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MS.

FORESTERS' MANUAL

Forest Engineering—Section 2

TOPOGRAPHICAL SURVEYING AND MAPPING

FORESTS DEPARTMENT
PERTH
WESTERN AUSTRALIA

SECTION 2

TOPOGRAPHICAL SURVEYING AND MAPPING

CONTENTS

TOPOGRAPHICAL SURVEYING AND MAPPING

Mapping Procedures

1. The mapping of the forest areas of the State is accomplished by plotting the topographical detail from vertical aerial photographs using stereoplotting instruments with a high order of accuracy. Such a machine is the Wild B8 Aviograph. This mapping technique is employed to prepare large-scale maps for the detailed planning of Departmental field operations and medium-scale maps for overall planning and administrative control. Large-scale mapping includes the A.P.I. topographical and type series, plantation, settlement and special project mapping. Where required, these maps are prepared to show contours.

Control for mapping is obtained by ground surveys to establish the position of selected photo-control points. The horizontal position is determined by traversing with a theodolite and 100 metre survey band from established survey pegs, while vertical control is obtained by barometric heighting. In all cases the position of the control point is identified on an aerial photograph.

Types of Surveys

2. Field surveys are carried out in the following circumstances:—

Theodolite Surveys

(i) Traversing to obtain control for mapping. Normally this will be performed by selected staff of the Drafting Branch, but Divisional Offices may be required to provide field assistants and four-wheel-drive vehicles.

(ii) The traverse of selected roads used as survey control and tied to the State survey system. This was the accepted method of obtaining mapping control but has now been superseded by photogrammetric methods. This type of survey would now be rarely performed and only with the approval of Head Office.

Compass and Survey Band

(iii) Marking the boundaries of Departmental leases.
(iv) Laying out plantation subdivisions.
(v) Traversing of newly constructed roads and tracks.
(vi) Traversing forest roads and tracks for the purpose of establishing reference trees.
(vii) Establishing the position of major improvements in settlement areas.

Compass and Pacing

(viii) Determination of the boundaries of trade cutting.
(ix) The location of minor improvements.

Survey Instruments

Theodolite

3. This is a precision instrument used for measuring horizontal and vertical angles. The instructions for its use and adjustments are contained in the appropriate handbooks, which must be carefully studied by the operator. It should not be used by untrained staff.

Prismatic Compass, Oil Float or Dry Card Type

4. The prismatic compass consists of a flat circular brass or gun-metal box of 0.08 m diameter containing a card circle divided into half degrees. Underneath and across the diameter of this circle a flat permanent magnet is fixed having an agate screwed into its centre. The card is supported at the agate on a pivot point screwed precisely in the centre of the bottom of the brass case. In the front of the box a magnifying right-angle prism is fitted and held in a small dove-tailed slide which allows this prism to be raised or lowered in order to bring the divided circle accurately into focus. The prism box is hinged so that it may be folded back when replacing the cover to protect the glass of the compass. Above the peephole of the prism, a slit is cut so that

the user can bring the vertical wire opposite the prism, into line with the object sighted and at the same time read the divided circle. The vane carrying the vertical wire should be folded down on the glass before replacing the cover. A leather case and strap are provided to protect the compass when not in use.

As a compass leaves Head Office, it should be in good adjustment and the user is seldom, if ever, called upon to make any alterations to the original settings. In fact, there is hardly anything he can do to correct any apparent errors, and the whole instrument is so simple that the only adjustments likely to be required are those due to serious damage which would necessitate its return to Head Office for repairs.

Care should be taken that the sighting vane is folded down whenever the instrument is being carried from place to place.

Should a persistent air bubble occur in an oil float type compass, the instrument should be returned to Head Office for repairs.

KB-14 SUUNTO Pocket Compass

5. This hand-compass has a frame of solid corrosion-resistant lightweight alloy. The scale card is immersed in a dampening fluid and contained in a hermetically-sealed transparent housing. The sighting lens has a slit aperture and crosshair. The instrument is operated by sighting through the aperture with the right or strongest eye so that the scale is read through the lens. It is most important that both eyes be kept open. An optical illusion makes the hair-line appear to continue above the instrument frame and thus discernible against the terrain. The compass is turned horizontally until the cross-hair is against the object. The bearing is then read on the compass card.

The plastic window above the card-housing may accumulate a static charge if rubbed against cloth, which will cause the card to stick. It is freed by breathing against the window.

PM5/360 PC SUUNTO Clinometer

6. This instrument is most commonly used to ascertain the correction required for the reduction of slope distance to horizontal. It is also used to ascertain tree heights.

The construction is similar to the SUUNTO Compass with the scale card being immersed in a dampening fluid. The vertical angle is obtained by holding the instrument vertically with the window facing left. The operator sights at the object through the aperture with his right or strongest eye and reads the angle of elevation or depression against the cross-wire which will appear to extend outside the frame. It is necessary that both eyes be kept open when observing.

Abney Level

7. This clinometer is a hand-held level adapted for measuring vertical angles. In use, the line of sight, which is defined by a pin-hole at one end of the tube and a cross-bar at the other, is directed towards the object and the milled wheel turned until the reflected image of the bubble appears in the plane of sight. The required angle is then read on the arc.

To test and adjust the instrument, two points at different elevations are selected, and the vertical angle between them is observed from both. The angle of elevation observed from the lower station should equal the angle of depression taken at the upper. If these differ, their mean is the correct value of the inclination, and the instrument is made to record this by means of the adjusting screws controlling the level tube.

Survey Band

8. This equipment is normally 100 metres in length and graduated at each metre. The first and last metre length is graduated at intervals of 0.01 m.

Care must be exercised in the handling of this equipment as, if carelessly used, it is liable to be broken especially by pulling it when twisted into loops or by stepping on it.

In the event of a survey band being broken, the ends should be cleaned with sandpaper and a brass sleeve fitted and soldered to make a firm, neat joint. Repair outfits are obtainable on requisition from Head Office.

To prevent rust, bands should be run off their reel, cleaned and wiped with an oily rag after use and before returning to storage.

Bands should be examined and tested at intervals against a known distance.

Classification of Surveys

9. Departmental surveys are classified in accordance with the following standards:—

Theodolite Control Surveys

TA. Surveys closed by calculation to within a limit of 1:4000.
TB. Surveys closed by calculation to within a limit of 1:800.
TC. Surveys closed by calculation to within a limit of 1:400.
Reference trees marked on A., B. and C. traverses are shown with a double circle.

Compass and Chain Surveys

CD. Compass surveys closed by plot to within a limit of 1:350 and tied to other Lands Department surveys or F.D. theodolite surveys at not more than 5 km intervals.

CE. Compass surveys closed by plot to within a limit of 1:175 and tied to other surveys as above at not more than 5 km intervals.
Reference trees marked on CD and CE traverses to be shown with a single circle.

CF. Compass surveys showing a misclose of more than 1:175 or tied to other surveys as above at more than 5 km intervals.
Reference trees marked on F traverses will be shown with a broken circle to indicate that position is doubtful.

Compass and Pacing Surveys

CG. Surveys by compass and pacing. Misclose to be not more than 1:20.
No reference trees are to be marked along these unreliable traverses.

Magnetic Variation or Declination

10. The magnetic variation or declination is the horizontal angle between the magnetic north and true north and should always be taken into account when plotting compass traverses.

As the magnetic poles do not coincide with the geographic poles, the magnetic meridian does not coincide with true meridian except in certain localities. The direction and amount of variation between the two alters at different localities on the earth's surface. It is not constant but is subject to small periodic fluctuations.

The magnetic variation may be ascertained by setting up and checking by fore and back sighting between any two survey pegs fixed by theodolite, the true bearing of which being known. Care must be taken that local magnetic attraction does not exist when the compass is being tested. The backsight indicates this.

All bearings taken with a compass are "magnetic bearings" and plotting is always done in relation to a true north line. Before plotting, therefore, magnetic bearings must first be converted to true bearings. In the case of 5° westerly, the true bearing is obtained by subtracting 5° from the magnetic bearings.

The compass needle may be deflected from its natural direction by the attraction of any magnetic substance near it, such as iron ore, the rails of a railway, wire fence, etc. Local attraction is very often met with, and special pains must be taken to avoid the errors and loss of time to which it may give rise. When the bearing determined by a fore-sight does not agree with the reverse bearing of a backsight, the usual cause of the variation is local magnetic attraction and is often found to be confined to a comparatively small area. By selecting some other turning point on the traverse (shortening or prolonging the "shot" affected) the local attraction may be reduced to within negligible limits, if not altogether avoided.

Index Error of Compass

11. Each compass is subject to an inherent error called the Index Error, caused by faults in manufacture or assembly. This must be determined by testing over a line of known true bearing and its value noted permanently on the body of the compass. The index error must be applied as a correction to all observed bearings.

Compass Surveys—Procedure

Prismatic Compass and Survey Band

12. The survey should commence at some known point, *e.g.*, survey pegs at a reference tree, the corner of a location, a road survey or the survey pegs along a survey line from which the magnetic variation plus any small individual variation in the compass may be ascertained. Survey may also be commenced at a reference tree fixed by compass, but a point fixed by theodolite survey is preferable. Ties should be made as often as possible to known points during the traverse in order to ensure all possible accuracy and to localise errors.

The magnetic bearing is read from the starting point (entered as O in the field book of Traverse A, or an alphabetical designation, and AO on the waddy) to the first waddy of the traverse (entered as A- in the field book). The waddies should be placed to give the longest possible shots.

Where the "slope" of the ground exceeds 4°, allowance should be made when measuring the shot, the degree of slope being read with an Abney Level or other clinometer and the measured distance adjusted in accordance with the table in Appendix 4.

The distance along a traverse line to any feature intersected such as the edge of a flat, stream, culvert, track formation, etc., should be noted. Features off the traverse line should also be noted and distance ascertained by pacing offsets, *i.e.*, pacing at right-angles from the traverse line to the feature. The back bearing is read from Station A1 back to Station AO. This should be ± 180° of foresight if not subject to local attraction. The bearing is then read to Station A2 and the traverse proceeds as before.

The compass is read to only ½° and therefore small adjustments may be made by halving the variation ± 180° between foresight and backsight of a traverse line to a difference of 1°. If the difference is greater than this correction should be made in accordance with the following method which actually is an adjustment of the included angle at each turning point on the traverse:—

(i) Convert backsight to read as a foresight by adding or subtracting 180° to backsight when foresight is under or over 180°.

(ii) Compare these bearings and enter the ± angle required to make backsight equal foresight under "± variations".

(iii) Ascertain the total differences ± over a group of bearings. If the totals do not balance within 1° the compass bearings have been either incorrectly read or entered and need checking.

(iv) Add ± variation progressively and enter results opposite the next succeeding bearing under "± progressive variation".

(v) Add or subtract to or from foresights and enter under "corrected bearing".

The following is an example of field notes:—

Compass Bearing		Variation		Progressive Variation		Corrected Bearing	Distance (metres)
F.S.	B.S.	+	—	+	—		
304 °	124 °	....	....	....	....	304 °	189·7
322 °	138 °	4 °	....	0	0	322 °	218·7
329¾°	156¼°	....	6½°	4 °	....	333¾°	86·9
315 °	125 °	10 °	....	....	2½°	312½°	153·7
347 °	173¼°	....	6¼°	7½°	....	354¼°	180·7
6¼°	186 °	¼°	....	1¼°	....	7½°	129·2
71 °	254¼°	....	3¼°	1½°	....	72½°	308·0
88¼°	262¼°	6 °	....	....	1¾°	86½°	210·6
46 °	232 °	....	6 °	4¼°	....	50¼°	128·6
71 °	249¾°	1¼°	....	....	1¾°	69¼°	109·2
168¾°	349¼°	....	½°	0	½°	168¼°	151·1
181 °	1 °	....	....	....	....	181 °	167·4
		21½°	22½°				

In the course of traversing, particularly in the South-West, ironstone formations having magnetic properties are frequently passed over or approached. In practice it will be found that this local attraction occurs on a short section of the traverse and rights itself on leaving the source of the disturbance. Under these circumstances each "group" of variable readings requires adjustment which should not be carried on over fore and backsights which agree ± 180°.

As the traverse continues the following points in booking should be noted:—

(a) Where "shots" are longer than 100 metres, each 100 metres and the broken length is to be noted in the field book (see Appendix 2) to avoid the common error of dropping 100 metres in the total distance.

(b) Calculations of correction for slope are to be shown in the margin and the corrected figure shown in the "Distance" column.

(c) The distance between stations shall be shown between parallel lines. The figures 00 should be shown in the same way at each instrument station—see Appendix 2.

(d) At the end of the traverse the total distance of the traverse shall be shown.

(e) As each field book is completed or submitted for despatch to Head Office, the index shall be filled in.

(f) Care and accuracy in recording readings, sketching features and establishing ties is more important to the final result than demanding a minimum amount of measurement per day.

Prismatic Compass and Pacing (With Backsight)

13. This method of survey is employed for the mapping of improvements and minor tracks. A 40-metre misclose is the acceptable maximum. A point is selected which can be identified on the A.P.I. Topo map and its position marked with a waddy. Each angle-point of the traverse is similarly marked, with the last being tied to a map-identified feature, preferably a survey post or referenced tree.

The survey is commenced at the last waddy put in which is numbered 1. A foresight is taken to the next waddy which is numbered 2 and the bearing noted. The distance to Waddy 2 is paced and a backsight read to Waddy 1. A foresight is now read to Waddy 3 and the survey proceeds, with backsights and foresights being observed at each station.

The forward and back bearings of a line should differ by exactly 180°. Should they not do so with bearings correctly observed, the difference is caused by local magnetic attraction. Where the difference does not exceed 5° the mean of the two bearings is accepted as the corrected bearing. However, where this figure is exceeded the method of adjustment described in paragraph 14 should be employed.

To obtain satisfactory results from compass and pacing, the pacer must calibrate his steps. This should be done before starting each compass survey job, unless the officer is frequently engaged in this class of work, in which case he should check his pacing at least once every month. The method to be followed will be to walk naturally along a surveyed line for a distance of 100 or 200 metres and count the paces taken. Between 1929 and 1955, where reference trees have been established by theodolite, two survey pegs have been put in at these trees, 100 metres apart in one of the cardinal directions. One peg would be near the reference tree and trenched giving the direction of the second peg. Base lines have also been run through the major axes of compartments and pegs put in 100 metres apart. The number of paces taken by an officer may be ascertained or checked between these pegs.

When running a traverse the paces taken between each angle should be noted in the field book and converted later to metres when back at camp or office. A sample page of the field book and method of calculation appears below.

SPECIMEN PAGE OF FIELD BOOK

Traverse of Track in Windsor Block A.P.I. Topo Map 280.
Pacing Standard for 100 metres equals 123 paces.

Sight No.	Fore-sight	Back-sight	Corrected Bearing	Distance		Remarks
				Paces	Metres	
1	310 °	130 °	....	181	147	Ref. Tree DF 75–1
2	253 °	77 °	255 °	198	161	
3	291 °	106 °	288½°	136	111	
4	274 °	91 °	272½°	112	91	
5	268 °	93 °	270½°	229	186	
14	259 °	75 °	257 °	130	106	Fire line
15	194 °	16 °	195 °	385	313	Formation crosses fire line

Note.—The entry in the column headed "Metres" is made after returning to camp or office and is worked out as follows:—

For each traverse line multiply the number of paces taken by 100 and divide by your standard. This figure should be a constant for each officer but must be given at the top of each page used of the field book, so that calculations can be checked if required. Thus, 181 paces multiplied by 100 and divided by 123 equals 147 metres.

The foresights should be corrected to give the bearing to be used in plotting, thus at Waddy No. 2 180° added to the backsight read at No. 3 77° = 257° and the foresight read at No. 2 = 253°, therefore the mean = 255°.

Prismatic Compass and Pacing (Without Backsight)

14. This method of survey is of sufficient accuracy for the definition of the boundaries of top disposal, tree marking, and similar work. The maximum acceptable misclose is 100 metres.

The survey is commenced from a point which can be identified on the A.P.I. Topo map such as a track intersection, survey peg, referenced tree, or other feature. A tree is sighted in the direction of traverse and the bearing noted to the nearest degree. The distance is paced to the tree and entered in the field notes. Another tree is now selected and the survey continues until the traverse is completed by tying to a known point identified on the Topo map.

SPECIMEN PAGE OF FIELD BOOK

Traverse of Top Disposal Area Boundary within S.M.P. 834 A.P.I. Map 232.
Pacing Standard for 100 metres equals 126 paces.

Sight No.	Bearing	Distance		Remarks
		Paces	Metres	
1	89°	98	78	Ref. Sq. DF70 tracks intersect
2	225°	216	171	
3	117°	158	125	
4	109°	139	110	
5	227°	181	144	
6	258°	87	69	
18	247°	175	139	Track
19	319°	284	225	Track crosses formation

Note.—The entry in the column headed "Metres" is made after returning to camp or office and is worked out as follows:—

> For each traverse line multiply the number of paces taken by 100 and divide by your standard. This figure should be a constant for each officer but must be given at the top of each page used of the field book, so that calculations can be checked if required. Thus, 216 paces multiplied by 100 and divided by 126 equals 171 metres.

Reference should be made to paragraph 13 for instructions on the method to be adopted in the calibration of pacing.

Field Notes

15. The field book is identified by the user's name and a consecutive number, *e.g.*, Smith No. 1, Smith No. 2, etc. Description of survey, type of instrument and magnetic variation must be clearly stated in the field book, together with the registered F.D. number of compass and survey band. Each traverse entered in the field book should be initialled and dated.

Field notes are entered in columns providing for compass readings, foresights and backsights; Variations ±; Progressive Variation ±; Corrected Bearing and measured distance. The first, second and last columns record actual readings on the traverse, intervening columns are used for adjustment of bearings when required.

Reference Trees

16. Reference trees should be marked adjacent to roads and tracks at not less than 800 m and not more than 1600 m intervals, unless otherwise directed by the D.F.O. They are best placed at the intersection of roads or, where no branch roads exist, on the tops of ridges, in saddles, or near creek crossings. Trees should be selected for permanency and should be reasonably wind-firm and healthy. Avoid any trees, especially hollow-butts, subject to damage or destruction by fire, but do not mark vigorous growing stock of the A, B, or C type.

The selected tree is serially numbered within the reference square in which it is situated. On the side facing the road a shield is blazed and into the face is cut a broad arrow, the grid reference of the reference square and the serial number. The dimensions of the shield and size of lettering are shown in Appendix 3.

Trees will not be permanently marked until Head Office has confirmed the grid reference and advised of the serial number.

Reference trees will be tied to the traverse by a foresight bearing and measured distance from the nearest instrument point.

Protection of Survey Marks and Reference Trees

17. *Survey Marks:* It is an offence under the provisions of the Licensed Surveyors Act for unauthorised persons to interfere with survey posts or other survey marks. These marks, whether established by Departmental surveyors or by other agencies, are the basis of horizontal control for mapping and it is of great importance that they be preserved.

In most cases where posts have been placed or located in the forest they have been further marked by the erection of a 0.12 m x 0.12 m post 1.8 m in length which is placed with 0.45 m in the ground and leaning so that its white-painted top is above the survey post.

Every effort must be made to preserve survey marks during logging operations and road construction. When located they should be raked around as a protection from fire.

Reference Trees: Reference trees must also be preserved. If it is necessary to remove a reference tree it should be cut above the marking thus retaining the shield on the stump. The destruction of a reference tree must be reported to Head Office in order that it may be cancelled on Departmental records.

General Instructions

18. (a) A description of the feature surveyed, *i.e.*, existing or proposed main forest road, road, track, etc., together with its name should be noted at the start of the traverse.

(b) Ties should be made to two or more original survey pegs (not fence posts) and the position of the tie shown by a sketch in the Field Book with the number of the location or road post. Do not interfere with survey posts. Unfenced surveys are usually best suited for obtaining good ties.

(c) Distances are required between original survey pegs found.

(d) An index of field notes signed and dated should be shown on the last page of the Field Book, *i.e.*, page number, feature traversed.

Theodolite Surveys

(e) Angles at Traverse Stations and Ties to and along original surveys should be read by doubling the angle, face left and face right, second angle being turned from reading noted in Field Book.

(f) Angles should be read to the nearest twenty seconds.

(g) An angular close is required to original surveys tied to.

(h) Each broken distance measured shoud be noted with angle of rise or fall and adjusted total distance noted at the end of each traverse line.

(i) Adjustments should be made to measured distances for slopes of one or more degrees.

(j) Position of reference trees should be fixed by angle and distance from traverse to broad arrow cut on tree.

(k) Compass check posts when established at reference trees should be placed true North and South or East and West.

(l) Survey data should be noted along traverse lines and other surveys in Field Book as illustrated on F.D. Plan 1050.

Compass Surveys

(m) Fore and backsight bearings are required along traverse lines and original surveys to which traverse is tied.

(n) A difference in readings of not more than one degree can be accepted without correction for local attraction.

(o) Each broken distance measured should be noted and adjustment made for slopes of four degrees or more. An Abney Level or Clinometer should be used for this purpose.

(p) Fore and back bearing and adjusted total distance of each traverse line should be noted at the top of page. Distances should be shown at the end of each traverse line (see F.D. Plan 1050).

(q) Magnetic variation of each compass used and position where checked should be noted in Field Book.

(r) For compass work, use F pencils or, if not available, an H pencil—HB is too soft, 2H too hard.

(s) Take care of your equipment—clean and oil the 100 metre band when not in use—place the compass in its case and see the case and leather straps are in good condition.

APPENDIX 1

CONVENTIONAL SIGNS

1st Class Road .....

2nd Class Road .....

3rd Class Road .....

Railway W.A.G.R. .....

Timber Tramway .....

Powerline .....

Watercourse mainly intermittent .....

Swamp .....

Forests Dept. Headquarters .....

Sawmill .....

Lookout Tower .....

Reference Tree Theodolite .....

Reference Tree Compass .....

Post Office .....

Catchment Boundary .....

Loading Ramp .....

Permanent Water Supply .....

Permanent Water Supply Developed .....

Fenceline .....

Telephone Line .....

Firebreak - trafficable .....

Firebreak - nontrafficable .....

Flats (non forest) .....

Telephone .....

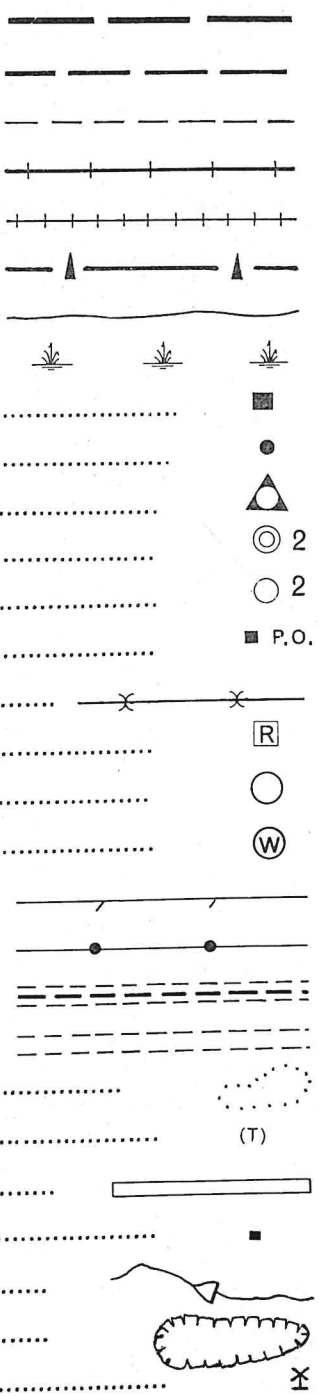
Landing Ground .....

Building .....

Dam .....

Quarry etc. .....

Windmill .....



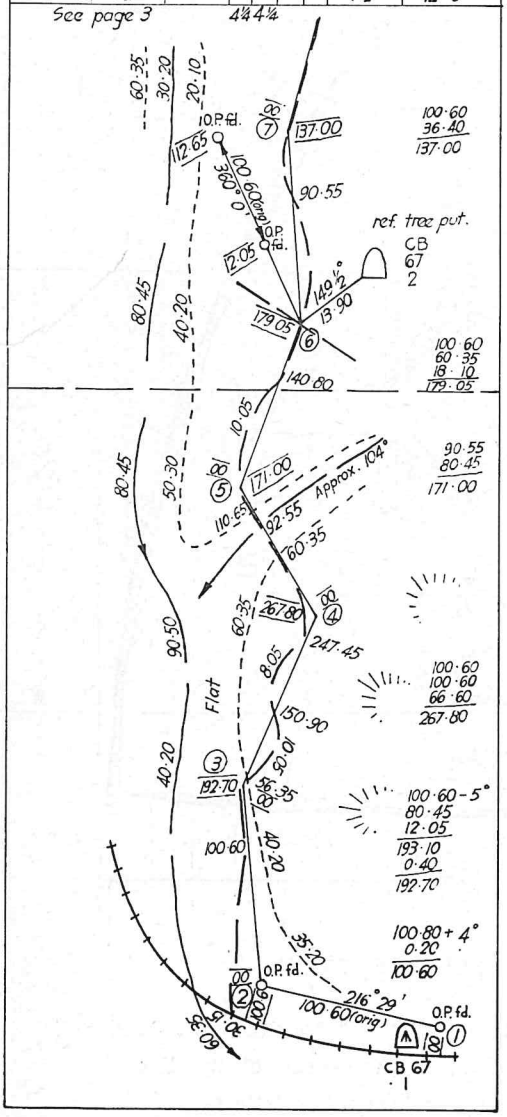
APPENDIX 2

FIELD NOTES

2

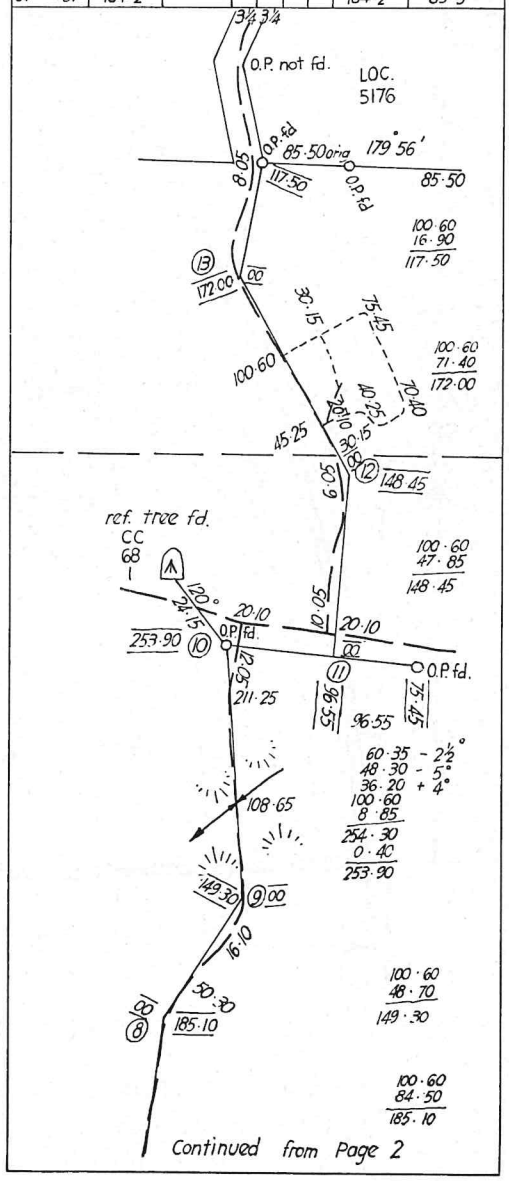
Traverse 'A' Brooks Road. From posts near CB/67/1 to N.W. corner of Loc. 5176. Compass Var. 4½°W.
Note: All distances measured in metres

Line	FS	BS	+	−	+	−	Bear.	Dist.
1 to 2	40	220					40°	100·6
2 3	107 3/4	288½		3/4			107 3/4°	192·7
3 4	148	325	3			3/4	147 1/4°	267·8
4 5	133	316½		3½			135 1/4°	171·0
5 6	141	320½	½			1/4	139 3/4°	179·0
6 7	89	268 1/4	3/4			3/4	88 1/4°	137·0
Tie (6-OP)	4½						4½°	12·0



3

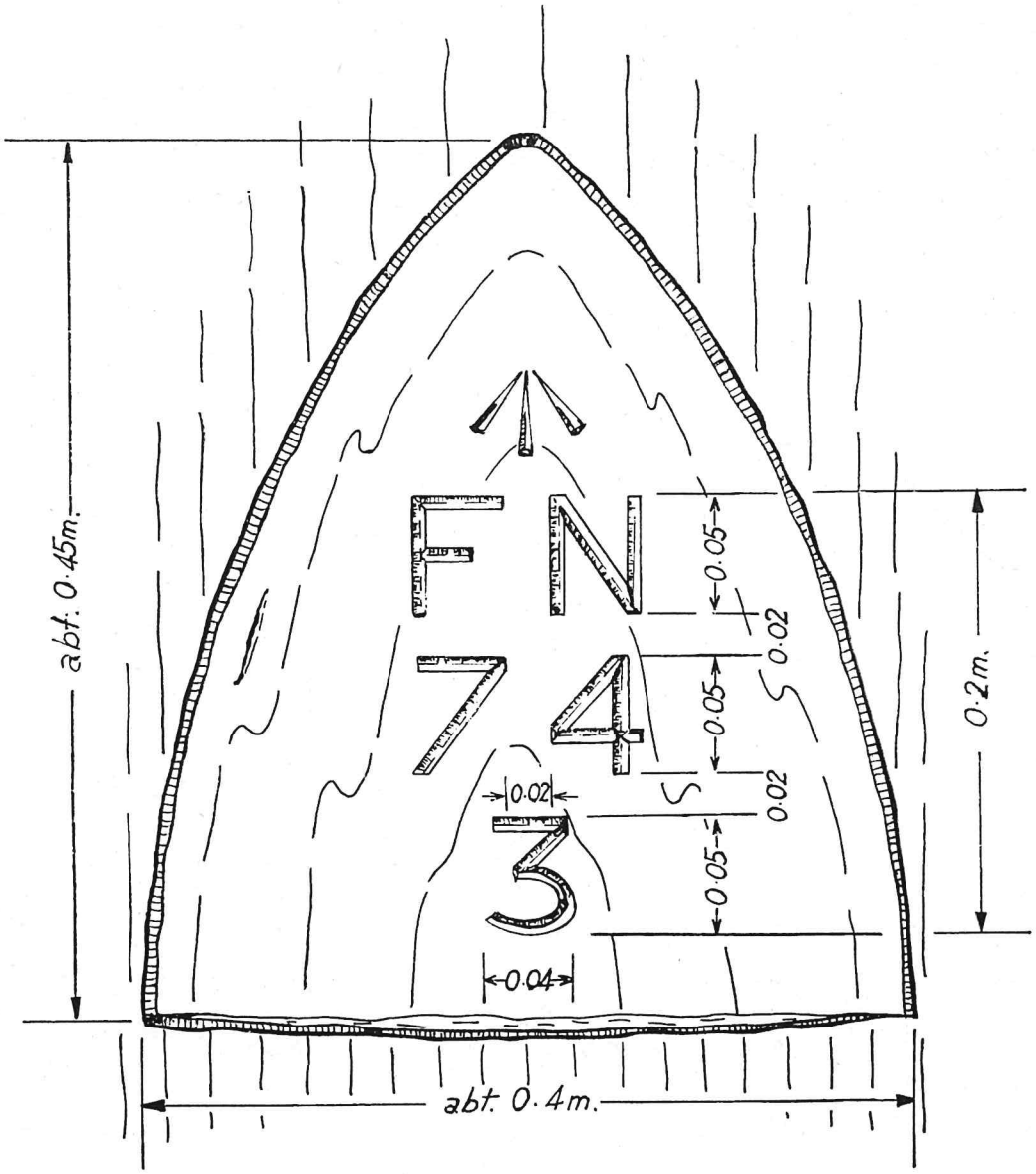
Line		FS	BS	+	−	+	−	Bear.	Dist.
7	8	111	291					111°	185·1
8	9	124 1/4	305		3/4			124 1/4°	149·3
9	10	97 3/4	278 1/4		½		3/4	97°	253·9
10	11	168 3/4	349		1/4		1/4	167½°	96·5
11	12	105 1/4	287		1 3/4		1½	103 3/4°	148·4
12	13	86 1/4	263	3 1/4			3/4	83°	172·0
13	OP	95	275					95°	117·5
OP	OP	184½						184½°	85·5



Specimen pages of field book.

APPENDIX 3

Marking a Reference Tree.



MARKING A REFERENCE TREE

Dimensions of letters approximate only; a matchbox may be used to determine the size of the letters, the thickness of the box being used to determine the spacing between the letters.

APPENDIX 4

TABLE OF VERSED SINES

CORRECTION FOR SLOPE FOR EACH 100 METRES

Deg.	Min.	Corr (M)	Deg.	Min.	Corr. (M.)	Deg.	Min.	Corr. (M)
	30	0·004	9	....	1·231	17	....	4·370
	45	0·009	....	10	1·277	....	10	4·455
1	....	0·015	....	20	1·324	....	20	4·541
1	15	0·024	....	30	1·371	....	30	4·628
1	30	0·034	....	40	1·420	....	40	4·716
1	45	0·047	....	50	1·469	....	50	4·805
2	....	0·061	10	....	1·519	18	....	4·894
	10	0·071	....	10	1·570	....	10	4·985
	20	0·083	....	20	1·622	....	20	5·076
	30	0·095	....	30	1·675	....	30	5·168
	40	0·108	....	40	1·728	....	40	5·260
	50	0·122	....	50	1·782	....	50	5·354
3	....	0·137	11	....	1·837	19	....	5·448
	10	0·153	....	10	1·893	....	10	5·543
	20	0·169	....	20	1·950	....	20	5·639
	30	0·187	....	30	2·008	....	30	5·736
	40	0·205	....	40	2·066	....	40	5·833
	50	0·224	....	50	2·125	....	50	5·932
4	....	0·244	12	....	2·185	20	....	6·031
	10	0·264	....	10	2·246	....	10	6·131
	20	0·286	....	20	2·308	....	20	6·231
	30	0·308	....	30	2·370	....	30	6·333
	40	0·332	....	40	2·434	....	40	6·435
	50	0·356	....	50	2·498	....	50	6·538
5	....	0·381	13	....	2·563	21	....	6·642
	10	0·406	....	10	2·629	....	10	6·747
	20	0·433	....	20	2·696	....	20	6·852
	30	0·460	....	30	2·763	....	30	6·958
	40	0·488	....	40	2·831	....	40	7·065
	50	0·518	....	50	2·900	....	50	7·173
6	....	0·548	14	....	2·970	22	....	7·282
	10	0·579	....	10	3·041	....	10	7·391
	20	0·610	....	20	3·113	....	20	7·501
	30	0·643	....	30	3·185	....	30	7·612
	40	0·676	....	40	3·258	....	40	7·724
	50	0·710	....	50	3·333	....	50	7·836
7	....	0·745	15	....	3·407	23	....	7·950
	10	0·781	....	10	3·483	....	10	8·064
	20	0·818	....	20	3·560	....	20	8·178
	30	0·856	....	30	3·637	....	30	8·294
	40	0·894	....	40	3·715	....	40	8·410
	50	0·933	....	50	3·794	....	50	8·528
8	....	0·973	16	....	3·874	24	....	8·645
	10	1·014	....	10	3·954	....	10	8·764
	20	1·056	....	20	4·036	....	20	8·884
	30	1·098	....	30	4·118	....	30	9·004
	40	1·142	....	40	4·201	....	40	9·125
	50	1·186	....	50	4·285	....	50	9·247

EXAMPLE (THEODOLITE SURVEY)

Measured slope distance = 94·055 (read to nearest 0·005 m)

Angle of slope = 5° 20'

Correction = $\frac{94}{100} \times 0{\cdot}433$

= 0·405 (calculated to nearest 0·005 m)

Horizontal distance = 94·055 — 0·405

= 93·65 (recorded in field notes to nearest 0·01 m)

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