



mainroads
WESTERN AUSTRALIA

Electrical & Intelligent Transport Systems Infrastructure Asset Drawing Guidelines

Main Roads Western Australia

Electrical Asset Management

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Amendments

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0	07/09/2001	Original	
0	28/03/2011	Original	

0	25/05/2011	Original	
0	08/06/2011	Original	
0	06/07/2011	Original	
0	29/08/2011	Original	
1	09/02/2012	Original	
2	23/03/2012	Original	
3	06/07/2012	Original	
4	25/09/2015	Complete Review, editorial and Reference Drawing Number	
5	20/05/2020	Complete rewrite of content	All
6	25/08/2020	Revision to include text regarding “Brownfields” work.	Section 9.1
7	01/09/2020	Revision to include text regarding Principal’s right to expedite review process.	Section 8.1

1 PURPOSE

The intent of design standards is to specify requirements that assure effective design and delivery of fit for purpose Main Roads Electrical and Intelligent Transport System (ITS) infrastructure assets for best whole-of-life value with least risk to State Government service standards and safety. Design standards are also intended to promote uniformity of approach by Engineers, Drafters and Constructors to the design, construction, commissioning and delivery of road infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Main Roads Western Australia has adopted a policy of outsourcing most of the electrical engineering and electrical detailed design associated with the procurement of its assets. The drawings which document the resulting assets need to be in accordance with Main Roads operational needs and standard practices. With the increasing amount of road upgrade projects, the drawings also need to be in an acceptable state to allow future projects to efficiently build upon past works. The cost to the State Government of designing Electrical and ITS infrastructure anew for each upgrade is uneconomic.

This design Standard does not address all issues that will need to be considered by the Engineer in respect to a particular installation.

It is an objective of Main Roads Western Australia that Electrical and ITS assets will be documented so that these can be constructed and maintained at minimum long term cost. In respect to matters not covered specifically in this Standard, the Engineer must aim his / her practices at achieving this objective.

2 SCOPE

The scope of this Standard covers all drafting documentation for Electrical and ITS, which includes all electrical power, instrumentation, controls and communications aspects of assets to be owned, operated and / or maintained by Main Roads.

3 MANDATORY REQUIREMENTS

In general, all requirements of this Standard are mandatory. If there are special circumstances, which would justify a deviation from this Standard, the matter must be referred to the Main Roads Principal Electrical Standards Engineer (PESE). In the event of such a circumstance, written requests can be submitted via the Technical Query and Request for Information Form, which can be found on the Main Roads external website. No deviation from the requirements of this Standard is to be implemented without written approval from the PESE.

The use of the imperative 'must' indicates a mandatory requirement. The use of verbs such as 'will', 'should' or 'may' indicates recommended and preferred practice.

4 DEFINITIONS

Term	Definition
AS/NZS	Australian and New Zealand Standards
Drafter	The draftsman responsible for producing the CAD drawing.
Engineer	The person responsible for the design.
IFC	Issued for Construction
ITS	Intelligent Transport Systems
Main Roads	Main Roads Western Australia
PESE	Principal Electrical Standards Engineer
SLK	Straight Line Kilometres

5 REFERENCES

The drafting practices recommended by the withdrawn Australian Standards Electrotechnology AS 1102 series as well as AS 3702, form the basis of the Main Roads design and drafting system. Although withdrawn, this system also forms the basis for the design and drafting system at most major heavy industrial plant facilities in Western Australia and so will ensure transferability of skills and availability of relevantly skilled staff. This system is also used extensively within Western Australian State Government, for example the Water Corporation Design Standard DS 24, as well as Western Power.

Although the system was originally derived from European International Electrotechnical Commission Standards, reference has not been made to these more current documents owing to the cost of purchase. Although the withdrawn Australian Standards are not current, the basic framework is still fit for purpose and widely available at low cost; therefore, the use of withdrawn Australian Standards is a cost saving measure and will be adhered to for this reason. In time, it is expected that Standards Australia may obtain funding to update these withdrawn standards.

It must be noted that, as a result of the withdrawn standards not being sufficiently current; the Engineer must perform significant additional design work on each project which otherwise would not be required. This work consists of ensuring that these aged standards issues are identified and each addressed in turn. It is expected that appropriate Engineering judgement will be shown in respect of how this result is achieved.

Australian and New Zealand Standards (AS/NZS), Main Roads Western Australia (Main Roads) Standards and Main Roads Test Methods are referred to in abbreviated form, e.g. AS 1234, MRS 67-08-43 or WA 123. The full titles are given below for convenience.

Acts and Regulations

Electricity Act 1945 (WA)

Electricity (Licensing) Regulations 1991 (WA)

Western Australian Electrical Requirements

Australian and New Zealand Standards

AS 3702	Item Designation in Electrotechnology
AS 1100.101	Technical Drawing Part 101: General Principles
AS 1102.101	Graphical Symbols for Electrotechnical Documentation – General Information and General Index (Withdrawn)
AS 1102.103	Graphical Symbols for Electrotechnical Documentation Part 103: Conductors and Connecting Devices (Withdrawn)
AS 1102.106	Graphical Symbols for Electrotechnical Documentation Part 106: Production and Conversion of Electrical Energy (Withdrawn)
AS 1102.107	Graphical Symbols for Electrotechnical Documentation Part 107: Switchgear, Controlgear and Protective Devices (Withdrawn)
AS 1046.1	Letter Symbols for use in Electrotechnology – General (Withdrawn)
AS 1046.2	Letter Symbols for use in Electrotechnology – Telecommunication and Electronics (Withdrawn)
AS/NZS 4381.1	Preparation of Documents used in Electrotechnology Part 1: General Requirements (Withdrawn)
AS/NZS 4381.2	Preparation of Documents used in Electrotechnology Part 2: Functional-orientated diagrams (Withdrawn)
AS/NZS 4381.3	Preparation of Documents used in Electrotechnology Part 3: Connection Diagrams, Tables and Lists (Withdrawn)
AS/NZS 4381.4	Preparation of Documents used in Electrotechnology Part 3: Location and Installation Documents (Withdrawn)

Other Standards

AS ISO1000 The International System of Units (SI) and its application

Main Roads Specifications and Documents

Main Roads Western Australia 700 Series Specifications

6 DRAWING MANAGEMENT

6.1 Drawing Content Responsibility

All Contractors must modify and complete the Main Roads Title Block on all drawings. The following fields must be complete with the appropriate personnel as follows:

- Drawn: The draftsman responsible for the delivery of the drawing content;
- Engineer: The professionally qualified Engineer with discipline experience, responsible for instructing the draftsman, e.g. Electrical – Refer *Electricity (Licensing) Regulations r.19 (1A)*;
- Verified: A professionally qualified Engineer of the appropriate discipline for verification; and
- Approved: Principal Electrical Engineer or Project Manager.

All final As-Constructed Drawings submitted to Main Roads must be wet signed and dated by the above personnel in Tagged Image File Format - *.tif. Note that the AutoCAD files and a PDF generated direct from the AutoCAD, with names and initials in place of the wet signatures, is also required.

6.2 Electronic Document Management

AutoCAD version 2015 or later must be used for the production of drawings. MicroStation drawings will not be accepted.

Final As-Constructed Drawings must be submitted in all formats below:

- AutoCAD *.dwg;
- Portable Document File Format *.pdf – directed generated from the CAD; and
- Tagged Image File Format *.tif – wet signed by the responsible personnel.

Where drawings have related references such as 'Xref's', these must be included in the handover of all AutoCAD drawings by either one of the following methods:

- Binded to original drawings; or
- Submitted as separate AutoCAD files along with the original drawing.

Each drawing prepared by a Contractor may carry an unobtrusive company or Alliance logo, electronically inserted in the Title Block.

6.3 Drawing Numbering

In respect of numbering, the following stipulations apply:

- All drawings at every point of existence must contain a unique Main Roads drawing number;
- Two drawings with the same drawing number and revision with differing content must never exist; and
- Two drawings with the same content or of the same asset, but with differing drawing numbers must never exist.

In progress design revisions must be numbered with an alpha character, e.g. Revision 3A if a new design after Revision 3 is being prepared. The Issued for Construction (IFC) Revision must be the next revision number or Revision 0 if a new drawing.

Drawing file names must consist only of the drawing number, with a lower case r followed by the revision number, e.g. 202018-1234r1 or 202018-1234r1A for a design revision. After which 202018-1234r2 would be IFC. Following construction, Red-line markups must be allocated a new revision and the file name appended with –RED, e.g. 202018-1234r3-RED. The As-Constructed drawings would then be allocated the drawing number 202018-1234r3. Drawing comments must be allocated the same drawing number but the file name appended with –COM, e.g. comments on design drawing 202018-1234r1A are to be saved as file name 202018-1234r1A-COM.

All drawings for review and final submission must contain Main Roads drawing numbers. Upgrades of existing roads must book out the existing drawings via Electricalplanrequest@mainroads.wa.gov.au and use that same drawing number with a new revision of the asset.

Drawing numbers are ten integers in length in format yyyyrr-xxxx, where:

- yyyy - Year of allocation;
- rr - Main Roads Region, Branch or Directorate who will own final drawings; and
- xxxx - Individual drawing identifier within the sequential block of drawings allocated by Main Roads.

All cross-referencing must be done using Main Roads drawings numbers.

6.4 Drawing Title

The Drawing Title has five lines of space; these are to be designated as follows:

- Road or project name;
- Section of road or description of specific location (if applicable);
- SLK details or coordinates (if applicable);
- Asset name (if applicable); and
- Type of drawing, e.g. Electrical Schematic, Termination and Interconnection or General Arrangement.

7 DRAWING AND DRAFTING GENERAL REQUIREMENTS

7.1 CAD Software

Conventional two-dimensional drafting is the preferred method for the production of electrical drawings. Drawings drafted using AutoCAD LT, AutoCAD Electrical, PowerCAD and Revit will not be accepted.

Three-dimensional modelling is not a mandatory requirement for the production of electrical drawings but may be employed to convey detail of complex arrangements and components, where practicable.

7.2 Presentation

As a general requirement, the presentation of all drawings must incorporate the following features:

- Clarity of detail;
- Drawn top to bottom and left to right;
- Balanced uncluttered appearance;
- A reasonable amount of space for future extensions and additions; and
- Critical views of components to be given preference when considering view sizes and available space.

7.3 Colour

All submitted drawings will be printed in greyscale only.

Drawing must not include technical detail requiring colour printing for interpretation. For example, to distinguish between removed and new assets clouding must be used. Refer Section 7.18 Revision Clouds.

Rare exceptions to the colour requirements will be made on a case-by-case basis, for example, in respect of isolux plots and fibre splice allocation. These must be an exigent need though, as colour printing is an expensive business cost for Main Roads when compared to greyscale printing. Consider that while some offices may work in a paperless manner, the vast majority of field work is still conducted on paper copies.

7.4 Title Blocks

All drawings must be prepared on A1 drawing sheets, as provided by Main Roads.

Where the contents of a drawing will exceed the confines of a single drawing sheet, the drawing can be divided into separate drawings and identified by including the sheet number in the dedicated section within the title block.

Refer Main Roads Presentation Drawing 201848-3281.

7.5 Legends

Legends must be used where symbols or line types are not covered in this Standard. Symbols and line types used in the legend must be followed by a short description using layer 25, 2.5 mm text. Refer Appendix 2.

7.6 Notes

Generally notes are used to complement specific drawing detail only, where further clarification is required. Notes must be succinct, clear and concise.

Notes within the body of a drawing must be as close as practicable to the relative items and not obscure any part of the drawing detail. Notes are to be positive and written in the imperative.

Where there is insufficient room for notes within the drawing, 'refer note x' can be used, pointing to the notes section.

Using the notes section for general comments should be avoided, as the detail is to be shown on the drawings. Expansive notes risk rejection by Main Roads.

Text to be layer T25, red and 2.5 mm in height. For example, refer Standard Drawing 201948-3315.

7.7 North Point

A north sign must be located on all site plans and arrangements irrespective of orientation. Preferred located to be top left of drawing.

7.8 Layer, Line Types and Colours

All layers, line types and colours must be in accordance with Presentation Drawing 201948-3289.

7.9 Lettering

All lettering must adhere to the requirements of AS 1100.

All text must be clear, legible and maintain visible separation between drawing components and lines. Other constraints include the following:

- The minimum character height is 2.5 mm at sheet size A1;
- All text must be capitalised except for units of measurement; and
- Bold and italic text must not be used.

Refer Table 1 below for lettering layers, colour and text size.

Layer	Colour	Text Size
T18	Cyan	Text – 1.8 mm
T25	Red	Text – 2.5 mm
T35	Green	Text – 3.5 mm
T50	White	Text – 5.0 mm
T70	Blue	Text – 7.0 mm
T10	Yellow	Text – 10.0 mm

Table 1 – Drafting Layers, Colours and Text Size

T25 – 2.5 mm must be used on the following drawing components:

- Drawing notes;
- Schedules;
- Termination designations;
- Dimensions;
- Item numbers;
- Ferrules; and
- Scale bars.

T35 – 3.5 mm must be used for subheadings. For example:

- Notes;
- Bill of Materials;
- Schedules; and
- Component views.

T50 – 5.0 mm must be used for main headings.

7.10 Hatching

Only standard AutoCAD hatch patterns as supplied with AutoCAD are permitted on drawings.

Note, the designer / drafter can use discretion.

7.11 Underlining

Underlining can be used as a main designation. For example, main titles within the body such as Section A or Detail A.

7.12 Subscripts, Superscripts and Symbols

The use of subscripts and superscripts are encouraged in order to maintain the readability of the drawing. For example:

- 2.5 mm²;
- ± 50 °C; and
- 28 ms⁻¹.

7.13 Dimensions and Units of Measurement

All units must be of International Standard, in accordance with AS ISO 1000.

7.14 Decimal Places

The number of decimal places associated with drawings dimensioned in millimetres and metres must be no greater than zero and one respectively. A greater number of decimal places are to be seldom used and typically reserved for machining detail. If the number is a 'whole number', e.g. 10 mm, decimal places must not be used.

7.15 Fractions

Full height characters must be used on electrical drawings, when required. For example:

- 1/2;
- 1/4; and
- 7/8.

7.16 Abbreviations

The use of abbreviations on drawings is not recommended; however if required, abbreviations should adhere to the Equipment Identifier list in Appendix 1 and the Australian Standard of Symbols and Abbreviations for Building and Construction, HB 24-1992, unless otherwise specified in this document.

Where conflict arises, the Equipment Identifier List in Appendix 1 takes precedence.

7.17 Scaling

Preferred Scaling for electrical drawings at full size A1 are to be as follows:

- Not to Scale (N.T.S.);
- 1:1;
- 1:2;
- 1:5;
- 1:10;
- 1:20;
- 1:25;
- 1:50;
- 1:100;
- 1:200;
- 1:250;
- 1:500; and
- 2:1.

All scale bars must be present if a scale has been used. If the drawing is specifically not to scale, N.T.S. must be written in replace of a scale bar.

7.18 Revision Clouds

All revisions must be undertaken using revision clouds to identify modified drawing areas. This applies in a good practice sense for alpha design revisions, e.g. A, B and is mandatory for IFC revisions, e.g. 0, 1, 2. Note that the initial issue of a new drawing at Revision 0 will of course have no revision clouds.

All changes including deletions and additions are to be captured using revision clouds on the drawings in the following format:

- Irregular in shape to include only the amended regions of change;
- Clear of all lines and detail; and
- Include a revision triangle, located in the left hand bottom corner, where practicable.

The two figures below are examples of the inclusion of a Residual Current Breaker with Overcurrent Protection in Revision B. Figure 1 is an example of an acceptable revision cloud. Figure 2 is not acceptable. It is unnecessarily regular in shape; revision triangle located in the right hand corner and unrevised drawing space included.

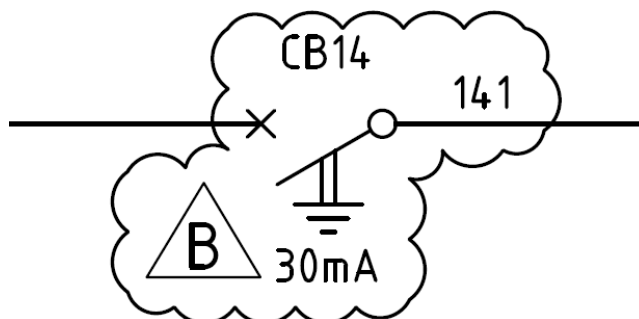


Figure 1 – Typical Revision Cloud

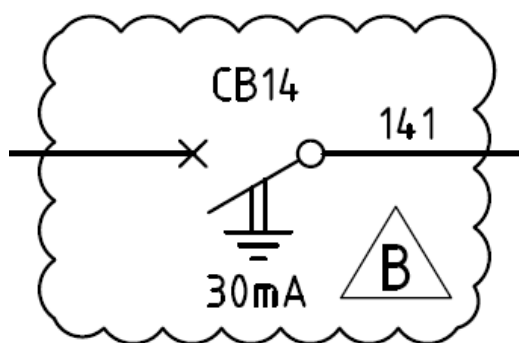


Figure 2 – Incorrect Revision Cloud

All revisions are to be captured in the revisions section of the title block, accompanied with a brief description of changes made. Refer Presentation Drawing 201948-3288.

7.19 Hold Clouds

Hold clouds are to capture any dimensions and configurations that may be unknown or subject to change. This may be due to missing or unclear specific vendor detail; however, it must be minor in detail and of minimal consequence.

A hold cloud is typically of the same format as the revision cloud but inverted. Refer Figure 3 below.

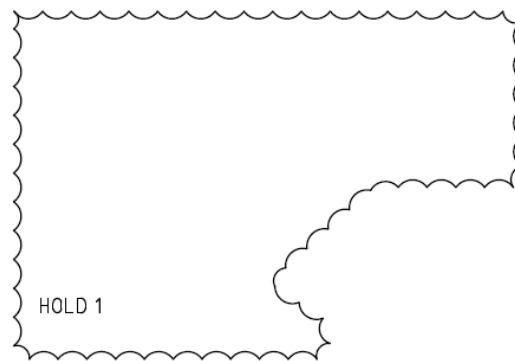


Figure 3 – Typical Hold Cloud

Holds will be numerically incremented per drawing with a short description detailing the reason for the hold and any instructive information. Refer Presentation Drawing 201948-3288.

8 MAIN ROADS ELECTRICAL ASSET MANAGEMENT REVIEWS

8.1 General

Designs for review by Main Roads Electrical Asset Management must be submitted to elec&itsreviews@mainroads.gov.au.

Reviews will be conducted on the basis that all submitted detailed design drawings will be further revised to As-Constructed / Main Roads Asset Drawing status, with the exception of specific construction detail, such as hold points.

Unless otherwise agreed, Main Roads Electrical Asset Management will review completed Electrical and ITS drawings only, typically at the submission of a completed detailed design, i.e. 100%.

If a submission is incomplete but there are specific drawings or detail for review, these must be clearly stated upon submission. Incomplete submissions with no direction given, risk being marked as incomplete and returned without review. Refer Section 8.2.3 C3 Incomplete - Resubmit.

Upon request, Main Roads Electrical Asset Management will review appropriate submissions and provide comments, if required. These will be in the form of initialled and dated comments on the drawings and documentation themselves and scanned back to the originator upon completion.

'Comment Forms' or 'Comment Spreadsheets' should not be used as a communication tool during the modification and resubmittal process, unless prior agreement has been arranged. The reason for this is that separating comments from the design drawings can introduce uncertainty and miscommunication.

Technical minor clarifications can be done via the telephone between designer and reviewer if required and is encouraged.

Note: The Main Roads Principal Engineer reserves the right to bypass the design review process on simple design submissions, in order to expedite low risk projects.

8.2 Drawing Decal

Each submitted individual drawing and document will be reviewed and signed off using the drawing decal in Appendix 4. This signed off decal will provide one of four Review Recommendation Status Grades:

- C1: Proceed;
- C2: Proceed – change as noted and resubmit;
- C3: Incomplete – resubmit; and
- C4: Do not proceed.

8.2.1 C1 Proceed

Drawings and documentation returned with 'C1 Proceed' status is a recommendation for the project to proceed based on the reviewed material. This does not release the Superintendent or Project Manager from responsibility for quality and scope of construction.

Resubmission of drawings and documentation with this recommendation are not required.

8.2.2 C2 Proceed – Change as Noted and Resubmit

Drawings and documentation returned with 'C2 Proceed – Change as Noted and Resubmit' status is a recommendation to amend certain aspects of the submission. The Superintendent or Project Manager is to consider the comments and resubmit at the next submission; i.e. a drawing has been reviewed and given C2 status, Main Roads will expect to see the comments considered and incorporated at the next revision.

If the project does not incorporate the comments, there is an increased risk of delays occurring during auditing and handover, particularly due to non-conformances with Main Roads Electrical and ITS Technical Specifications.

If the Superintendent or Project Manager disagrees with any comments, they may contact the relevant Engineer for a detailed explanation or to seek withdrawal of a comment. The Superintendent or Project Manager is of course entitled to proceed contrary to advice provided, but in such situations is solely responsible for outcomes resulting from failure to follow technical Engineering advice.

8.2.3 C3 Incomplete – Resubmit

Drawings and documentation returned with 'C3 Incomplete – Resubmit' status is a recommendation for the project to complete and resubmit. This is likely to occur when critical detail or entire drawings are missing, such as drawings referred in Section 10 Drawing Guidelines.

All submissions are to be complete; however, if there is specific material to be reviewed within an incomplete submission, this must be clearly stated upon submission.

8.2.4 C4 Do Not Proceed

Drawings and documentation returned with 'C4 Do Not Proceed' status is a recommendation for the complete design or certain aspects of the design to stop progressing along the current trajectory. This may be due to certain aspects being deemed materially unacceptable or unsafe.

The Superintendent or Project Manager should generally contact the Main Roads Principal Electrical Standards Engineer for clarification in the event of a C4 grade being returned.

9 DRAWING PROCESS AND REVISIONS

9.1 General

For purposes of clarity, approved As-Constructed Drawings are the 'Asset Drawings'. As-Constructed and Asset Drawings are used interchangeably throughout this document.

If existing assets are to be modified, the project must request the current Asset Drawings in CAD format. These can be requested from Main Roads Electrical Asset Management via Electricalplanrequest@mainroads.wa.gov.au. Asset Drawings can only be booked out to one project at a time.

A project must *never* attempt to obtain or produce Asset Drawings for existing assets by any other means as this can lead to severe adverse construction and safety consequences in that two or more projects may then be attempting to make different changes to the same asset at the same time. Which, of course, is physically impossible and likely to lead to both Electrical and Road Safety issues if attempted.

In the event that Asset Drawings do not exist, the project must first as-build the asset, provide these drawings for Main Roads approval and entry into the E&ITS Drawings register and then ensure that these drawings are booked out to the project for modification.

In general, design drawings are the antecedent to the final As Constructed / Main Roads Asset Drawings and consequently reviewed as such.

A typical process for the design and review of existing Electrical Infrastructure Drawings is as follows:

- Request Asset Drawings for modification to existing assets;
- Submission of complete detailed design;
- Submission of Issued For Construction drawings and documentation;
- Red-line marked-up drawings for commissioning and operational use; and
- Submission of Final As-Constructed drawings at handover.

Refer external website, url

<https://www.mainroads.wa.gov.au/BuildingRoads/StandardsTechnical/Electricalits/Pages/processes.aspx>.

NOTE: Where existing Electrical and ITS Drawings are to be revised (i.e. "Brownfields" work) and the previous project has adopted a significantly different drawing methodology to the one described in this guideline, then the existing drawing methodology for that site should generally be followed. The designer is to try and incorporate the requirements of this guideline where practicable and it is expected that appropriate Engineering judgement will be shown in respect of how this result is achieved.

9.2 Drawing References

In general, each drawing must reference all other drawings contained within the same system. For example, an Electrical Schematic for a Switchboard Panel should as a minimum, reference the following:

- All other Schematic Sheets;
- All relative Termination Diagrams;

- All relative Interconnections Diagrams;
- Panel General Arrangements;
- Site Layouts of all end devices and equipment;
- Cable Schedules;
- Pole Schedules; and
- Sub-Board Schematics, if applicable.

Further general guidelines are as follows:

- Interconnection and Termination Diagrams must reference the appropriate Electrical Schematics;
- Electrical Schematics of Distribution Panels, i.e. Intelligent Transport Systems (ITS) Cabinets or Traffic Signal Controller Cabinets must reference the relative Switchboard Schematic;
- Site Layouts must reference all other Site Layout drawings within the same system, and Schematic; and
- Sub Main Board Schematics must reference Main Switch Board Schematics, etc.

The referenced drawings are to provide guidance during construction, operations and maintenance. The proper referencing of system drawings will enable efficient delivery of the As – Constructed Drawings at handover. Refer Section 9.5 As-Constructed Drawings.

9.3 Design Drawings

If the first submitted design is an amendment of an existing Asset Drawing, the changes can be clouded, in order to make clear the proposed changes to the asset.

All submitted designs must include Asset Numbers. All requests for new Asset Numbers must be made using the Electrical Asset Number Request Form and submitted to ElectricalAssetrequest@mainroads.wa.gov.au.

Design drawing revisions are to be alphabetically incremented.

9.4 Issued for Construction

For new assets, IFC drawings will be Revision '0'. If the drawing is a revision of an existing asset, the drawing revision number will be the next integer, e.g. existing Asset Drawing with revision number '2' is booked out, the subsequent IFC drawing will be Revision '3'.

9.5 As-Constructed Drawings (Main Roads Electrical and ITS Asset Drawings)

As-Constructed drawings must accurately reflect what has been built, inclusive of any in-project changes. These drawings are to become Main Roads Record Drawings and need to be developed with the multiple purposes of construction, operations, maintenance and future construction in mind.

Red-line marked up or clouded IFC drawings are to be used during Commissioning and submitted in order to obtain energisation approval; however, these must not be submitted as the final As-Constructed drawings.

As-Constructed revision numbers are the next integer from IFC. Where drawings are unchanged from IFC, the drawings must still be formally revised, in order to manage submissions and documentation.

For example, the amendments section of the Title Block for a new asset shows Revision '0' as IFC and Revision '1' as the Asset Drawing (As-Constructed). Refer Figure 4 below.

1	05/04/20	AS-CON - NEW SWITCHBOARD	JM	TP	AM
0	09/12/19	IFC - CONTRACT XX/XX	JM	TP	AM
No.	DATE	DESCRIPTION	DRN	ENG	APP
AMENDMENTS					

Figure 4 – Example Amendments Section for a New Main Switchboard Schematic

Refer Handover of Electrical Assets Procedure at Main Roads external website; url <https://www.mainroads.wa.gov.au/BuildingRoads/StandardsTechnical/Electricalits/Pages/quality.aspx>.

10 DRAWING GUIDELINES

10.1 General

The standards and practices of electrical drawings and documentation prepared for Main Roads must be in accordance with those outlined in the AS/NZS 4381 series, Preparation of Documents used in Electrotechnology.

In general, all new Electrical, Instrumentation and Control Systems must have the following drawings to represent the system from the point of attachment to all end devices, as a minimum:

- Electrical Schematics;
- Termination Diagrams;
- Interconnection Diagrams;
- Site Layouts;
- General Arrangements; and
- Cable Schedules.

Note that Splice Allocation drawings are a form of termination drawing.

10.2 Electrical Schematics

Electrical Schematics must use the detached representation, in accordance with AS/NZS 4381, in order to achieve a clear representation of the system.

Schematics are to provide detailed information on the wiring scheme of the Electrical and Communication System.

Schematics must contain all electrical and communication components, represented using a standard set of symbols. If a new component is required, it must be drawn in accordance with AS 1100.

Guidelines for Schematics are as follows:

- Detached representation to be used;
- All active and neutral conductors are to be shown;
- All connections to equipment and end devices; and
- Source of power supply and input voltage.

10.2.1 Grid Reference System

All Electrical Schematics must employ a wiring grid-reference system for the locating of equipment to facilitate efficient commissioning, fault finding and future upgrades.

The largest row (line) reference number is determined by the size of the electrical scheme. The column reference number must be between zero and nine. For example, the grid references 12, 458, 1246 respectively refer to the following parameters:

- Row 1, Column 2;
- Row 45, Column 8; and
- Row 124, Column 6.

All equipment must be uniquely labelled with a numerical identifier representing the row on the Schematic, e.g. CB17 - Circuit Breaker on row 17. There must be no other CB17 with the Electrical System, from point of attachment to end devices.

The drawing may be split vertically to incorporate two grids per sheet. This is the preferred method; however, with drawings of extensive complexity, the design Engineer has discretion to use one grid reference per sheet for presentation purposes. Refer Appendix B.

10.2.2 Ferrules

Each node within the system must be given a unique ferrule number using the grid reference. For ease of readability, ferrule numbers can be repeated if a node is represented on multiple sheets. No single core can have two different ferrule numbers.

Earth cables and cable numbers are typically not shown on these drawings but instead, on the Termination and Interconnection Diagrams.

Refer Standard Drawings in Appendix 2.

10.3 Termination and Interconnection Diagrams

The diagrammatic representations of these drawings are to be in accordance with AS/NZS 4383.

Interconnection and Termination Diagrams are essential and must be produced to identify all panel, marshalling applications, field interconnections and cable terminations at origin and destination. These drawings are to be read in conjunction with the Schematic.

All cables and connections are to be identified, including all earth cables and stakes. These diagrams are to assist in the installation and troubleshooting of systems.

Details on these drawings include:

- Cable numbers and ferrule numbers;
- Designation of all terminal strips and terminal numbers;
- Cable connections to all devices to be shown;
- All Electrical and communication equipment internal to the panel; and
- All external equipment within the system.

Main Roads preference is for a hybrid termination and interconnection diagram depicting interconnections between terminals, equipment and field devices. Ferrule numbers shown are taken from the respective Schematic facilitating efficient equipment lookup.

For larger systems, stand-alone termination and interconnection diagrams can be used at the discretion of the design Engineer.

10.4 Site Layouts

Site layouts must be two-dimensional and depict the geographical location of all assets and cable routes. All assets, including conduits and pits, must be clearly identified.

Site layouts must capture the specific project zone, e.g. Perth Coastal Grid 1994. Refer <https://mrwebapps.mainroads.wa.gov.au/publicmaps/surveyportal> for Main Roads Project Zones and Main Roads Presentation Drawing 201948-3287 – Item 18.

10.5 General Arrangement Drawings

Where General Arrangement drawings are required, such as for switchboard panels, traffic signal cabinet and ITS cabinets, the drawing must show all equipment and housing arrangement. A Bill of Materials must accompany the General Arrangement whereby the identification of equipment will be in accordance with the Schematics and Termination diagrams.

10.6 Cable Schedules

Cable schedules are to accompany any electrical drawings. Details typically include at a minimum:

- Cable number;
- Cable origin;
- Cable destination;
- Voltage;

- Size;
- Number of cores;
- Number of phases;
- Max Demand;
- MCB size;
- Sub-main and Total Voltage Drop;
- Impedance (calculated and maximum allowable);
- Current Rating;
- De-rating and de-rated Current;
- Cable type;
- Route length;
- Supplier; and
- Installation Method.

Refer Appendix B for an example format.

10.7 Symbols

Symbols used in drafting of Schematic must be in accordance in AS 1102 and Appendix B, unless otherwise specified.

11 APPENDICES

Appendix	Title
Appendix 1	List of Equipment Identifiers
Appendix 2	Example Drawings
Appendix 3	Example Cable Schedule
Appendix 4	Design Review Drawing Decal

Appendix 1: Equipment Identifiers

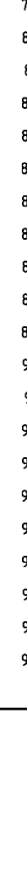
Equipment Identifier	Description
AC	Air Conditioning Unit
ACA	Analogue Camera
AGD	Above Ground Detector
ANT	Antenna
AM	Amp Meter
AP	Access Point
BF	Surge Protection Device Backup Fuse
BS	Bus Electrical
BT	Bluetooth Device
CB	Circuit Breaker
CN	Contactor
CP	Pump Controller
DB	Distribution Board
DCA	Digital Camera
DTRC	Digital Recorder
EB	Earth Bar
FN	Fan
FB	FOBOT – Fibre Optic Break-out Tray
F	Fuse

G	Generator
GR	Ground
KWM	Kilowatt Meter
IS	Field Isolator
LS	Light Switch
MB	Mounting Block
MS	Main Switch
NS	Network Switch
PB	Push Button
PP	Pump
PS	Power Supply
RCBO	Residual Current Breaker Over Current
RCD	Residual Current Device
RE	Relay
SD	Surge Diverter
SF	Surge Filter
SP	Surge Protection (CAT6)
SW	Switch
TP	Loop Termination Panel
TS	Traffic Signal
TX	Power Transformer

VDU	Vehicle Detector Unit
VM	Volt Meter
XC	Capacitor
XL	Inductor

Appendix 2: Example Drawings

Drawing Number	Description
201948-3315 0	Specification 708 – VDS Schematic – XL 1000
201948-3316 0	Specification 708 – VDS Termination and Interconnection Diagram
201948-3287 0	Title Block Layout
201948-3288 0	Dimensions and Clouds
201948-3289 0	Drawing Linetypes
201848-4821 0	Traffic Signals Drawing Symbols
201848-4822 0	Electrical and Communication Block Symbols
201848-3290 0	General Drawing Symbols



NOTES

1. ALL INTERNAL WIRING AND PROTECTION EQUIPMENT TO BE SIZED BY PROJECT
2. FBOBT AND NETWORK SWITCH TO BE SIZED BY PROJECT.
3. n REFERS TO THE NUMBER OF PORTS ON RESPECTIVE DEVICE.
4. ALL OPTIC FIBRE INSTALLATIONS MUST BE IN ACCORDANCE WITH MAIN ROADS SPECIFICATION 705.
5. ALL FEEDER CABLES MUST BE LABELLED WITH THEIR LOOP NUMBERS AND START AND FINISH
6. ALL FEEDER CABLES FOR VEHICLE DETECTOR MUST BE IN LINE WITH AS/NZS 2276.2.

ELECTRICAL & ITS STANDARDS STANDARD DRAWING			
SPECIFICATION 708 - VDS SCHEMATIC - XL 1000			
LOCAL AUTHORITY:		REV:	SHEET:
MRWA DRG No: 201948-3315		0	
MRWA ASSET No:		TYPE:	1 of 1

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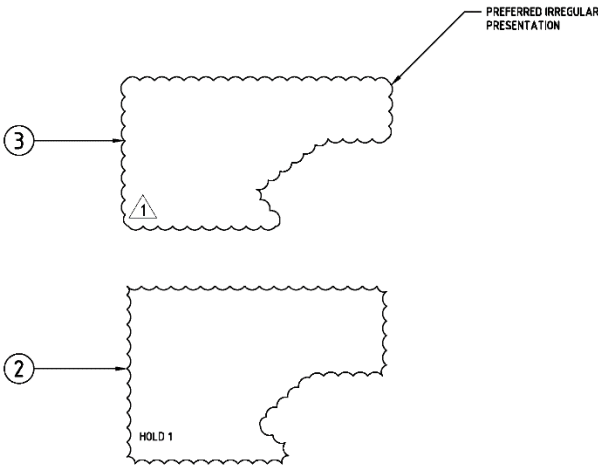
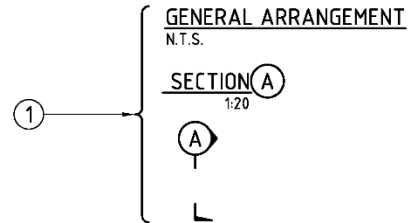
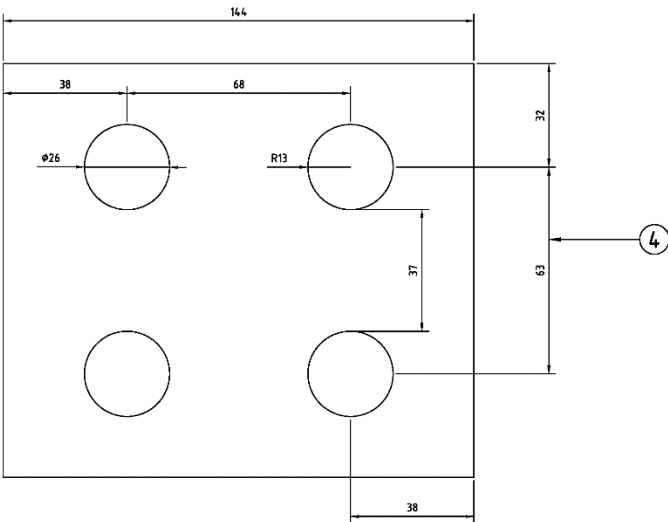
DRAWN:	J. MORAN	DATE:	12/09/19
ENGINEER:	T. PEACOCK	DATE:	12/09/19
VERIFIED:	R. NAIR	DATE:	12/09/19
APPROVED:	A. MARTIN	DATE:	12/09/19



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PLOTTED BY: Merin John (Cen) DATE: 12/12/2019
DRAWING FILE LOCATION: \\D:\ASSET\01\Electrical Asset Management\Drawings\6.1\Electrical Standards Drawings\6.1.1\Legends\2019-6-3288_0.dwg

- ① → **ELECTRICAL STANDARDS**
A1 SAMPLE LAYOUT
- NOTES:
- LETTERING:
 - T25 – 2.5 mm LETTERING – NOTES, DIMENSIONS, ITEM NUMBERS, WIRE NUMBERS, SCALE BARS, SUB HEADING OF BILL OF MATERIAL, SCHEDULES, TERMINATION DESIGNATION AND GENERAL TABLES.
 - T35 – 3.5 mm LETTERING – HEADING, E.G. NOTES, BILL OF MATERIALS, SCHEDULES ETC. FRONT VIEW, SCALE OF SECTION A-A AND EQUIPMENT DETAILS.
 - T50 – 5.0 mm LETTERING – MAIN HEADING USED IN DRAWINGS E.G. POWER DIAGRAM, CUBICLE LAYOUT, DETAIL DESCRIPTION I.E. GENERAL ARRANGEMENT, SECTION A-A.
 - WHERE FINAL DIMENSIONS OR CONFIGURATIONS ARE UNKNOWN OR MAY BE SUBJECT TO CHANGE, A HOLD CLOUD WITH A SHORT DESCRIPTION OF THE REASON FOR THE HOLD MUST BE DOCUMENTED IN THE HOLD SECTION ON THE RIGHT HAND SIDE OF THE DRAWING. THE SPECIFIC HOLD NUMBER IS FOR REFERENCE IN THE DESCRIPTION.
 - REVISION CLOUD USED TO HIGHLIGHT CHANGES FROM REVISION TO REVISION. THE REVISION CLOUD TO HAVE A REVISION TRIANGLE WITH THE SAME REVISION AS THE DRAWING AND BE SITUATED IN THE BOTTOM LEFT HAND SIDE WERE POSSIBLE. THE PREFERRED METHOD OF REVISION CLOUDS ARE IRREGULAR IN PRESENTATION.
REVISION CLOUD & REVISION TRIANGLE TO BE ON:
 - LAYER: REVISION CLOUD & REVISION TRIANGLE.
 - COLOUR SET AT RED AND BY LAYER.
 - MINIMUM AND MAXIMUM ARC LENGTH: 4.5 mm.
 - THE UNIT OF MEASUREMENT FOR ALL ELECTRICAL POWER, INSTRUMENTATION, CONTROL AND COMMUNICATION MUST BE IN MILLIMETRES.
THE FOLLOWING FORMAT MUST BE FOLLOWED:
 - TEXT STYLE – T25.
 - TEXT HEIGHT – 2.5 mm.
 - LAYER – DIM.
 - ARROW SIZE – 2.5 mm OR 3 mm.
 - WHOLE NUMBERS PREFERRED.



EXAMPLE DRAWING ONLY. FOR PRESENTATION PURPOSES ONLY.

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EQUIPMENT DETAILS		
ID	DESCRIPTION	MODEL NO.
1	DESCRIPTION	MODEL NUMBER
HOLDS (IF APPLICABLE)		
NOTES		
LEGEND		
ELECTRICAL & ITS STANDARDS PRESENTATION DRAWING DIMENSIONS AND CLOUDS		
LOCAL AUTHORITY: MRWA DRG No: 201948-3288		REV: 0 SHEET: 1 of 1
MRWA ASSET No:		TYPE:

No.	DATE	ISSUED FOR USE	DESCRIPTION	DRN	ENG	APP	DRAWING No.	DESCRIPTION
0	12/12/19							
AMENDMENTS				REFERENCES				

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ENGINEER: T. PEACOCK	DATE: 12/12/19
VERIFIED: R. NAIR	DATE: 12/12/19
APPROVED: A. MARTIN	DATE: 12/12/19

LOCAL AUTHORITY: MRWA DRG No: 201948-3288		REV: 0	SHEET: 1 of 1
MRWA ASSET No:		TYPE:	

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A 1




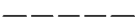










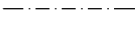






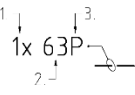
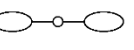


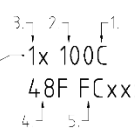

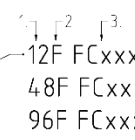
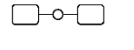














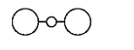





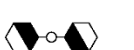


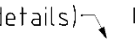
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ENGINEER:	T. PEACOCK	DATE:	12/12/19					
VERIFIED:	R. NAIR	DATE:	12/12/19	DRAWING LINETYPES				
APPROVED:	A. MARTIN	DATE:	12/12/19	LOCAL AUTHORITY:				
				MRWA DRG No:	201948-3289	REV:	0	SHEET:
				MRWA ASSET No:		TYPE:		1 of 1

PLOTTED BY: Merin John (Cen) DATE: 15/09/2019

DRAWING FILE LOCATION: \\D:\ASSETS\Electrical Asset Management\Drawings\6.2 Electrical Standard Drawings & Guidelines\6.2.15 Legend\2018-4-822_0 - ELECTRICAL SYMBOLS.dwg

ENCLOSURES		MONITORING		POLES		UNDERGROUND SERVICES	
	ITS FIELD CABINET (INDICATE TYPE: ITS, VMS, VDS)		CAMERA - CCTV		HINGED POLE		CONDUIT (USE LEADER TO INDICATE CONDUIT DETAILS) (typ: HD PVC)
	ITS CABIN		CAMERA - WEB		LIGHT POLE		CONDUIT - ROAD UNDER BORE (USE LEADER TO INDICATE DETAILS) (typ: HD PE)
	ITS NODE CABINET		FREEWAY LOOP DETECTOR (NOTE 1)		MULTIFUNCTION POLE		ITS BACKBONE (USE LEADER TO IDENTIFY CONTENTS)
	SWITCHBOARD - ELECTRICAL		SENSYS SENSOR UNIT	SCHOOL ZONES			BLOWN OPTIC FIBRE DUCT (USE LEADER TO INDICATE CABLE DETAILS)
LIGHTING			SENSYS REPEATER POINT		SCHOOL ZONE SIGN - ILLUMINATED (WITH SOLAR PANEL)		Non-MRWA CONDUIT
	LIGHT POLE - ROAD WAY (SINGLE OUTREACH)		SENSYS ACCESS POINT		VARIABLE MESSAGE SIGN - CANTILEVER (TYPE TO BE INDICATE) (NOTE 1)		LEADER - CONDUIT 1. No. OF CONDUITS 2. CONDUIT DIAMETER (mm) 3. SERVICE TYPE (P=POWER, C=COMMS)
	LIGHT POLE - ROAD WAY (DOUBLE OUTREACH)		VARIABLE MESSAGE SIGN - GANTRY (TYPE TO BE INDICATE) (NOTE 1)		SCHOOL ZONE SIGN - ILLUMINATED (MAINS OR REMOTE SOLAR POWERED)		LEADER - COMMUNICATIONS (CABLE IN CONDUIT) 1. C = COMMS CONDUIT 2. CONDUIT DIAMETER (mm) 3. QUANTITY OF CONDUITS 4. CORES IN CABLE (F = FIBRE OPTIC) 5. ASSET No. OF OPTIC FIBRE
	LIGHT POLE - PEDESTRIAN SHARED PATH (SINGLE OUTREACH)	PITS		TRAFFIC LIGHT INFRINGEMENT			LEADER - COMMS (FIBRE) (BLOWN FIBRE DUCT) 1. No. OF CORES IN CABLE 2. F = OPTIC FIBRE 3. ASSET No. OF OPTIC FIBRE
	LIGHT POLE - PEDESTRIAN SHARED PATH (DOUBLE OUTREACH)		PIT - COMMUNICATIONS (INDICATE PIT TYPE No. 2, 4, 6, 8, 9)		RED LIGHT INFRINGEMENT CAMERA	VARIOUS EQUIPMENT	
	LIGHT - UNDER BRIDGE (CEILING OR WALL MOUNT)		PIT - COMMUNICATIONS (SPLICE) (INDICATE PIT TYPE No. 8, 9 (8 DIGIT PIT ID, BEGINS WITH 'SPL'))		RED LIGHT FLASH UNIT		HELP TELEPHONE
	LIGHT - UNDER PASS (CEILING OR WALL MOUNT)		PIT - EARTH		RED LIGHT RADAR UNIT		JUNCTION BOX
	LIGHT POLE - NON-MRWA (SINGLE OUTREACH)		PIT - ELECTRICAL TYPES: P1, P2, P4, P6, P8, P9		RED LIGHT INTEGRATED UNIT (COMBINED CAMERA, FLASH & RADAR)		POINT OF ATTACHMENT
	LIGHT POLE - NON-MRWA (DOUBLE OUTREACH)		PIT - ELECTRICAL (DOUBLE LID) TYPE FC12				Non-MRWA EQUIPMENT
	LIGHT POLE - UTILITY (SINGLE OUTREACH)		PIT - ELECTRICAL (LARGE) TYPE FC18				SOLAR POWER PANEL
	LIGHT POLE - UTILITY (DOUBLE OUTREACH)						UN-METERED POWER SUPPLY
							UN-INTERRUPTIBLE POWER SUPPLY
							DETAIL LEADER

AMENDMENTS

No.	DATE	DESCRIPTION	DRN	ENG	APP
0	20.09.2018	ISSUED FOR USE	LC	SH	AM

NOTES:


1. TRAFFIC DIRECTION OF TRAVEL

2. DETAIL LEADERS TO BE USED AS OFTEN AS REQUIRED.

3. DRAWING CONTENT SHOWN AN ENLARGED SCALE OF 2:1 FOR EXAMPLE PURPOSE ONLY.

REFERENCES

DRAWING No.	DESCRIPTION
8320-0400	ELECTRICAL SYMBOLS LEGACY
201848-4821	TRAFFIC SIGNAL SYMBOLS
201848-4835	CABLE SCHEDULE TEMPLATE



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L.COADY	SEP 2018
ENGINEER:	DATE:
S.HOWELLS	SEP 2018
VERIFIED:	DATE:
R.LEE	SEP 2018
APPROVED:	DATE:
A.MARTIN	SEP 2018

ELECTRICAL & ITS STANDARDS

PRESENTATION DRAWING

ELECTRICAL & COMMUNICATION

BLOCK SYMBOLS

LOCAL AUTHORITY:

MRWA DRG No: 201848-4822

REV: 0

SHEET: 1 of 1

MRWA ASSET No:

TYPE:

COMMISSIONED

Document No: D19#622530 Page 32 of 36

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PLOTTED BY: Megan John [cm] PLOTTED ON: 12/12/2019 3:06 PM

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ELECTRICAL & ITS STANDARDS PRESENTATION DRAWING							NOTES	
GENERAL DRAWING SYMBOLS							1. THE SYMBOLS AND METHODS OF PRESENTATION SHOWN MUST BE USED IN PREFERENCE TO ANY OTHER SYMBOLS OR METHODS OF PRESENTATION FOR SIMILAR ITEMS OF EQUIPMENT. 2. WHERE A REQUIRED SYMBOL IS NOT SPECIFIED REFER AS 1102.	
ELECTRICAL & ITS STANDARDS PRESENTATION DRAWING								
GENERAL DRAWING SYMBOLS								
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MRWA ASSET No:							TYPE:	
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Appendix 3: General Example Cable Schedule

Document Title:
Document Number:
Date:
Revision:

By:
Checked By:
Approved By:

Cable Identification Number:	Cable Origin Origin Area / Equipment	Cable Destination Destination Area / Equipment	Voltage (V)	Size (mm ²)	Cores	SM Max Demand (A)	SM MCB (A)	SM Volt Drop (%)	Total Volt Drop (%)	Calc. Impedance (Ω)	Max. Allowable Impedance (Ω)	Rated Current (A)	Derating	Derated Current (A)	Cable Type	Route Length (m)	Supplier	Installation Method
CABITSxxxxx-P1	SWBxxxxx	CABITSxxxxx	240	16	2	6.7	16 Type C CB	1.20	1.20	0.70	1.53	50	0.7	35	XLPC/PVC	20	Supplier	In Conduit

Table 2 – Example Cable Schedule

Appendix 4: Drawing Decal

Main Roads Electrical Asset Management Standards Review Recommendation	
Electrical & Intelligent Transport Systems	
<input type="checkbox"/> C1 Proceed	
<input type="checkbox"/> C2 Proceed – change as noted and resubmit	
<input type="checkbox"/> C3 Incomplete – resubmit	
<input type="checkbox"/> C4 Do not proceed	
This review is a recommendation only and not a direction under the Contract/Purchase Order.	
Signed:	Date:
Engineer:	

Figure 5 – Design Review Drawing Decal