LOS OSOS COMMUNITY SERVICES DISTRICT

SCADA SYSTEM ASSESSMENT REPORT

November 16, 2020

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List of Acronyms

Term/Acronym	Explanation
CMMS	Computerized Maintenance Management System
HMI	human-machine interface (generally refers to the primary computer-based graphical operator interface)
I&C	instrumentation and controls
I/O	input/output
ICS	industrial control system
IT	information technology
LAN	local area network
MCC	motor control center
OIT	operator interface terminal (refers specifically to a PanelView or other panel-mounted terminal)
OT	operations technology
PCIS	process control and instrumentation system
PCN	process control network
PLC	programmable logic controller
PTP	point to point
PTMP	point to multipoint
RF	radio frequency
RTU	remote terminal unit (alternate terminology for PLC/controllers)
SCADA	supervisory control and data acquisition – a general term for overall control system often used for the central control station
UPS	Uninterruptable Power Supply
VFD	variable-frequency drive
VPN	virtual private network

Executive Summary

The Los Osos Community Service District (District) water and stormwater systems are operated from the LOCSD Utilities Water Yard located at 8th Street and El Moro Ave, which monitors and controls the distribution facilities consisting of 6 wells, 1 water tank (10th Street), 2 water tanks with booster station, 1 intertie with GSWC and 4 drainage pump stations. The District utilizes a Master Controller at 8th Street/El Moro for remote monitoring and control of well sites and tank facilities. Drainage sites and Intertie do not provide remote monitoring and control functionality.

The SCADA system is a combination of local control panel with mix of Tesco controllers, FRM (Fluid Resource Management) controllers, and pump controllers. There is no centralized SCADA workstation that allows complete monitoring and control of the water and stormwater system or allows generating reports or alarm notification via a dialer. The existing Tesco controllers are antiquated and near the end of their useful lives. The FRM controllers are proprietary hardware/software combinations with limitations of interfacing to modern SCADA software. This SCADA Assessment Report comprehensively reviews existing hardware, software, and operational requirements of the current SCADA system and documents condition assessment of each site. Recommended improvements in this report are intended to be used as a roadmap for the development of a Request for Proposals (RFP) for design-build SCADA improvements, or development of detailed design documents to retrofit the existing SCADA system. This Report also provides guidelines for modernization of the District's SCADA system to meet current standards.

Following are recommendations included in this Assessment Report:

- Replace existing controllers with state-of-the-art Programmable Logic Controllers (PLC). For hardware consistency, communication protocol, ease of maintaining spare parts, and staff's knowledge base on technology, the District should standardize on make/model of the PLC/controllers.

- The newer PLCs will provide a much faster processor, better process control, efficient management of software, and easy integration of new instruments. New operator interface terminals (OITs) are also recommended for display of site status, alarms and control functions.

- Replace existing communication systems with a private, reliable, radio-based communication system with an option of backup cellular communication system. A field survey was performed by Applied Technologies to confirm reception quality, antenna heights and radio frequencies. Communication system design parameters and communication equipment location and height can be based on the comprehensive report submitted by Applied Technologies.

Provide dedicated operator workstation, engineering workstation, SCADA application servers, and associated network equipment at the Water Yard. District and design consultant shall explore SCADA software which offers easy programming, low installation costs, and low maintenance costs.Upgrades to the SCADA system will improve reliability of the water and stormwater management systems through newer technology and unified system operation. The upgrade will also significantly improve monitoring and control of process parameters and alarm notifications. Different sites demand varied design approaches and scope definitions and also require multidisciplinary coordination between electrical, structural, and instrumentation engineers. Therefore, it is highly recommended to develop a very clear RFP defining the SCADA design/specification requirements for developing site specific plans and performance specification.

Section 1
Purpose and Scope

1.1 Introduction

The Los Osos Community Services District provides quality services to the community of Los Osos various services including water distribution, and drainage system. In total, The LOCSD Utilities Department maintains five drainage pump stations, three water tanks, one booster pump station, and five well sites throughout Los Osos.

The Los Osos Community Service District (District) water and stormwater systems are operated from the RTU-1 in the Master Control Panel at LOCSD Utilities Water Yard located at 8th Street and El Moro Ave. RTU-1 is a Tesco controller that polls signals from RTU-2 through RTU-4 over leased telephone lines.

The District does not use any centralized Supervisory Control and Data Acquisition (SCADA) system software to monitor process parameters, perform normal operational controls, and generate alarm conditions to alert operators to changing, unusual, or failure conditions. The SCADA network includes field instrumentation, variety of controllers, human machine interface (HMI) screens, and serial network interfaces to bridge the hardware. Communication is a combination of leased phone lines and radios.

The District's current SCADA system is obsolete in some areas, proprietary in nature and lacks consistency due to hardware platform upgrades that have been made over time. Operations staff is limited with monitoring and control capabilities offered in current date and time.

It is the District's desire to evaluate the existing water and stormwater systems and develop an assessment report to upgrade to a modern the SCADA system. The new system should be reliable, non-proprietary, expandable, easily maintained, and operate at a high performance. This report evaluates the existing system and recommends new hardware including PLCs, operational software, and, most importantly validates design criteria for reliable, cost effective, high-speed communication.

1.2 Project Objectives

The primary objective of the Assessment Report is to identify and recommend improvements to the system that will result in a reliable, uniform, expandable, and easy-to-operate/maintain SCADA system. AECOM developed this report with coordination with District staff to provide the District with a roadmap for a future SCADA improvement project.

The upgraded SCADA system should include existing instrumentation at each site and provide automation capability both locally and system wide. The remote sites should be capable of communicating with the Water Yard using a robust District-wide network radio system. The SCADA system will provide visualization capability for monitoring and control using graphical operator interfaces at the Water Yard and portable devices wirelessly connected to the SCADA system. Alarm notification will yield what, where, and when problems exist and will provide comprehensive monitoring and control of the process. Historian and reporting functions will provide structured recordkeeping and support regulatory compliance. Overall, the newer SCADA system will have a software application for use by Los Osos CSD operators, maintenance, engineering, and management staff.

Section 2
Existing SCADA System

2.1 Water Yard SCADA System

The SCADA system components housed at the District's 8th Street Office (Water Yard) contains Master Control Panel RTU-1. Leased-line telephone communication exchanges SCADA signals from the following remote sites to a modem in the Water Yard building.

- RTU-2: South Bay Well Site
- RTU-3: 10th St Tank
- RTU-4: Palisades Well Site
- RTU-5: 3rd Street Well Site
- 16th Street Tanks and Booster Station

The following sites do not have any direct communication with RTU-1:

- LOCSD/GSWC Intertie
- 16th Street Drainage Site
- 6th Street Drainage Site
- 8th Street Drainage Site
- Bay Ridge Drainage Site
- Don and Mitchell Drainage Site

RTU-1 is the most critical process controller accepting signals from RTUs and responsible for monitoring and control, making the entire water and stormwater management system centralized. The system is vulnerable and susceptible to the risk of CPU failure as well as subsequent communication failure to connected remote sites.

2.2 Remote Sites

District staff expressed an interest in receiving guidance to determine whether their existing remote telemetry system should be upgraded to the PLC-based SCADA system and prepare RFP including design documentation and performance specification. AECOM's experience within the water/wastewater industry is that the RTUs utilized by the District are experiencing upgrades by end users are being replaced with PLCs by those agencies. The decline of RTUs in the industry is for essentially the following reasons:

- End of life
- For a PLC-based system, ability to work with any System Integrator for non-proprietary hardware-software.
- Popularity of PLC and its ease of programming

Well Sites (5)

The telemetry and control system components at each well site are enclosed in individual control panels inside the well control room. The system components at well sites include either Tesco or FRM controllers. Both Tesco and FRM provide HMI display option and graphic software is developed and configured only by these vendors. Data is communicated to the RTU-1 at District Yard using leased telephone lines. There are no instrument control panel temperature control features. 8th Street and 3rd Street control panels have battery backup and South Bay Well site has uninterruptable power supply (UPS) to protect from power failure. 8th St well and office is connected to a county backup generator.

Following is a list of well sites:

- 8th Street Well Site
- South Bay Well Site
- Palisades Well Site
- 3rd Street Well Site
- 10th Street Tank and Well Site

Pump Stations and Tanks (2)

The telemetry and control system components at both tank sites are enclosed in individual control panels inside the pump station control room. The system components at pump stations and tank sites include either Tesco or FRM controllers. Data is communicated to the RTU-1 at the District Yard using leased telephone lines. There are no instrument control panel temperature control features. 10th Street Tank control panel has UPS/battery backup upon power failure.

Following is a list of pump stations with tanks:

- 16th Street Tank and Booster Station

Drainage Stormwater Pump Stations (5)

The control system components at 8th Street Drainage, Bay Ridge Drainage, and Don and Mitchell Drainage sites are in individual control panels located under outdoor shade structures. Currently 6th Street Drainage does not have a control panel. The system components at 8th Street Drainage and Bay Ridge Drainage are Liquid Level Controllers with Intrinsic Safe Relays, that control the on/off function of these stormwater pump stations. Drainage sites do not have communication links with the RTU-1 at the District Yard. There are no instrument control panel temperature control features or battery backup upon power failure. 8th St drainage does have backup power by way of County generator.

Following is a list of stormwater pump stations:

- 6th Street Drainage Site
- Don and Mitchell Drainage Site
- 8th Street Drainage
- Bay Ridge Drainage Site
- 16th Street Paso Robles Drainage Site

Intertie (1)

LOCSD / GSWC Intertie does not have a control panel.

2.3 Communication Network

Currently, the District's communication system is a combination of radio systems, and a dedicated phone line-based communication system linking the RTU-1 at Water Yard to some of the remote facilities. The leased phone lines are provided by AT&T. The leased line is an antiquated technology with slower data rates and brings cost and dependency on carrier providers. South Bay Well and Palisades Well have 900 MHz radios for communication link to 10th Street Tank.

Section 3
SCADA Architecture

3.1 Introduction

The purpose of this section is to establish supervisory control and data acquisition (SCADA) architecture for the District. It shall serve as a guideline for procuring SCADA system hardware, recommended software configuration, and industry best practices irrespective of SCADA vendor/platform procured by the District.

3.2 SCADA Hardware

Figure 3-1 describes general SCADA architecture. Actual SCADA hardware and software configuration may vary based on selected vendor. Hardware redundancy, software virtualization, data backup, and implementation using industry-wide standards are the primary design criteria.

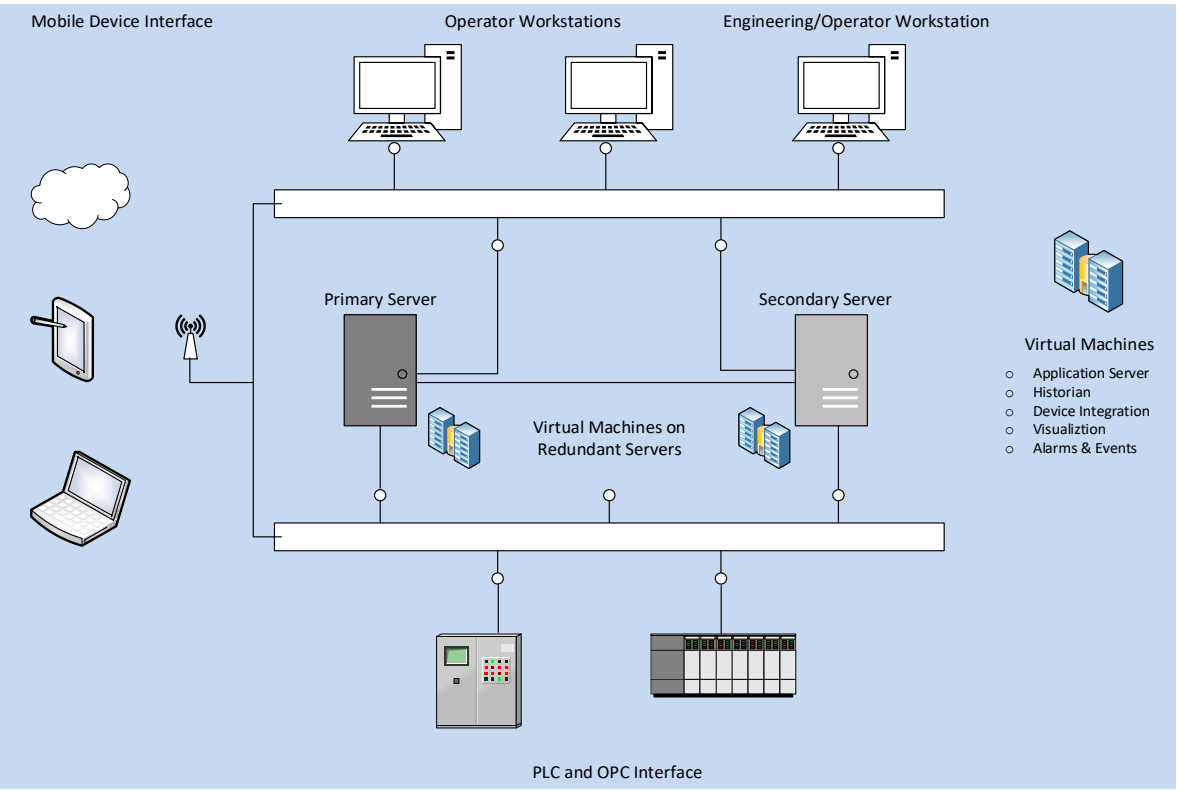

Figure 3-1. SCADA Architecture

SCADA Server

A server-class computer running a standalone SCADA application will be configured in a virtual environment capable of providing terminal service SCADA functionality to the client's nodes. The server equipment is the most critical hardware element that hosts the SCADA software and is responsible for data processing and rendering it in visual-graphical form on operator workstations. The server shall be able to host CMMS software in addition to SCADA software. The server units shall be the latest model and sized adequately in terms of memory usage, processor clock speed, CPU cores, and storage. Hardware shall be scalable to add

future data storage units, memory, etc. Parameters, such as future expansion, increasing software sizes, high performance graphics and number of users accessing the data, shall be carefully reviewed before sizing the hardware. SCADA software vendors shall be consulted in hardware selection, and system integration firm shall comply with software vendor's user manuals for guaranteed performance.

The District's preferred manufacturer for computer equipment is Hewlett Packard Enterprises. Hardware selection and warranty terms shall be consistent with the District's IT department.

Engineering Workstation

An engineering workstation is a thin client which is a desktop PC machine connecting to the SCADA servers via a Windows terminal service or similar connection. SCADA and PLC programming/development software shall be installed in the engineering workstations. Therefore, hardware shall be chosen with sufficient memory and processing speed to accommodate these additional programs. The engineering workstation shall be supplied with appropriate color monitors and keyboard-mice.

Operator Workstation

An operator workstation is a thin client[1] machine connecting to the SCADA servers via a Windows terminal service or similar connection.[2] SCADA graphics are displayed on these machines. Except Microsoft Office Suite, no other software shall be installed in these machines. Operator workstations shall be supplied with appropriate color monitors and keyboard-mice.

Tablets and Smart Phones

Handheld devices, such as cell phones, tablets, and laptops, can be configured as thin client machines to provide mobile access to the SCADA system. These devices provide operators with the convenience of having access to the SCADA system from anywhere provided network connectivity is present. Handheld devices can be configured to communicate over cellular or Wi-Fi networks using virtual private network (VPN) connection.

3.3 Design Criteria

Availability

Overall architecture design of the SCADA system, including redundant servers and multi-core processing, should provide a high degree of availability. Uptimes should exceed 99%.

Response Time

The responsiveness of the SCADA system is gauged by the time interval from issuing a command at an operator workstation to seeing the response. The command response cycle includes the following steps:

- The operator issues a command at an operator workstation (a computer or mobile device).
- The command is transmitted to the SCADA server(s), via local network or VPN connection.

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[1] A thin client is a lightweight computer that has been optimized for establishing a remote connection with a server-based computing environment. The server does most of the work. (Wikipedia)

[2] The Windows terminal service allows a user to control a remote computer or virtual machine over a network connection.

- The SCADA server(s) relay the command to the particular site over a communication network.
- The PLC at the particular site receives and acts on the command.
- The feedback status is transmitted from the site to the SCADA server(s) over a communication network.
- The received status is transmitted from the SCADA server(s) to the operator's graphical interface.

Responses of 5 seconds maximum or less are generally seen as acceptable. Responses of no more than 5 seconds is favorable and targeted with the SCADA upgrades.

SCADA Network Protocol

SCADA servers, workstations, PLCs, and managed/unmanaged network switches shall use one common communication protocol for information exchange. TCP/IP is the most preferred communication protocol for native and/or web-based network access. Network peripherals shall be procured with compatible data ports and sufficient spare parts and shall be most advanced with maximum data rate available.

Redundancy

To increase system integrity, multiple servers shall be configured in a dual-redundant or hot-standby topology, providing control and monitoring even in the event of a primary server failure. Fail-over shall be seamless with practically no time delay and without any modification by operators. Servers shall be fully redundant to run a complete SCADA application for monitoring and control of complete process parameters on either of the servers.

Open Architecture

The software shall be open-system architecture rather than a vendor-controlled proprietary environment. System integrators and District staff shall be able to make any modification and configuration changes without vendor intervention. The vendor shall have a comprehensive, easy-to-understand user guide for the District's personnel to learn step-by-step procedures for any system level or visual graphic change.

Virtualization, Backup, and Recovery

SCADA infrastructure virtualization helps to reduce the number of physical servers for each application, hence benefits in capital cost saving. Virtualization and cloud computing offers multiple options to protect SCADA applications when complete system failure occurs (i.e., both the primary and the single backup server fail).

Security

The SCADA system shall be integrated into its own domain rather than integrated into other office-level systems. System security between the SCADA system and outside networks shall be protected by a demilitarized zone (DMZ) on any interconnection that allows access.

HMI Consistency

The HMI screens at the remote sites shall mimic or be consistent with SCADA screens developed for Operator Workstations at the Water Yard. Section 5 describes the detailed criteria for HMI selection and graphical user interface development.

Section 4
Programmable Logic Controller

This section of the Assessment Report details PLC design and programming guidelines. The SCADA Assessment Report is written with a futuristic approach, and standardization of control system hardware and software ensures its implementation and benefits. SCADA system standardization provides control system uniformity across current remote sites and future expansion.

4.1 Acceptable Manufacturer

The PLC make and model can affect the reliability of data processing and needs to be compatible with the monitoring and control of the SCADA system. The PLC shall be an outdoor rated, industrial grade, high performance, high-speed micro-controller unit. The standard industry options to choose from are Schneider Electric's M340 PLC, SCADAPack 334 RTU, and Allen-Bradley CompactLogix PLCs. PLC software development environment shall have IEC61131-3-compliant interface, symbolic programming with structures, arrays, and a comprehensive instruction set that serves many types of applications.

4.2 PLC Network Connections

Wherever PLCs are used for equipment or process control, they shall be connected to the plant control system. The preferred method for providing this connection is through a TCP/IP Ethernet connection. Where connections are made within the same building and in an environmentally-controlled office building, the connection can be made using CAT-5e cabling. Any connection over 300 feet and all other connections on the premises shall use fiber-optic cabling and transceivers unless otherwise approved by the District.

4.3 Input/Output Requirements

In order to monitor and control the process, signals must be connected to the PLC. The items requiring connection to the PLC include equipment-running status information, equipment speed, alarms, valve opened/closed position, and others. These types of signals are considered "inputs". Signals coming out of the PLC primarily allow control of equipment starts/stops and control of valve position. Control signals are considered "outputs." This section details the requirements for signal levels, and equipment standard input/output (I/O).

Regardless of how equipment is monitored and controlled through the PLC, the designer shall recommend the state (e.g. closed or open for valves, running or shut down for pumps) that the device should go to on failure (i.e. fail-safe state). The District shall be given the opportunity to review the recommended failure state and approve the choice.

For hardwired (non-networked I/O) signals, 24-volt dc inputs and outputs shall be used. Digital outputs shall be provided with an interposing relay. Analog inputs and outputs shall be 4-20 milliamps. All hardwired I/O shall use cable-fast systems. The cable-fast system shall consist of prefabricated PLC terminal adapter, multiconductor cable(s), and terminals. The multiconductor cabling shall have prefabricated plugs on each end as the only means of termination.

Section 5
SCADA HMI Software

5.1 SCADA HMI Software Selection

The supervisory software package consists of a software application also known as an integrated development environment (IDE) used to develop the graphical user interface and a software application for the visualization of day to day process operations. The SCADA application consists of graphical screens and associated logic, databases, and the affiliated functions to provide the complete operator interface for process monitoring and control.

The SCADA software market is very competitive, and offerings of different vendor packages are comparable, with subtle differences. The selection of a SCADA software system will come down to user experience, existing infrastructure, initial costs, and staff expertise to adapt the change. Other important considerations are availability of local support, licensing and maintenance costs.

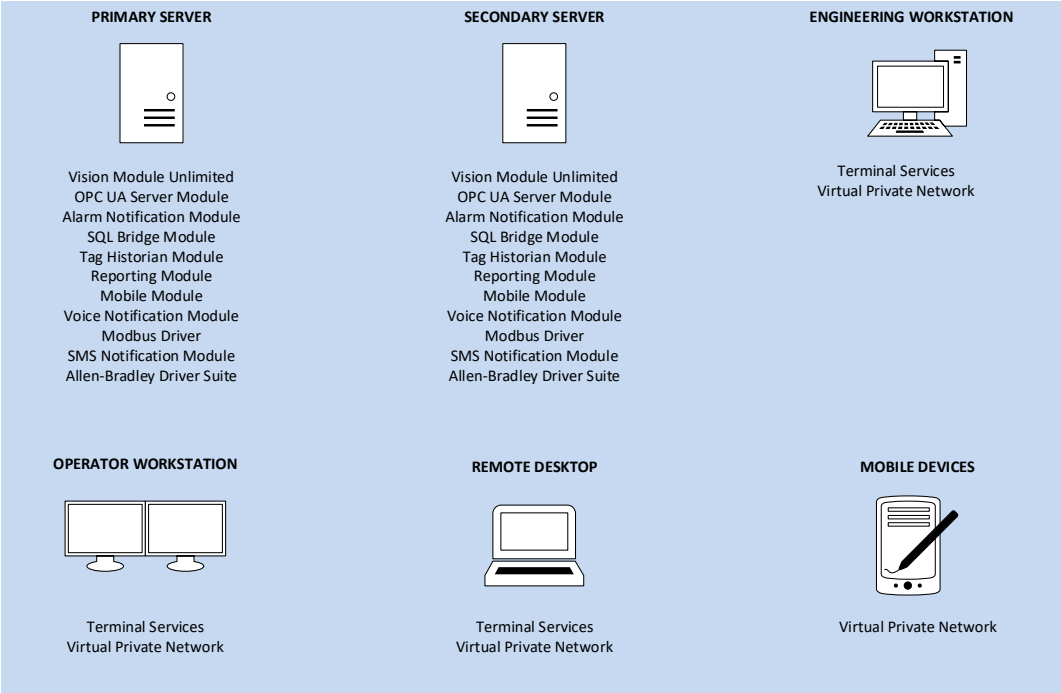


Figure 5-1. SCADA ARCHITECTURE

Key Differentiator

Software platforms will be further evaluated and compared during design stage. Following are some of the key criterion in selection of the SCADA software.

Cost Effective:. Capital and maintenance costs are very competitive.

Easy to Program: Programming and development is easier than other systems and has the ability to easily add more signals at a later date.

Technology Adoption: Feature-rich software with excellent performance and reliability.

Licensing: Offers an unlimited number of I/O tags, screens, and users accessing the software.

Section 6
Human Machine Interface

6.1 Introduction

The human-machine interface (HMI) element of the SCADA system empowers the operators to interact with the process automation. The user interface makes process monitoring and control efficient and easy to operate. The hardware technology has evolved to high-resolution graphic rendering, responsive touch screens, and fast Ethernet communication. Likewise, the software side has evolved to offer easy integration, configuration, inclusion of mobile devices, and user-friendly graphics library. The SCADA operator interacts with HMI software at operator workstations, and the field operators interact at an operator-interface terminal (OIT) on the instrument control panel.

6.2 Overall HMI Display Philosophy

The philosophy behind the HMI display system standards is to promote consistency in graphical and tabular presentations of the processes being monitored and controlled by the PLC system. Standardization of the HMI display system's "look and feel" will facilitate process monitoring and controls, allow prompt display of abnormal conditions, and reduce training needs for operators and system maintenance staff. The HMI design and programming guidelines shall also apply to OITs.

6.3 Display Hierarchy

Displays shall be organized in a logical fashion to help ease navigation through the process and alarms. Organization of the displays and the method of navigating through the displays is referred to as display "hierarchy." Defined herein are the general HMI hierarchy levels and types of displays. Examples of types of displays are shown in Table 5-1.

Table 5-1. Types of Graphic Displays

Graphic Display Type	Explanation
Facility Overview (Level 0)	Represents the entire facility in a process flow diagram (PFD) format.
Process Area Overview (Level 1)	Represents equipment related to one specific process in P&ID – like format with little detail.
Detailed Process (Level 2)	Represents equipment, including related status and alarm text, and related instrumentation in P&ID format.
Equipment Detail (Level 3)	Represents all status and alarm conditions, as well as control buttons for individual pieces of equipment.
Alarm Summary	Display that provides a history of all alarm occurrences. Ability to temporarily and permanently disable alarm.
Historical Tools and Reporting	This includes all full-screen trends and any historical information reporting.
PLC and Network Health	Provide a network health overview screen to monitor PLC and communication failure.

Figure 5-1 shows the general relation of the displays.

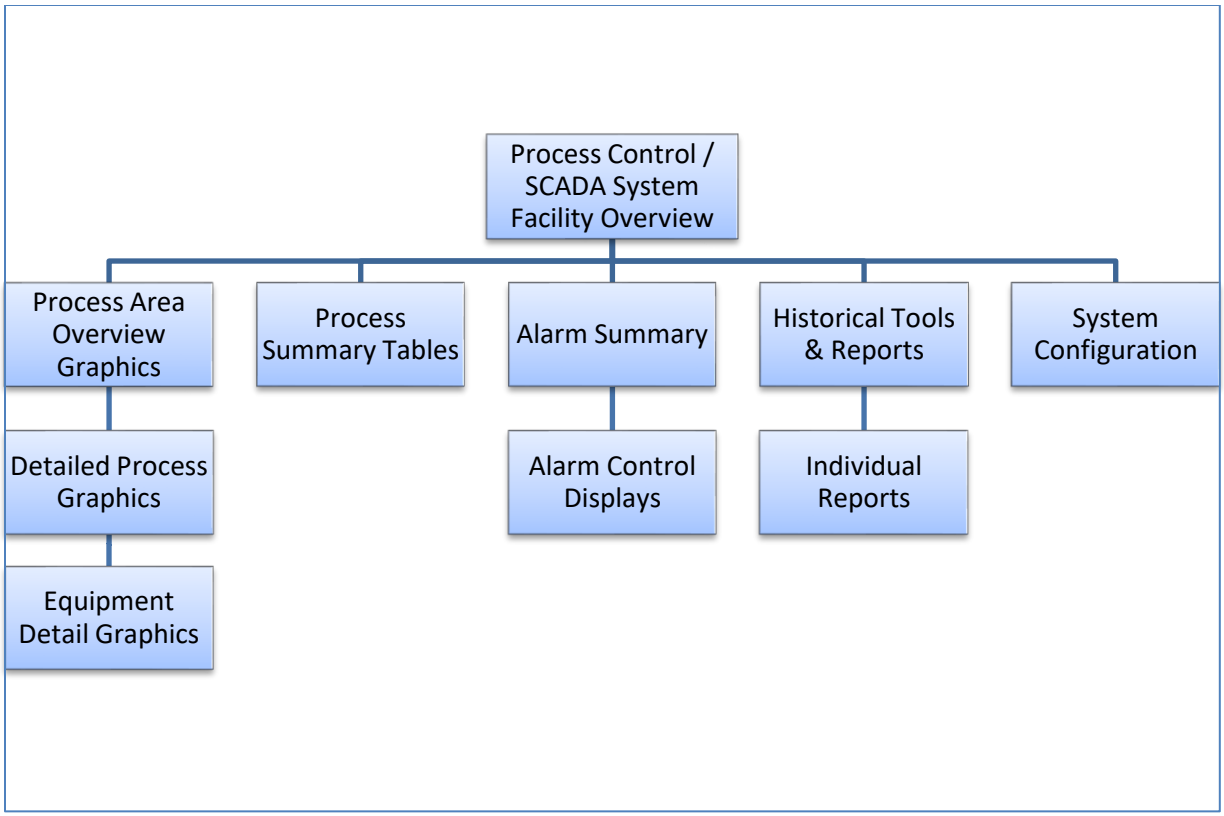


Figure 6-1. Graphic Screen Hierarchy

6.4 Process Display Content

HMI graphics should represent major pieces of equipment, piping, valves, and gates schematically. HMI graphics are not meant to depict all piping fittings and similar ancillary devices. In general, overview-type displays should have less detail than process or equipment detail-type displays. Any equipment shown on the HMI graphic should be designated with its tag number shown directly above a written description of the equipment. Additionally, the position of its local control switch (e.g., remote or local) and the status (e.g., running vs stopped, or opened vs closed) should be shown in close proximity to the equipment.

6.5 Control Functions

Auto-manual control stations should be configured as popup windows to provide the user a means of switching equipment modes, controlling equipment in manual, entering setpoints, and providing pertinent equipment status information. Popup windows shall be used to provide access to control functions for all equipment controlled by the PLC. The auto-manual station should also provide targets to higher-level control functions, such as PID (proportional, integral, and derivative) tuning and control strategy parameter input. Targets to higher-level control functions should appear “unavailable” and should not function if the user does not have the appropriate security level.

6.6 Historical and Real-Time Trends

Historical and real-time trends should be accessible from the HMI display system. The trending and reporting display should include Windows-type pushbuttons which navigate the user to preconfigured or ad-hoc trends.

Section 7
Radio Communication

7.1 Introduction

The SCADA data can be transferred from remote sites to the central control room in a variety of ways. A wired communication link is always a first choice provided the infrastructure installation is viable and cost-effective. The alternative to a wired communication link is wireless communication which includes radios and cellular. Radio communication is a cost-effective, reliable, technology that is a proven and widely acceptable means of connecting distant sites miles apart. Cellular communication is cost-effective with low installation costs and provides very high throughput; however, it does have a recurring cost for the service. The District staff has also stated that cellular service is sporadic and therefore this method of data communication will not be considered a viable alternative as the prime communication link. However, it can serve as a backup to the radio system for redundancy.

7.2 Radio Communication

SCADA radio telemetry is primarily in either a 300 MHz – 3 GHz ultra-high frequency range or a 3–30 GHz super-high-frequency range. Radio signals are affected by terrain elevation between the sites, and obstructions such as trees and buildings that may be between the two sites. Radio signals are also affected by atmospheric and other weather-related conditions. Typically, lower frequency will travel further and have better penetration through trees and buildings as compared to higher-frequencies. The tradeoff is the higher frequency radio units can carry larger bandwidth and can accommodate video streaming whereas the lower frequencies, especially 900MHz and below, cannot stream video effectively.

Radio studies determine the signal strength required to overcome transmission losses and are performed to determine overall configuration of radio frequency equipment i.e. frequency, transmission power of radio, antenna gain, antenna mounting location, and antenna elevation.

A radio study is an analysis of how radio waves travel from a transmitter site to a receiver site through the atmosphere. Radio waves travel in a straight line and require a line of sight between receiver and transmitter. Fresnel zones (space between and around a transmitting antenna and receiving antenna), are used to determine reception between transmitters and receivers. A longer distance between transmitting and receiving antennas will result in a greater radius of the Fresnel* zone. This is important because it determines the height of the transmitter and receiver antennas to ensure clear and strong communication.

Point-to-Point Radios

As the name suggests, point-to-point (PTP) radios are configured in pairs and are used to communicate between two sites. PTP links offer long distance (up to 30 miles) connectivity and high bandwidths. The strengths of PTP radios include simple installation, secure wireless connection, long range, and are cost-effective.

*Fresnel Zone: While installing a wireless communication system, it is important to keep an elliptical region between the transmit antenna and the receive antenna free from any obstruction for the proper functioning of the system. This 3D elliptical region between the transmit antenna and the receive antenna is called the **Fresnel Zone**. The size of the ellipse is determined by the frequency of operation and the distance between the two sites.*

Point-to-Multipoint (PTMP) Radios

Point-to-multipoint PTMP radios are configured for the applications that require data to be transmitted simultaneously from one point to many other points. This is achieved by setting up a base station also known as “access point” that can support multiple sites also known as nodes.

7.3 Radio Study Summary

Table below represents each site, required antenna height and mounting equipment for the radio antenna. 16th Street Tank and 10th Street Tank will serve as Master Sites interfacing to various remote sites as listed below.

Site Name	Antenna Height	Tower/Mast	Master Site
6th Street/El Moro Drainage Site	30’ AGL	New Mast	16th Street Tank
Don and Mitchell Drainage Site	30’ AGL	New Mast	10th Street Tank
8th Street Drainage	15’ AGL	New Mast	16th Street Tank
Bay Ridge Drainage Site	25’ AGL	New Mast	16th Street Tank
16th Street and Paso Robles Drainage	25’ AGL	New Mast	16th Street Tank
LOCSD/GSWC Intertie	20’ to 35’ AGL	New Mast	16th Street Tank
16th Street Tank and Booster Station	15’ above tank	New Mast	-
10th St Tank and Pump Station	15’ above tank	New Mast	16th Street Tank
South Bay Well Site	25’ to 30’ AGL	New Mast	16th Street Tank
Palisades Well Site	27’ AGL	Existing Mast	10th Street Tank
8th Street Well Site/Water Yard	15’ AGL	Existing Mast	16th Street Tank
3rd Street Well Site	35’ AGL	New Mast	10th Street Tank

AGL – Above Ground Level

Section 8
Design Implementation

8.1 Design Workshop #1

The purpose of the workshop is to kick-off the RFP preparation and allow the design consultant to state the design assumptions, parameters and the characteristics of associated electrical and instrumentation equipment and review it with the District before starting the design effort. District's hardware and software preferences, operational requirements, and coordination with other agencies shall be documented. Instrumentation equipment information shall include the type of instrument, voltage and power source, location, and information on the parameters that they will communicate to the PLC. Workshop#1 meeting minutes shall be submitted to the District for review.

8.2 50% Design Submittal

After the design criteria are approved by the District, the 50% design shall be submitted. The 50% design submittal shall consist of the following:

- Single-line diagram
- Electrical plans
- Load calculations
- Panel schedules
- Schematic diagrams
- Construction details
- Piping and instrumentation diagrams
- Electrical and instrumentation equipment specifications
- Construction cost estimate

8.3 Design Workshop #2

The purpose of the workshop is to review 50% design plans and specifications with the District, address any comments and add/remove project scope. Workshop #2 meeting minutes shall be submitted to the District for review. Comments from the workshop will be incorporated into the 90% design documents.

8.4 90% Design Submittal

After the 50% preliminary design drawings have been approved by the District, the 90% design shall be submitted. Comments from the 50% preliminary design submittal shall be incorporated into the 90% design submittal. The 90% design submittal shall consist of the following:

- Single line diagram
- Electrical plans
- Load calculations
- Panel schedules

- Schematic diagrams
- Construction details
- Network and communication block diagram
- Piping and instrumentation diagrams
- Electrical and instrumentation equipment specifications
- Draft I/O list
- Construction Cost Estimate

8.5 Final Design

Final design is a Bid ready set for traditional Design-Bid-Build project implementation. The final design submittal drawings and specifications shall be signed and sealed by a registered Electrical or Instrumentation Engineer as required by the Los Osos statutes.

8.6 Construction Phasing

Construction phasing shall be completely detailed in the design construction documents including the order in which sites are to be upgraded, downtime allowances, testing requirements, and acceptance criteria. Construction shall implement cutover procedures that minimize impacts on operations. The procedures shall be discussed between design engineer, operations staff, and senior management to fully prepare staff for the SCADA upgrade.

Project start-up and commissioning shall commence only on entire systems that are complete and ready to run. The SCADA hardware and software shall be factory tested to provide a comfort level that the installation will go smoothly. A complete system implies that all station input/output as well as alarm points and remote telemetry functions have been verified and tested by the contractor without failure, 24 hours a day for a period of 7 consecutive days.

The contractor shall start up and place all electrical, instrumentation, and control equipment installed into successful operation according to the manufacturer's instructions and as instructed by the manufacturer's field representative. All system and subsystem components must be tested and proven operable before they can be started up for continuous operation. Start-up is considered complete when the facility operates for 7 days continuously without any equipment failures.

8.7 System Integrator Selection Criteria

System integrators are a group of individuals or a contracting firm specializing in PLC/SCADA programming, hardware/software integration, and are typically instrument panel manufacturers. The prospective system integrator must demonstrate substantial experience as a supplier of real-time data acquisition and control, telemetry, and communications systems similar in size, nature, and complexity to the proposed system. In addition, the system integrator must show the capability to provide continued hardware and software support over the projected life of the system. The system integrator must have a maintenance organization that can support the District's SCADA system.

AECOM recommends selecting a system integrator certified by Control System Integrators Association (CSIA). Considering required technical knowledge and expertise of engineering, information technology, and communication systems, AECOM feels that it is very important that the District utilize a qualified system integrator that is active in the water industry to implement the District's SCADA upgrade project.

AECOM recommends the District compile a system supplier prequalification questionnaire that requires the suppliers to demonstrate their ability to supply the District's SCADA system. The questionnaire categories shall include information relative to the system suppliers:

- Background
- Financial position
- Human resources
- Location
- Maintenance capabilities
- Project references
- Description of similar project examples
- Technical capabilities

Section 9
Recommendations

9.1 New SCADA Software

AECOM recommends replacement of the Master Control Panel with dedicated hot-standby servers, workstations, printers, and associated network equipment at the Water Yard to completely modernize the existing antiquated system. AECOM can recommend SCADA software that is easy to operate or configure, has low installation and maintenance cost. SCADA system that is open architecture, has a good reputation, positive user feedback, and a sufficient number of programmers in the California would be a good fit. The SCADA vendor also provides a variety of free training material that would be of benefit to District staff. With its unlimited licensing feature, new operator workstations can be easily added without additional cost.

It is recommended that SCADA screens developed for the Water Yard and remote sites be identical for any given process and site. SCADA architecture with inherent security features and hardware separation between enterprise network and control network is recommended.

9.2 Controller Replacement

AECOM recommends replacing the aging Tesco controllers and any other proprietary controllers at remote sites and standardizing with state-of-the-art PLC-type controllers for high-speed processing and I/O scan time. The newer PLCs will provide a much faster processor, better process control, efficient management of software, and easy integration of new instruments. New OITs are also recommended for display of site status, alarms and control functions.

9.3 Control Panel Improvements

AECOM recommends new control panels for most sites as it will be cost effective as compared to retrofitting existing enclosures. Fan/AC, heater, intrusion detection, UPS, 3 point locking mechanism will be additional advantageous features when upgraded to new control panels.

9.4 Communication System

Communication equipment’s network coverage, constructability, redundancy, and maintenance are vital factors to be considered in selecting a SCADA communication system. AECOM recommends replacement of the slow-speed leased telephone line communication system with a private, reliable, radio-based communication system with cellular communication system as a backup for critical sites. GE MDS 900MHz unlicensed radios from two tanks sites to individual sites, along with cellular phone backup is recommended. Antenna installation shall be on existing infrastructure if possible and if needed aluminum tower shall be procured for radio system installation.

9.5 Site Specific Task Matrix

	PLC Upgrade			Control Panel Upgrade			Communication Upgrade			Other Upgrades		
Site Reference	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
8th Street Well	X				X		X		X	X	X	X
3rd Street Well	X				X				X	X		
South Bay Well		X		X					X	X		
Palisades Well		X		X					X	X		
10th St Tank & Pump Station	X				X				X			
16th Street Tank and Booster Station		X	X	X					X			
LOCSD/GSWC Intertie						X		X				X
6th Street Drainage						X		X				X
Bayridge Drainage				X				X				X
Don and Mitchell Drainage				X				X				X
8th Street Drainage					X			X				X
16th Street Paso Robles Drainage						X		X				X

A Replace existing Tesco controller with new PLC
B Replace existing FRM controller with new PLC
C Replace existing Siemens controller with new PLC
D Reuse existing control panel and retrofit to install new PLC
E Demolish existing control and provide new control panel enclosure
F Provide new control panel

G Demolish leased line modems
H Provide new radio, network switch and radio tower
I Provide new radio, network switch and antenna mast
J Provide new door mounted HMI
K Provide SCADA servers, operator workstation
L Interface site specific instruments and local control panels as required

Appendix A
Condition Assessment Forms

8th STREET WELL

GENERAL SITE INFORMATION

The 8th street well, located at 8th Street and El Moro, is comprised of future upper well pump and existing lower well. The chemical treatment includes CL2 and Turbidity monitoring, chemical injection, and filters.

SCADA TELEMETRY

The control system hardware (RTU, I/O Module, network equipment) resides in a control cabinet inside the water yard control room. Operator Interface for automated control is located on the panel door. Additional Hand-Off-Auto (HOA) switches are mounted on the panel door. SCADA telemetry equipment make and models are listed in table below. AECOM's field investigation notes and proposed recommendations are listed in following section.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: The control system processor i.e. Remote Terminal Unit (RTU) by Tesco System is obsolete. The operator interface, chart recorder on panel door are also obsolete. The control panel does not have any required temperature control features or UPS for power backup.

Proposed Improvements: Provide completely new Instrument Control Panel with latest Programmable Logic Controller, HMI, network switch, and radio in new instrument control panel. Provide dedicated UPS and temperature control features for instrument control panel. Engineering and Operator workstations can be installed with modern SCADA software system for advanced monitoring, control and reporting functionality. Provide dedicated UPS and temperature control features for instrument control panel and communication rack.

Instrumentation

Existing Conditions: During the site visit, condition assessment of existing instrumentation was not evaluated. The instruments appear to be in working condition.

Proposed Improvements: Instrumentation improvements to be evaluated at design phase. Existing Instruments including flowmeter shall interface to new SCADA system during construction of the SCADA upgrade project.

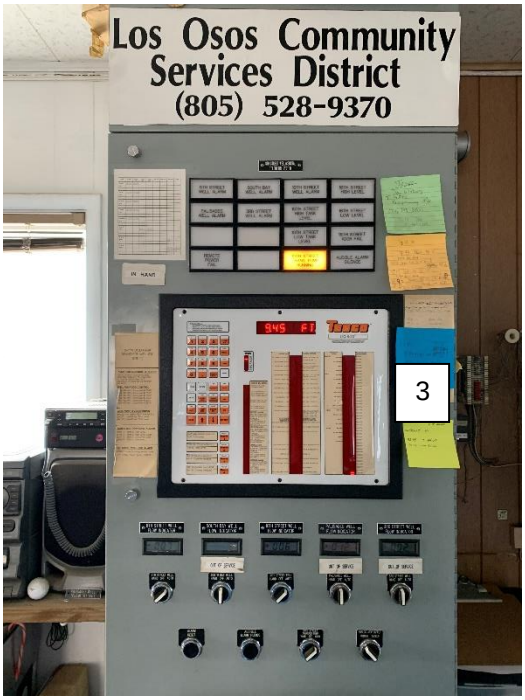
Communications

Existing Conditions: SCADA telemetry is a leased line serial communication with limited throughput and transmission rate. For site specific SCADA communication, RTU-2 through RTU-5 connects directly to RTU-1 at the Water Yard.

Proposed Improvements: SCADA telemetry shall be upgraded to latest IP (Internet Protocol) based system. Communication system using 900 MHz radio based with cellular backup is recommended. Refer to radio study in Appendix B for radio antenna height requirement and design recommendations.

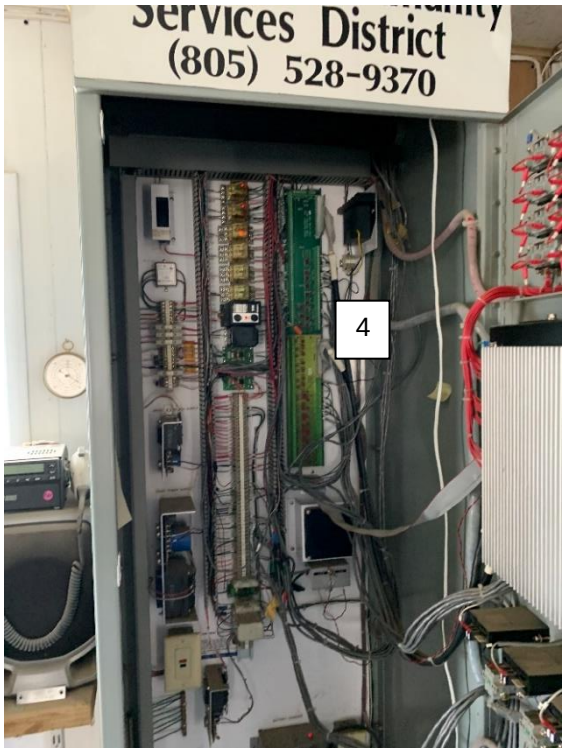
RTU	1	Enclosure	Indoor
RTU Controller	Tesco	UPS	None
Operator Interface	Tesco	Telemetry	Leased Line

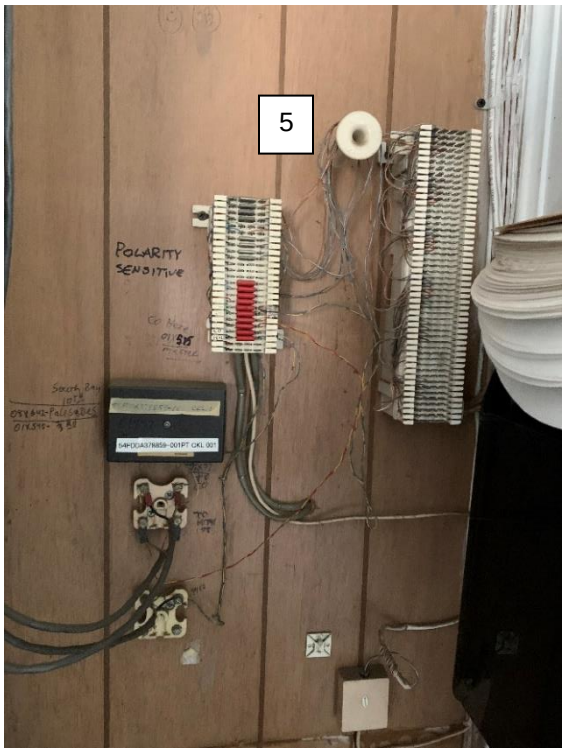
8th STREET WELL

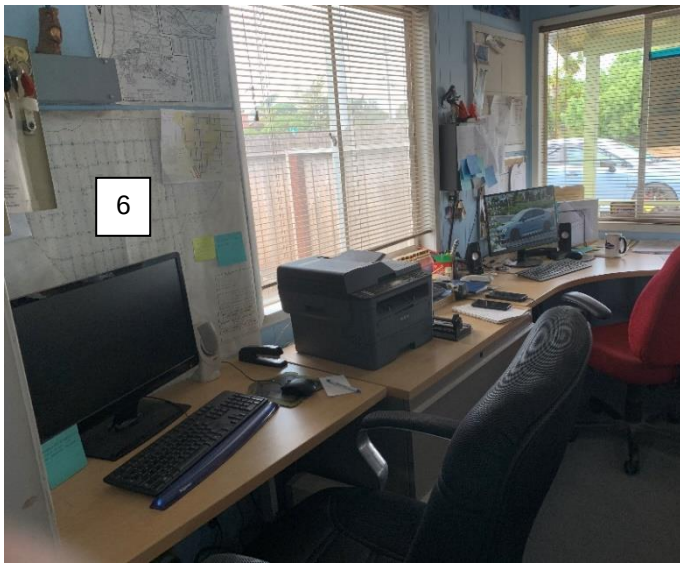


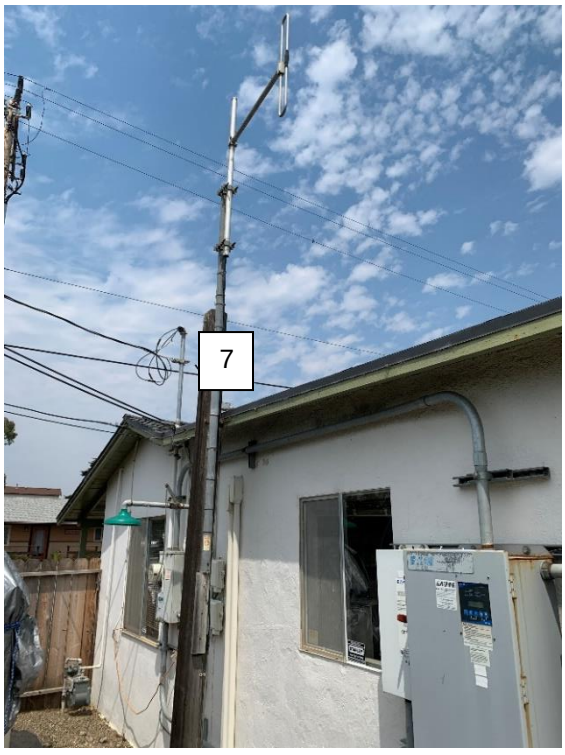
Notes:
1. Possible Location for Communication Cabinet – above new Instrument Control Panel
2. Possible Location for new Instrument Control Panel
3. Existing Tesco / RTU-1 Master Control Panel

8th STREET WELL









Notes:
4. Tesco controller & I/O module
5. Serial communications system
6. Possible Location for new Engineering & Operator workstations
7. Existing radio antenna mast. Retrofit and reuse.

SOUTH BAY WELL

GENERAL SITE INFORMATION

The South Bay Well, located at South Bay Boulevard/Nipomo Ave, is comprised of upper and lower well pumps, iron/manganese treatment, turbidity, nitrate and CL2 monitoring.

SCADA TELEMETRY

The control system hardware (RTU, I/O Module, network equipment) resides in a control cabinet inside the pump control room. Operator Interface for automated control is located on the panel door. Additional Hand-Off-Auto (HOA) switches are mounted on the panel door. SCADA telemetry equipment make and models are listed in table below. AECOM's field investigation notes and proposed recommendations are listed in following section.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: The control system processor i.e. Remote Terminal Unit (RTU) by FRM is a proprietary controller and has failed multiple times in the past. The control panel does not have any required temperature control features or UPS for power backup. The existing control panel can be retrofitted to accommodate the new PLC. Nitrate treatment system has limited interface with the well control panel, not all monitoring and control is made available on well control panel.

Proposed Improvements: Provide completely new Instrument Control Panel with latest Programmable Logic Controller, HMI, network switch, and radio in new instrument control panel. Provide dedicated UPS and temperature control features for instrument control panel. Ice cube relays can be replaced with solid state relays to create additional space for PLC hardware, radio, and ethernet switch. Provide complete interface from Nitrate Control Panel to Well Control Panel.

Instrumentation

Existing Conditions: During the site visit condition, assessment of existing instrumentation was not evaluated. The instruments appear to be in working condition.

Proposed Improvements: Instrumentation improvements to be evaluated at design phase. Instruments shall interface to new SCADA system during construction of the SCADA upgrade project.

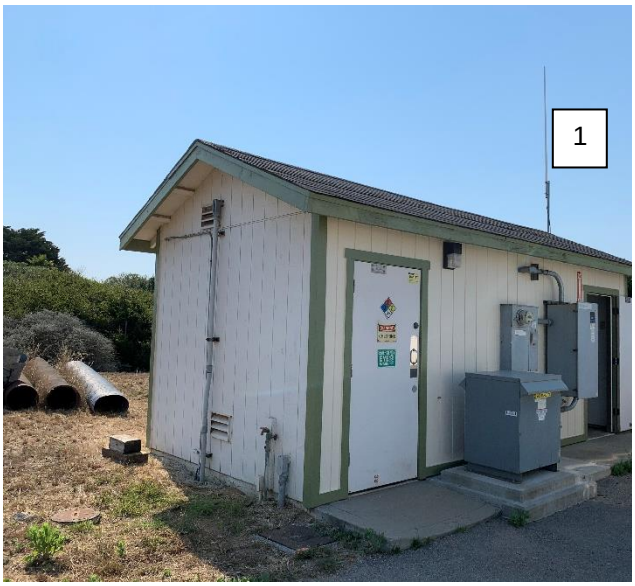
Communications

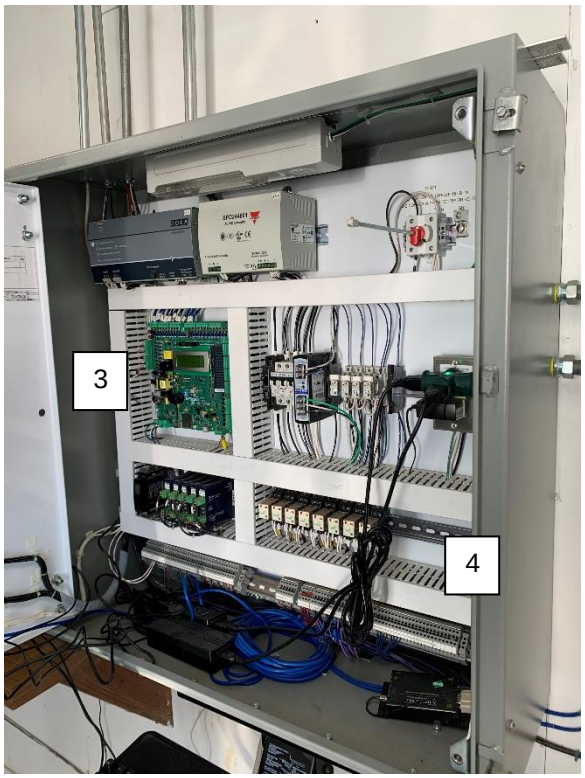
Existing Conditions: Existing control system connects directly to RTU-1 at the Water Yard. SCADA telemetry is a leased line serial communication with limited throughput and transmission rate. There is a radio with omni antenna communicating to 16th Street Tank and Palisades Well. This site also has an internet access, operators can remote login to the operator interface and make changes to HMI graphics.

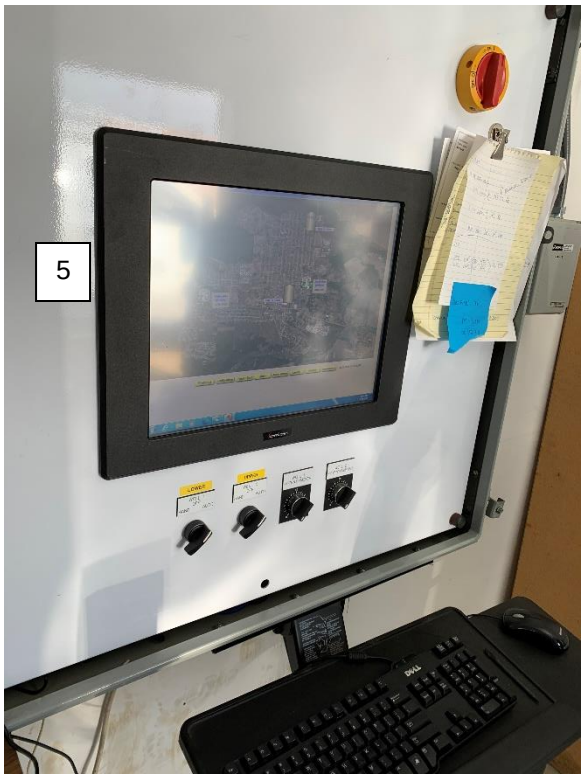
Proposed Improvements: SCADA telemetry shall be upgraded to latest IP (Internet Protocol) based system. Communication system using 900 MHz radio based with cellular backup is recommended. Refer to radio study in Appendix B for radio antenna height requirement and design recommendations.

RTU	2	Enclosure	Indoor
RTU Controller	FRM RF SCADA 32	UPS	None
Operator Interface	FRM Superlogics	Telemetry	Leased Line, Radio, Internet

SOUTH BAY WELL







Notes:
1. Omni Antenna
2. Nitrate Removal Control Panel Front Door
3. FRM Controller
4. Ice Cube Relays
5. Swingout Door with HMI

10TH STREET WELL AND TANK

GENERAL SITE INFORMATION

The 10th street well and tank site located at 10th Street and Los Olivos Ave, is comprised well pump, tank, transfer pump, turbidity and CL2 monitoring system.

SCADA TELEMETRY

The control system hardware (PLC, I/O Module, Network equipment) resides in a control cabinet. Operator Interface for automated control is located on the panel door. Additional Hand-Off-Auto (HOA) switches are mounted on the panel door. SCADA telemetry equipment make and models are listed in table below. AECOM's field investigation notes and proposed recommendations are listed in following section.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: The control system processor i.e. Remote Terminal Unit (RTU) by Tesco is obsolete and is prone to failure. The control panel does not have any required temperature control features or UPS for power backup. The existing control panel can be retrofitted to accommodate new PLC. Operations staff expressed desire to have soft starter for the well pump.

Proposed Improvements: Provide completely new Instrument Control Panel with latest Programmable Logic Controller, HMI, network switch, and radio in new instrument control panel. Provide dedicated UPS and temperature control features for instrument control panel. Replacing only backpanel while keeping enclosure as is an alternative to installing new control panel.

Instrumentation

Existing Conditions: During the site visit, condition assessment of existing instrumentation was not evaluated. The instruments appear to be in working condition. Operations staff requested that existing flowmeter be connected to SCADA.

Proposed Improvements: Instrumentation improvements to be evaluated at design phase. Instruments shall interface to new SCADA system during construction of the SCADA upgrade project.

Communications

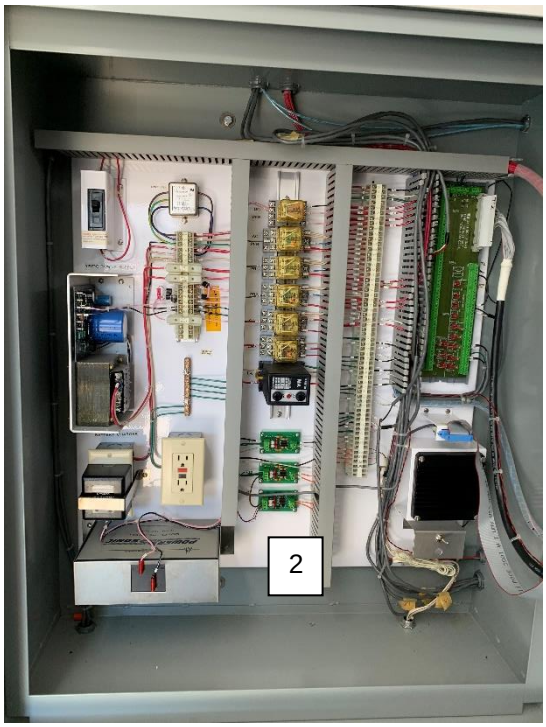
Existing Conditions: Existing control system connects directly to RTU-1 at Water Yard. SCADA telemetry is a leased line serial communication with limited throughput and transmission rate.

Proposed Improvements: SCADA telemetry shall be upgraded to latest IP (Internet Protocol) based system. Communication system using 900 MHz radio based with cellular backup is recommended. Refer to radio study in Appendix B for radio antenna height requirement and design recommendations.

RTU	3	Enclosure	Indoor
RTU Controller	Tesco LIQ 5/30	UPS	None
Operator Interface	Tesco LIQ 5/30	Telemetry	Leased Line

10TH STREET WELL AND TANK

1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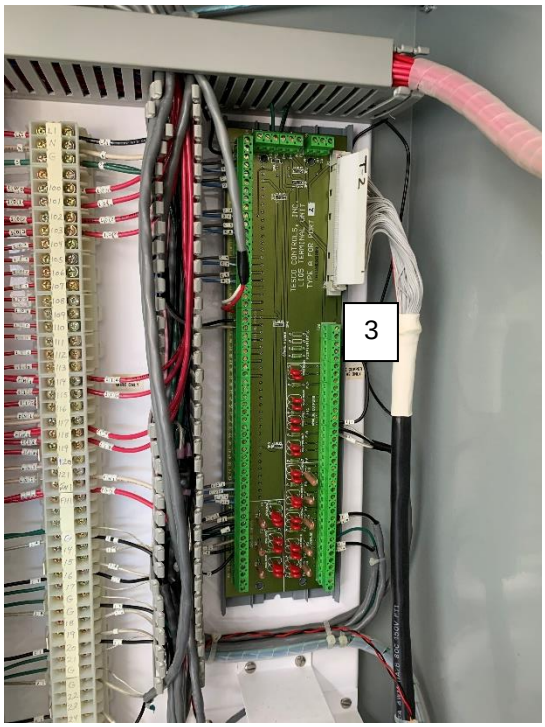

3

Notes:
1. Control Panel Exterior
2. Control Panel Interior
3. Tesco Controller

PALISADES WELL

GENERAL SITE INFORMATION

The Palisades Well, located at Palisades Ave/North of LOVR, is comprised of well pump and chemical dosing system.

SCADA TELEMETRY

The control system hardware (PLC, I/O Module, Network equipment) resides in a control cabinet. There is no door mounted Operator Interface or Hand-Off-Auto (HOA) switches available on the control panel. SCADA telemetry equipment make and models are listed in table below. AECOM's field investigation notes and proposed recommendations are listed in following section.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: The control system processor i.e. Remote Terminal Unit (RTU) by FRM is proprietary controller. The control panel does not have any required temperature control features or UPS for power backup.

Proposed Improvements: Provide completely new Instrument Control Panel with latest Programmable Logic Controller, HMI, network switch, and radio in new instrument control panel. Provide dedicated UPS and temperature control features for instrument control panel.

Instrumentation

Existing Conditions: During the site visit condition, assessment of existing instrumentation was not evaluated. The instruments appear to be in working condition.

Proposed Improvements: Instrumentation improvements to be evaluated at design phase. Instruments shall interface to new SCADA system during construction of the SCADA upgrade project.

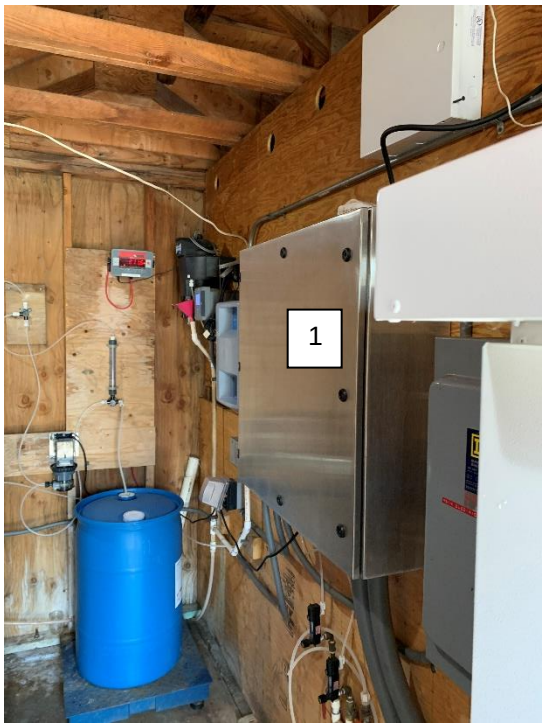
Communications

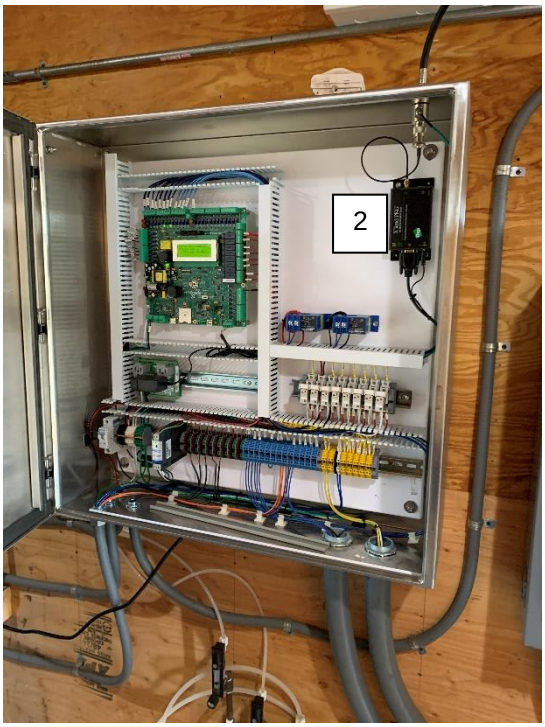
Existing Conditions: Existing control system connects directly to RTU-1 at the Water Yard. SCADA telemetry is a leased line serial communication with limited throughput and transmission rate. There is a radio with Yagi antenna communicating to South Bay Well.

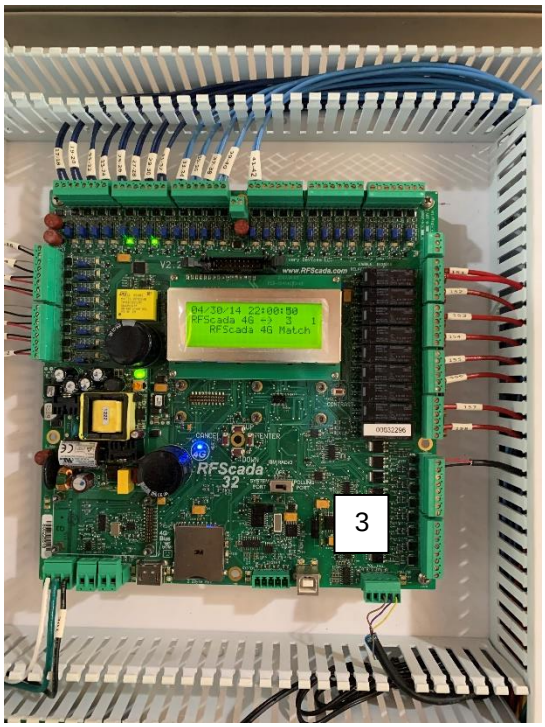
Proposed Improvements: SCADA telemetry shall be upgraded to latest IP (Internet Protocol) based system. Communication system using 900 MHz radio based with cellular backup is recommended. Refer to radio study in Appendix B for radio antenna height requirement and design recommendations.

RTU	4	Enclosure	Indoor
RTU Controller	FRM RF SCADA 32	UPS	None
Operator Interface	None	Telemetry	Leased Line, Radio

PALISDES WELL







Notes:
1. Control Panel Exterior
2. Control Panel Interior
3. FRM Controller

3rd STREET WELL

GENERAL SITE INFORMATION

The 3rd Street Well site located at 3rd Street, South of El Moro Ave, is comprised of well pump and analyzer instrumentation.

SCADA TELEMETRY

The control system hardware (PLC, I/O Module, Network equipment) resides in a control cabinet. Operator Interface for automated control is located on the panel door. Additional Hand-Off-Auto (HOA) switches are mounted on the panel door. SCADA telemetry equipment make and models are listed in table below. AECOM's field investigation notes and proposed recommendations are listed in following section.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: The control system processor i.e. Remote Terminal Unit (RTU) by Tesco is obsolete and prone to failure. The control panel do not have any required temperature control features. Battery backup is provided inside the control panel. The existing control panel can be retrofitted to accommodate new PLC.

Proposed Improvements: Provide completely new Instrument Control Panel with latest Programmable Logic Controller, HMI, network switch, and radio in new instrument control panel. Provide dedicated UPS and temperature control features for instrument control panel. Replacing only backpanel while keeping enclosure as is an alternative to installing new control panel.

Instrumentation

Existing Conditions: During the site visit, condition assessment of existing instrumentation was not evaluated. The instruments appear to be in working condition.

Proposed Improvements: Instrumentation improvements to be evaluated at design phase. Instruments shall interface to new SCADA system during construction of the SCADA upgrade project.

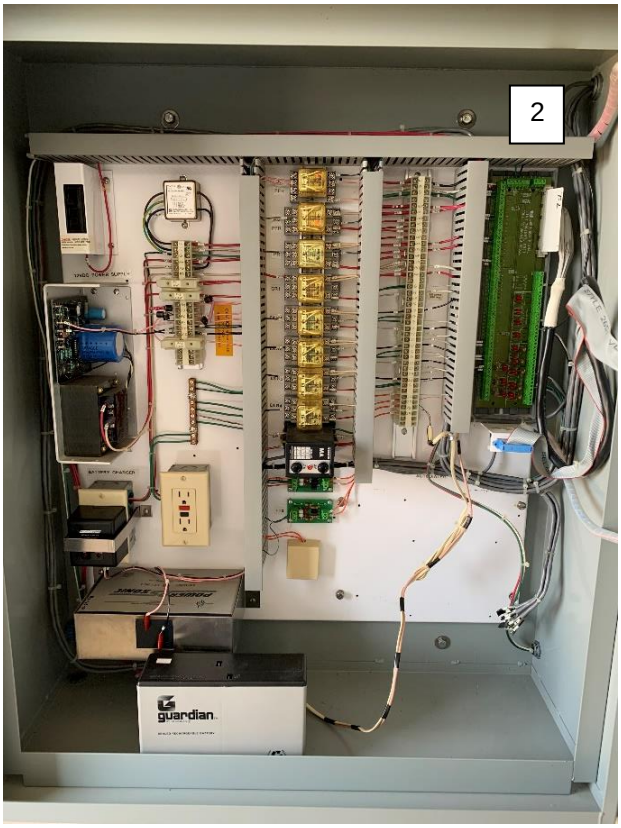
Communications

Existing Conditions: Existing control system connects directly to RTU-1 at the Water Yard. SCADA telemetry is a leased line serial communication with limited throughput and transmission rate.

Proposed Improvements: SCADA telemetry shall be upgraded to latest IP (Internet Protocol) based system. Communication system using 900 MHz radio based with cellular backup is recommended. Refer to radio study in Appendix B for radio antenna height requirement and design recommendations.

RTU	5	Enclosure	Indoor
RTU Controller	Tesco LIQ 5/30	UPS	None
Operator Interface	Tesco LIQ 5/30	Telemetry	Leased Line

3rd STREET WELL



Notes:
1. Control Panel Exterior
2. Control Panel Interior – Tesco Controller
3. Possible Tower Location

16TH STREET TANK AND BOOSTER STATION

GENERAL SITE INFORMATION

The 16th street tank site and pump station at 16th Street/South of Santa Maria Ave, is comprised of tank and booster pumps.

SCADA TELEMETRY

The tank control system hardware (PLC, I/O Module, Network equipment) resides in a dedicated control cabinet whereas pump controls are in an MCC lineup inside the “Autosensory Panel” bucket. There is no Operator Interface or HOA switches on the panel door. SCADA telemetry equipment make and models are listed in table below. AECOM’s field investigation notes and proposed recommendations are listed in following section.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: The tank control system processor i.e. Remote Terminal Unit (RTU) by FRM is a proprietary controller. The control panel does not have any required temperature control features or UPS for power backup. The booster pump control is by Siemens PLC.

Proposed Improvements: Provide completely new Instrument Control Panel with latest Programmable Logic Controller, HMI, network switch, and radio in new instrument control panel. Provide dedicated UPS and temperature control features for instrument control panel. Recommended approach is to integrate tank control panel with booster pump control panel with one PLC and unified logic to completely monitor and operate this site.

Instrumentation

Existing Conditions: During the site visit condition, assessment of existing instrumentation was not evaluated. The instruments appear to be in working condition.

Proposed Improvements: Instrumentation improvements to be evaluated at design phase. Instruments shall interface to new SCADA system during construction of the SCADA upgrade project.

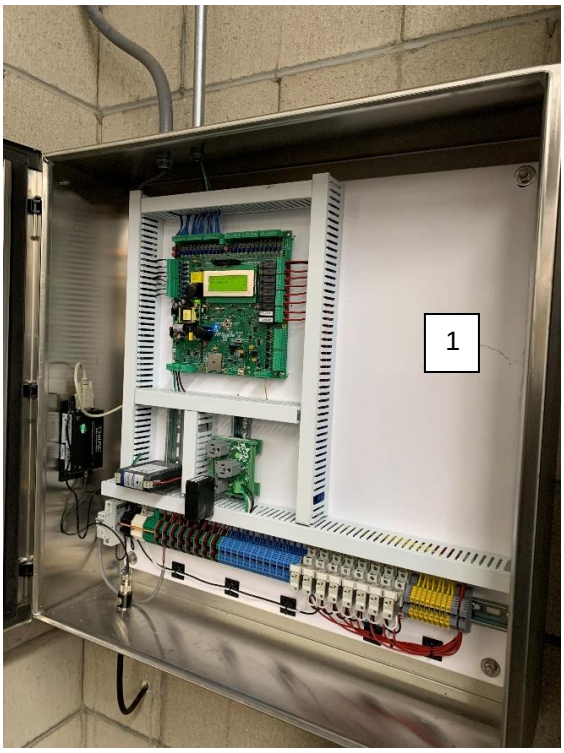
Communications

Existing Conditions: 16th Street Tank level is transmitted to South Bay Well PLC using 900 MHz Radio.

Proposed Improvements: SCADA telemetry shall be upgraded to latest IP (Internet Protocol) based system. Communication system using 900 MHz radio based with cellular backup is recommended. Refer to radio study in Appendix B for radio antenna height requirement and design recommendations.

RTU	Number not assigned	Enclosure	Indoor
RTU Controller	FRM RF SCADA 32	UPS	None
Operator Interface	None	Telemetry	900 MHz Radio

16TH STREET TANK AND BOOSTER STATION



Notes:
1. Control Panel
2. Booster Pump Control Panel
3. Siemens Controllers

6TH STREET DRAINAGE

GENERAL SITE INFORMATION

The 6th street drainage, located at 6th Street and El Moro, is comprised of two drainage pumps.

SCADA TELEMETRY

None.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: None.

Proposed Improvements: Provide completely new outdoor rated Instrument Control Panel with latest Programmable Logic Controller, network switch, and radio in new instrument control panel. Provide dedicated UPS and temperature control features for instrument control panel. Shade structure with antenna mast will serve to keep enclosure cooler and support for antenna mast.

Instrumentation

Existing Conditions: None.

Proposed Improvements: To be evaluated at design phase.

Communications

Existing Conditions: Power lines are right above the drainage vault.

Proposed Improvements: Communication system using 900 MHz radio based with cellular backup is recommended. Location of radio tower or antenna mast shall be determined with factors such as conduit routing from incoming power supply, overhead power lines, underground piping and drainage structure.

6TH STREET DRAINAGE

Notes:
1. Possible Control Panel & Radio Tower Location
2. Power Feed for Proposed Control Panel

BAY RIDGE DRAINAGE

GENERAL SITE INFORMATION

The Bay Ridge drainage, located at South Bay Boulevard/Bay Oaks Drive, is comprised of one submersible drainage pump and level controller.

SCADA TELEMETRY

Traditional control system hardware (PLC, I/O Module, Operator Interface, Network equipment) is not present in control cabinet. Dedicated pump controller with relay logic is implemented to provide control capabilities. Drainage site is not interfaced to RTU-1 at Water Yard. AECOM's field investigation notes and proposed recommendations are listed in following section.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: The control panel has liquid level controller to operate pumps based on float switch activation. The control panel does not have RTU, HMI, telemetry or UPS for power backup.

Proposed Improvements: Existing control panel can be retrofitted to accommodate Programmable Logic Controller, network switch, and radio. Icecube relays can be replaced with small solid state relays to create additional space. Provide dedicated UPS and temperature control features for instrument control panel. Liquid level controller can serve as a backup to PLC or another cost effective means would be to install radio unit with I/O to intercept and transport signals from liquid level controller to SCADA servers.

Instrumentation

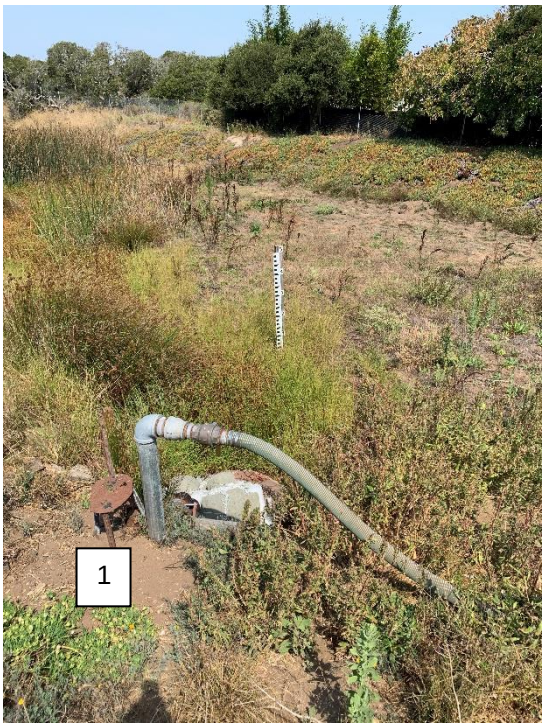
Existing Conditions: During the site visit, condition assessment of existing instrumentation was not evaluated. The instruments appear to be in working condition.

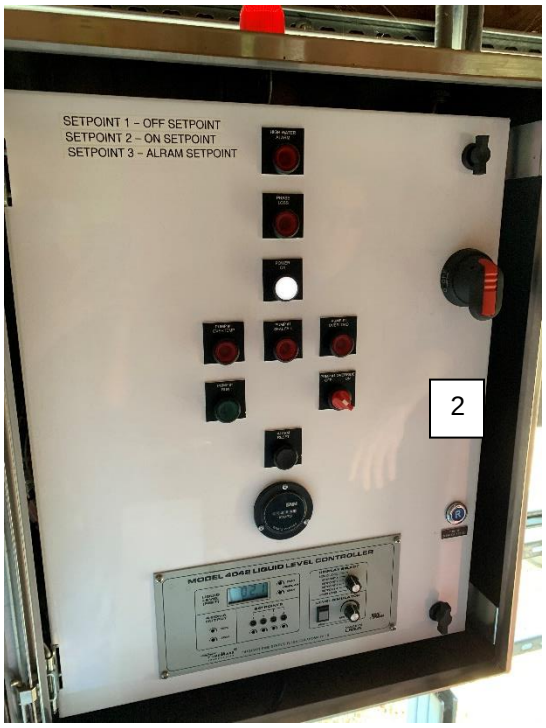
Proposed Improvements: Instrumentation improvements to be evaluated at design phase. Instruments shall interface to new SCADA system during construction of the SCADA upgrade project.

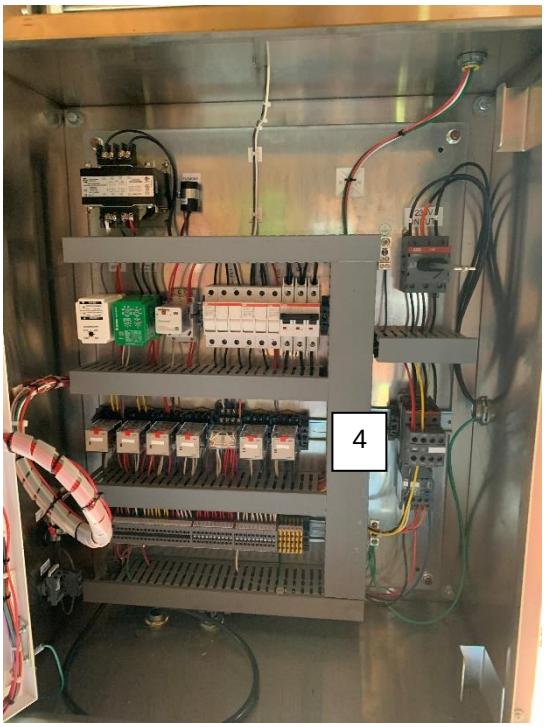
Communications

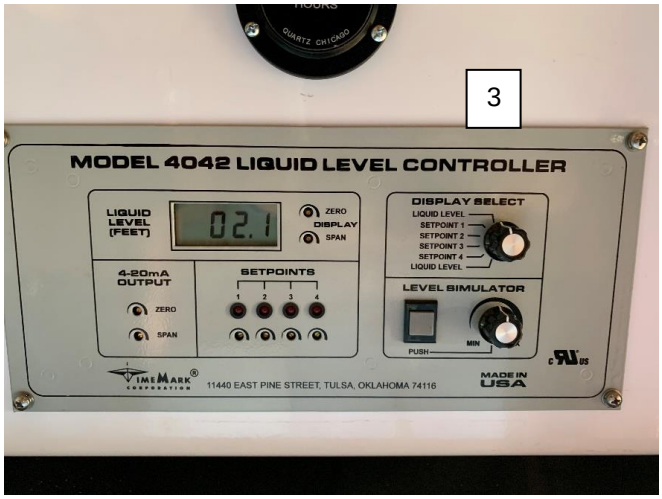
Existing Conditions: None.

Proposed Improvements: SCADA telemetry shall be upgraded to latest IP (Internet Protocol) based system. Communication system using 900 MHz radio based with cellular backup is recommended. Refer to radio study in Appendix B for radio antenna height requirement and design recommendations.









Notes:
1. Drainage Pump
2. Swingout Panel
3. Pump Controller
4. Interposing Relays

DON AND MITCHELL DRAINAGE

GENERAL SITE INFORMATION

Don and Mitchell drainage, located at Don Ave/Mitchell Dr, is comprised of two drainage pumps and level controller.

SCADA TELEMETRY

Traditional control system hardware (PLC, I/O Module, Operator Interface, Network equipment) is not present in control cabinet. Dedicated pump controller with relay logic is implemented to provide control capabilities. Drainage site is not interfaced to RTU-1 at the Water Yard. AECOM's field investigation notes and proposed recommendations are listed in following section.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: The control panel has relay logic based alternator to operate pumps based on float switch activation. The control panel does not have RTU, HMI, telemetry or UPS for power backup.

Proposed Improvements: Existing control panel can be retrofitted to accommodate Programmable Logic Controller, network switch, and radio. Icecube relays can be replaced with small solid state relays to create additional space. Provide dedicated UPS and temperature control features for instrument control panel. Liquid level controller can serve as a backup to PLC or another cost effective means would be to install radio unit with I/O to intercept and transport signals from liquid level controller to SCADA servers.

Instrumentation

Existing Conditions: During the site visit, condition assessment of existing instrumentation was not evaluated. The instruments appear to be in working condition.

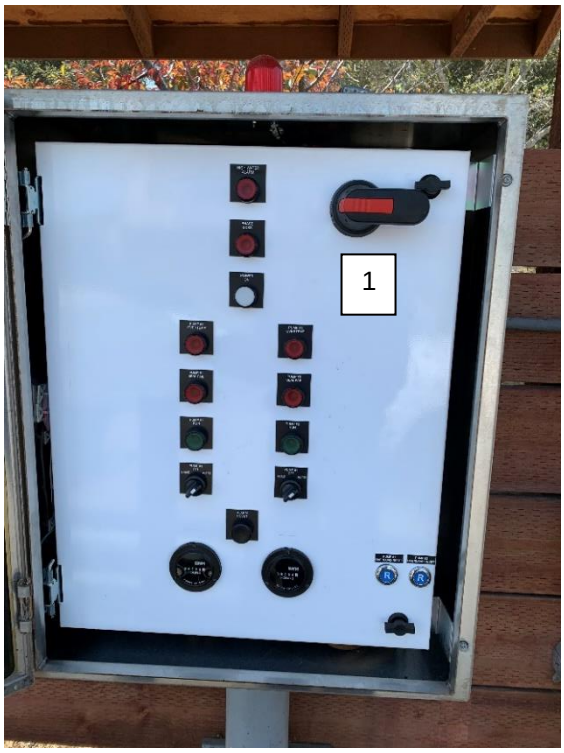
Proposed Improvements: Instrumentation improvements to be evaluated at design phase. Instruments shall interface to new SCADA system during construction of the SCADA upgrade project.

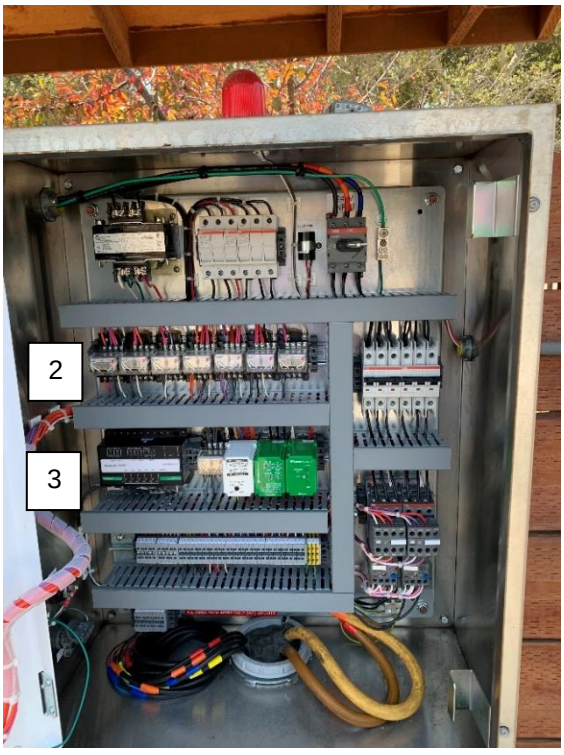
Communications

Existing Conditions: None.

Proposed Improvements: SCADA telemetry shall be upgraded to latest IP (Internet Protocol) based system. Communication system using 900 MHz radio based with cellular backup is recommended. Refer to radio study in Appendix B for radio antenna height requirement and design recommendations. Location of radio tower or antenna mast shall be determined with factors such as conduit routing from incoming power supply, overhead power lines, underground piping and drainage structure.

DON AND MITCHELL DRAINAGE





Notes:

1. Control Panel Swingout Door
2. Interposing Relays
3. Pump Controller
4. Possible Radio Tower Location

8TH STREET DRAINAGE

GENERAL SITE INFORMATION

The 8th street drainage, located at 8th Street and El Moro, is comprised of two drainage pumps and level controller pumps.

SCADA TELEMETRY

Traditional control system hardware (PLC, I/O Module, Operator Interface, Network equipment) is not present in control cabinet. Dedicated pump controller with relay logic is implemented to provide control capabilities. Drainage site is not interfaced to RTU-1 at the Water Yard. AECOM's field investigation notes and proposed recommendations are listed in following section.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: The control panel has relay logic based alternator to operate pumps based on float switch activation. The control panel does not have RTU, HMI, telemetry or UPS for power backup. Backup power comes from the county generator which will power the pumps and the control panel.

Proposed Improvements: Existing control panel can be retrofitted to accommodate Programmable Logic Controller, network switch, and radio. Icecube relays can be replaced with small solid state relays to create additional space. Provide dedicated UPS and temperature control features for instrument control panel. Liquid level controller can serve as a backup to PLC or another cost effective means would be to install radio unit with I/O to intercept and transport signals from liquid level controller to SCADA servers.

Instrumentation

Existing Conditions: During the site visit, condition assessment of existing instrumentation was not evaluated. The instruments appear to be in working condition.

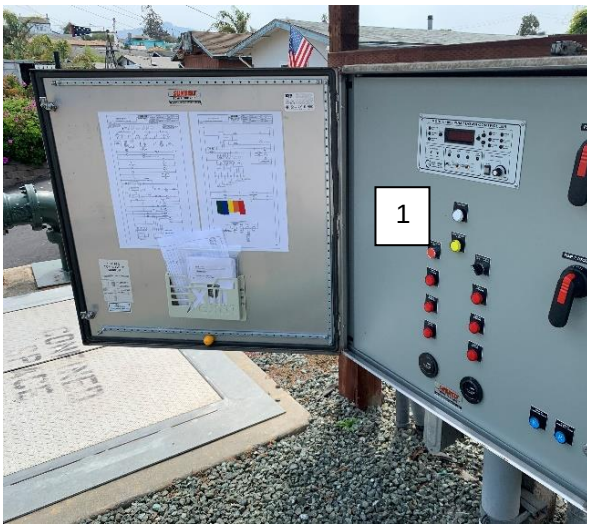
Proposed Improvements: Instrumentation improvements to be evaluated at design phase. Instruments shall interface to new SCADA system during construction of the SCADA upgrade project.

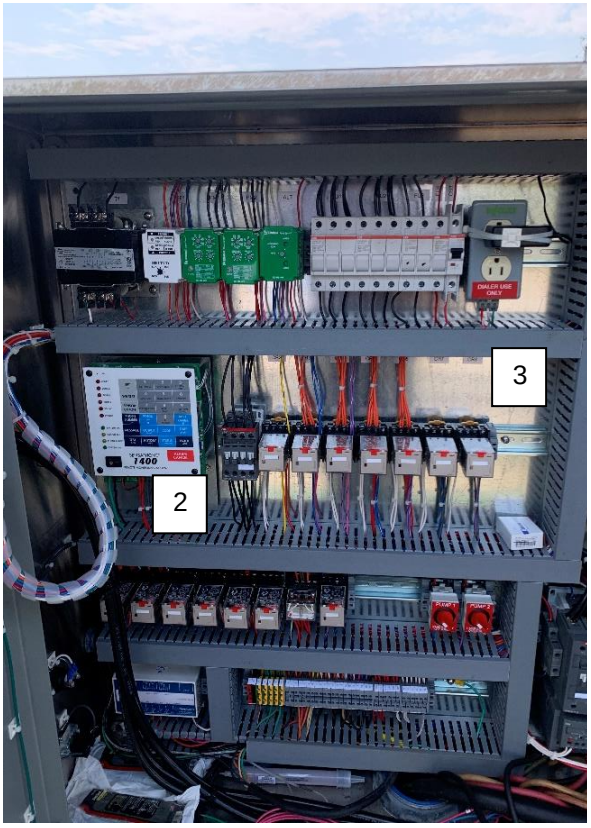
Communications

Existing Conditions: None.

Proposed Improvements: SCADA telemetry shall be upgraded to latest IP (Internet Protocol) based system. Communication system using 900 MHz radio based with cellular backup is recommended. Refer to radio study in Appendix B for radio antenna height requirement and design recommendations. Location of radio tower or antenna mast shall be determined with factors such as conduit routing from incoming power supply, overhead power lines, underground piping and drainage structure.

8TH STREET DRAINAGE





Notes:
1. Control Panel
2. Pump Controller / Alarm Dialer
3. Interposing Relays

16TH STREET DRAINAGE

GENERAL SITE INFORMATION

The 16th street drainage, located at 16th Street/Paso Robles Ave, is comprised of 1 small submersible pump and 1 diesel powered larger pump for heavy rain incidents pumps.

SCADA TELEMETRY

Traditional control system hardware (PLC, I/O Module, Operator Interface, Network equipment) is not present in control cabinet. 16th Street Drainage site is not interfaced to RTU-1 at the Water Yard. AECOM's field investigation notes and proposed recommendations are listed in following section.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: None.

Proposed Improvements: Provide completely new Instrument Control Panel with latest Programmable Logic Controller, HMI, network switch, and radio in new instrument control panel. Provide dedicated UPS and temperature control features for the instrument control panel.

Instrumentation

Existing Conditions: During the site visit, condition assessment of existing instrumentation was not evaluated. The instruments appear to be in working condition.

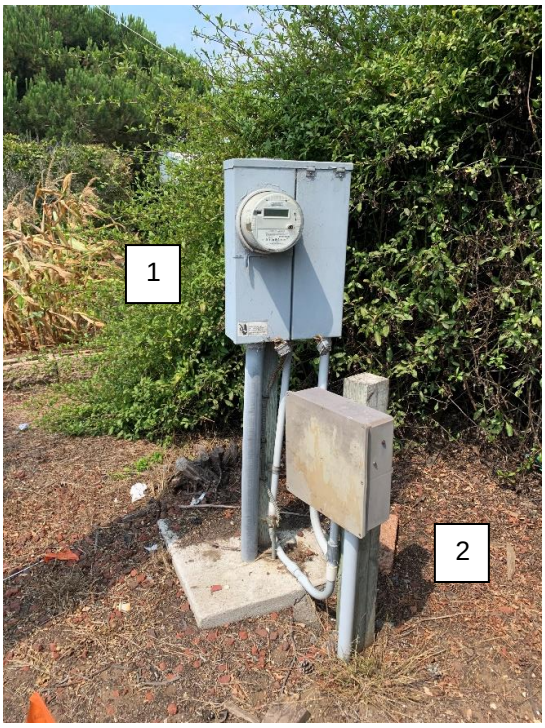
Proposed Improvements: Instrumentation improvements to be evaluated at design phase. Instruments shall interface to new SCADA system during construction of the SCADA upgrade project.

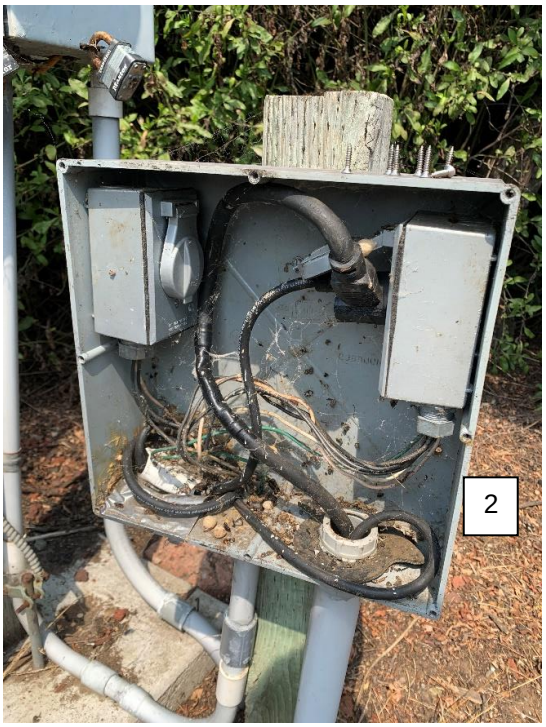
Communications

Existing Conditions: Existing control system connects directly to RTU-1 at the Water Yard. SCADA telemetry is a leased line serial communication with limited throughput and transmission rate.

Proposed Improvements: SCADA telemetry shall be upgraded to latest IP (Internet Protocol) based system. Communication system using 900 MHz radio based with cellular backup is recommended. Refer to radio study in Appendix B for radio antenna height requirement and design recommendations.

16TH STREET DRAINAGE





Notes:
1. Power Feed
2. Pump Disconnect
3. Possible Radio Tower Location
4. Diesel Pump

LOCSD/GSWC INTERTIE

GENERAL SITE INFORMATION

The LOCSD/GSWC Intertie is located at Los Olivos Ave/11th Street.

SCADA TELEMETRY

None.

EXISTING CONDITION AND PROPOSED IMPROVEMENTS

Control Systems

Existing Conditions: None.

Proposed Improvements: Provide completely new outdoor rated Instrument Control Panel with latest Programmable Logic Controller, network switch, and radio in new instrument control panel. Provide dedicated UPS and temperature control features for instrument control panel. Shade structure with antenna mast will serve to keep enclosure cooler and support for antenna mast.

Instrumentation

Existing Conditions: None.

Proposed Improvements: To be evaluated at design phase.

Communications

Existing Conditions: None.

Proposed Improvements: Communication system using 900 MHz radio based with cellular backup is recommended. Location of radio tower or antenna mast shall be determined with factors such as conduit routing from incoming power supply, overhead power lines, residential restriction, underground piping and intertie structure. Wooden power pole can be utilized for mounting antenna.

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LOCSD/GSWC INTERTIE

Notes:
1. Possible Control Panel Location
2. Possible Radio Tower Location

Appendix B
Applied Technology Radio Study

APPLIED TECHNOLOGY

SPECIALIZED COMMUNICATIONS SERVICES

Los Osos Community Service District

LOS OSOS COMMUNITY SERVICES DISTRICT

Radio Site Survey Report

Prepared for

AECOM

August 25, 2020

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1.0 Executive Summary

Applied Technology Group, Inc. (ATG) has prepared this report at the request of AECOM to investigate the feasibility of a future SCADA radio system to replace Los Osos Community Service District's (LOCSD) existing system of only a handful of sites. Eleven sites were surveyed including the 16th Street Tank site which will be the main repeater site.

ATG studied the various site locations utilizing Google Earth mapping software. This is the first step in the process that allowed us to verify the overall feasibility of an on-site radio site survey. We determined that there would be sites that might require a repeater or repeaters, so we identified several possible repeater sites to be included in the site survey if required.

The two-day survey began on Tuesday, August 18th and was completed on the following day, Wednesday, August 19th. Eleven sites were surveyed and once it was determined that there existed sites requiring a repeater, these sites were re-surveyed to the most likely repeater site until every site had an acceptable radio path back to SCADA. We positioned our 50 ft. survey van at 16th Street Tank with its mast raised to the maximum height of 50 ft. which allowed us to simulate an omni antenna mounted on a 10 ft. mast attached to the railing on the top of the tank. The other survey van has a 35-foot mast and was used to survey from the remote sites at various heights. Once the initial sites were surveyed, we re-positioned our 50 ft. survey van at the 10th Street Tank.

The following sites were surveyed:

Site Name	Latitude	Longitude	Elevation (ft.)
Central Office	35 19 33.73	120 50 02.79	28
8th Street Drainage	35 19 34.00	120 50 04.17	26
6th & El Moro Drainage	35 19 33.84	120 50 11.28	22
3rd Street Well	35 19 31.66	120 50 24.18	11
Don & Mitchell Drainage	35 19 09.47	120 50 43.73	12
Palisades Well	35 18 48.93	120 50 15.78	87
10th Street Tank (Rptr)	35 18 46.86	120 49 57.91	133
LOCSD / GSWC Intertie	35 18 47.77	120 49 52.32	114
Bayridge Drainage	35 18 32.02	120 49 37.02	174
South Bay Well	35 18 57.21	120 49 26.57	107
16th St. Paso Robles Drainage	35 19 27.97	120 49 31.28	74
16th Street Tanks & Booster Station (Rptr)	35 19 39.57	120 49 30.71	152

Table 1 – Surveyed Sites and Coordinates

The following sites were considered as possible additional repeater sites:

Site Name	Latitude	Longitude	Elevation (ft.)
10th Street Tank	35 18 46.86	120 49 57.91	133
Palisades Well	35 18 48.93	120 50 15.78	87
Don Mitchell Drainage	35 19 09.47	120 50 43.73	12

Table 2 – Potential Repeater Sites

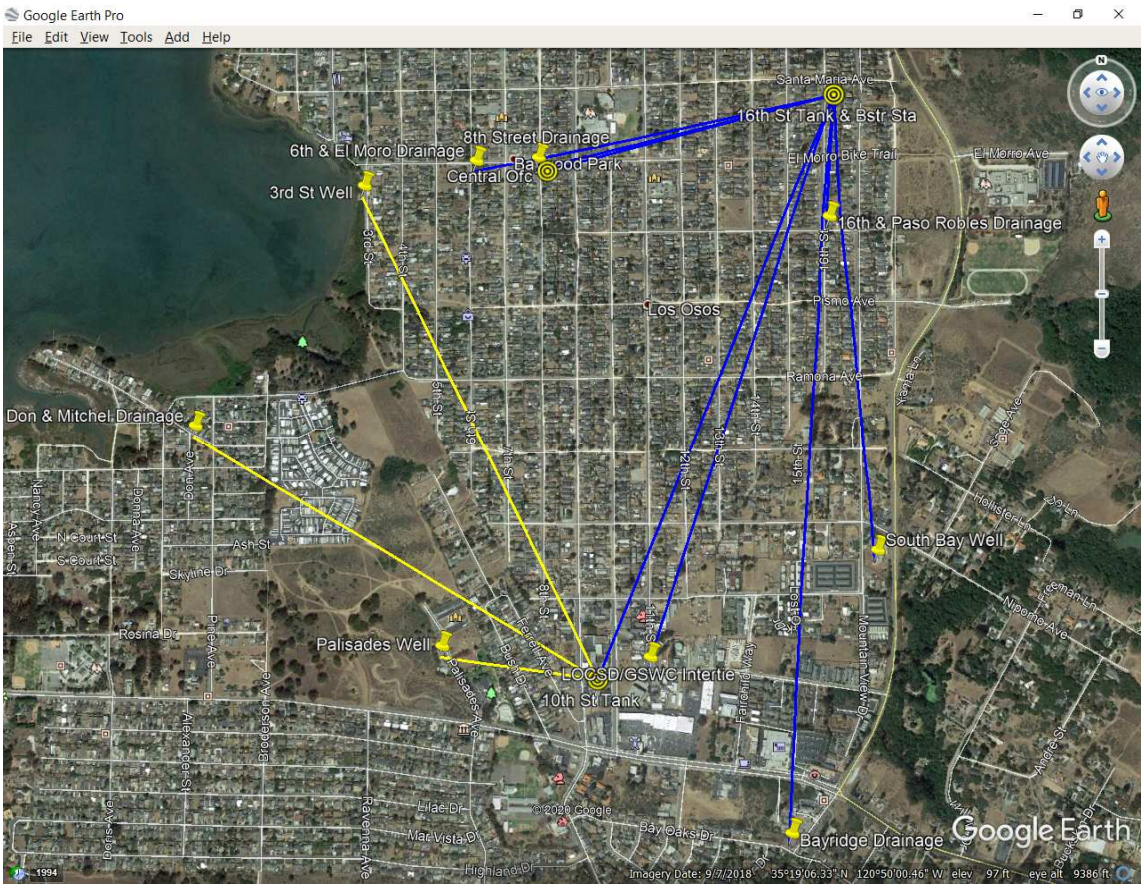

Figure 1 – Site Map Showing Recommended Paths

2.0 Radio Survey Details

This survey was conducted utilizing our telescoping mast survey vans. I will refer to the van located at the 16th Street Tank Repeater site as the Access Point Van and the other van shall be referred to as the Remote Van. The mast on the Access Point survey van located at the 16th Street Tank site was extended to its maximum height of 50 ft. for the duration of the initial survey. This simulated a 40 ft. tank with a 10 ft. antenna mast mounted on the top of the tank.

At the Remote Van, once set up in the correct location, we raised the mast to its maximum height of 35 ft. to assure the yagi antenna is seeing the strongest signal as it is optimized in the correct direction. From this height, we drop the mast in increments of 5 ft. to record the survey results all the way down to a height where the parameters begin to result in unacceptable numbers or if an existing antenna is on site, we will survey down to the As Built height.

We perform several tasks designed to alleviate problems and skew survey results before arriving on site to perform the survey.

1. The survey radios are pre-programmed and benched tested at our facility.
2. The coax and antennas are tested for Reflected Power at our facility before being loaded into our survey vans. This assures that the survey results are accurate and not skewed by faulty coax or antennas.
3. On-site, before leaving the Access Point Survey van, we verify communication between the survey radios.

Once on site, we also make sure the vans are sitting level or the antenna is adjusted so that the antenna sits true on both the Access Point survey van and the Remote survey van's yagi. It is critical to understand that an antenna that has up tilt or down tilt will not reflect the same performance (good or bad) as RF results are collected, as when it is actually installed, since antennas are typically mounted plumb to the ground.

The information we collect

Before reviewing the results, you will see several terms that I refer to and are values that we collect during the survey, I will discuss the meaning of the terms, RSSI, SNR and LQI and what they mean in relation to a dependable radio link:

RSSI (Received Signal Strength Indicator) it is expressed as a negative number where the closer towards a positive number you are, the better or stronger the signal, i.e. -70 is a **stronger**, more desirable signal than -76. Simply put, this is how "loud" the signal is. Radios have an RSSI level at which they

begin to experience data bit errors and thus corrupted data transmissions. This number varies depending on the manufacturer of the radio. It should be noted that these numbers are arrived at in a controlled "bench test" environment and are not real world; in the real world, the radio will fail at a much higher (better) signal strength (instead of failing at the published -100dB, it may actually start failing at -90dB). When evaluating RSSI levels for a radio system, we usually look for a 20dB "fade margin" between the RSSI recorded and the RSSI at which the radio begins to fail. This fade margin gives the radio some operating room if it encounters a degradation of signal while operating. This may be a result of maturing vegetation; new structures being built in the path or a new nearby radio system coming on the air.

It should be noted that Fade Margin is something that can only be improved by improving certain aspects of the site such as antenna height, antenna orientation, coax size, antenna gain, radio power or moving the antenna around the site to improve the signal if possible.

SNR (Signal-to-Noise ratio): A measure of how well the signal is being received at a radio relative to noise on the channel. The HIGHER the number the better. Simply put, this is the radio frequency "environment", in other words, how "noisy" or how much interference is out there and how hard will it be for the radio to hear any other radio it may need to communicate with. The higher the number, the quieter the frequency band the radio is utilizing. This is very important because if the radio has such a quiet operating environment i.e. 45, it will tolerate a lesser RSSI or signal strength. When the SNR levels fall to lower numbers i.e. mid to high 20's, typically a radio either cannot communicate or the transmission error rate begins to climb, and the radio begins to retry transmissions, which in turn creates latency and unreliable communications.

LQI: (Link Quality Indicator) Important Notes and Information Regarding LQI (taken directly from the GEMDS Orbit MCR 900 manual)
LQI is dependent on the modulation format and should be used as a relative measurement of the link quality. A low LQI value indicates a better link quality than a high value. Algorithmically, using GFSK modulation, the transceiver calculates the value by measuring the frequency of each "bit" and compares it with the expected frequency based on the channel frequency and the deviation and the measured frequency offset.

- LQI is a metric of the quality of the received signal.

- Unlike RSSI which simply measures signal strength, LQI is only a measurement of the "correctness" of this signal. (This means how easily the received signal can be correctly demodulated.)
- In general, the lower the LQI the better the quality.
- LQI should be used as a "relative" measurement. Precision is fairly loose and subject to variation from radio to radio and modulation format.
- For each modem (125,250,500…) LQI means something different because each modulation has varying receive bandwidths which can affect LQI calculations.

The following table (see next page) can used as a reference to quickly check the LQI reading and determine if it is good or not, and whether you should move to the next modem.
For example: Running Modem 1000 and the LQI reads 9, change to Modem 500. LQI then reads 16, change to Modem 250 and so forth.

Digital Energy
MDS

LQI Reference Table

LQI / Modem	125 kbps	250 kbps	500 kbps	1000 kbps	1000W kbps	1250 kbps
Pristine	8	16	8	4	1	1
Usable	14	21	14	6	3	3
Sensitivity (dBm) based on $1x10^{-6}$ @ XXX kbps	-105	-103	-99	-95	-95	-95

Again, the LQI on modem's 1000W and 1250 are usually low. Display of an LQI value indicates a signal is present. Due to the Receiver's wide bandwidth in 1000/1000W/1250 Modems, the dynamic range is lower which typically resolves on a low LQI.

For the remaining modems, "Pristine" means in an absolutely perfect signal environment the best LQI will be less than or equal to the number in the table.

"Usable" means the signal quality is good and the radio should be able to demodulate correctly, however if LQI averages are approaching this limit then errors would be expected. Ideally average LQI should fall somewhere in between the two values shown for each modem.

Lastly, keep in mind this is a "relative" measurement. Please do not make any hard decisions based on this metric. Systems (obviously) are not all the same and optimizing the system may take a little configuring based on Noise Floor/Data Type/Data Volume…

Another note on Modems and distance. The lower the kbps the further the units may be separated (lower the sensitivity). A 125kbps modem can reach out the farthest and the 1250kbps Modem would be the shortest. The Orbit will support up to 7 Hop Store-and-Forward to extend these distances (although Latency must be considered with each additional hop).

Figure 2 – LQI Reference Table and Verbiage from GEMDS Manual

Throughput Performance: In addition to collecting RSSI, LQI, SNR and antenna height at each site during the survey, we also run a program called WS Ping ProPack / Throughput Test. We typically will collect 3 throughput tests so that we can get a good average. Understand that this test DOES NOT report actual as-built system throughput, it is only used to measure a path's performance in relation to the noise level and for comparison purposes when looking at the difference the antenna's height makes on the radio's performance. When reading these "throughput" numbers in this report as they relate to mast height; please note that a lower throughput performance value equals a lower quality communications performance level which is a result of timeouts which may result in packet loss and radio retries. It is important to install at least as high a mast as recommended and even a little bit higher if you can get away with it. We understand that you cannot always build what is recommended, however also understand that the radio system may not run at its full potential if not built out in such a way as to optimize the communications between radios.

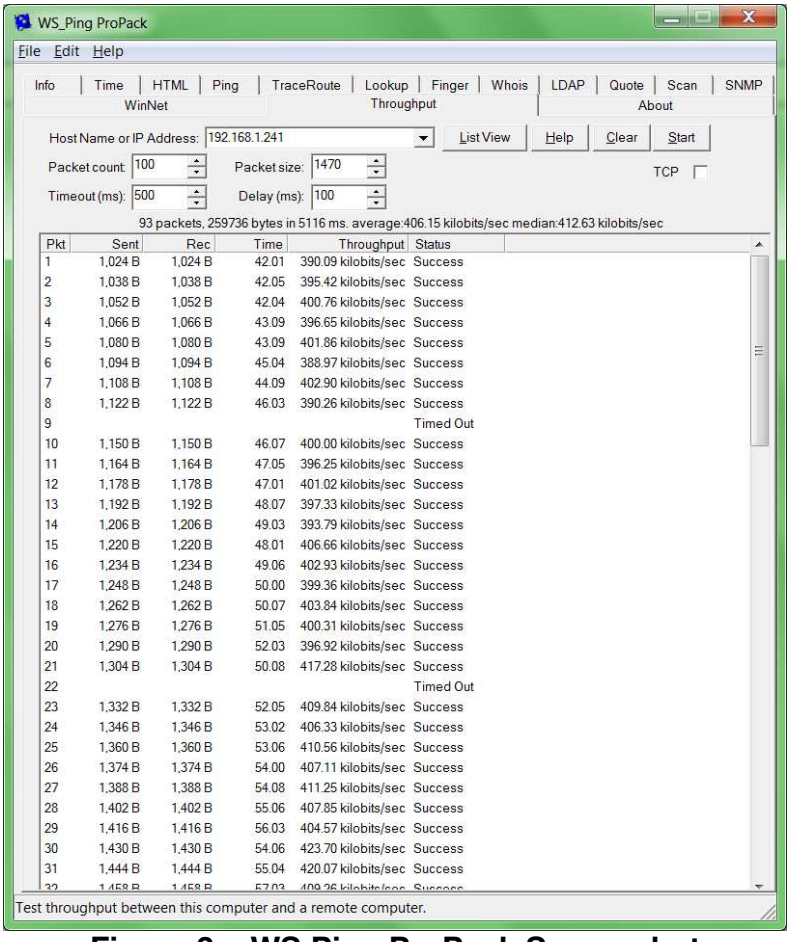

Figure 3 – WS Ping ProPack Screenshot

3.0 Testing Equipment

Radios: The Ethernet / serial radio used for this survey was the GEMDS Orbit MCR900 and ECR900. This radio operates in the 900MHz ISM unlicensed frequency band with a maximum output power of the radio at the antenna port of 1 watt.

MCR900

ECR900

This radio can operate in any one of six modulation rates, however, the default setting of 500 was used for this survey. Either radio can be used as an Access Point or Remote. The larger **MCR** radio can accept an additional radio NIC such as 900 unlicensed with a cellular modem in the same chassis. The MCR also offers various data port combinations i.e. 2 Ethernet and 1 Serial interface OR 1 Ethernet and 2 Serial interfaces. The **ECR** offers only a single radio NIC and only 1 Ethernet port and 1 Serial port.

Antennas:
Access Point Van: Andrew Decibel DB586Y 6dBd omni antenna.

Remote Van: GEMDS 97-3194-A14 10dBd yagi antenna.

Coax:
Access Point Van: 75-ft. Terrawave TWS400

Remote Van: 50-ft. Terrawave TWS400

Loss per 100-ft.: 3.9dB at 900MHz

Please note that we usually recommend using ½ Heliax for the final build out as this will not only improve signal strength but is also more resistant to the elements.

Laptop Computer: Windows 10 Laptop

4.0 Final Repeater Sites and Sites they Service

Site Name	Latitude	Longitude	Elevation (ft.)
16th Street Tanks	35 19 39.58	120 49 30.71	152
10th Street Tank	35 18 46.85	120 49 57.90	134

Table 3 – Final Repeater Sites

Site Name	Latitude	Longitude	Elevation (ft.)
Central Office	35 19 33.73	120 50 02.79	28
8th Street Drainage	35 19 34.00	120 50 04.17	26
6th & Elmore Drainage	35 19 33.84	120 50 11.28	22
16th & Paso Robles Drainage	35 19 27.97	120 49 31.28	74
South Bay Well	35 18 57.21	120 49 26.57	107
Bayridge Drainage	35 18 32.02	120 49 37.02	174
10th Street Tank	35 18 46.86	120 49 57.91	133
LOCSD / GSWC Intertie	35 18 47.77	120 49 52.32	114

Table 4 – Remote Sites Using 16th Street Tank Repeater

Site Name	Latitude	Longitude	Elevation (ft.)
3rd Street Well	35 19 31.66	120 50 24.18	11
Don & Mitchell Drainage	35 19 09.47	120 50 43.73	12
Palisades Well	35 18 48.93	120 50 15.78	87

Table 5 – Remote Sites Using 10th Street Tank Repeater

Site Name	Omni	Yagi	Hgt.	Path	Kbps Avg	RSSI	SNR	LQI	Comments
Central Office		X*	As Built	16th St Tank	497	-49	49	9	*Recommend using a 6dBd yagi.
8th Street Drainage		X*	15'	16th St Tank	492	-52	56	9	*Recommend using a 6dBd yagi.
6th & El Moro Drainage		X	30'	16th St Tank	457	-69	38	11	Note that the mast will have to be over to the side of the actual site – heavy trees – note survey van position.
3rd Street Well		X	35'	10th St. Tank	458	-65	42	8	The RF numbers are much better to 10th St. Tank when compared to 16th St. Tank
Don & Mitchell Drainage		X	30'	10th St. Tank	445	-66	40	9	This site was the most challenging – Either way, you will need a 30-35 ft. mast here unless you go Orbit cellular modem.
Palisades Well		X	As Built	10th St. Tank	493	-51	55	9	Use the existing As Built mast (existing yagi is not legal gain for unlicensed radios.)
10th Street Tank (Rptr)	X	X	*15' on Tank	16th St Tank	482	-63	37	10	*Mount omni on top of 15' mast mounted on top of Tank and Yagi 8 ft. below omni
LOCSD / GSWC Intertie		X	20'/35'	16th St. Tank	480	-64	41	9	10th St. Tank will be a good alternative Rptr site if ever required.
Bayridge Drainage		X	25'	16th St Tank	483	-62	43	10	No comments
South Bay Well		X	25'/30'	16th St Tank	488	-62	44	9	Existing 22 ft. omni mast might be acceptable, but 25/30 ft. is recommended.
16th St. Paso Robles Drainage		X*	25'	16th St Tank	498	-45	60	9	*Recommend using a 6dBd yagi.
16th Street Tanks & Booster Station (Rptr)	X	X	50'	Main Repeater	NA	NA	NA	NA	Omni mounted on a 15 ft mast on top of tank and Yagi mounted approx. 8 ft. below Omni

Table 6 – Survey Results At-A-Glance

5.0 Site Survey Results Details

All heights are AGL (above ground level). You will see that we surveyed many sites at several mast heights so that you may see how much the throughput is affected by lowering the antenna. I will always recommend the higher mast height over the lower however, circumstances may prevent you from building the mast to optimum height so if you must build it lower, understand that it may affect overall system performance. I will highlight my recommended mast height throughout this report. **This survey reflects the RF environment at this moment in time and is subject to change should another radio system come into the area.**

Regarding the survey results, you can expect as good but most likely better RF performance results when the system is built out because at the remote survey van we used a 50 foot TWS400 test coax which is probably much longer than what your typical remote site will eventually be and given the fact that we recommend using ½" Heliax coax for the installation, this will also provide less signal loss which will translate to even slightly better signal strength.

Site Survey Results to 16th Street Tank Repeater Site

Omni Antenna at 50 ft.

Figure 4 – 16th Street Tank Access Point Site

Figure 5 – Central Office

Central Office

Test Height: 15 ft. as built

RSSI: -49

SNR: 58

LQI: 9

Average Throughput: 497 kbps

Link Rating: Excellent

Comments: This site had line of site to the 16th Street Tank omni and excellent RF parameters. The throughput test backs up the resulting SNR and LQI numbers we are seeing. We were not able to position our survey van at the existing antenna on site however, the position in the picture above is approximately in line with the existing antenna and therefore would simulate actual performance. We recommend a small 6dBd yagi antenna for this site. (antennas will be addressed later in this report)

Figure 6 – 8th Street Drainage

8th Street Drainage

Test Height: 15 ft.

RSSI: -52

SNR: 56

LQI: 9

Average Throughput: 492 kbps

Link Rating: Excellent

Comments: This site had line of site to the 16th Street Tank omni and excellent RF parameters. We recommend a small 6dBd yagi antenna for this site.

Figure 7 – 6th & El Moro

6th & El Moro

Test Height:	20 ft.	30 ft.	35 ft.
RSSI:	-69	-69	-69
SNR:	38	38	38
LQI:	10	11	13
Average Throughput:	411 kbps	457 kbps	463 kbps
Link Rating:	Good	Good	Good

Comments: Because of the presence of heavy trees and bushes, it will be important to mount the mast over to the side of the actual site. If we were to set up right behind the trees, the signal would have been heavily attenuated with poor signal quality. You should mount the yagi antenna to at least 20 ft. however, as you can see, the throughput seemed to improve even though the signal quality diminished slightly. I would recommend splitting the difference at 30 ft.

Figure 8 – 3rd Street Well

3rd Street Well

Test Height:	20 ft.	25 ft.	30 ft.	35 ft.
RSSI:	-82	-76	-74	-71
SNR:	26	32	34	37
LQI:	10	9	9	9
Average Throughput:	217 kbps	369 kbps	397 kbps	458 kbps
Link Rating:	Bad	Marginal	Marginal	Good

Comments: The path to 10th Street Tank Repeater was much better at the same heights. Overall, these RF parameters are not acceptable given the performance numbers to 10th St. Tank.

Figure 9 – Don Mitchell Drainage

Don & Mitchell Drainage

Test Height:	20 ft.	25 ft.	30 ft.	35 ft.
RSSI:	-83	-81	-87	-83
SNR:	24	25	19	22
LQI:	10	10	14	11
Average Throughput:	213 kbps	296 kbps	58 kbps	187 kbps
Link Rating:	Bad	Bad	Bad	Bad

Comments: The path to 10th Street Tank Repeater was much better at the same heights. I know the recommended height may not be possible in this neighborhood. The solution may be to use an Orbit cellular modem. See the survey to 10th St.

Figure 10 – Palisades Well

Palisades Well

Test Height:	28 ft. as built	30 ft.	35 ft.
RSSI:	-71	-72	-67
SNR:	35	34	37
LQI:	9	10	10
Average Throughput:	407 kbps	420 kbps	472 kbps
Link Rating:	Marginal	Marginal	Marginal

Comments: The path to 10th Street Tank Repeater was much better at the same heights. My Link Rating is based on comparison to the 10th St. path which was much better. See the survey to 10 Street.

Figure 11 – 10th Street Tank

10th Street Tank

Test Height: 35 ft. (Install mast on top of tank)

RSSI: -63

SNR: 37

LQI: 10

Average Throughput: 482 kbps

Link Rating: Excellent

Comments: The Remote Van was not able to simulate the height at which the mast will be mounted so, we can expect even better RF parameters than what were collected. The antenna mast will be mounted on the top of the tank, most likely on one end or the other of the handrail. The build will be identical to the 16th St. Tank site with a 15 ft. mast on which the omni antenna will be mounted and approximately 8 ft. down from the omni, the yagi pointing to 16th Street Tank. This too will be a two-radio repeater.

Figure 12 – LOCSD / GSWC Intertie

LOCSD / GSWC Intertie

Test Height:	20 ft.	25 ft.	30 ft.	35 ft.
RSSI:	-64	-65	-62	-59
SNR:	41	38	40	43
LQI:	9	9	9	9
Average Throughput:	482 kbps	480 kbps	487 kbps	485 kbps
Link Rating:	Excellent	Excellent	Excellent	Excellent

Comments: We had to survey right through several large trees, but we still had excellent RF parameters. This may be because we were looking through an opening in the trees or it is probably the fact that the 16th St. Tanks are another 50 ft. higher than this site so it is an otherwise unobstructed path. Since the 10th Street Tank is right down the street, should the path to 16th St. Tanks ever deteriorate, you will have this repeater to fall back on. You can use whatever height you can get away with.

Figure 13 – Bayridge Drainage

Bayridge Drainage

Test Height:	20 ft.	25 ft.	30 ft.	35 ft.
RSSI:	-62	-62	-61	-58
SNR:	41	43	43	44
LQI:	9	10	10	10
Average Throughput:	469 kbps	483 kbps	482 kbps	478 kbps
Link Rating:	Excellent	Excellent	Excellent	Excellent

Comments: Very good site RF parameters. The 25 ft. was chosen because anytime we can get a higher SNR at a reasonable height, we will take it every time.

Figure 14 – South Bay Well

South Bay Well

Test Height:	20 ft.	25 ft.	30 ft.	35 ft.
RSSI:	-65	-62	-59	-59
SNR:	41	44	47	46
LQI:	9	9	9	9
Average Throughput:	480 kbps	488 kbps	488 kbps	490 kbps
Link Rating:	Excellent	Excellent	Excellent	Excellent

Comments: All excellent paths. We would recommend 25 ft or 30 ft.

Figure 15 – 16th Street Paso Robles Drainage

16th Street Paso Robles Drainage

Test Height:	20 ft.	25 ft.	30 ft.	35 ft.
RSSI:	-49	-45	-45	-45
SNR:	58	60	60	60
LQI:	9	9	9	9
Average Throughput:	515 kbps	498 kbps	499 kbps	467 kbps
Link Rating:	Excellent	Excellent	Excellent	Excellent

Comments: A survey was also taken at 15 ft. however, given the tree directly in front of the antenna, I would rather not recommend an antenna so close to the existing height of the tree. I will recommend a smaller 6dBd yagi antenna for this site.

Site Survey Results to 10th Street Tank Repeater Site

6 dBd Vertical Omni Antenna at 35 ft.

NOTE: A picture of this site with the Omni was not taken – **The 6dB Omni was used to survey the remote sites that will utilize this repeater.**

Figure 16 – 10th Street Tank Repeater Site

The antenna build at 10th Street Tank Repeater will be the same as the 16th Street Tank site. The above picture does not depict the 6 dB omni that was used to survey this site as a repeater site.

Figure 17 – Palisades Well

Palisades Well

Test Height:	15 ft.	27 ft. as built
RSSI:	-54	-51
SNR:	53	55
LQI:	9	9
Average Throughput:	489 kbps	493 kbps
Link Rating:	Excellent	Excellent

Comments: Might as well use the existing mast as it will help in years to come to alleviate signal fade from foliage or construction. Use new 10dB yagi. The existing yagi's gain (if 900 MHz) is not FCC legal unless power is turned way down, and you really do not want to do that. If this antenna is for a different system, then use the 15 ft. height.

Figure 18 – Don & Mitchell Drainage

Don & Mitchell Drainage

Test Height:	20 ft.	25 ft.	30 ft.	35 ft.
RSSI:	-83	-70	-66	-63
SNR:	23	36	40	43
LQI:	12	9	9	9
Average Throughput:	184 kbps	429 kbps	445 kbps	472 kbps
Link Rating:	Bad	Good	Excellent	Excellent

Comments: This site was the most challenging, either way you will need to be at 25 ft. to 30 ft. and of course 35 ft. would be best if you can get away with it. If a mast is out of the question, then you may need to go with an Orbit Cellular Modem if you have signal.

Figure 19 – 3rd Street Well

3rd Street Well

Test Height:	20 ft.	25 ft.	30 ft.	35 ft.
RSSI:	-75	-72	-69	-65
SNR:	33	36	38	42
LQI:	8	9	8	9
Average Throughput:	364 kbps	437 kbps	444 kbps	458 kbps
Link Rating:	Marginal	Good	Good	Excellent

Comments: Again, we are 4 points higher in the SNR and that means that it will be a lot more reliable than even the "Good" 30 ft. height. If you must, 30 ft. will work.

6.0 Material Recommendations by Site Type

This is by no means a comprehensive list of materials because at this point in the project, it is too early to get into details. These are just the basics, there there are many other items that go into the build-out of a radio system.

16th Street Tank Repeater & 10th Street Tank Repeater:

Antennas: Omni: Andrew Decibel DB586Y 6dBd (**Both Tank Repeater Sites**)
Yagi: Laird Y8063 6dBd (**For 16th Street Tank**)
Yagi: GE MDS 973194A14 10dBd (**For 10th Street Tank**)

Coax: Commscope / Andrew LDF4-50 ½ " Heliax

Ground Kits: Commscope / Andrew SG12-12B2U

Radio: GEMDS MCR / ECR900 900MHz unlicensed Ethernet radio.

Lightning Protection: Polyphaser ISB50LNC2 or the IS50NXC2 depending on the application as one is a bulkhead passthrough and the other is for mounting inside an enclosure.

Additional items such as Ground Buss bars, coax hanger kits, coax jumpers, power supplies, weatherproofing kits, antenna mounting tower hardware etc. all of which will be determined at a later date once a proper Job Walk has been performed at each site.

Typical Remote Site

Mast: Typically, 2" outside diameter aluminum or galvinized pipe. Heights as per recommendations in survey report.

Antennas: We recommend a GEMDS 10 dBd yagi 973194A14 at most every site except those where the signal is too strong. For these specified sites, we recommend the Laird Y8063 6dBd yagi antennas.

Coax: Commscope / Andrew LDF4-50 ½ " Heliax

Radios: GEMDS MCR900 900MHz unlicensed Ethernet radio.

Lightning Protection: Polyphaser ISB50LNC2 or the IS50NXC2 depending on the application as one is a bulkhead passthrough and the other is for mounting inside an enclosure.

Additional items such as Ground Buss bars, coax hanger kits, coax jumpers, power supplies, weatherproofing kits, antenna mounting tower hardware etc. all of which will be determined at a later date once a proper Job Walk has been performed at each site.

It has been a pleasure working with AECOM on this project. Please feel free to let me know should you have any questions regarding the contents of this report.

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