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STANDARD SURVEY METHODS

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TECHNICAL METHODS FOR HIGHWAYS

TMH 11

STANDARD SURVEY
METHODS

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PREFACE

TECHNICAL METHODS FOR HIGHWAYS 11 (TMH 11) is written for the practising surveyor and describes current, recommended practice concerning surveys. The recommendations are based on South African experience and have the full support and approval of the Committee of Land Transport Officials (COLTO).

Provision is made in this document for Road Authorities to augment or add specific requirements for particular projects or applications. In the interests of uniformity, any amplifications or additions must be done with the utmost circumspection. Users of this document must ensure that they are fully aware of any such amplifications or additions applicable to a particular project or application prior to commencement of the survey.

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1. GENERAL INFORMATION

NOTE

In the Agreement between the Client and the Surveyor, a responsible officer shall be nominated to whom all reports and queries regarding the project must be addressed.

1.1 Entry into a Region

Before commencing fieldwork in any district or region the Surveyor shall notify the responsible Surveyor under whose jurisdiction the survey falls, as to the nature of the work and the area in which it is to be carried out.

1.2 Entry into Private Property

1.2.1 Before commencing field work on any property, the Surveyor shall personally call on the owner, occupier, or person in charge of the property and request permission to proceed with the survey. Surveyors should be aware of local custom regulations.

1.2.2 Should it be necessary to establish one's bona fides and identity, a copy of the official letter of appointment shall be produced.

Forms for notice to owners or occupiers of land shall be obtained from the client.

1.2.3 Should the owner not be available at the time of calling, the procedure as laid down by the Client shall be followed.

1.2.4 In the event of the right of entry being refused, the Surveyor shall contact the Client as soon as possible.

1.3 Destruction of Property

Where the destruction of any kind of property becomes necessary, the Surveyor shall keep a record of such destruction, together with the name of the owner and description of the property, and forward this information to the responsible officer at Head Office. The owner shall be consulted before any destruction takes place and all local ordinances shall be strictly adhered to.

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1.3.1 The following records shall be kept

Sugar Cane	:	Area, ratoon, age and type.
Grain Crops	:	Area, age and type.
Other Crops	:	Area, age and type.
Timber	:	Area, age and type.
Large trees	:	Number, mean circumference and height.
Ornamental shrubs & trees	:	Type & height

1.4 **Traffic Control**

Flags and warning signs in terms of the Traffic Ordinance shall be erected and moved with the progression of the survey.

1.5 **Survey Pegs (Damage and/or Injury)**

To prevent any damage to tyres of vehicles or injury to humans and livestock, the following regulations shall be strictly adhered to.

1.5.1 Steel pegs in concrete shall not protrude more than 10mm above the surface of the concrete.

1.5.2 Steel pegs not in concrete shall be driven down to within 5mm of the surface of the ground.

1.5.3 Roofing screws or steel pegs used on a surfaced road shall be driven down flush with the road surface.

1.5.4 Steel pegs used on a gravel road shall be sunk to a depth of 70mm below the road surface and be backfilled with lime.

1.6 **Stake Value**

1.6.1 The term "**chainage**" and "**staked kilometre distance**" shall be replaced with the term "**stake value**" wherever they appear on survey plans or any other correspondence.

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1.6.2 All surveys shall run from left to right in the direction of increasing route section numbers or stake values, where applicable, unless otherwise specified.

1.7 **Field books**

If electronic Field books are not used, only survey books approved by the Client shall be used for levelling, triangulation and traversing.

1.8 **Monthly Report**

This report shall state the progress of any part of a survey project on a monthly basis, as a percentage of e.g. basic survey, ground control, calculations, sectioning, plotting, drawing or cadastral compilation.

1.9 **Technical Report**

A technical report dealing with all aspects of the survey, e.g. methods, instruments used, closures, name and height of level datum point, results of accuracy checks and any other significant details regarding the survey project, shall be submitted on completion. See annexure 2.

1.10 **Delivery Note**

A detailed list of all items delivered and of those still outstanding shall be submitted. The Surveyor shall ensure that all goods are handed to and received in good order by the officer responsible for the contract.

1.11 **Indemnity**

The contract surveyor shall indemnify the client against any claims for injury to persons or damage to property other than specified in paragraph 1.3

2. SURVEY REGULATIONS AND STANDARDS OF ACCURACY

2.1 Units of Measurement

The units of measurement shall be metric and in Sexagesimal measure.

2.2 Horizontal Control (National Triangulation System)

Unless permission is granted in writing to the contrary, all surveys shall be based on the appropriate Lo. system of the National Triangulation network.

2.3 Horizontal Standards of Accuracy

2.3.1 Triangulation - Permanent Survey Stations (Allowable Error)

Triangulated survey stations shall be surveyed in accordance with the Survey Act, (Act 9 of 1927) and Survey Regulations as amended, to class A accuracy. See Annexure 1.

Where A is equal to $0,04 + \frac{S}{30\,000}$ and S is the distance in metres between the known and unknown survey station. The comparison is made between any observed ray or measured distance from the final co-ordinate of the survey station fixed and a known survey station.

2.3.2 Traverse and Polars - Permanent Survey Stations (Allowable Error)

Traversed survey stations shall be surveyed in accordance with the Survey Act, (Act 9 of 1927) and Survey Regulations as amended, to class A accuracy. See Annexure 1.

Where $A = 0,04 + \frac{S}{30\,000}$ and the comparison is made to the linear misclosure of the traverse, where S is the total length of the traverse in metres.

2.3.3 Global Positioning (GPS) Survey - Permanent Survey Stations (Allowable Error)

Global Positioning (GPS) survey stations shall be surveyed in accordance with the survey Act, (Act 9 of 1927) and Survey Regulations as amended to class A accuracy where $A = 0,04 + \frac{S}{30\,000}$. When a comparison is made between the vector derived from the final co-ordinate and the measured vector after the datum transformation has been applied. S is the distance between the known and the unknown survey station. See Annexure 1.

SURVEY REGULATIONS AND STANDARDS OF ACCURACY

2.4 Vertical Control - Permanent Survey Stations (National Geodetic Benchmarks N.G.B. M)

- 2.4.1 Wherever possible, elevations shall be based on the National Geodetic Benchmarks (N.G.B.M.).
- 2.4.2 When no N.G.B.M. can be found within 10km of the survey, instructions shall be obtained from the Client.
- 2.4.3 Any benchmark to be used in a survey shall be verified from at least one or preferably two other benchmarks before its height can be adopted.
- 2.4.4 **Origin of Elevation**

The origin of the elevation and the datum level point shall be recorded in the field book, calculation file and noted on the plan (e.g. N.G.B.M. 34A26=1216.453m or NRB20 = 1314.120m).

2.5 Vertical Standard of Accuracy for Permanent Survey Stations

- 2.5.1 The closing error (in metres) of a levelled circuit shall not exceed: $0,003 \sqrt{\text{setups}}$, in height difference between the forward and reverse levelling of successive permanent survey stations;
e.g. for 1km (10 setups) levelling and 10 setups check levelling = 20 setups.

For 1km = $0,003 \sqrt{20 \text{ setups}} = 0,013\text{m}$

The mean closing error of a levelled circuit **between terminal points** shall not exceed:

$0,025 \sqrt{K}$ metre, where K is the single length of the circuit in kilometres.

- 2.5.2 Forward and check spirit levelling shall not be done simultaneously.
- 2.5.3 The final elevations of spirit levelled beacons shall be given to 3 decimals of a metre.

SURVEY REGULATIONS AND STANDARDS OF ACCURACY

2.6 Detail Accuracy

The position of all well defined detail shall be plotted in relation to the co-ordinate grid so that the positional error of the detail checked shall not exceed 0,5mm on the plan.

2.7 Contour Accuracy

The accuracy of contours shall be such that the variation in elevation of 90% of the points checked, determined by interpolation between contours, when compared with their elevations as determined in the field, shall not exceed 0,3 times the contour interval.

2.8 Spotheight Accuracy

The accuracy of spotheights shall be such that the variation in elevation of 90% of the points as checked in the field, shall not exceed 0,25 times the contour accuracy. See paragraph 2.7.

2.9 Instrument Accuracy

The Surveyor shall ensure that all instruments and equipment used in the survey, are in proper adjustment and test results shall be submitted.

2.10 Digital Terrain Model (DTM) Accuracy

Horizontal accuracy 100mm and Vertical accuracy 25 mm.

These tolerances apply to any part of the feature and not to the actual spot on which it was surveyed. See paragraph 13.5.4

The data supplied shall be such that accurate contours can be derived at 1 metre intervals, but the density of the surveyed points shall permit interpolation to 0,5 metre intervals. (ie. YXZ points along photogrammetric contours shall not be accepted as surveyed points for interpolation purposes.)

2.11 Global Positioning (GPS) Accuracy

See paragraph 2.3.3

SURVEY REGULATIONS AND STANDARDS OF ACCURACY

2.12 Photo Ground Control Accuracy

Horizontal and vertical photo ground control points shall be accurate enough to meet the requirements as set out in paragraphs 2.6, 2.7 and 2.8.

2.13 Staking Accuracy

2.13.1 Key Points

Key points shall be fixed to class A accuracy and may not be more than 20mm from their true position.

2.13.2 Intermediate Points

The position of 20m staked points shall not differ from their required true position by more than 20mm, unless otherwise specified.

The distance between any two consecutive staked points must be within the accuracy 1:1 000. Over any 500m length the distance accuracy must be within 1:5 000.

2.13.3 Curves

In the case of curves, the closing error shall not exceed 1:5 000. Any error smaller than 1:5 000 must be adjusted pro-rata over the length of the curve. Where the error on curves exceeds 1:5 000 the curve shall be re-staked so that the error is less than 1:5 000 and subsequently adjusted pro-rata over the curve length.

2.13.4 Heights

Unless otherwise specified, the elevations of the permanent survey stations shall control the levels of the staked line key points and the standard of accuracy shall be the same as that laid down for the permanent survey stations. See paragraph 2.5.

3. SURVEY AND PHOTO GROUND CONTROL

3.1 Permanent Survey Stations and Ground Control

It is stressed that the value of the survey depends largely on the permanency of its survey stations.

3.1.1 Permanent survey stations: Spacing, Siting, Numbering and Intervisibility

3.1.1.1 Unless otherwise specified, a backbone of permanently marked survey stations shall be established along any strip survey, spaced not more than 500m apart. Successive survey stations shall be intervisible.

3.1.1.2 Care shall be taken to place the survey station in a safe position where it will be least exposed to disturbance or damage. Wherever it is possible to ascertain the position of the road reserve boundary, the survey station should be placed as close to such boundary as convenient and preferably one metre inside the reserve.

Survey stations may be placed alternately on either side of a road if this will improve intervisibility except where there is a possibility that median plants may obscure the intervisibility.

3.1.1.3 From every survey station at least two permanent reference objects (R.O.'s), being either survey stations of the same survey or trig beacons, shall be made visible at the time of the survey.

3.1.1.4 Unless otherwise specified, all permanent survey stations shall be numbered in sequence in the direction of increasing route and/or section numbers. The numbering shall be done on a strip of aluminium 0,7mm to 1,5mm in thickness, firmly set in the concrete.

Unless otherwise specified, the following information shall be shown with lettering of not less than 7 mm in size:

- (a) Station number/year, e.g. NRB 2/91 or PRD 99/91.
- (b) Route & section number, e.g. N17/1.
- (c) Project number, e.g. 274/360 (for Department of Transport projects).

3.1.1.5 The numbering shall be positioned facing the direction of the next survey station.

3.2 Construction of Permanent Survey Beacons

3.2.1 Concrete Beacons

Unless otherwise specified every permanent survey station shall be marked by a 25mm internal diameter, galvanised pipe, driven into the ground in such a way that the top of the pipe is not damaged or burred. The pipe shall be 460 mm long, flattened at the end to be driven into the ground, so that 35mm of the pipe protrudes above ground level. A hole, 275mm deep and 300mm in diameter, shall be dug around the pipe and filled with concrete consisting of a mixture of one part fresh cement, three parts clean, sharp sand and five parts crushed stone (minimum crushing strength of concrete to be 15 MPa) so as to leave approximately 10mm of pipe clear above the concrete. See Annexure 10.

A mould, 250mm in diameter and not more than 100mm in height, shall be used to shape and finish off the top of the concrete beacon. The final height of the concrete shall not be more than 25mm above ground level.

3.2.1.1 Each permanent survey station shall be marked by means of a 1,8 metre iron standard, driven $\pm 0,8\text{m}$ into the ground. The iron standard shall be painted with white enamel paint and be placed in such a position as to protect the beacon from maintenance equipment in use within the road reserve or, as otherwise specified.

3.2.1.2 If the above type of beacon is not suitable to the conditions of a particular survey, written approval shall be obtained for a more suitable type.

3.2.2 Pillar Beacons

Pillar beacons shall only be placed on request and in consultation with the client. For specifications see annexure 9.

3.3 Horizontal Fixing of Permanent Survey Beacons

Permanent survey stations shall be fixed by recognised methods of triangulation, traversing and/or Global Positioning (GPS) surveys.

The Surveyor shall at all times perform sufficient fieldwork to enable a thorough check to be carried out on every part of the survey.

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Observations at any station or beacon shall consist of at least one arc.

3.3.1 Traversing Method

- (a) A traverse terminal point shall be fixed by either triangulation, traversing and/or Global Positioning (GPS) methods.

For limits and allowable errors see paragraphs 2.3.1, 2.3.2 and 2.3.3.

- (b) The maximum number of traverse legs between terminal points shall be 20 (twenty), unless otherwise authorised. Observations for outside orientation shall be taken wherever possible.

When traversing between two fixed points, observations must be taken at both fixed points in order that the traverse may be properly adjusted.

For limits and allowable errors see paragraph 2.3.2.

- (c) Distances shall be measured with electronic distance measuring equipment unless written approval has been obtained for the use of other instrumentation. All corrections shall be applied to ensure the required accuracy.

3.3.2 Triangulation Method

- (a) When a permanent survey beacons position is determined by intersection or trilateration, the angle at the vertex of any triangle used in such determination shall not be less than 30 degrees nor greater than 150 degrees.

- (b) Its position shall not be determined by resection from less than four surveyed points favourably situated, and the observations used in such determination shall consist of not less than two arcs, unless three of such surveyed points are within 3 000 metres of the survey point being determined, in which case only one arc is required.

- (c) Its position shall not be determined by a single triangle only, unless observations are made at all three points and on at least two different parts of the circle.

3.3.3 Global Positioning System Method (GPS)

- 3.3.3.1 In a Global Positioning (GPS) survey the position of **permanent survey beacons** shall be determined from at least two known L.O. points. Sufficient GPS

SURVEY AND PHOTO GROUND CONTROL

vectors shall be measured to determine the local relationship between the GPS datum, i.e. World Geodetic System of 1984 (WGS 84), and the National Reference Survey Datum by connection to at least three trigonometrical stations or permanent reference beacons. The survey shall fall within the perimeter of these trigono-metrical stations or permanent reference beacons thus no extrapolation of surveys shall be allowed. All GPS observation adjustments for the determination of final co-ordinates of permanent survey beacons shall be done by post processing, using a network adjustment program. Only the local transformation parameters as determined by the GPS survey shall be used for the transformation of the adjusted WGS 84 co-ordinates to the L.O. system.

3.3.3.2 Records to be submitted on completion

The following must be submitted in a calc file:

- A technical report dealing with all aspects of the survey, e.g. instruments used, methods, checks carried out, problems encountered and any other significant details regarding the survey.
 - A locality sketch
 - A working diagram showing all surveyed stations as well as all known co-ordinated points used in the transformation.
 - A full co-ordinate list shall be prepared showing the final co-ordinates and heights of all the Survey stations. The elevation and description of the datum point of the survey shall be shown on this list. Points shall be listed in numerical and/or alpha-betical order.
 - A hard copy printout of the actual transformed co-ordinates.
 - A copy of all the rawdata in rinex format on a diskette.
 - A text file of the detailed logfile of the all processing computations on a diskette.
 - A hard copy log file of the transformation parameter.
-

SURVEY AND PHOTO GROUND CONTROL

- A list showing the comparison between the spirit and GPS levels.
- A disk containing all the final co-ordinates in ASCII format. The format shall be comma delimited.

3.3.4 Triangulation and Traverse Calculations

- 3.3.4.1 Final error figures shall be plotted to a scale of one in ten; provisional figures may be plotted to any convenient scale. The figures shall be plotted in bold pencil lines and shall show against each ray, in the conventional manner, its name, direction of observation and length.
- 3.3.4.2 If the final position of a triangulated point is not obtained by means of an error figure, the final direction, the orientated observed direction and the error limit for every ray used to fix the point, shall be given.
- 3.3.4.3 All measured distances shall be corrected in the fieldbooks or on the field sheets before being used in the calculations, except where a computer programme makes provision for these corrections.
- 3.3.4.4 The fieldbook and calculation reference (pages 2000-2999) shall show every survey point used and determined during the survey. See Annexure 5.
- 3.3.4.5 A separate and full co-ordinate list (punched for filing in the same way as the calculation pages - see paragraph 4.1.6) shall be prepared to show all the co-ordinates and heights of the basic and photo control survey points. The elevation and description of the datum point of the survey shall be shown on this list. All surveyed points shall be listed in numerical and/or alphabetical order. See Annexure 4.
- 3.3.4.6 Triangulation, traverse and/or Global Positioning System (GPS) calculations shall be adhered to as specified in paragraph 4.3.

Legible copies of the original computer printouts shall be bound and treated as part of the calculation sheets. No thermal prints shall be allowed.

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The Surveyor shall clearly indicate the methods of calculation used, and the computer printouts shall be sufficiently detailed with regard to printed headings and actual printed data, to show all relevant data as accuracies, tolerances and in the case of GPS surveys vector residuals as stated in the Land Survey Act.

3.3.5 Final co-ordinates of surveyed beacons shall be given to the second decimal place.

3.4 Vertical Fixing of Permanent Survey Beacons

3.4.1 Levelling

3.4.1.1 For allowable errors and other relevant detail requirements see paragraphs 2.4 and 2.5. The elevations of traverse stations shall be determined by spirit levelling unless otherwise specified.

Level instrument adjustment checks shall be performed daily before the commencement of surveys and be reflected in the field book.

3.4.1.2 All station elevations determined by spirit levelling shall be measured twice, i.e. by forward and reverse levelling using the adjusted mean.

Simultaneous levelling on a common staff is not allowed.

3.4.1.3 The reduced level, given to 3 decimals of a metre for any survey beacon, shall be the top of the peg marking the survey beacon. Where any peg protrudes more than 40mm above the ground, the height difference to the top of the peg above normal ground level shall be quoted to two decimals of a metre, in addition to the reduced level of the top of the peg.

3.4.1.4 Wherever the framework of the levelling is such that two or more lines of levels run parallel to each other, they shall be interconnected by cross levelling at intervals of not more than 1 kilometre. The adjustment of the spirit levelling shall be done in successive circuits, starting from a terminal Bench mark, along the left level line, cross over at the 1 kilometre distance to the right level line and back to another terminal Bench mark. For the successive circuits the survey beacons at the cross over positions from the left to the right line, shall be used as terminal bench marks.

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3.4.1.5 All spirit levelling of permanent survey stations shall, in addition to the reverse levelling, be independantly checked by GPS levels or Trigonometrical height determination at the time of the traversing.

3.4.2 Trigonometrical Height Traversing

3.4.2.1 The Client may allow the use of simultaneous reciprocal trigonometric levelling for the determination of elevations in steep terrain. If this method of height determination is allowed, distances between consecutive survey station should be kept to within 500 metres and the vertical angle shall be obtained from at least two arcs of observations. Signal and instrument heights shall be measured and recorded before as well as after the completion of the observations. Written permission to use this method of height determination shall be obtained from the Client. See also paragraph 4.2.2.5.

3.4.3 GPS Heighting

GPS survey methods shall not be used to determine the elevations of permanent survey beacons.

3.4.4 Elevations: Reduction and Calculation

3.4.4.1 The reduction of spirit levelling observations shall be done in the field books, either by the "rise and fall" or "collimation" methods where reductions are not done by computerised method. Computerised reductions shall be included in the calculation file.

3.4.4.2 On each page of every level book, any reducing, balancing, extending and cross referencing shall be clearly shown.

3.4.4.3 In trigonometrical levelling, corrections for curvature and refraction shall be applied, except in cases of simultaneous reciprocal levelling.

3.5 Photo Ground Control

3.5.1 Vertical Photo Control - (LPC)

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A level photo control points shall be a point on the ground which can be easily and positively identified on the photograph. It shall permit maximum accuracy in **height** to be obtained when observed stereoscopically.

The minimum requirements for a fully controlled stereo model are 4 height control points (wing points, LPCs) and 3 premarked or identified co-ordinated photo control points (PCs) along the centre of the strip, or, alternatively, 6 points fixed by aerial triangulation. Each model shall have one height control point (LPC) in each corner of the model which shall fall well outside the area to be mapped and not less than 30mm from the edge of the photograph. At a photo contact scale of 1/6000 the heighted points (LPCs) shall be $\pm 170\text{mm}$ apart as measured on the photograph and ± 1000 metres as measured on the ground. No extrapolation shall be permitted.

In adverse and extreme terrain conditions these requirements may, in consultation with the Client, be relaxed. The photographs concerned shall be submitted for inspection. See paragraph 4.10.1.1

GPS survey methods shall not be used to determine the elevation of photo control points unless evidence can be shown that a sufficient number of known height points, spread over the entire survey project, has been included in the observations to determine the exact Geoid of the area, for interpolation to the Geoid on the new points.

Refer to paragraph. 3.7. for the aerial triangulation point distribution.

3.5.2 Horizontal Photo Control Point

3.5.2.1 Permanent Survey Stations

Each permanent survey station to be used for a photogrammetric project shall be marked by means of a white cross, provided that under unusual conditions, e.g. on white sand, a black cross may be used. The width of the premark shall not be less than 0,25m and the length of each leg shall not be less than 1,3 metre. A cross will be clearly seen on the photograph if its overall length is 0,5mm in the scale of the negative; e.g. for 1/6000 photography the overall length of the cross will be 3,0 metres. The length of each member will thus be 1,5 metres. (See

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Annexure 7). A black cross shall be widened to at least 0,35m to offset the effect of halation (flare) and shall not incorporate any shiny or reflecting material.

3.5.2.2 Photo Control Points (PC)

A photo control point (PC) shall be a premarked point or a point of natural detail which can be easily and positively identified on the photograph. It shall permit maximum accuracy in **height and planimetry** to be obtained when observed stereoscopically and shall be fixed accordingly.

These points may be permanent survey stations and/or survey points between permanent survey stations and will be used as planimetric control in each stereoscopic model if aerial triangulation is not employed. Three planimetric control points shall appear along the centre of each model and be co-ordinated in Y, X and Z.

3.5.2.3 Distribution of Planimetric Photo Control Points

3.5.2.3.1 When full planimetric photo ground control is required for mapping and unless the nature of the terrain dictates differently, the maximum spacing between photo control points shall be calculated from the formula $0,031S$, where S is the contact scale of 60% overlapping photography.

3.5.2.3.2 When aerial triangulation is employed, the maximum distance between photo control points shall be calculated from the formula $0,27S$ where S is the contract scale of the photography. This represents three times the distance between the photo centres of 60% overlapping photography. (For aerial triangulation see paragraph 3.7).

3.5.3 Selection of PC and LPC Points on Existing Photography

3.5.3.1 A photo control point shall be selected on the photograph with the aid of a (pocket) stereoscope so as to obtain an operator's view.

3.5.3.2 The emphasis shall be on the quality of the selected point in terms of definition and level ground, and not on the ease with which it can be fixed.

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3.5.3.3 In difficult terrain additional points should be identified and fixed.

3.5.4 Marking of Identified Ground Control: Photo Control (PC), and Level Photo control (LPC)

3.5.4.1 The point shall be marked only on the photograph on which it appears nearest to the photo centre.

3.5.4.2 The point shall be pricked on the photograph in the marked area, using a very fine needle.

3.5.5 Field Sketch

A sketch of the point shall be prepared in the field in accordance with the following procedures using a suitable pen.

3.5.5.1 The photograph shall be turned over longitudinally along the direction of the strip.

3.5.5.2 The sketch shall be drawn on the reverse side of the photograph and in the area relevant to that point.

3.5.5.3 The sketch shall be drawn as seen under a stereoscope and not as seen on the ground.

3.5.5.4 The sketch shall be supplemented with a description of the point to assist the stereoplotter operator in its identification.

3.5.5.5 Whenever the selection of a point on a raised position cannot be avoided, the Surveyor shall state whether its height refers to the raised position or to ground level; the height difference shall always be noted.

3.5.6 Marking on the Photograph

A photo control point shall be circumscribed by an ink circle of ± 5 mm diameter on the front of the photograph and numbered accordingly.

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The number shall be printed above the circle on the front of the photograph and above the sketch on the back of the photograph.

3.6 Premarking

- 3.6.1 Each Permanent Survey Station shall be premarked. See paragraph 3.5.2.1.
- 3.6.2 Photo ground control points shall be premarked on a contrasting background and shall be positioned where they are least likely to be destroyed or covered by dust.
- 3.6.3 Care shall be taken to ensure that the point will not be in shadow at the time of the photographic flight.
- 3.6.4 The surveyor shall satisfy himself that the point will not be obscured by tall features, i.e. not less than 45° from the horizontal.
- 3.6.5 To facilitate accurate heighting by the stereoplotter operator, premarks should not be placed on steep slopes. For premarks see Annexure 7.

3.7 Aerial Triangulation for Large Scale Mapping

3.7.1 Planimetric Photo Control by Aerial Triangulation

Where full height photo ground control (fixed in the field by the prescribed methods) is used for mapping purposes, aerial triangulation may be used to obtain Y and X co-ordinates for minor photo control points for each model, provided that the procedure and the results of the adjustment of the aerial triangulation fulfil the following requirements:

- 3.7.1.1 Aerial triangulation shall be performed on either a first order analogue stereoplotter, an analytical plotter or a comparator.
- 3.7.1.2 A minimum of 3 tie points shall be used for each model connection in a strip. These tie points shall be marked along the middle section (at right angles to the line of flight) of each diapositive, which is covered by the overlapping parts of both adjacent diapositives in the strip (in the so-called "superlap" or "3-fold"

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overlap). Tie points shall be selected at the top and bottom parts of this section; if any adjacent parallel strips are present the tie points shall also fall in the area covered by the side laps of such strips. A third tie point shall be selected at the centre of the section, close to the principal point.

3.7.1.3 The adjustment of the aerial triangulation observations may be performed by any accepted block adjustment method and with the Client's prior approval of such method. A direct solution for the block adjustment is recommended.

3.7.1.4 The method of "high flown/low flown" aerial triangulation shall not be allowed unless authorised by and under full control of the Client.

3.7.2 Planimetric and Height Photo Control by Aerial Triangulation

3.7.2.1 Wherever the Client allows the use of aerial triangulation to obtain planimetric and height photo control points for mapping purposes with the minimum of photo ground control points, the following specifications shall apply, unless otherwise specified.

3.7.2.2 Aerial triangulation on an analytical plotter or comparator will be allowed only if all corrections for known errors, such as instrument errors, lens distortion, refraction, earth curvature and film deformation, are applied to the triangulation observations. A minimum of 4 fiducial marks shall be used and the output shall be full model co-ordinates including of the perspective centres.

3.7.2.3 Artificial tie points shall be marked with a precision point marking device, the accuracy of which shall be better than 5 microns.

3.7.2.4 Double tie points (1 to 3mm apart) may be marked in the upper and lower parts of the middle section of the diapositive as described in paragraph 3.7.1.2 and a single tie point shall be marked close to the principal point. The double tie points shall be used simultaneously to connect models and any adjacent strips.

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3.7.2.5 Double and single tie points shall form a rigorous network geometry for the block, given that the ground control points shall form their own rigorous network.

3.7.2.6 A rigorous, block adjustment program (e.g. PATM independent model block adjustment program) shall be used for the adjustment of the aerial triangulation. The block adjustment shall be performed in such a manner that the statistics will reflect the accuracy of the photogrammetric observations and the residual errors at the planimetric and height ground control points.

3.7.2.7 All photo ground control points shall be premarked.

3.7.3 Planning Photo Ground Control for Aerial Triangulation

Perimeter planimetric photo ground control points (PC's) shall be planned to fall in the corners of the block of photography and spaced not more than 4 model base lengths apart along the perimeter of the block.

Height photo ground control points (LPC's) shall be placed in lines across the strips forming the block and at the beginning and at the end of each strip, not more than 2 model base lengths apart. Spacing may be relaxed to 3 or 4 model base lengths inside the block, but shall remain 2 model base lengths along the perimeter of the block unless otherwise specified by the Client.

The height photo ground control points (LPC's) shall fall within the sidelap of any overlapping adjacent strips, as well as along the perimeter of the photographic block, to fully control each strip for lateral tilt.

For single strips the height photo ground control points (LPC's) shall not be more than 2 model base lengths apart.

3.7.4 Photography for Aerial Triangulation

When planning the photo coverage of an area to be mapped and where aerial triangulation is to be used to obtain planimetric and height control, the following shall be borne in mind :

In the aerial triangulation block adjustment the largest errors occur along the edges of the block. It is therefore imperative that the photo cover be extended beyond the borders of the area to be mapped by at least one model at the beginning and one model at the end of each strip and at least by half a strip width along the borders covered by the photography. The perimeter photo ground control points controlling the block will, as a result of the above planned photo coverage, fall outside the borders of the area to be mapped, thus maintaining a rigid control over the photographic block, with the largest errors occurring outside the area being mapped.

3.7.5 GPS Supported Aerial Triangulation

If aerial photography incorporating Global Positioning (GPS) methods to fix the camera's principal point at the time of exposure, is to be used for the purpose of reducing photo ground control for aerial triangulation purposes, prior permission must be obtained from the client who will issue the relevant specification.

4. SURVEY RECORDS

4.1 General

4.1.1 The arrangement of survey records and the methods of reduction shall be such that a simple scrutiny of the results will allow an immediate assessment of:

- (a) the standard of the work and
- (b) the likelihood of the absence of errors; this principle applies equally to calculations done by computer.

4.1.2 The reference number allocated to the survey records shall be ascertained in advance and shall be added to all field books and calculation pages as the work progresses.

4.1.3 All records shall be on non thermal A4 size paper, orderly and fully annotated, cross-referenced and adequately checked.

4.1.4 Plans, fieldbooks and sets of calculations shall bear the Surveyor's signature and date.

4.1.5 Field books shall be numbered consecutively as one series for each project and the pages in each book shall be numbered consecutively.

4.1.6 Calculation pages shall be punched in advance, with two holes spaced 80mm apart and centred in the upper margin, for filing in the prescribed file.

4.1.7 Calculation pages shall be numbered consecutively from 1000 upwards, in the following order:

First pages (not numbered)	-	Technical report. See Annexure 2.
Pages 1000 - 1999	-	Working plan and level diagram.
Pages 2000 - 2999	-	Fieldbook and calculation reference summary page

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Pages 3000 - 4999	-	Orienting joins and
	-	All calculations and direction sheets (except cadastral calculations) arranged in their chronological order.
Pages 5000 - 5999	-	All elevation calculations in their chronological order.
Pages 6000 - 6999	-	Aerial triangulation calculation and printouts.
Pages 7000 - 7999	-	All photogrammetric setting records.
Pages 8000 - 8999	-	GPS records.
Pages 9000 - 9999	-	Any other not specified in this list (fieldwork).

4.1.8 Transcription of data shall be avoided to minimise the risk of mistakes.

4.1.9 Co-ordinate lists shall clearly indicate the level datum, Geodetic System, job description and survey date.

4.2 **Fieldbooks (General)**

4.2.1 **Types of Fieldbooks.**

Only the Client's approved survey fieldbooks shall be used.

Wherever electronic data capturing is used, a hardcopy printout in accordance with the requirements as set out in paragraph 4.2.2 and 4.2.3 shall be placed on the survey file, indexed as "Electronic Field Book", complete with a legend of abbreviations/symbols used.

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4.2.2 Entries in Fieldbooks (Conventional Fieldbooks)

4.2.2.1 All field entries shall be written boldly in pencil and shall be clear, legible and complete.

If so instructed by the Client, the Surveyor shall repeat that part or all of the survey work for which the entries in the fieldbooks do not comply with the requirements of the following clauses:

4.2.2.2 No erasures shall be permitted, nor shall any letter or figure be overwritten. Alterations shall be made by crossing out the incorrect entry with a single line so that it remains legible and by writing the correct entry above it. Where there is a possibility of confusion, the whole series of entries may be crossed out and rewritten; however, no such copy shall be accepted unless accompanied by the original, properly cross-referenced where ne-cessary.

4.2.2.3 Entries made in field books in the office and the final reductions of the observations shall be in ink.

4.2.2.4 The final descriptions, co-ordinates and reduced levels of benchmarks and permanent survey stations shall be written in **red** ink in the field books, opposite the stations concerned. The same entries shall be made for temporary survey stations in **blue** ink in the field books.

4.2.2.5 Reduced levels shall be written in full as follows:

- (a) Spirit levelling to 3 decimals of a metre.
- (b) Trigonometrical height traversing to 2 decimals of a metre (3 decimals for simultaneous reciprocal observations).
- (c) Trigonometrical levelling to 1 decimal of a metre.

4.2.2.6 The observer's name, signature and the date shall be entered on the first and last pages of each day's observations. The index page of each book shall be properly completed.

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4.2.3 Referencing

4.2.3.1 Every fieldbook shall be given a unique reference number; the numbers of all books pertaining to one project shall form a series.

4.2.3.2 Every fieldbook shall have a title page giving the name and address of the Surveyor, description/title of the survey, the year, the number of the book and an index page listing the contents of the book.

4.2.3.3 The source of all starting data (e.g. first orientation direction, elevation and name of starting benchmark, etc.) shall be clearly stated in the fieldbooks.

4.2.3.4 Cross-referencing shall be done in and between fieldbooks.

4.2.3.5 Constants and factors used for the reduction of distances shall be entered on the first page of each field book, referring to the number of the field-book page on which the relevant measurements were entered.

4.3 Calculations (General and Cross-Referencing)

4.3.1 Calculations shall follow the principles in common use in the Republic of South Africa as described in the Annexures to the Survey Regulations framed under the Land Survey Act 9 of 1927 as amended. See Annexure 1.

4.3.2 Whenever a point has been measured or observed more than once, the comparison between the various measurements and the finally adopted value shall be shown clearly, either in the field book or in the calculations.

4.3.3 Cross referencing of the calculations shall be done meticulously along the following lines:

- a) The fieldbook and calculation reference summary page (pages 2000 - 2999) shall be regarded as the key to the calculations and shall show, opposite each point, the page number where the field observation and co-ordinate calculation can be found. See Annexure 5.

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- b) The direction sheets (page 3000 - 4999) shall show the fieldbook page numbers for each set of observations at the triangulation points.

4.3.4 All hand calculations shall be entered in ink and on one side of the paper only.

4.3.5 Legible copies of the printouts of the computer calculations shall be bound. Computer calculations shall be sufficiently detailed with regard to printed headings and actual printed data.

4.4 **Working Plan**

4.4.1 A working plan shall accompany the basic survey calculations including Global Positioning System (GPS) surveys and shall be drawn on a stable base transparent material to any convenient scale, or on a transparent 1 : 50 000 Topo Cadastral map. See Annexure 13 and 14.

4.4.2 The working plan may be drawn in sections and shall not exceed 210mm in width so that it can be filed without lengthwise folding.

4.4.3 The plan shall show all trigonometric beacons and all permanent survey stations. If the stipulated width of 210mm is not sufficient, a separate plan at a smaller scale, showing all the survey points, shall be produced.

4.4.4 All rays used to fix the terminal survey points shall be shown on the plan.

4.4.5 If the working plan is not compiled on a 1:50 000 Topo Cadastral map it shall show the approximate positions of prominent features (towns, rivers, railways, etc.) which lie on or across the survey route, in order to give a reasonable picture of the relative positions of the various sections of the survey.

4.4.6 The working plan shall show a suitable co-ordinate grid, north direction and approved final sheet layout.

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4.5 Level Diagram

A level diagram, schematically showing all lines of levels, circuits, benchmarks, height differences between adjacent benchmarks, lengths of lines, closing errors and allowable closing errors of all lines and circuits, shall be submitted. The direction in which a line was levelled shall be indicated by an arrow. See Annexure 12.

4.6 Cadastral Key Plan

The Surveyor shall supply a cadastral key plan on standard A0 size sheets unless otherwise specified, at a scale of between 1/5000 to 1/25000, depending on the density of the cadastral information. The key plan shall show the following:

- (a) All survey sheets accurately scaled and plotted.
- (b) All farm boundaries, subdivisions and townships (only block corners and streets).
- (c) All cadastral beacons, numbered according to the cadastral data as calculated.

4.7 Co-ordinate List

4.7.1 The co-ordinate list shall provide all information reflected in Annexure 4.

4.7.2 Full co-ordinate values shall be shown and no constants shall be subtracted.

4.8 Cadastral Data See chapter 6.

4.9 Photogrammetric Setting Sheets

4.9.1 All points falling in the stereoscopic model shall be indicated on the setting sheet in their relative positions in the model.

4.9.2 Final residual closures obtained from observations after the absolute orientation has been accepted shall be indicated next to each point on the setting sheet or on the computer printout. (Final residual closures are not the adopted absolute orientation residuals).

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- 4.9.3 The following information shall be shown on the setting sheet or computer printout:
Job name and number, stereoplotter type and number, model number, strip number, photo scale, model scale, plan scale, camera type, number and focal length, operator's name and the date of compilation.

4.10 Records to be Submitted on Completion

The Surveyor shall submit all records as defined hereunder :

4.10.1 Photographic

- 4.10.1.1 The following records shall be submitted for approval by the Client as soon as possible after the photography has been completed.
- a) One (1) set of contact prints.
 - b) The flight plan (see paragraph 5.6).
- 4.10.1.2 On completion of the survey, the following shall be submitted:
- a) All negatives.
 - b) All diapositives.
 - c) All contact prints as specified.

4.10.2 Basic Survey

All fieldbooks including printouts of electronic fieldbooks, calculations, working plans, level diagrams and co-ordinate lists relating to the basic survey.

4.10.3 Photo Control

- 4.10.3.1 All fieldbooks, including printouts of electronic field books, calculations, working plans, level diagrams, sketches and co-ordinate lists relating to the survey of photo ground control points.
- 4.10.3.2 All prints used for annotation, ground and/or photogrammetric control purposes.

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4.10.3.3 All photogrammetric calculations, aerial triangulation records and machine setting sheets.

4.10.4 Plotting Data

The set of survey plans together with the relevant key plans and digital data.

4.10.5 Cadastral Data

All cadastral data, diagrams, compilations, calculations, keyplans and digital data.

4.10.6 Electronic Data

All co-ordinates and heights of survey ground control, photo ground control and cadastral calculations shall be supplied in separate files on good quality computer disks and labelled as specified by the Client.

All Computer Aided Draughting (CAD) data shall be supplied in a format specified by the client.

4.10.7 Technical Report

A technical report dealing with all aspects of the survey, e.g. methods, instruments used, closures, name and height of level datum, results of accuracy checks and any other significant detail regarding the survey project, shall be submitted on completion. See Annexure 2.

4.10.8 Delivery Note

The delivery note shall consist of a detailed list of all items delivered and a list of all items still outstanding. The contractor shall ensure that all goods are handed to the officer responsible for the contract.

5. AERIAL PHOTOGRAPHY

5.1 Purpose of the Survey

This chapter covers technical requirements, standards of equipment, execution and recommended procedures for aerial photography as used for the photogrammetric compilation of topographical maps and for natural resources evaluation. It is applicable to panchromatic, colour, infra-red and (false) colour infra-red photography.

5.1.1 Unless otherwise specified, an aerial photography contract shall include the supply of the processed negative film, two sets of contact prints, one set of contact diapositives and the flight plan.

5.2 Camera

5.2.1 Type

The photography shall be done with an approved, nominally distortion free, standard wide angle (152 mm) photogrammetric camera of 230x230 mm format.

5.2.2 Calibration

A full calibration report shall be submitted showing the radial distortion of image points with reference to the principal point of autocollimation not exceeding 0,02 mm measured in the focal plane, as well as lens type, make and manufacturer's number and date of calibration.

This certificate shall be considered valid for a period of not more than 3 years.

Should any part of the camera that affects the calibration be dismantled, a new calibration shall be carried out after reassembly.

5.2.3 Filters

Any filters used shall be plane parallel to within 10 seconds and be coated to compensate for loss of illumination towards the outer field.

5.2.4 Operational Test

5.2.4.1 The contractor shall, at his own expense, annually photograph an approved test area with each camera that he proposes to use as described below.

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5.2.4.2 The photography shall cover two or more overlapping film negatives.

5.2.4.3 The test area shall contain at least twenty four (24) readily identifiable photo ground control points well distributed throughout the entire overlap area of the two negatives. The mean square error in position and height of the photo ground control points shall not exceed $\pm 0,05\text{m}$ and $\pm 0,15\text{m}$ respectively.

5.2.4.4 The contractor shall supply the following records in respect of the photography of the test area on request.

- (a) Plan of the test area.
- (b) Co-ordinates, height and description of each photo ground control point.
- (c) An enlarged photographic print, on which the photo ground control points are clearly marked at such a scale as to allow their easy identification.
- (d) One set of diapositives and contact prints each, for any one test area.

5.2.4.5 Any inconsistency between the results obtained from the photography of the test area and the camera calibration data may result in the rejection of any photographs taken by that camera.

5.3 Operational Requirements

5.3.1 Area to be Photographed

The location, size and boundaries of the area to be photographed or mapped shall be specified by the client in the tender requirements.

5.3.2 Flight Lines

5.3.2.1 Each flight line shall be continuous and unbroken for its entire length over the area being photographed. Breaks in strip continuity shall be allowed only where necessitated by unfavourable weather conditions or when a change in altitude is required to comply with sidelap or scale requirements. When a break in strip

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continuity occurs, the separate sections of the strip shall overlap by at least five exposures.

5.3.2.2 Coverage beyond the limits of the area to be mapped parallel to the flight lines, shall not be less than 20 percent of the width of the photographic strip. The first two exposures as well as the last two exposures of each strip, including the required overlap, shall be completely outside the area being mapped.

5.3.2.3 Photographs covering more than 25% non-stereoscopic area, will not be acceptable.

5.3.3 Overlap

5.3.3.1 Fore and Aft Overlap

The fore and aft overlap shall generally average 60%; any overlap less than 55% or more than 65% shall be considered sufficient grounds for rejection of the entire strip. In the event of extreme variations in elevation in an area, deviations from the above requirement may be permitted. Deviations shall be limited to the area where such conditions prevail and complete stereoscopic coverage will be required at all times.

5.3.3.2 Sidelap

Unless otherwise specified, the sidelap (overlap between parallel strips) shall average 25% and any sidelap less than 15% or more than 40% shall be considered sufficient grounds for rejection of the entire strip.

5.3.4 Flight Altitude

The departure from the required flying height above the mean ground elevation shall not exceed 2% lower or 5% higher than the required flying height.

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5.3.5 Photographic Conditions

Photography shall be undertaken only when conditions are such that acceptable negatives can be produced. Photography shall not be attempted when the ground is obscured by haze, smoke, dust or when clouds or cloud shadows may appear on any one photograph.

5.3.6 Solar Altitude

Unless otherwise specified, photography shall be undertaken with a solar altitude of not less than 30 degrees. The Client may place an upper limit on the solar altitude in which case this will be defined in the tender requirements.

5.3.7 Crab

During the photographic flight the camera shall be compensated for crabbing of the aircraft, such that the edges of the photographs in the strip are parallel to within 5 degrees with the line of flight.

5.3.8 Tilt

Departure of the camera lens axis from the vertical shall not normally exceed 2° though isolated exposures with up to 4° will be allowed in turbulent conditions. Relative tilt shall not exceed 6°.

5.3.9 Course Corrections

Corrections to the aircraft's course between successive photographs shall not exceed 3°.

5.4 Aerial Film

5.4.1 Type and Base

The film to be used shall be unexpired. The base or carrier for the emulsion shall not be less than 0,1mm thick and be of dimensionally stable safety polyester film.

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5.4.2 Exposures

The exposure shall produce a negative with most of its image densities located on the approximately straight portion of the characteristic curve of the photographic material. Minimum density shall not be less than 0,2 above base fog. In choosing the exposure to meet the requirements, consideration must be given to the effective film speed at the average gradient necessary to deal with the brightness range of the terrain to be photographed.

The exposure shall be made at the aperture and shutter speed setting for maximum resolution. When image motion due to ground speed is likely to be the limiting factor on resolution, exposures shall be made at maximum shutter speed consistent with adequate exposures.

5.4.3 Processing

Processing procedure shall be in accordance with the recommendations of the manufacturer of the film type used. For black and white negatives the degree of development shall be determined with due regard to the brightness range of the terrain. The average gradient shall be within the range 0,6 to 1,2 although in extreme cases, where the photography is of terrain of low brightness, processing to a value of as high as 1,5 may be desirable.

The lower values apply to areas of a brightness range such as in mountainous terrain where deep shadows and highlights may occur in close proximity.

The processing procedures should be sufficiently uniform to ensure that for any single exposure, the average gradient should not vary by more than 10% from the mean value.

The processing procedure shall not have a detrimental effect on the dimensional characteristics of the photographic image. At no time during the development or drying shall the film be subjected to a tension or temperature change sufficient to cause permanent dimensional changes.

All films shall be developed within 16 days of exposure.

5.4.4 Photographic Quality

The photography shall be clear and sharp in detail, of uniform density and have the proper degree of contrast for all detail to show clearly in both shadow and highlight areas. Photography having excessive contrast, or low in contrast, may be rejected. It shall be free from clouds and cloud or ground shadow, smoke, haze, excessive snow, any marks due to processing and handling and other blemishes.

5.4.5 Standard Recorded Data

The film, contact prints and diapositives, shall clearly reflect the following data in respect of each exposure.

5.4.5.1 The allocated Photographic Job Number on the right as supplied by the client.

5.4.5.2 A standard four digit photo number on the left, agreeing with that of the feeder counter; the number shall consist of at least four digits and zeroes shall be used before the digits of a number below 1000.

5.4.5.3 The strip number.

5.4.5.4 The calibrated principal distance corresponding with the latest calibration certificate.

5.4.5.5 The camera altimeter reading, which shall be synchronised with the aircraft's altimeter.

5.4.5.6 The chronometer which shall record South African Standard Time.

5.4.5.7 The approximate contact scale of the photography.

5.4.5.8 The date(s) of the photography.

5.4.5.9 The number of the lens cone.

5.4.5.10 Any other useful data such as the face of the circular bubble.

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5.4.5.11 The route number and its description.

Any of the above items not photographically recorded shall be added to the negative film; no data shall encroach on the image area of the film nor obscure fiducial marks.

5.4.6 Film Index

A film index, as shown in Annexure 3, shall be submitted with every job and shall contain the following information: film numbers, job number, strip number, photo numbers and the date(s) of photography. This information shall also appear on the film canister and the flight plan.

5.5 Contact Prints and Diapositives

- 5.5.1 The required number of prints, as stated in the tender requirements or specifications, shall be submitted with the aerial film. Contact paper prints shall be on double weight, semi matt, waterproof paper.
- 5.5.2 Special care shall be taken to ensure proper development and thorough fixing. The prints shall be clean and free from all blemishes and shall be thoroughly washed to clear them of chemicals that may impair their permanency.
- 5.5.3 They shall be uniform in tone and density and the degree of contrast shall be such that all detail in both dark and bright areas will show clearly.
- 5.5.4 Diapositives shall be of dimensionally stable film within 20 microns with the calibrated distance when measured across the fiducial marks unless otherwise specified. If required, diapositives may be produced in an electronic printer with automatic balancing of contrast. Each diapositive shall reflect all the information as specified for the negative film.

5.6 Flight Plan

A flight plan, drawn on a durable transparent 1:50 000 Topo Cadastral map, shall be supplied with each photographic job and shall show the following: (See annexure 16)

- 5.6.1 The approximate contact scale of the photography.
- 5.6.2 The date(s) of photography.

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- 5.6.3 The make of camera, number of the lens cone, its focal length and type of film used.
- 5.6.4 Route number, title and Job Number.
- 5.6.5 The scale of the flight plan, co-ordinate grid system and North sign.
- 5.6.6 The strip positions and extent of coverage.
- 5.6.7 Photo centres shall be plotted as accurately as possible at the beginning and end of each strip and approximately every fifth photo centre on each strip shall be shown. The photo centres shall be marked with a cross and labelled with their full exposure number.
- 5.6.8 Acceptable excess photographs beyond the specified requirement shall be numbered and indicated on the flight plan by a broken line.
- 5.6.9 The numbers of the first and last exposure of each strip shall be reflected in tabular form.
- 5.6.10 The contractor's identification mark.

5.7 Photographic Records

The following records shall be supplied in respect of each job:

- 5.7.1 The full negative film of each exposure in the standard metal or plastic canister.
- 5.7.2 The film index as specified in paragraph 5.4.6.
- 5.7.3 Sets of contact photographs and/or diapositives as specified.
- 5.7.4 The flight plan as specified in paragraph 5.6.
- 5.7.5 The calibration certificates as specified in paragraph 5.2.2.
- 5.7.6 Any other records required in terms of paragraph 5.2.4.

6. CADASTRAL DATA

6.1 Purpose of the Survey

This section covers the collection of all data defining the cadastral boundaries of properties in respect of which deeds of tenure are registered in Deeds Registries.

The purpose of this phase will be to provide current, up to date and accurately calculated cadastral information to compile detailed cadastral plans of a project to:

- establish road reserves
- produce expropriation plans
- supplement and complete the final mapping project.

This shall **exclude** short term leases, and the interior boundaries of separate mining titles which together constitute single mining properties, but shall **include** all farms, subdivisions, smallholdings, township lots, servitudes, road proclamations, etc., falling within the surveyed area as at the date of the survey.

6.2 Copies of Diagrams

The primary source of cadastral information shall be the office of the Surveyor General (S.G.), from which copies of existing cadastral compilation sheets and diagrams can be obtained.

6.3 Sorting of Diagrams

6.3.1 Diagrams shall be grouped separately under parent farms or blocks in alphabetical order. Within these groups the subdivisional diagrams shall be arranged in sequence according to subdivision number.

6.3.2 Official S.G. numbers shall be used for all diagrams.

6.4 Cadastral Calculations

Calculations of co-ordinates for plotting purposes shall be checked and arranged in an orderly manner. A complete co-ordinate list in numerical order shall be supplied.

6.5 Cadastral Plotting

- 6.5.1 Unless otherwise specified the plotting of cadastral lines on the survey sheets shall be extended to at least 100 metres beyond the surveyed area.

For key plan plotting see paragraph 6.7.1.

6.5.2 Numbering of Cadastral Beacons

For ease of correlation, all beacons featuring in the cadastral calculations shall be arranged in numerical order. Such numbers shall be noted in red if on Lo and in blue if on any other system, on the compilation plans as well as on the individual diagrams. These numbers shall not be annotated on the final plans, but only on the cadastral key plan, or as otherwise specified.

- 6.5.3 All boundaries of servitudes and rights of way shall be indicated by dashed lines, except where these lines are also the boundaries of subdivisions.

6.6 Cadastral Draughting Requirements

- 6.6.1 All boundaries, beacons and property descriptions shall be drawn in black uppercase lettering, or as otherwise specified, on the original plans. Prior authority shall be obtained for any deviation from this instruction.

- 6.6.2 All cadastral farm names shall appear immediately outside and at the top or bottom of the survey area. This will generally depend on the density, shape and size of the farm. It may be necessary in some cases to reduce the size of the farm name to not less than 3mm height, to be able to accommodate the name outside of the area mapped.

- 6.6.3 Farm names shall at all times appear on the edges of the mapping and in a parallel position along the main cadastral boundaries. All cadastral information shall form part of the digital CAD contour and detail survey.

6.6.1 Pen and Letter Sizes

- 6.6.1.1 For pen sizes see the draughting symbol list in chapter 11.

- 6.6.1.2 When the property sizes are small in area, as in township layouts, discretion shall be used when annotating the property description and numbers.

CADASTRAL DATA

6.6.1.3 Descriptions of both farms are required to be written along the common boundary line and adjacent to each other, using a 0,5 pen, e.g.:

EDMORE NO. 264

BOULDERHILL NO. 156

NB Care shall be taken to ensure that property descriptions and subdivisional numbers agree with their respective diagrams.

6.6.1.4 The cadastral description ie. farm name and S.G. number shall be shown for each farm, subdivision, servitude and right of way.

6.7 Cadastral Key Plan

6.7.1 Unless otherwise specified, the contractor shall supply a cadastral key plan on standard A0 size sheets, as well as in a CAD format at a scale of between 1/5000, 1/10 000 or 1/25000, depending on the density of the cadastral information. The key plan shall show the following:

- (a) All survey sheets, accurately plotted on the A0 sheet. Separate CAD layer, with the survey sheets plotted, shall accompany the digital (CAD) key plan.
- (b) All farm boundaries, subdivisions and townships. The full property effected by the survey must be calculated and plotted.
- (c) The numbers of all cadastral beacons referring to the relevant cadastral calculations.

6.8 Filing

6.8.1 Cadastral Records

All cadastral data shall be filed in an A4 file and to the following specifications:

CADASTRAL DATA

6.8.1.1 Index

Shall be grouped separately under parent farms in alphabetical order.

6.8.1.2 Diagrams:

Shall be filed according to the index on the first page of the file and arranged in numerical sequence according to subdivisional numbers.

6.8.1.3 Compilations

Compilation sheets shall be folded in A4 format and filed in sequence, with the compilation number on the outside of the folded sheet.

6.8.1.4 All co-ordinates shall be supplied on good quality discs in the prescribed ASCII format, labelled to identify the contents.

6.9 Standards of Accuracy: Cadastral Plotting

Errors in the plotting of cadastral boundaries, whether by co-ordinates or by angle and distance, shall not exceed 1mm in relation to the co-ordinate grid.

7. SMALL SCALE SURVEYS

7.1 Purpose of the Survey

The purpose of the survey is to provide digital data and detailed plans as specified by the client for comparisons of different routes with regard to gradients, curvature, extent of earthworks, severance of properties, etc., as a preliminary to large scale surveys of selected routes.

7.2 Phases of the Survey

The following are recognised as separate phases of the survey and shall be carried out or omitted as specified in the Survey Requirements:

7.2.1 **The Photography**, being the aerial photography, the processing of the film, the supply of all negatives, contact prints, diapositives and flight plans, as specified. See chapter 5.

7.2.2 **The Photo Control**, being all ground survey work required for the establishment of photo control points, the annotation of detail on the photographs, the aerial triangulation and the supply of all related records.

7.2.3 **The Plotting**, being the photogrammetric compilation and electronic data capturing of all detail, the drawing of the plans, the final checking in the office and the supply of all related records. See chapter 11.

7.2.4 **The Cadastral Phase**, being the collection of the data defining all cadastral boundaries and designations from the office of the Surveyor General and other sources; the preparation and plotting thereof on the plans and the supply of all related records. No cadastral key plan is required. See chapter 6.

7.3 Scale and Units

7.3.1 The scale shall be 1:5000 or as laid down in the Survey Requirements.

The width of the strip shall be 2 000 metres or as laid down in the Survey Requirements.

The contour interval shall be as laid down in the Survey Requirements.

SMALL SCALE SURVEYS

7.4 The Photography

- 7.4.1 The photography shall be taken at a mean flying height above ground elevation not exceeding 3060m (1:20 000) or as laid down in the Survey Requirements.
- 7.4.2 The centre line of the photography shall fall along the approximate middle of the area to be surveyed and the average flying height shall not exceed 2% lower nor 5% higher than the specified height.

7.5 Flight Plan and Sheet Layout

- 7.5.1 The survey shall run from left to right in the direction of increasing route/section numbers.
- 7.5.2 A sheet layout shall be submitted for approval before the draughting of the survey is commenced (See Annexure 13), a working plan is not required.
- 7.5.3 The flight plan shall be supplied as per paragraph 5.6. and Annexure 16.

7.6 Photo Control

- 7.6.1 Each model shall be fully controlled.
- 7.6.2 Ground control points fixed in the field may be supplemented by means of aerial triangulation.
- 7.6.3 Photo ground control points, if not premarked, shall be positively identified in the field under a stereoscope. Each point shall be pricked on one photograph only. To avoid misidentification a description of each point shall be given and a sketch made on the back of the photograph on which it appears. See paragraphs 3.5.4 and 3.5.5.
- 7.6.4 The position of the ground control points shall be such that the entire strip to be surveyed falls inside the control pattern; extrapolation will not be allowed.
- 7.6.5 If aerial triangulation is to be carried out, the spacing of photo ground control points shall be such that the number of models per section between photo ground control points shall not exceed 3 base lengths.

SMALL SCALE SURVEYS

- 7.6.6 Photo control points fixed by aerial triangulation may be suitable points of detail, identified and marked on the photograph, or they may be suitable marks in the emulsion of the diapositive.
- 7.6.7 The Lo co-ordinates and heights of photo ground control points shall be fixed by Global Positioning (GPS) or normal survey methods from surrounding trig beacons. The generally accepted principles, being adequate checking, orderly recording of field notes and calculations, shall apply. Sufficient fieldwork shall be done to ensure that every part of the field survey is checked. For GPS heighting see paragraph 3.5.1
- 7.6.8 A separate and full co-ordinate list, punched for filing as specified in paragraph 4.1.6, shall be prepared to show every photo control point with its co-ordinates and height.
- 7.6.9 Although annotation is not generally a prerequisite for this type of survey, a certain amount of annotation is required in order to identify important detail which may have a bearing on the location of a road.

Names of homesteads, villages, stations, rivers, important features, as graves, holy and historic places, etc., shall be given as well as destinations of main roads and railways.

7.7 **Aerial Triangulation**

- 7.7.1 Planimetric and height photo control by aerial triangulation.
- 7.7.1.1 Aerial triangulation shall be performed on either a precision analogue stereoplotter or an analytical plotter or comparator.
- 7.7.1.2 At least 3 tie points shall be used to connect models in a strip. These tie points shall be marked along the middle section of each photograph which is covered by the overlapping parts of the adjacent photographs in the strip (in the "3 fold" or "super"lap). One point each shall be marked in the top and bottom parts of the section in the area covered by the sidelaps of any adjacent strips and one point at the centre of the section close to the principal point.

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7.7.1.3 The adjustment of the aerial triangulation may be done by any accepted block adjustment method after satisfying the Client of its adequacy. A direct solution for block adjustment is recommended.

7.7.1.4 No "high flown/low flown" aerial triangulation will be allowed. The photography to be used for mapping purposes shall be aerial triangulated to obtain control for each individual stereoscopic model, i.e. a minimum of 6 control points, 4 of which shall fall in the four corners of the model.

7.7.1.5 For Global Positioning (GPS) supported Aerial Triangulations see paragraph 3.7.5.

7.8 Plotting

7.8.1 In general, all topographical features and manmade structures, consistent with the scale of the plans and the purpose of the survey, shall be plotted. In addition to major detail, the main requirements are the contours and the supplementary spotheights which shall be sufficiently frequent to ensure accurate interpolation of heights for the comparison of earthwork quantities of different routes.

Frequent spotheights shall be given on existing roads, railways and in areas subject to flooding.

7.8.2 Where the ground is obscured by vegetation or other matter, the required detail shall be surveyed in the field if requested. In this case, the contours shall be supplemented by means of spotheights surveyed in the field and shown on the plan.

7.8.3 Unless otherwise specified, contours shall be plotted at 5 metre vertical intervals and supplemented by spotheights wherever the contours are insufficient to portray ground shapes faithfully.

7.8.4 A good quality double matt, stable based, transparent material of not less than 0,075mm nor more than 0,150mm thickness and in standard A0 sheets shall be used, unless otherwise specified.

The first sheet and digital Computer Aided Draughting (CAD) data shall be submitted to the Client for approval before commencing with the remainder of the project.

SMALL SCALE SURVEYS

- 7.8.5 Wherever a change of Lo system occurs, except for the 15 minute exclusion zone, the co-ordinate axes and values of both Lo systems shall be shown on the sheet straddling the Lo meridian.

If a survey does not extend for more than 15 minutes beyond the Lo system of origin, only the system of origin shall be used.

In addition, at least three adjoining survey points on the affected sheet shall be given on both Lo systems. Both sets of co-ordinates shall be given in the co-ordinate list and on the relevant plan.

The remainder of the survey shall be completed in the new Lo system.

- 7.8.6 All symbols used shall conform to those laid down in the drawing specifications. See chapter 11.

Plans and Digital Computer Aided Draughting (CAD) data shall be carefully checked after completion by the Surveyor, both in the field and office. Wherever the ground is obscured by dense vegetation, contours shall be supplemented by spot heights fixed in the field and shown on the plan. **All records of field and office checks shall be submitted with the final plans.**

The spelling of place names shall be strictly according to the South African Book of Place Names, available from the Government Printer.

- 7.8.7 Each plan shall show:

All detail as prescribed in paragraph 7.8.1.

Co-ordinate grid lines and their full values. See paragraph 11.2.5.

Values of contours at intervals of approximately 400 mm along the contour and at the end(s) of each contour.

A title block according to the clients specifications.

All survey stations, photo control points and trig beacons which plot within the limits of the sheet.

All photo centres.

- 7.8.8 All detail and contours shall be digitally captured in a format as specified by the client. See paragraph 11.1.13, or as otherwise specified.

7.9 Standards of Accuracy

7.9.1 Photo Ground Control Points (PC's)

The planimetric photo control stations shall be surveyed in accordance with the Survey Act of 1927 as amended (Act 9 of 1927) and Survey Regulations as amended, to a class C accuracy. See Annexure 1.

The vertical error of a photo ground control point shall not exceed 0,15 metre.

7.9.2 Planimetric

The position of any well defined point of detail on the plan shall agree to within 0,5mm with its position as derived by ground survey methods. Such point shall be tested only against such fixed points in its vicinity as were actually used to fix it or are near enough to have been so used under normal circumstances. The planimetric errors of 90% of all points checked shall not exceed 0,5mm.

7.9.3 Contours

The accuracy of the contours shall be such that the difference of the elevations of the checked points as determined by interpolation between contours when compared with the elevations as determined in the field, shall not exceed 0,05% of the flying height; e.g. if the scale of the photography is 1/20 000 and the focal length of the camera is 152mm, the flying height is thus 3060 metres and the accuracy of 90% of all contours checked shall be within 1,50m of their true values.

7.9.4 Spotheights

The accuracy of photogrammetric spotheights is generally required to be approximately twice the accuracy of the contours. In the above case of 1/20 000 photography the accuracy of 90% of all spotheights checked shall be within 0,75 metres of their true values.

7.9.5 Co-ordinate Grid

The co-ordinate axes shall be plotted accurately at a spacing of 200mm. The variation in the spacing of any two grid lines shall not exceed 0,3mm from this distance, nor shall the grid line intersections deviate from the rectangular by more than 5 minutes.

7.9.6 Co-ordinated Points

Co-ordinated points shall be plotted on the plan to within 0,5mm of their true position in relation to the co-ordinate grid.

7.9.7 Cadastral Plotting

The positional error of a plotted cadastral point shall not exceed $\pm 1,0\text{mm}$ in relation to the co-ordinate grid.

7.10 Methods of Testing and Inspection

7.10.1 Photography

On receipt, the Client shall visually inspect a set of contact prints for photographic quality and flight conditions. Further inspection or tests, deemed desirable after visual inspection, may be carried out by the Client.

7.10.2 Photo Control

The errors in any check survey, carried out to test the accuracy of the photo ground control points, shall not exceed the tolerances laid down in paragraph 7.9.1.

7.10.3 Planimetry

No mapping shall be rejected because of planimetric inaccuracy unless the error, derived from at least twenty (20) check points, exceeds the tolerance specified in paragraph 7.9.2. Check points shall be well distributed and shall be well defined points of detail.

7.10.4 Contours

No map sheet shall be rejected because of inaccuracy of the contours unless the error derived from at least twenty (20) test points exceeds the tolerance specified in paragraph 7.9.3. Check points shall be well distributed.

7.10.5 Completeness of Detail

The completeness of topographic and cultural detail may be determined by an inspection in the field.

7.11 Records

The surveyor shall submit all relevant records as specified in chapter 4.

8. LARGE SCALE PHOTOGRAMMETRIC SURVEYS 1:500 to 1:2000

8.1 Purpose of the Survey

The purpose of this survey shall be to provide detailed plans and digital data for the selection of a road centre line, to provide a backbone of permanently marked and accurately fixed survey beacons for future use in staking, for revision surveys, to study the engineering requirements of road construction and for rehabilitation and expropriation purposes.

8.2 Phases of the Survey

The following are recognised as separate phases of the survey and shall be carried out or omitted as specified in the Survey Requirements.

8.2.1 The Photography, being the aerial photography, the processing of the film, the supply of all negatives, contact prints, diapositives and flight plans, as specified in chapter 5.

8.2.2 The Basic Survey, being the establishment of a horizontal and vertical survey network of permanent survey stations, and the supply of all related records. See chapter 3.

8.2.3 The Photo Ground Control, being all field survey work required for the establishment of photo control points, the annotation of detail on the photographs, the aerial triangulation, and the supply of all related records. See chapter 3.

8.2.4 The Plotting, being the photogrammetric or other plotting and digital data recording of all detail, the drawing of the plans, the final checking in the field and office, and the supply of all related records. See chapter 11.

8.2.5 The Cadastral Compilation, being the collection of all data defining the cadastral boundaries and designations from the office of the Surveyor-General or other sources; the preparation and plotting of the data on the plans, including all necessary field survey and the supply of all related records and key plans. See chapter 6.

8.3 Scale and Units

8.3.1 The scale shall be as laid down in the Survey Requirements.

8.3.2 All horizontal and vertical measurements shall be recorded in metres.

8.3.3 All angles shall be recorded in sexagesimal measure.

8.3.4 The width of the strip to be surveyed shall normally be 750m for surveys of 1 in 2 000 scale, 400m for surveys of 1 in 1 000 scale and 250m for surveys of 1 in 500 scale wherever the outline is not shown on the photographs or otherwise indicated or laid down in the Survey Requirements.

8.4 The Plotting

8.4.1 The Plotting in General (Sheet Requirements)

8.4.1.1 A Set of plans shall be plotted to a scale laid down in the Survey Requirements, using such photogrammetric instruments and supplementary means as specified. Each plan or a model of the whole project shall also be supplied in digital format according to the clients requirements, See paragraph 11.1.13.

8.4.1.2 Before commencing plotting operations the Surveyor shall submit to the Client for approval, a provisional plan on a transparent Topo Cadastral map at a scale of 1 in 50 000 showing the proposed sheet layout. On completion of the survey project a final key plan at a scale of 1 in 50 000 on a transparent Topo Cadastral map shall be supplied, on which the sheets are correctly shown. The sheet layout need not be a separate plan but may be drawn on the working plan.

The survey shall run from left to right in the direction of increasing route/section numbers, or as otherwise specified.

8.4.1.3 A double matt, stable based, transparent film material of good quality, not less than 0,075mm nor more than 0,15mm thick, 841mm wide and 1189mm long (A0 Size) shall be used for the final plans, unless otherwise specified.

The first fairdrawn sheet together with the corresponding digital Computer Aided Draughting (CAD) data shall be submitted to the Client for approval, before commencing with the remainder of the project.

8.4.1.4 Co-ordinate grid shall be plotted accurately at a spacing of 200mm. The co-ordinate lines shown shall be for those values which are multiples of: 100m for plans

at 1: 500, 200m for plans at 1: 1 000 and 400m for plans at 1: 2 000 scale. Their full values are to be indicated along the edges of the sheet.

8.4.1.5 Wherever a change of Lo system occurs, the co-ordinate axes and values of both Lo systems shall be shown on the sheet straddling the meridian.

In addition, at least three adjoining survey points on this sheet shall be given in both Lo systems; both sets of co-ordinates shall be given on the co-ordinate list and on the plan.

The balance of the survey shall be completed on the new Lo system, except where the survey does not extend more than 15 minutes beyond the adjacent system.

8.4.1.6 The plotted detail shall not extend beyond the margin of the plan. Unless otherwise specified, the survey sheet shall overlap the adjoining sheets by not less than 50mm measured on the plan if the sheets are lying roughly in the same direction; if not, the overlap shall be increased so that reasonable continuity is maintained. If grid intersections do not fall within the overlap area it will be necessary to draw three well spaced orientation crosses in the overlap. See paragraph 11.2.3.

8.4.1.7 Drawing symbols for survey plans, as, specified in Chapter 11, shall be strictly adhered to.

8.4.1.8 Plans and Digital Computer Aided Draughting (CAD) data shall be carefully checked after completion by the Surveyor, both in the field and office. Wherever the ground is obscured by dense vegetation, contours shall be supplemented by spot heights surveyed in the field and shown on the plan. All records of field and office checks shall be submitted with the final plans.

The spelling of place names shall be strictly according to the South African Book of Place Names, available from the Government Printer.

8.4.1.9 Each sheet shall show:

- (a) All detail as prescribed in paragraph 8.5.
- (b) Co-ordinate grid lines and their full values without the deduction of any constant.

- (c) Contour values at the end(s) of contours and at approximately 400mm intervals along the contour.
- (d) A title block according to the clients specifications, showing the title of the survey, route and section numbers, the name of the contracting firm and the date of survey; a co-ordinate list of permanent survey stations; the reference number and height of the benchmark of origin (Level datum).
- (e) All permanent survey stations, north direction, photogrammetric ground control points, benchmarks and trig beacons which plot within the limits of the sheets.
- (f) All photo centres.
- (g) Sheet numbers shall increase in the direction of increasing route and section numbers or as otherwise specified.
- (h) Space shall be allowed for a sheet index on all A0 sheets in the right hand bottom corner of the working area of the sheet or, if so specified, in the individual title blocks. If in exceptional circumstances this cannot be done, the layout shall be drawn wherever space allows. The sheet index shall show the sheet in relation to its adjoining sheets; only sheet outlines and numbers need be shown. If separate cadastral overlays are necessary, cross referencing in the space provided shall be used;

The sheet index on the topographical sheets shall show adjoining survey sheets whereas the layout on the cadastral overlay shall show the adjoining cadastral sheet(s).

8.5 Detail to be Surveyed

- 8.5.1 In general all detail which may have a bearing on the selection of the final road centre line and on the engineering requirements for road construction, shall be surveyed.
- 8.5.2 Contours representing 2 metre vertical intervals (unless otherwise specified), supplemented by spot heights wherever the contours are insufficient to portray ground shapes faithfully;

in addition spot heights at frequent intervals and on such features as roads, railways and bridges, etc., where elevations may affect the engineering design. In particular, deck levels of all bridges shall be given and spot heights at least every 100 metres on railway tracks and major roads. Sufficient heights shall appear on the plans to enable a reliable longitudinal profile of the proposed road to be plotted.

- 8.5.3 Rivers, streams, springs, canals, dams and their full supply levels, pans, marshes and areas subject to tidal flooding (calling for additional spot heights); names, if any, of such features and direction of flow where applicable, shall be indicated on the plans.
- 8.5.4 Highest known flood levels of main streams, as near as can be determined from local evidence or information; the source of such information and the specific point and date concerned, shall be indicated on the plans.
- 8.5.5 High tide marks, high water marks of tidal rivers and water levels of streams and dams at the date of survey.
- 8.5.6 Forest, bush, scrub, plantations, orchards, avenues, cultivated lands, hedges, individual trees which are landmarks, etc., with the outlines of such areas correctly shown.
- 8.5.7 Rock outcrops, cliffs, sand dunes, eroded areas and gullies.
- 8.5.8 Railways, differentiating between standard and narrow gauge and between Spoornet and privately owned lines. The destinations of all railway lines shall be indicated on the plans.
- 8.5.9 Roads, differentiating between bitumen, concrete paved and gravel surfaces, indicating status, number and destinations, footpaths, guard rails, kerbing, manholes and side drainage shall be shown.

The destinations and descriptions of roads shall correspond with the route description in the title block as supplied by the Client.

- 8.5.10 Bridges (stating bridge numbers) and culverts, including detail regarding the dimensions and types of construction relating to those structures which are situated on or across roads, or which have a bearing on the drainage thereof.
- 8.5.11 Elevations of the centre of the road at the point of intersection of road and culvert, as well as the invert levels of culverts, bridges and drop inlets shall be obtained by means of ground survey methods, or as otherwise specified.

- 8.5.12 Drainage and irrigation furrows.
- 8.5.13 All buildings, differentiating between types of construction and stating the function of the building other than domestic dwellings, e.g. store, school, etc.
- 8.5.14 National monuments and buildings or structures of historical interest, stating names.
- 8.5.15 Power and telephone lines, showing individual pylons and poles.
- 8.5.16 Underground pipe lines, cables and other features, the position of which shall be ascertained from surface indications or from the responsible authorities.
- 8.5.17 Gates and fences, differentiating between boundary, stockproof, verminproof and security fencing, etc. All access points shall be shown.
- 8.5.18 Stone or brick walls, wells, boreholes and windmills, indicating depths and supply rating when obtainable.
- 8.5.19 Cuttings, embankments, quarries, borrowpits, tunnels and mine workings.
- 8.5.20 Cemeteries and solitary graves.
- 8.5.21 Rock outcrops, loose boulders and bedrock.
- 8.5.22 Kilometre markers and all other road signs, shall be indicated by the specified symbols.
- 8.5.23 Wherever a surveyed feature of any kind, in particular those listed under paragraphs 8.5.6 and 8.5.7 is contained within well defined outlines, these outlines shall be shown in their true shape and by the correct symbol.
- 8.5.24 In general, all topography and manmade structures, the plotting of which is consistent with the scale of the plans.

In respect of such areas as built up townships, industrial or mining sites, etc., written approval shall be obtained for the omission of detail which is considered to be irrelevant.

8.6 Standards of Accuracy

8.6.1 General

8.6.1.1 The standard of accuracy of the survey shall be taken as the standard of accuracy relative to the trig beacons, bench marks or other reference points upon which the survey is based.

8.6.1.2 When comparing the results of a survey with the results of a check survey, due allowance shall be made for the standard of accuracy of the latter.

8.6.1.3 All the points in the stereoscopic model shall be indicated on the setting sheet in their relative position to each other. Final absolute closures shall be indicated next to each point on the setting sheet.

8.6.2 For Accuracy Tolerances see chapter 2.

8.7 Methods of Testing and Inspection

8.7.1 Photography.

On receipt thereof the Client shall visually inspect a set of contact prints, for photographic quality and flight conditions. Further inspection or tests, as deemed desirable may be carried out by the Client.

8.7.2 Basic Survey and Photo Ground Control

The errors in any check survey, carried out to test the accuracy of the basic survey and photo ground control points, shall not exceed the tolerances as laid down in chapter 2.

8.7.3 Planimetry

No mapping sheet shall be rejected because of planimetric inaccuracy unless the error, derived from at least twenty (20) check points, exceeds the tolerance as laid down in paragraph 2.6. Check points shall be evenly distributed and shall be well defined points of detail.

8.7.4 Contours

No mapping sheet shall be rejected because of inaccuracy of the contours unless the error, derived from at least twenty (20) test points, exceeds the tolerance as laid down in paragraph 2.7. Check points shall be evenly distributed and shall be well defined points of detail.

8.7.5 Completeness of Detail

The completeness of all topographic detail shall be determined by a thorough inspection in the field.

8.7.6 General

8.7.6.1 In addition to a field inspection and other tests, the Client reserves the right to inspect any or all phases of the work at any time, either in the field or at the surveyor's premises.

8.8 Records

The surveyor shall submit all records as defined in chapter 4.

9. LARGE SCALE PHOTOGRAMMETRIC COMPLETION SURVEYS 1:1000 to 1:2000

9.1 Purpose of the Survey

The purpose of this survey shall be to provide accurate plans and digital data of completed roads, showing all details of construction and to provide a backbone of permanently marked, accurately fixed survey beacons for future use.

9.2 Phases of the Survey

The following are recognised as separate phases of the survey and shall be carried out or omitted as specified in the general survey requirements for large scale mapping.

9.2.1 **The Photography**, being the aerial photography, the processing and supply of the negative film, the supply of all contact prints, diapositives and flight plans, as specified. See Chapter 5.

9.2.2 **The Basic Survey**, being the establishment of a horizontal and vertical survey network of permanent survey stations and the supply of all related records. See Chapter 3.

9.2.3 **The Photo Ground Control**, being all field survey work required for photo control, the annotation of detail on the photographs, the aerial triangulation and the supply of all related records. See Chapter 3.

9.2.4 **The Plotting**, being the photogrammetric or other plotting and digital data recording of all detail, the fairdrawing of the plans, the final checking in the field and office, and the supply of all the related records. See Chapter 11.

9.2.5 **The Cadastral Phase**, being the compilation of all the data defining the cadastral boundaries and designations obtained from the office of the Surveyor General or other sources. The proper preparation and plotting on the plans, including such field survey as may be necessary and the supply of all the related records and key plan(s). See Chapter 6.

9.3 Scales and Units

9.3.1 The scale shall be as laid down in the survey requirements.

9.3.2 Lengths and distances, both horizontal and vertical, shall be recorded in metres.

9.3.3 Angles shall be recorded in sexagesimal measure.

9.3.4 The width of the strip to be surveyed shall normally cover 250m outside either road reserve boundary for surveys of 1: 2000 and 1: 1000 scale. The width of the surveyed strip shall be increased at all interchanges, road junctions and road intersections to cover a radius of 500 metres from the intersection of the centre lines of such structures, unless otherwise specified.

9.4 The Plotting

9.4.1 The Plotting in General (Sheet Requirements)

9.4.1.1 A Set of plans shall be plotted to a scale as laid down in the survey requirements, using such photogrammetric instruments and supplementary means as specified. Each plan, or a model of the whole project shall also be supplied in digital format according to the clients requirements, see paragraph 11.1.13, unless otherwise specified.

9.4.1.2 Before commencing any plotting operations, the Surveyor shall submit to the Client, for his approval, a provisional key plan on a transparent Topo Cadastral map, at a minimum scale of 1 : 50 000, showing the proposed sheet layout. A final key plan at a minimum of 1 : 50 000, on a transparent Topo Cadastral map, shall be submitted at the completion of the survey project, on which the sheets are correctly shown. The sheet layout need not be a separate plan, but may be drawn on the working plan.

The survey shall run from left to right in the direction of increasing route and section numbers, unless otherwise specified.

9.4.1.3 A double matt, stable base transparent film material of good quality and not less than 0,075mm nor more than 0,15mm thick, 841mm wide and 1189mm long (A0 Size), shall be used for the final drawing of the survey sheets, unless otherwise specified.

The first draughted sheet together with the corresponding digital Computer Aided Draughting (CAD) data shall be submitted to the Client for approval before commencing with the remainder of the project.

9.4.1.4 Co-ordinate grids shall be plotted accurately at a spacing of 200mm. The co-ordinate lines shown shall be for those values which are multiples of: 100m for plans at 1: 500, 200m for plans at 1: 1 000 and 400m for plans at 1: 2 000 scales. The full values shall be indicated along the edges of the sheet.

9.4.1.5 Wherever a change of Lo system occurs, the co-ordinate axes and values of both Lo systems shall be shown on the sheet straddling the meridian at which the change of system occurs.

In addition, at least three adjoining survey points on this sheet shall be given on both Lo systems; both sets of co-ordinates shall be given on the co-ordinate list of the relevant plan.

The balance of the survey shall be completed on the new Lo system, except when the survey does not extend more than 15 minutes beyond the adjacent system.

9.4.1.6 The plotted detail shall not extend beyond the margin of the plan. **Unless otherwise specified**, survey sheets shall overlap the adjoining sheets by not less than 50mm, as measured on the plan, if the sheets are lying roughly in the same direction. If not, the overlap may be increased so that reasonable continuity is maintained. If the 200mm grid intersections do not fall in the overlap area it will be necessary to draw three well spaced orientation crosses for matching purposes. See paragraph 11.2.3.

9.4.1.7 The symbols as specified in the drawing specifications, chapter 11, shall be used for the survey plans.

9.4.1.8 Plans and Digital Computer Aided Draughting (CAD) data shall be carefully checked after completion by the Surveyor, both in the field and office. Wherever the ground is obscured by dense vegetation, contours shall be supplemented by spot heights surveyed in the field and shown on the plan. All records of field and office checks shall be submitted with the final plans.

The spelling of place names shall be strictly according to the South African Book of Place Names, available from the Government Printer.

9.4.1.9 Each sheet shall show:

- (a) All detail as prescribed in paragraph 9.5.
- (b) Co-ordinate lines and their full values without the deduction of any constant.
- (c) Contour values at frequent intervals on the contour. ($\pm$ every 400mm) and at the ends of the contour lines.
- (d) A title block according to the clients specifications, showing the title of the survey, the route and section numbers, the name of the Contractor and the date of survey; a co-ordinate list of permanent survey stations and the benchmark reference number and elevation (Level datum).
- (e) All permanent survey stations, north direction, photo ground- and aerial triangulation control points, any benchmarks and trig beacons which plot within the limits of the sheets.
- (f) All photo centres.
- (g) Sheets shall be numbered in the direction of increasing route and section numbers, unless otherwise specified.
- (h) Space shall be allowed for a sheet index on all A0 sheets in the right hand bottom corner of the working area of the sheet if provision is not already made for this in the individual title blocks.

If in exceptional circumstances this cannot be done, the index shall be drawn where space allows. The index shall show the sheet in relation to all adjoining sheets and only sheet outlines and numbers need be shown. If separate cadastral overlays are necessary, cross referencing in the space provided shall be used. The index on the survey sheets shall show adjoining survey sheets only whereas the index on the cadastral overlay shall show only the adjoining cadastral sheets.

9.5 Detail to be Surveyed

In general, all detail within the specified width, including that which has resulted from the construction of the road, with special regard to drainage and services, shall be surveyed and plotted in ink. Existing "As Built" plans of the road shall be used to support the annotation process; including:

9.5.1 Contours at 2 metre vertical intervals, unless otherwise specified, with supplementary spot heights wherever the contours are insufficient to portray ground shapes faithfully; frequent spot heights, rounded off to one decimal of a metre, on such features as roads, railways and bridges, etc., where elevations may be necessary for engineering design; in particular, spot heights shall appear on all bridge decks, culverts and at least at 100 metre intervals on railway tracks and major roads).

Enough heights shall appear on the plans to enable a reliable longitudinal profile of the road to be plotted. The determination of the roads horizontal and vertical alignments can be requested by the client.

9.5.2 Rivers, streams, springs, canals, dams, pans, marshes and areas subject to tidal flooding (requiring additional spot heights), etc; the names, if any, of such features and the directions of flow where applicable shall be indicated on the plans.

9.5.3 Highest known flood levels of main streams as near as can be determined from local evidence or information. The source of such information and the specific point and date concerned shall be indicated on the plans.

9.5.4 High tide marks and full supply levels of dams.

9.5.5 Forest, bush, shrub, plantations, orchards, avenues, hedges and individual trees which are landmarks, etc, with the outlines of such areas correctly shown.

9.5.6 Cultivated lands, rock outcrops, loose boulders, bedrock, cliffs and sand dunes, etc.

9.5.7 Eroded areas and gullies.

9.5.8 Railways, differentiating between standard and narrow gauge and between Spoornet and privately owned lines.

- 9.5.9 Roads, footpaths and tracks, differentiating between bitumen, concrete, paved and gravel surfaces, indicating status and number of the road and the measured width of the surfaced top with destinations at both ends of the road.
- 9.5.10 Bridges (indicating bridge number) and culverts and their detail regarding the number, dimensions and type of construction, relating to those structures which are situated on or across roads, or which have a bearing on the drainage thereof.
- 9.5.11 Elevations on the centre line of the road at the intersections of road and culverts as well as invert levels of culverts, bridges and drop inlets shall be obtained by means of field survey methods, or as otherwise specified.
- The deck of every numbered bridge shall be accurately levelled and plotted on the map sheet, using the wing walls and expansion joints of the deck to obtain the outline.
- 9.5.12 Drainage and irrigation furrows.
- 9.5.13 All buildings, differentiating between types of construction and stating their function other than domestic dwellings, e.g. store, school, etc. and any important features.
- 9.5.14 National monuments and buildings or structures of historical interest, indicating names.
- 9.5.15 Power and telephone lines and carrier routes, showing individual poles and pylons.
- 9.5.16 All underground services, such as pipe lines, cables and other features, the position of which can be ascertained from surface indications shall be investigated, researched and supplemented with cadastral servitudes.
- 9.5.17 Gates and fences, differentiating between boundary, stockproof, verminproof and security fences. All access points shall be shown.
- 9.5.18 Stone or brick walls.
- 9.5.19 Wells, boreholes, windmills.
- 9.5.20 Kilometre markers.
-

9.5.21 Cuttings, embankments, quarries, borrowpits, tunnels, mine workings.

9.5.22 Cemeteries and solitary graves.

9.5.23 Rock outcrops, loose boulders and bedrock.

9.5.24 The revised South African Road Sign Manual shall be used as reference to this paragraph.

All permanently placed and approved road signs, e.g. Stop, Yield, Route Information signs, etc. shall be indicated on the plans by a black positional dot connected by a short black line to an ellipse outside detailed survey area in which the relevant reference for that road sign is indicated (See page 11.27 of the symbol list).

9.5.25 Wherever a surveyed feature of whatever nature, but in particular those listed under paragraphs 9.5.5 and 9.5.6 above, is contained within well defined outlines, these outlines shall be shown in their true shape with the correct symbol.

9.5.26 The survey shall show all topography and manmade structures, the plotting of which is consistent with the scale of the plans, with the provision that in respect of such areas as built up townships, industrial or mining sites, etc. written approval shall be obtained for the omission of detail which is considered to be irrelevant.

9.6 Standards of Accuracy

See Large Scale Mapping, paragraph 8.6.

For tolerance errors see Chapter 2.

9.7 Methods of Testing and Inspection

See Large Scale Mapping, paragraph 8.7.

9.8 Records

The Surveyor shall submit the records as defined in chapter 4.

10. ORTHOPHOTO MAPS

10.1 Purpose of the Survey

The purpose of this survey shall be to provide accurate small and large scales orthophoto maps for design and planning purposes.

10.2 Phases of the Survey

The following are recognised as separate phases of the survey, to be carried out or omitted, as specified in the Survey Requirements.

10.2.1 **The Photography**, being the aerial photography, the processing and supply of the negative film, all negatives, contact prints, diapositives and flight plans as required. See Chapter 5. The photo scale shall depend on the final scale of the orthophoto.

10.2.2 **The Photo Ground Control**, being all field survey work required for the establishment of photo ground control points, the annotation of detail on the photographs, the aerial triangulation and the supply of all related records. See chapter 3 or paragraph 7.6 for small scale orthophoto's.

10.2.3 **The Orthophoto Process**, being the digital photogrammetric process to produce orthophoto maps.

10.2.4 **The Cadastral Phase**, being the collection of data defining all cadastral boundaries and designations from the office of the Surveyor General or other sources. The preparation and plotting, or overlaying thereof, on the orthophoto maps, including such field surveys as may be necessary and the supply of all related records. See Chapter 6.

10.3 Scales and Units

10.3.1 The scale shall be as laid down in the Survey Requirements.

10.3.2 The area to be mapped shall be indicated on a set of photographs or map(s) or as laid down in the Survey Requirements.

10.4 The Orthophoto Process

10.4.1 The layout of the final map sheets shall be planned so as to allow as far as possible for three parallel strips to be plotted per map sheet. Before commencing with the preparation of the orthophotos the contractor shall submit for approval a provisional key plan on transparent material to a scale of 1:50 000, showing the proposed layout of the sheets. The plan shall show major features such as rivers, towns, roads, railways and interchanges within the area to be mapped. A final key plan on transparent material, on which the final sheets are shown, shall be submitted on completion of the work.

10.4.1.1 The following shall be supplied with each map sheet:

- a) The final orthophoto map sheet as a composite, screened transparency, laterally reversed on the emulsion side and comprising one or more road strips.
- b) The Digital Elevation Model (DEM) containing the raw observations and rigid grid on stiffy or compact disc in a format as specified by the client.

10.4.1.2 The following detail shall be shown:

- (a) A title block according to the clients specification, showing the title of the survey, the sheet number, scale and a co-ordinate list of permanent survey stations.

The title block and data boxes, in accordance with the clients specifications, shall be drawn along the bottom of each sheet with one of the long edges as the bottom of the sheet.

- (b) Grid lines, in accordance with the requirements set out in paragraph 10.4.6.
- (c) Cadastral boundaries, including the limits of all road proclamations.
- (d) The property name and number shall be entered on each separate property, provided that when this is not possible, such as in a high density township layout, streets and blocks of erven only need be shown.

ORTHOPHOTO MAPS

- (e) Contours at 2 metre vertical intervals, with spot heights on isolated features, unless otherwise specified. Contour values shall be given at not less than 400mm intervals.
- (f) All permanent survey stations, benchmarks and trig beacons which plot within the limits of the survey strip.
- (g) The north direction for each survey strip. The layout of each strip shall always be from left to right in the direction of increasing route and section numbers, unless otherwise specified.
- (h) The positions, names and descriptions of annotated detail, in accordance with paragraph 10.4.7. below.

10.4.5 The Final Orthophoto Map Sheet

The map shall be printed on a matt surfaced, positive film, laterally reversed so that direct emulsion to emulsion printing is possible. The film shall be approximately 0,1mm thick.

10.4.6 Requirements for Grid Lines

10.4.6.1 The grid lines shall be plotted accurately along the length of the survey strip and shall be at a spacing of 200mm. At least two axes shall be shown across the strip and the spacing shall be reduced to 100mm, if necessary to achieve this. The full values, i.e. without the deduction of any constant, are to be indicated along the edge of the survey strip. See paragraph 11.2.6.

10.4.6.2 Wherever a survey crosses from one Lo system of the national triangulation to another, the plotting may be continued on the first Lo system across the meridian dividing the two systems, provided that on the next sheet the appropriate Lo system shall be used. In addition, wherever a change of system occurs, the co-ordinate axes and values of both Lo systems shall be shown on the two survey strips concerned for alignment purposes. Also refer to paragraph 7.8.5.

- 10.4.6.3 No overlap between strips is required if the road strips are lying roughly in the same direction; if not, the overlap shall be not less than 50mm so that reasonable continuity is maintained. In the overlap area alone, the grid spacing shall be reduced to 100mm and only crosses shall be drawn at the intersection of the extra grid lines. At least three crosses shall fall in the overlap area and shall be specifically drawn for matching purposes if necessary.

10.4.7 Features to be Annotated

The features listed below shall be annotated and described on the final orthophoto sheet. The description of a feature shall be positioned to clearly indicate the feature. Where a feature is large enough to be clearly visible on the final orthophoto, such as large rivers, dams, etc., the name of the feature need only be given:

- (a) Power and telephone lines to be shown as symbols, not individual poles, but as close to the correct position of the line as possible.
- (b) Underground services, such as pipe lines and cables, the position of which shall be ascertained from surface indications or the responsible authorities. The positions of approved, but not yet constructed wayleaves, shall be obtained from the Client and indicated on the plans, using relevant symbols.
- (c) All fences shall be shown, particular attention shall be given to fences demarcating properties, boundaries and road reserves. In built up areas internal fences may be omitted.
- (d) Kilometre markers, usually at every full km value.
- (e) River and stream names, springs, canals, boreholes, dams, pans, marshes and areas subject to tidal flooding (with additional spot heights).
- (f) The type of crop grown on major cultivated lands.
- (g) The origin and destination of all roads and railways.
- (h) Cemeteries and individual graves.

- (i) Bridges and culverts.
- (j) An applicable note in an area of extensive rock outcrops.

10.5 Standards of Accuracy

See Large Scale Mapping Specifications, paragraph 8.6, or Small Scale Mapping Specifications, paragraph 7.9, depending on the final orthophoto scale.

10.6 Methods of Testing and Inspection

See Large Scale Mapping Specifications, paragraph 8.7.

10.7 Records

The contractor shall submit all the relevant records as specified in chapter 4, together with all material that was used to produce the final orthophoto maps. (See paragraph 10.4.1.2)

11. DRAUGHTING OF TOPOGRAPHICAL PLANS

11.1 General

11.1.1 **THIS CHAPTER IS ALSO APPLICABLE FOR COMPUTER AIDED DRAUGHTING (CAD) DRAWINGS.**

In the case of manual fairdrawings, ISO size pens and stencils shall be used.

11.1.2 Lettering shall be done so that it may be read from the bottom or the bottom right hand corner of the plan.

11.1.3 Only specified draughting symbols shall be used, unless otherwise specified. See pages 11-13 to 11-38

11.1.4 **Unless otherwise specified**, a minimum overlap of 50mm shall be provided between adjoining plans. The detail on the overlaps shall be identical to each other. See para-graphs 8.4.1.6 and 9.4.1.6.

11.1.5 The north direction sign shall be drawn in a prominent position on each plan.

11.1.6 The co-ordinates of all permanent survey stations appearing on the plan shall be listed on the plans as indicated by the client.

11.1.7 The level datum shall be noted in the space provided for in the co-ordinate list block.

11.1.8 Unless otherwise specified by the client, a bar scale shall be shown in the lower right hand border area of the sheet, the length shall be 100mm of which the first 10mm shall be graduated in millimetres and the remainder in multiples of 1cm.

11.1.9 All sheet numbers shall be obtained from the Client.

11.1.10 **Material**

Unless otherwise specified, a double matt, stable base transparent film material of good quality not less than 0,075mm and nor more than 0,15mm thick, 841mm wide and 1189mm long (A0 Size), shall be used for the final drawing of the survey sheets.

11.1.11 Preparation of Sheets

The size of the sheet shall be based on the A0 DIN size and be prepared according to the Survey Requirements, or as specified by the client.

11.1.12 Layout of Sheets and Approval

11.1.12.1 Layout

The draughting space shall be utilised to the maximum, unless otherwise specified. The sheet layout shall be from left to right, in the direction of increasing route and section numbers.

11.1.12.2 Approval of Layout

Before any final draughting commences the surveyor shall submit to the Client a sheet layout on a key plan to a minimum scale of 1:50 000 for approval. Plan numbers shall be allocated by the Client and shall be entered on the final key plan in the appropriate spaces by the contractor. The final key plan forms part of the working plan. See paragraph 4.4.

11.1.12.3 Information on Sheet Layout/Key Plan (Working Plan)

All towns, major roads, railways and rivers falling in the surveyed area, as well as the proposed outlines of the sheets shall be indicated. See paragraph 4.4.

11.1.13 Computer Aided Draughting (CAD) Information

11.1.13.1 Survey Map Sheets

Unless otherwise specified, all survey maps shall be supplied in CAD format in accordance with the specifications of the client.

11.1.13.2 Standardization and Uniformity of Mapping Procedures

In order to standardize mapping procedures all digital compiled maps shall be standardized in terms of Computer Aided Draughting

(CAD) levels, colours, pen sizes and symbols to ensure effective use in design and Geographic Information Systems (GIS).

To minimize editing, all line types and symbols shall be configured to be presented in different colours and levels, before the mapping process starts.

Configuration data as specified for the compilation of digital maps shall be available from the client.

As an example General Configuration Standards for the compilation of digital maps in Microstation format using Usmart software with respect to the draughting standards as set out in this manual, is available on page 11.39 to 11.47.

11.2 Co-ordinate Grids and Grid Values

- 11.2.1 A co-ordinate grid shall appear on each plan. The grid lines shall be plotted 200mm apart and drawn across the plan using a 0,25mm pen (solitary crosses at the intersections are not acceptable).
- 11.2.2 Full co-ordinate values shall be indicated at both ends of the grid lines; a 2,5mm letter size with a 0,25mm pen shall be used.
- 11.2.3 Unless otherwise specified, a minimum of three grid intersections shall appear in the overlap area of adjoining sheets, otherwise orientation crosses of 10mm radius shall be provided in the overlap area.
- 11.2.4 When an additional grid outside the mapped area is added to facilitate the plotting of cadastral data, only grid intersection crosses shall be plotted and these shall have a radial length of 40mm. Where these grid lines intersect the perimeter of the draughting area it shall be indicated by a line 40mm long. The full co-ordinate values prefixed by the appropriate Survey/Lo system shall be indicated.
- 11.2.5 The table below indicates the grid intervals for the various mapping scales, unless otherwise specified.

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Plan Scale	Grid Interval (Metric)
1:100	20 metres
1:200	40 metres
1:500	100 metres
1:1000	200 metres
1:2000	400 metres
1:5000	1000 metres

11.2.6 All grid lines shall meet the following conditions and requirements.

- a) Between two adjoining grid lines the measured grid difference must be within ,3mm accuracy.
- b) Over a distance of one metre the measured distance must be within the ,3mm accuracy with the grid or calculated distance.

11.3 Draughting

11.3.1 Draughting Quality

The draughting shall be of a high quality and all work shall be neat, of a uniform standard and opaque throughout. Lines shall be uniform in width and all annotation shall be done parallel to the bottom edge of the plan.

11.4 Spotheights

11.4.1 Spotheights shall be inked parallel to the bottom edge of the plan.

11.4.2 The same dot shall indicate the position and the decimal in the elevation.

11.4.3 Spotheights shall have a 2.0mm letter size.

11.5 Contours

11.5.1 Contours shall be drawn using black drawing ink.

11.5.2 Index contours, which occur at an interval five times that of the specified contour interval, shall be drawn to a thickness of $\pm 0,50\text{mm}$ and they shall reflect the full contour value

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above Mean Sea Level (MSL). The intermediate contours shall be drawn to a thickness of $\pm 0,25\text{mm}$, with only the last two digits of their value shown.

11.5.3 Contour values shall be 2.0mm letter size and 0,35mm pen size.

11.5.4 Contour values shall appear at both ends of each contour and at intervals of $\pm 400\text{mm}$ along the contour. See paragraph 11.10.1.

11.6 Control Points

11.6.1 Ground Control

11.6.1.1 All concreted pegs shall be indicated by two concentric circles of 2,0mm and 3,0mm diameter respectively.

11.6.1.2 Directional arrows shall be drawn between consecutive traverse stations. The length of these arrows shall be 15mm.

11.6.1.3 The number shall be indicated within a circle of 25mm diameter placed in a convenient position and joined to the beacon using a 0,35mm pen.

11.6.1.4 The number shall correspond to that of the inscription on the aluminium plate, marking the Survey beacon in the field and be indicated with a 0,35mm pen and 2,5mm letter height.

11.6.1.5 The elevation of permanent survey stations shall be given to three decimal places.

11.6.1.6 Level Photo Control points (LPC's) shall be plotted by means of aerial triangulation co-ordinates or by stereoplotter when co-ordinates are not available.

11.6.1.7 Level control points shall be indicated by a circle of 2,5mm diameter with a vertical diametric line. The centre of the circle shall be the position of the point.

11.6.1.8 The circle shall be the decimal for the elevation with the number of the point placed above the circle.

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- 11.6.1.9 The elevation shall be rounded off to two decimal places.
- 11.6.1.10 The point number and elevation shall be indicated using a 2,5mm letter size and 0.35mm pen.
- 11.6.1.11 The Photo Control Points (PC's) shall be indicated by a 2,5mm diameter circle with a horizontal and a vertical diametric line. The elevation and numbering shall be as laid down in paragraphs 11.6.1.9 and 11.6.1.10.

11.6.2 Photogrammetric Control

- 11.6.2.1 Aerial triangulated points shall be indicated by a circle of 2,5mm radius, with no diametric lines.
- 11.6.2.2 The elevation and numbering shall be as laid down in paragraphs 11.6.1.9 and 11.6.1.10. The number and elevation shall be indicated using a 2,5mm letter size.
- 11.6.2.3 Tie points shall be shown as aerial triangulated points except that the number shall be preceded by the prefix CP.
- 11.6.2.4 Photo centres shall be indicated by a cross of 4mm diameter, using a 0,35mm pen.
- 11.6.2.5 The number shall be written parallel to the direction of the strip using a 3,5mm letter size. The strip number shall be shown to the left of the cross, and the exposure number, in full, to the right. Both numbers shall be underlined with lines 15mm long to which an arrowhead is added in the direction of flight

11.7 Detail

11.7.1 Sizes of Symbols, Stencils and Line Thicknesses

11.7.1.1 Sizes of Symbols

Sizes of symbols shall be shown to scale where applicable, otherwise as laid down in these specifications.

11.7.1.2 Letter Sizes

Letter sizes are indicated next to each symbol on the list of symbols.
Letter sizes shall be as laid down in these specifications with a minimum size of 2,0mm.
All general annotation shall be done with a 0,35mm pen and 2,5mm letter size.

11.7.1.3 Line Thicknesses

Line thicknesses are indicated next to each symbol on the list of symbols.
NB. All lettering shall be upright; only capital letters and numerals shall be used, except in the case of graphical road sign boards.

11.7.2 Detail to be Shown

Refer to the large and small scale survey specifications for detail to be shown on the final plans.

11.7.3 Ink

Only black ink, suitable for use on polyester base draughting material, shall be used.

11.7.4 Symbols

Symbols used shall be strictly in accordance with the standards laid down in these specifications, unless otherwise specified.

11.8 Utilities

11.8.1 Roads

- 11.8.1.1 Status and number of all classified roads shall be shown.
- 11.8.1.2 Names of streets shall be shown as indicated on the General Plan of the township or as determined by field annotation.
- 11.8.1.3 Destinations shall be stated at the ends of each road on all plans.

11.8.2 Bridges (All dimensions shall be in millimetres)

The number and name of the bridge, i.e. B12: Glenroy Bridge, shall be shown (this information may be obtained from the Client if a number is not displayed on the bridge structure) including number of spans and horizontal and vertical dimensions, e.g. 3/1200 X 1600, ie. number of openings/horizontal X Vertical dimension.

11.8.3 Culverts

Unless otherwise specified culverts shall be identified by a number and the relevant details provided in a table on each sheet, giving the number of openings and the span & height or diameter of each culvert as well as invert levels obtained by ground survey methods or as otherwise specified.

- 11.8.3.1 Box culverts indicating the number of openings and horizontal and vertical dimensions: 2/4000mm x 2500mm B.C.
- 11.8.3.2 Pipe culverts indicating the number of openings and diameter: 600mm Ø PC or 3/800mm Ø P.C.

11.8.4 Railways.

- 11.8.4.1 The names of all railway stations and railway sidings shall be shown.
- 11.8.4.2 Destinations shall be stated at both ends of a railway line on each sheet.

11.8.4.3 If not Spoornet, state the ownership

11.8.5 Telephone and Power Lines

11.8.5.1 Telephone Lines

Telephone poles shall not be connected by a continuous line, but designated by means of lines on either side of the symbol circles.

11.8.5.2 Power Lines

The appropriate symbol shall be used, i.e. power poles shall be connected by means of a continuous line and the zigzag pattern inserted approximately halfway between the power poles or pilons.

11.9 Topography: Cuts and Fills

Only straight lines (hatching) shall be used to indicate the symbol for all cuts and fills. Lines shall not be thickened at the top.

11.10 Contours, Erosion, etc.

11.10.1 Contours

Contour values shall be read from the bottom or right hand side of the plan. They shall be placed approximately 50mm from the end of the contour line and thereafter approximately every 400mm. Values shall be written in line with and on the contour; the full value for principal (index) contours and only the last two digits for intermediate contours shall be shown. Where the space between the principal contours is less than 10mm, no intermediate values shall be shown.

11.10.2 Erosion

All watercourses in the eroded area shall be shown and the appropriate symbol and arrows to indicate direction of water flow shall be indicated.

11.11 Buildings, Trees, etc.

11.11.1 Buildings

All buildings shall be shown to actual shape and size and permanent buildings shall be hatched. Only buildings such as schools, police stations, shops, factories, flats, offices, garages, hospitals, etc. shall be described according to function. Domestic buildings shall not bear a description.

11.11.2 Special Features

The names of important features shall be shown.

11.12 Road Signs, etc.

11.12.1 For completion surveys the positions of all road signs shall be indicated with a black dot, connected by a short black line to an ellipse in which the relevant reference number, as obtained from the South African Road Sign Manual, is indicated. See page 11-26 of the symbol list.

11.12.2 For all other surveys the road signs shall be indicated as shown in the symbol list on page 11-26.

11.13 Vegetation

11.13.1 Cultivation

Only perennial crops shall be described.

11.13.2 Orchards, Vineyards and Hedges

These shall be properly described, eg. "Vineyard". In the case of orchards the type of fruit shall be described.

11.14 Cadastral

- 11.14.1 The symbolisation of cadastral boundaries shall be in strict accordance with the line symbols for different features and scales, as given in the list of symbols in this document. Descriptions shall be given exactly as they appear on the title deeds. Letter sizes shall be as given in the list of symbols and may be adjusted to suit very small areas covered by a property, but shall not be less than 5mm in size.

Cadastral farm boundaries shall be highlighted according to the requirements of the Client.

- 11.14.2 Information relating to existing proclamations shall, whenever available, be indicated on the plans and symbolised in accordance with the list of symbols. Road reserve boundary lines shall be solid where they coincide with boundary lines of registered properties, in all other cases they shall be broken lines. The road reserve beacon point numbers shall be given exactly as they appear on the proclamation.

The proclamation number, relevant Gazette number and date shall be indicated on each sheet in an obvious place.

11.15 Title Block, North Direction and Sheet Index

11.15.1 Title Block

The title block layout and details shall be obtained from the client.

11.15.2 North Direction

A north direction sign in accordance with the requirements of the client shall appear on all sheets.

11.15.3 Sheet Index

Unless otherwise specified space shall be allowed for a sheet index in the right hand bottom corner of the working area of the sheet if provision is not already made for this in the individual title blocks.

11.16 Office Check

The surveyor shall submit the first completed sheet together with the relevant CAD data for approval before commencing with the remainder of the survey draughting.

All plans shall be checked thoroughly by the surveyor after completion. All plans and further data shall be submitted in a neat and clean condition. Damaged, folded or soiled plans will not be acceptable.

All records of field and office checks shall be submitted with the final plans.

11.17 Draughting symbols

For Computer Aided Draughting (CAD) and draughting symbols see pages 11-13 to 11-38.

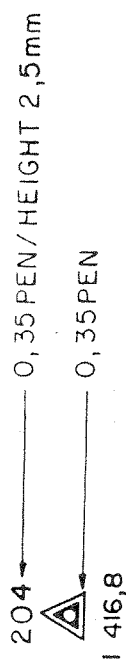
SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL

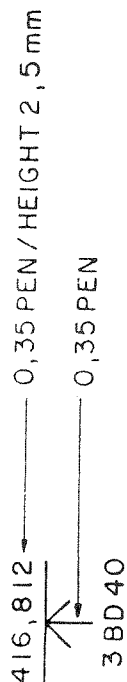
TRIG SURVEY BEACON

NUMBER ABOVE AND ELEVATION
AT GROUND LEVEL BELOW THE SYMBOL

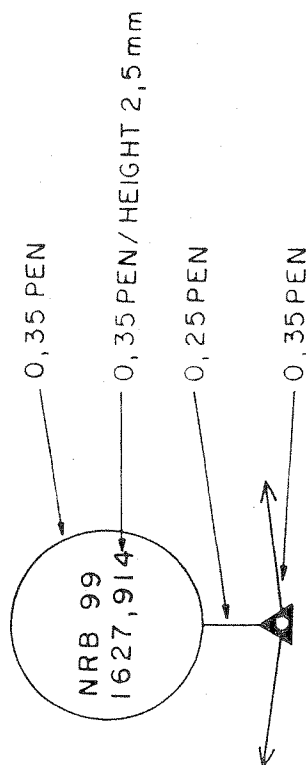


TRIG SURVEY BENCH MARK

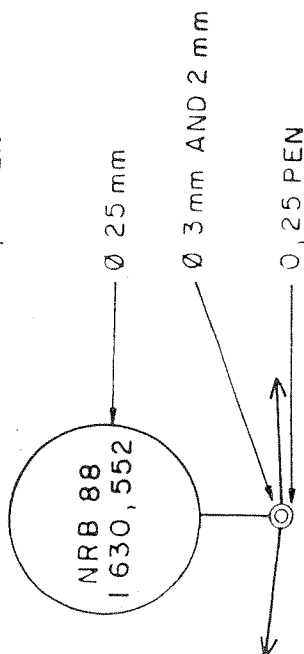
INDICATE ELEVATION AND NUMBER



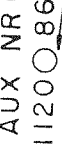
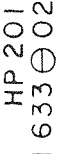
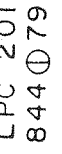
PERMANENT SURVEY STATION FIXED TRIGONOMETRICALLY OR GPS



PERMANENT SURVEY STATION FIXED BY TRAVERSING



SURVEY DRAUGHTING SYMBOLS

TITLE	SYMBOL
PROPERTY BEACONS AND STAKED LINE PEGS	 0,35 PEN / Ø 2 mm
TEMPORARY SURVEY STATION	 AUX NR 6 1120086 0,35 PEN / HEIGHT 2,5 mm 0,35 PEN / Ø 2,5 mm
TACHE SURVEYS	
PHOTO GROUND CONTROL POINT	 HP 201 1633002 ditto
FIXED HORIZONTALLY	
PHOTO GROUND CONTROL POINT	 LPC 201 1844079 ditto
FIXED VERTICALLY	

SURVEY DRAUGHTING SYMBOLS

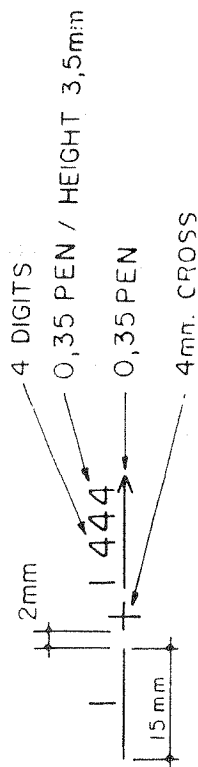
TITLE

PC 201 0,35 PEN / HEIGHT 2,5 mm
 2897 ⊕ 05 0,35 PEN / Ø 2,5 mm

PHOTO GROUND CONTROL POINT

CP 234 / I ditto
 1234 ○ 5

PHOTO GROUND CONTROL POINT



AERIAL PHOTO PRINCIPAL POINT

5 2 5 0,25 PEN / HEIGHT 2 mm

SPOT HEIGHT

SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL

STREET NAMES

JONES STREET (AVENUE, GROVE, SINGLE)
OR SMALLER

0,50 PEN / HEIGHT 3,5 mm

INTERNATIONAL BOUNDARY

— ··· SOUTH AFRICA — 0,70 PEN
— ··· BOTSWANA — 0,50 PEN / HEIGHT 3,5 mm

PROVINCIAL BOUNDARY

— ··· GAUTENG — ditto
— ··· MPUMALANGA —

DISTRICT OR MUNICIPAL BOUNDARY

— ··· PRETORIA — ditto
— ··· JOHANNESBURG —

TOWN OR FARM BOUNDARIES

— LOOF 391 JR — ditto
— VAALKOP 267 JR —

SURVEY DRAUGHTING SYMBOLS

TITLE

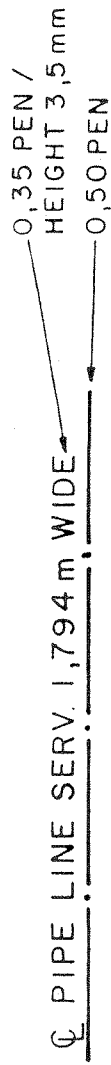
SYMBOL

ERVEN OR FARM SUBDIVISION BOUNDARY



0,50 PEN

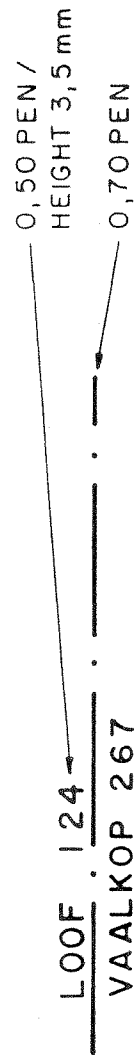
SERVITUDE OR APPROVED
BUT NOT REGISTERED SUBDIVISION



FENCE ON SUBDIVISION BOUNDARY



CENTRE LINE (MID RIVER)

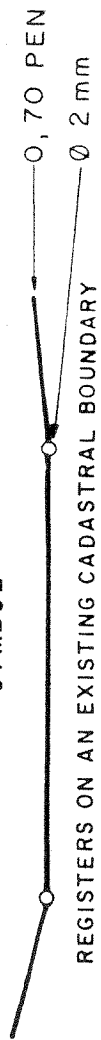


SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL

NATIONAL ROAD RESERVE BOUNDARY



NATIONAL ROAD RESERVE BOUNDARY



FARM OR TOWNSHIP NAMES

LOOF 391 JR

1473/83 (S.G. NUMBER)

OR SMALLER TO FIT AVAILABLE SPACE
0,35 PEN /
HEIGHT 2,5mm

SUBDIVISION NUMBERS /REMAINDERS

PTN 8 / REM

1476/82 (S.G. NUMBER)

OR SMALLER TO FIT AVAILABLE SPACE
0,50 PEN /
HEIGHT 4,5 mm
0,35 PEN /
HEIGHT 2,5mm

ERF OR AGRICULTURAL HOLDINGS NUMBERS

679

OR SMALLER TO FIT AVAILABLE SPACE
0,50 PEN /
HEIGHT 4,5 mm

SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL

TELEPHONE LINES

INDIVIDUAL POLE POSITIONS
NOT FIXED BY SURVEY



TELEPHONE LINES

INDIVIDUAL POLE POSITIONS
FIXED BY SURVEY



POWER LINES

INDIVIDUAL POLE POSITIONS
NOT FIXED BY SURVEY



POWER LINES

INDIVIDUAL POLE POSITIONS
FIXED BY SURVEY



PYLONS



LAMP POST (SOLITARY)



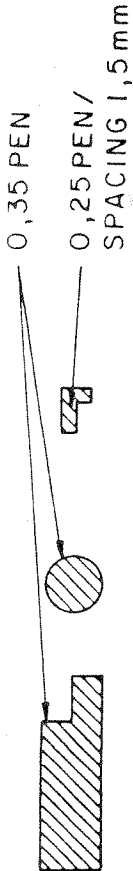
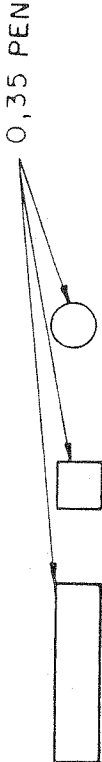
POWER POLE



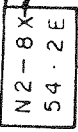
PIPE LINES OR CABLES

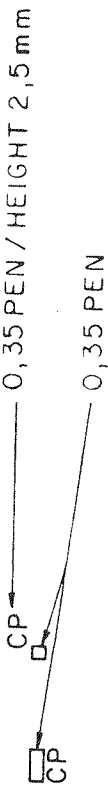
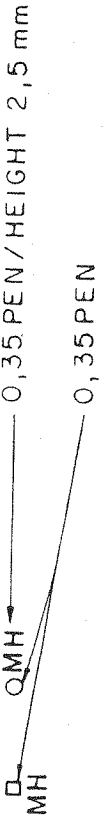
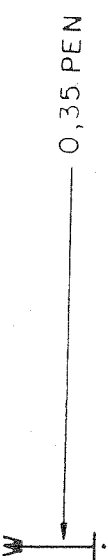
BELOW GROUND
(DESCRIBE APPROPRIATELY) 100 mm U/G SEWER 0,35 PEN / HEIGHT 2,5 mm 0,35 PEN

SURVEY DRAUGHTING SYMBOLS

TITLE	SYMBOL	
PIPE LINES	ABOVE GROUND : WATER AIR, SEWER ETC. 	
CHURCH BUILDING	DESCRIBE e.g. : CHURCH, MOSQUE, SYNOGOGUE, ETC. 	
PERMANENT BUILDINGS		
TEMPORARY BUILDINGS		
BUILDING UNDER CONSTRUCTION OR RUIN		

SURVEY DRAUGHTING SYMBOLS

TITLE	SYMBOL	
DIP		0,35 PEN/HEIGHT 2,5 mm
TROUGH		0,35 PEN/HEIGHT 2,5 mm 0,35 PEN
SILLO		0,35 PEN
KRAAL		0,35 PEN/HEIGHT 2,5 mm 0,35 PEN
PIPE CULVERTS	 OR 600 mm Ø PC	0,35 PEN/HEIGHT 2,5 mm 0,35 PEN/HEIGHT 2,5 mm 0,35 PEN/HEIGHT 2,5 mm
BOX CULVERTS	 OR 2/2000 x 3000 BC (HOR.) X (VERT.)	ditto
ROUTE MARKERS		0,35 PEN 0,25 PEN/HEIGHT 2,0 mm 0,25 PEN Ø 2 mm

SURVEY DRAUGHTING SYMBOLS		
TITLE	SYMBOL	
CATCHPIT		
MANHOLE		
INSPECTION HOLE		
MONUMENT		
RADIO MAST		
WINDMILL		
WINDMILL AND WELL		

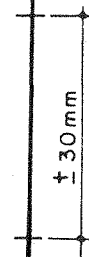
SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL

SINGLE TRACK

← BRITS



0,35 PEN

0,50 PEN

MARIKANA

0,50 PEN /
HEIGHT 4,5 mm

MULTIPLE TRACK



0,70 PEN

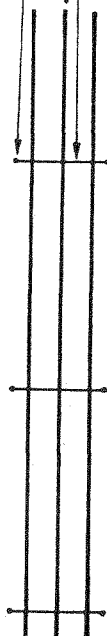
ELECTRIFIED SINGLE TRACK



0,70 PEN

0,35 PEN

ELECTRIFIED MULTIPLE TRACK



0,70 PEN

0,35 PEN

PRIVATE LINE (STATE OWNERSHIP)



0,70 PEN

0,35 PEN

SIDINGS AND HALTS

STATION

0,50 PEN
HEIGHT 4,5 mm

0,70 PEN

SIGNALS

SIGNAL

Ø 2 mm

0,70 PEN

0,35 PEN

NB: FOR SCALE 1 : 5 000

SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL

COCOPAN TRACK



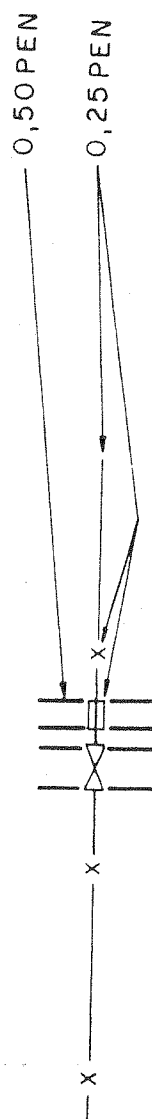
AERIAL CABLEWAY



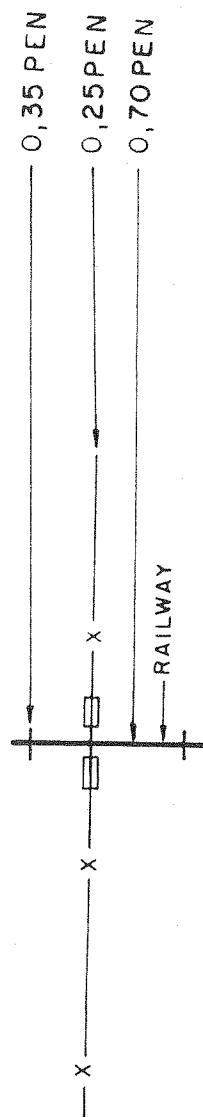
SECURITY FENCE



FENCE, GATE AND MOTORGRID



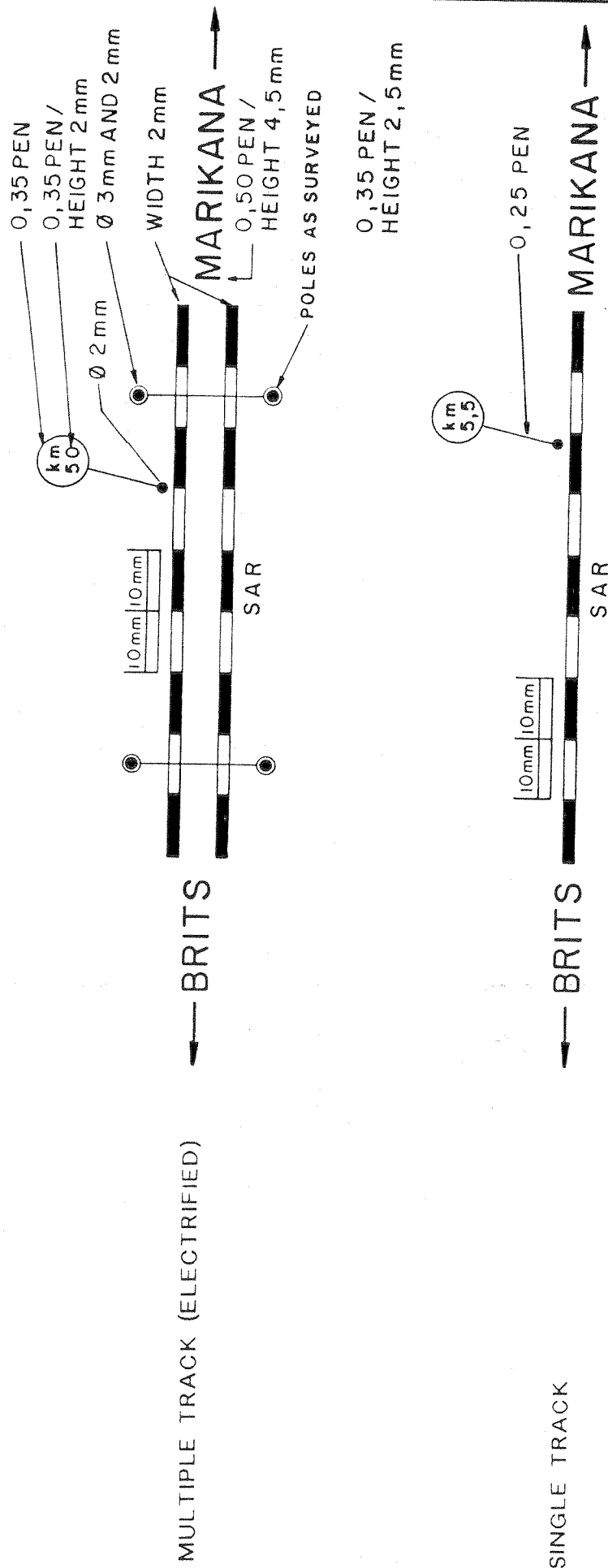
CATTLE GUARDS



SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL



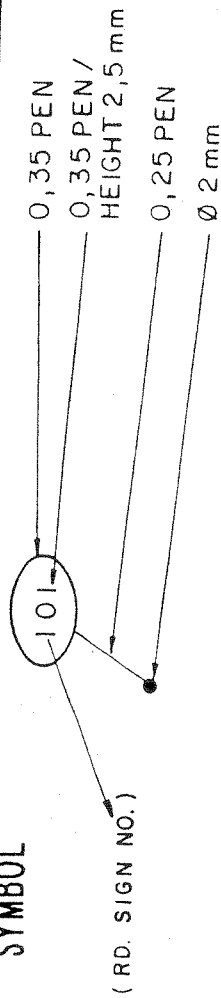
NB: FOR SCALES 1:500, 1:1000, 1:2000

SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL

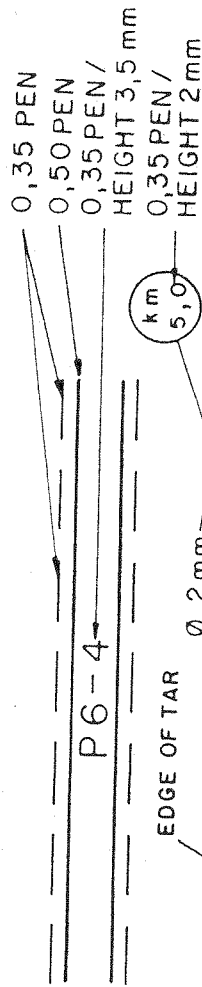
ROAD SIGNS
(COMPLETION SURVEYS ONLY)



ROAD SIGNS

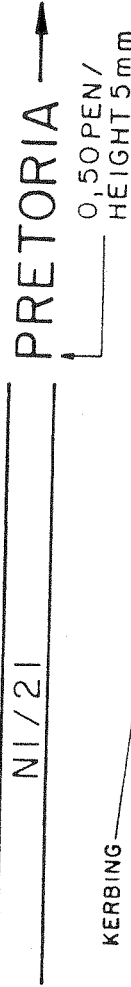


TARRED ROAD GRAVEL SHOULDERS

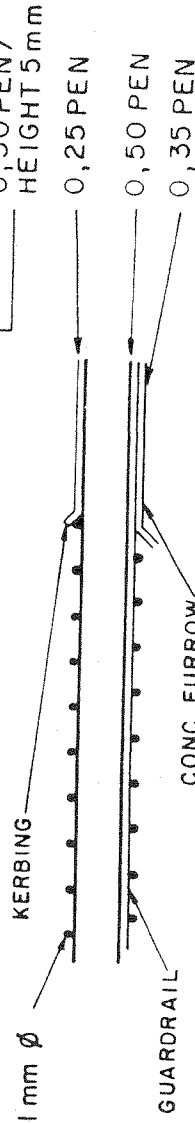


TARRED ROAD

FREEWAY ; WITH PAVED SHOULDERS



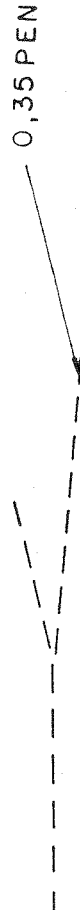
GUARDRAIL, KERBING AND
CONCRETE FURROW



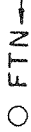
GRAVEL ROAD



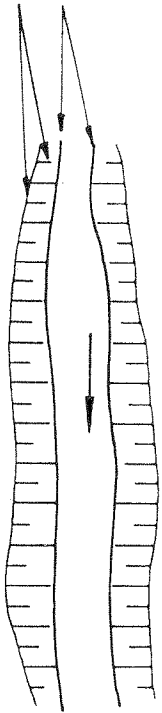
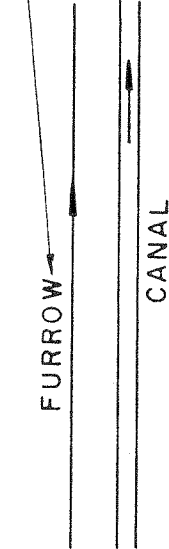
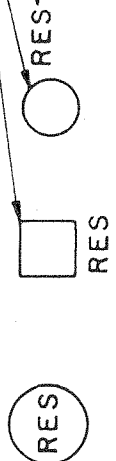
FOOTPATH



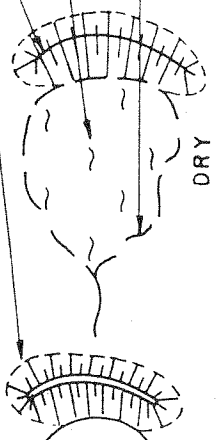
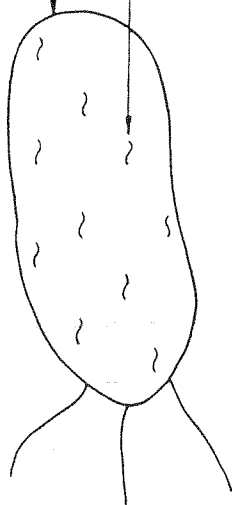
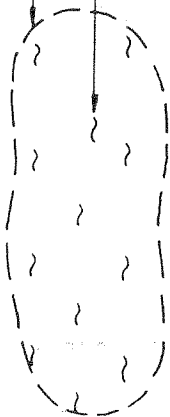
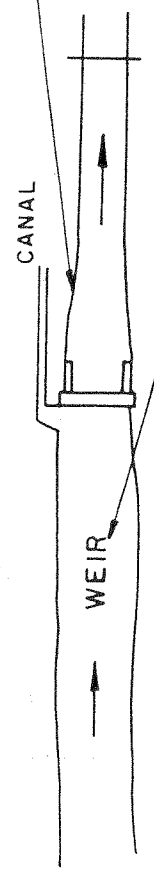
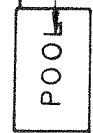
SURVEY DRAUGHTING SYMBOLS

TITLE	SYMBOL
FOUNTAIN	 O FTN ——— 0,35 PEN / HEIGHT 2,5 mm
BOREHOLE	 O BH ditto
WELL	 O W ditto
WATER TANK	 O WT ditto
FUEL TANK	 □ FT ditto

SURVEY DRAUGHTING SYMBOLS

TITLE	SYMBOL
RIVER BANKS	 0,25 PEN 0,35 PEN
RIVERS AND STREAMS	 0,35 PEN/ HEIGHT 3,5mm 0,35 PEN
WATER COURSES PERENNIAL / SEASONAL	 0,35 PEN
HIGHEST KNOWN FLOOD LEVEL STATE DATE OF FLOOD AND SOURCE OF INFORMATION	 0,35 PEN/HEIGHT 2mm 0,35 PEN
FURROWS AND CANALS INDICATE DIRECTION OF FLOW AND DESCRIBE	 0,35 PEN/HEIGHT 2,5mm 0,35 PEN
RESERVOIRS SHOW ACTUAL SHAPE AND DESCRIBE	 0,35 PEN/HEIGHT 2,5mm

SURVEY DRAUGHTING SYMBOLS

TITLE	SYMBOL
DAMS	 0,25 PEN 0,25 PEN 0,35 PEN PERMANENT DRY
LAKES	 0,35 PEN 0,25 PEN
PANS	 0,35 PEN 0,25 PEN DRY
WEIR	 0,35 PEN 0,35 PEN / HEIGHT 2,5 mm 0,35 PEN 0,35 PEN / HEIGHT 2,5 mm CANAL WEIR
SWIMMING POOL	 0,35 PEN 0,35 PEN S/P

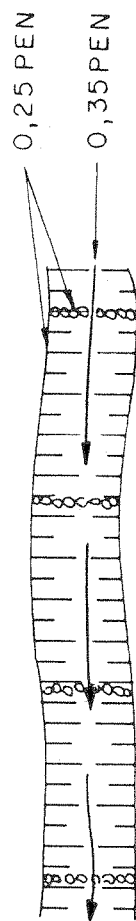
SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL



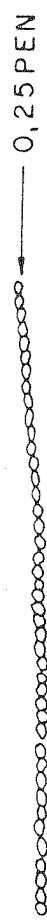
CLIFF



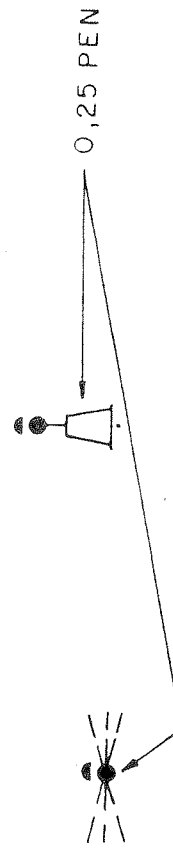
DONGA WITH ROCK CHECKS



WALLS (BRICK, CONCRETE, MASONRY)



WALLS (DRY STONE)

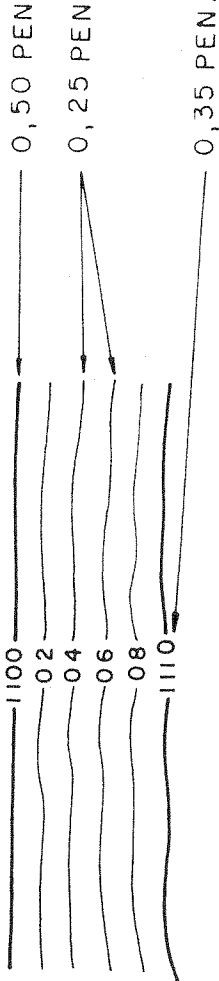
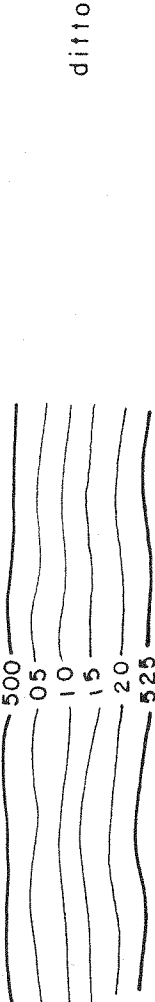
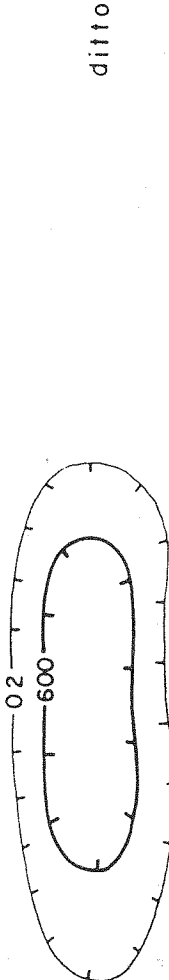
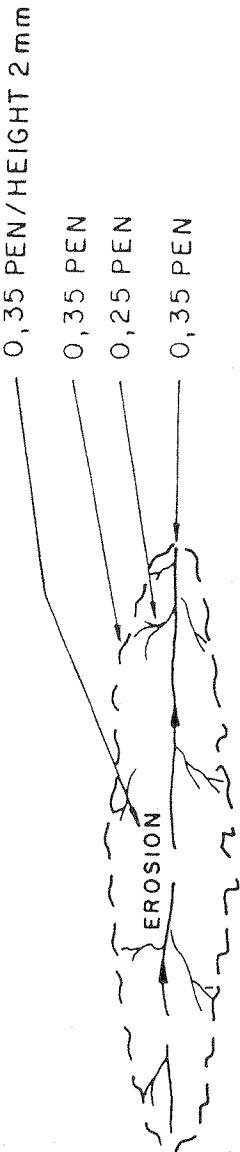
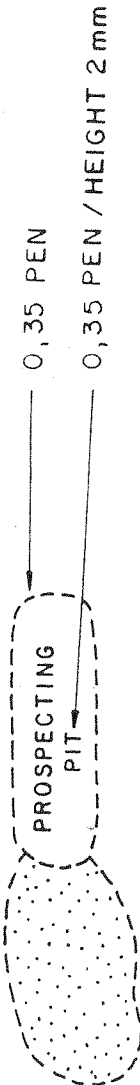


HARBOUR LIGHT, LIGHT HOUSE



BUOY

SURVEY DRAUGHTING SYMBOLS

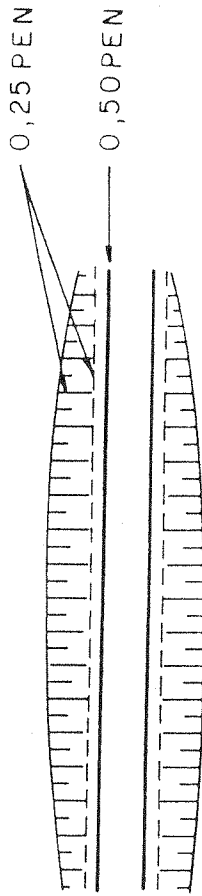
TITLE	SYMBOL
CONTOURS (2m INTERVALS)	 0,50 PEN 0,25 PEN 0,35 PEN/HEIGHT 2 mm
CONTOURS (5m INTERVALS)	 ditto
CONTOURS IN A DEPRESSION	 ditto
SURFACE EROSION	 0,35 PEN/HEIGHT 2 mm 0,35 PEN 0,25 PEN 0,35 PEN
SAND / PROSPECTING PIT	 0,35 PEN 0,35 PEN / HEIGHT 2 mm

SURVEY DRAUGHTING SYMBOLS

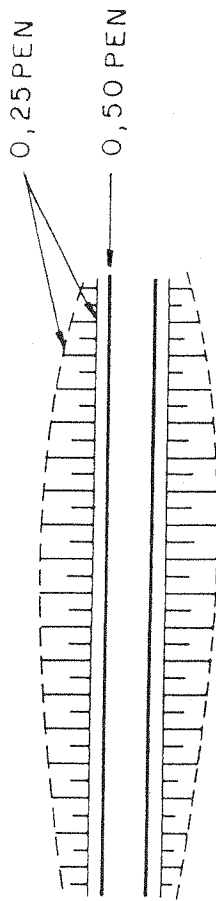
TITLE

SYMBOL

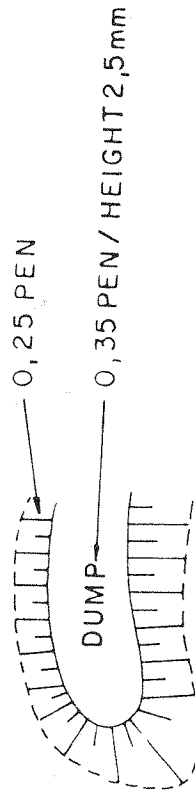
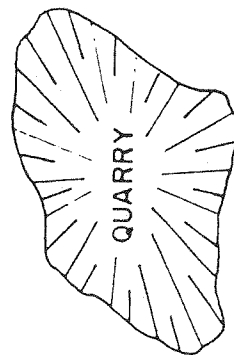
CUTTING



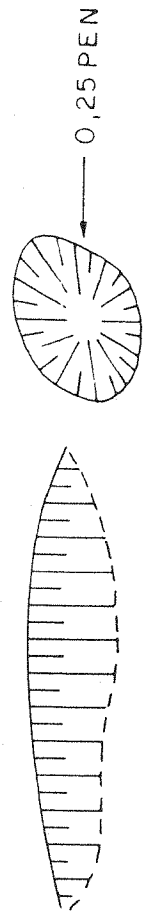
EMBANKMENT



QUARRY AND DUMP



NATURAL EMBANKMENT AND SINKHOLE



SURVEY DRAUGHTING SYMBOLS

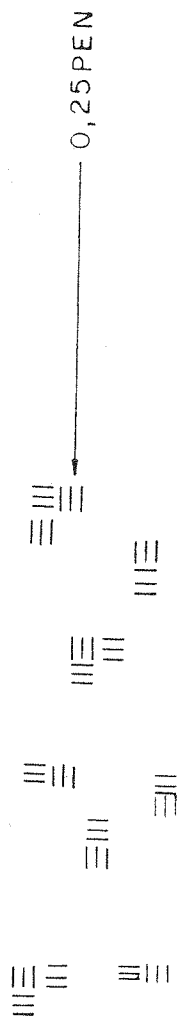
TITLE

SYMBOL

ROCK OUTCROP



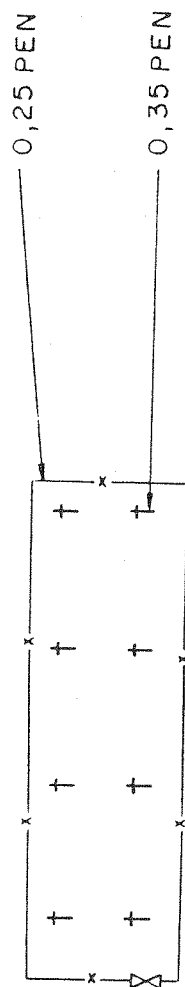
SCATTERED ROCK



SOLID ROCK



GRAVEYARD



GRAVE INTERSECTION OF CROSS INDICATES POSITION

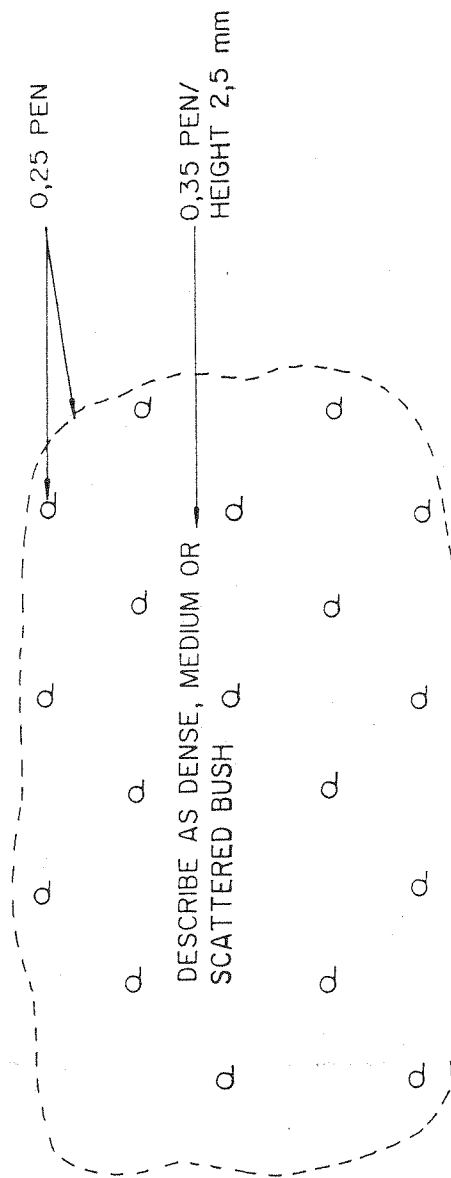


SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL

BUSH

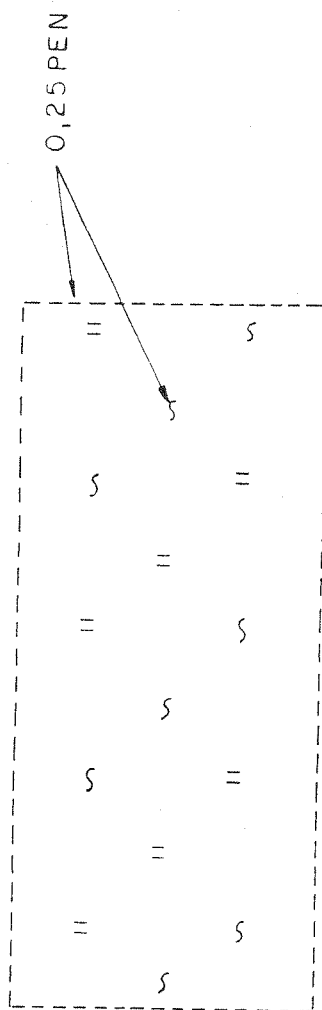


SURVEY DRAUGHTING SYMBOLS

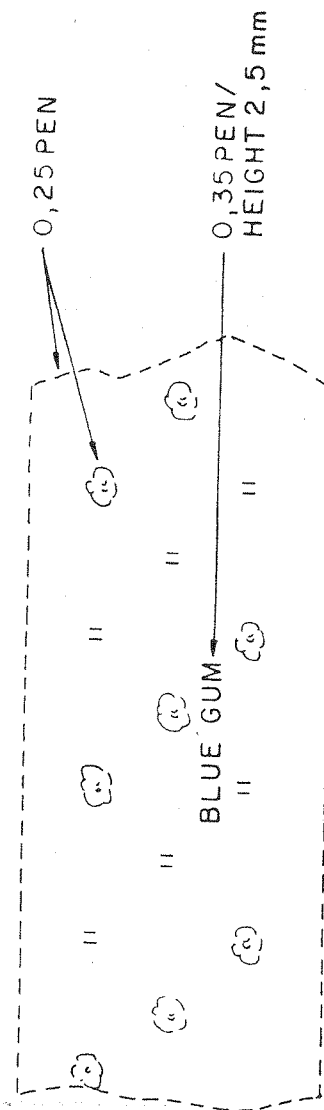
TITLE

SYMBOL

IRRIGATED CULTIVATION



PLANTATION
(INDICATE TYPE OF TREE)

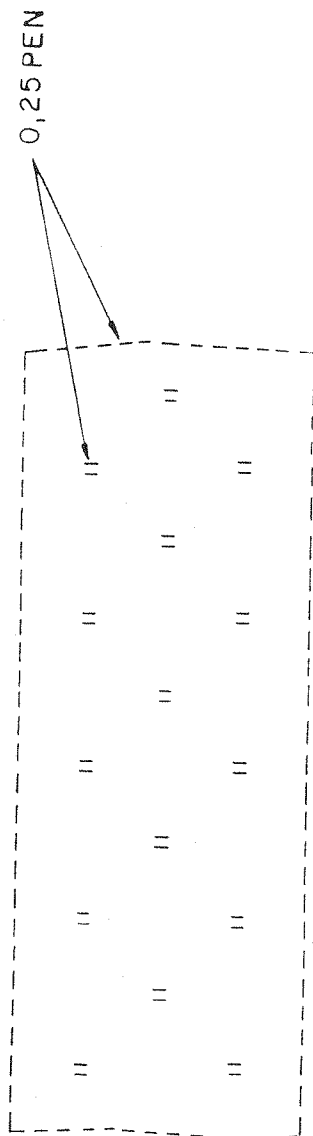


SURVEY DRAUGHTING SYMBOLS

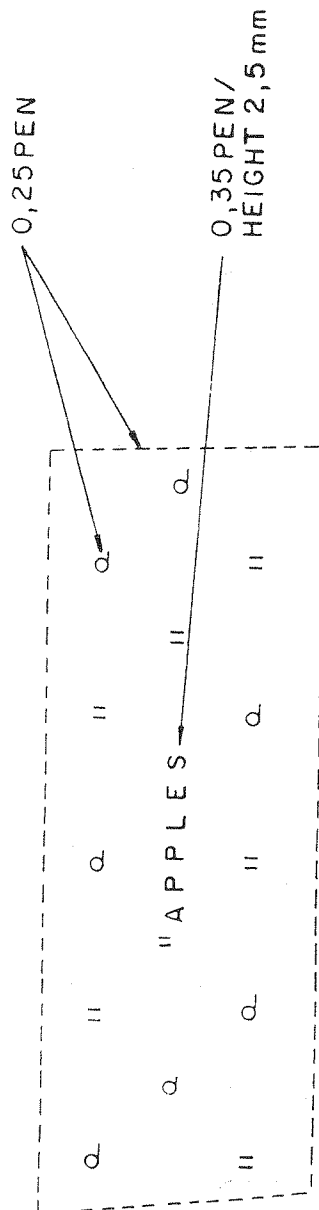
TITLE

SYMBOL

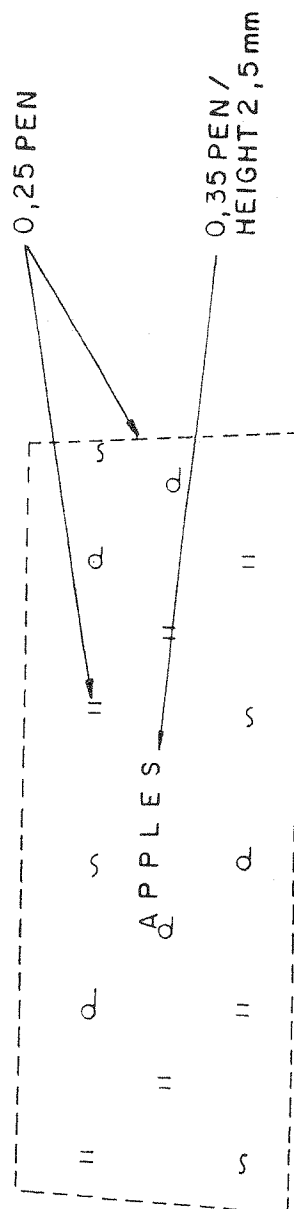
CULTIVATION



ORCHARD OR VINEYARD (DESCRIBE)



IRRIGATED ORCHARD OR VINEYARD (DESCRIBE)

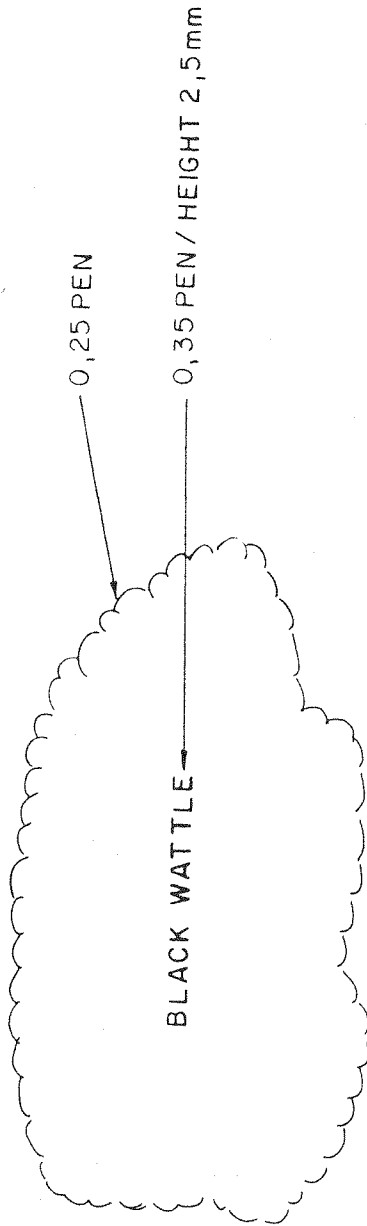


SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL

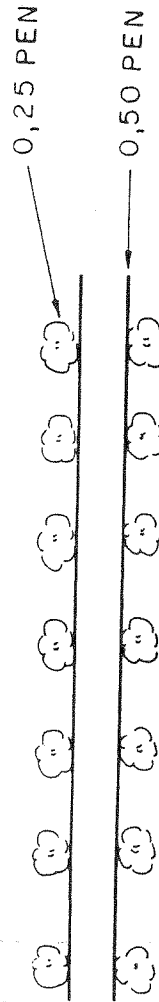
FOREST (INDICATE NAME)



SINGLE LINE OF TREES



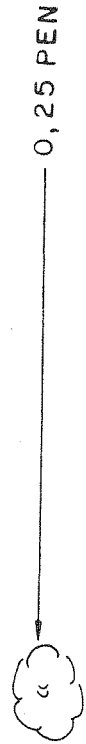
AVENUE



HEDGE



SINGLE TREE

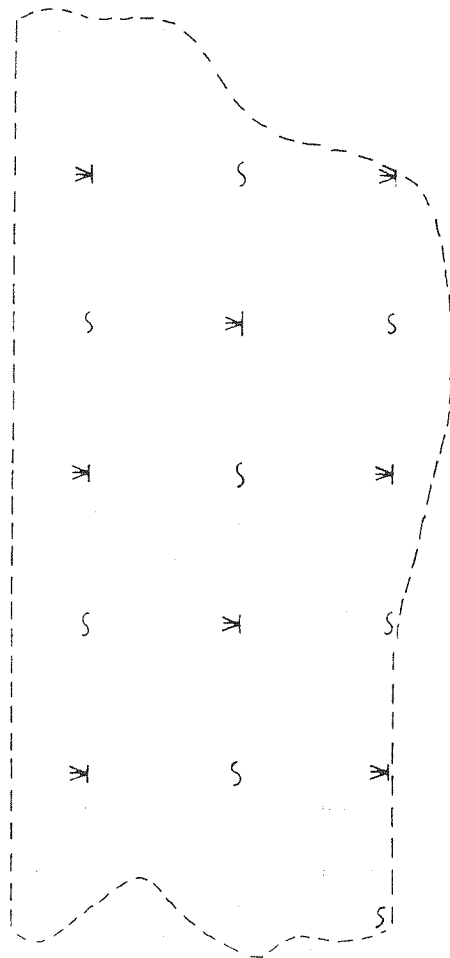


SURVEY DRAUGHTING SYMBOLS

TITLE

SYMBOL

VLEI/MARSH



TMH 11 SPECIFICATIONS FOR MICROSTATION AND USMART MAPPING
(DEFAULT SCALE 1:1000) PLOTTER HP DRAFT MASTER

LEVEL	DESCRIPTION	*LINE WIDTH	LINE STYLE	COLOUR AND CODE	PEN	CELLS	REMARKS
1	Title, Border, etc. Title, Border: Proclamation sketches Strip Nr. of Proclamation sketches	0	0	Blue (33)	3	Sheet: A0PSP Sheet: A4CAD	Place Cell 1:1000 Ø = 6mm Text = 25 mm height (1:10 000)
2	Cadastral Farm boundary Ervan/Portion/Sub-division boundary International Boundary Provincial Boundary District and Municipal Boundary Centre line (River) and Farm Boundary	2 1 2 2 2 1	0 0 0 0 0 0	Red (51) Yellow (36) Red (51) Red (51) Red (51) Red (51)	4 3 4 4 4 4	Linear Linear Linear Linear Linear Linear	
3	Servitudes Lines	1	3	Yellow (36)	3	Linear	
4	Cut/Fill Top Bottom Hatching	1 0 0	0 2 0	Brown (6) Brown (6) Brown (6)	1 1 1	Bank Bank Bank	
5	Contours Major Minor Major Labels Minor Labels	1 0 0 0	0 0 0 0	Yellow (36) Brown (6) Yellow (20) Yellow (20)	3 1 2 2	Contour Contour Contour Contour	Place Place Label: Height 2,0 mm Label: Height 2,0 mm

* Line width may vary depending on the type of plotter used.

LEVEL	DESCRIPTION	*LINE WIDTH	LINE STYLE	COLOUR AND CODE	PEN	CELLS	REMARKS
6	Edge River	2	0	Blue (17)	2	Linear	
	Flow arrows for rivers & canals (centre river)	1	0	Blue (17)	2	Linear	
	Chute						
	Edge Canal	0	0	Blue (17)	2	Linear	
	Streams/Ditches:	0	0	Blue (17)	2	Linear	
	Perennial River	0	0	Blue (17)	2	Linear	
	Seasonal River	0	0	Blue (17)	2	Linear	
	Concrete Furrow	0	0	Blue (17)	2	Linear	
	Drainage Furrow	1	0	Blue (17)	2	Linear	
		0	0	Blue (17)	2	Linear	
7	Roads						
	Major Tar	2	0	Red (35)	3	Linear	
	Minor Gravel, Gravel Road	1	3	Red (19)	2	Linear	
	Gravel shoulder	0	3	Red (19)	2	Linear	
	Remains Road	0	3	Red (3)	1	Linear	
	Minor Tar	2	0	Red (19)	2	Linear	
	Bridge	2	0	Red (35)	3	Structure	
	Culvert	2	0	Red (19)	2	Linear	
	Guard Rail	2	0	Yellow (4)	1	Linear	
	Kerb	2	0	Yellow (4)	1	Linear	
	Sign Board (All Road Signs)	0	0	Purple (21)	2	Symbol	Miscellaneous: Sign Board SB 1, SB 2
	Route Mark/Km Stone			Purple (5)	1		Miscellaneous, Km/RM height = 2 mm
	Route Mark/Km Stone Text	0	0	Red (19)	2	Symbol	
				Red (3)	1		
	Railways						
	Single Track	2	0	Yellow (36)	3	Linear	
	Electrified Track	2	0	Yellow (36)	3	Linear	
	Signal	0	0	Yellow (20)	2	Symbol	
	Cocopan Track	1	0	Yellow (20)	2	Linear	
	Aerial Cable	1	0	Yellow (20)	2	Linear	
9	Lakes/Pans/Dams (Outline)	1	0	Blue (17)	2		
	Dam Symbol (Water Symbol)	0	0	Blue (7)	1	Symbol	Geological

LEVEL	DESCRIPTION	*LINE WIDTH	LINE STYLE	COLOUR AND CODE	PEN	CELLS	REMARKS
10	Temporary Building	0	0	Red (19)	2	Structure	Place cells
	Hatching	0	0	Red (3)	1	45° Angle	Place cells
	Outline	1	0	Red (19)	2	Structure	Place cells
	Ruins	0	3	Red (19)	2	Structure	Place cells
	Water Tank	0	0	Blue (17)	2	Structure	Place cells
	Sport Fields/Courts	0	5	Green (18)	2	Structure	Place cells
	Catch Pit	0	0	Red (19)	2	Structure	Place cells
	Fire Hydrant	0	0	Blue (23)	2	Symbol	Place cells
	Flag Pole	0	0	White (0)	1	Symbol	Place cells
	Graves	0	0	Purple (29)	2	Symbol	Place cells
	Manhole	0	0	Blue (17)	2	Symbol	Place cells
	Monument	0	0	Purple (29)	2	Symbol	Place cells
	Tap/Breather	0	0	Blue (23)	2	Symbol	Place cells
	Dip	0	0	Blue (17)	2	Structure	Place cells
	Trough	0	0	Blue (17)	2	Structure	Place cells
	Silo	0	0	Red (19)	2	Symbol	Place cells
	Kraal	0	0	Red (19)	2	Linear	Place cells
	Inspection Hole	0	0	Red (19)	2	Symbol	Place cells
	Radio Mast	0	0	Red (19)	2	Symbol	Place cells
	Rondavel/Hut	0	0	Red (19)	2	Structure	Place cells
	Carport	0	0	Red (19)	2	Structure	Place cells
	Foundation	0	0	Red (19)	2	Structure	Place cells
	Stoop	0	0	Red (19)	2	Structure	Place cells
	Ramp	0	0	Red (19)	2	Structure	Place cells
	Shack	0	0	Brown (22)	2	Structure	Place cells
	Reservoir	0	0	Brown (22)	2	Structure	Place cells
	Fuel Tank	0	0	Blue (17)	2	Structure	Place cells
	Septic Tank	0	0	Blue (23)	2	Structure	Place cells
	Windpump	0	0	White (16)	2	Structure	Place cells
	Windpump and well	0	0	Blue (23)	2	Symbol	Place cells
	Fountain	0	0	Blue (17)	2	Symbol	Place cells
	Graveyard outline	0	2	Purple (13)	1	Linear	Place cells
	Concrete Wall	0	0	Red (19)	2	Linear	Place cells
	Dry Stone Wall	0	0	Yellow (4)	2	Linear	Place cells
	Borehole	0	0	Blue (23)	2	Symbol	Place cells

LEVEL	DESCRIPTION	*LINE WIDTH	LINE STYLE	COLOUR AND CODE	PEN	CELLS	REMARKS
11	Fences						
	Standard	0	0	Blue (1)	1	Linear	Place cells
	Boundary (cadastral)	0	0	Blue (33)	3	Linear	Place cells
	Security	0	0	Blue (1)	1	Linear	Place cells
	Around buildings (short fence)	0	0	Blue (1)	1	Linear	Place cells
	Gate	0	0	Yellow (4)	1	Symbol	Place cells
	Cattle Grid	0	0	Blue (7)	1	Symbol	Place cells
12	Vegetation						
	Outline	0	2	Green (2)	1	Linear	Cultivation, land
	Symbol	0	0	Green (2)	2	Symbol	
	Golf Course	0	2	Green (2)	1	Linear	
	Land/Cultivation	0	0	Green (2)	1	Symbol	
	Bush	0	0	Green (2)	1	Symbol	Bush
	Trees	0	0	Green (2)	1	Symbol	Trees
	Reeds	0	0	Green (2)	1	Symbol	Reeds
	Hedge	0	0	Green (2)	1	Linear	Linear
	Irrigated Land	0	0	Green (2)	1	Symbol	Cultivation, hatch area
	Irrigated orchard/vineyard	0	0	Green (2) Blue (7)	1	Symbol	Cultivation, hatch area
		0	0	Yellow (4)	1	Symbol	Cultivation, hatch area
	Orchard/vineyard	0	0	Green (2)	1	Symbol	Trees, hatch area
		0	0	Yellow (4)	1	Symbol	
	Plantation	0	0	Green (2)	1	Symbol	Reeds, hatch area
	Forrest	0	0	Green (2)	1	Symbol	
	Reeds/Marsh	0	0	Green (2) Blue (7)	1	Symbol	
13	Electric Power						
	Powerline	0	0	Red (3)	1	Pole	
	U/G Line	0	1	Red (3)	1	Linear	
14	Telephone/Telec/Radio						
	Poles (telephone, electric)	1	0	White (0)	1	Pole	
	Light Pole	0	0	Red (19)	1+2	Pole	
	Line	0	0	White (0)	1	Pole	
	Under ground line	0	2	Red (19)	1	Linear	
	Poles	0	0	Green (2)	1+2	Pole	
	Telephone pole without position	1	1	Green (2)	1	Pole	

LEVEL	DESCRIPTION	*LINE WIDTH	LINE STYLE	COLOUR AND CODE	PEN	CELLS	REMARKS
15	Pipelines						
	Surface Pipe	0	0	Blue (17)	2	Linear	
	Under ground Pipe	0	2	Blue (17)	2	Linear	
16	Shafts	0	0	Red (3)	1	Shaft	
17	Paths						
	Footpath	0	2	Brown (22)	2	Linear	
	Track	0	3	Brown (6)	1	Linear	
18	D.T.M						
19	Mining Lease	2	0	Green (18)	2		
	Boundary Beacons	0	0	Green (18)	2		
20	Grid/Values	1	0	Blue (17)	2		
21	Sand						
	Symbol	0	0	White (24)	2	Symbol	Geological
	Outline	0	2	Brown (22)	2	Linear	
	Rock						
	Symbol	0	1	Brown (6)	1	Symbol	Geological
	Outline	0	2	Brown (22)	2	Linear	
	Solid Rock/Scattered Rock	0	0	Brown (6)	1	Symbol	Geological
22	Fire Break	0	2	Brown (6)	1	Linear	
	Soil Erosion/Eroded Area	0	2	Brown (22)	2	Linear	
23							

LEVEL	DESCRIPTION	*LINE WIDTH	LINE STYLE	COLOUR AND CODE	PEN	CELLS	REMARKS
24	Control All text 2,5 mm height NRB Symbol Height Number Photo control (X, Y, Z) Trig Bench Mark Trig Survey Beacon Temporary Survey Station Photo ground control (X,Y) HP Horizontal Photo ground control (Z) LPC Vertical PGC (photogram) CP Traverse Arrow	1		Yellow (4) Yellow (20) Yellow (20) Yellow (20) Yellow (20) Red (35) Purple (21) Purple (21) Purple (21) Purple (21) Yellow (20)	1 2 2 2 2 2 2 2 2 2 2	SPoint, NRB Spoint, DES Structure, NRB DES, Circle + Text SPoint, PGC SPoint TSBM SPoint, TBN SPoint, TEMP SPoint, HP SPoint, LPC SPoint, CP Symbol	2mm and 3mm ø 25mm ø 2,5 mm ø ø, 2,5 mm ø φ 2,5 mm ø o, 2,5 mm ø
25	Spotheight mark	0	0	Yellow (20)	2	SPoint, Spot	
26	Township Streets Gravel Road	1 1	0 3	Yellow (20) Yellow (20)	2 2		
27	Connection Circle/Property Beacon Text	0	0	Brown (22)	2		Height = 2,5mm/12 mm for 1/5 000
28	Connection Circle for all Cadastral Lines	0	0	White (16)	2	SPoint, CCON	ø = 2 mm
29	Township Dimensions	0	0	Red (19)	2		1,5 mm test & Font 1
30	Coord-List	0	0	Yellow (20)	2		
31	Small Scale Title + North Arrow Project Nr. Sheet Layout Overlap Cross	0 0 0 0	0 0 0 0	Red () Red (3) Red (19) Yellow (52) Purple (5)	1 2 4 1	Symbol Sign	North Arrow Text = 2mm Place Block, 45 X 30 Text = 3 mm ø = 6 mm

LEVEL	DESCRIPTION	*LINE WIDTH	LINE STYLE	COLOUR AND CODE	PEN	CELLS	REMARKS
38	Text for Level 8 Station Name	0	0	Yellow (36)	3		4,5 mm text 4,5 mm text
39	Text for Level 9 (Dam)	0	0	Blue (17)			2 mm text & Font 1
40	Text for Level 10	0	0	Colour should match the colour of the symbol eg (17), (18) etc.	2		All text on this level: Font 1, height 2,5 mm, 0,35 mm Pen
41	Text for Level 11	0	0	Blue (17)	2		All text on this level: Font 1, height 2,5 mm, 0,35 mm Pen
42	Text for Level 12	0	0	Green (18)	2		All text on this level: Font 1, height 2,5 mm, 0,35 mm Pen
43	Text for Level 13	0	0	Red (19)	2		All text on this level: Font 1, height 2,5 mm, 0,35 mm Pen
44	Text for Level 14	0	0	Green (18)	2		All text on this level: Font 1, height 2,5 mm, 0,35 mm Pen
45	Text for Level 15	0	0	Blue (17)	2		All text on this level: Font 1, height 2,5 mm, 0,35 mm Pen
46	Text for Level 16	0	0	Green (18)	2		All text on this level: Font 1, height 2,5 mm, 0,35 mm Pen
47	Text for Level 17	0	0	Red (19)	2		All text on this level: Font 1, height 2,5 mm, 0,35 mm Pen
48	Text for Level 18	0	0	Red (19)	2		All text on this level: Font 1, height 2,5 mm, 0,35 mm Pen
49	Text for Level 19	0	0	Green (18)	2		2,5 mm Text & Font
50	Photo Centres Symbol Text	1 0	0 0	Green (18) Green (18)	2 2	Symbol Symbol	Photo Centre 2,5 mm text

LEVEL	DESCRIPTION	*LINE WIDTH	LINE STYLE	COLOUR AND CODE	PEN	CELLS	REMARKS
51	Text for LV 21 (Sand)	0	0	Brown (22)	2		2,5 mm Text & Font 1
52	Text for LV 22	0	0	Brown (22)	2		2,5 mm Text & Font 1
53	National Road Reserve Line	0	3(0)	Red (51)	4		Import Sline, Adjust Configure * change style to (0) when N.R.R falls on Cadastral
54	National Road Reserve Beacon	0	0	White (0)	1	Create Cell under Spoint	1:1000 - = 0,6 mm 1:10 000 = r = 6 mm
55	Hatching of National road Reserve Area	0	0	Green	1	Create Cell under Sign	Hatch Pattern Area 1:10 000 r = 1 mm
56	National Road Reserve Beacon Number	0	0	Brown (6)	1	SPoint (name)	Height = 2,5 mm 15 mm (1:10 000)

PEN 1 = 0.25 MM
PEN 2 = 0.35 MM
PEN 3 = 0.50 MM
PEN 4 = 0.70 MM

Line width

0
1
2
3
=

etc.

Line style

0
1
2
3
4
5
6
7
=

12. STAKING

12.1 Purpose of the Survey

The purpose of this survey shall be to establish survey points, both temporary and permanent on pre-calculated positions in the field, and to obtain sufficient field data for the complete geometric design before construction.

12.2 Phases of the Survey

The following are recognised as separate phases of the survey and shall be carried out or omitted as specified in the general survey requirements for staking.

12.2.1 The Basic Survey, being the establishment of a horizontal and vertical survey network of permanent survey beacons and the supply of all related records in cases where no permanent survey beacons were established during previous surveys. See Chapter 3.

12.2.2 Staking being the establishing and fixing of alignment keypoints and alignment intermediate points on terrain either it is done by centreline, offset, with referencing or without referencing staking methods.

12.2.3 Sectioning being the field survey work required to determine the ground profile for the producing of long- and cross- sections.

12.2.4 The Plotting, being the extraction and plotting of long- and cross-sections by computer or hard copy.

12.2.5 Checking being the final checking of all information and the supply of all related records.

12.3 General

Provision is made for four methods of staking:

Normal centre line staking without referencing

Normal centre line staking with referencing.

Offset Staking without referencing

Offset Staking with referencing.

It is essential that the Surveyor confirm which method of staking is required and whether cross-sections are required before starting the staking.

For cross-sections without staking see chapter 13 (Digital Terrain Models).

12.3.1 The Staking Interval

The standard staking interval shall be 20m, or 10m in the case of curves with radii of less than 200m, unless otherwise specified by the Client.

12.3.2 Stake Value

The stake value of any point shall be recorded in metres and to three decimals of a metre, e.g. 1276,320.

12.3.3 Horizontal Alignment Pre-calculation

The approved horizontal alignment will be supplied by the Client.

12.4 Basic Survey

All provisions of chapter 3 are applicable.

12.5 Staking

12.5.1 Establishing of Alignment Key Points and Alignment Intermediate Points.

The key points, e.g. Beginning of Curve (BC), End of Curve (EC), Beginning of Transition Curve (BTC), Beginning of Circular Curve (BCC), etc. and intermediate key points at every even 200m along straights, e.g. 12 200 and 12 400, etc and on curves every 100m, e.g. 14 100 and 14 200, etc, shall be established in the field from existing permanent survey beacons. Intermediate key points closer than 5m to a key point need not be placed or referenced. In the case of curves of under 200m radius, the peg nearest to the centre of the curve, shall be a intermediate key point.

The centre line intermediate points required for long- and cross- sections shall be set out from key points, intermediate key points or permanent survey beacon.

12.5.1.1 Peg Sizes

Steel pegs of a minimum diameter of 10mm and length of 300mm shall be used for all key points (paragraph 12.5.1). For all other peg information refer to paragraph 1.5.

12.5.1.2 Concreting of Key Points

Pegs for key points shall be firmly fixed with a concrete casting to a minimum depth of 200mm below the ground. The concrete casting shall have a minimum diameter of 200mm and shall be moulded to allow not more than 5mm of the peg to protrude above the surface of the concrete, unless otherwise specified. Refer to paragraph 3.2.1. for strength of concrete and paragraph 12.9 for numbering and lettering.

Key points shall not be used for survey purposes until the concrete has set.

12.5.1.3 Marking of Key Points

Key points specified in paragraph 12.5.1 shall be marked with a 1,8m "Y" iron standard driven 0,8m into the ground, $\pm 0,5m$ from the peg and on line to the next key point, or by a stone cairn at least 0,3m high, coated with white water resistant paint.

Intermediate points shall be suitably marked to facilitate the measuring and heighting of the cross-sections. Pegs are not required unless specified.

12.5.2 Heighting of Key and Intermediate Points

12.5.2.1 All staked key points as mentioned in paragraph 12.5.1 and references, if placed, shall be spirit levelled and their distances recorded fully in metres in the level book.

12.5.2.2 All key points shall be check levelled.

STAKING

-
- | | |
|----------|--|
| 12.5.2.3 | Forward and reverse levelling shall not be carried out simultaneously with one instrument, even if two different staffs are used. |
| 12.5.2.4 | When using a conventional field book the final elevations of all staked points and BC's, EC's, BTC's, etc., shall be entered in blue ink and those of intermediate points in pencil. All reference peg elevations shall be shown in red ink in the level book. |
| 12.5.2.5 | The height of intermediate points do not need to be levelled, but can be determined by tacheometric methods. |
| 12.5.2.6 | Differences of more than 50mm between the top of the peg and ground level shall be recorded and mentioned in the technical report. |

12.6 Sectioning

12.6.1 Cross-sections

Cross-sections shall be taken at 20m intervals perpendicular to the staked line and shall extend 10m beyond the road reserve width, unless otherwise specified.

12.6.2 Longitudinal-sections

Long-sections shall be derived from the cross-section measurements as well as from additional measurements taken on the centreline at features and changes of slopes.

12.6.3 Measurement Requirements for Longitudinal and Cross-sections

Levels shall be taken on the following features and their stake values recorded:

- | | |
|----------|---|
| 12.6.3.1 | All changes of grade. |
| 12.6.3.2 | Top and toe of banks, water's edge and bed levels of water courses. |
| 12.6.3.3 | Beginning and end of bridge decks. |
| 12.6.3.4 | Invert levels at both ends of culverts. |
-

STAKING

- 12.6.3.5 Railway tracks (both rails).
- 12.6.3.6 Road intersections (both edges)
- 12.6.3.7 Power and telephone lines (lowest wire). Elevations of the lowest wire shall be determined at the centre line and both shoulder break points of the proposed road. See Annexure 11.

Heights of power lines shall not be measured with a staff or tape. Temperature at time of measuring shall be recorded in the case of power lines and shown on the longitudinal section.

- 12.6.3.8 When the staked line ties into an existing road, levels shall be taken along the centre line of the existing road at 20m intervals for at least 200 metres beyond the staking. On minor accesses these levels shall be taken for 100m beyond the staking, unless otherwise instructed.

12.6.4 Omissions From Plans

Any topographical feature which is incorrect, or a feature that does not appear on the survey plan within 50m of the staked line, shall be surveyed and updated on the existing survey plan.

12.7 Offset Staking

All provisions of paragraphs 12.1 to 12.6 apply.

Offset staking shall be permitted only with the approval of the Client.

The offset stake values shall be calculated perpendicular to the centre line. All key points staked at an offset shall indicate the distance and direction from the centre line, e.g. 2200/5m R, on the beacon.

All information listed in paragraph 12.6 shall relate to the centreline.

12.8 Staking with Referencing

All provisions of the previous paragraphs in this chapter are applicable.

STAKING

12.8.1 Reference pegs

- 12.8.1.1 As a rule reference pegs shall be placed at 15m or 20m on either side of the centre line (depending on the width of the road reserve) and normal to the centre line (i.e. at 90° to the tangent at the centre line). Reference pegs shall be placed where they are least likely to be disturbed.
- 12.8.1.2 The Surveyor shall liaise with the Client to ensure that reference pegs are placed clear of any proposed earthworks.

12.8.2 Referencing Requirements

- 12.8.2.1 Straights - multiples of 200 metres.
- 12.8.2.2 Curves - BC's, BTC's, EC's, ETC's and multiples of a 100 metres.
- 12.8.2.3 Short curves under 200m in length - BC's, EC's, etc as well as the peg nearest to the centre of the curve which shall be an intermediate keypoint.

12.8.3 Horizontal Accuracy

Reference pegs shall be placed within 20mm of their required true position in relation to the centre line peg.

The distance from the centre line of each reference peg shall be noted in the level book opposite the appropriate stake value.

12.9 Numbering and Lettering

- 12.9.1 Pegs indicating the position of the key points shall be numbered and lettered so as to be read when facing in the direction of the staking.
- 12.9.2 The point description (eg BC1, EC1, 12 200, etc) shall be punched with lettering of not less than 7mm in size on a strip of non-corrosive metal, 0,7mm to 1,5mm in thickness, firmly set in the concrete, or by white road paint when pegs are placed in a tarmac or similar surface.

12.9.3 In the case of reference pegs, the letters R (right reference) or L (left reference) and the offset distance shall be used.

12.10 Standards of Accuracy

12.10.1 **Horizontal Standards of Accuracy**

The key points referred to in paragraph 12.5.1 shall be fixed to an accuracy of not less than that specified in paragraph 2.3.2., and may not be more than 20mm off their true position.

The position of 20m intermediate staked points shall not differ from their required true position by more than 20mm, unless otherwise specified.

The distance between any two consecutive pegs must be within the accuracy of 1:5000.

In the case of curves, the closing error shall not exceed 1:5 000. Any error smaller than 1:5 000 must be adjusted pro-rata over the length of the curve. Where the error on curves exceeds 1:5 000 the curve shall be re-staked so that the accuracy is within 1:5 000 and subsequently adjusted pro-rate over the curve length.

12.10.2 **Vertical Standard of Accuracy of Levelling**

Unless otherwise specified, the elevation of the permanent survey beacons shall control the levels of the staked key points. The standard of accuracy shall be the same as that stipulated for the basic survey beacons. See paragraph 2.5.

12.11 Plotting of Sections

12.11.1 **Plotting of the Longitudinal Section (if required)**

12.11.1.1 Unless otherwise specified, the longitudinal section shall be prepared on a standard A0 size sheet and the scale shall be 1:100 vertical and 1:1000 Horizontal.

12.11.1.2 The direction of the profile shall correspond to the direction of the increasing stake value on the layout plan.

STAKING

12.11.1.3 Each sheet shall start on an even kilometre distance and there shall be no overlap between adjoining longitudinal sections.

12.11.1.4 When a staked line ties into an existing road alignment the profile shall be extended in accordance with the levels referred to in paragraph 12.6.3.8

12.11.1.5 **Additional features**

The stake values and elevations of the following features shall be shown on the longitudinal section:

Beginning and end of bridge decks.

Culvert dimensions and invert levels (i.e. inside bottom).

Railway tracks (both rails).

Intersecting road (both sides).

Power and telephone lines, lowest line (bottom sags).

Underground pipes and cables.

12.11.2 **Plotting of Cross-sections (if required)**

12.11.2.1 Unless otherwise specified, the scale shall be 1:100.

12.11.2.2 Cross-sections shall be plotted parallel to the horizontal edge of the sheet and the stake value shall increase from the bottom edge of the sheet towards the top of the sheet, commencing at the bottom left hand corner of the sheet.

12.11.2.3 **Abbreviations:** Features shall be shown on the cross-section by using the following abbreviations where applicable:

CL Centre line of staking

CLR Centre line of existing road

LER Left edge of existing road

RER Right edge of existing road

ETS Edge tar shoulder of existing road

EGS Edge gravel shoulder of existing road

ET Edge tar of existing road

TF Top of fill of existing road

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TC	Top of cut of existing road
FF	Foot (toe) of fill of existing road
FC	Foot (toe) of cut of existing road
TB	Top of bank (natural feature, river, donga, etc)
FB	Foot of bank (natural feature, river, donga, etc)
CS	Centre of stream
EW	Edge of water
F	Fence
RR	Right reference peg
LR	Left reference peg
TL	Telephone line
PL	Power line
K	Kerb
C	Channel
G	Gutter
GR	Guardrail
BC	Beginning of curve
EC	End of curve
BTC	Beginning of transition curve
ETC	End of transition curve
SV	Stake Value

Note :

With features such as dongas, erosion, drains, etc. where the banks become self evident from the shape of the profile, only the centre need to be annotated.

12.12 Placing of Road Reserve Boundary Beacons (When required and not otherwise specified)

- 12.12.1 To demarcate the road reserve, permanent boundary beacons shall be placed at the bending points of the proposed fence according to the co-ordinates as supplied by the Client.
- 12.12.2 The boundary beacons shall be "Y" type Iron standards weighing not less than 3 kg per metre, or an iron peg of not less than 20mm diameter, in each case not less than 1 metre in length, driven into the ground to a depth of at least 850mm. If the boundary beacon is on solid rock, a hole 10mm in diameter shall be drilled into the rock to a depth of 25mm. An identification aluminium tag shall be fixed to the iron

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standard/peg. If deemed necessary, the iron standard or iron peg may be embedded in a symmetrical block of concrete. When the boundary beacons falls in soft or sand ground the length of the iron standard or iron peg shall be increased sufficient to ensure the stability and permanance of the boundary beacon.

When a post of an existing fence falls on bending point, it may be adopted as a boundary beacon.

12.12.3 Where the road reserve boundary crosses a fenced cadastral boundary in rural and peri-urban areas, wooden stakes shall be placed at the correct distance from the centre line of the road to demarcate the proclaimed width of the road reserve.

12.12.4 Where the road reserve boundary crosses a cadastral boundary, the intersection of the boundaries shall be calculated and marked as indicated in paragrapg 12.12.2.

12.12.5 Care shall be taken to ensure that the wooden stakes are placed at the correct distance from the centre line, i.e. they serve as line boundary beacons for the road reserve boundary.

12.13 Records to be submitted

12.13.1 In all cases of staking, whether completed longitudinal sections are required by the client or not, a comprehensive survey report is to be submitted under covering letter, stating all relevant data such as Job title, File number, Contract number, Road number, section number and start and end kilometre distances and, if available, plan numbers.

12.13.2 The survey records shall comprise a fully indexed file of all relevant calculations, grouped together according to data type.

Pages are to be numbered consecutively; The survey report referred to in para. 1.9 shall be the first pages in the file.

Page 1000, the Index, indicating page number and data type groupings.

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Page 2000, an A4 extract of the 1:50 000 sheets, showing the locality of the job.
Two or more sheets should be used in the case of very long sections of road.

Page 3000, the co-ordinate list or centreline calculations, thereafter other data type groupings to the end of the file.

- 12.13.3 For example, a list of co-ordinates of all basic survey beacons, traverse and co-ordinate calculations (with reference to field book and page number for observations) if a basic survey was undertaken as part of the staking contract. These would be centre line calculations, list of centre line heights, list of reference point heights and offset distances, list of culvert invert levels, stake values and any other relevant or special requirements such as bridge deck start and end distances and elevations, power line elevations, etc.
- 12.13.4 Thermal paper printouts will not be acceptable. Good quality non gloss photostatic copies (punched for filing in the required manner) shall be submitted, according to the requirements of the client and filed in the prescribed cover.
- 12.13.5 Field books used shall be of a type prescribed by the Client and shall not have removable pages. See paragraph 4.2.
- 12.13.6 Field book headings shall be completed daily. All entries shall be in pencil, cross referenced in the index in the front of the field book. Only final reduced values shall be entered in ink. Red ink shall be used only for trigonometric benchmark elevations, trigonometric beacon co-ordinates or an elevation which has been independently checked twice after determination relative to a trigonometric benchmark. No erasures shall be made. Incorrect entries shall be crossed out and the correct entry made above the crossed out entry.
- 12.13.7 Field books shall be clearly marked (e.g. "Book 1 of n - books") and the route number and section and job number shall be entered on the front page.
- 12.13.8 No permanent markings shall be made on the outside cover of the field book except by the client after allocation of his survey record number.
- 12.13.9 Where electronic data capturing is used, a hardcopy printout in accordance with the specifications for the survey file, shall appear in the file, indexed as "Electronic

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Field Book" extracts, complete with a legend of symbols used. See paragraph 12.11.2.3 for examples.

- 12.13.10 In addition, a diskette, with data stored according to the clients specification for calculation and draughting, shall be submitted.

13. DIGITAL MAPPING AND TERRAIN MODELLING (DTM)

13.1 The Purpose of the Survey

The purpose of this survey is to represent the original ground line as accurately as possible and to produce a comprehensive topographical strip survey from which an accurate horizontal and vertical alignment can be derived for design purposes. This will obviate the necessity for staking, referencing and cross-sectioning along the proposed alignment during the design stages. The setting out will only take place immediately prior to construction. Furthermore, the Digital Terrain Model (DTM) will also be used to accurately quantify volumes during construction.

13.2 Phases of the Survey

The survey shall include the following phases:

13.2.1 **Basic Survey;** see chapters 2 and 3.

13.2.2 **The Detailed Digital Terrain Model (DTM) Survey.**

13.2.3 **Check Cross-Sections** (after submission of the Digital Terrain Model (DTM) survey).

13.2.4 **Submitting of Records.**

13.3 General

Conventional survey, photogrammetric or Global Positioning System (GPS) equipment can be used, in conjunction with a data capturing system with software that will process the data in the format as specified by the client.

The Surveyor shall ensure that the instruments and other equipment used in the survey are in proper adjustment.

The surveyed data shall be provided in the form of a Digital Terrain Model (DTM) suitable for use in a specified software package used to derive best fit horizontal and vertical alignments and other design elements. Once the alignments are known, cross-sections shall be derived digitally to:

- (a) permit the design of the road surface, drainage and other features
- (b) accurately calculate volumes of any earthworks for estimation purposes.

- (c) accurately calculate volumes of important materials for estimation purposes.

13.4 Permanent Survey Beacons

13.4.1 Placing of Permanent Survey Beacons

This entails the establishment of a network of permanent survey beacons, premarked for aerial surveys, placed in suitable locations, for the ultimate setting out of the construction works. See chapter 3.

The permanent survey beacons shall be intervisible and the distance between beacons shall not exceed 500 metres.

13.4.2 Construction of Permanent Survey Beacons

The beacons shall be built to the specification as laid down in paragraph 3.2.

13.4.3 Horizontal Fixing

The survey beacons shall be linked to the National Lo System, unless otherwise specified.

The standard of accuracy shall comply with that laid down in paragraph 2.3 "Horizontal Standards of Accuracy".

13.4.4 Vertical Fixing

The elevations of the survey beacons shall be based on the National Geodetic Bench Marks (NGBM), unless otherwise specified.

Simultaneous reciprocal observations with a single second theodolite may with approval from the client be used to height beacons in difficult terrain. Application to use this method shall be made in writing to the Client.

The standard of accuracy shall comply with that laid down in paragraph 2.5 "Vertical Standards of Accuracy".

NOTE: Departure from any of the above specifications is subject to prior approval of the Client.

13.5 The Detail Survey

13.5.1 The Following Detail Shall Be Surveyed.

- 13.5.1.1 The edges of all existing gravel roads, including the convex or concave shape of the road surface and any superelevation.
- 13.5.1.2 The edges of an asphalt, and/or kerbing (top and bottom in the case of ground survey) of all surfaced roads, including the convex or concave shape of the road surface and any superelevation.
- 13.5.1.3 The positions and inverts of all side drains (whether lined or not).
- 13.5.1.4 The positions and inverts of all drainage and storm water pipe inlets and outlets, even if these extend beyond the defined strip.
- 13.5.1.5 All power and telephone lines.
- 13.5.1.6 Fences
- 13.5.1.7 Cover, invert and ground levels of all manholes.
- 13.5.1.8 Valve chambers of existing water mains.
- 13.5.1.9 Top and toe of cut and fill batters and all changes in slope that might have an influence on the creation of a Digital Height Model (DHM) and contours.
- 13.5.1.10 Existing accesses to properties.
- 13.5.1.11 Any encroachment within the road reserve.
- 13.5.1.12 Any erosion within the road reserve.
- 13.5.1.13 In addition, any feature not listed above, that may be required to accurately model the surface or may affect earthworks and designs within the surveyed area.

DIGITAL MAPPING AND TERRAIN MODELLING (DTM)

13.5.1.14 All breaklines that might have an influence on the creation of a Digital Height Model.

13.5.2 The detail may be surveyed by any suitable method with the provision that the required tolerances, are met.

13.5.3 Every point of detail shall be fixed in Y, X and Z and have a standard feature description. The density of surveyed and breakline points shall be sufficient to enable cross-sections to be generated from the data at 10 metre intervals.

13.5.4 Digital Terrain Model (DTM) Tolerances

Feature	Ground Survey		Aerial Survey	
	Horizontal	Vertical	Horizontal	Vertical
Kerbing and edge of asphalt	100mm	25mm	150mm	150mm
Storm water pipes	100mm	25mm	200mm	150mm
Lined drains	100mm	25mm	200mm	150mm
Gravel roads:	100mm	50mm	200mm	150mm

General topographic data etc.: (normal tacheometric standards)

NOTE

- (a) These tolerances are the permissible deviation (i.e. +/- value)
- (b) The required accuracy shall dictate the survey method to be used.
- (c) The tolerances apply to any part of the feature and not to the actual spots on which it was surveyed.
- (d) To satisfy the above tolerance after interpolation, it may be necessary to survey the feature to a higher degree of accuracy.

- (e) The data supplied shall be such that accurate contours can be derived at 1 metre intervals, but the density of the surveyed points excluding contours captured photogrammetrically shall permit interpolation to 0,5 metre intervals. (ie. YXZ points along photogrammetric contours shall not be accepted as surveyed points for interpolation purposes.)
- (f) All features required for detail, but not required for the DTM, shall be isolated.

13.6 Checking of Cross-Sections

- 13.6.1 After the first two phases of the Digital Terrain Model (DTM) survey are completed and supplied, the Client shall indicate the positions at, and extent to which cross-sections shall be taken to check the DTM. The number of cross-sections may vary between two and five per kilometre, depending on the terrain.
- 13.6.2 The position of the check cross-section surveyed in the field, shall not differ by more than 2 metres from the position as indicated by the client and new Y, X, and Z co-ordinates shall be calculated. Reasons for shifting the position shall be clearly stated.
- 13.6.3 The surveyed check cross-sections shall be compared against a digitally derived cross-section at the same point.

13.7 Records to be Submitted

- 13.7.1 The following records shall be provided on completion of the task: (See chapter 4.)
 - 13.7.1.1 Detailed survey plans normally at a scale of 1:500 with contours at 1 metre vertical intervals together with the relevant (CAD) data, unless otherwise specified.
 - 13.7.1.2 Survey data used to produce the plans shall be well labeled and supplied on a stiffy or tape in a format as specified by the Client. All feature break lines shall be included. The Surveyor shall indicate in the technical report the number of surveyed points used in the DTM.
 - 13.7.1.3 A separate data file of those points surveyed but not used in the DTM.

- 13.7.1.4 The check cross-sections, field books and annotated plots of the cross-sections.

14. BRIDGE SITE SURVEYS

NOTE: The recommendations given in this chapter should be viewed only as a guide to good practice.

The extent of each site survey shall be determined in consultation with the client.

14.1 Purpose of the Survey

The purpose of the survey is to provide plans showing contours and other topographical details of the site as well as relevant longitudinal and cross-section pertaining to roads or waterways etc. for the design and accurate siting of the proposed structures, and to establish accurately fixed permanent survey stations for future setting out of the structure, control of construction and subsequent monitoring.

14.2 Phases of the Survey

14.2.1 Basic Survey, being the establishment and survey of the horizontal and vertical position of a network of permanent survey stations in selected positions within the site area.

14.2.2 Detailed Survey, being the survey of all natural and man-made features which may have an impact on the siting of the bridge.

14.2.3 Sectioning, being the ground survey work required to determine the ground profile of future and existing roads, railway lines and river beds for the determination of long- and cross-sections as required by the client.

14.2.4 Preparation of plans, being the plotting of all detail and contours for the preparation of final site plans, and the plotting of cross-sections and long-sections in a format or medium as required by the client.

14.3 General Requirements

14.3.1 Permanent Survey Stations and Reference Pegs

The positions of all centre line pegs, key points, intermediate key points, reference pegs and permanent survey stations shall be shown on the survey plan. If an offset reference line is staked, a note as to the relevant position of the centre line must be made on the survey plan.

It is important to note that the accuracy of both the horizontal and vertical setting out of the proposed structure depends on the permanence and stability of all the survey pegs.

14.3.1.1 Permanent Survey Stations

At least four permanent survey stations shall be placed in selected positions within every site survey area to ensure proper control of the setting out and construction. The survey stations shall be mutually visible and tied into the National Triangulation network.

Care shall be taken to ensure that survey stations are placed away from road shoulders and drains, and as far as possible outside lands. Survey stations shall not be placed closer than 20 m from the centre line of the proposed road.

It is important that at least four of the permanent survey stations, two on each side of the crossing, remain functional after completion of the construction so that they can be used as references for monitoring the deflections of the structure, as part of the bridge maintenance programme. Care must be exercised in selecting their positions to ensure their stability and safety from being disturbed during, and after construction. It is recommended that these survey stations be placed no closer than 20 m from the centre line of the road, and preferably no further than 50 m from the proposed bridge.

The appropriate sections of Chapter 1, Chapter 2 and paragraphs 3.1 through 3.4 regarding procedure, general survey regulations and standards of accuracy, and survey control shall apply to this specification.

14.3.1.2 Centre Line Pegs, Line Key Points, Intermediate Key Points and Reference Pegs

Chapter 12 shall apply to this specification.

14.3.1.3 Co-ordinates

All centreline pegs, key points, intermediate key points, reference pegs and permanent survey stations shall be co-ordinated on the appropriate Lo-system

in accordance with the standards of accuracy specified in Chapter 2. The co-ordinates shall be listed on the survey plan in the co- ordinate list block.

14.3.2 Horizontal Control and Vertical Datum

The horizontal control and vertical datum to be used depends on whether or not large scale plans covering the area of the site exist. In either case the co-ordinate system and constants, as well as the vertical datum and its origin must be stated on the survey plan.

14.3.2.1 Where Large Scale Plans Exist

Where large scale plans exist, the co-ordinate system as well as the height datum of the existing plans must be adopted for the bridge site survey.

14.3.2.2 Where Large Scale Plans Do Not Exist

Where no large scale plans exist, the survey shall be based on the L.o System. If L.o System co-ordinates are not readily available a local or arbitrary system may be used after obtaining approval from the client (see paragraph 2.2).

Elevations shall be based on National Geodetic Benchmarks in this case. In the absence of such datum points within 10 km of the bridge terrain, instructions shall be obtained from the client.

14.3.3 Digital Terrain Models

Bridge site surveys may be called for in digital format. This must be undertaken in accordance with the specification contained in Chapter 13. The scale and complexity of the terrain must be carefully studied to ensure that sufficient spot heights are taken to depict all break lines to facilitate the extraction of accurate cross-sections and longitudinal sections in any position, as may be required by the client.

The format of presentation shall be either handdrawn, computer plotted or in appropriate digital format, as required by the client.

14.4 Detail to Be Surveyed

14.4.1 All natural and man made features which may have an impact on the siting of the bridge (including the selection of the final position of the abutments and piers) and access ramps in the case of an interchange, and on the engineering requirements of the bridge construction, as well as information which may affect the bridge and the road approaches shall be surveyed. The survey shall provide the following information, as appropriate:

14.4.1.1 Contours to 0,5 m vertical intervals on a scale of 1:500 and to 1 m on a scale of 1:1 000 with supplementary spot heights wherever the contours are unable to portray ground shapes faithfully. Frequent spot heights shall be given on features such as roads, railways, bridges, etc where elevations may be necessary for engineering design. Tacheometric spot heights shall be taken on all changes of slope, on top of ridges and in the bottom of valleys. See also paragraph 14.6.4.

14.4.1.2 Positions of survey stations.

14.4.1.3 Rivers, streams, springs, canals, dams, pans, marshes and areas subject to tidal flooding together with names and direction of flow, as appropriate.

14.4.1.4 Highest known flood levels of main streams, as near as can be determined from local evidence or information.

14.4.1.5 The source of such information and the specific point and date concerned must be indicated on the plan.

14.4.1.6 High tide marks, high water marks of rivers, streams and dams.

14.4.1.7 A description of the bed of a stream, e g sandy, boulders, solid rock, silted, etc.

14.4.1.8 Forest, bush, shrub, plantations, orchards, avenues, hedges, individual trees which are landmarks, or the preservation of which may be desirable for scenic purposes, etc.

14.4.1.9 Cultivated lands (differentiating between dry and irrigated), rock outcrops and hard or continuous rock, cliffs, sand dunes, etc.

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- 14.4.1.10 Eroded areas and gullies.
- 14.4.1.11 Water mains.
- 14.4.1.12 Other services such as sewer, stormwater and gas.
- 14.4.1.13 Manholes.
- 14.4.1.14 Spotheights.
- 14.4.1.15 Road levels.
- 14.4.1.16 Cuttings and banks (road and rail).
- 14.4.1.17 Fences and property beacons.
- 14.4.1.18 Culvert dimension shall be given.
- 14.4.1.19 Natural drainage and drainage improvements.
- 14.4.1.20 Structures affected by planning.
- 14.4.1.21 Existing access to adjoining properties.
- 14.4.1.22 Position of foundation test holes with reduced ground levels if available.
- 14.4.1.23 North point.
- 14.4.1.24 Any special features.
- 14.4.1.25 Roads and footpaths, differentiating between blacktop and other surfaces as well as between national, provincial and other roads. The road numbers and destinations of the roads leaving the surveyed area shall be given.
- 14.4.1.26 Structures, with details regarding the openings, sizes, structure number and types of construction relating to those structures which are situated on or across primary and secondary roads, or which have a bearing on their drainage. Measurements of sizes are to be given. See paragraph 14.5.4 for

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detail on existing structures which may be affected by the planned construction.

- 14.4.1.27 Drainage and irrigation furrows.
- 14.4.1.28 All individual buildings, differentiating between types of construction, and stating the general use of the building or groups of buildings other than dwellings (e.g. store, school, etc).
- 14.4.1.29 National monuments and buildings or structures of historical interest. Describe briefly.
- 14.4.1.30 Power and telephone lines, showing individual poles or pylons in their surveyed positions.
- 14.4.1.31 Underground pipe lines, cables and other buried services the positions of which shall be determined from local authorities and surface indications, e.g. manholes, cable markers, etc, if such services will be affected by the planned construction.
- 14.4.1.32 Other services e.g. signal cables, telephone cables, sewers, etc.
- 14.4.1.33 Gates and fences, differentiating between ordinary, stockproof, jackalproof, security fences, etc.
- 14.4.1.34 Stone, brick or any other type of walls.
- 14.4.1.35 Wells, boreholes, windmills.
- 14.4.1.36 Kilometre markers.
- 14.4.1.37 Quarries, tunnels, mine workings, etc.
- 14.4.1.38 Graves and cemeteries.
- 14.4.1.39 All cadastral and servitude information shall be shown in the surveyed strip with names of owners and municipal boundaries, if applicable. Where it is

difficult to supply cadastral information and where such data can be omitted without detrimental effect, approval shall be obtained from the client.

14.4.1.40 Angle of intersection between roads.

14.4.2 In the Case of Railway Crossings, the Following Additional Information Shall Be Provided:

14.4.2.1 Angle of intersection between road and rail centre lines.

14.4.2.2 Rail kilometre value of point of intersection.

14.4.2.3 Rail kilometre value of existing level crossings.

14.4.2.4 Rail levels (Both rails).

14.4.2.5 Sufficient information to determine radii of road and rail curves.

14.4.2.6 Rail kilometre and grade posts.

14.4.2.7 Kilometre distance along road and rail.

14.4.2.8 Turnouts.

14.4.2.9 Signals.

14.4.2.10 Signal wire runs.

14.4.2.11 Electrification masts.

14.4.2.12 Telephone and telegraph routes.

14.4.2.13 Powerline routes.

14.4.2.14 Cables (signal, power and communication).

14.4.2.15 Railways, indicating ownership and destinations.

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14.4.2.16 Road and railway layout with leading dimensions in respect of formation width, and distance between carriageways and between railway lines.

14.4.2.17 Position of overhead electric gantries and masts on railway lines.

14.4.2.18 Position of cross-overs and crossings on railway lines.

14.4.3 In general, all topography and man-made structures, the plotting of which is consistent with the scale of the plan, shall be included. In the case of areas such as built-up townships, industrial or mining sites, etc, written approval may be obtained for the omission of detail which is considered to be irrelevant.

14.5 Detail Requirements for Different Bridge Surveys

NOTE: The extent of each site survey shall be determined in consultation with the client because the requirements of these surveys vary from structure to structure.

14.5.1 Road Crossings (Including Footbridges)

14.5.1.1 Site Plan

The site plan shall contain the locality sketch, unless otherwise indicated, and the survey plan.

14.5.1.1.1 Locality Sketch

The locality sketch shall be shown as an inset on the site plan, unless otherwise indicated. All relevant detail as longitude, latitude and reference to the 1:50 000 map for locating the site from any direction shall be shown, including:

Co-ordinate grid.

The position and kilometre distance of the bridge site shall be clearly marked and the site shall form the focal point of the plan.

The direction of true north oriented the same as the survey plan.

The scale of the plan (a scale of 1:50 000 is usually used).

Existing, proclaimed and staked roads and railway lines with their numbers and destinations.

Rivers, streams and dams, showing the directions of flow together with names if applicable.

Cities, towns and railway stations.

The position and names of interchanges.

Kilometre distances at regular intervals.

Distance to nearest residential centres if such centres are not shown on the sketch.

14.5.1.1.2 Survey Plan

The survey plan shall be an accurately drawn plan of the site showing details and contours.

Any required staking shall be completed before the survey is done, if the appropriate information is available.

Staking shall be done with referencing, or as otherwise agreed with the client, in accordance with the requirements of Chapter 12.

The plan shall cover the terrain within a distance of 150 m from each side and each end of the structure, or as otherwise specified. The scope of the survey shall also include the full extent of any deviations of existing services and/or natural watercourses as supplied by the client.

Contours and spot heights shall satisfy the requirements of paragraph 14.6.4.

A scale of 1:500 is preferred, but it may be changed to suit the area covered by the survey relative to the size of the drawing sheet specified by the client.

In addition to the requirements listed in paragraph 14.4 the following data shall be given:

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- (a) An indication of true North and the scale.
- (b) Co-ordinates in a co-ordinate list block.
- (c) Existing road(s) with destinations in each direction.
- (d) Any existing staked line including stake value of crossing point(s) and angle of skew.

The survey plan shall always be rotated so that the stake values or kilometre distances of the bridge increases from left to right.

For a bridge crossing the proposed road, left shall be the left abutment of the proposed bridge when looking in the direction of the increasing kilometre distances of the proposed road.

14.5.1.2 Longitudinal Sections Along Road Centre Lines

The longitudinal sections along the road centre lines are required for the proper vertical alignment of the structure.

A section is required along the centre line of each road (proposed as well as existing) involved in the bridge crossing. For dual carriageway roads, a section shall be taken along the centre line of each carriageway.

The longitudinal sections shall cover a distance of at least 300 m on either side of the proposed bridge(s). However, the exact length shall be confirmed with the client. Sections shall be taken in the direction of increasing kilometre distances.

A scale of 1:100 vertically and 1:1 000 horizontally is preferred, but it may be changed to suit the length of the section relative to the size of the drawing sheet specified by the client.

Stake values shall always increase from left to right. Longitudinal sections shall be drawn as separate profiles on the same sheet, if possible.

The section along the centre line of a proposed road shall show the following:

- (a) Stake values and the levels at staked line pegs.
- (b) Levels at slope changes.
- (c) Geometric data in respect of the vertical and horizontal alignment of the proposed road, if available.
- (d) Road numbers and destinations.
- (e) The position of any existing structures including drainage pipes and services.

The section along an existing road shall show the following:

- (a) Levels taken on the road centre line together with the corresponding kilometre distances or stake value, if available.
- (b) Geometric data in respect of the vertical and horizontal alignment of the existing road, if available.
- (c) Road number and destinations.
- (d) The position of existing structures including road drainage pipes and services.

14.5.1.3 Cross-sections Along Road Centre Lines

Cross-sections of existing and proposed roads shall be taken at regular intervals of 20 m over the full length of the longitudinal sections as defined in paragraph 14.5.1.2. The width of the sections must extend beyond the toe lines of the proposed embankment but will have to be specified by the client.

These cross-sections shall show the staked line or centre line, road surface, median, lane, shoulder and footwalk widths, cross fall or camber on the carriageway(s), the side slopes and natural ground line (as applicable). The recommended scale is 1:100 vertically and horizontally.

BRIDGE SITE SURVEYS

The format of presentation shall be either handdrawn, computer plotted or in appropriate digital form, depending on the requirement of the client.

14.5.2 **River Crossings**

14.5.2.1 **Site Plan**

The site plan shall contain the locality sketch, unless otherwise indicated, and the survey plan.

14.5.2.1.1 **Locality Sketch**

The locality sketch shall be shown as an inset on the site plan. In addition to the required information listed for road over road bridges (see paragraph 14.5.1.1.1, the position and size of existing structures within 3 km upstream or downstream from the proposed structure shall be shown, together with a description of each structure. Generally, it is not necessary to show more than two structures on either side.

14.5.2.1.2 **Survey Plan**

The survey plan shall comply with the requirements as listed in paragraph 14.5.1.1.2.

14.5.2.2 **Longitudinal Sections Along Road Centre Lines**

The longitudinal sections along the road centre lines are required for the proper vertical alignment of the structure.

The longitudinal sections shall comply with the requirements as listed in paragraph 14.5.1.2 with the addition that: the section along the centre line of a proposed and existing roads shall also show:

- (a) The profile of river channel.
- (b) The highest known flood levels and approximate dates of flood levels as well as high and low tide levels for tidal water, if close to the sea.

14.5.2.3 Cross-sections Along Road Centre Lines

Cross-sections along the Road Centre lines shall comply with the requirements as listed in paragraph 14.5.1.3 with the exception that it shall be taken at regular intervals of 20 m over the full length of the longitudinal sections as defined in paragraph 14.5.2.2.

14.5.2.4 Cross-Sections of the River

A minimum of three cross-sections of the river, taken perpendicular to the direction of river flow, shall be surveyed and drawn as required for the purpose of determining the natural design flood level. The number, positions and extent of the sections shall be as specified by the client and shall be agreed upon before the survey is undertaken.

The format of presentation shall either be handdrawn, computer plotted or in appropriate digital form. Cross-sections shall be shown with the left hand side of the cross-section being the approach side at the smallest stake value of the bridge, irrespective the direction of the river longsection (see paragraph 14.5.2.5). A scale of 1:100 horizontally and vertically is preferred.

The positions of the cross-sections shall be shown on the survey plan.

14.5.2.5 Longitudinal Section Along the Riverbed

A Longitudinal section along the centre line of the riverbed $\pm 250\text{m}$ up and downstream at a scale 1:100 vertical and 1:1 000 horizontal shall be surveyed and plotted. The direction of the river longitudinal section shall be from left to right, where left is the left side of the river when looking in the direction of the increasing kilometre distances of the proposed road. This shall not always be in the direction of flow.

Note: The direction of the cross-sections and the longitudinal sections shall be clearly indicated on the presentation with respect to the direction of flow.

14.5.3 Railway Crossings

14.5.3.1 Site Plan

The site plan shall contain the locality sketch, unless otherwise indicated, and the survey plan.

14.5.3.1.1 Locality Sketch

The locality sketch shall be shown as an inset on the site plan. The information to be shown shall be taken as listed for road crossings (see paragraph 14.5.1.1.1). The rail kilometres of the crossing point shall also be shown.

14.5.3.1.2 Survey Plan

The survey plan shall comply with the requirements as listed in paragraph 14.5.1.2 except that it shall extend 200 m either side and 150 m from each end of the structure, or as otherwise specified. In addition, the survey shall also cover a strip 50 m to either side of the centre line of the road which extends from 150m to 600m behind each end

of the structure. However, this distance shall be confirmed with the client. The scope of the survey shall also include the full extent of any deviations of existing services and/or natural watercourses as supplied by the client.

In addition to the requirements listed in paragraph 14.4 and 14.5.1.2, the following data shall be given:

- (a) Existing road(s) and rail(s) with destinations in each direction.
- (b) Any existing staked and/or centre lines including stake value of the road and the kilometre distance of the rail at the crossing point(s) and angle of skew.

14.5.3.2 Longitudinal Section Along Road Centre Line

The longitudinal sections shall comply with the requirements as listed in paragraph 14.5.1.2 with the exception that it shall cover a distance of at least

600 m on each side of the bridge and that this long section shall extend a sufficient distance on each side of the structure to cover the full extent of the proposed approach embankments to the bridge (i.e. from original road level on the one side to original road level on the other side). However, the exact length shall be confirmed with the client.

In addition to paragraph 14.5.1.2 the section along the centre line of a proposed or existing road shall also show the rail kilometre distance and levels on both rails at the crossing point.

The requirements of the appropriate railway authority for the longitudinal section along the road centre line must also be met.

14.5.3.3 Cross-Sections Along Road Centre Lines

Cross-sections along the road centre lines shall comply with the requirements as listed in paragraph 14.5.1.3 with the exception that it shall be taken at regular intervals of 20m over the full length of the longitudinal

sections as defined in paragraph 14.5.3.2.

14.5.3.4 Longitudinal Sections Along Railway Tracks

A longitudinal section is required along the centre line of each railway line (proposed as well as existing) involved in the bridge crossing. The sections shall cover a distance of at least 300 m on either side of the proposed bridge(s). However, the exact length shall be confirmed with the client.

A scale of 1:100 vertically and 1:1000 horizontally is preferred.

Kilometre distances shall always increase from left to right. The format of presentation shall be either handdrawn, computer plotted or in appropriate digital form and the sections shall be shown as separate profiles.

The sections shall show the following:

- (a) Levels on top of both rails at 10 m intervals together with rail kilometre distances.

- (b) Formation levels and approximate original ground levels at 10 m intervals.
- (c) Geometric data in respect of the vertical and horizontal alignment of the rail track, if available.
- (d) The crossing point of the rail and road centre lines.
- (e) Rail destinations.
- (f) The position of existing structures including rail drainage pipes and services.

The requirements of the appropriate railway authority for the longitudinal section along the rail must also be satisfied.

14.5.4 Widening of Existing Structures

In the case of the widening of an existing structure, the extent of the survey depends on the nature of the envisaged works. It is therefore important that the exact scope of the survey and the requirements for the drawings be agreed with the client.

14.5.4.1 Site Plan

The site plan shall contain the locality sketch, unless otherwise indicated, and the survey plan.

14.5.4.1.1 Locality Sketch

The locality sketch shall be shown as an inset on the site plan and shall comply with the requirements for the corresponding crossing as listed in paragraphs 14.5.1.1.1, 14.5.2.1.1 or 14.5.3.1.1, as appropriate.

14.5.4.1.2 Survey Plan

The survey plan shall comply with the requirements for the corresponding crossing as listed in paragraphs 14.5.1.1.2, 14.5.2.1.2 or 14.5.3.1.2, as appropriate.

In addition to these requirements, the position and leading dimensions of the existing structure shall be shown.

14.5.4.2 Longitudinal Section Along Overpassing Road Centreline

The longitudinal section along the centreline or staked line of the overpassing road shall comply with the requirements for the corresponding crossing as listed in paragraphs 14.5.1.2, 14.5.2.2 or 14.5.3.2, as appropriate.

In addition to these requirements, the stake value and level at the beginning and end of each span of each deck shall be shown.

14.5.4.3 Longitudinal Section Along Underpassing Road/rail Track Centre Line

The longitudinal section along the centre line or staked line of the underpassing road/rail shall comply with the requirements for the corresponding crossing as listed in paragraphs 14.5.1.2 or 14.5.3.4, as appropriate.

In addition to these requirements, the minimum vertical clearance as well as all levels on the soffit profile above the centre line or staked line, as the case may be, shall be shown.

14.5.4.4 Cross-sections Along Road Centre Lines

The cross-sections along road centre lines shall comply with the requirements for the corresponding crossing as listed in paragraphs 14.5.1.3, 14.5.2.3 or 14.5.3.3, as appropriate.

14.5.4.5 Cross-sections of the River

The cross-sections of the river shall comply with the requirements as listed in paragraph 14.5.2.4.

14.5.4.6 Elevations and Cross-sectional Profile of the Bridge

14.5.4.6.1 Elevations and cross-sections shall be surveyed and drawn on a separate sheet showing the following levels and dimensions, to be measured on each side of each deck:

BRIDGE SITE SURVEYS

- (a) Total length of each span of each deck.
- (b) Clear span of each span of each deck.
- (c) Width and length of each support at top and bottom, if possible.
- (d) Overall width of deck and width of each footwalk.
- (e) Depth of deck.
- (f) Levels on top of footings, if possible.
- (g) Soffit levels.
- (h) Roadway levels at regular intervals not exceeding 10 m and at each end of each span along each edge and centre line of deck.
- (i) Kerb levels at supports.
- (j) Asphalt thickness at kerbs at ends of spans on each edge of deck.

14.5.4.6.2 For culvert type structures the following additional levels and dimensions shall be given:

- (a) Level on top of headwall, level of soffit below headwall and level on top of deck directly behind headwall at inlet and outlet. These levels are required on each side, left and right of structure.
- (b) Invert level at inlet and outlet.
- (c) Dimensions and relative positions of wingwalls.
- (d) Perpendicular width of each opening and each support at inlet and outlet, measured at the top and the bottom.
- (e) Position of headwalls relative to the centre line or staked line of the road.

14.5.5 Culverts

The survey and drawing requirements for culverts shall be taken as specified for river crossings (see paragraph 14.5.2). However, the exact scope of the survey must be agreed with the client.

14.6 Standards of Accuracy

14.6.1 Staking

The requirements of Chapters 2 and 12 shall apply to this specification. The following requirements shall also be adhered to:

In the case of curves, the closing error shall not exceed 1:5 000. Any error smaller than 1:5 000 must be adjusted pro-rata over the length of the curve. Where the error on curves exceeds 1:5 000 the curve shall be re-staked so that the error is less than 1:5 000 and subsequently adjusted pro-rata over the curve length.

On straights the pegs may not be more than 20 mm from the designed position.

The distance between any two consecutive pegs must be within the accuracy 1:5 000.

14.6.2 Levelling

The requirements of Chapter 2, paragraphs 2.4 and 2.5, Chapter 3 paragraph 3.4 and Chapter 12 shall apply to this specification.

14.6.3 Permanent Survey Stations

The requirements of Chapters 2 and 3 shall apply to this specification. Also take note of paragraph 14.3.2.

14.6.4 Spot-heights and Contours

Contours shall be drawn to 0,5 m vertical intervals on a scale of 1:500 and to 1 m on a scale of 1:1 000.

15. QUARRY SITE SURVEYS

15.1 Purpose of the Survey

The purpose of the survey is to produce plans for Quarry sites as required by the Inspector of mines.

15.2 Phases of the Survey

15.2.1 **Field survey** being the survey of all detail to produce the necessary plans.

15.2.2 **Cadastral** being the compilation of all the data defining the cadastral boundaries.

15.2.3 **Plotting** being the plotting of all detail and the drafting of plans in the format as required by the client and the inspector of mines.

15.2.4 **Checking** being the final checking of the quarry survey in the field and in the office, and the supply of all the related records.

15.3 Field Survey

15.3.1 Quarry Surveys Where Blasting is to Take Place

15.3.1.1 An area extending 500m from the perimeter of the quarry is to be surveyed. This shall be contoured at 5m intervals and plotted at a scale of 1:2 000.

15.3.1.2 A further area extending 20m from the perimeter of the quarry is to be surveyed. This shall be contoured at 1m intervals, and plotted at a scale of 1:200 and 1:500 so as to fit on an A0 sheet.

15.3.2 Quarry Surveys Where No Blasting is to Take Place

15.3.2.1 An area extending 20m from the perimeter of the quarry is to be surveyed. Where detail such as buildings and power or pipeline servitudes are within 100m of the perimeter of the quarry, the area must be extended to include them. This shall be contoured at 1m intervals and plotted at a scale of 1:200 or 1:500 so as to fit on an A0 sheet.

15.3.3 Detail to Be Surveyed

- 15.3.3.1 All topography and man-made structures and detail, which is consistent with the scale of the final plan, shall be surveyed.

15.3.4 Boundary Surveys

- 15.3.4.1 If the quarry was fenced prior to survey, the positions of corner posts and gates shall be surveyed and listed.
- 15.3.4.2 If the quarry is unfenced the client shall indicate the approximate positions of the proposed corner posts of the fence to be surveyed.
- 15.3.4.3 The client will indicate the required area to be set out.
- 15.3.4.4 Steel pegs 10mm diameter and 460mm long to demarcate all corner position shall be used. A substantial cairn of stones shall be placed over each peg and painted with a durable white paint. Where a cairn of stones has for some reason not been placed over the peg a fencing standard is to be driven in next to the peg and painted white, to indicate the approximate position of the peg.

15.3.5 Co-ordinates

All corner post pegs of the quarry shall be co-ordinated on the appropriate L.O system of the South African National Grid and the error shall not exceed the limits expressed in paragraph 2.3.

15.4 Cadastral

All cadastral boundaries shall be calculated and the appropriate property descriptions shall be shown on each survey plan. See Chapter 6. No cadastral key plans are required.

15.5 Draughting Requirements

- 15.5.1 The drawings shall be produced on the standard A0 size (841mm x 1189mm) stable polyester base transparent draughting material in accordance with the requirements of Chapter 11.

QUARRY SITE SURVEYS

15.5.2 The titles and quarry numbers of the drawings as well as the field books and calculation file number shall be obtained from the client.

15.5.3 The co-ordinates of control pegs and corner pegs shall be listed on the drawing in the co-ordinate list block.

15.5.4 The height datum and the origin of the elevation shall be stated on the drawing.

15.6 Survey Records

15.6.1 All records shall be submitted as stated in chapter 4.

15.6.2 Locality Sketch - The position of the quarry shall be shown on an A4 size print of a 1:50 000 topo sheet and be binded into the calculation file.

15.6.3 The numbers of the relative field books and calculation file shall be listed on the drawing.

15.6.4 After the necessary checks has been performed the calculation files and field books shall be submitted together with the completed plans.

15.7 Standard of Accuracy

For standards of accuracy see chapter 2.

16. SUPERVISION SURVEYS FOR THE CONSTRUCTION OF ROADS AND BRIDGES

16.1 Purpose of the Survey

The purpose of this survey shall be to provide adequate surveyed information to ensure that the road and bridge works, are constructed within the tolerances of the design. The survey system shall provide a management tool to the engineer for the evaluation of material quantities, claims from the contractor, preparation of payment certificates, on site designs checking, setting out works, comparison of quantities for quick and effective decision making by the engineer.

16.2 Phases of the Survey

The following are recognised as separate phases of the survey and shall be carried out or omitted as specified in the requirements of the contract.

16.2.1 The Construction Beacon Survey being the establishment of a planimetric and vertical survey network of permanent survey beacons and the supply of all related records. The permanent survey beacons can either be pillar beacons or normal survey beacons, depending on the type of terrain. (See chapter 3).

16.2.2 The Survey of Ground Lines to serve as a reference datum for the determination of quantities.

16.2.3 The Preparation of a Design Model which involves the merging of the design and the original ground line on computer, to serve as a design model during the construction phase.

16.2.4 The Checking of the Contractors Staking by independent survey methods.

16.2.5 The Measurement during the progress of construction work, or after the completion of a section, for the evaluation of specified dimensional tolerances and the controlling of quantities.

16.2.6 The Utilization of the Design Model as a tool for supervision purposes which involves:

- Evaluation of design tolerances
- Calculation of quantities for payment items as stipulated in the Bill of quantities

- Design alterations and additional designs
- Investigation of design alternatives for cost comparisons
- Management tool for effective site supervision

16.2.7 The Collection of As Built Data and the noting of alterations.

16.2.8 The Survey for the Compilation of a Completion Survey Map.

16.3 General

16.3.1 At the beginning of the contract, the Supervisory Surveyor shall make himself acquainted with the relevant Standard Specification for Road-and-Bridge Works. Particular attention shall be paid to the sections which deals with measurements and payments.

16.3.2 The Supervisory Surveyor shall make himself acquainted with the contract documents, the bill of quantities, the detail drawings and all surveying information.

16.3.3 The Supervisory Surveyor shall in co-operation with the Engineer, evaluate the contractor's setting out procedures to ensure that complicated elements of the road design like interchanges, structures and other important sections, are placed accurately. See the relevant Standard Specifications.

16.3.4 An agreement must be reached between the Supervisory Surveyor's measurement and calculations and that of the Construction Surveyor, before any material is removed or covering up of any work takes place. Agreement of differences of measurement shall be confirmed in writing.

16.4 Supervision Survey Guidelines

The client will decide which survey methods shall be applicable for supervision purposes depending on the extent of the project. The Survey can be done by either conventional or advanced survey methods.

16.4.1 Construction Beacon Survey

The client will be responsible for the timely establishment of the construction survey beacons at positions as allowed by the topography and the design, but not further than 500m apart. These beacons can be effectively used for the measuring of works and the breaking down of the survey network for establishing intermediate survey beacons and bench marks.

16.4.1.1 The establishment of the construction beacons shall be done in accordance to the client's requirements and shall be based on the specifications for the establishing of permanent reference points as set out in chapter 3.

16.4.1.2 Sufficient survey beacons, on which the original design survey was based on, shall be incorporated into the construction beacon survey to determine horizontal and vertical displacement between the two survey systems. When the linear displacement exceeds more than 100mm in the horizontal, and 20mm in the vertical, then the matter shall be referred to the Client for instructions in this regard.

16.4.1.3 The establishment and the fixing of construction beacons can be undertaken by outside survey firms although the planning of the positions and the co-ordination of the survey shall remain the responsibility of the client. The Engineer shall issue the final co-ordinates and levels of the construction beacons to the contractor prior to commencement of any work. All surveys for the duration of the contract shall be based on these co-ordinates.

16.4.1.4 With the establishment of the construction beacons, tying into the beacons of adjacent contracts shall be carried out meticulously. If any displacement is greater than specified as in paragraph 16.4.1.2 the matter must be referred to the Client for further instructions.

16.4.2 Protection of Beacons

The replacement of any construction beacon, damaged during construction activities shall be replaced by the Contractor, at his own cost, except for those beacons which the engineer has given permission to destroy.

Any existing cadastral beacons which may be destroyed by construction must first be referenced from any construction beacon by a registered professional Surveyor before it

is destroyed. This procedure does not exempt the Contractor from the requirements of the Standard Specifications, and the Land Survey act. (Act 9 of 1927).

16.4.3 The Ground Line Survey (Reference Plane)

A Ground line shall be surveyed as a reference plane for the determination of quantities. Survey measurements shall be at regular cross section intervals or by random DTM survey to get a true representation of the terrain. A terrain model shall be created if the latter method is utilized. Ground line surveys shall be undertaken at all areas affected by the construction works and as dictated by the Bill of Quantities, for example, quarries, borrowpits, spoil areas, road and bridgework areas etc.

16.4.4 The Preparation of a Design Datum Model

This phase involves the merging of the design (alignment, cross sections, pavement layers, edge development etc.) with the original ground line. All interim surveys for the evaluation of tolerances, and determination of quantities done as the construction progresses shall be entered into the datum model as interim measurements. The interim measurements shall be superimposed on the ground line and design cross sections, to serve as a data set for progress measurements, design tolerances evaluation, and quantity determination for payment items.

- 16.4.5 All setting out done by the Contractor shall be checked by independent survey methods. All, checks shall be based on the agreed construction beacon co-ordinates and levels.

16.4.6 Taking of Levels

The measurement of any levels can be done by conventional spirit levelling or DTM methods. For larger projects, it is recommended that the DTM method be applied to keep up with the pace of the construction. The DTM method offers the further advantage of the simultaneous collecting of positional data from which dimensional tolerances, progress and quantity calculations can be carried out. Levels for layer checks shall be taken on the cross section at positions agreed upon prior to the commencement of works between the Engineer and the Contractor.

Design levels shall be calculated for these agreed positions, and all layer checks shall be surveyed on these agreed positions.

16.4.6.1 Field Spirit-Level Method

If levels are determined by means of a spirit level, the normal principles of closed level runs shall be adhered to. No circular runs shall however be allowed. Layer check levels at the positions as agreed upon in paragraph 17.4.6 shall be taken on the same position in the form of a cross section at 20m intervals unless otherwise specified. All levels taken to check design tolerances shall be taken at the design level positions.

16.4.6.2 Field Digital Terrain Model (DTM) Method

If survey measurements are carried out using tacheometric methods, then the positions measured can be taken at random or at agreed cross section intervals. If levels are not measured in the same position as the design levels, then calculated levels shall be extracted in the same position as the design levels. To stay within the allowable tolerances, DTM observations for layer checks shall be restricted to a maximum distance of 100 metres.

The height of the theodolite may be determined by tape if adequate provision is made for the offset error incurred by tape measurements. However, determination of the level of the collimation line of the theodolite should preferably be utilized. This shall be done by means of vertical triangulation methods.

For interim DTM measurements to determine progress, quantities etc. see Chapter 13.

16.4.6.3 The Submission of Measurements

Data shall be submitted in the format of the relevant judgement plan, and out of specification tolerances shall be highlighted, dated and signed by the supervisory surveyor, and shall form part of the submission to the Engineer. All submissions shall be safeguarded and filed in an orderly system with clear reference to chainage, layer and section phase. If computer calculations are used, then clear reference shall be made with regards to the relevant computer file information.

16.4.6.4 All phases of the construction shall be carefully checked. Under abnormal circumstances when a 100% checking is not viable, a statistical judgement

plan shall be applied until normal test methods can be resumed. When any section is tested, whether a normal sized section or an isolated section, all measurements shall be taken in a stratified random sampling method.

16.4.7 As Built Data

The collection of as built data is the responsibility of the supervisory surveyor. This process involves the collection of all alterations to the original design and the noting of these alterations on the copies of the design plans kept on site.

16.4.8 Completion Surveys

16.4.8.1 The survey and compilation of a completion survey involves the updating of the layout plans after completion of the works. Relevant data collected for the as built purposes shall form part of the completion plans. If no layout plans exist, a tacheometric survey shall be undertaken between the road reserve boundaries, as fenced. If layout plans do exist, then a tacheometric survey shall be undertaken at all areas that have been affected by the construction works. Detail to be surveyed shall be done according to chapter 9.

16.4.8.2 The new strip survey of the construction area shall be clipped onto the original survey, design or layout plan, by means of a photographic or draughting process. This shall be done in consultation with the client. All relevant surveyed data previously measured during the contract shall form part of the completion survey and only outstanding information shall be surveyed and added to compile the completion plan. The supervisory surveyor shall provide the strip survey information in a Computer Aided Draughting (CAD) and hard copy format as specified in chapter 11.

16.5 Standards of Accuracy

The standards of accuracy for all surveys shall be taken as specified in the relevant chapters of the TMH 11 manual, Standard Specifications for Road and Bridge Works and the Project Specifications.

16.6 Records

- 16.6.1 All survey records during the construction period shall be filed in a orderly manner to ensure that information on all phases of the contract can be easily extracted when needed.
- 16.6.2 All survey records shall be continiously saved by a backup system and safeguarded at an independent storage place. This is normally done by daily transferring electronic survey data to Head Office of the supervisory firm.
- 16.6.3 Records, for the completion survey, geometric alignment and levels for the final layer, shall after completion of the contract be provided on a computer disk. Clear reference shall be made to the format of the data stored on the disk.

17. LIST OF ANNEXURES

ANNEXURE	DESCRIPTION
1.	Accuracy of Fieldwork; Land Survey Act
2.	Framework for Technical Reports
3.	Film Index
4.	Co-ordinate List
5.	Fieldbook and Calculation reference
6.	Standard Sheet Sizes
7.	Premarks
8.	Angle of Skew
9.	Pillar Beacon
10.	Conical Beacon
11.	Level requirements on Power Lines
12.	Level Diagram
13.	Working Plan
14.	Working Plan
15.	Cadastral Key Plan
16.	Flight Plan

SURVEY REGULATIONS IN TERMS OF THE LAND SURVEY ACT 9 OF 1927**LIMITS OF ALLOWABLE ERRORS IN FIELDWORK**

When the position of a point is determined by polars, traverse, triangulation, trilateration, Global Positioning Sytem (GPS) or a combination of these methods, the displacement between any observed ray, measured distance or Global Positioning Sytem (GPS) vector and the equivalent quantity derived from the final co-ordinates of the point fixed **shall not exceed:**

for Class A : A metres;

for Class B : 1,5A metres;

For Class C : 3A metres;

where A is equal to: $0,04 + \frac{S}{30\,000}$

and S is the distance in metres between the known and the unkown point: Provided that in the case of a Global Positioning Sytem (GPS) vector the comparison is made between the vector derived from the final co-ordinates and the measured vector after the datum transformation has been applied: Provided further that in the case of a traverse the comparison is made to the misclosure of the traverse, **where S is the total length of the traverse in metres.**

**GUIDELINE FRAMEWORK FOR THE COMPILATION
OF SURVEY REPORTS**

TECHNICAL SURVEY REPORT

1. SURVEY PROJECT DESCRIPTION

2. SURVEY PROJECT NUMBER

3. SURVEYED BY *(Name of Organisation that performed the Survey)*

4. DESCRIPTION OF THE PROJECT

4.1 Locality of the Survey Area.

4.2 Terrain Type Description.

4.3 Size of the Survey.

4.4 Date and Duration of the Survey.

4.5 Surveyors Involved *(names, qualifications and registration numbers)*.

5 Execution of the Survey Project

5.1 Instrumentation and Equipment Used.

5.2 Special Aids.

5.3 Application of Special Techniques.

5.4 Survey Methods Applied.

5.5 Problem Situations and Solving of Problems.

5.6 Delays Due to Unforeseen Circumstances.

5.7 Accuracies Obtained and Out of Specification Tollerances Accepted.

5.8 Survey Projection System and Height Datums.

- | | |
|------------------------|---|
| 6. RECORDS | <i>(Records submitted to the client and the format of digital data supplied.)</i> |
| 7. RECOMMENDATIONS | <i>(Results of the survey to be kept in mind for future surveys in the same area.)</i> |
| 8. GENERAL INFORMATION | <i>(Information which the surveyor wants to bring to the attention of the client, and not mentioned elswere in the report.)</i> |

SIGNATURE

Printed name

Designation

Date

NOTE: *This report can be supplemented with photographs, and included in the calculation file*

FILM INDEX

[illegible]

ANNEXURE 4

CO-ORDINATE LIST

SURVEY RECORDS No

SURVEY OF

SYSTEM LO

NAME AND HEIGHT OF LEVEL DATUM

DATE OF SURVEY _____

[illegible]

SURVEYED BY: Name _____

Signature _____

CHECKED BY: Name _____

Signature _____

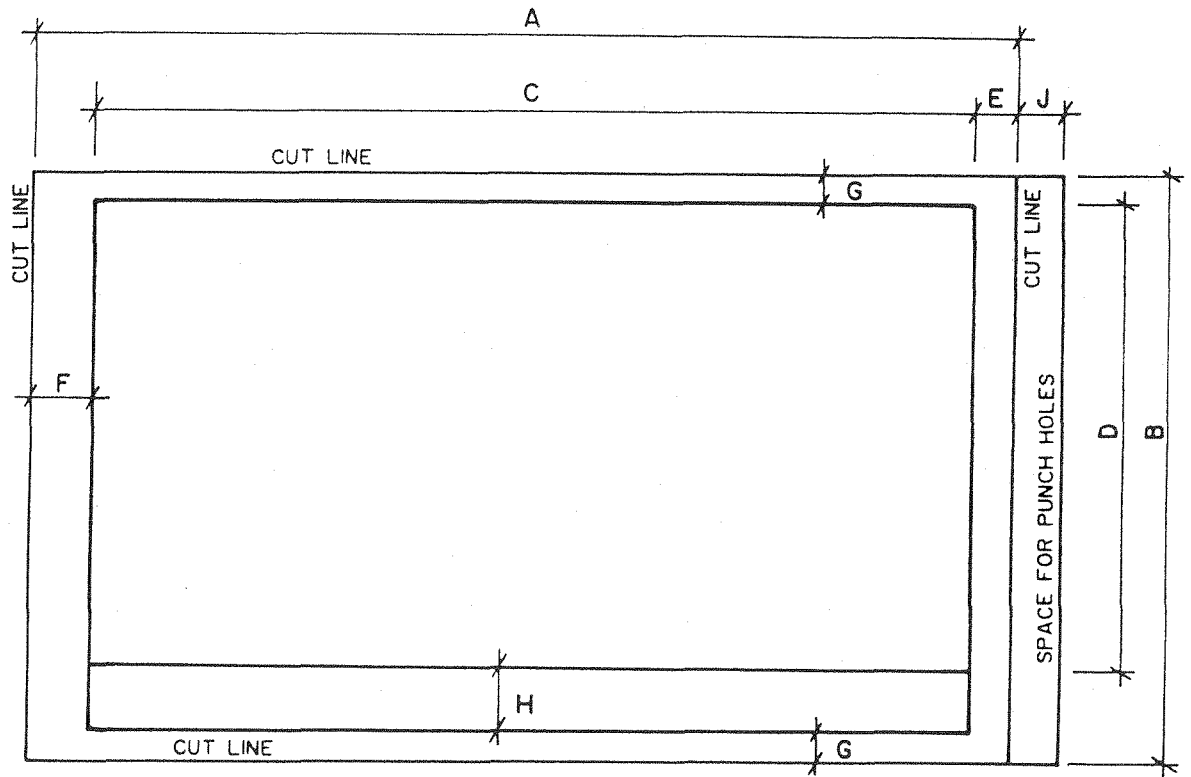
DATE: _____

ANNEXURE 5

FIELDBOOK AND CALCULATION REFERENCE

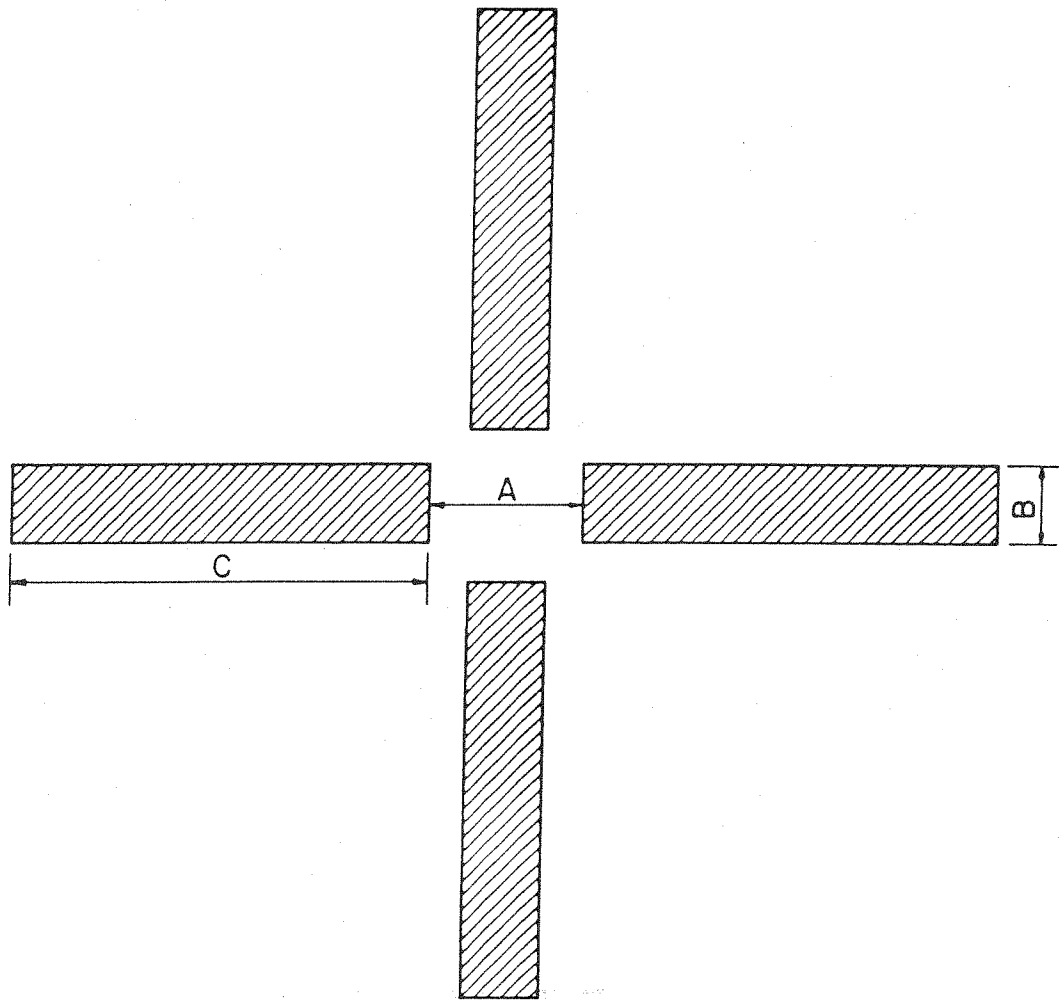
[illegible]

STANDARD SHEETS - A0, A1, A2 AND A3



SH.	A	B	C	D	E	F	G	H	J
A0	1189	841	1099	741	30	60	20	60	36
A1	841	594							
A2	594	420							
A3	420	297							

PRE-MARK FOR AERIAL SURVEY



PRE-MARK FOR PHOTOGRAPHY (ALL SCALES)

$$A = \left(\frac{60}{1000} \times \text{SCALE FACTOR} \right) \text{ mm}$$

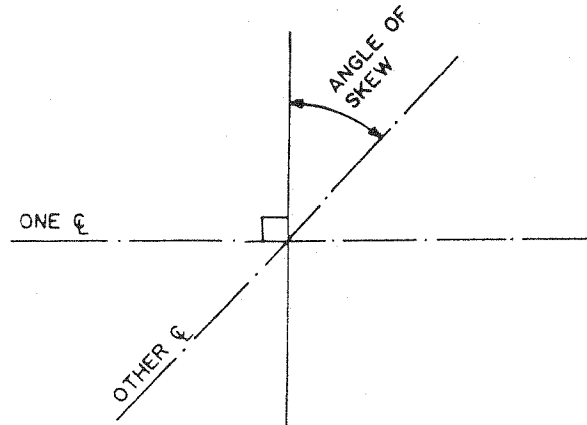
$$B = \frac{A}{2}$$

$$C = \frac{1}{2} \left(\frac{\text{SCALE FACTOR}}{2} \text{ mm} - A \text{ mm} \right) \text{ mm}$$

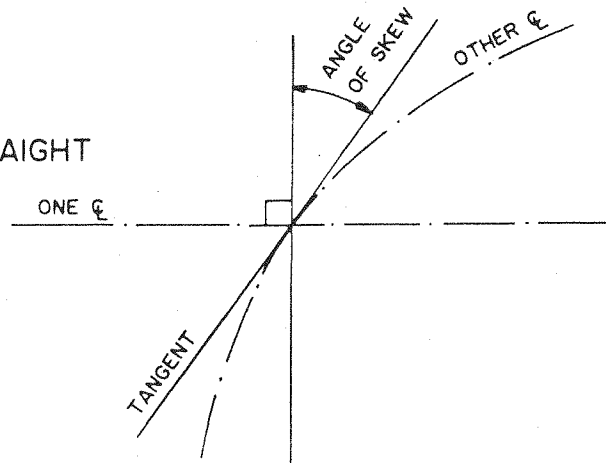
EXAMPLE OF ANGLE OF SKEW

CASE 1

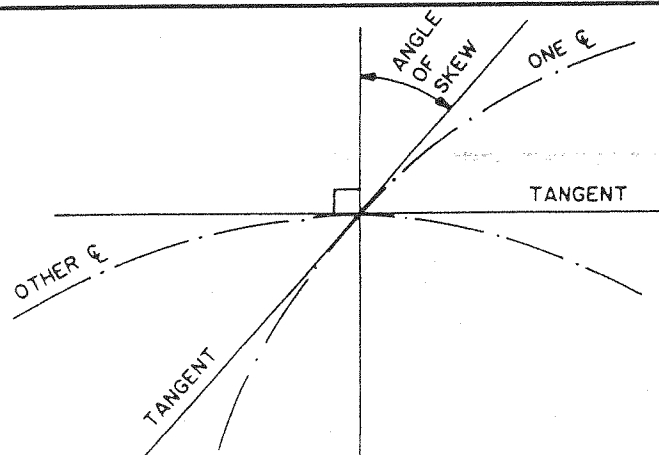
TWO STRAIGHTS

CASE 2

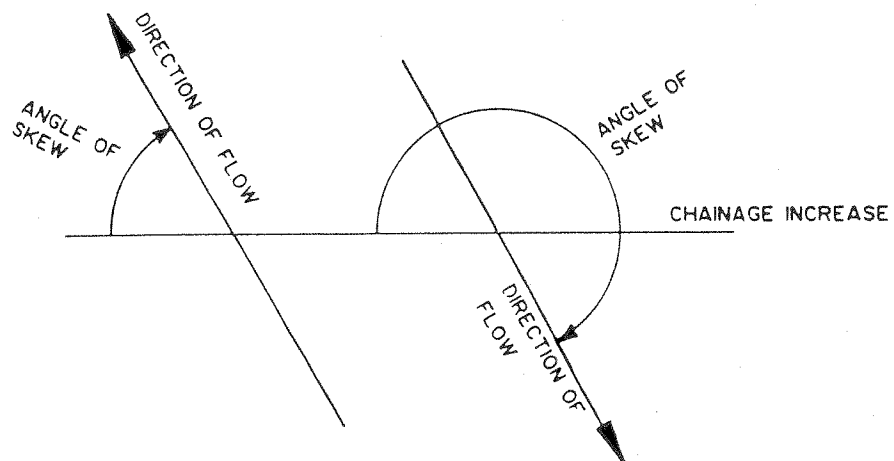
A CURVE AND A STRAIGHT

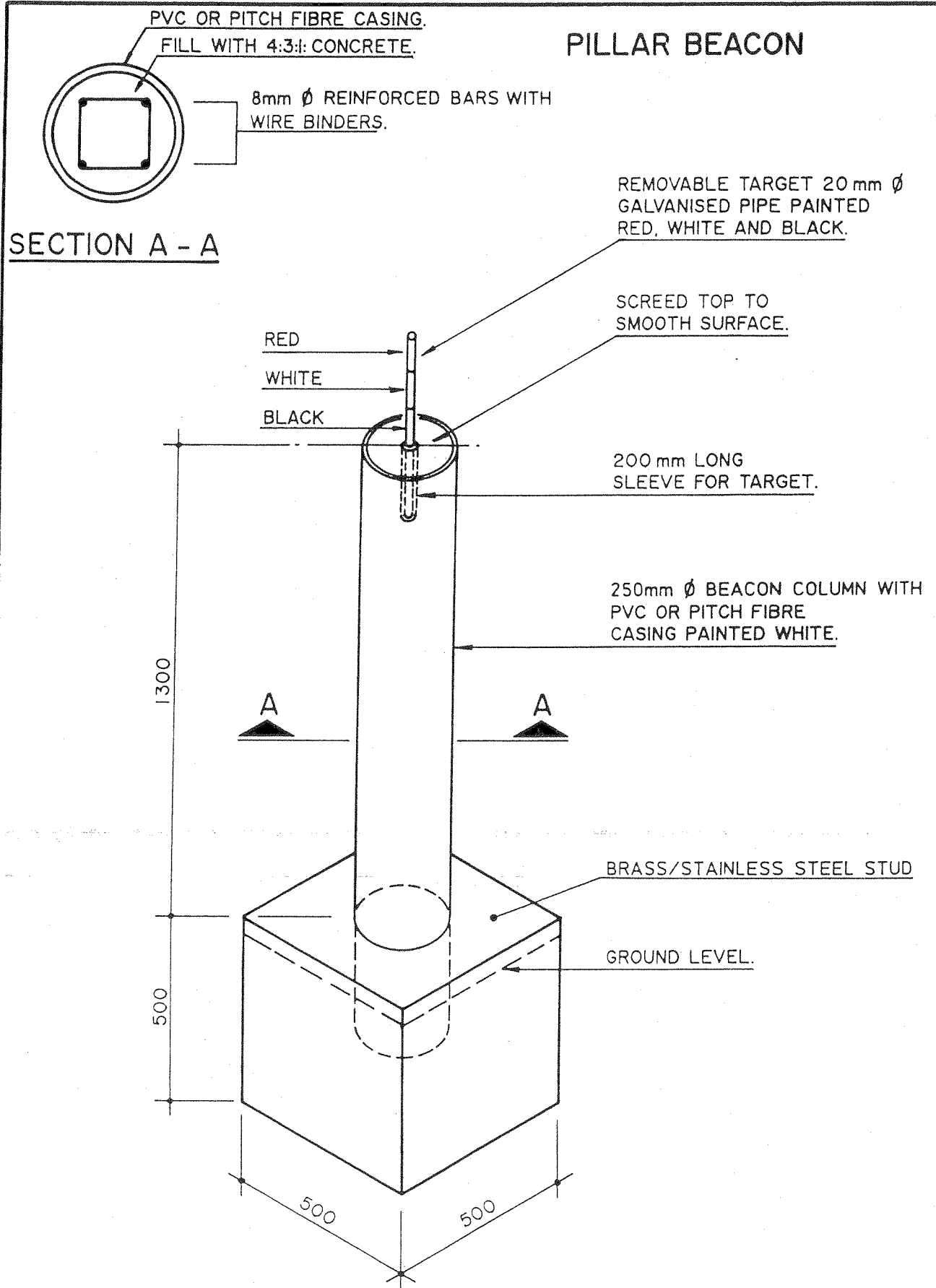
CASE 3

TWO CURVES

CASE 4

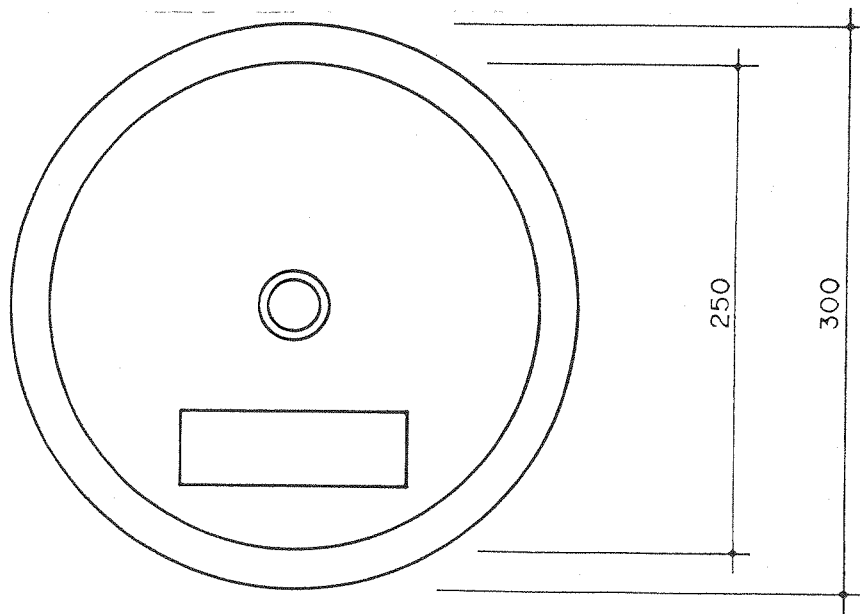
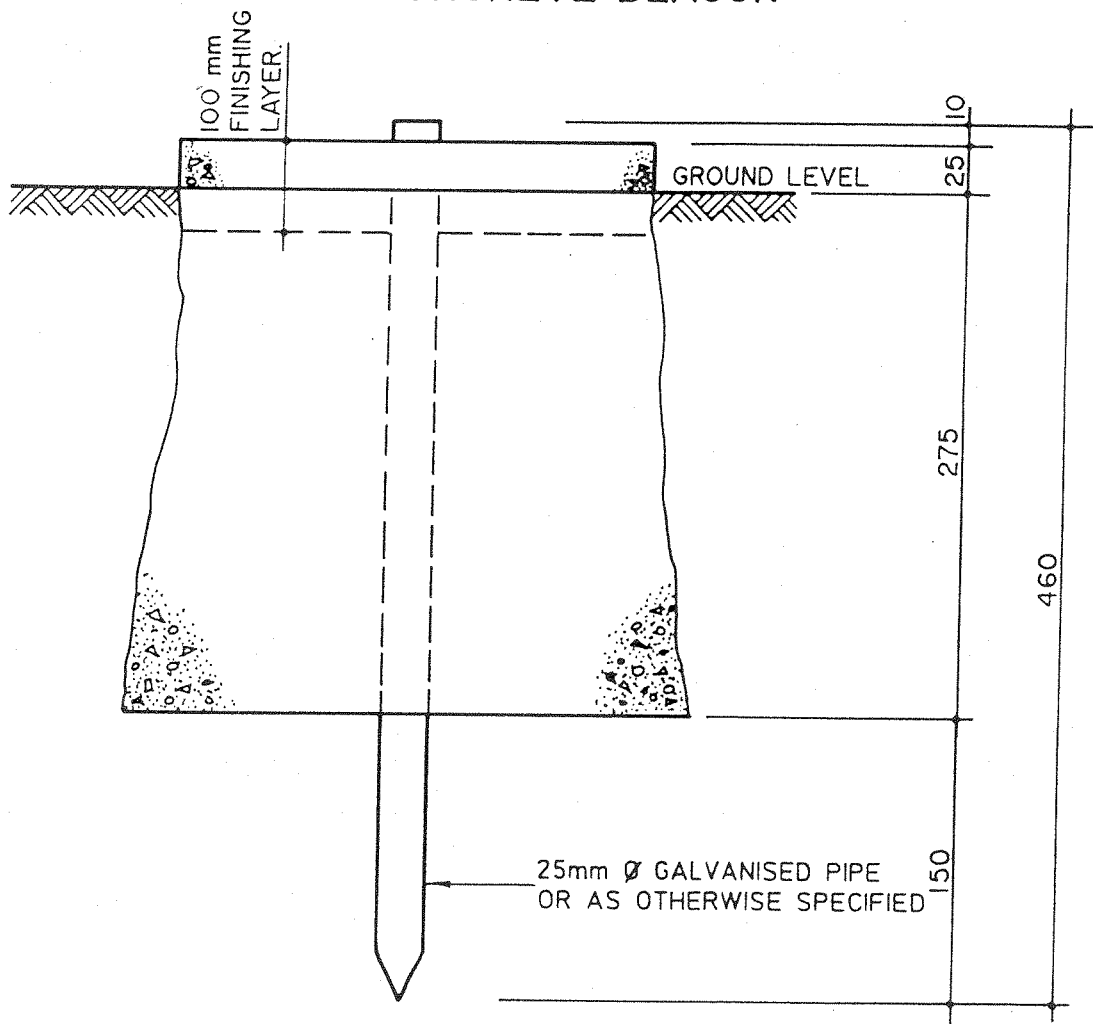
RIVER CROSSINGS



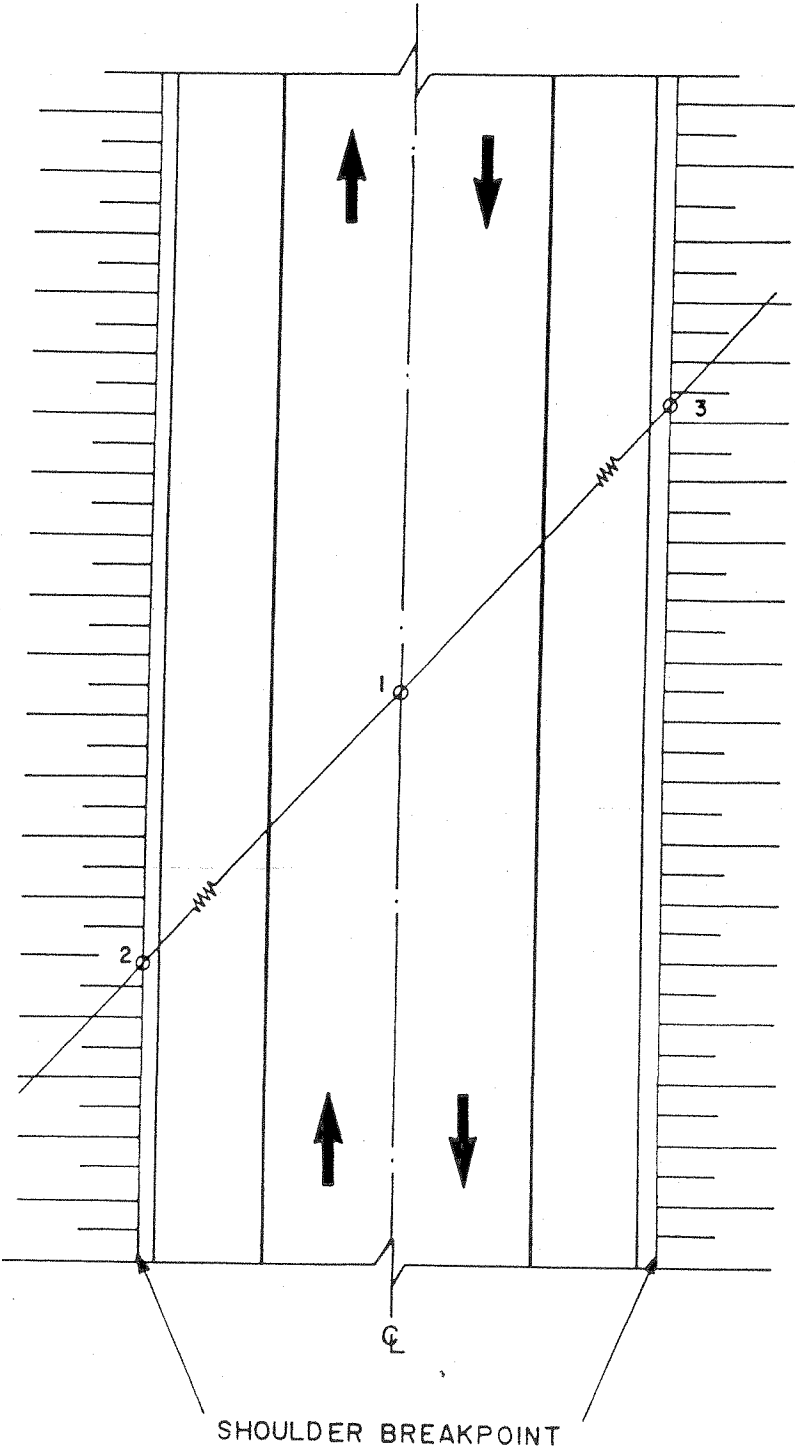


- NOTES :** 1. DRIVE IRON STANDARD INTO GROUND TO ENSURE STABILITY IN SOFT MATERIAL.
2. CONCRETE MIX TO BE 4:3:1 (STONE,SAND,CEMENT)

CONCRETE BEACON

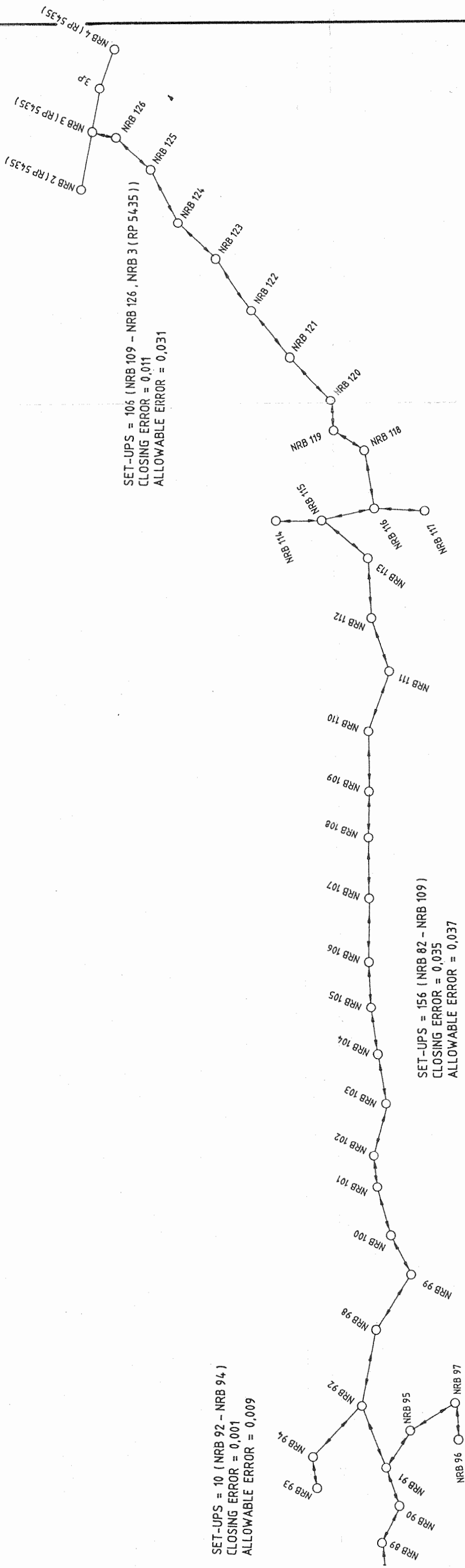


LEVELS REQUIRED ON POWER LINES



LEVELS REQUIRED AT POINTS 1, 2 AND 3

LEVEL DIAGRAM ROAD N1 - 25 MIDDLEFONTEIN - NABOOMSPRUIT SCALE

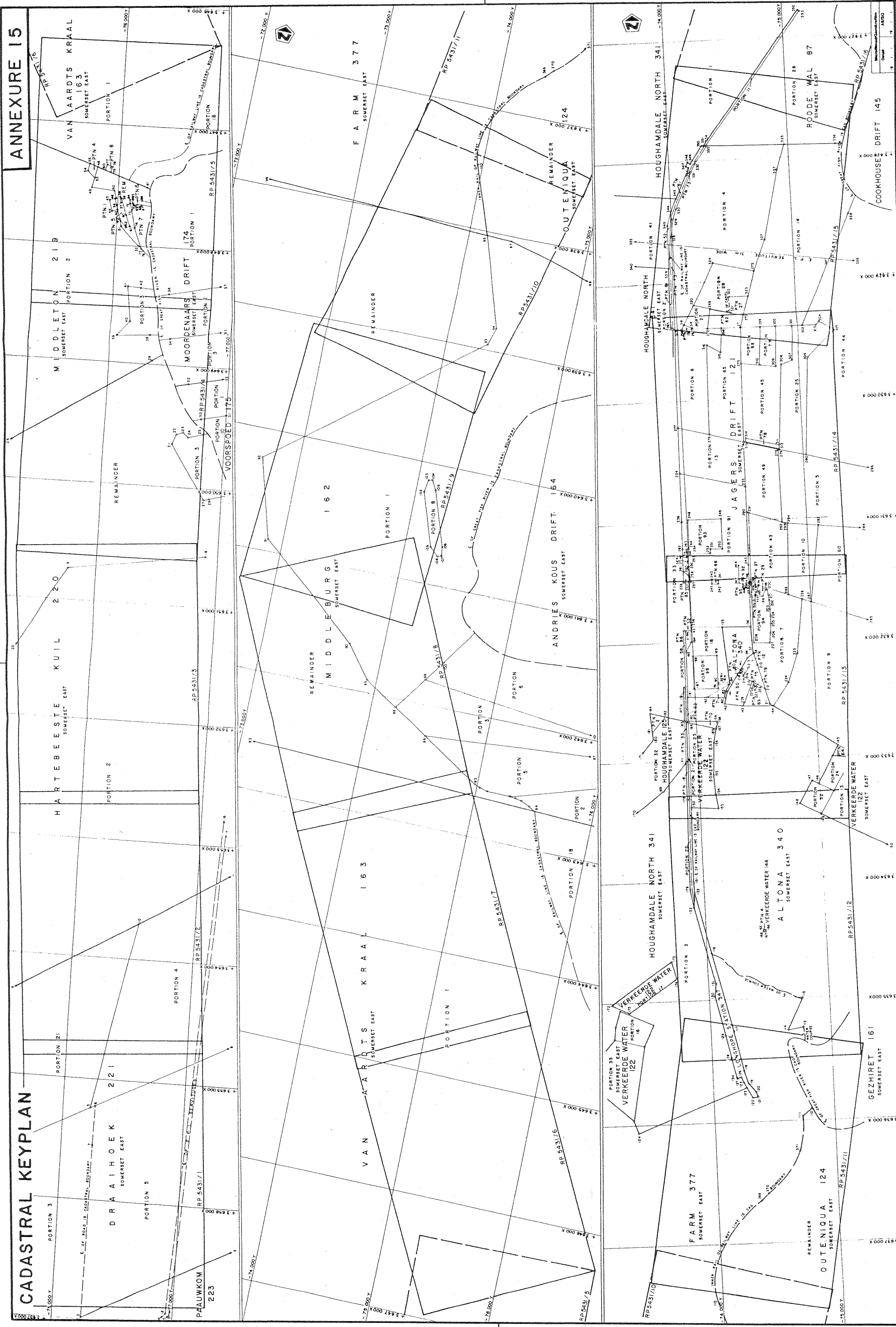


WORKING PLAN & SHEET LAYOUT





CADASTRAL KEYPLAN

[illegible]

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