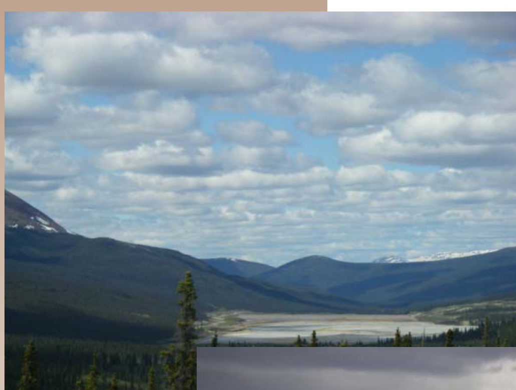
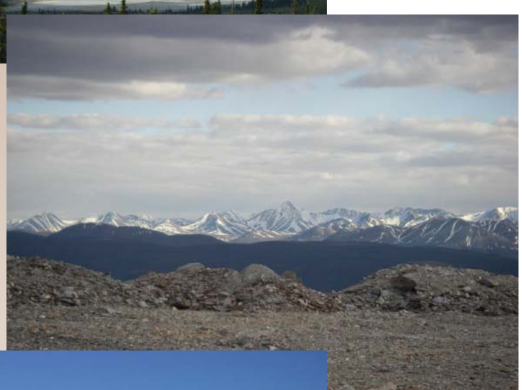
Faro Mine Complex
Vangorda Lysimeter As-built Report
Yukon, Canada

2007/08 Task 30 - FINAL





Prepared for

Deloitte and Touche Inc.

On behalf of

Faro Mine Closure Planning Office

Prepared by

SRK Consulting
Engineers and Scientists

Project Reference Number
SRK 1CD003.095

November 2008

Faro Mine Complex

Vangorda Lysimeter As-built Report

Yukon, Canada

2007/08 Task 30 - Final

Deloitte & Touche Inc.

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On behalf of

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SRK Project Number 1CD003.095

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Executive Summary

Title: Faro Mine Complex, Vangorda Lysimeter As-built Report

Consultant: SRK Consulting (Canada) Inc.

Status: Final

Date: November 2008

Size: 14 Pages of text (including cover, introductory and reference list); 8 Pages of Figures (including 1 flysheet); 6 Appendices containing 241 pages)

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Objectives and Primary Findings

This report documents the design, construction and instrumentation of two lysimeters on the Vangorda waste rock pile. These lysimeters were constructed to enhance the data collection ability of the six cover test plots that were constructed at the same location in 2004. Each of the two lysimeters measure about 25 x 25 m, and contain 1 m of waste rock overlain by 1 m of till. In one lysimeter the till is compacted and unvegetated, whilst the second lysimeter was finished with a loose hummocky surface and vegetated with willow sticks.

Construction of the lysimeters was conducted in August 2007, and instrumentation was installed and commissioned in June 2008. Data gleaned from the lysimeters include in-situ moisture content, soil matric suction, temperature as well as runoff and infiltrate volumes through the till cover. The instrumentation is mostly automated and will be managed and maintained in conjunction with the existing cover trial monitoring plan.

Future Recommendations

There are no recommendations stemming from this report.

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1 Introduction

1.1 General

Deloitte & Touche Inc. (D&T) was appointed interim Receiver of the property, assets and undertaking of Anvil Range Mining Corporation (ARMC), and its subsidiaries, Anvil Range Properties Inc., (collectively "Anvil") pursuant to an Order of Mr. Justice Blair of the Ontario Court (General Division) dated April 12, 1998. SRK Consulting (Canada) Inc. (SRK) has been retained by D&T, on behalf of the Faro Mine Closure Planning Office (FMCPO) to assist in the development of a Final Closure and Reclamation Plan (the "Plan") for the Anvil Range Mining Complex. Based on current expectation, this Plan will be submitted to the relevant regulating authorities in 2009. Engineering studies are being undertaken in the interim to provide the necessary scientific background information required to characterize and estimate costs for various closure methods that may be used in the Plan.

This report documents the design, construction and instrumentation of two lysimeters on the Vangorda waste rock pile, immediately adjacent to six other trial covers constructed in 2005. This work has been completed as Task 30, identified as "Lysimeter Construction", under the 2007/2008 D&T work plan.

1.2 Background of the Project

Six waste rock trial cover test plots were constructed in 2004 and instrumented in 2005. The intent of that work was to monitor the performance of till soil covers at the ARMC over a period of five or more years in order to develop appropriate cover design criteria for implementation of the Final Closure and Reclamation Plan. The Independent Peer Review Panel (IPRP) recommended in early 2007 that since the six cover trials do not directly measure infiltration through the covers, retrofitting one or more of the test plots by installing a lysimeter would add credibility to the collected dataset.

SRK subsequently demonstrated that given the scale of the test covers, retrofitting to install lysimeters into the existing covers would create too much of a disturbance and subsequently it was decided to install two new test cover plots, but to construct those as complete separate fully contained lysimeters. To allow direct comparison of the new lysimeter data with the existing test cover data, one lysimeter was constructed to match the configuration of one of the existing test covers, i.e. the 1 m thick compacted till cover. The second lysimeter also consists of a 1 m thick till cover; however the upper 0.5 m layer is finished as a rough hummocky surface which serves to inhibit surface runoff and promote micro topography suitable for vegetation establishment. This lysimeter was subsequently vegetated in the fall of 2007 by means of willow sticks.

The two lysimeters were constructed on top of the Vangorda waste rock pile, immediately adjacent to two of the previous test covers as illustrated in Figure 1.

1.3 Report Layout

Section 2 of this report provides an overview of the lysimeter design. Construction details are provided in Section 3 whilst the instrumentation details are documented in Section 4. The Appendices contain construction photos as well as other supporting documentation.

2 Lysimeter Design

2.1 Design Intent

The lysimeters are designed to be fully contained test cover cells, where the amount of water that infiltrates the till cover, and ultimately passes through to the base of the waste rock pile can be physically measured. Historically lysimeters were relatively small collectors which were buried beneath the ground; however, the current state of the art in lysimeter design is large full scale test cells where the entire experiment is contained. Based on this trend SRK designed the Vangorda lysimeters to be 25 x 25 m fully enclosed test cells which would allow for actual measurement of the full test cell water balance.

2.2 Numerical Modeling

To ensure that the flow being measured in each lysimeter is not influenced unduly by the geometry and design of the lysimeter, numerical modeling was undertaken. The SoilVision code by SVS Systems, which is a multidimensional true flux boundary unsaturated flow model was used. The modeling confirmed that the side slopes of the lysimeter will experience some boundary layer effects; however, they are expected to be small. However, to allow potential quantification of such effects the infiltration collection system was divided into an outer ring and an internal collection system. This means that the infiltrate coming from the outer perimeter of each lysimeter where the boundary layer effect of the side slopes may be experienced are collected and measured separately from the internal core of the lysimeter where no boundary layer effects are expected.

2.3 Design Geometry

Each lysimeter has an overall top surface area of about 25 x 25 m, and an overall depth of about 2 m. The lysimeter looks like an inverted truncated pyramid excavated into the ground with side slopes of about 1.5:1. The entire lysimeter is lined with an impermeable liner and backfilled with 1 m of waste rock underneath a 1 m thick till cover. A synthetic geonet installed underneath the waste rock and connected to drainage pipes allows for collection and measurement of any water that infiltrates through the cover and waste rock.

3 Construction

3.1 Timing and Personnel

The lysimeters were constructed between August 8 and 28, 2007. The primary contractor was Tim Moon Construction (TMC); however, additional equipment was supplied by ARMC. Engineering supervision was provided by SRK Engineer Jozsef Miskolczi, with support from SRK Engineer Tayfun Gurdal and two engineering summer students, Chris Croy and John Minder employed by ARMC.

3.2 Construction Documentation

SRK was the designer and Engineer-of-Record for the lysimeters. It was agreed with all parties involved that detailed Construction Drawings and Engineering Specifications would not be produced. The construction documentation therefore consisted of hand sketches by SRK Engineers which was subsequently implemented by the SRK site Engineer directing the Contractor.

3.3 Construction Equipment

TMC provided two highway tandem axle dump-trucks (8 m^3 capacity), two excavators (Hyundai; CAT EL200B), and a front end loader. A third tandem axle dump-truck was sub-contracted by TMC.

ARMC supplied a CAT D5 dozer, a CAT D9 dozer (August 9 only), a Linkbelt 460LX (August 27 and 28 only), a road grader (August 28 only) and a 1 tonne vibrating smooth drum compactor.

3.4 Construction Details

3.4.1 Setting Out and Surveying

The 25 x 25 m extents of each lysimeter were marked out on site by SRK engineers Maritz Rykaart and Jozsef Miskolczi, as illustrated in Figure 2 on August 8, 2007. Setting out was done by tape measure and a surveying level (dumpy level) belonging to ARMC.

3.4.2 Construction Materials

TMC hauled and stockpiled till for construction of the lysimeter covers from the Grum Overburden Dump between August 8 and 11. On August 10 an alternate location on the Grum Overburden Dump was selected due to the presence of aluminum cables at the original location. Two stockpiles, with an estimated volume of 800 m^3 each (based on 100 truck loads) were created on the east and the west side of the lysimeter location. An additional 400 m^3 of till was hauled on August 25. Boulders greater than 300 mm in size were removed from the till at the time of loading.

The Coletanche NTP1 bitumen liner arrived at the mine on August 12, and was transported to the construction site on August 13. The drainage geo-net arrived on site on August 19. An initial shipment of 2-inch schedule 40 PVC pipes used for the drainage collection system was delivered to site on August 13, followed by another shipment on August 23.

3.4.3 Lysimeter Excavation

The D9 Dozer was used on August 9 to remove the upper 0.4 m of blended till and waste rock from the lysimeter footprint areas. This material was spoiled as it was not suitable for use in the lysimeters.

Excavation of the lysimeters was done using the excavator. Lysimeter #2 (eastern lysimeter) was completed first, starting on August 10. Both lysimeter excavations were completed on August 13. For each lysimeter the excavation was started by excavating the central 19 x 19 m square core, 2 m deep, with angle of repose side slopes. Next an access ramp was developed into each lysimeter (north-west and north-east corner for Lysimeter #1 and #2 respectively). Excavated waste rock was placed on the side of the excavation, and subsequently removed with the front loader and stockpiled North of the construction site for later re-use in backfilling. Once the central excavation was complete in each lysimeter, the side slopes were excavated to a finished grade of 1.5:1 (horizontal:vertical), and finished to a smooth surface using the back of the excavator bucket.

The final step in shaping each lysimeter was creating drainage channels in the central base. This consisted of a 2.5 meter wide and 0.3 meter deep perimeter drainage channel, whilst the internal area was sloped towards the center.

3.4.4 Liner and Geonet Installation

Liner installation was carried out on August 14 and 15 by ARMC staff. The Coletanche NPT1 bituminous liner was delivered in 459 m^2, 5.1 m wide rolls weighing 1,700 kg each. Strips of the liner was cut and placed across each lysimeter in an east-west direction, but starting from the center and working towards the north and south. Seam overlaps for heat bonding ranged between 0.3 and 0.5 m.

Heat-bonding of the liner strips was done according to manufacturers specifications, using a tiger torch and special rollers manufactured on site by ARMC personnel. After the seams were heat-bonded the entire lined surface was inspected and where there was any damage noted, a patch was heat-bonded. Likewise any areas where there was evidence of a large stone that inadvertently ended up beneath the liner, the liner was cut, the rock removed and a patch installed. All patches were cut at least 0.3 m wider than the repaired area in all directions.

A 0.5 x 0.5 m square of liner was cut and the intake end of the drainage outlet pipes inside each lysimeter was placed through a hole in this square and heat-bonded. This assembly was in turn placed at the appropriate drainage location in each lysimeter and heat bonded to provide a permanent sealed drainage connection.

The geonet, which is delivered in 4 m wide rolls, was manually placed in strips on the base of each lysimeter (central section), extending about 0.5 m up the slope, with 0.3 m overlaps.

3.4.5 Lysimeter Backfill – Waste Rock Material

The bottom 1 m of each lysimeter was backfilled with waste rock. The source of this waste rock was the material that was excavated from each lysimeter in the first instance. Backfilling was done in two lifts by placing a layer of waste rock (about 0.5 m thick) into the lysimeter, directly onto the geonet using the front end loader. The loader was driven into the lysimeter after construction of an access ramp using waste rock material. This ramp was constructed by placing material carefully with the excavator.

Each completed layer of waste rock was spread and levelled using the D5 dozer, and compacted using the tracked excavator. Backfilling was closely monitored at all times and where tears or punctures were observed in the liner, backfill material was removed by hand and liner patches were applied as necessary.

A method specification was developed to determine appropriate compaction. This was done by constructing a small test pad of waste rock backfill material and testing the in-situ density as the compacter was moved across this test pad. In-situ density was measured by EBA Engineering Ltd. form Whitehorse using a Troxler nuclear densometer. Results of the test pad compaction are listed in Table 1, and indicate why Dozer compaction was deemed sufficient for the waste rock in Lysimeter #1. The waste rock used in Lysimeter #2 was however significantly drier and the compactor was used to facilitate compaction.

Table 1: Results of Test Pad Compaction of Waste Rock Material

Compaction Level		Dry Density [Kg/m^3]	Moisture Content [%]	% Compaction [%]
Reference		2362	6.8	100
2 passes		2397	3.1	101.5
		2388	2.8	101.1
		2385	3.1	101.0
	Average	2390	--	101.2
3 passes		2443	2.8	103.4
		n/a	3.6	101.7
		2436	2.4	103.1
	Average	2440	--	102.8
4 passes		2540	3.3	107.5
		2613	2.5	110.6
		2408	3.5	101.9
	Average	2520	--	106.7
5 passes		2520	2.6	106.7
		n/a	3.1	102.9
		2423	3.2	102.6
	Average	2472	--	104.1

3.4.6 Lysimeter Backfill – Till Material

After completion of the waste rock backfill, the waste rock ramp into each lysimeter was removed and replaced with a till ramp. The first lift of till material in each lysimeter was placed as a loose thickness of about 0.7 m, which after 3 passes of the compactor was reduced to 0.5 m thickness. The second lift on Lysimeter #2 was completed in the same way.

The second lift of till on Lysimeter #1 was placed using the front end loader to represent a series of random, irregular, loose (uncompacted) hummocks with an overall relief of about 0.3 to 0.5 m.

The till compaction specification was based on the outcome of a material specific test pad similar to what was described for the waste rock. Results of the test pad compaction are listed in Table 2.

Table 2: Results of Test Pad Compaction of Till Material

Compaction Level	Dry Density [Kg/m^3]	Moisture Content [%]	% Compaction [%]
Reference	2130	9.0	100
2 passes	2055	8.3	96.5
	2244	5.1	102.0
	2095	6.3	98.4
3 passes	2131	7.8	100.0
	2085	6.7	97.9
	2151	6.9	101.0
4 passes	2125	7.4	101.0
	2079	7.4	97.6
	2105	9.1	98.8

The final surface of Lysimeter #2 was graded smooth with an overall surface gradient of about 1% towards the south edge of the lysimeter, to allow collection and drainage of surface runoff. The hummocky surface of Lysimeter #1 however precludes collection of surface runoff water.

Each lysimeter was finished off by constructing a 0.5 m high containment berm around it using till material. The material was placed with the front-end loader, shaped with the excavator and compacted.

3.4.7 Drainage Pipe Installation

Pipe trenches for leachate collection from each lysimeter were excavated as illustrated in Figure 2. A single trench about 15 m long was excavated from each lysimeter in a "Y" shape before joining together and leading south towards the instrumentation hut. At its deepest the trench was about 3.9 m deep, 1.5 m wide and has side slopes of 1:1.5. Bell-bottom 2-inch diameter PVC drainage pipes in 6 m long lengths were installed and connected (using two-phase PVC cement) to each lysimeter, before backfilling the trenches.

The containment berm on the south side of each lysimeter was breached to install drainage pipe to allow monitoring of surface runoff. The 2-inch diameter PVC drainage pipe leading from each lysimeter was installed inside a 5 m long steel pipe, contained in a 0.6 m deep pipe trench. This was done to prevent crushing of the buried PVC pipes as vehicles and equipment move about around each lysimeter. Beyond this point the pipes were directed towards the instrument hut.

3.4.8 Site Drainage

After completion of the lysimeters the area surrounding the lysimeters was levelled with the D5 dozer, and finished with the grader. A drainage ditch to divert water away from the other test cells constructed in 2004 was excavated in June 2008, as illustrated in Figure 2.

3.4.9 Instrument Hut

A timber instrument hut was constructed by ARMC carpenters at the mill site and transported to the construction site on August 23. Since the instrument hut is installed into an excavation, and it is expected that the walls of the excavation will cave in over time, the hut was constructed strong enough to withstand these external pressures. The frame is constructed from 2x4 dimensional lumber with the walls and roof cladding being 1/2 inch plywood; the roof is covered with bitumen shingles.

All six drainage pipes from the lysimeters are led into the instrumentation hut.

4 Instrumentation

4.1 Timing and Personnel

Lysimeter instrumentation was installed between May 26, 2008 and June 7, 2008 by SRK Engineer Jozsef Miskolczi with support from two ARMC summer students, Chris Croy and Mike Brewer.

4.2 Flow Monitoring Instruments

4.2.1 Flow Meters

Six (three for each lysimeter) SeaMetrics TX80 series turbine type flow meters were installed to monitor higher flow rates emanating from either surface runoff or infiltration. Each turbine is installed into a custom designed PVC “T” connector that is installed onto the flow collection pipe leading from each lysimeter, inside the instrumentation hut. Each flow meter has its own battery powered data logger, the SeaMetrics DL75 model, which samples the flow rate at a user specified time interval.

4.2.2 Tipping Bucket Flow Gauges

Plastic RainWise rain gauge tipping buckets (0.25 mm tip capacity) were installed on each of the six drainage pipes to record the low flow range. These instruments were installed inside the instrument hut, and were downstream of the SeaMetrics flow meters. Each tipping bucket is connected to the central Campbell Scientific CR1000 data logger.

4.2.3 Water Level Sensors

Each lysimeter has a small wooden box overflow weir (10 cm wide, 25 cm high and 60 cm long) to prevent excessive ponding. To quantify weir flow, HOBO water level sensors are used. The HOBO sensors are integrated pressure sensors accurate to ±3 mm, with a data logger taking spot measurements at pre-determined time intervals.

4.3 Volumetric Moisture Content

4.3.1 Sentek Diviner

Volumetric Moisture content in each lysimeter is measured using the manual Sentek Diviner Instrument. The Diviner probe is manually inserted into permanent access tubes allowing recording of in-situ moisture content profile with data points every 10 cm.

A total of ten access tubes were installed in each lysimeter in a grid pattern as illustrated on Figure 7. The 2-inch diameter, 2 m long PVC access tubes were installed by drilling a 2-inch diameter pilot hole with a Pionjar vibrating hammer drill, and then widening the hole to 3-inches. The access pipes were then slid down the hole and the annulus around the pipe backfilled. This installation was done by a subcontractor, Rocky Mountain Soil Sampling.

4.3.2 Sentek EnviroScan

One array of ten Sentek EnviroScan volumetric moisture content sensors was installed in each lysimeter as illustrated in Figure 5, in close proximity the matric suction sensors (see below). The sensors themselves are installed on a railing inside a housing tube, similar to those used for the Diviner. These sensors are all connected to the CR1000 data logger for automatic data collection.

4.4 Soil Matric Suction

Soil matric suction in each lysimeter is measured using four Campbell Scientific 229 Thermal Conductivity sensors, connected to the CR1000 data logger. Details of the exact location of each of the sensors are illustrated in Figure 6.

Matric suction sensors were installed by excavating a test pit through the cover and the waste rock, and placing the sensors into the test pit side walls.

The matric suction sensors also record the in-situ soil temperature.

4.5 Calibration of EnviroScan and Matric Suction Sensors

Material specific calibration curves for each matric suction sensor were developed by the supplier and are included as Appendix F. Material specific calibration of the EnviroScan sensors was not required as these sensors are installed in similar materials as the instruments installed for the Vangorda Cover Trial experiment in 2005, for which calibration curves are available.

During installation of the Diviner access tubes select samples were collected and subjected to moisture content testing to facilitate any additional calibration that may be required. The results of this testing is listed in Table 3.

Table 3: Gravimetric Moisture Content of Till and Waste Rock Samples

Date	Location (Diviner tube #)	Depth (cm)	Material Tested	Moisture Content (%)
06/02/08	57	170	WR	5.44
06/02/08	57	60	Till	7.20
06/02/08	56	120	WR	5.62
06/02/08	55	100	Till	7.65
06/02/08	56	80	Till	7.82
06/04/08	53	10	Till	7.20
06/04/08	53	50	Till	8.50
06/04/08	53	80	Till	7.72
06/04/08	53	180	WR	7.62
06/04/08	53	140	WR	6.76

4.6 Automated Data Collection System

The primary data logger is a Campbell Scientific CR1000. Complete wiring diagrams are included in Appendix C.

Volumetric moisture content and matric suction is recorded at 6 hour intervals, starting midnight every day. Tipping buckets record flow continuously if and when water is present. Batch data is recorded every half hour by the data logger. The data logger also monitors the system battery output voltage. The program listing for the data logger is included in Appendix B.

The EnviroScan sensors are connected to the CR1000 through an SDI 12 intelligent interface, with unique identifiers for each sensor. The SDI 12 boards are located inside the EnviroScan probe's housing tube, attached to the sensor railing.

Matric suction sensors are connected to the data logger through a Campbell Scientific AM25 T multiplexer. Power to the heating resistor is provided by a Campbell Scientific CE8 constant current device. Both the multiplexer and the constant current device are controlled by the CR1000. The CR1000 is installed in a weatherproof enclosure in the instrument hut and the multiplexer and constant current device is installed in a weatherproof enclosure mounted on a 4x4 wooden post on the southwest corner of Lysimeter #2.

The CR1000 is powered by a large car battery, which is in turn recharged by a 20W solar panel.

5 Closure

Two lysimeters were constructed on top of the Vangorda waste rock pile at the ARMC, immediately adjacent to six other trial cover test cells constructed in 2004. The lysimeters are designed to enhance the data collection capability of the 2004 test cells. Construction of the lysimeters was completed in August 2007, and instrumentation installation was done in June 2008.

This report, "**1CD003.095 – Faro Mine Complex, Vangorda Lysimeter As-built Report: 2007/08 Task 30 - FINAL",** was prepared by SRK Consulting (Canada) Inc.

Prepared by

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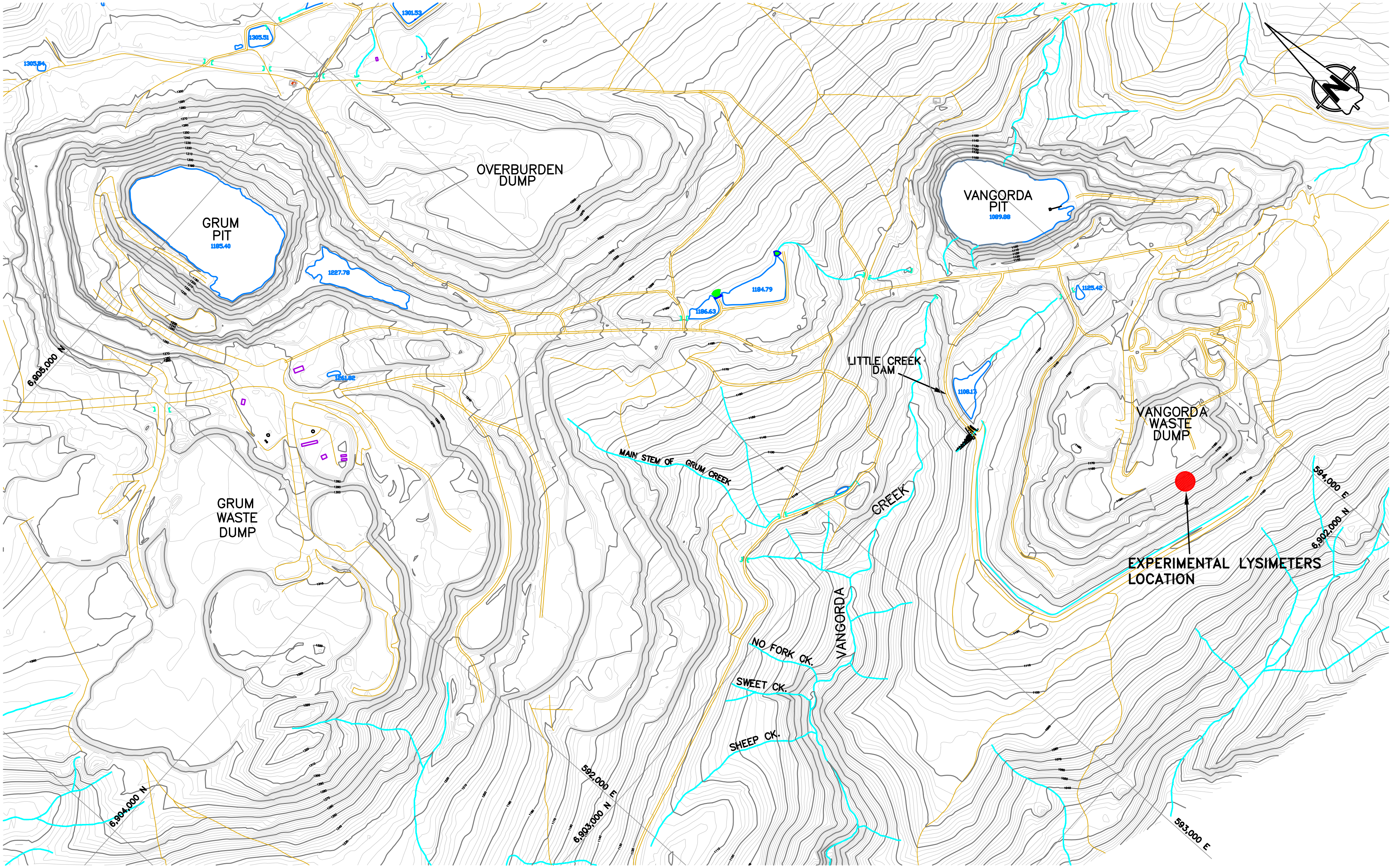
Figures



SRK Consulting
Engineers and Scientists
Vancouver

Deloitte & Touche

Experimental Lysimeters
As-built Report

Location Plan for
Experimental Lysimeters

SRK JOB NO.: 1CD003.095/500

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Anvil Range Mining Complex

DATE:	APPROVED:	FIGURE:
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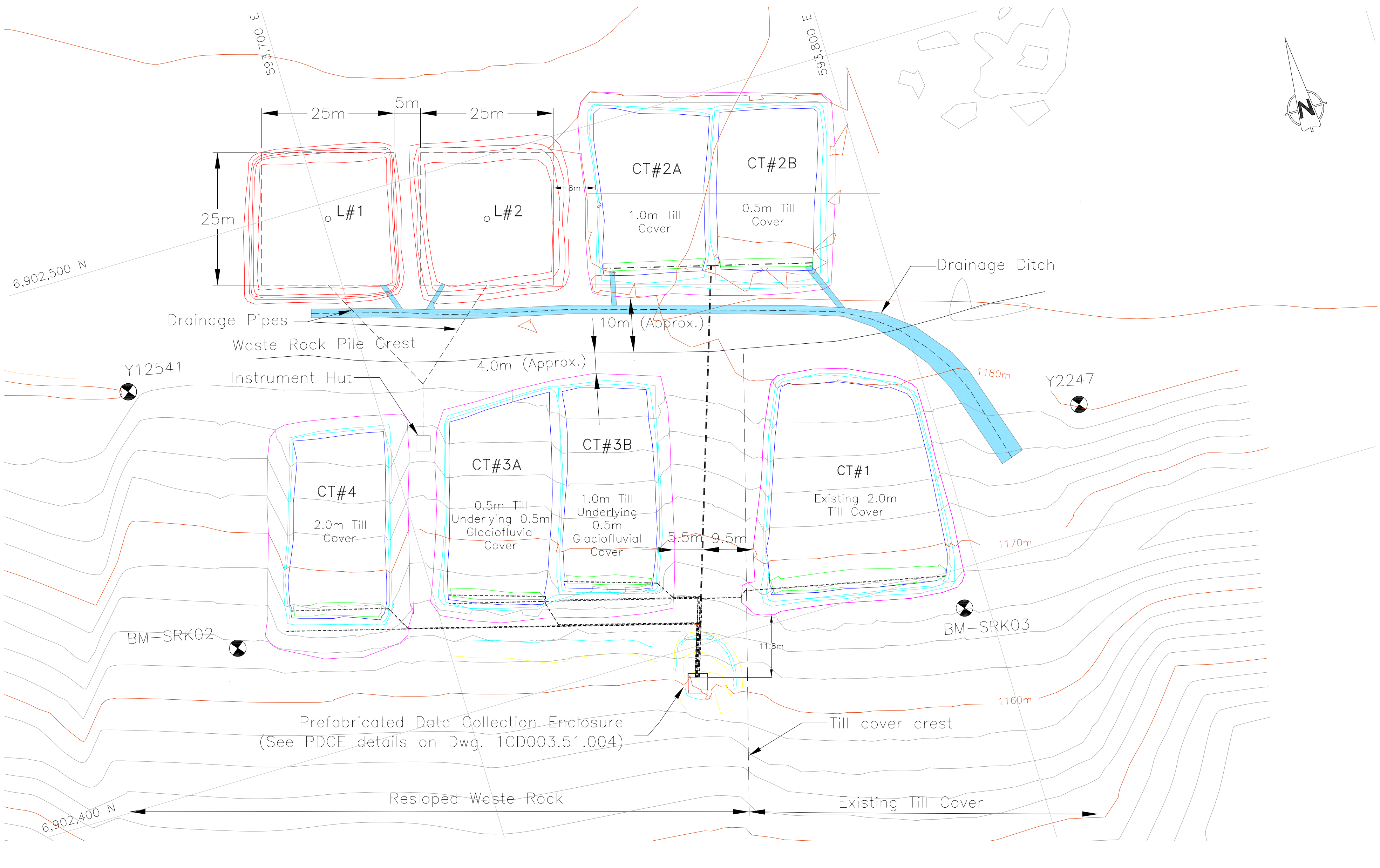

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Experimental Lysimeters

Lysimeters Layout

SRK JOB NO.: 1CD003.095.500

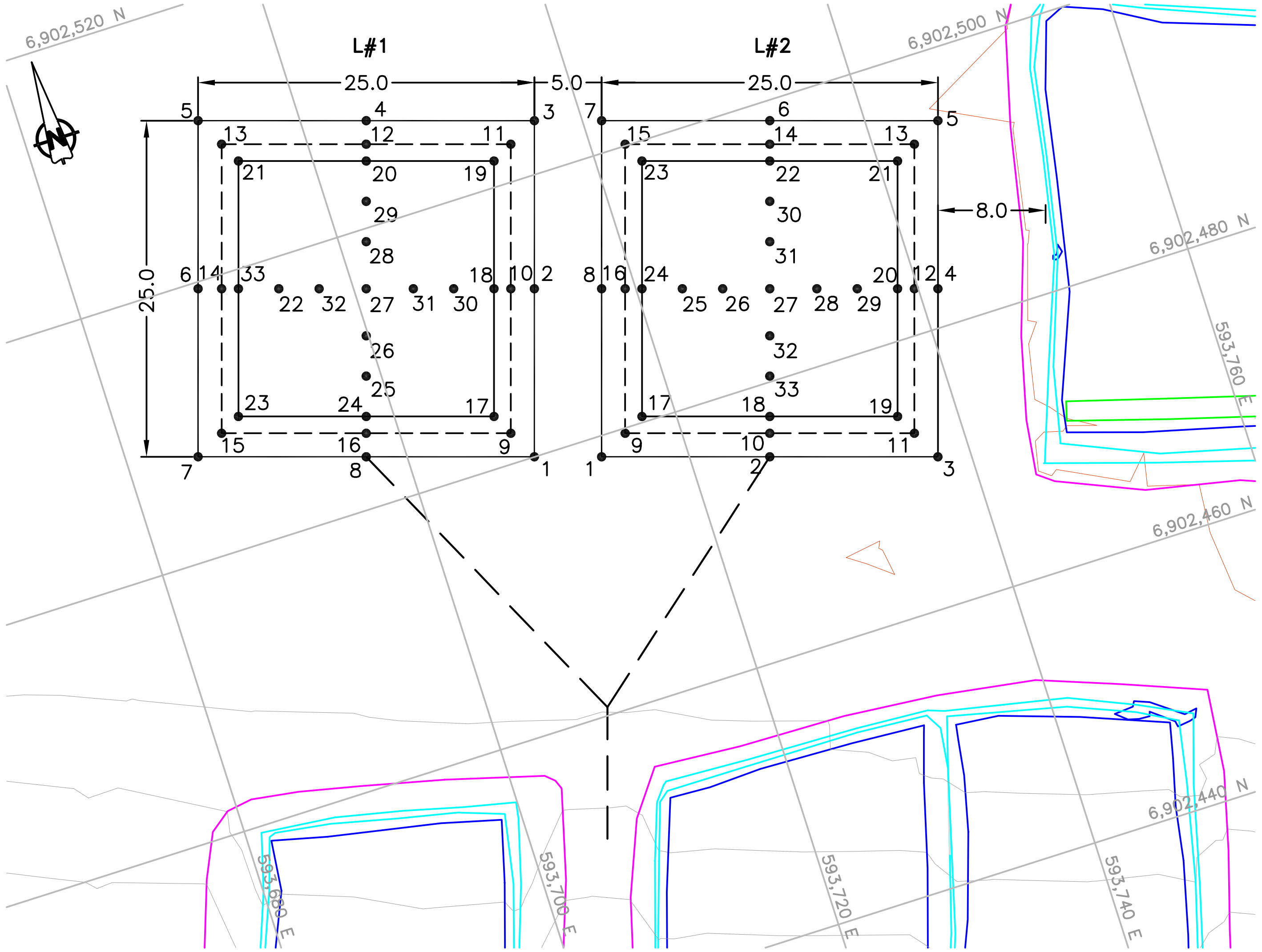
FILE NAME: Test Covers Asbuilt.dwg

Anvil Range Mining Complex

DATE: July 2008

APPROVED: JM

FIGURE: 2



PLAN
1:500

Compacted Waste Rock Elevations

L#1			L#2		
Point #	Elevation	Depth	Point #	Elevation	Depth
1	1308	0.215	1	1663	0.403
2	1287	0.194	2	1639	0.379
3	1093	0	3	1823	0.563
4	1282	0.189	4	1617	0.357
5	1319	0.226	5	1341	0.081
6	1325	0.232	6	1498	0.238
7	1265	0.172	7	1260	0
8	1232	0.139	8	1439	0.179
9	3843	2.75	9	3880	2.62
10	3741	2.648	10	3929	2.669
11	3738	2.645	11	3857	2.597
12	3583	2.49	12	3802	2.542
13	3640	2.547	13	3704	2.444
14	3763	2.67	14	3639	2.379
15	3870	2.777	15	3659	2.399
16	4051	2.958	16	3829	2.569
17	3421	2.328	17	3541	2.281
18	3489	2.396	18	3582	2.322
19	3449	2.356	19	3517	2.257
20	3502	2.409	20	3602	2.342
21	3388	2.295	21	3499	2.239
22	3502	2.409	22	3462	2.202
23	3546	2.453	23	3482	2.222
24	3568	2.475	24	3560	2.3
25	3666	2.573	25	3636	2.376
26	3788	2.695	26	3739	2.479
27	3881	2.788	27	3879	2.619
28	3745	2.652	28	3839	2.579
29	3641	2.548	29	3773	2.513
30	3640	2.547	30	3601	2.341
31	3784	2.691	31	3710	2.45
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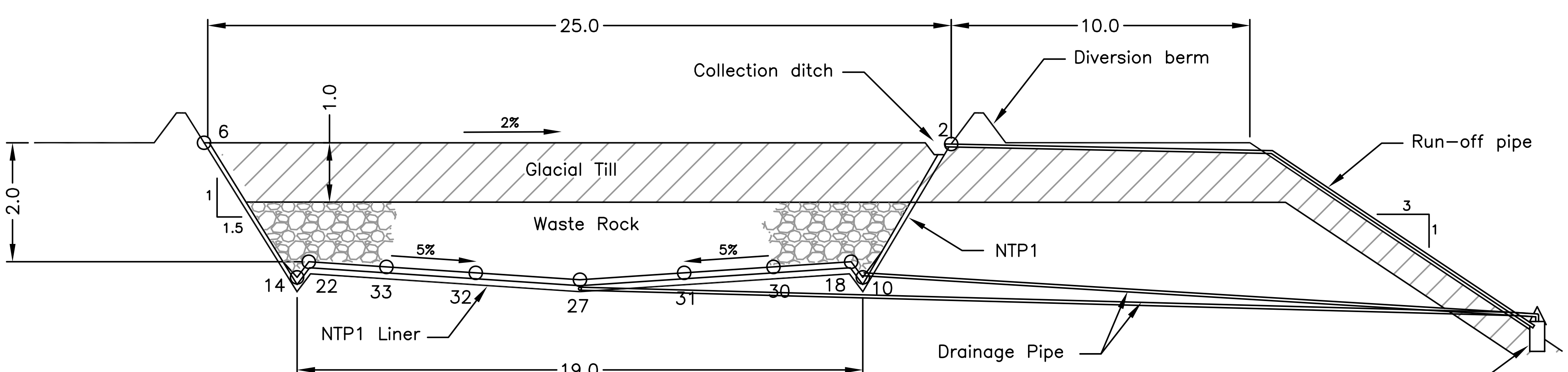
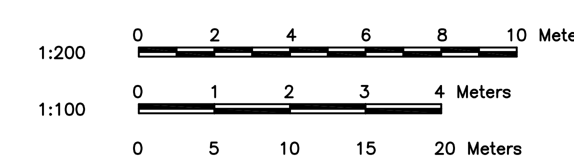


SECTION
Horizontal Scale 1:200
Vertical Scale 1:100

Notes:

1. All dimensions and elevations are in Metres.



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SRK JOB NO.: 1CD003.095.500
FILE NAME: Sections.dwg

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Anvil Range Mining Complex

Experimental Lysimeters

Lysimeters Section and Elevations

DATE: July 2008
APPROVED: JM
FIGURE: 3

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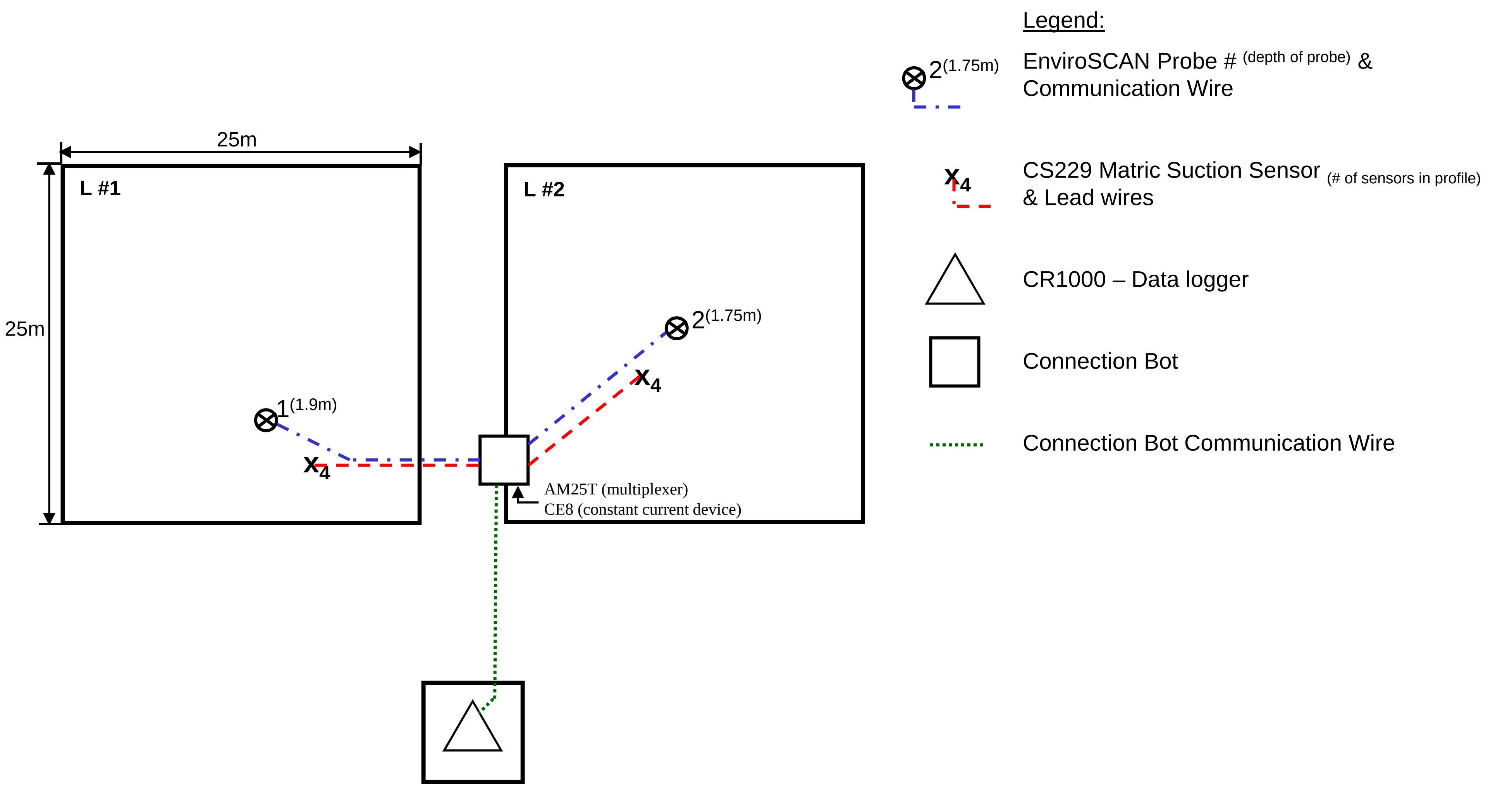

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Instruments Layout

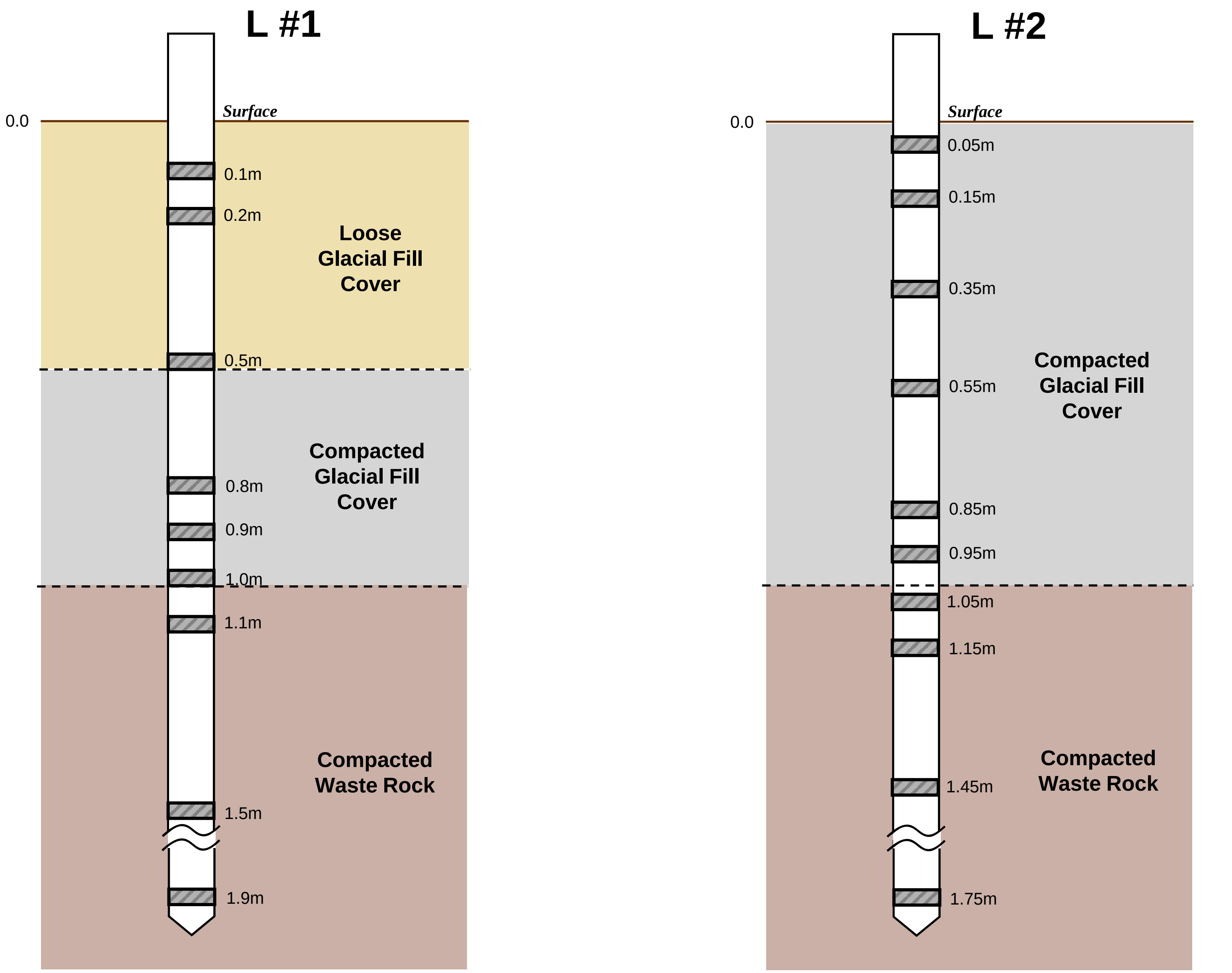
Location of EnviroScan and 229 Sensors

Job No: 1CD003.095.500

Filename: Figures4,5,7.ppt

Anvil Range Mining Complex

Date:	Approved:	Figure:
Nov. 2008	**JM**	**4**



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Deloitte & Touche

Experimental Lysimeters

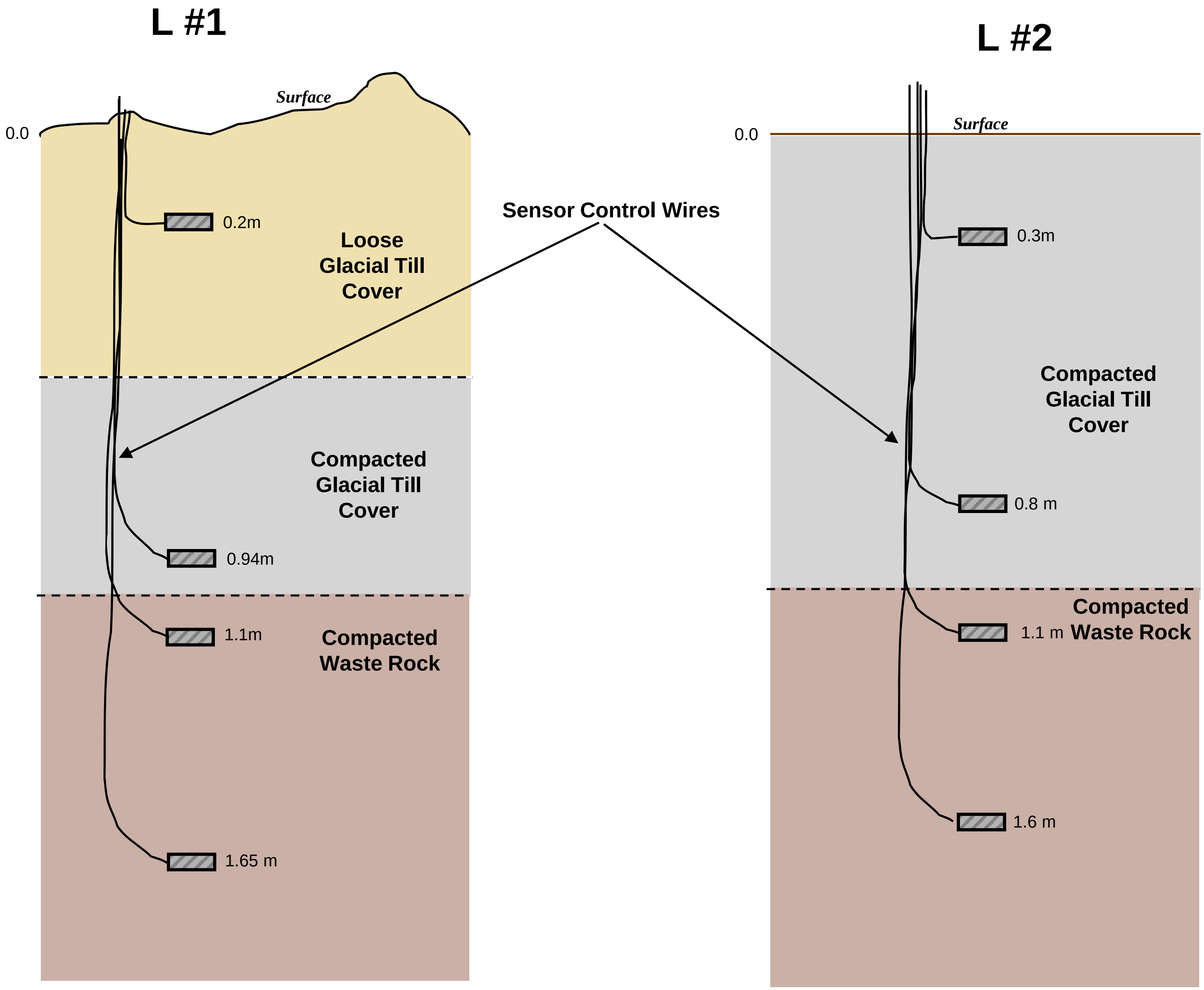
Spatial Distribution of EnviroScan Sensors

Job No: 1CD003.095.500

Filename: Figures 4,5,7.ppt

Anvil Range Mining Complex

Date: **Nov 2008** | Approved: **JM** | Figure: **5**



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Deloitte & Touche

Experimental Lysimeters

Spatial Distribution of 229 Matric Suction Sensors

Job No: 1CP001.037.B02.06

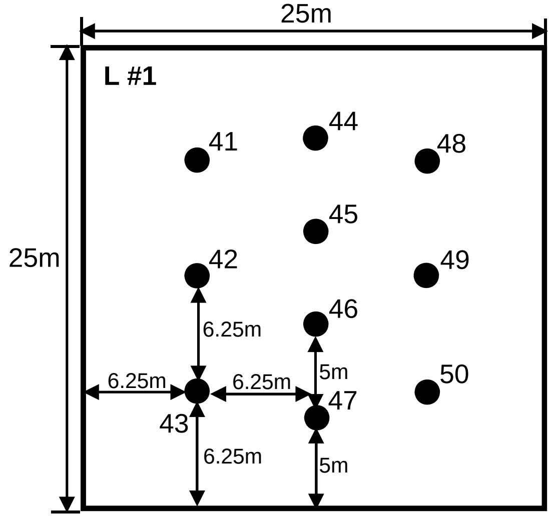
Filename: EnviroScn_thermistor_ver01.ppt

Anvil Range Mining Complex

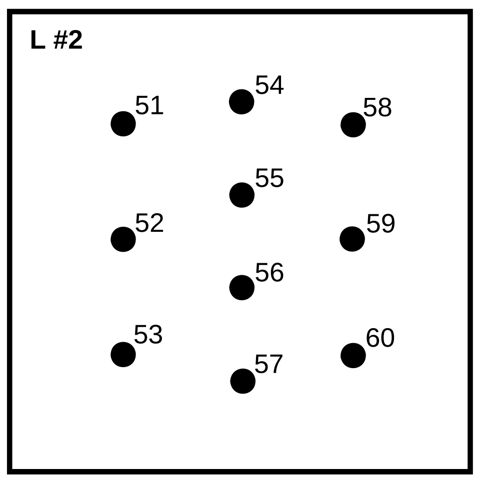
Date:	Approved:	Figure:
Nov. 2008	JM	6

Legend:

● 41 Access Tube #



Access Tube #	Depth [m]
41	1.9
42	1.9
43	1.9
44	1.9
45	1.9
46	1.9
47	1.9
48	1.9
49	1.9
50	1.9



Access Tube #	Depth [m]
51	1.9
52	1.8
53	1.8
54	1.9
55	1.9
56	1.9
57	1.9
58	1.9
59	1.9
60	1.8

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Sentek Diviner Access Tube Locations

Location of Sentek Diviner Access tubes

Job No: 1CD003.095.500

Filename: Figures 4,5,7.ppt

Anvil Range Mining Complex

Date:	Approved:	Figure:
Nov. 2008	JM	7

Appendix A
Compaction Test Results

EBA Engineering

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No: **W14101076**

Project: S.R.K. Site Works Compaction Testing

Client: **S.R.K.**
VANCOUVER, BC

Att'n:

Test Apparatus : Nuclear Machine No: 37595

Soil Description: Till -silt-sand-gravelly

Temperature Air: ____ °C Soil: ____ °C

Specified Compaction: 93.0

Compaction Standard: Standard Proctor

Minimum Dry Density:

Maximum Dry Density: **2130**

Optimum M.C.: 9.0

Date Tested: **2007.08.17** By: J.P.

Test No./ Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m^3	% Compaction
97/200	CT2a 5th from South (25m) Middle of Pad		5.6	2085	97.9
98/200	CT2a 5th from South (25m) 1st from West		4.8	2098	98.5
99/200	Test Strip 2 Passes		8.3	2055	96.5
100/200	Test Strip 2 Passes		5.1	2244	102.0+
101/200	Test Strip 2 Passes		6.3	2095	98.4
[illegible]	[illegible] 2 Passes		[illegible]	[illegible]	[illegible]

Remarks: Control Test Strip For 0.5 m Lift of Till.

Reviewed By: ______

c.c.
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S.R.K.
VANCOUVER, BC

Data present hereon is for the sole use of the stipulated client. EBA is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of EBA.

The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide upon written request.

eba

EBA Engineering

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No: **W14101076**

Project: SRK Site Works Compaction Testing

Client: **S.R.K.**
VANCOUVER, BC

Att'n:

Test Apparatus : Nuclear Machine No: 37595

Soil Description: Till - Sand - Silt - Gravelly

Temperature Air: °C Soil: °C

Specified Compaction: 93.0

Compaction Standard: Standard Proctor

Minimum Dry Density:

Maximum Dry Density: **2130**

Optimum M.C.: 9.0

Date Tested: **2007.08.17** By: J.P.

Test No./ Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m^3	% Compaction
102/200	test strip, 3 passes		7.8	2131	100.0
103/200	test strip, 3 passes		6.7	2085	97.9
104/200	test strip, 3 passes		6.9	2151	101.0
105/200	test strip, 4 passes		7.4	2152	101.0
106/200	test strip, 4 passes		7.4	2079	97.6
107/200	test strip, 4 passes		9.1	2105	98.8

Remarks: Control Test Strip for 0.5m Lift of Till

Reviewed By:

c.c.
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S.R.K.
VANCOUVER, BC

EBA Engineering

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No: **W14101076.001**

Project: SRK Site Works Compaction Testing

Client: **S.R.K.**
VANCOUVER, BC

Att'n:

Test Apparatus : Nuclear   Machine No: 37595

Soil Description: Wast Rock Reference Test

Temperature Air: ____ °C Soil: ____ °C

Specified Compaction: 93.0

Compaction Standard: standard compaction

Minimum Dry Density:

Maximum Dry Density: **2350**

Optimum M.C.: 9.0

Date Tested: **2007.08.17**   By: JP

Test No./ Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m^3	% Compaction
108 /200	test pad #2, 2 passes		6.8	2362	100.5
109 /200	test pad #2, 2 passes		3.1	2397	102.0+
110 /200	test pad #2, 2 passes		2.8	2388	101.6
111 /200	Test pad #2, 2 passes		3.1	2385	101.5
112 /200	test pad #2, 3 passes		22.8	2443	102.0+
113 /200	test pad #2, 3 passes		3.6	2403	102.0+
114 /200	test pad #2, 3 passes		2.4	2436	102.0+
115 /200	test pad #2, 4 passes		3.3	2540	102.0+
116 /200	test pad #2, 4 passes		2.5	2613	102.0+
117 /200	test pad #2, 4 passes		3.5	2408	102.0+
118 /200	test pad #2, 5 passes		2.6	2520	102.0+
119 /200	test pad #2, 5 passes		3.1	2431	102.0+
120 /200	test pad #2, 5 passes		3.2	2423	102.0+

Remarks: Control Test Strip For Waste Rock
Max. Dry Density assumed

Reviewed By:

c.c.
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S.R.K.
VANCOUVER, BC

Appendix B
Data Logger Program Listing

```
'CR1000 Series Datalogger


'Tha data logger is controlling the following instruments, listed by location:
' Lysimeter L#1
'    - Sentek EnviroScan Probe 1 (10 sensors)
'    - 229 Matric Suction Sensors #1 through #4
'    - Tiping Bucket Flow Gauges (3 flow gauges)

' Lysimeter L#2
'    - Sentek EnviroScan Probe 2 (10 sensors)
'    - 229 Matric Suction Sensors #5 through #8
'    - Tiping Bucket Flow Gauges (3 flow gauges)

' The following peripherals are also controlled by the data logger
'    - AM25T multiplexer (Campbell Scientific)
'    - CE8 constant current device (Campbell Scientific)
' both peripherals are located inside the weatherproof box installed in the
' South-West corner of L#2


'date: June 24, 2008

'program author:
'Jozsef Miskolczi EIT,
'SRK Consulting (Canada) Inc.
'2200-1066 West Hastings street, Vancouver, BC
'phone; (604)681-4196



'Declare Public Variables

Public batt_volt, tips(6), Ref_Ti, Ref_Tf, TC_temp_Ini(8), TC_temp_Fin(8),
TC_temp_diff(8), ES_1(10), ES_2(10)

'Declare Constants
Const high = true
Const low = false

'Define Data Tables

'output minimum battery voltage for the past day at midnight, timestamp included
DataTable(BattVolt,1,-1)
DataInterval (0,1440,Min,-1)
Minimum (1,batt_volt,FP2,False,True)
```

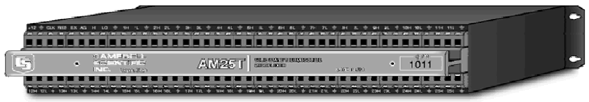
```
EndTable
'every 6 hours, on the hour, store in memory the Sentek ES (Volumetric Water Content)
sensor output
DataTable (Sentek_ES,1,-1)
DataInterval (0,360,Min,0)
Sample (10,ES_1(),IEEE4)
Sample (10,ES_2(),IEEE4)
EndTable

'every 6 hours, on the hour, store in memory the output of the 229 (Thermal
Conductivity) sensors
DataTable (Suction,1,-1)
DataInterval (0,360,Min,0)
Sample (8,TC_temp_Ini,IEEE4)
Sample (8,TC_temp_diff,IEEE4)
EndTable

' every 30 minutes store in memory the total # of tips for each tipping bucket
DataTable(TB,1,-1)
DataInterval (0,30,Min,0)
Totalize (6,tips(),FP2,False)
EndTable

'Define Subroutines
Sub (Temp_Diff)
TC_temp_diff(1) = TC_temp_Fin(1) - TC_temp_Ini(1)
TC_temp_diff(2) = TC_temp_Fin(2) - TC_temp_Ini(2)
TC_temp_diff(3) = TC_temp_Fin(3) - TC_temp_Ini(3)
TC_temp_diff(4) = TC_temp_Fin(4) - TC_temp_Ini(4)
TC_temp_diff(5) = TC_temp_Fin(5) - TC_temp_Ini(5)
TC_temp_diff(6) = TC_temp_Fin(6) - TC_temp_Ini(6)
TC_temp_diff(7) = TC_temp_Fin(7) - TC_temp_Ini(7)
TC_temp_diff(8) = TC_temp_Fin(8) - TC_temp_Ini(8)
EndSub


'Main Program
BeginProg
Scan (1,Min,0,0)
'monitor battery voltage
Battery (Batt_volt)
'monitor the tipping buckets by scanning each channel
PulseCount (tips(1),1,1,2,0,1.0,0)
PulseCount (tips(2),1,2,2,0,1.0,0)
PulseCount (tips(3),1,11,2,0,1.0,0)
PulseCount (tips(4),1,12,2,0,1.0,0)
```

```
PulseCount (tips(5),1,13,2,0,1.0,0)
PulseCount (tips(6),1,14,2,0,1.0,0)


IfTime (0,360,Min)
'measure volumetric water content from Sentek EnviroScan sensors
SDI12Recorder (ES_1(),5,1,"M!",1.0,0)
SDI12Recorder (ES_2(),5,2,"M!",1.0,0)

'measure innitial temperature of the 229 sensors
AM25T (TC_temp_Ini,8,mV2_5,12,1,TypeT,Ref_Ti,6,7,Vx2,True ,0,_60Hz,1.0,0)
'turn on power to CE8 constant current device
PortSet (8,1)
'heat the 229's resistor for 30 seconds
Delay (0,30,Sec)
'measure final temperature of the 229 sensors (250 microsecond per sensor)
AM25T (TC_temp_Fin,8,mV2_5,12,1,TypeT,Ref_Tf,6,7,Vx2,True ,0,_60Hz,1.0,0)
'turn off power to CE8 constant current device
PortSet (8,0)
'calculate temperature difference
Call (Temp_Diff))



'Call Output Tables
CallTable (BattVolt)
CallTable (Sentek_ES)
CallTable (Suction)
CallTable (TB)

NextScan
EndProg
```

Appendix C
Wiring Diagrams

AM25T WIRING DIAGRAM

COMPANY:	SRK Consulting
PROJECT:	Faro Lysimeters / May 15, 2008
DOCUMENTED BY:	Jozsef Miskolczi

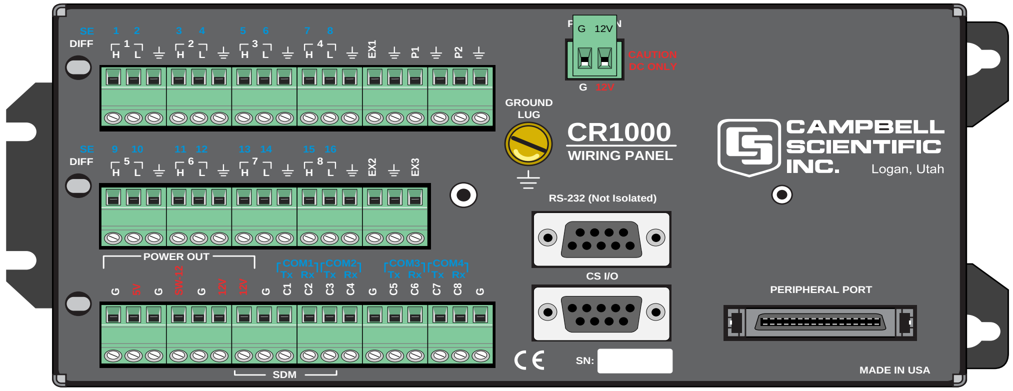


AM25T Solid State Thermocouple Multiplexer

Wire	Terminal	Terminal	Wire
Blue of 229 #1	12H	+12	12VDC from CR1000
Red of 229 #1	12L	⏚	Ground from CR1000
Clear of 229 #1	⏚	CLK	C6 of CR1000
Blue of 229 #2	13H	RES	C7 of CR1000
Red of 229 #2	13L	EX	EX 2 of CR1000
Clear of 229 #2	⏚	AG	Ground from CR1000
Blue of 229 #3	14H	HI	1H of CR1000
Red of 229 #3	14L	LO	1L fo CR1000
Clear of 229 #3	⏚	⏚	
Blue of 229 #4	15H	1H	
Red of 229 #4	15L	1L	
Clear of 229 #4	⏚	⏚	
Blue of 229 #5	16H	2H	
Red of 229 #5	16L	2L	
Clear of 229 #5	⏚	⏚	
Blue of 229 #6	17H	3H	
Red of 229 #6	17L	3L	
Clear of 229 #6	⏚	⏚	
Blue of 229 #7	18H	4H	
Red of 229 #7	18L	4L	
Clear of 229 #7	⏚	⏚	
Blue of 229 #8	19H	5H	
Red of 229 #8	19L	5L	
Clear of 229 #8	⏚	⏚	
	20H	6H	
	20L	6L	
	⏚	⏚	
	21H	7H	
	21L	7L	
	⏚	⏚	
	22H	8H	
	22L	8L	
	⏚	⏚	
	23H	9H	
	23L	9L	
	⏚	⏚	
	24H	10H	
	24L	10L	
	⏚	⏚	
	25H	11H	
	25L	11L	
	⏚	⏚	

CR1000 Wiring Diagram

Company:	SRK Consulting
Project:	Faro Lysimeters / May 15, 2008
Documented By:	Jozsef Miskolczi



	G		12V	Common High AM25T	1H (SE1)
100kΩ Resistor x 4	5V		G	Common Low AM25T	1L (SE2)
Ground of CE8	G				⏚
	SW-12		5H (SE9)		2H (SE3)
Ground of AM25T	G		5L (SE10)		2L (SE4)
12VDC to AM25T	12V		⏚		⏚
12VDC to SDI-12 & 12VDC to CE8	12V		6H (SE11)		3H (SE5)
TB_CentralInf&PerimInf_L#1_black	G		6L (SE12)		3L (SE6)
TB_Central Infiltr_L#1_white & 100kΩresistor	C1 (COM1 Tx)		⏚		⏚
TB_Perimeter Infiltr_L#1_white & 100kΩ resist	C2 (COM1 Rx)		7H (SE13)		4H (SE7)
TB_Central Infiltr_L#2_white & 100kΩ resistor	C3 (COM2 Tx)		7L (SE14)		4L (SE8)
TB_Perimeter Infiltr_L#2_white & 100kΩresist	C4 (COM2 Rx)		⏚		⏚
TB_CentralInf&PerimInf_L#2_black	G		8H (SE15)		EX1
Signal from SDI-12	C5 (COM3 Tx)		8L (SE16)		⏚
Clock of AM25T	C6 (COM3 Rx)	Analog ground of AM25T	⏚	TB _runoff_L#1_white	P1
Reset of AM25T	C7 (COM4 Tx)	Excitation to AM25T	EX2	TB _runoff_L#1_black	⏚
Control of CE8	C8 (COM4 Rx)		⏚	TB _runoff_L#2_white	P2
Ground of SDI-12	G		EX3	TB _runoff_L#1_black	⏚

Appendix D

HOBO Water Level Loggers – Operation and Maintenance

SRK Consulting (Canada) Inc.
Suite 2200 – 1066 West Hastings Street
Vancouver, B.C. V6E 3X2
Canada

vancouver@srk.com
www.srk.com

Tel: 604.681.4196
Fax: 604.687.5532

Memo

To:	File	**Date:**	July 2, 2008
cc:	Anvil Range Lab	**From:**	Jozsef Miskolczi
Subject:	HOBO Water Level Loggers – operation and maintenance	**Project #:**	1CD003.095

1 General considerations

The HOBO Water Level Loggers were installed during the last week of June 2008 with the purpose of upgrading the capacity of monitoring run-off from the surface of the cover trials and lysimeters situated on the top of the Vangorda waste rock pile, i.e. CT#2A/B, L#1, and L#2 respectively.

The containment berm of each of the mentioned experimental pads was breached and a wooden weir was installed. The dimensions of the weirs are: 10cm width, 25 cm height, and 60 cm length. One HOBO logger was installed in each of the weirs in such way the port of the pressure sensor is flush with the bottom of the weir, ensuring that water level will be measured as accurately as possible. The annulus between the sensor and the housing hole was sealed with silicone.

The HOBO loggers provide continuous monitoring of the water level in the weir. The data collection interval was set to 16 seconds, meaning that one data point will be recorded every 16 seconds. The logger is recording absolute pressure and temperature values. The water level will be calculated by reducing the pressure data by compensation with barometric pressure values recorded at the weather station located on CT#2A/B and temperature values recorded by the HOBO logger.

The measured temperature and pressure data will be stored in the HOBO's solid state memory. The capacity of the datalogger is 64 Kb, which allows for 21,700 data points to be stored. Based on the current collection frequency setting there is sufficient capacity for 4 days of continuous operation. **NOTE: Datalogger stops recording data when the memory is full.**

2 Downloading the data

Prerequisite to operating and downloading data from the HOBO Water Level Logger is the HOBO Ware Pro software (already installed on the field notebook computer).

To download the data from the HOBO logger please follow the procedure detailed below:

- Start HOBOware Pro
- Remove (unscrew) the black protective cap of the HOBO data logger
- Connect the provided base station to the appropriate USB port of the field computer
- Attach the optical connection port (the black plastic coupler) to the HOBO logger, aligning the flat of the logger with the arrow on the coupler, then insert the base station
- On the bottom-left corner of the HOBOware Pro main screen the status will be displayed notifying the user when the datalogger is connected and ready to communicate with the computer
- From the main screen choose the "Device" menu and then the "Readout" option; a new window will pop open asking for confirmation of the particular sensor/datalogger
- Choose "Stop sensor" before downloading the data.

- Download
- When download was finished, save the data file with the logger's name and the current date (e.g.L#1 _20080702.hobo); check the graphs for obvious problems
- **Without closing the graph window, choose the "Device" menu and the "Launch" option to restart the datalogger. This step is very important, since otherwise the logger remains inactive.**
- Disconnect the base station and replace the protective cap of the HOBO logger
- Export each of the data files to Excel by choosing the appropriate option from the "File" menu
- Attach files to the packet of data files normally emailed to the Vancouver office

3 Maintenance

The HOBO sensor/datalogger is enclosed in a rugged stainless steel case, and no major issues are anticipated regarding the maintenance of the logger itself. Closer attention will have to be paid to the state of the weirs. The fines and debris carried by the run-off water may be settling around the sensor's body possibly plugging the pressure sensor's port, therefore it is important to check the weirs after every major rainfall event and clean out the fines if necessary.
The nature of the data transfer from the data logger to the computer, i.e. optical, requires both the loggers' optical port as well as the base station to be clean and free of dust. To clean the connecting areas, please wash with abundant water rather than just dry wipe to avoid scratching the plastic surfaces.
In case of frost do not try to defrost using hot water, because heat shocks may damage the temperature sensor. Frost issues will be dealt with in a document to follow.

For any questions regarding the operation of the HOBO Water Level Loggers please contact Jozsef Miskolczi in the Vancouver office of SRK Consulting; ph. (604) 681-4196, or e-mail: jmiskolczi@srk.com.

Appendix E
Instrumentation Manuals Library

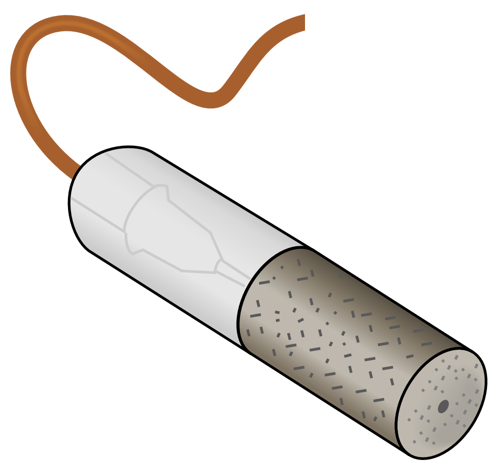
Appendix E.1

Matric Water Potential Sensor (229) Hardware Manual

INSTRUCTION MANUAL

229 Heat Dissipation Matric Water Potential Sensor

10/06



WARRANTY AND ASSISTANCE

This equipment is warranted by CAMPBELL SCIENTIFIC (CANADA) CORP. ("CSC") to be free from defects in materials and workmanship under normal use and service for **twelve (12) months** from date of shipment unless specified otherwise. ***** **Batteries are not warranted.** ***** CSC's obligation under this warranty is limited to repairing or replacing (at CSC's option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CSC. CSC will return such products by surface carrier prepaid. This warranty shall not apply to any CSC products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CSC is not liable for special, indirect, incidental, or consequential damages.

Products may not be returned without prior authorization. To obtain a Return Merchandise Authorization (RMA), contact CAMPBELL SCIENTIFIC (CANADA) CORP., at (780) 454-2505. An RMA number will be issued in order to facilitate Repair Personnel in identifying an instrument upon arrival. Please write this number clearly on the outside of the shipping container. Include description of symptoms and all pertinent details.

CAMPBELL SCIENTIFIC (CANADA) CORP. does not accept collect calls.

Non-warranty products returned for repair should be accompanied by a purchase order to cover repair costs.

CAMPBELLSCIENTIFIC
CANADA CORP.
11564 - 149 street - edmonton - alberta - T5M 1W7
tel 780.454.2505 fax 780.454.2655
www.campbellsci.ca

229 Sensor Table of Contents

PDF viewers note: These page numbers refer to the printed version of this document. Use the Adobe Acrobat® bookmarks tab for links to specific sections.

List of Tables

List of Figures

229 Heat Dissipation Matric Water Potential Sensor

1. General Description

The 229 Heat Dissipation Matric Water Potential Sensor uses a heat dissipation method to indirectly measure soil water matric potential. The active part of the 229 Soil Water Potential Sensor is a cylindrically-shaped porous ceramic body. A heating element which has the same length as the ceramic body is positioned at the center of the cylinder. A thermocouple is located at mid-length of the ceramic and heating element. The position of the heating element and the thermocouple is maintained by placing both inside a hypodermic needle. This also protects the delicate wires. The volume inside the needle which is not occupied by wiring is filled with epoxy.

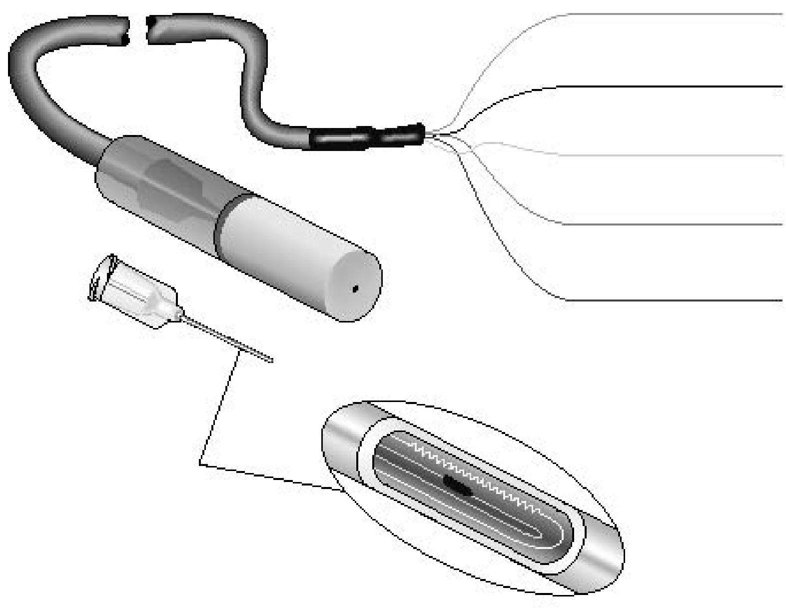


FIGURE 1-1. A 229 Heat Dissipation Matric Water Potential Sensor is shown at the top. The hypodermic assembly (without epoxy and ceramic) is shown just below. Cutaway view shows longitudinal section of the needle with heater and thermocouple junction.

The ceramic cylinder has a diameter of 1.5 cm and a length of 3.2 cm. Three copper wires and one constantan wire, contained in a shielded, burial-grade sheath provide a path for connection to measuring instrumentation. An epoxy section which is the same diameter as the ceramic matrix gives strain relief to the cable.

The 229 is used to measure soil water matric potential in the range -10 kPa to -2500 kPa. The method relies on hydraulic continuity between the soil and the sensor ceramic for water exchange. The variability in heat transfer properties among sensors makes individual calibration by the user a requirement. See Section 6 for calibration information.

Use of the 229 sensor requires a constant current source. Campbell Scientific offers the CE4 and CE8 current excitation modules (Figure 1-2), which have respectively four and eight regulated outputs of 50 milliamp ±0.25 milliamp. All of the outputs of the excitation module are switched on or off simultaneously by setting a single datalogger control port to its high or low state.

The –L option on the model 229 Heat Dissipation Matric Water Potential Sensor (229-L) indicates that the cable length is user specified. This manual refers to the sensor as the 229.

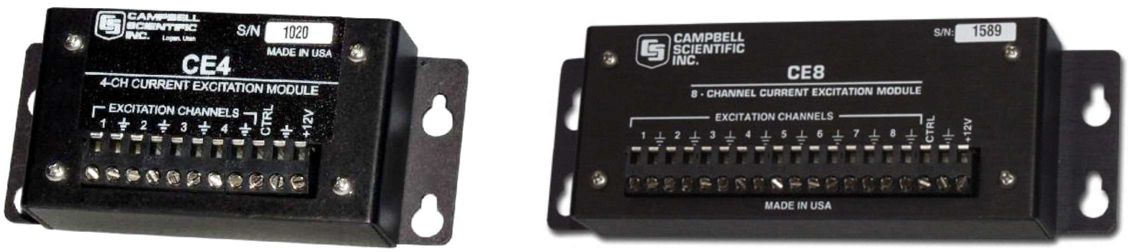


FIGURE 1-2. CE4 and CE8 Current Excitation Modules

1.1 Datalogger Compatibility

The 229 sensor is compatible with the 21X, CR7, CR10(X), CR23X, CR800, CR850, CR1000, and CR3000 dataloggers.

1.2 Measurement Principle

Movement of water between the 229 ceramic matrix and the surrounding soil occurs when a water potential gradient exists. When the water potential of the soil surrounding a 229 sensor changes, a water flux with the ceramic matrix will occur. The time required for hydraulic equilibration of the water in the soil and ceramic depends on both the magnitude of the water potential gradient and the hydraulic conductivity. Typically this equilibration time is on the order of minutes or tens of minutes.

A change in the water potential and water content of the ceramic matrix causes a corresponding change in the thermal conductivity of the ceramic/water complex. As the water content in the ceramic increases, the thermal conductivity of the complex also increases. At very low water contents, the ceramic material controls the thermal conductivity. As water content in the ceramic increases, water films are established between the solid particles, resulting in a rapid increase in thermal conductivity. As the pores in the ceramic continue to fill, the thermal conductivity becomes increasingly controlled by the continuous water and the increase in thermal conductivity of the ceramic/water complex approaches a constant value.

When a constant power is dissipated from the line heat source, the temperature increase near the heat source will depend on the thermal conductivity of the ceramic/water complex surrounding the heater. A temperature increase is caused by heat that is not dissipated. As the water content and thermal conductivity of the ceramic increases, the temperature increase as measured by the thermocouple will be reduced because conduction of the thermal energy from the heat source is greater. A drier sensor will have a lower thermal conductivity, so the thermal energy will not dissipate as quickly and the temperature rise will be greater. When 50 milliamps is passed through the heating element for 30 seconds, the temperature increase ranges from approximately 0.7ºC under wet conditions to 3.0ºC when dry. Figure 1-3 presents a typical temperature response in a silt loam.

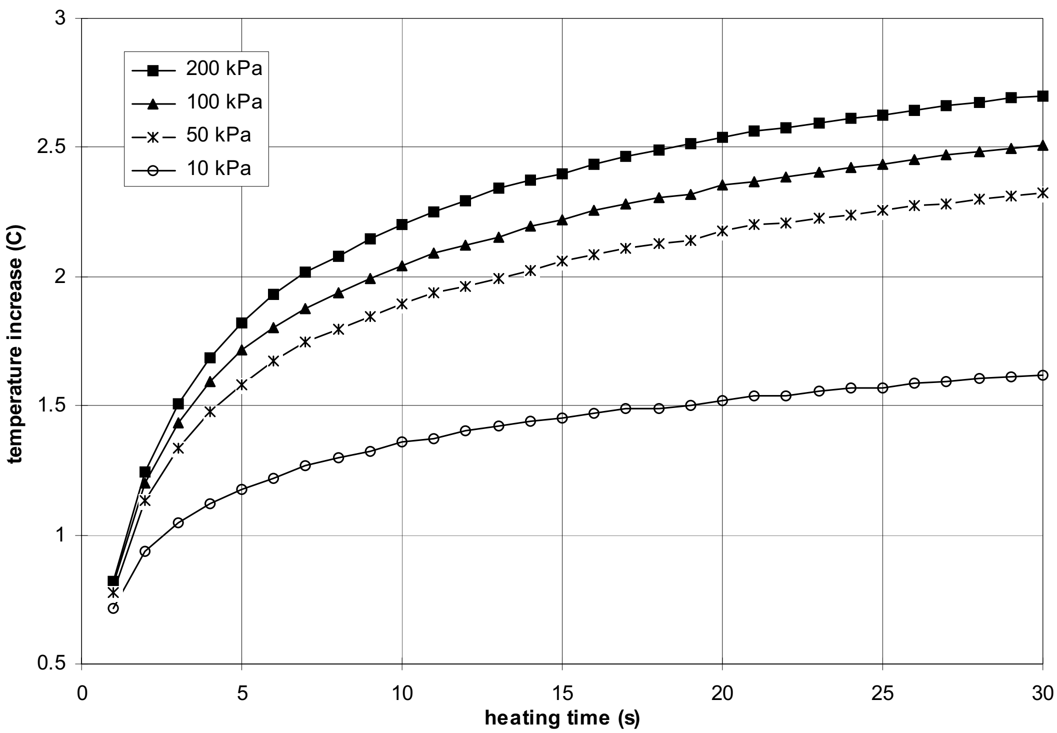


FIGURE 1-3. Typical Temperature Response of 229 Sensor in Silt Loam Soil

2. Specifications

229

Measurement range:	-10 to -2500 kPa
Measurement time:	30 seconds typical
Thermocouple type:	copper / constantan (type T)
Dimensions:	1.5 cm (0.6”) diameter 3.2 cm (1.3”) length of ceramic cylinder 6.0 cm (2.4”) length of entire sensor
Weight:	10 g (0.35 oz) plus 23 g/m (0.25 oz/ft) of cable
Heater resistance:	34 ohms plus cable resistance
Resolution:	~1 kPa at matric potentials greater than -100 kPa

CE4/CE8

Output:	50 mA ±0.25 mA per channel, regulated
Output channels:	CE4: 4 CE8: 8
Current drain(while active):	25 mA + 50 mA * no. of 229's connected to the CE4 or CE8 output channels.
Dimensions:	CE4: 11.5 cm (4.5") x 5.4 cm (2.1") x 2.7 cm (1.1") CE8: 16.5 cm (6.5") x 5.4 cm (2.1") x 2.7 cm (1.1")
Weight:	CE4: 131 g (4.6 oz) CE8: 184 g (6.5 oz)

3. Installation

3.1 Orientation

For best measurement results, the 229 should be installed horizontally at the desired depth of the soil. This will reduce distortion of typical vertical water flux.

3.2 Contact

Good contact must exist between the ceramic matrix and the soil since the measurement relies on water flux between the two. Adequate contact will result if the sensor is 'planted' in a manner similar to that used for seedlings. Sufficient contact in coarse texture soils such as medium and coarse sand can be obtained by surrounding the ceramic portion with a slurry of fine silica (sometimes referred to as silica flour).

3.3 Equilibration and Saturation of the Sensor Before Installation

The smaller the difference in water potential between the 229 ceramic and the surrounding soil, the sooner equilibrium will be reached. Filling the ceramic pores with liquid water will optimize the hydraulic conductivity between the ceramic and soil.

Simple immersion of the sensors in water can leave some entrapped air in the pores. Complete saturation can be closely approached if (1) deaerated water is used, and (2) saturation occurs in a vacuum. Soaking the ceramic in free water for 12 hours followed by soaking under a vacuum of ≥71 kPa (0.7 atm) atmosphere for 1 hour results in complete saturation of the sensor.

4. Wiring

Table 4-1 shows wiring information for the 229 sensor and CE4 or CE8 excitation module when connecting sensors directly to the datalogger without the use of a multiplexer. Figure 4-1 shows a simple schematic of these connections.

See the multiplexer program in Section 5 for details on multiplexer wiring.

TABLE 4-1. 229 Sensor and CE4/CE8 Wiring

229 Wire Color	Function	CR10(X), CR23X, CR800, CR850, CR1000, CR3000	CE4/CE8
Blue	Thermocouple High	High side of differential channel	
Red	Thermocouple Low	Low side of differential channel	
Green	Heater High		Current excitation channel
Black	Heater Low		⏚
Clear	Shield	G	
	CE4/CE8 Power	12V	+12V
	CE4/CE8 Ground	G	⏚
	CE4/CE8 Enable	Control Port	CTRL

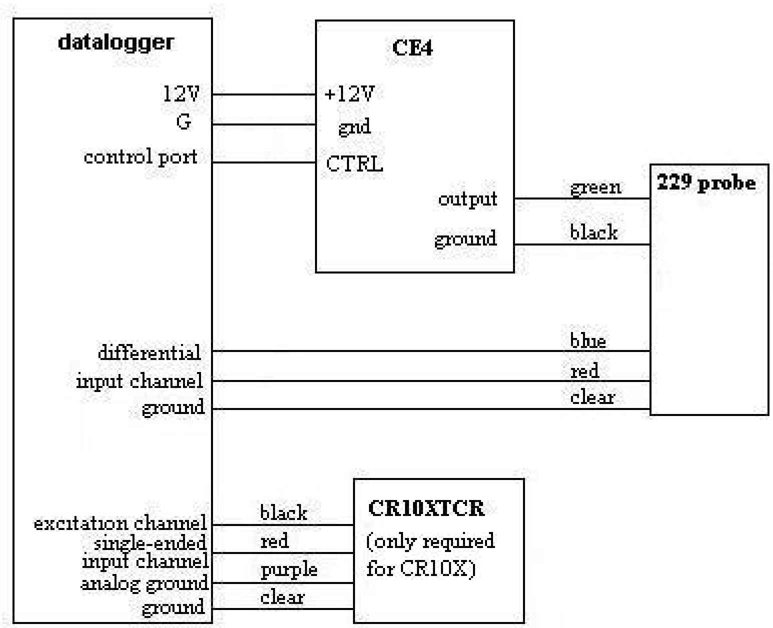


FIGURE 4-1. Schematic of Connections for Measurement of a 229 Sensor

5. Example Programs

5.1 Choosing a Reference for the Thermocouple Readings

A fundamental thermocouple circuit uses two thermocouple junctions with one pair of common-alloy leads tied together and the other pair connected to a voltage readout device. One of the junctions is the reference junction and is generally held at a known temperature. The temperature at the other junction can be determined by knowing the voltage potential difference between the junctions and the reference temperature.

A Campbell Scientific datalogger can read a single thermocouple junction directly because the temperature at the wiring panel is measured with a thermistor and this temperature is converted to a voltage which is then used as a thermocouple reference. A thermocouple circuit voltage potential is affected by the temperature of all dissimilar metal junctions. When using an AM16/32 multiplexer with the 229 sensor, the temperature of the AM16/32 can be used as the reference temperature if a thermistor probe such as the 107 is taped to the multiplexer panel near the 229 wires. Alternately, a CR10XTCR can be used to get an accurate reading of the CR10X wiring panel temperature and type T thermocouple wire (copper-constantan) can be used for the signal wires between the differential voltage channel on the datalogger and the appropriate common channels on the multiplexer (see program example #2 below). The CR23X, CR800, CR1000, and CR3000 can use their own internal panel temperature measurement instead of the CR10XTCR and type T thermocouple wire to the multiplexer common channels as previously noted. The use of insulation or an enclosure to keep the AM16/32 and temperature sensor at the same temperature will improve measurement quality.

5.2 Adjusting for Thermal Properties of Sensor During Early Heating Times

The discussion presented at the beginning of the calibration section (Section 6) describes how thermal properties can vary from sensor-to-sensor. The thermal properties of the needle casing, wiring, and the amount of contact area between the needle and the ceramic have a slight effect on the temperature response. Most of the nonideal behavior of the sensor is manifest in the first second of heating. The measurement is improved if the temperature after 1 s is subtracted from some final temperature. A typical ΔT would be T(30 s) - T(1 s).

5.3 Datalogger Program Structure and Multiplexers

The sequence of datalogger instructions for a 229 measurement is as follows:

1) Measure sensor temperature prior to heating.

2) Set a control port high to enable constant current excitation module and being heating.

3) Wait for one second of heating and measure sensor temperature.

4) Wait for 29 more seconds of heating and measure sensor temperature.

5) Set control port low to disable the constant current excitation module and end heating.

6) Calculate temperature rise by subtracting T(1 s) from T(30 s).

Since all of the output channels of the CE4 or CE8 are activated when the control terminal is set high, power will be applied to all of the 229 sensors connected to the current source. Inaccurate measurements can result if the temperature of multiple sensors is simply read sequentially. The inaccuracy can occur because a finite amount of time is required to execute each of the temperature measurement instructions.

For example, a CR10X making multiple differential thermocouple readings with 60 Hz rejection takes 34.9 ms to read one thermocouple, and 30.9 ms more for each additional thermocouple. In a configuration where six 229 sensors are connected to a CE8 with their thermocouple wires connected sequentially to the CR10X wiring panel, the sixth 229 sensor will heat for 154.5 ms longer than the first sensor each time its temperature is measured. The amount of time between temperature measurement of the first sensor and the last sensor can be as long as 0.5 seconds under some measurement configurations.

The error caused by this difference in heating times can be minimized if the sensors are connected to the constant current excitation module and datalogger during calibration in exactly the same order they will be wired during field deployment. The difference in heating times can be eliminated altogether by heating the sensors one at a time through a multiplexer such as the AM16/32.

The AM 16/32 multiplexer in 4x16 mode provides a convenient method to measure up to sixteen 229 sensors. Since four lines are switched at once, both the thermocouple and the heating element leads for each sensor can be connected to a multiplexer channel. A measurement sequence is executed on each sensor. See program example #2 below for instructions on wiring and programming multiple 229 sensors on a multiplexer.

NOTE When using multiplexers, the user should be aware that switching currents of greater than 30 mA will degrade the contact surfaces of the mechanical relays. This degradation will adversely affect the suitability of these relays to multiplex low voltage signals. Although a relay used in this manner no longer qualifies for low voltage measurements, it continues to be useful for switching currents in excess of 30 mA. Therefore, the user is advised to record which multiplexer channels are used to multiplex the 50 mA excitation for the 229-L sensors in order to avoid using those channels for low voltage measurements in future applications.

5.4 Temperature Correction

The rise in temperature over the 30 second heating time will be affected by the initial temperature of the 229 sensor. The measurement can be corrected for temperature if it can first be normalized. See Section 6.2.1 for more information on normalizing the sensor output.

Correct for temperature in the datalogger program following these steps outlined in Flint, et al. (2002):

1. Determine normalized dimensionless temperature rise, T_{norm} as described in Section 6.2.1 equation 3

$$T_{norm} = \frac{\Delta T_{dry} - \Delta T}{\Delta T_{dry} - \Delta T_{wet}}$$

2. Determine where T_{norm} falls on the dimensionless slope function, s*

$$s^* = -0.0133T_{norm}^{\ 5} + 0.0559T_{norm}^{\ 4} - 0.0747T_{norm}^{\ 3} + 0.0203T_{norm}^{\ 2} + 0.011T_{norm} + 0.0013$$

3. Determine corrected dimensionless temperature rise, $T_{normcorr}$

$$T_{normcorr} = T_{norm} - s^*\left(T_{soil} - T_{cal}\right)$$

4. Determine corrected temperature rise, ΔT_{corr}

$$\Delta T_{corr} = \Delta T_d - T_{normcorr}\left(\Delta T_{dry} - \Delta T_{wet}\right)$$

The corrected temperature rise can now be used to calculate soil water matric potential. Example 4 below shows how to make the temperature correction with a CR1000.

5.5 Example #1 — CR10X with 229 Sensor

Table 5-1 shows wiring information for reading a single sensor with a CR10X datalogger, CE4 current excitation module, and CR10XTCR thermocouple reference temperature sensor.

TABLE 5-1. 229 Sensor and CE4/CE8 Wiring with CR10XTCR

229	Function	CR10(X)	CE4	CR10XTCR
Blue	229 Thermocouple High	1H		
Red	229 Thermocouple Low	1L		
Green	229 Heater High		Channel 1	
Black	229 Heater Low		⏚	
Clear	229 Shield	G		
	CE4/CE8 Power	12V	+12V	
	CE4/CE8 Ground	G	⏚	
	CE4/CE8 Enable	C1	CTRL	
	CR10XTCR Signal	2H		Red
	CR10XTCR Signal Return	AG		Clear
	CR10XTCR Excitation	E3		Black

```
;{CR10X}
;Program to read 1 229-L sensor
;Reading 1 sensor takes 30 seconds

*Table 1 Program
  01: 60          Execution Interval (seconds)

1:  If time is (P92)
  1:   0          Minutes (Seconds --) into a
  2:   60         Interval (same units as above)
  3:   11         Set Flag 1 High

2:  If Flag/Port (P91)
  1:   11         Do if Flag 1 is High
  2:   30         Then Do

    3:  Temp (107) (P11)                     ;Measure reference temperature
      1:   1          Reps
      2:   3          SE Channel
      3:   3          Excite all reps w/E3
      4:   1          Loc [ Ref_Temp  ]
      5:   1.0        Multiplier
      6:   0.0        Offset

    4:  Thermocouple Temp (DIFF) (P14)       ;Measure initial sensor temperature
      1:   1          Reps
      2:   1          2.5 mV Slow Range
      3:   1          DIFF Channel
      4:   1          Type T (Copper-Constantan)
      5:   1          Ref Temp (Deg. C) Loc [ Ref_Temp  ]
      6:   2          Loc [ Tinit_1   ]
      7:   1.0        Mult
      8:   0.0        Offset

  5:  Do (P86)                               ;Turn on CE8
      1:   41         Set Port 1 High

  6:  Excitation with Delay (P22)            ;Wait one second before taking first reading
      1:   1          Ex Channel
      2:   0000       Delay W/Ex (0.01 sec units)
      3:   100        Delay After Ex (0.01 sec units)
      4:   0          mV Excitation

  7:  Thermocouple Temp (DIFF) (P14)         ;Take 1 second temperature reading
      1:   1          Reps
      2:   1          2.5 mV Slow Range
      3:   4          DIFF Channel
      4:   1          Type T (Copper-Constantan)
      5:   1          Ref Temp (Deg. C) Loc [ ref_temp  ]
      6:   3          Loc [ T1sec_1   ]
      7:   1.0        Mult
      8:   0.0        Offset
```

```
8:  Excitation with Delay (P22)                    ;Wait  29 more seconds for next reading
    1:  1           Ex Channel
    2:  0           Delay W/Ex (0.01 sec units)
    3:  2900        Delay After Ex (0.01 sec units)
    4:  0000        mV Excitation

9:  Thermocouple Temp (DIFF) (P14)                 ;Take 30 second temperature reading
    1:  1           Reps
    2:  1           2.5 mV Slow Range
    3:  4           DIFF Channel
    4:  1           Type T (Copper-Constantan)
    5:  1           Ref Temp (Deg. C) Loc [ ref_temp  ]
    6:  4           Loc [ T30sec_1  ]
    7:  1.0         Mult
    8:  0.0         Offset

10:  Do (P86)                                      ;turn off CE8
    1:  52          Set Port 2 Low

11:  Z=X-Y (P35)                                   ;Calculate delta T
        1:  4           X Loc [ T30sec_1  ]
        2:  3           Y Loc [ T1sec_1   ]
        3:  5           Z Loc [ deltaT_1  ]

12:  Do (P86)                                      ;Save readings to final storage
    1:  10          Set Output Flag High (Flag 0)

  13:  Set Active Storage Area (P80)
    1:  1           Final Storage Area 1
    2:  229         Array ID

  14:  Real Time (P77)
    1:  1220        Year,Day,Hour/Minute (midnight = 2400)

  15:  Sample (P70)
    1:  1           Reps
    2:  2           Loc [ Tinit_1   ]

  16:  Sample (P70)
    1:  1           Reps
    2:  5           Loc [ deltaT_1  ]

17:  Do (P86)                                      ;Disable flag 1
    1:  21          Set Flag 1 Low

18:  End (P95)
```

5.6 Example #2 — CR10X with AM16/32, CE4, and Sixteen 229 Sensors

Table 5-2 shows wiring information for connecting multiple 229 sensors and CE4 or CE8 excitation module to an AM16/32 multiplexer and CR10X datalogger. A CR10XTCR or 107 probe should be used for the reference temperature measurement as described at the beginning of this section. See Figure 6-4 for a schematic of this wiring configuration.

TABLE 5-2. 229 Sensor and CE4/CE8 Wiring with AM16/32 Multiplexer

229	107/CR10XTCR	Function	CR10(X)	CE4/CE8	AM16/32 (4x16 mode)
Blue		229 Thermocouple High			ODD H (1H, 3H, etc)
Red		229 Thermocouple Low			ODD L (1L, 3L, etc)
Green		229 Heater High			EVEN H (2H, 4H, etc)
Black		229 Heater Low			EVEN L (2L, 4L, etc)
Clear		229 Shield	G		⏚
		CE4/CE8 Power	12V	+12V	
		CE4/CE8 Ground	G	⏚	
		CE4/CE8 Enable	C1	CTRL	
			1H		COM ODD H*
			1L		COM ODD L*
		CE4/CE8 current excitation channel		Channel 1	COM EVEN H
		CE4/CE8 ground		⏚	COM EVEN L
		AM16/32 Power	12V		12V
		AM16/32 Ground	G		GND
		AM16/32 Enable	C2		RES
		AM16/32 Advance	C3		CLK
	Red	107 Signal	SE5		
	Black	107 Excitation	E1		
	Purple (Clear for CR10XTCR)	107 Signal Ground	AG		
	Clear (107 only)	107 Shield	G		

* Run copper wire from COM ODD H and COM ODD L to 1H/1L if using a 107 probe taped to the AM16/32 as the reference temperature sensor. If using a CR10XTCR as the reference temperature sensor, run copper wire from COM ODD H to 1H and run constantan wire from COM ODD L to 1L.

```
;{CR10X}
;Program to read 16 229-L sensors using 1 AM16/32 multiplexer
;and 1 CE4 or CE8 constant current interface
;Manually set Flag 1 high to force readings

*Table 1 Program
  01: 30           Execution Interval (seconds)

1: Batt Voltage (P10)
  1:  1            Loc [ Batt_Volt ]

2: If time is (P92)                          ;Set Flag 1 high each hour
  1:  0            Minutes (Seconds --) into a
  2:  60           Interval (same units as above)
  3:  11           Set Flag 1 High

3: If Flag/Port (P91)
  1:  11           Do if Flag 1 is High
  2:  30           Then Do

  4: Do (P86)                                ;Turn on AM16/32
     1:  4            Set Port 2 High

  5: Beginning of Loop (P87)                 ;Loop of 16 for 16 sensors on AM16/32
     1:  0            Delay
     2:  16           Loop Count

  6: Do (P86)                                ;Advance to next multiplexer channel
        1:  73           Pulse Port 3

  7: Temp (107) (P11)                        ;Measure reference temperature
        1:  1            Reps                ;This is the same instruction
        2:  5            SE Channel          ;for both the CR10X and 107
        3:  1            Excite all reps w/E1
        4:  2            Loc [ Tref_C    ]
        5:  1.0          Mult
        6:  0.0          Offset

  8: Thermocouple Temp (DIFF) (P14)          ;Read initial temperature
        1:  1            Reps
        2:  21           10 mV, 60 Hz Reject, Slow Range
        3:  1            DIFF Channel
        4:  1            Type T (Copper-Constantan)
        5:  2            Ref Temp (Deg. C) Loc [ Tref_C    ]
        6:  3         -- Loc [ Tinit_1   ]
        7:  1.0          Mult
        8:  0.0          Offset

  9: Do (P86)                                ;turn on CE8
        1:  41           Set Port 1 High
```

```
  10:  Excitation with Delay (P22)                  ;Delay of 1 second
         1:   1              Ex Channel
         2:   0000           Delay W/Ex (0.01 sec units)
         3:   100            Delay After Ex (0.01 sec units)
         4:   0              mV Excitation

  11:  Thermocouple Temp (DIFF) (P14)               ;Read thermocouple after 1 second of heating
         1:   1              Reps
         2:   21             10 mV, 60 Hz Reject, Slow Range
         3:   1              DIFF Channel
         4:   1              Type T (Copper-Constantan)
         5:   2              Ref Temp (Deg. C) Loc [ Tref_C    ]
         6:   19        --   Loc [ T1s_1     ]
         7:   1.0            Mult
         8:   0.0            Offset

  12:  Excitation with Delay (P22)                  ;delay 29 more seconds
         1:   1              Ex Channel
         2:   0              Delay W/Ex (0.01 sec units)
         3:   2900           Delay After Ex (0.01 sec units)
         4:   0000           mV Excitation

  13:  Thermocouple Temp (DIFF) (P14)               ;read temperature after 30 seconds heating
         1:   1              Reps
         2:   21             10 mV, 60 Hz Reject, Slow Range
         3:   1              DIFF Channel
         4:   1              Type T (Copper-Constantan)
         5:   2              Ref Temp (Deg. C) Loc [ Tref_C    ]
         6:   35        --   Loc [ T30s_1    ]
         7:   1.0            Mult
         8:   0.0            Offset

  14:  Do (P86)                                     ;turn off CE8
         1:   51             Set Port 1 Low

  15:  Z=X-Y (P35)                                  ;Calculate temperature rise
         1:   35        --   X Loc [ T30s_1    ]
         2:   19        --   Y Loc [ T1s_1     ]
         3:   5         --   Z Loc [ dT_1      ]

  16:  End (P95)                                    ;end of loop

17:  Do (P86)                                       ;Turn off AM16/32
  1:    52             Set Port 2 Low

18:  End (P95)                                      ;End of then do statement

19:  If Flag/Port (P91)
  1:    11             Do if Flag 1 is High
  2:    10             Set Output Flag High (Flag 0)

20:  Set Active Storage Area (P80)
  1:    1              Final Storage Area 1
  2: 229               Array ID
```

```
21:  Real Time (P77)
 1:  1220         Year,Day,Hour/Minute (midnight = 2400)

22:  Sample (P70)                         ;Sample 16 initial soil temperature readings
 1:  16           Reps
 2:  3            Loc [ Tinit_1   ]

23:  Sample (P70)                         ;Sample 16 delta T readings
 1:  16           Reps
 2:  51           Loc [ dT_1      ]

24:  Do (P86)
 1:  21           Set Flag 1 Low
```

5.7 Example #3 — CR1000 with CE4 and Four 229s

Table 5-3 shows wiring information for reading four 229 sensors with a CR1000 datalogger and CE4 current excitation module.

TABLE 5-3. Wiring for Four 229s with CR1000 and CE4

229	**CR1000**		**229**	**CE4**
229 #1Blue	1H		229 #1 Green	Channel 1
229 #1Red	1L		229 #1 Black	⏚
229 #2Blue	2H		229 #2 Green	Channel 2
229 #2Red	2L		229 #2 Black	⏚
229 #3Blue	3H		229 #4 Green	Channel 3
229 #3Red	3L		229 #3 Black	⏚
229 #4Blue	4H		229 #4 Green	Channel 4
229 #4Red	4L		229 #4 Black	⏚
229 #1 Clear				⏚
229 #2 Clear				⏚
229 #3 Clear				⏚
229 #4 Clear				⏚
	12V			+12V
	G			⏚
	C1			CTRL

```
'CR1000
SequentialMode

Const Num229 = 4                     'Enter number of 229 sensors to measure
Dim LoopCount
Public RefTemp_C, StartTemp_C(Num229), Temp_1sec_C(Num229)
Public Temp_30sec_C(Num229), DeltaT_C(Num229)
Public Flag(1) as Boolean

Units StartTemp_C()=Deg C
Units DeltaT_C()=Deg C

DataTable(Matric,Flag(1),-1)
  Sample(Num229,StartTemp_C(),FP2)
  Sample(Num229,DeltaT_C(),FP2)
EndTable

BeginProg
  Scan(30,Sec,1,0)
    PanelTemp (RefTemp_C,250)
    If IfTime (0,240,Min) Then Flag(1)=True  'Every 4 hours set Flag(1) high
    If Flag(1) = True Then                   'Flag(1) true triggers 229 readings
      'Measure starting temperature before heating
      TCDiff(StartTemp_C(),Num229,mV2_5C,1,TypeT,RefTemp_C,True,0,_60Hz,1,0)
      PortSet (1,1 )                         'Set C1 high to activate CE4
      Delay (0,1,Sec)                        'Wait 1 second
      'Measure temperature after 1 second of heating
      TCDiff(Temp_1sec_C(),Num229,mV2_5C,1,TypeT,RefTemp_C,True,0,_60Hz,1,0)
      'Measure temperature after 30 second of heating
      Delay (0,29,Sec)                       'Wait 29 seconds more for total of 30 seconds heating
      TCDiff(Temp_30sec_C(),Num229,mV2_5C,1,TypeT,RefTemp_C,True,0,_60Hz,1,0)
      PortSet (1,0 )                         'Set C1 low to deactivate CE4
      For LoopCount=1 to Num229
        'Calculate temperature rise
        DeltaT_C(LoopCount)=Temp_30sec_C(LoopCount)-Temp_1sec_C(LoopCount)
        'LoopCount=LoopCount+1
      Next LoopCount
    EndIf                                    'Ends Flag(1) true condition
    CallTable(Matric)                        'Call Data Tables and Store Data
    Flag(1)=False                            'Set Flag 1 false to disable 229 measurements
  NextScan
EndProg
```

5.8 Example #4 — CR1000 with AM16/32, CE4 and Sixteen 229 Sensors with Temperature Correction

Table 5-4 shows wiring information for connecting multiple 229 sensors and CE4 excitation module to an AM16/32 multiplexer and CR1000 datalogger. See Figure 6-4 for a schematic of this wiring configuration.

TABLE 5-4. 229 Sensor and CE4 Wiring with CR1000 and AM16/32

229	107	Function	CR1000	CE4	AM16/32 (4x16 mode)
Blue		229 Thermocouple High			ODD H (1H, 3H, etc)
Red		229 Thermocouple Low			ODD L (1L, 3L, etc)
Green		229 Heater High			EVEN H (2H, 4H, etc)
Black		229 Heater Low			EVEN L (2L, 4L, etc)
Clear		229 Shield	G		⏚
		CE4 Power	12V	+12V	
		CE4 Ground	G	⏚	
		CE4 Enable	C3	CTRL	
			1H		COM ODD H
			1L		COM ODD L
		CE4 current excitation channel		Channel 1	COM EVEN H
		CE4 Ground		⏚	COM EVEN L
		AM16 Power	12V		12V
		AM16/32 Ground	G		GND
		AM16/32 Enable	C1		RES
		AM16/32 Advance	C2		CLK
	Red	107 Signal	SE 3		
	Black	107 Excitation	EX1		
	Purple	107 Signal Ground	⏚		
	Clear	107 Shield	G		

```
'CR1000
SequentialMode
Const Num229 = 16                         'Enter number of 229 sensors to measure
Const read229 = 60                        'Enter Number of minutes between 229-L readings
Const CalTemp = 20                        'Enter calibration temperature (deg C)
Dim i, dTdry(Num229), dTwet(Num229)
Dim Tstar, Tstarcorr, DeltaTcorr, s
Public RefTemp_C, StartTemp_C(Num229), Temp_1sec_C(Num229)
Public Temp_30sec_C(Num229), DeltaT_C(Num229), dTcorr(Num229)
Public Flag(1) as Boolean

Units StartTemp_C()=Deg C
Units DeltaT_C()=Deg C
Units dTcorr() = Deg C

DataTable(Matric,Flag(1),-1)
  Sample(Num229,StartTemp_C(),FP2)
  Sample(Num229,DeltaT_C(),FP2)
  Sample(Num229,dTcorr(),FP2)
EndTable

Sub TempCorr                              'Subroutine to temperature correct DeltaT_C
  Tstar=(dTdry(i)-DeltaT_C(i))/(dTdry(i)-dTwet(i))
  s=-0.0133*Tstar^5+0.0559*Tstar^4-0.0747*Tstar^3+0.0203*Tstar^2+0.011*Tstar+0.0013
  Tstarcorr=Tstar-s*(StartTemp_C(i)-CalTemp)
  DeltaTcorr=dTdry(i)-Tstarcorr*(dTdry(i)-dTwet(i))
EndSub

BeginProg
'Enter dTdry and dTwet values obtained for each probe (these are examples):
dTdry(1)= 3.421:  dTdry(2)=3.417:  dTdry(3)=3.433:  dTdry(4)=3.418
dTdry(5)= 3.412:  dTdry(6)=3.407:  dTdry(7)=3.422:  dTdry(8)=3.428
dTdry(9)= 3.399:  dTdry(10)=3.377: dTdry(11)=3.405: dTdry(12)=3.406
dTdry(13)=3.422:  dTdry(14)=3.431: dTdry(15)=3.423: dTdry(16)=3.408
dTwet(1)= 0.752:  dTwet(2)=0.695:  dTwet(3)=0.731:  dTwet(4)=0.724
dTwet(5)= 0.709:  dTwet(6)=0.752:  dTwet(7)=0.739:  dTwet(8)=0.737
dTwet(9)= 0.723:  dTwet(10)=0.754: dTwet(11)=0.691: dTwet(12)=0.760
dTwet(13)=0.722:  dTwet(14)=0.745: dTwet(15)=0.739: dTwet(16)=0.748
  Scan(30,Sec,1,0)
    Therm107(RefTemp_C,1,3,1,0,_60Hz,1.0,0.0)      'Reference temperature measurement
    If IfTime (0,read229,Min) Then Flag(1)=True    'Set Flag(1) high based on time
    If Flag(1) = True Then                         'Flag(1) triggers 229 readings
      PortSet(1,1)                                 'Set C1 High to turn on multiplexer
      For i=1 to Num229
        PulsePort(2,10000)                         'Switch to next multiplexer channel

        'Measure starting temperature before heating
        TCDiff(StartTemp_C(i),1,mV2_5C,1,TypeT,RefTemp_C,True,0,_60Hz,1,0)
        PortSet (3,1 )                             'Set C3 high to activate CE4
        Delay (0,1,Sec)                            'Wait 1 second

        'Measure temperature after 1 second of heating
        TCDiff(Temp_1sec_C(i),1,mV2_5C,1,TypeT,RefTemp_C,True,0,_60Hz,1,0)
        Delay (0,29,Sec)                           'Wait 29 seconds more
```

```
          'Measure temperature after 30 second of heating
          TCDiff(Temp_30sec_C(i),1,mV2_5C,1,TypeT,RefTemp_C,True,0,_60Hz,1,0)

          PortSet (3,0 )                               'Set C3 low to deactivate CE4
          DeltaT_C(i)=Temp_30sec_C(i)-Temp_1sec_C(i)'Calculate temperature rise
          Call TempCorr                                'Call temperature correction subroutine
          dTcorr(i)=DeltaTcorr
        Next i
      EndIf                                            'Ends Flag(1) high condition
      PortSet(1,0)                                     'Turn multiplexer Off
      CallTable(Matric)                                'Call Data Tables and Store Data
      Flag(1)=False                                    'Disable 229 measurements
    NextScan
EndProg
```

6. Calibration

6.1 General

The heat transfer properties of a 229 sensor depend both on the thermal properties of the various sensor materials and on the interfaces between the different materials. Heat transfer between the stainless steel needle containing the heating element and thermocouple and the ceramic material depends on the density of points-of-contact between two different materials. Heat transfer also depends on the arrangement of the wires in the hypodermic needle and the amount of contact between the needle and the ceramic. The uncontrollable variability in heat transfer properties warrants individual calibration of the 229 sensors.

The calibration used to relate temperature increase and the soil water potential is strictly empirical, and the functional expression of the relationship can take several forms. The most commonly used function is:

$$\psi = \exp(\alpha * \Delta T + \beta) \qquad [1]$$

with ψ the soil water potential, exp the exponential function, ΔT the temperature increase during the chosen heating period of time, α the slope and β the intercept.

The relationship between the natural logarithm of soil water tension and the temperature increase is linear which simplifies derivation of the calibration function.

$$\ln(|\psi|) = \alpha * \Delta T + \beta \qquad [2]$$

(Soil water potential is a negative value and becomes more negative as soil dries.) Figure 6-1 is a typical calibration and the data set is easily described with linear regression. A power function works well in applications when calibration is needed for -500 kPa ≤ matric potential ≤ -10 kPa. A power function calibration has the form $|\psi| = a*(\Delta T)^b$ with the multiplier, a, and exponent, b, as fitted parameters.

A variety of calibration methods are suitable. The sole requirement is that the water potential of the medium surrounding the sensor must be known. Either the applied potential can be controlled at a specified value or the water potential can be independently measured. Hanging water columns and pressure plate extractors are typically used. Several data values which correspond to the water potential expected during sensor use should be included in the calibration

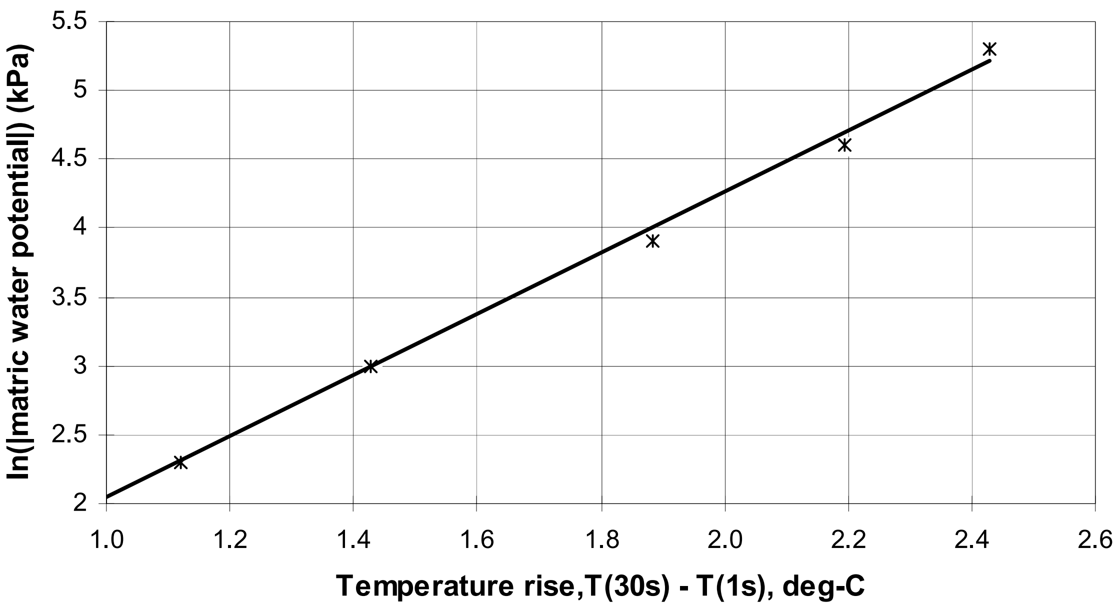


FIGURE 6-1. Data Points (x) and Regression for Typical Calibration

6.2 Normalized Temperature Change and Correction for Soil Temperature

6.2.1 Normalized Temperature Change

The effect of sensor-to-sensor variability can be reduced by using normalized temperature increase, ΔT_{norm}, described by

$$\Delta T_{norm} = \frac{\Delta T_{dry} - \Delta T}{\Delta T_{dry} - \Delta T_{wet}} \qquad [3]$$

where ΔT_{dry} is the change in temperature during measurement when the 229 sensor is dry, ΔT_{wet} is the change in temperature during measurement when the 229 sensor is fully saturated and ΔT is the change in temperature during the measurement. The range of ΔT_{norm} will be 0 to 1 with ΔT_{norm} equal 0 for dry soil and 1 for saturated soil.

The ΔT_{wet} value requires full saturation of the ceramic. The ceramic portion of the sensor must be immersed in water while under vacuum to remove all air from the ceramic. Measurements at the factory show that complete saturation will occur after 3-4 hours at 0.7 atmospheres (70 kPa) vacuum. However, the arrangement of the sensors in the water during vacuum extraction may hamper movement of air from the ceramic. When tapping or jarring the container shows no release of bubbles, the ceramic is saturated.

The ΔT_{dry} value requires that the ceramic be as dry as possible. Sensors can be dried with desiccant or in an oven at temperature no greater than 60 °C. Temperatures greater than 60 °C may damage the sensor cable.

Reece (1996) suggested that inverse thermal conductivity can also be used as a normalization technique but work by Campbell Scientific has not shown significant advantage for this method over normalization as described by equation [3].

A calibration equation using ΔT_{norm} and having a form similar to equation [2] is

$$\ln(|\psi|) = \alpha * \Delta T_{norm} + \beta . \qquad [4]$$

The slope of equation [2] will be positive while the slope of equation [4] will be negative.

6.2.2 Correction for Soil Temperature

The heat dissipation method of matric potential measurement is sensitive to temperature and correction for the temperature dependence may be necessary to maintain accuracy of the measurement. If the soil temperature when the matric potential measurements are made is close to the temperature at the time of sensor calibration there is no need for correction.

The 229 measurement method uses heat transfer away from a heated line source and the heat transfer depends on the thermal conductivity of the ceramic. The thermal conductivity of the ceramic depends on the combination of the conductivities of water, vapor and solid constituents. The vapor component has a strong temperature dependence and consequently imparts sensitivity of the measurement to temperature. The sensitivity is related to the difference between the temperature of the sensor at time of measurement (soil temperature) and the temperature of the sensor during calibration. Figures 6-2 and 6-3 show the response of the matric potential measurement for a range of temperatures when the calibration temperature is 20 C.

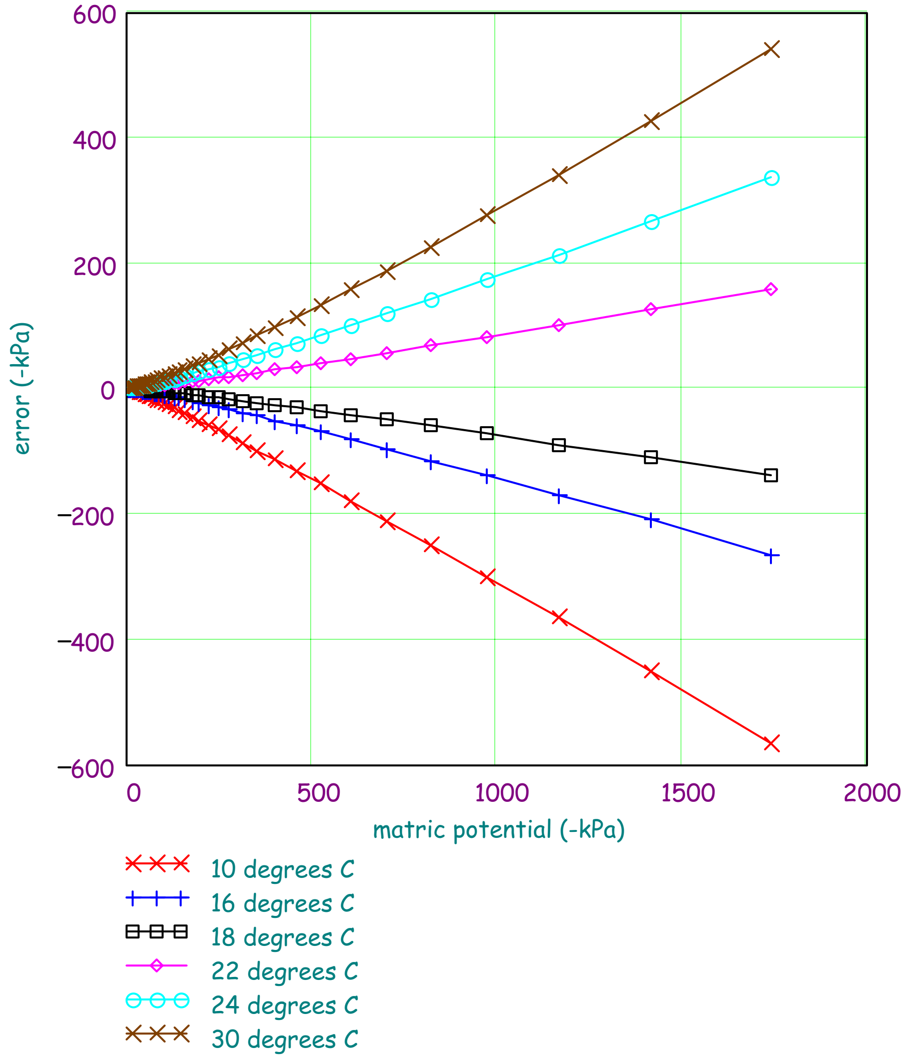


FIGURE 6-2. Measurement error for range of soil temperatures and wide range of matric potential.

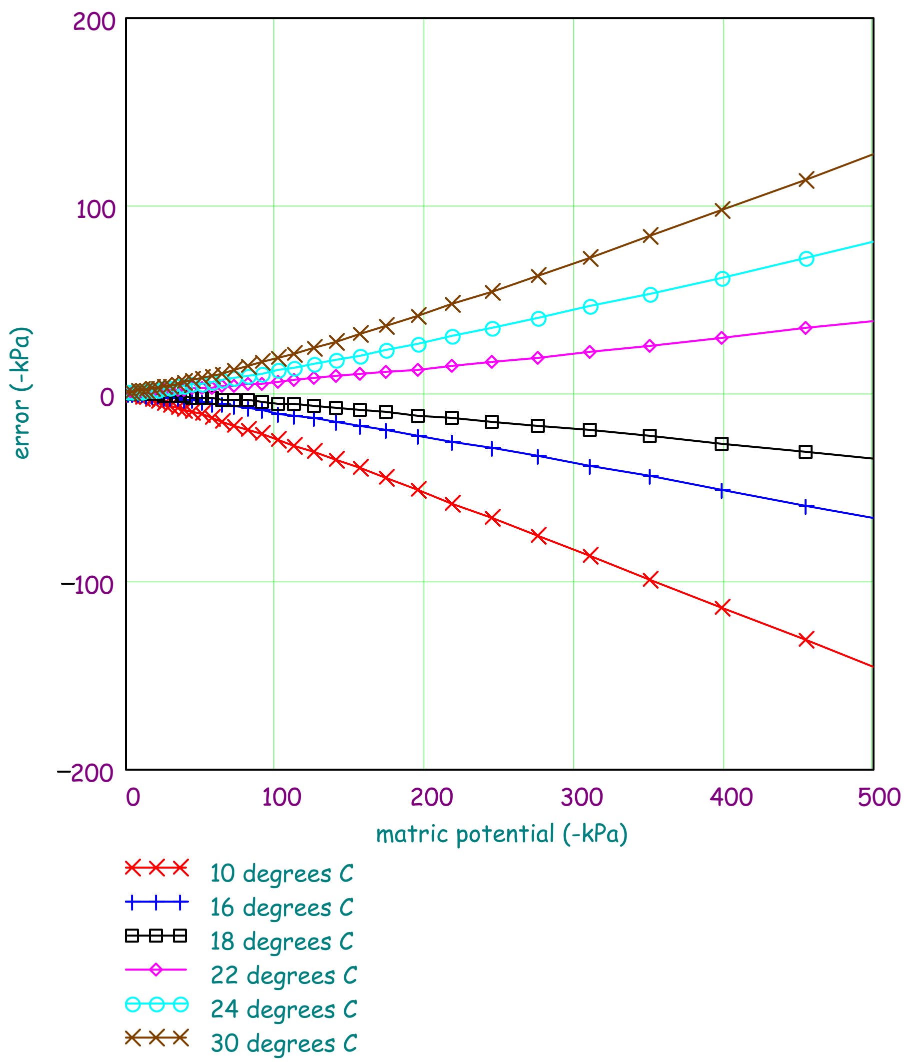


FIGURE 6-3. Measurement error for range of soil temperatures and wetter range of matric potential.

A temperature correction for the difference in temperature at time of calibration and time of measurement is provided in the work of Flint et al., 2002. To implement the correction, normalized temperature must be used for the calibration variable. Normalized temperature is as defined in equation [3].

The correction procedure is an iterative method. Examples of implementing the iterative routine with dataloggers are given in programming examples 5 and 6. The general sequence for using the temperature correction method is:

1. Determine ΔT_{dry} and ΔT_{wet} prior to calibration and with sensor conditions as described in 6.2.1. The recommended ΔT is the sensor temperature after 30 seconds of heating minus the sensor temperature after 1 second of heating.

2. With the sensor in place, use the ΔT from the in situ measurement along with the ΔT_{dry} , ΔT_{wet} values for the particular sensor to calculate ΔT_{norm} .

3. Implement the iterative temperature correction as presented in datalogger example program #4 to obtain a corrected ΔT_{norm} .

4. Use the corrected ΔT_{norm} in the calibration equation, e.g. equation [4].

6.3 Using Pressurized Extraction Methods

Pressurized extraction methods use a porous material (typically ceramic or stainless steel) to separate the pressurized soil sample from atmospheric pressure. One side of the porous material is in contact with the soil sample and the other side is at atmospheric pressure. A simple configuration is a cylinder which has the porous material as a bottom and a solid cap at the top which provides a pressure-tight seal after the soil sample has been placed on the porous bottom. This allows pressurization of the soil sample which will force water from the soil. The air entry pressure of the porous material is dependent on the effective pore diameter and must be greater than the maximum pressure applied during calibration. When a specified pressure is applied, all soil water at water potentials greater than -1*(applied pressure) will move through the soil sample and through the porous bottom. The time required for the soil water to leave the sample system depends on the pressure gradient and the hydraulic conductivity of the soil and the porous bottom plate.

Equilibration of water potential throughout the system must be attained or the accuracy of the water potential measurement using the derived calibration will be reduced. The simplest way to confirm equilibration is to repeat the measurements at a given applied pressure until readings do not change.

6.4 General Description of Calibration/Measurement Process using Pressure Plate Extractor

A pressure plate extractor consists of a high-pressure vessel, a porous plate and tubing to remove soil water from the soil sample. A ring with diameter slightly less than the diameter of the ceramic plate can be used to hold the soil in which the 229 sensors are buried. Smaller rings can also be used. The porous plate, soil and 229 sensors must be thoroughly saturated at the beginning of the calibration routine. Complete saturation of the ceramic plate and 229 sensors is better achieved by applying vacuum. The number of sensors that can be calibrated in a single pressure vessel will depend on the 229 cable lengths because of the limited space in the vessel.

The general calibration sequence is:

1. The extractor plate, soil and sensors are saturated and positioned in the pressure vessel.

2. The lowest calibration pressure chosen by the user (>10 kPa) is applied and the soil solution, which is held by the soil at an energy level less than that applied, is allowed to leave the pressurized system.

3. Measurements of sensor temperature response are made periodically to determine if equilibration is attained. This will require depressurization of the pressure vessel if a pressure-tight feedthrough is not used. Prior to depressurization, it is important that the effluent hose be blocked by clamping or other method to prevent solution from re-entering the soil and sensors.

4. When equilibration is attained, the effluent hose is blocked, the vessel is depressurized and 229 measurements are recorded.

5. The next calibration pressure is then applied and the process repeated.

Pressure-tight bulkhead connectors are available for some pressure vessels. Determining whether equilibrium has been reached is simplified when using a feedthrough connector since the pressure vessel doesn't have to be depressurized and opened for each reading. A temporary connector can be used to disconnect the datalogger from the other components installed in the pressure vessel.

Pressurized readings can be used for determining equilibrium but should not be used for calibration data. Thermal properties are affected by pressure and calibration data should be collected at the same pressure the sensors will be used—in most cases this is atmospheric pressure.

6.4.1 Wiring for Calibration using Pressure Plate Extractor

The wiring arrangement of Figure 6-4 depicts a datalogger with an AM16/32 multiplexer, a CE4 current source and a thermistor being used in a typical 229 calibration arrangement. This is similar to the wiring for program example #2 and #4 (see Section 5). All components except the datalogger can be placed inside a 5 bar pressure vessel. If this method is used, the electronic components in the pressure vessel should be protected against moisture damage. Place the components in a container such as plastic bag with desiccant.

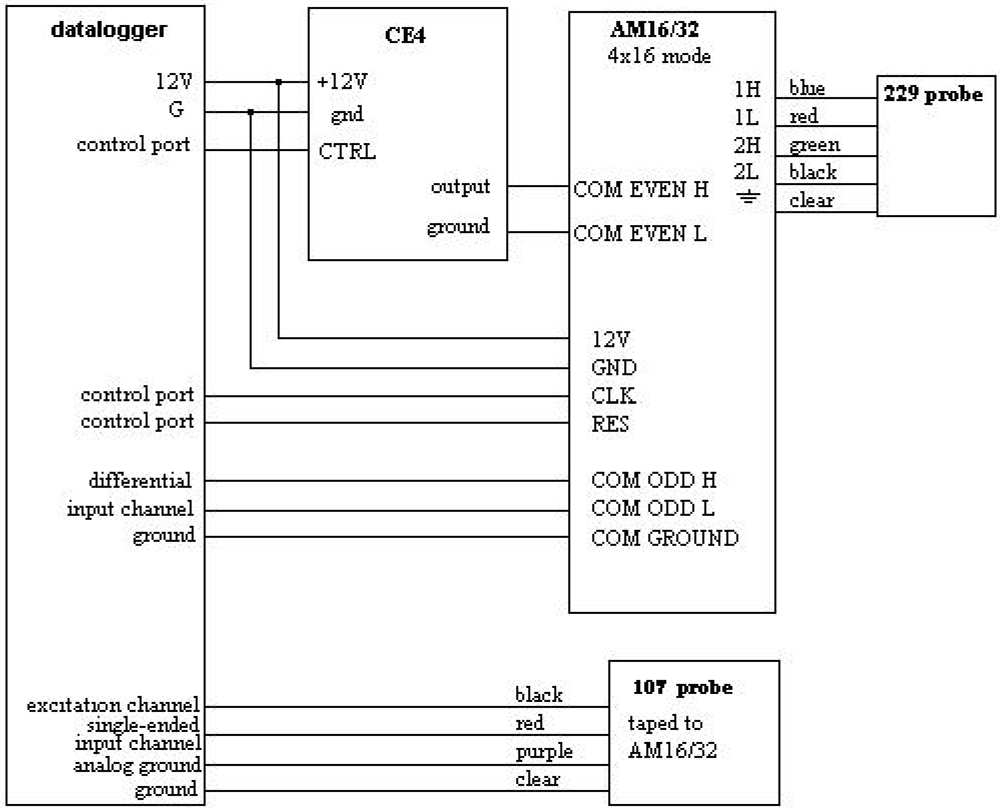


FIGURE 6-4. Datalogger and Peripheral Connections for 229 Calibration

7. Maintenance

The 229 does not require maintenance after it is installed in the soil. The datalogger, current excitation module, and multiplexer, if used, should be kept in a weatherproof enclosure. Periodic replacement of the desiccant in the enclosure is required to keep the electronics dry and free of corrosion.

8. Troubleshooting

Symptom	Possible Cause	Action
Temperature reading is offscale (-6999 or NAN)	Thermocouple wire not connected to correct datalogger channel	Check program to see which differential input channel 229 should be connected to and verify that it has a good connection to that channel
	Break in thermocouple wire	Use ohm-meter to measure resistance between blue and red wires. The reading in ohms should be approximately the cable length in feet. An open circuit indicates a break in the wire
	Multiplexer not operating properly	Make sure that multiplexer has 12V between 12V and GND terminals. Check for a good electrical connection on the wires that connect RES and CLK to datalogger control ports. Check for a good electrical connection on the wires going from the common channels to the datalogger and the current excitation module. Check program to make sure that the control port connected to RES is being set high and the control port connected to CLK is being pulsed.
DeltaT reading close to zero	Heater wire broken or not properly connected	Check resistance between terminal screws for green and black wires. It should read 34 - 40 ohms.
	Current excitation module not turning on	Check for 12V between +12V and ground terminals Check for good electrical connection on wire connecting CTRL with datalogger control port Check program to make sure that control port connected to CTRL is being set high
Temperature decreases during heating	Thermocouple wires reversed	Make sure blue wire is on the high side of the differential input channel and red is on the low side
Readings for first sensor on multiplexer are all right, but all others read zero	All readings are being written to the same input location (Edlog dataloggers)	Check program to make sure measurement instructions in the multiplexer loop are indexed (-- next to the input location number. Press F4 or C to toggle the --)

9. References

Flint, A. L., G. S. Campbell, K. M. Ellett, and C. Calissendorff. 2002. Calibration and Temperature Correction of Heat Dissipation Matric Potential Sensors. Soil Sci. Soc. Am. J. 66:1439–1445.

Reece, C.F. 1996. Evaluation of a line heat dissipation sensor for measuring soil matric potential. Soil Sci. Soc. Am. J. 60:1022–1028.

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Appendix E.2
Sentek Enviro Scan Hardware Manual

EnviroSCAN

Hardware Manual

Version 3.0
July 1997

Table of Contents

Chapter 1: Introduction

About this Manual

This manual describes the EnviroSCAN RT5 & RT6 soil water monitoring system and includes technical information, installation and maintenance procedures.

It is intended to be used as a guide to the assembly and maintenance of the EnviroSCAN RT5 and RT6 system.

This manual should be read in conjunction with the "EnviroSCAN Software Manual" and the "EnviroSCAN Probe Installation Manual".

Study of this manual does not allow users who have not undertaken the appropriate EnviroSCAN training course to install, maintain and repair the EnviroSCAN system under the warranty conditions.

Glossary of Terms

♦♦ *Caution:* A caution defines a procedure which, if not strictly observed, could result in damage to, or destruction of, equipment.

♦♦ *Warning:* A warning defines a procedure which, if not strictly observed, could result in personal injury or loss of life.

Communication Describes the process of transferring commands or data between the logger and the computer.

RS232 Is the standard which describes the specification for single ended serial transmission of data, which is the standard for the COM 1 and COM 2 ports on a computer.

RS422/RS485 Is the standard which describes the specification for serial transmission of data, which is the standard for long distance communications. This is a differential signal and is specified to be used with cable runs up to 1km depending on baud rate and type of data cable used.

Radio Modem Is the circuitry that converts the signals from the logging facility into a form that can be transmitted and received by radios.

PCB Is an abbreviation for "Printed Circuit Board"

VHF Is a frequency band used by radio and is an abbreviation for "Very High Frequency"

UHF Is a frequency band used by radio and is an abbreviation for "Ultra High Frequency"

AC This an abbreviation for "Alternating Current" and describes the type of current and voltage which is commonly used to power solenoids (eg 24 volts AC)

DC This is an abbreviation for "Direct Current" and describes the type of current and voltage which is derived from batteries (eg 12 volts DC)

EMC Abbreviation for Electro-Magnetic Compliance

EMI Abbreviation for Electro-Magnetic Interference

SLA Abbreviation for Sealed lead Acid. This describes the construction of the type of battery used to power the logger.

I/O Abbreviation for “Input” (I) and “Output” (O) usually in reference to signals into and out of a device

ID Abbreviation for “Identification”

Electro-Magnetic Compliance

EMC approvals

The EnviroSCAN RT6 system has been tested and found to comply with the following EMC guidelines:

EN55011/CISPR11 (AS/NZS2064) Group 1 Class B
EN50082-1 : 1992 (IEC 801-2,3,4)
FCC Part 15 Class B
FCC Part 2 Class B

Marking

The above EMC approvals allow the product to be CE and C-tick marked.

♦♦ ***Caution:***

Any modifications to any part of the system or to any peripherals may void the EMI compliance of the system or peripherals.

♦♦ ***Caution:***

The sensors/probes are not to be operated in free air as they may cause interference to radio communication devices.

♦♦ ***Caution:***

External power supplies connected to the logging facility must comply with safety and EMC requirements of the country in which the system is to be used.

♦♦ ***Caution:***

Ferrite clamps must be fitted to both ends of the probe cabling in order to comply with EMC and FCC requirements.

Chapter 2: General Description

System Overview

The EnviroSCAN system has been designed to log readings from multiple SENTEK soil moisture probes/sensors at pre-selected time intervals (as short as 1 minute) for downloading into a computer. The software provides graphical data manipulation for analysis by trained growers, scientists or agronomists.

System components

The EnviroSCAN system consists of :

- logging facility
- probes
- access tube/top cap
- sensors
- cabling
- software

Appendix A illustrates the components that make up a typical EnviroSCAN RT5/RT6 system and how it appears in the field.

Maximum configuration

The central logging facility is connected by cable to probes at each monitoring site. Probes can be located within cable runs of up to 500 metres from the logger. The logging facility supports 2 cable runs with each run supporting up to 16 sensors. See Appendix B for examples of configurations. The 16 sensors on each run can be connected on 1 probe or spread across up to 4 probes depending on application. With standard components the array of sensors can extend to a soil depth of 5.5 metres. Probes are available in standard lengths of 0.5m, 1m, 1.5m, 2m, 3m, 4m and 5.5m. The system has the capability of monitoring greater depths if required upon special request. See Appendix C for examples of probe configurations.

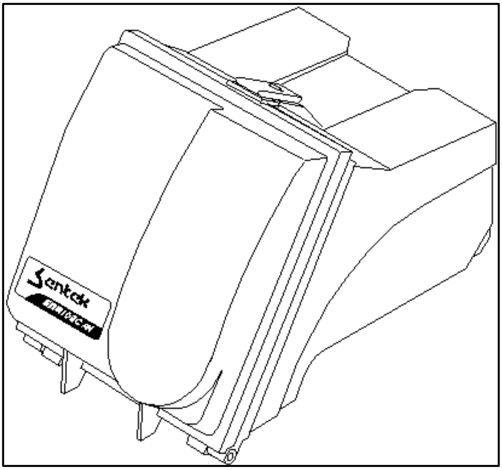
Downloading of data can occur either in the field via a

Downloading

downloading cable to a notebook computer or in the office by removing the logger and transferring the data to a desktop computer. Additionally external telemetry devices can be connected to the RT6 Main Board to provide remote communication or the system can be hard-wired to a computer utilising RS485 communication.

System description

Logging Facility



The logging facility consists of :

- water resistant housing
- front panel
- Main Board
- removable logger
- battery

Housing

The UV-resistant housing is fixed to an aluminium mounting pole. The solar panel (if used) will also mount onto this pole.

The housing is designed to be water resistant and manufactured from a compound which is resistant to chemicals typically used in agricultural applications. The housing has a latched front lid that opens to gain access to the communication port for data downloading, removing logger for downloading back at office, running diagnostics or for servicing (replacing fuses, etc).

Front Panel

The front panel is fixed to the Main Board and provides :

- front panel accessible fuses (RT6 only)
- RS232 local communication port
- local/remote switch (RT6 only)

See Appendix D for visuals of RT5 and RT6 front panels.

Main Board

The Main Board provides the I/O connections to the removable logger, battery, probes, solar panel and external communications. The Main Board also performs the following functions :

- solar charger for SLA battery
- 10.5/11.5volt battery cut-off (ensures the SLA battery does not over-discharge)
- RS485 communication drivers (RT6 only)
- RS232 communication drivers (RT6 only)
- power drivers for Run-A and Run-B
- encoders, drivers and buffers for Run-A and Run-B
- receiver decoders for Run-A and Run-B
- lightning/surge protection

The removable logger contains the intelligence of the logging facility for control of I/O signals and recording of measurements.

The removable logger performs the following

Removable logger

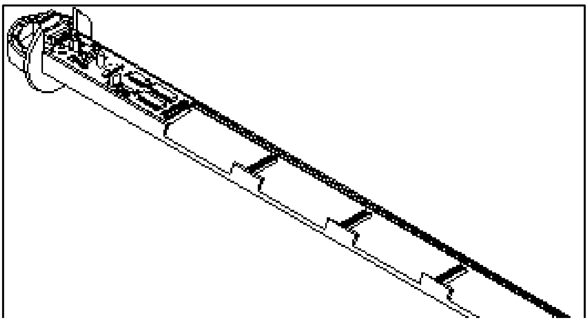
functions :

- controls individual addressing of sensors to be powered and measured
- measures signal from sensors at preset sampling intervals
- stores measurements from sensors into battery backed memory
- controls separate powering of probe runs when sampling
- controls individual addressing of sensors to be powered and measured
- stores logger configuration in non-volatile memory
- battery backed time/day clock
- provides serial data communication with computer or external telemetry devices
- measures system voltages during diagnostics

The SLA battery provides power to the logging facility during night periods (if solar powered) or in the event of external power failure.

Battery

Probes



The probe consists of :

- a plastic extrusion
- datum setting handle
- 4-wire or 5-wire interface board
- 20 way ribbon cable running along its length with connectors for sensors every 100mm

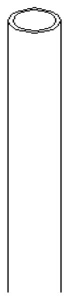
Up to 16 sensors may be connected at desired depths on any one probe for example sensors placed at 10, 20, 30, 50, 70, 90 and 120 cm. The sensors snap on to the probe with slots provided every 10 centimetres allowing the user to specify the sensor depths during installation or subsequently re-positioning sensors if required. See Appendix C for examples.

Standard length probes of 0.5 metres are used for shallow rooted crops or turf while 1, 1.5 or 2 metre probes are used for tree crops, vines and broadacre crops such as cotton. In research, waste water management, environmental and mining applications probes of longer lengths such as 5, 10 or 15 metres are used.

Up to 4 probes may be connected to each run to support multiple probes on a site or multiple sites. See Appendix B for examples of configurations.

The maximum distance of any probe from the logging facility is *a 500 metre cable length*.

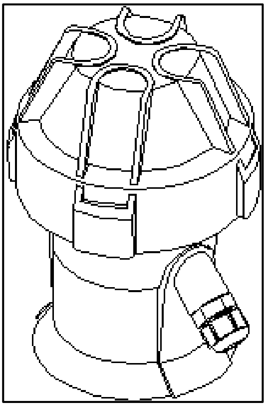
Access Tube



The access tubes have been manufactured to very high standards with a fine tolerance inside diameter so as to provide minimal internal air gap for the sensor.

Tube installation tools and cutting edges have been specially designed to install the access tubes into various soil types without air gaps. See the EnviroSCAN Probe Installation Manual for details.

Top Cap



The Top Cap assembly has been designed to prevent water and dust entry to IP55 standards. The assembly is made up of a body which has a removable cap with "O" ring that is screwed onto the body. The Top Cap body is glued to the top of the access tube. Removing the screw cap enables easy insertion and removal of the probe for repair or re-configuration without disturbing the soil profile surrounding the site.

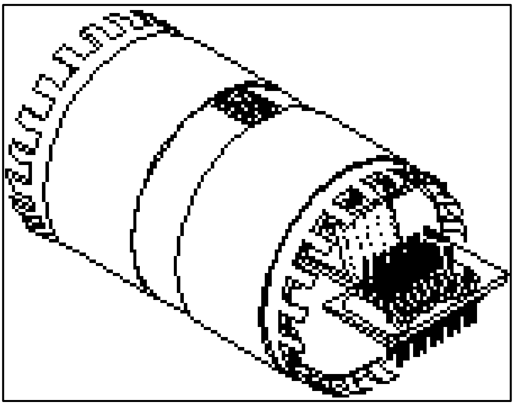
The Top Cap has locaters for the probe which minimises translocation effects resulting from rotating the probe in the tube following removal and re-insertion.

A cable gland located at the bottom of the body provides a watertight entry of the cable from the logging facility.

The Top Cap also has a stop for the probe so that the sensors are positioned vertically in the correct position in relation to the soil depth being monitored. The body automatically positions the probe so that it locates the first sensor at 10cm depth. Location of the first sensor at 50mm is achieved by fixing the body of the top cap assembly onto the access tube at 50mm from the soil surface.

After installation of the access tube, bottom stopper and top cap (see the EnviroSCAN Probe Installation Manual), the probe is lowered into this tube. Readings of soil water content are taken through the PVC access tube without any contact between the sensor and the soil. The bottom of the access tube is sealed with a watertight bottom stopper to protect the probe from entry of water.

Sensors



The sensor consists of a tubular housing with two conductive surfaces. The electronic circuit contained within this housing plugs into a ribbon cable running along the extruded support rod which supports the sensors. This support rod can be fitted with multiple sensors (up to 16), located at 100mm intervals along its length.

The sensors are placed on the extrusion at the desired depth and rotated to click into place using the sensor location tool. The sensors may be rotated in the opposite direction and then re-positioned or replaced in the field. No gluing or soldering is necessary. A link is provided on each sensor to enable it to be easily addressed and re-addressed.

The sensors can be mounted on the support rod at depth intervals to suit a variety of crops and soil variability (see Appendix C). Each configuration of multiple sensors on the support rod is called a "probe".

The sensors/probe are lowered into a 50mm plastic access tube which is vertically installed in the soil and sealed at the top (with a screwed top cap) and bottom (with an expandable bung).

Cabling

The cabling between the logging facility and probes can be either:

1. TYFLO irrigation cable

The manufacturers of the TYFLO irrigation cable state it is suitable for direct burial. Specifications of the TYFLO cable are :

Make	TYFLO
Code	WMW57032
Cores	5
Size	7/0.32
Area	0.56mm

2. SENTEK specific cable

SENTEK has undertaken to produce its own cable based on the exact electrical specifications of the TYFLO cable in two versions :

- UV resistant outer sheath with standard colours of inside cables
- termite resistant outer sheath with standard colours of inside cables

with both versions of SENTEK specified cable have solid filled sheathing to minimise water travelling down inside of the sheath into the access tubes. Specifications of SENTEK cable are:

Make	TYFLO for SENTEK
Code	WMX57032
Cores	5
Size	7/0.32
Area	0.56mm

The cables can be joined by way of water resistant 3M crimp connectors which are placed inside a water resistant junction box which also provides mechanical protection to the joins. The junction boxes can be filled with approved epoxy compounds to provide additional water resistance if required.

It is recommended that the cabling be installed in conduit to prevent damage by machinery, insects (ants, termites, etc) and animals.

Software

The software is an interactive system which provides the user with multiple options to display the processed data.

For more information on the EnviroSCAN software and its use, consult the EnviroSCAN Software Manual.

Chapter 3: Technical Description

General System Operation

Sampling

Between sampling only the necessary circuitry of the logging facility is powered while it waits for the next sampling period. No power is applied to the probe cabling or probes between sampling.

During sampling the EnviroSCAN RT5/RT6 logger applies power to the probe cabling (and probes) and a signal to power up (address) a particular sensor. The address signal is processed by the probe interface (4-wire or 5-wire board) which applies power down one of the wires of the ribbon cable on the probe. The sensor that has been addressed (via PCB link) picks up the power from the ribbon cable and begins to oscillate at a frequency depending on moisture content of the soil. The signal from the sensor (open collector 40 to 80 kHz) is applied to a common wire on the probe ribbon cable back to the interface board.

Signal from sensor to logging facility

The 4-wire board does not process the signal from the sensor. The open collector signal from the sensor is diverted to the probe cable back to the logger (RT5 without receiver only). The 5-wire interface board however converts the signal from open collector to differential drivers for transmission back to the logger (RT5 with receiver or RT6) via probe cabling.

Signal measurement

After addressing the sensor the logger waits for 0.5 seconds (while sensor stabilises) then counts pulses for 0.5 seconds and records the reading in the removable loggers memory with a time/date stamp. The logger then sends a signal to power up (address) the next sensor (while turning off previous sensor) and repeats the process. Once all sensors have been recorded the logger removes power from the probes and waits for the next sampling interval.

Detailed technical description

Logging facility

The logging facility is capable of reading and storing data from multiple sensors at pre-selected sampling intervals ranging from 1 minute to 9999 minutes (ie. 6.9 days). The sampling interval can be readily altered using the software. Note sampling intervals of less than 10 minutes require external power to be supplied to the logger as the solar panel may not provide sufficient charge for long term logging at 1 minute sampling intervals.

The logger memory will only hold a certain amount of data before the memory "wraps" and the oldest data is overwritten with newer data. Refer to Appendix J – Formula to Calculate Logger Storage Capacity to determine the time before readings are overwritten in the logger memory.

Between sampling intervals only the removable logger and part of the Main Board is powered and no power is supplied to the probes/sensors. When the sampling interval begins power is supplied to the first cable run (Run-A) and a signal is sent from the logger to power up (address) the first sensor. The logger waits for 0.5 seconds (while sensor stabilises) then counts pulses for 0.5 seconds and records the reading with a time/date stamp. The logger then sends a signal to power up the second sensor (turning the previous sensor off) and repeats the process. Once all sensors configured on Run-A are recorded the logger powers up Run-B (while removing power from Run-A) and repeats the process until all sensors configured on Run-B are recorded. The logger then removes power from Run-B and waits for next sampling interval. Therefore the power is only applied to probes/sensors for a maximum of 32 seconds (32

sensors) at typical sampling intervals of 15 to 120 minutes which minimises power consumption.
The removable logger is fitted with a Ni-Cad battery which is charged by the solar panel (or external power supply) and the internal SLA battery. The Ni-Cad battery protects the contents of the data memory and time/date clock when the logger is removed to download data in the office. Once removed from the logging facility the data is secure for approximately 2 days.

A computer is connected to the logging facility to configure the system and set the time/date clock. The configuration is stored in the removable loggers non-volatile memory which includes:

- Number of sensors on Run A
- Number of sensor on Run B
- Sampling interval
- Logger ID

Probe

Each EnviroSCAN probe comprises one or more sensors placed along a support rod. The probe, usually with an array of multiple sensors, is installed into a vertical PVC access tube at representative locations.

During sampling the logger applies power to the probes and a signal to power up (address) a particular sensor. The address signal is processed by the interface (4-wire or 5-wire board) which applies power down one of the wires of the ribbon cable. The sensor that has been addressed (via PCB link) picks up the power from the ribbon cable and begins to oscillate depending on moisture content of the soil. The signal from the sensor (open collector 40 to 80 kHz) is applied to a common wire on the ribbon cable back to the interface board.

The 4-wire board does not process the signal from the sensor. The open collector signal is diverted down the probe cable back to the logger (RT5 only). The 5-wire interface board however converts the signal from open collector to differential drivers (RS485 type) for transmission back to the logger (RT5 with receiver or RT6) via probe cabling.

Sensor

The principle of operation of the EnviroSCAN soil moisture sensor is based on capacitance.

A capacitor consists of two conductive plates separated by an insulating material (dielectric). The value of capacitance (C) is determined by the area of the plates, distance between the plates and the dielectric constant of the material between the plates.

The conductive rings of the sensor forms the plates of the "capacitor". As the area of the plates/rings and the distance between the plates/rings are fixed on the EnviroSCAN sensor, the capacitance (C) varies with varying complex dielectric constant of the material (dielectric) surrounding the plates/rings.

This “capacitor” is connected to circuitry which forms an oscillator. The frequency of oscillation is depending on the capacitance (C) which is effected by the changing complex dielectric constant of the material in the sensors sphere of influence. The oscillating capacitance field generated between the two rings of the sensor extends beyond the PVC access tube into the surrounding medium/soil (dielectric). Sensor sensitivity (sphere of influence) has been independently identified in laboratory conditions to be horizontally - 130 mm to 150 mm radius of axial centre in free air and vertically – 85 mm to 120 mm either side of axial centre.

If we assume that the soil and organic matter remains constant then capacitance varies with varying fertiliser (salinity), water and air. The frequency of oscillation was selected from scientific studies on high frequency excitation of various soil types with varying salinity, temperature and moisture content. The EnviroSCAN sensor has been designed to oscillate at frequencies where variations in salinity and temperature have minimal effect. Therefore the sensor is relatively immune to salinity/fertiliser variations at levels typically found in irrigated crops so responds by varying frequency of oscillation proportional to varying moisture content.

Due to logistics of transmitting (along cable) and recording very high frequencies (VHF) the frequency of oscillation of the sensor has been divided down by a factor of 2048 thus providing an output frequency proportional to frequency of oscillation. The data logger powers the sensor up for 0.5 seconds then counts the pulses over 0.5 seconds to provide a "count" (hence equal to half the frequency). For example if the sensor is oscillating at 100 MHz the output of the sensor would be 48.828 kHz (100,000,000/2048) so the logger would record a count (equal to half frequency) of 24,414 (48,828/2).

These counts are recorded by the logger and downloaded to a computer without being processed. Software in the computer passes the counts through a calibration equation to provide values in soil water content for graphing. The default calibration equation provided in software was independently established (by CSIRO, USDA, etc) on various soil types using gravimetric sampling which is the international standard used to calibrate soil moisture sensors and soil moisture instruments such as the Neutron Probe.

♦♦Caution:

The default calibration equation in the EnviroSCAN software is provided for those customers who require only soil moisture dynamics for irrigation scheduling purposes. Customers who

require accurate soil moisture data for their particular soil type must calibrate the sensors to that soil. Gravimetric sampling is the recognised method for determining calibration equation (and constants) for a particular soil type.

Following the calibration process on a specific soil/medium the constants of the calibration equation can be changed in the software to provide more accurate data.

Power Supply

SLA battery

The EnviroSCAN RT6 has an internal 12 volt 5.7A/hr SLA battery which provides power during night periods (if solar powered) or in the event of external AC/DC power failure. This battery has its charge maintained by applying a power source to the Main Board which incorporates a charger specifically designed to charge SLA batteries.

Power sources

The following power sources can be applied to the Main Board :

- Solar panel which is rated at 10 watts at 12 volts
- External DC supply which can range from 16 to 24 volts DC capable of supplying 1.5 amps. This can be from available DC supply or via two 12 volt car batteries (in series to give 24 volts)
- External AC supply which can range from 12 to 16 volts AC. This can be from available low voltage AC supply or via a 240 volt AC plug pack which delivers 16 volts AC at 1.5 amps.

Ni-Cad charger

The datalogger board is fitted with a Ni-Cad battery which is also charged by the solar panel (or external power supply) or the SLA battery. This battery protects the contents of the data memory and time/date clock if the logger is removed to download data in the office. Once removed from the logging facility the data is secure for approximately 2 days. Connecting the logger to an "Office Download Cable" which is connected to power will charge this battery, thus prolonging the time the logger can be removed from the logging facility.

There are 3 power modes being;

Power modes

1 With the battery cable plugged into the main board and **without** the logger plugged in, the battery charging circuit is active and is ready to receive charge from the external supply. This is done so that the battery can continue being charged while the logger has been removed from the logging facility for downloading.

2 When the logger is connected to the unit then power is applied only to the circuitry that runs continuously. This is done to minimise power drain.

3 During sampling of data from the sensors, only the circuitry that is required is powered. This is under control of the logger and is done also to minimise power requirements of the system.

The removable logger acts as a power on/off switch when plugged and unplugged.

Logger as on/off switch

Always unplug the logger when repairing or re-configuring probes and probe cabling.

♠♠***Caution:***

Comparison of RT5 and RT6 Main Boards

Similarities

Similarities between the RT5 and RT6 Main Board are:

1. same SLA battery
2. compatible circuitry to enable mix of RT5 and RT6 components
3. uses existing software with exception of MDL (in place of DL) and MDIAG (in place of DIAG) which provides multi-drop RS485 and radio communication capability

Differences

Differences between the RT5 and RT6 Main board are:

1. receiver is incorporated onto the RT6 Main Board
2. components on the RT6 are mounted flat to prevent mechanical damage during handling and transport
3. SLA battery charger on RT6 Main Board is redesigned to be more efficient over extended temperature ranges and provides trickle charging
4. the RT6 has more robust buffering of signals to probes to prevent damage from lightning surges and/or shorts in probe cabling
5. front panel accessible fuses on RT6
6. local/remote communication switch on front panel of RT6 instead of jumper settings as on RT5
7. improved lightning immunity on RT6
8. automatically resetable fuses on RT6 to prevent damage if a surge occurs during sampling. These fuses automatically reset themselves when power is removed (between sampling)
9. the RT6 supports multi-drop RS485 communication with computer

The RT6 Main Board is a direct replacement for the RT5 Main Board (only with receiver).

The RT6 will work with probe runs having 4-wire boards with transmitters.

Compatibility

Connecting probe runs with 4-wire boards (no transmitters) to the RT6 Main Board may cause damage to components.

♠♠***Caution:***

Removable Logger revision

The RT5 logger will work with the RT6 Main Board and the RT6 logger will work with the RT5 Main Board.

However the removable logger must be RT6 version (with RT6 Main Board) to enable remote telemetry via multi-drop RS485 or radio.

Comparison of 4-wire and 5-wire board

The 5-wire board is the combination of the circuitry of the 4-wire board and transmitter. In addition to this the 5-wire board has resetable fuses to resist damage if a surge occurs during sampling. These fuses automatically reset themselves when power is removed (between sampling).

Compatibility

Probes with 5-wire boards can be mixed on a probe run with probes having 4-wire boards (only with transmitters).

♠♠***Caution:***

Probes on a run with 5-wire boards will not work with probes on the same run with 4-wire boards (without transmitters). Damage to components may occur if connected together on the same run.

Data downloading Options

The downloading of data from a logger can be performed in the following ways;

- in the field by using a notebook computer and a "Field Download Cable" connected to the front panel
- in the office by removing the logger and connecting to a desktop computer via an "Office Download cable"
- in the car by connecting to a notebook computer via a "Car Download cable"
- via an external RS232 remote telemetry device connected to the Main Board
- via a remote device with RS485 capability connected to the Main Board (RT6 only)

Consult the EnviroSCAN Software Manual for details regarding the download process.

Chapter 4: System Installation

This chapter discusses the physical installation and electrical connection of the logging facility, solar panel and probes.

For information on the software see the EnviroSCAN Software Manual.

For information on site selection, mounting pole and access tube installation see the EnviroSCAN Probe Installation Manual.

Positioning

Mounting poles

The aluminium mounting poles are used to mount the logging facility and solar panel. Care should be taken when selecting the position of the mounting pole to ensure that there are no buried pipes or cables in close proximity.

See the EnviroSCAN Probe Installation Manual for details on installation of the mounting poles for the EnviroSCAN logging facility and solar panel.

Logging Facility

The logging facility should be attached onto the mounting pole in a position that gives easy access to the user and is out of the way of machinery. The logging facility should also be placed away from the access tubes to avoid compaction of the surrounding soil.

Solar Panel

The solar panel is mounted on top of its mounting pole so that it is free from obstruction of current and

potential crop canopy.
It should point:
due north - for the southern hemisphere or
due south - for the northern hemisphere.

The panel should be angled to suit the sites latitude and season so that the sun shines at right angles to the face of the solar panel. In normal applications fixed setting of the unit to 45^{o} from horizontal should suffice. For more efficiency the panel can be angled typically to 60^{o} from horizontal in winter and 30^{o} from horizontal in summer. The solar panel bracket has slots cut into the side to assist in setting these angles.

Access Tubes

The access tubes should be positioned to provide the best representation of the site to be monitored.

See the EnviroSCAN Probe Installation Manual for details on installation of the access tubes and top caps.

Top Caps

See the EnviroSCAN Probe Installation Manual for details on installation of the access tubes and top caps.

Cabling

External Power

The length of the cable supplied with the solar panel should be sufficient for normal applications. If alternative external power sources are to be connected to the unit or the solar panel cable needs to be extended then the cable to be used is a 2 core sheathed cable with 16/0.3mm conductors.

Joining Cables

The following describes the method used for extending cable if greater distance is required or a repair is necessary.

1 Insert the cables into the junction box and pull through enough cable to make joining easy (approx 50cm).

2 Strip back the outer sheath so that 5cm of inner cables are exposed.

3 Insert the cables to be joined into the 3M connectors (Scotchloks) and crimp. To do this hold the connector with the button side down and insert the wires all the way into the ports and then crimp the button fully. Ensure that the cables are fully inserted into the gel-filled connectors prior to crimping. Failure to do this may result in unreliable connections.

4 After all connections have been made pull back the cables so that 5-10mm of the outer sheath protrudes from the cable gland. Tighten the cable glands.

5 Tuck the connections into the box and attach the top cover.

Connection

The cables should be connected to the "SOLAR PANEL" connector X10 (for RT5) or X5 (for RT6) with the following colour allocation (see Appendix E – Overlay Diagrams);

Solar Panel	White	=	+
	Black	=	-

♦♦ ***Note:***

The panels may be supplied to American standards which is the reverse of the above.

These cables should be marked with + and – however they can be checked with multi-meter for correct polarity. Check with diagnostics following installation and if diagnostics shows that Vsol is 0 volts (or low voltage) then cable is wrong way around.

If Extension Cable is used connect

red	=	+
black	=	-

Internal Battery Cabling

The cable supplied to connect the internal battery to the main board has spade connectors at one end and a 2-pin plug at the other. The cables should be connected to the "BATT" connector X11 (for RT5) or X6 (for RT6) and the battery with the following colour allocation (see Appendix E – Overlay Diagrams);

Battery Cable	red	=	+
	Black	=	-

Probe Cabling – at probe

Only the specified cable should be used to interconnect probes with the logging facility.

The following is the method of connection of the cable run to the probe;

1 Pass the cable through the cable gland and into the centre of the top cap assembly.

2 Strip back the outer sheath of the cable so that 150mm of inner cables are exposed.

3 Strip the inner cables to expose 5 mm of bare copper conductor.

4 Screw the conductors into the 5-way connector plug found on the 5-wire board (or transmitter, in the case of a 4-wire board) according to the wiring diagram in Appendix F. Check that the connector is crimping the copper wire strands and not the plastic sheath of the cable. Ensure that less than 2mm of copper wire protrudes

from connector else the cables may short when moved.

5 Pull the cable back through the cable gland until the black outer sheath no longer protrudes into the top cap.

6 Tighten the cable gland with a 15-mm open-end spanner.

7 Inject a small quantity of silicon into the centre of the cable and around the edges of the conductors, this will stop any moisture that may enter into the top cap assembly via the cable.

8 Fit ferrite clamps on the cable within 10cm of the top cap. A cable tie is used around the clamp to secure it.

♠♠ **Caution:** ***Ferrite clamps must be fitted to both ends of the probe cabling in order to comply with EMC and FCC requirements.***

Probe Cabling – at logging facility

Only the specified cable should be used to interconnect probes with the logging facility.

The following is the method of connection of the cable run to the logging facility;

9 Pass the cable through the cable gland at the bottom of the logging facility housing.

10 Strip back the outer sheath of the cable so that 150mm of inner cables are exposed.

11 Strip the inner cables to expose 5 mm of bare copper conductor.

12 Screw the conductors into the 5-way connector

plug supplied with the Main Board according to the wiring diagram in Appendix F. Check that the connector is crimping the copper wire strands and not the plastic sheath of the cable. Ensure that less than 2mm of copper wire protrudes from connector else the cables may short when moved.

13 Pull the cable through the cable gland until sufficient length is available to provide easy access to Main Board when tilted forward for servicing.

14 Tighten the cable gland with a 15-mm open-end spanner.

15 Fit ferrite clamps on the cable within the logging facility. A cable tie is used around the clamp to secure it.

♦♦ ***Caution:*** ***Ferrite clamps must be fitted to both ends of the probe cabling in order to comply with EMC and FCC requirements.***

External RS232 cabling

The "RS232" connector on both the RT5 and RT6 Main Boards (see Appendix E – Overlay Diagrams for locations) provide serial RS232 signals which can be connected to external devices. These devices may be in the form of radio modems, computers, etc.

The following signals are made available for connection to these devices:

0V	=	0 volts or ground
RTS	=	request to send
TD	=	transmit data
RD	=	receive data
12V	=	12 volts (fused)

Consult the external device manual for the correct wiring method to these devices. Note that null modem connections need to be made at the computer end (see Appendix H) of the cable.

The cable used for connection should be attached through a cable gland in the base of the logger housing to ensure a watertight seal is maintained.

RT5 Jumper Settings:

To enable external RS232 connection the following jumper settings (see Appendix E – Overlay Diagrams) should be followed:

Jumper J1 enables remote connection.
Jumper J2 enables local connection (front panel).

RT6 Jumper Settings:

Jumper JP2 (see Appendix E – Overlay Diagrams) is used to select either RS232 or RS485 external communications.

To enable external RS232 connection the “RS232/RS485” jumper should be in the “RS232” position as marked.

Front panel/remote switch

Also, the switch on the Front Panel should be set to “Remote” position for communication through the external RS232 connection or to “Front Panel” for local communication through front panel RS232 connector.

RS485 cabling (RT6 only)

Multiple RT6 logging facilities can be connected together (multi-dropped RS485) on a twisted pair screened data cable back to a computer. Note normal telephone cable is not suitable. Although only one pair is required for RS485 communication it is recommended that at least a two pair cable be installed in the event of failure.

Cable lengths up to 1km from computer to last logger can be used depending on cable specifications and data rate (baud rate). If problems are experienced with data rate (baud rate). If problems are experienced with communication then lower baud rates should be tried.

The cable must daisy chain from logger to logger without the use of junction boxes or joins which effect the efficiency of the cables screen. Under no circumstances are T-joins to be used as this will effect reliable data transmission.

All "A" wires are connected together and all "B" wires are connected together and all screens are connected together. See Appendix I for wiring diagrams.

Jumper settings

The RS485 signal must be terminated at both ends of the cable. The last logger is terminated by installing the "Term" jumper (JP1). All other loggers connected to the cable must have their "Term" jumper removed.

Note unterminated loggers can be removed without effecting data communication between computer and loggers. However the last terminated logger can not be removed without leaving the cable terminated. The RS485 connector can be inserted into an RS485 terminator socket if the loggers Main Board is to be removed for a period during which data communication is to occur.

Jumper JP2 (see Appendix E – Overlay Diagrams) is used to select either RS232 or RS485 external communications. To enable RS485 connection the "RS232/RS485" jumper should be in the "RS485" position as marked.

Also, the switch on the Front Panel should be set to "Remote" position for communication through the RS485 connection or to "Front Panel" for local communication through front panel RS232 connector.

Front panel/remote switch

Various forms and makes of RS232-RS485 converters are available for computers which may be purchased from local computer suppliers along with appropriate twisted pair screened data cable.

RS232-RS485 converters

Assembly

Probes

Handle

Attach the probe handle to the probe rod with the use of the backing plate and four locating screws.

Interface board

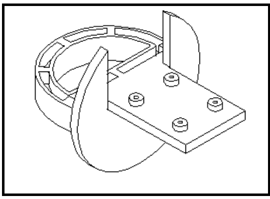
Attach the 4-wire board (or 5-wire board) to the probe rod making sure the connector pins are properly located in the socket on the probe rod and secure using four screws.

A cable tie placed around the probe rod at the 4-wire (or 5-wire) boards connector that plugs onto the probe will prevent it from becoming loose and causing intermittent contact.

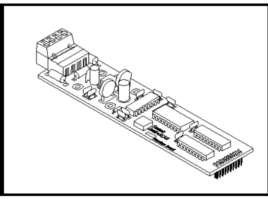
Transmitter

Transmitters are only required on probes with 4-wire boards fitted. The 5-wire boards have the transmitter circuitry incorporated.

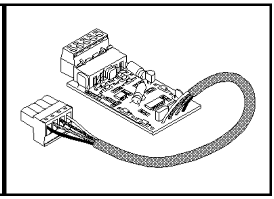
Attach the transmitter to the probe rod on the opposite side of the 4 wire board and connect the transmitter to the four wire board, as shown below:



Handle



4 wire board



Transmitter

Physically number each probe (on the probe handle, top cap and access tube) as per the system specification to avoid mixing up the components during assembly and for easy recognition in the field.

Fitting sensors

Slide sensors onto the probe rod and loosely position at the required depth locations. To allow the sensor to be easily slid along the probe rod gently pull out the ribbon/pin connector assembly and fold it back over the top of the sensor.

Press pin connector on the sensor into the probe rod ensuring the connector on the rod doesn't dislodge from its position.

Using the sensor location tool, click the sensors into place ensuring not to damage the sensor and making sure they are seated properly along the probe rod.

Addressing sensors

Once all sensors have been attached to the probe rod address them using the addressing link according to the system specifications (refer to Appendix G for address link positioning). Run diagnostics to ensure the sensors have been addressed correctly.

The probe can be inserted into the access tube ensuring that the cut-out in the probe handle aligns with the tabs inside the top cap. The connector can be plugged into the interface board and the top cap screwed on.

Logging Facility

♦♦ ***Caution:*** ***All cabling must be completed before plugging the battery cable or external power (solar panel etc) into the main board.***

♦♦ ***Caution:*** ***Never work on the unit or cabling when either the battery or external power is connected and the logger is plugged in.***

Order

Plug cables into the Main Board/Front panel in the following order;

- RS485 (X8 for RT6)
- external RS232 (X12 for RT5, X7 for RT6)
- probe cables (X3/4 for RT5, X2/3 for RT6)
- battery power (X11 for RT5, X6 for RT6)

- external power (X10 for RT5, X5 for RT6)

Reverse the above order when removing Main Board.

Probe cables

RT5 Main Board (no receiver)

Attach each 4 way connector of the cable runs to the main board at position X3 or X4 (see Appendix E – Overlay Diagrams) taking care to connect the Run A cable to the Run A connector (X3) on the Main Board and likewise with Run B (X4).

RT5 Main Board (with receiver)

Attach each 5 way connector of the cable runs to the sockets on the receiver. The receiver has two electronically separate circuits that can be used for either run A or run B. Connect the 4 way connectors of the receiver to position X3 or X4 (see Appendix E – Overlay Diagrams) taking care to connect the Run A cable to the Run A connector (X3) on the Main Board and likewise with Run B (X4). Position the receiver in the logger housing underneath the battery area.

RT6 Main Board

Attach each 5 way connector of the cable runs to the main board to position X2 or X3 (see Appendix E – Overlay Diagrams) taking care to connect the Run A cable to the Run A connector (X2) on the Main Board and likewise with Run B (X3).

Battery

The SLA battery is inserted into the logger housing with the terminals positioned to the rear and the cable protruding over the top left-hand side of the battery.

Connect the battery to the Main Board at position X11 for RT5 or X6 for RT6 (see Appendix E – Overlay Diagrams).

Fixing Main Board/front panel

Position the main board/front panel assembly in the logger housing with the logger ribbon connection cable protruding from under the left side of the Main Board and secure with screws, taking care not to screw through the logger cable.

Logger

Connect the logger to the logger ribbon cable and position the logger in the fold-down front cover of the logging facility. Velcro fasteners will hold the logger in place when the front cover is closed.

♦♦ *Caution:*

Only connect the logger once all other components (including probes, probe wiring, external power wiring, etc.) have been assembled, installed and connected.

Chapter 5: Operating Instructions

Once installed the EnviroSCAN system will operate continuously without requiring the user to perform any regular ongoing tasks.

The logger will store readings taken by the sensors and hold these readings in its memory until cleared by the user or overwritten by the logger itself.

Note: The logger memory will only hold a certain amount of data before the memory "wraps" and the oldest data is overwritten with newer data. Refer to Appendix J – Formula to Calculate Logger Storage Capacity to determine the time before readings are overwritten in the logger memory.

At the appropriate time, when required, the user will download these readings from the logger and store them in the database on a computer for manipulation using the EnviroSCAN software. (Refer to the EnviroSCAN Software Manual for instructions regarding the download process and other software information).

Removing the logger for downloading

Removal of the logger from the logger housing to download the data onto the computer should be done and returned as quickly as possible. The reasons for this are twofold:

- Whilst removed from the system no further readings are being taken of the soil moisture content. The logger controls the process of data collection and stores these readings. Without the logger connected this cannot occur.

- The logger contains a rechargeable Ni-Cad battery that maintains the contents of the loggers memory as well as the time and date clock. If this battery is discharged sufficiently this information can be lost and vital data along with it. When connected to the system, this battery is recharged to the correct level. Disconnected from the system the battery should hold the configuration for approximately 48 hours.

Chapter 6: Maintenance

System

Regular maintenance of the EnviroSCAN system should consist of cleaning of the logger housing to ensure dust and grime is kept to a minimum.

The probe top caps should be checked regularly for cracks or breakages. Machinery should be kept well away from the probes. This will avoid damage to the probe rods as well as avoid compacting of the soil around the probe, thus giving a false indication of the soil moisture content

The logging facility and probes should be checked regularly for insect infestation. Some insects can cause low resistance between wiring tracks on the PCB which can cause intermittent or unreliable operation.

EnviroSCAN Distributors can provide a regular maintenance program which consists of regular visits by an authorised installer to test and ensure correct operation of the system. A regular maintenance program such as this will ensure that the EnviroSCAN system functions properly and continues to give worry free operation.

If problems are experienced, running diagnostics may assist in determining any system faults. Consult the EnviroSCAN Software Manual for further details.

Solar Panel

Keep solar panel clean at all times. Clean with water and dry with soft cloth. A commercially available glass cleaner can be used for stubborn stains.

Regular checks on the orientation and angle of the solar panel should be performed. Winds, birds etc. can move the panel from its ideal position reducing its efficiency. If birds are a problem a “Bird Scarer” can be fitted to top of solar panel.

Cabling

Regular inspection of the cabling for damage from insects, animals or machinery should be carried out. If necessary the cabling can be trenched (with or without conduit) or elevated away from potential damaging elements.

Joining Cables

The following describes the method used for repairing damaged cable;

1. Insert the cables into a two-way junction box and pull through enough cable to make joining easy (approx 50cm).

2. Strip back the outer sheath of the cable so that 5cm of inner cables are exposed. If transmitters and receivers are not being used in the system then cut back the white cable.

3. Insert the cables to be joined into the 3M connectors (Scotchloks) and crimp. To do this hold the connector with the button side down and insert the wires all the way into the ports and then crimp the button fully. Ensure that the cables are fully inserted into the gel-filled connectors prior to crimping. Failure to do this may result in unreliable connections.

4. After all connections have been made pull back the cables so that 5-10mm of the outer sheath protrudes from the cable gland. Tighten the cable glands.

5. Tuck the connections into the box and attach the top cover.

SLA battery

The SLA battery supplied with the EnviroSCAN has a typical life expectancy of 1 to 3 years. The life of the battery is effected by number of discharges, depth of discharges and operating temperature. When the battery does not hold charge (causing loss of data at night) it will require replacing.

Removable loggers Ni-Cad battery

The Ni-Cad battery inside the removable data logger has a typical life expectancy of 1 to 3 years. The life of the battery is effected by number of discharges, depth of discharges and operating temperature. When the battery does not hold charge (causing loss of data and time/date when removable logger is unplugged) it will require replacing.

Chapter 7: Moving & Storing

The EnviroSCAN system has been designed as a system that can be removed, transported, stored and re-installed with care. It has not been designed as a truly portable unit and therefore great care must be taken when this is undertaken.

♦♦ ***Caution:*** ***The SLA battery must be removed from the logger housing whenever it is being moved or transported. Failure to do this may result in mechanical damage.***

♦♦ ***Caution:*** ***To maintain the EnviroSCAN Warranty, system removal and re-installation should only be undertaken by an Authorised Installer***

System Removal

The following steps are to be followed when removing the system. This will ensure the system will function correctly when re-installed:

Disconnect the Logger

- Open the logger housing and disconnect logger by carefully pulling out the connector

Remove SLA battery

- Remove the front panel to gain access to the battery
- Remove the battery and replace the front panel

Disconnect the Probe/s

- Unscrew the top cap
- Unplug the 5 wire cable from the transmitter

Remove the Probe/s from the access tubes and immediately place in transport tube/s

- Grasp the probe handle and while holding the 5-wire cable out of way, pull out the probe. Gently wobble the probe while pulling upwards to assist

in removal if necessary
- Place probes inside transport tubes and seal.

Where probes are long or removal is in an awkward situation preventing the probes from immediate placement in transport tubes, a clean ground sheet is essential to place probes on.

Remove the Top Cap Lower Assembly
- carefully remove the top cap lower assembly from the access tube
- clean inside the top cap assembly to remove any silastic

Remove the Bottom Stopper from the access tube
- Use the bottom stopper tool (found in Toolkit 1) to remove the bottom stoppers from the access tubes.

Remove the Access Tube
- Short access tubes (0.5m) can often be pulled out by hand
- Longer tubes may require digging out or wetting of the soil to pull out, or use of the probe extraction tool contained in Toolbag No. 2
- If access tube is to be re-used inspect the tube for damage and clean as appropriate

Remove the Solar Panel and Logger Housing from the Mounting Pole
- Leaving the solar panel cable connected to logger housing, loosen the solar panel bracket and remove from the mounting pole
- Loosen the logger housing bracket and remove from the mounting pole
- Remove and roll up the probe cabling carefully to avoid tangling, and secure
- Remove the logger housing/solar panel mounting pole
- Place the logger housing and solar panel into padded transport box/boxes

The SLA battery must be removed from the logger

♦♦ ***Caution:*** ***housing whenever it is being moved or transported. Failure to do this may result in mechanical damage due to battery movement.***

Transportation

The following should be observed whenever transporting the EnviroSCAN system:

♦♦ ***Caution:*** ***Never tip logger housing forward with battery installed as this may cause damage to Main Board by battery movement***

♦♦ ***Caution:*** ***The SLA battery must be removed from the logger housing whenever it is being moved or transported. Failure to do this may result in mechanical damage due to battery movement.***

♦♦ ***Caution:*** ***Probes/logger housing/solar panel must be transported in padded transport boxes/transport tubes and these must be secured***

♦♦ ***Caution:*** ***Solar panels should be protected from any damage by objects dropping onto the glass***

♦♦ ***Caution:*** ***Avoid dropping or jarring of equipment during transport***

Storage

While the EnviroSCAN is not installed in the ground it can be safely stored until it is required for re-installation.

The following points should be observed to ensure the system is fully functioning when re-installed:

- Remove the EnviroSCAN system according to the procedures outlined above.
- Transport the system to storage area according to procedures outlined above
- Connect the solar panel and SLA battery to the main board. Leave the removable logger disconnected.
- Store the system in a secure area where the solar panel receives direct light in normal daylight conditions. Ensure that the logger is positioned so that the SLA battery can not move forward.
- Clean the solar panel from time to time

♦♦ ***Caution:*** ***Failure to follow this procedure will cause the internal SLA battery to discharge below the recommended minimum voltage which may damage the battery permanently, requiring replacement.***

Chapter 8: Trouble Shooting

♦♦ *Caution:* ***Trouble shooting and fault rectification should only be undertaken by a trained EnviroSCAN installer. Failure to do so will result in the Warranty being void.***

Fuses

RT5 Main Board

There are three fuses located on the Main Board which may be faulty and require replacement. Refer to Appendix E, for their location on the RT5 Main Board.

Description:

- Fuse F3 (1 amp): Protects the power supply circuitry that provides power to each of the cable runs,
- Fuse F5 (3.15 amp): Protects the Solar Panel or Plug Pack from damage caused by failure in the rest of the EnviroSCAN system, and in some cases damage to the system from Plug Pack power surges,
- Fuse F6 (3.15 amp): Protects the battery against damage caused by system failure.

RT6 Main Board

To allow easier replacement of fuses the RT6 Main Board has the three fuses which protect the circuitry, accessible from the front panel (see Appendix D).

Description:

- Fuse F1 (0.5 amp): Protects the power supply circuitry that provides power to each of the cable runs,
- Fuse F10 (1.0 amp): Protects the Solar Panel or Plug Pack from damage caused by failure in the rest of the EnviroSCAN system, and in some cases damage to the system from Plug Pack power surges,
- Fuse F11 (1.0 amp): Protects the battery against damage caused by system failure.

Faults

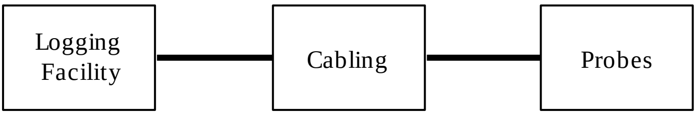
The EnviroSCAN system has been developed to a point that allows relatively easy identification of faulty or troublesome parts and enables quick identification and replacement of these parts.

To assist in diagnosing and determining the components most likely at fault the software contains a "Diagnostics" program. (Refer to the EnviroSCAN Software Manual for an explanation of this program).

Identifying a fault: There are three ways of identifying whether the EnviroSCAN system has a problem that requires attention. They are:

- The Diagnostics program not showing any "Immediate" value on one or more sensors,
- The "ES2 – Dynamic Data Viewer" not showing any values in the graphs for one or more sensors,
- Unable to connect to the logger when running the ESUtility, Diagnostics or Download programs.

When determining where in the EnviroSCAN system a problem lies, it is easier to divide the components into three major sections and identify which of these areas could be at fault. They are as follows:



Once you have been able to determine in which of these three major components the problem lies, it is then easier to identify and replace the faulty unit or repair the fault.

Symptom	Possible Cause	Rectification
No communication with logger	Battery low	Solar panel failed or dirty
	Fuse blown	Replace fuse
	Download cable faulty	Replace cable
	Logger faulty	Replace logger
	Main board faulty	Replace main board
	Jumpers incorrectly set	Check positioning of jumpers
	Local/Remote switch on RT6 front panel incorrectly positioned	Check and reposition if necessary
Missing data	Battery faulty	Replace battery
	Solar panel faulty	Clean or replace solar panel
Sensor not working	Sensor failed	Replace sensor
	4WB/5WB failure	Replace 4WB/5WB
	Probe failure	Replace probe rod
	Main board failure	Replace main board
	Logger failure	Replace logger
Probe not working	Probe failed	Replace probe rod
	Transmitter failed	Replace transmitter
	Receiver failed	Replace receiver
	5WB failed	Replace 5WB
	Cable faulty	Repair or replace cable
	Main board failure	Replace main board
	Logger failure	Replace logger
Run A and/or B not working	Cable faulty	Repair or replace cable
	Fuse blown	Replace fuse
	Main board failure	Replace main board
	Logger failure	Replace logger

Cable Faults

Checking for breaks:

Disconnect all components from the cable run that you wish to test.

Place a Shorting Link on the connector at one end of the cable run and at the other end using a multimeter check the resistance between every conductor on all of the connectors on that run.

Zero resistance for each of the conductors between the shorting link and multimeter indicates that there is no break.

Infinite resistance indicates there is a break in the cable run and you may need to move the multimeter or shorting link to another location to pinpoint the section of cable in which the break occurs.

Checking for shorts:

Disconnect all components from the cable run that you wish to test.

Using a multimeter check the resistance between every conductor on any of the connectors on that run.

Low resistance indicates there is a short somewhere on that cable run. If the cable run has 3-way junction boxes on it you will need to remove the scotchlocks from the conductors showing the short and test each section of cable individually until the short is located.

Replacement Procedures

Battery

1. Unplug logger
2. Remove the front panel screws and tilt panel to access rear of main board
3. Unplug the battery cable from main board and remove battery from compartment

4 Remove battery cable from old battery and connect to new battery
5 Install battery into compartment in housing
6 Plug in battery cable into main board
7 Screw front panel onto housing
8 Plug in logger
9 Run diagnostics

Main Board/ Front panel

1 Unplug logger
2 Remove the front panel screws and tilt panel to access rear of main board
3 Unplug cables from main board/front panel in the following order;
- external power (X10 for RT5, X5 for RT6
- battery power (X11 for RT5, X6 for RT6)
- probe cables (X3/4 for RT5, X2/3 for RT6)
- external RS232 (X12 for RT5, X7 for RT6)
- RS485 (X8 for RT6)

4 Plug cables into a replacement main Board/Front panel in the following order;
- RS485 (X8 for RT6)
- external RS232 (X12 for RT5, X7 for RT6)
- probe cables (X3/4 for RT5, X2/3 for RT6)
- battery power (X11 for RT5, X6 for RT6)
- external power (X10 for RT5, X5 for RT6)

5 Insert the front panel screws
6 Plug in logger
7 Run diagnostics

Probe

1 Remove the top cap
2 Lift probe sufficiently to unplug the connector of the probe cable
3 Lift probe completely from access tube
4 Insert new probe into access tube until cable can be plugged in
5 Plug in probe cable connector
6 Insert probe fully into access tube
7 Replace top cap

4-wire board/ 5-wire board

1 Remove the top cap
2 Lift probe sufficiently to unplug the connector of the probe cable
3 Lift probe completely from access tube
4 Remove the 4 screws that hold the 4-wire (5

wire) board
5 Remove the faulty 4-wire (5 wire) board
6 Insert the replacement 4-wire (5 wire) board
7 Install the 4 screws that hold the 4-wire (5 wire) board
8 Insert probe into access tube until cable can be plugged in
9 Plug in probe cable connector
10 Insert probe fully into access tube
11 Replace top cap

Sensor

1 Remove the top cap
2 Lift probe sufficiently to unplug the connector of the probe cable
3 Lift probe completely from access tube
4 Remove the sensors from the probe until the faulty sensor has been removed
5 Replace the faulty sensor
6 Replace the sensors that have been removed
7 Perform sensor normalisation as per instructions in the EnviroSCAN Software Manual
8 Insert probe into access tube until cable can be
9 plugged in
9 Plug in probe cable connector
10 Insert probe fully into access tube
11 Replace top cap

Solar Panel

1 Unplug logger
2 Remove the front panel screws and tilt panel to access rear of main board
3 Unplug the solar panel cable from main board
4 Remove cable from plug
5 Undo the cable gland and remove the solar panel cable
6 Unbolt the faulty solar panel from the solar panel bracket
7 Install the replacement solar panel and check angle
8 Insert cable into cable gland at bottom of housing
9 Install cable into plug (note orientation)
10 Plug the cable into the main board
11 Tighten the cable gland

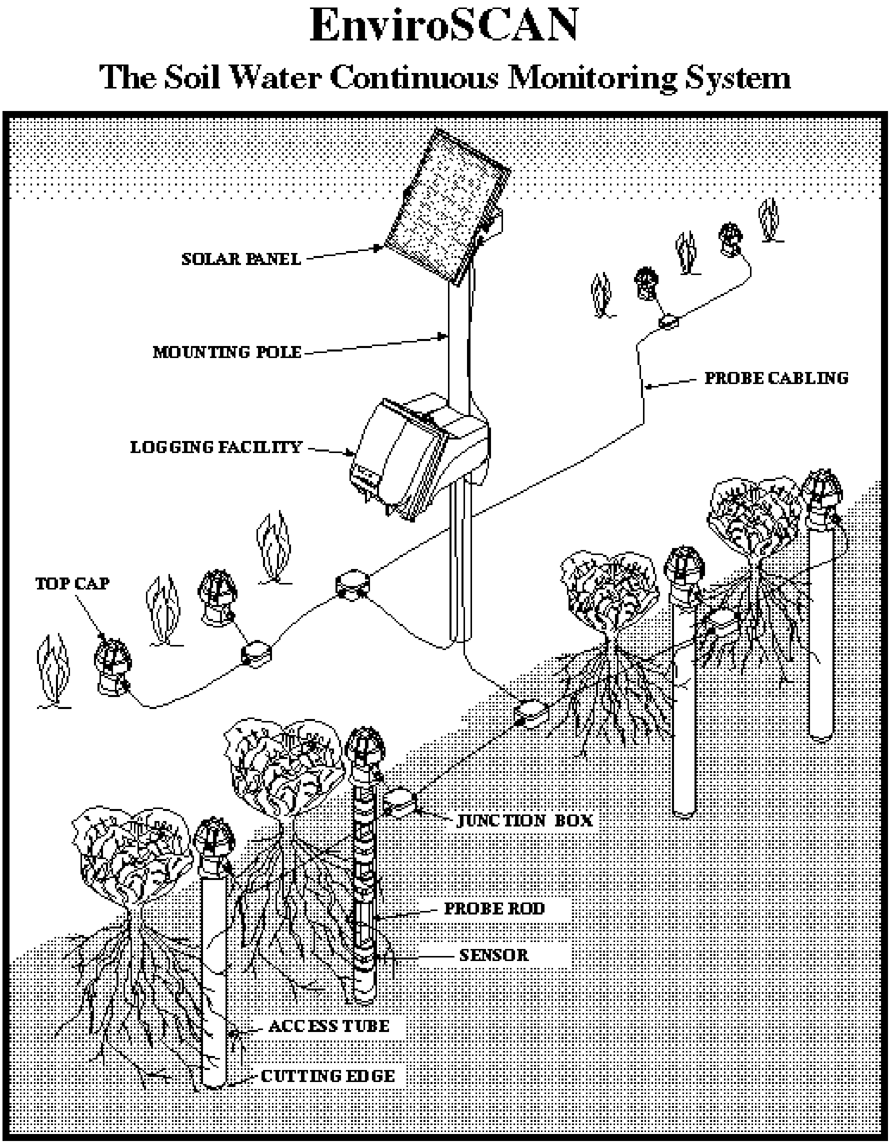
12 Screw front panel onto housing
13 Plug in logger
14 Run diagnostics

Logger

1 If possible download the data.
3 Unplug the logger
4 Plug in the replacement logger
5 Configure the logger as per the EnviroSCAN Software Manual
5 Run diagnostics

APPENDIX A

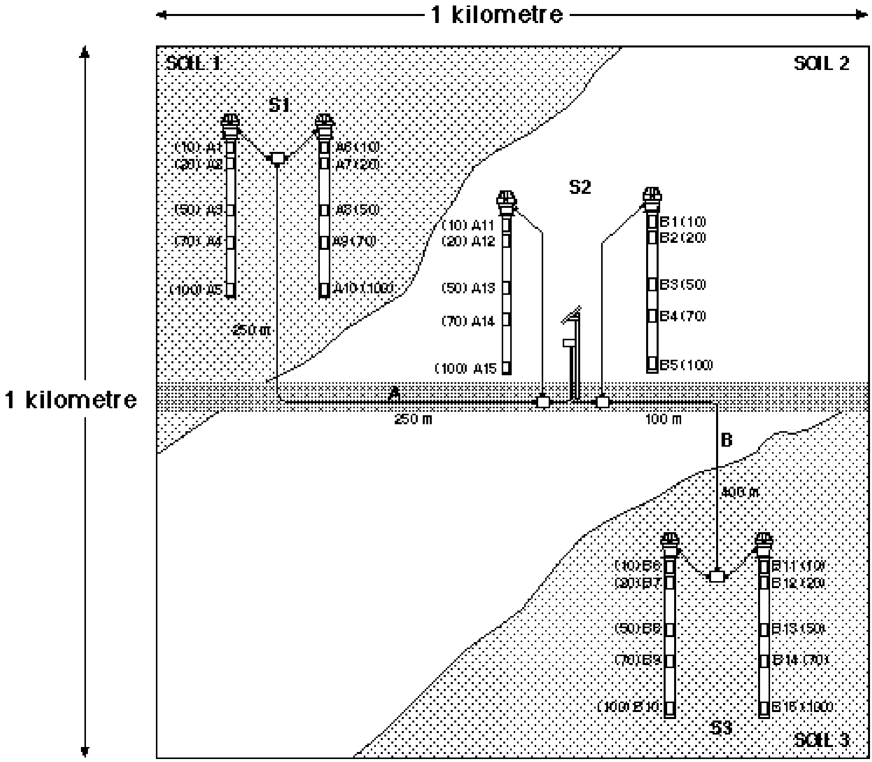
System Overview



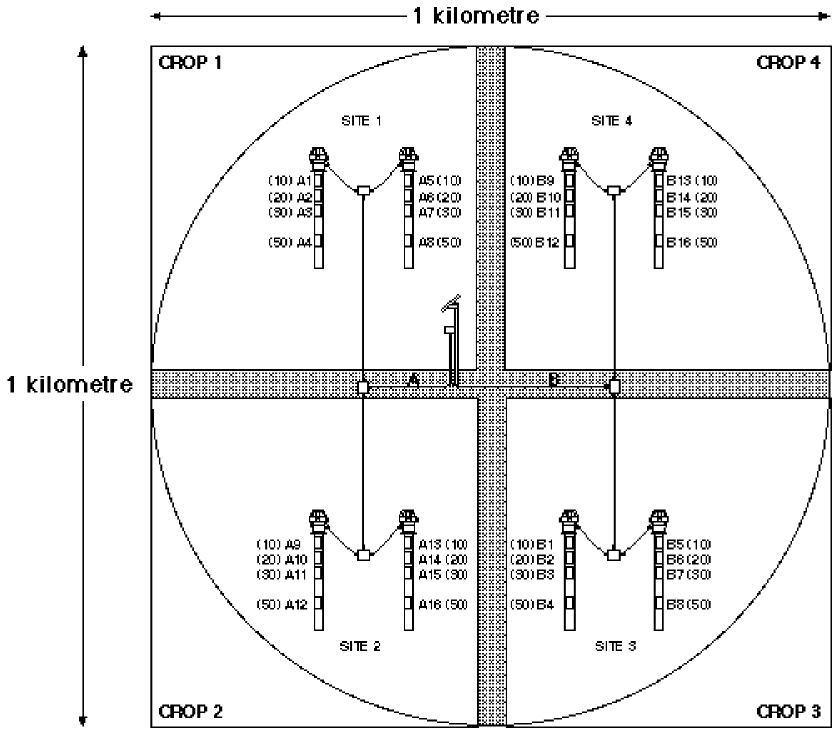
APPENDIX B

System configuration examples

CABLING AND SENSOR ADDRESSING
Example of a 6 Probe, 30 Sensor System



CABLING AND SENSOR ADDRESSING
Example of an 8 Probe, 32 Sensor System

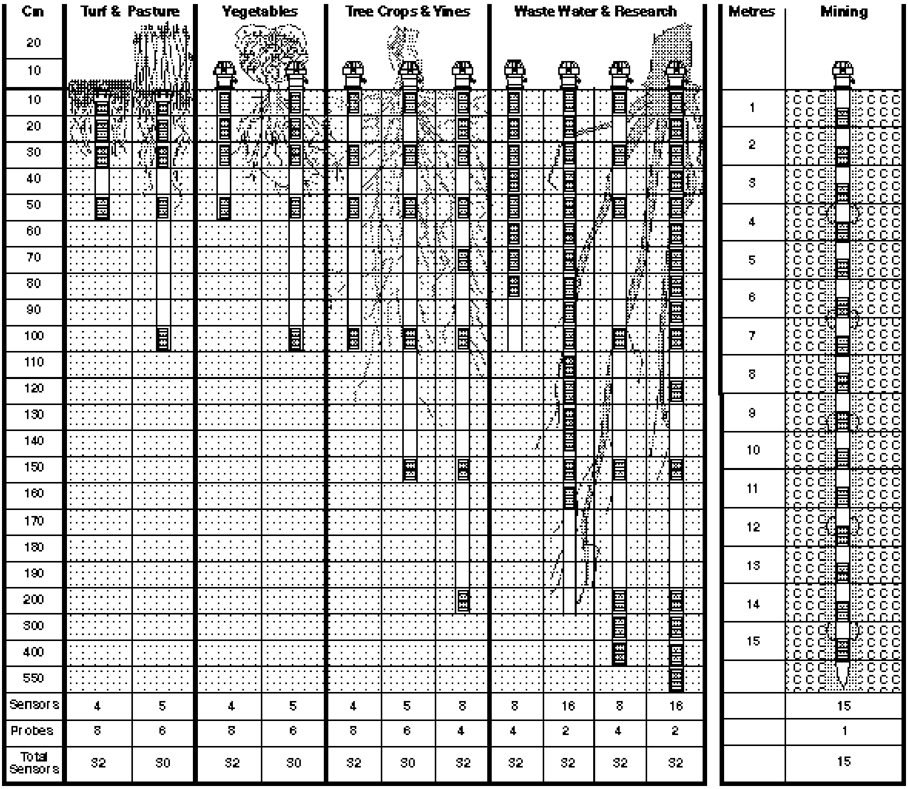


APPENDIX C

Probe configuration examples

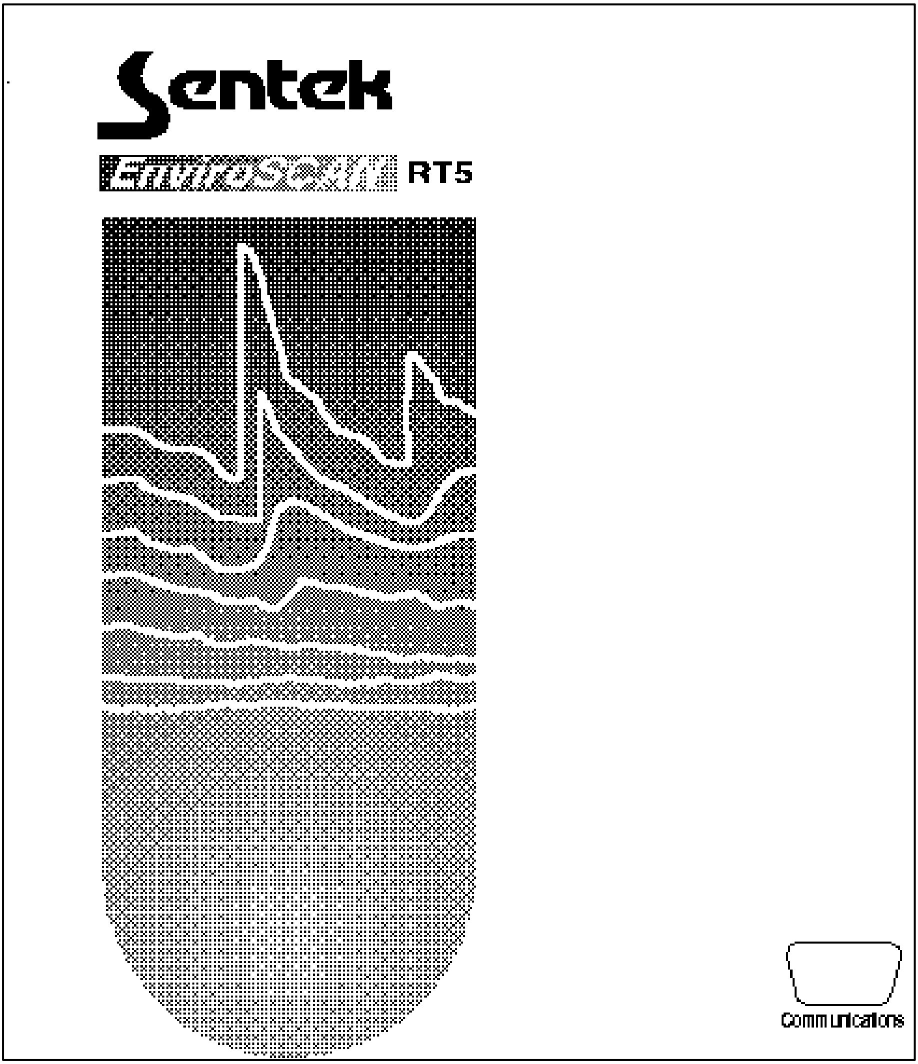
Sentek
ENVIRONMENTAL INNOVATIONS

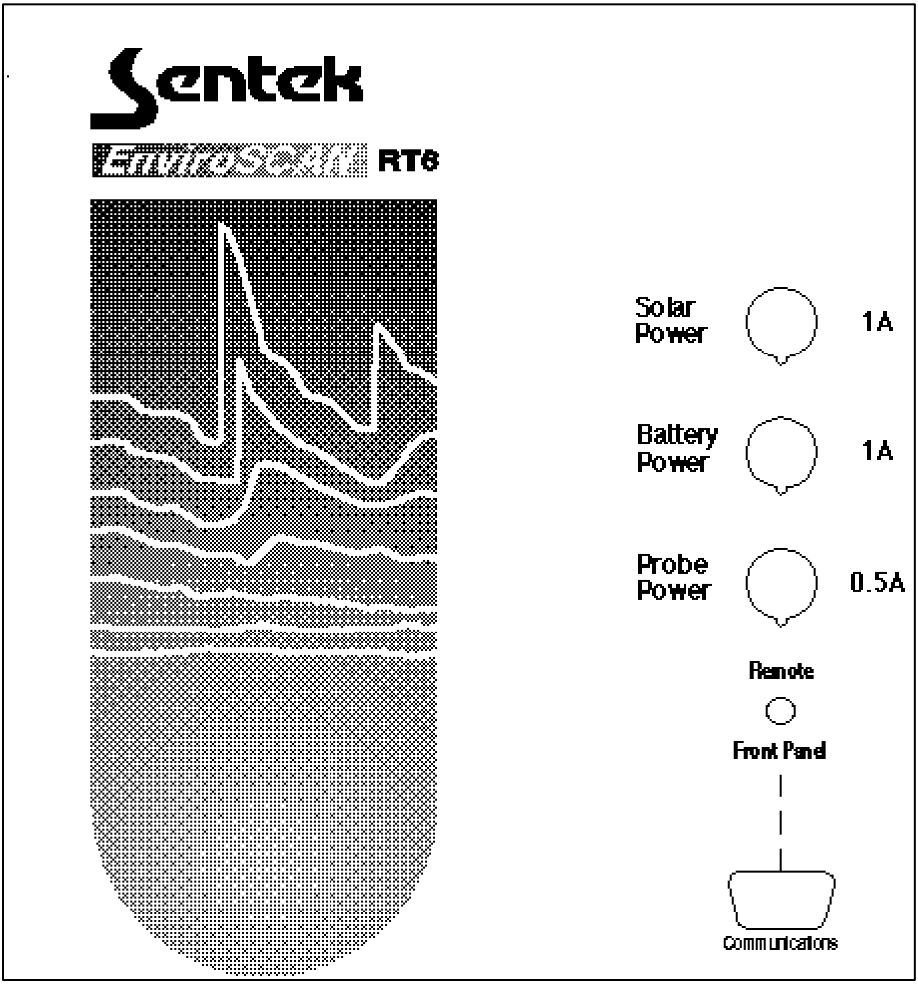
SENSOR DEPTHS



APPENDIX D

Front panel visuals

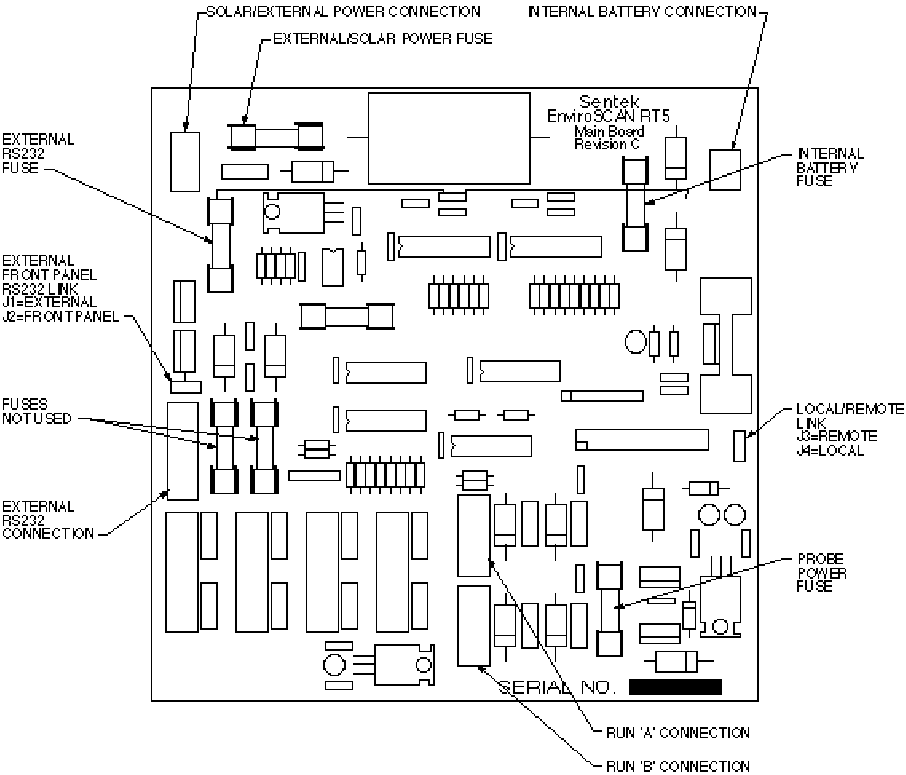



Sentek
EnviroSCAN RT6
Solar Power
1A
Battery Power
1A
Probe Power
0.5A
Remote
Front Panel
Communications

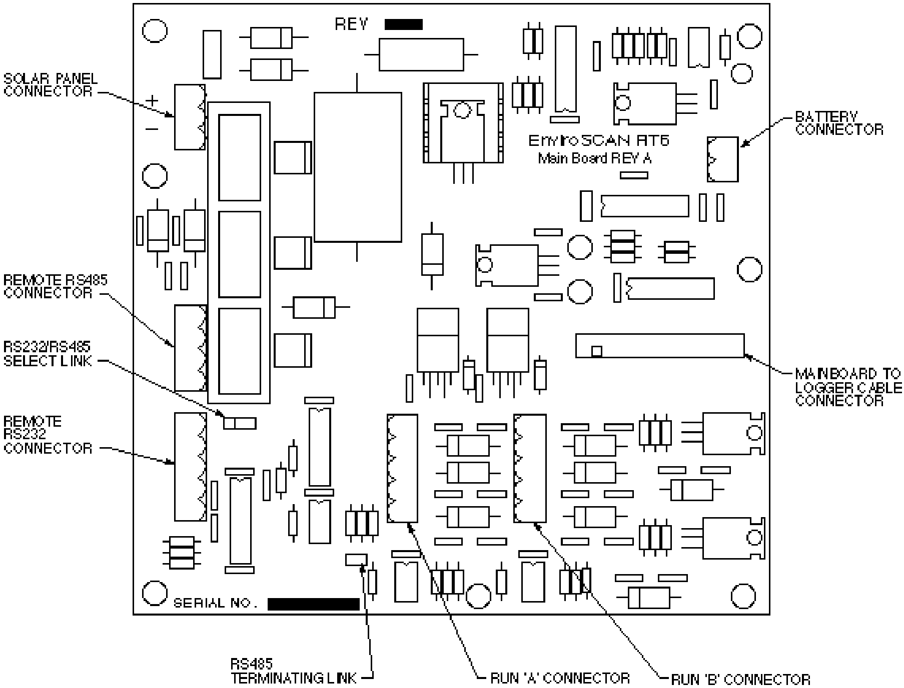
APPENDIX E

Overlay diagrams

RT5 Main Board (Rev. C) Overlay

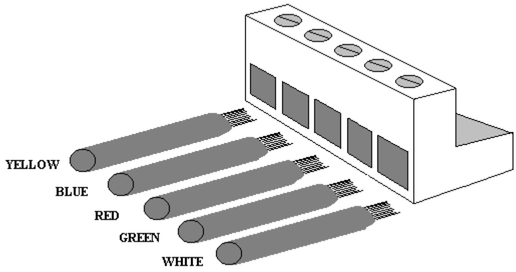


RT6 Main Board Overlay

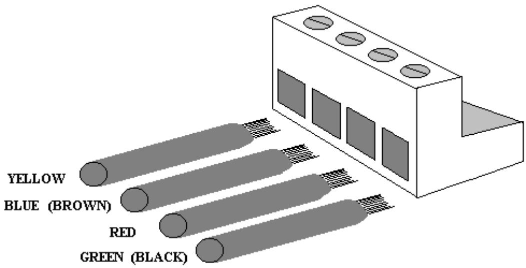


APPENDIX F

Cable Wiring Order



5 Wire Connector

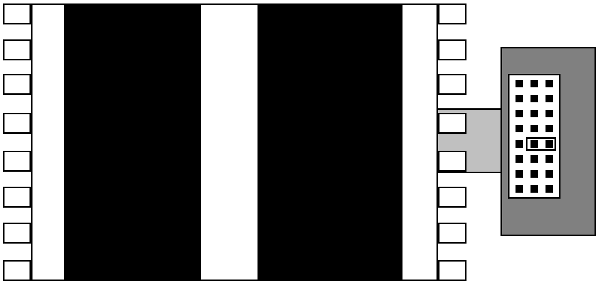


4 Wire Connector

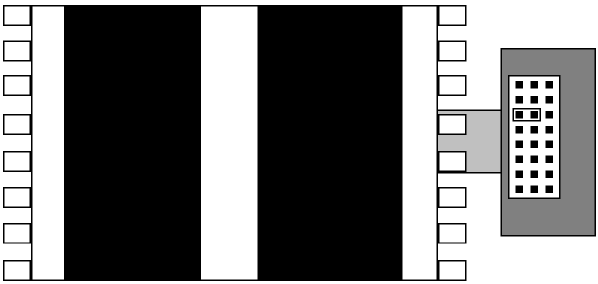
APPENDIX G

Sensor Addressing

RunA	-	Addressed as 1 to 16
	-	address as 1 to 16 in software setup
RunB	-	Addressed as 1 to 16
	-	address as 17 to 32 in software setup

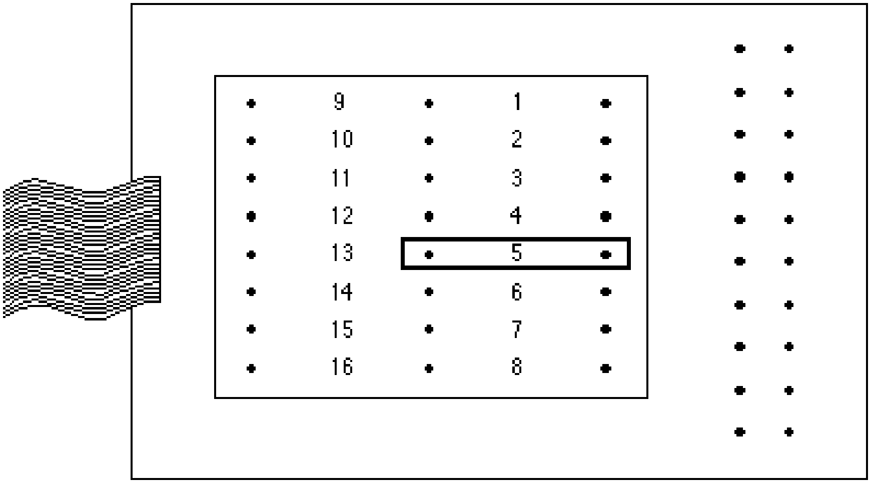


Box around pin number five shows the link installed to address as sensor five.



Box around pin number eleven shows the link installed to address as sensor eleven.

RUN A
- ADDRESSED AS 1 TO 16
- ADDRESS AS 1 TO 16 IN SOFTWARE SETUP



BOX AROUND NUMBER FIVE SHOWS THE LINK INSTALLED TO ADDRESS FOR FIVE.

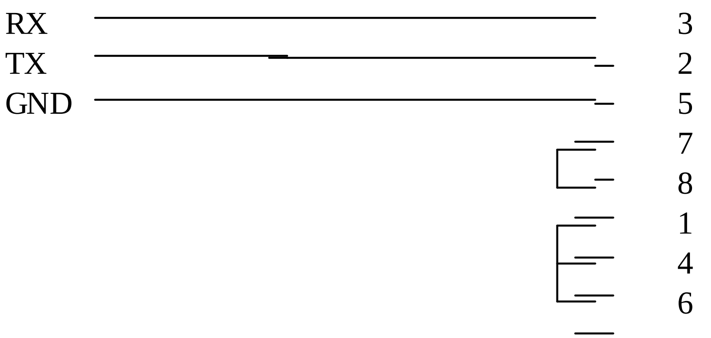
RUN B
- ADDRESSED AS 1 TO 16
- ADDRESS AS 17 TO 32 IN SOFTWARE SETUP

APPENDIX H

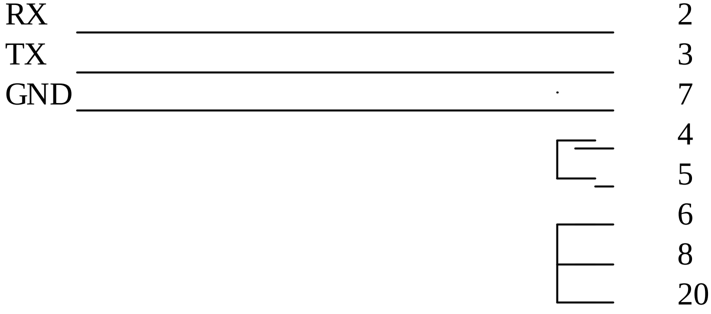
External RS232 to computer cable diagram

The following diagram shows the wiring connections between the external RS232 connector and computers serial port.

RT6 **Computer 9 pin serial port**



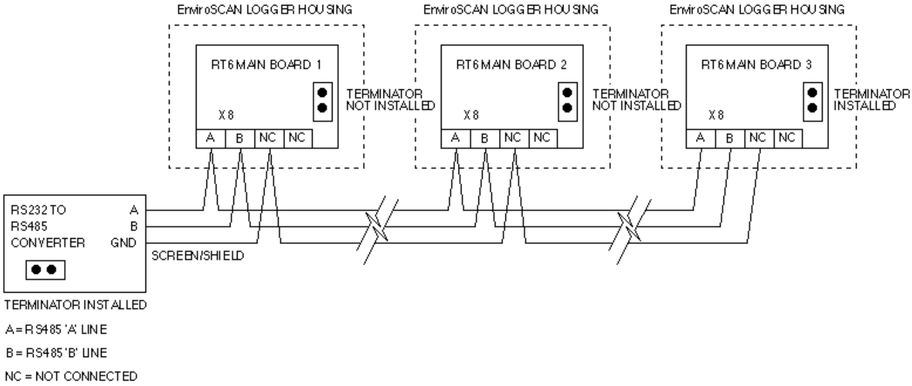
RT6 **Computer 25 pin serial port**



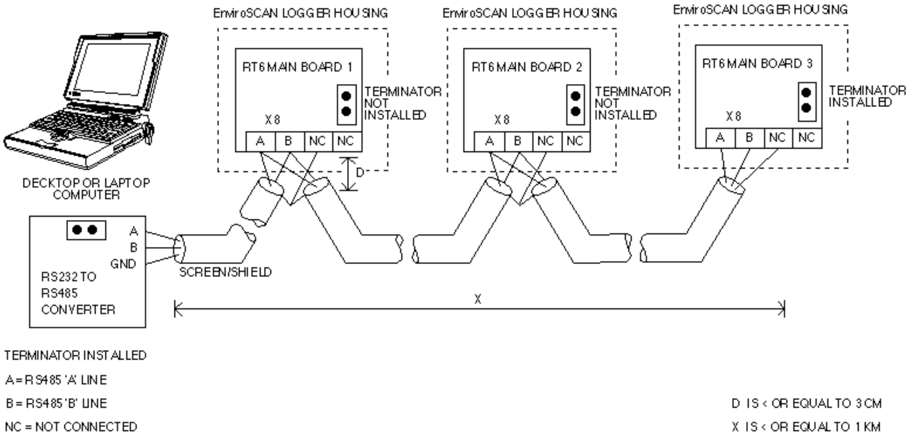
APPENDIX I

RS485 connections

RS485 Circuit Diagram



RS485 Physical Connections



APPENDIX J

Formula to Calculate Logger Storage Capacity

Please use the formula below to calculate the maximum period that you can allow to pass before you have to download your logger. Failure to download data within this period will lead to a partial loss of data, since the logger's memory will start to overwrite the data. The length of that period is determined by a constant (86), the sampling interval in minutes (which can be altered) and the number of sensors installed (variable).

$$\textbf{No. of Days until memory wraps} = \frac{\textbf{86 x Sampling Interval (min.)}}{\textbf{Number of Sensors}}$$

Example:

16 sensors logging every 2 hours: $\frac{86 \text{ x } 120}{16}$ = 645 days

12 sensors logging every 1 hours: $\frac{86 \text{ x } 60}{12}$ = 430 days

5 sensors logging every 10 minutes: $\frac{86 \text{ x } 10}{5}$ = 172 days

32 sensors logging every 10 minutes: $\frac{86 \text{ x } 10}{32}$ = 26 days & 21 hours

APPENDIX K

Specification Sheets

Sensor

Measuring Principle	Capacitance via the dielectric effect	
Installation	Non-contact via Sentek' s 50mm PVC access tube	
Depth	Up to 5.5 m vertical depth (deeper upon request)	
Framework	PVC	
Sensing Element	2 copper rings	length = 25mm diameter = 49mm spacing = 10mm
Sensitivity	Horizontal	130mm to 150mm radius of axial centre in free air
	Vertical	85mm to 120mm either side of axial centre
Spacing	Minimum interval between sensors of 100mm between axial centres	
Signal output	Maximum 100khz open collector (free air)	
Temperature range	-30 to +85 degrees Celsius	
Measurement range	No upper or lower limits of Volumetric soil water	
Resolution	+/- 0.002% (+/- 1 count in 50000)	
Accuracy	The correlation coefficient of the probe signal with soil water content is at R^2 = 0.984 (as tested by CSIRO)	
Drift	Less than +/- 0.5%	

RT5/RT6 logger

Processor	Intel 80C552
Clock rate	11.0592 Mhz
Memory	512K 100nS RAM 512K 200nS EPROM 256 x 8-bit Static CMOS EEPROM
Data retention	2 days from removal of power
I/O Capabilities	RS232 and TTL serial communications which are software selectable for 1200, 2400, 9600 and 19.2K Baud rates.16-bit counter
On board facilities	Clock Calendar (battery backed) Power fail detection
On board power	3.6 Volt Nickel Cadmium battery 5 Volt regulation
Capability	Maximum of sensors = 32 (2 runs of 16 sensors)
I/O Connections	Via female DB25 connector to Main Board

RT5 Main Board (Rev C)

Power regulation	SLA floating voltage battery charging circuitry 50mA constant current Ni-Cad charger 5 Volt linear regulators
Protection	Over voltage protection for SLA charger Battery cutout at 10.5 Volts with 1 Volt Hysteresis 3.15 Amp fuse in line with 12 Volt battery 3.15 Amp fuse in line with solar/external power 1 Amp fuse in line with sensor drivers Over voltage protection on solar panel input Internal battery reverse bias protection Solar / external power reverse bias protection Lightning protection on all inputs and outputs
I/O Capabilities	2 x 4-wire drivers (to drive 2 runs of 16 sensors)
I/O Connections	25 way IDC connector to logger (1) DB9 connector on front panel for RS232 (1) 4 way screw connectors to probes (2) 2 way screw connector for battery power (1) 3 way screw connector for solar / external power (1) 5 way screw connector for ext. RS232 serial port (1) 6 way screw connectors – not used (4)
Capabilities	Drivers on board to address 32 sensors (2 runs of 16)

RT6 Main Board

Power regulation
SLA specific battery charging circuitry
50mA constant current Ni-Cad charger
5 Volt linear regulators

Protection
Over voltage protection for SLA charger
Battery cutout at 10.5 Volts with 1 Volt Hysteresis
1 Amp fuse in line with 12 Volt battery
1 Amp fuse in line with solar/external power
0.5 Amp fuse in line with sensor drivers
Over voltage protection on solar panel input
Internal battery reverse bias protection
Solar / external power reverse bias protection
Lightning protection on all inputs and outputs

I/O Capabilities
2 x 5-wire drivers (to drive 2 runs of 16 sensors)

I/O Connections
25 way IDC connector to logger (1)
DB9 connector on front panel for RS232 (1)
5 way screw connectors to probes (2)
2 way screw connector for battery power (1)
3 way screw connector for solar / external power (1)
5 way screw connector for ext. RS232 serial port (1)
4 way screw connector for RS485 serial port (1)

Capabilities
Drivers on board to address 32 sensors (2 runs of 16)

Power supply

Internal Battery

Make - Sonnenschein Dryfit A200
Model - A 212/5.7 S
Rating - 12 Volt / 5.7 Amp/Hr
Type - Sealed / rechargeable SLA

Make – YUASA
Model – NP7-12
Rating - 12 Volt / 7 Amp/Hr
Type - Sealed / rechargeable SLA

Solar Panel

Make – Solarex
Model - MSX-10
Type - Semicrystalline Silicon
Rating - 10 Watts at peak power
- 17.5 Volts at peak power
- 0.54 Amps at operating voltage
Temperature range -40 to 90 degrees Celsius
Wind loading exceeding 200km/h
Surface withstands impact of 1" hail at terminal velocity (87km/h) without breakage

External DC Power

The DC supplied should be between 18 and 30 volts DC with sufficient current to operate circuitry and charge the internal battery.

The external DC supply can be provided from;

1. A DC supply which is rated at between 16 and 24 volts DC and be able to supply 1.5 amps.
2. Two car batteries connected in series which will supply 24 volts DC

External AC Power

The AC supplied should be between 12 and 16 volts AC and able to supply 1.5 amps.

The external AC supply can be provided from;

1. 240 volt AC to 16 volt 1.5A AC plug pack
2. AC supply which is rated at between 12 and 16 volts AC and be able to supply 1.5 amps.

Appendix E.3
Davis Vantage Pro Weather Station Manual

Integrated Sensor Suite Installation Manual

for Vantage Pro Weather Stations

Product # 6320, 6320C, 6321, 6321C, 6325, 6325C, 6326, 6326C

Contents

FCC Part 15 Class B Registration Warning

This equipment has been tested and found to comply with the limits for a class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications not expressly approved in writing by Davis Instruments may void the user's authority to operate this equipment.

Integrated Sensor Suite Installation Manual

Rev. B, January 26, 2004
Document: 07395.149
Products: 6320, 6320C, 6321, 6321C, 6325, 6325C, 6326, 6326C

This product complies with the essential protection requirements of the EC EMC Directive 89/336/EC.

Vantage Pro is a registered trademark of Davis Instruments Corp., Hayward, CA. The Information in this document is subject to change without notice.

Introduction

The Integrated Sensor Suite (ISS) collects outside weather data and sends the data to a Vantage Pro console or Weather Envoy. Wireless and cabled versions of the ISS are available, as well as standard and plus versions. The Wireless ISS is solar powered and sends data to the console via a low-power radio. The Cabled ISS sends data and receives power via the console cable.

Standard versions of the ISS include a rain collector, temperature sensor, humidity sensor and anemometer. The ISS Plus adds a solar radiation sensor and an ultra-violet (UV) sensor. Temperature and humidity sensors are mounted in a passive radiation shield to minimize the impact of solar radiation on sensor readings. The anemometer measures wind speed and direction and can be installed adjacent to ISS or apart from it, *see "Siting the ISS and Anemometer" on page 9* for siting guidelines.

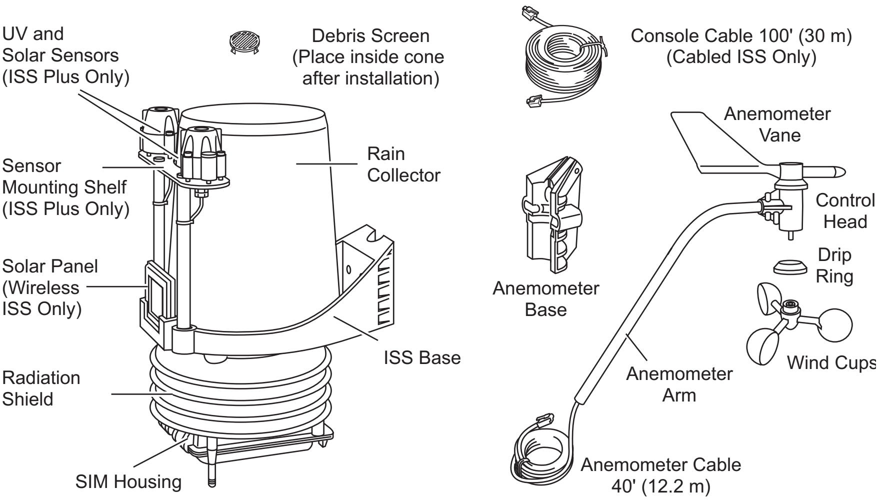
The solar and UV sensors are mounted next to the rain collector cone. Solar and UV sensors are available separately to upgrade a standard ISS. See "Appendix B: Optional Accessories" on page 20.

The Sensor Interface Module (SIM) contains the "brains" of the ISS and is located on the bottom of the radiation shield. The SIM collects outside weather data from the ISS sensors and then transmits the data to your Vantage Pro console or Weather Envoy.

Included Components and Hardware

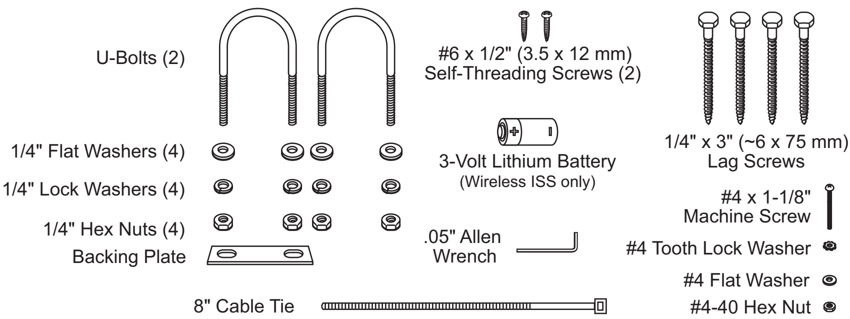
The ISS comes with all the components and hardware shown in the following illustrations. If you purchased your ISS as part of a Weather Station, additional components may be included in the package that are not shown here.

Components



Note: *Do not touch the small white diffusers on top of the UV and solar radiation sensors. Oil from skin reduces their sensitivity. Clean using ethyl alcohol on a soft cloth. NO RUBBING ALCOHOL.*

Hardware



Tools for Setup

- Small Phillips-head screwdriver
- Scissors or wire-cutters
- Adjustable wrench or 7/16" wrench
- Compass or local area map
- Ballpoint pen or paper clip (small pointed object of some kind)
- Drill and 3/16" (5 mm) drill bit (if mounting on a vertical surface)

Preparing the ISS for Installation

Please follow the steps in the order they are presented. Each step builds on tasks completed in previous steps.

Note: *We recommend using a well-lit worktable to prepare the ISS for installation.*

The steps to prepare the ISS for installation are:

- Assemble the anemometer
- Check the factory-installed sensor cable connections to the SIM.
- Connect the anemometer sensor cable to the Sensor Interface Module, or “SIM”.
- Apply power to the ISS and test communications with the console.
- Change the transmitter ID for wireless communication, if necessary

Assemble the Anemometer

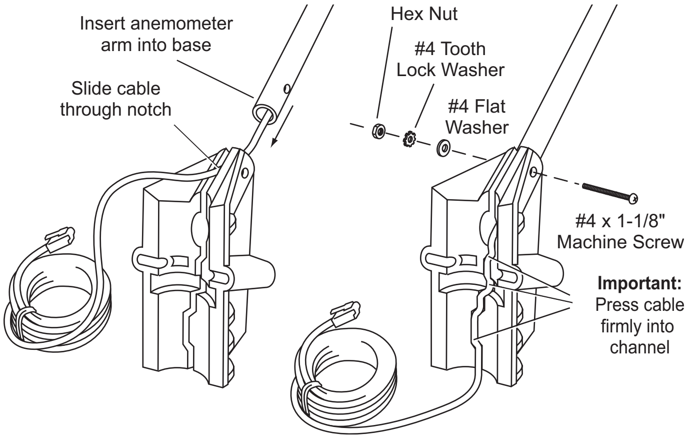
The anemometer measures wind direction and speed. The wind vane is already attached to the anemometer arm, but you will need to install the wind cups and attach the arm to the base.

Please locate the following parts to prepare the anemometer:

- Anemometer arm (wind vane and cable already attached)
- Anemometer base
- Wind cups
- Drip ring
- Allen wrench (0.05")
- #4 machine screw, #4 tooth-lock washer, #4 flat washer, #4 hex nut

Attaching Anemometer Arm to Base

1. Insert the anemometer arm into the base, sliding the cable through the notch in the base as shown in illustration.
   Be sure to line up the small hole in the arm with the holes in the base.



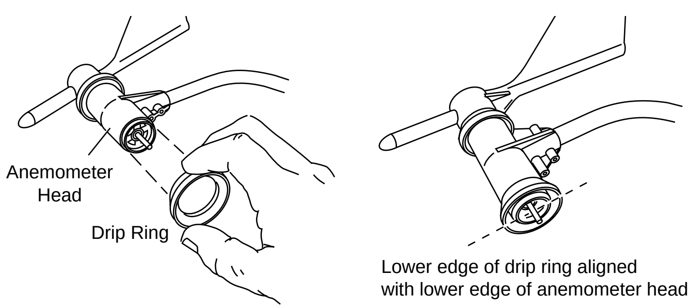
2. Insert the machine screw through the holes in the base and arm.
3. Slide the flat washer, tooth-lock washer and hex nut onto the machine screw. Tighten the hex nut while holding the screw with a Phillips screwdriver to prevent it from turning.
4. PRESS the sensor cable firmly and completely into the zig-zagging channel in the base, taking up any slack between arm and base.

Note: *The U-bolt used to mount the ISS can pinch or cause wear on the anemometer cable if the cable is not pressed completely into the channel,.*

Attaching the Drip Ring and Wind Cups

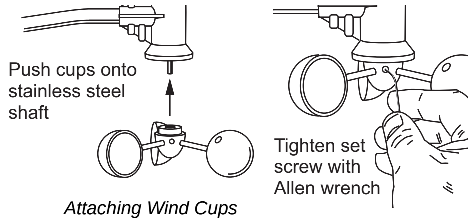
The drip ring attaches to the bottom edge of the anemometer head to help protect the wind cups from icing over. Install the drip ring first, then install the wind cups.

1. Place the black plastic drip ring on the bottom edge of the anemometer head. Gently push the drip ring onto the head until it clicks into place.
2. Make sure the lower edge of the drip ring is aligned with the lower edge of the anemometer head.



Attaching the Drip Ring

3. Push the wind cups up onto the anemometer's stainless steel shaft.
4. Slide the wind cups up the shaft as far as possible.
5. Use the Allen wrench provided to tighten the set screw on the side of the wind cups. When you let go of the wind cups, they should drop slightly.



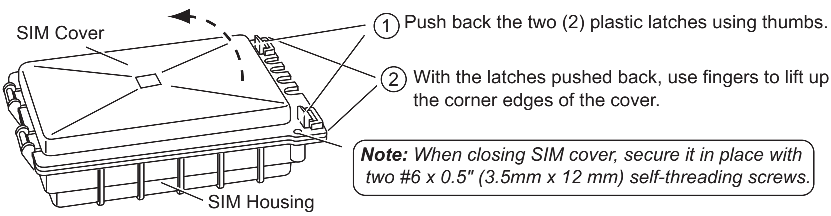
Attaching Wind Cups

6. Spin the wind cups.
7. If the wind cups spin freely, the anemometer is ready and can be set aside while you prepare the rest of the ISS for installation.
8. If the wind cups don't spin freely, repeat steps 1, 2 and 3.

Check SIM Sensor Connections

Open the SIM Housing Cover

1. Turn ISS upside down with the rain collector cone on the bottom.
2. Push back on the two plastic latches to release the SIM cover, then open the cover. You should now be able to see the SIM.

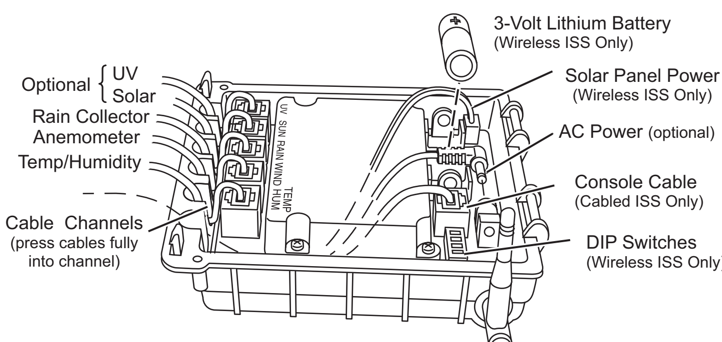


> **Note:** *When closing SIM cover, secure it in place with two #6 x 0.5" (3.5mm x 12 mm) self-threading screws.*

Opening the SIM Housing Cover

Check the Factory Installed Sensor Connections

1. Verify that the rain sensor and temp/hum sensor cables are plugged into the receptacles labeled "RAIN" and "TEMP HUM" on the SIM.



SIM Connections

2. If your station includes UV and/or solar radiation sensors, verify that the sensor cables are plugged into the SIM.

Connect the Anemometer Cable to the SIM

1. Unwind the coil of cable enough to work with the anemometer. Do not unwind the entire coil of anemometer cable just yet.
2. Gently insert the end of the anemometer cable into the connector labeled “WIND” on the SIM.
3. Press the cable fully into the channel next to the connector as shown on the next page.

Cabled ISS: Powering and Testing

Applying Power

The 100' (30 m) console cable provides power to the ISS and is used to send data from the ISS to the console. The console cable can be extended up to 1000' (305 m) in length‘.

1. Locate the 100’ console cable included with your system.
2. On the SIM, gently insert one end of the 4-conductor cable into the modular connector located apart from the sensor connectors. Refer to the figure “SIM Connections” on this page.
3. If you haven’t powered up the console yet, refer to the installation instructions in the *Vantage Pro Console Manual* and apply power to the console.
4. On the back of your console, insert the other end of the console cable into the modular receptacle labeled “ISS.”

   Plugging the console cable into the console powers the ISS and establishes communication between the ISS and the console. Your ISS should immediately begin collecting weather data and start sending the data to the console. Data is sent through the cable that you connected during the preceding step in order to power the ISS.

Verifying Communication

Use these steps to verify reception of ISS data at the console for a Cabled Vantage Pro and to test the operation of the ISS sensors.

1. If the console is in Setup Mode, press and hold down the **DONE** key until the “Current Weather” screen appears.

   The console should now display sensor readings from the ISS.
2. Near the center of the screen, look for inside and outside temperatures.
3. Spin the wind cups to check wind speed, pressing the **WIND** key if necessary to alternate between speed and direction in the compass rose.
4. Turn the wind vane, and allow 5 seconds for the wind direction display to stabilize before moving it again.
5. Approximately one minute after power-up the outside relative humidity reading should be displayed on the console.
6. If you have a UV sensor and or solar radiation sensor, press the **UV** key for current ultraviolet readings or press **2ND** then press **SOLAR** for solar radiation readings.

   UV and solar readings should be zero or close to zero if the ISS is inside. Zero is a valid reading — dashes are displayed if no data comes from the sensors.
7. Current weather data displayed on the console confirms successful communication. If the console is not receiving data, proceed to “Troubleshooting Cabled ISS Reception.”
8. You may wish to disconnect the console cable from the SIM at this point to ease the installation of the ISS.
9. Close the SIM housing cover on the ISS.
10. Continue on to “Prepare the Rain Collector” on page 8.

Troubleshooting Cabled ISS Communication

If your console is not receiving sensor readings from the ISS, please try the following troubleshooting procedures.

1. Check the console to make sure you are using the supplied AC adapter. Other adapters may not work.
2. Make sure the console cable is firmly plugged into the ISS connector on the console.
3. At the ISS, check that the console cable is firmly plugged into the correct modular connector. Refer to the figure “SIM Connections” on page 4.
4. Verify that all sensor cables are firmly plugged in.
5. If you still don’t get readings, reboot the console by disconnecting the AC power adapter from the console and removing the console batteries for at least 30 seconds.
6. If your console is still not displaying sensor readings from the ISS, please contact Davis Technical Support. See page 18 for details.

Wireless ISS: Powering and Testing

Use these steps to power a Wireless ISS, to verify communication with the console, and to verify the operations of ISS sensors.

Note: *A super capacitor stores energy from the solar panel for power at night. The battery powers a Wireless ISS when the super capacitor is depleted.*

Applying Power to a Wireless ISS

1. Insert the 3-volt lithium battery into the SIM.

   Once powered, your ISS will immediately begin transmitting data to the console.

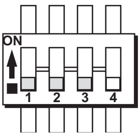
CAUTION: *Be sure to match the “+” sign on the battery with the “+” sign on the SIM.*

Checking Transmitter ID

A Vantage Pro console can receive data from up to eight different wireless stations.

1. The default transmitter ID for the ISS and console is ‘1’.

   In most cases it will not be necessary to change the transmitter ID. Your console and ISS should begin communicating automatically when power is applied.



Settings for Transmitter ID 1:
DIP Switch 1 = OFF
DIP Switch 2 = OFF
DIP Switch 3 = OFF

2. If it is necessary to change the transmitter ID, remember to use the same the ID for the ISS and console. See “Appendix A: Wireless Transmitter IDs” on page 19.

Verifying Communication with the Console

1. If you haven’t powered up the console yet, refer to the *Vantage Pro Console Manual* and apply power the console.

Note: *The console automatically enters Setup Mode when powered up.*

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2. If the console is not in Setup Mode, press and hold the **DONE** key then press the **“-”** key.

   You should see the words: “RECEIVING FROM...” and “STATION NO.” followed by the transmitter IDs that your console detects.
3. Look for the ISS transmitter ID which will be ‘1’ unless you have changed it. If the console shows the ISS transmitter ID then your ISS is being detected.

4. If you see the ISS ID number, press and hold down the **DONE** key to view ISS data.

Note: Be sure to allow up to a minute for the ID number to appear on the screen.

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5. If the console does not display the number of the ISS transmitter ID setting, refer to “Troubleshooting Wireless ISS Reception” later in this section.

Verifying Data from the ISS Sensors

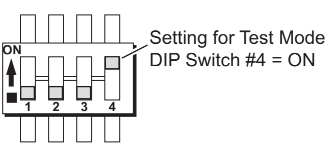
Your console should now display weather readings from the ISS. Refer to the *Vantage Pro Console Manual* for more information.

1. Near the center of the screen, look for inside and outside temperatures.
2. Spin the wind cups to check wind speed. Press the **WIND** key if necessary to toggle the wind display between speed and direction readings.
3. Turn the wind vane, and allow 5 seconds for the wind direction display to stabilize before moving it again.
4. The outside relative humidity reading takes approximately one minute to display after power-up.
5. If you have a UV sensor and or solar radiation sensor, press the **UV** key for current ultraviolet readings or press **2ND** then press **SOLAR** for solar radiation readings.
   UV and solar radiation readings should be zero or close to zero if the ISS is inside. Zero is a valid reading — dashes are displayed if no data comes from the sensors.
6. Display of current weather data confirms communication. If the console is not receiving ISS data, proceed to “Troubleshooting Wireless ISS Reception” below.
7. Press the **DONE** key to exit Setup Mode.
8. Close the SIM housing cover on the ISS.
9. Continue on to “Prepare the Rain Collector” on page 8.

Troubleshooting Wireless ISS Reception

If the console isn’t displaying data from the ISS, perform the following steps:

1. Verify that the console is powered and is not in Setup Mode.
2. Make sure that all ISS sensor cables are firmly connected to the SIM and the ISS battery is properly installed.
3. Walk around the room with the console, standing for a few moments in various locations to see if you are picking up signals from the ISS. Look on the screen’s lower right corner. An “X” toggles on and off when the console receives a transmission.
4. If you do not see the “X” slowly blinking, no matter where you stand with the console, put your ISS in Test Mode.



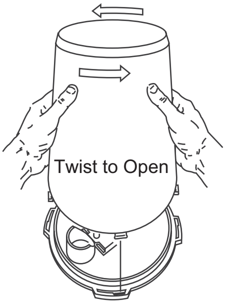
   - DIP switch #4 on the SIM (see the diagram below) is the Test Mode switch. Switch it to the ON position, using a ball-point pen or paper clip.
   - An LED indicator light on the SIM will flash each time the ISS transmits, which is once every 2.5 seconds.
5. If the LED remains dark, there is a problem with the ISS transmitter. See “Contacting Davis Instruments” on page 18.

6. If the LED flashes repeatedly but your console isn't picking up a signal anywhere in the room, it could be related to one of the following causes:
    - You changed the ISS transmitter ID at the ISS or console, but not at both.
    - Reception is being disrupted by RF (radio frequency) interference. Interference has to be strong to prevent the console from receiving a signal while in the same room as the ISS! In high-interference environments, it may be preferable to install the Cabled Vantage Pro.
    - There is a problem with the console.
7. If you are unable to resolve a problem with the wireless transmission, please contact Technical Support for assistance (see page 18).
8. When you are finished testing wireless transmission, set DIP switch # 4 to OFF to take the SIM out of Test Mode.

Note: *If the SIM is left in Test Mode, the blinking LED will significantly reduce ISS battery life.*

Prepare the Rain Collector

Prepare the rain collector by releasing the tipping bucket. The tipping bucket is secured at the factory to protect it from wear and damage during shipping.

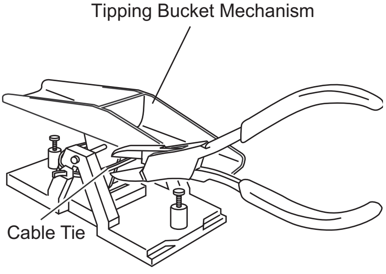


1. Remove the rain collector cone from the ISS base by rotating the cone counter-clockwise. When the cone's latches line up with openings in the base, lift the cone off the ISS base.

Note: *When new the cone fits tightly in the base and may require extra pressure to remove the first few times.*

Tip: *Steady the ISS base between your knees when removing the cone.*

2. On Vantage Pro Plus, the UV and solar radiation sensor cables are routed through the ISS base. Please make sure the cables are not moved during this procedure. Make sure the cables do not interfere with the tipping bucket mechanism or with your ability to get the cone latched back onto the base.
3. Carefully cut and remove the plastic cable tie (usually black in color) that holds the tipping bucket mechanism in place during shipping.
4. On your console screen, look for DAILY RAIN display.
5. While watching the daily rain display, slowly tip the bucket mechanism until it drops to opposite side. Each tip indicates 0.01" of rain and may take up to 10 seconds to register at the console. If the number doesn't change, you may be tipping the bucket too quickly. Try again, more slowly this time.



Cut the plastic cable tie.

6. Temporarily reinstall rain collector cone until you are ready to mount the ISS outside.

Siting the ISS and Anemometer

For your weather station to perform at its best, use these guidelines to select the best mounting locations for your ISS and anemometer. Be sure to take ease of access for maintenance, sensor cable lengths and wireless transmission range into consideration when siting your station.

General ISS Siting Guidelines:

- Place the ISS at least 5' (1.5 m) away from sources of heat such as chimneys and exhaust vents.
- Avoid placing the ISS near or above any object or area that collects and radiates heat in the sunshine. This includes any kind of paving, patio or deck, or metal or concrete structures or objects.
- Ideally, place the ISS 5' (1.5 m) above the ground in a grassy area.
- Avoid locating the ISS in an area that is prone to precipitation runoff — look out for trees and nearby buildings.
- If you have a wireless ISS, or if you have a solar radiation or UV sensor, look for a location with good sun exposure throughout the day.
- Mount a Wireless ISS so that the solar panel receives the maximum amount of sunshine available at that location.
- For Agricultural applications install the ISS and anemometer as a single unit 6.5' (2 m) above the ground. This is especially important for evapotranspiration (ET) calculations.

Anemometer Siting Guidelines

- Generally, the anemometer and ISS have different siting requirements and will provide better readings when mounted apart from each other.
- For best results place the Anemometer above local objects that obstruct the wind flow.
- If mounting on a roof, mount the anemometer at least 4' (1.2 m) and ideally 10' (3 m) above the roof line.
- The standard for meteorological and aviation applications is to place the anemometer 33 feet (10 m) above the ground.

Note: *For roof mounting, and for ease of installation in other locations, we recommend using the optional Mounting Tripod #7716.*

Cable Length Considerations

- All Vantage Pro stations include a 40' (12m) cable to go between the ISS and the anemometer. This can be extended up to 540' (165m) using optional cables. See "Extending Wireless Transmission Range" on page 15
- The Cabled Vantage Pro includes a 100' (30m) cable to go between the console and the ISS. This can be extended up to 1000' (300m) using optional cables.

Wireless Transmission Considerations

The range of the radio transmission depends on several factors. Try to position the transmitter and the receiver as close as possible for best results.

- Typical maximum ranges:
  - Line of sight: 400 feet (120 m)
  - Under most conditions: 75 to 150 feet (23 to 46 m)

- Range may be reduced by walls, ceilings, trees, foliage, a metal roof or other large metal structure or objects such as aluminum siding, metal ducting, and metal appliances such as a refrigerator.
- Radio-frequency interference (RFI) will also reduce transmission distance. Cordless phones (900 Mhz) and ham radios are common examples of RFI.
- Transmission between wireless units may be obscured by something you cannot identify, or by some obstacle that you can't work around.
- As a general rule, orient the ISS antenna and the console antenna so that they are parallel with each other.
- The signal may be weak directly underneath the ISS. Try rotating the ISS and the console antennas to parallel, horizontal positions if you are installing the ISS directly over the console.
- Turn the gain on to improve reception for a weak signal. Refer to the *Vantage Pro Console Manual* for information on setting the console gain.
- If necessary, consider using a Wireless Repeater #7624 or #7625, to strengthen the signal or increase the distance between your ISS and the console. See "Optional Wireless Stations" on page 16

Testing Wireless Transmission at ISS Location

Note: *After you have found a suitable place for your wireless ISS, it is very important to test reception from that location before permanently mounting it there.*

---

1. Set the ISS where you intend to install it. You may want to have someone hold it in place during the test.
2. Set console where you intend to use it.

Note: *For example, let's say you are installing a Wireless Vantage Pro with the ISS mounted on a fence at the back of the property. With the ISS up on the fence temporarily, test the console's reception where you intend to use it.*

---

3. On the console, press and hold the **TEMP** button and press the **TIME** button to display reception statistics.
   - It's a good idea to test the console's reception anywhere that you might want to use or mount it now or in the future. Take your time. If you aren't picking up a strong signal where you intend to place your console, try rotating the antenna on the console and ISS or try moving the console and ISS to different positions.
   - If you have irregular terrain in the area, it may interfere with the signal. For example, if the ISS is mounted downhill from the console, the ground may block a wide angle of the transmitted signal.
4. Press and hold the **DONE** button to return to the normal screen when finished testing.

Note: *See the Troubleshooting section of the* Vantage Pro Console Manual *for information on how to check wireless signal strength and for more information on troubleshooting reception problems.*

Installing the ISS

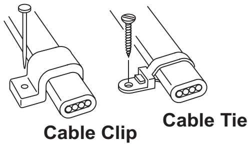
The anemometer and the main part of the ISS can be installed either together as a single unit on a pole, or apart from each other. The main part of the ISS includes the rain collector, the temperature and humidity sensors, the radiation shield, and the SIM housing. Use the U-bolts to install the ISS and anemometer the together or separately on a pole. Use the lag screws to install them separately on a flat, vertical surface.

The anemometer comes with a 40' (12 m) cable so you can flexibly configure your system to monitor wind conditions. For example, you could mount the anemometer at the highest point of a roof, then place the main part of the ISS on a fence closer to ground level.

General ISS Installation Guidelines

- Install the ISS as level as possible to ensure accurate rain measurements. Use a bubble level or carpenter's level to make sure the ISS is level
- In the Northern Hemisphere, the solar panel should face south for maximum sun exposure.
- In the Southern Hemisphere aim the solar panel North for maximum sun exposure.
  Either install the ISS and anemometer separately, each facing North, or mount them as a single unit with solar panel facing north and the wind vane re-oriented to the south. See "Appendix C: Re-orienting the Wind Vane"
- If you are near the equator aim the solar panel east or west. Pick the direction that receives the maximum sunshine at your location.

Guidelines for Securing Cables



- To prevent fraying or cutting of cables, secure them so they will not whip about in the wind.
- Secure a cable to a metal pole using cable ties or by wrapping electrical tape around them both.
- Place clips or ties approximately every 3 – 5' (1 – 1.6 m).
- Mounting clips, cable ties or additional hardware not included with your station can be easily obtained at a hardware or electronics store.

Note: *Do not use metal staples or a staple gun to secure cables. Metal staples — especially when installed with a staple gun — have a tendency to cut the cables.*

Orient the Wind Vane

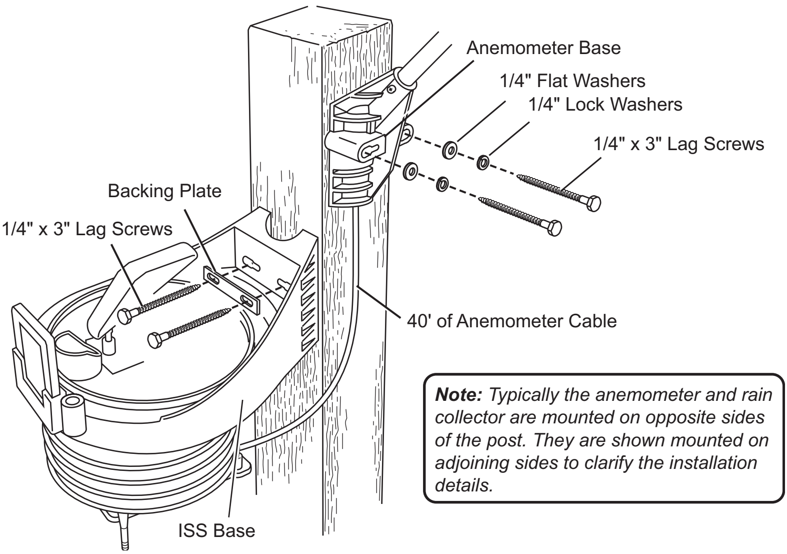
The wind vane rotates 360° to display current and dominant wind directions on the compass rose of the display. To obtain accurate readings, the vane must be *correctly oriented* when you mount the anemometer outside. By default, the wind vane on the anemometer detects the correct wind direction if the anemometer arm points North.

You can ensure correct orientation of the wind vane in one of two ways:

1. Mount the anemometer so that the arm points north.
   The wind vane will be ready for use immediately if you do this.
2. If you mount your anemometer so that it does not aim North, you will need to remove the wind vane and re-attach it aiming toward the preferred direction.
   Refer to the instructions in "Appendix C: Re-orienting the Wind Vane" on page 21.

Installing the ISS on a Flat Surface

Refer to the following illustration to install the ISS on a post or flat, vertical surface.



> ***Note:*** *Typically the anemometer and rain collector are mounted on opposite sides of the post. They are shown mounted on adjoining sides to clarify the installation details.*

Installing the ISS on a Post or Flat Surface

1. With a 3/16" (5 mm) drill bit, drill two holes approximately 2-1/8" (54 mm) apart. Use a carpenter's level to ensure the holes will be level.

   Use the metal backing plate as your guide when marking the holes.
2. Remove the rain collector cone if it is installed on the ISS mounting base.
3. Insert the 1/4" x 3" lag screws through the metal backing plate and the holes in the mounting base into the post.
4. Using an adjustable wrench or 7/16" wrench, tighten the lag screws.
5. Re-attach the rain collector cone. Set the cone back on the base so its latches slide downward into the latch openings on the base. Rotate cone clockwise.
6. Place the debris screen (shown in the illustration on page 2) inside the cone, "feet-down" over the funnel hole.

Installing the Anemometer on a Post or Flat Surface

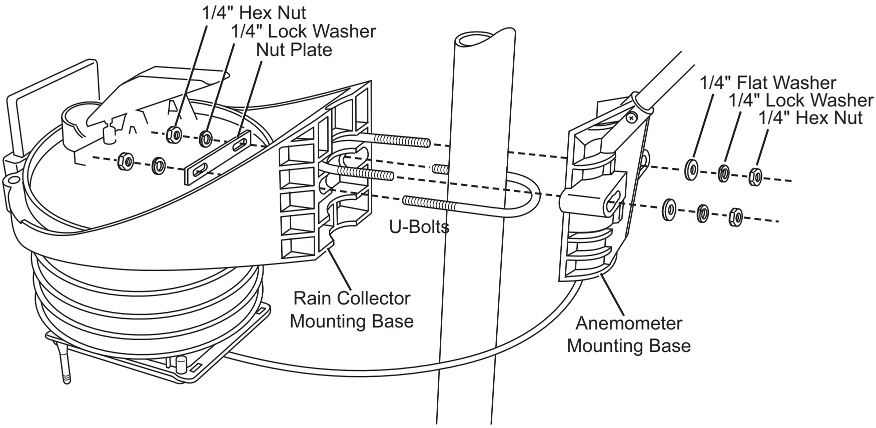
1. With a 3/16" (5 mm) drill bit, drill two holes approximately 2-1/8" (54 mm) apart. Use a carpenter's level to ensure the holes will be level.
2. Insert the 1/4" x 3" lag screws through the flat washers and the holes in the anemometer mounting base into the post.
3. Using an adjustable wrench or 7/16" wrench, tighten the lag screws.

   If the anemometer arm is not pointing north, follow the instructions in "Appendix C: Re-orienting the Wind Vane" on page 21.

Installing the ISS on a Pole

When installing the ISS on a pole, the rain collector and radiation shield section of the ISS can be mounted as a single unit with the anemometer section, or the two sections can be mounted separately.

Refer to the following illustration when installing the ISS or anemometer on a pole:



Mounting the ISS on a Pole

Accessories for Pole Mounting

- Use the Mounting Tripod #7716 for easy roof-mounting.
- The Mounting Pole Kit #7717 can raise the installation height of your ISS by up to 37.5" (0.95 m).

General Guidelines for Installing on a Pole

- With the supplied U-bolts, the ISS can be mounted on a pole having an outside diameter ranging from 1-1/4" to 1-3/4" (32 – 44mm).
- Larger U-bolts (not supplied) can be used to mount to a pole with a maximum outside diameter of 2-1/2" (64mm).
- To mount on a smaller diameter pole, obtain a U-bolt that fits the base openings but that has a shorter threaded section. If you try to mount on a smaller pole with the included U-bolts, the threaded parts of the bolt will interfere with the rain collector cone.

Guidelines for Installing the ISS on a Pole

- It is very important to remember, when mounting both sides together, that whichever side of your ISS is mounted first, the U-bolt from the opposite side ALSO must be placed around the pole before you tighten anything. (If it is not, there is no way to slide it in later.)
- In each side's mounting base, there is a groove to accommodate the other side's U-bolt.
- Once you loosely mount the two sides of your ISS together on a pole, you'll be able to swivel the unit to the correct direction and then tighten the hex nuts.
- You will also be able to slide it vertically to the desired height.

Installing ISS and Anemometer Together

Please remember to install your ISS so the anemometer arm is aiming North. If the arm doesn't point North you will need to re-orient the wind vane. See "Appendix C: Re-orienting the Wind Vane" on page 21.

1. Place the U-bolt for the anemometer around the pole so that its round end will fit in the top groove of the rain collector side's plastic mounting base.
   The groove is right above two large holes.
2. While holding the mounting base of the rain collector side against the pole, place the two ends of the remaining U-bolt around the pole and through the two holes in the base.
3. Slide the metal backing plate over the bolt ends as they stick out over the rain collector base. Secure the backing plate with a lock washer and hex nut on each of the bolt ends as shown previously. ***Do not tighten the nuts yet.***

Note: *Leave the nuts loose enough to swivel the ISS base on the pole.*

---

4. The two ends of the anemometer's U-bolt should now be pointing away from the mounted rain collector side. Slide the anemometer's mounting base over the protruding bolt ends. Place a flat washer, a lock washer and a hex nut on each of the bolt ends as shown above. Do not tighten the nuts yet.
5. Raise the ISS unit to the desired height on the pole and swivel it so the anemometer arm is pointing north.
6. Using an adjustable wrench or 7/16" wrench, tighten all four hex nuts until the ISS is firmly fastened on the pole.
7. Re-attach the rain collector cone by setting the cone back on the base so its latches slide downward into the latch openings on the base, then rotate the cone clockwise.
8. Place the debris screen (shown in the illustration on page 2) inside the cone, "feet-down," over the funnel hole.

Note: *When installing the ISS as a single unit, we recommend tucking the coil of anemometer cable between the rain collector cone and the ISS base.*

Installing ISS Only

1. While holding the mounting base against the pole, place the two ends of a U-bolt around the pole and through the two holes in the base.
2. Slide the metal backing plate over the bolt ends as they stick out toward the rain collector cone. Secure the backing plate with a washer, a lock washer, and a hex nut on each of the bolt ends. Do not tighten the nuts yet.
   For the wireless ISS, swivel the ISS base so the solar panel is facing south (in the Northern Hemisphere), or north (in the Southern Hemisphere).
3. Using an adjustable wrench or 7/16" wrench, tighten the nuts.
4. Re-attach the rain collector cone.
   Set the cone back on the base so its latches slide downward into the latch openings on the base. Rotate cone clockwise.
5. Place the debris screen (shown in the illustration on page 2) inside the cone, "feet-down," over the funnel hole.

Installing Anemometer Only

1. While holding the mounting base against the pole, place a U-bolt around the pole and through the two holes in the base.
2. Place a flat washer, a lock washer and a hex nut on each of the bolt ends.

3. Swivel the anemometer until the arm is pointing north.
   If the anemometer arm is not pointing north, go to “Appendix C: Re-orienting the Wind Vane” on page 21 after tightening the nuts.
4. Using an adjustable wrench or 7/16" wrench, tighten the nuts.

Finishing the Installation

Level the Solar and UV Sensors

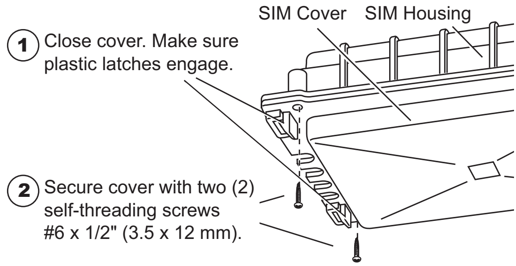
If your station includes a solar or UV sensor, use the bubble level on the sensor as a guide to verify that the sensor is level.

You can adjust the level by tightening or loosening the screws that hold the sensor onto the shelf.

Securing the SIM Cover

We recommend using screws to securely fasten the SIM cover.

1. Make sure the SIM cover is completely closed with the plastic latches engaged.
2. Secure the SIM cover using the two #6 1/2” (3.5 mm x 12 mm) screws included in the ISS hardware.



Note: *Plastic latches alone may not keep the SIM cover fastened during windy conditions. Use screws to secure the SIM Cover in place.*

Clearing Data Collected During Testing and Installation

Now that your ISS is mounted outside, you may want to clear out all data that was collected in the Vantage Pro console during testing and mounting.

To clear all the collected data in the console:

1. Select the **WIND** key on the console so that graph icon appears adjacent to the wind data on the display.
2. Press the **2ND** key, then press and hold the **CLEAR** key for at least six seconds and until you see “CLEARING NOW” in the console ticker display.

Additional Mounting Options

Extending Wireless Transmission Range

You can use our optional repeater stations to extend the wireless transmission range:

- Wireless Repeater, AC-Powered #7624
- Wireless Repeater, Solar-Powered #7625

Extending the Console Cable (Cabled ISS Only)

You can install a Cabled ISS up to 1000’ (300m) away from the console by using our extension cables, #7876.

Relocating the Anemometer

Using Extension Cables:

Note: *Not all cables are compatible with your Vantage Pro system. To be sure they will work, order Davis extension cables from your dealer or directly from Davis Instruments.*

If you would like to locate the anemometer more than 40’ (12 m) from the ISS, use our extension cables #7876.

Be aware that the maximum measurable wind speed reading decreases as the total length of cable from the anemometer to the ISS increases. If the cable length is greater than 540' (165m), the maximum measurable wind speed may be less than 100 mph (161 km/h).

Using the Anemometer Transmitter Kit (Wireless ISS Only)

Use the Anemometer Transmitter Kit #6330 to add an independent wireless transmitter to your anemometer. The kit allows the anemometer to function as a transmitter station sending wind data directly to the console, instead of transmitting via the ISS.

Remote Mounting the Solar and UV Sensors

The solar and UV sensors have a 3' (0.9 m) cable. If you wish to install these sensors away from the ISS, you can extend the length of the sensor cables with our extension cables, #7876.

Note: *Not all cables are compatible with your Vantage Pro system. To be sure they will work, order Davis extension cables from your dealer or directly from Davis Instruments.*

Optional Wireless Stations

Use our optional wireless sensor stations to collect additional weather measurements, without the inconvenience of routing cables:

- Wireless Temperature Station #6370
- Wireless Temperature/Humidity Station #6380 or #6385
- Wireless Leaf & Soil Moisture/Temperature Station #6343

For more details, please visit our website or see the Weather Instruments catalog. Some information is also available in “Appendix A: Wireless Transmitter IDs” on page 19.

Maintenance

Maintaining UV and Solar Radiation Sensors

Make every effort to avoid touching the small white diffusers at the top of the sensors. Any skin oil will reduce the sensitivity of the sensors. For accurate readings, clean the diffusers at least once per month using ethyl alcohol on a soft cloth (NOT rubbing alcohol).

Due to the sensitivity of ultraviolet and solar radiation sensors it is common practice for manufacturers to recommend re-calibration after a period of time. Here at Davis Instruments we have seen less than 2% drift per year on the readings from these sensors. For applications demanding higher accuracy, however, the sensors should be calibrated once every year.

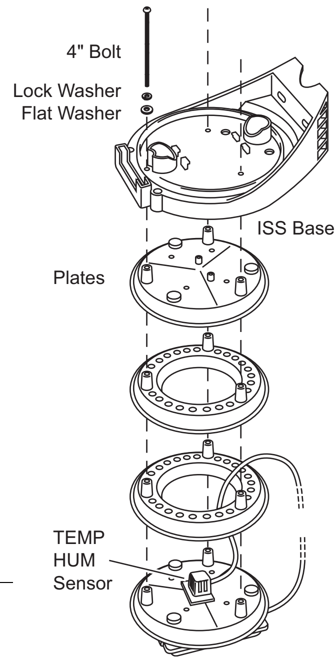
Contact Technical Support about returning your sensor for calibration. See “Contacting Davis Instruments” on page 18.

Cleaning the Radiation Shield

Check the radiation shield for debris or insect nests at least once a year and clean when necessary. A buildup of material inside the shield will reduce its effectiveness and may cause inaccurate temperature and humidity readings.

To clean the radiation shield:

1. Remove the rain collector cone.
2. Using a Phillips head screwdriver, loosen the three 4" (~100mm) bolts holding the radiation shield plates together.
3. Separate the plates as shown and remove all debris from inside the shield.
4. Reassemble the radiation shield plates and fasten them together using the bolts as shown in the illustration. Use a Phillips screwdriver to tighten the bolts.



ISS Radiation Shield Assembly

Cleaning the Rain Collector

To maintain accuracy, thoroughly clean the rain collector several times a year.

Note: Cleaning the tipping bucket may cause false rain readings. See your Vantage Pro Console Manual for instructions on clearing weather data.

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1. Separate the cone from the base by turning it counter-clockwise.
2. Use soapy water and a soft cloth to remove any debris from the cone, cone screen, and tipping bucket. Watch out for spiders — they seem to like rain collectors!
3. Use pipe cleaners to clear the funnel hole in the cone and drain screens in the base.
4. When all parts are clean, rinse with clear water.
5. Re-attach the cone and replace the debris screen.

Troubleshooting

If a Sensor Functions Intermittently

Carefully check all connections from the sensor to the ISS. See "Check SIM Sensor Connections" on page 4.

Loose connections account for a large portion of potential problems. Connections should be firmly seated in receptacles, and plugged in straight. If you think a connection may be faulty, try jiggling the cable while looking at the display. If a reading appears intermittently on the display as you jiggle the cable, the connection is faulty. Try removing and then re-installing the cable to correct the faulty connection. If the sensor still functions intermittently contact Davis Technical Support.

The Most Common Rain Collector Problem

If the rain collector seems to be under-reporting rainfall, remove the rain collector cone to clean the tipping bucket and clear out any debris.

The Most Common Anemometer Problems

Note: *If the anemometer is sending no data, the wind display indicates 0 speed and a North direction.*

"The anemometer head is tilted when I mount the anemometer."

With your Allen wrench, loosen the screws holding the anemometer head on the arm. (The screws are on the bottom of the anemometer head, by the wind cups.) Turn the anemometer head so it is straight and then tighten the screws.

"The wind cups are spinning but my console displays 0 mph."

The signal from the wind cups may not be making it back to the display. Remove the cups from the anemometer (loosen the set screw shown on page 4). Put the cups back onto the shaft and adjust them up or down 1/16 – 1/8 inch (1.5 – 3 mm). Check your cables for visible nicks and cuts. Look for corrosion in the "WIND" jack on the SIM and on splices in the cable (if any). If you are using an extension cable, remove it and test using only the anemometer cable. If you still haven't resolved the problem, contact Technical Support and ask for a wind test cable.

"The wind direction is stuck on north, or displays dashes."

It is likely that there is a short or break somewhere between the wind vane and the display. Check your cables for visible nicks and cuts. Look for corrosion in the "WIND" jack on the Sensor Interface Module and on splices in the cable (if any). If possible, remove any extensions and try with the anemometer cable only. If none of these steps get the wind direction working, contact Technical Support and ask for a wind test cable.

"The wind cups don't spin or don't spin as fast as they should."

First check for and clear out any spider webs. Also, the anemometer may be located where wind is blocked by something, or there may be friction interfering with the cups' rotation. Friction usually can be remedied by the user — remove the wind cups (loosen the set screw shown on page 4) and clear out any bugs or debris. Turn the shaft the cups rotate on. If it feels gritty or stiff, contact Davis Technical Support. DO NOT LUBRICATE THE SHAFT OR BEARINGS IN ANY WAY. When replacing the cups, make sure they are not rubbing against any part of the anemometer head.

"Wind readings aren't what I expected them to be."

Comparing data from your ISS to measurements from TV, radio, newspapers, or a neighbor is NOT a valid method of verifying your readings. Wind speed and direction can vary considerably over short distances. How you site the anemometer can also make a big difference. If you have questions, contact Technical Support.

Contacting Davis Instruments

If you have questions about your ISS or Vantage Pro Station, or encounter problems installing or operating your weather station, please contact Davis Technical Support.

Note: *Please do not return items to the factory for repair without prior authorization.*

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(510) 732-7814 – Technical Support phone, Monday – Friday, 7:00 a.m. – 5:30 p.m. Pacific Time.

(510) 670-0589 – Technical Support Fax.

support@davisnet.com – E-mail to Technical Support.

info@davisnet.com – General e-mail.

www.davisnet.com – Download manuals and specifications from the Support section. Watch for FAQs and other updates. Subscribe to the e-newsletter.

Appendix A: Wireless Transmitter IDs

Changing ISS Transmitter ID

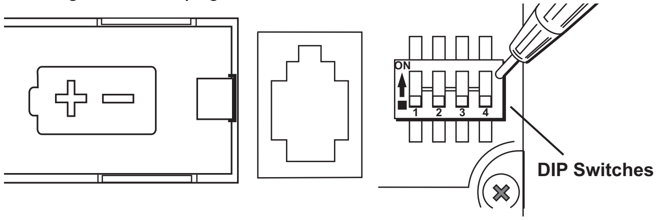
Each wireless transmitting station, including the Integrated Sensor Suite (ISS), uses one of eight selectable transmitter IDs. DIP switches #1, 2 and 3 on the transmitter allows you to control the ID — or “channel” — the station will transmit on. (DIP switch #4 is used for transmission testing, not for transmitter ID.)

Note: The transmitter and receiver communicate with each other only when ***both*** *are set to the same ID.*

The default transmitter ID is “1” for both the ISS and the Vantage Pro console, and should work fine for most situations. In some cases, such as those listed below, you may want to change the transmitter ID.

- Another Davis Instruments wireless weather station operating nearby already uses transmitter ID ‘1’.
- You purchased additional wireless transmitting stations with your Vantage Pro or Vantage Pro Plus and want to designate one of them as Station No. 1 instead of the ISS.

On the ISS the transmitter ID is set using the DIP switches located on the Sensor Interface Module (SIM). To access the SIM, open the SIM housing cover. See “Open the SIM Housing Cover” on page 4.



Transmitter ID DIP Switches in Top-right Corner of SIM

To change to another ID, use a ballpoint pen or paper clip to toggle DIP switches #1, 2, and 3. The settings for transmitter IDs 1 – 8 are shown in the table below:

ID Code	Switch 1	Switch 2	Switch 3
#1 (default)	off	off	off
#2	off	off	ON
#3	off	ON	off
#4	off	ON	ON
#5	ON	off	off
#6	ON	off	ON
#7	ON	ON	off
#8	ON	ON	ON

Use this table to ensure that each wireless transmitting station in your system is broadcasting on its own transmitter ID.

Be sure to set your Vantage Pro console to the same IDs as the transmitters, as described in the *Vantage Pro Console Manual*.

Using Multiple Transmitting Stations

This table shows the maximum number of each type of station that can be used with a single Vantage Pro console.

Transmitter Type	Maximum (8 total)
Integrated Sensor Suite (ISS)	1
Anemometer Transmitter Kit	1
Leaf Wetness/Temperature Station	1
Soil Moisture/Temperature Station	1
Temperature Station	8
Temperature/Humidity Station	8

Appendix B: Optional Accessories

For more information on these accessories and other weather products, call Davis Instruments or visit our website: www.davisnet.com/eather/. See “Contacting Davis Instruments” on page 18. Also see “Additional Mounting Options” on page 15.

Solar Radiation and UV Sensors

You can upgrade your ISS to an ISS Plus by installing a solar radiation sensor and a UV sensor. For ease of installation, use the mounting bracket listed below:

- UV Sensor #6490
- Solar Radiation Sensor #6450
- Sensor Mounting Shelf #6672

Other Accessories

- Daytime Fan-Aspirated Radiation Shield Kit #7745 - Uses a solar-powered fan to reduce the effect of solar radiation on temperature readings.
- Rain Collector Heater #7720 - For use in cold climates, to measure the moisture content of frozen precipitation (freezing rain, snow, hail, etc.).
- Wireless Repeater #7624 or #7625 - For extending the range of wireless transmission. Go around corners or increase the distance between transmitter and console.
- Extension Cables #7876 - Extends the anemometer, solar radiation, UV, and console cable lengths. Available in lengths of 8’ (2.4m), 40’ (12m), 100’ (30m), and 200’ (61m).
- Complete System Shelter #7724 - To locate your Vantage Pro console outside.
- Complete System Shelter Heater #7726 - For use in sub-freezing temperatures.
- Solar Power Kit #6610 - To mount your Cabled Vantage Pro console outside where there is no AC power supply or to mount your wireless console outside without having to replace the console batteries as often.
- Car/Boat/RV Lighter Cord #6604 - To power your Cabled Vantage Pro console from a standard cigarette lighter.
- AC Power Adapter for Vantage #6625 - If your wireless ISS is mounted near a standard AC outlet, use the AC adapter as backup to solar power. (And leave the battery installed as backup to the AC power in case electricity goes out during a storm.)

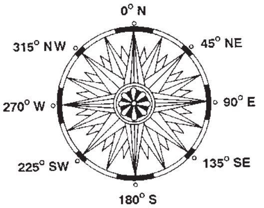
Appendix C: Re-orienting the Wind Vane

Your Vantage Pro station is configured to register wind direction correctly if the anemometer points to true North. If you are unable to mount the anemometer shaft pointing to true North, use the following instructions to correct the wind vane orientation.

- Do not rely on a compass unless it is properly calibrated. In North America there can be up to 15° variation between true North and a raw compass reading.
- You can also correct the wind direction readings by calibrating the wind direction in the Vantage Pro console. See the *Vantage Pro Console Manual* for information.
- To orient the wind vane accurately, you will need to look at the console display. You may wish to have a friend or family member on the ground do this for you.
- You can also re-orient the wind vane before you install the anemometer if you know the direction in which the anemometer will be installed.

To re-orient the wind vane:

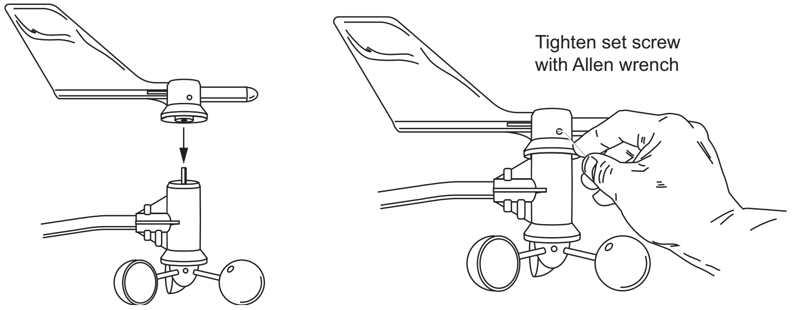
1. Loosen the Wind Vane set screw.
2. Pull the vane directly up and off the steel shaft on which it turns.
3. Press WIND key on console to display current wind direction in degrees.
4. Use a reliable map or a landmark to determine in which direction (S, E, W, etc.) the anemometer arm is now pointing.
5. Use the wind direction chart or compass markings to find the degree reading which corresponds to that direction.



Wind Direction Chart

6. Slowly turn the stainless-steel wind direction shaft with your fingers. Stop turning when the display reaches the degree reading obtained in step 3.

   Please allow the wind direction display approximately 5 seconds to stabilize after the shaft is turned. You will have to turn the shaft, wait, and turn it again until the desired wind direction is displayed on the console.
7. Being careful to keep the stainless-steel shaft from turning, place the wind vane on top of shaft with the vane's nose pointing in the same direction as the arm.
8. Slide the wind vane down the shaft as far as it will go.
9. Use the Allen wrench provided to tighten the set screw on the side of the wind vane.



Installing Wind Vane on Anemometer Shaft

10. Test your anemometer by pointing the wind vane in any direction and making sure the console displays the correct wind direction. Remove and re-adjust the vane if it does not. Allow the wind direction display approximately 5 seconds to stabilize after turning the shaft.

Specifications

Complete specifications for the ISS and other products are available in the Weather Support section of our website: www.davisnet.com.

Cabled ISS

Temperature range: . . . . -40 to 140° Fahrenheit (-40 to 60° Celsius)
Power input: . . . . Console Cable from Vantage Pro console

Wireless ISS

Temperature range: . . . . -40 to 140° Fahrenheit (-40 to 60° Celsius)
Transmission frequency: . . . . 916.5 MHz for North America
868.35 MHz for overseas versions: EU, UK, and OV
Transmitter ID codes: . . . . 8 user-selectable
License: . . . . low power (less than 1 mW), no license required
Primary power: . . . . Solar power – Davis solar charger
Backup power: . . . . CR-123A 3-volt lithium battery (2 year service life)
Alternate primary power . . . . AC power adapter

ISS Weather Variable Update Intervals

Wind speed: . . . . 2.5 to 3 seconds
Wind direction: . . . . 2.5 to 3 seconds
Accumulated rainfall: . . . . 10 to 12 seconds
Rain rate: . . . . 10 to 12 seconds
Outside temperature: . . . . 10 to 12 seconds
Outside humidity: . . . . 50 seconds to 1 minute
Ultraviolet radiation: . . . . 50 seconds to 1 minute
Solar radiation: . . . . 50 seconds to 1 minute

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DAVIS

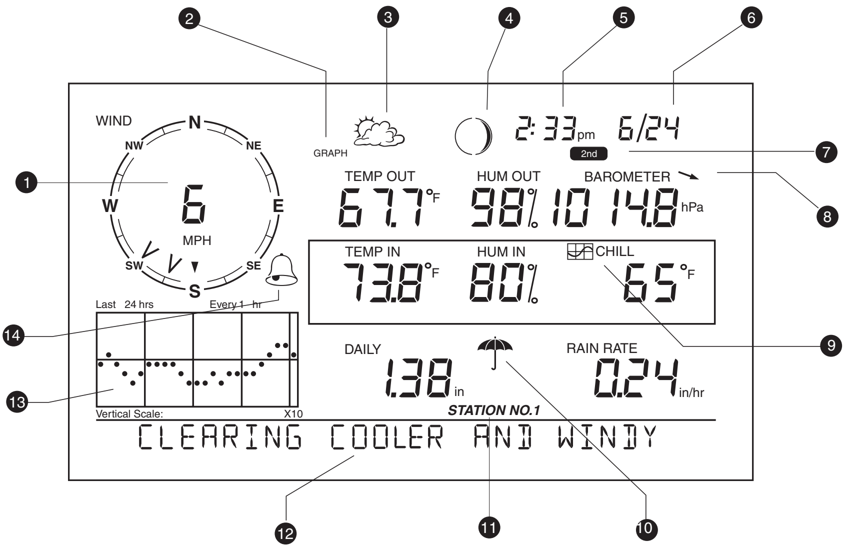
Vantage Pro®

Weather Station

Console Manual

Product # 6310 & 6310C

Vantage Pro Console Display Features



1. *Compass Rose*
2. *Graph & Hi/Low Mode Settings*
3. *Forecast Icons*
4. *Moon Phase Indicator*
5. *Time / Sunrise Time*
6. *Date / Sunset Time*
7. ***2ND** Button Indicator*
8. *Barometric Trend Arrow*
9. *Graph Icon*
10. *Current Rain Icon*
11. *Station Number Indicator*
12. *Weather Ticker*
13. *Graph Field*
14. *Alarm icon*

Vantage Pro Console Manual

Rev. C, October 23, 2003
Document Part Number: 07395.134
Product # 6310 & 6310C

This product complies with the essential protection requirements of the EC EMC Directive 89/336/EC.

Contents

1. Welcome to Vantage Pro

Welcome to your Vantage Pro® Weather Station console. The console displays and records your station's weather data, provides graphing and alarm functions, and interfaces your weather data to a computer using our optional WeatherLink software.

Vantage Pro stations are available in two basic versions: Cabled and Wireless. A Cabled Vantage Pro station transmits outside sensor data from the Integrated Sensor Suite (ISS) to the console using a standard four-conductor cable. A Wireless Vantage Pro station transmits outside sensor data from the ISS to the console via a low-power radio. Wireless stations can also collect data from the optional Vantage Pro stations listed on page 3.

The *Vantage Pro Quick Reference Guide* included with your station provides an easy to use reference for most console functions.

Console Features

Keyboard & Display

The keyboard lets you view current and historical data, set and clear alarms, change station modes, enter calibration numbers, set up and view graphs, select sensors, and read the forecast. The keyboard consists of 12 command keys located next to the screen console and four navigation keys located below the command keys.

A weather variable or console command is printed on each command key. Just press a key to select the variable or function printed on that key.

Each command key also has a secondary function which is printed above the key on the console case. To select the secondary function, press and release the **2ND** key (on the front of the console, upper right corner) and then immediately press the key for that function.

Note: *After pressing the* **2ND** *key, the screen displays the* **2ND** *icon for three seconds. All secondary key functions are enabled during this time. Keys resume normal operation after the icon disappears.*

The the **+**, **-** , **<**, and **>** navigation keys are used to select command options, adjust values, and to provide additional functions when used in combination with a command key.

To learn more about the keyboard, see “Selecting Weather Variables” on page 21.

Console Modes

The Vantage Pro console operates in five different modes:

TABLE 1-1: CONSOLE OPERATING MODES

Mode	Description
Setup	Use Setup mode to enter the time, date, and other information required to calculate and display weather data.
Current Data	Use Current Data mode to read the current weather information, change measurement units, and to set, clear or calibrate weather readings.
High/Low	High/Low mode displays the daily, monthly or yearly high and low readings.
Alarm	Alarm mode allows you to set, clear, and review alarm settings.
Graph	Graph mode displays your weather data using over 100 different kinds of graphs.

Vantage Pro Options

Optional Sensors

Vantage Pro stations are extremely flexible. Use the following optional sensors and wireless stations to enhance the weather monitoring capabilities of your Vantage Pro. See our website for complete details: www.davisnet.com.

Note: *Optional wireless stations can only be used with Wireless Vantage Pro Stations.*

Wireless Weather Envoy (#6314)

The Wireless Weather Envoy performs much of the same functions as a Vantage Pro console, but in a much smaller package. Use Envoy to interface your wireless station to a computer when you’d rather place the console in a better location for viewing weather conditions.

Anemometer Transmitter Kit (#6330)

Provides more flexible anemometer placement for wireless stations.

Wireless Leaf & Soil Moisture/Temperature Station (#6343)

Measures and transmits leaf wetness, soil moisture and temperature data.

Wireless Soil Moisture/Temperature Station (#6361)

Measures and transmits soil moisture and temperature data.

Wireless Temperature Station (#6370)

Measures and transmits temperature data.

Wireless Temperature/Humidity Station (#6380)

Measures and transmits air temperature and humidity data.

Wireless Temperature/Humidity Station with Fan-Aspirated Radiation Shield (#6385)

Measures and transmits air temperature and humidity data. Uses our patented fan-aspirated radiation shield for much more accurate readings.

Solar Radiation Sensor (# 6450)

Measures solar radiation. Required for calculating evapotranspiration (ET). Available for cabled and wireless stations. Requires Sensor Mounting Shelf (#6672).

Ultraviolet (UV) Radiation Sensor (#6490)

Measures UV radiation. Required for calculating the UV dose. Available for Cabled and Wireless stations. Requires Sensor Mounting Shelf (#6672).

Optional WeatherLink® Software

Our WeatherLink software and data logger connect your Vantage Pro station directly to a computer, providing enhanced weather monitoring capabilities and powerful internet features. The WeatherLink data logger fits neatly on the console and stores weather data even when the computer is turned off.

WeatherLink® for Vantage Pro, Windows version (#6510C)

Requires computer running Windows 95, 98, 2000, ME, NT or XP and one free serial port. Includes data logger, eight foot cable, software, and manual.

WeatherLink® for Vantage Pro, Mac version (#6520C)

Requires a Macintosh computer running OS X 10.01 or newer and a USB-to-serial (DB-9) Cable (#8434) or third-party USB-to-serial port adapter. Includes data logger, eight foot cable, 9-pin DIN connector, software, and manual.

Optional Accessories

The following accessories are available from your dealer or may be ordered directly from Davis Instruments.

Sensor Mounting Shelf (#6672)

Required for mounting the optional Solar Radiation and/or UV sensors. The mounting shelf attaches to the ISS.

Car/Boat/RV Lighter Cord (#6604)

Allows the Vantage Pro to draw power from a standard car cigarette lighter.

USB-to-Serial (DB-9) Cable (#8434)

Allows WeatherLink to connect to a USB port on your computer.

Telephone Modem Adapter (#6533)

Allows a dialup connection between the station and the computer.

Extension Cables (#7876)

Allows you to place the Cabled Vantage Pro ISS further away from the console. Maximum cable length is 1000' feet (300 m).

- #7876-040 Cable, 40' (12 m)
- #7876-100 Cable, 100' (30 m)
- #7876-200 Cable, 200' (61 m)

Davis Baseball Cap (#PR725)

100% cotton twill cap is two-toned with a washed khaki crown, dark blue brim, and embroidered Davis logo. Self-fabric closure with brass buckle. One size fits all.

2. Installing the Console

The Vantage Pro console is designed to give extremely accurate readings. As with any precision instrument, use care in its assembly and handling. Although installing the console is relatively simple, following the steps outlined in this chapter and assembling the Vantage Pro correctly from the start will help ensure that you enjoy all of its features with a minimum of time and effort.

Powering the Console

Cabled Vantage Pro Stations

Cabled Vantage Pro consoles supply power to the Integrated Sensor Suite (ISS) through the console cable. Because of the added power consumption of the ISS, the cabled console requires an AC power adapter or optional Car/Boat/RV Lighter Cord for the main power supply. The console batteries will provide backup power for up to four to six weeks.

Wireless Vantage Pro Stations

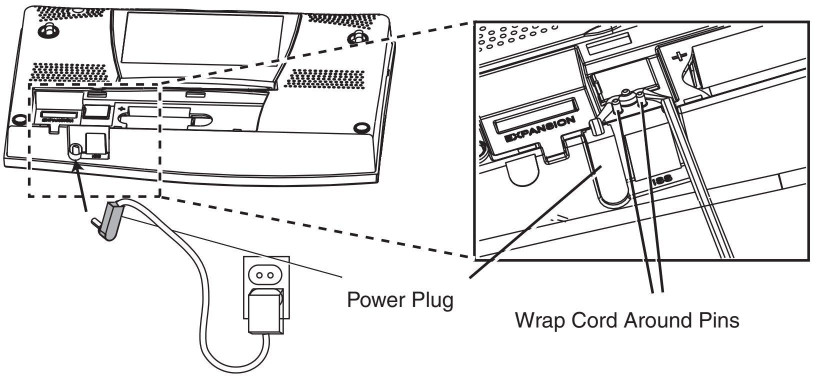
Wireless Vantage Pro consoles have been optimized to reduce power consumption and do not require the use of an AC adapter. You may use the included adapter if you wish, but the three C-cell batteries should power a wireless console for up to one year.

WARNING: *Be sure to use the power adapter supplied with your Vantage Pro Console. Your console may be damaged by connecting the wrong power adapter.*

Note: *The console does not recharge the batteries. Because of this, and because NiCad batteries will not power the console as long as alkaline batteries, we recommend using alkaline batteries in your console.*

Installing the AC Power Adapter

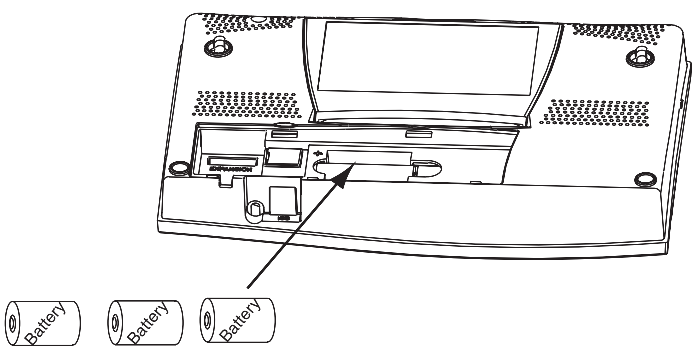
1. Find the power jack located on the bottom of the console case.



2. Insert the power adapter plug into the console power jack then plug the other end of the adapter into an appropriate power outlet.
3. Check to make sure the console runs through a brief self-test procedure successfully. The console will display all the LCD segments and then beep twice.
4. After power-up the console automatically enters Setup mode. Setup mode guides you through steps required to configure the station. See “Setup Mode” on page 11 for more information.

Installing Batteries

1. Remove the battery cover located on the back of the console by pressing down on the two latches at the top of the cover.



2. Insert three C batteries into the battery channel, negative (or flat) terminal first.

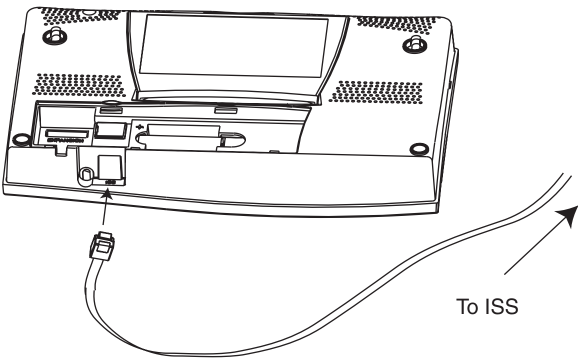
3. Replace the battery cover.

Note: *To remove old batteries, see “Changing Batteries” on page 43.*

Connecting Cabled Stations

Cabled Vantage Pro stations come with 100 feet (30m) of cable. Maximum cable length from ISS to console is 1000 feet. See “Optional Accessories” on page 3 to purchase additional cable.

1. Gently insert the console end of the 4-conductor wire into the console receptacle marked “ISS” until it clicks into place.



WARNING: *Do not force the connector into the receptacle.*

2. Ensure that the ISS cable is not twisted through the access hole.

Note: *The ISS must be assembled and powered before you can test the console connection.*

3. Test the connections between the ISS and the console.

Spin the wind cups and change the direction of the vane. If the ISS is powered and the connection between the ISS and the console is correct, you should see the wind direction and speed fields changing. Tip the rain bucket back and forth. You should see rain registering. Also check the outside temperature and outside humidity readings, as well as readings for the optional solar and UV sensors, if installed in your station.

Note: *If you are installing a wireless station, you will be checking communications between your console, ISS and any optional wireless stations when you perform the Setup Mode instructions located in the next chapter. See “Setup Mode” on page 11.*

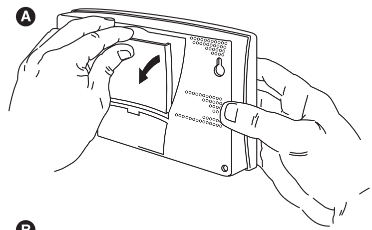
Console Location

You should place the console in a location where the keyboard is easily accessible and the display is easy to read. For more accurate readings, follow these suggestions:

- Avoid placing the console in direct sunlight. This may cause erroneous inside temperature and humidity readings and may damage to the unit.
- Avoid placing the console near radiant heaters or heating and air conditioning ducts.
- If you are mounting the console on a wall, choose an inner or interior wall. Avoid walls that heat up or cool down depending on the weather.
- If you have a wireless console, be aware of possible interference from cordless phones and other devices. To prevent interference, maintain a distance of 10 feet between the Vantage Pro console and a cordless phone (handset and base).
- Avoid positioning a wireless console near large metallic surfaces such as beside a refrigerator.

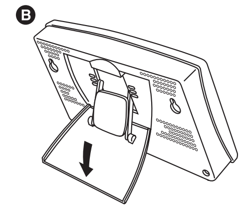
Table & Shelf Placement

The console kickstand can be set to five different angles providing five different display angles.



1. Lean the kickstand out by pulling on its top edge.

   You'll see the indentation for your finger at the top edge of the console.

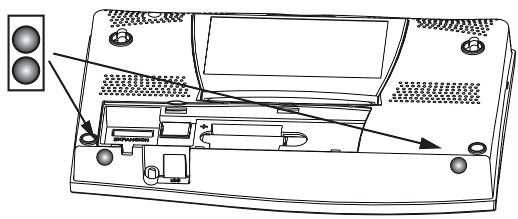


2. Slide the catch to arrest the kickstand in the appropriate angle.

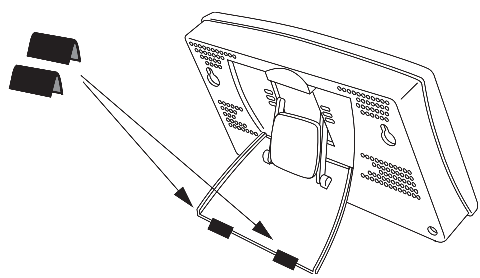
   Choose low angles for display on a coffee table or other low area. Choose higher angles for display on a desk or shelf.

3. Pull up on the stand to close it. It will be a little tight, so it's okay to push hard enough to get it to slide.

4. Install the two round rubber feet on the bottom of the console.



5. Install the two rubber channel feet on the kickstand.

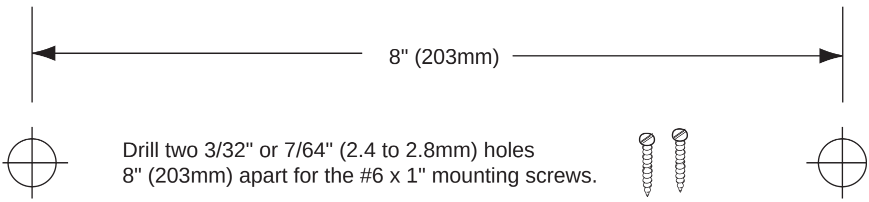


Wall Mounting

The console mounts to the wall using two keyholes located on the back of the case.

To mount the console on a wall:

1. Use a ruler to mark two mounting hole positions on the wall 8 inches (203 mm) apart.



Note: *Drawing not to scale.*

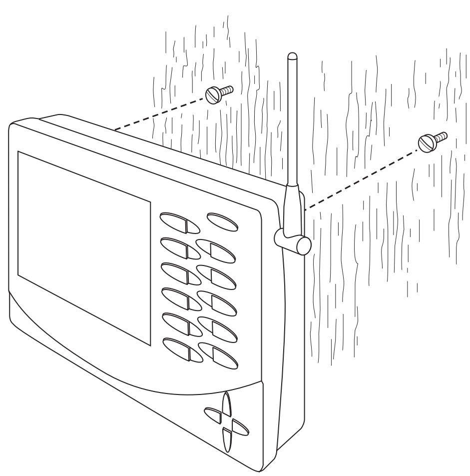
If you are installing a standard Vantage Pro console with sensor cable running inside the wall, mount the console over an empty switch box.

2. Use an drill a 3/32 or 7/64” (2.5 mm) drill bit to drill two pilot holes for the screws.

3. Using a screwdriver, drive the two #6 x 1” pan head self-threading screws into the wall. Leave at least 1/8” (3 mm) between the wall the heads of the screws.

4. If the kickstand has been pulled out from the case, push it back into its upright and locked position.

5. Guide the two keyholes on the back of the console over the two screw heads.



Wall Mounting the Console

3. Using Your Weather Station

The console LCD screen and keyboard provide easy access to your weather information. The large LCD display shows current and past environmental conditions as well as a forecast of future conditions.The keyboard controls console functions allowing you to view current and historical weather information, set and clear alarms, change station modes, view and/or change station settings, set up and view graphs, select sensors, get the forecast, and so on.

The console operates in five basic modes: Setup, Current Weather, Highs and Lows, Alarm, and Graph. Each mode allows you to access a different set of console functions or to display a a different aspect of your weather data.

Setup Mode

Setup Mode provides access to the station configuration settings that control how the station operates.

Setup Mode Commands

Use the following commands to enter, exit and navigate Setup Mode:

- Enter Setup Mode by pressing **DONE** and **-** at the same time.

  Note: *The console automatically enters Setup Mode when first powered.*

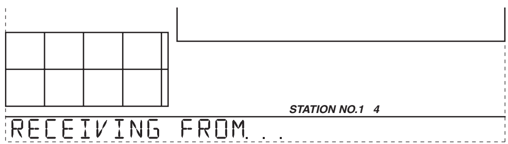
- Exit Setup Mode by pressing and holding **DONE** until the Current Weather screen appears.
- Press **DONE** to move to the next screen.
- Press **BAR** to move to the previous screen.

Screen 1: Active Transmitters

Screen 1 displays the message “Receiving from...” and shows the transmitters being received by the console. In addition, an “X” will blink in the lower right-hand corner of the screen every time the console receives a data packet from the ISS. The rest of the LCD screen will be blank.

If you have a cabled station, or if your wireless ISS uses the factory settings and you are receiving the signal, the screen displays “Receiving from station No. 1”. Any optional stations you are installing should also appear.

Note: *An ISS or optional station must be powered for the Console to recognize it. Refer to the installation instructions for the ISS or optional station for more information.*



1. Make a note of the station number(s) listed on the screen.
2. Press **DONE** to move to the next screen.

The console can receive signals from up to eight transmitters total, but there is also a limit on the number of certain types of transmitters. Table 1 below lists the maximum number for each type of transmitter:

TABLE 3-1: MAXIMUM NUMBER OF TRANSMITTERS

Transmitter Type	Maximum Number
Integrated Sensor Suite (ISS)	1
Anemometer Transmitter Kit	1
Leaf & Soil Moisture/Temperature Station	1
Soil Moisture/Temperature Station	1
Temperature Station	8
Temperature/Humidity Station	8
SensorLink	1

Screen 2: Configuring Transmitter IDs - Wireless Only

Note: *If you have a cabled station, you can press* **DONE** *and go to Screen 4: Time & Date.*

Setup screen 2 allows you to change the ISS transmitter ID and to add or remove optional transmitter stations. The default setting works fine for most installations. The default transmitter ID setting is “1” (ISS).

Vantage Pro Transmission Intervals

You may also need to set an alternate transmission interval for an ISS (alternate interval = “.25X”), a Temperature Humidity Station (alternate interval = “4X”) or Temperature Station (alternate interval = “4X”). A station may need to use the alternate transmission interval if it is being substituted for another type of station or because of changes we have made to the products.

ISS Transmitter ID Settings:

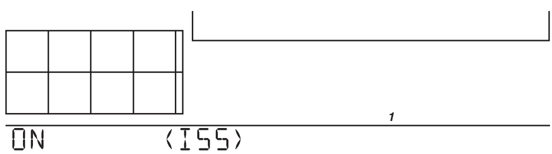
- ISS Station used as an ISS: ISS
- ISS Station used as a Temp/Hum Station: TEMP HUM and 4X

Temperature/Humidity Station Transmitter ID Settings:

- Temp/Hum Stations built before April 2003: TEMP HUM
- Temp/Hum Stations built April 2003 or later: TEMP HUM & “4X.”
- Temp/Hum Stations built before April 2003, used as an ISS station: ISS & “.25x”
- Temp/Hum Stations built April 2003 or later, used as an ISS station: ISS

Temperature Station Transmitter ID Settings:

- Temperature Stations built before April 2003: TEMP
- Temperature Stations built in April 2003 or later: TEMP HUM & “4X”.



1. If you have a cabled station, or if you have a wireless station and are using the default transmitter ID setting, press **DONE** to move to the next screen.

   Note: *Typically, you can use the default transmitter ID setting of unless you are installing one of the optional transmitter stations or unless a nearby neighbor has a Vantage Pro Station that uses transmitter ID 1 for the ISS.*

2. Press the **<** and **>** keys to select the transmitter ID.

   When you select a transmitter ID, the ID number is displayed on the screen as well as the current configuration.

3. Press **+** or **-** to toggle console reception of signals from transmitters using that ID ON and OFF.

4. Press **GRAPH** to change the type of station assigned to each transmitter number. Scroll through the station types - ISS, TEMP, HUM,TEMP HUM, WIND, LEAF, SOIL, LEAF/SOIL and SENSORLINK - until the correct type appears.

   Note: *Select SENSORLINK if the transmitter station is a Wireless Weather Monitor II or Wireless Weather Wizard II weather station.*

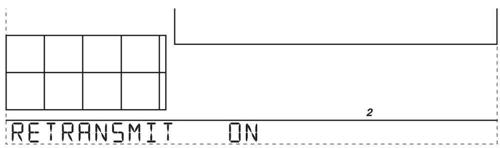
5. To change the transmission interval for a transmitter station, press and hold **TEMP** then press **HI/LOW**.

   The alternate interval for that station type is indicated on the screen: ".25X" or "4X".

6. Press **DONE** to move to the next screen.

Screen 3: Retransmit - Wireless Only

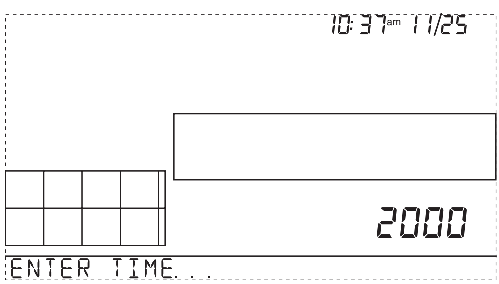
The console can transmit data from the ISS and other outside sensors to other Vantage Pro consoles or to the Davis Weather Echo and Weather Echo Plus.



1. Press the **+**, **-, >** or **STATION** key to enable retransmit. The first available transmitter ID is automatically assigned.
2. Press the **+** or **-** key to toggle retransmit ON and OFF.
3. When retransmit has already been enabled, pressing **>** will change the transmitter ID used for retransmit.
4. Press **DONE** to move to the next screen.

Screen 4: Time & Date

The very first time you power-up the console, the time and date are set to 12:00am 1/1 2000. Be sure to enter the correct date and local time.



To change the time and date:

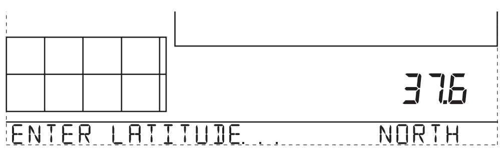
1. Press **<** and **>** to select the hour, minute, month, day or year. The selected time or date setting will blink on and off.
2. To change a setting, press **+** or **-** to adjust the value up or down.

3. To choose a 12-hour or 24-hour clock, first select either the hour or minute setting, then press **2ND** and immediately press **UNITS.** This will switch the console from one type of clock to the other.
4. To choose a MM/DD or DD/MM display for the date, first select either the day or month setting, then press **2ND** and immediately press **UNITS.** This will switch the console from date display to the other.
5. When you're finished, press **DONE** to move to the next screen.

Screen 5: Latitude

Be sure to enter the correct latitude. The console uses latitude along with longitude to determine your location, allowing it to adjust the forecast and calculate the times for sunset and sunrise.

- Latitude measures distance north or south of the equator.
- Latitude is used with longitude to identify your position on earth.
- If you do not know your latitude and longitude, there are several ways to find out. Many atlases and maps include latitude and longitude lines. You can also talk to the reference department of your local library, call your local airport, or search on the Internet. The more accurate you are, the better; however, a reasonable estimate will work, too.

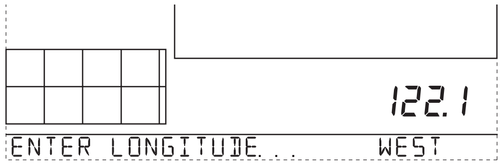


1. Press **<** and **>** to move between fields.
2. Press **+** and **-** to change the settings up or down.
3. To select the Northern or Southern Hemisphere, press **2ND**, then **UNITS**.
4. Press **DONE** to move to the next screen.

Screen 6: Longitude

Be sure to enter the correct longitude. The console uses longitude along with latitude to determine your location, allowing it to adjust the forecast and calculate the times for sunset and sunrise. See Screen 5: Latitude for information on determining your longitude.

- Longitude measures distance east or west of the Prime Meridian, an imaginary line running north and south through Greenwich, England.
- Longitude is used with latitude to identify your position on earth.



1. Press **<** and **>** to move between fields.
2. Press **+** and **-** to change the settings up or down.
3. To select the Northern or Southern Hemisphere, press **2ND**, then **UNITS**.
4. Press **DONE** to move to the next screen.

Screen 7: Time Zone

The console is pre-programmed with a combination of US time zones and the names of major cities representing time zones around the world. You can also configure your time zone using the Universal Time Coordinate (UTC) offset.

Note: *UTC offset measures the difference between the time in any time zone and a standard time, set by convention as the time at the Royal Observatory in Greenwich, England. Hayward, California, the home of Davis Instruments, observes Pacific Standard Time. The UTC offset for Pacific Standard Time is -8:00, or eight hours behind Universal Time (UT). When it's 7:00 pm (1900 hours) UT, it's 19 - 8 = 1100 hours, or 11:00 am in Hayward.*

1. Press **+** and **-** to cycle through time zones.
2. If your time zone is not shown, press **2ND** then press **+** and **-** to set your UTC offset.
3. Press **DONE** to select the time zone or UTC offset shown on the screen and move to the next screen.

Screen 8: Daylight Savings Settings

In most of North America, including Mexico (excepting Saskatchewan, Eastern Indiana, Arizona, and Hawaii), as well as in Australia (excepting Western Australia, Northern Territory, and Queensland) and in Europe use the AUTO Daylight Savings setting. The console is pre-programmed to use the correct starting and stopping dates for Daylight Savings Time in these areas, based on the time zone setting in screen 7.

Weather stations located in areas not listed above should use the MANUAL setting.

1. Press **+** and **-** to choose Auto or Manual.
2. Press **DONE** to move to the next screen.

Screen 9: Daylight Savings Status

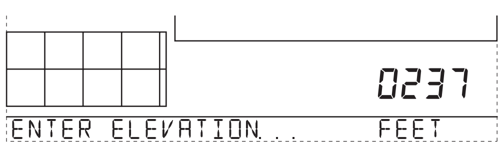
Use this screen to either verify the correct automatic Daylight Savings status or to control Daylight Savings manually.

1. If you have a MANUAL Daylight Savings setting, press **+** and **-** to turn Daylight Savings Time on or off on the appropriate days of the year.
2. If you have an AUTO Daylight Savings setting, the console will display the appropriate setting based on the current time and date.
3. Press **DONE** to move to the next screen.

Screen 10: Elevation

Meteorologists standardize barometric pressure data to sea level so that surface readings are comparable, whether they're taken on a mountainside or by the ocean. To make this same standardization and ensure accurate readings, enter your elevation in this screen.

If you do not know your elevation, there are several ways to find out. Many atlases and almanacs include elevation for cities and towns. You can also check with the reference department of your local library. The more accurate you are, the better; but a reasonable estimate works too.



1. Press **<** and **>** to move from one numeral in the elevation to another.
2. Press **+** and **-** to adjust a numeral up or down.
3. To switch between feet and meters, press **2ND** then press **UNITS**.

4. If you are below sea level, such as some places in California like Death Valley, first enter the elevation as a positive number. Then, select the “0” immediately to the left of the left most non-zero digit (the second zero from the left in 0026, for example, or the first zero from the left in 0207) and press **+** and **-** to switch from a positive to negative elevation.

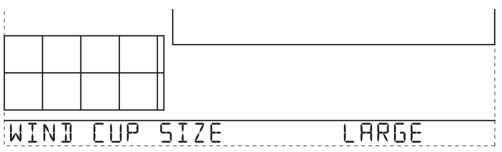
Note: *You can only set the elevation to negative after you have entered a non-zero digit and when the zero in the position immediately to the left of the left-most non-zero digit has been selected.*

5. Press **DONE** to move to the next screen.

Screen 11: Wind Cup Size

Vantage Pro Stations come standard with large wind cups. Switch this setting to small only if you have separately purchased and installed small wind cups.

Note: *Large wind cups are more sensitive to low wind speeds and are the best choice for most users. Small wind cups are less sensitive at low wind speeds but can measure much higher wind speeds. Install small wind cups if you wish to measure winds over 150 mph (242 km/h).*

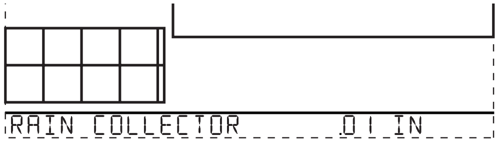


1. Press **+** and **-** to switch between large and small wind cups.

2. Press **DONE** to move to the next screen.

Screen 12: Rain Collector

The tipping bucket in your Vantage Pro rain collector has been calibrated at the factory to measure 0.01” of rain with each tip. Although the console provides 0.01”, 0.1mm or 0.2 mm settings, the rain collector requires the 0.01” setting to accurately measure rainfall.



1. Press **DONE** to use the 0.01” setting and move to the next screen.

Note: *See “Metric Rain Collector Settings” on page 27 for instructions on how to set up your station to display rain data in millimeters instead of inches.*

Screen 13: Rain Season

Because rainy seasons begin and end at different times in different parts of the world, you must specify the month you wish your yearly rain data to begin. January is the default.

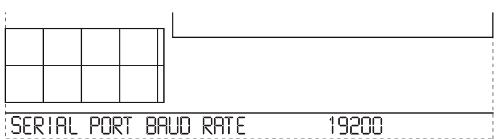
1. Press **+** and **-** to select the month for the start of the rainy season.
2. Press **DONE** to move to the next screen.

Screen 14: Serial Baud Rate

The console uses the serial port to communicate with a computer. If you are connecting the console directly to your computer, leave the setting at 19200, the highest rate for the port. If you're using a modem, use the highest setting your modem can handle.

Note: *The baud rate setting on your console must match the serial port setting in the software on your computer. If you are using WeatherLink for Vantage Pro, refer to WeatherLink help for instructions on setting the serial port baud rate on your computer.*

Note: *The console must be equipped with a WeatherLink data logger in order to communicate with a computer.*



1. Press **+** and **-** to select the baud rate.

   Vantage Pro supports baud rates of 1200, 2400, 4800, 9600, 14400, and 19200.
2. You have completed the console setup. To exit Setup Mode, press and hold **DONE** until the current weather screen appears.

Clear All Command

After you have completed the above setup procedures and have exited the Setup Mode, please use the **Clear All** command before putting your weather station into service.

Note: *The Clear All command clears all stored high and low weather data including monthly and yearly highs and lows and clears the alarm settings.*

1. Press the **WIND** key on the console.

2. Press the **2ND** key, then press and hold the **CLEAR** key for at least six seconds.

3. Release the **CLEAR** key when you see the following message displayed at the bottom of the console's screen: "CLEARING NOW".

Current Weather Mode

The Current Weather Mode displays the current data readings from your station, select units of measure, and also to calibrate, set or clear weather variables. You can see up to ten weather variables on the screen at the same time, as well as the time and date, the moon and forecast icons, a forecast or special message from your station, and a graph of the currently selected variable. A few variables are always visible on the console screen while most variables shared their location with one or more other variables. You can select any variable not currently on the screen to display it.

Selecting Weather Variables

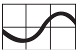
Select a weather variable to display it's data on the screen if it isn't already visible or to graph the variable in the Current Weather Mode screen.

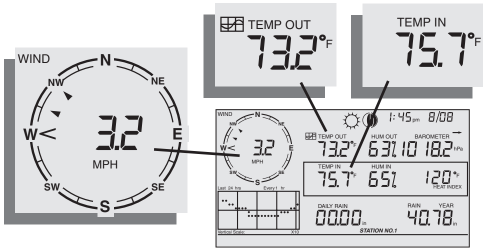
Weather variables are selected via the console command keys:

- If the variable is printed on a key, just press the key to select the variable.
- If the variable is printed on the console housing, first press and release the **2ND** key, then quickly press the key below the variable to select it.

Note: *After pressing the* **2ND** *key, the screen displays the* **2ND** *icon for three seconds. Command key secondary functions are enabled during this time. The keys return to normal operation after the icon disappears.*

- You can also select any variable currently displayed on the LCD screen using the **+**, **-** , **<**, and **>** navigation keys. Push **+** to move up the screen. Push **-** to move down the screen. Push **<** to move left and push **>** to move right.
- The console places a graph icon on the screen to indicate the currently selected variable.





Wind Speed and Direction

Press **WIND** to select wind speed. Wind speed may be displayed in miles per hour (mph), kilometers per hour (km/h), meters per second (m/s), and knots (knots). The 10 minute average wind speed will be displayed in the ticker. (See item 12, “Weather Ticker”, on the Inside Front Cover)

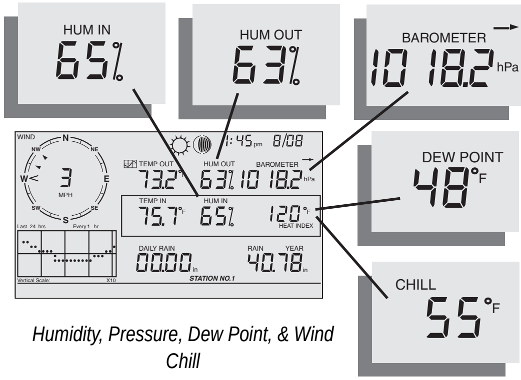
A solid arrow within the compass rose indicates the current wind direction. Arrow caps indicate up to six different 10-minute dominant wind directions to provide a history of the dominant wind directions for the past hour.

Press **WIND** a second time to display the wind direction in degrees instead of the wind speed. Each additional **WIND** key press toggles the display between wind speed and wind direction in degrees.

Outside and Inside Temperature

Press the **TEMP** key to select outside temperature. Temperature may be displayed in degrees Fahrenheit (ºF) or Centigrade (ºC).

Press the **TEMP** key again to select inside temperature.



Humidity, Pressure, Dew Point, & Wind Chill

Humidity

Press the **HUM** key to select outside humidity. Pressing the **HUM** key a second time selects inside humidity. Humidity is displayed in percent relative humidity.

Wind Chill

Press the **2ND** key then press the **CHILL** key to select Wind Chill. Wind Chill is displayed in either degrees Fahrenheit (ºF) or Centigrade (ºC).

Note: *The console uses the ten-minute average wind speed to calculate wind chill.*

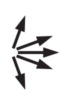
Dew Point

Press the **2ND** key then press the **DEW PT** key to select Dew Point. Dew Point is displayed in either degrees Fahrenheit (ºF) or Centigrade (ºC).

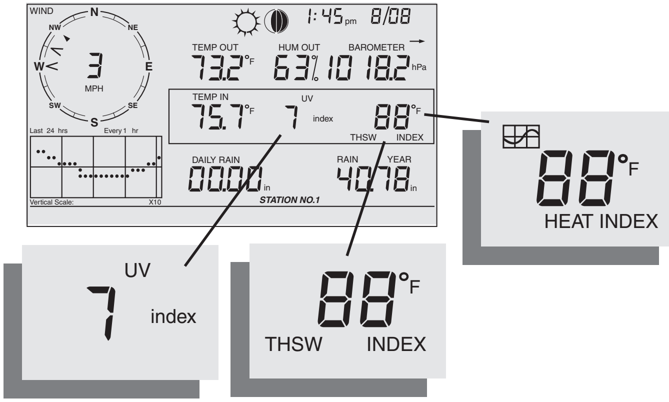
Barometric Pressure

Press the **BAR** key to select barometric pressure. Barometric pressure may be displayed in inches (in), millimeters (mm), millibars (mb) or hectoPascals (hPa).

Pressure Trend



The pressure trend arrow indicates the current barometric trend, measured over the last 3 hours. The pressure trend requires three hours of data in order to be calculated so you won't see it right away on a new station. The pressure trend is always indicated on the console screen, as long as required data is available.



Daily Rain, Rain Storm, Rain Year, Rain Month, & Rain Rate

UV (Ultraviolet Radiation)

Press the **UV** key to display the current UV Index. Press again to see MEDS. See "Apparent Temperatures" on page 45.

Note: *Requires a UV sensor. (See "Optional Sensors" on page 2)*

Heat Index

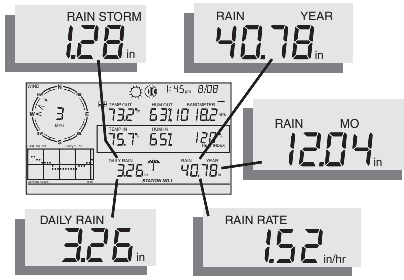
Press the **2ND** key then press **HEAT** to display the Heat Index. See "Apparent Temperatures" on page 45.

THSW Index

After you have selected the Heat Index, press the **2ND** key then press **HEAT** again to select the Temperature Humidity Sun Wind (THSW) Index. The THSW Index is only available on stations equipped with a solar radiation sensor. See "Apparent Temperatures" on page 45.

The Heat Index and the THSW Index appear in the same place on the screen and are displayed in degrees Fahrenheit (ºF) or Centigrade (ºC).

Daily Rain, Rain Storm, Rain Year, Rain Month, & Rain Rate



Rain Rate

Press the **RAINYR** key to display the current rain rate. Rain Rate may be displayed as either inches per hour (in/hr) or millimeters per hour (mm/hr). Rain Rate will show zero and the umbrella icon will not appear until 0.02 in (.508mm) of rain falls within a 15–minute period.

Month-to-date precipitation

Press the **RAINYR** again to select the month-to-date precipitation record. Monthly rain displays the precipitation accumulated since the calendar month began. Month-to-date precipitation is displayed in inches (in) or millimeters (mm).

Year-to-date precipitation

Press the **RAINYR** key a third time to display the year-to-date precipitation record. Yearly rain displays the precipitation accumulated since the 1st of the month you've chosen in Setup Mode (See "Screen 13: Rain Season" on page 19.) Year-to-date precipitation is displayed in inches (in) or millimeters (mm).

Note: *The "Year-to-date" and "Month-to-date" registers record precipitation accumulation for one year and one month respectively; however, you may start each counting period whenever you wish.*

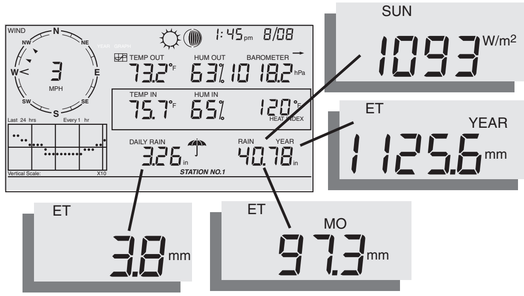
Daily Rain

Press and release the **2ND** key, then press the **RAINDAY** key. Daily Rain displays the rain accumulated since 12 midnight. Any rain accumulated in the last 24 hours will be displayed in the ticker.

Rain Storm

Rain Storm displays the rain total of the last rain event. It takes two rain clicks to begin a storm event and 24 hours without rain to end a storm event.

Press and release the **2ND** key, then press the **RAINDAY** key. Rain Storm will only increment after 0.02 in (.508mm) rain. Rain accumulation may be displayed as either millimeters (mm) or inches (in).



Solar Radiation, Current ET, ET Month & ET Year

Solar Radiation

Press and release the **2ND** key, then press the **SUN** key to display the current solar radiation reading. Solar radiation is displayed as Watts per square meter (W/m^2).

Note: *Requires a solar radiation sensor. (See “Optional Sensors” on page 2)*

Current Evapotranspiration (ET)

Press and release the **2ND** key, then press the **ET** key to display the current evapotranspiration reading.

Monthly Evapotranspiration (ET)

Press the **2ND** key then press the **ET** key, then repeat this key sequence again to display Monthly ET.

Yearly Evapotranspiration (ET)

Press the **2ND** key then press the **ET** key, then repeat this key sequence two more times to display the ET reading since January 1st of the current year.

Note: *Requires a solar radiation sensor. (See “Optional Sensors” on page 2)*

Displaying the Forecast

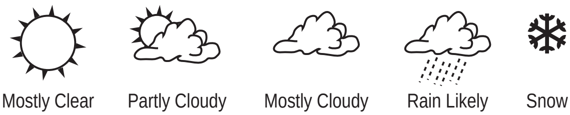
Your console generates a weather forecast based on the barometric reading & trend, wind speed & direction, rainfall, temperature, humidity, latitude & longitude, and time of year. Included in the forecast is of a prediction of the sky condition (sunny, cloudy, etc.) and changes in precipitation, temperature, wind direction or wind speed.

Press the **2ND** key then press the **FORECAST** key to display the forecast.

Note: *The forecast is updated once an hour, on the hour.*

Forecast Icons

The forecast icons show the predicted weather for the next 12 hours. If rain or snow is possible but not necessarily “likely”, you will see the partly cloudy icon along with the rain or snow icon.



Forecast Ticker Tape Message

The forecast ticker message predicts the weather up to 48 hours in advance.

Displaying Time & Date or Sunrise & Sunset

Your console shows the sunrise and sunset time in the same place on the screen used by the current time and date.

Press the **TIME** key to toggle the screen between the current time and date or the sunrise and sunset times for the current day.

Note: *See “Screen 4: Time & Date” on page 14 to change the console time and date or to select a 12- or 24-hour clock.*

Selecting Units of Measure

Most weather variables may be displayed in at least two different measurement units, including US and Metric systems, although some variables feature more possibilities. Barometric pressure, for example, may be displayed in millibars, millimeters, inches, or hectoPascals. Note that you can set each variable’s units independently, and at any time, as you like.

To change units:

1. Select the weather variable.

See “Selecting Weather Variables” on page 20.

2. Press and release the **2ND** key.

3. Press the **UNITS** key.

The selected variable’s units will change. Repeat steps 2 and 3 until the desired units appear.

For example, to change the Barometric pressure units, first select Barometric pressure by pushing **BAR**. Next, press and release the **2ND** key, then press the **UNITS** key. Repeating these steps cycles through the units available for Barometric pressure: millibars, millimeters, inches, and hectoPascals.

Barometric Pressure Units: millibars (mb), millimeters (mm) and inches (in)

Metric Rain Collector Settings

Use the following procedures to set up your Vantage Pro station to display rain data in millimeter. See “Rain” on page 47 for more information.

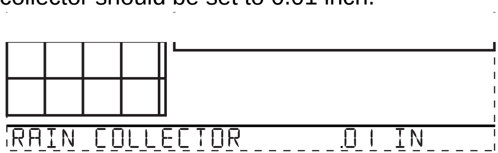
Note: *Vantage Pro stations measure rain in 0.01 inch increments and also store rain data in inch units. When you select metric units for rain data, the logged data is converted from inches to millimeters at the time it is displayed.*

Console Setup: Rain Collector Settings

1. Enter Setup Mode by pressing **DONE** and **-** at the same time.

2. Press **DONE** repeatedly until you see the Rain Collector setup screen.

The rain collector should be set to 0.01 inch.



3. If necessary, press **+** or **-** to change the setting to 0.01”.

The rain collector tipping bucket is calibrated at the factory to measure 0.01” of rain with each tip. The 0.1mm and 0.2 mm settings will not provide accurate rain measurements.

4. Exit Setup Mode by pressing and holding **DONE** until the Current Weather screen appears.

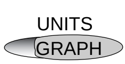
To Display Rain in Metric Units on the Console

1. Press the **RAINYR** key to display the current rain rate.

Selecting Metric units for one rain variable will also set all the other rain variables to Metric units.

2. Press and release the **2ND** key.

3. Press the **UNITS** key once.



The units used to display Rain data will toggle between inches and millimeters each time you repeat this key sequence.

To Display Rain in Metric Units in WeatherLink

Refer to WeatherLink Help for instructions required to set the rain collector to 0.01” and to select millimeters as the unit for rain.

Calibrating, Setting, and Clearing Variables

To fine-tune your station, you can calibrate most of the weather variables. For example, if your outside temperature seems consistently too high or too low, you can enter an offset to correct the deviation.

Calibrating Temperature And Humidity

You can calibrate inside and outside temperature, inside and outside humidity, as well as any extra temperature or humidity sensors you have transmitting to Vantage Pro.

1. Select the variable to be calibrated.

See “Selecting Weather Variables” on page 20.

2. Press and release **2ND**, then press and hold **SET**.

After a moment, the variable you’ve selected will begin to blink. Keep holding the **SET** key until the Calibration Offset message appears in the ticker.

Note: *The ticker displays the current calibration offset.*

3. Press **+** and **-** to add to or subtract from the temperature offset value.

Inside and outside temperature are calibrated in 0.1 °F or 0.1 °C increments, up to a maximum offset of +12.7 (°F or °C) and a minimum offset of -12.8 (°F or °C). The variable will change value and the ticker will show the offset you’ve entered.

4. When you are finished, press **DONE** to exit calibration.

Calibrate Wind Direction Reading

You can use this procedure to correct your the anemometer reading. This is useful if the anemometer does not point North in your installation.

1. Check the current direction of the wind vane on the anemometer. Compare it to the wind direction reading on the console. If the wind vane is pointing south, for instance, the wind direction reading on the screen should be 180°.

- If the wind direction reading is greater than 180°, subtract 180 from the reading and subtract the amount of the offset from the wind direction reading.
- If the wind direction reading is less than 180°, subtract the reading from 180 and add the amount of the offset to the wind direction reading.

2. Press **WIND** as necessary to display the wind direction in degrees.

3. Press and release **2ND**, then press and hold **SET**.

The wind direction variable will begin to blink.

4. Continue holding the key until the CAL message appears in the ticker.

Note: *The ticker displays the current wind direction calibration value.*

5. Press **<** or **>** to select digits in the anemometer’s current reading.

6. Press **+** and **-** to add to or subtract from the anemometer reading.

7. Repeat steps 4 and 5 until you have entered the offset value from Step 1.

8. When you are finished, press **DONE** to exit calibration.

Calibrating Barometric Pressure

Note: *Before calibrating the barometric pressure, be sure the station is set to the correct elevation.*

1. Press **BAR** to select barometric pressure.
2. Press and release **2ND**, then press and hold **SET**.
The pressure variable will blink.
3. Continue holding the key until the ticker reads “set barometer...”.
4. Press **<** or **>** to select digits in the variable.
5. Press **+** and **-** to add to or subtract from the digit’s value.
6. When you are finished, press **DONE** to exit calibration.

Setting Weather Variables

To set a weather variable’s value:

1. Select the variable you wish to change.
2. Press and release **2ND**, then press and hold **SET**.
The variable will blink.
3. Keep holding the key until all digits are lit and only one digit is blinking.
4. Press **<** or **>** to select digits in the value.
5. Press **+** and **-** to add to or subtract from the selected digit.
6. When you are finished, press **DONE** to exit.

You can set values for the following weather variables:

Daily rain

This sets the daily rain total. Monthly and yearly rain totals are updated.

Monthly rain

This sets the current months total rain. Does not affect yearly rain total.

Yearly rain

The sets the current year’s rain total.

Daily ET

This sets the daily ET total. Monthly and yearly ET totals are updated.

Monthly ET

This sets the current month’s ET. Does not affect yearly total.

Yearly ET

This sets the current year’s total ET.

Clearing Weather Variables

To clear a single weather variable:

1. Select the weather variable.

See “Selecting Weather Variables” on page 20.

2. Press and release **2ND**, then press and hold **CLEAR**.

The variable you’ve chosen will blink. Keep holding the key until the value changes to zero or, in the case of the barometer, the raw barometer value.

Clear All Command

This command clears all stored high and low weather data including monthly and yearly highs and lows and clears alarm settings all at once:

1. Press the **WIND** key on the console.

2. Press the **2ND** key, then press and hold the **CLEAR** key for at least six seconds.

3. Release the **CLEAR** key when you see the following message displayed at the bottom of the console’s screen: “CLEARING NOW”.

You can clear the following weather variables:

Barometer

Clearing the barometer value clears (a) any pressure offset used to calibrate the station, and (b) the elevation entry.

Daily rain

Clearing the daily rain value will be reflected in the daily rain total, the last 15 minutes of rain, the last three hours of rain sent to the forecast algorithm, the umbrella icon, and the monthly and yearly rain totals.

Clear the daily rain total to correct if your station accidentally recorded rain when the ISS was installed.

Monthly rain

Clears the monthly rain total. Does not affect yearly rain total.

Yearly rain

Clears the yearly rain total.

Wind

Clears the wind direction calibration.

Daily ET

Clears daily ET and subtracts the old daily ET total from the monthly and yearly ET totals.

Monthly ET

Clears the current monthly ET total. Does not affect †he yearly ET total.

Yearly ET

Clears the current yearly ET total.

Highs and Lows Mode

The Vantage Pro records highs and lows for many weather conditions over three different periods: days, months, and years. Except for Yearly Rainfall, all high and low registers are cleared automatically at the end of each period. \

For example, daily highs are cleared at midnight, monthly highs are cleared at month–end midnight, yearly highs are cleared at year–end midnight. You may enter the month that you would like the Yearly Rainfall accumulation to clear. The Yearly Rainfall will clear on the first day of the month you choose.

TABLE 3-2: WEATHER DATA HIGHS AND LOWS

Weather Variable	High	Low	Day, Time & Date	Month	Year	Additional Information
Outside Temperature	Yes	Yes	Yes	Yes	Yes	
Inside Temperature	Yes	Yes	Yes	Yes	Yes*	
Outside Humidity	Yes	Yes	Yes	Yes	Yes*	
Inside Humidity	Yes	Yes	Yes	Yes	Yes*	
Barometer	Yes	Yes	Yes	Yes	Yes*	
Heat Index	Yes		Yes	Yes	Yes*	
Temp/Hum/Wind/Sun (THSW) Index	Yes		Yes	Yes	Yes*	requires solar radiation sensor
Wind Chill		Yes	Yes	Yes	Yes*	
Wind Speed	Yes		Yes	Yes	Yes	Includes direction
Rainfall Rate	Yes		Yes	Yes	Yes	
Daily Rain			Total	Total	Total	
UV Index	Yes		Yes	Yes	Yes*	requires UV sensor
Solar Radiation	Yes		Yes	Yes	Yes*	requires solar radiation sensor
Dew Point	Yes	Yes	Yes	Yes	Yes*	
Evapotranspiration			Total	Total	Total	requires solar radiation sensor
Soil Moisture	Yes	Yes	Yes	Yes	Yes*	requires soil moisture sensor
Leaf Wetness	Yes	Yes	Yes	Yes	Yes*	requires leaf wetness sensor

* Only stores the yearly high for the current year.

Viewing Highs and Lows

1. Press the **HI/LOW** key to enter the Highs and Lows mode.

   The DAY and HIGHS icons light up and the station displays the highs for all visible fields.

2. Press the **+** and **-** keys to scroll between Day Highs, Day Lows, Month Highs, Month Lows, Year Highs and Year Lows.

   The HIGH or LOW icon, as well the DAY, MONTH or YEAR icon will light to show you which High/Low screen you've selected. See "Graph & Hi/Low Mode Settings" on the inside of the front cover.

3. Press the **<** and **>** keys to scroll back and forth through the last 24 days.

   Pressing the **<** key moves you to the previous day's highs. Each time you press the **<** key, the date moves back another day. The 24 dots in the graph field also represent each of the last 24 days; the right-most dot is today. As you move backward and forward the flashing dot changes to show what day you're looking at.

4. Use the console keys to select a different weather variable.

   The console's time display will the show the time of the selected variable's high or low.

5. When you are finished, press **DONE** to exit the Highs and Lows mode. The console screen will switch to the Current Weather mode.

Alarm Mode

The Vantage Pro features more than 30 alarms that can be programmed to sound whenever a reading exceeds a set value. With the exception of barometric pressure and time, all alarms sound when a reading reaches the alarm threshold. For example, if the high outside temperature alarm threshold is set at 65 ºF, the alarm will sound when the temperature rises to 65.0 ºF.

When an alarm condition exists, the audible alarm sounds, the alarm icon blinks repeatedly, and an alarm description appears in the ticker at the bottom of the screen. The alarm sounds for a maximum two minutes if the console is battery-powered, but the icon will continue to blink and the message will stay in the ticker until you clear the alarm or the condition clears. If you're using the AC adapter, the alarm will continue sounding as long as the condition exists.

The alarm will sound again for each new alarm. If more than one alarm is active, the description for each active alarm cycles onto the screen every four seconds. A "+" symbol appears at the end of the alarm text if more than one alarm is tripped.

Low alarms work the same way. For example, if the wind chill threshold is set for 30 ºF, the alarm condition begins when the temperature drops to 30 º and will continue until the temperature rises above 30º.

Three Special Alarms

ET (Evapotranspiration)

ET is updated only once an hour, on the hour. If during a given hour the ET Value exceeds the alarm threshold, the ET alarm sounds at the end of that hour. This is true for daily, monthly, and yearly ET alarms. You must have the optional Solar Radiation Sensor to use this alarm. See “Evapotranspiration (ET)” on page 50 for a description of this variable.

Barometric Pressure

The Vantage Pro allows you to set two barometric pressure alarms: a “rise” alarm and a “fall” alarm. You may select any rate of change per three hours between 0.00 and 0.99 Hg; the alarm will sound if the rate of change (in either direction) exceeds your threshold you set.

Time

The time alarm is a standard “alarm clock” alarm. It will sound at the time you’ve set. Make sure you choose am or pm, if you’re in 12-hour mode. It will sound for one minute.

Setting Alarms

1. To view or set the high alarm thresholds, press **2ND** then press the **ALARM** key enter the Alarm Mode.

   The screen shows the current high alarm thresholds. The ALARM and HIGHS icons also appear.
2. To view or set the low alarm thresholds, first press **2ND** then press the **ALARM** key enter the Alarm Mode. Then press the **HI/LOW** key to display the low alarm threshold settings.

   The ALARM and LOWS icons appear. See “Graph & Hi/Low Mode Settings” on the inside of the front cover.
3. Press the **<** and **>** keys to select one of the variables displayed on the screen or use the console keys to select any weather variable.
4. Press **2ND** then press **SET** to change the selected variable’s alarm setting.

   The right-most digit in the alarm threshold will begin blinking.
5. Press the **<** and **>** keys to select digits in the threshold value.
6. Press the **+** and **-** keys to change the digit’s value up and down.
7. When you are finished changing the alarm setting, press the **DONE** key.
8. Repeat steps 3 through 7 to change additional alarm settings.
9. When you are finished, press **DONE** to exit Alarm Mode.

Setting the Time Alarm

1. Press **2ND** then press the **ALARM** key to enter the alarm mode.
   The ALARM and HIGHS icons appear.
2. Press **Time**, then press **2ND,** and then press **SET**.
   The time field will begin blinking.
3. Press **<** and **>** to select hours, minutes, or am/pm.
4. Press the **+** and **-** keys to change the digit's value up and down.
5. When you are finished, press **DONE** to exit Alarm Mode.

Clearing Alarm Settings

1. Press **2ND** then press the **ALARM** key to enter the alarm mode.
   The ALARM and HIGHS icons will appear.
2. Select the alarm setting you wish to clear.
3. Press **2ND**, then press and hold **CLEAR** until the setting changes to all dashes.
   You have cleared the alarm setting.
4. When you are finished, press **DONE** to exit Alarm Mode.

Silencing Alarms

1. Press **DONE** to silence an alarm.

TABLE 3-3: VANTAGE PRO STATION ALARMS

Variable	Alarms
Barometric Pressure Trend	Storm Warning - uses trend value rising rate Storm Clearing - uses trend value falling rate
Evapotranspiration	ET Alarm - uses total ET for the day
Humidity, Inside	High and Low
Humidity, Outside	High and Low
Dew Point	High and Low
Leaf Wetness	High and Low
Rain	Flash Flood Alarm - uses current 15 minute rainfall total 24 Hour Rain Alarm - uses current 24 hour rainfall total
Storm	Storm Alarm - uses current storm rainfall total
Rain Rate	High
Soil Moisture	High and Low
Solar Radiation	High
Inside Temperature	High and Low

TABLE 3-3: VANTAGE PRO STATION ALARMS (CONTINUED)

Variable	Alarms
Outside Temperature	High and Low
Extra Temperature	High and Low
Heat Index Temperature	High
THSW Index Temperature	High
Wind Chill Temperature	Low
UV Radiation Index	High
UV Radiation MED	High -- uses the current total if variable has been reset
Wind Speed	High
Time & Date	Yes - the alarm sounds for 1 minute.

Graph Mode

The Vantage Pro console includes a powerful Graph Mode that allows you to view over 100 graphs of different kinds right on the screen. - all without connecting to a personal computer.

See Table "Vantage Pro Console Graphs" on page 36 for a list of the available graphs.

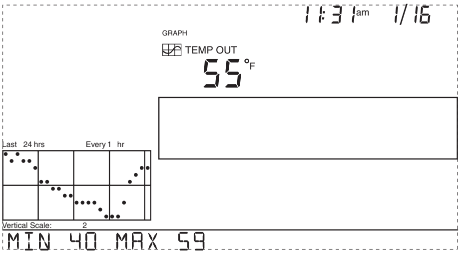
Viewing Graphs

Although the graphs available may vary for each weather variable, you display the graphs in the same way:

1. Press **Graph** to enter Graph Mode.

Only the date, graph, graph icon, and selected variable are visible.

The rest of the screen will be blank.



2. Select a variable to graph.

Values for the each of the last 24 hours are displayed in the graph, each hour represented by a dot. The dot at right end of the graph is the value for the current hour. You'll notice that the dot is blinking.

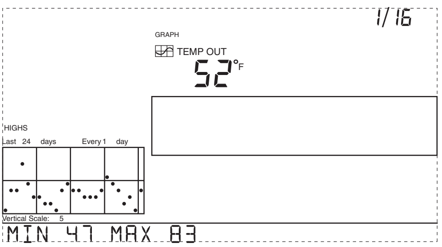
3. Press the **<** key and the second dot from the right will start blink.

The screen displays the new dot's value. The time display will show you what hour of the last 24 you're looking at.

4. Press the **<** and **>** keys to view the variable's values for each of the last 24 hours. The console also display the maximum and minimum temperatures recorded in the last 24 hours.

5. Press the **+** and **-** keys to shift the graph's time span.

If you press the **-** key, the graph will shift from the last 24 hours to the last 24 days. Now each dot represents the high recorded on the day shown in the date field. To see the lows recorded in the last 24 days, press the **HI/LOW** key. Press the **<** and **>** keys to move between days.



If you press the **-** key again the graph will shift to show the highs of the last 24 months. As before, use the **<** and **>** keys to move between months. Press the **HI/LOW** key to shift between the highs and lows.

If you press the **-** key again, the graph will shift one more time to show the highs of the last 24 years! Use the **HI/LOW** key to shift between highs and lows.

Note: *The console beeps when you've reached the first or last possible value or time span for the graph.*

Note: *Since the console only graphs data collected by your station, the graphs can only show data collected since your station was first installed.*

View graphs of all other variables the same way:

1. Enter graph mode.
2. Select the variable you want to view.
3. Use the **<** and **>** keys to select different variables.
4. Press the **+** key to shorten the time range.
5. Press the **-** key to lengthen the time range.
6. Press **HI/LOW** to shift between highs and lows.
7. Press **DONE** to exit.

TABLE 3-4: VANTAGE PRO CONSOLE GRAPHS

Weather Variable	Available Graphs[a]							
	Current	1 Min	10 Min	15 Min	Hourly	Daily	Monthly	Yearly
Barometric Pressure	C			C	C	H,L	H,L	
Evapotranspiration (ET)[b]	T				T	T	T	T
Humidity, Inside	C				C	H,L	H,L	
Humidity, Outside	C				C	H,L	H,L	

TABLE 3-4: VANTAGE PRO CONSOLE GRAPHS (CONTINUED)

Weather Variable	Available Graphs[a]							
	Current	1 Min	10 Min	15 Min	Hourly	Daily	Monthly	Yearly
Dew Point	C				C	H,L	H,L	
Leaf Wetness[c]	C				C	H,L	H	
Rain	T			T	T	T	T	T
Storm[1]								
Rain Rate	H	H			H	H	H	H
Soil Moisture	C				C	H,L	H,L	
Solar Radiation[b]	A				A	H	H	
Inside Temperature	C				C	H,L	H,L	
Outside Temperature	C				C	H,L	H,L	H,L
Heat Index Temperature	C				C	H	H	
Temp/Hum/Sun/Wind (THSW) Index Temperature[b]	C				C	H	H	
Wind Chill Temperature	L				L	L	L	
UV Radiation Index[d]	A				A	H	H	
UV Radiation MED (Minimal Erythemal Dose)[d]	T				T	T		
Wind Speed	A		A		AH	H	H	H
Direction of High Wind Speed	Y					Y	Y	Y
Dominant Wind Direction	A				A	A	A	

a.A = Average, H = Highs, L = Lows, T = Totals, Y = Yes, C = Current reading at the end of each period
b.Requires solar radiation sensor
c.Requires Wireless Leaf & Soil Moisture/Temperature Station
d.Requires UV sensor

4. Troubleshooting & Maintenance

Vantage Pro Troubleshooting Guide

While your Vantage Pro weather station is designed to provide years of trouble-free operation, occasional problems may arise. If you are having a problem with your station, please consult this troubleshooting guide before calling the factory. You may be able to quickly solve the problem yourself. If you need help, please contact Davis Technical Support, page 43.

Note: *Refer to the ISS Installation Manual for additional troubleshooting information.*

Table 4-1: Troubleshooting Guide

	Problem	Solution
Display	Display is blank	Unit is not receiving power. Check the power adapter connections and/or replace batteries.
	Display shows dashes in place of weather data	ISS not plugged in (cabled station). See ISS manual. Sensors not transmitting (wireless station). See ISS (or other transmitter) manual. Console not receiving (wireless station) - See “Troubleshooting Reception Problems” on page 41. A reading has exceeded the limits indicated in the specifications table. Calibration numbers may be causing readings to exceed display limits. Check calibration number and adjust if necessary.
	Console is sluggish or does not work at low temperatures	The console and display may not work below 32º F (0ºC). Use an External Temperature sensor in low-temperature locations.
	Display “locks up”	If the console “locks up”, reset the console by removing AC and battery power then restoring power. If this occurs frequently in an AC-powered console, plug the AC power-adapter into a surge suppressor.

TABLE 4-1: TROUBLESHOOTING GUIDE

	Problem	Solution
Temperature	Outside temperature sensor reading seems too high	Check calibration number and adjust if necessary. ISS or temp sensor may need to be relocated. See ISS or other transmitter manual.
	Inside temperature sensor reading seems too high	Move the console out of direct sunlight. Make sure that the console or sensor is not in contact with an exterior wall that heats up in sunlight or when outside temperature rises. Make sure the console or sensor is not near a heater or other internal heat source (lamps, appliances, etc.). Check calibration number and adjust if necessary.
	Outside temperature seems too low	Check calibration number and adjust if necessary. Sprinklers may be hitting the ISS radiation shield. Relocate. See ISS manual.
	Inside temperature sensor reading seems too low	Make sure the console or other temperature sensor is not in contact with an exterior wall that cools down when outside temperature drops. Make sure the console or other temperature sensor is not near an air conditioning vent. Check calibration number and adjust if necessary.
Humidity	Inside humidity seems too high or too low	Make sure the console is not near a humidifier or de-humidifier. Check calibration number and adjust if necessary. If inside humidity is low, and inside temperature is too high, see “inside temp” above.
Wind Speed	Wind speed reading seems too high or too low.	For low readings, remove the wind cups and check for friction sources. Check ISS location. Is it sheltered from the wind? See ISS manual for additional wind speed troubleshooting information
	Wind speed reads 0 either all the time or intermittently	The problem may be with the anemometer. Test anemometer by spinning wind cups. Check fields one-b and two-b on diagnostic screen. May require call to tech support.
Wind Direction	Wind direction reading is dashed out	Wireless model - check reception. See Reception Problems below. Cabled model - cable may be faulty. If these steps do not reveal the problem, the anemometer may be faulty. Call the factory for return authorization.
	Wind direction always says North	Usually an ISS problem, especially if outside temperature is dashed out as well. See the ISS manual for troubleshooting information
Chill	Wind chill reading seems too high or too low	Check calibration numbers for temperature. Remember, wind chill depends on temperature and wind speed. Make sure they’re working.
Heat	Heat Index reading seems too high or too low	Check calibration numbers for temperature. Remember, the heat index depends on temperature and outside humidity. Make sure they’re working.
Dew	Dew Point reading seems too high or too low	Check calibration numbers for temperature. Remember, dew point depends on temperature and outside humidity. Make sure they’re working.
Rain	No rain readings	Make sure cable-tie is removed from rain collector. See ISS manual. If you are using wireless sensors from a Weather Monitor II or Weather Wizard III, set the station type to SensorLink

TABLE 4-1: TROUBLESHOOTING GUIDE

	Problem	Solution
Time	Incorrect times for sunrise and sunset	Check your latitude and longitude settings. Sunrise and sunset times are calculated from the console latitude and longitude settings

Troubleshooting Reception Problems

While we have tested the Wireless Vantage Pro radio extensively, each site and each installation presents its own issues and challenges. Obstructions, particularly metal, will often cut down your station's reception distance. Be sure to test reception between the console and ISS, in the locations you intend to install them, or before permanently mounting your ISS or other transmitter(s).

You can quickly see the console's reception status by looking at the lower right corner of the screen:

- An “X” flashes for every data packet received by the console.
- An “R” flashes when the console is trying to re-establish a lost connection.
- An “L” flashes when the signal has been lost.
- When no data packets have been received for 10 minutes, the console dashes-out any missing sensor readings

Check Console Reception

Enter Setup mode by pressing **DONE**, then pressing **-**. Wait a few moments while the console lists all the stations transmitting within range. If the console detects your transmitter, check the following:

- Is the ID you're receiving configured in the console?
  See Table “Maximum Number of Transmitters” on page 12.
- Is the correct station type set?
  See “Maximum Number of Transmitters” on page 12.
- Use the diagnostic screen to obtain useful signal strength information.
  See “Console Diagnostic Screen” on page 42
- Adjust the console and ISS antennas to be parallel to each other.
- Try turning on the Gain.

  See “Diagnostic Screen Commands” on page 42.
- Reduce the distance between the ISS and the console.

  Move the console closer to the ISS, but make sure you're not standing directly beneath it. Do you receive a signal?

Check the ISS

Refer to the ISS Installation Manual for instructions on how to check the ISS for potential transmission problems.

Console Diagnostic Screen

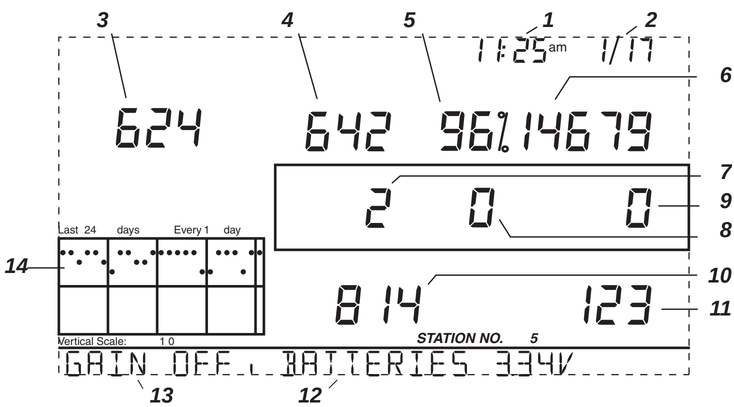
In addition to logging weather data, the console continuously monitors the station's radio reception. The signal You may find this information very helpful, especially when you are choosing locations for your console and ISS.

Note: *Radio transmission data is cleared each day at midnight.*

Diagnostic Screen Commands

- Press and hold the **TEMP** key, then press the **TIME** key to display the diagnostic screen.
- Press the **DONE** key to exit the diagnostic screen.
- Press the **STATION** key to display signal statistics for the next installed transmitter ID.
- Press the **HI/LOW** key to toggle Gain on and off. The message in the ticker indicates the current Gain status. The Receiver Gain setting provides some control over the receiver sensitivity. If you're having trouble with reception, try turning the Gain on.

Diagnostic Screen Features



1. *(a) Time of day or (b) number of times the reed switch was seen closed when sampled. The reed switch closes once each rotation. Use the* **WIND** *key to toggle between readings.*
2. *(a) Date or (b) number of times the reed switch was seen open when sampled. The anemometer counts rotations. The reed switch is part of the anemometer mechanism.* **WIND** *key toggles display.*
3. *(a) Number of CRC errors or (b) 8 bit timer value of next reception. CRC is an error checking protocol. Toggle display with* **CHILL**.
4. *Number of missed data packets.*
5. *Percentage of scheduled data packets received.*
6. *Total number of packets received.*
7. *(a) Number of times the console resynchronized with the transmitter or (b) maximum number of packets missed in a row without losing synchronization. Toggle using the* **TEMP** *key.*

8. *Number of times the console lost communications with the transmitter for more than 10 minutes.*
9. *Current number of consecutive misses. The counter increments when the console is synchronized but the packet is not.*
10. *Longest streak of consecutive packets received.*
11. *Current streak of consecutive packets received.*
12. *Current console battery voltage*
13. *Receiver Gain Status*
14. *Graph of last 24 days' percentage of scheduled ISS data packets.*

Console Firmware Versions

In some cases the problem may be that your console firmware doesn't support what you are trying to do. Use this command to determine the firmware revision level in your console. You can find more information on Vantage Pro console firmware versions and changes in the Weather Software Support section of our website. See "Contacting Davis Technical Support" on page 44 for information.

Press and hold the **DONE** key then press the **+** key to display the console firmware version in the ticker at the bottom of the screen.

Console Maintenance

Changing Batteries

Use this procedure to change console batteries without loosing any stored weather data or console configuration settings.

1. Plug in the AC adapter
2. Enter Setup Mode by pressing the **DONE** and **-** keys.

   Entering Setup Mode makes sure the station isn't writing any data to memory when you remove power.
3. Remove the battery cover located on the back of the console by pressing down on the two latches at the top of the cover
4. Place the console face down on a flat, firm surface.
5. Insert a fingertip between the two exposed batteries then press the middle battery down toward the notch (toward the "hidden" battery). This will relieve tension on the first battery and allow you to remove it

Contacting Davis Technical Support

If you have any questions, or encounter problems installing or operating your Vantage Pro weather station, please contact Davis Technical Support. We'll be glad to help.

Note: *Please do not return items for repair without prior authorization.*

(510) 732-7814 – Monday – Friday, 7:00 a.m. – 5:30 p.m. Pacific Time. We are unable to accept collect calls.

(510) 670-0589 – Technical Support Fax.

support@davisnet.com – E-mail to Technical Support.

info@davisnet.com – General e-mail.

www.davisnet.com – Davis Instruments web site. See the Weather Support section for copies of user manuals, product specifications, application notes, and information on software updates. Watch for FAQs and other updates. Subscribe to the e-newsletter.et.com

One Year Limited Warranty

For details on our warranty policy, please refer to the *Maintenance, Service, and Repair Information* brochure included with your station.

Appendix A: Weather Data

Refer to this appendix to learn more about the weather variables that are measured, displayed, and logged by your Vantage Pro Station.

Note: *Some weather variables require optional sensors. See "Optional Sensors" starting on page 2.*

Wind

The anemometer measures wind speed and direction, and is part of the Integrated Sensor Suite (ISS). The console also calculates a 10-minute average wind speed and 10-minute dominant wind direction. The 10-minute average wind speed is displayed in the console ticker whenever wind has been selected on the console. The last six 10-minute dominant wind directions are included in the compass rose wind display.

Temperature

The ISS houses the outside temperature sensor in a vented and shielded enclosure that minimizes the solar radiation induced temperature error. The console houses the inside temperature sensor. Additional temperature sensors are available for wireless stations and can be used to measure up to eight locations.

Apparent Temperatures

Vantage Pro calculates three apparent temperature readings: wind chill, Heat Index, and the Temperature/Humidity/Sun/Wind (THSW) Index. Apparent temperatures use additional weather data to calculate what a human body perceives the temperature to be in those conditions.

Wind chill

Wind chill takes into account how the speed of the wind affects our perception of the air temperature. Our bodies warm the surrounding air molecules by transferring heat from the skin. If there's no air movement, this insulating layer of warm air molecules stays next to the body and offers some protection from cooler air molecules. However, wind sweeps that comfy warm air surrounding the body away. The faster the wind blows, the faster heat is carried away and the colder you feel.

Heat Index

The Heat Index uses temperature and the relative humidity to determine how hot the air actually "feels." When humidity is low, the apparent temperature will be lower than the air temperature, since perspiration evaporates rapidly to cool the body. However, when humidity is high (*i.e.*, the air is more saturated with water vapor) the apparent temperature "feels" higher than the actual air temperature, because perspiration evaporates more slowly.

Note: *Vantage Pro measures Heat Index only when the air temperature is above 57° F (14° C), because it's insignificant at lower temperatures. (Below 57°, Heat Index = the air temperature.) The Heat Index is not calculated above 135° F (52° C).*

Temperature/Humidity/Sun/Wind (THSW) Index

The THSW Index uses humidity and temperature like the Head Index, but also includes the heating effects of sunshine and the cooling effects of wind (like wind chill) to calculate an apparent temperature of what it "feels" like out in the sun. The THSW Index requires a solar radiation sensor.

Humidity

Humidity itself simply refers to the amount of water vapor in the air. However, the amount of water vapor that the air can contain varies with air temperature and pressure. Relative humidity takes into account these factors and offers a humidity reading which reflects the amount of water vapor in the air as a percentage of the amount the air is capable of holding. Relative humidity, therefore, is not actually a measure of the amount of water vapor in the air, but a ratio of the air's water vapor content to its capacity. When we use the term humidity in the manual and on the screen, we mean relative humidity.

It is important to realize that relative humidity changes with temperature, pressure, and water vapor content. A parcel of air with a capacity for 10 g of water vapor which contains 4 g of water vapor, the relative humidity would be 40%. Adding 2 g more water vapor (for a total of 6 g) would change the humidity to 60%. If that same parcel of air is then warmed so that it has a capacity for 20 g of water vapor, the relative humidity drops to 30% even though water vapor content does not change.

Relative humidity is an important factor in determining the amount of evaporation from plants and wet surfaces since warm air with low humidity has a large capacity to absorb extra water vapor.

Dew Point

Dew point is the temperature to which air must be cooled for saturation (100% relative humidity) to occur, providing there is no change in water vapor content. The dew point is an important measurement used to predict the formation of dew, frost, and fog. If dew point and temperature are close together in the late afternoon when the air begins to turn colder, fog is likely during the night. Dew point is also a good indicator of the air's actual water vapor content, unlike relative humidity, which takes the air's temperature into account. High dew point indicates high water vapor content; low dew point indicates low water vapor content. In addition a high dew point indicates a better chance of rain and severe thunderstorms.

You can also use dew point to predict the minimum overnight temperature. Provided no new fronts are expected overnight and the afternoon Relative Humidity ≥ 50%, the afternoon's dew point gives you an idea of what minimum temperature to expect overnight, since the air cannot get colder than the dew point anytime.

Rain

Vantage Pro incorporates a tipping-bucket rain collector in the ISS that measures 0.01" for each tip of the bucket. Your station also logs rain data in inch units. If you select millimeters for the rain measurement unit, your station still logs rain data in inches but will convert the logged totals from inches to millimeters at the time it is displayed. Converting the logged rain totals reduces possible conversion losses to a minimum.

Four separate variables track rain totals: "rain storm", "daily rain", "monthly rain", and "yearly rain". Rain rate calculations are based on the interval of time between each bucket tip, which is each 0.01" rainfall increment.

Barometric Pressure

The weight of the air that makes up our atmosphere exerts a pressure on the surface of the earth. This pressure is known as atmospheric pressure. Generally, the more air above an area, the higher the atmospheric pressure, this, in turn, means that atmospheric pressure changes with altitude. For example, atmospheric pressure is greater at sea-level than on a mountaintop. To compensate for this difference and facilitate comparison between locations with different altitudes, atmospheric pressure is generally adjusted to the equivalent sea-level pressure. This adjusted pressure is known as barometric pressure. In reality, the Vantage Pro measures atmospheric pressure. When you enter your location's altitude in Setup Mode, the Vantage Pro stores the necessary offset value to consistently translate atmospheric pressure into barometric pressure.

Barometric pressure also changes with local weather conditions, making barometric pressure an extremely important and useful weather forecasting tool. High pressure zones are generally associated with fair weather while low pressure zones are generally associated with poor weather. For forecasting purposes, however, the absolute barometric pressure value is generally less important than the change in barometric pressure. In general, rising pressure indicates improving weather conditions while falling pressure indicates deteriorating weather conditions.

Solar Radiation

What we call "current solar radiation" is technically known as Global Solar Radiation, a measure of the intensity of the sun's radiation reaching a horizontal surface. This irradiance includes both the direct component from the sun and the reflected component from the rest of the sky. The solar radiation reading gives a measure of the amount of solar radiation hitting the solar radiation sensor at any given time, expressed in Watts /sq. meter (W/m^2). Solar radiation requires the solar radiation sensor.

UV (Ultra Violet) Radiation

Energy from the sun reaches the earth as visible, infrared, and ultraviolet (UV) rays. Exposure to UV rays can cause numerous health problems, such as sunburn, skin cancer, skin aging, and cataracts, and can suppress the immune system. The Vantage Pro can help analyze the changing levels of UV radiation and can advise of situations where exposure is particularly unacceptable. UV radiation requires the UV radiation sensor. The Vantage Pro displays UV readings in two scales: MEDs and UV Index.

CAUTION: *Your station's UV readings do not take into account UV reflected off snow, sand, or water, which can significantly increase your exposure. Nor do your UV readings take into account the dangers of prolonged UV exposure. The readings do not suggest that any amount of exposure is safe or healthful. Do not use the Vantage Pro to determine the amount of UV radiation to which you expose yourself. Scientific evidence suggests that UV exposure should be avoided and that even low UV doses can be harmful.*

UV MEDs

MED stands for Minimum Erythemal Dose, defined as the amount of sunlight exposure necessary to induce a barely perceptible redness of the skin within 24 hours after sun exposure. In other words, exposure to 1 MED will result in a reddening of the skin. Because different skin types burn at different rates, 1 MED for persons with very dark skin is different from 1 MED for persons with very light skin.

Both the U.S. Environmental Protection Agency (EPA) and Environment Canada have developed skin type categories correlating characteristics of skin with rates of sunburn. See "EPA Skin Phototypes" and "Environment Canada Skin Types and Reaction to the Sun" for a description of skin types.

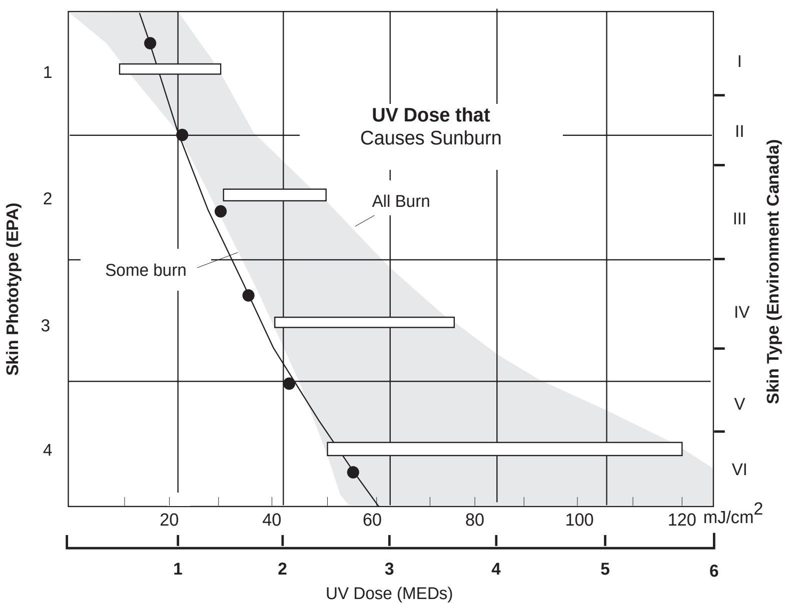
Table A-1: EPA Skin Phototypes

Skin Phototype	Skin color	Tanning & Sunburn history
1 - Never tans, always burns	Pale or milky white; alabaster	Develops red sunburn; painful swelling, skin peels
2 - Sometimes tans, usually burns	Very light brown; sometimes freckles	Usually burns, pinkish or red coloring appears; can gradually develop light brown tan
3 - Usually tans, sometimes burns	Light tan; brown, or olive; distinctly pigmented	Rarely burns; shows moderately rapid tanning response
4 - Always tans; rarely burns	Brown, dark brown, or black	Rarely burns; shows very rapid tanning response

Table A-2: Environment Canada Skin Types and Reaction to the Sun[a]

Skin Type	Skin Color	History of Tanning & Sunburning
I	White	Always burns easily, never tans
II	White	Always burns easily, tans minimally
III	Light Brown	Burns moderately, tans gradually
IV	Moderate Brown	Burns minimally, tans well
V	Dark Brown	Burns rarely, tans profusely
VI	Black	Never burns, deep pigmentation

a. *Developed by T. B. Fitzpatrick of the Harvard Medical School. More about the Fitzpatrick Skin Types is available in: Fitzpatrick TB. Editorial: the validity and practicality of sun-reactive skin types I through VI. Arch Dermatol 1988; 124:869-871*



UV Dose and Sunburn - Use this plot to estimate the MED dose leading to sunburn. A person with Type II (Environment Canada) skin type might choose 0.75 MED as the maximum for the day; in contrast, a person with Type V (Environment Canada) Skin Type might consider 2.5 MEDs a reasonable dose for the day. NOTE: the Vantage Pro assumes a Fitzpatrick (Environment Canada) Skin Type of II.

UV Index

Vantage Pro can also display UV Index, an intensity measurement first defined by Environment Canada and since been adopted by the World Meteorological Organization. UV Index assigns a number between 0 and 16 to the current UV intensity. The US EPA categorizes the Index values as shown in 2. The lower the number, the lower the danger of sunburn. The Index value published by the U.S. National Weather Service is a forecast of the next day's noontime UV intensity. The Index values displayed by the Vantage Pro are real-time measurements.

TABLE A-3: UV INDEX

Index Values	Exposure Category
0 - 2	Minimal
3 - 4	Low
5 - 6	Moderate
7 - 9	High
10+	Very High

Evapotranspiration (ET)

Evapotranspiration (ET) is a measurement of the amount of water vapor returned to the air in a given area. It combines the amount of water vapor returned through evaporation (from wet vegetation surfaces and the stoma of leaves) with the amount of water vapor returned through transpiration (exhaling of moisture through plant skin) to arrive at a total. Effectively, ET is the opposite of rainfall, and it is expressed in the same units of measure (Inches, millimeters).

The Vantage Pro uses air temperature, relative humidity, average wind speed, and solar radiation data to estimate ET, which is calculated once an hour on the hour. ET requires the optional solar radiation sensor.

Leaf Wetness

Leaf wetness (see "Optional Sensors" on page 2) provides an indication of whether the surface of foliage in the area is wet or dry by indicating how wet the surface of the sensor is. The leaf wetness reading ranges from 0 (dry) to 15. Leaf wetness requires an optional Leaf & Soil Moisture/Temperature Station and is only available for Wireless Vantage Pro Stations.

Soil Moisture

Soil Moisture, as the name suggests, is a measure of the moisture content of the soil. Soil moisture is measured on a scale of 0 to 200 centibars, and can help choose times to water crops. The soil moisture sensor measures the vacuum created in the soil by the lack of moisture. A high soil moisture reading indicates dryer soil; a lower soil moisture reading means wetter soil. Soil Moisture requires an optional Leaf & Soil Moisture/Temperature Station or Soil Moisture Station and is only available for Wireless Vantage Pro Stations.

Time

A built-in clock and calendar track the time and date. The console automatically adjusts for daylight savings time and for leap years.

Appendix B: Specifications

See complete specifications for your Vantage Pro Station at our website: www.davisnet.com

Console Specifications

Console Operating Temperature	+14° to +140°F (-10° to +60°C)
Display Temperature	+32° to +140°F (0° to +60°C)
Non-operating Temperature	-5° to +158°F (-20° to +70°C)
Console Current Draw	Wireless: 0.67 mA average, 15 mA peak, (add 80 mA for display lamps, add 0.125 mA for each transmitter station received by console) at 4 to 6 VDC Cabled: 10 mA (average), 15 mA (peak) (+80 mA for illuminated display) at 4 to 6 VDC
Power Adapter	5 VDC, 200 mA
Battery Backup	3 C-cells
Battery Life (no AC power)	Wireless: up to 1 year; Cabled: 1 month (approximately)
Connectors	Modular RJ-11
Housing Material	UV-resistant ABS plastic
Console Display Type	LCD Transflective
Display Backlight	4 LEDs
Dimensions:	
Console (with antenna)	10.375" x 6.125" x 1.5" (264 mm x 156 mm x 38 mm)
Console (no antenna)	9.625" x 6.125" x 1.5" (244 mm x 156 mm x 38 mm)
Display	5.94" x 3.375" (151 mm x 86 mm)
Weight (with batteries)	1.88 lbs. (.85 kg)

Wireless Transmission Specifications

Transmit/Receive Frequency	US Models: 916.5 MHz Overseas Models: 868.35 MHz
DavisTalk™ ID Codes Available	8
Output Power	916.5 MHz: FCC-certified low power, less than 1 mW, no license required 868.35 MHz: CE-certified, less than 10 mW, no license required
Range	
Line of Sight	up to 400 feet (120 m)
Through Walls	75 to 150 feet (23 to 46 m)

Console Data Display Specifications

Historical Data	Includes the past 24 values listed unless otherwise noted; all can be cleared and all totals reset
Daily Data	Includes the earliest time of occurrence of highs and lows; period begins/ends at 12:00 am
Monthly Data	Period begins/ends at 12:00 am on the first of the month
Yearly Data	Period begins/ends at 12:00 am on the first of January unless otherwise noted
Current Data	Current data appears in the right most column in the console graph and represents the latest value within the last period on the graph; totals can be set or reset
Graph Time Interval	1 min., 10 min., 15 min., 1 hour, 1 day, 1 month, 1 year (user-selectable, availability depends upon variable selected)
Graph Time Span	24 Intervals + Current Interval (see Graph Intervals to determine time span)
Graph Variable Span (Vertical Scale)	Automatic (varies depending upon data range); Maximum and Minimum value in range appear in ticker
Alarm Indication	Alarms sound for only 2 minutes (time alarm is always 1 minute) if operating on battery power. Alarm message is displayed in ticker as long as threshold is met or exceeded. Alarms can be silenced (but not cleared) by pressing the DONE key.
Update Interval	Varies with sensor - see individual sensor specs Also varies with DavisTalk transmitter ID code - #1=shortest, #8=longest
Forecast:	
Variables Used	Barometric Reading & Trend, Wind Speed & Direction, Rainfall, Temperature, Humidity, Latitude & Longitude, Time of Year
Update Interval	1 hour
Display Format	Icons on top center of display; detailed message in ticker at bottom
Variables Predicted	Sky Condition, Precipitation, Temperature Changes, Wind Direction and Speed Changes

Weather Data Specifications

Note: *These specifications include optional sensors that may not be installed in your Vantage Pro Station.*

TABLE 3-1: WEATHER DATA SPECIFICATIONS

Variable	Required Sensors	Resolution	Range	Nominal Accuracy (+/-)
Barometric Pressure[a]	Included in Console	0.01” Hg; 0.1 mm; 0.1 hPa; 0.1 mb	26” to 32” Hg; 660 to 810 mm; 880 to 1080 hPa; 880 to 1080 mb	0.03” Hg; 0.8 mm Hg; 1.0 hPa; 1.0 mb
Barometric Trend (3 hour)		Change Rates Rapidly: ≥.06” Hg; 1.5 mm Hg; 2 hPa; 2 mb Slowly: ≥.02” Hg; 0.5 mm Hg; 0.7 hPa; 0.7 mb	5 Arrow Positions: Rising Rapidly Rising Slowly Steady Falling Slowly Falling Rapidly	
Evapotranspiration (ET)	ISS or Temp/Hum Station & Solar	0.01”; 0.25 mm	Daily to 99.99”; 999.9mm Monthly & Yearly to 199.99”; 1999.9mm	greater of 5% or 0.01”; 0.25 mm
Inside Humidity	Included in Console	1%	10 to 90%	5% RH
Outside Humidity	ISS or Temp/Hum Station	1%	0 to 100%	3% RH; 4% above 90%
Extra Humidity	ISS or Temp/Hum Station	1%	0 to 100%	3% RH; 4% above 90%
Dew Point (overall)	ISS or Temp/Hum Station	1°F; 1°C	-105° to +130°F; -76° to +54°C	3°F; 1.5°C
Frost/Dew Point at High Humidity	ISS or Temp/Hum Station	1°F; 1°C	-105° to +130°F; -76° to +54°C	2°F; 1°C
Leaf Wetness	Leaf & Soil Station	1	0 to 15	0.5
Soil Moisture	Leaf & Soil Station or Soil Moisture Station	1 cb	0 to 200 cb	
Daily & Storm Rainfall	Rain Collector	0.01”; 0.25 mm	to 99.99”; 999.9 mm	greater of 4% or 1 tip,
Monthly & Yearly Rainfall		0.01”; 0.25 mm (1 mm at totals over 2000 mm)	to 199.99”; 19,999 mm	greater of 4% or 1 tip
Rain Rate		0.01”; 0.25 mm (	to 100”/hr; 1999.9 mm/hr	greater of 5% or 0.04”/hr; 1 mm/hr
Solar Radiation	Solar sensor	1 W/m^2	0 to 1800 W/m^2	5% of full scale
Inside Temperature	Included in Console	0.1°F; 0.1°C	+32° to +140°F; 0 to +60°C	1°F; 0.5°C

TABLE 3-1: WEATHER DATA SPECIFICATIONS

Variable	Required Sensors	Resolution	Range	Nominal Accuracy (+/-)
Outside Temperature[b]	ISS, Temp Station or Temp Hum Station	0.1°F; 0.1°C	-40 to +150°F; -40° to +65°C	1°F; 0.5°C
Extra Temperature	ISS, Temp Station, Temp Hum Station, Leaf Soil Station or Soil Station	1°F; 1°C	-40 to +150°F -40° to +65°C	1°F (0.5°C)
Heat Index	ISS or Temp/Hum Station	1°F; 1°C	-40 to +135°F; -40° to +57°C	3°F (1.5°C)
Temp-Hum-Sun-Wind index (THSW)	ISS & Solar Radiation	1°F; 1°C	-90 to +135°F; -68° to +64°C	4°F (2°C)
Time	Included in Console	1 min	24 hours	8 sec/mon
Date		1 day	month/day	8 sec/mon
UV Index	UV Radiation	0.1 Index	0 to 16	5% of full scale
UV Dose		0.1 MED < 20, 1 MED > 20	0 to 199 MEDs	5%
Wind Direction	Anemometer	1°	0 to 360°	7°
Compass Rose		22.5°	16 compass pts	0.3 compass pt
Wind Speed (large cups)		1 mph; 1 kt; 0.5 m/s; 1 km/h	2 to 150 mph; 2 to 130 kts 3 to 241 km/h, 1 to 68 m/s	greater of 2 mph/kts; 1 m/s; 3 km/h or 5%
Wind Speed (small cups)		1 mph; 1 kt; 0.5 m/s; 1 km/h	3 to 175 mph; 3 to 150 kts 1.5 to 79 m/s 5 to 282 km/h	greater of 3mph; 3 kts; 1 m/s; 5km/h or 5%
Wind Chill	ISS	1°F; 1°C	-120° to +130°F -84° to +54°C	2° F;1°C

***a** Barometric pressure readings are standardized to sea level. The range displayed is for the standardized value. The console can be set to standardize readings within an elevation range of -1500 to +12,500 (-460 to + 3810 m); however, the console screen limits selection and display of lower elevation to -999' when using feet as elevation unit.*

***b** Solar radiation induced error for standard radiation shield: +4°F (2°C) at solar noon; for fan-aspirated radiation shield: +0.6°F (0.3°C) at solar noon (insolation = 1040 W/m^2, avg. wind speed ≤ 2 mph (1 m/s), reference: RM Young Model 43408 Fan-Aspirated Radiation Shield)*

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FCC Part 15 Class B Registration Warning

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment on and off, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Changes or modification not expressly approved in writing by Davis Instruments may void the warranty and void the user's authority to operate this equipment.

Vantage Pro Console Icons

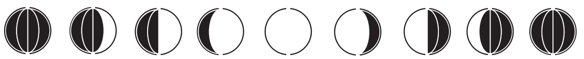
Console icons indicate weather conditions and special functions.

Forecast

Mostly Clear Partly Cloudy Mostly Cloudy Rain Likely Snow

Indicates the weather forecast for the next 12 hours.

Moon Phase



New Moon First Quarter Full Moon Last Quarter New Moon

Shows the current moon phase. Sequence shown for Northern Hemisphere. Reverse sequence for the Southern Hemisphere.

Alarm Bell

Flashes when an alarm is triggered. Also indicates when the console is in Alarm Mode.

Graph

Appears next to the currently selected weather variable. Also indicates the graphed variable on most screens.

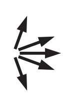
Second Function

Appears when you press **2ND** *key. Indicates that console key secondary functions are enabled.*

Rain

Appears when the console is currently detecting rain.

Barometric Pressure Trend



Arrows show direction of pressure change for last three hours.

Davis Instruments

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Appendix E.4
CR1000 Data Logger Brochure

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CR1000

measurement & control datalogger

A rugged instrument with research-grade performance.

CR1000

Measurement & Control System

The CR1000 provides precision measurement capabilities in a rugged, battery-operated package. It consists of a measurement and control module and a wiring panel. Standard operating range is -25° to +50°C; an optional extended range of -55° to +85°C is available.

Input/Output Connections—Individually configured for ratiometric resistive bridge, thermocouple, switch closure, high frequency pulse, low-level ac, serial sensors, and more.

Removable Power Terminal—simplifies connection to external power supply.

CS I/O Port—connects with AC-powered PCs and communication peripherals such as phone, RF, short-haul, and multidrop modems.

Peripheral Port—one 40-pin port interfaces with a CFM100 or NL115 module, which store data on a CompactFlash card. The NL115 also supports Ethernet communications.

RS-232—provides a 9-pin DCE port for connecting a battery-powered laptop, serial sensors or RS-232 modems.

Features

- 4 Mbyte memory*
- Program execution rate of up to 100 Hz
- CS I/O and RS-232 serial ports
- 13-bit analog to digital conversions
- 16-bit H8S Renesas Microcontroller with 32-bit internal CPU architecture
- Temperature compensated real-time clock
- Background system calibration for accurate measurements over time and temperature changes
- Single DAC used for excitation and measurements to give ratio metric measurements
- Gas Discharge Tube (GDT) protected inputs
- Data values stored in tables with a time stamp and record number
- Battery-backed SRAM memory and clock ensuring data, programs, and accurate time are maintained while the CR1000 is disconnected from its main power source
- Measures intelligent serial sensors without using an SDM-SIO4

Measurement and Control Module

The module measures sensors, drives direct communications and telecommunications, reduces data, controls external devices, and stores data and programs in on-board, non-volatile storage. The electronics are RF shielded and glitch protected by the sealed, stainless steel canister. A battery-backed clock assures accurate timekeeping. The module can simultaneously provide measurement and communication functions. The on-board, BASIC-like programming language supports data processing and analysis routines.

Wiring Panel

The CR1000WP is a black, anodized aluminum wiring panel that is compatible with all CR1000 modules. The wiring panel includes switchable 12 V, redistributed analog grounds (dispersed among analog channels rather than grouped), unpluggable terminal block for 12 V connections, gas-tube spark gaps, and 12 V supply on pin 8 to power our COM-series phone modems and other peripherals. The control module easily disconnects from the wiring panel allowing field replacement without rewiring the sensors. A description of the wiring panel's input/output channels follows.

**Originally, the standard CR1000 had 2 Mbytes of data/program storage, and an optional version, the CR1000-4M, had 4 Mbytes of memory. In September 2007, the standard CR1000 started having 4 Mbytes of memory, making the CR1000-4M obsolete. Dataloggers that have a module with a serial number greater than or equal to 11832 will have a 4 Mbyte memory. The 4 Mbyte dataloggers will also have a sticker on the canister stating "4M Memory".*

Analog Inputs

Eight differential (16 single-ended) channels measure voltage levels. Resolution on the most sensitive range is 0.67 µV.

Pulse Counters

Two pulse channels can count pulses from high level (5 V square wave), switch closure, or low level AC signals.

Switched Voltage Excitations

Three outputs provide precision excitation voltages for resistive bridge measurements.

Digital I/O Ports

Eight ports are provided for frequency measurements, digital control, and triggering. Three of these ports can also be used to measure SDM devices. The I/O ports can be paired as transmit and receive for measuring smart serial sensors.

CS I/O Port

AC-powered PCs and many communication peripherals connect with the CR1000 via this port. Connection to an AC-powered PC requires either an SC32B or SC-USB interface. These interfaces isolate the PC's electrical system from the datalogger, thereby protecting against ground loops, normal static discharge, and noise.

RS-232 Port

This non-isolated port is for connecting a battery-powered laptop, serial sensor, or RS-232 modem. Because of ground loop potential on some measurements (e.g., low level single-ended measurements), AC-powered PCs should use the CS I/O port instead of the RS-232 port (see above).

Peripheral Port

One 40-pin port interfaces with the CFM100 CompactFlash® Module or the NL115 Ethernet Interface and CompactFlash Module.

Switched 12 Volt

This terminal provides unregulated 12 V that can be switched on and off under program control.

Power Supplies

Any 12 Vdc source can power the CR1000; a PS100 or BPALK is typically used. The PS100 provides a 7-Ahr sealed rechargeable battery that should be connected to a charging source (either a wall charger or solar panel). The BPALK consists of eight non-rechargeable D-cell alkaline batteries with a 7.5-Ahr rating at 20°C.

Also available are the BP12 and BP24 battery packs, which provide nominal ratings of 12 and 24 Ahrs, respectively. These batteries should be connected to a regulated charging source (e.g., a CH100 connected to a unregulated solar panel or wall charger). For information about analyzing the system's power requirements, see our Power Supply product literature or Application Note 5-F. Both can be obtained from: www. campbellsci.com

Storage Capacity

The CR1000 has 2 Mbyte of FLASH memory for the Operating System, and 4 Mbytes of battery-backed SRAM for CPU usage, program storage, and data storage. Data is stored in a table format. The storage capacity of the CR1000 can be increased by using a CompactFlash card.

Enclosure/Stack Bracket

A CR1000 housed in a weather-resistant enclosure can collect data under extremely harsh conditions. The enclosure protects the CR1000 from dust, water, sunlight, or pollutants. An internal mounting plate is prepunched for easy system configuration and exchange of equipment in the field.

The 17565 Stack Bracket allows a small peripheral to be placed under the mounting bracket, thus conserving space. With the bracket, the CR1000 can be attached in a "horizontal" orientation (i.e., the long axis of the CR1000 spanning the short axis of the ENC10/12 enclosure). This stack bracket also places the terminals on the wiring panel at about the same height as the terminals on a PS100.

The stack bracket as viewed from the side with a CR1000 attached.

Communication Protocols

The CR1000 supports the PakBus® communication protocol. PakBus networks have the distributed routing intelligence to continually evaluate links. Continually evaluating links optimizes delivery times and, in the case of delivery failure, allows automatic switch over to a configured backup route.

The CR1000 also supports Modbus RTU protocol—both floating point and long formats. The datalogger can act as a slave, master, or both.

Data Storage and Retrieval Options

To determine the best option for an application, consider the accessibility of the site, availability of services (e.g., cellular phone or satellite coverage), quantity of data to collect, and desired time between data-collection sessions. Some communication options can be combined—increasing the flexibility, convenience, and reliability of the communications.

Radios

Radio frequency (RF) communications are supported via narrow-band UHF, narrow-band VHF, spread spectrum, or meteor burst radios. Line-of-sight is required for all of our RF options.

Meteorological conditions measured at Lake Louise, Alberta, Canada are telemetered via phone-to-RF link to a base station.

Telephone Networks

The CR1000 can communicate with a PC using landlines, cellular CDMA, or cellular GPRS/EDGE transceivers. A voice synthesized modem enables anyone to call the CR1000 via phone and receive a verbal report of real-time site conditions.

Multidrop Interface

The MD485 intelligent RS-485 interface permits a PC to address and communicate with one or more dataloggers over a single two-twisted-pair cable. Distances up to 4000 feet are supported.

Short Haul Modems

The SRM-5A RAD Short Haul Modem supports communications between the CR1000 and a PC via a four-wire unconditioned line (two twisted pairs).

Direct Links

AC-powered PCs connect with the datalogger's CS I/O port via an SC32B or SC-USB interface. These interfaces provide optical isolation. A battery-powered laptop can be attached to the CR1000's RS-232 port via an RS-232 cable; no interface required.

Keyboard Display

The CR1000KD can be used to program the CR1000, manually initiate data transfer, and display data. The CR1000KD displays 8 lines x 21 characters (64 x 128 pixels) and has a 16-character keyboard. Custom menus are supported allowing customers to set up choices within the datalogger program that can be initiated by a simple "toggle" or "pick list".

Ethernet

Use of an NL100 or NL115 interface enables the CR1000 to communicate over a local network or a dedicated Internet connection via TCP/IP. The NL115 also supports data storage on a CompactFlash card.

CD295 DataView II Display

This two-line, 32-character LCD displays one real-time value, a description, and units. It is typically mounted in an enclosure lid, which allows customers to view the CR1000's data on-site without opening the enclosure.

CompactFlash®

A CFM100 or NL115 module attached to a CR1000 can store data on a CompactFlash (CF) card. The PC reads the CF card using either the CF1 CompactFlash Adapter or an ImageMate® Reader/Writer. Please note that the CF card should be industrial-grade with a storage capacity of 2 Gbytes or less.

PDAs

Customers can set the CR1000's clock, monitor real-time data, retrieve data, graph data, and transfer CR1000 programs via a PDA. PDAs with a Palm™ OS require PConnect software (purchased separately); PDAs with a Windows® Pocket PC/Windows Mobile OS require PConnectCE software (purchased separately).

Satellite Transmitters

Our NESDIS-certified GOES satellite transmitter provides one-way communications from a Data Collection Platform (DCP) to a receiving station. We also offer an Argos transmitter that is ideal for high-altitude and polar applications and a METEOSAT transmitter for European applications.

This station for the National Estuarine Research Reserve (NERR) in Virginia transmits data via our GOES satellite transmitter.

Channel Expansion

Synchronous Devices for Measurement (SDMs)

SDMs are addressable peripherals that expand the CR1000's measurement and control capabilities. For example, SDMs are available to add control ports, analog outputs, pulse count channels, interval timers, or even a CANbus interface to the system. Multiple SDMs, in any combination, can be connected to one CR1000 datalogger.

Multiplexers

Multiplexers increase the number of sensors that can be measured by a CR1000 by sequentially connecting each sensor to the datalogger. Several multiplexers can be controlled by a single CR1000. The CR1000 is compatible with the AM16/32B and AM25T.

4-Channel Low Level AC Module

The LLAC4 is a small peripheral device that allows customers to increase the number of available low-level ac inputs by using control ports. This module is often used to measure up to four anemometers, and is especially useful for wind profiling applications.

The LLAC4 mounts directly to the backplate of our environmental enclosures.

Software

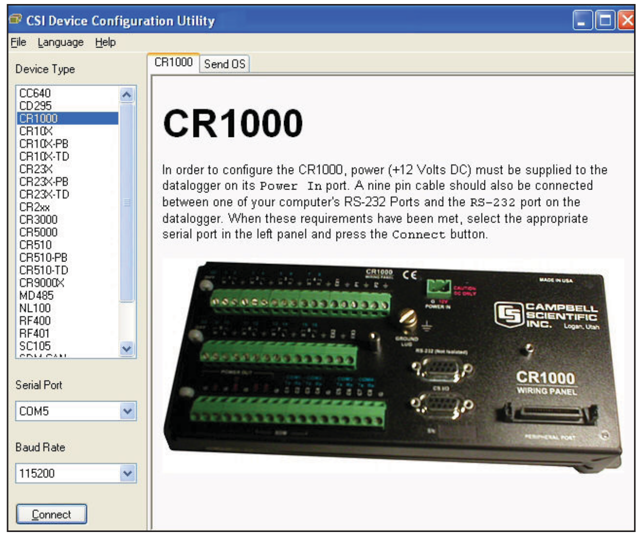
Starter Software

Our easy-to-use starter software is intended for first time users or applications that don't require sophisticated communications or datalogger program editing. SCWin Short Cut generates straight-forward CR1000 programs in four easy steps. PC200W allows customers to transfer a program to, or retrieve data from a CR1000 via a direct communications link.

At www.campbellsci.com/downloads you can download starter software at no charge. Our Resource CD also provides this software as well as PDF versions of our brochures and manuals.

Datalogger Support Software

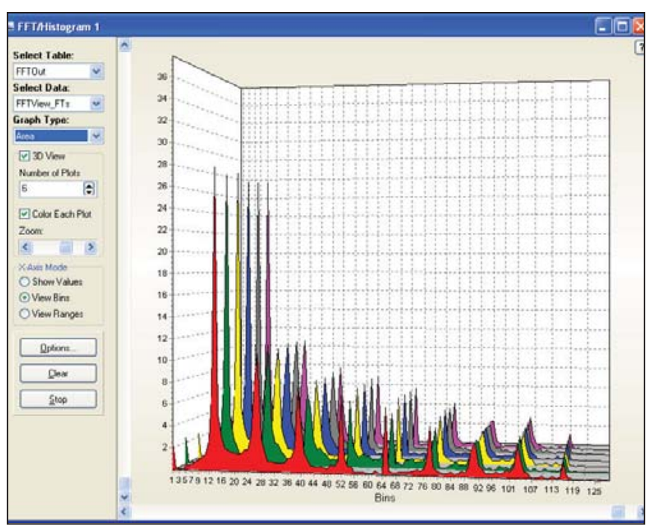
Our datalogger support software packages provide more capabilities than our starter software. These software packages contains program editing, communications, and display tools that can support an entire datalogger network.



Our device configuration (DevConfig) utility is bundled with PC400, LoggerNet, and RTDAQ and can be downloaded, at no charge, from our Web site. DevConfig allows you to send new operating systems to the CR1000.

PC400, our mid-level software, supports a variety of telemetry options, manual data collection, and data display. For programming, it includes both Short Cut and the CRBasic program editor. PC400 does not support combined communication options (e.g., phone-to-RF), PakBus® routing, or scheduled data collection.

LoggerNet is Campbell Scientific's full-featured datalogger support software. It is referred to as "full-featured" because it provides a way to accomplish almost all the tasks you'll need to complete when using a datalogger. It supports combined communication options (e.g., phone-to-RF), PakBus® routing, or scheduled data collection.



The CR1000 is also compatible with RTDAQ Real-Time Data Acquisition Software.. FFT is an example of the many real-time data displays offered by RTDAQ that allow you to view the measurements instantly.

Applications

The measurement precision, flexibility, long-term reliability, and economical price of the CR1000 make it ideal for scientific, commercial, and industrial applications.

Meteorology

The CR1000 is used in long-term climatological monitoring, meteorological research, and routine weather measurement applications.

Our rugged, reliable weather station measures meteorological conditions at St. Mary's Lake, Glacier National Park, MT.

Sensors the CR1000 can measure include:

- cup, propeller, and sonic anemometers
- tipping bucket rain gages
- wind vanes
- pyranometers
- ultrasonic ranging sensor
- thermistors, RTDs, and thermocouples
- barometric pressure sensors
- RH sensors
- cooled mirror hygrometers

Agriculture and Agricultural Research

The versatility of the CR1000 allows measurement of agricultural processes and equipment in applications such as:

- plant water research
- canopy energy balance
- machinery performance
- plant pathology
- crop management decisions
- food processing/storage
- frost prediction
- irrigation scheduling
- integrated pest management

This vitaculture site in Australia integrates meteorological, soil, and crop measurements.

Wind Profiling

Our data acquisition systems can monitor conditions at wind assessment sites, at producing wind farms, and along transmission lines. TThe CR1000 makes and records measurements, controls electrical devices, and can function as PLCs or RTUs. Because the datalogger has its own power supply (batteries, solar panels), it can continue to measure and store data and perform control during power outages.

Typical sensors for wind assessment applications include, but are not limited to:

- sonic anemometers
- three-cup and propeller anemometers (up to 10 anemometers can be measured by using two LLAC4 peripherals)
- wind vanes
- temperature sensors
- barometric pressure
- wetness
- solar radiation

Photo courtesy npower renewables

A Campbell Scientific system monitors an offshore wind farm in North Wales.

For turbine performance applications, the CR1000 monitors electrical current, voltage, wattage, stress, and torque.

Soil Moisture

The CR1000 is compatible with the following soil moisture measurement technologies:

- Soil moisture blocks are inexpensive sensors that estimate soil water potential.
- Matric water potential sensors also estimate soil water potential but are more durable than soil moisture blocks.
- Time-Domain Reflectometry Systems (TDR) use a reflectometer controlled by a CR1000 to accurately measure soil water content. Multiplexers allow sequential measurement of a large number of probes by one reflectometer, reducing cost per measurement.
- Self-contained water content reflectometers are sensors that emit and measure a TDR pulse.
- Tensiometers measure the soil pore pressure of irrigated soils and calculate soil moisture.

Air Quality
The CR1000 can monitor and control gas analyzers, particle samplers, and visibility sensors. It can also automatically control calibration sequences and compute conditional averages that exclude invalid data (e.g., data recorded during power failures or calibration intervals).

Road Weather/RWIS
Our fully NTCIP-compliant Environmental Sensor Stations (ESS) are robust, reliable weather stations used for road weather/RWIS applications. A typical ESS includes a tower, CR1000, two road sensors, remote communication hardware, and sensors that measure wind speed and direction, air temperature, humidity, barometric pressure, solar radiation, and precipitation.

Water Resources/Aquaculture
Our CR1000 is well-suited to remote, unattended monitoring of hydrologic conditions. Most hydrologic sensors, including SDI-12 probes, interface directly to the CR1000. Typical hydrologic measurements:

- **Water level** is monitored with incremental shaft encoders, double bubblers, ultrasonic ranging sensors, resistance tapes, strain gage pressure transducers, or vibrating wire pressure transducers. Vibrating wire transducers require an AVW200-series or another Vibrating Wire Interface.
- **Ionic conductivity measurements** use one of the switched excitation ports from the CR1000.
- **Samplers** are controlled by the CR1000 as a function of time, water quality, or water level.
- **Alarm and pump actuation** are controlled through digital I/O ports that operate external relay drivers.

A turbidity sensor was installed in a tributary of the Cedar River watershed to monitor water quality conditions for the city of Seattle, Washington.

Vehicle Testing
This versatile, rugged datalogger is ideally suited for testing cold and hot temperature, high altitude, off-highway, and cross-country performance. The CR1000 is compatible with our SDM-CAN interface, GPS16-HVS receiver, and DSP4 Heads Up Display.

Vehicle monitoring includes not only passenger cars, but airplanes, locomotives, helicopters, tractors, buses, heavy trucks, drilling rigs, race cars, and motorcycles.

The CR1000 can measure:

- **Suspension**—strut pressure, spring force, travel, mounting point stress, deflection, ride
- **Fuel system**—line and tank pressure, flow, temperature, injection timing
- **Comfort control**—ambient and supply air temperature, solar radiation, fan speed, ac on and off, refrigerant pressures, time-to-comfort, blower current
- **Brakes**—line pressure, pedal pressure and travel, ABS, line and pad temperature
- **Engine**—pressure, temperature, crank position, RPM, time-to-start, oil pump cavitation
- **General vehicle**—chassis monitoring, road noise, vehicle position and speed, steering, air bag, hot/cold soaks, wind tunnels, traction, CANbus, wiper speed and current, vehicle electrical loads

Other Applications
- Eddy covariance systems
- Wireless sensor/datalogger networks
- Mesonet systems
- Avalanche forecasting, snow science, polar, high altitude
- Fire weather
- Geotechnical
- Historic preservation

CR1000 Specifications

Electrical specifications are valid over a -25° to +50°C range unless otherwise specified; non-condensing environment required. To maintain electrical specifications, Campbell Scientific recommends recalibrating dataloggers every two years. We recommend that the system configuration and critical specifications are confirmed with Campbell Scientific before purchase.

PROGRAM EXECUTION RATE

10 ms to 30 min. @ 10 ms increments

ANALOG INPUTS

8 differential (DF) or 16 single-ended (SE) individually configured. Channel expansion provided by AM16/32 and AM25T multiplexers.

RANGES and RESOLUTION: Basic resolution (Basic Res) is the A/D resolution of a single conversion. **Resolution of DF measurements with input reversal is half the Basic Res.**

Input Referred Noise Voltage

Input Range (mV)[1]	*DF Res (μV)*[2]	*Basic Res (μV)*
±5000	667	1333
±2500	333	667
±250	33.3	66.7
±25	3.33	6.7
±7.5	1.0	2.0
±2.5	0.33	0.67

[1]Range overhead of ~9% exists on all ranges to guarantee that full-scale values will not cause over-range.

[2]Resolution of DF measurements with input reversal.

ACCURACY[3]:
±(0.06% of reading + offset), 0° to 40°C
±(0.12% of reading + offset), -25° to 50°C
±(0.18% of reading + offset), -55° to 85°C

[3]The sensor and measurement noise are not included and the offsets are the following:

Offset for DF w/input reversal = 1.5·Basic Res + 1.0 μV
Offset for DF w/o input reversal = 3·Basic Res + 2.0 μV
Offset for SE = 3·Basic Res + 3.0 μV

INPUT NOISE VOLTAGE: For DF measurements with input reversal on ±2.5 mV input range; digital resolution dominates for higher ranges.

250 μs Integration: 0.34 μV RMS
50/60 Hz Integration: 0.19 μV RMS

MINIMUM TIME BETWEEN VOLTAGE MEASUREMENTS: Includes the measurement time and conversion to engineering units. For voltage measurements, the CR1000 integrates the input signal for 0.25 ms or a full 16.66 ms or 20 ms line cycle for 50/60 Hz noise rejection. DF measurements with input reversal incorporate two integrations with reversed input polarities to reduce thermal offset and common mode errors and therefore take twice as long.

250 μs Analog Integration: ~1 ms SE
1/60 Hz Analog Integration: ~20 ms SE
1/50 Hz Analog Integration: ~25 ms SE

COMMON MODE RANGE: ±5 V

DC COMMON MODE REJECTION: >100 dB

NORMAL MODE REJECTION: 70 dB @ 60 Hz when using 60 Hz rejection

SUSTAINED INPUT VOLTAGE W/O DAMAGE: ±16 Vdc max.

INPUT CURRENT: ±1 nA typical, ±6 nA max. @ 50°C; ±90 nA @ 85°C

INPUT RESISTANCE: 20 Gohms typical

ACCURACY OF BUILT-IN REFERENCE JUNCTION THERMISTOR (for thermocouple measurements):
±0.3°C, -25° to 50°C
±0.8°C, -55° to 85°C (-XT only)

ANALOG OUTPUTS

3 switched voltage, active only during measurement, one at a time.

RANGE AND RESOLUTION: Voltage outputs programmable between ±2.5 V with 0.67 mV resolution.

ACCURACY: ±(0.06% of setting + 0.8 mV), 0° to 40°C
±(0.12% of setting + 0.8 mV), -25° to 50°C
±(0.18% of setting + 0.8 mV), -55° to 85°C (-XT only)

CURRENT SOURCING/SINKING: ±25 mA

RESISTANCE MEASUREMENTS

MEASUREMENT TYPES: The CR1000 provides ratiometric measurements of 4- and 6-wire full bridges, and 2-, 3-, and 4-wire half bridges. Precise, dual polarity excitation using any of the 3 switched voltage excitations eliminates dc errors.

RATIO ACCURACY[3]: Assuming excitation voltage of at least 1000 mV, not including bridge resistor error.

±(0.04% of voltage reading + offset)/V_x

[3]The sensor and measurement noise are not included and the offsets are the following:

Offset for DF w/input reversal = 1.5·Basic Res + 1.0 μV
Offset for DF w/o input reversal = 3·Basic Res + 2.0 μV
Offset for SE = 3·Basic Res + 3.0 μV

Offset values are reduced by a factor of 2 when excitation reversal is used.

PERIOD AVERAGING MEASUREMENTS

The average period for a single cycle is determined by measuring the average duration of a specified number of cycles. The period resolution is 192 ns divided by the specified number of cycles to be measured; the period accuracy is ±(0.01% of reading + resolution). Any of the 16 SE analog inputs can be used for period averaging. Signal limiting are typically required for the SE analog channel.

INPUT FREQUENCY RANGE:

Input Range	*Signal (peak to peak)*[4] *Min*	*Max*	*Min. Pulse W.*	*Max*[5] *Freq.*
±2500 mV	500 mV	10 V	2.5 μs	200 kHz
±250 mV	10 mV	2 V	10 μs	50 kHz
±25 mV	5 mV	2 V	62 μs	8 kHz
±2.5 mV	2 mV	2 V	100 μs	5 kHz

[4]The signal is centered at the datalogger ground.

[5]The maximum frequency = 1/(Twice Minimum Pulse Width) for 50% of duty cycle signals.

PULSE COUNTERS

Two 24-bit inputs selectable for switch closure, high-frequency pulse, or low-level AC.

MAXIMUM COUNTS PER SCAN: 16.7×10^6

SWITCH CLOSURE MODE:
Minimum Switch Closed Time: 5 ms
Minimum Switch Open Time: 6 ms
Max. Bounce Time: 1 ms open w/o being counted

HIGH-FREQUENCY PULSE MODE:
Maximum Input Frequency: 250 kHz
Maximum Input Voltage: ±20 V
Voltage Thresholds: Count upon transition from below 0.9 V to above 2.2 V after input filter with 1.2 μs time constant.

LOW-LEVEL AC MODE: Internal AC coupling removes AC offsets up to ±0.5 V.

Input Hysteresis: 16 mV @ 1 Hz
Maximum ac Input Voltage: ±20 V
Minimum ac Input Voltage:

Sine wave (mV RMS)	*Range (Hz)*
20	1.0 to 20
200	0.5 to 200
2000	0.3 to 10,000
5000	0.3 to 20,000

DIGITAL I/O PORTS

8 ports software selectable, as binary inputs or control outputs. C1-C8 also provide edge timing, subroutine interrupts/wake up, switch closure pulse counting, high frequency pulse counting, asynchronous communications (UART), SDI-12 communications, and SDM communications.

HIGH-FREQUENCY PULSE MAX: 400 kHz

SWITCH CLOSURE FREQUENCY MAX: 150 Hz

OUTPUT VOLTAGES (no load): high 5.0 V ±0.1 V; low <0.1

OUTPUT RESISTANCE: 330 ohms

INPUT STATE: high 3.8 to 5.3 V; low -0.3 to 1.2 V

INPUT HYSTERISIS: 1.4 V

INPUT RESISTANCE: 100 kohms

SWITCHED 12 V

One independent 12 V unregulated sources switched on and off under program control. Thermal fuse hold current = 900 mA @ 20°C, 650 mA @ 50°C, 360 mA @ 85°C.

SDI-12 INTERFACE SUPPORT

Control ports 1, 3, 5, and 7 may be configured for SDI-12 asynchronous communications. Up to ten SDI-12 sensors are supported per port. It meets SDI-12 Standard version 1.3 for datalogger mode.

CE COMPLIANCE

STANDARD(S) TO WHICH CONFORMITY IS DECLARED: IEC61326:2002

CPU AND INTERFACE

PROCESSOR: Renesas H8S 2322 (16-bit CPU with 32-bit internal core)

MEMORY: 2 Mbytes of Flash for operating system; 4 Mbytes of battery-backed SRAM for CPU usage, program storage and data storage.

SERIAL INTERFACES: CS I/O port is used to interface with Campbell Scientific peripherals; RS-232 port is for computer or non-CSI modem connection.

PARALLEL INTERFACE: 40-pin interface for attaching data storage or communication peripherals such as the CFM100 module

BAUD RATES: Selectable from 300 bps to 115.2 kbps. ASCII protocol is one start bit, one stop bit, eight data bits, and no parity.

CLOCK ACCURACY: ±3 min. per year

SYSTEM POWER REQUIREMENTS

VOLTAGE: 9.6 to 16 Vdc (reverse polarity protected)

TYPICAL CURRENT DRAIN:
Sleep Mode: ~0.6 mA
1 Hz Scan (8 diff. meas., 60 Hz rej., 2 pulse meas.)
w/RS-232 communication: 19 mA
w/o RS-232 communication: 4.2 mA
1 Hz Scan (8 diff. meas., 250 μs integ., 2 pulse meas.)
w/RS-232 communication: 16.7 mA
w/o RS-232 communication: 1 mA
100 Hz Scan (4 diff. meas., 250 μs integ.)
w/RS-232 communication: 27.6 mA
w/o RS-232 communication: 16.2 mA

CR1000KD CURRENT DRAIN:
Inactive: negligible
Active w/o backlight: 7 mA
Active w/backlight: 100 mA

EXTERNAL BATTERIES: 12 Vdc nominal

PHYSICAL SPECIFICATIONS

MEASUREMENT & CONTROL MODULE SIZE: 8.5" x 3.9" x 0.85" (21.6 x 9.9 x 2.2 cm)

CR1000WP WIRING PANEL SIZE: 9.4" x 4" x 2.4" (23.9 x 10.2 x 6.1 cm); additional clearance required for serial cable and sensor leads.

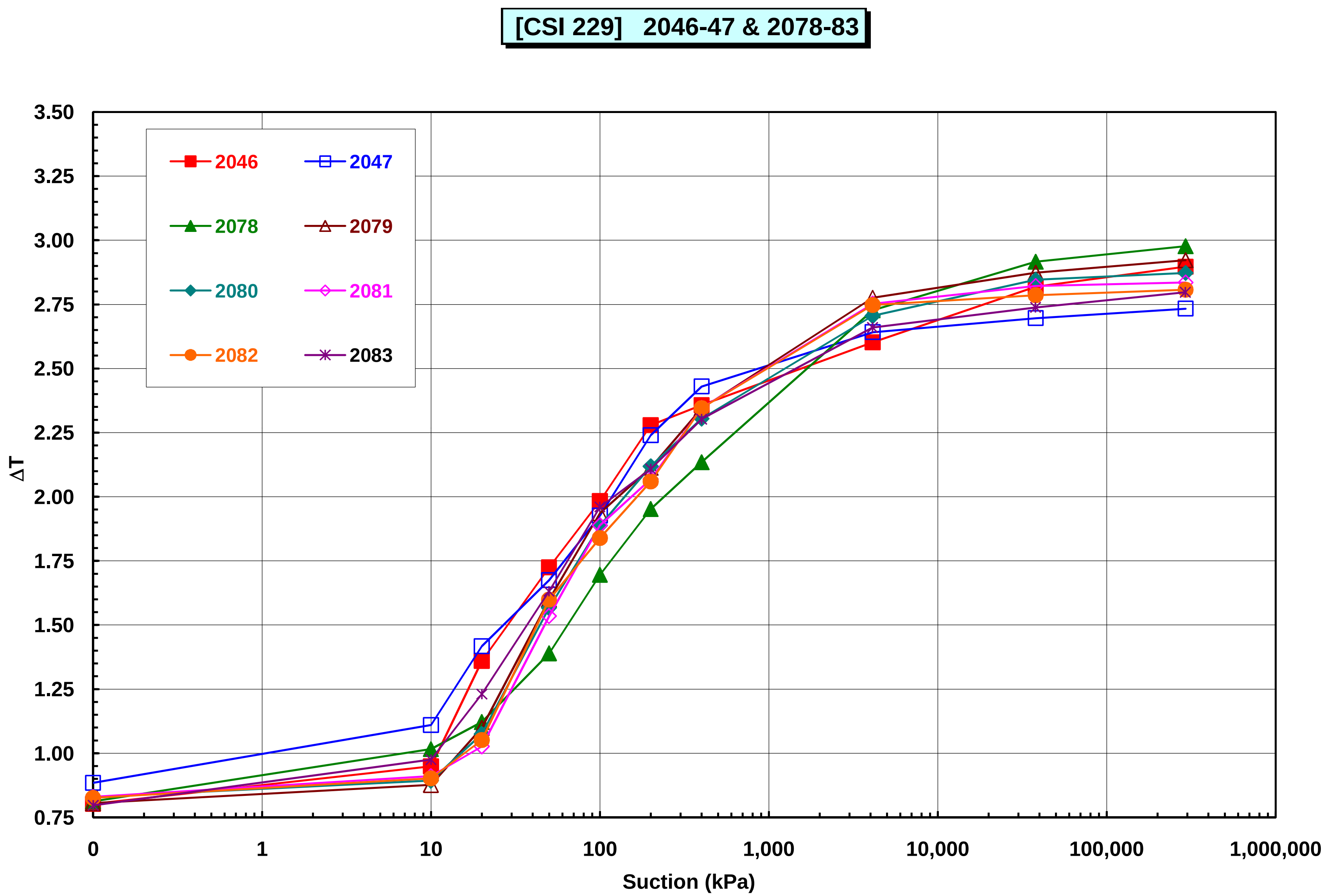
WEIGHT: 2.1 lbs (1 kg)

WARRANTY

Three years against defects in materials and workmanship.

11564 149 Street | Edmonton, AB T5M 1W7 | CAN | phone (780) 454-2505 | www.campbellsci.ca
Australia | Brazil | Canada | England | France | Germany | South Africa | Spain | USA [headquarters]

Appendix F
Matric Suction Sensor Material Specific Calibration Curves



[CSI 229] 2046-47 & 2078-83
2046
2047
2078
2079
2080
2081
2082
2083
ΔT
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0
1
10
100
1,000
10,000
100,000
1,000,000
Suction (kPa)

Summary of sensor calibration for the 229 Thermal Conductivity Sensors installed at the Faro lysimeters

CSCC Suction Sensors	Matric							
OKC	2046	2047	2078	2079	2080	2081	2082	2083
CSI								
(kPa)	(ΔT)	(ΔT)	(ΔT)	(ΔT)	(ΔT)	(ΔT)	(ΔT)	(ΔT)
0.1	0.8027	0.8847	0.8130	0.8055	0.8298	0.8302	0.8261	0.7969
10	0.9491	1.1100	1.0167	0.8768	0.8936	0.9110	0.9022	0.9751
20	1.3600	1.4174	1.1223	1.0993	1.0752	1.0266	1.0510	1.2306
50	1.7245	1.6750	1.3898	1.5988	1.5668	1.5349	1.5990	1.6318
100	1.9832	1.9262	1.6961	1.9359	1.8876	1.8885	1.8389	1.9604
200	2.2794	2.2398	1.9524	2.1130	2.1186	2.0687	2.0593	2.1082
400	2.3575	2.4300	2.1345	2.3444	2.3045	2.3462	2.3453	2.3025
4120	2.6022	2.6418	2.7267	2.7752	2.7049	2.7526	2.7468	2.6596
38000	2.8190	2.6965	2.9158	2.8724	2.8455	2.8214	2.7852	2.7379
293000	2.8967	2.7331	2.9764	2.9216	2.872	2.8351	2.8064	2.7972

Sensor Normalization values for Sentek EnviroScan sensors installed at the Faro Lysimeters.

Sensor #	Air Count	Water Count
1	36663	25147
2	37203	24860
3	37615	25257
4	36836	24860
5	36819	24833
6	36917	24952
7	36216	24871
8	36434	24887
9	36505	25147
10	37461	24671
11	36899	24984
12	37039	25057
13	36456	24593
14	37071	25001
15	37296	25002
16	37037	25073
17	36618	24782
18	37001	25049
19	37002	24952
20	36766	25008

Appendix G
Construction Photos

Photo 1: Glacial Till Borrow Site

Photo 2: Top layer of Waste Rock removed from the surface of L#1

Photo 3: L#1 roughly excavated (Rolls of Bitumen Liner in the right hand side of the picture)

Photo 4: Sloping the sides of L#2

Photo 5: Reshaping the slopes of L#1

Photo 6: L#2 excavated with drainage pipe trench open

Photo 7: Partially placed liner in L#2

Photo 8: Placing the liner in L#1

Photo 9: Liner place in both Lysimeters

Photo 10: Drainage Geo-Net placed in L#1

Photo 11: Perimeter Drainage Pipe welded into the Liner

Photo 12: Central Drainage Pipe intake installed and welded into the liner of L#2

Photo 13: Tears in the Liner of L#2

Photo 14: Repaired tears in the Liner on L#2

Photo 15: Placing the First Layer of Waste Rock backfill in L#1

Photo 16: Placing the second layer of Waste Rock Backfill on L#2

Photo 17: Compacting the Waste Rock Backfill

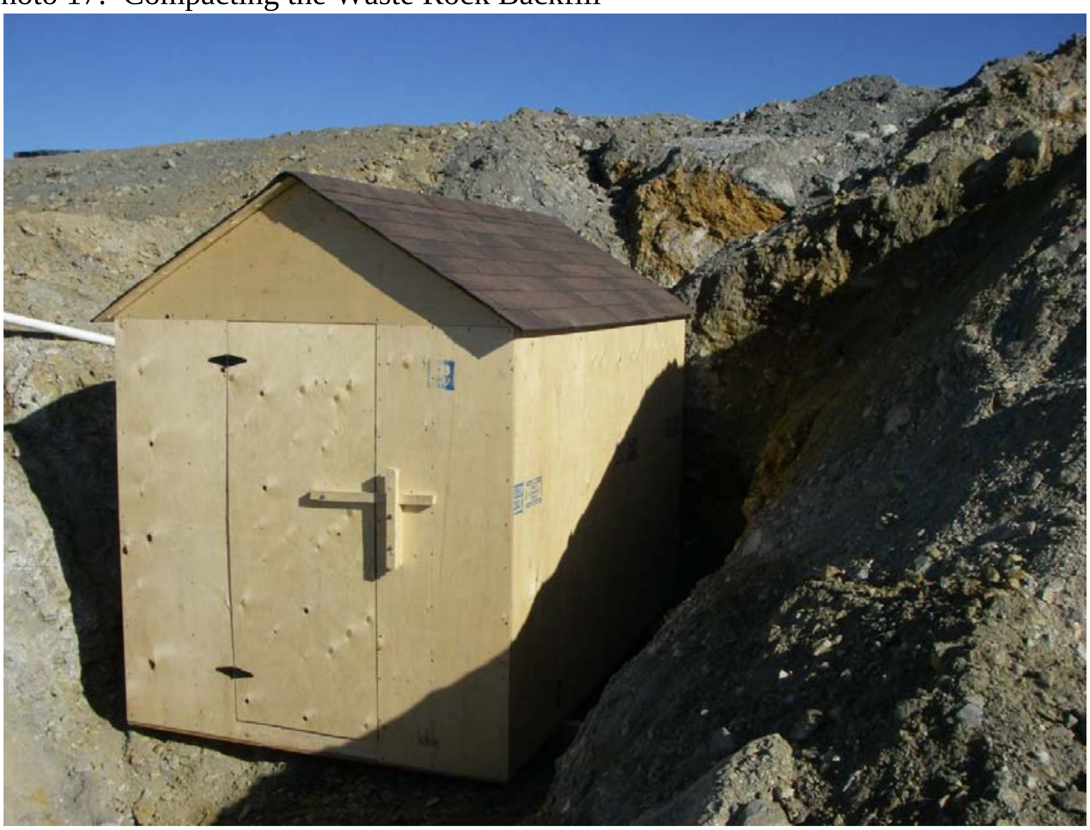


Photo 18: Front View of Instrument Hut

Photo 19: Rear View of Instrument Hut

Photo 20: Backfilling the Wiring Trench

Photo 21: Excavating the Test Pit on L#2 for installation of the Matric Suction Sensors

Photo 22: Matric Suction Sensors installed in the Test Pit on L#2

Photo 23: Backfilling the Wire Trench on L#2

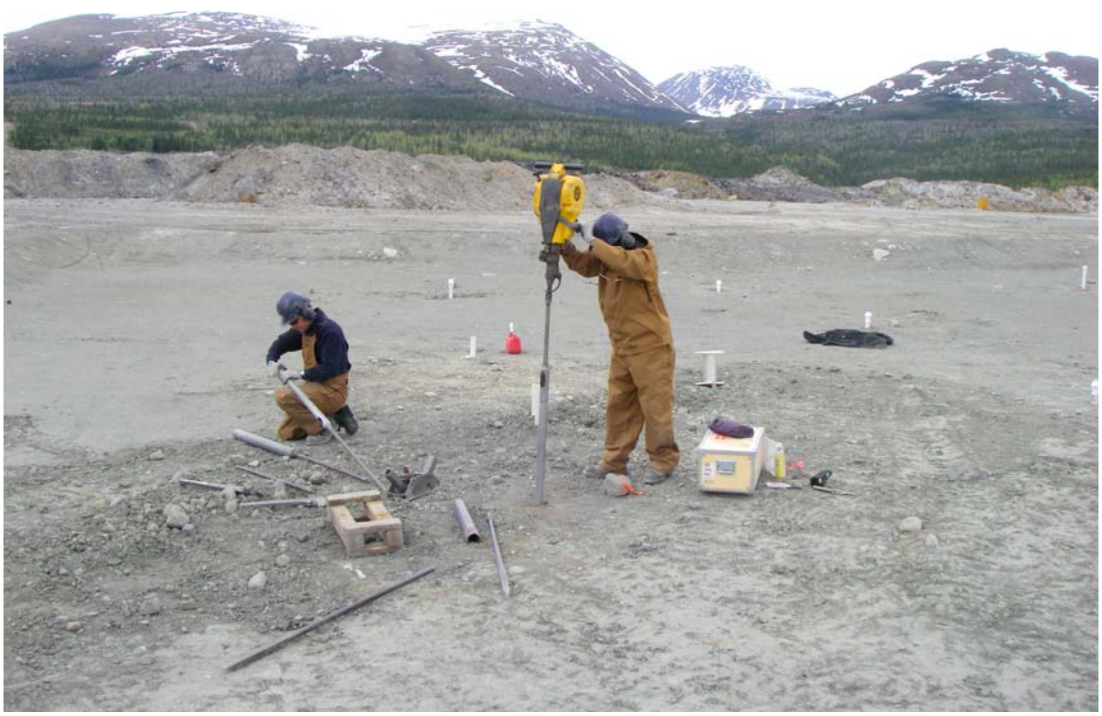


Photo 24: Drilling the Holes for the Diviner Access Tubes on L#2

Photo 25: Sentek EnviroScan Probe Being Lowered Into Access Tube

Photo 26: Hummocky finish of Till Surface on L#1

Photo 27: Top Cap Assembly of a Diviner Access Tube on L#1. Note that the cover was revegetated during fall of the previous year

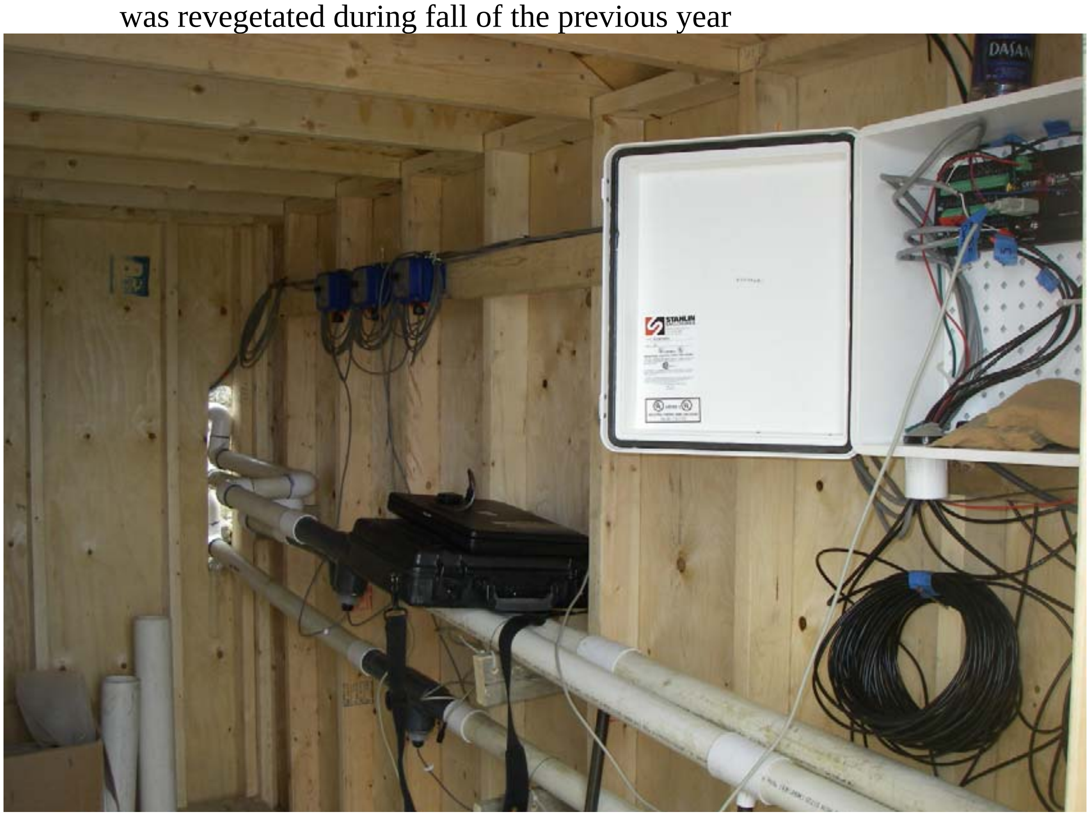


Photo 28: Detail of the Instrument Hut with the CR1000 Data Logger Housing Box in the foreground and the Flow Meter data loggers in the background

Photo 29: Detail of the Instrument Hut with the CR1000 data logger Housing box on top and the Tiping Bucket Flow Gauges on the Bottom of the photo