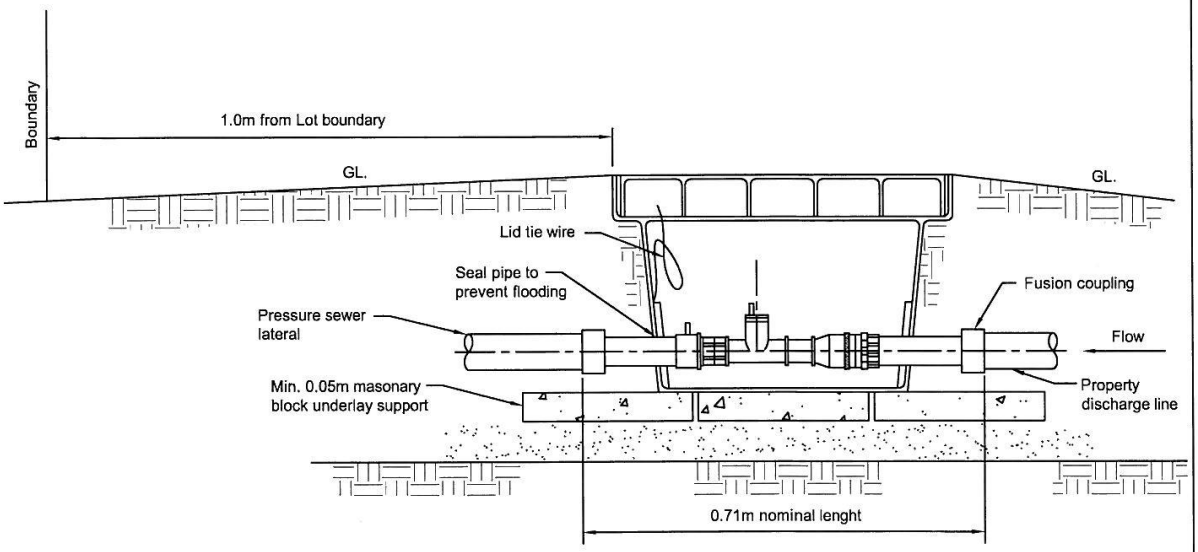
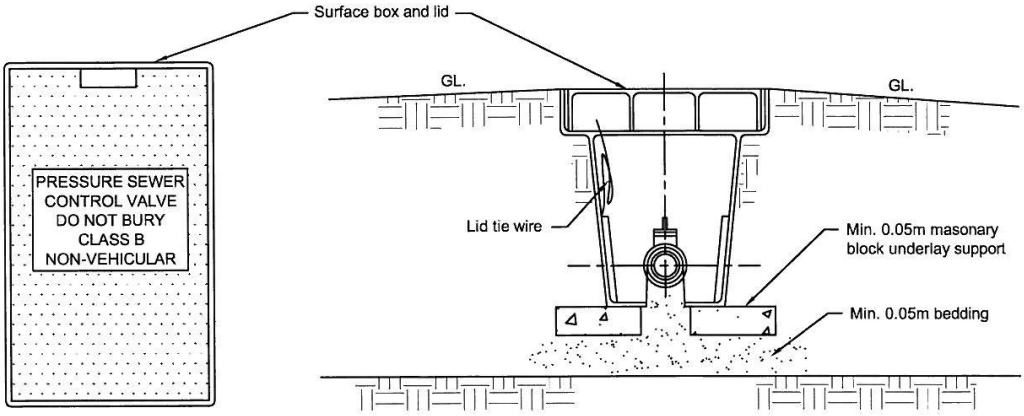
NOTES:

1. All dimensions in meters unless otherwise specified
2. Use only approved components
3. Ensure that the lid of surface box is marked as shown. Where the warning/name plate is not cast or moulded into the lid, affix an engraved SS name plate using SS fasteners
4. Prepare bedding metal under box to specification
5. Install surface box slightly proud of surface so the GL. can be graded away from the lid
6. Test assembly and connecting pressure sewers hydrostatically after installation in accordance with the KDC code
7. All pressure pipework items to be PN 16



SIDE ELEVATION



PLAN

END ELEVATION

BOUNDARY CONNECTION KIT

No.	Revisions	Date
Designed	M.WINCH	08/08
Approved		09/09
Drawing Status	IMPLEMENTATION	
Office Location	CPG, WHANGAREI	

KAIPARA DISTRICT

KAIPARA DISTRICT COUNCIL
ENGINEERING STANDARDS 2009

Drawing S40
Revision 0
Scale N.T.S.

ORIGINAL SIZE mm A4

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12. APPENDIX B

Mangawhai EcoCare Project
Pump Stations Communication Standard

Communication Standard Pump Stations

Mangawhai Ecocare Project

Customer:	**Water Infrastructure Group**
Document Number:	**225-310-FD-004**
Revision:	**V2.0**
Status:	**For Construction**
Date:	**04-08-2009**
Author:	**Bart Post / Ariel Racioppi**

McKay

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1 Introduction

The purpose of this document is to describe the standard for the interfacing between the Pump Stations and the Waste Water treatment Plant for the Mangawhai Ecocare Project.
The first part of the Ecocare project, comprising of the Waste Water Treatment Plant and ten Pump Stations, has been implemented. In the future more Pump Stations will be connected to the Treatment Plant. To avoid having multiple telemetry systems and communication standards in the system, this document can be used to design future Pump Stations in a way that the interfacing is compatible with the current Pump Stations.
The first part of this document describes the control and telemetry components used for the first stage. Part two deals with the minimal requirements regarding the telemetry interface of future pump stations.

McKay

2 System Overview first stage

The system overview in figure 1 shows the configuration of the first stage of the Ecocare project, the Waste Water Treatment Plant and ten Pump Stations.
Each pump station is controlled by two Altivar61 Variable Speed Drives (VSD) with "controller inside" (CI) and Ethernet cards. The CI cards control the pump station depending on the signals from the field like the analogue level and the level switches. They are working in a redundant configuration, which means that if one of the drives fails, the other drive is still capable of operating automatically.
Data buffering is achieved by using a Kingfisher RTU that communicates with the speed drives through a Modbus/TCP connection. The RTU works as a data concentrator/data buffer only and has no control function. From the RTU, the data is passed on to the WWTP by using a cellular modem that creates a Virtual Private Network (VPN) link to the router at the WWTP side. The cellular modems keep the VPN open all the time, so basically a Wide Area Network (WAN) is created between the pump stations and the WWTP.

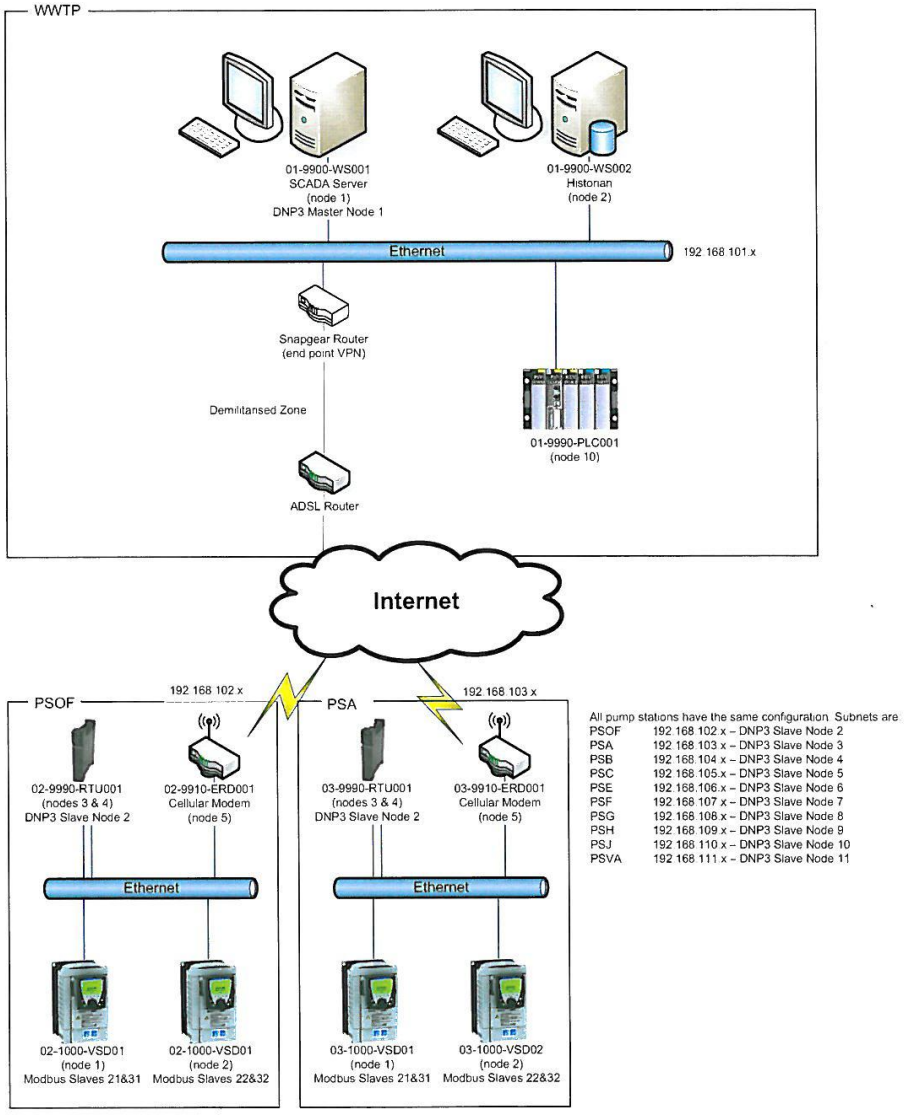

Figure 1; Control System Overview

3 Monitoring and control structure first stage

3.1 Control System

Each Pump Station is fitted with the following equipment:

- One cellular modem: allows the communication between the Waste Water Treatment Plant (WWTP) SCADA and the pump stations.
- One Ethernet Switch: allows the internal communication between Radio, Remote Terminal Unit (RTU) and VSD's
- One Remote Terminal Unit (RTU): acts as a buffer, data concentrator and communication gateway between the WWTP SCADA and the VSD's. The RTU is DNP3 slave node (with the SCADA being the Master) and a Modbus/TCP master node (with the VSD's being the slaves). There is no direct communication between the RTU and the PLC in the WWTP.
- Two Variable Speed Drives (VSD):

Each VSD has its own controller card that contains a wet well control program with configurable control algorithms required to monitor and control the individual pumps and share information with the other pump. The VSD's are connected together via a CANOpen Network that allows the VSD's to work together as one integrated unit or if the CANOpen Network is lost, the VSD's can operate as standalone devices. The system also allows for handling external signals like the contacts from the surge arrestor monitor or the circuit breaker of an independent device like a fan. Therefore there is no need for a PLC or IO on a RTU. All interfacing between the field and the controls is done through the IO on the VSD cards.

The control card in the VSD allows for several operating modes, but for this application there are only the following:

- Automatic; The pumps are controlled from the controller inside cards.
- Local Manual; by pressing the F4 function key on the drive's keypad, the drive can be controlled locally. This means that the pump can be started and stopped by pressing the start and stop buttons on the drive's keypad and that the speed can be controlled by the wheel on the drive. Pressing the F4 button again will take it out of manual mode.
- Remote Manual; when the drive is in remote (this is the normal situation) a pump can be started and its speed controlled from the SCADA at the WWTP site. This is done from the faceplate of each individual pump on the HMI screen.

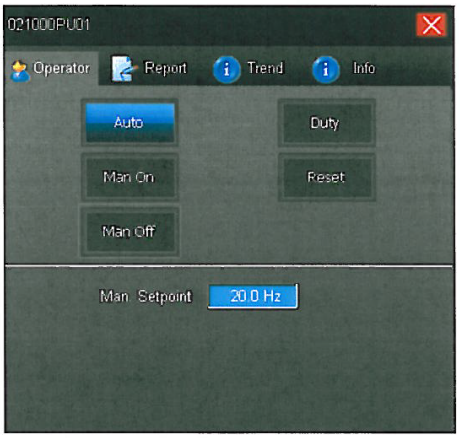

Figure 2; Faceplate for remote control of pump station pumps

When a VSD starts-up the drive will always be in remote.

The system controls in a duty / standby arrangement, whereby one VSD is the duty and the other is the standby. The duty status of the VSD's can be cycled between the VSD's or remain with one VSD. It's also possible to issue a remote command from the WWTP SCADA system to swap the duty and standby pumps (see faceplate above). When a fault is detected in the duty drive, the control is automatically handed over to the standby drive.
If a VSD has a fault, the operator can try to reset the VSD, both locally on the drive's keypad or remotely on the WWTP SCADA system (see faceplate above).

3.1.1 Control philosophy

The pumps are started and stopped in a duty/standby configuration dependant on the level in the wet well. (See figure Figure 3; Wet Well level limits) In the picture pump 1 is the duty pump and pump 2 the standby.
The duty pump starts at the "pump 1 start level" at the preconfigured "start speed". If the level keeps rising the speed is increased to the preconfigured "pump 1 limit level speed ", which is the maximum speed. If the level decreases and gets below the "pump 1 limit level" the speed will decrease until the level reaches the "pump 1 start level". The pump will keep pumping at the "start level speed" until the level gets below the "pump 1 low stop" setpoint.
If the level gets above the "pump 2 start level", it is assumed that the duty pump has a problem and this pump will be stopped and the standby pump will be started.
The "high" switch point provided by one of the two floating balls generates an extra "switch on" command for the duty pump. The speed is preconfigured at 50Hz. The pump will keep running for a preconfigured time.
The "HighHigh" switch point of the upper floating ball provides an alarm to the WWTP. This is the same level as the overflow level of the pump station.

For some pump stations, the mains power supply is not sufficient to run both pumps at the same time. Therefore an interlock has been put in place that prevents a pump from running if the other pump is running. This is a hardware interlock, so it will work in both local manual, remote manual and auto modes.

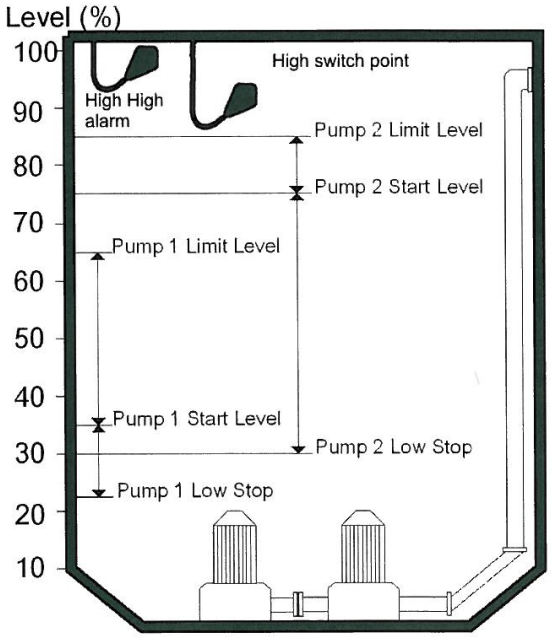

Figure 3; Wet Well level limits

A typical profile for this type of control is outlined below:

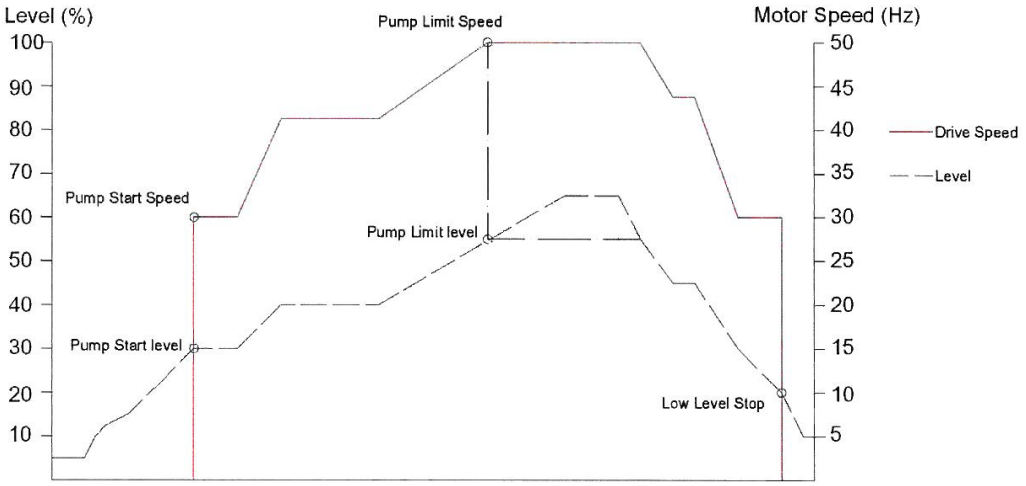

Figure 4; Typical pump profile

The wet well controller card in the VSD's comes with a number of features, of which only the following are used:

- **Pipe fill algorithm:**
  On initial start of the duty pump, the algorithm presets the speed to a configurable value (50Hz) (only on the drive itself) for a configurable time (30s). After the timer has expired, the normal control will take over. The mechanism is used for flushing the pipe.
- **Anti Jam:**
  The Anti Jam function is used to dislodge any product or detritus that may be attached to the pump impeller. It may also be used to clear a blocked pipe or valve. The anti Jam function works by rapidly accelerating and decelerating the pump for an adjustable amount of cycles. All speeds, acceleration, deceleration rates and times are adjustable depending on the pump station configuration. The trigger for this program is the motor current.
- **High Water:**
  If the Hi switch input is activated, the pump will run at a preconfigured speed ("Switch Speed") for a preconfigured time ("Switch Time") or until there is "no load current"
- **High High:**
  The High High switch will generate an alarm to indicate that the well overflows into the emergency storage.

The Wet Well Controller will respond to a fault condition in one of three ways, depending on the nature of the fault.

- **Warning:**
  Each alarm condition can be set up to give a warning message. The alarm will not trip the drive or stop the pump. The VSD's HMI will display a Flashing warning message on the status display which will also be shown on the HMI of the WWTP.
- **Trip:**
  This is a pump system fault that is considered too serious to allow the pump to continue operating. If the pump trips, then the pump will remain in fault until a reset is initiated. A relevant fault message will be displayed which will also be shown on the HMI of the WWTP.
- **Reset:**
  This is a pump system related fault that is expected to clear if the pump (system) shuts down temporarily. A relevant fault message will be displayed. The system will automatically reset a certain amount of times for each individual fault. The number of resets and the interval between resets can be configured. (3 resets, 1800sec interval)

The following protections are defined in the VSD:

- **Cavitation Protection: (Reset)**
  Cavitation protection is activated when the pump is running at high speed, but the current is low. When cavitation is detected, the pump will stop and display the status. The system will auto restart after 15min
- **Cycling protection: (Reset)**
  If the pump cycles between start and stop faster than at a configurable frequency, the cycling protection will be activated. Both the cycle time (3min) and the cycle count (4) can be configured.

3.1.2 Hardware I/O

Each VSD has the following hardware interface:

Analogue Well Level:	AI2
High Level switch:	CI_LI54
HighHigh Level switch:	CI_LI57
Surge Arrestor:	CI_LI58
Switchboard fan trip:	LI5
Control power:	LI3
Thermistor:	LI6

3.1.3 Alarms

The following alarms are defined in the VSD:
(For the description of the alarm handling procedure see the functional specification of the HMI)

Internal

Alarm	Category	Note
Power failure	Urgent	When both drives detect "line power failure"
VSD 1 Phase failure	Not urgent if one drive fails, otherwise urgent	
VSD 2 Phase failure	Not urgent if one drive fails, otherwise urgent	
VSD 1 Communication failure	Not Urgent	If the communication between VSD1 and the RTU fails
VSD 2 Communication failure	Not Urgent	If the communication between VSD2 and the RTU fails
VSD 1 Fault	Not urgent if one drive fails, otherwise urgent	Signal is parallel to the fault contact on the drive
VSD 2 Fault	Not urgent if one drive fails, otherwise urgent	Signal is parallel to the fault contact on the drive

External

Alarm	Category	Note
Level Transmitter Analogue Signal Fault	Urgent	Detects a failure in the 4-20 mA from the level transmitter. The signal is looped to both VSD's. If one of the VSD's detects a failure, the alarm will be activated
Level Switch High (fail safe)	Not Urgent	Digital input from a floating ball in the wet well
Level Switch High High (fail safe)	Urgent	Digital input from a floating ball in the wet well
Odour Fan Flow Switch Low (fail safe)	Not Urgent	Digital input from the flow switch detecting flow from the odour fan
Surge Arrestor Alarm	Not Urgent	Digital input from the surge arrestor, indicating that it is blown
Switchboard Ventilation Fan Tripped (fail safe)	Urgent	Digital input from the circuit breaker of the ventilation fan
Pump 1 Thermistor	Not urgent if one drive fails, otherwise urgent	Thermistor input of the VSD is activated
Pump 2 Thermistor	Not urgent if one drive fails, otherwise urgent	Thermistor input of the VSD is activated

Control power failure (fail safe)	Urgent	The radio, Ethernet switch, RTU and the controller and Ethernet cards of the VSD have a 24VDC power supply that's backed up by a battery. When the system swaps from power supply to batteries, this alarm is activated

3.2 Interfacing Pump Station / WWTP

The following data flows can be identified between pump stations and the WWTP:

- Dataflow A: event based updates of the status of the pump station
- Dataflow B: adhoc commands to the pump station (e.g.manual operation) and settings (e.g. level setpoints)
- Dataflow C: maintenance

3.2.1 Dataflow A; event based status updates

Dataflow A is the main stream of information that provides a status overview of the pump station at the WWTP including alarms and reporting data. Dataflow A uses DNP3, an event based protocol, specifically designed for telemetry to keep data throughput low.
Please refer to the DNP3 Profile (4.2.1) for more information.

3.2.2 Dataflow B; adhoc commands and settings

Dataflow B is used only when an operator at the WWTP wants to make changes to the operation or settings of a pump station. This dataflow uses DNP3 also.
Please refer to the DNP3 Profile (4.2.1) for more information.

3.2.3 Dataflow C; maintenance

Dataflow C is used when an operator or engineer wants to diagnose problems with the control equipment of the pump station. The Altivar VSD's for example, have an web server built in that can be browsed from the WWTP using an Internet Explorer. This dataflow can be any Ethernet based protocol as long as the firewalls allow it to be used.

4 Future pump stations

When new pump stations are going to be added to the the Ecocare Project, it is important that a similar communication system is used as the one described above. This means that all communication has to be based on DNP3/TCP and that the data formats have to be the same. Although the control structure of each pump station can be completely different from the structure implemented during the first stage, having a standard control system with standard components would be the preferred choice from a maintenance point of view. This chapter will describe the minimum requirements for communication and control equipment

4.1 Cellular modem

The preferred cellular modem is a NetComm NTC-790seu.(www.netcomm.com.au). Although alternative brands can be used, it is not recommended. The IPSec protocol which is used for the VPN can have incompatibility issues between modem and router. Additionally, the current Snapgear router, which is the other side of the VPN link, needs to be setup to accept communication from the new cellular modem. Having one brand will make that process easier.
Stage 1 is running on the Telecom XT network but the Netcomm modem can be fitted with an alternative sim card which makes the cellular link service provider independent.
The cellular modem needs a battery backup to keep the communication alive during an outage.

4.2 RTU

Basically any RTU that supports DNP3 can be used. For stage 1 the Kingfisher CP11 is configured as a data concentrator and buffer. All IO's are connected to the VSD's and communicated through the Modbus/TCP link between the drives and the RTU. When VSD's without control are implemented, there are several options to provide automatic control; the RTU can be fitted with IO-cards and the control can take place in the RTU. Alternatively a separate PLC can be installed that communicates with the RTU. The interfacing between the RTU and the SCADA system however is standardised and can't be changed.

4.2.1 DNP3 Profile

The following interface needs to be implemented between RTU and pump station

Digital Inputs

TYPE	DNP_OBJECT#	Description	Notes
DI	1	Fan Tripped	1
DI	2	Odour Fan Stopped	1
DI	3	High Level Reached	1
DI	4	High High Level Reached	1
DI	5	Surge Arrestor Fault	1
DI	6	Both Drives in NLP (No Line Primary)	1
DI	7	Comms Fault Drive 1	1
DI	8	Comms Fault Drive 2	1
DI	9	Drive 1 in NLP	1
DI	10	Drive 2 in NLP	1
DI	11	4-20 mA Loss	1
DI	12	Fault Drive 1	1, 2
DI	13	Fault Drive 2	1, 2
DI	14	PTC/Thermistor Drive 1	1
DI	15	PTC/Thermistor Drive 2	1
DI	16	24VDC Power Fault	1

Notes:
1) In all cases, "1" means alarm, "0" means normal
2) Any other fault from the drive

Analog Inputs / Outputs

TYPE	DNP_OBJECT#	Description	Notes
AI/AO_16	1	Duty Pump Start level	1

AI/AO_16	2	Duty Pump Start Speed	1
AI/AO_16	3	Duty Pump Limit Level	1
AI/AO_16	4	Duty Pump Limit Speed	1
AI/AO_16	5	Duty Pump High Stop	1
AI/AO_16	6	Duty Pump Stop Level	1
AI/AO_16	7	Standby Pump Start level	1
AI/AO_16	8	Standby Pump Start Speed	1
AI/AO_16	9	Standby Pump Limit Level	1
AI/AO_16	10	Standby Pump Limit Speed	1
AI/AO_16	12	Standby Pump Stop Level	1
AI/AO_16	25	Spare	
AI/AO_16	26	Spare	
AI/AO_16	27	Pump 1 Control Word	2
AI/AO_16	28	Pump 2 Control Word	2
AI/AO_16	29	Pump 1 Manual Speed	
AI/AO_16	30	Pump 2 Manual Speed	
AI_16	31	Pump 1 Pump Status Enum	3
AI_16	32	Pump 2 Pump Status Enum	3
AI_16	33	Wet Well Level	
AI_16	34	Pump 1 TotalCycles	4
AI_16	35	Pump 2 TotalCycles	4
AI_16	36	Pump 1 Duty Cycles	4
AI_16	37	Pump 2 Duty Cycles	4
AI_16	38	Pump 1 Status Word	5
AI_16	39	Pump 2 Status Word	5
AI_16	40	Pump 1 Motor Current	6
AI_16	41	Pump 2 Motor Current	6
AI_16	42	Pump 1 Drive Speed	6
AI_16	43	Pump 2 Drive Speed	6
AI_16	44	Pump 1 Altivar Status word	7
AI_16	45	Pump 2 Altivar Status word	7
AI_16	46	Pump 1 Altivar Logical Inputs	7
AI_16	47	Pump 2 Altivar Logical Inputs	7
AI_16	48	Pump 1 CI card Logical Inputs	7
AI_16	49	Pump 2 CI card Logical Inputs	7
AI_16	50	Pump 1 CI card Logical Outputs	7
AI_16	51	Pump 2 CI card Logical Outputs	7

Notes:

1) AI/AO16 means that the SCADA writes to the AO16 object, but reads from the AI16 object.
2) The Control Word layout is as follows:

BIT#	Description	Notes
1	Pump Inhibit	A
2		
3	Reset Status Fault	B
4	Set this Pump as Duty Pump	C
6		
7		
8	Manual Run	A
9		
10		
11		
12		
13		
14		
15		
16		

Notes:

a) Bits 1 and 8 work together:

Bit 1 and 8 Off: Automatic Mode
Bit 1 and 8 On: Manual Stopped
Bit 1 Off and 8 On: Manual Run

b) SCADA sets it to "1", RTU sets it to "0" when command has been applied.