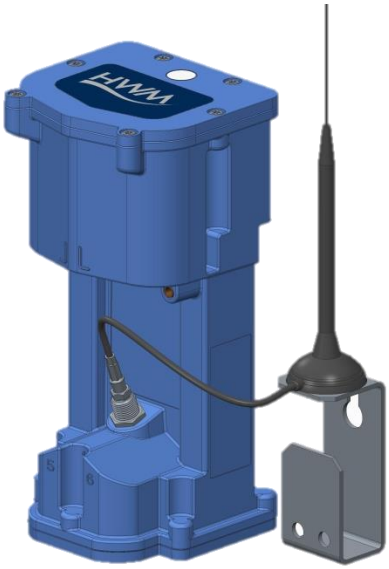
Antenna Installation Guide.



MAN-072-0001-K March 2022.

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1 INTRODUCTION

1.1 DOCUMENTATION AND SUPPORT

This user guide gives guidance information for the selection and installation of an antenna to use with your HWM logger equipment (or other HWM system) that uses a mobile network (cellular) service for communications.

The user-guide should be read in conjunction with the user-guide(s) of the equipment it is being used with. Also refer to the user-guide of the software tool for on-site setup and test of the logger (e.g., IDT), if required.

HWM provides support by means of our customer support webpages:

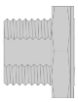
https://www.hwmglobal.com/help-and-downloads/

Should you have any questions that are not covered by this manual or the system's online help, please contact the HWM Technical Support team on +44 (0) 1633 489479, or email cservice@hwm-water.com

1.2 ANTENNA CONNECTORS

The antenna connector should match the one fitted to your logger. Loggers have two alternative connector types:

- Antenna connector type with a plastic connector shell. (Also known as "Bulgin").
- Antenna connector type with metal connector). (Also known as "FME").



Metal (FME)

Plastic (Bulgin)

The plastic version is preferable for installations where the logger may be frequently submerged (due to flooding, etc).

The plastic antenna connector should be tightened to finger-tight only.

No sharp bends should exist in the cable routing of the antenna.

1.3 ANTENNA INSTALLATION CONSIDERATIONS

The method of installation at site should be carefully selected.

Signal strength within a cellular network can vary dramatically even within the same cell; proximity to the transceiver, type of antenna used, position, angular orientation of the antenna, time of day, all have a significant effect on the ability of a device to reliably communicate with the cellular network.

Also consider that network operators can change the operating power during the day / night so this can lead to times of the day when communications is not possible.

To ensure reliable cellular data communications, it is essential that the most suitable antenna is selected, and that it is mounted in the most appropriate location.

Installing a device without considering the type of antenna and its installation constraints can lead to disrupted and unreliable data communications and accelerated battery consumption. The following gives practical advice on how to minimise potential problems.

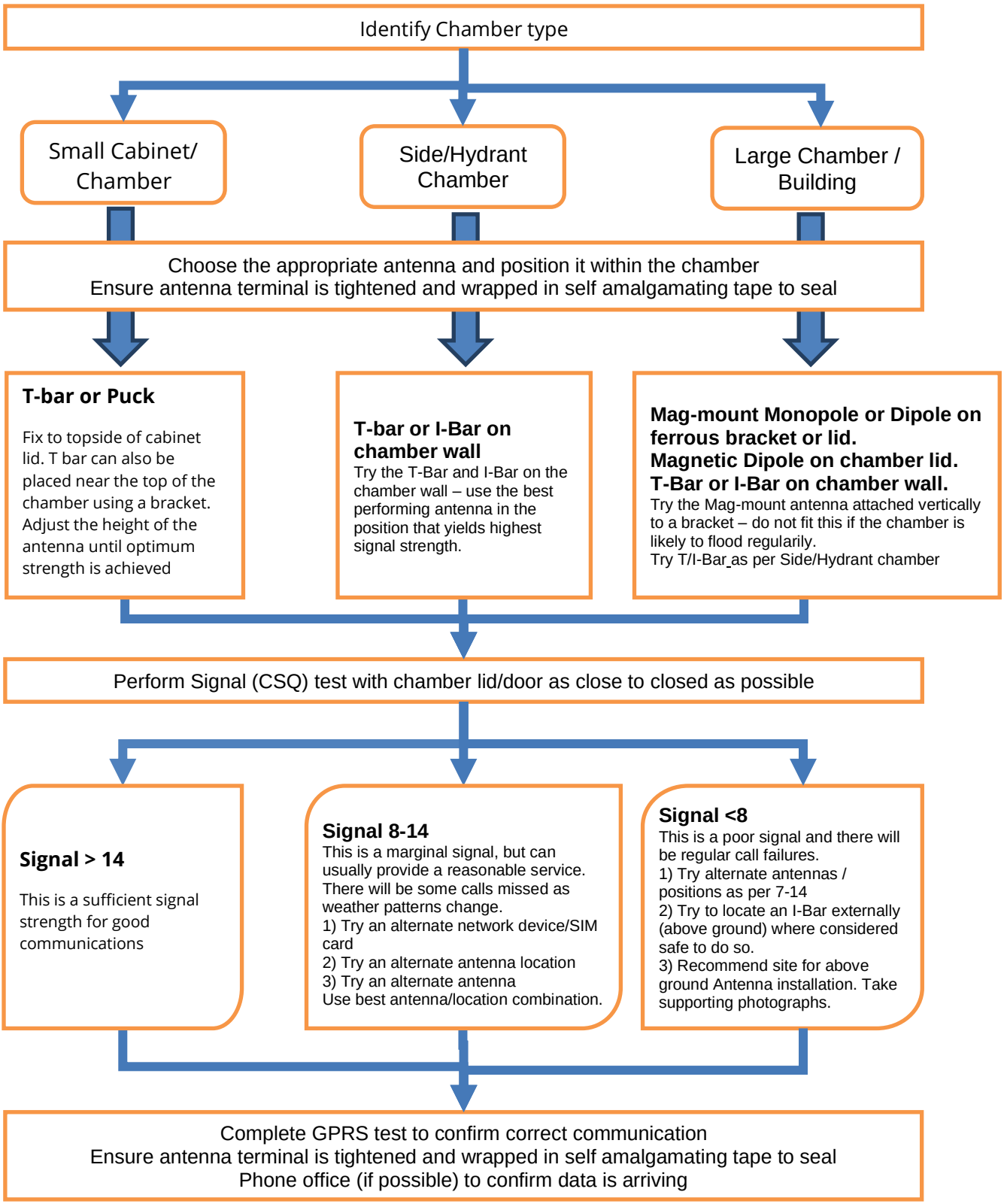
If the logger has poor mobile network service, it can also result in the failure to send sound files or transient files, since these files are much larger and will be more vulnerable to transmission failure.

General Considerations

- Always perform multiple signal strength tests using the IDT or Radwin signal (CSQ) check. Try moving the antenna to different positions during the test (please see below for description of signal strength test results).
- When performing Signal Strength (CSQ) Tests ensure that the chamber lid/cabinet door is in as close to the normally closed position as possible to ensure an accurate result.
- When fitting the “puck” antenna to a cabinet, always fit it to the top wherever possible. Ensure the surface is as clean as possibly prior to attaching the antenna with the adhesive pad and that the nut on the inside of the cabinet is fully tightened.
- Try to avoid moving the device and/or cables after performing the CSQ and GPRS tests as this can change the result. The final GPRS test should be performed with the antenna cables and device in the final positions.
- If the device is installed in an underground chamber consider, where possible, locating the antenna in a secure position outside the chamber, e.g., inside a hollow marker post or attached to the back of a concrete one.
- A steel post can also work to get the antenna above the snow level, but always make sure the antenna is not shielded within the metal; fit it inside a plastic cap.

- When positioning the antenna in an underground chamber, be aware that the best signal is not always at the very top of the chamber. A few centimetres below the metal lid can improve signal reception.
- Always try both antenna polarities (Horizontal and Vertical). Most antennas work best when the long side is positioned vertically, but sometimes the horizontal position can be better.
- Ensure that the antenna connector is in good condition and correctly tightened (finger-tight is not sufficient for the metal type of connectors used). Adequate tightening of the connector reduces the risk of water ingress and thereby signal attenuation as a result of changes in impedance.
- Never attempt to modify the dielectric seal of the antenna connector, it is designed to keep moisture away from conducting parts which lead to corrosion and attenuation.
- Consider using secondary environmental protection for the metal antenna connector such as self-amalgamating tape.
- Use the shortest possible antenna lead and ensure that there are no kinks or tight radius bends in the cable. A kinked cable can cause signal loss.
- The signal emitted from any antenna submerged under water or deep snow will be significantly reduced and will normally not work; place the antenna in a location where it will not become submerged or buried.
- Always ensure that the latest firmware is installed in the device.

1.4 INSTALLATION PROCESS DECISION TREE



Cellular Network Signal Strength (as measured by CSQ Test)

0 -7	**Poor** (The device may be able to register with network but will not be able to send or receive data reliably).
7 - 14	**Acceptable** (Depending upon the ambient conditions data transmission may be possible. It is important to select the correct antenna and install it in the most suitable location).
14 - 21	**Adequate** (Data transmission should be reliable).
21+	**Ideal** (Strong signal strength ; data transmission will be reliable).

Antenna Options (note images show Intelligens device, but the same approach will work with all GSM devices)

2 ANTENNA TYPES & ACCESSORIES

Only use HWM-provided antenna for the logger, to ensure the radio interface meets approvals requirements (i.e., safety, type approvals, etc).

2.1 MAG-MOUNT ANTENNAS

Mag-mount antennas of various designs may be provided by HWM according to the suitability for use with the logger equipment.

Most mag-mount style antenna provided by HWM have the appearance of an upright pole attached to a magnetic base. The base can be used for mounting onto a ferrous surface. Where no ferrous surface is available, HWM may be able to provide a suitable bracket; contact your HWM representative for details. (see also section 2.9).

For most installations using the cellular communications network, the Mag-mount antenna will give the best performance.

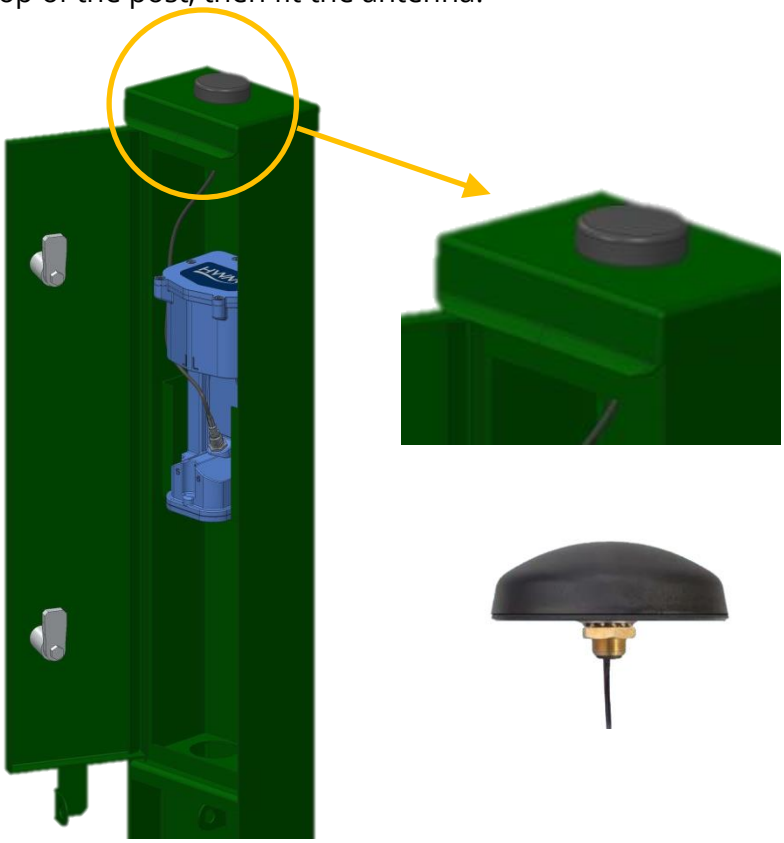
Installation Considerations

- For optimum performance the antenna requires a metal grounding plane. Consider installing a metal bracket made of a ferrous material to attach the magnetic base of the antenna.
- Install the antenna near to as close to the surface in large underground chambers, ensuring that the lid will not interfere with the antenna when being opened/closed.
- This antenna is vertically polarised. It should always be installed in the vertical orientation where possible.
- Never bend the radiating element of the antenna.
- The mag-mount can also be attached to an installation bracket mounted to an existing marker post

2.2 PUCK OR DOME

This antenna is designed to be fitted into the top of a cabinet or post.

First drill an appropriate hole in the top of the post, then fit the antenna.



Installation Considerations

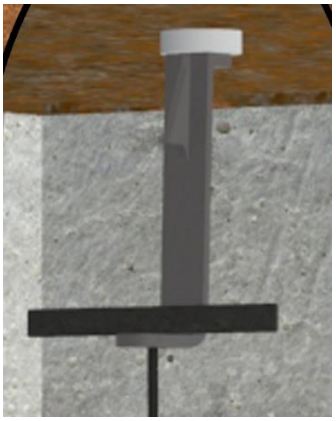
- Ensure the top of the post is clean and that the adhesive pad is firmly located to prevent water getting into the cabinet.

2.3 T-BAR

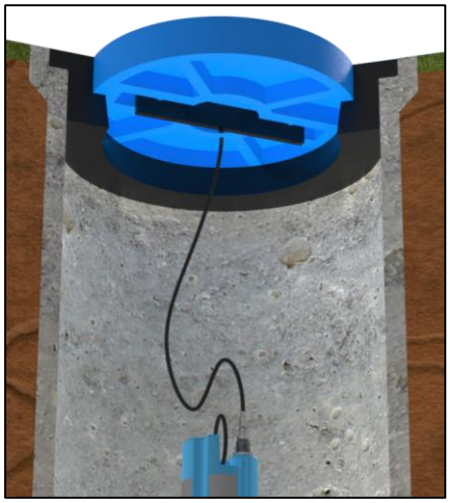
This antenna is suitable for installing above the device especially in locations with restricted space.

The antenna is of a di-pole type and is best positioned near the top of the chamber and surrounded by free space (no other objects). A narrow plastic bracket can be used to support the antenna.

Installations Considerations



- Mount the antenna at the top of the chamber, but spaced away from any metal lid.
- A bracket with magnetic mount is available to attach the antenna to a metal lid and also provide a gap; secure the antenna to the bracket using a tie-wrap.
- Avoid attaching the T-Bar directly to a metallic surface as this can adversely affect signal strength and performance, however it may be better than underground.

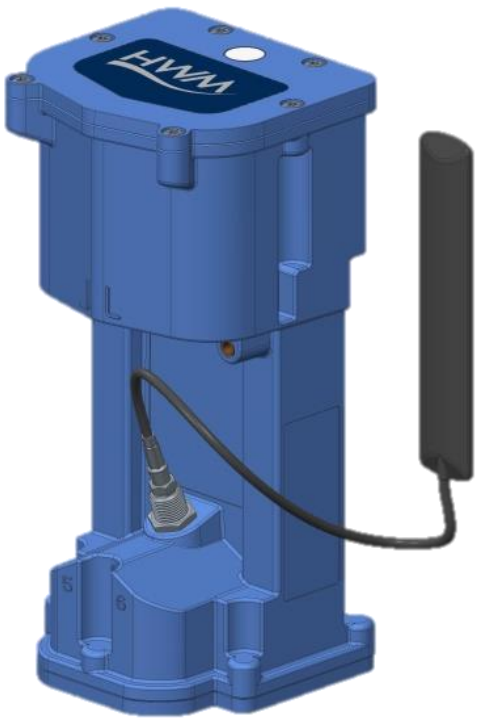


- Certain chamber lids can be replaced with a plastic version to which the T-Bar antenna can be mounted.
- Keep the antenna cable as short as possible (e.g., 0.5m), but allowing for installation and removal of the lid without damage or injury.

- The antenna can be adhered to external structures using marine quality adhesive (such as the brand 'Goop').

2.4 I-BAR

The physical construction of this antenna makes it ideal for attaching to structures external to subsurface chambers.



Installations Considerations

- Antenna can be attached to the side wall of a small chamber or to the top side of the chamber lid.
- The I-bar can also be incorporated into the design of a composite chamber lid.
- Avoid attaching the I-Bar to a metallic surface as this adversely affects signal performance
- Keep the antenna cable as short as possible, 0.5m.

- With the use of a longer cable version (or an extension cable where absolutely necessary) and a sealing compound (such as the brand 'Goop'), this antenna can also be fitted in the ground, on marker posts, or in cracks or brickwork near to the chamber.
- If the antenna is to be placed outside the chamber care must be taken to physically protect both the antenna and cable from damage. This can be done by burying the cable or installing a suitable conduit.

- Where the device is in the middle of a roadway, consider cutting into the top tar layer and burying the antenna in a hole under a skim of new tar.

- Always protect the antenna before encasing it in tar.

2.5 1/4 WAVE

This antenna is suitable for direct connection to the data logger where signal strength is reasonably strong, and space is a premium.

Installations Considerations

- The antenna is attached directly to the device but must always be positioned with the radiating element facing up (connector at the bottom). This may mean rotating the logger to accommodate this.
- Orientation of the battery needs to be considered if using this antenna (wrong orientation of internal battery may affect battery life).

2.6 MAGNETIC DIPOLE

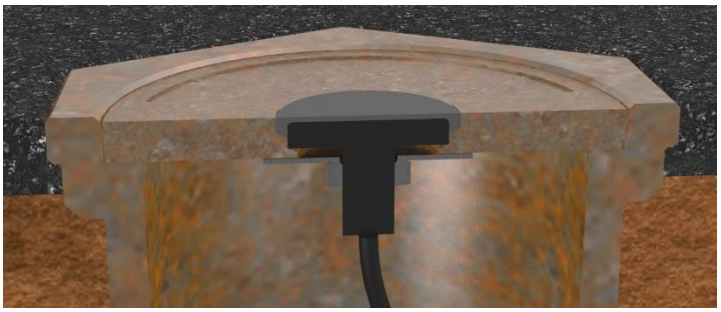
The magnetic mounting of this antenna makes it ideal for attaching to metal structures inside larger chambers.

Installations Considerations

- Antenna can be attached to the side wall of a chamber or to the underside side of the chamber lid.
- Best installation is with the antenna vertically polarised.

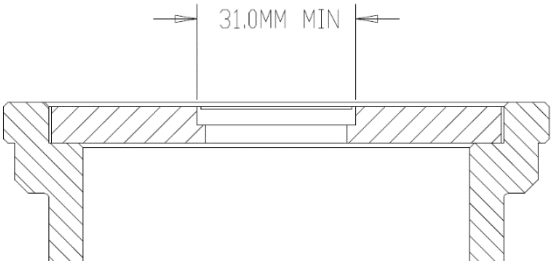
2.7 BUTTON

The button type of antenna is designed for mounting into chamber lids.



Installation Considerations

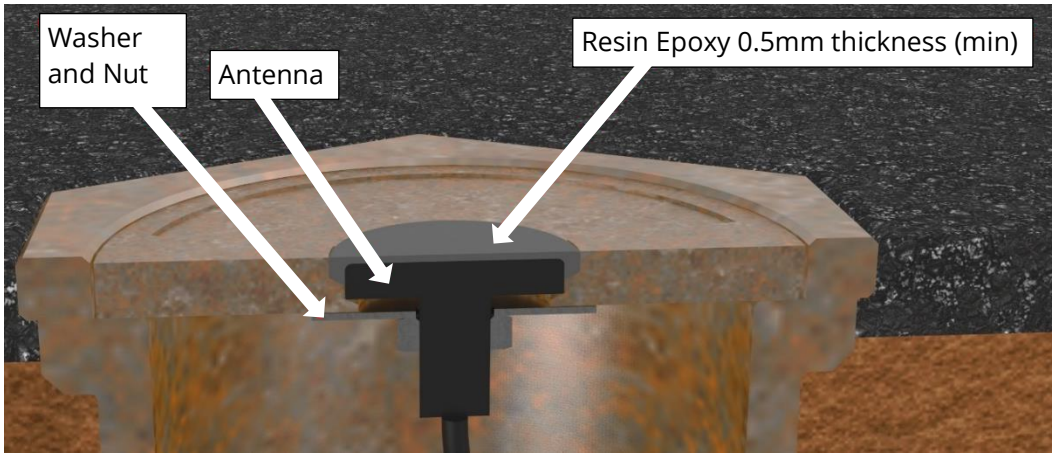
- The chamber lid is required to be drilled out to accommodate the body of the antenna.



Use a 31mm core drill to make a suitable countersink in the lid to fit the antenna.

(These are available from specialist tool suppliers).

- The top surface of the antenna needs to be a minimum of 0.5mm below the surface of the lid to prevent damage.
- Drill through the lid to make a path for the cable and connector to pass through.
- Drill partially into the lid using a wider drill to make a suitable countersink or recess that the body of the antenna can fit into. Check before drilling the recess that the size shown in the diagram still applies (the antenna supplied may be of a different size).
- Fasten the antenna using the nut supplied. A washer may be required.



- Once fitted, cover the top of the antenna with a resin epoxy such as “Marine Goop”. Ensure all surfaces are clean and dry before applying the adhesive. Follow the adhesive manufacturer’s instructions.
- Ensure the antenna cable does not become damaged (e.g., by the lid) during installation and use.

<u>Installation pictures:</u>

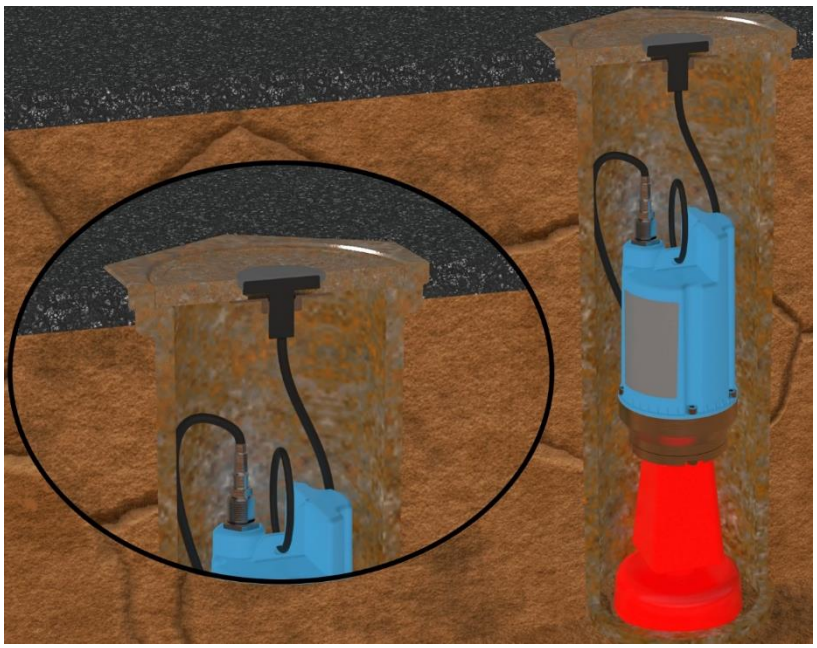
Drill hole in lid to provide a recess for the antenna body.

Thread antenna cable through hole, washer, and nut.

Secure antenna to the lid using the washer and nut.

Apply a resin epoxy such as Marine “Goop”, covering the antenna to protect it.

Illustration of an installed logger with a button antenna:



2.8 MAGPOT / HANGING CONE

These antenna types are designed for restricted spaces.

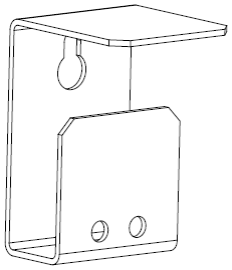
They are secured to a ferrous material, either directly or by means of a magnetic hanging accessory.

2.9 ANTENNA ACCESSORIES

HWM can supply a variety of accessory brackets for equipment, including those required for antenna mounting. Some examples are shown below.
Refer to your HWM sales representative for details on the currently available range.

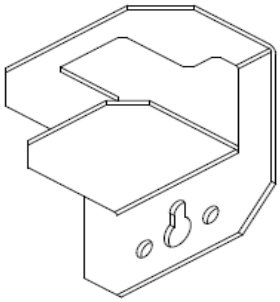
HDW8159

A mild steel bracket suitable for magnetic mount of certain mag-mount or dipole antenna to the top surface. There is a hook for cable management below.



HDW8650

A mild steel bracket suitable for a captive mount of certain magnetic-base mag-mount or dipole antenna. The base of the antenna is inserted into the slot, and the bracket is fixed to the wall, holding the antenna captive.



3 PERFORMING A SIGNAL (CSQ) CHECK

A signal check can be made using the appropriate tool for you logger.

The following tools are available:

- IDT (PC version) for Windows.
- IDT (mobile app version).
- Radwin for Windows.

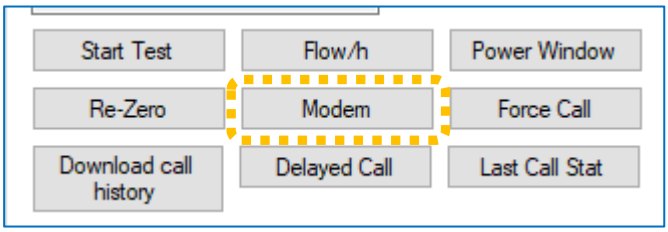
Ensure the antenna is connected to the antenna port of the logger.

The signal checks will depend on your logger's modem and network being used.
For 4G networks, refer to the IDT (PC version) user guide or the IDT (mobile app version) user guide for parameters to check; These are MAN-130-0017 and MAN-2000-0001 respectively.

The best location for the antenna can be found by comparing the CSQ value at various alternative locations. (CSQ applies to 2G and 3G networks only).

3.1 USING IDT (PC VERSION)

1. Launch the IDT
2. Click Read Device
3. Select the Hardware Tests tab
4. Click the <<Modem>> button to show the advanced diagnostics



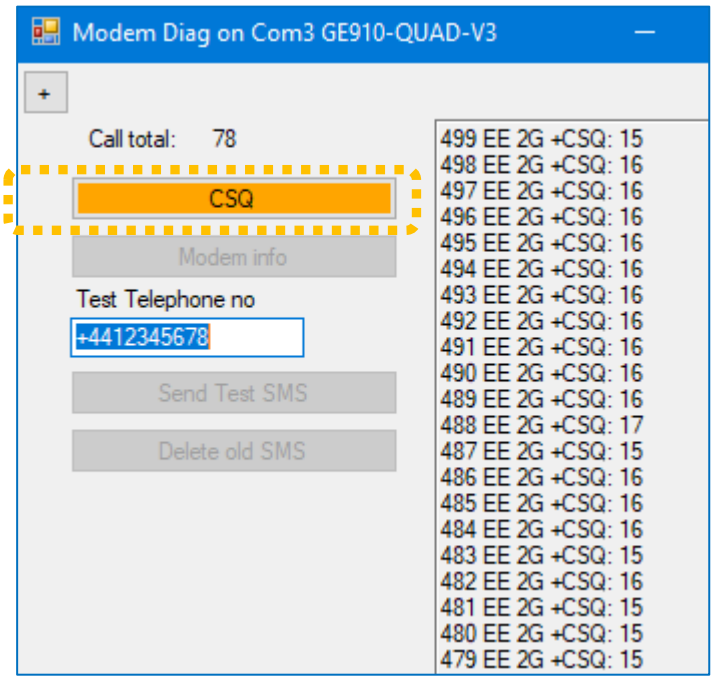
5. Click CSQ to start a signal check.

   The signal strength is shown by the CSQ result.

   (Refer to section 1.4 for interpretation of the CSQ number).

   CSQ values are in the range of 1 to 33; a higher number is better.

   Move the antenna to various alternative locations to find the most suitable position. Stand well back from the antenna whilst the measurement is being made to ensure you are not blocking the signal.



Initially, this test should be done with an open chamber. This is to verify that the connection to the mobile network works, and to determine what the local signal strength is.
Then, with the test still running, close the chamber (or nearly close it … due to the communications cable). The CSQ will drop due to the lid of the chamber reducing the strength of the received signal.

Re-position the antenna within the chamber to find the best signal strength (CSQ).
The antenna should finally be installed in the best signal-strength position.

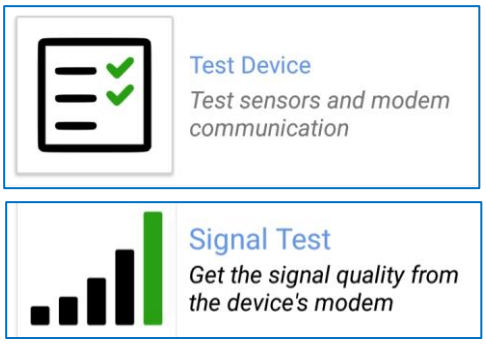
To stop the test, click the CSQ button once more.

3.2 USING IDT (MOBILE APP VERSION)

To access the logger test menu, tap on the "Test Device" line.

Access the "Test Device" menu and then tap on "Signal Test".

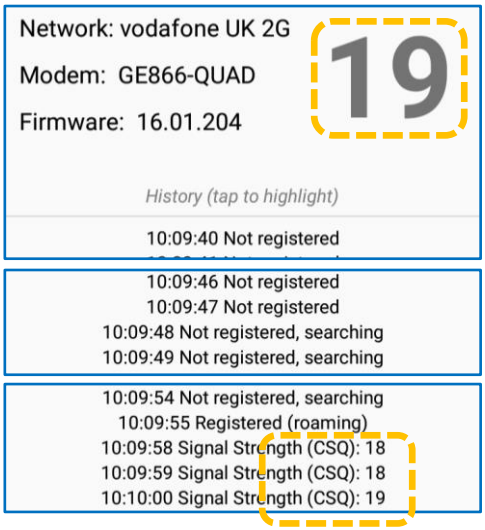
This test measures the **signal strength** (CSQ) of the received 2G / 3G mobile network signal.



Once connected to the mobile network, the provider details and signal strength indicator (CSQ) are displayed. The default is to show the average value of the last 10 readings, but it can be changed to show the latest value (by tapping on the number).

Initially, this test should be done with an open chamber. This is to verify that the connection to the mobile network works, and to determine what the local signal strength is.

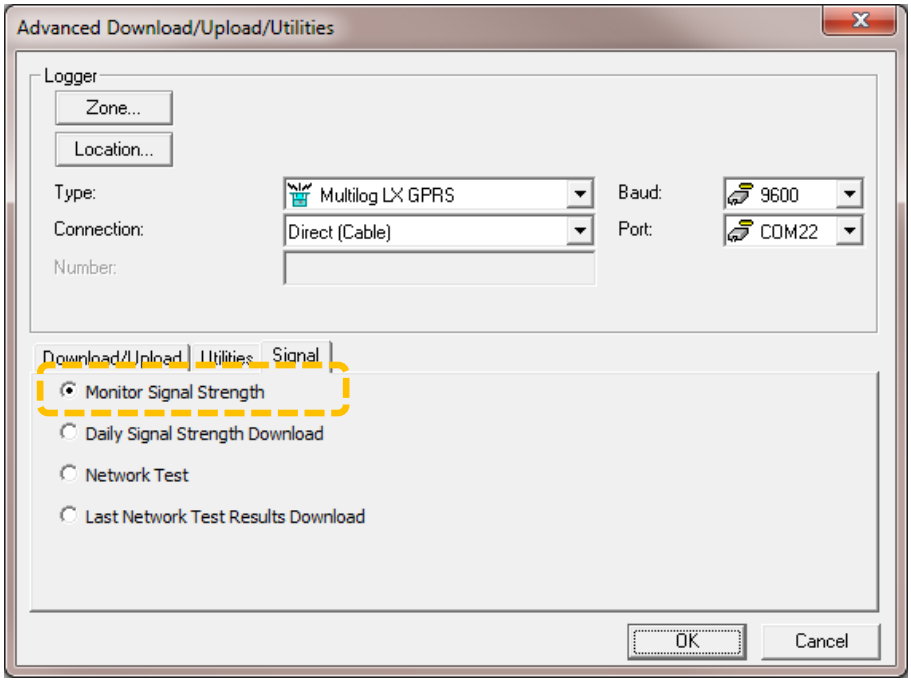
Then, with the test still running, close the chamber. The CSQ will drop due to the lid of the chamber reducing the strength of the received signal.
Re-position the antenna within the chamber to find the best signal strength (CSQ).
The antenna should finally be installed in the best signal-strength position.



End the modem test when finished.

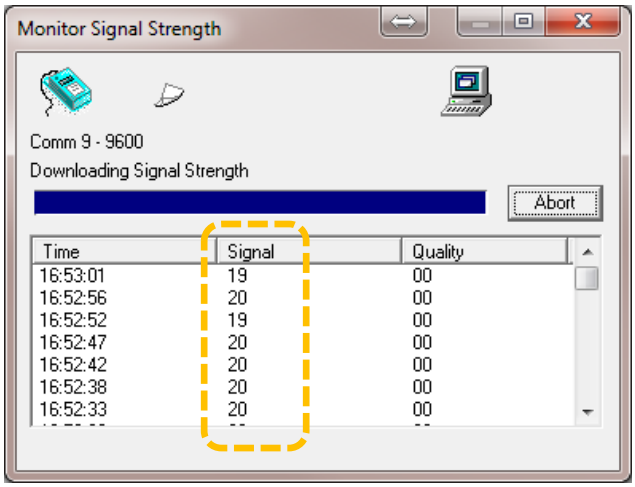
3.3 USING RADWIN FOR WINDOWS

1. Launch Radwin Manual Call
2. Select Options → Advanced Download/Upload/Utilities…
3. Select the Signal tab



4. With Monitor Signal strength selected, click OK

5. The signal strength is displayed in the Signal column; you can ignore the Quality column.



4 FINAL SITE COMMISSIONING CHECKS

Note: This section applies to loggers using the IDT (PC version) only.

Having made all the configuration and commissioning checks to the logger (checked all the wiring is good, verified the instantaneous values are what you need and confirmed communications with a GPRS test), there is one last check that you can make with your mobile phone to confirm everything is working as it should.

1. In the Hardware Diag tab, click the <<Power Window>> button to power up the device for 10 minutes.
2. Close the chamber or cabinet such that everything is in its final positions.
3. Now using a standard mobile phone, send a text message to the SMS number of the device including the international dialling code if needed.
   The text message should read **TTTT#**
4. After a few seconds/minutes (depending on the network operator) the device will send a message back to you with details of its current status.
   Example response from a device:
   TTTT138-002 V01.70CSQ:1010.9VyouridRT hh:mm ss dd-mm-yy ...
5. To decipher the message returned, please refer to the table below:

Message	**Description**
TTTT	Original command text without #
138-002	Device type number
V01.00	Firmware version in Device.
CSQ: nn	Signal strength nn (nn = 6 to 30)
10.9V	Operating voltage
yourid	Your Device ID
RT hh:mm ss dd-mm-yy	Real Time Clock setting
ST hh:mm ss dd-mm-yy	First Time the device was started
LR hh:mm ss dd-mm-yy	Last Time the device was re-started
Ch1 (A) 0029.0	Channel 1 29.0 units
Ch2 (A) 0002.2	Channel 2 2.2 pulses/sec

6. If the CSQ: value in the message is OK, then the installation is complete.
   The device will automatically go back to sleep after 10 minutes.

7. There can be delays in the SMS network, so the response to your message may not be immediate. If you have had no response in 10 minutes, re-open the chamber and using the modem diagnostic send yourself a test SMS. If this gets through, then improve the location of the antenna and try again.

Note: Some Roaming SIM cards do not accept incoming text messages.
Check with your service provider if you are unsure.

4.1 AUTOMATIC DEVICE TEST MESSAGE

Most modern HWM devices will send a delayed data message automatically to the data service (e.g., DataGate) a few minutes after the device is setup. This allows you to close the chamber prior to this call.
You can then check (if you have the required access to the DataGate system) that the message has been received.

The format of the message is an alarm type and will be similar to example below:

Datagate alarm from 09:37 00 290216 , _Site_ID, System, Test CSQ: **10** FW138, 0000.00"5F3234306D415757100B25091D021000008100"

As you can see, the signal strength (CSQ value) of the system test call is sent through with the message.

4.2 ADDITIONAL INFORMATION:

Cell Signal Strength
(Source: www.PowerfulSignal.com)

What do bars mean?
Bars on a cell phone usually are not an accurate measure of cell phone strength. They are like a fuel gauge, they give you an idea of what the signal is, not the actual strength. You can have two different brands of cell phones next to each other using the same carrier and they might show different bars. Some carriers have bragged they have more bars than anyone else. Once the carrier knows you have enough signal to make a call and talk, bars can be displayed anyway they want, and the caller does not know the difference.

What is the real cell signal strength?
Many cell phones, especially the newer smart phones, have the ability to display the cell signal dB reading. This is a much more accurate number than the bars. On most Android phones this signal reading can be found by pressing the menu button on the front of the cell phone, then selecting "Setting", scroll down the screen and select "About Phone", then select "Status", towards the bottom of the screen you can see the "Signal strength" display like in the image shown to the right. You will notice a number with a negative sign in front of it. This dBm number may periodically change while you view it.

To relate this to the HWM device CSQ, the formula is:

0	(-113) dBm or less
1	(-111) dBm
2..30	(-109) dBm..(-53)dBm / 2 dBm per step
31	(-51) dBm or greater
99	not known or not detectable

What does the dB number mean?
The dB number is a measurement in relation to a milliwatt. Usually, these kinds of numbers are measured with expensive RF meters so the accuracy might be off a bit with a cell phone, but it should be close enough.

The closer you are to your carrier's cell tower the closer to -40 this number gets. The farther away from your carrier's cell tower you get, the closer to -100 you get.

dB Signal - A basic guide

-50 to -60 (very strong, near a cell tower)	CSQ 31 to 27
-60 to -70 (extremely good, rare)	CSQ 26 to 22
-70 to -85 (normal downtown)	CSQ 21 to 14
-90 to -95 (getting on the weak side)	CSQ 13 to 10
-95 to -98 (weak, dropping calls)	CSQ 9 to 8
-98 to -100 (bad, hard to stay connected)	CSQ 7 to 6
-100+ (basically no usable signal)	CSQ 5 and below

When installing an HWM device below ground, always aim to keep the CSQ to 8 or above.

Why does cell signal fluctuate?
Signals from cell towers fluctuate up and down around 5dB. This fluctuation is caused by several different things. One of the main reasons for cell signal fluctuation is the load on the tower. The more people using the tower, the weaker the signal. You might notice the strength of your cell signal in a certain area change depending upon the time of day because of rush hour or lunch hour, etc.

Not only the number of callers, but smartphones and their ability to view and stream data can put considerable load on a tower. These types of activities cause a cell tower cell signal strength to constantly change. If your cell signal is -95 you can usually talk all day. If your -95 signal fluctuates down to -100 because of the load on the tower, you might drop the call for a moment, but be able to redial and resume in a couple of seconds.

When choosing call times for your devices, always try to avoid these peak call times and if you are deploying a fleet of devices, use the Random offset feature or spread the call times around.

Concrete, Metal, Low-E Glass and Shadowed areas
You can be near a cell tower, but still have a weak cell signal. Many building materials such as concrete, metal, and low-e glass reduce or block cell signal from entering into a building. Stucco with its wire mesh, metal roofs, large logs, and vapour barriers in attics also impede cell signals and cause weak cellular reception inside buildings

When you are outside, dense forest, bluffs, and hills do a good job of reducing or blocking cell signals, especially when the leaves are wet. Even low areas around lakes, rivers can have problems. A lot of times in low areas, there is a signal, but it is above you. A dry day vs wet day can make a difference with underground installs; wet leaves on trees and wet ground also impede signals.

Cities with their tall buildings have different types of problems. Sometimes the top floors of buildings, 40-50 stories up cannot get a good cell signal because towers are broadcasting at a lower elevation.

I can see my tower, but I have no signal.
Sometimes you can see your carrier's tower down the road or off in the distance, but you still have a bad cell signal. Just because you can see the tower does not mean that the tower is broadcasting in your direction. This type of issue is more common along remote highways where cell signal broadcast is concentrated up and down the highway and not too much to the side. Directional sector antennas are used on cell towers to direct the broadcast of signal in certain directions. Just because you can see the tower does not mean that it sees you. Also, are you really sure that it is your carrier's tower.

Frequency and technology limitations
Different frequencies can carry different distances. Carriers that use 800MHz frequency range can broadcast their signals more than twice the distance of Carriers that use 1900MHz frequencies. So why don't all the carriers use 800MHz. There are only so many licences available and when they are gone, other frequencies have to be used. 800MHz also has better penetration capabilities than 1900MHz, so cell signals in buildings may be stronger with 800MHz compared to 1900MHz. If you can find out which frequency your carrier uses in your area, you might be able to answer some of your reception issues.

HWM-Water Ltd.
Ty Coch House
Llantarnam Park Way
Cwmbran
NP44 3AW
United Kingdom
+44 (0)1633 489479
www.hwmglobal.com