V1.3

VWM-2000
WEIR MONITOR

INSTRUCTION MANUAL

CE

GEOSENSE


GEOSENSE

CONTENTS Page

1.0 INTRODUCTION

This manual is intended for all users of the **VWM-2000** Weir Monitor and provides information on its installation, operation and maintenance**.**

It is VITAL that personnel responsible for the installation and use of this VWM-2000 Weir Monitor, READS and UNDERSTANDS this manual, prior to working with the equipment.

1.1 General Description

The **VWM-2000** vibrating wire weir monitor utilises a vented vibrating wire force transducer in combination with a cylindrical weight suspended from it to monitor water levels.

The vibrating wire force transducer is vented to atmosphere so that any atmospheric changes are automatically compensated.

Both are contained within a PVC slotted pipe which can be located within the weir or tank as necessary and the vent tube is terminated within a moisture trap. Periodic change of the desiccant is required.

The cylindrical weight is partially suspended in the water level being monitored and as the water level changes the force on the transducer by the cylinder alters which in turn alters the tension of the vibrating wire.

As with all vibrating wire sensors the output is frequency and therefore not affected by changes of cable resistance so that extremely long cable lengths are possible. Typical installation in combination with a V-notch weir are shown in Figure 1 below.

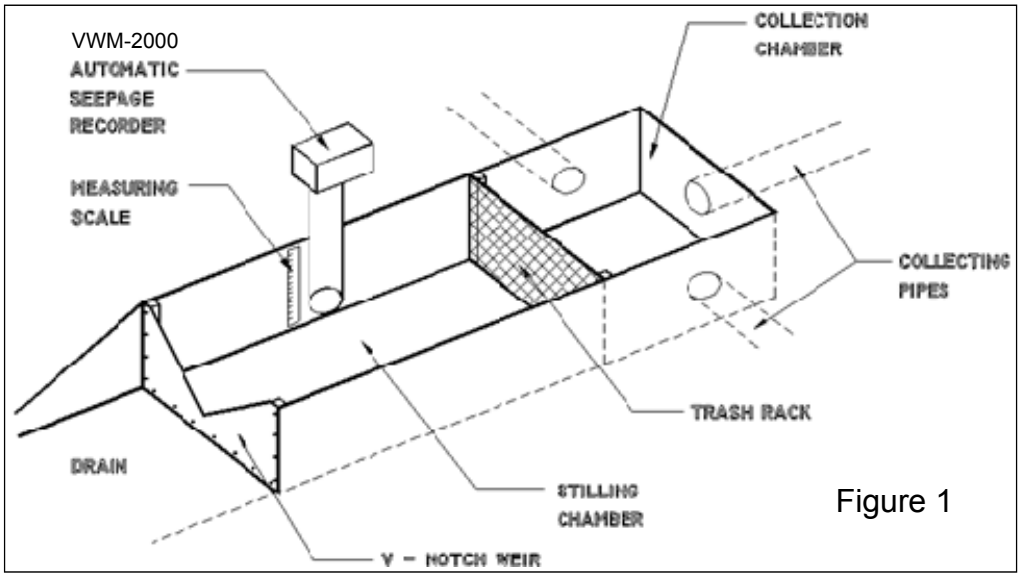


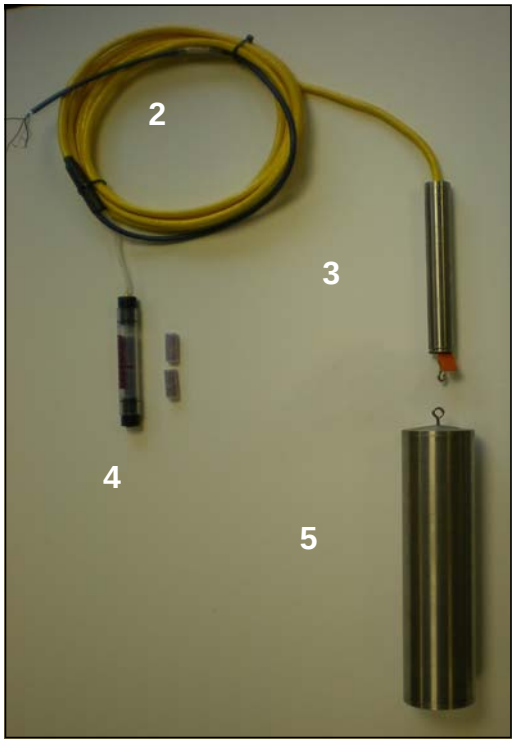
Figure 1

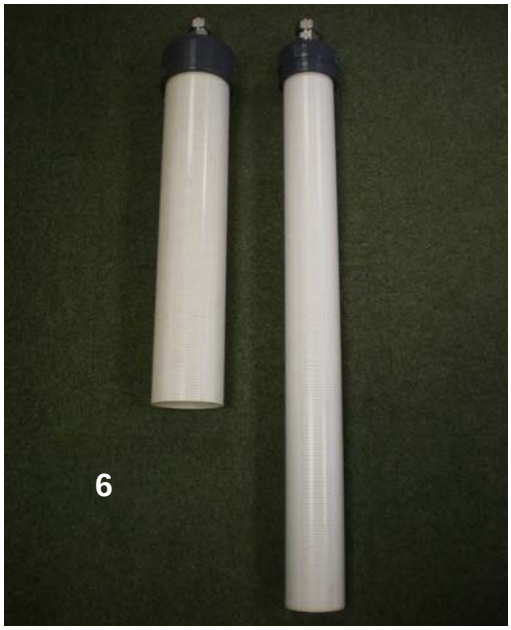
1.1 General Description contd...

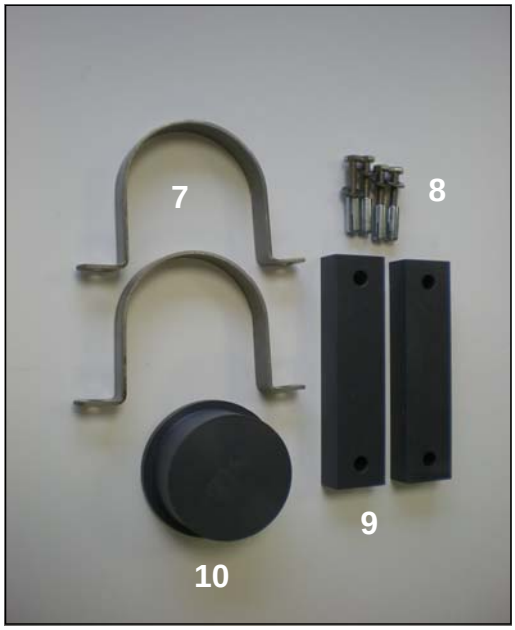
The unit consists of the following component parts:-

1. Unit mounted inside PVC screen
2. Vented cable
3. Force transducer
4. Desiccant filter
5. Weight*
6. PVC screen*
7. Mounting brackets*
8. Rawl bolts
9. Mounting blocks*
10. Bottom plug*

* Size varies according to range







1.2 How it works

The force transducer consists of a tensioned steel wire anchored at both ends into flanges. The wire is enclosed in a stainless steel tube. The internal parts of all Geosense force transducers are essentially identical, only the body geometry and the inclusion of additional springs change within the units with longer gauge lengths. The configuration of the sensing elements may also vary slightly from model to model.

Electromagnetic coils are located within the body close to the axis of the wire. When a brief voltage excitation, or swept frequency excitation is applied to the coils, a magnetic field is induced causing the wire to oscillate at its' resonant frequency. The wire continues to oscillate for a short period through the 'field' of the permanent magnet, thus generating an alternating current (sinusoidal) output. The frequency of this current output is detected and processed by a vibrating wire readout unit, or by a data logger equipped with a vibrating wire interface, where it can be converted into 'Engineering' units of mm.

Forces within the transducer are altered by the amount of weight that is being exerted from the suspended weight which causes the length of the transducer to change. This causes a change in the tension of the wire within the transducer. It is the tension in the wire that produces the value that can be converted to strain.

A change in length of the wire changes the tension of the wire which results in a change in resonant frequency of oscillation of the wire. The change in the square of frequency of oscillation is directly proportional to the change in strain in the structural element.

For further information see Section 6.0 - Data Handling.

1.3 Applications

The VWM-2000 Weir Monitor can be used for the precision water level measurement of: -

- Weirs
- Streams
- Reservoirs
- Tanks

2.0 CONFORMITY

Geosense Ltd
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Email: info@geosense.co.uk, Web: www.geosense.co.uk

Declaration of Conformity

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

Low Voltage Directive 2006/95/EC
Electromagnetic Compatibility Directive 2004/108/EC
The Construction Products Directive 89/106/EEC

CE

Equipment description	**Vibrating Wire Weir Monitor**
Make/Brand	**Geosense**
Model Numbers	**VWM-2000**

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

Martin Clegg
Director

3.0 MARKINGS

THE TRANSDUCER & WEIGHT ARE A CALIBRATED MATCHED PAIR AND CARE MUST BE TAKEN ESPECIALLY WITH MULTIPLE INSTALLATIONS THAT THE SERIAL NUMBER ON THE TRANSDUCER MATCHES THE SERIAL NUMBER ON THE WEIGHT

Geosense **VWM-2000 Weir Monitors** are labelled with the following information:-

Manufacturers name & address

Product type

Model

Serial number

CE mark

In addition the weight has its own unique number which is linked to the serial number of the transducer.

4.0 DELIVERY

4.1 Packaging

VWM-2000 Weir Monitors are 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 Geosense.

4.2 Handling

Whilst they are a robust devices, **VWM-2000 Weir Monitors** 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 **VWM-2000 Weir Monitors** remain in their original packaging for storage or transportation.

Cable should be handled with care. Do not allow it to be damaged by sharp edges, rocks for example, and do not exert force on the cable as this my damage the internal conductors/vent line and render the instrument useless.

4.3 Inspection

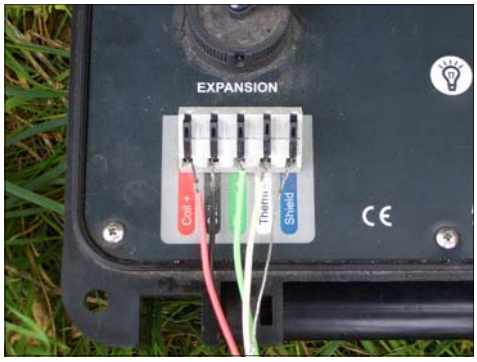
It is vital to check all the equipment in the shipment as soon as possible after taking delivery and well before installation is to be carried out. Check that all the components that are detailed on the documents are included in the shipment. Check that the equipment has not been physically damaged.

Although the system is not fully assembled, a function check can still be carried out by connected the VW Cable to the Readout as in picture.

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

The displayed values of the strain gauge reading and temperature, should be reasonably stable (+/- 3 full digits) for this check.

Where possible, select the audio function on the readout and listen to the ‘ring’ of the gauge. The ‘ring’ should be clear and un-distorted.



Typical readout panel and connections

If components are missing or damaged, contact the delivery company, the supplier and / or Geosense.

4.4 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.

No other special requirements are needed for medium or long-term storage although temperature limits should be considered when storing or transporting associated components, such as readout equipment.

5.0 INSTALLATION

The following sections describe a typical installation for Geosense **VWM-2000 Weir Monitors.**

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

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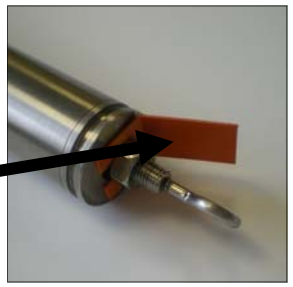
As stated before, it is vital to check all the equipment in the shipment soon after taking delivery and well before installation is to be carried out. Check that all components that are detailed on the shipping documents are included.

5.1 Getting started

AS A SAFETY MEASURE TO PROTECT THE SENSOR FROM DAMAGE DURING TRANSPORT AN ORANGE SPACER IS FITTED BETWEEN THE BASE OF THE SENSOR AND THE NUT ON THE HOOK ASSEMBLY.

THIS MUST BE REMOVED BEFORE FITTING THE WEIGHT CYLINDER



Record the assigned unique identifying code for the sensor and the weight against the designated location (if applicable).

Ensure there will be enough cable to route it to the intended readout / monitoring location.

5.2 Functionality check

The gauge and weight assembly can now be checked by connecting the sensor to the readout and measuring the output of the sensor with the weight hanging from it.

The readings in “B” units should read within 200 digits of the factory zero reading as shown on the calibration sheet.

MAKE SURE THE SENSOR IS HELD FIRMLY AND ALLOW THE SYSTEM TO STABILISE

DO NOT ALLOW THE WEIGHT TO SWING

5.3 Installation

The PVC wellscreen must be installed in a vertical position in an area where there will be minimum turbulence and positioned in such a way that the average water level coincides with the mid-point of the weight. See Steps 1 to 10 for installation method.

NON-VERTICALITY WILL AFFECT THE PRECISION OF THE INSTRUMENT

STEP 1
Measure mid point of water level and if necessary cut the PVC to length.

Figure 3

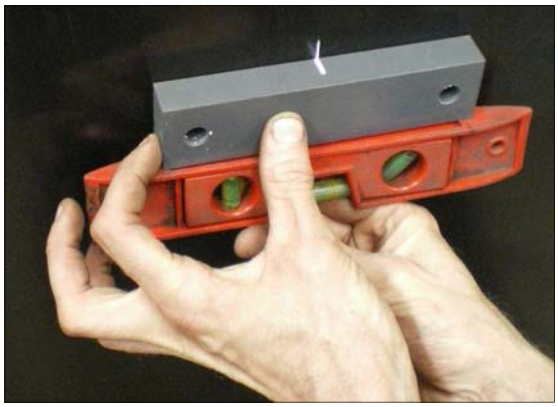
STEP 2
Mark out a vertical plumb line

Figure 4

5.3 Installation contd

STEP 3

Making sure the spacer block is level mark the position of the holes.

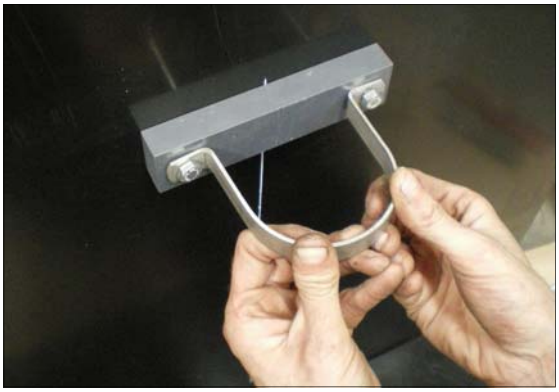


STEP 4

Drill the holes for the fixing bolts/Rawl bolts.

STEP 5

Fit the pipe clamps onto the spacer blocks & tighten bolts. It is recommended that the blocks are positioned 150mm from the top & bottom of the PVC screen.



STEP 6

Place PVC solvent cement onto the bottom plug and fit into bottom of the PVC screen.

NOTE: The screen can be shortened a little if space limitation is a problem

STEP 7

Place PVC screen into the pipe clamps until it sits on the bottom of the tank/ weir.

STEP 8

Push the sensor into the Swagelok fitting until there is approximately 25mm protruding from the Swagelok.

Tighten the Swagelok one full turn after finger tight.

STEP 9

Carefully attach the weight to the eyebolt on the base of the sensor.

STEP 10

Carefully lower the assembly into the PVC wellscreen until the cap sits on the top.

The unit is now fully installed.

REMEMBER TO TAKE THE SITE INITIAL/BASE READING

I.E. INITIAL HEIGHT OF THE WATER

The yellow vented readout cable can now be extended to a local readout location where an optional terminal box can be used to enclose the end of the vented cable and the vent line moisture trap.

If the readout location is remote from the weir location then an un-vented cable can be used between the terminal box containing the moisture trap and the readout location.

REMEMBER TO REPLACE THE SILICA GEL FILTERS ONCE THEY TURN FROM BLUE TO PINK

6.0 DATA HANDLING

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

6.1 Taking readings

The **VWM-2000** weir monitor contains temperature sensors. Where a system is installed in a zone where its temperature is likely to fluctuate significantly, records of both liquid level and temperature data should be used to assess any effects temperature has on the data.

6.1.1 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 **VW2106** 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. Switch on the unit and, where necessary, select range B

3. The readout displays the current VW reading (in $Hz^2/1000$) and a temperature reading in degrees Centigrade.

Whilst it is not critical that the polarity be observed for most VW instruments, a stronger signal may be obtained if the correct polarity is adopted. Since the temperature sensor is a Thermistor, its connection polarity is not important.

6.1.2 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 / RST in both single and multi-channel configurations, together with equipment manufactured by independent suppliers.

Geosense configure and supply equipment manufactured by both Campbell Scientific Ltd. and DataTaker Ltd. These are the most commonly adopted third party manufacturers of data loggers that can be readily used with Vibrating Wire Settlement Systems. Specific configuration and programming advice can be obtained from Geosense and or the manufacturers documentation.

6.2 Data Reduction

Overview

Readings from a **VWM-2000** typically in form that is a function of frequency. Commonly the units would be either **Frequency** - Hertz, **Linear** - $Hz^2/1000$ or $Hz^2/1000000$ or **Period** - 1/T.

Having recorded the initial reading and temperature after installation, the Base/Initial reading is now established and all subsequent data can be referred to these numbers. Use the initial reading as R_o and the initial temperature recorded as T_o. Refer to the calibration sheets for the appropriate calibration and thermal factors for each system.

6.2.1 Calculation of water elevation

At a given temperature, the change in elevation of the water is directly proportional to the change in output of the transducer. The following formula applies for the determination of the water relative to the sensor:-

$$\Delta H = (R_1 - R_0\ )\ G$$

Where:

ΔH = Change in water level
R_0 = Initial reading
R_1 = Subsequent reading
G = Calibration factor

The water level is determined by

$$EL = \text{Ref EL} + \Delta H$$

Where:

Ref EL = the elevation of water at R_0

THE ELEVATION OF THE WATER AT THE INITIAL READING R_0, MUST BE ESTABLISHED BY MEASURING THE WATER LEVEL RELATIVE TO THE TIP OF THE V-NOTCH

6.2.2 Corrections for temperature changes

The vibrating wire sensor itself is insensitive to temperature changes within its normal operating range. The system however can be affected by changes in water temperature which influences the density & therefore the effective buoyancy of the fluid. The influence is relatively minor and can be accounted for to some degree by measuring the water temperature and making density corrections.

Alternatively two sensors can be used, one of which is completely submerged at all times and whose output can be used to make corrections for the other sensor. This technique is not fool proof either as the water may have temperature gradients which the submerged sensor may not detect.

A temperature/density curve for water is shown in Figure 2 below. As can be seen from the data the density of water changes very little in the normal operating range of the sensor.

The following equation is used to correct for temperature/density changes:-

$$\Delta H = (R_o)\, G/(1-0.0002T_0) - (R_1)\, G/(1-0.0002T_1)$$

Where:

T = water temperature in ° C

Density & compressibility

Density is defined as the mass per unit volume, and it depends on the temperature and pressure. The density of pure water is given in Figure 2.

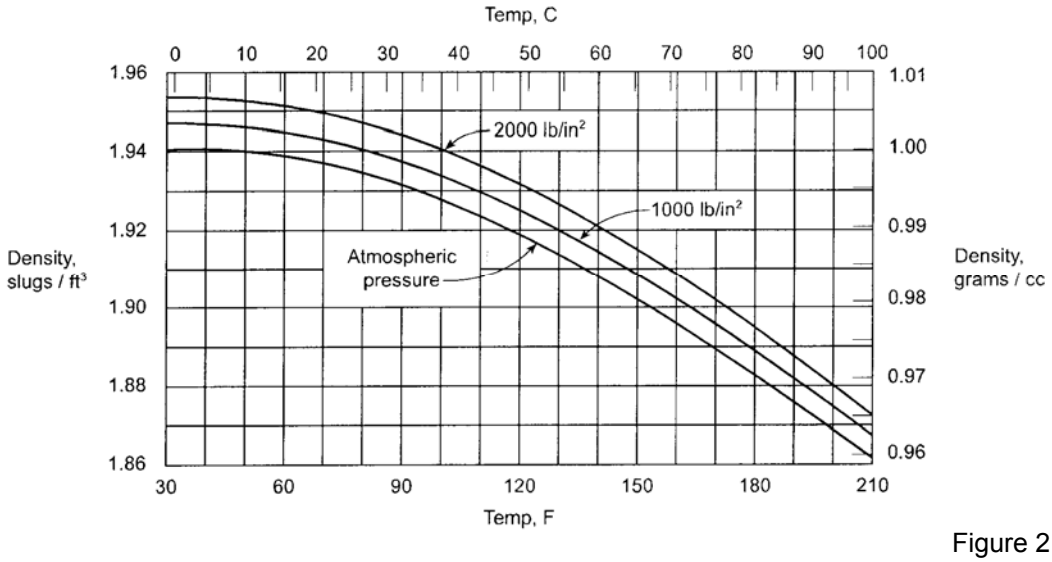


Figure 2

6.2.3 Thermistor Linearization

USING STEINHART & HART LOG

Thermistor Type. YSI 44005, Dale 1C 3001 B3, Alpha 13A3001-B3

Resistance/ temperature equation:-

$$T= (1 / (A + B (LnR) + C(LnR)^3)) - 273.2$$

Where:-

T = Temperature in degrees Centigrade
LnR= Natural log of Thermistor resistance.
A= $1.4051 * 10^{-3}$
B= $2.369 * 10^{-4}$
C=$1.019 * 10^{-7}$

Resistance versus temperature table

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	30	525.4	70	153.2	110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	3000	25	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149

7.0 MAINTENANCE

7.1 Moisture trap

The vibrating wire sensor has a vent tube to prevent loading on the sensor due to changes in atmospheric pressure. A moisture trap is fitted on the end of this vent which contains desiccant capsules. These capsules need to be changed periodically and the frequency of this will depend on weather conditions but 3 - 6 months is typical.

The capsules have a colour change indicator (from blue to pink) which identifies when they need replacing.

7.2 Weight

Since the weight is assumed to be of constant mass, it is important that it be kept clean and free of encrustation, algal growth etc. This will be dependent on the water quality but periodic observations should be made.

7.3 VW sensor

The transducer itself has no maintenance but periodic checks should be made for the condition of the cable connections and terminals.

8.0 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. Where possible begin fault finding from the sensor itself.

However if the unit fails to read the following steps should be taken:-

1. Check the coil resistance. Nominal resistance is 180 Ω ± 10 plus cable resistance (22 gauge copper = approximately 15 Ω per 333m)

   A.) If the resistance is high or infinite a cut cable should be suspected.

   B.) If the resistance is low or near to zero a short should be suspected.

   C.) If the resistances are within the nominal range and no readings are obtainable on any transducer then a faulty readout should be suspected and Geosense contacted.

2. If cuts or shorts are found the cable may be repaired in accordance with recommended procedures (contact Geosense for kits & procedures).

9.0 SPECIFICATION

Range:	150, 300, 600, 1500mm
Resolution:	0.025% Full Scale
Accuracy*:	±0.1% Full Scale
Linearity	<0.5% Full scale
Temperature operating Range	-20 to + 80 ^{o}C
Temperature Sensor	Thermistor (3kΩ @ 25^{o}C)
Frequency range:	1400 - 3500 Hz
Materials:	Sensor & weight - Stainless steel
	Stilling screen - PVC or stainless (optional)
Cable:	4 - conductor, 22 gauge, PVC sheath
Sensor:	Diameter - 25mm, Length - 216mm

*** Accuracy achieved by using a polynomial expression**

10.0 SPARE PARTS

The strain gauge is a sealed unit and no spare parts are available.

As the strain gauge & weight are a calibrated pair it is not possible just to replace the weight should it become damaged.

The following spare parts are available:-

Description	
STRAIN GAUGE	
	Moisture trap
	Desiccant capsules
CABLE	Yellow PU cable with integral vent tube (2 twisted pairs)
PVC SCREEN	
	4” PVC screen
	4” cap
	6” PVC screen
	6” cap

11.0 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 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 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.

11.1.1 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.

11.1.2 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 **VWM-2000** 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 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.

11.2 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.

11.3 Transport & Storage

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

12.0 LIMITED WARRENTY

The manufacturer, **Geosense Ltd** warrants the **VWM-2000 Weir Monitor** manufactured by it, under normal use and service, to be free from defects in material and workmanship under the following terms and conditions:-

Sufficient site data has been provided to **Geosense** by the purchaser as regards the nature of the installation environment to allow **Geosense** to check material compatibility of the **VWM-2000 Weir Monitor** 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 **VWM-2000 Weir Monitor** equipment shall be installed in accordance with the manufacturer's recommendations.

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 VWM-2000 Weir Monitor 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 **VWM-2000** Weir Monitor equipment from the time of delivery to Purchaser.

13.0 CALIBRATION SHEET

Typical calibration sheet

VWM-2000 Weir Monitor Calibration Sheet

Model #:	VWM-2000
Serial #:	100000
Date:	06/05/2010
Temp °C:	24.8

Calibrated by: _____

Applied Load L (lbs)	Equivalent (mm H_2O)	Reading 1st Cycle	Reading 2nd Cycle	Average Reading (R)	Change	Linearity (%FS)	Polynomial Fit % (FS)
1.430	169.8	4390	4390	4390			
2.090	248.3	6039	6040	6040	1650	0.33	0.00
2.752	326.8	7676	7676	7676	1637	0.44	-0.01
3.415	405.6	9303	9304	9304	1628	0.34	0.01
4.080	484.6	10920	10920	10920	1617	0.00	0.00

Factory reading with cylindrical weight hanging in air = 5864

Mid-range reading = 2702

Cylinder Dimensions (mm): WEIGHT Range: 300mm

	1	2	3
Top	70.08	69.75	69.90
Middle	69.80	70.23	69.80
Bottom	69.93	69.88	69.93

Average Diameter (D): 69.92

Volume Factor (K): 118.77 mm/lb

Calibration Factor (G) : 0.0482 (mm/digit)

Change in Sensor Elevation = $G(R_1-R_0)$

Polynomial Gage Factors:

A: 5.1487E-09 B: 0.0018189 C: -1.3980

Polynomial: $P = AR_1^2 + BR_1 + C$

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