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City of Oxnard

Public Works Integrated Master Plan

WATER

PROJECT MEMORANDUM 2.8
SCADA ASSESSMENT

FINAL DRAFT
December 2015

Engineers...Working Wonders With Water™

City of Oxnard

Public Works Integrated Master Plan

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TABLE OF CONTENTS

Page No.

LIST OF TABLES

SCADA ASSESSMENT

1.0 INTRODUCTION

The purpose of this Project Memorandum (PM) is to develop the list of projects related to the Supervisory Control and Data Acquisition (SCADA) for the City's water system to be included in the 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 City's water infrastructure. 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 1.4 – Overall – Basis of Cost.
- PM 2.5 – Water System – Supply and 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 SCADA analysis:

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

2.0 SUMMARY OF FINDINGS

The City of Oxnard's Water Treatment Plant SCADA System provides plant automation and operates on serviceable hardware and software.

The 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.

2.1 EXISTING SYSTEM

The Oxnard Water Treatment Plant uses a SCADA process control system to monitor and control processes at the facilities. The automation hardware and software inside the facility is primarily some variant of the Rockwell Automation platforms. It consists of Rockwell ControlLogix 5000 and SLC 500 series PLCs, networked over Ethernet/IP to approximately nine stand-alone HMI (Human-Machine-Interface) computers, each running “RSView32 7.2” software. This software runs on the Microsoft Windows XP operating system which is no longer supported nor will further security patches be released.

ProUsys is an Industrial Integrator with a local office in Ventura, CA, that maintains the control system(s) for the water treatment facilities. They have handled all modifications since 2000 and performed the desalter upgrade in 2009. There is one primary control room for the operator at the Water Campus, which also serves as Blending Station #1. The desalting process is also located at this facility and it is controlled by a Rockwell ControlLogix series PLC. The control room has two HMI computers that can see all blending stations and the desalting process. These computers also serve as a primary and secondary alarm server, which is “Win911” software that notifies the on-duty operator when alarm conditions occur in the system.

The water treatment system also consists of four other blending stations, three of which are controlled by Allen Bradley SLC series controllers. Only Blending Station #2 is controlled by a Modicon 984 series PLC. It is the only station that uses hardwired analog visualization and control devices.

2.2 CONDITION

There are no immediate concerns for the Water Treatment Plant or its associated blending stations as it pertains to PLCs. While some of the hardware and software used is nearing the end of its life cycle and many parts have been obsoleted, it is still in maintainable condition and most of the common parts are still available. Rockwell Automation does have migration paths available for the Allen Bradley SLC 500 series into their current ControlLogix 5000 platform.

3.0 SCADA SYSTEM NEEDS

3.1 Recommended Projects

3.1.1 HMI Software Upgrade

The RSView HMI software's operating system compatibility is of moderate concern, as Microsoft no longer supports licensing of Windows XP. Maintenance and/or replacement of the computers controlling the facility will become a larger issue as the system ages. It is recommended that the City upgrade the HMI software to Rockwell Automation's Factory Talk View Site Edition (SE) of the most recent version within the next 3 to 5 years. The version of the software should be evaluated at the time of the project's execution. This allows for long term operating system compatibility and/or virtualization of the application, and conformity to the preferred standard expressed by plant personnel to a package similar to that used at the Recycled Water Processing Facility.

Rockwell Automation does have migration paths available for the Allen Bradley SLC 500 series into their current ControlLogix 5000 platform. It is recommended that PLCs in the SLC series be upgraded in a 2 to 4 year timeframe.

The Modicon PLC at Blending Station #2 is also of moderate concern. This is an older product in the Schneider Electric brand and will soon be nearing the end of its life cycle. It is recommended that this PLC be replaced with a controller in Allen Bradley's Logix 5000 family to conform with the preferred PLC vendor.

3.1.2 PLC System Standardization

A PLC is an industrialized computer used to automate processes 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 should be wired to field terminal blocks in the PLC cabinet. The PLC backplane should include three spare backplane slots or 25 percent additional slots, whichever is greater. Additionally it is recommended that a minimum of 50 percent spare program volatile memory be provided. Communication ports should also be provided to support the necessary networking requirements of the specific project, and a minimum of one Ethernet/IP port for connection to the process communications network as well as uploading and downloading of PLC application programs is recommended.

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 Water Campus facility HMI application was built with Rockwell Automation's FactoryTalk 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:

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

b. 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.

c. 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.

d. 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.
5) 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.
6) Stop the load once it reaches minimum speed.
7) Operate all remaining equipment at the same speed following the output of the speed control algorithm.

3.1.5 Facility SCADA and Control Communication Networking Standardization

For PLC and SCADA, networks will utilize a fiber optic backbone for Ethernet/IP communication throughout the facility. Managed Ethernet switches should be located in each PLC or network panel for both the SCADA and PLC network. A connection port should be provided on the front of all PLC cabinets to allow connection to the SCADA network. Switches should 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 construction estimates of similar facilities and configurations at other locations. Please see PM 1.4, *Overall - Basis of Cost* 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	Start Year	End Year	Un-escalated Project Cost ($)
PLC Cabinet Replacements (6)	R&R	2015	2018	$2,050,000
SCADA Programming	Performance	2016	2021	$2,100,000
Asset Management Software Package Installation	Performance	2021	2022	$100,000
Network Upgrades (8)	Performance	2015	2022	$400,000
Control Room Upgrades	Performance	2016	2021	$300,000
				$5,000,000

4.1 Unit Costs

The unit cost multiplier used was based upon replacing the six existing control panels. For incremental replacements based on the process improvements identified in this PM, the costs can be used proportionally.

APPENDIX A – WATER PCM EVALUATION

APPENDIX B - PLC LIFECYCLES

APPENDIX C - ICS NETWORK ARCHITECTURE