Ashghal ICA Specification

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Acronyms and Abbreviations

1	ICA	INSTRUMENTATION, CONTROL AND AUTOMATION
2	DNMC	DRAINAGE NETWORK MANAGEMENT CENTRE
3	SCADA	SUPERVISORY CONTROL AND DATA ACQUISITION
4	TWN	TREATED WATER NETWORK
5	FS	FOUL SEWER
6	SGW	SURFACE AND GROUND WATER
7	BS	BRITISH STANDARDS
8	EN	EUROPEAN STANDARDS
9	QCS	QATAR CONSTRUCTION SPECIFICATIONS
10	PLC	PROGRAMMABLE LOGIC CONTROLLER
11	HMI	HUMAN-MACHINE INTERFACE
12	I/O	INPUT OUTPUT
13	P&ID	PIPING AND INSTRUMENTATION DIAGRAM
14	RTU	REMOTE TERMINAL UNIT
15	OEM	ORIGINAL EQUIPMENT MANUFACTURER
16	CCS	COMMON CONTROL SECTION
17	O&M	OPERATION AND MAINTENANCE
18	PCC	PROJECT COMPLETION CERTIFICATE
19	SFDS	SCADA FUNCTIONAL DESIGN SPECIFICATION
20	NTP	NETWORK TIME PROTOCOL
21	GPRS	GENERAL PACKET RADIO SERVICE
22	GSM	GLOBAL SERVICE FOR MOBILE COMMUNICATION

Version Control

Version	Amendment Description	Issue Date	Planned Revision Date
0	First Release	14-June-2021	14-June-2022

1. INTRODUCTION

1.1. This document describes the control standard requirements at the remote sites and connection to DNMC MASTER SCADA system. ASHGHAL reserves the right to approve changes based on site-specific design requirements to ensure consistency with these standards.

1.2. The type of sites are:

1.2.1. Pumping Station

1.2.2. TWN Chambers

1.2.3. FS/SGW Network Penstocks

1.2.4. Lagoon and Emergency Flood Area (EFA)

1.2.5. Dewatering

1.2.6. Network Manholes

1.3. This document describes and list all equipment attributes.

1.4. The ICA Design and Engineering shall be carried out according to the guideline references

2. CODES AND STANDARDS

2.1. Codes and Standards

The ICA Design and Engineering shall be carried out according the following latest design guideline references and other codes and standards including but not limited to the following:

Qatar Sewerage and Drainage Design Manual (QSDDM Volume 6 – Pumping stations, latest edition), Public Works Authority

Qatar Sewerage and Drainage Design Manual (QSDDM Volume 2 – sewerage, latest edition), Public Works Authority.

Qatar Construction Specifications (QCS) - 2014 Section10 and Section 21.

Instrumentation Society of Automation Standards

General provisions for Electrical design, equipment and installation requirements shall comply with the regulations as issued by the Qatar General Electricity and Water Corporation (QGEWC) Qatar.

British Standards as applicable.

National Electrical Code issued by National Fire Protection Association (NFPA), USA

NFPA Codes as applicable.

IEC Standards and regulations as applicable

ASHGHAL SCADA Functional Design Standards Rev 2.0

The following list of standards indicates the minimum requirements. However, if no standard is specified, the relevant BS/IEC Standard or in the absence of such standard, international standard will be applied.

BS EN 60873-1	Electrical and pneumatic analogue chart recorders for use in industrial-process control systems. Methods for performance evaluation
BS EN 60546-1, 2	Controllers with analogue signals for use in Industrial - process control systems. Controllers with analogue signals for use in industrial-process control systems. Methods for evaluating performance, Guidance for inspection and routine testing
BS EN 60874-1	Connectors for optical fibers and cables. Generic specification.
BS EN 61000-6	Electromagnetic Compatibility
BS EN 60073	Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators
BS 5863-1	Analogue signals for process control systems
BS 6739	Code of practice for instrumentation in process control systems: installation design and practice
BS EN50288-7	Instrumentation Cable
BS 1646	Symbolic representation for process measurement control functions and instrumentation
BS EN 60255-22-5	Surge protection
BS EN 61131-3	Programming Languages for Programmable Controllers.
BS EN ISO 9000-3	Recommendation for achievement of quality in software
BS ISO/IEC 6592	Documentation of computer based systems
BS ISO/IEC 9075	Structured Query Language (SQL)
BS EN 60654	Operating conditions for industrial process measurement and control
BS ISO 5725	Accuracy of measurement methods and results
ISO 3511	Process measurement
BS 907	Dial gauges for linear measurement
BS 1042	Flow Measurement
BS 1780	Bourdon tube pressure and vacuum gauges
BS 1904	Industrial platinum resistance thermometer sensors
BS 2765	Dimensions for temperature detecting equipment and their pockets
BS 3680	Open channel Flow and Level Measurement
BS EN 50014 to BS EN 50020	Protection

BS EN 60529	Ingress Protection
BS EN ISO 6817	Flow measurement for conductive liquids
BS 5515	Documentation of computer based systems
BS 7165	Recommendation for achievement of quality in software
BS EN 50081	Electromagnetic Compatibility
BS EN 61131-3P	Programming Languages for Programmable Controllers
IEEE 472-1974	Surge protection
ISO 3511	Process measurement control functions - instrumentation symbolic representation
ISO 9075 (BS 6964)	Structured Query Language (SQL)
BS EN 10084	Case hardening steels. Technical delivery conditions
BS ISO 9000-2	Quality procedures
BS 88	Fuses
BS 546	Electrical outlets
BS EN 60898	Design of MCBs
BS 7430	Code of practice for earthing
BS EN 60529	Ingress protection
BS EN 60439	Low voltage switchgear and control gear assemblies
BS EN 60839	Alarm and electronic security systems
BS EN 60079 (IEC 60079)	Explosive Atmosphere
BS EN 50173-3	Information technology. Generic cabling systems
ASTM A123, A386	Galvanizing
ASTM A36, A500, A501, A570, A618	Structural steel shapes
BS 970	Wrought steel for mechanical and allied engineering purposes
BS 5967	Operating conditions for Industrial Process Measurement and Control Equipment

2.2. Environmental Ambient Temperature (As per QCS 2014)

All materials, equipment, instruments, devices that are supplied under this contract, including their finishes, shall withstand, without deterioration or malfunction, the prevailing environmental conditions to which they are subjected. This shall apply during transportation, unloading, storage, erection and operation throughout the design life.

Temperature & Pressure

Average summer maximum shade temp. (Design temp.) 50 °C

Maximum recorded shade ambient temp. in summer 55 °C

Minimum recorded shade temp.	0 °C
Maximum external surface temp. (Direct exposure to sun)	85 °C
Average barometric pressure	0.98 bar
Relative Humidity:	
Annual average humidity	100%
Absolute maximum humidity	100%
Absolute minimum humidity	1%

3. GENERAL REQUIREMENTS

3.1. All equipment, including software, shall be proven, preferably in a sewage environment and shall be as per Ashghal approved vendor list, locally supported with fully capable locally based engineering and technical expertise. Local expertise shall be experienced in the detailed technical and engineering aspects of the equipment and software. Control system components shall be designed for service life of minimum 10 years for new systems

3.2. All the equipment selected shall be produced by Manufacturers in accordance with latest QCS.

3.3. Submit all the catalogues with Technical Data sheets, all certified and calculation sheets for all different systems and components according to the required parameters and Engineers instructions in addition to the certificate of origin.

3.4. Where possible Single manufacturer of International standard shall be selected for the supply of all instrumentation/ equipment's performing similar functions and shall obtain the maximum uniformity of instruments/equipment as well to limit the operational spares.

Particular examples include:

- Field Instruments
- Panel mounted instruments
- Fuses, MCBS
- Auxiliary relays (AC, DC Coils)
- Terminal Blocks
- PSU
- PLC & PLC modules
- HMI
- SCADA Servers, Workstations
- UPS

3.5. The equipment shall be constructed to operate accurately and safely under the operating conditions described or implied in this standard and the project

specifications, without undue strain, wear, heating, vibration, corrosion or other operating troubles.

3.6. All parts shall be made accessible and capable of convenient removal. Parts subject to wear shall have adequate means of adjustment and replacement.

3.7. Parts subject to substantial temperature changes shall be designed and supported to permit free expansion and contraction without causing fluid leakage, harmful distortion or misalignment.

3.8. Design all the transmitters, receiving instruments and electrical control devices to have one (1) standard signal range. Analogue signals shall be one of four types:

i. RTD's-100 ohm Platinum.
ii. Electric Control Signals, 4 - 20 mA with HART
iii. As required by the SCADA Communication System
iv. Special volts, 1 – 10 VDC (only inside control panels).

3.9. Where more than one device utilizes the same measurement or control signal, the transmitter or other signal source shall be fully equipped to provide all signal requirements. The system shall be arranged so that failure of any recorder, indicator, control component, etc. shall not open the signal loop nor cause loss or malfunction of signal to other devices using the same signal. The design shall permit removal from service of any indicating or recording device without upsetting the control systems or requiring readjustment.

3.10. All instrument wetted parts (such as Bourdon tubes, pressure capsules, bellows, etc.) in contact with process fluid shall be fabricated from material suitable for respective process application. All pipe threads shall be protected by Teflon tape.

3.11. Locally mounted instruments shall be provided to indicate pressure, temperature, liquid levels, etc., where necessary for maintenance, local monitoring and control valve bypass operation.

4. DESIGN DELIVERABLES

4.1. Detailed Design Report

4.2. Detailed Design Drawings

4.2.1. Layout drawings

4.2.2. Piping and Instrumentation Diagrams (P&IDs)

4.2.3. Instrument loop & hook up diagrams

4.2.4. Interconnection wiring diagrams

4.2.5. Network block diagrams

4.2.6. Cable block diagrams

4.2.7. Control panel drawings

4.2.8. Internal Circuit and wiring diagrams for instruments and control panels/ junction boxes

4.2.9. All panel/ junction box shop/ fabrication drawings

4.2.10. Process piping and valves, as appropriate.

4.3. Functional Design Specifications

4.3.1. Programmable-device functional design specification including communication with RTU

4.4. Compliance Sheets

4.4.1. Scope and Project compliance sheet.

4.4.2. QCS compliance sheet.

4.5. Schedules and Data Sheets

4.5.1. I/O schedules with I/O allocation for main PLC and vendor PLC, Station Full IO List: which includes all hard-wired signal, soft signal from third party system, vendor panel and calculated generated signals from SCADA/PLC system

4.5.2. RTU mapping I/O schedule

4.5.3. Instrument index and datasheets

4.5.4. Equipment and instrument tag numbers

4.5.5. Motors and motor control equipment.

4.5.6. Equipment and instrument voltages.

4.5.7. Cable schedules

4.6. Calculations

4.6.1. Intrinsic safe cable calculations

4.6.2. All documents related to calculation of MCB selection, cables selection, Heat, exhaust fan, level, and solar power calculation. All documents shall be produced to Ashghal Engineer during the material Approval stage, as well as during inspection

4.7. Testing documentation: FAT and SAT latest document sample to be collected from Ashghal O&M Engineer prior to FAT or SAT. RTU & MASTER SCADA signals to be tested during FAT/SAT

5. INSTALLATION WORKS

5.1. All ICA Installation works shall comply with BS 6739: Code for practice for instrumentation in process control systems installation design and practice and requirements specified in QCS 2014 Section 10 part 1 and Section 21 part 1.

5.2. All activities related to PLC, RTU & SCADA System shall be carried out by professionally qualified and certified personnel from the system vendor (OEM) and approved by Ashghal.

5.3. Each instrument and sensing device shall be installed in accordance with the recommendations or instructions of the respective manufacturer and in accordance with industry best practice. Accessibility and maintainability shall be given careful consideration. Each mounting position shall be chosen to give correct operation of the equipment, faithful reproduction of the quantity to be measured, ease of operation, reading, maintenance and servicing, freedom from any condition which could have adverse effects and with particular regard to the safety of personnel and pump station. Each item of pump station shall be levelled and securely fixed to the surface, bracket or framework on which it is mounted.

5.4. Instruments with local readout panels shall be mounted 1.5 metres above standing level.

5.5. Instrument junction boxes shall be located in a position where they are easily accessible to personnel without the use of ladders.

5.6. Transmitters shall not be mounted on machinery or process lines to minimize the effects of vibration.

5.7. Any Pressure, Flow, Temperature Installation shall require Local Indicator to show the reading in field.

5.8. Field devices shall be secured via through-bolts and lock nuts. Tapped holes should be avoided.

5.9. With the exception of heavy equipment all fixings including screws, nuts, bolts, washers, masonry anchors shall be stainless steel.

5.10. Where mountings require the welding of base plates and/or brackets onto mechanical equipment or structures, only the appropriately certified tradesperson(s) shall be assigned to this task.

5.11. Complete all miscellaneous works associated with installation of instruments. For example, stilling wells.

5.12. Instruments to be installed in areas of high or low temperature or high humidity shall be provided with adequate protection from adverse effects. Such protection can include mounting in an air-conditioned environment and/or being shaded from direct sun and protected from possible accidental damage. Unless otherwise specified, instruments and analyzers installed outdoors shall be housed within stainless steel panel of the outdoor type as specified elsewhere in the Specification.

5.13. ICA Equipment for installation in hazardous areas shall be selected and installed in accordance with BS EN 60079.

5.14. Field equipment/ instrument shall be tagged with assigned instrumentation tag number and function. Tags shall be black lamacoid with engraved white characters of 5 mm minimum height. Tags shall be attached to equipment with a commercial tag holder using a stainless-steel band with a worm screw clamping device or by a holder fabricated with standard hose clamps and meeting the same description. In some cases where this would be impractical, use 0.5 mm^2 stainless steel wires. For field panels or large equipment cases use stainless steel screws, however, such permanent attachment shall not be on an ordinarily replaceable part. In all cases the tag shall be plainly visible to a standing observer. In addition to tags, field mounted control stations, recorders or indicators shall have a nameplate indicating their function and the variable controlled or displayed. Nameplate shall be attached by one of the above methods.

5.15. All externally powered Instrumentation, vendor package PLCs', etc. shall be fed from UPS.

5.16. Colour differentiation as per Standards shall be used for control cables with different voltage levels and signals from hazardous locations and obtain Ashghal Engineer approval.

5.17. All Instruments, PLC system, Vendor PLC shall be connected to dedicated Instrumentation earth system.

5.18. Instrumentation Earth bit Installation drawing with Tag no and Installed location identification all shall be submitted.

5.19. Outdoor mounted instruments shall have proper sunshades to protect from direct sun.

5.20. Installation and position of level/float switches shall ensure efficient operation and ease of maintenance.

5.21. Piping, tubing, and capillary tubing shall be of stainless steel. If this material is unsuitable for ambient or process conditions, piping and tubing shall be of a material approved by the Engineer. Slope lines according to service to promote self-draining or venting back to the process. Terminate connection to process lines or vessels in a service rated block valve that will permit closing off the sense line or removal of the element without requiring shut down of the process. Include drip legs and blow-down valves for terminations of sense lines at the instruments when mounted such that condensation can accumulate. Process vessels, line penetrations, connecting fittings, and block valves shall be furnished and installed under other Sections of these Specifications but coordinated by the ICA Parts. Instrument process taps shall be a minimum 19 mm BSP except flowmeter taps which shall be 12 mm BSP.

5.22. Before connecting any instrument to its associated impulse or air supply pipe work all isolating valves shall be opened and the pipe work blown through to clear any matter. Each line shall be flow-tested for continuity, followed by a pressure test for leak check. Instruments and other ancillary equipment shall be connected immediately after the successful completion of the pressure test, if possible, and all open tube ends shall be sealed against the ingress of moisture.

5.23. Dedicated Sampling line required for Quality Monitoring Analysers and Pressure Instruments Measurements. Tapping not allowed for to take the sampling water provision for lab analysis. Separate tapping to be provided for Lab Analysis sampling requirement.

5.24. Incoming and outgoing cables shall be identified and shall pass through glands fitted to a properly designed gland plate and spaced so as to allow access to both sides of the glands, without the use of special tools. All unused cable entry points shall be fitted with a proprietary plug to maintain the protection rating.

5.25. Provide ICA cabling system comprising all communication, signal, control, and UPS backed power and non-UPS power to all equipment as required. Examples of equipment include, but not limited to, enclosures, LCP panels, VCP panels, HMI

panels, marshalling panels, instruments, and other relevant equipment classified under ICA works. Refer electrical general specifications for more details on cabling and earthing specifications.

5.26. Analogue signal circuits shall be grounded only at the control panel and on a clean earth. Analogue signal cables shall be physically segregated from all power and control cables and from unshielded cables carrying digital or pulse type signals.

5.27. Shields shall be earthed to a clearly identifiable insulated Instrument earthing system for the ICA equipment which is separated from the power earth system. Wherever practicable, screens and armour shall be earthed at the non-field end only. Cable shields shall be electrically continuous to avoid multiple earth paths and loops. At junction boxes and instrumentation cabinets cable screens and earth wires shall be terminated on a terminal strip or earth bar insulated from earth and other conductors. At the point of termination, the shield shall not be stripped back any further than necessary from the terminal block.

5.28. All spare cores shall be terminated and identified as spares. Where it is not possible to terminate spare cores in components such as sensors, the cores shall be cut back and insulated at the field end, whilst the other end should be terminated and connected to earth.

6. POWER SUPPLY REQUIREMENT

6.1. Supply, install, test and commission Service cabinet and Energy meter for KAHRAMAA power supply as per KAHRAMAA latest regulation and specification.

6.2. Supply, install, test and commission the power and instrument cables for KAHRAMAA Service cabinet, Energy meter connections, RTU panels, level sensors and actuators as per the specifications of Qatar General Electricity and Water Corporation (QGEWC) Qatar.

6.3. Where applicable based on Ashghal approval, supply, install, test and commission solar panel systems including solar controllers, batteries, fitting, enclosure and mount bracket.

6.4. Following specification shall be adhered to

i. System Voltage: 24VDC
ii. Solar panel type: Monocrystalline
iii. Battery type: Deep-cycle, As per QCS 2014
iv. Days without charging (Autonomy): 4 days.
v. Days to recharge the battery: 2 days.

6.5. In case of permanent KAHRAMAA power source is not available in the vicinity and denied by KAHRAMAA, solar panel with battery back up and/or generator shall be considered as an alternative supply with the approval of Engineer.

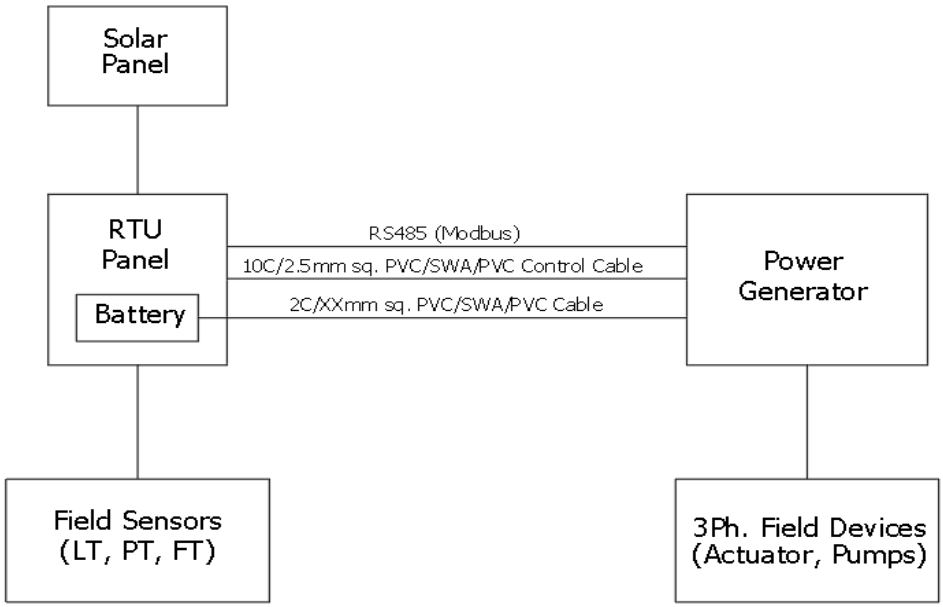


Figure 1 - RTU-Power Supply Arrangement Block Diagram

6.6. The solar panel shall provide the power supply to the RTU panel. The battery of the solar system in the RTU panel shall also serves as the standby battery for the power generator. The RTU shall continuously monitor the field sensors and the status of the power generator.

6.7. The power generator shall be equipped with control unit with hardwired and serial RS485 communication (Modbus) for monitoring and control by the RTU.

6.8. The power generator shall be able to be controlled locally from the RTU panel and remotely from DNMC SCADA. A local control cluster for the generator local operation shall be provided on the RTU panel.

6.9. The following documents to be submitted to the Ashghal Engineer for review prior to procurement and commencing the work: -

i. The detailed sizing calculation of the solar power system for each site.
ii. The detailed mount bracket/pole drawing for the solar panel.
iii. Solar power system enclosure arrangement drawings and bill of materials.

iv. Selection of Battery and Battery Autonomy calculation Study.

6.10. Provide all civil/structural works related to the foundation work, concrete plinth, installation of cables, KAHRAMAA service cabinets, RTU panel and other required works as per site condition.

6.11. The work shall include though is not necessarily limited to; excavation in any ground condition (natural soil/rock/concrete/filled soil, etc.), including existing trench and virgin ground conditions.

6.12. Any trench excavation, backfilling with approved materials, warning tape installation, compaction to the coil MDD limit including importing appropriate filling/sand/aggregate/concrete, dewatering, duct installation as per respective authority specification and landscape reinstatement to original condition.

6.13. Metallic fence and single swing gate with lock including foundation to be provided to protect the Solar system.

7. SITE MONITORING AND CONTROL SYSTEMS

7.1. FSW/SGW Pumping Station

7.1.1. Pump Operation control

The pump shall be controlled from the following control modes:

i. MCC control
ii. PLC Control
  a. Local Control Cluster on PLC panel
  b. Auto Logic Control
iii. Local HMI Control
iv. Master SCADA Control
v. Set-Point Control
vi. Level Transmitter & Float Switches Controls
vii. Pump Tripping
viii. Pump Changeover operation
ix. Master SCADA 'RESET'

i. MCC Control

In this control mode, the MCC controls the pump by the following selection modes:-

- LOCAL
- OFF
- AUTO

LOCAL

In this selection mode, the MCC will have full control of the pumps through the start and stop pushbuttons.

OFF

In this selection, the pump will be isolated from operation.

AUTO

In this selection mode, the pumps will be automatically controlled by the PLC according to the station's control philosophy.

Float Level Backup System

The MCC shall be equipped with a hardwired float backup circuit (LFR) system to control the pumps in the event of any one of the following conditions: -

1. PLC System failure
2. PLC System healthy, any one of the pumps in ready-to-start condition, wet well at HI level but no pump is running.

The float backup circuit shall consist of all the hardware required (control and interposing relays, changeover timers, etc.) to independently control the pumps without the availability of the PLC system.

When the PLC System is healthy, The PLC will energize a fail-safe relay to bypass the LFR circuit. In the event of the above-mentioned conditions occur, the fail-safe relay will be de-energized, and the pump control is transferred to the LFR circuit. When the PLC is normalized, the PLC will resume the pump control.

ii. PLC Control

Local Control Cluster on PLC panel

The mode of operation of the pumping station shall be initiated from a Local Control Cluster installed on the PLC panel. The selections from the local control cluster shall provide feedbacks to the PLC and will be displayed on the local HMI. A typical Local Control Cluster for a 'Single Wet well of 3 pumps @ Duty/Assist/Standby operation with 2 level transmitters' is as depicted in Figure 2 which consists of the following components: -

i. One (1) no. 4-way 'Pump on Duty' selector switch
ii. One (1) no. 4-way 'Level Transmitter on Duty' selector switch
iii. One (1) no. 'Global Inhibit (GIR)' LED indicator
iv. One (1) no. 'Level Float Inhibit (LFR)' LED indicator
v. One (1) no. '2nd Duty Inhibit (2nd Duty)' LED indicator
vi. One (1) no. Lamp test pushbutton
vii. One (1) no. 'Master SCADA Control' LED indicator
viii. One (1) no. High High (HH) level LED indicator
ix. One (1) no. High (HH) level LED indicator
x. One (1) no. Low (LO) level LED indicator
xi. One (1) no. Low Low (LL) level LED indicator

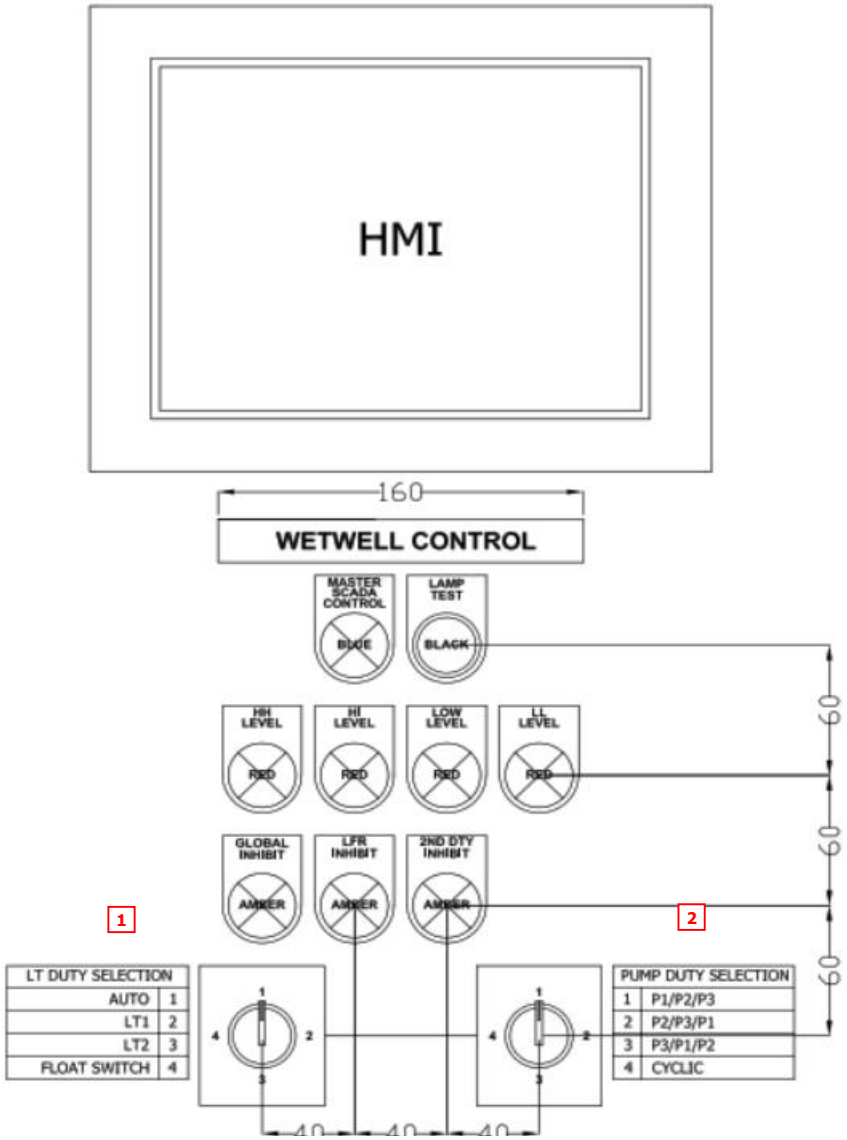


Figure 2 - Typical Local Control Cluster arrangement

1 LT on Duty Selection

The LT on Duty Selection determines which level transmitter will be referred to by the PLC for the station's operation. The duty selection will have the following selection modes: -

i. Auto
ii. LT1
iii. LT2
iv. Float Switch

AUTO mode

In Auto selection mode, the PLC will select the Radar level transmitter as the primary reference and the Hydrostatic level transmitter as the secondary. If the primary transmitter fails, the PLC will select the secondary transmitter for the level reference. If both level transmitter fail, the PLC will automatically select the level float switches as the reference for the station's operation. The operations by the level transmitters and float switches are described in the Level Transmitter & Float Switches Controls in the following chapter.

LT1 mode

In this selection mode, the PLC will always refer to the Radar level transmitter for the station's operation. If the Radar level transmitter fails, the PLC will refer to the level float switches as the reference for the station's operation.

LT2 mode

In this selection mode, the PLC will always refer to the Hydrostatic level transmitter for the station's operation. If the Hydrostatic level transmitter fails, the PLC will refer to the level float switches as the reference for the station's operation.

Float Switch

In this selection mode, the PLC will bypass the level transmitters and refers to the float switches for the station's operation.

2 Pump on Duty Selection

The Pump on Duty Selection determines the sequence of the pump's operation by the PLC. The duty selection will have the following selection modes: -

i) Cyclic
ii) P1 - P1/P2/P3
iii) P2 - P2/P3/P1
iv) P3 - P3/P1/P2

Cyclic

In Auto Logic Control, the station will be controlled by the PLC programmed logic based on the level control set-points. The pump's on duty are automatically selected by the PLC as described in the Pump Changeover operation in the following chapter.

P1, P2 and P3 Duty Selections

In these selection modes, the pumps on duty are determine by the switch's selections. The PLC will control the pumps based on the selections as described in the 'Pump on Duty' Operation Selection Mode in the following chapter.

iii. Local HMI Control

The local HMI monitors and controls the station's parameters through the PLC. The local HMI shall display all the station's parameters and controls in text format and in text boxes with color schemes as per Ashghal's standards. Please refer to Chapter 3 Master SCADA Screen Templates. The local HMI controls the pumps in the following modes: -

- AUTO Mode
- MANUAL Mode

AUTO Mode

In this selection mode, the PLC shall automatically control the logic sequences of the pumps according to the station's control conditions.

The pump's control selection in the **MCC** and in the **Master SCADA** shall be selected in '**AUTO**' and '**REMOTE AUTO**', respectively, for the pumps to be controlled from the HMI. If any one of the selections is not fulfilled, the respected pump shall be bypassed from the logic control sequence.

Each pump shall have a control pop-up with '**AUTO**' and '**MANUAL**' selection buttons, '**START**' and '**STOP**' control buttons and the pumps' main statuses (RUN, STOP, FAULT, etc.). If any one of the '**AUTO**' (MCC) and '**REMOTE AUTO**' (Master SCADA) selection has been removed, all the selection and control buttons in the pump's pop-up shall be disabled.

In '**AUTO**' mode, the pump's '**AUTO**' selection and the '**START**' and '**STOP**' control buttons in the pop-up shall be disabled while the '**MANUAL**' selection button will be enabled.

The change of the pump's control from '**AUTO**' to '**MANUAL**' mode shall not change the last state of the pump. For example, if the pump has been started in '**AUTO**' mode, the pump shall continue to run even when the pump control changes to '**MANUAL**' mode.

MANUAL Mode

In this selection mode, each pump can be controlled manually from the pump's control pop-up. The pump manual control can only be selected when the pump's selection in the **MCC** and in the **Master SCADA** have been selected in '**AUTO**' and in '**REMOTE AUTO**' mode, respectively. If any of the conditions are not met, all the pump's control selections in the pump's pop-up shall be disabled.

In '**MANUAL**' mode and when the pump is in **idling** status, the '**MANUAL**' selection and the '**STOP**' buttons shall be disabled, while the '**AUTO**' selection and the '**START**' buttons shall be enabled.

In '**MANUAL**' mode and when the pump is in running status, the '**MANUAL**' selection and the '**START**' button shall be disabled, while the '**AUTO**' selection and the '**STOP**' buttons shall be enabled.

The change of control selection from '**MANUAL**' to '**AUTO**' shall not change the last state of the pump. For example, if the pump has been started in '**MANUAL**' mode, the pump shall continue to run even when the pump control changes to '**AUTO**' mode.

The change of control selection from '**AUTO**' to '**MANUAL**' shall also not change the last state of the pump. For example, if the pump is in running status, the pump shall continue to run even when the pump control changes to '**MANUAL**' mode.

The above controls, however, only applicable when the 'Pump on Duty' selection has been selected in '**Cyclic**' mode. The controls for the other 'Pump on Duty' selections are subjected to the selection mode.

The pump selected to '**MANUAL**' mode shall be bypassed from the auto logic sequence.

The summary of the local HMI pump control selections is as below: -

	Master SCADA	Pump Status	Selection on Local HMI				
			Pump Control Mode	Auto Selection	Manual Selection	Start Button	Stop Button
1	Remote Auto	Stop	Auto	**Disable**	**Enable**	**Disable**	**Disable**
2			Manual	**Enable**	**Disable**	**Enable**	**Disable**
3		Run	Auto	**Disable**	**Enable**	**Disable**	**Disable**
4			Manual	**Enable**	**Disable**	**Disable**	**Enable**
5	Remote Manual	Stop	Auto	**Disable**	**Disable**	**Disable**	**Disable**
6		Run		**Disable**	**Disable**	**Disable**	**Disable**

In a pump station with the 'Duty/Assist' control operation, if a duty pump has been started by the PLC in 'AUTO' mode, manually starting the assist pump in manual mode shall not stopped the running duty pump.

In a pump station with the 'Duty/Standby' control operation, if a duty pump has been started by the PLC in 'AUTO' mode, manually starting the assist pump in manual mode shall stopped the running duty pump.

iv. Master SCADA Control

The Master SCADA shall be able to control the operation of each pump and setting of the control set-points remotely. The Master SCADA '**IN ACTIVE**' mode shall be indicated by a BLUE colored LED with '**Master SCADA Active**' marker plate on the PLC panel and by text indication on the local HMI.

Pump controls

The Master SCADA shall be able to remotely control each individual pump by '**REMOTE AUTO**' and '**REMOTE MANUAL**' modes.

Remote Auto

In '**REMOTE AUTO**' mode, the PLC shall have full control of the pumps according to the station's operational condition.

In this mode, the pumps shall be able to be controlled from the local HMI.

The change of the pump's control from '**REMOTE AUTO**' to '**REMOTE MANUAL**' mode shall not change the last state of the pump. For example, if the pump has been started in '**REMOTE AUTO**' mode, the pump shall continue to run even when the control changes to '**REMOTE MANUAL**' mode.

Remote Manual

In '**REMOTE MANUAL**' mode, each pump can be controlled remotely from the Master SCADA. However, this control mode can only be selected when both the MCC and HMI controls are selected in '**AUTO**' modes. The start and stop control functions are similar to the HMI's manual control operations.

When selected to '**REMOTE MANUAL**' mode, all the '**AUTO/MANUAL**' and '**START**' and '**STOP**' control buttons in the pump's pop-up on the HMI shall be disabled.

The pump selected in '**REMOTE MANUAL**' mode shall be bypassed from PLC logic sequence.

The change of the pump's control from '**REMOTE MANUAL**' to '**REMOTE AUTO**' mode shall not change the last state of the pump. For example, if the pump has been started in '**REMOTE MANUAL**' mode, the pump shall continue to run even when the control changes to '**REMOTE AUTO**' mode.

Shutdowns & Restart controls

The Master SCADA shall be able to initiate the below shutdown controls: -

a) Immediate Shutdown
b) Gradual Shutdown
c) 2nd Duty Inhibit
d) Complete restart

a) Immediate Shutdown

On initiation of an immediate shutdown command from the Master SCADA, all operating pumps shall be stopped immediately regardless of the wet well level status. The command from the Master SCADA is written into the station RTU which in turn writes to the station PLC. The local PLC shall energize the bi-stable relays which locks-out and inhibits all pumps from operating even from the MCC local control. The immediate shutdown control shall be indicated by a '**GIR INHIBIT**' LED indicator (AMBER) on the PLC panel and a "**SHUTDOWN**" display on the local HMI.

The Immediate shutdown shall not be initiated from the local HMI.

The shutdown indicators on the local HMI and on the PLC panel shall be as below: -

	Mode	Text Indicator on HMI Screen	LED Indicator on PLC Panel		
			GIR	LFR	2nd Duty
1	Immediate	'Shutdown'	ON	ON	ON
2	Gradual	'Gradual' -> 'Shutdown'	OFF -> ON	OFF -> ON	OFF -> ON
3	2nd Duty Inhibit	'2nd Duty Inhibit'	OFF	ON	ON
4	Complete Restart	-	OFF	OFF	OFF

b) Gradual Shutdown

There are two (2) conditions in this shutdown mode: -

No pump running

If no pump is running and the water level is above the 1st duty stop level, upon receiving of the gradual shutdown command from the Master SCADA, the HMI will display a "**GRADUAL**" notification display on the HMI screen while the PLC will immediately initiate a start command on the 1st duty pump. Upon reaching to the 1st duty stop level, the PLC will initiate a stop command on the running pump and energizes the "GIR Inhibit" bi-stable relay. Through one of the GIR relay's contact, all pumps will be lock-out and inhibited from operation, even from the MCC local control. The immediate shutdown control shall be indicated by a '**GIR INHIBIT**' LED indicator (AMBER) on the PLC panel

through one of the GIR bi-stable relay's contact. A "**SHUTDOWN**" display indicator will be displayed on the local HMI.

Any pump running

On initiation of the gradual shutdown command from the Master SCADA, the HMI will display a "**GRADUAL**" notification display on the HMI screen while the running pump(s) shall continue to run until the 1st duty stop level. The PLC will initiate stop commands on the running pump (s) and energizes the GIR latch bi-stable relays which locks-out and inhibits all pumps from operating even from the MCC local control. The immediate shutdown control shall be indicated by a '**GIR INHIBIT**' LED indicator (AMBER) on the PLC panel and a "**SHUTDOWN**" display on the local HMI.

The Gradual shutdown shall not be initiated from the local HMI.

c) 2nd Duty Inhibit

In this command mode, the PLC will only enable one (1) duty pump to run regardless of the water level status. The 2nd Duty Inhibit shall be indicated by a '**2nd DUTY INHIBIT**' LED indicator (AMBER) on the PLC panel and a "**2nd Duty Inhibit**" display on the local HMI.

The 2nd Duty Inhibit shall not be initiated from the local HMI.

d) Complete Restart

The Global and the duty inhibits shall be reset from the Master SCADA. In the event of communication failure between the Master SCADA and the station, the Global and duty inhibits can also be reset from a "**RESET**" pushbutton installed inside the PLC panel. Upon receiving the complete restart command from the Master SCADA or from the reset pushbutton, the PLC will reset all inhibits and normalizes the pumps' operations. The complete restart shall not be initiated from the local HMI.

v. Set-Point Control

Each duty pump shall has dedicated start and stop level set-points. For a Duty and Assist station operation, the set-point shall be as the following sequence: -

a) Duty Start
b) Assist Start

c) Assist Stop

d) Duty Stop

The control sequence is as describe in the Level Transmitter Healthy narration below.

Master SCADA in Active mode

In Master SCADA in Active mode, the set-points can only be changed from the Master SCADA. The set-points will be written from the Master SCADA to the PLC through the RTU and will be displayed on the HMI. All the set-points adjustment options in the HMI shall be disabled.

Master SCADA in Not Active mode

In this mode, the set-points will be adjusted from the local HMI. The Master SCADA will read the set-points set in the HMI from the PLC through the RTU.

vi. Level Transmitter & Float Switches Controls

The pumps shall operate based on the level transmitter's signal (Primary & Secondary) and shall be backed-up by the level float switches.

For station with a single level transmitter, a 2-way selector switch will be provided on the PLC Panel with the following selections: -

Selection	Description
Auto	In this selection mode, the PLC will select the level transmitter's signal as the primary reference. In the event of the level transmitter failure, the PLC will automatically switch the reference to the float switches.
Float Switch	In this selection mode, the PLC will bypass the level transmitter and select the level float switches as the primary reference.

For station with Radar and Hydrostatic level transmitters, a 4-way selector switch will be provided on the PLC panel with the following selection modes: -

Selection	Description
Auto	In this selection mode, the PLC will select the Radar level transmitter as the Primary reference while the Hydrostatic as the Secondary. In the event of the Radar failure, the PLC will automatically select the

	Hydrostatic transmitter as the reference. In the event of Hydrostatic failure, the PLC will switch the level reference to the float switches.
LT1 Radar	In this selection mode, the PLC will select the Radar transmitter as the main reference while the Hydrostatic is bypassed. In the event of Radar failure, the PLC will switch the level reference to the float switches.
LT2 Hydrostatic	In this selection mode, the PLC will select the Hydrostatic transmitter as the main reference while the Radar is bypassed. In the event of Hydrostatic failure, the PLC will switch the level reference to the float switches.
Float Switch	In this selection mode, the PLC will bypass the level transmitters and select the level float switches as the primary reference.

Level Transmitter Healthy

When the level transmitter is healthy, the PLC will refer to the analog signals receive from the transmitters to control the operation of the pumps as per the control level set-points. The selection on the 'Pump-on-Duty' is narrated in the Pump Changeover Operation below.

Subjected to the site condition, the set-point control of a typical 3 pumps Duty/Assist/Standby operation shall be configured as the below control sequence:

Set-Point	Pump Operation
Duty Start	Pump with the **longest idling period** (in seconds) in the operation cycle.
Assist Start	Pump with the **least idling period** (in seconds) in the operation cycle.
Assist Stop	Pump with the **longest running period** (in seconds) in the operation cycle.
Duty Stop	Pump with the **least running period** (in seconds) in the operation cycle.

Level Transmitter Faulty

When the level transmitter is faulty, the PLC will refer to the digital input signals receive from the float switches to control the operation of the pumps as the below operations: -

Float Level	Pump Operation
HH	High Alarm
HI	Pump with the **longest idling period** in the operation cycle followed by the pump with the **least idling period** after a pre-determined timer delay.

LO	Pump with the **longest running period** in the operation cycle followed by the pump with the **least running period** after a pre-determined timer delay.
LL	Dry run protection

The selection on the 'Pump-on-Duty' is narrated in the 'Pump Changeover Operation' below.

The dry run protection level (LL) shall trip all running pumps. The dry run protection shall automatically reset when the water level has normalized to allow restart of the pump's auto-operation.

vii. Pump Tripping

The MCC shall be equipped with hardwired circuit mechanism for tripping the pumps during the following conditions: -

1. No flow Alarm
2. Vibration High Alarm
3. Bearing Temperature Hi Alarm
4. Winding Temperature Hi Alarm

viii. Pump Available To Run

In PLC, the pump "available" logic has to be built as the following:-

1. Pump in Auto Mode
2. Pump ACB is ON
3. Pump healthy
4. Pump Not Tripped/Fault
5. Emergency PB not pressed
6. No Low-Low Level alarm
7. No Low Level alarm
8. Suction/Discharge Valve Open
9. No Shutdown command given

The same above interlocks shall be displayed & available for the operator in local SCADA/HMI.

ix. Pump Changeover operation

'Cyclic' Operation Selection Mode

In the Auto 'Cyclic' sequence mode, the pump on duty 'start' selection will be based on the idling period of the pump in a 'duty cyclic operation', while the pump 'stop' selection will be based on the running period of the pump in a 'duty cyclic operation'.

- 1st Duty Control Level Pump Operation

In this operation control level, the PLC will select the pump having the longest idling period among the available pumps. The PLC will control the duty pump start and stop operation according to the level set-point.

The 'Next Pump-to-Start' selected by the PLC will be displayed on the pump's graphics on the local HMI.

In the next operation cycle, the PLC will select the next available pump with the longest idling period among the available pumps.

The same duty pump selection process will be repeated in the subsequent operation cycle.

If the duty pump tripped, the PLC will immediately start the next available pump having the longest idling period among the available idling pumps.

If the duty pump has reached to its run-hour changeover limit, the PLC will start, after a pre-determine timer delay, the next available pump with the longest idling period.

- 2nd Duty or Assist Control Level Pump Operation

In this operation control level, the PLC will select the duty pumps in the similar process as described above with the following selection sequence: -

Pump	Start	Stop
1st Duty	Pump with the **longest idling period** in the operation cycle.	Pump with the **least running period** in the operation cycle.
2nd Duty	Pump with the **least idling period** in the operation cycle.	Pump with the **longest running period** in the operation cycle.

The 'Next Pump-to-Start' selected by the PLC will be displayed on the pump's graphics on the local HMI.

If any of the duty pump tripped, the PLC will immediately start the next available pump having the longest idling period among the available idling pumps.

If any of the duty pump has reached to its run-hour changeover limit, the PLC will start, after a pre-determine timer delay, the next available pump with the longest idling period.

‘Pump on Duty’ Operation Selection Mode

In this selection mode, the operational sequence of the pumps shall be based on the selection of the pump.

For a 3-pump station configuration, the pump on duty selection shall be as follows:

Mode	1st Duty	2nd Duty	Standby
P1	Pump 1	Pump 2	Pump 3
P2	Pump 2	Pump 3	Pump 1
P3	Pump 3	Pump 1	Pump 2

In P1 mode, the PLC will select Pump 1 as the 1st duty pump, Pump 2 as the 2nd duty pump and Pump 3 as the standby pump. Regardless of the idling period of each pump, the PLC will initiate the pump start/stop command according to the sequence of the pumps as below: -

Pump	Start	Stop
1st Duty	Pump 1	Pump 1
2nd Duty	Pump 2	Pump 2

In the event that the 1st duty or 2nd duty pump tripped, the PLC will immediately start the standby pump (Pump 3) and it shall remain running, even when the tripped pump has been normalized, until the level reaches to the stop level.

Similar operation sequence applies for the P2 and P3 selection modes.

There is no run-hour changeover limit operation in this selection mode.

x. Master SCADA ‘RESET’

The following soft alarms and pump’s parameters can be reset from the Master SCADA: -

- Soft alarms
  - Pump ‘FAIL-to-START’ alarm

- Pump 'FAIL-to-STOP' alarm

- Pump's parameters
  - Running Hours (Accumulative, Today, Yesterday)
  - No. of Start count (Accumulative, Today, Yesterday)

The soft alarms can also be reset from a '**RESET**' pushbutton installed inside the PLC panel.

Hard alarms such as pump tripped, vibration alarms, valve fault, shall only be reset locally from the station.

7.1.2. Typical PS I/O Monitored & Controlled from DNMC SCADA

Item	I/O	Signals	Read (R)/ Write (W)
1.	Fire Alarm	▪ Fire alarm activated status ▪ Fire Alarm panel healthy status	▪ R ▪ R
2.	Room Temperature	▪ Room Temperature reading (°C)	▪ R
3.	Kahramaa Main Incomer Supply	▪ Main Incomer Supply Healthy/Fault status ▪ Incomer Phase Current – I1, I2, I3 ▪ Incomer Phase Voltage – Vab, Vbc, Vca ▪ Incomer Frequency ▪ Incomer Power Factor ▪ Incomer Power Consumption (kWh/MWh)	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
4.	MCC incoming supply	▪ MCC incoming supply Healthy/Fault status ▪ MCC breaker healthy/trip status	▪ R ▪ R
5.	UPS	▪ UPS on Battery status ▪ UPS on Bypass status ▪ UPS Battery Low status ▪ UPS Fault/Alarm status	▪ R ▪ R ▪ R ▪ R
6.	Auxillary/Main Generator	▪ Generator Run Status ▪ Generator Fault status ▪ Generator Bulk Tank Low status ▪ Generator Daily Tank Low status	▪ R ▪ R ▪ R ▪ R
7.	PLC	▪ PLC Healthy status (No internal/external faults) ▪ PLC External communication Healthy/Fault status ▪ PLC Panel Door(s) Open/close status	▪ R ▪ R ▪ R ▪ R ▪ R
8.	RTU	▪ RTU Modem Signal Strength ▪ RTU Signal Quality ▪ RTU Healthy (No Error) ▪ DNMC Communication Healthy/Fault status ▪ PLC Communication Healthy/Faulty status ▪ RTU Clock (seconds)	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
9.	RTU Panel	▪ RTU panel temperature HIGH status ▪ RTU panel humidity HIGH status ▪ RTU panel Remote/Local Control selection	▪ R ▪ R ▪ R

Item	I/O	Signals	Read (R)/ Write (W)
		▪ Reset Push Button status ▪ RTU panel temperature reading ▪ RTU Panel Door Open/Close Status ▪ DC Supply Healthy/Fault Status	▪ R ▪ R ▪ R ▪ R
10.	Deodorizer	▪ Deodorizer Run status ▪ Deodorizer Fault status ▪ Deodorizer Inlet H2S alarm status ▪ Deodorizer Outlet H2S alarm status ▪ Deodorizer Inlet H2S reading ▪ Deodorizer Outlet H2S reading	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
11.	Exhaust/Ventilation Fan	▪ Fan High Speed Run status ▪ Fan Low Speed Run status ▪ Fan Fault status	▪ R ▪ R ▪ R
12.	Screen	▪ Screen Run status ▪ Screen Fault status ▪ Upstream Level reading ▪ Upstream Level HI level switch ▪ Upstream Level LO level switch ▪ Downstream Level reading ▪ Downstream Level HI level switch ▪ Downstream Level LO level switch	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
13.	Level Transmitter	▪ Radar reading (LT1) ▪ Hydrostatic reading (LT2) ▪ Level Tx ‘On Duty’ selection status o Auto o LT1 o LT2 o FS ▪ Radar Transmitter Fault status ▪ Hydrostatic Transmitter Fault status	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
14.	Level Float Switches	▪ High High Alarm Status ▪ High Alarm Status (Duty Start*) ▪ Low Alarm Status (Duty Stop*) ▪ Low Low Alarm Status & reading (Dry protection) * Subjected to site condition	▪ R ▪ R ▪ R ▪ R
15.	Wet Well on Duty	▪ Wet well On Duty selection status o WW1 o WW2 o Common (W1+W2)	▪ R
16.	Pump on Duty	▪ Pump on Duty selection status* o Cyclic o P1 o P2 o P3 * Subjected to site condition	▪ R
17.	Master SCADA Control	▪ Master SCADA in Control Command ▪ Master SCADA in Control status ▪ Pump Control	▪ W ▪ R ▪ W

Item	I/O	Signals	Read (R)/ Write (W)
		○ Pump Remote Auto/Remote Manual Control select	▪ W ▪ W
		○ Pump Remote Start command	▪ W
		○ Pump Remote Stop command	▪ W
		○ Pump soft alarm Reset command	
		○ Pump parameters Reset command	▪ R/W
		▪ Set-Points	▪ R/W
		○ 1st Duty Pump Start set point	▪ R/W
		○ 2nd Duty Pump Start set point	▪ R/W
		○ 1st Duty Pump Stop set point	▪ R/W
		○ 2nd Duty Pump Stop set point	▪ R/W
		○ High High Level set-point	
		○ Suspect Overflow set-point	▪ R/W
		▪ Flow	▪ R/W
		○ Flow rate High Alarm set-point	
		○ Flow rate Low Alarm set-point	▪ R/W
		▪ Pressure	▪ R/W
		○ Pressure High Alarm set-point	
		○ Pressure Low Alarm set-point	▪ W
		▪ Shut Down	▪ W
		○ Immediate shutdown command	▪ W
		○ Gradual shutdown command	▪ W
		○ 2nd Duty Inhibit command	▪ R
		○ Complete restart command	▪ R
		○ Global Inhibit status	▪ R
		○ Level Float Inhibit status	
		○ 2nd Duty Inhibit status	
18.	Main Pump	▪ Pump MCC Auto Control selection status	▪ R
		▪ Pump Feeder Breaker Open/Close status	▪ R
		▪ Pump RUN status	▪ R
		▪ Pump FAULT status	▪ R
		▪ Pump Emergency Stop status	▪ R
		▪ Pump Fail-to-Start Status	▪ R
		▪ Pump Fail-to-Stop status	▪ R
		▪ Pump No Flow Trip status	▪ R
		▪ Pump Vibration Alarm status	▪ R
		▪ Pump Bearing Temperature High status	▪ R
		▪ Pump Winding Temperature High status	▪ R
		▪ Pump Vibration reading	▪ R
		▪ Pump Top Bearing Temperature reading	▪ R
		▪ Pump Bottom Bearing Temperature reading	▪ R
		▪ Pump R Winding Temperature reading	▪ R
		▪ Pump Y Winding Temperature reading	▪ R
		▪ Pump B Winding Temperature reading	▪ R
		▪ Pump Motor Current reading	▪ R
		▪ Pump Motor Voltage reading	▪ R
		▪ Pump Speed reading (rpm)	▪ R
		▪ Pump no. of Start Count – Accumulative	▪ R
		▪ Pump No. of Start Count – Today	▪ R
		▪ Pump No. of Start Count – Yesterday	▪ R

Item	I/O	Signals	Read (R)/ Write (W)
		▪ Pump Run Hours – Accumulative (in Hours) ▪ Pump Run Hours – Today (in minutes) ▪ Pump Run Hours – Yesterday (in minutes)	▪ R ▪ R ▪ R
19.	Dry Well	▪ Dry well Pump RUN status ▪ Dry well Pump FAULT status ▪ Dry well level High Status	▪ R ▪ R ▪ R
20.	Wet Well Transfer Pump	▪ Transfer Pump RUN status ▪ Transfer Pump FAULT status	▪ R ▪ R
21.	Penstock/MOV	▪ MOV Fully Opened status ▪ MOV Fully Closed status ▪ MOV Fault status ▪ MOV Fail-to-Open status ▪ MOV Fail-to-Close status ▪ MOV Position feedback (%)	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
22.	Non-Return Valve	▪ NRV Fully Opened Status ▪ NRV Fully Closed Status ▪ NRV Fault status	▪ R ▪ R ▪ R
23.	Flow (Primary connection via MODBUS)	▪ Flow rate instantaneous reading (in l/s) ▪ Flow totalizer – Today (in m^3) ▪ Flow totalizer – Yesterday (in m^3) ▪ Flow rate High Alarm ▪ Flow rate Low Alarm ▪ Flow transmitter Fault status	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
24.	Suction, Discharge, Line Pressure	▪ Pressure instantaneous reading (in bar) ▪ Pressure High Alarm ▪ Pressure High Trip ▪ Pressure Low Alarm ▪ Pressure transmitter Fault status	▪ R ▪ R ▪ R ▪ R ▪ R
25.	Main Inlet	▪ Main Inlet Level High status	▪ R
26.	Local SCADA/HMI	▪ Local SCADA/HMI Pump Auto/Manual Control select status	▪ R

7.1.3. Recommendation for Flow Meter Monitoring

i. Primary protocol of communication between FM to RTU/PLC shall be Modbus.

ii. 4-20mA shall be terminated and provisioned for future to be used in the RTU/PLC panel.

iii. Signals like Instantaneous flow, total flow, shall be configured in the RTU/PLC.

iv. In SCADA shall be shown in Yesterday Cumulative flow reading.

v. Instantaneous flow shall be in LPS and Total Flow shall be in Cubic Meter; if any changes required as per the process requirement; it shall be discuss and change prior approved by PWA Engineer.

vi. Reverse Flow shall be programmable in the transmitter.

7.2. TWN Chambers

The TWN chambers consists of Flow Meter Chamber, Valve Chamber or Flow & Valve Chamber. All the chambers parameters shall be monitored and controlled locally from the RTU panels as well as remotely from Ashghal DNMC SCADA station through the local RTU panel.

7.2.1. RTU Panel

i. Supply, install, test and commission complete factory assembled RTU panel at each TWN chamber. RTU is the key element required to collect data from the chamber and to control valve operation locally from the RTU panels as well as remotely Ashghal DNMC SCADA.

ii. RTU shall be mounted with other equipment within an outdoor installed GRP enclosure.

iii. RTU panel shall include the following as a minimum:

a. GRP enclosure shall comply with the requirement of QCS 20014 sections 21.

b. RTU for the chambers shall be mounted in an IP 65 Box, well protected from dust and rain.

c. RTU Panel shall be of two-layered door (outer and inner), with look-in window on the outer door. The RTU panel shall have minimum external dimension of 1000Wx500Dx1200H mm size. A typical TWN RTU panel is a depicted in figure below: -

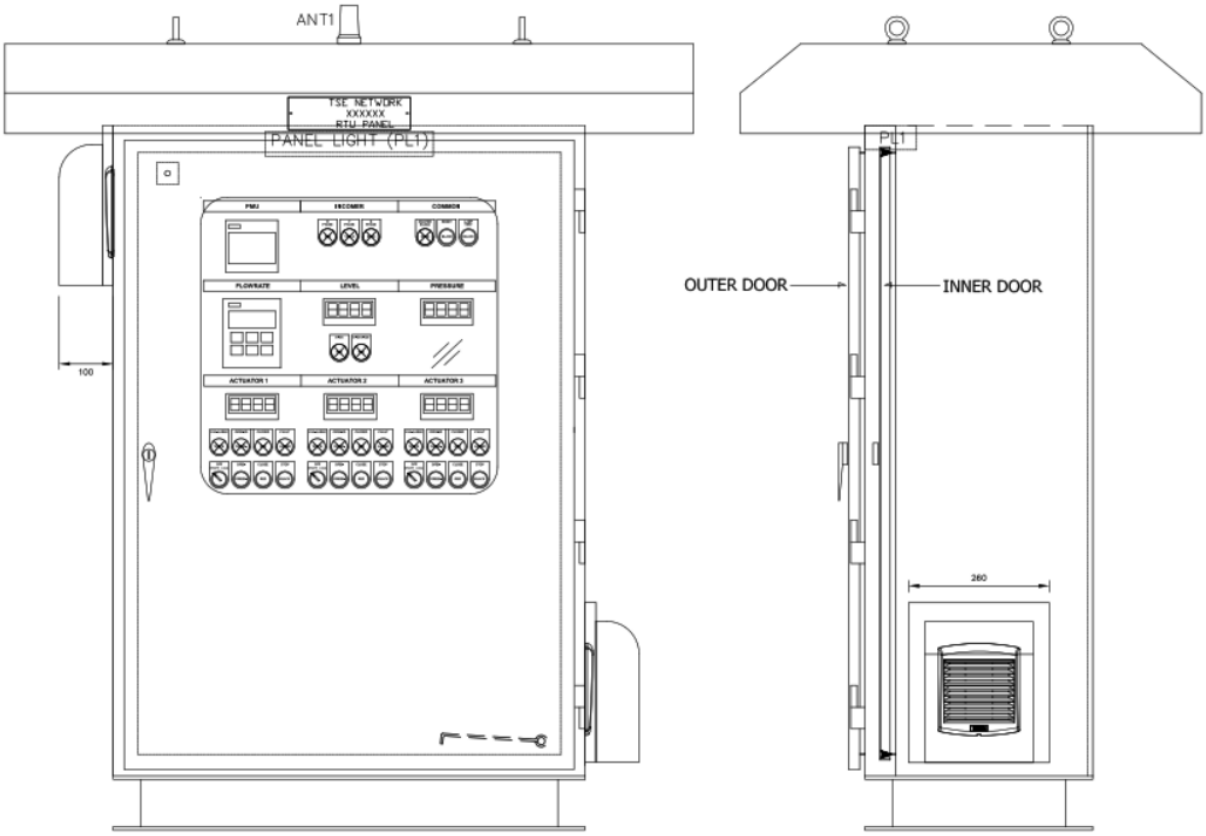


Figure 3 - Typical TWN Chamber's RTU Panel

d. A 'SCADA Bypass' local 'Cluster Control' with incomer supply status and power metering unit, digital display panels for the flowrate and penstock's position feedback, LED indicators, selector switches and pushbuttons for the local monitor and control of the field instrument from the RTU panel to be mounted on the inner door.

e. All components mounted shall be in a manner that shall permit servicing, adjusting, testing and removal without disconnecting, moving or removing of any other component. Components mounted shall be mounted on a mounting plate and not directly.

f. Any Pressure Transmitter installation and any MOV's Position feedback shall have Local indicator for Local Measurement and operational requirement.

g. All the panels shall be supplied with nameplates which identify the panel. The nameplate shall be stainless steel. Each component inside the panel shall also have nameplates.

h. All panels shall be provided with anti-condensation heater controlled by a humidistat and an overriding ON/ OFF switch.

i. All panels shall be provided with ventilation louvers with dust protection to prevent temperature build-up inside of the panel.

j. Power and signal cables shall be routed in separate wire ways. Different wiring systems shall be terminated on separate terminal blocks.

k. Discrete inputs and outputs (DI & DO) shall have 2 terminals per points.

l. Analogue inputs /outputs shall have 3 terminals per shielded pair connection with adjacent terminal assignments for each point. The third terminal is for shielded ground connection for cable pairs. Ground the shielded signal cable at the RTU. All active and spare RTU points shall be wired to terminal blocks. All discrete outputs to the field shall be isolated within the isolating fuse switch terminal block with a flip cover and neon blown fuse indicator.

m. All wiring shall be clearly tagged and color coded.

n. Each panel shall have a single tube, fluorescent light fixture, mounted internally to the ceiling of the panel.

o. The panel shall be provided with an isolated copper grounding bus for all signal and shield ground connections. Shield grounding shall be in accordance with the instrumentation manufacturers' recommendations. Each panel shall be provided with a separate copper power grounding bus.

p. All panels shall be provided with aesthetic canopy to protect from direct sun.

q. Complete all cabling works including excavations, laying cables, cable termination and associated works required for the RTU connection.

r. No additional cost shall be claimed for power supply connections associated works.

7.2.2. Typical TW I/O Monitored & Controlled from DNMC SCADA.

Item	I/O	Signals	Read (R)/ Write (W)
1.	Kahramaa Main Incomer Supply	▪ Main Incomer Supply Healthy/Fault status ▪ Incomer Phase Current – I1, I2, I3 ▪ Incomer Phase Voltage – Vab, Vbc, Vca ▪ Incomer Frequency ▪ Incomer Power Factor ▪ Incomer Power Consumption (kWh/MWh)	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
2.	Solar System	▪ Solar Controller status ▪ Charging Voltage ▪ Battery Voltage	▪ R ▪ R ▪ R

Item	I/O	Signals	Read (R)/ Write (W)
		▪ Battery Temperature ▪ Power Inverter Healthy status ▪ Battery Voltage Low status ▪ Battery Autonomy (In minutes) ▪ Battery Capacity (AH)	▪ R ▪ R ▪ R ▪ R ▪ R
3.	MCC incoming supply	▪ MCC incoming supply Healthy/Fault status ▪ MCC breaker healthy/trip status	▪ R ▪ R
4.	UPS	▪ UPS on Battery status ▪ UPS on Bypass status ▪ UPS Battery Low status ▪ UPS Fault/Alarm status	▪ R ▪ R ▪ R ▪ R
5.	Auxillary/Main Generator	▪ Generator Run Status ▪ Generator Fault status ▪ Generator Bulk Tank Low status ▪ Generator Daily Tank Low status	▪ R ▪ R ▪ R ▪ R
6.	RTU	▪ RTU Modem Signal Strength ▪ RTU Signal Quality ▪ RTU Healthy (No Error) ▪ DNMC Communication Healthy/Fault status ▪ RTU Clock (seconds)	▪ R ▪ R ▪ R ▪ R ▪ R
7.	RTU Panel	▪ RTU panel temperature HIGH status ▪ RTU panel humidity HIGH status ▪ RTU panel Remote/Local Control selection ▪ Reset Push Button status ▪ RTU panel temperature reading ▪ Panel Door Open/Close Status ▪ DC Supply Healthy/Fault Status	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
8.	Chamber Level Transmitter	▪ Level reading ▪ Level Transmitter Fault	▪ R ▪ R
9.	Chamber Level Float Switches	▪ High High Alarm Status ▪ High Alarm Status	▪ R ▪ R
10.	Master SCADA Control	▪ Master SCADA in Control Command ▪ Master SCADA in Control status ▪ Flow o Flow rate High Alarm set-point o Flow rate Low Alarm set-point ▪ Pressure o Pressure High Alarm set-point o Pressure Low Alarm set-point	▪ W ▪ R ▪ W ▪ W ▪ W ▪ W
11.	Penstock/MOV	▪ MOV Power Isolation Feedback ▪ MOV Remote/Local Control selection ▪ MOV Auto/Manual status ▪ MOV Fully Opened status ▪ MOV Fully Closed status ▪ MOV Fault status ▪ MOV Fail-to-Open status ▪ MOV Fail-to-Close status ▪ MOV Position feedback (%) ▪ MOV Remote Open Command ▪ MOV Remote Close Command	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ W ▪ W

Item	I/O	Signals	Read (R)/ Write (W)
		▪ MOV Remote Stop Command	▪ W
12.	Flow (Primary connection via MODBUS)	▪ Flow rate instantaneous reading (in l/s) ▪ Flow totalizer – Accumulative (in m^3) ▪ Flow totalizer – Today (in m^3) ▪ Flow totalizer – Yesterday (in m^3) ▪ Flow rate High Alarm ▪ Flow rate Low Alarm ▪ Flow transmitter Fault status	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
13.	Pressure	▪ Pressure instantaneous reading (in bar) ▪ Pressure High Alarm ▪ Pressure Low Alarm ▪ Pressure transmitter Fault status	▪ R ▪ R ▪ R ▪ R

7.2.3. Flow Meter

i. Working Principal shall be Electromagnetic Type with PN 16 Flange process connections

ii. Accuracy shall be more than 0.5%; repeatability shall not be more than 0.2%.

iii. Shall be tested and calibrated by the manufacturer or enlisted approved companies for calibration.

iv. Electrodes shall be Hastelloy C22 material.

v. Earthlings rings, flanges and tube shall be of stainless steel 304 BS 970

vi. The sensor operating voltage shall be between 10-40 VDC (based on the size of the pipe) The flow meter shall powered up with 230VAC any changes subjected to Ashghal Engineer Approval.

vii. Sensor IP rating shall be IP68 rated casing unaffected by meter position or in-line piping stresses.

viii. Measurement in both directions.

ix. Flowmeter selection shall be based on Wastewater and Treated Sewage Effluent conductivity parameter.

x. Primary head linear material shall be in Teflon material as per QCS 2014 Section 10.

xi. Flow meter Manufacturer shall confirm the Flow Meter Detector Head (Primary Head) sensor Internal Part immersion exposure aggressive substances in soil and ground water as follows:-

   i. Chloride Content 30,000 mg/l

   ii. Sulphate content 5,000 mg/l

iii. Ground water Temperature 25 Deg Cen to 35 Deg Cen

iv. Ground Water pH 7.0- 8.0

xii. Ambient temperature as per Middle East requirements. (Not less than 70 degree centigrade considering the enclosure/ locations like chambers)

xiii. Lining has to be as per corrosive nature of the sewage water / Treated water. The lining has to be considering the liquid temperature of 140 degree centigrade.

xiv. With unrestricted flow tube for minimal pressure loss.

xv. Transmitter. Transmitter shall be installed inside the RTU panel. Transmitter power supply shall be 24 V DC with battery pack and solar panel supported for specific requirement upon Ashghal Engineer Approval.

xvi. If transmitter is installed outside RTU separate GRP panel with fan and louver shall be provided.

xvii. Flow direction: Flow meter can self-check forward / reverse flow and the flow arrow on sensor indicates forward flow direction. Option to select either of the flow direction shall be available in the transmitter.

xviii. Transmitter shall be microprocessor based with programmable range and engineering units.

xix. Outputs shall be isolated 4-20 mA and pulse with adjustable span. Programmable in-built alarm relays shall be provided for empty pipe, low and reverse flows. Transmitter shall have an inbuilt digital display for flow rate, total and alarms. Transmitter enclosure shall be protected to IP65. Calibration and programming kit shall be provided.

xx. The flowmeter shall support serial communication module: -
   a) RS 232
   b) RS 485

xxi. Primary protocol of communication between FM to RTU shall be Modbus.

xxii. 4-20mA shall be terminated and provisioned for future to be used in the RTU panel.

xxiii. Signals like Instantaneous flow, total flow, shall be configured in the RTU.

xxiv. Current flow shall configure in l/sec and totalizer in m3 at transmitter as well as in RTU.

xxv. Reverse Flow shall be programmable in the transmitter.

xxvi. In situations where control valves are installed on the pipeline, the flow meter shall be installed at the upstream for accurate readings.

xxvii. The Electromagnetic flow meter shall install always primary head (Flow Tube) filled with process media even low flow rate in such a manner, it shall be install to get the accurate flow reading.

xxviii. The Primary head to the remote mounted Flow transmitter screened & armored cable shall be supplied, cable shall be terminated and IP68 shall be done (by using potting compound) into the primary head by the OEM at factory itself.

xxix. The flow meter shall have Inbuilt calibration verification software provision enabled to verify the calibration verification at site whenever required by O&M team without OEM present or any assistance requirement.

xxx. Upstream Pipe measurement shall be at least 5D (D = Diameter of the pipe)

xxxi. Downstream measurement shall be at least 2D.

xxxii. Pipe should be fixed on the installation foundation. For underground installation, supports are required at the two ends of the pipeline.

xxxiii. Grounding Ring for the flow meter shall be installed.

xxxiv. FM on Metal Pipe: Copper wire with minimum $4mm^2$ shall be used.

xxxv. FM on GRP: Grounding rings, cables shall be used in compliance with QCS requirements.

xxxvi. Casing and nameplates shall be as per mentioned in the QCS 2014.

xxxvii. Installation shall adhere to OEM guideline. During Material approval submissions and inspections, it is necessary to produce all the installation guidelines by OEM to the Engineer

xxxviii. Specifications for other Primary Elements, their design, manufacture, installation, and commissioning, which are not mentioned above, shall be as per QCS 2014 , section 10, Part 3, clause 3.2.1, pg. 3. In addition to, other related clauses.

7.2.4. Pressure Transmitter

i. Isolation valves shall be fixed (1/2" BSP pressure tight seal should be made using a sealing washer) over the threaded tapped pipe-flanged spool. Vent drain plug on the meter body. 3 valve manifold shall be provided for easy removing of the transmitter during maintenance to avoid disturbance in the piping connections

ii. Accuracy shall be +/- 0.25 %.

iii. Shall be tested and calibrated by the manufacturer or Ashghal enlisted approved companies for calibration.
iv. Fault / out of range signal shall be configurable.
v. Voltage supply shall be 24VDC and can be optioned by solar power to monitor the pressure in case of power failure in the vicinity.
vi. Transducer range selected shall be as close to operating range
vii. Indicator / Transmitter shall be installed inside the RTU Panel.
viii. The installation needs to have tapping wherein the pressure gauge shall be installed (In case the Pressure Transmitter fails or the pressure reading need to be cross checked and verified).
ix. Shall give 4-20 mA / Modbus protocol for connecting to the RTU. Primary connection shall be thru Modbus protocol and 4-20mA provision shall be provided inside the RTU panel for future use.
x. Casing and nameplates shall be as per mentioned in the QCS 2014.
xi. Provide Block & Bleed Manifold Type of isolation valve
xii. The High-pressure alarm shall be configured inside the RTU/PLC as per the readings specified by Ashghal O&M.
xiii. Vibration can affect the dial reading of pressure gauge, these areas should be avoided as much as possible.
xiv. Calibration certificate needs to be submitted for Engineers review during inspection and calibration sticker shall provide on the pressure transmitter.
xv. Provide Drain valve
xvi. Specifications for other Primary Elements shall be as per QCS 2014 Section 10.

7.2.5. Pressure Gauge

i. Shall be of accuracy level +/-1%, with ½ inch NPT.
ii. The gauge range shall be of 25 percent more than the maximum pressure pipe withstanding operating range.
iii. Dialer shall be with White background and black markings, with Bourdon Tube sensor 270-degree dialer.
iv. Specifications for other Primary Elements shall be as per QCS 2014 Section 10.
v. Vibration can affect the dial reading of pressure gauge, these areas should be avoided as much as possible.

vi. For corrosive fluids, stainless steel should be specified.

vii. Calibration certificate needs to be submitted for Engineers review during inspection and calibration sticker shall provide on the pressure gauge.

viii. Pressure Gauge shall be installed with 3 way Manifold valve.

ix. Dial size for gauges shall be a minimum of 4 inch.

x. Casing and nameplates shall be as per QCS 2014

xi. Provide Drain valve

7.2.6. Level Switches

i. Working principal shall be conductive property type since its expected rainwater or other impure water. This type of level sensing switches is to send the alarm to SCADA as well to isolate the power supply to the chamber, hence providing safety.

ii. Level Limit switch with multiple point detection (min 3 conductive rod points).

iii. For Hi Level –Send Alarm to SCADA thru RTU for water Hi level in the chamber.

iv. For Hi-Hi Level –Send Alarm to SCADA thru RTU. The level switch shall isolate any kind of power supply to the chamber (415 VAC /240/VAC/24VDC)

v. Level probe shall install at lowest area of chamber and have easy access for maintenance.

vi. High alarm level shall set at bottom of the pipe and High High alarm level at middle of the pipe.

vii. Level probe fixing clamp shall stainless steel.

viii. Casing and nameplates shall be as per mentioned in the QCS 2014.

ix. Sensor Input power source: 110VAC, @ 50 Hz.

x. Probes shall not use more 10 -11V and current not more than 1mAmp. The electrode design has to be verified and tested for high sensitivity to rainwater.

xi. The probes shall be rod type, 316 stainless steel to BS970; holder shall be cadmium-plated cast iron. The holder mount shall be conduit type.

xii. The unit shall be IP68 rated and housed inside the chamber in a IP68 rated enclosure.

xiii. Specifications for other Primary Elements shall be as per QCS 2014, section 10.

7.2.7. Position/Limit Switches shall be provided to sense the limiting positions of equipment, such as valves. The switches shall be non-contact reed type, magnetically coupled to the actuating device. SPST contacts shall be rated 110 V a.c. 3A. Reed switch shall have a life expectancy of one million operations.

7.2.8. Motorized valve

i. The following signals needs to be configured in the RTU: -
   a) MOV Fault
   b) MOV Fully Opened
   c) MOV Fully Closed
   d) MOV Position Percentage
   e) MOV transition time
   f) MOV Auto/Manual Select
   g) MOV Fail-to-Opened
   h) MOV Fail-to-Closed

ii. Provide the chamber with enough space to accommodate MOV for normal operations as well as be accessible for maintenance.

iii. Install the valve in appropriate orientation.

iv. Provide piping with ample support and to be aligned with valve.

v. The full open and full close positions to be set with limit switching and should be match with mechanical position indicator. The actuator has to be calibrated as per Ashghal s requirement. The calibration certificate needs to be submitted for Engineers review during inspection.

vi. Double sealed intermediate frame shall use between the plug socket connector and housing of device. [Water proofing].

vii. Open (green), close (red) and fault (amber) feedback LEDs, local/off/remote selector switch, open (green)/stop (black)/ close(red) pushbutton shall provide for each MOV on the control panel. Fault reset pushbutton shall be provided as well. The nameplates shall be aligned under each MOV. No common control accept “Lamp Test and “shall be provided.

viii. Cable glands shall be of brass.

ix. Cable size and lugs: depending on the size of the MOV rating PE cable shall not be less than 2.0 mm2 and ring lugs. Control contacts shall also be as per the OEM recommendation

x. Two Spare cable pair shall provide to the MOV for control signal.

xi. If the MOV's installed in the Valve Chamber the MOV Control Circuit shall be extended and it should installed above the Chamber and Comply with OEM Standard Installation Procedure.

7.2.9. Submit the solar panel specification and battery calculation based on the below mentioned load for a minimum of 3 days of backup:

i. RTU component
ii. Flow Meter sensor & Transmitter
iii. Pressure Transmitter
iv. Level Switches
v. Local Cluster Control LED Indicators, digital displays.

7.2.10. There shall be 20% space available for future SCADA upgradation works.

7.2.11. All design, construction and materials should comply with QCS 2014 and ASHGHAL standards. All TSE connection proposals and materials shall be approved by ASHGHAL prior to construction at site.

7.2.12. Uninterruptible Power Supply/Battery Backup

i. Panels shall be provided with a UPS to provide power to the RTU and PLC support, interface and communication equipment for minimum of 8hrs upon failure of local power and to provide non-interruptible power supply.

ii. A UPS is not required for local backup control panel. UPS shall provide full time EMI/RFI filtering and clamping response time shall be less than five nanoseconds.

iii. Provide visual UPS "on" and "fault", "Bypass "indicators. Provide audible "on battery", "low battery" and "overload" indicators. Signals shall be configured in RTU to be mapped to SCADA.

iv. Provide internal "on-battery" current limiting and "on-line" circuit breaker for UPS overload protection.

7.2.13. Civil Works:

i. Foundation and general arrangement details of RTU panel, flow meter and pressure transmitter shall be as per Ashghal Standard drawing SD 8-4-417.

ii. O/G type weatherproof TSE RTU/Control panel over 300mm concrete plinth consisting of the power and control units. The concrete plinth shall be projecting 150mm on all side from the external face of the TSE Control / RTU/Control panel. The RTU/Control panel plinth should be surrounded by 300mm the gravel fill all around. The overall pit excavation for the plinth and gravel fill should be projecting 1m from the external face of the TSE Control / RTU/Control panel. The TSE panel should be of double wall construction with thermal insulation in-between.

iii. Three separate PVC conduit for the power & signals cables shall be laid. Each of the conduct shall not be less than 25 mm dia.

iv. All stakeholder approvals and permits shall be obtained before commencement of the works at site.

7.3. SGW/FSW Network Penstock

7.3.1. The actuated valves/penstock shall be monitored and controlled locally from the RTU panel as well as remotely from ASHGHAL DNMC SCADA system.

7.3.2. Real-time monitoring of the water level at the upstream & downstream chamber.

7.3.3. The water level shall be monitored locally from the field via the RTU panel. A local digital display indicator shall be mounted on the RTU panel.

7.3.4. The water level High and High High by float level switches shall be monitored by LED indicators locally on the RTU panel.

7.3.5. The water level reading and float switches status shall be monitored remotely at the ASHGHAL DNMC SCADA system via the RTU.

7.3.6. The level sensor shall be either Radar or Hydrostatic subjected to Ashghal Engineer approval and powered by a permanent power supply source with the following requirement:

a) Supply Voltage: 10-36 VDC
b) Output Signal: 4-20mA, Modbus Serial

7.3.7. The actuated penstock shall be able to be monitored & controlled locally from the RTU panel: -

i. Indication Lamps to show the status of the actuated penstock
   a) Fully Opened – Green
   b) Fully Closed – Red
   c) Fault – Amber

d) DNMC in Control Active – Blue

e) Auto/Manual Selection - White

ii. RTU panel Remote/Local Control Selection

iii. Open pushbutton – Green

iv. Close pushbutton – Red

v. Stop pushbutton - Black

vi. Digital display panel to show the Penstock position feedback (%)

vii. All control shall be housed securely with key.

7.3.8. Typical Network Penstock I/O Monitored & Controlled from DNMC SCADA

Item	I/O	Signals	Read (R)/ Write (W)
1.	Kahramaa Main Incomer Supply	▪ Main Incomer Supply Healthy/Fault status ▪ Incomer Phase Current – I1, I2, I3 ▪ Incomer Phase Voltage – Vab, Vbc, Vca ▪ Incomer Frequency ▪ Incomer Power Factor ▪ Incomer Power Consumption (kWh/MWh)	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
2.	Solar System	▪ Solar Controller status ▪ Charging Voltage ▪ Battery Voltage ▪ Battery Temperature ▪ Power Inverter Healthy status ▪ Battery Voltage Low status ▪ Battery Autonomy (In minutes) ▪ Battery Capacity (AH)	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
3.	MCC incoming supply	▪ MCC incoming supply Healthy/Fault status ▪ MCC breaker healthy/trip status	▪ R ▪ R
4.	Auxillary/Main Generator	▪ Generator Run Status ▪ Generator Fault status ▪ Generator Bulk Tank Low status ▪ Generator Daily Tank Low status	▪ R ▪ R ▪ R ▪ R
5.	UPS	▪ UPS on Battery status ▪ UPS on Bypass status ▪ UPS Battery Low status ▪ UPS Fault/Alarm status	▪ R ▪ R ▪ R ▪ R
6.	RTU	▪ RTU Modem Signal Strength ▪ RTU Signal Quality ▪ RTU Healthy (No Error) ▪ DNMC Communication Healthy/Fault status ▪ RTU Clock (seconds)	▪ R ▪ R ▪ R ▪ R ▪ R
7.	RTU Panel	▪ RTU panel temperature HIGH status ▪ RTU panel humidity HIGH status ▪ RTU panel Remote/Local Control selection ▪ Reset Push Button status ▪ RTU panel temperature reading ▪ Panel Door Open/Close Status	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R

Item	I/O	Signals	Read (R)/ Write (W)
		▪ DC Supply Healthy/Fault Status	▪ R
8.	Master SCADA Control	▪ Master SCADA in Control Command ▪ Master SCADA in Control status	▪ W ▪ R
9.	Penstock	▪ MOV Power Isolation Feedback ▪ MOV Remote/Local Control selection ▪ MOV Auto/Manual status ▪ MOV Fully Opened status ▪ MOV Fully Closed status ▪ MOV Fault status ▪ MOV Fail-to-Open status ▪ MOV Fail-to-Close status ▪ MOV Position feedback (%) ▪ MOV Remote Open Command ▪ MOV Remote Close Command ▪ MOV Remote Stop Command	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ W ▪ W ▪ W
10.	Level Switch	▪ High status ▪ High-High status	▪ R ▪ R
11.	Level Transmitter	▪ Level instantaneous reading ▪ Level transmitter Fault status	▪ R ▪ R

7.3.9. The RTU panel incomer supply shall be monitored by Power Meter Unit (PMU) to be mounted on the RTU panel with the following parameters: -

i. Phase Voltage
ii. Phase Current
iii. Power Factor
iv. Frequency
v. Power consumption

All parameters shall be monitored from the DNMC SCADA.

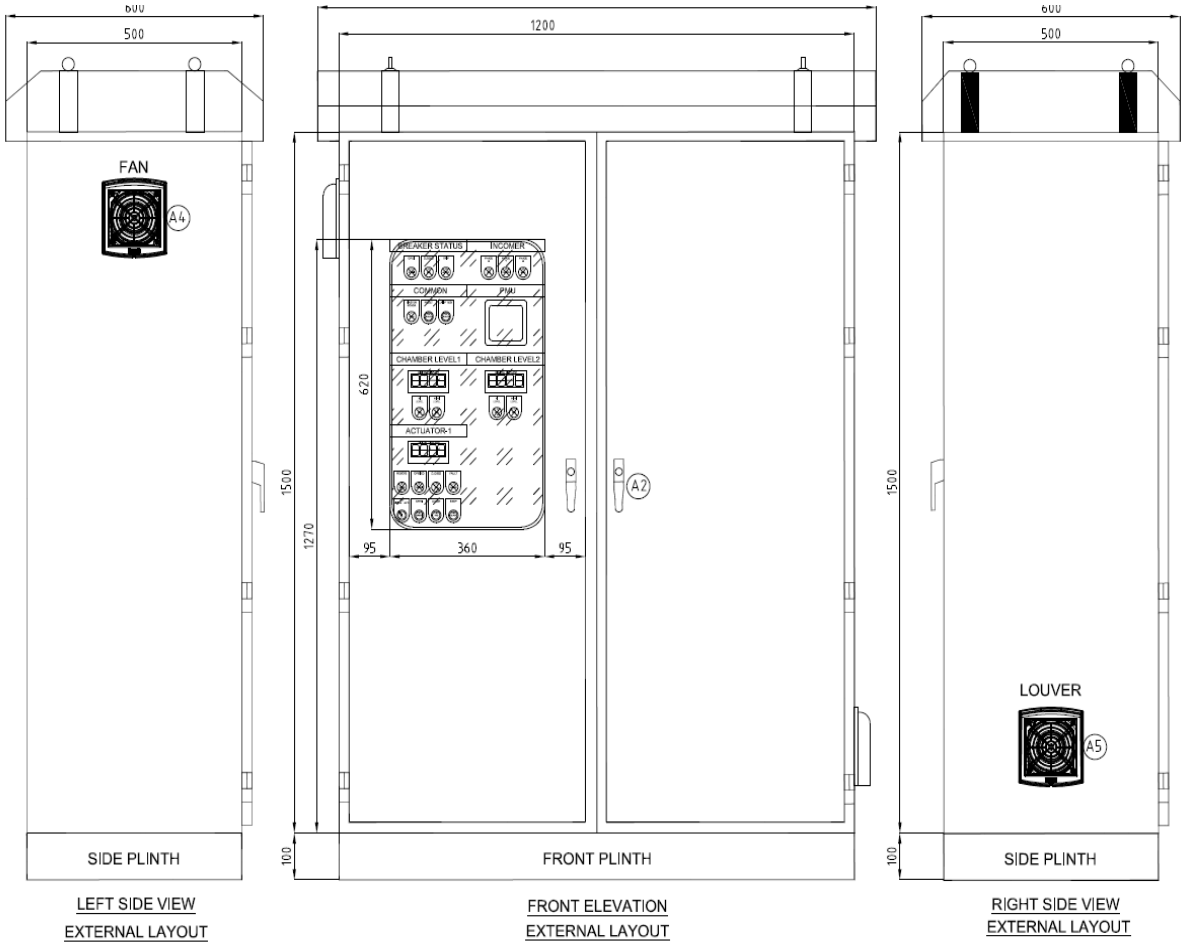


Figure 4 - RTU General Layout

7.4. Lagoon And Emergency Flood Area (EFA)

7.4.1. To monitor the level status and water quality of the lagoon and EFA.

7.4.2. The parameter to be monitored from the lagoon shall be but not limited to: -

i. Water level reading
ii. Water level High and High High status
iii. Temperature

7.4.3. The parameter to be monitored for Deep Injection Holding Tank shall be, but not limited to: -

i. Water level reading
ii. Water level High and High High status
iii. Temperature
iv. pH
v. Dissolved Oxygen (DO)
vi. Turbidity

vii. Conductivity

7.4.4. RTU shall be mounted with other equipment within an outdoor installed GRP enclosure,

7.4.5. GRP enclosure shall comply with the requirement of QCS 20014 sections 21.

7.4.6. RTU Panel shall be of two-layered door (outer and inner), with look-in window on the outer door. The RTU panel shall have minimum external dimension of 600Wx350Dx600H mm size. The final panel dimension shall be as per site condition and Engineer's approval.

7.4.7. RTU shall be mounted on a pole mounted bracket with Solar System for charging powering the RTU panel and the field instruments, which consist of a solar controller, battery, fitting, materials, enclosure, mount bracket and works as the following specifications: -

i. System Voltage: 12VDC
ii. Solar panel type: Monocrystalline
iii. Battery type: Deep-cycle, As per QCS 2014
iv. Days without charging (Autonomy): 4 days.
v. Days to recharge the battery: 2 days.

7.4.8. The following document to be submitted to the Engineer for review prior to procurement and commencing the work: -

i. The detailed sizing calculation of the solar system for each site.
ii. The detailed mount bracket/pole drawing for the solar panel.
iii. The detailed Solar component enclosure general arrangement drawing.

7.4.9. A local pushbutton to be mounted at the bottom of the panel to turn on the digital display indicator.

7.4.10. All components mounted shall be in a manner that shall permit servicing, adjusting, testing and removal without disconnecting, moving or removing of any other component. Components mounted shall be mounted on a mounting plate and not directly.

7.4.11. All the panels shall be supplied with nameplates which identify the panel. The nameplate shall be stainless steel. Each component inside the panel shall also have nameplates.

7.4.12. All panels shall be provided with anti-condensation heater controlled by a humidistat and an overriding ON/ OFF switch.

7.4.13. All panels shall be provided with ventilation louvers with dust protection to prevent temperature build-up inside of the panel.

7.4.14. Power and signal cables shall be routed in separate wire ways. Different wiring systems shall be terminated on separate terminal blocks.

7.4.15. Discrete inputs and outputs (DI & DO) shall have 2 terminals per points.

7.4.16. Analogue inputs /outputs shall have 3 terminals per shielded pair connection with adjacent terminal assignments for each point. The third terminal is for shielded ground connection for cable pairs. Ground the shielded signal cable at the RTU. All active and spare RTU points shall be wired to terminal blocks. All discrete outputs to the field shall be isolated within the isolating fuse switch terminal block with a flip cover and neon blown fuse indicator.

7.4.17. All wiring shall be clearly tagged, and color coded as per Ashghal Engineer approval.

7.4.18. The RTU panel shall have a single tube, fluorescent light fixture, mounted internally to the ceiling of the panel with a turn on switch.

7.4.19. The panel shall be provided with an isolated copper grounding bus for all signal and shield ground connections. Shield grounding shall be in accordance with the instrumentation manufacturers' recommendations. Each panel shall be provided with a separate copper power grounding bus.

7.4.20. All panels shall be provided with aesthetic and canopy to protect from direct sun.

7.4.21. Complete all cabling works including excavations, laying cables, cable termination and associated works required for the connection.

7.4.22. Typical Lagoon & EFA I/O Monitored from DNMC SCADA

Item	I/O	Signals	Read (R)/ Write (W)
1.	Incoming supply	▪ Incoming supply Healthy/Fault status ▪ Breaker healthy/trip status	▪ R ▪ R
2.	Solar System	▪ Solar Controller status ▪ Charging Voltage ▪ Battery Voltage ▪ Battery Temperature ▪ Power Inverter Healthy status ▪ Battery Voltage Low status ▪ Battery Autonomy (In minutes) ▪ Battery Capacity (AH)	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
3.	UPS	▪ UPS on Battery status ▪ UPS on Bypass status ▪ UPS Battery Low status	▪ R ▪ R ▪ R

Item	I/O	Signals	Read (R)/ Write (W)
		▪ UPS Fault/Alarm status	▪ R
4.	RTU	▪ RTU Modem Signal Strength ▪ RTU Signal Quality ▪ RTU Healthy (No Error) ▪ DNMC Communication Healthy/Fault status ▪ RTU Clock (seconds)	▪ R ▪ R ▪ R ▪ R ▪ R
5.	RTU Panel	▪ RTU panel temperature HIGH status ▪ RTU panel humidity HIGH status ▪ RTU panel Remote/Local Control selection ▪ Reset Push Button status ▪ RTU panel temperature reading ▪ Panel Door Open/Close Status ▪ DC Supply Healthy/Fault Status	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
6.	Water Level	▪ High status ▪ High-High status ▪ Level instantaneous reading ▪ Level Transmitter Fault ▪ Temperature	▪ R ▪ R ▪ R ▪ R ▪ R
7.	Flow (Primary connection via MODBUS) Subjected to site condition	▪ Flow rate instantaneous reading (in l/s) ▪ Flow totalizer – Accumulative (in m^3) ▪ Flow totalizer – Today (in m^3) ▪ Flow totalizer – Yesterday (in m^3) ▪ Flow rate High Alarm ▪ Flow rate Low Alarm ▪ Flow transmitter Fault status	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
8.	Deep Injection Holding Tank	▪ High status ▪ High-High status ▪ Level instantaneous reading ▪ Level Transmitter Fault ▪ Temperature ▪ PH ▪ Dissolved Oxygen (DO) ▪ Turbidity ▪ Conductivity ▪ Water Quality Transmitter Fault	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R

7.4.23. Flow Meter & Level Transmitter Monitoring

i. Primary protocol of communication between FM/LT to RTU/PLC shall be Modbus.
ii. 4-20mA shall be terminated and provisioned for future to be used in the RTU/PLC panel.
iii. Signals like Instantaneous flow, total flow, level, high, low, etc. shall be configured in the RTU/PLC.
iv. Current flow shall configure in l/sec and totalizer in m3 at transmitter as well as in RTU/PLC.
v. Reverse Flow shall be programmable in the transmitter (if applicable)

vi. The flowrate instantaneous and the actual level readings shall be displayed on digital display indicator mounted on the inner door of the RTU panel.

7.4.24. The general Layout is as depicted in below figure 5 . The final layout approval shall be obtained from Ashghal Engineer and is subjected to site condition as well as project requirement.

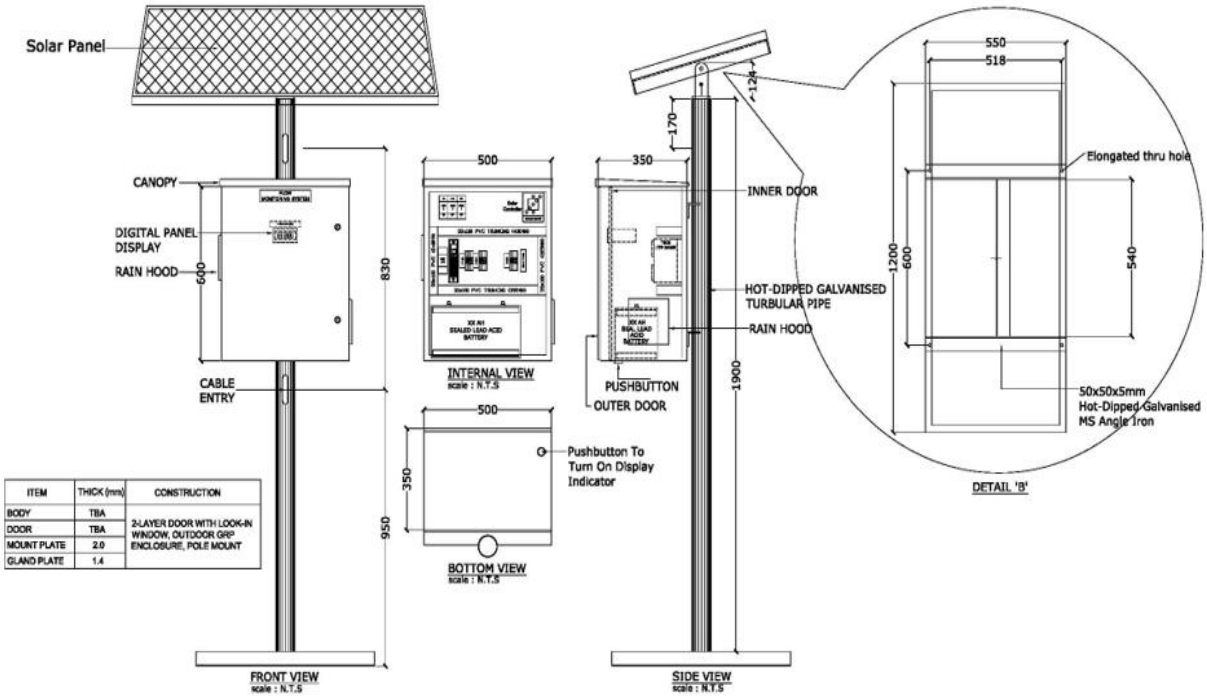


Figure 5 - RTU with Solar Panel Arrangement

7.5. **Dewatering**

7.5.1. To monitor the flow rate (l/s) & flow consumption (m3)

7.5.2. The dewatering site consist of flow meter(s) to monitor the volume of discharged water volume, connected to an RTU. The system will be powered by a solar system

7.5.3. The RTU shall be selected according to the specifications listed in section 10. In particular :

i. Primary protocol of communication between FM to RTU shall be Modbus.
ii. 4-20mA shall be terminated as well.
iii. Signals like Instantaneous flow, total flow, shall be configured in the RTU.
iv. Current flow shall configure in l/sec and totalizer in m3 at transmitter as well as in RTU.

7.5.4. The flowrate instantaneous reading(s) shall be displayed on a digital display indicator mounted on the door of the RTU panel. It shall be visible to Ashghal SCADA inspector at anytime.

7.5.5. RTU shall be mounted with other equipment within an outdoor installed GRP enclosure,

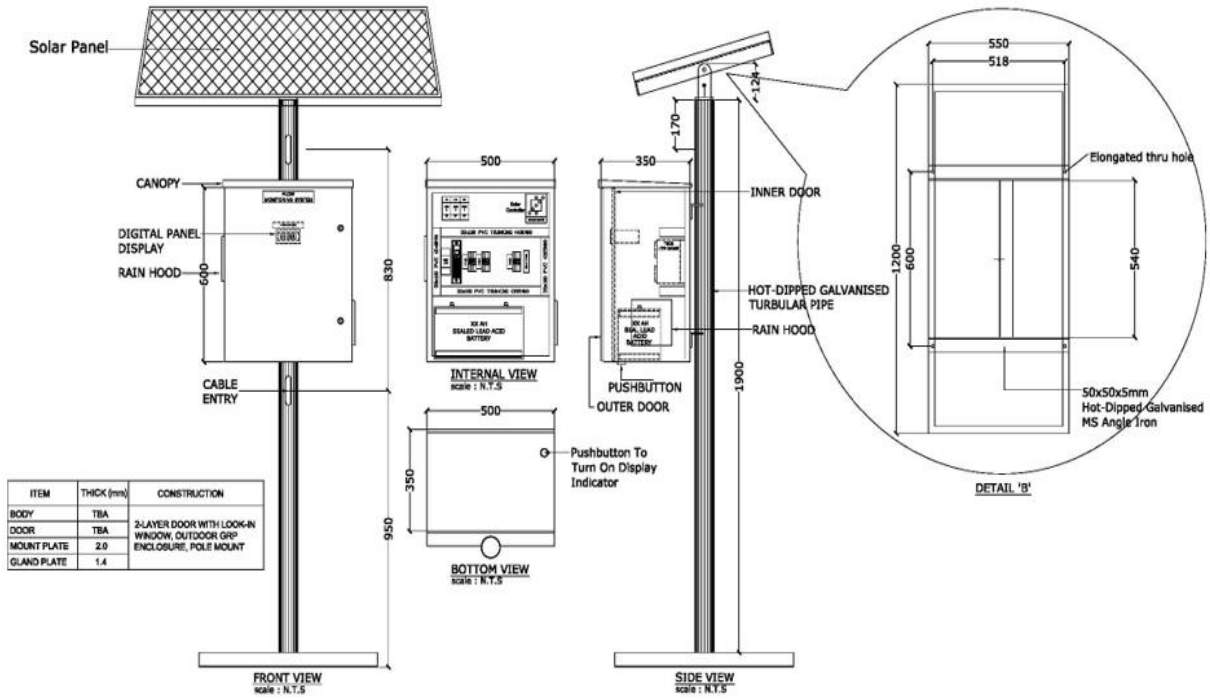
7.5.6. RTU shall be mounted on a pole mounted bracket with Solar System for charging powering the RTU panel and the field instruments, which consist of a solar controller, battery, fitting, materials, enclosure, mount bracket and works as the following specifications: -

i. System Voltage: 12VDC
ii. Solar panel type: Monocrystalline
iii. Battery type: Deep-cycle, As per QCS 2014
iv. Days without charging (Autonomy): 4 days.
v. Days to recharge the battery: 2 days.

7.5.7. Typical Dewatering I/O Monitored from DNMC SCADA

Item	I/O	Signals	Read (R)/ Write (W)
1.	RTU	▪ RTU Modem Signal Strength ▪ RTU Signal Quality ▪ RTU Healthy (No Error) ▪ DNMC Communication Healthy/Fault status ▪ RTU Clock (seconds)	▪ R ▪ R ▪ R ▪ R ▪ R
2.	RTU Panel	▪ RTU panel temperature HIGH status ▪ RTU panel humidity HIGH status ▪ RTU panel Remote/Local Control selection ▪ Reset Push Button status ▪ RTU panel temperature reading ▪ Panel Door Open/Close Status ▪ DC Supply Healthy/Fault Status	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
3.	Flow (Primary connection via MODBUS) Subjected to site condition	▪ Flow rate instantaneous reading (in l/s) ▪ Flow totalizer – Accumulative (in m^3) ▪ Flow totalizer – Today (in m^3) ▪ Flow totalizer – Yesterday (in m^3) ▪ Flow rate High Alarm ▪ Flow rate Low Alarm ▪ Flow transmitter Fault status	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R

7.5.8. The general Layout is as depicted in below figure . RTU with Solar Panel Arrangement. The final layout shall be subjected to site condition and requirement.



RTU with Solar Panel Arrangement

7.6. Network Manholes

7.6.1. To monitor critical manholes in Foul water network (FWN), surface ground water network (SGWN) and underpasses/interchanges

7.6.2. To collect data from network in order to develop and calibrate a hydraulic model

7.6.3. The Monitoring Equipment arrangement shall consist of the following arrangements:

i. Measurement Instrumentation
ii. Communications Equipment
iii. RTU and power distribution panel(s).
iv. Civil and mechanical works

7.6.4. Monitors type

i. Level
ii. Flow/Velocity
iii. Odor
iv. Salinity/Conductivity

7.6.5. All manholes measured parameters shall be monitored locally from the field via the RTU panel. A local digital display indicator shall be mounted on the RTU panel or instrument transmitters.

7.6.6. Communication Equipment

i. The preferred hardware for communication for permanent monitoring is RTU with permanent power supply provided from kahramaa or solar panel.
   a) The RTU has to send data to DNMC only
   b) The RTU has to comply with section 10.
   c) Communication should be Real-Time-Communication (less than one minute)

ii. To collect data and for temporary monitoring, the contractor can use a data logger or RTU. Data logger/RTU not necessary to communicate with DNMC.
   a) Data logger has to comply with Section 11
   b) Data frequency can vary depends on the Hydraulic Modelling team requirement during project execution
   c) The logger data shall be at least in CSV format in case PWA Engineer ask to import data to DNMC data warehouse.

7.6.7. For communication protocols, connection details, please refer to section 9.6

7.6.8. All instrumentation equipment and works shall be in compliance with QCS

7.6.9. All electrical, civil and mechanical equipment and works shall be in compliance with QCS

7.6.10. Instrumentation

i. Level Monitoring

   a) Contractor shall use a Radar Level sensor for monitoring the Network Manholes as a permanent arrangement.

   b) Contractor shall use either Radar/Ultrasonic level Sensor for monitoring and data capturing as a Temporary arrangement in the Network Manholes. (PWA considering the Temporary arrangement duration between 3 months to 1 year).

   c) The instruments shall have a proven records and history in a similar application

d) Accuracy shall be as per QCS and as per acceptance by O&M SCADA and Hydraulic Modeling Team
e) The transmitter shall be complete with in-built indication for level or for flow, if used for open channel flow measurement.
f) The configuration shall be able to be performed remotely via Bluetooth and via mobile network as well as locally on site via serial communication channel.
g) The instrument shall be capable of handling remote configuration from the SCADA control center
h) The transmitter shall be provided with an in-built keypad or a hand held programming unit for programming the instrument.
i) Calibration shall be done regularly as recommended by the vendor & approved by the O&M engineer.

ii. Flow/Velocity Monitoring

a) The contractor shall be able to monitor the flow at the selected manhole/chamber/open channel.
b) The contractor shall use a high accuracy flow meter. Accuracy shall be as per QCS and as per acceptance by O&M SCADA and Hydraulic Modeling Team
c) Flow meter technology shall be decided as per manhole/chamber condition and as per approved by O&M engineer.
d) The flow meter instruments shall be reviewed & approved by O&M SCADA and Hydraulic modeling team.
e) The instruments shall have a proven records and history in a similar application
f) The configuration shall be able to be performed remotely via Bluetooth and via mobile network as well as locally on site via serial communication channel.
g) The instrument shall be capable of handling remote configuration from the SCADA control center
h) The transmitter shall be provided with an in-built keypad or a hand held programming unit for programming the instrument.
i) Calibration shall be done regularly as recommended by the vendor & approved by the O&M engineer.

iii. Odor (H2s) Monitoring

a) The contractor shall be able to monitor manhole H2S value of the top of the manhole and as well inside the chamber. The H2S sensor shall be suitable of such location, rugged and has a longer life comparing to normal H2S sensors.

b) The contractor shall use a high accuracy H2S. Accuracy shall be as per QCS and as per acceptance by O&M SCADA and Hydraulic Modeling Team

c) The H2S instrument shall be reviewed & approved by O&M SCADA and Hydraulic modeling team.

d) The instrument shall have a proven records and history in a similar application.

e) If the transmitter is built-in, than a remote display indicator shall be placed on the remote panel.

f) If the transmitter is separate, than it shall be installed at the front inner door of the remote RTU panel.

g) The configuration shall be able to be performed remotely via Bluetooth and via mobile network as well as locally on site via serial communication channel.

h) The instrument shall be capable of handling remote configuration from the SCADA control center

i) The transmitter shall be provided with an in-built keypad or a hand held programming unit for programming the instrument.

j) Calibration shall be done regularly as recommended by the vendor & approved by the O&M engineer.

iv. Salinity/Conductivity Monitoring

a) The contractor shall be able to monitor the sewage quality inside the chamber. The sensor shall be suitable of such location, rugged and has a longer life comparing to normal sensors.

b) The contractor shall use a high accuracy instrument. Accuracy shall be as per QCS and as per acceptance by O&M SCADA and Hydraulic Modeling Team

c) The Salinity/Conductivity instrument shall be reviewed & approved by O&M SCADA and Hydraulic modeling team.

d) The instrument shall have a proven records and history in a similar application
e) The configuration shall be able to be performed remotely via Bluetooth and via mobile network as well as locally on site via serial communication channel.
f) The instrument shall be capable of handling remote configuration from the SCADA control center
g) The transmitter shall be provided with an in-built keypad or a hand held programming unit for programming the instrument.
h) Calibration shall be done regularly as recommended by the vendor & approved by the O&M engineer.

7.6.11. For SGW modelling, the temporary instruments (rain gauges) on the SGW networks shall be installed to record the rainy seasons as per Ashghal requirements. There shall be provision of remote switch functionality on the sensor from SCADA room during rainy seasons and switch off data loggers/RTU remotely during non-rainy seasons.

7.6.12. RTU & Power distribution panel

i. RTU shall be mounted with other equipment within an outdoor installed GRP enclosure
ii. GRP enclosure shall comply with the requirement of QCS 20014 sections 21.
iii. RTU Panel shall be of two-layered door (outer and inner), with look-in window on the outer door. The RTU panel shall have minimum external dimension of 600Wx350Dx600H mm size. The final panel dimension shall be as per site condition and Engineer's approval.
iv. All manhole's monitored parameters shall be displayed on the inner door.
v. If the power source is solar, please refer to Solar panel specifications requirements listed in section 7.4.
vi. If the power source is kahramaa, please refer to specifications requirements listed in section 7.3.

7.6.13. Typical Network Manhole Monitored from DNMC SCADA

Item	I/O	Signals	Read (R)/ Write (W)
1.	Kahramaa Main Incomer Supply	▪ Main Incomer Supply Healthy/Fault status ▪ Incomer Phase Current – I1, I2, I3 ▪ Incomer Phase Voltage – Vab, Vbc, Vca ▪ Incomer Frequency ▪ Incomer Power Factor ▪ Incomer Power Consumption (kWh/MWh)	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
2.	Solar System	▪ Solar Controller status ▪ Charging Voltage ▪ Battery Voltage ▪ Battery Temperature ▪ Power Inverter Healthy status ▪ Battery Voltage Low status ▪ Battery Autonomy (In minutes) ▪ Battery Capacity (AH)	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
3.	MCC incoming supply	▪ MCC incoming supply Healthy/Fault status ▪ MCC breaker healthy/trip status	▪ R ▪ R
4.	UPS	▪ UPS on Battery status ▪ UPS on Bypass status ▪ UPS Battery Low status ▪ UPS Fault/Alarm status	▪ R ▪ R ▪ R ▪ R
5.	RTU	▪ RTU Modem Signal Strength ▪ RTU Signal Quality ▪ RTU Healthy (No Error) ▪ DNMC Communication Healthy/Fault status ▪ RTU Clock (seconds)	▪ R ▪ R ▪ R ▪ R ▪ R
6.	RTU Panel	▪ RTU panel temperature HIGH status ▪ RTU panel humidity HIGH status ▪ RTU panel Remote/Local Control selection ▪ Reset Push Button status ▪ RTU panel temperature reading ▪ Panel Door Open/Close Status ▪ DC Supply Healthy/Fault Status	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R
7.	Data Logger	▪ Signal Strength ▪ Signal Quality ▪ Healthy (No Error) ▪ DNMC Communication Healthy/Fault status ▪ Data Logger Heartbit ▪ Data Logger Battery Voltage & status ▪ Sensor Fault status	▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R ▪ R

Item	I/O	Signals	Read (R)/ Write (W)
		▪ Number of Calls ▪ Last call time IN	▪ R
8.	Level	▪ Level instantaneous reading ▪ Level transmitter Fault status ▪ Level no change status ▪ Level alarm status	▪ R ▪ R ▪ R ▪ R
9.	Flow/Velocity	▪ Flow/Velocity instantaneous reading ▪ Flow/velocity transmitter Fault status ▪ Flow totalizer ▪ Flow/Level no change status ▪ Flow/velocity alarm status	▪ R ▪ R ▪ R ▪ R ▪ R
10.	H2S	▪ H2S instantaneous reading ▪ H2S transmitter Fault status ▪ H2S no change status ▪ H2S alarm status	▪ R ▪ R ▪ R ▪ R
11.	Salinity/Conductivity	▪ Instantaneous reading ▪ Transmitter Fault status ▪ Reading no change status ▪ Alarm status	▪ R ▪ R ▪ R ▪ R

8. PLC/SCADA SYSTEM

8.1. PLC

8.1.1. The major hardware components of the Main PLC Panel include (but not limited to):

i. Redundant (Hot-Standby or Hot-Hot) CPUs with redundant power supply and Ethernet

ii. PLC shall have inbuilt Ethernet ports available with a serial port and a dedicated programming port

iii. Distributed IO modules

iv. Redundant Power Supply

v. Engineering industrial 15” Laptop (Minimum 16GB RAM, 1 TB SSD. Latest processor, RW Hard Disc Drive in-built) for PLC programming on site

a. Operating Software Windows 10 Pro or Higher which is latest available in the market

b. MS Office (Latest edition available in the Market)

c. Antivirus (McAfee or Symantec Norton Antivirus Business Pack latest Edition)

d. Laptop Carry bag

e. Wireless Mouse

vi. Redundant network

8.1.2. The PLC shall have built-in security features. The PLC shall be protected with access-level login. Program blocks, function blocks and subrountines shall not be protected with passwords.

8.1.3. The PLC shall be free of malware/virus and shall be protected against outside unwanted access.

8.1.4. The PLC shall support NTP time synchronization.

8.1.5. The PLC shall communicate with local PLC/HMI and the RTU on redundant TCP/IP network and on Modbus Protocol. If both located in a different building, then it shall communicate using FO link. For SCADA and PLCs located on different building, the SCADA-PLC communication shall be on fiber optic link

8.1.6. The HMI-PLC network architecture shall support two point of failures.

8.1.7. PLC shall be restricted to maximum of up to 8 I/O racks unless/otherwise justified by the PLC manufacturer and approved by engineer.

8.1.8. PLC I/O allocation within I/O rack and modules has been designed in such way that single module failure will not result in failure of both duty and standby equipment.

8.1.9. The PLC communication ports shall support Modbus protocol.

8.1.10. All devices shall be locked & secured. Only authorized personnel can have the access. All un-used port shall be disabled.

8.1.11. In the Electrical Section, used PMU shall be powered thru UPS system.

8.1.12. The PLC Panel installed outdoor closer with application requirement then this PLC Panel shall have Panel Mounted Air conditioner unit to maintain the panel temperature as per the PLC OEM recommendation.

8.1.13. The PLC's digital and analogue I/O protection device required against surge and spikes from the field signal. The protection device shall be of DIN-rail type and shall be able to protect multiple input and output signals. The PLC and I/O Protection Circuit drawing shall be verified and required approval by Ashghal Engineer prior to the project execution.

8.1.14. The PLC and SCADA software shall be purchased under "Ashghal" Name.

8.1.15. The PLC's " Software & Tools" deliverable shall Include:

i. Engineering laptop – 15", 16GB Ram, 1TB SSD

ii. Runtime Licenses
iii. Communication driver licenses
iv. MS Office Latest available in Market
v. Antivirus (Recommended by the OEM and Subjected to Ashghal Engineer Approval)
vi. PLC programming software
vii. Engineering Licenses
viii. As-Built program backup

8.2. **SCADA/HMI**

8.2.1. The major hardware components of SCADA system have as follows (but not limited to):

i. Operator Workstation
ii. Engineer Workstation
iii. Redundant IO & Application Server
iv. Redundant Historian
v. Storage & Backup Solution
vi. NMS solution
vii. Security Solution (including cyber security, malware & antivirus)
viii. Firewall

8.2.2. The RTU/PLC/SCADA system shall be secure from external & internal unwanted access.

8.2.3. The NMS shall discover, manage and monitor the performance of Information & Communication Technology (ICT) Infrastructure. The SCADA System shall have an Alarm Management System. And the following Network Components shall be added in the NMS System:

i. Fire Walls
ii. Switches
iii. Wireless LAN Controllers
iv. Wireless Access Points
v. Server Nodes
vi. Virtual Machines
vii. Workstation Servers

viii. Historian Servers

ix. Storage/Archiving System

x. Reporting/Analytics Software

xi. RTU

xii. PLC

xiii. Printers etc.,

8.2.4. The SCADA system shall have a reporting software

8.2.5. The SCADA system shall have a change management capability

8.2.6. The SCADA/HMI mimics shall comply with the latest QCS, international standards and as instructed by DNMC SCADA Team

8.2.7. The local HMI shall support full SCADA application.

8.2.8. The HMI hardware and software shall support redundant communication on Modbus Protocol.

8.2.9. The SCADA/HMI system shall support NTP time synchronization.

8.2.10. The local HMI shall be able to log, historize and trend data for 6 months.

8.2.11. The local HMI shall be able to generate report as per DNMC SCADA standard and as required by the DNMC SCADA team.

8.2.12. Submit SCADA/HMI equipment/object library for DNMC SCADA team & approval.

8.2.13. Submit SCADA/HMI color scheme for DNMC SCADA team & approval.

8.2.13.1. The SCADA/HMI/Alarming system shall refer to ANSI/ISA standards

8.2.13.2. In general ,The SCADA/HMI system shall be designed and configured to be able to:

a. Provide early-detection, diagnosis and proper response to abnormal conditions.

b) Provide an overview of the equipment under the user's control.

c) Allow the user to navigate to information in a timely manner.

d) Provide ease in addressing multiple malfunctions based on tasks and the priority required for those tasks.

8.2.13.3. Desired guidelines

a) Consistency of design

b) Consistent colors

c) Visual The concept of Display Hierarchy

8.2.13.4. Use Of Color

i) Submit the SCADA/HMI Color scheme for PWA CCS team to review and approval. The below information will help to the contractor to build SCADA Graphics

a) White Background shall be used for all SCADA Screens. And Primary colors (Red, Green, Blue) Should not be used as a Background Color.

b) The Graphical representation of Process equipment, Piping and Instrumentation shall be displayed as 3D where as possible and required, Otherwise it shall be a 2D representation of the 3D Model.

- There shall be Graphical representation of the all plant areas (Inlet, dry/Wetwell, Rising etc.,) in light grey color faceplate in the White Background SCADA screen.
- The process equipment shall be drawn in their respective areas.
- The pipe, Tank, Process SBR process changes shall be animated & filled with process color when is active. In addition, water and airflow direction shall be indicating.

c) Bright Colors shall use only highlighted alarms and any abnormal situations indicating purpose.

d) Colors that are used for Alarms shall not use anywhere else in SCADA Screens.

ii) The Symbols/Animation shall divide into multiple categories

a. Run Time Widgets

i. These widgets will provide summarized and high-level information related to the overall condition of an area (like a pumping station) or its performance such as a comparison of its totalized power per day with its totalized flow for that day.

ii. These widgets are dynamic i.e. they keep on updating in runtime and provide an interim platform to analyse the overall performance before looking at the detailed historical reporting of that area.

b. Process Equipment Symbology: Such as valves, pumps, transmitters.

c. Alarms

d. User Interactions: Such as Control Buttons.

e. Navigation links and Buttons.

8.2.13.5. Typical Color Scheme

a) Red is used for: Emergency or Prohibition (High Attention) (Un Healthy Status)

b) Green is used for: Running/Closed in Safe Condition (Healthy Status)

c) Grey is used for: Stopped in Safe Condition

d) Amber/Yellow are used for: Tripped/Faulty (Process Interlock)

e) Dark Grey used for: To Indicate the Static Equipment

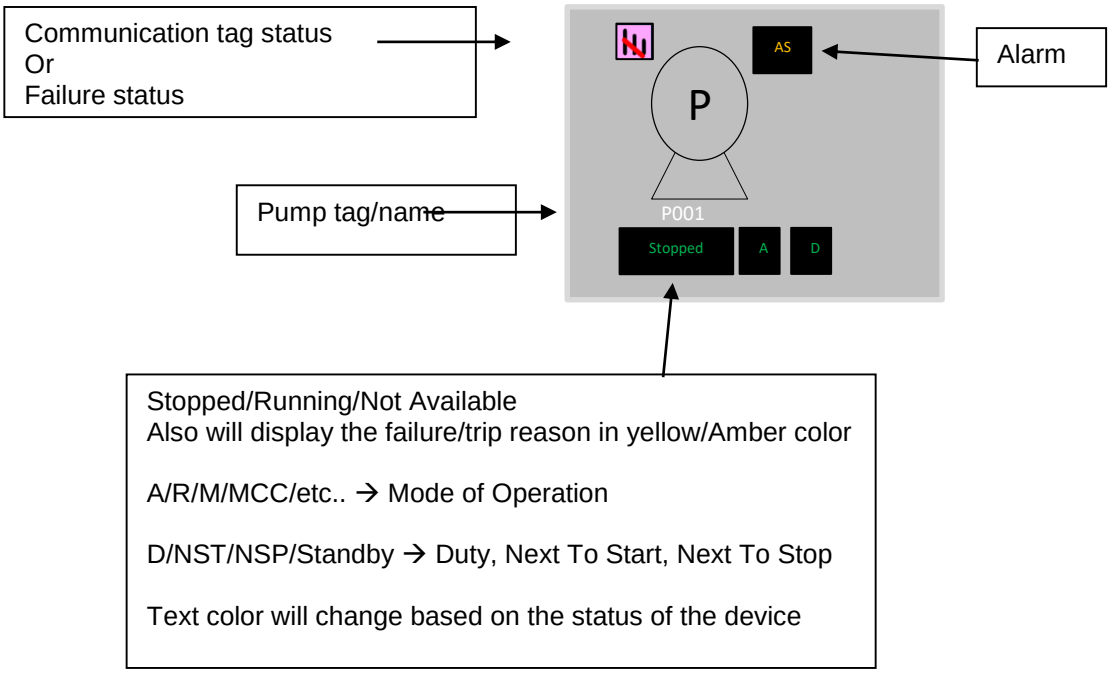
f) It shall always text next to the equipment describing the following:

- Status of the Device (Running/Stop/Available/Trip/Process Interlock)
- Mode of Operation (Auto/ Remote/Manual HMI/Manual MCC)
- Communication Status (Active/Fail)
- If Alarm is Suppressed or disabled

g) The static text shall be white over the grey faceplate of black over the white background.

h) The Dynamic text color shall be as per device status (Green, Red and Yellow)

i) The dynamic readings display color shall be green



Equipment	Situation	Color
Main Pump	Stopped, Healthy, Available	Light Grey (same as faceplate color/background)
	Running, Healthy	Green (safe condition)
	Tripped/Faulty within attendance SLA time	Yellow/Amber (to be attended by maintenance)
	Tripped/Faulty after attendance SLA time	Red (To indicate Emergency)
Motorized Valve/Penstock	Healthy, Fully Closed	Red
	Health, Fully opened	Green
	Actuator Faulty	Yellow/Amber
	Traveling to Closed/opened position	Half red & half green with arrow indicating the traveling direction into destination color

	Not fully closed & Not fully opened	If it is more opened then closed, than use the “open” color at left of the object and use the “closed” color at the right. If it is more closed then opened, than use the “closed” color at left of the object and use the “open” color at the right.
Non-Return Valve (*)	Pump Stopped & NRV fully Closed	Light Grey (same as faceplate color/background)
	Pump Stopped & NRV Not fully Closed	Red
	Pump Running & NRV Not fully opened	Red
	Pump Running & NRV fully opened	Green
	No Flow Trip	Yellow/Amber
Non-Return Valve (**)	Pump Stopped & NRV fully Closed	Light Grey (same as faceplate color/background)
	Pump Stopped & NRV Not fully Closed	Red
	Pump Running & NRV Not fully Closed	Green
	No Flow Trip	Yellow/Amber
Non-Return Valve (***)	Pump Stopped & NRV fully Opened	Light Grey (same as faceplate color/background)
	Pump Running & NRV Not fully opened	Red
	Pump Running & NRV fully opened	Green

	No Flow Trip	Yellow/Amber
(*) NRV with two feedback signals : Fully closed & Fully Opened *(**) NRV with one feedback signal only : Fully closed* *(***) NRV with one feedback signal only : Fully Opened*		

8.3. Alarms

Alarms warn about process & system conditions that can potentially cause problems

The alarm system may include both the basic process control system and the safety-instrumented system, each of which uses measurements of process conditions and logic to generate alarms

This section provides the technical details of the alarm configuration with respect to:

- Alarm Aggregation
- Prioritization
- Alarm & Event application/table configuration

8.4. Alarms Aggregation

Alarm aggregation is based on the model view hierarchy. The Runtime Alarm List for SCADA shows all alarms by default. The aggregate alarms of a particular area/ facility can be accessed through alarm filters.

A sample of major alarms groups is listed as follows:

- Process alarms
    - Equipment
        - Main Sewage Pump
        - Blowers
        - Mixers
        - Valves
    - Electrical
        - Fire Alarm
        - Incomers/breakers
        - Generator

- Instruments
  - Flow meter
  - Pressure Transmitter/switch
  - Level Transmitter/switch

- System Alarms
  - Communication
  - IT hardware performance & status

8.5. **Prioritization**

There is 3 severities shall be defined in Alarm & Events configuration as below:

Severity	**Severity Level**	**Color Assignment**	**Description/SLA**
Critical	1	Red	Station in risk (Process & communication) SLA : immediate (with thin 1 hour) • Fire Alarm • Main Incomer Fail • Main Incomer Fail & Generator Fail to Start • Overflow level alarm System alarms which require immediate action • PLC/RTU communication failure • Station Communication failure • IO/Application/Historical Server shutdown
High	2	Yellow	Main Process Equipment & instrumentation which used for control: • Pump/Blower/Mixer Alarms • Level High-High & Low-Low Level Alarm

Low	3	Amber	Secondary Process Equipment and instruments which are not used frequently. Performance Information to Operator

8.6. **Alarm & Event application/table configuration**

a) Every HMI/SCADA shall have the minimum following alarm/event dashboard/page:

- Current Active Alarm/Event Summary
- Historical Active/Event Summary
- List of Shelve/suppressed alarms

b) Typical alarm/event displays

a. Alarm summary display (current and recent alarms & events)
b. Alarm status display
c. Alarm & Event historical display
d. Overview display
e. Process display
f. Tag details display
g. Firs-out display
h. Shelved alarm display
i. Out-Of-service alarm display
j. Suppressed-by-design alarm display

c) All alarm table shall be equipped with filter as follows (as minimum):

a. Group (Area/Process)
b. State
c. Severity
d. Attribute
e. Sort by Tag Alphabet

f. Sort by Time , customized time selection

g. Alarm Query to find specific alarms (based on user privilege)

d) Use of Color

a. Representing a SCADA object/text in “alarm” condition:

- Object (equipment, communication) in Alarms : Use Amber color

b. Active Alarm/Event Page

This page/table shall display only the current “Active” alarm list

Background color might change, however alarm text color must be visible and distinguished

State	Description	Text Color	Background Color
UNACK-ALM	Alarm Active & Unacknowledged	Flashing as per the priority color assigned	Black
ACK-ALM	Alarm Active & Acknowledged	As per priority color assignment but steady	Black
UNACK-RTN	Alarm return to normal state & Unacknowledged	Disappear	N/A
ACK-RTN	Alarm return to normal state & Acknowledged	Disappear	N/A
EVENT	Event in active State	Blue	Black

c. Historical Alarm/Event list

The historical alarm dashboard/page shall have all the alarm logs and shall be equipped with filters as specified above in section C as a minimum.

Also, the data shall be able to be exported to CSV/PDF file.

Background color: White

Alarm text color: Black (unack-alm, ack-alm, unack-rtn, ack-rtn)

Even text color: Black

8.7. **Sample**

No.	Description	Alarm	Alarm Type
1	Main Sewage Pump	Power ON Fault	High
2		Fault	High
3		Fail to Start/Stop	High
4	Penstock/Motorized valve	Faulty / Emergency Stop	High
5	Fire Alarm	Fire Alarm ON	Critical
6	Generator	Faulty/Fail/Tripped & main incomer ON	High
7		Faulty/Fail/Tripped & main incomer OFF	Critical
8	Power Failure	MCC PWR Fail / M INC Fail	Critical
	UPS	Faulty/Faulty	High
9	Level	Overflow (By logic)	Critical
	Pressure	Low/high Limit (By Logic)	High
10	Level Float Switch	H-H (Level Switch)	High
11		L-L (Level switch)	High
12	Flow Meter	Faulty/Failure Low Flow High Flow	High Low Low
13	Pressure Transmitter	Faulty High	High High
15	Level Transmitter	Faulty	High

16	H2S	Dangerous Level	High
17	H2S Transmitter	Faulty	High
18	Communication	Station communication Fail PLC/RTU communication Fail	Critical
19	Server	Shutdown/fail	Critical
20	Exhaust FAN / Bar Screen OCU FAN	Fail/Faulty	Low

8.7.1. Deliver all SCADA/HMI licenses along with the program backup:

i. Engineering Licenses
ii. Runtime Licenses
iii. Communication driver licenses

9. CONNECTION TO DNMC

9.1. Pumping Station

9.1.1. The RTU shall be integrated with the local site PLC.

9.1.2. Submit a security risk assessment for ASHGHAL's Engineer review and approval.

9.1.3. Supply, Install, Test and Commission all necessary equipment to comply with Ashghal requirements in order to achieve secure communication between the RTU, plant PLC and remote DNMC SCADA system.

9.1.4. Supply the RTU solution design

9.1.5. Modify the existing site PLC software to provide collection of all data into one MASTER PLC area mapped to MODBUS registers (for collection by the RTU) and/or provide hardwired signals to the RTU as required

9.1.6. Configure the RTU and establish MODBUS communication with the existing site (i.e. MASTER) PLC and install & configure the MODBUS software/hardware as required.

9.1.7. Test and commission all signals (i.e. End-to-End) between field instruments and the RTU

9.1.8. Test and commission all signals between the site RTU and the centralized DNMC SCADA System.

9.1.9. Supply as-built design deliverables (including all RTU and PLC software and associated licenses as required).

9.1.10. Supply all licenses and associated software and hardware needed to establish MODBUS communication between the site PLC and RTU as required.

9.1.11. Samples of accessories for approval and all the required tests as directed by the Engineer

9.1.12. Design, Supply, Test and Commission RTU panel and submit it for Engineers approval.

9.1.13. Coordinate with the Project Contractors /Catchment Framework Zone Contractor or any other authority for Work access.

9.1.14. Obtain approval from Ashghal Engineer on the mode, medium and protocol for communication before connecting PLC to RTU.

9.1.15. Programming the approved RTU to connect all the instruments from the field to Ashghal DNMC SCADA system. Obtain approval for the I/O list from Ashghal O&M and follow the programming template as directed by the Ashghal Engineer. Ashghal shall provide the SIM card for connecting to DNMC SCADA. Program and connect all the signals to DNMC SCADA as per the Ashghal latest standards. The minimum signals to be connected shall not be limited to the monitoring, control, internal RTU bits, GSM module and connectivity bits, etc.

9.1.16. Supply, Install, Test and Commission all the wiring works from the field instruments till the RTU panel.

9.1.17. In case the RTU panel is at separate location from the PLC, submit the best and safest cable routing to the RTU panel. The Duct for the Power cables shall be separated from the signal cables. Provide additional spare ducts with plugs (to close if not used) and the rope (to pull cables). The quality and standard of the cable duct provided has to be as per the latest QCS or Engineers approval.

9.1.18. All the signals shall be connected for the field instruments as per the I/O list. Ashghal approval shall be obtained on the connectivity protocol from instruments to RTU.

9.1.19. The contractor shall perform all the necessary works including required accessories, hardware as well as software, to connect and configure any existing field Equipment

/Instruments available at the site that require monitoring and control from DNMC to the RTU/PLC. The work shall include configuration of the Equipment/Instrument and the RTU/PLC as per the requirement of the Ashghal O&M Engineer.

9.2. **TWN Chamber**

9.2.1. Samples of accessories for approval and all the required tests as directed by the Engineer

9.2.2. Design, Supply, Test and Commission RTU panel and submit it for Engineers approval.

9.2.3. Programming the approved RTU to connect all the instruments from the field to Ashghal DNMC SCADA system. Obtain approval for the I/O list from Ashghal O&M and follow the programming template as directed by the Ashghal Engineer. Ashghal shall provide the SIM card for connecting to DNMC SCADA. Program and connect all the signals to DNMC SCADA as per the Ashghal latest standards. The minimum signals to be connected shall not be limited to the monitoring, control, internal RTU bits, GSM module and connectivity bits, etc.

9.2.4. Supply, Install, Test and Commission all the wiring works from the field instruments till the RTU panel.

9.2.5. Construct concrete base for the RTU Panel /Solar Panel /UPS panel (if required as per the direction of the Engineer). The base shall be as per the QCS 2014 standards. Provide ducts for the cables and ensure Duct for the Power cables are separated from the signal cables. Provide additional spare ducts with plugs (to close if not used) and the rope (to pull cables). The quality and standard of the cable duct provided has to be as per the latest QCS or Engineers approval.

9.2.6. Provide DB terminal box as per latest QCS.

9.2.7. All the signals shall be connected from the field instruments as per the I/O list. Ashghal approval shall be obtained on the connectivity protocol from instruments to RTU.

9.3. **Network Penstock**

9.3.1. Install the RTU panel along with permanent power supply or a Solar panel as power source.

9.3.2. The solar power requirements and the battery calculation shall be submitted.

9.3.3. Samples of accessories for approval and all the required tests as directed by the Engineer

9.3.4. Design, Supply, Test and Commission RTU panel and submit it for Engineers approval.

9.3.5. Programming the approved RTU to connect all the instruments from the field to Ashghal DNMC SCADA system. Obtain approval for the I/O list from Ashghal O&M and follow the programming template as directed by the Ashghal Engineer. Ashghal shall provide the SIM card for connecting to DNMC SCADA. Program and connect all the signals to DNMC SCADA as per the Ashghal latest standards. The minimum signals to be connected shall not be limited to the monitoring, control, internal RTU bits, GSM module and connectivity bits, etc.

9.3.6. Supply, Install, Test and Commission all the wiring works from the field instruments till the RTU panel.

9.3.7. Construct concrete base of the RTU Panel /Solar Panel /UPS panel (if required as per the direction of the Engineer). The base to be build has to be as per the QCS 2014 standards. Provide ducts for the cables and ensure Duct for the Power cables are separated from the signal cables. Provide additional spare ducts with plugs (to close if not used) and the rope (to pull cables). The quality and standard of the cable duct provided has to be as per the latest QCS or Engineers approval.

9.3.8. Provide DB terminal box as per latest QCS.

9.3.9. All the signals shall be connected from the field instruments as per the I/O list. Ashghal approval shall be obtained on the connectivity protocol from instruments to RTU.

9.4. **Lagoon & EFA**

9.4.1. Submit RTU design and power supply arrangement for Engineers approval.

9.4.2. Samples of accessories for approval and all the required tests as directed by the Engineer.

9.4.3. Design, Supply, Test and Commission RTU panel and submit it for Engineers approval.

9.4.4. Programming the approved RTU to connect all the instruments from the field to Ashghal DNMC SCADA system. Obtain approval for the I/O list from Ashghal O&M and follow the programming template as directed by the Ashghal Engineer. Ashghal

shall provide the SIM card for connecting to DNMC SCADA. Program and connect all the signals to DNMC SCADA as per the Ashghal latest standards. The minimum signals to be connected shall not be limited to the monitoring, control, internal RTU bits, GSM module and connectivity bits, etc.

9.4.5. Supply, Install, Test and Commission all the wiring works from the field instruments till the RTU panel.

9.4.6. Construct concrete base of the RTU Panel /Solar Panel (if required as per the direction of the Engineer). The base to be build has to be as per the QCS 2014 standards. Provide ducts for the cables and ensure Duct for the Power cables are separated from the signal cables. Provide additional spare ducts with plugs (to close if not used) and the rope (to pull cables). The quality and standard of the cable duct provided shall be as per the latest QCS or Engineers approval.

9.4.7. All the signals shall be connected from the field instruments as per the I/O list. Ashghal approval shall be obtained on the connectivity protocol from instruments to RTU.

9.5. **Dewatering**

9.5.1. Submit RTU design and power supply arrangement for Engineers approval.

9.5.2. Submit the IO List and RTU configuration for Engineer's review & approval.

9.5.3. All the signals shall be connected from the field instruments as per the agreed I/O list. Ashghal approval shall be obtained on the connectivity protocol from instruments to RTU, from RTU to DNMC.

9.6. **Network Manholes**

9.6.1. In each location where new permanent monitoring equipment is required an RTU shall be provided and powered from the nearest local power source or solar panel to provide continuous power supply for the unit. Each RTU shall:

i. Communicate to the remote DNMC SCADA system instantly (where applicable and instructed by PWA Engineer) using 4G/5G technology or fiber optic.
ii. Be provided with a post feeder with transformer to feed the battery during the night time (to recharge the battery with continuous power during the daytime).

iii. Be provided with a fused and segregated mains supply (where applicable) with short circuit and earth leakage protection devices.

iv. Be capable of being accessed remotely for re-configuration of software and alarm settings.

v. Provide instantaneous level, flow, level alarm state, H2S, Water quality readings, water quality & H2S alarm, intruder alarm, and instrument fault and communication time out alarm to the DNMC SCADA as applicable at each location

vi. Send SMS notification for remote users on time without any delay

9.6.2. The data logger shall be used for temporary monitoring or as specified by O&M Engineer for the permanent monitoring location where it shall comply with specifications requirements listed in this document.

9.6.3. The data logger calling & sampling time shall be agreed with Ashghal's Engineer.

9.6.4. Install the RTU panel along with permanent power supply or a Solar panel as power source.

9.6.5. The solar power requirements and the battery calculation shall be submitted.

9.6.6. Samples of accessories for approval and all the required tests as directed by the Engineer

9.6.7. Design, Supply, Test and Commission RTU panel and submit it for Engineers approval.

9.6.8. Programming the approved RTU to connect all the instruments from the field to Ashghal DNMC SCADA system. Obtain approval for the I/O list from Ashghal O&M and follow the programming template as directed by the Ashghal Engineer. Ashghal shall provide the SIM card for connecting to DNMC SCADA. Program and connect all the signals to DNMC SCADA as per the Ashghal latest standards. The minimum signals to be connected shall not be limited to the monitoring, control, internal RTU bits, GSM module and connectivity bits, etc.

9.6.9. Supply, Install, Test and Commission all the wiring works from the field instruments till the RTU panel.

9.6.10. Construct concrete base of the RTU Panel /Solar Panel /UPS panel (if required as per the direction of the Engineer). The base to be build has to be as per the QCS 2014 standards. Provide ducts for the cables and ensure Duct for the Power cables

are separated from the signal cables. Provide additional spare ducts with plugs (to close if not used) and the rope (to pull cables). The quality and standard of the cable duct provided has to be as per the latest QCS or Engineers approval.

9.6.11. Provide DB terminal box as per latest QCS.

9.6.12. All the signals shall be connected from the field instruments as per the I/O list. Ashghal approval shall be obtained on the connectivity protocol from instruments to RTU.

10. RTU REQUIREMENTS

10.1. Supply, Install, Test and Commission a panel mounted RTU or RTU integrated into existing panels, including connection of any hardwired field signals as required.
The RTU solution shall consist of the following:

i. Rack
ii. Power Supply Card
iii. CPU Card
iv. Ethernet Card
v. GSM Card
vi. IO Cards as required

10.2. The RTU shall be compatible with the latest QCS and to the satisfaction of the Ashghal Common Control Section Engineer.

10.3. The RTU shall be compatible with the DNMC SCADA software.

10.4. The RTU panel shall be powered up with UPS system.

10.5. All electrical, civil and mechanical equipment and works shall be in compliance with QCS and to the satisfaction of ASHGHAL Engineer. Submit a minimum of three models/vendors for approval.

10.6. RTU specification

10.6.1. Communicate to the remote DNMC SCADA system instantly (where applicable and instructed by Ashghal Engineer) using Fiber Optic and 4G/5G technology.

10.6.2. Redundant Communication over Ethernet TCP/IP with the local PLC system

10.6.3. The RTU shall be made of compact or modular design and embed controller, monitoring and telemetry functionality.

10.6.4. RTU shall be new, reliable, and economic and use recent technology that will be supported for a considerable period in the future. There shall be means of extending

the facilities, such as I/O modules or data links, in order to allow for the collection of more extensive plant information.

10.6.5. The RTU enclosure shall be ruggedized, not in plastic and preferably made out of high-density aluminum material or similar

10.6.6. The RTU shall comply with:

i. High noise immunity and compliance with the most demanding norms
ii. High computing power
iii. Easy programming tools (Ladder Diagram, Function Blocks)
iv. High memory capacity
v. User-friendliness
vi. High security (Firewall, IPsec, HTTPs, SSH)

10.6.7. The RTU shall support operation specifications: -

i. Working conditions: -20°C to 70°C
ii. Storage conditions: -40°C to +80°C
iii. Humidity: 0 to 95% non-condensing

10.6.8. The RTU shall support installation on standard DIN rails

10.6.9. The CPU of the RTU shall operates on a 32bit processor

10.6.10. The CPU shall have a processor that can run in a real multi-tasking environment and must have sufficient memory in order to store:

i. Automation programs in a Ladder-Diagram type (minimum 64 Kbytes of program) and in BASIC
ii. Custom drivers (C, assembler, etc ...).
iii. Communication protocol drivers able to communicate with COM ports: RS232, RS485, Ethernet or modems.
iv. HTML pages for the visualization and command of the outstation from a remote Internet Browser.

10.6.11. The CPU shall have internal lithium battery for the CPU clock and memory with minimum lifetime of 5 years.

10.6.12. The CPU shall have LED indicators for ‘RUN’, ‘STOP’, ‘ALARM’ indications and hard reset select selector.

10.6.13. The RTU shall support watchdog and self-diagnostic features on the RTU functionality and communication debugging tools; and shall capable of generating error notification.

10.6.14. The RTU shall support the following communication capabilities with Tx/Rx indications: -

i. RS232 serial port
ii. RS485 2-wire port
iii. Networking Ethernet Port
iv. GSM-GPRS Cellular Modem
v. USB port

10.6.15. Each of the RTU communication port shall support various communication protocols.

10.6.16. All the RTU communication ports shall operate simultaneously and independently.

10.6.17. The GSM modem shall support 800/900/1800/2100/2600 MHz frequency band, with IP mode communication through APN and send/receive SMS function.

10.6.18. The GSM antenna shall be Omni directional outdoor antenna with 3 meter low-loss antenna cable

10.6.19. In standard firmware, the RTU shall support the following communication protocols:

i. Modbus RTU (Modbus RTU master and Modbus RTU Slave)
ii. Modbus ASCII
iii. Modbus TCP (Master & Slave)
iv. DNP3.0
v. SNMP

10.6.20. All standard communication protocol drivers shall be embedded in the RTU with no additional charge.

10.6.21. The RTU shall support the below communication protocols, but not limited to:

i. UA OPC
ii. IEC-60870

10.6.22. All communication protocol driver shall be free of charge.

10.6.23. The power supply module of the RTU shall support: -

i. +8 to 30 VDC input
ii. +85 to 265 VAC input
iii. Built-in battery charger - Max 13.8 VDC output to +12 VDC battery

iv. 24 VDC output

10.6.24. The RTU shall support CPU and communication redundancy

10.6.25. The RTU shall support I/O expansion module:

i. Digital Input
ii. Digital Output
iii. Analog Input
iv. Analog Output
v. RTD Input
vi. High-speed counting Input
vii. Relay Output

10.6.26. The RTU shall support external communication modules

i. GSM/GPRS
ii. PSTN
iii. ISDN

10.6.27. The RTU shall be able to be programmed and controlled locally as well from remotely through remote communication.

10.6.28. The RTU shall be able to send customized messages/alarms in text and data to multiple recipient (minimum 100 recipient) through the GSM network using the SMS technology (short message service).

10.6.29. The RTU shall be able to receive remote command by SMS text and acknowledgment of alarms by SMS using a mobile phone

10.6.30. The RTU must be able to log multiple data tags, in chronologies (Sequence of Event) and in Sampling Tables (periodical recording) with minimum time stamping of 1 second and storage of up to 100,000 records.

10.6.31. The RTU shall support integration of Internet technology: -

i. Embedded WEB Server
ii. Email support (POP3, SMTP)
iii. FTP (push)
iv. NTP (Network Time Protocol)
v. DynDNS
vi. NAT
vii. IP forwarding
viii. Ping request

10.6.32. The RTU shall be able to use standard Internet browser (I/E, Chrome) from Windows to view dynamic pages directly within the system, including to view all alarms (and acknowledge them), and to display the archives of the outstation through trend graphs.

10.6.33. The RTU shall be able to send data and statistical report (historical data and alarms) through the email with attachments or by FTP to several designated users by fixed schedule or by alarm triggering. The information shall be able to be analyzed off-line.

10.6.34. The RTU shall be able to perform CPU time clock synchronization with a NTP server through any communication port.

10.6.35. The RTU shall support the following notifications: -

i. RTU clock synchronization status with NTP server
ii. GPRS signal strength level
iii. GPRS network connectivity status

10.6.36. The RTU programming software shall include:

i. Logic programming:
ii. Programming languages: IEC 61131-3 Ladder Diagram; BASIC Function and Functions blocks
iii. Import/export of Function and Function block
iv. Real-time display of the program
v. Easy configuration through user friendly menu:
vi. Import/Export of Tags
vii. Communication port configuration
viii. IP services configuration
ix. Alarm conditions, recipients, messages
x. Datalogging conditions
xi. Periodical events
xii. Communication with remote devices (slaves)
xiii. All communication protocol drivers
xiv. Dedicated Report editor
xv. Dedicated HTML editor
xvi. Access Protection Level (User ID & Password)

10.6.37. The RTU shall be able to be programmed from a laptop by Ethernet, USB, GPRS or Serial communication.

10.6.38. The RTU programming shall use standard communication cable available off-the shelf (UTP, USB, RS232).

10.6.39. The RTU application software shall send the program's configurations and the communication protocol drivers to the RTU. The RTU shall store the configurations and communication drivers in its memory.

10.6.40. The RTU program shall be able to be retrieved from the RTU using the RTU's application software by locally or remotely, without the presence of the original program. All the tags, descriptions, configurations, communication drivers and logic programming shall be intact as per the original program.

10.6.41. The RTU shall have the latest communication, security & logging features.

10.6.42. The RTU shall be able to be programmed without license (evaluation/development mode) with full application features for a limited duration. The RTU shall stop the program from running after the duration has expired. The program shall, however, remain stored in the RTU memory.

10.6.43. The RTU application software shall be of hard dongle license. The dongle shall be of plug and play USB type. The license shall be registered to the dongle and shall not be transferable from the dongle.

10.6.44. The RTU application software shall be able to be upgraded to the latest version 'ON-LINE' from the OEM website free of charge.

10.6.45. The RTU shall have security features to secure the packet transferred or moved (Prevent unwanted access).

10.6.46. The RTU communication drivers shall be available to be downloaded 'ON-LINE' from the OEM website free of charge.

10.6.47. The RTU shall be connected to the local power supply via an earth leakage protection device.

10.6.48. Surge protection shall meet the requirements of IEEE 472-1974.

10.6.49. Total internal scan time interval for all inputs and outputs in an RTU shall not exceed 1 second.

10.6.50. The RTU shall have a watchdog function and full self-diagnostics capable of detecting and reporting faults to the master station and displayed locally.

10.6.51. The program structure and logic shall be as per standards, easy to understand, well documented in English, and as per Ashghal Engineer approval

10.6.52. The program shall include coding comments, clear names, titles, and tags and as per Ashghal Engineer approval.

10.6.53. The RTU programming software and license (dongle) and the soft copy backup of the programs shall be submitted to the Centralized Control Section in an Engineering Laptop of the latest specification as approved by the Engineer.

11. SOLAR SYSTEM REQUIREMENTS

The below describes Solar System specification as a reference and requirements. Ashghal reserves the right to approve changes on site-specific design requirements to ensure the consistency with these standards.

The Solar components, solar sizing, Battery Selection, Battery Autonomy calculation all shall submit to PWA CCS in the Design phase itself to PWA review and approval.

11.1. PV Modules

11.1.1. General Requirements

i. Modules to be used shall be reliable modules with a proven track record in performance and operation from an established manufacturer.

ii. Modules shall comply with IEC 61215 and IEC 61730-1,2. Modules shall only be used in applications corresponding to their declared class ratings.

iii. Only PV modules of class II as described in IEC 61730 shall be used.

iv. PV modules installed in coastal areas shall comply with IEC 61701 for salt mist corrosion.

v. All modules to be supplied shall be of the same type and from a single manufacturer. The Contractor shall be responsible for modules' arrangement to minimize the losses due to mismatching and maintain maximum power. Moreover, the quality of equipment supplied shall be generally controlled to meet the guidelines for engineering design included in the standards and codes listed in the relevant IEC and other standards.

vi. PV arrays with voltages greater than 50 V d.c. shall have bypass diodes, unless the manufacturer doesn't require them or if shading is not possible due to the design or the location characteristics.

vii. All transportation, storage, handling and installation of the modules shall be done in accordance with the manufacturer specifications; to not to void the module manufacturer is guaranteed.

viii. PV Module's Technical Requirements

Parameter	Requirement
PV technology	Crystalline silicon technology (mono or Poly)
Array rated power	≥ 240 Wp
Module efficiency	≥ 15%
Temperature coefficient on Pmp	≤ -0.45%/°C
Nominal power tolerance from module	+3%
Array maximum system voltage	1,500 V d.c.
Power output guaranteed during the first year of	Minimum 97%
Operation Degradation until year 25	Linear
Product warranty against manufacturing defects	Minimum 10 years
Wind load rating	Minimum 2400 Pa
Module certifications IEC 61215	IEC 61730-1,2 IEC 61701(for coastal installations)
Manufacturer certifications	ISO9001:2008 ISO14001:2004 OHSAS18001

11.1.2. Array Mounting Structure Requirements

i. Modules shall be mounted on a corrosion-resistant support structure made of suitable materials capable of maintaining structural integrity.

ii. There shall be the minimum necessary clearance between top roof (if used) level and bottom edge of PV modules.

iii. The array structure shall be designed to occupy minimum space without sacrificing the output from PV panels due to shadowing, orientation or tilt at the same time.

iv. Support structural material shall be corrosion resistant and electrolytic ally compatible with the materials used in the module frame, its fasteners, nuts and bolts, and mounting clamps should be stainless steel. The support structure shall be free from corrosion when installed.

v. Adequate spacing shall be provided between two panel frames and rows of panels to facilitate personnel protection ease of installation, replacement, cleaning of panels and electrical maintenance.

vi. Minimum clearance between lower edge of PV panel and ground/roof top ground level to allow ventilation for cooling; also ease of cleaning and maintenance of panels as well as cleaning of ground/roof top.

vii. The supplier shall specify installation details of the PV modules and the support structures with appropriate diagrams and drawings. Such details shall include, but are not limited to, the following;

a. Determination of true south at the site
b. Array tilt angle to the horizontal, with permitted tolerance
c. Detailed drawings for fixing the modules
d. Detailed drawings of fixing the junction/terminal boxes
e. Interconnection details inside the junction/terminal boxes
f. Structure installation details and drawings
g. Electrical grounding (earthing)
h. Inter-panel/Inter-row distances with allowed tolerances
i. Safety precautions to be taken

11.2. **Power Conversion Equipment (PCE)**

11.2.1. Power conversion equipment (PCE) are electric energy conversion devices such as d.c/a.c inverters and battery charge controllers. PCE in standalone solar PV systems optimize PV array performance and (for systems with batteries) provide optimal battery charging while protecting the batteries from overcharging.

11.2.2. General Requirements

i. All PCE shall comply with IEC 62109. PCE used as battery charge controllers shall comply with IEC 62509. PCEs shall also be qualified according to IEC 62093. Safety specifications of the PCE shall comply with UL 1741.

ii. CE certification for low voltage directive (EN 50178: 1997) is recommended.

iii. Battery charge controllers shall be used to control the battery charging process from the PV array, which complies with the requirements of the battery manufacturer, to ensure the maximum life of the batteries.

iv. The charger controller shall be compatible with the PV array and batteries being used in terms of rated current and voltage respectively.

v. Efficiency of the PV charger controller should not be less than 80%

vi. The PV charger controller shall be rated for at least 125% of the full rated current.

vii. The PV charger controller shall also provide reverse polarity protection for both battery and PV connection, over voltage protection and under voltage cut off.

viii. PCE ingress protection rating shall comply with IEC 62093.The charger controller should have easy-to-read indicators illustrating the battery's state of charge, including a light indicator that shows when the battery is fully charged and a series of light indicators to indicate the level of charge.

ix. Temperature compensation should adjust the charging current to the battery against varying ambient conditions.

x. The workmanship warranty of the solar charge controller shall be 5 years minimum.

xi. The Charge Controller must protect against short circuits in the charge terminal.

11.3. **Battery**

11.3.1. General Requirements

i. The batteries shall be solar photovoltaic batteries of the following types: deep-cycle lead-acid and made of hard rubber container or Lithium-ion batteries.

ii. Batteries shall comply with IEC 61427, IEC 60896 (BCIS-21 specification for non-spillable certification valve), and/or relevant BCI, DIN, BS and IEC standards.

iii. Lead acid batteries shall be installed and maintained in accordance with IEEE Std. 937-2007.

iv. The manufacturer's requirements for storage, shipping, installation, and safety shall be observed.The batteries shall use 2V cells and battery capacity is to be designed at C10/C20 rate with end cell cut off voltage of 1.75 V/cell.

v. Battery terminal shall be provided with covers.

vi. Batteries shall be provided with micro porous vent plugs with floats.

vii. Charging instructions shall be provided along with the batteries.

viii. Suitable carrying handle shall be provided.

ix. A suitable battery rack with interconnections & end connector shall be provided to suitably house the batteries in the bank.

x. The batteries shall be rated for operating in the environmental conditions in the State of Qatar.

xi. The self-discharge of batteries shall be less than 3% per month at 20 °C and less than 6% per month at 30 °C.

xii. The charge efficiency shall be more than 90%.

11.3.2. Technical Specification of the Battery:-

Sl.No	Parameter	Requirement
1	Battery technology	Deep-cycle Lead-acid battery/Lithium- ion battery
2	Rate of discharge	C/10 or C/20
3	Battery efficiency	≥ 90%
4	Operation temperature	-5 °C to 55°C
5	Self-discharge	less than 3% per month
6	Batteries enclosure IP rating	IP65
7	Product warranty against manufacturing defects	≥ 5 years
8	Workmanship warranty	Minimum 5 years
9	Quality and safety certifications	BCIS-21 (specification for non-spill able certification valve) IEC 61427-1:2013 IEC 60896 Other applicable BCI, DIN, BS and IFC Standards

11.4. **Inverter**

11.4.1. The solar inverter converts d.c. electrical energy generated by PV arrays (which may then be stored in a battery) into a.c. electrical energy.

11.4.2. General Requirements

i. Inverters shall comply with IEC 62109, IEC 62093, and the safety specifications of UL 1741.

ii. Inverters to be used shall be reliable inverters with a proven track record in performance and operation.

iii. The inverter selected shall be European standard certified.

iv. The inverters specifications shall be selected with respect to the local climatic and environmental conditions, especially regarding temperature, dust and humidity.

v. The output of the inverter shall be 240V (with standard tolerance level), 50 Hz single phase AC.

vi. If the load requirement is 3phased power, the inverter selected shall be tri-phased. A tri-phase inverter converts a DC input into a three-phase AC output. Its three arms are normally delayed by an angle of 120° so as to generate a three-phase AC supply. Recommended not to use 3 separate inverters unless agreed by Ashghal Engineer.

vii. The inverter shall incorporate suitable d.c./a.c. fuses/circuit breakers and a surge protective device. Fuses used in the d.c. circuit shall be d.c. rated.

viii. The inverter shall have internal protection against any sustained faults and/or lightening in d.c.

ix. The kVA ratings of inverters for the PV systems should be chosen as per the PV system wattage and should not be less than the total power rating of the loads.

x. The Inverter enclosure shall be weatherproof (IP65) and capable of surviving climatic changes and should keep the Inverter intact under all conditions in the room where it will be housed. Moisture condensation and entry of rodents and insects shall be prevented in the inverter enclosure.

11.4.3. The minimum technical specifications of the inverter are given below

No	Parameter	Requirement
Inverter Characteristics		
1	Inverter type	Standalone inverter
2	Maximum conversion efficiency	≥ 97%
3	European efficiency	≥ 97%
4	Operating temperature range	-5 °C to 55°C
5	Maximum DC voltage	1,500 V
6	Connection phases	One/Tri-Phase
7	Frequency	50 Hz
8	Total harmonic distortion	≤ 3%
9	Maximal current ripple	3% PP
10	Power factor	0.95 inductive to 0.95 capacitive
11	Minimum IP rating for enclosure	IP65
12	String failure detection	Required
13	DC overvoltage protection	Required
14	Surge protection	Required
15	Product warranty	≥ 5 years

11.5. **Balance of System (BoS)**

11.5.1. All BoS equipment shall be qualified according to IEC 62093.

11.5.2. Junction Boxes and Array Combiner Junction Box

i. The junction boxes shall be provided in the PV yard for termination of connecting cables. The junction boxes shall be made of fibre-reinforced plastic (FRP)/cast aluminium/copper with full dust, water & vermin proof arrangement. All wires/cables shall be terminated through cable lugs. The junction boxes shall be such that input & output termination can be made through suitable cable glands.

ii. Copper bus bars/terminal blocks shall be housed in the junction box with suitable termination threads.

iii. Junction boxes should be at IP65 rated and comply with IEC 62208. Hinged door with EPDM rubber gasket shall be used to prevent water entry.

iv. Junction box shall use single compression cable glands, have proper earthing and should be placed at a suitable height for accessibility.

v. Each junction box shall have high quality suitable capacity metal oxide varistors (MOVs)/surge arrestors, and suitable reverse blocking diodes. The junction boxes shall have suitable arrangement monitoring and disconnection for each of the groups.

vi. String/array combiner boxes shall incorporate d.c. string circuit breakers, d.c. array disconnect switch, lightening and over voltage protectors, screw type terminal strips, strain-relief cable glands, any other required protection equipment.

vii. String/array combiner boxes shall be secured onto walls or metal structures erected separately on the terrace.

11.5.3. D.C. Distribution Box

i. The d.c. distribution box shall receive the d.c. output from the array field with a measurement meter for voltage, current and power from different combiner boxes so as to check any failure in the array field.

ii. The d.c. distribution box shall be dust & vermin proof. The bus bars should be made of copper of desired size. Suitable capacity circuit breaker to be provided for controlling the d.c. power cable feeding the inverter along with necessary surge arrestors.

iii. The d.c. distribution box shall incorporate d.c. disconnect switch, lightening surge protectors, any other protection equipment, screw type terminal strips and strain-relief cable glands.

iv. The d.c. distribution box shall be wall mounted inside the control room.

11.5.4. A.C. Distribution Box

i. The a.c. distribution box shall control the a.c. power from the inverter and should have necessary surge arrestors. The interconnection from the a.c. distribution box to the mains at the LV bus bar shall be carried out. All equipment, sensors, and measurement devices shall be installed in the a.c. distribution box. An a.c. distribution box shall be provided at the cable terminating point emanating from the inverter for interconnection control of the dedicated electrical loads.

ii. The a.c. distribution box shall incorporate a.c. circuit breakers, surge protective devices, any other protection equipment, plant energy meter, screw type terminal strips and strain-relief cable glands.

iii. The a.c. distribution box shall be wall mounted inside the control room.

11.5.5. Cables & Wires

i. Cable Marking: All cable/wires shall be marked in a proper manner by good quality ferule or by other means so that the cable can be easily identified. All cable schedules/layout drawings shall be approved from the purchaser prior to installation. All cable tests and measurement methods should confirm to IEC 60189-3.

ii. All d.c. and a.c. cables shall be terminated using suitable crimped cable lugs/sockets and screw type terminal strips. No soldered cable termination shall be accepted.

iii. Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted.

iv. Conduits/concealed cable trays shall be provided for all d.c. cabling on the ground/roof. Conduits/concealed cable trays shall be adequately secured onto the ground/roof.

v. The d.c. and a.c. cables of adequate electrical voltage and current ratings shall be also rated for in conduit wet and outdoor use.

vi. The d.c. and a.c. cable size shall be selected to maintain losses within specified limits over the entire lengths of the cables. The maximum voltage drop should be limited to 1%.

vii. d.c. cables from array combiner box to d.c. distribution box shall be laid inside a cable duct where available or secured with conduits/concealed cable trays where duct is not available.

viii. d.c. and a.c. cabling between inverter and distribution boxes shall be secured with conduits/concealed cable trays.

ix. All cable conduits shall be GI/ high-density Polyethylene type or rigid PVC.

x. All cable trays shall be powder coated steel, GI, or equivalent.

xi. Multi strand, annealed high conductivity copper conductor should be used.

xii. PVC type ‘A’ pressure-extruded insulation should be used.

xiii. Overall PVC insulation for UV protection should be implemented.

xiv. Armoured cable for underground laying should be used.

xv. All cables shall conform to Ashghal and the relevant international standards.

xvi. All electrical cables/wires inside the building to be fixed in accordance with specifications for electrical works.

xvii. Proper laying of cables shall be ensured in appropriate cable trays, pipes / trenches as per site requirement.

xviii. a.c. supply cables shall be terminated at the distribution boxes.

xix. For laying/termination of cables, latest international codes & standards shall followed.

Sl.No	Component	Specification
1	String/array junction boxes	IP65, Protection Class II
2	Surge protective devices	Type 2, d.c. 1000V rated
3	Enclosures for inverters and charge controllers	IP65
4	PV module/string/string combiner box interconnects	MC4 compatible, d.c. 1000V rated
5	The central Inverter shall be rated for	IP65
6	The d.c./a.c. distribution boxes shall be rated	IP65
7	The data acquisition systems shall be rated	IP65
8	All d.c. and a.c. cables, conduits, cable trays, Hardware	Relevant International Standards
9	Earthing System	TN-S earthing system in accordance with IEC 60364

11.5.6. Auxiliary Systems

i. Fire Extinguishers

A fire fighting system for the proposed PV system shall consist of:

a. Portable fire extinguishers in the control room for fire caused by electrical short circuits.

b. The installation of fire extinguishers shall confirm to Qatar's Civil Defense regulations and international standards. Fire extinguishers shall be provided in the control room as well as on the site where the PV arrays have been installed.

ii. Lightning Protection

Where required, a lightning protection system shall be installed, wherever applicable and available to be connected.

iii. Earthing System

a. PV array structures, d.c. equipment, inverter, a.c. equipment and distribution wiring shall be earthed as required.
b. All metal casing/shielding of the plant shall be thoroughly grounded. In addition, the lightning arrester/masts should also be provided inside the array field.
c. Equipment grounding (Earthing) shall connect all non-current carrying metal receptacles, electrical boxes, and PV panel mounting structures in one long run. The grounding wire should not be switched, fused or interrupted.
d. The complete earthing system shall be electrically connected to provide return to earth from all equipment independent of mechanical connection.
e. Earth resistance should be tested in presence of the representative of Ashghal after earthing by a calibrated earth tester.

iv. Cooling System

a. The Contractor shall submit the heat Dissipation.
b. Air cooling system shall be used to reduce the heat dissipated by the Batteries and Inverter located within the same enclosure or area.
c. AC load calculation shall be considered in the Solar Power calculation.

v. System Documentation

A system manual shall be submitted with each standalone solar PV system that includes the following:

a. A complete equipment list for the system alongside the technical specifications and datasheets for each component.
b. Product quality certificates, from a certified testing laboratory, and manufacturer guarantee certificates, for PV panels, inverters, charge controllers, batteries, and any other devices used in the system.
c. A summary of the system specifications (including electrical protection equipment), load characteristics, and monthly system performance.
d. Electrical line diagrams for the system.
e. System operation procedures.
f. Emergency procedures.
g. Copies of engineering calculations and drawings.
h. Installation and O&M manuals.

12. DATA LOGGER SPECIFICATION REQUIREMENTS

12.1. The data logger shall be rugged, durable and suitable for the sewage application with all relevant ATEX approvals. The data logger shall be suitable for installation in Foul sewer, Surface ground water or storm water network

12.2. All data logger cables, connectors and accessories shall be suitable for the sewage application and shall be as per specified by the vendor.

12.3. Data loggers shall be reliable (life expectancy up to 20 years) and highly available (easily accessible in the market).

12.4. Data Logger internal battery shall have minimum life of 5 years.

12.5. Data Logger battery capacity shall be scalable

12.6. Data logger and all associated instruments & accessories shall be capable of being submerged with the sewage.

12.7. Data logger installation shall be simple and fast. The installation arrangement & accessories shall be supplied along with the data logger. It shall be possible to maintain the data logger from outside the manhole/chamber.

12.8. Data logger settings reset and network troubleshooting shall be possible remotely. Site visit shall be as minimum as possible

12.9. In addition to the above applicable requirements, the RTU shall have as minimum:

i. Not come with any proprietary software.

ii. Use standard industry water standard (WITS) and standard DNP3, OPC UA and MODBUS

iii. Bi-directional

12.10. The data logger shall have the capability of sending data to multiple remote servers.

12.11. The Data Logger software/applications provided shall be compatible with VMWARE and Hot-Standby configuration. If the provided system/software does not support hot-standby configuration, then the software has to be able to be configured as highly available or as cold backup solution (VM machines will have backup, which can be restored within 1 minute when primary node fails).

12.12. Data Logger shall be communicating with DNMC SCADA historian or DNMC ODW. In case data logger has its own application, It shall be no data time delay between the application and DNMC SCADA/ODW. All data, warning, events and alarms shall be able to send to DNMC from data logger.

12.13. The data logger shall have built-in modem 4G/5G and capable to be connected to a fiber optic network.

12.14. The data logger shall be able to be powered from Battery, Solar panel and Kahramaa.

12.15. The data logger shall be capable to send Historical & actual data

12.16. Data logger settings/parameter shall be able to be adjusted remotely from DNMC

12.17. Data Logger shall be able to be accessed remotely to check the current sensors readings, settings parameters and the user will be able to edit/modify the sensor channel settings.

13. INSPECTION, TESTING AND ACCEPTANCE PLANS

13.1. Inspection, testing and site acceptance testing requirements shall comply with all relevant portions of the original contract.

13.2. Develop System-wide Inspection, Testing, and Acceptance Plans

13.3. The plans shall include the requirements for the inspection, testing and acceptance of the RTU communications system.

13.4. Provide a Test Plan and detailed Test Specification for each IO signal and other system features & functionalities.

13.5. Provide equipment, instruments, qualified personnel necessary to inspect the work and perform the tests required by the Contract Documentation to validate that the system implementation complies with the approved plans and designs.

13.6. All inspections and tests shall be conducted in accordance with written test procedures as detailed in the Quality Management Plan and Inspection and Test Plan that have been reviewed and approved by the Ashghal Engineer.

13.7. Approved procedures and instructions shall be readily available and used by inspection and test personnel at the time of inspection or test. All revisions to these procedures and instructions shall be approved prior to being used to inspect or test the work.

13.8. Furnish the Ashghal Engineer with a signed and stamped inspection report for each item of work to be inspected. The report shall indicate whether the item of work, material and/or equipment complies with all the inspection/test criteria, within a maximum 2 days after testing.

13.9. Repeat tests and inspections after correcting non-conforming work until all work complies with the requirements. All re-testing and re-inspections shall be performed at no additional cost to Ashghal.

13.10. Inspections and tests conducted by person or agencies other than the Contractor, shall not in any way relieve the Contractor of the responsibility and obligation to meet all specifications and referenced standards.

13.11. All test instruments shall hold a valid calibration certificate

14. DOCUMENTATION

14.1. Provide O&M Manual including special tools which shall contain, but is not limited to:

i. Product Manual
ii. Manufacturers' final documents and certifications
iii. Manufacturers' Operation & Maintenance guidelines
iv. Part lists and equipment drawings
v. Complete license & software details
vi. Complete PLC/RTU/SCADA program backup
vii. RTU Software engineering license
viii. Special tools to be able to connect to new added devices (RTU, Switch, etc.)
ix. All design specifications and standards developed or provided during or related to the Project
x. All training manuals and materials developed or provided during or related to the Project
xi. System architecture diagrams
xii. New Added / Modified Existing Panel GA and internal wiring
xiii. Communication system details
xiv. Vendor equipment manuals
xv. Software files and documentation including version control details
xvi. Other information as may be identified in the course of the project
xvii. ATEX Certificates
xviii. Contact Details of the Product regional Office and Local Agent.

14.2. Incorporate all Ashghal comments from each approved draft submission and submit as a final O&M manual.

14.3. Prepare all draft and final system documentation in an electronic format and that complies with a formatting guide that will be provided to the selected Contractor by Ashghal O&M.

14.4. In general, all content must be in its native file format and/or native PDF format. Scans of Contractor-produced or vendor documents will not be accepted.

14.5. Prepare and submit an Asset Register for all permanent install equipment as per Ashghal approved procedure.

14.6. Complete asset tagging on all permanent install equipment as per Ashghal approved procedure

15. TRAINING REQUIREMENTS

15.1. Provide both "classroom" and "hands-on" training in the programming, installation, operation, and maintenance of the new RTU communication

15.2. The trainer shall be from the OEM and not the trader or dealer of the product and shall be certified to provide training services for approved product.

15.3. Training requirements shall comply with all relevant portions of the original contract and QCS 2014 Standards requirements.

16. WARRANTY REQUIREMENTS

16.1. Ensure the equipment to be free from defects in materials and workmanship

16.2. Warranty services shall comply with all relevant portions of the original contract

16.3. The Contractor shall be solely responsible for the warranty.

16.4. Provide manufacturer’s guarantee and warranty certificates for all equipment, duly registered with the manufacturer, prior to handover and final acceptance.

16.5. A warranty period of minimum 400 days from the date when item is placed into full time operation or issue date of the completion certificate.

16.6. Any defects in the material shall be replaced as soon as possible and without major impact in system operation.

16.7. Items that fail during the warranty period excluding expendable items shall be replaced without cost to the owner.

17. SPARE PARTS

17.1. Provide recommended spares during the maintenance period and in addition shall provide sufficient spares for 2 years of operation on issue of the PCC.

17.2. Ashghal GSD and the relevant Engineer’s signed Spare part list shall be incorporated in the Ashghal Submission O& M Manual.