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1 INTRODUCTION

The Lake Diagnostic System (LDS) is a unique diagnostic system developed at the Centre for Water Research, designed to assist in the management of lakes and reservoirs. The system consists of a lake station and shore station, that communicate via telemetry. The lake station measures the water column temperature profile and the wind speed at the center of the lake. The lake station is controlled by the LAKEMON software at the shore based station, where the data is collected almost in real-time via telemetry. The LDS is also available with optional meteorological sensors, conductivity sensors or dissolved oxygen sensors and radio or cellular phone telemetry.

As well as its role for data acquisition, LAKEMON uses the temperature and wind speed to calculate the Lake Number, which characterises the strength of the mixing activity in the lake. The Lake Number has been shown to give good indication of the dynamic physical behaviour of the lakes and reservoirs. With a knowledge of the mixing activity and historical water quality data for the lake, LAKEMON will use empirical relationships to model the concentrations of dissolved oxygen and metal ions, such as manganese and iron, at depth in the lake.

The Lake Number is dependent on the degree of stratification in the lake and the wind speed over the surface of the lake. If the Lake Number is below the critical value, oxygen can reach the bottom. If the Lake Number is consistently greater than the critical value, then biological uptake decreases oxygen levels. Hence, the water quality in the lake may be influenced by changing the stratification of the water column and this may be done by installing either a bubble plume generator or a series of mixing pumps. Coupled with a destratification system, the LDS is a valuable diagnostic and predictive tool for water quality management.

The installation of the LDS hardware is described in this manual. Refer to the LAKEMON Software Manual for detailed tutorials describing operation of the software.

2 DESCRIPTION OF HARDWARE

2.1 Possible configurations of LDS

COMPONENT NAME	DESCRIPTIONS
Station Main Frame	Made by CWR, Standard or Water level compensating station available.
Thermistor Chain	Made by PME
Wind Anemometer & Direction	Met One Instruments, Model # 034B Datasheet
Net Pyrradiometer	Middleton Solar, CN1-R Manual Datasheet
Pyranometer	Middleton Solar, EQ08 Manual Datasheet
Relative Humidity & Air Temperature Probe	Vaisala, HMP45A
Radiation Shield for HMP45A	RM Young, 41003-2 Gill Plate
Lake GSM Antenna	3dB antenna
Radio Modem Antenna Intermediate & Lake Station	RFI 5db cellular Antenna CD1795
GSM Modems – lake CDMA Modem	Wavecom GSM Modem WMOD2B G900/1800 GPM-3000 800Mhz GIGA Modem
AMPS Modems - Lake	Cellular Data Link – AMPS CDL-900
Satellite modem RST610A CTX1147L L5 13565	TR Telecom
Suppressors– lake	Polyphaser, IS-B50LN-C2 SERIES suppressors for surge protection on antenna cables
Radio Modem	Freewave radio modem DGR115
Datalogger	CWR/PME DATA LOGGER
Canister	Made by PME
Floats	Station dependent
Solar regulator	Phocos, PR1210L 12 Volt 10 Amp Regulator
Solar Panels	PB Solar, SX10M 12 volt 10 watt Datasheet
Battery	Power Sonic, sealed lead-acid; 12volt, 7AH Dimension: 151mm?65mm?97.5mm
Telephone land modem	Configuration dependent.

COMPONENT	SUPPLIER (Australia unless stated)	CONTACT DETAILS
Thermistor chain	Precision Measurement Engineering, Inc. (PME) 2792 Loker Ave West, Suite 105, Carlsbad, CA 92010 USA	Ph (760) 579-0300 Ph (888) 841-7464 (toll free) USA & Canada only Fax (760) 579-0301
Logger & Station	Precision Measurement Engineering, Inc. (PME) 2792 Loker Ave West, Suite 105, Carlsbad, CA 92010 USA OR Centre for Water Research The University of Western Australia 35 Stirling Hwy, Crawley, WA, 6009	Ph (760) 579-0300 Ph (888) 841-7464 (toll free) USA & Canada only Fax (760) 579-0301 Ph (08) 9380 3701 Fax (08) 9380 1015
Wind Sensors	Precision Measurement Engineering, Inc. (PME) 2792 Loker Ave West, Suite 105, Carlsbad, CA 92010 USA	Ph (760) 579-0300 Ph (888) 841-7464 (toll free) USA & Canada only Fax (760) 579-0301
Net Radiation & Relative Humidity/Air Temperature Sensors	Precision Measurement Engineering, Inc. (PME) 2792 Loker Ave West, Suite 105, Carlsbad, CA 92010 USA	Ph (760) 579-0300 Ph (888) 841-7464 (toll free) USA & Canada only Fax (760) 579-0301
Freewave Radio Modems fo USA	FreeWave Technologies 1880 S. Flatiron Court Suite F, Boulder, CO 80301, USA.	Ph (303) 444-3862 Fax (303) 786-9948
Short Wave Radiation sensor & Radiation shield	Precision Measurement Engineering, Inc. (PME) 2792 Loker Ave West, Suite 105, Carlsbad, CA 92010 USA	Ph (760) 579-0300 Ph (888) 841-7464 (toll free) USA & Canada only Fax (760) 579-0301
GSM Modems	Intercel 33 Glenvale Crescent, Mulgrave, Victoria, 3170	Ph (03) 9561 1666 Fax (03) 9561 2614
AMPS Cellular Modems	International Data Communications Inc 47873 Fremont Blvd Fremont, CA 94538 USA	Ph (510) 623 7526 Fax (510) 623 7839
Solar Panels	Southwest Photovoltaic Systems 212 East Main Tomball, Texas 77375 USA	Ph (218) 351-0031 Fax (218) 351-8356
Solar Charge Regulator	Phocos 742 E. 46th Street Tucson, Arizona 85713 USA	Ph (520) 882-9100 Fax (520) 844-6316
Antennas	RF Industries 26 Collingwood St Osborne Park WA, 6017	Ph (08) 9244 2668 Fax (08) 94464263
Antenna Suppressor	Talley 12976 Sandoval Street Santa Fe Springs, CA 90670 USA	Ph (800) 949-7079 (toll free) in USA & Canada Fax (562) 906-8080

MAJOR COMPONENTS AND THEIR PRINCIPLES:

2.2 Thermistor Chain

Thermistor chains are manufactured by PME. They comprise up to 60 thermistors on a single polyurethane sheathed cable with a kevlar fiber core. Each thermistor is encased in an Inconel 625 tube for mechanical & chemical protection. This tube and electronic circuitry are then molded into durable polyurethane casting for mechanical protection and water integrity.

The logger measures electrical resistance of each thermistor and temperature values are obtained by LAKEMON software applying calibration coefficients. The coefficients are for a 5th order polynomial calculation and are unique to each thermistor (see logger manual for further details).

2.3 CWR Data Logger

This is a multi channel 16 bit data logger with 2 Mega Byte's of internal memory developed at the Centre for Water Research and manufactured at PME specifically for the Lake Diagnostic System (see logger manual for further details).

MEMORY STORAGE CAPACITY (examples):

SAMPLING INTERVAL	**40 THERMISTOR CHAIN + WEATHER STATION**
10 SECOND	2 DAYS
1 MINUTE	12.2 DAYS
10 MINUTE	122 DAYS
1 HOUR	733 DAYS

2.4 Wind Anemometer and Direction Sensors

Met One 034B Anemometer provides a pulsed frequency output with 0 Hz = 0 MPS, 10Hz = 8.27 MPS 30Hz =24.25MPS ETC.

The Wind Direction output is 0 - 2.5 Volt linear output, hence an output voltage of 0 volts corresponds to a wind direction of 0 degrees, and an output voltage of 2.5 volts corresponds to a wind direction of 360 degrees. An output voltage of 1.25 volts corresponds to a wind direction of 180 degrees (see logger manual for further details).

Datasheet

2.5 Solar Radiation Sensors

Two solar radiation sensors are fitted to the standard weather station:

a. Middleton (EQ08) PYRANOMETER measuring incoming shortwave solar radiation (light spectrum wave band 300 to 3000nm) Sensitivity 15uV/Wm^{-2}
   Datasheet

b. Middleton (CN1-R) NET PYRRADIOMETER measuring net total radiation flux (solar, terrestrial & atmospheric) 0.3 to 60 um , Sensitivity 35 to 45 uV/W.m^{-2} (see logger manual for further details)
   Datasheet

2.6 Relative Humidity & Air Temperature Probe

One Vaisala (HMP45A) dual purpose probe is fitted to the standard weather station, this is designed for the measurement of relative humidity and temperature from 0.8 to100%RH (O/P 0-1V) and –40 to 60 C (O/P 0-1V) (see logger manual for further details)

2.7 Solar Charging System

Two 10-watt BP Solar panels (BP SX10M) are mounted on the station main frame, about 1 metre above the water surface. Both panels' output in parallel to one Phocos (PR1210L) regulator located in the direct communications box below the solar panels. This supplies 12 volt charging to the Power Sonic (PS-1270) sealed lead acid battery located in the electronics' canister (see logger manual for further details).

2.8 Radio Telemetry

Applicable if radio telemetry is part of the LDS. The system is a commercial 915 - 928Mhz, spread spectrum (baud rate 9600bps), configured as back-to-back RS232 links. The modems are FreeWave modems. Both the lake and shore station antennae are 5dB omnidirectional antennae. Distances of up to 15km can be achieved dependent on local terrain, atmospherics and antenna placement.

2.9 Cellular Phone Telemetry

In locations where Cellular Phone Networks with data capabilities are available, small size and low power consumption GSM/CDMA Modems can be used for Telemetry in most countries. AMPS cellular modems can also be used with this system in North America. Customs changes are made to the LDS to accommodate other telemetry types, to suit the application.

2.10 Main Lake Station Frame

There are two types of LDS stations available:

1. Standard Station
2. Water Level Compensating Station

1: Standard Station

Refer to Figures 3.1 and 3.2. This station contains a manually operated winch for raising or lowering the station as the water level changes, so it is not recommended for reservoirs with large changes in water level over short periods of time. The flotation is provided by two polystyrene floats (approx 130kg of lift) through which the float- pole is fitted. These floats are deployed just below the water surface. The float-pole is fitted with a cross arm that when the station is winched down sits at the water surface. From this, the chain is shackled and side anchor ropes are attached to both sides. The underwater canister is mounted inside a cage on the opposite side to the chain.

The solar panels are mounted on a slide-on bracket on the instrument vertical pole approx 1 meter above the water surface. The same instrument pole supports both the radiation shield and the instrument cross arm on which are mounted the anemometer, wind direction sensor, net pyrradiometer, SW pyranometer and modem antenna. The humidity and air temp sensor is fitted inside the radiation shield.

The operational stability is achieved as follows:

a) The central mast has a stainless steel cable running from the winch down through its center, attached to a length of rope for the bottom and attached to a nominal +150kg main anchor weight at the bottom. The steel cable is then winched up until the cross arm is just below the water surface. Hence the respective sections of stainless steel cable and rope need to be such that the steel cable can be winched up and down sufficiently when the water level rises and falls. Rope length must be less than expected lowest water level, as the rope cannot be coiled on the winch for tensioning the station.
b) To help provide vertical stability and prevent tilting, 6kg of dive weights are attached to the bottom of the float pole extension, about 4m below the water surface (this can be increased if required).
c) To prevent rotation, two side anchor weights (+70kg each) are deployed with rope out from each side of the cross-arm at a 45-degree angle. A 30kg lift float is attached on each rope about one-third down to help apply tension to the rope as the water level changes slightly. If water levels vary considerably, then the length of the side anchor ropes must be adjusted at the station.

2: Water Level Compensating Station

Refer to Figures 3.3 and 3.4. This LDS station is designed to compensate for the rise and fall of the water level throughout the year (15-20m larger ranges available depending on design).

It is essentially a balanced floating station that is held in place in a fixed direction by the side anchors/float system. The station flotation is provided by four large polystyrene floats (approx 120kg of lift) attached to the float cross arm and deployed below the water surface and two compensation floats attached to the main mast. The thermistor chain is attached to one float cross arm of the station and the anchor lines are connected to two opposing cross arms. The underwater canister is mounted inside a cage on the opposite side to the chain.

The solar panels are mounted on a slide-on bracket on the instrument vertical pole approx 1 meter above the water surface. The same instrument pole supports both the radiation shield and the instrument cross arm on which are mounted the anemometer, wind direction sensor, net pyrradiometer and SW pyranometer. The humidity and air temp sensor is fitted inside the radiation shield.

The operational stability is achieved as follows:

d) vertical stability is provided by approx 60kg of counter weight attached to the bottom of the float pole extension, about 5m below the water surface,
e) to prevent rotation, a side anchors/float system consisting of two side anchor weights 200kg each and ten 22kg lift floats are used. The distance between anchors and positioning of the floats is a function of water depth and water level variation.

2.11 Shore Station

The shore station consists of a computer running the LAKEMON software and a modem for telemetry. The LAKEMON software (described in the LAKEMON Software Manual) controls the real time collection of data from the lake station, via telemetry. In the case of a radio modem system, the shore station computer will be connected to a radio modem and antenna. However, if the shore station cannot be within sufficient distance or line-of-sight of the lake station, then an intermediate station is used. The shore station computer would be connected to a telephone land-line cellular modem that communicates with an intermediate station containing radio and telephone modems (see 2.11). In the case of a mobile phone telemetry system, then the computer can be connected to either a mobile phone modem or a telephone land-line modem and communicate directly with the lake station. LAKEMON can be easily configured by the user to communicate with any of these combinations.

2.12 Intermediate Station

In the case where radio telemetry is to be used, but the shore station will not be within sufficient distance or line-of-sight of the lake station, then an intermediate station can be used to relay the data to the shore station. The intermediate station usually consists of a radio modem (and antenna) and a telephone land-line and modem (or cellular modem). The intermediate station is effectively transparent to both the lake station and the shore station and simply relays any communication and data.

3 INSTALLATION PROCEDURE

3.1 Assembling the Main Frame of the Lake Station on Shore

3.1.1 Standard Station

Figure 3.1 shows the main frame of the Standard lake station. Follow the sequence below to assemble the parts on shore:

1. Put water level cross arms on the long float pole and secure them by bolts.

2. Slide the floats up the float pole.

3. Attach the winch pole via the three bolt flange to the top of the float pole.

4. Attach the float pole bottom extension.

5. Tension the winch pole tensioners.

6. Loosely attach the bottom canister cage arm to the float pole.

7. Connect the u-bolts at the canister cage top to the water level cross arm and bolt the cage to the bottom cage arm below the floats.

8. Tighten up canister cage arm to float pole brackets.

9. Add winch to the short stainless steel mast by using u-bolts and the positioning stud (if not fitted).

10. Place silicon rubber sealant on all nuts on the station to prevent them from vibrating loose over time.

11. The winch cable is then fed through the centre of the mast over the pulley and out at the bottom of the float pole bottom extension.

12. Place 2 dive weights on each side of the float pole bottom extension at the shackle holes. Note that these should not hang below the float pole bottom extension, in order to avoid chaffing of the steel cable.

13. Cut the ropes for the two side anchors and position floats about one third along the rope from the station side, taking care to leave 5m extra for taking the slack in the rope up

during deployment (Figure 3.2). Assemble the weights for the two side anchors and the main anchor.

3.1.2 Water Level Compensating Station

Figure 3.3 shows the main frame of the lake station. Follow the sequence below to assemble the parts on shore:

14. Put the float cross bar plate onto the main float pole.
15. Attach the cross bars and tighten the u-bolts.
16. Attach the top float pole via the three bolt flange to the top of the main float pole.
17. Attach the float pole bottom extension.
18. Attach the two surface floats to the top float pole using the nylon straps and large SS self taping screws.
19. Loosely attach the bottom canister cage bracket to the float pole.
20. Connect canister cage top to the cross bar plate and bolt the cage bottom to the cage bracket.
21. Tighten the canister cage nuts.
22. Attach the four large floats to the cross arms using the PVC/SS clamps.
23. Fit the 2 tensioners between the top of the top float pole and two opposite float pole ends (note the t-chain must hang off one of these pole ends).
24. Assemble the diffuser wings to the diffuser using the pole brackets supplied and slide the diffuser on to the main float pole below the canister cage and tighten in place.
25. Attach the bottom extension pole and secure with for bolts and SS wire through bolts.
26. Place silicon rubber sealant on all nuts on the station to prevent them from vibrating loose over time.
27. Place 60kg of standard barbell weights on the bottom weight pole and secure. NOTE: a length of 14mm rope is attached to the bottom of the station for lifting the station base up and adding or removing weights to balance the station. When the station is fully deployed the bottom surface float will be submerged approx 50%. NOTE: this step may

be carried out on the boat just before deployment to keep the station weight down while transporting.

Assembly of Sensor pole and electronics

28. Typically it is easier to fit all the sensors to the sensor pole prior to fitting the sensor pole to the station (see figure 3.6 for sensor layout). On the shore, first slide the direct communication box down the pole, secondly slide the solar panel frame down the pole and secure with the through bolt. The solar panel frame consists of 1 PVC top bar and 2 stainless steel lower bars. The solar panels slide into the large nuts and bolts on the top & bottom bars and then secured by tightening the bolts. Position the communication box under the solar panel fame and secure with U-bolts. Next, fit and position the solar radiation shield to the pole above the solar panel as to give the least shadow to the solar panels. Assemble the top cross sensor bars as per Figure 3.7. Continue by fitting the wind and solar radiation sensors to the top cross bars. The wind and small SW radiation sensors are held in place by the grub screws. The long net radiation sensor must be fitted with the bubble level facing up) and bolt to top of pole (the top cross arm can be positioned at many angles to reduce shadow on the solar panels and to help prevent birds perching directly above the solar panels. Next insert the humidity sensors into the radiation shield and secure with the pressure flange. Finally, fit the lake antenna to the sensor arm by holding the base through the antenna frame and screwing the antenna onto it. Note that the antenna base should be assembled correctly to achieve maximum performance. Cut-off cable ties can be used on the sensor arms to prevent birds from perching on them and fouling the solar panels, but assure that they do not interfere with the wind sensors or cast shadows on the radiation sensors. All sensor cables are run down the sensor pole and the black joining moldings are secured under the solar panels with cable ties.

29. Once all the sensors are located on the top pole it is best to connect all the sensor plugs and the thermistor chain to the canister. A very light smear of silicon grease is required on each plug to help with fitting. Extreme care must be taken not to get any grease onto the connectors when fitting the plugs. When pushing on the waterproof plugs, they will try to spring back due to the compressed air inside. Massaging the air out with your

fingers can rectify this and the plugs will clip on smoothly **(See figure 3.5 for plug position)**

Note: Sensor and chain plugs must NEVER be fitted while power is connected to the logger. Although the underwater plugs can only be fitted one way, the contacts can contact the wrong pins temporarily and destroy the system.

Once all the connectors are fitted and the locking caps screwed down you can now

1. Grease the O-ring on the main canister.

2. Install the modem antenna cable ensuring that the o-rings are fitted to the canister plug and that a thin even smear of silicon grease is applied. The SMA connector at the end of the cable should be covered to protect it from grease. Note that the antenna cable comes in 2 sections, the first runs from the canister to the lightning suppressor and the second from the suppressor to the antenna. The suppressor is fitted under the long bolt at the base of the sensor pole. This bolt can be screwed out of the base and the suppressor fitted underneath. The suppressor must make good electrical contact with the pole base. After the sensor pole is fitted to the station in the lake and is fully tightened, denso tape can be wrapped around and molded over the lightning suppressor to waterproof it. This **must not** be done prior to assembling the station fully as the wax on the denso tape may inhibit the electrical contact between the suppressor and the station.

3. Uncover the SMA connector and connect it to the modem.

4. Insert the battery into the battery slot. Connect the battery cables. (NOTE: although the batteries used in these systems are a standard size worldwide, they do vary slightly depending on manufacturers so the battery slot has been made slightly oversize and it is advised to pack the slot with foam rubber to stop the battery from moving).

5. Connect the 9-volt backup battery.

6. Press the small blue reset button.

7. Insert a small pack of desiccant into the canister to absorb any moisture in the air.

8. Seal the canister.

All the electronics are now connected and ready to deploy. Although it is now a two-man job to carry the sensor pole, canister and thermistor chain to the boat, this simplifies work on the boat during deployment and eliminates the chances of water entering the canister, as it will not have to be opened again.

30. Check the system before going out on the lake by sending the logger a Command File and checking that the appropriate data are being logged. Attach the direct communication cable from your computer to the serial plug on the communication's box (located below the solar panels) and Refer to Section 4.3 in the Lakemon Manual to test the lake station operation and the telemetry operation respectively.

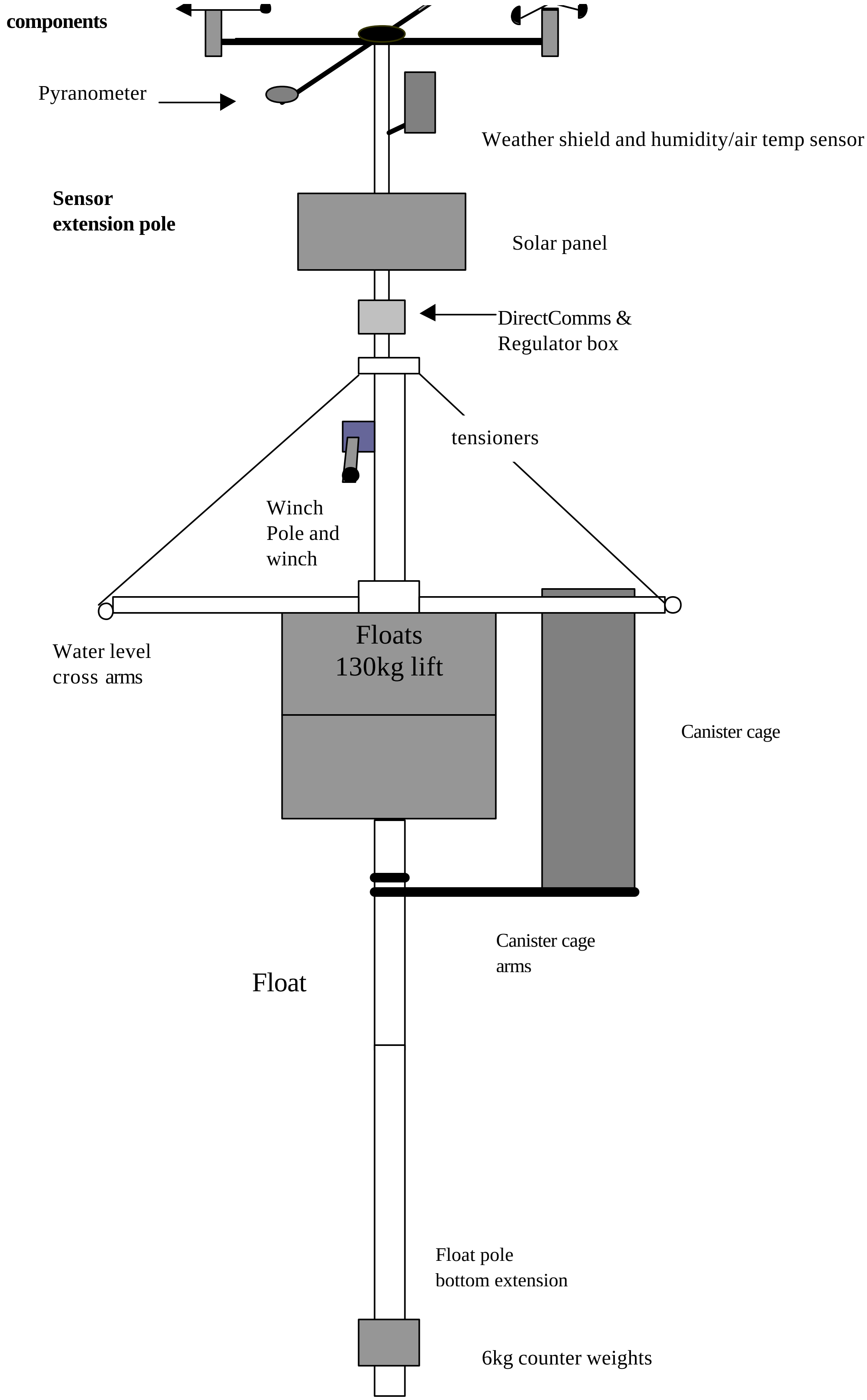


Figure 3.1: Schematic Diagram of Standard Station Assembly

3.2 Deploying the Lake Station from a Boat

3.2.1 Standard Station (note: PME does not supply the standard station anymore)

Refer to Figure 3.2.

1. Once at the desired position for deployment, attach the main anchor weight (+150kg) to the end of the anchor rope.

2. Place the main frame of the station into the water **LEAVING ENOUGH CABLE** to keep the main anchor weight on the boat.

2. **RELEASE THE WINCH LATCH** so that the cable can run freely.

3. Ensure that the cable cannot get caught on anything. The retrieval line also needs to be able to run freely, since it is attached to the main anchor weight.

4. **MAKE SURE EVERYONE IS STANDING WELL CLEAR**.

5. Lower the weights down slowly using either a winch or the boats Bollard's for control.

6. Winch the station upright, but avoid putting full tension on the main anchor cable. This is to allow easy installation of the remaining components.

7. Secure the winch latch and let the station free so it can spin out any twists in the cable.

8. Attach one side anchor rope to one side of the water level cross arms, with the +70kg weight still on the boat.

9. Drive the boat away and drop the 70kg weight roughly equidistant to the current depth away from the station. Note: the positions of the weights are dependent on the desired orientation of the station. **Correct orientation for the station cross arms and side anchors is recommended to be in line with the direction of the dominant wind, to prevent drag on the side anchors or station.**

10. Attach the second side anchor rope to the other side of the water level cross arms and drop the second 70kg weight in the opposite direction.

11. Attach the Sensor pole with all sensors fitted, to the top of the winch pole and do up bolts for most favorable orientation of the solar panels. (there is enough cable length for the thermistor chain and the canister to remain in the boat while this is happening)

Attention: During installation, keep all the electronic instruments and their connectors well clear of water. The boat should not moor to the station main frame in windy conditions.

12. Remove the securing bars from the canister cage and place the canister inside and replace securing bars.
13. (NOTE attach a dive weight to the bottom of the thermistor chain strain rope before deploying.) Shackle the T-chain strain rope top end to the cross arm opposite the canister and slowly feed out the cable from the other end so it hangs vertically and is not caught up on the station.
14. Strap all loose cables to the station using the split rubber tubing for sheathing to protect the cable from chaffing on the station.
15. Modify the orientation of the wind direction sensor if necessary to ensure the marker on the sensors faces north. This is achieved by loosening the grub scrcew in the PVC sensor bracket.
16. Adjust the winch so that the cross arms are just below the water level.
17. See Figure 3.8 for an example of a deployed lake station.

3.2.2 Water Level Compensating Station

Refer to Figure 3.4.

1. Once at the desired position for deployment, attach the anchor weight (200kg) to the end of one of the anchor ropes.
2. Lower the weights down slowly using either a winch or the boats Bollard's for control. **NOTE: During deployment of the 200kg anchors all unnecessary personnel must be kept well out of the work area and extreme caution must be made by all personnel to keep out of the anchor line area to avoid entangling**.
3. When the float attachment eye (float attachment strop joined to the anchor line at a set distance from the anchor) is over the winch or bollard, attach the float/rope arrangement

(typically 3 large floats strung together on a rope strop) with a large shackle to the attachment eye and continue to lower the anchor until it sits on the bottom.

4. Next attach the top float to the anchor lines top eye using a large shackle.
5. Measure the distance required (supplied by CWR) to the second anchor using either a GPS and repeat the last step with the second anchor
6. **NOTE: Correct orientation for the stations side anchors is recommended to be in line with the direction of the dominant wind, to prevent drag on the side anchors or station.**
7. You should now have the two side anchors deployed with their two surface floats attached.
8. It is now required that the surface floats be pulled together until the tension is appropriate for the current water level (CWR to supply). This can be done by securing one to the rear of the boat on a ten meter length of rope and pulling in the other by a long length of rope previously attached. After the floats are tensioned, tie the first to the second and release from the boat
9. When the floats are tensioned tie the first to the second and release from the boat.
10. You are now ready to attach the station (assembled previously). This is done by placing it in the water and with the two surface ropes supplied, connect the anchor connection points on the station to the eyes on the top of the anchor lines(these should be approx 500mm below the water surface the same as the anchor attachment points on the station).
11. Once the surface lines are attached the tensioning line that was attached between the surface floats previously, can be removed
12. Attach the sensor pole with all sensors fitted, to the top of the winch pole and do up bolts for most favorable orientation of the solar panels. (there is enough cable length for the thermistor chain and the canister to remain in the boat while this is happening)

Attention: During installation, keep all the electronic instruments and their connectors well clear of water. The boat should not moor to the station main frame in windy conditions.

13. Place the canister in the cage and bolt the securing pole to the station

14. To deploy the T-chain attach the chain to the stations side arms attach a 30 kg weight to the bottom of the chain and a tuna float to the underwater attachment point on the t-chain. Now drive the boat at 90 degrees to the station and lower the 30 Kg weight to the bottom. Prior to the weight reaching the bottom the subsurface float will be pulled under water. Finnish lowering the weight to the bottom and release the spare cable to hang freely from the station arm.

15. Strap all loose cables to the station using the split rubber tubing for sheathing to protect the cable from chaffing on the station.

16. Modify the orientation of the wind direction sensor if necessary to ensure the marker on the sensors faces south. This is achieved by loosening the grub screw in the PVC sensor bracket.

3.3 Installation of the Intermediate Station

This section is only relevant where there is an intermediate station required.

1. If the antenna needs to be mounted outside the building to achieve sufficient line-of-site and height: Mount the antenna securely to the roof of the intermediate station building such that it has a clear line of sight to the lake station and has sufficient height to cover the required range. Note that the antenna base should be assembled correctly to achieve maximum performance (see Figure 3.7).

2. Inside the building, choose a location where access to power points is available.

3. Connect the large antenna cable to the radio antenna, then to the lightning suppressor and then to the thin antenna cable. Connect the thin cable to the radio modem. The suppressor should be secured to an EARTH in order to provide lightning surge protection. Note, this is only required if the antenna is mounted outside the building. **DO NOT** power up the modem without the antenna connected.

4. Connect the radio modem via the serial cable to the telephone modem and the telephone modem to the telephone system.

5. Connect power to the modems. It is recommended that a power surge protector is connected between the main power supply and the modem power supplies.

3.4 Installation of the Shore Station

1. Connect the mobile telephone or radio modem system to the Shore Computer. In the case where a telephone land-line is being used, then connect the telephone line to the computer's in-built modem.

2. Connect the computer to the internet and configure it with an IP address recognized by the local network. This will allow LAKEMON to automatically FTP data to a designated directory (CWR). This data can then be automatically plotted on the web for monitoring purposes.

3. Start LAKEMON and configure the system for data acquisition via telemetry as described in section 4.3 of the LAKEMON software manual.

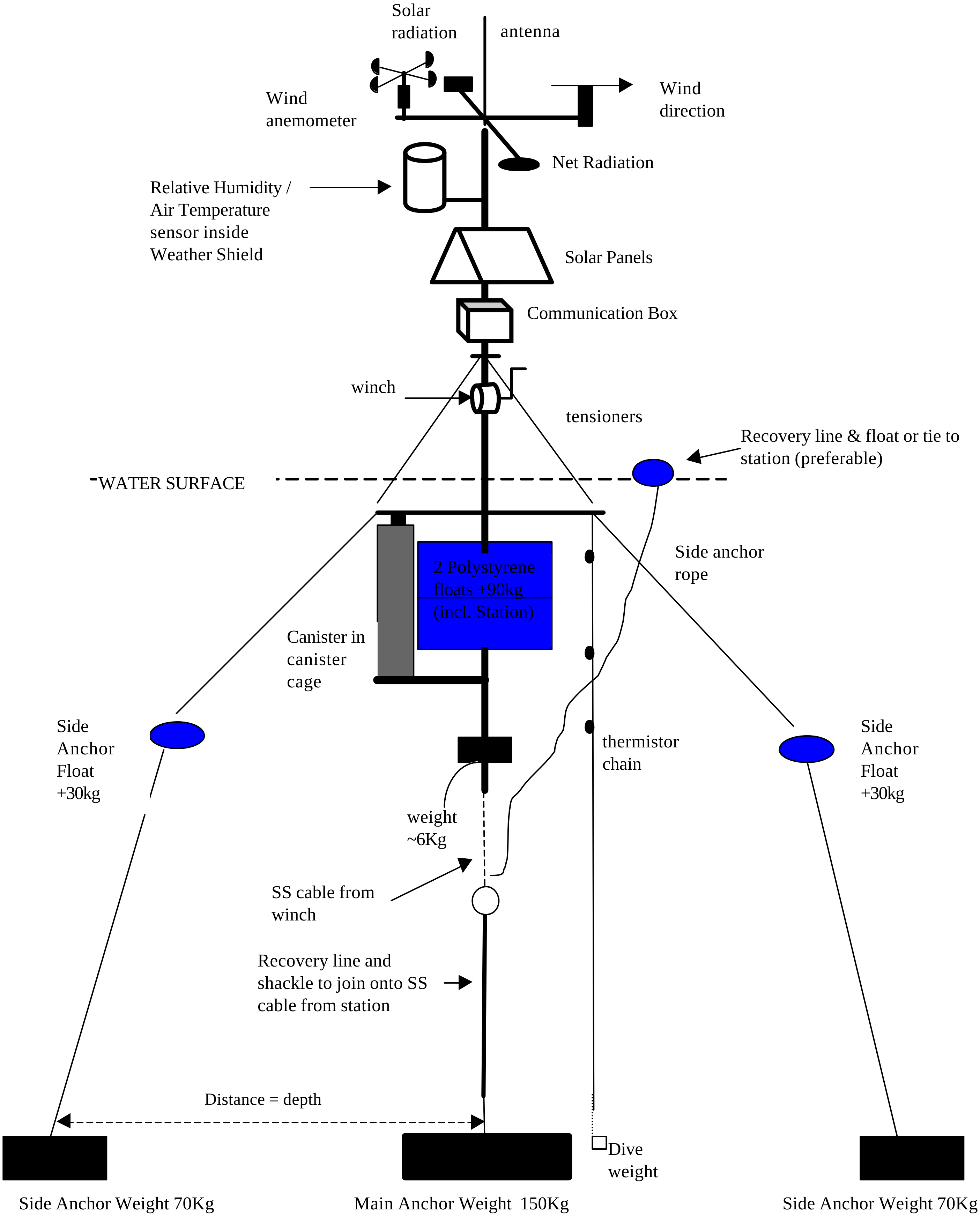
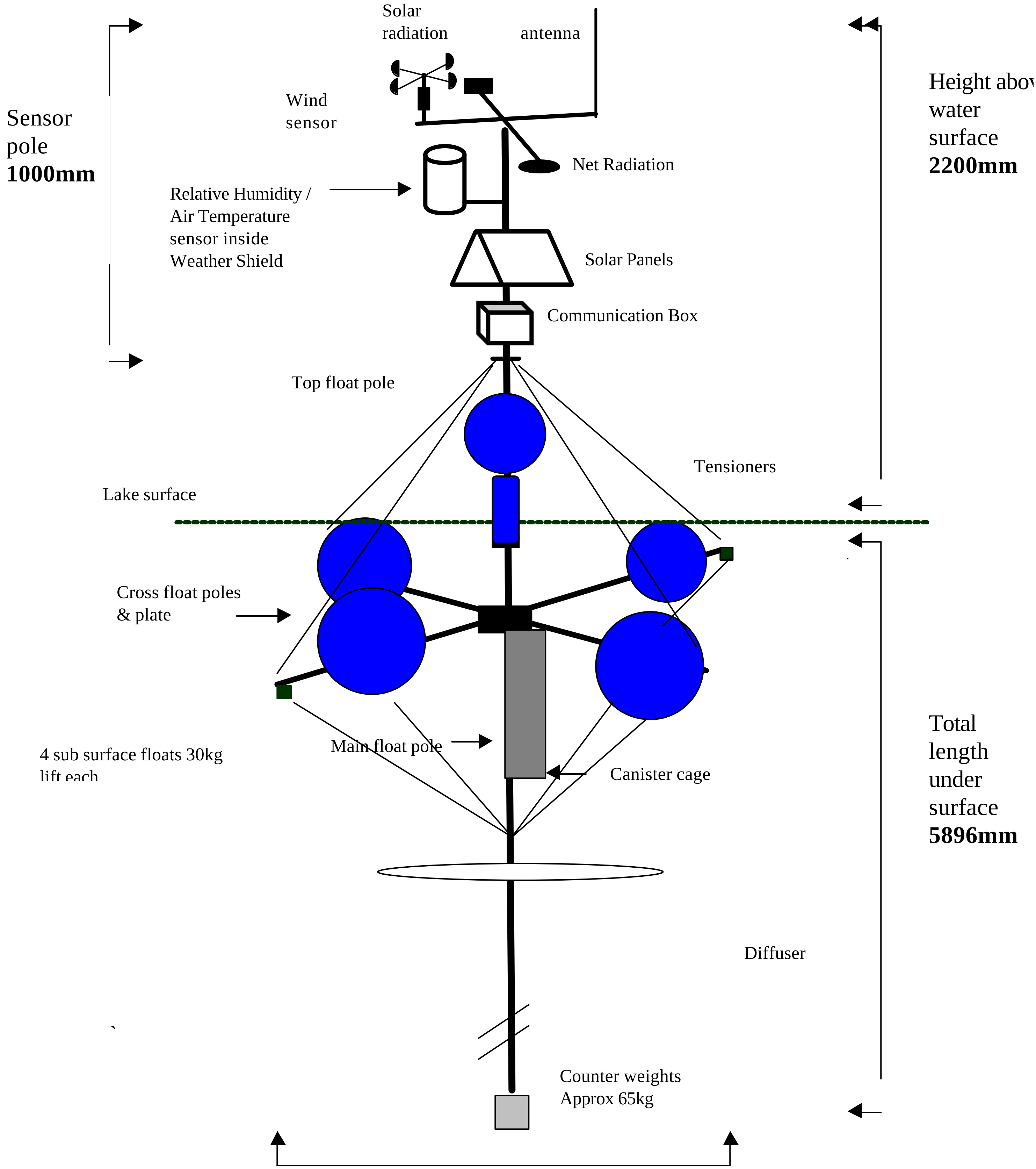

Solar
radiation
antenna
Wind
anemometer
Wind
direction
Net Radiation
Relative Humidity /
Air Temperature
sensor inside
Weather Shield
Solar Panels
Communication Box
winch
tensioners
Recovery line & float or tie to
station (preferable)
WATER SURFACE
2 Polystyrene
floats +90kg
(incl. Station)
Side anchor
rope
Canister in
canister
cage
Side
Anchor
Float
+30kg
thermistor
chain
Side
Anchor
Float
+30kg
weight
~6Kg
SS cable from
winch
Recovery line and
shackle to join onto SS
cable from station
Distance = depth
Dive
weight
Side Anchor Weight 70Kg
Main Anchor Weight 150Kg
Side Anchor Weight 70Kg

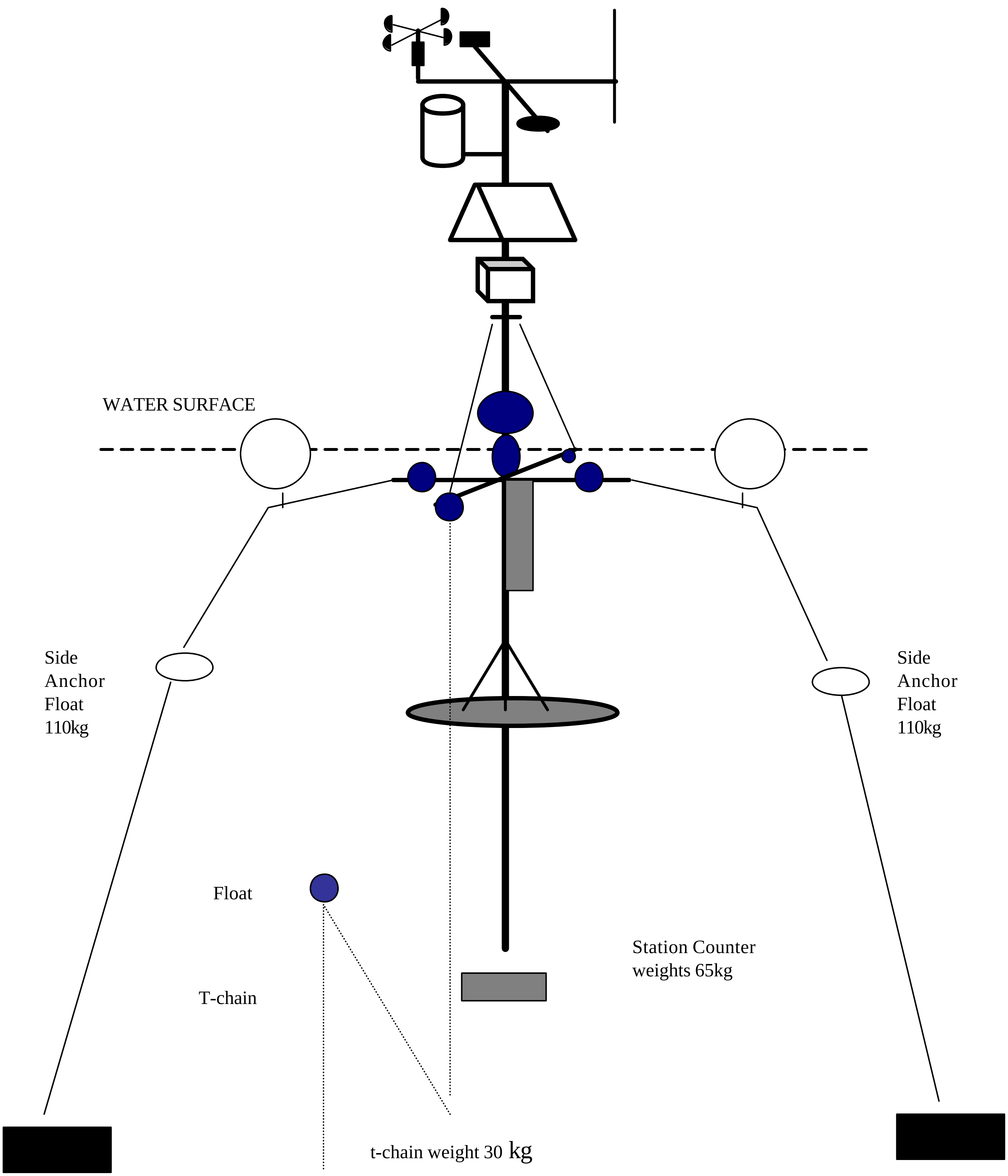
Figure 3.2 : Schematic Diagram of Lake Diagnostic System (Standard) Lake Station Deployed with Weather



Total width of station **1888mm**

NOT TO SCALE

Figure 3.3: Schematic Diagram of Water Level Compensating Station Assembly



Side Anchor Weight 200Kg

Side Anchor Weight 200Kg

Figure 3.4 : Schematic Diagram of Lake Diagnostic System (Water Level Compensating ion Deployed with Weather Sensors. Not to scale – 60kg c

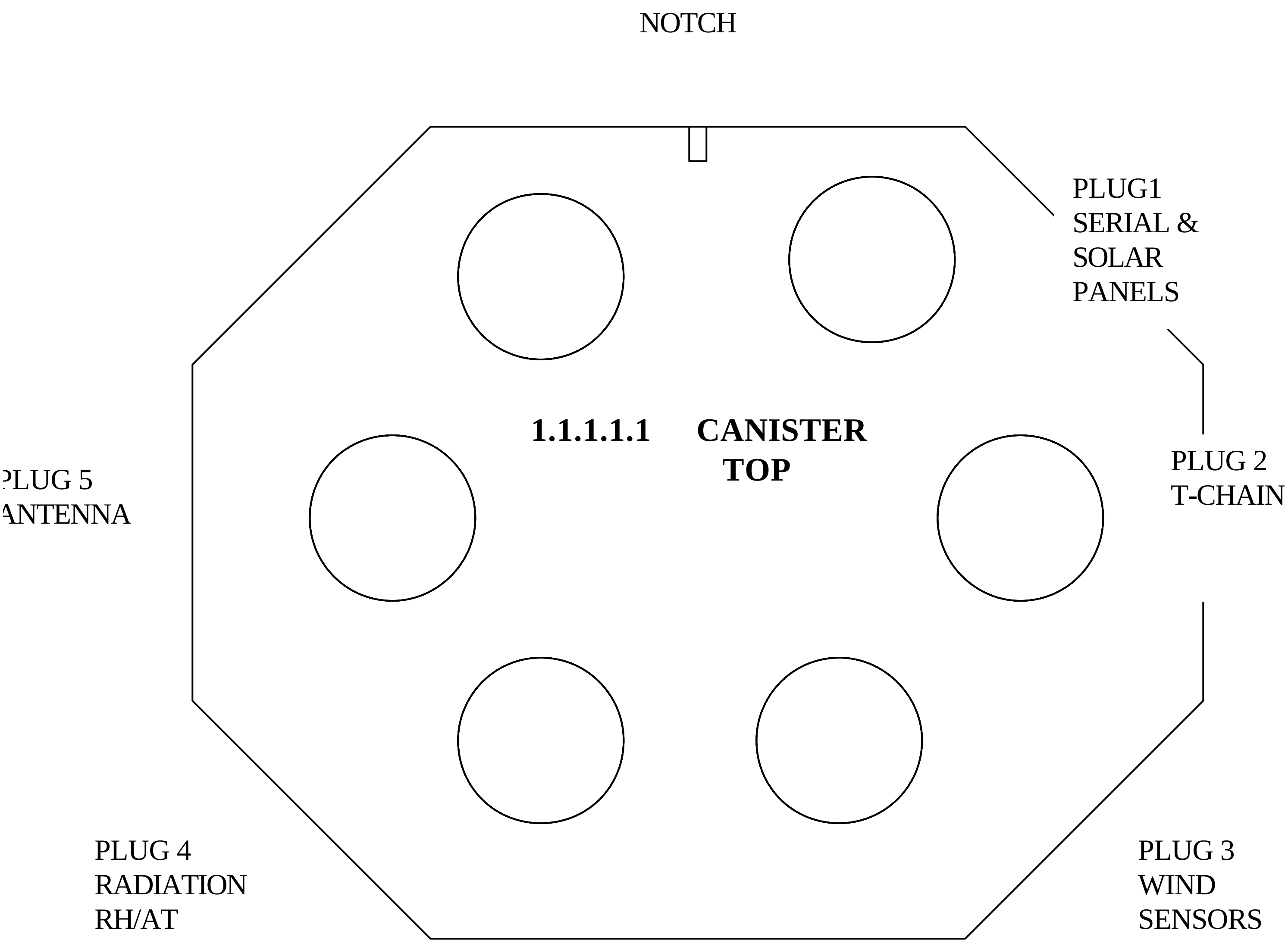
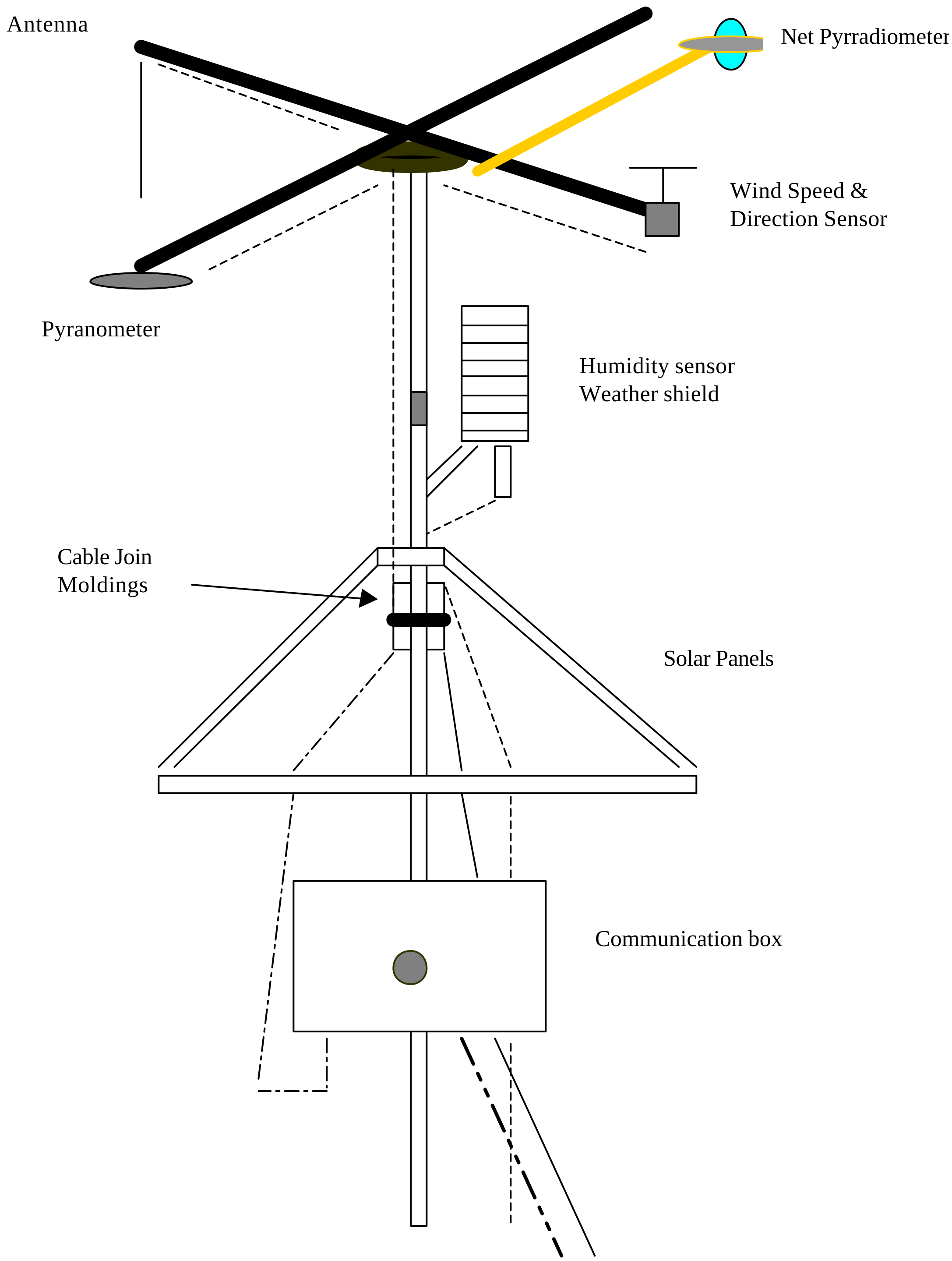


Figure 3.5 : Canister top Connector layout plan (viewed from top)


Antenna
Net Pyrradiometer
Wind Speed &
Direction Sensor
Pyranometer
Humidity sensor
Weather shield
Cable Join
Moldings
Solar Panels
Communication box

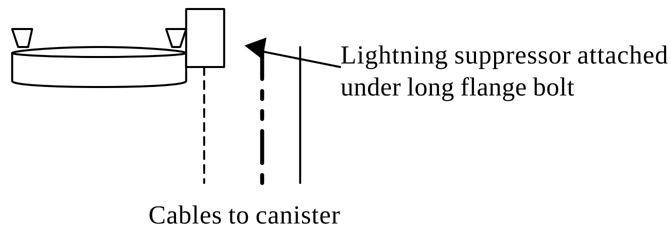
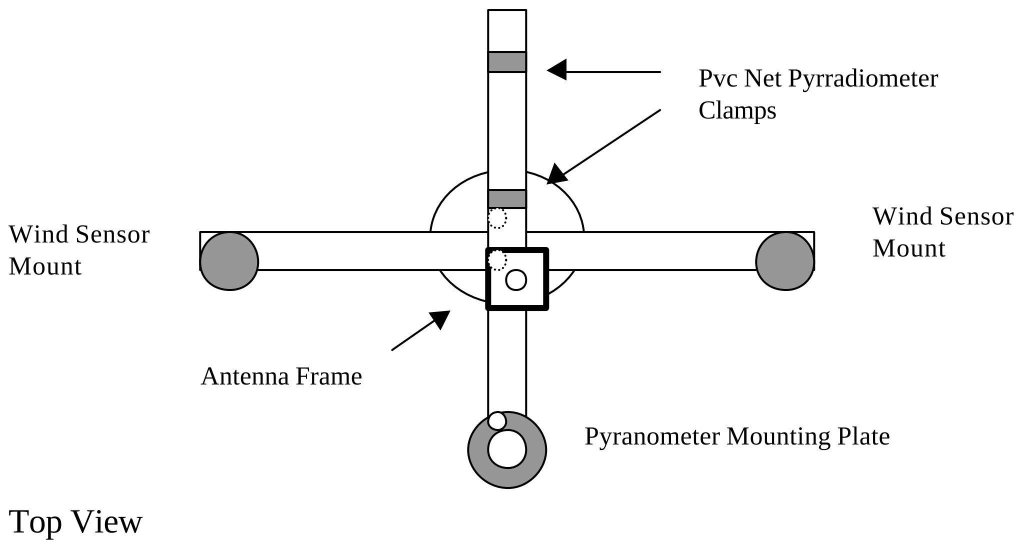
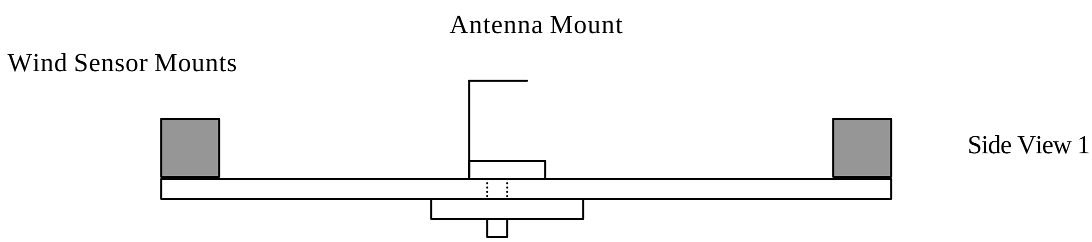
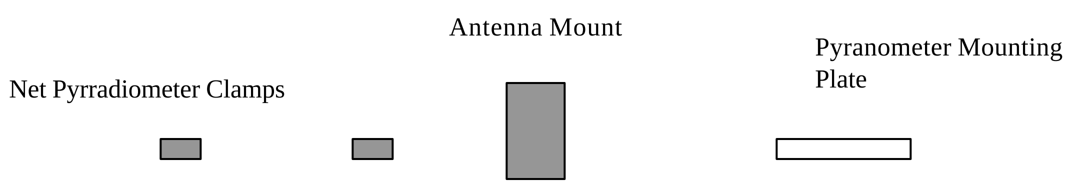


Figure 3.6 : Sensor Pole Layout







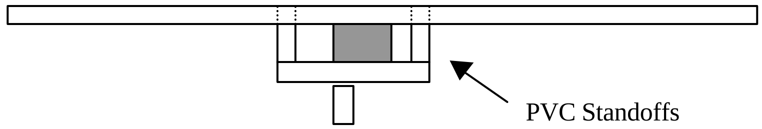


Figure 3.7 : Cross Sensor Bars

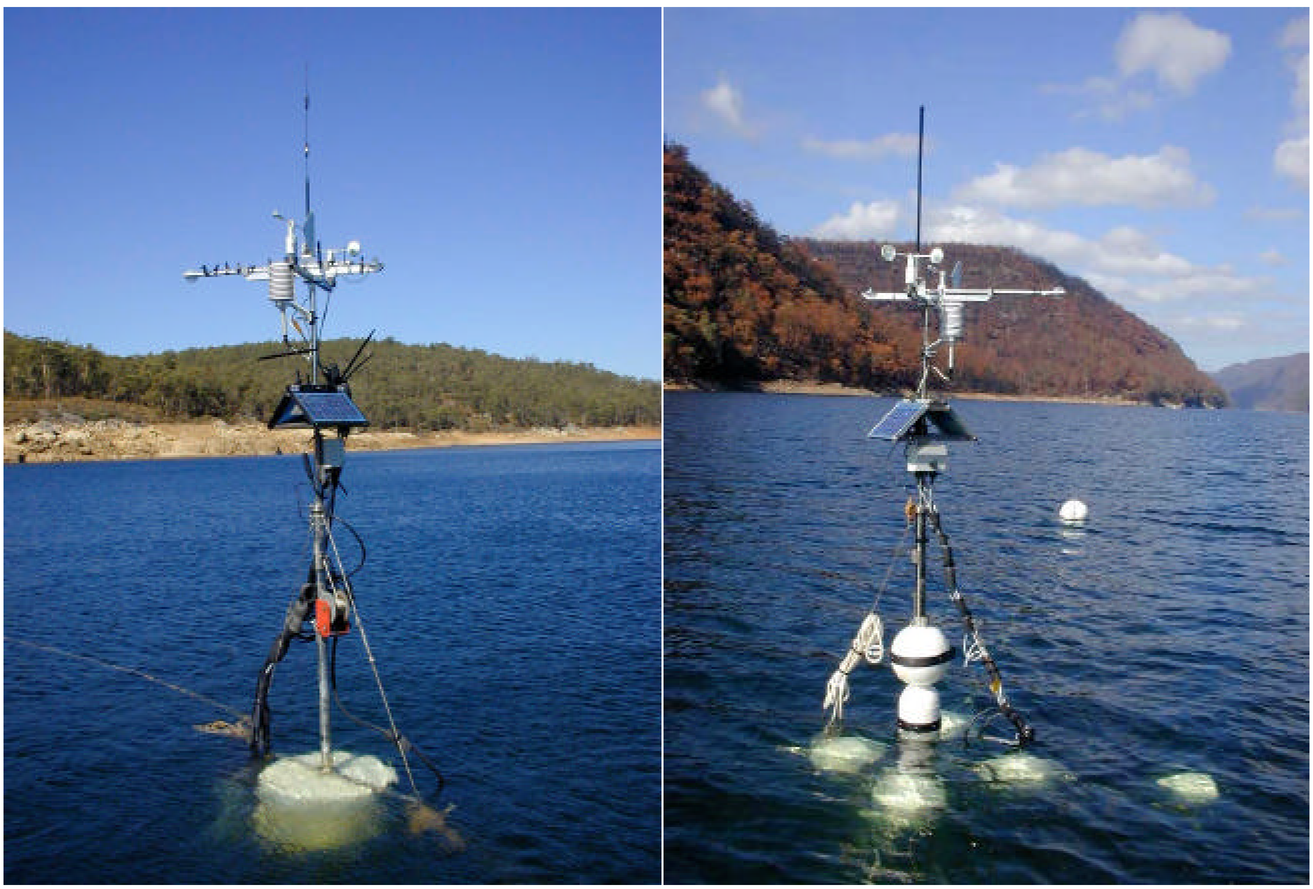


Figure 3.8 Example of standard and water-level compensating lake stations.

4 ROUTINE MAINTENANCE

Refer to the Specifications Manual for your LDS to see any maintenance tasks specific to your LDS.

4.1 Regular Maintenance

The following should be checked regularly, when passing by the station during other routine visits to the lake:

1. **Due to the submerged rope/anchor arrangement on the water level compensating stations, regular careful checks of the station and side anchor ropes/floats should be carried out to look for navigational hazards such as ropes & anchors close to the surface. If a navigation hazard exists then it should be reported and marked clearly to warn of the Hazard for other boat users. As a general rule all boat operators should be refreshed on the subsurface anchoring arrangement of these stations and requested to keep a minimum distance of 120 meters from the centre station when possible. Where this is not possible due to sampling / navigation requirements, they should be asked to reduce the boat speed to a slow safe speed incase of entanglement with the subsurface ropes (this is increasingly important as the water level in the reservoir drops).**

2. The marker on the wind direction sensor should be facing South at all times, since it is the point of reference for the sensor output. It can be re-oriented by loosening the screw in the PVC wind sensor cross arm.
3. Observe that the station is sitting upright, the side anchors / solar panels / station cross arm are still oriented in the direction providing the least resistance to the dominant wind, all cables and anchor ropes are secured to the station neatly and all cable connectors (solar panels and wind sensors) are secured well clear of the water.
4. In the case of reservoirs for recreational or fishing use, a flashing light should be fitted. Check that the flashing light is still functioning, since this is the only means of warning

other boats that the station is there, these lights only function in dark condition so cover if necessary for test.

4.2 Medium Term Maintenance

As the lake water level varies the water-level cross arms of the station will need to be adjusted (standard station only):

1. The standard station must be winched up or down in order to keep the water-level cross arms just below the water surface. Approximately 150mm as been found to be the most suitable depth for station stability. The side anchor ropes may also need to be adjusted as the cross arms are winched up and down. This maintenance ensures that the station remains stable and that the sensors and other electronics do not get too wet.

4.3 Minor Service

Every three to six months the following service should be performed:

1. The solar panels should be washed with detergent to ensure they are working at or close to their maximum efficiency. The cable ties that have been cut to leave sharp projecting points should keep most birds off.
2. New net solar radiation domes should be fitted.
3. Careful cleaning of the SW solar radiation sensor with a soft cloth. This includes all white sensor area top and sides.

4.4 Major Service

It is recommended that a major service should be performed once per year. To perform the service, the thermistor chain, underwater canister and weather station need to be removed from the lake by following this procedure:

1. Remove the canister, T-chain and weather station as one unit.
2. Back on land, inside the laboratory (where there is no sunlight on the solar panels, or cover the solar panels), clean and dry water from the outside of the canister, then open the canister carefully, so that water trapped in the o-ring area does not get splashed into the canister.

3. Check the condition of the 12V/7Ah and 12V/12AH battery under load and replace if thought to be necessary. Normally it will be ok, but if it has been allowed to discharge completely at any time it should be replaced.
4. Disconnect the main battery and 9V battery. Only now can sensors/solar panels/antenna be carefully unplugged if necessary.
5. Replace (or restore by drying) the Silica Gel packages in the Canister. Silica Gel can be obtained from general hardware or chemical supply stores
6. Clean thermistor moldings of all growth with detergent and a toothbrush, being careful NOT to apply too much mechanical stress to the thermistor tube or surrounding urethane.
7. It is also recommended that this opportunity is used to check the calibration of the thermistors against a standard temperature sensor and recalibrate if necessary. Return to CWR to provide this service or consult local laboratory.
8. Weather sensor units all have recalibration periods as recommended by the manufactures in the manuals and calibrations certificates supplied in the Specification manual.
9. It is also recommended that this opportunity be used to check the mechanical parts of the lake station, before reinstalling the electronics.
10. Follow the instructions in sections 3 to redeploy.

5 OxyGuard Model 525 Dissolved Oxygen Probe
In Field Calibration Procedure

In field calibration of the OxyGuard 525 dissolved oxygen probe is required periodically to assure accurate data.

Although this calibration period will vary from location to location depending on water quality I recommend recalibration every 4 months initially while keeping an eye on the DO data and looking for an obvious down ward drop of readings which indicates the probe membranes need cleaning.

We have found that Calibration in air saturated water rather than in air gives a more stable and accurate calibration by helping to reduce temperature changes of the probes during the calibration.

This involves the air saturation of a container of water using a fish pond aerator.

Calibration Procedure

Secure boat to LDS station and retrieve the DO chain by lifting up the large float on the DO frame and pulling the chain on board.

¾ fill the bucket of water and start the bubblers saturating the water

Run the aerator for a minimum of 60 minutes prior to calibration, this will ensure saturation. Have the bubbler units approx 200mm below the water surface

Hang all the sensors and the thermometer over the side of the bucket so the sensors are suspended ½ way up the side but still fully submerged. Leave the bubbler going for the entire calibration as this ensures saturation and also movement of water over the membranes. Leave the sensors in the water for 15 minutes to temperature stabilize.

Plug the LDS communication cable into the LDS and into com port 1 of the field laptop.

A. Start the laptop and open **Lakemon 5.5** software.

B. Click on Administrator button and enter Password "PASSWORD".

C. Select **Advanced terminal**.

D. Select **COM1** com port

E. Select **LOCAL DIRECT** comms link

F. Select **CONNECT** at the bottom of the screen and a message "connected to logger xxxx" will appear at the top of the screen. You can now talk to the logger.

G. to test communications type MODE in the **SEND window** and press enter. The logger should echo back the state of the logger stating if its running remoteon etc.

H. Load the correct command file for the reservoir you are on by selecting the **LOAD** button in the Command File window and select the file eg: C:\Lakemon5_5\sugarloaf\ sugarDO_t130sec_2hr.cmd

We now have to reduce the sampling period for the calibration to 10 seconds. This is done by selecting **View/Edit** button in the Command Window and changing the Period line to **00:00:10** and saving the file.

Now send the file to the logger by selecting "**Send File**" button in Command File window A warning will come up about the remote port, select **OK**. The file will be echoed back to you in the receive window.

When the file has been loaded successfully it will give you a message saying.

Command file loaded successfully

Now send a **REPORTON** command from the send window. This will echo back the raw data from each sensor every 10 seconds when a sample is taken.

I. If the water is saturated and the sensors have temperature stabilized in the water for 15 minutes then they can now be calibrated. This is done by checking the temperature of the water and comparing it to the Calibration Table supplied by CWR.

The table gives a raw count figure that the sensor should output for that temperature. You now located the 1st DO sensors and watch it raw counts on the screen.

(for Sugarloaf the 8 DO sensors data are the last 8 sets of raw count figures on the screen and for Silvan the last 5)

Use the small yellow screwdriver supplied and adjust the trimming pot on the side of the sensor while continuing to hold the sensor under water. 1st adjust it ½ a turn and note the change in the raw counts. This will give you a feeling for how much and in what direction you must adjust the trimmer pot. Remember the Raw data only changes every 10 seconds so take your time especially with the 1st sensor and get it as close as possible to the correct counts.

NOTE: the sensors raw data does drift around some what and you will have to adjust as best you can.

Repeat this procedure for the remaining DO sensors

Note keep checking the temperature of the water as bubbling the water through it may cause it to rise through out the calibration.

If it does rides then adjust the output to get as close as possible.

If one sensor stands out from the rest during calibration eg it drifts considerably more than the rest, then the membrane may need replacing.

This is very simple just follow the instructions on page 6 of the Oxy Guard service manual.

After calibration of the chain return it to the water and continue viewing the output. It may take 5 minutes or so but you should notice higher readings from the surface to lower readings towards the bottom.

We now have to change the sampling period back to its original period. This is done by selecting View/Edit button in the Command Window and changing the Period line to 00:00:30 (original period) and saving the file.

Now send the file to the logger by selecting Send File button in Command File window A warning will come up about the remote port select OK. The file will be echoed back to you in the receive window.

When the file has been loaded successfully it will give you a message saying so.

Now send a “mode” command and confirm that the system is Running and Remote is on.

If so unplug the umbilical from the LDS.

Temp	Counts	Oxy(mg/l)
10	36719	11.277
11	35886	11.016
12	35085	10.766
13	34315	10.525
14	33576	10.294
15	32864	10.072
16	32179	9.858
17	31520	9.651
18	30885	9.453
19	30272	9.261
20	29682	9.077
21	29112	8.898
22	28562	8.726
23	28030	8.56
24	27517	8.4
25	27020	8.244
26	26540	8.094
27	26075	7.949
28	25624	7.808
29	25188	7.671
30	24765	7.539

6 LDS Station Training and Safety Notes

6.1 Introduction:

The Water-Level Compensating Station is a self adjusting system which uses a submerged anchor and float setup to keep side tension on the floating sensor platform as the water level rises and falls. See figure 5.1 for a typical example of the anchoring arrangement. This diagram shows the submerged anchor lines at both minimum and maximum predicted water levels for a particular lake (see specification manual for specific lake diagram).

These stations are designed for a predicted water level range supplied by the client from empirical data. The aim of the design is to keep the submerged side floats as deep as possible and still provide suitable tension on the station over the water level range specified, this is done to keep the navigation risk to a minimum but the customer must be made aware that the installation of these stations is far from an exact procedure meaning that submerged float depths can vary by the variation in rope stretch, positioning of the anchors, contour of the lake bottom etc.

As a general rule all boat operators should be refreshed on the subsurface anchoring arrangement of these stations and requested to keep a minimum distance of 120 meters from the centre station when possible. Where this is not possible due to sampling / navigation requirements, they should be asked to reduce the boat speed to a slow safe speed incase of entanglement with the subsurface ropes (this is increasingly important as the water level in the reservoir drops).

Figure 3.3 and 3.4 show the station and anchoring arrangement in an out of scale form. To give an Idea of the set up of the Water Level Compensating Stations.

6.2 Points to demonstrate to Client:

1. LDS Anchoring system layout and positioning (refer to figure 3.9 and Specification manual for specific lake setup).

2. Maintenance requirements of LDS (see section 4)

3. Navigation Hazard of the LDS (make client aware of subsurface gear).

4. Side float and station torpedo float levels to be aware of.

5. Electronic equipment layout, removal & replacement.

6. Correct routine for removing, opening/closing and replacing electronic canister.

7. Electronics / plug layout.

8. Calibration routines & requirements

9. Communication with station directly and remotely, understanding of software and command files . See Section 5.2 below

6.3 Lakemon Training Notes

1 *LAKEMON Software installation on laptop/Shore station:*

1.1 On Windows NT /2000/XP, you need to login as a user with Administrator Privilege or Administrator.

1.2 Install LAKEMON by following the instructions in "install.txt" in the installation CD (See Appendix A). Also install the Labview Runtime Engine and the NI_VISA package.

1.3 Copy over all files from the "LAKEMON Configuration" floppy disk to c:\lakemon5_6.

1.4 If you didn't install LAKEMON on C:\ drive, you will need to make the appropriate changes to the LAKEMON Configuration Panel. Also note that the path to the CAL file will also need to be changed in the command file

1.5 If the user is not in the Administrator's group, there may be trouble in accessing the serial port. You can quickly check this by trying to make a connection through Advanced Terminal. If you cannot connect and the error.log file shows "......", you will need to perform the procedure in the Appendix B. The procedure is simple but you need to log in as Administrator.

1.6 If you have installed LAKEMON as the Administrator, then run LAKEMON as a different user. In Windows XP, you might experience permission on the LAKEMON directory. For example, the error.log file doesn't get updated when you are performing operation on LAKEMON. If this is the case, you will need to follow the instructions in Appendix D.

2 LAKEMON Operation:

2.1 Overview of LAKEMON software & its role:

- ? as a logger terminal ("Lakemon - Advanced Terminal") either via direct or remote connection
- ? aAutomatic remote data collection and data conversion.
- ? automatic ftp of data files to CWR (or an alternative location)

2.2 LAKEMON Configuration Panel.

2.2.1 Go through all parameters in "General", "COM", "Command File", "Auto Data Collection" and "LN".

2.2.2 Need to emphasis the command file has to match the one running in the logger. When the command file is changed they should always create a NEW file so that the file header is correct.

2.2.3 Editing a command file using the "Command File Editor".

2.2.4 Sending a command file from LAKEMON Configuration Panel.

2.2.5 Changing the station depth and Lake depth when water level changes.

2.2.6 Point out that the "Automatic File Size" determines the automatic FTP frequency.

2.3 Dial-up schedules & considerations about timing of visits to the lake stations. Also need to consider the effect on the call cost and power consumption (DOUT or LOUT).

2.4 Advanced Terminal:

- 2.4.1 Overview of Advanced Terminal and the communication parameters.
- 2.4.2 Show operation with both Directly and Remote connection.
- 2.4.3 Significance of LKMON and LKEND commands. Need to point out special sequence, eg. STOP before CDATA, REMOTEOFF (if connected via local port) before STOP, etc.
- **2.4.4** Synchronizing the DATE and TIME. **It is important to ensure that the computer's clock is correct.**
- 2.4.5 Show logger commands described in the logger manual.
- 2.4.6 Procedure for sending a command file, ie UNLOAD previous data prior to sending command file, making appropriate changes in LAKEMON Configuration afterwards.

2.5 Command File & Cal File structure.

2.6 "ftp.txt" for automatic FTP'ing to CWR.

2.7 "lk_copy.txt" for making a backup of all the t files on another disk. This is a text file with the destination directory, eg. d:\data_backup. This file is in the same directory as the "error.log" file.

2.8 "error.log" file interpretation: Need to show then how the user interactions or automated processes got logged in this file. A sample error.log file is shown in Appendix C.

2.9 Data file format conversion.

2.10 Graphic display.

Appendix A: install.txt as in installation LAKEMON CD

Installation procedure

```
1. Insert the installation CD into CD drive (assume this is D:\
drive).

2. There are 3 directories in the CD, LAKEMON5_6, Labview_Engine and
VISA_install

3. Change directory to D:\LAKEMON5_6 and run "setup.exe" to install
LAKEMON 5.6. Then follow the instructions given by the installation
program. Please note that you can go back and change values where
appropriate by clicking on the Back button. You can exit the
installation where appropriate by clicking on the Cancel button.

5. Once LAKEMON is installed, you will need to install the Labview
Run-Time Engine and NI-VISA package if they were not already
installed.

4. To install the NationalInstrument Run-Time Engine, run
D:\Labview_Engine\lvrteinstall.exe and follow the prompt.

5. Then you need to install the NI-VISA package which is in
D:\VISA_install. You need to run "NIvisa25Runtime.exe" to install it.
If you encounter problem when installing it directly from the CD, you
should copy this directory to a temporary directory in your hard disk
and run the installation from there.
```

Appendix B: Enable Serial Port Access

User (Non-Administrator) Cannot Use NI-VISA On Windows NT/2000 System
Product Group: VISA Software
Product Name: NI-VISA for Windows 2000/Me/NT/9x
Version/Revision: 2.5
Problem: I cannot communicate with my instrument in Measurement and Automation Explorer using VISA Interactive Control or in LabVIEW using VISA Read and VISA Write when logged in as a User, not the Administrator. When I am logged in as the Administrator, I can communicate with my instrument using both of these methods. What is the cause of this?
Solution: Members of the Users group are not configured to have "Full Control" with NI-VISA, while Administrators do have "Full Control". You can change this configuration for Users through the following steps.
Log on to the NT/2000 system as the Administrator. From a DOS window (or **Start»Run**) type "regedt32" to start the Registry Editor tool.
Open the Key: **HKEY_LOCAL_MACHINE»SOFTWARE»National Instruments**.
Highlight **NI-VISA for Windows 95/NT**.
From the toolbar at the top of the regedt32 screen select **Security»Permissions...**.
Select the "Users" line.
Check the "Full Control" box then press OK.
Exit the regedt32 program.
Reboot your computer and log in as the User.

NI-VISA will now work for User accounts.

Appendix C: Typical LAKEMON error.log file during automated operation

```
9/23/04 6:00:02 AM Dialing Station: t1 in collie
9/23/04 6:00:34 AM Connection String Received:ATD6610427433506

CONNECT

9/23/04 6:00:39 AM sent: LKMON Received:LKMON

*
9/23/04 6:00:39 AM Session Successful
9/23/04 6:00:43 AM DATE
 echoed: DATE
23-09-04 0001728

*
9/23/04 6:00:44 AM TIME
 echoed: TIME
06:02:08 0021728

*
9/23/04 6:00:47 AM UNLOAD 1728 14587 1728 16386 echoed: UNLOAD 1728 14587 1728
16386

9/23/04 6:00:52 AM 54  records has been collected
9/23/04 6:00:56 AM UNLOAD 1728 16369 1728 18168 echoed: UNLOAD 1728 16369 1728
18168

9/23/04 6:01:01 AM 54  records has been collected
9/23/04 6:01:04 AM UNLOAD 1728 18151 1728 19950 echoed: UNLOAD 1728 18151 1728
19950

9/23/04 6:01:09 AM 54  records has been collected
9/23/04 6:01:13 AM UNLOAD 1728 19933 1728 21670 echoed: UNLOAD 1728 19933 1728
21670

9/23/04 6:01:18 AM 52  records has been collected
9/23/04 6:01:21 AM sent: LKEND Received:LKEND

*
9/23/04 6:01:32 AM Performing Automatic Calculation
9/23/04 6:01:32 AM All data files updated
9/23/04 6:01:33 AM Auto new file name:  l1060004.267
9/23/04 6:01:43 AM FTP Successful: t1180104.266
9/23/04 7:00:00 AM transferring error.log
9/23/04 7:00:01 AM FTP Successful: error.log
9/23/04 8:00:01 AM transferring error.log
9/23/04 8:00:01 AM FTP Successful: error.log
9/23/04 8:00:05 AM Dialing Station: t1 in collie
9/23/04 8:00:38 AM Connection String Received:ATD6610427433506

CONNECT

9/23/04 8:00:40 AM sent: LKMON Received:LKMON

*
9/23/04 8:00:40 AM Session Successful
9/23/04 8:00:44 AM DATE
 echoed: DATE
23-09-04 0001728
```

```
*
9/23/04 8:00:45 AM TIME
 echoed: TIME
08:02:09 0028929
```

Appendix D: Enable Full Control Permission for The LAKEMON Directory (Windows XP)

1. Log on as "Administrator"
2. Right mouse click on the directory C:\LAKEMON5_6 and select "Properties".
3. Then click on the "Security" Tab
4. In "Group or User Names" panel, select "Everyone" and skip the next step. If "Everyone" is not in the list, proceed to the next step.
5. If "Everyone" is not in the list, click on the "Add" button, then in "Enter the Object name to select (examples)" panel, type in "Everyone" and click the "OK" button to return to the previous window. Now select "Everyone" from the "Group or User Names" panel.
6. In Permission for Everyone" panel, click (ie. put a tick on it) on the "Full Control" check box. Click the "OK" button to close the window.
7. Log out as Administrator and login as the "normal LAKEMON user".
8. Right mouse click on the directory C:\LAKEMON5_6 and select "Properties".
9. Disable the "Read Only" property and click the "OK" button. In the next prompt, you should select the "Apply changes to this folder, sub-folders and files" option and click "OK".
10. Start LAKEMON 5_6 now and check if the "error.log" file get updated appropriately.