

# final report

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## **Review of Automatic Weather Stations for cattle feedlots**

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## Executive summary

Katestone Environmental Pty Ltd (Katestone) was commissioned by Meat & Livestock Australia Limited (MLA) to provide a review of automatic weather stations (AWS) that can measure meteorological parameters important for calculating the Heat Load Index (HLI) at a cattle feedlot site. While the National Feedlot Accreditation Scheme (NFAS) currently requires feedlots to be able to calculate cattle heat load from observations, future NFAS accreditation requirements are likely to include the mandatory real-time collection of meteorological parameters and daily calculation of HLI.

The purpose of this report is to provide feedlot managers with a standardised reference document that details information on how to meet the requirements of calculating HLI at a feedlot site, including:

- Information on instrument requirements, site selection, operation, maintenance and calibration
- A summary of a range of AWS's that meet the requirements for calculating HLI and are also suitable for uploading to Katestone's HLDN (Heat Load Data Network), detailing the AWS instruments, indicative cost and supplier contact information that can be used by a feedlot operator to purchase its own AWS
- A brief summary of alternative options for measuring heat stress at a feedlot

A list of eight AWS suitable for calculating HLI has been provided in the report, including weather station(s) from the following suppliers:

- Campbell Scientific Australia Pty Ltd
- Ecotech Pty Ltd
- Envirodata Weather Stations Pty Ltd
- Instrument Choice
- Measurement Engineering Australia (MEA)
- Pacific Data Systems Pty Ltd
- Thomson Environmental Systems Pty Ltd

The base cost of the eight AWS range between \$2,200 and \$16,000 and include, as a minimum, logger, sensors (wind speed, relative humidity, temperature (either as BGT or temperature and solar radiation)), a 2 m tower and all cables and brackets to mount instruments. The costs provided in the report should be taken as an estimate only, with actual inclusions and associated additional costs varied between suppliers. For further information and a quotation, it is advised to contact the suppliers directly.

To ensure accurate and reliable data as well as HLI and AHLU calculations, it is important to:

- Select an appropriate site for the AWS and ensure the monitor is installed correctly
- Maintain the weather station
- Calibrate the weather station sensors and conduct validation checks of the data

Further information and guidance on the above has been included in the review report, with additional assistance available by contacting Katestone and/or the AWS supplier directly.

While the eight AWS detailed in the report are the preferred option as they meet the Australian Standard and enable hourly calculation of HLI, the report has also provided a brief overview of alternative options for monitoring heat stress at a feedlot. The report also provides a brief discussion of why the alternative options are not the preferred method for monitoring heat stress at cattle feedlots.

## Table of contents

<b>1. Introduction</b> .....	5
1.1. Background.....	5
1.2. Scope of work.....	6
<b>2. Automatic Weather Station requirements</b> .....	7
2.1. Sensors .....	7
2.2. Hardware.....	7
2.3. Communication .....	7
2.4. Power Requirements.....	8
<b>3. Weather Station Good Practice Guide</b> .....	9
3.1. Siting and installation of a weather station .....	9
3.2. Maintenance of a weather station.....	11
3.3. Calibration and field checks .....	13
<b>4. Feedlot Weather Station Information</b> .....	14
<b>5. Alternative options for monitoring weather parameters to estimate heat stress in cattle</b> .....	19
5.1. Overview .....	19
5.2. Hobbyist weather stations .....	19
5.3. Hand-held weather monitoring devices .....	20
5.4. Summary .....	21
<b>6. AWS supplier contact details</b> .....	22
<b>7. References</b> .....	23
<b>8. Appendix A: Information Brochures</b> .....	24
8.1. Envirodata .....	24
8.2. Pacific Data Systems.....	24

# 1. Introduction

Katestone Environmental Pty Ltd (Katestone) has been commissioned by Meat & Livestock Australia Limited (MLA) to provide a review of automatic weather stations (AWS) that can measure meteorological parameters important for calculating the Heat Load Index (HLI) at a cattle feedlot site.

The current requirement of the National Feedlot Accreditation Scheme (NFAS) is that feedlots must be able to calculate cattle heat load from observations. The NFAS requirement does not provide guidance on the heat load calculation such as the calculation methods, duration or frequency of monitoring. Further to this, future NFAS accreditation requirements are likely to include the mandatory real-time collection of meteorological parameters and daily calculation of HLI.

The purpose of this report is to provide feedlot managers with a standardised reference document that details information on how to meet the requirements of calculating daily HLI at a feedlot site, including information on instrument requirements, site selection, operation, maintenance and calibration. This report includes a summary of a range of AWSs that meet the requirements for calculating HLI and are suitable for uploading to the HLDN (Heat Load Data Network). The summary details the AWS instruments, indicative cost and supplier contact information that can be used by a feedlot operator to purchase its own AWS. The list is not exhaustive but includes all suppliers currently servicing the industry. A brief summary of alternative options for measuring heat stress at a feedlot site is also provided.

## 1.1. Background

Katestone has been working with MLA, researchers and feedlot operators for a number of years to assist with determining heat load in feedlot cattle. The HLI and (Accumulated Heat Load Units) AHLU model is a tool to assess the heat load in feedlot cattle and is based on more than 10 years of targeted research investigating and assessing heat events in the context of Australian feedlot conditions.

Feedlot cattle can become heat stressed by prolonged periods of hot weather due to external and internal heat loads. Cattle deaths are possible during extreme heat load periods. Given prior warning and real-time calculation of HLI and AHLU, feedlot operators can take management actions such as changing diet, providing water or moving high risk cattle to shaded pens to reduce heat load.

The Cattle Heat Load Toolbox (CHLT) is an internet based service provided by Katestone since 2002 that delivers an accessible and targeted forecast of cattle heat load for feedlot sites in Australia. The CHLT service provides a site-specific forecast for feedlot operators registered with the service. Currently 250 feedlots are registered with CHLT.

During the summer season, the CHLT provides a daily forecast of the next seven days of HLI and AHLU. AHLU is a combination of the HLI and specific animal and environment factors relevant to each feedlot.

In order to improve the accuracy of the CHLT forecast service, Katestone developed the Heat Load Data Network (HLDN) in 2013. The HLDN was established because a number of feedlots receiving the site-specific CHLT forecasts had on-site weather stations. The HLDN allows feedlots to transfer their weather station data to Katestone on a daily (or hourly) basis for viewing on a website. The on-site data is used to initiate the site-specific AHLU forecast. Currently, there are 39 feedlots that provide their on-site weather station observations to the HLDN.

## 1.2. Scope of work

The 39 feedlots that provide on-site AWS data to the HLDN use a variety of techniques and different types of weather stations. Many more feedlots have on-site observations to calculate HLI but do not provide the data to HLDN.

The primary purpose of this report is to provide a standardised reference document on how a feedlot should conduct on-site weather monitoring that is suitable to calculate HLI and provide data to the HLDN. While it is not a current requirement to upload the monitoring data to the HLDN, this review report has focused on the available AWS that allow this option.

This report includes information on the following:

- Automatic weather station requirements including:
  - Meteorological parameters required to calculate HLI
  - Hardware required to calculate HLI
  - Methods of uploading data to the HLDN
- Good practice weather station guide including:
  - Siting and installation
  - Maintenance
  - Calibration and field checks
- Summary of suitable weather stations, including:
  - System description
  - Indicative cost
  - Manufacturer contact information

For the summary of suitable weather stations, Katestone has gathered information from a number of manufacturers and suppliers. It should be noted that there are a wide variety of weather stations available from inexpensive hobbyist units to scientific research grade stations. It has not been possible to provide information on all available weather stations within the budget of this report. Therefore, the focus has been on weather stations that can be used to calculate HLI and that can also be uploaded to the HLDN. A brief overview of the hand-held Kestrel agriculture and livestock heat stress trackers has been provided, along with a discussion of why these are not the preferred method for monitoring heat stress.

## 2. Automatic Weather Station requirements

### 2.1. Sensors

The calculation of HLI requires the following meteorological parameters to be measured:

- Relative Humidity (RH) expressed as a percentage
- Wind Speed (WS) in m/s
- Black Globe Temperature (BGT) in °C

In the absence of a BGT sensor, the BGT can be estimated from measurements of temperature (T) and solar radiation (SR) although it is preferred to use the BGT, as the equations used to estimate the BGT increase the error in the HLI.

Wind direction and rainfall, common instruments on AWSs, are not required to calculate HLI. However, it is noted that rainfall measurement is a requirement of NFAS accreditation.

### 2.2. Hardware

The weather station will require a data logger to record the measurements of each sensor at an interval of no longer than 1-hour. A 10-minute interval is preferred.

Once data is recorded there are two options for calculating HLI:

1. Data logger internally calculates HLI
2. Data is downloaded from logger and HLI is calculated

Having the data logger internally calculate HLI is an advantage as immediate information will be available to assess the heat load situation and, if preferred, can also be uploaded to the HLDN without further calculation (although, the HLDN does recalculate the HLI from the base parameters to provide a check of your system).

If the data has to be downloaded in order to calculate HLI, this can be done on a computer using a spreadsheet or by a simple customised program.

### 2.3. Communication

In both data logger options described in the previous section, the AWS data needs to be transferred from the AWS to either a local computer, direct to the manufacturer's server, or direct to the HLDN for storage and analysis. Three commonly used communication options are described below.

1. Weather Station to Katestone HLDN.
  - The weather station logger is connected directly to Katestone's HLDN server through a WiFi / mobile phone / satellite connection. There is no feedlot operator user requirements except to maintain the weather station in good working order (see Maintenance "Tips and Tools") and ensure that annual data costs are paid.

Your weather station data can be viewed on the CHLT web site on your "my site" page by selecting the weather station tab.

2. Weather Station to off-site server to Katestone HLDN

- The weather station is connected to the manufacturers server (e.g. Envirodata's WeatherMation or MEAs GreenBrain) through the same communications methods as Option 1. The benefit of this system over Option 1 is that the feedlot operator can view its weather station data on a website at any time. The manufacturer's server provides the data to the Katestone HLDN. There are no feedlot operator user requirements except to maintain the weather station in good working order (see Maintenance "Tips & Tools") and ensure that annual data costs are paid.

3. Weather Station to feedlot Computer to Katestone HLDN

- The weather station is connected to a computer at the feedlot via a local area network connection (WiFi or physical cable). Alternatively, weather station data can be manually transferred from the weather station to the feedlot computer using a USB device (labour intensive process). Once the data is on the feedlot computer, if required, it can be sent to the HLDN via the internet. A scheduled task can be setup to do this on a daily basis.

The method of communication between the weather station, the feedlot operator and the HLDN is variable and subject to a number of factors. One factor that remains constant is the ability to connect to the internet, whether it is via WiFi, 3G/4G, broadband, cable or satellite, one way or another to reach the HLDN, your feedlot needs to access the internet.

The recommended method of communication and data transfer is Option 2, the data is sent from the weather station to the manufacturer's off-site server before being sent to Katestone HLDN. The feedlot operator is then able to view the data on either the manufacturers or Katestone's website. This option is the most reliable and has no feedlot operator requirements following the initial setup, other than ensuring data costs are paid and the monitoring station is maintained in good working order. Manufacturers are also able to assist with the ongoing maintenance of the weather station at an additional cost.

## 2.4. Power Requirements

A weather station can be run off either mains power or using a solar panel. The advantage of using a solar panel system is that during any mains power outages (such as storms) the solar systems will continue to log data. Weather stations with solar panels are also not constrained by main power connection availability making siting easier. Further to this, the majority of solar panel systems include a battery backup system that provides power in the instances when solar power is unavailable or reduced (such as night-time and cloudy days). It is important to keep track of the status of the battery as this can impact the recording of some instruments at night (see "Tips & Tools" for more information).



### 3. Weather Station Good Practice Guide

This section provides an overview of important considerations for operating a weather station at a feedlot to measure heat load. Information has been provided on the:

- Siting and installation of a weather station
- Maintenance of a weather station
- Calibration of a weather station and validation of data

#### 3.1. Siting and installation of a weather station

A weather station should be sited so the variables measured are representative of the general surrounds. Subtle variations in the environment may mean that the data are not representative. For example, a tree shadow falling across a BGT sensor will result in HLI and AHLU values that are lower than they should be for as long as that shadow is on the sensor.

Weather stations operated by the Australian Bureau of Meteorology have strict siting requirements and have to meet an Australian Standard (AS 3580.14). The siting requirements from the Australian Standard for temperature, relative humidity and solar radiation are summarised below. Note that there is also requirement for the siting of wind sensors at a height of 10 m above ground level. This requirement is not needed for the measurement of heat load as measurements at 2 m are more representative of the wind speed at the height of the animal.

Temperature and relative humidity:

- Mounted over a plot of open level ground at least 9m in diameter free of obstructions, and freely exposed to sunshine and wind
- To be clear of obstructions, this means a distance of at least four times the obstruction height
- Located at least 30m from large paved areas and not close to hollows or ridges or other changes in terrain
- Area should ideally be unwatered short grass, or natural earth (not concrete)
- Should not be located close to artificial or natural sources of moisture
- Measurements at 2m or higher above ground

Solar radiation and black globe temperature:

- An upward-looking solar radiation sensor should be free from any obstructions above the sensor
- No shadows should be cast on the sensor
- Should be located away from light-coloured walls or other objects likely to reflect sunlight

It is sometimes not practical to meet these standards at a particular location. In these instances, the station should ideally be located:

- On a flat cleared area - either a grassy surface, or one that is similar to the feedlot
- Clear from obstructions such as buildings and trees (a rule of thumb would be to locate the weather station ten times the height of the obstruction away)

The station should not be:

- In a gully or other depression
- On a geological formation such as a rock outcrop
- On or near steep slopes, cliffs, or ridges
- On a veranda or under an awning

If there is a solar panel, this should face north.

Further to the above Australian Standard, ISO standard 7243 (1998) *"Hot environments - Estimation of the heat stress on working man, based on the WBGT-index wet bulb globe temperature"* includes specific requirements for measurement of BGT, including:

- Globe diameter: 150 mm
- Mean emission coefficient: 0.95 (matt black globe, as thin as possible and preferably made of copper)
- Measuring range 20°C - 120°C

The Australian Standard AS 3580.14 also provides a minimum requirement for weather monitoring equipment accuracy. Table 1 details the relevant accuracy requirements for sensors likely to be used at a feedlot.

**Table 1 Minimum requirement for weather monitoring equipment accuracy (AS 3580.14)**

Sensor	Minimum requirements
Wind speed	±2 m/s or 1%
Relative humidity	±2% (10-90% RH), ±4% (90-100% RH)
Air temperature	±0.3°C
BGT	Assume Air temperature accuracy <sup>1</sup>
Note <sup>1</sup> Not part of the Australian Standard	

### 3.2. Maintenance of a weather station

The quality of the AWS data collected is important for accurate calculation of HLI. Manufacturers of weather stations will usually provide recommendations to keep your AWS in good working condition for optimum data integrity. We recommend that your AWS is serviced once every year by a professional; however, between services it is a good idea to routinely check your weather station to make sure all sensors are clean, free of debris and insects and in good working condition. Once a sensor has been identified as faulty it is usually best to replace the sensor rather than try and repair it, with most sensors having a warranty period. It is a good idea to write down the serial numbers of each instrument on your AWS to ensure any replacement of parts or the entire instrument is with the correct sensor.

Specific tips for the typical parts common to an AWS are detailed in Table 2.

**Table 2 Weather station maintenance tips and recommended frequency**

Component	Tips	Recommended frequency
General AWS tips	<ul style="list-style-type: none"> <li>Inspect cables and make sure certain mounting brackets, poles, posts, etc. are stable, vertical and sound and that all AWS instruments are securely fastened.</li> <li>Open the weather station enclosure and use a flashlight to check for corrosion near plugs and connectors.</li> </ul>	At least once per year
Pole and tripod	<ul style="list-style-type: none"> <li>The AWS pole or tripod should be checked every 6 months.</li> <li>Checks should include the level and alignment of the tripod and checks for structural or physical damage.</li> <li>If structural or physical damage is identified then the pole or tripod should be replaced immediately.</li> </ul>	At least once every six months
Cables	<ul style="list-style-type: none"> <li>If the AWS is cabled then the wiring and cable connectors should be checked for damage from exposure to the elements.</li> <li>Wiring and cables that show damage should be replaced to ensure the AWS data collection is accurate.</li> <li>Wires should be free from any strain.</li> </ul>	At least once every three months
Enclosure	<ul style="list-style-type: none"> <li>Desiccant is used as a drying agent in a data logger enclosure. The humidity indicator card (if included) should be checked every month and replaced after every 2 to 3 years. The desiccant packs should be changed if the humidity inside the enclosure becomes more than 35%.</li> <li>The sealing of the data logger enclosure and the access</li> </ul>	Every month

	<p>hole for wiring should be checked carefully in order to prevent pest entry and unnecessary condensation inside the enclosure.</p>	
<p>Temperature, BGT and relative humidity sensors</p>	<ul style="list-style-type: none"> <li>• The temperature, BGT and humidity sensors should be cleaned with distilled water.</li> <li>• Any debris like dust, webs, etc should be removed from the radiation shield.</li> <li>• Check the coating on the BGT sensor and ensure it is solid matt black all over</li> </ul>	<p>Every month</p>
<p>Wind sensor</p>	<ul style="list-style-type: none"> <li>• A visual inspection of the anemometer at low wind speed should be done to ensure free movement.</li> <li>• If the anemometer delivers any unusual humming sound or rotation (for cup and vane types), then there might be some problems with the bearings of the anemometer. Replacement of bearings or any of the anemometer parts must be always conducted by an experienced technician or by the manufacturer itself.</li> </ul>	<p>Every month</p>
<p>Solar radiation</p>	<p>Check the solar radiation sensor is level and free from any dirt or dust. The level of the sensor can be checked with the help of a levelling bubble. Any dust or debris on the sensor head should be removed by using compressed air or a soft bristle brush.</p>	<p>Every month</p>
<p>Power supply including solar panels</p>	<p>If the weather station is solar powered, the panel must be checked for the following:</p> <ul style="list-style-type: none"> <li>• Orientation must be checked and adjusted for proper tilt and direction.</li> <li>• The glass of the solar panel should be checked and cleaned with a soft and slightly moistened cloth, because if the glass is dusty it can reduce the power output of the solar panel.</li> <li>• Never use abrasive pad or cleaner as these might put a scratch and permanently damage on the glass of the solar panel.</li> <li>• Make sure that no part of the solar panel is covered in shade</li> <li>• The solar panel must always be faced towards the north direction. Tree branches that are likely to provide shade to the solar panel should to be removed. Plants or trees that are growing around the pole or tripod holding the</li> </ul>	<p>Every three months</p>

	<p>weather station solar panel unit must be removed, as these might cause problems later in future.</p> <ul style="list-style-type: none"> <li>• If any problem is suspected with the output of the solar panel, then the voltage should be checked. If there is a problem, the solar panel should be checked by an experienced technician or sent back to the manufacturer.</li> </ul>	
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### 3.3. Calibration and field checks

Calibration is the practice of checking an instrument against another of known accuracy, or with a process of known properties. Calibration is essential to provide accurate data but is one of the most commonly neglected tasks.

Calibration can be difficult to achieve without access to standard, calibrated check-instruments and an approach in accuracy to that is only achieved in the professional environment. This can only be achieved by sending instruments to the manufactures at a considerable cost; however, it is best to calibrate weather stations every two years using an approved technician or the manufacturer of the equipment to ensure the accuracy of the sensors are within approved limits. The Australian Standards (AS/NZ 3580.14:2014) recommend calibration of sensors at an interval not exceeding 2 years. The specific calibration frequencies for each sensor to meet the Australian Standards are provided in Table 3. Calibration checks can be carried out by returning the sensor to an accredited laboratory or by performing a field check using the steps outlined in AS/NZ 3580.14:2014. It is important to plan ahead for a suitable time to take the weather station off-line for maintenance. This could be during winter when cattle heat load events are less likely to occur.

**Table 3 Recommended frequency of calibration of sensors to ensure compliance with Australian Standards**

Parameter	Recommended calibration frequency
Wind speed and wind direction	Checked or recalibrated at an interval not exceeding two years, with dusty or corrosive conditions requiring more frequent checks.
Ambient temperature	An operational recalibration at an interval not exceeding twelve months as well as a single point (in-situ check) at an interval not exceeding six months.
Relative humidity	A calibration procedure at an interval not exceeding twelve months as well as an operational precision check at an interval not exceeding six months.
Solar radiation	Recalibration at an interval not exceeding twelve months.

While calibration cannot be done onsite, it is recommended that simple field checks occur from time to time to ensure the weather station is in good working order. A number of simple field checks are detailed below.

For relative humidity and temperature sensors, periodically check the readings against readings from another nearby weather station such as any Bureau of Meteorology stations. If possible, use a thermometer (traditional glass one will do) to check readings of the temperature sensor. A check on relative humidity can be done during dewy mornings or rainy weather, during this type of weather the sensor should be reading close to 100%, if not then the sensor may be in error.

For the wind sensors, the anemometer should spin freely and be free of debris of any kind. Periodically inspect the anemometer in strong wind conditions (20 - 30 km/hr or 5 - 8 m/s) and calm conditions (winds less than 2 km/hr or 0.5 m/s) and check the data being recorded to make certain it is working correctly. If your sensor records zero wind speed for a significant period of time this may indicate a fault. If your sensor records zero wind speed every night, there may be an issue with the battery backup of your solar panel.

A simple field check for BGT involves checking the readings against a recently calibrated benchmark sensor side by side. While two sensors are unlikely to have the exact same reading, the differences between the readings should be less than the sum of the inaccuracies of the two sensors.

Hand held instruments can be used as a simple check of your system. They are typically less accurate and therefore should not be solely relied on, but will generally indicate if a sensor is malfunctioning.

## 4. Feedlot Weather Station Information

This section provides a summary of currently available weather stations that can be used to calculate HLI and are suitable to the data to the HLDN if desired. Katestone contacted a number of manufacturers and suppliers to request information regarding weather stations that meet these requirements. Information was provided from the following suppliers:

- Campbell Scientific Australia Pty Ltd
- Ecotech Pty Ltd
- Envirodata Weather Stations Pty Ltd
- Instrument Choice
- Measurement Engineering Australia (MEA)
- Pacific Data Systems Pty Ltd
- Thomson Environmental Systems Pty Ltd

All of the AWS summarised in this report include sensors for measuring wind speed, relative humidity, air temperature and solar radiation, while six out of the eight presented measure black globe temperature. The measurement of BGT is preferred for the calculation of the HLI and AHLU, however, a BGT can be estimated from the measurements of temperature and solar radiation.

Table 4 presents basic information on each AWS including the unit name and the parameters measured. As a way of ensuring that weather station costings were comparable, a minimum specification in terms of sensors, components and data access was developed to determine the base cost of each AWS.

The basic cost of the AWS has been presented in Table 5 and includes, at a minimum, logger, sensors (wind speed, relative humidity, temperature (either as BGT or temperature and solar radiation)), a 2 metre tower and all cables and brackets to mount instruments. The costs should be taken as an estimate only. You should contact the weather station suppliers directly to obtain a quotation for the delivery of a system.

The base cost of the eight AWSs provided in this review ranged between \$2,220 and \$16,000. Additional cost considerations include power requirements, data and communications cost, additional hardware for Australian Standard compliance (if required), installation, software and maintenance. Actual inclusions and associated additional costs vary between suppliers.

Table 5 also provides additional information on the AWS including the following:

- Method for HLI calculation (internal/external to logger)
- Communication and data transfer method
- Installation and software requirements
- Base cost inclusions
- Any additional costs

Generally, communication options are both hardwired and wireless, depending on the site location. The cost for communication is not typically included in the base price, however, the supplier can provide a cost estimate. Some of the units can be installed by the end user following a simple instructional video or manual included with the unit; while others require the supplier to install the station at an additional cost.

An estimated annual cost for the first year for each AWS is provided in Table 5. This is based on the base cost provided as well as any specific additional requirements detailed by the supplier, including installation, software, and data and communication costs if organised through the supplier.

Further information on each weather station can be obtained by contacting the suppliers directly and requesting a quotation.

**Table 4 Summary of suitable AWS for calculation of HLI and upload to HLDN – basic requirements**

Manufacturer / Supplier	Model	Required parameters						Meets Australian Standards
		Wind speed	Relative humidity	Air temperature	Solar radiation	Black Globe Temperature (BGT)	Solar power	
Campbell Scientific	CR300 Standards based AWS	yes	yes	yes	yes	yes	yes	yes
Campbell Scientific	CR300	yes	yes	yes	yes	yes	yes	All except wind speed
Davis Instruments (Instrument Choice)	6163AU-IP	yes	yes	yes	yes	no	yes	All except wind speed and temperature
Ecotech	-	yes	yes	yes	yes	no	yes	Yes
Envirodata	Weather Maestro	yes	yes	yes	yes	yes	yes	yes
MEA	MEA153 Feedlot Weather Station	yes	yes	yes	optional	yes	yes	yes
Pacific Data Systems	PDS-AWS-FL-3G	yes	yes	yes	yes	yes	yes	No
Thomson Environmental Systems	Met Master Pro 1000 (MMP1000) and Weather Sensor 501 (WS501)	yes	yes	yes	yes	yes	yes	yes



**Table 5 Summary of suitable AWS for calculation of HLI and upload to HLDN – Features and estimated cost (list in alphabetical order by manufacturer)**

Manufacturer / Supplier	Model	Basic cost (\$ excl GST)	Features							Estimated annual cost for first year*
			HLI calculated in logger	Communication and Data Transfer			Installation & Setup	Software	Additional costs	
				Type	Details	Communication and data cost				
Campbell Scientific	CR300 Standards based AWS	\$14,095	yes	Hardwired and wireless	3G or satellite available depending on site location	Not included	End user install	Required at a cost of \$955		\$15,050
Campbell Scientific	CR300 Standards based AWS	\$9,523	yes	Hardwired and wireless	3G or satellite available depending on site location	Not included	End user install	Required at a cost of \$545		\$10,068
Davis Instruments (Instrument Choice)	6163AU-IP	\$2,220	no	Hardwired and wireless	Wireless outdoor sensors to indoor console, hardwired Ethernet cable from console to broadband router	Included in basic cost	End user install	N/A		\$2,220
Ecotech	-	\$16,000	yes	Hardwired and wireless	3G	Can be included at an additional cost of \$1,100 per year (communication) and \$170 per month (website access and daily data check provided by Ecotech)	Manufacturer installation required at a cost of \$750	N/A	10m mast for AS compliance (+\$3,400+ install), NATA calls of sensors prior to install (\$2,800) and annually (+\$1,600) (except wind which is every 2 years(+\$1,200))	\$19,890
Envirodata	Weather Maestro	\$5,950	yes	Hardwired and wireless	Direct cable / Ethernet / MODBUS / Cellular Modem / UHF / Satellite / Web Portal / SMS / Email / FTP	Included at an additional cost of \$350 per year (free first year) for WeatherMation LIVE service and \$37.50 per month for data (uploaded once per minute)	End user install	Included in basic cost	10m mast for AS compliance as well as second wind speed sensor at 2m for HLI/AHLU calculation (+\$4,900+ install)	\$6,400
MEA	MEA153 Feedlot Weather Station	\$5,300	No, but can be calculated on local PC using software	Wireless ONLY (VHF/UHF, 3G, satellite, etc.)	Can be downloaded to local PC at no additional expense, or can transmit through Telstra network at a cost of \$250 per year	\$250 per year if downloading using Telstra network	Can be installed at additional cost of \$950	Magpie software for local PC and calculation of HLI included in package. A	\$300 for shipping (refundable on return of shipping crate) unless installed by supplier.	\$5,650

Manufacturer / Supplier	Model	Basic cost (\$ excl GST)	Features							Estimated annual cost for first year*
			HLI calculated in logger	Communication and Data Transfer			Installation & Setup	Software	Additional costs	
				Type	Details	Communication and data cost				
			package (included)					website can be created for a single station at a cost of \$1,900 plus \$100 for each additional weather station	Optional solar radiation sensor at \$950	
Pacific Data Systems	PDS-AWS-FL-3G	\$4,999	Yes	Wireless ONLY (VHF/UHF, 3G, satellite, etc.)	3G only, this comes with a mandatory monthly subscription www. Spokedata.com.au (this includes 3G data consumption, SMS/email alerting, email reporting and access to hosted data at web portal.	Included at an additional cost of \$360 per year	End user install	N/A		\$5,359
Thomson Environmental Systems	Met Master Pro 1000 (MMP1000) and Weather Sensor 501 (WS501)	\$9,355	yes	Hardwired and wireless	Can operate via Modem or direct connection	Can be included at an additional cost of \$420 per year (communication) and \$150 per month (data and basic report provided by TES)	End user install	N/A		\$11,575

Table note:  
 \* Estimated annual cost for first year is based on the base cost provided as well as any specific additional requirements detailed by the supplier, including installation, software, and data and communication costs if organised through the supplier.

## 5. Alternative options for monitoring weather parameters to estimate heat stress in cattle

### 5.1. Overview

The current requirement of the National Feedlot Accreditation Scheme (NFAS) is that feedlots must be able to calculate cattle heat load from observations. The previous sections of this report have provided information on AWSs that meet the Australian Standards and enable hourly calculation of HLI and the daily upload of data to the HLDN. These are the preferred options to monitor heat stress at a feedlot. However, there are other options available that allow feedlot operators to monitor weather conditions at their site that can give an indication of the level of heat stress including:

- Hobbyist weather stations
- Hand-held devices

These types of weather stations/instruments are generally cheaper than the AWSs detailed in Section 4. However, there are some disadvantages to using them rather than one of the preferred AWS presented in Section **Error! Reference source not found.**

### 5.2. Hobbyist weather stations

There are a wide variety of hobbyist weather stations available for under \$500 such as:

- Oregon Scientific - WMR86 Complete Home Weather Station
- Instrument Choice - IC0348 Wireless Weather Station with Touch Screen
- Digitech - Wireless Weather Station XC-0348

As a minimum, to calculate HLI, a weather station is required to measure wind speed, relative humidity, BGT and/or temperature and solar radiation for the calculation of the HLI. The majority of hobbyist weather stations do not measure BGT or solar radiation.

The hobbyist weather station instruments will also not provide a sufficient level of accuracy. Therefore, the HLI calculation using data from the hobbyist weather station may be misrepresentative of the actual heat load. Most hobbyist weather stations units are generally battery or AC operated and supplemented by solar power. They are not usually designed for long-term use in a harsh environment and have reduced storage for data logging. In addition, the transmission distances are generally limited to a few hundred metres between the sensor and console. Hobbyist weather stations are generally designed for personal use (in homes or schools).

Notwithstanding the above, a cheap hobbyist weather station could be used by a feedlot operator as a backup option for emergency situations such as power failure at the site. They could also be used as an alternative measurement to check the AWS is working properly.

### 5.3. Hand-held weather monitoring devices

Examples of this type of weather monitoring device include the range of handheld Kestrel pocket weather meters supplied by Pacific Data Systems (and others) or available directly from the manufacturers web site (<http://kestrelmeters.com.au/collections/agriculture>).

Typically, these hand-held devices are used for monitoring current or short-term weather conditions out in the field. The monitors can be set up on a mount to provide a data-logging weather station; however, this is limited to the more expensive devices and logging is limited to up to 2,000 data points before the data must be manually uploaded to a computer. The devices are also less weather resistant compared to those presented in Section **Error! Reference source not found.**

The Kestrel agriculture and livestock range of heat stress trackers are between \$250 and \$1,800. A basic description and features of the models are provided in Table 6.

The simplest system (DROP D2) is designed to be a small monitor that can be hung inside a barn, transport vehicle or livestock housing facility and monitors temperature, relative humidity and dew point temperature which are then used to provide an indication of Temperature-Humidity Index (THI) and Dew Point Temperature. While this model cannot be used to calculate HLI or AHLU, it can give an indication of heat conditions. The THI calculation is limited as it fails to account for sun, air flow or accumulation effects.

The top of the range, 5400 system, is a hand-held monitor that can be used within the pen or yard to perform spot-checks on heat stress conditions. This model monitors black globe temperature, relative humidity and wind speed and can also provide an indication of THI, HLI and AHLU based on input herd and pen parameters. However, any calculations of HLI need to be interpreted with caution due to the reduced accuracy of hand-held devices. We don't recommend using the device to calculate your AHLU as it will not take into account the true historical conditions. If you are sure you start monitoring in one location when the load is zero and then leave the monitor in the same location, then it may give you some indication of the heat load. This model can also be mounted at the pen to provide continuous measurements; however, battery life is limited to around 400 hours and data transfer through Bluetooth/wireless is limited to within 100 feet.

The limited accuracy and specification range of the wind speed, temperature and relative humidity sensors means that the kestrel handheld monitors do not meet the requirements of the Australian Standards (AS/NZ 3580.14:2014). The Kestrel devices are also only applicable to certain conditions, with direct and prolonged sunlight affecting the accuracy of the sensors. In addition, following exposure to rapid changes in environmental conditions the sensors require an equilibration period (up to around 15 minutes) to reach stated accuracy.

**Table 6 Hand-held Kestrel agriculture and livestock heat stress trackers**

Information	Drop D2AG Livestock Heat Stress Monitor	5200 Professional environmental Meter	5400 Cattle Heat Stress Tracker with LiNK + Vane Mount
Cost <sup>3</sup>	\$249	\$669	\$1,799
Wind speed	no	yes <sup>1</sup>	yes <sup>1</sup>
Relative humidity	yes <sup>1</sup>	yes <sup>1</sup>	yes <sup>1</sup>
Air temperature	yes <sup>1</sup>	yes <sup>1</sup>	yes <sup>1</sup>
Solar radiation	no	no	no
Black Globe Temperature (BGT)	no	no	yes <sup>2</sup>
Table note: <sup>1</sup> Not measured to Australian Standards AS/NZS 3580.14.:2014 <sup>2</sup> Not measured to International Standards ISO 7243 <sup>3</sup> Costs are in Australian Dollars excluding GST ( <a href="http://kestrelmeters.com.au/collections/agriculture">http://kestrelmeters.com.au/collections/agriculture</a> accessed 10 January 2017)			

## 5.4. Summary

While the limitations of alternative weather stations discussed here indicate the preference to the AWS provided in Section **Error! Reference source not found.**, there are advantages to using a hand-held device, to supplement the data provided by the preferred AWS, for example to:

- Assist in calibration and validation of data
- Provide a backup monitoring system in the event of an emergency (power outage, battery fail, etc.)
- Mobile monitoring at locations across the feedlot
- Hot spot monitoring to identify high risk pens

## 6. AWS supplier contact details

Contact details for suppliers of the AWSs detailed in Section **Error! Reference source not found.** are provided in Table 7. Further information on the weather stations discussed in this review can be found on the websites of each supplier and by contacting suppliers directly.

**Table 7 Details of weather station suppliers**

Supplier	Weather Station	Contact person	Contact details
Campbell Scientific Australia Pty Ltd	CR300	Gavin Hewitt	411 Bayswater Road Garbutt, QLD 4814  Phone: 07 4401 7700 Email: gavin@campbellsci.com.au Website: <a href="http://www.campbellsci.com.au">www.campbellsci.com.au</a>
Ecotech Pty Ltd	Various	Mark Neaves	84 Lomandra Drive Brisbane Airport, QLD 4008  Phone: 07 3393 7407 Email: mark.neaves@ecotech.com Website: <a href="http://www.ecotech.com">www.ecotech.com</a>
Envirodata Weather Stations Pty Ltd	Weather Maestro	Matthew Probeta	42-44 Percy Street Warwick Queensland 4370  Phone: 07 4661 4699 Email: sales@envirodata.com.au matthew@envirodata.com.au Website: <a href="http://www.envirodata.com.au">www.envirodata.com.au</a>
Instrument Choice	Davis 6163AU-IP	Tim Trainor	22A Cavan Road Dry Creek SA 5094  Phone: 1300 737 871 Email: tim@instrumentchoice.com.au Website: <a href="http://www.instrumentchoice.com.au">www.instrumentchoice.com.au</a>
Measurement Engineering Australia (MEA)	Feedlot Weather Station	Joe Hoogland	41 Vine Street MAGILL SA 5072  Phone: 08 8332 9044 Email: joe.hoogland@mea.com.au Website: <a href="http://www.mea.com.au">www.mea.com.au</a>
Pacific Data Systems Pty Ltd	PDS-AWS-FL-3G	Paul Gapes	27 Hi-Tech Court Eight Mile Plains QLD 4113  Phone: 07 3361 2000 Email: sales@pacdatasys.com.au Website: <a href="http://www.pacdatasys.com.au/">http://www.pacdatasys.com.au/</a>

Thomson Environmental Systems Pty Ltd	MMP1000 with WS501 sensor	Paul Thomson	3/65 Captain Cook Drive, Caringbah NSW 2229 Phone: 02 9526 8199 Email: paul.t@thomsongroup.com.au Website: <a href="http://www.thomsongroup.com.au/">http://www.thomsongroup.com.au/</a>
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## 7. References

Katestone, 2013. *Final Report: Weather Station Review*, prepared for Meat & Livestock Australia June 2003.

SAI Global, 2014. Australian/New Zealand Standard (AS/NZS) 3580.14.2014 Methods for sampling and analysis of ambient air – Part 14: Meteorological monitoring for ambient air quality monitoring applications.

SAI Global, 1989, International Standard (ISO) 7243 Hot environments – Estimation of the heat stress on working man, based on the WBGT-index (wet bulb globe temperature

## **8. Appendix A: Information Brochures**

### **8.1. Envirodata**

### **8.2. Pacific Data Systems**





## Feedlot Weather Stations

Envirodata has designed and built weather stations to meet the needs of Lot Feeders for over 25 years.

Our current generation of feedlot weather stations are tougher, more accurate, more reliable, and better at surviving Feedlot conditions than any other weather station on the market.

### Features:

- Robust, Reliable & durable
- Easy to install, easy to use
- HLI & AHLU built in
- Accurate sensors not prone to drift
- Industrial & Commercial grade
- Designed specifically for weather recording
- Australian Designed, Owned and Made
- Local Support and backup, we are the manufacturer
- Installation and servicing on site available
- Current readings, 10 minute, hourly and daily weather data
- Over 12 months data storage typical.
- *Upgrades from older systems a speciality*

### Heat Stress Weather Stations

- Full size 6" Copper Globe for Black Globe Temperature
- 3 Cup Anemometer with ceramic bearings
- Relative humidity sensor with field replaceable tip

Envirodata's Weathermate, WeatherMaster 3000 and Weather Maestro weather stations can all calculate HLI and AHLU. Each system uses the heat stress algorithms exactly as published by Katestone Environmental & MLA.



12 year old station upgraded to Weather Maestro in 2013



Weather Maestro with UHF link installed 2010

### Envirodata Weather Stations Pty Ltd

P.O. Box 395, WARWICK, Queensland, 4370, Australia

Phone: (07) 4661 4699

Fax: (07) 4661 2485

ABN: 77 131 757 125

Int. Phone: + 61 7 4661 4699

Int. Fax: +61 7 4661 2485

Proudly Australian Owned

<http://www.envirodata.com.au>

e-mail: [sales@envirodata.com.au](mailto:sales@envirodata.com.au)

Version 140312



## More than Heat Stress

Environdata's feedlot weather stations are exceptional at monitoring your feedlot for heat stress. However your feedlot may have additional weather monitoring requirements.

## Dust or Odour Drift

If you have an environmental licence to monitor dust or odour drift, then our wind direction sensor and air movement firmware are a worthwhile upgrade. You might even need to use our 10 metre mast to mount the wind sensors to meet Australian Standards.

## Rainfall

Rainfall monitoring is required as part of your feedlot accreditation, so why not add a tipping bucket rain gauge to your weather station to automate your rainfall data collection?

Whatever your additional weather monitoring needs, perhaps needing soil moisture or ETo for a cropping operation, we will be happy to help build a solution to meet them.

## Connectivity Options

- Direct cable
- UHF Links
- Next G Modems
- Satellite Modems

Whatever your requirements, we can provide a method for getting your data onto your network and in front of the staff you need to see it.

## Integration Options

### Katestone

We have worked with Katestone many times to achieve data connection from our feedlot weather stations into their databases. This enables your feedlot to have forecasts and nutrition advice tailored to your site specific weather conditions.

## WeatherMation LIVE

Environdata's WeatherMation Live service takes all the headache out of managing your data collection, storage and distribution.

- Environdata manages data collection, storage and distribution for you
- Hosted on Environdata's secure servers
- One or many Weather Stations
- One or many users with secure login access from any web browser
- Live & historical weather data
- Optional SMS and E-mail alerts
- Automatic FTP of your data to Katestone (on your behalf, at your request)
- Mobile device display

Talk to us about how this service may make your data collection and management easier than ever.



10m Mast Weather Maestro to suit Australian Standards

## Environdata Weather Stations Pty Ltd

P.O. Box 395, WARWICK, Queensland, 4370, Australia

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e-mail: [sales@environdata.com.au](mailto:sales@environdata.com.au)

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## Feedlot Weather & HLI/AHLU Monitor

### *Heat Stress Management For Livestock*

*Excessive heat load (EHL), or heat stress, can be detrimental to the health and wellbeing of livestock (potentially resulting in death), as well as leading to reduced feed intake, fertility and milk production. For primary producers this equates to a loss of income and increase in operational costs. Therefore, being forewarned and knowing when to implement effective heat stress management programs, is crucial to a productive livestock industry.*

### Benefits and Features

- **Respond Quickly To Excessive Heat Load Events**  
Activate your EHL event response plan prior to physical signs of heat stress being identified. Avoid production losses and possible cattle deaths.
- **Complete Automation**  
No time-consuming manual measurements or calculations required.
- **Long-Term Reliability - Made For Rugged Environments**  
No moving parts means no maintenance. Sensors are “field-replaceable” by the user.
- **Fast Installation**  
Integrated “turn-key” design simplifies on-site installation. Professional installer or electrician not required.



The *Pacific Data Systems* Feedlot Weather Heat Load Index and Accumulated Heat Load Unit (HLI & AHLU) Monitor addresses the needs of the livestock and feedlot industry.

The HLI & AHLU Monitor records relative humidity, wind speed and black globe temperature readings. It then uses these readings to calculate the Heat Load Index and Accumulated Heat Load Unit, to assess and inform producers on the real-time heat stress conditions experienced by livestock.

The system has been engineered and manufactured in Australia using custom-developed sensors and existing instrumentation.



## Standard Inclusions

- *Ultrasonic wind, temperature & relative humidity sensor*
- *Black Globe Temperature sensor*
- *Internal data logger*
- *Weatherproof Enclosure*
- *Solar panel and battery backup*
- *Mast*

## Optional



### *Remote data communications (Radio, 3G or Satellite)*

- Access your HLI & AHLU Monitor anywhere, anytime\*



### *Tipping bucket rain gauge*

- For a complete weather station.

## Specifications

Sensor	Accuracy	AS (Australian Standard)
Wind speed	±0.5m/s or 10% winds < 5 m/s ±1m/s or 5% winds > 5 m/s	±2 m/s or 1%
Wind direction	±5° winds < 5 m/s ±2° winds > 5 m/s	±3°
Relative humidity	±4%	±2% (10-90%), ±4% (90-100%)
Air temperature	±0.2°C	±0.3°C
Black Globe Temperature (BGT)	±0.2°C	-

\*requires PC or iOS device with a suitable Internet connection