

**Approval Date: 11 August 1999****Reviewed on 23 October 2007****Version: 4****Purpose**

The Digital Water Level Recorder (DWLR) is to record readings of water level versus time in rivers, lakes and reservoirs. Optionally, the actual level reading could be shown on a LCD display.

**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.
- The recorder zero shall be adjustable to zero of gauge.
- A pressure sensor shall measure the water level, directly (immersed) or indirectly (bubbler).
- The method of pressure measurement shall compensate for the effects of ambient air-pressure, 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.
- The instrument shall not need a stilling well for wave and turbulence suppression but shall have a wave suppression filter implemented in software.
- All batteries associated with the DWLR, 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 data logger memory.
- Data retrieval and other communication shall be possible through a Data Retrieval System (DRS), i.e. a Palmtop Computer or a Handheld Terminal (not included in the scope of the DWLR supply) loaded with dedicated software.
- For communication with the DRS an RS232C serial interface shall be available.
- The delivery shall include cables for connecting the DWLR to the DRS and to a serial port of a PC.
- For some DWLR implementations, interface adapters, e.g. for IrDA or RS485, are needed to communicate with the 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 and between DWLR and PC.
- 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. Commands, programs, water level records and all other data are exchanged under control of the protocol and data may only be accepted if they are error 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.
- All hardware, firmware, software and data shall be fully Y2K compliant.

## Specifications

The purchaser may execute his judicious discretion in the choice of configuration and options.

### 1. Pressure sensor

<b>sensor type</b>	vented gauge pressure sensor
<b>measuring range</b>	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.

#### **Accuracy**

<b>overall accuracy</b>	0.1% Full Scale
<b>temperature coefficient</b>	<0.01% Full Scale/°C (on water level reading including 50 m suspension cable)
<b>long term stability</b>	0.1% Full Scale/year
<b>reproducibility</b>	0.05% Full Scale

**Note:** Overall accuracy, long term stability and reproducibility include pressure sensor, suspension 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°C, i.e. whatever the actual temperature coefficient, the overall error shall not exceed the accuracy specifications as given under the item 'overall accuracy'.

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.

**overload pressure** 2 times Full Scale

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

**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.

**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. Data logger

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

**measuring interval** pre-set at 1 hour, adjustable from 10 minutes to 24 hours.

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, 01h00, etc. The first record after initiation of the instrument, should be made at the first instant of 00 or 30 minutes in the hour.

**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.

### **wave attenuation filter**

The wave attenuation filter, which is implemented in software is defined by two controls, viz.:

- **sampling interval in seconds, e.g.** 1 to 10 seconds
- **averaging number, e.g.** 1 to 240 samples

The instrument should at least be capable to take the average of 30 or more samples collected over a period of 30 seconds or more. Only the average value is recorded.

**date** day, month, year in the following format: DD/MM/YYYY with leading zero's (01/03/2001 for 1<sup>st</sup> of March 2001)  
the logger and software shall be Y2K compliant

**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 logger handles these.

**recording capacity** minimum of 20,000 water level readings.

The recorded data shall also contain an instrument serial number and/or station identification code and information on date and time of recorded water levels readings. The serial number shall be uniquely attached to the data logger. The station identification code shall be uniquely attached to the data logger at installation 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.

**error marking** error code, i.e. –99.999

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.

**recording resolution** 0.001 m or better

**memory type** non volatile memory or volatile memory

Volatile memory (RAM) shall be protected from data loss by a Lithium 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).

### ***Lithium batteries***

**power supply** built-in standard Lithium batteries, like AA, C or D size

**OR**

### ***Alkaline batteries***

**power supply** built-in standard Alkaline batteries, like AA, C or D size

Preferably, the batteries are kept inside a separate enclosure, above the maximum water level. Alternatively, batteries may be kept inside the data logger enclosure. However, wherever the batteries are kept, they shall be easily replaceable, on site.

The delivery shall include sufficient batteries for at least one year of operation under the following conditions:

- a recording interval of 30 minutes
- the DWLRs will have the wave suppression filter enabled taking the average of 30 samples at an interval of 1 second.  
If the sampling interval can only be set to less than 1 second, than the average over 30 seconds shall be calculated.  
If the sampling interval can only be set to more than 1 second, then the average over 30 samples shall be calculated.
- regular access of the DWLRs for data retrieval and monitoring purposes which may affect the power autonomy

**remaining battery lifetime** indication on DRS and/or calculation scheme

**data offload power use** capacity for  $\geq 6$  full data offloads per annum of rated battery capacity, e.g. if rated battery capacity is 5 years than  $\geq 30$  full offloads shall be supported in that 5 years.

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

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

**baud rate** 9600 or more

**operating temperature** 0 to 60°C.

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

**built-in clock** time keeping better than 1 minute per month

**displayed time resolution** 1 second

**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, e.g. for water quality), external power supply and data communication interface.

**water level indicator** LCD display with 1 mm resolution (optional)

### 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. The enclosure(s) shall comply with the following specifications.

All DWLR materials and combinations thereof shall be corrosion proof.

#### ***Submerged enclosure***

Integrated pressure sensor and data logger The pressure sensor and data logger shall be contained in a single enclosure which will be submerged.

<b>dimensions</b>	outer diameter shall be less than 75 mm, length <0.6 m
<b>material</b>	Delrin or stainless steel (AISI 316) or equivalent
<b>mass</b>	sufficient to keep suspension cable taut, $\geq 1.25$ kg on flexible cable and $\geq 2.5$ kg on stiff cable
<b>operating temperature</b>	0 to 50°C
<b>ingress protection</b>	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

**OR**

#### ***In-well enclosure***

Submerged pressure sensor and data logger for mounting in a protection pipe, but above water

<b>dimensions</b>	outer diameter shall be less than 75 mm, length <0.6 m
<b>material</b>	Delrin or stainless steel (AISI 316) or equivalent
<b>mass (pressure sensor)</b>	sufficient to keep suspension cable taut, $\geq 1.25$ kg on flexible cable and $\geq 2.5$ kg on stiff cable
<b>ingress protection</b>	enclosure and cable assembly shall have IP65 protection
<b>operating temperature</b>	0 to 60°C
<b>humidity</b>	100%
<b>submerged parts</b>	IP68 protection for permanent suspension at a maximum depth of 2 times the rated measuring range

### 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. Preferable, the cable is of a detachable type for increased operational flexibility. The vent tube inlet at the above water section of the cable shall be fitted with a moisture blockage system.

The cable shall have the following features:

- strength members for good longitudinal stability of the cable
- incorporated vent tube for barometric air-pressure compensation of the vented gauge pressure sensor

- a moisture blocking system on the vent tube based on a hydrophobic filter and desiccator, to prevent accumulation of moisture and condensation of water in the vent tube and in the sensor
- desiccant capacity shall be adequate for at least 6 months of unattended operation under worst case environmental conditions. For each instrument, two desiccant replacements shall be part of the delivery. The desiccant shall be field replaceable.
- optionally, as an extra protection, a flexible bag moisture blocking may be added.
- good flexibility
- the electrical wires shall have sufficient conductivity to allow for extension of the cable by 25 m without degrading accuracy, stability and data communication
- cable screen, to be connected to the data logger ground terminal to minimise electrical interference
- a cable suspension bracket allowing the DWLR to be adjusted to the required depth, in a stable and reproducible manner
- the cable shall be of such a design that the suspension forces on the suspension bracket are passed to the integrated strength member to benefit from the strength member's longitudinal stability.
- A perforation of the cable jacket shall not result in ingress of water into the sensor and/or electronics compartment. For that, the cable shall be moulded to the sensor and/or electronics compartment. In case a detachable connector is used, then the connector shall act as a water blockage.

#### **Quantitative specifications**

<b>conductor</b>	tinned copper wires with insulation like nylon or PTFE (Teflon), insulation thickness $\geq 0.5$ mm
<b>vent tube</b>	Nylon, PTFE or equivalent, inner diameter $\geq 1$ mm and $\leq 2$ mm, thickness minimum 0.4 mm
<b>strength members</b>	stainless steel, Kevlar or equivalent to keep the sensor at the correct suspension depth, while using a depth adjustable suspension clamp on the cable at the top of the well.
<b>temperature coefficient</b>	$< 15 \times 10^{-6} / ^\circ\text{C}$ (longitudinal)
<b>cable screen</b>	braid of 36 AWG tinned copper or similar effective material
<b>outer jacket</b>	Surlyn, Polyurethane, PTFE (Teflon) or similar
<b>jacket thickness</b>	1 mm or more
<b>cable size</b>	outer diameter 7 to 12 mm
<b>cable length</b>	to be specified in m as per Schedule of Requirements

#### **5. DRS software**

The DRS 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 shall 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 permitted.
- The DRS software shall support error free transfer of the retrieved data to a PC.
- Note that in particular the graphics capabilities are a major reason to apply a palmtop computer as DRS.

## **6. PC Software**

- PC software shall be part of the delivery and will 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 have functions for conversion of the collected data into ASCII (text) tables.
- The PC software shall have functions for conversion of the collected data into ASCII (text) files. The tabular data will be imported by other software packages, e.g. for analysis and presentation in a spreadsheet and for storage in a database.
- The export file format is specified in Chapter 7.
- The PC software shall support the same and more tabular and graphical presentation functions as specified under Palmtop software.

## **7. Standard DWLR text file format**

The text file is the intermediate data representation that is used for loading of the data into the hydrological data base system.

- The PC based software shall have a facility to generate a text file with waterlevel data in the standardised format.
- The text file formatting function may be part of the standard proprietary PC software. Alternatively, the function may be implemented in a separate, MS-Windows95/98 based program.
- The text file facility shall be easy to use.
- Only SI-units shall be presented, i.e. m and °C for levels and temperature respectively.
- Non-SI units like feet, inches, °F are not permitted.
- The text file shall have a section with header lines.
- The header lines shall precede the data lines.
- The header lines shall contain instrument serial number, reference level that was used to convert from pressure head in to water level, applied specific gravity.
- In case a software wave attenuation filter is implemented, the averaging number and the sampling interval shall be presented in the header.
- The header may contain other data such as measuring range, station ID, installation depth, top of casing reference relative to MSL, station co-ordinates and similar data.
- For each specific instrument make and model, the number of the header lines must be fixed, i.e. all instruments of that make and model shall always generate the same number of header lines, in the same format.
- The contents of the header lines is for use by the operator but will not be automatically assessed by the Data Entry Software (SW/GW DES).

- All header lines shall be terminated by a <CR><LF> sequence.
- The data shall be organised in columns
- column 1: date in dd/mm/yyyy  
Leading zero's shall be included, i.e. 06 February 2001 will be expressed as 06/02/2001. The </> character may be omitted, then the format becomes ddmmyyyy.
- column 2: time in hh:mm:ss  
Time shall be expressed in 24 hours. The AM/PM representation is not permitted. Leading zero's shall be included, i.e. 6 o'clock in the morning shall be represented by 06:00:00. The <:> character may be omitted, then the format becomes hhmmss.
- column 3: water level in metres with millimetre resolution, e.g. 49.640 m.
- column 4: in case temperature is measured then temperature shall be expressed in °C with 0.1°C resolution, e.g. 32.8 °C.
- Alternative data sequences are not permitted.
- If a parameter can be negative, then a character position for the minus sign shall be reserved.
- The column separator shall be one of the following: <space>, <tab>, <comma>, or <semicolon>.
- Only one type of separator may be applied.
- End-of-line is indicated by <CR><LF> sequence.
- All data lines shall comply with this column format, empty lines or intermediate partly filled lines, e.g. with date and/or time only, are not permitted.
- All columns shall be complete, i.e. each field in a column shall always contain data. If no temperature data are measured, then column 4 may be omitted.
- Erroneous or missing water level data shall be indicated by -99.999.
- Erroneous or missing temperature data shall be indicated by -99.9.

Examples of data lines:

30/05/1998	11:00:00	9.875	28.7
30/05/1998	12:00:00	-99.999	28.7
30/05/1998	13:00:00	9.989	-99.9
30/05/1998	14:00:00	10.380	28.8
30/05/1998	15:00:00	10.800	28.7

The four columns contain date, time, water level and temperature data respectively.

### Accessories

- tools and spares
- signal, power and communication cables as required for all normal user operations
- 220 VAC  $\pm$ 25%, 47 to 53 Hz, charger for NiCd, NiMH or Li-ion battery pack

### Consumables

- batteries
- desiccator for the hydrophobic filter and electronics
- replacement hydrophobic filters
- replacements for the (optional extra) moisture blockage bag

Approval Date: 11 August 1999

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### Purpose

The Digital Water Level Recorder (DWLR) is to record readings of water level versus time in rivers, lakes and reservoirs. Optionally, the actual level reading could be shown on a LCD display.

### 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.
- The recorder zero shall be adjustable to zero of gauge.
- A pressure sensor shall measure the water level, directly (immersed) or indirectly (bubbler).
- The method of pressure measurement shall compensate for the effects of ambient air-pressure, by application of a vented gauge pressure sensor or other compensation method.
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- The delivery shall include cables for connecting the DWLR to the DRS and to a serial port of a PC.
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- 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.
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## Specifications

The purchaser may execute his judicious discretion in the choice of configuration and options.

### 8. Pressure sensor

<b>sensor type</b>	vented gauge pressure sensor
<b>measuring range</b>	0 to xx m water column (e.g. 0 to 10 or 0 to 20 m) as per Schedule of Requirements

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<b>temperature coefficient</b>	<0.01% Full Scale/°C (on water level reading including 50 m suspension cable)
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<b>reproducibility</b>	0.05% Full Scale

**Note:** Overall accuracy, long term stability and reproducibility include pressure sensor, suspension 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.

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**overload pressure** 2 times Full Scale

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

**burst pressure** >3 times Full Scale

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

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## 9. Data logger

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

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

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the logger and software shall be Y2K compliant

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with leading zero's (08:05:07)

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**error marking** error code, i.e. -99.999

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.

**recording resolution** 0.001 m or better  
**memory type** non volatile memory or volatile memory  
Volatile memory (RAM) shall be protected from data loss by a Lithium 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).

***Lithium batteries***

**power supply** built-in standard Lithium batteries, like AA, C or D size

**OR**

***Alkaline batteries***

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The delivery shall include sufficient batteries for at least one year of operation under the following conditions:

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**remaining battery lifetime** indication on DRS and/or calculation scheme

**data offload power use** capacity for  $\geq 6$  full data offloads per annum of rated battery capacity, e.g. if rated battery capacity is 5 years than  $\geq 30$  full offloads shall be supported in that 5 years.

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

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

**baud rate** 9600 or more

**operating temperature** 0 to 60°C.

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

**built-in clock** time keeping better than 1 minute per month

**displayed time resolution** 1 second

**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, e.g. for water quality), external power supply and data communication interface.

**water level indicator** LCD display with 1 mm resolution (optional)

## 10. 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. The enclosure(s) shall comply with the following specifications.

All DWLR materials and combinations thereof shall be corrosion proof.

### ***Submerged enclosure***

Integrated pressure sensor and data logger The pressure sensor and data logger shall be contained in a single enclosure which will be submerged.

<b>dimensions</b>	outer diameter shall be less than 75 mm, length <0.6 m
<b>material</b>	Delrin or stainless steel (AISI 316) or equivalent
<b>mass</b>	sufficient to keep suspension cable taut, $\geq 1.25$ kg on flexible cable and $\geq 2.5$ kg on stiff cable
<b>operating temperature</b>	0 to 50°C
<b>ingress protection</b>	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

OR

### ***In-well enclosure***

Submerged pressure sensor and data logger for mounting in a protection pipe, but above water

<b>dimensions</b>	outer diameter shall be less than 75 mm, length <0.6 m
<b>material</b>	Delrin or stainless steel (AISI 316) or equivalent
<b>mass (pressure sensor)</b>	sufficient to keep suspension cable taut, $\geq 1.25$ kg on flexible cable and $\geq 2.5$ kg on stiff cable
<b>ingress protection</b>	enclosure and cable assembly shall have IP65 protection
<b>operating temperature</b>	0 to 60°C
<b>humidity</b>	100%
<b>submerged parts</b>	IP68 protection for permanent suspension at a maximum depth of 2 times the rated measuring range

## 11. 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. Preferable, the cable is of a detachable type for increased operational flexibility. The vent tube inlet at the above water section of the cable shall be fitted with a moisture blockage system.

The cable shall have the following features:

- strength members for good longitudinal stability of the cable
- incorporated vent tube for barometric air-pressure compensation of the vented gauge pressure sensor
- a moisture blocking system on the vent tube based on a hydrophobic filter and desiccator, to prevent accumulation of moisture and condensation of water in the vent tube and in the sensor
- desiccant capacity shall be adequate for at least 6 months of unattended operation under worst case environmental conditions. For each instrument, two desiccant replacements shall be part of the delivery. The desiccant shall be field replaceable.
- optionally, as an extra protection, a flexible bag moisture blocking may be added.
- good flexibility

- the electrical wires shall have sufficient conductivity to allow for extension of the cable by 25 m without degrading accuracy, stability and data communication
- cable screen, to be connected to the data logger ground terminal to minimise electrical interference
- a cable suspension bracket allowing the DWLR to be adjusted to the required depth, in a stable and reproducible manner
- the cable shall be of such a design that the suspension forces on the suspension bracket are passed to the integrated strength member to benefit from the strength member's longitudinal stability.
- A perforation of the cable jacket shall not result in ingress of water into the sensor and/or electronics compartment. For that, the cable shall be moulded to the sensor and/or electronics compartment. In case a detachable connector is used, then the connector shall act as a water blockage.

### Quantitative specifications

<b>conductor</b>	tinned copper wires with insulation like nylon or PTFE (Teflon), insulation thickness $\geq 0.5$ mm
<b>vent tube</b>	Nylon, PTFE or equivalent, inner diameter $\geq 1$ mm and $\leq 2$ mm, thickness minimum 0.4 mm
<b>strength members</b>	stainless steel, Kevlar or equivalent to keep the sensor at the correct suspension depth, while using a depth adjustable suspension clamp on the cable at the top of the well.
<b>temperature coefficient</b>	$< 15 \times 10^{-6} / ^\circ\text{C}$ (longitudinal)
<b>cable screen</b>	braid of 36 AWG tinned copper or similar effective material
<b>outer jacket</b>	Surlyn, Polyurethane, PTFE (Teflon) or similar
<b>jacket thickness</b>	1 mm or more
<b>cable size</b>	outer diameter 7 to 12 mm
<b>cable length</b>	to be specified in m as per Schedule of Requirements

## 12. DRS software

The DRS 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 shall 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 permitted.
- The DRS software shall support error free transfer of the retrieved data to a PC.

- Note that in particular the graphics capabilities are a major reason to apply a palmtop computer as DRS.

### **13. PC Software**

- PC software shall be part of the delivery and will 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 have functions for conversion of the collected data into ASCII (text) tables.
- The PC software shall have functions for conversion of the collected data into ASCII (text) files. The tabular data will be imported by other software packages, e.g. for analysis and presentation in a spreadsheet and for storage in a database.
- The export file format is specified in Chapter 7.
- The PC software shall support the same and more tabular and graphical presentation functions as specified under Palmtop software.

### **14. Standard DWLR text file format**

The text file is the intermediate data representation that is used for loading of the data into the hydrological data base system.

- The PC based software shall have a facility to generate a text file with waterlevel data in the standardised format.
  - The text file formatting function may be part of the standard proprietary PC software. Alternatively, the function may be implemented in a separate, MS-Windows95/98 based program.
  - The text file facility shall be easy to use.
  - Only SI-units shall be presented, i.e. m and °C for levels and temperature respectively.
  - Non-SI units like feet, inches, °F are not permitted.
  - The text file shall have a section with header lines.
  - The header lines shall precede the data lines.
  - The header lines shall contain instrument serial number, reference level that was used to convert from pressure head in to water level, applied specific gravity.
  - In case a software wave attenuation filter is implemented, the averaging number and the sampling interval shall be presented in the header.
  - The header may contain other data such as measuring range, station ID, installation depth, top of casing reference relative to MSL, station co-ordinates and similar data.
  - For each specific instrument make and model, the number of the header lines must be fixed, i.e. all instruments of that make and model shall always generate the same number of header lines, in the same format.
  - The contents of the header lines is for use by the operator but will not be automatically assessed by the Data Entry Software (SW/GW DES).
  - All header lines shall be terminated by a <CR><LF> sequence.
- 
- The data shall be organised in columns
  - column 1: date in dd/mm/yyyy  
Leading zero's shall be included, i.e. 06 February 2001 will be expressed as 06/02/2001. The </> character may be omitted, then the format becomes ddmmyyyy.
  - column 2: time in hh:mm:ss  
Time shall be expressed in 24 hours. The AM/PM representation is not permitted.

Leading zero's shall be included, i.e. 6 o'clock in the morning shall be represented by 06:00:00.

The <:> character may be omitted, then the format becomes hhmms.

- column 3: water level in metres with millimetre resolution, e.g. 49.640 m.
- column 4: in case temperature is measured then temperature shall be expressed in °C with 0.1°C resolution, e.g. 32.8 °C.
- Alternative data sequences are not permitted.
- If a parameter can be negative, then a character position for the minus sign shall be reserved.
- The column separator shall be one of the following: <space>, <tab>, <comma>, or <semicolon>.
- Only one type of separator may be applied.
- End-of-line is indicated by <CR><LF> sequence.
- All data lines shall comply with this column format, empty lines or intermediate partly filled lines, e.g. with date and/or time only, are not permitted.
- All columns shall be complete, i.e. each field in a column shall always contain data. If no temperature data are measured, then column 4 may be omitted.
- Erroneous or missing water level data shall be indicated by -99.999.
- Erroneous or missing temperature data shall be indicated by -99.9.

Examples of data lines:

30/05/1998	11:00:00	9.875	28.7
30/05/1998	12:00:00	-99.999	28.7
30/05/1998	13:00:00	9.989	-99.9
30/05/1998	14:00:00	10.380	28.8
30/05/1998	15:00:00	10.800	28.7

The four columns contain date, time, water level and temperature data respectively.

## Accessories

- tools and spares
- signal, power and communication cables as required for all normal user operations
- 220 VAC  $\pm 25\%$ , 47 to 53 Hz, charger for NiCd, NiMH or Li-ion battery pack

## Consumables

- batteries
- desiccator for the hydrophobic filter and electronics
- replacement hydrophobic filters
- replacements for the (optional extra) moisture blockage bag