BRISBANE CITY COUNCIL
BRISBANE WATER

Australia Trade Coast Sewer Project

SP298

Lytton Rd No. 4 Pump Station

Operation & Maintenance Manual

Contract No. BW30137-02/03

Volume No. 1

BRISBANE CITY COUNCIL
Brisbane Water
Lytton Road P/S SP298 Australia Trade Coast Sewer Project

BW30137-02/03

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Lytton Road No.4 Pump Station SP298

Australia Trade Coast Sewer Project

Item No	Volume No	Section	Description	Revision No	Revision Date	Name	Signature

1.1

1. Introduction
Lytton Road P/S SP298 No 4 Australia Trade Coast South

Flow from the Fisherman Islands PS and Pritchard St PS is currently directed through a rising main to the existing Brisbane River crossing and then to the Luggage Point WWTP. In the long term the Fisherman Island (PBC) will be a stand-alone system, independent of the ACT system. The Prichard St PS connection to this is temporary and it will become part of the ATC South system.
On completion of the ATC South system, the existing Pritchard Street PS will be disconnected from the Fisherman Island system and directed into a new rising main discharging to Lytton Rd SP298 No. 4 PS.

Kianawah Rd PS, and several other pump stations share a rising main to the Bulimba Trunk Sewer, in the Gibson Island WWTP catchment. To reduce the load on the Gibson Island WWTP, it is proposed to interconnect this rising main with the ATC South System at Lytton Rd SP298 No.4 PS with a rising main to utilise any spare capacity available in that system.

1.1 Description of System and Overview Locality Keyplan

The Australia Trade Coast Sewer Project consisting of the following infrastructure.
Refer to Locality Keyplan BW drg 486/5/7-TR201/001.

a) Incoming rising mains from Pritchard Street P/S SP085 (refer to drg 486/5/8-SM20/021) and connection to Kiawanah Road P/S SP49 (refer to drg 486/5/8-SM21/021) rising main at Lindum Road.

b) Lytton Road No.4 Pumping Station SP298. (refer to drg 486/5/7-WR101/000).

c) Rising main from Lytton Road P/S SP298 No.4 to Serpentine Road Pump Station SP300. (refer to drg 486/5/8-SM18/021).

d) Serpentine Road Pumping Station SP300. Outgoing rising mains to Eagle Farm Rising Mains.

e) Incoming rising main from Kingsford Smith Drive Pumping Station SP146 to Serpentine Road Pump Station SP300.

f) Viola Place Pumping Station SP299.

g) Rising mains from Viola Place Pumping Station SP299 to Eagle Farm Rising Mains.

1.2 Design and Process
Lytton Rd P/S SP298 No.4 Overview of Incoming Rising Mains

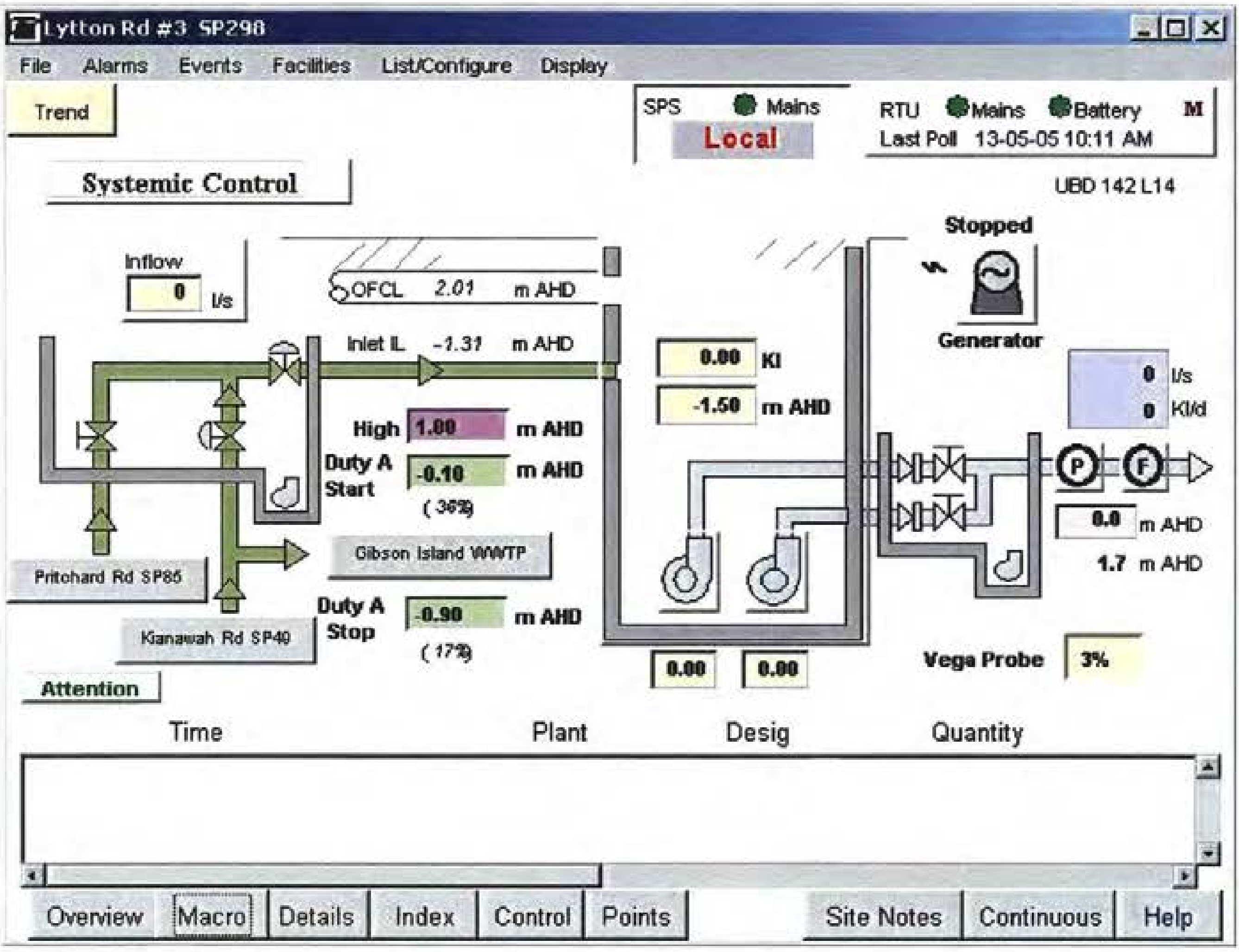
The incoming sewage flows into Lytton Rd P/S SP298 No.4 are from the following three (3) rising mains.

a) Pritchard Street P/S SP085 **DN315 PN12.5 PE100 rising main** BW drg 486/5/8-SM20/021. Isolation of SP085 & redirect to existing rising main BW drg 586/5/8-SM20/027 (Page 7 of 13).

b) Kianawah Road P/S SP049 **DN355 PN12.5 PE100 rising main** BW drg 486/5/8-SM21/021. Isolation connection at Lindum Rd BW drg 486/5/8-SM21/025. (Page 5 of 10).

c) Local development low pressure **OD200 PE100 PN12.5** connection main BW drg 486/5/7-WR101/030. (Page 10 of 89). This connection has not been shown on Fig.0

Fig. 0
Process and Instrumentation Overview



1.3 Pumping System Operation.

a) Sewage from the developing SP298 catchment will be discharged into the inlet valve pit at SP298 No.4, under pressure to the grit chamber and then gravitate to the SP298 wet well (ref to Fig.3 & 4).

An actuated valve on the Kianawah Road SP049 rising main (ref to Fig.1 Mark No 34) will regulate the amount of flow discharged to SP298. Under some operating conditions, BW will direct flows from Kianawah Road SP049 towards the Gibson Island WWTP, rather than to SP298.

As part of contingency planning, BW has requested that an actuated valve be installed on the inlet pipe to the Grit Collector (ref to Fig.1Mark No 34) so that SP298 may be bypassed for operational purposes.

b) Lytton Rd P/S SP298 is a sewerage pumping station with two (2) variable speed 60KW (nominal) submersible pumps (ref to Fig.3 & 4 c) operating in duty/standby arrangement. Note: High wet well level two (2) pumps will run.

c) With one pump running, SP298 discharges a maximum of 160 L/s of raw sewage through an OD450 PE100 and OD400 PE100 rising main (refer to BW drg 486/5/8-SM18/021) to the inlet structure at SP300 Serpentine Road Pinkenba, approximately 2.6 km to the northwest. This figure increases to 210 l/s when both pumps are running at maximum speed of 50Hz. The rising main includes a Horizontal Directional Drilled (HDD) section under the Brisbane River at approximately RL-50mAHD which is OD400 PE100. A pressure transmitter and flow transmitter are installed in the discharge pipe work.

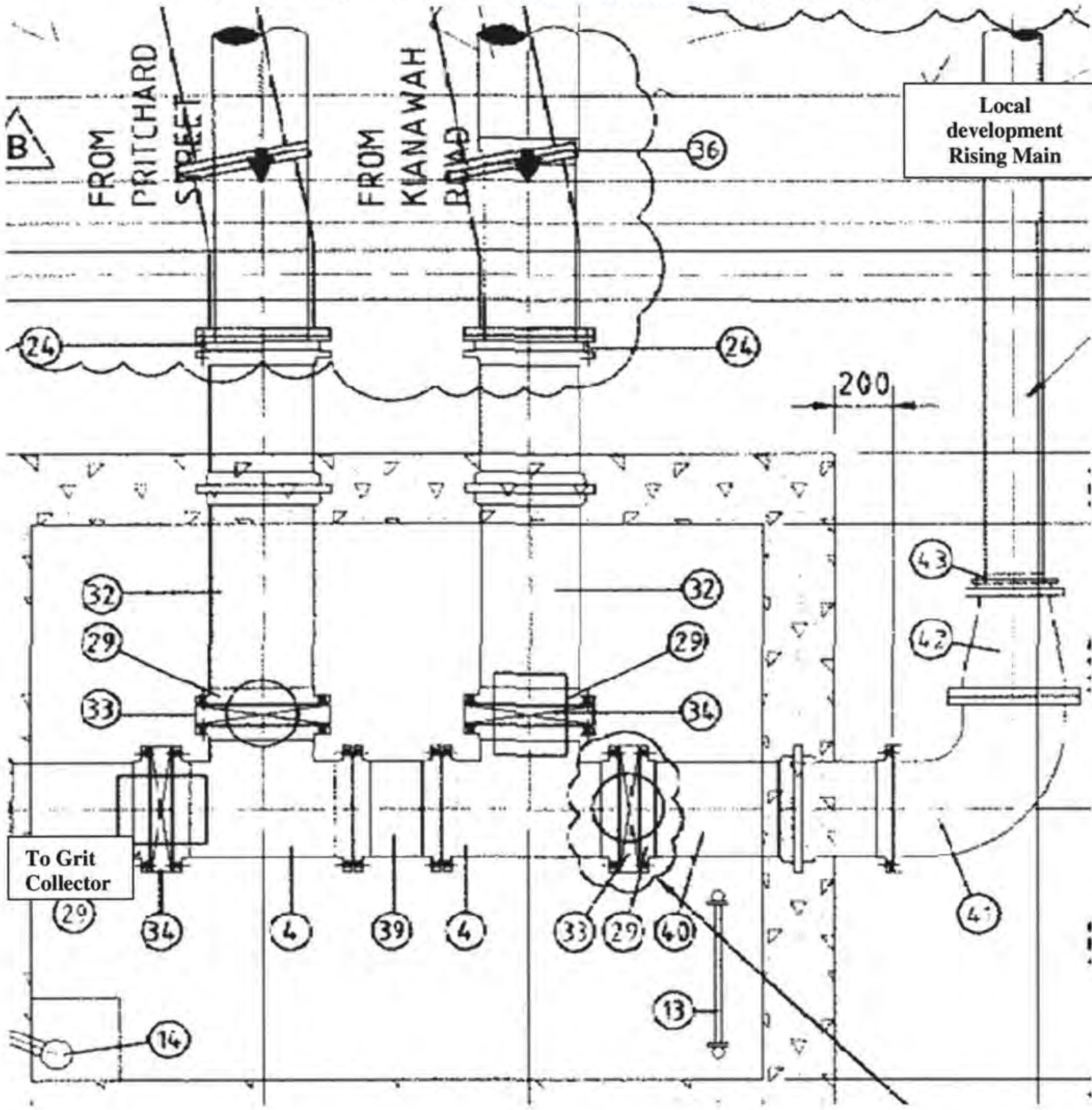
d) Pump Nameplate Data:

Pump Type---Hidrostal
Pump Code---H08K-M02R+HEVT4-XMEK4+NDB6-13
Pump Motor Power P2--------------------------------60Kw.
Pump G.P.--200l/s
Pump Head--22.5
Voltage--400V
Hz---50
Current Max--117A
Pump Fabrication No,s------------------------------138075,138076
O.NR---2004/05353
VDE0530--07/91
Cos--0.88
RPM--1471
IP---68
I.CL---F

1.4 Inlet Valve Pit at SP298 No.4 Interconnected Rising Mains

The Pritchard Street P/S SP085/ Kianawah Road P/S SP049 and Local development rising mains are interconnected in the **inlet valve pit at SP298 (**Fig.1).

Fig.1
SP298 Inlet Valve Pit (refer to drg 486/5/7-WR101/030 Page 10 of 89)



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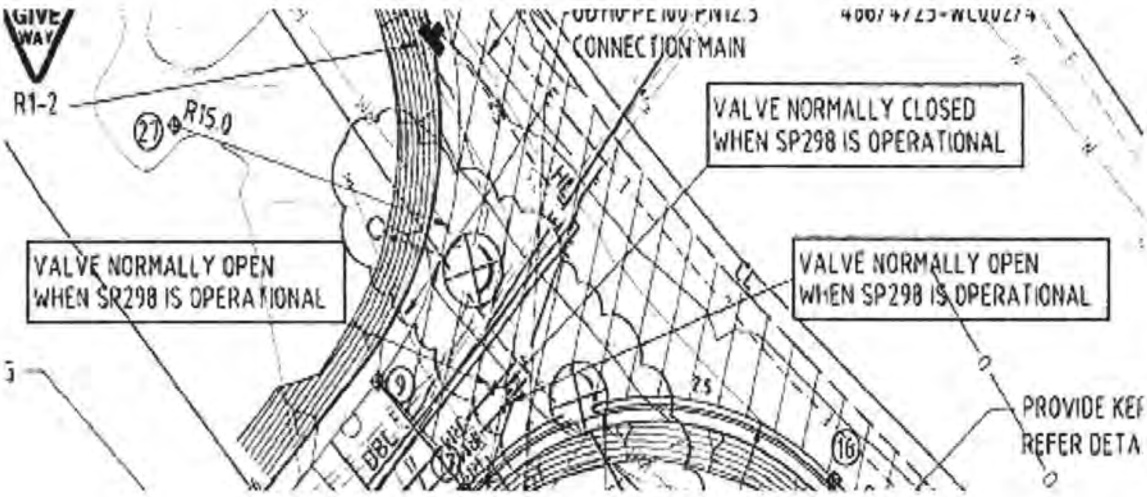
1.5 Interconnected Rising Mains Manual Operated Valves

There are **three (3) manual operated valves** (Fig.2) interconnecting the two rising mains from Pritchard Street P/S SP085 and Kianawah Road P/S SP049 these valves are normally left in the positions as stated on BW drg 486/5/7-WR101/022 page 5 of 89. For a more detailed view of the valving arrangement refer to BW drg 486/5/8-SM21/025 page 5 of 10.

Fig.2
Interconnecting Manual Operated Valving SP085 & SP049 Rising Mains



1.6 Flow Diverted from SP298 No.4 to Gibson Island WWTP

The following reasons where **flow can be diverted from SP298 No4 to Gibson Island WWTP** BW drg 486/5/7-WR101/030 page 10 of 89.

a) Close Kianawah Road rising main valve (Mark No.34 actuated DN300 ref to Fig.1), flow diverted to Gibson Island WWTP:

Reason: To reduce flow into SP298.
Burst rising main.

b) Close valve (Mark No. 34 actuated DN300 ref to Fig.1), feeding to Grit Collector, all flow into SP298 will be diverted to Gibson Island WWTP:

Reason: To clean out Grit Collector.
To clean out Wetwell.
To reduce flow into Serpenting Rd P/S SP300.
To work on equipment at Lytton Rd P/S SP298.
Serpentine Rd P/S SP300 complete failure.
Burst rising main.

1.7 Pump Station SP298 No.4 Layout

The pump station SP298 is made up of the following (Fig.3 & 4):

a) Inlet Valve Chamber.

b) Grit Collector.

c) Pump Wetwell.

d) Discharge Valve Camber.

Fig.3
Pump Station Plan View (refer drg 486/5/7-WR101/030 page 10 of 89)

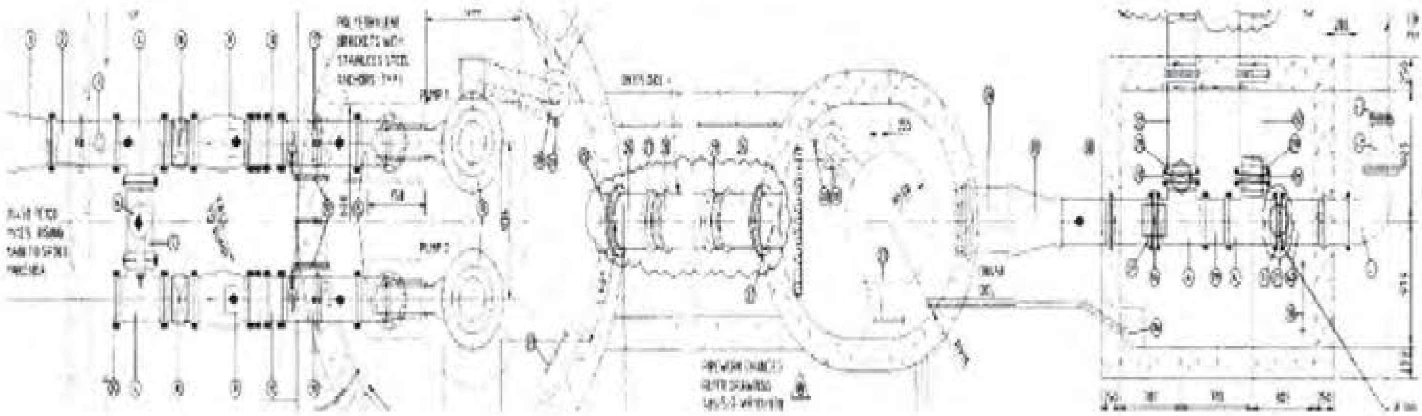
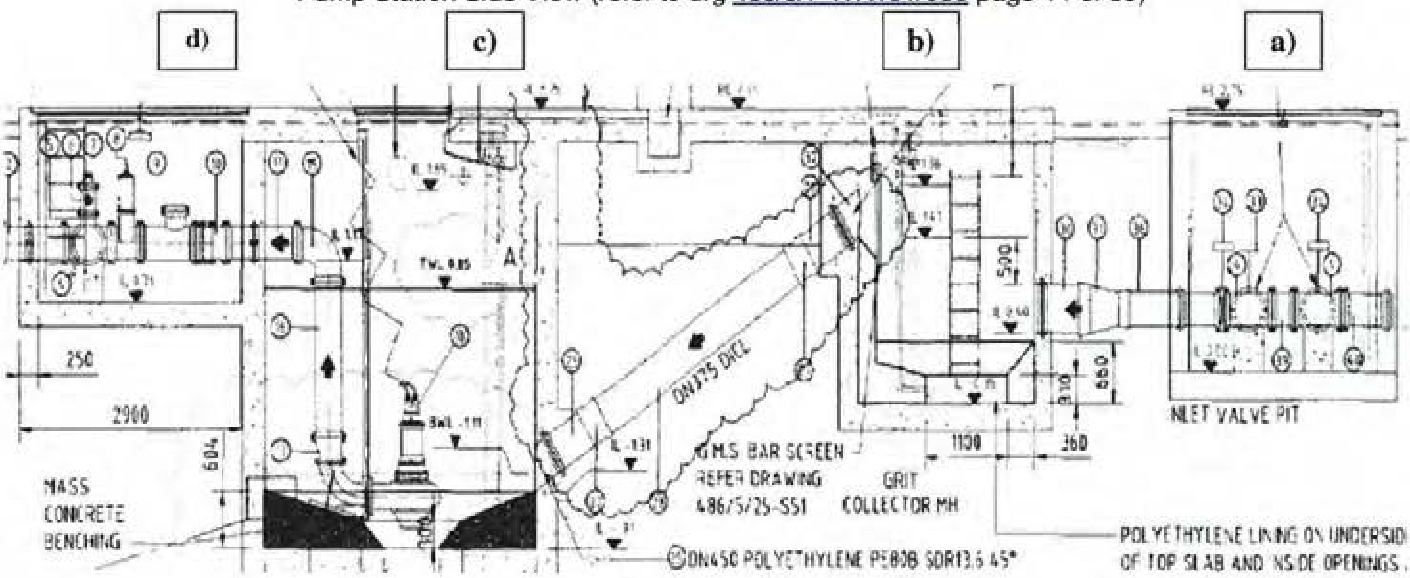


Fig.4
Pump Station Side View (refer to drg 486/5/7-WR101/030 page 11 of 89)



1.2

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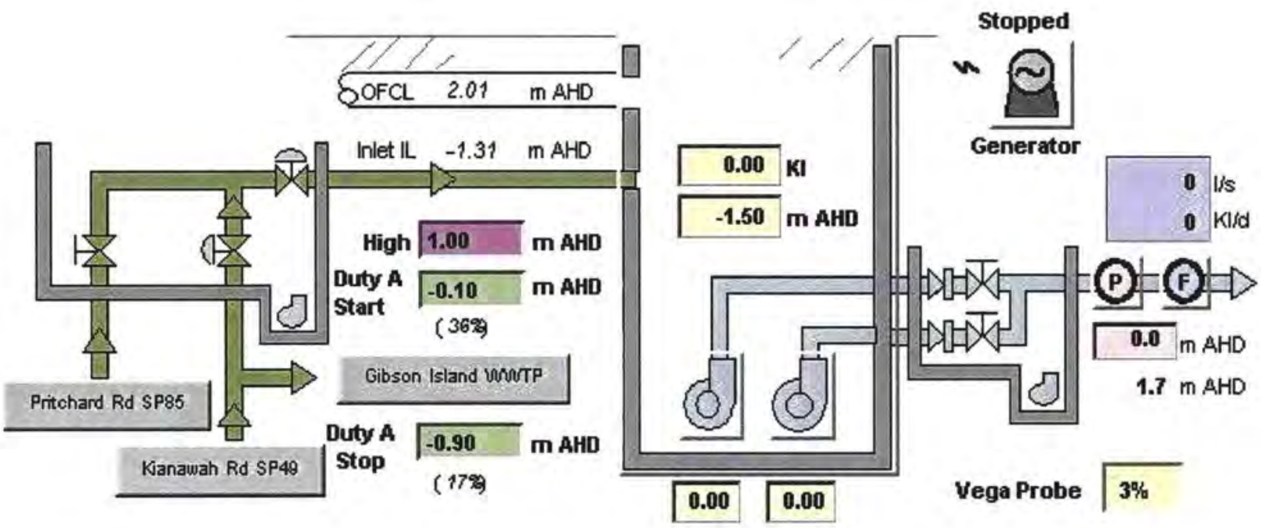
Network Control Systems



FUNCTIONAL SPECIFICATION

SP298 Lytton Rd #4

Sewage Pumping Station

Submersible 2 Pumps With VSD

Document Signoff

Approval

	Name	Role	Signature	Date
Supervising Elec. Eng *Engineering Design Services*	Alan Mooney	Recommend		
Supervising Elec. Eng *Engineering Design Services*	Henri Lai	Concur		
Team Leader *Network Control Systems*	Peter Sherriff	Concur		
Manager *M & E Planning*	Peter Casey	Concur		
Manager *Water & Sewerage Operations*	George Henry	Concur		
Project Manager	Andrew Bannik	Approve		

Distribution

	Name	Role	Section

Revision Control

Revision Number	Date	Amendment Details	Responsible Officer
Version 0.00	11/11/2004	Original Draft – Developed from Leightons Revised Functional Spec – Version 4	Alex Witthoft
Version 0.03	26/11/2004	Issued for Comment	Alex Witthoft
Version 0.04	29/11/2004	Added Comments by Malcolm Barrett	Alex Witthoft
Version 1.00	15/02/2005	Added Comments by Leightons and PB	Alex Witthoft
Version 1.01	16/02/2005	Added Comments by Reg McGirr	Alex Witthoft
Version 1.02	16/02/2005	Minor spelling corrections	Alex Witthoft
Version 1.03	08/03/2005	Set points changed after commissioning	Alex Witthoft
Version 1.04	09/05/2005	Changed Lytton Rd #3 to Lytton Rd #4	Alex Witthoft
Version 1.05	13/05/2005	Minor Modifications requested by Reg McGirr	Alex Witthoft
Version 1.10	21/11/2005	Levels modified after official NSM surveying	Alex Witthoft

Document Consultation

Please review the attached document and add your comments where necessary. To ensure that the process is kept within reasonable timeframes, it would be appreciated if you could return this document by the **Requested Return Date** listed below.

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0.03	Malcolm Barrett	Cullen Ave	26/11/04	03/12/04	03/12/04	Y	Y
0.04	Peter Sherriff	Cullen Ave	29/11/04	06/12/04	06/12/04	Y	Y
0.04	George Henry	Cullen Ave	29/11/04	06/12/04	21/11/04	Y	Y
0.04	Alan Mooney	TCB	29/11/04	06/12/04	06/12/04	N	N
0.04	Peter Casey	TCB	29/11/04	06/12/04	06/12/04	N	N
0.04	Henri Lai	TCB	29/11/04	06/12/04	06/12/04	N	N
0.04	Frank Mitchell	Leightons	29/11/04	21/12/04	21/12/04	Y	Y
0.04	Dean Maguire	Parsons Brinckerhoff	29/11/04	21/12/04	21/12/04	Y	Y

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Definitions

IDTS	Integrated Departmental Telemetry System
RTU	Remote Telemetry Unit
SCADA	Supervisory Control And Data Acquisition
mAHD	Metres above Australia Height Datum

1 INTRODUCTION

This document contains the site specific details and describes the non standard functional requirements for control, monitoring and telemetry at sewage pump station SP298 at Lytton Road Lytton. The functional requirements described in the document are in addition to the standard functionality detailed in "SPSV3 SEWAGE PUMPING STATION SUBMERSIBLE 3 PUMPS WITH VFD" [1].

The standard specification was written for a 3 pump station, of which only 2 pumps are allowed to run at any given time. The functionality for SP298 Lytton Road #4 is identical, except that SP298 only has 2 pumps, both of which can run simultaneously.

This site specific details and the non standard functional requirements in this document was derived from the functional specification written by Leighton Contractors Pty Ltd "SP298 FUNCTIONAL SPECIFICATION REV 4" [2].

SP298 Lytton Rd #4 is a sewerage pumping station with two variable speed 68 kW (nominal) submersible pumps operating in a duty/standby arrangement. This station is located on the northwest side of Lytton Road Lytton, approximately 300 m southwest of Freight Street.

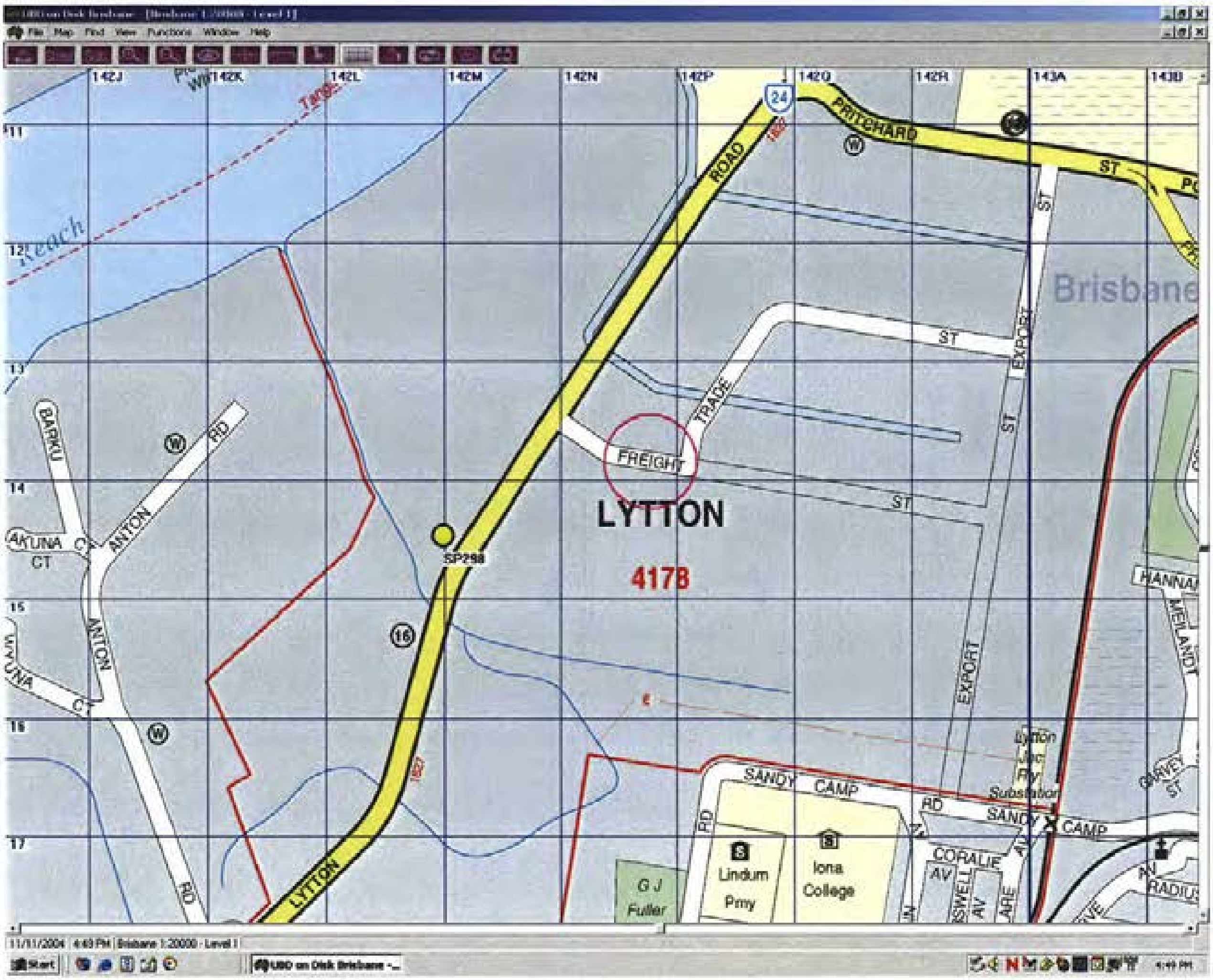


Figure 1: SP298 Location Map

1.1 General Process Description

The incoming sewage at SP298 is pumped from SP049 Kianawah Rd and SP085 Pritchard St. A branch was constructed on the SP049 rising main to allow flow into SP298 from the existing SP049, which originally pumped to Gibson Island WWTP. SP049 is still capable of pumping directly to Gibson Island WWTP when the new branch is isolated at the inlet to SP298. An actuated knife gate valve is installed at the end of the branch to allow this diversion to be triggered remotely. Refer to drawing 486/5/7-WR101/030.

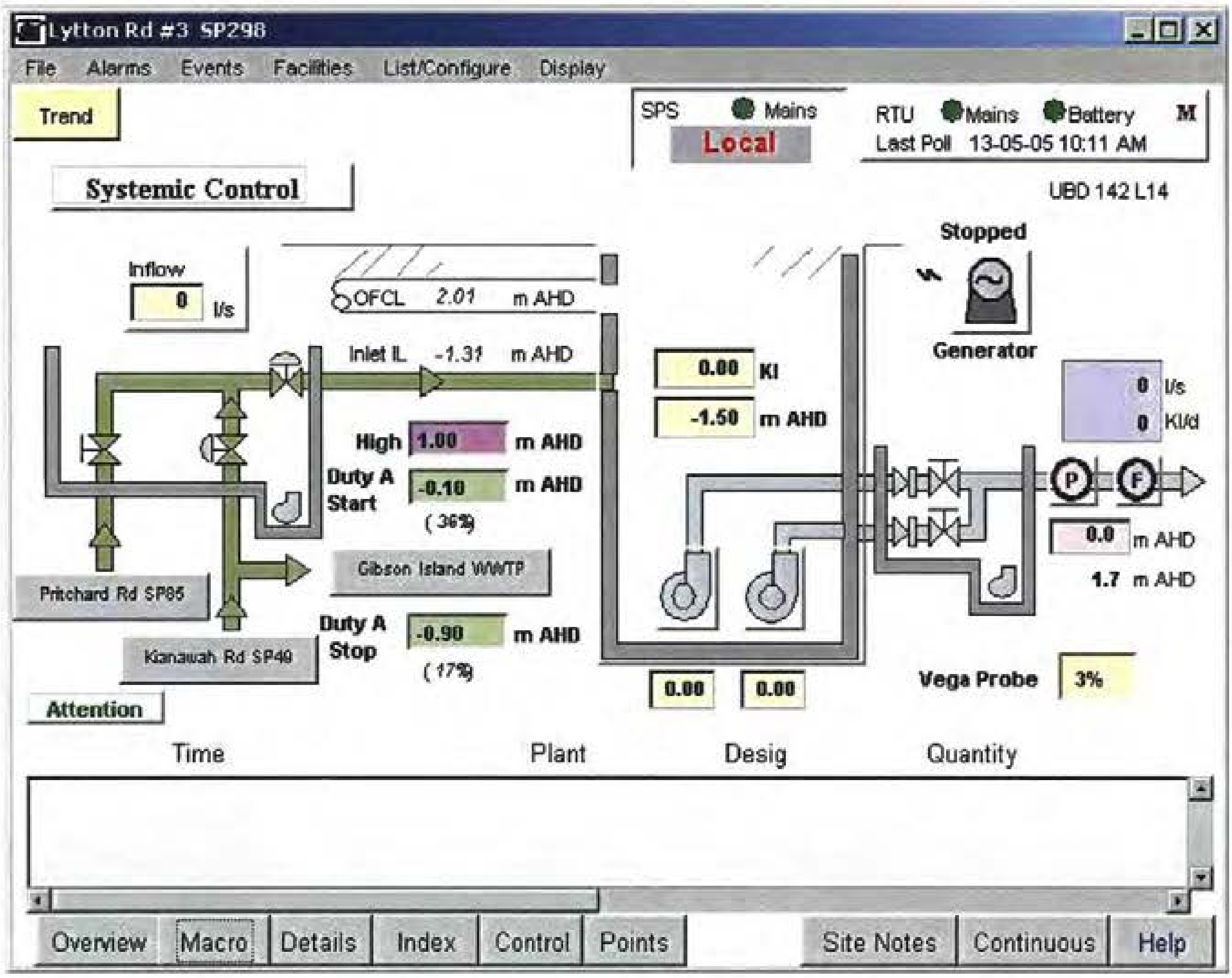


Figure 2: SP298 Process and Instrumentation Overview

The Kianawah Road branch and Pritchard Street rising main are connected in a valve chamber upstream of SP298 and discharge through a common pipe into the SP298 grit collector maintenance hole (GCMH). From the GCMH, the sewage flows directly into the wet well through a submerged pipe.

With one pump running, SP298 discharges a maximum of 160 L/s of raw sewage through an OD450 PE100 and OD400 PE100 rising main to the inlet structure at SP300 at Serpentine Road Pinkenba, approximately 2.6 km to the northwest. This figure increases to 210 l/s when both pumps are running at maximum speed. The rising main includes a Horizontal Directional Drilled (HDD) section under the Brisbane River at approximately RL-50mAHD which is OD400 PE100. A pressure transmitter and flow transmitter are installed in the discharge pipe work.

2 EQUIPMENT INSTALLED

2.1 Standard Equipment

SP298 Lytton Rd #4#4 pump station has the following standard equipment installed. The functionality for the control, monitoring and alarming for these items is fully described in the standard functional specification.

Pumps	Two Hidrostal H08K submersible pumps with 68 kW (nominal) four pole electric motors are installed in the wet well. Each pump is fitted with moisture probes in the oil chamber and thermistors in the stator windings.
Pump Starters	Two Danfoss VLT8000 Variable Frequency Drives (VFDs) are installed in the pump station switchboard. The VFDs will also provide soft starting functionality.
Flowmeters	One direct buried DN450 ABB Magmaster electromagnetic flowmeter is installed in the DN450 PE100 discharge main downstream of the valve chamber. The flowmeter will be used in the flow control algorithm (PID Loop) to control the speed of the pumps.
Level Sensors	One Vega hydrostatic level transmitter and one Multitrode level probe are installed in the wet well.
Pressure Transmitters	One Vegabar 64 pressure transmitter is installed on the discharge pipework in the valve chamber.

2.2 Non Standard Equipment

SP298 Lytton Rd #4#4 pump station has the following non standard equipment installed. The functionality for the control, monitoring and telemetry for is described in the following sections as these items is NOT described in the standard specification. (ref 1: Document ID 003589)

Emergency Generator	One 133kVA diesel powered backup generator is installed on a slab adjacent to the valve chamber. The generator includes its own GE FANUC PLC mounted in a dedicated control panel inside the generator housing.
Manual Valves	A manually operated DN300 Keystone Figure 951 knifegate valve would be installed on the rising main from SP085 (V3). and from future new developments at Lytton Rd
Actuated Valves	Two actuated DN300 Keystone Figure 951 knifegate valves shall be installed at the inlet valve pit. These valves will be located on the rising main from SP049 (V1) and on the common main to SP298 (V2).

2.2.1 Emergency Generator

The emergency generator is designed to the standard functionality as described by "DIESEL STANDBY GENERATOR LOCAL CONTROL PANEL FUNCTIONAL DESCRIPTION". [3] The generator is supplied with the PLC fully configured and programmed with the standard program. The RTU (Logica MD3311) is programmed with the standard interface program that will provide the monitoring, control and telemetry to the IDTS master station.

2.2.2 Manual Valve

A manually operated valve is installed on the rising main from SP085 Prichard Rd to allow the rising main to be isolated in the event of a burst in the rising main.

2.2.3 Actuated Valves

SP298 Lytton Road #4 has two actuated valves (V1 and V2 – refer to Figure 2: SP298 Process and Instrumentation OverviewFigure 2: SP298 Process and Instrumentation OverviewFigure 2: SP298 Process and Instrumentation Overview) installed to allow the inflow to the station to be controlled under high flow and failure conditions.

Normal Flow Conditions

Under normal conditions both of the actuated valves (V1 and V2) will be open and both SP085 Prichard Street and SP048 Kianawah Road will deliver flow to the SP298 Lytton Road #4.

High Inflow Conditions

If SP298 Lytton Road #4 can not keep up with the inflow to the station, the wet well level will rise. Once the surcharge imminent level is reached, the station is deemed to be under high inflow condition. To reduce flow into the station, the flow from SP049 will be diverted to Gibson Island WWTP by closing the actuated valve (V1) fitted to the rising main.

Failure Conditons

IF both pumps are unavailable to run, the site will be deemed to be under failure condition. All flow is diverted to Gibson Island WWTP by closing the actuated valve before the inlet to the wet well (V2) while the actuated valve on the rising main from SP049 Kianawah (V1) is open.

NOTE: Both actuated valves will NOT be able operate during an electrical outage (ie both Energex and generator power is unavailable) under the control of the PLC. It can be only operated manually by an on site operator.

2.3 Provision for Future Non-Standard Equipment

Although the project has made civil provision for the following future equipment, no PLC or RTU code has been developed

- Dosing Pump
- Activated Carbon Scrubber

Any future project to install the above equipment will provide funding for the functional specification and programming of the control, monitoring and telemetry.

2.3.1 Dosing Pumps

Provision was made for two chemical dosing pumps (nominally Alldos 0.09 kW) to be installed adjacent to the dosing slab. Provision was made for VFDs for these pumps to be installed in a dedicated control panel adjacent to the pumps. These will need to be flow paced to allow for the two flow duties. Provision for a 3-phase power supply has been made in the pump station switchboard.

2.3.2 Activated Carbon Scrubber

Provision was made for one activated carbon odour scrubber (nominally RKR Engineering Airclenz) to be installed adjacent to the wet well. Provision was made for the starter and controls for the activated carbon unit to be installed in a dedicated control panel adjacent to the scrubber Provision for a 3-phase power supply has been made in the pump station switchboard.

3 CONTROL PHILOSOPHY

The station will operate according to the control philosophy detailed in the standard functional specification (SPSV3) with the following modifications.

3.1 Normal Operation

In the event of a sudden failure of the SP298 pumps (eg power failure, emergency stop etc), there is some risk of the momentum of the water column to drain the SP298 pump well. Water hammer modelling was undertaken by Parsons Brinckerhoff to identify a solution to this problem.

From these investigations, it was found that the momentum issue would be controlled by ensuring that the volume in the well is sufficient for the current flow rate of the station.

To achieve this the pump station will run a single pump at minimum flow rate of 90 l/s while it is under 0.000mAHD. Above this level a single pump will be controlled to gradually increase the flow rate, via a proportional only control loop, to 160/s at 0.500mAHD. A single pump will be limited to 160 l/s. The second pump will be started at 0.600mAHD and both pumps will be contolled to produce 160 l/s. Above 0.600mAHD the two pumps will be controlled to gradually increase the flow rate, via a proportional only control loop, to 210 l/s at 0.800mAHD. The same proportional loops will reduce the flow rate of the station as the wet well level decreases.

All the above levels and flow rates are displayed graphically in Figure 3: SP298 Station Level Set Points~~Figure 3: SP298 Station Level Set Points~~~~Figure 3: SP298 Station Level Set Points~~

To achieve this change in control philosophy, the PID Loops detailed in the standard specification (ref 1: Document ID 003589) will have an integral coefficient of 0 and a proportional coefficient to provide the necessary flow increase as the wet well level increases.

If the flow meter is invalid, the proportional loop will provide a VFD speed set point equivalent to the desired flow.

Number of pumps running	Flow Rate	Equivalent Speed
1 pump	90 l/s	25 Hz
1 pump	160 l/s	50 Hz
2 pumps	160 l/s	?? Hz ?????????????
2 pumps	210 l/s	50 Hz

3.2 Duty Rotation Algorithm

The duty rotation algorithm will now control only two pumps instead of three. The number of pumps allowed to run remains the same (2) and the initialisation block will be configured with the site specific set points listed in the tables in the next section.

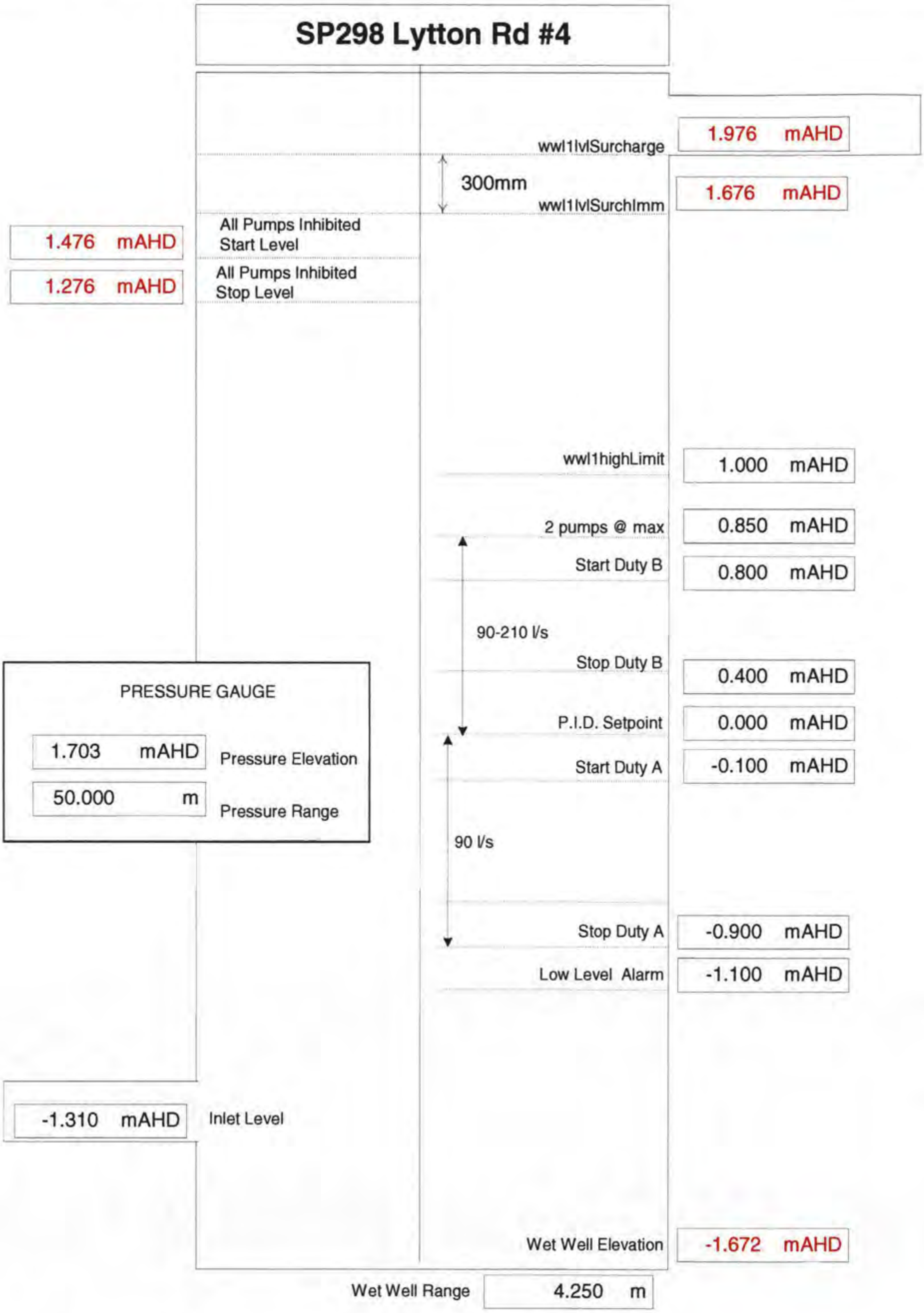


Figure 3: SP298 Station Level Set Points

3.3 Site Specific Values

Table 1: Site Specific Constants defined in the PLC

Tag Name	Description	Type	Value	Units
Sewerage Pumping Station				
Stn01grSurchPumpingTime	Surcharge pumping duration [3]	Integer	45	Sec
Delivery flow				
Flw01txRange	Delivery flow – Range	Real	250.0	l/s
Stn01grMinFlow1Pmp	Delivery flow – Minimum flow	Real	90.0	l/s
Stn01grMaxFlow1Pmp	Delivery flow – Maximum flow – 1 Pump	Real	160.0	l/s
Stn01grMaxFlow2Pmp	Delivery flow – Maximum flow – 2 Pumps	Real	210.0	l/s
Delivery pressure				
Pre01txRange	Delivery pressure - Range	Real	50000	mmAHD
Pre01txZero	Delivery pressure – Elevation of the transducer	Real	1703	mmAHD
Pump Blockage				
Stn01grPmpBlockFlowKneeSP	Flow blocked limit for flow/level PID control (knee)	Integer	1000	l/s x 10
Stn01grPmpBlockSpeedKneeSP	VFD speed blocked limit for flow/level PID control (knee)	Integer	800	Hz x 10
Stn01grPmpBlockSpeedMinSP	VFD speed blocked limit for minimum flow PID control	Integer	900	Hz x 10
Wet well level				
Wwl01txRange	Wet well level range	Integer	4250	mmAHD
Wwl01txSurchImmLevelSP	Wet well surcharge imminent level	Integer	1676	mmAHD
Wwl01grInhStartLevelSP	Wet well inhibit mode start level	Integer	1476	mmAHD
Wwl01grInhStopLevelSP	Wet well inhibit mode stop level	Integer	1276	mmAHD
Wwl01grRunatMaxLvlSP	Wet well run at maximum speed level	Integer	850	mmAHD
Wwl01txDtyBStartLevelSP	Wet well duty B pump start level	Integer	800	mmAHD
Wwl01txPIDLevelSP	Wet well PID set point	Integer	0	mmAHD
Wwl01txDtyBStopLevelSP	Wet well duty B pump stop level	Integer	400	mmAHD
Wwl01txDtyAStartLevelSP	Wet well duty A pump start level	Integer	-100	mmAHD
Wwl01txDtyAStopLevelSP	Wet well duty A pump stop level	Integer	-900	mmAHD
Wwl01txZero	Wet well empty level (4mA of Probe)	Integer	-1672	mmAHD
Variable Frequency Drive				
Stn01grMinSpeed	Variable Frequency Drive – Minimum Speed	Integer	2500	Hz x 100
	Variable Frequency Drive – Maximum Speed (DN1840)	Integer	3300	Hz x 100
Stn01grMaxSpeed	Variable Frequency Drive – Maximum Speed (DN1370)	Integer	5000	Hz x 100

Table 2: Site Specific Constants defined in the RTU

Tag Name	Description	Type	Value	Units
Delivery flow				
flw1almInhibitTm	Delivery flow - Alarm inhibit timer	Integer	15	sec
Delivery pressure				
pre1almInhibitTm	Delivery pressure - Alarm inhibit timer	Integer	15	sec
Wet well level				
wwl1surchLvlVol	Wet well volume at surcharge level	Real	30.50	kl
wwl1lvlSurcharge	Wet well surcharge occurring level	Real	2.014	mAHD
Pumps 1 - 3				
Pmp[x]almInhPwrTm	Pump [x] - Motor power alarm inhibit timer.	Integer	15	sec
pmp[x]almInhCrntTm	Pump [x] - Motor current alarm inhibit timer.	Integer	15	sec
pmp[x]currRange	Pump [x] - Motor current range	Real	115.0	Amps

Table 3: Site specific Variable defined in the RTU

Tag Name	Description	Type	Value	Units
Wet well level				
wwl1highLimit	Wet well level - High alarm set point	Integer	850	mmAHD
wwl1lowLimit	Wet well level - Low alarm set point	Integer	-1100	mmAHD
Delivery flow				
flw1highLimit	Delivery flow - High alarm set point	Integer	250000	ml/s
flw1lowLimit	Delivery flow - Low alarm set point	Integer	0	ml/s
Delivery pressure				
pre1highLimit	Delivery pressure - High alarm set point	Integer	51703	mmAHD
pre1lowLimit	Delivery pressure - Low alarm set point	Integer	1703	mmAHD
Pumps 1 - 2				
pmp[x]currHiLimit	Pump [x] - Motor current high alarm set point	Integer	115000	mAmps
pmp[x]currLoLimit	Pump [x] - Motor current low alarm set point	Integer	0	mAmps
pmp[x]powHiLimit	Pump [x] - Motor power high alarm set point	Integer	68000	Watts
pmp[x]powLoLimit	Pump [x] - Motor power low alarm set point	Integer	0	Watts

Table 4: Wet Well Level vs Volume Data

	Height (mAHD)	Volume m^3	Remaining Storage m^3	% Level	% Volume
1	-0.72	0.0	46.3	0%	0%
2	-0.27	7.3	39.0	16%	16%
3	-0.12	9.8	36.5	21%	21%
4	0.21	15.1	31.2	33%	33%
5	0.51	20.0	26.3	43%	43%
6	0.66	22.4	23.9	48%	48%
7	0.76	24.0	22.3	52%	52%
8	1.25	32.0	14.3	69%	69%
9	1.45	35.3	11.0	76%	76%
10	1.65	38.5	7.8	77%	77%
11	2.11	46.0	0.3	99%	99%
12	2.13	46.3	0.0	100%	100%

Figures in red need to be adjusted for storage in BW overflow pipe.

3.4 Non Standard Control

3.4.1 Valve Control

There are 3 valid modes of operation, controlled by the open and close status of valve 1 and valve 2. These modes are:

Mode	Valve 1	Valve 2	Description
1 – Normal	OPEN	OPEN	Both SP049 and SP085 pump into SP298
2 – Surcharge Pumping	CLOSED	OPEN	Only flow from SP085 will inflow to SP298 Flow from SP049 directed to GI to reduce inflow to SP298
3 – Failure	OPEN	CLOSED	Flow from SP085 directed to GI through valve 1. No flow to SP298 Flow from SP049 also directed to Gibson Island as the pressure from SP085 will be greater than the pressure from SP049.
4 – Invalid	CLOSED	CLOSED	NOT VALID – Flow from SP085 has no destination.

Mode 1 – Normal

In this mode both SP085 and SP049 will contribute flow to SP298. The station will be in this mode unless one of the other modes is activated.

Mode 2 – Surcharge

The flow from Kianawah is to be diverted to Gibson Island when the surcharge pumping mode is active. Surcharge pumping mode is fully explained in the standard specification. By closing valve 1 flow coming from SP049 is stopped which reduces the total inflow to SP298. Once surcharge pumping mode is deactivated, the valves will revert back to Mode 1 – Normal (ie Valve 1 will open).

Mode 3 – Failure

When this mode is active the valves are configure to divert all flow into the station (from Prichard and Kianawah) to Gibson Island. This mode will be active when either of the following conditions are true:

- Both pumps are unavailable and the well has filled to the wet well high level.
- Both pumps are inhibited. (ie all pumps inhibited mode should not start the pumps).

If a pump becomes available (or not inhibited), then once that pump has started and pumped the wet well down below the duty A start level valve 2 will open.

Local Control

The valves can also be controlled locally via hard wiring (independent of the PLC). While in local control, it is the responsibility of the on site technician to ensure the correct position of the valve.

3.4.2 Pump Control

Number of Pumps

The station acts as per the functionality outlined in the standard Functional Specification. The duty block is modified to only consider 2 pumps (the standard has 3 pumps).

All Pumps Inhibit Mode

As mentioned in the Valve Control section, this stations 'All Pumps Inhibit Mode' not only modifies the start and stop level, it also prevents all inflow to the station by diverting the flow to Gibson Island. This mode will be activated, by the control room officer, as part of the SP300 Serpentine Rd contingency plan to reduce the inflow to SP300 Serpentine Rd.

3.5 Non Standard Monitoring and Alarms

3.5.1 Additional Valve Monitoring and Alarms

The following alarms and events are associated with both valves

Plant	Quantity	Priority
Valve	Available	1
Valve	Available_remote	0
Valve	Open	0
Valve	Closed	0
Valve	Fail_open_alarm	1
Valve	Fail_close_alarm	1

Available

The valve is considered available only when all of the following conditions are present:

- Available for Remote
- Not "Failed to Open"
- Not "Failed to Close"

Available for Remote

The digital input status for "valve available for remote" is transferred directly to the IDTS master station.

Open

The digital input status for "valve open" is transferred directly to the IDTS master station. This is used to animate the valve status on the main IDTS page.

Closed

The digital input status for "valve closed" is transferred directly to the IDTS master station. This is used to animate the valve status on the main IDTS page.

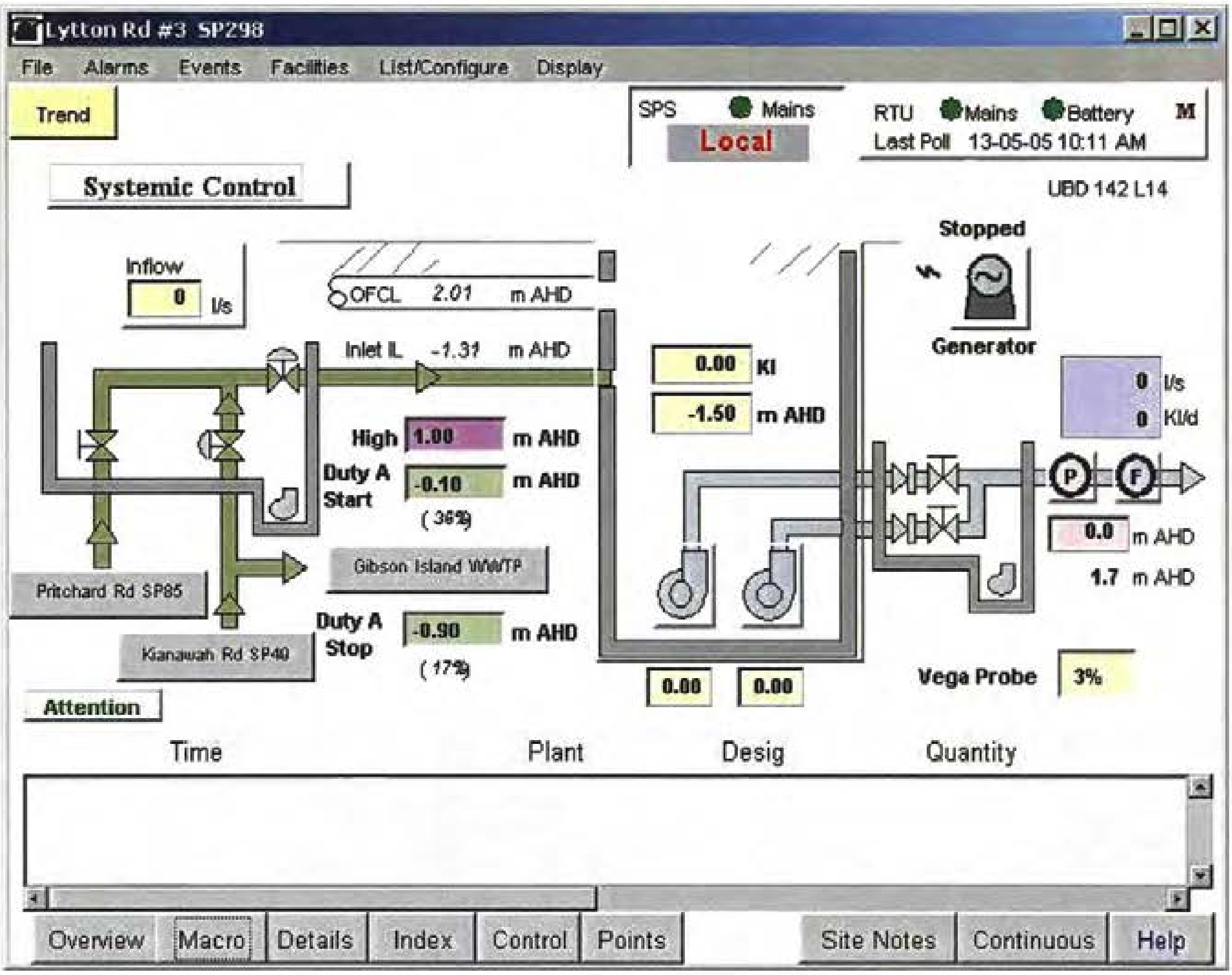
Fail to Open

If the valve is commanded to open and does not reach the open limit within the pre determined time period (set at two times the normal travel time) then the failed to open alarm will be activated. This alarm can be reset locally by pressing either of the pump (1 & 2) reset push buttons or remotely by the IDTS master station.

Fail to Close

If the valve is commanded to close and does not reach the close limit within the pre determined time period (set at two times the normal travel time) then the failed to close alarm will be activated. This alarm can be reset locally by pressing either of the pump (1 & 2) reset push buttons or remotely by the IDTS master station.

3.6 Non Standard IDTS Picture



3.6.1 Additional Valves

The two valves will be displayed and will be animated to indicated open, closed and faulted conditions. Double clicking on the valve will bring up the valve control page, on which the operator will be able to send a remote reset.

3.6.2 Additional Pipe Animation

The two inlet pipes will be animated to show a "filled" condition if their respective valve is open. An arrow on the inlet pipe from SP049 Kianawah will indicate the direction of flow (ie into SP298 or back to Gibson Island).

4 References

1

TITLE	SPSV3 Sewage Pumping Station Submersible 3 Pumps With VFD – Functional Specification
Document ID	003589
Version	0.30
Author	Alex Witthoft , Brisbane Water – Network Control Systems
Document owner	Peter Sherriff, Brisbane Water – Network Control Systems

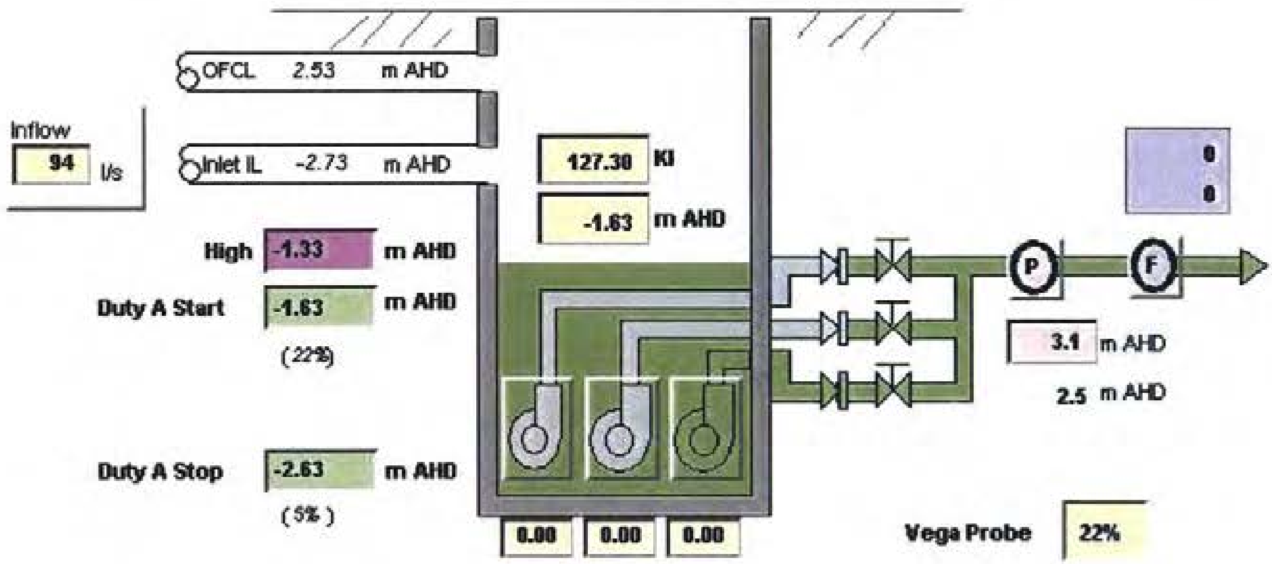
2

TITLE	SP298 Functional Specification
Document ID	N/A
Version	Revision 4
Author	M. BRAND
Document owner	Leighton Contractors Pty Ltd

3

TITLE	Diesel Standby Generator - Local Control Panel - Functional Description
Document ID	N/A
Version	02
Author	South East Power Generation
Document owner	

SPSV3
SEWAGE PUMPING STATION SUBMERSIBLE
3 PUMPS WITH VARIABLE FREQUENCY DRIVES



FUNCTIONAL SPECIFICATION

BW NET M&E 04/04
Network Branch

Project Owner:
George Theo.

Project Manager:
Peter Sherriff

Document Signoff

Approval

	Name	Role	Signature	Date
Project Manager NCS - Team Leader	Peter Sherriff	Recommend		
Team Member NCS - Capital Projects	Paul Daley	Concur		
Team Member NCS - IDTS Administrator	John Titmarsh	Concur		
Supervising Elec. Eng *Engineering Design Services*	Alan Mooney	Concur		
Manager *M & E Planning*	Peter Casey	Concur		
Manager Water & Sewerage Operations	George Henry	Concur		
Project Owner	George Theodorakopoulos	Approve		

Distribution

	Name	Role	Section
For Action			
For Information	Shane Harrison	Manager	Maintenance Planning

Revision Control

Revision Number	Date	Amendment Details	Responsible Officer
Version 0.00	09/09/2004	Original Draft - developed from the standard spec for a 2 pump soft starter site with Soft Starters	Alex Witthoft
Version 0.11	14/09/2004	Draft Issued for review	Alex Witthoft
Version 0.13	17/09/2004	Comments included from Malcolm Barrett	Alex Witthoft
Version 0.15	29/09/2004	Comments included from George Henry	Alex Witthoft
Version 0.30	26/10/2004	Final draft issued for comments	Alex Witthoft

Document Consultation

Please review the attached document and add your comments where necessary. To ensure that the process is kept within reasonable timeframes, it would be appreciated if you could return this document by the **Requested Return Date** listed below.

Project Sponsor: George Theo	Officer Code: NSMBW	Location: Cullen Ave
Author: Alex Witthoft	Officer Code: CTAMP12	Location: Cullen Ave
Document Administrator: Peter Sherriff	Officer Code: TL1SBW	Location: Cullen Ave

Version Number (1,2,3 etc)	Forwarded To: (Name / Officer Code)	Location (eg,TCB, Cullen Ave)	Date Sent	**Requested Return Date**	Date Returned	Comments Received (Y / N)	Comments Incorporated (Y / N)
0.11	Malcolm Barrett	Cullen Ave	14/09/2004	17/09/2004	17/09/2004	Y	Y
0.13	Ian Dixon	TCB	17/09/2004	24/09/2004	23/09/2004	Y	Y
0.13	George Henry	Cullen Ave	17/09/2004	24/09/2004	24/09/2004	Y	Y
0.15	Paul Daley	Cullen Ave	01/10/2004	22/10/2004	-	N	N
0.15	Alan Mooney	TCB	01/10/2004	22/10/2004	-	N	N
Version 0.15 superseded – Paul Daley and Alan Mooney issued with later version for review.							
0.30	Paul Daley	Cullen Ave	05/11/2004	12/11/2004			
0.30	Alan Mooney	TCB	05/11/2004	12/11/2004			
0.30	John Titmarsh	Cullen Ave	05/11/2004	12/11/2004			
0.30	Peter Sherriff	Cullen Ave	05/11/2004	12/11/2004			
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Definitions

IDTS	Integrated Departmental Telemetry System
RTU	Remote Telemetry Unit
SCADA	Supervisory Control And Data Acquisition
MAHD	Metres above Australia Height Datum
TWL	Top Water Level
BWL	Bottom Water Level
PID	Proportional, Integral and Derivative

1 EXECUTIVE SUMMARY

This document outlines the functional requirements for the control, monitoring, and telemetry of a standard three-pump submersible sewerage pump station with variable frequency drive (VFD), controlled by a GE-Fanuc 90-30 PLC which communicates to the IDTS master station via a Logica CMG MD3311 Remote Telemetry Unit (RTU).

The boundary of this functional specification is to form the basis for the PLC and RTU code development. The Summary of IDTS SCADA configuration and control room operator actions are provided for completeness only.

This type of station is equipped with variable frequency drives to reduce odour emission (caused by the 'bellows effect' of a continually rising and falling wet well). The variable frequency drives also enable the smoothing of the fluctuation in delivery flow to the down stream sewer network. This is particularly important for waste water treatment plants which operate more effectively under constant flow conditions.

The station is designed, and is normally selected, to run autonomously under the control of the GE-Fanuc PLC based on the value of the wet well level. This 'remote' mode starts the duty pump when the wet well level reaches the start duty A level (refer to *Figure 1: Wet Well Level Set Points*) and continues to run the pump while the wet well level is above the stop duty A level. A second pump will operate if the wet well rises to the start duty B level (when the inflow into the station is above the flow capacity of one pump). The station will be interlocked (within the code) so that only two pumps can operate at any one time.

The 'remote' mode control algorithm will gradually vary the speed of the pump (thereby limiting delivery flow fluctuations), to maintaining the wet well to as constant a level as possible. In effect, the change in speed will control the delivery flow to match the inflow to the station. The inflow varies according to the stations diurnal flow pattern, therefore the station delivery flow will also have a diurnal flow pattern (refer to *Figure 2: Typical Diurnal Flow Pattern*).

For a sudden change in the station's inflow, caused by the on/off cycling of an upstream station, the pumps will vary their speed (and thus the delivery flow) in a controlled manner, using the wet well as a temporary storage buffer. Once the delivery flow has converged on the inflow, it will slightly over compensate, so that over time, the wet well level will be brought back to the desired level. Thus the change in wet well level is controlled while still minimising delivery flow fluctuations.

To provide redundancy for the Vega probe (which measures the wet well level) a surcharge imminent electrode is installed. This electrode not only provides redundancy in the alarming of abnormally high wet well levels, it also serves as a backup signal to start the pumps, ensuring that the station does not surcharge due to a fault in the Vega probe. If the pumps are started using this electrode, the station is said to be in 'surcharge pumping' mode. This mode will start two pumps and command them to run at maximum speed.

The station is also designed, and may be selected, to operate under local control. The primary use of local control is for testing the system during maintenance. The speed of the pumps in local mode is also locally controlled via a dial on the switchboard.

In an emergency situation, if the PLC has failed, a qualified technician is able to start any individual pump via VFD by activating the VFD keypad (changing the VFD from auto to manual (keypad) control). In manual mode, however, the VFD can **not** be controlled by the PLC.

The pumping station, as part of a larger sewer network, will be pumping to either downstream pump station, waste water treatment plant or downstream sewer network. In the event of a downstream failure, the control room operator can delay and minimise the volume pumped by selecting 'all pumps inhibited' mode. This mode delays and minimises the volume pumped by fully utilising the storage capacity of the wet well and the inlet sewer system. This can avoid or minimise the volume surcharged downstream of the station.

The RTU will report by exception (eg alarm) to the IDTS master station if an event occurs outside its normal operating parameters. The control room operator, via the IDTS master station, can modify certain PLC/RTU operating parameters to respond to an abnormal situation, but can not override the PLC/RTU logic.

The program written for the PLC has significant 'intelligence' to be able to cope with any abnormal events and continue to operate the station in a safe manner. The functional specification also describes the control strategies for the majority of failure scenarios, for which the intervention by the control room operator is not relied upon.

The station is interrogated hourly via the telemetry network to routinely update the status of the station to the IDTS master station and upload the previous hour's historical data. The station also requests an immediate upload when any critical event occurs at the station. The IDTS master station will then alert the control room operator of any abnormal conditions at the station. Calculations are also performed and telemetered to the IDTS master station to aid system planning and fault finding for the station and surrounding sewer network.

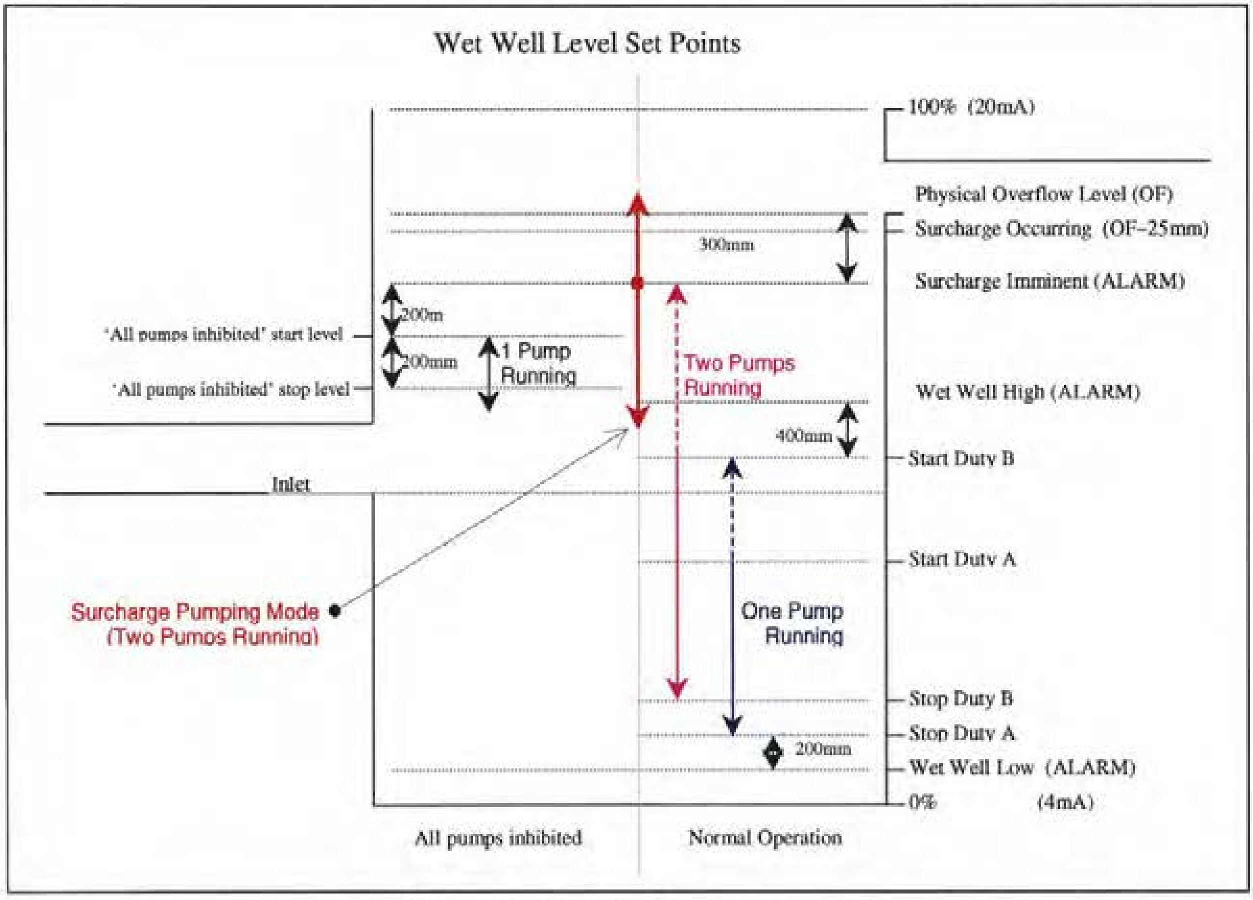

Figure 1: Wet Well Level Set Points

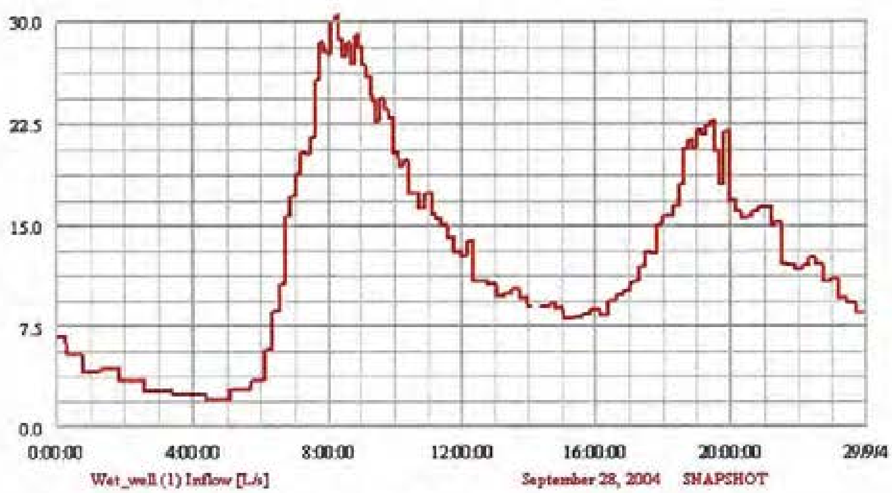

Figure 2: Typical Diurnal Flow Pattern

2 CONTROL PHILOSOPHY

2.1 Overview

The following section outlines the operating philosophy of a standard three-pump submersible sewerage pump station with variable frequency drives. The size of the sewer pumps shall be selected so that one pump will be adequate for normal dry weather flow. Two (only) pumps are allowed to run simultaneously to cope with higher flows during wet weather conditions.

The station can be selected to be in one of the following three modes

- Remote Mode (Normal Operating Mode)
- Local Mode
- Emergency Mode (VFD Keypad control)

All mode selection is done on site by the on site technician via the local/remote selector switch. Both local and remote control are controlled by the GE-Fanuc 90-30 PLC, independently from the MD3311 RTU. The RTU is only required for the monitoring of the station by the IDTS master station.

The station is designed, and is normally selected, to run autonomously under the control of the GE-Fanuc PLC based on the value of the wet well level. The station is also designed, and may be selected to run under local control. Local mode is designed for an on site technician to manually control the pumps. Its primary use is for testing the system during maintenance.

In the event of a complete RTU failure, the PLC will continue to operate in the mode that it is selected. The IDTS master station will alert the control room operator of a communications fault.

In the event of a PLC failure, the RTU will immediately alarm a PLC fault at the IDTS master station and each pump can be individually run via the VFD keypad when a technician arrives on site, completely independent of the PLC. Keypad control is initiated via each pumps individual VFD control keypad.

2.1.1 Normal Operation (Remote Mode)

Under normal operation (in remote mode) the station is controlled using 'dutyA pump stop level' and 'dutyA pump start level'. Once one pump is running, if the level continues to rise above the 'dutyB start level', a second pump will start and run until the level falls to the 'dutyB stop level'. The second pump will run at the same speed as the dutyA pump - as calculated by the control algorithm. The pump station will be interlocked so that only two pumps can operate at any time. The start and stop levels are measured in mAHD and are site specific (refer to *Figure 1: Wet Well Level Set Points* for a graphical representation of the various wet well level set points).

As described in the executive summary, under normal operating conditions, the 'remote' mode control algorithm will gradually vary the speed of the pump to control both the wet well level and the flow. Provided the delivery flow meter signal is valid, the pump speed will be controlled by a 'level-flow-speed' cascaded P.I.D.[1] loop. This loop will be 'tuned' to control the wet well level to a constant set point, to minimise the 'bellows' effect, while limiting excessive fluctuations in the delivery flow.

In the event that the delivery flow meter signal is invalid, a basic 'level-speed' P.I.D. loop will be utilised to maintain the desired wet well level. This P.I.D. loop will be 'tuned' to control the wet well level to a constant set point to minimise the 'bellows' effect.

[1] A proportional-integral-derivative (PID) controller tracks the error between the process variable and the setpoint, the integral of recent errors, and the rate by which the error has been changing. It computes its next corrective action from a weighted sum of those three terms (or modes), then outputs the results to the process and awaits the next measurement.

Cascaded 'Level to Flow to Speed' PID Control

The pump speed will increase, using a cascaded PID loop controlling both wet well level and flow rate, until it reaches its maximum speed. The diagram below shows the PID loop for flow control. (The control algorithm of the PID integration and output values is limited to within minimum and maximum values for flow rates and VFD speed.)

The cascaded PID loop control relies on the wet well level set point. This set point is compared with the actual wet well level. When the wet well level is greater/smaller than the wet well level set point the flow control set point will increase/decrease accordingly. This flow control set point is then compared with the actual flow reading and the speed of the VFD is adjusted to achieve the required flow set point.

The PID loop will be tuned so that as the inflow to the station increases, the outflow increases to match, thereby maintaining the wet well level set point. The secondary PID loop will be tuned so that the rate of change of the flow rate is controlled and undue flow fluctuations are minimised.

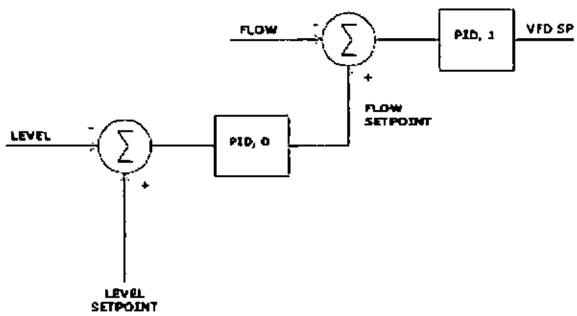

Figure 3 :Cascade Level-Flow Pid Loop Control

'Level to Speed' PID Control

In the event of a failure of the flow meter, a simple level-speed PID control loop will control the speed of the pumps to maintain a constant level. The diagram below shows the PID loop control for the level/flow control.

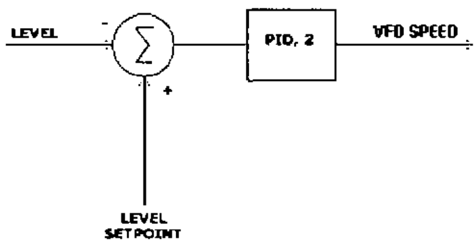

Figure 4: Wet Well Level Pid Loop Control

The value of the VFD speed is adjusted to achieve the required level set point. The PID loop will be tuned so that as the inflow of the station increases, the speed of the variable frequency drive will increase to match the flow, thereby maintaining the level set point. The wet well level will only fall below the set point if the inflow to the station is less than the flow rate produced when the VFD is at minimum speed.

2.1.2 Surcharge Pumping Mode

If the level continues to rise above the Duty B start level then depending on the level reached, 'High', 'Surcharge Imminent' and 'Surcharge Occurring' alarms will be raised and sent back to the control room operator. The control room operator is also alerted to 'Low' and 'Invalid' conditions (Refer to *2.5.1 Wet Well Level Invalid*). The alarm conditions are normally set as follows:

Wet Well Low	200mm (nominal) below 'dutyA pump stop level' set point (BWL)
Wet Well High	400mm (nominal) above 'dutyB pump start level' (TWL)
Surcharge Imminent	300mm below actual surcharge level
Surcharge Occurring	25mm below actual surcharge level

When the level reaches the surcharge imminent level (as per the physical surcharge imminent electrode or according to the wet well Vega probe) the station will initiate the surcharge pumping mode. In surcharge pumping mode two available pumps will be commanded to run at maximum speed. The speed analog output will be clamped at maximum speed and as a backup, the 'run at maximum' digital output will also be activated. For environmental reasons, surcharge pumping mode has priority and all pump inhibits and wet well level duty stop set points are ignored.

There are three main reasons that a station will fill to the surcharge imminent level.

1. The Vega probe measuring the wet well level is invalid (pumps will not start if the level is not valid)
2. The Vega probe measuring the wet well level is 'frozen' at a valid level but below the start level.
3. The inflow to the station is higher than the pumping capacity of the available pumps running.

The surcharge pumping mode is active while the wet well level is at or above the surcharge imminent level and for a site specific minimum of time after the level falls below the surcharge imminent condition. Once surcharge pumping mode is deactivated the station will revert to its previous mode of operation (normal operation or all pumps inhibited mode).

NOTE: The site specific minimum time is calculated as half the time taken to pump from surcharge imminent level to the dutyA stop level under normal dry weather conditions.

2.1.3 All Pumps Inhibited / Blocked Mode and Individual Pump Inhibit / Blocked

The control room operator can inhibit one or more of the station's pumps. If a single pump is inhibited, then that pump is considered inhibited from operating under normal operating conditions. If all pumps are inhibited, then the whole station is considered inhibited and in 'all pumps inhibited mode'

NOTE: If a pump blockage alarm is active for a specific pump then this will have the same effect as if the control room operator has inhibited the pump.

Single Pump Inhibit (Blocked) Mode

A single or pair of pumps can be inhibited if they are not operating efficiently (eg partially or fully blocked). This will remove them from the duty cycle allowing the more efficient pump(s) to permanently operate as the duty pump until the inhibit is removed. This will allow the station to run normally until the inefficient pump(s) can be unblocked or repaired.

If the uninhibited duty pump(s) can not keep up with the inflow and the wet well level rises, as the respective alarm levels are reached, the wet well high alarm will activate as a warning. If the level continues to rise above the surcharge imminent level, then the surcharge imminent alarm will activate and, if less than two pumps are running, one of the inhibited pumps, if available, will automatically be commanded to run to ensure two pumps are running under surcharge pumping mode. They effectively ignore the inhibit placed upon it by the control room operator. After the surcharge pumping cycle is completed, the pump(s) will remain "inhibited" and are only uninhibited by a command from the control room operator.

All Pumps Inhibited Mode

All pumps inhibited mode is utilised to delay the flow of sewerage to downstream sites in an emergency. This will mitigate a surcharge situation at either a failed downstream pump station or a problem in the sewer network downstream from the pump station. To activate 'all pumps inhibited' mode, all the pumps at a site have to be either inhibited individually by the control room operator or have their respective 'pump blockage' alarm active.

When the whole pumping station is in 'all pumps inhibited' mode, it is desirable to minimise the volume pumped. This is achieved by utilising the wet well storage capacity to a safe maximum level. Nominally the duty start level is raised to 200mm below surcharge imminent. At this level a single pump will run for a minimum of 2 minutes and until the wet well level drops to 400 mm below surcharge imminent (both conditions need to be satisfied before the pump stops). Refer to *Figure 1: Wet Well Level Set Points* for a graphical representation of these new start and stop levels.

NOTE: In the case where some of the pumps are inhibited and some have the pump blockage alarm active, the pumps which are inhibited are started in preference to the pumps that are blocked.

If the inflow volume causes the wet well level to rise above the 'all pumps inhibited' start level and reach the surcharge imminent level, the surcharge imminent alarm will activate and command the pumps to follow the surcharge pumping mode instead of the 'all pumps inhibited' mode.

Surcharge pumping mode is designed to control the well level and will run the pumps for a longer minimum duration than 'all pumps inhibited' mode. Although this is contrary to the purpose of 'all pumps inhibited' mode, which is to minimise the flow to the down stream station, surcharge pumping mode takes precedence. The inflow to the station would have to be significantly higher than the dry weather average inflow to cause the level to reach surcharge imminent level set point.

Once the surcharge pumping mode deactivates, the station will revert back to 'all pumps inhibited' mode. The station will remain in this mode until at least one pump is both uninhibited by the control room operator and is not blocked. As a feedback indicator for the control room operator, the sewer pump displayed on the IDTS master station has a yellow inner circle if it is inhibited. The pump blockage alarm is itself a priority 1 alarm and is not part of the pump availability condition.

The wet well high alarm will be suppressed when 'all pumps inhibited' mode is active as the well level, in 'all pumps inhibited' mode, is above the wet well high alarm set point.

NOTE: As the 'all pumps inhibited' mode is operating within 200mm of the surcharge imminent level set point, a calibration 'drift' in the wet well Vega probe can cause the station to trigger a surcharge imminent alarm during dry weather conditions. This will trigger a 'wet well calibration fault' alarm to the control room operator, instructing him to schedule a calibration of the Vega probe.

2.2 Station Instrumentation

The station has the following instrumentation connected to the MD3311 RTU or GE-Fanuc 90-30 PLC. All I/O must be connected as per the standard site physical I/O connections (Refer to *Appendix A: Standard Physical I/O List*). For a full equipment list refer to the standard drawing set. (Refer to *Appendix C: Drawing List*)

Table 1: Station Instumentation

Station Energex power relay	Status of power on the line side of the main incomer
Station mains power relay	Status of power after the main incomer
Pump mains power relay	Status of power after the pump circuit breakers
RTU mains power relay	Status of power after the RTU circuit breaker
Main incomer CB status	Status of the Main Incomer CB (used in conjunction with Energex and station mains power relays to determine whether a generator is currently running on site)
Battery system	Status of the battery system
Surge diverter	Status of surge diverter
Site door switch status	Combined status of all switchboard door (All closed or not)
Wet Well Vega Probe	The probe is positioned in the well to cover the operating level of the well. in mAHD
Pressure Gauge	Delivery pressure of the pump station in mAHD
Flow Meter	Delivery flow of the pump station in l/s
Wet Well Surcharge Imminent Electrode	Electrode to detect if wet well level has reached surcharge imminent level
Station Local Controls and Indication	Site attention reset push button Local/remote selector switch Site attention indication lamp Wet Well level % indicator gauge Battery Check relay
Pump Local Controls and Indication	Start push button Stop push button Emergency stop push button Pump status indication lamp
Pump Variable Frequency Drives (Danfoss)	VFD control and display panel Running Feedback Fault Feedback Run Command Reset Command Local Speed Command (4-20 from Potentiometer) Remote Speed Command (4-20mA from PLC) Speed Feedback (4-20mA to PLC) Modbus link to RTU for pump power and current Moisture in Oil (Optional)

2.2.1 IO Allocation between RTU and PLC

The IO is split into the MD3311 RTU and GE-Fanuc PLC, determined by whether or not the I.O. is required for the control of the pumps.

Signals which are required for monitoring only, or controls not associated with the control of the pumps (ie generator I.O.) are wired directly into the MD3311 RTU. All I.O., which are wired into the MD3311 RTU, are backed up by the battery system and will continue to function even during power outages.

All pump I.O. required for pump control are wired into the GE-Fanuc PLC. All monitoring and controls are communicated via the Modbus link to the MD3311 RTU and then to the IDTS master station. The I.O. wired to the GE-Fanuc PLC are not backed up by the battery system and will fail during power outages. This is not detrimental to the operation of the station as the pumps can not run without 415VAC.

Even though wet well level analog signal is required for the control of the pumps, it is also critical during power outage. Therefore it is wired, in series, to both the RTU and the PLC.

2.2.2 Modbus Communications

The Modbus communications will be configured as over a RS485 link as per the diagram below.

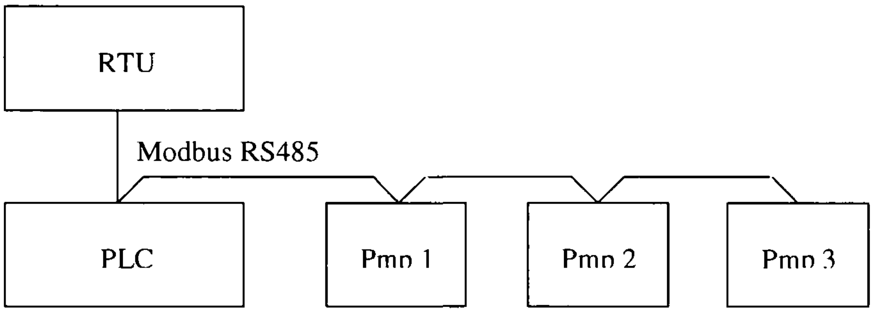

Figure 5: Modbus RS485 Network Diagram

For a full description on how to configure this network, refer to the following range of technical documents found on the Brisbane Water Infonet.

Branch	Section	Document Type	ID	Title
Newtorks	Water &Sewerage Operations	Technical Manual Or Specification	003590	Modbus Md3311 To Ge 90-30
Newtorks	Water &Sewerage Operations	Technical Manual Or Specification	003591	Modbus Ge 90-30 To Danfoss
Newtorks	Water &Sewerage Operations	Technical Manual Or Specification	003592	Modbus Md3311 To Ematron.Doc

The IO that is calculated in the PLC and then transferred from the PLC to the RTU is listed in the tables below.

The Modbus communication fault is determined by a watchdog counter which is passed back and fourth from the RTU and the PLC and incremented on each pass in the PLC. If the RTU does not register an increment in any given 30 second time period, then a communication fault alarm is activated.

Table 2: Modbus Digital Signals to the RTU

GE-Fanuc Tag Name	Description
Pmp[x]dsMainsPower	Pump No.[x] Mains Power IDTS Indication
Pmp[x]dsAvailableIDTS	Pump No.[x] Available IDTS
Pmp[x]dsRunning	Pump No.[x] Running
Pmp[x]dsInhibit	Pump No.[x] Inhibited
Pmp[x]dsEStop	Pump No.[x] Emergency Stop Fault
Pmp[x]dsFault	Pump No.[x] Fault
Pmp[x]dsVFDFlt	Pump No.[x] VFD Fault
Pmp[x]dsVFDAuto	Pump No.[x] VFD Auto
Pmp[x]dsMIO	Pump No.[x] Moisture in Oil
Pmp[x]dsBlockAlm	Pump No.[x] Blockage Alarm
Pmp[x]dsVFDFltExceeded	Pump No.[x] VFD Fault Count Exceeded
Pmp[x]dsVFDFltAutoReset	Pump No.[x] VFD Fault Auto Reset
Pmp[x]dsSpeedInvalid	Pump No.[x] Speed Signal Invalid
Stn01dsSurchImm	Surcharge Imminent
Stn01dsRemote	Station Remote Selected
Wwl01dsInvalid	Wet Well Level Signal Invalid
Pre01dsInvalid	Delivery Pressure Signal Invalid
Flw01dsInvalid	Delivery Flow Signal Invalid
Plc01dsFirstScan	PLC 1 first scan

Table 3: Modbus Digital Controls to the PLC

GE-Fanuc Tag Name	Description
Pmp[x]dcStart	Pump No.[x] Remote Start Command
Pmp[x]dcStop	Pump No.[x] Remote Stop Command
Pmp[x]dcReset	Pump No.[x] Remote Reset
Pmp[x]dcInhibit	Pump No.[x] Remote Inhibit
PLC01dcinitReset	PLC 1 initiate reset

Table 4: Modbus Integer Signals to the RTU

GE-Fanuc Tag Name	Description
Wwl01txSurchImmLevelSP	Surcharge Imminent
Wwl01txDtyBStartLevelSP	Duty B Pump Start Level (mmAHD)
Wwl01txPIDLevelSP	PID Level Setpoint (mmAHD)
Wwl01txDtyAStartLevelSP	Duty A Pump Start Level (mmAHD)
Wwl01txDtyBStopLevelSP	Duty B Pump Stop Level (mmAHD)
Wwl01txDtyAStopLevelSP	Duty A Pump Stop Level (mmAHD)
Wwl01txEGU	Wet Well Level (mmAHD)
Wwl01txRange	Wet Well Level Range (mm)
Wwl01txZero	Wet Well Zero (mmAHD)
Pre01txEGU	Delivery Pressure (mmAHD)x10
Pre01txRange	Delivery Pressure Range (mm)
Pre01txZero	Delivery Pressure Zero (mmAHD)x10
Flw01txEGU	Deliver Flow (l/s) x 10
Flw01txRange	Delivery Flow Range (l/s) x 10
Pmp01txSpeedEGU	Pump 1 Speed (%) x 10
Pmp02txSpeedEGU	Pump 2 Speed (%) x 10
Pmp03txSpeedEGU	Pump 3 Speed (%) x 10

2.3 Remote Mode

Remote mode is the normal operating mode of the station. In this mode the PLC program controls the pumps in a duty standby configuration, starting and stopping the pumps according to the wet well start and stop set points (as described in the overview and illustrated in *Figure 1: Wet Well Level Set Points*)

The control room operator can issue remote manual commands to the PLC, via the RTU, to control the station outside the normal set point parameters. The following are the controls available to the control room operator.

- Stop — Stops a specific pump provided that the station is in its 'normal' wet well range (below the Start Duty A level. If the wet well level is abnormal (higher than Start Duty A level but below surcharge imminent level), then the "inhibit" can be used to stop a pump.
- Start — Start a specific pump provided the wet well level is above the 'bottom water level' (duty A pump stop level). The 'start command' over rides the pump lockout which restricts the number of starts per hour under autonomous control.
- Reset — Allows the operator to remotely reset any latched pump alarms provided the original fault condition has cleared.
- Inhibit — Allows the operator to inhibit a specific pump from operating under the normal operating mode, effectively removing it from the duty rotation. If all pumps are inhibited the operator has 'inhibited' the station causing the station to run under 'all pumps inhibited' mode.

The control room operator can also send the following site commands:

- Attention Activate — By sending this control the operator activates a site attention indicator requesting the on site technician to contact the control room.
- Abnormal Operation Reset — This command reset the abnormal operation alarm which is activated whenever the RTU or PLC has an 'abnormal operation' (ie the RTU or PLC resets by itself).
- Alarm limit set points — The operator has the ability to modify the set points for the high and low alarms configured for various signals (eg. pressure, motor current and motor power and wet well).

The Control Room Operator can NOT:

- Switch the station from local to remote mode. (Physical switch on site only)
- Start or Stop the pumps if the station is in local mode.
- Modify operational set points, eg. Start/Stop dutyA/B level set points.
- Change alarm priority class or alarm triggering configuration on the communications channel.
- Control the speed of the pumps. The PLC automatically determines the speed of the pumps using the PID control algorithms

2.3.1 Pump Duty Selection

The duty rotation is based on a simple rotational basis. When the duty pump stops running, the duty is rotated to the next pump available for normal duty standby operation. If a pump is unavailable, inhibited, blocked or locked out then that pump will not be set as duty A or duty B. If no pumps are running and the control room operator issues the command for a specific pump to run then that pump is assigned to be the duty A pump.

2.3.2 Pump Lockout

In remote mode, under normal operating conditions (the station is not in either surcharge pumping or 'all pumps inhibited' mode) a pump is locked out from starting for 5 minutes since its last start. This is to protect the motor and starting equipment from thermal failure due to too many starts per hour. The lockout is bypassed by the remote start command sent from the IDTS master station.

2.3.3 Pump Start Delay

In remote mode, the stations pumps are prevented from starting simultaneously by a pump start delay of 10 seconds commencing from the last time a pump has started. This will minimise any inrush current to the station and also minimise water hammer effects.

2.4 Local Mode

The on site technician can completely control the site by switching the site into local mode and manually operating the pumps via the push buttons. The speed of each pump can be controlled via individual potentiometers.

WARNING: In local mode there are no automatic controls. Once the pumps have been started they will 'run to destruction', that is, they will **not** switch off automatically due to wet well level reaching the 'stop duty A level' set point. If the on site technician does not stop the pump before the wet well level falls below the pump intake, then the pump will 'suck' air and will 'air lock' making the pump inoperable until it is either 'bled' or 're-primed'. It is up to the on site technician to ensure the pump only runs while the level is above the stop level.

The on site technician has the following local station controls:

- Station Local / Remote — Selector switch to determine operating mode of the station
- Site attention reset — Reset the attention indication sent by the control room operator

The on site technician has the following local controls for each pump:

- Start — Push button to start pump
- Stop — Push button to stop pump (soft stop via VFD)
- Emergency Stop — Latched push button (hard stop via electrically isolation)
- Reset — Push button (reset any latched alarms in RTU related to pump)
- Speed Control — Potentiometer that allows the selection of speed between minimum and maximum configured in the VFD

Local indication on the switchboard includes:

- Site attention — Indication lamp – on site technician required to contact control room operator
- Pump status — Indication lamp
  - On continuously — Pump running
  - Slow Flash (2 sec) — Pump faulted
  - Fast Flash (1 sec) — Pump lockout
- Wet well level — Provides the wet well level indication in %
- Variable Frequency Drive — Control panel to configure the parameters of the Variable Frequency drive and also to display motor status (i.e. motor current, VFD speed)

2.5 Station Fault Conditions

2.5.1 Wet Well Level Invalid

Remote mode relies on the wet well level from the Vega probe to operate normally. If the wet well level becomes invalid (is outside the operating range of 4-20 mA) then the station will rely on the surcharge imminent probe to control the starting and stopping of the pumps. The wet well level is deemed invalid if it is

[Less than (4mA – dead band) OR greater than (20mA + dead band)] for 2 seconds.

Once the invalid alarm has been activated it can only be reset when the signal is both greater than 4mA and less than 20mA for 20 seconds. The time delays ensure that a signal is truly invalid before an alarm is set and that it is stable before it is reset.

2.5.2 Site Power

The site requires 3 phase mains power (Energex) to operate the sewer pumps. The RTU requires DC power and is equipped with a backup battery supply that lasts for approximately 2 hours. These batteries also supply standby power to the communications device (eg Trio radio), the wet well level Vega probe and surcharge imminent electrode. The PLC is **NOT** backed up by the Battery as it requires 240VAC.

The control room operator is alerted of a site power outage. Any consequential alarms resulting from the power outage are suppressed as described in the section 4.4.6 Alarm Suppression Tree. The control room operator is able to monitor the wet well level and is alerted to a wet well high condition and eventually a surcharge imminent condition during the power outage (until the battery goes flat).

The station switchboard has a generator connection cubicle allowing a mobile generator to be connected under extended power outages. The generator is manually operated and can supply power via a generator circuit breaker which is mechanically interlocked with the mains circuit breaker. The pump station will operate normally (with at least one pump) while the site power is supplied from the generator. Depending on the capacity of the generator the station may have to be further interlocked to a limit of one pump.

NOTE: The on site technician is required to remain on site while the generator is connected and running, to ensure the safety of the public as the generator connection are temporary and are not secured.

An optional upgrade to a pump station is to have a semi-permanently connected generator which automatically runs the station on generator supply following an Energex power failure. This upgrade provides an automatic transfer switch (ATS) to disconnect Energex and connect the generator. Extra physical I.O and IDTS alarms are configured in the RTU to provide full feedback on the status of the semi-permanent generator.

2.5.3 Pump Availability

All electrical fault and interlock conditions pertaining to a particular pump must be healthy before that pump can be run. A pump is considered 'available' if all these conditions are met. The PLC will only command a pump to run if it is available. If a pump becomes unavailable at any time while the pump is running, it will stop immediately.

Any one of the following on site fault conditions will make the pump unavailable.

- Site mains power fail - Switchboard does not have 415V mains power supplied
- Pump well flooded trip - The pump dry well has flooded above the trip level
- Pump mains power fail - Pump does not have 240V control power supplied
- Pump fail - Pump has failed to start
- Pump VFD not in Auto - Pump is in Keypad control
- Pump VFD fault - Pump VFD motor protection has activated
- Pump VFD fault Count Exceeded - Three or more faults in the last 8 hours
- Pump emergency stop input faulted - Push button has been pressed
- Pump emergency stop fault latched - Emergency fault has not been reset

The functional descriptions of these conditions are described under section 4.6 Alarm and Event Description

To ensure that there is redundancy in the number of pumps available, each pump station is designed to require only one pump to run under dry weather conditions. If one pump becomes unavailable, the another pump will become the duty pump until such time as the unavailable pump is once again available for duty rotation.

As a feedback indicator for the control room operator, the sewer pump displayed on the IDTS master station has a red inner circle if it is unavailable.

If all pumps become unavailable, then the station will not run any pumps and contingency measures are initiated by the control room operator to ensure that no surcharge occurs.

3 SITE SPECIFIC VALUES

Although each pump station is built according to a standard, there are variables which are site specific and must be programmed directly into the PLC code. This is achieved by an initialisation block in which all the site specific values are loaded with an initial value. The code for each site is identical except for this initialisation block. This initialisation block is divided into two distinct sections:

1. Site specific Constants
2. Site specific Variables

The site specific constants are internal parameters of the code and can be directly written to by a move command. The site specific variables are also adjustable by the control room operator, an operate block is used to 'load' a default value into these pseudo inputs. Most constant values are listed as 'site specific', but where a default value is commonly used its' value is listed in the table below.

3.1 Site Specific Constants defined in PLC

Description	Type	Value	Units
Sewerage Pumping Station			
Minimum time between starts for each pump	Integer	300	Sec
Fail to start/stop timer	Integer	30	Sec
Minimum time 'all pumps inhibited' run is active.	Integer	120	Sec
Surcharge pumping duration [3]	Integer	Site Spec	Sec
Delivery flow			
Delivery flow – Range	Real	Site Spec	l/s x 100
Delivery flow – Minimum flow	Real	Site Spec	l/s x 100
Delivery pressure			
Delivery pressure - Range	Real	Site Spec	mmAHD
Delivery pressure – Elevation of the transducer	Real	Site Spec	mmAHD
Pump Blockage			
Flow blocked limit for flow/level PID control (knee)	Integer	Site Spec	l/s x 100
VFD speed blocked limit for flow/level PID control (knee)	Integer	Site Spec	Hz x 100
VFD speed blocked limit for minimum flow PID control (min)	Integer	Site Spec	Hz x 100
Wet well level			
Wet well level range	Integer	Site Spec	mmAHD
Wet well surcharge occurring level	Integer	Site Spec	mmAHD
Wet well surcharge imminent level	Integer	Site Spec	mmAHD
Wet well inhibit mode start level	Integer	Site Spec	mmAHD
Wet well inhibit mode stop level	Integer	Site Spec	mmAHD
Wet well duty B pump start level	Integer	Site Spec	mmAHD
Wet well duty A pump start level	Integer	Site Spec	mmAHD
Wet well duty A pump stop level	Integer	Site Spec	mmAHD
Wet well duty B pump stop level	Integer	Site Spec	mmAHD
Wet well empty level (4mA of Probe)	Integer	Site Spec	mmAHD
Variable Frequency Drive			
Variable Frequency Drive – Minimum Speed	Integer	Site Spec	Hz x 100
Variable Frequency Drive – Maximum Speed	Integer	Site Spec	Hz x 100

3.2 Site Specific Constants defined in RTU

Tag Name	Description	Type	Value	Units
Sewerage Pumping Station				
atn1duration	Attention alarm duration	Integer	15	min
stn1calFltDelay	Delay wet well calibration fault on start up [1]	Integer	3600	sec
rtu1BattChkDur	Battery check test duration [2]	Integer	600	sec
ste1percent	Percentage value of analog alarm hysteresis	Real	1.0	%
Delivery flow				
flw1almInhibitTm	Delivery flow - Alarm inhibit timer	Integer	15	sec
Delivery pressure				
pre1almInhibitTm	Delivery pressure - Alarm inhibit timer	Integer	15	sec
Wet well level				
wwl1surchLvlVol	Wet well volume at surcharge level	Real	Site Spec	kl
Pumps 1 - 3				
Pmp[x]almInhPwrTm	Pump [x] - Motor power alarm inhibit timer.	Integer	15	sec
pmp[x]almInhCrntTm	Pump [x] - Motor current alarm inhibit timer.	Integer	15	sec
pmp[x]currRange	Pump [x] - Motor current range	Real	Site Spec	Amps

3.3 Site Specific Variables defined in RTU

Tag Name	Description	Type	Value	Units
Wet well level				
wwl1highLimit	Wet well level - High alarm set point	Integer	Site Spec.	mmAHD
wwl1lowLimit	Wet well level - Low alarm set point	Integer	Site Spec.	mmAHD
Delivery flow				
flw1highLimit	Delivery flow - High alarm set point	Integer	Site Spec.	ml/s
flw1lowLimit	Delivery flow - Low alarm set point	Integer	Site Spec.	ml/s
Delivery pressure				
pre1highLimit	Delivery pressure - High alarm set point	Integer	Site Spec.	mmAHD
pre1lowLimit	Delivery pressure - Low alarm set point	Integer	Site Spec.	mmAHD
Pumps 1 - 3				
pmp[x]currHiLimit	Pump [x] - Motor current high alarm set point [4]	Integer	Site Spec.	mAmps
pmp[x]currLoLimit	Pump [x] - Motor current low alarm set point [5]	Integer	Site Spec.	mAmps
pmp[x]powHiLimit	Pump [x] - Motor power high alarm set point	Integer	Site Spec.	Watts
pmp[x]powLoLimit	Pump [x] - Motor power low alarm set point	Integer	Site Spec.	Watts

Notes

1. Upon start-up a delay of 1 hour ensures that, if PLC/RTU initialises while the level is above the surcharge imminent level, the station has adequate time to pump the level back to within normal operating levels. This prevents invalid 'calibration fault' alarms from being triggered.
2. The battery test checks that the battery is able to provide backup power long enough (ten minutes) after a station mains fail to send the station mains fail alarm back to the IDTS master station.
3. The surcharge pumping duration is calculated as half the time taken to pump from surcharge imminent level to the dutyA stop level under normal dry weather conditions.
4. The current high alarm set point is configured to detect high current reading which is a symptom of a jammed pump.
5. The current low alarm set point is configured to detect a low current reading which is a symptom of an air locked, a worn pump or a blocked pump.

4 ALARMS AND EVENTS

4.1 Introduction

Acquisition of data from the site is performed by the IDTS master station regularly "polling" the RTU once every hour. When this poll occurs the current status of all digital and analog values are transmitted to the IDTS master station. Additionally, time stamped historical values for selected points may also be uploaded. (This information is used for trending purposes).

The regular polling routine is overridden by an "Alarm call" message generated by the RTU if a "significant' point changes state at the site. An "Alarm call" is a short message sent to the IDTS Master station requesting an immediate communication with the site. The master station then schedules a "poll"

1. Significant : Alarm call the master station on change of state or prescribed deviation
2. History : Time stamp events in the RTU at the prescribed frequency and deviation

The RTU communicates to the IDTS master station via a communication channel, typically the Trio radio network. To conserve the radio channel bandwidth the RTU only priority 1 alarms are set up to be significant points.

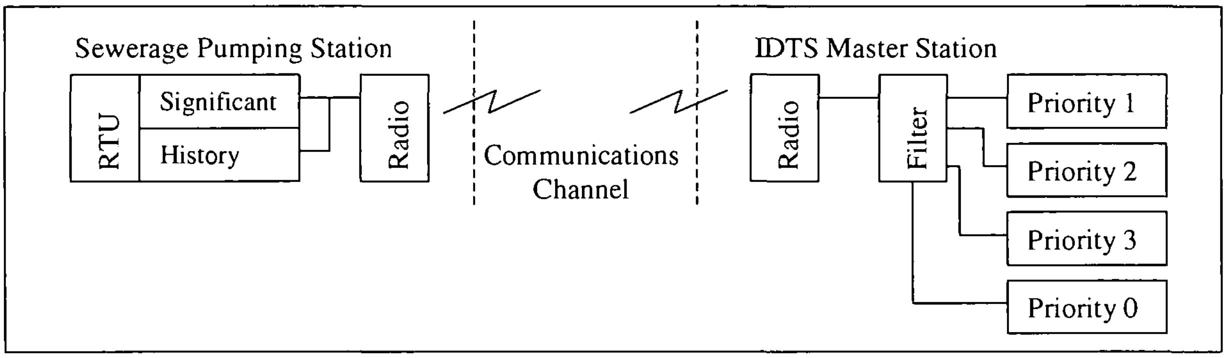

Figure 6 Radio Communication Channel

4.2 Alarm and Event Definitions

All Boolean signals sent back to the IDTS master station are given an alarm priority classification which will determine weather they are alarms or events. These priorities are as follows:

Priority 1	Alarm	Immediate action
Priority 2	Alarm	Action next calendar day
Priority 3	Alarm	Action next working day
Priority 0	Event	No Action required

4.2.1 Alarms

As the definition of a Priority 1 alarm is that immediate action is required. All Priority 1 alarms are classified as significant. Any change of state triggers an alarm call from the RTU to the IDTS master station requesting an immediately poll of the RTU. All other non-significant alarms/events which are configured for history are time stamped and placed in the RTU history to be uploaded when:

- the RTU is polled by the IDTS or
- the buffer becomes full or
- a priority 1 alarm occurs causing all the buffer contents to be sent.

NOTE: The MITS MD3311 RTU's synchronise their time with the master station using a UNIX time routine.

The alarm priority class is shown by colour in the control room operator's alarm page picture on the IDTS. The IDTS SCADA alarms are filtered by priority class, then by the time stamp. A log file records the time and date of the activation and deactivation of alarms at the RTU.

NOTE: Alarms which have an initial state of 'TRUE' (i.e. Available) should be initialised as TRUE in the point configuration of ISaGRAF to avoid erroneous alarm on the first scan of the RTU.

4.2.2 Events

Events are actions recorded by the RTU, which are not in an alarm category, for example pump running (start/ stop action). The events are stored in the RTU history with a time and date stamp and are transmitted to the IDTS master station with the priority 2 and 3 alarms. To avoid multiple alarms for a single pump fault, all pump faults have been classified as events. They all trigger the pump available alarm, which is a priority 1 alarm.

4.3 Alarm Instructions

Each event or alarm that requires an action from the control room operator is provided with an 'Alarm Instruction'. This 'alarm instruction' is in the form of a text file that is associated with all alarms and events. A typical action may be to send an electrician to the site or to order a sewerage tanker. Refer to Section *6.5 IDTS Alarm Instructions* for an example of an alarm instruction file.

4.4 Alarm Suppression

An alarm's primary function is to notify the control room operator that an abnormal situation exists at a sewerage pump station. The Brisbane Water operational instructions for each sewerage site determine the action the control room operator takes in response to an alarm. To avoid consequential alarming (one fault condition triggering multiple alarms at the IDTS SCADA system) alarm suppression is used on secondary alarms. All alarm suppression is performed in the RTU therefore modification to the RTU code is required to alter the suppression of any alarms.

4.4.1 Local Mode

When the station is switched to local mode, the site is under control of the on site technician. An alarm is triggered at the IDTS SCADA system to indicate the station is in local control. All pump alarms are suppressed as the on site technician has assumed responsibility for the station. Surcharge imminent, based on the wet well level, is also suppressed to avoid triggering Surcharge pumping mode during the maintenance of the Vega probe. The wet well level alarms of wet well high, surcharge imminent (triggered by the surcharge imminent electrode), and surcharge occurring are **not** suppressed in local mode.

4.4.2 Station Mains Fail

The main consequential alarm condition is Site Power Fail. If site power fails the following secondary alarms are suppressed:

- RTU Mains Fail
- Sewer pump not available
- Sewer pump motor power
- Current Invalid
- Delivery pressure Invalid
- Flow Invalid

4.4.3 All Pumps Inhibited

When the 'all pumps inhibited' mode is active, the wet well high alarm is suppressed, since the normal wet well level in inhibit mode is above the wet well high point.

4.4.4 Wet Well Invalid

If the wet well level becomes invalid, the wet well low and high alarm, surcharge imminent based on wet well level and surcharge occurring alarms are suppressed.
NOTE: As the wet well level is backed up by the battery – the site power does **not** suppress the invalid alarm.

4.4.5 Signal Invalid Alarm

Any analog signal (delivery pressure) not backed up by the RTU battery has its invalid alarm suppressed by the station mains power input. The signal high and low alarms are suppressed by both the signal invalid alarm and the station mains power input.

4.4.6 Alarm Suppression Tree

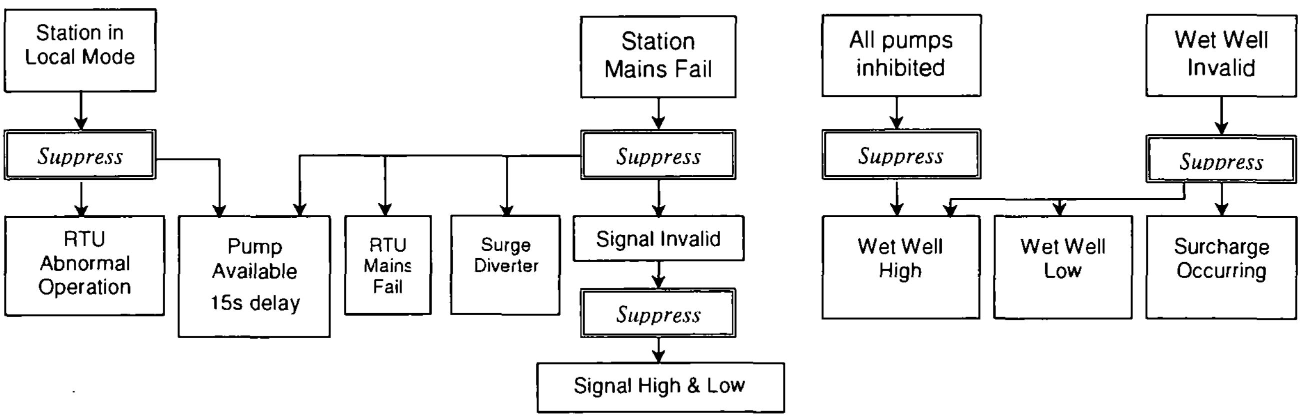

Figure 7: Alarm Suppression Tree

4.5 Alarm and Event Listing

Table 5: Priority 1 Alarms

Plant	Quantity	Desig	Alarm Description
Plc	Abnormal_operation	1	Abnormal operation of PLC
Plc	Comms_fault	1	Modbus communications to PLC has failed
Rtu	Abnormal_operation	1	Abnormal operation of RTU
Rtu	Battery	1	RTU power failure (battery)
Rtu	Heartbeat	1	RTU heartbeat to IDTS has failed
Rtu	Mains_fail	1	RTU power failure (mains)
Power_supply	Surge_diverter_fault	1	Surge Diverter fault
Sewage_pumping_station	Local_remote	1	Station in local mode
Sewage_pumping_station	Mains_fail	1	Site main power fails
Sewer_pump	Available	1-3	Pump unavailable
Sewer_pump	Blocked	1-3	Pump blocked
Wet_well	Level_invalid	1	Wet well measuring instrument faulted
Wet_well	High	1	Wet well level rises above a high alarm level
Wet_well	Surcharge_imminent	1	Wet well level reaches the surcharge imminent level
Wet_well	Surcharge_occuring	1	Wet well level reaches the surcharge occurring level

Table 6: Priority 2 Alarms

Plant	Quantity	Desig	Alarm Description
Sewer_pump	Inhibit_Fbk	1-3	Pump 1 inhibited by control room operator
Security	Door_limit_switch	1	One or more of the switchboard doors is open

Table 7: Priority 3 Alarms

Plant	Quantity	Desig	Alarm Description
Wet_well	Low	1	Wet well level is low
Wet_well	Calibration_fault	1	Wet well level calibration fault
Pressure_gauge	High	1	Delivery pressure high
Pressure_gauge	Low	1	Delivery pressure low
Pressure_gauge	Invalid	1	Delivery pressure invalid
Flow_meter	High	1	Delivery flow high
Flow_meter	Low	1	Delivery flow low
Flow_meter	Invalid	1	Delivery flow invalid
Variable_speed_drive	Automatic_reset	1-3	VFD starter fault has reset automatically
Variable_speed_drive	Speed_invalid	1-3	VFD speed feedback is invalid

Table 8: Events (Priority 0 Alarms)

Plant	Quantity	Desig	Alarm Description	Alarm
Attention	Automatic_reset	1	Site attention indication has automatically reset	N/A
Rtu	Battery_test_failed	1	Battery test has failed	N/A
Rtu	Battery_test_inprogress	1	Battery test is in progress	N/A
Power_supply	Generator_online	1	Generator is Running	N/A
Power_supply	Main_incomer_CB_closed	1	Main Incomer CB is closed	N/A
Sewer_pump	Emergency_stop_fault	1-3	Pump Emergency stop active	Pump Avail
Sewer_pump	Fault	1-3	Pump Failed to start or stop	Pump Avail
Sewer_pump	Mains_power	1-3	Pump Mains power fault	Pump Avail
Sewer_pump	Moisture_in_oil_fault	1-3	Pump Moisture in oil fault	Pump Avail
Sewer_pump	Motor_power_high	1-3	Pump motor power high	N/A
Sewer_pump	Motor_power_low	1-3	Pump motor power low	N/A
Sewer_pump	Motor_current_high	1-3	Pump motor current high	N/A
Sewer_pump	Motor_current_low	1-3	Pump motor current low	N/A
Sewer_pump	Running	1-3	Pump Running	N/A
Variable_speed_drive	Auto	1-3	VFD starter not in keypad mode	Pump Avail
Variable_speed_drive	Count_exceeded	1-3	VFD starter faults exceeds maximum allowed	Pump Avail
Variable_speed_drive	Fault	1-3	VFD starter fault	Pump Avail

4.6 Alarm and Event Description

4.6.1 Attention

The following alarms and events are associated with the Attention Command

Plant	Quantity	Priority
Attention	Automatic_reset	0

Automatic Reset

The site attention control controls a indication lamp or strobe light at the RTU site. The control room operator is able to initiate and cancel the "attention indication" from the work stations. The on site technician will be required to contact the control room operator by radio or telephone when they see the alarm lamp/strobe.

Once activated, the attention alarm shall remain on for a period of 15 minutes. If it is not acknowledged it is then reset automatically. The attention indication can be acknowledged by the on site technician pushing the local 'attention acknowledge' pushbutton. An alarm flag is returned to the IDTS master station if the site attention was reset automatically.

4.6.2 Flow meter

The following alarms and events are associated with the delivery flow meter.

Plant	Quantity	Priority
Flow_meter	High	3
Flow_meter	Low	3
Flow_meter	Invalid	3

The delivery flow meter low alarm is only checked when station power and the invalid alarms are healthy. It will be active at all times but when a pump starts the alarms will be inhibited for a period determined by the flow meter alarm inhibit time (default 15 seconds). This ensures that any instability caused by the pump starting has dissipated.

Invalid

The signal is deemed invalid if it is

Less than (4mA – dead band) or greater than (20mA + dead band) for 2 seconds.

Once the invalid alarm has been activated it can only be reset when the signal is both greater than 4mA and less than 20mA for 30 seconds. The time delays ensure that a signal is truly invalid before an alarm is set and that it is stable before it is reset. The dead band is calculated using the site invalid hysteresis value multiplied by the range.

Low Alarm

If all the alarm conditions are satisfied then the flow low alarm is activated if the signal is less than the low limit set point. It is deactivated if any of the above conditions become false or the signal is greater that the low limit set point plus the dead band. The dead band is calculated using the alarm hysteresis value multiplied by the range.

High Alarm

If all the alarm conditions are satisfied then the flow high alarm is activated if the signal is greater than the high limit set point. It is deactivated if any of the above conditions become false or the signal is less that the high limit set point minus the dead band. The dead band is calculated using the alarm hysteresis value multiplied by the range.

4.6.3 Pressure Gauge

The following alarms and events are associated with the delivery pressure gauge.

Plant	Quantity	Priority
Pressure_gauge	High	3
Pressure_gauge	Low	3
Pressure_gauge	Invalid	3

The high and low alarms are only checked when station power and the invalid alarms are healthy and a pump has been running for the pressure alarm inhibit time (default 15 seconds). This ensures that any instability caused by the pump starting has dissipated.

Invalid

The signal is deemed invalid if it is

Less than (4mA – dead band) or greater than (20mA + dead band) for 2 seconds.

Once the invalid alarm has been activated it can only be reset when the signal is both greater than 4mA and less than 20mA for 20 seconds. The time delays ensure that a signal is truly invalid before an alarm is set and that it is stable before it is reset. The dead band is calculated using the site invalid hysteresis value multiplied by the range.

Low Alarm

If all the alarm conditions are satisfied then the pressure low alarm is activated if the signal is less than the low limit set point. It is deactivated if any of the above conditions become false or the signal is greater that the low limit set point plus the dead band. The dead band is calculated using the alarm hysteresis value multiplied by the range.

High Alarm

If all the alarm conditions are satisfied then the pressure high alarm is activated if the signal is greater than the high limit set point. It is deactivated if any of the above conditions become false or the signal is less that the high limit set point minus the dead band. The dead band is calculated using the alarm hysteresis value multiplied by the range.

4.6.4 Security

The following alarms and events are associated with the Security.

Plant	Quantity	Priority
Security	Door_limit_switch	2

Door Limit Switch

This alarm indicates that someone authorised or not, has opened a switchboard door. All the doors of the switchboard have a limit switch to indicate the status of that door. All of these limit switches are wired in series to give a combined signal which indicates whether all the doors are closed or at least one door is open. This signal is fed back directly to give a status indication of all the doors on the switchboard to the control room operator.

4.6.5 Switchboard Power Monitoring

The switchboard at a sewerage pumping station has multiple points of isolation and failure. There are various monitoring relays and circuit breaker status inputs to determine the power status for the entire switchboard.

The following alarms and events are power alarms associated with the switchboard (refer to Figure 8: Example of Switchboard Power Monitoring Diagram, to locate the point of failure for the switchboard).

Drawing ID	Plant	Quantity	Priority
1	Sewage_pumping_station	Energex_power	1
2	Power_supply	Main_incomer_CB_closed	0
1&2	Power_supply	Generator_online	0
3	Sewage_pumping_station	Mains_fail	1
4	Power_supply	Surge_diverter_fault	1
5	Rtu	Battery	1
6	Rtu	Mains_fail	1
7 & 8	Sewer_pump	Mains_fail	0

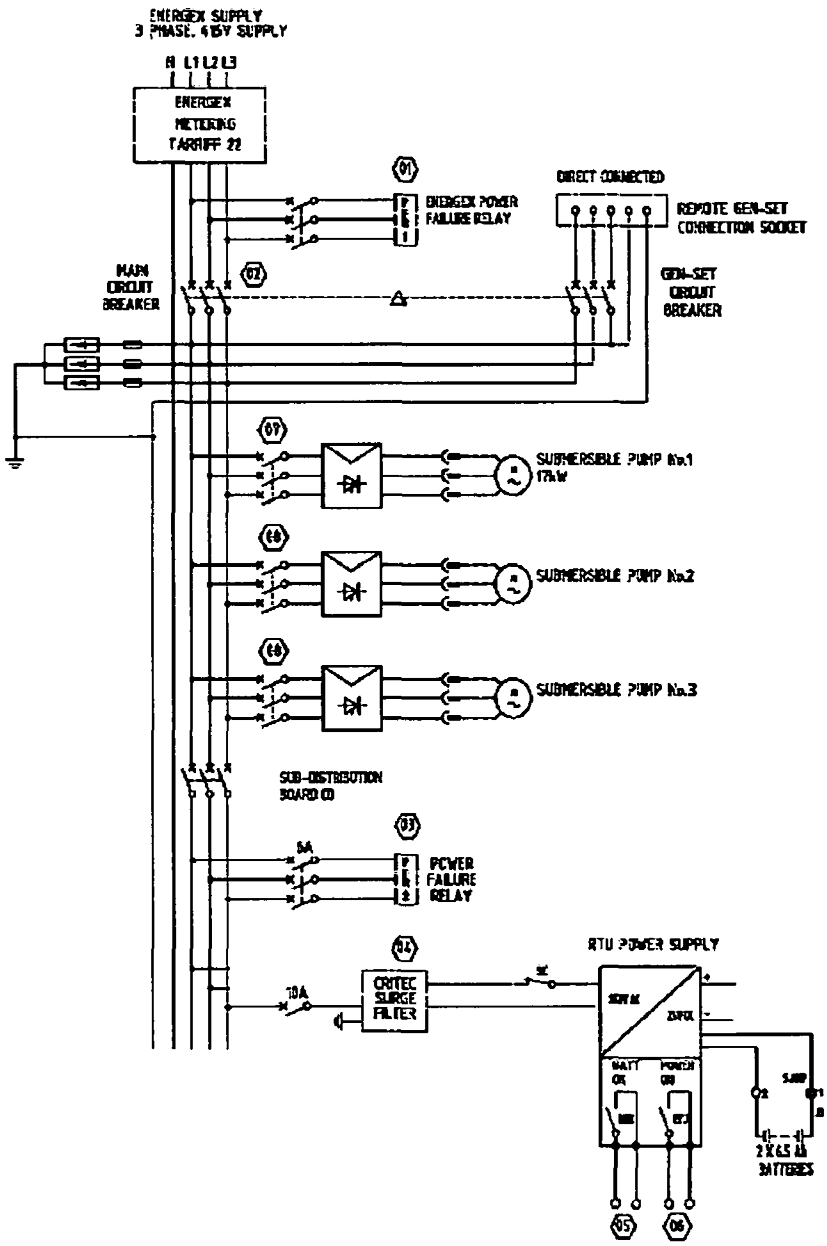

Figure 8: Example of Switchboard Power Monitoring Diagram

Energex Power

If the power monitoring relay on the Energex side of the main incomer is indicating a fault then after a 120 seconds delay, the Energex power signal will be set to the fault state. This signal is used to determine if the Energex power is healthy while the station is running on a generator. The 120 second delay is used to eliminate alarms due to brown outs and momentary losses of power.

Main Incomer Circuit Breaker Closed

This event is a direct feedback of the digital input indication the status of the main incomer circuit breaker.

Generator Online

The main incomer circuit breaker is interlocked with the generator circuit breaker, only one can be closed at any given time. If the main incomer circuit breaker is not closed and the station still has mains power then, the station must be powered by the generator. Therefore after a 5 second delay, the generator online status is activated.

Station Mains Fail

If the power monitoring relay on the station side of the main incomer is indicating a fault then after a 15 seconds delay, the Mains fail signal will activated. This signal is used to determine if station has power, from either the line side of the main incomer or from the generator. The 15 second delay is to eliminate alarms due to brown outs and momentary losses of power.

Surge Diverter Fault

The surge diverter has a healthy status fed back to the RTU. If this signal indicates a fault, and the site power is still active, then after a 2 second delay the surge diverter fault is activated.

RTU Mains Fail

If the circuit breaker feeding the 240VAC to 24VDC power supply is tripped, and the station mains power is healthy, then after a 15 seconds delay, the RTU mains fail alarm is activated.

Pump Mains power

If the pump control power is faulted and the station mains fail is healthy, then after a 2 second delay, the pump mains power is set to the fault condition.

Battery (Fault)

This alarm indicates whether the power supply has a healthy battery system connected and that the batteries are adequately charged. If the battery system signal is in the fault state (and the battery check is not in progress) then the RTU Battery signal becomes faulty after a 20 second delay.

4.6.6 Station Mode

The following alarms and events are associated with the Mode of the switchboard

Plant	Quantity	Priority
Sewage_pumping_station	Local_remote	1

Local Remote

When the station is turned into local mode it ceases to be autonomous and can no longer be controlled by the control room operator. The pumps can only be started and stopped locally by the on site technician.

The status of the local remote switch is sent back directly to the control room operator. This signal is a priority one alarm to immediately inform the control room operator that the station is no longer running under automatic control.

4.6.7 Sewer Pump

The following alarms and events are associated with the sewage pump.

Plant	Quantity	Priority
Sewer_pump	Available	1
Sewer_pump	Blocked	1
Sewer_pump	Emergency_stop_fault	0
Sewer_pump	Fault	0
Sewer_pump	Inhibit_Fbk	2
Sewer_pump	Mains_power	0
Sewer_pump	Moisture_in_oil_fault (optional)	0
Sewer_pump	Motor_power_high	3
Sewer_pump	Motor_power_low	3
Sewer_pump	Motor_current_high	3
Sewer_pump	Motor_current_low	3
Sewer_pump	Running	0
Variable_speed_drive	Auto	0
Variable_speed_drive	Automatic_reset	3
Variable_speed_drive	Count_exceeded	0
Variable_speed_drive	Fault	0
Variable_speed_drive	Speed_invalid	0

Available

The pump considered available only when all of the following conditions are not present:

- Site mains power fail - Switchboard does not have 415V mains power supplied
- Pump mains power fail - Pump does not have 240V control power supplied
- Pump fail - Pump has failed to start
- Pump VFD not in Auto - Pump is in Keypad control
- Pump VFD fault - Pump VFD motor protection has activated
- Pump VFD fault Count Exceeded - Three or more faults in the last 8 hours
- Pump emergency stop input faulted - Push button has been pressed
- Pump emergency stop fault latched - Emergency fault has not been reset

As the emergency stop fault is latched and has a 2 second delay, both the emergency stop input and the emergency stop fault are needed to ensure the pump becomes unavailable and stops immediately when the emergency stop button is pressed. It also ensures that although the emergency stop button may be unlatched, the emergency stop fault must be reset by the on site technician before the pump can start.

The availability alarm is suppressed by the station mains power fault condition and the station being in local mode. The pump must also be unavailable for 15 seconds before the alarm is sent to the IDTS master station. All the conditions which make the pump unavailable are event and can be easily identified by the control room operator by listing the abnormal points for the station.

Running

The pump running status input is directly fed back to the sewer pump running indication signal to the IDTS master station.

Emergency Stop Fault

If the emergency stop input becomes faulty and the station mains power is still healthy then, after a 2 second delay, the emergency stop fault is activated. Once activated, the emergency stop button must be unlatched and then the on site technician must press the local reset button.

Fault

The sewer pump fault flag is activated by the pump failing to start or failing to stop. If the pump is commanded to start or stop and the running indication does not match the running command, then after a site specific time period, the pump fault will become active. The time period is dependant on the ramp up and ramp down period of the VFD. (Default 30 seconds).

Moisture in Oil (Optional)

If the moisture in oil relay is in the fault condition and the station mains fail is healthy, then after a 2 second delay, the pump moisture in oil fault is activated. The moisture in oil relay is only installed on pump motors which are 22kW or greater in size.

Pump Blockage

Pump Blockage is designed to identify a possible blockage in an individual pump.

The pump blockage alarm is set if the pump is running individually in remote and for longer than a certain time period either:

1. The speed is too high for producing the minimum flow **or**
2. The flow is lower than the 'blocked flow rate limit' while the pump speed is greater that the 'blocked speed limit'.

The first condition will ensure that the pump does not speed up continuously to meet the minimum required flow rate. The second condition has site specific set points, which ensure that, while flow rate is above the minimum required, the speed to achieve this is not excessive. Two conditions are required so that the pump blockage can be determined in both low flow and peak flow conditions.

Once the pump blockage alarm is set for a pump is can be reset by the on site technician pressing the local reset button or the control room operator sending a remote reset (if the station is in remote mode).

It is not desirable to run a blocked pump as it may damage the pump. To ensure that a pump which has a potential blockage does not run unnecessarily, the pump blockage alarm effectively 'inhibits' the blocked pump from running. (refer to section 2.1.3 All Pumps Inhibited / Blocked Mode and Individual Pump Inhibit / Blocked). If all the pumps are either blocked or inhibited, then the inhibited pumps will be given preference to run.

Motor Current High and Low Alarms

The pump current high and low alarms are only checked when station power is healthy and the pump has been running for the pump alarm inhibit time (default 15 seconds). This ensures that any instability caused by the pump starting has dissipated.

If all the above conditions are satisfied then the high alarm is activated if the signal is greater than the high limit set point. It is deactivated if any of the above conditions become false or the signal is less that the high limit set point minus the dead band. The dead band is calculated using the alarm hysteresis value multiplied by the range. A high alarm is indicative of a jammed pump or a pump motor fault.

If all the above conditions are satisfied then the low alarm is activated if the signal is less than the low limit set point. It is deactivated if any of the above conditions become false or the signal is greater that the low limit set point plus the dead band. The dead band is calculated using the alarm hysteresis value multiplied by the range. A low alarm is indicative of an air locked pump or a blocked pump.

Motor Power High and Low Alarms

The pump power high and low alarms are only checked when station power is healthy and the pump has been running for the pump alarm inhibit time (default 15 seconds). This ensures that any instability caused by the pump starting has dissipated.

If all the above conditions are satisfied then the high alarm is activated if the signal is greater than the high limit set point. It is deactivated if any of the above conditions become false or the signal is less that the high limit set point minus the dead band. The dead band is calculated using the alarm hysteresis value multiplied by the range.

If all the above conditions are satisfied then the low alarm is activated if the signal is less than the low limit set point. It is deactivated if any of the above conditions become false or the signal is greater that the low limit set point plus the dead band. The dead band is calculated using the alarm hysteresis value multiplied by the range.

Variable Frequency Drive Auto

Direct feedback of the digital input status to indicate whether the VFD is on auto or keypad control.

Variable Frequency Drive Fault

If the variable frequency drive fault input becomes active and the station mains power is healthy and the emergency stop button has not been pressed, then after a 2 second delay, the variable frequency drive fault signal is activated. Once activated, the variable frequency drive fault input must clear before the fault signal can be reset.

The fault signal can be reset by the on site technician pressing the local reset button, the control room operator sending a remote reset (if the station is in remote mode) or by an automatic reset. All these three resets will activate the reset relay for 2 seconds, which sends a physical reset command to the variable frequency drive.

Variable Frequency Drive Fault Automatic Reset

Once the variable frequency drive fault input becomes healthy, to avoid the unnecessary unavailability of the sewer pump, the latched variable frequency drive fault signal will be reset automatically after the variable frequency drive fault reset delay time (default 20 minutes).

Variable Frequency Drive Fault Count Exceeded

The purpose of the fault count exceeded alarm is to prevent a reoccurring variable frequency drive fault being continuously reset automatically.

The fault count exceed signal is activated if 3 automatic resets have occurred in the last 8 hours. This signal can only be reset by the on site technician pressing the local reset button or by the control room operator sending a remote reset (if the station is in remote mode).

Variable Frequency Drive Speed Invalid

The signal is deemed invalid if it is

Less than (4mA – dead band) or greater than (20mA + dead band) for 2 seconds.

Once the invalid alarm has been activated it can only be reset when the signal is both greater than 4mA and less than 20mA for 20 seconds. The time delays ensure that a signal is truly invalid before an alarm is set and that it is stable before it is reset. The dead band is calculated using the site invalid hysteresis value multiplied by the range.

4.6.8 Wet Well

Plant	Quantity	Priority
Wet_well	Level_invalid	1
Wet_well	Low	3
Wet_well	High	1
Wet_well	Surcharge_imminent	1
Wet_well	Surcharge_occuring	1
Wet_well	Calibration_fault	3

As the Vega wet well probe takes a few seconds to initialise, all the wet well alarms except for invalid, are suppressed for 10 seconds upon RTU start up

Invalid

The signal is deemed invalid if it is

Less than (4mA – dead band) or greater than (20mA + dead band) for 1 second.

Once the invalid alarm has been activated it can only be reset when the signal is both greater than 4mA and less than 20mA for 20 seconds. The time delays ensure that a signal is truly invalid before an alarm is set and that it is stable before it is reset. The dead band is calculated using the site invalid hysteresis value multiplied by the range.

Low Alarm

A low alarm indicates that the wet well level may be lower than the intake for the pump. This puts the pump at risk of air locking. An air locked pump must be primed by an on site technician to make it available to run.

If the signal is valid and the start up delay has expired then the low alarm is activated if the signal is less than the low limit set point. It is deactivated if any of the above conditions become false or the signal is greater that the low limit set point plus the dead band. The dead band is calculated using the alarm hysteresis value multiplied by the range.

High Alarm

A high alarm indicates that the wet well level is above the normal operating range of the pump station and that the inflow is higher than the current pumping capacity of the station. The control room operator must now initiate contingency plans to minimise the possibility of a surcharge.

If the signal is valid and the start up delay has expired then the high alarm is activated if the signal is greater than the high limit set point. It is deactivated if any of the above conditions become false or the signal is less that the high limit set point minus the dead band. The dead band is calculated using the alarm hysteresis value multiplied by the range.

Surcharge Imminent Alarm

The surcharge imminent alarm is a final warning to the control room operator that the site is at immediate risk of surcharging. This serves as a reminder to the control room operator in implementing the contingency plans. It also provides a statistical count of all sites that came close to surcharging.

As this alarm is triggered by the surcharge imminent electrode, it also provides a redundancy to the wet well high alarm that the Vega probe should activate. The surcharge imminent alarm is the first alarm that the control room operator receives if the wet well level Vega probe is not functioning correctly.

The surcharge imminent alarm is primarily activated by the surcharge imminent electrode input. When this signal is active for 10 seconds then the surcharge imminent alarm is activated. To prevent repetitious alarms due to wave action the signal is kept active for 1 minute after the surcharge imminent electrode deactivates.

As a backup, a valid wet well level signal exceeding the surcharge imminent level by 100mm, for 10 seconds, will also trigger the surcharge imminent alarm while the station is in remote mode. This 100mm is ignored during power outages.

The surcharge imminent electrode is 24VDC and is backed up by the battery system. On all previous installations for HWT sites the surcharge imminent electrode has been powered by mains power and was not backed up by the battery.

Surcharge Occurring Alarm

This alarm is the final alarm that the control room operator will receive as the wet well level rises until it overflows. This alarm is used to calculate the duration of the surcharge event (surcharge duration).

When the wet well level is greater than or equal to the surcharge level minus 25 mm the surcharge occurring signal is activated. To prevent repetitious alarms due to wave action the signal is kept active for 1 minute after the wet well level falls below the surcharge occurring level.

Wet Well Calibration Fault

The wet well calibration fault is activated one of two ways. The first is if the surcharge imminent electrode is activated while the wet well level (reading on the Vega probe) is more than 100mm below the surcharge imminent level. The second is if the wet well level (reading on the Vega probe) reaches 100mm above the surcharge imminent level without the surcharge imminent electrode being activated.

Both of these methods are inhibited for 1 hour after the RTU intitialises. This prevents the alarm raised if on power up the wet well level is already above the surcharge imminent level. To reset the calibration fault signal the control room operator sends a calibration fault reset command from the IDTS master station.

4.6.9 RTU and PLC

The following alarms and events are associated with the RTU.

Plant	Quantity	Priority
Rtu / Plc	Abnormal_operation	1
Rtu	Heartbeat_failed	1
Plc	Comms_fault	1
Rtu	Battery_test_failed	3
Rtu	Battery_test_inprogress	0

Abnormal Operation

An abnormal operation alarm identifies when the RTU or PLC operating system program has restarted. This restart is determined by the presence of the 'first scan' flag. A first scan can occur when the RTU has reset itself due to a fault condition. Any abnormal operation should be investigated by a technical officer from the Networks Control Systems (NCS).

As downloading the code by a technical officer also causes a first scan, the technical officer can turn the station to local to suppress and/or reset this alarm. The alarm can also be reset by control room operator using the RTU abnormal operation reset command from the IDTS master station.

Heartbeat failed

A counter increments every 1 minute and is sent to the IDTS master station. The IDTS master stations then checks that this 'heartbeat' figure has incremented every time the site has polled. If it has not, then a heartbeat failed alarm is by the IDTS master station to alert the control room operator that the RTU has stopped operating.

PLC Comms Fault

The Modbus communication fault is determined by a watchdog counter which is passed back and fourth from the RTU and the PLC and incremented on each pass in the PLC. If the RTU does not register an increment in any given 30 second time period, then a communication fault alarm is activated.

Battery Test in Progress

The battery test is used to check the state of the battery system. When a battery test is initiated, the battery test output relay is driven to disconnect the RTU power supply from mains power for 10 minutes. During this test, and while the station and RTU mains power signals are healthy and the battery system signal is healthy, the battery test in progress signal is active.

Battery Test Failed

A battery test failed alarm indicates that the batteries have failed their test and need to be replaced. The battery test failed signal is activated if the battery test in progress is deactivated because the battery system signal is in the fault state. This alarm is latched until a new battery test is activated or a battery test failed reset signal is sent by the control room operator.

5 CALCULATIONS

The RTU performs calculations for both the controls of the station and for analytical analysis of the station's performance. The calculated values are stored in ordinary RTU memory and are lost when the RTU restarts. The calculated values are sent back periodically to the IDTS SCADA system and stored in the history database. Access to this information is via the operators control station or a casual use work station. All the control variables are also sent back to the IDTS SCADA system as feedback points to allow the control room operator to view the current control parameters.

5.1 Calculated Values

Plant	Quantity	Desig	Alarm Description
Flow_meter	Flow_rate	1	Delivery flow rate in l/s
Flow_meter	Volume	1	Daily volume in kL
Flow_meter	Volume_yesterday	1	Daily volume for past 24 hrs in kL
Pressure_gauge	Pressure_mahd	1	Delivery Pressure in mAHD
Pressure_gauge	Pressure_kpa	1	Delivery Pressure in kpa
Rtu	Battery_discharge_time	1	Time taken for Battery to discharge during test
Rtu	Site_id	1	Network Address of RTU
Sewer_pump	Hours_run	1-3	Hours run for pump running by itself since midnight
Sewer_pump	Hours_run_yesterday	1-3	Hours run for pump by itself yesterday
Sewer_pump	Hours_run_12	1	Run hours of pumps 1&2 operating since midnight
Sewer_pump	Hours_run_12_yesterday	1	Run hours of pumps 1&2 operating yesterday
Sewer_pump	Hours_run_13	1	Run hours of pumps 1&3 operating since midnight
Sewer_pump	Hours_run_13_yesterday	1	Run hours of pumps 1&3 operating yesterday
Sewer_pump	Hours_run_23	1	Run hours of pumps 2&3 operating since midnight
Sewer_pump	Hours_run_23_yesterday	1	Run hours of pumps 2&3 operating yesterday
Sewer_pump	Motor_current	1-3	Motor current
Sewer_pump	Motor_power	1-3	Motor power
Sewer_pump	Number_of_starts	1-3	Number of starts for pump since midnight
Sewer_pump	Number_of_starts_yesterday	1-3	Number of starts for pump yesterday
Sewer_pump	Total_kWHrs	1-3	Total kWHrs for pump since midnight
Sewer_pump	Total_kWHrs_yesterday	1-3	Total kWHrs for pump yesterday
Sewer_pump	Total_outflow	1-3	Total outflow for pump since midnight
Sewer_pump	Total_outflow_yesterday	1-3	Total outflow for pump yesterday
Variable_speed_drive	Speed_Fbk	1-3	Variable frequency drive operating speed
Wet_well	Inflow	1	Average inflow to the station
Wet_well	Level	1	Level of the wet well in mAHD
Wet_well	Surcharge_duration	1	Duration of last surcharge event
Wet_well	Surcharge_time_remaining	1	Estimated time until surcharge if pumps do not run
Wet_well	Total_inflow	1	Total inflow to the station since midnight
Wet_well	Total_inflow_yesterday	1	Total inflow to the station yesterday
Wet_well	Volume	1	Current Volume in the wet well

5.2 Feedback Values

Plant	Quantity	Desig	Alarm Description
Flow_meter	High_limit_Fbk	1	Delivery flow High alarm set point
Flow_meter	Low_limit_Fbk	1	Delivery flow Low alarm set point
Pressure_gauge	Elevation_Rtu	1	Static elevation of the pressure gauge in mAHD
Pressure_gauge	High_limit_Fbk	1	High alarm set point
Pressure_gauge	Low_limit_Fbk	1	Low alarm set point
Pressure_gauge	Pressure_range_Fbk	1	Range of the pressure gauge in meters
Sewer_pump	Motor_current_high_limit_Fbk	1-3	High alarm set point
Sewer_pump	Motor_current_low_limit_Fbk	1-3	Low alarm set point
Sewer_pump	Motor_power_high_limit_Fbk	1-3	High alarm set point
Sewer_pump	Motor_power_low_limit_Fbk	1-3	Low alarm set point
Sewerage_pumping_station	Blockage_flw_SP_knee_Fbk	1	Blockage flow setpoint at the 'knee' of the curve
Sewerage_pumping_station	Blockage_spd_SP_knee_Fbk	1	Blockage speed setpoint at the 'knee' of the curve
Sewerage_pumping_station	Blockage_spd_SP_min_Fbk	1	Blockage speed setpoint for the minimum flow
Wet_well	Duty_A_start_setpoint_Fbk	1	Start duty pump set point
Wet_well	Duty_A_stop_setpoint_Fbk	1	Stop duty pump set point
Wet_well	Duty_B_start_setpoint_Fbk	1	Start standby pump set point
Wet_well	Duty_B_stop_setpoint_Fbk	1	Stop standby pump set point
Wet_well	High_limit_Fbk	1	High alarm set point
Wet_well	Level_range_Fbk	1	Range of Vega Instrument measuring wet well level
Wet_well	Low_limit_Fbk	1	Low alarm set point
Wet_well	Zero_MAHD_Fbk	1	Bottom of wet well Vega Probe in mAHD

5.3 Analog Signal Processing

5.3.1 Analog Clamping

Before it is used to calculate the engineering value of the signal the raw analog input signal is clamped to the 4-20mA limits if the value is above or below these values plus and minus the flux value respectively. Flux value is the range of the signal multiplied by the site percent variable which represents the acceptable error percent.

5.3.2 Analog Filtering

The engineering values are filtered using a five element FIFO (first in, first out) stack sampled every 1 second to produce a rolling average.

5.3.3 Analog Conversion to Engineering Unit

The analog input card converts the 4-20mA signals received to a raw count of 800 to 4000 for the RTU and 6400 to 32000 in the GE Fanuc PLC. This raw count is converted in the code to engineering units using the following formula. This is to be done in the code using the site specific values (conversion tables are not to be used).

Engineering Unit (RTU) = (Raw signal – 800)/3200 x Engineering Range.
Engineering Unit (PLC) = (Raw signal – 6400)/32000 x Engineering Range.

The following are the signals received by the RTU.

Signal	Engineering Units
Flow Meter	Litres per second
Delivery Pressure	meters
Wet Well Level	meters
Flow Meter	Litres per second
Motor Power	kW
Motor Current	Amps
VFD Speed	Hz

5.4 Delivery Flow Rate kl/day

The flow is measured in litres per second. For every sewerage flow meter a flow rate conversion is performed to get the equivalent flow rate in kilolitres per day (kl/day) and sent back to the IDTS SCADA system.

Flow (kl/day) = Flow (l/s) * K
k = 86.4 (converts l/s to kl/day)

IDTS Database Record Name		
Plant	**Quantity**	**Description**
Flow_meter	Flow_kl	Flow rate in l/s converted to kl/day value

5.5 Delivery Flow - Volume Pumped (kl)

The total volume pumped for the station is calculated using the flow rate (l/s) integrated over time, while the any pump is running. A snapshot of this figure is recorded at midnight to give the previous days volume pumped and this integral is reset.

IDTS Database Record Name		
Plant	**Quantity**	**Description**
Flow_meter	Volume	Total volume pumped since midnight
Flow_meter	Volume_yesterday	Total volume pumped yesterday

5.6 Delivery Pressure mAHD

The pressure probe measures the pressure in kPa. So that the control room operators can compare different sewerage sites successfully, the Pressure in mAHD is calculated and sent back to the IDTS SCADA system.

Pressure (mAHD) = Pressure (kPa) / k + Pres Elev (mAHD)
k = 9.803 (Pressure constant to convert from kPa to metres)
Pres Elev (mAHD) = Site specific pressure elevation of pressure gauge

IDTS Database Record Name		
Plant	**Quantity**	**Description**
Pressure_gauge	Pressure_kpa	Delivery pressure (if gauge operating) of pumps - kpa units
Pressure_gauge	Pressure_mahd	Delivery pressure (if gauge operating) of pumps - MAHD units

5.7 Pump Hrs Run / day

The hours a pump runs individually are accumulated. The hours when both pumps run together are also accumulated. These integrals are reset at midnight

NOTE: To calculate the total hours run for a pump for one day the individual pump run hours are added to the both pumps running together run hours.

IDTS Database Record Name		
Plant	**Quantity**	**Description**
Sewer_pump	Hours_run	Pump only run hours since midnight
Sewer_pump	Hours_run_yesterday	Pump only run hours yesterday
Sewer_pump	Hours_run_12	Run hours of pumps 1&2 operating simultaneously since midnight
Sewer_pump	Hours_run_12_yesterday	Run hours of pumps 1&2 operating simultaneously yesterday
Sewer_pump	Hours_run_13	Run hours of pumps 1&3 operating simultaneously since midnight
Sewer_pump	Hours_run_13_yesterday	Run hours of pumps 1&3 operating simultaneously yesterday
Sewer_pump	Hours_run_23	Run hours of pumps 2&3 operating simultaneously since midnight
Sewer_pump	Hours_run_23_yesterday	Run hours of pumps 2&3 operating simultaneously yesterday

5.8 Pump Starts / day

The number for starts per day counter is incremented every time a pump starts. This counter is reset at midnight.

IDTS Database Record Name		
Plant	**Quantity**	**Description**
Sewer_pump	Number_of_starts	Starts of Pump since midnight
Sewer_pump	Number_of_starts_yesterday	Starts of Pump yesterday

5.9 Pump kl / day

The volume that an individual pump delivers is calculated by integrating the flow rate over time while that pump is running by itself. This integral is reset at midnight

NOTE: outflow, while a pump is running in tandem with the other pump, is ignored.

IDTS Database Record Name		
Plant	**Quantity**	**Description**
Sewer_pump	Total_outflow	Volume pumped by Pump running by itself
Sewer_pump	Total_outflow_yesterday	Volume pumped yesterday by Pump running by itself

5.10 Pump kW hrs / day

The kilowatt-hours that an individual pump consumes are calculated by integrating the power over time while that pump is running by itself. This integral is reset at midnight

NOTE: kilowatts while a pump is running in tandem with the other pump are ignored.

IDTS Database Record Name		
Plant	**Quantity**	**Description**
Sewer_pump	Total_KWHrs	Pump power consumption
Sewer_pump	Total_KWHrs_yesterday	Pump power consumption yesterday

5.11 Wet Well Level mAHD

The on site indication on the switchboard is in level % of full range. This value is also sent back to the control room so that the on site technician and control room operator can compare values in the same units. The Control room operator also requires the wet well level in mAHD to be able to do a meaningful comparison between different sites. The following formulas are used to calculate these values.

WWL (mAHD) = WWL (meters) + WWL Zero Level (mAHD)

IDTS Database Record Name		
Plant	**Quantity**	**Description**
Wet_well	Level	Level of wet well

5.12 Wet Well Volume

The wet well volume is calculated using a 'wet well levels vs volume' look up table stored in the RTU database (.main file). The look up table has a maximum 32 point specification of the non-linear relationship of the wells 'Level vs Volume'. Volume in wet well is an interpolation of the well vs volume lookup table values. The site specific data is obtained from a table in an Excel spreadsheet (Table 9: Level vs Volume Lookup Table) which also provides a graphical representation of all the sample points (Figure 9: Level vs Volume Chart).

Table 9: Level vs Volume Lookup Table (SAMPLE)

	Excel Data		RTU Data
	Wet Well LevelAHD]	Remaining Storage Capacity [m^3]	Current Storage Volume [m^3]
BWL of PS	[illegible]	[illegible]	[illegible]
	1.866	9.020	0.199
	1.941	8.821	0.398
	2.017	8.622	0.597
	2.093	8.423	0.796
	2.168	8.224	0.995
	2.244	8.025	1.194
	2.319	7.826	1.392
TWL of PS	2.390	7.641	1.578
	2.471	7.429	1.790
	2.546	7.207	2.012
	2.622	6.832	2.387
	2.698	6.139	3.080
High Alarm Level	2.790	4.968	4.251
	2.849	4.130	5.089
	2.924	3.005	6.213
	3.000	2.139	7.079
	3.076	1.417	7.802
	3.151	0.709	8.510
Surcharge Level	3.227	0.000	9.219

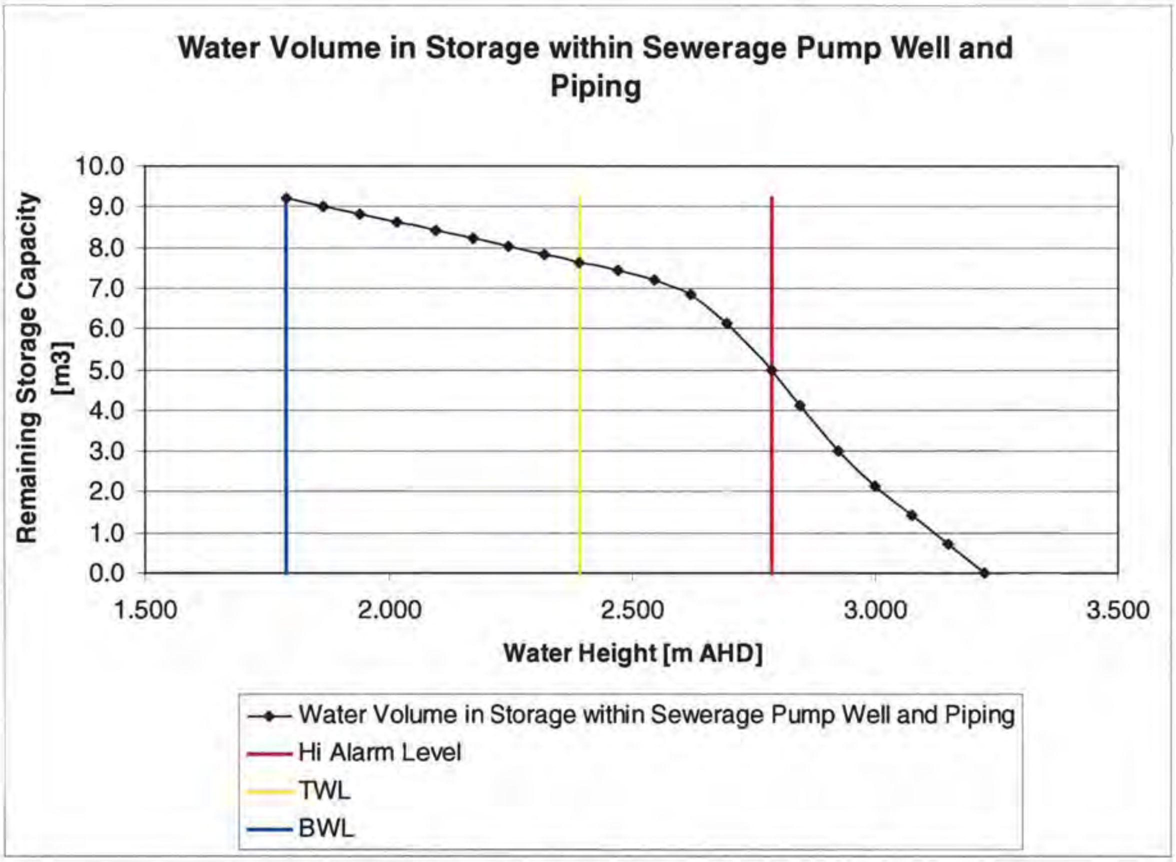

Figure 9: Level vs Volume Chart (SAMPLE)

The non-linearity of the curve level vs volume curve is caused by non cylindrical shape of the wet well, the displacement of volume caused by object inside the well (pumps and pipe work) and the additional capacity provided by the inlet pipes that feed the wet well. Refer to *Figure 10: Wet well diagram*

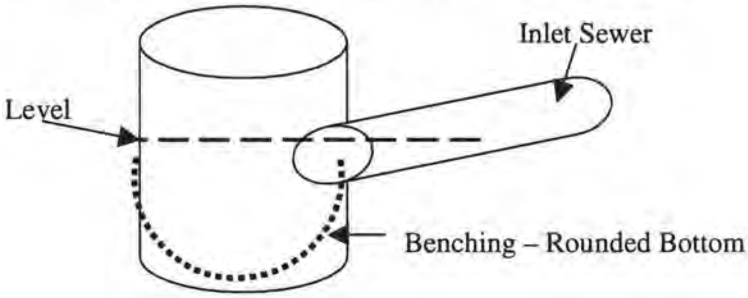

Figure 10: Wet well diagram

The data in the RTU database is stored in an array of 32 'segments'. Each segment has the volume of that segment and the height of that segment. (Not a cumulative height and volume as per the table shown). The site specific RTU database includes the 'SPxxx.main' file is stored on the IDTS server and can download directly to the RTU from the server. (Refer to *Appendix B: Spxxx.main File* for an example of a site *.main file).

The wet well vs volume table is derived from the 'As Constructed' civil drawings of the station and are provided by the System Planning section of Brisbane Water.

In *Figure 9: Level vs Volume Chart,* the 'Top Water Level' (TWL) is the Duty A Start, and the 'Bottom Water Level' (BWL) is Duty A Stop.

IDTS Database Record Name		
Plant	**Quantity**	**Description**
Wet_well	Volume	Volume of sewerage in wet well calculated from using the level in the lookup table

5.13 Station Surcharge Duration

While the surcharge occurring alarm is active, a timer is accumulated to measure the duration of the surcharge event. This figure is stored until a new surcharge occurring alarm is triggered, at which time the timer is reset to zero.

IDTS Database Record Name		
Plant	Quantity	**Description**
Wet_well	Surcharge_duration	Time duration of surcharge

5.14 Station Time to Surcharge (UNDER DEVELOPMENT)

When both pumps are stopped, the Station Inflow is used to calculate the time it would take the fill the remaining storage capacity (wet well capacity - current Wet Well Volume). The time (in minutes) to surcharge is only displayed on the station MITS GUI picture after the wet well high alarm is raised.

IDTS Database Record Name		
Plant	**Quantity**	**Description**
Wet_well	Surcharge_time_remaining	Estimated time in minutes until surcharge when both pumps are NOT running

5.15 Station Inflow (UNDER DEVELOPMENT)

The simplified formula for calculating the inflow over a period of time is

Inflow (l/s)	=	Volume Difference (litres) / Δt (s) + Outflow (l/s)
Volume Difference (l)	=	difference in volume over the sample period
Δt (s)	=	sample period
Outflow (l/s)	=	Integral of the flow meter for the sampling period

5.15.1 Method A – Time between Start and Stop

To ensure a change in volume large enough to make the inherent errors in the volume calculations negligible, method A takes the time to fill the well between the pump stop and start levels as the sampling time and the difference as the change in volume between the duty A stop and duty A start levels. This produced an average inflow over the sample period.

5.15.2 Method B – Array method

To remove the errors inherent in calculating small changes of wet well level, method B applies a 17 element FIFO (first in, first out) stack sampled every 15 second to produce a rolling average filter of the well level. The filter is reset (cleared) when a pump stops.

To calculate the instantaneous inflow, the volume calculated using the filtered wet well level is recorded every 2 minutes (every 8 samples of the wet well level). The volume difference is the change in volume over a sample period of 2 minutes.

To further stabilise the calculated instantaneous inflow calculation, the calculated inflow value itself is passed through a 7 element moving average filter. This filter is not reset between pump running transitions.

5.15.3 Combining Method A and Method B results

Due to the moving average filter and sample intervals used by method B, the first raw inflow value can not be calculated until 6 ¼ minutes after the pumps stopped. If the pumps are stopped long enough for method B to calculate a new inflow value then this new value if loaded into the inflow filter. The average of the last 7 values calculated is the new calculated average inflow figure.

Method A is used to calculate the inflow during high inflows (Off time is less than 6 ¼ minutes). When the flow is high enough that the off time is less than 6 ¼ minutes then the value calculated is 'flooded' into all elements of the inflow filter to make the average inflow value equal to newly calculated inflow value derived by method A.

5.15.4 Total Inflow

The total inflow for each day is the integration of the calculated average inflow value using 15 second sample rate.
Total Inflow (kl) = Total Inflow (kl) + [Inflow (l/s) x 15 (s)/1000]

IDTS Database Record Name		
Plant	**Quantity**	**Description**
Wet_well	Inflow	Instantaneous inflow to the wet well when pumps are NOT running
Wet_well	Total_inflow	Total inflow to the wet well since midnight when pumps are NOT running

6 IDTS SCADA CONFIGURATION

Every site on the IDTS SCADA system has to be configured individually. To make each site the following data must be released into the online database.

- Points Database
- Significant/Trigger Points
- History Database
- Site RTU database
- Alarm Instructions
- Site Picture

6.1 IDTS Points Database

The points database consists of all the points configured for communication with site RTU. They fall under one of three categories

- Digital Alarms and Events (Boolean)
- Control Points (Boolean, Real and Integer)
- Analog Status (Integer and Real)

These points are detailed on the 'IDTS spreadsheet' which is created for each site. This spreadsheet details each point's corresponding address in the RTU, sets up any alarm priority and all other point attributes. The site 'IDTS spreadsheet' is used by the IDTS system administrator to populate the online database with the site points required.

6.2 IDTS Significant Points

All points which are classified as priority 1 alarms are configured as 'significant' points. This is done on the online IDTS database and is then downloaded to the RTU. Any alarm configured to be significant will cause the RTU to immediately transmit to the IDTS master station.

6.3 IDTS History Database

All digital and analog points, for which trend data is to be stored, must be populated in the history database and have their parameter (such as sample granularity) configured. Only points configured in the history database can be trended on the IDTS SCADA system. The history database is configured by the IDTS system administrator.

6.4 IDTS Site RTU database

Each MD3311 or MD1000 RTU commissioned in the field has a RTU database generated from in the IDTS master station. This database stores all I/O (physical and pseudo) and also stores the wet well level vs volume data. This database can be used to re-configure the RTU CPU in case of failure. The RTU database is created using by the IDTS master station using the IO configuration, history configuration, significant points configuration as well as the *.main file in the IDTS server. (Refer to *Appendix B: Spxxx.main File* for an example of a site *.main file).

6.5 IDTS Alarm Instructions

The IDTS administrator installs the alarm instruction list onto the IDTS master station. Each file is linked to its associated alarm and provided the control room operator the actions required if that alarm is triggered. Below is an example of an alarm instruction file for the "Sewerage_pumping_station – Mains_fail alarm".

```
Contact Energex

If Energex are aware of the problem.
Request an estimate of when power will be restored.

If Energex are unaware of any problem.
An urgent inspection is required.

     Obtain estimate from contingency data as to likelihood of times station will
     overflow.

Normal hours:

Notify Field Services to attend.
Notify Field Services Duty Officer.
Inhibit flow from pumping stations upstream of station outage if possible.

Monitor & check regularly with Energex.

After hours:
Notify Field Services Duty Officer.
Inhibit flow from pumping stations upstream of station outage if possible.


If Energex are unaware of any problem.
An urgent inspection is required.
```

The alarm instructions are generic for each alarm plant and quantity. The IDTS administrator can generate a site specific instruction file if the site needs a unique instruction. It is preferable, however, to expand on the generic alarm instruction where possible as this reduces the amount of deviation from the standard. (Easier to maintain the current set of alarm instruction list)

6.6 IDTS Pictures

6.6.1 Main Site Detail Screen

Each 3 pump submersible pump station has as a detail screen as shown below:

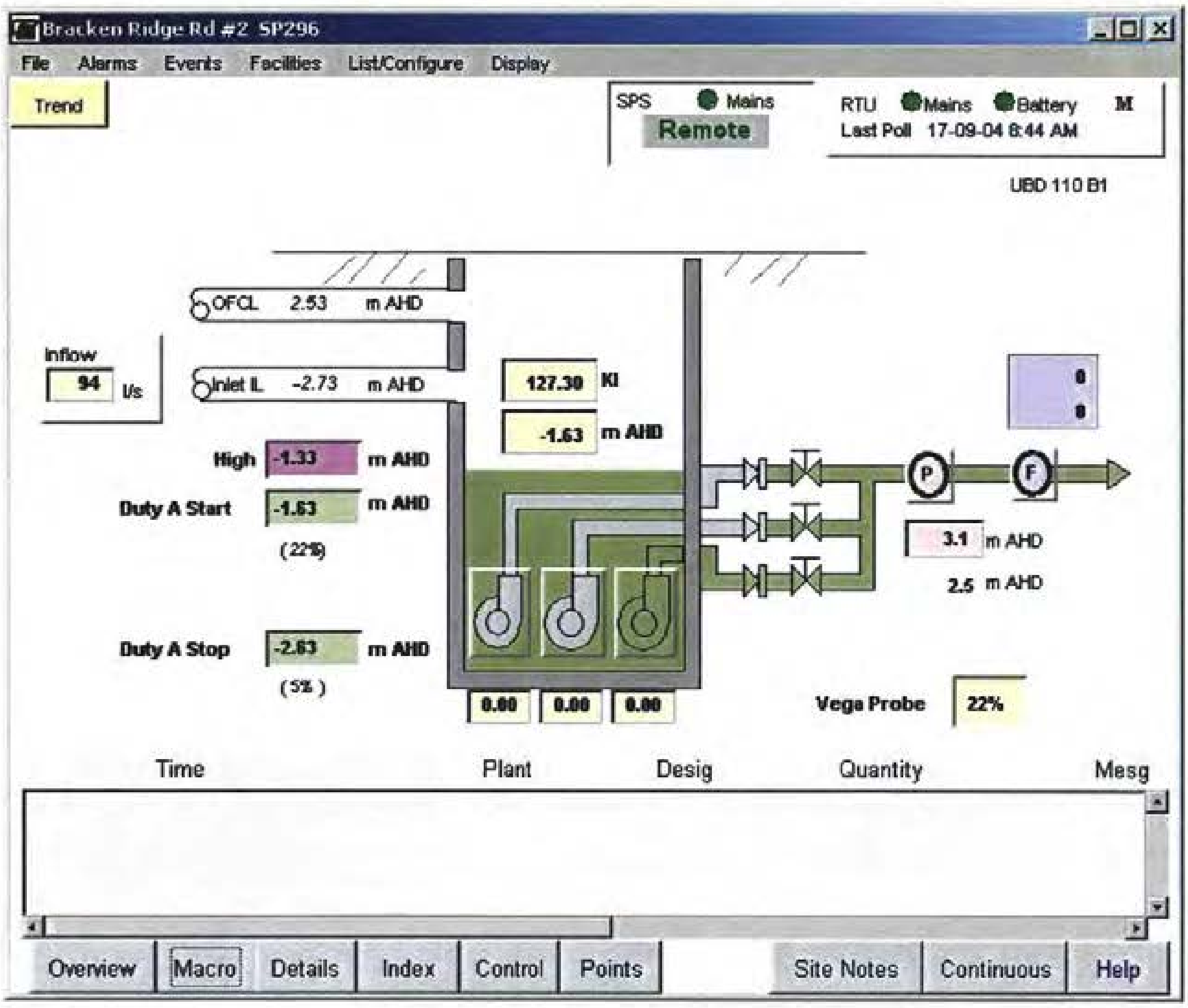

Figure 11: Site Detail Screen

Live points from RTU fed back to picture:

- Wet well level in metres AHD and % full.
- Pump duty A start level (in metres AHD and percentage), pump duty A stop level, and wet well high level
- Status of each pump (available, running, inhibited status shown by colour)
- Speed of each pump
- Delivery pressure in metres AHD
- Delivery flow in l/s (and volume for the day)
- Site power status
- Local/ remote control status
- Station inflow (when pumps are not running)
- Wet well volume
- Time (in minutes) to surcharge (when pumps are unavailable and wet well high alarm is active)

IDTS database points in the picture are stored in the IDTS database and not in the RTU. These values are displayed in the main station picture:

- The Inlet level (metres AHD)
- Overflow Control Level (metres AHD)
- Site Level (metres AHD)

6.6.2 Popup Controls Screens

Pump Control Popup

Each pump can be controlled by the following popup. Clicking on the pump icon on the main operator screen activates the individual pump control screens.

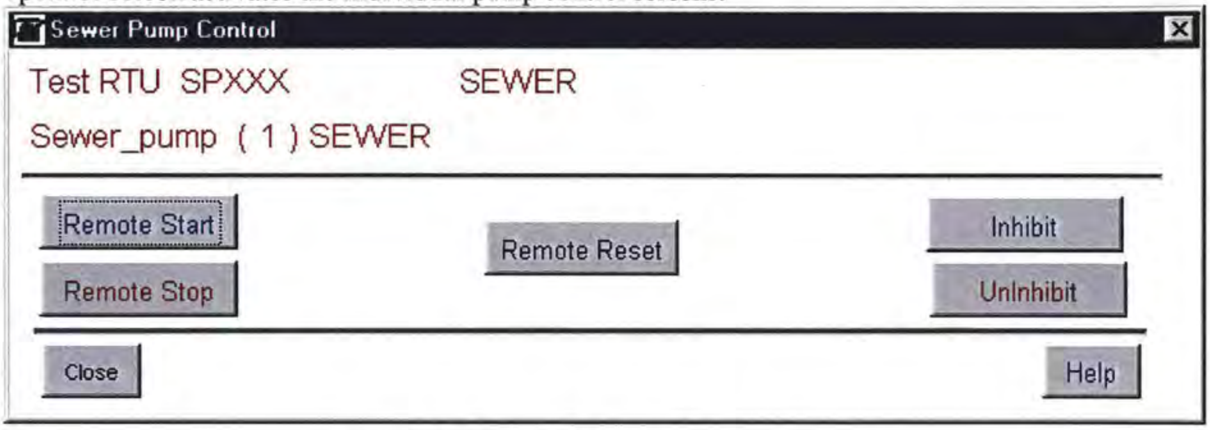

Figure 12: Pump Control Popup

Attention Alarm button

The Site Attention Control Popup is activated by pressing the "Attention" button of the main control page (bottom LHS of screen).

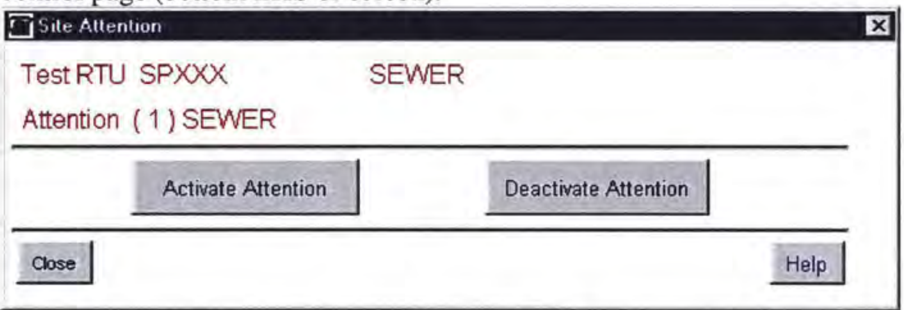

Figure 13: Set Point Control Popup

Set point adjustment - alarm limits

Clicking on a set point will give you the set point control popup.

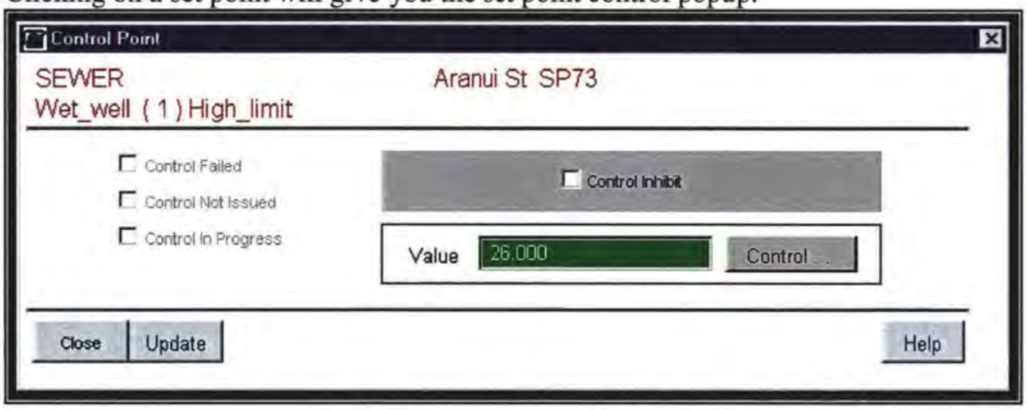

Figure 14: Control Point Page

Appendix A: STANDARD PHYSICAL I/O LIST

The Physical IO Spreadsheet will be created for each site, identifying not only the standard IO, but the Drawing Numbers which are unique to each site. This Physical IO Spreadsheet becomes part of the On-site documentation, providing a quick reference guide of the Physical IO to the on site technician.

Brisbane Water

MITS MD3311 EA (Extended I-O) DIGITAL INPUTS (0-15) SP103 Heroes Ave Sewage Pumping S

I/O #	Description	MITS Tag	Off State	On State	Term. #	Wire #	Drawing #
0	Spare	-	-	-		DI00	
1	Spare	-	-	-		DI01	
2	Spare	-	-	-		DI02	
3	Spare	-	-	-		DI03	
4	Spare	-	-	-		DI04	
5	Spare	-	-	-		DI05	
6	Spare	-	-	-		DI06	
7	Spare	-	-	-		DI07	
8	Spare	-	-	-		DI08	
9	Spare	-	-	-		DI09	
10	Spare	-	-	-		DI10	
11	Spare	-	-	-		DI11	
12	Site attention alarm reset pushbutton	atnlacknowledge	Not Pressed	Pressed		DI12	
13	Spare	-	-	-		DI13	
14	Spare	-	-	-		DI14	
15	Site Power	stnlsitePower	Fault	Healthy		DI15	

SP103 Heroes Ave Sewage Pumping S

Brisbane Water

MITS MD3311 EA (Extended I-O) DIGITAL INPUTS (16-31)

I/O #	Description	MITS Tag	Off State	On State	Term. #	Wire #	Drawing #
16	Spare	-	-	-		DI16	
17	Spare	-	-	-		DI17	
18	Spare	-	-	-		DI18	
19	Spare	-	-	-		DI19	
20	Spare	-	-	-		DI20	
21	Spare	-	-	-		DI21	
22	Spare	-	-	-		DI22	
23	Spare	-	-	-		DI23	
24	Spare	-	-	-		DI24	
25	Spare	-	-	-		DI25	
26	Spare	-	-	-		DI26	
27	Spare	-	-	-		DI27	
28	RTU Power	RTUpower	Off	On		DI28	
29	Surge Diverter Alarm	Stn1SurgeDivAlm	Healthy	Fault		DI29	
30	Spare	-	-	-		DI30	
31	Spare	-	-	-		DI31	

SP103 Heroes Ave Sewage Pumping S

MITS MD3311 EA (Extended I-O) DIGITAL INPUTS (32-47)

I/O #	Description	MITS Tag	Off State	On State	Term. #	Wire #	Drawing #
32	Generator Fault	gen1tripped	Ok	Tripped		DI32	
33	Generator Warning	gen1warning	Ok	Alarm		DI33	
34	Generator Low Fuel	gen1lowFuel	Ok	Low		DI34	
35	Generator Running	gen1running	Stopped	Running		DI35	
36	Generator Connected	gen1connected	Energex	Generator		DI36	
37	Energex Power	energexPower	Available	Not Available		DI37	
38	Generator Security	gen1security	Unsecured	Secured		DI38	
39	Generator CB Status	gen1locCBTripped	Closed	Tripped		DI39	
40	Generator Mode	gen1auto	Auto	Not Auto		DI40	
41	Generator On Site	gen1onSite	False	True		DI41	
42	Spare	-	-	-		DI42	
43	Security Alarm	???	Alarm	Healthy		DI43	
44	Main Incomer CB Closed	???	Open	Closed		DI44	
45	Battery System OK	???	Fault	Healthy		DI45	
46	Cathodic Protection Alarm Reset	???	Not Pressed	Pressed		DI46	
47	Cathodic Protection Power	???	Off	On		DI47	

Brisbane Water

MITS MD3311 EA (Extended I-O) DIGITAL OUTPUTS (0-15)

I/O #	Description	MITS Tag	Off State	On State	Term. #	Wire #	Drawing #
0	Spare	-	-	-		DO00	
1	Spare	-	-	-		DO01	
2	Spare	-	-	-		DO02	
3	Spare	-	-	-		DO03	
4	Spare	-	-	-		DO04	
5	Spare	-	-	-		DO05	
6	Spare	-	-	-		DO06	
7	Spare	-	-	-		DO07	
8	Generator Remote Start	gen1start	Off	On		DO08	
9	Generator Remote Stop	gen1stop	Off	On		DO09	
10	Spare	-	-	-		DO10	
11	Wet Well Washer Solenoid	Wwl1Washer	Off	On		DO11	
12	Attention alarm Indicator	atn1indicator	Off	Alarm		DO12	
13	Battery Check	BattCycRelay	Off	On		DO13	
14	Cathodic Protection Alarm Indicator	cp1Alarm	Off	Alarm		DO14	
15	Cathodic Protection De-energise Rectifier Unit	cp1DeEnergise	Energise	De-Energise		DO15	

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MITS MD3311 EA (Extended I-O) ANALOG INPUTS (0-7)

SP103 Heroes Ave Sewage Pumping S

I/O #	Description	MITS Tag	4mA	20mA	Term. #	Wire #	Drawing #
0	Cathodic Protection Rectifier Current	cp1RectCurrent	Site Specific	Site Specific		AI00 +/-	
1	Wet Well Level	wwl1level	0.000 m	??.000 m		AI01 +/-	
2		-	-	-		AI02 +/-	
3		-	-	-		AI03 +/-	
4		-	-	-		AI04 +/-	
5		-	-	-		AI05 +/-	
6		-	-	-		AI06 +/-	
7		-	-	-		AI07 +/-	

Brisbane Water

GE-Fanuc 90-30 PACK 0

SP103 Heroes Ave Sewage Pumping Station

GE FANUC

RACK: 0
Slot: 3
Card Type: IC693MDL645
Description: 16 Point Digital Input 24VDC

I/O #	Term. #	Description	GE Tag	Address	Off State	On State	Term. #	Wire #	Drawing #
1	2	Station Local remote switch.	Stn01diRemote	%I0001	Local	Remote		DI1-01	
2	3	Station Surcharge Imminent level	Stn01diSurchImm	%I0002	Healthy	Surcharge Imm		DI1-02	
3	4	Spare	%I0003	%I0003	-	-		DI1-03	
4	5	Spare	%I0004	%I0004	-	-		DI1-04	
5	6	Spare	%I0005	%I0005	-	-		DI1-05	
6	7	Spare	%I0006	%I0006	-	-		DI1-06	
7	8	Spare	%I0007	%I0007	-	-		DI1-07	
8	9	Spare	%I0008	%I0008	-	-		DI1-08	
9	10	Spare	%I0009	%I0009	-	-		DI1-09	
10	11	Spare	%I0010	%I0010	-	-		DI1-10	
11	12	Spare	%I0011	%I0011	-	-		DI1-11	
12	13	Spare	%I0012	%I0012	-	-		DI1-12	
13	14	Spare	%I0013	%I0013	-	-		DI1-13	
14	15	Spare	%I0014	%I0014	-	-		DI1-14	
15	16	Spare	%I0015	%I0015	-	-		DI1-15	
16	17	Spare	%I0016	%I0016	-	-		DI1-16	

Brisbane Water

GE FANUC

SP103 Heroes Ave Sewage Pumping Station

RACK: 0
Slot: 4
Card Type: IC693MDL645
Description: 16 Point Digital Input 24VDC

GE-Fanuc 90-30 PACK 0

I/O #	Term. #	Description	GE Tag	Address	Off State	On State	Term. #	Wire #	Drawing #
1	2	Pump 1 Pump power on	Pmp01diPower	%I0017	Off	On		DI2-01	
2	3	Pump 1 Reflux Valve Open	Pmp01diRefluxOpen	%I0018	Not Open	Open		DI2-02	
3	4	Pump 1 Local start pushbutton	Pmp01diLocalStartPB	%I0019	Not Pressed	Pressed		DI2-03	
4	5	Pump 1 Local stop pushbutton	Pmp01diLocalStopPB	%I0020	Not Pressed	Pressed		DI2-04	
5	6	Pump 1 Emergency Stop	Pmp01diEStop	%I0021	Fault	Healthy		DI2-05	
6	7	Pump 1 VFD Auto	Pmp01diVFDAuto	%I0022	Manual	Auto		DI2-06	
7	8	Pump 1 VFD Ready	Pmp01diVFDReady	%I0023	Fault	Ready		DI2-07	
8	9	Pump 1 local reset pushbutton	Pmp01diLocalReset	%I0024	Not Pressed	Pressed		DI2-08	
9	10	Pump 1 Running	Pmp01diRunning	%I0025	Not Running	Running		DI2-09	
10	11	Pump 1 Moisture in Oil	Pmp01diMIO	%I0026	Healthy	Fault		DI2-10	
11	12	Pump 1 Thermistor Fault	Pmp01diTermistor	%I0027	???	???		DI2-11	
12	13	Pump 1 Bearing Temperature	Pmp01diBearingTemp	%I0028	???	???		DI2-12	
13	14	Spare	%I0029	%I0029	-	-		DI2-13	
14	15	Spare	%I0030	%I0030	-	-		DI2-14	
15	16	Spare	%I0031	%I0031	-	-		DI2-15	
16	17	Spare	%I0032	%I0032	-	-		DI2-16	

Brisbane Water

SP103 Heroes Ave Sewage Pumping Station

GE FANUC

RACK: 0
Slot: 5
Card Type: IC693MDL645
Description: 16 Point Digital Input 24VDC

GE-Fanuc 90-30 PACK 0

I/O #	Term. #	Description	GE Tag	Address	Off State	On State	Term. #	Wire #	Drawing #
1	2	Pump 2 Pump power on	Pmp02diPower	%I0033	Off	On		DI3-01	
2	3	Pump 2 Reflux Valve Open	Pmp02diRefluxOpen	%I0034	Not Open	Open		DI3-02	
3	4	Pump 2 Local start pushbutton	Pmp02diLocalStartPB	%I0035	Not Pressed	Pressed		DI3-03	
4	5	Pump 2 Local stop pushbutton	Pmp02diLocalStopPB	%I0036	Not Pressed	Pressed		DI3-04	
5	6	Pump 2 Emergency Stop	Pmp02diEStop	%I0037	Fault	Healthy		DI3-05	
6	7	Pump 2 VFD Auto	Pmp02diVFDAuto	%I0038	Manual	Auto		DI3-06	
7	8	Pump 2 VFD Ready	Pmp02diVFDReady	%I0039	Fault	Ready		DI3-07	
8	9	Pump 2 local reset pushbutton	Pmp02diLocalReset	%I0040	Not Pressed	Pressed		DI3-08	
9	10	Pump 2 Running	Pmp02diRunning	%I0041	Not Running	Running		DI3-09	
10	11	Pump 2 Moisture in Oil	Pmp02diMIO	%I0042	Healthy	Fault		DI3-10	
11	12	Pump 2 Thermistor Fault	Pmp02diTermistor	%I0043	???	???		DI3-11	
12	13	Pump 2 Bearing Temperature	Pmp02diBearingTemp	%I0044	???	???		DI3-12	
13	14	Spare	%I0045	%I0045	-	-		DI3-13	
14	15	Spare	%I0046	%I0046	-	-		DI3-14	
15	16	Spare	%I0047	%I0047	-	-		DI3-15	
16	17	Spare	%I0048	%I0048	-	-		DI3-16	

SP103 Heroes Ave Sewage Pumping Station

GE FANUC

RACK: 0
Slot: 6
Card Type: IC693MDL645
Description: 16 Point Digital Input 24VDC

GE-Fanuc 90-30 PACK 0

I/O #	Term. #	Description	GE Tag	Address	Off State	On State	Term. #	Wire #	Drawing #
1	2	Pump 3 Pump power on	Pmp03diPower	%I0049	Off	On		DI4-01	
2	3	Pump 3 Reflux Valve Open	Pmp03diRefluxOpen	%I0050	Not Open	Open		DI4-02	
3	4	Pump 3 Local start pushbutton	Pmp03diLocalStartPB	%I0051	Not Pressed	Pressed		DI4-03	
4	5	Pump 3 Local stop pushbutton	Pmp03diLocalStopPB	%I0052	Not Pressed	Pressed		DI4-04	
5	6	Pump 3 Emergency Stop	Pmp03diEStop	%I0053	Fault	Healthy		DI4-05	
6	7	Pump 3 VFD Auto	Pmp03diVFDAuto	%I0054	Manual	Auto		DI4-06	
7	8	Pump 3 VFD Ready	Pmp03diVFDReady	%I0055	Fault	Ready		DI4-07	
8	9	Pump 3 local reset pushbutton	Pmp03diLocalReset	%I0056	Not Pressed	Pressed		DI4-08	
9	10	Pump 3 Running	Pmp03diRunning	%I0057	Not Running	Running		DI4-09	
10	11	Pump 3 Moisture in Oil	Pmp03diMIO	%I0058	Healthy	Fault		DI4-10	
11	12	Pump 3 Thermistor Fault	Pmp03diTermistor	%I0059	???	???		DI4-11	
12	13	Pump 3 Bearing Temperature	Pmp03diBearingTemp	%I0060	???	???		DI4-12	
13	14	Spare	%I0045	%I0061	-	-		DI4-13	
14	15	Spare	%I0046	%I0062	-	-		DI4-14	
15	16	Spare	%I0047	%I0063	-	-		DI4-15	
16	17	Spare	%I0048	%I0064	-	-		DI4-16	

Brisbane Water

GE FANUC

SP103 Heroes Ave Sewage Pumping Station

RACK: 0
Slot: 7
Card Type: IC693MLD940
Description: 16 Point Ditital relay Output 2A

GE-Fanuc 90-30 PACK 0

I/O #	Term. #	Description	GE Tag	Address	Off State	On State	Term. #	Wire #	Drawing #
1	2	Pump 1 Status Indicator	Pmp01dqLamp	%Q0001	Off	On		DO1-01	
2	3	Pump 1 Run Command	Pmp01dqGo	%Q0002	Off	Run		DO1-02	
3	4	Pump 1 Fault Reset	Pmp01dqReset	%Q0003	Off	Reset		DO1-03	
4	5	Pump 1 Run at Maximum Speed	Pmp01dqRunMax	%Q0004	Off	Maximum Speed		DO1-04	
5	7	Pump 2 Status Indicator	Pmp02dqLamp	%Q0005	Off	On		DO1-05	
6	8	Pump 2 Run Command	Pmp02dqGo	%Q0006	Off	Run		DO1-06	
7	9	Pump 2 Fault Reset	Pmp02dqReset	%Q0007	Off	Reset		DO1-07	
8	10	Pump 2 Run at Maximum Speed	Pmp02dqRunMax	%Q0008	Off	Maximum Speed		DO1-08	
9	12	Pump 3 Status Indicator	Pmp03dqLamp	%Q0009	Off	On		DO1-09	
10	13	Pump 3 Run Command	Pmp03dqGo	%Q0010	Off	Run		DO1-10	
11	14	Pump 3 Fault Reset	Pmp03dqReset	%Q0011	Off	Reset		DO1-11	
12	15	Pump 3 Run at Maximum Speed	Pmp03dqRunMax	%Q0012	Off	Maximum Speed		DO1-12	
13	17	Spare	%Q0013	%Q0013	-	-		DO1-13	
14	18	Spare	%Q0014	%Q0014	-	-		DO1-14	
15	19	Spare	%Q0015	%Q0015	-	-		DO1-15	
16	20	Spare	%Q0016	%Q0016	-	-		DO1-16	

Brisbane Water

GE FANUC

SP103 Heroes Ave Sewage Pumping Station

RACK: 0
Slot: 8
Card Type: IC693ALG221
Description: 4 Channel Analog Input Current (Isolated)

GE-Fanuc 90-30 PACK 0

I/O #	Term. #	Description	GE Tag	Address	4mA	20mA	Term. #	Wire #	Drawing #
1	3,5	Wet Well Level	Wwl01aiRaw	%AI001	0.000 m	??.000 m		AI1-01P	
2	4,6	Delivery Pressure	Pre01aiRaw	%AI002	0.00 m	???.00 m		AI1-02P	
3	13,15	Delivery Flow	Flw01aiRaw	%AI003	0.0 l/s	???.00 l/s		AI1-03P	
4	14,16	Spare	%AI004	%AI004	-	-		AI1-04P	

Brisbane Water

SP103 Heroes Ave Sewage Pumping Station

GE FANUC

RACK: 0
Slot: 9
Card Type: IC693ALG221
Description: 4 Channel Analog Input Current (Isolated)

GE-Fanuc 90-30 PACK 0

I/O #	Term. #	Description	GE Tag	Address	4mA	20mA	Term. #	Wire #	Drawing #
1	3,5	Pump 1 VFD Running Speed	Pmp01SpeedFbk	%AI005	0.0%	100%		AI2-01P	
2	4,6	Pump 2 VFD Running Speed	Pmp02SpeedFbk	%AI006	0.0%	100%		AI2-02P	
3	13,15	Pump 3 VFD Running Speed	Pmp03SpeedFbk	%AI007	0.0%	100%		AI2-03P	
4	14,16			%AI008				AI2-04P	

Brisbane Water

SP103 Heroes Ave Sewage Pumping Station

GE FANUC

RACK: 0
Slot: 10
Card Type: IC693ALG392
Description: 8 Channel Analog Output Current

GE-Fanuc 90-30 PACK 0

I/O #	Term. #	Description	GE Tag	Address	4mA	20mA	Term. #	Wire #	Drawing #
1		Pump No.1 Speed Command	Pmp01aqControlSpeed	%AQ001	0%	100%		AO1-01P	
2		Pump No.2 Speed Command	Pmp02aqControlSpeed	%AQ002	0%	100%		AO1-02P	
3		Pump No.3 Speed Command	Pmp03aqControlSpeed	%AQ003	0%	100%		AO1-03P	
4				%AQ004				AO1-04P	
5				%AQ005				AO1-05P	
6				%AQ006				AO1-06P	
7				%AQ007				AO1-07P	
8				%AQ008				AO1-08P	

Appendix B: SPXXX.MAIN FILE

```
/*
 *      SP285 - Aringa Cres
 */
#include "../include/rtudata.h"
#include "../include/md3scanlist.h"
#include "../include/ctrlschl.h"
#include "../include/grfb0002.h"
#include "../include/grfb0006.h"
#include "../include/db_constants.h"

#ifndef PERMANENT

defineclass remote_rtu REMOTE_RTU_CLASS

/* Master station dial-in radio numbers */

record 1                                        /* Trio Alarmcall               */
        trio_ipad       0xc0a82346              /* Source IP Address (RTU)      */
        ipad            0xc0a82301              /* Destination IP Address (CSU) */


defineclass rtu_rtu RTU_RTU_CLASS
/*
 *  Vaga Probe length = ?m
 *  Diameter = ?.???m
 *  the volume value is derived from the formula PI*(r^2)*h, where
 *  r = d/2, h = level and PI = 3.1415927. the volume value represents
 *  the volume of the segment defined by the level associated with
 *  the volume value and the previous level/volume record. If the
 *  current record is the first of the list then the segment is defined
 *  by the level associated with the volume value and the level of 0.0.
 *
 *  level values are entered as millimetres.
 *  volume values are entered as m^3 (or kL).
 */

defineclass wetwell WETWELL_CLASS

/* wet well level to volume lookup table - based on vega probe 0 level */
record 1
        { level 88      volume 0.000 }
        { level 207     volume 0.653 }
        { level 308     volume 0.552 }
        { level 445     volume 0.753 }
        { level 564     volume 0.653 }
        { level 708     volume 0.784 }
        { level 803     volume 0.521 }
        { level 922     volume 0.653 }
        { level 1041    volume 0.728 }
        { level 1160    volume 1.026 }
        { level 1280    volume 1.108 }
        { level 1399    volume 1.331 }
        { level 1518    volume 1.320 }
        { level 1637    volume 1.233 }
        { level 1756    volume 1.170 }
        { level 1876    volume 1.208 }
        { level 1995    volume 1.392 }
        { level 2114    volume 1.342 }
        { level 2233    volume 1.470 }
        { level 2353    volume 1.436 }
        { }

/* wet well surcharge outflow per second lookup table - based on lip of surcharge */
record 2
        { level 0250    volume 1.000 }
        { level 0500    volume 1.000 }
        { level 0750    volume 1.000 }
        { level 1000    volume 1.000 }
        { level 2000    volume 4.000 }
        { }

/*
 * Automatically Generated Database files
 */
#include "SP285.scanlist"
#endif
#include "SP285.reset_fm"
```

Appendix C: DRAWING LIST

TO BE COMPLETED ONCE THE STANDARD DRAWINGS HAVE BEEN CREATED

Electrical Drawing List			
Sheet #	Drawing #	Rev.	Title