NATIONAL MAPPING COUNCIL
OF
AUSTRALIA

STANDARD SPECIFICATIONS FOR HORIZONTAL AND VERTICAL CONTROL

PREPARED ON BEHALF OF THE NATIONAL MAPPING COUNCIL
OF AUSTRALIA BY THE DIRECTOR OF NATIONAL MAPPING,
DEPARTMENT OF THE INTERIOR, CANBERRA, A. C. T.

NMO/53/11.2

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STANDARD SPECIFICATIONS
for
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INTRODUCTION

1. These specifications apply to control surveys for determining latitude, longitude and elevation of marked stations distributed throughout an area to be mapped.

CLASSIFICATION

2. These control surveys will be classified as first, second, third or fourth order according to the degree of accuracy achieved in accordance with these specifications.

HORIZONTAL CONTROL
General

3. Horizontal control will normally be provided by triangulation or traverse or a combination of both. Triangulation will normally be used in preference to traverse.

4. When traverse is employed it shall be run in closed loops or it shall connect between previously established control stations of equal or of a higher grade of accuracy. All lines on first or second order traverse shall be measured twice with different chains one of which shall be graduated in feet and the other in links or metres.

5. In executing traverse or triangulation of the three higher orders particular effort should be made to locate additional stations by the intersection method. These additional stations may either be suitable existing objects of a permanent nature or specially marked points. In selecting such additional stations consideration should be given firstly to their subsequent use by the topographer or surveyor working from the ground and secondly to their use in providing control for mapping undertaken by aerial survey methods.

First Order

6. In areas that are likely to be intensively mapped, chains of first order triangulation and/or lines of first order traverse shall normally be executed in grid form enclosing areas approximately 100 miles square and may be used in

conjunction with second order triangulation or traverse to provide additional control within these areas. First order triangulation or traverse should also be used to connect between such areas.

7. First Order Triangulation shall conform to the following specification -

(a) average triangle misclosure shall not exceed 1",

(b) maximum triangle misclosure shall not exceed 3",

(c) chains of triangulation shall not normally exceed 200 miles in length between base lines,

(d) base lines shall be measured with an accuracy represented by a probable error not exceeding 1 part in 1,000,000 and an estimated actual error not exceeding 1 part in 300,000,

(e) La Place azimuths are to be observed with an accuracy represented by a probable error not exceeding 0.3" and a La Place station shall be established -

(i) at a triangulation station in the immediate vicinity of each base line,

(ii) at a triangulation station situated approximately at the mid point of each chain of triangulation connecting pairs of base lines.

(f) chains of triangulation shall be so designed and executed, that after the side and angle equations have been satisfied, the probable error of the length obtained for the closing base, when computed from the starting base as an ordinary side of the triangulation shall not exceed 1 part in 100,000 and the actual discrepancy between the computed value and the measured value of the closing base shall not exceed 1 part in 25,000.

8. First Order Traverse shall conform to the following specification -

(a) the probable error in the standardisation of each of the chains used shall not exceed 1 part in 200,000, and the linear distance between adjoining permanently marked stations shall be determined with an accuracy represented by a probable error not exceeding 1 part in 100,000,

(b) traverses shall be subdivided into sections of approximately 10 miles length between selected permanently marked stations at which azimuths shall be observed. The angles of the traverse shall be measured to such a uniform degree of accuracy, and the controlling azimuths observed with sufficient accuracy and at sufficient intermediate stations to ensure, that after the adjustment of angular discrepancies, the probable error of displacement over each section due to these factors shall not exceed 1 part in 100,000 of the length of the section,

(c) La Place azimuths are to be observed with an accuracy represented by a probable error not exceeding 0.5" and La Place stations shall be established at approximately 100 mile intervals along traverses, or at such closer intervals as are considered necessary to eliminate errors caused by gravity anomalies.

Second Order

9. Second order triangulation or traverse shall normally be used to subdivide the area between first order control for the purpose of providing the immediate control required for third order triangulation or traverse and shall be so designed as to provide a network of first and second order stations over the entire area to be mapped, at distances apart of approximately 10 to 15 miles.

10. Second Order Triangulation shall conform to the following specification -

(a) average triangle misclosure shall not exceed 3",

(b) maximum triangle misclosure shall not exceed 5".

In certain circumstances it may be necessary to use independent chains of second order triangulation, in which case -

(c) chains of triangulation shall not normally exceed 150 miles in length between base lines and such base lines shall consist of lines specially measured as second order bases, or of sides of a first order triangulation,

(d) base lines shall be measured with an accuracy represented by a probable error of not more than 1 part in 500,000 and an estimated actual error not exceeding 1 part in 150,000,

(e) La Place azimuths are to be observed with an accuracy represented by a probable error not exceeding 0.5" and a La Place station shall be established at a triangulation station situated approximately at the mid point of each chain of triangulation connecting pairs of base lines,

(f) chains of triangulation shall be so designed and executed that after the side and angle equations have been satisfied the probable error of the length obtained for the closing base, when computed from the starting base as an ordinary side of the triangulation, shall not exceed 1 part in 50,000 and the actual discrepancy between the computed value of the closing base and the value determined by measurement or from first order triangulation shall not exceed 1 part in 15,000.

11. Second Order Traverse shall conform to the following specification -

(a) the probable error of standardisation of each tape used shall not exceed 1 part in 100,000 and the linear distances between adjoining permanently marked traverse stations shall be determined with an accuracy represented by a probable error not exceeding 1 part in 50,000,

(b) traverses shall be subdivided into sections of approximately 10 miles length between selected permanently marked stations at which astronomical azimuths shall be observed. The angles of the traverse shall be measured with such a uniform degree of accuracy and the controlling azimuths observed with sufficient accuracy and at sufficient intermediate stations, to ensure that after the adjustment of angular discrepancies the probable error of displacement over each section due to these factors shall not exceed 1 part in 50,000.

Third Order

12. Third order triangulation or traverse shall normally be used to subdivide the area between first and second order stations for the purpose of providing a network of third or higher order stations over the entire area to be mapped, at distances apart of approximately five miles. The position of third order stations shall be determined with such accuracy, that after adjustment it will be most unlikely that the computed distance between a third order station and any adjacent third or higher order station will be in error by more than 1 part in 10,000.

13. The horizontal control shall be tested where considered necessary by carrying out a first order traverse between adjacent third order stations. The discrepancy between the computed distance and the measured distance should not exceed the permissible limit of 1 part in 10,000.

14. Third Order Triangulation shall conform to the following specification -

(a) average triangle misclosure shall not exceed 5",

(b) maximum triangle misclosure shall not exceed 10".

15. Third Order Traverse shall conform to the following specification -

(a) the probable error of standardisation of the chain used shall not exceed 1 part in 50,000 and the linear distances between adjoining permanently marked stations shall be determined with an accuracy represented by a probable error not exceeding 1 part in 25,000.

(b) traverses shall be subdivided into sections of 4 to 6 miles in length between selected permanently marked stations at which astronomical azimuths shall be determined. The angles of the traverse shall be measured with such a uniform degree of accuracy and the controlling azimuths observed with sufficient accuracy and at sufficient intermediate stations, to ensure that after adjustment of the angular discrepancies the probable error of displacement over each section due to these factors shall not exceed 1 part in 25,000.

Fourth Order

16. Fourth order triangulation or traverse shall be used to connect the control of higher grades of triangulation or traverse with mapping operations in a region. The sole requirement of accuracy in fourth order control surveys is that the positions of stations shall be located with errors too small to be appreciable on the resulting map.

VERTICAL CONTROL

17. The elevations of horizontal control stations shall be determined by fourth or higher order levelling.

Datum for Elevations

18. All elevations should be based on mean sea level datum.

First Order

19. In areas that are likely to be intensively mapped first order levelling shall normally be run in grid form enclosing areas approximately 100 miles square and may be used in conjunction with second order levelling to provide additional control points within these areas. First order levelling should also be used to connect between such areas. All lines of first order levelling shall be divided into sections $\frac{3}{4}$ to $1\frac{1}{4}$ miles in length and shall be levelled in opposite directions under different atmospheric conditions. The two levellings of each such section shall not differ by more than $.017\sqrt{M}$ feet where M is the length of the section in miles.

Second Order

20. Second Order levelling shall normally be used in subdividing grids of first order levelling so as to provide a network of lines of first or second order levels spaced approximately 25 miles apart. All lines of second order levelling shall be divided into sections $\frac{3}{4}$ to $1\frac{1}{4}$ miles in length and shall be levelled in opposite directions under different atmospheric conditions. The two levellings of each such section shall not differ by more than $.035\sqrt{M}$ feet where M is the length of the section in miles.

Third Order

21. Third Order levelling shall normally be used in subdividing grids of first or second order levelling for the purpose of providing lines of levels which may be single run lines but must always be run in loops, or in circuits which close upon lines of equal or higher order bench marks. Closing checks are not to exceed $0.05\sqrt{M}$ feet where M is the length of the circuit in miles.

Fourth Order

22. Levelling in which closure checks are greater than the limit stated for third order work, but which is of sufficient accuracy to control the contouring of the area being mapped may be classified as fourth order levelling.

MARKING OF STATIONS AND BENCH MARKS

Standard Station Marks and Bench Marks

23. All triangulation stations, and selected traverse stations at intervals of approximately one mile, shall be permanently marked and permanent bench marks shall be established at intervals of approximately one mile along lines of first, second and third order levelling.

24. Permanently marked horizontal control stations and permanent bench marks shall be marked by standard metal tablets closely resembling the tablet shown in the diagram attached hereto as Appendix "A" or by such standard marks as are approved by the Surveyor-General of a State or Territory. These tablets shall be made of non-corrodable metal and be firmly set in a pre-cast concrete block or in concrete poured into a roughly cut hole and tamped. The upper surface of the concrete block shall have an area of not less than twentyfive square inches and the lower not less than fifty square inches. Unless on a solid base the concrete block shall be two feet in depth or of such greater depth as is necessary to obtain a sound foundation. The concrete shall be of a good standard quality and the whole shall be constructed and placed in a workmanlike manner. Every Standard Station Mark shall be so constructed and placed as to be capable of serving the purposes of theodolite reference mark and bench mark.

Special Marks

25. Under certain conditions special marks may be used. Where by its location it would be unduly expensive to construct a concrete mark, a metal pipe of suitable size and of non-corrodable material may be used. The base of this pipe should be so shaped as to resist extraction of the pipe and should preferably be set in concrete. In swamps a long metal pipe set inside a drain tile filled with hydraulic cement, may be used. Where a station mark must be set on land subject to cultivation it is preferable to have the top of the mark about 12 inches below the surface.

Sub-Surface Marks

26. Sub-surface marks shall normally be established as follows -

(a) at every first and second order triangulation station,

(b) at permanently marked stations at about 10 mile intervals along first and second order traverses; these stations should preferably coincide with the sectional terminal stations established in accordance with sub-paragraphs 8(b) and 11(b).

Sub-surface marks should preferably be made of concrete not less than 6 inches thick and 10 inches in diameter with the station point marked by a metal tablet, copper bolt, or other durable substance. The sub-surface mark should be 4 or 5 inches below the base of the concrete surrounding the standard permanent mark and extreme care must be taken that the sub-surface mark is directly underneath the centre of the surface mark.

Reference Marks

27. At least one, and preferably two reference marks should be set at each triangulation station. They should be set in concrete and consist of metal tablets similar to the standard station mark but bearing a different inscription and preferably, inscribed with an arrow pointing toward the station. Where more than one reference mark is used at a station, the tablets should be stamped and numbered serially clockwise as viewed from the station. Particular care should be taken to select sites for these reference marks where they will not be subject to disturbance. Where possible two suitable reference trees or tall stumps should also be marked.

Azimuth Marks

28. At triangulation stations and at permanently marked traverse stations where a reference azimuth cannot conveniently be obtained by sighting to an adjacent station, azimuths shall be specially observed to suitable reference marks of a permanent nature.

29. These azimuths shall be observed with an accuracy represented by a probable error not in excess of 5" in the case of first and second order stations and not in excess of 10" in the case of third order stations.

STATION NAMES AND REFERENCES

30. It is recommended that triangulation stations shall be referred to by name, permanently marked traverse stations by a combination of letters and numbers and permanently marked bench marks by the letters B M followed by a number which shall not be repeated within selected subdivisions of a State or Territory. The names of triangulation stations and the reference letters and numbers of traverse stations and bench marks shall be stamped on the standard permanent marks preferably before they are set in concrete.

31. Names for triangulation stations should have a geographic significance wherever possible. Care should be taken by the officer in charge of the survey party to ascertain the name which is most prevalent for a particular geographic feature. It is recommended that the Surveyor-General of the State or Territory shall be the final authority for these names and reference letters and numbers.

DESCRIPTION OF STATIONS

32. A clear, concise and complete description and a sketch plan shall be made out for each Standard Station Mark and for each Bench Mark established, showing sufficient information to permit of the ready location of the mark itself. This report and sketch plan should be filed in convenient form in the central office of the organisation responsible for surveys in the State or Territory.

RECOVERY OF ANY STANDARD STATION MARK OR BENCH MARK

33. It is recommended that survey organisations engaged in mapping should instruct their field officers to report on the condition of Standard Station Marks or Bench Marks which may be visited by them. If the mark is found, the recovery report should state the condition in which it was found and should give any modifications or additions to the descriptions which would make it more easily found in the future. If the mark is not found, the report should indicate the thoroughness of the search made and give recommendations as to whether or not the station should be marked "lost" in the records. These recovery reports should be filed in the central office responsible for maintaining the records of station descriptions.

34. If a properly equipped field party of such an organisation under the immediate direction of a Licensed Surveyor finds in poor condition a Standard Station Mark of a third or higher order of accuracy and if its proper location can be determined with certainty and accuracy, either by a recovered underground mark or by measurements from two or more reference marks, the party should re-mark the station if practicable. If the tablet marking the original station is recovered, it should be re-set. If an underground mark exists due care must be exercised to ensure that the new surface mark is exactly centered over the sub-surface mark.

35. If a Bench Mark is reported as having been disturbed an approved survey organisation may establish a new Bench Mark in the immediate vicinity and determine the level of this new mark from adjacent Bench Marks using the same order of levelling as was used when determining the level of the original Bench Mark.

PUBLICATION OF RESULTS

36. It is recommended that values of horizontal and vertical control stations should be published as soon as possible after these values have been determined.

37. The basic datum of such published values shall be clearly shown on the same page as the values themselves.

38. The values determined for the position of first and second order horizontal control stations shall be given both by rectangular and by geographical co-ordinates.

39. Elevations of vertical control stations shall be given in feet.

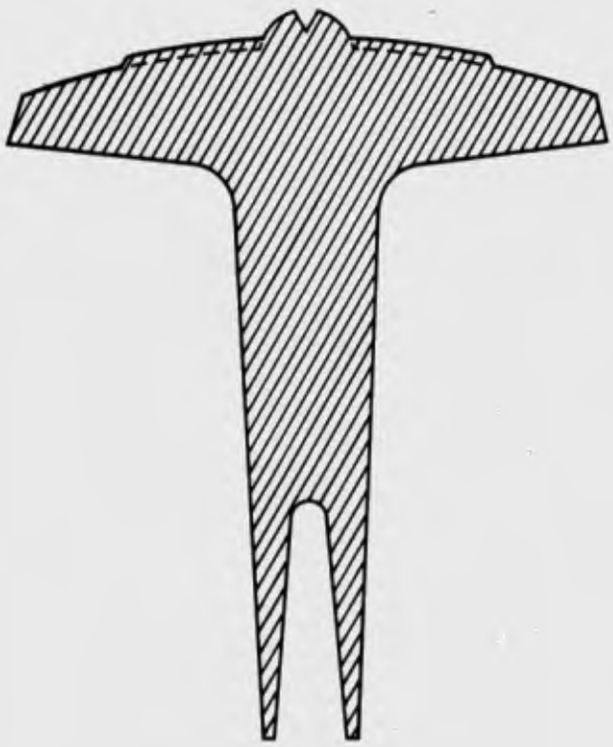
40. Each publication containing horizontal or vertical control data shall include an index map showing the areas covered by the data in the publication.

APPENDIX A

STANDARD STATION MARK

Scale : Full Size

PLAN



SECTIONAL ELEVATION

AMENDMENT NO. 1

NATIONAL MAPPING COUNCIL OF AUSTRALIA

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(NMO/53/11.2 - February, 1953)

1. Page 9, after paragraph 27 add the following new sub-heading and paragraph:

Connections to Other Surveys

27(a) It is desirable that all control points shall be connected to existing evidence of other surveys where such is easily accessible.

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Issued on behalf of the
National Mapping Council by:-

Director of National Mapping,
National Mapping Office,
Department of the Interior,
CANBERRA.....A.C.T.

8.8.1955.