Road Reference Marks
67/08/36
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Amendments

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1 PURPOSE
The purpose of this Standard is to detail Main Roads requirements for Road Reference Marks.

2 SCOPE
This Standard shall apply for all Road Reference Marks established for Main Roads. Advice and further information can be obtained by contacting the Senior Geodetic Surveyor.

3 DEFINITIONS
The following terms used in this procedure have the specific meanings indicated:

<table>
<thead>
<tr>
<th>Term</th>
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<tr>
<td>MGA</td>
<td>Map Grid Australia</td>
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<tr>
<td>GDA</td>
<td>Geocentric Datum of Australia</td>
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<tr>
<td>AHD</td>
<td>Australian Height Datum</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>RTK</td>
<td>Real Time Kinematic</td>
</tr>
<tr>
<td>DGPS</td>
<td>Differential Global Positioning System</td>
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<td>ICSM</td>
<td>Intergovernmental Committee on Surveying &amp; Mapping</td>
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<tr>
<td>SSM</td>
<td>Standard Survey Mark</td>
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<tr>
<td>RM</td>
<td>Reference Mark</td>
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<td>RRM</td>
<td>Road Reference Mark</td>
</tr>
<tr>
<td>VRS</td>
<td>Virtual Reference Station</td>
</tr>
<tr>
<td>CORS</td>
<td>Continuously Operating Reference Station</td>
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<tr>
<td>MCP</td>
<td>Minor Control Point</td>
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<td>GNSS</td>
<td>Global Navigation Satellite System</td>
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4 REFERENCES AND RELATED DOCUMENTS

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<thead>
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<tr>
<td>ICSM – Standard for the Australian Survey Control Network (SP1 ver. 2.1)</td>
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<td>GDA94 Technical Manual, Version 2.4</td>
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<tr>
<td>67-08-100</td>
<td>Survey and Mapping Guideline- Metadata Requirements</td>
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<td>67-08-38</td>
<td>Differential Levelling Standard</td>
</tr>
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<td></td>
<td>Landgate Requirements for GNSS Geodetic Surveys</td>
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5 ENTRY ONTO LAND

It is the Consultant's responsibility to seek and obtain permission from landowners, occupiers or management authorities before entering any property to undertake any survey and mapping work. Property includes Crown land which may consist of Reserves, National Parks or State Forests. Survey and mapping work may include, but is not limited to, the investigation, capture, placement and coordination of survey control points, the placement and removal of survey control targets, the collection of digital terrain models and the undertaking of field audits.

The consultant shall maintain a written report of all contact made with landowners while working on the survey or mapping contract. Details of landowner contact are to be outlined in the metadata statement. Any queries made by land owners with respect to the project are to be referred to the Main Roads project manager.

If access onto land is refused by the owners, the consultant will be required to immediately contact the Main Roads project manager to discuss the need for entry onto the land. If entry is required for the completion of the contract and there are no other alternatives, then Main Roads will arrange formal notification using delegated powers under the Land Administration Act. A formal notice of entry requires Main Roads to provide 7 days' notice to the owners. The process to arrange the formal notice of entry may take some time and the consultant must liaise with the Project Manager to ensure disruption to the contract schedule is minimised.

6 ENVIRONMENTAL IMPACT

All work is to be performed such that environmental impact is minimised. Any breach of environmental and heritage legislation during the execution of works is the sole responsibility of the consultant.

The consultant shall ensure any disturbances to the environment are kept to an absolute minimum. The consultant shall reinstate, clean-up and leave the site as close to its pre-disturbed condition as possible on completion of any work or investigation.

New tracks shall not be formed, existing tracks altered, fencing cut, clearing carried out, or damage or disturbance made of any kind unless approved by the Main Roads project manager.

The consultant shall be responsible for the cost of reinstating any damage to property or the environment resulting from their work.

7 ROAD REFERENCE MARKS

7.1 GENERAL

RRMs are established, coordinated and levelled on most project sites to create the control network to facilitate construction set out, audit, monitoring and to support future works. These marks are permanent ground marks intended to remain after the project is complete.

It is preferable, though not always possible; to place these marks after the clearing extents have been cleared/ earth worked/ set out.

It is critical that accuracy standards of the RRMx are maintained to ensure construction tolerances can be met. The relative uncertainty (RU) between adjoining RRMx should not exceed \(0.006\text{m}\). For a definition of RU please refer to the SP1 Standard, section 4.
7.2 REFERENCE DATUM

The horizontal positions of all RRMs will be supplied in the datum (either GDA94 or GDA2020) and the coordinates using the relevant project grid as specified in the scope of works.

The level datum shall be AHD71 unless an alternative is specified in the scope of works.

7.3 PLACEMENT OF MARKS

Unless otherwise specified, RRMs shall be:

- Located to ensure safety of the surveyor and public.
- Situated at a maximum of 400 metres apart.
- A minimum of 15 metres and preferably 25 metres from the design or existing centreline or at other locations considered safe during construction. EG. Outside the clearing line.
- Intervisible to at least one adjacent RRM or SSM. This requirement can be relaxed when the spacing is specified to be greater than 400m.
- Located adjacent to all intersections so that it is possible to define intersection details and be able to see a minimum of 100 metres along the intersecting road. For a large intersection, a pair of marks may be required.
- Located away from underground services in the area. Due to the depth of the star picket there is a real danger that some underground cables may be damaged. Such damage will be the responsibility of the Surveyors placing the RRMs.
- Facilitates the use of GNSS where possible.

7.4 CONSTRUCTION OF MARKS

Construction as per Appendix A (Urban) must be adhered to for all RRMs installed in the metropolitan and rural townsite areas. RRMs may be installed under a reticulation type cover (plastic or concrete) where this will improve pedestrian safety and the amenity of the area it is located in.

Construction as per Appendix B and C applies to rural areas outside townsite limits.

Construction as per Appendix D and E may be considered for specific job needs.

Where an RRM is set in concrete, it must have its allocated number stamped on an aluminium plate set flush in the concrete to aid in its identification.

It is preferable in areas of soft sand, that each RRM be referenced by two spikes set in concrete. In small projects where only one to four RRMs are placed it is a requirement that at least one RRM be referenced.

It is essential to provide a bearing to each Reference Mark placed for future re-location and use in verification of the RRM. These can be magnetic or Grid bearings and labelled as such on the summary. The RMs must be more than 2m away from the primary mark and orientated away from the road and obstructions.

Where a long traverse of 5 or more RRMs is established, then the referencing can be reduced to every fourth mark but must include the first and last mark.

Existing Landgate Benchmarks or SSMs may be used as RRMs if suitable and safe to do so. Their coordinates may be upgraded or adopted as appropriate to the survey and their position or height checked from their reference marks found. Upgraded BMs must be referenced with at least 2 RMs.
Witness plates are an important way of visually locating and protecting RRMs and their use is recommended for most situations. A stamped witness plate (RRM number and distance to mark) should be attached to a star picket then placed a suitable distance from the RRM (0 to 1 metre) and on the road side, only if its placement will not compromise the safety of the Surveyor or the public. Other options for a pedestrian area would be to nail the plate flush into the concrete surround of the RRM or place it on nearby poles or wire fences etc.

Brass plaques and witness plates may be obtained from the Main Roads Senior Geodetic Surveyor (08 9323 6381). Email: rod.stone@mainroads.wa.gov.au

### 7.5 INSTALLATION OF CONSTRUCTION PILLARS

Construction pillars can be used where the construction techniques may benefit from the installation of force centred pillars and the pillars are located in such a way that a vehicle cannot collide with them.

The spacing of these pillars would be dependent on the requirements of the construction needs. These pillars would be considered RRMs. Thus the types of RRMs shown in Appendix A, B and C may be replaced by more solid construction pillars with stainless plate and thread to facilitate efficient instrument setup (Photos below). These marks need to be coordinated as accurately as possible into the State Geodetic network as well as two way differential levelled to validated control - prior to the start of construction.

If the pillars are within the road corridor or on Crown land, they could become SSMs in their own right with appropriate numbers obtained from the Survey Section of Landgate. Observations and documentation to Landgate standards would be required.

See appendix D and E for specifications.

### 7.6 PROTECTION OF RRMs

The protection, replacement and or installation of RRMs required during construction is the responsibility of the principle contractor. Please refer to the contract documents. Any RRMs identified that could potentially be impacted by works must be identified to the Senior Geodetic Surveyor who may provide approval to remove an RRM without replacement.
8 RRM POINT PRECISION

8.1 HORIZONTAL PRECISION

New RRMs are to be established by closed survey network or traverse from a minimum of two and preferably more existing registered RRMs and/or Landgate SSMs of suitable positional uncertainty (PU) and Horizontal accuracy. Existing marks used must be validated from their RMs and the measurements documented. A minimum of two RMs (if available) that agree to the published values within 10mm are required.

In Metropolitan or Townsite areas, ideally only Landgate SSMs of 30mm PU (GDA2020) horizontal accuracy or less are to be used for RRM networks. In Rural areas where SSM control may be sparse, it would be preferable to use those marks with 50mm PU stated accuracy or less. The Main Roads Senior Geodetic Surveyor or Survey and Mapping Project Manager must be consulted. If existing marks cannot be found that conform to this requirement.

The horizontal accuracy of any existing RRMs used in the new network must be verified in the network least squares adjustment, prior to adoption. Thus in the initial adjustment, with just the SSMs fixed (if possible), these RRMs should be “floated” to see if their existing coordinates can be adopted. In many areas of the State and with the GDA2020 national adjustment strategy which has regular adjustment updates the existing RRMs may have values based upon SSMs which have been adjusted by Landgate since initial placement. The coordinate date published by Landgate and the establishment date of the RRM should be compared. Where existing RRMs are used it may be wise to re-observe them fully if they are more than 5 years old or the RRM is older than the published Landgate coordinate date.

To achieve the accuracy required and to align with Landgate Geodetic Standards the GNSS static baselines are to be observed for a period no less than 50 minutes plus 2 minutes per km of baseline length. Rapid static baselines are not acceptable.

8.1.1 RTK USE FOR OBSERVATIONS NOT PERMITTED

Static GNSS baselines or total station measurements are required for new mark placement. Previous use of RTK techniques to coordinate new RRMs introduced uncertainty into the positional accuracy as highlighted by Audit surveys and thus has been removed as an option for new control placement surveys.

8.1.2 AREAS REMOTE FROM EXISTING STATE SSMs AND OR BENCHMARKS

In some areas it will be necessary to bring coordinates and or height in utilising the AUSPOS online processing service with a minimum of 4 hours of GNSS data. In these cases, newly placed RRMs must be linked by conventional levelling (and ideally a traverse) buy adopting one of the AUSPOS derived level (AHD) values. A least squares adjustment incorporating all data should be performed to reveal and report on any inconsistencies. This method must be stated on the RRM summaries and in the field report and should be approved by the Senior Geodetic Surveyor prior to survey.

9 VERTICAL PRECISION

9.1.1 SECTION TOLERANCES

All new RRMs shall be levelled with a two way traverse unless otherwise instructed which must include a minimum of one validated Landgate Benchmark or two existing RRMs validated from reference marks.
The difference between the forward and backward levelling of any section or any combination of adjacent sections shall not exceed:

- \( 0.012 \sqrt{K} \) metres (12RootK) where \( K \) is the distance in kilometres. Any section between new marks over 1KM that approach 12RootK should be reviewed and possibly be relevelled as it is MRWA's expectation that modern digital instruments with calibrated staves will obtain repeatability around 4 to 6RootK.

- The vertical accuracy for distances less than 1km shall be on a prorata basis relative to a 1 km tolerance (0.012 meters). For example the accuracy for a section 260 meters long shall be ±0.0031 metres or better.

### 9.1.2 TRAVERSE TOLERANCE

The misclose of a traverse between validated datum bench marks should not exceed 12RootK where \( K \) is the total distance of a traverse in kilometres. When this tolerance is achieved the level traverse is to be adjusted to the datum values proportionally according to distance along the traverse. When the misclose between existing Landgate marks is outside of the 12RootK tolerance the Senior Geodetic Surveyor must be notified prior to adjusting the level network. Refer to Appendix A in the Main Roads Differential Levelling Standard 67-08-38 for a worked example.

All levelling for RRM placements must be carried out using calibrated Fibreglass (or Invar) staves to conform to Landgate Standards for data lodgement, provide improved accuracy and repeatability between survey crews. The calibration certification must be less than 5 years old as per SP1 standards and the certificate supplied when lodging the data. Currently, Landgate do not offer a self service computation of the calibration values. The observed data must be supplied to Landgate as per the instructions on the Landgate website (https://www0.landgate.wa.gov.au/business-and-government/specialist-services/geodetic/edm-calibration) As such self calibration certificates will not be accepted until Landgate provides a self service for staff calibration again.

### 10 ADJUSTMENT

All networks or traverses must be adjusted using a Least Squares adjustment. When using software that incorporates transformations within the adjustment (such as Trimble Business Centre) this function must be disabled. Adjustments submitted with transformation parameters may be rejected by MRWA.

MRWA may opt to have Landgate perform the adjustment of the RRMns to upgrade the State Geodetic Network at the same time. This need may be identified in the scope of survey works or become evident once the RRM network has been observed. If, after observing the RRM network in GDA2020, there are anomalies identified in the published state geodetic network the MRWA Senior Geodetic Surveyor must be contacted to discuss if an upgrade to the State Geodetic Network would be beneficial prior to preceding.

The GDA94 State Geodetic Network was locked in late 2016 and cannot be upgraded.
11 RRM NUMBER ALLOCATION

RRMs are uniquely numbered according to the current Main Roads road number. Such RRM number allocations are to be obtained from the Senior Geodetic Surveyor. The application for numbers should include road number, road name, start and finish SLK where known, plus the road section name and the number of marks required. RRM numbers allocated but not used, are to be documented and may be re-allocated by Main Roads to another survey.

12 DATA LODGEMENT

For each project involving the placement of RRMs, the following information must be submitted to the Senior Geodetic Surveyor. **Failing to supply the data to MRWA Senior Geodetic Surveyor renders the installation of RRMs non-compliant to MRWA standard 67/08/36.**

a) A brief survey report (summary) with details of methodology used, and any other relevant information which expedites finalisation and registration of the new RRMs and clarifies all issues found.

b) A sketch of the network observed shall be provided. This can be generated from the software package used for the least squares adjustment. It is very important for Main Roads to know what marks were used to provide coordination for the new RRMs.

c) An RRM summary form (APPENDIX F or G) shall be completed for each RRM established. All details on the RRM Summary form must be completed including MGA and Project Zone coordinates. Please use the correct form for the datum as required for the survey.

d) An excel or .csv file showing: pt. #, E, N, RL, Zone, Datum, Constrained H(orizontal) and or V(ertical) in the adjustment for all points in the network and a brief header showing project information. State whether marks are new or existing.

e) GNSS data including raw and RINEX files (either 2.x or 3.x), Antenna measurement and mark images (see Landgate Requirements for GNSS Surveys) and booking sheets or field notes. If the RRMs are positioned exclusively using terrestrial observations then this data is not required. If a combination of both GNSS and terrestrial observations are used, then both sets of raw data is required.

f) Raw levelling instrument files and abstract or company adopted level reduction files. Temperature records are required to be documented. Include staff calibration certificate.

g) Documentation showing the measurements of RMs used to validate the primary existing marks. A marked up summary sheet is sufficient.
## 13 APPENDICES

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<tr>
<th>Appendix</th>
<th>Title</th>
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<tr>
<td>Appendix A</td>
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<td>Road Reference Mark for Stable Soil Rural Areas Only</td>
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<td>Appendix C</td>
<td>Road Reference Mark for Unstable Soil – Where Clay, Blacksoil, &quot;Crab-holes' Exist. Rural Areas Only</td>
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<td>Appendix D</td>
<td>Road Reference Mark Permanent Machine Control Construction Pillar</td>
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<td>Appendix E</td>
<td>Road Reference Mark Construction Pillar Temporary</td>
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<td>Road Reference Mark Summary for GDA94 datum projects</td>
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<td>Road Reference Mark Summary for GDA2020 datum projects</td>
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APPENDIX A: BRASS PLAQUE ROAD REFERENCE MARK URBAN AND RURAL TOWNSITE AREAS

BRASS PLAQUE

CONCRETE

GROUND

LEVEL

TIE WIRE TO SECURE BRASS PLAQUE TO STAR IRON PICKET

NORMAL CLASS CONCRETE N20

STAR IRON PICKET MIN. LENGTH 675

250

450 min.

700

NOT TO SCALE
DIMENSIONS IN MILLIMETRES
APPENDIX B: ROAD REFERENCE MARK FOR STABLE SOIL. RURAL AREAS ONLY

- **50 x 50 ALUMINIUM TAG**
- **250 Ø**
- **CONCRETE**
- **GROUND**
- **LEVEL**
- **Eg. SAND, GRAVEL**
- **NORMAL CLASS CONCRETE N20**
- **STAR IRON PICKET MIN. LENGTH 675**

NOT TO SCALE
DIMENSIONS IN MILLIMETRES
APPENDIX C: ROAD REFERENCE MARK FOR UNSTABLE SOIL – WHERE CLAY, BLACKSOIL, “CRAB-HOLES” EXIST. RURAL AREAS ONLY

- P.V.C. SLEEVE
- 50 x 50 ALUMINIUM TAG
- 250 Ø
- CONCRETE
- GROUND
- E.g. BLACKSOIL, CLAY
- NORMAL CLASS CONCRETE N20
- P.V.C. SLEEVE 500 N.B.
- STAR IRON PICKET MIN. LENGTH 675
APPENDIX D: ROAD REFERENCE MARK PERMANENT MACHINE CONTROL CONSTRUCTION PILLAR

SURVEY PILLAR
DESIGN EXAMPLE (2)

CONCRETE FILLED 300mm PVC / PRESSURE PIPE

EXCAVATED HOLE FILLED WITH CONCRETE TO A DEPTH OF APPROXIMATELY 1 METRE

STAINLESS STEEL PLATE WITH STANDARD S/S 3/8" THREADED BOLT, SET INTO TOP OF PIPE.

1500 - 1700mm

1700 - 2000mm

640 MIN

ELEVATION 1:20

NOTES
1. EXCAVATED HOLE TO BE FILLED WITH CONCRETE TO A DEPTH OF APPROXIMATELY 1 METRE, ONCE PIPE IS MADE VERTICAL.
2. CONTACT SURVEY & MAPPING BRANCH FOR STAINLESS PLATE SUPPLIERS.
3. PILLAR TO BE PAINTED DARK GREEN.
4. CONCRETE CLASS N25

SURVEY PILLAR
STANDARD DRAWING
DESIGN EXAMPLE (2)

A. BERRY

201031-0173
### MARK HAS BEEN SURVEYED ON THE GDA94 DATUM

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<th>ROAD NAME</th>
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<td>SECTION</td>
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<td>REGION</td>
<td>LOCAL AUTHORITY</td>
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**ESTABLISHING SURVEYOR DATA REFERENCES:**

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<th>NORTHING</th>
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<td>PROJECT GRID 94</td>
<td>EASTING</td>
<td>NORTHING</td>
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<tr>
<td>AHD HEIGHT (MARK)</td>
<td>(RM1)</td>
<td>(RM2)</td>
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**OBSERVATION TYPE:**
- GNSS STATIC □
- TOTAL STATION □

### DESCRIPTION AND LOCATION DIAGRAM

Mark is a [GDA](image)
## APPENDIX G: ROAD REFERENCE MARK SUMMARY (GDA2020)

**MARK HAS BEEN SURVEYED ON THE GDA2020 DATUM**

| ROAD NAME : | Road No. |
| SECTIONS : | SLKm : |
| REGION : | LOCAL AUTHORITY : |
| SURVEYOR : | DATE |

**ESTABLISHING SURVEYOR DATA REFERENCES:**

| MGA 2020 ZONE : | EASTING : |
| PROJECT GRID 2020 : | NORTHING : |
| AHD HEIGHT (MARK) : | (RM1) : (RM2) : |

**OBSERVATION TYPE:**

- GNSS STATIC □
- TOTAL STATION □

**DESCRIPTION AND LOCATION DIAGRAM**

Mark is a 🏗️ GDA2020