably due to varying performance of DO instrumentation. The mechanical aerators are the largest energy consumers at the facility.

For a single motor, the high speed setting imparts the highest electric energy demand with the low speed setting equaling approximately 58% of the high demand. The combination of settings for each tank determines the overall electric energy demand. The patterns of electric energy demand during the submetering period are shown on FIGURE 3-4. A major peak in electric energy demand was observed beginning September 8, 2004. The reason for this peak is that the aerator motor speeds were increased in response to a perceived need due to precipitation events. A listing of the rainfall amounts during this period is shown below:

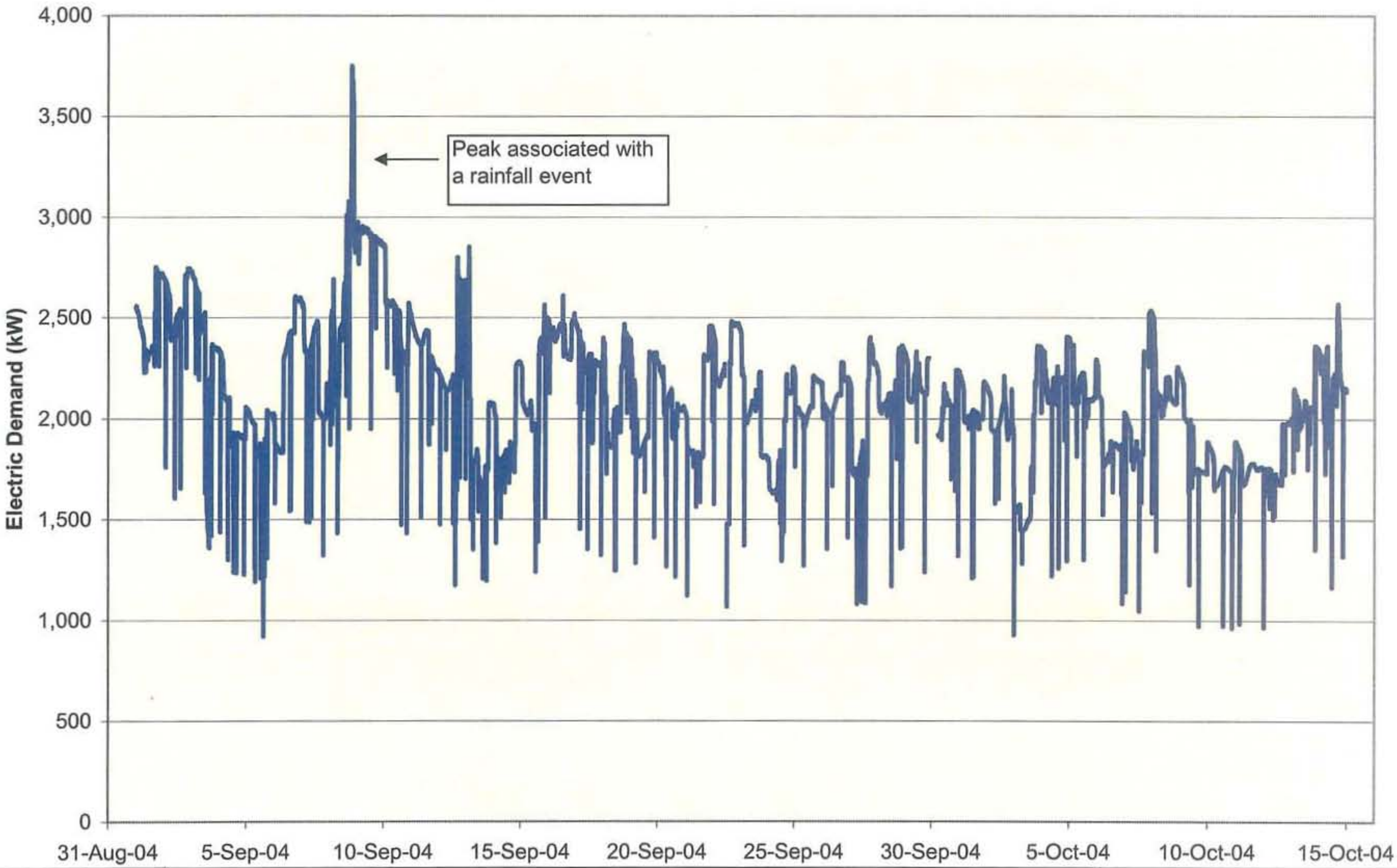


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FIGURE 3-4
SUBMETERING - AERATION TANK ELECTRIC DEMAND

- September 7, 2004 - 0.61 inches
- September 8, 2004 - 1.43 inches
- September 9, 2004 - 2.08 inches

The collection system consists of a combined sewer overflow (CSO), therefore the rain event had a large impact on influent flows. The flow prior to the rain event was approximately 88 million gallons per day (MGD) and quickly increased to a peak of 196 MGD during the rain event. The overall number of tanks in operation did not change; therefore the increase in electric energy demand may have been a result of having a large number of aerators operating at high speed at the same time.

Upon evaluating data for the entire submetering period, the peaks in electric energy demand correspond with times when more of the mixers were operating at high speed. A subroutine was set up in the control system to record the amount of time at each setting. The relative percentage of time that the aerators were operating at each setting is listed below:

- High Speed - 66%
- Low Speed - 5%
- Off - 29%

The average electric energy demand of all of the aerators over the course of the submetering period was 2,147 kW.

There is a seasonal variation in the electric energy demand of the aeration process. Electric energy usage is over 30% higher during the summer months (June through September) than the winter months (December through March). The solubility of oxygen is lower during the warm months and biological activity is elevated, making oxygen supply more energy intensive. Although the glycol in the influent during the winter may increase the oxygen demands on a relative basis, the highest electric energy usage is in the summer.

TABLE 3-3 summarizes the electric energy usage and estimated cost for the aerators during the submetering period. Extrapolating the data to a full year, it is estimated that the total annual electric energy usage of the aeration tank process would be 18,805,099 kWh, with a total estimated cost of $1,147,111, approximately 68% of the total annual electric energy cost. These data were collected during warmer temperatures, which correspond to higher electric energy usage. Extrapolating peak seasonal electric energy usage data to a full year most likely results in overly conservative estimates since the electric energy usage at the FEV WWTF is typically 30% lower in the winter months. A secondary and potentially more realistic estimation of the annual electric usage can be based on the relative percentage of total facility electric energy usage. The percentage of total facility electric energy usage based on electric energy usage information recorded during the submetering period was only 61%, as opposed to the 68% based on summer electric energy usage extrapolation. The relative percentage of electric energy usage may be a more realistic basis for the full year electric energy usage. Applying the 61% to the annual facility-wide electric energy usage yields an electric energy usage for the aeration process of 16,684,020 kWh, with a total estimated cost of $1,017,725.

Table 3-3: Summary of Aeration Tank Aerators During the Submetering Period

Process	Electric Energy Usage (kWh)	Estimated Cost*
Aerators	2,266,916	$ 138,282

* Estimated using $0.061 per kWh, which was the average of 2004 data

3.3.3 Solids Handling Building

Data from the two electric circuits supplying the solids handling building (SHB) were collected for the duration of the submetering period. The SHB contains all equipment associated with dewatering including centrifuges, cake pumps as well as the sludge incinerators. A more detailed listing of the major pieces of equipment is provided below:

- Centrifuge Bowl Motors
- Centrifuge Scroll Drive
- Dewatered Sludge Pumps
- Induced Draft Air Fan
- Incineration Process Water Pumps
- Incineration Wastewater Pumps
- Ash Pumps
- Combustion Air Fans
- Cooling Air Fans
- Afterburner Turbos
- Instrument Air Compressors

FIGURE 3-5 presents the electric energy demand during the submetering period for the SHB. The figure shows that circuits A3 and B3 were constantly supplying electric energy over the period. The regular drops in electric energy demand seen in the figure correspond to weekends when the dewatering and incineration processes were taken off-line. The average total electric energy demand on weekdays for the submetering period was 574 kW versus an average weekend electric energy demand of 221 kW. The electric energy demand decreased by 62% at the weekends when the bulk of the solids handling equipment is taken off-line. Facility staff indicated that the incinerators are typically operated 114 hours per week. The overall average electric energy demand for circuits A3 and B3 were 182.7 kW, and 280.6 kW, respectively yielding a total average of 463.3 kW.

TABLE 3-4 summarizes the electric energy usage and estimated cost for the SHB during the submetering period. Extrapolating the data to a full year, it is estimated that the total annual electric energy usage of the solids handling building would be 4,058,508 kWh, with a total estimated cost of $247,569, which is approximately 14.8% of the total annual electric energy cost.

Table 3-4: Summary of Solids Handling Building During the Submetering Period

Process	**Electric Energy Usage (kWh)**	**Estimated Cost***
Solids Handling Building	489,237	$ 29,843

* Estimated using $0.061 per kWh, which was the average of 2004 data

3.3.4 Return Effluent Pumps

The electric energy usage associated with the 100 hp return effluent (RE) pumps was monitored for the duration of the submetering period. The return effluent pumps convey recycle flows from processes such as the gravity thickeners, centrifuges, and the incinerator scrubbers from the facility sewer line to the primary clarifiers. There are a total of four variable speed pumps, two of which run on a constant basis with one routed to the east primary clarifiers and one routed to the west primary clarifiers. The flow rate is based on the RE wet well level.

FIGURE 3-6 presents the electric energy demand during the submetering period for the RE pumps. The figure shows that there are regular drops in electric energy demand. The periods of decreased electric energy demand, such as the periods surrounding September 5, 2004 and September 12, 2004, coincide with weekends when the sludge dewatering and incineration process is off-line. Major components of the pumping requirements are the centrate from the centrifuges and the blowdown from the incinerator scrubbers. The average electric energy demand of the two RE pump motors over the submetering period was 97.0 kW.

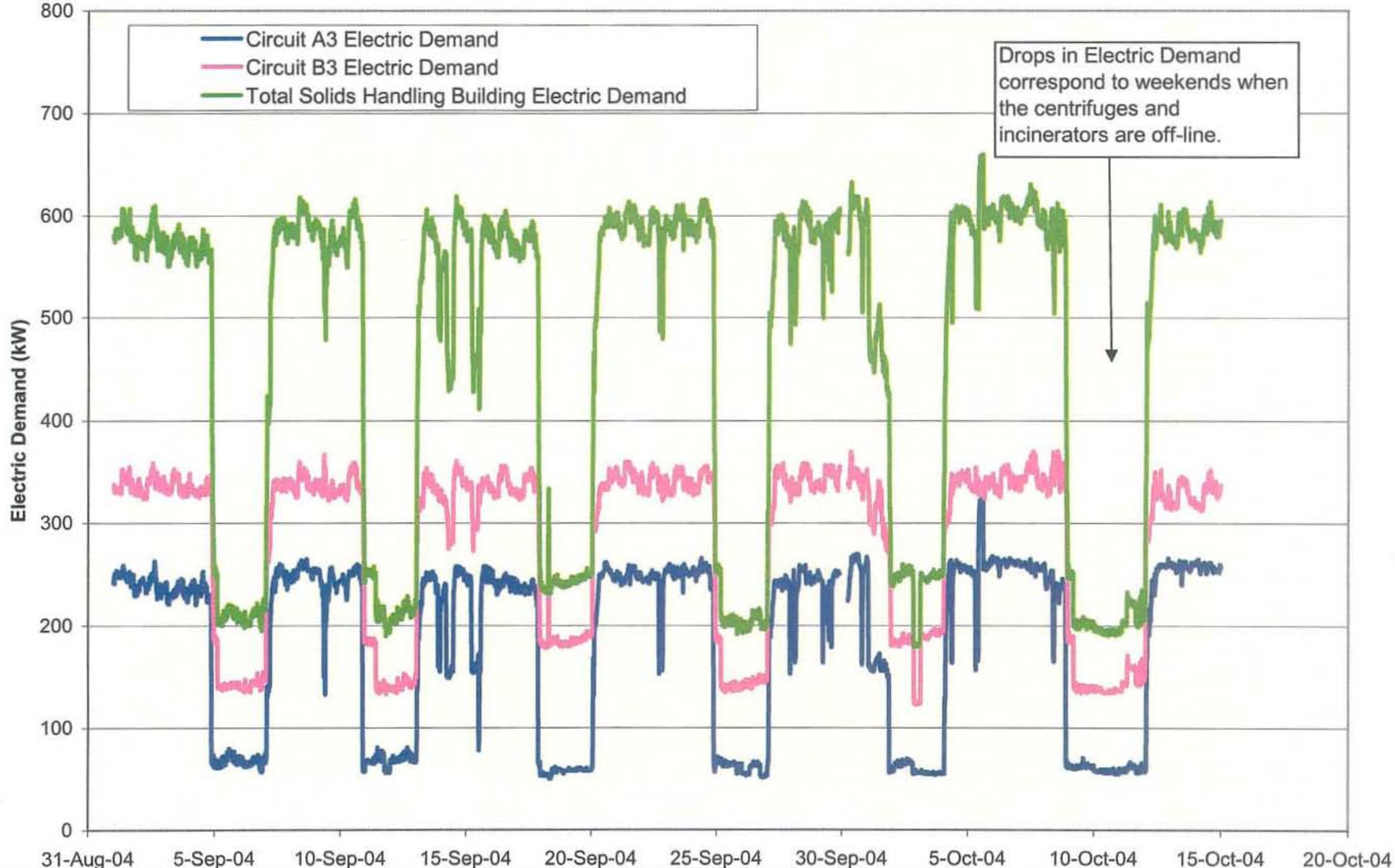

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FIGURE 3-5
SUBMETERING - SOLIDS HANDLING BUILDING ELECTRIC DEMAND

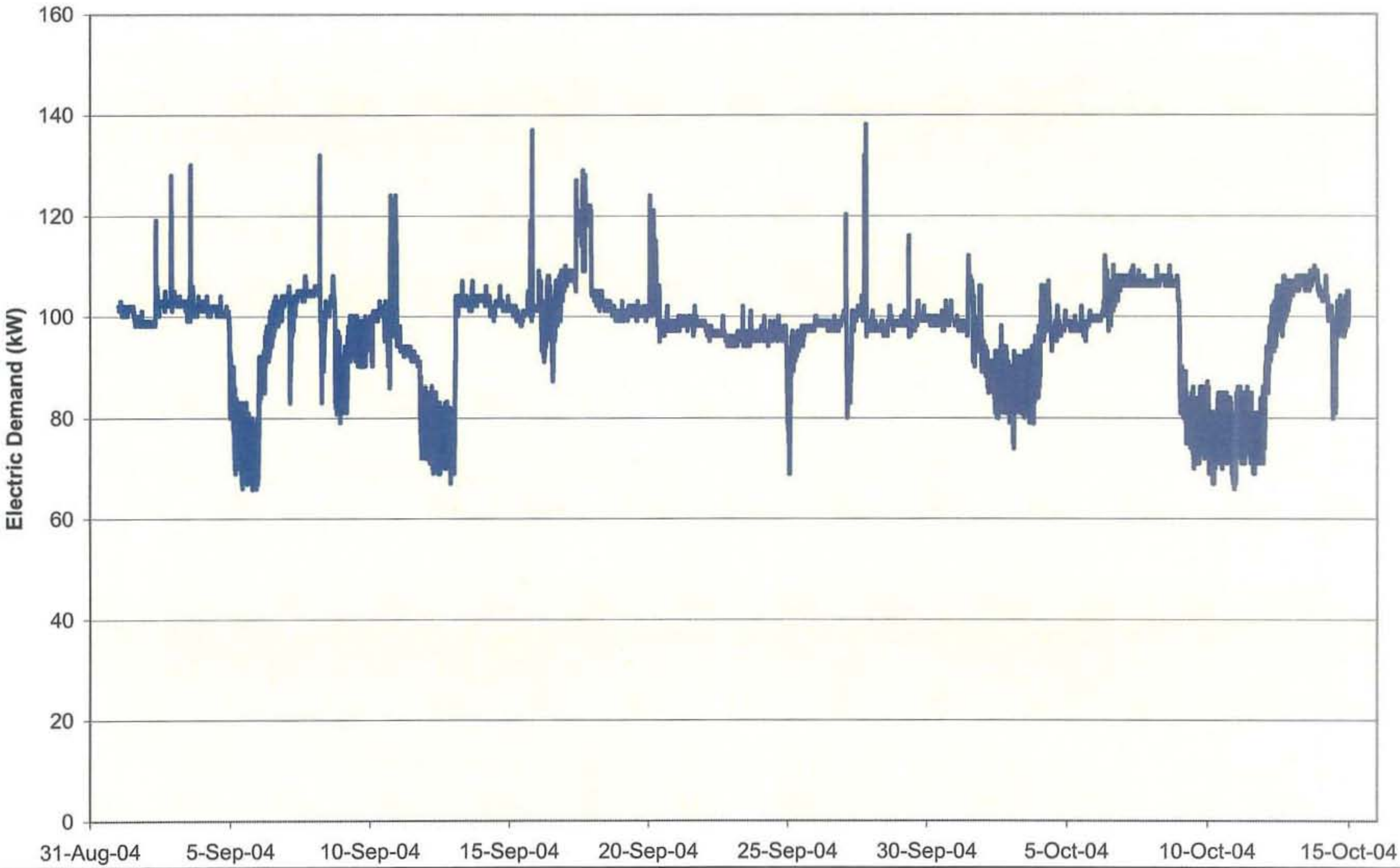

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FIGURE 3-6
SUBMETERING - RETURN EFFLUENT PUMPS ELECTRIC DEMAND

TABLE 3-5 summarizes the electric energy usage and estimated cost for the RE pumps during the submetering period. Extrapolating the data to a full year, it is estimated that the total annual electric energy usage of the RE pumps would be 847,392 kWh, with a total estimated cost of $51,691, which is approximately 3.1% of the total annual electric energy cost.

Table 3-5: Summary of Return Effluent Pumps During the Submetering Period

Process	Electric Energy Usage (kWh)	Estimated Cost*
Return Effluent Pumps	102,385	$ 6,245

* Estimated using $0.061 per kWh, which was the average of 2004 data

3.3.5 Return Dilution Pumps

The electric energy usage associated with the 30 hp return dilution (RD) pumps was monitored for the duration of the submetering period. The RD pumps convey secondary clarifier effluent water to the gravity thickeners for elutriation (i.e. enhancement of thickening) purposes. There are a total of four variable speed pumps, two of which run 98% of the time.

FIGURE 3-7 presents the electric energy demand during the submetering period for the RD pumps. The figure shows that there are occasional variations in electric energy demand. The changes in electric energy demand coincide with increased or decreased demand for the flow of elutriation water, which is selected by operators. The average electric energy demand of the two pump motors over the submetering period was 18.6 kW.

TABLE 3-6 summarizes the usage and estimated cost for the RD pumps during the submetering period. Extrapolating the data to a full year, it is estimated that the total annual electric energy usage of the return dilution pumps would be 162,669 kWh, with a total estimated cost of $9,923, which is approximately 0.6% of the total annual electric cost.

Table 3-6: Summary of the Return Dilution Pumps During the Submetering Period

Process	Electric Energy Usage (kWh)	Estimated Cost*
Return Dilution Pumps	19,702	$ 1,202

* Estimated using $0.061 per kWh, which was the average of 2004 data

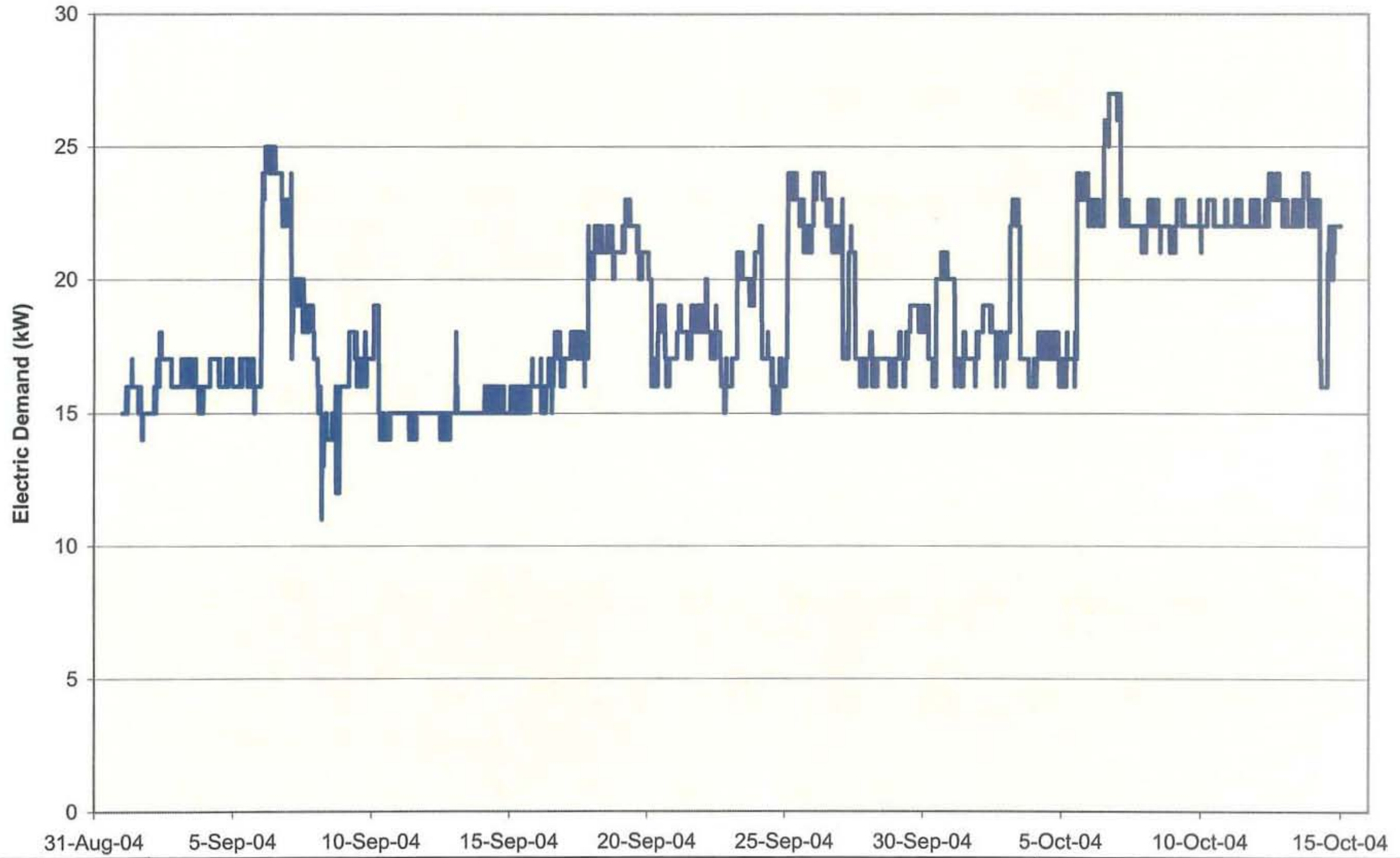

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FIGURE 3-7
SUBMETERING - RETURN DILUTION PUMPS ELECTRIC DEMAND

3.3.6 Return Sludge Pumps

The electric energy usage associated with the 50-hp return sludge (RS) pumps was monitored for the duration of the submetering period. The RS pumps convey settled solids from the final clarifiers back to the aeration tanks. There are a total of fourteen variable speed pumps, eight of which run on a continuous basis. The pumps are paced to the influent flow rate.

The patterns of electric energy demand during the submetering period are shown on FIGURE 3-8. The figure shows that there was an increase in electric energy demand on September 8, 2004. The increase in electric energy demand corresponds to a sharp increase in influent flow to the facility. The RS pumping rate increased to respond to the higher flow. The average electric energy demand over the submetering period was 151.7 kW.

TABLE 3-7 summarizes the electric energy usage and estimated cost for the RS pumps during the submetering period. Extrapolating the data to a full year, it is estimated that the total annual electric energy usage of the return sludge pumps would be 1,328,892 kWh, with a total estimated cost of $81,000, which is approximately 4.9% of the total annual electric cost.

Table 3-7: Summary of Return Sludge Pumps During the Submetering Period

Process	Electric Energy Usage (kWh)	Estimated Cost*
Return Sludge Pumps	160,195	$ 9,772

* Estimated using $0.061 per kWh, which was the average of 2004 data

3.3.7 Thickener Pumps

The sludge pumps associated with the thickeners convey thickened sludge to the sludge holding tanks. There are a total of eight pumps that cycle on and off at set intervals throughout the day. The main electric feed to the thickener pumps was monitored for the duration of the submetering program.

The submetering data indicated that the average daily operating time for the pumps was 6.3 hours per day. Facility staff estimates of operating time throughout the year equals approximately 7.9 hours of operation per day. The average daily flow of all of the thickener pumps equals 476,315 gallons per day (gpd). A summary of the electric energy demand for the thickener pumps over the submetering period is presented on FIGURE 3-9. The figure shows that the typical electric energy demand ranges from 60 kW to 90 kW, but there are times when extremes are reached. The maximum electric energy demand would correspond with a higher fraction of the pumps being cycled on, and the minimum electric energy demand would

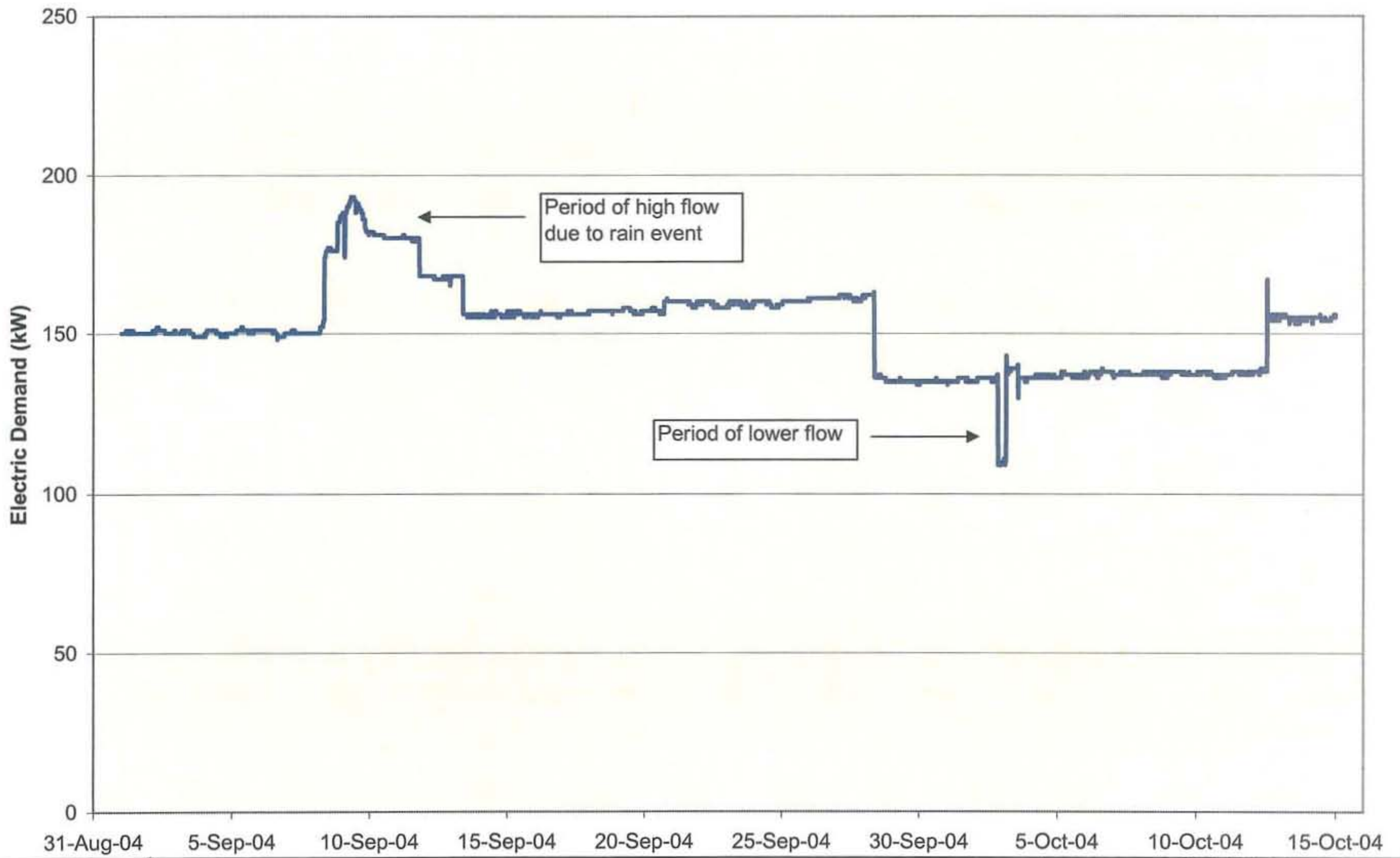

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FIGURE 3-8
SUBMETERING - RETURN SLUDGE PUMPS ELECTRIC DEMAND

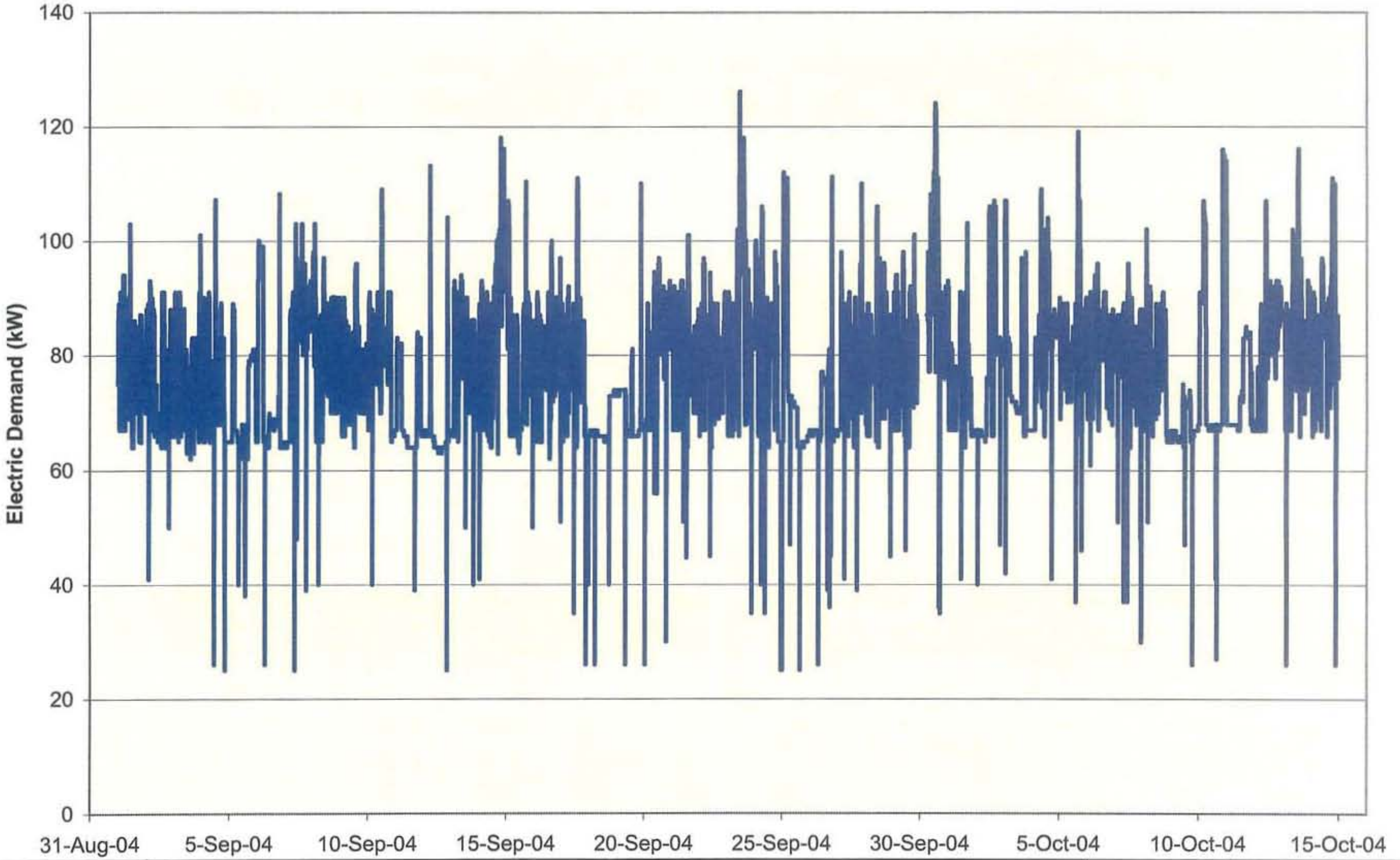

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FIGURE 3-9
SUBMETERING - THICKENER PUMPS ELECTRIC DEMAND

correspond to a higher fraction of the pumps being cycled off. The average electric energy demand over the submetering period was 80.1 kW.

TABLE 3-8 summarizes the electric energy usage and estimated cost for the thickener pumps during the submetering period based on instantaneous pump demand readings and time of use data. Extrapolating the data to a full year, it is estimated that the total annual electric energy usage of the pumps would be 132,918 kWh, with a total estimated cost of $8,108, which is approximately 0.5% of the total annual electric cost.

Table 3-8: Summary of Thickener Pumps During the Submetering Period

Process	Electric Energy Usage (kWh)	Estimated Cost*
Thickener Pumps	16,387	$ 1,000

* Estimated using $0.061 per kWh, which was the average of 2004 data

3.3.8 Day Tanks

The day tanks are used to condition and mix sludge from the holding tanks prior to dewatering. Sludge is pumped from the holding tanks to the day tanks using a rotary lobe pump. There are a total of four day tanks and each has two 5 hp mixing motors. The electric energy usage associated with the day tank mixers and other ancillary equipment was monitored for the duration of the submetering period.

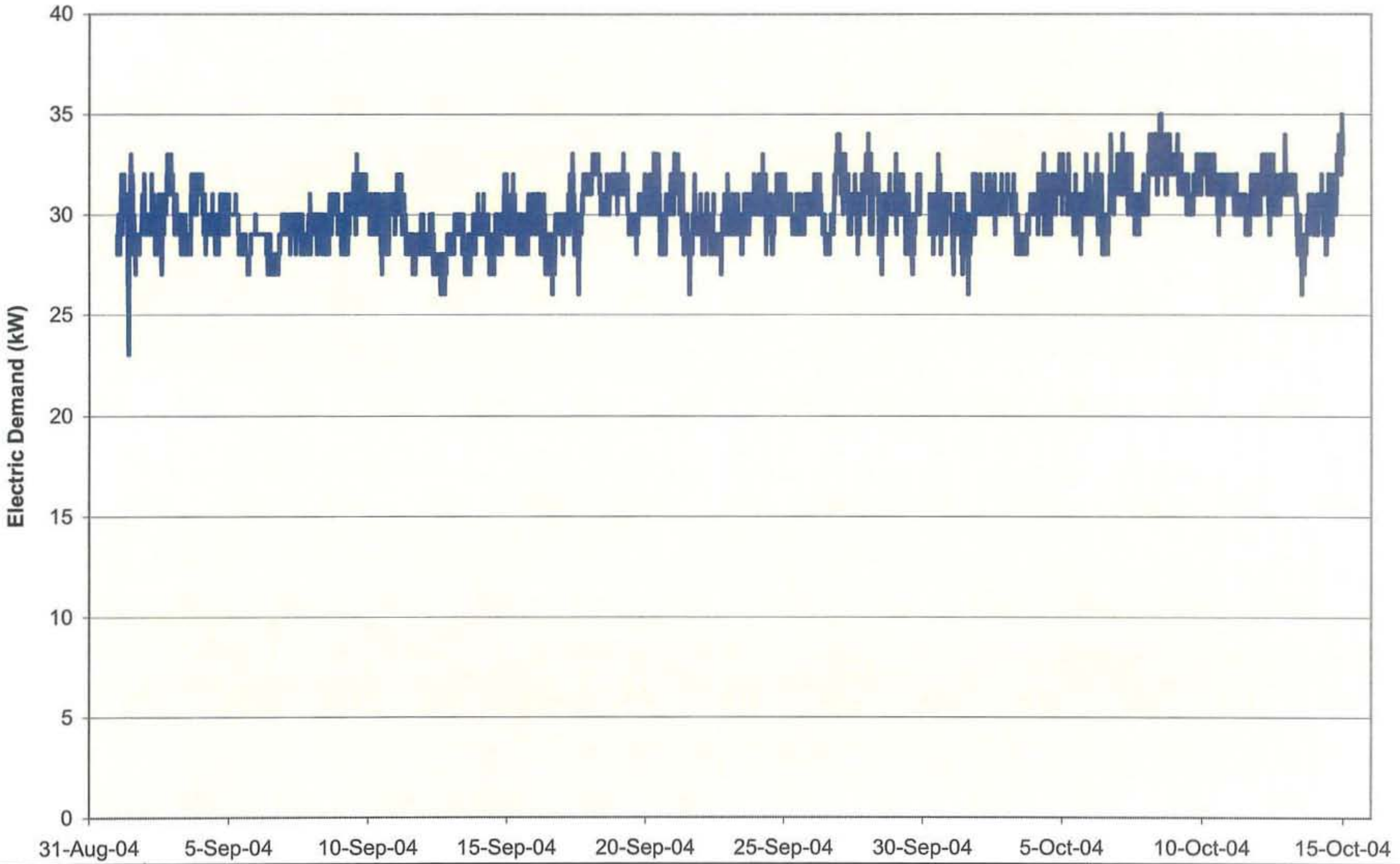
The patterns of electric energy demand during the submetering period are shown on FIGURE 3-10. The figure shows that the electric energy demand for the day tanks averages 30 kW and does not vary significantly.

TABLE 3-9 summarizes the electric energy usage and estimated cost for the day tank mixers during the submetering period. Extrapolating the data to a full year, it is estimated that the total annual electric energy usage of the day tanks would be 271,636 kWh, with a total estimated cost of $16,570, which is approximately 1.0% of the total annual electric cost.

Table 3-9: Summary of Day Tanks During the Submetering Period

Process	Electric Usage (kWh)	Estimated Cost*
Day Tanks	32,745	$ 1,997

* Estimated using $0.061 per kWh, which was the average of 2004 data



MALCOLM PIRNIE	NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION MONROE COUNTY DES - FRANK E. VAN LARE WWTF	FIGURE 3-10 SUBMETERING - DAY TANKS ELECTRIC DEMAND

3.4 SUMMARY OF INSTANTANEOUS SUBMETERING

Instantaneous power draw measurements were obtained from a number of motors at the WWTF for equipment that is either in continuous use or operated on a set schedule. The data were collected to verify electric energy demand at the facility, as well as to monitor changes in electric energy demand as the equipment is cycled on and off.

Instantaneous measurements were obtained using hand-held meters. A summary of the instantaneous readings is presented in TABLE 3-10.

Table 3-10: Instantaneous Electric Energy Demand Readings

Equipment	Electric Energy Demand (kW)	Volts	Amps	Power Factor
Centrifuge Feed Pump #4	3.68	490	4.4	0.99
Sludge Holding Tank Pump #3	8.6	482	13.3	0.79
Thickener Sludge Pump T2-A	5.12	485	12.2	0.5
Thickener Sludge Pump T3-B	6.44	485	14.8	0.52
Thickener Sludge Pump T4-B	5.75	485	14.2	0.48
Thickeners Scrubber Blower	11.1	485	20.0	0.64
Thickeners Scrubber Recycle Pump	7.64	483	12.4	0.74
Sludge Holding Tank Scrubber Blower	10.7	485	19.3	0.66
Sludge Holding Tank Scrubber Recycle Pump	8.9	485	13.3	0.79
Waste Activated Sludge Pump F8	2.87	488	5.7	0.59
Aeration Motor 5A - High Speed	63.6	481	94.2	0.81
Aeration Motor 5C - Low Speed	37.2	482	62.7	0.72
East Primary Sludge Pump Motor N10	4.98	490	14.9	0.68
West Primary Sludge Pump Motor P5	3.5	475	8.3	0.52
Aerated Grit Blower G2	71.1	478	98.6	0.87

These pieces of equipment are operated on a continuous basis. For comparison purposes, the instantaneous demand values were used in conjunction with continuous submetering results to develop total annual electric energy usage. TABLE 3-11 presents an overall summary of annual electric energy usage and cost for the equipment monitored in both the continuous and instantaneous submetering.

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New York State Energy Research and Development Authority
Municipal Wastewater Treatment Plant Energy Evaluation

Monroe County DES - Frank E. Van Lare WWTF

Table 3-11 Estimates of Electric Usage and Costs[1,2]

Process	Use	MCC Location	Size (hp)	Efficiency Rating[3]	Estimate of Electric Energy Usage				Notes
					Estimated Hours Per Year	Power Draw (kW) per motor	Estimated Annual Usage (kWh)	Estimated Cost[4]	
Preliminary Treatment	Aerated Grit Blowers	AGF Building	100	91.4%	8,268	71.1	587,855	$ 35,859	Run 1 (159 hrs per week)
Preliminary Treatment	Aerated Grit Pumps	AGF Building	25	87.9%	NA	NA	0	$ -	Currently not in operation
Preliminary Treatment	Non-Aerated Grit Pumps	NAG Building	25	87.9%	1,152	8.6	9,907	$ 604	Run 1 (22 hrs per week)
Solids Handling, Sludge Pumping	West Primary Sludge Pumps	Primary Buildings	15	86.5%	30,750	3.5	107,625	$ 6,565	Run 11 (591 hrs per week)
Solids Handling, Sludge Pumping	East Primary Sludge Pumps	Primary Buildings	15	86.5%	16,796	4.98	83,644	$ 5,102	Run 6 (323 hrs per week)
Solids Handling, Sludge Pumping	RAS Pumps	Recirculation Pump Station	50	89.9%	69,888	19	1,327,872	$ 81,000	Run 8 constantly
Plant Recycle	Dilution Water Pumps	Recirculation Pump Station	30	88.1%	17,123	9.5	162,669	$ 9,923	Run 2 (329 hrs per wk)
Plant Recycle	Return Effluent Pumps	Recirculation Pump Station	100	91.4%	17,472	48.5	847,392	$ 51,691	Run 2 constantly
Plant Recycle	Process Water Pumps	Disinfection Building	100	91.4%	15,288	54.8	837,347	$ 51,078	Run 3 (294 hrs per week)
Solids Handling, Thickening	Thickener Sludge Pumps	Odor Abatement Building	25	87.9%	23,036	5.77	132,918	$ 8,108	Run 8 (443 hrs per week)
Solids Handling, Thickening	Holding Tank Pumps	Odor Abatement Building	25	87.9%	9,699	8.6	83,411	$ 5,088	Run 2 (144 hrs per wk)
Solids Handling, Thickening	Instrument Air Compressor	Odor Abatement Building	25	87.9%	1,300	8.6	11,180	$ 682	Run 1 (25 hrs per week)
Secondary Treatment	Aeration Motors	Aeration Tanks	150	92.1%	393,120	42.4	16,684,020	$ 1,017,725	Ave kW of all motors
Solids Handling, Dewatering	Centrifuge Bowl Motors	Solids Building	200	92.5%	11,856	80.2	950,400	$ 57,974	Run 2 (228 hrs per week)
Solids Handling, Dewatering	Centrifuge Scroll Drive	Solids Building	30	88.1%	11,856	12.0	142,560	$ 8,696	Run 2 (228 hrs per week)
Solids Handling, Incineration	Induced Draft Fans	Solids Building	100	91.4%	11,856	40.1	475,200	$ 28,987	Run 2 (228 hrs per week)
Solids Handling, Incineration	Combustion Air Fans	Solids Building	30	88.1%	11,856	13.4	158,400	$ 9,662	Run 2 (228 hrs per week)
Solids Handling, Incineration	Cooling Air Fans	Solids Building	25	87.9%	11,856	11.1	132,000	$ 8,052	Run 2 (228 hrs per week)
Solids Handling, Incineration	Afterburner Turbos	Solids Building	25	87.9%	11,856	11.1	132,000	$ 8,052	Run 2 (228 hrs per week)
Solids Handling, Incineration	Ash Pumps	Solids Building	40	89.4%	10,608	16.0	170,072	$ 10,374	Run 2 (204 hrs per week)
Solids Handling, Incineration	Process Water Pumps	Solids Building	40	89.4%	12,584	17.8	224,168	$ 13,674	Run 2 (242 hrs per week)
Solids Handling, Incineration	Wastewater Pumps	Solids Building	30	88.1%	18,200	12.0	218,842	$ 13,349	Run 3 (350 hrs per week)
Solids Handling, Incineration	Instrument Air Compressor	Solids Building	25	87.9%	4,680	11.1	52,105	$ 3,178	Run 1 (90 hours per week)
Solids Handling, Dewatering	Dewatered Sludge Pumps	Solids Building	125	91.8%	11,856	55.7	660,000	$ 40,260	Run 2 (228 hrs per week)
Odor Control	Sludge Holding Tanks Scrubber Blower	Odor Abatement Building	25	87.9%	8,736	10.7	93,475	$ 5,702	Run 1 (168 hrs per week)
Odor Control	Thickeners Scrubber Blowers	Odor Abatement Building	25	87.9%	17,472	11.1	193,939	$ 11,830	Run 2 (336 hrs per week)
						TOTALS	**23,891,146**	**$ 1,457,360**	

Notes:
[1] All equipment listed is 3-phase.
[2] Energy demand determined by submetering and instantaneous power draw measurements with plant reports of operating hours.
[3] Efficiency Rating for Motors based on motor size, using standard efficiencies.
[4] Costs based on 2004 average costs of $0.061/kWh.

3.5 SUMMARY OF ENTIRE SUBMETERING PROGRAM

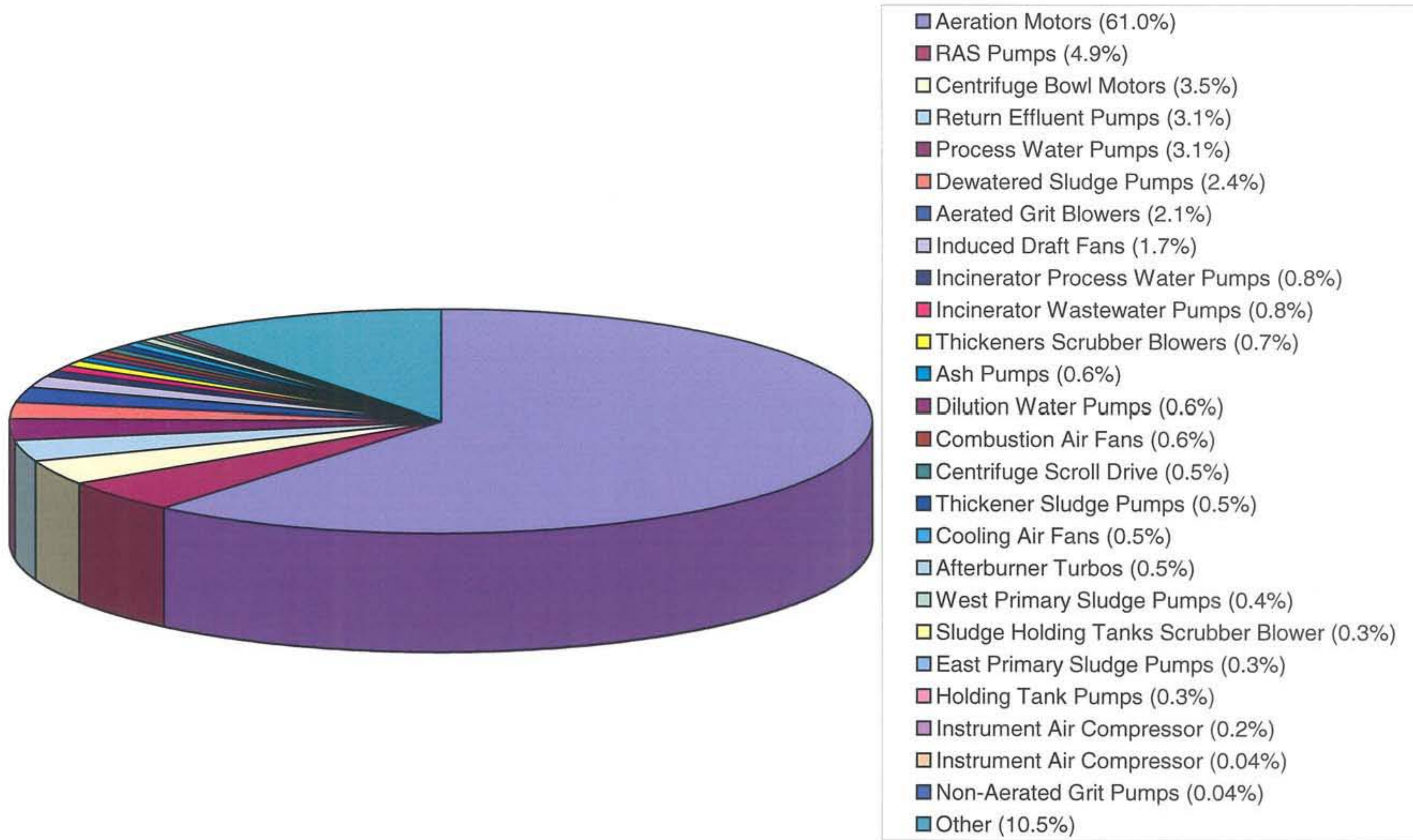
FIGURE 3-11 summarizes the apparent electric energy usage distribution among the larger motors at the FEV WWTF. TABLE 3-12 also presents the corresponding percentages of total electric energy usage.

Table 3-12: Summary of Major Equipment Total Estimated Electric Energy Usage and Cost at the FEV WWTF

Equipment	Electric Energy Usage (kWh)	Electric Energy Cost	Percentage of Total Electric Energy Cost
Aeration Motors	16,684,020	$ 1,017,725	61.0%
RAS Pumps	1,327,872	$ 81,000	4.9%
Centrifuge Bowl Motors	950,400	$ 57,974	3.5%
Return Effluent Pumps	847,392	$ 51,691	3.1%
Process Water Pumps	837,347	$ 51,078	3.1%
Dewatered Sludge Pumps	660,000	$ 40,260	2.4%
Aerated Grit Blowers	587,855	$ 35,859	2.1%
Induced Draft Fans	475,200	$ 28,987	1.7%
Incinerator Process Water Pumps	224,168	$ 13,674	0.8%
Incinerator Wastewater Pumps	218,842	$ 13,349	0.8%
Thickeners Scrubber Blowers	193,939	$ 11,830	0.7%
Ash Pumps	170,072	$ 10,374	0.6%
Dilution Water Pumps	162,669	$ 9,923	0.6%
Combustion Air Fans	158,400	$ 9,662	0.6%
Centrifuge Scroll Drive	142,560	$ 8,696	0.5%
Thickener Sludge Pumps	132,918	$ 8,108	0.5%
Cooling Air Fans	132,000	$ 8,052	0.5%
Afterburner Turbos	132,000	$ 8,052	0.5%
West Primary Sludge Pumps	107,625	$ 6,565	0.4%
Sludge Holding Tanks Scrubber Blower	93,475	$ 5,702	0.3%
East Primary Sludge Pumps	83,644	$ 5,102	0.3%
Holding Tank Pumps	83,411	$ 5,088	0.3%
Instrument Air Compressor	52,105	$ 3,178	0.2%
Instrument Air Compressor	11,180	$ 682	0.04%
Non-Aerated Grit Pumps	9,907	$ 604	0.04%
Other	2,871,851	$ 175,183	10.5%
Total Cost	27,350,852	$ 1,668,402	100.0%

*Power usage based on both instantaneous and continuous measurements @ $0.061/kWh

The figure and table show that the largest "identified" use of electric energy at the facility is associated with the aeration process (i.e. mechanical aerator motors). Approximately 10.5% of the total electric energy usage is accounted for as "other", which would involve equipment such as heating and ventilating



MALCOLM PIRNIE	NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION MONROE COUNTY DES - FRANK E. VAN LARE WWTF	FIGURE 3-11 ESTIMATED DISTRIBUTION OF ELECTRIC USAGE AND COST

fans, lights, and other equipment with electric motors less than 25-hp that were not included as part of this submetering program.

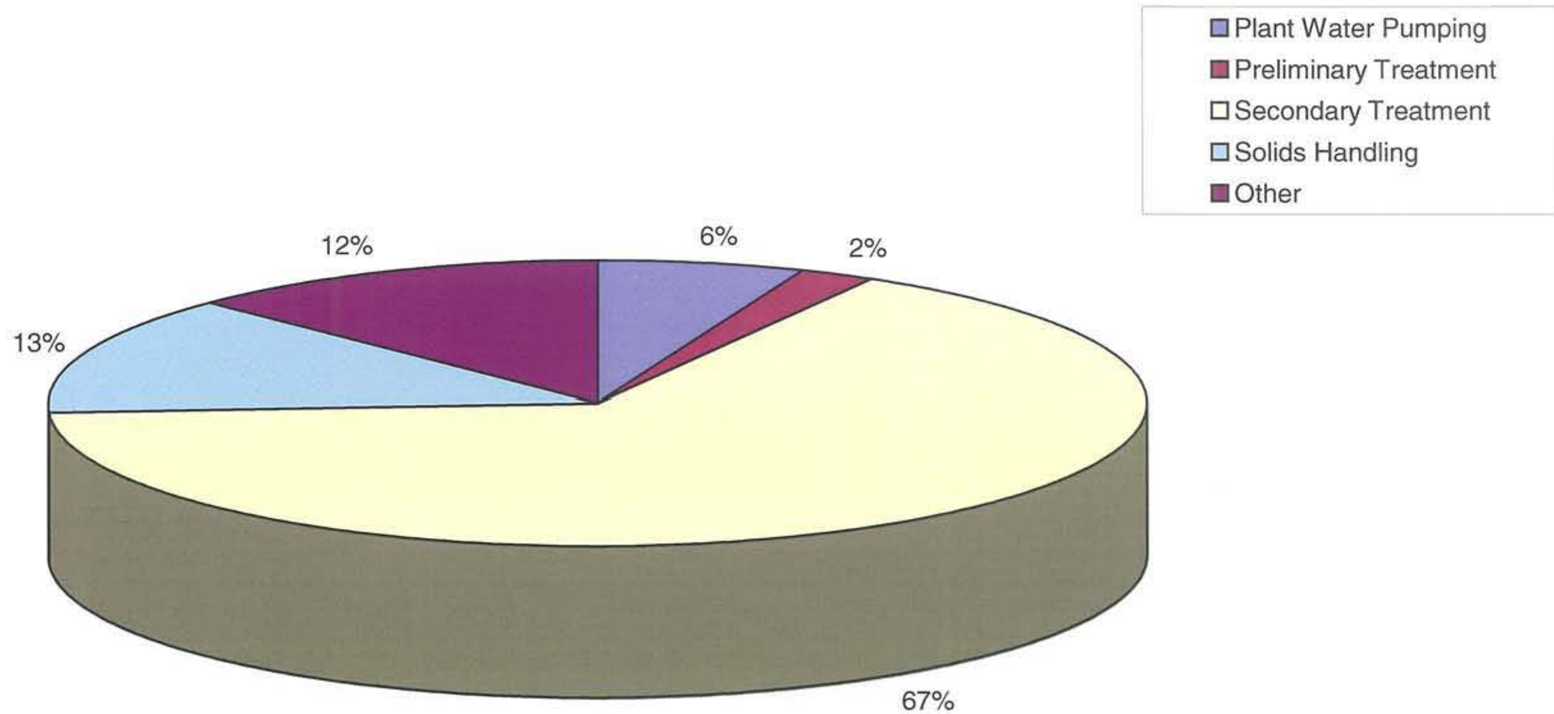
FIGURE 3-12 presents the distribution of estimated electric energy usage among the major processes at the facility. Equipment was grouped into processes as follows:

- Preliminary Treatment – aerated grit blowers.
- Primary Treatment – no major energy users noted.
- Secondary Treatment – aerator motors and RS pumps.
- Plant Water Pumping – process water and return effluent pumps.
- Solids Handling – solids handling building, primary sludge pumps, thickener pumps, return dilution pumps, sludge holding tank pumps.
- Other – all other equipment not listed.

The secondary treatment process is the largest consumer of electric energy at the FEV WWTF. It is estimated that approximately 0.74 kWh of electric energy is consumed per lb of BOD_5 removed in the secondary process.

The distribution of estimated electric energy usage in the solids handling process is shown on FIGURE 3-13. The solids handling equipment was categorized as follows:

- Pumping and Mixing – primary sludge pumps, WAS pumps, sludge holding tank pumps, thickener pumps, incinerator process water pumps, incinerator wastewater pumps.
- Dewatering – centrifuge bowl motors, centrifuge scroll drive, dewatered sludge pumps.
- Disposal – incinerator induced draft fans, combustion air fans, cooling air fans, afterburner turbos, ash pumps.



MALCOLM PIRNIE	NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION MONROE COUNTY DES - FRANK E. VAN LARE WWTF	FIGURE 3-12 DISTRIBUTION OF ELECTRIC USAGE AMONG PROCESSES

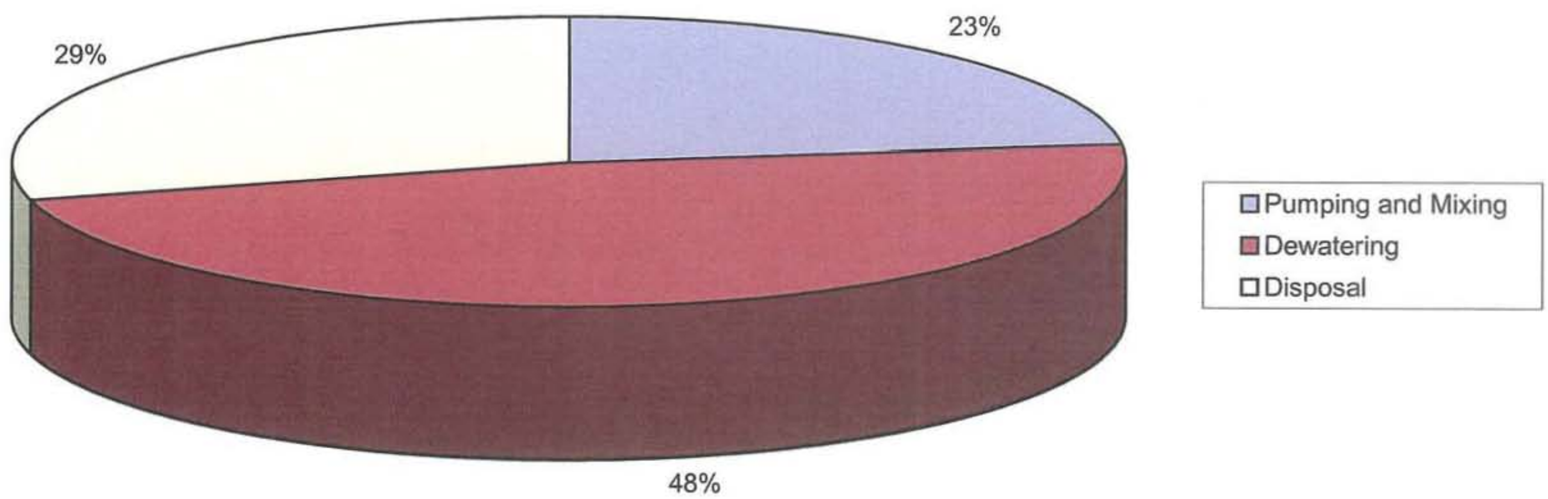


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FIGURE 3-13
DISTRIBUTION OF ELECTRIC USAGE IN SOLIDS HANDLING

Section 4

PROCESS PERFORMANCE DURING SUBMETERING

Process data were collected during the continuous submetering. These data were compared to historical facility data to determine if facility operations and corresponding energy usage during the submetering period could be considered typical for the Frank E. Van Lare (FEV) Wastewater Treatment Facility (WWTF).

4.1 SUMMARY OF PROCESS PERFORMANCE PARAMETER MONITORING

For the duration of the submetering program, the following process performance data were collected:

- Influent wastewater flow.
- Influent, primary effluent, and final effluent biochemical oxygen demand (BOD_5).
- Influent, primary effluent, and final effluent total suspended solids (TSS).
- Influent, primary effluent, and final effluent total kjeldahl nitrogen (TKN).
- Return Sludge (RS) flow, TSS, and volatile suspended solids (VSS).
- Aeration tank dissolved oxygen (DO).

FIGURE 4-1 shows the influent, primary effluent, and final effluent BOD_5 concentrations during the course of the submetering program. The BOD_5 concentrations were measured daily during the submetering program. During the monitoring period, the influent BOD_5 concentrations were at a minimum during a flow peak in early September and the drop in concentration is most likely due to dilution effects. Similarly, there was a peak in concentration during a period of lower flows in early to mid October 2002, which may be explained by FEV's practice of using the tunnels for CSO control as described below. FIGURE 4-2 shows the relationship between BOD_5 loading (in pounds per day) and influent flow to the facility. The tunnel system used for storing combined wastewater during periods of high flow may affect the loading to the plant. Storage during rain events may retain a portion of the typical BOD_5 loading in the tunnel system. Some of the BOD_5 could remain in the tunnels for a period of time and be flushed out at a later date, causing peaks in BOD_5 loadings. This would explain the pattern seen in FIGURE 4-2, which shows a drop in loading after the flow begins to peak and then a spike in loading as the flow drops off. The spike may be the excess BOD_5 being released from the tunnel system.

FIGURES 4-3 and 4-4 show the TSS concentrations and loadings for the influent, primary effluent, and final effluent. TSS concentrations and loadings appear to follow trends similar to the BOD_5 concentrations and loadings.

FIGURES 4-5 and 4-6 show the TKN concentrations and loadings for the influent and facility effluent. TKN concentrations and loadings also appear to follow trends similar to the BOD_5 concentrations and loadings.

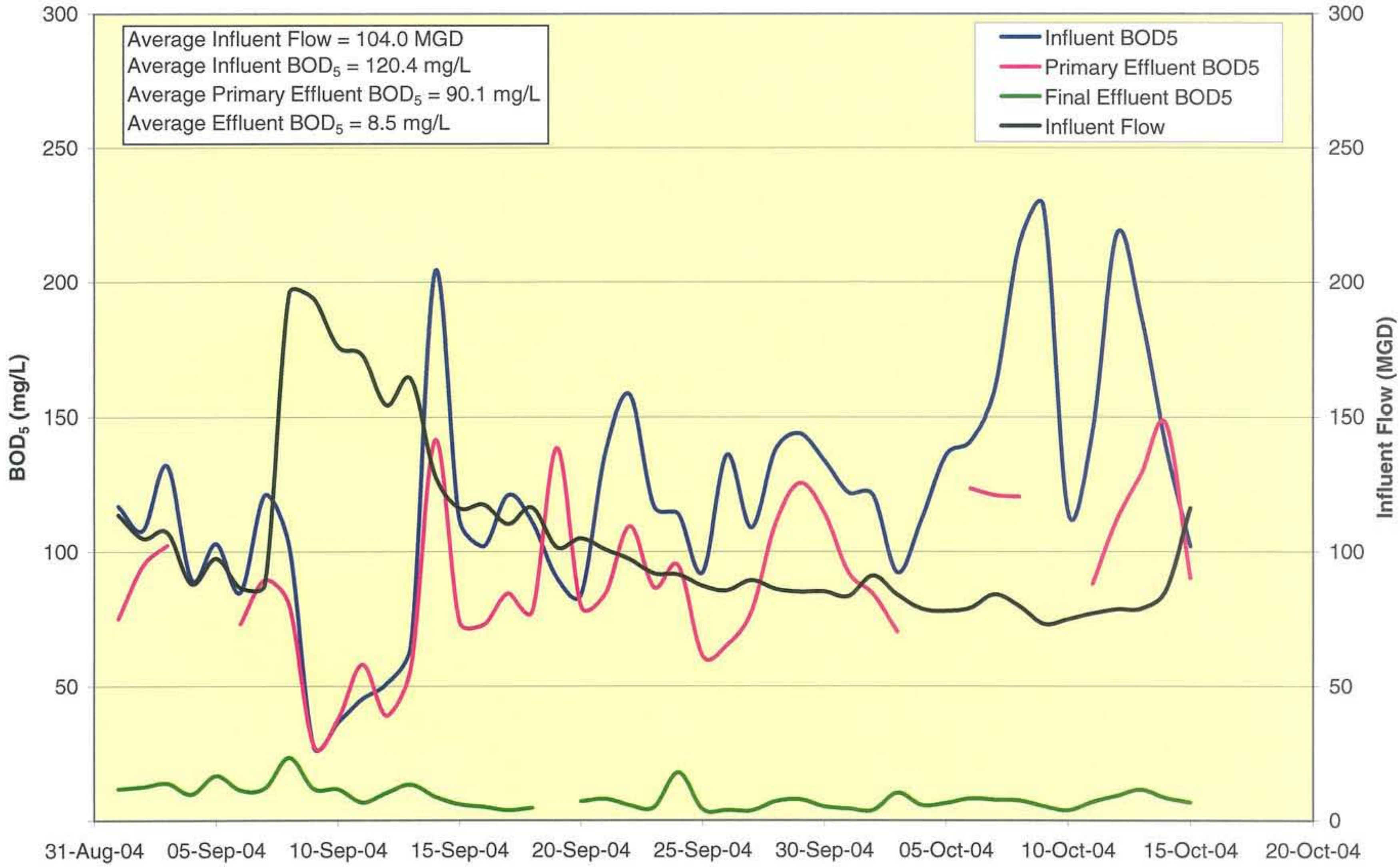

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FIGURE 4-1
SUBMETERING - BOD_5 vs. INFLUENT FLOW

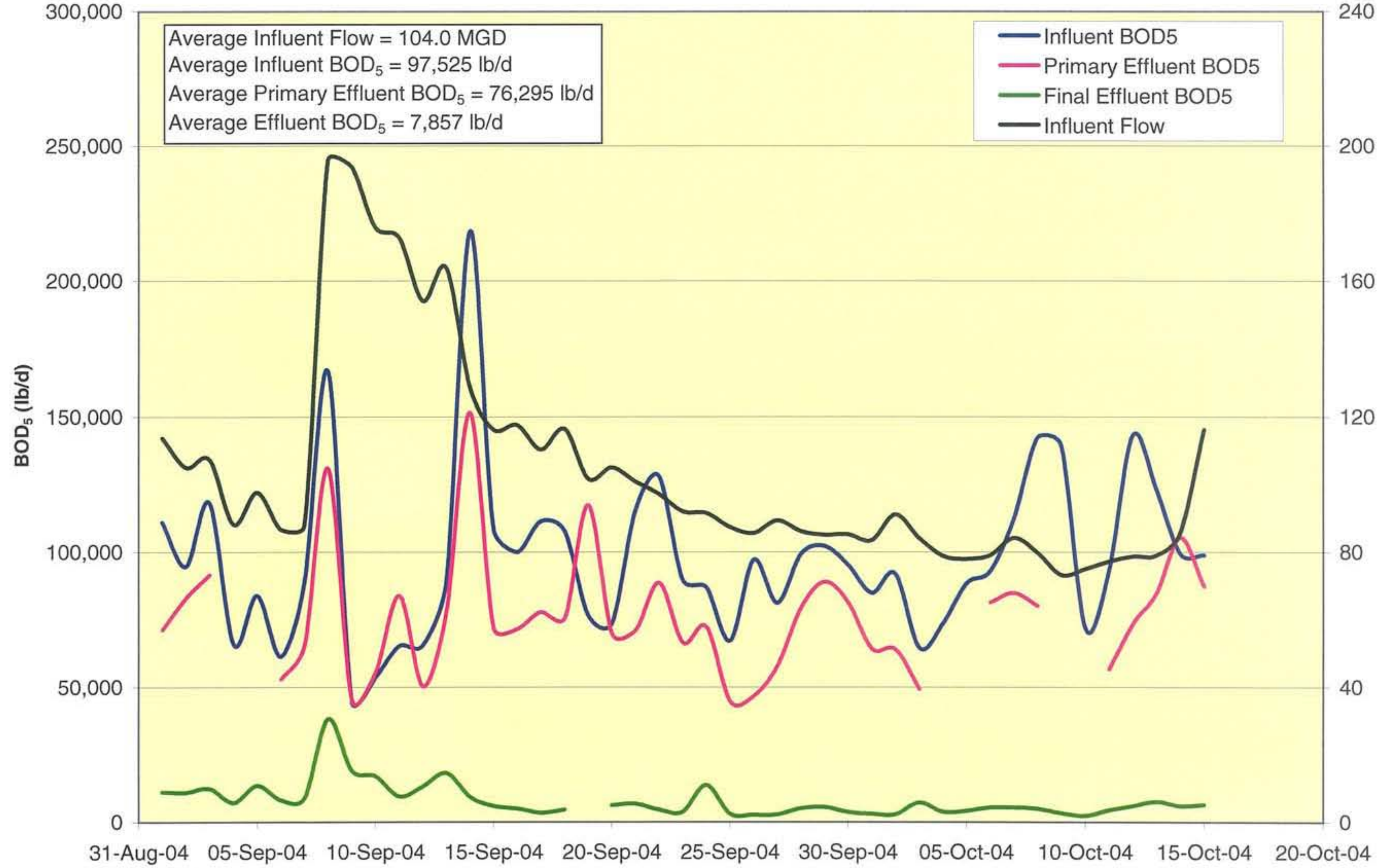

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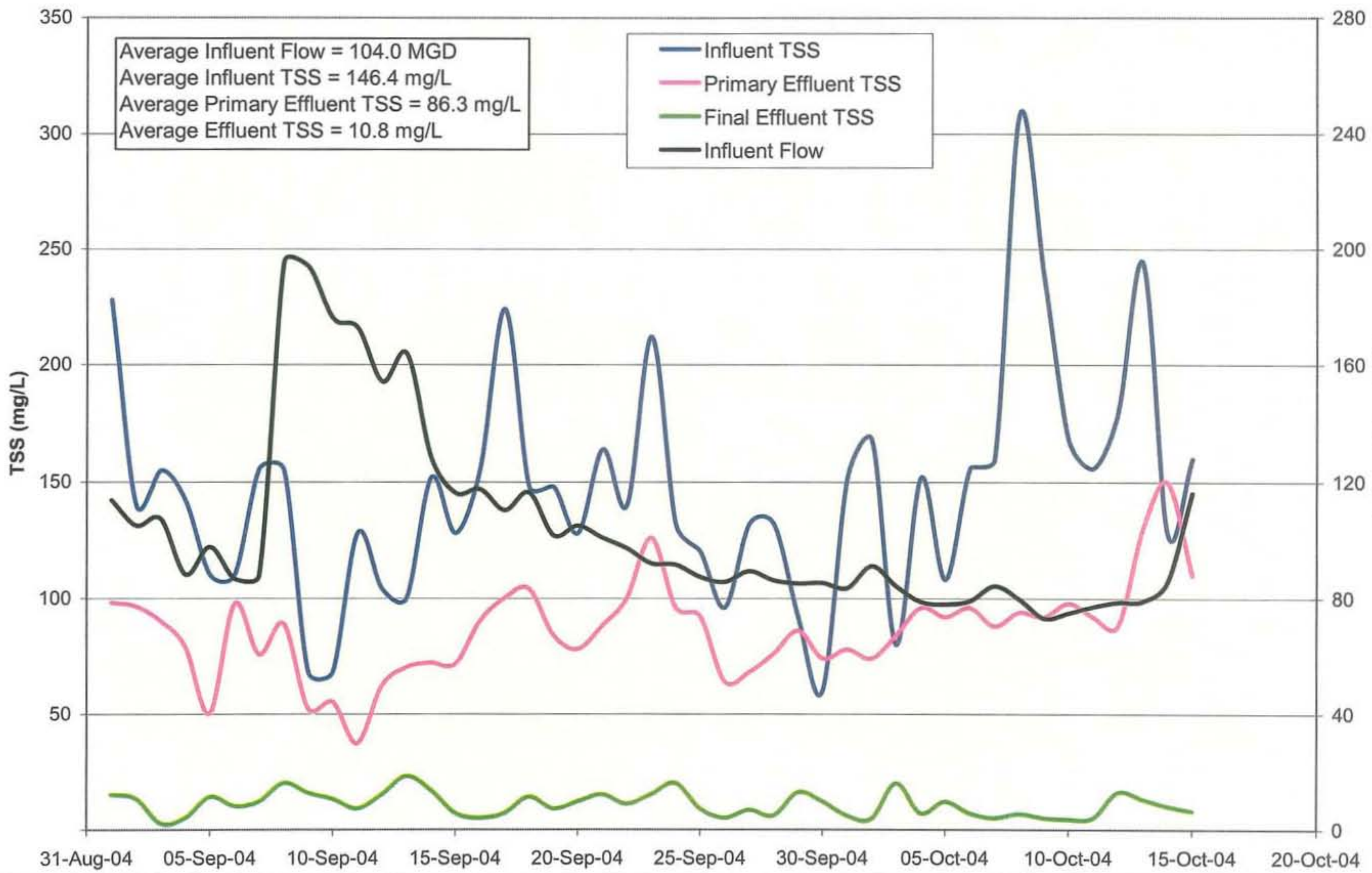
FIGURE 4-2
SUBMETERING - BOD_5 LOADING vs. INFLUENT FLOW



MALCOLM PIRNIE	NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION MONROE COUNTY DES - FRANK E. VAN LARE WWTF	FIGURE 4-3 SUBMETERING - TSS vs. INFLUENT FLOW

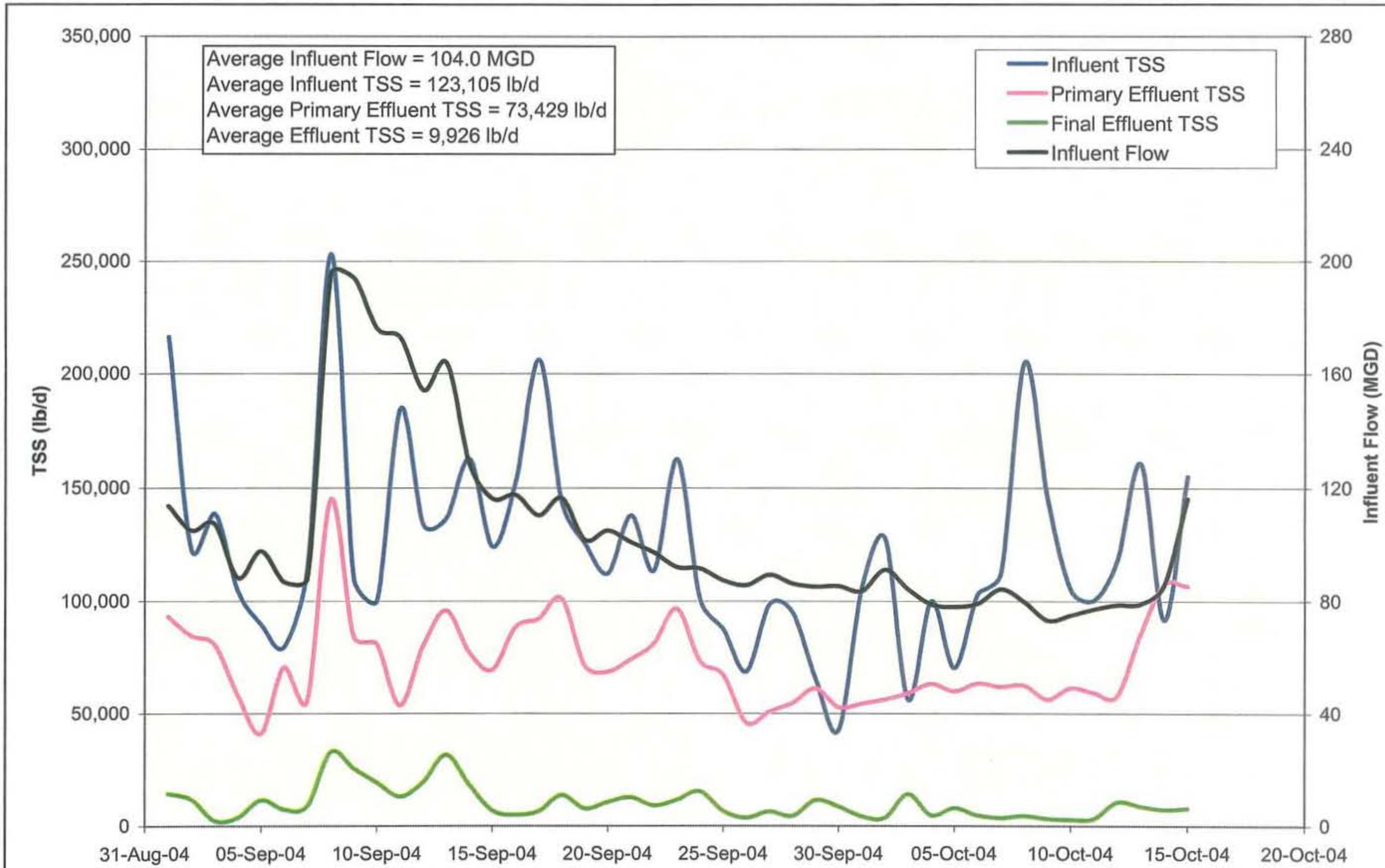


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FIGURE 4-4
SUBMETERING - TSS LOADING vs. INFLUENT FLOW

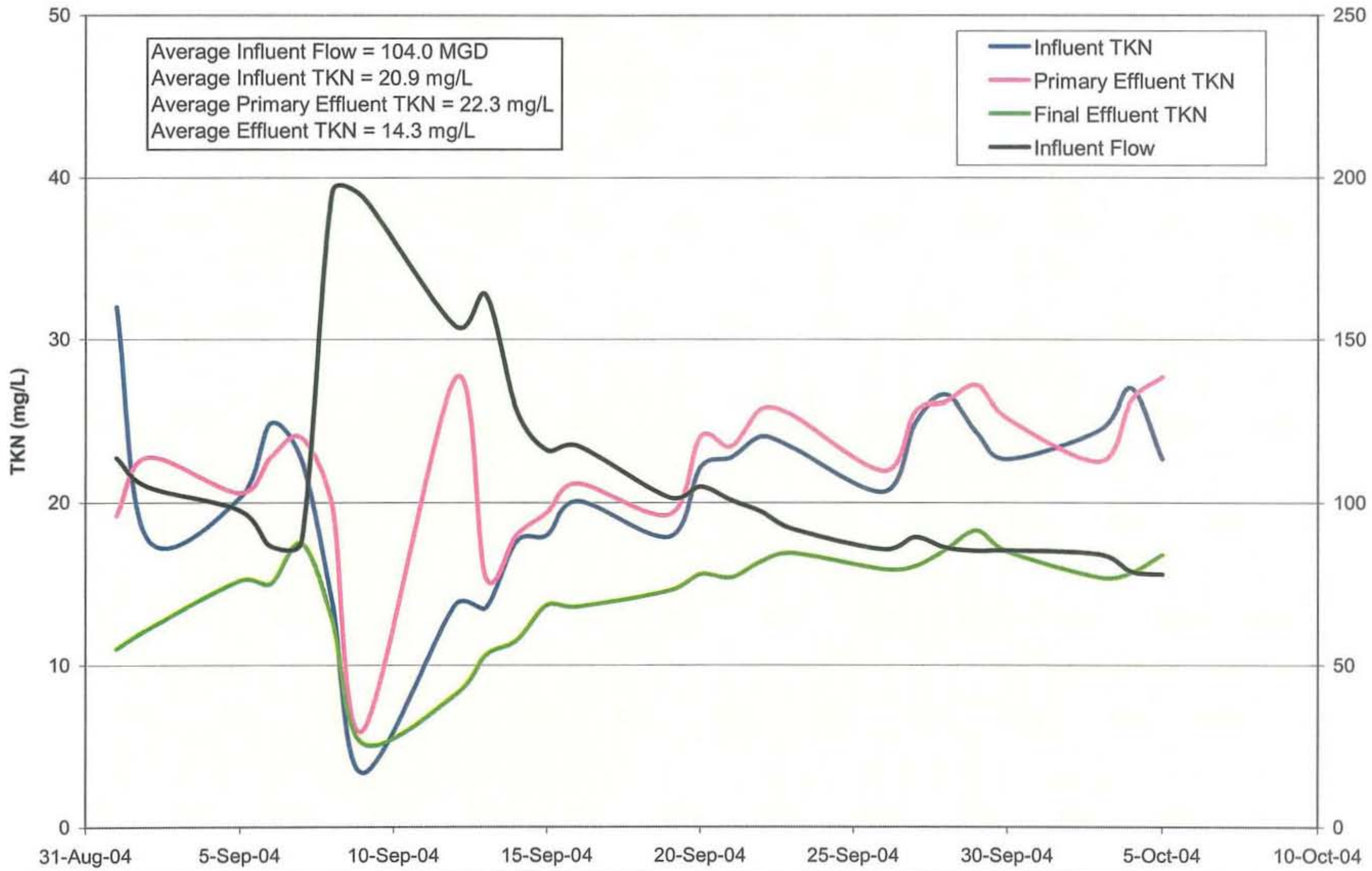

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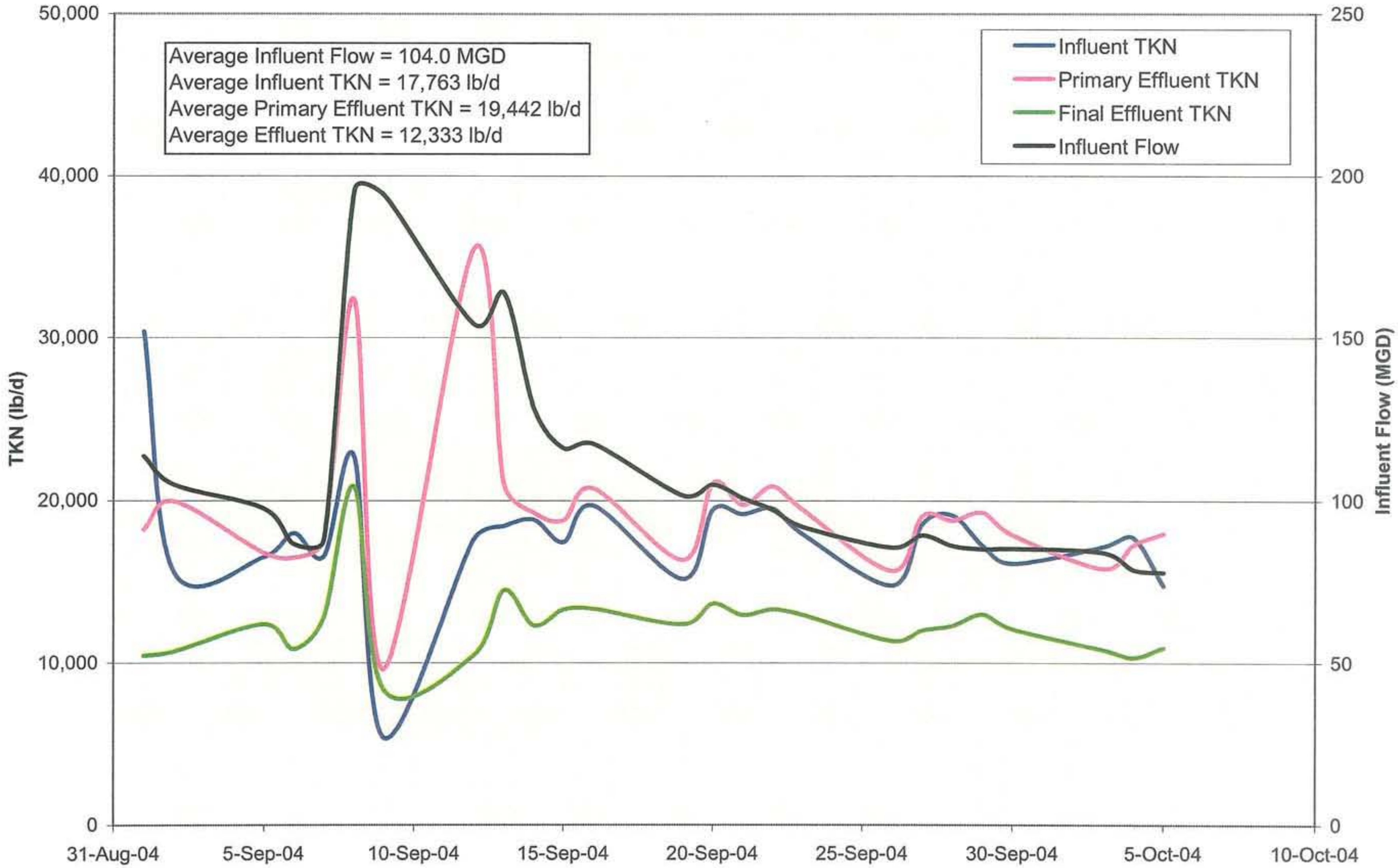
FIGURE 4-5
SUBMETERING - TKN vs. INFLUENT FLOW



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MONROE COUNTY DES - FRANK E. VAN LARE WWTF

FIGURE 4-6
SUBMETERING - TKN LOADING vs. INFLUENT FLOW

The RAS flow rate was maintained at a constant 45 MGD, with a TSS concentration of 4,698 milligrams per liter (mg/L) and a VSS concentration of 3,939 mg/L.

4.2 RELATIONSHIP BETWEEN FACILITY PROCESS DATA AND SUBMETERING DATA

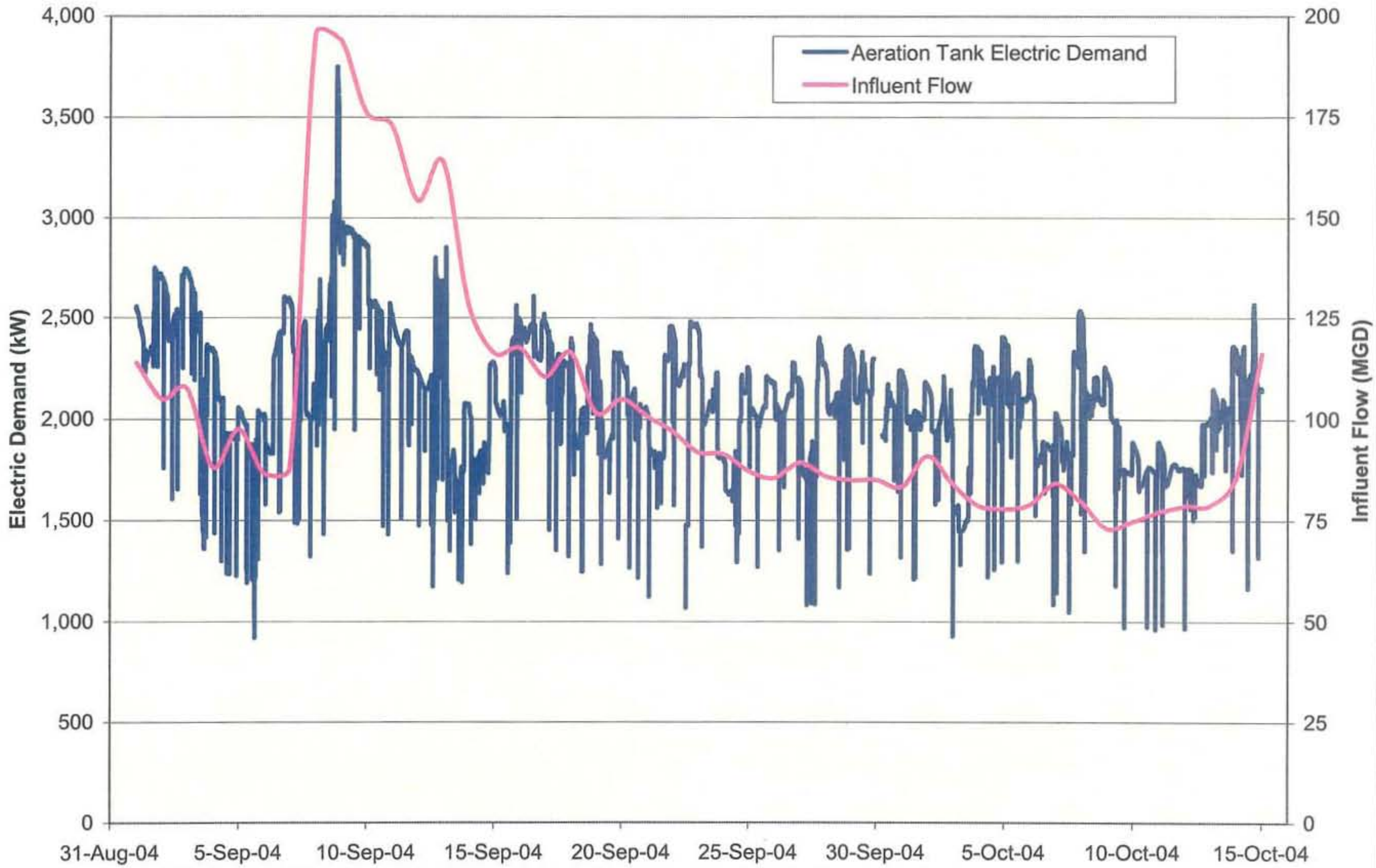
4.2.1 Aeration Tanks

The FEV WWTF has a total of 20 aeration basins, each with three mechanical aerator units. FEV WWTF staff operate between 10 and 16 basins depending on flow and biological loading, both of which vary seasonally. A total of 14 of the 20 aeration basins were in service during the submetering period. Each mechanical aerator is driven by a 150/85 horsepower (hp) motor and has two operating speeds, high and low speed. The number operating and speed of the aerators is manually controlled and is governed by the dissolved oxygen (DO) concentrations within the tanks. When DO concentrations are relatively high, the aerators are either shut off or set to low speed and when the DO drops, the aerators are set to high speed. Due to the high number of units (60) as well as the relatively high horsepower rating, the mechanical aerators are by far the largest users of energy at the FEV WWTF.

FIGURE 4-7 presents the relationship between the aeration system demand and influent wastewater flow. A distinct pattern is shown indicating that the aerator electric energy demand increased in conjunction with peaks in influent flow during the submetering period. As flow increases, the aerators are often operated at higher speeds increasing electric energy usage. The relationship between electric energy demand and DO concentrations in the aeration basins is shown on FIGURE 4-8. In general, the DO concentrations follow the varying electric energy demand levels exerted by the aerators because the more power that is input the more DO is transferred. It should be noted that the DO spiked during the period of high flow in early September, suggesting that excessive aeration was taking place. The peak in electric energy demand may have been exaggerated during the period of high flow.

4.2.2 Process Water Pumps

A total of four 100 hp constant speed pumps supply treated secondary effluent to the process water system, providing 50 pounds per square inch gauge (psig) to 70 psig in water pressure. One of the pumps was out of service during the submetering period, therefore only three pumps were used for the total supply. One of the main demands for process water is the incineration process, specifically the exhaust scrubbers for the incineration system. As shown in Section 2, the electric energy usage decreases significantly on the weekends when the incinerators are not in operation. The total flow averaged 4,886 gpm while the incineration process was in operation and 1,577 gpm when the incineration process was off-line. A summary of the discharge pressure and the corresponding combined flow of all operating pumps are presented on FIGURE 4-9.



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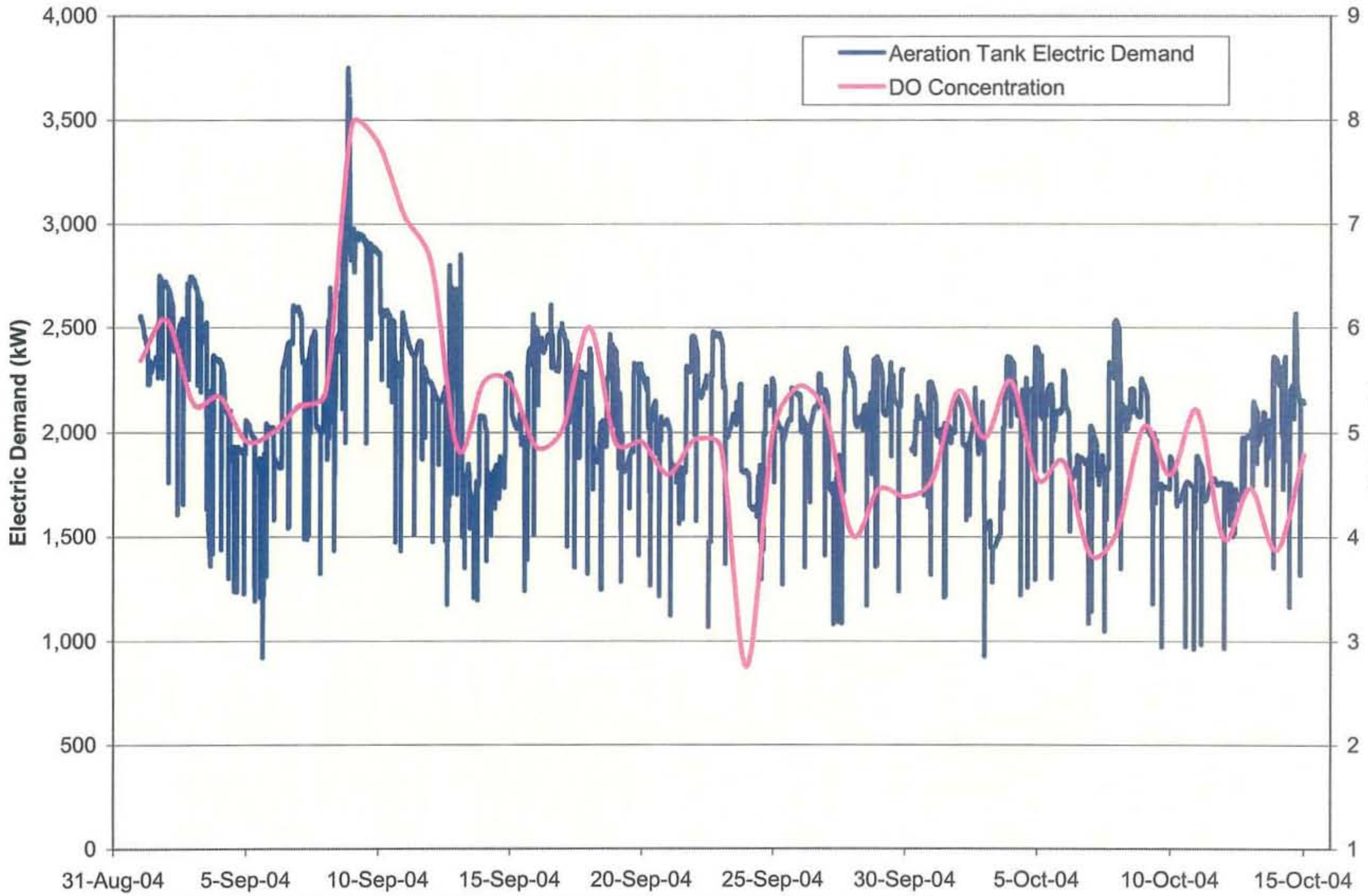
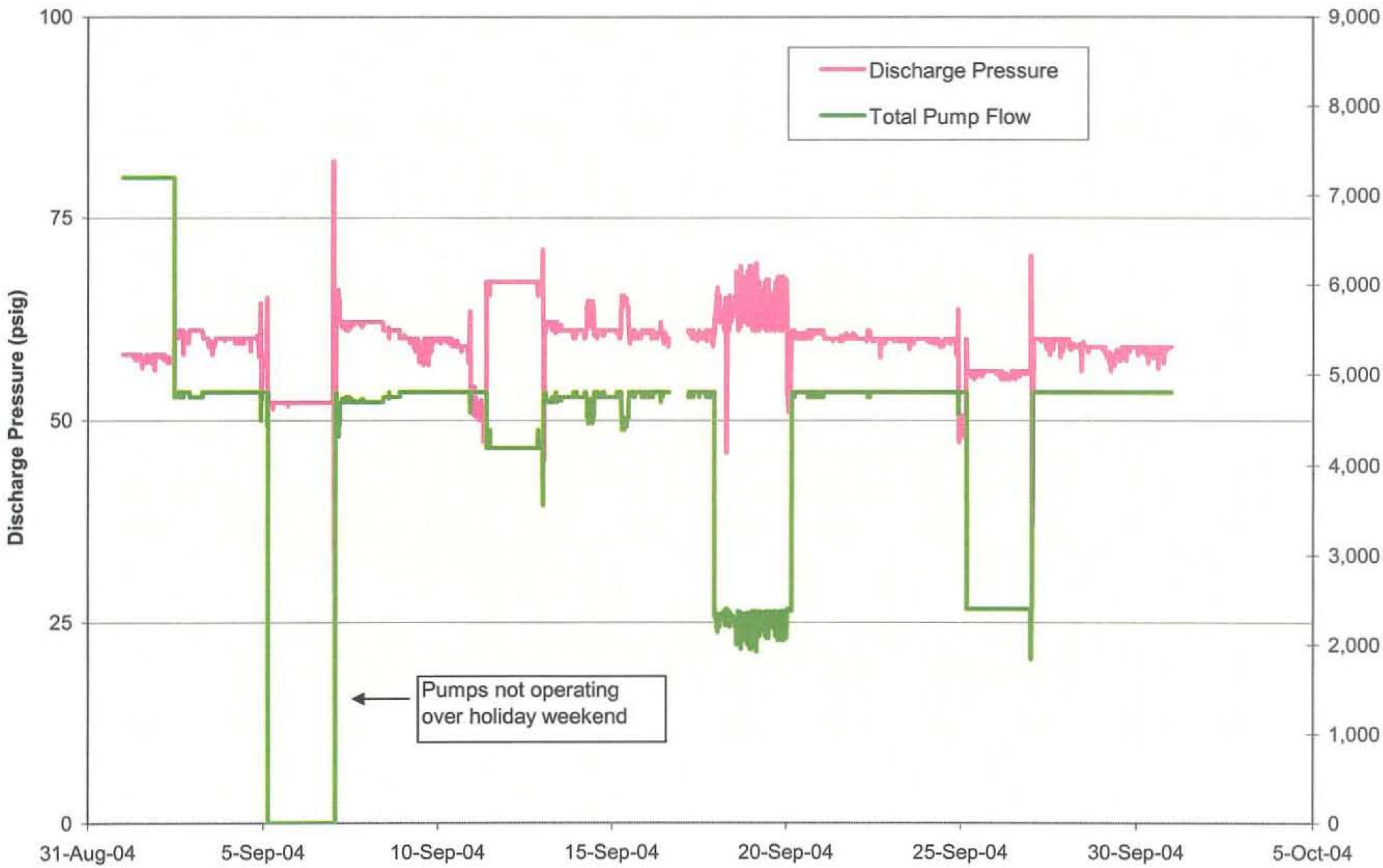
NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION
MONROE COUNTY DES - FRANK E. VAN LARE WWTF

FIGURE 4-7
SUBMETERING - AERATION TANK ELECTRIC DEMAND AND INFLUENT FLOW



MALCOLM PIRNIE	NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION MONROE COUNTY DES - FRANK E. VAN LARE WWTF	FIGURE 4-8 SUBMETERING - AERATION TANK ELECTRIC DEMAND AND DO



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NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION
MONROE COUNTY DES - FRANK E. VAN LARE WWTF

FIGURE 4-9
SUBMETERING - PROCESS WATER PUMPS
DISCHARGE PRESSURE vs. TOTAL FLOW

Submetering data indicates that one pump can meet the process water demand when the incinerators are not in service. It is expected that the incinerators will be off-line for extended periods after the biosolids outload facility is in full operation.

4.2.3 Solids Handling Building

The Solids Handling Building (SHB) processes include the dewatering centrifuges, sludge cake pumps, as well as the incineration process, which includes the following electric energy driven equipment:

- Induced draft fans.
- Combustion air fans.
- Cooling air fans.
- Afterburner drives.
- Ash pumps.
- Water pumps.

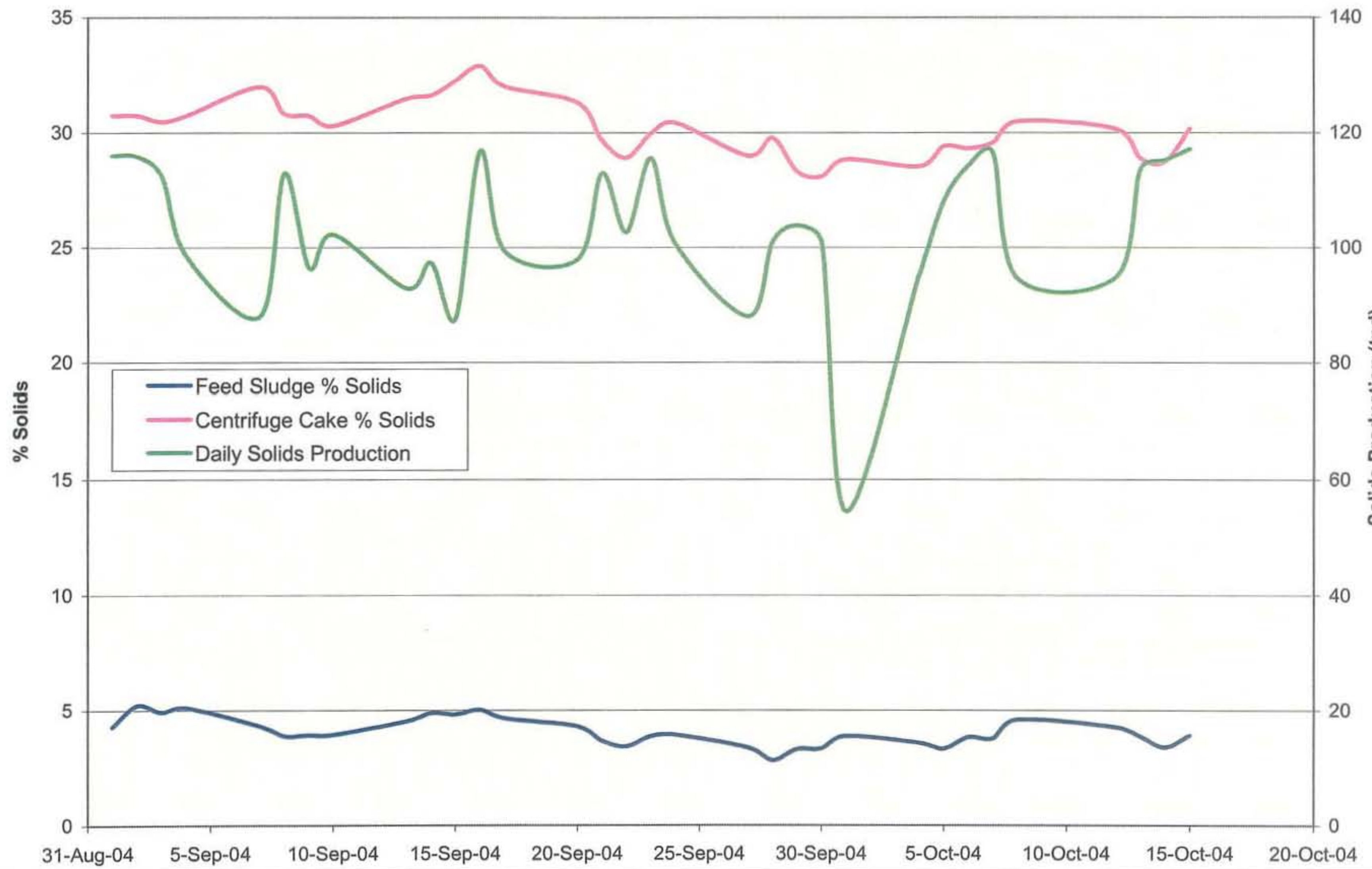
The submetering conducted for the study included all electric energy usage for the building, which would include smaller horsepower motors as well as lighting and other pieces of miscellaneous equipment that would not account for a very large percentage of the total electric energy usage.

The equipment operates for differing amounts of time each week. Most of the equipment is run only during the weekdays, corresponding to approximately 70% of the total time of the week. The combustion air and cooling air fans are operated on a nearly continuous basis. The time of use data obtained from the submetering support the operating time estimates supplied by facility staff.

Sludge production data were collected during the submetering program. FIGURE 4-10 presents the percent solids of the sludge fed to the centrifuges, the percent solids of the sludge cake, as well as the total dewatered sludge production sent to the incinerator. The figure shows that the centrifuges dewater the sludge from an average of 4% solids to an average of nearly 30% solids. Approximately 103 tons per day (tpd) is pumped to the incinerators. The natural gas cost for the incinerators averaged just under $30/dry ton over the course of the submetering period.

4.2.4 Primary Sludge Pumps

The primary sludge pumps are divided into the east and west sets of pumps. There are a total of 12 east pumps and 17 west pumps. At the time of the study, there were six east pumps in operation and 11 west pumps in operation. The pumps are operated on a staggered timing pattern that is set by an operator. The amount of time that each pump



MALCOLM PIRNIE	NYSERDA MUNICIPAL WASTEWATER TREATMENT PLANT ENERGY EVALUATION MONROE COUNTY DES - FRANK E. VAN LARE WWTF	FIGURE 4-10 SUBMETERING - SOLIDS HANDLING DATA

was operated per hour was set and maintained over the course of the submetering period. If a pump was removed from the timing pattern and operated in hand mode, it was noted by the operator. The average amount of time that each pump was operated on an hourly basis is presented below:

- East pumps – 20.5 minutes per hour
- West pumps – 19.6 minutes per hour

Instantaneous electric energy demand measurements were taken for a pump from each set and the total electric energy usage was determined based on the pre-set time of operation.

4.2.5 Return Sludge Pumps

There are a total of 14 return sludge (RS) pumps, eight of which operate on a continuous basis based on influent flow and convey settled sludge from the final settling tanks to the influent end of the aeration tanks. During the submetering period, the pumps conveyed an average flow of 45 MGD to the secondary process, which is typical of year-round facility operation. The total electric energy demand from all the pumps was recorded during the submetering period and is considered representative of typical electric energy usage. The historical TSS average (2002 through 2003) for the return sludge is 4,584 mg/L with an average total VSS average of 4,273 mg/L. The electric energy demand of the RS pumps correlates with influent flows.

4.2.6 Waste Activated Sludge Pumps

There are a total of six WAS pumps that are operated on a timing basis similar to the primary sludge pumps. The pumps are operated approximately 32% of the time, meaning that each hour, they operate 19.2 minutes on average. An instantaneous power draw measurement was taken for one of the WAS pumps and was used with the average time of operation to determine overall electric energy usage.

4.2.7 Thickener Pumps

The thickened sludge pumps are operated for varying amounts of time each day. The time of use and flow rate for each of the eight pumps in operation were recorded as part of the submetering program. The average time of use during the submetering program was 6.3 hours per day, which is just under the estimate of seven hours of daily operation supplied by a facility operator. The average daily flow rate over the submetering period was 476,315 gpd of sludge with 4% solids content.

4.2.8 Return Dilution Pumps

There are two return dilution (RD) pumps that are operated 98% of the time. The rate of dilution water supply to the thickeners varied over the course of the submetering program. The average electric energy usage of the pumps was determined using the continuous submetering results.

4.2.9 Aerated Grit Tank Blower

The aerated grit tank blower is operated on a nearly constant basis. The blower is turned off when the flow exceeds 150 million gallons per day (MGD). Based on facility staff estimates, the blower is off approximately 460 hours per year. The instantaneous electric energy demand measurement and time of use information supplied by an operator allow the determination of annual electric energy usage.

4.2.10 Odor Control Scrubbers

Instantaneous electric energy demand measurements were taken from the main motors of the odor control systems for the sludge thickeners, sludge holding tanks, day tanks, and portions of the SHB. Airflow from the sludge thickeners is treated by two 27,200 cubic feet per minute (cfm) scrubbers and airflow from the sludge holding tanks, day tanks, and SHB is treated by a single 28,900 cfm system. Each scrubber has a 25-hp blower motor and a 15-hp recycle pump motor that operate on a continuous basis.

4.2.11 Other Equipment

Other equipment at the facility includes:

- Lighting.
- Heating, ventilating, and air conditioning (HVAC) equipment.
- Screening motors.
- Grit collectors.
- Grit screw conveyors.
- Polymer pumps.
- Chemical pumps.
- Chemical mixers.
- Sludge grinders.

- Miscellaneous water pumps.
- Electrically automated valves.
- Sample pumps.

For the above mechanical equipment, the small size of the associated motors and/or the low frequency of use have indicated that any further evaluation of the equipment would most likely not yield significant energy-related cost savings.

4.3 SUMMARY OF PROCESS PERFORMANCE

The energy demand measured at the selected equipment was compared to the facility process performance during the monitoring period. Overall, the facility performance was good with both BOD_5 and TSS removal efficiencies averaging 93% (as compared to the 85% removal requirement in the facility's discharge permit). All of the BOD_5 and TSS effluent concentrations and loadings were below the State Pollutant Discharge Elimination System (SPDES) 30-day mean concentration and loading limits. A comparison of average historical wastewater parameters (2002 to 2003) and average submetering values (September 1, 2004 to October 15, 2004) is presented in TABLE 4-1.

Table 4-1: Comparison of Historical and Submetering Wastewater Parameters

Wastewater Parameter	Historical Average (2002 and 2003)	Submetering Average (September 1, 2004 To October 15, 2004)
Influent WWTF Flow	96.0 MGD	104.0 MGD
Influent BOD_5 Concentration	133.6 mg/L	120.4 mg/L
Influent BOD_5 Loading	101,745 lb/day	97,525 ld/day
Average BOD_5 Removal	89%	93%
Influent TSS Concentration	146.3 mg/L	146.4 mg/L
Influent TSS Loading	114,208 lb/day	123,105 lb/d
Average TSS Removal	91%	93%
Influent TKN Concentration	22.4 mg/L	20.9 mg/L
Influent TKN Loading	17,473 lb/day	17,763 lb/d
Average TKN Removal	29%	32%

The table shows that the submetering conditions were very similar to historical conditions.

As previously discussed in Section 3, the aeration process, part of the secondary treatment system, is the largest electric energy consumer at the facility. The electric energy usage is often related to the BOD_5 loading of the influent flow and corresponding oxygen demand.

The second highest electric energy consumers are the return sludge pumps, which are also part of the secondary treatment system. The pumps currently operate at a constant speed and maintain an average flow of 45 MGD.

During the submetering period, the FEV WWTF consumed an average of 82,173 kWh per day, with an average influent flow of 104.0 MGD. The standardized electric consumption of the entire facility, or energy used per MG of wastewater treated, was 790 kWh/MG.

The facility removed an average of 89,668 lb/d BOD_5. The energy used per pound of BOD_5 removed was 0.92 kWh/lb BOD_5.

Section 5

ENERGY SAVINGS MEASURES THROUGH CAPITAL IMPROVEMENTS

5.1 CAPITAL IMPROVEMENT ALTERNATIVES TO REDUCE ENERGY USE

The Monroe County Department of Environmental Services (MCDES) has made a significant effort to reduce energy usage at the Frank E. Van Lare (FEV) Wastewater Treatment Facility (WWTF), as described in Section 2 of this report. However, some additional energy-savings opportunities exist at the facility.

Although the mechanical aerators represent an opportunity for significant electric energy usage savings, the MCDES plans to explore the potential savings in a separate study. Aeration options such as more energy efficient aerators, automated control based on dissolved oxygen (DO), and using high purity oxygen will most likely be evaluated.

The following measures were explored in this study in an effort to further reduce electric energy usage:

- Replacing the existing constant speed process water pumps with new more efficient pumps.
- Installation of variable frequency drives (VFDs) on the process water pump motors to provide automatic pump control based on pressure requirements.
- Replacing the existing domes on the sludge holding tanks and thickeners with flat covers to reduce air flow to odor control systems.
- Replacing the existing primary and return sludge pump motors with new more efficient motors.

5.1.1 Replacement of Existing Process Water Pump Motors with Premium Efficiency Motors

The current motors driving the process water pumps are standard efficiency units manufactured by Reliance Electric. There are currently a total of four 100 hp motors with three operating intermittently and one unit out of service. The National Electrical Manufacturers Association (NEMA) has set forth a specification providing minimum efficiencies that must be met to term a motor "energy efficient" or "premium efficiency". TABLE 5-1 presents standard efficiencies as well as typical premium efficiencies for the 100-hp motors.

Table 5-1: NEMA Efficiency Ratings for Standard and Premium Efficiency Motors – Process Water Pump Motors

Motor Size	Standard Efficiency (Existing Motors)	NEMA Premium Efficiency (Proposed Motors)
100-hp	91.4%	95.4%

Based on the submetering data, a maximum of two pumps are required when the incineration process is off-line, with one pump sufficient for supplying the required amount of process water for the remainder of the facility under most conditions. Once the new biosolids outload facility is fully operational, the incineration process will be used far less frequently. For this reason, it is recommended that only three of the four pump motors be replaced, which will allow two pumps with premium efficiency motors to operate at a given time with one pump on stand-by. For future use, it was assumed that one pump would be operating full-time with a second pump operating 30% of the time.

5.1.2 Installation of Variable Frequency Drives on the Process Water Pump Motors

The process water pumps are currently operated at a constant speed and the number of pumps in operation at a given time is selected by plant operators depending on Facility operations (i.e. incineration). The pumps operate at full speed regardless of the actual water demand with output varying with demand. As water demand decreases, the outlet pressure of the pumps increase, which decreases the total output flow of the pumps.

A common way of controlling water supply from pumps is through the use of a VFD that is linked to a pressure transducer at the pump outlet. A VFD can be set to maintain a constant outlet pressure by varying the speed of the pump motor, and through digital communication, will automatically cycle pumps on and off as required.

5.1.3 Replacement of Existing Covers on the Sludge Thickeners and Holding Tanks

The fiberglass dome covers installed on the Sludge Holding Tanks (2) and Sludge Thickeners (8) are approaching the end of their useful life and may require replacement in the near future. Headspace within these tanks is ventilated and the air is treated in wet scrubbers. Odor control design is often driven by the number of air changes desired for a certain headspace volume. Larger volumes require more air to be drawn from the space and minimizing the headspace volume of the tanks would decrease the required airflow rate for any odor control system. Lower airflow rates would correspond to lower energy demands for the air blower as well as the liquid recycle pumps and less conditioning chemical usage.

Because the covers are approaching the end of their useful life, it may be beneficial to consider the electric energy savings associated with the installation of a flat cover versus a low-profile dome cover for each of the tanks. A flat cover will reduce the headspace volume and associated airflow rate required for odor control.

There are currently three odor control scrubbers in use, two associated with the Sludge Thickeners (four thickeners per scrubber) and one associated with the Sludge Holding Tanks and Day Tanks and to a lesser extent, the Solids Handling Building. The headspace volume associated with each scrubber system was determined based on both dome and flat covers. The current airflow rates were then compared to the estimated airflow rates based on flat covers. A summary of the analysis is presented in TABLE 5-2.

Table 5-2: Odor Control Airflow Rate Comparison

Scrubber System	Dome Cover Headspace (ft^3)	Dome Cover Airflow (cfm)	Flat Cover Headspace (ft^3)	Flat Cover Airflow (cfm)	% Reduction
Sludge Holding	276,520	28,900	186,040	19,400	33%
Thickeners 1-4	215,510	27,200	46,180	5,800	79%
Thickeners 1-8	215,510	27,200	46,180	5,800	79%

The Sludge Holding Tanks are seldom kept full; therefore, the majority of the headspace is within the tank wall area. Reducing the headspace associated with the covers has less of an effect on the Sludge Holding Tanks compared to the Sludge Thickeners. The majority of the headspace associated with the Sludge Thickeners is due to the dome covers; therefore replacement with flat covers will greatly reduce the required airflow for odor control purposes.

5.1.4 Replacement of Existing Primary Sludge Pump Motors with Premium Efficiency Motors

The existing primary sludge pumps are driven by standard efficiency motors. There are currently 29 15-hp primary sludge pump motors, with 11 typically operating at the West Primary Clarifiers, and six typically operating at the East Primary Clarifiers. The primary sludge pumps are operated intermittently. TABLE 5-3 presents standard efficiencies as well as typical premium efficiencies for the pump motors.

Table 5-3: NEMA Efficiency Ratings for Standard and Premium Efficiency Motors – Primary Sludge Pump Motors

Motor Size	Standard Efficiency (Existing Motors)	NEMA Premium Efficiency (Proposed Motors)
15-hp	86.3%	92.4%

As indicated in the table, some energy savings may be obtained by replacing the sludge pump motors.

5.1.5 Replacement of Existing Primary Sludge Pumps (Wet End)

The existing primary sludge pumps are aging and are relatively inefficient. Wet end replacement of the pumps would increase the overall wire-to-water efficiency of the primary sludge pumping process and would reduce electric energy usage. For the purpose of this evaluation, it was assumed that a 15% gain in wire to water efficiency could be realized as compared to current operation.

5.2 ESTIMATE OF ENERGY USE, DEMAND, AND COST SAVINGS

5.2.1 Replacement of Existing Process Water Pump Motors with Premium Efficiency Motors

TABLE 5-4 summarizes the current and future energy use and cost savings associated with upgrading the motors on three of the process water pumps. By replacing the motors with premium efficiency motors, it is estimated that approximately 26,166 kWh of electric energy use will be saved each year, corresponding to an annual cost savings of $1,596.

5.2.2 Installation of Variable Frequency Drives on the Process Water Pump Motors

The electric energy savings were based on weekend operating data, which better approximates the future operating conditions after the biosolids outload facility is brought on-line. Electric energy savings were estimated using the current total dynamic head (TDH) and flow rate as well as the suction pressure, desired discharge pressure and pump efficiency after a VFD is installed. The information used for the calculations is listed below:

- Current Flow Rate - 2,217 gpm
- Current TDH - 139 feet
- Suction Pressure - 4 psi
- Desired Discharge Pressure - 55 psi
- Pump Efficiency - 80%

The electric energy savings correspond to a decrease in motor speed and discharge pressure that could be accomplished by using a VFD.

TABLE 5-5 presents the total annual electric energy usage and cost savings based on the installation and use of VFDs. The savings are based on one pump operating full-time and a second pump operating 30% of the time.

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Municipal Wastewater Treatment Plant Energy Evaluation

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Table 5-4: Replacement of Process Water Pump Motors with Premium Efficiency Motors[1]

Process	Use	MCC Location	Quantity	Size (hp)	Estimated Hours Per Year	Current Motor Operation				Premium Efficiency Motor Operation				Energy Savings	
						Efficiency Rating[2]	Power Draw (kW) per motor	Estimated Annual Usage (kWh)	Estimated Energy Cost[4]	Premium Efficiency Rating[3]	Power Draw (kW) per motor	Annual Energy Usage (kwh)	Estimated Energy Cost[4]	Estimated Annual Usage Savings (kWh)	Estimated Annual Cost Savings[4]
Plant Recycle	Process Water Pumps	Disinfection Building	3	100	11,388	91.4%	54.8	624,062	$ 40,564	95.4%	52.5	597,896	$ 38,863	26,166	$ 1,596
								624,062	$ 40,564			597,896	$ 38,863	26,166	$ 1,596

Notes:
[1] All equipment listed is 3-phase.
[2] Efficiency Rating for Motors based on motor size, using standard efficiencies, for current operation.
[3] Premium efficiency rate obtained from motor manufacturer.
[4] Costs based on average 2004 rate of $0.061/kWh.

Table 5-5: Installation of VFDs on the Process Water Pumps

Equipment	Annual Electric Energy Usage Savings (kWh)	Annual Cost Savings* ($)
Process Water Pumps	108,080	$6,593

* Estimated using $0.061 per kWh, which was the average cost for 2004

5.2.3 Replacement of Existing Covers on the Sludge Thickeners and Holding Tanks

The electric energy savings associated with reducing airflow will be driven by lower electric energy usage by the air blowers and liquid recirculation pumps. The current airflow rates and corresponding electric energy usage were applied to the low profile dome option. All of the scrubbers associated with the odor control process are approaching the end of their useful life; therefore, electric energy usage estimates for the flat cover option are based on fan and pump motors properly sized for the proposed airflows. The actual costs of replacing the fan and pump motors were not included in the analysis.

TABLE 5-6 presents the electric energy usage associated with low profile dome covers compared to the flat cover option for the Sludge Holding Tank scrubber system. Electric energy usage reduction estimates are based on the 33% reduction in total airflow to the system.

Table 5-6: Sludge Holding Tanks Scrubber Cover Options

Motor	Annual Electric Energy Usage (kWh)	Annual Cost* ($)
Low Profile Dome Option		
Fan Motor	93,475	$5,702
Recirculation Pump Motor	77,964	$4,756
Flat Cover Option		
Fan Motor	62,927	$3,839
Recirculation Pump Motor	52,485	$3,202
Total Savings	**56,026**	**$3,418**

* Estimated using $0.061 per kWh, which was the average cost for 2004

The reduction in airflow would allow the installation of a 20-hp fan motor and a 10-hp recirculation pump motor, which would replace, respectively, the 25-hp and 15-hp motors already in place.

The airflow reduction associated with the installation of flat covers on the thickeners is much greater than that for the sludge holding tank. The reduction in airflow would allow the 54,400 cfm currently treated by two scrubbers to be combined and treated in a single 11,700 cfm system. TABLE 5-7 presents the electric energy usage associated with low profile dome covers compared to the flat cover option for the thickeners scrubber system.

Table 5-7: Thickeners Scrubber Cover Options

Motor	Annual Electric Energy Usage (kWh)	Annual Cost* ($)
Low Profile Dome Option		
Fan Motor	193,939	$11,830
Recirculation Pump Motor	133,852	$8,165
Flat Cover Option		
Fan Motor	20,364	$1,242
Recirculation Pump Motor	14,054	$857
Total Savings	**293,373**	**$17,896**

* Estimated using $0.061 per kWh, which was the average cost for 2004

The reduction in airflow would allow the installation of a 15-hp fan motor and a 10-hp recirculation pump motor, which would replace the two 25-hp and two 15-hp motors already in place.

5.2.4 Replacement of Existing Primary Sludge Pump Motors with Premium Efficiency Motors

TABLE 5-8 summarizes the current and future electric energy usage and cost savings associated with upgrading the motors on the primary sludge pumps. By replacing the primary sludge pump motors with premium efficiency motors, it is estimated that approximately 12,627 kWh of electric energy usage will be saved each year, corresponding to an annual cost savings of $770. Although there are a good number of pumps that operate, the relatively small motor size and the intermittent operation limit the amount of electric energy that can be saved.

5.2.5 Replacement of Existing Primary Sludge Pumps (Wet End)

TABLE 5-9 summarizes the current and future electric energy usage and cost savings associated with upgrading the wet end of the primary sludge pumps. By replacing the primary sludge pumps with newer, more efficient units, it is estimated that wire-to-water efficiency can be increased by 15%. A total of 28,690 kWh of electric energy usage would be saved each year, corresponding to an annual cost savings of $1,750.

Table 5-8: Replacement of Primary Sludge Pump Motors with Premium Efficiency Motors[1]

Process	Use	MCC Location	Quantity	Size (hp)	Estimated Hours Per Year	Current Motor Operation				Premium Efficiency Motor Operation				Energy Savings	
						Efficiency Rating[2]	Power Draw (kW) per motor	Estimated Annual Usage (kWh)	Estimated Energy Cost[4]	Premium Efficiency Rating[3]	Power Draw (kW) per motor	Annual Energy Usage (kwh)	Estimated Energy Cost[4]	Estimated Annual Usage Savings (kWh)	Estimated Annual Cost Savings[4]
Solids Handling, Sludge Pumping	West Primary Sludge Pumps	Primary Buildings	11	15	30,750	86.3%	3.5	107,625	$ 6,565	92.4%	3.3	100,520	$ 6,132	7,105	$ 433
Solids Handling, Sludge Pumping	East Primary Sludge Pumps	Primary Buildings	6	15	16,796	86.3%	4.98	83,644	$ 5,102	92.4%	4.7	78,122	$ 4,765	5,522	$ 337
								191,269	$ 11,667			178,642	$ 10,897	12,627	$ 770

Notes:
[1] All equipment listed is 3-phase.
[2] Efficiency Rating for Motors based on motor size, using standard efficiencies, for current operation.
[3] Premium efficiency rate obtained from motor manufacturer.
[4] Costs based on average 2004 rate of $0.061/kWh.

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Table 5-9: Replacement of Primary Sludge Pumps (Wet End)

					Current Operation			New Pump Operation				Energy Savings	
Process	Use	MCC Location	Quantity	Estimated Hours Per Year	Power Draw (kW) per motor	Estimated Annual Usage (kWh)	Estimated Energy Cost[1]	Wire-to-Water Efficiency Gain	Power Draw (kW) per motor	Annual Energy Usage (kwh)	Estimated Energy Cost[1]	Estimated Annual Usage Savings (kWh)	Estimated Annual Cost Savings[1]
Solids Handling, Sludge Pumping	West Primary Sludge Pumps	Primary Buildings	11	30,750	3.5	107,625	$ 6,565	15.0%	3.0	91,481	$ 5,580	16,144	$ 985
Solids Handling, Sludge Pumping	East Primary Sludge Pumps	Primary Buildings	6	16,796	4.98	83,644	$ 5,102	15.0%	4.2	71,097	$ 4,337	12,547	$ 765
						191,269	**$ 11,667**			**162,579**	**$ 9,917**	**28,690**	**$ 1,750**

Notes:
[1] Costs based on average 2004 rate of $0.061/kWh.

5.3 ESTIMATE OF CAPITAL COST AND SIMPLE PAYBACK

5.3.1 Replacement of Existing Process Water Pump Motors with Premium Efficiency Motors

TABLE 5-10 presents the capital cost associated with replacing the process water pump motors listed in TABLE 5-2 with premium efficiency units. The probable cost to change out the existing motors is approximately $37,000, which results in an estimated payback of 23.2 years.

5.3.2 Installation of Variable Frequency Drives on the Process Water Pump Motors

TABLE 5-11 presents the capital cost associated the installation of VFD controllers on three of the current process water pumps. The probable cost to install the VFDs is approximately $74,100, which results in an estimated payback of 11.2 years.

5.3.3 Replacement of Existing Covers on the Sludge Thickeners and Holding Tanks

The existing covers are approaching the end of their useful life and will need to be replaced in the near future. Capital costs were estimated for both low profile dome covers and flat covers. Low profile dome covers would be replacement in-kind, while the flat covers would require mid-span supports. TABLES 5-12 and 5-13 present the costs of each option for the Sludge Holding Tanks. The payback for flat covers will be based on the difference in cost of the in-kind replacement with low profile dome covers and replacement with flat covers. This assumes that the covers are at the end of their useful life and will be replaced in the near future. The total in-kind replacement cost for the Sludge Holding Tank covers is estimated at $536,050, with a flat cover replacement cost of $659,390, yielding a difference of $123,340. The payback on the difference in replacement costs is estimated to be 36.1 years.

TABLES 5-14 and 5-15 present the costs of each cover option for the Sludge Thickeners. The total in-kind replacement cost for the Sludge Thickener covers is estimated at $1,815,280, with a flat cover replacement cost of $2,144,180, yielding a difference of $328,900. The payback on the difference in replacement costs is estimated to be 18.4 years. The payback in this analysis is based on electric energy usage only. The analysis assumes that the scrubbers associated with the thickeners will be replaced in the near future. Flat covers would eliminate the capital cost of one complete scrubber system and the installed scrubber would be significantly smaller than the current systems. It may be beneficial to take these savings into consideration for further evaluation of the flat cover option in the future. Further consideration would also have to be given to the maintenance of the Sludge Thickeners. Flat covers would make floatable removal and weir clean out more difficult for plant staff.

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Table 5-10: Capital Costs of Replacing Process Water Pump Motors with Premium Efficiency Motors

Process	Use	MCC Location	Quantity	Size (hp)	Costs				
					Materials		Labor		Total
					Unit	Total	Unit	Total	
1. Equipment									
Plant Recycle Pump Motors	Process Water Pumps	Disinfection Building	3	100	$ 6,000	$ 18,000	$ 1,800	$ 5,400	$ 23,400
Equipment Subtotal						**$ 18,000**		**$ 5,400**	**$ 23,400**
2. Electrical and Instrumentation (25% of Total Equipment Costs)									**$ 5,850**
Subtotal of Equipment, Electrical, and Instrumentation									**$ 29,250**
3. Contractor Overhead and Profit (15%)									**$ 4,390**
Subtotal									**$ 33,640**
4. Miscellaneous (10%)									**$ 3,360**
Total									***$ 37,000***

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Table 5-11: Installation of VFDs on Process Water Pump Motors for Flow Control

Process	Quan-tity	Costs				
		Materials		Labor		Total
		Unit	Total	Unit	Total	
VFD Equipment	3	$ 10,900	$ 32,700	$ 3,300	$ 9,900	$ 42,600
Miscellaneous Electrical Work (10%)	1				$ 4,260	$ 4,260
Subtotal			**$ 32,700**		**$ 14,160**	**$ 46,860**
Contractor Overhead and Profit (15%)						**$ 7,030**
Subtotal						**$ 53,890**
Contingency (10%)						**$ 5,390**
Engineering, Legal, & Admin (25%)						**$ 14,820**
Total						***$ 74,100***

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Table 5-12: Replacement of Sludge Holding Tank Covers In Kind

Process	Quan-tity	Costs				
		Materials		Labor		Total
		Unit	Total	Unit	Total	
Demolition	2	NA	NA	$ 20,000	$ 40,000	$ 40,000
Low Profile Fiberglass Dome Covers	2	$ 115,000	$ 230,000	$ 34,500	$ 69,000	$ 299,000
Subtotal			**$ 230,000**		**$ 109,000**	**$ 339,000**
Contractor Overhead and Profit (15%)						**$ 50,850**
Subtotal						**$ 389,850**
Contingency (10%)						**$ 38,990**
Engineering, Legal, & Admin (25%)						**$ 107,210**
Total						***$ 536,050***

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Table 5-13: Replacement of Sludge Holding Tank Covers with Flat Covers

Process	Quantity	Costs: Materials Unit	Materials Total	Labor Unit	Labor Total	Total
Demolition	2	NA	NA	$ 20,000	$ 40,000	$ 40,000
Midspan Supports	2	$ 20,000	$ 40,000	$ 6,000	$ 12,000	$ 52,000
Flat Fiberglass Covers	2	$ 125,000	$ 250,000	$ 37,500	$ 75,000	$ 325,000
Subtotal			**$ 290,000**		**$ 127,000**	**$ 417,000**
Contractor Overhead and Profit (15%)						**$ 62,550**
Subtotal						**$ 479,550**
Contingency (10%)						**$ 47,960**
Engineering, Legal, & Admin (25%)						**$ 131,880**
Total						***$ 659,390***

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Table 5-14: Replacement of Sludge Thickener Tank Covers In Kind

Process	Quantity	Costs				
		Materials		Labor		Total
		Unit	Total	Unit	Total	
Demolition	8	NA	NA	$ 20,000	$ 160,000	$ 160,000
Low Profile Fiberglass Dome Covers	8	$ 95,000	$ 760,000	$ 28,500	$ 228,000	$ 988,000
Subtotal			**$ 760,000**		**$ 388,000**	**$ 1,148,000**
Contractor Overhead and Profit (15%)						**$ 172,200**
Subtotal						**$ 1,320,200**
Contingency (10%)						**$ 132,020**
Engineering, Legal, & Admin (25%)						**$ 363,060**
Total						***$ 1,815,280***

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Table 5-15: Replacement of Sludge Thickener Tank Covers with Flat Covers

Process	Quantity	Costs: Materials Unit	Materials Total	Labor Unit	Labor Total	Total
Demolition	8	NA	NA	$ 20,000	$ 160,000	$ 160,000
Midspan Support Modification	8	$ 10,000	$ 80,000	$ 3,000	$ 24,000	$ 104,000
Flat Fiberglass Covers	8	$ 105,000	$ 840,000	$ 31,500	$ 252,000	$ 1,092,000
Subtotal			**$ 920,000**		**$ 436,000**	**$ 1,356,000**
Contractor Overhead and Profit (15%)						**$ 203,400**
Subtotal						**$ 1,559,400**
Contingency (10%)						**$ 155,940**
Engineering, Legal, & Admin (25%)						**$ 428,840**
Total						***$ 2,144,180***

5.3.4 Replacement of Existing Sludge Pump Motors with Premium Efficiency Motors

TABLE 5-16 presents the capital cost associated with replacing the primary sludge pump motors listed in TABLE 5-8 with premium efficiency units. The probable cost to change out all of the existing primary sludge pump motors is approximately $78,420, which results in an estimated payback of 101.8 years.

5.3.5 Replacement of Existing Primary Sludge Pumps (Wet End)

TABLE 5-17 presents the capital cost associated with replacing the wet end of the primary sludge pumps with new, more efficient units, and also includes the cost of basic piping modifications. The probable cost to change out all of the existing primary sludge pumps is approximately $862,100, which results in an estimated payback of 492.6 years. Although the payback is exceptionally long, many of the pumps will require replacement in the near term for operational purposes.

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Table 5-16: Capital Costs of Replacing Primary Sludge Pump Motors with Premium Efficiency Motors

Process	Use	MCC Location	Quantity	Size (hp)	Costs: Materials Unit	Materials Total	Labor Unit	Labor Total	Total
1. Equipment									
Primary Sludge Pump Motors	Primary Sludge Pumps	Disinfection Building	29	15	$ 1,310	$ 37,990	$ 400	$ 11,600	$ 49,590
				Equipment Subtotal		$ 37,990		$ 11,600	$ 49,590
2. Electrical and Instrumentation (25% of Total Equipment Costs)									$ 12,400
				Subtotal of Equipment, Electrical, and Instrumentation					$ 61,990
3. Contractor Overhead and Profit (15%)									$ 9,300
				Subtotal					$ 71,290
4. Miscellaneous (10%)									$ 7,130
				Total					***$ 78,420***

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Table 5-17: Capital Costs of Replacing Primary Sludge Pumps (Wet End)

Process	Use	Quantity	Costs				
			Materials		Labor		Total
			Unit	Total	Unit	Total	
1. Equipment							
Primary Sludge Pumps	Primary Sludge Pumping	29	$ 12,000	$ 348,000	$ 3,600	$ 104,400	$ 452,400
Piping Modifications	Sludge Conveyance	29	$ 1,000	$ 29,000	$ 3,000	$ 87,000	$ 116,000
Equipment Subtotal				$ 377,000		$ 191,400	$ 568,400
2. Electrical and Instrumentation (25% of Pump Equipment Costs (Excluding Piping)							$ 113,100
Subtotal of Equipment, Electrical, and Instrumentation							$ 681,500
3. Contractor Overhead and Profit (15%)							$ 102,230
Subtotal							$ 783,730
4. Miscellaneous (10%)							$ 78,370
Total							***$ 862,100***

Section 6
ENERGY SAVING MEASURES THROUGH OPERTATION MODIFICATIONS

6.1 OPERATION MODIFICATIONS TO REDUCE ENERGY USAGE

Typically, major operational changes that can be made to reduce energy usage are load shifting, peak shaving, and greater use of real-time data in energy-related decision making. Load shifting is the practice of changing the time of use of certain loads to reduce the total facility energy demand during peak demand periods. Peak shaving is the practice of dispatching on-site generating assets to reduce dependence on the grid during peak demand periods. The increased use of real-time data by the installation of permanent submeters and the monitoring of significant energy-using equipment can assist the facility in making informed decisions regarding energy usage and offer alternatives to reduce energy usage.

At the same time, automatic control of the aerators based on dissolved oxygen (DO) may provide a better control tool and should be considered as part of the aerator study.

6.1.1 Load Shifting

Total facility electric energy demand was recorded during the submetering period at the Frank E. Van Lare (FEV) Wastewater Treatment Facility (WWTF). FIGURE 6-1 presents the electric energy demand curves for the total facility and the mechanical aerators for September 8, 2004. The figure shows that there is a 25% fluctuation in total facility electric energy demand throughout the day. The overall electric energy demand of the aerators varies by 30% and is driven by maintaining a target dissolved oxygen (DO) level of the aeration tanks, which is influenced by a number of factors including diurnal variations in the influent flow rate and biochemical oxygen demand (BOD_5) loading. None of these driving factors can be controlled by FEV WWTF staff.

It should be noted that the FEV WWTF staff currently conducts load shifting in association with the Cross Irondequoit Bay Pump Station (CIPS) and the mechanical aerators. In preparation for the starting of a main pump at the CIPS facility, which could draw up to 1,000 kW of electric energy demand, FEV WWTF staff will temporarily shut down, or reduce the speed of several mechanical aerators in order to reduce the overall electric energy demand and associated charges.

The remainder of the facility [excluding the Solids Handling Building (SHB)] must be operated on a 24 hours per day, seven days per week schedule, it is unlikely that any substantial opportunities for load shifting would be available within the facility.

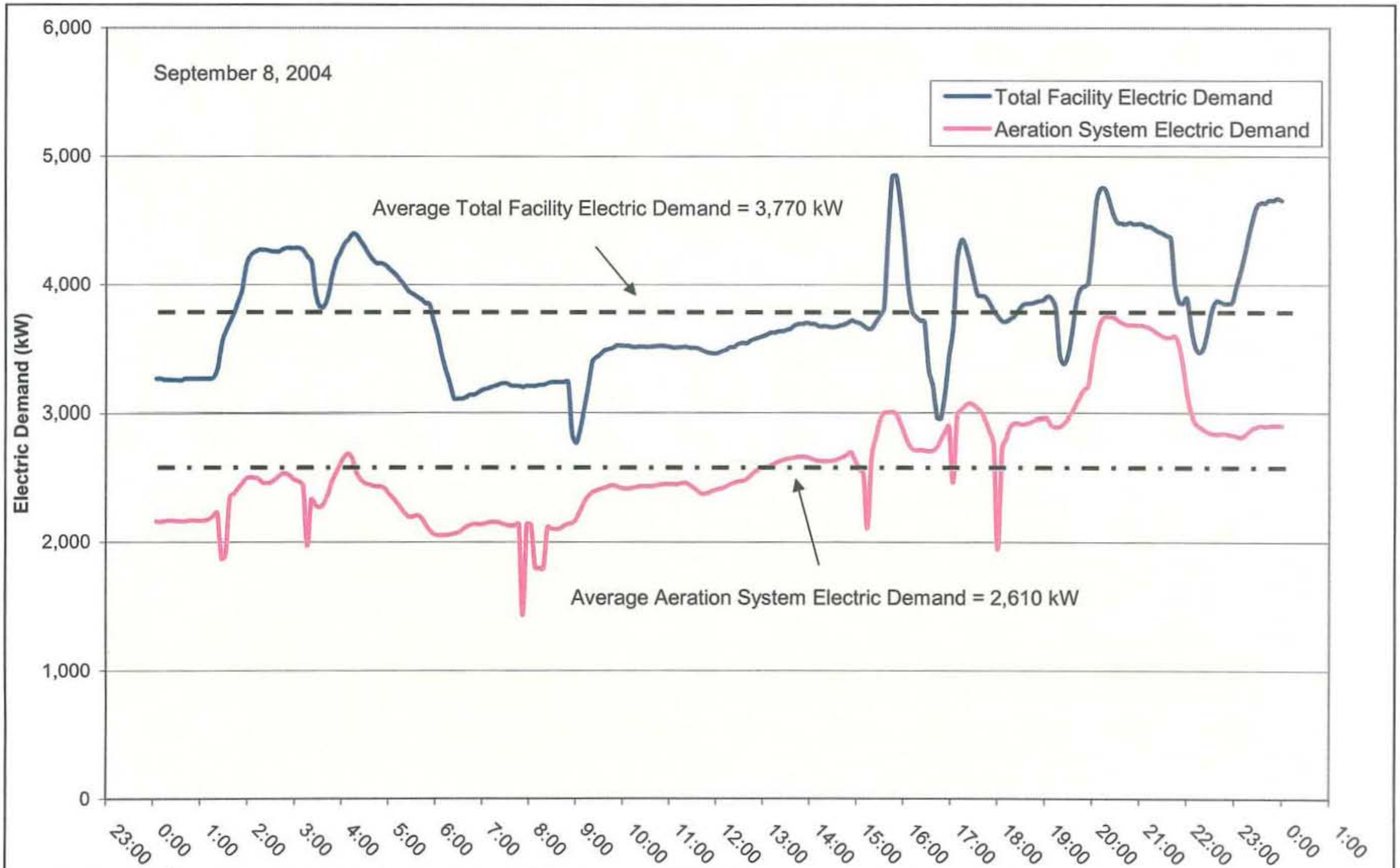

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FIGURE 6-1
TOTAL FACILITY AND AERATION SYSTEM HOURLY ELECTRIC DEMAND

6.1.2 Peak Shaving

Peak shaving refers to the practice of reducing demand during peak demand periods by using on-site generation capabilities to offset the "peak" electric energy usage and even out the electric energy demand over a day.

Currently, the FEV WWTF does not have any permanent on-site generating capacity; therefore peak shaving opportunities do not exist at this facility.

6.1.3 Real-time Energy Usage Data

As mentioned in Section 3, a total of 18 submeters are permanently installed throughout the FEV WWTF. The submeters are installed on main feeders or in Motor Control Centers and monitor the following locations:

- Two submeters on the main electrical feeds to the WWTF – one meter for each feed (Russel and Norton).
- Two submeters on the feeds to the CIPS facility – one meter for each feed.
- Four submeters for the aeration process – one meter per circuit.
- Two submeters for the Solids Handling Building – one meter per circuit.
- Four submeters for the recirculation pumps – one meter for the Return Dilution (RD) pumps, one meter for the Return Effluent (RE) pumps, and two meters for the Return Sludge (RS) pumps.
- One submeter for the Odor Abatement Building.
- One submeter for the Day Tanks.
- Two submeters for the gravity sludge thickeners – one meter for the North Thickeners and one meter for the South Thickeners.

All of the submetered information is monitored on a real-time basis by the facility-wide supervisory control and data acquisition (SCADA) system. The SCADA system is based on the commercially available software CITECT. The following electric energy information is available on a facility-wide basis:

- Total facility electric energy usage.
- Total facility electric energy demand.
- Projected total facility electric energy demand.
- Total facility electric energy demand for a specific date and time.

Pop-up windows can also be opened to view the electric energy demand trends for each of the 18 submeters.

Electric energy information is also available through the County intranet site where instantaneous meter readings can be viewed. Summaries of electric energy information can be viewed through Crystal reports.

Real-time electric energy information is readily available at the FEV WWTF. The information is currently used to make process decisions regarding the coordination of equipment start-up and utilization. Although energy-savings associated with real-time submetering and control cannot be readily quantified, FEV facility staff states that this system is an important tool for facility operations and day-to-day decision making.

6.1.4 Sludge Pumping Practices

At the time the initial scope for this project was developed, primary and thickened sludge was pumped on an inconsistent basis and there was an opportunity to formalize the process and reduce electric energy demand and usage. Recently, a structured pumping schedule has been implemented to better control the operation of the sludge pumps and the pumps are now operated for a fixed amount of time each hour of the day. The start and stop times of the pumps are staggered to minimize the total electric energy demand exerted at a given time. The current timing system is an effective way to control pumping practices and minimize electric energy demand.

6.2 ESTIMATE OF ENERGY USAGE, DEMAND, AND COST SAVINGS

Based on the evaluation of submetering and process data, no significant energy savings measures resulting from operation modifications were identified.

Section 7

ENERGY SAVINGS THROUGH LIGHTING/HVAC MODIFICATIONS

7.1 LIGHTING/HVAC MODIFICATIONS TO REDUCE ENERGY USAGE

In order to evaluate potential electric energy usage reductions through lighting/heating ventilating and air conditioning (HVAC) modifications, a survey of the lighting and HVAC units that are currently in place was conducted.

7.1.1 Lighting

The site inspection revealed that existing facility lighting ranges from inefficient T-12 2, 4, and 8-foot (ft) fluorescent fixtures with 2, 3, and 4 lamps to a range of high intensity discharge (HID) fixtures. The HID fixtures ranged from 150 watt, 175 watt, 250 watt, and 400 watt metal halide to 175 watt mercury vapor and 175 watt high pressure sodium. The majority of the exit signs have compact fluorescent lamps.

7.1.2 Heating, Ventilation, and Air Conditioning

There are a number of HVAC systems throughout the Frank E. Van Lare (FEV) Wastewater Treatment Facility (WWTF) site. With the exception of the administration, instrumentation and electric (I&E), solids handling, and recirculation building, the primary function of the heating and cooling systems is not for comfort conditioning. The administration building is occupied 24 hours per day 7 days per week.

The heating systems throughout most of these buildings are comprised of hot water unit heaters, 100% outdoor air heating and ventilating air handling units, multizone constant volume air handling systems, indirect gas-fired rooftop heating and ventilating units and various small unit systems. One 120-ton air-cooled reciprocating direct expansion chiller provides chilled water to the air-handling units in these buildings. This chiller runs 24 hours per day, 7 days per week and is in need of replacement. The heating, ventilating, and multizone units are constant volume. Two 300-horsepower (hp) Cleaver-Brooks hot water boilers produce hot water for the air-handling unit of each building. Hot water is conveyed through an underground hot water piping distribution system. One boiler is located on the north side of the facility and the other is on the south side of the facility. Only one boiler runs at a time with the other on stand-by. These boilers are original and were installed in 1971. The south boiler has been re-tubed as of 2004. The north boiler was re-tubed in 1997. These boilers are in good working condition, but are relatively old and somewhat inefficient compared to modern high-efficiency units.

7.2 ESTIMATE OF ENERGY USAGE, DEMAND, AND COST SAVINGS

7.2.1 Lighting

This facility demonstrates many areas for energy efficient lighting opportunities.

Convert Exit Signs to Light Emitting Diodes

All of the exit signs inspected were operated with 2-lamp 40 watt incandescent lamps and or compact fluorescent lights. Light emitting diode (LED) exit signs consume only 2 watts to 6 watts of power and operate maintenance free for 15 to 25 years. The electric energy usage reduction associated with this option is estimated to be 163,934 kWh, corresponding to an annual cost savings of $10,000.

T-12 to T-8 Lighting Upgrade

Many of the fluorescent 4-ft and 8-ft industrial grade fixtures are 2, 3 or 4, lamp T-12 lamps with energy efficient magnetic ballasts. These fixtures should be retrofitted with new energy efficient T-8 technology lamps with electronic ballasts not just for the energy savings but also for reducing the diversity of inventory. The electric energy usage reduction associated with this option is estimated to be 1,147,541 kWh, corresponding to an annual cost savings of $70,000.

Mercury Vapor to Metal Halide Fixtures

The lighting in many areas of the facility consists of 175-watt mercury vapor fixtures. These fixtures are very inefficient and should be replaced with metal halide fixtures. Some of these fixtures can be retrofitted and other fixtures will be replaced. The electric energy usage reduction associated with this option is estimated to be 655,738 kWh, corresponding to an annual cost savings of $40,000.

Based on the three lighting modifications discussed in this section, the overall electric energy usage reduction is estimated to be 1,967,213 kWh, corresponding to a cost savings of $120,000 per year.

7.2.2 Heating, Ventilation and Air Conditioning

This facility demonstrates many areas for energy efficient HVAC opportunities.

Replace Existing 120-ton Air-Cooled Direct Expansion (DX) Chiller with a High Efficiency Unit

The existing unit is antiquated and should be replaced. Many new air-cool units have efficiencies in the range of 0.7 kW per ton to 1.25 kW per ton. The existing unit should be replaced with a high efficiency 120-ton air-cooled chiller. The electric energy usage reduction associated with this option is estimated to be 196,721 kWh, corresponding to an annual cost savings of $12,000.

Replace Two Existing Cleaver-Brooks Hot Water Boilers with New High Efficiency Condensing-Type Boilers

The existing hot water boilers are original and are running in the 75% to 85% efficiency range. Energy savings will be achieved by replacing these units with 91% or higher efficiency condensing hot water boilers. The electric energy usage reduction associated with this option is estimated to be 673,771 kWh, corresponding to an annual cost savings of $41,100.

Replace Existing Electric Motors on the Heating and Ventilation Units with High Efficiency Motors

The existing motors on the heating and ventilation air-handling units are original and inefficient. These motors run 8,760 hours per year. Replacing these motors with high efficiency motors will greatly reduce the annual electric energy usage. Many of the new high efficiency motors have efficiencies in the range of 86% to 93% for the horsepower sizes similar to the current units. The electric energy usage reduction associated with this option is estimated to be 129,508 kWh, corresponding to an annual cost savings of $7,900.

Based on the above changes, the overall electric energy usage reduction is estimated to be 1,000,000 kWh, corresponding to a cost savings of $61,000 per year.

7.3 ESTIMATE OF CAPITAL COSTS AND SIMPLE PAYBACK

A summary of the estimated capital costs and simple payback periods is presented in TABLE 7-1.

Table 7-1: Lighting/HVAC Improvement Estimated Capital Cost and Simple Payback

Improvement	Capital Cost ($)	Annual Savings ($)	Simple Payback (years)
Lighting			
Convert Exit Signs to LEDs	$ 12,650	$ 10,000	1.3
T-12 to T-8 Lighting Upgrade	$ 350,000	$ 70,000	5.0
Mercury Vapor to Metal Halide Fixtures	$ 287,350	$ 40,000	7.2
Overall Lighting	**$ 650,000**	**$ 120,000**	**5.4**
HVAC			
Replace Existing 120-ton DX Chiller	$ 120,000	$ 12,000	10.0
Replace Two Existing Hot Water Boilers	$ 575,000	$ 41,100	14.0
Replace Existing HVAC Electric Motors	$ 45,000	$ 7,900	5.7
Overall HVAC	**$ 740,000**	**$ 61,000**	**12.1**

Section 8
RECOMMENDATIONS

8.1 SUMMARY OF EVALUATIONS

This report identified and evaluated several alternatives that could potentially reduce energy usage at the Frank E. Van Lare (FEV) Wastewater Treatment Facility (WWTF). One of the largest opportunities for electric energy savings is the replacement of the current mechanical aerators. The options for modifying the aeration process are part of a separate project and are not evaluated in this report. The energy-saving alternatives considered in this report include:

- Replacing the existing constant speed process water pumps with new more efficient pumps.
- Installation of variable frequency drives (VFDs) on the process water pump motors to provide automatic pump control based on pressure requirements.
- Replacing the existing domes on the sludge holding tanks and thickeners with flat covers to reduce air flow to odor control systems.
- Replacing the existing primary sludge pump motors with new, more efficient, motors.
- Replacing the wet end of the primary sludge pumps with new, more efficient, pumps.
- Conversion of exit signs to light emitting diodes (LED).
- Upgrading T-12 to T-8 lighting.
- Conversion from mercury vapor to metal halide fixtures.
- Replacing existing 120-ton air-cooled direct expansion (DX) chillers with a high efficiency unit.
- Replacing two existing Cleaver-Brooks hot water boilers with new high efficiency condensing-type boilers.
- Replacing existing electric motors on the heating and ventilating units with high efficiency motors.

TABLE 8-1 summarizes the estimated energy savings, implementation costs, and simple payback periods for all of the alternatives. The payback periods for the various measures range from 5 to 493 years.

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Table 8-1: Summary of Energy Savings Alternatives Presented in Sections 5, 6, and 7

ECM#	Measure Description	Non-Energy Related Benefits	Fuel Type Saved	Energy Saved (kWh)	Total Annual Dollars Saved*	Implementation Costs	Simple Payback Period (years)
1	Installation of Premium Efficiency Motors on Process Water Pumps	N/A	Electric	26,166	$1,596	$37,000	23.2
2	Installation of VFDs on the Process Water Pumps	Flexibility to vary pumping rate as needed	Electric	108,080	$6,593	$74,100	11.2
3a	Sludge Holding Tank Flat Covers	N/A	Electric	56,026	$3,418	$123,340	36.1
3b	Thickener Tank Flat Covers	N/A	Electric	293,373	$17,896	$328,900	18.4
4	Installation of Premium Efficiency Motors on Primary Sludge Pumps	N/A	Electric	12,627	$770	$78,420	101.8
5	Installation of New Primary Sludge Pumps (Wet End)	N/A	Electric	28,690	$1,750	$862,100	492.6
6	Convert Exit Signs to LEDs	N/A	Electric	163,934	$10,000	$12,650	1.3
7	T-12 to T-8 Lighting Upgrade	N/A	Electric	1,147,541	$70,000	$350,000	5.0
8	Replacement of Mercury Vapor with Metal Halide Fixtures	N/A	Electric	655,738	$40,000	$287,350	7.2
9	Replace Existing 120-ton DX Chiller	N/A	Electric	196,721	$12,000	$120,000	10.0
10	Replace Two Existing Hot Water Boilers	N/A	Electric	673,771	$41,100	$575,000	14.0
11	Replace Existing HVAC Electric motors	N/A	Electric	129,508	$7,900	$45,000	5.7

*Dollars saved calculated by multiplying the energy saved by the average 2004 rate of $0.061/kWh

8.2 SUMMARY OF RECOMMENDATIONS

Based on the evaluation results, the following alternatives are recommended for implementation:

- **Installation of VFDs on the process water pump motors to provide automatic pump control based on pressure requirements**. Although the payback for this replacement is longer that what is typically considered attractive, installation of VFDs on the process water pump motors will provide energy savings as well as increased operational flexibility. The controllers will automatically cycle pumps on and off as needed, which will eliminate the need for an operator to manually start and stop the equipment.

- **Conversion of Exit Signs to Light Emitting Diodes (LED).** This alternative is relatively inexpensive and has the shortest of all of the payback periods.

- **Upgrading T-12 to T-8 Lighting.** This option would convert the magnetic ballasts to electronic ballasts and would also have the added benefit of reducing the diversity of the lighting inventory.

- **Conversion from Mercury Vapor to Metal Halide Fixtures.** Many of the mercury vapor fixtures are very inefficient.

- **Replacing Existing Electric Motors on the Heating and Ventilating Units with High Efficiency Motors.** The motors run on a constant basis and significant electric energy savings can be realized by switching to high efficiency motors.

The remaining alternatives are not recommended due to long payback periods.

TABLE 8-2 summarizes the recommended energy-savings measures, associated costs to implement the recommended alternatives, potential savings, and simple payback. The set of recommended alternatives is estimated to cost a total of $769,100, resulting in a potential electric energy savings of 2,204,801 kWh and $134,493 annually. The overall payback for the set of recommended alternatives, if implemented together, is 5.7 years.

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Municipal Wastewater Treatment Plant Energy Evaluation

Monroe County DES - Frank E. Van Lare WWTF

Table 8-2: Summary of Recommended Alternatives

ECM#	Measure Description	Non-Energy Related Benefits	Fuel Type Saved	Energy Saved (kWh)	Total Annual Dollars Saved*	Implementation Costs	Simple Payback Period (years)
1	Installation of VFDs on the Process Water Pumps	N/A	Electric	108,080	$6,593	$74,100	11.2
2	Convert Exit Signs to LEDs	N/A	Electric	163,934	$10,000	$12,650	1.3
3	T-12 to T-8 Lighting Upgrade	N/A	Electric	1,147,541	$70,000	$350,000	5.0
4	Replacement of Mercury Vapor with Metal Halide Fixtures	N/A	Electric	655,738	$40,000	$287,350	7.2
5	Replace Existing HVAC Electric motors	N/A	Electric	129,508	$7,900	$45,000	5.7
TOTALS OF RECOMMENDED ALTERNATIVES				2,204,801	$134,493	$769,100	5.7

*Dollars saved calculated by multiplying the energy saved by the average 2004 rate of $0.061/kWh