Functional Description Specification

**Theodore, Water Treatment Plant Telemetry upgrade**

**For**

**Banana Shire Council**



|  |  |
| --- | --- |
| **Prepared for:** | Banana Shire Council |
| **Prepared by:** | 360 Engineering Pty LtdLucian AnastasiuSenior Engineerlanastasiu@360engineering.com.au |
|  |  |

|  |  |
| --- | --- |
|  |  |
| **Reviewed by:** | Liam MorrisonEngineering Managerlmorrison@360engineering.com.au |
|  |  |

Document Control

|  |  |
| --- | --- |
| **Property** | **Value** |
| Document Title | Theodore, Water Treatment Plant Telemetry upgrade |
| Author | 360 Engineering |
| Version | 1.2 |

|  |  |
| --- | --- |
| **Version** | **Modification** |
| 1.0 | Initial build – reverse engineered from existing functionality (SCADA) |
| 1.1  | Minor revision |
| 1.2 | Revised after client review |

**Contents**

[1. Introduction 5](#_Toc105504379)

[1.1 Overview 5](#_Toc105504380)

[2. Devices and instrumentation 6](#_Toc105504381)

[2.1 Station IO configuration 6](#_Toc105504382)

[3. Functionality 6](#_Toc105504383)

[3.1 Safety in Design 6](#_Toc105504384)

[3.2 Brodersen 32M RTU 7](#_Toc105504385)

[3.3 Current Control Loops => Future Peer-to-Peer links 7](#_Toc105504386)

[3.4 Filling WTP Reservoir 7](#_Toc105504387)

[3.5 Peer-to-Peer watchdogs 8](#_Toc105504388)

[3.6 Filling Elevated Reservoir, Control High & Low Setpoints 9](#_Toc105504389)

[3.7 High Lift Pump Start Condition 9](#_Toc105504390)

[3.8 High Lift Pump Stop Condition 9](#_Toc105504391)

[3.9 Alarming WTP Reservoir Level, High High & Low Low Alarms 9](#_Toc105504392)

[3.10 Alarms and Interlocks 10](#_Toc105504393)

[3.11 Control Modes for High Lift Pumps – Manual and Auto 10](#_Toc105504394)

[3.12 Pump duty rotation 10](#_Toc105504395)

[3.13 Pump Availability 11](#_Toc105504396)

[3.14 Pump Failed to Start 11](#_Toc105504397)

[4. SCADA Interface 11](#_Toc105504398)

[4.1 Communications 11](#_Toc105504399)

[4.2 Mimics 11](#_Toc105504400)

[4.3 SCADA logic 11](#_Toc105504401)

[4.4 SCADA setpoints and commands 12](#_Toc105504402)

[4.5 Historic Data 12](#_Toc105504403)

**Annexes**

* IO list

**Glossary of Terms**

* RTU: Remote Telemetry Unit
* SCADA: Supervisory Control and Data Acquisition
* WTP: Water Treatment Plant
* RWPS: Raw Water Pump Station
* PLC: Programmable Logic Controller
* RTU: Remote Terminal Unit
* DO: Digital Output
* AO: Analog Output
* NO: Normally Open
* NC: Normally Closed

# Introduction

This document describes the functionality of Water Treatment Plant Telemetry Station existing at Theodore. Since no such a document has been made before, we analysed configuration of SCADA in order to capture all fine details of functions present.

The purpose of this site is to monitor important signals from Water Treatment Plant, feed the Elevated Reservoir with treated water and call for water to raw water pumps.

## Overview

Existing site control consists from a Radtel 5000 RTU, analog radio and remote GeoSCADA. Remote link is established via the analogue radio using Radtel protocol. All communications between devices at this site are serial.

The water is fed from Theodore RWPS and this site plays a key role into the raw water control loop. Furthermore, after the water has been treated with the help of a local PLC, this site plays another key role into the second control loop, which feeds treated water to the Elevated Reservoir.

After the upgrade, the site will communicate DNP3 with GeoSCADA and control logic will be executed by site RTU. The control loops that are now run via SCADA will be replaced by peer-to-peer direct communication between RWPS-WTP and WTP-Elevated Reservoir.

Below is the site layout for information only.

 

# Devices and instrumentation

Theodore WTP consists of the following devices and instrumentation, controlled and wired at the telemetry station:

* 2 high lift pumps, controlled by one DO each
* High Float for Clear Water Tank, giving 1 DI, NC
* Low Float for Clear Water Tank, giving 1 DI, NC
* Clear Water Reservoir Level Transmitter, giving 4-20mA signal, scaled 0-100%, 0-3.6ML
* Inflow Flowmeter, giving 4-20mA signal, scaled 0-55l/s
* Clear Water Flowmeter, giving 4-20mA signal, scaled 0-60l/s
* Turbidity Analyser for Filter 1, giving 4-20mA signal, scaled 0-500NTU
* Turbidity Analyser for Filter 2, giving 4-20mA signal, scaled 0-500NTU
* Clarifier Sludge Depth Transducer, giving 4-20mA signal, scaled 0-1?Mm
* Chlorine Residual Analyser, giving 4-20mA signal, scaled 0-20
* Treated Water pH Analyser, giving 4-20mA signal, scaled 0-14.2

## Station IO configuration

Please see Annex1, IO list.

# Functionality

## Safety in Design

The primary objective of the telemetry station at Theodore WTP is to monitor important process values, and to keep the Clear Water and Elevated Reservoir Levels within setpoints.

There are SMS alarms set-up for:

* when pumps are faulty
* phase failure or mains fail
* turbidity alarm for Clear Water
* chlorine leak alarms
* chlorine residual high or low
* high and low floats for Clear Water
* high high and low low Clear Water level
* site intruder
* telemetry battery low

Future implementation will have a watchdog for each peer-to-peer link. The watchdog failure stops the pump/s and assures that no overflow of any reservoir can occur in case the peer-to-peer link is down. When peer-to-peer link is down an alarm is generated.

## Brodersen 32M RTU

Brodersen RTU 32M has been chosen as a replacement for Radtel 5000 RTU. Brodersen RTU is more versatile in terms of communication and it can handle the peer-to-peer links well. Furthermore, this RTU is a suitable replacement for the current PLC that is running the WTP, and is expected to be utilised as such in the future planned site upgrade.

Brodersen RTU will talk over Ethernet with the 4RF radio, DNP3 with GeoSCADA and Modbus with peer-to-peer links from RWPS and Elevated Reservoir.

## Current Control Loops => Future Peer-to-Peer links

Current controls that keep reservoir levels within high/low setpoints rely on SCADA as intermediary to monitor the level and run the logic which sends commands to start/stop corresponding pumps. This setup has some drawbacks, for example if any of the two the radio links to SCADA are down or the server that runs SCADA is not online.

Final implementation will consist of two Modbus peer-to-peer links, one between Theodore RWPS and Theodore WTP and one between Theodore WTP and Theodore Elevated Reservoir.

Theodore WTP RTU will send call for water (start/stop) command to its peer at RWPS. For this matter, Brodersen RTU will receive from SCADA Control High/Low setpoints for Clear Water Level.

The RTU will also receive Elevated Reservoir Level from its peer at Elevated Reservoir site, as well as Control High/Low setpoints for this level, from SCADA. When the Elevated Reservoir Level crosses the control setpoints, Brodersen RTU will run or stop the high lift pumps.

## Filling WTP Reservoir

WTP Reservoir is filled by raw water pumps based on Control High & Low setpoints. When the level reaches Low Level Setpoint, the duty raw water pump is called to run. Pump will stop when the reservoir level matches High Level Setpoint.

As a safety measure, pump will also be stopped when the watchdog between RWPS and WTP has failed.

Brodersen RTU will produce a Call for Water bit that will be sent to RWPS peer every 2 minutes along with the watchdog.

Call for Water bit will become active if all the following conditions are true:

* Clear Water High Float not active
* Clear Water Level High High Alarm not active
* Clear Water Level equal or below Control Low setpoint

Call for Water bit will become inactive if one the following conditions is true:

* Clear Water High Float active
* Clear Water Level High High Alarm active
* Clear Water Level equal or above Control High setpoint

## Peer-to-Peer watchdogs

* RWPS-WTP P2P link

The watchdog consists of a single bit toggled ON/OFF every 2 minutes. Every 2 minutes this bit along with Call for Water bit are sent via Modbus peer-to-peer. The purpose of the watchdog bit is to stop the raw water pump/s in case it didn’t change 3 times in a row, which equates to 6 minutes (3x2min=6min).

Failure of watchdog bit 3 times in a row means that Modbus peer-to-peer link is down which should stop the pump/s. In this case, we stop the pump/s with the premise that Call for Water signal is unknown therefore is unsafe to run the pump/s. Once the watchdog bit changes (meaning Modbus peer-to-peer link is healthy) the operation of the pump/s resumes.

Watchdog functionality applies only when raw water pumps are placed in Auto Mode. The watchdog is produced and sent by WTP RTU.

* WTP-Elevated Res P2P link

The watchdog consists of a single bit toggled ON/OFF every 2 minutes. Every 2 minutes this bit along with Reservoir Level and High Float Status are sent via Modbus peer-to-peer. The purpose of the watchdog bit is to stop the high lift pump/s in case it didn’t change 3 times in a row, which equates to 6 minutes (3x2min=6min).

Failure of watchdog bit 3 times in a row means that Modbus peer-to-peer link is down which should stop the pump/s. In this case, we stop the pump/s with the premise that Reservoir Level and High Float Status are unknown therefore is unsafe to run the pump/s. Once the watchdog bit changes (meaning Modbus peer-to-peer link is healthy) the operation of the pump/s resumes.

The watchdog is produced and sent by Elevated Reservoir RTU.

## Filling Elevated Reservoir, Control High & Low Setpoints

Elevated Reservoir is filled by high lift pumps based on Control High & Low setpoints. When the level reaches Low Level Setpoint, the duty high lift pump is called to run. Pump will stop when the reservoir level matches High Level Setpoint.

As a safety measure, pump will also be stopped when High Float received from Elevated Reservoir is active or watchdog between Elevated Reservoir and WTP has failed. High lift pumps are located at WTP compounds and Brodersen RTU from WTP will receive Control High/Low setpoints associated to Elevated Reservoir Level.

## High Lift Pump Start Condition

The duty high lift pump at Theodore WTP is called to run if all following conditions are met:

* No stop condition is active
* Elevated Reservoir Level equal or less than Control Low setpoint (Auto Mode)
* Manual Start from SCADA active (Manual Mode)

## High Lift Pump Stop Condition

The duty high lift pump at Theodore WTP stops if one of the following conditions is met:

* Pump is not available (see section 3.13 for conditions)
* Elevated Reservoir Level equal or more than Control High setpoint (Auto Mode)
* Elevated Reservoir High Float active (any Mode)
* Manual Stop from SCADA active (Manual Mode)
* Watchdog bit didn’t change in 6 minutes (3 times peer-to-peer parcel received, this applies only to Auto Mode)

## Alarming WTP Reservoir Level, High High & Low Low Alarms

High High and Low Low Level Setpoints are available to be set from SCADA. The range defined by this set of setpoints is meant to include inside Control High/Low set of setpoints. SMS alarms are attached to High High and Low Low Setpoints, should the Reservoir Level reach these values.

The following order from top to bottom is meant to be set via setpoints:

* High High Setpoint (highest value, set below High Float position in reservoir)
* Control High (for stopping high lift pump/s)
* Control Low (for starting high lift pump/s)
* Low Low Setpoint (lowest value, set above Low Float position in reservoir)

All these setpoints are set from SCADA at the Theodore WTP RTU.

## Alarms and Interlocks

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Alarm/Interlock | Edge | SMS | Action/Comment |
| Phase Failure Alarm | A&I | neg | Y | Interlock high lift pumps |
| Pump 1 Fault Alarm | A&I | neg | Y | Interlock high lift pumps |
| Pump 2 Fault Alarm | A&I | neg | Y | Interlock high lift pumps |
| Peer-to-Peer Link Down | A&I | neg |  | Interlock high lift pumps |
| Pump1 Failed to Start Alarm | A | pos | Y | Interlocks for 30seconds |
| Pump2 Failed to Start Alarm | A | pos | Y | Interlocks for 30seconds |
| Pump Station in Manual Mode | A | pos | Y |  |
| Telemetry 240Vac Failed | A | pos | Y |  |
| Telemetry Battery Low | A | pos | Y |  |
| Clear Water Turbidity Alarm | A | pos | Y |  |
| Chlorine Leak1 Alarm | A | pos | Y |  |
| Chlorine Leak2 Alarm | A | pos | Y |  |
| Clear Water High Float Alarm | A | pos | Y | Interlock raw water pumps |
| Clear Water Low Float Alarm | A | pos | Y |  |
| Clear Water High High Level Alarm | A | pos | Y | Interlock raw water pumps |
| Clear Water Low Low Level Alarm | A | pos | Y |  |
| Intruder Alarm | A | pos | Y |  |
| Site Comms Failure | A | pos | Y |  |

##

## Control Modes for High Lift Pumps – Manual and Auto

Final implementation will consist of 2 different modes of operation for the high lift pump, Manual and Auto.

In Manual Mode, the pump can only be operated from GeoSCADA using manual Start/Stop commands.

In Auto Mode, the pump will be operated by RTU logic, being controlled by data received from its peer.

On site, a local facility exists to run the pumps directly from panel, independent of SCADA and RTU.

## Pump duty rotation

Control High/Low setpoints for Elevated Reservoir will start the high lift pump which is currently in duty. The pump has to be available in order to be considered for duty. Every time a pump is stopped, the duty is rotated to the other available pumps, or in case of no availability, same pump will stay on duty.

## Pump Availability

Each pump is considered available if all following conditions are satisfied:

* Pump is not faulted
* Phase failure is healthy
* Mains is healthy
* Pump didn’t fail to start (reset every 30 seconds if activated)

## Pump Failed to Start

The pump is considered Failed to Start if there is a request to run and after 30 seconds (logic hardcoded) the running signal is not present.

# SCADA Interface

## Communications

The site PLC communicates back to the SCADA server via private radio link using DNP3 protocol. The site has a unique device address for SCADA to identify the source.

A counter is incremented each minute since the last response has been received from a site. If the count exceeds the Timeout setpoint (default 77mins) then a CommsFail Timeout Alarm is triggered.

## Mimics

New mimics will be developed to match the look and feel of the DNP3 sites currently implemented in the SCADA system. Operators will be able to see all the data coming from RTU, alarms, trends, change setpoints and release commands.

## SCADA logic

Logic running in the SCADA system evaluates the following:

* Comms Fail Timeout Alarm – Count since last response received exceeds SCADA setpoint
* Calculating pumps start and runtime
* Calculating yesterday and today values for flows

## SCADA setpoints and commands

|  |  |  |
| --- | --- | --- |
| Name | Range, unit | Description |
|  Pump Mode: Manual/ Auto | Manual/ Auto | Manual=Pump is set to remote manual; Auto=Auto operation on RTU logic is allowed |
| Pump 1 Remote Manual Command | Start/Stop | Command that starts/stops the pump when in Manual Mode |
| Pump 2 Remote Manual Command | Start/Stop | Command that starts/stops the pump when in Manual Mode |
| Elevated Reservoir Level Control High  | 0-150% | Control High Setpoint for Elevated Reservoir |
| Elevated Reservoir Level Control Low | 0-150% | Control Low Setpoint for Elevated Reservoir |
| Clear Water Reservoir Level Control High  | 0-150% | Control High Setpoint for Clear Water Reservoir |
| Clear Water Reservoir Level Control Low | 0-150% | Control Low Setpoint for Clear Water Reservoir |
| Clear Water Reservoir Level Alarm High High | 0-150% | Alarm High High Setpoint for Clear Water Reservoir |
| Clear Water Reservoir Level Alarm Low Low | 0-150% | Alarm Low Low Setpoint for Clear Water Reservoir |

## Historic Data

All points within SCADA are expected to have historic data enabled for performance and maintenance purposes. Compression is to be enabled.