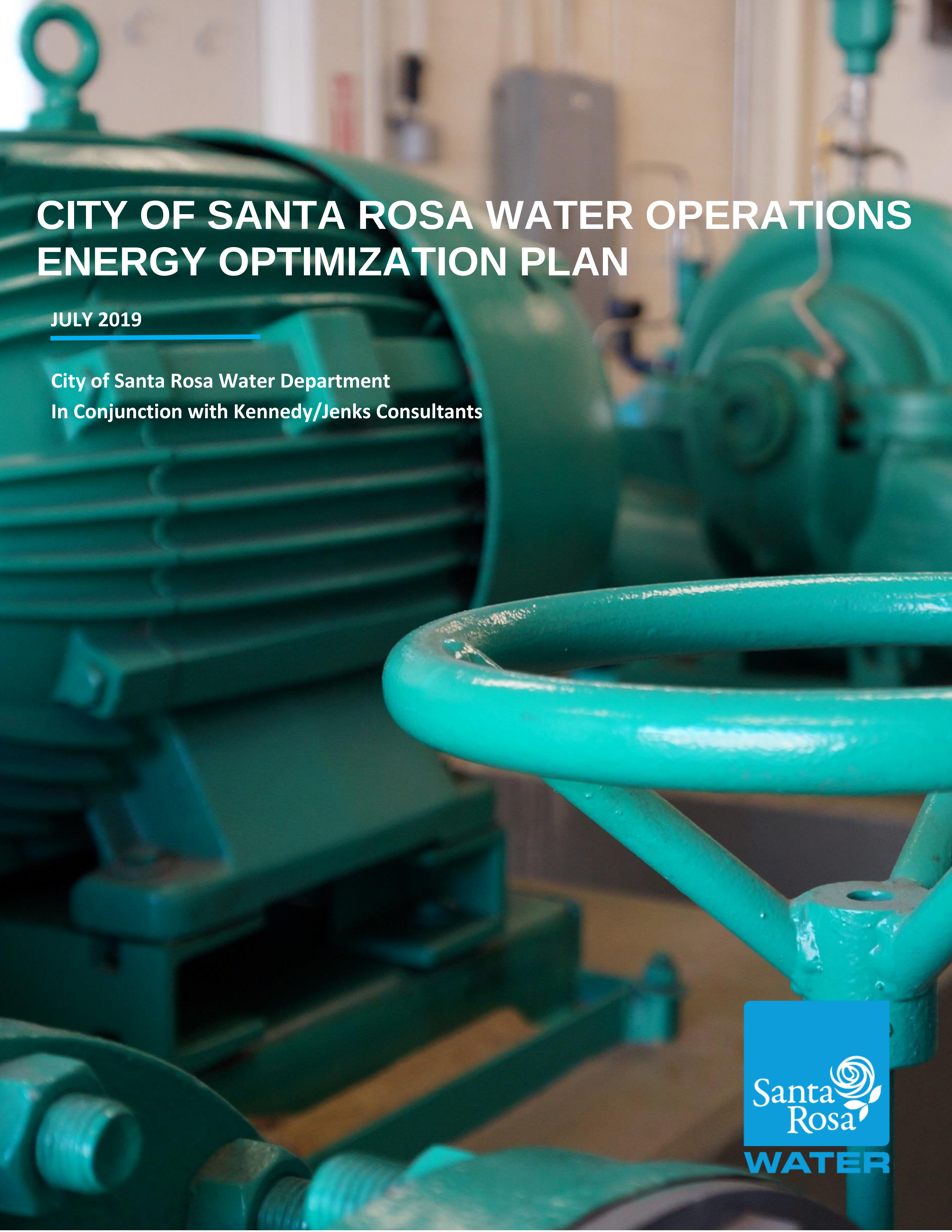

CITY OF SANTA ROSA WATER OPERATIONS ENERGY OPTIMIZATION PLAN

JULY 2019

City of Santa Rosa Water Department
In Conjunction with Kennedy/Jenks Consultants

Santa Rosa WATER

City of Santa Rosa Water Operations Energy Optimization Plan

July 2019

PREPARED BY

City of Santa Rosa WATER

IN CONJUNCTION WITH

Kennedy/Jenks Consultants

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EXECUTIVE SUMMARY

The Water Operations Energy Optimization Plan (EOP) serves as a roadmap for strategically and systematically optimizing energy use in Santa Rosa Water's Water Operations system, including water distribution, wastewater collection, and urban water reuse. The purpose of the EOP is two-fold: (1) to evaluate current Water Operations systems and practices and memorialize the many energy efficiency and renewable energy projects completed to-date; and (2) to identify opportunities and a cost-effective project portfolio to move towards energy independence and meeting or exceeding Santa Rosa's greenhouse gas (GHG) reduction target (20% below 2000 levels by 2020). The EOP also supports City Council's Goal, *Promote Environmental Sustainability: Santa Rosa protects and improves the environment through its policies and actions.*

Kennedy/Jenks Consultants (K/J), with assistance from City staff, completed a system energy audit to document the energy use and cost of Water Operation meters, analyze and benchmark the data for energy intensive meters, and set a baseline of energy use and cost. The group held a brainstorming workshop to develop a list of past energy and GHG reducing accomplishments, and a list of potential projects and processes ("measures") that would enhance Water Operations' energy efficiency, reduce energy demand, increase renewable energy generation, and/or improve energy management. K/J then completed seven detailed investigations of the chosen measures. The energy overview, the brainstorming session, and the seven investigations are analyzed in nine technical memorandums (TMs):

- TM #1: System Energy Overview
- TM #2: Brainstorming Workshop
- TM #3: Utility Management Systems Investigations
- TM #4: Optimizing Pump Sequencing Logic Investigation
- TM #5: Pump Efficiency Investigation
- TM #6: SCADA Programming Investigation
- TM #7: Solar Photo Voltaic Investigation
- TM #8: Variable Frequency Drive Investigation
- TM #9: Time of Use (TOU) Rate Optimization Investigation

The TMs evaluate Energy Efficiency Measures (EEMs) and Renewable Energy Measures (REMs). The analyses are meant to give Santa Rosa Water enough information to determine if a measure would likely result in energy reductions and/or cost savings for the City, and the approximate magnitude of those savings. For measures with direct energy savings, the TMs provide a quantified cost-benefit analysis. For measures with indirect energy savings that are difficult or impossible to quantify (e.g., updating SCADA dashboards to show pump station specific energy), potential energy and cost savings are discussed but not calculated.

SRW staff evaluated and prioritized potential measures for implementation using several metrics. Staff first evaluated the feasibility of projects, given the parameters of the department's water systems and how implementation could affect operations. For projects deemed operationally feasible, staff considered the potential costs and energy savings, staff availability, and how easily the measure could be implemented. Measures were ultimately sorted into four categories:

- **Pursue:** These projects are considered top priority. The City will gather additional research to confirm if and how the measure should be implemented. If a measure is confirmed for implementation it will be will be evaluated as part of the Capital Improvements Program as appropriate. See Table ES-1.

- **Completed or In Planning:** These measures have been implemented by SRW staff, are currently in the process of being implemented, or are already in planning stages for future implementation. See Table ES-2.

- **Not Pursue at this Time:** These measures will not be pursued by SRW at this time for reasons such as operational infeasibility, uncertainty regarding potential energy and cost savings, or plans to use an alternative solution to the problem. See Table ES-3.

- **Not Recommended:** These measures were evaluated by K/J but not recommended for implementation. In most cases, the capital costs outweigh potential cost savings. In other cases, the potential project is infeasible or operationally impractical. See Table ES-4.

Tables ES-1 through ES-4 summarize all measures evaluated as part of the EOP, sorted by category (Pursue, Not Pursue at this Time, Not Recommended), and provide the rationale for how each measure was prioritized. Each project is described in detail in its respective TM.

Table ES-1. Measures to Pursue

Tech Memo	Title	Description	Prioritization Rationale
#7: Solar PV Investigation	REM 7-1: Own and Operate 134 KW solar system	City to own and operate a 134 kW solar photovoltaic (PV) project on existing waste transfer station structure behind the UFO.	All four REMs show a positive internal rate of return. Net present values of cumulative savings range from $2,800 (REM 7-2) to $424,900 (REM 7-6). The City will further investigate potential solar installation sizes and configurations, as well as funding options, via a Request for Proposals from qualified consultants.
	REM 7-2: Own and operate 320 KW solar system	City to own and operate a 320 kW solar PV project on a single new carport/truckport structure in the north part of the asphalt transfer area behind the UFO.	
	REM 7-5: Power Purchase Agreement (PPA) for 320 KW solar system	City to enter a PPA with a third-party solar developer that would design, build, own, operate, and maintain a 320 kW PV system on a new carport/truckport structure in the north part of the asphalt transfer area behind the UFO.	
	REM 7-6: PPA for 1257 KW solar system	City to enter a PPA with a third-party solar developer that would design, build, own, operate, and maintain a 1257 kW PV system on four new carport/truckport structures in the north part of the asphalt transfer area behind the UFO.	
#9: Time of Use (TOU) Investigation	EEM 9-1: Heating at UFO	Determine if it is acceptable, by doing a pilot program, to have the UFO building heating system start time be later and stop time be earlier to eliminate the 1 to 2 hours of energy use, thereby lower heating costs.	These measures can be investigated at no cost to SRW. Staff will test the measures to determine if they work for the building after the UFO's boilers are have been replaced (in process).
	EEM 9-2: Cooling at UFO	Run a pilot program limiting the run time of the cooling system during Peak Period (e.g., starting the cooling 1 to 2 hours after noon and stopping it 1 to 2 hours before 6 p.m.), adjusting the temperature set-point up 1 to 2 degrees, and then assessing if the building stays cool enough for occupants.	
	EEM 9-3: HVAC Equipment	If the test of the current air changes at the UFO building show excess air changes per hour, adjust the HVAC equipment to the minimum requirement.	
	EEM 9-4: Window Blinds	Make sure UFO building occupants understand the TOU rate schedule and when to use the window blinds to reduce solar gain.	This measure can be implemented at no cost to SRW. Staff will educate building occupants accordingly, in particular after the TOU schedule changes in 2020.
	EEM 9-5: Natural Light	Investigate adding additional skylights or solar tubes in the darker work space areas of the UFO building.	This measure can be implemented at low cost to SRW. Staff will ask for feedback regarding potential locations for better natural lighting.

Tech Memo	Title	Description	Prioritization Rationale
	EEM 9-7: Education	Run a "Turn Me Off!" education campaign with stickers at switches in the UFO building and mention it at staff meetings.	This measure can be implemented at no cost to SRW. Staff will educate building occupants accordingly.

Table ES-2. Measures Complete or in Planning

Tech Memo	Title	Description	Prioritization Rationale
#6: SCADA Programming Investigation	EEM 6-2: Add Manual Controls via SCADA for Setting Pump Sequence	Add manual controls to allow for mode and sequence changes to be made remotely, using SCADA, saving travel time. Create a typical HMI screen for making sequence changes and linking this screen to existing ones. Modify PLC programs to accommodate this additional remote control. Modify telemetry to exchange needed supervisory control data.	The City's SCADA/PLC systems are scheduled to be upgraded in 2019. The City is further evaluating these EEMs as part of that project.
	EEM 6-3: Add SCADA Provisions for Optimizing TOU Settings	Add SCADA provisions that would allow staff to change all the settings for all the pump stations at once, or to store sets of settings for easy recall and deployment.	
	EEM 6-4: Add Software Flow Totalizers for the Pump Stations	During the upcoming project to replace existing L2000s with L3000s, get a price for developing the PLC software needed to program the PLCs to totalize flow in the SCADA software. Although the time delay because of telemetry will remain, operators will see nearly up to the minute values, and engineering can have access to a database for analytical purposes.	
#9: Time of Use (TOU) Investigation	TOU Optimization at water pump stations and sewer lift stations	Shift to off peak and partial peak hours at water pump stations and sewer lift stations (SLSs) to reduce costs.	This measure has been implemented where feasible. Water pump stations operate to minimize on peak and partial peak usage as feasible. Pumping for all SLSs occurs when stations need to pump and cannot be restricted to just the Off-Peak TOU period for operational reasons. Staff is closely monitoring upcoming changes to TOU rates and schedules, and will adjust operations in the future accordingly.

Table ES-3. Measures to Not Pursue at This Time

Tech Memo	Title	Description	Prioritization Rationale
#3: Utility Management System	EEM 3-1: Further investigate using SmartWorks Software	Further investigate using SmartWorks software to help staff better track SRW's energy meters, monitor and report utility costs, help fix data problems, and identify energy inefficiencies.	This measure will not be pursued because of cost and the availability of a cheaper alternative. With an estimated cost of $24,000 plus an annual fee, it is unlikely that energy savings alone would justify the cost of the SmartWorks Software. Also, SmartWorks does not monitor data in real-time; it takes 1.5 to 2 days to get and review the energy data from the utilities. Software that monitors energy in real time would be preferable. SRW will proceed with an alternate energy-tracking system using data from PG&E.
	EEM 3-2: Further investigate installing Specific Energy software	Install Specific Energy software designed to optimize energy use of pump stations by using real time monitoring and pump data, to enable the City to efficiently and sustainably manage and continually operate pump stations at peak efficiency.	SRW staff prefers an alternate energy-tracking system using data from PG&E, which is free. Staff will stay educated on industry trends in energy-monitoring software.
#4: Optimize Pump Sequencing Logic/ #6: SCADA Programming Investigation	EEM 4-1, and 6-1: Optimize Pump Sequencing Logic at Water Pump Stations	Reprogram the pump sequencing logic at water pump stations to use the most efficient pumps before using less efficient pumps.	This measure is unnecessary. Pumps are tested every two years for efficiency; these tests consistently show minimal difference between the pumps at each station. Staff time to reprogram the minimally more efficient pump every two years would erase any cost savings.
#6: SCADA Programming Investigation	EEM 6-5: Update SCADA Dashboards to Show Pump Station Specific Energy	In addition to the flow totalizers proposed in EEM 6-4, add an electricity measuring instrument on each pump to do specific energy calculations, and forward values to the SCADA screens. Add specific energy data to the existing Water Distribution Overview screen. Investigate feasibility as part of L2000 upgrade.	SRW staff prefers to use PG&E's free pump efficiency testing program to establish pump energy efficiency on a biannual basis.

Table ES-4. Measures Not Recommended

Tech Memo	Title	Description	Prioritization Rationale
#4: Optimize Pump Sequencing Logic	Optimize Pump Sequencing Logic at Pump Stations S-16 and S-18	Change the pump sequencing to prioritize the most efficient pump(s) at pump stations S-16 and S-18	Specific energy is already so low that there would be virtually no energy savings, and thus no economic benefit, to changing the pump sequencing logic.
#5: Pump Efficiency Investigation	Replace or retrofit inefficient pumps.	Retrofit inefficient water pump station pumps with new high efficiency pumps.	A cost-effectiveness analysis was performed on all water pump station pumps of 30 horsepower (HP) or greater that had an overall pumping efficiency less than 65%, to determine which ones could be cost-effectively retrofitted with new high efficiency pumps. The calculations indicate that no replacements create a net savings, a positive net present value, or a positive rate of return.
#6: SCADA Programming Investigation	EEM 6-6: Provide Real Time Calculation of Specific Energy and the Ability to Manage Pump Sequences via the HMI	Add the ability to monitor specific energy in SCADA in real time: -Connect pump VFD power-monitoring hardware to the PLCs. -Provide pump energy monitors for the 27 pumps that do not use VFD. -Modify PLC software to do specific energy calculations in real time. -Modify the HMI to acquire this new data, update the Wonderware Historian to store specific energy points, provide a management dashboard screen, and provide supervisory control of pump sequences. -Install and test the new Liquitronic and HMI software.	Calculations show this measure is cost prohibitive.
#8: Variable Frequency Drives Investigation	VFDs for water pump stations S02, S03, S04B, S04R, S05, S09, S10, S13, S14, and S15	Equip pumps not currently equipped with VFDs at water pump stations S02, S03, S04B, S04R, S05, S09, S10, S13, S14, and S15.	These pumps were excluded from analysis for one or more reasons: all pumps were already equipped with VFDs, the pump station is not currently in service, the pump only runs during emergencies, etc.
	EEM 8-1: VFD for Water Pump Station S01	Equip four 125-HP pumps with VFDs.	Calculations show these measures are cost prohibitive.
	EEM 8-2: VFD for Water Pump Station S04	Equip one 50-HP pump with a VFD.	
	EEM 8-3: VFD for Water Pump Station S06	At water pump station S06, equip pumps P-1 and P-3 with VFDs.	

Tech Memo	Title	Description	Prioritization Rationale
	EEM 8-4: VFD for Water Pump Station S07	Equip three 50-HP pumps with VFDs.	
	EEM 8-5: VFD for Water Pump Station S08	Equip P-2 (75-HP) with VFD.	
	EEM 8-10: VFD for Water Pump Station S11	Equip P-2 and P-3 (60-HP) with VFDs.	
	EEM 8-11: VFD for Water Pump Station S12	Equip three 40-HP pumps with VFDs.	
	EEM 8-12: VFD for Water Pump Station S16	Equip P-2 (75-HP) with VFD.	
	EEM 8-13: VFD for Water Pump Station S17	Equip P-2 (75-HP) with VFD.	
	EEM 8-14: VFD for Water Pump Station S18	Equip two 30-HP pumps with VFDs.	
	EEM 8-15: VFD for SLS01	Equip two 60 HP pumps with VFDs.	
	EEM 8-16: VFD for SLS02	Equip four 20 HP pumps with VFDs.	Not applicable. Station destroyed in 2017 wildfire.
	EEM 8-17: VFD for SLS03	Equip two 11 HP pumps with VFDs.	Calculations show these measures are cost prohibitive.
	EEM 8-18: VFD for SLS04	Equip four 25 HP pumps with VFDs.	
	EEM 8-19: VFD for SLS05	Equip two 5 HP pumps with VFDs.	
	EEM 8-20: VFD for SLS09	Equip two 15 HP pumps with VFDs.	
	EEM 8-21: VFD for SLS10	Equip two 2 HP pumps with VFDs.	
	EEM 8-22: VFD for SLS12	Equip two 5 HP pumps with VFDs.	
	EEM 8-23: VFD for SLS13	Equip two 2 HP pumps with VFDs.	
	EEM 8-24: VFD for SLS15	Equip two 2 HP pumps with VFDs.	
	EEM 8-25: VFD for SLS16	Equip two 5 HP pumps with VFDs.	
	EEM 8-26: VFD for SLS17	Equip two 15 HP pumps with VFDs.	
	EEM 8-27: VFD for SLS18	Equip four 15 HP pumps with VFDs.	
	EEM 8-28: VFD for SLS19	Equip four 10 HP pumps with VFDs.	
	EEM 8-29: VFD for SLS20	Equip four 10 HP pumps with VFDs.	Not applicable. Station destroyed in 2017 wildfire.
	EEM 8-30: VFD for SLS21	Equip one 23 HP pump with VFD.	Calculations show this measure is cost prohibitive.

February 27, 2017

FINAL Technical Memorandum #1

To: Joe Schiavone, Ron Marincic, Rick Santarini, Claire Myers, and Tasha Wright, City of Santa Rosa

From: Alan Zelenka, Kennedy/Jenks Project Manager

Subject: Local Operations Division Energy Optimization Plan
Task 1.1 – System Energy Overview

1.1 Purpose and Scope of Services

The purpose of the System Energy Overview task is to document the energy use and cost of the Local Operations Division (Local Ops) meters, analyze and benchmark the data for energy intensive meters, and to set a baseline of energy use and cost from which we can measure future savings that result from the Energy Optimization Plan (EOP). Local Ops meters include those for the water distribution system and wastewater collection system, and are distinct from the Subregional System meters.

1.2 Process

Santa Rosa Water staff provided monthly energy use, cost, and flow data in Excel spreadsheets for the 2011 through 2015 operations years for each of Local Operation's 82 meters[1]. The complete list of meters is included in Appendix A and in the spreadsheet entitled "Santa Rosa - Local Ops Energy Use and Cost v3". The monthly meter data included: service address, meter number, type of fuel (i.e., electricity or natural gas), type of facility (i.e., sewer lift stations, boosters, flow meters, administration building, reservoirs or wells), kWh, therms, cost (both PG&E and Sonoma Clean Power), and flow data (in gallons pumped per month where available). Kennedy/Jenks summed and formatted the data in order to analyze the information. The analysis of the data is summarized in the next section.

1.3 Total Energy Use and Cost

The total annual energy costs for 2011 through 2015, both electricity and natural gas, are shown in Table 1 and Figure 1. Local Ops energy cost for 2015 was nearly three-quarters of a million dollars. Table 2 breaks down the energy use and cost by electricity and natural gas. The dominant type of energy used by Local Ops is electricity, accounting for 97.6% of total energy costs for the 5 year period.

[1] The analysis includes only those meters that directly serve and are paid for by Local Operations. These exclude meters that serve asset management (i.e., flow meters), administrative building space not used by Local Operations staff, and Subregional facilities.

Memorandum

Santa Rosa Water/Local Ops EOP: Final Tech Memo #1 - System Energy Overview

Table 1: Total Annual Local Ops Energy Cost

Year	Total Cost	% Change from Previous Year
2011	$629,870	
2012	$719,392	14%
2013	$650,731	-10%
2014	$808,473	24.%
2015	$730,854	-10%

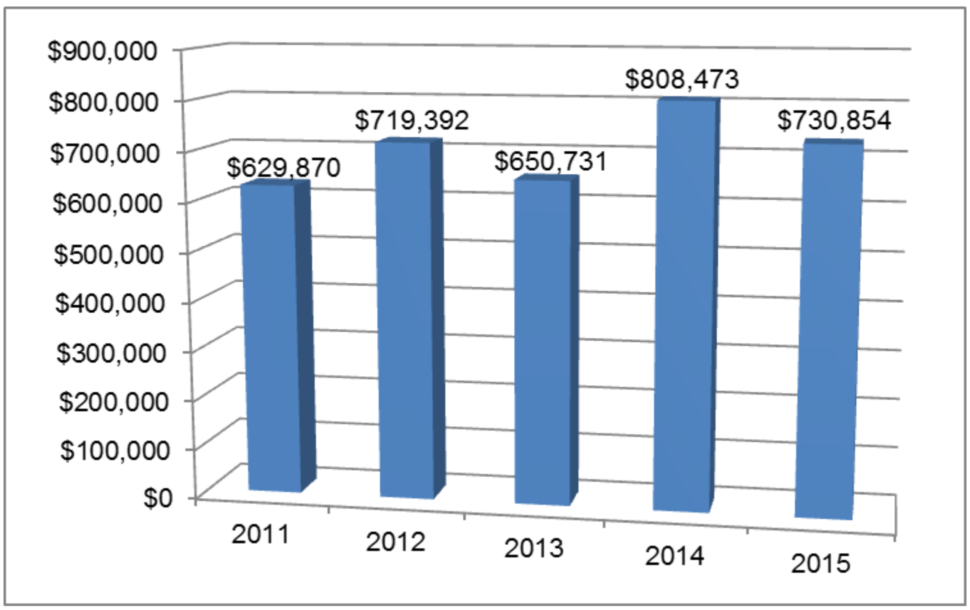

Figure 1: Local Ops Annual Energy Costs

Table 2: Total Annual Local Ops Energy Use and Cost by Type of Energy

	Electricity			Natural Gas		
Year	kWh	$	% of Total	Therms	$	% of Total
2011	3,844,613	$616,582	97.9%	12,410	$13,288	2.1%
2012	3,764,013	$702,596	97.7%	18,471	$16,796	2.3%
2013	4,148,483[1]	$632,287	97.2%	19,755	$18,444	2.8%
2014	3,841,111[1]	$790,133	97.7%	16,881	$18,340	2.3%
2015	4,045,407[1]	$712,207	97.4%	18,035	$18,647	2.6%

[1] PG&E accidentally stopped billing and metering Station 02 from 2013 to 2015; Kennedy/Jenks used the average electricity use and cost for 2012 and part of 2013 as estimates for 2013 to 2015.

Memorandum

Santa Rosa Water/Local Ops EOP: Final Tech Memo #1 - System Energy Overview

As is shown in Tables 1 and 2, while natural gas use is relatively constant, electricity usage is quite variable year-to-year. The 14% decline in cost from 2012 to 2013, and then 24% increase from 2013 to 2014, comes primarily from three meters:

1. **Booster S04** (meter number 1009947845) – This meter captures electricity use of the booster pump, as well as energy use for two wells at the facility, and is thus the single largest Local Ops booster pump station and meter - nearly twice as much as the next highest meter. For the period from May through August the energy use and cost varies significantly. For instance, the electricity use for this period in 2013 was only 2/3 (64%) of the 2012 electricity use; then it increased 163% 2013 to 2014, and then decreased 36% from 2014 to 2015. Since this is the largest Local Ops meter large swings in electricity use and cost are readily reflected in the overall year-to-year energy use and cost for Local Ops.
2. **Booster S14** (meter number 1009537729) – This meter in 2013 used only one-third or 34% of the energy used in 2012.
3. **Booster S07** (meter number 2P1138) – This meter in 2013 used only about half or 52% of the energy used in 2012.

Together these three meters account for most of the year-to-year volatility in electricity use and cost. For a more detailed look see the “Santa Rosa - Local Ops Energy Use and Cost v3” spreadsheet, “Annual Data” tab.

Overall average rate by type of energy is shown in Table 3. These figures represent the total 2015 energy cost divided by the 2015 energy use (e.g., $712,207 divided by 4,045,407 = $0.1761/kWh).

Table 3: Local Ops 2015 Average Energy Costs by Type of Energy

Energy Type	Avg Rate
Electricity	$0.1761/kWh
Natural Gas	$1.0340/Therm

1.4 Electricity Use by Type of Facility

The bulk of the electricity use and cost by Local Ops comes from the booster pump stations (84%), followed by administration buildings (8%), sewer lift stations (6%), wells (1%), and reservoirs (1%). Table 4 shows electricity usage, cost, and average rate by facility type. The average rate will be used in Part 2 of the EOP to calculate the savings from energy efficiency projects at each of the facility types.

Memorandum

Santa Rosa Water/Local Ops EOP: Final Tech Memo #1 - System Energy Overview

Table 4: Total 2015 Local Ops Electricity Use and Cost by Type of Facility

Facility Type	Electricity Use (kWh/Year)	Annual Cost ($)	% of Total	Avg Rate ($/kWh)
Boosters	3,387,804	$599,611	83.7%	$0.1770
Admin Buildings[1]	344,883	$49,096	8.5%	$0.1424
Lift Stations	223,754	$45,445	5.5%	$0.2031
Wells	54,596	$9,883	1.3%	$0.1810
Reservoirs	33,815	$7,597	0.8%	$0.2247
Water Monitoring Stations	555	$575	0.0%	$1.0364
TOTAL	**4,045,407**	**$712,207**	**100%**	**$0.1761**

[1] Local Ops paid for approximately 64% of the Utility Field Office (UFO) administration building electricity costs in fiscal year 2015/2016 (and 92% of UFO gas costs). Local Ops has been allocated its share of the overall admin building energy use and cost accordingly.

Figure 2 shows a pie chart distribution of the Local Ops electricity use by its different types of facilities.

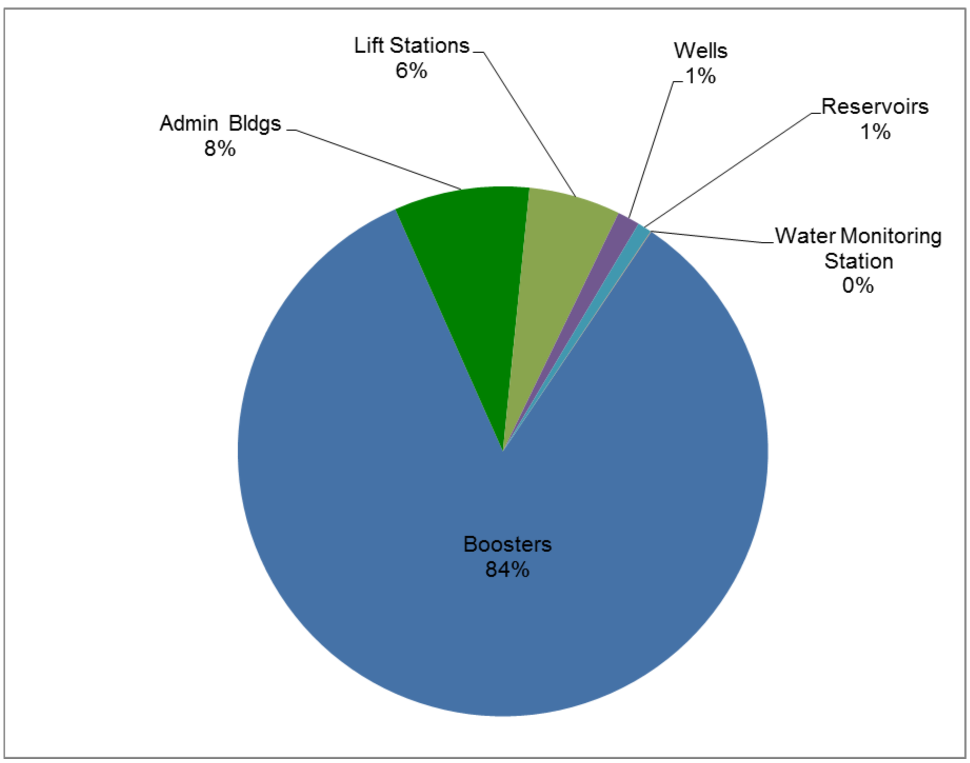

Figure 2: 2015 Local Ops Electricity Use & Cost by Type of Facility

Natural gas represents only a small fraction (2.6%) of the overall energy use and cost by Local Ops. Of that modest amount of natural gas use 96% of it is used in the Admin Buildings, with tiny amount used by Booster Pump Stations (3%) and Lift Stations (1%).

Table 5: Total 2015 Local Ops Natural Gas Use and Cost by Type of Facility

Facility Type	**Natural Gas Use (Therms/Yr)**	**% of Total**	**Annual Cost ($)**	**% of Total**	**Avg Rate ($/Therm)**
Admin Buildings	17,232	96%	$15,790	85%	$0.9163
Boosters	625	3%	$1,261	7%	$2.0172
Lift Stations	178	1%	$1,597	9%	$8.9684
Reservoirs	0	0%	$0	0%	$0.0000
Wells	0	0%	$0	0%	$0.0000
Water Monitoring Station	0	0%	$0	0%	$0.0000
TOTAL	**18,035**	**100%**	**$18,647**	**100%**	**$1.0340**

1.5 Energy Cost Forecast

Assuming a conservative 3% annual increase in the price of energy, Local Ops's current $730,000 annual energy bill could increase over the next 20 years to $1.32 million between now and 2035. That is an increase of over 180% over 20 years.

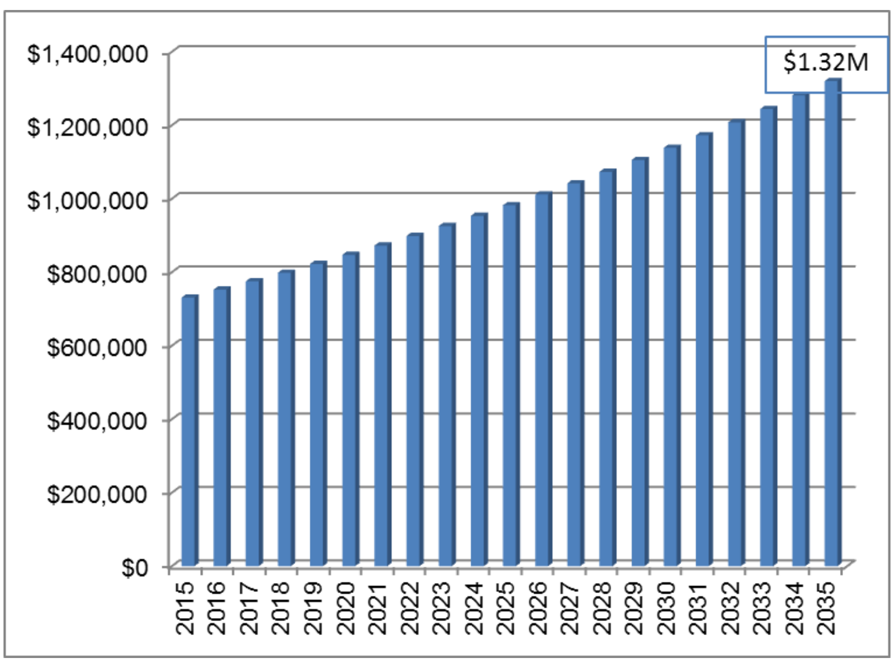

Figure 3: Forecast of Local Ops Energy Costs

Memorandum

Santa Rosa Water/Local Ops EOP: Final Tech Memo #1 - System Energy Overview

A common metric to determine and compare the energy consumption of various pumps is the specific energy of the pump, or the amount of electricity needed to pump one million gallons (kWh/Mgal). Santa Rosa Water staff provided separate files for monthly energy use and monthly flow data for each meter. Flow data was not included for all the meters, and those meters without flow data are not shown in the following tables.

Unfortunately, the monthly time periods for the energy data and flow data do not correspond exactly (i.e., the monthly energy read dates for a meter were often different from the monthly flow read dates). This made an exact calculation of the specific energy impossible; therefore, Kennedy/Jenks applied the closest range of dates for the flow reads to the energy data reads to generate average daily flow amounts. These were then used to estimate flow rates over any given year rather than a precise amount.

Dividing the total annual electricity use by the estimated total annual flow for each pump, enables us to calculate the specific energy metric for each pump for the years 2014 and 2015. The Booster Pump Stations are listed by Booster Station number in Table 6, and are ranked in order of specific energy in Table 7. The top ranked booster pump was S07 which uses 7.4 times less electricity to pump one million gallons than the lowest ranked booster pump (S05) of the 13 pumps analyzed. Table 8 lists the 16 Sewer Lift Stations (SLS) by their SLS number, and Table 9 rank orders the each SLS by their specific energy. Table 9 shows that SLS 21 uses nearly 50 times more energy to pump one million gallons than the top ranked SLS 12. Figure 4 shows the comparison of the Booster Pump Stations rank ordered by their specific energy.

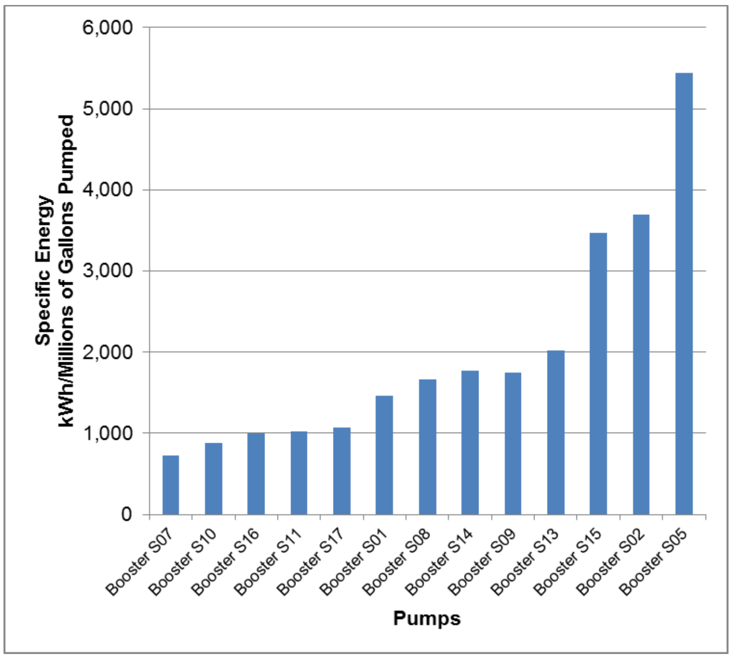

Figure 4: Booster Pump Stations – Specific Energy Comparison and Ranking

Figure 5 shows the comparison of the Sewer Lift Stations rank ordered by their specific energy.

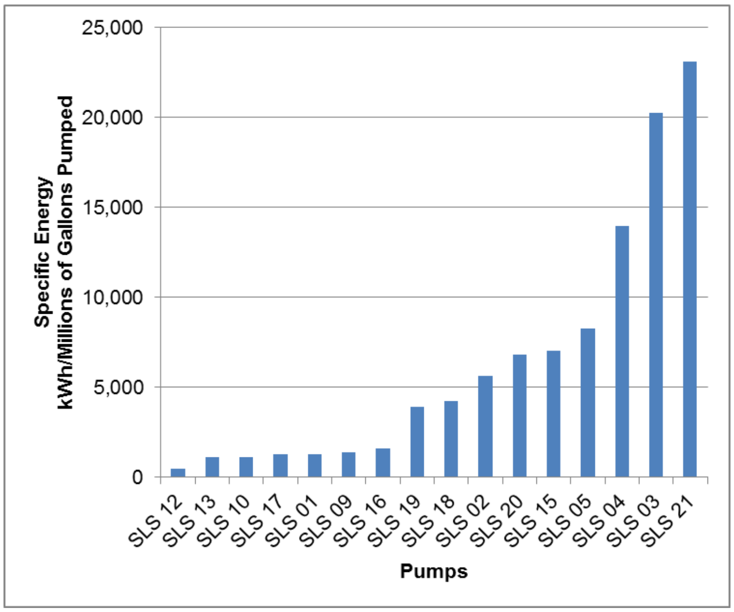

Figure 5: Sewer List Stations – Specific Energy Comparison and Ranking

Table 6: Specific Energy of Booster Pump Stations

	Address	Booster #	Meter Number	2014 Gallons/Yr	2014 kWh/Mgal	2015 Gallons/Yr	2015 kWh/Mgal	Multiple of Best
1	280 Fountain Grove Pkwy	Booster S01	1004578251	317,544,562	1,397	232,099,274	1,457	1.0
2	2260 Sonoma Ave # 3012	Booster S02	1009947845	293,172,918	3,493	338,054,754	3,699	2.5
3	3785 Skyfarm Dr	Booster S05	1009504395	10,413,511	6,947	12,289,175	5,438	3.7
4	5219 Monte Verde Dr	Booster S07	2P1138	242,113,087	702	168,345,441	730	Best
5	Mountain Hawk Dr & Sailing Hawk Ave	Booster S08	56M161	15,276,390	1,686	18,565,287	1,668	1.1
6	2889 Summerfield Rd	Booster S09	1004578249	307,570,086	1,564	251,288,966	1,744	1.2
7	4738 Woodview Dr	Booster S10	1004578376	7,939,565	717	7,018,009	885	0.6
8	1825 Kawana Springs Rd	Booster S11	1006710275	71,652,283	943	48,304,140	1,017	0.7
9	801 White Oak Dr	Booster S13	1009537783	20,535,780	2,126	22,500,417	2,025	1.4
10	1051 White Oak Dr	Booster S14	1009537729	13,880,502	2,440	15,587,476	1,769	1.2
11	6348 Sonoma Hwy	Booster S15	1005379013	10,366,202	3,254	10,622,723	3,465	2.4
12	4177 Chanate Rd	Booster S16	1009504397	73,691,849	1,059	116,347,899	1,005	0.7
13	2750 Fountain Grove Pkwy	Booster S17	1009513036	66,416,672	1,039	109,839,841	1,067	0.7

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Table 7: Specific Energy of Booster Pump Stations (Ranked by Specific Energy)

				2014		2015		
	Address	**Booster #**	**Meter Number**	**Gallons/Yr**	**kWh/Mgal**	**Gallons/Yr**	**kWh/Mgal**	**Multiple of Best**
1	5219 Monte Verde Dr	Booster S07	2P1138	242,113,087	702	168,345,441	730	Best
2	4738 Woodview Dr	Booster S10	1004578376	7,939,565	717	7,018,009	885	1.2
3	4177 Chanate Rd	Booster S16	1009504397	73,691,849	1,059	116,347,899	1,005	1.4
4	1825 Kawana Springs Rd	Booster S11	1006710275	71,652,283	943	48,304,140	1,017	1.4
5	2750 Fountain Grove Pkwy	Booster S17	1009513036	66,416,672	1,039	109,839,841	1,067	1.5
6	280 Fountain Grove Pkwy	Booster S01	1004578251	317,544,562	1,397	232,099,274	1,457	2.0
7	Mountain Hawk Dr & Sailing Hawk Ave	Booster S08	56M161	15,276,390	1,686	18,565,287	1,668	2.3
8	1051 White Oak Dr	Booster S14	1009537729	13,880,502	2,440	15,587,476	1,769	2.4
9	2889 Summerfield Rd	Booster S09	1004578249	307,570,086	1,564	251,288,966	1,744	2.4
10	801 White Oak Dr	Booster S13	1009537783	20,535,780	2,126	22,500,417	2,025	2.8
11	6348 Sonoma Hwy	Booster S15	1005379013	10,366,202	3,254	10,622,723	3,465	4.7
12	2260 Sonoma Ave # 3012	Booster S02	1009947845	293,172,918	3,493	338,054,754	3,699	5.1
13	3785 Skyfarm Dr	Booster S05	1009504395	10,413,511	6,947	12,289,175	5,438	7.4

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Table 8: Specific Energy of Sewer Lift Stations

	Address	SLS #	Meter Number	2014 Gallons/Yr	2014 kWh/Mgal	2015 Gallons/Yr	2015 kWh/Mgal	Multiple of Best
1	100 Stage Coach Rd	SLS 01	5000102247	20,715,587	1,294	19,602,871	1,291	1.0
2	3957 Skyfarm Dr	SLS 02	1006472173	4,198,754	5,184	3,670,386	5,653	4.4
3	3977 Clearbrook Ct, Lift Station D	SLS 03	1006591314	219,918	21,172	240,213	20,282	15.7
4	4021 Skyfarm Dr	SLS 04	1009916449	1,422,485	14,566	1,332,114	13,987	10.8
5	3925 Fawn Glen Pl	SLS 05	79463T	719,466	7,508	651,209	8,294	6.4
6	605 Piezzi Rd	SLS 09	1008842210	10,489,222	1,247	8,977,657	1,369	1.1
7	1426 Country Manor Dr	SLS 10	1009126831	1,069,682	1,188	1,155,682	1,151	0.9
8	818 Mohawk St	SLS 12	1009453401	17,204,413	458	15,104,118	464	Best
9	541 Pawnee St	SLS 13	1008669561	2,060,486	1,164	2,178,847	1,118	0.9
10	111 Alderbrook Dr	SLS 15	1009068938	168,261	5,117	115,597	7,016	5.4
11	5391 Montgomery Dr	SLS 16	1005532923	1,214,492	1,960	1,142,484	1,590	1.2
12	8810 Oakmont Dr	SLS 17	1006864985	11,129,079	1,256	9,743,476	1,267	1.0
13	3975 Shelter Glen Way	SLS 18	1006591912	5,662,225	3,733	4,216,533	4,236	3.3
14	3710 Newbury Ct	SLS 19	1006883488	3,874,998	3,629	3,433,685	3,898	3.0
15	3978 Hansford Ct	SLS 20	1006883489	1,080,595	6,913	1,003,320	6,816	5.3
16	3919 Flintridge Dr, Lift Station E	SLS 21	1006591315	314,307	19,284	271,345	23,096	17.9

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Table 9: Specific Energy of Sewer Lift Stations (Ranked by Specific Energy)

				2014		2015		
	Address	SLS #	Meter Number	Gallons/Yr	kWh/Mgal	Gallons/Yr	kWh/Mgal	Multiple of Best
1	818 Mohawk St	SLS 12	1009453401	17,204,413	458	15,104,118	464	Best
2	541 Pawnee St	SLS 13	1008669561	2,060,486	1,164	2,178,847	1,118	2.4
3	1426 Country Manor Dr	SLS 10	1009126831	1,069,682	1,188	1,155,682	1,151	2.5
4	8810 Oakmont Dr	SLS 17	1006864985	11,129,079	1,256	9,743,476	1,267	2.7
5	100 Stage Coach Rd	SLS 01	5000102247	20,715,587	1,294	19,602,871	1,291	2.8
6	605 Piezzi Rd	SLS 09	1008842210	10,489,222	1,247	8,977,657	1,369	3.0
7	5391 Montgomery Dr	SLS 16	1005532923	1,214,492	1,960	1,142,484	1,590	3.4
8	3710 Newbury Ct	SLS 19	1006883488	3,874,998	3,629	3,433,685	3,898	8.4
9	3975 Shelter Glen Way	SLS 18	1006591912	5,662,225	3,733	4,216,533	4,236	9.1
10	3957 Skyfarm Dr	SLS 02	1006472173	4,198,754	5,184	3,670,386	5,653	12.2
11	3978 Hansford Ct	SLS 20	1006883489	1,080,595	6,913	1,003,320	6,816	14.7
12	111 Alderbrook Dr	SLS 15	1009068938	168,261	5,117	115,597	7,016	15.1
13	3925 Fawn Glen Pl	SLS 05	79463T	719,466	7,508	651,209	8,294	17.9
14	4021 Skyfarm Dr	SLS 04	1009916449	1,422,485	14,566	1,332,114	13,987	30.2
15	3977 Clearbrook Ct, Lift Station D	SLS 03	1006591314	219,918	21,172	240,213	20,282	43.7
16	3919 Flintridge Dr, Lift Station E	SLS 21	1006591315	314,307	19,284	271,345	23,096	49.8

1.6 Conclusions

All of this information and data will be valuable as we proceed with the detailed investigations in Part 2 of the Local Ops Energy Optimization Plan (EOP). Key conclusions and recommendations are:

- The Local Ops staff has done a tremendous job over the past five years of creating practices and developing projects that save energy. The long list of accomplishments is detailed in Tech Memo #2, but includes projects such as: purchasing the most efficient pump available, reconditioning of all motors when taken out of service to do maintenance, participating in the PG&E Pump Efficiency Testing Program, installing Variable Frequency Drives (VFDs), developing solar photovoltaic (PV) projects, constructing LEED gold buildings, doing lighting retrofits, optimizing Time-Of-Use rates, and reducing fleet fuel use. However, the three quarters of a million dollars spent on energy is still a substantial sum of money for Local Ops to budget for energy purchases every year, and in the absence of further energy efficiency measures or projects this amount is likely to rise over time with increases in energy rates.
- The 2015 energy use, flow, and cost data (as well as future updated 2016 data) will be used as a benchmark from which to measure the success of the energy efficiency measures and other projects that will be implemented as a result of the system-wide Local Ops EOP.
- The Booster Pump Stations are the largest energy users, and also represent the biggest opportunity for savings. For example, if the booster pump operations were to increase efficiency and reduce energy usage by 10%-20%, this would yield an annual savings of approximately $50,000 to $100,000 per year. It therefore makes sense to prioritize the investigation into these improvements.
- The preliminary pump specific-energy analysis done in the Tech Memo is just the first step in increasing boosters' energy efficiency and cutting Local Ops' energy bill. A more-detailed analysis would be needed to prepare a rigorous business-case evaluation of operational changes and improvements, and is planned for Part 2 of the Local Ops EOP.
- All of the seven projects selected for further investigation during the Brainstorming Workshop in Task 2 of Part 1 of the EOP will be able to use and build on the information gathered for this Tech Memo.
- We recommend analyzing, as part of the Pump Optimization investigation in Part 2 of the EOP, a pump optimization software program. A product such as the Optimization Suite from Specific Energy can:
    - Perform regular pump station tests, automatically.
    - Monitor pump operations in real time, and provide information to operators.
    - Ensure operation within each pump's preferred operating range for peak energy efficiency and time-of-day rate optimization.
    - Identify and document underperforming pumps.

- Generate monthly operations reports to allow management decisions based on precise financial analysis and operational data that is collected and analyzed in real time.

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Appendix A – 2015 Santa Rosa Local Ops Meter List (by Service Activity Description)

Address	Fuel	Type	Service Activity Description	Meter No.	kWh	$
35 Pfister Rd	E	Admin Bldg	Admin Building - UFO (64% Allocation)	1003648615	186,376	$24,548
280 Fountain Grove Pkwy	E	Booster	Booster (E) - S01 - Fountaingrove 1	1004578251	371,233	$48,957
1395 Fountain Grove Pkwy	E	Booster	Booster (E) - S02 - Fountaingrove2	1006733881		
5803 Thomas Lake Harris Dr (Update To 3503)	E	Booster	Booster (E) - S03 - Fountaingrove 3	5000036764	2,080	$468
2260 Sonoma Ave # 3012	E	Booster	Booster (E) - S04 - Station 4	1009947845	1,362,064	$202,333
2260 Sonoma Ave	E	Booster	Booster (E) - S04/BV - Bennett Valley Pump	5000033984	80,345	$13,194
2521 Del Rosa Ave	E	Booster	Booster (E) - S04B - Proctor	1006910542	7,701	$1,406
Murdock Rd @ Franklin Dr	E	Booster	Booster (E) - S04R - Murdock	5000033936	47,379	$9,103
3785 Skyfarm Dr	E	Booster	Booster (E) - S05 - Skyfarm	1009504395	74,452	$12,698
5220 Montgomery Dr,@ City-Wtr Pumps-6	E	Booster	Booster (E) - S06 - Rincon 1	1004779467	311,442	$43,205
5219 Monte Verde Dr	E	Booster	Booster (E) - S07 - Rincon 2	2P1138	135,030	$18,238
Mountain Hawk Dr & Sailing Hawk Ave	E	Booster	Booster (E) - S08 - Skyhawk	56M161	34,705	$6,166
2889 Summerfield Rd	E	Booster	Booster (E) - S09 - Bennett Valley	1004578249	545,688	$130,528
4738 Woodview Dr	E	Booster	Booster (E) - S10 - Woodview	1004578376	6,985	$1,124
1825 Kawana Springs Rd	E	Booster	Booster (E) - S11 - Kawana	1006710275	54,994	$9,259
297 Valley Oaks Dr	E	Booster	Booster (E) - S12 - Oakmont	1010026096	33,446	$3,704
801 White Oak Dr	E	Booster	Booster (E) - S13 - Wild Oak 1	1009537783	50,351	$7,359
1051 White Oak Dr	E	Booster	Booster (E) - S14 - Wild Oak 2	1009537729	30,590	$4,645
6348 Sonoma Hwy	E	Booster	Booster (E) - S15 - Meadowridge	1005379013	40,967	$6,707

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Address	Fuel	Type	Service Activity Description	Meter No.	kWh	$
4177 Chanate Rd	E	Booster	Booster (E) - S16 - Fountaingrove 4	1009504397	129,089	$18,834
2750 Fountain Grove Pkwy	E	Booster	Booster (E) - S17 - Fountaingrove 5	1009513036	129,639	$19,624
2195 Fountain Grove Pkwy, @ X-Newgate-Ct	E	Booster	Booster (E) - S18 - Fountaingrove 6	1006883486	12,085	$2,168
3899 Parker Hill Rd (Aka 3801)	E	Reservoir	Reservoir - R02A	1009127936	3,529	$648
4905 Rockridge Ln	E	Reservoir	Reservoir - R04A	1008722272	10,840	$1,908
3884 Skyfarm Dr	E	Reservoir	Reservoir - R05	1009322151	10,821	$1,863
5079 Harville Rd	E	Reservoir	Reservoir - R06	1009339015	1,526	$342
5623 Yerba Buena Rd	E	Reservoir	Reservoir - R07	1009322196	543	$188
6801 Sun Hawk, Skyhawk Water Tank	E	Reservoir	Reservoir - R08	1009331492	1,225	$297
7492-4800 Annadel, Heights Dr	E	Reservoir	Reservoir - R09A and R09B	1009069898	1,613	$361
4762 Woodview Dr	E	Reservoir	Reservoir - R10	1007123775	744	$214
441 Oak Point Ct	E	Reservoir	Reservoir - R12A	1009166610	611	$200
457 Woodley Pl (Aka 467 Woodley Pl)	E	Reservoir	Reservoir - R12B	1009167325	609	$200
1510 White Oak Dr	E	Reservoir	Reservoir - R14	1008756191	1,509	$340
2201 Newgate Ct	E	Reservoir	Reservoir - R17	1008885240	5,703	$1,036
100 Stage Coach Rd	E	Lift Station	SLS (E) - 01 - Fountaingrove	5000102247	28,279	$4,983
3957 Skyfarm Dr	E	Lift Station	SLS (E) - 02 - Skyfarm "A"	1006472173	23,249	$4,042
3977 Clearbrook Ct, Lift Station D	E	Lift Station	SLS (E) - 03 - Clearbrook	1006591314	5,618	$1,085
4021 Skyfarm Dr	E	Lift Station	SLS (E) - 04 - Skyfarm "B"	1009916449	20,911	$3,757
3925 Fawn Glen Pl	E	Lift Station	SLS (E) - 05 - Fawnglen	79463T	6,203	$1,198
605 Piezzi Rd	E	Lift Station	SLS (E) - 09 - Willowside	1008842210	13,854	$2,529
1426 Country Manor Dr	E	Lift Station	SLS (E) - 10 - Country Manor	1009126831	1,591	$359
W College Ave, @ Fulton Rd	E	Lift Station	SLS (E) - 11 - West College	5000046600	74,285	$13,348

Address	Fuel	Type	Service Activity Description	Meter No.	kWh	$
818 Mohawk St	E	Lift Station	SLS (E) - 12 - Mohawk	1009453401	8,006	$1,569
541 Pawnee St	E	Lift Station	SLS (E) - 13 - Pawnee	1008669561	2,814	$559
111 Alderbrook Dr	E	Lift Station	SLS (E) - 15 - Alderbrook	1009068938	1,017	$265
5391 Montgomery Dr	E	Lift Station	SLS (E) - 16 - Spring Lake	1005532923	2,130	$442
8810 Oakmont Dr	E	Lift Station	SLS (E) - 17 - Oakmont	1006864985	13,911	$2,534
3975 Shelter Glen Way	E	Lift Station	SLS (E) - 18 - Shelter Glen	1006591912	19,985	$3,410
3710 Newbury Ct	E	Lift Station	SLS (E) - 19 - Hadley Hill	1006883488	15,037	$2,621
3978 Hansford Ct	E	Lift Station	SLS (E) - 20 - Hansford	1006883489	7,800	$1,442
3919 Flintridge Dr, Lift Station E	E	Lift Station	SLS (E) - 21 - Flintridge	1006591315	7,164	$1,305
771 Farmers Lane	E	Well	Well - W004-2	1009125374	1,497	$368
3026 Leete Ave (Aka 3812 Leete Ave)	E	Well	Well - W01	1006591313	240	$240
811 Carley Rd (Aka 805 Carley Rd)	E	Well	Well - W02	1009484377	55,783	$8,240
1304 Cleveland Ave	E	Well	Well - W03	1006910045	2,379	$585
751 Farmers Ln	E	Well	Well - W04-1	1006883261	1,423	$451
4340 Occidental Rd	E	WMS	WMS - 11 - Occidental TO	1009127107	403	$159
4336 Sebastopol Rd	E	WMS	WMS - 12 - Sebastopol TO	1009127106	305	$150
239 Todd Rd	E	WMS	WMS - 13 - Todd TO	1009167253	264	$146
Farmers Ln,& Sonoma Ave	E	WMS	WMS - SUMP - PRA 60	1009125613	120	$120

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Address	Fuel	Type	Service Activity Description	Meter No.	Therm	$
35 Stony Point Rd	G	Admin Bldg	Admin Building - UFO (92% Allocation)	60677189	8,616	$7,895
280 Fountain Grove Pkwy	G	Booster	Booster (G) - S01 - Fountaingrove 1 - Backup Generators	47863992	12	$109
1395 Fountain Grove Pkwy	G	Booster	Booster (G) - S02 - Fountaingrove2 - Generator	51995812	334	$409
2260 Sonoma Ave	G	Booster	Booster (G) - S04 - Station 4	48851715	240	$229
4738 Woodview Dr	G	Booster	Booster (G) - S10 - Woodview	61545731	8	$106
6348 Sonoma Hwy	G	Booster	Booster (G) - S15 - Meadowridge	45585320	13	$104
4177 Chanate Rd	G	Booster	Booster (G) - S16 - Fountaingrove 4	47265559	11	$103
2750 Fountain Grove Pkwy	G	Booster	Booster (G) - S17 - Fountaingrove 5	47265581	2	$100
2195 Fountain Grove Pkwy,@ X-Newgate-Crt	G	Booster	Booster (G) - S18 - Fountaingrove 6	47266043	5	$101
100 Stage Coach Rd	G	Lift Station	SLS (G) - 01 - Fountaingrove - Standby Generator	47854521	9	$103
3957 Skyfarm Dr	G	Lift Station	SLS (G) - 02 - Skyfarm "A"	47854510	7	$102
3977 Clearbrook Ct, Lift Station D	G	Lift Station	SLS (G) - 03 - Clearbrook	55321783	5	$103
4021 Skyfarm Dr	G	Lift Station	SLS (G) - 04 - Skyfarm "B"	61448266	4	$102
3925 Fawn Glen Pl	G	Lift Station	SLS (G) - 05 - Fawnglen	61320903	4	$102
605 Piezzi Rd	G	Lift Station	SLS (G) - 09 - Willowside - Standby Generator	4726556X	7	$102
1426 Country Manor Dr	G	Lift Station	SLS (G) - 10 - Country Manor	40743780	3	$100
1098 Fulton Rd	G	Lift Station	SLS (G) - 11 - West College - Generator	42401106	104	$365
8004 Oakmont Dr	G	Lift Station	SLS (G) - 17 - Oakmont - Standby Generator	61086674	2	$99
3975 Shelter Glen Way	G	Lift Station	SLS (G) - 18 - Shelter Glen	48962540	10	$104
3978 Hansford Ct, Sewer Lift Station	G	Lift Station	SLS (G) - 20 Hansford	60159857	12	$108
3919 Flintridge Dr, Lift Station E	G	Lift Station	SLS (G) - 21 - Flintridge	60113137	6	$104
3710 Newbury Ct	G	Lift Station	SLS (G) - Hadley Hill	52503484	5	$103

July 12, 2016

Technical Memorandum #2

To: Claire Myers and Tasha Wright, City of Santa Rosa

From: Alan Zelenka, Kennedy/Jenks Project Manager

Subject: Local Operation Energy Optimization Plan
Task 2.2 – Brainstorming Workshop Summary and Short-List of Projects to Investigate

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2.1 Workshop Date

Thursday, February 25, 2016 (9:00 am to noon)

2.2 Workshop Location

UFO - Conference Room F, 35 Stony Point Road, Santa Rosa, CA 95401

2.3 Workshop Attendees

City of Santa Rosa - B Amador, Troy Atha, Jason Dyer, Simon Hood, John Keating, Ron Marincic, Owen Porter, Mark Powell, Rick Santarini, and Tasha Wright

Kennedy/Jenks - Alan Zelenka and Rod Houser

2.4 Purpose

The purpose of this Technical Memorandum is to develop a list of past energy and greenhouse gas (GHG) reducing accomplishments of Santa Rosa Water's (SRW's) Local Operation's (Local Ops) division, explain the workshop process, convey the compiled list of potential projects discussed at the workshop, describe the workshop's short-list of project ideas to be investigated in detail, and create a bulleted list of scope-of-work items for each short-listed project.

2.5 Accomplishments List

At the beginning of the workshop the group listed all of the previous projects, practices, and programs accomplished by Local Ops staff over past years that reduced energy use and GHG emissions. The following list is in no particular order:

1. Premium efficiency motors - purchasing the most efficient pump available.
2. Reconditioning of all motors when taken out of service to do maintenance.

3. Participated in PG&E Pump Efficiency Testing Program - received rebates on retrofit pumps (created a baseline on all pumps in 2005-2007).
4. Reduced pumping at Station 9 by reconfiguring the plumbing (1993).
5. Variable Frequency Drives (VFDs) installed at Station 4 (1993).
6. Oakmont Treatment Plant – modified VFD settings which allowed shifting away from more energy intensive “warm stand-by mode.”
7. Sewer Lift Station 11 – upgraded the pump and installed an automatic controller that got away from a simple on/off manual switch (2007).
8. Local Ops solar PV projects – including small projects at remote reservoirs.
9. UFO building constructed to LEED gold building standard.
10. UFO lighting retrofits and installation of LEDs.
11. Incorporate forward thinking about energy in new construction projects by installing conduit for future solar PV projects and electric vehicle charging stations.
12. Time-Of-Use rate optimization by switching to off-peak lower cost night time pumping (since 1992).
13. Leveraged the SCADA system to reduce energy use and O&M costs.
14. Optimize efficiency of maintenance trips and fleet logistics by using a map grid system.
15. Fleet fuel reductions from using CNG, buying hybrids and propane trucks, sizing engines according to vehicle’s primary task or need, and preparing for hydrogen as the fuel of the future.

2.6 Workshop Process

The Brainstorming Workshop started by reviewing a list of 22 potential projects developed by Kennedy/Jenks prior to the workshop. The list was partially based on the SubRegional Brainstorming workshop list of projects and lists from other similar workshops conducted by Kennedy/Jenks. The workshop attendees came up with two additional projects for a total of 24 potential projects. All the projects were listed on a flip chart at the front of the room.

Each project was reviewed by discussing how it could be specifically adapted to fit with Local Ops equipment and operations practices. Once everyone understood each potential project we conducted a voting exercise to narrow the field of projects to a short-list of preferred projects. To accomplish this each workshop attendee was given five dots to place on the flip chart. They were allowed to vote for any of the 24 projects but could only put one vote per project. The two Kennedy/Jenks participants were also allowed to vote.

Memorandum

Santa Rosa Water/Local Ops EOP: Task 2.2 – Brainstorming Workshop Summary and Short-List of Projects to Investigate Investigation

Once all of the attendees voted for their top five projects, the Kennedy/Jenks staff tallied the votes and rank ordered the projects. The table below shows the full list of projects and the total number of votes each project received. The top vote getting projects are ranked by the number of votes they received. The projects not included in the short-list are shaded in gray.

Table 1: List of Potential Projects and the Number of Votes Received

Project #	Rank	Votes	Project Title
1	1	10	Optimizing Pump Sequencing Logic
2	1	10	Pump Efficiency Program (testing, benchmarking & retrofits)
4	3	8	SCADA Programming
7	4	7	Solar Project
3	5	5	Install VFDs
24	5	5	Flow Meters
17	7	4	Time-Of-Use (TOU) Rate Optimization
9		1	Fleet Fuel Reductions (no idle, hybrids, CNG, biodiesel)
21		1	I&I Energy Impacts (on pumping and treatment)
23		1	Hydro Pneumatic Tanks
5		0	SCADA Projects Assessment
6		0	Energy Management Software
8		0	Sewer Lift Station Efficiency
10		0	Purchase RECs and/or GHG Offsets
11		0	Purchase Renewable/Green Power
12		0	Water Conservation Programs
13		0	Graywater & Rainwater Programs
14		0	Micro-Hydro (inline)
15		0	Recycled Water Projects
16		0	Sequestration Projects
18		0	Well Efficiency Program (testing, benchmarking & retrofits)
19		0	Reservoir Efficiency
20		0	AMR/Irrigation Optimization
22		0	Solar Water Heater Rebate Program

2.7 Short-List of Projects

There were two tiers of projects on the short-list: Tier 1 had four projects and received between 10 and 7 votes; and Tier 2 projects received 4 or 5 votes. The short-list of projects in rank-order is:

- Optimizing Pump Sequencing Logic
- Pump Efficiency Program
- SCADA Programming
- Solar Project
- Install VFDs
- Flow Meters
- Time-Of-Use (TOU) Rate Optimization

In reviewing the short list of projects, SRW staff recognized a need for an overarching data management and dashboard system ("utility management system" or "UMS") that will give them the tools to closely track energy usage and cost over time, monitor the effectiveness of the projects described in this technical memo, and inform future management decisions. Specifically, a UMS would allow management to calculate the benefits associated with project implementation (e.g., energy, GHG, cost), make decisions using best-available data and information, and present findings in a format that is easy to understand to staff and the public. Further details on determining the appropriate UMS for SRW are provided in the scope-of-work for Project 1, below.

In addition, further research showed that SRW's Asset Management division is already in the process of reviewing the department's flow meter program, including goals, if/how data from the flow meters could be useful in the near and long-term, and costs of continued operations of the flow meters. The SRW Energy and Sustainability Team will work with Asset Management to identify potential energy inefficiencies within the system as appropriate, as part of the team's work pertaining to energy account monitoring and department-wide energy efficiencies. As such, flow meters operations will not be evaluated as part of this EOP.

2.8 Scope of Work Bullets for Short-Listed Projects

Bulleted scope-of-work tasks were developed for each short-listed project.

1. Utility Management System (UMS)

- Describe how a UMS could facilitate decision-making and track energy efficiency and cost improvements pertaining to Local Ops projects, including those listed in this technical memo.
- Determine options for a UMS for SRW that would:
  - Allow managers to easily monitor energy (kWh and therms) and cost ($) data on a per meter and/or facility basis, at minimum using monthly data and preferably also using real-time data.
  - Aggregate data from multiple sources such as PG&E and Sonoma Clean Power, as well as the City's IFAS, CMMS, and SCADA systems.
  - Present data in a customizable dashboard format that is easy for staff and management to use.
  - Produce clean visuals such as graphs and charts that show trends over time.
- Evaluate potential UMS options considered by SRW (e.g., SmartWorks, EnergyCAP, UMPro, Facility Dude) as well as others.
- Provide a recommendation on which system(s) would work best for SRW, and explain why.
- Create a Tech Memo with recommendations and Action Plan.

2. Optimizing Pump Sequencing Logic

- Calculate the specific energy (kWh per million gallons pumped) for appropriate Local Ops pumps.
- Examine the existing on/off logic and operating regime for appropriate pumps, and determine if turning them on or off earlier could optimize energy use and lower costs.
- Determine if the pump sequence logic is operating to meet the established operational parameters for the least amount of energy use possible.
- Evaluate how the UMS could be used to help track and report the success (energy and cost) of implementing pump sequencing logic, and inform future management decisions.
- Create a Tech Memo with recommendations and Action Plan.

3. Pump Efficiency Program

- Develop a list of all Local Ops pumps including: their size, age, annual energy use, and energy cost.
- Review all recent existing pump efficiency tests.
- Coordinate with the existing PG&E pump efficiency testing program to conduct efficiency tests on pumps without recent tests.
- Benchmark the efficiency of each Local Ops pump.
- Do an analysis to determine which pumps could cost-effectively be retrofitted with new high efficiency pumps.
- Evaluate how the UMS could be used to help track pump efficiency, report on energy and cost improvements resulting from implementation of identified measures, and inform future management decisions.
- Create a Tech Memo with recommendations and Action Plan.

4. SCADA Programming

- Use the applicable data and information gathered and analyzed in the SubRegional EOP Energy Management System investigation.
- Review and understand existing Local Ops SCADA system uses and strategies for optimizing energy use and cost.
- Identify additional strategies to increase energy efficiency and reduce costs (e.g., fist-on-first-off strategies based on pump efficiency).
- Describe operational impacts of the strategies.
- Identify SCADA programming and equipment needs to implement strategies and estimate their cost-effectiveness.
- Evaluate how the UMS could interface with SCADA programming for effective tracking and reporting on implementation of identified measures.
- Create a Tech Memo with recommendations and Action Plan.

5. Solar Project

- Use the applicable data and information gathered and analyzed in the SubRegional EOP Solar PV investigation.

- Develop a list of potential solar PV sites and apply site evaluation criteria to each site.
- Create a short-list of three potential sites and do a cost-effectiveness analysis on these sites.
- Evaluate how the UMS could be used to help track data from implementation of solar projects, and inform future management decisions.
- Create a Tech Memo with recommendations and Action Plan.

6. Variable Frequency Drives

- Identify current uses of VFDs and evaluate their effectiveness.
- Identify opportunities for using additional VFDs and possible replacement of existing inefficient VFDs; assess potential energy reduction and cost savings.
- Describe their operational impacts.
- Conduct a cost-effectiveness analysis on appropriate strategies.
- Evaluate how the UMS could be used to help track energy and cost impacts associated with VFD management, and inform future management decisions.
- Create a Tech Memo with recommendations and Action Plan.

7. Time-Of-Use (TOU) Rate Optimization

- Identify applicable TOU rate schedules for appropriate Local Ops PG&E accounts.
- Identify opportunities and strategies to optimize TOU rates to reduce cost and energy use.
- Describe their operational impacts.
- Identify necessary SCADA reprogramming and equipment needs and estimate capital costs of appropriate strategies.
- Determine energy and cost savings, and conduct a cost-effectiveness analysis on appropriate strategies.
- Evaluate how the UMS could be used to track and report on energy and cost savings associated with TOU rate optimization, and inform future management decisions.
- Create a Tech Memo with recommendations and Action Plan.

2.9 Next Steps

Kennedy/Jenks would work with City staff to develop a proposal for conducting the bulleted scope-of-work items for the short-listed projects, with a budget and schedule. The City would submit the proposal for approval by the BPU.

Attachments

1. Workshop Agenda
2. Workshop PowerPoint
3. Workshop Voting Results Spreadsheet

AGENDA

City of Santa Rosa
Local Operations Division
Energy Optimization Plan
Brainstorming Workshop
February 25, 2016 (9:00 – Noon)

Time	Minutes	Agenda Item
9:00 – 9:20	20	Introductions
9:20 – 9:50	30	Why are we here? Workshop purpose
9:50 – 10:20	30	Local ops Accomplishment List
10:20 – 11:20	60	Brainstorm Project Ideas
11:20 – 11:35	15	Dot Process
11:35 – 11:55	20	Short-List of Project Review
11:55 – 12:00	5	Next Steps
12:00		Adjourn

Energy Optimization Plan: Lowering Operating Costs While Saving Energy and GHGs

Brainstorming Workshop

Santa Rosa – Local Operations Division
Alan Zelenka - Energy Services Leader
February 25, 2016

Kennedy/Jenks Consultants

AGENDA

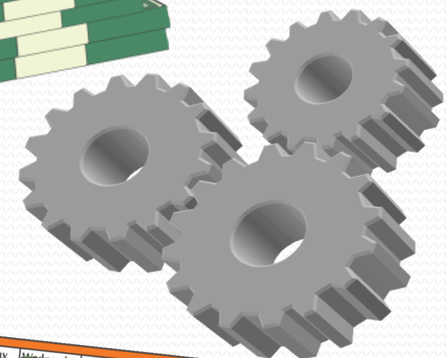
1. Introductions
2. Why Are We Here?
3. Local Ops Accomplishments List
4. Brainstorm Project Ideas
5. Dot Process
6. Short-List of Projects
7. Next Steps
8. Adjourn (at Noon)

Why Are We Here?

Opportunity!

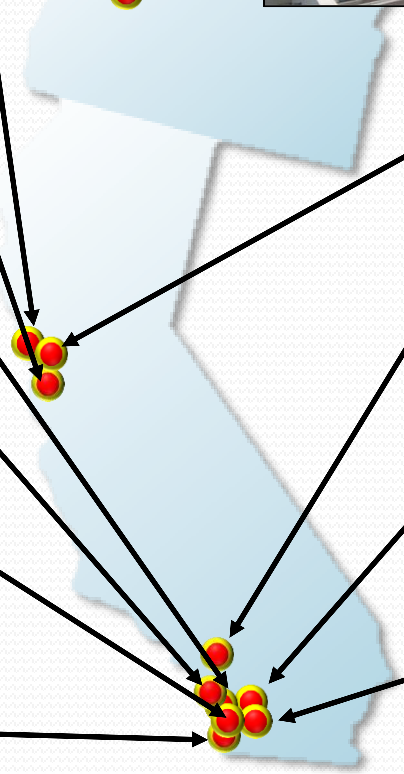
Primary Benefits From An EOP

- **Lowers Your Operating Costs**
- **Optimizes Your Operations & Improves Your Infrastructure**



- **Quick Payback**

An Actionable Plan To Guide Future Decision Making



2009 Oregon Association of Clean Water Agencies, OR

2009 ACEC Oregon Statewide Project-of-the-Year
2009 AAEE Grand Award for Planning

2015 Santa Rosa Utilities Department, CA

2012 scwd² Desalination Plant, Santa Cruz, CA

2012 Irvine Ranch Water District, CA
2012 AWWA/CA-NV Outstanding Energy Management Award

2010 Huntington Beach Desalination Plant, CA

2011 Encina Wastewater Authority, CA

2009 Carlsbad Desalination Plant, CA
2009 ACEC Engineering Excellence Award

2012 Bay Area Regional Desalination Project, CA

2014 City of Camarillo, CA

2014 Riverside Water Utility, CA

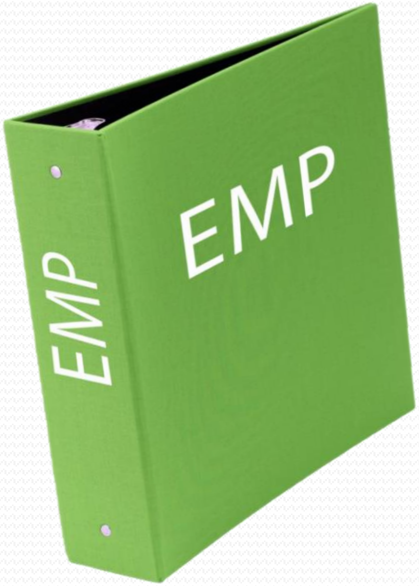
2014 Eastern Municipal Water District, CA
2014 AWWA/CA-NV Outstanding Energy Management Award

Kennedy/Jenks Consultants

Everybody Has Already Done Quite A Bit

Cogeneration/WTE

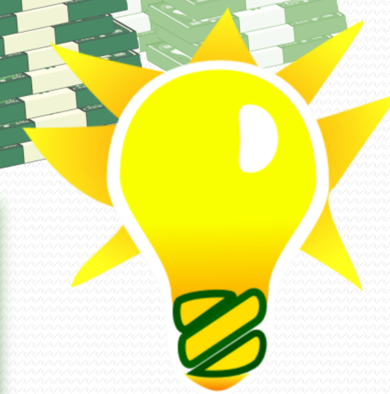
Renewables/ Solar PV



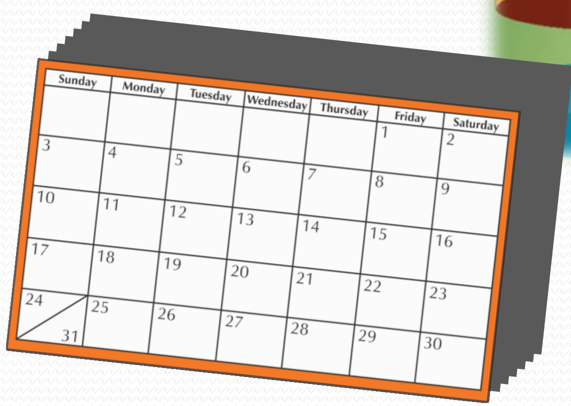
Energy Efficiency

An EOP will take you to the next level of savings!

Savings Are Substantial



- $5 Million per Year
- $100 Million Cumulatively
- 865 Million kWh
- 336,000 MTs of GHGs
- Payback of Less Than One Year



Case Study Results

	IRWD	Riverside	Eastern
Short-Listed Projects	9	12	7
Annual Net Savings	$1.4 M	$1.3 M	$1.2 M
Cumulative Net Savings	$23.7 M	$26.3 M	$24.2 M
Cumulative kWh Saved	127 Million	215 Million	205 Million
Metric Tons of CO_2 Reduced	53,000	69,200	59,000

Santa Rosa Subregional EOP (so far …)

Projects investigated	5
Annual Net Savings	$427,000
NPV of Cumulative Savings	$7.3 Million

Subregional Energy Audits

1. Laguna Treatment Plant
2. Geysers
3. Recycled Water
4. Composting

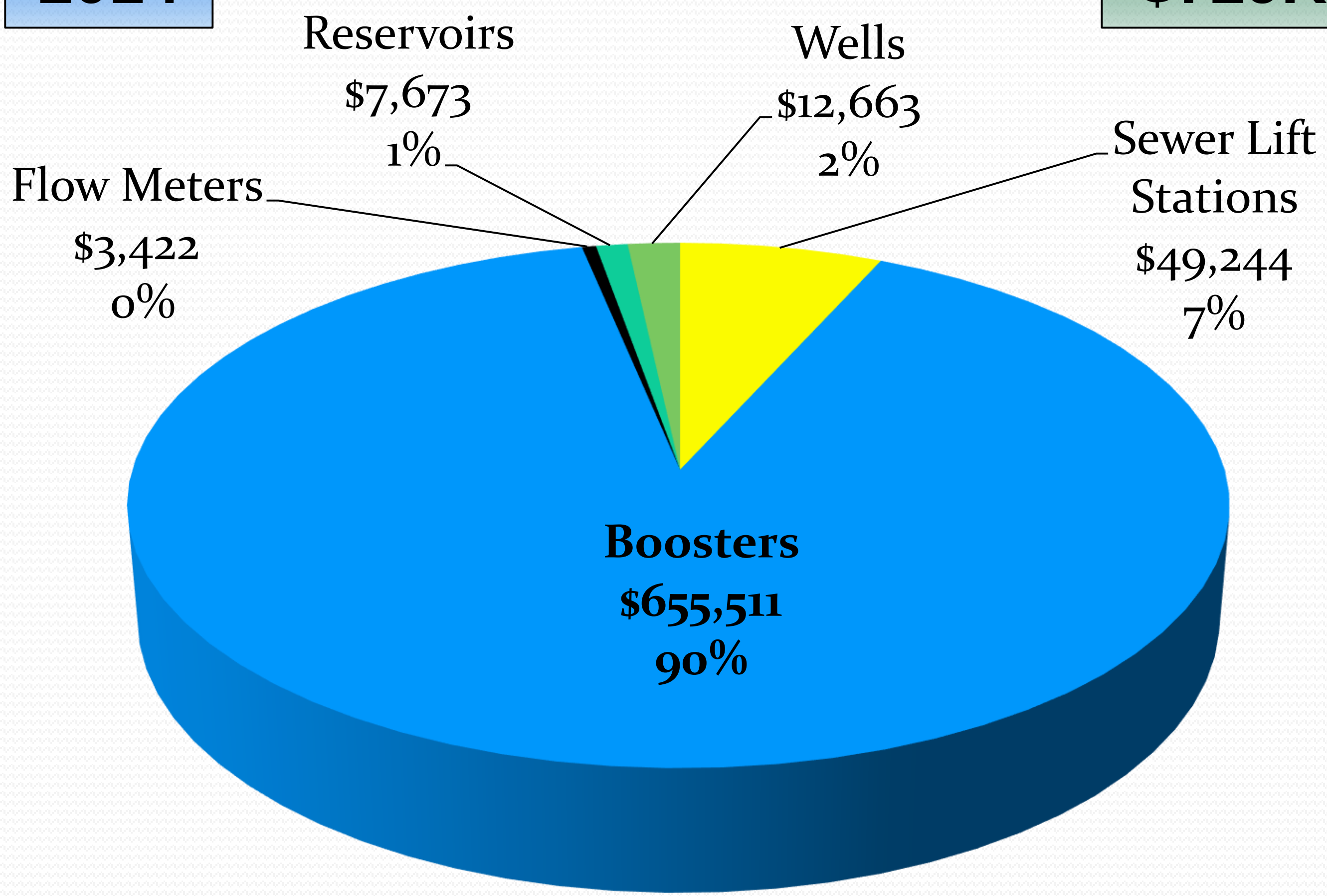
Subregional Brainstorming Workshop

- Workshop Resulted in 49 Potential Projects
- Narrowed Down to Five Projects To Investigate:
  1. Waste Heat
  2. Energy Management Software
  3. Irrigation System Optimization
  4. Solar PV
  5. Mechanical Digester Mixing

Local Ops Energy Use & Cost

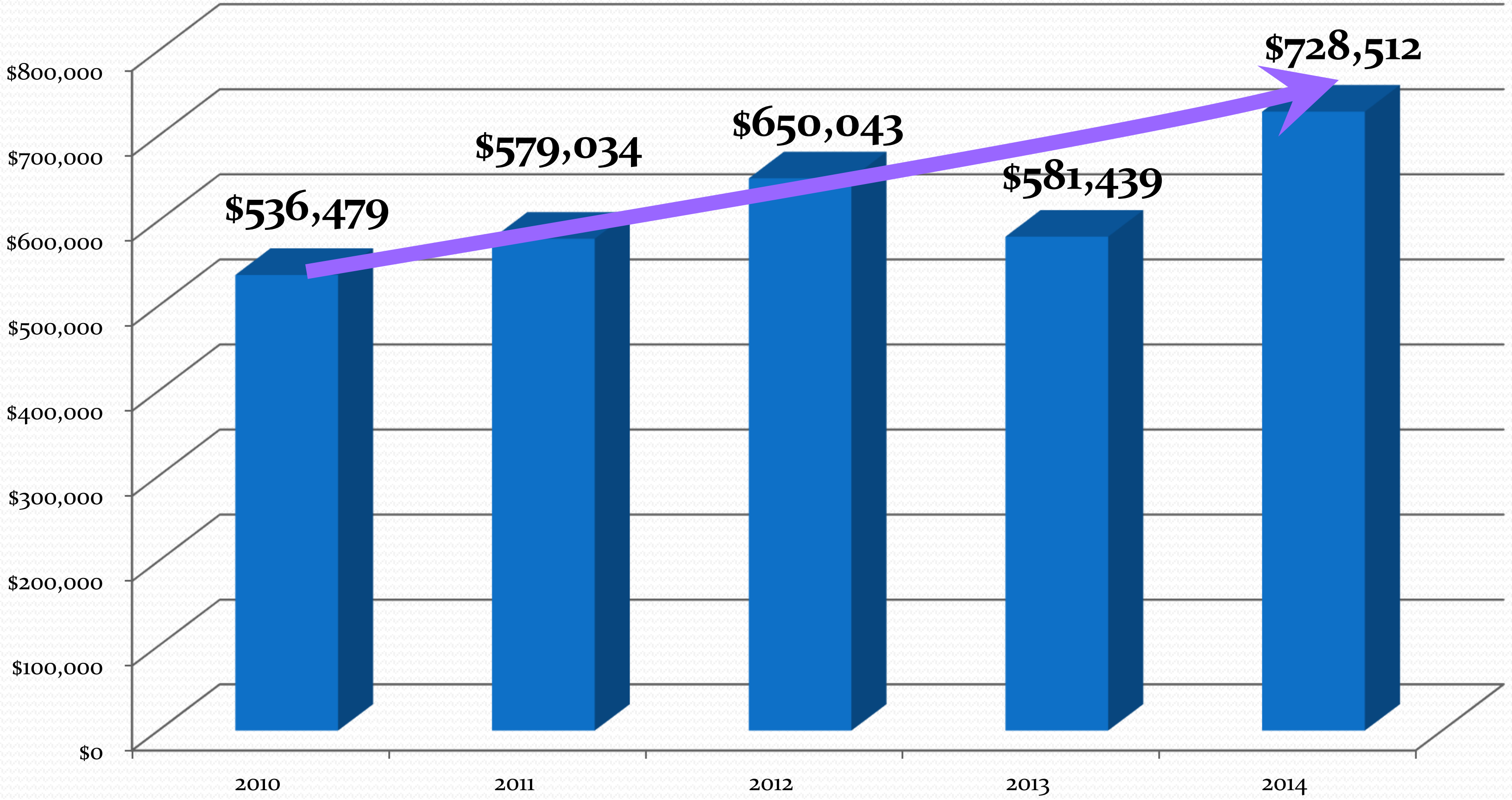
2014

$729K

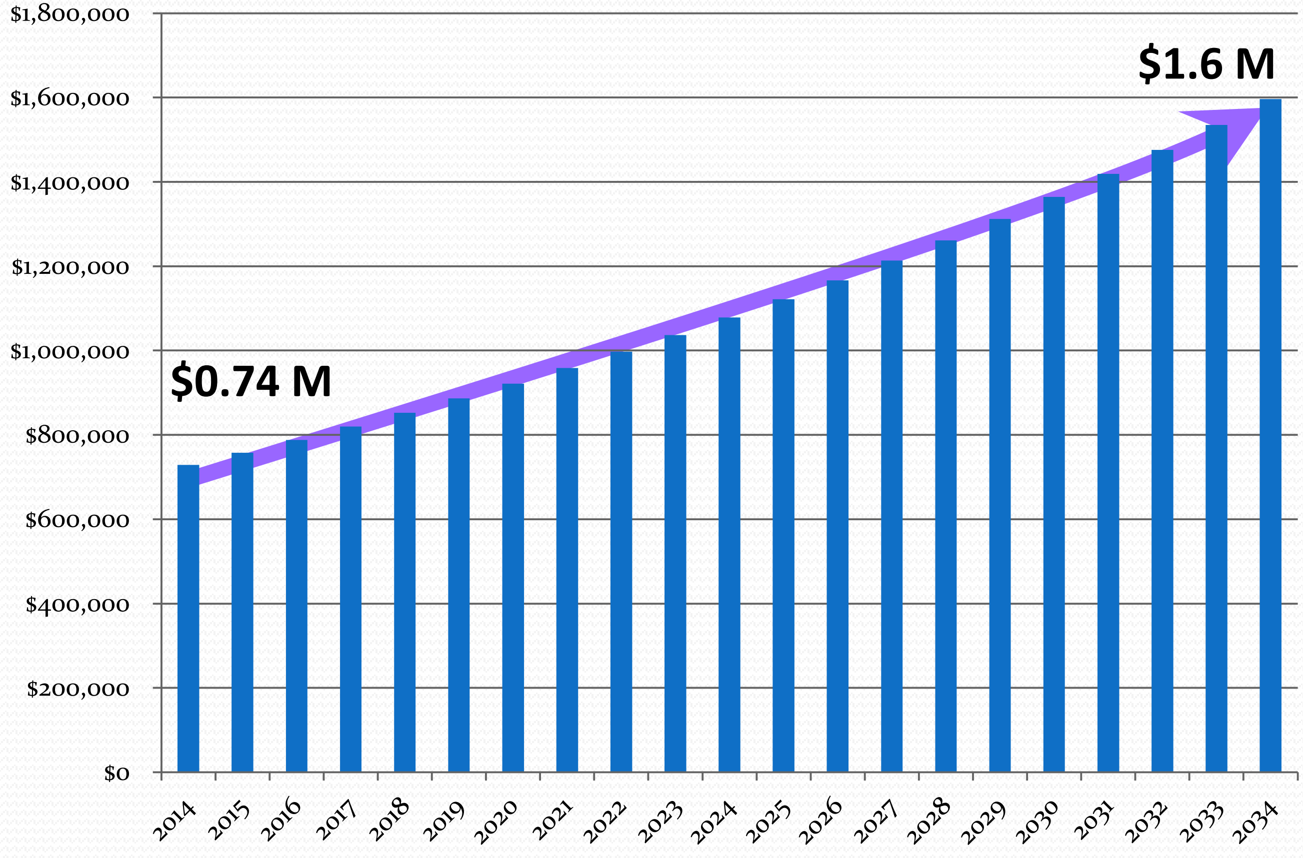


Kennedy/Jenks Consultants

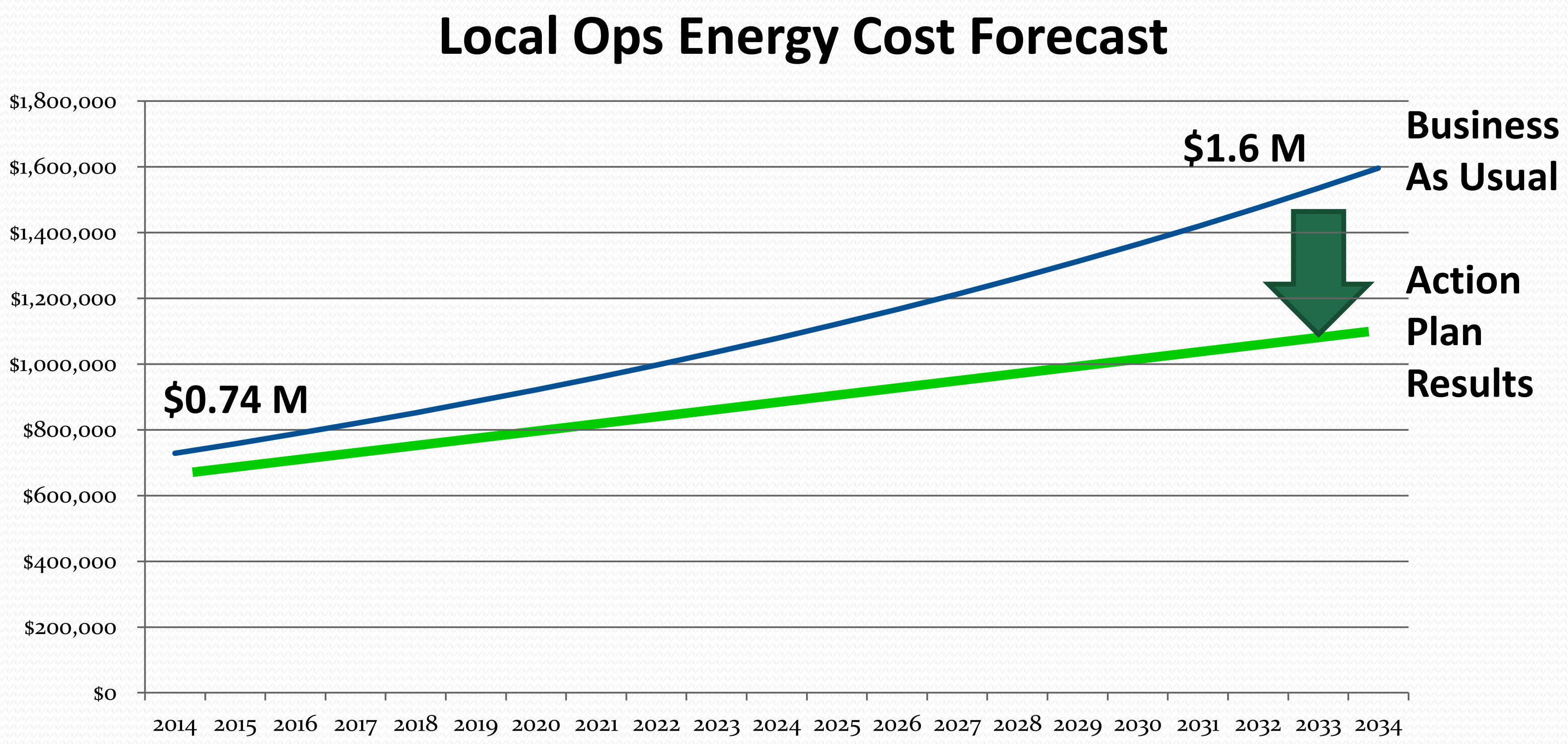
Local Ops - Recent Energy Costs



Forecast of Energy Costs



Reducing Energy Costs Is The Goal



Kennedy/Jenks Consultants

Local Ops Accomplishment List

- TOU – pumping at night (1992)
- Premium Efficiency Motors purchasing (most efficient available)
- Station 9 reduced pumping by replumbing & VFDs Station 4 (1993)
- Pump Efficiency Testing (PG&E program with rebates on retrofits) (2005-7 baseline on all pumps
- Reconditioning motors during maintenance
- UFO Lighting & LEDs
- Solar PV Projects
- UFO LEED Building Standard (probably Gold level)
- Reservoir solar PV small projects
- Leveraging SCADA (use data and O&M)
- Optimize Maintenance Trips/Fleet Logistics/Efficiency by Geography using a map grid system
- Fleet (CNG, hybrids & propane truck, engine sizing according to task/need, looking to hydrogen as the fuel of the future)
- Sewer Lift Station 11 controller (2007) switch from on/off, pump upgrade
- Oakmont Treatment Plant (modifying VFD settings away warm stand-by)
- Forward thinking about energy ie – conduit for solar and EVs

Project Idea Screening

SCADA Projects

Sewer Lift Stations

Recycled Water Projects

Optimize Pump Sequencing

Fleet Fuel Reductions

Renewable Energy Credits

Pump Efficiency

Fleet Fuel Reductions

Water Conservation

Microhydro

Wind Power

Solar Power

Brainstorming Projects

- Optimizing Pump Sequencing Logic
- Pump Efficiency Program
- VFDs
- SCADA (FO/FO)
- SCADA Projects Assessment
- Energy Management Software
- Solar Project
- Sewer Lift Station Efficiency
- Fleet Fuel Reductions
- Purchase RECs and/or GHG Offsets
- Purchase Renewable/Green Power
- Water Conservation Programs
- Graywater & Rainwater Programs
- Micro-Hydro (inline)
- Recycled Water Projects
- Sequestration Projects
- TOU Rate Optimization and Rate Schedule and submetering
- Well Efficiency Program
- Reservoir Efficiency
- AMI/(Irrigation Optimization)
- I&I Energy Impacts
- Solar Water Heater Rebate Program

Brainstorming Projects

- **Retrofit Hydro Pneumatic tanks w/wo VFDs**
- **Unused collection system Flow meters**

Dot Process

- Everybody Gets the Same Number of Dots
- Vote For The Project That You Believe Will Yield the Best Results
- One Dot Per Project
- When You Are Done Take A Break
- We Will Total the Dots and Rank the Projects

Next Steps

- Scope of Work, Budget and Schedule
- BPU Approval and Funding
- Project Assessments
- Action Plan
- Implementation

Short-List of Projects

Santa Rosa - Local Ops EOP
Brainstorming Workshop

#	Rank	Votes	Dots	Project
1		10		Optimizing Pump Sequencing Logic
2		10		Pump Efficiency Program (testing, benchmarking & retrofits)
4		8		SCADA (FO/FO)
7		7		Solar Project
3		5		VFDs
24		5		Flow Meters
17		4		Time-Of-Use Rate Optimization (TOU)
9		1		Fleet Fuel Reductions (no idle, hybrids, CNG, biodiesel)
21		1		I&I Energy Impacts (on pumping and treatment)
23		1		Htdro Pneumatic Tanks
10		0		Purchase RECs and/or GHG Offsets
11		0		Purchase Renewable/Green Power
12		0		Water Conservation Programs
13		0		Graywater & Rainwater Programs
14		0		Micro-Hydro (inline)
15		0		Recycled Water Projects
16		0		Sequestration Projects
19		0		Reservoir Efficiency
22		0		Solar Water Heater Rebate Program
5				SCADA Projects Assessment
6				Energy Management Software
8				Sewer Lift Station Efficiency
18				Well Efficiency Program (testing, benchmarking & retrofits)
20				AMR/Irrigation Optimization

30 January 2018

Final Technical Memorandum #3

To: Joe Schiavone, Ron Marincic, Rick Santarini, Jason Tibbals, Simon Hood, Claire Myers, and Tasha Wright– City of Santa Rosa

From: Alan Zelenka, Project Manager, Kennedy/Jenks

Subject: Task 1 – Utility Management Systems Investigation
Santa Rosa Energy Optimization Plan (EOP) – Part 2
K/J Project: 1368024*04

3.1 Purpose of this Investigation

The purpose of Task 1 – Utility Management Systems (UMS) Investigation was to:

- Describe how a UMS could facilitate decision-making and track energy efficiency and cost improvements pertaining to Water Operations' projects, including those listed in this scope of work.
- Evaluate how, and to what degree, the "SmartCity" or "SmartWorks" UMS (by Harris Utilities) would, or would not, achieve the following objectives:
    - Allow managers to easily monitor energy use (kilowatt hours [kWh] and therms) and cost ($) data on a per meter and/or facility basis, at minimum using monthly data, and preferably also using real-time data.
    - Aggregate data from multiple sources such as Pacific Gas & Electric (PG&E) and Sonoma Clean Power (SCP), as well as the City's IFAS, CMMS (current and upcoming), and SCADA systems.
    - Present data in a customizable dashboard format that is easy for staff and management to use.
    - Produce clean visuals such as graphs and charts that show trends and projections over time.
- Evaluate up to five other UMS options necessary to meet needs not met by SmartCity (e.g., Wonderware, Motors@Work, EnergyCAP, UMPro, Facility Dude, and others).
- Provide a recommendation on which system(s) would work best for Water Operations and explain why.

3.2 Summary of Recommendations

Kennedy/Jenks recommends further investigation into the benefits associated with billing and account tracking from using the SmartWorks software, energy efficiency measure (EEM) 3-1. Proceeding with the pilot could help the City identify and quantify its benefits. However, it is unclear, but not probable, that energy savings alone could justify the cost of SmartWorks.

Kennedy/Jenks also recommends that the City further investigate a pump optimization software suite such as Specific Energy (EEM 3-2). Using a reasonably conservative savings estimate of 10%, Table 3-1 shows that the Specific Energy software could be a cost-effective energy efficiency measure for the City. Savings from the $222,000 capital investment could be $39,000 per year on average, with a Net Present Value (NPV) over its 20-year life of $566,000. Kennedy/Jenks recommends as a next step a webinar demonstration of Specific Energy software optimization suite, and to solicit an implementation proposal and cost estimate. If implemented, the City should consider a pilot study using Specific Energy on the top seven energy consuming water pump stations (sometimes referred to as “Booster” stations).

Table 3-1: Summary of Recommended Energy Efficiency Measure Savings

Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Emission Reduction (MT/Yr)	Net Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	NPV of Cumulative Net Savings ($)	Rate of Return (%)	Cumulative GHG Reductions (MT)
263,400	$51,200	27	$222,500	$21,200	$39,000	$566,100	14.8%	535

3.3 SmartWorks Software Background

SmartWorks is a UMS developed by Harris Utilities. It was originally designed for large commercial and industrial companies to more easily track numerous energy accounts across multiple utility providers. Data inconsistencies and discrepancies for these accounts were often difficult to identify and track. SmartWorks was designed to help companies better track the accounts, monitor and report utility costs, and help fix data problems. The City of Santa Rosa is the first large municipal utility to test SmartWorks.

In 2016-2017, Harris Utilities provided the City a demonstration version of SmartWorks program, using real City data for water pump stations. Harris Utilities subsequently provided a “proof concept” proposal on July 24, 2017, which proposes a scope of work for fully implementing SmartWorks for all Santa Rosa Water Department energy meters. According to Harris Utilities, the benefits include:

- Reduced time that City employees invest in resolving utility account problems.
- Reduced account uncertainty through accurate reporting and monitoring.
- Improved financial tracking.
- Increased energy efficiency.

Harris Utilities conducted a webinar on June 20, 2017 for Kennedy/Jenks and City project staff, and created a temporary log-on account so Kennedy/Jenks could explore the demonstration version of the SmartWorks software.

3.4 SmartWorks Software Description

SmartWorks creates a single database of:

- Utility account information including account identifiers and meter numbers.
- Utility billing data, including rate schedules and costs.
- Energy use by Time-of-Use (TOU) periods and 15-minute interval energy and demand data.

The software can handle multiple sources of account data and will download data from both PG&E and SCP.[1] PG&E data could be automatically downloaded using PG&E's "Share My Data" tool. Entering SCP data would require SCP to create a spreadsheet and provide it to Harris Utilities for entry.

Once the database was populated with account data SmartWorks would continually analyze for missing data, analyze for inconsistencies and changes, identify new meters and new accounts, and, if found, deliver exception-based email messages or alerts (e.g., alert the City when data is abnormal). It would also identify accounts with changes to the Service Agreement ID (SAID) number, meter number, address, or location.

SmartWorks has a robust reporting system and can create ten different reports from a menu on the dashboard, including:

- **Usage Overview** – shows energy use in a bar graph over a specified period for a meter or group of meters (e.g., all the water pump stations).
- **Combined Usage** – shows a stacked bar, pie chart, or numerical table for a meter or group of meters.
- **Coincident Peak** – shows a stacked bar, pie chart, or numerical table for a meter or group of meters.
- **Meter Usage Chart** – shows a bar chart for a single meter.
- **Meter Usage by Billing Period** – shows a bar chart for a single meter for the Summer or Winter Peak, Partial-Peak and Off-Peak periods.
- **Time Period Comparison** – single meter line graph over specified period.
- **Threshold Tracking** – tracks single meter energy use or cost above or below a specified threshold for specified period.
- **Cost Calculation** – shows a cost table by TOU period for a specified period for a single meter.
- **Time Series Plot** – shows a line graph over specified period for a single meter or multiple meters.

[1] PG&E and SCP provide the same energy data, but each provide their own cost data. Therefore, getting the full cost of energy requires adding cost data from PG&E and SCP.

- **Key Performance Indicators (KPI)** – there are multiple reports that can be created under this report title:
  - Cost Estimate – shows a bar graph for a single meter for a specified period.
  - Load Factor - shows a bar graph for a single meter for a specified period.
  - Max Usage – shows a bar graph for a single meter or multiple meters for a specified period.
  - Meter Usage Comparison – shows a bar graph comparing two meters for a specified period.
  - Total Usage – shows a bar graph for a single meter or multiple meters for a specified period.
  - Usage During Time Window - shows a bar graph for a single meter for a specified period, but not for TOU time periods.

Threshold warnings for most of the above KPIs can be set and shown visually on the dashboard with either a traffic light, thermometer, speedometer, or an icon.

Not all reports can be created for a group of meters; some reports can be created for only one meter at a time.

Finally, SmartWorks can create individual customized dashboards that can show any of the reports, and are discussed in more detail below in Section 3.6.3.

3.5 Other City UMS Software

3.5.1 Wonderware

Wonderware 2014R2 is the SCADA human machine interface (HMI) software widely used by City staff. Technical Memo #6 describes how the City's SCADA system works, and identifies opportunities for energy efficiency measures. Overview SCADA screens summarize real-time status including flows, pressures, and levels.

3.5.2 EnergyCAP

Doug Williams, the City Facilities Manager, reported that EnergyCAP was purchased by his predecessor, Mark Armstrong. It was used to track facility energy use, but staff had to input all the data manually. In the time that Mr. Williams has been Facilities Manager he has not had time to investigate using the program other than asking PG&E about automating the data upload, which they indicated could be possible. He would like to use EnergyCAP to track facility energy use and costs and monitor buildings, but that is only likely if the downloading of data can be automated. The City should consider comparing EnergyCAP to SmartWorks to determine how redundant they would be in capturing and presenting account data and energy use and cost information.

3.6 SmartWorks Evaluation

This section is an evaluation of the energy and cost monitoring, data aggregation, and reporting capabilities of the SmartWorks software (EEM 3-1).

3.6.1 Monitoring Energy Use and Cost

SmartWorks was designed to track utility accounts and bills, and to monitor energy use and costs. It does these functions very well. The reports and charts supplied by SmartWorks can provide managers with excellent data that will allow them to easily understand the details of their energy use and cost.

This capability is particularly important because most city managers and operators do not see, on a regular basis, the energy use and cost for which they are responsible. Getting this information in front of the people that use the equipment is an essential element of increasing energy efficiency in Water Operations.

SmartWorks can set up different types of email alerts should a meter, or group of meters, exceed threshold levels of energy use or cost. The thresholds can be determined by the user. For example, an alert could be set up for the group of water pump stations to monitor their TOU Peak period energy use. If any of the water pumps were to use Peak period energy, SmartWorks would send an alert email to City staff. This could inform managers and operators of energy use that occurred during this expensive Peak period, allowing corrective action to be taken, if feasible, to ensure it does not happen in the future.

Harris Utilities seems eager to adapt their software for the City. The pilot that they are proposing would make the City the first large utility to use SmartWorks. This “proof of concept” pilot would provide Harris Utilities the opportunity to refine their software for this type of client. If successful it could open up a large new market for SmartWorks. This makes them eager to make this pilot work and be successful, and this benefit to Harris Utilities appears to be reflected in the price of the pilot. This software program is very adaptable and can potentially be programmed to meet most of the City’s needs, but to accomplish this goal, it would likely require substantial effort on the part of the City. Having said that, as proposed to the City SmartWorks is more a tool for analyzing the past than optimizing the future because there is not the ability at present to telemeter energy usage and flows in real time.

3.6.2 Aggregating Data

SmartWorks can automatically download PG&E account, energy use, and cost data using PG&E’s “Share My Data” program. SmartWorks would immediately populate the database as soon as it is received without any effort by Harris Utilities or the City (i.e., no labor hours are required). PG&E takes 1.5 to 2 days to review and release the data through the “Share My Data” program; SmartWorks is therefore limited by the speed at which it can get the data from PG&E. With this delay the City cannot get energy use and cost data in real time. SmartWorks allows for analysis and operational changes to optimize energy use and costs based only on historical data, looking backwards. It is possible to download meter reads on a 15-minute interval through a cellular connection.

It is not an automatic process to download SCP cost data. It must first be manually downloaded into a spreadsheet and then the spreadsheet would need to be manually entered into the SmartWorks database. Fortunately, the downloading of the data into the SmartWorks database is included in the price of the pilot. Getting data from SCP and then inputting it into SmartWorks would at best take several days, and would not be in real time.

The SCP and PG&E cost data are automatically added together within SmartWorks to provide a total energy cost.

Flow data from the City's SCADA system could be automatically uploaded into the SmartWorks. While this is not part of the pilot it could be added to the pilot for an additional fee. Flow data and energy use data are both necessary to calculate a pump's specific energy (kWh per million gallons pumped). However, there are several issues that would need to be resolved for this information to be provided. First, SmartWorks does not currently provide a report or a KPI for specific energy, but this could be added for an additional fee. Second, monthly data for PG&E, SCP, and flow may have meter reads from different dates making it difficult to match-up the data. To overcome this problem, one could potentially match-up 15-minute interval data, or daily data, but this would require all three sources to use the same interval level.

3.6.3 Dashboards and Visuals

To increase energy efficiency in operations and reduce costs, SRW decision-makers must be aware of the energy use and cost of the systems they manage because one cannot manage what one doesn't measure. This important data can be conveyed through the dashboard.

For a dashboard to be successful, it must be easy to create, easy to access, and provide information that can be used to increase energy efficiency and lower costs. Shown in Figure 3-1, the SmartWorks dashboard allows users to customize windows and reports. The dashboard is easy to access and use on a daily basis, although would take a small initial investment on the part of the City of time and technical assistance for managers and operators to be able to learn and set up their own dashboards. For example, Kennedy/Jenks staff were able, within 3 hours, to learn the software and create their own dashboard. They created a dashboard window (see Figure 3-2) for the energy use and cost of all water pump stations for the past year, and an energy "usage during time window" report for water pumps that used energy during the Peak TOU period. (noon to 6:00 pm).

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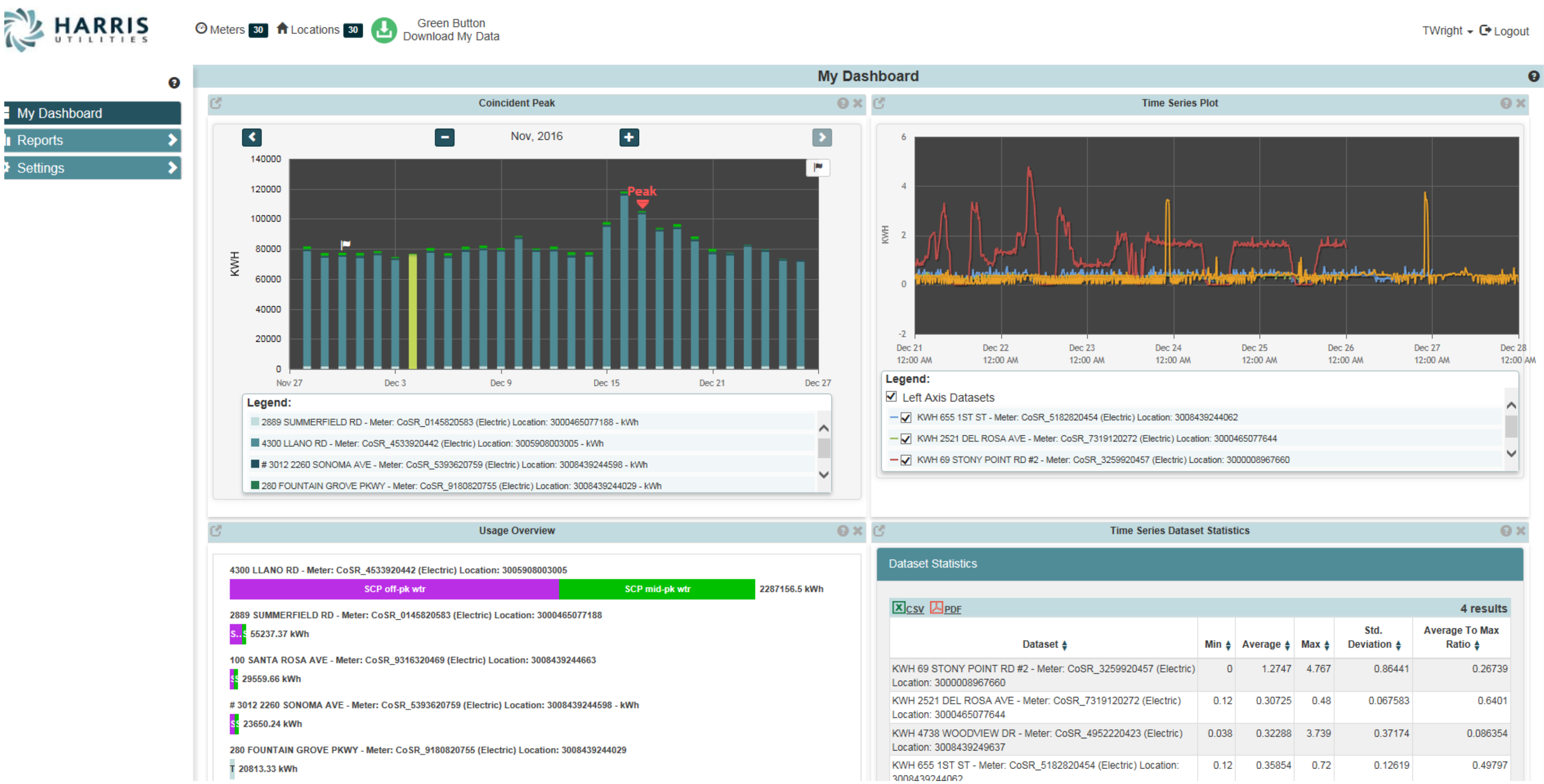

Figure 3-1: SmartWorks Dashboard

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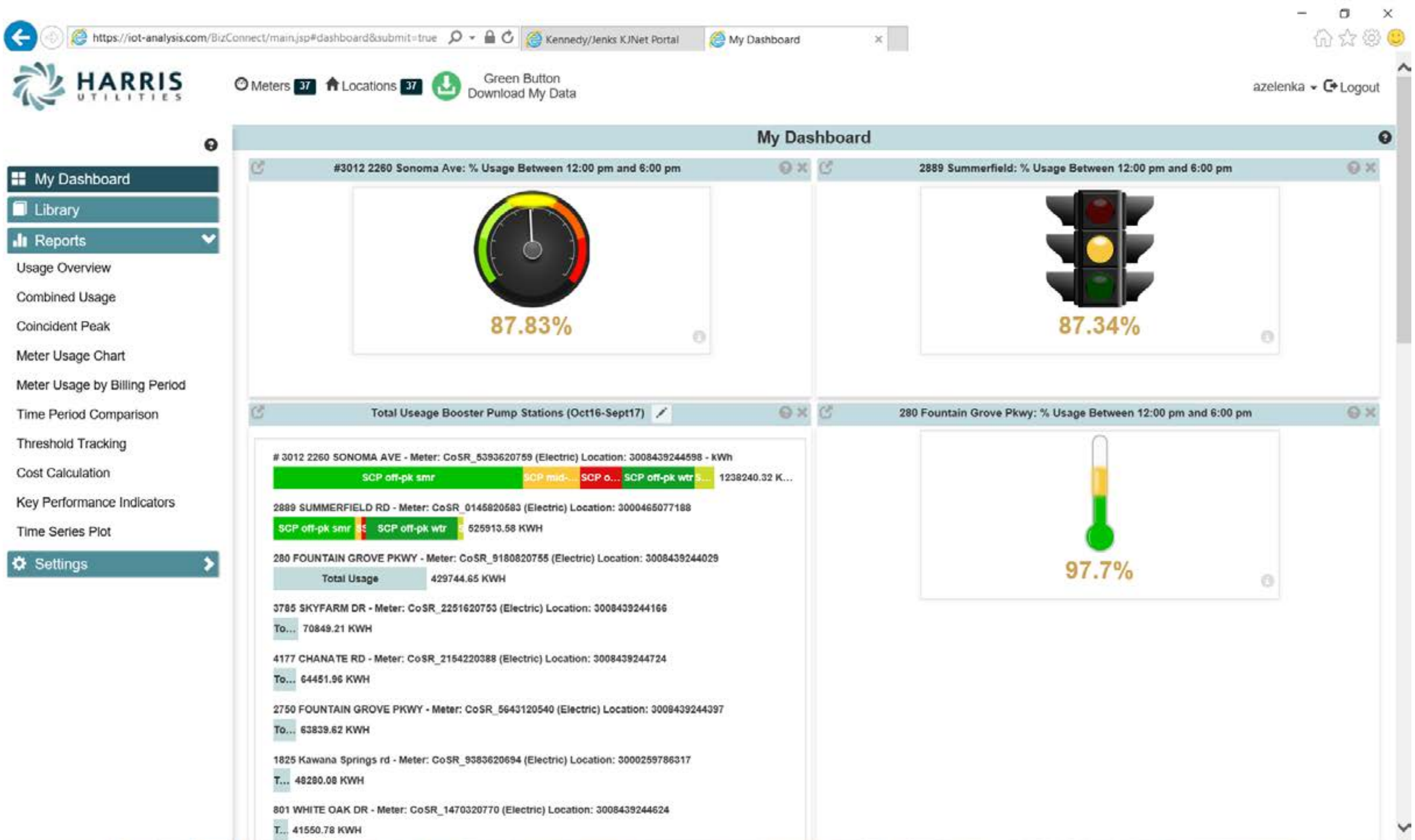

Figure 3-2: Water Pump Station Dashboard Created by Kennedy/Jenks

Another dashboard use would be to identify near and long-term trends of energy use for key equipment, and setting up an alert based on deviations from benchmarked or “targeted” expected values for energy use and cost. These alerts could identify spikes in energy use that could indicate equipment or operational problems, and this information could be used to modify operations that would lower costs and energy use.

The most useful and effective energy efficiency metric for Water Operations is the specific energy (kWh/Mgal) metric for pumps at water pump stations. Since these pumps account for 90% of Water Operations electricity costs, using the specific energy of pumps to optimize energy costs could provide Water Operations with significant savings. SmartWorks was not initially designed to be an energy optimization tool; it was designed to do billing and account tracking. It could be adapted with a substantial amount of effort, changes, and expense to deliver energy efficiency, and it would be possible to eventually create dashboard windows that showed the specific energy of water pump stations and individual pumps. But the main problem with using SmartWorks for this purpose is the timeliness of the data. It is not real-time data, and for the foreseeable future could not be real time data. Using historic data that is at least 2 days old or older is a much less effective tool for optimizing pumps, because it would not allow operational adjustments immediately in real time. Making adjustments to optimize pumps 2 days later may not result in any savings.

3.7 Energy Optimization Software

In contrast to SmartCity, other UMS software is designed from the ground up to do energy efficiency and optimization. This section discusses a relatively new energy management system that is designed to optimize energy use of pump stations by using real time monitoring and pump data, to enable the City to efficiently and sustainably manage and continually operate pump stations at peak efficiency.

3.7.1 Pump Optimization Energy Efficiency Measure Description

Currently banks of pumps are run to equalize run-time on each pump. While a classic or traditional asset management approach, this does not optimize energy use and cost savings. Operating the bank of pumps based on their specific energy metric (kWh/Mgal pumped) would optimize energy use and lower costs. Pump optimization is discussed in detail in Technical Memorandum #4 – Optimizing Pump Sequencing Logic.

By calculating the specific energy of each pump within the same pump station, the more efficient pumps have been identified (see Technical Memorandum #4). An operating regime could then be developed to use the more efficient pumps first (those with a lower specific energy metric) and the least efficient pumps last (those with a higher specific energy). Following this operating regime would optimize pumping for a given pump station, thereby reducing energy use and lowering operating costs. The primary targets for this analysis would be the 13 water pump stations. However, to optimize the operations of these pumps, detailed energy use data, flow data, and specific energy data is required.

One software package that is designed from the ground up to optimize the energy use of pumps and pump stations is called “Specific Energy.” This software was developed a few years ago by a Texas water engineering firm because they simply could not find a water pump station energy optimization software package.

According to the developer, Specific Energy "determines the most efficient combination of pumps and speeds to maximize efficiency while delivering the required flow. As system conditions change throughout the day" their software "ensures the station continues to operate at peak efficiency while assuring that each pump operates within its preferred operating range at all times." The software suite can also manage peak demand and optimize TOU rate savings. The software suite can be used in information only mode or in full authority mode, either providing advisory information to operators or working with the plant SCADA system to automatically optimize operations. Access to the software is through the internet. This software is currently being used by the Cities of Dallas and Houston, as well as others.

This Technical Memorandum analyzes a pilot project where the City would install the Specific Energy software only on the top seven water pump stations (EEM 3-2). Those 25 pumps use over 80% of the total water pump station energy. Installation and utilization of Specific Energy software would require energy meters for the 18 pumps that do not already have variable frequency drives at a total installed cost of approximately $115,000. The purchase and installation of the Specific Energy software suite would cost about $47,500 and there would be an annual software license fee of $8,500. Specific Energy stated that separate flow meters on each pump was not necessary. In fact, they preferred one common flow meter for the entire pump station; therefore, we did not assume any costs for additional flow meters. EEM 3-2 assumes an incremental staff labor increase requirement of about 4 hours per week. This project would likely be eligible for PG&E's Customized Incentive program (granting 8 cents per kWh saved and $150 per KW reduced). Specific Energy reports a range of 5% to 38% savings from existing installations depending on how much optimization they are currently doing, and this result is consistent with our professional judgment and experience with other energy optimization software packages.

3.7.2 Results

The EEM 3-2 analysis assumes the Specific Energy software optimization suite would reduce water pump station energy use by 10%, a conservative point within Specific Energy's range of savings. This would save approximately 263,000 kWh per year, which equates to an average annual net savings of over $39,000 per year, a Net Present Value (NPV) of $566,000, and a rate of return on the $222,000 investment of nearly 15%. Greenhouse gas (GHG) emission would be reduced over 535 metric tons over 20 years. Without the incentive the project is still cost-effective with a rate of return on the $243,750 investment of 13.3%.

Table 3-2: Summary of EEM 3-2, Installing Specific Energy Software

Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Emission Reduction (MT/Yr)	Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	Rate of Return (%)	Cumulative GHG Reductions (MT)
263,400	$51,200	27	$222,500	$21,200	$39,000	$779,700	$566,100	14.8%	535

The savings from EEM 3-2 depends greatly on the assumption of the amount of savings that can be gained from optimizing the operations of the water pump stations. Accordingly, the cost-effectiveness spreadsheet was run using different savings percentages. Table 3-3 shows the

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average annual net savings differences based on different percent efficiency gains from using the Specific Energy software. To break even, Specific Energy would need to save just over 4%.

Table 3-3: Estimated Savings Comparisons

Savings Percentage (%)	Estimated Annual Energy Savings (kWh)	Estimated Annual Net Savings ($/Year)	NPV of Cumulative Net Savings ($)	Rate of Return (%)	Cumulative GHG Reductions (MT)
5%	131,700	$6,300	$91,500	-4.9%	268
10%	263,400	$39,000	$566,500	14.8%	535
15%	395,100	$71,700	$1,040,800	28.7%	803
20%	526,800	$104,400	$1,515,500	43.0%	1,071
25%	658,500	$137,000	$1,990,200	58.7%	1,338

3.8 Recommendations

3.8.1 Recommendation #1

Kennedy/Jenks recommends further investigation into the benefits associated with billing and account tracking from using the SmartWorks software (EEM 3-1). Proceeding with the pilot could help the City identify and quantify these benefits. However, it is unclear, but not probable, that energy savings alone could justify the cost of SmartWorks.

3.8.2 Recommendation #2

Kennedy/Jenks also recommends that the City further investigate a pump optimization software suite such as Specific Energy (EEM 3-2). The purchase and use of the Specific Energy software could be a cost-effective EEM for the City. We recommend as a next step a webinar demonstration of Specific Energy software optimization suite, and to solicit an implementation proposal and cost estimate. If implemented, the City should consider a pilot study using Specific Energy on only the top seven energy using water pump stations.

Attachments

- Specific Energy Software Suite brochure
- Cost-Effectiveness Spreadsheet for EEM 3-2

26 January 2018

Final Technical Memorandum 4

To: Joe Schiavone, Ron Marincic, Rick Santarini, Jason Tibbals, Simon Hood, Claire Myers, and Tasha Wright – City of Santa Rosa

From: Rod Houser, P.E., BCEE, Project Investigation Lead, Kennedy/Jenks
Alan Zelenka, Project Manager, Kennedy/Jenks

Subject: Task 2 – Optimize Pump Sequencing Logic Investigation
Santa Rosa Energy Optimization Plan (EOP) – Part 2
K/J Project: 1368024*04

4.1 Purpose of this Investigation

The purpose of Task 2, Optimize Pump Sequencing Logic Investigation, was to:

- Calculate the specific energy (kWh per million gallons pumped) for Water Operations potable water station pumps, from information provided by Santa Rosa Water (SRW).
- Examine the existing on/off logic and operating regime for appropriate water station pumps, and determine if turning them on or off earlier could optimize energy use and lower costs.
- Determine if the pump sequencing logic is operating to meet the established operational parameters for the least amount of energy use possible.
- Evaluate how the Utility Management System (UMS) could be used to help track and report the success (energy and cost) of implementing pump sequencing logic, and inform future management decisions.

4.2 Summary of Recommendations

The recommended energy efficiency measure (EEM) 4-1 would have the City reprogram the pump sequencing logic at the City's water pump stations (a.k.a. Boosters) to optimize energy savings and lower operating costs. Presently, automation logic programmed into the City's programmable logic controllers (PLCs) causes the pumps to alternate LEAD, LAG, and STANDBY duty to balance runtime evenly across all the operating units within a given pump station. However, balancing runtime across units does not take into consideration that all the pumps are not equally efficient in the energy required to pump a given volume of water, i.e., the "specific energy" or kilowatt-hours per million gallons pumped (kWh/Mgal). Under an optimized sequencing system, pump(s) with the lowest specific energy are prioritized, rather than balancing runtime across all units.

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Santa Rosa Water Operations EOP – Part 2: Task 2 – Optimize Pump Sequencing Logic

Table 4-1: Recommended Energy Efficiency Measure

EEM	EEM Title
4-1	Optimize Pump Sequencing Logic at Water Pump Stations

The potential savings from the recommended EEM is summarized in Table 4-2, below. With an incentive from PG&E, the EEM would create a net annual average savings for the City of approximately $4,500 per year. Cumulatively, over 20 years, it would save nearly $91,000, with a Net Present Value (NPV) of $65,000 with almost no capital cost, resulting in a rate of return of over 500%. Even without an incentive, the average annual net savings are $4,300, and the NPV of cumulative net savings is almost $61,000.

Table 4-2: Summary of Recommended Energy Efficiency Measure Savings

	Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Emission Reduction (MT/Yr)	Net Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	IRR (%)	Cu Re
With Incentive	**25,000**	**$4,400**	**3**	**$700**	**$4,700**	**$4,500**	**$90,900**	**$65,300**	**528%**	
Without Incentive	**25,000**	**$4,400**	**3**	**$5,400**	**$0**	**$4,300**	**$86,200**	**$60,800**	**48%**	

4.3 Background Information and System Description

During the first part of the EOP for Water Operations Kennedy/Jenks determined that the water pump stations consumed 84% of Water Operations' electricity while sewer lift stations only consume 6%. This is because water station pumps deliver water at much higher pressures compared to sewer pumps, and the additional pressure requires more energy. To provide the greatest overall value from the investigation it made sense to focus this investigation on only the water pump stations.

All the City's water pump stations are started and stopped automatically using PLCs. These controllers are typically configured in such a way as to cause a LEAD pump to start when water level drops sufficiently in a receiving storage tank. The LEAD pump runs while the water level in the tank returns to the "full" setpoint, at which time the PLC stops the pump. The next time water level drops sufficiently to start a pump, the PLC designates a different pump to be LEAD. In this way the PLC should balance runtime across all the pumps within a given pump station. This causes all the pumps to be routinely exercised, which is a common asset-management practice, but it does not minimize energy use and it is not always a cost-effective strategy.

While it is the City's intent to balance runtime across all units within a given pump station, this has not always been the case at every facility. Therefore, historical runtime records for each pump were used to characterize baseline energy usage across the equipment lineup.

Annual water production volumes and energy use (for the period from 2014 through 2016) was also gathered for each pump station. This data, summarized in Table 4-3, is used to establish a baseline for the operations of each pump station.

Table 4-3: Santa Rosa's Water Pump Stations

Water Pump Station	Name	Average Annual Volume (Mgal/Year)	Average Daily Volume (gal/min)	Average Annual Energy Usage 2014 to 2016 (kWh/Year)
S-1	Fountain Grove 1	277	526	396,000
S-2	Fountain Grove 2	210	399	236,000
S-3	Fountain Grove 3	51	96	36,000
S-4	Station 4	292	555	1,186,000
S-4B	Proctor	n/a	n/a	n/a
S-4R	Murdock	n/a	n/a	n/a
S-5	Skyfarm	10	20	70,000
S-6	Rincon 1	59	111	193,000
S-7	Rincon 2	197	374	145,000
S-8	Skyhawk	17	33	28,000
S-9	Bennett Valley	300	570	461,000
S-9-BV	Bennett Valley	n/a	n/a	n/a
S-10	Woodview	n/a	n/a	n/a
S-11	Kawana	59	112	58,000
S-12	Oakmont	133	254	71,000
S-13	Wild Oak 1	21	40	44,000
S-14	Wild Oak 2	14	27	32,000
S-15	Meadowridge	10	19	35,000
S-16	Fountain Grove 4	82	157	87,000
S-17	Fountain Grove 5	75	143	84,000
S-18	Fountain Grove 6	17	32	15,000

Grayed-out Stations, S-4B (Proctor) and S-4R (Murdock) are in limited use, and they were not evaluated in this optimization study.

The City has periodically monitored pump efficiency and energy performance at their water pump stations using PG&E's free pump efficiency testing program. Through the program PG&E

pays for performance tests on any pump larger than 25 horsepower. As part of the test the City receives a detailed report for each pump tested, and the data is tabulated in a spreadsheet that can be used to analyze and track pump performance. For many of the pumps the last test performed was in 2005. In July 2017 the City was able to have 53 pumps tested through the PG&E program. Information collected from these tests is used in this investigation to estimate energy savings.

4.4 Specific Energy

A list of all the water pump station pumps and their respective pump sizes are listed in Table 4-4. The table also lists the specific energy that was measured during the July 2017 round of performance tests. For pumps where data was not available the table shows a “n/a”.

Table 4-4: Summary Results from Water Pump Station Pump Tests

Water Pump Station	Name	Pump Number	Pump Size (HP)	Specific-Energy (kWh/Mgal)
S-1	Fountain Grove 1	Station 1 P1	125	1,187
		Station 1 P2	125	1,185
		Station 1 P3	125	1,216
		Station 1 P4	125	1,205
S-2	Fountain Grove 2	Station 2 P1	100	919
		Station 2 P2	100	979
		Station 2 P3	100	962
		Station 2 P4	100	955
S-3	Fountain Grove 3	Station 3 P1	40	806
		Station 3 P2	40	839
		Station 3 P3	100	1,007
S-4	Station 4	Station 4 P1	150	1,350
		Station 4 P2	150	1,350
		Station 4 P3	150	1,354
S-5	Skyfarm	Station 5 P1	50	1,267
		Station 5 P2	50	1,173
		Station 5 P3	300	1,210

Water Pump Station	Name	Pump Number	Pump Size (HP)	Specific-Energy (kWh/Mgal)
S-6	Rincon 1	Station 6 P1	125	831
		Station 6 P2	125	800
		Station 6 P3	125	794
S-7	Rincon 2	Station 7 P1	50	726
		Station 7 P2	50	702
		Station 7 P3	50	735
S-8	Skyhawk	Station 8 P1	75	823
		Station 8 P2	75	793
S-9	Bennett Valley	Station 9 P1	300	1,117
		Station 9 P2	300	1,083
		Station 9 P3	300	1,098
		Station 9 P4	75	617
		Station 9 P5	75	624
S-9-BV	Bennett Valley	n/a	n/a	n/a
S-10	Woodview	n/a	n/a	n/a
S-11	Kawana	Station 11 P1	75	636
		Station 11 P2	75	654
		Station 11 P3	75	680
S-12	Oakmont	Station 12 P1	40	633
		Station 12 P2	40	650
		Station 12 P3	40	631
S-13	Wild Oak 1	Station 13 P1	40	1,379
		Station 13 P2	75	1,429
		Station 13 P3	75	1,395
S-14	Wild Oak 2	Station 14 P1	40	909
		Station 14 P2	50	966

Water Pump Station	Name	Pump Number	Pump Size (HP)	Specific-Energy (kWh/Mgal)
		Station 14 P3	50	1,022
S-15	Meadowridge	Station 15 P1	n/a	n/a
		Station 15 P2	n/a	n/a
		Station 15 P3	50	1,616
S-16	Fountain Grove 4	Station 16 P1	75	859
		Station 16 P2	75	881
S-17	Fountain Grove 5	Station 17 P1	75	881
		Station 17 P2	75	961
S-18	Fountain Grove 6	Station 18 P1	30	297
		Station 18 P2	30	298

There are a few notes about the above table:

- Because pumps under 25 HP are not tested in the PG&E program there was no data available for S-10 (Woodview), or for P1 and P2 at S-15 (Meadowridge).
- Two of the pumps listed for Water Pump Station 9 (Bennett Valley), P4 & P5, deliver water to a different zone (Hydraulic Grade Line or HGL of 219' to 224') compared to the remaining three pumps that were tested at that facility (HGL of 347'). Staff noted that P4 and P5 are no longer in service, and there are no plans to replace them.
- Water Pump Station 4 at 39.85 Hertz was not associated with a pump station, and is on its own meter.

4.5 Overview of Methodology

EEM 4-1 would have the City reprogram the pump-sequencing logic at the City's water pump stations to optimize energy savings and lower operating costs. As described in Section 4.3, current automation logic programmed into the City's PLCs cause the pumps to alternate LEAD, LAG, and STANDBY duty to balance runtime evenly across all the operating units within a given pump station. However, balancing runtime across units does not take into consideration that all the pumps are not equally as efficient in the energy required to pump a given volume of water, i.e., the "specific energy" (kWh/Mgal). Under an optimized sequencing system pump(s) with the lowest specific energy are prioritized, rather than balancing runtime across all units.

In addition, at most pump stations the LAG and STANDBY pumps are rarely needed because all the demand can usually be accommodated with a single pump, i.e., the LEAD pump. This means that the LEAD pump will do most of the pumping, until the sequencing designation is changed. The City can use this as an opportunity to replace or rebuild the STANDBY pump, as time and maintenance priorities allow.

The cost of implementing this EEM is negligible. It focuses exclusively on changed operational practices, without new equipment and capital cost, by taking advantage of actionable data that the City obtains through PG&E's free pump testing program. All work to modify pump sequencing logic can be performed by City staff who routinely perform maintenance on the City's SCADA system. For purposes of performing a cost-effectiveness analysis, a recurring (every 5 years) cost of $5,400 was estimated to cover the City's effort to reprogram sequencing logic at each of the 18 pump stations. This is based on the assumption that it will take one PLC technician approximately 2 hours to modify and test the logic at each of the 18 pump stations. The "loaded cost" for this labor was estimated at $150 per hour. Including this cost is a conservative assumption in that the $5,400 is redirected staff time rather than a new incremental capital cost.

Under an optimized sequencing system, once the new logic is established it remains static until a new performance test reveals a different pump with lowest specific energy. Typically, this would be every 4 to 5 years under a preventive maintenance program for a given pump station; in the cost-effectiveness analysis we assumed the test would occur every 5 years, even though PG&E pays for testing on 2-year intervals. The City would also retest the pumps and reprogram the pump sequencing designations whenever one or more units within a pump station were replaced, repaired or rebuilt.

These tests can be done through the free PG&E pump testing program, but also can be performed at the City's convenience using existing instrumentation. For example, most variable frequency drives (VFDs) that the City owns measure and display power delivered to a pump. Existing flowmeters can be used to measure flow produced by the same pump. Taken together, these two values determine the specific energy for that pump. Alternatively, hand-held instruments can be used to measure power delivered to a pump if that capability is not available from the existing VFD or motor starter.

For this analysis, to determine the energy savings associated with EEM 4-1, the specific energy for each individual pump at a pump station was determined. Then the energy use of the pump station using the most efficient pump, i.e., the one with the lowest specific energy, was compared to the energy use of the pump station using the average specific energy from all the pumps. The difference in the two scenarios is the estimated energy savings that could be achieved by changing the pump sequencing logic.

The following example illustrates how the baseline annual energy usage was estimated for each pump. We used Water Pump Station S-7 as an example:

- Historical average annual production at S-7 has been approximately 197 Mgal/year.

- Historical runtime for P2 and P3 were 288% and 71% of the runtime of P1, respectively. Output of the three pumps was taken from PG&E performance testing (941 gpm, 941 gpm, and 950 gpm, respectively).

- Specific energy for each pump was taken from PG&E testing (726 kW/Mgal, 702 kW/Mgal, and 735 kW/Mgal, respectively).

- Baseline runtimes for each pump were then calculated to achieve the annual production (i.e., 197 Mgal/year) while using PG&E's performance data for pump output and energy usage. The relative runtimes for each pump were then adjusted to achieve the same distribution of runtime hours as was previously recorded, i.e., 100%, 288%, and 71%, respectively; and 759 hours, 2,186 hours, and 539 hours, respectively.

- Annual production for each pump was estimated by multiplying the output of a given pump by the estimated runtime (43 Mgal/year, 123 Mgal/year, and 31 Mgal/year, respectively).

- Annual energy usage for each pump was estimated by multiplying the annual production by the specific energy (31 MWh, 87 MWh, and 23 MWh), for a total of 140 MWh/year.

In contrast, optimized annual energy usage for pump station S-7 was estimated using the following methodology:

- The pump with the lowest specific energy (P2) was assumed to deliver nearly all the annual production for the pump station. It would operate as the LEAD pump in all cases until new test data revealed a more efficient pump at the pump station.

- The pump with the second-lowest specific energy (P1) was assumed to operate as a LAG pump. 24 hours of runtime was assumed for the LAG pump (P2) to account for the brief periods of time during the year when output from the LEAD pump would not provide adequate pumping.

- Runtime for the LEAD pump (3,465 hours) was estimated by dividing the annual production (197 Mgal/year) by the LEAD pump output (941 gpm), after subtracting the LAG pump contribution (1 Mgal/year).

- Annual production (196 Mgal and 1 Mgal) and energy usage (137 MWh and 1 MWh) for each pump was then estimated using the same method as the baseline calculations.

Energy savings from the optimized sequencing (2 MWh/year) is calculated as the difference from the baseline scenario (i.e., 140 MWh – 138 MWh).

At most pump stations output from a single pump will be adequate to meet all demands during a typical year. In these cases, a single LEAD pump is assumed to deliver all the demand, without supplementing the pumping with a LAG pump.

4.6 Recommended Energy Efficiency Measure

The table below shows the estimated savings and potential reduction in energy use from EEM 4-1 for each water pump station.

Table 4-5: Prioritized List of Water Pumps for Optimization

Water Pump Station	Name	Priority	Estimated Demand Reduction (KW)	Energy Savings (kWh/Yr)	Energy Savings (% Reduction)	Annual First Year Savings ($)
S-2	Fountain Grove 2	1	2.6	7,294	3.6%	$1,501
S-3	Fountain Grove 3	1	3.7	4,044	9.0%	$832
S-1	Fountain Grove 1	1	1.2	3,762	1.1%	$774
S-17	Fountain Grove 5	1	2.0	2,872	4.2%	$591
S-7	Rincon 2	1	0.6	2,001	1.4%	$412
S-12	Oakmont	1	0.4	1,012	1.2%	$208
S-11	Kawana	2	1.2	946	2.5%	$195
S-6	Rincon 1	2	1.7	816	1.7%	$168
S-14	Wild Oak 2	2	1.8	680	5.1%	$140
S-4	Station 4	2	0.1	414	0.1%	$85
S-13	Wild Oak 1	2	0.7	392	1.3%	$81
S-5	Skyfarm	2	0.8	384	3.2%	$79
S-8	Skyhawk	2	1.2	327	2.4%	$67
S-16	Fountain Grove 4	n/a	0	62	0.1%	$13
S-18	Fountain Grove 6	n/a	0	8	0.2%	$2

The greatest savings can be realized by implementing this optimized sequencing system on the first tier of six water pump stations:

1. Pump Station S-2, Fountain Grove 2
2. Pump Station S-3, Fountain Grove 3
3. Pump Station S-1, Fountain Grove 1
4. Pump Station S-17, Fountain Grove 5
5. Pump Station S-7, Rincon 2
6. Pump Station S-12, Oakmont

The second tier to be implemented is made up of the following seven water pump stations:

7. Pump Station S-11, Kawana
8. Pump Station S-6, Rincon 1
9. Pump Station S-14, Wild Oak 2
10. Pump Station S-4, Station 4
11. Pump Station S-13, Wild Oak 1
12. Pump Station S-5, Skyfarm

13. Pump Station S-8, Skyhawk

4.7 Results of Recommended EEM

The potential savings from EEM 4-1 are summarized in Table 4-6, below. With an incentive from PG&E, EEM 4-1 would create a net annual average savings for the City of nearly $4,500 per year. Cumulatively, over 20 years, it would save nearly $91,000, with a Net Present Value (NPV) of $65,000 with almost no capital cost, resulting in a rate of return of over 500%. Even without an incentive, the average annual net savings are $4,300, and the NPV of cumulative net savings is almost $61,000.

Table 4-6: Summary of Recommended Energy Efficiency Measure

	Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Emission Reduction (MT/Yr)	Net Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	IRR (%)	Cu Re
With Incentive	**25,000**	**$4,400**	**3**	**$700**	**$4,700**	**$4,500**	**$90,900**	**$65,300**	**528%**	
Without Incentive	**25,000**	**$4,400**	**3**	**$5,400**	**$0**	**$4,300**	**$86,200**	**$60,800**	**48%**	

4.8 Not-Recommended EEMS

Specific energy is already so low that there would be virtually no energy savings related to changing the pump sequencing logic at the following facilities:

- Pump Station S-16, Fountain Grove 4
- Pump Station S-18, Fountain Grove 6

While there would probably be no harm in implementing an "optimized" sequencing system at these facilities, there would be virtually no economic benefit to do so.

The following water pump stations are either too small (i.e., less than 75 HP) to qualify for PG&E's free testing program, or the City no longer plans to operate them on a regular basis:

- Pump Station S-4R, Murdock
- Pump Station S-9, Bennett Valley
- Pump Station S-10, Woodview
- Pump Station S-15, Meadowridge

4.9 Impact of Utility Management System on Pump Sequence Logic Optimization

A utility management system (UMS) could be used to track specific energy for each pump station, as well as for each pump. This information could be used to flag pumps that should be redesignated for LEAD or LAG service depending on performance relative to other pumps at the same station. Monitoring the specific energy is also an accurate way of identifying latent problems with the pump and motor system that would not otherwise be readily apparent from visual observations.

Implementing a UMS to optimize pump sequencing would require the following instrumentation:

- Power input to each motor: this can often be obtained from solid-state soft starters and VFDs. Alternatively, power-monitoring equipment can be installed at each motor starter or VFD for this purpose.
- Pump output: this can be provided from the station's flowmeter, but the data needs to be filtered to properly consider the impact of multiple pumps operating simultaneously.
- Suction and discharge pressures: this information can usually be provided from pressure transmitters installed on the suction and discharge manifolds.

Taken together, information provided by the instrumentation listed above provides the ability to calculate specific energy in real time, rather than every 5 years. When specific energy is monitored in real time through the City's existing SCADA system, or a future UMS, it allows alarm thresholds to be configured so staff can be alerted to abnormal conditions.

Some commercially available UMS packages also include modules for asset monitoring and condition assessment. These tools provide actionable information that can be used to predict failures and identify optimal maintenance intervals.

Attachment

- "Cost Effectiveness Tool EEM 4-1" spreadsheet.

26 January 2018

Final Technical Memorandum #5

To: Claire Myers, Tasha Wright, Joe Schiavone, Simon Hood, Jason Tibbals, Ron Marincic, and Rick Santarini – City of Santa Rosa

From: Leif Macrae, Project Investigation Lead, Kennedy/Jenks
Rod Houser, Project Investigation Lead, Kennedy/Jenks
Alan Zelenka, Project Manager, Kennedy/Jenks

Subject: Task 3 – Pump Efficiency Investigation
Santa Rosa Energy Optimization Plan (EOP) – Part 2
K/J Project: 1368024*04

5.1 Purpose of this Investigation

The purpose of Task 3 – Pump Efficiency Investigation was to:

- Develop a list of all Water Operations potable water pump station pumps, including: their size, age, annual energy use, and energy cost.
- Review all pump efficiency tests.
- Coordinate with the PG&E pump efficiency testing program to conduct efficiency tests on pumps without recent tests.
- Benchmark the efficiency of each pump with test data.
- Perform an analysis to determine which pumps could cost-effectively be retrofitted with new high efficiency pumps.
- Evaluate how a Utility Management System (UMS) could be used to help track pump efficiency, report on energy and cost improvements resulting from implementation of identified measures, and inform future management decisions.
- Provide guidelines for determining when and if the City should replace or rebuild a pump.

5.2 Summary of Recommendations

A cost-effectiveness analysis was performed on all water pump station pumps of 30 horsepower (HP) or greater that had an overall pumping efficiency less than 65%, to determine which ones could be cost-effectively retrofitted with new high efficiency pumps. This analysis indicates that no pumps are recommended for replacement or for rebuilding.

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Santa Rosa Water Operations EOP – Part 2: Task 3 – Pump Efficiency Investigation

5.3 Background Information and System Description

Water Operations manages distribution of potable water and the collection of sewage through a system of pipelines and pump stations. This Technical Memorandum assesses potential cost-effective energy efficiency measures for only the 17 potable water pump stations, because they account for the vast majority (84%) of Water Operations electricity costs, while sewer lift stations only account for 6% of electricity costs from 18 pumps. The analysis was limited even further by eliminating pumps below 30 HP because any savings from these pumps would be negligible. Therefore, this analysis includes 52 pumps from 17 water pump stations, ranging from 30 to 300 HP, with installation dates from 1973 to 2015.

5.4 Energy Use and Cost

The following tables list the pump sizes, year installed, age, year of rebuild if applicable, specific energy, electric rate, annual energy use, annual electricity cost, and overall pumping efficiency. The tables sort this data by five different key attributes:

1. Table 5-1: sorted by **station name and pump number**
2. Table 5-2: sorted by **specific energy (kWh/Mgal pumped)**
3. Table 5-3: sorted by **annual energy cost ($)**
4. Table 5-4: sorted by **overall pumping efficiency (OPE)**
5. Table 5-5: sorted by **year installed**

Table 5-6 shows all the above rankings in one table.

These tables are intended to be used by City staff as reference data and for benchmarking pump performance over time. For instance, City staff should focus on pumps with high specific energy numbers, high energy cost, low overall pump efficiency, and the oldest pumps. Several pumps were on several of the lists and should be closely monitored. If significant deterioration in a pump's data should occur, City staff should redo the cost-effectiveness calculation to determine if the City should replace the pump. The list of pumps to initially monitor is:

- Pump Station 15, Pump 3.
- All the pumps at Pump Station 6.
- All the pumps at Pump Station 4.

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Table 5-1: Water Pump Stations Sorted by Station Name and Pump Number

Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use[1] (kWh/Yr)	Energy Cost[2] ($/Yr)	Overall Pumping Efficiency (%)
Bennett Valley P4	50	1994	n/a	2005	361	$0.1812	0	High flow	62%
Franklin Murdock	30	2000	17	2016	1,321	$0.2000	14,822	$2,964	33%
Station 1 P1	125	n/a	n/a	2002	1,187	$0.1447	82,070	$11,876	67%
Station 1 P2	125	n/a	n/a	2002	1,185	$0.1447	81,955	$11,859	67%
Station 1 P3	125	n/a	n/a	2002	1,216	$0.1447	84,125	$12,173	65%
Station 1 P4	125	2018	n/a	n/a	1,205	$0.1447	83,367	$12,063	66%
Station 2 P1	100	1984	33	n/a	919	$0.2000	48,193	$9,639	71%
Station 2 P2	100	1984	33	n/a	979	$0.2000	51,381	$10,276	66%
Station 2 P3	100	1984	33	n/a	962	$0.2000	50,489	$10,098	67%
Station 2 P4	100	1984	33	n/a	955	$0.2000	50,114	$10,023	68%
Station 3 P1	40	2015	2	2015	806	$0.2251	20,434	$4,600	62%
Station 3 P2	40	2015	2	2015	839	$0.2251	21,276	$4,789	60%
Station 3 P3	100	2015	2	2015	1,007	$0.2251	0	High flow	52%
Station 4 P1	150	1981	36	n/a	1,350	$0.1618	131,405	$21,261	69%
Station 4 P2	150	1981	36	n/a	1,350	$0.1618	131,405	$21,261	69%
Station 4 P3	150	1981	36	n/a	1,354	$0.1618	131,821	$21,329	69%
Station 5 P1	50	1999	18	n/a	1,267	$0.1900	6,648	$1,263	54%
Station 5 P2	50	1999	18	n/a	1,173	$0.1900	6,157	$1,170	58%
Station 5 P3	300	1999	18	n/a	1,210	$0.1900	0	High flow	67%
Station 6 P1	125	1981	44	2002	831	$0.1523	16,232	$2,472	44%
Station 6 P2	125	1981	44	2017	800	$0.1523	15,631	$2,381	47%
Station 6 P3	125	1981	44	2017	794	$0.1523	15,521	$2,364	46%
Station 7 P1	50	1983	34	2002	726	$0.1484	47,607	$7,065	66%
Station 7 P2	50	1983	34	2016	702	$0.1484	46,039	$6,832	69%
Station 7 P3	50	1983	34	2002	735	$0.1484	48,191	$7,152	67%
Station 8 P1	75	2004	13	n/a	823	$0.1992	7,112	$1,417	73%
Station 8 P2	75	2004	13	n/a	793	$0.1992	6,850	$1,364	69%
Station 9 P1	300	2006	11	n/a	1,117	$0.2978	111,617	$33,239	73%
Station 9 P2	300	2006	11	n/a	1,083	$0.2978	79,893	$23,792	78%
Station 9 P3	300	2006	11	n/a	1,098	$0.2978	81,012	$24,125	77%
Station 9 P4	75	2006	11	n/a	617	$0.2978	24,174	$7,199	72%
Station 9 P5	75	2006	11	n/a	624	$0.2978	24,436	$7,277	74%

Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use[1] (kWh/Yr)	Energy Cost[2] ($/Yr)	Overall Pumping Efficiency (%)
Station 11 P1	75	2002	15	n/a	636	$0.1884	12,432	$2,342	48%
Station 11 P2	75	2002	15	n/a	654	$0.1884	12,797	$2,411	48%
Station 11 P3	75	2002	15	n/a	680	$0.1884	13,301	$2,506	46%
Station 12 P1	40	1985	32	2010	633	$0.1107	28,146	$3,116	67%
Station 12 P2	40	1985	32	2011	650	$0.1107	28,909	$3,200	64%
Station 12 P3	40	1985	32	2011	631	$0.1107	28,085	$3,109	67%
Station 13 P1	40	1996	21	n/a	1,379	$0.1615	6,030	$974	68%
Station 13 P2	75	1996	21	n/a	1,429	$0.1615	11,715	$1,892	69%
Station 13 P3	75	1997	20	n/a	1,395	$0.1615	11,440	$1,848	66%
Station 14 P1	40	1996	21	n/a	909	$0.1684	3,737	$629	66%
Station 14 P2	50	1996	21	n/a	966	$0.1684	4,960	$835	65%
Station 14 P3	50	1997	20	n/a	1,022	$0.1684	5,249	$884	62%
Station 15 P3	50	1994	23	n/a	1,616	$0.1822	16,119	$2,937	34%
Station 16 P1	75	1994	23	n/a	861	$0.1610	35,427	$5,704	66%
Station 16 P2	75	1994	23	n/a	859	$0.1610	35,368	$5,694	67%
Station 17 P1	75	1994	23	n/a	881	$0.1675	36,240	$6,070	66%
Station 17 P2	75	1994	23	n/a	961	$0.1675	39,556	$6,626	65%
Station 18 P1	30	1994	23	n/a	297	$0.2029	12,212	$2,478	45%
Station 18 P2	30	1994	23	n/a	298	$0.2029	12,253	$2,486	45%
WTP P1[3]	125	n/a	n/a	n/a	510	$0.0000	n/a	n/a	58%
WTP P2	125	n/a	n/a	n/a	538	$0.0000	n/a	n/a	55%

[1] Energy use is calculated by using a flow value that is allocated evenly based on average annual flow divided by the number of pumps. For stations with different sized pumps, the annual energy use is allocated based on rated flow.
[2] HFP = High Flow Pumps. They are not included in normal operation.
[3] WTP P1 and P2 are scheduled to be moved and replaced in 2019, with new pumps that will have VFDs.

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Santa Rosa Water Operations EOP – Part 2: Task 3 – Pump Efficiency Investigation

Table 5-2: Summary of Water Pump Stations Sorted by Specific Energy

This table sorts the pumps by Specific Energy. Specific energy is a metric (kWh/Mgal pumped) to compare the performance of pumps doing the same duty at a pump station. A high specific energy does not necessarily mean a pump should be replaced. For instance, it is likely to not be cost-effective to replace a high specific energy pump if it is not used very much. However, by using the pumps with the lowest specific energy, one can optimize a pump station's energy use.

Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use (kWh/Yr)	Energy Cost ($/Yr)	Overall Pumping Efficiency (%)
Station 18 P1	30	1994	23	n/a	297	$0.2029	12,212	$2,478	45%
Station 18 P2	30	1994	23	n/a	298	$0.2029	12,253	$2,486	45%
Bennett Valley P4	50	1994	n/a	2005	361	$0.1812	0	High flow	62%
WTP 1	125	n/a	n/a	n/a	510	$0.0000	n/a	n/a	58%
WTP 2	125	n/a	n/a	n/a	538	$0.0000	n/a	n/a	55%
Station 9 P4	75	2006	11	n/a	617	$0.2978	24,174	$7,199	72%
Station 9 P5	75	2006	11	n/a	624	$0.2978	24,436	$7,277	74%
Station 12 P3	40	1985	32	2011	631	$0.1107	28,085	$3,109	67%
Station 12 P1	40	1985	32	2010	633	$0.1107	28,146	$3,116	67%
Station 11 P1	75	2002	15	n/a	636	$0.1884	12,432	$2,342	48%
Station 12 P2	40	1985	32	2011	650	$0.1107	28,909	$3,200	64%
Station 11 P2	75	2002	15	n/a	654	$0.1884	12,797	$2,411	48%
Station 11 P3	75	2002	15	n/a	680	$0.1884	13,301	$2,506	46%
Station 7 P2	50	1983	34	2016	702	$0.1484	46,039	$6,832	69%
Station 7 P1	50	1983	34	2002	726	$0.1484	47,607	$7,065	66%
Station 7 P3	50	1983	34	2002	735	$0.1484	48,191	$7,152	67%
Station 8 P2	75	2004	13	n/a	793	$0.1992	6,850	$1,364	69%
Station 6 P3	125	1981	44	2017	794	$0.1523	15,521	$2,364	46%
Station 6 P2	125	1981	44	2017	800	$0.1523	15,631	$2,381	47%
Station 3 P1	40	2015	2	2015	806	$0.2251	20,434	$4,600	62%
Station 8 P1	75	2004	13	n/a	823	$0.1992	7,112	$1,417	73%
Station 6 P1	125	1981	44	2002	831	$0.1523	16,232	$2,472	44%
Station 3 P2	40	2015	2	2015	839	$0.2251	21,276	$4,789	60%
Station 16 P2	75	1994	23	n/a	859	$0.1610	35,368	$5,694	67%
Station 16 P1	75	1994	23	n/a	861	$0.1610	35,427	$5,704	66%
Station 17 P1	75	1994	23	n/a	881	$0.1675	36,240	$6,070	66%
Station 14 P1	40	1996	21	n/a	909	$0.1684	3,737	$629	66%

Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use (kWh/Yr)	Energy Cost ($/Yr)	Overall Pumping Efficiency (%)
Station 2 P1	100	1984	33	n/a	919	$0.2000	48,193	$9,639	71%
Station 2 P4	100	1984	33	n/a	955	$0.2000	50,114	$10,023	68%
Station 17 P2	75	1994	23	n/a	961	$0.1675	39,556	$6,626	65%
Station 2 P3	100	1984	33	n/a	962	$0.2000	50,489	$10,098	67%
Station 14 P2	50	1996	21	n/a	966	$0.1684	4,960	$835	65%
Station 2 P2	100	1984	33	n/a	979	$0.2000	51,381	$10,276	66%
Station 3 P3	100	2015	2	2015	1,007	$0.2251	0	High flow	52%
Station 14 P3	50	1997	20	n/a	1,022	$0.1684	5,249	$884	62%
Station 9 P2	300	2006	11	n/a	1,083	$0.2978	79,893	$23,792	78%
Station 9 P3	300	2006	11	n/a	1,098	$0.2978	81,012	$24,125	77%
Station 9 P1	300	2006	11	n/a	1,117	$0.2978	111,617	$33,239	73%
Station 5 P2	50	1999	18	n/a	1,173	$0.1900	6,157	$1,170	58%
Station 1 P2	125	n/a	n/a	2002	1,185	$0.1447	81,955	$11,859	67%
Station 1 P1	125	n/a	n/a	2002	1,187	$0.1447	82,070	$11,876	67%
Station 1 P4	125	2018	n/a	n/a	1,205	$0.1447	83,367	$12,063	66%
Station 5 P3	300	1999	18	n/a	1,210	$0.1900	0	High flow	67%
Station 1 P3	125	n/a	n/a	2002	1,216	$0.1447	84,125	$12,173	65%
Station 5 P1	50	1999	18	n/a	1,267	$0.1900	6,648	$1,263	54%
Franklin Murdock	30	2000	17	2016	1,321	$0.2000	14,822	$2,964	33%
Station 4 P1	150	1981	36	n/a	1,350	$0.1618	131,405	$21,261	69%
Station 4 P2	150	1981	36	n/a	1,350	$0.1618	131,405	$21,261	69%
Station 4 P3	150	1981	36	n/a	1,354	$0.1618	131,821	$21,329	69%
Station 13 P1	40	1996	21	n/a	1,379	$0.1615	6,030	$974	68%
Station 13 P3	75	1997	20	n/a	1,395	$0.1615	11,440	$1,848	66%
Station 13 P2P	75	1996	21	n/a	1,429	$0.1615	11,715	$1,892	69%
Station 15 P3P	50	1994	23	n/a	1,616	$0.1822	16,119	$2,937	34%

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Table 5-3: Water Pump Stations Sorted by Annual Energy Cost
This table sorts the pumps by their energy cost. High annual energy cost does not necessarily mean a pump should be replaced, it could simply indicate a large pump that is used often. To determine if it is cost-effective to replace a pump one should look at energy cost, along with its energy use and its OPE.

Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use (kWh/Yr)	Energy Cost ($/Yr)	Overall Pumping Efficiency (%)
Station 14 P1	40	1996	21	n/a	909	$0.1684	3,737	$629	66%
Station 14 P2	50	1996	21	n/a	966	$0.1684	4,960	$835	65%
Station 14 P3	50	1997	20	n/a	1,022	$0.1684	5,249	$884	62%
Station 13 P1	40	1996	21	n/a	1,379	$0.1615	6,030	$974	68%
Station 5 P2	50	1999	18	n/a	1,173	$0.1900	6,157	$1,170	58%
Station 5 P1	50	1999	18	n/a	1,267	$0.1900	6,648	$1,263	54%
Station 8 P2	75	2004	13	n/a	793	$0.1992	6,850	$1,364	69%
Station 8 P1	75	2004	13	n/a	823	$0.1992	7,112	$1,417	73%
Station 13 P3	75	1997	20	n/a	1,395	$0.1615	11,440	$1,848	66%
Station 13 P2	75	1996	21	n/a	1,429	$0.1615	11,715	$1,892	69%
Station 11 P1	75	2002	15	n/a	636	$0.1884	12,432	$2,342	48%
Station 6 P3	125	1981	44	2017	794	$0.1523	15,521	$2,364	46%
Station 6 P2	125	1981	44	2017	800	$0.1523	15,631	$2,381	47%
Station 11 P2	75	2002	15	n/a	654	$0.1884	12,797	$2,411	48%
Station 6 P1	125	1981	44	2002	831	$0.1523	16,232	$2,472	44%
Station 18 P1	30	1994	23	n/a	297	$0.2029	12,212	$2,478	45%
Station 18 P2	30	1994	23	n/a	298	$0.2029	12,253	$2,486	45%
Station 11 P3	75	2002	15	n/a	680	$0.1884	13,301	$2,506	46%
Station 15 P3	50	1994	23	n/a	1,616	$0.1822	16,119	$2,937	34%
Franklin Murdock	30	2000	17	2016	1,321	$0.2000	14,822	$2,964	33%
Station 12 P3	40	1985	32	2011	631	$0.1107	28,085	$3,109	67%
Station 12 P1	40	1985	32	2010	633	$0.1107	28,146	$3,116	67%
Station 12 P2	40	1985	32	2011	650	$0.1107	28,909	$3,200	64%
Station 3 P1	40	2015	2	2015	806	$0.2251	20,434	$4,600	62%
Station 3 P2	40	2015	2	2015	839	$0.2251	21,276	$4,789	60%
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Station 17 P1	75	1994	23	n/a	881	$0.1675	36,240	$6,070	66%
Station 17 P2	75	1994	23	n/a	961	$0.1675	39,556	$6,626	65%

Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use (kWh/Yr)	Energy Cost ($/Yr)	Overall Pumping Efficiency (%)
Station 7 P2	50	1983	34	2016	702	$0.1484	46,039	$6,832	69%
Station 7 P1	50	1983	34	2002	726	$0.1484	47,607	$7,065	66%
Station 7 P3	50	1983	34	2002	735	$0.1484	48,191	$7,152	67%
Station 9 P4	75	2006	11	n/a	617	$0.2978	24,174	$7,199	72%
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Station 1 P1	125	n/a	n/a	2002	1,187	$0.1447	82,070	$11,876	67%
Station 1 P4	125	2018	n/a	n/a	1,205	$0.1447	83,367	$12,063	66%
Station 1 P3	125	n/a	n/a	2002	1,216	$0.1447	84,125	$12,173	65%
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Station 4 P2	150	1981	36	n/a	1,350	$0.1618	131,405	$21,261	69%
Station 4 P3	150	1981	36	n/a	1,354	$0.1618	131,821	$21,329	69%
Station 9 P2	300	2006	11	n/a	1,083	$0.2978	79,893	$23,792	78%
Station 9 P3	300	2006	11	n/a	1,098	$0.2978	81,012	$24,125	77%
Station 9 P1	300	2006	11	n/a	1,117	$0.2978	111,617	$33,239	73%
Bennett Valley P4	50	1994	n/a	2005	361	$0.1812	0	High flow	62%
Station 3 P3	100	2015	2	2015	1,007	$0.2251	0	High flow	52%
Station 5 P3	300	1999	18	n/a	1,210	$0.1900	0	High flow	67%
WTP P1	125	n/a	n/a	n/a	510	$0.0000	n/a	n/a	58%
WTP P2	125	n/a	n/a	n/a	538	$0.0000	n/a	n/a	55%

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Table 5-4: Water Pump Stations Sorted by Overall Pumping Efficiency

This table sorts the pumps by their Overall Pumping Efficiency (OPE). The lower a pump's OPE, the more likely it could be cost-effectively replaced. Replacement will depend on a pump having low OPE combined with sufficient energy use and cost. For instance, a pump with a low OPE that is not used very often may not be cost-effective to replace.

Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use (kWh/Yr)	Energy Cost ($/Yr)	Overall Pumping Efficiency (%)
Station 9 P2	300	2006	11	n/a	1,083	$0.2978	79,893	$23,792	78%
Station 9 P3	300	2006	11	n/a	1,098	$0.2978	81,012	$24,125	77%
Station 9 P5	75	2006	11	n/a	624	$0.2978	24,436	$7,277	74%
Station 9 P1	300	2006	11	n/a	1,117	$0.2978	111,617	$33,239	73%
Station 8 P1	75	2004	13	n/a	823	$0.1992	7,112	$1,417	73%
Station 9 P4	75	2006	11	n/a	617	$0.2978	24,174	$7,199	72%
Station 2 P1	100	1984	33	n/a	919	$0.2000	48,193	$9,639	71%
Station 13 P2	75	1996	21	n/a	1,429	$0.1615	11,715	$1,892	69%
Station 4 P2	150	1981	36	n/a	1,350	$0.1618	131,405	$21,261	69%
Station 7 P2	50	1983	34	2016	702	$0.1484	46,039	$6,832	69%
Station 4 P1	150	1981	36	n/a	1,350	$0.1618	131,405	$21,261	69%
Station 8 P2	75	2004	13	n/a	793	$0.1992	6,850	$1,364	69%
Station 4 P3	150	1981	36	n/a	1,354	$0.1618	131,821	$21,329	69%
Station 2 P4	100	1984	33	n/a	955	$0.2000	50,114	$10,023	68%
Station 13 P1	40	1996	21	n/a	1,379	$0.1615	6,030	$974	68%
Station 2 P3	100	1984	33	n/a	962	$0.2000	50,489	$10,098	67%
Station 16 P2	75	1994	23	n/a	859	$0.1610	35,368	$5,694	67%
Station 1 P2	125	n/a	n/a	2002	1,185	$0.1447	81,955	$11,859	67%
Station 12 P3	40	1985	32	2011	631	$0.1107	28,085	$3,109	67%
Station 7 P3	50	1983	34	2002	735	$0.1484	48,191	$7,152	67%
Station 1 P1	125	n/a	n/a	2002	1,187	$0.1447	82,070	$11,876	67%
Station 5 P3	300	1999	18	n/a	1,210	$0.1900	0	High flow	67%
Station 12 P1	40	1985	32	2010	633	$0.1107	28,146	$3,116	67%
Station 7 P1	50	1983	34	2002	726	$0.1484	47,607	$7,065	66%
Station 14 P1	40	1996	21	n/a	909	$0.1684	3,737	$629	66%
Station 16 P1	75	1994	23	n/a	861	$0.1610	35,427	$5,704	66%
Station 2 P2	100	1984	33	n/a	979	$0.2000	51,381	$10,276	66%
Station 1 P4	125	2018	n/a	n/a	1,205	$0.1447	83,367	$12,063	66%
Station 13 P3	75	1997	20	n/a	1,395	$0.1615	11,440	$1,848	66%

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Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use (kWh/Yr)	Energy Cost ($/Yr)	Overall Pumping Efficiency (%)
Station 17 P1	75	1994	23	n/a	881	$0.1675	36,240	$6,070	66%
Station 17 P2	75	1994	23	n/a	961	$0.1675	39,556	$6,626	65%
Station 1 P3	125	n/a	n/a	2002	1,216	$0.1447	84,125	$12,173	65%
Station 14 P2	50	1996	21	n/a	966	$0.1684	4,960	$835	65%
Station 12 P2	40	1985	32	2011	650	$0.1107	28,909	$3,200	64%
Bennett Valley P4	50	1994	n/a	2005	361	$0.1812	0	High flow	62%
Station 3 P1	40	2015	2	2015	806	$0.2251	20,434	$4,600	62%
Station 14 P3	50	1997	20	n/a	1,022	$0.1684	5,249	$884	62%
Station 3 P2	40	2015	2	2015	839	$0.2251	21,276	$4,789	60%
WTP 1	125	n/a	n/a	n/a	510	$0.0000	n/a	n/a	58%
Station 5 P2	50	1999	18	n/a	1,173	$0.1900	6,157	$1,170	58%
WTP 2	125	n/a	n/a	n/a	538	$0.0000	n/a	n/a	55%
Station 5 P1	50	1999	18	n/a	1,267	$0.1900	6,648	$1,263	54%
Station 3 P3	100	2015	2	2015	1,007	$0.2251	0	High flow	52%
Station 11 P1	75	2002	15	n/a	636	$0.1884	12,432	$2,342	48%
Station 11 P2	75	2002	15	n/a	654	$0.1884	12,797	$2,411	48%
Station 6 P2	125	1981	44	2017	800	$0.1523	15,631	$2,381	47%
Station 11 P3	75	2002	15	n/a	680	$0.1884	13,301	$2,506	46%
Station 6 P3	125	1981	44	2017	794	$0.1523	15,521	$2,364	46%
Station 18 P1	30	1994	23	n/a	297	$0.2029	12,212	$2,478	45%
Station 18 P2	30	1994	23	n/a	298	$0.2029	12,253	$2,486	45%
Station 6 P1	125	1981	44	2002	831	$0.1523	16,232	$2,472	44%
Station 15 P3P	50	1994	23	n/a	1,616	$0.1822	16,119	$2,937	34%
Franklin Murdock	30	2000	17	2016	1,321	$0.2000	14,822	$2,964	33%

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Table 5-5: Water Pump Stations Sorted by Installation Date

This table sorts the pumps by date installed. The older the pump the more likely it is a candidate for cost-effective replacement, unless it has been recently rebuilt.

Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use (kWh/Yr)	Energy Cost ($/Yr)	Overall Pumping Efficiency (%)
Station 1 P4	125	2018	n/a	n/a	1,205	$0.1447	83,367	$12,063	66%
Station 3 P1	40	2015	2	2015	806	$0.2251	20,434	$4,600	62%
Station 3 P2	40	2015	2	2015	839	$0.2251	21,276	$4,789	60%
Station 3 P3	100	2015	2	2015	1,007	$0.2251	0	High flow	52%
Station 9 P1	300	2006	11	n/a	1,117	$0.2978	111,617	$33,239	73%
Station 9 P2	300	2006	11	n/a	1,083	$0.2978	79,893	$23,792	78%
Station 9 P3	300	2006	11	n/a	1,098	$0.2978	81,012	$24,125	77%
Station 9 P4	75	2006	11	n/a	617	$0.2978	24,174	$7,199	72%
Station 9 P5	75	2006	11	n/a	624	$0.2978	24,436	$7,277	74%
Station 8 P1	75	2004	13	n/a	823	$0.1992	7,112	$1,417	73%
Station 8 P2	75	2004	13	n/a	793	$0.1992	6,850	$1,364	69%
Station 11 P1	75	2002	15	n/a	636	$0.1884	12,432	$2,342	48%
Station 11 P2	75	2002	15	n/a	654	$0.1884	12,797	$2,411	48%
Station 11 P3	75	2002	15	n/a	680	$0.1884	13,301	$2,506	46%
Franklin Murdock	30	2000	17	2016	1,321	$0.2000	14,822	$2,964	33%
Station 5 P1	50	1999	18	n/a	1,267	$0.1900	6,648	$1,263	54%
Station 5 P2	50	1999	18	n/a	1,173	$0.1900	6,157	$1,170	58%
Station 5 P3	300	1999	18	n/a	1,210	$0.1900	0	High flow	67%
Station 13 P3	75	1997	20	n/a	1,395	$0.1615	11,440	$1,848	66%
Station 14 P3	50	1997	20	n/a	1,022	$0.1684	5,249	$884	62%
Station 13 P1	40	1996	21	n/a	1,379	$0.1615	6,030	$974	68%
Station 13 P2	75	1996	21	n/a	1,429	$0.1615	11,715	$1,892	69%
Station 14 P1	40	1996	21	n/a	909	$0.1684	3,737	$629	66%
Station 14 P2	50	1996	21	n/a	966	$0.1684	4,960	$835	65%
Bennett Valley P4	50	1994	n/a	2005	361	$0.1812	0	High flow	62%
Station 15 P3	50	1994	23	n/a	1,616	$0.1822	16,119	$2,937	34%
Station 16 P1	75	1994	23	n/a	861	$0.1610	35,427	$5,704	66%
Station 16 P2	75	1994	23	n/a	859	$0.1610	35,368	$5,694	67%
Station 17 P1	75	1994	23	n/a	881	$0.1675	36,240	$6,070	66%
Station 17 P2	75	1994	23	n/a	961	$0.1675	39,556	$6,626	65%

Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use (kWh/Yr)	Energy Cost ($/Yr)	Overall Pumping Efficiency (%)
Station 18 P1	30	1994	23	n/a	297	$0.2029	12,212	$2,478	45%
Station 18 P2	30	1994	23	n/a	298	$0.2029	12,253	$2,486	45%
Station 12 P1	40	1985	32	2010	633	$0.1107	28,146	$3,116	67%
Station 12 P2	40	1985	32	2011	650	$0.1107	28,909	$3,200	64%
Station 12 P3	40	1985	32	2011	631	$0.1107	28,085	$3,109	67%
Station 2 P1	100	1984	33	n/a	919	$0.2000	48,193	$9,639	71%
Station 2 P2	100	1984	33	n/a	979	$0.2000	51,381	$10,276	66%
Station 2 P3	100	1984	33	n/a	962	$0.2000	50,489	$10,098	67%
Station 2 P4	100	1984	33	n/a	955	$0.2000	50,114	$10,023	68%
Station 7 P1	50	1983	34	2002	726	$0.1484	47,607	$7,065	66%
Station 7 P2	50	1983	34	2016	702	$0.1484	46,039	$6,832	69%
Station 7 P3	50	1983	34	2002	735	$0.1484	48,191	$7,152	67%
Station 4 P1	150	1981	36	n/a	1,350	$0.1618	131,405	$21,261	69%
Station 4 P2	150	1981	36	n/a	1,350	$0.1618	131,405	$21,261	69%
Station 4 P3	150	1981	36	n/a	1,354	$0.1618	131,821	$21,329	69%
Station 6 P1	125	1981	44	2002	831	$0.1523	16,232	$2,472	44%
Station 6 P2	125	1981	44	2017	800	$0.1523	15,631	$2,381	47%
Station 6 P3	125	1981	44	2017	794	$0.1523	15,521	$2,364	46%
Station 1 P1	125	n/a	n/a	2002	1,187	$0.1447	82,070	$11,876	67%
Station 1 P2	125	n/a	n/a	2002	1,185	$0.1447	81,955	$11,859	67%
Station 1 P3	125	n/a	n/a	2002	1,216	$0.1447	84,125	$12,173	65%
WTP P1	125	n/a	n/a	n/a	510	$0.0000	n/a	n/a	58%
WTP P2	125	n/a	n/a	n/a	538	$0.0000	n/a	n/a	55%

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Table 5-6: Consolidated Ranking of Water Pumps

This table is an amalgamation of all the rankings presented in tables 5-1 through 5-5. Qualitatively, the redder the cells in a specific row the higher the likelihood the pump is a good candidate for cost-effective replacement or rebuild. The pumps with the reddest cells should be the ones that the City staff most closely monitors.

Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use[1] (kWh/Yr)	Energy Cost ($/Yr)	Overall Pumping Efficiency (%)
Bennett Valley P4	50	1994	n/a	2005	361	$0.1812	0	High flow	62%
Franklin Murdock	30	2000	17	2016	1,321	$0.2000	14,822	$2,964	33%
Station 1 P1	125	n/a	n/a	2002	1,187	$0.1447	82,070	$11,876	67%
Station 1 P2	125	n/a	n/a	2002	1,185	$0.1447	81,955	$11,859	67%
Station 1 P3	125	n/a	n/a	2002	1,216	$0.1447	84,125	$12,173	65%
Station 1 P4	125	2018	n/a	n/a	1,205	$0.1447	83,367	$12,063	66%
Station 2 P1	100	1984	33	n/a	919	$0.2000	48,193	$9,639	71%
Station 2 P2	100	1984	33	n/a	979	$0.2000	51,381	$10,276	66%
Station 2 P3	100	1984	33	n/a	962	$0.2000	50,489	$10,098	67%
Station 2 P4	100	1984	33	n/a	955	$0.2000	50,114	$10,023	68%
Station 3 P1	40	2015	2	2015	806	$0.2251	20,434	$4,600	62%
Station 3 P2	40	2015	2	2015	839	$0.2251	21,276	$4,789	60%
Station 3 P3	100	2015	2	2015	1,007	$0.2251	0	High flow	52%
Station 4 P1	150	1981	36	n/a	1,350	$0.1618	131,405	$21,261	69%
Station 4 P2	150	1981	36	n/a	1,350	$0.1618	131,405	$21,261	69%
Station 4 P3	150	1981	36	n/a	1,354	$0.1618	131,821	$21,329	69%
Station 5 P1	50	1999	18	n/a	1,267	$0.1900	6,648	$1,263	54%
Station 5 P2	50	1999	18	n/a	1,173	$0.1900	6,157	$1,170	58%
Station 5 P3	300	1999	18	n/a	1,210	$0.1900	0	High flow	67%
Station 6 P1	125	1981	44	2002	831	$0.1523	16,232	$2,472	44%
Station 6 P2	125	1981	44	2017	800	$0.1523	15,631	$2,381	47%
Station 6 P3	125	1981	44	2017	794	$0.1523	15,521	$2,364	46%
Station 7 P1	50	1983	34	2002	726	$0.1484	47,607	$7,065	66%
Station 7 P2	50	1983	34	2016	702	$0.1484	46,039	$6,832	69%
Station 7 P3	50	1983	34	2002	735	$0.1484	48,191	$7,152	67%
Station 8 P1	75	2004	13	n/a	823	$0.1992	7,112	$1,417	73%
Station 8 P2	75	2004	13	n/a	793	$0.1992	6,850	$1,364	69%
Station 9 P1	300	2006	11	n/a	1,117	$0.2978	111,617	$33,239	73%
Station 9 P2	300	2006	11	n/a	1,083	$0.2978	79,893	$23,792	78%

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Station Name & Pump Number	Pump Size (HP)	Year Installed	Age (Yrs)	Last Rebuild	Specific Energy (kWh/Mgal)	Avg Electric Rate ($/kWh)	Annual Energy Use[1] (kWh/Yr)	Energy Cost ($/Yr)	Overall Pumping Efficiency (%)
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Station 11 P2	75	2002	15	n/a	654	$0.1884	12,797	$2,411	48%
Station 11 P3	75	2002	15	n/a	680	$0.1884	13,301	$2,506	46%
Station 12 P1	40	1985	32	2010	633	$0.1107	28,146	$3,116	67%
Station 12 P2	40	1985	32	2011	650	$0.1107	28,909	$3,200	64%
Station 12 P3	40	1985	32	2011	631	$0.1107	28,085	$3,109	67%
Station 13 P1	40	1996	21	n/a	1,379	$0.1615	6,030	$974	68%
Station 13 P2	75	1996	21	n/a	1,429	$0.1615	11,715	$1,892	69%
Station 13 P3	75	1997	20	n/a	1,395	$0.1615	11,440	$1,848	66%
Station 14 P1	40	1996	21	n/a	909	$0.1684	3,737	$629	66%
Station 14 P2	50	1996	21	n/a	966	$0.1684	4,960	$835	65%
Station 14 P3	50	1997	20	n/a	1,022	$0.1684	5,249	$884	62%
Station 15 P3	50	1994	23	n/a	1,616	$0.1822	16,119	$2,937	34%
Station 16 P1	75	1994	23	n/a	861	$0.1610	35,427	$5,704	66%
Station 16 P2	75	1994	23	n/a	859	$0.1610	35,368	$5,694	67%
Station 17 P1	75	1994	23	n/a	881	$0.1675	36,240	$6,070	66%
Station 17 P2	75	1994	23	n/a	961	$0.1675	39,556	$6,626	65%
Station 18 P1	30	1994	23	n/a	297	$0.2029	12,212	$2,478	45%
Station 18 P2	30	1994	23	n/a	298	$0.2029	12,253	$2,486	45%
WTP 1	125	n/a	n/a	n/a	510	$0.0000	n/a	n/a	58%
WTP 2	125	n/a	n/a	n/a	538	$0.0000	n/a	n/a	55%

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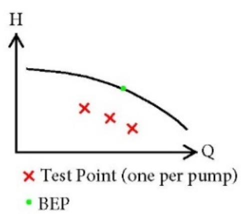
5.5 Guidelines for Replacing or Rebuilding Pumps

The following guidelines are intended to help City staff determine if a pump should be replaced or repaired. This methodology was used in this analysis to determine if any of the pumps should be replaced or repaired.

Step 1: Perform a flow test of the pump at full speed and plot the flow (Q) versus the head (H) on the factory pump curves provided by the manufacturer to create test points.

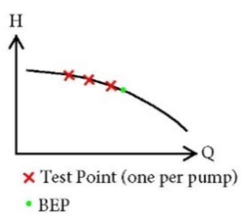
Step 2: Match the test points created in Step 1 with the following four possible scenarios and take the indicated action.

Scenario 1: Test points located below the curve.



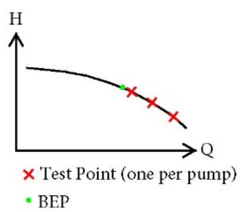
In this situation, a rebuild option should be explored as the pump is not reaching the factory curve. If the pump motor is turning the shaft at the correct speed, test points below the curve are likely associated with impeller damage. While replacing the pump would also fix the issue, a less costly repair would likely be adequate.

Scenario 2: Test points located to the left of best efficiency point (BEP).



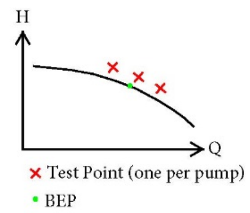
In this situation, the pump is not moving water as optimally as it should. This may be because the pump may have been sized for a previous duty condition that is no longer appropriate and is now over-sized. In this scenario, additional electricity is being used to move less water and City staff should perform a cost-effectiveness analysis with a more appropriately sized premium efficiency pump. Another reason for these test points could be that downstream conditions not associated with the pump (e.g., sediment buildup on the pipes), may be creating additional frictional losses causing the pump to overwork. In that case the downstream condition should be remedied.

Scenario 3: Test points located to the right of BEP.



In this situation, the pump is moving more water than it was designed to do. This means it is using less electricity to move more water and the pump is producing less head than originally planned. Operating extremely far away from BEP (e.g., to the left less than 0.7 BEP or to the right greater than 1.4 BEP) can have other detrimental effects on the pump itself such as, impeller fatigue failure due to unbalanced radial forces, cavitation, etc. In this situation, City staff should investigate the cost effectiveness of installing a VFD or downsizing the impeller.

Scenario 4: Test point located above the curve.



In this situation, the test points indicate that either the test was run incorrectly or that the pump curve used is not correct or appropriate for the pump being tested. The latter can occur if the pump has been rebuilt with a different trim or diameter impeller. City staff should first investigate if the pump was rebuilt, and if that does not answer the question, then the test should be redone.

5.6 Overview of Methodology

There were three steps to this analysis: plotting the test data on the pump curves, benchmarking the pump data, and performing cost-effectiveness analyses.

5.6.1 Plotting Pump Test Data on Pump Curves

Using the Pump Efficiency Testing Service (PETS) data provided by the City, test points were plotted for each pump. All pumps that were tested and had a pump curve available had their flow and pressure data plotted on their respective pump curves (see Appendix A). This graphical representation of the current duty condition illustrates where the pump is operating in relation to the original design BEP, and under which scenario from Section 5.5 the pump is operating. Plotting the current duty condition also allows for easy comparison of test points of the other pumps at the same pump station.

5.6.2 Benchmarking

The key attributes of the pumps were calculated using the data provided by the City. The results are in Tables 5-1 through 5-6. Note that direct wire-to-water conversion efficiency is dependent on the system curve which is unique to each pump station. Basically, if one pump station must only lift 10 feet of head, it will require much less energy than another pump station that is required to lift 100 feet of head. Once calculated, these efficiencies can be compared from one pump to another in the same pump station but not across all pump stations. Additionally, when performing the cost-effectiveness analysis, efficiency is only one of the variables in the calculation. Other important factors include how often the pump is used and the cost of electricity. Tables 5-1 through 5-6 are useful in comparing pump data across all pump stations to inform operational decisions and rebuild or replace decisions. This data can also be used to prioritize pumps for monitoring and evaluation.

5.6.3 Cost-Effectiveness Analysis

A cost-effectiveness analysis was performed on all pumps with an overall pump efficiency of less than 65%. The analysis used the calculated energy savings using the current electricity rate of $0.1959 per kWh with a 2.5% annual escalation rate. The cost of a new pump was determined using cost estimates provided in August 2017 by Pump Repair Services (a company local to the Santa

Rosa area that not only offers pump repair services but also is a distributor for various new high-end pumps such as Flow-way & Flowserve). The cost data provided was for both repair and replacement of pumps of three different sizes from 50 HP, 125 HP, and 300 HP.

Table 5-7: Summary of Pump Repair and Replacement Cost

Pump Type:		Split Case Centrifugal	Vertical Turbine
	Size (HP)	Total Cost[1]	Total Cost[1]
Replace	50	$28,000	$46,000
	125	$39,000	$98,000
	300	$57,000	$140,000
Rebuild	50	$15,500	$17,000
	125	$18,500	$20,500
	300	$27,500	$35,500

[1] Total Cost includes labor and installation costs.

The data presented in Table 5-7 and was used to plot figures 5-1 & 5-2, creating trendlines superimposed to get cost for intermediate pump sizes not provided (i.e., a 200 HP pump).

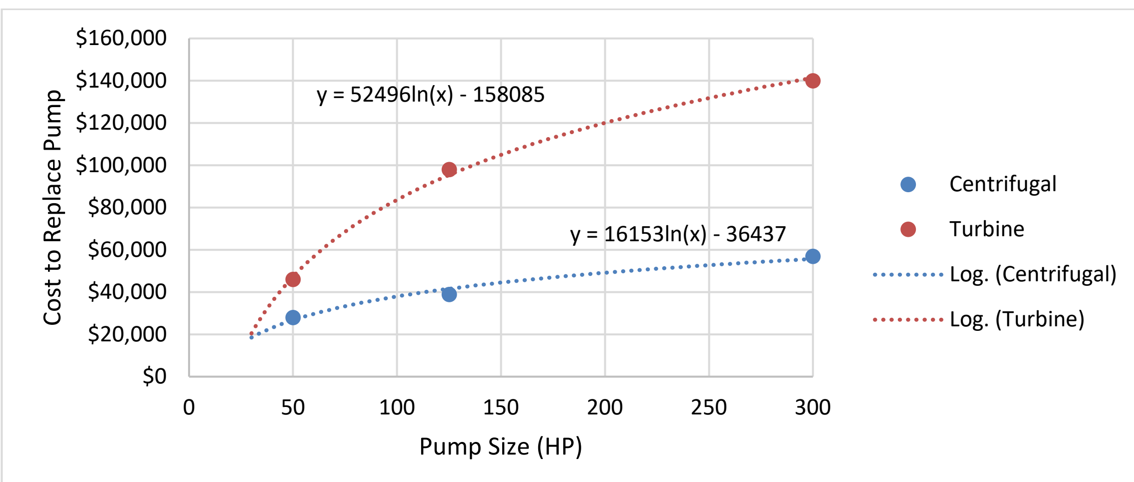


Figure 5-1: Pump Replacement Cost Curve

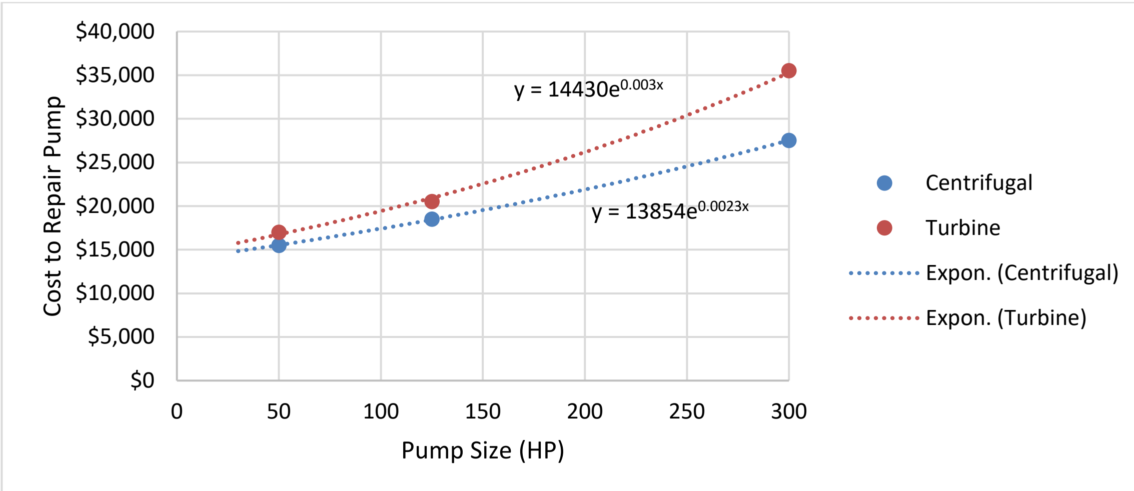


Figure 5-2: Pump Repair Cost Curve

The cost-effectiveness analysis calculates the annual savings amount and the net present value (NPV) over the 20-year life of the project. The general rule of thumb is that analyses that result in a positive NPV means the City would be better off doing the project than not doing the project, and therefore the project is recommended. A project with a negative NPV should not be pursued and is not recommended. The results are presented in Table 5-7.

Cost estimates provided in this analysis are based on the Association for the Advancement of Cost Engineering International (AACEI) standards for cost estimating accuracy of +50% and -30%.

5.7 Recommended Energy Efficiency Measures

None of the pumps are recommended for replacement or a rebuilding. Table 5-8 summarizes the cost-effectiveness of replacing or rebuilding each pump; it shows that no replacements create a net savings, a positive net present value, nor a positive rate of return (IRR).

5.8 Analysis Recommended for Further Investigation

Repair or Replace Threshold Value Analysis

A threshold value for each pump can be calculated that would indicate at what specific energy number a pump would become cost-effective to replace or rebuild. Because this type of calculation is fairly time intensive, as there are over 50 pumps to analyze, it is beyond the budget and scope of this analysis.

To accomplish this task, one would use the Cost-Effectiveness Tool and the cost data shown in Table 5-7 to figure out at what specific energy value the NPV of 20 years of cost would become zero. It is at this value that any increase in the specific energy metric would make replacement of the pump cost-effective. A table could be developed to show the threshold specific energy value for each pump that could be used by operators to monitor pumps. Should this threshold value be reached the City should consider doing a cost-effectiveness analysis to see if a pump should be replaced or rebuilt. It is at this incremental cost that an increase in the specific energy outweighs the cost of a new pump. To do this calculation one would use the “goal seek” function within Excel seeking a zero for the NPV cell in the Cost-Effectiveness Tool (cell L 29).

5.9 Not Recommended EEMS

Although some of the pump test data showed test points plotted below the factory curves (see attached Appendix A), the instances where that occurred also happened to be right of the BEP (see Section 5, Scenario 3). So, the likely cost-effectiveness of replacing the pump is low; therefore, no pump rebuilds are recommended.

Cost-effectiveness has been calculated, as described in Section 5.6.3 using the Kennedy/Jenks Cost-Effectiveness Tool, and the results are shown in Table 5-8. Only pumps that have an overall pump efficiency below 65% were analyzed, as replacement of pumps with higher efficiencies are not likely to be cost-effective. The analysis indicates that all the pumps we analyzed for replacement resulted in a negative NPV and replacements are not deemed to be cost-effective. Therefore, no pump replacements or rebuilds are recommended.

Table 5-8: Summary of Cost-Effectiveness Analysis

Station Name and Pump Number	Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Emission Reduction (MT/Yr)	Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	IRR (%)	Cumulative GHG Reductions (MT)	Overall Pump Efficiency (%)
Station 12 P2	3,031	$624	0	$35,174	$542	($1,613)	($32,266)	($24,071)	-6.2%	6	64%
Station 3 P1	2,913	$600	0	$35,183	$533	($1,645)	($32,896)	($24,524)	-6.5%	6	62%
Station 3 P2	3,641	$749	0	$35,125	$591	($1,450)	($28,992)	($21,717)	-4.9%	7	60%
Station 5 P2	1,184	$244	0	$47,036	$395	($2,912)	($58,231)	($43,032)	-13.9%	2	58%
Station 5 P1	1,672	$344	0	$46,997	$434	($2,781)	($55,613)	($41,149)	-11.9%	3	54%
Station 11 P1	4,069	$837	0	$68,090	$626	($3,596)	($71,914)	($53,393)	-8.7%	8	48%
Station 11 P2	4,316	$888	0	$68,071	$645	($3,529)	($70,588)	($52,439)	-8.3%	9	48%
Station 6 P2	5,513	$1,135	1	$94,791	$741	($5,046)	($100,910)	($74,903)	-8.9%	11	47%
Station 11 P3	4,820	$992	0	$68,030	$686	($3,394)	($67,884)	($50,495)	-7.6%	10	46%
Station 6 P3	5,649	$1,163	1	$94,780	$752	($5,009)	($100,181)	($74,378)	-8.7%	11	46%
Station 18 P1	940	$193	0	$20,239	$375	($1,140)	($22,795)	($16,890)	-10.3%	2	45%
Station 18 P2	951	$196	0	$20,238	$376	($1,137)	($22,735)	($16,848)	-10.2%	2	45%

Station Name and Pump Number	Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Emission Reduction (MT/Yr)	Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	IRR (%)	Cumulative GHG Reductions (MT)	Overall Pump Efficiency (%)
Station 6 P1	6,282	$1,293	1	$94,730	$803	($4,839)	($96,782)	($71,934)	-8.0%	13	44%

5.10 Utility Management System Interface

Using a UMS to inform management decisions concerning pump efficiency can be done if the UMS can calculate or show the specific energy (kWh/Mgal) metric. To calculate specific energy, two measurements are needed: energy usage and flow. Energy usage is readily available and is typically collected by a UMS. Gathering flow data is more of a challenge, especially if one wants to find the specific energy associated with each individual pump to compare and benchmark pump efficiencies. This usually requires flowrate data for each individual pump.

However, it is important to note that it may not require a flow meter on every pump for a UMS to calculate specific energy for each pump. It may be possible to utilize the pump station flow meter currently installed to measure each pump's individual flow. However, this requires that the UMS can matchup in time the flow meter data with the energy use data for individual operating pumps. Synchronizing the data collection times would also be necessary. This calculation becomes more difficult if a station runs two pumps at the same time.

A UMS can also access SCADA data while tracking energy usage. For a pump station, this means that a UMS could be set up to track specific energy in near real time so long as the energy use data and flow meter data are automatically uploaded in real time and synchronized. Currently this is not being done by the City.

Finally, using the cost data gathered for this task, a threshold value for specific energy could be calculated for each pump and inputted into a UMS. This threshold value of specific energy, as described in Section 5.8, could inform the City's about pump replace or repair decisions. With a UMS, an alert could be setup to notify City staff of the situation where the threshold value for specific energy is reached.

Attachments

Appendix A: Pump data plotted onto factory pump curves

Appendix B: Cost-Effectiveness Spreadsheet and rankings

26 January 2018

Final Technical Memorandum #6

To: Joe Schiavone, Ron Marincic, Rick Santarini, Jason Tibbals, Simon Hood, Claire Myers, and Tasha Wright – City of Santa Rosa

From: Nicholas Peros, Project Investigation Lead, Kennedy/Jenks
Alan Zelenka, Project Manager, Kennedy/Jenks

Subject: Task 4 – SCADA Programming Investigation
Santa Rosa Energy Optimization Plan (EOP) – Part 2
K/J Project: 1368024*04

6.1 Purpose of this Investigation

The purpose of Task 4 – SCADA Programming Investigation was to:

- Use the applicable data and information already gathered and analyzed in the SubRegional EOP Energy Management System investigation, and request additional information to be provided by Water Operations.
- Review and understand existing Water Operations supervisory control and data acquisition (SCADA) system uses and strategies for optimizing energy use and cost.
- Identify additional strategies to increase energy efficiency and reduce costs (e.g., first-on-first-off strategies based on pump efficiency).
- Describe potential operational impacts of the strategies.
- Identify SCADA programming and equipment needs to implement strategies and estimate their cost-effectiveness.
- Evaluate how a Utility Management System could interface with SCADA programming for effective tracking and reporting on implementation of identified measures.

6.2 Summary of Recommendations

The recommended energy efficiency measure (EEM) of this Task is to pursue the same recommendation from Task 2 – Optimize Pump Sequencing Logic Investigation (Technical Memorandum #4), and thus the results are repeated here but the savings should not be double counted. Several EEMs are recommended for further investigation, and are explained in Section 6.6. Table 6-1 below shows the savings from Technical Memorandum #4 EEM 4-1.

Table 6-1: Summary of Recommended Energy Efficiency Measure Savings

Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Emission Reduction (MT/Yr)	Net Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	IRR ($)	Cumulative GHG Reductions (MT)
25,000	$4,400	3	$700	$4,700	$4,500	$90,900	$65,300	528%	51

6.3 Background Information and System Description

The existing SCADA system for water distribution and wastewater collection consists of:

- 60 programmable logic controllers (PLCs) as manufactured by TESCO. (Note: Liquitronic 2000 units are presently installed and the upgrade to Liquitronic 3000 units is planned.)
- Serial radio telemetry using MODBUS protocol.
- Centralized monitoring and control from Santa Rosa Water's headquarters at 35 Stony Point Road.
- Wonderware 2014R2 human machine interface (HMI) software with VMware high availability virtualized server components as follows:
    - **Active Directory** controller for user authentication and security.
    - **Historian** for archiving field data and reporting.
    - **Terminal Server** for rendering HMI screens.

Figures 6-1 and 6-2 below show overview screens for both SCADA systems.

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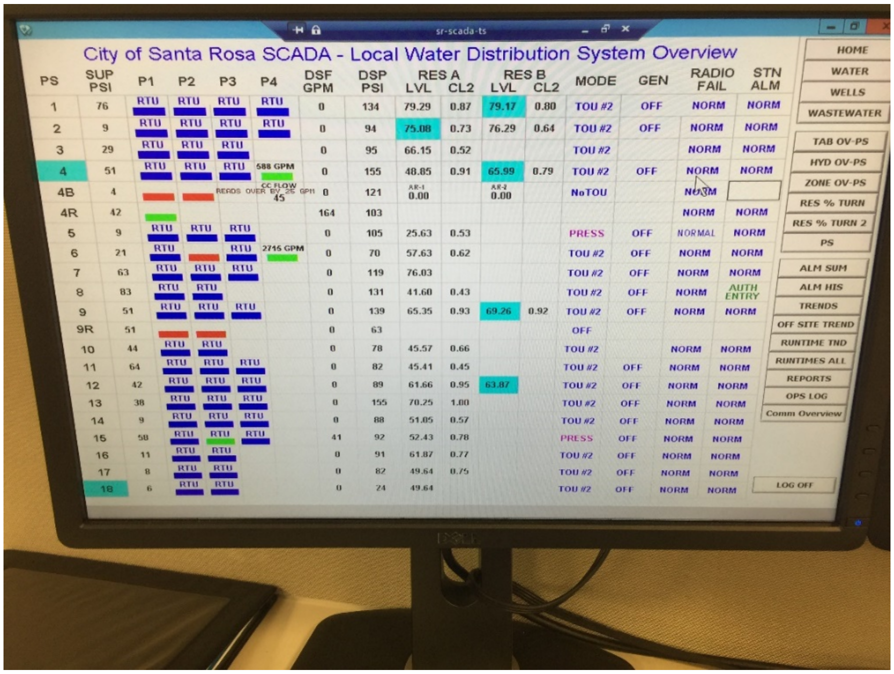

Figure 6-1: SCADA Overview Screen - Water Distribution

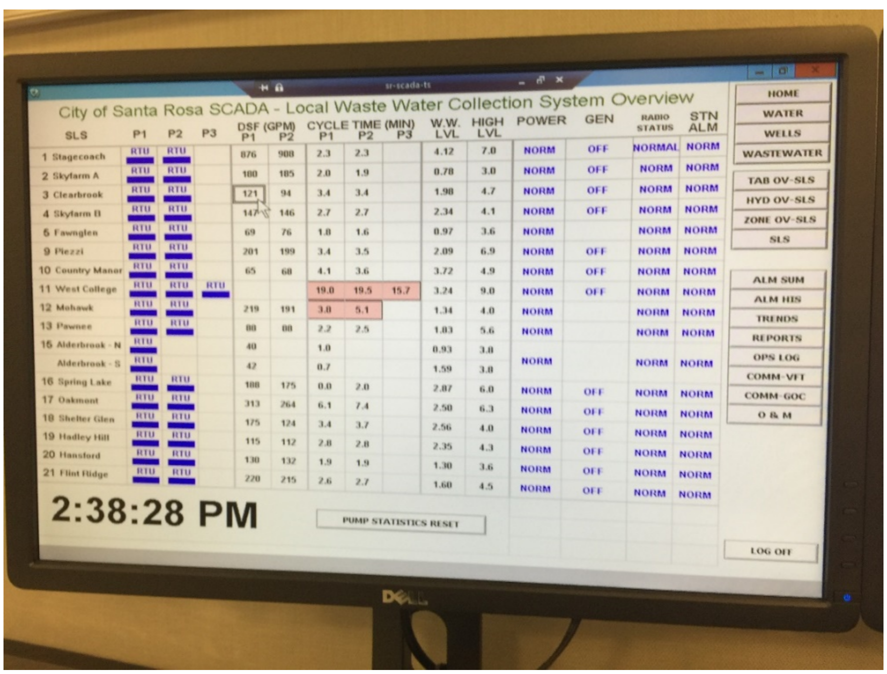

Figure 6-2: SCADA Overview Screen - Wastewater Collection

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Consistent with industry best practices, control of the remote facilities is done locally by the PLCs at each site and not by the Wonderware HMI systems at Headquarters. Also, water pump stations get level readings directly from reservoirs, completely independent of the HMI. The SCADA system provides, however, two types of supervisory control:

1. Selection of either RTU logic or HMI pushbuttons for pump start/stop (Figure 6-3).
2. Time-of-Use (TOU) settings for starting and stopping water system pumps (Figure 6-4).

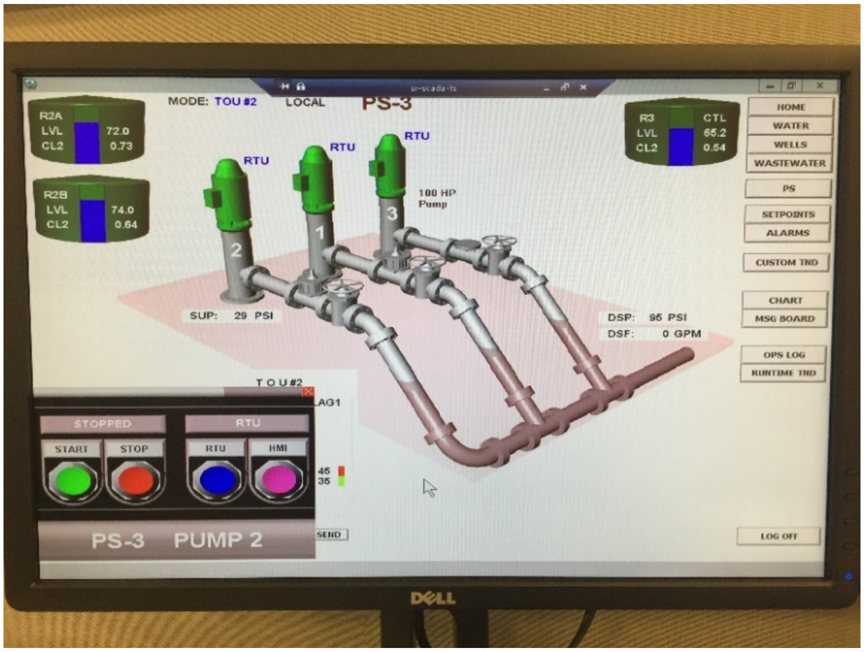

Figure 6-3: Supervisory Control - RTU/HMI Mode and Pump Start/Stop

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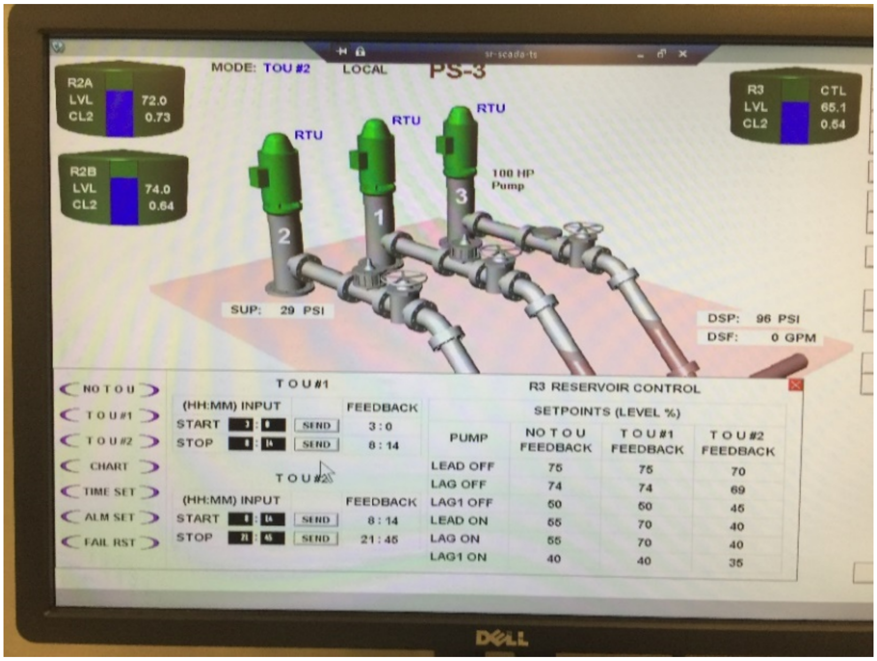

Figure 6-4: Supervisory Control - Water TOU Time Settings

Only the water SCADA system has TOU controls with the objective to fill reservoirs overnight. These controls help reduce the cost of electricity by preferentially pumping more when utility rates are lowest, from 9:00 p.m. at night to 8:30 a.m. the following morning. SCADA adjustments include the time to commence a specific pumping program and the reservoir levels (Figure 6-5).

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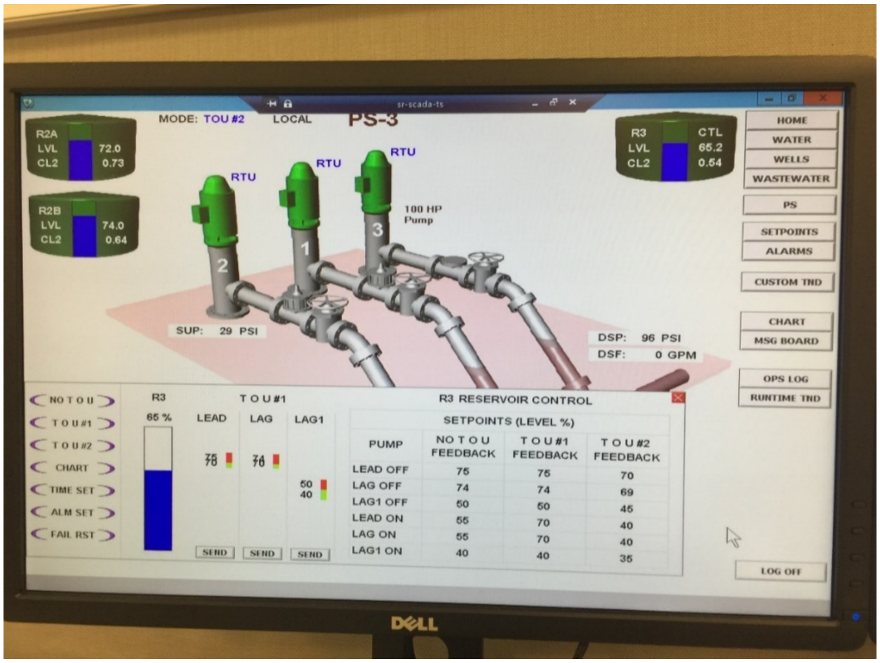

Figure 6-5: Supervisory Control - Water TOU Level Settings

There do not appear to be provisions for automatically adjusting settings by the day of the week.

Both radio telemetry and hardwired connections are used to forward data.

For water distribution system reliability, water pump stations utilize hardwired connections to get reservoir levels, even when reservoirs are not on the same property; water pumping therefore depends neither on the telemetry system or the Wonderware HMI.

SCADA for both the water distribution system and the wastewater collection system use polling-type radio telemetry to communicate from the pump stations to Headquarters. This approach introduces a time delay between measurement and reporting on the HMI screens, typically about 1 minute. This latency is rarely a problem in operating water or wastewater SCADA.

6.4 Overview of Methodology

This analysis focuses only on the water pump stations because they use 84% of the electricity used by Water Operations. The analysis evaluates strategies to increase energy efficiency and reduce costs; and these strategies fall into two categories – ones which do not involve SCADA and ones which do:

- **Optimizing Pump-Sequencing Logic Using Existing Controls and making no changes to SCADA (neither PLC Programming nor the Wonderware HMI),** see:
  - EEM 6-1: Optimize Pump-Sequencing Logic Using Existing Controls.

- **Using SCADA enhancements, including PLC programming, Wonderware programming, or both,** see**:**
  - EEM 6-2: Add Manual Controls via SCADA for Setting Pump Sequence.
  - EEM 6-3: Add SCADA Provisions for Optimizing TOU Settings.
  - EEM 6-4: Add Software Flow Totalizers for the Pump Stations.
  - EEM 6-5: Update SCADA Dashboards to Show Pump Station Specific Energy.
  - EEM 6-6: Provide Real Time Calculation of Specific Energy and the Ability to Manage Pump Sequences via SCADA.

6.5 Recommended Energy Efficiency Measure

EEM 6-1: Optimize Pump-Sequencing Logic Using Existing Controls

This EEM is the same as EEM 4-1 described in Technical Memorandum #4 - Optimize Pump Sequencing Logic Investigation.

Existing controls at the pump stations provide for two choices: automatic alternation to minimize run time and fixed sequence. Presently, automatic alternation is in use and causes the pumps to alternate LEAD, LAG, and STANDBY duty to balance runtime evenly across all the operating units within a given pump station.

Balancing runtime across units, however, does not take into consideration that all the pumps are not equally as efficient in the energy required to pump a given volume of water, i.e., the “specific energy” or kilowatt-hours per million gallons pumped (kWh/Mgal). Under an optimized sequencing system, pump(s) with the lowest specific energy are prioritized, rather than balancing runtime across all units.

By switching to fixed sequence and selecting the pumps with the lowest specific energy as lead and follow, the strategy described in Technical Memorandum #4 can be achieved at a very low five-year recurring cost.

Table 6-2: Summary of EEM 6-1 Savings

Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Emission Reduction (MT/Yr)	Net Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	IRR ($)	Cumulative GHG Reductions (MT)
25,000	$4,400	3	$700	$4,700	$4,500	$90,900	$65,300	528%	51

6.6 EEMs Recommended For Further Investigation

EEM 6-2: Add Manual Controls via SCADA for Setting Pump Sequence

Logic in many pump station PLCs already accommodates local changes to pump sequencing. Typically, the logic provides for automatic alternation to equalize run time, but it also allows for setting manual mode with a fixed but operator-modifiable lead-lag sequence. These are software provisions using the display of the PLC. EEM 6-1 uses these same provisions but requires an operator to go to the pump stations to make changes.

This EEM allows for mode and sequence changes to be made remotely, using SCADA thereby saving travel time. SCADA programming work would include:

- Creating a typical HMI screen for making sequence changes and linking this screen to existing ones.
- Modifying PLC programs to accommodate this additional remote control.
- Modifying telemetry to exchange needed supervisory control data.

Making routine changes via SCADA gives operators more time to oversee operations and requires less time on things like travelling to a pump station just to modify settings.

We recommend that the City further investigate this potential for improved staff efficiency.

EEM 6-3: Add SCADA Provisions for Optimizing TOU Settings

Figures 6-4 and 6-5 show existing SCADA provisions for changing TOU settings for water distribution pump stations. Provisions make it easy to change individual pump settings for individual pump stations. There doesn't appear to be any way, however, to change all the settings for all the pump stations at once or to store sets of settings for easy recall and deployment.

Some water agencies use the ability to make regular global changes, such as these, to save energy. SCADA is set up to pre-store one set of values for weekdays, for example, and another for weekends. With one action, the operator can change all the settings. Settings changes can also be semi-automatic with simple operator approval. Different sets of settings also can be stored and selected depending on time of year or other criteria. It seems likely that only a few new HMI screens would be needed to implement this feature.

We recommend that the City further investigate adding SCADA provisions for optimizing TOU settings for water pumps stations.

EEM 6-4: Add Software Flow Totalizers for the Pump Stations

Figures 6-1 and 6-2 show that flow totals are not accumulated and displayed in SCADA in real time. This situation is not just a simple omission because the City uses a polling type of telemetry system. Values from the field are updated about every minute; so, accumulation of flow totals in SCADA would likely have quite a bit of error.

One solution sometimes used in the industry is to program the PLCs to totalize flow in the software, thereby avoiding errors likely to be introduced by telemetry. For flowmeters with counters, the pulses can be counted, and totals will very closely match totalizers on the flowmeters themselves. Flowmeters with analog output can be summed algebraically. Although the time delay because of telemetry will remain, operators will see nearly up to the minute values, and engineering can have access to a database for analytical purposes.

There is an upcoming planned capital improvement program project which will replace existing L2000s with L3000s. We recommend getting a price for developing the PLC software needed for this EEM as part of that upgrade project, then assessing the cost-effectiveness of this EEM before making a decision to implement.

EEM 6-5: Update SCADA Dashboards to Show Pump Station Specific Energy

Specific energy is the amount of energy needed to pump a unit of flow and is typically measured in kWh/Mgal. Pumps with lower specific energy use less electricity and are more cost-effective to operate. By displaying pump station specific energy in real time via SCADA, staff could optimize operations and lower costs by determining and using the pump(s) with the lowest specific energy.

This EEM is a companion to EEM 6-4 which totalizes flows in real time using existing flowmeters. This EEM would require the addition of an electricity measuring instrument, on the whole pump station or preferably on each pump, in order to do specific energy calculations and forward values to the SCADA screens.

The L2000 replacement project might be an excellent opportunity to develop a standard software object that can accomplish either or both of what is described in EEM 6-4 and this EEM.

Rather than developing a new dashboard screen for specific energy, it appears possible to add this information to the Water Distribution Overview Screen (Figure 6-1).

We recommend that the City further investigate updating SCADA dashboards to show pump specific energy.

6.7 Not Recommended EEMs

EEM 6-6: Provide Real Time Calculation of Specific Energy and the Ability to Manage Pump Sequences via the HMI

By adding the ability to monitor specific energy in SCADA in real time, changes in specific energy can be used to inform the selection of lead pumps for minimizing energy costs. The City would not have to wait two to five years for PG&E pump tests because pump specific energy numbers would be updated each time it runs. Improvements needed to implement this strategy include:

a) For the 25 pumps which have VFDs, connect pump VFD power-monitoring hardware to the PLCs.

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b) Provide pump energy monitors for the 27 pumps that do not use VFD. New hardware would be an Ethernet-connected energy monitor for each pump, (e.g., Schneider METSEPM5340, plus three current transformers, plus installation).

c) Modify PLC software to do specific energy calculations in real time[1]. This work includes developing software for the Liquitronic units to compute pump specific energy using data from VFDs or energy monitors, as appropriate, and flowmeters. Software should keep track of average values when each pump is running and when multiple pumps are running.

d) Modify the HMI to acquire this new data, update the Wonderware Historian to store specific energy points, provide a management dashboard screen, and provide supervisory control of pump sequences.

e) Install and test the new Liquitronic and HMI software.

The energy savings from this EEM are assumed to be the same as EEM 6-1 (25,000 kWh/year), but the implementation costs are different. Total cost to perform these actions is estimated to be about $140,000 (not including a $2,300 up-front incentive). However, this EEM would result in a net average annual cost of about $3,400 per year or a cost of approximately $68,000 over 20 years, and is thus not recommended.

Table 6-3: Summary of EEM 6-6 Savings

Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Emission Reduction (MT/Yr)	Net Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	IRR ($)	Cumulative GHG Reductions (MT)
25,000	$4,700	3	$137,900	$2,300	($3,400)	($67,800)	($52,200)	-1.1%	51

6.8 Impact of Utility Management System on SCADA Programming

SCADA Systems and Utility Management Systems (UMS) both store historical and real-time data in databases; so, a programmer can use straight-forward database and other techniques to exchange and display information from the other system. Examples include:

1. The specific energy information potentially viewable to SCADA operators per EEM 6-5 could also be sent automatically and securely to the UMS for analysis by managers, engineers, and accounting.

[1] We've estimated approximately $14,000 just to develop the PLC objects to do this calculation. Additional effort would be needed to install and test these objects for each pump.

2. SCADA data on VFDs, contemplated in Technical Memorandum #8, could be sent electronically to the UMS obviating the need for a custom interface.

There are potential cost savings if the needs of both systems were reviewed together and planned at one time rather than proceeding ad hoc as features are added over time. If for example, only a small amount of data is exchanged initially, then export/import via CSV files might be expedient. If near real-time exchange of data is needed, then an entirely different approach would probably be used such as a secure database connector. Planning the export/import needs of both systems at one time will help minimize redundant work and minimize overall costs.

Alternatively, a set of secure SCADA screens tailored to managers would allow them to view data already in the SCADA system. Using the secure remote desktop functionality of Wonderware, the optimization of pump sequencing described in Technical Memorandum #4 could be evaluated in real time by managers. While this approach does not rely on a UMS, it is an alternative which could be evaluated on a case-by-case basis.

Attachments

"Cost-Effectiveness Tool – EEM 6-6 SCADA Reprogramming" spreadsheet.

16 February 2018

Final Technical Memorandum #7

To: Joe Schiavone, Rick Santarini, Ron Marincic, Claire Myers, and Tasha Wright – City of Santa Rosa

From: Alan Zelenka, Project Manager, Kennedy/Jenks

Subject: Task 5 – Solar PV Investigation
Santa Rosa Energy Optimization Plan (EOP) – Part 2
K/J Project: 1368024*04

7.1 Purpose of this Investigation

The purpose of Task 5 – Solar Photovoltaic (PV) Investigation was to:

- Use the applicable data and information gathered and analyzed in the Subregional EOP Solar PV investigation for this investigation.
- From information provided by Water Operations, develop a comprehensive list of potential solar PV sites in coordination with City staff; and do a fatal flaw analysis on each site, similar to the one conducted for the Subregional EOP, to eliminate inappropriate or undevelopable sites.
- Create a short-list of up to three potential sites, apply site evaluation criteria from the Subregional EOP, and do a cost-effectiveness analysis on these sites.

7.2 Summary of Recommendations

Further investigate a third-party ownership structure Power Purchase Agreement (PPA) for either a 320 kW (Renewable Energy Measure [REM] 7-5) or 1257 kW (REM 7-6) carport/truckport rooftop mounted solar PV project at the Asphalt Parking and Transfer Facility, west/southwest of the Utilities Field Offices (UFO) building.

If the City would prefer to own and operate the solar system, it should further investigate building a 134 kW system on the existing structure rooftop as a net metering project using part of the remaining UFO building energy use (REM 7-1). Alternatively, while less cost-effective, the City could investigate building a new carport/truckport structure at the southern end of the asphalt area adjacent to the pond and fence, and that rooftop could support an approximately 320 kW-sized system (REM 7-2). Note that this final option is marginally cost-effective.

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Santa Rosa Water Operations EOP – Part 2: Task 5 – Solar PV Investigation

Table 7-1: List of Recommended Renewable Energy Measures (REMs)

REM #	Title
Tier One Recommendations	
7-5	PPA for a 320 kW System Mounted on a New Truckport Structure
7-6	PPA for a 1257 kW System Mounted on Four New Truckport Structures
Tier Two Recommendations	
7-1	Own & Operate a Design-Build 134 kW System on the Existing Rooftop Structure
7-2	Own & Operate a Design-Build 320 kW System on a New Truckport Structure

Table 7-2 shows the potential savings from the recommended REMs. The details of each REM is described in Section 7.9. Kennedy/Jenks has two tiers of recommendations. Tier One recommends developing solar projects using a PPA, where a third-party owns and operates the system. The Tier Two recommendations should be considered if the City wants to own and operate the solar project.

The first recommendation, REM 7-5, is for a 320 kW system on a single carport/truckport structure using a PPA (at a flat rate of $0.1250/kWh for 25 years). The net present value (NPV) of the cumulative net savings over 25 years is over $327,000 and has a rate of return (ROR) of 17.5%. The next most cost-effective solar project option, REM 7-6, is a PPA for a 1257 kW system on four new carport/truckport structures (at a flat rate of $0.1200/kWh for 25 years). The NPV of the cumulative net savings over 25 years is nearly $425,000 and has a ROR of 6.4%. The option with the higher ROR (REM 7-5) is the preferred recommendation even though the NPV is higher for REM 7-6 because it offers a better “bang-for-the-buck” investment.

Should the City wish to own and operate the system, then Kennedy/Jenks recommends REM 7-1, a design-build 134 kW system on the existing rooftop at the north end of the asphalt area. This project has a NPV of nearly $220,000 and a ROR of 6.3%. A larger design-build system of 320 kW and would involve building a single carport/truckport structure and roof mounting the solar panels. This project has a NPV of only $2,800 and a ROR of 4.0% and should be considered only marginally cost-effective.

Table 7-2: Summary of Recommended Energy Efficiency Measure Savings

REM #	Title	Capital Cost ($)	Average Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	ROR (%)
Tier One Recommendations						
7-5	PPA for 320 kW System	$25,000	$23,600	$591,200	$327,400	17.5%
7-6	PPA for 1257 kW System	$125,000	$39,700	$993,600	$424,900	6.4%
Tier Two Recommendations						
7-1	Design-Build 134 kW System	$341,700	$8,700	$218,600	$121,900	6.3%
7-2	Design-Build 320 kW System	$1,133,200	$4,300	$107,000	$2,800	4.0%

7.3 Background Information

The Subregional EOP Technical Memorandum #9, *Comprehensive Solar PV Investigation* (December 30, 2016), provided the City with a substantial amount of information and analysis about solar PV projects. While that information is used in this analysis, it is not repeated in this Technical Memorandum. For an in-depth understanding of the following information, please see Subregional EOP Technical Memorandum #9:

- Siting criteria and a site scoring matrix.
- Ownership structure descriptions: own and operate (O&O), PPA, and land lease.
- The impacts of Sonoma Clean Power (SCP) on solar PV projects including: GHG emissions, rates, and incentives.

Technical Memorandum #9 also included six appendices that provided the following background information about solar PV projects:

- Appendix A - Energy Production from Different Types of Solar Systems.
- Appendix B - Solar PV Installation Options.
- Appendix C - Local Solar PV Companies and Considerations in Making a Selection.
- Appendix D - Purchase Structures and Roles.
- Appendix E - Potential Solar PV Incentive Programs.
- Appendix F - Evaluation of Existing City Solar PV Systems.

7.4 Overview of Methodology

This analysis followed the same evaluation process as the Subregional EOP Solar PV evaluation, including:

- An assessment of each Water Operations-owned site for its solar PV potential.
- Determining if any Water Operations site has a fatal flaw that would eliminate it from consideration for a solar PV project.
- Creating a short-list of potential Water Operations sites and applying the siting criteria.
- Performing a cost-effectiveness analysis on the short-listed sites for the O&O and third-party PPA ownership options.
- Making a recommendation and identifying next steps.

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7.5 Water Operations Site Assessments

Table 7-3, provided by City staff, shows all the Water Operations potential solar sites and any site issues that would make a site undevelopable.

Table 7-3: Potential Water Operations Sites and Identified Site Issues

Site Name	APN	Nickname	Parcel Size (acres)	Open Area (acres)	Address	Site Issues
West College Facility	010-320-030	Asphalt Area and Transfer Facility	117.1	2.6 and 0.13	2100 W College Ave	Area used for parking large vehicles. Freestanding structures would have to be at least 14' tall to let large trucks pass through. Potential pole barn to be built on south portion of lot. Asphalt is not flat; has swales to prevent ponding of water. Closest substation over a mile away (1550 Guerneville Rd).
		Pond 2		30		Former retention pond. Site purchased with General Fund money; uses are negotiated among all City Departments. Many planned future uses.
		Pond 1 - North		2		Current pond for reclaimed water. Controlled by Subregional division, not Water Operations.
		Pond 1 - South		9		Backup pond for stormwater retention. Controlled by Subregional division, not Water Operations. Empty most of the year, filled with sewage overflow approximately 15 days a year. Ineligible for ground-mount; not ideal for floating solar since pond is mostly empty, and when filled, water would be raw sewage. Concerns about flotovoltaics interfering with weed abatement and cleaning.
		Southern-most area		6.5		Former disposal site that has been encapsulated with dirt and barricaded. Disturbance may instigate clean-up of potentially hazardous waste. SRW would need to apply directly to the EPA for funding.

Site Name	APN	Nickname	Parcel Size (acres)	Open Area (acres)	Address	Site Issues
	010-320-007	Parcel SW of MSCS	5.5	3	2090 W College Ave	Large flat field. No water meter onsite. Underground radials from radio station on adjacent parcel stretch into this parcel; no construction is permitted on top of the radials. Site purchased with General Fund money; uses are negotiated among all City Departments.
Oakmont Treatment Plant	016-030-005	Oakmont Treatment Plant	6.3	1+	6308 Stone Bridge Road	Construction projects planned for site make potential future uses uncertain. Concerns about proximity to trails and access issues. Adjacent to scenic location (Annadel Park). Open area too small.
Bennett R9B	049-120-032	Reservoir - Bennett R9B	18.8	1 to 2	3446 Summerfield Road	No road access to open part of parcel, and ~1,000 feet from the closest meter. Adjacent to Annadel State Park. Would need extensive fencing for protection from the public. SRW staffing concerns since this part of the site is not currently monitored. Construction may be difficult since it's located on rock.
Southeast R11	038-261-012	Reservoir - Southeast R11	1.4	0.5	0 Aston Ave	Too small.
Los Alamos R8	030-141-017	Reservoir - Los Alamos R8	1.4	0.4		Too small.
None	010-680-014	MSCS		0.4	69 Stony Circle	Building shared with another City department. Future of building is uncertain. Too small.
None	010-320-030	Lot North of UFO		0.4	35 Stony Point Road	Possible future admin building. Too small.
Rincon R7	153-101-001	Reservoir - Rincon R7	1.8	0.3	None	Too small. Close to residences, access issues, fencing needs.

Site Name	APN	Nickname	Parcel Size (acres)	Open Area (acres)	Address	Site Issues
Abandoned - Reservoir 9C	049-170-017	Reservoir - 9C	3.3	1.5	4788 Bennett Valley Road	Reservoir being decommissioned. City considering selling parcel. Not located near an electricity load. Open area is small.
S11 Pump Station	044-510-013	Pump Station S11	6.2	<1	0 None	Future Kawana Springs Community Park. Open area is small.
Oakmont R12B	016-180-073		5.1	0	None	Lot is entirely covered with dense trees that are a part of Annadel State Park.
Rincon R6	029-030-016		3.0	0	Harville Road	Center of lot covered by reservoir. Remainder of lot covered with trees that screen the reservoir from adjacent residences and roadways.
S4B Pump Station	181-160-013		2.8	0	0 Alice Street	Majority of lot is covered by two reservoirs. The remainder is covered with trees that screen the reservoirs from adjacent residences and roadways.
Oakmont R12A	016-180-008		0.9	0	None	Lot is very small and covered with a reservoir and trees that screen the reservoir from adjacent homes and Annadel State Park.
Montecito R4B & S16 Pump Station	173-390-019		0.9	0	4177 Chanate Road	Lot is very small and covered with a reservoir and trees that screen the reservoir from adjacent homes, businesses, and roadways.
Fountain R1A\B & S2 Pump Station	173-670-027		0.9	0	0 None	Lot is small and covered in two reservoirs, a building, and trees that screen the facility from adjacent homes, roadways, and Nagasawa Community Park.
Fountain R2A	173-590-045		0.8	0	Lot Common Area #G	Small lot covered in reservoir, trees, and Paulin Creek.

Site Name	APN	Nickname	Parcel Size (acres)	Open Area (acres)	Address	Site Issues
Fairway R10	147-420-073		0.6	0	Woodview Drive	Small lot covered in reservoir and trees that screen the facility from adjacent homes, roadway, and Annadel State Park.
S18 Pump Station	173-530-003		0.6	0		Small lot covered in reservoir, building, and paved areas.
S17 Pump Station	173-400-003		0.6	0		Odd shaped parcel, no open space for solar panels.
none	038-261-011		0.6	0	0 Aston Ave	Access road only.
S4 Pump Station	014-161-027		0.6	0	2260 Sonoma Ave	Entirely built-out with buildings (Farmer's lane). Rooftop already has solar PVs.
Wild Oak R13	031-370-017		0.5	0	White Oak Drive	Small lot covered entirely with trees; adjacent to Annadel State Park.
Fountain R2B & S5 Pump Station	173-750-058		0.5	0	None	Tiny open area covered in shadow.
Wild Oak R14	031-380-038		0.5	0	1510 White Oak Drive	Small lot covered in a reservoir, driveway, and trees that screen the facility from adjacent residences.

7.6 Results of Site Assessment

City staff reviewed each site and assessed it using the site constraints used in Subregional EOP Technical Memorandum #9:

- Solar resource
- Size
- Impact on operations
- Whether there are neighbors nearby that would be sensitive to a solar installation
- Whether there is a sensitive environment nearby
- Constructability of a solar project

The only site that does not have a fatal flaw is the 2.6-acre West College Facility Asphalt Area and Transfer Facility highlighted in green in Table 7-3. The rest of the sites are either too small, limited by on-site water infrastructure facilities, limited by steep slopes, impeded by heavy vegetation, and/or limited by sensitive neighbors or environments (e.g., scenic parks).

7.7 Site Description

The Asphalt Area and Transfer Facility is located west/southwest of the UFO building and is used for parking large utility trucks and other vehicles, and as an equipment transfer area.

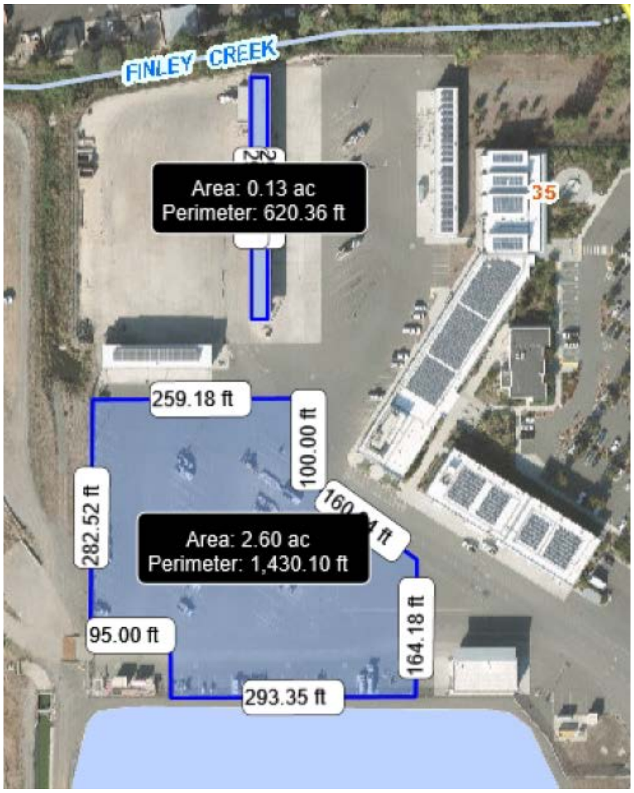

Figure 7-1: Asphalt Area and Transfer Facility

7.8 Project Description

A solar PV project would need to include carport structures that are at least 14 feet tall because this site would still need to be used for truck parking. A truckport structure would need to be designed specifically for this site to allow trucks to easily park and pull through the structure. Figures 7-2 and 7-3 are examples of the type of structures that could be built, upon which the solar PV panels could be mounted.

Examples in Figure 7-2 come from Schletter Solar Mounting Group a German company in Arizona and North Carolina (see their web page at https://www.schletter.us/carport.html). From their website: “Park@Sol creates new usable surfaces for solar energy while also providing shade for parking or pedestrian areas. The Park@Sol system is the most versatile solar carport solution on the market offering several different design options for both single and double rows of parking. To accommodate any site situation, customized foundation options are available including cast-in-place concrete ballasts, concrete pillars, and ‘micropile integrations’. Utilizing state of the art production processes, we are able to achieve longer spans between foundations reducing cost and simplifying the installation process. No on-site welding or cutting is necessary to construct this streamlined and architecturally pleasing solar carport.”

Figure 7-2: Example Solar PV Carport Structures

Figure 7-3: Example Solar PV Carport Structures

The current parking scheme for this area has parking rows running northwest to southeast, diagonally. For solar PV to work optimally, the parking rows would need to be reoriented to run east and west. This could probably still accommodate the drive through functionality of the current parking row configuration. Figure 7-4 below shows the parking area with a potential design for solar carport structures oriented east and west. This amount of rooftop could provide approximately 1,257 kW of solar PV electricity, and the northern existing structure could support an additional 134 kW. The rooftop of the southern-most structure adjacent to the pond and the fence could provide approximately 320 kW of solar PV electricity.

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Figure 7-4: Solar PV Carport Layout

7.9 Cost-Effectiveness Analysis

Kennedy/Jenks modelled the cost-effectiveness of six different options for developing solar at this site. The two main ownership structures modelled are Design-Build (DB) which has the City own and operate the solar system, and a Power Purchase Agreement (PPA) which has the solar system owned and operated by a third party and the output is purchased by the City.

There are three incentive rates for which solar projects get reimbursed for their generation: Net Energy Metering (NEM), Renewable Energy Self-Generation Bill Credit Transfer (RES-BCT), and the Sonoma Clean Power Feed-in Tariff (ProFIT). Each incentive rate has a different price and they are shown below in the more detailed analyses of each of these options.

There are four different sized solar system options modelled: one was a 134 kW system on the existing north structure, and three options were on the rooftops of newly constructed carport/truckport structures: 320 kW that equates to the net energy use of the UFO, 999 kW to comply with the ProFIT project size limitation of not more than 1000 kW, and 1257 kW that maximizes the potential available new carport/truckport rooftop space.

In total six options were analyzed and are listed in Table 7-4.

Table 7-4: Solar PV Options

Option #	Option Title
7-1	DB-1: Design-Build 134 kW at NEM Rate
7-2	DB-2: Design-Build 320 kW at NEM Rate
7-3	DB-3: Design-Build 1257 kW at NEM & RES-BCT Rate
7-4	DB-4: Design-Build 999 kW at ProFIT Rate
7-5	PPA-1: Power Purchase Agreement of 320 kW at Flat Price of $0.125/kWh
7-6	PPA-2: Power Purchase Agreement of 1257 kW at Flat Price of $0.12/kWh

7.9.1 Design-Build (Own and Operate) Model

With this ownership structure option, the City would own and operate a solar PV project on the rooftop of the existing structure in the north part of the site and on the rooftop of newly constructed carport/truckport structures. The following parameters were used in this analysis:

- Capital costs used in this analysis are for a turn-key project and include: the cost of the custom designed carports/truckports, PV panels, inverters, wiring, engineering, permits and fees, installation, NEC-compliant electric connections and utility grid interconnection, warranty, and a performance monitoring and reporting service. Specifically, these prices are based on 350-watt monocrystalline solar modules/panels, SMA STP24000TL-US-10 inverter(s), and live solar monitoring web page.

- Indicative pricing for both the carport/truckport structures with solar PV panels, and for solar PV mounted on the existing structure on the north part of the site, were provided by Advance Energy Systems in September 2017. Should the City choose to pursue this project, a price quote based on a more detailed design would need to be obtained.
- It should be noted that the future price of PV modules is uncertain, because of the possibility of tariffs being imposed at the federal level on foreign made PV modules, and this could substantially increase the price of modules.
- No California Solar Initiative (CSI) incentive is available.
- Failures that require replacements are rare and are usually covered by the warranty; however, replacement of the inverter in year 10 is included in the analysis at a cost of $256,000 and $26,000 respectively for the larger and smaller systems. The inverter is replaced again at year 20. This cost can also be included in a vendor maintenance agreement.
- Internal project development costs associated with contract administration, legal, and procurement process were estimated at $100,000 and $25,000; respectively for the larger and smaller systems.
- To qualify for RES-BCT or the ProFIT incentive rates the City must also conduct a Rule 21 interconnection study with an estimated cost of $25,000 for the study.
- System maintenance for the 1257 kW and 999 kW systems require approximately 1 hour per week, plus a contract for $15,000 per year through a solar vendor. For the 320 kW and 134 kW systems one-quarter of an hour per week and $1,500 per year are required. Regular maintenance is minimal over the life of the system and includes periodically washing and cleaning the panels, as well as testing and cycling the inverters.
- The lifetime of most PV arrays is up to 30 years, but a conservative 25-year design life is assumed for this analysis.
- Generation is approximately 1,486 kWh/kW/year as estimated by Advanced Energy Systems.
- Panel performance degrades at 0.5% per year. The degradation of the system capacity begins at year 1 and continues throughout the system lifetime. Manufacturer warranties take this degradation into account.
- Cost estimates provided in this analysis are based on the Association for the Advancement of Cost Engineering International (AACEI) standards for cost estimating accuracy of +50% and -30%.

Table 7-5: Summary of Cost and Generation Parameters

System Size (kW)	Installed Cost ($/Watt)	Total Capital Cost ($million)	Annual O&M Cost	1st Year Generation (kWh/Yr)	25th Year Generation (kWh/Yr)
DB-1: 134 kW	$2.36	$0.34M	¼ hour/week plus $1,500/Yr	199,100	176,600
DB-2: 320 kW	$3.47	$1.13M	¼ hour/week plus $1,500/Yr	475,000	421,200
DB-3: 1257 kW	$3.47	$4.48M	1 hour/week plus $15,000/Yr	1,485,800	1,317,400
DB-4: 999 kW	$3.47	$3.59M	1 hour/week plus $15,000/Yr	1,867,100	1,655,500

Financial parameters used in this cost-effectiveness analysis include:

- Financed using a 25-year 4% bond.
- The projects would use the NEM, the RES-BCT, or the ProFIT programs to interconnect the PV system to the facility's electricity meter and get reimbursed for the generation.
- The solar project would partially offset the average rate for the UFO building in 2016 which is $0.1592/kWh escalating at 4% per year; the NEM incentive rate is $0.1090/kWh, and the RES-BCT incentive rate is $0.0796/kWh. The NEM rate would only apply to the energy use of the UFO building net of the existing solar project generation, or up to about 475,000 kWh per year. The ProFIT incentive rate is $0.95/kWh, and it is assumed that the project would get the 5-year $0.02/kWh bonus for using a previously developed site and using a local solar developer business. The ProFIT incentive rate would apply to all generation from a system sized up to 1000 kW.

The results of the cost-effectiveness analysis on these four Design-Build systems are shown in Table 7-6. The analysis indicates that both larger system options would result in a net cost to the City and are therefore not recommended. The smaller 134 kW system (on the existing rooftop) and the 320 kW system (on and including a new carport structure) result in overall net lifetime savings to the City and are therefore recommended. Both projects start out with a net cost in the first year, but as the utility cost escalates the 320 kW system creates savings in the 5th year, and the 1257 kW system creates savings in the 13th year. Both projects have a positive net present value of cumulative savings and a positive rate of return.

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Table 7-6: Summary of Results for Design-Build Options

REM #	Option Title	Average Electricity Generated (kWh/Yr)	Capital Cost ($)	First Year Incentive Rate ($/kWh)	First Year Savings ($/Yr)	Average Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	ROR (%)
7-1	DB-1: 134 KW @ NEM	187,600	$341,700	$0.1090	($2,500)	$8,700	$218,600	$121,900	6.3%
7-2	DB-2: 320 KW @ NEM	447,600	$1,133,200	$0.1090	($23,600)	$4,300	$107,000	$2,800	4.0%
7-3	DB-3: 1257 KW @ NEM & RES-BCT	1,759,300	$4,481,000	$0.0871	($144,600)	($59,300)	($1,483,600)	($1,239,300)	1.8%
7-4	DB-4: 999 KW @ ProFIT	1,400,000	$3,591,500	$0.1150	($78,700)	($85,500)	($2,137,900)	($1,559,800)	0.1%

7.9.2 Power Purchase Agreement Model

Under a PPA ownership structure, the City would enter into a PPA with a third party solar developer that would design, build, own, operate, and maintain the solar PV project.

Some upfront costs may be required for contract negotiations. Ongoing monitoring of the maintenance contract and the energy production is estimated to require minimal City staff time (approximately 4 hours per month for the larger system and about 1 hour per month for the smaller system).

A PPA for both a 320 kW and a 1257 kW PPA solar PV system were modelled with the following assumptions:

- 25-year PPA contract term. There is a possibility of a “lease-buyout” of the contract after 10 years, but that would need to be negotiated with the solar company.
- PPA flat prices of $0.12/kWh for the 1257 kW system and $0.125/kWh for the 320 kW system were used in the analysis. A flat PPA price means there is a 0% annual escalator, meaning the price stays flat for the term of the contract. A sensitivity analysis was conducted to show the results of PPA flat prices between $0.10/kWh and $0.14/kWh.
- The PPA price includes the cost of the carport/truckport structure.
- The solar project would partially offset the average rate for the UFO building in 2016 which is $0.1592/kWh escalating at 4% per year; the 320 kW system would offset the NEM incentive rate of $0.1090/kWh in the first year, and the 1257 kW system would receive the NEM incentives rate for the first 475,000 kWh per year, and the remain generation would offset the RES-BCT incentive rate of $0.0796/kWh. Combining the two incentive rates for the 1257 kW system results in a rate of $0.0871/kWh.
- No CSI incentive is available, but the vendor would accrue the Federal Investment Tax Credit.
- Generation is 1,486 kWh/kW/year.

- Panel performance degrades at 0.5% per year.
- Generation over time:
    - 1257 kW system is 1,867,100 kWh/year decreasing to 1,655,500 kWh/year after 25 years,
    - 320 kW system it starts at 475,000 kWh/year decreasing to 421,200 kWh/year after 25 years.
- Replacement cost of the inverter in year 10 (at a cost of $256,000 for the larger system and $26,000 for the smaller system) would be covered by the solar vendor.
- Internal project development costs associated with contract administration, legal, and procurement process (estimated at $100,000 for the larger system and $25,000 for the smaller system) and $25,000 for a Rule 21 Interconnection study for the larger system.
- System maintenance would be covered under the PPA contract.
- Cost estimates provided in this analysis are based on the Association for the Advancement of Cost Engineering International (AACEI) standards for cost estimating accuracy of +50% and -30%.

The results of the cost-effectiveness analysis indicate that a PPA for both a smaller system (320 kW at a flat PPA rate of $0.125/kWh) and a larger system (1257 kW at a flat PPA price of $0.12/kWh) are cost-effective projects for the City. Both projects start out with a net cost in the first year, but as the utility cost escalates the 320 kW system creates savings in the 5th year, and the 1257 kW system creates savings in the 10th year. Since both projects have a positive net present value of cumulative net savings and a positive rate of return and are therefore recommended.

Table 7-7: Summary of Results for the PPA Options

REM #	Option Title	Average Electricity Generated (kWh/Yr)	PPA Rate ($/kWh)	Capital Cost ($)	First Year Incentive Rate ($/kWh)	First Year Savings ($/Yr)	Average Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	ROR (%)
7-5	PPA-1: 320 KW @ NEM	447,600	$0.125	$25,000	$0.1090	($8,200)	$23,600	$591,200	$327,400	17.5%
7-6	PPA-2: 1257 @ NEM & RES-BCT	1,759,300	$0.120	$125,000	$0.0871	($63,900)	$39,700	$993,600	$424,900	6.4%

7.9.3 PPA Sensitivity Analysis

The PPA options' cost-effectiveness is dependent on two key variables: the annual electric rate escalator and the PPA rate.

Electric Rate Escalator Sensitivity

For the 320 kW system at a $0.125/kWh flat PPA rate, the system remains cost-effective (positive NPV) if the annual electric rate escalator is above 1.5% per year.

For the larger 1257 kW system at a $0.12/kWh flat PPA rate, the system remains cost-effective if the annual electric rate escalator is above 3.1% per year.

PPA Rate Sensitivity

Table 7-8 shows the NPV and ROR as the PPA price for the 320 kW system changes. The cost-effectiveness analysis in this Tech Memo was done using a $0.125/kWh PPA flat price. As shown in the table, if the PPA price were to increase the benefits to the City would go down, and if the PPA price were to decrease the benefits to the City would increase.

Table 7-8: PPA Rate Sensitivity for 320 kW System

PPA Price ($/kWh)	Average Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	ROR (%)
$0.10	$34,800	$870,900	$521,600	38%
$0.11	$30,400	$759,000	$443,900	28%
$0.12	$25,900	$647,100	$366,200	20%
$0.125	**$23,600**	**$591,200**	**$327,400**	**18%**
$0.13	$21,400	$535,200	$288,500	15%
$0.14	$16,900	$423,400	$210,800	11%

Table 7-9 shows the NPV and ROR as the PPA price for the 1257 kW system changes. The cost-effectiveness analysis above was done using a $0.12/kWh PPA flat price. From the table one can see that if the PPA price were to increase the benefits to the City would go down, and if the PPA price were to decrease the benefits to the City would increase.

Table 7-9: PPA Rate Sensitivity for 1257 kW System

PPA Price ($/kWh)	Average Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	ROR (%)
$0.10	$74,930	$1,873,250	$1,035,554	15%
$0.11	$57,337	$1,433,429	$730,202	10%
$0.12	**$39,744**	**$993,609**	**$424,851**	**6%**
$0.13	$22,152	$553,788	$119,499	3%
$0.14	$4,559	$113,968	($185,852)	0%

7.9.4 GHG Reduction Summary

The GHG reductions from solar projects results from offsetting grid power from SCP with a renewable resource with zero emissions. The 2015 emissions factor for SCP is 217 pounds of CO2 per MWh delivered (lbs of CO2/MWh). Multiplying the emissions factor by the solar project generation yields the total annual GHG emission reductions. While it is likely SCP's emissions factor will decrease over time, this analysis and all of the EOP analyses for the City, assume a static emissions factor over the 25-year life of the projects. This allows an apples-to-apples comparison of projects.

Table 7-10: GHG Reductions from Solar Project Options

REM #	Option Title	Annual GHG Emission Reduction (MT/Yr)	Cumulative GHG Reductions (MT)
7-1	DB-1: 134 KW @ NEM	20	463
7-2	DB-2: 320 KW @ NEM	47	1,104
7-3	DB-3: 1257 KW @ NEM & RES-BCT	184	4,341
7-4	DB-4: 999 KW @ ProFIT	147	3,454
7-5	PPA-1: 320 KW @ NEM	47	1,104
7-6	PPA-2: 1257 @ NEM & RES-BCT	184	4,341

7.10 Recommendation

Tier One Recommendation

Further investigate a third-party ownership structure PPA for either a 320 kW (REM 7-5) or 1257 kW (REM 7-6) carport/truckport rooftop mounted solar PV project at the Asphalt Parking and Transfer Facility west/southwest of the UFO building.

Tier Two Recommendation

If the City would prefer to own and operate the solar system, it should further investigate building a 134 kW system (REM 7-1) on the existing structure rooftop as a net metering project using part of the remaining UFO building energy use. Alternatively, while less cost-effective, the City could investigate building a new carport/truckport structure at the southern end of the asphalt area adjacent to the pond and fence (REM 7-2), and that rooftop could support an approximately 320 kW-sized system. Note that this final option is only marginally cost-effective.

7.11 Next Steps

If the City elects to proceed with these recommendations, the following steps should be taken:

1. Discuss the potential solar PV projects with PG&E and SCP and determine any concerns and utility requirements the City will need to take into consideration in developing a carport/truckport solar PV project.
2. Do a detailed analysis of the existing UFO building electricity use, current and expected generation from the existing solar PV system, and calculate the net remaining energy use that could be applied to a NEM project. This calculation will determine the size of the NEM solar project at the UFO building meter.
3. Do a detailed rate study to determine the exact RES-BCT and NEM rates that would apply to the various potential solar projects connected to the UFO building meter. Model seasonal and hourly generation, matched up with anticipated hourly energy use (and associated TOU rates) at the UFO building and other potential meters.
4. Develop a bid packet including the general layout for the carport/truck structures, existing structure located at the north end of the lot, the electrical connections, and the rates that solar developers should use in responding to design-build costs or PPA prices.
5. Investigate the feasibility, reliability, and cost of integrating a battery storage system with solar PV systems. If the investigation shows this option could be sufficiently reliable and cost-effective add it as an option for vendors in steps 6 and 7 below.
6. Solicit PPA prices for a single carport/truckport structure with a 320 kW roof mounted solar system, and/or four carport/truckport structures with a 1257 roof mounted solar system.
7. Obtain an installed price quote from solar vendors for a 134 kW existing rooftop system, and/or a 320 kW carport/truckport structure with roof mounted panels.

8. Conduct a new cost/benefit analysis using the information obtained from steps 1 through 6 and make a decision on which potential project, or mix of projects and ownership structures, works best for the City.

26 January 2018

FINAL Technical Memorandum #8

To: Claire Myers, Tasha Wright, Jason Tibbals, and Rick Santarini – City of Santa Rosa

From: Paul Chau, Project Investigation Lead, Kennedy/Jenks
Alan Zelenka, Project Manager, Kennedy/Jenks

Subject: Task 6 – Variable Frequency Drive Investigation
Santa Rosa Energy Optimization Plan (EOP) – Part 2
K/J Project: 1368024*04

8.1 Purpose of this Investigation

The purpose of Task 6, Variable Frequency Drives (VFDs) Investigation, was to:

- Identify current uses of VFDs and evaluate their effectiveness, from information provided by Water Operations.
- Identify opportunities for using additional VFDs and replacing inefficient existing VFDs; assess potential energy reductions and cost-effectiveness of each opportunity.
- Describe the operational impacts of cost-effective strategies.
- Evaluate how a Utility Management System (UMS) could be used to help track energy and cost impacts associated with VFD management and inform future management decisions.

Potential energy savings and cost-effective analyses are provided for each water pump station or sewer lift station (SLS) with pumps that are not equipped with VFDs. A list of all the pumps within the water distribution and sewer collection systems is provided at the end of this document in Table 8-10.

8.2 Summary of Recommendations[1]

As shown in Table 8-1, energy efficiency measure (EEM) 8-3 is recommended for installation of VFDs at Water Pump Station S06. This water pump station has a sufficient combination of energy use and savings to justify the capital cost of equipping the constant-speed pumps with VFDs.

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[1] The analysis in this TM uses energy data from 2015, which was an unusually high year in terms of energy use. SRW staff have since recalculated energy use and savings using 2016 energy data, a more representative year. Using 2016 data, there is no net annual savings (average or cumulative) from equipping the constant-speed pumps at Water Pump Station S06 with VFDs.

Table 8-1: List of Recommended Energy Efficiency Measures

EEM#	EEM Title
8-3	VFD for Water Pump Station S06

Table 8-2 provides a summary of the total energy and cost savings from the recommended EEM.

Table 8-2: Summary of Recommended Energy Efficiency Measure Savings

Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Emission Reduction (MT/Yr)	Net Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	IRR ($)	Cumulative GHG Reductions (MT)
75,000	**$15,750**	**8**	**$64,400**	**$16,600**	**$10,000**	**$99,900**	**$83,800**	**23%**	**76**

For pumps already equipped with VFDs, Kennedy/Jenks recommends verifying that the units are operating greater than 50% of full speed under all operating conditions. If VFDs are operating beyond this turndown ratio, Kennedy/Jenks recommends the City evaluate pump sizes that provide a better fit for the operating conditions.

8.3 Overview of Methodology

This technical memo provides the results of a cost-effectiveness analysis for each potable water pump station and sewer lift station that has one or more pumps not equipped with a VFD. The energy savings are calculated for each pump and totaled for the pump station, based on an assumed energy efficiency of 75% that can be achieved with installation of a VFD. The existing pump efficiencies are provided from pump efficiency tests conducted in July 2017; if no pump efficiency test data was available, a 10% efficiency gain is assumed. For pumps with an existing efficiency of at least 75%, VFD installation is not recommended because no efficiency gains could be achieved and thus a cost-effectiveness analysis was not conducted. About 55% of the water pump stations within the distribution system are not equipped with VFDs. An analysis for each water pump station is provided in Sections 8.4 and 8.5. Analysis for each sewer lift station is in Section 8.6.

Material and installation costs for VFDs of various pump sizes are provided in Table 8-3. The material cost is based on information from Rockwell Automation, a VFD manufacturer, and installation cost is based on 2016 construction cost data from RSMeans by the horsepower (HP) of the pump.

Table 8-3: VFD Material and Installation Costs

Pump Size (HP)	Material Cost ($)	Installation Cost ($)	Total Cost ($)
1.5	$8,500	$1,800	$10,300
2	$9,000	$1,900	$10,900
5	$9,900	$2,100	$12,000
7.5	$10,400	$2,200	$12,600
10	$10,800	$2,300	$13,100
15	$11,700	$2,500	$14,200
20	$12,600	$2,700	$15,300
25	$13,000	$2,800	$15,800
30	$14,300	$3,100	$17,400
40	$16,100	$3,500	$19,600
50	$17,800	$3,800	$21,600
60	$19,600	$4,200	$23,800
75	$22,200	$4,800	$27,000
100	$29,000	$6,300	$35,300
125	$31,000	$6,700	$37,700
150	$35,400	$7,600	$43,000
200	$44,200	$9,500	$53,700
300	$61,000	$13,200	$74,200

Cost savings derived from the calculated energy savings are also provided, based on the average 2016 electricity rate of $0.21/kilowatt-hour (kWh) with a 2.5% annual escalation rate starting in 2019. The cost-effectiveness analysis calculates the Net Present Value (NPV) over the 10-year life of the pump. The general rule of thumb is that analyses that result in a positive NPV means the City would be better off doing the project than not doing the project, and therefore the project is recommended. A project with a negative NPV should not be pursued and is not recommended.

Cost estimates provided in this analysis are based on the Association for the Advancement of Cost Engineering International (AACEI) standards for cost estimating accuracy of +50% and -30%.

8.4 Recommended EEMs – VFDs for Potable Water Pump Stations

This section describes potential cost-effective opportunities to install VFDs for constant-speed pumps at potable water pump stations. VFDs are recommended for constant-speed pumps at Water Pump Station S06.

Water Pump Station S06

This water pump station consists of three 125 HP pumps that convey water to Reservoir R-6. Pump P-2 is equipped with a VFD, while pumps P-1 and P-3 are not. In 2015, the water pump station used 311,442 kWh of energy. The constant-speed pumps have a low average pump efficiency of only 48% based on pump efficiency tests conducted in 2017. Pump Station S06 is unique among all the water pump stations in that it has a low overall efficiency and it uses a significant amount of energy. This combination is what allows a VFD, which improves the station's efficiency to 75%, to be cost-effective. Most of the other pump stations without VFDs had overall efficiencies of 68% to 74% and would not gain much improvement with a VFD. For the other two pump stations with low efficiencies, S11 (49%) and S18 (50%), they simply do not use enough energy (54,000 kWh and 12,000 kWh respectively) to justify the investment in a VFD.

Table 8-4 provides the cost-effectiveness analysis results for equipping pumps P-1 and P-3 with VFDs. Installing VFDs results in energy savings of approximately 75,000 kWh per year, which equates to an average annual net savings of $10,000 per year, a NPV of $83,800, and a rate of return of 23% on the $64,400 investment. GHG emissions would be reduced 76 metric tons over 10 years. Therefore, this VFD is recommended.[2]

Table 8-4: EEM 8-3 Water Pump Station S06 VFD Analysis

Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Emission Reduction (MT/Yr)	Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	IRR ($)	Cumulative GHG Reductions (MT)
75,000	**$15,750**	**8**	**$64,400**	**$16,600**	**$10,000**	**$99,900**	**$83,800**	**23%**	**76**

8.5 Not Recommended EEMs – VFDs for Potable Water Pump Stations

Table 8-5 shows pump stations for which Kennedy/Jenks did not quantify VFD-related energy savings, and the reasons for their exclusion. As stated earlier in this document, for pumps already equipped with VFDs, Kennedy/Jenks recommends verifying that the units are operating at greater than 50% of full speed under all operating conditions. If VFDs are operating beyond this turndown ratio, Kennedy/Jenks recommends the City evaluate pump sizes that provide a better fit for the operating conditions.

Table 8-5: Water Pump Stations Excluded from Energy Savings Analysis

Water Pump Station	Reason for Exclusion
S02	This water pump station is provided electricity via a geothermal energy generator. Because this analysis is focused on saving electricity, an analysis is not conducted for this water pump station.

[2] As stated on page 8-1, the analysis in this TM uses energy data from 2015, which was an unusually high year in terms of energy use. Using 2016 data, there is no net annual savings (average or cumulative) from equipping the constant-speed pumps at Water Pump Station S06 with VFDs.

Water Pump Station	Reason for Exclusion
S03	All the pumps at this water pump station are equipped with VFDs.
S04B	This water pump station is currently not in service and will not be utilized in the foreseeable future.
S04R	The pump at this water pump station is equipped with a VFD.
S05	All the pumps at this water pump station are equipped with VFDs.
S09	This water pump station consists of three 300 HP pumps (P-1, P-2, and P-3) that convey water to Reservoirs R-9A and R-9B, and two 75 HP pumps (P-4 and P-5) that convey water to water pressure zone R9R1. Pumps P-1, P-4, and P-5 are equipped with VFDs, while pumps P-2 and P-3 are not equipped with VFDs. In 2015, the water pump station used 548,688 kWh of energy. The constant-speed pumps, P-4 and P-5, have a high pump efficiency of 81% based on pump efficiency tests conducted in 2017. In addition, pumps P-4 and P-5 are currently not in service and will not be put in service in the foreseeable future.
S10	All the pumps at this water pump station are equipped with VFDs.
S13	All the pumps at this water pump station are equipped with VFDs.
S14	All the pumps at this water pump station are equipped with VFDs.
S15	This water pump station consists of two 10 HP pumps (P-1 and P-2) and one 50 HP pump (P-3). Pumps P-1 and P-2 are equipped with VFDs, while pump P-3 is not. Pump P-3 is rarely run and is only utilized in a catastrophic event.

For the remaining pump stations, Kennedy/ Jenks quantified potential cost-effective opportunities to install VFDs but determined that the costs exceed the benefits. Adding VFDs would reduce GHG emissions, but VFDs are not recommended because the cost-effectiveness analyses show an average annual net cost, a negative NPV, and/or a negative internal rate of return (IRR). Table 8-6 shows the pump stations that do not warrant VFD installation, the pumps evaluated within those stations, the data used to inform the analyses, and the cost-effectiveness results. Most of these pump stations have overall efficiencies of 68% to 74% and would not gain much improvement with a VFD. For the two pump stations with low efficiencies, S11 (49%) and S18 (50%), they simply do not use enough energy (54,000 kWh and 12,000 kWh respectively) to justify the investment in a VFD.

Table 8-6: Water Pump Stations Not Recommended for VFDs

EEM	Pump Station	Pumps without VFDs	Reservoirs Served	Pump Station 2015 Energy (kWh)	Pump Efficiency (%)	Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Reduction (MT/Yr)	Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	IRR (%)	Cumulative GHG Reductions (MT)
8-1	S01	Four 125 HP pumps	R-1A and R-B1	371,233	70%	23,547	$4,945	2	$148,420	$3,836	($12,123)	($121,233)	($103,180)	-14.4%	24
8-2	S04	One 50 HP pump	Pressure zone R9R1	80,345	68%	7,274	$1,528	1	$20,957	$936	($783)	($7,827)	($6,733)	-3.4%	7
8-4	S07	Three 50 HP pumps	R-7	135,030	71%	7,9788	$1,317	1	$64,209	$281	($2,748)	($54,350)	($40,670)	-5.2%	15
8-5	S08	P-2 (75 HP)	R-8	34,705	69%	494	$104	0.1	$26,833	$463	($3,077)	($30,770)	($26,120)	-35.2%	1
8-10	S11	P-2 and P-3 (60 HP)	R-11	54,994	49%	12,693	$2,666	1	$50,541	$6,238	($3,028)	($30,285)	($25,859)	-8.3%	13
8-11	S12	Three 40 HP pumps	R-12A and R-12B	33,446	71%	1,921	$403	0.2	$58,499	$701	($6.510)	($65,098)	($55,271)	-30.5%	2
8-12	S16	P-2 (75 HP)	R-16	129,089	74%	1,284	$270	0.1	$26,843	$378	($2,872)	($28,924)	($24,563)	-27.2%	1
8-13	S17	P-2 (75 HP)	R-17	129,639	70%	4,748	$997	0.5	$33,668	$2,124	($2,000)	($19,995)	($17,028)	-12.7%	5
8-14	S18	Two 30 HP pumps	R-17	12,085	50%	4,043	$849	0.4	$32,768	$3,924	($3,056)	($30,555)	($25,982)	-17.7%	4

8.6 Not Recommended EEMs – VFDs for Sewer Lift Stations

This section describes potential opportunities to install VFDs for constant-speed pumps at sewer lift stations. As of 2017, only the pumps at Sewer Lift Station 11 are equipped with VFDs, which leaves about 93% of the collection system pumps not equipped with VFDs (including the two stations destroyed in the October 2017 fire - SLS02 and SLS20).

Because recent pump efficiency tests were not available for sewer lift station pumps, the analysis assumed an energy savings of 10% per pump. Most of the pumps have relatively small motors and have relatively low load factors, which lead to low energy and cost savings potential. Kennedy/Jenks' analysis shows that VFDs are not cost-effective at any of the sewer lift stations, and thus none are recommended for installation. Table 8-7 shows the sewer lift stations evaluated, the specific pumps evaluated within those stations, the data used to inform the analyses, and the cost-effectiveness results.

Table 8-7: Sewer Lift Station VFD Analyses

EEM	Sewer Lift Station	Pumps without VFDs	Manholes Served	SLS 2015 Energy (kWh)	Electricity Savings (kWh/Yr)	Electricity Savings ($/1st Yr)	GHG Reduction (MT/Yr)	Net Capital Cost ($)	Incentive Amount ($)	Avg Annual Net Savings ($/Yr)	Cumulative Net Savings ($)	NPV of Cumulative Net Savings ($)	IRR (%)	Cumulative GHG Reductions (MT)
8-15	01	Two 60 HP pumps	#6	28,279	2,828	$594	0.3	$45,403	$4,616	($4,738)	($47,379)	($40,245)	-24,7%	2.9
8-16	02 [1]	Four 20 HP pumps	St. Andrews Dr.	23,249	2,325	$409	0.2	$59,763	$3,263	($3,572)	($71,438)	($52,843)	-12.3%	4.7
8-17	03	Two 11 HP pumps	#30	5,618	562	$118	0.1	$26,795	$45	($3,057)	($30,566)	($25,948)	-34.2%	0.6
8-18	04	Four 25 HP pumps	#30	20,911	2,091	$439	0.2	$62,993	$727	($7,005)	($70,474)	($59,474)	-30.4%	2.1
8-19	05	Two 5 HP pumps	#36	6,203	620	$130	0.1	$24,050	$161	($2,716)	($27,163)	($23,060)	-32.6%	0.6
8-20	09	Two 15 HP pumps	#19	13,854	1,385	$291	0.1	$28,269	$446	($3,038)	($30,383)	($25,803)	-27.0%	1.4
8-21	10	Two 2 HP pumps	#51	1,591	159	$33	0.02	$21,318	$52	($2,500)	($24,995)	($21,215)	-41.7%	0.2
8-22	12	Two 5 HP pumps	#8	8,006	801	$185	0.1	$24,036	$176	($2,672)	($26,721)	($22,688)	-30.4%	0.8
8-23	13	Two 2 HP pumps	#38	2,814	281	$59	0.03	$21,915	$67	($2,542)	($25,419)	($21,576)	-37.9%	0.3
8-24	15	Two 2 HP pumps	#69	1,017	102	$21	0.01	$21,929	$53	($2,586)	($25,859)	($21,947)	-44.8%	0.1
8-25	16	Two 5 HP pumps	#1	2,130	213	$45	0.02	$24,083	$129	($2,816)	($28,160)	($23,901)	-40.6%	0.2
8-26	17	Two 15 HP pumps	#79	13,911	1,391	$292	0.1	$28,269	$447	($3,037)	($30,369)	($25,791)	-26.9%	1.4
8-27	18	Four 15 HP pumps	#14	19,985	1,999	$420	0.2	$56,768	$495	($6,286)	($62,857)	($53,370)	-29.9%	2.0
8-28	19	Four 10 HP pumps	#68	15,037	1,504	$316	0.2	$52,472	$344	($5,891)	($58,908)	($50,013)	-31.7%	1.5
8-29	20 [1]	Four 10 HP pumps	#84	7,800	780	$137	0.1	$52,530	$286	($3,424)	($68,475)	($50,533)	-17.5%	1.6
8-30	21	One 23 HP pump	HH-28-06, #9	7,164	716	$150	0.1	$15,667	$572	($1,696)	($16,960)	($14,403)	-27.6%	0.7

Note:
[1] These two lift stations (#2 and #20) were destroyed in the October 2017 Tubbs Wildfire.

8.7 Utility Management System (UMS) Interface

A UMS can track energy use and cost of pumps that are equipped with VFDs, which can be compared to historic data to determine the savings from installing the VFDs. In addition, VFDs provide a UMS with real-time data that can be used to optimize energy use and rates by allowing pumps to operate over a greater flow range, while still close to the best efficiency point.

Communication between VFDs and a UMS should not be an issue. Based on data sheets for Specific Energy software (see Technical Memorandum #3 - UMS), the software can support VFDs that utilize Modbus serial, Modbus TCP, USS protocols; and can receive data via RS-232, RS-485, and Ethernet.

8.8 Background Information

Table 8-8 lists the current (2017) water pump station and sewer lift station pumps, indicating which ones have VFDs installed. Of the 55 water pumps 30 (55%) do not have VFDs installed, and 41 out of 44 (93%) of the sewer lift pumps do not have VFDs installed.

Table 8-8: List of Potable Water Pump Station and Sewer Lift Station Pumps

Station No.	Pump Number	Pump Size (HP)	Installed VFD
Water Pump S01	P-1	125	
Water Pump S01	P-2	125	
Water Pump S01	P-3	125	
Water Pump S01	P-4	125	
Water Pump S02	P-1	100	
Water Pump S02	P-2	100	
Water Pump S02	P-3	100	
Water Pump S02	P-4	100	
Water Pump S03	P-1	40	X
Water Pump S03	P-2	40	X
Water Pump S03	P-3	100	X
Water Pump S04	P-1	150	
Water Pump S04	P-2	150	
Water Pump S04	P-3	150	
Water Pump S04	P-4	50	
Water Pump S04R	P-1	30	X
Water Pump S05	P-1	50	X
Water Pump S05	P-2	50	X
Water Pump S05	P-3	300	X
Water Pump S06	P-1	125	
Water Pump S06	P-2	125	X
Water Pump S06	P-3	125	
Water Pump S07	P-1	50	

Station No.	Pump Number	Pump Size (HP)	Installed VFD
Water Pump S07	P-2	50	
Water Pump S07	P-3	50	
Water Pump S08	P-1	75	X
Water Pump S08	P-2	75	
Water Pump S09	P-1	300	X
Water Pump S09	P-2	300	
Water Pump S09	P-3	300	
Water Pump S09	P-4	75	X
Water Pump S09	P-5	75	X
Water Pump S10	P-1	7.5	X
Water Pump S10	P-2	7.5	X
Water Pump S11	P-1	75	X
Water Pump S11	P-2	75	
Water Pump S11	P-3	75	
Water Pump S12	P-1	40	
Water Pump S12	P-2	40	
Water Pump S12	P-3	40	
Water Pump S13	P-1	40	X
Water Pump S13	P-2	75	X
Water Pump S13	P-3	75	X
Water Pump S14	P-1	40	X
Water Pump S14	P-2	50	X
Water Pump S14	P-3	50	X
Water Pump S15	P-1	10	X
Water Pump S15	P-2	10	X
Water Pump S15	P-3	50	
Water Pump S16	P-1	75	X
Water Pump S16	P-2	75	
Water Pump S17	P-1	75	X
Water Pump S17	P-2	75	
Water Pump S18	P-1	30	
Water Pump S18	P-2	30	
SLS 01	P-1	60	
SLS 01	P-2	60	
SLS 02	Destroyed in October 2017 wildfire		
SLS 03	P-1	11	
SLS 03	P-2	11	
SLS 04	P-1	25	

Station No.	Pump Number	Pump Size (HP)	Installed VFD
SLS 04	P-2	25	
SLS 04	P-3	25	
SLS 04	P-4	25	
SLS 05	P-1	5	
SLS 05	P-2	5	
SLS 09	P-1	15	
SLS 09	P-2	15	
SLS 10	P-1	2	
SLS 10	P-2	1.5	
SLS 11	P-1	40	X
SLS 11	P-2	40	X
SLS 11	P-3	40	X
SLS 12	P-1	5	
SLS 12	P-2	5	
SLS 13	P-1	2	
SLS 13	P-2	2	
SLS 15	P-1	2	
SLS 15	P-2	2	
SLS 16	P-1	5	
SLS 16	P-2	5	
SLS 17	P-1	15	
SLS 17	P-2	15	
SLS 18	P-1	15	
SLS 18	P-2	15	
SLS 18	P-3	15	
SLS 18	P-4	15	
SLS 19	P-1	10	
SLS 19	P-2	10	
SLS 19	P-3	10	
SLS 19	P-4	10	
SLS 20	Destroyed in October 2017 wildfire		
SLS 21	P-1	23	

26 January 2018

Final Technical Memorandum #9

To: Joe Shiavone, Rick Santarini, Ron Marincic, Jason Tibbals, Simon Hood, Claire Myers, and Tasha Wright, City of Santa Rosa

From: Brooke Harrison, Project Investigation Lead, Kennedy/Jenks
Alan Zelenka, Project Manager, Kennedy/Jenks

Subject: Task 7 – Time of Use (TOU) Rate Optimization Investigation
Santa Rosa Energy Optimization Plan (EOP) – Part 2
K/J 1368024*04

9.1 Purpose of this Investigation

The purpose of Task 7 – Time of Use (TOU) Rate Optimization was to:

- Identify the potable water pump station, sewer lift station, and administrative building electricity meters over which Santa Rosa Water, Water Operations, has discretion, and the potential to shift energy use from Peak to Partial-Peak or Off-Peak periods.
- Identify opportunities and strategies to optimize TOU rates to reduce cost, and potentially energy use. Describe their operational impacts.
- Identify necessary SCADA reprogramming and equipment needs and estimate the capital costs of appropriate strategies.
- Determine cost and energy savings, and conduct a cost-effectiveness analysis on appropriate strategies. The decision to pursue any strategy will be the sole purview of the City.
- Evaluate how a Utility Management System (UMS) could be used to track and report on energy and cost savings associated with TOU rate optimization, and inform future management decisions.

9.2 Recommendation Summary

No TOU strategies for the pumps were found to be cost-effective, and thus none are recommended. However, several TOU strategies for the Utility Field Office (UFO) Administration Building merit further investigation and they are listed in Section 9.7.

9.3 Background Information

Most of the City's energy accounts are currently on TOU rates, and the remainder will be converted at a future date as required by the California Public Utilities Commission. For accounts that are on TOU rates, instead of a single flat rate ($/kWh) for energy use, TOU rates are higher when electric demand is higher. As such, *when* the City uses energy is just as important as *how much* it uses. Under TOU rates, winter has two rate periods: Off-Peak and

Partial-Peak, and summer has three rate periods: Off-Peak, Partial-Peak and Peak. During the Peak period electric rates are the highest, Partial-Peak rate is lower than the Peak rate, and the Off-Peak rates are the lowest. Figure 9-1 shows the hours for Peak, Partial-Peak, and Off-Peak rates for summer and winter.

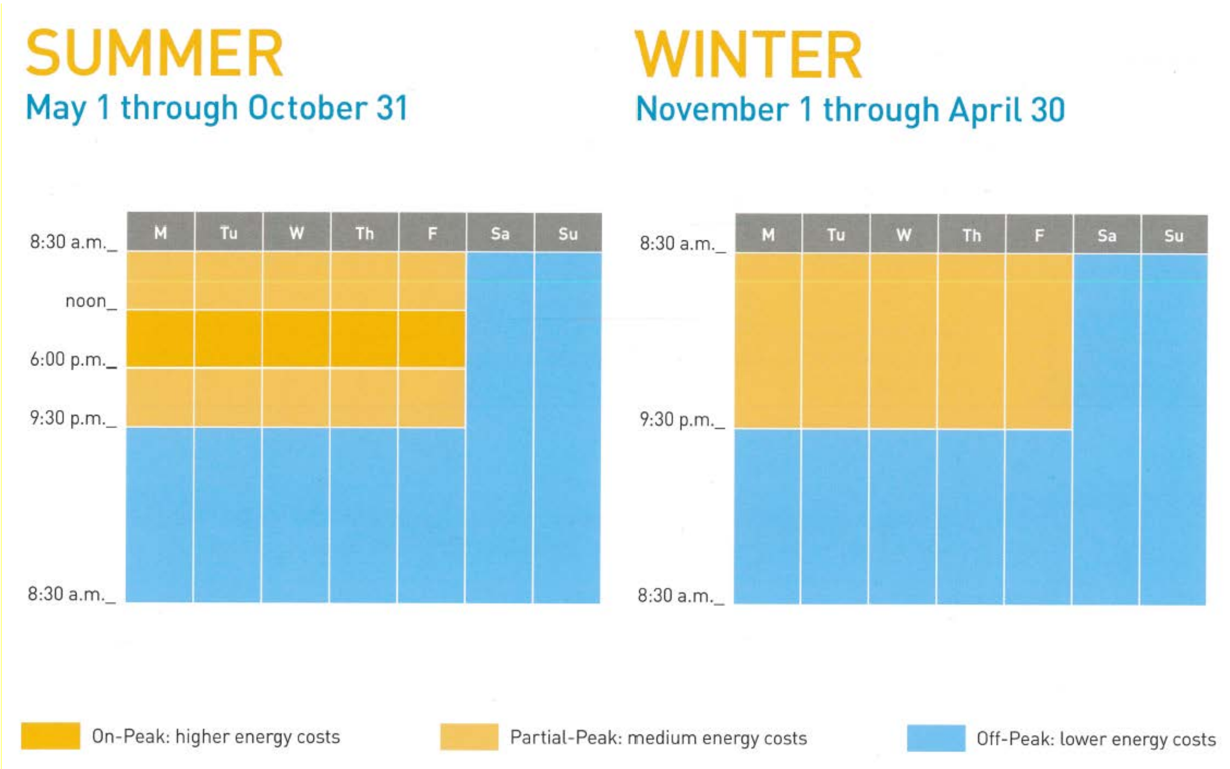

Figure 9-1: Time of Use Structure

The City's water pump stations, sewer lift stations, and administration buildings are on Sonoma Clean Power's (SCP) Commercial Customer rate schedule. Table 9-1 below describes the rates schedule and charges. The A1 and A6 rates are the most common for water pump stations and are provided as examples.

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Table 9-1: SCP Commercial Customer TOU Periods and Rates

TOU Classification	Period	A1 Rate ($/kWh)*	A6 Rate ($/kWh)*
Summer Rates: May 1 through October 31			
Peak	Noon to 6:00 p.m. Monday - Friday	$0.10541	$0.33649
Partial-Peak	8:30 a.m. to Noon and 6:00 p.m. to 9:30 p.m. Monday - Friday	$0.08199	$0.09988
Off-Peak	9:30 p.m. to 8:30 a.m. Monday - Friday All day Saturday and Sunday and Holidays	$0.05491	$0.04230
Winter Rates: November 1 through April 30			
Partial-Peak	8:30 a.m. to 9:30 p.m., Monday - Friday	$0.08198	$0.06758
Off-Peak	9:30 p.m. to 8:30 a.m. Monday - Friday All day Saturday and Sunday and Holidays	$0.06128	$0.05027

*Sonoma Clean Power Commercial Rates, effective March 1, 2017
https://sonomacleanpower.org/wp-content/uploads/2016/03/Commercial-Rates-as-of-March-1-2017-1.pdf

Shifting from summer Peak to Partial-Peak periods lowers the A1 energy rate by 22% and the A6 rate by 70%. Shifting from Partial-Peak period to the Off-Peak period reduces the A1 rate by 33% and the A6 rate by 58%. Shifting from winter Partial-Peak to Off-Peak reduces the A1 rate by 25% and the A6 rate by 26%.

9.4 System Description

Kennedy/Jenks provided the City with a list of water pump stations, sewer lift stations, and administrative building meters for their review. The City was requested to assess each meter for potential savings from shifting TOU periods.

Below is a summary of existing conditions and potential savings from optimizing for TOU rates:

- 19 of the 21 water pump stations are already programmed to **ONLY** pump during Off-Peak hours (the period includes a 15-minute buffer and is actually 9:45 p.m. to 8:15 a.m.). The current control strategy calls for the water pump stations to fill their associated storage tanks only during the night. Two water pump stations (S-4 and S-4R) are controlled by system pressure and must operate when required by demand.

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- Pumping for all 19 sewer lift stations occurs when stations need to pump and is not restricted to just the Off-Peak TOU period. This prevents spills, as the sewer lift stations are controlled by elevations in the wet well. The elevation setpoints at which the pumps start and stop were designed to accommodate fluctuating conveyance flows and to prevent overflow conditions. The City has determined that overflow prevention is a high enough priority to preclude the sewer lift stations from any operational changes to optimize TOU rates.
- Santa Rosa Water occupies the entire UFO administrative building, and shares occupancy of the Municipal Services Center South (MSCS) administrative building with the Department of Transportation and Public Works. Santa Rosa Water occupies approximately 50% of MSCS and, therefore, only has partial discretion or control over building electricity use.

Table 9-2 lists each of the Water Operations' water pump station, sewer lift station (SLS), and administrative building meters (shaded in gray).

Table 9-2: Water Operations Meters and TOU Savings Potential

Description	Name	Rate	TOU Potential
Pump Station S-1	Fountain Grove 1	A6X	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-2	Fountain Grove 2	A1P	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-3	Fountain Grove 3	A1P	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-4	Station 4	NEMEXPM	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S0-4	Station 4	HE19SV	None. Must run when they reach certain thresholds.
Pump Station S-4B	Proctor	HA1X	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-4R	Murdock	HA10S	None. Must run when they reach certain thresholds.
Pump Station S-5	Skyfarm	HA6	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-6	Rincon 1	A6X	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-7	Rincon 2	A6X	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-8	Skyhawk	A1P	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-9	Bennett Valley	E19S	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-10	Woodview	HA6	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-11	Kawana	HA1X	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-12	Oakmont	A1P	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-13	Wild Oak 1	HA6	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-14	Wild Oak 2	HA6	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-15	Meadowridge	HA1X	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-16	Fountain Grove 4	HA6	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-17	Fountain Grove 5	HA6	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
Pump Station S-18	Fountain Grove 6	HA1X	Already pumps only during Off-Peak hours (9:45 p.m. to 8:15 a.m.)
35 Pfister Rd	Admin Building - UFO	NEMEXPM	New LEED building with not much flexibility in operations.
69 Stony Point Rd #1	Admin Building - MSCS	HA1X	Shared with Dept. of Transportation & Public Works
69 Stony Point Rd #2	Admin Building - MSCS + FS solar	NEMEXPM	Shared with Dept. of Transportation & Public Works

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Description	Name	Rate	TOU Potential
69 Stony Point Rd #3	Admin Building - MSCS	HA1	Shared with Dept. of Transportation & Public Works
69 Stony Point Rd #4	Admin Building - MSCS - West End	HA1	Shared with Dept. of Transportation & Public Works
69 Stony Point Rd #5	Admin Building - MSCS - East End	HA1X	Shared with Dept. of Transportation & Public Works
69 Stony Point Rd #6	Admin Building - MSCS	HE19SX	Shared with Dept. of Transportation & Public Works
SLS-01	Fountaingrove	HA6	None. Must pump at specific thresholds.
SLS-02	Skyfarm "A"	HA6	None. Must pump at specific thresholds.
SLS-03	Clearbrook	HA1X	None. Must pump at specific thresholds.
SLS-04	Skyfarm "B"	HA6	None. Must pump at specific thresholds.
SLS-05	Fawnglen	A1P	None. Must pump at specific thresholds.
SLS-09	Willowside	HA6	None. Must pump at specific thresholds.
SLS-10	Country Manor	HA1X	None. Must pump at specific thresholds.
SLS-11	West College	HA6	None. Must pump at specific thresholds.
SLS-12	Mohawk	HA6	None. Must pump at specific thresholds.
SLS-13	Pawnee	HA1X	None. Must pump at specific thresholds.
SLS-15	Alderbrook	HA1X	None. Must pump at specific thresholds.
SLS-16	Spring Lake	HA1X	None. Must pump at specific thresholds.
SLS-17	Oakmont	HA6	None. Must pump at specific thresholds.
SLS-18	Shelter Glen	HA1X	None. Must pump at specific thresholds.
SLS-19	Hadley Hill	HA1X	None. Must pump at specific thresholds.
SLS-20	Hansford	HA1X	None. Must pump at specific thresholds.
SLS-21	Flintridge	HA1X	None. Must pump at specific thresholds.
SLS-Oakmont	Oakmont Treatment Plant	HE19SW	None. Must pump at specific thresholds.
SLS-Oakmont GC	Oakmont - Golf Course	A6	None. Must pump at specific thresholds.

9.5 Water Pump Station Peak Energy Use

As part of the investigation into the SmartWorks software from Harris Utilities, Kennedy/Jenks reviewed the total historic (as opposed to real-time) energy use of the water pump stations, and used SmartWorks to create a report showing the historic energy use by TOU period for all the water pump stations. The figure below shows a screenshot of the SmartWorks Dashboard showing the water pump energy use over the past year (October 2016 to September 2017).

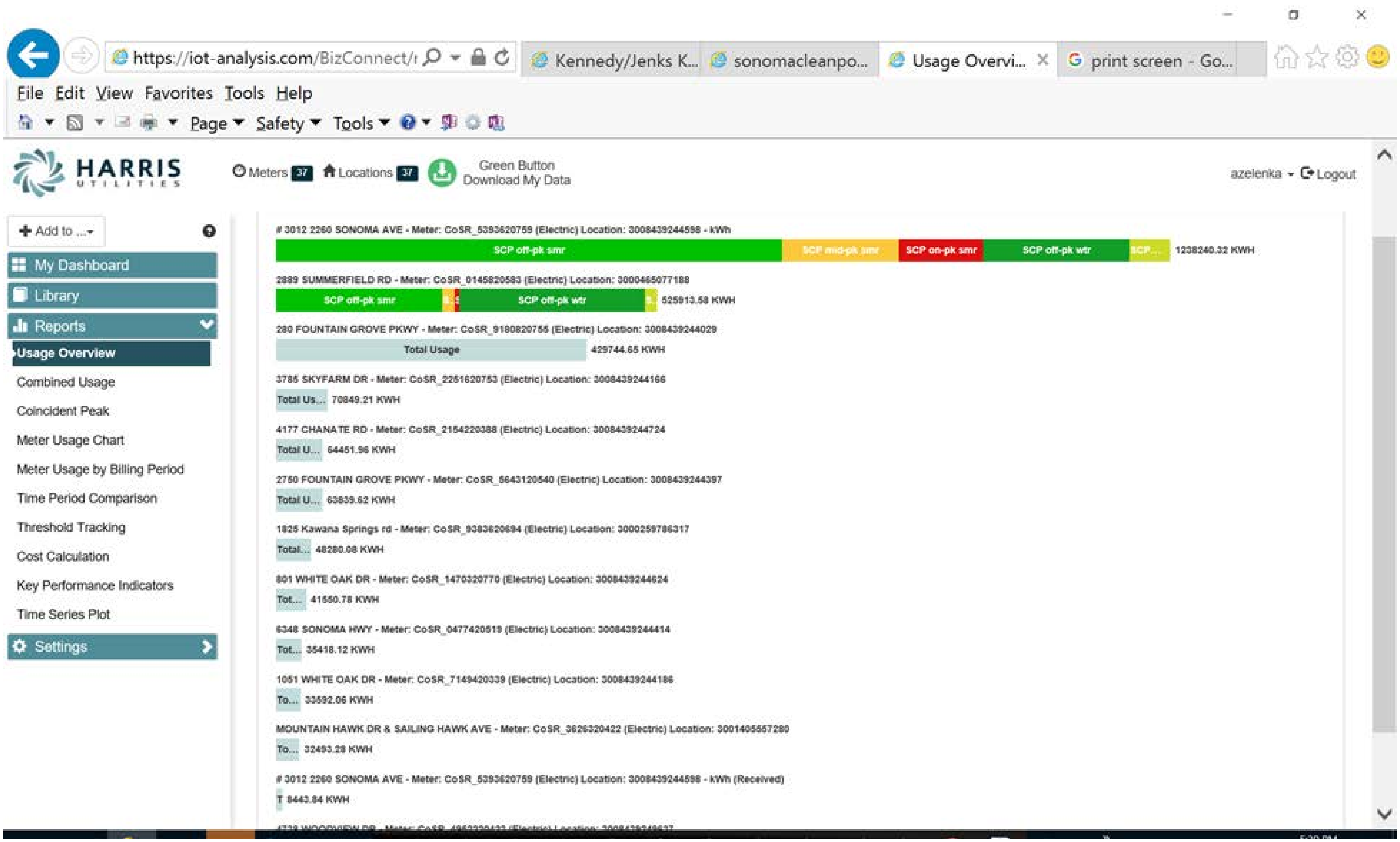

Figure 9-2: SmartWorks Screenshot of Dashboard Showing Water Pump Station Energy Use

Kennedy/Jenks analyzed the energy use during the summer Peak period (May 1 to October 31, noon to 6:00 p.m.) for 2016 and 2017 (through September 2017). The electricity meters for Pump Stations S-4 and S-9 showed the Peak period energy use totaling 99,000 kWh in 2017 (so far without October 2017 data) and 114,000 kWh in 2016. This amounts to about 7% of total energy use during the summer period. Shifting this energy use to Partial-Peak period could have saved $3,800 in 2017 and $4,300 in 2016.

However, City staff explained that the Peak energy use could not be shifted to the Partial-Peak period because the City must pump during these hours for operational reasons. The longer explanation is that the City no longer needs to run the pumps at Water Pump Station S-9. The City runs the Bennett Valley water station pump at S-4 twenty-four hours a day from April to November. They found that the demand from Pressure Zone 9 and Pressure Zone 9 Reduced is so great that it will drain the tanks to the point that the pumps at R-9 must turn on during the day. The City realized that running the 50 horsepower (HP) pump at S-4 costs less than running a 300 HP pump at S-9 during the Peak period. Secondarily, and almost as important, the City pumps the water from the Well Treatment Plant with the Bennett Valley water station pump into Pressure Zone 9 Reduced from April to November to distribute treated well water into the Bennett Valley. So, none of the Peak period energy use can be shifted to the Partial-Peak period.

9.6 Administration Building TOU Strategies

Typical categories for energy optimization in administrative buildings include heating ventilation and air conditioning (HVAC), lighting, water heating, and plug loads. Some of the City buildings are LEED certified and already fairly efficient. Typical work schedules are during the Peak period and thus don't allow for much flexibility in shifting the energy use of lighting or HVAC loads, and plug loads are typically too small to garner much savings. Kennedy/Jenks provided a list of typical TOU optimization strategies for the administration buildings and asked the City to respond to each strategy for the UFO building. The UFO building was built in 2011 to LEED gold standards; however, the building was not officially LEED certified. The City's comments and Kennedy/Jenks' responses are provided in the table below. The strategies that are grayed-out are either already done or were deemed infeasible.

In addition, the older MSCS building occupied by Santa Rosa Water personnel are shared with another City department and are operated by City Facilities, and not Santa Rosa Water. Facilities is in the middle of an examination into all City buildings including MSCS, investigating energy efficiency and renewable opportunities, and will address energy opportunities for MSCS through that process. As such, Table 9-3 does not include MSCS. However, all of these strategies should be considered at some point for MSCS, and for all City buildings.

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Table 9-3: Administrative Building Potential TOU Optimization Strategies

Area	#	Potential TOU Optimization Strategies	UFO Comments	K/J Response
HVAC	1	Install programmable setback thermostats that can eliminate summer cooling equipment from turning on for the entire 6-hour Peak Period (noon to 6:00 p.m.), or at least from turning on during the shoulders of the Peak Period (e.g., right before it begins or ends).	We have one thermostat that controls the UFO, and wall mount thermostats that can only be changed 2 degrees up or down. The main thermostat has set times that start/stop at the beginning of the day and at the end of the day.	Determine the start/stop times and temperature set-points for the cooling system. To reduce overall energy consumption and lower costs, run a pilot program limiting the run time of the cooling system during Peak Period (e.g., starting the cooling 1 to 2 hours after noon and stopping it 1 to 2 hours before 6 p.m.), adjusting the temperature set-point up 1 to 2 degrees, and then assess if the building stays cool enough for occupants.
	2	In summer months (May through October) use programmable thermostats to “super cool” the building during the Off-Peak period (9:30 p.m. to 8:30 a.m.) or Partial-Peak period (8:30 a.m. to noon and 6:00 p.m. to 9:30 p.m.) to push back the time before the cooling system equipment needs to come on. This strategy would be aided by installing thermal mass in the building, making sure the windows are double pane low-e glass, and making sure that the building is fully insulated and sealed.	We have one thermostat that controls the UFO, and wall mount thermostats that can only be changed 2 degrees up or down. The main thermostat has times that start/stop at the beginning of the day and at the end of the day.	Determine the start time and temperature set-point for the cooling system. To reduce overall energy consumption and lower costs, run a pilot program that super cools the building before noon, and allows for the cooling system to be programmed to turn off during the beginning hours of the peak period (e.g., noon to 2 p.m.), and then assess if the building stays cool enough for occupants.

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Area	#	Potential TOU Optimization Strategies	UFO Comments	K/J Response
	3	During the winter (November through April) use programmable thermostats to super heat the building during the Off-Peak period (9:30 p.m. to 8:30 a.m.) to push back the time before the heating system equipment needs to come on. This strategy would be aided by installing thermal mass in the building, making sure the windows are double pane low-e glass, and making sure that the building is fully insulated and sealed.	The building starts heating up at 4 am and stops at 7 pm.	To reduce overall energy consumption and lower costs, run a pilot program starting the heating 1 to 2 hours later and stopping it 1 to 2 hours earlier, and assess if the building stays warm enough for occupants. Double check the windows, insulation, and amount of thermal mass.
	4	Use window blinds or shades during the summer Peak Period (noon to 6:00 p.m.) to reduce the solar gain through the windows and reducing the need for the cooling system to come on.	We have them installed.	Make sure occupants understand the TOU rate schedule and when to use the blinds to reduce solar gain.
	5	During the winter months use insulated window covers that reduce heat loss through the windows.	Newer windows.	Done.
	6	Consider window film to reduce solar gain.	There is a film on the windows but not dark.	Done.
	7	Test the number of air changes per hour, and if they are in excess of the required minimum air changes, adjust the ventilation equipment to reduce the air changes per hour.	Looking into it.	If the test shows excess air changes per hour, adjust the HVAC equipment to the minimum requirement.

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Area	#	Potential TOU Optimization Strategies	UFO Comments	K/J Response
	8	Regularly tune-up the HVAC equipment.	It is on a preventative maintenance program.	Done.
	9	Make sure the HVAC equipment is up-to-date high efficiency equipment, and check to see if new replacement equipment (e.g., geothermal heat pump, air-source heat pumps) can be cost-effectively retrofitted, and look for electric utility rebates.	Newer building with energy conservation in mind.	Done.
Lighting	10	Reduce use of lighting during summer Peak Period (noon – 6:00 p.m.) by installing light sensors with timers to partially or fully shut off banks of lights. This could be deployed in areas where there is sufficient daylighting and banks of lights near windows that can be turned off when the sensor detects sufficient daylighting. This strategy would eliminate some energy use during the Peak Period.	Building lights are on a timer and motion sensors.	Done.
	11	Retrofit lighting with more energy efficient technologies such as CFLs or LEDs that will reduce energy use during the Peak Period (noon – 6:00 p.m.).	Participated in PGE's lighting retrofit program in 2015; changed lights to LEDs.	Done.
	12	Install motion sensors that turn off the lights in vacant rooms or offices.	Done.	Done.

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Area	#	Potential TOU Optimization Strategies	UFO Comments	K/J Response
	13	Install skylights and “solar tubes” to create more daylighting allowing light fixtures to be turned off.	In restrooms we have solar tubes.	Investigate adding additional skylights or solar tubes in the darker work space areas.
Water Heating	14	Install on-demand water heaters and replace traditional water heater tanks which constantly cycle on during the Peak Period (noon – 6:00 p.m.).	We have them at both kitchens.	Done.
	15	Super insulate water heaters, or upgrade to new super insulated water heater that cycle on less frequently during the Peak Period (noon – 6:00 p.m.).	I do believe so.	Done.
	16	Install a water heater timer that prevents Peak Period cycling (noon – 6:00 p.m.).		Not applicable.
	17	Install solar water heaters in buildings with showers or heavy hot water use.	Too many solar panels on our roofs.	Infeasible.
	18	Run the dishwasher in the Off-Peak (9:30 p.m.to 8:30 a.m.) or Partial-Peak (8:30 a.m.to noon and 6:00 p.m.to 9:30 p.m.) Periods.	Only use dishwasher when we have events.	Instruct users to use the delay function on the dishwasher to start it at the beginning of the Partial-Peak Period.
Plug Loads	19	Conduct an energy awareness campaign about saving money and energy during the Peak Period (noon to 6:00 p.m.) by encouraging employees to turn off equipment and lights when not in use.	Most of the UFO employees are out in the field 90% of the work day.	Run a "Turn Me Off!" education campaign for staff who work in the office, with stickers at switches, and mention it at staff meetings.

Area	#	Potential TOU Optimization Strategies	UFO Comments	K/J Response
	20	Require the purchase of Energy Star equipment and make it is a standard operating procedure to turn on the sleep function that shuts down computers, monitors, and copiers when they are not being used.	The City's Environmental Purchasing Policy requires that "All products purchased by the City, and for which the U.S. EPA Energy Star certification is available, shall meet the Energy Star certification and possess the Energy Star label, when practicable. When products with Energy Star labels are not available, choose energy-efficient products that are in the upper 25% of energy efficiency as designated by the Federal Energy Management Program."	Done.
	21	Retrofit old appliances (e.g., refrigerators, dishwasher, microwaves, etc.) with new high efficiency appliances, and look for electric utility rebates.	Everything is under 6 years old. New purchases would be subject to the Environmental Purchasing Policy; discussed under item 20 above.	Done.

9.7 Administration Building TOU Strategies Recommended For Further Investigation

To summarize the Potential TOU Optimization Strategies from Table 9-3, the following actions merit further investigation:

- EEM 9-1: Determining if it is acceptable, by doing a pilot program, to have the UFO building heating system start time be later and stop time be earlier to eliminate the 1 to 2 hours of energy use, thereby lower heating costs.
- EEM 9-2: Determine the start/stop times and temperature set-points for the cooling system. To reduce overall energy consumption and lower costs, run a pilot program limiting the run time of the cooling system during Peak Period (e.g., starting the cooling 1 to 2 hours after noon and stopping it 1 to 2 hours before 6 p.m.), adjusting the temperature set-point up 1 to 2 degrees, and then assess if the building stays cool enough for occupants.

- EEM 9-3: If the test of the current air changes at the UFO building show excess air changes per hour, adjust the HVAC equipment to the minimum requirement.
- EEM 9-4: Make sure UFO building occupants understand the TOU rate schedule and when to use the window blinds to reduce solar gain.
- EEM 9-5: Investigate adding additional skylights or solar tubes in the darker work space areas of the UFO building.
- EEM 9-6: Instruct users to use the delay function on the UFO dishwasher to start it at the beginning of the Partial-Peak period (i.e., after 6 p.m.).
- EEM 9-7: Run a "Turn Me Off!" education campaign with stickers at switches in the UFO building, and mention it at staff meetings.

9.8 Water Operations SCADA Capabilities

The Water Operations SCADA system uses programmable logic controllers (PLCs) to implement control strategies, the latest supervisory control software from Wonderware, and local control via touchscreens. These systems are programmable and can:

- Implement control strategies to improve energy efficiency.
- Minimize energy use.
- Utilize TOU rates to lower operating costs.

Some existing process and SCADA control strategies already assist in increasing energy efficiency strategies including:

- Data logging of water pump station and sewer lift station pump run times.
- Pump station starts and stops are controlled by elevation setpoints.
- Pump station speed is controlled by SCADA.
- Pump station wet well elevations are monitored via visual display at the SCADA Screen.

In addition, standard operation of the potable water pump stations already takes into consideration TOU rates to minimize energy use and costs by programming pumping to only occur during the Partial-Peak and Off-Peak periods.

There does not appear to be any explicit SCADA screen display of electricity costs in real time using the applicable TOU rate schedules. The City currently monitors TOU rate accounts. However, as more City accounts are converted to TOU rates in the coming years, future monitoring of TOU energy use will become even more important.

9.9 Impact of Utility Management System on TOU Rate Optimization

A Utility Management System (UMS) can help optimize TOU rates for water pumps in two ways:

- A UMS can track energy usage over time during peak periods and create an alert report when such usage occurs. This would allow Santa Rosa Water to review the alerts and make sure that only unavoidable pumping is done during the peak periods. If the pumping is determined to be avoidable, actions could be taken to shift this energy use to partial-peak periods.
- Tracking energy use for individual pumps and creating trendline graph reports of energy use over time can be used to identify potential problems with the pump or identify leaks. For instance, sudden or sustained changes in energy may indicate pending equipment failure or deferred maintenance issues.

A UMS can also help optimize TOU rates for administration buildings in two ways:

- A UMS can track building cooling and heating system energy use, as well as appliance energy use (if the plug loads are separately metered), during peak periods and create an alert report when such usage occurs. This closer monitoring could allow adjustments to be made to operations to shift energy use out of the peak period if possible.
- A UMS would also allow Santa Rosa Water to better track and calculate the results of the recommended pilots for shifting the start/stop times for the heating and cooling systems.