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City of Oxnard

Public Works Integrated Master Plan

WASTEWATER

PROJECT MEMORANDUM 3.10 SCADA ASSESSMENT

FINAL DRAFT
December 2015

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City Of Oxnard

Public Works Integrated Master Plan

WASTEWATER

PROJECT MEMORANDUM 3.10
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SCADA ASSESSMENT

1.0 INTRODUCTION

The purpose of this Project Memo (PM) is to develop the list of projects to be included in the wastewater Capital Improvement Program (CIP) of the Public Works Integrated Master Plan (PWIMP) with associated project cost and drivers. The CIP is an estimate of the City's capital expenses over the next 25 years to address limitations, rehabilitation needs, and recommended improvements to the wastewater treatment plant. The CIP is intended to assist the City in planning future budgets and making financial decisions.

1.1 PMs Used for Reference

The recommendations outlined in this PM include recommendations from the following other PMs:

- PM 3.2 - Wastewater - Flow and Load Projections.
- PM 3.4 - Wastewater - Treatment Plant Performance and Capacity.
- PM 3.5 - Wastewater - Condition Assessment.
- PM 3.6 - Wastewater - Seismic Assessment.
- PM 3.9 - Wastewater - Arc Flash Assessment.
- PM 3.7 - Wastewater - Treatment Alternatives.

1.2 Other Reports Used for Reference

In developing this report, recommendations from other reports were incorporated to ensure a holistic and, un-biased approach. The followings reports are used in this PWIMP analysis:

- *Guide to Industrial Control Systems (ICS) Security,* National Institute of Standards and Technology, June 2011.

2.0 SUMMARY OF FINDINGS

2.1 Existing System

The City of Oxnard's Waste Water Treatment Plant SCADA System provides plant automation and operates on obsolete hardware and software. The Supervisory Control and Data Acquisition (SCADA) system is a computer system that monitors and controls the facility-based processes. The SCADA system consists of the following subsystems:

- SCADA-based Human Machine Interface (HMI), which is the apparatus that presents process data to the human operator; and through this the human operator monitors and controls the process.
- A SCADA computer system, acquiring and storing data on the process from the programmable logic controllers (PLCs) and controlling the process by sending commands to the PLC.
- Communication infrastructure connecting the SCADA system to the PLCs.

The Oxnard Waste Water Treatment Plant uses a Supervisory Control and Data Acquisition (SCADA) process control system to monitor and control processes at the facility. The automation hardware inside the WW facility was installed as an upgrade to the facility in approximately 1990. It consists primarily of SquareD SY/MAX PLCs interfaced over a RS422 Communication bus for Peer to Peer (PLC to PLC) and PLC to HMI communications. This uses a low bandwidth, ASCII based protocol. There is a Primary and a Secondary Kepware KEPServer that each function as an OPC bridge to provide data to the FactoryTalk View SE 6.0 HMI software platform.

The Lift Stations use an Allen Bradley CompactLogix L33E PLC with local I/O for control. These are interfaced into to the rest of the SCADA system through copper phone lines. The phone lines are operated and maintained by Verizon, the local phone provider. There were numerous discussions with plant personnel in regards to the copper lines being switched to fiber. Fiber optic cable provides would provide a much higher data bandwidth to the stations. However, this upgrade is being performed by Verizon and it is unclear when the upgrade would be performed.

2.2 Condition

The life cycle of the SquareD SY/MAX PLC platform ended in the mid-1990s and the last hardware components became obsolete in 2002. Replacement parts are not widely available and would need to be sourced through a 3rd party vendor. These PLCs control nearly the entire WW facility, a PLC hardware failure could mean that an entire section of the facility would have to be operated in manual, with little to no process visualization by which to make process decisions. The current programs were uploaded by Pacific Rim Automation, and are undocumented. This makes any modification of the original code very labor intensive.

The overall wiring condition of the SCADA systems are fair to poor, which is to be expected for the age of the system(s). In discussions with staff that maintains the equipment, many of the repairs to the wiring have gone undocumented, and visual inspection of cabinets verified these reports. Much of the downtime related to the SCADA system stems from loose or failing wire connections, and tracing wires to their source to troubleshoot an outage.

There are also reports of communication faults within the system due to Electro-Magnetic Interference (EMI) that happen during regular system events, such as large motors starting and stopping. This is likely due to poor cable, non-isolated wiring, incorrect shielding, and terminating. These events compound themselves by causing SY/MAX nodes to try and re-establish themselves on the network, resulting in unscheduled messages that will lock-up the OPC server(s). This causes reduced process visualization and disruption of the control system for relatively short amounts of time.

3.0 SCADA SYSTEM NEEDS

3.1 Recommended Projects

3.1.1 PLC Cabinet Replacements

There is an immediate concern surrounding the age of PLCs and equipment used at the waste water treatment facility. It is highly recommended that installation of new PLCs and control cabinets should accompany any process equipment upgrades or replacements. This allows for the process controls to be optimized in a new system rather than conform to the footprint of the existing system, as the existing programs would be difficult and expensive to modify. Based on the city's desire to match the architecture used at the Advanced Water Purification Facility, any new PLC's should be in the Allen Bradley Logix 5000 family of controllers. In interviews with plant personnel, this preference was also expressed.

The present state of the panels is such that a field cleanup of the panels is less cost effective than a replacement of the panel in its entirety, given the wiring conditions and age of other equipment inside.

3.1.2 PLC System Standardization

A PLC is an industrialized computer used to automate process used for the treatment and/or conveyance of water. Typically, each major process will have its own PLC.

During interviews with city personnel and ProUsys, there was a preference expressed for the Allen Bradley ControlLogix platform. As this was the platform used in the newly constructed Recycled Water Processing Facility, it is recommended that any new PLCs should also be of the Allen Bradley ControlLogix or CompactLogix platform.

Each PLC processor should be sized to support the required input/output (I/O) plus 25 percent spare I/O capacity for each type of I/O signal at every PLC. All spare I/O points shall be wired to field terminal blocks in the PLC cabinet. The PLC backplane shall include three spare backplane slots or 25 percent additional slots, whichever is greater. Provide a minimum of 50 percent spare program volatile memory. Communication ports should be provided to support the necessary networking requirements of the specific project. Provide a minimum of one Ethernet/IP port for connection to the process communications network as well as uploading and downloading of PLC application programs.

3.1.3 HMI System Standardization

The HMI is defined as operator interface devices with a graphic display. These provide operations or maintenance staff access to control and monitor process activities, setpoints, equipment status, and alarms within the PLC. The City of Oxnard's Waste Water facility HMI application was built with Rockwell Automation's Factory Talk View SE 6.0 software. Any new PLC should interface with the existing application, and the existing application should be modified to accommodate the new PLC.

3.1.4 Typical Control Methodologies

3.1.4.1 Process Control Interface System (PCIS) Control

The PCIS system refers to the operator interface system consisting of both the HMI and the SCADA interface.

Where indicated, provide HAND-OFF-AUTO and START-STOP selections in the PCIS, accessed from an HMI or SCADA for operators with sufficient security, to provide the following operating modes:

1. PCIS AUTO: The normal, automatic control mode of the strategy, which allows full PLC control in response to process conditions and programmed sequences.

2. PCIS HAND: Enables PCIS Manual control where control decisions are made by an operator through the PCIS START-STOP, OPEN/CLOSE, or other selections as indicated.

3. PCIS OFF: Automated PCIS control is disabled and PLC calls for all associated equipment to stop and valves to close or go to their identified safe state.

4. Program the PLC so that switching strategy between AUTO and HAND (either direction) occurs with a smooth transition. Keep running or position status unchanged when control is switched to HAND until a change is requested using the operator selections (START, STOP, OPEN, CLOSE). Keep running and position status unchanged when control is switched to AUTO until the control logic determines a change is required.

3.1.4.2 Motor Control

1. Provide local controls at each motor. The controls could be housed in a local control panel (LCP) at each motor or at the compartment containing the motor control hardware in the motor control center (MCC):
   a. LOCAL-OFF-REMOTE (LOR) selector switch.
   b. START pushbutton.
   c. STOP pushbutton.

2. Monitor the device’s LOR switch to determine when the PLC has control of the associated equipment:

   a. Display current REMOTE status on the SCADA and HMI screens.

3. Monitor the device’s running status from the starter auxiliary or run status input:

   a. Display the current status (running or stopped) on the SCADA and HMI screens.
   b. Use status to calculate total run time and daily run time, and to count total starts and daily starts.
   c. Provide time stamp for each start.

4. For motors 200 hp and greater, provide software to prevent exceeding the manufacturer’s recommended maximum starts per hour.

5. When equipment control has been given to the PLC as reported by the LOCAL-OFF-REMOTE switch, allow selection of PCIS AUTO or PCIS HAND control modes based upon operator selection using the SCADA or HMI screens.

6. Starting, Stopping, and running when the device LOR is in LOCAL:

   a. With the LOR switch in the LOCAL position, the motor is controlled by the START and STOP pushbuttons.
   b. With the LOR switch in the OFF position, the motor is prohibited from running.
   c. With the LOR switch in the REMOTE position, the motor is controlled remotely.

7. Starting, stopping, and running when the device LOR is in REMOTE:

   a. When the motor is expected to be running (PLC has issued a START or RUN due to process conditions or operator selection), LOR is in REMOTE, and the device is not reported to be running, start an operator adjustable “Control Activation” time:

      1) Provide “Control Activation”{ timers for each piece of controlled equipment:

         a) If the LOR and required running status do not change, and the PLC does not receive running status within the “Control Activation” time period:

            (1) De-activate the output.

            (2) Place the device in a “Failed” state.

            (3) Generate a “Failed to Respond” alarm.

   b. When the motor is not expected to be running (PLC has issued a STOP or removed the RUN output, LOR is in REMOTE, and the device is reported to be running, start the “Control Activation” timer:

      1) If the LOR and required stopped status do not change, and the PLC does not lose the running status within the “Control Activation” timer period:

         a) Keep the RUN output off or the STOP output on.

         b) Place the device in a “Failed” state.

         c) Generate a “Failed to Respond” alarm.

c. Re-establish PLC control of a device in a "Failed" state only after operator turns the device's LOR switch out of REMOTE, and back to REMOTE (i.e., REMOTE input to the PLC cycles off and back on).

8. Simultaneous starts:

a. Prevent more than one motor-driven load 25 hp or larger in the same facility from starting concurrently:

1) When starting one load, inhibit start logic for all other such equipment until the load being started is up to speed (reduced voltage solid state RVSS or variable frequency drive VFD, or after a setpoint time delay (full-voltage starters and miscellaneous equipment).

b. Use the same logic to prevent multiple large devices from starting concurrently on restoration of power after a power outage, whether operating on generator or utility power.

9. Speed control:

a. Modulate speed on VFD-driven motors using jog and hold, or process identification document (PID) control algorithms to maintain process conditions as described in the specific loop descriptions.

b. Operate speed control within a pre-defined range:

1) Minimum speed as determined by equipment manufacturer. The higher of:

a) Minimum motor speed to maintain adequate cooling for the type of load driven (constant or variable torque).

b) Minimum equipment speed, such as minimum speed to deliver flow or to deliver minimum flow for equipment cooling or lubrication.

2) Maximum speed 100 percent (60 Hz) or as identified by equipment manufacturer.

c. Where multiple equipment may operate together to maintain the same process condition:

1) Provide an operator selection for starting sequence.

2) Start the first equipment at a preset starting speed.

3) When one or more equipment is running and the speed control algorithm reaches a preset "Start Nex" speed value (initially 95 percent of speed range) through a preset time delay:

a) Start the next available equipment at the preset starting speed.

b) Ramp speed of previously running equipment down to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same flow or process condition with the new load running at the starting speed.

c) Once the previously running equipment reaches the preset speed, resume the speed control algorithm for that equipment.

d) Ramp the speed of the equipment that had just started until it reaches the speed of the previously running equipment.

e) Operate all equipment at the same speed following the output of the speed control algorithm.

4) When two or more pieces of equipment are running, monitor for a “Stop Next” condition:

a) Where flow rate is monitored, use a preset “Stop Next” flow rate for each possible number and combination of equipment:

(1) Determine initial “Stop Next” speed based on the flow that can be provided with one fewer piece of equipment running at a speed slightly below the “Start Next” speed.

b) When the “Stop Next” condition exists through a preset time delay:

(1) Ramp Speed of running equipment except for the equipment to be stopped up to a preset value based on the number of items running. Determine preset values for each condition based on equipment and system characteristics to provide approximately the same total flow or process condition with one fewer load running (typically slightly below the preset “Start Next” speed) while ramping speed of equipment to be stopped down to the preset minimum speed.

(2) Stop the load once it reaches minimum speed.

(3) Operate all remaining equipment at the same speed following the output of the speed control algorithm.

3.1.5 <u>Facility SCADA and Control Communication Networking Standardization</u>

For PLC and SCADA, networks will utilize a fiber optic backbone for Ethernet/IP communication throughout the facility. Managed Ethernet switches shall be located in each PLC or network panel for both the SCADA and PLC network. A connection port shall be provided on the front of all PLC cabinets to allow connection to the SCADA network. Switches shall utilize the IEEE Rapid Spanning Tree Protocol (RSTP) for network routing and optimization in a ring topology. In the event of a network switch failure, RSTP will automatically determine the most efficient way to re-route network traffic in order to re-establish communication throughout the network. Vendor PLCs and control panels will also comply with this design.

Appendix C contains a typical diagram for an Industrial Network with the architecture and security infrastructure recommended by the National Institute of Standards and Technology (NIST) and the Department of Homeland Security (DHS). Staff interviews indicate that the ability to view facility status throughout the City’s Wide Area Network (WAN) is desired.

Further information can be found in NIST Special Publication (SP) 800-82, *Guide to Industrial Control Systems (ICS) Security*.

4.0 CAPITAL IMPROVEMENT PROGRAM

The purpose of this section is to summarize the estimated capital funding requirements for SCADA system projects. The costs presented here are based on direct replacement of equipment in layouts of the existing system. Project costs are estimated based on unit costs developed from estimates of similar facilities and configurations at other locations. Please see Project Memo (PM) 1.5 for a more detailed discussion on the Basis of Cost for the costs shown in Table 1.

Table 1 Recommended Capital Improvement Projects
Public Works Integrated Master Plan
City of Oxnard

Project Name	Driver	End Year	Start Year	Un-escalated Project Cost ($)
PLC Cabinet Replacements (12)	R&R	2018	2015	$4,601,000
SCADA Programming (12)	Performance	2021	2016	$4,989,000
Asset Management Software Package Installation	Performance	2022	2021	$104,000
Network Upgrades (12)	Performance	2022	2015	$776,000
Control Room Upgrades	Performance	2021	2016	$346,000
			TOTAL:	**$10,816,000**

4.1 Unit Costs

The unit cost multiplier used was based upon replacement of the existing twelve RTU and “MUX” control panels. For incremental replacements based on the process improvements identified in PM 3.7, the costs can be used proportionally.

APPENDIX A – WASTEWATER PCM EVALUATION

City of Oxnard WWTP
Condition Assessment Form

Facility: Waste Water
Equipment Location: Lift Station 4
Equipment Name:
Discipline: Electrical / Instrumentation

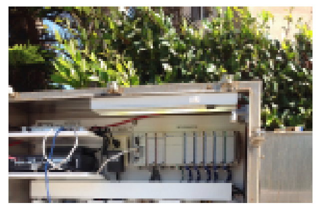
Equipment Information

Cabinet ID: Lift Station 4
Cabinet Location:
Process(es) Served: Lift Station 4
Panel Dimensions:
GPS Location: 34.190296 , -119.242545

Inspection Date: 8/6/2014
Inspection By: K. Pepler
Install Date:
Condition*: **3** out of 5

Picture – Panel External

Picture – Panel Internal



General Comments:

Manual Pump Controls on Front Cabinet which has pump controls.
Rear cabinet houses Control System hardware.

Controller Model : AB Compact Logix

*Condition
1 – Very Good
2 – Minor Defects
3 – Needs Significant Matenance
4 – Requires Rehabilitation
5 – Requires Replacement (>50%)

Component Models

Enclosure
Model Number:
NEMA: 4X
Mounting: Flange
Thermal Management: Forced Air
Accessories:
Side Panels: No

PLC
Manufacturer: Allen Bradley
Processor: L34E
Communications: Ethernet / Modem
Accessories:
Redundant Processors: No

UPS
Model: Yes
Size:
Communication:
Condition*: out of 5

Components
Circuit Breaker:
SPD:
Relays:
HMI/OIT:
Ethernet: 1 Switch
Radio:
DC Power Supply:
Switches:
Amount of I/O: 7
Other: Cabinets Built by FluidIQs

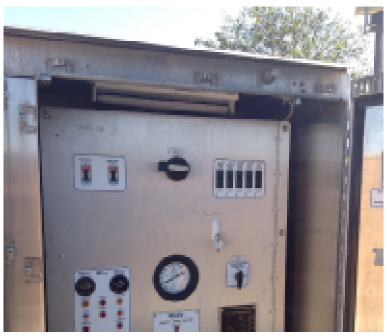
City of Oxnard WWTP
Condition Assessment Form

Facility: Waste Water Campus
Equipment Location: Lift Station 8
Equipment Name:
Discipline: Electrical / Instrumentation

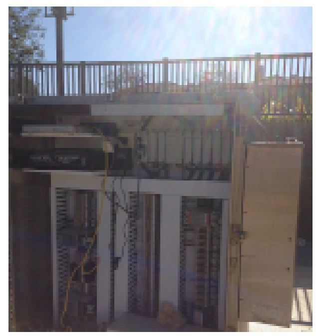
Equipment Information

Cabinet ID:	Lift Station 8	Inspection Date:	8/6/2014
Cabinet Location:		Inspection By:	K. Pepler
Process(es) Served:	Lift Station 8	Install Date:	
Panel Dimensions:		Condition*:	**3** out of 5
GPS Location:	34.188542 , -119.224652		

Picture – Panel External



Picture – Panel Internal



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Component Models

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Model Number:
NEMA: 4X
Mounting: Flange
Thermal Management: Forced Air
Accessories:
Side Panels: No

PLC
Manufacturer: Allen Bradley
Processor: L34E
Communications: Ethernet / Modem
Accessories:
Redundant Processors: No

UPS
Model: Yes
Size:
Communication:
Condition*: out of 5

Components
Circuit Breaker:
SPD:
Relays:
HMI/OIT:
Ethernet: 1 Switch
Radio:
DC Power Supply:
Switches:
Amount of I/O: 7
Other: Cabinets Built by FluidIQs