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Technical Assistance
HYDROLOGY PROJECT

DHV CONSULTANTS & DELFT HYDRAULICS with HALCROW, TAHAL, CES, ORG & JPS

VOLUME 4
GEO-HYDROLOGY

REFERENCE MANUAL

STEPS IN THE PROCUREMENT OF DWLR

Table of Contents

GENERAL

This Reference Manual comprises the testing of Digital Water Level Recorder (DWLR) and procedures to be followed for procurements and installation. The digital water level recorder is to record water table data in piezometer wells versus time. It consists of two parts:

Part I: Specifications for Digital Water Level Recorder (GW),

Part II: Acceptance Protocol.

In the Annexes to Part I a detailed Specification and Requirement Form related to bid on delivery of DWLR is presented including also a list of information to be furnished by the supplier.

PART I: SPECIFICATIONS FOR DIGITAL WATER LEVEL RCORDER (GW)

1 CONDITIONS AND REQUIREMENTS

- The instrument shall be of such a design that it operates reliably and accurately under the prevailing environmental conditions.
- The instrument shall be easy to operate and maintain.
- All materials on the instrument exterior shall be non-corrosive.
- A pressure sensor shall measure the water level, directly (immersed) or indirectly (bubbler).
- The method of pressure measurement shall compensate for the effects of barometric air-pressure, e.g. by application of a vented gauge pressure sensor or other compensation method.
- The instrument shall have a short settling time, i.e. rated accuracy shall be reached quickly after (re-) installation and there shall be no need to wait on site or even return later for re-adjustment to accommodate for initial settling drift. It should be noted that the instrument regularly will be recovered for maintenance and inspection.
- All batteries associated with the DWLR and the DRS, i.e. the batteries for normal operation and the backup batteries, shall be easily replaceable.
- During battery replacement the instrument settings and data shall be retained.
- The instrument shall be supplied with the accessories as needed for effective deployment.
- The instrument shall have an expected technical lifetime of not less than 10 years.
- The instrument shall be capable to operate at least 6 months without any servicing.
- Calibration data and test certificate shall be part of the delivery for each DWLR.
- The DWLR shall support adjustable specific gravity over a range of 0.9 to 1.03.
- The water level readings shall be recorded in datalogger memory.
- The communication between DWLR and DRS and PC shall be suitable for the cable lengths involved.
- An error monitoring communication protocol shall be used. The protocol shall ascertain error free data exchange between DWLR and DRS/PC. The protocol shall function in both directions; i.e. commands, programs, water level records and all other data exchange is under control of the protocol and may only be accepted if they are free.
- The communication protocol shall be based on packet wise data exchange, the packets shall be accompanied by a CRC code for checking at the receiving end. Defective or not received packets shall be retransmitted upon request by the receiving end.
- The DWLR shall be capable to measure the voltage of the internal battery(ies).
- A simple and accurate tool to assess remaining battery lifetime shall be made available. The tool shall enable proper planning of battery replacement without risk of data loss due to unexpected battery depletion. The tool may be implemented in the DWLR or alternatively, in the DRS. The operator may be prompted to enter specific parameters.
- Operator's and maintenance manuals, related to the type and model of the instrument, shall be part of the delivery.
- Comprehensive operators and maintenance training for respectively field observers and instrument specialists shall be part of the delivery.
- The proper functioning of each instrument shall be demonstrated at Delivery.

2 SPECIFICATIONS

The specifications include requirements regarding:

- pressure sensor,
- data logger,
- enclosures for pressure sensor and data logger,
- cable,
- data retrieval system,
- PCs software
- Palm top software,
- accessories, and
- consumables.

These are elaborated in the following sections:

Appendix I: Specifications and requirement form related to bid on delivery of DWLR; Ref. Bid No.

Appendix II: Supplier to furnish following information.

2.1 PRESSURE SENSOR

i.	**sensor type**	vented gauge pressure sensor
ii.	**measuring range**	0 to xx m water column (e.g. 0 to 10 or 0 to 20 m) as per Schedule of Requirements

The Schedule of Requirements gives the numbers to be quoted for and their associated ranges and is attached to this document. The Bidder shall specify for the closest standard range of the offered product with respect to the required measuring range. The quoted range shall be equal or larger than the required range.

Standard accuracy

iii.	**overall accuracy**	0.1% Full Scale
iv.	**temperature coefficient**	< 0.01%/ºC (on water level reading at 50 m suspension cable)
v.	**long term stability**	0.1% Full Scale/year
vi.	**reproducibility**	0.05% Full Scale

Note: Overall accuracy, long term stability and reproducibility include pressure sensor, cable and data logger. Stability shall also cover the longitudinal cable properties, e.g. elongation and creep of the suspension cable at the cable length specified in the Schedule of Requirements.

The temperature coefficient covers all the combined temperature effects on pressure sensor, data logger (zero and scale) and suspension cable.

The vendor shall specify the temperature effects on: sensor reading (zero and scale effects), cable length and data logger. The instrument shall maintain the specified **overall accuracy** over a temperature fluctuation of at least 10 ºC, i.e. whatever the actual temperature coefficient, the overall error shall not exceed the accuracy specifications as given under iii.

In case of a separate sensor, the electronics unit shall be field exchangeable without affecting the level reading beyond the rated system accuracy and such without any requirement for adjustments to the electronics, e.g. for zero and/or span control. Adjustment in software settings to accommodate for a sensor replacement is acceptable.

vii. **overload pressure** 2 times Full Scale

Overload pressure is the maximum pressure the sensor can sustain without effect on calibration upon return to rated measuring range.

viii. **burst pressure** > 3 times Full Scale

Loading a sensor beyond the burst pressure most likely results in puncture or collapse of the sensor membrane(s). Water may invade into the electronics compartment, damage the instrument severely, and destroy recorded data.

ix. **over-voltage protection**on supply and sensor wires

All pressure sensors suspended on a cable shall have a built-in protection against over-voltage in addition to an over-voltage scheme on the associated datalogger electronics.

2.2 DATALOGGER

i. **resolution of measurement** 12 bit A/D converter or better

ii. **measuring interval** pre-set at 6 hours, adjustable from 30 minutes and multiples to 24 hours; for pump tests an interval range of 1 minute to 1 hour

The measuring interval shall be user adjustable, recordings shall be executed at 'integer times'. Example, if the measuring interval is 30 minutes, then recording should take place at 00h00, 00h30, 01h30, etc. The first record after initiation of the instrument, should be made at the first instant of 00 or 30 minutes in the hour.

iii. **settling time** < 60 minutes after submersion at the time of installation.

Upon installation, after submersion, the DWLR including pressure sensor and electronics, adjusts to the changed temperature, pressure and cable tension; the water level readings shall settle to the required accuracy within the specified settling time.

iv. **date** day, month, year in the following format: DD/MM/YYYY with leading zero's (01/03/2001 for 1st of March 2001)

No millennium bug.

v. **time** hh:mm:ss (0 to 23 hours, 0 to 59 minutes, 0 to 59 seconds) with leading zero's (08:05:07)

The specification given above is only valid for the way date and time are presented to the user and does not apply to the way the data loggers handles these.

vi. **recording capacity** minimum of 10,000 wate rlevel readings.

The recorded data shall also contain an instrument serial number or well identification code and information on date and time of recorded water levels readings. The serial number or the well identification code shall be uniquely attached to the data logger and shall not be added after data retrieval by user interference. The memory shall have a ring organisation (endless loop). The memory shall be protected against accidental erasure by a password or equivalent.

vii. **error marking** error code, e.g. –9999 or similar

Out of range data and errors shall be clearly and unambiguously marked and be distinguishable from valid data. The error mark is an impossible value, which cannot be generated by valid measurements.

viii. **recording resolution** 0.001 m or better

ix.	**memory type**	non volatile memory or volatile memory Volatile memory shall be protected from data loss by a backup battery. The battery capacity shall be sufficient to retain memory contents more than one year after main power disconnection (removal of the supply batteries).
x.	**power supply**	built-in standard Lithium batteries, like AA, C or D size for at least 5 years of unattended operation at a measuring interval of 6 hours

- The batteries shall be kept inside the datalogger enclosure, or in a separate enclosure. The latter shall be enclosed in the well above the maximum water level close to the wellhead.
- Battery replacement shall be easy; return of the instrument to the manufacturer for battery replacement is unacceptable.

xi.	**communication interface**	serial RS232 C at DRS / PC end

The communication between DWLR and DRS and PC shall be suitable for the cable lengths involved.

xii.	**baud rate**	9600 or more
xiii.	**operating temperature**	0 to 50°C.

The operating temperature range specification applies to all components of the DWLR, like: sensor, cable, data logger, batteries, etc.

xiv.	**built in clock**	time keeping better than 1 minute per month
xv.	**displayed time resolution**	1 second
xvi.	**over-voltage protection**	on all i/o lines, regardless mode of connection during deployment

Built-in over-voltage protection is required on the electronics unit, in particular on all external connections, e.g. sensor supply and signal (also on optional sensors), external power supply and data communication interface.

2.3 ENCLOSURE FOR PRESSURE SENSOR AND DATA LOGGER

- The sensor electronics, data logger, electronics, batteries and all other electrical components shall be contained in one or more protective enclosures.
- All materials and combinations thereof shall be corrosion proof.
- The pressure sensor and data logger shall be contained in a single enclosure which will be submerged. in the piezometer well.

The enclosures shall comply with the following specifications.

i.	**dimensions**	outer diameter should be less than 70 mm, length <0.6 m
ii.	**material**	stainless steel (AISI 316) or equivalent
iii.	**weight**	sufficient to keep suspension cable taut, 2 kg or more
iv.	**operating temperature**	0 to 50°C
v.	**ingress protection**	enclosure and cable assembly shall have IP68 protection to a minimum of 100 m water column or 2 times the rated measuring range, whichever is larger.

vi.	**above-water parts**	The above-water parts shall have IP65 protection, and operating conditions are 0 to 50°C and humidity 100% or less

2.4 CABLE

The design of the support for the water level recorder depends on the site-specific conditions. The engineer in charge shall provide details on support and housing in collaboration with the bidder. The cable is preferably of a detachable type for increased operational flexibility.

The cable shall have the following features:

i. strength members for good longitudinal stability of the cable;
ii. incorporated vent tube for barometric air-pressure compensation of the vented gauge pressure sensor;
iii. a moisture blocking system based on a hydrophobic filter and desiccator, to prevent condensation of water in the vent tube and in the sensor. The desiccant capacity shall be sufficient for 6 months of unattended operation. The desiccant shall be field replaceable;
iv. the desiccant capacity should be adequate for at least 6 months of unattended operation under worst case environmental conditions. For each instrument, two desiccant replacements should be part of the delivery;
v. good flexibility;
vi. cable screen, to be connected to the datalogger ground terminal to minimise electrical interference;
vii. a cable suspension bracket allowing the DWLR to be adjusted to the required depth in the well in a stable and reproducible manner.

Quantitative specifications

i.	**conductor size**	minimum 26 AWG 19/38 tinned copper wires with insulation like nylon or PTFE (Teflon), insulation thickness minimum 0.5 mm.
ii.	**vent tube**	Nylon, PTFE or equivalent, inner diameter approx. 1.5 mm, thickness minimum 0.4 mm
iii.	**strength members**	stainless steel, Kevlar or equivalent to keep the sensor at the correct depth in the well
iv.	**temperature coefficient**	$<15 \times 10^{-6}$ /ºC (longitudinal)
v.	**cable screen**	braid of 36 AWG tinned copper or similar effective material.
vi.	**outer jacket**	Surlyn or PTFE (Teflon), Polyurethene
vii.	**jacket thickness**	1 mm or more
viii.	**cable size**	outer diameter 7 to 12 mm
ix.	**cable length**	to be specified in m as per Schedule of Requirements

2.5 Data retrieval system

- The Data Retrieval System (DRS) for communication with the DWLR shall be portable, handy and lightweight.

- The delivery shall include cables for connecting the DRS to the DWLR and to a serial port of a PC.
- The DRS shall communicate by a serial protocol.
- For some DWLR implementations, the interface adapters, e.g. for IrDA and RS485, are needed to communicate with DRS and/or PC. These adapters, including manuals, software, cables and all other required accessories shall accompany each DRS, both for communication between DWLR and DRS between DWLR and PC.
- If required for use with the DRS and/or PC, e.g. to cope with long cable lengths, suitable adapters shall be part of the delivery.
- The DRS shall support the communication protocol as specified under Data logger, item Communications.
- The data exchange between DWLR and DRS as well as between DRS and PC shall be protected by similar error-free protocols.

The DRS shall have the following features:

Palmtop computer

i.	**data handling**	capable of programming, controlling, downloading and monitoring the DWLR
ii.	**capacity**	sufficient to offload all data of 10 entirely filled DWLR recorders
iii.	**ports**	at least one serial RS232 port to connect a DWLR or a PC
iv.	**baud rate**	9600 or more, matching DWLR
v.	**entry and display**	keyboard and LCD screen for efficient control of the DWLR
vi.	**readability**	the display shall be easily readable under field conditions
vii.	**software functions**	DWLR control functions, display of historical data, battery voltage, present water level reading and instrument time
viii.	**operating system**	capable of running MS-Windows CE (preferably), MS-Windows 95 or MS-DOS operating system with matching software for instrument control and tabular and graphical presentation of time series of collected data on the LCD screen
ix.	**power supply**	operative with standard Alkaline batteries, easily available in India, or rechargeable battery pack
x.	**power autonomy**	at least 12 hours continuous operation on a single battery charge
xi.	**supply backup**	all volatile data have to be protected by a back-up battery of sufficient capacity to retain all data for at least one year of failure of main batteries
xii.	**weight**	less than 0.5 kg
xiii.	**operating temperature**	0 to 50°C
xiv.	**humidity**	95%
xv.	**robustness**	the Palmtop PC should be capable to survive a few drops on stone.

2.6 PC SOFTWARE

- PC software shall be part of the delivery and is to be used in the office, e.g. on a desktop PC.
- The PC software shall efficiently and reliably transfer the collected data from the DRS to a PC environment.
- The PC software shall support functions for conversion of the collected data into ASCII (text) tables.
- The data tables shall have the following format: dd/mm/yyyy hh:mm:ss lll.lll. Level (lll.lll) shall be presented with 0.001 m resolution. If measured, temperature shall be appended in the 4th column, with a resolution of 0.1°C.
- The PC software shall support exporting of the tabular data to other software packages, e.g. for analysis and presentation by a spreadsheet and for storage in a database
- The PC software shall support the same and more tabular and graphical presentation functions as specified under Palmtop software.

2.7 PALMTOP SOFTWARE

- The Palmtop software shall support functions for conversion of the collected data into ASCII (text) tables, and for efficient visualisation of the time series in tabular and graphical form.
- Graphical axes shall be generated automatically and be manually adjustable. Units along the axes shall not be awkward but intuitive and easily understandable.
- All axes shall have sufficient graduation.
- The labels along the time axis shall be in sensible time intervals, i.e. hh:mm for relatively short periods and dates, e.g.: DD/MM/YYYY, for long periods. The same applies for the level axis.
- The unit-labels shall not cover each other.
- To enhance readability, adequate gridlines, both along time and level axes, shall be generated automatically by the graphics functions, approximately 5 gridlines per axis.
- The gridlines should also be user adjustable.
- The user interface shall support efficient functions to select and visualise subsets of the time series, e.g. a single day or several days somewhere out of many weeks of data.
- Efficient window functions shall be available to visualise the data in the required resolution, i.e. the level scale shall be user adjustable.
- Software that can only display sample counts or total duration or does not support axis and grid adjustment is not acceptable.
- Note that in particular the graphics capabilities are a major reason to apply a palmtop computer as DRS.

2.8 ACCESSORIES

- tools
- spares
- signal, power and communication cables as required for all normal user operations
- 230 VAC, 47 to 53 Hz, charger for NiCd, NiMH or Li-ion battery pack

2.9 CONSUMABLES

- batteries for DWLR and DRS
- desiccator for the hydrophobic filter and the electronics
- replacement hydrophobic filters

APPENDIX I: SPECIFICATIONS AND REQUIREMENT FORM RELATED TO BID ON DELIVERY OF DWLR; REF BID NO.:.....

Summary of Instructions

Particulars of Manufacturer and local agent cum representative are to be given under rows Model and Address.

All entry boxes in column 4 shall be filled-in accurately and comprehensively. Quantitative fields shall be filled in accurately. It is not acceptable to use Yes, No, Compliant or similar evading words. In bids for Surface Water application, the fields marked GW do not have to be filled in and for Groundwater application the fields marked SW may be neglected. Requested materials and information shall be enclosed with the bid and be unambiguously associated with instruments as offered in the bid

Negligence to comply with the instructions and requirements as stated above makes the bid liable to be rejected.

Abbreviations: GW-Groundwater; SW-Surface Water; OD-Outer Diameter; ID-Inner Diameter; FS-Full Scale; Pa-Pascal (unit of pressure).

DWLR-Digital Water Level Recorder; DRS-Data Retrieval System; HHT-Hand Held Terminal.

Sample interval is the interval at which samples or sensor readings are taken. The recording interval defines the interval at which the data records are stored in memory. A data record can represent a single sample or the average of a number of samples. In particular the result of the wave suppression filter is a single record representing the average value of a number of samples.

Entries requiring special attention:

4.4 The longitudinal properties of the suspension cable affect the accuracy directly. Specify all factors affecting the longitudinal properties of the suspension cable: e.g. length creep due to sensor and cable weight (submerged), longitudinal temperature coefficient, uncoiling after installation, expansion/contraction of jack due to temperature and aging, etc.

4.10 How is moisture prevented to enter into the vent tube?

In entries 7.0 .. 10.0 the bidder's experience with the offered equipment should be clearly reflected. The proposed maintenance interval and the recommended spares as offered in the bid shall be based on instrument deployment history. The training proposal shall be based on experience in similar cases. Moreover, it shall consider the educational level and specialisation of the trainees.

Model	**DWLR Model**	**Pressure sensor make and model**	**DRS make and model**
Address	**DWLR Manufacturer** Name Place Tel: Fax: E-mail: WWWeb:		**Local Agent for DWLR Manufacturer:** Name Place Tel: Fax: E-mail: WWWeb:

Sl.No	Feature	As required in Bidding Document	As offered in Bid	REMARKS
1	2	3	4	5
0.0	**General Information**			
0.1	Number produced of offered model First year that more than ***25*** units were sold in a single year	***>50*** year		
0.2	Brochure of DWLR	1 unit		
0.3	Photo of DWLR, A4 size	1 unit		
0.4	Brochure of DRS	1 unit		
0.5	Photo of DRS	1 unit		
0.6	Demo software on 3.5" diskette/CD	# Diskettes; # CD's		
1.0	**Pressure Measurement**			
1.1	Pressure sensor manufacturer Sensor type/model Class	 Vented gauge pressure sensor	Manufacturer Type/model	
1.2	Measuring range	Water level variation: e.g. 0 to 20 m (as per Schedule of requirements)		
1.3	Overall accuracy **(incl.** datalogger)	***0.1*** % FS, i.e. 20 mm for 20 m. range		
1.4	Temperature coefficient (on water level reading at 50 m suspension cable)	**<**0.01% FS/ºC		
1.5	Long-term stability **(incl.** Datalogger)	***0.1*** %/year, i.e. 0.02 m @ 20 m range		
1.6	Reproducibility	0.05 % FS		
1.7	Overload pressure	2 time FS, without effect on accuracy		
1.8	Burst pressure	> 3 times FS		
1.9	Overvoltage/surge protection	On all I/O wires		
1.10	Protection against water ingress	IP68 100 m water column or 2 x FS whichever greater		
1.11	Size	Maximum O.D.: 75 mm		
1.12	Weight	Adequate to keep the cable taut: >2 kg		
1.13	Enclosure material	Stainless steel, titanium, hastelloy		
1.14	Membrane material	Stainless steel, titanium, silicon		
1.15	Cable entry	Moulded, gland, connector	Specify	
2.0	**Datalogger**			
2.1	ADC (digitising) resolution	12-bit A/D or better		
2.2	Measuring/recording interval A record comprises level data and all other parameters to recover ID, date and time.	GW: 30 minutes and multiples, max 24 hrs, including 6 hours SW: 15 minutes and multiples, max 24 hrs; 10 minutes for tidal areas		
2.3	Settling time upon installation	<60 minutes		
2.4	Date presentation	DD/MM/YYYY with leading zero's		
2.5	Time presentation	hh:mm:ss (00 to 23; 00 to 59; 00 to 59)		

Sl.No	Feature	As required in Bidding Document	As offered in Bid	REMARKS
1	2	3	4	5
2.6	Recording capacity	GW: >10,000 records SW: >20,000 records		
2.7	Error marking	number, -9999 or similar		
2.8	Recording resolution	0.001 m or better		
2.9	Memory type	Solid State: EEPROM, SRAM or NVRAM		
2.10	Power supply, battery type Autonomy	GW: Lithium battery (e.g. C or D size) >5 Year @ 1 record / 6 hours SW: Alkaline battery (e.g. C or D size) >1 Year @ 1 record / hour	Type Size Nominal voltage: Autonomy in months	
2.11	Communication interface	Serial, RS232 C at DRS and PC end		
2.12	Baud rate	9600 or more		
2.13	Operating temperature range	0 to 50°C		
2.14	Clock stability	1 minute per month or better		
2.15	Displayed time resolution	1 second		
2.16	Built-in overvoltage and surge (ESD) protection	On all I/O contacts and I/O wires		
2.17	Data offload power use	How many full data offloads can be executed during specified battery life (re 1.10)	Number	
2.18	Attached display (optional)	LCD, to show level reading	Description	
2.19	SW wave suppression filter Based on averaging over specific number of fast samples	SW: only; filter adjustment range Sample interval: 1 - 10 s Number to average: 1 - 120 samples		
3.0	**Electronics Enclosure**			
3.1	O.D. and Length (mm)	70 mm maximum and 600 mm maximum		
3.2	Material	Stainless steel (AISI 316), (Delrin), FRP		
3.3	Weight submerged section Weight above surface section	Enough to keep cable taut (>2, <4 kg) <4 kg		
3.4	Operating temperature	0 to 50°C		
3.5	Ingress protection of enclosure(s), connector(s) and cable incl. gland(s)	All submerged parts: IP68 100 m water column or 2 x FS whichever greater Above water parts: IP65		
3.6	Protection above water enclosure Temperature range Humidity	IP 65 0 to 50°C 100 % maximum		
4.0	**Cable**			
4.1	Conductor size Insulation	26 AWG minimum 0.5 mm nylon or PTFE minimum		
4.2	Vent tube	Air-pressure compensation tube of approx. 1 to 2 mm I.D.		
4.3	Strength members	Kevlar, stainless steel or equivalent		
4.4	Longitudinal temperature coefficient	$< 15 \times 10^{-6}$ m/m/ºC		
4.5	Cable screen	Braid of 36 AWG tinned copper or equivalent		
4.6	Outer jacket	PTFE, Surlyn, Polyurethene		

Sl.No	Feature	As required in Bidding Document	As offered in Bid	REMARKS
1	2	3	4	5
4.7	Jacket thickness	1 mm or more		
4.8	Cable outer diameter	7 to 12 mm		
4.9	Cable length	Length in m (as per Schedule of requirements)		
4.10	Moisture ingress prevention method	Hydrophobic filter and silica gel desiccator	Details:	
4.11	Water lock at cable access into submerged instrument	Water invaded into the electrical cable should be blocked from ingress into any submerged compartment	Explain:	
4.12	Cable sample	Cable sample (>0.3 m), encl. with bid		
5.0	**Data Retrieval System (DRS)**			
5.1	Data handling	Programming, controlling, downloading and monitoring of the DWLR	Details	
5.2	DRS capacity to offload data	All data of 10 entirely filled DWLRs		
5.3	Ports	Serial, RS232 compliant		
5.4	Baud rate	9600 or more, matching DWLR		
5.5	i. Entry ii. Display	Alpha-numerical Key Board/ Key Pad LCD	Details	
5.6	Readability	Good readability in all field conditions		
5.7	Software functions	i. Capable of DWLR programming (y/n) ii. Resetting the DWLR (y/n) iii. Retrieving data from DWLR (y/n) iv. Graphical display of time series (y/n) v. Display of DWLR level reading (y/n) vi. Display of DWLR battery voltage (y/n) vii. Display of DWLR time (y/n) viii. Transferring data to PC (y/n)	Details	
5.8	Operating system	MS Windows CE or MS-DOS		
5.9	Power supply for DRS	Rechargeable battery and standard Alkaline		
5.10	Power autonomy	>12 hours continuous operation on single battery charge		
5.11	Backup battery for DRS	Autonomy without main battery: >1 year		
5.12	Weight	<0.5 kg		
5.13	Operating temperature. of DRS	0 to 50°C		
5.14	Operating humidity range	Up to 95 %		
5.15	Robustness	Survives several drops on stone without damage		
6.0	**PC utility software**			
6.1	Utility software on PC	MS-Windows (CE/95/98), (MS-DOS optional)	OS versions supported:	
6.2	Communication with DRS	By serial connection; RS232C		

Sl.No	Feature	As required in Bidding Document	As offered in Bid	REMARKS
1	2	3	4	5
6.3	Logger control	Control of all logger functions and settings		
6.4	Logger monitoring	Display of logger activity and functioning		
6.5	Data management	Offload of collected data, memory erasure		
6.6	Conversion of offloaded logger data	Output file types: ASCII, CSV, others	Details	
6.7	Time series graph	Graph of selected period, with adjustable scale and auto-scale		
7.0	**DWLR spares To cover 4 years of operation**			
7.1	Pressure sensor			
7.2	Datalogger module (possibly pressure sensor and datalogger are encompassed in a single enclosure)			
7.3	Signal cable(s) types and lengths			
7.4	Top termination unit and/or connector (possibly containing air-inlet, batteries, data connection)			
7.5	Batteries			
7.6	Field calibration instrument based on application of compressed air-pressure to DWLR sensor and a highly accurate pressure sensor	Pressure range: Sensor accuracy: Transportable and running on internal or external battery: Hand pump and flask with compressed air: Precise pressure regulator: Sensor adapter and tubing:		
7.7	Guaranteed availability of sufficient spares in **India**	No. of years:		
8.0	**Data Retrieval System spares To cover 4 years of use**			
8.1	DRS module			
8.2	Connection cables			
8.3	Memory modules			
8.4	Batteries			
8.5	Battery charger			
9.0	**Maintenance**			
9.1	Zero adjustment			
9.2	Scale and zero calibration, required to maintain rated accuracy			
9.3	Battery check			
9.4	Maximum response time by service provider on service request			
9.5	Maximum repair/replacement turn-around time			
10.0	**Training requirements in man days**			
10.1	Field operator			

Sl.No	Feature	As required in Bidding Document	As offered in Bid	REMARKS
1	**2**	**3**	**4**	**5**
10.2	Data collector			
10.3	Supervision staff			
10.4	Trouble shooting staff			
11.0	**Any special features**		1. 2. 3. 4. 5. 6. 7. 8. 9. 10.	

APPENDIX II: SUPPLIER TO FURNISH THE FOLLOWING INFORMATION

1. What are make, type and model of the Digital Water Level Recorder?
2. What are make, type and model of the pressure sensor?
3. What are make, type and model of the Data Retrieval System?
4. What is your (comprehensive) definition of accuracy as stated in the brochure and filled in on the form at entry 2.4?
5. What is the recommended re-calibration interval to achieve and maintain the rated accuracy?
6. How do span and zero drift vary with time and mode of application?
7. What is the method of moisture control on the air-vent system: hydrophobic filter, desiccator?
8. What method of over-voltage protection is being used and to which I/O lines does it?
9. Is the sensor submitted to any type of enforced ageing, if so please specify?
10. Provide a comprehensive Method Statement on the applied calibration and in-factory test procedures, both technically and procedural. The Statement should reveal at what temperatures calibration measurements are taken and how long the instrument is allowed to settle at each new temperature. An example audit trail to national standards on all instruments and facilities used for testing and calibration is requested.
11. Outline Quality control procedures that are implemented during and after production.
12. A set of typical calibration and test forms used for the instrument. The calibration form should express overall calibration, i.e. calibration of the complete Digital Water Level Recorder, including the pressure sensor.
13. CSV type ASCII data files is requested giving typical calibration and test data, e.g. for scale, zero stability, scale stability and temperature effects on these parameters. An example of typical time series in a PC-file is requested as well.
14. If the cable gets punctured, will water then reach the electronics: clarify.
15. Specify longitudinal cable properties: length creep due to datalogger weight; longitudinal temperature coefficient; uncoiling after installation
16. What material is being used for the grip and suspension cable?
17. Is hardware span and/or zero adjustment required in the field during normal operation or during service visits?
18. What schedule of re-calibration is to be applied for the sensor and is this to be done by the Manufacturer or is it done by the service provider in India?
19. Can the battery be replaced by the user or by the service provider or do they have to be returned to the Manufacturer?
20. Is hardware span and/or zero adjustment required after replacement of electronics or sensor, and can/should this be done in the field or in the office?
21. Documents. Please attach each of the following documents:
    - System Manual (giving a comprehensive description of the entire system, covering all components)
    - Service and Maintenance Manual
    - Operator's Manual, and
    - Training handouts.
22. Details of the local representative in India, with special reference to:
    - training facilities/capabilities.
    - after sales and maintenance facilities.
    - availability of spare parts.

PART II: ACCEPTANCE PROTOCOL

1 GENERAL

The delivery of bid goods/equipment and software should be in accordance with the order placed with the Supplier. To formalise the process of delivery an Acceptance Protocol is prescribed.

The Acceptance Protocol shall serve as a formal guidance during delivery of the DWLRs. Its primary goals are twofold.

1. Ascertain the delivery and completeness of all ordered products and related documents.
2. Check the functioning of the equipment and software in a formal way against the specifications by application of Acceptance Tests. The tests also verify the accuracy and stability of the equipment.

The Acceptance Protocol shall be executed in close co-operation between the Supplier and the Client.

Products shall be accepted only if they meet the requirements and are functioning in compliance with the technical specifications, and the related documents are complete and correct. Defective products and any other discrepancies shall have to be replaced/resolved, within a pre-defined time frame.

2 DOCUMENTS

The following documents shall accompany the delivery of the instruments and software:

1. Administrative and QA documents
2. Test and calibration documents
3. Manuals and Guidelines

All documents shall have identification and references to subject or instrument, date, time, location and officer in charge.

The Acceptance Report lays down the findings and observations during the execution of the Acceptance Protocol and is a formal document to record the acceptance or rejection of any item as covered in the Bid document. Any flaws or findings are to be reported. The forms and checklists filled out during the execution of the Acceptance Protocol are to be enclosed with the Acceptance Report. The Supplier receives a signed copy of the Acceptance Report, which the Supplier can use as proof that the items listed in the report were accepted.

The content of the various documents shall be as follows:

2.1 ADMINISTRATIVE AND QA DOCUMENTS

These Quality Assurance (QA) documents shall include:

- Production documents associated with the instruments.
- Type codes, serial numbers and other identification data on, possibly externally procured, sensors and major assemblies, to clearly demarcate the sensors/major assemblies associated with each DWLR.

- Shipping documents indicating instrument/product type, serial number, measuring range, cable length and other similar data.

2.2 Test and calibration documents

A comprehensive Method Statement on the applied calibration and in-factory test procedures shall accompany the bid document. The Method Statement defines the test and calibration methods applied on the instruments and the components thereof. The Method Statement shall also include, for each calibrated product, an audit trail to national standards on all instruments and facilities used for testing and calibration. The Audit Trail Report shall associate the calibration of the reference instruments and test equipment to the national calibration standards.

If the Supplier or Manufacturer is not in a position to deliver an Audit Trail Report to the national standards, the Manufacturer shall explain what the quality standards are and how they are maintained and monitored.

Conditions during calibration, such as room and/or instrument temperature, equipment and facilities used, shall be included in the calibration and test documents.

The test and calibration documents shall contain the data generated during calibration and testing, including:

- Calibration data supplied by the Manufacturer of pressure sensor,
- Calibration and test data of the datalogger electronics,
- Calibration data on overall DWLR calibration, i.e. comprising both pressure sensor and electronics. A table listing applied reference pressures versus instrument readings is to be delivered for each sensor and instrument. Furthermore, that table shall also show the test conditions during calibration,
- Data on hysteresis test,
- Data on temperature tests,
- Data on zero stability test,
- Data on scale stability test,
- Humidity test, in particular for vented gauge pressure sensors,
- Temperature cycling of sensor and electronics,
- Spray test on enclosure(s), connectors and cables.

2.3 MANUALS AND GUIDELINES

The manuals shall meet the requirements on style and clarity, completeness, preciseness, detail and accessibility. This includes:

- System manual,
- Operation, Maintenance and Service manuals,
- Observation guideline, and
- Training handouts.

3 ACCEPTANCE TESTS

3.1 General

Qualified engineers under responsibility of a test manager shall execute the Acceptance Tests. The progress of the Acceptance Tests is monitored and supervised by the Client and/or his authorised representative. The Client may have any tests redone or additional tests executed as he deems required based on the results of previous tests conducted. The Client's test party has the right of access to any instrument and may request any data or information at any time. The Supplier has the obligation to deliver requested information without delay; i.e. collected test data and documents must be available at the test site.

It is important that all activities (what, when, where, who, which instrument, etc.) are annotated and uniquely linked to the individual instruments.

The Acceptance Tests mainly comprise three levels viz.:

1 Functional Tests

The Functional Tests shall verify the proper functioning of the instruments and the associated software. Primary goal is to verify that the instrument performs its functions according to the bid specifications.

2 Accuracy Tests

The Accuracy Tests shall verify that each individual instrument is functional and operates according to the bid specifications. A number of relatively simple accuracy tests are routinely exercised on the instruments.

3 Overall Test

The main purpose of the Overall Test is to verify the common features that are identical to all the instruments in a series. Typical components of the Overall Test are: in-built software functions, materials of the instrument, cables, connectors, etc. Further tests include battery and memory autonomy, details of sensor specifications like temperature effects, hysteresis, long term stability etc.

The above tests can be executed at any one of the following locations:

- Premises of the Manufacturer/Supplier;
- Premises of the Client;
- Independent organisation.

The charges for testing at the Manufacturer's/Supplier's premises shall be borne by the Manufacturer/Supplier. The Client may at his cost be present during the performances of the tests. If the tests are executed at the Client's premises, the charge for testing shall be borne by the Client and the Supplier shall be responsible for conducting the tests. The bidder in his bid shall indicate the independent organisation and the charges for testing. The Client reserves the right to accept the independent organisation and its charges or get the tests done by any other agencies. However, the Supplier shall be permitted the opportunity to be present at these tests.

The details of these tests are as follows.

3.2 FUNCTIONAL TESTS

The Functional Tests include:

- visual inspection, and
- user tests.

3.2.1 VISUAL INSPECTION

Visual inspection includes the following activities.

- All items are visually checked for damage, e.g. on cables, sensor and housing.
- Availability of non-removable identification codes and specifications are verified, e.g. serial number, type identification, manufacturer and measuring range.
- Cables have to be marked as well: each cable is to have an identification code and name.
- Cable connectors shall have their ends marked suitably to indicate the device to which it is to be connected, e.g. PC, HHT, Power Supply etc. Suitable precaution shall be taken so that the connectors are not connected to wrong terminals, i.e. it shall be impossible to connect a power cable to a communication bulkhead socket.

3.2.2 USER TESTS

All instruments have to be identical except for measuring range, cable length, identification code and similar aspects. Consequently there is no need to check the functionality of all systems. It is assumed that the functional compliance with the specifications is tested under the Overall Tests. The objective of the user test is to detect any malfunction and/or defect. From practical point of view, the user tests can be coupled with other test, e.g. the stability tests.

Basic functions to be tested are:

- Pre-deployment preparation, e.g. setting of clock, erasing of memory, setting data logging parameters, entry of identification data
- Facilities for execution of on-site functional checks
- Data retrieval and data transfer to PC
- Conversion of retrieved data into ASCII table for application by user's software
- Battery status and voltage
- Simple output test by observing pressure reading while the sensor is immersed in a bucket filled with water

3.3 ACCURACY TESTS

The Accuracy tests include:

- accuracy tests on clock, and
- accuracy tests on pressure measurement

3.3.1 ACCURACY TESTS ON CLOCK

The clock of the datalogger shall be carefully checked against national time, e.g. taking the radio broadcast time beeps as a reference. The datalogger clock is set precisely and checked at the start of the individual tests and upon instrument and/or data retrieval. In between, the clock should not be re-adjusted.

The clock test shall cover at least 3 days to get sufficient time resolution. The reference clock, e.g. a watch, must be carefully tuned against national time prior to and during the tests. The clock drift, converted to seconds per month (31 days) shall comply with the defined specifications. This test method makes use of the specified time resolution of 1 s.

3.3.2 ACCURACY TESTS ON PRESSURE MEASUREMENT

The accuracy test on the pressure sensor is an overall accuracy test covering both the pressure and electronics systems. The pressure tests are to be executed against accurately known reference pressure(s). Pressure can be generated from compressed air (gas) or by submerging the sensor to known depths in water.

Reference pressure may be created via a precision pressure reduction valve from a source of compressed air. A high precision sensor like a Paroscientific DigiQuartz pressure sensor or a Dead Weight Tester can be implemented to quantify the applied pressure. Pressure should be measured in kPa (or mbar).

When applying the immersion method it is much more difficult to check the instruments because water density affects the reading. Moreover, it is not simple to establish the exact depth of sensor immersion. And especially in narrow wells, while immersing a pressure sensor on its cable into a well, the waterlevel will rise due to the additional volume of the immersed pressure sensor and cable. The water level will gradually fall again, when the well level adjusts again to equilibrium with the ground water level. In order to achieve a high accuracy these effects have to be assessed.

During the tests, temperature and barometric air-pressure should be accurately logged against time, preferably by automatic instruments or otherwise by half hourly manual reading, i.e. 48 times a day. In particular for the zero stability tests, logging by digital instruments makes subsequent computerised data processing more effective. Data retrieved from chart records and manual readings must be keyed into a computer file during the tests. The data entry shall not be delayed beyond execution of the stability tests to ascertain a proper check during the tests and to allow for quick verification of the results and feedback, if required.

The pressure sensor tests include:

1 Zero stability test
2 Scale test
3 Scale stability test

The pressure sensor tests shall focus on temperature effects on zero, scale and cable length, and in addition to that establish quantitative data on drift of zero, scale and creep of cable length.

Zero stability test

During the zero-test the instruments are in logging mode, say at an interval of 30 minutes, and shall be kept in a separate room where they will not be touched for at least 3 days. The instruments must

be dry, i.e. not in a bucket of water, to exclude any water effect on the sensor, and hence, the instrument reading is expected to be 0.0.

Under this test, each instrument will record its short term zero drift and inherently the effectiveness of the air-pressure compensation method. During the zero-test, the instruments shall be in the same and constant position, vertical or horizontal. The room temperature shall vary over 5 ºC or more, e.g. due to daily temperature fluctuation, this to assess temperature effects on the instrument reading. This requirement may affect the choice of venue for the zero-tests. To avoid any adverse temperature strain, no direct sunlight shall fall on the instruments. At the end of the test, the collected data are offloaded from the datalogger memory and analysed for zero stability. As the instruments are kept in air and are not touched, the reading shall be stable and not change over time, that is not beyond permissible limits.

Room temperature is to be logged against time, preferably by digital method. In case the DWLR has a built-in temperature sensor, that sensor may be used for temperature logging. The pressure sensors shall not be tested in an air-conditioned room for several reasons. First, temperature fluctuations may be so rapid that the sensor temperature compensation scheme may not be able to cope with it. Moreover, rapid air-pressure fluctuations may not be handled properly by the air-vent system and/or the pressure measurement method. This is to be understood from the perspective that the instruments are designed to operate in wells where changes occur but not rapidly. One or more fans may be operated continuously to minimise temperature gradient across the test room.

To test the creep and elongation of the electrical cum suspension cable some vertical open space is required, e.g. a stairwell can be used for this purpose. However, it is important that the cable is protected against touch to avoid interference with the measurements. The cable is loaded with some weight to emulate the weight of cable and sensor. The length of cable under tests shall be as long as possible, i.e. 10 m or more, to get the best accuracy of the tests. The lowest point is suspended to about 0.15 m above the floor. The gap between lowest point and floor is monitored against time. Initially readings are taken every 30 minutes for 12 hours, subsequently the reading interval may be increased to 6 hours. The cable test shall be executed during 7 days. Resolution of measurement should be 1 mm or better. The result is to be presented in mm length change per meter suspended cable length. Only one cable is to be tested.

Scale test

A precisely known pressure is applied on the instrument and the instrument reading is taken. The instrument reading is converted into level or pressure whatever is applicable. The calculated value is compared with the applied value; the difference is regarded as the FS error. In case the specifications of the applied pressure sensor may give reason to doubt the instrument's linearity, then a midscale test is to be executed as well.

Scale stability test

Scale stability is tested by subjecting the instrument to the full-scale pressure for at least 24 hours. During the test, the applied pressure/level is to be accurately monitored by taking reference readings either by a reference logger of high accuracy or by manual readings. The accuracy and resolution of the reference measurement must be 1 mm water column or 0.01 kPa (0.1 mbar).

3.4 OVERALL TEST

Part of the Overall Test is also covered under the Functional Tests and Accuracy Tests. The Overall Test comprises tests on:

- autonomy
- fitness for environment
- functionality
- calibration
- stability
- reproducibility, and
- main power failure

Details of the various tests are as follows.

3.4.1 Autonomy

Two autonomy tests shall be conducted:

- battery capacity versus the power consumption per measurement, and
- memory capacity

Battery autonomy test

To execute the test, the instrument is set to a fast data collection interval and the capacity, i.e. the number of samples, is established by a continuous process of data collection until the batteries are depleted. The test shall be executed on new batteries. In this context, the batteries are deemed depleted when the instrument stops functioning because the battery voltage watch-dog function detects a too low battery voltage or the normal operation of the instrument stops.

Memory capacity verification

The memory is filled at the highest data-recording rate and the volume of collected data are verified against the bid specification. This test could be combined with the battery autonomy test and the samples are taken at a high rate to minimise the test duration.

3.4.2 FITNESS FOR ENVIRONMENT

Connectors, cable glands, cables and housing must be suitable for the environment of operation, be it submersed, in a well or above the ground. Water ingress can be assessed by visual inspection and / or by insulation measurement. Visual inspection may only reveal ingress of a significant amount of water. The insulation measurement is more sensitive, especially for cables, connectors and encapsulated electronics, but requires specialised equipment.

- The above-surface components have to be compatible with IP65 standard and shall be tested accordingly by exposing them to a heavy shower for 3 minutes. Subsequently the ingress of water is assessed by opening of the instrument and connectors.
- The submersible components must comply with IP68 standards. To verify this, the instrument shall be suspended in a well for at least one week, to a maximum depth, without affecting the calibration of the pressure sensor and not exceeding 2 times the rated measuring range. Although most pressure sensors can withstand considerably more than 2 times the rated measuring range, there is no need to exceed this. Prior to this test, the zero and scale of the sensor have to be established and verified again upon recovery.

3.4.3 FUNCTIONALITY

- Functionality has to be verified for all requirements for operation of the DWLR and DRS with reference to the bid specifications and the instrument specifications as given by the Manufacturer. Missing functionality shall be reported.
- All (software) functions as stated in the instrument manual(s) and the instrument specifications are tested for correct functioning. Any detected flaws are reported which shall be repaired/rectified by the Manufacturer/Supplier within seven days.

3.4.4 CALIBRATION

The instrument calibration is checked for compliance with the bid specifications. In particular accuracy, stability, linearity, hysteresis and reproducibility are verified.

The scale or sensitivity of the complete instrument, including sensor and electronics, is to be checked for at least 11 pressures, equally distributed over the full measuring range. Furthermore, the calibration data as delivered with the instrument are verified for accuracy and consistency with data obtained from the calibration tests. The calibration may be executed by application of accurately known air-pressure or by immersion in a well. The temperature effects on the calibration should also be verified at low, mid and maximum range temperatures.

Note: Prior to execution of immersion tests, the effective position of the sensor membrane relative to the sensor housing is to be assessed and measured, e.g. by execution of a bucket experiment. In this experiment, the sensor is partly immersed in a water filled bucket to a depth where the related reading has changed by several centimetres, relative to the 'in-air' reading. During the test, the position of the water surface on the sensor's body shall be observed and marked accordingly. The 'effective-sensor-zero' lies below the water surface during the test. The position of the effective-sensor-zero is below the above mentioned water-surface mark by the equivalent of the sensor reading expressed in centimetres. The effective-sensor-zero may be close to the sensor membrane but not necessarily coincides with it.

3.4.5 STABILITY

Stability related to the DWLR is defined as a variation over time of the instrument specifications, whereas the circumstances and pressure do not vary. Parameters to be checked are:

- zero: offset stability
- scale: full scale stability
- cable: length (extension/contraction) and creep stability

The methods to assess these stability factors are explained under the section on Accuracy Tests.

3.4.6 REPRODUCIBILITY

The sensor reading in air is annotated, subsequently the sensor is immersed to the rated measuring depth, and a stable reading is collected. Then the sensor is recovered to the surface and again a stable reading is taken. This process is repeated 5 times and results are duly annotated. It is important that during the complete test the instrument is kept in the same, vertical position.

3.4.7 MAIN POWER FAILURE

Some instruments operate on replaceable batteries or even external power and have a built-in back-up facility, usually based on a Lithium battery. It is quite possible that on some instruments the external power supply or the replaceable batteries fail because of total depletion, disconnection, defect on the cable or connector etc. In such an event, the instrument must retain its clock, its program setting and most importantly all the collected data.

The Functional Tests are executed in conjunction with the stability test. Upon finalising these tests and after successful retrieval of all test data the power is disconnected by removing the main power batteries and/or disconnecting the power cable. The instrument is to be left in that state for at least 24 hours. Then the power shall be connected again and clock, program settings and recorded data are checked for availability and correctness.

Instruments with entirely built-in factory replaceable batteries cannot be tested in this way. In such case, the Manufacturer shall provide a technical description of the method applied to avoid loss of clock, program and collected data.

4 TEST EXECUTION

Two test programmes are to be executed:

- All Units Test Programme
- Single Unit Test Programme

Prior to execution of the tests, a detailed test script has to be drafted and agreed upon. The test script shall define:

- test sequence.
- the test conditions and requirements for each test.
- place of the test.
- person(s) responsible for conducting the tests.
- reporting requirements.
- handling failures and problems.

4.1 ALL UNITS TEST PROGRAMME

The All Units Test Programme aims to identify the malfunctioning instruments and those not compliant with the bid specifications. The Functional Tests, the Clock Accuracy Test and the Zero Stability Test must be executed on each instrument. The design of the tests shall be selective and practical and enable execution with simple means, preferably at the Client's premises.

4.2 SINGLE UNIT TEST PROGRAMME

A full system shall be tested, that is: pressure sensor, electronics, cable, power supply, DRS, software and manuals. The Single Unit Test Programme is a combination of the Functional Tests, the Accuracy Tests and the Overall Test. The Client shall randomly select an instrument for testing from the instruments delivered. The Single Unit Test Programme can only be started after verification that all documents related to the order/delivery, including manuals, calibration data, QA data etc., are

delivered to the Client. Any other unit, for which doubts arise on its compliance with the bid specifications, shall also be tested on the client's request.

Failing to pass the Single Unit Test Programme results in rejection of the entire delivery until the defective units have been repaired to meet the technical specifications, and such to the satisfaction of the Client.

5 EVALUATION OF TEST RESULTS

The test results have to be evaluated and results and conclusion shall be reported. Instruments that do not meet the bid specifications, shall be replaced by properly functioning and satisfactorily tested instruments.

6 POST ACCEPTANCE PERFORMANCE MONITORING

After installation and field deployment the instrument performance shall be continuously monitored by taking manual observations, initially at a relatively high rate, e.g. every 3 hours, gradually migrating towards the normal monitoring interval. The level comparisons are required for reference and validation purposes. Manual observations and automatic readings shall be taken at short intervals after each other, in practice the time difference shall be kept to less than 15 minutes. The primary criterion though, is that the manual reading shall be taken before the water level changes more than 1 mm.

Other checks are on functioning of the internal clock, data recording and retrieval, battery discharge, siltation of the sensor, moisture ingress and any development of corrosion.

The tape used for taking the reference readings shall be of high accuracy, considerably better than the accuracy of the DWLR, only then the performance of the high accuracy instruments can be monitored. However, an accuracy of 1 mm over the full measuring range is enough. Only best quality tapes, e.g. the electric types, come close to this requirement. The tapes shall be checked for accuracy against a precise reference, e.g. over 10 or 20 m on a single stretch. Verification by a standard ruler will not reveal to overall accuracy of a tape. The 'tape verification reference' could be prepared using high accuracy geodetic equipment. A long, straight corridor, or a quiet stretch of road, could accommodate the length reference marks, the accuracy should be 1 mm relative to the reference point (0.000 m).

7 INSTRUMENT HISTORY FILE

For each instrument, an individual History File shall be opened and maintained. In the History File the full instrument history and all documents generated shall be stored. This also includes any changes, adaptations, repairs etc. made to the instruments. The products and results of the execution of the Acceptance Protocol shall be included in the Instrument History File.

Some document types and entries are listed below.

7.1 Instrument identification

The instrument identification uniquely defines the instrument particulars.

- Make, vendor, service provider, date of manufacturing, date of delivery
- Instrument make, model and serial number

- Instrument configuration
- Measuring range
- Cable type, length
- Manual version
- Instrument status: e.g. working, under calibration, under repair

7.2 FUNCTIONAL, ACCURACY AND OVER-ALL TESTS

For each of the three test categories, a separate and unambiguous record shall be maintained. The test conditions and results shall be duly recorded. Obviously any failures or irregularities shall be annotated accurately and comprehensively, as well as the actions taken and their results.

At least the following data shall be recorded:

- Administrative data: what, when, where, who, which instrument and configuration
- List of tests
- Specifications for each test
- Results of each test
- Failures, actions, conclusions

7.3 Piezometer well definition

The piezometer well definition is required in order to link the instrument readings to MSL and the hydro-geological properties of the well. The piezometer identification shall have sufficient detail to link it with the hydro-geological data recorded in the project database. The reference point on the piezometer well, as used for the level measurements, shall be unambiguously depicted and its height above MSL defined. The particulars of the local benchmark (name, location, and co-ordinates, height above MSL, etc.) shall be recorded for reference purposes. Following entries are indicative and not conclusive.

- Piezometer: District, name, location, co-ordinates, identification
- Photo
- Elevation relative to MSL
- Description of reference point particulars
- Identification of reference spot on piezometer well
- Local benchmark: district, location, identification, co-ordinates, height above MSL

7.4 DEPLOYMENT

Another part of the history file covers the deployment: installation, servicing, maintenance, data retrieval etc. All facts shall be recorded, (what, when, where, who, which instrument and configuration). The suspended depth of the instrument relative to the reference point shall be annotated. Further, manual water level observations (when, who, level, reference) shall be taken regularly and verified with the instrument records. To allow for an accurate comparison, the time and other particulars of the manual observation shall be recorded. The manual observations shall coincide with the programmed automatic instrument readings. This shall be regularly repeated. Photos showing the mode of installation are very useful.

Some of the required particulars are:

- Suspension depth relative to the reference point on the piezometer well
- Recording interval
- Photos of the deployed instrument and piezometer well

Following two shall be repeated regularly:

- Manual observations, taken concurrently with the automatic measurements
- Observer, date and time of manual reading

The following entries are associated with any changes made to the instruments. Again, the 'what, when, where, who, which instrument and configuration' shall be recorded, for each event:

- Repairs: minor and major repairs and including change of silt filter or battery etc.
- Adaptations: e.g. replacement of EPROM, RTC clock speed adjustment
- Settings: these are the common operational settings such as recording interval, suspension depth and the like.
- Calibration: most likely calibration is executed in a special workshop. Obviously calibration is a major event and has to be recorded and documented accurately and comprehensively. This implies also the method of calibration, reference instruments used (and including a paper trail to national standards or other proof of calibration cum accuracy), conditions during calibration, officers in charge etc.