

**1. Work to be Carried Out at each Tide Gauge**

In accordance with the procedures and recommendations contained in these instructions, carry out the following work:

- 1.1 Subject to the owners agreement calibrate each automatic recorder.
- 1.2 Complete "Tide Gauge Details" sheets for each tide gauge.
- 1.3 Inspect existing bench marks and, where necessary, install additional or supplementary marks to bring the number of stable marks in the vicinity of each gauge to at least three.
- 1.4 Determine the difference in height between each of the tide gauge bench marks and the zero of the tide staff and/or recorder at each installation.
- 1.5 If not already, and where reasonably possible, connect the tide gauge bench marks to a level traverse of the national Levelling Survey.
- 1.6 Make a photographic record of each automatic recorder, the tide staff and nearby features.
- 1.7 Prepare a plan of each tide gauge installation.
- 1.8 If necessary, identify each gauge and the bench marks on aerial photography.
- 1.9 Discuss with the owners and/or operators of the gauges any faults found with and possible improvements to each gauge and its records.
- 1.10 Send a copy of all documentation to the PCTMSL as soon as possible after installation.

**2. Calibration of Automatic Recorders**

Automatic recorders may be calibrated in accordance with the following procedure:-

- 2.1 Each gauge should be calibrated both before and after cleaning of the sensor or stilling well inlets unless inspection shows them to be clear.
- 2.2 Use the "Tide Gauge Calibration" forms provided to record the level of the sea inside the stilling well as indicated by the automatic recorder, the level of the sea outside the well as indicated by the tide staff, and the date and time of observation, and other relevant details, every 1/4 hour on the 1/4 hour, continuously for a period of the complete tide range including both the rising and falling tide, ideally at springs.
- 2.3 Clean the sensor or stilling well inlets and repeat the test.
- 2.4 Where the tide staff is not conveniently placed to enable observation of the recorder height and the tide staff height to be simultaneous, a temporary tide staff is to be established in a suitable position and its height is to be related to the existing tide staff.
- 2.5 A careful inspection of the tide staff should be made to see that it is firmly fixed and in a vertical position. If necessary, but only with the agreement and co-operation of the operator of the gauge, the tide staff should be firmly secured in a vertical position without disturbing the height of the tide staff zero. Any work carried out on the tide staff should be noted on both the tide gauge chart and the calibration record.

- 2.6 In exposed locations or in rough water the tide staff may be difficult to read without adequate stilling precautions. If necessary, a length of 1/2 inch diameter clear plastic tube, open at the top and fitted with a suitable notched plug at the lower end, may be fixed to the tide staff so that the water level in the tube can be read. It is essential to ensure that the tube does not become clogged and that there is sufficient opening at the lower end. If there is any wave movement on the outside, the water in the tube should show perceptible oscillation.
- 2.7 Record wind speed and direction and atmospheric pressure during the calibration period at 6 hourly intervals, unless readings are available from an nearby meteorological station
- 2.8 Make arrangements, if possible, with the owner or operator of the gauge for the supply to the Permanent Committee on Tides and Mean Sea Level of a copy of at least that portion of the recorder chart and or digitally recorded readings covering the period of the calibrations.

**3. Tide Gauge Details Sheets**

- 3.1 In consultation with the owner and or the operator of the gauge and by personal inspection and observation complete the 4 pages of "Tide Gauge Details" in as much detail as possible.
- 3.2 These sheets serve as a permanent record of the tide gauge installation and it is important that as much information as possible be obtained and that the information is accurate.
- 3.3 If any information differs from previous records attempt to find out when the changes occurred and note. Do not destroy the old information.
- 3.4 With reference to environmental effects (Question 28) describe in detail any feature which may limit exposure of the gauge to open water (e.g. shallows narrows etc.).

**4. Bench Marking**

- 4.1 Inspect existing permanent bench marks in the vicinity of each tide gauge and if these are inadequate in number and/or quality establish new permanent marks so that at least three marks of good quality and stability are available at each gauge.
- 4.2 New marks should be about 100 metres apart and away from any anticipated construction activity or other possible cause of disturbance.
- 4.3 Marks established as tide gauge bench marks should preferably be constructed of brass rod set at least 150 mm into solid rock concrete foundations or other suitable structures the top of the rod protruding not more than 5 mm and indicated by a brass numbering plate. If no suitable rock or structure is available bench marks are to be established in accordance with Part C "Recommended Marking Practices" of the ICSM Special Publication 1 "Standards and Practices for Control Surveys Version 1.5 May 2002
- 4.4 The identification number allocated to each new bench mark is to be legibly stamped on the brass numbering plate.
- 4.5 Each new bench mark is to be fully described in the field level book and a Permanent bench Mark Record is to be prepared for each new mark on the forms provided.
- 4.6 Benchmarks established during the level observations from the tide gauge bench marks to National Levelling, Survey traverses shall be constructed in accordance with the above Schedule.
- 4.7 Supply a copy of all Permanent Bench Mark Records to the State Survey Authority.

**5. Levelling to the Zero of Tide Staffs**

- 5.1 The differences in height between all tide gauge bench marks and the zero of the tide staff is to be determined in accordance with section 6.1 and 6.2 below.
- 5.2 A diagram showing the differences in height between the tide gauge zero and the tide gauge bench marks is to be prepared for each gauge.
- 5.3 Information relating to any change in the position of the tide staff or damage to it in recent years should be sought from the gauge owner or operator and included in the report on the tide gauge.
- 5.4 Check the graduations on the tide staff itself for accuracy and note any anomalies.

**6. Connection to the National Levelling Survey**

- 6.1 If the tide gauge bench marks have not already been connected to a traverse of the National Levelling Survey such a connection shall be carried out to class LC in accordance with Part B Best Practice Guidelines for Surveys and Reductions sub section 2.4 Differential Levelling of the ICSM Special Publication 1 "Standards and Practices for Control Surveys Version 1.5 May 2002
- 6.2 All levelling is to be checked and a summary completed before leaving the site of the survey.
- 6.3 The levelling summary should be submitted to the State Survey Authority for incorporation into the National Levelling Survey adjustment.

**7. Photographic Record of the Tide Gauge**

- 7.1 Two photographs of each tide gauge bench mark shall be taken. One photograph shall be a close-up of the actual mark and the other shall show the detail of the area surrounding the mark.
- 7.2 Two photographs of the tide gauge recorder hut shall be taken, from different directions.
- 7.3 Two photographs of the tide staff shall be taken, one a close-up of the tide staff and the other, if possible, showing both the tide staff and the recorder hut.
- 7.4 Two photographs showing the recorder inside the hut shall be taken from different positions.
- 7.5 Two or more photographs shall be taken from a considerable distance and shall show the tide gauge installation in relation to other prominent local features.
- 7.6 A record of the exposures in their correct sequence is to be kept on the photography record sheet provided.
- 7.7 On completion of a film it is to be labeled with the names of the photographed tide gauges on both the wrapping paper and the cassette or container.

**8. Plan of the Gauge Installation**

- 8.1 The position of the recorder, the tide staff and all bench marks shall be shown on a large scale plan of the area.
- 8.2 A suitable map of the area can usually be obtained from local authorities. Where such plans or maps are unobtainable a sketch shall be prepared showing the recorder hut, the tide staff, the bench marks and other local features in their proper relative positions and identify their location on aerial photography as described below.

- 8.3 The automatic recorder and all bench marks shall be identified on aerial photography by pricking their positions on the photos with a fine needle and by suitable annotation.

Where an identification is in doubt, an easily identifiable point nearby shall be identified. The photo annotation shall refer to this nearby point as the "Photo Reference Point" and shall indicate its bearing and distance from the recorder and the bench marks.

- 8.4 The plan of tide gauge installation should be included with the Tide Gauge Details sheets.

**9. Discussion with Owners and Operators**

- 9.1 The owners of the gauges should be advised well in advance by letter that the survey party from a designated organisation will be visiting each gauge. A few days before the party is expected to arrive at each gauge the party leader shall try and contact the operator by telephone to let him know when to expect the party.

- 9.2 Any faults in the gauge or the records shall be discussed with the owner and or operator but no adjustments are to be made without the agreement of the owner or operator.

**10. Permanent Committee on Tides and Mean Sea Level**

- 10.1 Supply a copy of the Tide Gauge Details sheets, plan of installation, annotated aerial photograph (if applicable) and height connection diagram (see paragraph 5.3) to the PCTMSL as soon as possible after installation.

- 10.2 If any changes occur to the details provided or the gauge is removed, the PCTMSL should be informed immediately.



20. Chart time scale
21. Type of Record
22. Records stored at
23. Float operated gauge:
  - Diameter of float
  - Diameter of well
  - Height of inlet above the sea bed
  - Specifications and configuration of inlet /s
24. Pressure operated gauge: (Strain gauge gas purge etc)
  - Type of sensor /s
  - Depth of sensor /s below gauge zero
  - Distance of sensor /s from recorder
  - Method of pressure transmission
25. Pulse flight time operated sensor (downward looking radar or acoustic pulse sensors)
  - Type of sensor /s
  - Height of sensor above gauge zero
  - Distance of sensor from recorder
26. Are water density, temperature and salinity measured? If yes, how often:
27. Recorder calibrated:
  - Period
  - Method
28. Environmental effects on gauge
29. Description of bench marks
30. Height of benchmarks:
  - above tide staff zero
  - above recorder zero
  - above Australian Height Datum
  - above hydrographic chart datum
  - above Low Water Datum
  - above other datums
31. A.H.D. height of:
  - Tide staff zero
  - Recorder zero
32. Levelling Section:
  - Number
  - Levelling By
  - Level Books
35. Other relevant details:  
Issue:                                      Prepared by:                                      Date:





A comparison of the Doodson numbers in the IOS (UK) and IOS (Canada) prediction programs revealed a difference in the interpretation of the constituent Sa that has the potential to degrade the accuracy of tidal predictions in Australia. The former program is used by the National Tidal Facility Australia and the Coastal Data Centre Department for Planning and Infrastructure of West Australia while the latter program is used by the Hydrographic Office RAN and a significant number of other Australian organisations.

Constituent Sa, which represents the seasonal variation (with period of about one year) in mean sea level is quite significant in Australian waters. It may have an amplitude of up to 0.4metres but generally is in the order of 0.1 metres.

The Doodson numbers for Sa used in the IOS(UK) program (Reference A Table 4) are 0 0 1 0 0 0. Those used in the IOSD(Canada) (Reference C, Appendix 4) are 0 0 1 0 0 -1. The former set involves only the mean longitude of the sun and its rate of change. The latter set also involves the mean longitude of the solar perigee and its rate of change. The effects of the difference in the last number are calculated in Annex A. While the effect on the speed of the constituent is almost negligible, the effect on our programs calculation of the initial phase of Sa is large giving rise to inaccurate tidal predictions.

<b>Source of Constituent Constant</b>	<b>IOS (UK)</b>	<b>Difference</b>	<b>IOS (Canada)</b>
Constituent name	Sa		Sa
Interpretation Doodson numbers	0 0 1 0 0 0		0 0 1 0 0 -1
Speed (degrees/hour)	0.0410686	0.0000019	0.0410667
Period (mean solar days)	365.24254		365.24995
Phase in degrees at time origin	(0000 GMT 1/1/76) 278.78841	-77.472360	357.26077
Phase in degrees at	(0000 GMT 4/4/84) 9.54387	-77.33048	86.874358

It is not particularly important which Doodson numbers are used for the constituent as long as those used in the prediction program are the same as those used in the tidal analysis that gave

The effect of the differing Doodson number on the accuracy of past predictions was demonstrated by test predictions for a year using Sa with Doodson Numbers 0 0 1 0 0 0 and 0 0 1 0 0 1. Using a typical amplitude of 0.1m, the difference in tidal height varied from zero to 0.13m.

There are two ways to deal with the difference in interpretation

- 1 Include details of the Doodson number for Sa in the metadata accompanying tidal constituent constants
- 2 Modify analysis and prediction programs to use the IOS (UK) interpretation i.e. the Doodson number for Sa is 0 0 1 0 0 0

It would be prudent to implement both.

**References**

A: "The Fine Resolution of Tidal Harmonics" by M. Amin 1975.  
 B: "The Harmonic Development of the tide generating Potential" by A.T. Doodson 1921.  
 C: "Manual for Tidal Heights Analysis and Prediction" MGG Foreman. IOS (Canada) 1977.