SETTLEMENT SYSTEMS

VIBRATING WIRE LIQUID SETTLEMENT SYSTEM *VWLSS-200*

INSTRUCTION MANUAL

CE

GEOSENSE

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1.0 INTRODUCTION

This manual is intended for all users of **Vibrating Wire Liquid Settlement System (VWLSS-200)** manufactured by Geosense and provides information on its installation, operation and maintenance**.**

It is VITAL that personnel responsible for the installation and use of this Settlement System, READS and UNDERSTANDS this manual, prior to working with the equipment.

1.1 General Description

The Vibrating Wire Liquid Settlement System (VWLSS-200) is used to monitor settlement or heave in soils and other structures such as embankments, earth & rockfill dams. A typical installation is shown in Figure 1, below.

The main components are a fluid reservoir, liquid filled tubing and a vibrating wire pressure transducer, mounted on a plate or, for a borehole application, attached to an anchor.

The vibrating wire sensor is positioned at a point where settlement is to be detected. The pressure sensitive side of the sensor is connected to a reservoir, located on stable ground, by two liquid-filled tubes to create a continuous fluid column. As the sensor settles with the surrounding ground, the height of the column is increased and the corresponding higher pressure is detected by the sensor. Settlement or heave is calculated by converting the liquid pressure registered by the sensor, into metres of liquid head. The sensor is fitted with a 4 core cable to obtain the pressure and temperature readings.

Each sensor contains a Thermistor for the temperature measurement, and gas discharge tubes for lightning protection. The system uses de-aired solution of antifreeze and water to prevent freezing and algae growth. The system uses two liquid lines so that it could be flushed to remove air bubbles from the system.

The effects of changes in atmospheric pressure are removed by either using a vented transducer or mathematically, using information from another sensor.

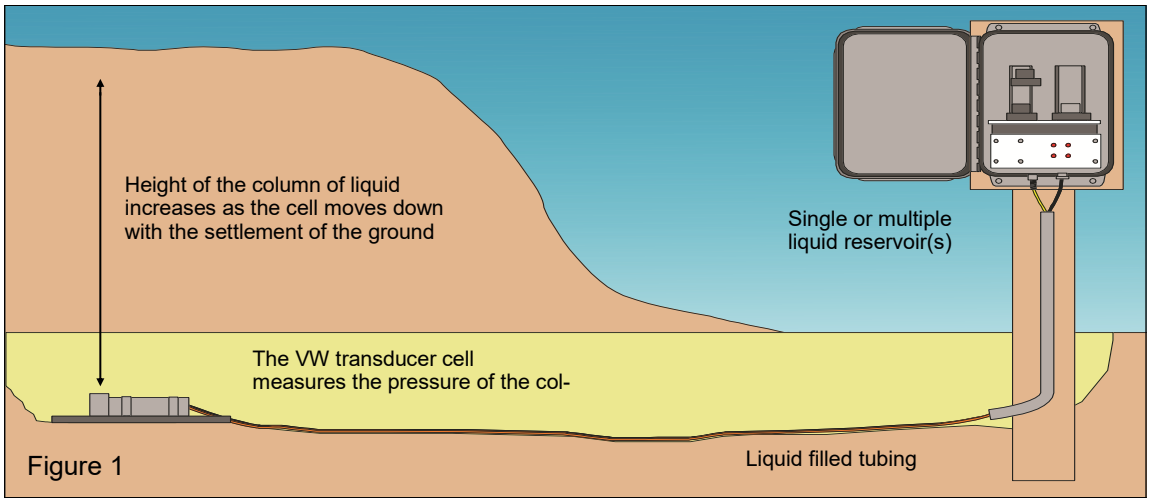

Figure 1

The Vibrating Wire Liquid Settlement System (VWLSS-200) is available in two options and comprises of the following components:-

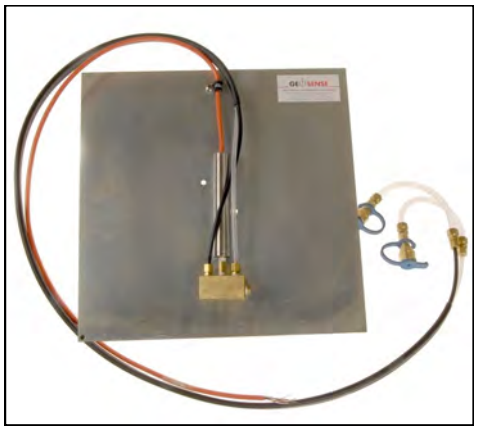

Plate Mounted VW Settlement Cell

Pressure range 70 to 345 kPa

OR

Drive-in Settlement Cell

Pressure range 70 to 345 kPa

Tubing & Cable

Twin tubing with over sheath

PUR coated, 4 core screened cable

Lengths cut to suit individual requirements

Header Reservoir

Available for single and multiple Settlement Cells (up to 10).

2.0 CONFORMITY

Geosense Ltd
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Declaration of Conformity

We Geosense Ltd at above address declare under our sole responsibility that the Geosense products detailed below to which this declaration relates complies with protection requirements of the following harmonized EU Directives:-

- Electromagnetic Compatibility Directive (EMC) 2014/30/EU
- Restriction on Hazardous Substances Directive RoHS 3 (EU Directive 2015/863)

Equipment description	**Vibrating Wire Liquid Settlement System**
Make/Brand	**Geosense**
Model Number	**VWLSS-200**

Compliance has been assessed with reference to the following harmonised standard:

EN 61326-1:2006 Electrical equipment for measurement, control and laboratory use.
EMC requirements. General requirements.

A technical file for this equipment is retained at the above address.

January 2021

Martin Clegg

Director

3.0 DELIVERY

This section should be read by all users of Vibrating Wire Settlement Systems manufactured by **Geosense®**

3.1 Packaging

Geosense® Vibrating Wire Liquid Settlement Systems (VWLSS-200) are appropriately packed for transportation to site. Packaging is suitably robust to allow normal handling by transportation companies. However, inappropriate handling techniques may cause damage to the packaging and the enclosed equipment. The packaging should be carefully inspected upon delivery and any damage MUST be reported to both the transportation company and to **Geosense®** .

3.2 Handling

Whilst they are a robust devices, **Geosense® Vibrating Wire Liquid Settlement Systems** are precision measuring devices. They and their associated equipment should always be handled with care during transportation, storage and installation.

Once the shipment has been checked (see below), it is recommended that Settlement Systems remain in their original packaging for storage or further transportation.

Cable and tubing should be handled with care. Do not allow them to be damaged by sharp edges (rocks for example) and do not exert force on them as this may damage the internal conductors or cause leaks and rendering the instruments useless.

3.3 Inspection/functionality

Calibration Sheets contain VITAL information about the piezometer. They MUST be stored in a safe place. Only COPIES of calibration certificates should be taken to site The original certificates should be stored safely.

It is vital to check all the equipment in the shipment as soon as possible after taking delivery and well before installation is to be carried out. Check that all the components that are detailed on the documents are included in the shipment. Check that the equipment has not been physically damaged.

If components are missing or damaged, contact the delivery company or **Geosense**.

Although the system is not connected to the reservoir, a functional check can still be carried out by connecting the VW Sensor Cable to a VW Readout, typically as in picture.

Prior to carrying out function checks, ensure that the Settlement System has been stored in a ‘reasonably stable’ temperature for at least 2 hours.

3.3 Inspection/functionality contd….

To carry out the check, connect a Vibrating Wire readout As follows:-

RED	=	VW +
BLACK	=	VW -
GREEN	=	Temp
WHITE	=	Temp

Record the values (and units) displayed on the readout together with the pressure transducer serial numbers.

The “CHECK” readings should coincide with the factory zero on the calibration sheet (see the example calibration sheet in Section 9) within +/- 50 digits after barometric and temperature corrections are made.

The displayed values of the VW sensor reading and temperature, should be reasonably stable (+/- 3 full digits) for this check. Ensure body, plate and tubing are stationary.

The elevation of the **Geosense**® factory is +60 metres above sea level and barometric pressures change with altitude by approximately 1.2kPa per 100 metres

The ‘CHECK Readings WILL be affected by changes in atmospheric pressure and temperature changes.

3.4 Storage

All equipment should be stored in an environment that is protected from direct sunlight.

It recommended that cables be stored in a dry environment to prevent moisture migrating along the cable in the unlikely event of prolonged submersion of exposed conductors.

Storage areas should be free from rodents as they have been known to damage connecting cables and tubing.

No other special requirements are needed for medium or long-term storage although

4.0 INSTALLATION

The following sections describe some typical installation procedures for **Geosense**® VW Settlement Systems.

This section of the manual is intended for all users of Vibrating Wire Settlement Systems manufactured by **Geosense**® and is intended to provide guidance with respect to their installation.

It must be remembered that no two installations will be the same and it is inevitable that some 'fine tuning' of the following procedures will be required to suit specific site conditions.

It is VITAL that personnel responsible for the installation and use of the Settlement System READ and UNDERSTAND this manual, prior to working with the equipment.

****

As stated before, it is vital to check all the equipment in the shipment soon after taking delivery and well before installation is to be carried out. Check that all components that are detailed on the shipping documents are included.

4.1 Preparation for Installation

When installing more than one System Plate / Body, record the assigned unique identifying code for particular positions (remembering to ensure that the System fitted with the longest cables are selected for the most distant installations).

Ensure there will be enough cable and tubing to route it to the intended readout / monitoring location. The location of the Reservoir need not be the same as the electrical termination, but it is commonly so.

The elevation / location of the Settlement System installations should be identified by the Engineer responsible for the interpretation of the data, or as detailed on contract drawing or in the specification.

It is important to consider the protection of the Reservoir when selecting a suitable location. It should be remembered that Reservoir and connecting tubes must be protected from damage as they are sensitive and vulnerable. In some locations it will be necessary to install protective sleeves or enclosure.

The function of the system should be checked prior to installation as described in section 3.3. Check the system using a readout with the audio function switched on. A clear 'ping' should be produced.

It is preferable to install the terminal panel and reservoir prior to installing the settlement cells. This allows for simple connection and testing, prior to backfilling over the cells and tubing.

4.2 Installation of Plate Mounted Sensors

For a Liquid Settlement System (VWLSS-200) supplied with the plate option, use the following guide:

1. Pour a layer of sand upon the surface plane intended for installation of the Settlement Plate, approximately 5 to 10 cm thick.

   If the subsurface includes voids, a layer of geotextile material should be placed under the sand to prevent it migrating into the voids.

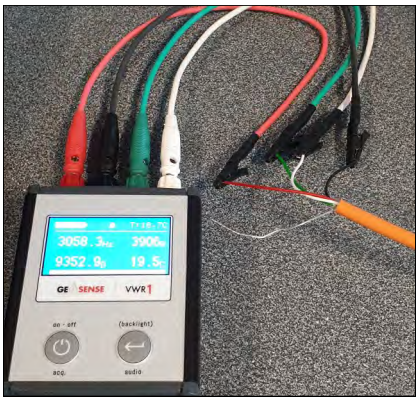
2. Spread out the sand and flatten to create a compacted, smooth layer.

3. Place the Settlement Plate onto the sand layer with the VW Transducer uppermost. Use a small spirit level to ensure the plate is level. Putting force only on the plate itself, firmly push the metal plate into the sand, twisting slightly from side to side to ensure that good contact is made.

4. Starting from the centre, pour a cover layer of sand over the entire Settlement Plate, approximately 5 to 10 cm thick.

5. This is now a good time to do a final CHECK on the function of the equipment, before completing the backfill.

6. Connect the VW Cell Sensor Cable to a readout and confirm the sensor is producing a reading. (At this stage the value is not important but it should not fluctuate too much).



To perform a simple functional check, note the reading on the display and then, with the readout still connected, raise the coupling end of the liquid filled tubing by about 1 metre.

Observe the 'Digits' / 'B units' / 'Frequency' value on the readout and it should be reducing as the tube is raised and increasing again when it is lowered.

7. Install the Terminal Panel & Reservoir.

It is highly recommended that the terminal cabinet is installed and commissioned prior to backfilling the plate locations and cable trenches.

The terminal panel and reservoir should be mounted outside the settlement area, with sufficient weather protection to minimise any temperature fluctuations in the liquid.

8. BEFORE connecting the tubes from the settlement cells to the reservoir connector block, partly fill the reservoir with the de-aired liquid (supplied in separate bottles).

With the reservoir partly filled, remove the transport plugs from inside the reservoir, using a screwdriver or socket spanner.

(In the photo - liquid removed for clarity)

9. Prepare to connect each pair of tubes from the settlement cells to the connector block. To do this, first remove the protective covers from the 'male' connectors on the terminal block.

These are arranged in pairs (front and back) for each cell.

10. Then remove the protective cap from the ‘female’ connectors on the settlement cell tubes.

    To remove the risk of introducing air bubbles into the terminal block, fill this ‘female’ connector with the de-aired liquid BEFORE connecting it to the ‘male’ connector on the terminal.

    To fit the connector, pull back the outer sleeve on the ‘female’ connector and push the connectors together until they latch in place.

    The tubes from each cell are usually connected to the panel arranged ‘Front’ and ‘Back’.

11. With the cell tubes connected, top up the liquid in the reservoir until it reaches the line (just below the overflow)

12. Replace the lid of the reservoir to prevent evaporation

13. The signal cable from each cell must be terminated so as to enable gathering of the settlement data. Termination can take many forms from a simple connector panel for a portable readout, through stand-alone data loggers to remotely accessed data recording modules.

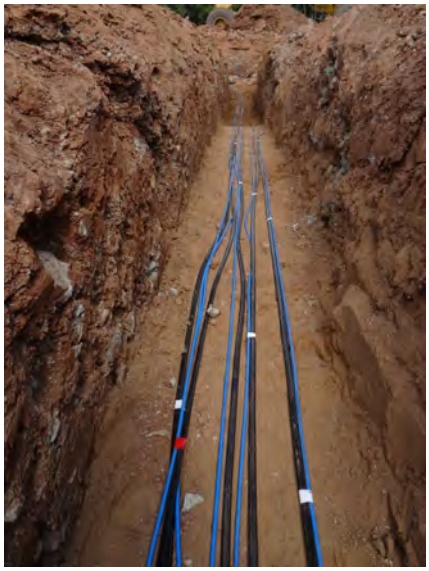
14. Excess tubing should be coiled and buried in a shallow pit close to the terminal panel to protect it and reduce the affects of temperature changes on the liquid. The pit should be not less than 0.5m deep and backfilled with clean sand to protect the tubes.

    DO NOT CUT THE TUBING

Transducer cables can be either ‘plain’ or ‘vented’. The latter is used to eliminate the effects of changes in barometric pressure. Where vented cables are used, they are fitted with moisture traps to prevent moisture build-up in the vent tubes.

The absorbent beads in the moisture traps must be replaced at regular intervals to avoid erroneous readings due to pressure imbalances.

Typical Settlement Plate Installation



Cables (blue) and Tubes (Black)

Prior to placing of protective sand layers below and above.

Danger

- Risk of damage to tubes

Always backfill around buried cable and tubes with ‘stone-free’ material.

Typical Terminal Cabinet

Fitted with Vented cables / Desiccant Moisture Traps / LINX Data Logger

4.3 Push-in Installations

Some installations require a Settlement Sensor to be pushed into undisturbed material at the bottom of a borehole or pushed into the ground from the surface. For this purpose, Geosense produces specially designed Push-in Settlement Systems. The installation involves the use of a pushing adaptor connected to steel placing rods or drilling rods. The rod(s) must be strong enough to withstand the load that will be required to push the Settlement Sensor into the material at the base of the borehole or from ground level.

Only purpose built PUSH-IN Settlement Sensors can be used for this type of installation.

A special designed pushing adaptor is required to support and push the Settlement Sensors into a borehole. This adaptor is normally manufactured by Geosense and can be fabricated or modified to suit the size of the drilling rods / tubes to which it will be connected. The design of the adapter allows the Settlement Sensor to be pushed to the required elevation and then the rods and adaptor can be extracted, leaving the cell in place and connected to the tubes and cables.

Where drilling rods are to be used to push the Settlement System into the base of the borehole the Settlement Cell cable and tubing must remain inside the rods to protect them. **They cannot be attached to the outside of the drilling rods as the installation is inserted into the borehole**.

Any preliminary borehole may be cased or un-cased. The final installation procedure will need to be created to include the following variations and based upon the previously described installation procedures.

1. Prepare the Settlement Sensor and confirm that a VW reading is obtainable from the Sensor, as described in Section 4.

2. Fit the specially designed pushing shoe to the lower end of the first ‘Pushing / Placing Rod’. Grease the inside the of the pushing shoe to make it easier to release the Sensor and minimise the risk of ‘binding’.

3. Place the Settlement Sensor near the installation location then unroll the Sensor cable and the Liquid Lines.

4. The tubing and cable must be threaded through the rods used to push the sensor. Thread the cable and tubes through the pushing shoe and first rod.

5. The Settlement Sensor must be pushed up inside the shoe until it is firmly bearing against the back of the shoe. Make sure that the cable and tubing is loose inside the pushing rod.

6. As the rods are lowered into a borehole, the cable / tubes must be restrained to prevent the Settlement Sensor dropping out of the shoe.

7. As rods are added, they are slid over the cable and tubing. In an open hole, care must be taken to maintain light tension on the cable / tubes as the rods are coupled together over the installation. Failure to do so may allow the sensor to drop out of the shoe which could cause it to be damaged when it reaches the base of the hole.

   Never rotate the lower rods when connecting additional rods. This could cause the cable or tubing to become twisted and could result in a damaged installation.

8. Always count the rods into the holes so as to be sure of the Settlement Sensor's elevation at any time. (In soft ground, heavy rods could push the Settlement Sensor beyond its intended location without applying any driving force).

9. When the sensor is in its intended position, slowly withdraw the pushing rods and adaptor, taking care to allow the tubing and cable to pass through the rods freely, as the rods are withdrawn.

   AGAIN … Never rotate the lower rods when removing the rods. This could cause the cable or tubing to become twisted and could result in a failed installation.

10. Feed the cable and tubes through the rods as they are removed.

11. For trenching and termination, please refer to page 10

This system can be a cost effective solution where Settlement Sensors are to be installed in soft ground but care must be taken not to damage the Cable / Tubing when the pushing rods are withdrawn.

Push-in Settlement Sensor with cable and tubing

Push-in Settlement Sensor ready for installation

5.0 DATA HANDLING

The function of the instrument is to provide useful and reliable settlement data. Accurate recording and handling of the data is essential if it is to be of any value.

5.1 Monitoring the Settlement System Readings

Geosense **Vibrating Wire Liquid Settlement System (VWLSS-200)** bodies contain Temperature sensors. Where a system is installed in a zone where its temperature is likely to fluctuate significantly, records of both settlement and temperature data should be used to assess any effects temperature has on the data.

5.1.1 Portable Readouts

Geosense offer a range of readout and data logging options. Specific operation manuals are supplied with each readout device.

Below is a brief, step-by-step procedure for use with the Geosense **VW1** portable readout.

1. Connect signal cable from the sensor to the readout following the wiring colour code. Conductor colours may vary depending upon the extension cable used.

RED	=	VW +
BLACK	=	VW -
GREEN	=	Temp
WHITE	=	Temp

2. Press the ‘On/Off’ button to switch the unit on. Press it again to acquire a reading from the connected instrument.

3. The readout displays the Vibrating Wire readings in both ‘Frequency’ (in Hz) and Linear ‘B’ Digits (in $Hz^2/1000$). Temperature reading in both resistance (Ohms) and degrees C.

   For more details see the readout manual.

4. Press and hold down the On/Off’ button to switch the unit off.

INITIAL readings from the sensors should be recorded after they have been fully installed and the cables buried.

5.1.2 Data Loggers

A number of data loggers are available to automatically excite, interrogate and record the reading from Vibrating Wire instruments. These include devices manufactured by Geosense in both single and multi-channel manufacturers of data loggers that can be readily used with Vibrating Wire Settlement Systems. Specific configuration and programming advice can be obtained from Geosense.

5.2 Data Reduction

Overview

The system, essentially, comprises a column of water with the Reservoir at one end and the sensor at the other. If the elevation of the sensor reduces (settlement) and the elevation of the reservoir remains constant (as should be the case), the column of water increases in height.

This increase in liquid column height applies more pressure on the sensor, resulting in a changed reading. Due to the nature of the Vibrating Wire sensor, this increase in pressure produces an DECREASE in the 'Raw' reading. (This is as a result of the flexing of the sensor diaphragm and the consequential reduction of tension in the attached 'Vibrating Wire'. It's tension being measured in frequency.)

'Raw' readings from a VW Settlement System are, therefore, typically in form that is a function of frequency. Commonly the units would be either **Frequency** - Hertz(Hz), **Linear** - $Hz^2/1000$ or $Hz^2/1000000$ or **Period** - 1/T.

Settlement is conventionally expressed as a negative value and calculated simply by subtracting an 'Initial' reading from the 'Current' reading and multiplying it by a Sensor 'Constant'.

Having recorded the 'Initial' VW reading and Temperature after the installation has stabilised, all subsequent readings can be referred to these values. Use the Initial VW Reading as R_o and the Initial Temperature value as T_o. The effects of changes in atmospheric pressure can be significant and are removed by either using a vented transducer or mathematically using data from a Barometric pressure sensor.

Refer to the individual calibration sheets for the appropriate calibration and thermal factors for each sensor. Use the following formula to determine settlement.

5.2.1 Linear calculation of data for a '<u>non-vented</u>' system (using mbar barometric correction)

$$\textit{Settlement} = [\{(CF * \Delta R) + (T_K * \Delta T)\} - (Bk * \Delta B)] / SG$$

$$\Delta R = R_C - R_0$$
$$\Delta T = T_C - T_0$$
$$\Delta B = B_C - B_0$$

Where:

CF	= Calibration Factor (from Calibration Sheet - see note on P16)
SG	= Specific gravity of system liquid (1.037 kg/l)
R_0	= Initial site reading
R_C	= Current reading
T_K	= Thermal Factor (from Calibration Sheet)
T_0	= Initial Temperature
T_C	= Current Temperature
B_0	= Initial Barometric pressure (at installation)
B_C	= Current Barometric pressure (at time of readings
B_K	= Conversion factor from millibar to metres of water (0.0102)

(Continued on page 17)

Geosense Calibration Sheets provide a NEGATIVE (-) Calibration Factor value for Settlement Cells. The equations REQUIRE a POSITIVE (+) Calibration Factor to produce a NEGATIVE value representing Settlement.

5.2.2 Calculation of data for a self compensating, 'vented' system.

$$Settlement = \{(CF * \Delta R) + (T_k * \Delta T)\} / SG$$

$$\Delta R = R_c - R_0$$
$$\Delta T = T_c - T_0$$

Where:

CF	= Calibration Factor (from Calibration Sheet)
SG	= Specific gravity of system liquid (1.037 kg/l)
R_0	= Initial site reading
R_C	= Current reading
T_K	= Thermal Factor (from Calibration Sheet)
T_0	= Initial Temperature
T_C	= Current Temperature

For example, using the non-vented equation:

Initial VW Readings R_0 after installation was **7905** Digits (Hz^2 /1000)
at sensor temperature T_0 of **17**°C
and Barometric pressure B_0 of **1012** mb
Current VW Reading R_C is **7530** Digits
at sensor temperature T_C of **15**°C
and Barometric pressure of **1025** mb
Calibration sheet shows **- 0.002324**m/Digit for CF
and **- 0.010512** m/(°C) for T_K

$$\Delta R = R_C - R_0 \quad = 7530 - 7905 \quad = -375 \text{ Digits}$$
$$\Delta T = T_C - T_0 \quad = 15 - 17 \quad = -2\ ^0C$$
$$\Delta B = B_C - B_0 \quad = 1012 - 1025 \quad = -13 \text{ mb}$$

$$Settlement = [\{(0.002324 * -375) + (-0.010512 * -2)\} - (0.0102 * -13)] / 1.037$$
$$= [\{ -0.8715 + 0.021 \} + 0.1326] / 1.037$$
$$= 0.692 \text{ m}$$

From the above sample calculation, it can be seen that generally the temperature effects are small, which is commonly true for buried sensors. However, the effects upon the liquid cannot be included in this compensation and where tubing is exposed the effects can be more significant.

*** If calculated settlements appear to be RISING, check the liquid level in the reservoir and check the elevation of the reservoir in case it has settled. Also confirm that a positive Calibration Factor has been used in the calculations.*

5.3 Typical calibration Sheet

GEOSENSE QUALITY FORM
FORM No GQF-C143
ISS. 6
DATE Dec-18
SIG. QC

VENTED VW SETTLEMENT CELL CALIBRATION

Model	VWPS-200V	Cal date	28/02/2019	SN.	8233
Serial	349999	Baro	1004.0	Readout No.	2108
Works ID	GV2 14 1	Temp °C	19	R/O Cal. date	09/05/2018

Applied pressure		Readings [digit]			Calculated Pressure		Error % fso	
psi	kPa	1st Cycle	2nd Cycle	avg [digit]	in kPa	corr [kPa]	linear	polynomial
0.000	0.000	9239.1	9241.6	9240.4	0.04	0.00	0.06%	0.01%
2.030	14.000	8827.5	8829.7	8828.6	13.99	13.99	-0.02%	-0.01%
4.061	28.000	8014.0	8016.3	8015.1	27.96	28.00	-0.05%	-0.01%
6.091	42.000	7399.2	7401.3	7400.3	41.98	42.01	-0.04%	0.01%
8.122	56.000	6784.0	6786.0	6785.0	56.00	56.00	-0.01%	0.01%
10.152	70.000	6165.1	6170.0	6169.0	70.03	70.00	0.05%	-0.01%

Calibration of Fluke Pressure Controller PPC4EX S/N: 8233 valid from 23rd March 2012. Certificate of Calibration No 47924 Chamois Metrology UKAS No 0822

CALIBRATION FACTORS

Linear factor (k)

kPa per digit	psi per digit	mH_2O per digit
-0.022788496	-0.003305	-0.002324

Polynomial factors

	kPa	psi	mH_2O
A	-3.06898E-08	-4.45102E-09	-3.1296E-09
B	-0.022316581	-0.003236	-0.002276
C			

Thermal factor (T)

kPa per °C	psi per °C	mH_2O per °C
-0.103084258	-0.014950581	-0.010512

Note: Digits are $Hz^2 \times 10^{-3}$ units.

(please consult the User Manuals for conversion of alternative reading units)

Polynomial calculation [kPa] = A * (Reading)^2 + B * (Reading) + C + T * (Current Temp - Site Zero Temp)

C = -A*(Site Zero Reading^2) - B*(Site Zero Reading)

Linear calc = k (kPa) * (Current Reading - Site Zero Reading) + T * (Current Temp - Site Zero Temp)

THIS CERTIFICATE IS VALID ONLY WHEN CARRYING THE OFFICIAL ORIGINAL STAMP OF GEOSENSE BELOW

Novus House, Rougham Industrial Estate, Rougham, Bury St Edmunds, Suffolk, IP30 9ND, England
t: +44 [0]1359 270437 e: sales@geosense.co.uk www.geosense.co.uk

6.0 MAINTENANCE

If the VW readings appear unusual *(see 7.0 Troubleshooting)* then it maybe necessary to flush the system.

The **Vibrating Wire Liquid Settlement System (VWLSS-200)** is designed so that if the contained fluid becomes contaminated or a significant number of air bubbles appear, the system can be flushed through and fluid replaced with fresh de-aired Water/Glycol mix. (Contact Geosense for advise & assistance)

Maintenance is not required on the sensor body/plate, or any below soil surface parts.

Very low and general maintenance is sufficient for the remainder of the (above soil) System, consisting mainly of visual checks every 2-3 months for:

- Ensure the reservoir level is up to the overflow tube - top up if necessary,
- Connection tubes are still firmly in place and sealed,
- The fluid tubes are clean and clear.
- Wiring connections are in good order.

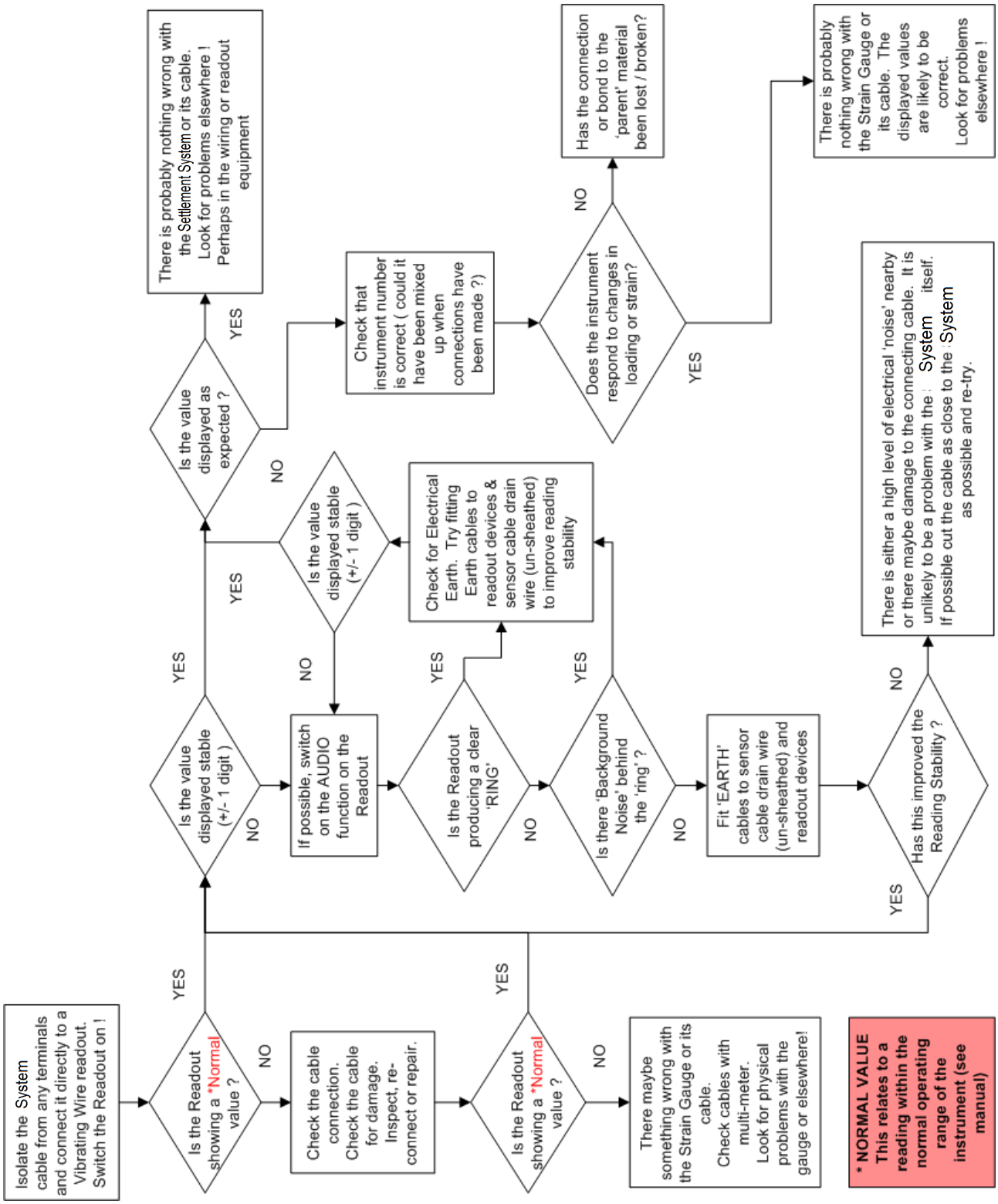
Where 'Vented' transducers are employed, the desiccant beads in the moisture traps MUST be replaced at regular intervals

Maintenance of wiring connections between the **Vibrating Wire Liquid Settlement System (VWLSS-200)** and any terminal panels / or loggers should involve occasional tightening of any screw terminals to prevent loose connections, or cleaning contacts to prevent the build up of corrosion.

7.0 TROUBLESHOOTING

It is generally accepted that when a Vibrating Wire instrument is producing a stable reading on a suitable readout, the value will be correct. Only on very rare occasions will this be untrue.

In almost all cases, a fluctuating reading is a sign of a faulty signal from the sensor. The fault could be in either the sensor, the connecting cable, any switch boxes or the readout. The best way to fault find an instrument is to isolate it from all other instruments and connections.



8.0 SPECIFICATION

Resolution	0.05% Full Scale (readout dependent)
Sensor Accuracy	0.1% Full Scale
Thermal Effect	Less than 0.02% Full Scale per ^{o}C **
Thermal Operating Range	-20 to + 80 ^{o}C
Temperature Sensor	Thermistor (3kΩ @ 25^{o}C)
Operating Range	7m (standard) - others available upon request
Over Range Capacity	Range + 20%
Excitation	Pluck or Swept Frequency

Standard Range* 7, 17 metres

Sensor accuracy 0.1% full scale

System accuracy Site dependent

Resolution 0.025% full scale

Temperature range -20°C to +80°C

MODEL DESCRIPTION

VWPS-201V VW vented pressure sensor 70 kPa

VWPS-202V VW vented pressure sensor 140 kPa

VWPS-203V VW vented pressure sensor 175 kPa

VWPS-204V VW vented pressure sensor 345 kPa

VWPS-201S VW sealed pressure sensor 70 kPa

VWPS-202S VW sealed pressure sensor 140 kPa

VWPS-203S VW sealed pressure sensor 175 kPa

VWPS-204S VW sealed pressure sensor 345 kPa

The above technical specification is accurate at the time of the last document revision and is intended as guide only.

The information above is liable to change without notice and may not, therefore, be 100% accurate for the supplied sensors.

9.0 SPARE PARTS

The Liquid Settlement System consists of both buried components and above soil components.

The Vibrating Wire Settlement System Body (Drive-in or Plate) is a sealed unit, it is neither serviceable nor does it contain any replaceable parts.

Above soil component items such as the Reservoir, junction box and readout are all interchangeable and replaceable.

Civil engineering sites are hazardous environments and instrument cables can be easily damaged, if they are not adequately protected. Geosense can therefore provide the following parts that may be required to effect repairs to instrument cables and tubes.

- PU coated 4 Core Sensor cable with foil shield and copper drain.
- PVC coated, armoured, 4 Core cable suitable for direct burial.
- Epoxy jointing kit for forming a waterproof cable joint.
- Tubing and couplings

Please contact Geosense for price and availability of the above components.

Repairs to tubing will require specialist knowledge and the facility to 'flush' the liquid lines once any repair has been carried out.

10.0 RETURN OF GOODS

11.1 Returns procedure

If goods are to be returned for either service/repair or warranty, the customer should contact **Geosense®** for a **Returns Authorisation Number,** request a **Returned Equipment Report Form QF034** and, where applicable, a **Returned Goods Health and Safety Clearance Form QF038** prior to shipment. Numbers must be clearly marked on the outside of the shipment.

Complete the **Returned Equipment Report Form QF034**, including as much detail as possible, and enclose it with the returned goods.

All returned goods are also to be accompanied by a completed **Returned Goods Health and Safety Clearance Form QF038** attached to the outside of the package (to be accessible without opening the package) and a copy of both forms should be faxed in advance to the factory.

10.1.1 Chargeable Service or Repairs

Inspection & estimate
It is the policy of **Geosense®** that an estimate is provided to the customer prior to any repair being carried out. A set charge for inspecting the equipment and providing an estimate is also chargeable.

10.1.2 Warranty Claim

(See Limited Warranty Conditions)
This covers defects which arise as a result of a failure in design or manufacturing. It is a condition of the warranty that the Vibrating Wire Strain Gauge must be installed and used in accordance with the manufacturer's instructions and has not been subject to misuse.

In order to make a warranty claim, contact **Geosense®** and request a **Returned Equipment Report Form QF034.** Tick the warranty claim box and return the form with the goods as above. You will then be contacted and informed whether your warranty claim is valid.

10.2 Packaging and Carriage

All used goods shipped to the factory **must** be sealed inside a clean plastic bag and packed in a suitable carton. If the original packaging is not available, **Geosense®** should be contacted for advice. **Geosense®** will not be responsible for damage resulting from inadequate returns packaging or contamination under any circumstances.

10.3 Transport & Storage

All goods should be adequately packaged to prevent damage in transit or intermediate storage.

11.0 LIMITED WARRENTY

The manufacturer, **Geosense Limited,** warrants the **Vibrating Wire Liquid Settlement System (VWLSS-200)** manufactured by it, under normal use and service, to be free from defects in material and workmanship under the following terms and conditions:-

At the time of ordering, sufficient site data must be provided to **Geosense®** by the purchaser with regard to the nature of the installation environment so as to allow **Geosense®** to check material compatibility of their **Vibrating Wire Liquid Settlement System (VWLSS-200)** and other component parts.

In the absence of any site data being provided by the purchaser, standard construction materials will be supplied. All costs for subsequent modifications will be borne by the purchaser.

The **Vibrating Wire Liquid Settlement System (VWLSS-200)** equipment shall be installed in accordance with the manufacturer's recommendations and in line with their operating manual.

The equipment is warranted for 1 year from the date of shipment from the manufacturer to the purchaser.

The warranty is limited to replacement of part or parts which, are determined to be defective upon inspection at the factory. Shipment of defective part or parts to the factory shall be at the expense of the Purchaser. Return shipment of repaired / replaced part or parts covered by this warranty shall be at the expense of the Manufacturer.

Unauthorised alteration and / or repair by anyone which, causes failure of the unit or associated components will void this **LIMITED WARRANTY** in its entirety.

The Purchaser warrants through the purchase of the Vibrating Wire Liquid Settlement System (VWLSS-200) equipment that he is familiar with the equipment and its proper use. In no event shall the manufacturer be liable for any injury, loss or damage, direct or consequential, special, incidental, indirect or punitive, arising out of the use of or inability to use the equipment sold to the Purchaser by the Manufacturer.

The Purchaser assumes all risks and liability whatsoever in connection with the **Vibrating Wire Liquid Settlement System (VWLSS-200)** equipment from the time of delivery to Purchaser.

NOTES

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