REPUBLIC OF YEMEN

MINISTRY OF AGRICULTURE AND IRRIGATION

IRRIGATION IMPROVEMENT PROJECT

(IDA Credit No. 3412 – YEM)

Main Technical Assistance Package for IIP

WORKING PAPER 5[A]

ANNEX (REVISED)

Flood Warning System
System Specification

June 2003

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Contents

1 INTRODUCTION

1.1 OBJECTIVES OF FLOOD WARNING SCHEME

The traditional water rights in spate irrigation areas in Yemen are governed by the *Sharia'a law*, which embodies the principle of *Ala'ala Fala'ala*. The principle gives precedence to upstream users both between and within diversion structures and canal systems. The upstream user has the first right to full irrigation (ankle deep) before allowing the water to flow downstream. In Wadi Zabid a spate flow diversion calendar is applied between diversion structures whereas the *Ala'ala Fala'ala* principle is applied below each diversion structure.

The lower areas benefit from the excess flows that cannot be fully diverted upstream. As the high peaks have short durations often the lower farmers are not ready to utilize these flows when they arrive, as they did not have a sufficiently early warning of the incoming flows. An early flood warning system will not only result in better utilization of spate water but will also give time for undertaking protection measures for the safety of the irrigation and rural infrastructure from flood damages. The early warning information will allow better and timely coordination of activities during floods including the operation of diversion gates in a more timely and efficient manner.

Much of the sediment is transported during the higher flows, and closure of head regulator gates during such conditions can substantially reduce the entry of sediment into the canal systems. However, closure of these gates during small floods can substantially reduce the amount of water being diverted.

1.2 SCOPE OF FLOOD WARNING SCHEME

The Supervisory Control and Data Acquisition (SCADA) system required for this phase of IIP to provide automatic monitoring and control is being set up as a pilot for testing its operation and sustainability. This trial will be undertaken for the two irrigation areas of the Wadi Zabid and Wadi Tuban systems.

There are two basic requirements of the flood warning system:

- Monitor data from the catchment of the irrigation schemes that will be an indication of possible flood flows;
- Dissemination of the warnings within the schemes.

The Flood Warning system shall interface to the Management Information System (MIS) and the Spate Management Model (SMM).

2 SCOPE OF WORKS

2.1 GENERAL

The following outlines the Scope of Work.

The work included within the Contract is for the design, manufacture, testing, delivery to site, commissioning and setting to work of the Flood Warning SCADA system, including, but not limited to:

1. Detailed design of the complete Flood Warning SCADA system including masterstation computers, communications system and remote data gathering outstations to enable the requirements of this specification to be met.
2. The design and supply of all associated computer hardware, software and peripheral devices for two Control Centres, one for Wadi Zabid area and the other for Wadi Tuban area to enable the requirements of this specification to be met.
3. The provision of all necessary software, licences and back-up copies of all bespoke software for the implementation and continued operation of the Flood Warning Scheme.
4. The supply of all necessary power cables and interconnecting wiring to all items of equipment supplied under this Contract and to plant not supplied but required to be monitored.
5. The supply of all communications hardware and software to enable the download of data from the Flood Warning SCADA system to the following systems over a PSTN communications circuit.
   a. Management Information System (MIS)
   b. Spate Management Model (SMM)
   c. National Water Resources Authority (NWRA)
   d. Tihama Development Authority (TDA)

   The data shall be downloaded on an as requested basis from the SCADA system supplied to the MIS, SMM, NWRA and TDA systems in the appropriate formats. In addition the SCADA system shall enable remote users, with the correct level of access, to log on and download data as necessary.
6. The supply of flood monitoring and flood alert control equipment and control software at the following locations:
   a. Flow monitoring station at Kolah in Zabid
   b. Wadi level station upstream of Kolah in Zabid
   c. Flow monitoring station at El-Dukeim in Tuban

   d. Wadi level station upstream of Aqqan in Tuban
   e. Wadi level station along Wadi Billa in Tuban
   f. Flood alert stations at Weirs 1 and 3 for Wadi Zabid
   g. Flood alert stations at Al Arais and Ras al Wadi weirs for Wadi Tuban
   h. 4No Rain gauge stations to be installed in the Zabid and Tuban catchments
7. The supply and setting to work of level measurement instrumentation.
8. The supply of housing to protect all equipment for each site and provision of solar panel cells and batteries to maintain continuous operation of the site throughout the year.
9. The supply of UPS and batteries to maintain continuous operation of control centre equipment.
10. The supply of all necessary earthing and surge protection equipment at all locations.
11. Full configuration of all components of the flood monitoring scheme.
12. Factory Tests of the full flood monitoring control system.
13. Site Acceptance Tests (SAT) and commissioning of the full flood monitoring control system, communications system and all remote instrumentation.
14. Supply of comprehensive installation, operation and maintenance manuals
15. Supply of manufacturers data and documentation for all hardware and software provided.
16. Provision of installation support and training
17. Supply of spares
18. Supply of all specialist test equipment
19. Supply of consumables for 2 years operation following system handover
20. Supply of 35 GSM mobile handsets for use by the field operators and supervisors

3 FLOOD WARNING SCHEME SYSTEM REQUIREMENTS

3.1 GENERAL

The function of the Flood Warning Supervisory Control and Data Acquisition (SCADA) system is to provide early warning information to allow the control of irrigation structures and gates in a more timely and efficient manner. Data are to be gathered from remote monitoring stations upstream of the structures and from rain gauges in the catchment areas to provide an indication of the severity of a pending spate in the wadi. The flood warning SCADA system will then transmit this information so that appropriate action can be taken before the flood reaches the irrigation control structures.

3.2 USER REQUIREMENTS

The User requirement for the flood warning system can be summarised as follows.

- The existing gauging stations at Kolah and El Dukeim are to be supplemented with automatic monitoring equipment that can transmit the data to a flood early warning SCADA system on an as needed and a 'real time' basis.
- The data gathered from the gauging stations is required to be made available from the SCADA system to the MIS, SMM and to NWRA and TDA.
- Water levels in the wadis upstream of the irrigation structures are required to be monitored in 'real time' in order to provide approximately 2 hours warning of a flood arriving at the structures.
- Rain gauges in the catchment areas are monitored in 'real time' in order to assist in the determination of a possible flood condition and an assessment of the severity of the flood.
- The flood warning SCADA system is required to assess the severity of any possible flood.
- The flood warning SCADA system is required to alert appropriate personnel of any impending flood and an indication of its severity.
- The flood warning is to automatically send out voice messages and/or SMS or take other action for pre-determined events.

3.3 OVERALL SYSTEM CONFIGURATION

The SCADA system configuration shall be based on a central control system that shall communicate to a number of remote terminal units (RTUs) out in the field primarily over the Global Satellite Mobile (GSM) network or by satellite telephone systems if GSM access cannot be achieved. An identical SCADA system configuration is required for both the Wadi Zabid and Wadi Tuban systems.

The SCADA computer will be focus of the system. It will receive data from RTUs in the site. This data will be processed by the SCADA system to determine the probability and severity of a flood condition. If a flood is predicted, the SCADA system will output flood warnings to the RTUs at the weir sites and also send messages to the fixed or mobile telephones of appropriate personnel. In addition the SCADA system shall display graphical mimics of all remote sites and their communications status. Mimics shall consist of links to current and historic site data that shall be available for operator use.

The RTUs at the remote sites will interface to the local instrumentation such as level devices or rain gauges and transmit data to the control centre either on demand or at a frequency as set in the SCADA system. The data shall be logged by the RTU for download to the SCADA system, the RTU shall be capable of storage of up to 8 days between downloads of data to the SCADA system in the case of communications errors. The data are required to review instantaneous information or to build trends of historical data.

Communication between the RTU and SCADA system will, in general, be via mobile GSM telephone network but in some locations where GSM mobile access cannot be achieved satellite telephone systems will be employed.

The SCADA system will be able to display current and historical data gathered from its RTU. It will also be able to download these data to other system such as MIS, SMM, NWRA and TDA using standard communications modems over the national public switched telephone network (PSTN).

The SCADA system shall be designed to operate on a continuous basis automatically gathering, logging and archiving data without manual operator input or supervision.

4 CENTRAL CONTROL SYSTEM

4.1 GENERAL

The central control system shall include all the equipment and software necessary to provide the flood warning functional requirements. The system shall include:

- Central processing unit
- Operator interface
- Communications controllers and modems
- Archive data storage
- Record and alarm printers
- Proprietary software (and licences)
- System software developed for this project
- Dedicated Uninterruptible Power Supply (UPS)
- Desk/workstation in control room to site PC based equipment
- Communications racks to house GSM, PSTN modems

Two SCADA systems shall be supplied, one for the Zabid irrigation system and the other for the Tuban irrigation system. Each system shall operate independently with the equipment located at different sites.

However the applications software and the system configuration shall be designed such that at a date in the future the two systems can be moved to a central site where they will operate in a main/standby arrangement (with the minimum of modification to hardware and software), capable of controlling both the existing areas plus an additional 5 schemes as the flood warning system is expanded.

The system shall also be capable of receiving, storing and distributing data from additional similar outstations installed by the Employer or other parties under separate Contracts.

4.2 SYSTEM FACILITIES

The facilities provided by the SCADA centre should include:

- Receive alarm warnings from measuring stations
- Include processing techniques to evaluate flood profiles, generate flood alarms and estimate flood volumes
- Transmit flood alerts to the diversion weir structure location both automatically and/or with the requirement for operator confirmation
- Transmit voice and SMS text messages to mobile and fixed telephones

- Allow operator to generate a flood alert
- Allow operator to send messages to text display units at the weir stations
- Reset warnings sent to weir locations
- Have bilingual (English / Arabic) capability in messaging and user interfaces
- Record and archive all level data and rainfall data received from monitoring sites
- Automatically receive download of data from measuring and monitoring sites every 24 hours and check all stations are operating correctly
- Alert operator when fault detected at any station
- Alert operator when any measuring site indicates a potential flood. Alert to be initially by local buzzer but if the alarm is not acknowledged within a predefined period set off a siren in the control centre site
- Provide flood warning system map as a mimic, a mimic of each site, charts and graph of both current and archived data held on the system
- Allow operator to interrogate any measuring or monitoring station from its associated mimic page at any time to obtain current data
- Have forms for input of data from weather observers and store the data for future analysis
- Include communication modems to enable other PCs to access all current and archived data subject to security password protection. This facility to be mainly available for interfacing to MIS and SMM and for access by TDA and NWRA.
- Contain text fields and online help for the operational plans to assist operators to direct the correct actions to the correct parties in various flood scenarios (note the text will be input by operators/supervisors as the operational procedures develop over time).
- Include the capability of undertaking validity checking of measurement and monitored data prior to archiving.
- Allow remote download via telecom lines of appropriate data to the MIS, SMM, NWRA and TDA systems in the appropriate formats from the SCADA system, including the facility for remote users, with the correct level of access, to log on and download required data.

4.3 SYSTEM HARDWARE

4.3.1 CENTRAL PROCESSING UNIT

The central computer system shall utilise a standard commercially available Personal Computer (PC), which has a clock speed and memory capacity suitable to undertake the specified functionality for the initial trial phase of two irrigation/catchment areas and be capable of being expanded to a total of seven irrigation/catchment areas in the future.

The Central Control System shall comprise a PC based system operating a SCADA type data monitoring and control package on a commercially available operating system such as Windows 2000. The equipment chosen shall be designed to operate unattended and continuously at all times in a non air-conditioned office environment in the Yemen.

The requirement is for a centralised SCADA system.

All equipment required to fulfil the requirements shall be industry standard proven computing equipment with a demonstrable long-term life cycle and support.

To permit other manufacturer's equipment, e.g. other RTUs, to be added to the SCADA system, all equipment shall interface using open-system communications protocols.

The strategic importance of the SCADA system requires a high level of system availability, i.e. not less than 99.9% availability for each calendar year. The SCADA system shall therefore be provided with an Uninterruptible Power Supply (UPS).

The SCADA system shall be provided with, or connected to, a UPS capable of supporting all the main computer equipment (central processing units, discs, communications processors etc.), operating consoles and the alarm/event printer for a period of not less than 8 hours. The UPS shall be sized to cater for a 50% increase in load without the need for additional hardware.

The system implemented should be able to operate within the control strategy described but shall be flexible enough to be easily changed should the control philosophy change.

The proposed system shall provide:

- A centralised data management (masterstation).
- Communications to RTUs via GSM dial-up connections.
- Distributed intelligence using microprocessor based remote terminal units (RTUs) for monitoring and data logging. Under normal operating conditions, the RTUs shall monitor and control plant to given schedules and record the installation's operational/performance data e.g. flow, level etc.
- The RTUs shall have programmable alarm limits for discrete and rate of change settings. This shall apply to both real and derived values. There shall be a facility for high and low priority alarms, e.g. low, very low, high and very high.

In the event of communications failures, the RTU shall be capable of holding a minimum of 8 days worth of data as follows:

Analogue; totalised and derived signals - on significant change/15 minute intervals.

Digital signals on change of state.

The data gathered from RTUs shall be incorporated into the SCADA database and shall also be made available to applications programs written by the client.

Where RTUs are programmed to perform local control of plant it shall be possible for the programmes, schedules, set-points etc. to be downloaded from the SCADA masterstation. Subject to being assigned suitable privileges, system users shall have the facility to make short term alterations to RTU control schedules via the control centre, e.g. to implement remedial action when an alarm occurs.

SCADA control shall be effected at two levels, these being:

- RTU local control via programs stored locally at the RTU, e.g. fallback control.
- Supervisory control from the control centre. An authorised user at the control centre shall be able to modify control routines at any RTU by downloading new control (start/stop) schedules and performance criteria.

There shall be a capability to download control programs and schedules to the RTUs from the masterstation via the communications network.

The preferred method of communication with the RTUs shall be stated in the communications specification. As future developments may require different forms of communication at specific sites, the equipment shall be capable of operating in all modes with minimal software changes.

4.3.2 SCADA EQUIPMENT

The SCADA equipment shall be provided with all necessary communications equipment to support:

- All operator workstations.
- All printing devices.
- The communications network

Data Storage

Each master station shall be provided with the following storage media:

- Random Access Memory - to store the "real-time"/instantaneous database.
- Hard discs - mirrored dual hard disk configuration synchronised to enable operation to continue if one hard disk fails - to store the system configuration, mimics and local short-term (70 days) historical database etc.:
  - Digital points on change of state
  - Analogue points at 15 minute intervals
  - Derived points
- CDR / RW - to store off-line (greater than 30 days old) historical database, system backups, data transfer etc.
- IBM PC 3.5 inch flexible diskette - to transfer data to off-line PC equipment.

Operator Workstations

The control system shall support fixed user workstations that shall have the facility to provide remote RTU programming.

The fixed workstation shall be used as the primary located in the Operations Centre and shall include a keyboard, optical mouse and high definition colour graphics display.

Monitor Screen Requirements

The screen shall be a liquid crystal display with a minimum of 17" diagonal viewing area, 16.7 million colours, and a resolution of 1.3-mega pixels, (1280 x 1024 pixels) with dot pitch of at least 0.26mm. The screen shall provide flicker-free, legible displays that can be observed for long periods without fatigue, horizontal frequency 24-60 kHz and vertical frequency 56-75 Hz. The screen shall have easy swivel and tilt mobility.

The screen shall be non-reflective and have a minimum contrast ratio of 400:1 and a brightness of 250cd/m^2.

The specific performance shall be maintained over the full ambient temperature range and range of power supply variations.

The workstation shall have a structured, segmented, multiple window screen. A window is defined as an area of the screen through which the user can view any display produced by the system.

Use of a WIMP (Windows Icons, Mouse and Pull-down Menus) environment shall be preferred as long as this does not compromise other requirements of this Specification.

The keyboard shall be a standard QWERTY type unit with the keys engraved with both English and Arabic lettering.

A mouse shall supplement the keyboard to enable scroll and select functions.

Input Devices

The system shall be capable of supporting the following types of input device:

(a) Keyboard including 'soft' function keys and cursor control keys.

(b) Optical mouse or trackerball.

User's keyboards shall be supplied which shall be separate from the display, have matt, non-reflective surfaces and well-contrasted symbols.

In addition to any function keys, there shall be alpha characters and numeric characters arranged in a standard 'QWERTY' layout and a numeric keypad area to the right. Each key shall be engraved to identify its function.

Cursor control facilities shall be provided by mouse, or as an alternative, by a trackerball.

The cursor control input devices shall be integrated with the keyboard function in a logical and consistent manner.

Printing Devices

The SCADA system shall be provided with two types of printing device:

REPORT PRINTER: A4 monochrome laser printer to provide a hard copy log of all operator/manager requested reports.

Colour Printer: A4 colour laser printer to provide high quality printed output for report summaries, programme development, copies of mimic displays, historical trends etc.

Remote Data Transfer

The SCADA system shall be capable of processing the data received from operational sites e.g. into daily minimum, maximum and means, and forwarding the raw and processed data to off-line packages e.g. Excel

SCADA System Features

General

The SCADA system required should constitute a proven system supplied with proven software.

System Access

Users of the SCADA system shall be allocated individual passwords allowing each user an appropriate level of access commensurate with their requirements, responsibilities and areas of knowledge and interest.

Three general categories of access have been identified:

- Data only
- Data and Control
- Data and System Management

Data only shall be generally available to all system users. Data and control shall be limited to those personnel with the knowledge and responsibility to take control actions.

Monitor Screen Display

The following display types shall be available on all screens:

- Mimic diagrams
- Help pages
- Graphs
- Bar charts
- Alarm and event log listings
- System configuration and maintenance displays

Mimic Diagrams

Mimic diagrams are required to present a pictorial representation of the plant and its present status. Features required are as follows:

- Display of fixed (background) diagrammatic plant information and text.

- Display of variable information i.e. symbols or text displaying plant status
- Easy picture creation.

Display of Variables

Variables can be considered as digital on/off parameters, analogue or totalisors.

Digitals may be either status (e.g., running/stopped) or alarm points, and shall be displayed by:

- Text changing
- Symbol colour changing
- Symbol shape changing
- Text or symbol flashing

It must be possible to associate more than one digital point with a symbol, so that more than two colours/shapes can have operational meaning. For example, an outstation may be shown in four colours indicating running/ stopped/ failed/ non-operational.

In addition, it shall be possible to associate any number of symbols within different mimics with a particular digital point.

Analogues and totalisers shall be displayed by:

- Numeric value
- Bar chart
- Graph

It shall be possible to display all these three types of indication in mimic diagrams. Colour changes shall be used to indicate further information about a point, e.g. if an alarm limit has been exceeded.

Display Attributes

Using the display facilities described above, the mimic diagrams shall indicate the following attributes for analogue, digital and totaliser points:

Attribute	Point Type
Status On/Off	Digital Status
Alarm/Normal	Digital Alarms
1st Stage Alarm (High, Low)	Analogues
2nd Stage Alarm (High-High, Low-Low)	Analogues
Communications Failure	All
Alarm Manually Suppressed (out of service)	All
Alarm Automatically Suppressed	All
Out of Range	Analogues

Picture Creation

It is essential that picture creation is straightforward; a CAD type package would be suitable. It must be possible to create symbols which may then be

used in any orientation, size and colour and to create a symbol library, i.e. a part of a diagram which may then be used many times. It must be possible to display, on any single mimic diagram, information from anywhere within the SCADA system.

Help Pages

Help pages shall be available within the system, to assist the operators in dealing with received alarm conditions. These pages will be compiled by the managers and will provide advice as to which staff shall be notified of which alarms.

Help pages may be presented as individual pages accessed from a mimic, or as a window superimposed on a mimic.

Graphs

Graphical representation of historical data is required, with a selectable time base and the ability to put up to four graphs on display at once on the same axes, using different colours.

The system must be easy to use, with automatic default facilities so that only a minimum of instructions need be given to the system to obtain each plot.

Features that will be required are:

- Pre-configured and ad-hoc trend displays.
- Ability to compare graphs over different time spans, e.g. today's flow compared against yesterday's flow.
- Read-out of the actual value of a graph at a given time point.
- Ability to roll a graph forward and backwards in time.
- Ability to set the scale for each graph.
- Trend graphs giving a plot of the selected variable up to the last scan, updating when a new value is received.
- Ability to incorporate a trend graph as a feature on a mimic diagram.
- Graphical output of both analogue and digital signals (real and derived). Digital signals will produce a square wave type plot.
- Auto ranging scale unless manually overridden.
- Ability to display data from different sites within the same trend display

Bar Charts

A bar chart type representation of analogue variables is required. This is required on mimic diagrams, and must be capable of horizontal or vertical orientation, with selectable scaling.

Alarm and Event Log Listings

All alarms and changes of status (i.e. digital events) in the system shall be logged to disc. It shall be possible to recall this information to the screen via a select and sort programme. This programme shall sort and display information on at least the following bases:

- Process Area
- Site type

- Site name
- Time period
- Signal identification numbers
- Signal state (on/off)
- Alarm status i.e. cleared, accepted and unaccepted.
- Alarms or status occurrences required

System Set-up and Maintenance Displays

Suitable displays of information shall be provided to display all set-up features of the SCADA system. These displays will be closely associated with the SCADA system set-up facilities.

Logging On/Off

Every user of the SCADA system shall be required to log on (i.e. activate) his terminal when he wishes to operate on it. The system will be aware of which terminals are logged on and the access rights of the user and will therefore be aware of where to send certain information.

Alarm Facilities

General

Digital points within the SCADA system shall be capable of operating as either status (e.g. water/dry) or alarm points (e.g. normal/failed). A digital alarm point shall enter the Alarm State when it is either a logical `1' or logical `0' as designated in the system set-up for each point, the opposite state being the normal condition.

Analogue points shall be provided with two high alarm limits (high and high-high), and two low alarm limits (low and low-low). Should an analogue value either rise or fall from a value considered to be normal, a first stage high or low alarm limit will be encountered resulting in a new alarm condition. Should the value continue to rise/fall it will then encounter the second stage high-high or low-low alarm limit again resulting in a new alarm condition.

Alarm Priorities

Every alarm generated within the SCADA system shall be allocated a priority to indicate the importance. Whereas a digital point will have only one alarm priority, an analogue point will have three. This will allow the relative importance of the first and second stage high and high-high (low and low-low) alarms to be set. The alarm priority is used in conjunction with the ‘area of interest’ of the users logged on the system to determine where and when a new alarm is annunciated. The priority of an alarm shall change if required depending on the time and date.

Alarm Annunciation

Alarms are to be annunciated on the appropriate operator workstations both visually and audibly, and have clear and unambiguous acceptance procedures. High priority alarms shall be presented for acceptance before low priority ones.

Alarms Filtering

The SCADA system shall have a "tool-kit" of facilities that may be applied to individual points in the system in order to prevent unnecessary annunciation of alarms. These shall typically include:

Analogues:

- dead-band
- delays before initial alarm
- minimum alarm repeat interval
- logical suppression of new alarm if other conditions are present
- averaging values in RTU

Digitals:

- delay before initial alarm
- minimum alarm repeat interval
- logical suppression of new alarm if other conditions are present

Users, subject to authorisation (i.e. correct level of access), shall be able to manually suppress an alarm, e.g., if a transducer is faulty. Suppression of alarms shall be logged to the event list.

Derived Alarms

A combinational and sequential logic package is required within the SCADA system, allowing signals to be combined to form derived alarms. These may be combinations of analogue and digital information obtained from different sites.

Historic Information

RTUs will sample and store values of analogue parameters at predetermined intervals to cater for loss of communications. These will normally be 15 minutes but shall be user configurable between 1 minute and 24 hour intervals. Note requirement to change sampling frequency when observations exceed pre-set thresholds.

Master station

In addition to the raw operational data, a long-term archive of analogue max/min/mean values etc. will be maintained. Values stored will be as detailed within the Particular Specification SCADA.

Controls

Manual Control

It shall be possible to perform control operations from any of the operator consoles. Access to controls will be limited by the access rights assigned to the individual passwords for various operatives (see System Access).

The issuing of control instructions shall take precedence over scanning for alarms.

A well organised select check and execute system is required.

Automatic Controls

Automatic control features shall be available within the SCADA system, and fall into two categories:

Combinational and sequential control:

The package used for alarm derivation will also fulfil automatic control requirements. The following shall be provided as a minimum:

- Logical AND/OR/NOT/EXOR/EQUALS
- IF-THEN-ELSE Constructions
- Arithmetic operations including >, $, >, #, =, +, -, H,), /.
- Logical constructions including time and data
- Look-up tables, with interpolating facilities
- Input to functions from any system point including digital, analogues, totalisors, controls from a keyboard, set-point input from a keyboard.
- Output from functions to be available as digital, analogue or totaliser points, or transmitted to any RTU as a control or set point.
- Access to point attributes in addition to present value, including:
- Suppressed, SCADA failed, in alarm (and for analogues, which alarm level).

Terminal Time-out

When a terminal is used for any purpose, it shall have to be logged on specifically for that function. If it is not used for a user configurable period of time (e.g. 5 minutes) in this mode, it shall automatically revert to a display only mode. A warning should be provided one minute prior to the auto log off.

System Record

A record shall be kept on disc within the SCADA system of all operator actions, such as alarm acceptance or control actions performed on the system. The record shall include:

- Time and date
- Action
- Operator

This record shall be retrievable from the system using a similar select and sort routine to that specified for status and alarm logs.

Report Generation

The SCADA system shall be capable of generating both regular and individual reports. Reports must be easily configured and altered in order to maintain their relevance.

An example of a regular report which may be produced from the system is the following, designed to be made available each morning:

- River flows
- Rainfall: previous day
- Rivers: level
- Alarms that have occurred during the night

SCADA System Time

The SCADA system shall support:

- Greenwich Mean Time (GMT/UCT).
- Daylight Saving Time (DST).
- Leap Years.

- All data shall be logged at GMT/UCT + 3 hours, but automatically displayed in the appropriate local time adjusted for daylight saving.
- SCADA System Database Configuration
- The SCADA system shall be provided with privileged and secure on-line database building utilities i.e. it shall not be necessary to stop the scanning and alarm presentation facilities. Any configuration shall not be installed into the active database until completed, verified and authorised by the user. A reliable verification procedure shall be required to prevent the creation on invalid files and the deletion of in-use files.
- It shall be possible to define process point files, calculated/derived point files, remote SCADA files, to include:
- Meaningful point identification and description
- Allocation of points to groups/locations
- Range of analogue values in Engineering Units
- Alarm limits/categories
- Scan control/frequency
- Report control (whether change of state is to be logged to the alarm/event printer)
- Save control (whether values are to be archived)
- MIS control (whether values may be transferred to other systems)

System Response Times

The SCADA system provided shall meet the following performance criteria:

4.3.3 COMMUNICATIONS CONTROLLERS AND MODEMS

Communications controllers, device drivers and modems shall be supplied to support all the necessary communications interfaces for the provision of the flood warning system facilities, which shall include the following:

- Communication with the RTU at the level monitoring, flood warning and rain gauge sites. The system equipment shall include both a communications path interfaced to a standard PSTN circuit and also one connected to a GSM mobile network. Under normal circumstances the system will use the GSM for linking to RTUs connected to GSM network with the fallback to PSTN if GSM connection is unavailable. For the RTU connected to the satellite the system shall use the PSTN link and fallback to GSM if this fails.
- Communications to the field system operators by GSM mobile with fallback to PSTN circuit. These telephone circuits shall be separate from those used for the RTU.
- Communication access for the remote downloading data to NWRA and TDA offices and the MIS and SMM systems. This connection can use the same telephone circuits as those used for communications to field operators.

Item	Description	Response (seconds)
1	From change of state of plant being reported by RTU	5
2	From change of state detected by the remote RTU to updating SCADA database	5
3	From change of state in the SCADA database to updating the alarm list	0.5
4	From change of state in the SCADA database to updating the active mimic	0.5
5	All requests for mimic displays, alarm lists and help pages from completion of operator request.	3
6	All requests for trend displays and event lists from completion of operator request.	10
7	Time to perform screen dump from completion of the operator request	10

- Communication access for remote connection of a maintenance/engineers (laptop) terminal over the telephone network. This connection can use the same telephone circuits as used for communications to field operators.
- Interface to local operator interface.
- Interface to the archive data storage device.

- Interface to the report/alarm printer.

Each SCADA system shall have a minimum of two PSTN and two GSM modems located within the equipment supplied. The RTUs shall utilise the GSM communications as the primary path with PSTN as a fallback in case of primary routing failure.

The SCADA system shall have the facility to dial out to personnel, via a PSTN modem, in the event of an emergency. The PC shall contain an integral headset/microphone to facilitate voice calls to personnel contained within an emergency telephone list.

The SCADA system shall also be subject to personnel at remote locations dialling into and logging onto the system for the purposes of data retrieval in NWRA, TDA, MIS or SMM format and for remote viewing of system status. The system shall support up to three concurrent dialup connections without affecting system performance.

The SCADA system shall be configured for communications to:

- Receive remote data from remote RTUs
- Send automatic messages to remote sites
- Send manual/automatic SMS messages to mobile telephones with warning messages
- Send manual/automatic messages to pagers
- Remotely interrogate the database

The system shall be configured such that all scenarios above can operate concurrently with no detriment to system performance.

Spare capability, minimum 50%, shall be provided to enable future expansion of the communications network.

4.3.4 ARCHIVE DATA STORAGE

A redundant archive data storage system shall be provided. The system shall have the capacity to store a minimum of 10 years data collected by the system. The system shall be expandable when necessary to cater for any extension of the flood warning system in the future.

The archive system shall have the facility to produce copies of the data onto CDR media.

4.3.5 SITE SIREN

The site alarm siren shall be a self contained unit suitable for outdoor installation and have a sound output of at least 115 dBA at 1 metre with tap setting (or volume control) to enable one of at least 8 different output levels to be selected as appropriate for its chosen location.

4.4 PROPRIETARY SOFTWARE (AND LICENCES)

The flood warning control system at each location shall run under a proprietary software operating system such as Windows 2000. Both systems to be provided shall be selected so that a single hot-standby master station may be configured in the future, so the database and historical archive must be capable of meeting this expansion requirement.

The data gathering and processing facilities shall be provided by the installation of a proprietary SCADA software package, which shall be chosen to:

- Provide all the functionality necessary to implement the flood warning scheme
- Provide a 'User Friendly' and intuitive operator interface which is identical at both master stations
- Provide an expandable and flexible system to allow development of functions and facilities in the future
- Have a large existing user base with multiple sources available for undertaking modifications to system programming and parameter configuration

The software packages shall be dual language allowing the operator to select operation in either English or Arabic script.

The supply of all software for the Contract shall include all necessary licences for the use of all of the proprietary software for the needs of the flood-warning scheme.

4.5 SYSTEM SOFTWARE DEVELOPED FOR THIS PROJECT

The proprietary software shall be configured to meet the needs of the flood warning system for display, processing and disseminating of the data.

4.5.1 CONFIGURATION

All data inputs from the RTU shall be configured to ensure all points outstations and alarms etc are described correctly with meaningful descriptions and engineering units.

Mimic diagrams shall be drawn for the schematic representation of the scheme and instrumentation showing current and historic data in the most advantageous format. Typical mimics that shall be produced shall include:

- Log on/off of the system (incorporating user password protection giving appropriate pre-defined level of access)
- Schematic displays showing current measurements
- Text and help pages to assist operators making decisions
- Alarm and fault lists detailing all alarms and faults with their status

- Record and report displays showing current and archive information in text or graphical formats

An engineering facility shall be available to re-configure the system data, modify or add new mimics reports etc.

4.5.2 DATA PROCESSING

The system shall be capable of processing the raw data from the RTU undertaking logical, arithmetic and algebraic manipulation and calculations.

The system shall be capable of generating formulae to determine the probability of a flood and its approximate severity from data collected from the monitoring sites. Initially the system shall be configured to automatically raise flood alerts when the water level at monitoring sites reaches preset levels with the severity determined by the maximum height of the flood. As operational experience is gained then the system shall have the capability for the supervisor/engineer to develop more complex algorithms incorporating data from other sites, rain gauges and observer reports for example.

The system shall be capable of generating a series of relationships, which identify what actions are taken for different flood alarm conditions. Each relationship shall identify which sites are to be alerted and what output to be sent, what text messages are sent to which numbers and what voice messages are output to which numbers. Initially the system shall be configured with 10 of these relationships but shall have the capacity for a minimum of 100.

The system shall be capable of allowing the comparison of current trends of a flood crest waveform with simulated or historic floods to assist the operators/supervisor in estimating the volume of a flood.

The system shall be capable of calculating a flood volume from the level measurements at the monitoring site and its appropriate rating curve. The system shall be configured to automatically calculate and archive the time, date, flood crest peak, peak volume, total volume and duration of every flood event. A flood event duration shall be defined as from the detection of a rising water level until the water level has dropped below a predefined limit (initially set at 100mm).

All data collected from the monitoring sites shall be output in Microsoft Access or Excel compatible format (such a delimited text files) for transmission to the MIS, SMM, NWRA and TDA, in near real time.

4.6 DEDICATED UNINTERRUPTIBLE POWER SUPPLY (UPS)

The control centre SCADA computer equipment and peripherals, including communications equipment, shall be powered through a UPS supply to protect the equipment from power source surges and to enable continued operation for a minimum of 8 hours in the event of the power source failure.

The Contractor shall submit working drawings and calculations for equipment in accordance with the Contract requirements.

Spare Parts and Special Tools

The Contractor shall provide all Manufacturer recommended spare parts and tools. In addition to recommended spares, furnish all of the following minimum spare parts, tools and devices.

Quality Assurance

All materials and equipment furnished shall be new, free from defects, and of first quality, produced by recognized product manufacturers.

General

The UPS units shall be furnished to provide a reliable source of isolated, regulated, Uninterruptible power, with no break in AC output during full or partial interruption of incoming line power. Power to the load shall not be interrupted at any time or for any duration while the UPS is functioning. The UPS shall provide a high degree of lightning/surge protection to the loads.

The units shall be capable of functioning under the Climactic conditions within Yemen without the need for special support equipment.

UPS units shall be sized based on the Contractor's recommendations and the following parameters. The Contractor shall furnish each unit sized at a minimum of 150% of the final connected load it serves. Overload capability based on unit rating shall be 150% during surge and 125% for 10 minutes on line power and 150% during surge and 110% for 10 minutes on inverter power.

The UPS furnished shall be a true separately derived power source with output neutral bonded to earth. There shall be no direct connection between input and output and less than 2 pF effective input to output capacitance.

The unit shall deliver computer grade sine wave power with five percent (5%) or less total harmonic distortion.

The following alarm conditions shall also be available:

- Low Battery and low Battery Warning, High Battery, Low Runtime Left, Low and High Output Voltage, Output Overload, High Ambient Temp, Check Battery, Check Inverter, High Input Voltage

Bypass

A maintenance bypass switch designed for the unit shall be provided. The switch shall allow service personnel to disconnect the UPS to remove it from service while not interrupting the supply to the load.

Batteries

Batteries shall be provided with all units and be maintenance free and of a type readily available locally.

Installation

The Contractor shall install each item in accordance with the equipment manufacturer's recommendations.

Enclosures in which units are installed shall provide adequate cooling and ventilation for operation at full load for extended periods as per Manufacturer’s recommendations.

4.7 CABINET TO HOUSE EQUIPMENT

The control centre equipment shall be housed in a lockable cabinet as a self-contained unit. This cabinet should contain all flood warning system equipment. The cabinet should have a front mounted alarm annunciator panel to indicate system status with warning lights/buzzer to alert an operator in the event of a change of equipment status. This unit shall include any ventilation, cooling, air filters or air conditioning necessary to maintain the equipment within its operational environmental limits when installed in a non air-conditioned office in the Yemen.

The UPS and batteries shall be housed in a separate cabinet adjacent to the computer cabinet.

5 REMOTE TERMINAL UNITS

5.1 GENERAL

Three types of RTUs shall be provided for the flood warning system. These shall be:

- Level monitoring stations (initially 5 units required);
- Weir Alert Stations (initially 4 units required);
- Rain gauge stations (initially 4 units required).

Each of these types of station shall be developed as complete modules which can be provided to an installation team to install on site at the most appropriate location. See appendix A. for location description of the stations.

General

RTUs shall be capable of operating as a standalone unit providing local operator interface information complete with communications facilities.

The RTU shall be a modular unit capable of expansion.

The RTU shall operate from a nominal power source of 12/24V.

The RTU shall have adequate memory and I/O ports to receive all control and sequencing signals and drive all indicator lamps, relays or solenoids as may be required to accurately control all the necessary functions of the control system.

The controller shall indicate the operating state of the outputs by means of light-emitting diodes (LED's) and be equipped with sets of LED's to indicate the controller status and to notify of any internal faults.

An integral means of turning all outputs off and ceasing the processor operation shall be fitted.

The RTU shall perform sequential functions and shall drive, either directly or by interposing relays, all the necessary outputs.

Where the output load exceeds the rated capacity of an output port of the controller, suitably rated, D.I.N. rail mounted interposing relays shall be installed in the cabinet to amplify output controls signals.

D.I.N. rail mounted terminals shall be fitted in the bottom of the cabinet to allow the termination of all control and sequencing cabling. The terminals shall accept up to $4mm^2$ stranded conductor.

All output ports from the controller shall be correctly fused in order to protect the controller (by means of fused terminals). Fuse links shall be to BS 1362 or BS 4265 where fast action or semi conductor fuse links are required.

The RTU shall be capable of supporting the following component parts either inherently or via expansion when required and shall support all the required process I/O

- Digital input
- Digital output
- Analogue output
- Communications
- High speed pulse counter

Power Supply Requirements

The equipment shall be designed to operate from a 24V DC supply with full protection against accidental reversal of the supply polarity.

System circuitry shall be fully isolated from its power supply, using isolating barriers having resistances of not less than 2 megohms, measured at 500V DC to the requirements of BS 4743.

System cable terminations shall be made in a discrete termination section, housing terminal blocks sized, barriered and uniquely identified, to suit the voltage and current demands of the circuitry. Pinch screw type terminals will not be acceptable.

Within the following ranges variation of the power supply to any system shall not cause it to operate outside the performance requirements of this specification as required under BS 6438.

- -12% to +10% of the nominal 24V DC supply.

5.2 LEVEL MONITORING STATIONS

The level monitoring stations shall comprise a water level monitoring instrument connected to a data logger/telemetry unit with an associated communications link and power supply.

5.2.1 LEVEL TRANSDUCER

Level shall be monitored by means of a measuring system consisting of an ultrasonic level transducer with associated transmitter to provided 4-20mA output proportional to level. The transducer shall comply with the following requirements:

- The transducer shall be to IP68 with a fixed waterproof connection.
- The transducer shall be supplied complete with a suitable cable of 30 metre length.

The controller/transmitter together with the transducer shall satisfy the following requirements:

- Range : 10 metres.
- Span : Site adjustable throughout range.
- Accuracy : Better than ± 0.15% of range.

- Surge Protection : To protect against voltages up to 2 KV to comply with IEC 801.
- Temperature compensation: To compensate for ambient temperature variations
- Output : 4-20mA
- Power Supply : 12/24 V DC.
- Operating Temperature : -10^{O}C to +65^{O}C
- IP rating : IP65
- Alarm outputs : Lost Echo/Power Failure
- Commissioning : All appropriate controls and facilities shall be provided to facilitate commissioning and periodic testing, recalibration and re-ranging.

The transducers are to be installed above flood level in suitable accessible, but tamper-proof, mountings, over low flow channels at the designated locations.

5.2.2 DATA LOGGING/TELEMETRY UNIT

The data logger/telemetry unit at the level sites should include analogue and digital input capabilities for the level instrumentation and alarm indications. The functions and facilities of the data logger/telemetry unit should include:

- Data storage time logging at a configurable rate between 1 minute and 1 hour
- Data storage rate to be selectable on event detection i.e. level reading on instrument
- Data storage capacity to be at least 10,000 time stamped records
- System to read instrument every 10 minutes under normal (non-flood) conditions
- System to read and record/log instrument reading every 1 minute while level measurement is within a preset range
- Data logging to be every hour under non-flood conditions
- Transmit an alarm to the control centre when the water level reaches certain preset limits (initially set 500mm and every 250mm above this level)
- Monitor state of battery and any solar power generator and alarm fault or battery low
- Initiate an instrument fault when current reading is outside 4 – 20mA range
- Download any current and stored data on request from the control centre
- Send text messages to specified mobile phone handsets if data has not been successfully downloaded after a predetermined number of attempts
- Send text messages to specified mobile phone handsets if transmission to control centre fails when a flood alarm warning is issued
- Equipment to be suitable for environment e.g. –10^{O}C to +65^{O}C

- Equipment to be housed in cabinet to meet IP67
- Equipment to be low power consumption
- Have connection point for connecting a laptop PC to download data and reconfigure the unit if necessary

5.2.3 INPUT/OUTPUT REQUIREMENTS

Digital Input Requirements

Classes of input shall be nominal 12/24V DC input rating, opto-isolated, reverse polarity protected.

Mixing of voltages at input ports in any given single installation shall not be acceptable.

Field contact inputs shall be de-bounced such that status changes will not be recognized unless the contact condition is maintained for at least 25 milliseconds.

Digital Output Requirements

Digital output shall be of the volt-free contact type.

Each output shall be electrically isolated from other outputs, the rest of the circuitry and earth. It shall have an insulation resistance to the rest of the circuitry and earth of greater than 2 megohms, when tested for 1 minute with 500V DC insulation tester.

System functionality shall be maintained when each output terminal is earthed in turn.

Analogue Input Requirements

The preferred analogue input signal is 4-20mA; continuous; linear supporting a fully floating max 250ohm input impedance load. Analogue/Digital conversion shall have a minimum 16-bit resolution, linear to ±1%, accepting signals in the range 0-10mA, 4-20mA and 0-20mA and voltages 1-5V, 0-1V and 0-100mV as required.

Analogue Output Requirements

The preferred analogue output shall be 4 to 20 mA DC electrical signal with a linearly increasing output for increasing measured value, complying with the requirements of BS 5863 Part 1, excluding Clause 3.6.

When the load resistance across the output terminals is varied from 0 to 1000 ohms the output signal current shall not change by greater than 0.1% of span, over the full output range.

Communication Ports

Communication ports will only be necessary on the RTU when its use is required as part of an overall networked system. When required they shall provide the communication link between the RTU and other RTUs or PC based system.

Protocols

Provision of the communication required to satisfy this Specification shall include all necessary protocols for its successful operation.

A serial RS 232 port shall be available to enable interfacing to local PC's for MMI purposes to allow local database and control sequence loading, interrogation or modification. The port shall cater for communication with a suitable encoding device.

High Speed Pulse Counter

This input module shall accept voltage level input signals of 5, 12, or 24 volt and have counting speeds up to 50 kHz. Encoded count signals of either 16 or 32 bit, bidirectional, shall be selectable and a minimum of 2, source or sink, independently configurable outputs shall be provided.

5.2.4 COMMUNICATIONS

General

The data logger/RTU shall connect to the communications equipment to enable the transmission of data and alarms to the control centre. The interface shall also include the capability of the telemetry unit being able to send voice or SMS text messages to specific GSM mobile or fixed telephones automatically in the event of an alarm message not being accepted by the control centre.

In order to achieve communications in the areas where the data loggers/telemetry units will be located, a mobile radio based communications system shall be provided therefore appropriate modems shall be incorporated. The modems shall be housed within a rugged casing designed for industrial use.

Wherever possible, use will be made of GSM mobile (operators are Spacetel or Sabafon in Yemen). As coverage may be marginal, signal booster equipment and external antenna (antennae height shall be calculated in order to provide optimum signal reception), shall be provided if necessary to ensure an acceptable signal is available at all times.

At any locations where GSM mobile access is not available the system shall use the satellite based mobile network from Thuraya (service provider Partners Company Ltd in Yemen).

Facilities shall be provided to enable a suitable mobile handset to plug into the antenna and signal booster so that voice communication can be made from these locations.

Three of the Level stations shall be complete with the GSM mobile equipment and the other two shall be complete with the satellite mobile equipment.

The Contractor shall provide surveys to assist with the design of the communications network and shall present these to the Engineer for approval.

Method of Operation of the Communications

The method of system operation using the public mobile and satellite networks shall be based on a daily download from each site with event driven data transfer when an alarm situation occurs.

In normal conditions the remote measuring site shall call the control centre once every day to download its accumulated data and confirm its continued operation. Data transfer rate shall be at 1200 baud or greater.

Should an event occur such as a level reaching an alarm limit or an internal fault occurring, the station shall immediately call the control centre, download its current data and alarm status.

The control centre shall automatically process this data and in conjunction with other station data and with supervisor/operator input as required, will output a warning to the diversion weir structure operators and farmers as necessary.

The control centre equipment shall also be able to interrogate any station at any time for its current data and status.

5.2.5 HOUSING AND POWER SUPPLY

Housing of equipment

The instrumentation and the data logger/telemetry unit shall each be packaged in housings with an IP67 rating.

The data logger/telemetry units and communication equipment shall be housed in a ventilated protective heavy-duty metal cabinet with a heavy-duty lock.

A heavy-duty hood that also acts as a sunshade shall protect the ultrasonic detector head.

Power supply

The Level Station equipment shall be powered by a battery which is trickle charged by a photovoltaic/solar cell fitted to the top of the equipment cabinet.

The battery shall be sized to provide continued operation, without any recharge, for 90 days based on a data-logging period of every 10 minutes. Operation during flood conditions (i.e. logging at 1 minute intervals) should be greater than 30 days.

The photovoltaic/solar cell shall be sized to maintain continued operation throughout the year.

Detection equipment shall be included to detect photovoltaic /solar cell failure and battery low voltage.

5.3 WEIR ALERT STATIONS

5.3.1 GENERAL

The weir alert stations shall be the same as the level stations with the differences as detailed below.

5.3.2 LEVEL TRANSDUCER

Level monitoring is not required at these sites.

5.3.3 DATA LOGGER / TELEMETRY UNIT

These data logger/telemetry units are installed primarily to provide the weir operators with a warning of an approaching flood with an indication of its severity and flood volume. A siren shall be sounded to warn of the flood approach and a set of high intensity flashing lights to indicate the severity/volume. The siren shall be on a timer to sound for only a preset time and also have a local reset button for the operator to silence it if so required.

In addition to the primary function these locations shall also include a level measuring device to monitor the water height at the weir structure.

These stations shall have the basic functions as at the measuring stations with the following additions and exceptions:

- Alarm warnings shall only be generated on equipment faults and not on any level measurements
- Up to 8 control outputs to be provided to drive lights, audible alert unit and a siren
- An LED/LCD display of at least 30 characters to display text (in Arabic) or numerals with a scroll facility to display longer messages sent from the control centre.
- A local audible alert unit such as a bell shall be provided to draw the attention of the operator that a message had been sent on the text display.

5.3.4 INPUT / OUTPUT REQUIREMENTS

Input/outputs as Level Stations with the addition of:

- 4 Digital outputs (total 8)
- 30 character LED/LCD display

5.3.5 COMMUNICATIONS

Communications shall be as for Level Stations with 3 of the sites fitted with GSM mobile communications, antennae height shall be calculated in order to provide optimum signal reception, and 1 with satellite communications.

5.3.6 HOUSING AND POWER SUPPLY

The equipment at these sites will be housed in the operators building adjacent to the structure. It shall be housed in a lockable wall mounting cabinet, which has the LED/LCD text display mounted on the front along with the bell and siren reset buttons.

The solar panels, siren and lights shall be mounted on a bracket that can be fitted onto the roof of the operators building.

The battery at these stations shall be sized to power the data logger/telemetry equipment as for the level stations plus additional capacity to power the siren for a period of 20 minutes and the lights for a period of 4 hours. The solar panel shall be sized to enable a full recharge of the batteries over a period of 3 days.

5.4 RAIN GAUGE STATIONS

5.4.1 GENERAL

The rain gauge stations shall be similar to the Level Stations except that there shall be a tipping bucket rain gauge connected to the data logger/telemetry unit rather than an ultrasonic level instrument.

5.4.2 RAIN GAUGE

The rain gauge shall be a conventional tipping bucket rain gauge:

Orifice size	200 mm diameter.
Resolution/bucket size	0.25mm
Output	Double output relay contacts
Levelling	Built in spirit level
Environment	IP67

5.4.3 DATA LOGGER/TELEMETRY UNIT

The data logger/telemetry unit shall have similar functions to the Level Station with the following additions and exceptions:

- Data logger shall count the operations of the tipping bucket of the rain gauge.
- Data logger shall record the number of operations of the tipping bucket for each 15 minute period
- Transmit an alarm to the control centre when the number of operations of the tipping buckets exceeds a certain preset limit over a preset time period.

5.4.4 INPUT / OUTPUT REQUIREMENTS

The input/output requirement shall be as the Level Stations with the digital inputs being used for the count inputs.

5.4.5 COMMUNICATIONS

Communications shall be as for Level Stations with all sites fitted with satellite communications.

5.4.6 HOUSING AND POWER SUPPLY

The housing and power supply for the rain stations shall be the same as for the Level Stations.

6 OTHER EQUIPMENT

6.1 MOBILE TELEPHONE HANDSETS

35 GSM mobile telephone handsets shall be provided. The handsets shall be chosen to provide a better than average sensitivity to give the best reception possible in low/marginal signal areas and provided with external antenna sockets. The Contractor shall provide evidence to support the selection.

The telephones shall come complete with manual, mains charger and carrying pouch, which can be attached to a belt or similar.

The Contractor shall provide all handsets fully operational and shall register ownership in the name of the Client.

The Contractor shall provide one handset, mounted in the control room desk for operator use during emergency events.

6.2 SPARES, TEST EQUIPMENT AND CONSUMABLES

A full set of spares and consumables for RTUs (e.g. batteries and I/O cards), instrumentation (e.g. transmitters), and other equipment (e.g. printer spares, main UPS batteries) shall be provided to enable a full 2 years of operation of the system after handover.

One spare unit shall be provided for approximately 10% of the total units supplied. Proprietary equipment such as PC and mobile telephone handsets do not need to be included.

Any special test equipment necessary for maintenance or calibration of instruments shall be provided within the Contractors tender.

A list of all spares, test equipment and consumables offered shall be provided with the offer and fully detailed.

To minimise the spares holding, the Contractor's design should consider the benefits of standardisation.

6.3 INSTALLATION SUPPORT, TRAINING AND COMMISSIONING

The provision of a suitably qualified and experienced engineer for a period of 6 weeks in the Yemen shall be provided to

- Review the installation
- Provide training on the operation and maintenance of the equipment
- Test and commission the SCADA systems and undertake full acceptance/handover tests

- Provide technical support during the first two weeks of operation after take-over

The systems shall be subject to a defects liability period of 12 months after the date of Take Over. The Contractor shall agree the procedure for reporting and rectification, including maximum time for remediation of problems during this time.

6.3.1 TRAINING

The Contractor shall at time of tender state any minimum levels of training/experience required for participants, prior to attending courses.

The Contractor shall provide training for Operational staff. Training courses may be structured to meet the technical offer. The courses shall be subject to the approval of the Employer and shall be detailed at the time of Tender.

Training courses shall be provided at Employer's offices. However some courses may be held at the manufacturer's works as agreed by the Employer but all costs of attendance shall be included in the contract.

The Contractor shall provide all course materials and equipment needed.

Training shall be organised such that the system operators shall be able to fully operate and maintain the SCADA system following completion of all training courses.

System Operators

The Contractor shall provide for 4 no. Operators attending each course.

This purpose-designed course must be provided in advance of commissioning to:

- Enable the Employer's user staff to participate in the full process commissioning of the system
- Safely operate plant and maintain the SCADA system.

System take-over shall not be given until satisfactory training has been provided.

Content

This course shall be designed to familiarise participants with the general running of the operating system and the SCADA package to include but not limited to:

- Loading and starting up the Operating System
- System Operators interface
- Operator control of program/task execution
- Operator control of disc files
- File transfer tasks - archiving, retrieval
- Operator response to system failure, on-line/off-line diagnostics, transfer of control between the computers synchronisation of the system database

- SCADA system interrogation facilities - alarm lists, log printouts select mimic and trend displays etc.
- Alarm acknowledge accept/delete
- Control actions, e.g. issue flood warning
- All functions associated with each access level of the SCADA system.

Systems Supervisors Personnel

The Contractor shall provide a five-day course for 3 No. Attendees.

To be held at the Employer's premises prior to the system hand-over and shall consist of all of the above tasks plus:

- Basic systems design overview
- The use of computers to perform diagnostics and to tune other parts of the system
- Changing passwords and access control
- Sequence verification
- Preventative maintenance

Systems Developers/Programmers/Engineers

The Contractor shall provide one five-day course for 3 No. Attendees.

This course shall be designed to cover all configuration and advanced facilities of the SCADA package. To include, but not be limited to:

- The system database structure
- System database building/configuration
- Mimic building
- Applications program interface to the system database
- Management information system interface
- Downtime loading of control programs/sequences to RTUs
- Advanced operating features

Site Training

The Contractor shall liase to establish the following:

- Training required for operating and maintenance staff?
- Who is to be trained?
- Who will provide the training and when?

The Contractor shall supply full and approved O & M documentation prior to training. A section of the plant shall not be handed to the Employer for operation until training on the control systems has been completed. Should defects occur prior to Take-over of the whole scheme the Contractor shall be responsible for rectifying the fault prior to any other phased handover of the scheme.

This training course/workshop shall be designed as a "reference" course rather than a formal educational course, i.e. the Contractor's personnel shall be present to assist the Employer's personnel, as necessary, with any technical difficulties.

6.3.2 TESTING

The Contractor shall provide for full system testing. Tests shall conform to BS 5887 (code of practice for testing of computer based systems) and BS 6238 (code of practice for performance monitoring of computer based systems).

The Employer shall approve all acceptance procedures for inclusion within the system specification.

Factory Acceptance Test

General

The Contractor shall provide all labour, materials, equipment and incidentals required to perform factory testing to verify system components meet the functional and performance requirements.

The Contractor shall submit information on his test procedures to verify testing fulfils the requirements. Submittals shall be made 28 working days in advance of scheduled testing and shall include dates of scheduled tests. When requested by the Employer, factory testing on some items shall be witnessed and certified by the Employer or a third party agency hired by the Employer.

When factory tests have been successfully completed in the absence of the Employer or a third party agency hired by the Employer, a report shall be submitted to the Employer. The equipment shall not be shipped until Notice of Acceptance signed by the Employer is received by the Contractor.

Control System Tests - System performance shall be tested using a fully integrated system, including all software and hardware. To achieve this, the entire control system, including all the peripheral devices and all interconnecting cables, shall be assembled on the factory test floor and the complete operational program loaded and simulated inputs applied. The Contractor shall carry out a 100-hour full system test, during which the entire system shall operate continuously without failure in accordance with the requirements of the Specifications. If a component fails during test, the 100-hour test period shall be restarted after operation is restored. THE CONTRACTOR SHALL SUBMIT CERTIFICATION TO THE EMPLOYER IN WRITING THAT THIS TEST HAS BEEN SUCCESSFULLY COMPLETED PRIOR TO WITNESS TESTING.

System Software Demonstration

The Contractor shall demonstrate all system software utility and security programs in the system to illustrate the functions and capabilities specified.

The Contractor shall demonstrate operation and display of all software based on simulation of 10% of total I/O count, analogue and discrete, as selected by the Contractor. The Employer may randomly select at the test a further 5% I/O to be simulated. Demonstration shall show the monitoring and control software associated with the I/O performs the intended functions.

System performance shall be tested using a fully integrated system, including all software and hardware as necessary. The complete system, including all peripheral devices and all communications shall be assembled at the factory test and simulated inputs applied. The Contractor shall carry out a full system test,

during which the entire system shall operate continuously without failure in accordance with the requirements of the Specification.

The Contractor shall provide process I/O simulation for the test:

- Toggle switches to simulate field or other input contacts.
- Indicating lights to simulate outputs from tested panels.
- Control relays to simulate MCC (Motor Control Centre) coil inputs.
- Time relays to simulate position switches.
- Indicators (mA) to indicate all 4-20mA DC output from tested panels.
- Potentiometers to simulate 4-20mA DC inputs to tested panel.
- Software simulation to demonstrate interfaces to existing SCADA and RTU systems.

Every device shall have nameplate with description and device tag number.

Demonstration of communication between RTUs/SCADA systems or to remote I/O shall be included in the Test Procedure where applicable.

Operator Interfaces

Prior to system testing, display environments shall have been configured to the agreed display structure, loaded and data base parameters linked to the specified fields. During this phase of the acceptance test, the overall structure shall be demonstrated, including environment configurations, passwords, security, etc. The memo display contents shall be reviewed to demonstrate how an operator navigates within the system. Each graphic display shall be reviewed for correctness in terms of the layout, symbols, colour scheme, etc. The operation of standard alarm management displays (Current Alarm Display, Alarm History, etc.) shall also be demonstrated. A demonstration of each type of report specified shall be performed. Printing shall be an integral part of report demonstration.

The Contractor shall provide full Factory Acceptance Testing of the configured system, to include:

- The RTU network
- Support for all RTUs with all points over an integrated network, simulated to include all types of communications units and interfaces
- Mimic display pages on the system

Test 1

Simultaneous occurrence of:

- The control centre polling outstations in normal (i.e. daytime) operational mode receiving 50% of data from each RTU with 10% of points in alarm conditions.

- 2 operator workstations performing

1) Simultaneous access

2) Access staggered by 2 seconds

Test 2

(a) As test 1.

(b) Performing daily system archive.

Test 3

(a) As test 1.

(b) Performing archive data recovery

1) Full daily archive recovery

2) Four data points for one week (15-minute intervals)

Test 4

(a) As test 1.

(b) Performing screen dump

(c) Printing daily report

The simulation package shall use the SCADA system to demonstrate proper performance under full utilisation conditions.

The Contractor shall record the following:

- DISPLAY RESPONSE: This shall be no greater than as specified.
- PERCENTAGE CPU UTILISATION
- SCAN TIME: No greater than 1 minute for full system scanning.
- TIME TO CLEAR BACKLOG: The Contractor shall also record any adverse conditions that become apparent.
- The Contractor shall substantiate the validity of the simulation to the Engineer and shall confirm, at the time of Tender, by what means simulation will be carried out.

RTU to demonstrate

All control and failure recovery sequences, simulating all digital and analogue inputs and outputs on each system.

Communications system to demonstrate

Full simulation utilising all interface nodes, with RTUs connected, in order to prove performance over the network. Failures shall be simulated in order to prove automatic re-routing of communications to SCADA system.

Factory Acceptance Test - Witnessing

The Factory Acceptance Test may be conducted in the presence of witnesses, who shall be nominated, in writing. The witnesses shall be empowered to act during the Factory Acceptance Test, on behalf of the parties they represent, to judge the success or failure of a particular test. Either party as necessary, in writing may appoint nominated Deputies. If the Factory Testing is not witnessed the Contractor shall self-certify all testing and submit the results prior to system delivery.

The Contractor shall also provide evidence that full tests (FAT/SAT) have been successfully performed prior to any witnessing by the Engineer.

Factory Acceptance Test – Records

A log shall be maintained during the Factory Acceptance Test. This log shall record for each test performed:

- The test results.
- Any faults which occur.
- Any remedial action taken.
- Re-test results.
- Decisions taken by the witnesses that may affect the test results.

The witnesses of both parties shall initial all entries within the log.

Copies of the log shall be provided to the Employer on completion of testing.

Failure and Re-test

The success or failure shall be determined as follows:

- If the system performs as laid down in the Functional Design Specification the test shall be deemed successful.
- Tests shall not be failed due to external conditions, e.g. power fail, provided the system fulfils the resilience criteria detailed within this tender document and any subsequent project specification.
- The tests shall not be failed through incorrect operation provided the fault can be corrected by normal operating procedures and provided the test performed satisfactorily in all other aspects (e.g. printer failure).

Any test that is deemed unsuccessful may be retried following any remedial action that may be necessary.

If the system should fail any test and it is apparent that the fault may have affected the result of tests previously regarded as successful any or all of the tests affected may be re-tested.

To allow all participants to fully understand all aspects of the Factory Acceptance Test, the Factory Acceptance Test Specification as agreed between all parties shall be issued with the Contractor's Project Specification (CPS).

System Management

The Factory Acceptance Test shall include, but not be limited to, the following as defined within Contractor's Project Specification.

Hardware

- The hardware configuration being tested shall be fully detailed and cross-referenced against the Tender Return Document.

System Start-up and Shut-down Procedures

- Tests shall exercise system start-up/shut-down commands including:

  (a) System start-up commands.

  (b) Operator log-in and log-out commands.

  (c) Password verification.

  (d) Any special function command keys.

  (e) Orderly system shut-down.

System Back-up and Recovery

These tests shall exercise the system back-up and recovery procedures, including:

(a) System back-up to archive media.

(b) System re-build from system archive media.

(c) Synchronisation of the Master Station and outstations.

SCADA Database Configuration

These tests shall exercise the SCADA database commands including:

- Password and level of access maintenance.
- The creation and amendment of RTUs.
- The maintenance of RTUs communications parameters, e.g. telephone numbers, radio characteristics, change of media, scanning intervals, on/off SCADA scan.
- Regions of interest.
- Creation and amendment of SCADA points:

(a) Name.

(b) Type, e.g. status, analogue, derived.

(c) Alarm limits.

(d) Historic data recording and characteristics.

(e) Re-transmission of value to associated points.

(f) Scaling factors.

(g) Calculation formulae maintenance.

(h) Set output control parameters for digital, analogue and derived controls.

Picture Configuration

Tests shall exercise picture configuration commands available to privileged operators, including:

- The creation of picture pages, to include foreground/dynamic and background/static picture elements.
- The modification of picture pages, to include foreground/dynamic and background/static picture elements.
- The deletion, copying and renaming of pictures.
- Any function control key usage.
- Examples of all picture types, e.g.:

(a) Static information pages (e.g. indices).

(b) Mimics for information display/control monitoring.

(c) Alarm list pages.

(d) Statistical pictures (e.g. trends, histograms).

(e) Help/text pages.

- The display and printing of pictures.

Data Collection

Tests shall exercise data collection commands available to privileged operators, including:

- The collection of digital, analogue and derived parameters.
- The collection of all data from outstations at frequencies defined by the privileged operator.
- The manual entry of data.
- The inhibition of data collection from a RTU.
- The inhibition of data collection from an individual point.
- The editing of stored data (subject to correct level of access)

Supervisory Control

These tests shall exercise the supervisory control commands, including:

The creation and downline loading of control sequences.

Digital, e.g. open/close, and analogue, e.g. set point control of individual points.

Revertive checks to ensure the correct control point is addressed.

Alarm/Event Handling

These tests shall exercise the alarm and event reporting procedures, including:

- Digital and analogue alarms generated at an outstation:

(a) Reported on the alarm/event printer.

(b) Logged to disc.

(c) Reported to the operator console, i.e. regions of interest.

- Events, e.g. issue remedial control command,

(a) are only issued from appropriate operator consoles

(b) logged to the alarm/event printer

(c) logged to disc

(d) are subject to correct level of access/regions of interest

- Alarm acceptance/acknowledgement procedures.
- Alarm list interrogation procedures.
- Alarm list printing.
- Alarm inhibit for an outstation and individual point.

Data Logging

These tests shall exercise the data logging and archiving procedures including:

- Tests to ensure all data/alarms collected are logged to the on-line archive storage.
- Tests to ensure data can be archived to and recalled from long term archive media.

RTU Programming

These tests shall exercise the RTU sequence programming procedures, including:

- Sequence program editing, compilation and loading.
- The ability to load new sequences on demand by a privileged operator.

Management Information System Development

These tests shall demonstrate the use of the enquiry package and the applications programs development tool kit, including:

- The editing and compilation of programs.
- The abstracting of data from the SCADA database.
- The automatic scheduling of programs as a result of time of day queues and as a result of a SCADA event/alarm, this to include the download in a suitable format of all recently acquired and near real time rainfall, water level and discharge data collected by the RTUs, and all such data received and processed by the control centre.

Site Acceptance Tests

The Contractor shall provide for full site acceptance tests for each SCADA system and associated outstations to include interface to the marshalling unit, the communication system, the earthing system and full functionality as demonstrated at the Factory Acceptance Test.

Systems Acceptance Test

The Contractor shall provide for full system tests on completion to include all SCADA, RTU and communications tests as stated above.

All special test equipment relevant to the Contractor supplied equipment shall become the property of the Employer on completion.

6.4 DESIGN DOCUMENTATION

The Contractor shall provide the following documentation as a minimum for the approval of the Engineer:

Preliminary Information

1. Block diagram(s) of the proposed system configuration shall be provided. A functional description of the block diagram(s) of not less than 25 and not more than 50 single spaced pages shall also be provided. The functional description shall describe the overall system operation, interaction between system elements, system response time estimate.
2. Overview of software design and organization.
3. Identification of critical engineering activities and long lead-time procurement items.
4. A preliminary activity schedule shall be submitted for Employer's review. The schedule shall show all shop drawing submittal, engineering, deliveries to site, factory testing, calibration installation, and start-up tasks from start to finish.

Design Information

1. Answers to all unresolved matters from the preliminary review meeting.
2. Detailed Instrument Activities Schedule.

A complete Instrument Activities Schedule shall be submitted. The schedule shall be broken into the following groups.

a. Long lead time items.

b. In line instruments.

c. Off line instruments.

d. Local control panels workstations.

e. Point to point interconnection wiring diagrams for the entire Instrumentation and Control System.

f. Distributed control system equipment.

g. Factory testing of the entire Digital Control System.

Each group shall have the following scheduled activities:

Field Instruments:

- Installation.

- Field Testing.

Panels:

- External connection diagrams.

- Wiring diagrams, schematics, point-to-point and loop diagrams.

Distributed Control System Equipment:

- Enclosure drawings.

- External connection diagrams.

- Control strategy diagrams.

- Loop diagrams.

- Point to point wiring diagrams.

- Configuration data.

- Control room equipment interconnection diagrams.

- Shop drawings for hardware and software.

Software Information:

- Overall description of software organization.

- List and description of all process control system software.

- A detailed description of how data base points, control strategies, text and schematic displays and textural reports are implemented and modified.

A copy of the proposed Process Control System Maintenance Contract after expiration of initial warranty.

6.5 OPERATIONS & MAINTENANCE DOCUMENTATION

General

This Contract shall include full documentation for all equipment and software provided under this Contract. The documentation shall be written in a clear and concise manner, which is fully formatted and indexed to provide documentation that is easy to understand and friendly to use. It shall be capable of incorporating upgrades and amendments to information in an efficient and effective manner. Generally the documentation shall be compiled in A4 ring binders. Liaison will be required regarding contents of the individual manuals.

All documentation shall also be provided in electronic format in the Client's standard format current at the letting of the Contract. The Employer shall hold the copyright for these documents.

All drawings, unless within word-processing documents, shall also be provided electronically in AutoCAD format, or other media agreed with the Employer. All documentation shall conform to ISO 6592 Code of Practice for Documentation of Computer Based Systems. The Tenderer may offer manuals structured to meet his technical offering. These manuals shall be subject to the approval of the Engineer and shall be detailed at the time of Tender. The documentation shall be submitted to the Engineer for approval and shall include, but not limited to:

Full System Operating Procedures (4 no. Copies)

The Contractor shall provide full operating procedures detailing how to use the SCADA system, to include but not limited to:

- Loading and starting up the Operating System
- System Operators interface, including:
- System mimic navigation

- SCADA system interrogation facilities - alarm lists, event log printouts and trend displays etc.
- Alarm acknowledge accept/delete
- Control actions
- All functions associated with each access level of the SCADA system.
- Operator control of program/task execution
- Operator control of disc files
- File transfer tasks - archiving, retrieval
- Operator response to system failure, on-line/off-line diagnostics, transfer of control between the computers synchronisation of the system database

Full Software Documentation (4 no. Copies)

The complete software specification shall be provided and include system design specification, flowcharts, logic diagrams, system software definitions, program index, system build definition, and system data for each system and module. Information shall not be disclosed to any third party without the author's consent.

Hardware Manuals (4 no. Copies)

The Contractor shall provide documentation for all equipment supplied under the Contract.

RTU Programming Documentation (4 no. Copies)

The Contractor shall provide a copy of all necessary RTU programming documentation as supplied by the RTU manufacturer.

6.6 QUALITY ASSURANCE

General

The SCADA Contractor shall be registered to ISO9001.

Quality Plan

The Contractor shall provide a quality plan within 4 weeks of award of the Contract.

Software Development

All software development shall be carried out under an EU-recognised quality system compatible with ISO 9001 that is defined in the quality plan.

Product Audit

The Engineer shall have the right to audit the product at any time during the Contract.

Quality Records

The Contractor shall maintain quality records in line with the quality plan throughout the period of the Contract. These will provide an audit trail for the design and implementation of the technical solutions adopted for the project.

Access for the Engineer's Representative

The Employer shall have the right to audit the project at any time during the Contract.

Sub-Contractors

The Contractor shall be responsible for the quality of any sub-contracted work and the quality plan shall incorporate all the work undertaken by sub-Contractors.

The Tenderer shall nominate sub-Contractors in his response. The Contractor shall be required to obtain permission (which will not be unreasonably withheld) to change any nominated sub-Contractor.

6.7 SYSTEM RECOVERY

The Contractor shall supply a full backup set of all supplied software, on suitable archival media (e.g., CD-ROM, magnetic tape, optical disk, etc.). The Contractor shall also himself keep a full backup of the supplied software for the life cycle of the supplied equipment.

6.8 CONSUMABLES

The Contractor shall supply all consumables for the SCADA equipment and RTUs for the duration of the Contract, including, but not limited to:

Printer paper

Printer cartridges

Storage media

Cleaning materials

Back up batteries

6.9 DELIVERY AND INSTALLATION

Scope

The Contractor shall be responsible for all costs involved with the delivery and installation of the equipment for the SCADA System.

Delivery

The Contractor shall provide all personnel and equipment necessary to unload the equipment and transport the equipment to its' final location.

Installation

The Contractor should be aware that there may be periods such as flood events or for operational reasons, that the Contractor will not be allowed to work on the system or some particular part of the system or RTU, for some specified period.

The Contractor shall make due allowances for this in his costing and programming of his installation and commissioning works.

The working hours will be detailed by the Employer; working outside these hours will only be permitted with written permission following a written request from the Contractor.

7 BILL OF QUANTITIES

Item Description	Quantity	Unit Cost US$	Total Cost US$
Control Centre system	2		
Level Station RTU with GSM mobile communication interface	3		
Level Station RTU with satellite mobile communication interface	2		
Wadi Alert RTU Stations with GSM mobile communication interface	4		
Rain Gauge RTU Stations with GSM mobile communication interface	2		
Rain Gauge RTU Stations with satellite mobile communication interface	2		
GSM mobile telephone handsets	35		
Complete installation and O&M manuals for all equipment supplied	Set		
Installation support, training and commissioning on site	6 weeks		
Set of spares, special test equipment and consumables	Set		
Total Costs			

The costs of equipment shall include for all design, testing, carriage and import duties to a designated location in Yemen.

The costs of services in Yemen shall include all travel time and expenses.

A list shall be provided of all spares, special test equipment and consumables included in the offer.

Appendix A

LOCATION DESCRIPTION OF STATIONS

A. LOCATION DESCRIPTION OF STATIONS

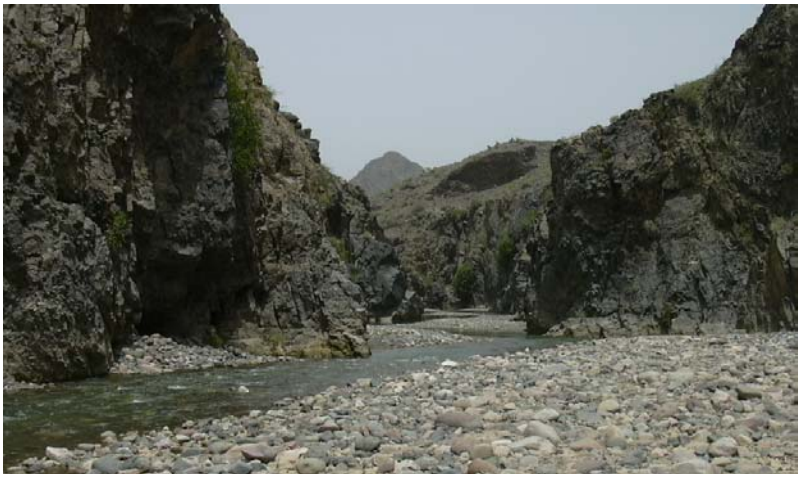
EMPTY

EMPTY

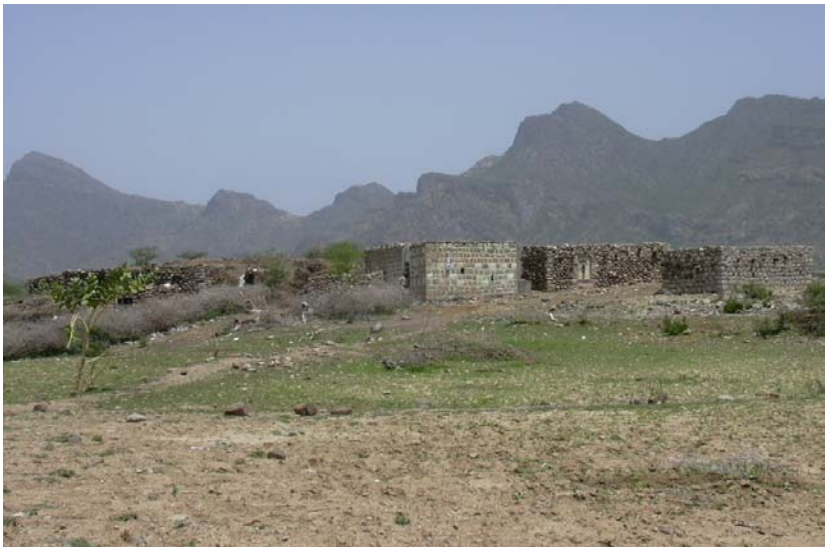
EMPTY

WADI ZABID

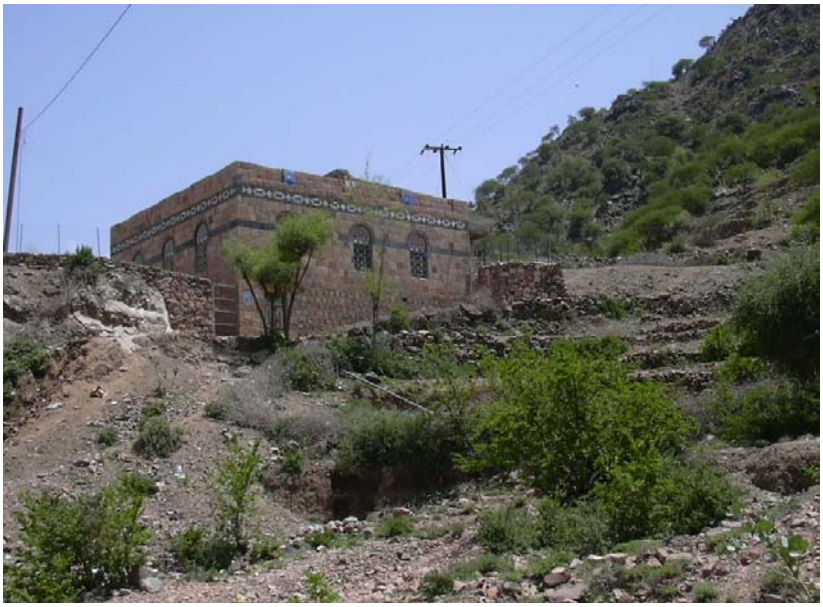
Al-Farisi Water level site



Almaqha'a Rainfall Station site



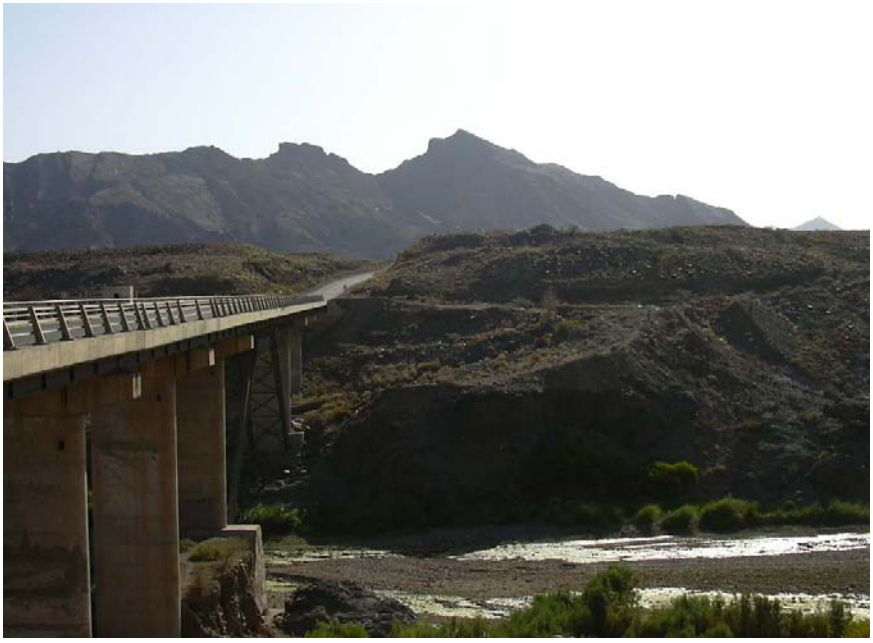
Al-Mazahim Rainfall Station site



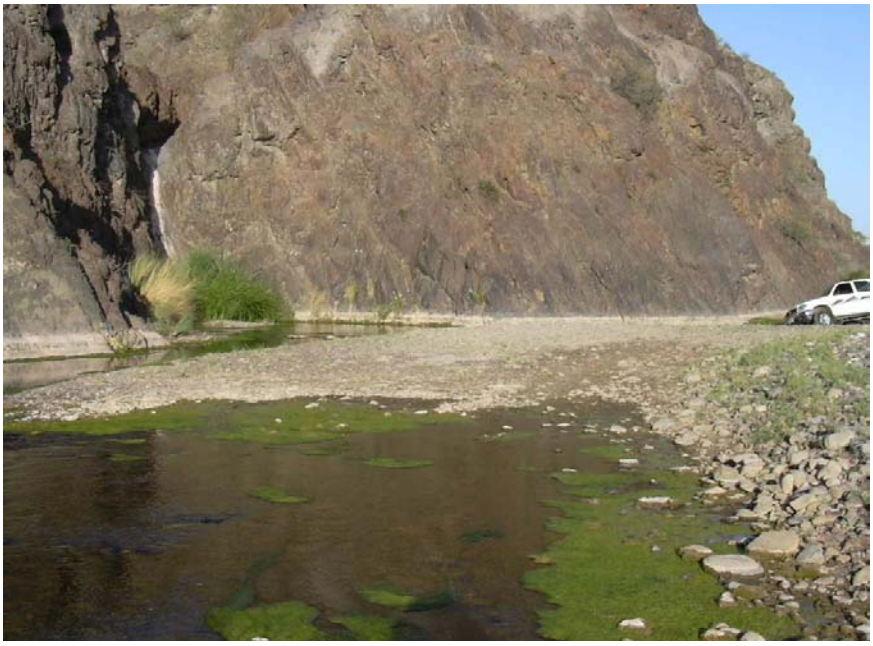
WADI TUBAN

Wadi Billah Water Level site

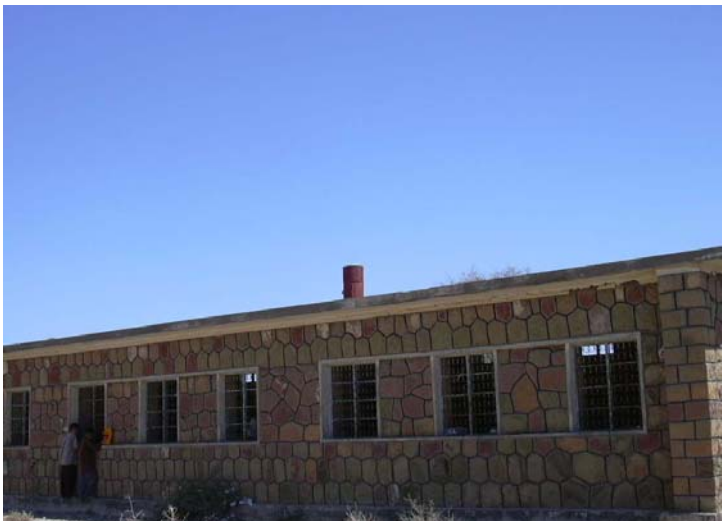
Water level station site as originally proposed near Aqan bridge



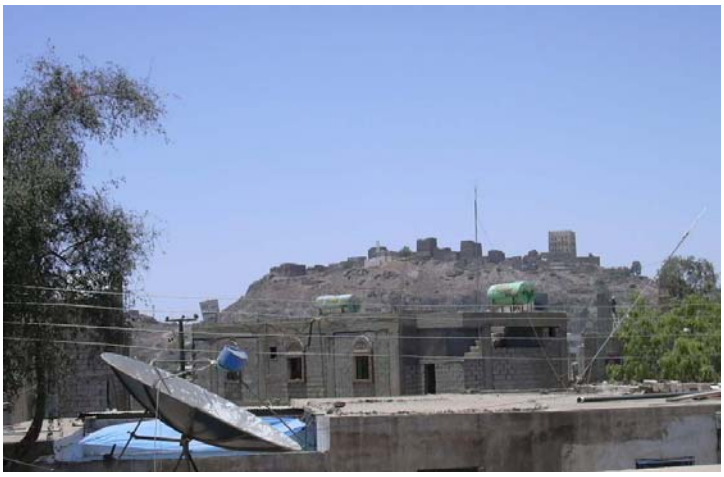
Water level station site as proposed 2.3 km downstream of Aqan bridge



Rainfall station site at Wazaran



Rainfall station site in Al-Dala



NWRA Rainfall station at Warazan