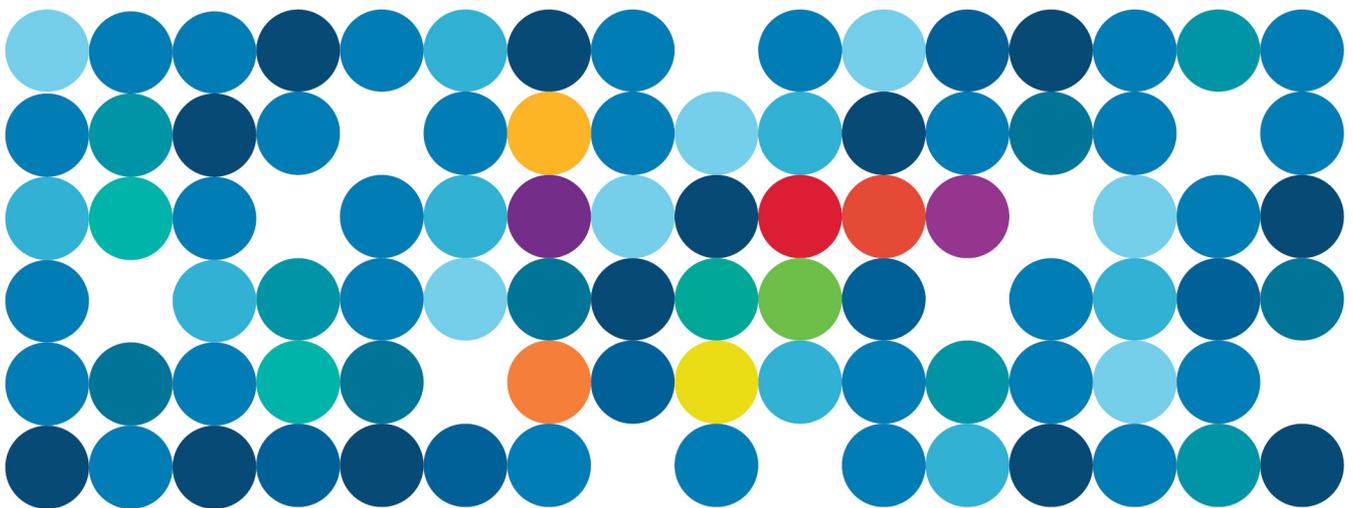


# Water Pipeline AC Interference

## Earth Potential Rise

Process and Technical Requirements for Land Development Projects





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## 1 Background

This document supersedes and replaces Water Corporation’s “EPR Guideline for Land Developers” which was issued in April 2012.

This “Process and Technical Requirement” manual is written solely for the land development industry in delivery of land sub-divisions to comply with Water Corporation’s requirements on pipeline AC interference effects related to Earth Potential Rise (EPR) ONLY.

For other types of AC interference (e.g. low frequency induction & capacitive coupling), the land developer should contact Water Corporation for more information.

The content of this document (hereby referred to as the “Manual”) shall be read in conjunction with Water Corporation’s Design Standard DS23 “Pipeline AC Interference and Substation Earthing”.

A copy of the Design Standard DS23 can be requested via the web link [IDB.StandardsEnquiries@watercorporation.com.au](mailto:IDB.StandardsEnquiries@watercorporation.com.au)

EPR analysis, mitigation design and verification test shall be carried out in accordance with the requirements of Design Standard DS23 and only varied as stated in this Manual

## 2 Purpose

The Manual covers:

- AC interference – Analysis and mitigation requirements of the electrical hazards on metallic water pipelines mainly due to conductive coupling (Earth Potential Rise) ONLY. The effects of inductive coupling (Low Frequency Induction) and capacitive coupling are beyond the scope of this document.
- Design Standard DS23 addresses the contradictions between AS4853:2012 (including AS2067-2008) and the 2011 Work Health Safety (WHS) Act. Essentially the target level of risk approach adopted by these Australian standards is in conflict with the WHS Act and arguably the precautionary nature of the Australian legal system. The Act requires demonstration that all reasonably practicable precautions (due diligence) have been taken and are in place. Although AS4853:2012 and AS2067:2008 stipulate that probabilistic target level of risk methods is to be used to determine safe touch voltage limits, this Manual (and DS23) takes the precautionary approach as described in the WHS Act. In this Manual, touch voltage limits have therefore been computed using traditional deterministic methods focusing on body impedances and fibrillation curves presented in AS60479.1:2010.



### 3 References

The following key Australian Standards and International Standards were referred to in compiling this Manual:

- AS4853:2012 – Electrical Hazards on Metallic Pipelines
- AS2067:2008 – Substation and High Voltage Installations Exceeding 1kV a.c.
- AS60479.1:2010 – Effects of current on human beings and livestock, Part 1: General Aspects
- AS3835.1:2006 – Earth potential rise – Protection of telecommunications network users, personnel and plant, Part 1: Code of Practices
- AS3835.2:2006 – Earth potential rise – Protection of telecommunications network users, personnel and plant, Part 2: Application Guide
- AS3000:2007 – Wiring Rules
- IEEE Standard 80:2000 – Guide for safety in AC substation grounding
- IEEE Standard 81:2012 – Guide for measuring earth resistivity, ground impedance and earth surface potentials of a grounding system
- Water Corporation’s Design Standard DS23 “Pipeline AC Interference and Substation Earthing”

### 4 Process

The process for EPR assessments shall consist of three stages, namely:

- AC interference analysis and associated report,
- AC interference mitigation design and associated report and drawings, and
- Verification testing (current injection) and associated report.

The following flowchart shows the steps to be involved at each stage for a typical underground water pipeline and the appurtenances. For ABOVE GROUND pipes, both the pipes and the appurtenances must be mitigated in the event that the touch voltages are above the safety limit(s).

Under Clause 2.2.1 of Design Standard DS23, soil testing, analysis, design and verification must be carried out by the SAME organisation.

However, this requirement may be varied for land development projects if deemed appropriate by the developer or designer.

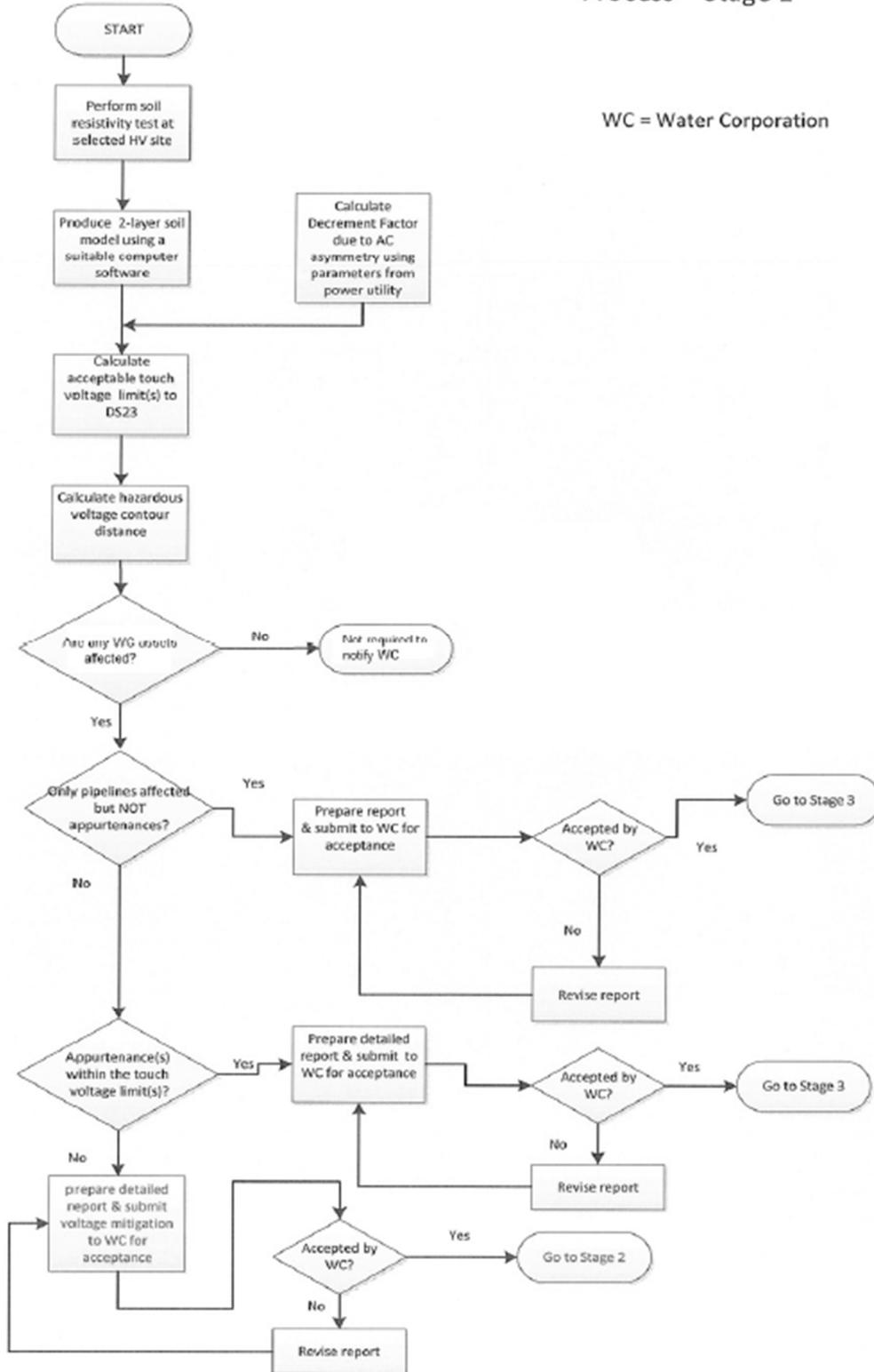
If the designer has undertaken an assessment in accordance with the requirements of this document and found that there is no impact on Water Corporation infrastructure, there is no requirement to notify the Water Corporation of the result or seek their approval.



Power Utility (e.g. Western Power) require pipeline owner's approval

Process – Stage 1

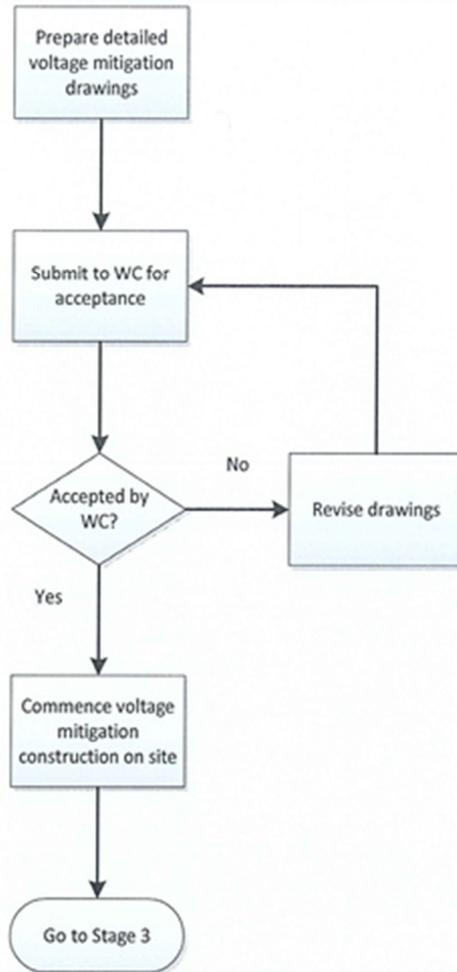
WC = Water Corporation





## Process – Stage 2

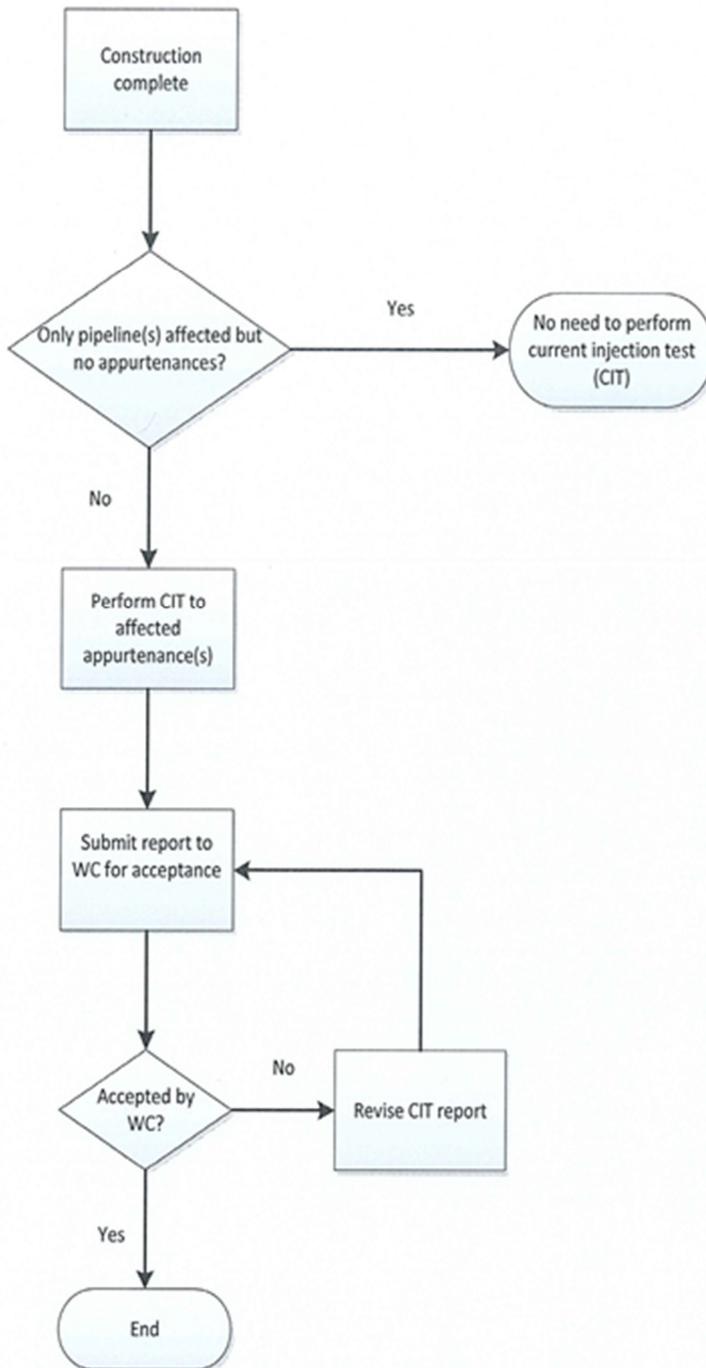
WC = Water Corporation





### Process – Stage 3

WC = Water Corporation





## 5 Water Corporation Assets

Water Corporation has fresh water, drainage & wastewater infrastructure assets covering the State of Western Australia.

The term “water” pipes covered in this Manual refers to all of the above infrastructure types.

The majority of the water pipelines are direct buried below ground.

The common types of water pipes are:

- Steel (Sintakote coated) - new
- Steel (Bitumen coated) – old
- Ductile iron (laid in PE tubing)
- Reinforced concrete
- Cast iron
- Asbestos cement
- Copper (mainly for services of short lengths)

The types of infrastructure which require assessment of electrical hazards are mainly;

- Direct buried steel pipes and appurtenances
- Direct buried ductile iron pipes and appurtenances, and
- Above ground conductive pipes and appurtenances

The above-mentioned infrastructure assets include trunk mains, distribution mains fire services, sewerage and drainage that are owned by the Water Corporation.

The land developer shall arrange to conduct the assessment in accordance with the process and technical requirements stipulated in this Manual and Design Standard DS23.

Only qualified electrical designers shall be engaged to perform the assessments



## 6 Qualified Electrical Designers

### 6.1 Earth Potential Rise (EPR) Assessments

To ensure quality & standard are maintained in assessing electrical hazards associated with water pipelines and appurtenances, Water Corporation requires the electrical designer must possess relevant qualification and experience.

The electrical designer who conducts the assessments and prepares the reports shall be eligible for admission to the Corporate Membership of the Institution of Engineers, Australia and possesses at least 4 years relevant engineering experience in electrical power.

The senior engineer who reviews the assessments shall also be eligible for admission to the Corporate Membership of the Institution of Engineers, Australia and possesses at least 6 years relevant engineering experience in electrical power.

The relevant experience in electrical power must include earthing design but excluding secondary system such as instrumentation, control and SCADA.

The author and the reviewer shall sign on the front page of the assessment report before submitting it to Water Corporation for review and acceptance.

There are situations which the land developer engages the electrical designer to conduct the assessment but uses a separate specialist company to perform the soil resistivity test. Under these circumstances, the latter must possess the same or equivalent qualification and experience as stipulated above.

### 6.2 Low Frequency Induction (LFI) Assessments

Due to the level of complexity being involved in LFI, the analysis, design and mitigation shall be carried out strictly in accordance with the Design Standard DS23 utilising the services of a specialist earthing consultant approved by the Principal Electrical Engineer (Power) of the Infrastructure Design Branch.

## 7 Modelling Software

Refer to Section 2.2.6 of the Design Standard DS23.

Water Corporation prefers the assessments to be performed using the CDEGS software (**C**urrent **D**istribution, **E**lectromagnetic Fields, **G**rounding and **S**oil Structure Analysis) as it is widely accepted by the majority of the electrical utilities nation-wide.

However the electrical designer may use other power system earthing software available on the market for EPR analysis.

Due to the complexity being involved in AC interference analysis, hand calculations are NOT acceptable.



## 8 Soil Resistivity and Modelling

Refer to Section 2.2.4 of the Design Standard DS23.

Assumed soil resistivity values shall NOT be used for the soil modelling and AC interference assessment.

Wenner Four-Pin method soil resistivity testing & measurements shall be carried out in accordance with AS4853:2012 or IEEE Standard 81:2012 and DS23.

The measured data shall be converted to a computer model which best represents the soil structure seen by the tests.

Multi-layer soil models with a minimum of two layers shall be used for the AC interference assessment for the water pipelines and appurtenances.

## 9 Touch and Step Voltage Limits

Refer to Section 2.2.7 of the Design Standard DS23.

The electrical designer may choose to calculate the touch and step voltage limits either manually or using computer software.

If manual calculation is chosen, every step shall be clearly shown in the assessment report.

Both prospective touch voltage and loaded touch voltage limits shall be included in the assessment report.

The report should also show graphically the touch voltage contour limit from each HV source.

## 10 AC Interference Mitigation Design

Refer to Section 2.3 of the Design Standard DS23.

The land developer is fully responsible for the supply and installation of the voltage mitigation to the affected Water Corporation assets.

Construction of the voltage mitigation shall NOT be commenced until the mitigation report and all the final design drawings are accepted by Water Corporation.



## 11 Site Verification Testing

Refer to Section 2.4 of the Design Standard DS23.

It is the responsibility of the land developer to organise the site verification test.

Site verification test shall be performed prior to the commissioning of the HV substation.

The current injection test (CIT) report shall be submitted to Water Corporation for review and acceptance.

The land developer shall NOT energise the HV substation until a written acceptance on the CIT report is received from Water Corporation.

## 12 Report Formats and Review Timeframe

The Designer shall prepare the EPR assessment report in accordance with the format shown in Appendix A.

The CIT report shall be prepared in accordance with the format shown in Appendix B.

The MGA co-ordinates (in numbers) of each EPR source shall be included in both the assessment report and the CIT report.

The usual turn-around time to process and review each report is 3 working weeks. It is due to other reports which are already in the queue. However, Water Corporation will endeavour to review the reports ASAP.

The same timeframe will also apply for each subsequent review of the revised report.

## 13 Communication Protocol

Water Corporation will only communicate with the developer or his/her designated designer for AC interference issues.

The designer's subcontractor(s) should direct all the issues and the related reports to its client (i.e., the designer or the developer).



## 14 Water Corporation Contacts

The following electrical engineers may be contacted:

### Electrical hazards on water pipelines – General Policies

Ed Gliwski

Senior Principal Electrical Engineer (Power)

Engineering Advisory

Email: [Ed.Gliwski@watercorporation.com.au](mailto:Ed.Gliwski@watercorporation.com.au)

### Electrical hazards on water pipelines – Project Specific/EPR Enquiries

Bridger Wong,

Senior Electrical Engineer

Engineering Field Services

Email: [Epr.Enquiries@watercorporation.com.au](mailto:Epr.Enquiries@watercorporation.com.au)



## 15 Appendix A – EPR Assessment Report Format

### Earth Potential Rise Assessment Report

#### Water Corporation’s Assets (Distribution Systems)

**Location:**

Project Number:

Western Power Reference Number:

Prepared by: **Company name**

**Electrical Engineer (Name & Qualification)**

Date:

| Version | Date | Author<br>Electrical Engineer<br>(Name, qualification<br>& signature) | Reviewed by a Qualified<br>Senior ELECTRICAL<br>Engineer of the company<br>(Name, qualification &<br>signature) | Change |
|---------|------|---|---|--------|
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## 1 TABLE OF CONTENTS

## 2 PURPOSE

*[Explain the purpose of the Report.]*

## 3 ABBREVIATIONS

*[Include all the abbreviations used in the Report and the associated explanations.]*

## 4 INFORMATION & ASSUMPTIONS

*[Include short project description and design drawing of site plan showing earthing layout.]*

### 4.1 Site Details

| Item                      | Description  | Source |
|---------------------------|--|--------|
| Location of Site(s)       | <i>[Include MGA co-ordinates – Easting &amp; Northing]</i> |        |
| Equipment to be installed |  |        |
| Earthing Arrangement      |  |        |
| Design Drawing(s)         |  |        |
| Feeder Network            |  |        |

### 4.2 Fault Levels & Protecting Clearing Times

| Item  | Description | Source |
|---|-------------|--------|
| Nearest upstream network node                                       |             |        |
| Prospective fault level at site or at the nearest upstream node (A) |             |        |
| Upstream protection device & type                                   |             |        |
| Fault clearing times (s)  |             |        |
| Current pickup (A)  |             |        |
| Time multiplier settings (TMS)                                      |             |        |
| TCC curve(s)  |             |        |
| Total reactance (X)   |             |        |



|                      |  |  |
|----------------------|--|--|
| Total resistance (R) |  |  |
|----------------------|--|--|

### 4.3 Soil Resistivity

For details of soil resistivity tests, refer to Appendix B

| Item                          | Description                            |                        | Source             |                        |
|-------------------------------|--|------------------------|--------------------|------------------------|
| Soil resistivity test results | [Reference to soil report, if any]     |                        | [Performed by who] |                        |
|                               | [Reference to drilling report, if any] |                        | [Performed by who] |                        |
| Soil model:                   |  |                        |                    |                        |
| Model                         | Model #1                               | Model #2 (if required) |                    | Model #3 (if required) |
| Top layer                     |  |                        |                    |                        |
| Middle layer                  |  |                        |                    |                        |
| Bottom layer                  |  |                        |                    |                        |

[Explain what standard is used for the soil resistivity testing]

[Explain clearly how the test data sets are interpreted and the rationale behind the soil model developed]

### 4.4 Water Corporation’s Asset Details

| Item                          | Description                  | Source/comments                                       |
|-------------------------------|------------------------------|---|
| Before You Dig Australia maps | [Reference e.g., Sequence #] |   |
| Utilities identified          | Water Corporation            | [e.g., water pipes, accessible valves, manholes etc.] |

### 4.5 Hazard Scenarios & Limits

[Details of affected water infrastructure assets]

[Include maps showing all electrical hazards identified with distances to project site (HV source)]

a) Touch voltage limits calculation

[Show details on how the touch voltage limits are calculated based on DS23]

[Include calculation on Decrement Factor due to fault current asymmetry]



b) Summary Table on Hazard Scenarios & Touch Voltage Limits

| Hazard location # | Hazard scenario   | Distance from distribution site   | Contact scenario   | Standard safety limits  |
|-------------------|---|---|--|---|
| 1                 | EPR at pipeline   | Separation distance between power system stake and Water Corporation's pipeline | Insulation damage due to voltage rise                              | 5000V   |
| 2                 | Loaded touch voltage at BURIED insulated metallic pipeline  | Normally same as above  | Touch voltage during maintenance or repairs – excavation required  | As per WC's Manual "Pipeline AC Interference – Process & Technical Requirements for Land Development Projects" & DS23 – <b>Notification only</b>    |
| 3                 | Loaded touch voltage at ABOVE GROUND metallic pipeline  | Normally same as above  | Touch voltage applied to public or unskilled operational personnel | As per WC's Manual "Pipeline AC Interference – Process & Technical Requirements for Land Development Projects" & DS23 – <b>Mitigation required.</b> |
| 4                 | Loaded touch voltage on accessible metallic assets (e.g. valves) connected to insulated metallic pipeline | Separation distance between power system stake and Water Corporation's pipeline | Touch voltage applied to public or unskilled operational personnel | As per WC's Manual "Pipeline AC Interference – Process & Technical Requirements for Land Development Projects" & DS23 – <b>Mitigation required.</b> |
| 5                 | [Water Corporation's assets]  |   |  |   |
| 6                 | [Water Corporation's assets]  |   |  |   |



## 5 MODELLING / CALCUATIONS

### 5.1 Assumptions for Modelling / Calculation

[Details of computer software used for modelling]]

[Details of assumptions made during computer modelling / calculation]

### 5.2 Results

[Details of modelled / calculated result – both prospective & loaded touch voltages]

[Results assessed to the Safety Limits in Section 3.5]

[Graphical presentation]

### 5.3 Mitigation

[Details of mitigation options assessed to reduce risk if results exceed limits]

### 5.4 Water Corporation's Assets

[Summary of the assessment on Water Corporation's assets]

| Asset type | Limit                                       | Value from Study result |
|------------|---|-------------------------|
|            | [Safety Limits as specified in Section 3.5] |                         |
|            |   |                         |

## 6 SAFETY-IN-DESIGN

[Details of ANY safety-in-design risks and measured to be taken at the distribution site during construction]

## 7 CONCLUSION / RECOMMENDATION

[Prepare a summary of the assessment]

## 8 TESTING REQUIRMENTS

[Details of site verification testing to validate the calculated values)



**APPENDIX A – Before You Dig Australia (BYDA) Maps**



## APPENDIX B – Soil Resistivity Test Data

*[Location – Include map showing test directions]*

*[Date of testing]*

*[Equipment details]*

*[Test method used – Wenner, Schlumberger-Palmer etc.]*

*[Site ground condition]*

*[Weather details on day of test and preceding week]*

*[Water table data in the area]*

*[DBYD of test location]*

*[Test measurements – Data interpretation in tabular & graphical formats of the two-layer model]*



## 16 Appendix B – Current Injection Test (CIT) Report Format

### Report

#### Verification Test Report

#### Water Corporation’s Assets

#### (Distribution Systems)

#### Location:

Project Number:

Western Power Reference Number:

Prepared By:

Company name

Electrical Engineer (Name & Qualification)

Date:

#### Revision History

| Version | Date | Author<br>Electrical Engineer<br>(Name, qualification<br>& signature) | Reviewed by a Qualified<br>Senior ELECTRICAL<br>Engineer of the company<br>(Name, qualification &<br>signature) | Change |
|---------|------|---|---|--------|
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|         |      |   |   |        |



## 1 Table of Contents

## 2 Introduction

[Explain the purpose of the Report.]

[Explain in detail how the test was carried out.]

[Include the MGA co-ordinates (in numbers) of each HV site here.]

## 3 Referenced Standards

[List all the relevant standards used.]

## 4 Apparatus

[Refer to the relevant standard(s) of testing – Clause no.]

[List all the apparatus used in the test]

[Include a circuit diagram on how the instruments are connected]

## 5 Fault Levels & Protection Clearing Times

[List on the following table the parameters]

| Item  | Description | Source                |
|---|-------------|-----------------------|
| Nearest upstream network node                                       |             | (e.g., Western Power) |
| Prospective fault level at site or at the nearest upstream mode (A) |             |                       |
| Upstream protection device and type                                 |             |                       |
| Fault clearing times (s)  |             |                       |
| Current pickup (A)  |             |                       |
| Time multiplier settings (TMS)                                      |             |                       |
| TCC curves(s)   |             |                       |
| Total reactance (X)   |             |                       |
| Total resistance (R)  |             |                       |

[Include a calculation on "Decrement Factor" due to fault current asymmetry – refer to IEEE Standard 80-2000]



## 6 Injection Test Layout

*[Provide in detail with site plans on how the current injection test(s) are laid out including voltage reference, direction of tests and current injection reference]*

*[Explain how each test is done]*

## 7 Verification Test Results

*[Tabulate the test result of each site similar to the table format in AS3835.2:2006 – Figure 6.8]*

*[Include in the Table the value of the top layer soil resistivity]*

*[Include in TWO additional columns to show the prospective and loaded touch voltages]*

*[Show the formula on how the loaded touch voltage is calculated using prospective touch voltage and top layer soil resistivity]*

## 8 Error Corrections

*[Explain what test errors are present and how the test errors are reduced – AS3835.2:2006]*

*[Explain what interferences are present and how they are eliminated – AS3835.2:2006]*

## 9 EPR Voltage Contour Graphs

*[For each site, indicate on the graph(s) showing the EPR Contour (Prospective & Loaded touch voltages) versus Distance based on the test result]*

*[Indicate clearly on the graph(s) the distance of the affected Water Corporation assets to the HV source]*

## 10 Conclusion

*[Prepare a summary]*

*[Include a site diagram indicating the measured EPR hazardous distance (in circle) from the HV source – The EPR hazardous distance must be drawn to scale]*

*[Indicate that the test results are acceptable or not. If not, what voltage mitigation to be followed]*