IMPLEMENTING A STATE OF THE ART AUTOMATION CONTROL, SCADA AND
INFORMATION SYSTEM INTO AN EXISTING MANUALLY OPERATED 20 MGD
WWTP BELOW BUDGET, ON SCHEDULE AND WITHOUT PROCESS
INTERUPTION

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ABSTRACT

A presentation on a unique design/build and integration of an automation control system upgrade with a redundant Allen-Bradley PLC control and Rockwell Automation distributed SCADA monitoring system for a 12 MGD wastewater treatment plant including cellular wireless communications to 12 remote pumping stations. The upgrade was performed without interruption to the plant operations and provided alarming and voice annunciation with WIN911. The paper describes all major “state of the art” ControlLogix PLC, RSView SCADA and wireless architectures utilizing AirLink cellular radios and OPC communications to remote controllers such as MultiTrode. Data analysis and reporting was performed with PlantMetrics and RSSQL Historian. Also included is a discussion on procurement methods and budget monitoring. The project was performed on time and below budget.

KEYWORDS

Design, build, integration, automation, control system, redundant, Allen-Bradley, PLC, Rockwell, SCADA, monitoring, cellular, wireless, communication, alarming, voice, annunciation, WIN911, ControlLogix, PLC, RSView, SCADA, wireless, AirLink, cellular, OPC, MultiTrode, PlantMetrics, RSSQL, Historian, procurement, monitoring, budget
INTRODUCTION:

Schofield Wastewater Treatment Plant is located at Wheeler Army Air Base near the center of the island of Oahu adjacent to the town of Wahiawa, Hawaii.

It was built in 1975 with several modifications thereafter. Raw influent is supplied from twelve remote lift stations within a 15-mile radius of the plant. The plant has a maximum flow design of 12 MGD with a daily average of 2 to 3 MGD. The plant had a simple control system consisting
of mostly relay logic operating the EQ basin pumps and RAS pumps, Effluent pumps etc. However, the operators mainly ran the plant manually and relied on an AutoCon alarm system that operated in conjunction with a Zetron telephone dialer. Since 1975, the US Army Department of Public Works (DPW) operated it with additional support from contract personnel.
BUDGETING
In 2003 Aqua Engineers, Inc. was awarded an operations and maintenance contract for the treatment plant from the DPW. The automation portion of the contract included reconnecting the existing plant I/O to a new PLC and SCADA system. The total budget for the PLC/SCADA monitoring system upgrade was $575,000 and must be completed without interruption of the plant operations and within 24 months. The electrical engineering was awarded to Morikawa & Associates. In turn, Automation Consulting & Education (ACE) was the design/build subcontractor for the PLC and SCADA installation. Briant Construction performed the electrical installation.

The engineering/integration team of Morikawa and ACE proceeded on a design/build basis and developed a budget based on four major components on a “not to exceed basis”. Consisting of three major components:

1. Hardware/Software (Hardware, Software & Equipment)
2. Electrical Labor (Electrical field installation)
3. System Integration (design engineering, programming, testing & training)

<table>
<thead>
<tr>
<th>Description</th>
<th>Hardware</th>
<th>Software</th>
<th>Electrical Labor</th>
<th>ACE Integration</th>
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</thead>
<tbody>
<tr>
<td>Year 1 Pumping Stations (12 stations - existing I/O)</td>
<td></td>
<td></td>
<td>$2,400</td>
<td>$3,000</td>
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<tr>
<td>Upgrade Communications (6)</td>
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<td>$6,000</td>
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<tr>
<td>Electrical Contractor to install wiring to 4 PLCs (16 hours each)</td>
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<tr>
<td>Software (CPU Driver)</td>
<td>$2,000</td>
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<tr>
<td>Supply &amp; Program 4 PLCs and GDM/Dialog Radios</td>
<td>$19,060</td>
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<tr>
<td>ACE Programming PLC SCADA, Alarm/Historical etc.</td>
<td></td>
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<td>$45,004</td>
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<tr>
<td>Training for 4 PLCs at Pumping stations</td>
<td></td>
<td></td>
<td>$2,000</td>
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<tr>
<td>Pumping Station Subtotals</td>
<td>$24,380</td>
<td>$8,500</td>
<td>$46,804</td>
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<tr>
<td>Year 1 Pumping Stations Total</td>
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<tr>
<td>Year 1 - Main Control Room (Note 1)</td>
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<td>$61,249</td>
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<td>Hardware (control panels, workstations)</td>
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<td>$12,399</td>
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<tr>
<td>Software, SCADA OPC, etc. 16 hours</td>
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<td>$6,000</td>
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<tr>
<td>Subcontract labor for design/programming/testing</td>
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<td>$15,805</td>
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<tr>
<td>Calibration and testing equipment</td>
<td>$1,959</td>
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<tr>
<td>Training</td>
<td>$4,000</td>
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<tr>
<td>Freight</td>
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<tr>
<td>Main Control Room Subtotals</td>
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<td>Year 1 Control Room Total</td>
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<td>Year 1 Total Budget</td>
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<tr>
<td>Year 2 - Treatment Plant Control System Upgrade</td>
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<td>$25,600</td>
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<tr>
<td>Electrical Contractor labor</td>
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<td>$25,600</td>
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<tr>
<td>Electrical Contractor Materials (cable, etc.)</td>
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<td>Treatment Plant SCADA System Programming</td>
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<td>Main Control Room Redundant Master PLCs</td>
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<td>Treatment Plant Remote I/O Racks &amp; Logic Programming (not included)</td>
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<td>$50,567</td>
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<tr>
<td>Freight</td>
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<tr>
<td>Year 2 Treatment Plant Subtotals</td>
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<td>Year 2 Total</td>
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<td>Total Project Budget over 2 Years</td>
<td>$571,452</td>
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Note 1: Budget excludes construction of new control room
Note 2: Budget excludes installation of fiber optic ring
PROCUREMENT

After the approval of the conceptual design, the system integrator (ACE) performed all procurement activities including equipment specifications, pricing, freight, delivery, warranty etc. This information was then forwarded to Aqua Engineers (owner’s representative) who then purchased the specified items. A purchasing journal was updated frequently and the information on the journal was shared among all parties. The following is an example of the purchasing journal.

### Schodell WWTTP Purchasing Journal

#### Year 2 - Wastewater Treatment Plant

<table>
<thead>
<tr>
<th>Description</th>
<th>Contract Number</th>
<th>Item Price</th>
<th>Material Quantity</th>
<th>Budgeted Quantity</th>
<th>Item Unit Price</th>
<th>Material Unit Price</th>
<th>Purchase Order #</th>
<th>Material Quantity</th>
<th>Budgeted Quantity</th>
<th>Item Unit Price</th>
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<th>Material Expenditure</th>
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</table>

**Note:**

- The budget is based on monitoring only of existing IoT in the plant at the time of submission of the proposal.
- The original budget included supply only of four capeaxis. This has been removed from the scope of this budget.
This type of purchasing scenario had many benefits:

1. The owner (end user = Aqua) immediately established a relationship with all vendors
2. Aqua staff was intimately involved in the entire installation from the start of the project
3. Aqua had control of the budget and could modify equipment specifications if necessary.
4. All equipment savings, rebates and discounts benefited Aqua Engineers.
5. All hardware, software and equipment warranties were immediately registered by Aqua.
6. The owner developed a detailed understanding of the cost of the equipment directly from the manufacturer or vendor.

As a result of this type of material management and procurement administration, the final material, hardware and software costs were under budget.

INSTALLATION
The field installation was broken into two phases and performed over a two-year period.

1. Phase 1: Monitoring 12 remote pumping stations using cellular wireless communications.
2. Phase 2: Installing a new SCADA system for the treatment plant.

PHASE I: PUMPING STATIONS
- Wireless communication to 12 remote pump stations for monitoring by SCADA
- Pump Station alarming system including voice, telephone and visual annunciation
- Historical collection, trending, analysis and report generation
The major hardware and software components are as follows:
- Allen-Bradley ControlLogix PLCs (SRM redundant configuration)
- Rockwell Automation RSView SE 3.2 distributed SCADA system
- Allen-Bradley VersaView Single Board Computers (SCADA thin Clients)
- ACP Thin Manager – Industrial Thin Client Management Software
- Rockwell Automation RSSQL Historian
- Rockwell Automation PlantMetrics
- AirLink Communications cellular wireless CDMA radios
- Software Toolbox TopServer OPC certified drivers
- Specter Industries WIN 911 voice alarming & notification
- MultiTrode Pump Controller and also Mission Communications

The following is the typical data flow of a remote pump station to the central SCADA server.
REPORTING AND DATA ANALYSIS:
Rockwell PlantMetrics provided “on-demand” real-time charts and reports as seen below:

Pumping Stations: All Pump Run Times
PHASE 1 - COMPLETION SUMMARY
Phase 1 was completed on schedule within one year and all materials including hardware and software were under budget. The SCADA infrastructure was in place including the major portions of the new central control room.

PHASE 2 – PLANT CONTROL SYSTEM
The main portion of work in Phase 2 was the installation of a master redundant ControlLogix PLC with four remote I/O racks communicating over a self-heal fiber optic ring. All existing I/O alarming and process monitoring points were re-connected to the nearest ControlLogix I/O rack. Process logic and alarm algorithms were processed in the central master PLC. New SCADA graphics, alarm management, historical collection and display and alarm voice annunciation are performed from the new central SCADA system.

CENTRAL CONTROL ROOM
- New control room with concealed UPS power, Ethernet and control wiring
- Distributed SCADA system with four remote SCADA clients
- Central redundant PLCs
- Self-healing fiber optic ring
- Three servers: SCADA, Historian & Terminal Server
- Redundant Internet connectivity with auto fail-over between DSL and Cellular
- Redundant UPS power supplies
- Single Board Computers as SCADA clients with Terminal Server connections
- Thin Client communications to SCADA clients over fiber optics
- VPN capability for remote programming and technical support
REMOTE I/O RACKS

- Four remote I/O racks with ability for future expansion
- Redundant power supplies and UPS
- Self-healing fiber optic ring communications
- Connections to all existing I/O alarm points
- Connections to all existing I/O for process monitoring and control

Typical ControlLogix I/O rack connecting to existing wiring.
BYPASSING EXISTING CIRCUITS TO AUTOCON

All of the alarm points in the plant were run in underground wiring to a centrally located AutoCon controller as shown below.

Central AutoCon Control Panel

Since all wiring was run to a central location in a mass of wiring inside the cabinet, it was very difficult to trace and troubleshoot. Overtime the wiring insulation deteriorated and faulted to ground and became inoperable. Over time with modifications and maintenance plus the added factor of the aging of the underground wiring, the AutoCon alarm system to become unreliable.
The wiring to the central AutoCon control panel was accessed through manhole covers.

Accessing underground wireways

The wiring inside the manholes was difficult to trace and also contained many terminations rated for dry locations only. This resulted in many faulted terminations and poor signals to the AutoCon control panel.
WIRING REPLACED BY FIBER OPTIC SELF-HEALING RING

The wiring to the central AutoCon control panel was re-routed to the nearest Allen-Bradley I/O rack. In essence, a single fiber optic self-healing ring as shown below replaced the long underground runs.

Architecture for redundant Allen-Bradley 5561 processors communicating with remote I/O racks via ControlNet over a self-healing fiber optic ring, utilizing Phoenix Digital OCX modules.

Layout of self-healing fiber optic ring communicating with remote I/O racks and redundant master PLCs.
CONCLUSION

At the completion of Phase II all of the monitoring and alarming on the existing plant I/O was performed from the new control room. Both the remote pumping stations and the wastewater treatment plant are controlled from a central location. The control system for Phase II was also completed on time and under budget.

ACKNOWLEDGEMENTS

Automation Consulting & Education, Inc. – Tampa, Florida
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MultiTrode, Inc. - Boca Raton, Florida
Rockwell Automation – Milwaukee, Wisconsin
Software Toolbox, Inc. – Charlotte, North Carolina