Department of Environment
and Resource Management

# Water Monitoring

## Depth Logger Installation and Post Processing of Data

## AEMF013

July 2011

Queensland Government

# Aquatic Ecosystems

# Field Method

Number: AEMF013

Version Number: 3.2

## SIGN OFF BY DELEGATED OFFICER:

| | | | | |
|---|---|---|---|---|
| **1. Operationally capable of being implemented** | | | | |
| **Endorsed by:** | **Position:** | Director, Healthy Waters Policy | **Signature:** |  |
| | **Date:** | 11/07/2011 | | |
| **2. Meets business policy and legislative needs** | | | | |
| **Endorsed by:** | **Position:** | A/General Manager, Water Quality and Accounting | **Signature:** |  |
| | **Date:** | 11/07/2011 | | |

***Version History***

| Version Number | Date | Changed by | Nature of amendment |
|---|---|---|---|
| 0.1 | 21.02.2006 | Sharon Marshall | Created methods |
| 0.2 | 27.02.2006 | Jaye Lobegeiger | Review and minor edit |
| 1.1 | 16.11.2006 | Sharon Marshall | Update to include post processing of data |
| 1.2 | 12.12.2006 | Bernie Cockayne | Review and minor edit |
| 2.0 | 3/02/2007 | C. Marshall | |
| 2.1 | 15/07/2008 | S. Clifford<br>N. Polaschek | Review, formatting, added Permits and Approvals and WH&S section and updated method to new NRW departmental corporate identity standard. |
| 3.0 | 29/07/2008 | Tom Espinoza | Updated to include installation considerations in bores and added Appendix D and E |
| 3.1 | 10/06/2010 | Sharon Marshall | Updated to include programming, downloading and compensating using Diver-Office software, and instructions for storing data in AQEIS |
| 3.1 | 16/07/2010 | Jaye Lobegeiger | Review of updates to method |
| 3.1 | 02/08/2010 | Sharon Marshall | Update to incorporate reviewers comments |
| 3.2 | 07/07/2011 | Sharon Marshall | Updated QA/QC section and added Appendix F |

***Metadata***

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| Review trigger | Annual |

# Contents

# 1 Purpose and Scope

Depth loggers are installed in waterholes to record the rate of depth change in the absence of river flow. This, when combined with bathymetry data from survey and gauged flow data, will give indication of the rate of volume loss of waterholes and should permit the development of estimates of maximum persistence times for individual waterholes. It is possible that there may be groundwater-surface water interactions in some or all waterholes. Depth logger data and water ionic analysis from samples collected from the waterholes at intervals during a no-flow period should give indication if this is in fact occurring.

# 2 Associated Methods

WMO015A Bathymetric surveys of waterholes
AEML013 Post-processing of waterhole bathymetric survey data
AEMF032 Measures for estimating groundwater infiltration to surface water

# 3 Permits and Approvals

Under the Queensland Nature Conservation Act 1992 (NCA), activities involving protected wildlife and places are restricted. Refer to the 'WM26 – Department of Environment and Resource Management approvals for activities involving protected species or places' work practice for further information.

To ensure you have all the correct permits and approvals in place before using this method, refer to the Permits and approvals checklist.

# 4 Workplace Health and Safety

Risk assessment is of vital importance in reducing risks from potential hazards in the workplace. In section 27A of the *Workplace Health and Safety Act 1995*, five basic steps are outlined that must be followed to manage exposure to risks. The Workplace Health and Safety Queensland Risk Management Code of Practice 2007 outlines the obligations of both the employer and employee when carrying out risk assessment in the workplace. More information can be found at:

Workplace Health and Safety Queensland Risk Management Code of Practice 2007
Workplace Health and Safety Act 1995

Also refer to the current departmental Risk Management Standard.

**Before following the methods contained in this document, a detailed risk assessment must be undertaken. Table 1 outlines the areas to be completed.**

The following remote area and fieldwork health and safety guidelines should be adhered to when using this procedure:

DERM Draft remote area and field operations policy and standard:
http://insite2.dnr.qld.gov.au/policy_register/documents/3011/hrs_2007_3011.pdf

For all fieldwork there must be a minimum of two persons per sampling party. Ensure that all risk assessment and trip approval paperwork is complete and that a phone-in schedule has been arranged.

Previous documents have addressed the following issues, which should be considered when completing the risk assessment table (Table 1) prior to using this procedure:

- Minimum of two persons per sampling party
- Guidelines for remote area operations
- Appropriate vehicle for the terrain covered
- Appropriate recovery equipment
- Appropriate communication tools e.g. satellite/mobile phone, radio, EPIRB
- Ring-in policy
- Appropriate clothing, footwear, hat
- Sunscreen, insect repellent
- Current First Aid accreditation
- First Aid kit
- 4WD training
- Adequate supply of drinking water

**Table 1: Workplace Health & Safety Risk Assessment for Depth Logger Installation and Post Processing of Data (See Appendix A for DERM Risk Analysis Matrix and DERM Risk Scores)**

| **CONTEXT**<br>Define the context of what risks are to be covered & identify the specific activity to be assessed | **HAZARDS**<br>Make a record of each hazard (a hazard is something with the potential to cause harm) | **RISK**<br>List the risks to health & safety posed by each hazard | **RISK RATING**<br>Evaluate the risks to health & safety posed by each hazard | | | **CONTROL MEASURES**<br>List suitable control members to eliminate, substitute, isolate, reduce or engineer out the risks | **MONTORING**<br>What monitoring is proposed or already in place, to ensure that controls are effective in reducing/eliminating risks of hazards | **REVIEW DATE**<br>List suggested times for the review/update of monitoring procedures |
|---|---|---|---|---|---|---|---|---|
| | | | ***CONSEQUENCE*** | ***LIKELIHOOD*** | ***RATING*** | | | |
| FIELD OPERATIONS<br>- undertaking sampling on-site | Unpredictable water depths & velocities | Drowning<br>Personal Injury | Major | Unlikely | Medium (14) | Life-jackets to be worn at all times<br>Ensure staff are capable swimmers<br>First Aid Qualifications | Life-jackets to be tested<br>Updating of First Aid qualifications<br>Appropriate call-in procedure in place | Annually |
| | Sun & heat exposure | Sunburn & heat exhaustion | Minor | Unlikely | Low (5) | Appropriate PPE to be utilised | Monitor condition of PPE | Annually |
| | Navigation of unstable terrain | Personal Injury | Minor | Possible | Medium (8) | Appropriate PPE to be utilised<br>First Aid Qualifications<br>Two staff members to travel together at all times | Monitor condition of PPE<br>Updating of First Aid qualifications | Annually |
| | Collision<br>Car Rollover<br>Breakdown | Personal Injury | Catastrophic | Rare | Medium (15) | Recovery equipment to be carried at all times<br>Drive with due care<br>4WD training qualifications | Condition of car & recovery equipment to be inspected prior to leaving office<br>Updating of driving licences | Annually |
| FIELD OPERATIONS<br>- driving to / from site | Manual Handling<br>Awkward postures | Personal Injury | Minor | Possible | Medium (8) | Two people to perform lifting of heavy objects<br>Safe handling techniques covered in DOTS | Ensure staff are aware of new correct manual handling procedures | Annually |

[Note: Table 1 below has been filled out as an example. Each new method will require an assessment to be made against the criteria in Table 1. Refer to Appendix A for explanation of risk rating]

# 5 Skills/Competency and Experience Required

If a boat is to be used for installation, boat operators require a Queensland Recreational Boat Operators licence. At least one member of the field team should be a competent swimmer and at least one should hold a current Senior First Aid certificate.

Staff skills, training and experience records should be kept up to date in the Sharepoint training database: http://sharepoint/water/WQA/Accounting/Monitoring/StaffTraining/default.aspx

# 6 Chemicals

None identified.

# 7 Equipment

Water holes:

- Depth loggers (TD Divers)
- BaroDivers
- USB Reading Unit
- 4 m lengths of 1″ electrical conduit (plus some shorter lengths with an attached collar for extensions)
- 4 m lengths of 2″ PVC pipe (slotted or with holes drilled at regular intervals along the length)
- Short star pickets for BaroDivers
- Short lengths of 2″ PVC pipe for BaroDivers
- Steel cable
- 2 mm swages
- Swager (crimper)
- Steel wire cutters
- Star picket driver
- Floats
- Cable ties
- Rope
- Hacksaw and spare blades
- Laptop with Diver-Office or LDM software
- Rubber inflatable boat and oars for downloading
- Air compressor with cigarette plug adaptor
- Carabiner (optional – see section 8.2.1)

Bores:

- 1.9mm stainless steel cable
- 1.9mm swages
- Crimping tool
- Cordless drill and various drill bits
- Groundwater measuring tape (“plopper”)
- Measuring tape
- TD Diver and Baro Diver
- Stainless steel weight (for bores >10m)
- Diver logger field sheet

# 8 Method

## 8.1 Programming loggers prior to sampling

Before installation, the TD and Baro Divers must be programmed using the software package provided with the logger. It is important that the location name and sample frequency are appropriately set according to the project requirements. The following instructions relate to the use of the software package Diver-Office. This program is available for download from the web at http://www.swstechnology.com/groundwater-software/diver-data-management/diver-office?tab=4

1. Start computer and connect the USB Reading Unit
2. Launch Diver-Office
3. Insert the logger into the reader
4. From the Diver-Office toolbar, select the **Diver** icon. The diver dialog will open displaying the settings and status of the Diver (Figure 1)

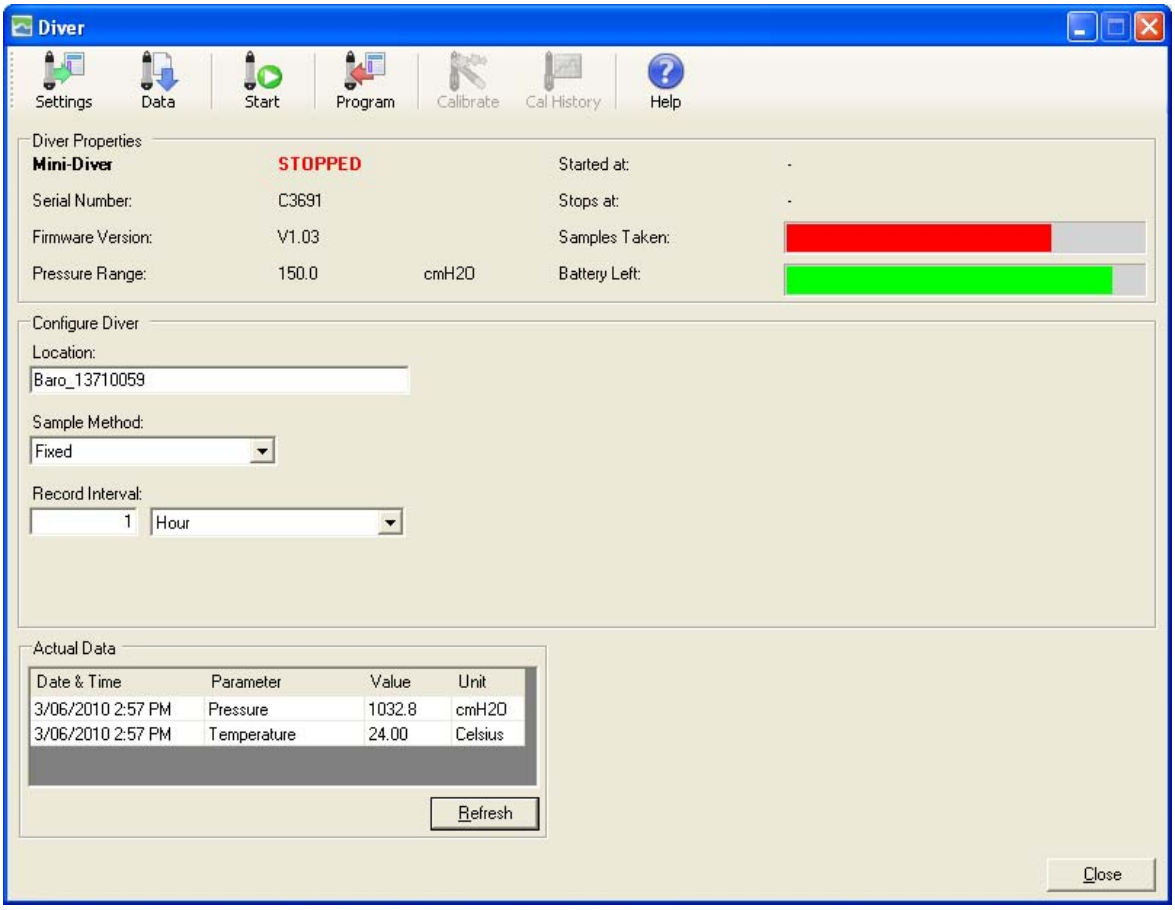



**Figure 1**: Diver dialog box for the Diver Office software

Enter the following information in the Diver dialog:

| | |
|---|---|
| Location | Location name must be unique, otherwise compensation of the TD with the Baro will not be possible. A suggested naming convention is: site number_diver serial number (e.g. 1381099_C3105) |
| Sampling Method | Choose between Fixed, Event, Averaging or User-defined, according to project requirements. Fixed is most commonly used. |
| Record Interval | Enter a record interval (0.5 sec – 99 hr) |

5. Click the **Program** icon from the Diver toolbar

6. Click **Start** from the Diver toolbar. From the Start Diver dialog, select the appropriate start method e.g. Immediate Start, Future Start or Smart Future Start. These options are described in more detail in the Diver-Office online help (http://www.aqualab.com.au/files/104/manual.pdf or Diver Office>Help>Contents). It is recommended to choose **Future Start**, and round the **Start Time** to the nearest hour (Figure 2). The reason for this is so readings are collected at even time intervals, on the hour, which will make for easier compensation with the barometer. Furthermore, this practice will save on battery power and prevent unwanted readings at the start of the series.

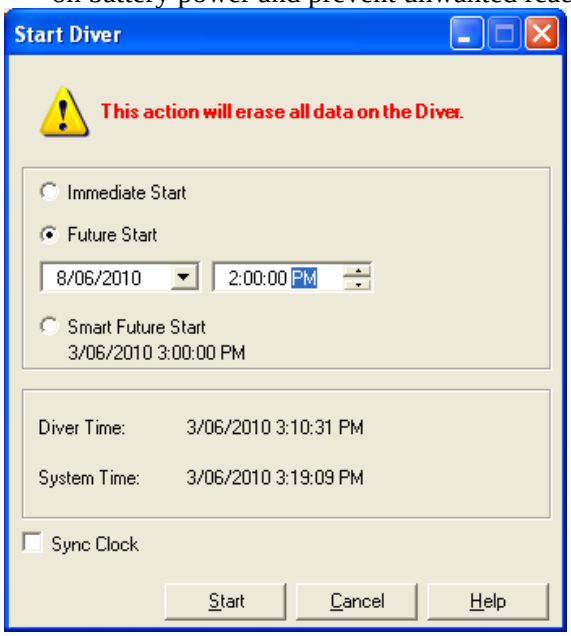



**Figure 2:** Start Diver dialog box

7. Ensure **Sync Clock** is checked, and click **Start** from the Start Diver dialog to complete the process. A correctly programmed Diver will have the **Stop** icon enabled, and will display the Future Start date (Figure 3)

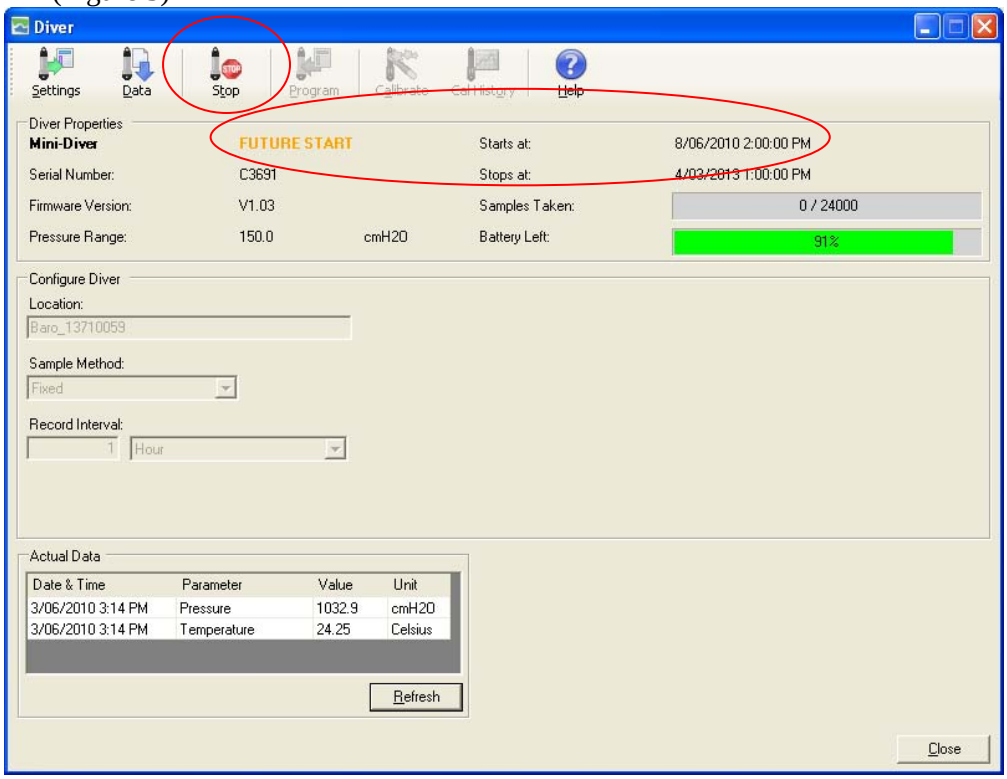



**Figure 3:** Display of Future Start date in the Diver dialog box

## 8.2 Installing depth loggers

### *8.2.1 Waterholes*

As well as the BaroDiver for air pressure measurements, there are five TD Diver models for measuring water levels (to 5 m, 10 m, 20 m, 30 m and 100 m levels). The appropriate depth logger (TD Diver) should be selected for the depth of water being recorded and preferably installed in a location that is not at risk of drying out. Profiling the waterhole prior to installing the logger will give a good indication of the best position to install the diver.

Stabilise the boat whilst installing the logger by tying ropes from the bank to the boat (Appendix 1). An anchor may also help. Cut the conduit to length using a hacksaw, and drive in using a star picket driver from the side of the boat. The length of the conduit will be determined by the depth of the waterhole and the requirements for driving it in. Extensions can be added once the conduit is in place.

Cut the PVC pipe to length using the hacksaw, ensuring a drilled hole is near one end of the pipe so you can thread the cable wire through to suspend the logger. Aim to cut the PVC pipe a length similar to the depth at time of installation, allowing a little extra so the pipe can protrude above the water surface. Before tying the PVC pipe to the conduit, secure the TD Diver inside the PVC pipe. This is done using steel wire, swages and a crimper. Thread the steel wire through a 2 mm swage, then through the Diver, then back through the swage forming a loop. Crimp the swage tight using the swager. Alternatively, if the logger is to be removed frequently for downloading, a carabiner may be used for easy removal. Place the Diver attached to the steel wire into the PVC pipe and lower until it hangs a short distance from the bottom of the PVC pipe. Cut the wire using the steel cutters, leaving enough spare to tie to the top end of the pipe. Thread the wire through another 2 mm swage, then through the drilled hole at the top of the PVC pipe, then back through the swage. Crimp the swage tight using the swager. The Diver should now be secured inside the slotted PVC pipe (Appendix C).

Place the PVC pipe adjacent to the conduit and cable tie in 4 places along the length of the pipe. The distance from the substrate to the bottom of the Diver should be noted and recorded on the field sheet, along with the Diver's serial number.

Attach a float to some rope and tie to the top of the PVC pipe. Also tie a rope from the wire loop at the top of the PVC pipe (which suspends the diver) to a tree on the nearest bank, to help secure the diver in place. Record the date and time the diver was installed on the fieldsheet.

A BaroDiver is used to measure air pressure variations. The BaroDiver is installed in exactly the same way on the bank in a position that is not at risk of being flooded. It is also recommended to install the Baro out of direct sunlight to minimise diurnal temperature fluctuations. Use a shorter length of PVC pipe, and secure the PVC pipe to a short star picket. Generally speaking, one BaroDiver is enough for an area of fifteen square kilometres, however terrain conditions will play a role.

An alternative approach to logger installation is to use 40 mm slotted gal pipe, as opposed to poly (Appendix B).

### *8.2.2 Bores*

Pre-installation Procedure

1. Select bore and download borecard from SPIN or GWDB (SISM)
2. Using 'Groundwater Plotter' generate a "Water level elevation query" of relevant bore to assess water level fluctuations and movement.
3. Ascertain an appropriate depth for the diver to be installed (take into account the divers depth threshold)
4. Purchase suitable length of stainless steel cable and materials (s/steel weight if necessary)
5. Program Diver and Baro to the required sampling rate and future start.

Installation Procedure

1. Remove PVC cap from bore and measure bore water level using the Groundwater measuring tape ("plopper") (see field method WMO022 – Water Level Measurement – Subartesian) and record on Diver logger field sheet
2. Drill a hole in the middle of PVC cap using a 3mm drill bit
3. Feed s/steel cable through the bottom of the cap and crimp end flush with swage.
4. If necessary, feed Diver weight onto s/steel cable
5. Crimp Diver to the other end of s/steel cable
6. Using the groundwater measuring tape, measure total length of cable from the Diver reference point to bottom of crimp at the cap end. Ensure to tighten cable and tape for an accurate reading and record.
7. Feed Diver into bore and replace PVC cap. (the crimp should sit flush on top of PVC cap)
8. Using a measuring tape, measure from top of PVC cap to top of bore protector ensuring your measurement is flush and record.
9. Place Baro Diver within the housing structure of the bore.

NOTE:
1. It is a good rule of thumb to set Divers to hour logging on the hour. Groundwater staff will not dip bores 5 minutes either side of the hour.
2. Diver depth is important to ensure data capture. Ensure the diver will record within the manufactures threshold.
3. See Appendix D for images

## 8.3 Downloading loggers in the field

It is recommended that the loggers be checked at regular intervals (i.e. every 3 months) to download the data. This will ensure they are functioning correctly, that there is enough space left in the memory, and the battery charge is sufficient.
A boat may be required to access the logger, depending on the location where the logger has been installed within the waterhole.
To download the loggers:

1. Start the computer and connect the USB reading unit
2. Launch Diver-Office
3. Select **Project** from the menu bar and select **Settings.** Here you can define the project settings for the current project and choose the folder location where all time series data will be exported to. It is recommended to check **Export on Download,** that way; data is automatically exported to the folder location defined above whenever data is downloaded from a Diver. Select which file types to generate when exporting time series data. As a minimum, both .MON files (for later manipulation in Diver Office) and .CSV files (for storage and spreadsheet manipulation) should be stored at download. Note, this step only has to be completed the first time a logger is downloaded in Diver Office. Subsequent downloads only need a quick check of the project settings.
4. Insert the baro or Diver in the reader
5. From the Diver-Office toolbar, select the **Diver** icon. The Diver dialog will open displaying the settings and status of the Diver.
6. Click on the **Data** icon from the Diver Dialog. The download progress is shown in the bottom left corner of the Diver dialog
7. Once downloaded, the Diver dataset will be listed in the project tree and displayed on the screen.
8. Loggers not reading should be sent back to the supplier on return from the field for data retrieval and logger replacement.

NOTE: There is a small amount of instrumental error associated with depth loggers (ranges are specified by the manufacturers) but this can increase over time, and can vary with depth. Each time you visit the

loggers for downloading, you should manually measure the water depth at the logger for an indication of this error. To do this, the actual distance between the water surface and depth logger transducer should be recorded and compared with the reading from the logger. The easiest way to do this is to measure and record the distance between (a) top of pvc pipe/cable and transducer on logger, and (b) top of gal pipe and water level. Subtract (b) from (a) and you will get the depth of water the diver is sitting in.

If possible, some surveying work should be conducted at the site to determine the AHD for the Diver (as it is sitting inside the gal pipe in the waterhole) so that all Diver data can be expressed as Depth AHD. Record the Diver AHD on the fieldsheet for future reference.

## 8.4 Compensating TD Divers with Baro

The TD Diver measures water level with a pressure sensor that measures absolute pressure. Subtracting air pressure measurements from absolute pressure measurements *compensates* for air pressure variations. This is done using Diver-Office. For compensation using LoggerDataManager, refer to Appendix E. The sampling speed of the BaroDiver does not have to be the same as the Diver measurements it compensates. Linear interpolation for air pressure values are used if they are not measured at the same time as the water level. For compensation:

1. Open **Diver-Office,** and select diver from the project tree. In **Location settings**, ensure **Barometric location** is recorded. If not, select the barometer for this diver from the dropdown list.
2. Highlight the uncompensated diver data file. Right click, and choose **compensate.**
3. Select the desired barometric compensation method from the **BaroComp** dialog (for our purposes, *Water column above diver*, other options are explained in the Help menu), and click **Baro.Comp** to perform the barometric compensation.
4. When the compensation is complete, the barometric compensation log will show, displaying a summary with details. Note, a partly compensated time series will result if the dates for the baro data don't match up with the dates from the diver data.
5. Click **close** to finish. You can now view the compensated data in the time-series table and plot. You will notice that the time series symbol in the **Project Tree** will change to a green tick once compensation has been performed. A yellow exclamation mark indicates a partially compensated time series. Refer to Diver Office manual for further detail.
6. The compensated data can be exported, if desired, by right clicking on the compensated file, selecting **Export**, choose the destination folder, check **compensated**, then click **ok**.

## 8.5 Post Processing of Data

1. Using the uncompensated diver data, baro data, and the compensated file, prepare a spreadsheet as follows:
    a. Column A: **Date/Time.** Encompasses time-series start date through to time-series end date, and all dates in between.
    b. Column B: **Pressure (cm).** This is the time-series uncompensated diver data.
    c. Column C: **Barometric pressure (cm).** This is the time-series raw barometric pressure data, collected from the baro diver.
    d. Column D: **Compensated depth (cm).** This is the time-series diver data compensated with the baro data (see 8.4 above).
    e. Column E: Leave blank (for later adjustments to depth readings, see step 4)
    f. Column F: Leave blank (for later adjustments to depth readings, see step 4)
    g. **Temperature (°C).** This is the time-series water temperature data from the compensated diver file.

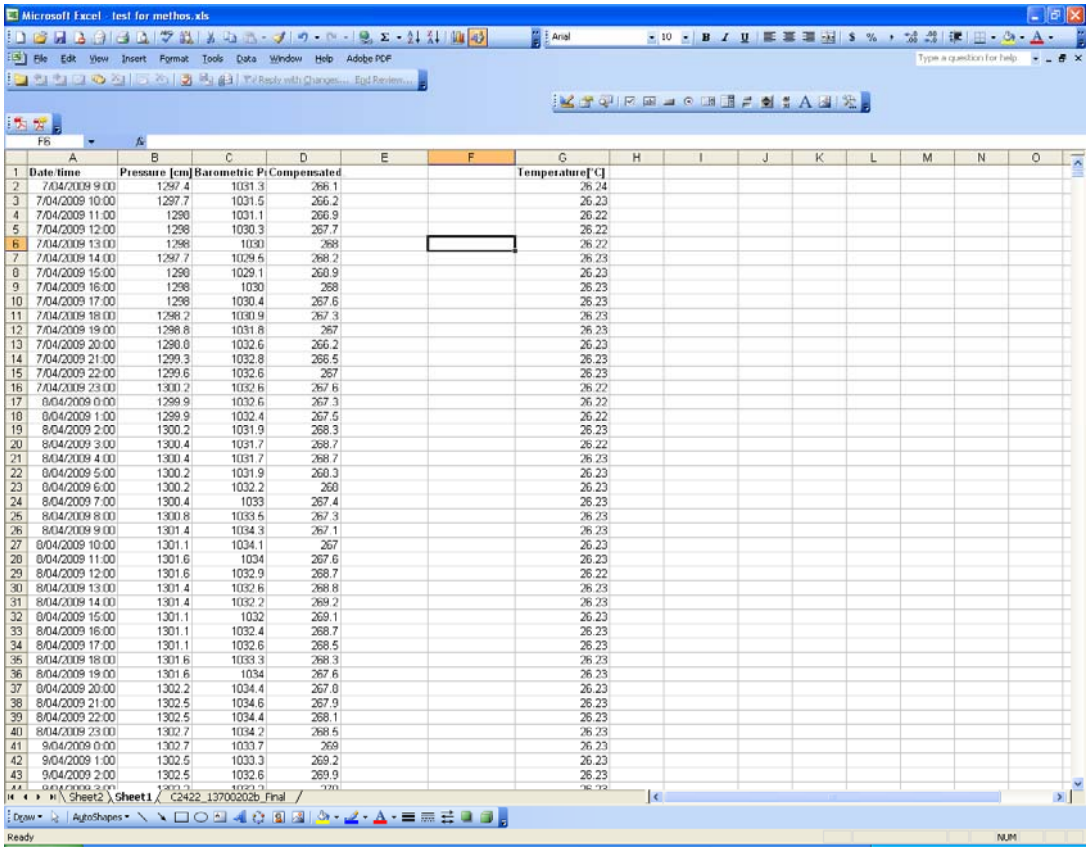



**Figure 4:** Post-processing of data: preparing the spreadsheet.

Note, if **Immediate start** was selected during logger programming, as opposed to **Future Start** (refer to section 8.1, step 6) then records prior to the actual installation in the waterhole will be displayed as negative values, or will appear odd with respect to the other values (i.e. smaller numbers). All of these records prior to the actual installation date and time should be deleted.

2. Graph date time and compensated depth as a line graph. The purpose of this step is to display any anomalies in the data set. An anomaly may occur in the case where the logger has been pulled in for downloading at the time when a reading is due, or if the logger has malfunctioned and taken an odd reading (Fig. 5).

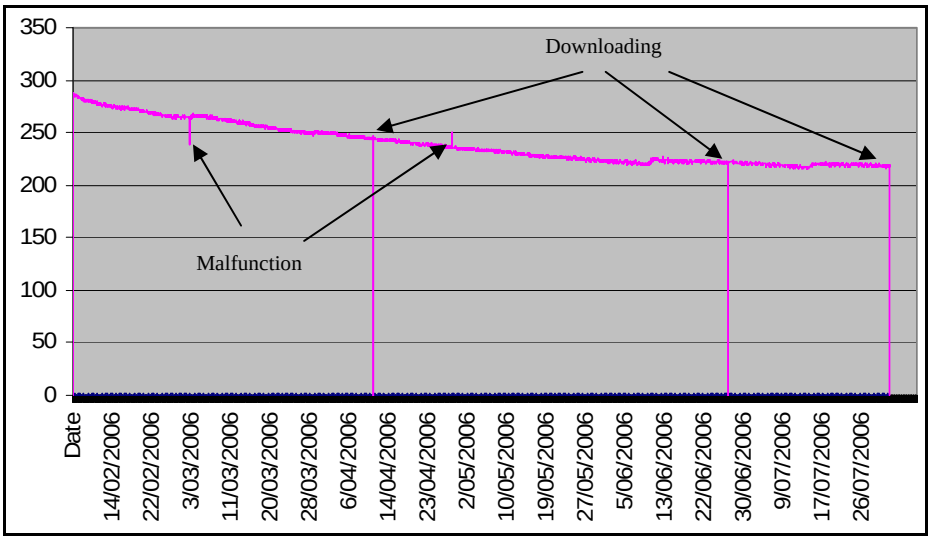
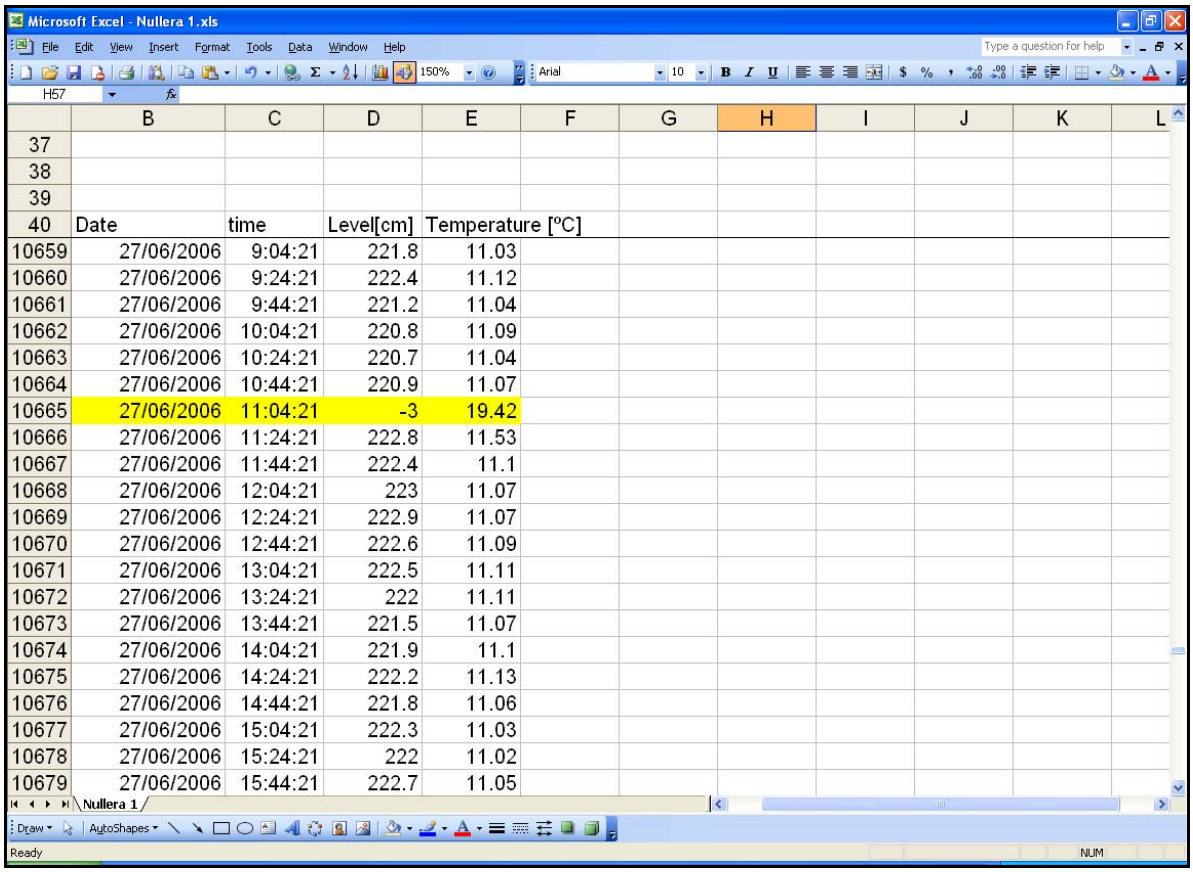


**Figure 5:** Post-processing of data: plot of compensated depth versus date/time to identify anomalies in the data set.

3. Locate the anomalies in the dataset and delete the row. Check the rows above and below the anomaly and ensure they are equal. Often, in the case where the logger has been removed from the water for downloading, it is put back in a slightly different depth. When this happens, all measurements below the point of removal have to be adjusted accordingly, by either adding or subtracting the difference (Fig. 5). In this example, row 10665 would need to be deleted and 1.9 cm subtracted from all subsequent rows.




| | B | C | D | E |
|---|---|---|---|---|
| 37 | | | | |
| 38 | | | | |
| 39 | | | | |
| 40 | Date | time | Level[cm] | Temperature [°C] |
| 10659 | 27/06/2006 | 9:04:21 | 221.8 | 11.03 |
| 10660 | 27/06/2006 | 9:24:21 | 222.4 | 11.12 |
| 10661 | 27/06/2006 | 9:44:21 | 221.2 | 11.04 |
| 10662 | 27/06/2006 | 10:04:21 | 220.8 | 11.09 |
| 10663 | 27/06/2006 | 10:24:21 | 220.7 | 11.04 |
| 10664 | 27/06/2006 | 10:44:21 | 220.9 | 11.07 |
| 10665 | 27/06/2006 | 11:04:21 | -3 | 19.42 |
| 10666 | 27/06/2006 | 11:24:21 | 222.8 | 11.53 |
| 10667 | 27/06/2006 | 11:44:21 | 222.4 | 11.1 |
| 10668 | 27/06/2006 | 12:04:21 | 223 | 11.07 |
| 10669 | 27/06/2006 | 12:24:21 | 222.9 | 11.07 |
| 10670 | 27/06/2006 | 12:44:21 | 222.6 | 11.09 |
| 10671 | 27/06/2006 | 13:04:21 | 222.5 | 11.11 |
| 10672 | 27/06/2006 | 13:24:21 | 222 | 11.11 |
| 10673 | 27/06/2006 | 13:44:21 | 221.5 | 11.07 |
| 10674 | 27/06/2006 | 14:04:21 | 221.9 | 11.1 |
| 10675 | 27/06/2006 | 14:24:21 | 222.2 | 11.13 |
| 10676 | 27/06/2006 | 14:44:21 | 221.8 | 11.06 |
| 10677 | 27/06/2006 | 15:04:21 | 222.3 | 11.03 |
| 10678 | 27/06/2006 | 15:24:21 | 222 | 11.02 |
| 10679 | 27/06/2006 | 15:44:21 | 222.7 | 11.05 |

**Figure 6:** Post-processing of data: Removing anomalies from the dataset

4. In the blank columns (column E and column F) left in the spreadsheet during step 1, add the following:
    a. Column E: **Depth adjusted for logger error (cm).** The logger error may change over the time series, so this has to be considered. The actual diver depth (i.e. the distance between diver transducer and water level) should be manually measured and recorded at the time of installation and at every download (see note p11). To calculate the depth adjusted for logger error, first calculate the incremental error adjustment (EA), using the equation ***EA=(End Error – Start Error)/n,*** where
        - Start Error = logger reading minus actual diver depth (for the first datapoint in the series). Note, this number will be a positive value if the logger reading is greater than the actual diver depth. Conversely, this number will be a negative value if the logger reading is less than the actual diver depth.
        - End Error = logger reading minus actual diver depth (for the last datapoint in the series)
        - n is the number of datapoints in the series.

    *Depth adjusted for logger error* = compensated depth – (start error + cumulated increment) (Figure 7) (The cumulated increment will be the error from the preceding day plus the

incremental error). ***Note, can only enter data in column E when the logger error is known at both the start date, and end date in the series.***

b. Column G: **Depth (AHD).** Divide column E by 100 (to get into metres), then add to this the diver AHD, if known. This will express the depth of water above the diver as AHD (Figure 7).

c. Insert a text box in the spreadsheet and enter one of the following for future reference:
*In the case where logger error has been determined **at both** the start and end date in the data series (i.e. column E contains data):*

> Logger error (*insert **start date** in time series*) = X cm (logger reading = X cm; actual diver depth = X cm)
>
> Logger error (*insert **end date** in time series*) = X cm (logger reading = X cm; actual diver depth = X cm)
>
> Data series incrementally adjusted to account for logger error

*In the case where logger error cannot be determined for one reason or another (i.e. Column E contains no data. This may occur when the retrieved data (emailed from Aqualab from a failed logger) end date does not match download date so a logger error cannot be determined at the end date in series)*

> Logger error (*insert start date in time series*) = not determined
>
> Logger error (*insert end date in time series*) = not determined
>
> Data series has not been adjusted to account for logger error.
>
> Note: Actual diver depth (*insert download date*) = X cm (use this value to determine logger error at start of series on next download)

Completed spreadsheet should look similar to Figure 7.

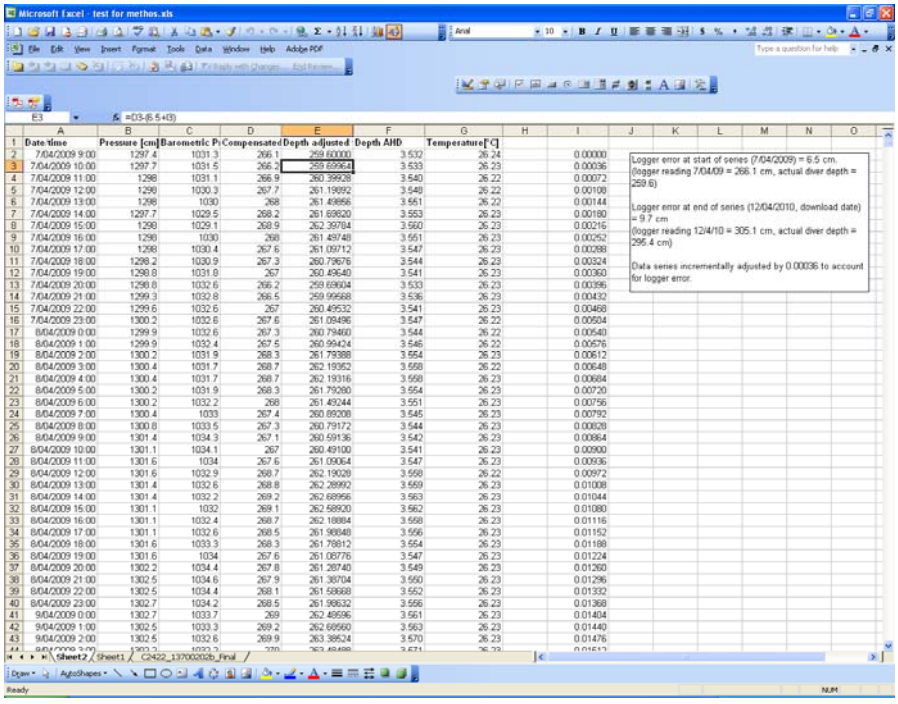
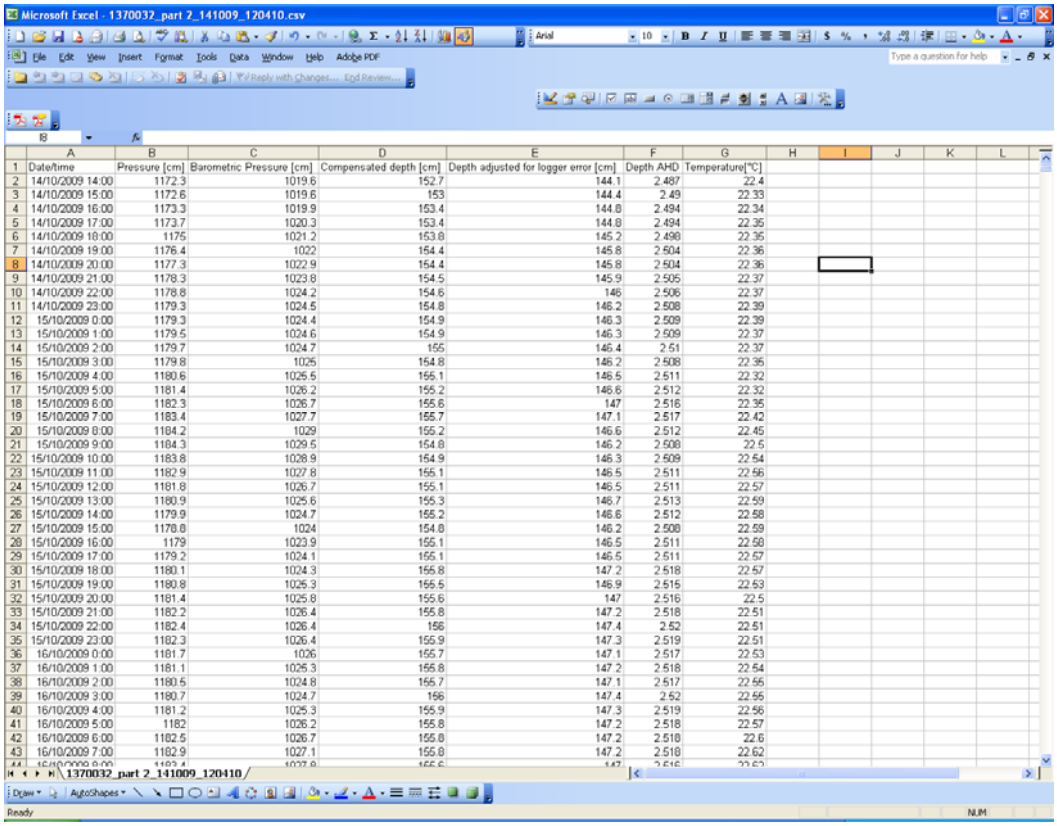



**Figure 7: Post-processing of data:** Completed spreadsheet**.**

## 8.6 Input to AQEIS

Before loading the data, save the excel spreadsheet created above as a .csv file. Delete the textbox, and also any other columns containing data used to work out the logger error increments (i.e. column I in Figure 7). Format the cells to the correct number of decimal places, as determined by the AQEIS property variable specifications, as per Figure 8. The final csv file ready for loading to AQEIS should look similar to Figure 8.




| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | Date/time | Pressure [cm] | Barometric Pressure [cm] | Compensated depth [cm] | Depth adjusted for logger error [cm] | Depth AHD | Temperature[°C] |
| 2 | 14/10/2009 14:00 | 1172.3 | 1019.6 | 152.7 | 144.1 | 2.487 | 22.4 |
| 3 | 14/10/2009 15:00 | 1172.6 | 1019.6 | 153 | 144.4 | 2.49 | 22.33 |
| 4 | 14/10/2009 16:00 | 1173.3 | 1019.9 | 153.4 | 144.8 | 2.494 | 22.34 |
| 5 | 14/10/2009 17:00 | 1173.7 | 1020.3 | 153.4 | 144.8 | 2.494 | 22.35 |
| 6 | 14/10/2009 18:00 | 1175 | 1021.2 | 153.8 | 145.2 | 2.498 | 22.35 |
| 7 | 14/10/2009 19:00 | 1176.4 | 1022 | 154.4 | 145.8 | 2.504 | 22.36 |
| 8 | 14/10/2009 20:00 | 1177.3 | 1022.9 | 154.4 | 145.8 | 2.504 | 22.36 |
| 9 | 14/10/2009 21:00 | 1178.3 | 1023.8 | 154.5 | 145.9 | 2.505 | 22.37 |
| 10 | 14/10/2009 22:00 | 1178.8 | 1024.2 | 154.6 | 146 | 2.506 | 22.37 |
| 11 | 14/10/2009 23:00 | 1179.3 | 1024.5 | 154.8 | 146.2 | 2.508 | 22.39 |
| 12 | 15/10/2009 0:00 | 1179.3 | 1024.4 | 154.9 | 146.3 | 2.509 | 22.39 |
| 13 | 15/10/2009 1:00 | 1179.5 | 1024.6 | 154.9 | 146.3 | 2.509 | 22.37 |
| 14 | 15/10/2009 2:00 | 1179.7 | 1024.7 | 155 | 146.4 | 2.51 | 22.37 |
| 15 | 15/10/2009 3:00 | 1179.8 | 1025 | 154.8 | 146.2 | 2.508 | 22.35 |
| 16 | 15/10/2009 4:00 | 1180.6 | 1025.5 | 155.1 | 146.5 | 2.511 | 22.32 |
| 17 | 15/10/2009 5:00 | 1181.4 | 1026.2 | 155.2 | 146.6 | 2.512 | 22.32 |
| 18 | 15/10/2009 6:00 | 1182.3 | 1026.7 | 155.6 | 147 | 2.516 | 22.35 |
| 19 | 15/10/2009 7:00 | 1183.4 | 1027.7 | 155.7 | 147.1 | 2.517 | 22.42 |
| 20 | 15/10/2009 8:00 | 1184.2 | 1029 | 155.2 | 146.6 | 2.512 | 22.45 |
| 21 | 15/10/2009 9:00 | 1184.3 | 1029.5 | 154.8 | 146.2 | 2.508 | 22.5 |
| 22 | 15/10/2009 10:00 | 1183.8 | 1028.9 | 154.9 | 146.3 | 2.509 | 22.54 |
| 23 | 15/10/2009 11:00 | 1182.9 | 1027.8 | 155.1 | 146.5 | 2.511 | 22.56 |
| 24 | 15/10/2009 12:00 | 1181.8 | 1026.7 | 155.1 | 146.5 | 2.511 | 22.57 |
| 25 | 15/10/2009 13:00 | 1180.9 | 1025.6 | 155.3 | 146.7 | 2.513 | 22.59 |
| 26 | 15/10/2009 14:00 | 1179.9 | 1024.7 | 155.2 | 146.6 | 2.512 | 22.58 |
| 27 | 15/10/2009 15:00 | 1178.8 | 1024 | 154.8 | 146.2 | 2.508 | 22.59 |
| 28 | 15/10/2009 16:00 | 1179 | 1023.9 | 155.1 | 146.5 | 2.511 | 22.58 |
| 29 | 15/10/2009 17:00 | 1179.2 | 1024.1 | 155.1 | 146.5 | 2.511 | 22.57 |
| 30 | 15/10/2009 18:00 | 1180.1 | 1024.3 | 155.8 | 147.2 | 2.518 | 22.57 |
| 31 | 15/10/2009 19:00 | 1180.8 | 1025.3 | 155.5 | 146.9 | 2.515 | 22.53 |
| 32 | 15/10/2009 20:00 | 1181.4 | 1025.8 | 155.6 | 147 | 2.516 | 22.5 |
| 33 | 15/10/2009 21:00 | 1182.2 | 1026.4 | 155.8 | 147.2 | 2.518 | 22.51 |
| 34 | 15/10/2009 22:00 | 1182.4 | 1026.4 | 156 | 147.4 | 2.52 | 22.51 |
| 35 | 15/10/2009 23:00 | 1182.3 | 1026.4 | 155.9 | 147.3 | 2.519 | 22.51 |
| 36 | 16/10/2009 0:00 | 1181.7 | 1026 | 155.7 | 147.1 | 2.517 | 22.53 |
| 37 | 16/10/2009 1:00 | 1181.1 | 1025.3 | 155.8 | 147.2 | 2.518 | 22.54 |
| 38 | 16/10/2009 2:00 | 1180.5 | 1024.8 | 155.7 | 147.1 | 2.517 | 22.55 |
| 39 | 16/10/2009 3:00 | 1180.7 | 1024.7 | 156 | 147.4 | 2.52 | 22.55 |
| 40 | 16/10/2009 4:00 | 1181.2 | 1025.3 | 155.9 | 147.3 | 2.519 | 22.56 |
| 41 | 16/10/2009 5:00 | 1182 | 1026.2 | 155.8 | 147.2 | 2.518 | 22.57 |
| 42 | 16/10/2009 6:00 | 1182.5 | 1026.7 | 155.8 | 147.2 | 2.518 | 22.6 |
| 43 | 16/10/2009 7:00 | 1182.9 | 1027.1 | 155.8 | 147.2 | 2.518 | 22.62 |

**Figure 8:** Final CSV file to be uploaded into AQEIS.

To upload data into AQEIS:

1. Logon to AQEIS
2. Click on Assessments→ Maintain Sample Runs
3. Query up the Project eg. ROP138 (Figure 9)

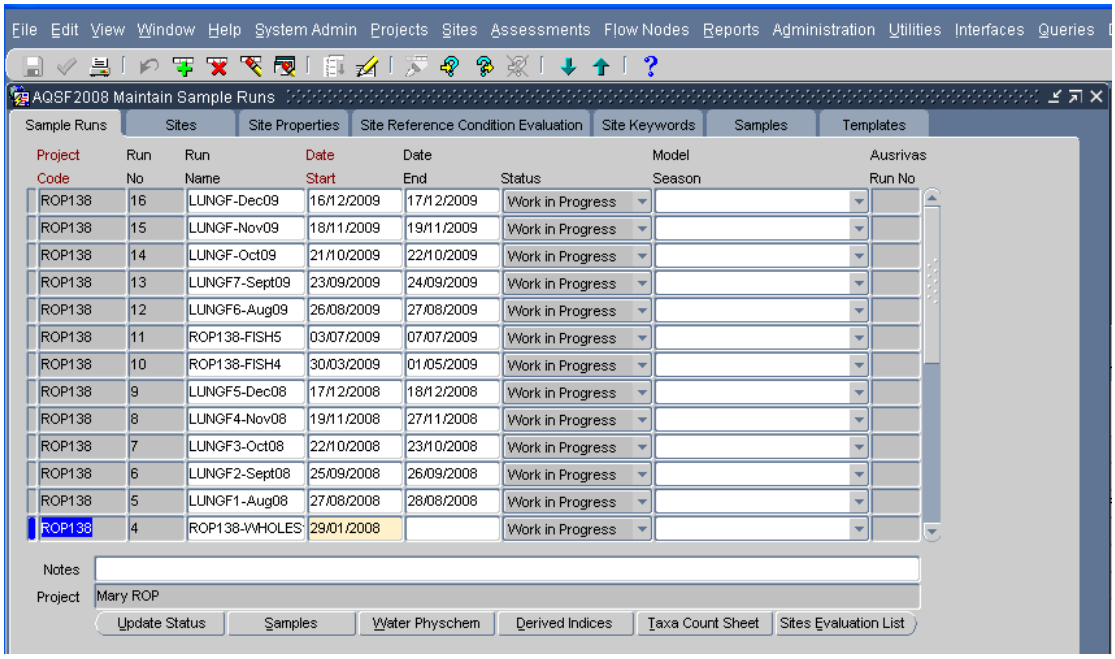



**Figure 9:** Dialog box for a query in AQEIS

4. Choose an existing run or create a new run based on the dates of your logger data
5. Click on the Sites tab and choose an existing site or enter a new site (Figure 10)

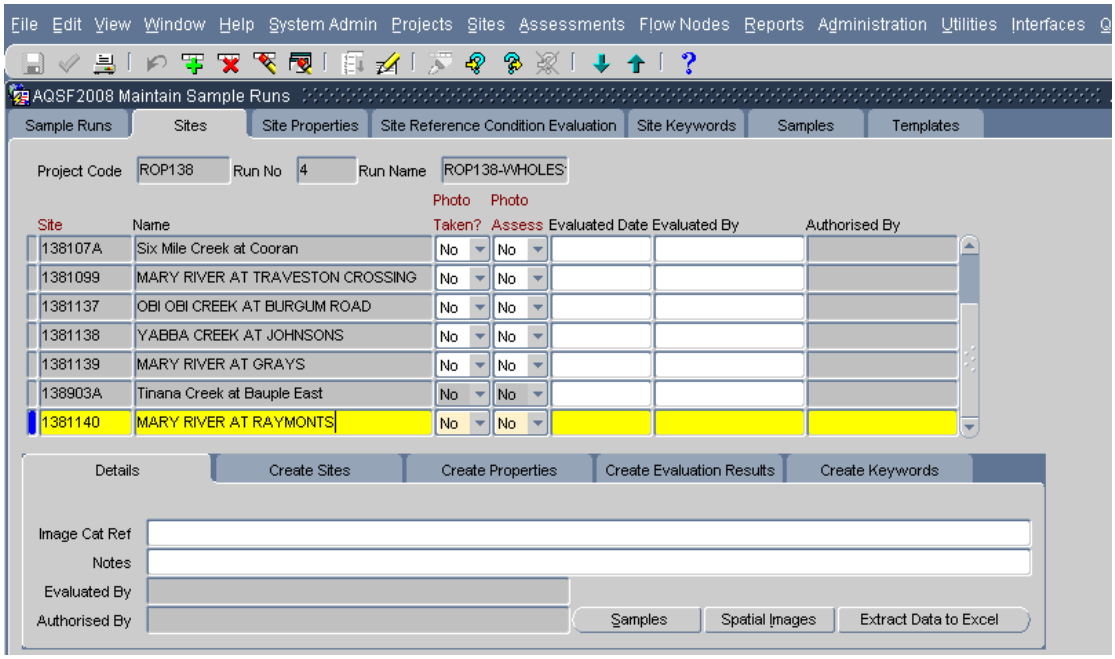



**Figure 10:** Entering new site or selecting an existing site in AQEIS.

6. Click on Samples

7. Enter the Sample details as pictured below in Figure 11, and click on SAVE

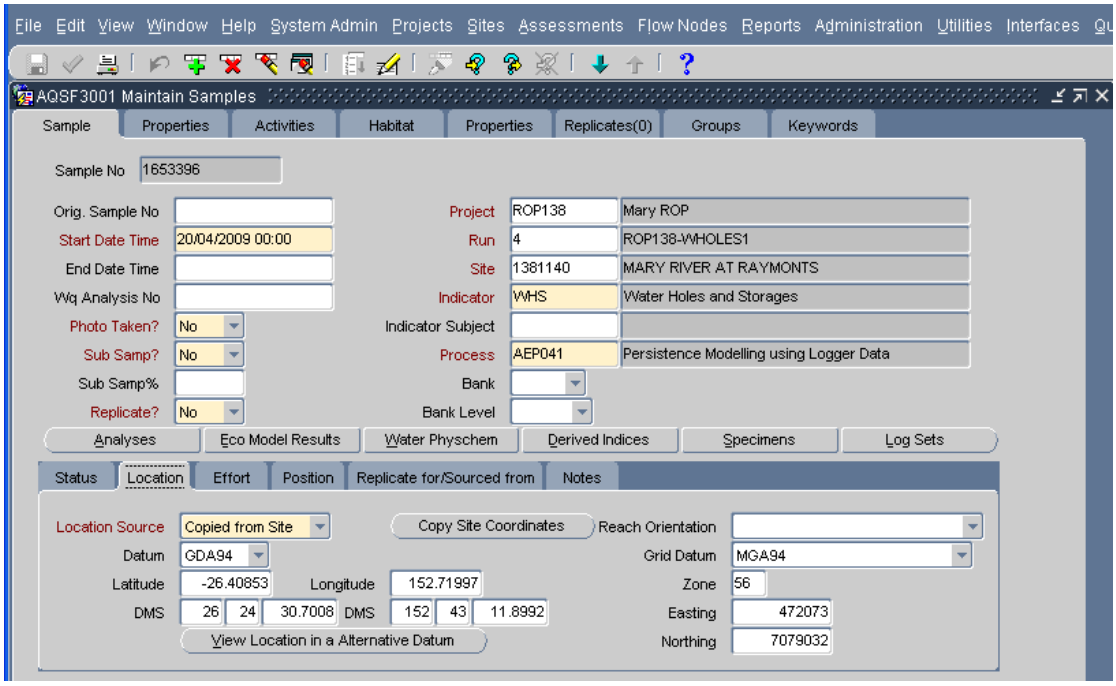



**Figure 11:** Entering sampling details into AQEIS.

8. Click on Log Sets
9. Enter the Log Set details as pictured below in Figure 12, and click on SAVE

The Log Format Type is set to **DEPTHTEMP2** which is set up to handle the file format from the Diver Logger. Reminder, **you will have to save the file to csv before loading the file.**

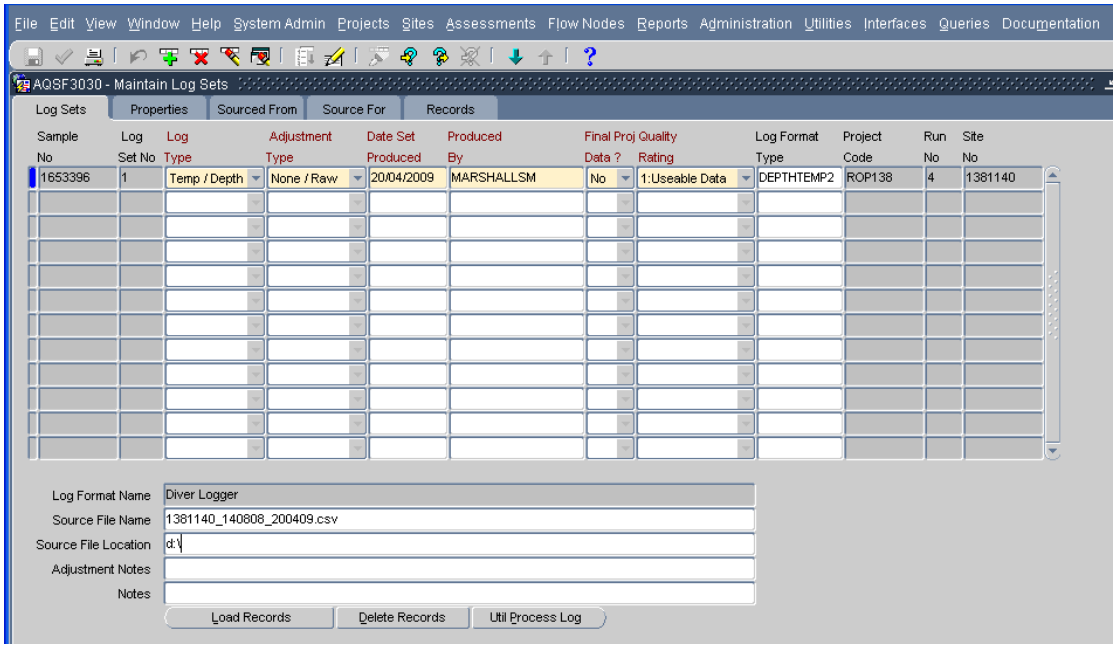



**Figure 12:** Entering LogSet details into AQEIS.

10. Click on Load Records at the bottom of the screen. Follow the prompts and select the file you want to load. Click Yes and Ok to all prompts.
11. You can monitor the load progress by clicking on the Util Process Log button at any time (Figure 13). The Log Status column will tell you what is happening. Once finished the Log Status should say 'Completed'. Close this form to go back to the Maintain Log Sets form.

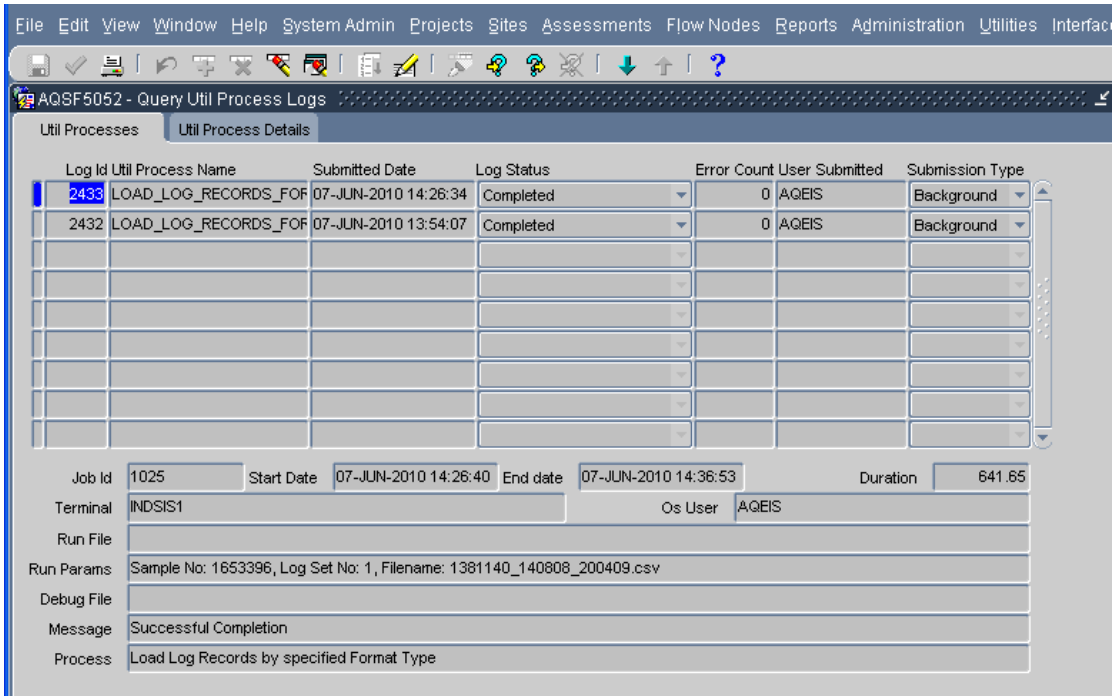



**Figure 13:** Dialog box to monitor the load progress in AQEIS.

12. Click on the Enter Query button and then click on the Run Query button to refresh the screen. Then click on the Records tab to view your logger data (Figure 14). Note, if the screen is not first refreshed, then the logger data will not be displayed.

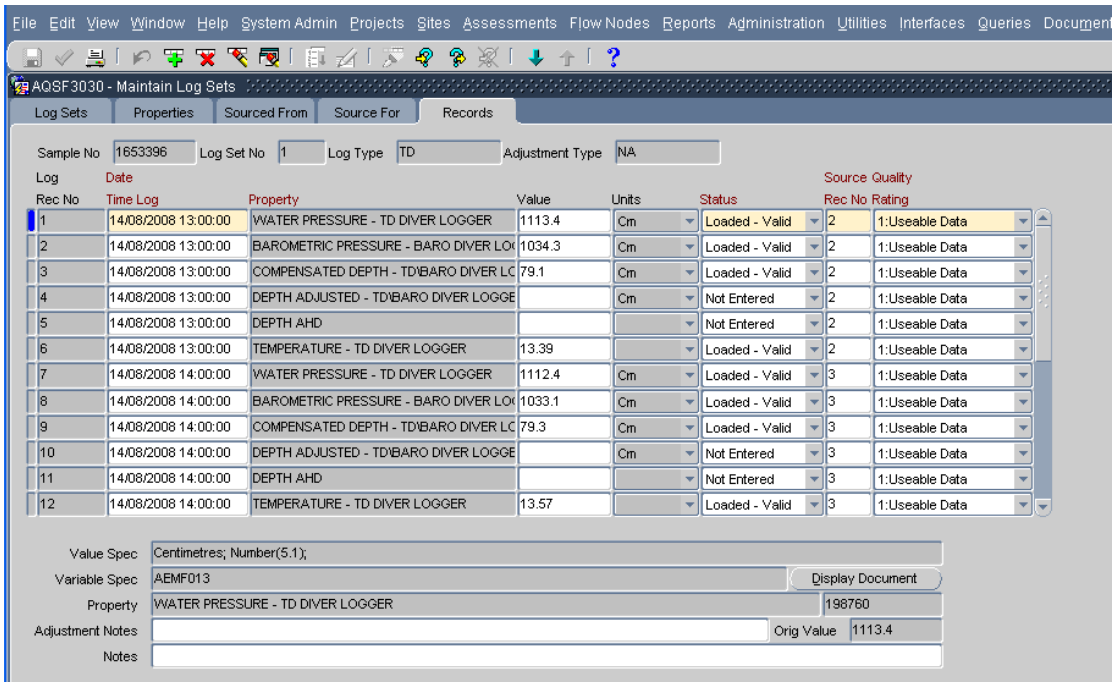



**Figure 14:** Viewing uploaded logger data in AQEIS.

## 8.7 Variation to method

Diver loggers can be programmed, downloaded and compensated using LoggerDataManager software. Appendix E details instructions using this software package.

| Project | Project Code (AQEIS) | Description of variation, rationale and any project specific variables |
|---|---|---|
| | | |
| | | |
| | | |

### 8.8 Limitations of Use

A different installation method may be necessary for loggers in depths greater than 4 m, as securing cable ties and measuring the distance between substrate and diver may be difficult in deep water.

# 9 Quality Assurance

The diver is always active, therefore it is critical to record the start date and time and end date and time on the datasheet. It is also important to select the correct type of Diver for the depth of water being surveyed, and to place the BaroDiver within an appropriate distance from the Diver (within a 15 km radius, depending on the topography).

Before leaving the field on a logger download trip, the following checks should be completed to assure quality data is collected:

1. The diver data should be compensated with the appropriate baro data (see section 8.4 above)
2. The compensated data should be visually assessed to ensure that the daily variation in flow appears normal (i.e. no abrupt fluctuations or blocky data), and to ensure that the compensated depth values are realistic (i.e. not peaking at unrealistic heights).
3. If compensated data appears suspect, the diver should be removed and a replacement one should be installed in its place.

Note: It is possible that a logger may read successfully during the download process however on closer inspection of the data it becomes obvious that the logger has malfunctioned. These checks are recommended to avoid unnecessary trips back to a site to replace a diver that has malfunctioned, despite reading successfully.

# 10 References

None identified.

# 11 Appendices

## Appendix A

**Table 2: DERM Risk Analysis Matrix**

| LIKELIHOOD | CONSEQUENCES | | | | |
|---|---|---|---|---|---|
| | **Insignificant** No measurable physical effects on staff/public, no medical treatment, incident of low level short term inconvenience. | **Minor** Minor effects on staff/public, minimal medical treatment, minor threat to safety systems, low level incident. | **Moderate** Serious harm to staff/public (<30%), medical treatment required, safety system breach, significant incident. | **Major** Single fatality or major physical harm to staff/public (30%), serious medical treatment/hospitalisation, safety systems major failure. | **Catastrophic** Multiple fatalities or significant irreversible damage to public/staff (>50%), large-scale medical attention/hospitalisation, complete breakdown of safety system. |
| **Almost certain** is expected to occur in most circumstances >90% | **Medium (11)** | **Medium (16)** | **High (20)** | **Extreme (23)** | **Extreme (25)** |
| **Likely** Will probably occur in many circumstances 70% | **Low (7)** | **Medium (12)** | **High (17)** | **High (21)** | **Extreme (24)** |
| **Possible** Will probably occur at some time 30-70% | **Low (2)** | **Medium (8)** | **Medium (13)** | **High (18)** | **High (22)** |
| **Unlikely** Could occur at some time but it is improbable 10-30% | **Low (2)** | **Low (5)** | **Medium (9)** | **Medium (14)** | **High (19)** |
| **Rare** May occur only in exceptional circumstances <10% | **Low (1)** | **Low (3)** | **Low (6)** | **Medium (10)** | **Medium (15)** |

**Table 3: DERM Risk Scores**

| Risk Level | Risk Score | Definition/Action Required |
|---|---|---|
| **Extreme** | **23-25** | Grave risk, risk not acceptable, immediate urgent action required. Stop activity immediately. |
| **High** | **17-22** | Risk not acceptable. Prompt management action required. |
| **Medium** | **8-16** | Prompt action is highly desirable. Scheduled management action required. |
| **Low** | **1-7** | Scheduled corrective actions as part of normal operations. |

## Appendix B

**Figure 9: Installing the logger**

**Figure 10: Installing the logger (cont.)**

**Figure 11: Installing the logger (cont.)**

**Figure 12: Alternative approach to logger installation**

Slotted gal pipe can be used in place of poly pipe. The logger can be installed at the edge in situations where it is not at risk of drying (i.e. in supplemented waterholes, where the river flows even during the driest period). If necessary, a lock can be attached (as shown in the above picture).

**Figure 13: Alternative approach to logger installation (cont.)**

Positioned on the downstream side of the tree/log to prevent damage from debris.

**Figure 14: Alternative approach to logger installation (cont.)**

An alternative approach to the baro setup described in this method is to use 25 mm conduit with 2 caps, and secure to a tree using screws (as seen in above picture). Position the baro above the flood mark.

## Appendix C

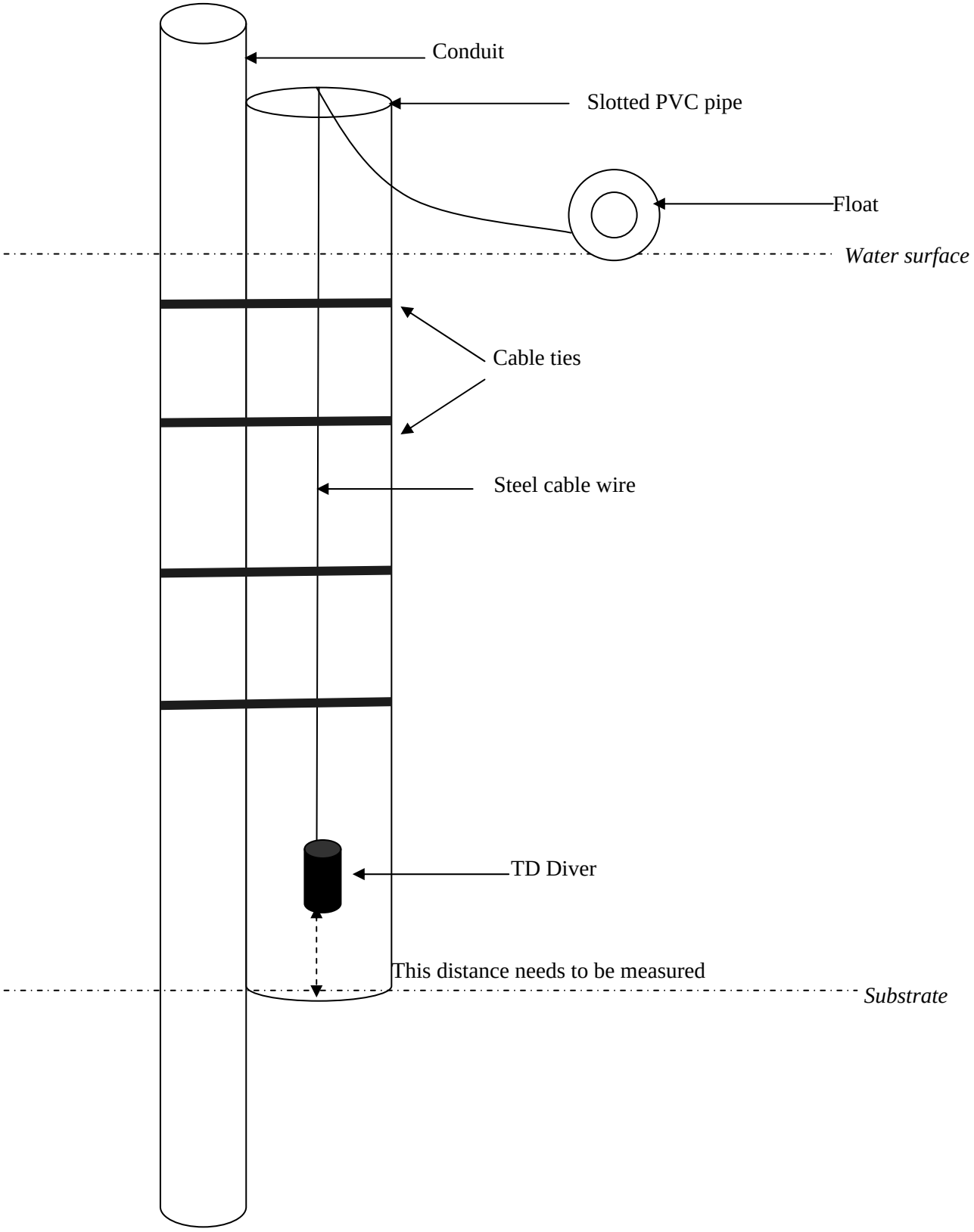



**Figure 15: Diagrammatic sketch of logger installation**

## Appendix D

*Installing the logger in bore*


**Figure 16: TD Diver with stainless steel weight attached (Note the two attachment points for the diver and the steel cable)**

**Figure 17: Bore being measured with plopper**

**Figure 18: Stainless steel cable attached to diver and bore cap**

**Figure 19: Baro Diver placed inside the housing structure of the bore. Note the secure attachment of the steel cable to the bore cap**

# Appendix E

**Programming, downloading and compensating loggers using LoggerDataManager software**

## 1 Programming loggers prior to sampling

Before installation, the TD and Baro Divers must be programmed using the software package provided with the logger. It is important that the location name and sample frequency are appropriately set according to the project requirements. The following instructions relate to the use of the software package LoggerDataManager.

8. Start computer and open LDM
9. Insert the optical reader into a USB port
10. Insert the logger into the optical reader
11. Click on **Application Management** tab, and select the **Advanced** option in the **User type** box. This will allow the **Locations** tab to be visible.
12. Click **Program Settings to Connected Logger** icon (3rd on toolbar). The following page is displayed (Figure 1).

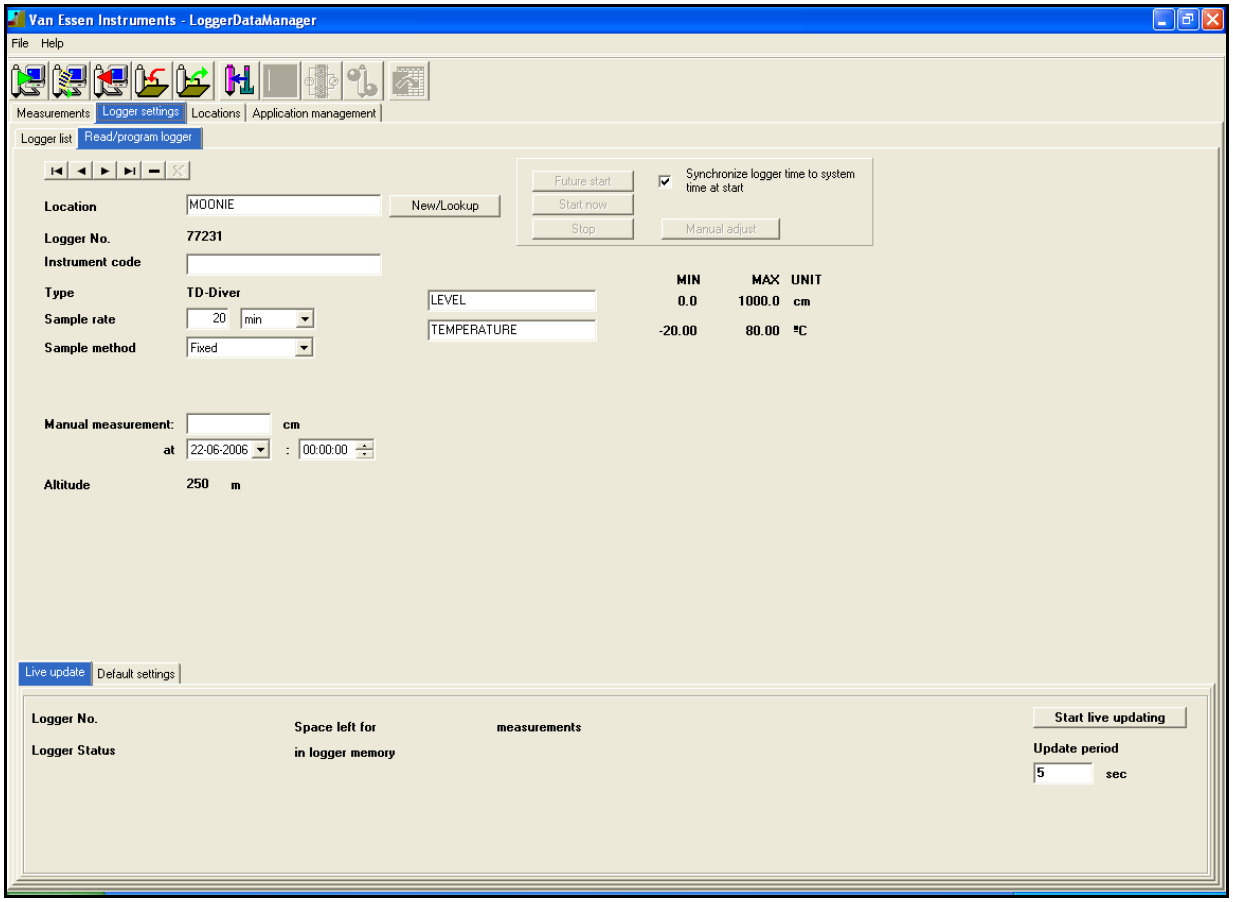



**Figure 1: Programming the logger prior to sampling using the LoggerDataManager software**

13. Insert a **Location Name**. It is important that the location name is unique for every Diver; otherwise compensation of the TD Diver with a Baro will not be possible. A suggestive format for the location name is the site name followed by either a 'TD' (if the diver is a TD), or a 'B' (if the Diver is a Baro) eg. '*AppletreeTD'* for the TD at Appletree and *'AppletreeB'* for the Baro at Appletree. For TD Divers, it is important to select the appropriate **Barolocation** from the drop down list under the **Locations** tab, otherwise the diver will not know which Baro to compensate from.

To rename the location of a file after download:
1. Before compensating, open the downloaded .MON file in excel
2. In rows 16 and 35 (Location =), change the location parameter as desired, then save the file
3. Import into LDM and compensate as normal

14. Set the **Sample Rate** according to the project requirements.
15. Click **Start Live Updating**, and then click **Start Now**. Will prompt for confirmation.
16. Record the following on an excel spreadsheet for future reference:
    a. serial number
    b. location name
    c. sample frequency
    d. date set
    e. memory full date

**2 Downloading loggers in the field**

It is recommended that the loggers be checked at regular intervals to download the data, and to ensure they are functioning correctly and that there is enough space left in the memory.
A rubber inflatable boat may be required to access the logger, depending on the location where the logger has been installed within the waterhole.
To download the loggers:

9. Start the computer and open LDM
10. Connect the optical reader
11. Insert the baro or TD Diver in the optical reader
12. Click **Read Settings from Connected Logger** (1st icon on toolbar)

NOTE: If 'no timely response' error is displayed, select application management tab and check the selected COM port is correct. To find out what COM port a device is using go to control panel, select system, click on the hardware tab and select device manager, expand ports (COM and LPT) and a list of the COM ports currently in use will be displayed. If your reader is made of clear Perspex, the outside light may affect its ability to read the data in which case you will receive the 'no timely response error'. If this happens, try covering the reader with a rag to block light.

1. Check **Sample Rate** is still correct, and sample method is **Fixed**. Check there is still space left for measurements in logger memory. [If not, you will have to first read and export measurements, then **Stop** logging, and **Restart** to free up some space]
2. If settings are correct, proceed to step 6.
3. If settings are not correct, first read and export measurements then click **Stop**, change settings, click **Program Settings to Connected Logger** icon (3rd on toolbar), click **Start Live Updating** and then click **Start Now**. Will prompt for confirmation. Note new memory full date.
4. Click **Read Settings and Measurements from Connected Logger** (2nd icon on toolbar). Logger will start downloading.
5. When download is complete, click on selected series from list and at this stage you can view the **Graph** or **Table** if desired.
6. Backup DB folder (C:\Program Files\LDM\Exe\DB) and BackupofReadings folder (C:\Program Files\LDM\Exe\back up of readings) daily.
7. Note: The BackupofReadings folder contains the .MON files which are later imported back into LoggerDataManager to compensate TDs with BaroDivers.
8. If desired, the series can be exported as a .CSV file. To export the series, click **Export** (icon 10 on toolbar):
9. Select path to export to:
    a. Level = uncompensated
    b. Export format = CSV
    c. Store as: [Filename]
    d. With field separator = ;

e. Uncheck date/time field as a single field
f. Check excel friendly
g. Export

NOTE: Each time you visit the loggers for downloading, you should manually measure the water depth at the logger to compare against the recorded logger depth. This will give indication of instrumental error. The easiest way to do this is to measure and record the distance between (a) top of pvc pipe/cable and transducer on logger, and (b) top of gal pipe and water level. Subtract (b) from (a) and you will get the depth of water the diver is sitting in.

If possible, some surveying work should be conducted at the site to determine the AHD for the Diver (as it is sitting inside the gal pipe in the waterhole) so that all Diver data can be expressed as Depth AHD. Record the Diver AHD on the fieldsheet for future reference.

### 8.4 Compensating TD Divers with Baro

The TD Diver measures water level with a pressure sensor that measures absolute pressure. Subtracting air pressure measurements from absolute pressure measurements *compensates* for air pressure variations. This is done using the LoggerDataManager wizard. The wizard uses linear interpolation for air pressure values if they are not measured at the same time as the water level. The sampling speed of the BaroDiver does not have to be the same as the Diver measurements it compensates. It only has to register the variations in the atmospheric pressure; a measurement with a fixed sampling speed of 1 per 30 minutes is usually good enough.

1. Before beginning compensation, ensure all previous records are removed from the 'Measurements', 'Locations' and 'Logger List' tabs.
2. In the **File** menu, click **Import Files**. Measurements with the following file formats can be imported: (1) Text files with the extension .MON or .LEV (2) Character-based files; these files usually have the extension .DAT. Select the required files you want to import and click **Open**.
3. The user is prompted 'Does this file contain barometer compensated data?' for each TD Diver .MON file that is imported. Click **No**. In the event that the location code of the logger that has been read is also new, then LoggerDataManager will add this location to the locations list. LoggerDataManager assigns the default location settings to the new location. You will have to change this manually if you are not compensating with the default Baro. The measurements have now been imported and saved. You can now view the measurements.
4. Click on the **Locations** tab, and check that the Barolocation is correct for the TD.
5. Click back to the **Measurements** tab and highlight the TD file under *locations* in the measurements box on the left. Check the status of the file, which is displayed in the white box on the right under **Comp**. For uncompensated files, the measurements series gets the compensation status 'Do'. If the file does contain compensated data, the series will get the status 'Done'. BaroDivers will automatically get the status 'Not appl.' because barometer compensation is not applicable.
6. Open the **Barometer wizard** ($6^{th}$ icon on toolbar). The dialog 'Barometer compensation, physical corrections and external reference' appears (Fig. 2).

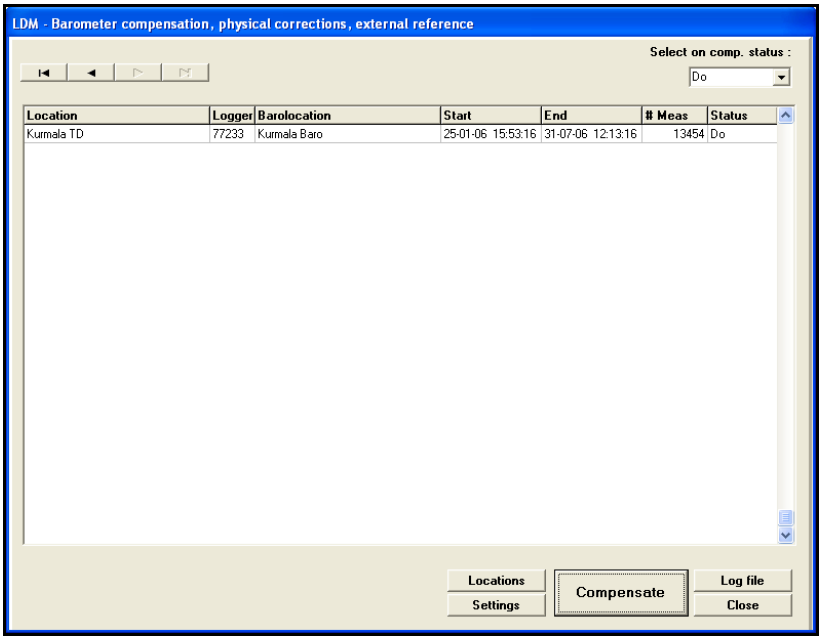



**Figure 2:** Barometer Wizard dialog box.

7. The Diver measurement series that require compensation are displayed. Check that the Barolocation is correct for compensating the TD.
8. Click on the **Compensate** button. The compensation process starts up.
9. Once the process is finished, you will see the message 'Compensation process completed. See log file', which must be confirmed. Click OK (Fig. 3)

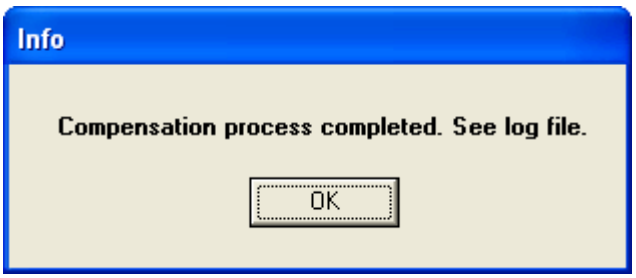



**Figure 3:** Dialog box to confirm that the process has been completed.

Click on **Close** to return to the main window of LoggerDataManager. You will now see that the status has changed from 'Do' to 'Done' (Fig. 4). See Table 1 for a list of status types and an explanation.

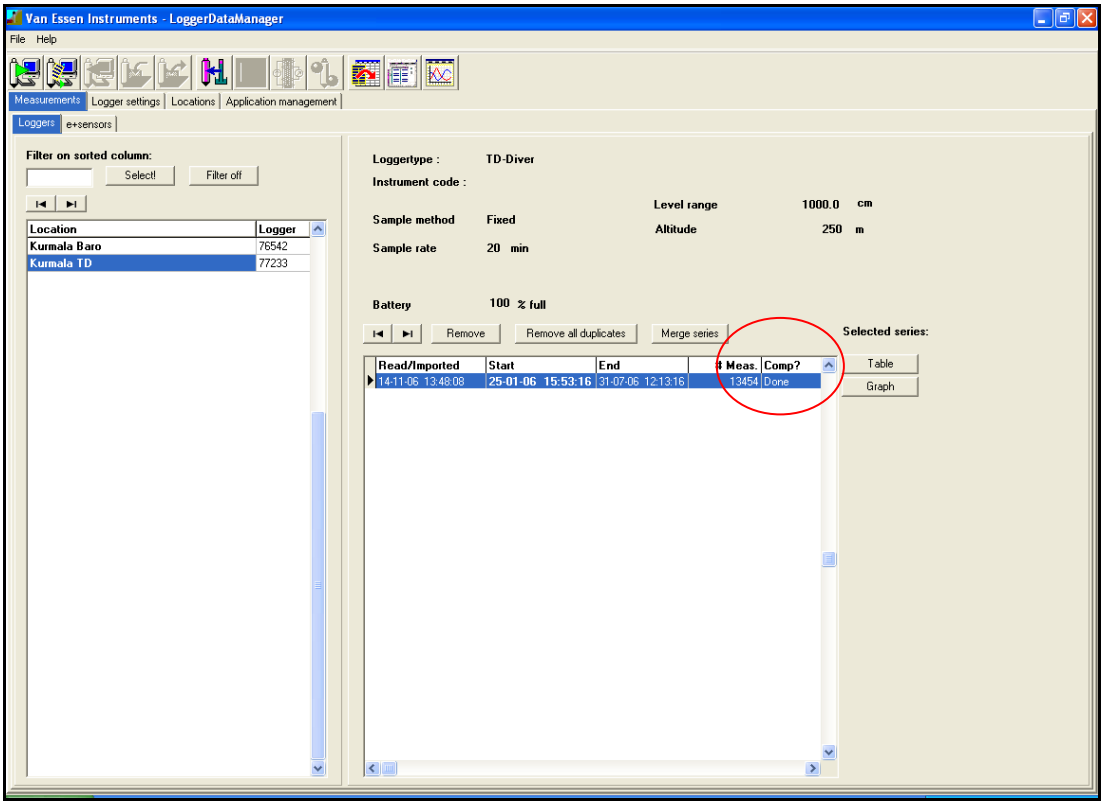



**Figure 4: Checking status after compensation**

**Table 1: List of Status types**

| Status | Explanation |
|---|---|
| Do | Compensation is still to be performed. |
| Done | Compensation is complete. |
| Unfit | Compensation is not possible due to a lack of data. |
| Incompl. | Series has been partially compensated despite the lack of barometer data throughout the entire series period. |
| Not yet | Series is theoretically due for compensation but has been temporarily excluded from compensation by you or another user. |

10. You can view the **Graph** or **Table** of the compensated series at this point, using the buttons at the right of the screen.
11. **Export** (10th icon on toolbar) the compensated series as a .CSV file (Fig. 5).

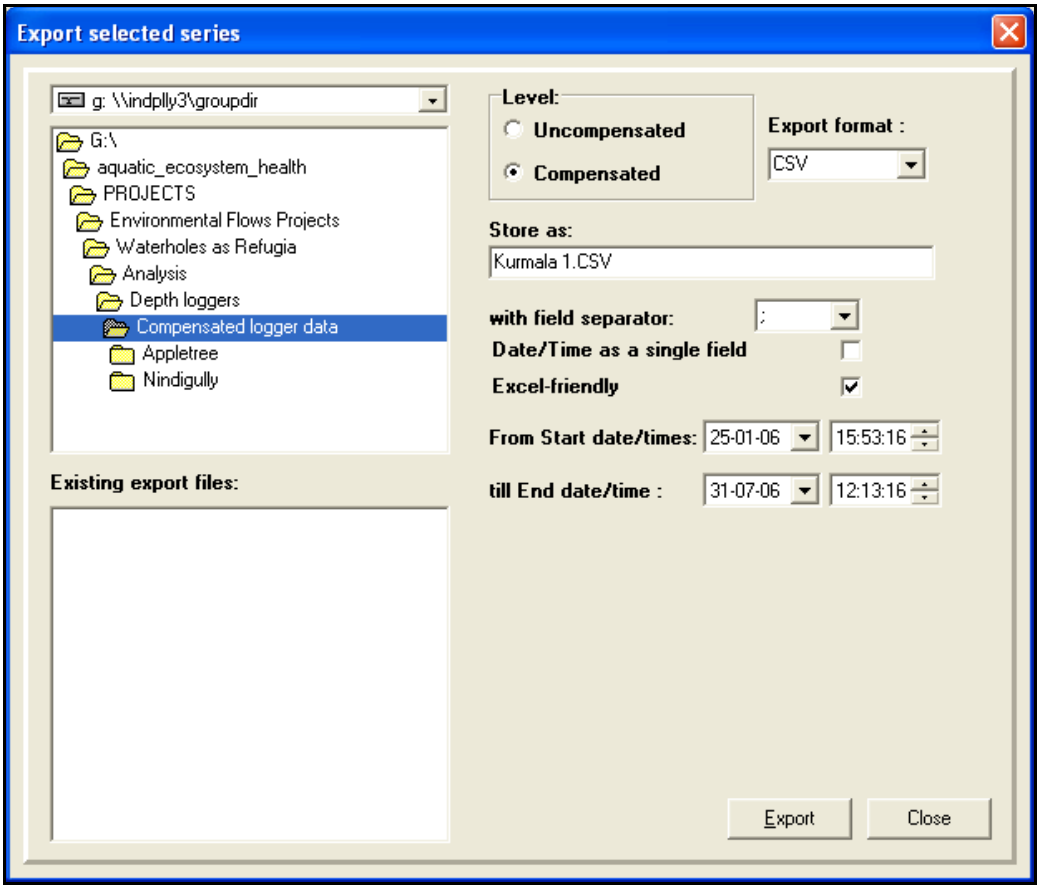



**Figure 5: Exporting the compensated series**

## APPENDIX F: Logger fieldsheet

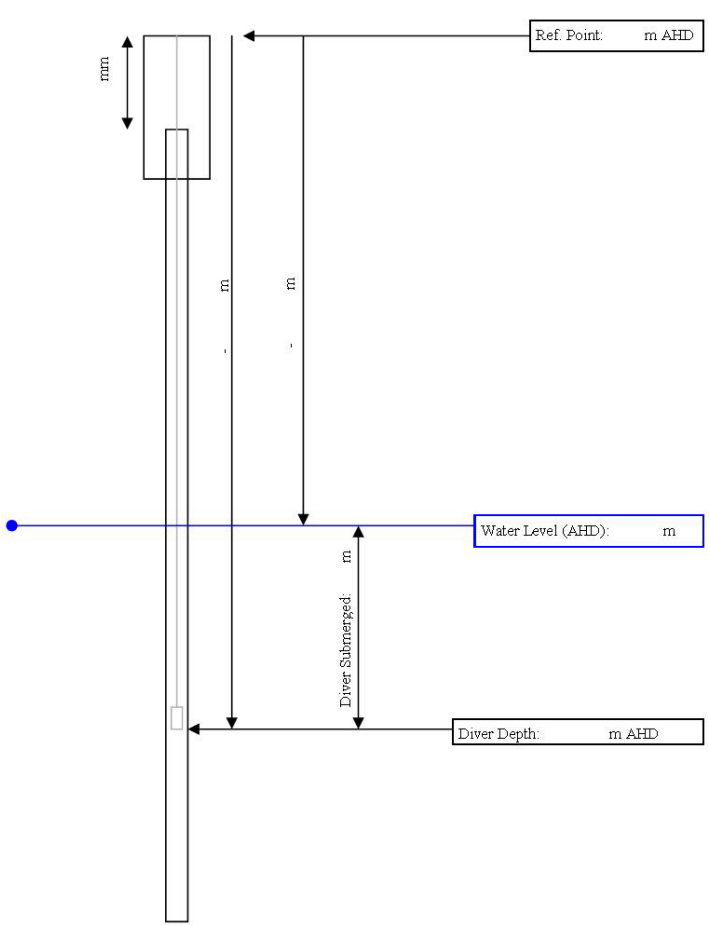
**DIVER LOGGER INSTALLATION**

| **General** | |
|---|---|
| Date: | |
| Sampler initials: | |
| Site Number and Name: | |
| Location: | |
| Project: | |
| Installation Time: | |
| Diver Number: | |
| Baro Number: | |
| Diver GPS: | S |
| | E |
| Baro GPS: | S |
| | E |
| Diver Logging Rate: | |
| Baro Logging Rate: | |
| Future Start: | Time: Date: |
| Druck Cal. Check: | Yes / No Sus / Ok |
| Photo Numbers: | |
| Additional Comments: | |
| **Surfacewater Details** | |
| Stream: | |
| Location: | |
| Remarks: | |
| GHt: | |
| Diver Depth: | |
| **Groundwater Details** | |
| Bore Number: | |
| Pipe: | |
| Water Level: | |
| Diver Depth: | |
| Total Depth of Bore: | |
| Reference Point: (AHD) | |

**DIVER LOGGER DOWNLOAD**

| **General** | |
|---|---|
| Date: | |
| Sampler initials: | |
| Site Number and Name: | |
| Location: | |
| Project: | |
| **SW Diver** | |
| Download Time: | Diver Depth: |
| Diver Number: | |
| Logging Rate: | |
| Data QA check: | Compensation complete: Yes / No / Partial |
| | Daily variation normal: Yes / No / Sus |
| | Depth data realistic: Yes / No / Sus |
| Download successful: | Yes / No / Sus |
| Replacement diver installed: | Yes / No S/N: |
| | Druck Cal Check: Yes / No / Sus |
| | Future start: Time: Date: |
| | Logging rate: |
| **GW Diver** | |
| Bore Number: | Diver Depth: |
| Download Time: | |
| Diver Number: | |
| Logging Rate: | |
| Data QA check: | Compensation complete: Yes / No / Partial |
| | Daily variation normal: Yes / No / Sus |
| | Depth data realistic: Yes / No / Sus |
| Download successful: | Yes / No / Sus |
| Replacement diver installed: | Yes / No S/N: |
| | Druck Cal Check: Yes / No / Sus |
| | Future start: Time: Date: |
| | Logging rate: |
| **Baro Diver:** | |
| Download Time: | |
| Diver Number: | |
| Logging Rate: | |
| Data QA check: | Compensation complete: Yes / No / Partial |
| | Daily variation normal: Yes / No / Sus |
| | Depth data realistic: Yes / No / Sus |
| Download successful: | Yes / No / Sus |
| Replacement diver installed: | Yes / No S/N: |
| | Druck Cal Check: Yes / No / Sus |
| | Future start: Time: Date: |
| | Logging rate: |

**Diver Installation**
**RN:**
**Date Time (24hrs)**




**Diver Installation**
**Site:**
**Date:**
**Time (24hrs):**