Technical Specification- Earthing and Lightning Protection system

Table of Contents

Revision details

Version No.	Date	Clause	Description of revision
1.0	-	All	General revision
2.0	-	All	General revision
3.0	-	All	Format update, changing ‘must’, ‘should’ and ‘may’ to must where relevant to Sydney Water, ‘approved’ replaced with ‘accepted’, minor editorial changes elsewhere.
4.0	07/04/2025	All	Major update – The specification document was re-written incorporating both HV and LV earthing and lightning protection system.

Introduction

This Specification covers the design, supply, installation and commissioning of Earthing and Lightning Protection Systems for Sydney Water assets. It also includes the inspection and testing requirements for these installations.

Sydney Water makes no warranties, express or implied, that compliance with the contents of this Specification must be sufficient to ensure safe systems or work or operation.

It is the user’s sole responsibility to ensure that the copy of the Specification is the current version as in use by Sydney Water.

Sydney Water accepts no liability whatsoever in relation to the use of this Specification by any party, and Sydney Water excludes any liability which arises in any manner by the use of this Specification.

For the purpose of this Specification “Sydney Water” is the nominated person or organisation that has written authority to act on Sydney Water’s behalf.

This document is uncontrolled once printed or downloaded.

Copyright

Acronyms

Acronym	Definition
AC (ac)	Alternating Current
ALARP	As low as reasonably practicable
AS	Australian Standard
CP	Cathodic Protection
DC (dc)	Direct Current
DNSP	Distributed Network Service Provider
ECC	Earth Continuity Conductor
EG-0	ENA DOC 025 2022 - Power System Earthing Guide
EG-1	ENA DOC 045 2022 - Substation Earthing Guide
ELV	Extra Low Voltage (i.e. ≤ 50 V AC or ≤ 120 V DC)
EPR	Earth Potential Rise
HV	High Voltage (i.e. > 1000 V AC or > 1500 V DC)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronic Engineers
ISO	International Standards Organisation
LPL	Lightning Protection Level
LPS	Lightning Protection System
LV	Low Voltage (i.e. greater than ELV but ≤ 1000 V AC or ≤ 1500 V DC)
MEN	Multiple Earthed Neutral
SLD	Single Line Diagram
SPD	Surge Protection Device
TNSP	Transmission Network Service Provider
UGOH	Under Ground to Overhead
V_{ptt}	Prospective Tolerable Touch Voltage
V_t	Touch Voltage

General Terms & Definitions

Term	Definition
Buried bare earth conductor	All buried bare earth conductors referred in this document is for bare earth conductors directly buried in ground.
Distributed facility	Standalone structures that are interconnected with electrically conductive services within a facility boundary.
Earth Potential Rise	The Voltage developed between an earthing system and remote earth during an earth fault
Hand to Hand Voltage	The voltage between two metallic items (nominally 2m away) experienced by a person bridging both metallic items.
Low Risk	A ‘low risk’ design is defined as one that ensures touch voltage compliance, achieving an individual probability of fatality less than 1 in 1,000,000 per year.
Lightning Ground Flash Density (Ng)	The number of ground flashes per square kilometre per annum for lightning.
Lightning Protection Level	Lightning protection level is a classification used to determine the effectiveness of an LPS in safeguarding a structure against lightning strikes. It is a set of maximum (sizing criteria) and minimum (interception criteria) lightning current parameters used to determine the rolling sphere radius
MEN	A method of multiple connections between an LV system neutral and earth and the general mass of the earth such that the reticulated neutral can return earth fault current and earth paths can return neutral current. (AS2067)
NER (Neutral Grounding Resistor)	A method of reducing fault current during an earth fault event by installing a series impedance between the neutral point of a transformer or generator and the earth grid. During the earth fault event, healthy phase to earth voltages will increase above normal phase to neutral magnitudes.
Solidly bonded	A permanent and low impedance connection which provide an effective and reliable fault current path
Solidly earthed system	Solidly earthed system is a system where the neutral point is directly bonded to the system earth via a low impedance.
Step Voltage	The voltage in the earth surface potential experienced by a person bridging 1m with their feet without contacting any earthed object.
Touch Voltage	The voltage between an earthed structure and the earth surface at the point (nominally 1m away) where a person is standing, while touching the earthed structure.

1. General

1.1 Scope

This specification covers the technical requirements for design, supply, installation and commissioning earthing and lightning protection system in Sydney Water High Voltage (HV) and Low Voltage (LV) Electrical installations and structures. Additional requirements for earthing and lightning protection relating to -instruments and control installations are outlined in HSS0009 (Technical Specification – Instrumentation and Control).

It must be noted that this specification takes precedence over other Sydney Water specifications in relation to requirements covered under the scope of this document.

Where conflicts exist between this specification and any statutory requirement (e.g. the Work Health and Safety Act and Regulations), the statutory requirement prevails.

Where conflict exists between this specification and any other nominated Contract document including technical specification documents, SWC must be notified in writing to nominate which will take precedence.

1.2 Proprietary items

Nomination of a proprietary item by Sydney Water does not imply preference or exclusivity for the item identified.

Proposed alternatives that are equivalent in performance to the specified items must be submitted to Sydney Water for approval. The submission must include relevant technical details, datasheets, samples, calculations, and an appropriate justification and risk assessment for the proposed substitution.

2. Technical requirements – General Design

This section outlines the design process for earthing and lightning protection systems, applicable to both new and existing installations. The design of these systems, as detailed in this specification, must conform to relevant Australian and IEC standards. All electrical equipment must have earthing provisions that are designed, installed, commissioned, and maintained to meet the requirements of a solidly earthed system.

2.1 Earthing and Lightning Protection System Design Stages and Process

The earthing and lightning protection system design process for Sydney Water assets must be followed in accordance with EG-0's design process in conjunction with AS/NZS3000, AS2067, and AS1768. Design process must be subjected to the following stages in sequence:

Basic Design: the initial stage that determines the fundamental configuration, electrode details, and conductor sizes needed to achieve the required earth resistance and safety criteria limits. The steps for this stage must include:

a) Review and assess applicable part of existing earthing system
b) Perform data collection and site survey (as a minimum must including develop soil resistivity model *, acquire preliminary fault levels and clearing time, identify safety criteria limits,
c) Provide conceptual earthing system layout,
d) Establish first pass safety criteria,
e) Identify nearby utilities, pipelines, metallic structures or third-party services,
f) Perform preliminary risk assessments,

Detailed Design: this stage involves precise calculations, simulations, and material selection to create a comprehensive, safe, and functional plan that meets all technical and regulatory requirements. The steps for this stage that must be considered are as follows:

a) Review and cross check deliverables from previous design phase including verification assumptions
b) Perform simulation of earthing system performance using specialised software (e.g CDEGS),
c) Develop earthing system layout,
d) Develop earthing system connection SLD, Schematics drawings
e) Perform EPR/LFI calculations,
f) Perform preliminary touch and step voltage calculations/simulation, transfer hazards and develop exclusion zones,
g) Ensure compliance with the DNSP requirements, if applicable
h) Finalised risk profiles and risk assessment,
i) Integrate the lightning protection systems, if applicable
j) Develop preliminary construction details.

Final Design: This step finalises the design and construction details for earthing and lightning protection system.

a) Review and cross check deliverables from previous design phase including verification assumptions,
b) Finalise earthing system design layout (including construction details),
c) Finalise earthing system connection SLD, Schematics and details drawings (including construction details),

d) Finalise touch and step voltages transfer hazards and exclusion zones verified under required fault scenarios,

e) Finalised lightning protection system.

The latter stages must be cross referenced with the prior stages, where changes from previous stage is required, deviations with justification must be provided to SW prior to finalisation of the design.

In instances when there is a need for different stages of the design work to be carried out by different delivery mechanism/parties, the working party must clearly specify the applicable stage to be undertaken as part its responsibility.

**Note : For small LV installation where the perspective earth fault current is less than 10kA, the soil resistivity test is exempted, considering standard electrode design suffices.*

2.2 New and Existing installations

Greenfield installations must follow the full design stages and process for earthing and lightning protection system.

Alteration works* for existing site installations must incorporate the existing earthing and lightning protection systems into the new design. The existing installations must be re-evaluated to comply with AS1768, AS2067, and AS3000.

For alteration works, evaluation must be performed on the latest earthing system's design, including:

a) EPR, safety criteria, touch voltage hazards, earthing configuration, and earth grid layout.

b) Inspect and test the relevant part of existing installation to verify its condition and service life before proceeding with the new design.

For lightning protection, assessment must be performed to determine whether the existing LPS can provide adequate and compliant protection for the altered installation, aligning with risk assessment criteria as described in section 5. Furthermore, its intended performance and installation condition must be evaluated.

**Note: The definition of alteration work is covered under AS/NZS 3000, for the purpose of this document, it applies to all installations referred in the Section 1.1.*

3. Technical requirements – Earthing Design: HV Installations

3.1 HV Earthing System Design Philosophy

AS2067 is the mandatory standard for the development of all HV systems, documents EG-0 and EG-1 are to be used in conjunction with AS2067 for the development of HV earthing systems.

A first pass safety criteria limit must be developed to determine compliance of the conceptual earthing system. This limit must be developed in accordance with AS60479.1 C1 curve as a conservative first pass assessment.

The design of the HV earthing system for all installations must achieve at least a 'low risk' classification. However, designs should not be limited to meeting only the 'low risk' threshold. Where reasonably practicable, additional measures must be implemented to further reduce risk. Such measures should be applied if:

a) The cost is not grossly disproportionate to the level of risk reduction achieved, or

b) The measure is considered standard industry practice.

Reasonably practicable risk mitigation options must be identified through a formal risk assessment process and approved by Sydney Water.

3.2 Safety criteria design development

If the first pass safety criteria are not met, then safety criteria must be developed in accordance with AS2067, using direct probabilistic approach. Direct probabilistic tools such as the ENA Argon tool must be used to develop safety criteria. The design deliverables must provide the outputs including the following input,

a) The primary earth fault clearing,

b) Fault frequency based on historical data per year,

c) Applicable contact scenarios (frequency and duration) as per AS2067,

d) Footwear type,

e) Surface layer inputs must also be considered in the development of safety criteria.

3.3 Soil Resistivity Measurement and Model Development

For all HV installations, a soil resistivity model must be established as part of the design deliverables. This can be done using an existing soil resistivity model provided by Sydney Water, if available. If no such model exists, soil resistivity testing must be conducted using the Wenner method as detailed in EG-1. The results of the soil resistivity test and the corresponding soil resistivity model must be documented and submitted to Sydney Water.

3.3.1 Wenner Method Test Spacings and Traverses

The number of tests spacings and traverses for a HV installation must be determined based on the size of the installation and the characteristics of the soil. However, all installations must include spacings of up to at least 32 meters and two orthogonal traverses. Measurement errors to be minimised and recorded. Additionally, the testing should avoid rainfall and extreme dryness days, environmental conditions (moisture, temperature) on the day the tests are conducted must be recorded.

3.4 Earth fault level determination

Earth fault data for the HV installation must be gathered from the relevant up stream supply including confirmation with the utility at the point of connection to determine the worst-case earth fault scenario. The following points must be examined at each voltage level present in an installation:

a) Single phase to earth fault level
b) Double phase to earth fault level
c) Fault current asymmetry (Refer to EG-1 clause 8.11 for decrement factor)
d) System maximum voltage magnitude
e) Primary and back up clearing times must be gathered for safety criteria and conductor sizing respectively.

If the actual fault level details are unknown during the initial assessment, typical primary and backup clearing times, as outlined in EG-0 clause C.3.1, can be used. However, actual fault levels and clearing times must be used in the detailed design.

Additionally, future fault levels must be considered for the design if there are expected changes to the system.

3.5 Software modelling requirements

Computer modelling of the HV earthing system must be completed using CDEGS, other alternative equivalent software may be used with SW prior approval.

3.6 Earth Grid Installation Requirements

3.6.1 Earth Grid Connections

All direct buried bare earthing conductors must be made using stranded or hard-drawn copper wire. Buried bare earthing conductor connections must utilize 2x IEC 837 complied C-crimp or cadweld connections.

Electrode connections must utilize 2x IEC 837 complied C-crimp connections. The buried earth grid must be solidly bonded to the main earth bar using a minimum of two connections located as far apart from each other as practicable. All connections, whether they are cadweld or other, must be protected from the environment. No joints in runs of HV earthing and bonding conductors would be permitted.

3.6.2 Electrode Requirements

Earth electrodes are to be sized at no longer than 20m with due consideration to the ground conditions and electrode separation requirements. Electrodes must be made of hard-drawn copper, and stainless steel 316 electrode must be used for near chemical areas or within 5km from a coastal environment material. Where the ground permits, the earth electrodes must be driven. Where extendible electrodes are used, they must be extended only with fittings specified in 3.6.1.

For earth electrode cables connected directly to a nearby earthing grid or grounding ring, where the risk of mechanical damage is minimal (e.g., buried in stable soil, protected by structural barriers, or routed in non-trafficked areas), conduits protection is not required. In all other cases, conduits or mechanical protection must be provided to safeguard the earth cable from physical damage, environmental degradation, or accidental impact.

If the ground is rocky or the electrodes cannot be driven, 75 mm diameter holes must be drilled to suit the electrodes installation. After drilling of the holes, they must be filled with a mixture of 50% gypsum and 50%

Bentonite by volume, to which must be added 1% by volume washing soda. The mixture must be thoroughly mixed, formed into a slurry and poured into the earth electrode holes. The earth electrode must then be lowered into a hole. It must be ensured that the connection between the earth cable and the earth electrode is accessible above the level of the Bentonite mixture.

3.6.3 Electrode Pits

Electrode pits are preferred to be installed using non-conductive material. High or low load bearing electrode pit lids must be installed based on the location and expected traffic across the electrode pit lid.

Earth electrodes must be installed complete with pit and cover. The connection point must be no greater than 50mm below the lid.

A pit must be provided around the top 250 mm of the earth electrode. The pit must be installed such that the lid must be flush with the ground surface or aggregate. The pit lid must include provision for the easy removal using a tool. A minimum of two lid removal tools must be supplied to Sydney Water per site upon the completion of the installation.

The contractor must provide a site layout drawing detailing the location of each earth electrode and its corresponding GPS position.

3.6.4 Main Earth Bar

A main earth bar of dipped tinned copper material must be installed in each switchroom or substation and be centrally located where it is easily accessible. It must be mounted on a solid structure to a height such that cables can be adjusted sideways to allow for easy access of a clamp meter. Connections must have a minimum of 70 mm spacing from adjacent connections. The main earth bar must also be designed to suit the purpose of carrying out continuity testing.

All equipment and earthing components must be solidly bonded to the main earth bar using single lugged connections (double lugged or piggy backed connections are not permitted). All earth bar connections must be clearly labelled using stainless steel tag permanent fixtures (permanent marker is not permitted). Earth conductors must not be looped between items of equipment. Removal of any piece of equipment must not require the disconnection of earthing connections to any other piece of equipment. Reliance on a metallic structure which are not designed for earthing purpose as an ‘earth bar’ for earth continuity is not acceptable.

If the main earth bar cannot accommodate all earth bond connections due to size or location constraints, an additional bonding conductor earth bar may be installed. In all cases, earth bars must have a minimum of 30% spare pre-punched holes, complete with bolts, washers, and nuts fitted. The use of earth cable to connect adjacent sections of earth bars must be prohibited.

3.6.5 Cable Trays/Ladders

Metallic cable containment system carrying HV cables are to be bonded to the earthing system and to supporting structure column.

Bonding conductors must be installed at all hinged horizontal and vertical splice plate connections along the cable ladder routes of HV cabling. Fish plates are not considered to be adequate mediums for achieving solid bonding.

All bonding and bridges conductors are to be sized in accordance with Clause 3.6.6.

3.6.6 Earthing Conductor Requirements

Earth conductor and bonding conductors (bare and insulated) are to be sized sufficiently to withstand the respective worst-case earth fault current and duration. Bare conductors are to be sized such that they do not exceed 250°C, with insulated conductors not exceeding 160°C.

Direct buried earth conductors must be bare stranded or hard drawn copper wire. Bare earth conductors for use other than being part of the buried earthing grading ring, must have prior written approval from Sydney Water. In all other instances earth conductors must be PVC insulated and coloured a combination of yellow and green. The use of green PVC tape is not permitted.

For mechanical robustness, main earthing and earth conductor for bonding must not be sized less than 70mm^2 copper. Adequately sized tinned copper lugs and as minimum of M12 SS316 fixings must be used.

For HV installation, equipotential bonding conductors that are not in the direct path for an HV earth fault must not be sized less than 16mm^2 copper. Adequately sized tinned copper lugs and as minimum of M10 SS316 fixings must be used for equipotential bonding connections.

Paint or other coating materials must be removed prior to the application of an earth bond to eliminate the series resistance of the coating. The surface must be cold galvanised and then re-painted to ensure adequate surface protection.

Acceptable anti-corrosion treatments are detailed in clause 6.

3.6.7 General Metallic Structures

Metallic buildings, support beams, stairwells, or other structural elements must be bonded via direct welded tags to the steel structure, if tag welding is impractical, the earth bond conductors must be applied to the structure whereby it is flush with the surface of the structure. Earth bonds must be completed with a flat washer in series with the bolt and nut connection.

3.6.8 Embedded Steelwork

The embedded steelwork of HV equipment such as plinths, precast walls, or other structural components inside the HV installation or facility perimeter must be bonded to the earthing system. Steelwork must be welded together to ensure electrical continuity.

The embedded steelwork of the HV plinth must be welded together to form an equipotential grading ring around the HV asset. At least two surface ferrules connected to the welded structure must be made available on the slab surface at diagonally opposite ends of the steelwork for earthing and bonding purposes. Refer to Appendix A for typical connection details.

Welded steelwork must be sized appropriately to withstand the worst-case earth fault current and back up clearance time duration.

3.6.9 Conductor Redundancy

All HV equipment must have an appropriate earthing connection redundancy. Redundant earth bond points must be located on diagonally opposite sides of the equipment by at least two separate independent conductors originating from the earth grid or main earth bar. Items to contain at least two points of earthing connection within a HV installation must include but not limited to:

a) HV transformers
b) HV switchgear

c) HV metallic supports
d) HV cable metallic support systems including reinforced concrete trenches
e) HV motor starter panel

3.6.10 Metallic Fencing

All HV installation fencing must be electrically continuous and contain a direct earth bond between the buried earth grid or main earth bar at every second fence post. The point of connection between the earthing system and fence must be made internal to the installation to prevent vandalism. Sections of fence which are below overhead conductors are to contain a connection to each fence post. Earth conductor for bonding must be sized in accordance with Clause 3.6.6. Fence posts must have a welded tab with a 14 mm hole in the centre to allow for bonding.

3.6.11 Hinged equipment

Earth conductor for bonding to structures that are movable such as substation gates or equipment panels must be made with tinned copper braided earth bonds and contain no looping. Tinned copper braids must be sized in accordance with Clause 3.6.6. The tinned copper braid must be installed such that the braid does not experience any excessive tension throughout the full range of movement of the gate.

3.7 High Resistivity Surface Layer Requirements

All outdoor HV assets which have restricted access and are enclosed by a metallic fence or boundary must have crushed rock aggregate installed within its boundary. Additional locations requiring surface layer aggregate may be identified through the HV earthing system design process or through the commissioning process, which needs a prior approval from Sydney Water. Surface layer aggregate must not be used as a primary mitigation strategy.

Where crushed rock is not practicable for the local environment, asphalt free of metallic components may be considered as an alternative.

3.8 HV Cable Screen Bonding

HV assets internal to Sydney Water sites must have HV cable screens bonded at both ends, provided that the worst-case transfer hazard for faults at both ends of the cable are assessed and demonstrated to comply.

Sydney Water assets that connect to non-Sydney Water assets are to be single point bonded at the source end. Double point cable screen bonding can be considered in the following design process:

a) Designs must first demonstrate that a standalone earthing arrangement within the SW site is unable meet touch or step voltage compliance
b) Risk assessment must be carried out with Sydney Water to assess whether AS2067 allowable probabilistic limits (developed in accordance with clause 3.2) can be applied.
c) Should the previous two steps be unable to produce a compliant design, evidence must be provided to the DNSP and Sydney Water to gain approval to connect supply cable screens at the DNSP supply point(s).
d) If the application of cable screen bonding is unable to produce a compliant design, evidence must be provided to the DNSP and Sydney Water to gain approval to design ECCs which connect between the DNSP supply point(s) and the Sydney Water earthing system.

3.9 Combined/Separated HV and LV Earthing Systems

Combined HV and LV earthing system approach must be considered as the preferred earthing system design, however if such a design cannot be achieved then Sydney Water approval is to be sought before a separated earthing system design proceeds.

3.9.1 Separate Earthing System Insulation

Any necessary separation requirements must be clearly specified between both systems. Separation requirements must include the EPR transfer of a HV earth fault onto an LV MEN connected item. Separate HV and LV earthing system designs must have the insulation rating of the LV earthing systems verified to be at least twice the worst case HV earth fault EPR value.

3.10 UGOH Poles and Overhead Assets

UGOH pole and other overhead assets (such as pole mounted transformers and switchgear) must contain at least a single earth electrode bonded to the cable screens or HV asset via a solidly bonded earthing connection to facilitate lightning strike dissipation and maintain equipotential bonding, the size of the earth electrode must be determined though an earthing design and achieve at no greater than10Ω resistance as set by AS1768, the minimum electrode size for an installation is 2.4m. Electrodes must be sized in accordance with clause 3.6.6.

3.10.1 Operator Mats and handles

Operator mats and handles must be solidly bonded together via a direct connection and contain no looped connections, tinned copper braided connections must be used for the operator handle earth connection. Conductors must be sized in accordance with clause 3.6.6.

3.11 HV Motors

The frame of the motor must be provided with reliable earthing connections. A minimum of two earthing studs must be fitted to the frame of each motor additional to a stud in the motor control box. Additional requirements for HV motors must comply with the requirements of DOC0010 SW Technical Specification HV motors.

3.12 Mechanical Protection

Main earth cables which extend above ground and are accessible by the public must be effectively protected from mechanical damage from ground level to a height of 2.4m. Mechanical protection must be non-conductive materials.

3.13 Special Condition: Local Generation

Sydney Water HV assets that are supplied locally (such as local biogas, diesel and renewable sources) will require special consideration. The HV design must consider the increased earth fault level and clearance time impact on EPR and touch voltage compliance. The design must also account for other auxiliary fault current return paths that may present transfer voltage hazards.

3.14 Earth Potential Rise (EPR) and Low Frequency Induction (LFI)

3.14.1 General

The worst-case EPR at the electrical asset must be calculated, including any applicable exclusion zone requirements. Touch voltage hazards in and around the asset must be assessed and designed to ensure compliance. Mesh voltage calculations within an earth grid are required to meet touch and step voltage compliance. Public areas on Sydney Water property must be evaluated for compliance to safety criteria from clauses 3.1 and 3.2. Installation of electrical feeders must consider the effects of both LFI and EPR onto metallic structures.

3.14.2 Pipeline Assets within the Facility Boundary

Electrical assets that are expected to be installed and contribute LFI and EPR hazards onto pipeline assets within the Sydney Water Plant boundary (regardless of if owned or not by Sydney Water) must undergo an AS4853 level 1 assessment. If non-compliance is identified in the level 1 assessment, further assessment will be required to evaluate touch voltage hazards introduced along the pipeline, considering both EPR and LFI hazards.

Once touch voltages along the pipeline have been modelled, compliance with applicable safety criteria will be determined. If non-compliance is identified, Sydney Water must be informed and provided with possible mitigation options to reduce touch voltage hazards to ALARP.

If an electrical hazard assessment has reached a level 3 assessment (risk-based compliance), then Asphalt mitigation must be applied regardless. The contact assumptions detailed in AS4853 must be adhered to. Pipeline instrumentation must be confirmed rated for the EPR.

3.14.3 Third Party Pipeline Assets (Pipeline Assets outside the Facility Boundary)

HV installations that are expected to contribute LFI and EPR hazards onto Sydney Water pipelines (external to the Sydney Water Plant) must have an AS4853 assessment completed. As a minimum AS4853 level 2 voltage compliance limits for water valve operation, gas valve operation and CP test points inspection must be considered when developing exclusion zones limits from a HV asset.

If an electrical hazard assessment has reached a level 3 assessment (risk-based compliance), then Asphalt mitigation must be applied. The contact assumptions detailed in AS4853 must be adhered to. Pipeline instrumentation must be demonstrated to be rated for the EPR.

3.14.4 Sydney Water Pipeline Static Electricity (Non-Hazardous Areas)

Assessment and control of static electricity hazards on Sydney Water pipelines must comply with AS 1020.

3.14.5 Telecommunication Assets

Third party telecommunication assets near to the proposed HV installation (exhibiting conductive properties) must have both EPR and LFI assessments complete to assess voltage hazardous introduced from the installation. EPR and LFI hazards must be assessed accordingly with AS3835 and guidance from HB101. Sydney Water telecommunication assets near to the proposed HV installation must follow requirements as set out in clause 8.7 of HS0009.

3.15 Impedance Calculations

Earthing system designs must calculate and document the expected earthing system impedance for the installation and the local standalone grid resistance of the installation.

4. Technical Requirements – Earthing Design: LV Installations

4.1 Design Philosophy

The design of the LV earthing system will be completed in accordance with AS/NZS3000. Specific requirements for LV earthing issues are detailed in the following clause.

Notwithstanding some provisions of AS/NZS 3000 and AS/NZS 3017 regarding use of constructional bolts or studs for earthing or earthing terminals, all metal to be earthed must be connected from an earth terminal directly to the earth bar or link with an electrically continuous copper conductor.

4.2 Transferred Voltage Hazards During HV Earth Fault

All HV earthing system designs must consider the transfer hazards posed by HV earth faults onto the LV system and ensure compliance, regardless of whether combined or separate earthing system strategies are used.

4.3 MEN Requirements

Common bonded earthing systems must consider the size of the MEN system and consider its performance for the overall earthing system. The MEN system impedance value must be determined through appropriate modelling or testing and provided in relevant design deliverables.

4.4 Earth Grid Installation Requirements

4.4.1 General requirements

For earth grid connections, requirements in Section 3.6.1 must be followed.

For general metallic structures, requirements in Section 3.6.7 must be followed.

For embedded steelwork, requirements in Section 3.6.8 must be followed.

For metallic fencing, requirements in Section 3.6.10 must be followed.

For hinged equipment, requirements in Section 3.6.11 must be followed.

4.4.2 Main Earth and Neutral Bar

The main earth and neutral bars must be:

a) Hot dip tinned copper
b) Sized adequately and labelled in accordance with AS/NZS 3000
c) Located such that it is easily accessible for maintenance and future work
d) Mounted with stand-off insulators on a solid structure to allow connections to be appropriately torqued
e) All connections are to be clearly and permanently labelled with stainless steel fixtures with cable numbers which indicate their destinations
f) Having a minimum of total 30% spare pre punched holes complete with bolts, washers and nuts fitted, the spare connections must be evenly distributed at the two ends of the bar

g) Main earth and neutral connections must have a minimum of 50 mm spacing from adjacent connections to permit tong meter testing when required
h) The main earth and neutral bars should be mounted at a height that earth cables can be adjusted sideways to allow sufficient space for easy access of a clamp meter.

4.4.3 Earth Electrodes

LV earth electrodes must follow the requirements of Clause 3.6.2, however the length of the electrode must be calculated and based on the worse case fault scenario and be no longer than 3 metres. LV electrode pits must follow the requirements of Clause 3.6.3. If a lightning protection system is connected to the LV earthing system, then an earthing system must have resistance to earth not exceeding 10Ω (with lower values preferred for critical installations) as per AS1768 before any bonding to services that are not part of the LPS.

4.5 LV Equipment Earthing and Bonding Requirements

4.5.1 General

All LV electrical equipment, exposed metal conductive parts on which electrical equipment is mounted including metal cable glands, electrical cabinets, cable ladders, armouring and screening and all conductive structures within the zone of arm's reach as defined in AS/NZS 3000 must be solidly bonded to earthing system. The resistance of equipotential bonding between the target item and main earth bar must be 0.5Ω or less.

All insulated earthing conductors must be identified by the colour green and yellow. Other colours will not be acceptable. Under no circumstances must the colour green and yellow be used for anything other than earth conductor identification.

4.5.2 LV Cable Trays

All conductive cable ladder sections must be bonded to adjacent cable ladders at their joints via an earth conductor or flat tinned copper braid bond as a minimum. Metallic cable containment system and their supporting metallic structures are to be bonded to the earthing system. Bonding conductors must be installed at all hinged horizontal and vertical splice plate connections along the cable containment. Fish plates are not considered to be adequate mediums for achieving solid bonding.

4.5.3 LV Switchboards

All switchboard separate support frames, cubicles of the kiosk/SCA/MCC and all gland plates, hinged doors (internal and external) and other metal components such as weather shields and equipment's mounting plates must be effectively bonded to the switchboard's earth bar using a minimum of 4 mm^2 earth wire.

4.5.4 Surge Diverters

All metallic framework of a surge diverter must be bonded together using, at a minimum, a stranded 6.0 mm^2 green/yellow PVC-insulated earth cable, installed in a manner that ensures segregation from all other cables.

4.5.5 LV Motors

An earthing stud must be provided on both the motor frame and in the main terminal box. The driving end bearing must be earthed via a removable copper shunt. Additional requirements for LV motors must comply with requirements from CPDMS0022 clause E12.

4.6 LV Earthing Conductor Sizing

No joints in runs of LV earthing and bonding conductors would be permitted.

LV installation equipotential bonding conductors must be sized at minimum 4 mm^2 earth conductor for indoor/internal areas, and a minimum of 6 mm^2 earth conductor for outdoor areas. Adequately sized tinned coppered lugs and SS316 fixings must be used for equipotential bonding connections.

Protective earthing conductors must be sized based on fault loop impedance calculations to ensure compliance with AS 3000. The sizing must guarantee that the conductors can safely carry fault currents without exceeding their thermal withstand limits and ensure the reliable operation of protective devices within the specified disconnection times. Additionally, the design must prioritise electrical safety by minimizing touch voltages and ensuring effective fault current dissipation. Adequately sized tinned coppered lugs must be used, and a minimum of M10 SS316 fixings must be used perspective earth fault no greater than 10kA, in all other cases, a minimum of M12 SS316 fixings must be used for fault carrying earthing conductor connections.

Refer to Instrumentation and Control Technical Specification HSS0009 for earthing requirements of instrumentation and control equipment.

4.7 LV Earthing and Bonding Conductor Redundancy

The design of LV earthing and bonding conductors must incorporate redundancy to eliminate single points of failure and ensure system reliability. This includes the installation of multiple parallel earth electrodes and the use of ring or mesh configurations for earthing conductors to provide alternative fault current paths.

Bonding conductors for critical equipment must include redundant, independently routed paths to ensure continuity in the event of a conductor failure. The critical equipment may include but not limited to:

- Switchgear and controlgear assembly
- Motor control centre
- LV switchboards and motor starter metallic structure and supports
- Motor starters
- Pumps
- Backup power system including generators, etc.
- Critical HVAC system

All fault carrying conductors must be sized in accordance with AS/NZS 3000 and IEC 60364 to independently carry maximum prospective fault currents and must be constructed from corrosion-resistant materials suitable for the installation environment ensure long-term performance.

4.8 Installations and Selection of SPDs

Installation of SPDs must follow the requirements set out in HSS0009 and AS1768. Additional specifications for SPD requirements for lightning protection systems can be found in Clause 0. Specifications for installation SPDs must comply with requirements set in Appendix F of AS1768.

5. Technical Requirements- Lightning Protection Design

AS1768 is the standard for managing the risk of lightning and designing lightning protection systems for most common structures and electrical systems. While Sydney Water assets will be treated as a 'distributed system' mainly and require special consideration, the risk assessment process of AS1768 is still applicable.

5.1 Risk Assessment Procedure

All applicable assets defined in section 2 require a lightning risk assessment, the risk assessment procedure documented in AS1768 must be followed, applying suitable mitigations to reach a ‘tolerable risk design’. The completed risk assessment must be provided to Sydney Water, documenting any inputs and outcomes.

5.1.1 Loss of Essential services

In Lightning risk assessment for Sydney water asset, to evaluate the loss of essential services for the wastewater asset, same overvoltage damage factor used for water services must be applied.

5.1.2 Economic Risk

Lightning risk assessments for Sydney Water assets must select a 'tolerable risk of economic losses' that is appropriate for the asset. A tolerable risk must be selected based on economic or cost/benefit consideration as per SW risk matrix. If data for this analysis is not available, a maximum tolerable risk of 1 in 1000 years (10^{-3}) must be considered.

5.2 Lightning Protection System Design

If an LPS is deemed necessary, it must achieve the required Lightning Protection Level (LPL) and implement the necessary protection measures to achieve a tolerable risk design as indicated through the AS1768 risk assessment process. Lightning protection components must be sized as specified in AS1768 table 3.3.

LPS designs must be clearly specified with any air terminal, downconductor, termination network and SPD components described with specified locations and requirements.

5.2.1 Air terminals

Air terminals may consist of a vertical rod, raised horizontal conductor or natural component of the structure. The rolling sphere method must dictate the positioning of dedicated air terminals and whether natural components may be used. Air terminals must comply with AS1768.

Dedicated air terminations must consist of a single copper rod sized in accordance with AS1768. Tape conductors must be copper and held in position by copper saddles or clips at a spacing of not more than 1000 mm.

5.2.2 Downconductors

Downconductors may consist of dedicated conductors and/or natural components of a structure. Downconductors must comply with AS1768.

The use of natural components for down conduction is permitted by Sydney Water, with the exception of certain special condition structures that must be avoided (refer to Clause 5.4).

Downconductors must be bonded to the earthing system by direct permanent exothermic weld connections (e.g. cadwelds). Test points between downconductors and the earth termination network must be made accessible to facilitate maintenance and future testing.

5.2.3 Earth Termination Network

The earth termination network consists of conductors and earth electrodes and/or natural components of the structure below ground. In most cases the structural and foundational concrete and steelwork may be used for the earth termination network, with the exception of certain special condition structures that must be avoided (refer to clause 5.4).

The LPS must achieve an earth grid value which does not exceed 10Ω. The lightning protection system must be bonded to all services as described in AS 1768.

Earth rods must be housed in inspection pits clearly labelled 'Lightning Protection Earth'.

5.3 Distributed Facilities

For Sydney Water assets deemed 'distributed facility' (i.e., a standalone structure with electrical interconnections within a facility boundary) the following steps must be specified:

a) Assess the facility as a whole using the risk assessment detailed in AS1768.

b) If non-tolerable risk is identified, apply SPDs on interconnecting cables and equipment in accordance AS1768 Clause 4.6. Interconnecting cable and equipment must be rated for primary SPDs specifications (see AS1768 clause 4.6.3)

c) Ensure that conductive structures are self-protecting.

d) Apply the risk assessment to individual structures to determine if additional protection measures are needed. Consideration should be given to individual structure where it may be protected by the lightning protection system from the adjacent structures.

e) Sydney Water treatment or distribution facilities would fall into the aforementioned definition of a ‘Distributed Facility’. Examples of Sydney Water assets which are not defined as ‘distributed’ would be as follows:

   i. Single outdoor kiosk substations
   ii. Single outdoor pumping stations
   iii. Reservoirs
   iv. Vent shafts

5.4 Special Conditions: Natural Component Selection

Assets or structures that are not design for lightning strike tolerance natively, or unable to provided natural components for down conduction must require dedicated down conductors to conduct lightning strikes from the air terminal network to the earth termination network. This is primarily due to the structures having poor electrical continuity and being a critical asset for Sydney Water’s operation. Assets that may conform to this category can include above ground vent tunnel structures or reservoir infrastructure. Down conductor requirements for the system must follow the requirements set out in AS1768.

5.5 Special Conditions: Hazardous Areas (Waste Treatment Plant)

Sydney Water facilities, such as waste treatment plants, may contain hazardous areas. These sites require additional assessment under AS1768 and, depending on their classification, specific mitigation measures. Classifications for hazardous areas are set out in AS/NZS 60079. Flammable gas or flammable vapor are defined by AS/NZS 60079.10.1, while combustible dust is defined in AS/NZS 60079.10.2. Regardless of the area classification, an AS1768 lightning risk assessment must be completed separately.

Requirements for lightning protection of hazardous areas is set out in Appendix J of AS1768 and must include the following:

a) Equipotential bonding of all metallic parts and equipment to minimize potential differences (see clause J.2.2 and J.2.3 of AS1768 for equipotential bonding and earth bonding point requirements).

b) Specification of a suspended air terminal network, adhering to the specified clearances for suspended air terminal networks as outlined in clause J.2.4 of AS1768.

c) Installation of SPDs (requirements are to be determined through the AS1768 risk assessment procedure and installed in accordance with AS1768 clause 4).

5.5.1 Other Specific Structures

Precautions for specific structures, such as steel tanks, jetties, and barges, is provided in AS1768 Clause J.4.1 and must be implemented accordingly.

5.6 Existing Structures

Alterations to an existing structure that already contains an LPS must have a re-assessment carried out for the structure in accordance with the AS1768 risk assessment procedure, changing any attribute from the structure’s original assessment with updated characteristics (such characteristics can include size or material of the structure), the outcome of the risk assessment will dictate the required LPL of the structure.

If the structure’s shape or surrounding structures and assets have been altered, then modelling must be completed to ensure that the structure achieves its intended LPL. Further if the structure requires a different LPL, it will require design remediation works such that it achieves its required LPL.

If the risk assessment of the structure, requires SPDs then the remediation works will need to specify and updated the locations of any required SPDs. Alterations or extensions to the building must identify any changes to the locations of SPDs.

5.7 SPD Installations

Installation of SPDs for lightning protection must be adhered to as detailed in Appendix F of AS1768.

6. Technical Requirements - Corrosion Mitigation

Corrosion mitigation must be considered in the design of earthing and lightning protection systems, the following dictates Sydney Water's requirements for minimising corrosion.

6.1 Dissimilar Metals

Care must be taken to avoid galvanic corrosion where there are dissimilar metal connections. In general dissimilar metal connections must be avoided. If a dissimilar metal connection exhibiting poor corrosive characteristics (as identified AS4036) is unavoidable, then the following mitigation options must be implemented (where practicable):

- Coating connections with epoxies
- Installation of petroleum jelly between connections
- Installation of standoffs.

Where surface preparation and treatment works are required for earthing and lighting connections and equipment, relevant part of WSA201 and Sydney Water Supplement must be followed. Stainless Steel 316 material does not require surface treatment.

6.2 Air-Soil Interfaces

Air-soil interface connections between buried earthing system components and above-ground assets (such as HV assets or fences) must include PVC covering to mitigate corrosion.

6.3 Corrosive Soils

Soil testing must be completed prior to developing an installation to determine its suitability for installing a buried earth grid. Highly corrosive soils must be considered when sizing earthing conductors. In such cases, earthing conductors may be oversized to prolong the lifetime of the earth grid.

7. Additional Technical Requirements

Requirements for earthing of instrumentation and control services can be found in HSS0009. The following must be treated as additional requirements.

7.1 Screened Cables

Cable screen bonding for Signalling, Controls and Communication assets must comply HSS0009 clause 10.1.

Situations where screens are to be connected at both ends must consider the HV earth fault transfer scenario into the LV system and consider the risk of signal or instrumentation box connections. Touch voltage hazards at these installations must be assessed for compliance.

7.2 Equipotential Bonding

Equipotential bonding for Signalling, Controls and Communication assets must comply HSS0009 clause 10.5.

7.3 DC Supplies

The negative of instrument loop signals must be earthed only at the DC voltage source. For a common DC voltage source, the negative of the source voltage only must be earthed via control cubicle earth bar.

8. Technical Requirements – Other Earthing System Interactions

8.1 Railway traction systems

Where Sydney Water assets are in proximity to the running rails of an electrification system, an assessment of the stray return traction current impact on the asset and its earthing system must be carried out.

Guidance for this assessment can be found in EN50122-2, TfNSW, ARTC and Sydney Metro Standards.

8.2 HV Utility (TNSP/DNSP) Earthing Systems

If other HV earthing system assets are near to the proposed installation (that are intended to be separate earthing systems), the transfer risk for earth faults between both systems must be considered with any exclusion zones adhered to.

8.3 Sydney Water Facility Fencing

Metallic fencing outside a substation environment which is under an overhead line will require an earthing assessment complete. The assessment must consider both EPR/LFI touch voltage hazards on the fence. Subject to the assessment, the fence must be fitted with an isolation panel on either side of the crossing.

9. Documentation Requirements

9.1 Earthing System Report

Earthing system and lightning protection design reports are to be well formatted and clearly legible. The report must include following aspects as a minimum:

1. Executive Summary including key design outcomes
2. Scope and Introduction/Project Description
3. Input Data and Assumptions (Including fault level and protection information)
4. Soil resistivity test results and models
5. Safety criteria development
6. Earthing/Lightning Protection system design, arrangement and details
7. Modelling outcomes and design compliance (including calculated software results for EPR, Touch Voltage, step voltage, transfer hazard and exclusion zones)
8. Earthing conductor sizing
9. Conclusion and Recommendations

Staged earthing system design report can be submitted for review purpose, the stages set must be aligned with Section 2.1 of this document. One final report includes all elements mentioned above must be provided as part of the WAE package in both native and PDF format.

9.2 Lightning Protection System Report

1. Executive summary including key design outcomes
2. Introduction (background/scope/relevant document)
3. Input Data
4. Assumptions
5. Methodology
6. Risk assessment (input data, rolling sphere simulations, calculations and results)
7. Lightening Protection design for structure (including rolling sphere methods details) and equipment
8. Conclusion and recommendation

Staged lightning system design report can be submitted for review purposes, the stages set must be aligned with Section 2.1 of this document. One final report includes all elements mentioned above must be provided as part of the WAE package in both native and PDF format.

9.3 Deliverable Drawings

Earthing system SLD and typical earthing details must be developed as per Appendix 1. All drawings must be well formatted, have legend and clearly legible. As minimum following drawings must be provided,

a) Earthing system layout

b) Earthing system connection SLD

c) Earthing system schematic/connection diagram per area

d) Lightning protection system layout (including connection details to earthing system and construction details per area)

e) Lightning Protection layout with rolling sphere details

f) Typical earthing details

‘As built’ drawing must be provided for all earth systems showing, in relation to the fixed electrical equipment, the position of equipotential bonds and position and depths of all earth electrodes, grid conductors. All drawing files must be in both AutoCAD and PDF format.

10. Testing Requirements

10.1 General requirements

The delivery party must carry out tests as necessary to demonstrate compliance with the requirements of this this specification and relevant Australian and International standard referred in this document.

The testing requirements provided in this document is only intended for design, construction and commissioning stage of the earthing system.

‘Tests’ must include all checks, measurements and tests necessary to prove compliance.

All test equipment and instrumentation used for testing must be traceable to a National Association of Testing Authorities (NATA) Registered Laboratory and have a current test sticker affixed. The responsible work party is responsible for ensuring that test equipment and instrumentations used is traceable. The calibration certificate must be provided as part of testing documentation.

Quality system procedures and test records sheets must be provided for review and approval prior to commencing testing.

The test records must clearly describe the details of the tests and the test results. All calculations must be provided.

Defects found in any work pre-formed must be rectified and/or replaced.

A test plan for installation must be developed and provided to SW for approval before proceeding. Representatives from Sydney Water must be given the opportunity to witness the tests. 14 calendar days’ notice must be given to Sydney Water prior to tests being conducted.

10.2 Earthing system testing

All HV and LV installations earthing system testing must be tested prior to energization to verify that the installation meets design performance and outcomes. As a minimum, the test plan must include applicable item specified in Table 1 - Test requirements.

10.3 Lightning protection System Testing

DC continuity of the LPS system must be carried out to ensure that all components are solidly bonded together. Test results must prove the intended design performance and compliance to AS1768.

10.3.1 Design/Construction Testing

Testing of the LPS must be conducted throughout the construction phase. DC continuity testing must be completed to ensure solid bonding between the LPS air terminal, down conduction, and earth termination network.

10.3.2 Final Commissioning

Final commissioning testing of the earth termination network must determine an earth grid value to ensure that the 10Ω earth grid resistance target is met. Testing methods to determine the local earth grid resistance value must be appropriately chosen, considering the number of auxiliary paths connected to the earth termination network.

Table 1. Testing requirements

Item	Testing	Installation Type	Stage required	Hold point	Additional notes
1	Soil Resistivity test to determine soil conductivity (if required).	HV & LV (exemption applies for some LV installations as specified in the notes)	Design/ Construction	Yes - Design input and dependency	• Perform Wenner 4-point test to model soil layers. Required if design assumptions change. For small LV installation where the perspective earth fault current is less than 10kA, the soil resistivity test is exempted, considering standard electrode design suffices
2	Visual Inspection to verify correct installation and absence of defects.	HV & LV	Design/ Construction & Commissioning	Yes - Ensure compliance before concealment	• Verify electrode placement, conductor integrity, and corrosion protection per design drawings.
3	Continuity Testing to ensure low resistance of earth conductors and bonding connections.	HV & LV	Design/ Construction & Commissioning	Yes - Prevent rework post-concealment	• Measure resistance between electrodes, bonds, and equipment
4	Earth Resistance to measure overall resistance to earth. Measure through each electrode for overall resistance.	HV & LV	Commissioning	Yes - Critical for safety	• Use fall-of-potential method (IEEE 81) to confirm grid resistance. • For LV earthing system must be carried out in compliance with AS/NZS 3017.
5	Impedance Testing to assess impedance under fault conditions.	HV	Commissioning	Yes - Fault performance	• Inject current to measure impedance under simulated fault (AS 2067). Validate fault current dissipation.
6	EPR Measurement to quantify potential rise during fault (for larger installations).	HV	Commissioning	Yes - Safety compliance	• Measure Earth Potential Rise (EPR) during fault; limit to <430V (AS 2067) for HV substations.
7	Touch & Step Voltage Measure potential voltage	HV & LV (exemption applies for some LV installations	Commissioning	Yes – Safety risk	• For small LV installation where the perspective earth fault current less than 10ka, if earth

Item	Testing	Installation Type	Stage required	Hold point	Additional notes
	gradients around the earthing system.	as specified in the notes)			resistance is compliant to AS/NZS 3000 and the electrodes are having adequate space, then touch and step measurement is exempted. • Test point for touch and step potential must be cross referenced with respective modelling work, the quantity of the test points must be a reflection of the risk levels indicated from the model.
8	Earth fault loop impedance measurement	LV	Commissioning	Yes – Compliance safety requirement	• Apply AS/NZS 3000 Earth fault loop impedance testing method and acceptable limits.
9	Current Injection Testing to simulate fault conditions and assess overall earthing system performance.	HV	Commissioning	Yes - System validation	• Apply high current verify dynamic performance (soil ionisation, thermal stability). • Earth fault current split/distribution measurements.

Earthing system verification and testing must comply AS 2067, AS/NZS 3000, AS/NZS 3017 and any applicable DNSP requirements.

At the completion of testing, checks must be made to ensure that all links have been closed and tightened, and all terminations are tight.

10.4 Documentation

A comprehensive Site Test report must be submitted to Sydney Water for approval within five working days of completion of the tests (or on handover, whichever is the earlier). The final test report including all tests records must be provided as part of the WAE package including both native and PDF files.

10.4.1 Earthing System Test Reports

Test report for earthing system must include as minimum,

1. Executive summary including key outcomes and statement confirming compliance with all specified and legislated requirements.
2. Assumptions, if any
3. Visual inspection (relevant photos to be provided)
4. Methodology, test equipment and test route
5. DC Continuity test measurements (including HV and LV combined/separated)
6. Earth electrode impedance measurement (Fall of potential/Current injection test)
7. Overall earthing system impedance and through each earth electrode impedance (Fall of potential/Current injection test)
8. Earth potential rise measurements (Current injection test)
9. Earth fault current split/distribution measurements (Current injection test)
10. Touch and step voltage assessment (Current injection test). The test locations to be numbered on plan layout of the facility (GPS co-ordinates of the above test locations must also be provided on the layout). A comparison table for measured results and allowable limit must be provided.
11. Earth fault loop Impedance measurement in comparison with max allowable limit
12. Equipotential bonding verification results as per AS/NZS 3017
13. Any exclusion zones for third party assets (if applicable)
14. Conclusion, observations and recommendation

10.4.2 Lightning Protection system Test Reports

Test report for LPS must include as minimum,

1. Executive summary including key outcomes
2. Assumptions
3. Visual inspection (photos to be provided)
4. Methodology, test equipment (and calibration certificate)
5. DC Continuity test measurements (including HV and LV combined/separated)
6. Earth electrode impedance measurement
7. Overall earthing system impedance
8. SPD testing results
9. Conclusion, observations and recommendation

11. References

Document type	Title
Legislation	- Latest edition of the Work Health and Safety Act - Latest edition of the Service and Installation Rules of New South Wales
Policies and procedures	- WSA201 - Manual for Selection and application of protective coatings - Supplement to WSA201 - Manual for Selection and application of protective coatings. - PCS100 - Protective Coatings
Other documents	- D0002010 - Engineering Standard governance - HSS0009 Technical Specification – Instrumentation and Control
Standards	- AS/NZS 1020: The control of static electricity in non-hazardous areas - AS 1289: Methods of testing soils for engineering purposes - AS 1319: Safety signs for the occupational environment - AS/NZS 1768: Lightning protection - AS 1824 (IEC 60071): Insulation coordination (phase-to-earth and phase-to-phase, above 1k V) (Parts 1 and 2) - AS 2067: Switchgear assemblies and ancillary equipment for alternating voltages above 1 kV - AS/NZS 3000: Electrical installations (known as the Australian/New Zealand Wiring Rules) - AS/NZS 3008.1.1: Electrical installations - Selection of cables - Cables for alternating voltages up to and including 0.6 / 1 kV - Typical Australian installation conditions - AS/NZS 3017: Electrical installations - Verification by inspection and testing - AS/NZS 3835: Earth potential rise - protection of telecommunications network users, personnel and plant - AS/NZS 4853: Electrical hazards on metallic pipelines - AS/NZS 60079: Explosive atmospheres - AS 60479: Effects of current on human beings and livestock - AS/NZS 60990: Methods of measurement of touch current and protective conductor current - ENA EG0: Power System Earthing Guide - ENA EG1: Substation earthing guide - HB101: Coordination of power and telecommunications - Low Frequency Induction (LFI) - Code of practice for the mitigation of hazardous voltages induced into telecommunications lines - IEC60634-4-54: Low-voltage electrical installations - Selection and erection of electrical equipment - Earthing arrangements and protective conductors - IEC62305: Protection against Lightning

Document type	Title
	- IEEE Std 80-2000: IEEE Guide for safety in AC substation grounding - IEEE Std 81: IEEE Guide for measuring earth resistivity, ground impedance, and earth surface potentials of a ground system - IEEE Std 81.2: IEEE Guide for measurements of impedance and safety characteristics of large, extended or interconnected grounding systems - IEEE Std 837: Standard for qualifying permanent connections used in substation grounding

11.1 Conflicts between specification, standards and/or codes

Review the above standards and make use of them where they are applicable. Identify any conflicts between the above standards and recommend which criteria to use. The Contractor must refer any conflicts in the information to Sydney Water for clarification.

Ownership

Ownership

Role	Title
Group	Water and Environment Services
Owner	Manager of Engineering Modernisation
Author	Technical Director- Electrical

Change history

Version No.	Prepared by	Date	Approved by	Issue date
1	Robert Lau / Andrew Manganas / Paul Zhou	05/12/2014	Norbert Schaeper	05/12/2014
2	Robert Lau / Paul Zhou	14/09/2018	Ken Wiggins	14/09/2018
3	Paul Zhou	20/02/2020	Steve-Keevil Jones	20/02/2020
4	Paul Zhou/ Hedi Aghdam	4/04/2025	Norbert Schaeper	30/04/2025

Appendices

Attachment	Title
1	Standard Drawings Terms and Conditions
2	Typical Large Earthing and Bonding Connection Schematic Diagram
3	Typical Embedded Steelwork Earthing Details
4	Typical Fence and Gate Earthing Details
5	Main HV and LV Earth Bar Details and Electrode and General Earth Grid Earthing Details
6	Typical Small Earthing and Bonding Connection Schematic Diagram

Appendix 1 Standard Drawings

Sydney Water's standard drawings are intended to assist engineers in developing designs that meet the requirements, promoting consistency, efficiency, operability and maintainability through standardisation. The use of Sydney Water's Standard Drawings is subject to the following Terms and conditions.

A1.1 Terms and conditions of use of Sydney Water Standard drawings

Sydney Water provides Standard drawings free of charge for use when designing Sydney Water assets. Sydney Water Standard drawings must only be used by competent design personnel complying with requirements of the Sydney Water Engineering Competency Standard D0000833.

The user of Standard drawings must carry out the necessary investigations to confirm Sydney Water Standard drawings are suitable as a design basis for their application. Limitations and the rules of application are shown on the Standard drawings.

Sydney Water Standard drawings may not be suitable for construction. Standard drawings are to be used as a guide/basis for designers to prepare fit for purpose design documentation for their intended application. Standards drawings must not be referred to.

Use of Sydney Water Standard drawings may introduce unintended safety risks. The user shall manage safety risks through site specific risk assessment.

The user is responsible to ensure they are using the latest published version of standard drawings.

Sydney Water has prepared standard drawings using all reasonable, care and skill. Sydney Water gives no warranties or representations concerning the standard drawings, and accepts no liability arising from the use of Standard drawings.

By using the Sydney Water Standard drawings, you are accepting the above terms and conditions.

A1.2 Instruction for use of Standard Drawings

There are in total 5 sheets in this drawing set:

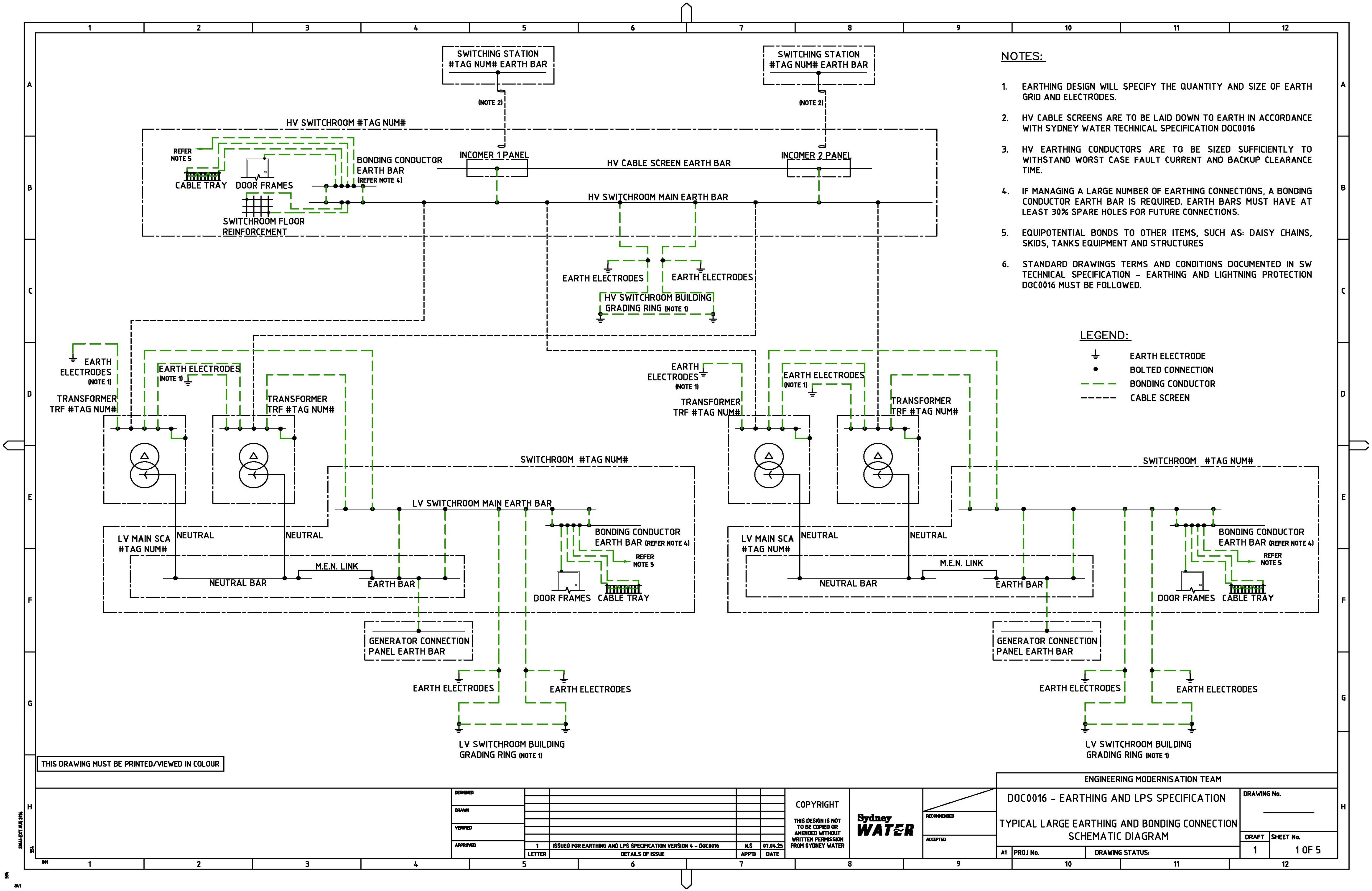
- Sheets 1 and 5 are earthing and lightning system diagram details.
- Sheets 2, 3 and 4 are design and construction details for specific elements of earthing and lightning components.

The use of the Sydney Water's Standard Drawings is subjected to following additional requirements.

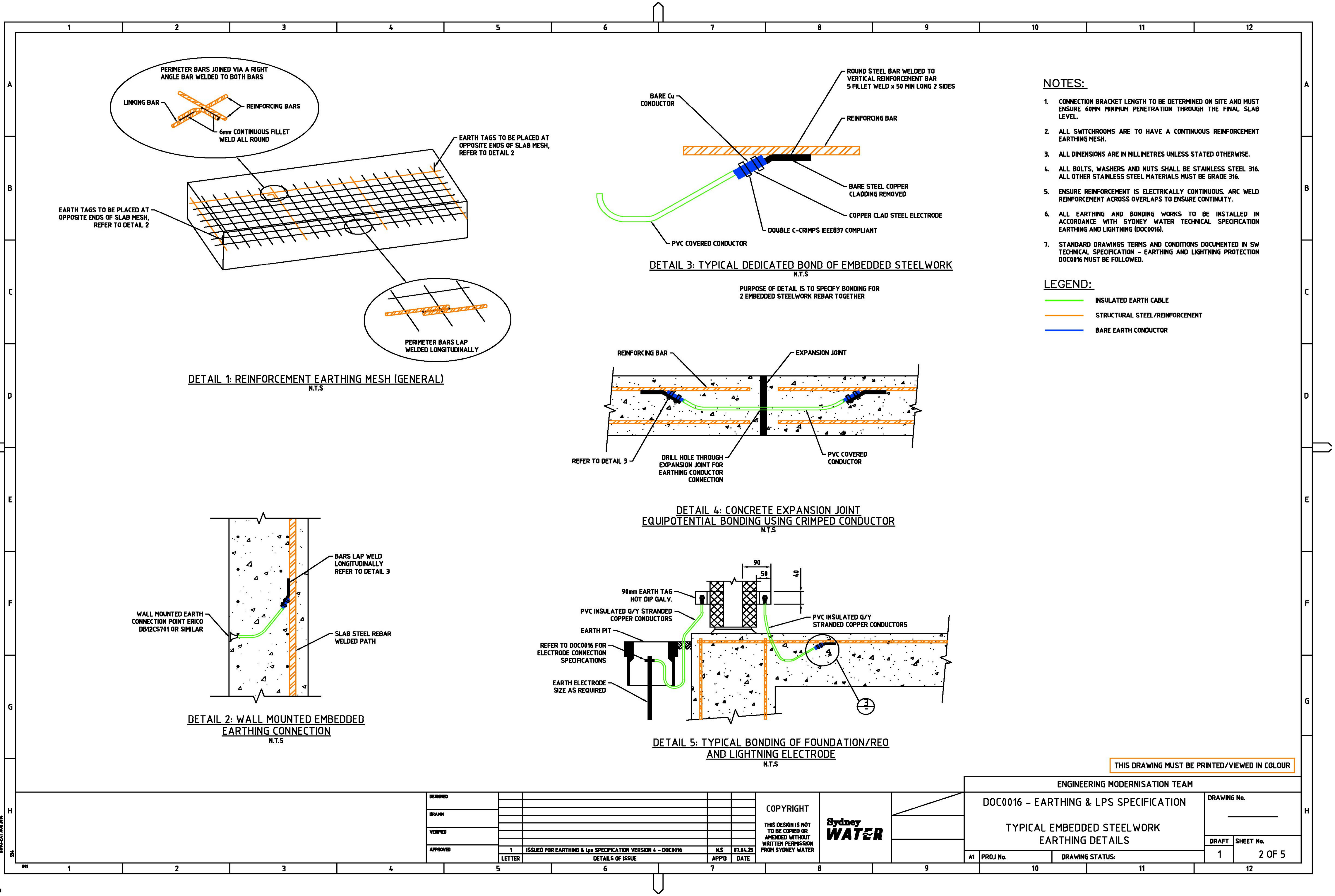
- For the system diagram details (sheet 1 and 5), the delivery party must apply the relevant parts of the system in accordance with Section 2 of this document and produce deliverables scalable to applicable parts.
- For the design and construction detail drawings (sheet 2 ,3 and 4), the delivery party must apply the applicable detail arrangement based on what's required.
- This set may not cover all scenarios and details applicable for the design, it is the responsibility of the delivery party to produce designs outside what has been covered in this drawing sets. Where applicable, the details of the new design must be based on the requirements in this specification document and similar design arrangement provided in this drawing sets to achieve consistency and standardisation.

- These drawings set may not cover the full extended of delivery details for WAC drawings, other SW source documents such as SW AutoCAD standard, asset creation process, etc. must be followed.

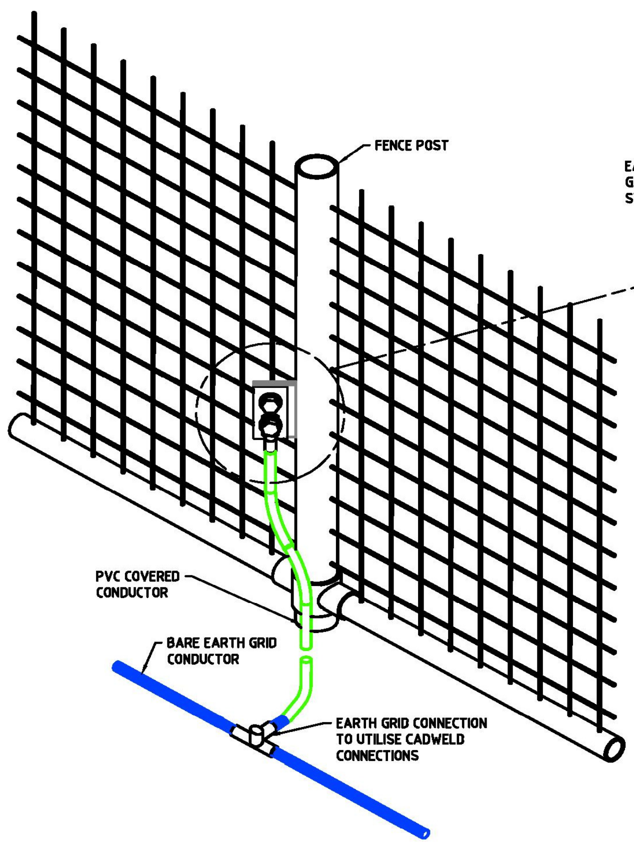
Appendix 2 – Typical Large Earthing and Bonding Connection Schematic Diagram



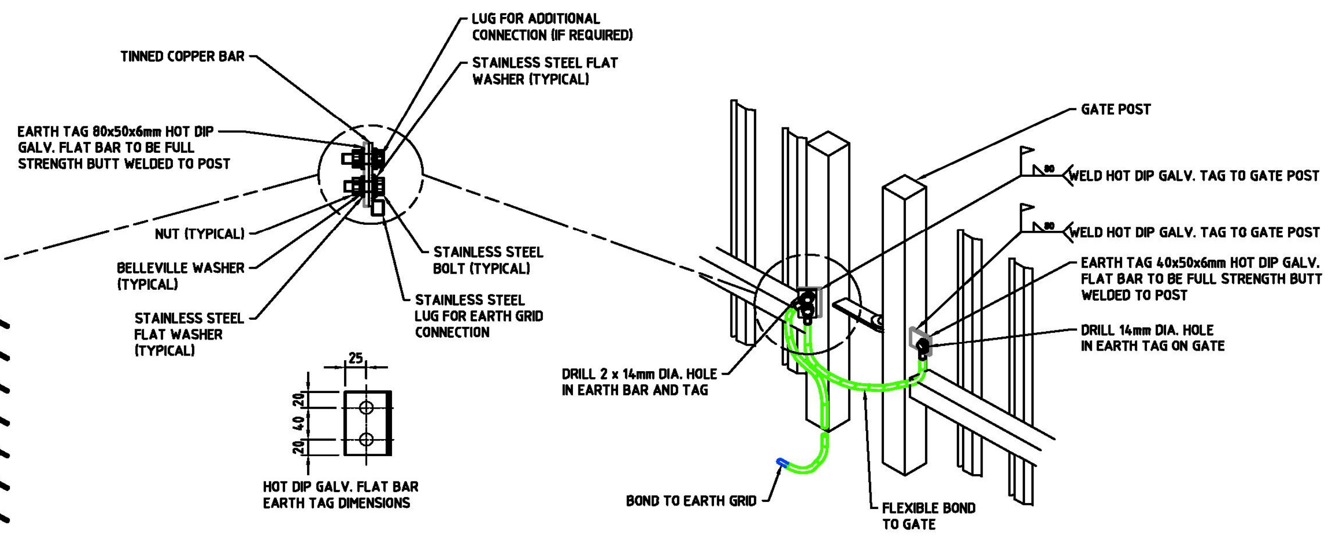
Appendix 3 – Typical Embedded Steelwork Earthing Details



Appendix 4 – Typical Fence and Gate Earthing Details



DETAIL 1: TYPICAL BONDING OF FENCE POST TO EARTH GRID
N.T.S



DETAIL 2: BONDING OF PALISADE FENCE GATE POST TO EARTH GRID
N.T.S

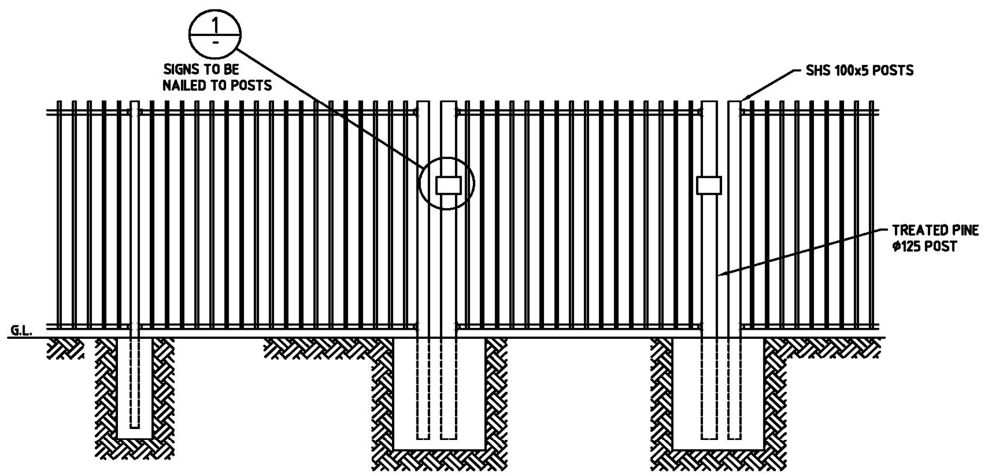
ALL BONDS TO GATE POST TO BE INSTALLED INSIDE ONLY.
NO CONDUCTOR TO BE RUN OVER KERB.

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS STATED OTHERWISE.
2. ALL BOLTS, WASHERS AND NUTS SHALL BE STAINLESS STEEL 316. ALL OTHER STAINLESS STEEL MATERIALS MUST BE GRADE 316.
3. ALL EARTHING AND BONDING WORKS TO BE INSTALLED IN ACCORDANCE WITH SYDNEY WATER TECHNICAL SPECIFICATION EARTHING AND LIGHTNING (DOC0016).
4. THE EARTHING AND BONDING CONNECTIONS FOR NON-ELECTRICAL INSTALLATION FENCES AND GATES ARE SUBJECTED TO THE EARTHING AND LIGHTNING DESIGN.
5. STANDARD DRAWINGS TERMS AND CONDITIONS DOCUMENTED IN SW TECHNICAL SPECIFICATION – EARTHING AND LIGHTNING PROTECTION DOC0016 MUST BE FOLLOWED.

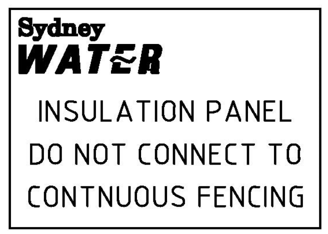
LEGEND:

- INSULATED EARTH CABLE OR TINNED Cu BRAID CONDUCTOR (green line)
- BARE EARTH CONDUCTOR (blue line)



SPACING OF INSULATION PANELS TO BE SPECIFIED FROM EARTHING ASSESSMENT

DETAIL 3: TYPICAL ISOLATION PANEL
N.T.S



STAINLESS STEEL (SS316) SIGN TO BE SUPPLIED

DETAIL 1/-

THIS DRAWING MUST BE PRINTED/VIEWED IN COLOUR

DESIGNED				
DRAWN				
VERIFIED				
APPROVED	1	ISSUED FOR EARTHING & LPS SPECIFICATION VERSION 4 – DOC0016	N.S	07.04.25
	LETTER	DETAILS OF ISSUE	APP'D	DATE

COPYRIGHT
THIS DESIGN IS NOT TO BE COPIED OR AMENDED WITHOUT WRITTEN PERMISSION FROM SYDNEY WATER

Sydney WATER

ENGINEERING MODERNISATION TEAM

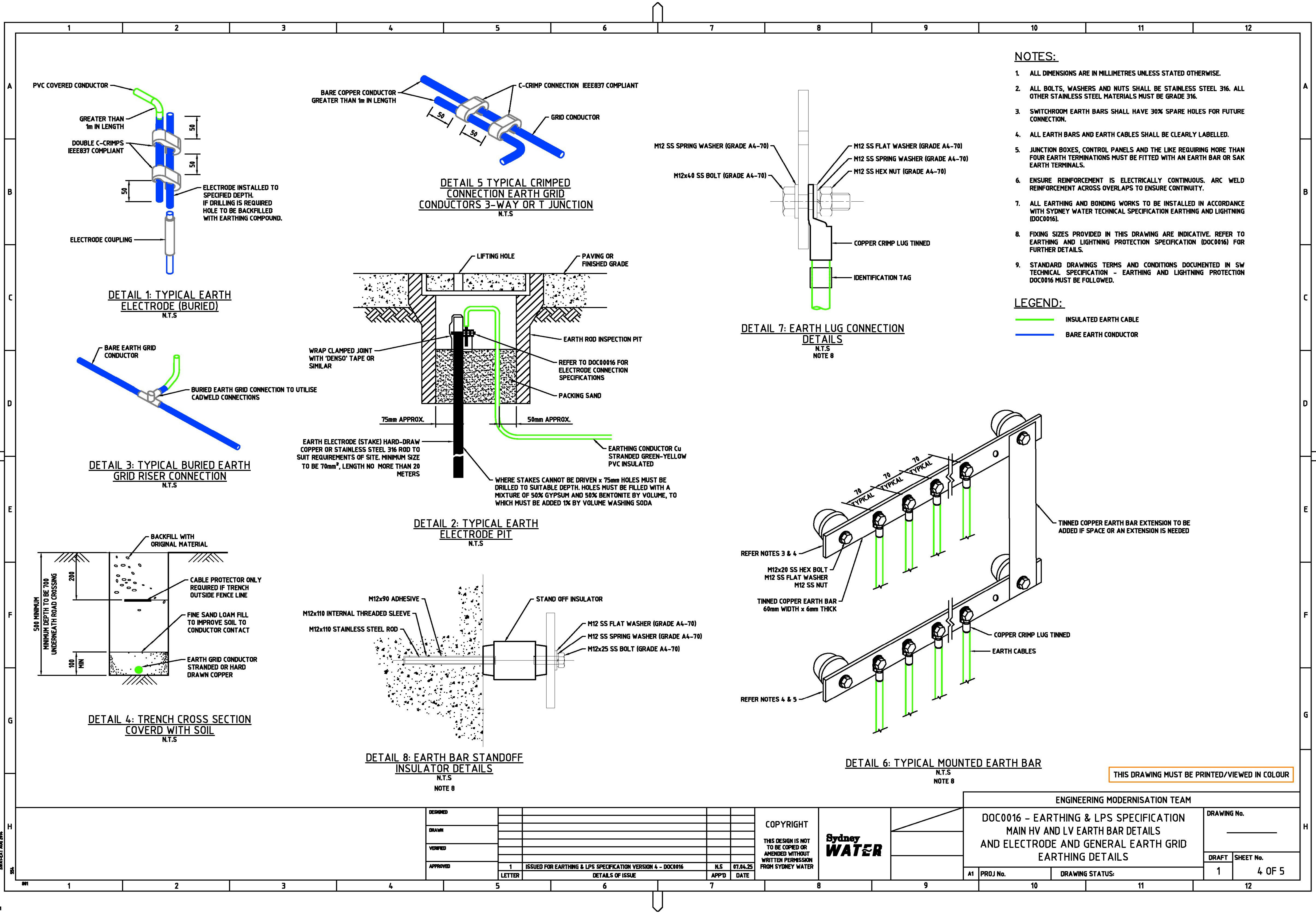
DOC0016 – EARTHING & LPS SPECIFICATION

TYPICAL FENCE AND GATE EARTHING DETAILS

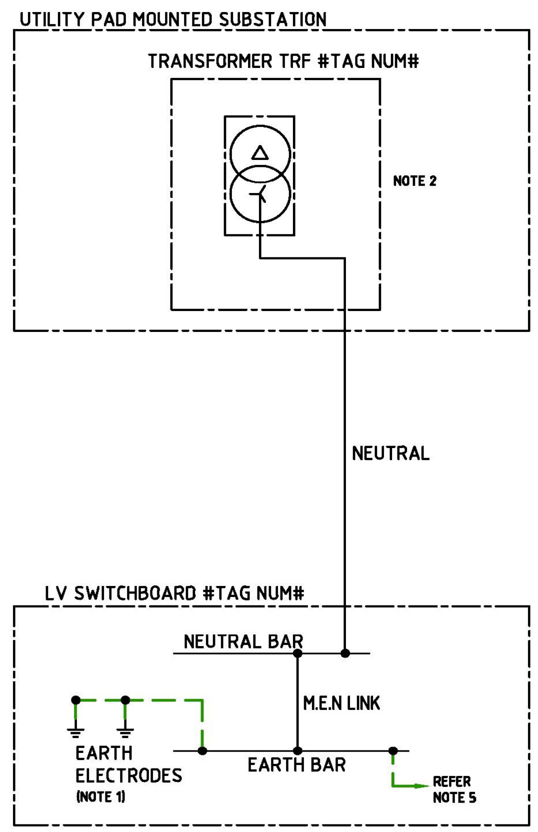
DRAWING No.

A1 | PROJ No. | DRAWING STATUS: | DRAFT 1 | SHEET No. 3 OF 5

Appendix 5 – Main HV and LV Earth Bar Details and Electrode and General Earth Grid Earthing Details



Appendix 6 – Typical Small Earthing and Bonding Connection Schematic Diagram



NOTES:

1. EARTHING DESIGN WILL SPECIFY THE QUANTITY AND SIZE OF EARTH GRID AND ELECTRODES.
2. ASP3 EARTHING DESIGN FOR UTILITY ASSET TO CONSIDER TRANSFER VOLTAGES AND IMPACT ON SYDNEY WATERS ASSETS AS PER SYDNEY WATER TECHNICAL SPECIFICATION DOC0016.
3. HV EARTHING CONDUCTORS ARE TO BE SIZED SUFFICIENTLY TO WITHSTAND WORST CASE FAULT CURRENT AND BACKUP CLEARANCE TIME.
4. IF MANAGING A LARGE NUMBER OF EARTHING CONNECTIONS, A BONDING CONDUCTOR EARTH BAR IS REQUIRED. EARTH BARS MUST HAVE AT LEAST 30% SPARE HOLES FOR FUTURE CONNECTIONS.
5. EQUIPOTENTIAL BONDS TO OTHER ITEMS.
6. EARTHING BETWEEN TRANSFORMER AND LV SWITCHBOARD EARTH BAR TO BE RELIED UPON BY PROTECTIVE EARTHING CONDUCTORS. IF ONLY ONE, INSTALL ADDITIONAL BONDING CONDUCTOR.
7. STANDARD DRAWINGS TERMS AND CONDITIONS DOCUMENTED IN SW TECHNICAL SPECIFICATION – EARTHING AND LIGHTNING PROTECTION DOC0016 MUST BE FOLLOWED.

LEGEND:

- EARTH ELECTRODE
- BOLTED CONNECTION
- BONDING CONDUCTOR
- CABLE SCREEN

THIS DRAWING MUST BE PRINTED/VIEWED IN COLOUR

DESIGNED				
DRAWN				
VERIFIED				
APPROVED	1	ISSUED FOR EARTHING & LPS SPECIFICATION VERSION 4 - DOC0016	N.S	07.04.25
	LETTER	DETAILS OF ISSUE	APP'D	DATE

Sydney WATER

ENGINEERING MODERNISATION TEAM

DOC0016 – EARTHING & LPS SPECIFICATION

TYPICAL SMALL EARTHING AND BONDING CONNECTION SCHEMATIC DIAGRAM

DRAWING No.

A1 PROJ No. DRAWING STATUS:

DRAFT 1 SHEET No. 5 OF 5