

# **STARLOG**

## **Precision Water Level Instrument**

**Model 6541  
Model 6509**

**CE**

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# 1. INTRODUCTION

Water level measurements are fundamental to many studies of natural hydrology and are also widely used for projects to monitor, manage and utilise water resources.

There are many types of transducers used to measure waterlevel. Pressure, capacitive and acoustic instruments are widely used for depth and level measurement however these may require regular calibration and are subject to a range of systemic errors.

The most accurate type of instrument to use for long term water level monitoring can be a float-operated system. The new UNIDATA Model 6541 Precision Water Level Instrument has been designed with the range to monitor surface and underground waters and the resolution and precision to measure rainfall and evaporation.

The Precision Water Level Instrument is a digital instrument that uses a high resolution optical encoder to monitor the position of a shaft that is rotated by a float as the water surface rises or falls. The instrument displays the water level and produces a serial digital signal to suit any UNIDATA data logger. The data logger can record the basic waterlevel measurement and use this to compute and log other information such as the flow rate in open channels, or the rainfall or evaporation. The information can also operate sampling equipment and telemetry alarms and be used to control other processing equipment.

A well designed float system can produce data with an accuracy of  $\pm 2$  mm. This accuracy can be maintained for the service life of the instrument without calibration and with little maintenance apart from battery changes. This avoids the calibration and aging problems found with many other types of waterlevel instruments that rely on analogue measuring techniques.

## 2. FEATURES

The Model 6541 Instrument has been designed to be simple to install and use. At installation all adjustments are made by switches located inside the front cover. Each instrument has a LCD screen. This is set to display the water level reading and it is then automatically updated as the level changes. Instruments are powered by an internal pack of alkaline batteries with a service life of more than 12 months. A low battery warning flashes when there is less than 2 months of capacity remaining. The battery pack is the same as used by the UNIDATA STARLOGGER and can be changed without disturbing the transducer operation.

This single instrument can be used to monitor the water level at a range of different sites. The float pulley is changed to vary the units and resolution of the measurement. Typical applications include monitoring water level in:

- rivers, streams, canals, channels, sewers and drains for flow measurement,
- reservoirs and lakes for management and water supply,
- bores, piezometers, springs and soaks for aquifer studies and management,
- harbors and estuaries for tidal and coastal hydrology studies,
- rainfall captured in measuring tanks for long term precipitation data, and
- evaporation from measuring pans for automatic evaporation monitoring.

### **2.1. Models**

The Model 6541 Instrument can be supplied in a number of versions to suit different application. These are indicated by a three digit code appended to the instrument model number. For instance 6541-110 is the instrument with a 500mm pulley, alkaline battery and UNIDATA HSIO digital signal as output.

Config.	Model 6541-0 Model 6541-1 Model 6541-2 Model 6541-3 Model 6541-4	No pulley wheel 500mm circ. float pulley, metric, 1mm resolution. 1 foot circ. float pulley, Imperial, 0.01ft resolution. 100mm circ. float pulley, metric rain, 0.2mm res. 5 inch circ. float pulley, Imperial rain. 0.01inch res.
Battery	Model 6541-_0 Model 6541-_1	No battery UNIDATA Model 6901B Alkaline Battery Pack
Output	Model 6541-__0 Model 6541-__A Model 6541-__B Model 6541-__C	Standard UNIDATA HSIO Output Second UNIDATA HSIO Output 4–20mA Output Microwire Output

## **2.2. Output Options**

The standard signal output from the instrument is the UNIDATA HSIO serial signal to suit UNIDATA loggers. A number of optional circuit cards can be added to produce additional outputs. The original HSIO output may be used as well as one additional signal for each card added.

### ■ Second HSIO signal

This may be used if a second and independent UNIDATA logger is to be connected to the instrument. Full accuracy specifications are maintained for both instruments.

### ■ 0-20 or 4-20 mA signals

This card will produce an analog mA signal suitable to current loop instruments used for process control systems. The full instrument range is distributed over the output range. The accuracy and resolution of the resulting data will be related to the performance of the current loop.

### ■ Microwire signal

This card produces a serial digital signal to microwire protocol specifications. The instrument accuracy specifications are maintained with this digital signal.

## **2.3. Mounting And Installation Options**

There are a range of mounting options to help simplify your installation and to adapt the instrument for different applications.

## ■ Mounting Adapter Plates

These can be bolted to the base to allow the 6541 to mount on the same holes as the 6509.

## ■ Offset Pulley

These attach to the instrument mounting bracket to guide the float line to hang correctly inside the float well. They are not normally used as the added friction reduces the system sensitivity.

## **2.4. Float Systems**

UNIDATA can supply the float systems that are essential for accurate operation at your site. A range of float systems can be supplied. All float systems have potential errors and these are minimised by using the largest practical float. See section 8 for details of float systems.

Although the instrument is normally driven by its own float it can be coupled to another float operated instrument or a pressure sensing unit. UNIDATA can supply sprockets and plastic chain to link to other industry standard instruments. When driven from another instrument the 6541 accuracy will reflect the accuracy of this instrument.

## 3. UNIDATA DATA LOGGING SYSTEM

The Model 6541 Precision Water Level Instrument is designed to monitor water level as part of the STARLOG Data Logging System. When it is connected to a STARLOG Data Logger, the water level sensed by the instrument is logged and stored according to a program you define as a Scheme, using the STARLOG Software Package.

The STARLOG Software Package runs on a computer using DOS or Windows operating systems. Using the program, you generate a data logging program — called a Scheme — then load the Scheme into a Data Logger. For information on how to use this program see the STARLOG Users Manual (For Version 3, see manual #6245, for Version 2, see manual #6203.)

### 3.1. Creating a Scheme For Your Project

A Scheme has to be loaded into each UNIDATA logger. The scheme is unique to a site or project and tells the logger what instruments are connected and what, how and when to log data. The data produced are scaled to the transducer scaling information in the scheme and the output format is defined as reports within the scheme.

Follow the instructions in your software manual to prepare your scheme. As the 6541 is a new instrument you may have to add it to the Instrument data base in your software.

#### 3.1.1. Adding an Instrument to a Scheme

Use the Instruments window in the Scheme Editor to add the Precision Water Level Instrument to a Scheme. If this model instrument does not appear in your instrument list, you must add it by using the Instrument Editor and selecting Instrument and New. An easy way is to select a similar instrument (such as the 6509) then edit the transducer details and save the result as a new instrument.

From the list, select:

<b>6541-1</b>	<b>Water Level Instrument - Metric Pulley 500mm</b>
<b>6541-2</b>	<b>Water Level Instrument - Imperial Pulley 12"</b>
<b>6541-3</b>	<b>Water Level Instrument - Metric Pulley 100mm</b>
<b>6541-4</b>	<b>Water Level Instrument - Imperial Pulley 5"</b>



Transducer 1

Description: Water Level

Output:	Word	↕	Channel:	S0	↕
Min:	0				
Max:	65535				
Scale:	FullScale a to b	↕	Title:	Level	
a:	0		Units:	mm	
b:	6553.5		Using:	####.#	↕
Formula:		↕			

*Model 6541-3 Metric Water Level With 100mm Pulley*

Transducer 1

Description: Water Level

Output:	Word	↕	Channel:	S0	↕
Min:	0				
Max:	65535				
Scale:	FullScale a to b	↕	Title:	Level	
a:	0		Units:	inches	
b:	655.35		Using:	###.##	↕
Formula:		↕			

*Model 6541-4 Imperial Water Level With 5 Inch Pulley*

## **3.2. When To Log**

When you log data you save it in the memory of the Starlogger. This is the information that you permanently record for later use. You can select what data to log, and when to log it, so the time series of data that you capture will suit your project and application. This is often a compromise between the memory size of the logger, the data detail that you wish to record and the frequency at which you wish to unload and process the data.

The logger will regularly read the 6541 at the scan intervals you select. You have the option of time based logging (say each 15 minutes), event based logging (say each time the waterlevel changes 5mm) or a combination of time and events (say once each day and each time the level changes 10mm).

### ■ Time based Logging

The default method is time based logging and this is typically used for water level measurement. The log interval is selected to suit the site and project. For reservoirs and groundwater aquifers, changes may happen slowly and regularly logging the average water level each 1 hour may be adequate. In larger rivers logging each 15 minutes may be suitable. The water level in smaller streams and drains can change rapidly and you may need to log each 1 to 5 minutes to capture the maximum rates of change that can occur. For rainfall or evaporation you may require hourly or daily totals or you may wish to log detailed data from which you can derive maximum rainfall intensities needed for design studies. The memory use is consistent and the time and date when the memory will be full can be predicted accurately.

Three fields are used to detail the time element of the logged data.

The scan rate defines the frequency at which the logger wakes into operation and interrogates the instrument. This is typically 5 seconds however a shorter interval may be defined for better data definition, or a longer interval to conserve data logger battery power.

The log interval is the time interval between entries saved to the logger memory. The ideal log interval will capture adequate details for your project without wasting memory, or producing excessive data to be processed and managed. Natural water levels may change slowly for most of the time except during very intense rainfall when rapid changes may happen. For many projects you will want to record these extreme events and will need to select your log interval accordingly. Key in the log interval. It must equal an even number of scans. Logs will be aligned to logical real times, e.g. hourly data will log on the hour.

The sub-interval allows you to average data over a portion of the log interval. For example, if you have selected a log interval of 1 hour and you enter a sub-interval of 5 minutes, the data you log (if you select (ave)) will be the average of all scans in the last 5 minutes of the log interval.

## ■ Event Based Logging

You have the option of specifying an event-based scheme. Event-based logging can extend the memory endurance by only logging when a specified event has been detected. A simple example of an event is to log each time there is a defined level change (say >5mm).

Events are defined in the Event window as in the following example.

Each time an event is true the time, date and instrument value is logged. This uses additional memory and the memory use will be unpredictable, depending on the rate at which the events occur.

### 3.3. What To Log

You specify what data is logged by placing an X within the brackets of the log buffer window. The data from the last scan (raw), the average of some (ave) or all (AVE) scans or the maximum (MAX) or minimum (MIN) scan can be logged. For example with a time based scheme you may want to log the average value of all scans, and also the maximum during each log period.

Averaging data has the effect of smoothing out minor variations. It is a useful way of eliminating spikes due to waves or ripples. Logging an average over a long period, say 1 hour, may desensitize the data. Using the “sub interval” of say 1 minute would log the average of the last 1 minute of data in each hour.

Simply select as many log actions as required by placing an [X] in each required column on the line next to the transducer’s channel.

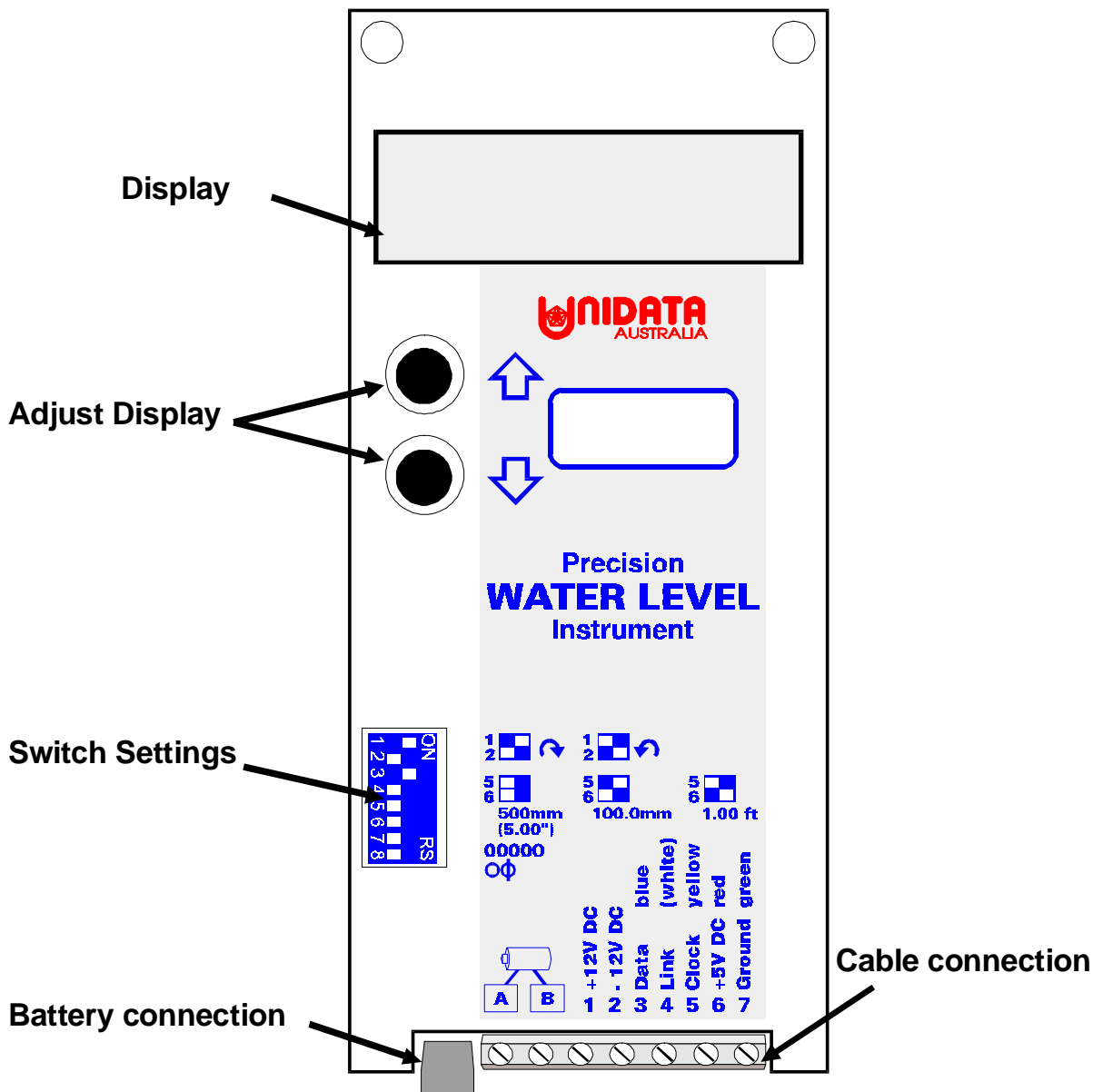
```
[ ]===== Log Buffer 1 =====4=[ ]
6004B - STARLOGGER Data Logger 128K + KB
Channel Xducer RAW MAX MIN T1 T2 T4 AVE SD ave
s0      Level  [ ] [X] [X] [-] [ ] [ ] [ ] [-] [ ]
```

Save the scheme you have created, using a name to suit the site or project.

You will also want to define how you want the data that you unload to be presented and saved. Use the report editor from the main menu. You can define a series of reports to show data plots and to save files for your processing and archive system.

## 4. PREPARING FOR INSTALLATION

This section describes the instrument options, then explains how to connect the instrument to a Data Logger and test the system. It is recommended that a new system be assembled and bench tested before installation at the site. Testing should include the logging and recovery of a period of data. This will allow an operator to confirm satisfactory operation of the entire system and to become familiar with the instruments and software.



## 4.1. Controls and Settings

All the controls you need to install and operate the 6541 are accessed by removing the front cover.

## 4.2. Details of Switch Settings

An 8-position DIL switch allows you to select or set the following:

- count either up or down
- measure in metric or imperial increments
- switch the internal battery on/off
- reset the instrument

Switches		Function
On	Off	
1	2	Display counts down with clockwise rotation of wheel
2	1	Display counts up with clockwise rotation of wheel
	3	Reserved
	4	Reserved
	5,6	Counts in metric (1mm increments) 500mm pulley Counts in points ( $1/100$ inch increments) 5 inch pulley
5	6	Counts in metric (0.2mm increments) 100mm pulley
6	5	Counts in imperial ( $1/100$ foot increments) 12 inch pulley
7		Switch on to reset display to zero
	7	Normal
	8	Switch Internal Battery Off
8		Internal Battery On

The factory default switch settings are:

- *Display counts up*
- *Counts in (1mm) metric increments*
- *Operates normally*
- *Internal battery is Off*

### **4.3. Connecting a Battery Pack**

Plug in one model 6901B STARLOGGER Battery pack to either of the sockets. The second socket is used when the battery is changed. The new pack is connected to the free socket, then the old pack removed. The instrument will continue to operate normally, as the power supply is not disturbed.

### **4.4. Connecting to the Data Logger**

Removing the front cover reveals a termination block to which the cable to the data logger is connected. This cable exits through the gland in the side of the instrument. External power may be connected to the designated terminals.

<b>Precision Water Level Instrument</b>		<b>STARLOGGER &amp; PDL</b>		<b>Macro Data Logger</b>	
<b>Wire Color</b>	<b>Function</b>	<b>Pin #</b>	<b>Term. #</b>	<b>Pin #</b>	<b>Term. #</b>
red	+5.00V DC (terminal 6)	13	<b>15, 16 or 17</b>	18	14 or 49 <sup>1</sup>
green	common (terminal 7)	23	<b>14</b>	28	13
blue	DATA IN (s0) (terminal 3)	21	<b>11</b>	32	11
white	Serial LINK* (terminal 4)				
yellow	Serial CLOCK (terminal 5)	9	<b>12</b>	14	12

#### **Notes:**

- » Pin # refers to the pins of the INPUT SIGNALS connector on a Logger
- » Term # refers to numbered screw terminals on a Field Termination Strip. This is the connection method you are most likely to use.
- » Serial Link is only used to interlink several instruments.
- » <sup>1</sup> This is the Scan Synchronised +5V regulated power source.

Refer to the supplement included with your Logger or Field Termination Strip for more information about these connections.



## **4.6. Bench Testing the Instrument System.**

---

If practical, assemble the equipment in the housings and on the mounting you will be using at the field site. This will ensure you have everything you will need, and that it will fit together and work as a system. When you have connected the instrument to the logger and selected the right settings, you load the scheme into the logger. Connect your PC to the logger and select the scheme you have prepared. Select “Program Logger with Scheme”, then “Scheme Test Mode”. The screen display should show the correct scheme details and the same value as displayed on the instrument LCD. When you change the LCD displayed level by rotating the float pulley wheel, the PC screen display should update each scan and display the correct value.

If you have a suitable test facility set up a temporary float system on a water surface and install your instrument system. If possible adjust you water surface to slowly rise and/or fall and log the data. Note check readings of the water surface and the LCD and PC test screen displays. After a period of data has been logged unload the data and review it using the scheme report. Ensure the data you require is being logged and that the system is operating accurately. Fix any problems. When all is OK pack the instrument system and all accessories for transport to your measuring site.

## 5. ON-SITE INSTALLATION

Installation of the instrument at your measuring location is a simple process if the system has already been prepared and bench tested.

1. Install the instrument in the position where it will be operated. Attach it firmly to a stable mounting bracket that will not move in relation to the water surface. The instrument position is normally at the top of the floatwell and at a level above the highest possible water level.
2. Install the float system. A float system consists of a float, with a floatline and counterweight. This system has to be installed so it turns the float pulley while the float moves through the complete range of waterlevel measurements required. The following technique is one way this can be done.
3. Select a float line of sufficient length. Handle it carefully as any kinks, particularly in beaded float line may cause failures.
4. Attach the counterweight using the swages supplied to crimp a secure loop through the counterweight eye.
5. Lower the counterweight into the well until it touches the well bottom or is below the minimum level to be measured.
6. Pass the float line over the float pulley of the instrument and back below the instrument bracket, and is above the maximum level to be measured.
7. Cut the float line to this length and form a loop through the float eye.
8. Lower the float, rest it on the water surface and let it float free.
9. Position the floatline in the groove of the float pulley. If beaded cable is used turn the pulley to engage the index beads into the holes in the float pulley groove.

## **5.1. Set the Instrument Waterlevel**

Remove the front cover of the instrument. Switch on the battery switch. Use the buttons to set the LCD display to read the approximate water level value. Turn the float pulley to simulate an increase in waterlevel. Confirm that the LCD increases. If it changes in the wrong direction change the position of switches 1 and 2. Use the buttons and adjust the display to the exact value.

The waterlevel that you set should be referenced to a site datum. This datum should originate from a fixed point that will not change during the period of the measuring project.

The value displayed should be set high enough so that changes in the water level do not cause it to fall below zero. If the pulley shaft is rotated back past the zero (00000) reading, the display and the data logger will wrap around to 65535.

For instance, if measuring a bore with a water level 20 metres down, set the display to 20 metres (20000). When the water level rises, the reading will change to 19999. When the water level falls, the reading will change to 20001.

## **5.2. Mounting and Cabling**

The Water Level Instrument may be installed on a shelf or bracket suitably positioned over a bore or stilling well.

It is connected to a Logger via a 4-wire cable less than 5 metres long (see note in connection details for cable lengths up to 10 metres). The cable is fed into the instrument through a cable gland in the base.

The water level instrument should be protected from direct weather by a shelter. It is not waterproof.

## 6. Flow Measuring Sites

To measure the flow in open channels it is a standard practice to measure the water level and convert this into a flow rate using a stage / flow relationship derived either from theory or actual measurements. This relationship can be entered into UNIDATA loggers as a formulae or look up table. The flow rate can then be logged instead, or as well as, water level. The accuracy of this practice depends on how well the relationship can be defined, and how stable this is. The selection of a suitable site and measuring structure is essential.

The location and design of measuring sites are covered in many standard texts on hydrology, fluid mechanics and water resources monitoring.

In small channels it is common practice to construct a small weir, flume or other measuring structure at a suitable location where all flow passes through. There are many different types of measuring structures. The relationship between the upstream water level and flow has typically been determined by laboratory experiments. Theoretically by monitoring water level you can produce flow data. It is important to understand the accuracy and limitations of different structures. Poor data may result from an unsuitable site or structure design.

In larger channels measuring weirs may be constructed that combine some form of calibrated structure for small flows and a natural channel for larger flows. Measurements of flow at different levels are normally required to define the level / flow relationship.

### **6.1. Floatwell Design for Measuring Waterlevel in channels**

A floatwell, or stilling well is required at any site where a 6541 transducer is to be used. At many sites floatwells are simple devices that can be constructed from lightweight materials such as PVC pipe. On larger rivers constructing new float wells can be uneconomic and alternative instruments such as UNIDATA Pressure transducers should be used.

The water surface in a natural channel frequently surges and swirls with the velocity and is disturbed by waves and ripples. These cause the float to move and bounce around and this affects the accuracy of the logged waterlevel. A floatwell creates a still water surface that moves with the major changes of the waterlevel, but not the minor ones.

A floatwell typically consists of a vertical pipe or cylinder of sufficient diameter for the float system used and robust enough not to change dimensions during the life of the site. This is fixed to foundations, piers or other structures so it can

not move. The base should be lower than the minimum level to be measured, and the top above the maximum possible water level. The well is closed at the bottom and open at the top.

Near the well bottom it is connected to the stream by two inlet pipe or some holes. These inlets should maintain the inside water level at the same as the outside. The cross section area of the inlets should be about 1% of the well cross section. This provides adequate damping of wave action without causing the well level to lag behind rapid natural water level changes.

Water velocity past the orifices of the inlets can affect the waterlevel inside the floatwell. The well should be located to avoid high velocities. If this is not feasible static tubes can be attached to inlet pipes. Inlet holes in the well should be parallel with the flow.

The waterlevel instrument is normally mounted on or over the float well. The float rests on the water surface and the floatline passes over the float pulley on the 6541. A counterweight is fitted to the end of the floatline to maintain tension. The floatline length should be sufficient to measure the full range required, without catching on any obstacles. Offset pulleys may be used to divert the floatline to better locations.

Data accuracy and reliability will be improved if:

- there is a stable mounting for the instrument. Movement of the 6541 will appear as a waterlevel change
- the instrument should be protected and kept dry, clean and secure,
- the cable to the data logger should be protected from damage.

It is a good practice to have a site check device from which the correct water level can be read. This reading should agree with the transducer. Any discrepancy should be investigated.

## **6.2. Measuring Rainfall**

Float instruments producing graphical charts were historically used for rainfall measurement. During the last 30 years these were superceded by tipping bucket rain gauges that produced high resolution digital data. These instruments also introduced calibration drifts and reliability uncertainties not experienced with float instruments.

The Model 6541 instrument has the precision to measure rainfall. Fitted with a 100mm circumference pulley will measure water level to a resolution of 0.2mm. An imperial version fitted with a 5" circumference pulley will measure in points (1/100"). These instruments can be used as a simple pluviograph to produce accurate and reliable rainfall data.

The rainfall funnel is connected to a tank of the same diameter. A float on the water surface is connected to the instrument. Rainfall accumulates in the tank and evaporation is prevented by a layer of light oil on the water surface.

The tank storage capacity should be sufficient not to be exceeded between visits by servicing staff. A sight tube allows the total rainfall to be read and a drain valve is used to reset the tank water level for another period of data.

An option can be provided to automatically drain the water from the tank whenever it reaches a preset level.

### **6.3. Measuring Pan Evaporation**

Pan evaporation is frequently measured as the total daily change in the water level in a measuring pan. This is usually manual observation done at the same time each day. Associated readings of rainfall, water temperature and wind run are usually taken.

UNIDATA Model 6529 has been produced to monitor the water level and temperature in a USGS Class A evaporation pan. The Model 6541 with a larger float well is now used to produce more accurate data.

### **6.4. Float System Disasters**

All float systems are subject to a range of minor errors due to variations in the float immersion level as the net weight of floatline acting on the float, changes. These are discussed in the following section.

Major errors can occur at sites such as reservoirs and bores where large variations in waterlevel can occur. When the float movement exceeds 20 metres special components or design may be required.

The endless floatline is an alternative type of float system that eliminates the transfer of weight from one side of the float to the other, and the errors so induced. It also solves the problem of potential line "run away".

### **6.5. Float Error Corrections**

The errors involved in the recordings made by a properly designed float operated level recorder are generally too small to be of great importance. However, the user should be aware of potential sources of error and means of compensating for these. These errors can become significant at sites where a large measuring range is proposed.

**Causes of Error** - The main causes of error in float line level measurement are:

- Float Line Shift
- Submergence of Counterweight
- Instrument Lag
- Temperature

Other minor causes relate to humidity and water saturation of wooden supporting structures and the expansion of such structures resulting from changes in temperature and water content.

### **6.5.1. Float Line Shift**

With every change in level, a portion of the float line passes from one side of the float pulley to the other side. This change of line weight (from one side of the pulley to the other) changes the depth of flotation of the float (and hence causes an error in the registered level).

The magnitude of this error varies with the amount of line shifted. (i.e. the amount the level has changed since the recorder was set to a known reference) and also varies with the weight of the line.

Weights of various float line are:

125mm beaded float line	= 6.0 grams/metre
0.4mm float line	= 1.2 grams/metre

For levels rising above a given reference (starting point) this error will make the level measure slightly high, for levels falling below the reference point the error makes the level appear low.

The amount of error may be calculated using formula (1) below. The error is inversely proportional to the square of the float diameter, therefore the larger the float, the smaller the error.

The error is slightly different for a float line submerged in water (as in the case of a counterweight being below the float). Formula (2) should be used for submerged float line shift corrections.

### **6.5.2. Submergence of Counterweight**

When the counterweight (and any portion of the float line) becomes submerged, the pull on the float is reduced and its depth of flotation is reduced.

In this case the level will measure slightly lower than it actually is. The amount of this error may be calculated from formula (3).

### 6.5.3. Instrument Lag

A certain amount of force is required to move the shaft mechanism of the level measuring instrument and also to bend the float line over the float pulley. This force must be supplied by the pressure of the water on the float.

This error (caused by friction in the measuring apparatus) is not cumulative and is usually not very large. Formula (4) details the error caused by instrument lag.

### 6.5.4. Temperature

Changes in temperature will cause the float line to expand and contract. The amount of expansion (contraction) is usually small and is often compensated by the simultaneous expansion (contraction) of the level instrument supporting structures. The floatline length change can be calculated from formula (5) using the following factors.

### 6.5.5. Coefficients of Expansion:-

Float Line	Coefficient	X Factor
1.2mm SS Beaded Cable	0.0000009	0.0009mm/°C/metre
0.4mm Stainless Steel	0.0000009	0.0009mm/°C/metre
Supporting concrete	0.0000065	0.0065mm/°C/metre

Therefore the error expected from a 10° change in ambient temperature in 10 metres of cable will be 0.9mm (The float line expands/contracts by 0.009mm/°C/metre).

### 6.5.6. Correction Formulae

Formula 1	$E = 2560 * (W/D^2) * S$
Formula 2	$E = 2350 * (W/D^2) * S$
Formula 3	$E = 117 * (C/D^2)$
Formula 4	$E = 2560 * (F/D^2)$
Formula 5	$E = X * T * L$

where:

E = measurement error in millimetres (mm)

W = weight of float line in grams/metre (gms/m)  
(6.0 for beaded cable, 1.2 for 0.4mm cable)

- D = diameter of float in millimetres (mm)  
( $D^2$  means diameter squared)
- C = weight of lead counterweight in grams (gms)
- F = frictional force within the instrument in grams  
( $F = 1.0$  for Model 6541A Water Level Instrument.)
- T = ambient temperature change in degrees centigrade
- S = shift of line level in metres (m)
- L = length of line between instrument and float (m)
- X = Coefficient of expansion (X Factor)

### 6.5.7. Example

A water level instrument has a 85 mm diameter float and a beaded stainless steel cable with a 160 gram counterweight (always above the float). What errors would occur if the level rose by 2 metres. (In this case we will ignore temperature changes as there is no information about the supporting structures).

From formula (1), the error in measurement would be 4.2mm too high. The error due to Instrument Lag (formula (4)) is 0.3mm and the total error 4.6mm. As the counterweight goes underwater a 2.6mm error occurs.

### 6.5.8. Reducing Errors

The following hints will assist in reducing errors in float operated level measurement systems.

- a) use lightweight float line (reduces line shift)
- b) use the largest diameter float possible (reduces all errors)
- c) have counterweight always above or always below the float (eliminates counterweight submergence errors).
- d) mount level measurement instrument as close to the level being measured as possible (reduces temperature errors).
- e) use a computer to apply automatic correction for all errors from a known reference level.

## 7. SPECIFICATIONS

### ■ Model 6541 Instrument

- Range: Standard 0 to 65535mm.  
Switch to 6553.5 mm, 655.35 feet or 655.35 inches to suit the float pulley used.
- Resolution: 1.0mm or 0.2mm, 0.01 foot or .01 inch, depending on the range selected.
- Accuracy:  $\pm 1$  resolution increments, with suitable float system.
- Tracking: Up to 1 shaft revolution / second.  
(500mm / second for standard unit).
- Output: High speed serial signal UNIDATA HSIO standard.  
Options for Microwire, 4-20 mA and dual HSIO channels  
Up to 8 instruments can be daisy chained.
- Cable: 5 metre long cable supplied.  
Up to 30 metres may be used.
- Power: Internal Alkaline battery pack.  
Expected life exceeding 12 months.  
Exchange battery pack UNIDATA Model 6910A.  
External battery power 9-15 V DC can be connected.
- Display: 6-digit LCD with low battery indicator.
- Construction: Exterior PVC, Aluminium and stainless steel.
- Housing: Sealed PVC enclosure. IP65.
- Temperature: -40 C to +60°C.
- Humidity: 0-100%, non-condensing.
- Size: Width 180mm, height 275mm and depth 140mm
- Weight: 2.7 kg, including battery.

## 8. FLOAT SYSTEMS

UNIDATA manufactures a range of float systems and accessories to suit the requirements of various customers. These products are available as options for the new 6541 Precision Water level Instrument. Each float is supplied with floatline swages and a 160g lead counterweight that has been epoxy painted.

### 8.1. Float lines

A range of special stainless steel float lines are available to suit different applications.

Model 6541D/U:	1mm SS floatline without beads.
Model 6541D/M:	(Previously model 6509D). 1mm SS metric floatline with brass beads each 125mm.
Model 6541D/I:	1mm SS imperial floatline with brass beads each 3 inches.
Model 6541E:	(Previously model 6509E) 0.4mm diameter lightweight and flexible floatline for use in boreholes and with small diameter float pulleys.

### 8.2. Floats

#### ■ Model 6541F-200 (Previously 6509M)

This is the largest float in the range. It is used to provide high accuracy data at sites measuring a large water level range. It is also recommended for use with other instruments with high mechanical friction or inertia. The float well size recommended is at least 250 mm diameter.

Dimensions:	Sphere of 200mm diameter. Maximum diameter of 220mm.
Material:	Molded black thermoplastic. Stainless steel fitting for floatline. Ballasted to float upright and on the centreline with a 160g counterweight.
Weight:	2300 gms.

#### ■ Model 6541F-170

This float is designed to produce high precision data at most sites with 6541 Instruments. It is constructed of PVC and may be used in floatwells with a minimum diameter of 200mm. The float has a cylindrical shape with a flat bottom for maximum sensitivity. It is suited for use at intermittently dry wells where the float may rest on the bottom.

Dimensions: Cylinder 170mm diameter and 85mm high.  
Materials: PVC pipe and fittings.  
Stainless Steel eye bolt for float line.  
Ballasted to float at the centreline when used with a 160g counterweight.  
Weight: 1100 gms.

■ Model 6541F-115

This float is suitable for sites with 6541 Instruments where the water level range is small, or a lightweight floatline is used. This float is designed for use in a floatwell with a minimum diameter of 150mm. The float has a cylindrical shape with a flat bottom for maximum sensitivity. It is suited for intermittently dry wells where the float may rest on the bottom.

Dimensions: Cylinder 115mm diameter and 60mm high.  
Materials: PVC pipe and fittings.  
Stainless Steel eye bolt for float line.  
Ballasted to float at the centreline when installed with a 160g counterweight.  
Weight: 500 gms.

■ Model 6541F-90 (Previously 6509F)

This float is suitable for sites with a small water level range or where a lightweight floatline is used. The float is designed for use in a floatwell with a minimum diameter of 125mm, or 100mm if a separate counterweight tube is used. The float has an ovoid shape and is weighted to float on the centreline.

Dimensions: Ovoid float 88mm diameter, 130mm long.  
Maximum diameter is 92mm at the join.  
Materials: Molded black thermoplastic.  
Stainless steel fitting for float line.  
Weighted to float at the centreline when installed with a 160g counterweight.  
Weight: 430 gms

■ Model 6541F-50 (Previously part of 6509C)

This float is a long cylinder intended for use in small bores and float wells. Smaller diameter versions of this float can be supplied at special request. Careful site design and installation is required to avoid significant float system errors when small diameter floats are used. Small floats should only be used

with lightweight float line and systems designed for minimum float line friction and weight transfer.

Dimensions: Cylinder 50mm diameter and 135mm long.

Maximum diameter is 60mm at end caps.

Materials: PVC Pipe and fittings.

Stainless Steel suspension fitting for float line.

Weighted to float upright and at a suitable depth when fitted with a 160g counterweight.

Weight: 250 gms

### **8.3. Float Pulleys**

Pulley 500mm circumference      Metric      Model 6541P/M500

Use with 1mm cable with optional beads each 125mm.

Pulley 12" circumference      Imperial      Model 6541P/I12

Use with 1mm cable with optional beads each 3 inches.

Pulley 100mm circumference      Metric      Model 6541P/M100

Use with 0.4mm cable.

Pulley 5 inch circumference,      Imperial      Model 6541P/M500

Use with 0.4mm cable.

Mounting mechanism to suit pulleys with 0.5" (12.7mm) bore, as supplied by other manufacturers. Model 6541U

### **8.4. Float System Accessories.**

Counterweight for float system. 160 gram lead weight, epoxy painted to seal the surface. Model 6541C

#### ■ Offset Pulley Option

Guide pulley to divert the float line to suit small float wells. Model 6541O

#### ■ Sprockets to Connect 6541 to other instruments

A system of nylon sprockets and plastic chain may be used to connect the 6541 instrument to existing mechanical instruments. Contact your UNIDATA support office for information.

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# Appendix A

## PREVIOUS WATER LEVEL INSTRUMENTS

Water Level Instruments with Serial Numbers 889 and below are designed differently. In some of these instruments, there is a toggle switch on the circuit board which is used to zero the instrument.

### **Zeroing the Instrument**

To RESET the Water Level Instrument, remove the main cover, switch off the battery pack via the toggle switch adjacent to the 7 pin terminals, wait one minute, switch on and replace the cover. The display and Data Logger reading should now both read zero.

## 9. MODEL 6509 INSTALLATION

There are a few options selectable by switch inside the instrument housing. This section describes these options, then explains how to connect the instrument to a Data Logger and lastly, states how to install the instrument on-site.

### 9.1. Internal Switch

An 8-position DIL switch (fitted to instruments from and including serial number 890) allows you to set the following:

- count either up or down
- measure in metric or imperial increments
- switch the internal battery on/off
- reset the instrument

Switches		Function
On	Off	
1 & 2	3 & 4	Display counts down with clockwise rotation of wheel
3 & 4	1 & 2	Display counts up with clockwise rotation of wheel
5	6	Counts in metric (1mm increments 500 counts per 0.5 metre wheel revolution)
6	5	Counts in imperial ( $\frac{1}{100}$ inch increments 100 counts per 12 inch revolution)
7		Reset
	7	Normal
8		Internal Battery On
	8	Internal Battery Off

The default switch settings are:

- Display counts up.
- Counts in (1mm) metric increments.
- Operates normally.
- Internal battery is On.

## 9.2. Connections

Removing the main cover reveals a termination block (partially concealed by the battery pack). The battery pack must be removed to allow access to the termination block on the Water Level Instrument's circuit board.

**WARNING !!!** *The battery wires must not be allowed to short together. This is critical for the Lithium Battery which will be permanently destroyed by even a brief short circuit.*

### 9.2.1. Battery Pack Connections

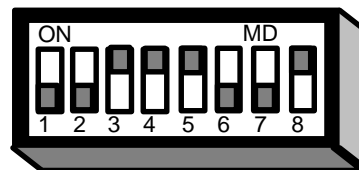
Battery +ve	Red wire	Terminal 1
Battery -ve	Green wire	Terminal 2

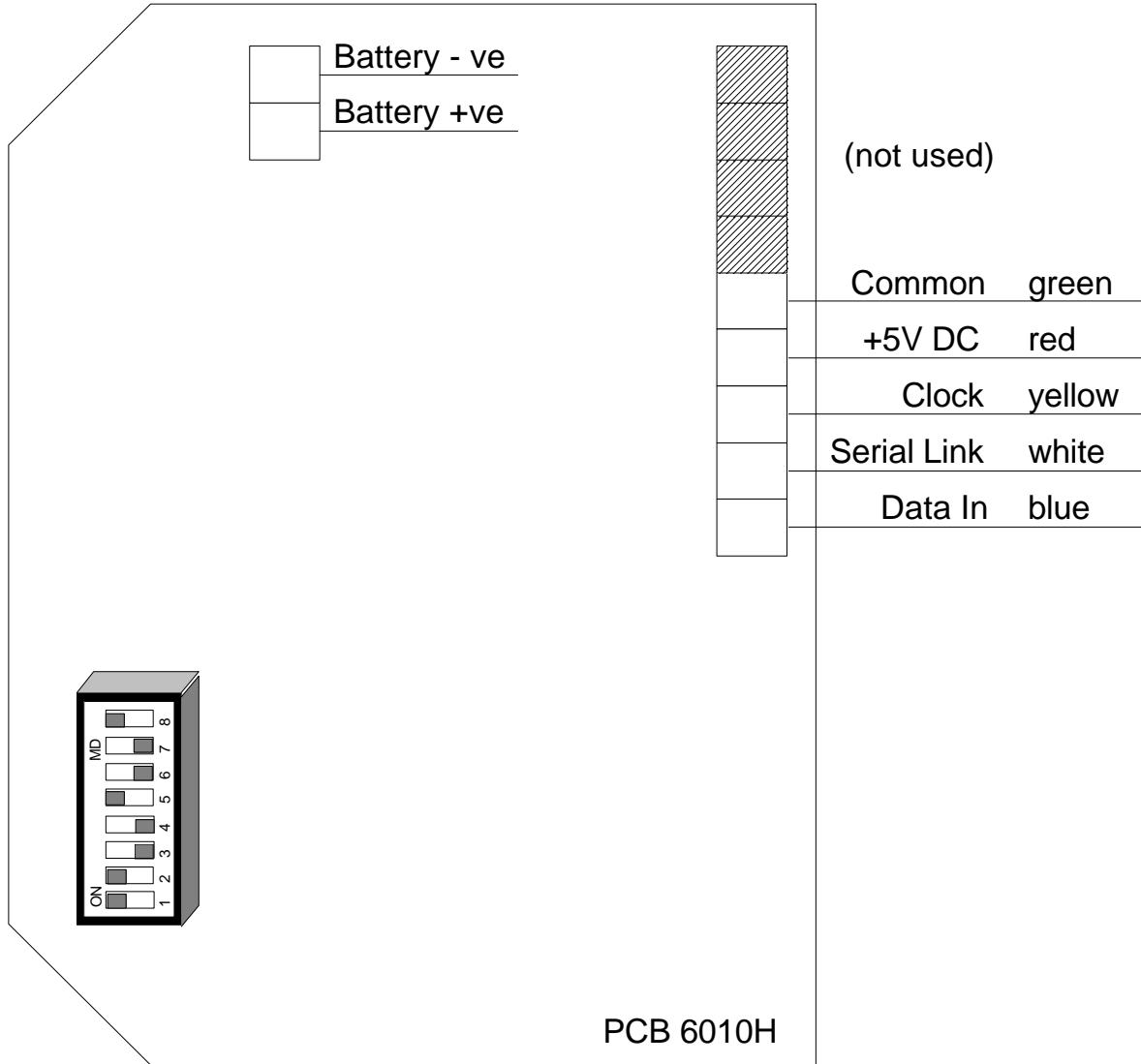
### 9.2.2. Connections: Model 6509 (4-core cable)

Shaft Encoder Water Level Instrument		STARLOGGER & PDL		Macro Data Logger	
Wire Color	Function	Pin #	Term. #	Pin #	Term. #
red	+5.00V DC (terminal 6)	13	<b>15, 16 or 17</b>	18	14 or 49 <sup>1</sup>
green	common (terminal 7)	23	<b>14</b>	28	13
blue	DATA IN (s0) (terminal 3)	21	<b>11</b>	32	11
white	Serial LINK* (terminal 4)				
yellow	Serial CLOCK (terminal 5)	9	<b>12</b>	14	12

#### Notes:

- » Pin # refers to the pins of the INPUT SIGNALS connector on a Logger
- » Term # refers to numbered screw terminals on a Field Termination Strip. This is the connection method you are most likely to use.





*Water Level Instrument Circuit Board 6010H*

- » Prior to Water Level Instrument serial number 345 the blue and yellow wires were transposed.
- » Serial Link is used to interlink several instruments.
- » <sup>1</sup> This is the Scan Synchronised +5V regulated power source.
- » **Model 6003A Portable Data Loggers:** For cable lengths from 5 to 30 metres, connect a 1k $\Omega$  resistor between pins 9 and 13 at the Data Logger connector.

Refer to the supplement included with your Logger or Field Termination Strip for more information about these connections.

## **9.3. On-Site Installation**

Installation of the instrument is a 3-step process: remove its front panel, put the water level measuring device in place and replace panel, then manually set a fixed value for the instrument.

### **General Notes:**

- Minimum voltage required: 5 V DC
- Cables up to 30 metres may be used

### **9.3.1. To remove the protective front panel (pulley side):**

1. Unscrew the bottom knurled bolt until it is clear on the panel.
2. Then lift the panel up and off the retaining studs.

### **9.3.2. To put the float line in place:**

1. First ensure that you have the correct length so that the float rests on the surface of the water when the instrument is in place.
2. Tie the float and counterweight to the two ends of the line.
3. Slip the wire around the pulley. Locate wire bead in holes on periphery.
4. Replace the panel (with the panel in position, the float wire cannot slip off the pulley and fall into the water).
5. Lower the float to the surface of the water.

### **9.3.3. To adjust the reading displayed on the instrument:**

You will want to set the value displayed to the actual water level or at least to a value high enough so that changes in water level do not cause it to fall to zero. If the pulley (water level) is rotated back past the zero (0) reading, the display will 'wrap around' to 99999, however the Data Logger reading (from the up/down counter) will 'wrap around' to 65535. The display (and reading) will synchronise again, when the shaft is rotated forward past zero again.

For instance, if measuring a bore with a water level 20 metres down, set the display to 20 metres (20000). When the water

level rises, the reading will change to 19999. When the water level falls, the reading will change to 20001.

1. Adjust the Water Level reading on the display by clamping the shaft spindle firmly and rotating the pulley wheel.

To hasten the task of rotating the pulley to the zero point you can reset the instrument to zero by switching DIL switch 7 On, then back to normal. (See section 3.1.)

2. Verify that the Data Logger reading is correct by examining the data at Address 201 (or 200 if the Site ID has been disabled). For any reason, should the display read differently to the Data Logger reading, the Water Level Instrument must be reset.

## **9.4. Mounting and Cabling**

The Water Level Instrument may be installed on a shelf or bracket suitably positioned over a bore or 'stilling well'.

It is connected to a Logger via a 4-wire cable less than 5 metres long (see note in connection details for cable lengths up to 10 metres). The cable is fed into the instrument through a cable gland in the base.

The water level instrument should be protected from direct weather by a shelter. It is not waterproof.

## **9.5. Connecting More Than One Encoder to a Logger**

Each Logger Serial Channel will support up to eight encoders. The encoders are connected in a "daisy-chain." The first encoder's DATA IN (blue wire) connects to the logger's serial channel input (S0), the second encoder's DATA IN (blue wire) connects to the first encoder's SERIAL LINK (white wire, S1) and so on.

All encoders' +5V DC (red), COMMON (green) and SERIAL CLOCK (yellow) signals connect together (in parallel) at the logger (or the adjacent encoder's terminal block if that is more convenient.)

Encoders (from PCB 6010H on) are reverse polarity protected.



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