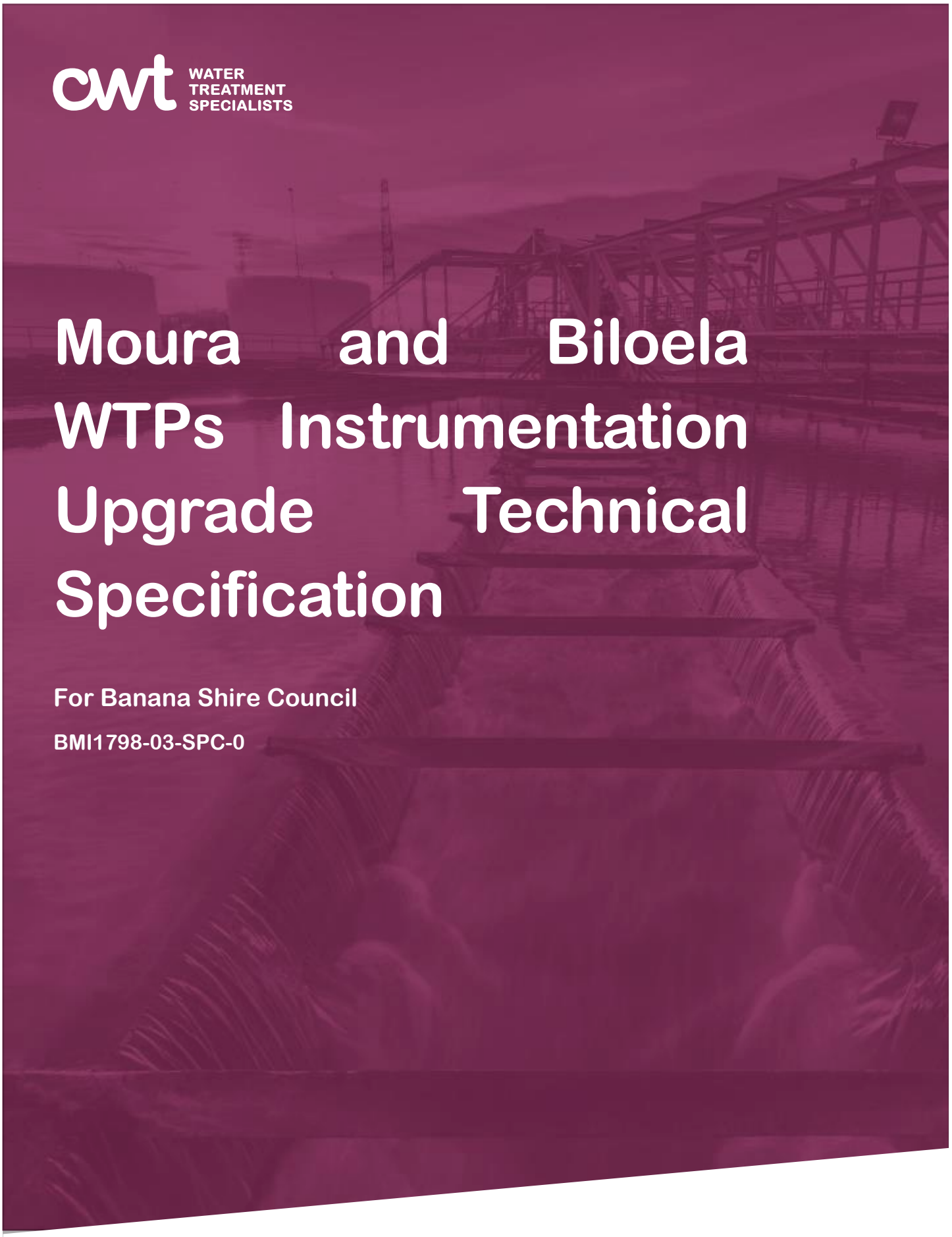

WATER TREATMENT SPECIALISTS

Moura and Biloela WTPs Instrumentation Upgrade Technical Specification

For Banana Shire Council

BMI1798-03-SPC-0

8 December 2023

Moura and Biloela WTPs Instrumentation Upgrade Technical Specification

For Banana Shire Council

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Issue Date	Revision	Issued to	Prepared by	Reviewed by	Comments
6/12/2023	A	BSC	TA	AD	Draft
8/12/2023	0	BSC	TA	AD	Final

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1 Specific Requirements of the Contract

1.1 Banana Shire

Banana Shire is situated in Central Queensland. The Shire is a large commodity producer within the region. The major industries of the Shire include coal mining, beef production, power generation and cropping (both dry land and irrigated). Biloela, located approximately 120 kilometres west of Gladstone, is the largest town and the administration centre for the Shire.

1.2 Location of Works

The works will take place across two sites in the Banana shire: Moura and Biloela.

The Moura Water Treatment Plant (WTP) site is located on the western edge of the town zone, nearby to the Moura Sewage Treatment Plant (STP). The WTP is accessed from Dawson Highway as shown in Figure 1.1 below.

The Raw Water Pump Station which supplies water to Moura WTP is located at the Dawson River Moura Weir, around 8km to the south-west of the WTP.

Figure 1.1: Location of Moura Water Treatment Plant.

The Biloela Water Treatment Plant (WTP) site is located outside the town zone, about 5 km to the east of the town centre. The WTP is accessed from Calvale Rd as shown in Figure 1.2 below.

The Raw Water Pump Station which supplies water to Biloela WTP is located near the Callide Dam wall, around 2km to the north-east of the WTP.

Figure 1.2: Location of Biloela Water Treatment Plant.

1.3 Site Conditions

1.3.1 Ambient Conditions

All the Works described as part of this Specification shall be suitable for operation in the following ambient conditions:

- Maximum temperature of 45°C;
- Minimum temperature of -5°C;
- Relative humidity ranges between 5 and 100%.

1.4 Overview of the Project

The existing Moura and Biloela WTPs each currently utilise a combination of manual and automated monitoring methods to track water quality parameters. While the existing systems provide some level of data collection, it is not fully integrated and do not provide real-time insights into the treatment processes. This can lead to delayed response times to water quality excursions and potential compromises in water safety. Council wishes to upgrade the instrumentation at each site to bring the systems in line with typical automated control systems at modern WTPs and reduce the level of operator involvement. This automation, a major part of the Works required, will involve the provision of new process instrumentation , connection to the existing control systems and updates to the existing control systems.

The Works required under this Contract are listed in the Scope of Works below and addressed in more detail in other sections of this Specification.

It is noted that the Works will need to be scheduled and undertaken in a manner which allows the WTP to continue to operate in a practical and safe manner, with minimal shutdown periods for connection of the new equipment.

1.5 Scope of Works

The work included under this Contract will comprise but not be limited to the specification, design, procurement, installation, configuration/ programming, commissioning, documentation, and operator training for the following:

- Instrumentation at Moura WTP:
  - Raw water turbidimeter (at RWPS);
  - Raw water dissolved oxygen meter;
  - Raw water conductivity probe;
  - Raw water pH meter;
  - Raw water UV254 analyser;
  - Filtered water (train 2) UV254 analyser;
  - Filtered water (train 2) manganese analyser;
  - Filtered water (train 2) chlorine analyser;
  - Filtered water (train 3) turbidimeters;
  - Filtered water (train 3) UV254 analyser; and
  - Filtered water (train 3) manganese analyser.
- Instrumentation at Biloela WTP:
  - Raw water dissolved oxygen meter (at RWPS);
  - Raw water turbidimeter (at RWPS);
  - Raw water conductivity probe (at RWPS);
  - Raw water pH meter (at RWPS);
  - Raw water UV254 analyser (at RWPS);
  - Clarified water turbidimeter;
  - Filtered water UV254 analyser; and
  - Filtered water manganese analyser.
- Removal and disposal of components made redundant by the Works (see section 1.9).

All instruments, where possible, shall include flow sensors (to minimise false readings), automatic cleaning modules, and a system check (to confirm instrument health).

1.5.1 Deliverable 1

The main scope of works for this project includes:

- Supply of instrumentation: The Contractor shall supply all instrumentation and wet racks required for the project. This includes, but is not limited to, the instrumentation outlined above.
- Installation of instrumentation: The Contractor shall install all instrumentation and wet racks in accordance with the manufacturer's instructions and the project specifications. This includes, but is not limited to, mounting the instrumentation, and running the wiring.

- Testing and commissioning of instrumentation: The Contractor shall test and commission all instrumentation to ensure that it is working properly. Note that the timing of commissioning will be dependent on completion of deliverable 2 at a minimum.
- Training: The Contractor shall provide training to plant personnel on the operation, calibration, maintenance and troubleshooting of the new instrumentation.

1.5.2 Deliverable 2 (Provisional)

Deliverable 2 is provisional and may or may not be included in the Contractor's proposal. The scope of works for this includes:

- Supply and installation of all necessary sample pumps and pipework: The Contractor shall supply and install all sample pumps, pipes, fittings, valves, and other components necessary to connect the sample points to the laboratory wet racks.
- Integration of the sample collection system with the existing plant piping system: The Contractor shall install isolation valves and check valves where necessary to prevent contamination of the plant piping system.
- Installation of sample collection points at designated locations: The Contractor shall install sample taps at all designated sample points.
- Testing and commissioning of the sample collection system: The Contractor shall test and commissioning the sample collection system, including:
  - Leak testing of all pipework and connections;
  - Testing of all valves and pumps;
  - Verification of proper flow rates; and
  - Demonstration of the system to plant personnel.

1.5.3 Deliverable 3 (Provisional)

Deliverable 3 is provisional and may or may not be included in the Contractor's proposal. The scope of works for this includes:

- PLC/SCADA System Update: The Contractor shall connect the new instrumentation and sample pumps to the plant's existing PLC/SCADA system, including where relevant, developing and implementing any new PLC/SCADA programming for new instruments.
- Training: The Contractor shall provide training to plant personnel on the updated PLC/SCADA system.

1.6 Project Delivery Method

The project will be delivered by a Design and Construct Lump Sum Contract. The Contract shall be to AS 4300 *General conditions of contract for design and construct*.

The Principal reserves the right to accept some, all or none of the Contractor's submissions with regards to each deliverable. The decision on whether to accept, reject, or negotiate a submission will be based on various factors, including, but not limited to:

- Compliance with the requirements outlined in this Specification;
- Overall quality and value of the submission; and

- Budgetary constraints.

1.7 Limits of Contract

1.7.1 Electrical

The Contractor shall provide and install the necessary cabling and circuitry required for the connection of new equipment supplied under this Contract to the WTP electrical supply point. The Contractor shall confirm their power requirements in the Tender.

1.7.2 Control

The Contractor shall provide and install the necessary hardware, software and configuration/ programming for connection of new equipment to the existing control system under this Contract.

1.7.3 Civil/Site Work

The Contractor shall provide all necessary civil/ site work required to install the equipment/ systems detailed in this Specification.

1.8 Site Facilities and Temporary Services

1.8.1 Contractor's Office and Ablutions

The Contractor shall provide its own office accommodation, if required, within the designated work area and shall make its own arrangements for ablution facilities at the work site. The Contractor shall provide statutory and necessary amenities and sanitary facilities for workers and other persons lawfully upon the site.

The proposed location and required power and water connections to temporary office, amenities and sanitary facilities shall be advised by the Contractor at the start of the project, for approval by the Principal. The Contract or shall be responsible for making the required power and water connections, once approved.

Temporary office, amenities and sanitary facilities shall be removed by the Contractor on completion of the Works.

1.8.2 Power Supply

The Contractor shall be responsible for the provision of power supply for construction purposes and for connection to office, amenities and sanitary facilities.

1.8.3 Water Supply

The existing potable water supply can be used by the Contractor for construction and ablution purposes only.

1.9 Removal of Old Equipment

The Contractor shall remove and dispose of all equipment, piping, electricals, and controls made redundant by the new works. This will include but not be limited to equipment from:

- Old control equipment made redundant by the instrumentation upgrade;
- Old pipework removed and replaced by new pipework; and

- Old valves removed and replaced by new equipment.

The Principal may wish to retain any or all of the following items after their removal for use at other Council sites. The Contractor shall confirm with the Principal prior to ultimate disposal of any of the following items.

1. Instrumentation
2. Pumps
3. Automatic valves

1.10 Asset Life

All new structures, pipework, civil work, and plant equipment to be constructed under the Contract shall meet specific design standards for minimum service life. The actual asset lives to be adopted shall be determined during the design process with due consideration of whole-of-life costs.

The following Table 1-1 specifies the minimum design service lives for all new system components.

Table 1-1: Design Service Lives of WTP Assets.

Item	Sub Item	Design Life (years)
Accessible drainage elements		20
Air-conditioning	Compressors, condensers	15
Airducts		25
Civil works (including pipework)		50 (pipework) 100 (others)
Communications	PABX, VoIP	12
Concrete Structures (water retaining)		50
Concrete Structures (non water retaining)		75
SCADA System	PLC, Telemetry	10
Diffusers		5
Epoxy coatings on Concrete/ Metal Structures		10
Exit Signs	Batteries, Lamps (LED)	5
FRP/GRP/Plastic tanks		25
Guttering & downpipes		20
Hatches and Manhole Covers		20
HV & LV switchboards	Protection relays	10
Instrumentation	Turbidimeters	5 – 10 (vendor to advise)
	Dissolved oxygen meters	5 – 10 (vendor to advise)
	Conductivity meter	> 1 (sensor life)
	pH meter	> 1 (sensor life)
	UV254 analyser	5 – 10 (vendor to advise)
	Manganese analyser	5 – 10 (vendor to advise)

Item	Sub Item	Design Life (years)
	Chlorine analyser	5 – 10 (vendor to advise)
	Indicator Transmitter	10
Internal Fitouts		20
Lighting	Fittings	10
	Fluoro tubes	3
	LEDs	5
	HPS lamps	4
Mechanical and Electrical Equipment		20
Motor Control Centres	Contactors, relays & indicator lamps	10
Protective coatings		15
Retaining Walls Including Reinforced Soil Walls		100
Roadwork		20
Safety Fencing		20
Security System	Main processor, electric door locks	12
Stairs, Platforms, Guardrails and Similar Metalwork		25
Structural Steelwork		50
Surface Coating Systems		10
UPS	Batteries	5
Waterproof Membranes		20

Note: Mechanical and electrical equipment may be assessed on an hours-run basis rather than a period of years.

1.11 Order of Precedence

The order of precedence for documents forming the Contract in order of highest precedence to lowest precedence shall be as follows:

1. Contract Specific Clauses;
2. Relevant Government and Statutory Requirements;
3. Relevant Australian Standards;
4. Australian Drinking Water Guidelines;
5. This Specification;
6. Other standards referenced by this specification such as WS-SPEC 2000 and ASTM standards; and,
7. Any tender documentation provided such as drawings and reports.

1.12 Warranties

Upon the completion of commissioning, the Contractor shall supply the Principal copies of all manufacturers' warrantees covering all individual components of each system. In addition, the Contractor shall forward to the Principal a written warranty certification, certifying that the warranty for any component that is not covered by the manufacturer of the equipment is in force from the date of completion of commissioning.

1.13 Defects Liability Period

The Defects Liability Period for the Works shall be twelve (12) months from the date of successful completion of the Proof of Performance.

2 Design, Documentation, and Management

2.1 Design and Workshops

2.1.1 General

The Contractor shall undertake the design of all Works associated with the Contract. The following specifies the design requirements.

2.1.2 Project Initiation and Site Visit Workshop

On award of the Contract, the Contractors shall attend a half-day project initiation and site visit workshop organised and run by the Principal.

The purpose of the workshop is for the Principal to meet with the Contractor's team and ensure the Contractor is familiar with the Principal's requirements.

The Contractor and their team will be required to give a presentation on the following and also attend a site visit:

1. Project overview
    a) Contactors experience with similar Projects
2. Design management
    a) Design team
    b) Design approvals
    c) Risk workshops that are applicable to the scope of work (HAZID, HAZOP etc)
    d) Interface with the Principal
3. Construction/ equipment installation management
    a) Site based team
    b) Quality control plan
    c) Inspection and test plans
    d) Inspection of the work and sign off
4. New control system design and implementation
    a) Control systems team
    b) New control system implementation procedure
    c) Inspection and test plans
    d) Conditions for sign off
5. Work, heath, safety, and environment
6. Contract management

2.1.3 Project Works Schedule

The Contractor shall provide a detailed project works schedule within two (2) weeks of contract award. The schedule shall show sufficient detail to determine the sequence of events planned to a resolution of one (1)

day. The schedule shall be updated once per month, or more frequently if required by the project or requested by the Principal.

The schedule shall maintain a baseline and show completed activities relative to the baseline.

A risk assessment and mitigation matrix with appropriate fall back measures shall be developed for the event that the new system fails to operate correctly.

2.1.4 Safety in Design

During the design phase, the Contractor shall address and minimise operational, maintenance, workplace, health, safety and environmental risks during the service life of the Works by eliminating risk in design.

All aspects of the design including structural, mechanical, electrical and controls shall be reviewed to ensure safety and prevention of damage to structures, equipment or environment under normal, breakdown and maintenance operation.

The Contractor shall identify all material hazards and shall eliminate those hazards during the design development and design phases. Hazards to be assessed include:

1. **Physical** such as noise, radiation, light, vibration, heat, and manual handling;
2. **Chemical** such as poisons, dusts, corrosive agents, flammable or explosive materials;
3. **Biological** such as viruses, plants and parasites;
4. **Gaseous** such as chlorine;
5. **Mechanical/ electrical** such as slips, trips and falls, tools, electrical equipment;
6. **Psychological** such as fatigue.

This risk assessment process shall:

a) Adopt a life cycle approach that considers construction, installation, commissioning, operation, maintenance, repair and demolition of the asset being designed;

b) Adopt a consultative approach during the design and construction phases with relevant stakeholders, including designers, constructors, operators, maintenance staff and WH&S personnel;

c) Include a facilitated risk assessment workshop attended by the Principal and other Council representatives, utilising appropriate risk assessment techniques; and

d) Identify and adopt risk control measures which reflect the hierarchy of controls.

If elimination of the hazard by design is not possible or feasible, then the risk still exists and shall be minimised by using the most effective method, in the following preference order:

1. Substituting the system of work or machinery with something safer;
2. Isolating the hazard;
3. Minimising the risk by introducing engineering controls (e.g. guard rails, scaffolding);
4. Minimising the risk by adopting administrative controls (e.g. warning signs, safe work practices); and/ or
5. Using personal protective equipment (e.g. safety glasses, ear muffs, gloves).

If no single control is sufficient to properly and adequately mitigate the hazard, a combination of the above controls shall be put in place by design and operations specifications to minimise the risk to the lowest level that is reasonably practical.

Where hazard mitigation is proposed to rely on control or procedure measures, the Contractor shall record that physical means were investigated and found to be impractical. This shall be clearly demonstrated in the quality system and records for the project through the quality plan, procedures, design calculations and documentation, verification process and check lists and the change records. Where control strategies are utilised, all shall be documented, and training shall be provided as necessary. The controls and/ or procedure measures shall be clearly identified and incorporated in the Functional Description and Operation and Maintenance Manuals.

2.1.5 Operations and Maintenance Design Criteria

The design shall take into consideration the number, type and positioning of plant and equipment and how this may impact on the operations and maintenance of the WTP.

The factors to be considered in designing for maintainability include:

1. **Standardising**: Using Australian and International Standards for all equipment;
2. **Accessibility**: Quantifying the number of parts requiring removal in order to replace a given component and access requirements for maintenance, including removal, and operations such as inspections, oil changes, etc.;
3. **Commonality**: In order to maximise equipment knowledge and to reduce spare parts holdings, the selection of plant and equipment shall consider the commonality of equipment and parts between plant items;
4. **Modularity**: To reduce replacement time, where possible sub-assemblies shall be modularised to allow for quick removal and replacement;
5. **Redundancy**: Suitable levels of redundancy shall be incorporated to ensure continued operation in the event of plant or equipment failure or maintenance down time.

Materials used in equipment, and plant in general shall be selected for use in the environment in which they are to operate, e.g. the materials used in chemical dosing systems must be compatible with the chemical in which they contact.

Priority shall be given to equipment that meets the following criteria:

a) Simplicity in concept;

b) Sturdiness of manufacture;

c) Maintenance support;

d) Suitability to its operating environment;

e) Interchange ability and commonality with other equipment; and

f) Availability of spare parts, in Australia and preferably in Queensland, throughout the life of the equipment.

Equipment/plant shall be designed to have low maintenance requirements/costs and provide high reliability and availability.

2.1.6 Equipment Redundancy and Spare Parts

Spares shall be readily available from Australian suppliers.

2.1.7 Draft Design Review

For the design of the instrumentation upgrades, the Contractor shall nominate and submit draft design information for the Principal to review and accept.

This information shall be presented during a Design Review Meeting with the Principal and their representatives. The required information shall be made available to the Principal for review two (2) weeks prior to the meeting.

The information provided for the design review shall include at a minimum the following:

1. Piping and instrumentation diagrams;
2. Control system diagrams;
3. Safety review;
4. Operability review;
5. Overall site general arrangement drawings;
6. General arrangement drawings for major civil or building components; and
7. Basic sections for civil works or building components.

Any changes to the design based on the outcome of the design review shall be made by the designer at the Contractor's expense.

2.1.8 HAZOP Study

Following completion of the design review, the Principal will determine if a hazard and operability study (HAZOP) of the intended design needs to be conducted. If the Contractor is instructed to complete HAZOP of the intended design, the study shall be presented in a workshop conducted in accordance with AS IEC 61882.

The duration of the workshop shall be nominated by the Contractor and the location shall be nominated by the Principal. All materials required for the workshop shall be provided by the Contractor.

The formal HAZOP Study will confirm the proposed equipment selection and its arrangement prior to the Contractor's finalising the design. Procurement of any items for incorporation into the work should not occur until the HAZOP Study is complete, unless specifically approved in writing by the Principal.

Any changes to the design based on the outcome of the HAZOP shall be made by the designer at the Contractor's expense.

2.1.9 Final Design

Following acceptance by the Principal of the design information submitted, final design information, in final report format, shall be submitted as follows:

1. At completion of the design of the Works (with all drawings marked "For Construction");
2. At "As-Built" stage, prior to Construction Completion.

The relevant documents shall include, to the extent applicable:

a) Contents list;

b) Design criteria, parameters and methods used;

c) Calculations and schedules;

d) Drawings;

e) References, specification requirements, codes, manuals and supporting documents used, drawing numbers and titles of drawings which are based on the design; and

f) Any other relevant information.

Process review will be undertaken progressively throughout the design of the works. The Contractor must make available all current process design documentation at any stage of the design, on demand.

2.2 Required Drawing and Drawing Approval

2.2.1 General

All drawings shall be prepared in accordance with the requirements of the relevant Standards Association of Australia (SAA) codes and good engineering drawing practice. Drawings shall be produced at A1 size, but will be required to be used and fully legible at A3. A logical set of drawing numbers shall be developed in consultation with the Principal. All drawings shall be clearly drawn to scale by competent draftspersons, in AutoCAD version 2012 or later versions acceptable to the Principal.

Electronic copies of drawings shall be provided to the Principal in both PDF and DWG formats to enable viewing without AutoCAD.

Drawings shall be sufficiently detailed to cover all aspects of the works construction and to allow inspection for acceptance. Full details of all services, fittings, fixtures and finishes as well as civil, structural, hydraulic, process, mechanical and electrical requirements shall be included.

One (1) A1 set and one (1) A3 set of final drawings shall also be provided. A CD or USB memory stick of the Detailed Design drawings and the "As-built" drawings shall be provided prior to the granting of Practical Completion. The information to be submitted, subject to any variance required by the Principal during the undertaking of the works, shall include but not be limited to the drawings listed in Section 2.2.4 through 2.2.7.

If the Contractor does not intend to submit any of the drawings requested under this Contract, they shall advise the Principal in writing allowing one (1) week for consideration by the Principal. The Principal reserves the right to determine whether or not the Contractor's request is justified.

2.2.2 Submission and Approval of Drawings

The Contractor shall at the earliest practical date, but not later than four (4) weeks prior to the construction of any relevant portion of the Works or commencement of manufacture of equipment, or placing firm orders for any components, submit to the Principal for review one (1) hard copy/ one (1) digital copy of the drawings.

Work shall not proceed on the manufacture or supply of equipment, components, or structure until the relevant drawings have been submitted, reviewed, revised, and approved provided by the Principal.

Should the Principal require additional information and/ or drawings, or any amendments to the previously submitted drawings, the Contractor shall supply them in the requested format within one (1) week of being requested to do so.

The Contractor shall also provide two sets of 'accepted' drawings in A3 format for the use of the Principal and the Council during the course of the works.

2.2.3 Approval of the Contractor's Drawings

Approval of the Contractor's drawings shall not relieve the Contractor of its full responsibility to comply with the requirements of the Contract Drawings and Specification.

Approval by the Principal of any drawing, method of work or any information regarding materials and equipment the Contractor proposes to supply shall not relieve the Contractor of its responsibility for any errors or omissions therein, and shall not be regarded as an assumption of risks or liability by the Principal, and the Contractor shall have no claim under the Contract on account of the failure or partial failure or inefficiency of any plan or method of work or material and equipment so accepted.

Such approval shall be considered to mean that the Principal has no objection to the Contractor using, upon its own full responsibility, the plan or methods of work proposed or supplying the materials and equipment proposed.

2.2.4 Process and Instrumentation Diagrams

The Contractor shall provide Process and Instrumentation Diagrams (P&IDs) for all new equipment installed, including a P&ID for each new chemical system installed. These shall feature:

1. Legend describing all symbols used in the respective drawings;
2. Pipeline labels including line number, pipe diameter and pipe material;
3. Drawing convention shall adopt flow being left to right of drawing sheet; and
4. Line flags at pipe end on right-hand side of drawing sheet referring to the next relevant drawing number and destination process unit.

2.2.5 Civil

Depending on the Contractor's final design, civil drawings that may be required by the Contractor include:

1. Earthworks drawings;
2. Foundation drawings;
3. Structural plans and elevation drawings;
4. Reinforced concrete drawings;
5. Structural steelwork and metalwork shop drawings;
6. Pipework layout and detail drawings; and
7. Landscaping drawings including layout of irrigation.

2.2.6 Mechanical

The Contractor shall provide the following mechanical drawings:

1. Mechanical layout drawings;
2. Equipment schedules;
3. Valve schedules; and
4. Piping schedules.

2.2.7 Electrical and Instrumentation

The Contractor shall provide the following electrical and instrumentation drawings and tables, as appropriate, for the upgraded control systems and for new equipment installed under this Contract:

1. Single line diagrams;
2. MCC/ Switchboard general arrangement drawings;
3. Electrical schematic drawings for each individual drive;
4. PLC I/O module connection/termination diagrams;
5. Instrument loop diagrams;
6. Local Control Panel general arrangement drawings;
7. Electrical equipment schedules;
8. Cable schedules;
9. Electrical equipment layout drawings;
10. Earthing Arrangement Diagrams;
11. Cable route drawings;
12. Instrument schedules and calibration certificates;
13. I/O allocation tables;
14. PLC and SCADA Local Area Network Block Diagrams;
15. Lightning protection;
16. RTU's connection diagrams;
17. SCADA System tag databases; and
18. PLC code listings.

2.3 SCADA Documentation and Files

2.3.1 General

The Contractor shall provide one (1) electronic and one (1) printed and bound copy of all documentation items unless otherwise specified. All hardcopies shall be bound in hard plastic cover folders. All electronic copies of documentation shall be provided in native application format and in Adobe PDF. Any photos included in the documentation shall be provided individually in their original size when taken.

Upon completion of the design, and prior to commencement of works onsite, the Contractor shall provide the following documentation:

1. Functional description;
2. SCADA alarm list;
3. Reporting specification;
4. Tag name coding;
5. Coding standard;

6. Logic diagrams;
7. Sequence diagrams;
8. Detailed design drawings of new equipment, including new and existing I/O;
9. Project works schedule; and
10. Acceptance test plans for factory, on-site, and operator tests.

Where applicable, the Contractor shall update existing documentation to show the proposed upgrades to the existing site.

The Contractor shall allow the Principal a review period of two (2) working weeks from the date of receipt of each document.

Before the completion of the project, the Contractor shall provide the following documentation:

1. 'As-built' amendments and new inclusions for the SCADA alarm list, reporting specification, coding standard, functional specification, logic diagrams, sequence diagrams and detailed design drawings;
2. PLC data schedule and SCADA data schedule;
3. Copies of onsite documentation to be left in the field PLC cabinets to enable a tradesperson to identify all equipment in the cabinet, the operation of the equipment in the cabinet, and any safety warnings;
4. Software manual;
5. User manual;
6. System operation and maintenance manual including a spare parts list and manufacturers equipment specifications; and
7. Training documentation used to facilitate training on the new SCADA System.

The Contractor shall provide the following electronic files before the completion of the project:

1. All final PLC project files; and
2. All final SCADA project files.

2.3.2 Functional Description

The Functional Description shall:

1. Include a detailed specification of all the required hardware for the communications network, SCADA System and PLC;
2. Address all project phases and equipment locations;
3. Include a detailed description of the software, equipment control and monitoring standard logic and configuration requirements for the communications network, SCADA System and PLC such that code can be developed and systems configured;
4. Include a detailed description of the process control philosophy of how the SCADA System will monitor and control the plant, including but not limited to:
    - Plant startup and shutdown;
    - Clarifier desludging;
    - Filter backwash triggers, queuing and backwash sequence;

- Chemical system operations and controls;
- Individual mechanical equipment startup and controls;
- Alarms and interlocks.

5. List, in detail, all items and features of the proposed SCADA System, whether specifically referenced in this Specification, implied by this Specification, or not referenced but necessary for the proper functioning of the WTP systems.

Where applicable, the Contractor shall update existing Functional Description to show the as-built upgrades to the existing site.

If, following any stage of acceptance testing, it is found necessary to amend the functional description to ensure compliance with the requirements of this specification, then the Contractor shall amend the documents and resubmit them to the Principal for review. Both parties shall provide written comment or implement changes within two (2) working weeks.

2.3.3 Design Drawings

Prior to commencing procurement, manufacture or installation of any equipment, the Contractor shall submit design drawings to the Principal for approval. The Contractor shall allow a period of two (2) working weeks from the date of receipt by the Principal for review of the drawings.

The design drawings shall include:

1. Site specific schematic diagrams for all equipment connection, power supply and communications cabling for all new and modified equipment;
2. System level drawings to explain the operation and layout of the system; and
3. Site specific layout and termination diagrams for all cabinets, and cable containment.

If, following any stage of acceptance testing, it is found necessary to amend the drawings to ensure performance compliance with the requirements of this specification then the Contractor shall amend the drawings and resubmit them to the Principal for review. Both parties shall provide written comment or implement changes within two (2) working weeks.

2.3.4 PLC Data Schedule

The Contractor shall provide a detailed data schedule describing all physically connected I/O, networked I/O and other defined internal variables. The data schedule shall be grouped logically by site location and/or sub-process. At a minimum, the data schedule shall provide the following information for each data item:

1. Rack ID, if applicable;
2. Slot ID, if applicable;
3. Channel ID, if applicable;
4. Address, if applicable;
5. Data type;
6. Equipment tag name, if applicable;
7. PLC code tag name;
8. Plant status description of logic 1 and O condition for digital I/O;

9. Engineering value at 0% and 100% of analogue range; and
10. Comment.

2.3.5 SCADA Data Schedule

The Contractor shall provide a data schedule describing all I/O exchanged between the SCADA server. At a minimum, the data schedule shall provide the following information for each item of I/O:

1. SCADA tag name;
2. Data type;
3. I/O device;
4. Address;
5. Data direction; and
6. Description.

2.3.6 Project Files

Final PLC and SCADA project files shall be provided in their entirety. This shall include any dependent files automatically created by the system as part of the project. The files provided shall permit full restoration of the PLC code and SCADA configuration without the need for any further code development, software configuration or the import of any other files.

2.3.7 User Manual

The Contractor shall provide an updated user manual for the SCADA System which comprehensively covers all aspects of user monitoring and control. This manual shall also include all screen shots of the SCADA System.

The on-line help facility on the SCADA screens will complement the user manual. However, it shall not substitute or replace in any way, the purpose served by or material covered in the printed media.

2.3.8 System O&M Manual

The Contractor shall provide an updated system O&M manual, which comprehensively covers the operation and maintenance requirements of any upgrades to the PLC, network equipment, and SCADA equipment. The manual shall enable operation of the equipment by trade personnel who have training in the required area of competency.

Each manual shall include an index, photographs and drawings as appropriate to enhance understanding of the equipment operations. Safety procedures and operations that pose a safety risk to personnel shall be highlighted by an icon, symbol or special highlighted text.

2.3.9 Software Manual

The Contractor shall update the existing software manual describing all PLC project code and SCADA configuration provided for the Plant. The manual shall be indexed and must fully describe the operation of the software, and include the following:

1. Systems overview - an overview of all user software modules within each project including detailed written descriptions, project trees and system configuration;

2. Module descriptions - a complete description of each user software module (program, routine and subroutine) including commented source code listings, indexed to allow easy identification and location from the systems overview page; and
3. Operating instructions - a complete set of user operating procedures including system generation, loading, configuration, start-up, on-line modification, shut-down and general troubleshooting.

Any special instructions and/or equipment required to load and/ or test software must be clearly identified in the associated documentation. Any special equipment needed to load, test and debug software must also be supplied.

2.3.10 Spare Parts

The system O&M manual shall include a spare parts list for all critical and consumable components. The Contractor shall identify all components that are required in the spare parts list as part of the detailed design.

2.4 Construction Management and Plans

2.4.1 Quality Assurance

The Contractor will control the quality of the work and must have a fully implemented quality management system in accordance with the requirements of the current Australian and International Standard AS/ NZS ISO 9001:2000.

It is the Council's intention that the project be undertaken to a high degree of Quality Assurance. Testing and verification of the works will be the primary responsibility of the Contractor.

The Principal reserves the right to conduct planned or unplanned audits on the Contractor's Quality Assurance System at its discretion.

To maintain quality across the life of the project, the Contractor shall submit for approval a Project Quality Plan that covers all relevant quality system elements applicable to this Contract. As a minimum, the Project Quality Plan shall contain at least the following information:

1. A Project Organisation Chart or list of nominated Project Personnel showing their positions, lines of communication and details of the responsibilities of the positions;
2. Nominated work lots with associated Witness Points and Mandatory Hold Points;
3. Inspection and Test Plans (ITPs) for the various phases during design, construction and commissioning shall be provided to the Principal at least seven (7) working days prior to commencement of relevant activities;
4. Project specific operating procedures or descriptions outlining as a minimum, details of activities, who is responsible for implementation/ verification, identification of relevant Quality Records and distribution and of such records, to be submitted at least seven (7) working days prior to commencement of relevant activities;
5. The method of isolating/ identifying non-conforming work, applying and releasing hold points, and the like; and
6. A Register of all intended Quality Records to be used on the project, together with pro-formas.

2.4.2 Inspection and Test Plans (ITPs)

ITPs and examples of their relevant activities checklists established for this Contract shall be submitted to the Principal for acceptance. Where it considers necessary, the Principal may request the Contractor to insert additional Hold Points or Witness Points. Provisions must be made for the Contractor or Designer and the Principal to sign off at these points.

ITPs shall contain at least the following information for each significant activity identified in the relevant process:

1. Description of activity;
2. Requirements/ reference elsewhere in this Principal's Project Requirements;
3. Person responsible for activity (title);
4. Hold Points and Witness Points;
5. Activity checklists;
6. Inspection and test type;
7. Tolerances or other acceptance criteria;
8. Identification of relevant procedure and quality records;
9. Test/ inspection frequency; and
10. Work item or work lot identification.

2.4.3 Conformance Reports

Conformance Reports shall be periodically prepared and shall include a verification statement certifying which items have been inspected and/ or tested in accordance with the Contractor's ITPs applicable to this Contract and that they comply with the specified requirements of the Contract's documents. Conformance Reports shall be accompanied by the following documents:

1. All relevant signed-off ITPs and associated Checklists;
2. NATA certified compliance test results (where applicable); and
3. Survey and measurement compliance data (where applicable).

2.4.4 Non-Conformance Reports

For non-conforming work, the Contractor shall submit a Non-conformance Report to the Principal within a week of a non-conformance. The Contractor's Non-conformance Report shall clearly detail, but not be limited to the following items:

1. The nature and extent of each non-conformance;
2. The work lot or work item number each relates to including the precise boundaries of the nonconforming work;
3. Any relevant information, data, test results and/ or measurements (as applicable);
4. The corrective and preventative actions the Contractor proposes to take; and
5. The timeframe within which non-conformances will be rectified.

The proposed corrective action is subject to approval from the Principal.

2.4.5 Hold Points and Witness Points

A Hold Point is defined as a position in the progress of the work under Contract, beyond which further work must not proceed without mandatory verification by the Designer and/ or the Principal.

A Witness Point is defined as a position in the progress of the work under Contract, where the Contractor must notify the Designer and/ or the Principal prior to proceeding and provide the option for attendance for witnessing any inspection or test. If any do not attend, then work may nevertheless proceed, unless otherwise instructed. Witness Points are to be used to verify compliance of the constructed works with the approved design drawings.

Mandatory Hold Points shall be as specified in the Contract or by the Designer to ensure compliance with the intent of the design and with other specified requirements, and to ensure that critical and/ or irreversible activities are not constructed incorrectly. Mandatory Hold Points apply prior to commencement of designated works lots or work items. To obtain authorisation to proceed, the Contractor shall ensure the following:

1. That all work lots or work items affected by the lot or item in question are conforming; and
2. That all Conformance Reports for all work lots or work items affected by the lot or item in question have been submitted at least twenty four (24) hours prior to the time the Contractor intends to proceed with the lot or item in question, thus ensuring that defective work is not built-in.

2.4.6 Subcontracted Work

The Contractor shall ensure that subcontracted works and procured supplies are subject to appropriate quality assurance standards, when incorporated into the overall works in order to comply with the requirements of this Contract. If requested by the Principal, the Contractor shall provide evidence of appropriate quality assurance for subcontracted work or procured items incorporated into the works under this Contract. This shall include verification by the Contractor.

2.4.7 Quality Records

The Contractor's quality system shall include sufficient quality records to provide objective evidence that the requirements of the Contract are met. This shall include Designers', Subcontractors' and Suppliers' records relevant to this Contract. The Contractor shall, when requested by the Principal, provide access to all quality records relevant to the Contractor's quality system under this Contract.

Within twenty eight (28) days of successful completion of the Proof of Performance (POP) Test, the Contractor shall forward a complete and bound clean copy of at least the following records to the Principal:

1. All Conformance and Non-conformance Reports;
2. All ITPs and associated checklists;
3. All test results, analyses, reports, measurements and observations; and
4. The original Project Quality Assurance Plan and any changes made to the Contractor's Quality System.

Previously submitted documents may be selected as appropriate.

Records must be maintained by the Contractor for a minimum period of two (2) years from successful completion of the POP Test or in accordance with the Contractor's statutory requirements if the latter exceeds the minimum period required for this Contract.

2.4.8 Quality Audits

The Contractor shall submit an audit schedule to the Principal at the time of submission of the Contractor's Quality System documentation. This shall include internal audits and external audits on Designers, Suppliers and Subcontractors.

2.4.9 Site Use Plan

Prior to undertaking any Works, the Contractor shall submit a Site Use Plan to the Principal which shall include at least the following:

1. Program for site establishment showing site office area and work areas;
2. Provisions for site visitors including sign in/sign out facilities and parking;
3. Induction plan for the Contractor's personnel;
4. Induction plans for site visitors to the work site;
5. Induction plans for areas outside the work site;
6. Procedures for accessing areas outside the work site; and
7. Procedures for encapsulating work areas outside the work site.

2.4.10 Work Health and Safety (WH&S) Systems

2.4.10.1 Site Safety

The Contractor, in accepting the Contract, shall accept responsibility as the Principal Contractor for authority, management and control of safety at the workplace. Knowledge of the current Queensland Work Health and Safety Act, WorkCover requirements, Codes of Practice, Australian Standards and other relevant legislation applicable to the health and safety obligations must be held by persons nominated by the Contractor to undertake the safety responsibilities of the contract works. Such persons must:

1. Hold a nationally recognised formal qualification in WH&S;
2. Have the necessary experience and background in the Building and Construction Industry; and
3. Have up to date knowledge of Qld safety legislation (Act and Regulations and Code of Practices as well as legislation pertinent to the Construction Industry).

Known hazards the Contractor may encounter onsite may include, but not be limited to:

1. Corrosive and combustible gases;
2. On-site toxic chemicals such as ACH and sodium hydroxide;
3. Electrical equipment including buried and exposed cables and installations;
4. Danger of falling;
5. Danger of drowning in open, flowing channels, tanks and lagoons;
6. Contact with waste chemicals and sludge and associated pathogens and other polluting matter;
7. Entry to enclosed (confined) spaces; and
8. Site traffic.

The Contractor must develop and implement a WH&S Management Plan detailing the systems and procedures which will apply during the term of the Contract. The Plan shall include safety policy, incident &

hazard reporting systems, consultation and work method statements for high risk tasks. The WH&S Management Plan must be submitted to the Principal for approval prior to the commencement of any works.

2.4.10.2 Incident Notification Requirement

If the Contractor is required by the relevant safety legislation or by any other regulations to give any notice of an accident or dangerous occurrence during the performance by the Works, the Contractor shall at the same time, or as soon thereafter as possible in the circumstances, give a copy of the notice to the Principal.

The Contractor shall promptly notify the Principal of any accident, injury, property or environmental damage that occurs during the carrying out of the Works. The Contractor shall immediately notify the Principal of all lost time incidents (LTIs). Within three (3) days of any such incident, the Contractor shall provide a report giving complete details of the incident, including results of investigations into its cause, and any recommendations or strategies for prevention in the future.

2.4.11 Environmental Protection

2.4.11.1 General

The Contractor shall comply with the Environmental Protection Act and associated legislation. Compliance includes, but is not limited to, seeking, holding and maintaining all environmental licences necessary to complete the Works Under this Contract.

The Contractor shall prepare and submit to the Principal within 14 days of the Letter of Acceptance and prior to the works commencing, a Construction Environmental Management Plan (EMP) to cover all Works Under this Contract.

The Contractor shall implement, operate and maintain all necessary measures to comply fully with the Construction EMP.

The EMP shall:

1. Be a practical and achievable plan;
2. Detail each environmental issue and impact to be addressed;
3. Include all control measures which the Contractor will undertake and any issues which the Contractor will address during the construction process including any required pre or post construction activity;
4. Detail who is responsible for ensuring the control measures are undertaken, the verification of such actions and a reporting process;
5. Provide a trigger for undertaking an action and, where possible, timing of each action;
6. Detail procedures for the monitoring of the Construction EMP by the Contractor;
7. Detail a system for registration and action of environmental incidents and complaints; and
8. Comply with all the relevant legislation.

The Contractor shall be fully responsible for undertaking all necessary control strategies, monitoring, reporting and corrective actions and shall be solely responsible for the full and complete implementation of the EMP for the contract works.

The Contractor is to satisfy himself that all environmental permits for the works have been obtained prior to undertaking works.

2.4.11.2 Environmental Management

During the implementation of the Works, the Contractor shall manage the following issues to the satisfaction of the Principal:

1. Flora and Fauna;
2. Landscaping/ Remediation Works;
3. Water Quality, Erosion and Sedimentation Control;
4. Bulk Storage of Chemicals/ Fuels/ Bunding;
5. Clean-up of spills and site remediation;
6. Ground Vibration;
7. Air Quality and Dust Suppression;
8. Machinery Access and Fuelling;
9. Maintenance Works Outside Normal Hours; and
10. Waste Disposal (Solid/ Liquid).

2.4.11.3 Protection of Vegetation

No vegetation shall be removed without approval of the Principal. Any vegetation which is to remain on the site after construction shall be protected from damage during construction. The Contractor shall reinstate any vegetated surface damaged during construction to its pre-existing condition.

2.4.11.4 Site Based Management

During the implementation of the Works, the Contractor shall manage the following issues to the satisfaction of the Principal:

1. Staff training in awareness of the environmental issues related to the activities and operational procedures and responsibilities for minimising potential impacts;
2. Control procedures to be implemented for routine operations for day-to-day activities to minimise the likelihood of environmental harm, however occasioned or caused;
3. Contingency plans and emergency procedures to be implemented for non-routine situations to deal with foreseeable risks and hazards, including corrective responses to prevent and mitigate environmental harm (including any necessary site rehabilitation);
4. Organisational structure and responsibility to ensure that roles, responsibilities and authorities are appropriately defined to ensure effective management of environmental issues;
5. Effective communication procedures to ensure two-way communication on environmental matters between operational staff and higher management; and
6. Monitoring of contaminant releases to the environment including procedures, methods and record keeping and investigation into the environmental impact of any release that causes or is likely to cause serious or material environmental harm.

2.5 As-Built Documentation

All drawings submitted by the Contractor shall be amended to show in precise detail the arrangement of the Works and design detail as actually constructed. This requirement also applies to all subcontractors drawings. Such amendments as are necessary to depict in detail the as-built condition shall be carefully and accurately prepared electronically by competent draftspersons. Where an as-built condition requires a drawing to be amended, then all related drawings influenced by this amendment shall similarly be amended.

Upon completion of relevant amendments, three (3) hard copies of each drawing, each clearly marked adjacent to the title block and signed by the Contractor as 'As-built drawing', shall be submitted. Receipt of all 'As-built' drawings is a condition precedent to the issue of Practical Completion and any remaining milestone payments.

An electronic copy of each drawing shall also be provided, both in a CAD format as previously specified, and as Acrobat pdf copies.

Following completion of construction, the Contractor shall amend the "As-built" drawings where necessary because of faulty or incorrect work or rework (including defects liability tasks) and for any changes modifying plant that is shown to be below specified performance. Amended drawings shall be submitted within ten (10) working days of receipt of review comments from the Principal or other agreed timeframe.

All flow directional arrows and all labelling on pipework, valves, tees and the like shall be accurate and shall also be reflected on as-built P&IDs.

2.6 Operation and Maintenance Manuals

2.6.1 Submission

Two weeks prior to the start of commissioning, the Contractor must provide the Principal with an electronic copy of the O&M Manual covering items and systems included in the Works under this Contract.

The operation and maintenance instructions supplied must be specific to the actual equipment installed under this Contract. Instructions that are of a general nature are not acceptable.

The O&M manuals will describe the purpose of the system and how it functions within the WTP system, contain details of how to operate and maintain the system. For individual components provided new under this Contract, separate suppliers instruction manuals and recommended maintenance scheduling shall be provided.

The provision of the O&M manuals will be considered a prerequisite for approval to proceed with commissioning.

2.6.2 Format

The contractor shall supply two (2) hard copies of the manuals and an electronic copy. The electronic version will be provided in MS Word 2010 or PDF format, following the existing O&M templates for the two sites. Where PDF format is used, the text elements must be in vector format, that is, not image based. Other formats may be approved subject to negotiation with the Principal. The manual will contain sufficient diagrams, and be written in English in a way easily understood by operators and maintenance fitters.

2.6.3 Content

The O&M manual information will be broken down into subsystems, and the following guide applies to each subsystem. Where applicable, the manual will cover the following topics:

2.6.3.1 Overview

The Overview section will include the following:

1. Introduction
2. Format of the Manual
3. Glossary of Terms and Definitions
4. Manual Amendment Record

2.6.3.2 Operational Modes

The Operational Modes section will include the following, where applicable:

1. General Operating Philosophy
2. Normal Operating Mode
3. Emergency Operating Mode
4. System Alarms
5. Telemetry
6. Specialised Construction Techniques and Activities
7. Investigation Activities

2.6.3.3 Routine Inspection, Monitoring, Testing & Maintenance Activities

The Routine Inspection, Monitoring, Testing & Maintenance Activities section will include the following, where applicable:

1. General
2. Daily Inspection, Monitoring, Testing & Maintenance Program Checklist
3. Weekly Inspection, Monitoring, Testing and Maintenance Program Checklist

2.6.3.4 Planned Maintenance Program

The Planned Maintenance Program section will include the following, where applicable:

1. General
2. Planned Maintenance Program Checklist, including recommended frequencies and resources required to perform the maintenance program

2.6.3.5 Station/ Facility Details

This section is to provide descriptions and details about the facility, and associated equipment.

1. General
2. Pump and Motor Details
3. Level Control Details
4. Controller Details
5. Control Cabinet/Switchboard details
6. Alarm Details

7. Telemetry/Pager Details
8. Miscellaneous Meters, Gauges, etc.
9. Miscellaneous

2.6.3.6 Plant & Equipment Technical Information

This section of the manual deals with the provision of relevant maintenance and technical information, usually provided by the manufacturer, of the plant and equipment installed at the facility. This section will cover original manufacturers O&M manual information not covered in detail in other sections of the manual.

The maintenance instructions should be in sufficient detail to enable overhaul and replacement of all parts of plant/ equipment by plant maintenance personnel. The maintenance instructions shall, where relevant, include, but not be limited to:

1. list of special tools and equipment required;
2. drawings, pictures, diagrams of the relevant piece of equipment;
3. a checklist of operations prior to dismantling;
4. dismantling sequence, with particulars of methods used/recommended;
5. types of inspections of components and checks of tolerances;
6. reconditioning, replacement and adjustment procedures;
7. particular care/maintenance and replacement instructions;
8. reassembly instructions with particulars of methods to be adopted including alignment of fittings/components and the resetting of controllers/operational devices; and
9. Include as attachments:
    a) all relevant maintenance instructions/schedules provided by the manufacturer;
    b) relevant drawings, pictures, diagrams of plant and equipment;
    c) checklists provided by the manufacturer;
    d) instructions/procedures recommended by the manufacturer; and
    e) trouble-shooting guides provided by the manufacturer (or developed by other qualified personnel).

2.7 Asset Register and Identification

2.7.1 Asset Register

The Contractor shall prepare and submit an asset register to the Principal comprising a catalogue of all components and equipment utilised during the Works. For each item, the asset register shall contain the following information at a minimum:

1. Unique asset number;
2. Manufacturer;
3. Supplier;
4. Description;

5. Model number; and,

6. Equipment Size.

The Principal will advise the Contactor of the specific format and requirements of the asset register on award of the Contract.

2.7.2 Asset Identification

An equipment identification plate manufactured from Grade 316/316L stainless steel or aluminium shall be attached to every item of major equipment (e.g. pumps, mixers, drives, machines) which is to show the name of the manufacturer, model and serial numbers, rated speed and capacity with other information as appropriate.

In addition, all process equipment shall have a label containing the asset number. The label shall be for general identification. Labels shall comprise Grade 316/316L stainless steel or aluminium dog tags or Traffolyte labels not less than 3 mm thick. Traffolyte label backgrounds shall be white with engraved black characters of sufficient size to allow easy reading. Labels shall be securely attached, utilising a means of permanent attached such as screws or wire.

Where the Principal deems the plate or label unreadable it shall be the Contractor's responsibility to rectify the identification plate(s) or label(s). Plates and labels shall be fixed to the equipment so that they may be conveniently read when in the installed position.

3 Performance and Process Requirements

3.1 System Overview

3.1.1 Moura WTP

The existing Moura WTP uses a conventional treatment process, consisting of coagulation and flocculation, followed by two trains of settling clarifiers and filters. Raw water is supplied from the Dawson River Moura Wier. The existing WTP process is shown in Drawing No. C-DWG-5200860-004: Moura WTP.

3.1.2 Biloela WTP

The existing Biloela WTP uses a conventional treatment process, incorporating the processes of coagulation, flocculation and clarification followed by filtration. Raw water is supplied from the Raw Water Pump Station, located near the Callide Dam wall, via the raw water mains. The existing WTP process is shown in Drawing No. C-DWG-5200860-023: Biloela WTP Upgrade.

3.2 Process Monitoring and Instrumentation

3.2.1 General

The following specifies the process monitoring and instrumentation requirements for Moura and Biloela WTPs. Tenderers may elect to offer additional instrumentation.

3.2.2 Water Quality Sampling Points

The water sampling points which shall be provided under this contract for the Moura WTP are outlined in Table 3-1 below.

Table 3-1: Summary of Sampling and Monitoring Locations for Moura WTP.

Sample Line	Process Location	Connections Required
Raw Water Pump Station	Raw water main, upstream of all pre-treatment chemical dosing	On-line turbidimeter to be located in RWPS building
Raw water	Plant inlet	On-line dissolved oxygen, conductivity, pH, and UV254 analysers to be located in laboratory building
Filtered water	Outlet of train 2 weir box	On-line manganese and UV254 analysers to be located in laboratory building
Filtered water	Downstream of chlorine dosing point	On-line chlorine analyser to be located in laboratory building
Filtered water	Outlet of train 3 filters	On-line turbidimeter (each filter) to be located in laboratory building
Filtered water	Train 3 combined filtered water line	On-line manganese and UV254 analysers to be located in laboratory building

The water sampling points which shall be provided under this contract for the Biloela WTP are outlined in Table 3-2 below.

Table 3-2: Summary of Sampling and Monitoring Locations for Biloela WTP.

Sample Line	Process Location	Connections Required
Raw Water Pump Station	Raw water main, upstream of all pre-treatment chemical dosing	On-line dissolved oxygen turbidity, conductivity, pH, and UV254 analysers to be located in laboratory building
Clarified water	Outlet of each clarifier	On-line turbidimeter to be located in laboratory building
Filtered water	Outlet of filters	On-line manganese and UV254 analysers to be located in laboratory building

3.2.3 On-line Instruments

The on-line instruments which shall be provided as part of the works under this Contract are listed in the following tables. The installation shall include provision of tapping points, sample pump (if required), water sampling line, drainage line, isolation and calibration valves, and power and signal cabling as applicable to each instrument. Signals from all instrumentation shall be provided to the SCADA System and displayed on the HMI. All readings from on-line instruments shall be trended in the SCADA system and instruments shall provide a healthy or fault signal to the SCADA system. Control functions of the instrument parameters shall be incorporated into the existing PLC/SCADA System.

Table 3-3: Summary of Online Instrumentation Requirements for Moura WTP.

Process Location	Parameter	Control Functions
Raw water main	Turbidity	High alarm
	Dissolved Oxygen	High and low alarm
	Conductivity	High and low alarm
	pH	Low and high alarm
	UV254	Low alarm
Filter outlet (train 2)	Manganese	High and high high alarm
	UV254	Low alarm
	Chlorine	Low low, low, high and high high alarm Option to have low low and high high act as a permissive/interlock
Filter outlets (train 3) (per filter)	Turbidity	High alarm and high high alarm Filter turbidity setpoint triggers a backwash Option to have high high act as a permissive/interlock
Filter outlet (train 3)	Manganese	High and high high alarm
	UV254	Low alarm

Table 3-4: Summary of Online Instrumentation Requirements for Biloela WTP.

Process Location	Parameter	Control Functions
Raw water main	Turbidity	High alarm
	Dissolved Oxygen	High and low alarm
	Conductivity	High and low alarm
	pH	Low and high alarm

	UV254	Low alarm
Clarifier outlets (per clarifier)	Turbidity	High alarm and high high alarm Filter turbidity setpoint triggers a backwash Option to have high high act as a permissive/interlock
Filter outlet	Manganese	High and high high alarm
	UV254	Low alarm

The Contractor shall ensure that all instruments are installed as per manufacturer's recommendations and appropriately protected from solar exposure. Instruments located below ground shall be installed in covered concrete lined pits that prevent the instruments from becoming blocked by infill.

Flow meters shall be located sufficiently upstream or downstream of chemical dosing points to prevent measurement issues arising from fluctuations in bulk water conductivity. Flow meters shall have a straight section of line upstream and downstream of sufficient length to prevent interferences from turbulence.

3.2.4 Analyser Wet Rack

Where possible, water quality (pH, dissolved oxygen, conductivity, turbidity, manganese, and UV254) analysers at the WTP sites shall be located on a Wet Rack inside the Laboratory to provide protection and facilitate ease of access and calibration. The Wet Rack shall comprise a board or panel set at an ergonomic working height on which the instruments and associated components may be mounted. The Wet Rack shall also include a tundish located below the board or panel into which the sample water may drain and be collected without splashing onto the surrounds or floor. The tundish shall drain or be pumped to the Supernatant Pump Station.

Sample water shall be provided to the instruments by sample lines from each sample point. The sample line to each instrument shall split at the Wet Rack to provide water to the instrument and also to a drain valve discharging into the tundish such that a greater flow of water than is required by the instrument can be continuously drawn through the sample line. The drain valve shall be globe, diaphragm, or gate type to facilitate fine adjustment. An analogue flow indication device such as a rotameter shall be included to allow operators to monitor and adjust flow through the sample lines.

The instruments shall be installed as per the manufacturer's recommendations. The inlet to each instrument shall include in order, an isolation valve for maintenance purposes, a strainer for protection, and a mechanical constant flow valve sized to provide the manufacturers' specified sample flow rate. Suitable constant flow valves are manufactured by Maric Flow Control. The instrument drain line(s) shall be plumbed into the tundish such that it provides the operator with a practical manual sampling point.

4 Instrumentation

4.1 General Requirements

4.1.1 Overview

Instruments shall be chosen and installed based on reliability, accuracy, suitability for the operating environment, low maintenance and easy calibration. The instrument availability shall be better than 99% including off-line duration for manual calibration and routine maintenance.

Instruments shall be supplied complete with suitable mounting brackets, preferably fabricated from 316 stainless steel. All instruments shall include provisions for conduit entry for electrical connections, and all entries shall be sealed with a gasket. External/outdoor mounted instruments shall be provided with stainless steel sun shields.

Programming tools/equipment shall be supplied for any instrument, if required, to permit programming and amendment on site. Instrument loop parameters shall meet all requirements of the process, and shall be suitable for automatic control and remote monitoring via PLC/SCADA system. The contractor shall determine the specific requirements for each instrument loop.

All instruments shall be installed as required by the manufacturer to ensure that readings accurately reflect the process conditions e.g. flow meters shall have the correct length of straight pipe before and after flow meter. All instruments and associated devices supplied shall be fully supported by spare parts and technical service local to the Queensland region.

The instrumentation shall contain all the necessary hardware to provide the operator with an easily accessible local indicator either on the instrument or in the field instrument panel. The values on the digital displays shall coincide with the values on SCADA. Where there are more than 5 displays required use a 15 inch colour touch HMI screen to display these values and connect the screen to the PLC network using Ethernet.

All instruments shall be loop powered or powered from 24Vdc. Analogue signal transmission shall be linear, 4 - 20mA DC proportional to the range of measured variable. Instrument signal cabling between the instrument and the PLC shall be protected against lightning on either end.

All transmitters shall be capable of working into instrument loop impedances of up to 600 ohms. All instrument loops shall perform reliably under the site conditions.

Analytical instruments which require an operator calibration such as free chlorine, dissolved oxygen, pH, turbidity etc. shall have the transmitter mounted in an enclosure with a treatment plant lock and the terminals and lightning protection units located in a separate enclosure which can be only be accessed by an electrical person. The terminal enclosure shall be labelled "Live terminals behind cover. Isolate elsewhere before removing cover".

All transmitters which have a black screen shall have suitable cover to protect the screen from the sunlight.

All instruments, where possible, shall include flow sensors (to minimise false readings), automatic cleaning modules, and a system check (to confirm instrument health).

4.1.2 Installation Below Ground

Install instrumentation below ground as directed by the Specification or Drawings. The instrumentation shall have a minimum rating of IP68.

Access chambers and pits shall be concrete and suitably sized to enable access to the equipment and removal of the equipment for maintenance. Provide a gravity drain from the pit. If gravity drainage is not possible install a sump pump. A pit flooded float switch shall be installed in all pits to bring up an alarm on SCADA. Access chambers and pits shall be approved by the Principal during detailed design.

Direct burial of equipment shall be in accordance with the manufacturer's requirements. In the absence specific manufacturer requirements, the void around the instrument shall be back-filled with a packing sand mixture and protected by completely packing the entire sensor (housing, bolts/nuts, and flanges) with mastic contour filler, then wrap it with a synthetic fabric based tape impregnated and coated with organic petroleum based compounds, followed by plasticised PVC, incorporating natural and synthetic rubber adhesive and fungal inhibitor. A polymeric cover which covers the entire instrument shall be installed 150mm below finished ground level.

Notify the Principal 3 working days prior to covering / backfilling installations to arrange inspection by the Principal's instrument engineer / technician.

4.1.3 Instrumentation Loops

All instrument loops shall have as a minimum requirement the following accuracies unless specified elsewhere:

1. Calibration accuracy ± 0.5% of span
2. Repeatability ± 0.1% of span
3. Sensitivity ± 0.1% of span

4.1.4 Instrumentation Tests

Test all instruments establishing the overall accuracy of the devices from primary element to the PLC.

Results shall be recorded on test sheets when complete, submit one copy of the test sheets within five working days and include a further copy in each copy of the Operation & Maintenance information / manuals.

4.1.5 Field Instrument Panels

Field mounted instrumentation panels shall be located adjacent to their respective primary element or sensor.

Each field instrument panel shall contain:

1. A means to isolate the power supply shall be provided within each instrumentation enclosure. All instrument field cabling shall be protected against lightning in the field instrumentation panel.
2. Digital display of analogue value in engineering terms, viewable with the cabinet door closed. The transparent material used for the viewing window shall be suitable for use in an outdoor environment without the material turning opaque. The displays are to be visible in bright sunlight and resistant to UV rays.
3. Terminals for all incoming and outgoing cable cores
4. Earth electrodes shall be installed at the location of each field instrumentation panel for surge protection. An insulated earth bar for surge protection earths, connected to the panel and a local earth electrode below the panel. Where instruments are mounted above tanks or where it is not possible to install an electrode below the pane, up to four instruments can use a single electrode but need to be individually wired and clamped to the electrode.

4.1.6 Instrument Communication

Instrumentation shall provide Modbus (preferable) communication. If Modbus communication is not available for the selected instrument, then 4 – 20 mA current output shall be required.

4.2 Flow Measurement Devices

4.2.1 General

All flowmeters on process liquid streams and delivery pipework shall be electromagnetic type except for chemical dosing flowmeters which shall be as per vendor's design.

Flowmeter flanges shall conform to AS4087. Flowmeters in pits shall be IP68 rated. Pits shall provide sufficient clearance for maintenance access and flowmeter removal.

Wherever possible all instruments shall be mounted above ground level. Where flowmeters are required below ground level, they shall be in covered weatherproof concrete lined pits. Direct buried meters shall not be acceptable.

4.2.2 Electromagnetic Flowmeter

Electromagnetic flow meters shall be supplied as complete sets incorporating the primary flow element, a separate solid state flow indicating transmitter and 316 grade stainless steel earthing rings for both upstream and downstream flanges which shall also protect lining material leading edges.

The metering method shall be based on the pulsed direct current principle. The flowmeter shall be suitable for use in empty pipes without the need to de-activate the flowmeter.

The flow tube body shall be provided with flanges sized in accordance with AS4087.

The element shall have electrodes and lining material suited to the application.

Primary element and indicating transmitter nameplates shall be stamped with instrument loop number, span in L/s and all associated calibration factors.

The transmitter shall display instantaneous flow and totalised flow on an LCD back lit screen. Provide a label attached to the transmitter with the parameters for the flow tube, these details shall also be included on the drawing.

Provide output from the transmitter for both instantaneous flow and totalised flow. Totalised flow held in the transmitter for display on the LCD screen is to be available also for interrogation by the treatment plant local SCADA system such that interruption of SCADA services does not result in loss of totalised flow records.

Submit a certified flow curve for the meter and include in O&M information / manual.

Accuracy of the primary element and transmitter together, from 10% to 100% of flow as sized shall be ±0.5% of actual flow rate increasing to ± 1% at 1% of meter capacity.

Flow tube enclosure rating shall be IP 66D. Convertor enclosure rating shall be IP 56.

4.2.3 Thermoelectric Flowmeter

The air flow measuring device shall consist of a flow element and a transmitter.

The flow element shall be manufactured from 316 grade stainless steel, and sized to suit the pipe and flow requirements.

Units shall be displayed in normal cubic metres per hour (Nm3/hr)

The overall accuracy of the transmitter and sensor shall be better than ±2% of reading, Repeatability: ±1% of reading and Turndown: 5:1 to 100:1 maximum

4.2.4 Thermoelectric Flow Switch

Thermoelectric flow switches may be used for flow indication in situations where there is no requirement for analogue signal.

The associated indicating transmitter shall be of the electronic solid state type with adjustable signal damping.

The indicating switch shall have an adjustable response time to dampen rapid flow fluctuations.

The unit shall transmit a TTL signal or contact closure to the PLC equipment.

4.2.5 Mass Flowmeters

Mass flowmeters shall be installed where a very high accuracy is required and shall use a Coriolis flow measurement.

4.3 Analytical Measurement Devices

4.3.1 pH Measurement Devices

Online pH meters shall be manufactured by a supplier approved by the Principal.

The pH measurement equipment shall include either single combination electrodes or discrete measurement and reference electrodes.

The reference electrode shall be a sealed, gel filled and non-flowing with a ceramic or similar junction that resists fouling.

The electrode assembly shall be mounted in a flow through type sensor housing manufactured from glass fibre reinforced polypropylene or similar. Protection rating of the electrode housing shall be class IP68.

The instruments shall be temperature compensated over a minimum range of -2 oC to 50 oC.

The instruments shall be designed for continuous use.

4.3.2 Dissolved Oxygen meters

Dissolved oxygen (DO) meters shall be manufactured by a supplier approved by the Principal.

The DO meters shall utilise either polarographic or optical DO probes. The DO meters shall have a measurement range of 0.0 mg/L to 20.0 mg/L, with an accuracy of ±2%.

The DO meters shall have a one-point or two-point calibration capability, with automatic calibration using air or saturated air-free water.

The instruments shall be temperature compensated over a minimum range of -2°C to 50°C.

The instruments shall be designed for continuous use.

4.3.3 Turbidimeters

Turbidimeters shall be manufactured by a supplier approved by the Principal.

The method of measuring turbidity shall be nephelometric using pulse scattered infrared light at 860nm at a 90° angle in accordance with/compliance with DIN EN ISO 7027. A. Other methods of turbidity measurement including those that require a sample cell or those with incandescent light sources are not acceptable.

Turbidimeters shall be provided with secondary standards and the user-configurable parameters shall be retained in the meter's memory when the unit is de-powered.

It is an important criteria that the displayed turbidity value and the analogue outputs can be trimmed at the operator interface without the need for a full calibration using primary standards and that the outputs are able to be trimmed regardless of value.

The transmitter shall include digital filter functions and sensor self-monitoring.

The filtered water and clear water turbidimeter/s shall have a measurement range of at least 0.001 – 10 NTU, with an accuracy of ±1%.

The raw water and supernatant return water turbidimeter/s shall have a measurement range of at least 0.1 – 100 NTU, with an accuracy of ±1%.

Turbidimeters used for raw water and supernatant return water analysis shall include automatic self-cleaning systems.

4.3.4 Free Chlorine Residual Analysers

The free chlorine residual analyser shall be manufactured by a supplier approved by the Principal.

The residual analyser/indicator shall have zero and span adjustments and automatic pH and temperature compensation.

The scale range shall be 0.0 to 5.0 mg/L free chlorine.

4.3.5 Manganese Analysers

The manganese analysers shall be manufactured by a supplier approved by the Principal.

The manganese analysers shall utilize an ion-selective electrode (ISE) measurement principle that does not require the use of reagents. The analysers shall have a measurement range of 0.01 mg/L to 5.0 mg/L, with an accuracy of ±1%.

The electrodes used in the analysers shall have a life expectancy of at least two years; and have an automatic electrode calibration function.

4.4 Temperature Measurement Devices

Temperature measurement devices shall be the resistance thermometer type (RTD).

The detector shall include a 3-wire platinum resistance temperature detector. The sensing element shall be sealed in a ceramic former and enclosed in a 316 stainless steel sheath.

A sensing current of up to 10mA shall not have significant effect on accuracy.

The transmitter enclosure shall include a suitable converter head with signal converter electronics segregated to allow wiring termination and calibration without exposing electronics.

4.5 Instrumentation in PLC Cubicles

4.5.1 Indicators

Indicators shall be digital loop powered type meters suitable for flush panel mounting.

Indicators shall have an input range of 4 - 20mA and engineering units as required. Appropriate labels shall be installed detailing the value being displayed and the engineering units. Accuracy and repeatability shall be ± 0.2% minimum.

Indicators shall be mounted in individual instrument case with front bezel and rear screw terminals for connection of wiring. Adjustment of zero & span shall be at rear, accessible without removing the indicator from its case.

Do not mount indicators on or through door viewing windows.

4.5.2 Current to Current Converters

Provide converters wherever the loop impedance of the load devices exceeds the source device capabilities. Converters shall be fully solid state capable of receiving 4 - 20mA and shall be provided for current isolation and as a source of power for repeating a current signal.

Converters shall be powered from 24Vdc and shall be capable of supplying 20mA into a loop resistance of 900 ohms. Front panel adjustments for span and zero shall be provided via 10 turn potentiometers. An LED shall indicate output loop current.

Current to current converters shall be installed on horizontal DIN rail and a DIN rail terminator shall be installed between each isolator to provide an air gap for cooling.

Current to current converters shall have the following:

1. Accuracy ±0.15% of span
2. Repeatability ±0.1% of span
3. Input impedance 50 ohms
4. Auxiliary voltage for input loop 22 Volts at 25mA

4.5.3 Terminal Strips

Terminal strips for instrumentation shall be standard disconnect miniature range rail mounted terminal block.

5 PLC and SCADA System

5.1 General

The new instrumentation shall be integrated into the existing SCADA (supervisory control and data acquisition) system at each site.

All equipment, instrumentation, valves, vendor packages, and other electrical items shall be connected to the existing programmable logic controllers (PLC) which shall connect with the SCADA system.

The SCADA system shall use GeoSCADA SCADA (for the Moura WTP) or Citect SCADA (for the Biloela WTP) software and shall interface with the Principal's appropriate water network SCADA system via telemetry. Refer to Appendix A for photos of the existing PLC/SCADA systems at each site.

5.2 Scope of Works for SCADA System

The SCADA works shall include but not be limited to the following tasks:

1. Modification (as required) of existing PLC and SCADA systems, including updating of Functional Description and drawings;
    a) Confirm the IO capacity of the existing PLC for new instrumentation and supply additional capacity as required
2. Supply, installation, programming, testing and commissioning of new equipment for PLC, SCADA, and UPS systems as required;
3. Connection of new equipment to the existing control systems;
4. Supervisory Control and Data Acquisition (SCADA) system programming as required for new equipment;
    a) SCADA information and processes status and alarms suitable for connection to ACC's SCADA system;
    b) SCADA to include time stamped events and alarm logs
5. Local controls for components as applicable.

5.3 System Requirements

The Contractor's design shall meet the following general requirements:

1. The use of PLC programming languages that comply with the IEC 61131 standard (ladder logic);
2. The use of standard I/O interfaces for all field devices (i.e. motors, actuators, transmitters, etc);
3. A SCADA system to display, monitor, alarm and report on all relevant activity;
4. Secure access and operation of the SCADA display from a remote location;
5. The ability to manually stop and start equipment from the SCADA system, and initiate automated control;
6. Monitor and control all equipment associated with the operation of the WTPs via SCADA;
7. Suitable licensing arrangements for the SCADA applications; and
8. Suitable licensing arrangements for PLC programming applications.

The Contractor shall ensure that equipment under the control of the SCADA system is operated within equipment and process constraints. The Contractor shall ensure that the control system:

1. Provides stable regulatory control under all conditions;
2. Incorporates equipment and process start and stop permissives for the safe operation of the WTPs;
3. Incorporates comprehensive automatic protection actions to ensure safety of personnel and WTPs;
4. Provides an intelligent alarm system that generates only genuine alarms which can be actioned by the operator and maintainer AND also has configured appropriate alarm conditioning logic to ensure the invalid alarm conditions are not raised (e.g. when plant is out of service);
5. Provides a logical hierarchical structure of screens for each piece of plant equipment (pumps, screw feeders, etc.), which progressively details all associated alarms/ interlocks/ latches/ permissives/ etc. to facilitate and expedite troubleshooting of that equipment;
6. Ensures equipment is operated within duty/ cycle constraints to maximise load sharing;
7. Operates equipment within valid set point ranges; and
8. Operates equipment within the manufacturers' specifications.

5.3.1 PLC System

5.3.1.1 General

The existing PLC system utilises Allen Bradley PLC equipment.

Digital inputs and outputs shall be 24Vdc.

Analogue I/O shall be 4 - 20mA, current sinking or sourcing as required and fully short circuit protected.

Connect all I/O to wiring using disconnect terminals. Each I/O point which connects to equipment in the field shall be suitably protected by a fuse.

5.3.1.2 PLC Equipment

The PLC based control system shall:

1. Be capable of providing the required programmable control functionality for the Works under this Contract;
2. Re-use the same generic code for all similar types of operation;
3. Communicate to the SCADA server via an open or acknowledged industry standard network communications protocol supported by the SCADA server;
4. Optimise the internal storage of data shared with the SCADA server to promote efficient data transfer;
5. Provide a 10/100 Mbps or better Ethernet physical communications interface;
6. Raise alarms based on direct I/O conditions or on a calculated value;
7. Provide 'smart alarms' whereby secondary alarms are masked by higher priority alarms;
8. Operate continuously in the environment conditions and at the availability requirements as set out in this Specification;
9. Utilise standardised I/O modules as far as is practicable throughout the system so as to minimise spares requirements; and

10. Include flash memory.

5.3.1.3 PLC Functionality

The PLC shall act as the system logic controller and interface device for the SCADA system. PLC programming software shall be capable of being executed on a standard PC running in a Microsoft Windows environment. The programming software shall also be capable of running on the SCADA server computer. If required, software key shall be provided.

Documentation required to describe the PLC code and data shall be stored on-board the PLC where spare PLC memory is available.

The PLC shall control all local and remote I/O and shall be capable of communicating with other serial communications enabled devices to exchange data. Data exchange shall be bi-directional.

The PLC shall provide the SCADA server with following diagnostic information:

1. I/O module/ channel status;
2. Power supply status, including UPS;
3. Local and remote RTU status;
4. Status of communications enabled devices;
5. Local network switch status;
6. CPU run/ stop/ fault status;
7. Software/ configuration fault;
8. Memory fault; and
9. Cubicle temperature alarm conditions.

Setpoints configured within the PLC for automatic control shall be adjustable from the SCADA. Provision shall be made to override normal automatic operation and sequencing of the equipment in and out of service by providing independent manual control of each field device from the SCADA operator terminal.

5.3.1.4 I/O and Communications Modules

Communications, local I/O and remote I/O modules shall be provided as necessary to meet the full requirements of the Work under this Contract.

The PLC shall connect to an Ethernet LAN to exchange data with the remote I/O, SCADA computer, variable speed drives (VSDs) and any communications enabled vendor packages.

5.3.1.5 Chassis and Power Supply

PLC chassis and module power supply shall be provided for the new hardware configuration. PLC power supplies shall be selected to ensure that under full module load conditions the power supply remains below 70% of its maximum power output capacity. Each power supply shall be installed with surge protection.

5.3.1.6 Fault Tolerance

The PLC shall be configured so that on hardware failure (e.g. short circuit, open circuit or loss of power), the state of digital and value of analogue outputs place equipment and process in a safe state.

On return from power failure, the PLC CPU shall automatically load the program and enter the run state and ensure that plant and process is placed in a defined and safe state. Communications with the SCADA server must be restored automatically upon restoration of the power supply.

The PLC shall not depend upon network communications to ensure the safe operation of the plant and process which it controls.

5.3.1.7 Configuration Development Software

The Contractor shall use the latest commercially released version of the manufacturer's recommended configuration development software. The Contractor shall supply and install one (1) PLC configuration license on a computer nominated by the Principal connected to the control system LAN. The development software shall be the same type and version used to develop the PLC configuration for this project.

5.3.1.8 Software Licensing

The Contractor shall provide one (1) unrestricted software license for the PLC programming software. The Contractor shall provide all original CD/DVD/USB Memory stick, documentation and packaging related to the programming software.

5.3.2 Communications Network

5.3.2.1 Communications Enabled Intelligent Electronic Devices

The Contractor shall design, procure, deliver install, configure, test and commission all equipment necessary to provide an Ethernet based LAN exclusively for the connection of control system equipment.

5.3.2.2 Control System LAN Topology

Control system communications shall be provided by a dedicated 100 Mbps or faster, full duplex, Ethernet LAN.

5.3.2.3 Network Switches

All network switches shall derive power from a surge protected power supply from the new UPSs. Final communications connection from network switches to control system equipment shall be made using category 6 copper Ethernet cable.

The network switches shall have the following features:

1. Sufficient 100 Mbps or faster fibre port capacity to connect interconnecting network switches;
2. Sufficient 100 Mbps or faster copper port capacity to connect interconnecting equipment;
3. Switch management functions through SNMP;
4. SNTP;
5. Remote diagnostics;
6. Web configuration interface;
7. Fault output hardwired to PLC (switch connected directly to PLC only);
8. DIN rail mounted; and
9. Be located no further than 1 m from the fibre patch panel they connect into.

The switch connected directly to the PLC shall provide a hard wired output to the PLC which shall activate on any fault or failure of the network switch. This output shall be used to alert the operator of any possible permanent or intermittent network faults or failures.

5.3.2.4 Media and Protocol Compatibility

All serial communications enabled devices shall maintain compatibility with the physical and upper protocol layers of the LAN and PLC. Media converters and protocol bridges shall be used wherever necessary to ensure compliance with the control system LAN and PLC.

5.3.2.5 Future Expansion

Every network switch which forms part of the control system LAN shall have a minimum of two (2) spare 100 Mbps (TX) or faster copper ports to permit the expansion of the network and the connection of computer equipment for maintenance purposes.

5.3.3 SCADA System

5.3.3.1 General

The SCADA system shall be operational on one (1) dedicated server computer located in the Control Room and be integrated with the existing SCADA at each WTP to allow remote access and control of the WTP from either location.

The Contractor shall provide proposed SCADA project standards to the Principal for approval prior to configuring the WTP's new graphic displays. The SCADA configuration shall be developed into a single project.

The SCADA system shall provide:

1. Local operator access via user log-on security at operating system and application level;
2. Plant visualisation via graphical user interface (GUI) screens;
3. Equipment fault troubleshooting via a logical hierarchical structure of screens which progressively details all associated alarms/ interlocks/ latches/ permissives/ etc.;
4. Plant control functionality;
5. Minimum 13 months historical and real-time trending sourced from server computer hard disks;
6. Display and processing of events and alarms;
7. Reporting functions;
8. Scalability – the ability to expand I/O and associated processing capability;
9. Support for backfilling data;
10. Use of mechanisms such as genies and templates to promote code reuse and maintainability;
11. Operations restricted by user type;
12. Use of tag naming convention for SCADA database; and
13. Use of a coding standard.

5.3.3.2 SCADA Software

The SCADA system version shall be the latest version of the relevant software (GeoSCADA for Moura WTP, and Citect for Biloela WTP), provided this is compatible with BSC's wider network. Approval of the proposed SCADA system additions and modifications will be given by the Principal following a review of the proposed design. The SCADA server license shall have sufficient points to cater for the requirements of this project as well an additional 500 points above and beyond the requirements for future upgrades.

5.3.3.3 SCADA Hardware

The upgraded server shall be housed in the Control Room with keyboard, mouse and monitor for use as a HMI for the operators to access the SCADA system.

Power for the server and associated equipment shall be sourced from a local UPS.

Any communications equipment (switches) associated with the SCADA server and/ or PLC shall be located in the PLC cubicle.

All SCADA servers, notebooks and associated equipment shall be manufactured by Dell.

5.3.3.4 Communications

The SCADA server shall be capable of receiving 'time-tagged' data and 'data backfill' and furthermore support 'open' or 'industry standard' protocols.

The SCADA server shall incorporate specific communications drivers to provide communications with all PLC, modem and network switch equipment.

The SCADA server shall also be capable of polling the managed network switches to determine the status of the control system network. The operator shall be alerted to the possibility of an intermittent communications failure by the generation and logging of an initial low priority alarm. Repeated intermittent or permanent communications failure shall cause the generation of a high priority alarm.

5.3.3.5 Data Storage and Retrieval

The types of data that will be stored in the SCADA system will fall into the following categories:

1. Status change of real-time I/O data based on field instrumentation and calculated information (e.g. tank level, daily flow, pump status, pump run hours, etc).
2. Historical data including:
    a) Time series instrument data;
    b) Operational setpoints;
    c) Filters' operation state (state numbers to correspond to sequence table provided in Functional Specification and shall include fault, offline, and online states, as well as all backwash sequence steps);
    d) Instrument settings and change logs; and
    e) Alarms and warning logs.
3. In addition, the SCADA system shall log:
    a) All alarm conditions including the handling of these alarms;
    b) All operator actions that change the state of the system such as pump inhibits and un-inhibits, alarm inhibits, and alarm trigger set points; and
    c) All supervisor and administrator actions that alters the state of the login system, user permissions, screen updates, and other system configuration changes.

The SCADA shall record time series instrument data, as well as Filters' operation state, on a per second basis. All other data may be sampled on a per 10 seconds basis.

The SCADA system shall log data over a rolling period of 13 months. Each month shall be stored as a separate file to simplify backup. The Contractor shall develop a procedure to enable the operator to perform a backup of each new month's data to both optical media and a storage located on the control system LAN.

5.3.3.6 HMI

The graphical monitoring screens of the HMI shall be composed in a hierarchical structure. The top level screen shall provide an overview of the entire WTP process. This screen shall display key process parameters and allow the user to click and zoom into the overview screens of individual processes at different locations within the site.

Individual overview screens shall graphically describe the plant equipment and process. The value and status of all instruments and all field equipment connected to the PLC such as pumps, valves, flow and level meters shall be represented as dynamic symbols or text objects, or combination of both. For example, levels shall be displayed as a dynamic filling of reservoir, tank, well or sump proportional to the level signal with values also displayed as a digital readout.

Each item of equipment shall have an associated pop-up which allows access to further monitoring and control. The popup shall allow the display of additional information such as status (e.g. running, stopped, fault). The popup shall also allow the operator to issue commands (e.g. start/stop, auto/manual, duty/standby) and enter setpoint data (e.g. speed, level).

Colour representations as given in Table 5-1 shall be used to represent the various states of the system.

Table 5-1: SCADA HMI Colour Representation.

Colour	Description
Red	On/ Running/ Active
Green	Off/ Stopped/ Available
Yellow	Fault/ Warning/ Alarm

The HMI shall be designed to be intuitive through the use of readily recognizable mimics and a navigation tree which permits operators to make frequently used screen changes with a single click. It shall be possible on every screen to navigate back to the previous screen, main overview screen, alarms screen and trends screen.

The HMI shall provide system status screens which permit the operator to see the integrity status of all control system equipment, including the communications network. This screen shall provide a clear indication of any breaks in the network or devices with a fault or failure.

The HMI screens shall:

1. Allow a point-and-click interface to access the various screen levels;
2. Have a logical hierarchical structure of screens grouped by process which progressively decreases in scope and increases in detail;
3. Clearly indicate exactly what each screen refers to using a consistent naming convention;
4. Reduce complexity on each screen to a minimum of frequently needed features by allowing the operator to drill down to less frequently used features when required;
5. Have a navigation system designed to make navigation intuitive and fast for the operator;

6. Provide all plant information that is interfaced to the PLC I/O;
7. Provide a logical hierarchical structure of screens for each piece of plant equipment (pumps, screw feeders, etc.) which progressively details all associated alarms/ interlocks/ latches/ permissives/ etc.;
8. Provide system status page(s) which displays diagnostic and error information of all control system equipment;
9. Use standardised colours, sizes, graphical symbols and dynamic characteristics for common items of equipment across all screens;
10. Restrict data entry within a valid (i.e. pre-defined) range;
11. Display engineering units for all engineering values and apply units consistently for each process variable type; and
12. Provide an online help facility for context-related reference and instructions. This may be a combination of mouse-over tool-tips, help pop-ups and a content-addressable and/or indexed drop-down help menu.

5.3.3.7 Alarms

The SCADA system shall raise and display individual alarms on the HMI on I/O and calculated values only when the operator or maintainer is required to carry out an action in response to an alarm.

The PLC will also have configured appropriate alarm conditioning logic to ensure the invalid alarm conditions are not raised (e.g. low outlet pressure when the blower is not in service).

The alarm priority levels shall be align with the existing functional description for each site.

The Contractor, in conjunction with the Principal, shall develop an alarms list that prioritises and rationalises plant alarms. The Contractor shall use this document, on the Principal's approval, for the design, configuration and testing of the SCADA system alarms.

5.3.3.8 Notification and Call-Outs

A remote control and alarming system is currently used by the Principal. The Contractor shall provide a list of new alarms for the WTPs for review by the operators and Principal prior to commissioning.

5.3.3.9 Trends

The following features shall be incorporated within the trend capability of the SCADA system as a minimum:

1. Trending data valid for a period of at least 13 months sourced from online hard disks;
2. Each online instrument displayed to provide an adjacent one-click link (or equivalent) to bring up a control window displaying the online trend for that instrument;
3. Configure and display at least eight (8) trend points on a trend group;
4. Display at least two (2) trend groups on a page for trend comparison – i.e. double trend screens;
5. Each new and modified individual sub-process shall have pre-configured trend groups;
6. Trend point values to be displayed at trend cursor;
7. Trend cursor normally placed at most recent trend point and updates position based on most recent point;
8. Capability to move cursor using keyboard keys and mouse-drag;
9. Capability to select a segment of trends using a mouse, and zoom in/out of trend selection;

10. Capability to scroll to past data values; and

11. Tools to save to a clipboard/ excel file, a selection of trend values including a data/time stamp.

5.3.3.10 Pre-configured Trends Groups

Each new sub-process shall have associated trend screens. The trend screens shall contain pre-configured trends of all analogue and digital trend points relevant to each sub-process.

5.3.3.11 Configurable Single Trend Group Screens

A minimum of four (4) configurable single trend group screens shall be provided and be accessible from all overview pages. These screens shall provide the operator with the capability to configure up to 14 trend points to be displayed on each screen. Trend points added to a configurable single trend group screen shall remain on the screen list until the operator removes them or replaces the trend point with others.

5.3.3.12 Configurable Double Trend Group Screens

A minimum of four (4) configurable double trend group screens shall be provided and be accessible from all overview pages. These screens shall provide the operator with the capability to configure up to eight (8) trend points to be displayed on each trend group window with two trend groups per screen. Trend points added to double trend screens shall remain on the screen configuration lists until the operator removes or replaces them with other trend points.

5.3.3.13 Reporting

Reports shall be provided by the SCADA software and shall be optimised for use by the operator.

The Contractor shall provide a document, which defines the reporting functionality identified in conjunction with the Principal. The Contractor shall use this document, on the approval of the Principal, as the basis for the design, configuration and testing of the reporting functionality required from the SCADA software.

The reporting period and start time for standard reports shall be operator configurable and shall as a minimum support the following set periods: daily, weekly, monthly, quarterly and annually. For each standard report an associated comparative report shall exist which allows comparison with the immediately previous period (e.g. today/yesterday, this week/last week, this year/last year).

Continuous numerical data in standard reports such as flow shall be represented with minimum, maximum and average values.

The system shall produce the standard reports listed in the table below in addition to any additional standard reports defined in conjunction with the Principal. Details of the required SCADA reports page will be confirmed by the Principal during the design stage.

Table 5-2: Required SCADA system reports.

Report	Description
Raw/ Process/ Final Water Quality Data	A summary of all water quality analysers from across the WTP
Alarm	A summary of alarm occurrences describing type, priority, time alarm was raised, acknowledged and cleared, operators actions and number of individual and total alarm occurrences.
Change log	A summary of key process changes made by the operator including the identification of the operator.

The following report features shall be provided:

1. Generation of reports using the previous 13 months stored SCADA data;

2. Automatic generation of reports at desired intervals (i.e. daily, weekly, monthly, quarterly, annual);
3. Automatic reports generated by exception (i.e. performance values outside pre-determined limit);
4. User initiated report generation;
5. Use of inferred values derived from numerical conversion of database values using constants and algebraic formulas;
6. Generation of reports in MS Excel format with the options of saving to a user configurable network location and sending to a user configurable email address; and
7. Generation of reports targeted to stakeholder (e.g. management, operator, maintenance, external bodies).

5.3.3.14 User Access

Local and remote user access shall be from connections using a client application. The SCADA system shall initially provide the following basic levels of access:

- **Management** - in this mode, the user can only view selected screens and will not be able to alter any system attributes, equipment status, handle any alarms, and generate any reports;
- **Operations** - in this mode, the user shall have access to the system depending on areas of interest, except the configuration of users, system permissions, and screens setup;
- **Engineer** - in this mode, the user shall have access to the entire system including configuration of users and access permissions.

5.3.3.15 Server Start Up

Should the server restart for any reason, it shall boot directly into the SCADA server software and resume normal server operations without requiring user-input.

5.3.3.16 Server Status

Health status of the SCADA server shall be monitored and alarms shall be activated in the event of a server failure.

5.3.3.17 Remote Access

Remote access to the WFP's local SCADA server/application is needed for remote monitoring and control of the plant. The Contractor shall design and provide the reliable and robust communications link which allows remote connectivity to the plant from the ACC's main office. This shall be done in conjunction with the ACC's IT and SCADA representative to ensure feasibility of selection and to comply with their cyber security policy requirements

5.3.3.18 Licensing

The Contractor shall supply one (1) server software license which support all points used in the system plus an additional 20% spare capacity. The installed server software shall support point expansion without the need for replacement of the server software.

Client software licenses supplied shall support concurrent access for a minimum of two (2) users on the LAN, and should not be limited to specific computers on the network i.e. a 'floating' licensing scheme is preferred. The number of licences shall be capable of being increased, and the Contractor shall provide the costs associated with adding extra licenses.

5.3.4 Electronic Security

As a minimum, the Contractor's design shall incorporate the following:

1. User authentication and authorisation for access to all SCADA and remote access software;
2. Remote access only through a secure, firewalled access portal (e.g. VPN) to prevent unauthorised access from external sources;
3. An independent high speed control system LAN for the SCADA server/ client, PLC, and other serial communications enabled control system devices;
4. Allow limited access to SCADA information on a need-to-know basis specific to "Areas of Interest" by defining user levels;
5. Devise password policies to enforce the use of strong passwords;
6. Ability to regularly update passwords;
7. Ability to delete users upon cessation of employment;
8. Use of PLC authentication functionality where available; and
9. Password authentication for configuration access to all control system network switches.

5.3.5 Coding Standard

The Contractor shall develop and provide a coding standard to ensure consistent, structured and well-documented SCADA and PLC code. The standard will be developed and applied to ensure consistency of all new code with the existing standards. The standard will be written such to allow any subsequent Contractor to maintain the code to a consistent level of quality.

The coding standard shall contain sufficient detail to ensure SCADA and PLC code has the attributes described in the next three (3) sub-clauses.

5.3.5.1 Common

1. Well defined code structure of functionally grouped subroutines/ functions;
2. Minimal dependency and coupling between subroutines/ functions with strong cohesion of functionality within subroutines/ functions;
3. Subroutine/ function comment header which describes operation, arguments, return values relevant process information, relevant documents/ drawings and version history;
4. Meaningful comments on algorithms which describe purpose, operation and how it relates to the process;
5. Consistent distribution of meaningful comments throughout the code;
6. Full comment descriptions for all variables, constants and I/O;
7. Consistent subroutine and function naming convention;
8. Application of the tag naming standard for all variables, constants and I/O;
9. Consistent format in the use of statements, expressions, operators, declarations, functions, indentation and whitespace;
10. Use of error detection and error handling mechanisms; and
11. No disabled code sections within operational code.

5.3.5.2 PLC Specific

1. Exclusive use of IEC 61131 ladder logic in PLC except in cases where required functionality is only available in another IEC 61131 language;
2. The use of PLC I/O mapping to reduce I/O hardware dependency within the code;
3. The use of PLC language constructs to reuse code wherever possible for standard operations such as motor control (e.g. function blocks);
4. No forced bits active on operational PLC code; and
5. Use of error bits provided by PLC hardware.

5.3.5.3 SCADA Specific

1. The use of language objects to reuse code such as page templates and genies; and
2. Appropriate use of variable scope to limit visibility to need-to-know parts of the code.

5.3.6 General Support Hardware

5.3.6.1 Equipment Housing

The Contractor shall design, procure, deliver and install PLC cabinets. The Contractor shall submit drawings of the proposed arrangement to the Principal for approval.

The Contractor shall use space allocated in the new Motor Control Centres (MCC) to house new, remote, control system equipment and wiring termination.

5.3.6.2 Equipment Labelling

The Contractor shall be responsible for ensuring all items of control system equipment are labelled. All labelling shall comply with ACC's naming convention. This standard shall be implemented across all electrical and mechanical drawings and maintenance manuals.

5.3.6.3 Cabling and Termination

The Contractor shall be responsible for ensuring all cable is designed, procured, installed, terminated, labelled, documented, tested and commissioned.

5.3.6.4 Cable Containment

The Contractor shall be responsible for ensuring all cable containment is designed, procured, installed, labelled, documented and tested.

5.4 Performance Requirements

5.4.1 Design

All electrical, mechanical, and structural components of the system shall be designed to operate continuously in the typical environmental conditions for a period of 10 years with availability of the system being 99.9% or greater for that period. The design of critical components shall be such that they are easily repaired by modular replacement. The system shall be designed to operate 24 hours a day for the expected service life of the system.

The design shall consider and make allowance for the system to have the ability to include future requirements such as:

1. Adding monitored and controlled devices;
2. Additional software licenses;
3. Limiting the amount of held spares required to meet the available performance; and
4. Allowing for potential upgrade paths.

5.4.2 Control System

5.4.2.1 PLC

1. The maximum scan time for the entire program including I/O updating shall be no more than 100 ms; and
2. Transfer of the program to and from the PLC shall take no more than two (2) minutes.

5.4.2.2 SCADA

1. HMI screen call up time including all dynamic data shall be a maximum of 1 second;
2. Trend screens call up time shall be within 2 seconds;
3. Commands and data entered by the operator from the SCADA system shall be output via the PLC I/O within 1 second;
4. Visual response to a mouse click or touch on the SCADA system shall be within 100 ms; and
5. Alarm conditions as seen at the PLC inputs shall be displayed on the alarm screen within 1 second.

5.4.3 Electrical

The Contractor shall be responsible for ensuring all power supplies, earthing and surge protection are designed, procured, installed, documented, tested and commissioned.

5.4.4 Environmental Conditions

All items supplied under this contract shall maintain their guaranteed performance when operated continuously or intermittently according to their installed environment. The equipment shall be capable of meeting the environmental requirements without the assistance of electro-mechanical devices. All equipment supplied shall conform to the requirements of the documents referenced in the related documents section of this document.

6 Mechanical Components

6.1 General Requirements

All equipment supplied under this Contract shall be new. The equipment shall be of heavy duty construction and design life shall be as per the asset lives specified in Section 1.10. Provision shall be made for ready renewal of all wearing parts.

Extensive use shall be made of stainless steel and aluminium, especially for components coming in contact with water or exposed to corrosives environments. Care shall be taken when working with stainless steels not to cross contaminate with carbon steel. This includes during both manufacture and installation with regards steel strapping, lifting equipment and cutting and grinding of other materials in close proximity to stainless steels.

Care shall be taken when using stainless steel with regard to crevice corrosion and chloride corrosion in general, and specifically when installing stainless steel under covered areas not exposed to the rain. Fine crevices shall be avoided in design and it shall not be acceptable to rely upon a corrosion allowance within the safety factor design of any structural member.

Common parts of equipment shall be interchangeable wherever possible.

All parts subject to wear shall be readily accessible with proper provision made for safe and easy access for inspection, maintenance and removal for all equipment.

The Contractor shall protect all equipment and materials against corrosion, mechanical damage, deterioration, etc., to the satisfaction of the Principal, while awaiting their installation and commissioning.

Materials shall be selected appropriate to the application to afford a long life free from corrosion and wear and with the required strength.

Barriers and/or isolating material shall be installed between dissimilar metals. The components shall be electrically isolated with a NEMA Grade 10 sleeved washer/gasket or equivalent.

All mechanical equipment shall be installed with dismantling capability enabling ease of removal for maintenance.

6.2 Valves

Valves shall be in accordance with WS-SPEC 2000 Sections SP20-SP30 and suitable for the application. The document WS-SPEC 2000 is available from the Australasian Procurement and Construction Council's website. Flanges to valves shall be in accordance with AS 4087.

Each pipework system shall be supplied with all valves necessary for the safe and efficient operation of the system. Valves shall be provided complete with all actuators, positioners, internal piping, strainers and the like, so that they are a complete and operable unit. All supply and installation of valves shall conform to the general requirements as listed below:

1. All actuated valves shall also be capable of manual operation, by means such as an electrical, mechanical, or pneumatic override;
2. All valves and actuators installed shall have a proven record of reliable operation in water treatment plant environments and shall have readily available spare parts in Australia and preferably in Queensland;

3. Valves shall be constructed in accordance with the relevant Australian standard specifications. Where no Australian standard applies the closest relevant international standard shall apply;
4. All valves shall be fully labelled indicating valve number and details as per the relevant P&ID;
5. All screws, nuts and bolts shall have standard ISO threads;
6. All parts requiring grease lubricating shall be fitted with hydraulic grease nipples;
7. All valves shall be clockwise closing;
8. Valves shall be capable of opening against the full unbalanced head and closing against full flow and shall open and close smoothly without excessive vibration or cavitation;
9. Tee-key valve operators and handwheels shall be sized to operate the valves under all operating conditions throughout their full range with no greater than 180 Newtons applied to the end of the key bar or the rim of the wheel;
10. Handwheels shall display an embossed or engraved arrow, together with "open" and/or "close";
11. Valves shall be installed such that they are easily and safely accessible for operating and maintenance purposes. Valves shall not be fitted in an inverted position.

Valves shall be located and/or orientated in such a way that:

a) Manual operation of the valves may be carried out with ease and without the need for any other extra equipment;

b) All valves and their actuators are easily accessible for maintenance purposes and are capable of being removed from their location in a pipeline without obstruction by the pipeline or other equipment.

Access platforms and stairs or ladders shall be provided to service any valves that are located more than 1.5m above floor level. Ladders shall only be used for infrequently accessed valves.

Stainless or galvanised steel extension spindles and spindle supports shall be provided where required to allow the valves to be operated.

6.3 Valve Actuators

6.3.1 General

Valve actuators shall be rated, designed and sized to safely operate over the full range of valve operating conditions. In addition, the design of the actuator shall permit it, under emergency operating conditions, to produce without damage or adjustment, 1.5 times the maximum torque or thrust required to actuate the valve over the full range of operating conditions.

All automatic valves shall be electrically or pneumatically actuated. Actuators shall provide a location indication of valve position.

All automatic valves shall be capable of manual operation and shall be fitted with a mechanical position indicator to clearly indicate whether the valve is fully open, fully closed, or in an intermediate position.

Major valves fitted with actuators shall be fitted with limit switches or micro switches to indicate when the valve is open and closed.

6.3.2 Electric Actuators

Electric actuators including all components, shall comply with the relevant Australian Standards and requirements of the Power Supply Authority.

Electric actuators shall be mounted on the driven equipment as required and shall be of the type driven by an electric motor through a gear reduction unit with hand wheel override. They shall incorporate torque and limit switch mechanisms.

The electric actuator housing shall incorporate the motor contactors, emergency stop, hand controls, remote local selector and all electrical controls to provide fault and status monitoring via volt free contacts and remote actuation by a 24 V DC control circuit. In addition, modulating valves shall be controlled using a 4 - 20 mA signal.

The electric actuator, with gear reduction unit and electric motor, shall be totally enclosed in a robust housing. All access openings and inspection ports must be gasketed and covers secured with set screws. All external nuts, bolts, washers, studs and screws must be Grade 316/316L stainless steel. Where located externally or subject to weather or splashing, the housing shall be weatherproof to IP56 or better.

The actuators shall be fitted with travel limit switches and over-torque limit switches.

Travel limit switches shall be readily adjustable in the field without the necessity to use tools that are not commonly commercially available. Travel limits shall be set to suit the equipment to which the actuator is fitted.

Over-torque limit switches shall be factory set to suit the application.

6.3.3 Pneumatic Actuators

Pneumatic actuators including all components, shall comply with the relevant Australian Standards and requirements of the Power Supply Authority.

Pneumatic actuators shall be single acting (fail open or fail closed) or double acting cylinder type, suitable for smooth operation with supply air pressure of 500kPa and shall be capable of operating satisfactorily at pressure of 700kPa and shall require no lubrication for normal operation. The fail position shall be based on the HAZOP study assessment.

The cylinder shall be sized to ensure smooth opening and closing of the valve under all operating conditions. For valves that require the rate of opening or closing to be controlled, the actuators shall be supplied with adjustable restrictors on each port.

6.3.4 Pneumatic Positioners

Valves requiring modulation shall be fitted with a pneumatic positioner controlled by a 4 – 20 mA 24volt control signal. Positioners shall be direct proportional and arranged for air-to-open relative to control signal.

Positioner performance shall be:

1. Dead band: < 0.3 % full scale
2. Hysteresis: < 0.7 % full scale
3. Linearity: < 2 % full scale

The positioners shall be either mounted directly to the actuator or on a robust mounting bracket and the mechanism housing shall be weatherproof and constructed of a corrosion resistant alloy. There must be easy access for adjustment of the mechanism.

The positioner shall be enclosed in in a robust housing and where located externally or subject to weather or splashing, the housing shall be weatherproof to IP56 or better.

6.3.5 Solenoid Valves

All solenoid valve coils shall operate on 24Vdc. The solenoid shall have a varistor, flyback diodes and safety fuse. All coils shall be continuously rated 24Vdc with protection to IP65 in accordance with current Australian standards.

All solenoid coils shall be a plug in type.

Coil replacement must be possible without shutting off water supply to the valve.

6.4 Pumps

6.4.1 General

All pumps shall meet the following requirements:

Be current models, which have been in successful operation under comparable conditions for at least two years;

Operate without cavitation or motor overload at both minimum and maximum system curves;

Have their best efficiency points as close as possible to the duty point;

The efficiency curve of the pumps shall be reasonably flat over the operating range for normal conditions, with maximum efficiency developed when pumping at average conditions;

The continuous rated output of the electric motor driving the pump shall be at least 10% in excess of the maximum power required by the pump under all operating conditions;

The Contractor shall guarantee that the performance of the pumping units will be in accordance with the curves submitted. The only tolerance allowed shall be plus or minus 2.5% on the head developed and overall efficiency at any flow to cover errors of instrumentation and observation.

6.4.2 Centrifugal Pumps

Pumps shall generally have dimensions and minimum performance ratings to ISO 2858.

Pump speeds shall not exceed 1500 RPM (unless otherwise specified or approved by the Principal).

Pumping units shall be supplied complete with drive unit, flexible coupling and guards.

Pumps shall be direct coupled to an electric motor via a flexible shaft coupling.

All motor driven equipment shall be mounted on a baseplate which shall be fabricated from Grade 304/316/316L stainless steel or hot dip galvanised mild steel. They shall be supplied by the manufacturer of the particular equipment and shall be adequate for the specified duty.

Holes drilled in base plates for concrete anchors shall be positioned so as not to interfere with mechanical equipment.

The fixed half of the pump casing shall be provided with substantial footings for bolting to the baseplate.

Sealing (wear) rings shall be constructed so that they can be easily replaced when necessary.

All pockets in the casing which permit the accumulation of air shall be fitted with bleed valves or nipples to allow all air to be released when the pumps are being primed.

Eyebolts shall be provided for lifting purposes.

Mechanical seals shall be suitable for long term service with water and fluids containing abrasives and requiring a minimum of maintenance.

Single mechanical seals are required and shall be of the balanced type, multi-spring cartridge mounted. The seals shall be suitable for long operation in pumping water. The seals shall incorporate both flush and quench ports. For vertical applications the seal shall incorporate a self-aligning stationary face. Viton or an equivalent O-rings shall be used for all applications.

Seal faces shall be lapped flat to within two (2) helium light bands and the depth of interface roughness shall not exceed 0.3 microns.

The pump and seal design shall be such that interface temperatures under operating conditions remain safely below the vaporisation temperature.

The impeller shall be of approved modern design with high efficiency and shall be fitted with replaceable wear rings.

The shaft which shall be designed to withstand vibration and whirling.

The pump components shall be constructed to the minimum material standards as shown in Table 6-1. Higher grade materials may be substituted for a specified material, e.g. stainless steel in place of cast iron.

Table 6-1: Centrifugal Pump Minimum Component Requirements.

Item	Material	Standard
Casings	S.G. Cast Iron	AS 1831-500-7
Impeller	Cast Iron	AS 1830-T220
Shaft	S.S. 416	AS 2837-416
Wear Rings	Bronze	AS 1565-C93500
Baseplate	Stainless Steel 304 or HDG mild steel	AS 2837-304
Fasteners	Stainless Steel 304	AS 2837-304

6.4.3 Submersible Pumps

Submersible pumps shall be driven by an integral electric motor. The impeller shall be fixed to the shaft of the motor and shall be separated from the motor by a double mechanical seal installed in an oil filled chamber.

Submersible pumps shall be arranged for seating on a discharge elbow comprising a duck-foot type elbow and to provide support for the pump in its operating position, and a seal face to allow the pump to be lifted off guide rails vertically for inspection and maintenance.

Casings shall be designed to suit the pump, seating arrangement and service specified.

The casing shall be designed to move up and down in guide rails and shall have provision for sealing the discharge to the discharge elbow. Casings shall be fitted with removable inlet wear rings. The guide-rails shall be round or circular section only, RHS and SHS guide-rails are not acceptable.

Seals shall be as for centrifugal pumps, except that tandem seals shall be used and customised type configuration of seals is acceptable (subject to supporting information being provided to the Principal) in lieu of cartridge mounted.

The pump components shall be constructed of the materials to the minimum standards as set out in Table 6-2. Higher grade materials may be substituted for a specified material, e.g. stainless steel in place of cast iron.

Table 6-2: Submersible Pump Minimum Component Requirements.

Item	Material	Standard
Casings	S.G. Iron	AS 1831-500-7
Impellers	Cast Iron	AS 1830-T220
Discharge Elbows	Cast Iron	AS 1830-T220
Shafts	S.S. 420	AS 2837-420
Wear Rings	Bronze	AS 1565-C83600
Seating Rings	Cast Iron	AS 1830-T220
Fasteners	Stainless Steel 304	AS 2837-304

Grade 316/316L stainless steel lifting chains and shackles (rated and tagged for the application) shall be supplied for installation and removal of submersible type pumps. The chain shall be a continuous length, sufficient to enable removal of the pump from the well, with a lifting eye attached to the chain to enable the pump to be raised and large enough for a sling or crane. A second lifting eye shall be fitted 1.5 m below the top eye.

The other end of the chain shall be shackled to the pump lifting bridle. The chain including the Grade 316/316L stainless steel lifting shackles shall be load rated and tagged for lifting. The link size, lifting eye and shackle shall be selected in accordance with the manufacturer's recommendations for the mass of the pump.

The lifting shackles shall have a minimum throat opening of 150 mm x 100 mm. The lifting chains, eyes and shackles shall be Grade 316/316L stainless steel.

The guide rails shall provide for alignment of, and ensure correct seating and sealing of, the pump to the discharge elbow connection.

The guide rails shall be twin circular and arranged to prevent binding of the pump whilst it is being raised or lowered and shall be secured with appropriate brackets in such a manner as to allow complete removal of the pump without dismantling either the pump or the guide rail system.

The guide rail and supports shall be stainless steel Grade 316/316L.

Electrical cables shall be flexible, heavy duty, insulated and sheathed cables specifically designed for continuous operation submerged in water to a depth of 15 m. The cable shall be fixed, using stainless steel cable stockings, to the lifting cable at regular intervals to avoid fouling or movement.

Oils used in submersible pumps shall be tasteless and odourless food grade oil suitable for clean water applications such as Mobil Whiterex or Shell Ondina.

6.5 Spare Parts

Spares shall be readily available from Australian suppliers.

Spares shall be packed and protected for storage to AS 2400. Electrical equipment shall be sealed in polythene or similar bags with a liberal supply of desiccant. Other items shall be protected so as to avoid

corrosion and spoilage for a minimum of twelve (12) months after delivery. Each package shall have attached to it, the part number, maker's name, and reference description.

The packages of items of spares shall be delivered into consignments of reasonable size and then packed in secure cases, each of which shall contain a contents list.

Items requiring special tools shall have the tools supplied with the item. Any special tools supplied under the Contract shall be supplied in lockable tool boxes to indicate the equipment they are to be used for. A lock and two keys shall be provided for each tool box.

The special tools required for the completion of the Works and must be handed over to the Principal in a completely new and unused condition at Practical Completion.

6.6 Safety

6.6.1 General

All equipment shall be designed to afford maximum protection and safety for operating personnel and site visitors. Safety equipment shall include guards, access covers, inspection covers, emergency stop equipment, safety interlocks, and other devices as specified or implied or as required by the relevant Australian Standard or statutory authority regulation.

6.6.2 Access

The equipment design shall allow for ease of access for operation and maintenance, particularly any regular cleaning, servicing or calibration requirements.

6.6.3 Guarding

All moving parts shall be provided with guards in accordance with AS4024 series of Standards and as required by any relevant authority. Guards shall be fabricated with inspection ports or shall be fitted with expanded sections to allow inspection without having to remove the guards. The design or redesign of any mechanical or electrical equipment required for compliance with this requirement shall be undertaken by the Contractor.

Inspection covers shall be readily opened without the use of tools. Grilles, bars, or mesh shall be provided behind these covers where moving equipment may be reached. Alternatively, interlocks shall be provided to stop equipment in the event that covers are opened. Any mechanical or electrical equipment, design or redesign required for compliance with this requirement shall be undertaken by the Contractor.

Items driven by belts shall, where possible, have the guards supplied with a means of checking the shaft speed safely using a hand held tachometer, without having to remove the entire guard. If the shaft end has a cover that needs to be opened to use a tachometer, then additional protection shall be provided inside the cover so that opening the cover does not require the machine to be shut down.

Guards shall incorporate drains to prevent a build-up of water and drain to approved drainage points.

6.6.4 Safety Signs

The Contractor shall supply and install all safety and warning signs associated with the equipment. Signs shall comply with AS 1319 and as required by any relevant authority.

The signs shall warn of potential hazards, assist in preventing accidents and give operational and emergency procedures for potentially hazardous situations. Signs shall provide warnings where equipment may start automatically, where equipment may move without warning and where other potential hazards may exist.

Where electrical interlocks are provided labels shall be provided which shall describe the operation of the interlock. The labels shall be permanently mounted and clearly visible from the operating position or walkway. Labels shall be manufactured from a durable long lasting material mechanically fixed to the satisfaction of the Principal.

7 Electrical Works

7.1 General Requirements

7.1.1 Scope of Electrical Work

Where applicable, the scope of Electrical and Instrumentation works for the plant shall include, but not necessarily be limited to, the following tasks:

1. Detailed design of all required electrical, instrument, and control works for the upgrades;
2. All necessary diagrams, drawings, schedules, lists, and plans to fully document the installed electrical and instrument systems;
3. Supply and install all electrical, control and instrumentation systems (including all water quality analysers) required for automated operation of the water treatment plants;
4. Supply and installation of a new main switchboard or upgrade of the existing switchboard to link to the PLC and SCADA control system;
5. Supply and install all required power, control, instrument, communication and data cabling for new equipment installed or new connections for existing equipment;
6. Provide all cable management systems comprising underground and above ground conduits, cable pits, cable ladder and trays for new equipment installed or new connections for existing equipment;
7. Supply and install earthing systems for new equipment and switchboard;
8. Supply and install all required SCADA system hardware and software as per the requirements of Section 4.5.3.
9. Provide factory testing, site testing and commissioning of all switchboards, control panels and all site electrical services as per this specification's requirements.

7.1.2 Standards

All materials, equipment, and workmanship supplied under the Contract shall conform to the relevant Australian Standard and shall meet any relevant statutory authorities.

Specifically including, but not limited to, the following Australian Standards, Acts, and Statutory Codes shall apply to electrical work:

1. AS 3000 SAA Wiring Rules;
2. AS 3008.1 Electrical Installations – Selections of Cables;
3. AS 3439 Low Voltage Switchgear and Control Gear Assemblies;
4. AS 4024.1-2006 Safety of Machinery;
5. AS 4070 Recommended Practices for the Protection of Low Voltage Electrical Installations and Equipment in MEN Systems from transient Overvoltages;
6. AS IEC 61131 Programmable Controllers;
7. AS 61508 Functional safety of electrical/electronic/programmable electronic safety related systems;
8. AS IEC 61511 Functional safety – Safety instrumented systems for the process Industry sector;

9. AS 62061 Safety of Machinery – Functional safety of safety related electrical, electronic, and programmable electronic control systems;
10. AS 60529 Degrees of Protection Provided by Enclosures (IP Code).
11. Queensland Electrical Safety Act (2002);
12. Queensland Electrical Safety Regulation (2013);
13. Electricity Legislation Amendment and Repeal Act (2001);
14. Queensland Workplace Health and Safety Act (2011).

7.1.3 Materials and Equipment

All materials and equipment used shall be from items stocked within Australia and shall be available from local suppliers in Queensland. All materials supplied shall be new and of the latest design, and selected to provide long term reliable service.

7.1.4 Standards of Work

Except where this Technical Specification or Contract Documents require a higher standard, all work shall be carried out in accordance with the current edition of the relevant Standards and Regulations.

Where required, submit a test certificate from an independent testing authority as proof of compliance with a standard or specified test.

7.1.5 Testing of Electrical Services

Inspection and testing shall be carried out to the requirements of by AS/NZS 3000.

7.2 Electrical Supply Network Assets

7.2.1 General

Work that is subject to the Supply Authorities' design, construction and installation standards shall only be performed by an accredited service provider. The service provider shall have the appropriate accreditation for the type and level of work being performed. This work includes, but is not limited to:

1. Designing electricity network assets;
2. Extending or increasing the capacity of the electricity network;
3. Relocating electrical network assets;
4. Connecting new installations to the electricity network;
5. Disconnecting redundant installations from the electricity network;
6. Installing and energising service lines; or,
7. Installing meters.

7.2.2 Low Voltage Installations

7.2.2.1 Phase Rotation

Phase rotation on all installations shall be positive.

Any change required to achieve positive phase rotation shall be done on the line side of the service protection device.

7.2.2.2 Consumer Mains Design

The maximum demand for the plant be based on all equipment, including any standby equipment, running simultaneously.

Mains shall be designed to supply the maximum demand plus a 25% additional allowance for future upgrades.

The maximum voltage drop shall not exceed two percent.

7.3 Design of Electrical System

7.3.1 Reliability

The electrical system design and selection of equipment shall be robust to provide long term reliability with enough built in redundancy to ensure down time is minimised. The electrical system shall be designed to allow for maintenance and ease of fault finding.

7.3.2 Power Supplies

On treatment plants where two separate power supplies are available and have been approved by the Supply Authority, the distribution of the power in the plant shall be split with the aim of allowing for half the plant to operate when one supply is lost. Liaise with the Principal to determine which process units shall be on each power supply.

7.3.3 Control of Equipment

All electrical equipment shall be supplied and controlled from a plant switchboard or motor control centre (MCC). Local switching panels shall not be used.

7.3.4 Harmonic Distortion (THD)

Design variable frequency controller systems to ensure the harmonics generated as set down in AS 61000 do not exceed the limits as set down by the Electricity Distributor and in any case no greater than 5% total harmonic distortion voltage on the low voltage system at the point of common coupling.

7.3.5 Power Factor

Power factor correction equipment shall, if required, be designed to achieve a target power factor of 0.95 lagging.

7.3.6 Earthing

7.3.6.1 General

All portions of the installation shall be considered an 'Earthed Situation' as defined in the SAA Wiring Rules and all exposed metal of equipment shall be earthed in accordance with the requirements of AS/NZS 3000 and those of the Local Electricity Distributor. The earthing system shall comprise the MEN (Multiple Earthed Neutral) system. Install earthing of all medium and low voltage electrical equipment and exposed metal on which electrical equipment is mounted. All metallic stands that have electrical equipment mounted on them shall be connected to earth using an earth wire.

The earth loop impedance for each system shall comply with AS/NZS 3000 at the worst point and the system earth loop resistance test shall be carried out at the point in the system specified. If no test point is specified then submit a suggested test point and do not carry out the test until confirmation to the submission is

received. If the earth loop impedance exceeds the maximum required value, additional measures must be implemented to achieve the required outcome.

All metal to be earthed shall be connected from an earth terminal directly to the earth bar or link with an electrically continuous copper conductor. Test earth electrodes shall be installed on all earthing systems.

7.3.6.2 Earth Electrodes

Earth electrodes shall be copper clad steel. For supplies up to 100A the electrode shall be 12mm diameter driven to a depth of 1200mm and for supplies above 100A the earth electrodes shall be 19mm diameter driven to a depth of 1800mm. The earthing conductor shall be connected to the reinforcing steel of the footing and/or slab and the driven electrode. Electrodes shall be a proprietary product. Submit details showing the proposed earthing and make available for inspection not less than 2 working days prior to pouring concrete. The connection at the top of all earth electrodes shall be installed in earthing boxes. The minimum opening size for earth boxes shall be 150mm x 250mm. Provide all earth electrodes with an accessible removable type connection or link to enable resistance tests to be carried out. Do not use bare earth conductors unless required for grading rings etc. The main earth shall be installed and labelled as required in AS/NZS3000.

7.3.6.3 Instrument Earths

At treatment plants all instrument earths shall be connected to an insulated earth bar located in the PLC cubicle, this earth bar shall be connected to the power earth with a 6mm^2 earth wire in one location only.

7.3.7 MCC Control Circuit Voltage

Control circuits and motor starters shall operate from a 24 volt direct current supply.

7.3.8 Cable Identification

Each end of every cable shall be identified with a numbered cable tag in accordance with the cable schedule. Cable schedules shall be produced using Microsoft Excel 2010 or later and each cable schedule shall have file name which is a drawing number related to the installation. Cable schedules shall have as a minimum the following column headings:

1. Cable Number;
2. From Drive/Service;
3. To Drive/Service;
4. Termination Diagram Drawing Number;
5. Number of cores;
6. Core size in mm^2;
7. Estimated Length; and
8. Comments.

Identifying cable tags shall consist of numbered ferrules mounted on a tag bar designed such that when attached to the cable the ferrules cannot be removed from the tag bar. The identifying tag shall be fixed to the cable with black nylon UV resistant cable ties.

All power cable cores shall be identified at each termination by the appropriate red, white and blue phase colour with black for the neutral. Every cable core with the exception of earth conductors is to be fully identified at both ends with "Multi-mark" type ferrules numbered in accordance with the circuit diagrams.

All earth conductors shall be identified at each termination by the colour green or green/ yellow and shall be ferruled with the cable number. Other colours or sleeving of cables will not be acceptable.

7.3.9 Conduit Schedules

Conduit schedules shall be produced for treatment plants using Microsoft Excel 2010 or later and each conduit schedule shall have file name which is a drawing number related to the installation. Conduit schedules shall have as a minimum the following column headings:

1. Conduit Number;
2. From Pit/Location;
3. To Pit/Location;
4. Conduit Diagram Drawing Number;
5. Conduit Size;
6. Cables Installed in Conduit;
7. Estimated Length; and
8. Comments.

7.3.10 Wire Numbering

Numbers shall be wired using a numbering system to the satisfaction of the Principal.

7.3.11 Stop Buttons

Stop buttons shall be either test stop buttons or emergency stop buttons. Latched stops shall not be used.

7.3.11.1 Test Stop Buttons

Test stop buttons shall be red non-latched stop buttons which only operate when the drive is running in test.

7.3.11.2 Emergency Stop Buttons

Emergency stop buttons shall be red mushroom head latched stop buttons with a propriety large yellow background with red writing label. They shall be "twist to reset" and operate when the drive is running in both test and automatic.

Emergency stops shall be installed to comply with either category 2 or category 4 as required in AS4024.1. Undertake a risk assessment to determine which category is to be used. All risk assessments carried out shall be provided during the 80% Design Review.

7.4 Switchboard Manufacture

7.4.1 Design

7.4.1.1 General

Switchboards shall be designed and manufactured such that they may be readily moved to, and installed in, the required locations. Indoor switchboards shall be able to be installed inside a completed building/switchroom using readily available lifting and handling equipment and without the need to remove doors, walls or roofs.

Position all equipment inside switchboards to provide safe and easy access for operation and maintenance. Provide a minimum of 40mm space between all equipment, wiring ducts and cable looms to facilitate wiring connections.

Switchboards shall be designed to operate in the local ambient conditions.

Switchboards will be connected to the Supply Authority Supply System and shall have generator changeover switch and connection point that can be safely accessed when switchboard is live. Nominal system parameters: 400 Volt, 3-phase, 4-wire, 50 Hz, multiple earthed neutral (MEN) system. MEN links shall be readily accessible as nominated within NSW Service Rules.

Use only stainless steel metric fixings. All equipment mounted on mounting plates shall be drilled and tapped using parallel threads. Screws, nuts and washers may only be used where nuts are easily accessible after assembly. Self-tapping or self-drilling screws shall not be used.

Busbar jointing bolts and panel screws are exempt from the above paragraph.

Package plant with a manufacturer's proprietary switchboard will be acceptable only if they conform to this specification (in particular colour coding of cables) unless any non-conformances have been noted in the tender documentation and accepted by the Principal in writing.

All control circuits, I/O and instrumentation shall have a 24Vdc supply. Where 24Vdc and LV are within one enclosure they shall be segregated. There shall be no LV terminations in cable zones. The motor power cables shall be directly connected to the last device in the power circuit. Each enclosure shall contain wiring which is isolated from one point of supply.

All PLC cubicles shall have a red double 240V 10A socket outlet inside the cubicle supplied from the UPS.

Light & Power Distribution boards shall be stand-alone propriety units and not part of an MCC. Distribution boards shall have the circuit breaker clearly numbered and the legend shall reference these numbers. For multi-pole circuit breakers, the circuit breaker number shall be the first active pole. Provide a neatly printed legend inside the door detailing each circuit designation and circuit breaker rating (hand written will not be accepted).

7.4.2 Indoor Switchboards

7.4.2.1 Classification

Indoor switchboards are defined as those that are located in a designated electrical switchroom or a building that does not have a wet environment or a damp atmosphere. Examples of indoor switchboards are:

1. Main Distribution Switchboards;
2. Motor Control Centres (MCCs);
3. PLC Cubicles; and
4. Indoor Distribution Boards, etc.

7.4.2.2 Indoor Switchboards Finish

Powder coat indoor switchboards. Undertake all surface preparation, powder coating and protective coating in a workshop or factory environment prior to shipping to site. Powder coating must be applied strictly in accordance with the manufacturer's instructions. All surfaces shall be buffed to give a uniform overall appearance.

7.4.2.3 Powder Coating

Powder coating of switchboards shall comply with the following:

1. Protect all surfaces from weather conditions after fabrication and complete powder coatings within 5 days of fabrication. Ensure white surface rust does not form prior to applying coatings;

2. Clean off all heat affected areas;
3. Use only lead free materials and powders;
4. Coatings shall use premium grade polyester powder designed for use over galvanised or zinc substrates;
5. Film thickness shall be 60 to 80 microns or 100 microns where translucence is a problem, e.g. orange pigments;
6. Apply and cure powder coatings in accordance with the relevant manufacturers recommendations;
7. Thoroughly remove any non-conforming coatings and reapply until a complying coating is achieved; and
8. Protect all coated surfaces during storage, transport and installation.

7.4.2.4 Finished Colours

Switchboard colours shall comply with AS 2700 and shall be:

1. Indoor switchboards X15 light orange, RAL2000, or similar; and
2. Internal / removable equipment panels N14 gloss White, RAL9010, RAL 7035, or similar.

7.4.2.5 Main Switchboards and Motor Control Centres Requirements

Main switchboards and MCCs shall be cubicle type switchboards constructed to the relevant parts of AS/NZS3439.1 with:

1. Degree of segregation: Form 4a;
2. Degree of protection: IP42;
3. Free-standing and self-supporting;
4. Front access only with bottom cable entry;
5. Adequately ventilated, dust proof and vermin proof;
6. Type of construction comprising folded sheet metal modules secured together to form a neat, flush composite assembly. Switchboards constructed from bolt together frames will not be accepted; and
7. Manufacture cabinets, covers, and doors from zinc annealed steel sheet with a minimum thickness of 2mm.

Main switchboards and MCCs have verification of performance when subjected to the following tests as per AS/NZS 3439.1-unless otherwise specified:

i. Verification of segregation;
ii. Verification of temperature-rise limits;
iii. Verification of dielectric properties;
iv. Verification of short circuit capacity to the fault level and duration indicated;
v. Comply with the requirements of Appendix ZD standard tests Satisfactory type test reports will be considered suitable verification for tests (i), (iii), (iv); and
vi. (v) and a satisfactory switchboard manufacturer's test report will be considered suitable for verification of test (ii).

Mount motor starters or motor starter equipment between 300mm and 1800mm of the finished floor level.

All doors on the face of the switchboards shall be held closed using turnbuckle locks with a 7mm square pin.

All low voltage connections including neutrals shall be contained within the cell. Use 4 pole bus droppers. Neutrals shall not be switched. Run neutral cables on the same route as the phase cables.

Fully shroud all connections on busbars.

Switchboards with cable zones shall have a minimum of 400mm wide cable zones and one cable zone per tier.

The main switch on all main switchboards and MCCs shall be a circuit breaker incorporating electronic protection with adjustable thermal, magnetic pickup and time delay settings. This circuit breaker shall be set to discriminate with the upstream protective device. Where cascading is used manufacturer's data sheets shall be provided to the Principal to verify correct equipment selection.

Floor mounted and free standing steel switchboards shall be mounted on a full perimeter minimum 100mm high x 50mm wide x 6mm thick mild steel channel plinth. The plinth shall be hot dipped galvanised after fabrication to a minimum thickness of 85 micrometres and shall not be painted.

7.4.2.6 PLC Cubicles

The PLC cubicle shall be to the same height as the remainder of the switchboard for each MCC to house the programmable logic controller (PLC) equipment and instrumentation equipment. This cubicle may be integral with the associated MCC where space and size permits. If constructed integrally with the MCC, provide a full height steel barrier between the PLC tier and any motor starters within the switchboard.

Control equipment (24Vdc / ac) and power equipment (240Vac) including wiring shall as far as practicable be segregated.

Provide a minimum of 25mm between all items of equipment, cable ducts and looms to facilitate termination and equipment removal.

Fully shroud all 240 volt equipment and terminals. Provide insulated distribution board enclosures with earth and neutral link for all 240 volt circuit breakers.

Allow a minimum of twenty five percent (25%) spare space within the PLC equipment cubicle for future additions.

7.4.2.7 Indoor Distribution Boards

Distribution boards shall not be part of an MCC but shall be a separate unit.

Distribution Boards shall be proprietary, enclosed, and with single or three-phase insulated busbars. All distribution boards shall be fitted with a main switch which is padlockable.

7.4.3 Outdoor Switchboards

7.4.3.1 Classification

Outdoor switchboards shall be used if they are to be installed external to a building, within a wet environment.

Examples of outdoor switchboards are:

1. Local Control Panels adjacent to mechanical machinery;
2. Field Instrument Panels;
3. Outdoor Distribution Boards;
4. Outdoor MCCs and Outdoor Pumping Station Switchboards;

5. Pumping Station Cable Connection Boxes; and

6. Junction Boxes in Outdoor Locations.

7.4.3.2 General

All outdoor switchboards must provide a minimum degree of protection IP56 in accordance with AS 1939.

Manufacture all switchboard metalwork (including inner doors and escutcheons) from 2.5mm aluminium grade C5251-h34 or 1.5mm stainless steel grade 316/316L.

Floor mounted and free standing aluminium switchboards shall be mounted on a full perimeter minimum 100mm high x 50mm wide x 6mm thick aluminium channel plinth.

Mount the operator panels and field instrument panels with the centre of the enclosure at 1.6m from the finished walkway surface on a stand fabricated from aluminium grade C5251-h34 or 316/316L grade stainless steel. The stand should be designed with no sharp edges or trip hazards and shall be robust, rigid. Ensure that clearance of not less than 600mm is provided for access and maintenance around the front of all outdoor switchboards with doors open.

The enclosure shall be separated from its support stand by appropriate corrosion barriers. Switchboards shall be mounted on dedicated support brackets and not attached to hand rails or guard rails.

All fixings shall be stainless steel.

Outdoor switchboards shall be fitted with lockable swing handles.

7.4.3.3 Local Operator Panels

Gland plates shall only be installed where required for the installation.

7.4.3.4 Field Instrument Panels

Incorporate in the respective field instrument panels, indicating transmitters, lightning protection devices, terminal strips with whole current isolation and including earth bar as indicated on the drawings.

At each field instrument panel provide a lightning earth stake connected to the earth clamping rail of the lightning protectors and earth bar in the panel. An alternative would be the provision of a lightning earth stake in each area of the plant with a common connection to the instruments in the area.

Where the field instrument panel contains an indication device this shall be visible through a window on the front of the field panel.

Gland plates shall only be installed where required for the installation.

7.4.3.5 Outdoor Distribution Boards

Distribution boards shall not be part of an MCC but shall be a separate unit except for standalone pumping station switchboards.

Distribution boards shall be proprietary, enclosed, and with single or three-phase insulated busbars. All distribution boards shall be fitted with a main switch which is padlockable.

7.4.3.6 Junction Boxes in Outdoor Locations

Junction boxes shall be mounted so they are easily accessed and not mounted in cramped locations. The access shall comply with the switchboard accessibility requirements in AS/NZS 3000.

7.4.4 Fault Levels

7.4.4.1 Fault Levels and Time of Duration

All switchboards shall be designed and constructed to meet or exceed the nominated fault level of the installation. Show the designed fault capacity of each switchboard on the single line diagram, shown in kA with time in seconds.

7.4.4.2 Fault Current Limiting

Circuit breaker cascading shall be used where fault current limitation is necessary provided equipment selection is as per manufacturer's data.

Fault current limiting fuses shall be only be used with approval from the Principal.

7.4.5 Busbars

Horizontal and/or vertical busbar zones shall be enclosed in separate modules completely isolated from each other by means of metal or insulated barriers. The busbars shall be marked with colour coding inside each access point.

In addition to other segregation requirements, where a switchboard has two incoming power supplies, the busbar sections for each supply are to be fully segregated from each other.

Only use type tested busbar systems. Submit documents confirming type testing verification with submission of the design.

Arrange vertical busbars to ensure that the phase sequence at all switchboard equipment terminals is red, white and blue from left to right when viewed from the front of the switchboard.

Earth bars shall run full length of the switchboard and shall be extended the full length of all cable zones.

Busbars shall be manufactured from hard drawn high-conductivity tinned copper.

Full radius or radius corner busbar shall be used.

Fit busbar flags to all equipment having main terminals inadequate for the cable size. The size of the flags shall be appropriate for the cable lugs to be terminated and shall have a current rating of not less than the maximum for the frame size of the equipment. Busbar flags shall be supported to ensure that no mechanical stress is placed on connections and maintain creepage and clearance distances.

7.4.6 Switchboard Cable / Wiring Systems

7.4.6.1 General

Do not use cables to link adjacent circuit breakers where a propriety busbar assembly can be used for this purpose.

Internal cabling shall be at least V75 insulated with stranded tinned copper conductors.

Control wiring shall be of a size not less than 1.0mm^2, multi-stranded flexible tinned PVC insulated.

Wiring from PLC cards shall be pre-formed cables designed for the purpose or where pre-formed cables are not available use a minimum of 0.5mm^2 to a terminal strip.

Instruments which have terminals too small to connect a 1.0mm^2 wire may be wired using 0.5mm^2.

Phase, neutral and earth cables shall be capable of withstanding the maximum thermal and magnetic stresses associated with the relevant fault level and time of duration.

Keep cables clear of busbars and metal edges.

All cables shall be enclosed in a duct. Ducts shall be fixed using screws or pop rivets do not use self-tapping screws or thread-cutting screws. Ducts shall be of a slotted type sized for the present installation plus an allowance of additional 20% spare capacity.

All wiring shall be lugged at each termination. Only use crimp style lugs sized in accordance with manufacturers' recommendations. Lugs shall be crimped with the correct tooling.

Do not loop earth or neutral cables. Terminate all earth cables at an earth link or earth bar and ensure continuous continuity.

Arrange cables to ensure that the phase sequence at all switchboard equipment terminals is red, white and blue from left to right, back to front and from top to bottom, when viewed from the front.

Each cable core shall be marked at both ends with neat fitting clear sleeve type identification ferrules with a minimum lettering size of 3mm and the markings shall agree with the endorsed circuit diagram. Ferrules shall be easily read from left to right top to bottom and shall be visible without removing any duct lids. Hand written or dot matrix wire numbers shall not be used.

7.4.6.2 Cable Identification Colours

Cable primary insulation shall be coloured in accordance with the following:

1. Phase wiring (A, B & C) – red, white, blue;
2. Voltmeter and current transformer connections – red, white, blue, black;
3. 240V control active (controlled by isolator in the cell or compartment) – white;
4. 240V active (not fully contained within the cell or compartment) – orange;
5. 240V neutral – black;
6. Extra low voltage (ELV) devices e.g. thermistor – blue;
7. ELV DC positive – brown;
8. ELV DC negative – grey;
9. ELV AC positive – brown with red stripe;
10. ELV AC negative – brown with white stripe;
11. Protective Earth – green-yellow; and
12. Functional Earth – purple.

For cables above 35mm^2, and for all double insulated cables, phase identification shall be 25mm wide heat shrink bands of the colours tabulated above applied at each end and at not more than 500mm intervals along the entire run.

7.4.7 Earthing of Equipment

All metal parts of the switchboard shall be bonded to earth using the mounting screws or by wire if these parts are not mounted on the switchboard metalwork. Demountable modules shall be fitted with an earth finger which connects to the earth bar.

7.4.8 Equipment Mounting Pans

Internal backing plates shall be 2.5mm mild steel powder coated gloss white and shall be suitably braced to form a rigid mounting surface. All mounting holes shall be drilled and tapped. Demountable modules shall be a minimum of 2mm thick painted mild steel.

All equipment mounting plates shall be earthed using a 6mm earth wire connected to the earth bar.

7.4.9 Gland Plates

Gland plates are required to provide access to both sides of the cable glands and to provide a means to facilitate pulling cables into cubicles.

The switchboards shall include full width removable gland plates for each tier or module, (several removable sections may be used), mounted on the base of the switchboard. Gland plates shall comprise 5mm thickness aluminium plate, shall be fixed with minimum M6 hexagon setscrews and a preformed gasket to maintain the IP rating of the switchboard.

For earth continuity a 6mm^2 earth wire shall be connected from a 6mm stud on the gland plate to the earth bar.

7.4.10 Doors and Covers

7.4.10.1 General

Doors and covers shall be manufactured with right angle welded corners of sufficient rigidity to prevent warping and flexing when fitted to, or removed from, the cabinet. All external doors shall have a minimum swing of 135° and inner doors shall have a minimum swing of 90°.

Incorporate locating and support brackets or studs for any unhinged removable covers, to facilitate easy removal and replacement of the cover.

All doors on outdoor switchboards shall be fitted with a permanent rigid retaining device to prevent inadvertent closing.

7.4.10.2 Sealing

Covers and doors shall seal to the nominated IP rating. The seal shall be continuous to allow all edges of the door to be completely sealed when closed and shall be continuous over hinges. Foam rubber shall not be used.

Secure door seals in place to prevent them sliding off and being damaged when the door is closed.

7.4.10.3 Equipment Mounting on Doors

Equipment mounted on the external surfaces of the switchboard shall be installed so the equipment does not degrade IP rating of the switchboard, meters shall be shrouded to achieve the require IP rating.

Equipment mounted on doors shall be arranged so that it does not foul on door openings etc when the door or panel is swung fully open.

Arrangement of equipment on door shall be consistent across the entire switchboard.

Only extra low voltage equipment shall be mounted on doors.

7.4.11 Shrouding

All live parts within the switchboard shall provide protection of at least IP2X.

Where possible all equipment shall be fitted with proprietary terminal shields which incorporate interpole barriers to prevent arcing between phases.

Where additional barriers are required to meet the IP rating above they shall be clear, rigid sheeting protecting small logical sections of the switchboard. These barriers shall be secured by permanent rigid brackets which allow easy removal and replacement.

All connections on the line side of a protective device in each incoming and outgoing functional unit shall be fully shrouded or insulated so as to prevent the possibility of a line side fault developing and to provide personnel protection.

7.4.12 Power Monitoring

Provide a power monitor on each Switchboard incoming mains supply. The power meter shall have a remote display mounted on the door with a communication cable to the base unit.

The power monitor shall communicate the required parameters to the SCADA system.

For all drives and packaged plant that are expected to use 35,000 kWh per year or more, provide a signal which corresponds to the instantaneous kW used. Use a power meter, an electronic motor protection relay or the controller etc for package plant to provide this signal.

7.4.13 Motor Starter Requirements

Control circuit for starters in all new switchboards shall be use a 24Vdc supply.

The motor starter cubicles shall be demountable or fixed modular type with items of equipment, arranged to fit within the modules. Withdrawable motor starter cubicles are not acceptable. All components associated with a particular motor or item of equipment shall be grouped together in an individual motor control module.

Modules shall be minimum size of 600mm x 200mm.

Demountable cubicles shall incorporate an early make late break earth connection.

Each module shall be self-contained with its isolator mechanically interlocked with the module's door. Module isolation door handles shall be located as close as possible to the modules door lock mechanism.

Select motor starter equipment for Type 2 short circuit coordination as per manufacturer's recommendations on treatment plants and pumping stations which are greater than 100A supply. For pumping stations which are 100A or less supply use Type 1 equipment.

All door mounted starter components shall be orientated in a consistent arrangement i.e.: push buttons, lamps, ammeters, etc, shall have the same orientation throughout the installation.

Provide individual control terminal strips in the cable zone for each incoming or outgoing control cable adjacent to each module.

Where power cables are connected to equipment, provide sufficient space for easy termination and equipment removal. Do not mount an item of equipment in front of other items of equipment. Arrange all equipment within a module to be fully accessible for inspection and maintenance without the removal of other components. Clearance around equipment shall be in accordance with manufactures recommendations and allow sufficient clearance for easy removal of the equipment.

Arrange and segregate each final sub circuit such that after the switching OFF of the circuit breaker or isolation switch (for that circuit) all associated equipment (contactors, indicator lights, meters, control equipment and the like) may be worked upon safely without isolating supply from any other source. The above shall also apply to terminating or replacing of cables.

7.4.14 Local Operator Panel Equipment

Supply and install a separate individual local operator panel adjacent to each individual drive at treatment plants where required.

Local operator panels shall contain:

1. Full current isolator for motors with early break late make contact in starter control circuit up to 55kW; and
2. Emergency stop button.

All control or protection equipment associated with any drive shall be mounted within the local operator panel or within the motor starter.

Locate local operator panels so they are readily accessible and identifiable with the drive motor and driven device with local operator panel visible from the device.

Local full current isolator switches shall be fixed on the enclosure mounting plate and mechanically interlocked with the door to prevent door opening while in the "ON" position. Isolators shall not be door mounted.

7.4.15 Labelling

7.4.15.1 General

Every item of electrical equipment within the installation shall be clearly and accurately labelled.

Labels inside switchboards/MCCs or within buildings shall be engraved laminated plastic or photo anodised rigid aluminium. Labels in outdoor locations shall be engraved aluminium. All labels shall comply with the following requirements.

1. Except where otherwise required, be fixed adjacent to, but not on any item of equipment;
2. Engraved lettering shall be black on a white background for laminated plastic;
3. Main switches labels shall be red lettering on a white background;
4. Warning and caution labels shall be white lettering on a red background; and
5. The minimum height of lettering shall be 5mm and of sufficient definition to allow easy reading.

Socket outlet labels should state point of isolation including distribution board and circuit breaker numbers.

Labels are to comply with AS 1319.

7.4.15.2 Fixing of Labels

Labels shall be securely fixed by using screws and double sided adhesive tape. Screw holes shall be tapped into the switchboard.

Mechanically expanded plastic rivets are acceptable instead of screws inside switchboards. Aluminium rivets shall be used to fix aluminium labels only.

Do not use self-tapping screws, thread-cutting screws or other screw fixings.

7.4.15.3 Labels

Provide a switchboard label which states the switchboard number, switchboard description and the source of electrical supply.

Separate sections of enclosures shall be labelled to describe the function of the enclosure e.g. "CABLE ZONE".

The label for any section or enclosure containing Supply Authority equipment shall comply with the requirements of the Supply Authority.

Submit a full label list including lettering size, label size, colours and lettering, 1 week prior to manufacture.

For identification of final sub-circuits in a distribution board, a neatly typed schedule shall be provided. A plastic sheet or laminating shall be used to protect the schedule fixed in a suitable frame mounted on the inside of the switchboard door.

7.4.15.4 Assembly Nameplates

Floor mounted and Free Standing switchboards shall be labelled with essential markings to AS/NZS3439.1 and AS/NZS3000 plus the following:

1. IP rating;
2. Busbar current rating;
3. Designed fault rating including time;
4. Form; and
5. Manufactured Date.

7.4.15.5 Assembly Equipment Labels

Labels identifying equipment within a switchboard shall be located such that the item referred to is obvious and the lettering is not obscured by any equipment or wiring.

The MEN link shall be labelled "MEN LINK" on the link and on the outside of the switchboard on indoor switchboards.

Labels for fuses shall indicate the rating of the fuse links fitted, for example: "FAULT CURRENT LIMITERS 160A".

7.4.15.6 Warning Labels

Install warning labels as required by Australian Standards or Supply Authority rules.

7.4.15.7 Hazard Markings

Where the removal of any barrier or shrouding during normal switchboard maintenance could lead to the possibility of direct contact, a label with appropriate wording shall be provided for each functional unit. An example of a suitable label is:

These labels shall be positioned to be readily seen, on the covers of functional units, and may be proprietary adhesive type.

"Danger xxxV" safety signs are to be positioned centrally below the door labels on each outer door for the highest voltage present in that cabinet. For outdoor switchboards this Danger Notice is to be 300mm x 225mm manufactured to match switchboard construction sheet with protective over laminate and fixed to the doors by four (4) pop rivets. Adhesive only external labels will not be accepted.

7.4.15.8 UPS Supply Labels

The circuit breaker which provides supply to the UPS shall be clearly labelled.

The circuit breaker which is supplied from the UPS shall be clearly labelled with red lettering on a white background.

7.4.15.9 Spare Cubicle Labels

Where spare cubicles exist in a switchboard, either provided in a new switchboard to allow for further additional equipment in the future or in an existing switchboard where all equipment has been removed from the cubicle, attach the following label to the exterior of the cubicle.

7.4.16 Factory Inspection and Testing

7.4.16.1 General

Make available all labour, materials testing equipment and the like required for the inspections and testing of all the equipment.

Give at least five working days' notice to the Principal in writing of all inspections and tests.

7.4.16.2 Inspection

Provide an opportunity for representatives of Principal to inspect switchboards during manufacture and prior to delivery to the site in accordance with the following Schedules:

MCCs

1. First Inspection: Metalwork finished and painted and Busbars installed
2. Second Inspection: Layout of equipment prior to fixing
3. Third Inspection: Equipment and Power cables installed
4. Final Inspection Functional checks

MCC Support Frames

1. First Inspection: After all fabrication, welding and cleaning has been completed.
2. Final Inspection

7.4.16.3 Factory Testing

For all the electrical control and instrumentation equipment, perform the tests as detailed below, together with any additional tests as required by the specification.

Ensure before having carried out any tests that all equipment likely to be damaged by such tests has been removed from the circuit under test or has been isolated and earthed. Other checks and/or tests of such equipment shall be carried out to ensure it operates as required.

The following tests to prove the proper operation of the switchboard shall be completed prior to despatch from the factory:

1. Insulation tests, using a 1,000V insulation tester, of all cables and equipment. Such tests shall include the following:
    a) Each phase and neutral to earth
    b) Each phase to neutral
    c) Between phases
2. Insulation tests at 2,000V AC for one minute of the main busbars and all secondary wiring including internal wiring of instruments, control equipment (but excluding electronic control equipment). Such tests shall include the following (leakage current not to exceed 10mA):
    a) Each phase and neutral to earth

b) Each phase to neutral

c) Between phases

3. Repeat insulation tests above and report any change in insulation;
4. Checks and/or tests to verify correct polarity, phase rotation together with fuse link ratings and the setting of overloads and protection equipment;
5. Operation checks and tests on instruments, selector switches, module door interlocks, push to test indicators and the like, to verify compliance with Australian Standards, the specification, drawings, and the Local Supply Authority;
6. Secondary injection tests on all protection equipment relays;
7. Test functionality of PLC inputs and outputs and the simulation of outputs by means of the force function in the PLC in order to test drive circuitry; and
8. Complete circuit component, continuity and termination checks against all relevant drawings.

Mark up drawings such that errors are corrected, omissions and modifications added. Redraw and submit all such drawings.

Should the equipment fail under these tests then the costs of replacement, repairs and any further testing shall be borne by the Contractor.

On completion of all checks and tests, ensure that all equipment disconnected and/or removed to enable such checks and tests to be carried out has been replaced and/or reconnected. For example, verify that all links have been closed and tightened, components replaced and/or reconnected, all covers and the like replaced.

7.4.17 Delivery

A technical information package comprising drawings, parts listings, supplier's component data sheets, test certificates, maintenance instructions, operational software files etc. shall be provided with each switchboard upon delivery.

The technical information must be specific to each individual switchboard delivered to site. A typical information package covering several switchboards is not acceptable.

7.4.18 Submission of Documents

7.4.18.1 Certificate of Compliance – Electrical Work

Place two copies of the completed switchboard manufacturers Inspection and Test Plans (ITPs) and a signed statement confirming the switchboard complies with the requirements of AS 3439.1 in a clear plastic A4 size envelope or pocket and affix to the metering panel or switchboard with tape.

Submit duplicate copies of all the above information prior to delivery of the switchboard(s) to site.

Include one copy of all documents in the Operation and Maintenance Manuals.

7.5 Switchboard Installation

7.5.1 General

Where a switchboard has been split for installation, it shall be reassembled on site using materials supplied by the switchboard manufacturer. A comprehensive inspection of the switchboard shall be carried out prior

to reassembly to ensure that no damage has occurred to the switchboard during transportation and unloading. Particular attention shall be given to busbar joints, which shall be torque tightened to the manufacturer's recommended torque and marked as tightened when complete.

If a switchboard is stored or installed in any area where building work is incomplete, it shall be adequately protected against moisture, corrosion, paint, dust and mechanical damage.

7.5.2 Switchboard Support

Provide adequate supports for new switchboards.

7.5.3 Switchrooms

Switchboards installed in switchrooms with computer type floors shall be installed on their own support frame. All MCC switchboards are to have a heavy duty stand anchored to the bottom of the cable pit to support the switchboard. Size and locate the support frame to allow for incoming and outgoing cables. For indoor switchboards made from coated mild steel, support frames shall be hot dip galvanised mild steel.

7.5.4 Outdoor Locations

Supports for other switchboards shall be fabricated from the same material as that of the switchboard e.g. Stainless steel switchboard shall have a stainless steel support, switchboards shall not be mounted on handrails or guard rails.

Non-floor mounted switchboards shall be mounted at 1.6 metres above finished ground level to the middle of the switchboard.

7.5.5 Cable Entries

Arrange the location and number of cable entry plates for cables so that the availability for future cable entries is maximised.

Where gland plates have limited access from below, mount the glands above the gland plate inside the switchboard. Fully seal all spare holes in gland plates. Cable glands shall be sized to allow cables to be removed with lugs still attached without removing the gland.

All cables shall be supported and not apply tension to any terminations.

Cables shall not enter through the top of weatherproof switchboards.

7.6 Electrical Equipment

7.6.1 Durability of Materials

Use UV resistant materials where exposed to sunlight or other UV light.

7.6.2 Fixings

Use only stainless steel metric fixings and where required use appropriate isolation materials to prevent electrolysis. All equipment mounted on mounting plates shall be drilled and tapped using parallel threads. Screws, nuts and washers may only be used where nuts are easily accessible after assembly. Self-tapping or self-drilling screws shall not be used.

7.6.3 Mounting of Equipment

Mount any equipment which needs to be operated or maintained a minimum of 300mm above of the finished floor level.

7.6.4 Circuit Breakers

7.6.4.1 General

Comply with relevant Australian Standards.

7.6.4.2 Miniature Circuit Breakers

Miniature circuit breakers (MCB) shall have a fault breaking capacity of 6kA and shall have fault current limiting devices installed where required to limit the fault level.

Circuit breakers shall have the facility to be padlocked in the 'open' position.

7.6.4.3 Moulded Case Circuit Breakers

Moulded case circuit breakers (MCCB) shall have a fault breaking capacity suitable for the fault rating at the point of connection. MCCBs shall be electronic with adjustable thermal and magnetic pickup and time delays.

Provide circuit breakers with a permanent facility for padlocking in the open position. All MCCBs shall be selected as appropriate for the installation fault level (Icu) and shall also have a service breaking capacity (Ics) rating of 100%.

Mount the circuit breaker on the equipment mounting plate with the handle shaft connecting to the door mounted handle. The handle shaft shall be installed to facilitate ready alignment with handle mechanism.

Circuit breakers shall have flags or indicators such that the position of the breaker can be visually determined with the door open or closed. These indicators or labels shall have "OFF" for the open position and "On" for the closed position, "O" & "I" alone are not acceptable. Handles shall be in the horizontal when the circuit breaker is in the "OPEN" position and shall rotate clockwise to turn circuit breaker CLOSE.

It shall not to be possible to open the cubicle door whilst the circuit breaker is in any position other than 'OPEN'. Circuit breakers must show a tripped condition by the mechanical movement of the operating mechanism to an independent tripped position.

These circuit breakers shall be used for motor circuits and other supply circuits on MCCs and main switchboards.

7.6.4.4 Air Circuit Breakers

Air circuit breakers (ACB) shall have a fault breaking capacity suitable for the fault rating at the point of connection. ACBs shall have electronic protection incorporated in the circuit breaker with adjustable instantaneous, thermal, magnetic settings and time delays. ACBs used as incomers shall also be fitted with ground fault protection.

The circuit breaker shall be mounted in a segregated cubicle and shall be draw-out type and have padlocking facilities for locking in the open and withdrawn position. For mechanical interlocking use a fortress key.

These circuit breakers shall be used as main switches on MCCs with ratings 800A and above.

7.6.4.5 Residual Current Circuit Breakers

Install residual current protection (MCB/RCD) on circuits as required by AS/NZS3000. The residual current protection devices shall incorporate overload and short circuit protection. For personal protection these breakers shall trip at 30mA.

7.6.4.6 Motor Circuit Breakers

Motor circuit breakers shall have a fault breaking capacity suitable for the fault rating at the point of connection and shall have adjustable thermal pickup.

Provide circuit breakers with a permanent facility for padlocking in the open position.

Mount the circuit breaker on the equipment mounting plate with the handle shaft connecting to the door mounted handle. The handle shaft shall be a minimum of 8mm square and installed to facilitate self alignment with handle mechanism.

Circuit breakers shall have flags or indicators such that the position of the breaker can be visually determined with the door open or closed. These indicators or labels shall have "OFF" for the open position and "On" for the closed position, "O" & "I" alone are not acceptable. Handles shall be in the horizontal when the circuit breaker is in the "OPEN" position and shall rotate clockwise to turn circuit breaker CLOSE.

It shall not to be possible to open the cubicle door whilst the circuit breaker is in any position other than 'OPEN'. Circuit breakers must show a tripped condition by the mechanical movement of the operating mechanism to an independent tripped position.

7.6.5 Fuses

Fuses shall only be used for extra low voltage circuits and phase failure relay supplies.

Fault current limiting shall be achieved using a combination of circuit breakers. If this is not possible, submit reasons in writing. Do not proceed with the design and installation of fuses prior to receiving approval from the Principal.

Use only M205 for ELV and NS fuses for phase failure relays.

Fuses shall be suitable for the fault level of the installation and shall discriminate properly with other protective equipment. Let-through energy and peak current cut-off shall suit the protected equipment.

Fault current limiter fuse links shall be held in proprietary holders, and shall be mounted for withdrawal directly towards the operator

A minimum of three spare fuse links shall be provided for every fuse size included in the switchboard, with the exception of fuses installed solely for fault current limiting. The spare fuse links shall be supplied in a lockable tool box.

7.6.6 Isolation Switches

Isolation switches shall comply with AS60947.3

Isolation switches shall be suitable for fault-making/load-breaking duties.

Mount the isolation switch on the equipment mounting plate with the handle shaft connecting to the door mounted handle. The handle shaft shall be installed to facilitate ready alignment with handle mechanism.

Isolation switches shall have flags or indicators such that the position of the switch can be visually determined with the door open or closed. These indicators or labels shall have "OFF" for the open position and "ON" for the closed position, "O" & "I" alone are not acceptable. Handles shall be in the horizontal when the switch is in the "OPEN" position and shall rotate clockwise to turn the isolation switch to the "CLOSED" position.

Generator changeover switches shall be arranged with the switch handles shall be in the horizontal position for the "open" position. Turn the handle from the "open" position anticlockwise to the generator position and turn the handle from the "open" position clockwise normal supply position.

Isolation switches are to have provision for the attachment of padlocks for isolation when the switch is in the 'open' position. It shall not be possible to open the cubicle door whilst the switch is in any position other than 'open'.

7.6.7 AC Contactors

AC contactors shall comply with AS60947

Coil voltages shall be 24vdc except for contactors coil consumption above 150W for pickup, these shall be interfaced with a relay to control 240Vac coil.

7.6.8 Protection Devices on LV Motors

All motors shall have overload protection and manual reset. Motors supplied from a VSD or soft starter shall use the inbuilt protection.

7.6.8.1 Motors Below 22kW

Install electronic overloads with a tripping class of 10, auto / manual reset, trip indicator and separate NO and NC contacts.

7.6.8.2 Motors Above 22kW

Install electronic overload devices which feature adjustable tripping curves, thermistor input, phase loss, asymmetry protection and power measurement.

7.6.9 Control Switching Devices

7.6.9.1 Control Relays

All control relays shall be 24Vdc and block type for all control applications.

PLC interface relays may be plug in type with only 2 changeover contacts and flat terminal bases.

7.6.9.2 Phase Failure Relays

Relays shall monitor the 3 phases for failure of one or more of these phases, asymmetry, adjustable undervoltage and adjustable overvoltage.

The relay shall automatically reset upon restoration of correct supply voltage and rotation.

7.6.9.3 Selector Switches

Comply with the following for all test / off / auto selector switches:

1. OFF: toggle pointing vertically up;
2. TEST: toggle pointing 45° to the left of the vertical; and
3. AUTO: toggle pointing 45° to the right of the vertical.

Escutcheon plates shall allow function and switch position labelling to be included on the plate. Switches shall have 4 only mounting holes at the corners of the escutcheon plate.

Terminals shall be arranged for rear access. Side access terminals will not be accepted.

7.6.9.4 Pushbuttons

The following colours shall be used for pushbuttons to indicate the function of the pushbutton:

1. Red: Stop, Close;
2. Green: Start, Open;
3. Black: Test, Level Override; and
4. Blue: Reset.

7.6.9.5 Indication Lights

Use super bright type LED indicator lights. All indication lights shall have press to test. The following colours shall be used for indication lights to indicate the function of the light:

1. White: Ready;
2. Red: Running, Opened;
3. Green: Stopped, Closed; and
4. Amber: Fault, Seal Failure.

7.6.10 Voltmeters and Ammeters

Meters shall comply with the following details:

1. Flush mounting;
2. Accuracy class 1.5 (minimum);
3. Meters shall be minimum 72mm square bezel with 90 degree quadrant scale. All meters shall be of the same style and size;
4. Ammeters on motor starter cells shall be a minimum of 48mm and shall be selected so that full scale is not less than the motor FLC; and
5. All meters mounted on cubicle doors shall be operated from 4 – 20mA Ammeters subject to motor starting currents shall be overscaled a minimum of five times.

7.6.11 Current Transformers

Current transformers for Electricity Distributor's equipment shall comply with the requirement of the Electricity Distributor.

All other current transformers shall comply with the following:

1. Current transformers shall be resin encapsulated window type and shall comply with AS 60044.1.
2. Rated primary current shall have a current rating equal to the maximum current rating of the frame size of the controlling device.
3. Secondary windings of measurement current transformers shall be rated at 5A. The burden shall be 0.4 ohms (10 VA) minimum and the accuracy shall be class 2 minimum.

Where fitted on busbar systems each current transformer shall be fitted on removable links to allow easy removal from the switchboard. Where fitted on cables, current transformers shall be installed to allow easy removal from the switchboard.

7.6.12 Power Factor Correction Equipment

7.6.12.1 General

Power factor correction equipment shall comprise modular capacitor steps with protection and associated switching devices, these steps shall be switched by an automatic programmable controller.

All capacitors shall be rated for 480V minimum. Anti-Harmonic reactors shall be fitted and have Class F insulation. They shall be rated to at least 1.25 times the rated capacitor current and designed to carry 1.5 times the rated capacitor current without saturating. Each step shall be tuned to a frequency of 189Hz to prevent resonance and to block currents of the fifth harmonic and above.

The power factor correction main switch shall isolate the power to all power factor correction equipment.

Tuned reactors shall comply with the Electricity Distributor's service rules.

Controller shall automatically disconnect all capacitors in the event of power failure with automatic switching restored on resumption of power after an adjustable time delay.

7.6.12.2 Treatment Plants

Steps shall be a minimum of 25kVAr and a maximum of 50kVAr. Over temperature protection shall be provided by temperature monitoring switch to activate a PLC alarm output above 55°C and disconnect the power factor correction system.

Ventilation shall be provided incorporating ventilation fan and filter with thermostat control. Rating of the fan and air circulation shall be provided to power factor equipment vendors recommendations.

Power factor equipment shall be mounted in a separate enclosure not in the MCC.

7.6.13 24V DC Power Supplies

7.6.13.1 General

Directly connect the zero V to earth.

7.6.13.2 Treatment Plant Switchboards

Power supplies shall be linear type for motor control circuits and shall be sized to provide capacity for the full load within the switchboard plus 20% spare capacity. Size these units to allow for the inrush current of contactors and relays. This capacity shall include sufficient overload capacity to ensure operation of downstream circuit breakers and fuses in the event of a fault on a sub-circuit.

Install separate power supply systems for motor control circuits and PLC I/O. Do not interconnect these separate power supplies.

Arrange power supplies as a redundant set with diodes and fuses on the output. A redundant set means that one unit can be replaced while the other keeps the switchboard operational. Each power supply within a redundant set shall have a fault contact individually wired to the PLC.

Both power supply units shall be connected to one set of active and zero V links. Directly connect the 0V link to earth.

Provide sufficient ventilation to prevent the power supplies from overheating. Mount power supplies to allow for one power supply to be removed while the other is still operational. Install power supplies which are over 2kg between 1.0m and 1.5m from finished ground level.

7.6.13.3 Pumping Stations

Install individual power supplies for each motor control circuit. Power supplies shall be 5A units.

7.6.14 Surge Protection

7.6.14.1 Mains Protection

Mains protection shall be shunt surge diverters and have fault contact wired to PLC to monitor condition of surge diverters, and shall have a maximum discharge current (8/20µs) of 50kA or greater.

Mains protection shall comply with AS/NZS1768 category C and installed in accordance with AS4070.

7.6.14.2 Control Device Protection

Control device protection shall be series surge protectors, and shall have a maximum discharge current (8/20µs) of 5kA or greater.

Control device Protection shall comply with AS/NZS1768.

7.6.14.3 Instrument Signal Protection

Instrument signal protection shall be series gas discharge surge protectors, and shall have a maximum discharge current (8/20µs) of 5kA or greater.

Instrument signal protection shall comply with AS/NZS1768.

7.6.14.4 Radio Antenna Protection

Radio antenna protection shall be series surge protectors, and shall have a maximum discharge current (8/20µs) of 20kA or greater.

Radio antenna protection shall comply with AS/NZS1768.

7.6.15 Equipment Earthing

All electrical equipment and exposed metal on which electrical equipment is mounted shall be earthed in accordance with the requirements of AS/NZS 3000, Part 1 and of the Local Supply Authority.

The earthing connections shall be such that removal of one component shall not affect continuity of the earthing conductor associated with any other equipment.

All powered equipment such as Power Supplies, PLC racks, Electronic starters etc. shall be earthed directly to the MCC earth bar with suitably rated copper conductors (note there are special requirements for variable speed drives).

Each enclosure within a switchboard shall have a 6mm earth stud which has been bonded to the earth bar with a 6mm earth wire. All module doors shall be bonded to the earth stud using 2.5mm^2 flexible earth wire and escutcheons shall be bonded to the earth stud with a 2.5mm^2 minimum sized earthing conductor.

One side of all current transformer secondaries shall be connected to the switchboard main earth bar.

Metal frames of fuse switches and circuit breakers shall be connected to the earth bar. The earthing cable shall be of a size suitable to the particular switch or circuit breaker.

Earthing of components by means of mounting fastening is not acceptable.

Identification of all earthing conductors shall be in accordance with this specification.

7.6.16 Functional Earthing

All functional earths shall be installed to comply with the requirements in AS/NZS3000.

7.7 Electronic Drives

7.7.1 General Requirements

All electronic drives shall be installed with line contactors in series. The line contactor shall close when the drive is required to run. The contactor shall open when the drive is not required to run or an emergency stop has been operated.

All drives shall have a HMI which is accessible without opening the door of the cell or enclosure housing the drive. The HMI cable shall have sufficiently high insulation rating and electromagnetic interference (EMI) immunity to be safely installed with other ELV control cables. Installation of such cables in the same duct or conduit as LV cables is prohibited.

Where pump controlled stopping is required, this shall be carried out using a variable speed drive.

All equipment required to operate a drive e.g. line chokes etc. shall be mounted in the same enclosure. Drive equipment which weighs more than 6 kilograms shall be mounted on welded studs. Submit a verified procedure and provide one set of any devices as required for safe removal of drive equipment from the switchboard.

All floor mounted drives shall be mounted on a full perimeter minimum 100mm high x 50mm wide x 6mm thick mild steel channel plinth. The plinth shall be hot dipped galvanised after fabrication to a minimum thickness of 85 micrometres and shall not be painted.

Electronic drives which have had additional equipment added such as circuit breakers, contactors, relays etc. shall be classified as switchboard and comply with the switchboard section in this specification.

7.7.2 Ventilation and Cooling

7.7.2.1 General

Cooling shall be provided to keep the temperature of all Electronic drives below their rated value. Subject to other specific requirements, cooling may consist of a combination of internally vented systems, externally vented systems and/or air conditioning. The design shall cater for an ambient temperature of 50 degrees and take into account the effect of any additional heat sources in the area. Submit calculations to the Principal one week prior to manufacture of ventilation system.

7.7.2.2 Internally Vented Systems

Air shall be drawn in from the surrounding area over the general sections of the enclosure requiring ventilation and exhausted externally. Air inlets and outlets shall be fitted with IP54 filters arranged for easy removal for cleaning, without the need to isolate the switchboard.

7.7.2.3 Externally Vented Systems

Air shall be drawn in from the switchroom area over the main heat sources and exhausted directly outside the switchroom via ductwork. If the enclosure includes a transformer or passive filter section, then this section shall be ventilated similarly. All equipment in the externally vented sections shall be fully segregated from any general control equipment which could be affected by dust, corrosive gas or other sources of pollution. In the case of transformers or passive filters, all exposed conductors shall be insulated or suitably shrouded.

Air inlets and outlets shall be fitted with fine mesh screens to prevent entry of insects and vermin.

Provide ductwork as necessary to exhaust air outside the building. Exhaust ductwork detail arrangement including switchroom wall penetrations shall be designed with:

1. Downward facing outlet opening to prevent possible rain ingress and easily accessible by operations personnel for routine removal and cleaning
2. Noise emissions from the VSD limited to a maximum of 65dBA, measured at one metre from the external outlet

7.7.3 Variable Speed Drives

7.7.3.1 General

Variable speed drives (VSD) shall be rated to deliver the following at 50°C ambient temperature:

1. Motor full load current (FLC) continuously
2. Minimum of 120% overcurrent (60secs) for variable torque loads (centrifugal pumps / fans) and 150% overcurrent (60secs) for constant torque loads (PD pumps / fans)
3. Minimum of 12 starts per hour
4. Switching frequency up to 8kHz

The controller shall be configured to be ready for operation following a power failure and subsequent restoration without manual intervention.

A separately fused 24VDC auxiliary supply shall be used to maintain control power to the VSD when mains power is switched off.

Each type of fault is to be individually indicated on the HMI. Fault indications should remain active after the controller has been stopped and or tripped due to the fault condition or the line contactor has been opened.

Variable speed drive used for pump deceleration shall be able to measure and control the motor torque with the ability to configure a decreasing torque ramp over an adjustable time of 5 to 40 seconds. The starter shall have a minimum torque cut-out which is active during the stop ramp adjustable between 10% and 90%.

7.7.3.2 Switchroom Installations

When installed in a switchroom, variable speed drives shall be installed separately outside of the switchboard and rated to a minimum of IP54.

Small drives e.g. 1.5kw or below may be installed in the switchboard where sufficient air space is provided to prevent drive overheating.

7.7.3.3 Protection

Protection within the VSD shall trip the controller in the event of a fault and prevent restarting of the controller until manually reset. Fault reset push buttons are to be mounted on the front of the enclosure.

All VSDs controlling motors rated 22kW and above shall include motor thermistor inputs. The VSD shall be capable of providing alarm and trip functions for motor thermistors.

7.7.3.4 Line Chokes / DC Bus Chokes

Provide either a line choke or DC bus choke on all VSD units to minimise THDi at the drive. Where drives are used in conjunction with active harmonic filters (AHF's), consult the AHF and drive manufacturer for recommended application of chokes.

7.7.3.5 Motor Chokes

Motor chokes may be required when VSDs are used with long motor cable lengths. Consult the VSD manufacturer and install as per their requirements. The choke shall include a thermostat switch which when operated, trips the VSD by activating a logic input. This trip shall be displayed on the drive HMI as an external fault or the like.

All chokes shall be installed in the same enclosure as the VSD. Separate enclosures shall not be used.

7.7.3.6 Radio Frequency Interference

All VSDs must not exceed interference limits set down in AS61800-3 Cat C2. In installations close to residential areas or other sensitive equipment, supply and install additional RFI filters if necessary to ensure the limits set down in AS61800-3 Cat C1 are not exceeded.

7.7.3.7 Switchroom Installations

Small VSDs rated up to 1.5kw may be installed in the MCC switchboard where sufficient air space is available for adequate air circulation around the VSD to prevent drive overheating. The use of filters / fans etc is acceptable providing the IP rating of the switchboard is not compromised. The VSD HMI shall be installed remotely on the MCC cell door and shall also not compromise the IP rating of the switchboard.

Larger VSDs shall be installed separately outside the MCC and when installed in a switchroom rated to a minimum of IP54.

VSDs weighing up to 25kg may be mounted on a switchroom wall, provided it can be demonstrated that such a wall can safely distribute the total weight of all VSDs and mounting hardware. Where VSDs weigh more than 25kg or where a suitable wall is not available, VSDs rated up to 75kW may be wall / floor mounted using a fabricated, frame that allows the bulk of the VSD weight to be supported by the floor.

Where VSDs are mounted to the wall using unistrut brackets etc, ensure that the drive may be easily removed without disturbing any wall anchors.

All wall / floor mounted VSDs shall be bottom connected using cable tray with adequate mechanical cable protection.

Large VSDs above 75kW shall be floor mounted in proprietary IP54 enclosures.

7.7.3.8 Outdoor Pump Station Installations

In addition to the General Requirements for Electric Drives, VSDs shall be installed so that adequate heat dissipation is achieved without direct ventilation of the VSD enclosure to atmosphere. Internal fans and vents maybe used to circulate air within the switchboard to assist with heat dissipation providing that any additional heat does not adversely affect other equipment.

Provide calculations to validate.

7.7.3.9 Earthing of Electronic Variable Speed Drive Units

Installation and earthing shall be in accordance with the manufacturer's recommendations and shall take into consideration the following.

VSDs mounted remotely from a switchboard shall be earthed directly to the main switchboard earth bar using multi-stranded, flexible cable of the same C.S.A. as the active drive power cables. Where drives are mounted within enclosures they shall be installed on a suitable galvanised and unpainted mounting pan.

Both the mounting pan and the enclosure door shall be earthed to the frame of the enclosure using flexible, braided straps. Building wire is not acceptable for this purpose.

All VSD motor earths shall be connected directly between the motor and the dedicated earth terminal on the VSD and shall be unbroken for its entire length where possible. Where a break in cabling is required e.g. within a cable link (joining) box, the connection shall done in a manner that insulates the motor earth conductors from the frame of the enclosure. The enclosure shall have a dedicated earth connected directly to the main earth bar in the switchboard.

Unless otherwise specified, braided screened cables shall be used for all motors controlled via a VSD. The cables screen shall be earthed at both ends using HWC approved EMC cable glands at the motor terminal box and/or other approved means at the VSD end.

Special attention is drawn to the correct application of the cable gland. Glands that have loose components such as springs or chains shall not be used (see HWC preferred equipment list for guidance).

7.7.3.10 VSD Communications

Provide a Modbus TCP/IP (Ethernet) connection between the VSD and the control system PLC for control and monitoring. Backup control shall be via a hard wired interface so when selected to "Test" the VSD will run with its speed reference coming from either its on-board HMI or pre-programmed reference.

Connection to the control system shall be via Cat5e screened patch leads with RJ45 metalised connectors. Factory made leads are preferred and shall be Green in colour.

7.7.4 Soft Starters

Soft starters shall be rated for continuous operation without bypass for the full load current of the motor and shall be capable of a minimum of 12 starts per hour at 500C. All soft starters are to be configured to run in bypass after motor is up to speed.

Semiconductor fuses for protection of the soft starter are not required for drives of 22kW or less.

7.8 Lightning Protection System

7.8.1 General

All new assets should be assessed on the need for lightning protection. This should include:

- Water pumping stations;
- All Treatment plant structures; and
- Telemetry masts etc.

The lightning protection system shall comply with the applicable codes of practice and shall cover all buildings, structures, equipment and personnel in the premises against lightning strike.

The lightning protection system shall include air terminations, down conductors, event counters, joints and bonds, test joints, earth terminations and electrodes. All ancillary equipment needed for a complete working system shall be provided.

Fixing of conductors to roof surfaces shall not damage roofing or weatherproof membranes. All holes made on walls, roofs or ceilings for installing equipment as part of this contract shall be filled, grouted or otherwise sealed to prevent the ingress or collection of water.

7.8.2 Design

Carry out a Lightning Risk Assessment in accordance with AS/NZS 1768 to determine what measures, if any, will be needed for protecting personnel and property from lightning damage.

All building structures and equipment in the premises shall be protected against lightning strikes in all directions from vertically downwards to 15° from the vertical.

Conductors shall be so sized to ensure a low resistance path for lightning discharges, in compliance with the applicable regulations and Standards.

Risk assessment, detailed design calculations and schematic diagrams shall be forwarded to the Principal for review.

7.8.3 Air Terminal Grid

The air terminal grid shall comprise vertical lightning rods, finials and/or spheres and an interconnecting network of high conductivity copper tape. All metallic projections and metallic equipment on building roofs and other structures shall be bonded to form part of the air termination network.

Proprietary air terminal bases shall be provided for vertical lightning rods and finials. If freestanding towers are provided for the air terminals, they shall be structurally designed for the appropriate loadings.

Interconnecting copper tape shall be appropriately sized to carry the anticipated lightning current but shall not be less than 25mm x 3mm in cross section in any case. All tapes shall be rigidly held by suitable saddles at 600mm minimum intervals for horizontal runs and 1000mm for vertical runs and shall be effectively bonded at junctions. The tape shall be supplied in continuous unbroken lengths. Jointing shall be avoided in straight runs as far as practicable.

7.8.4 Earth Conductors

All down conductors from the air terminal network to the earthing electrodes shall be of appropriately sized PVC-insulated copper tapes, subject to a minimum cross-section of 25mm x 3mm, run on clamps fixed to the surface of the building/structure at intervals not exceeding 1000 mm. The down conductors shall, as far as practicable, be unobtrusive and the colour of the PVC sheath shall match the colour of the building finish.

Bonding to air terminations shall be by exothermic chemical bonding. Down conductors shall follow the shortest possible route, vertically, along the building exterior to the nearest earthing electrode.

7.8.5 Joints and Connections

The number of joints on the lightning protective system shall be kept to a minimum. Joints shall be made in visible and accessible positions. Joints shall be electrically and mechanically effective. For overlapping joints, the length of overlap shall not be less than 25mm. Exothermal chemical bonds shall be used for all joints except testing joints. For bolted joints four bolt tape clamps shall be used and all contact surfaces shall be smooth and tinned.

No dissimilar metals shall be jointed without the written recommendations of the lightning protection system manufacturer. Where dissimilar metals are to be bonded together, purpose designed proprietary brand of bimetallic connectors shall be used and moisture shall be kept away from the joints. Conductors and joints that are exposed to corrosion shall be protected by the application of approved anticorrosive paint.

A testing joint shall be provided between each down conductor and its associated earth electrode. The positioning of the test joints shall be convenient for testing purposes but shall not obstruct other services or impair the architectural features of the building. All test joints shall be protected from mechanical damage by durable heavy duty non-metallic casings. The casings shall be suitably painted to match adjacent wall finishes and shall be unobtrusive when installed.

7.8.6 Earthing Electrodes and Pits

Earthing electrodes shall be of steel-cored copper or stainless steel rods, not less than 15mm in diameter. The rods shall be extensible in standard multiples with screw and socket joints. Each earth electrode shall be driven to a minimum depth of 5 metres into the ground. Where interconnecting conductors are to be buried in the ground, the minimum burial depth shall be 500mm below finished ground level.

Lightning earth rod design should be based on soil resistivity tests. Where an electrode cannot be driven it should be installed to a bored hole and backfilled using a suitable agent which helps to retain moisture and enhance soil resistivity.

A sufficient number of earthing terminations shall be provided for compliance with the applicable codes of practice. The earth resistance of each complete earth termination, measured separately, shall be less than 10 ohms. Where this is not possible with one earth electrode, additional electrodes shall be added 10 metres apart.

7.9 Accessories

7.9.1 General

Flush mounted light switches, isolating switches, and socket outlets shall be mounted in wall boxes. Mounting heights for switches shall be approximately 1.2m to the centre unless otherwise indicated. Accessories within a designated wet environment shall be IP56.

7.9.2 Wall Mounted Switches

7.9.2.1 General

Switches shall be a minimum 10A rating and comply with AS/NZS3133, and shall have a rotary action positive contact switch. Switches used for fluorescent loads shall be suitable for fluorescent loads.

Isolating switches shall be selected to meet the requirements of the location and function.

7.9.2.2 Installation of Switches

Switches installed adjacent to door openings shall be installed on the lock side of the door. Adjacent switches shall not be connected to different phases.

7.9.3 240V Outlets

Fittings and accessories shall be of approved manufacture and rating and shall be selected to meet the requirements of the location and function.

UPS outlets shall be red in colour.

7.9.4 415V Power Socket Outlet

This socket outlet shall be surface mounted switch socket assembly with neutral conductor in all cases. The capacity of each socket outlet shall be suitable for the indicated load.

Phase conductors connected such that a positive phase sequence will be indicated by a phase rotation meter connected by red, white and blue leads in a clockwise direction.

7.9.5 415V Outlets for Equipment

Outlets which are used to supply power to equipment installed on plants (e.g. mixers) shall be de-contactors which include a set of late make / early break control pins which will prevent starter from operating when not plugged in or stop the starter operating when unplugged.

7.9.6 ELV Power Socket Outlet

This socket outlet shall comprise 2 pins with flat pins at 90 degrees for DC, and flat parallel pins for AC.

7.9.7 Labelling

Switches, socket outlets and permanently connected equipment etc shall be labelled to provide ready identification including where they are fed from including distribution board number and circuit breaker number.

7.10 Luminaires

7.10.1 General

All lights shall be high energy efficiency types and include a mechanical protection over the lamp.

Install a sufficient number of luminaires and in an arrangement in accordance with Australian standards.

All luminaires shall be power factor corrected to minimum of 0.85 lagging. Incorporate lead/lag circuits or blocking inductors where indicated and/or where required by the Supply Authority.

7.10.2 Lamps

Unless otherwise indicated:

1. Fluorescent tubes shall only be used for indoor locations below a height of 3 metres.
2. All other lamps shall be Light Emitting Diode (LED) with a minimum efficiency of 80 Lumens/watt and minimum life of 20,000 hours, or a comparable technology approved by the Principal.

7.10.3 Installation of Luminaires

7.10.3.1 General

Provide all fixings necessary for the proper installation of luminaires. Fit packing pieces of approved material where required to level the luminaires and to prevent distortion.

All light fittings shall be readily accessible and not mounted above equipment or features (e.g. drops over tanks, voids etc) that impedes access or presents a high safety risk. All light fittings shall be at a height accessible from 2.4 metre step ladder or lower. If this is not possible provide an alternative means of access that is either fixed in place or stored on site.

All fixings in outdoor locations shall be corrosion resistant.

Clean all luminaires, accessories, equipment and appliances that have been supplied and/or installed immediately prior to commissioning.

7.10.3.2 Recessed Luminaires

Recessed luminaires shall be fitted with flexible cords with minimum 0.75mm$_2$ conductors and 3 pin plugs. A plug socket shall be located within 500mm from the edge of the access aperture to allow the luminaire to be plugged-in prior to fixing.

7.10.3.3 Post Top Luminaires

Unless otherwise indicated, post-top luminaires shall:

1. Be mounted on tapered columns with a hinge point to allow maintenance of light fitting.
2. Consist of proprietary brand aluminium poles, suitable for base plate mounting on rag bolt assembly set in a concrete pad.
3. The poles shall be adequately drained and shall be fitted with an approved weatherproof lockable enclosure to house the control gear and fuse, in the lower section of the pole, within 1000mm of ground level.

7.11 Reticulation and Wiring

7.11.1 General

All equipment installed shall be selected, sized and installed to current Australian standards. It is the Contractor's responsibility to determine the exact route of cables. The location of the cable routes shall be shown in the 'As Built' drawings.

All cabling shall be installed underground unless specified otherwise. Cables shall be installed in underground conduits between sections of plants. All above ground installations shall be approved prior to installation.

7.11.2 Cables and Wiring

7.11.2.1 General

All cables shall be copper and shall be sized to suit the voltage, current rating, voltage drop and fault loop impedance. Terminations, fittings and accessories shall be of proprietary type, suitable for the temperature and environmental duty.

Where cables are in hazardous locations, all terminations shall be made using fittings suitable for the hazardous area.

Conductors shall be terminated either into tunnel type connectors or by suitably sized lugs crimped in a correctly sized tool. Joints in cables shall not be made between equipment terminal connections.

Terminate all spare cores in terminal strip complete with cable identification "spare".

Cable cores shall be of distinctive colours and coded as follows:

1. Red, white, blue active: conductors in multi-phase mains and circuits
2. Red: active conductors in single phase mains and circuits
3. Black: neutral conductor
4. White: control circuit cabling outside of switchboards
5. Green-yellow: earth wires

7.11.2.2 Wiring to Equipment

Connecting of wiring to equipment shall not compromise the IP rating of the equipment being connected.

Wiring to permanently connected equipment which vibrates or may be moved for adjustment shall have multi-stranded flexible conductors protected by flexible conduits of length to suit the application. The

conductors shall be protected by PVC coated steel or PVC flexible conduit to suit the particular installation. The conduit shall terminate not more than 15mm prior to entering equipment and cable then enters the equipment through a cable gland. Install a cable loop ("pigtail") at the final field connection for all cables with a bending radius of less than 150mm.

An isolating switch shall be installed adjacent to each permanently connected piece of equipment and shall be located within 2000mm of the equipment at approximately 1200mm above floor. The switch shall be mounted so that the equipment or apart thereof can be readily isolated and/or removed for maintenance without interference to fixed wiring.

7.11.2.3 Final Sub-Circuit Wiring

The wiring shall be multi strand and the minimum size conductors shall be as follows:

1. Power Circuits: 2.5mm², copper conductors
2. Lighting Circuits: 1.5mm², copper conductors
3. Motor Circuits: 2.5mm², copper conductors
4. Control Circuits: 1.0mm², copper conductors

Final sub-circuit wires shall generally be terminated in tunnel type connectors. Where stud or pillar connections are made, stranded conductors shall be prevented from spreading. Twisting multi-stranded conductors is not a suitable method of termination except for socket outlets, light switches and other similar devices.

Final connections to equipment having parts of the surface at a temperature greater than the temperature rating of the circuit cable shall be made with cable having insulation at least rated to 200oC maximum operating temperature (i.e. Heater elements, hot plates etc).

7.11.2.4 Single Cables in Enclosures

Cables shall be insulated with 0.6/1kV grade with minimum V90 PVC insulation.

7.11.2.5 Underground Grade Insulated and Sheathed Cables

Cables shall be insulated with 0.6/1kV grade with minimum V90 or XLPE insulation and PVC Sheathed.

The cables shall have the manufacture's name and reference and the word "UNDERGROUND" clearly indented in the sheathing.

7.11.2.6 Armoured and Sheathed Cables

Cables shall be insulated with 0.6/1 kV grade with minimum V90 or XLPE insulation and shall have armouring of galvanised steel wire with PVC sheathing.

Armouring shall be glanded in a purpose built gland that connects the armouring to earth. It shall not be used as an earth conductor.

7.11.2.7 Material Insulated Metal Sheathed (MIMs) Cables

MIMS cables installed underground or in metal pipes shall be PVC covered. Follow the cable manufacturer's recommendations for cutting, sealing and potting cable ends.

Terminations of MIMS cables entering metal enclosures, e.g. switchboards, shall be by universal glands screwed into a non-ferrous plate secured to the enclosure. The sheath shall be earthed to this plate via suitable locknuts and washers.

Where dissimilar metals are likely to touch the cable sheath, a protective barrier of PVC or similar material shall be provided between them.

The insulation resistance of MIMS cables shall be tested at the time of termination, and 24 hours later. Submit a copy of test reports within 1 week of testing. The resistance shall be not less than 100 megohms.

7.11.2.8 Aerial Cables

Aerial cables attached to buildings shall be insulated.

7.11.2.9 Emergency Systems and Essential Service Cables

Cables supplying power to designated "Emergency Systems and Essential Services" shall consist of MIMS copper conductor copper sheath cables.

Where a number of services cross or follow a similar route, the "Emergency System/Essential Services" cable shall be located at the highest point and closest to the structural support.

Use metal cable fixings. Do not use nylon or plastic material for cable fixings.

7.11.2.10 Telephone Cables

Cables used for communication purpose shall be multi-pair telephone cables of nominal conductor diameter 0.4mm^2 minimum to Telstra/ AS/ACIF Specification.

7.11.2.11 Fire Alarm Cables

Cables used for the connection of thermal, smoke and manual fire detectors, or other associated equipment within the building shall be TPS minimum 1.5mm^2 250 V grade stranded copper cable and shall have red coloured sheathing.

7.11.2.12 Security Cables

Cables used for window and door seals, and associated equipment shall be minimum 0.5mm^2 stranded copper cable.

Cables for space detectors (ultrasonic, infra-red, microwave, etc) shall be minimum 0.5mm^2 stranded copper shielded twisted pairs or as per the manufacturer's installation requirements.

7.11.2.13 Variable Speed Drive (VSD) and Soft Start (SS) Motor Cables

Cables and cable glands used for VSD and SS motor drives shall be in accordance with drive manufacturers' recommendations. If screened cables are unavailable, an output filter shall be fitted to the drive to prevent RFI radiation.

Screens shall be terminated strictly in accordance with equipment manufacturers recommendations. All terminations shall maximise termination surface area (circumference clamping) and shall be bonded directly to the equipment frame via proprietary clamping or cable glands. Braid / tape screens shall not be extended for the purpose of earth connection, shall not be bundled with other screens and shall not be terminated into compression lugs.

Braided shielded motor cables shall be used between the VSD and the motor for all VSD applications. These shall be installed with matching EMC cable glands at the motor with a manufacturer's approved method of screen termination at the VSD end. The only exception shall be for special circumstances where written permission from HWC shall be obtained before proceeding with any alternate solution.

7.11.2.14 Instrumentation Cables

The cables to be used shall be PVC insulated and sheathed with an aluminium Mylar screen and base copper drain wire.

The cable shall be overall screened, or individual and overall screened, dependant on the application. The cable shall consist of pairs of 7 strands of minimum size 1.5mm^2

Cable pairs shall be twisted and be identified either by colours or numbers embossed on the PVC insulation.

Analogue signals and for digital signals shall be run in separate cables.

Screens shall be connected to earth at source end only. The screen shall be continuous from switchboard to the device including through j-boxes etc and shall be insulated from earth. Where terminated, screens shall be fitted with clear sleeving and ferruled with the cable number.

7.11.2.15 Submersible Pump Cables

Submersible pump cables shall be supported by a stainless steel stocking.

Where pumps have more than one power cable the stockings shall be connected together using a D shackle and a single sling which is used to connect them to the hook.

When installed in pumping stations with two or more pumps, the submersible pump cables shall be designed and long enough to allow connection to other cable connection boxes or the other starters within the switchboard.

7.11.2.16 Fibre Optic Cables

Fibre optic cables shall be a minimum of 6 core multimode 62.5/125um, and either 'loose tube' or 'tight buffered' as dictated by the installation requirements. In all cases, there shall be a minimum of two 'spare' Optic Fibre cores in each cable run after the installation is complete.

As a minimum, the optic fibre cable shall be enclosed in corrugated conduit where it passes through the electrical pits, and shall be installed in such a manner that the fibre is laid around the edges of the pit to prevent or minimise the possibility of the optic fibre cable being trodden on while any person is working in that pit.

The optic fibre cables shall be labelled where they pass through electrical pits with warning marker tape. The tape shall have words similar to 'Caution – Optic Fibre Cable – Do Not Disturb'.

Terminate fibre cores in an approved wall mount or 19" rack mount enclosure using SC type connectors. Splice pre-terminated SC connectors to all fibre cores in the fibre cable run.

Test the fibres with a light source and power meter, and results that confirm successful test outcomes submitted in both written and electronic format.

7.11.3 Segregation

All power, control, instrumentation equipment wiring and terminals shall be physically segregated from each other. Access to one shall not be through the other.

All terminations of mixed voltages shall be segregated and grouped according to voltage with barriers on both sides and labels affixed indicating the appropriate voltage e.g. 24Vdc, 240Vac.

Segregate data and power cabling in accordance with the requirements of table as shown below:

Table 7-1: Cabling Segregation Requirements.

Circuit Rating kVA	Unshielded Power Cables	Shielded Power Cables

≤1	300mm	25mm
>1 and ≤2	450mm	50mm
>2 and ≤5	600mm	150mm
>5	1500mm	300mm

7.11.4 Mechanical Protection

Supply and install mechanical protection on all cables, cable ladder, conduit and electrical equipment under the following, but not limited to:

1. For a distance of 300mm above any floor, walkway or concrete surface
2. Where subject to risk of damage during normal plant operation and maintenance
3. On which scaffolding or planks may be placed

Sheet metal covers installed to provide mechanical protection of electrical equipment shall be constructed to withstand the shock loading likely to occur in the area. Covers, when used outdoors, shall be constructed of minimum 5mm aluminium.

Sheet metal covers installed to provide mechanical protection of electrical equipment shall be constructed so as to enclose such electrical equipment and associated conduits. The covers shall be designed to provide adequate ventilation and light to prevent vermin making nests behind them while still providing mechanical protection and shading from sunlight.

Any device installed for the mechanical protection of conduits and/or cables shall be free of burrs and sharp edges. Additional bushing or sleeving shall be provided as required to prevent conduit and/or cable damage.

7.11.5 Aerial Reticulation (Power)

Carry out all work in accordance with local statutory requirements and applicable Australian Standards.

Unless otherwise indicated, poles shall be hardwood preservative treated.

7.11.6 Underground Reticulation

7.11.6.1 General

All cables to be run underground shall be enclosed in underground conduits.

Conduits shall not run lengthways under roads and where they cross roads they shall be at 900 to the roadway.

Underground conduits shall be laid straight grade conduits in the vertical plane to match the slope of the ground surface. Provide for release of water from the conduits at the lowest point.

Cables throughout the site shall be segregated into conduits allocated to the following groups:

1. Power and 240V control cables
2. 24 VDC control cables, thermistor cables, Instrumentation cables, potentiometer cables, PLC data cables etc

Submit plans and schedules of the size, route, distance and depth of all underground cables and conduits. Do not order cables nor commence excavation work before a confirmation to the design submission is received.

7.11.6.2 Trenching

The work associated with trenching shall include clearing, grubbing, excavation, filling and consolidation of the trench and all necessary pumping, drainage, shoring and bracing.

Where crossing or running parallel to other services underground cabling shall be spaced as required by AS/NZS 3000.

Comply with the requirements of telephone, gas, water and sewerage authorities.

When crossing concrete or bitumen surfaces cut the surfaces in a straight line with a masonry saw. Cut to a minimum depth of 75mm or the full depth of the surface coat (whichever is greater).

Where solid rock is encountered, cables may be chased into rock.

Avoid disturbance to tree root systems. Roots of 75mm diameter or larger are not to be severed.

7.11.6.3 Inspection of Trenches

All cable trenches shall be left ready for inspection at the following stages:

1. After laying the conduit, but before any backfilling, and
2. After laying covers or marker tape.
3. Give at least two full working days' notice prior to the programmed backfilling.

7.11.6.4 Backfilling and Reinstatement

PVC conduits shall be bedded in compliance with AS/NZS 3008.1.1 before backfilling the trench.

Cover conduits with stone-free spoil removed from the trench; do not use beach sand for bedding nor backfilling.

Lay cable marker tape 150mm below finished ground level for the full length of all underground conduits.

After laying the conduits in unpaved areas, the trench shall be backfilled and consolidated to about 100mm above the natural ground level. Remove all excess spoil and dispose of in accordance with the Contractor's Environmental Management Plan.

Existing grassed areas shall be backfilled and turf re-laid on a prepared bed to about 100 mm above natural ground level.

In existing concrete or brick paved areas, the trench shall be backfilled with clean sand to the underside of the reinstated pavement and consolidated by watering and mechanical compaction. Reinstate surfaces to the original level.

In existing bitumen paved areas, the reinstated surfaces shall be cambered so that the edges are flushed and the centre is 10mm above the existing pavement. The top 150mm (minimum) immediately below the bitumen, shall consist of finely crushed gravel mechanically compacted into the trench. The existing bitumen edges of the trench shall be prime coated with bitumen prior to laying 75mm minimum of hot "pre-mix" bitumen to the finished cambered surface. The repair procedure and materials shall be in accordance with the requirements of the authority responsible for the road.

7.11.6.5 Underground Cable Protection

Where additional cable protection is required it shall be polymeric type. Marker tape shall be a minimum of 150mm wide.

7.11.6.6 Underground Cable Draw in Pits

Locate draw-in pits:

1. At changes of horizontal direction of cable routes
2. At low points
3. Immediately prior to cables entering or exiting buildings
4. At a spacing of not greater than 50 metres

The pits shall be concrete having all walls to prevent ingress of water and all conduits shall enter pit from the side. For single conduit runs moulded PVC pits can be used with approval from the Principal.

Install proprietary pits in accordance with the manufacturer's instructions on a minimum 100mm thick bed of 20mm coarse aggregate in accordance with STS101. The bed shall extend under the entire pit bottom with the minimum drainage requirement of a 300mm wide x 100mm deep rubble drain graded away from the pit for a distance of 2000mm.

Pits shall be internally sized to allow for twice the bending radius of the largest cable to be installed in the pit plus 50%. Cables shall enter and exit HV pits on the diagonal to allow use the maximum space within the pit.

Conduits which enter or exit pits shall be fitted with bellmouths which are formed into the walls of the pit.

Pits greater than 400mm wide shall be fitted with covers and frames of cast iron and concrete. The covers shall maintain a stabilising fit with the frame by a taper contact on the sides. All vertical meeting surfaces are to be fitted to a maximum clearance of 0.25mm.

Covers and frames shall be suitable for the particular loading conditions. Refer to the following table for Classes and typical uses.

Table 7-2: Class Summary for Cables and Frames.

Class	Typical Use
B	Areas where there is no access by vehicles e.g. grassed areas, gardens, etc.
C	Areas where there is access to slow moving light commercial vehicles only
D	Areas where all vehicles can access

Refer to AS3996 for details of the load classifications such as wheel loadings only, the table above shall be used for the specific applications. The maximum weight of any individual section of the cover shall not exceed 50kg.

Pits 400mm wide and less shall be fitted with proprietary concrete covers. A proprietary lifting handle for all cable pit coverplates shall be supplied and mounted on a suitable bracket in the main switchroom.

All pits shall be installed with the top of the cover flush with finished ground level except in grassed areas where pits shall be 100mm above surface level with surrounding ground tapered to be flush with the top of the pit.

The minimum inside dimensions of a draw-in pit shall be 650mm x 350mm x 900mm deep.

7.11.6.7 Marking Plates

Provide surface identification of the location of all underground electrical cables using marking plates in the following locations:

1. At each cable pit
2. At each change of direction
3. At a maximum 10m spacing for straight runs

Marking plates shall be made of minimum 1.0mm thick brass, 75mm x 75mm and shall be fixed with waterproof adhesive and four brass screws.

The plate shall be engraved with an arrow pointing towards the location of the cable and the words "ELECTRIC CABLE". Marking plates shall be engraved with minimum 3.0mm high lettering.

Install marking plates on the concrete lip of a cable pit. Do not install marking plates on cable pit lids.

Marking plates shall be installed flush with the finished ground level. In paved areas, marking plates shall be recessed or bevelled.

Concrete blocks used for installing mounting plates shall be approximately 200mm x 200mm x 30mm deep.

7.11.6.8 Cable Entry to Building

Where underground cables enter a building, a marking plate shall be fixed to the wall at a suitable height as directed. The plate shall be engraved with an arrow pointing downwards and the words "ELECTRIC CABLE".

Fix a marking plate to concrete paving or the top face of a concrete block located immediately above the cable and as close as practical to the building. The plate shall be engraved with an arrow, pointing in the direction in which the cable is laid, and the words "ELECTRIC CABLE".

7.11.6.9 Cables Under Roads and Paths

Where a cable passes under a road or path, a marking plate shall be placed at each side of the road or path. The marking plate shall be engraved as detailed in the Clause above and fixed to a concrete block or to the kerb of a kerbed road. Re-instate the road surface to the requirements and approval of the Council or road authority.

7.11.7 Conduits, Fittings and Joints

7.11.7.1 General

All conduits, fittings, installation and number of cables installed in conduits shall comply with relevant Australian Standards. Conduits shall be a minimum of 20mm except for fire alarm systems where 16mm diameter will be accepted.

Bends shall be of large radius. For conduits made from non-metallic materials, all fittings shall be of the same material as the conduit and all joints shall be made with the manufacturer's recommended adhesive cement that is of contrasting colour to the conduit.

7.11.7.2 Fixing of Conduits

Fix conduits using double sided Grade 316 Stainless Steel saddles and stainless steel screws. Where a conduit run requires the use of expansion joints use PVC saddles which allow the conduit to move.

7.11.7.3 Conduit Installation

Only use uPVC conduits in areas that are not normally exposed to sunlight or other sources of ultra-violet radiation.

In coastal areas or other potentially corrosive environments use only non-metallic conduit.

Sunlight resistant PVC conduit and fittings shall be installed in locations where long term exposure to sunlight or other sources of UV radiation can occur. Short runs of HD-PVC conduits from underground sub-mains may be surface run where they enter an existing building if it is not practicable to conceal them, provided that they are suitably protected from mechanical damage and sunlight.

Conduits shall be installed to prevent them from transporting process materials and water to switchrooms and electrical cabinets. Termination of conduits within bund walls shall be a minimum of 100mm higher than the bund wall.

7.11.7.4 Expansion Joints

Install expansion fittings on all straight runs of PVC plastic conduit, except those embedded in concrete or wall chases. The spacing of expansion fittings shall not be greater than 8000mm. Install expansion couplings wherever expansion or contraction joints occur in a building slab.

7.11.7.5 Conduit in Slabs on Ground

Conduits run in the sub-base under floor slabs shall be HD-PVC.

Conduits in slabs shall be securely fixed to the reinforcing rods, passing above a single layer of rods or between a double layer of rods. Locate conduits mid-way in the thickness of the slab.

Avoid or minimise crossover of conduits within a slab. If a crossover cannot be avoided, intersection angle shall be greater than 30°. Tie together conduits at the point of crossover.

Keep a minimum horizontal clearance of 75mm between conduits in slabs.

The minimum cover over conduits shall not be less than the conduit diameter.

Inspect all conduits prior to pouring concrete. Prior to the concrete pour submit the slab inspection report, confirming that the conduits comply with the specification.

Supervise the concrete pour to ensure that conduits are not displaced, broken or damaged.

7.11.7.6 Draw in Points

For surface run conduit systems, draw-in points shall be provided at suitable intervals not exceeding 12 metres for straight runs or the equivalent of 2 x 90° bends for runs including directional changes. Where used, draw-in boxes shall be of adequate size to prevent undue deformation of the cables.

Materials used to lubricate cables whilst drawing-in to conduits shall be non-conductive, nonabrasive and non-hygroscopic.

7.11.7.7 Conduits for Future Use

All conduits for future use shall be provided with polypropylene draw cords. A length of cord 1000mm long shall be left securely fixed at the ends of each run. Conduits shall be capped and labelled.

7.11.7.8 Telephone Conduits and Cabling

Underground conduits shall be heavy duty PVC type, coloured white, and shall be spaced from other services to the requirements of AS/ACIF S009 - 2006.

7.11.8 Cable Protection and Support

7.11.8.1 General

This section relates to the manufacture, supply and installation of cable protection and support systems such as cable troughs, cable trays and cable ladders. Use proprietary systems unless otherwise specified.

All ducts, trays and ladders shall be mounted horizontal unless otherwise approved by the Principal.

7.11.8.2 Ducts

Ducts shall have screw fixed covers, unless installed in a location not readily accessible, where clip-on lids may be used. All fixing methods shall provide a smooth internal surface for the cables. Do not use self-tapping or self-drilling screws.

The ducts shall be adequately supported in accordance with the manufacturers' recommendations and load tables.

7.11.8.3 Materials

Select materials to suit the environment in which they are to be installed. Consider the material performance in environmental conditions such as corrosive sewerage gasses, ultraviolet light, water, salt spray and any other factors.

Galvanised materials shall not be used at inlet works or in coastal environments. Suitable materials include aluminium grade C5251-h34, 316 stainless steel, and PVC.

7.11.8.4 Cable Tray and Ladder

7.11.8.4.1 GENERAL

Perforated cable tray, cable ladder and all accessories shall be proprietary items from a single manufacturer whose range includes splice connections, expansion splices, covers, risers, crossovers, reducers, bends and all other accessories used.

Support brackets and accessories shall be manufactured from the same material as the cable tray and ladder. Cable trays and cable ladders shall have dedicated support brackets and shall not be mounted on hand rails or guard rails.

Metal cable tray and ladder shall be earthed utilising a 6mm$_2$ earth wire connected directly to the earth bar and remain electrically earthed along its entire length.

7.11.8.4.2 PERFORATED CABLE TRAY

Perforated cable tray shall be manufactured from aluminium.

7.11.8.4.3 CABLE LADDER

Cable ladder shall be manufactured from aluminium. The load rating of the ladder shall be selected to suit the span between supports for the ladder and be a minimum of 12A grade.

7.11.8.4.4 INSTALLATION

Cable tray and ladder shall be installed to the manufacturer's recommendations. Adequate access shall be provided to cable tray and ladder.

The side walls of the cable tray or ladder shall not be cut for the installation unless absolutely necessary cutting for brackets holding ladder above or below is not acceptable. The ladder shall have additional supports installed to support this weakened section.

Cables or groups of cables shall be securely strapped to the tray or ladder using proprietary UV resistant nylon cable ties or straps; for vertical runs at 400mm maximum; for horizontal runs at 1000mm maximum.

Cables shall leave the cable tray or ladder in such a manner that no cable shall be in contact with the side rails. In general, cable shall leave the tray or ladder in conduit, which shall be securely anchored to the tray or ladder with a minimum of two anchors.

Cables shall be installed in one layer on all ladders and trays there shall be a minimum of 20% spare capacity when project is complete.

7.11.8.5 Fixings

Fixings shall be secure and adequately sized to suit the type, weight, size, shape and location of the equipment being fixed. All fixings shall be stainless steel.

Use chemical anchors, in accordance with manufacturer's instructions for masonry applications.

7.11.8.6 Penetrations

Make all penetrations waterproof and vermin proof by sealing with compounds that do not degrade the fire rating of the material that is being penetrated.

Use an approved proprietary sealing method suitable for the installation. Do not use expanding foam for sealing of penetrations.

Do not construct penetrations through damp courses.

8 Pipe Work

8.1 General Requirements

8.1.1 General

Cement lined ductile iron or Grade 316/316L stainless steel pipes shall be used for all pipework cast into concrete structures.

All air lines including fittings, fixings and attachments shall be Grade 316/316L stainless steel where submerged or in splash zones. Other materials are acceptable in small lines in proprietary equipment where no reasonable alternative exists and which are not immersed in water. Expansion / contraction accommodation shall be provided in pipelines subject to significant temperature variations.

Small diameter potable water pipelines up to 50 mm diameter shall be copper or polyethylene.

Sufficient fixings shall be provided to ensure all air lines are fully supported to prevent sagging.

All external small diameter water or chemical solution pipework shall be suitably lagged to prevent freezing or excess solar heat gain i.e. safety showers. Lagging must be suitably protected from weathering and to the approval of the Principal. Pipework in cable trays outdoors shall be blanketed to prevent freezing where appropriate. Galvanised trays are unacceptable above wetted areas.

Sodium hydroxide pipelines shall be installed in accessible sleeve pipes. Such pipes shall drain to the on-site chemical waste tank and management shall be in accordance with relevant legislation. Where sodium hydroxide is proposed, Tenderers shall describe the proposed concentration and its potential for freezing.

Rocker pipes shall be provided with all buried pipe penetrations to allow for differential settlement across two pipe joints.

Overflow and drains external to the buildings shall be colour coded to match the building / enclosure. If internal, they shall be painted black. Painting is not required where the pipes are located within sealed trenches.

Buried pipelines shall comply with AS 2566 and shall be of pipe Class necessary for the location and service.

Where the pipe invert is at or below the natural water table level, the Contractor shall place geotextile filter fabric around the pipe embedment. The bedding shall be placed and compacted to support the pipe uniformly along the whole length of the barrel with chases provided for sockets and couplings. Where extremely poor ground conditions are encountered, the Contractor shall use of a bridging layer or timber piles may also be required.

Minimum depth of overlay (select fill over top of pipe in trench) over all pipes shall be 150 mm.

Routine sampling and testing of bedding and overlay shall be undertaken at a frequency necessary to ensure that only materials meeting specified requirements are supplied. Test results shall be submitted to the Principal upon request.

Only materials which meet the requirements below shall be acceptable:

1. Hard, tough, durable, and uncoated;
2. Contain no lumps, soft or flaky particles, or vegetable matter including roots or bark;
3. Not more than a total of 3% by dry weight of mica and not more than a total of the percentages listed below by dry weight of dust, clay, loam or silt when tested in accordance with Section 12 of AS 1141:

4. Coarse aggregates: 2 %
5. High Grade compaction sand: 3 %
6. Crushed rock dust, bedding sand and sand: 5 %
7. With a pH not less than 5.5 when tested in accordance with AS 1289.4.3.1; and
8. Able to meet the requirement of a salinity test and does not exceed 0.4mS/cm when tested by use of a conductivity meter in accordance with APHA Standard Method 2510B carried out in a solution of soil and distilled water prepared in accordance with AS 1289.4.3.1.

8.1.2 Selection of Pipe Materials

The materials used for construction of pipework shall be selected to provide reliable operation for the duration of the Asset Life specified in Clause 3.8 and shall conform to the relevant Australian Standards. Where materials must be selected that will provide a shorter life, such as PVC for chlorine application, the Contractor shall notify the Principal.

The materials used for all pipework and fittings in contact with drinking water shall not affect the quality of water when in extended contact when tested in accordance with AS 4020.

8.1.3 UV Protection

All plastic pipe and fittings (PVC, ABS, Polyethylene, GRP) that are visible and exposed to sunlight shall be of a suitably UV resistant grade or after cleaning and drying, protected with 2 coats of a suitably UV resistant acrylic paint to a minimum thickness of 50 m.

8.1.4 Colour

Pipework requiring painting shall have a final finish colour to identify the contents in accordance with AS 1345.

Fire service pipework and fittings above ground shall be Red R13 in accordance with AS 2700.

8.1.5 Metal Banded Flexible Couplings

Metal banded flexible couplings shall be manufactured in compliance with AS 4327.

8.1.6 Lubricants

Lubricants required for assembly of pipes and fittings, such as for o-ring joints, shall be food grade and comply with the requirements of AS/NZS 4020. Lubricants shall not cause degradation of any piping, o-ring, or fitting materials.

8.1.7 Encasement, Differential Settlement Joints and Isolation Valves

Pipelines that have less than the minimum cover over the top of the pipe barrel or where a building or structure is over the pipeline shall be encased in concrete. The encasement shall be extended to finish at the face of pipe joints.

Concrete for encasement, where specifically approved by the Principal, shall be Grade N25 minimum. Pipes shall be set to line and level on either bags filled with sand and cement mix, or on concrete saddles cast to the outside diameter of the barrel and located near the socket. Pipes shall be secure so that they do not move, float or deform while pouring concrete.

Where pipes pass through penetrations they shall be protected from wear by a sleeving or isolation barrier satisfactory to the Principal.

A 1500mm long pipe section shall be provided immediately (within 900 mm) upstream and downstream of pits, structures and concrete encasement to allow for differential movement.

Isolation valves shall be provided at each end of pipelines connected to tanks/vessels.

Where a buried pipeline is connected to a fixed structure above ground the design shall include flexible bellows joints to allow for ground settlement.

8.1.8 Selection Fill

For select fill use excavated material, free from organic matter and having a particle size no larger than 20 mm. The material shall be suitable to allow compaction as specified without causing damage to the pipeline. If material from the excavation does not comply, import non-cohesive material.

8.1.9 Trench Fill

Where the trench is not subject to traffic loading excavated material may be used for fill in the trench fill zone provided it has a particle size no greater than 75 mm across the largest dimension, is free from organic matter and can be placed into a dense mass free of voids and cavities.

8.1.10 Polyethylene Sleeving

Buried steel, ductile iron, and cast iron pipe and fittings shall be installed in polyethylene sleeving complying with AS 3680. The sleeving shall be installed in accordance with AS 3681. The polyethylene shall not be exposed to ultra-violet light both before and after laying for more than a total of seven (7) days.

8.1.11 Geotextile Filter Fabric

Geotextile filter fabric shall be approved inert material, BIDIM A34.

8.1.12 Timber Piles

Timber piles shall be treated hardwood, unless otherwise specified, of strength group F14, and in accordance with "Koppers - Standard Specification, Hardwood Foundation Piling". Timber treatment shall be to the requirements of AS 1604 Hazard Level 5.

8.2 Acceptable Pipe and Fittings

8.2.1 General

The following specifies the piping and fitting types the Contractor may utilise to deliver the required Works.

8.2.2 Ductile Iron Pipes and Fittings

Ductile iron spigot-socket pipe and fittings shall be Class PN35 complying with AS/NZS 2280. Pipe and fittings shall be cement mortar lined to AS/NZS 2280 and externally coated with bituminous or synthetic resin coating to AS/NZS 2280.

Elastomeric joint seals shall comply with AS 1646, EPDM and shall have product certification (ISO Type 5) to AS 1646.

Ductile iron pipe shall have product certification (ISO Type 5) to AS/NZS 2280.

Ductile iron fittings shall have product certification (ISO Type 5) to AS/NZS 2280. For fittings that have a fusion bonded coating or lining, the schedule of the certificate issued by the certification body shall include reference to AS/NZS 4158.

Ductile iron fittings to this specification may be used with pipes in imperial sizes manufactured from ductile iron, GRP or PVC (-M, -O and -U).

All products shall be marked in accordance with the certification body's requirements.

The supplier of products shall declare that products comply with the requirements specified.

8.2.3 Mild Steel Pipes and Fittings

Mild steel pipe and fittings to comply with AS 1579.

All steel pipes and fittings shall have a minimum wall thickness of 5 mm or a maximum dimensional ratio (external diameter to wall thickness dimension) of 120, whichever is the greater.

Pipes and fittings shall be cement mortar lined in accordance with AS 1281.

For buried applications, steel pipe and fittings shall be externally coated with fusion bonded polyethylene (medium density) complying with AS 4321.

Elastomeric ring joint seals shall comply with AS 1646, EPDM.

Steel pipe shall have product certification (ISO Type 5) to AS 1579. Elastomeric joint seals shall have product certification (ISO Type 5) to AS 1646. All products shall be marked in accordance with the certification body's requirements.

The pipes shall be installed with welded joints using welding collars or spherical spigot and socket joints or with flanged joints.

Weld details and cement mortar lining repairs shall comply with WSAA Water Supply Code of Australia WSA-03.

For internal surfaces a 3:1 sand / cement mortar (Tyco Eziline cement mortar repair system or equivalent) shall be applied over the weld and adjacent unprotected steel surfaces to leave a smooth surface without protuberances. For external coating repairs, a heat shrink sleeve system or petrolatum tape wrap system (Denso or equivalent) shall be applied as per the manufacturer's recommendations.

Mild steel fittings shall be manufactured under cover of a certified ISO 9000 management system. The scope of the certification shall include reference to "Manufacture of welded steel fittings for water supply pipelines" (or similar).

Fittings shall have Type 3 product certification, including verification that elastomeric joint design complies with the requirements of AS 1579.

Manufacturers of elastomeric joint seals shall have product certification (ISO Type 5) to AS 1646.

Flanged joints shall be raised face with full face gaskets to AS 4087 (for pipes up to DN1200) and to AS 4331.1 (for pipes greater than DN1200). Nuts and bolts for flanged fittings to be 316SS. All flanges shall be drilled off-centre.

Steel pipe and fittings shall be designed for a working pressure of at least 1600kPa.

Only installers who have completed an approved training program and have current accreditation from manufacturers shall be used. Proof of accreditation shall be provided to the Principal prior to commencement of work on-site.

All welding shall be undertaken using qualified welders and in accordance with AS/NZS 1554.1.

The testing of all welds shall be in accordance with AS 4041 and AS 4037 and all referenced standards using the following:

1. 100% visual examination of all welds;
2. Hydrostatic testing; and
3. Radiographic or ultrasonic testing together with magnetic particle testing or penetrant testing of 10% of all welds.

The suppliers of products shall certify that their products comply with the requirements specified.

8.2.4 PVC Schedule 80 Pressure Pipes and Fittings

Material shall be Schedule 80 Dark Grey PVC-U 1120 ASTM D1785 and assembled using a gap filling solvent cement such as 'Tangit' or approved equivalent.

Any PVC equipment (eg. valves, check valves, strainers, rotameters, loading valves, pressure relief valves, etc.) shall be fitted with barrel union ends for ease of replacement.

8.2.5 Stainless Steel Pipe and Fittings

Stainless steel pipe, tube, butt weld fittings and flanges shall be Grade 316L/316 stainless steel.

Pipe and tube shall be to AS 1769 or ASTM A312M.

All stainless steel pipes and fittings for liquid conveyance shall have a maximum dimensional ratio (external diameter / wall thickness) of 120.

All low pressure steel pipe and fittings for compressed air shall have a minimum wall thickness of:

1. 2 mm for DN less than or equal to 100 mm.
2. 3 mm for DN up to 500 mm.
3. 4 mm for DN greater than 500 mm.

Fabrication and quality certification shall comply with the requirements of AS 4041 and AS/NZS 1554.6.

Nuts and bolts for flanged fittings shall be Grade 316/316 stainless steel. All flanges shall be drilled off-centre. A nickel based anti-seize thread lubricant or equivalent shall be applied to all bolts prior to fitting nuts.

Fabricators shall be ASSDA accredited or equivalent. Evidence supporting knowledge, experience and competence must be supplied to the Principal where it is proposed to use a non-ASSDA fabricator.

Welding shall be to AS 4041 and AS/NZS 1554.6 and welding shall be undertaken by a welder certified to the requirements of AS/NZS 3992.

Testing of all welds shall be in accordance with AS 4041 and AS 4037 and all referenced standards using the following:

a) 100% visual examination of all welds.

b) Hydrostatic testing.

c) Radiographic or ultrasonic testing together with magnetic particle testing or penetrant testing of 10% of all welds.

Personnel responsible for inspection shall be accredited by the Welding Technology Institute of Australia or shall meet the requirements of AS 1554.6 and/or AS 4041.

Finishing and passivation shall be in accordance with the requirements of the Australian Welding Research Association (AWRA) Technical note 16 – 'Welding of Stainless Steel".

Inspection and test plans shall be in accordance with the requirements of HB 90.3.

Contact of stainless steel with other metals and/or rubbing with any other item during transportation shall be avoided. Adhesive labels shall not be used.

The suppliers of products shall declare that their products comply with the requirements specified.

8.2.6 PVC-O Pressure Pipe and Fittings

Polyvinylchloride (PVC-O) pressure pipe shall comply with AS/NZS 4441. Minimum pressure Class shall be PN16.

Use of moulded PVC fittings is not permitted.

Elastomeric joint seals shall comply with AS 1646, EPDM or NR and have product certification (ISO Type 5) to AS 1646.

Pipe bends shall have product certification (ISO Type 5) to AS/NZS 4441.

All products shall be marked in accordance with the certification body's requirements.

The suppliers of products shall certify that their products comply with the requirements specified.

8.2.7 PVC Non Pressure Pipe and Fittings

PVC-U pipe and fittings shall comply with AS/NZS 1260.

Pipe Stiffness Class shall be SN8 (for DN150 and above) or SN10 (for DN100).

PVC-U non-pressure pipe and fittings shall have product certification (ISO Type 5) to AS/NZS 1260.

Elastomeric joint seals shall have product certification (ISO Type 5) to AS 1646.

All products shall be marked in accordance with the certification body's requirements.

The suppliers of products shall certify that their products comply with the requirements specified.

8.2.8 PVC Flexible Pipe and Fittings

Flexible reinforced PVC pipe (Barfell super ultraflex 201666 or approved equivalent) shall comply with AS/NZS 2554.

Hose clamps shall be heavy duty stainless steel T-Bolt type. Worm drive clamps will not be accepted.

8.2.9 GRP Non Pressure Pipe

GRP pipe shall comply with AS/NZS 3571, centrifugally cast.

Pressure Class shall be PN16 minimum and stiffness Class shall be SN10000 minimum.

Isophthalic resins shall comply with the following:

1. Mole ratio of maleic / fumaric to isophthalic acid 1.2:1 minimum;
2. Heat distortion temperature 80°C minimum; and
3. Objective evidence of suitability for the environment (case history or standard laboratory immersion testing eg. ASTM C 581).

Elastomeric joint seals shall comply with AS 1646, EPDM and shall have product certification (ISO Type 5).

GRP pipe shall have product certification (ISO Type 5) to AS 3571.

All products shall be marked in accordance with the certification body's requirements.

The suppliers of products shall certify that their products comply with the requirements specified.

8.2.10 Coppe Pressure Pipes and Fittings

Copper pressure pipes, Type A or Type B, shall be manufactured in compliance with AS 1432.

Copper pressure pipe fittings and connectors shall be manufactured in compliance with AS 3688.

8.2.11 Polyethylene Pipes and Fittings

Polyethylene pipe shall comply with AS/NZS 4130 and shall be PE 80 or PE100, and minimum pressure Class PN16.

The Polyethylene Pipeline Code WSA 01—2004 Third Edition shall be complied with.

Polyethylene fittings shall comply with AS/NZS 4129.

Mechanical joints below ground shall be either butt welded or electrofusion welded.

Mechanical joints above ground can be compression fittings.

8.2.12 Polybutylene Pipes and Fittings

Pipes for internal plumbing applications shall be a minimum of Class16 Polybutylene (PB) material conforming to AS/NZS 2642.2:1994.

All fittings shall conform to AS/NZS 2642.3. All aspects of the installation shall conform to the national Plumbing Code, AS 3500.

8.2.13 Hose Reels and Fittings

Hose reels are required for both firefighting and service water. They shall all be nominal diameter 25 mm. For service water reels a length of 18m is required. All hose reels shall be manufactured in accordance with AS 1221.

Hose clamps shall be heavy duty stainless steel T-Bolt type. Worm drive clamps shall not be accepted.

8.2.14 ABS Pipes and Fittings

ABS pipes and fittings shall comply with AS 3518.1 and AS 3518.2.

Pressure pipe and fittings shall be Class PN16 minimum.

Priming fluid and solvent cement shall be to AS 3691.

Flanged joint bolting and backing rings shall be Grade 316/316L stainless steel unless in a location subject to chlorine corrosion where galvanised may be used with the approval of the Principal.

Any ABS equipment (i.e. valves, check valves, strainers, etc.) shall be fitted with barrel union ends for ease of replacement.

8.3 Pipe Laying and Jointing

8.3.1 Pipe Laying Tolerance – Gravity

Pipelines shall be constructed to the following tolerances:

1. Departure from the design level of any point shall not exceed 20 mm for pipelines with design Grades below 1.0% and shall not exceed 30 mm for pipelines with design Grades equal to or greater than 1.0%.
2. Departure from the design Grade of any pipe length of the pipeline shall not exceed 0.1%.
3. Horizontal departure from the design position of any point on the pipeline shall not exceed 30 mm.

4. Vertical deflection of PVC or GRP pipes due to external load shall not exceed 3% of the outside diameter of the pipe.
5. Angular deflection of flexible pipe joints shall not exceed the manufacturer's recommendations for the particular pipe material and size used.

8.3.2 Pipe Laying Tolerance – Pressure Pipeline

Pipelines shall be constructed to the following tolerances:

1. Horizontal departure from the design position of any point on the pipeline shall not exceed 50 mm.
2. Departure from the design level of any point on the pipeline shall not exceed 30 mm.
3. Unless stated otherwise, the depth from final ground surface level to the top of the pipe shall have or exceed the minimum cover.
4. All pipes, in a length between design high and low points shall have a continuously rising Grade towards the high point.

8.3.3 Pressure Main Thrust and Anchor Blocks

Provide concrete thrust / anchor blocks at all valves, flexibly jointed bends, tees, enlargers and reducers or at any other point where unbalanced forces resulting from internal pressures may occur.

The thrust / anchor blocks shall bear against undisturbed material normal to the direction of the thrust over the bearing area. The minimum required bearing area at each thrust block location shall be determined from the maximum design pressure for the pipework (including surge) and the maximum allowable lateral bearing capacities of the trench material.

Concrete thrust and anchor blocks shall be cured for a minimum of seven (7) days before being subjected to any thrust load.

Temporary anchorage adequate to restrain the pipe when under test shall be provided.

8.3.4 Flanged Joints

Flanges, gaskets, and o-rings on flanged joints shall be in accordance with the requirements of AS 4087.

Flanges up to DN1200 shall:

1. Be raised face with full face gaskets;
2. Be drilled off centre;

Washers shall be used under all nuts. Washers shall also be used under bolt heads connecting to items with protective coatings.

Where dissimilar metals would otherwise be in contact, high strength phenolic or PTFE insulating washers and sleeves shall be supplied and installed to all connections.

Gasket manufacturer's recommended bolt torque for the bolt diameter and gasket seal supplied shall be applied.

Ductile iron or steel raised-face pipe flanges shall not be matched with flat-face non-ductile iron or cast flanges on equipment supplied.

Flanges shall not be used in buried pipe application without the prior approval of the Principal.

UniFlanges, Adapta-Flanges or similar joints secured by set screws will not be accepted.

8.3.5 Pipeline Marking Tape

For all pipelines, marking tape (for PVC, RC & PE pipelines, tape to be detectable type) shall be laid on top of the pipe embedment material before backfilling. At valves and hydrants the tape shall be connected to the metal surface fitting.

The detectable marking tape shall comply with AS 2648.1. The tape width shall be 100 mm minimum. Tracer wire shall be 316SS, copper or other metal of equivalent corrosion resistance in a buried environment. Tracer wire shall allow at least 25% elongation of the plastic tape before breakage of the wire. The height of message letters shall be 40 mm.

For potable water mains, the tape colour shall be green (Jade G21 to AS 2700) and the tape message shall be "CAUTION POTABLE WATER MAIN BURIED BELOW".

For reclaimed water mains, the tape colour shall be purple (Violet P13 to AS 2700) and the tape message shall be "CAUTION NON-POTABLE WATER MAIN BURIED BELOW".

For gravity sewers the tape message shall be "CAUTION GRAVITY SEWER BURIED BELOW".

For chemical dosing pipework, the tape message shall be "CAUTION CHEMICAL DOSING LINES BURIED BELOW".

For sewer / sludge rising mains, the tape message shall be "CAUTION RISING MAIN BURIED BELOW".

8.3.6 Connections for Pipework and Fittings

Pipelines shall be connected to structures so that two flexible joints are provided within 900 mm each side of the structure. Pipes and fittings encased in concrete shall be considered as structures.

Dismantling joints shall be thrust type.

Uniflanges, Adapta- flanges or similar joints secured by set screws shall not be accepted.

8.3.7 Construction of Gravity Pipelines

After preparing pipe bedding (underlay), pipes shall be laid and jointed using methods, materials, tools and equipment in accordance with the manufacturer's and/or supplier's instructions and recommendations, the relevant Australian Standards and any specific requirements of this Specification.

For laying of DICL, PVC or GRP pipes only those installers who have completed an approved training and accreditation program shall be used.

All pipe system items shall be cleaned and examined before laying. Each joint seal shall be inspected for flaws before making the joint.

Witness marks shall be reinstated on unmarked length of any cut pipes and pipes shall not be scored when reinstating the witness mark.

Whenever possible laying shall commence at the downstream end of the pipeline. The pipes shall be laid with their sockets at the upstream end and their barrels firmly and evenly embedded on the bedding material. Holes shall be formed in the bedding to accommodate the pipe sockets or couplings to allow even bearing along the full length of the pipe barrel.

Pipework cover above the top of the pipe shall, unless otherwise approved by the Principal, be:

1. Under roadways or pavements, 900 mm; or
2. In non-trafficable areas, 600 mm.

Pipes already laid shall be restrained before the next joint is made to prevent movement of the pipe. Flotation of pipes during laying, backfilling and initial testing shall be prevented.

At the end of each day's laying, the end of the pipe shall be sealed to prevent ingress of trench material or water.

8.3.8 Hydrostatic Acceptance Testing of Water Mains

The hydrostatic test pressure shall be taken as 1.25 times the design pressure.

The maximum loss rate is given by:

(0.14 x N x L x H)/1000 L/h

where: **N** = Nominal pipe diameter (mm)

L = Length of pipeline under test (km)

H = Average value of test pressure (m)

Testing shall be carried out using a testing rig which has two (2) calibrated pressure gauges. Only pressure gauges which have been calibrated within three (3) months of the testing shall be used. Both gauges must read within 5% of the test head and 5% of each other. The gauge reading the lower pressure shall be used for the test readings. Before testing a pipeline section, it shall be cleaned and then slowly filled with water, ensuring that air has been completely expelled.

Testing shall be performed as follows:

1. The line shall be pressurised to 75% of the test pressure and left for a minimum of twelve (12) hours.
2. Provided after twelve (12) hours there is no obvious leak in the pipeline, the pressure in the pipeline shall be steadily raised until the specified test pressure is reached.
3. This pressure shall be maintained for a minimum of four (4) hours and the quantity of water needed to be added in order to maintain the pressure during the period of testing measured and recorded at half hour intervals.
4. During the pressure testing of the pipeline each valve shall sustain for at least fifteen (15) minutes, at least once, the full test pressure on one side of the valve closed position with no pressure on the other side.
5. The line shall be visually inspected for leaks and if a leak is suspected, but is not visible, aural or electronic assistance shall be used.

The pressure testing on a section of pipe shall be deemed to be satisfactory if:

a) There is no failure of any thrust block, anchor block, pipe, fitting, valve, joint or any other pipeline component;

b) There is no visible leakage; and

c) The average measured leakage rate during the last four (4) hours of the pressure testing does not exceed the maximum loss rate as determined in accordance with the formula described above.

Any failure, defect, or detectable leakage occurring during pressure testing shall be remedied and the pipeline shall then be retested.

8.3.9 Connection to Existing Water Mains

Written notice of intention to connect to the existing water main shall be given to the Principal, including full details of the proposed connection procedures, ten (10) working days prior to making the connection. The Contractor shall comply with any directions regarding the method and timing of the connection given by the Principal, which are necessary to meet operational needs of the existing water supply system.

The connection shall be undertaken on the approved date and at the approved time. The connection work shall not commence unless all necessary materials and equipment are available on-site. All work shall be undertaken so as to minimise interruption to the operation of the existing water supply system.

The Principal shall arrange with Council to shutdown the existing water mains to allow connection.

9 Commissioning and Testing

9.1 General

The Contractor shall be responsible for the plant performance in all facets of operation up to the successful completion of Proof of Performance.

When the Principal's Staff and Representatives are required to assist the Contractor, they shall work under the Principal's WH&S system. The Principal's operational staff will be available part-time for on the ground training and familiarisation. The Principal's staff will be available full time on-site to assist the Contractor in the operation of the WTP under the Contractor's supervision, following Practical Completion. Any error by the Principal's staff or representatives shall not relieve the Contractor of its obligations under the Contract.

The Contractor shall have on-site technical personnel specialising in the various aspects of the Works. The Contractor shall be responsible for the commissioning program up to the successful completion of full design flow proving. The Contractor shall provide continuous supervision by personnel experienced in the operation of the equipment and shall have qualified personnel in attendance to carry out all necessary adjustments and/ or remedial work during all the commissioning phases up to the successful completion of full design flow proving.

9.2 Commissioning Plan Document

The Contractor shall prepare and provide to the Principal, a comprehensive Commissioning Plan. Whilst a draft document shall be submitted and discussed towards the end of the design phase, this final document shall be provided four (4) weeks before the installation of any mechanical and electrical equipment. As a minimum, the document shall discuss the following:

1. Commissioning Team: Roles & responsibilities, key interfaces;
2. Commissioning risks and proposed corrective action steps to mitigate these risks;
3. A comprehensive construction and commissioning program, including Gantt chart, providing the Principal clear details of proposed dates/ milestones for the project, hold points, and conditions for pass/ fail;
4. Details of Contractor's approach to Commissioning;
5. Management of Alarms; and
6. Contractor's approach to the seven (7) day Proof of Performance (POP) Test.

9.3 Progressive Status Reports

The Contractor shall provide the following progressive status reports:

7. **Pre-commissioning**: From the date that the first item of mechanical and/ or electrical equipment is installed on-site, up until the formal start of Commissioning, the Contractor shall provide to the Principal, weekly pre-commissioning reports to address the status of installation works and perceived risks to complying with their approved Construction schedule.
8. **Commissioning**: From the date of Commissioning, up until completion of the Proof of Performance (POP) Test, the Contractor shall provide to the Principal weekly commissioning reports to address the

status of installation works and perceived risks to complying with their approved Commissioning Schedule.

9.4 Management of Alarms

9.4.1 Response Protocols

The management of alarms and the necessary protocols for escalating a response shall be clearly defined within the document including specific names, direct telephone numbers, mobiles and email addresses.

9.4.2 Attending to Alarms and After Hours Call-outs

All after hours alarms shall be attended by the Contractor's staff alone up until the successful completion of process proving. After hours is deemed to be between 3pm and 7am Monday to Friday and from 3pm Fri to 7am Monday inclusive.

9.4.3 Prioritising Alarms

As part of the Pre-Commissioning and Commissioning Procedures Document, a table of alarm priorities shall be provided. As a minimum, this shall include three (3) categories of CRITICAL, HIGH and LOW priority alarms with their associated agreed response times for each significant item of mechanical and electrical equipment for each process unit area throughout the entire plant.

9.5 Works Inspections and Testing

9.5.1 Definitions

Inspection is defined as inspections during the construction and installation of equipment to be supplied.

Inspections shall be carried out by the Contractor to ensure that the construction and installation is in accordance with the specified and tendered requirements.

Testing is defined as tests by the Contractor prior to Commissioning. Testing includes both works testing at the manufacturer's facilities and site testing.

The Commissioning Plan shall include the times for inspection and testing, and shall list all tests and test procedures.

9.6 Site Testing

9.6.1 General

When the Contractor and the Principal agree that the work under the contract is ready for testing, site testing shall begin.

Inspections shall be arranged, by the Contractor, with the relevant statutory authorities having jurisdiction over the works to ensure that all equipment has been installed and functions in compliance with their requirements.

The program for testing shall be submitted as part of the Commissioning Plan, which is a pre-requisite for any site works to occur. The program shall clearly indicate the dates proposed to conduct each phase of site testing. The Principal may alter the proposed dates or specify any additional tests not included in the program to be carried out.

All testing equipment, chemicals, external certification, labour and necessary facilities for all tests shall be supplied by the Contractor.

All plant maintenance and clean-up shall be undertaken by the Contractor.

The Contractor shall have representatives present on-site during all site tests and have available the necessary labour and equipment to carry out all repairs and modifications that may be required during the site testing period. Site testing of all equipment shall be supervised by the Contractor and representatives of the relevant sub-contractors.

Site testing shall be conducted in three (3) distinct phases, as follows:

a) A static and dimensional inspection to establish that all items of equipment are complete and the equipment is ready for no-load operation;

b) No-load operation to demonstrate that all equipment functions successfully, both separately and as components of integrated systems; and

c) Design load/ acceptance operation to demonstrate that all equipment can be successfully and reliably operated under working conditions.

The Contractor shall notify the Principal in writing of successful completion of phase 1 of testing, giving at least forty eight (48) hours notice before commencing phase 2. The Council will arrange for the Principal's specialist personnel to be present on-site during phase 2 and 3 to witness their successful completion.

Prior to commencement of the design load/ acceptance operation (phase 3), the Contractor shall ensure that the system is functioning correctly, with no known deficiencies or faults that could impair the load testing.

If it is not possible to activate any protective equipment or device, a test simulation shall be used.

Site testing shall include, but not be limited to, the following:

1. Inspecting the installation and testing of all equipment;
2. Performance tests of the mechanical and electrical equipment;
3. Calibration of level controllers and other instrumentation;
4. Adjustments and setting of all field control and safety devices;
5. Electrical and control tests (as detailed in the clauses below);
6. Functional check of all control and instrument loops and logic testing of circuitry and programs;
7. Confirming the hydraulic performance;
8. Auto/ manual start-up/ shut-down procedures;
9. Status/ alarm signals and indications;
10. Emergency shutdown operations;
11. Safety equipment/ requirements;
12. Duty point verification for all pumps, where required; and
13. MEN Earthing: Confirmation of effective earthing of exposed metal of electrical equipment.

9.6.2 Electrical and Control Tests

The Contractor shall be responsible for site testing of the completed electrical installation.

Circuit continuity, point to point checks, termination checks and component installation checks shall be carried out as a minimum.

9.6.2.1 Control and Operation Including SCADA

1. Point to point testing of all I/Os;
2. Functional operation of all equipment as specified; and
3. Operation of all hardware and software as required.

9.6.2.2 Motors

1. Manual turning of the rotor to ensure mechanical freedom;
2. Insulation resistance at 1,000 V between phases and each phase to earth;
3. Continuity of earth connections, and check on phase and earth connections in terminal boxes;
4. Continuity of all hard-wired control and monitoring circuits associated with respective motors;
5. Functional check of all control circuits and devices to ensure correct operation before motors are energised;
6. Local start/ stop operation and/ or control station operation to check direction of rotation;
7. Check motor for run and direction; and
8. Record no-load currents.

9.6.2.3 Earthing

The Contractor shall demonstrate that the continuity of the earthing system is in compliance with the requirements of AS 3000 and the relevant standards and that all specific installation requirements have been adhered to. The Contractor shall:

1. Check the earthing resistance for each section of the earth after isolating sections of the earth from the relevant test points;
2. Test all earthing conductors for continuity after installation;
3. Check all earth connections for correct termination; and
4. Provide an earthing report showing:
    a) Resistance to earth of each earth electrode; and
    b) Resistance to earth of each installation when all bonds are connected.

9.6.2.4 Lightning Protection System

All site tests as required in AS 1768.

9.6.2.5 Light and General Power

The Contractor shall test and demonstrate the operation of the complete lighting and general power installation for compliance with the drawings and shall:

1. Test all light fittings;
2. Test the operation of the switching circuits;
3. Test all power outlets and confirm phase rotation and circuit connections as applicable; and

4. Test all RCDs and earth leakage devices.

9.6.2.6 Field Mounted Equipment

The Contractor shall perform component integrity and terminations check.

Any defects associated with the supplied equipment and incorrect installation instructions disclosed during testing shall be rectified by the Contractor, and fresh tests shall be carried out. The Contractor shall meet all the costs of remedial work and tests.

The Contractor shall provide all testing and calibration equipment and instruments as necessary.

Test results shall be recorded and submitted as test certificates.

9.6.3 Testing of Pipelines and Tanks

Acceptance testing of all pipelines and tanks shall be undertaken as constructed. The Contractor shall ensure that structures and pipes are clean before any test is performed. Pressure testing shall not be undertaken during wet weather.

If any of the tests prove to be unsatisfactory, the fault shall be detected and repaired and then the test reapplied. The Contractor shall continue to repair and re-test until a satisfactory test is obtained. Even if testing produces satisfactory test results, any structure, pipeline or conduit in which there is a visible or detectable leak or blockage shall be repaired to the satisfaction of the Principal.

All pipelines and structures shall be tested for leakage as soon as practicable after they have been constructed. All pipe openings in the walls shall be plugged with the plugs placed in the pipes as near as practicable to the internal face of the well or the tank.

An exfiltration test shall be used unless it can be demonstrated to the satisfaction of the Principal that ground water is at a sufficiently high level to ensure that all construction joints and pipe penetrations can be adequately tested by an infiltration test.

The structure shall be totally filled with water and then, after allowing an interval for absorption of 4 hours, refilled. The loss of water shall then be measured during a period of 30 minutes.

9.7 Commissioning

Commissioning of the Works shall be undertaken by the Contractor. The objective of Commissioning is to prove that the Works and its associated equipment are now in a safe and proper condition and ready for operation in a fully integrated state. Its purpose is to check that all testing has been completed satisfactorily and it includes all aspects of operation such as safety, electrical, mechanical and instrumentation.

Prior to the commencement of commissioning, the Contractor shall submit one (1) signed copy of each completed individual unit site commissioning checklist countersigned by the Principal or their representative who witnessed the test.

Commissioning requires full liaison and co-ordination of the program and activities with the Principal. Representatives of the Principal may participate in commissioning tests and may elect to record an independent set of test results for evaluation.

9.7.1 Test Requirements

General requirements shall include:

1. Running the pumps to ensure that the minimum flow to the instruments is met;

2. Carrying out all necessary testing and adjustments until the works are proven adequate and suitable for normal starting and running under service conditions of normal and high demands;
3. Operation of all equipment under continuous operation and start-up/ shutdown of the plant, to check the performance in all aspects for compliance with this Specification; and
4. That the facility can operate in automatic mode.

9.7.2 Contractor Involvement

Throughout the commissioning process, the Contractor shall have on-site technical personnel specialising in the various aspects of the Works. At its expense, the Contractor shall be responsible for the preparation and revision of the construction program that must contain the critical path for Commissioning. The Contractor must provide continuous supervision of commissioning and its stages by key personnel experienced in the operation of the equipment and shall have key qualified personnel in attendance at all critical times and otherwise at the direction of the Principal, to carry out all necessary adjustments, defects and/ or remedial work during the commissioning tests.

9.7.3 Principal's Role

The Principal's duties during the commissioning and performance testing of the Works are as follows:

1. Approval of the commencement of Commissioning and Proof of Performance (POP) testing;
2. Declaration of Non-Eligible Days during the periods of the POP Test following application for such by the Contractor;
3. Certification of Commissioning Completion; and
4. Certification of the results of the POP Test.

All other resources and activities of whatever nature required to satisfactorily commission and test the Works are the sole responsibility of the Contractor.

9.8 Proof of Performance

9.8.1 Overview

In order for the Proof of Performance (POP) test to be deemed complete, 100% of the Performance Requirements shall be satisfied during the entire testing period. Failure to satisfy any one of the criteria strictly in accordance with this Technical Specification, shall constitute failure of the entire trial and the test shall be repeated anew, at the Contractor's expense. For the avoidance of doubt, all criteria described above must be satisfied to 100% of the requirements stated in the Technical Specification.

The POP requires the successful completion of one extended seven (7) day continuous performance trial strictly in accordance with the standards required under the Technical Specification which must be completed prior to granting of Practical Completion. This trial shall be conducted under typical flow conditions under which the WTP is being operated at the time.

9.8.2 Methodology

The POP shall be undertaken as follows:

1. Contractor provides three (3) days written notice to the Principal (email acceptable) that the POP is to commence.

2. If the performance of the WTP fails to satisfy the Performance Requirements on an Eligible Day, the Contractor must make necessary modifications to the plant and/ or process to achieve the Performance Specification.
3. When satisfied that the Performance Specification is being achieved, the Contractor must notify the Principal, and a new seven (7) day POP period commences.
4. This procedure must be repeated as many times as necessary to achieve at least the Performance Specification for a period of seven (7) consecutive Eligible Days with regard to the Performance Test being undertaken.
5. Council will not accept any form of monetary or other compensation for failure to achieve the Performance Specification. Rectification or modification works must be undertaken by the Contractor to achieve the Performance Specification.

9.8.3 Eligible Days

For the purposes of the POP, an Eligible Day must be any calendar day except:

1. One on which the quality of the incoming water exceeds the range of reported water quality; or
2. One that the Principal, having regard to the circumstances that may arise but nonetheless in its absolute discretion, declares to not be an Eligible Day.

The Principal will only declare a day not to be an Eligible Day subject to prior application, for such a declaration from the Contractor.

9.9 Assistance Post POP

Tenderers must provide a schedule of rates for the provision of assistance to Council in troubleshooting post formal process proving, inclusive of a cost for travel and accommodation.

Tenderers must provide a separate cost item for an additional Licence to have 'real time' read-only access to the plant SCADA.

Assistance shall be provided post project completion in two (2) phases as follows:

1. Phase 1: 3 months post POP
    a) Specialists as required to be contactable to assist Council staff as required within 24 hours notice; and
    b) Specialists as required to be called in to assist Council staff on-site as required within three (3) working days notice.
2. Phase 2: Months 4 to 12 post POP
    a) Specialists as required to be contactable to assist Council staff as required within 24 hours notice; and
    b) Specialists as required to be called in to assist Council staff on-site as required within seven (7) days.

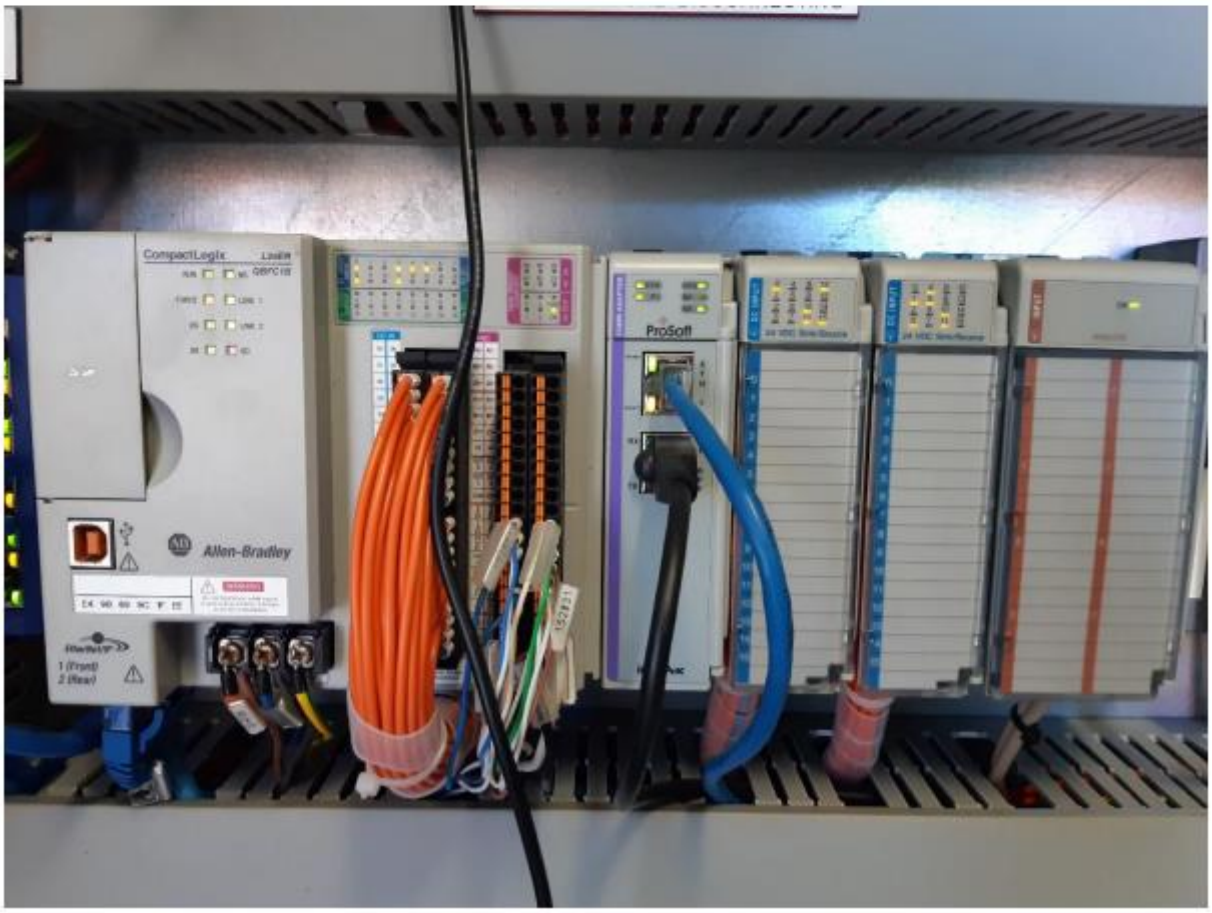
Appendix A Moura and Biloela Telemetry

Moura WTP – PLC

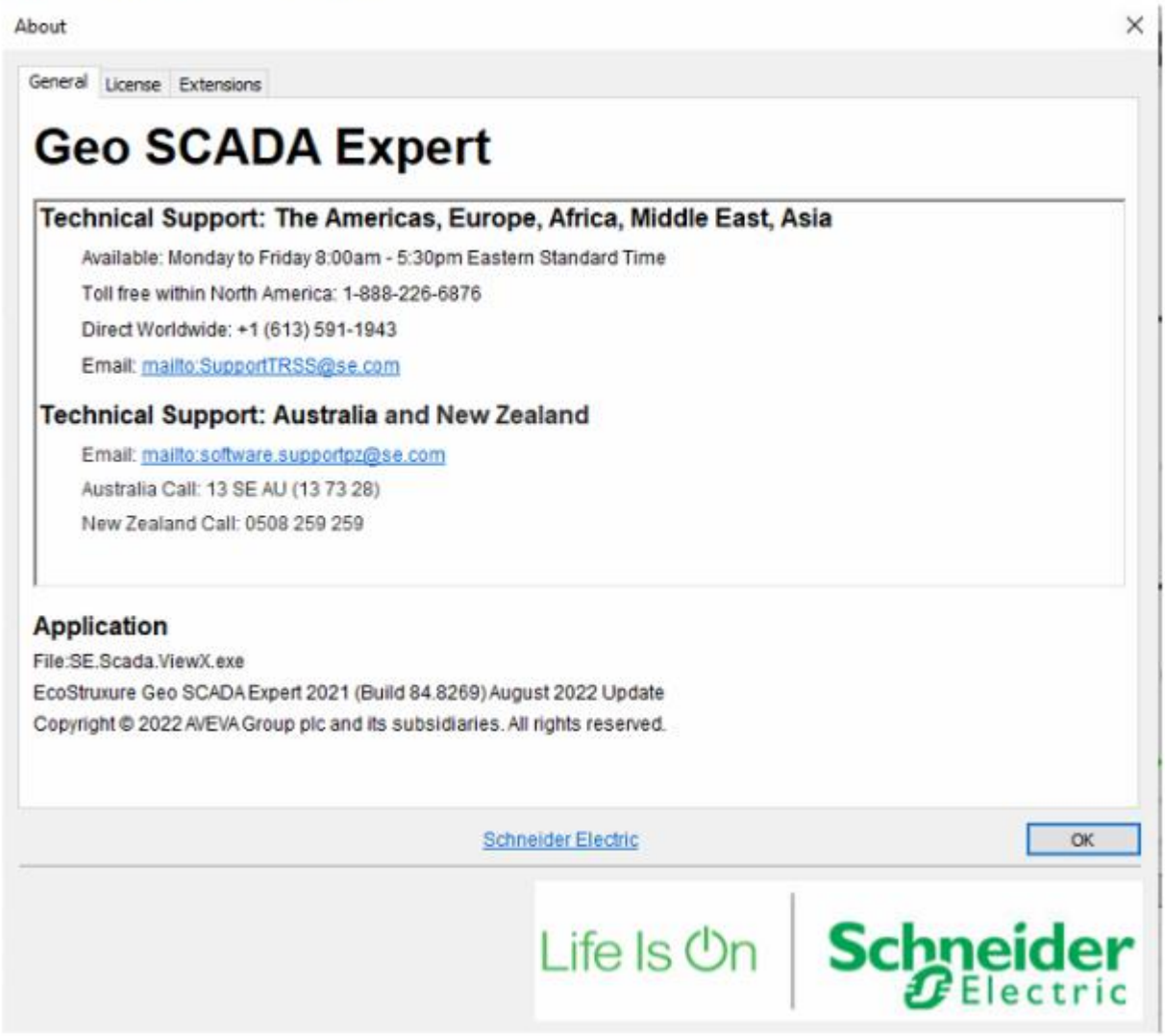
Moura WTP - Stratix Switch

Moura WTP – RTU

Moura WTP - Fluoride PLC



Moura WTP – GeoSCADA SCADA



Biloela WTP – PLC

Biloela WTP – Stratix Switch

Biloela WTP – RTU

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