Instrument Specification for High Precision Sea Level Monitoring Stations

The following is the statement of user requirements upon which the selection of equipment for the Australian baseline sea level monitoring stations was based. These specifications are provided as a guide to the selection of high precision tidal recording equipment.

User Statement of Requirements

Instrumentation is required for the purpose of high precision monitoring of the sea level. It is expected that the equipment, supported by appropriate operating techniques, will be capable of measuring sea level change attributed to the Greenhouse Effect.

The purpose of this document is to specify the requirements of the complete Field Unit hereinafter referred to as the field unit.

The field unit shall be a stand-alone, unattended, data acquisition and data transmission device capable of acquiring, storing and reporting water level measurements from remote locations. Low power consumption and high reliability are important considerations in the design of the field unit.

Instrument Requirements

The sensor/measurement subsystem of the field unit provides for the measurement of water level and ancillary meteorological and atmospheric phenomena necessary to fulfil the primary mission requirements for tide and water level measurements.

The sensor/measurement subsystem is required to accommodate up to eleven ancillary measurements.

Three of these are expected to be provided by sensors that provide a digital or frequency output; the remainder will provide analogue output.

The field unit shall be able to operate with different site-specific combinations of sensor inputs and power sources as specified herein. All possible sensor/power combinations shall be accommodated by on-site actions, which include setting switches, installing cables, and entering parameters via a temporarily connected operator's terminal or the public switched telephone network.

The configuration of an individual field unit will depend on the information requirements of the PCTMSL, as well as site-specific factors such as environmental conditions. However, the minimum configuration will consist of: -

- Primary water level sensor
- Seawater temperature
- Air temperature
- Barometric pressure
- Wind speed and direction
- Backup water level sensor

Resolution:

Primary Water Level: 0.0005 metres over a range of 0 - 15 metres.

Resolution: other sensors

Backup Water Level:	0.003 m over a range of 0 - 15 metres.
Temperature:	0.1 Deg. C over a range of -10 to +55 Deg. C.
Baro. Pressure:	0.01 hPa over a range of 800 to 1060 hPa.
Wind Speed:	0.5 m/s over a range of 0 to 50 m/s.
Wind Direction:	5 Deg. over a range of 0 to 360 Deg.

Accuracy of the Primary Water Level Sensor:

Height	+/-0.005 metres.
Time	+/-1 minute per year.
Datum	+/-0.001 metres. This must be maintained for a minimum period of twelve months between re-levelling.

Sample interval:
User selectable within the range 1 to 60 per hour.
The default value will be 12 per hour for the Primary Water Level Sensor.

It is required that each sensor be capable of being sampled at its own individual sample rate.

Integration time:
User selectable within the range 1 to 10 minutes, at a nominal rate of two samples per second with a default value of one sample per second. This must also be settable for each individual sensor.

Calibration:
Capable of regular calibration in the field, automatic self-calibration is required for the Primary Water Level Sensor.

Timing:
The sensor/measurement subsystem must contain a calendar clock capable of generating year, month, day, minute and second with leap year correction. Time shall be resolved to at least one second. The sensor/measurement subsystem shall, at least once a day, re-initialise its calendar clock with time and date from the satellite telemetry module, (where fitted) which is required to be more accurate.

The sensor/measurement subsystem must be capable of recording a sample on the integral hour.

Watchdog Timer:
The sensor/measurement subsystem shall contain a watchdog timer that can restart the field unit without loss of current system parameters or stored data.

This timer shall start the field unit after a fixed time delay unless the timer is itself reset by a software controlled signal. The presence of the timer shall ensure that the field unit will always operate when power is available, and there is no damage to the field unit itself.

Communications:
Five communication ports (four serial and one telephone) shall be provided, one shall be dedicated to the Backup water level sensor and one dedicated to satellite telemetry. The other two serial ports will be available for parameter set-up, data collection and external modem.

A common protocol shall be used for the latter two serial ports and the telephone port. This protocol shall be selected from protocols currently in use and supported by multiple users in industry and the government.

Telemetry:
Telemetry will be by telephone modem and/or satellite transmission. Satellite transmission will be by use of one or more of the following systems: GOES, GMS, ARGOS and AUSSAT.

Transmitter and telephone modem must conform to the standards required by the appropriate licensing authority.

Data Storage:
On board back-up:
Type: Digital.
Medium: Solid-state memory.
Output: RS232C compatible with downloading facility, software to be provided.

Memory retention:
Thirty (30) days minimum, obtained from the following representative configuration of sensors and measurement rates:

Primary water level sensor	12 measurements/hour
Six of the eleven ancillary sensors.	1 measurement/hour
Backup water level sensor	12 measurements/hour

All data acquired by the field unit through automatic sensor sampling shall be stored as a sequence of individually identified data entries. These data entries shall be stored in chronological order as they are acquired. The acquisition date and time of each data entry, to nearest minute, shall be available for each data entry. This date and time may either be stored with the entry or obtained by computation. All memory not used for other purposes shall be available for storage. When the storage has consumed all available memory, the oldest data entries shall be discarded to provide space for new entries.

Other types of data entries that shall be stored include, primarily:
Field unit system parameters.
Field unit performance status.

The field unit data storage capacity shall be expandable, on-site, by field maintenance personnel. The capacity shall be expandable by at least 50 per cent.

Power:
The complete field unit must be run from an internal rechargeable sealed battery. The unit must also contain a power conversion module capable of powering the field unit from any one of the following sources:
External 12v batteries.
Solar panels.
Wind generators
Single connection to a commercial power service (216 - 288v, 40 Hz. to 60 Hz.).

This module must also be capable of charging the internal batteries when connected to any of the above sources. The internal battery compartment, whilst it may be contained within the same environmental enclosure as the rest of the field unit, must have its own sealed enclosure, which is vented directly to the outside atmosphere. The batteries shall be sealed, shall not emit corrosive fumes, and shall be resistant to explosion. They shall also be compatible with locally available types for replacement purposes.

Primary Water Level Sensor
The Primary Water Level Sensor shall consist of an Air Acoustic Sensor and two Correction Air Temperature Sensors.

Air Acoustic Water Level Sensor.
The air acoustic water level sensor shall be an Aquatrak Model 2010-10-C or equivalent. This sensor shall use an active, air-acoustic, ranging technique to measure water level within a Government furnished protective well. The sensor shall have no active contact with the water e.g. (float). Passive

(static) contact, such as a protective tubing or a signal duct, is acceptable. The sensor shall perform in the presence of disturbances or other biological fouling, joints in the protective well, and ambient acoustic noise.

The sensor shall measure water level in a protective well that:

Will be a 0.1 to 2 m diameter pipe open at the top and bottom.
May be fabricated from one or more lengths of pipe to the length required by the station conditions.
Will be vertical to within 5 degrees.
May not have smooth walls or specially fabricated joints.

The sensor shall sample the water level at a nominal rate of two samples per second and have a digital output proportional to the water level. A sample is defined as a single observation of water level. The sensor shall have a dynamic response capable of measuring to the specified accuracy with a water level change rates up to 0.3 m/sec.

The field unit shall measure water levels via the Primary water level sensor at selected times and selectable rates as defined above. Each measurement shall be associated with an acquisition date and time (time-tag) computed to the nearest full minute.

A measurement shall consist of a mean water level value, two data quality assurance parameters, and two air temperatures for correcting measurement errors caused by temperature profile variations along the acoustic path.

The mean water level and data quality assurance parameters values shall be computed from a selectable fixed number of sequential samples acquired from the sensor, acquisition of this sequence of samples shall start before the time indicated by the time-tag, and shall be such that the middle of the sequence occurs at the time indicated. Timing shall be synchronized so that one of the time tags will be on the integral hour.

To allow for the most flexible operation of these instruments over their expected life, as much as possible of the operation and computation should be done under software control. As an example, the mean water level computations could be made as follows:

1. Compute the mean of the acquired sample sequence.
2. Compute the standard deviation about the mean.
3. Count all samples (outliers) that differ from the mean by more than three times the standard deviation.
4. Remove the outliers from the sample sequence.
5. Recompute the mean water level.
6. Recompute the standard deviation.

The value computed in step 5 shall be stored as the mean water level. The standard deviation computed in step 6 and the outlier count in step 3 shall be stored as the data quality assurance parameters values.

The contractor will be required to define the algorithm that is proposed to compute the mean water level.

The Primary water level sensor must have been designed, manufactured, assembled and tested for the marine environment.

The Primary Water Sensor must have a demonstrated field history of satisfactory performance of at least 12 months in use in a national/international monitoring program.

Redundancy of Water Level Sensor and Data Logger

The field unit shall also record water level by acquiring serial data from a Backup water level logger, which shall use a pressure transducer to determine water level. This sensor will be mounted separately from the Primary water level sensor.

The Backup water level logger shall be capable of operating independently of any other component of the field unit. There shall be no other connection between it and the rest of the field unit.

The unit shall meet the following specifications:

Measure water level by sampling and processing water pressure.
Compute water level and data quality assurance parameters data by the same method as that used for the Primary water level sensor.
Automatically compensate for local barometric pressure.
Transmit water level and data quality assurance parameters data periodically or upon demand serially.
Contain a calendar clock with equal resolution and accuracy as that in the sensor/measurement subsystem of the field unit.
Range: 0 to 15m.
Accuracy: +/- 0.015m.
Resolution: 0.003m.
Operate in the same environment as that defined for the Field Unit.
Pressure sensor shall withstand submersion to a depth of 30m without damage.
Operate for one year without service
Provide internal solid state data storage for the most recent 90 days of data.

Performance Monitoring

The field unit shall monitor its performance, non-invasively, shall encode the results into a status data set at the beginning of each hour, and shall store that set along with a time-tag.

Performance monitoring shall be done by a dedicated software task that is executed hourly and upon operator request. As a minimum, the following tests shall be performed:

Program memory check.
Random access memory check.
CPU check.
Telemetry interface check.
Battery voltage.
Charge rate (if external power is in use).
AC power-interruption (if AC power is used).
Other hardware/software checks, as required by system design.

The above tests shall also identify and record fault location, such as memory addresses and communication ports.

Interchangeability

All circuit boards, modules and sensors providing the same function(s) shall be completely interchangeable among the various modules and units without modification or adjustment.

Maintenance

The field unit shall be designed and constructed for reliable and simple maintenance and operation in the specified environment.

The design of the field unit and the maintenance program shall minimise the use of special facilities and test equipment. The contractor shall provide specialised test equipment which is designed to assist in the installation and check-out of the field units if they determine it is necessary to meet the

required specifications, and is advantageous to the program. This equipment shall obtain power primarily from its own internal batteries or optionally from the power conversion module of the field unit.

Minimum Operating Periods

The field unit shall be capable of fully automatic and unattended operation at a remote site for an operating period of not less than one year without replenishment of expendables or preventative maintenance.

The internal battery shall operate the field unit without loss of performance or data during interruption and re-establishment of commercial AC power for a period of at least 10 days with the following representative configuration of sensors and measurement rates:

Primary Water Level Sensor

12 measurements/hour. (includes level, data quality assurance parameters, and two correction air temperatures)

Backup Water Level Sensor

12 measurements/hour. (including level and data quality assurance parameters)

Six of the eleven ancillary sensors

1 measurement/ hour.

The field unit shall be able to repeat the ten day, no-power operation after recharging its internal batteries for a period no greater than 24 hours. Furthermore, the field unit shall be able to operate on this 10 day, no power, 24 hour recharge cycle with a full complement of 15 sensors (primary water, backup water, and eleven ancillaries) by adding more internal batteries in the field. The number of additional batteries required shall be determined by the contractor.

Operating Environment

The field unit will operate in the following climatic conditions:

Ambient Air Temperature:	-10 to +55 deg. Celsius
Air Temperature Change:	20 deg. Celsius per hour
Water Temperature:	-2 to +35 deg. Celsius
Salinity:	0 to 50 parts per 1000
Humidity:	0 to 100% condensing
Wind Speed:	0 to 50m/sec, with gusts to 60m/sec
Water Currents:	0 to 2.5m/sec
Shock/Vibration Resistance:	Resistant to 2g at 5 to 50 Hz.

Moderate sand and dust, salt spray and humid salt air:

Electromagnetic:

Capable of operating in an electromagnetic environment that includes commercial radio and television broadcast signals, UHF and marine radio transmission and reception and marine radar transmissions and stronger interference up to one volt per meter from several sources:

UHF Radio:	400 to 420 MHz.
VHF Radio:	30 to 170 MHz.
Radio Beacons:	280 to 300 KHz.
HF Radio:	0.5 to 30 MHz.
Radar:	S-band 2 to 4 GHz.
	C-band 4 to 8 GHz.
	X-Band 8 to 12 Ghz.

The field unit must have adequate protection against damage caused by indirect lightning strikes and static discharges, with particular attention to sensor lines, antenna leads and any power lines. Techniques such as opto-isolation, transformer coupling, surge diverters or combinations of these, in addition to adequate earthing and shielding techniques, shall be employed. An earth stud or terminal

of adequate current carrying capacity shall be provided on the outside of the field unit for connection to an earthing system. All surge protection circuits should be directed to this point.

In addition the water level sensors, which are part of this field unit specification, will be exposed to turbidity, biological fouling and water borne marine life expected in the tidal areas of Australia and surrounding territories.

Construction of Field Unit

The field unit must be an integrated unit of modular construction and housed in an environmentally protective cabinet.

Integration need not extend to the sensors which may be remote from the field unit itself, however all sensor and communication signals shall enter the field unit through an interconnection sub-unit, which shall consist of four components:

- Weather-proof entry.
- Terminal block
- Suppression circuits
- Connector for cable to the sensor/measurement subsystem.

Water-proof plugs or water-proof cable glands shall be used to ensure the waterproof integrity of the unit. The terminal block shall have sufficient capacity (terminals and space) to connect cables from a full complement of sensors plus 20 per cent spare capacity. Suppression circuitry shall be provided for all terminals on this terminal block.

The connector shall provide connections for a full set of sensors plus 20 per cent spare capacity, all wiring between the connector and the terminal block shall be installed.

If the field unit has provision for cable connection or entry through its bottom surface, then feet shall be attached to that surface so that cables can connect or enter without undue bending when the enclosure is placed on a work-bench or floor.

Each component located within the enclosure shall be easy to install and remove. Access shall be provided for the connection of all cables internal to each enclosure. All internal controls and displays shall be visible, accessible and clearly marked when the cover is open.

Each enclosure shall be weather-proof when permanently attached covers, caps, or lids are closed. All spaces containing electronics shall be at least weather resistant when operating with the covers open.

Each enclosure shall have tabs or other provision for wall mounting.

The Barometric Pressure sensor if housed in the environmental cabinet must be vented to the outside by means of a static head connection.

Vertical reference

The Primary water level and Back up water level sensors will be referenced to a set of high stability benchmarks by direct levelling. Each sensor shall have a permanent reference point suitable for use with surveyor's levelling instruments. This point shall be both visibly distinct and physically accessible so that a high precision levelling staff may be held against it.

This point shall be located at a fixed, known distance from the sensor mounting holes (or pins). This fixed distance shall be the same for all sensors; thus, sensors can be replaced, on-site, without resurvey (levelling) to the local benchmark.

Ancillary Sensors

The field unit shall be capable of acquiring and storing input signals from a minimum of eleven sensors simultaneously. Eight input ports shall be provided for analogue voltage signals, and three

input ports shall be provided for pulse stream of frequency signals. As well as the mandatory sensors already listed several other types of oceanographic and meteorological sensors may be utilised, typically:

Humidity	Water Current Speed
Rainfall (Tipping Bucket)	Water Current Direction
Water Conductivity	Water Density

Not withstanding the specifications already stated, the Ancillary sensors will, where possible be selected from a range in accordance with Bureau of Meteorology specifications AS2659.

All cables necessary to interface the sensors, external power sources and antenna to the field unit are to be supplied.

Transport

The field unit will be subjected to the following conditions during transport to and from sites:

Temperatures:	-40C to +60C.
Humidity:	0-100% condensing.
Shock:	1 meter drop.
Vibration:	2g, 5 to 50 Hz.

As these field units will be manually handled and located in remote areas, they could be transported by one or more of the following means: air freight, truck, four wheel drive vehicles, all terrain vehicles, car, survey ship, launch, small boat, light aircraft, helicopter and human carrying. They should therefore be of a size and weight to meet any such carrying restrictions and be easily handled by preferably one but no more than two persons.

Mandatory Documentation

Software/Firmware documentation:

Program specifications:
User Manuals: and
Program Maintenance Manuals.

Technical Manuals (including circuit diagrams).

Field Unit;
Backup Data Logger: and
Each additional environmental sensor.

User Manuals

Field Unit;
Backup Data Logger; and
Each additional environmental sensor.

Test Reports for each component must be supplied.