SNZ TS 3404:2018

Standards New Zealand Technical Specification

Durability requirements for steel structures and components

Superseding in part NZS 3404.1:2009

SNZ TS 3404:2018

Single User PDF Terms & Conditions

You have material which is subject to strict conditions of use. Copyright in this material is owned by the New Zealand Standards Executive. Please read these terms and conditions carefully, as in addition to the usual range of civil remedies available to Standards New Zealand on behalf of the New Zealand Standards Executive for infringement of copyright, under New Zealand law every person who infringes copyright may be liable to a fine of up to $10,000 for every infringing copy or imprisonment of up to 5 years, or a fine of up to $150,000 or imprisonment not exceeding 5 years.

You have access to a single-user licence to read this non-revisable Adobe Acrobat PDF file and print out and retain ONE printed copy only.

We retain title and ownership of the copyright in this PDF file and the corresponding permitted printed copy at all times.

Under this license use of both the PDF file and the single permitted printed copy of this PDF file you may make are restricted to you. Under no circumstances are you permitted to save, sell, transfer, or copy this PDF file, the one permitted printed copy of this PDF file, or any part of either of them.

You undertake that you will not modify, adapt, translate, reverse engineer, decompile, disassemble or create derivative works based on any of the downloaded PDF file, nor will you merge it with any other software or document, even for internal use within your organization.

Under no circumstances may this PDF file be placed on a network of any sort without our express permission.

You are solely responsible for the selection of this PDF file and any advice or recommendation given by us about any aspect of this PDF file is intended for guidance only and is followed or acted upon entirely at your own risk.

We are not aware of any inherent risk of viruses in this PDF file at the time that it is accessed. We have exercised due diligence to ensure, so far as practicable, that this file does not contain such viruses.

No warranty of any form is given by us or by any party associated with us with regard to this PDF file, and you accept and acknowledge that we will not be liable in any way to you or any to other person in respect of any loss or damage however caused which may be suffered or incurred or which may arise directly or indirectly through any use of this PDF file.

Regardless of where you were when you received this PDF file you accept and acknowledge that to the fullest extent possible you submit to New Zealand law with regard to this licence and to your use of this PDF file.

COMMITTEE REPRESENTATION

This technical specification was prepared by the P3404 Committee. The membership of the committee was approved and appointed by the New Zealand Standards Executive.

The committee consisted of representatives of the following nominating organisations:

Australasian Corrosion Association
Building Research Association New Zealand
Galvanizing Association of New Zealand
New Zealand Heavy Engineering Research Association
Steel Construction New Zealand
University of Auckland

ACKNOWLEDGEMENT

Standards New Zealand gratefully acknowledges the contribution of time and expertise from all those involved in developing this technical specification. We wish to thank committee members Dr Charles Clifton, Raed El Sarraf, Dr Zhengwei Li, Ash Arya, Dr Jing Cao, Zahid Hamid, and observers Ross MacKenzie and Kevin Cowie. We wish to particularly thank the New Zealand Heavy Engineering Research Association and National Institute of Water and Atmospheric Research for the use of Figures 1 to 7.

The P3404 Committee and Standards New Zealand also wish to thank Willie Mandeno and Hanieh Ghominejad of WSP Opus for their assistance in drafting this document.

The P3404 Committee and Standards New Zealand would like to acknowledge Steel Construction New Zealand for commissioning the development of this document.

Standards New Zealand would also like to thank Standards Australia for allowing the use of modified tables from AS 2159:2009 *Piling – Design and installation*: Tables 6.5.2(A), 6.5.2(B), 6.5.2(C) and notes, and Table 6.5.3 and notes, reproduced in this technical specification as Tables 10, 11, 12, and 13.

Cover photograph of Haast Bridge courtesy of Raed El Sarraf, WSP Opus.

Published by Standards New Zealand, PO Box 1473, Wellington 6140.
Telephone: (03) 943 4259, Website: www.standards.govt.nz.

AMENDMENTS

No.	*Date of issue*	*Description*	*Entered by, and date*

SNZ TS 3404:2018

Standards New Zealand
Technical Specification

Durability requirements for steel structures and components

ISBN (Print) 978-1-77673-253-1
ISBN (PDF) 978-1-77673-254-8

NOTES

CONTENTS

Table

Figure

REFERENCED DOCUMENTS

Reference is made in this document to the following:

Joint Australian/New Zealand standards

AS/NZS 2041:----	Buried corrugated metal structures
Part 1:2011	Design methods
AS/NZS 2310:2002	Glossary of paint and painting terms
AS/NZS 2312:2002	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
AS/NZS 2312:----	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
Part 1:2014	Paint coatings
Part 2:2014	Hot dip galvanizing
AS/NZS 3750:----	Paints for steel structures
Part 9:2009	Organic zinc-rich primer
Part 15:1998	Inorganic zinc silicate paint
AS/NZS 4534:2006	Zinc and zinc/aluminium-alloy coatings on steel wire
AS/NZS 4680:2006	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
AS/NZS 4792:2006	Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialised process
AS/NZS 5100:----	Bridge design
Part 6:2017	Steel and composite construction
AS/NZS 5131:2016	Structural steelwork – Fabrication and erection

International standards

ISO 8501:----	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness
Part 1:2007	Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings
ISO 9223:2012	Corrosion of metals and alloys – Corrosivity of atmospheres – Classification, determination and estimation
ISO 9224: 2012	Corrosion of metals and alloys – Corrosivity of atmospheres – Guiding values for the corrosivity categories

Australian standards

AS 1397:2011	Continuous hot-dip metallic coated steel sheet and strip – Coatings on zinc and zinc alloyed with aluminium and magnesium
AS 1627:----	Metal finishing – Preparation and pretreatment of surfaces
Part 4:2005	Abrasive blast cleaning of steel
AS 2159:2009	Piling – Design and installation
AS 2832:----	Cathodic protection of metals
Part 4:2006	Internal surfaces
AS 3894:----	Site testing of protective coatings
Part 3:2002	Determination of dry film thickness

American standards

ASTM D2244-16	Standard practice for calculation of color tolerances and color differences from instrumentally measured color coordinates
ASTM D4214-07(2015)	Standard test methods for evaluating the degree of chalking of exterior paint films

Other publications

American Architectural Manufacturers Association. *AAMA 2604-05 – Voluntary specification, performance requirements and test procedures of high performance organic coatings on aluminium extension and panels*. Schaumburg, Illinois, USA: American Architectural Manufacturers Association, 2005.

Edmeades, D C and Wheeler, D M. ‘Measurement of pH in New Zealand Soils, an examination of the effect of electrolyte, electrolyte strength and soil; solution ratio.’ *New Zealand Journal of Agricultural Research*, 33.1, (1990): 106 – 109.

El Sarraf, R, and Clifton, G C. *New Zealand steelwork corrosion and coatings guide*. HERA Report R4-133, 2nd ed. Auckland, New Zealand: HERA, 2011.

Penhale, H R. ‘Corrosion of mild steel plates in some New Zealand soils. *New Zealand Journal of Science*, no. 14 (1971): 336 – 353.

Penhale, H R. ‘Corrosion of mild steel plates in some New Zealand soils after 20 years.’ *New Zealand Journal of Science*, no. 27 (1984): 57 – 68.

New Zealand Transport Agency *Bridge manual* (SP/M/022)

New Zealand Transport Agency *Protective coatings for steel bridges*

New Zealand legislation

Chartered Professional Engineers of New Zealand Act 2002

New Zealand Building Code Clause B1 (Structure)

New Zealand Building Code Clause B2 (Durability)

Registered Architects Act 2005

Websites

www.legislation.govt.nz

LATEST REVISIONS

The users of this technical specification should ensure that their copies of the above-mentioned New Zealand standards are the latest revisions. Amendments to referenced New Zealand and joint Australian/New Zealand standards can be found on www.standards.govt.nz.

REVIEW OF STANDARDS

Suggestions for improvement of this standard will be welcomed. They should be sent to the Manager, Standards New Zealand, PO Box 1473, Wellington 6140.

FOREWORD

NZS 3404 Parts 1 and 2:1997 *Steel structures standard* sets out minimum requirements for the design, fabrication, erection, and modification of steelwork in structures in accordance with the limit state design method or in accordance with the alternative design method. It is currently referenced in New Zealand Building Code Compliance Document B1. NZS 3404 Parts 1 and 2 was amended in 2001 and 2007.

In 2009 a decision was made to split NZS 3404 Parts 1 and 2 into seven parts and that these parts would be developed and published in a phased manner. When all seven parts had been published, they would together supersede NZS 3404 Parts 1 and 2:1997 *Steel structures standard.* NZS 3404.1:2009 *Steel structures standard – Part 1: Materials, fabrication, and construction* was published setting out minimum requirements for the selection of materials, corrosion protection systems, and the fabrication, erection, and construction of steel structures.

Most of the material from NZS 3404.1:2009 has now been included in a new joint Australian/New Zealand standard, AS/NZS 5131:2016 *Structural steelwork – Fabrication and erection*. The major exception is section 5 (corrosion protection), which falls outside the scope of AS/NZS 5131.

SNZ TS 3404 *Durability requirements for steel structures and components* updates the information contained in section 5 of NZS 3404.1:2009 and is republished as a stand-alone technical specification.

This technical specification provides an advanced framework for specifying the durability requirements for steel structures and components. It is a simplification of the design procedure for durability determination given in Heavy Engineering and Research Association Report R4-133:2011 *New Zealand Steelwork Corrosion and Coatings Guide*. It will enable durability requirements to be met without over-specification or under-specification of coating systems.

This technical specification has been prepared for use by asset owners, designers (engineers and architects), contractors, specifiers of corrosion protection systems, and the surface coating industry. It covers the corrosion protection of structural steelwork exposed to the New Zealand atmospheric and non-atmospheric environments.

This technical specification has been written to satisfy the requirements of the New Zealand Building Code Clause B2, the New Zealand Transport Agency (NZTA) *Bridge manual*, and the NZTA *Protective coatings for steel bridges*; as well as remain compatible with NZS 3404 Parts 1 and 2:1997. It should be used in conjunction with AS/NZS 2312.1:2014 and AS/NZS 2312.2:2014. As the fabrication and erection provisions of NZS 3404 are in the process of being superseded by AS/NZS 5131 and AS/NZS 5100.6, SNZ TS 3404 is also written to be compatible with those documents.

SNZ TS 3404 supersedes in part NZS 3404.1:2009, specifically section 5 on corrosion protection. Refer to this technical specification instead of clause 3.4.6 in NZS 3404.1:1997.

Standards New Zealand Technical Specification

Durability requirements for steel structures and components

1 GENERAL

1.1 Scope

This technical specification sets out the technical requirements that are necessary to provide the required level of durability to steel structures and their component parts, in the New Zealand environment.

1.2 Interpretation

For the purposes of this technical specification, the word 'shall' refers to the requirements that are essential for compliance with the technical specification, while the word 'should' refers to practices that are advised or recommended.

Clauses prefixed by 'C' and printed in italic type are included as comments on the corresponding clauses. They are not to be taken as the only and complete interpretation. The technical specification can be complied with if the comment is ignored.

1.3 Definitions

For the purposes of this technical specification the definitions below, and those given in AS/NZS 2310, apply:

Asset owner — The owner of the structure being constructed or maintained, or their nominated representative

Contractor — A person or firm that undertakes a contract to perform the physical work in relation to the construction or maintenance of a steel structure or component

Corrosivity — A measure of the ability of an environment to cause corrosion

Damp — Internal environment where condensation may occur, such as a non-air conditioned or poorly insulated car parks and warehouses; or in a high-humidity environment with some pollution, such as in some food processing plants, sewage treatment buildings, and animal shelters

Designer	An engineer or architect with relevant experience and skills in the design of structures, who is responsible for interpretation of the requirements of this technical specification when used for structures design. A structural or materials engineer who is chartered under the Chartered Professional Engineers of New Zealand or Registered Architect Act would satisfy this requirement
Design life	Period over which a structure or structural element is required to perform its function
Dry	Internal environment, such as within a fully air-conditioned office or apartment building
Durability	The time elapsed before the first major maintenance of a coating system becomes necessary, to arrest corrosion
Environment	Surrounding region which contains one or more corrosive agents
Exposed	Opened to airborne salts, is washed by the rain, and can dry quickly after wetting
External	Exposed to the weather
Inspector	A person who, on the basis of experience or qualifications, is competent to carry out specific inspection duties stipulated by the asset owner, designer, or specifier, the requirements of this technical specification or a referenced standard
Internal	Protected from the weather by being located inside the structure
Nominal dry film thickness	Thickness specified for each coat or for the whole paint system to achieve the required durability
Protective coatings manufacturer	The organisation that manufactured and supplied protective coatings
Sheltered	Open to airborne salts but unwashed by the rain, such as under an awning or the deck of a steel bridge
Specifier	A person, who on the basis of experience and qualifications, is competent to specify a corrosion protection system for the given environment and durability requirements
Wet	Often wet for extended periods of time, such as crevices, or in low points and pockets that are not drained

1.4 Abbreviations

The following abbreviations are used in this technical specification.

ACA	Australasian Corrosion Association
APAS	Australian Paint Approval Scheme
FBE	Fusion bonded epoxy
NACE	NACE International
NEPCOAT	North East Protective Coating Committee
NORSOK	Norsk Sokkels Konkurranseposisjon
NZBC	New Zealand Building Code
NZTA	New Zealand Transport Agency
MIC	Microbial influenced corrosion

1.5 Notation

This technical specification uses the following notations:

r_{av}	Average corrosion rate for up to 10 years that correspond to the initial period of exposure
r_{corr}	Steel corrosion rate, in μm/annum
r_{lin}	Average corrosion rate during the first 30 years that is taken as being the steady-state corrosion rate
T_{DL}	Steelwork design life in years
T_{FM}	Total time to first major maintenance of initial and subsequent coating systems applications
t_{sl}	Steel thickness loss in μm/steel surface

1.6 Specified intended life and the New Zealand Building Code

The provisions of this technical specification shall apply to steel structures with a specified intended life of not less than 50 years for a building structure or not less than 100 years for a highway, road, or railway bridge. Compliance with this specification is intended to ensure that the structural steelwork is sufficiently durable to satisfy the requirements of the New Zealand Building Code (NZBC) Clause B2 or the New Zealand Transport Agency (NZTA) *Bridge manual* throughout the life of the structure, with only normal maintenance, including the refurbishment of the protective coating system without requiring reconstruction or major renovation.

C1.6
The 'specified intended life of the building' from Clause B2 of the New Zealand Building Code does not need to be the time to first major maintenance considered when selecting an appropriate method of corrosion protection. A shorter time to first major maintenance could be selected in conjunction with an inspection and maintenance programme, which together will meet the durability provisions of NZBC Clause B2.

1.7 Time to first major maintenance

The time to first major maintenance is the expected time from application of a corrosion protection system (such as protective coatings) up to when patch repair, patch and overcoat, or full refurbishment is required as part of normal maintenance. Minor repairs to these protection systems within the construction maintenance period are not considered when determining the time to first major maintenance. In addition, prior to the time of first major maintenance, minor repairs to protective coating may be required for aesthetic purposes to rejuvenate the finish and restore loss of gloss and colour.

The criteria for determining when the time to first major maintenance is reached are:

(a) For scattered general breakdown of protective coatings: when a specified percentage of rust is visible. This varies from under 0.5% of the total area for barrier coat systems, which exclude air and water from the steel surface, to up to 2% of the total area for sacrificial zinc-based systems which protect by galvanic action;

(b) For more severe localised breakdown of the corrosion protection system, for example missed or undercoated areas: when a specified percentage from 2% to 20% of the total area has occurred; and

(c) Where widespread blistering, flaking or rusting under the corrosion protection system surface is evident.

The expected time to first major maintenance of properly applied protective coating systems can be estimated from the atmospheric corrosion category given in Table 2, with examples of suggested protective coatings given in Table 4 to Table 8. A more comprehensive listing is given in the different parts of AS/NZS 2312:2014.

NOTE –

(1) These times assume planar surfaces on new steel which have been coated under optimum conditions and as recommended by the manufacturer.

(2) At the expected time to first major maintenance, the selection of the most cost-effective whole-of-life refurbishment option should be determined, based on the cause of corrosion breakdown and its extent. This should include considering both access and containment (when required) costs, as well as the asset owner's expectations and requirements. Refurbishment options may include patch repair, patch repair and full overcoat, or the full removal and reapplication of the corrosion protection system.

C1.7

The criteria for determining when the time to first major maintenance of coating system has been reached are based on AS/NZS 2312.1:2014 and AS/NZS 2312.2:2014, which include pictorial examples.

All corrosion protection systems could require minor repairs prior to the time to first major maintenance, for example caused by mechanical or welding damage, or areas welded after the coatings have been applied and at corners where the coating thickness is difficult to verify. Coating systems also change their appearance over time, such as paint, due to exposure to the sun's ultraviolet rays (UV). This could require refurbishing the coating for aesthetic reasons prior to the loss of effective protection to the underlying steel surface, implicit in the time to first major maintenance provisions.

All the above constitute part of the normal maintenance specified in NZBC Clause B2.

For structures with a specified intended life greater than a multiple of the expected time to first major maintenance of the corrosion protection system, one or more refurbishments are expected to be required.

1.8 Warranty considerations

The durability range is not a 'warranty time'. Durability is a technical consideration that can help the asset owner or the designer set up a maintenance programme. A warranty time is a consideration that is the subject of a clause in the contract. Although there are no definite rules that link the two periods of time, a warranty of about one-quarter to one-third of estimated durability should be the maximum expected.

A warranty may be provided to protect against a fault in the coating product, or the workmanship of application, rather than the durability of the coating system. Some issues with long warranties are:

(a) They are often too simple or conversely too complex, and there may be difficulties in enforcing them;

(b) They may be used as a commercial tool so written to prevent any liability;

(c) After a longer time period, it may be difficult to determine who is at fault;

(d) It may require a lengthy and costly court case to recover costs;

(e) Long warranties are likely to attract a price premium;

(f) Warranties are usually provided on a diminishing scale with only small percentage of the value at the end of the warranty term;

(g) For coatings (other than galvanizing) the protective coatings manufacturer typically warrants its product only and the applicator separately warrants they have correctly applied the coating manufacturer's product.

When preparing warranties, the design engineer or specifier should take note of the following:

(h) There should be a clause regarding ordinary wear and tear. This needs to be clarified as the definition of wear and tear can depend on the party;

(i) It needs to be clear what will be supplied in the event of a failure. A warranty may simply cover the cost of paint, but the cost of reapplication may be many times this figure;

(j) Reference areas or test coupons (see 4.5) will assist in determining whether the failure was caused by inappropriate specification, defective workmanship, or coating material. For warranty claims, such areas should be mandatory and coordinated by the owner or owner's representative;

(k) To overcome possible disagreements about coating failures, allow for the appointment of a suitably qualified independent referee;

(l) A warranty is intended to protect against a fault in coating product or its application, which would be expected to manifest itself early in the life of the coating system. It is therefore not realistic to expect a commercial warranty to cover the entire durability expectations noted in this technical specification;

(m) An owner concerned about long term durability of a coating system should consider taking out a maintenance contract and employing an independent coating inspector during preparation for, and application of, the coating(s).

For additional guidance on warranties refer to HERA Report R4-133.

1.9 Health, safety, and environment protection

It is a duty of the asset owner, designer, specifiers, contractors, paint manufacturers, inspectors, and all other personnel involved in a project to carry out the work for which they are responsible in such a manner that they do not endanger the health and safety of themselves or others.

They shall comply with all the statutory requirements that relate to the region in which the work, or any part of the work, is to be carried out.

1.10 Inaccessible surfaces

Members with surfaces that cannot be accessed for normal maintenance shall be assessed for structural adequacy for the specified design life after allowing for the effects of corrosion after loss of the protection from the initial coating, in accordance with 2.5.

1.11 Surface preparation and application of corrosion protection systems

Surface preparation, application, or installation of corrosion protection systems, including quality control inspections, shall be undertaken in accordance with the relevant specified standards and recommendations (such as AS/NZS 2312.1:2014 and AS/NZS 2312.2:2014) or other specified industry guidance or manufacturer's requirements for the system selected.

1.12 Galvanic corrosion

Galvanic corrosion and its mitigation by protective coatings shall comply with AS/NZS 2312.1:2014 and AS/NZS 2312.2:2014.

1.13 Detailing for durability

Guidance on detailing for durability is given in AS/NZS 2312.1:2014, AS/NZS 2312.2:2014, and HERA Report R4-133.

2 CORROSION PROTECTION OF STEEL IN ATMOSPHERIC ENVIRONMENTS

2.1 Corrosion protection systems

For the purpose of this technical specification corrosion protection systems are taken to include:

(a) Paint coatings: such as sacrificial, barrier and (wet applied) inhibitive coatings;

(b) Galvanized coatings: such as hot dip, or continuous;

(c) Thermal sprayed metal coatings: such as arc sprayed zinc, aluminium and their alloys;

(d) Thermoplastic powder coatings: such as ethylene copolymers;

(e) Barrier tape systems: such as viscoelastic (for example petrolatum) or polyethylene tapes.

NOTE – Thermoset powder coatings such as fusion bonded epoxy (FBE) are not included.

C2.1
For galvanized protective coatings, these include hot dip galvanizing such as those typically applied to steel fabrications (for example, AS/NZS 4680) and continuous galvanizing such as those applied to sheet, purlins, and continuously galvanized tube and wire (for example, AS/NZS 4534, AS/NZS 4792, and AS 1397).

2.2 Determining the atmospheric corrosivity category

2.2.1 First-year corrosion rates of steel

The range of first-year corrosion rates (r_{corr}) of carbon-manganese steel (the usual type of steel used in structures) for the different atmospheric corrosivity categories, based on ISO 9223, is given in Table 1.

Table 1 – First-year corrosion rates of steel in different atmospheric corrosivity environments

Corrosion rates (μm/annum)	Atmospheric corrosivity category					
	C1	C2	C3	C4	C5-M[a] or C5-I[a]	CX (M or I)[b]
	Very low	Low	Medium	High	Very high	Extreme
Steel	≤ 1.3	1.3 < r_{corr} ≤ 25	25 < r_{corr} ≤ 50	50 < r_{corr} ≤ 80	80 < r_{corr} ≤ 200	200 < r_{corr} ≤ 700

NOTE – Based on Table 1, indicative first-year steel macroclimate corrosion rates for New Zealand are given in Figure 1 and Figure 2, or the relevant city maps given in Figure 3 to Figure 7.

a Category C5 is subdivided into Marine (M) or Industrial (I). Marine is for immediately adjacent to seashore except open surf. Industrial is for within industrial facilities with corrosive processes and typically requires site-specific determination. It also applies to geothermal areas in accordance with note 3 of both Table 2 and Table 3.

b Category CX is subdivided into marine or industrial. Marine is for the most exposed open surf beaches; industrial is typically for the most severe geothermal exposure

C2.2

The regional corrosivity zone maps show the direction and intensity of two sorts of wind; prevailing wind and common wind. The difference meteorologically is that the common wind is a local effect wind generated by the local pressure conditions whereas the prevailing wind is generated by the regional weather patterns. The local effect on corrosivity is the same; however, the difference is in the way the wind is generated. It is most marked in Christchurch and Dunedin where the prevailing wind is from the westerly quarter, that is, the 'roaring 40s' westerly wind belt, but the effects of the Alps and the cold sea off the east coast means the north-easterly and the southerly winds are the most frequently observed winds.

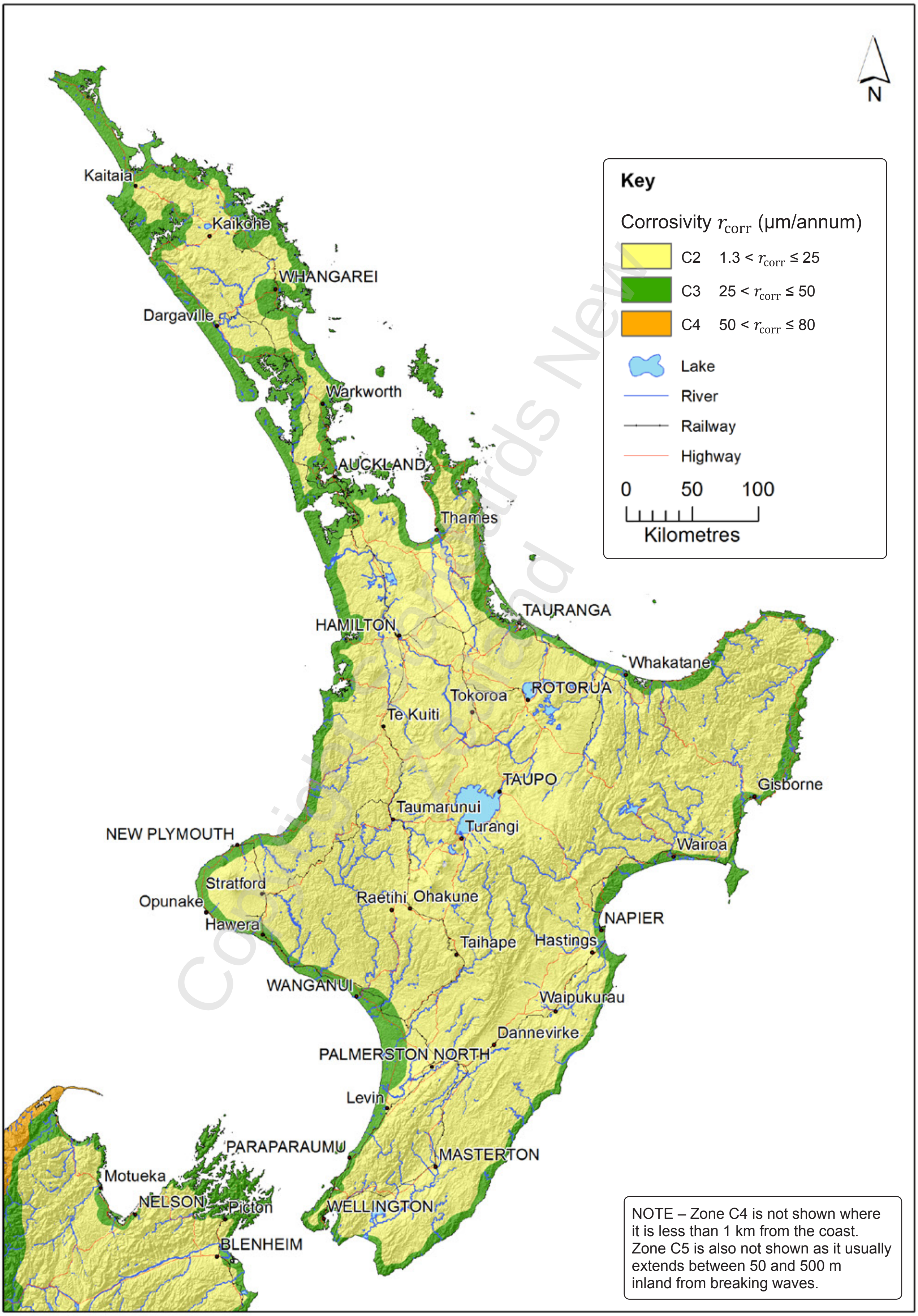


Figure 1 – North Island corrosivity zone map

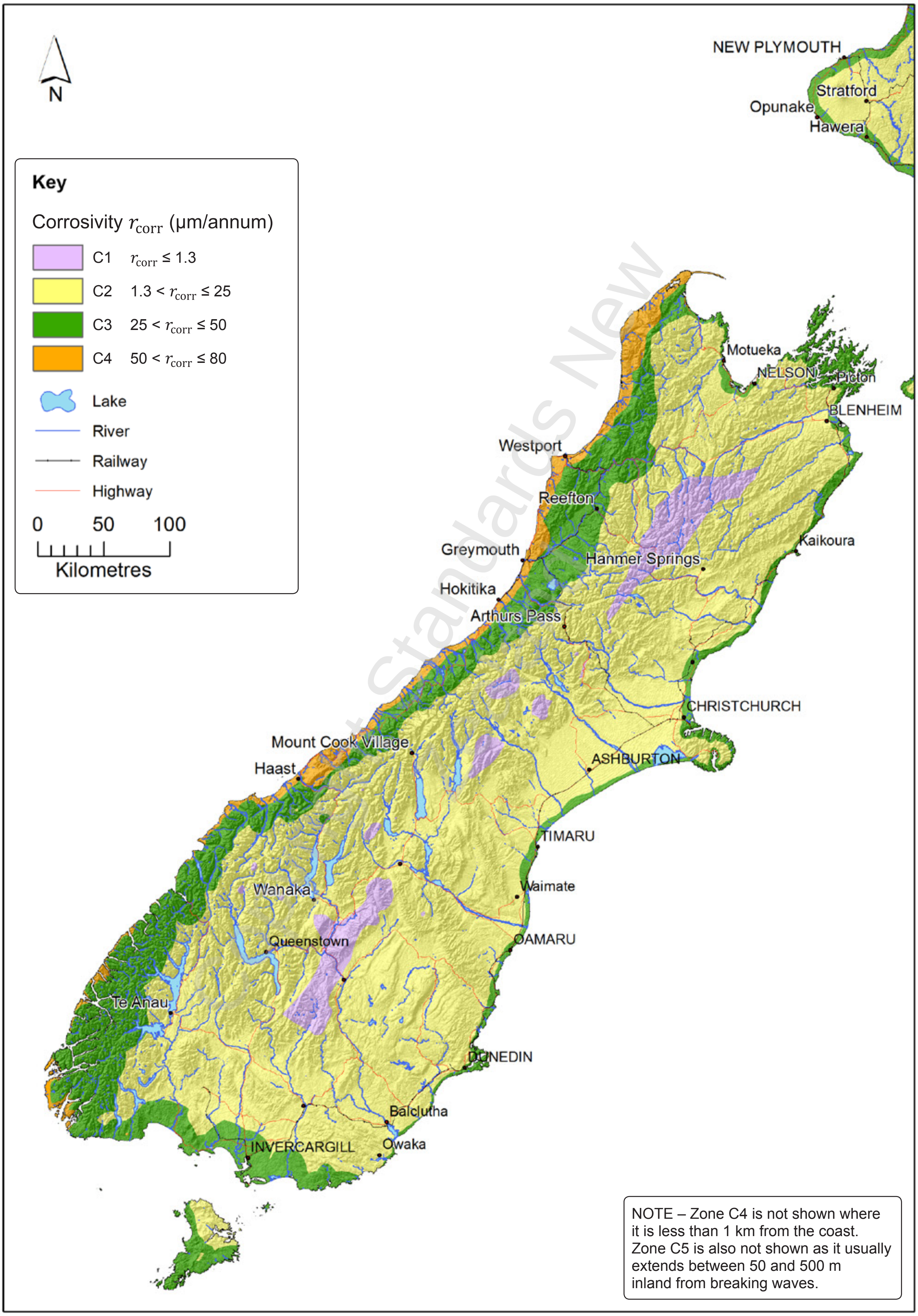


Figure 2 – South Island corrosivity zone map

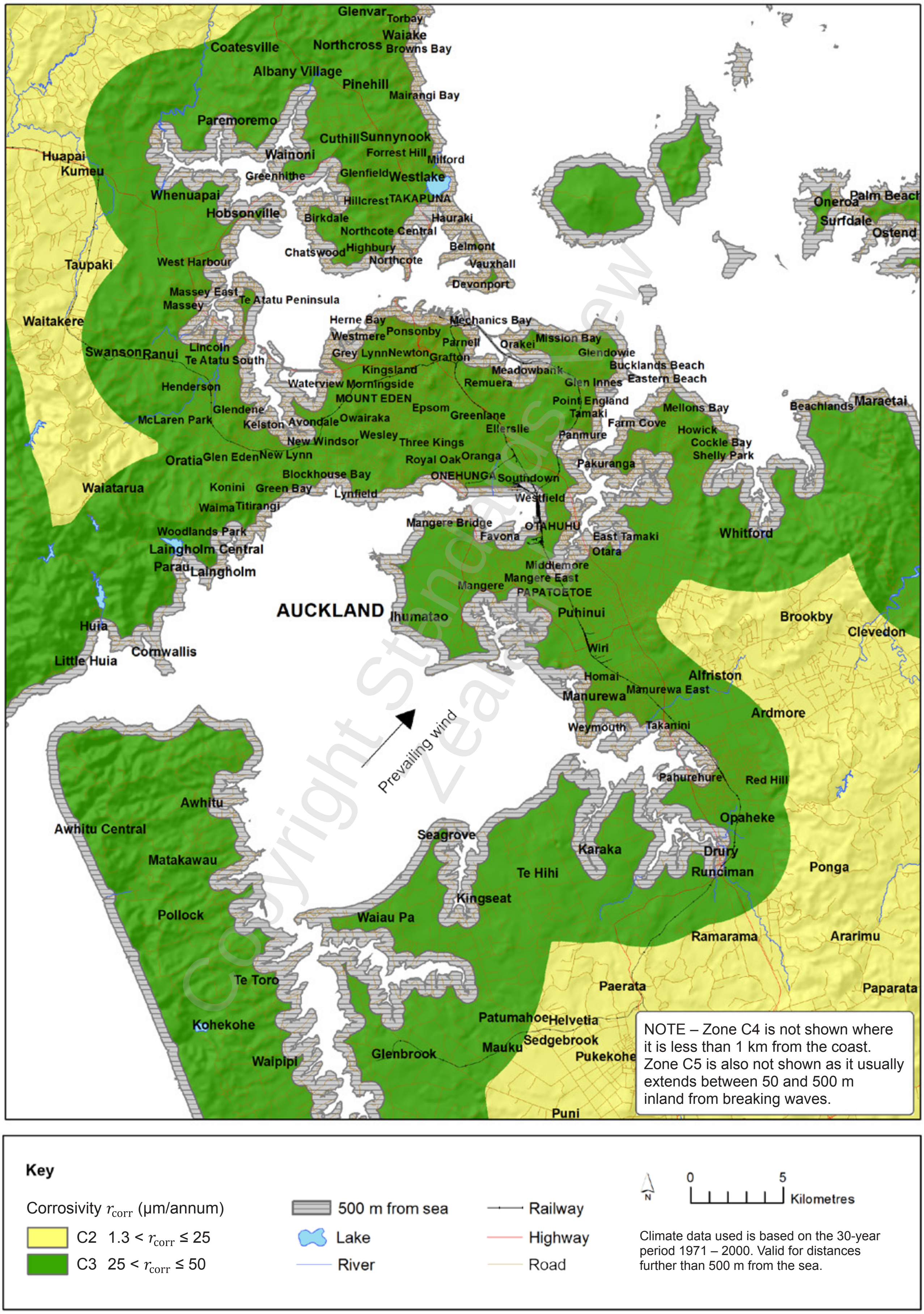
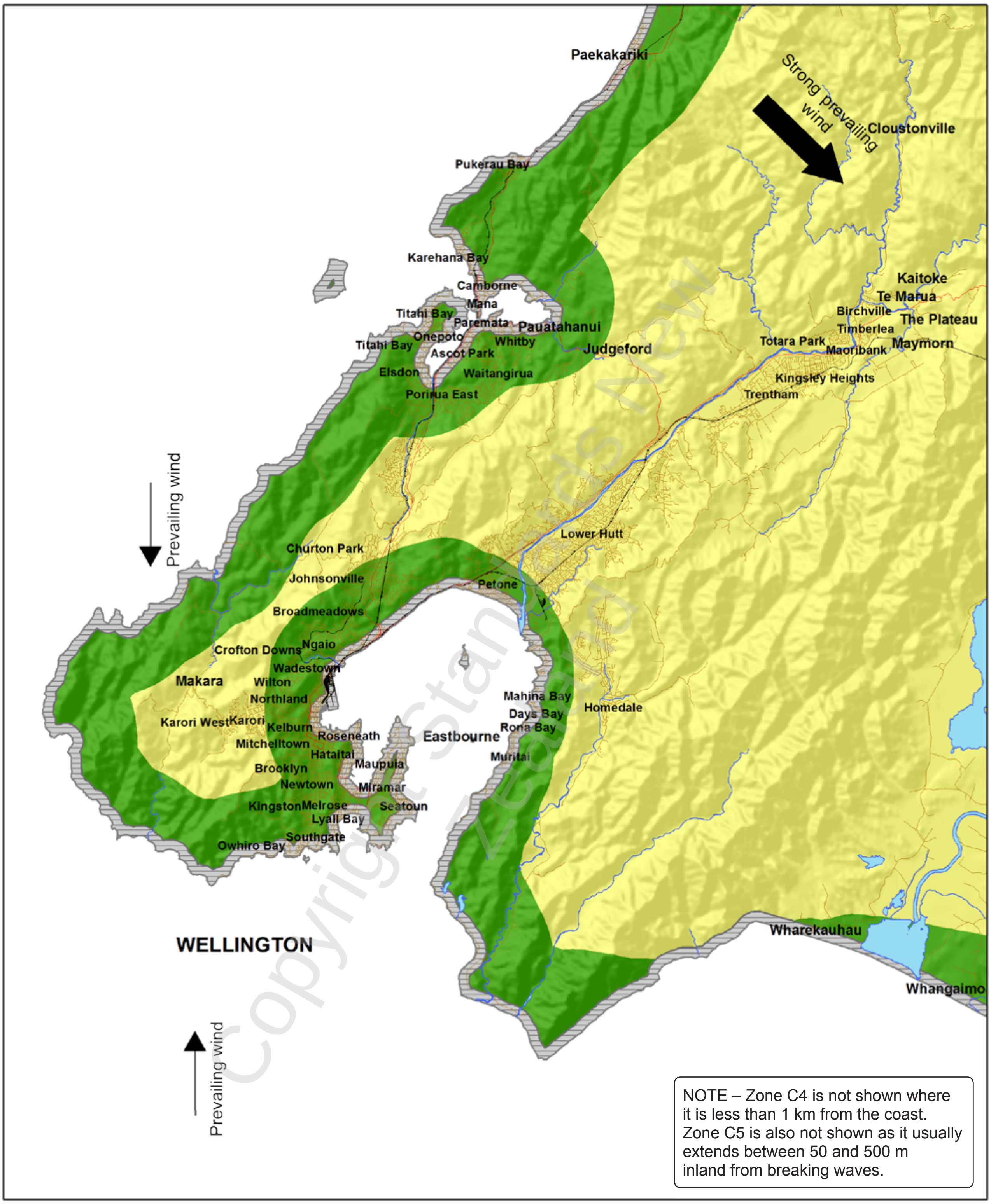


Figure 3 – Auckland corrosivity zone map



Key

Corrosivity r_{corr} (μm/annum)

C2 $1.3 < r_{corr} \leq 25$

C3 $25 < r_{corr} \leq 50$

500 m from sea

Lake

River

Railway

Highway

Road

N

0 5 Kilometres

Climate data used is based on the 30-year period 1971 – 2000. Valid for distances further than 500 m from the sea.

Figure 4 – Wellington corrosivity zone map

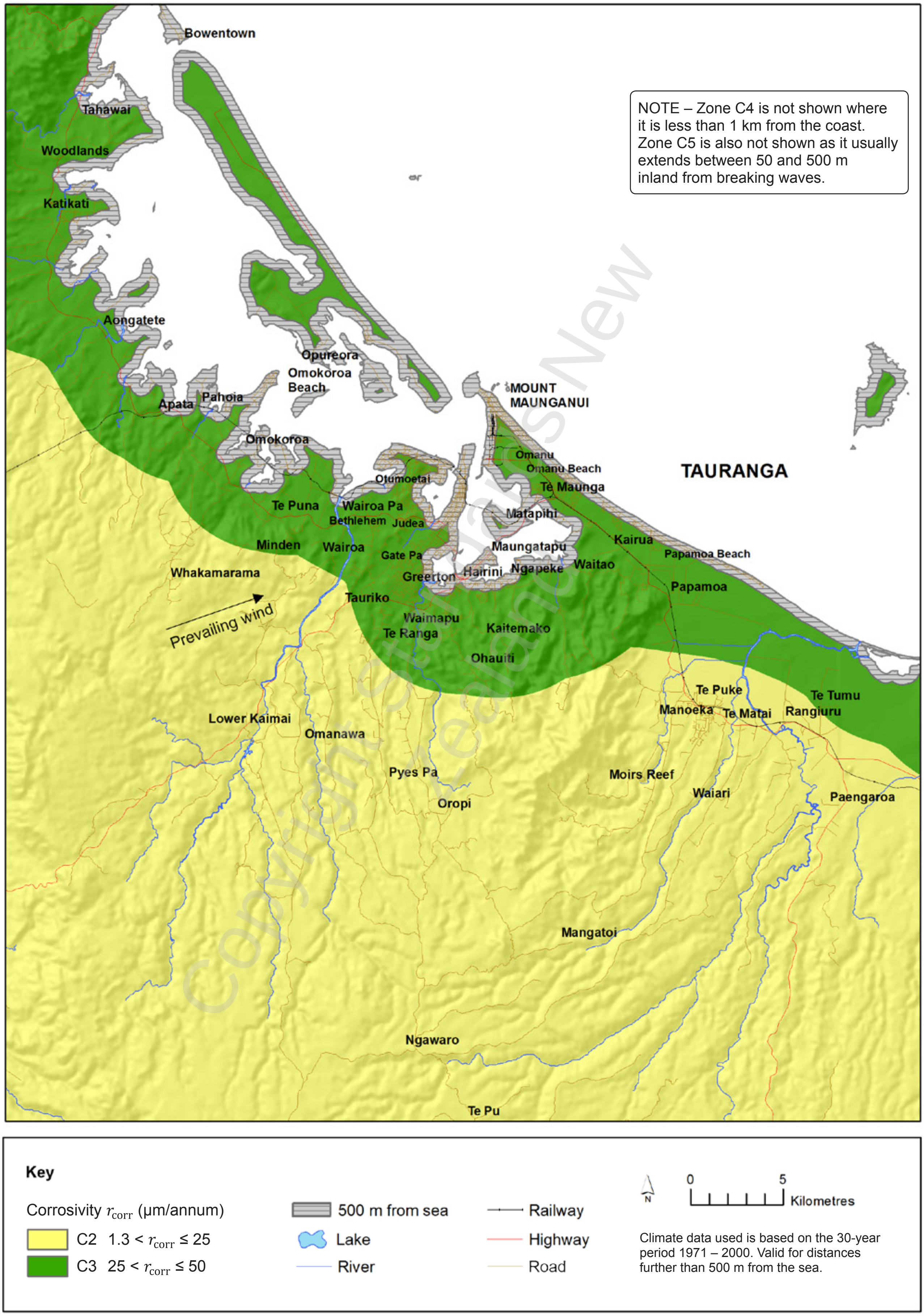


Figure 5 – Tauranga corrosivity zone map

Figure 6 – Christchurch corrosivity zone map

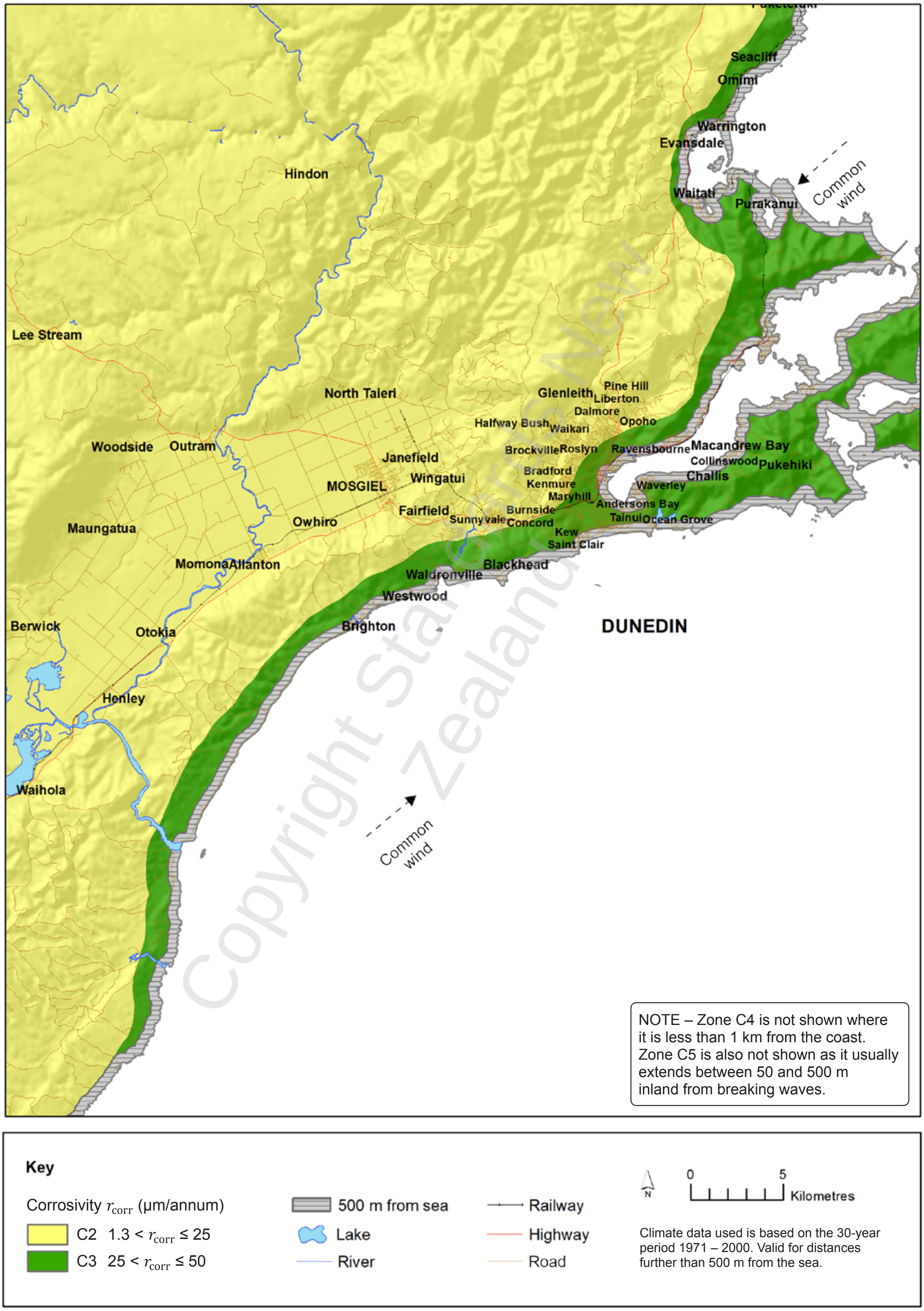


Figure 7 – Dunedin corrosivity zone map

2.2.2 New Zealand surface-specific corrosivity categories

Table 2 outlines the surface-specific atmospheric corrosivity categories for different locations, taking into account both the macroclimate and microclimate effects.

For cases not covered in Table 2, use the guidance given in Table 3.

C2.2.2

HERA Report R4-133 provides a more detailed calculated determination of the atmospheric corrosivity category and extent of exposure conditions. Weathering of the coating system during construction could be more severe than in its final state. This is often the case with single paint systems applied to wire-brushed steelwork. To ensure the intended in-service performance of the coating system is achieved, the allowable period of construction exposure is set at half the expected time to first major maintenance.

Areas shown as C2 north of Auckland to south of Dargaville, and Wellington to south of Porirua East, should be taken as being borderline C2/C3.

Table 2 – Surface-specific atmospheric corrosivity categories

<table>
<tr><th rowspan="3">Macroclimate corrosion category
(from AS/NZS 2312.1:2014)</th><th rowspan="3">Typically</th><th rowspan="3">Location</th><th rowspan="3">Characterised by</th><th colspan="5">Surface-specific atmospheric corrosivity</th></tr>
<tr><th colspan="3">External</th><th colspan="2">Internal</th></tr>
<tr><th>Exposed</th><th>Sheltered</th><th>Wet</th><th>Dry</th><th>Damp</th></tr>
<tr><td>C5-M</td><td>Within 200 metres of breaking surf on the west and south coasts of the South Island
Within 100 metres of breaking surf on west and south coasts of the North Island
Within 50 metres of breaking surf on all other coasts
This environment may be extended inland by prevailing winds and local conditions</td><td>All coasts</td><td>Heavy salt deposits
Almost constant smell of salt sea spray in the air</td><td colspan="3">C5-M</td><td rowspan="4">C1</td><td>C4</td></tr>
<tr><td>C4</td><td>Within 500 metres inland of breaking surf
Within 50 metres of calm salt water such as harbour foreshores
This environment may be extended inland by prevailing winds and local conditions</td><td>All coasts</td><td>Medium salt deposits
Frequent smell of salt sea spray in the air</td><td>C4</td><td colspan="2">C5-M</td><td rowspan="3">C3</td></tr>
<tr><td rowspan="2">C3</td><td>Within 20 km of breaking surf</td><td>West and south coasts of South Island</td><td rowspan="2">Minor salt deposits
Occasional smell of salt in the air</td><td rowspan="2">C3</td><td colspan="2">C5-M</td></tr>
<tr><td>Within 5 km of salt water</td><td>East coast of both islands, west and south coasts of North Island, and all harbours</td><td>C4</td><td>C5-M</td></tr>
</table>

Table 2 – Surface-specific atmospheric corrosivity categories (continued)

Macroclimate corrosion category (from AS/NZS 2312.1:2014)	**Typically**	**Location**	**Characterised by**	**Surface-specific atmospheric corrosivity**				
				External			**Internal**	
				Exposed	**Sheltered**	**Wet**	**Dry**	**Damp**
C2	More than 20 km to 50 km from salt water	West and south coasts of South Island	No marine influence	C2	C3	C4	C1	C3
	More than 5 km to 50 km from salt water	East coast of both islands, west and south coasts of North Island, and all harbours		C2	C3	C4		
C2	Inland, more than 50 km from salt water	North and South Islands		C2		C3		
See note 3	Close to geothermal source < 500 metres	Geothermal zone	Constant smell of hydrogen sulphide	See note 3				C4
-	Beyond 500 metres to geothermal source		Mild geothermal influence					C3

NOTE –

(1) The atmospheric corrosivity categories given provide an indication of the environment corrosivity to assist in the selection of a suitable corrosion protection system; taking into account the macroclimate and where required microclimate effects.

(2) For confirmation of a site-specific atmospheric corrosivity category (for example, for sites that are sheltered from marine influence by the local topography), then site-specific testing is required as described in HERA Report R4-133.

(3) For areas in the geothermal zones, both the macroclimate and the surface-specific corrosivity categories are dependent on the level of geothermal activities and distance from the geothermal source. The corrosivity category could range up to CX with considerable variation; thus in those areas site-specific corrosivity assessment is recommended. For areas that are more than 500 metres beyond the geothermal source or boundary (such as Sulphur Bay, Rotorua), and that have been assessed using the smell test as having minimal or non-existent geothermal influence, the other corrosion zones or categories apply based on distance from the sea.

Table 3 – Other atmospheric corrosivity environments

Exposure conditions for steelwork	Use surface-specific corrosion category given in Table 2
Within the external wall and roof cavity with the steel on the cold side of the dew point Steel in subfloor spaces	Damp
Steelwork near openings in external walls	Sheltered
High humidity and corrosive atmosphere, such as chemical processing plant, indoor swimming pools, paper manufacturing plants, boatyard over sea water, composting or pickling plants, foundries, or smelters	Specific engineering design required, refer to AS/NZS 2312.1:2014 and AS/NZS 2312.2:2014
Car parks	Specific engineering design required, refer to HERA Report R4-133

NOTE –

(1) The atmospheric corrosivity categories given provide an indication of the environment corrosivity to assist in the selection of a suitable corrosion protection system; taking into account the macroclimate and where required microclimate effects.

(2) For confirmation of a site-specific atmospheric corrosivity category (for example, for sites that are sheltered from marine influence by the local topography), then site-specific testing is required as described in HERA Report R4-133.

(3) For areas in the geothermal zones, both the macroclimate and the surface-specific corrosivity categories are dependent on the level of geothermal activities and distance from the geothermal source. The corrosivity category could range up to CX with considerable variations; thus in those areas site-specific corrosivity assessment is recommended. For areas that are more than 500 metres beyond the geothermal source or boundary (such as Sulphur Bay, Rotorua), and that have been assessed using the smell test as having minimal or non-existent geothermal influence, the other corrosion zones or categories apply based on distance from the sea.

2.3 Selecting a complying corrosion protection system

The surface-specific atmospheric corrosivity category determined from 2.2.2 shall be used to select a complying protective coating system for the required time to the first maintenance in accordance with 1.7.

Table 4 to Table 8 provide a selection of complying coating systems for required time to first major maintenance. Refer to AS/NZS 2312.1:2014 and AS/NZS 2312.2:2014 for more coating system options to suit the required time to first major maintenance.

For paint and powder coatings, the minimum dry film thickness specified in AS/NZS 2312.1:2014 and AS/NZS 2312.2:2014 shall comply with the requirements of clause 8.3 of AS 3894.3. For other coatings, the minimum coating thickness shall comply with the relevant standard.

For NZTA steel structures, if paints are specified they shall be approved by an independent body such as the Australian Paint Approval Scheme (APAS), the North East Protective Coating Committee (NEPCOAT), or NORSOK (the Norwegian petroleum industry standards). For all other types of structures, it is recommended that similar approvals should be considered.

For the selection of a corrosion protection system in a C5-I or CX environment, the selection shall be undertaken by a qualified coatings specialist.

With regard to fade resistance, when the colour is something other than white, a paint topcoat with UV-resistant stable resins and pigments like those used in automotive coatings, needs to be selected for elements that are exposed to sunlight, and the allowable gloss and colour shift over time needs to be specified and be covered by a performance guarantee. These requirements could be specified by referencing a performance standard such as AAMA 2604, used for coated aluminium panels on buildings, or specifying a colour fade rating to ASTM D2244 or a limit on chalking when measured to ASTM D4214. Consistent appearance over at least a 10-year period would be considered a reasonable requirement.

NOTE – Restrictions on levels of gloss may be imposed to reduce reflectivity, which can be hazardous to night-time drivers, or to reduce visual impact of the structure. Low-gloss coatings help disguise variations in profile but are less easily cleaned by rain or maintenance washing. Some softer coatings could have issues with dirt accumulation or biogenic contamination. Some paints like epoxy are vulnerable to chalking so where gloss stability appearance is important a UV-resistant and pigment topcoat paint should be used. A clear polyurethane should not be used over an epoxy where exposed to sunlight as the epoxy will still chalk from the UV and clear coat will then delaminate.

Batch hot dip galvanized coatings to AS/NZS 4680 are specified in that standard to vary in coating thickness, and hence levels of durability, by the steel thickness being galvanized. The formed coating thickness is largely a function of the steel thickness and steel chemistry and not controlled by the galvanizer. The specified minimum average coating thickness varies from 45 µm to 85 µm (320 g/m^2 to 600 g/m^2). Hot dip galvanized coatings thicker than 85 µm are not specified in AS/NZS 4680 but the general provisions of that standard apply and, together with specific thickness figures, can form a specification capable of third-party verification. It is a good idea to know the composition of the steel to be used and the galvanizer should be consulted before specifying, as these thicker coatings may not be available for all types of steel. Where the steel is suitable, thicker coatings may be specified. ➤

C2.3
General
Additional coating systems and guidance on the compatibility of various coating systems as an overcoat is given in AS/NZS 2312.1:2014, AS/NZS 2312.2:2014, and HERA Report R4-133.

Coating systems that provide protection in a severe, (for example, C5-M environment) will have a longer expected time to first major maintenance in less corrosive environments from a durability point of view. This does not include an expectation of gloss and colour retention.

For other types of corrosion protection systems (including protective coatings), not included herein, their use may be considered by the project engineer or a qualified corrosion specialist who is either an Australasian Corrosion Association (ACA) technician or technologist, with a relevant qualification, such as ACA's Coating Selection and Specification Certificate or NACE Coating Inspection Program (CIP) certification (minimum level 2), or is a certified NACE protective coating specialist or NACE corrosion specialist.

A galvanized coating will typically develop a matt grey colour, consistent over the entire surface, irrespective of whether the initial appearance is shiny, partially dull, and shiny or fully dull. This dulling will usually occur within 6 – 12 months of installation.

Galvanized coatings
Continuous galvanized coatings complying with AS 1397, such as those used for roll-formed purlins, have a coating thickness that is designated as the total mass of the coating on both sides of the substrate metal. For example, a purlin made from AS 1397 Z350 grade material has approximately 175 g/m^2 coating mass on each side (24 µm coating thickness). Tube supplied to AS/NZS 4792 will be designated with the coating mass on each face. For example, AS/NZS 4792 ZB135/135 will have at least 135 g/m^2 coating mass (24 µm coating thickness) on each face of the tube (internal and external).

Table 4 – Internal steelwork – Coating required only for appearance, surface-specific corrosivity category C1 and temporary protection during construction

System designation[a]	Surface preparation	Number of coats	Typical colour	Initial gloss	Allowable surface-specific corrosivity during construction[b]
ALK6	Sa 2½	3	Wide range	Flat to full gloss	C4
IZS1		1		Flat	
PUR1	St 3	2		Semi-gloss to full gloss	C4
ALK1[c]	St 3/Sa 2	1	Limited range	Flat to full gloss	C2[d]
ALK3		2	Wide range		C3

NOTE – All galvanized coatings are suitable for internal steelwork.

a Based on AS/NZS 2312.1:2014.

b Based on a maximum of 1 year's exposure during construction.

c The alkyd primer system ALK1 should not be used in grey colour because the breakdown of the system will be highly visible. Red oxide colour is preferred to reduce the visual impact of minor and structurally acceptable rusting that may occur on the ALK1 system in a few years.

d Based on a maximum of 4 weeks' exposure during construction.

Table 5 – Coatings for surface-specific corrosivity category C2

Years	System designation[a]	Surface preparation	Number of coats	Typical colour	Initial gloss
15	EPM3	Sa 2	2	Wide range	Low to semi-gloss
	ACC2	Sa 2½			Semi-gloss to full gloss
	PUR2				
25	MCU2	Sa 2½	3	Limited range	Semi-gloss
	PUR3			Wide range	Semi-gloss to full gloss
	IZS2		1	Mostly grey	Flat
40	PUR5		3	Wide range	Semi-gloss
	HDG390	See AS/NZS 4680	1	Grey[b]	Flat to semi-gloss
	TSZ100	Sa 2½	1		Flat

NOTE – All galvanized coatings provide 15 years' corrosion protection, for galvanized coatings >18 μm provide 25 years' corrosion protection, and galvanized coatings >28 μm provide 40 years' corrosion protection.

a Based on AS/NZS 2312:2002.

b Wide range when coloured sealer/topcoat is used.

Table 6 – Coatings for surface-specific corrosivity category C3

Years	System designation[a]	Surface preparation	Number of coats	Typical colour	Initial gloss
15	IZS2	Sa 2½	1	Mostly grey	Flat
	PSL1		2	Wide range	Semi-gloss to full gloss
	PUR4		3		
	ACC4				
	MCU2			Limited range	Semi-gloss
25	PUR5		3	Wide range	Semi-gloss
	HDG390	See AS/NZS 4680	1	Grey[b]	Flat
40	IZS4	Sa 2½	1	Mostly grey	Flat
	TSZ100[c]			Grey[b]	
	HDG600	See AS/NZS 4680			
	HDG600-5D	Sweep abrasive blast to AS/NZS 4680 or etch prime	2	Wide range	Semi-gloss to full gloss

NOTE – All galvanized coatings > 32 μm provide 15 years' corrosion protection. Galvanized coatings can be topcoated, known as a duplex coating, to provide not only colour but also enhanced corrosion protection. See AS/NZS 2312.2:2014 for additional guidance.

a Based on AS/NZS 2312:2002.

b Wide range when coloured sealer/topcoat is used.

c TSZ100 can be sealed or remain unsealed.

Table 7 – Coatings for surface-specific corrosivity category C4

Years	System designation[a]	Surface preparation	Number of coats	Typical colour	Initial gloss
15	TSZ100[b]	Sa 2½	1	Grey[c]	Flat
	PUR5		3	Wide range	Semi-gloss to full gloss
	ACC6				
	IZS4		1	Mostly grey	Flat
	HDG500	See AS/NZS 4680	1	Grey	
25	HDG900				
	HDG500-5D or 5I	Sweep abrasive blast to AS/NZS 4680 or etch prime	3	Wide range	Semi-gloss to full gloss
	HDG600-4D or 4I				
40	TSZ150S	Sa 2½	2	Grey[c]	Flat
	HDG600-5D or 5I	Sweep abrasive blast to AS/NZS 4680 or etch prime	3	Wide range	Semi-gloss to full gloss

a Based on AS/NZS 2312:2002.

b TSZ100 can be sealed or remain unsealed.

c Wide range when coloured sealer/topcoat is used.

Table 8 – Coatings for surface-specific corrosivity category C5-M

Years	System designation[a]	Surface preparation	Number of coats	Typical colour	Initial gloss
15	EHB6	Sa 2½	3	Limited range	Flat to semi-gloss
	PUR5			Wide range	Semi-gloss to full gloss
	TSZ150S[b]		2	Grey[c]	Flat
	HDG900	See AS/NZS 4680	1		
25	TSZ200S[b]	Sa 2½	2		
	TEC1[d]		1	Limited	Gloss
	HDG600-5D or 5I	Sweep abrasive blast to AS/NZS 4680 or etch prime	3	Wide range	Semi-gloss to full gloss
40	TSZ300S[b, e]	Sa 2½	2	Grey[c]	Flat
	TSA225S[e]	Sa 3			

a Based on AS/NZS 2312:2002.

b Only zinc/aluminium alloy (85% zinc, 15% aluminium) to be used in C5-M environment.

c Wide range when coloured sealer/topcoat is used.

d Thermoplastic ethylene copolymers with DFT > 300 µm.

e Thermal aluminium spray is mostly used for structures within 100 m from the sea due to the high corrosivity category and abrasiveness of the environment, while thermal zinc spray is used for structures in the < C5 categories.

2.4 Average steel loss over the design life of the structure

ISO 9224 outlines the methodology for determining the steel section loss over the design life of the structure.

NOTE – In ISO 9224 the corrosion rate for steel is considered to be appropriate for up to 20 years, and beyond that period the corrosion rate is considered to be only indicative.

2.5 Assessing the remaining steel loss at the end of the design life

For both atmospheric and non-atmospheric environments, when assessing the average steel loss on a surface that is not maintained after a given point in time (this period is taken as $T_{DL} - T_{FM}$), taking into account the corrosion protection system, use Equation 1 in conjunction with the surface-specific corrosivity category determined from 2.2.2.

$$t_{sl} = r_{corr}(T_{DL} - T_{FM}) \quad \text{Eq. 1}$$

where

t_{sl} Steel thickness loss in µm/steel surface

T_{DL} Steelwork design life in years

T_{FM} Total time to first major maintenance of initial and subsequent coating systems applications

r_{corr} Steel corrosion rate, in μm/annum, for steel in:

atmospheric environments – determine the surface-specific atmospheric corrosivity category using Table 2 and then determine r_{corr} from Table 9, based on r_{av} or r_{lin} as appropriate; or

non-atmospheric environments – determine the exposure classification from Table 10 to Table 12 and then determine r_{corr} which in this case is the uniform corrosion allowance from Table 13.

NOTE – Equation 1 does not account for localised pitting corrosion so is only applicable to a minimum steel thickness of 10 mm for steel in maritime environments or embedded in soil, and a minimum steel thickness of 8 mm for steelwork located elsewhere.

Table 9 outlines the average carbon steel corrosion rate in different atmospheric environments. These are given as average corrosion rate for up to 10 years that correspond to the initial period of exposure (r_{av}), and as the average corrosion rate during the first 30 years that are taken as being steady-state corrosion rates (r_{lin}).

Table 9 – Average corrosion rate (μm/annum) of carbon steel in different environments

Surface-specific corrosivity category	Average corrosion rate, r_{av}, during the first 10 years	Steady-state corrosion rate, r_{lin}, estimated as the average corrosion rate during the first 30 years
C1	$r_{av} \leq 0.4$	$r_{lin} \leq 0.3$
C2	$0.4 < r_{av} \leq 8.3$	$0.3 < r_{lin} \leq 4.9$
C3	$8.3 < r_{av} \leq 17$	$4.9 < r_{lin} \leq 10$
C4	$17 < r_{av} \leq 27$	$10 < r_{lin} \leq 16$
C5	$27 < r_{av} \leq 67$	$16 < r_{lin} \leq 39$
CX	$67 < r_{av} \leq 233$	$39 < r_{lin} \leq 138$

C2.5
Example:

Steel sections supporting a roof canopy will be recoated after 15 years with a 15-year time to first major maintenance coating system. No further recoats will be applied. The design life of the structure is 50 years. The surface-specific corrosivity category is assessed as C3 from Table 2. The extent of steel thickness loss, using r_{lin} as 10 μm/annum from Table 9, at the end of the design life is calculated using Eq. 1 as follows:

t_{sl} = 10 (50 – (15 + 15)) = 200 μm/steel surface.

The steel corrosion rate of r_{lin} was used, as the exposure period was greater than 10 years. If that period was equal or less than 10 years, then the r_{av} value would have been used.

3 CORROSION OF STEEL IN NON-ATMOSPHERIC ENVIRONMENTS

3.1 Exposure classification

The exposure classification of the surface of steel in a non-atmospheric environment shall be determined from Table 10 to Table 12. For the range of chemical conditions at steel surfaces in soil, the condition leading to the most severe condition shall be allowed for. Consideration shall be given to possible changes in groundwater levels. For embedded steel immersed in sea or fresh water, use Table 12.

Table 10 – Exposure classification for steel in water

Water type	Exposure condition	Exposure classification
Sea water	Submerged	Severe
	Tidal/splash zone	Very severe
	Accelerated low water corrosion	Extreme
Fresh water	Soft running water	Moderate
	Microbial influenced corrosion	Very severe

NOTE –

(1) Accelerated low water corrosion is a form of rapid pitting corrosion that typically occurs on marine piling in the aerated zone at or just below the low tide level and is associated with microbial induced corrosion (MIC). This is due to the conversion of sulphates in the steel to hydrogen sulphide and sulphuric acid by bacteria.

(2) MIC can occur on steel components in fresh water. It has been observed on sheet piles with sulphur inclusions in the steel; therefore, it is recommended that good quality steel with no sulphur inclusions be used.

Table 11 – Exposure classification for steel in refuse fill

Exposure condition	Exposure classification
Domestic waste	Severe
Industrial waste	Very severe

NOTE – Contamination by the tipping of mineral and domestic waste or by spillage from mining, processing, or manufacturing industries presents special durability risks due to the presence of certain aggressive acids (both organic and inorganic), salts, and solvents, which can chemically attack steel. In the absence of site-specific chemical information, the exposure classification should be assessed as given. Chemical and microbiological analysis of the latter could, however, lead to a lower risk classification.

Table 12 – Exposure classification for steel in soil

Exposure conditions				Exposure classification	
Soil pH	**Chlorides**		**Resistivity** (ohm-cm)	**Soil Condition A**[a]	**Soil Condition B**[b]
	In soil (ppm)	**In groundwater** (ppm)			
> 5	< 5000	< 1000	> 5000	Non-corrosive	Non-corrosive
4 – 5	5000 – 20 000	1000 – 10 000	2000 – 5000	Non-corrosive	Mild
3 – 4	20 000 – 50 000	10 000 – 20 000	1000 – 2000	Mild	Moderate
< 3	> 50 000	> 20 000	< 1000	Moderate	Severe

NOTE –

(1) Where high levels of sulphates exist (> 1000 ppm), sulphate-reducing bacteria may be present and active, sometimes leading to MIC. In such cases, classify as 'mild' for low permeability soils and 'moderate' for high permeability soils.

(2) For steel in disturbed soil, consider the assumption of soil condition B where accelerated corrosion is possible.

(3) The natural pH of most New Zealand soils ranges from 4 to 6, with most having pH > 5 (Edmeades et al 1990). Any soil modification for agriculture purposes raises the pH to between 6 and 7. Studies of New Zealand subsoils down to 0.9 m depth have been undertaken by Penhale (Penhale 1971; Penhale 1984), focusing on determining the corrosion performance of mild steel elements in a range of New Zealand subsoils. The types of soil that have pH below 4 include:

(a) Geothermally affected soils (where it can be < 3);
(b) Peat layers which occur in some swampy, low-lying areas;
(c) Highly weathered clays subject to alternate wetting and drying.

(4) Chloride ion concentration is related to distance from the sea but is very variable. Once this distance reaches or exceeds 20 km the chloride content is typically low.

(5) Resistivity is a measure of the moisture and chemical content of a soil and its porosity; within each pH band the resistivity is related to the porosity. Silts and clays have lower porosity than sands and gravels and therefore have higher resistance to corrosion currents.

(6) Site-specific soil testing for pH, chlorides and resistivity can be done by a number of New Zealand laboratories, and should be determined as part of the geotechnical investigation when required. This should be determined down the length of the soil column into which the steel is to be located at intervals as advised by the testing organisation or geotechnical engineer.

(7) Determine the soil pH from site-specific study or consult a geotechnical engineer. This gives the appropriate line in the table to read from for determining the exposure classification.

(8) If the chloride concentration is available, use that to define the uniform corrosion allowance within the given pH band.

(9) If the resistivity is available, use that to define the uniform corrosion allowance within the given pH band.

(10) Using this information, determine the exposure classification and the value of uniform corrosion allowance from Table 13; this can include interpolation from Table 13 for determining the uniform corrosion allowance.

a Soil condition A: Low permeability soils (such as silts and clays) that are in groundwater.

b Soil condition B: High permeability soils (such as sands and gravels) that are in groundwater or all soils above groundwater.

3.2 Corrosion rate of steel in non-atmospheric environments

Where no corrosion protection system or cathodic protection is applied, allowance shall be made for loss of section during the design life of the steel structure or component. Where a corrosion protective system (such as a protective coating) is provided, consideration shall be given to the likely life of the coating and allowance made for loss of steel section thereafter, as per 2.5.

Where no corrosion protection systems are to be applied to steel in non-atmospheric environments, allowance shall be made for uniform corrosion and loss of section. In the absence of other information, the corrosion rates given in Table 13 shall be used. If the site-specific corrosion rates are known, those site-specific rates may be used. Corrosion on the internal faces of a fully sealed closed-form pile may be assumed to be negligible.

Where steel components are electrically connected to a dissimilar metal, the resultant beneficial or adverse galvanic effect shall be taken into consideration.

Table 13 – Corrosion allowance for steel in non-atmospheric environments

Exposure classification	**Uniform corrosion allowance** (μm/annum)
Non-corrosive	< 10
Mild	10 – 20
Moderate	20 – 40
Severe	40 – 100
Very severe	100 – 200
Extreme	> 200

NOTE –

(1) The allowances may be reduced, as appropriate, where adequate corrosion protection systems (such as coatings or cathodic protection) are to be used. Coatings will reduce corrosion allowance while they remain in good condition. Coating damage, deterioration, and breakdown will result in the corrosion rate increasing and, in such circumstances, the corrosion allowances in this table shall apply.

(2) To allow for future retrofitting of cathodic protection it is good practice to provide electrical continuity throughout the piled system at the time of construction. In providing electrical continuity, consideration shall be given to the likelihood of stray current corrosion, especially if the completed structure is of significant length and adjacent to a cathodically protected system or within close proximity to direct current electrified traction or power supply systems.

(3) For very severe and extreme conditions a site-specific assessment should be sought.

(4) The natural pH of most New Zealand soils ranges from 4 to 6, with most having pH > 5 (Edmeades et al 1990). Any soil modification for agriculture purposes raises the pH to between 6 and 7. Studies of New Zealand subsoils down to 0.9 m depth have been undertaken by Penhale (Penhale 1971; Penhale 1984), focusing on determining the corrosion performance of mild steel elements in a range of New Zealand subsoils. The types of soil that have pH below 4 include:

- (a) Geothermally affected soils (where it can be < 3);
- (b) Peat layers which occur in some swampy, low-lying areas;
- (c) Highly weathered clays subject to alternate wetting and drying.

(5) Chloride ion concentration is related to distance from the sea but is very variable. Once this distance reaches or exceeds 20 km the chloride content is typically low.

(6) Resistivity is a measure of the moisture and chemical content of a soil and its porosity; within each pH band the resistivity is related to the porosity. Silts and clays have lower porosity than sands and gravels and therefore have higher resistance to corrosion currents.

(7) Site-specific soil testing for pH, chlorides, and resistivity can be done by a number of New Zealand laboratories, and should be determined as part of the geotechnical investigation when required. This should be determined down the length of the soil column into which the steel is to be located at intervals as advised by the testing organisation or geotechnical engineer.

C3.2

Corrosion rates of 300 μm/annum to 800 μm/annum due to accelerated low water corrosion in sea water and MIC in fresh water have been recorded. In such circumstances, additional corrosion protection is required.

Localised corrosion can also be found in the steel components embedded zone close to the soil-water or soil-air interface where microbial activity is high and where scouring can maintain high corrosion activity. Such localised corrosion is not covered by the corrosion allowances given in this clause, which are averaged rates for situations where general corrosion occurs.

A cathodic protection system for steel that is either buried or immersed is only fully effective up to approximately mid-tide level in sea or tidal waters, and up to ground level in soils.

3.3 Selecting a complying corrosion protection system

Protective coating systems may be used to increase the design life of the buried or immersed surfaces of steel components (such as piles). For steel surfaces that are exposed to the atmosphere, these should be treated as steel in atmospheric environments.

Table 14 describes a selection of suggested options.

Table 15 states the corrosion rate of zinc (such as galvanizing) in soil.

C3.3

AS/NZS 2041.1, AS/NZS 2312.1:2014, and AS 2159 have additional recommendations for protective coatings for piles. A number of methods can be used to increase the steel piles design life. These methods are:

(a) Use of a heavier section;

(b) Use of a higher grade steel at mild steel stress levels;

(c) Use a barrier tape system;

(d) Apply a protective coating;

(e) Apply cathodic protection; and

(f) Use concrete encasement where practicable.

In practice, a combination of protective coatings (or barrier tape) and cathodic protection is likely to provide the most cost effective long-term solution. Cathodic protection systems should be designed and installed in accordance with AS 2832.4.

Table 14 – Suggested protective coating systems for steel piles in non-atmospheric environments

System designation[a]	Coating	Surface preparation	No. coats	Total nominal dry film thickness (μm)	Typical areas of use	Typical time to loss of corrosion protection system (years)
EVHB2	Very high build epoxy	Sa 2½	1	400	Piers, jetties, bearing piles in corrosive soils	20+
EVH3	Glass flake epoxy		2	500	Piers, jetties, bearing piles in corrosive soils. For soils and immersion conditions that also require abrasion resistance	20+
PES1	Glass flake polyester/ vinyl ester		1	1000	Piers, jetties, bearing piles in very corrosive soils where abrasion resistance and chemical resistance area required	20+
HDG600	Hot dip galvanizing	See AS/NZS 4680	1	85	Retaining walls in non-marine environments	10 – 20

a Based on AS/NZS 2312.1:2014 and AS/NZS 2312.2:2014.

Table 15 – Average zinc corrosion rate (per side in contact) versus soil water, pH, or resistivity

Soil pH	**Range of average zinc corrosion rate** (µm/annum)	
	Drained soils	**Undrained soils**
< 4	> 6.5	> 20
4 – 4.9	2.6 – 5.2	6.7 – 13.3
5 – 7.9	2.2 – 4.3	5.5 – 11
8 – 9	3.3 – 6.5	6.1 – 12.1
> 9	> 8.6	> 17.2
Soil resistivity (ohm-cm)	**All soils**	
< 500	> 3.5	
500 – 1000	1.5 – 3.5	
1000 – 2000	1.3 – 1.5	
2000 – 5000	0.9 – 1.5	
> 5000	< 0.9	

NOTE –

(1) The loss rates shall be calculated from the worst-case loss for either pH or resistivity. The loss rates for pH and soil resistivity shall not be added together.

(2) In fully submerged conditions where oxygen levels are low, reduced metal loss rates can be expected.

(3) In marine splash zones, metal loss rates will exceed those given for severe coastal conditions.

4 MISCELLANEOUS

4.1 Inspection of coatings

Inspection of protective coating systems shall be carried out in accordance with the recommendations in AS/NZS 2312.1:2014 and AS/NZS 2312.2:2014 or AS/NZS 5131.

C4.1

Coating inspection recommendations are covered in detail in AS/NZS 2312.1:2014, AS/NZS 2312.2:2014, and AS/NZS 5131. These include confirmation of requirements and achievement of: specifications, standards of workmanship for each step in the system, surface preparation, method of application, suitability of equipment, drying and curing time intervals between coats and handling, coating thickness, method of handling, and reporting.

It is recommended that inspection of protective coating systems in locations with surface-specific corrosivity of C3 to CX be performed by a Certification Board for Inspection Personnel or NACE international certified coatings inspector, or ACA hot dip galvanized certified inspector.

In all surface-specific corrosivity categories, the performance of coating systems requiring steel surface preparation to ISO 8501-1 or AS 1627.4 of Sa 2½ or higher is very dependent on that quality of preparation being achieved. As well as removal of deleterious contaminates, this includes attaining a specific surface roughness where required for a particular coating (for example, thermal metal sprays require a sharp angular profile to a specified roughness depending on the type of metal spray being deposited).

4.2 Inaccessible surfaces

Surfaces in contact or near contact after fabrication or erection shall receive their specified surface preparation and treatment prior to assembly in accordance with AS/NZS 5131. In the case of paint coatings these shall be cured before assembly.

This requirement does not apply to the interior of sealed hollow or sealed box sections, or connection (faying) surfaces for joints with friction type bolting category where bare steel interfaces are specified.

4.3 Protection during transport and handling after corrosion protection

Structural members shall be adequately protected during handling and transport to minimise damage to the corrosion protection in accordance with AS/NZS 5131.

Units that are transported in nested bundles should be separable without damage to the units or their coatings. Consideration shall be given to the use of lifting beams with appropriately spaced lifting points and slings, or to lifting with properly spaced and protected forklift tines.

4.4 Repairs to corrosion protection

A corrosion protection system that has been damaged by welding, erection, bolting, or other causes shall be fully reinstated before the structure is put into service in accordance with AS/NZS 5131.

The damaged area shall be dry and clean, free from dirt, grease, and loose or heavy scale or rust before the corrosion protection is applied. The corrosion protection shall be applied as soon as practicable and before noticeable oxidation of cleaned surfaces occurs. Damaged zinc coatings shall be restored by applying an equivalent thickness of a suitable zinc paint conforming to AS/NZS 3750.9 or AS/NZS 3750.15, or with thermal zinc spray.

Damaged galvanized coatings shall be repaired in accordance with AS/NZS 4680.

4.5 Coatings reference areas and test coupons

To assist with determining the responsibility for coating failure between coating specification, coating material and workmanship; reference areas or test coupons may be used. These shall be located on the structure itself, and are prepared, installed, and the location recorded during the application of the protective coating systems, or in the case of hot dip galvanizing, at the time of installation.

For the use of reference areas, refer to AS/NZS 2312.1:2014.

For the use of test coupons, refer to the NZTA *Protective coatings for steel bridges*.

NOTES

NOTES

Approved by the New Zealand Standards Executive on 19 December 2017 to be a New Zealand technical specification.

First published: 22 February 2018

The following references relate to this technical specification:

Project No. P3404

Draft for comment No. DZ TS 3404

Typeset by: Standards New Zealand

STANDARDS®
NEW ZEALAND
PAEREWA AOTEAROA