September 2016

MANAGING FACILITIES DISCUSSION PAPER

Consultation notes:

The attached paper does not reflect the views or policy of the Australian Government and the Great Barrier Reef Marine Park Authority (GBRMPA).

The paper was prepared for GBRMPA by an independent contractor to provide discussion and options of various matters related to the management of facilities within the Great Barrier Reef Marine Park.

GBRMPA now seeks the public's views on the discussion and options presented in the attached paper. Public consultation is open until 4 November 2016. For more information, please visit www.gbrmpa.gov.au or email consultation@gbrmpa.gov.au.

Following public consultation, GBRMPA will consider submissions received in formulating updated guidelines for managing facilities.

This discussion paper forms part of a broader package which has been released for public comment and should be read in conjunction with:

a. The draft revised Environmental impact management policy: permission system (Permission system policy) explains how the management of the permission system ensures consistency, transparency and achievement of the objects of the Act.
b. The draft Risk assessment procedure explains how GBRMPA determines risk level and the need for avoidance, mitigation or offset measures.
c. The draft Guidelines: Applications for permission (Application guidelines) explain when permission is required and how to apply.
d. The draft Checklist of application information proposes information required to be submitted before an application is accepted by GBRMPA.
e. The draft Guidelines: Permission assessment and decision (Assessment guidelines) explain how applications are assessed and decisions made.
f. The draft Information sheet on deemed applications under the Environment Protection and Biodiversity Conservation Act (EPBC deemed application information sheet) explains how application, assessment and decision processes work for those applications that require approval under both the *Great Barrier Reef Marine Park Act* and the *Environment Protection and Biodiversity Conservation Act* (EPBC Act).
g. The draft Information sheet on joint Marine Parks permissions with Queensland (Joint Marine Parks permissions information sheet) explains how GBRMPA and the Queensland Government work together to administer a joint permission system.
h. The draft Guidelines: Value impact assessment in the permission system (Value assessment guidelines) provide further detail on specific values of the Marine Park, including how to determine risk and possible avoidance, mitigation or offset measures.
i. The draft Guidelines: Location-specific assessment in the permission system (Location-specific assessment guidelines) highlight places in the Marine Park that have site-specific management plans, policies or other information which may be relevant to decisions.
j. The draft Guidelines: Activity impact assessment in the permission system (Activity assessment guidelines) provide further detail on how GBRMPA assesses and manages specific activities.
k. The draft Guidelines: Activity impact assessment in the permission system – Fixed facilities propose changes to how GBRMPA manages facilities in the Marine Park.

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This report was prepared by Arup on behalf of the Great Barrier Reef Marine Park Authority in connection with managing facilities in the Marine Park. It takes into account our client's particular instructions and requirements and addresses their priorities at the time. This report was not intended for, and should not be relied on by, any third party and no responsibility is undertaken to any third party in relation to it.

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ACKNOWLEDGEMENTS

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iii. Australian Maritime Safety Authority
iv. Workplace Health and Safety Queensland
v. Board of Professional Engineers of Queensland
vi. Royal Institution of Naval Architects (RINA) Queensland Section
vii. Ergon Energy
viii. Association of Marine Park Tourism Operators
ix. Pacific Marine Group Pty Ltd

ACRONYMS

ADAS: Australian Dive Accreditation Scheme

AEP: Annual Exceedance Probability

ARI: Average Recurrence Interval

AMPTO: Association of Marine Park Tourism Operators

AMSA: Australian Maritime Safety Authority

ARRB: Australian Road Research Board

BPEQ: Board of Professional Engineers Queensland

CCTV: Closed Circuit Television

CSIRO: Commonwealth Scientific and Industrial Research Organisation

DEHP: Department of Environment and Heritage Protection

DILGP: Department of Infrastructure, Local Government and Planning

DNRM: Department of Natural Resources and Mines

DTMR: Department of Transport and Main Roads

GBRMPA: Great Barrier Reef Marine Park Authority

IPWEA: Institute of Public Works Engineering Australasia

MSQ: Maritime Safety Queensland

PMG: Pacific Marine Group

RINA: Royal Institution of Naval Architects

ROV: Remotely Operated Vehicles

RPEQ: Registered Professional Engineer of Queensland

SARA: State Assessment and Referral Agency

SDAP: State Development Assessment Provisions

WHSQ: Work Health and Safety Queensland

VTS: Vessel Tracking Services

GLOSSARY

Annual exceedance probability: chance or probability of a meteorological event occurring annually during the lifetime of the structure, usually presented as a percentage.

As built drawings: final drawings produced at the completion of a construction project.

Astronomical tide: the periodic rising and falling of the oceans, resulting from the gravitational attraction of the moon, sun and other astronomical bodies acting upon the rotating earth.

Average Recurrence Interval: the average, or expected, value of the periods between exceedance of a given event. It is implicit in this definition that the periods between each exceedance are generally fandom.

Coastal processes: natural process of the coast including sediment transport, fluctuations in the location and form of the foreshore, dune system and associated ecosystems, tides, changes in sea Level and coastal hazards, ecological processes and the natural water cycle.

Competent person: a person who has acquired through training, qualifications, experience or a combination of these, the knowledge and skills to carry out a particular task.

Condition rating: the state of a structure based on a set of rating; 1: Good; 2: Fair; 3: Poor; 4: Very Poor and 5: Unsafe. DTMR (2004) section 3.8.3 provides description of the rating.

Defined storm tide event: the event (measured in terms of likelihood of recurrence) and associated inundation Level adopted to manage the development or structure in a particular area. The defined storm event is the one per cent annual AEP storm tide, equivalent to 1 in 100 year ARI unless otherwise indicated.

Design life: period of time during which the structure is expected by its designers to work within its specified parameters

Encounter probability: risk of a meteorological event occurring during the lifetime of a structure.

Epifauna: animals living on the surface of the seabed or a riverbed, or attached to submerged objects or aquatic animals or plants.

Expected remaining life: The residual period over which a facility or facility component is expected to perform an intended function at the required Level of service without unforseen major repair.

General diving: all work carried out in or under water while breathing compressed gas by a worker that is not performing high risk diving work. Typically it includes:

i. scientific and resource management diving – including limited scientific diving work
ii. photographic and film making diving
iii. marine harvesting and aquaculture diving

iv. recreational diving undertaken by workers (e.g. dive instructors and divemasters.
v. minor work in the sea, bay, inlet or marina for cleaning, inspecting, maintaining or searching for a vessel or mooring
vi. work that is incidental to the conduct of a business (e.g. an actor working on an underwater film).

High risk diving: work carried out in or under water while breathing compressed gas that involves one or more of the following:

i. construction work (e.g. constructing a pipeline, renovating a ship, refurbishing a dock)
ii. testing, maintenance or repair work of a minor nature carried out in connection with a structure. For example conducting non-destructive testing on a bridge pylon
iii. inspection work carried out to determine if the above is necessary (e.g. inspecting a component of a dam to determine if maintenance is required)
iv. recovery or salvage of large items of plant or structures for commercial purposes (e.g. salvage of a vessel).

Highest astronomical tide: the highest water Level that can be predicted to occur under average meteorological conditions and any combination of astronomical conditions.

Marine surveyor: a person who conducts inspections, surveys or examinations of marine vessels to assess, monitor and report on their condition, as well as inspects damage caused to both vessels and cargo. Marine surveyors also inspect equipment intended for new or existing vessels to ensure compliance with various standards or specifications.

Maximum potential intensity: the theoretical limit of the strength of a tropical cyclone and a measure of its central pressure.

Metocean: refers to meteorology and oceanography such as wind, waves, tides and storm surge.

Mooring: a permanently located facility that is designed solely for mooring a floating component of a pontoon and may include a floating buoy, tag, tackle, pile and a structure fixing the mooring to the seabed.

Naval architect: a naval architect is an engineer who is responsible for the design, construction, and/or repair of ships, boats, other marine vessels and offshore structures.

Occupational diving: diving in the course of employment and comprising all diving work carried out as part of a business, service, for research or for profit.

Partial discharge: partial discharges are small electrical sparks that occur within the insulation of medium and high voltage electrical assets.

Pontoon or Pontoon Structure: a facility that consists of two components: a floating component (which provides a platform) and a mooring.

Professional liability: legal obligations arising out of a professional's errors, negligent acts, or omissions during the course of his or her professional practice.

Public liability: legal obligation against claims of personal injury or property damage that a third party suffers (or claims to have suffered) as a result of your business activities.

Registered Professional Engineer of Queensland: a person registered under the Professional Engineers Act 2002 by the Board of Professional Engineers Queensland.

Return Period: period that, on average, separates two occurrences.

Swell: waves that are not generated by the immediate local wind, instead by distant weather systems.

Swing mooring: a single anchor at the seabed with a chain or cable connected to a buoy on the surface. A pontoon or vessel connects to the chain and it can moor freely.

Significant event: a situation that exceeds design criteria or normal operating environment, or that involves actual or potential harm to the ecosystem including but not limited to:

a) a cyclone (further assessment required to determine minimum cyclone category)

b) a fire

c) an earthquake (further assessment required to determine minimum earthquake magnitude)

d) a tsunami (further assessment required to determine minimum tsunami wave height)

e) a reportable incidence under WHS laws

f) any shipping event that requires notification to a relevant authority under the *Queensland Marine Act 1958* or the *Navigation Act 1912*

g) any aircraft event that requires notification to the relevant Authority under the *Civil Aviation Act 1988*

h) discharge of any material which exceeds permitted limits.

EXECUTIVE SUMMARY

Background

This paper is prepared to provide advice on inspection regimes and, decommissioning and removal aspects for the management of facilities within the Marine Park. This paper forms part of Great Barrier Reef Marine Park Authority's (GBRMPA) major review of the permission system, including associated Regulations, policies, guidelines and procedures. GBRMPA started the major review in January 2015 and has undertaken round one of public consultation from October to December 2015 on 15 potential changes to the permission system, which includes a review of managing facilities. This paper is one of the outcomes from considerations of the public comments.

The following facilities are common in the Marine Park and are covered in this paper:

i. Barge ramp
ii. Cable
iii. Jetty
iv. Pipe
v. Pontoon
vi. Underwater observatory
vii. Wall

The stakeholders listed below were consulted to discuss their views which were reviewed and incorporated to formulate the inspection regimes.

i. Maritime Safety Queensland (MSQ)
ii. Australian Maritime Safety Authority (AMSA)
iii. Workplace Health and Safety Queensland (WHSQ)
iv. Board of Professional Engineers of Queensland (BPEQ)
v. Royal Institution of Naval Architects (RINA) Queensland Section
vi. Ergon Energy
vii. Association of Marine Park Tourism Operators (AMPTO)
viii. Pacific Marine Group Pte Ltd (PMG)

Specifically, MSQ, AMSA and WHSQ were consulted to identify any overlaps of gaps with GBRMPA's jurisdictions relating to managing facilities in the Marine Park.

This report is Arup's understanding of the input of the above providers.

Jurisdictions Overlap

Consultations with MSQ, AMSA and WHSQ were undertaken to understand their respective jurisdictions with regards to the scope covered in this paper. The aim was to identify overlaps and gaps with GBRMPA's jurisdictions. A number of suggestions were made for improving collaboration and with respect to overlaps.

Table 1. Jurisdictions overlap summary

Facility / Activity	Jurisdiction	Notes
All facilities	MSQ	Option for a Memorandum of Understanding (MoU) between GBRMPA and MSQ that address situations where GBRMPA need to consult MSQ and vice versa. Opportunity for GBRMPA to adopt a bilateral assessment and approval process where certain low risk activities are assessed against the State triggers for Marine Park Permit, works in a Coastal Management District and tidal works.
Pontoon	AMSA	For permits to be issued, GBRMPA could make reference to AMSA's requirements for pontoon Certificate of Survey. Through measures put in place for information sharing, GBRMPA could have access to certificates issued by AMSA and to AMSA's database that provides information on marine survey undertaken for pontoons.
Diving	WHSQ	During consultation with WHSQ, it was suggested that as part of the permit assessment process, GBRMPA makes the facility owners aware of the requirements for high risk works as sometimes this can be neglected or the facility owners might not be aware of. There could also be opportunity for GBRMPA to seek assistance from WHSQ to formulate safety requirements with regards to managing facilities in the Marine Park.

Inspection Regime Overview

The suggested inspection regime is based on three-level hierarchy as follows for barge ramps, jetties, pontoons, underwater observatories, walls and pipes.

i. Level 1: Routine maintenance inspection (above water)

ii. Level 2: Condition inspection (above and below water)

iii. Level 3: Detailed engineering inspection and investigation (depends on scope defined in Level 2 inspection)

Level 1 inspections are all above water, therefore this inspection level for underwater observatories and pontoon moorings are not applicable.

The inspection regime for cables are divided into inspection and testing requirements for high voltage cables and low voltage cables.

The hierarchy approach is based on the principles of the Bridge Inspection Manual developed by Department of Transport and Main Roads, DTMR (2004). This approach provides adequate inspection coverage with sufficient detail for the prescribed intervals. The inspectors have the option to escalate the inspection to the following level if deemed necessary to have a more detailed inspection undertaken on certain aspects.

Implementing an inspection regime may impose additional cost burden to the facility owner and it may also add administrative burden on GBRMPA. Practical inspection regimes were formulated to provide a balance which also manages risk to the Marine Park environment and users.

Suggestions for Facility Inspections

The suggested inspection regime is summarised in table 2 for all facility types covered in this paper except for cables. For each inspection level, frequency of inspection and inspector qualifications were suggested. The inspector should have inspection experience for the relevant facility.

Table 2. Summary of suggestions for facility inspections

Facility type	Level 1 – routine maintenance inspection (above water)		Level 2 – condition inspection (above and below water)		Level 3 - detailed engineering inspection and investigation	
	Frequency	Qualifications	Frequency	Qualifications	Frequency	Qualifications
Barge and boat ramp - less than 18 years old	Every 2 years	Level 1 Bridge Inspector	Every 6 years	RPEQ	When possible issues are identified by Level 2 inspection	RPEQ
Barge and boat ramp - 18+ years old	Every 1 year	Level 1 Bridge Inspector	Every 3 years	RPEQ	When possible issues are identified by Level 2 inspection	RPEQ
Pontoon (floating component classified as 'vessel') -	Every 2 years	Accredited marine surveyor	Every 4 years	For floating component: accredited marine surveyor	When possible issues are identified by Level 2 inspection	For floating component: Chartered Naval Architect For moorings

Facility type	Level 1 – routine maintenance inspection (above water)		Level 2 – condition inspection (above and below water)		Level 3 - detailed engineering inspection and investigation	
	Frequency	Qualifications	Frequency	Qualifications	Frequency	Qualifications
less than 16 years old				For moorings: GBRMPA *appropriately experienced person*		only: RPEQ
Pontoon (floating component classified as 'vessel') - 16+ years old	Every 1 year	Accredited marine surveyor	Every 2 years	For floating component: accredited marine surveyor For moorings: GBRMPA *appropriately experienced person*	When possible issues are identified by Level 2 inspection	For floating component: Chartered Naval Architect For moorings only: RPEQ
Pontoon (floating component not classified as 'vessel') - less than 16 years old	Every 2 years	Accredited marine surveyor	Every 4 years	For floating component: accredited marine surveyor For moorings: GBRMPA *appropriately experienced person*	When possible issues are identified by Level 2 inspection	For floating component: Chartered Naval Architect or RPEQ For moorings: RPEQ
Pontoon (floating component not classified as 'vessel') - 16+ years old	Every 1 year	Accredited marine surveyor	Every 2 years	For floating component: accredited marine surveyor For moorings: GBRMPA *appropriately experienced person*	When possible issues are identified by Level 2 inspection	For floating component: Chartered Naval Architect or RPEQ For moorings: RPEQ
Jetty (Concrete and steel structure) - less than 18 years old	Every 2 years	Level 1 Bridge Inspector	Every 6 years	RPEQ	When possible issues are identified by Level 2 inspection	RPEQ
Jetty (Concrete and steel structure) - 18+ years old	Every 1 year	Level 1 Bridge Inspector	Every 3 years	RPEQ	When possible issues are identified by Level 2 inspection	RPEQ
Jetty (Timber structure) - less than 12 years old	Every 2 years	Level 1 Bridge Inspector	Every 4 years	RPEQ	When possible issues are identified by Level 2	RPEQ

Facility type	Level 1 – routine maintenance inspection (above water)		Level 2 – condition inspection (above and below water)		Level 3 - detailed engineering inspection and investigation	
	Frequency	**Qualifications**	**Frequency**	**Qualifications**	**Frequency**	**Qualifications**
					inspection	
Jetty (Timber Structure) - 12+ years old	Every 1 year	Level 1 Bridge Inspector	Every 2 years	RPEQ	When possible issues are identified by Level 2 inspection	RPEQ
Seawall and breakwater	Every 3 years	RPEQ	Every 6 years	RPEQ	When possible issues are identified by Level 2 inspection	RPEQ
Underwater observatory - less than 10 years old	Not applicable, Level 1 inspection is for above water		Every 2 years	RPEQ	When possible issues are identified by Level 2 inspection	RPEQ
Underwater observatory - 10+ years old			Every 1 year	RPEQ	When possible issues are identified by Level 2 inspection	RPEQ
Pipe - Fuel, sewage, wastewater (high risk pipe)	Not applicable, Level 1 inspection is for above water		Every 1 year	RPEQ	Every 5 years	RPEQ
Pipe - desalination, potable water, seawater (low risk pipe)			Every 5 years	RPEQ	Every 10 years	RPEQ

The suggested inspection regime for cables is different from all other facilities addressed in this paper, it was formulated for submarine high voltage cables and low voltage cables. Rather than hierarchy levels, inspection and testing requirements were suggested. Frequency and inspector qualifications were suggested as summarised in table 3.

Table 3. Summary of suggested inspection regime for cables

Facility type	**Inspection**		**Testing**	
	Frequency	**Qualifications**	**Frequency**	**Qualifications**
Submarine high voltage power cables	every 5 years	Electrical mechanical licence, Electrical linesperson licence, or approved HV testing experience	At commissioning and at year 5, then 5 yearly unless results indicate degradation and then yearly	Electrical mechanic licence, Electrical linesperson licence, or approved HV testing experience
Low voltage power cables	every 1 year for limited inspection every 5 years for full inspection	Licensed electrical contractor	every 1 year for limited tests every 5 years for full test	Licensed electrical contractor

Decommissioning and Removal

This paper discusses a number of considerations for the decommissioning and removal of the facilities at the end of operation or design life. The considerations were generally around risk to environment and users of the Marine Park.

Summary of suggestions are provided in table 4 for all facility types.

Table 4. Summary of suggestions for decommissioning and removal

Facility type	Suggestion	Main Consideration
Barge and boat ramp	Fully remove	Disused structures in the Marine Park are unsightly and may be a hazard to the environment and users
Pontoon	Fully remove	Disused structures in the Marine Park are unsightly and may be a hazard to the environment and users
Jetty	Fully remove	Disused structures in the Marine Park are unsightly and may be a hazard to the environment and users
Seawall and breakwater	Fully remove, partially remove or leave in place	Removal decision should be assessed case by case that consider impacts on shoreline and surrounding environment
Underwater observatory	Case by case assessment for current structures Fully remove for future structures	Existing structures may be difficult to be removed due to design, location, age or encrusting coral growth. There may also be heritage considerations. A case by case assessment of historic observatories is recommended. Future structures should be designed and planned for decommissioning and complete removal.
Pipe	Fully remove, partially remove or decommission in place	The decision to remove a pipe or leave in place is to be assessed on a case by case basis, based on removal / ongoing maintenance costs if left in place, failure risks and the impacts of removal.
Cable	Case by case assessment for high voltage cables	Assessment for the removal for high voltage cables need to address a number of subjects such as location of the cable, installation and removal method, sensitivity of the surrounding environment and costs.
	Fully remove for low voltage cables	Low voltage cables are easily recovered for removal without major issues.

Overall, the decommissioning and removal decision of a facility should be assessed case by case. The final decision depends on the individual facility's Decommissioning and Removal Plan.

INTRODUCTION

GBRMPA's Jurisdiction and Role

The Great Barrier Reef Marine Park Authority (GBRMPA) is established by the *Great Barrier Reef Marine Park Act 1975* (the Act) as an Australian Government statutory authority. The Act is the primary Act relating to the Great Barrier Reef Marine Park (Marine Park). Other Commonwealth and Queensland Government legislation also applies. The Marine Park consists of areas declared by the Great Barrier Reef (Declaration of Amalgamated Marine Park Area) Proclamation 2004 made under the Great Barrier Reef Marine Park Act.

GBRMPA implements a range of policies and programmes, management strategies and legislative measures to work towards the following outcome:

The long-term protection, ecologically sustainable use, understanding and enjoyment of the Great Barrier Reef for all Australians and the international community, through the care and development of the Marine Park.

The permission system is a key tool for managing the Marine Park. The Act, *Zoning Plan* 2003 and *Great Barrier Reef Marine Park Regulations* 1983 establish that certain activities require written permission (a permit) from GBRMPA in certain zones. Constructing, operating, maintaining or removing a facility requires permission from GBRMPA in every zone (except those zones where facilities are specifically prohibited). The term 'fixed facility' is used to describe those facilities which are intended to be fixed in one location.

All permissions are temporary in nature, even for seemingly 'permanent' fixed facilities such as seawalls and jetties. Facility permits are usually issued for a period of between 3 to 10 years, but may be shorter or longer. Applications for new fixed facilities generally require public advertisement, so that the public has an opportunity to comment on whether the facility would limit their use of the area or would have unacceptable impacts.

When a permit nears its expiry date, the permit holder can apply for a new permit. This requires a new assessment of impacts based on the latest information. Approval of a facility in the past does not guarantee that the facility will be granted new approval. For this reason, all fixed facilities must be designed to be able to be removed from the Marine Park.

Paper Context and General Overview

Background

This paper provides advice on managing facilities within the Marine Park as part of GBRMPA's major review of the permission system, including associated Regulations, policies, guidelines and procedures.

GBRMPA started the major review in January 2015 in response to the findings of the following:

- Great Barrier Reef Region Strategic Assessment Program Report (Program Report), August 2014
- Reef 2050 Long-Term Sustainability Plan (Reef 2050 Plan), March 2015
- Findings of a Performance Audit by the Australian National Audit Office, August 2015

GBRMPA has undertaken round one of public consultation from October to December 2015 to invite comments from the public on 15 potential changes to the permission system, which includes a review of managing facilities. Response to public consultation on proposed changes were released in March 2016. Having considered the public comments, GBRMPA proposed a number of actions as follows:

- Update the Environmental Impact Management Policy to include critical policy positions on the design, maintenance and removal of facilities.
- Publish guidelines explaining in more detail GBRMPA's approach to managing facilities, such as design criteria for new facilities, ongoing inspections and maintenance requirements and how end-of-life decisions will be made.
- Revoke the Structures Policy, on the basis that the material is outdated and the new Environmental Impact Management Policy and guidelines will contain the latest information.
- Work with other agencies to harmonise and streamline the management of facilities.

Scope

As per the terms of reference provided by GBRMPA, this paper provides discussion and options on managing the following facilities in the Marine Park:

i. Barge ramps
ii. Cables
iii. Jetties
iv. Pipes
v. Pontoons
vi. Underwater observatories
vii. Walls

Specifically, the following is addressed in this paper for each of the facility type:

i. Inspection regime addressing general scope, frequency and inspector requirements

ii. Indicative cost estimates to carry out the inspections

iii. Discussions and risk considerations

iv. Decommissioning and removal considerations

The inspection regime is for condition inspections and does not include operational safety or maintenance routine inspections such as general cleaning, debris and vandalism. It should be noted that this paper does not cover a number of specific requirements for the operation of the facility such as fire protection, personal safety provisions, electrical safety and disability access.

In the context of this paper, buoy moorings, navigation channel, navigation aids and landside facilities are outside the scope.

Current Situation

Currently there is inconsistency in permits about when inspections are required and what type of inspections are required, depending on the age of the permit. This is because GBRMPA has reviewed and updated its requirements over time:

- Permits issued before 2010 typically require annual inspection by an experienced or qualified person (varies by permit), with proof of inspection provided to GBRMPA only upon request.
- Permits issued from 2010 to 2012 typically require annual inspections by a Registered Professional Engineer of Queensland (RPEQ), with proof of inspection provided to GBRMPA only upon request.
- Permits issued after 2012 typically require an annual or 3-yearly inspection by an RPEQ with the report submitted to GBRMPA.

Considerations in Reviewing the Inspection Regime

For a systematic inspection and condition assessment programme, the scope of inspection and frequency need to be considered for specific type of facility and the risk profile to the environment and users. The level of detail can be from a general condition inspection to higher level detail inspection which is more comprehensive and involves detailed structural engineering inspections.

It is recognised that implementing an inspection regime may impose additional administrative burden on GBRMPA as a regulator, as well as cost burden to the facility owners. Therefore, practical inspection regimes are formulated to provide a balance which also manages risk to the Marine Park environment and users.

The costs associated with these different levels of inspection also vary, lower cost for general inspections and accordingly higher costs for higher level detail inspections. The inspection Levels can be planned so that appropriate level of inspections are carried out without additional cost burden.

Therefore, a hierarchy level approach is considered an appropriate way of implementing an inspection regime which takes into account the type and age of the facility and eliminates additional cost burden. This similar hierarchy level approach is based on the Bridge Inspection Manual by Department of Transport and Mainroads, DTMR (2004) which is widely used in Queensland.

Inspection regime for pipes considered the type of facility. Pipes have been classified into 'Critical' for high risk pipes and 'Non-Critical' for low risk pipes. This is based on the fluid the pipes are conveying.

For cables, the inspection regime is divided into high voltage cables such as submarine power cables and low voltage cables which are cables likely to be in areas accessible to the general public.

Appropriate inspector qualification or experience is discussed for the different hierarchies for each facility type.

In preparing this paper, the following stakeholders were consulted and their views were incorporated to formulate the inspection regime. This paper also reviews jurisdictions of MSQ, AMSA and WHSQ to identify gaps and overlaps.

i. Maritime Safety Queensland (MSQ) – Queensland Government agency, refer to Page 13 for more details.

ii. Australian Maritime Safety Authority (AMSA) – Australian Government statutory authority, refer to Page 14 for more details.

iii. Workplace Health and Safety Queensland (WHSQ) – Queensland Government agency, refer to Page 15 for more details.

iv. Board of Professional Engineers of Queensland (BPEQ) – regulates the profession of engineering in Queensland.

v. Royal Institution of Naval Architects (RINA) Queensland Section – an international professional institution whose members are involved in the design, construction, maintenance and operation of marine vessels and floating structures (not fixed structures such as a jetty).

vi. Ergon Energy – A corporation owned by the Queensland Government. It distributes electricity across Queensland, excluding South East Queensland through a distribution network regulated by the Australian Energy Regulator (AER).

vii. Association of Marine Park Tourism Operators (AMPTO) – A peak industry body for marine tourism within the Marine Park. The association is a not-for-profit limited company, funded by members' contributions, whose role is to represent its members' interests in all forums.

viii. Pacific Marine Group Pte Ltd (PMG) – A marine construction company based in Queensland. This contractor undertakes construction of marine facilities in Queensland including within the Marine Park.

This paper also presents considerations of high level risks to GBRMPA, facility owners, the public and to the environment relating to the inspections of the facility.

For demolition and removal, the following should be noted and considered:

i. Requirements for notification and approvals for demolition

ii. Inspection and certification by an independent RPEQ that the site has been cleared of all demolition material

iii. Site requirements for demolition are similar to construction

iv. Assessment of environmental impacts

v. Conditions of demolition such as:

a. Noise
b. Vibration
c. Debris
d. Water quality
e. Photographic records and final inspection
f. Disposal and/or recycle waste
g. Reinstate the site to ‘natural’ environment
h. Safety plans
i. Marine fauna spotters

JURISDICTIONS OVERLAP

Consultations with MSQ, AMSA and WHSQ were undertaken to understand the jurisdictions of these government organisations, identify overlaps and gaps as well as any opportunities for streamlining.

The following sections describe Arup's understanding of the stakeholder consultation advice.

Maritime Safety Queensland

Overview

MSQ is a Queensland Government agency attached to DTMR responsible for protecting Queensland's waterways by:

- improving maritime safety for shipping and small craft through regulation and education
- minimising vessel-sourced waste and responding to marine pollution
- providing essential maritime services such as aids to navigation and vessel traffic services
- encouraging and supporting innovation in the maritime industry.

MSQ is also responsible for delivering a range of services on behalf of the national regulator, AMSA, under the *Marine Safety (Domestic Commercial Vessel) National Law Act 2012*. The national system arrangements are implemented together with MSQ's state marine legislative responsibilities. AMSA will take over responsibilities for services relating to domestic commercial vessels by July 2019, with a two year transition period commencing in July 2017.

MSQ's general role is in shipping and not in infrastructure. However, some infrastructure are in place under MSQ's responsibilities, they are:

- Buoy moorings
- Navigation aids for ports and major projects
- Vessel Traffic Services (VTS) facilities

MSQ is responsible for the management and control of buoy moorings in Queensland waters, except for Gold Coast waters. All applications for a buoy mooring authority must be made through a MSQ regional office. MSQ issues buoy mooring authorities for the establishment and occupancy of an allocated mooring position in Queensland waters. However, separate permission is required from Queensland Department of National Parks, Sport and Racing for buoy moorings within State Marine Parks, and from GBRMPA for buoy moorings within the GBR Marine Park.

MSQ has the power to establish aids to navigation. In major projects, MSQ enters into an agreement with the proponent to provide the aids to navigation, as endorsed by the Regional Harbour Master. These assets are then transferred to MSQ for ongoing maintenance. These arrangements are done through a formal agreement, not a permit system. Aids to navigation that are controlled by a State or Commonwealth authority do not require permission from GBRMPA, however, there are requirements of notification to GBMRPA prior to any works and compliance with any directions that GBMRPA gives in relation to those works. For smaller projects, MSQ reviews and comments on the proposed aids to navigation such as for breakwaters and end of pipeline.

From the consultation with MSQ, the interactions between MSQ and GBRMPA are mostly relating to vessel navigation. MSQ does not have a direct or formal role in GBRMPA's permission system, however have an interest that any facilities permitted by GBRMPA do not pose a hazard to navigation.

For structures in Queensland jurisdiction under the *Sustainable Planning Act 2009* (SP Act), consultation with MSQ is triggered for any tidal works development applications. Requirements for development applications are included in the State Development Assessment Provisions (SDAP) and, in conjunction with Department of Environment and Heritage Protection (DEHP) and Department of Natural Resources and Mines (DNRM) in the Prescribed Tidal Works Code. This reduces MSQ's work load for simple applications that come to MSQ for review and comment. For major projects or projects in areas that MSQ have determined would be "high risk" in relation to possible maritime safety impacts, MSQ will get to assess the applications and provide expert comments. MSQ's comments are included as conditions in the development approval issued by Queensland State Assessment and Referral Agency (SARA).

Queensland Marine Park permits and GBRMPA Marine Park Permits are separate to the approval process under the SP Act and it is understood that there is no legislative trigger to seek comment from MSQ for these permits. Marine Park permits for State jurisdictions may involve works over tidal water. Any works over tidal water will also trigger an operational works permit for tidal works under the SP Act, which in turn will be referred to MSQ as a concurrence agency.

The Queensland maritime jurisdictions map is provided in **Error! Reference source ot found.**. MSQ's jurisdiction in Queensland waters are shown in light green.

Option

It could be an option for a Memorandum of Understanding (MoU) in place between GBRMPA and MSQ that address situations where GBRMPA need to consult MSQ and vice versa. Permit applications such as for facilities that may have an impact on navigation safety and installation of navigation buoys or makers for breakwaters and pipelines should be consulted with MSQ.

Australian Maritime Safety Authority

Overview

AMSA is an Australian Government statutory authority established under the *Australian Maritime Safety Authority Act 1990* (the AMSA Act). AMSA operates under the AMSA Act and as a Corporate Commonwealth Entity is also subject to the *Public Governance, Performance and Accountability Act 2013*.

AMSA will assume responsibility for services relating to domestic commercial vessels by July 2019, with a two year transition period commencing in July 2017. This includes taking over MSQ's responsibility for domestic commercial vessel, including many pontoons.

AMSA issues the following certificates:

- Certificate of Survey: shows that a vessel has been surveyed and meets the standards for construction stability and safety equipment.

- Certificate of Operation: defines how an operation is undertaken, where it is undertaken, what vessels it can use and the manning requirements for those vessels. The Certificate of Operation sets out the need for a Safety Management System.
- Certificate of Exemption: issued on specific cases, such as special events or temporary arrangements. It generally contains conditions to be met for the exemption.

The *Marine Safety (Domestic Commercial Vessel) National Law Regulation 2013* defines a pontoon as a vessel. In relation to managing facilities in the Marine Park, vessels that are used for any commercial activity may be required to obtain a Certificate of Survey and will be subjected to AMSA's requirements.

More information on the requirements for Certificate of Survey is provided on AMSA's website.

For AMSA to issue a Certificate of Survey, a marine surveyor is required to survey the vessel/pontoon. The marine surveyor has to be accredited by AMSA. Accredited marine surveyors are only able to conduct surveys in accordance with their categories of accreditation. List of accredited marine surveyors and categories are available on AMSA's website.

It should be noted that AMSA does not have an oversight of permanent structures such as jetties or marinas.

Pontoons that AMSA does not have an oversight (do not require Certificate of Survey) and permanent structures are identified as gaps between AMSA's and GBRMPA's jurisdiction. This paper recognises these gaps and cover these two aspects of the facility.

Option

Marine Parks permit could make reference to AMSA's requirements and conditions. Where relevant, GBRMPA should request for copies of valid AMSA certificates or at least have access to these through AMSA. From the consultation with AMSA, it is suggested that AMSA and GBRMPA as government agencies put measures in place for information sharing. This would allow better coordination in the regulatory context and information can be made accessible easily to maintain obligations in the Marine Park. An example is GBRMPA to have access to AMSA's database that provides information on marine survey for pontoons. This has been identified as a gap where GBRMPA do not have information on pontoons if they are classified as domestic commercial vessel or not. Information relating to pontoon registration that is no longer current and no longer subject to certificate of survey by AMSA (or exempted from Certificate of Survey) could also be communicated to GBRMPA. These pontoons fall within GBRMPA's jurisdiction and subject to the inspection regime in this paper.

Workplace Health & Safety Queensland

Overview

The WHSQ jurisdiction is limited to Queensland land and waters. WHSQ enforces Queensland State work health and safety laws, investigates workplace fatalities, serious injuries, prosecutes breaches of legislation, and educates employees and employers on their legal obligations. Under WHS legislation, business owners are obliged to provide:

- safe premises
- safe machinery and materials
- safe systems of work
- information, instruction, training and supervision
- a suitable working environment and facilities
- insurance and workers compensation for employees.

WHSQ's jurisdictions are only for workplace areas where employees conduct business activities or work as well as for public health and safety that involves dangerous goods and high risk plant among others as described in Chapter 12 of the *Work Health and Safety Regulation 2011*.

In the context of the Marine Park, WHSQ covers occupational and recreational diving and snorkelling activities. Specifically, the Work Health and Safety Regulation sets out duties for a person conducting a business or undertaking to ensure the health and safety of people who carry out general diving work and high risk diving work. The duties of the business owner include ensuring:

- divers are medically fit and are competent through qualifications and/or experience for the type of diving work being undertaken
- a dive supervisor who has the required level of competence is appointed to supervise workers carrying out general diving work
- a dive plan is prepared by the dive supervisor, and
- a dive safety log is prepared.

Additional requirements include ensuring that high-risk diving work is carried out in accordance with the AS/NZS: 2299.1.2007 *Occupational diving operations – Standard operational practice.*

Safe Work Australia, a statutory Australian Government agency is responsible to improve occupational health and safety and workers' compensation arrangements across Australia. Safe Work Australia will review the WHS Regulations for commercial and tourism diving work during 2016 and has commenced preliminary consultation with the diving industry. Public consultation on options to improve the WHS Regulations for diving work is planned for mid-2016.

Further information on diving and snorkelling laws can be obtained from Workplace Health and Safety website

Although WHSQ has broad jurisdiction over all workplaces in Queensland, they focus on construction sites which also includes demolition and both occupational and recreational diving incidents. WHSQ will attend a workplace when there is an incident, health and safety audit of a major construction site or when they receive a complaint such as unsafe practices and use of equipment that is not suitable.

WHSQ may get involved in situations where there is a potential diving safety risk if referred to. An example outside the Great Barrier Reef Marine Park is the Tangalooma shipwrecks at Moreton Bay. The wrecks were a popular dive site but were in danger of collapsing due to their deterioration. MSQ worked closely with the Queensland Parks and Wildlife Service to ensure safety for the community and the environment. WHSQ assisted MSQ in developing appropriate management plans.

Option

During consultation with WHSQ, it was suggested that as part of the permit assessment process, GBRMPA makes the facility owners aware of the requirements for high risk works as sometimes this can be neglected or the facility owners might not be aware of. High risk works are defined in the Work Health Safety Regulation Schedule 3.

There could also be opportunity for GBRMPA to seek assistance from WHSQ to formulate safety requirements with regards to managing facilities in the Marine Park.

INSPECTION CONSIDERATIONS

Inspection Reference

The suggested inspection regimes are based on the principles of the Bridge Inspection Manual developed by Department of Transport and Main Roads, DTMR (2004). Even though this manual was developed for bridge inspections, it can be used for the types of facilities addressed in this paper by applying a similar approach and intent (except for pontoons, pipes and cables that are described separately). By adopting this manual as a point of reference, it provides consistency across the inspection regime.

This manual has been widely used and referenced in Queensland by councils and private property owners for inspection of marine structures. Most engineering consultants providing inspection services are familiar with this manual. There are also specialist service providers for inspections that provide inspection services based on this manual.

The basic approach is also adopted in other states by their road authorities such as Victoria Roads (VicRoads) in Victoria and Roads and Maritime Services (RMS) in New South Wales.

Hierarchy Based Inspection Regime

Marine Structures

For the purpose of this paper, the following facilities are grouped together and called marine structures.

i. Barge ramps

ii. Jetties

iii. Walls

iv. Pipes

For these marine structures, the inspection regime suggested is based on a three-level hierarchy as follows:

i. Level 1: Routine maintenance inspection – above water inspection to check on the general serviceability of the facility

ii. Level 2: Condition inspection – above water and under water inspection to assess structural and durability issues as well as to rate the condition of the facility

iii. Level 3: Detailed engineering inspection and investigation. The specific and targeted scope is determined by the Level 2 inspection and may include detailed engineering inspection for all or part of the facility, field and laboratory testing, engineering analysis of the structure and an assessment of the condition and performance of the facility. Projected material deterioration and recommendations for management strategies.

Level 1 inspections should be carried out to inspect the facilities above water, Level 2 includes above water and under water and Level 3 is specific inspection and investigation which may be above water only, under water only or a combination.

Level 1 and Level 2 inspections are carried out periodically where Level 1 inspections are more frequent than Level 2. Level 1 inspections are not required in the same year as Level 2 or 3 inspections. As part of the reporting, a higher Level inspection can be recommended by the inspector if required.

Level 3 inspections are only planned and carried out if recommended in a Level 2 inspection. The scope of the inspection should be determined from a Level 2 inspection and this can involve detail inspection, testing and analysis of a particular area or for the overall facility.

This approach provides adequate inspection coverage with sufficient detail for the prescribed intervals. The inspectors have the option to escalate the inspection to the following level if deemed necessary to have a more detailed inspection undertaken on certain aspects.

It is recognised that carrying out routine simple inspections are easy to be organised and implemented, therefore can be carried out more frequently. Higher level inspections are planned in advance and can be relatively expensive, therefore carried out at longer intervals. Carrying out proper and systematic inspections will assist in identifying maintenance requirements earlier on and therefore reduce risks to the Marine Park in terms of risks to the environment and users.

Pontoons

The suggested inspection regime for pontoons is based on whether or not the floating component is classified as a ‘vessel’ (require AMSA Certificate of Currency). The regime also considers that the moorings are mainly under water and hence not included in an above water Level 1 inspection.

Pontoons are not fixed structures (such as a jetty) and also commonly placed far from land within the Marine Park. Therefore, the DTMR (2004) manual Level 2 and Level 3 inspection format has not been applied to pontoons, however a tailored regime is suggested based on the specific information gathered on marine surveying of vessel and inspection of moorings.

Underwater Observatories

The suggested inspection regime for underwater observatories in the Marine Park is similar as described above for marine structures. However, since these structures are mostly underwater, Level 1 inspection is not considered. Only Level 2 and Level 3 inspections are suggested for these type of structures.

Cables

The inspection regime for cables is based on the type of cables, either high voltage (includes telecommunication cables) or low voltage cables. The DTMR (2004) manual does not include cables, hence inspection scope as well as testing requirements are suggested separately for high and low voltage cables as part of this report.

As-Built Drawings

If as-built drawings are not available, the facility owner should employ a surveyor to undertake surveys and produce ‘as-built’ information. Alternatively, an inspector should undertake measurements of dimensions and details and produce relevant ‘as-built’ plans and cross-sections in a Level 1 inspection. Having these details will assist in planning and undertaking future inspections. It is essential to have as-built drawings for Level 2 and Level 3 inspections because it is required to plan the inspection scope.

Cost

It is recognized that inspections impose a cost burden on the facility owners. However the risk to the facility owner, the Marine Park and wider community associated with inadequate facility performance can be very significant.

The suggested inspection regime addresses this issue and provides balance between cost and risks to the Marine Park users and environment.

Inspector Qualifications

Inspectors generally

In developing the suggested inspection regimes, appropriate inspector qualifications were considered and suggested for the various inspection Levels. The acceptable inspector credentials were proposed based on available 3rd party training and statutory registration requirements. This also takes into account GBRMPA's preference to utilise existing systems that do not add administrative burden and liability.

Level 1 inspections are general routine inspections carried out above water to check on the general serviceability of the structure. This type of inspections are to be carried out more frequently than Level 2 and Level 3 inspections. Any aspect of the inspection that needs further detailed inspection should be raised to Level 2. Therefore, the Level 1 inspector can have lower level of qualification. In the absence of any formal qualification for marine structures inspections, it is suggested that as a minimum, DTMR Level 1 Bridge Inspector is appropriate as the inspection principles are similar for marine structures.

Level 2 inspections involve both above and under water inspections. This type of inspections are detailed inspections to assess the deterioration of the facilities and make recommendations for required maintenance or further assessment. Level 3 investigations are detailed engineering inspections and may involve testing and analysis.

Therefore, most Level 2 inspection reports (with the exception of Cables and Pontoons) need to be signed off by a RPEQ (except for pontoons and cables), however the actual inspection field work can be undertaken by an engineer or diver working under the direct supervision of the RPEQ.

Level 3 inspections shall be undertaken by suitably experienced and qualified people / laboratories subject to the approval of the RPEQ (with the exception of Cables and Pontoons with a floating component classified as a 'vessel') who will oversee and signoff the overall report. Examples of people who may be used under the supervision of the RPEQ include surveyors, laboratory technicians, material scientists and testing specialists.

Requirements for divers assisting the inspector is described on page 22. For inspection of pontoons, the pontoon structure can be undertaken by a marine surveyor and the inspection of the moorings by a mooring inspector. The requirements for these inspectors are described below on page 22.

Level 1 Bridge Inspector

There are a number of organisations that provide the required training for Level 1 Bridge Inspector that is in accordance with DTMR (2004) requirements. The DTMR Inspector Accreditation Appraisal Procedure is provided in detail in the DTMR Bridge Inspection Manual Appendix E. A number of organisations such as IPWEA, ARRB Group and Informa provide inspector training based on the requirements of this manual.

A certificate is provided to persons who obtain Level 1 Bridge Inspector accreditation.

For Level 1 inspection of marine facilities (except for cables and pontoons), it is considered that an acceptable minimum qualification is DTMR Level 1 Bridge Inspector experienced in marine structures inspections. Criteria and approvals process for this type of qualification may need to be developed by the facility owner or GBRMPA.

RPEQ

Registration as RPEQ is a formal recognition of the qualification and competency of an engineer or naval architect. An engineer or a naval architect should have formal tertiary qualifications and both can be registered as RPEQ through the BPEQ accreditation process.

It should be noted that all RPEQs are bound by the RPEQ Code of Conduct and need to be registered in the appropriate areas of engineering recognised by the BPEQ. *The Professional Engineers Act (2002)* stipulates that a RPEQ must not carry out professional engineering services in an area of engineering other than an area of engineering for which the RPEQ is registered. Therefore, the inspections of the facilities and formal signoff by the RPEQ should be appropriate for the registered areas of engineering. The RPEQ must have sufficient knowledge, oversee and evaluate the carrying out of the service, have sufficient control over any outputs and takes full responsibility of the outputs as stipulated in the Code of Practice for Registered Professional Engineers.

More information on the RPEQ system can be obtained from the Engineers Australia Website.

Field work for inspections can be undertaken by an engineer who is working under the direct supervision of a RPEQ.

Naval Architect

A Naval Architect is a person with a degree and chartered status in the design, construction, maintenance and operation of marine vessels and floating structures. Chartership is recognised by Royal Institution of Naval Architects (RINA) Queensland Section. Two key components of naval architecture is:

- Stability assessment/design of a vessel or floating structure.
- Structural engineering assessment/design of a vessel or floating structure

Note that structural/civil/marine engineering assessment/design of any structures other than floating (including moorings) generally falls outside the competencies of a naval architect (unless that person has additional qualification as per below).

The role of naval architect and engineer was discussed with RINA. Some naval architects may also have an engineering degree and civil/structural RPEQ certification (and vice versa), but this is not always the case.

Level 1 and Level 2 inspections of floating components of pontoons can be carried out by an accredited marine surveyor (as a minimum).

For a Level 3 inspection and investigation (which is more focussed and may require analysis), a chartered naval architect is required for floating components classified as 'vessel' whereas for floating components not classified as 'vessel' an RPEQ with pontoon experience is also considered a suitable qualification.

Divers

Divers assisting the inspectors should be occupational divers and have appropriate qualifications and competencies according to WHSQ's requirements. There are two types of occupational diving: general diving and high risk diving.

For typical diving works required for underwater inspections, it can be considered as high risk diving. General diving and high risk diving are further described on the Worksafe website.

WHSQ has stipulated the required qualification and competency for diving works, they are described on the Worksafe website.

For examples of competencies for diving work are provided in, you can view this on the Worksafe website under the qualifications and competency section.

Divers and dive supervisors inspecting facilities should hold valid ADAS license or equivalent.

Marine Surveyor

Inspections of pontoons can be undertaken by an accredited marine surveyor in accordance with their categories of accreditation. List of accredited marine surveyors can be found on AMSA's website: https://www.amsa.gov.au/domestic/vessels-operations-surveys/certificates-of-survey/attested-marine-surveyors/

Mooring Inspector

For inspections of mooring systems in the Marine Park, GBRMPA have the following definition:

Appropriately experienced person means a person who holds appropriate public indemnity insurance and meets one or more of the following criteria:

a. a Registered Professional Engineer of Queensland; or
b. a moorings contractor with relevant experience in the installation and maintenance of moorings; or
c. complies with the Occupational Diving Work Code of Practice 2005, as amended from time to time, (relating to Divemaster (PADI) or Dive Controller (SSI) qualifications or higher) and approved by the managing agencies as having demonstrated competencies in mooring maintenance, or
d. approved by the managing agencies as having demonstrated competencies in mooring maintenance. This last criterion would only apply to low-risk private moorings (generally non-commercial).

The permittees can select any one of the above to undertake inspections of mooring system, however for the third option, the nominated individual must first be approved by GBRMPA as being recognised as an 'appropriately qualified person'.

In the context of this paper, mooring systems are referred to moorings for a pontoon facility. Buoy moorings are not covered in this paper.

Inspection Reporting

The inspection report format should be flexible and modified to the inspection intent, inspections are often carried out using bespoke inspection software and hand held data loggers. Reports can be generated on-site and submitted instantly upon completion of the inspections. The DTMR (2004) reporting format is paper based, but with the change in technology, other forms of reporting should be allowed.

Inspections After a Significant Event

Due to the Great Barrier Reef Marine Park's location, size and marine environment there is a risk of a number of occurrence of significant events impacting facilities.
A significant event can be considered as an event, which impacts a facility negatively in a short timeframe rather than deterioration of a facility over time (due to wear and tear). A facility can become non-operational and/or unsafe following a significant event.

GBRMPA facility permits include a definition of a 'significant event' and requirements for notification or inspection after a significant event. The definition currently includes events such as cyclones, vessel collisions, aircraft incidents and unplanned discharge of waste. GBRMPA can consider updating the definition to include other possible causes of damage to facilities, such as earthquake, fire, tsunami, or reportable incident under workplace health and safety laws.

As a minimum, Level 1 inspection (Level 2 for underwater observatories) should be carried out after a significant event prior to resuming operations.

There could be risks such as contamination of the environment from a damaged pipeline, hazard to public from a damaged jetty structure or hazard to navigation from debris. The inspector can suggest a Level 2 inspection if required based on findings of a Level 1 inspection.

If a Level 1 inspection is not practical nor possible and the facility is required to be operational during an emergency situation immediately after the significant event, a risk assessment should be carried out on case by case basis by the relevant authority responding to the significant event in association with the facility owner. In such cases, a full level 1 inspection should still be carried out as soon as possible, or no later than within one month after the event.

BARGE RAMPS

Overview

Barge ramp structures (and similarly boat ramp structures) are constructed in intertidal areas to provide access to land from the sea and vice versa at various tidal Levels. Depending on the site, often the barge ramp is accessible via a dredged channel that usually have navigation aids.

The ramp structure is usually a concrete slab with rock shoulder and toe. Some barge ramps have berthing piles to assist vessel berthing. Barge ramp structures are generally designed to have a 50 year design life. An example of a barge ramp is shown in figure 1. As of 27 November 2015, there were nine barge ramps permitted within the Marine Park.

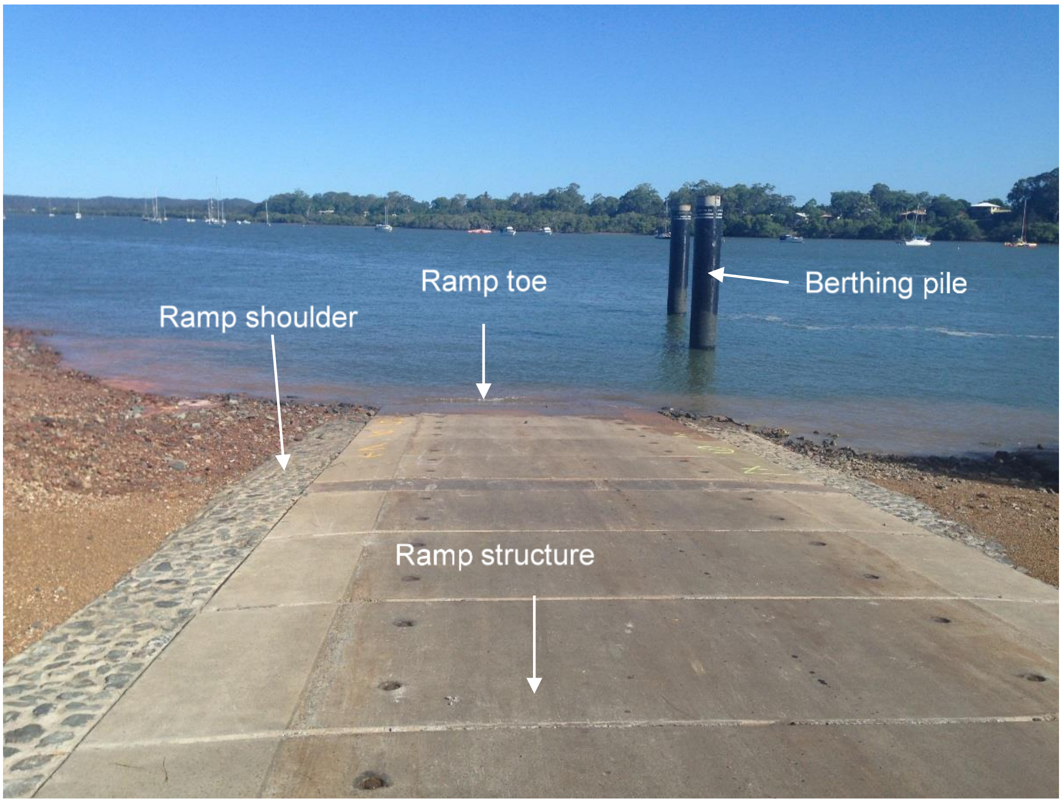


Figure 1. Barge Ramp

Facility Inspection Regimes

Discussion

The most common deterioration of a barge ramp is damage of the concrete ramp structure itself and scour around the barge ramp. The concrete ramp is subject to wear and tear from being in contact with the vessels' ramp door when the vessel docks. Scour at the toe and around the ramp shoulders could result in loss of fill under the ramp. These issues could cause the barge ramp structure to deteriorate and fail over time if not properly inspected and maintained. The damaged structure could be a hazard to public safety if continue to be used. A damaged structure could also be littered around and impact on the environment.

The inspection regime for Level 1 and Level 2 considers the age of the barge ramp. More frequent inspections are required with increased age of the barge ramp to assess deteriorations and any requirements for early maintenance interventions. Level 1 inspections are not required in the same year as Level 2 or 3 inspections.

Level 2 inspections identify structural and durability issues of the barge ramp structure and reports on the overall condition of the structure. In this inspection, a Level 3 inspection should be recommended if required on case by case basis to investigate and respond to specific issues, such as allowable loadings on the ramp based on the current state of the ramp structure.

Level 3 inspections are more comprehensive and involves detailed structural engineering inspections. Level 3 inspections are not only in the form of visual inspections but also may require on-site field work and testing, obtaining samples and laboratory testing. Therefore, Level 3 inspection is only undertaken when recommended by the inspector from a Level 2 inspection.

Field Work

Barge ramp structures can be inspected from above water and inspections should be planned to work within tidal windows. To maximise visibility, inspections should be planned to have adequate time on site during spring low tides.

The use of divers are not envisaged for frequent inspections. The ramp structure is usually in shallow water and can possibly be seen through from the surface or with the aid of an underwater inspection equipment. It is costly to use divers for a relatively small part of structure. Underwater camera that can be lowered below the water surface from a boat can be used for inspections of the ramp toe and berthing piles if required. Alternatively, at shallow water, snorkelling can be carried out for inspections.

Possible Inspection Regime

Level 1: Routine Maintenance Inspection

Level 1 inspection is a routine maintenance inspection and should be carried out visually to observe deterioration, hazards and risks. Table 5 provides Level 1 inspection requirements.

If as-built drawings are not available, the inspector should undertake necessary measurements of dimensions and details and produce relevant plans and cross-sections. Having these details will assist in planning and undertaking future inspections. The following information should be produced:

i. Ramp width, length and slope

ii. Ramp structural details including using cover meter or rebar locator to detect reinforcement

iii. Ramp shoulder and toe details

iv. Details of berthing piles including material, wall thickness and diameter

Table 5. Barge Ramp Level 1 Inspection Suggestions

Scope	i. Above water visual inspection of barge ramp structure at low tide comprising ramp structure, ramp shoulder, toe and berthing piles to observe deterioration ii. Specific considerations for scour/undermining, discontinuity at joints, and surface damage iii. General inspection for hazards to the barge ramp operations if any iv. General inspection for potential risk to the environment if any v. Note any maintenance requirements vi. Note and recommend any specific requirements for the next inspection cycle vii. Provide advice if the barge ramp need to be closed in the interim if required viii. Recommend Level 2 inspection if required based on observation or unusual behaviour of the structure ix. Inspection and reporting as per DTMR (2004) principles modified for barge ramp structure. Reporting format depends on inspection technology used. x. Undertake measurements and produce as-built drawings if as-built drawings are not available.
Maximum inspection interval	i. New to 18 years old: every 2 years ii. Beyond 18 years old: every 1 year iii. After any significant event
Acceptable inspector credentials	i. Level 1 Bridge Inspector experienced in marine structures inspection.

Level 2: Condition Inspection

Level 2 inspection is more detailed than Level 1 and carried out visually above and below water to inspect the condition of the barge ramp. Table 6 provides Level 2 inspection requirements.

Table 6. Barge Ramp Level 2 Inspection Requirements

Scope	i. Level 1 inspection scope items ii. Above water visual inspection of ramp structure (including measurement of crack widths) and ramp shoulder to observe deterioration. iii. Above water inspection of ramp toe and berthing piles. iv. Underwater inspection of ramp toe and berthing piles if recommended by Level 1 inspection or if potential issues are raised during above water inspection. v. Identify structural and durability issues of the facility vi. General inspection for hazards to the barge ramp operations if any vii. General inspection for potential risk to the environment if any viii. Assessment and reporting the condition of the structure and determine a condition rating of the structure based on DTMR (2004) section 3.8.3. ix. Identify maintenance requirements, including specifying immediate (<3 months), medium term (<6 months) and longer term/ongoing (>6 months) timeframes x. Note and recommend any specific requirements for the next inspection cycle xi. Provide advice if the barge ramp needs to be closed in the interim with reasons and recommended steps to rectify the deficiencies (what needs to be fixed before it re-opens) xii. Recommend Level 3 inspection if required clearly identifying the scope and purpose xiii. Inspection and reporting as per DTMR (2004) principles modified for barge ramp structure. Reporting format depends on inspection technology used.
Maximum inspection interval	i. New to 18 years old: every 6 years ii. Beyond 18 years old: every 3 years iii. When recommended in Level 1 inspection
Acceptable inspector credentials	RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine structures inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to sign off inspection reports.

Level 3: Detailed Engineering Inspection and Investigation

Level 3 inspection and investigation require as-built drawings to provide information and details of the jetty structure. This inspection may include undertaking measurements, testing and analyses to respond to specific issues raised in the Level 2 inspection. Table 7 provides Level 3 inspection requirements.

Table 7. Barge Ramp Level 3 Inspection Requirements

Scope		To be determined in Level 2 inspection, may include
	i.	Review of any previous inspection and testing reports
	ii.	Detailed inspection including measurements, testing and analyses to supplement visual inspection to better understand a Level 2 inspection
	iii.	Determination of material properties and structural behaviour
	iv.	Identification of components which are limiting the performance of the structure due to their current condition and capacity
	v.	Identify the probable causes and projected rate of deterioration and the effects of continued deterioration on the performance, durability and expected remaining life of the structure
	vi.	Recommendations of management actions and/or maintenance/rehabilitation options
	vii.	Inspection and reporting as per DTMR (2004) principles modified for barge ramp structure. Reporting format depends on inspection technology used.
Maximum inspection interval	i.	When recommended in Level 2 inspection
Acceptable inspector credentials		RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine engineering inspections. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

The inspection regime is summarised in a flow diagram shown in Figure 2.

Level 1

Scope: Routine maintenance inspection

Frequency:

Barge Ramp Life	Maximum Inspection Interval
New to 18 years	2 years
Beyond 18 years	1 year

By: Level 1 Bridge Inspector experienced in marine structures inspection.

When recommended in Level 1 inspection and to the Level 2 frequency

Carry out actions as required

Level 2

Scope: Condition inspection

Frequency:

Barge Ramp Life	Maximum Inspection Interval
New to 18 years	6 years
Beyond 18 years	3 years

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine structures inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

When recommended in Level 2 inspection

Carry out actions as required

Level 3

Scope: Detailed structural engineering inspection and investigation

Frequency: When recommended in a Level 2 inspection.

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine engineering inspections. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

Carry out actions as required

Figure 2. Inspection Regime for Barge Ramps

Risk Considerations

Risk considerations and discussions relating to barge ramp inspection are provided in Table 8.

Table 8. Inspection Regime Risk Considerations for Barge Ramps

No.	Category	Description	Discussion
1	Inspection scope and reporting.	Inadequate inspection scope and reporting. Varying standards of reporting.	Inspections and reporting as per DTMR (2004) intent. Reporting format to be flexible with technology used.
2	Underwater inspections.	Barge ramp structures are constructed in intertidal areas and subject to daily wetting and drying. The toe of the structure is generally in shallow water, around 0.5m to 1.0m below low water Level, depending on design requirements and allows shallow draft barges to access the barge ramp. As such, the entire length of the barge ramp may not be visible during low tide, the lower portion may be continuously submerged preventing visual observation.	It is not anticipated that divers will be engaged for Level 1 inspections of structures in less than 2m water depth. However, most of the barge ramp structure will be visible during spring low tides and will provide a good indication of the overall condition of the barge ramp. Underwater inspections to be undertaken for Level 2 inspections if required. Simple devices can be used for shallow water with good visibility.
3	Safety to users.	Not carrying out inspection and identifying required maintenance increases the risk to the barge ramp users, for example damage to the vessel doors or underkeel when berthing or damage to the barge ramp structure.	Inspection regime that covers appropriate time intervals to observe damage and deterioration early. Level 1 and Level 2 inspections to note any potential hazard, and maintenance requirements.
4	Damage to environment.	Lack of inspection and maintenance cause deterioration and eventually damage of the structures. Damaged structures displaced along the shoreline and at sensitive areas.	Inspection regime that covers appropriate time intervals to observe damage and deterioration early. Level 1 inspection to note any potential risk to environment and maintenance requirements.
5	Maintenance and repair cost.	Barge ramps that are not adequately inspected are at risk of having required interventions identified too late which can be costly to repair or maintain.	Early signs of deterioration or issues can be observed and monitored through the Level 1 and Level 2 inspection cycles.
6	Safety of personnel.	The location of barge ramps can be remote in the Marine Park.	Site specific safety plans need to be developed for inspections. Inspections carried out in pairs.
7	Inspections cost	Inspections can be costly and can be a huge burden to the owners.	Inspection regime of varying degree of details. Level 1 and Level 2 inspections are to be staggered. This alternating approach provides value without increasing cost burden to the barge ramp owners.

Decommissioning and Removal

The decommissioning and removal of barge ramps depend on a number of factors. Table 9 provides discussion on a number of considerations for barge ramp removal.

Table 9. Barge Ramp Removal Considerations

No.	Considerations	Description	Options
1	Design life	Barge ramp nearing design life and requires extension.	Extend design life with maintenance or reconstruction.
		Barge ramp nearing design life and do not require extension.	Consider items below.
2	Erosion issue and impact on coastal processes	Barge ramp structures are typically constructed perpendicular to the shoreline and usually interrupt the natural coastal processes.	Structure to be removed or partially removed with considerations of impact on shoreline and surrounding area. Berthing piles extracted and removed, if not possible cut 1m below sea bed and removed.
3	Materials	Barge ramp structures are generally concrete structures with steel berthing piles. These material are typically used in the marine environment and do not cause on-going harm to the environment, however when it deteriorates and become damaged over time, it will litter and accumulate in the Marine Park.	Structure to be removed. Berthing piles extracted and removed, if not possible cut 1m below sea bed and removed.
4	Direct potential environmental impact	The direct potential environmental impact of barge ramp is considered low. However, marine growth impede inspections and increase loads on the berthing piles that potentially exceed the design criteria.	Structure to be removed. Berthing piles extracted and removed, if not possible cut 1m below sea bed and removed.
5	Potential hazard to users	Barge ramp structure extending into the waterways could cause navigation hazard to boat users particularly at night. Damaged concrete structure broken into chunks could be moved around and create hazards to navigation in the area.	Structure to be removed or partially removed. Berthing piles extracted and removed, if not possible cut 1m below sea bed and removed.
6	Proposed adjacent causeway	Proposed construction of a new barge ramp adjacent to replace old structure interrupts in coastal processes and cause further erosion. Removal may also impact adjacent structures and natural environment.	Structure to be removed with considerations of impact on surrounding environment. Berthing piles extracted and removed, if not possible cut 1m below sea bed and removed.

No.	Considerations	Description	Options
7	On-going inspection cost	On-going inspection cost can be considered costly for disused or abandoned facility. Inspection cost does not justify leaving in place disused facility. There is also risk that inspection is not carried out.	Structure to be removed. Berthing piles extracted and removed, if not possible cut 1m below sea bed and removed.
8	On-going maintenance cost	On-going 5-10 yearly maintenance can be costly in the order of $3,000 to $5,000 per m length depending on the design and requirements. Major maintenance may be required following a cyclone event to make the structure safe. Maintenance cost does not justify leaving in place a disused facility.	Structure to be removed. Berthing piles extracted and removed, if not possible cut 1m below sea bed and removed.

In summary, it is proposed that barge ramp structures to be removed and the area made good to suit the natural profile of the coastline at the end of design life or end of operation. Disused structures in the Marine Park are unsightly and may be a hazard to the environment and users. However, the removal decision should also consider impacts on shoreline and surrounding environment. Berthing piles to be extracted from the sea bed and removed. Piles that cannot be completely extracted are to be cut minimum 1m below sea bed and removed from site.

PONTOONS

Overview

A Pontoon is a floating structure with moorings. The floating structure component does not have its own independent means of propulsion. Pontoons are considered 'fixed facilities' when they are moored in a single location. Pontoons are normally moored with concrete anchor blocks with chains attached, but may also be moored with guide piles.

For the purposes of this paper a pontoon or pontoon structure is defined as a facility that consists of two components: a floating component (which provides a platform) and a mooring.

Within the Marine Park, pontoons are mostly used for passenger transfer or landing, helicopter landing and vessel operations. Pontoon structures are generally designed to have 25 to 50 years operational life.

There were 59 pontoons permitted within the Marine Park as of 27 November 2015. Most of these are smaller facilities, with nine (9) large multi-purpose tourist pontoons having lengths in excess of 20m. An example of a pontoon is shown in figure 3.

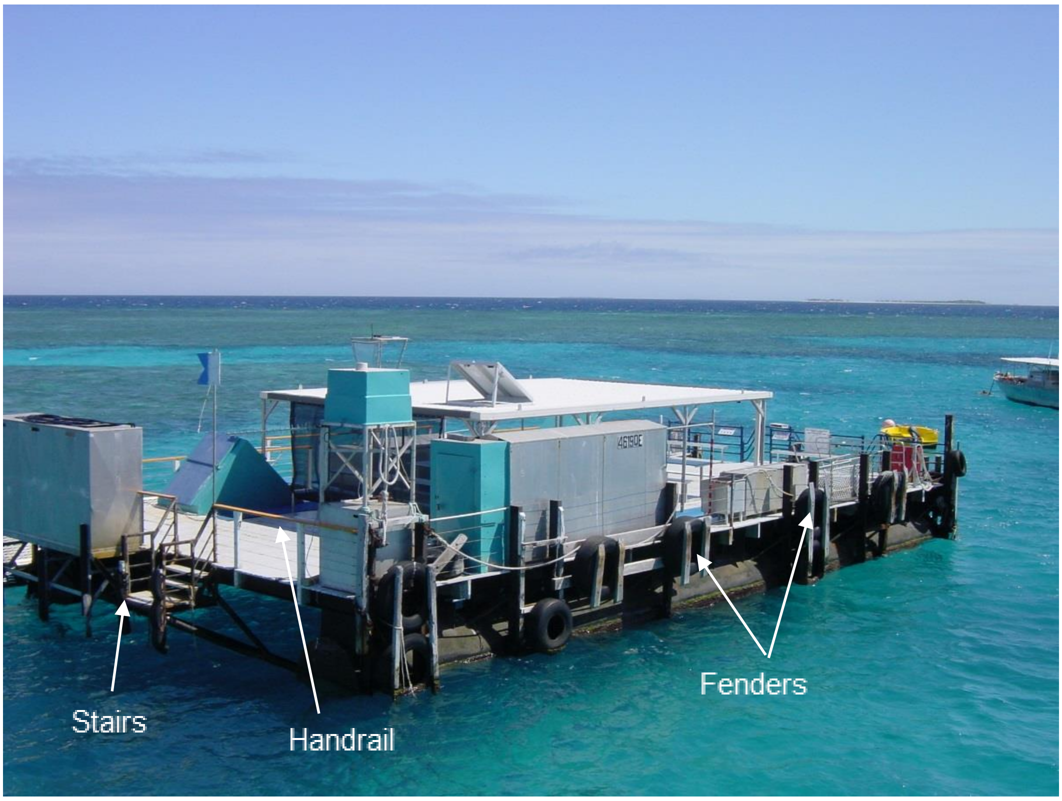


Figure 3. Pontoon (*source GBRMPA*)

Facility Inspection Regimes

Discussion

In consultation with RINA and AMSA, it became apparent that some pontoon floating components are classified as a domestic commercial 'vessel' and therefore require Certificate of Survey from AMSA, in addition to any GBRMPA requirements. A marine surveyor is required to undertake inspection (marine survey) of the pontoon floating component and issue Certificate of Survey as required by AMSA.

<u>More information are provided on AMSA's website.</u>

This paper describes the inspection regime for:

i. Pontoon floating components that are not subject to AMSA's requirements (do not require Certificate of Survey).

   <u>Refer to AMSA's website for more details:</u>

ii. Mooring structures that the pontoon floating components are attached to such as anchors, chains, guide piles, pile collars and gangways.

<u>Pontoons with floating component classified as 'vessel':</u>

For pontoon floating components that require Certificate of Survey, the pontoon mooring systems (such as anchors, chains and piles) are suggested to require inspection for GBRMPA's purposes. For pontoon floating components that do not require a Certificate of Survey, a variety of fixings such as handrails, ladders, timber fenders and concrete deck also need to be inspected, refer to figure 3.

Pontoon floating components that are deemed to require Certificate of Survey by AMSA have to follow AMSA's inspection requirements where an accredited marine surveyor is required to undertake the pontoon floating component inspection / survey. A marine survey is undertaken to assess against the standards it was designed to for construction stability and safety requirements.

In addition to the Certificate of Survey, AMSA also issue a Certificate of Operation and a Certificate of Exemption. These certificates are described on Page 15:

To avoid duplication and overlap of inspection by marine surveyors and RPEQs, the AMPTO inspection regime suggests that pontoons, which have received AMSA Certification of Survey of the floating components only require inspection of the pontoon mooring system, such as the anchors and/or piles.

<u>Pontoons with floating component not classified as 'vessel':</u>

Pontoon floating components that have not received AMSA Certification of Survey, should have both the mooring system and the pontoon floating component inspected.

The most common deterioration of a pontoon is wear and tear at connections to their moorings due to frequent movements from tidal and wave actions. Loss of buoyancy is also another common issue when the pontoon hull is not water tight. This could be due to corrosion of steel plates for steel hull pontoon floating components.

During a cyclone event or in certain weather conditions, pontoon floating components may be dismantled from the moorings and towed to a cyclone haven area or placed on a 'swing mooring' for temporary relocation. After such event, a Level 1 inspection is suggested to assess the mooring structures and to ensure the pontoon is correctly reattached.

Field Work

Pontoon floating component inspections should be carried out around the structure using a boat to view the sides and from the deck for other structures attached to it. Inspection of the floating component can be carried out independent of the tides as the structure floats on the water surface.

Divers or remotely operated vehicles (ROVs) can be used for inspection of the floating component hull under water and the mooring system.

Possible Inspection Regime

Level 1: Routine Maintenance Inspection

The inspection is carried out visually to inspect the structures above water. Table 10 provides Level 1 inspection requirements.

a) Pontoon floating component & Mooring System Inspections

If as-built drawings are not available, the inspector should undertake necessary measurements of dimensions and details such as:

i. Pontoon floating component width and length

ii. Details of pontoon furniture such as fenders, bollards and access ladders

iii. Structural details depending on the type and material of pontoon floating component

iv. Pontoon connection details to piles/moorings

v. Pile details including material, wall thickness, diameter and top level

vi. Anchor and chain details if possible

vii. Gangway dimensions and details

b) Mooring System Only Inspections

i. Pontoon connection details to piles/moorings

ii. Pile details including material, wall thickness, diameter and top level

iii. Anchor and chain details if possible

Plans and cross-section drawings should be prepared for each of the above inspection types. A photographic record of the pontoon may assist in the interpretation of the drawings. Having these details will assist in planning and undertaking future inspections.

Table 10. Pontoon Level 1 Inspection Requirements

Scope	i.	Above water visual inspection of pontoon structure including piles, pile collars, gangways and mooring connection points on-site to observe deterioration.
	i.	Measure freeboard at each corner
	ii.	General inspection for hazards to the pontoon operations if any
	iii.	General inspection for potential risk to the environment if any
	iv.	Note any maintenance requirements
	v.	Note and recommend any specific requirements for the next inspection cycle
	vi.	Provide advice if the pontoon need to be closed in the interim if required
	vii.	Recommend Level 2 inspection if required based on observation or unusual behaviour of the pontoon
	viii.	Reporting format depends on inspection technology used.
	ix.	Reporting by a marine surveyor
Maximum inspection interval	i.	New to 16 years old: every 2 years
	ii.	Beyond 16 years old: every 1 year
Acceptable inspector credentials	i.	Accredited marine surveyor

Level 2: Condition Inspection

Level 2 inspections are carried out visually above and below water to inspect the structures present on site to observe deterioration. Table 11 provides Level 2 inspection requirements.

Table 11. Pontoon Level 2 Inspection Requirements

Scope	i. Level 1 inspection scope items ii. Underwater inspection of floating component hulls, piles, anchors and chains on-site. iii. Cleaning may be required to remove sections of marine growth on piles, hulls, chains and other components to allow for regular inspection. iv. Identify structural and durability issues of the pontoon floating component and mooring structures v. Assessment and reporting the condition of the structure and determine a condition rating of the structure. vi. Identify maintenance requirements vii. Note and recommend any specific requirements for the next inspection cycle viii. Provide advice if the pontoon needs to be closed in the interim if required ix. Recommend Level 3 inspection if required clearly identifying the scope and purpose x. Reporting format depends on inspection technology used. xi. Reporting by marine surveyor - For pontoon floating component xii. Reporting by a GBRMPA *Appropriately experienced person* - For moorings
Maximum inspection interval	i. New to 16 years old: every 4 years ii. Beyond 16 years old: every 2 years iii. When recommended in Level 1 inspection
Acceptable inspector credentials	i. For pontoon floating component: Accredited marine surveyor ii. For moorings: GBRMPA *Appropriately experienced person* iii. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector.

Level 3: Detailed Engineering Inspection and Investigation

This inspection may include undertaking measurements, testing and analyses.

Level 3 inspections can be carried out on-site or out of water at a suitable maintenance and repair facility.

Level 3 inspections are more detailed inspections/investigations, testing and analysis to respond to specific issues raised in the Level 2 inspection. Table 12 provides Level 3 inspection requirements.

Table 12. Pontoon Level 3 Inspection Requirements

Scope		To be determined in Level 2 inspection, may include:
	i.	Review of any previous inspection and testing reports
	ii.	Detailed inspection including measurements, testing and analyses to supplement visual inspection to better understand a Level 2 inspection
	iii.	Determination of material properties and structural behaviour
	iv.	Identification of components which are limiting the performance of the structure due to their current condition and capacity
	v.	Identify the probable causes and projected rate of deterioration and the effects of continued deterioration on the performance, durability and expected remaining life of the structure
	vi.	Recommendations of management actions and/or maintenance/rehabilitation options
	vii.	Reporting format depends on inspection technology used.
	viii.	Reporting by Chartered Naval Architect or RPEQ - For pontoon floating component
	ix.	Reporting by RPEQ - For moorings
Maximum inspection interval	i.	When recommended in Level 2 inspection
Acceptable inspector credentials	i.	For pontoons: Chartered Naval Architect or RPEQ with experience in pontoon structures
	ii.	For moorings: RPEQ with experience in pontoon structures
	iii.	Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

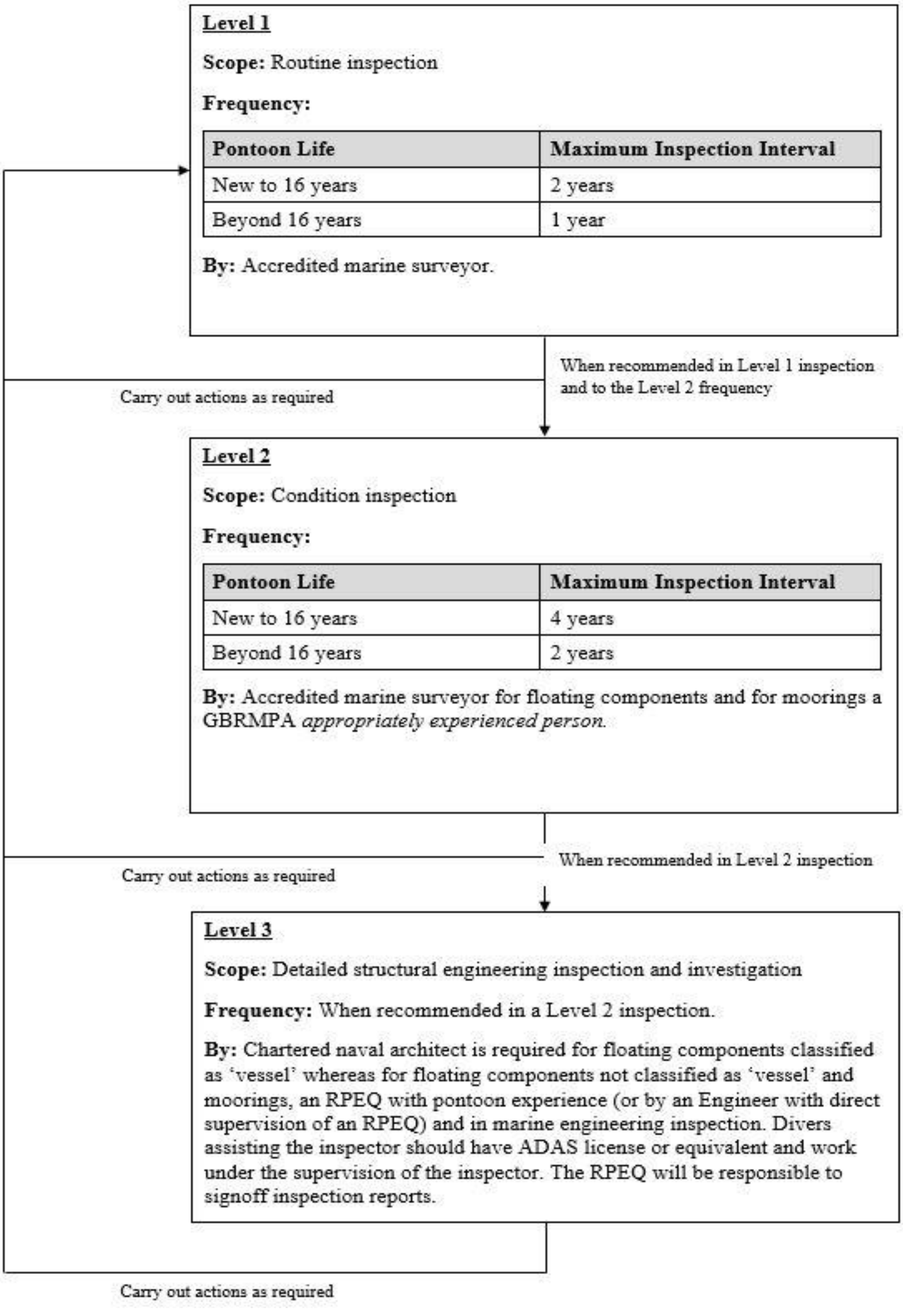


Figure 4. Inspection Regime for Pontoons and Associated Structures

Risk Considerations

Risk considerations and discussions relating to pontoon and associated structures inspection are provided in table 13.

Table 13. Inspection Regime Risk Considerations for Pontoons

No.	Category	Description	Discussion
1	Inspection scope and reporting	Inadequate inspection scope and reporting. Varying standards of reporting.	Reporting format to be flexible with technology used.
2	Underwater inspections	Underwater inspection scope. It may not be practical to inspect the entire hull depending on the size of the pontoon and marine growth.	Underwater inspections should be planned to inspect all piles, anchors and chains that the pontoons are attached to. Pile cleaning may be required to remove sections of marine growth. Underwater inspections of the pontoons should include the hull with removing small sections of marine growth.
3	Safety to users	Not carrying out inspection and identifying required maintenance increases the risk to the pontoon users, for example damage to the pontoon may cause floatation instability such as listing. A pontoon floating component that is not properly inspected and maintained could cause safety issues for the users such as people falling into the water if the floating component is lifting.	Level 2 inspection to include underwater dive inspection.
4	Safety hazard to navigation	Lack of inspection and maintenance cause deterioration and eventually damage of the structures. The attachments to secure the pontoons in place if not properly inspected and maintained could be damaged overtime or during a storm and cause the pontoon to detach and drift. This would be a hazard to navigation and environment.	Inspections to include pontoon attachments. Level 2 inspections to include underwater inspection of anchors and chains.
5	Damage to environment	Lack of inspection and maintenance cause deterioration and eventually damage of the structures. The attachments to secure the floating component in place if not properly inspected and maintained could be damaged overtime or during a storm and cause the pontoon to detach and drift. This would be a hazard to the environment (damage coral reef, seagrass, etc.).	Inspections to include pontoon attachments. Level 2 inspections to include underwater inspection of anchors and chains.
6	Maintenance and repair	Pontoons that are not adequately inspected are at risk	Early signs of deterioration or issue can be observed and

No.	Category	Description	Discussion
	cost	of having required interventions identified too late which can be costly to repair or maintain.	monitored through the Level 1 and Level 2 inspection cycles.
7	Safety of personnel	The location of pontoons can be remote in the Marine Park.	Site specific safety plans need to be developed for inspections. Inspections carried out in pairs.
8	Inspections cost	Inspections can be costly and can be a huge burden to the owners.	Level 1 and Level 2 inspections are to be staggered. This alternating approach provides value without increasing cost burden to the pontoon owners.

Decommissioning and Removal

The decommissioning and removal of pontoons depend on a number of factors. Table 14 provide discussions for pontoon removal considerations.

Table 14. Pontoon Removal Considerations

No.	Considerations	Description	Options
1	Design life	Pontoon nearing design life and requires extension.	Extend design life with maintenance or replacement.
		Pontoon nearing design life and do not require extension.	Consider items below.
2	Erosion issue and impact on coastal processes	Pontoon floating component and the mooring structures do not unreasonably interrupt with the natural coastal processes.	Structure left in place or removed.
3	Materials	Pontoon floating structures could be either made of concrete, steel, PVC or fibreglass. These material are typically used in the marine environment and do not cause on-going harm to the environment. Pontoon attachments such as furnishing, wiring, glass and plumbing could litter and accumulate in the Marine Park. Coral may grow on concrete anchor blocks, however the concrete block can shift and be a hazard during cyclones, risking damage to the reef and hazard to navigation.	Structure to be removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed. Concrete block anchors and chains removed.
4	Direct potential environmental impact	The direct potential environmental impact of a pontoon is considered low. However, marine growth impede inspections and increase loads on the structure that potentially exceed the design criteria.	Structure to be removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed.
5	Potential hazard to users	Disused pontoon structure could cause navigation hazard to boat users particularly at night. The disused structure may not be in an operational condition, there is risk that it may still be used. The attachments to secure the pontoons in place could be damaged overtime or during a storm and cause the pontoon to detach and drift. This would be a hazard to navigation.	Structure to be removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed. Concrete block anchors and chains removed.
6	On-going inspection cost	On-going inspection cost can be considered costly for disused or abandoned facility. Inspection cost does not justify leaving in place disused facility.	Structure to be removed. Piles extracted and removed, if not possible cut 1m below

No.	Considerations	Description	Options
		There is also risk that inspection is not carried out.	sea bed and removed.
7	On-going maintenance cost	On-going 5-10 yearly maintenance can be costly in the order of $10,000 to $50,000 depending on the design and requirements. Major repair may be required following a cyclone event. There is also risk that maintenance is not carried out. Maintenance cost does not justify leaving in place disused facility.	Structure to be removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed.

In summary, it is proposed that pontoon structures (incl. the associated mooring fixings) are to be removed at the end of design life or end of operation. Disused structures in the Marine Park are unsightly and may be a hazard to the environment and users. Piles to be extracted from the sea bed and removed. Piles that cannot be completely extracted are to be cut minimum 1m below sea bed and removed from site. All anchors and chains should be removed from site.

Design Criteria for Tourist Pontoons

Overview

The GBRMPA (2010) Structures Policy was reviewed in particular table 2 of the policy (provided below in table 15). The aim was to review the design criteria for tourist pontoons, detail any inadequacies and to provide suggestion of any revised design criteria that should be considered. The design criteria is referring to the design return period for the required design life and encounter probability.

Table 15. Design Encounter Probabilities and Return Periods for Pontoon Structures in the Marine Park (*source: Table 2 from GBRMPA (2010))*

Category	Description	P_E	L (yr)	Nominal R (yr)
1. Small (< 15 m)	e.g. – helicopter pontoon	0.10	10	100
2. Medium (< 40 m)	usually single story no overnight staff	0.10	20	200
3. Large (> 40 m)	often multi-story overnight caretakers	0.10	30	300
4. Overnight Visitors	any size less than about 20 overnight visitors	0.05	30	600
5. Floating Hotel multi-story	more than about 20 overnight visitors	0.05	50	1000

Marine structures including pontoons are subject to a number of metocean conditions, including wave, current, tides, storm surge and raising sea level. The design parameters vary from site to site. Depending on the design life, metocean loads are applied considering appropriate risk levels for the facility type. The risk levels are determined based on the frequency of occurrence of a certain return period in the design life.

Design criteria in the context of this paper is referring to the metocean return period to be considered for the design of pontoons and associated moorings such as piles and anchors.

It shall be noted that design criteria is referring to extreme events and excludes operational requirements such as human comfort and personal safety for design of the pontoon structure itself. Operational requirements normally considers lower return periods with the assumption that the pontoon will not be in operation during the extreme events.

Encounter Probability

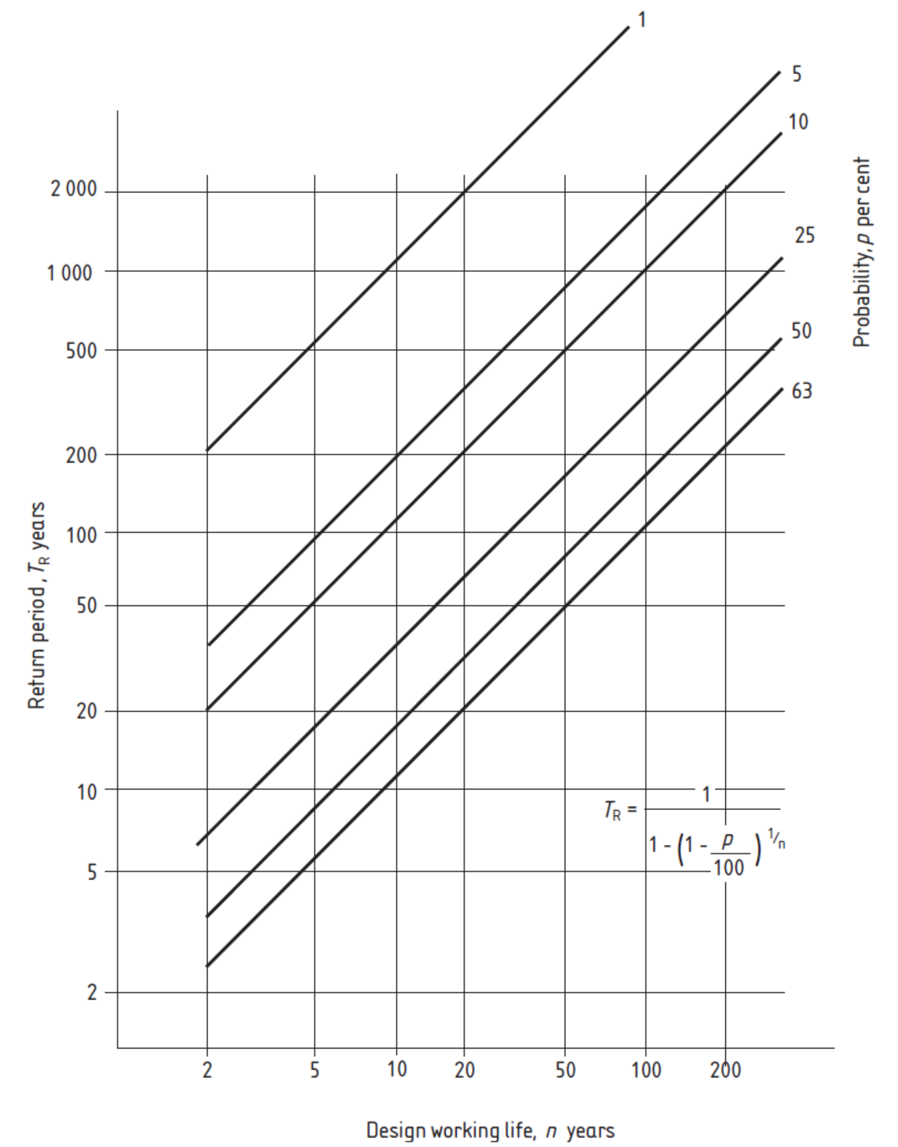
The frequency of recurrence of a meteorological event is often specified by its return period, T_R. The relationships between design working life, return period and the probability of meteorological event exceeding the norm (risk of event occurrence during the lifetime of a structure) are shown in table 16 based on The Rock Manual, CIRIA C683 (2007).

For example, a 50 year design life pontoon has approximately 64 per cent chance of being exposed to or exceeds a 1 in 50 year meteorological event and approximately 39 per cent chance for a 1 in 100 year meteorological event.

The information in table 16 can be represented in a graphical form as shown in figure 5.

Table 16. Event Probability during the Lifetime of a Structure for Various Return Periods (source: *CIRIA C683 (2007)*)

Design Life (years)	Event probability (per cent) for various return periods (years)								
	5	**10**	**20**	**30**	**50**	**100**	**200**	**500**	**1000**
5	67	41	23	16	10	5	2	1	<1
10	89	65	40	29	18	10	5	2	1
20	99	88	64	49	33	18	10	4	2
30	>99	96	78	64	45	26	14	6	3
50	>99	99	92	82	64	39	22	9	4
100	>99	>99	99	97	87	63	39	18	10



NOTE T_R is the return period of a particular extreme wave condition in years. p is the probability of a particular extreme wave condition occurring during design working life n years.

Figure 5. Relationship between Design Working Life, Return Period and Probability of Wave Heights Exceeding the Normal Average, (*source: BS6349-1, (2000)*)

The AS 4997 (2005) provides guidance for return period or annual probability of exceedance of design wave events based on function category and design working life, this is shown in table 17.

Table 17. Annual Probability of Exceedance of Design Wave Events (*source: AS 4997 (2005)*)

Function Category	**Category Description**	**Design Working Life (Years)**			
		5 or Less (Temporary Works)	25 (Small Craft Facilities)	50 Normal Maritime Structures)	100 or More (Special Structures/ Residential Development)
1	Structures presenting a low degree of hazard to life or property	1/20	1/50	1/200	1/500
2	Normal structures	1/50	1/200	1/500	1/1000
3	High property value or high risk to people	1/100	1/500	1/1000	1/2000

For normal pontoon structures with a design life of 50 years, the design return period is 1 in 500 years referring to table 17. This equates to a 9 per cent probability that this design event will be exceeded in the design life, as shown in table 16.

GBRMPA (2010) in table 2 (presented as table 15 above) provides recommendation for design return periods for pontoon structures in the Marine Park. The recommendations is based on Kapitzke IR, et.al (2002) which also discuss design loads for waves and winds in cyclonic conditions. The recommended return periods are for various categories of pontoons with varying design life from 10 years to 50 years with 10 per cent probability of exceedance for shorter design life to 5 per cent probability of exceedance for longer design life. The recommended design return periods are found to be in accordance with table 16 for the prescribed probability and design life.

Options

Design of a pontoon should consider the specific use of the pontoon. For the purpose of this paper, it is suggested that pontoons are categorised into four function category based on common pontoons in the Marine Park. The suggested design return periods and associated encounter probabilities are provided in table 18 for strength and stability considerations including ability of mooring systems to restrain the pontoon.

Table 18. Suggested minimum design return periods and encounter probabilities

Function Category		1	2	3	4
Category Description		Landing pontoon (e.g. for helicopter and sea plane operations)	Boat and vessel operations pontoon (e.g. marina, jetty)	Tourist operations pontoon (e.g. for tourist activities)	Visitors accommodation pontoon (e.g. floating hotel)
10 Years Design Life	Return Period	1 / 50	1/100	1/250	1/500
	Encounter Probability	18%	10%	~10%	~5%
25 Years Design Life	Return Period	1/100	1/250	1/250	1/500
	Encounter Probability	22%	~10%	~10%	~5%
50 Years Design Life	Return Period	1/200	1/500	1/500	1/1000
	Encounter Probability	22%	9%	9%	<5%
100 Years Design Life	Return Period	1/500	1/1000	1/1000	1/2000
	Encounter Probability	18%	10%	10%	<5%

It is suggested that function category 1 structures are designed for about 20 per cent probability of exceedance. These are structures of low risk. For structures of category 2 and 3, 10 per cent probability of exceedance is considered reasonable as these structures can be considered as presenting a moderate degree of hazard to life or property. Structures of function category 4 is of high value or high risk to people. It is proposed that these structures are designed for about 5 per cent probability of exceedance.

Depending on the site specific wave conditions, smaller pontoons such as for function category 1 and 2 can be impractical to be designed for high return periods such as more than 1 in 200 years. The design may result in a heavily engineered structure. In such situations, practical decisions such as relocating the pontoon to calmer areas can be considered. However, permanent mooring structures shall be designed to the required return period or risk level.

It can be assumed that pontoons of function category 3 and 4 will be designed for design life of 25 years or more as these structures are heavily engineered and require substantial capital investment.

If the pontoon is designed to be relocated during storm events, the frequency of relocation which depends on the metocean design limits shall be considered. This means that the structure may be capable of withstanding a certain low return period without relocating.

Although pontoons are floating structures, the storm tide levels and sea level rise projections shall be considered to determine the design high and low water levels. This information is essential for design of permanent structures including mooring anchors and piles that secures the pontoon. Loads acting on the permanent structure will vary with the design water levels.

Pontoons and marine structures in the Marine Park are subjected to cyclonic wave and winds, either directly impacted or from cyclones in the Coral Sea. It shall be noted that swells and locally generated wind waves that are not cyclonic waves can also be present and thus need to be considered as well with a site specific assessment to understand the critical loads that will govern the design loads.

The function categories suggested in table 18 cover broad range of pontoon type or usage that are typical in the Marine Park, whereas the function categories in GBRMPA (2012) mainly differentiates the pontoon categories by the size of pontoon and provision of overnight accommodation.

Table 18 also provide suggestions of return periods for various design life for a particular type of pontoon. This approach provides more information should other design life is anticipated which cannot be determined from GBRMPA (2012).

GBRMPA (2012) limits the probability of exceedance to 10 per cent and 5 per cent and then suggest the return period for a nominated design life. It shall be noted that in table 18, function category 1 can be considered as low risk structure, medium risk for function category 2 and 3 and high risk for function category 4. Therefore, the probability of exceedance suggested also varies, approximately 20 per cent, 10 per cent and less than 5 per cent respectively. It can be seen in table 18 that there is flexibility in determining the return period based on the required design life, this provides more information than in the GBRMPA (2012).

The designer shall assess the specific features of the proposed site, adjacent property and the pontoon and where appropriate shall select design return periods greater than the minimum given in table 18.

The designer shall consider the effects of combined impacts such as wind, wave and storm surge that may all occur concurrently in a tropical cyclone. The parameters used in this concurrent event shall represent a risk profile consistent with that in table 18 being cognisant of the probability of the combined event occurring concurrently.

JETTIES

Overview

Jetty structures are constructed to provide access from land to a landing platform or a vessel berth for the transfer of personnel and/or goods. An example of a jetty is shown in figure 6. Jetty structures generally consist of timber, concrete, steel or combination of these. As of 27 November 2015, there were 37 jetties permitted within the Marine Park.

Figure 6. Jetty (*source GBRMPA*)

Facility Inspection Regimes

Discussions

Jetty design life is generally about 50 years for concrete and steel structures. Timber structures typically have shorter design life of about 15 to 25 years.

The most common deterioration of a jetty is damage to the piles, deck and handrails. The jetty is subject to frequent wave and tidal action which cause durability issues. The structure can also be impacted from waves hitting the piles and deck. Berthing piles are subject to wear and tear from frequent vessel berthing.

The inspection regime proposed considers the type of the jetty, either steel or concrete and timber. Timber structures are not as durable as steel or concrete structures in the marine environment, therefore a separate timber jetty inspection regime is suggested with more frequent intervals.

Underwater pile inspection should be carried out in the Level 2 inspection. It is not envisaged that all piles are inspected but planned to inspect a representative sample and critical piles. Underwater pile cleaning can take a lot of effort and time to clean a small surface for inspection. It may only provide the opportunity to inspect that particular area but may not provide enough information on the condition of the whole structure. In this case, a Level 3 inspection will be recommended if required on case by case basis to investigate and respond to specific issues.

Level 3 inspections are more focused and involves detailed structural engineering inspections. Level 3 inspections are not only in the form of visual inspections but also may require on-site field work and testing, obtaining samples and laboratory testing. Therefore, Level 3 inspection is only undertaken when recommended by the inspector from a Level 2 inspection.

For long and complex jetties, as-built drawings can be used to customise the inspection scope and templates and observation details loaded to the inspection software which would assist in recording and reporting.

Field Work

Jetty inspections should be carried out along the jetty structure over water using a boat to inspect the underside of the jetty and divers for inspection of piles underwater. Inspections are to be planned to work within tidal windows. To maximise visibility, inspections are to be planned to have adequate time on site during spring low tide for pile inspection and high tide to inspect jetty under deck. Divers or remotely operated vehicles (ROVs) can be used for inspection of the piles underwater.

Possible Inspection Regime

Level 1: Routine Maintenance Inspection

Level 1 inspection should be carried out visually to inspect the structures present on site to observe deterioration. Table **19** provides Level 1 inspection requirements.

If as-built drawings are not available, the inspector should undertake necessary measurements of dimensions and details. Having these details will assist in planning and undertaking future inspections. The following information should be produced:

i. Dimensions and note on the type of material for pile, headstock, beam and deck structure

ii. Dimensions and type of bracing

iii. Details of handrail

iv. Details of jetty furniture such as fenders, bollards and access ladders

Table 19. Jetty Level 1 Inspection Requirements

Scope	i. Above water visual inspection at low tide of jetty structure (including under deck) to observe deterioration ii. General inspection for hazards to the jetty operations if any iii. General inspection for potential risk to the environment if any iv. Note any maintenance requirements v. Note and recommend any specific requirements for the next inspection cycle vi. Provide advice if the jetty need to be closed in the interim if required vii. Recommend Level 2 inspection if required based on observation or unusual behaviour of the structure viii. Inspection and reporting as per DTMR (2004) modified for jetty structure. Reporting format depends on inspection technology used.
Maximum inspection interval	a. Concrete and steel structure i. New to 18 years old: every 2 years ii. Beyond 18 years old: every 1 year b. Timber structure i. New to 12 years old: every 2 years ii. Beyond 12 years old: every 1 year
Acceptable inspector credentials	i. Level 1 Bridge Inspector experienced in marine structures inspection.

Level 2: Condition Inspection

Level 2 inspections are more detailed than Level 1 and involves underwater inspection to determine the condition of the jetty. Table 20 provides Level 2 inspection requirements.

Table 20. Jetty Level 2 Inspection Requirements

Scope	i.	Level 1 inspection scope items
	ii.	Above water visual inspection of jetty structure to observe deterioration (including measurement of crack widths).
	iii.	Above water visual inspection of jetty structure (including measurement of crack widths)
	iv.	Underwater inspection of piles (representative samples and critical piles)
	v.	Identify structural and durability issues of the jetty structure
	vi.	Assessment and reporting the condition of the structure and determine a condition rating of the structure based on DTMR (2004) section 3.8.3.
	vii.	Identify maintenance requirements
	viii.	Recommend any supplementary testing as appropriate
	ix.	Note and recommend any specific requirements for the next inspection cycle
	x.	Provide advice if the jetty need to be closed in the interim if required
	xi.	Recommend Level 3 inspection if required clearly identifying the scope and purpose
	xii.	Inspection and reporting as per DTMR (2004) modified for jetty structure. Reporting format depends on inspection technology used.
Maximum inspection interval	a.	Concrete and steel structure
	i.	New to 18 years old: every 6 years
	ii.	Beyond 18 years old: every 3 years
	iii.	When recommended in Level 1 inspection
	b.	Timber structure
	i.	New to 12 years old: every 4 years
	ii.	Beyond 12 years old: every 2 years
	iii.	When recommended in Level 1 inspection
Acceptable inspector credentials	i.	RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine structures inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

Level 3: Detailed Engineering Inspection and Investigation

Level 3 inspections provide engineering information on the condition of the structure and should be carried out to respond to specific issues raised in the Level 2 inspection. Table 21 provides Level 3 inspection requirements.

Table 21. Jetty Level 3 Inspection Requirements

Scope	To be determined in Level 2 inspection, may include i. Review of any previous inspection and testing reports ii. Detailed inspection including measurements, testing and analysis to supplement visual inspection to better understand a Level 2 inspection iii. Determination of material properties and structural behaviour iv. Identification of components which are limiting the performance of the structure due to their current condition and capacity v. Identify the probable causes and projected rate of deterioration and the effects of continued deterioration on the performance, durability and expected remaining life of the structure vi. Recommendations of management actions and/or maintenance/rehabilitation options vii. Inspection and reporting as per DTMR (2004) modified for jetty structure. Reporting format depends on inspection technology used.
Maximum inspection interval	When recommended in Level 2 inspection
Acceptable inspector credentials	RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine structures inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

The inspection regime is summarised in a flow diagram shown in **Error! Reference ource not found.** for concrete and steel structures; and in figure 8 for timber structures.

Level 1

Scope: Routine inspection

Frequency:

Jetty Life	Maximum Inspection Interval
New to 18 years	2 years
Beyond 18 years	1 year

By: Level 1 Bridge Inspector experienced in marine structures inspection.

When recommended in Level 1 inspection and to the Level 2 frequency

Carry out actions as required

Level 2

Scope: Condition inspection

Frequency:

Jetty Life	Maximum Inspection Interval
New to 18 years	6 years
Beyond 18 years	3 years

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine structures inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

When recommended in Level 2 inspection

Carry out actions as required

Level 3

Scope: Detailed structural engineering inspection and investigation

Frequency: When recommended in a Level 2 inspection.

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine engineering inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

Carry out actions as required

Figure 7. Proposed Inspection Regime for Jetties (Concrete and Steel Structure)

Level 1

Scope: Routine inspection

Frequency:

Jetty Life	Maximum Inspection Interval
New to 12 years	2 years
Beyond 12 years	1 year

By: Level 1 Bridge Inspector experienced in marine structures inspection.

When recommended in Level 1 inspection and to the Level 2 frequency

Carry out actions as required

Level 2

Scope: Condition inspection

Frequency:

Jetty Life	Maximum Inspection Interval
New to 12 years	4 years
Beyond 12 years	2 years

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine structures inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

When recommended in Level 2 inspection

Carry out actions as required

Level 3

Scope: Detailed structural engineering inspection and investigation

Frequency: When recommended in a Level 2 inspection.

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine engineering inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

Carry out actions as required

Figure 8. Proposed Inspection Regime for Jetties (Timber Structure)

Risk Considerations

Risk considerations and discussions relating to jetty inspection are provided in table 22.

Table 22. Inspection Regime Risk Considerations for Jetties

No.	Category	Description	Discussion
1	Inspection scope and reporting.	Inadequate inspection scope and reporting. Varying standards of reporting.	Inspections and reporting as per DTMR (2004) intent. Reporting format to be flexible with technology used.
2	Timber structures have shorter design life.	Timber structures are less durable and have relatively shorter design life in the marine environment.	Inspection regime acknowledge the age and durability of timber structures.
3	Underwater inspections.	Underwater inspection for all jetty piles will likely be costly. It is suggested that representative and critical piles are inspected in Level 2. Therefore, there is risk of not inspecting all piles underwater.	Underwater pile inspections should be planned to inspect a number of representative and critical piles, focussing on heavily loaded piles. Pile cleaning may be required to remove sections of marine growth. Underwater pile inspection can be considered in Level 1 inspection using simple underwater inspection equipment such as an underwater camera lowered from a boat if required.
4	Safety to users.	Not carrying out inspection and identifying required maintenance increases the risk to the jetty users, for example damage to the jetty structure and vessel during berthing. Jetty structures can also collapse if the supporting structures are beyond load capacity.	Inspection regime that covers appropriate time intervals to observe damage and deterioration early. Level 1 inspection to note any potential hazard, and maintenance requirements. Level 1 inspection also includes jetty under deck inspection. Level 2 inspections include piles underwater.
5	Damage to environment.	Hazardous material or risk items on the jetty falling into the water. Lack of inspection and maintenance cause deterioration and eventually damage of the structures and collapse into the water in sensitive environment. Hazardous material or risk items on the jetty could falling into the water as a result of damage to the structure from inadequate maintenance. This would be a hazard to the environment (damage coral reef, seagrass, etc.).	Inspection regime that covers appropriate time intervals to observe damage and deterioration early. Level 1 inspection to note any potential hazard and risk to environment and maintenance requirements. Level 1 inspection also includes under deck inspection. Level 2 inspections include piles underwater.

No.	Category	Description	Discussion
6	Maintenance and repair cost.	Jetties that are not adequately inspected are at risk of having required interventions identified too late which can be costly to repair or maintain.	Early signs of deterioration or issues can be observed and monitored through the Level 1 and Level 2 inspection cycles.
7	Safety of personnel.	The location of jetties can be remote in the Marine Park.	Site specific safety plans need to be developed for inspections. Inspections carried out in pairs.
8	Inspections cost	Inspections can be costly and can be a huge burden to the owners.	Inspection regime of varying degree of details. Level 1 and Level 2 inspections are to be staggered. This alternating approach provides value without increasing cost burden to the jetty owners.

Decommissioning and Removal

The decommissioning and removal of jetties depend on a number of factors. Table 23 provide discussions on a number of considerations for jetty removal.

Table 23. Jetty Removal Considerations

No.	Considerations	Description	Options
1	Design life	Jetty nearing design life and requires extension.	Extend design life with maintenance or reconstruction.
		Jetty nearing design life and do not require extension.	Consider items below.
2	Erosion issue and impact on coastal processes	Jetty structure are mostly above water, however the piles in the water has the potential to cause minor interruption to the coastal processes.	Structure removed or left in place with coastal process assessment if the removal will cause significant impact on the shoreline or surrounding area.
3	Materials	Jetty structures could be of either timber, concrete, steel or combination of these. These material are typically used in the marine environment and do not typically cause on-going harm to the environment, however when it deteriorates and become damaged over time, it will litter and accumulate in the Marine Park.	Structure removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed.
4	Direct potential environmental impact	The direct potential environmental impact of jetty is considered low. The structure could be providing habitat for marine fauna in the marine growth around the structure. However, marine growth impede inspections and increase loads on the structure that potentially exceed the design criteria. Deteriorated structure could cause damage to the reef from cyclone impact.	Structure removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed.
5	Potential hazard to users	Disused jetty structure could cause navigation hazard to boat users particularly at night. The disused structure may not be in an operational condition, there is risk that it may still be used occasionally. The jetty structure could be damaged overtime or during a cyclone and the debris would be a hazard to navigation and structures nearby.	Structure to be removed. Above water jetty structure to be dissembled and removed. Piles extracted and removed, if not possible cut piles 1m below sea bed and removed.
6	Proposed adjacent jetty to replace old	There is a risk that the disused jetty may still be used occasionally. The disused jetty could be	Structure to be removed. Above water jetty

No.	Considerations	Description	Options
	structure	damaged overtime and during a cyclone which the debris could damage adjacent jetty.	structure to be dissembled and removed. Piles extracted and removed, if not possible cut piles 1m below sea bed and removed.
7	On-going inspection cost	On-going inspection cost can be considered costly for disused or abandoned facility. Inspection cost does not justify leaving in place disused facility. There is also risk that inspection is not carried out.	Structure to be removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed.
8	On-going maintenance cost	On-going 5-10 yearly maintenance can be costly in the order of $20,000 to $100,000 (or higher for large facilities) depending on the design and requirements. Major repair may be required following a cyclone event. Maintenance cost does not justify leaving in place disused facility. There is also risk that maintenance is not carried out.	Structure to be removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed.

In summary, it is proposed that jetty structures to be removed at the end of design life or end of operation. Disused structures in the Marine Park is unsightly and may be a hazard to the environment and users. Piles to be extracted from the sea bed and removed. Piles that cannot be completely extracted are to be cut minimum 1m below sea bed and removed from site.

WALLS

Overview

Walls such as rock walls, revetment, groyne, breakwaters and bund walls provide protection to the shoreline or facilities such as a marina from wave action. These can be called coastal protection structures. Walls are generally constructed of rock armour or precast concrete armour. An example of a breakwater and revetment wall is shown in figure 9. figure 10 shows a typical revetment wall cross-section profile as an example.

This paper does not include structural engineering walls such as retaining walls of concrete blocks, bricks or steel.

As of 27 November 2015, there were 17 wall structures comprising rock walls, breakwaters and bund walls permitted within the Marine Park.

Figure 9. Breakwater and revetment (*source: GBRMPA*)

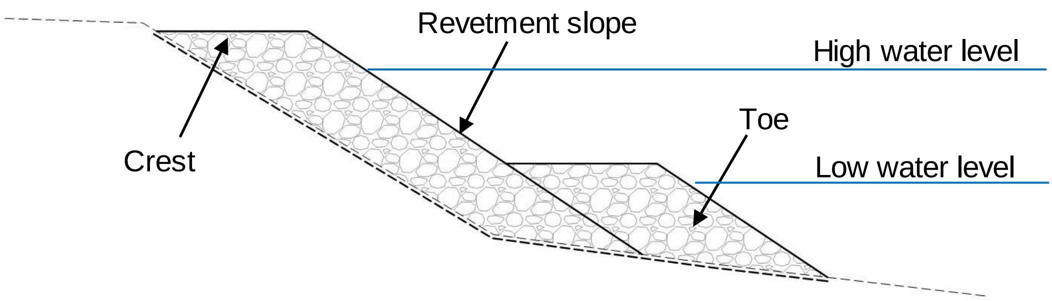


Figure 10. Typical revetment cross-section profile

Discussions

The Construction Industry Research and Information Association (CIRIA) is based in the United Kingdom (UK), was established as an independent and not-for-profit body that helps to improve the construction industry. CIRIA produces a number of publications from research and collaborative activities. One of the publication is a comprehensive manual used for design of coastal protection structures including walls, The Rock Manual, CIRIA C683 (2007). This manual also provides guidance for monitoring, inspection, maintenance and repair of coastal protection structures. This manual is currently widely used in Australia and internationally and has been reviewed and considered in this paper for walls.

Walls such as revetments and breakwaters in the marine environment are subjected to frequent wave and cyclic tidal actions. Typical issues related to deterioration of walls are erosion and damage at the crest, armour displacement and scour of the toe.

The suggested inspection regime considers three Levels of hierarchy similar to other facilities such as barge ramp and jetties presented in this paper. The proposed inspection frequency for Level 1 and Level 2 is longer than other marine structures. Walls that are constructed of rock and concrete armour are flexible type structures and can tolerate some damage depending on the adopted design criteria. These structures can tolerate some settlement. The design criteria for single layer concrete armour structures have provisions to address settlement issues which need to be considered during construction.

Multi beam survey is currently widely used instead of dive inspection to assess scour and profiles of the structure underwater. However, a dive survey may still be required in specific situations where the multi beam survey is insufficient to provide the required information or the multi beam survey identified requirements for a dive inspection.

Facility Inspection Regimes

Field Work

Inspections should be carried out above water by walking along the structure with care, or inspecting from a boat as close as possible to the wall. Generally wall type structures can be inspected visually above water and inspections shall be planned to work within tidal windows. To maximise visibility, inspections should be planned to have adequate time on site during spring low tides.

Underwater inspection can involve diver inspection, ROVs or multi-beam surveys of the slope and toe along the wall. Where there is risk of undermining and erosion of the toe, dive inspection or multi beam survey should be carried out.

Inspection Regime

Level 1: Routine Maintenance Inspection

Level 1 inspection should be carried out visually along the structure to inspect and observe deterioration above water. The inspection is usually carried out by walking along the crest of the wall or on the seabed, depending on the type of wall. Where possible and safe to do, inspection of the wall slope should be carried out to the toe of the structure. Table 24 provides Level 1 inspection requirements.

If as-built drawings are not available, the assets owner should undertake a topographic and bathymetry survey. The inspector should undertake necessary measurements of dimensions and details such as:

i. Crest width
ii. Wall slope
iii. Slope length
iv. Toe details
v. Rock and/or concrete armour sizing
vi. Rock and/or concrete armour layer thickness

Table 24. Wall Level 1 Inspection Requirements

Scope	i.	Above water visual inspection of the wall structure to observe settlement, displacement, damage and change in alignment
	ii.	Focus inspection at interface sections of walls and breakwater heads
	iii.	General inspection for hazards if any
	iv.	General inspection for potential risk to the environment if any
	v.	Note any maintenance requirements
	vi.	Note and recommend any specific requirements for the next inspection cycle
	vii.	Recommend Level 2 inspection if required based on observation or unusual behaviour of the structure
	viii.	Assessment and reporting of condition based on CIRIA C683 (2007) Table 10.13
	ix.	Reporting format depends on inspection technology used.
Maximum inspection interval		Every 3 years
Acceptable inspector credentials		RPEQ or by an Engineer with direct supervision of an RPEQ experienced in coastal protection structures inspection. The RPEQ will be responsible to sign off inspection reports.

Level 2: Condition Inspection

Level 2 inspection should be carried out similar to Level 1 inspection with more detail including underwater inspection. The inspection should focus on critical and representative areas for long sections of walls which should be planned in advance. table 25 provides Level 2 inspection requirements.

Table 25. Wall Level 2 Inspection Requirements

Scope	i.	Level 1 inspection scope items
	ii.	Above water visual inspection of the wall structure to observe settlement, displacement, damage and change in alignment.
	iii.	Note shape and size of armour including fractures
	iv.	Focus inspection at interface sections of walls and breakwater heads
	v.	Diver or multi-beam underwater inspection to identify armour displacement, toe scour, settlement and damage
	vi.	Inspect entire toe length
	vii.	Identify maintenance requirements
	viii.	Recommend any supplementary testing as appropriate
	ix.	Note and recommend any specific requirements for the next inspection cycle
	x.	Recommend Level 3 inspection if required clearly identifying the scope and purpose
	xi.	Assessment and reporting of condition based on CIRIA C683 (2007) Table 10.13
	xii.	Reporting format depends on inspection technology used.
Maximum inspection interval	i.	Every 6 years
	ii.	When recommended in Level 1 inspection
Acceptable inspector credentials		RPEQ or by an Engineer with direct supervision of an RPEQ experienced in coastal protection structures inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to sign off inspection reports.

Level 3: Detailed Engineering Inspection and Investigation

Level 3 inspection and investigation require as-built drawings to provide information and details of the structure. This inspection may include undertaking measurements, testing and analyses. A topographic and bathymetry survey will also be required. If as-built drawings are not available, the inspector will need to undertake necessary measurements of dimensions and details such as:

i. Crest width
ii. Wall slope
iii. Slope length
iv. Toe details
v. Rock and/or concrete armour sizing
vi. Rock and/or concrete armour layer thickness
vii. Samples and laboratory testing to determine density of rock and/or concrete armour

Level 3 inspections provide engineering information on the condition of the structure. Level 3 inspection is only required if recommended in a Level 2 inspection. Table 26 provides Level 3 inspection requirements.

Table 26. Wall Level 3 Inspection Requirements

Scope	To be determined in Level 2 inspection, may include i. Detailed inspection including surveys with multi-beam, testing and analyses to supplement visual inspection to better understand a Level 2 inspection report ii. Recommend management actions and/or maintenance/rehabilitation options iii. Assessment and reporting of condition based on CIRIA C683 (2007) Table 10.13 iv. Reporting format depends on inspection technology used.
Maximum inspection interval	When recommended in Level 2 inspection
Acceptable inspector credentials	RPEQ or by an Engineer with direct supervision of an RPEQ experienced in coastal protection structures inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to sign off inspection reports.

The inspection regime is summarised in a flow diagram shown in figure 11.

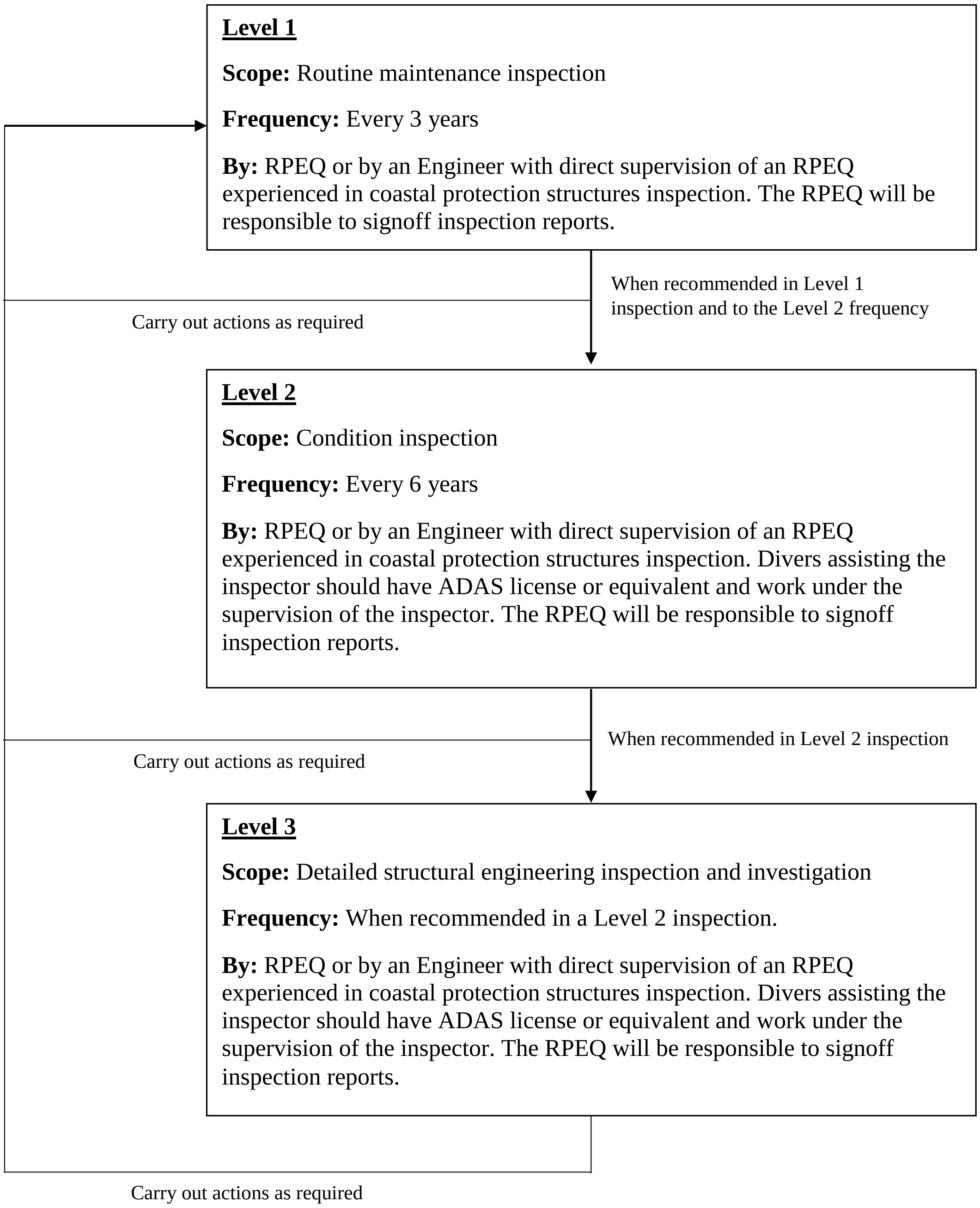


Figure 11. Proposed Inspection Regime for Walls

Risk Considerations

Risk considerations and discussions relating to wall inspection regime are provided in table 27.

Table 27. Inspection Regime Risk Considerations for Walls

No.	Category	Description	Discussion
1	Inspection scope and reporting	Inadequate inspection scope and reporting. Varying standards of reporting format.	CIRIA C683 (2007) can be used as a reference document. Reporting format depends on inspection technology used.
2	Damage to environment and properties	Walls that are not adequately inspected are at risk of having required interventions identified too late. Not carrying out required maintenance increases the risk to the properties that it is protecting, for example damage to the seawall structure not repaired promptly could become severe during a storm which erodes the shoreline and damage properties on the landside. A damaged breakwater could result in complete closure of a marina as it may not be providing the level of sea state that is required for the safe mooring of boats. Without frequent inspections, early signs are not identified, such as erosion at the crest of the wall from wave overtopping.	Early signs of deterioration or issues can be observed and monitored through the Level 1 and Level 2 inspection cycles.
3	Damage to environment and properties	Damaged walls increases the footprint of the damaged structure as a result of flattening and displacement of the material. This could damage adjacent sensitive areas such as coral and seagrass.	Early signs of deterioration or issues can be observed and monitored through the Level 1 and Level 2 inspection cycles.
4	Accessibility	Some areas of the walls may not be accessible which prevents inspection. Hazards from walking on the walls and slippery conditions may also prevent proper inspection.	Inspections to be planned and consider safety risks to the personnel. Use boat if required to get closer to the wall as possible.
5	Critical areas	The interface sections of walls and breakwater heads are weak areas and need to be inspected properly.	Inspection scope should specifically address these areas.
6	Inspection coverage underwater	Underwater inspections are planned to inspect the wall slope and toe. It may not be possible to inspect the entire slope length along the wall. Therefore, there is a risk that some critical sections are	Dive or multi beam inspection is suggested in Level 2 to inspect the wall underwater section including toe protection. Inspections need to consider representative and critical areas along the underwater slope. It is

No.	Category	Description	Discussion
		missed. A common cause of damage to walls are toe erosion and scouring.	suggested to inspect the entire toe length. Multi-beam survey can be undertaken in Level 3 inspection if required.
7	Safety of personnel.	The location of walls can be remote in the Marine Park.	Site specific safety plans need to be developed for inspections. Inspections carried out in pairs.
8	Inspections cost	Cost implication for carrying out inspections.	Inspections of varying degree of details. Level 1 and Level 2 inspections are staggered. This alternating approach provides value without increasing cost burden to the facility owner.

Decommissioning and Removal

The decommissioning and removal of walls depend on a number of factors.

Table 28 provide discussions on a number of considerations for wall removal.

Table 28. Wall Removal Considerations

No.	Considerations	Description	Options
1	Design life	Walls nearing design life and requires extension.	Extend design life with maintenance or reconstruction.
		Walls nearing design life and do not require extension.	Consider items below.
2	Erosion issue and impact on coastal processes	Walls that are parallel to the shoreline has less erosion issue and impact on coastal processes compared to perpendicular structures such as causeway, groyne or breakwaters.	Removal of structures to be assessed on case by case based on coastal process study and the impacts of removal.
3	Materials	Typically construction materials are rock or combined with concrete armour. Rock or concrete material does not cause on-going harm to the environment if left in place. The voids in the structure in fact provides habitat for marine fauna.	Structure left in place if supporting sensitive marine fauna.
4	Direct potential environmental impact	The direct potential environmental impact of walls is considered low, the structure could be providing habitat for marine fauna. However, specifically for breakwater type structures, should damage occur, the breakwater material could be displaced over a large area and potentially over sensitive areas.	Structure to be removed or partially removed assessed on case by case based on coastal process study and if the wall is supporting sensitive marine fauna.
5	Potential hazard to users	Walls extending into the waterways could cause navigation hazard to boat users particularly at night.	Structure to be removed or partially removed assessed on case by case based on coastal process study and the impacts of removal.
6	Proposed adjacent wall	Proposed construction of a new seawall and/or revetment. Wave energy can be reflected to adjacent shoreline.	Structure to be removed or partially removed assessed on case by case based on coastal process study and the impacts of removal.
7	On-going inspection cost	On-going inspection cost can be considered costly for disused or abandoned facility. Inspection cost does not justify leaving in place disused facility. There is also risk	Structure to be removed.

No.	Considerations	Description	Options
		that inspection is not carried out.	
8	On-going maintenance cost	On-going 5-10 yearly maintenance can be costly in the order of $3,000 to $10,000 per m wall length depending on the design and requirements. Major repair may be required following a cyclone event. There is also risk that maintenance is not carried out. Maintenance cost does not justify leaving in place disused facility.	Structure to be removed.

In summary, removal of wall structures to be assessed on case by case based on coastal process study and the impacts of removal. Some sections may need to be left in place if protecting sensitive area or an important asset.

UNDERWATER OBSERVATORIES

Overview

Underwater observatories provide the opportunity for tourists to view the reef and surrounding environment through a secure see through structure without getting into the water. Underwater observatories are usually constructed of glass, steel concrete or combination of these.

There were 2 underwater observatories permitted within the Marine Mark as of 27 November 2015, listed below. These underwater facilities are all steel structures.

i. Hook Island underwater observatory

ii. Green Island underwater observatory

An example of an underwater observatory is shown in figure 12.

Figure 12. Green Island underwater observatory (*source: GBRMPA*)

Facility Inspection Regimes

Field Work

This chapter covers external inspection of the underwater observatories which should be inspected with the assistance of divers. The internal sections and structures above water can be inspected similar to a jetty type structure, refer to Page 50. However, special attention should be considered such as inspection of joints to determine issues related to leaks.

Discussions

Underwater observatories are special structures. Based on research of publicly available literature, there is no manual or guidance for inspections of these type of structures. However, it is expected that designers should consider inspections and maintenance in the design process. In the absence of any specific guidance, the proposed inspection and reporting to be based on DTMR (2004) but modified to suit underwater observatory structure.

Underwater observatories are high risk facilities because people are accessing to confined space below water level and any damage to this type of facility will be catastrophic and will have huge consequences to personal safety.

For disused underwater observatories, the risk can be considered as medium because there is no public access. However, disused facility has the risk of not being maintained and can be damaged overtime or during a significant event.

A Level 1 inspection above water is not considered practical as the majority of the facility is located under water.

Level 2 inspections for underwater observatories are the most frequent of all facilities covered in this paper. Frequent inspections will be required for high risk facilities such as this.

Level 3 inspections are more comprehensive and involves detailed structural engineering inspections. Level 3 inspections are not only in the form of visual inspections but also may require on-site field work and testing, obtaining samples and laboratory testing. Therefore, Level 3 inspection is only undertaken if recommended by the inspector from a Level 2 inspection. The scope of Level 3 inspection will need to be clearly identified in a Level 2 inspection. Undertaking a Level 3 inspection may require the facility to be closed.

Specific issues relating to inspections of underwater observatories are:

i. Inspections may consider the structure material such as glass with concrete or steel structures.

ii. If cleaning of surface is required for inspections

iii. Leak detection and how is this carried out

iv. Anti-corrosion systems (cathodic)

Possible Inspection Regime

Level 1: Routine Maintenance Inspection

This level of inspection is considered not suitable for underwater observatories that are as the majority of the facility is located under water, hence an above water inspection is not practical.

Level 2: Condition Inspection

For this type of facility, if as-built drawings are not available, measurements should be undertaken during Level 2 inspections to produce as-built drawings as it will be required for Level 3 inspections. Table 29 provides Level 2 inspection requirements.

Table 29. Underwater Observatory Level 2 Inspection Requirements

Scope	i.	Underwater visual inspection of underwater observatory structure (including all piles and support structure) to observe deterioration
	ii.	General inspection for hazards to the underwater observatory operations
	iii.	General inspection for potential risk to the environment
	iv.	Identify structural and durability issues of the structure
	v.	Assessment and reporting the condition of the structure and determine a condition rating of the structure based on DTMR (2004) section 3.8.3.
	vi.	Identify maintenance requirements
	vii.	Recommend any supplementary testing as appropriate
	viii.	Note and recommend any specific requirements for the next inspection cycle
	ix.	Provide advice if the underwater observatory need to be closed in the interim if required
	x.	Recommend Level 3 inspection if required clearly identifying the scope and purpose
	xi.	Inspection and reporting as per DTMR (2004) modified for underwater observatory structure. Reporting format depends on inspection technology used.
Maximum inspection interval	i.	New to 10 years old: every 2 years
	ii.	Beyond 10 years old: every 1 year
Acceptable inspector credentials		RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine structures inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

Level 3: Detailed Engineering Inspection and Investigation

Level 3 inspections provide engineering information on the condition of the structure. As-built drawings will be required for this type inspection, otherwise the inspection cannot be planned. Therefore, if as-built drawings are not available, measurements should be undertaken during Level 2 inspections.

Table 30 provides Level 3 inspection requirements.

Table 30. Underwater Observatory Level 3 Inspection Requirements

Scope	To be determined in Level 2 inspection, may include i. Review of any previous inspection and testing reports ii. Detailed inspection including measurements, testing and analysis to supplement visual inspection to better understand a Level 2 inspection iii. Determination of material properties and structural behaviour iv. Identification of components which are limiting the performance of the structure due to their current condition and capacity v. Identify the probable causes and projected rate of deterioration and the effects of continued deterioration on the performance, durability and expected remaining life of the structure vi. Recommendations of management actions and/or maintenance/rehabilitation options vii. Inspection and reporting as per DTMR (2004) modified for underwater observatory structure. Reporting format depends on inspection technology used.
Maximum inspection interval	When recommended in Level 2 inspection
Acceptable inspector credentials	RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine structures inspection. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

The inspection regime is summarised in a flow diagram shown in figure 13

Level 2

Scope: Condition inspection

Frequency:

Underwater Observatory Life	Maximum Inspection Interval
New to 10 years	2 years
Beyond 10 years	1 years

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine engineering inspections. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

When recommended in Level 2 inspection

Carry out actions as required

Level 3

Scope: Detailed structural engineering inspection and investigation

Frequency: When recommended in Level 2 inspection.

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine engineering inspections. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

Carry out actions as required

Figure 13. Proposed Inspection Regime for Underwater Observatories

Risk Considerations

Risk considerations and discussions relating to underwater observatories inspection regime are provided in table 31.

Table 31. Inspection Regime Risk Considerations for Underwater Observatories

No.	Category	Description	Discussion
1	Underwater inspections.	The structure is located underwater and thorough planning is required to inspect the structure to the required Level.	Thorough planning and inspection requirements clearly communicated to the divers. Underwater inspections for piles and support structures may require cleaning to remove sections of marine growth.
2	Safety to users.	Underwater observatories are high risk structures. Not carrying out inspection and identifying required maintenance increases the risk to the users of the structure.	Level 2 inspection to note any potential hazard, and maintenance requirements, it also include inspecting all piles and supporting structures underwater. Early signs of deterioration or issue can be observed and monitored through the Level 2 inspection cycles.
3	Damage to environment.	Lack of inspection and maintenance cause deterioration and eventually damage of the structures and collapse in the sensitive environment. This would be a hazard to the environment (damage coral reef, seagrass, etc.).	Inspection regime that covers appropriate time intervals to observe damage and deterioration early. Level 2 inspection to note any potential hazard and risk to environment and maintenance requirements.
4	Maintenance and repair cost.	Underwater observatories that are not adequately inspected are at risk of having required interventions identified too late which can be costly to repair or maintain.	Early signs of deterioration or issue can be observed and monitored through the Level 2 inspection cycles.
5	Safety of personnel.	The location of underwater observatories can be remote in the Marine Park.	Site specific safety plans need to be developed for inspections.
6	Inspections cost	Inspections can be costly and can be a huge burden to the owners.	Underwater observatories are high risk structures and risk to the public cannot be compromised. Inspection costs to be considered as part of the operational cost by the facility owners.

Decommissioning and Removal

The decommissioning and removal of underwater observatories depend on a number of factors. Table 32 provide discussions on a number of considerations for underwater observatories removal.

Table 32. Underwater Observatory Removal Considerations

No.	Considerations	Description	Options
1	Design life	Underwater observatory nearing design life and requires extension.	Extend design life with maintenance or reconstruction.
		Underwater observatory nearing design life and do not require extension.	Consider items below.
2	Erosion issue and impact on coastal processes	Underwater observatory has the potential to cause minor interruption to the coastal processes.	Structure removed or left in place with coastal process assessment if the removal will cause significant impact on the shoreline or surrounding area.
3	Materials	Underwater observatory structures could be of either glass, steel concrete, timber or combination of these. These material are typically used in the marine environment and do not cause on-going harm to the environment, however when it deteriorates and become damaged over time, it will litter and accumulate in the Marine Park.	Structure removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed.
4	Direct potential environmental impact	The direct potential environmental impact of underwater observatory is considered low. The structure could be providing habitat for marine fauna in the marine growth around the structure. However, marine growth impede inspections and increase loads on the structure that potentially exceed the design criteria. Deteriorated structure could cause damage to the reef from cyclone impact.	Structure removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed.
5	Potential hazard to users	Disused underwater observatory structure could cause navigation hazard to boat users particularly at night. The underwater observatory structure could be damaged overtime or during a cyclone and the debris would be a hazard to navigation and structures nearby.	Structure to be removed. Above water structure to be dissembled and removed. Piles extracted and removed, if not possible cut piles 1m below sea bed and removed.
6	Proposed adjacent structure to replace old structure	The disused underwater observatory could be damaged overtime and during a cyclone which the debris could damage adjacent structures.	Structure to be removed. Above water structure to be dissembled and removed. Piles extracted and removed, if not possible cut

No.	Considerations	Description	Options
			piles 1m below sea bed and removed.
7	On-going inspection cost	On-going inspection cost can be considered costly for disused or abandoned facility. Inspection cost does not justify leaving in place disused facility. There is also risk that inspection is not carried out.	Structure to be removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed.
8	On-going maintenance cost	On-going 5-10 yearly maintenance can be costly in the order of $50,000 to $100,000 depending on the design and requirements. More costly major repair may be required following a cyclone event. Maintenance cost does not justify leaving in place disused facility. There is also risk that maintenance is not carried out.	Structure to be removed. Piles extracted and removed, if not possible cut 1m below sea bed and removed.

In summary, it is proposed that underwater observatories to be decommissioned and removed at the end of design life or end of operation. Disused structures in the Marine Park is unsightly and may be a hazard to the environment and users.

Piles to be extracted from the sea bed and removed. Piles that cannot be completely extracted are to be cut minimum 1m below sea bed and removed from site.

Any new underwater observatories should be designed and planned for removal at the end of their life. However, it is recognised that the observatories currently in the Marine Park may be difficult or costly to fully remove due to design, location, age or encrusting coral growth. There may also be heritage considerations. A case by case assessment of historic observatories is recommended.

PIPES

Overview

Subsea and underwater pipeline infrastructure within the Marine Park provide various utility services to end user developments and infrastructure, such as power, water, sewerage, desalination and refuelling stations. These pipelines convey fluids such as sewage, sea water, potable (treated) water and fuel and are varied in their functionality and operation.

As of 27 November 2015, there were a total of 68 pipelines permitted within the Marine Park, as summarised in table 33. These include discharge outfall pipes, intake pipes and transport pipes (which traverse the Marine Park without discharge or intake). Lengths of these pipes vary from very short lengths (< 10m outfall pipes) to much longer distances (> 1km water mains, etc.). An example of a typical pipeline within the Marine Park is shown in figure 14.

Table 33. Pipeline Permit Summary

Pipeline Type	Number of Permits (at 27 November 2015)
Pipelines - Desalination	15
Pipelines - Potable Water	8
Pipelines - Refuelling	2
Pipelines - Seawater	33
Pipelines - Sewage	7
Pipelines - Waste Water	3
Total	68

Pipeline installations vary depending on functionality, design and type of construction. Pipe installations are generally either:

1. **Buried underground pipes** – excavated and buried within a trench, drilled / bored underground by tunnelling or drill rig and can be either beneath the seabed in a waterway or beneath the ground surface level.
2. **Above ground pipes** – installed on pipe support cradles / structures (typically concrete or steel structures) or bridges (support frames attached to bridge). Additionally underwater pipelines, laid directly on the seabed supported by structures / anchors are classified as above ground pipes.

Underground pipelines are susceptible to soil corrosivity, ground movements, traffic loadings and typically fail through wall corrosion and pipe joint failure. Above ground pipelines and their support structures (surface) are typically exposed to more aggressive conditions than buried structures (UV exposure, tidal / splash zone corrosion, mechanical damage, etc.) and hence more susceptible to the associated degradation mechanisms. Due to the relative ease in accessing above ground pipes, these assets are typically easier to inspect and maintain. Underwater pipelines which are directly laid on the sea bed, have higher likelihoods of failure than buried pipelines due to their exposure to underwater currents, debris impacts during cyclonic conditions and risks of support failure and pipe undermining due to dynamic seabeds.

Buried and underwater pipelines may also have operating impressed current or galvanic cathodic protection systems. These systems will also require periodic inspection and maintenance to ensure the system is operating effectively and providing adequate protection to the asset.

Figure 14. Water intake pipe (*source: GBRMPA*)

Facility Inspection Regimes

Discussion

The inspection regime for each pipeline asset has been suggested based on whether the pipeline is deemed 'Critical' or 'Non-Critical'.

Critical pipelines are defined as pipelines conveying fluids with high consequences of failure, such as sewage and fuel. Non-Critical pipelines are those which convey fluids with low consequences of failure, such as seawater and potable water. Table 34 displays the criticality classifications for the different types of pipelines permitted in the Marine Park.

Table 34. Pipeline criticality classification

Pipeline Criticality	Pipeline Type
Critical	Refuelling Sewage Waste Water (including industrial waste)
Non-Critical	Desalination Potable Water Seawater

Inspections methods for pipelines are generally either carried out by boat from the water surface (utilising side scan sonar / multi-beam technologies), underwater by diver or remote controlled equipment or within the pipeline by Closed Circuit Television (CCTV) or other inspection equipment.

The American Bureau of Shipping – Subsea Pipeline Systems (ABS) in Chapter 4 provides guidance on inspection, maintenance and repair. Our suggested inspection regime has utilised a simplified inspection philosophy in order to identify major pipeline defects to assist with managing the risk of a failure.

The proposed inspection regime for Level 2 and Level 3 considers the fluid contamination risk of the pipeline and provides greater inspection frequency to pipelines deemed 'Critical'.

Level 2 inspections are more general condition inspections with higher frequency, with the intent to identify any major immediate defects / risks of failure. Level 3 inspections are detailed inspections (wall thickness, coating condition assessment, etc.) with lower inspection frequencies and may be able to provide expected remaining life assessments to inform the owner of the optimal time to invest capital to replace / rehabilitate pipelines, prior to pipeline failure.

Expected remaining life predictions as a result of Level 3 inspections are typically able to be undertaken with concrete and metallic pipelines. Plastic pipelines, however are more difficult to determine remaining pipeline life and condition. The Plastics Industry Pipe Association of Australia technical paper TP004 states *"For correctly manufactured and installed systems, the actual life cannot be predicted, but can logically be expected to be well in excess of 100 years before major rehabilitation is required".* For the condition assessment of plastic pipes, an experienced pipeline engineer shall be engaged to understand and investigate the design, installation and operating conditions of the plastic pipe system to determine the likelihood of failure. Plastic pipe failure can usually originate from factors such as incorrect pipe selection for operating conditions (operating system pressure > pipe rating, etc.), excessive stresses to pipe (fatigue stresses due to vibration/ cyclic stresses, ground crushing loads etc.) and incorrect pipe selection for environment (carbon black PE pipes recommended for UV exposure, etc.).

Pipeline condition is not necessarily dictated by the age of the pipe. A younger pipeline may fail earlier than an older pipe, due to site specific failure mechanisms triggered by the local environment, pipeline material, design, construction and operation. Also, a non-critical pipeline failure may not have a major detrimental effect to the local environment (failure of a seawater / potable water pipeline, etc.).

A risk based approach is typically employed to determine a pipeline's failure risk for decision making and inspection frequency. This risk assessment would include the consequence of failure (criticality / impact in a failure event) in addition to the likelihood of failure (pipe condition). For simplicity, the approach to the suggested inspection regime for pipes, uses the pipelines critical or non-critical nature (fluid contaminant) as an indication of failure risk.

Possible Inspection Regime

Inspections should be carried out as either Level 1, 2 or Level 3 inspections. Level 1 inspections can be undertaken for those pipelines where a significant proportion of the pipe is above ground or in shallow water. For these pipes, the entire length may be able to be inspected at low tide without the need for divers / ROVs (e.g. by foot, boat, etc.). Where above ground pipe sections are accessible, Level 1 visual inspections shall initially occur to establish any areas of poor condition which can then be further assessed by a Level 2 or 3 inspection. Level 1 inspections are not applicable to pipes which are underwater (in deeper water (>1m)) or underground. Level 2 inspections are intended as a condition inspection to be undertaken without interruption to pipeline operation. Level 3 inspections are intended to be detailed pipeline condition assessments that may require pipeline shutdown, operation and insertion of inspection equipment into the pipeline.

Certain pipelines may not require shut-down, due to the fluids clear visibility being conducive for internal CCTV inspections (potable water, sea water, etc.). Additionally smart pigging condition assessment technologies may enable internal assessments to be undertaken during operation of the pipe.

Existing metallic pipelines may have existing corrosion prevention systems installed (such as cathodic protection on steel pipes). Depending on the installed system type, asset owners shall ensure that proper routine maintenance on these systems are undertaken to ensure integrity of the systems. Analysis / assessment of these systems may be used as Level 2 inspections to indicate the need for further pipe condition assessments.

Due to a pipelines ability to fail at any section of the pipe, ideally the pipe condition shall be determined for the entirety of the pipeline. However, condition assessment of entire pipeline lengths are generally not practical due to high costs and labour requirement in undertaking entire pipeline condition assessments. Hence, localised Level 3 pipe condition assessments / inspections will be accepted such that potential high risk areas are identified and included as part of the inspection regime.

Level 1: Routine Maintenance Inspection

Level 1 inspection should be carried out visually to inspect accessible pipeline and support structures present on site to observe deterioration. Table 35 provides Level 1 inspection requirements.

If as-built drawings are not available, the inspector should undertake necessary measurements of dimensions and details. Having these details will assist in planning and undertaking future inspections. The following information should be produced:

i. Dimensions and note on the type of pipeline material and coating system

ii. Dimensions and type of support structures and fixings

Table 35. Pipeline Level 1 Inspection Requirements

Scope	i. Above ground visual inspection at low tide of pipeline and support structures (including fixings) to observe deterioration ii. General inspection for hazards to the pipeline operations if any iii. General inspection for potential risk to the environment if any iv. Note any maintenance requirements v. Note and recommend any specific requirements for the next inspection cycle vi. Provide advice if the pipeline needs to be closed in the interim if required vii. Recommend Level 2 inspection if required based on observation or unusual behaviour of the asset viii. Inspection and reporting as per DTMR (2004) modified for pipeline. Reporting format depends on inspection technology used.
Maximum inspection interval	i. Critical pipelines: every 6 months ii. Non-critical pipelines: every 2 years
Acceptable inspector credentials	i. Level 1 Bridge Inspector experienced in marine pipelines inspection.

Level 2: External Pipeline Inspection

Level 2 pipeline inspections require as-built drawings to understand the original design, pipeline material and constructed alignment. Where drawings are not available, the asset owners should survey pipes and record details (install year, pipe material, valves / fittings, depth, length, etc.) in their asset database to enable proper management of these assets. Boat access will usually be required to undertake inspections, however smaller intake / outfall pipes can often be checked at low tide by wading or snorkelling (where deemed safe and practical).

Level 2 inspection requirements are provided in table 36.

Table 36. Level 2 inspection requirements

Scope	i. Review of historical inspection / maintenance records and emergency shutdown plan. It shall be ensured that an approved emergency shut-down plan is in place for the pipeline. ii. Above water general visual condition inspection of the pipeline entering / exiting waterway banks or on above ground structures. iii. Underwater inspection of all associated pipeline infrastructure (such as anchors, diffusers, joints, grates, etc.) iv. Mapping of seabed and pipeline by side-scan sonar or multi-beam methods, via boat at water surface. v. Inspection results and comparisons with as-constructed drawings will indicate any: a. Major pipeline alignment changes / defects (kinks, etc.) on the seabed. b. Undermining of the pipeline seabed producing free spans beneath the pipeline. c. Major underwater objects lodged or impacting on the pipeline. d. Scouring of the seabed exposing a buried pipeline, compromising pipeline cover and protection. vi. Pipeline free span structural assessments, where required as a result of Level 2 inspections. vii. Diver inspections if pipeline scanning / multi-beam has indicated the need to closer inspect a potential defect. viii. Recommend Level 3 inspection if required
Maximum inspection interval	i. Critical pipelines: every 1 year ii. Non-critical pipelines: every 5 years
Acceptable inspector credentials	RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine pipelines. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

For pipes that are not underwater, the following alternatives could be used as Level 2 inspections and / or to indicate the need for a Level 3 inspection:

i. Identification of pipe leaks (unusual pressure drops along pipe, water meter readings while outlets are shut to identify potential leaks, etc.)

ii. Visual Inspection of joints, fittings, coatings and pipes.

iii. Cathodic protection system analysis to determine indicative coating and pipeline condition at certain sections of pipe.

Level 2 inspections can be carried out in the same year as Level 3 assessment. Outcomes from Level 2 inspections may immediately prompt a detailed Level 3 assessment.

Level 3: Detailed Pipeline Assessment

Level 3 inspections require as-constructed drawings and isolation of pipeline sections within the Marine Park.

Note: Emergency shut-down plans should be required for all pipelines within the Marine Park. This will ensure that any unplanned discharges / leaks to the environment can be isolated and that isolation facilities of the pipeline are possible for Level 3 inspections.

Level 3 inspection requirements are provided in table 37.

Table 37. Level 3 inspection requirements

Scope	i. Review of historical inspection / maintenance records and emergency shutdown plan. ii. Isolation and emptying of the pipeline section to enable internal / external inspection by: a. CCTV (closed circuit television) internal visual pipeline inspection. b. Internal pipe condition assessment / inspection by intelligent pigging methods to undertake leak detection, crack detection and pipe wall loss inspection. c. External pipe wall condition assessment methods for coatings, valves, fittings and joints (wall thickness testing, diver inspections, remote operated vehicle ROV).
Maximum inspection interval	i. Critical pipelines: every 5 years ii. Non-critical pipelines: every 10 years
Acceptable inspector credentials	RPEQ or by an Engineer with direct supervision of an RPEQ experienced in marine pipelines. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

Outcomes from Level 2 inspections may immediately prompt a detailed Level 3 assessment, depending on recommendations from the inspector. Deficiencies identified in Level 3 inspections should result in a rehabilitation or replacement plan for the pipeline.

The inspection regime is summarised in a flow diagram shown in

Level 1

Scope: Routine maintenance inspection

Frequency:

Pipeline Type	Maximum Inspection Interval
Critical pipeline	6 months
Non-critical pipeline	2 years

By: Level 1 Bridge Inspector experienced in marine pipelines inspection.

When recommended in Level 1 inspection and to the Level 2 frequency

Carry out actions as required

Level 2

Scope: External pipeline inspection

Frequency:

Pipeline Type	Maximum Inspection Interval
Critical pipeline	1 year
Non-critical pipeline	5 years

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in subsea pipeline engineering inspections. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

When recommended in Level 2 inspection and to the Level 3 frequency

Carry out actions as required

Level 3

Scope: Detailed pipeline assessment

Frequency:

Pipeline Type	Maximum Inspection Interval
Critical pipeline	5 year
Non-critical pipeline	10 years

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in subsea pipeline engineering inspections and assessment. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

Carry out actions as required

figure 15.

Level 1

Scope: Routine maintenance inspection

Frequency:

Pipeline Type	Maximum Inspection Interval
Critical pipeline	6 months
Non-critical pipeline	2 years

By: Level 1 Bridge Inspector experienced in marine pipelines inspection.

When recommended in Level 1 inspection and to the Level 2 frequency

Carry out actions as required

Level 2

Scope: External pipeline inspection

Frequency:

Pipeline Type	Maximum Inspection Interval
Critical pipeline	1 year
Non-critical pipeline	5 years

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in subsea pipeline engineering inspections. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

When recommended in Level 2 inspection and to the Level 3 frequency

Carry out actions as required

Level 3

Scope: Detailed pipeline assessment

Frequency:

Pipeline Type	Maximum Inspection Interval
Critical pipeline	5 year
Non-critical pipeline	10 years

By: RPEQ or by an Engineer with direct supervision of an RPEQ experienced in subsea pipeline engineering inspections and assessment. Divers assisting the inspector should have ADAS license or equivalent and work under the supervision of the inspector. The RPEQ will be responsible to signoff inspection reports.

Carry out actions as required

Figure 15. Proposed Inspection Regime for Pipelines

Risk Consideration

Risk considerations and discussions relating to pipelines inspection regime are provided in Table 38.

Table 38. Inspection regime risk considerations for pipelines

No.	Category	Description	Discussion
1	Damage to environment and properties – Contamination Risk	Critical subsea pipelines that are not inspected regularly are at risk of structural failure and can cause contamination to the Marine Park. Without frequent inspections, early signs of future failure are not identified. Contamination risk from the internal pipeline fluid is the main concern. Non-critical pipelines which carry seawater and potable water have very little or negligible contamination risk.	Early signs of deterioration or issue can be observed and monitored through the Level 1, 2 and 3 cycles of varying degree of details.
2	Damage to environment and properties – Construction / Maintenance activity within Marine Park	Pipelines on the seabed which fail structurally would require underwater repairs. Repairs such as underwater divers, welding, barges and underwater trenching, etc. will adversely impact marine life and habitat that may have developed around underwater pipeline structures.	Early signs of deterioration or issue can be observed and monitored through the Level 1, 2 and 3 cycles of varying degree of details. Maintenance methods shall have focused Environmental Management Plans to mitigate the risk impacts to marine life.
3	Access	Some areas of the pipelines may not be accessible which prevents inspection.	Inspections to be planned and consider safety risks to the personnel.
4	Critical areas of pipeline failure	Underwater pipelines which are directly laid on the sea bed, have higher likelihoods of failure than buried pipelines. Undermining, critical free span lengths and debris impacts all pose risks to exposed pipelines laid on the seabed.	Inspection scope to address these areas.
5	Pipe flotation Risk for pipelines on seabed	If the pipeline is to be emptied during inspection, there is a risk of buoyant forces causing the pipeline to break from its anchors. This is more of a concern for polyethylene pipes.	Ensure pipeline owner's shutdown plans consider and manage buoyant forces prior to emptying the pipeline.
6	Inspection coverage underwater	Build-up of marine habitat and sediment may be impacting the ability to properly display critical undermining and free-span sections from seabed mapping (side scan sonar and multi-beam).	Underwater dive inspections are recommended in Level 2 and 3, to provide closer inspections where seabed mapping is deemed inadequate.
7	Safety of personnel.	The location of pipelines can be remote in the Marine Park.	Site specific safety plans need to be developed for

No.	Category	Description	Discussion
			inspections. Inspections carried out in pairs.
8	Inspections cost	Cost implication for carrying out inspections. High costs for carrying out Level 3 inspection.	Inspections of varying degree of details for Level 1, 2 and 3. Frequency of inspection is proportional to criticality of pipeline (Non-critical → Low inspection frequency, etc.) A cost benefit analysis shall be undertaken as discussed to determine the economics of replacement vs inspections. Low cost pipeline rehabilitation methods shall be explored to renew the pipeline, utilising the existing pipeline structure.

Decommissioning and Removal

The decommissioning and removal of pipelines depend on a number of factors. Table 39 provide discussions on a number of considerations for pipeline removal.

Table 39. Pipeline removal considerations

No.	Criteria	Description	Recommended Decision
1	Design life	Pipelines nearing design life and requires extension.	Extend design life with maintenance and or rehabilitation / renewal.
		Pipelines nearing design life and do not require extension.	Consider items below.
2	Materials (for pipeline laid on seabed)	Typically subsea pipelines are made of either metallic (Steel), concrete or plastic pipe materials (Polyethylene, PE). Pipeline anchor blocks will typically be made of reinforced concrete. Various pipeline materials underwater may cause harm to the environment if left in place. These materials include banned and of-concern materials such as glues or metals (i.e. lead). Smaller plastic pipes and fragmented larger pipes present risks to the environment and marine life as they are not bio-degradable. Old asbestos cement (AC) pipes are only hazardous if impacted and made friable in open air. However, removal of AC pipes is recommended where practical to avoid third party exposure and risk. However, larger pipeline infrastructure / materials may be deemed feasible to leave in place (i.e. reinforced concrete pipe) and may provide habitat for marine fauna.	Pipeline left in place if supporting sensitive marine fauna. Pipeline to be removed if deemed hazardous to local environment / eco-system. Plastic pipes and other banned / hazardous materials will typically require removal.
3	Installation Type (Buried or Laid on Seabed, etc.)	The decommissioning and removal method will be different for different pipeline installation types. For direct buried pipelines beneath the seabed, they are typically left in place and capped and grout filled at either side of the waterway. For pipelines laid on the seabed, the decision to remove shall be carefully considered. Decommissioned pipelines on the seabed at risk of being washed away (cyclone conditions) and causing damage downstream shall be considered for removal or protected /	Pipeline left in place, unless there is a strong argument for removal. Consider scour / rock protection and rehabilitation for pipes at risk of washout as an alternative to complete removal. In summary, removal of a pipeline is to be assessed on case by case basis, based on the risk of a pipeline

No.	Criteria	Description	Recommended Decision
		rehabilitated to prevent failure risks.	washout, cost of removal and the impacts of removal.
4	Pipe Location	Consideration of the zone where the pipe is located. If pipe is in a zone where trawling is allowed, full removal is preferred. Pipes in high energy or shallow environments should be removed due to higher risk of disturbance.	Pipes shall be removed when the location presents a high risk of failure.
5	Direct potential environmental impact	The direct potential environmental impact of subsea pipelines is considered low. The structure could be providing habitat for marine fauna. If the pipe has been used to transport or discharge anything other than seawater, there needs to be an assessment of the coating or sludge that remains inside the pipe. This will leach out into the environment over time. Best practice is to 'pig' clean the pipe (towards land) before decommissioning, to remove contaminants that have built up inside the pipe. Decommissioned pipeline removal will generally have high impacts to the surrounding local environment (habitat / ecosystems). Any operation to remove a pipeline will require work / machinery in the Marine Park.	Pipeline left in place if supporting sensitive marine fauna. A decision to remove a pipeline is to be assessed on case by case basis, based on the risk of a pipeline washout, risk of pipe contaminants / hazards, cost of removal and the impacts of removal.
6	Pipe flotation Risk (for pipeline laid on seabed)	If a pipeline is emptied for decommissioning, there is a risk of buoyant forces causing the pipeline to break from its anchors. This is more of a concern for polyethylene pipes on seabeds.	Pipeline is to be left in place and grout filled to ensure buoyant forces are counteracted. Alternatively, the pipe may be "holed" along its length to allow water and sand to fill the pipe, weighing it down. CCTV / leak testing is recommended prior to grout filling to determine any major defects which may cause grout egress.
7	Decommissioning Cost	Grout filling a long large pipeline may be very costly – to resist buoyant forces of pipe. As a minimum, decommissioning shall include removal of sections of pipe either side of the pipeline,	Pipeline can be left in place without grout filling, subject to alternate methods of managing buoyant forces.

No.	Criteria	Description	Recommended Decision
		capping and grout filling of short sections of pipe. There is also the risk of grout leakage that need to be managed.	
8	On-going inspection cost	Level 2 side scan sonar investigations are required only for decommissioned pipelines. It can be considered costly for inspection of decommissioned or abandoned pipelines. There is also risk that inspections are not carried out.	Structure to be left in place with a review of inspection regime, environmental impacts and failure risk considerations.
9	On-going maintenance cost	Inspections and subsequent maintenance if required are recommended following a cyclone event. Debris impacts and strong undercurrents can potentially impact decommissioned pipelines – causing ongoing maintenance costs.	Consider on-going maintenance cost and above criteria in decision to either remove pipe or leave in place.

In summary, the decision to remove a pipeline or leave in place is to be assessed on a case by case basis, based on removal / ongoing maintenance costs if left in place, failure risks and the impacts of removal.

Ongoing maintenance may include inspection / maintenance of pipeline anchors to prevent pipe dislodgment from buoyancy effects and scouring / debris impact from cyclone conditions.

In addition to environmental impact considerations, removal of a pipeline should always consider the installation type, local conditions and environmental impacts of removal. For example, a decommissioned pipeline that is directly on a sand bed (with no surrounding habitat / ecosystem) may be considered for removal, as opposed to a direct buried / drilled pipeline that is within bedrock beneath the seabed that would be left in place. Similarly a pipeline laid within a sheltered area of a watercourse may be subject to less dynamic seabed conditions, hence could be left in place due to lower risks of scouring and undermining failure.

CABLES

Overview

A number of permits have been issued that include submarine electrical or combination electrical/telecommunication cables. These are addressed below as high voltage island-to-mainland and inter-island power cables and low voltage island foreshore power cables.

High Voltage Cables

Modern high voltage 11,000 volt submarine cables are typically manufactured using copper, aluminium, steel, cross-linked polyethylene or ethylene propylene rubber, and served with hessian tapes, polypropylene strings and bituminous compounds. Older cables may include impregnated paper and lead beneath the serving. Some high voltage cables incorporate a telecommunications cable.

Typical installation methods include ploughing, trenching or jetting to embed the cable into the sea bed, laying the cable directly on unconsolidated sediments where the cable is expected to self-bury, laying directly on the consolidated sea bed with concrete or other protection, or laid unsecured directly on the seabed. The method chosen depends on such parameters as water depth, seabed environment, volume and type of shipping traffic in the area, and the economics of the installation. Cables are generally buried at the landing point, well below the lowest astronomical tide for protection of the cable.

Of the current Marine Park permittees, only Ergon Energy currently holds a distribution authority in Queensland in accordance with the *Electricity Act 1994* as identified in the *Electricity Act 1994*. This allows Ergon Energy to supply electricity using a network within the distribution area stated in the authority.

However, other permittees may have a special approval which allows them to carry out activities normally authorised by a generation, transmission or distribution authority. For example, a special approval may allow the operator of an island resort, which is generating its own electricity and operating its own supply network within the resort, to perform those generation and distribution activities. Copies of individual authorities and special approvals are generally not published nor made available unless the holder consents.

The Regulator (the Director-General of the Department of Energy and Water Supply) issues authorities (licences) for generation, transmission and distribution activities in Queensland's electricity industry and is responsible for monitoring compliance with the conditions of authorities and special approvals.

Low Voltage Cables

Low voltage 415/240 volt cables are generally constructed of copper conductors with polyvinyl chloride, cross linked polyethylene or rubber insulation/sheathing materials. Installation is typically in conduit for protection. These cables are used for powering such items as lighting, socket outlets and motors along the foreshore area and consequently are more likely to be in areas accessible by the public.

These installations are governed by the Wiring Rules as they do not include generation, transmission or distribution. Any qualified electrical contractor may carry out the installation work.

Governance

Electrical safety matters, enforceable by the Electrical Safety Office, are addressed under:

- *Electrical Safety Act 2002*
- *Electrical Safety Regulation 2013*
- *Electrical Safety (Codes of Practice) Notice 2002*
- *Work Health and Safety Act 2011*
- *Work Health and Safety Regulation 2011*

The *Electrical Safety Regulation* also references

a) AS/NZS 3000 Wiring Rules

Facility Inspection Regimes

High Voltage Cables

High voltage submarine cables are typically installed and left undisturbed for their useful life, which can be in excess of 25 years, barring damage by underwater activity such as caused by earthquake or fishing vessels/boat anchors. Except for where the cable is laid directly on the seabed, visual inspections are generally not carried out, because the buried cables would not be visible.

On critical direct laid installations, such as the high voltage direct current submarine link between the North and South Islands of New Zealand, remotely operated vehicle surveys and diving inspections are used to assess the condition of the cable. These cables were installed in 1991, with a nominal life expectancy of 35 years. In 2013 they were reported to be undamaged and in good condition with virtually no corrosion of the armouring.

Submarine cables are costly to manufacture, costly to install and costly to repair. Consequently, the cables are designed to suit the harsh environment into which they will be installed and are expected to reach their design life provided they are not damaged.

Submarine cable technology is well-proven with robust design. The electrical conductors, insulation, bedding, and screening components (and sometimes a lead jacket is used) are all over covered with waterproof bedding material which is then surrounded with steel wiring armour to provide mechanical protection and then finished with the reasonably inert waterproof bituminous laden hessian tapes and polypropylene strings. Should the exterior waterproofing layer become damaged and allow exposure of the steel wire to sea water, some local corrosion may occur. The water ingress can then ultimately result in the failure of the cable. However, the cable construction methodology minimises any possibility of the cable becoming underwater debris through disintegration.

Reliability of supply is paramount to an energy supplier. During the design stages, expected future demand is factored into the cable capacity and cables are typically sized to ensure they are not operated anywhere near capacity. Consequently, within the park, it is unlikely that the cables would be operating in a condition that would result in a cable surface temperature that would have detrimental effects on the surrounding marine life.

Cable fault repair is a major cost as it typically involves external resources and equipment including the possible use of a remotely operated vehicle and specialist divers trained for electrical cables. These all have associated availability issues. In addition, there is the requirement to maintain electrical supply which may involve the deployment of diesel generator sets if no secondary cable has been installed.

Electricity supplier operations control centres monitor current flows 24 hours a day landside at both landings of submarine cables. If a fault occurs, automatic circuit protection is designed to disconnect the flow of energy. Historically, the majority of faults in high voltage submarine cables have been the result of damage to the cable caused by ships anchors or fishing.

This current monitoring is a useful method of continuously checking the condition of the cable. Any loss of integrity of the cable water barrier will allow moisture penetration resulting in a fault and disconnection of supply. The cause must then be determined and any cable damage rectified. Electricity suppliers are responsible for producing their own maintenance procedures for the safe installation, operation and maintenance of their electrical systems. This can include partial discharge testing to monitor over time the condition of the cable so that preventative maintenance can be carried out before the cable fails. It is also their responsibility to ensure that their high voltage testing personnel are suitably trained and experienced to carry out high voltage testing in accordance with electrical and workplace safety requirements.

The inspection regime suggested for high voltage submarine cables operated by a distribution authority or under special approval is split into two parts – physical inspection (provided in table 40) and electrical testing (table 41).

Table 40. Submarine High Voltage Power Cables Inspection Requirements

Scope	i.	Inspection of cable at landside if feasible
	ii.	Inspection of termination joint at waterline if any and if feasible
	iii.	Inspection of warning signage, general inspection for hazards/risks to the cable
	iv.	Note any maintenance requirements
	v.	Recommend any supplementary testing as appropriate
	vi.	Note and recommend any specific requirements for the next inspection cycle
	vii.	Where the cable is direct laid on the seabed, MOV or diver inspection of the cable and its installation
Maximum inspection interval	i.	5 years for landside inspections
	ii.	Risk based but 5 years indicative for laid on seabed cables
Acceptable inspector credentials	i.	Trained and competent high voltage tester accepted by the asset owner to work on their asset

Table 41. Submarine High Voltage Power Cables Testing Requirements

Scope	i.	Partial discharge testing of cable
	ii.	Review of previous tests and record any differences
	iii.	Note any maintenance requirements
	iv.	Recommend any supplementary testing as appropriate
	v.	Note and recommend any specific requirements for the next testing cycle
Maximum testing interval	i.	At commissioning and at year 5, then 5 yearly unless results indicate degradation and then yearly
Acceptable inspector credentials	i.	Partial discharge testing is a specialist procedure. Only personnel qualified to carry out HV testing and are suitably experienced with using the test equipment should conduct the tests.

Each cable would need to be assessed individually considering where and how it has been installed. Where a cable is buried 2m below the sea bed, the land based inspections with partial discharge testing would be appropriate. Where a cable is laid on the sea bed in a tidal flow more frequent inspection and testing may be required as the cable may have moved. The exact frequency should be monitored over time and adjusted to suit the cable and environment.

If a cable has been buried in the seabed due to environmental reasons, consideration should be given to possible cable inspections after a major storm to determine if the undersea environment has changed and the cable been affected.

Low Voltage Cables

Low voltage cables cover cables - supplying electrical energy to such items as lights on a pier, socket outlets on a marina pontoon or underwater pump stations.

The two common industry standard methods for the verification of these cables are by visual inspection and testing.

Verification of electrical installations is covered under:

- *AS/NZS 3000 Wiring Rules*
- *AS/NZS 3017 Electrical installations – Verification guidelines*
- *AS/NZS 3019 Electrical installations – Periodic verification*
- Verification specifically for the electrical installations of marinas is covered under:
- *AS/NZS 3004.1 Electrical installations – Marina and recreational boats Part 1 Marinas*

The inspection and testing regime proposed for low voltage cables is provided in Table 42. Works should be carried out in accordance with *AS/NZS 3000* and *AS/NZS 3019*, and *AS/NZS 3004.1* for marinas, as applicable.

Table 42. Low Voltage Inspection and Testing Requirements

<table>
<tr><td>Scope:
Verification by inspection and limited testing</td><td colspan="3">i. Visual inspection of cable landside
ii. Visual inspection of termination joint at waterline if any and if feasible
iii. Visual inspection of cable terminations
iv. Tests in accordance with the Wiring Rules
v. General inspection for hazards/risks to the cable
vi. General inspection for potential risk to the environment
vii. Note any maintenance requirements
viii. Recommend any supplementary testing as appropriate
ix. Note and recommend any specific requirements for the next inspection cycle</td></tr>
<tr><td>Scope:
Verification by inspection and full testing</td><td colspan="3">i. Visual inspection of cable landside
ii. Visual inspection of termination joint at waterline if any and if feasible
iii. Visual inspection of cable terminations
iv. Tests in accordance with the Wiring Rules including earth fault loop impedance tests
v. General inspection for hazards/risks to the cable
vi. General inspection for potential risk to the environment
vii. Note any maintenance requirements
viii. Recommend any supplementary testing as appropriate
ix. Note and recommend any specific requirements for the next inspection cycle</td></tr>
<tr><td rowspan="5">Maximum interval for verification</td><td>Test</td><td>Inspection/test Interval</td><td>Personnel</td></tr>
<tr><td>RCD</td><td>Monthly</td><td>Facility owner</td></tr>
<tr><td>RCD</td><td>Yearly</td><td>Licenced electrical contractor</td></tr>
<tr><td>Limited tests</td><td>Risk based but 1 year indicative</td><td>Licenced electrical contractor</td></tr>
<tr><td>Full test</td><td>Risk based but 5 years indicative</td><td>Licenced electrical contractor</td></tr>
<tr><td>Minimum inspector requirements</td><td colspan="3">i. A licenced electrical contractor must carry out the inspection and tests with the exception of the monthly test of the RCD which may be done by the facility owner.</td></tr>
</table>

Each cable would need to be assessed individually. Where inspections and tests indicate that the cable is not deteriorating, the interval can be increased. Where the monitored test results show that the cable has deteriorated from the previous testing, the frequency of inspection and tests should be increased. The exact frequency should be monitored over time and adjusted to suit the cable and environment.

Discussion

During the design and installation stages of high voltage cables particular attention is given to the risk factors involved with the particular installation and how the risks can be minimised to provide a safe and reliable electrical supply. The type of cable to be used, the cable route including surveys of the sea bed, alternative supply arrangements, shipping/recreational boating activity, installation methodology, and environmental factors are all considered along with the methodology for ongoing inspection and testing.

Where cables can be buried several meters into the seabed, there is minimal risk to the cable and hence the landbased inspections are typically sufficient along with partial discharge testing.

Where cables cannot be buried, regular inspections by remote operated vehicle or diver should be carried out at regular intervals, particularly on sections of the cable that may be at risk, along with the landbased inspections and partial discharge testing.

Where a base line is required for the external condition of a high voltage cable, a survey of the cable route of buried cables could be carried out to ensure they are still covered. A more detailed visible inspection could be carried out for cables laid on the sea bed. A judgement should be made on the relative risks associated with each cable.

While there are no mandatory ongoing testing requirements for high voltage cables, partial discharge testing can be carried out on live high voltage submarine cables without disrupting the facility. This is a non-destructive, non-invasive predictive maintenance tool that detects defects in high voltage cables. By detecting and trending partial discharge, it is possible to observe its development over time. Then strategic decisions regarding repair or replacement of the cable can be made prior to the cable failing. Personnel who are trained in the use of the specialist test equipment, are competent and accredited to carry out this type of non-invasive testing on in-service cables, carry out the testing procedure.

Disruptions in the high voltage power supply are detected by line monitoring which detects when current leakage has occurred. The cause of the problem in submarine cables, in the majority of cases, is damage to the cable by ships anchors or fishing methods. Dive crews are then required to inspect and assess the damage.

Where low voltage cables are installed, inspections and testing are carried out in accordance with the mandatory requirements of the Wiring Rules and associated standards to minimise the risk to persons, livestock and property from electric shock, fire and physical injury hazard. Guidance for these inspections and tests is provided in the Australian Standards mentioned on Page 93

Costs for actual inspection and tests would vary on the location of the installation, whether outside contractors would be required or whether in-house staff could be used, the extent and complexity of the installation, ease of access to the installation to be verified, cost of hiring specialist test equipment, and whether meals and accommodation would be required and if so whether these would be provided by the facility owner.

Risk Considerations

Risk considerations for high voltage submarine power cables are provided in table 43.

Table 43. Inspection regime risk considerations for high voltage submarine power cables

No.	Category	Description	Discussion
1	Inspection scope and reporting.	Inadequate inspection scope and reporting. Varying standards of reporting.	Inspections and reporting to be based on electricity entity standard procedures.
2	Cable landing inspections.	Landing inspection scope. It may not be practical to inspect the landing if the cable is buried in the seabed and continues buried on the land.	The cable should be left undisturbed except where there is a specific risk at this point eg. a cable joint. New cables should be installed with joints only at easily accessible landside locations.
3	Safety hazard to navigation.	Marine navigation charts should have all locations of submarine cables detailed. Prominent standard signage showing cable landings should be installed and properly maintained.	Inspections to include signage. Where inspection reveals that the cable has moved, relevant authorities need to be notified (Notice to Mariners etc).
4	Damage to environment.	Tidal currents, severe weather and physical disturbance (such as trawl or anchor) may cause a cable to move resulting in damage to marine life	Risk assessment during the design stage can provide a cost effective solution and help to avoid environmental damage. Visual inspections of cables laid on the sea bed may also be required particularly after a severe storm.
5	Maintenance and repair cost.	While routine inspections and maintenance can be allowed for, damage caused by unforeseen circumstances such as anchor snag, with consequent repair, is more difficult to allow for	Non-destructive testing of cables can detect early signs of deterioration and help predict failure of cable. A visual inspection can determine the condition of the cable surface.
6	Safety of personnel.	The location of submarine cable landings can be remote in the Marine Park.	Site specific safety plans need to be developed for inspections.
7	Inspections cost	Cost implication for carrying out inspections.	Land based inspections are relatively inexpensive compared with undersea inspections. Some initial inspections on cables installed on the sea bed that are considered to

No.	Category	Description	Discussion
			be at risk should be carried out as a base line to determine the condition of the cable and its environment. Once this initial data has been collected and analysed, the actual cable degradation and the effects of the cable on the GBR environment can be documented. A value judgement can then be made on the specific maintenance regime required.

Risk considerations for low voltage cables are provided in Table 44.

Table 44. Inspection regime risk considerations for low voltage cables

No.	Category	Description	Mitigation
1	Inspection scope and reporting.	Inadequate inspection scope and reporting. Varying standards of reporting.	Inspections and reporting to be based on Australian Standard procedures.
2	Maintenance and repair cost.	Low voltage cables can fail causing failure of connected services	Non-destructive testing of cables can detect early signs of deterioration and help predict failure of cable.
3	Safety of personnel.	The location of other can be remote in the Marine Park.	Site specific safety plans need to be developed for inspections.
4	Inspections cost and intervals	Cost implication for carrying out inspections.	Vary the initial yearly partial tests depending on test results

Decommissioning and Removal

The decommissioning and removal of high voltage power cables depends on a number of factors. Table 45 provides discussions on a number of considerations for high voltage cable removal.

Table 45. High voltage cable removal considerations

No.	Criteria	Description	Recommended Decision
1	Design life	Cables nearing design life and requires extension.	Extend design life with maintenance and or rehabilitation / renewal.
		Cables nearing design life and do not require extension.	Consider items below.
2	Materials	Modern submarine cables are typically manufactured using copper, aluminium, steel, cross-linked polyethylene or ethylene propylene rubber, and served with hessian tapes, polypropylene strings and bituminous compounds. Older cables may include impregnated paper and lead.	Consider each cable, where and how it is installed, and the long term environmental effects of abandoning the cable.
3	Installation Type (Buried or Laid on Seabed, etc.)	The decommissioning and removal method may be different for different cable installation types.	Full removal is preferred to neutralise future risk. Cables >30m below sea surface may be considered for decommissioning in-situ subject to other considerations (such as materials). Cables <30m below sea surface pose a high risk of future disturbance and should be removed, unless an environmental impact assessment determines that removal poses a higher long-term risk than decommissioning in situ.
4	Direct potential environmental impact	The direct potential environmental impact of decommissioned subsea cable is considered low.	Consider each cable, where and how it is installed, and the long term environmental effects of abandoning the cable.
6	Decommissioning Cost	The following decommissioning options are suggested: i. Cable could be decommissioned and	Full removal is preferred to neutralise future risk. Cables >30m below sea surface may be

No.	Criteria	Description	Recommended Decision
		abandoned as is ii. Sections of cable in sensitive areas, or at high risk of future disturbance, could be recovered and the ends of remaining cable capped iii. The complete cable could be recovered	considered for decommissioning in-situ subject to other considerations (such as materials). Cables <30m below sea surface pose a high risk of future disturbance and should be removed, unless an environmental impact assessment determines that removal poses a higher long-term risk than decommissioning in situ.
7	On-going inspection cost	Ongoing inspection costs would only be a consideration if the cable is not removed.	If the Decommissioning and Removal Plan concludes that the cable should be removed, there will be no ongoing inspection costs. Otherwise allowance needs to be made.
8	On-going maintenance cost	Ongoing maintenance costs would only be a consideration if the cable is not removed.	If the Decommissioning and Removal Plan concludes that the cable should be removed, there will be no ongoing maintenance costs. Otherwise allowance needs to be made.

The decision on whether the high voltage cable should be abandoned or recovered must be assessed on an individual cable basis. The assessment needs to address subjects such as:

i. the location of the cable

ii. how it is installed

iii. the type and length of cable

iv. the long term effects of that type of cable on the marine environment

v. the sensitivity of the environment and the extent of sensitive areas

vi. the potential damage to the environment and epifauna caused by the recovery of the cable

vii. the expense of carrying out underwater surveys

viii. the cost and availability of specialist crews and equipment to retrieve the cable

ix. whether the cable should be cut, capped and abandoned in low risk areas and removed in high risk areas.

x. When a decision is made to allow sections of a cable to remain decommissioned in place, appropriate long-term management arrangements need to be put in place by GBRMPA to ensure that any future incident response or clean-up costs are not borne by the Australian public. This might include maintaining a permit for a decommissioned facility (with a deed and bond), or a stand-alone deed (without a permit) to bind the facility owner to ongoing periodic inspection, maintenance or clean-up obligations.

Low voltage cables should be recovered and removed. If the service they are feeding is still required, they should be replaced.

COST OF INSPECTIONS

Indicative costs to undertake the inspection for various levels are provided in table 46. Generally, the inspection cost is more expensive for higher level inspections as it is more detail and requires more time for the inspection and reporting. Cost for Level 3 inspections depend on the scope of inspection, testing and analysis that may be required.

Table 46. Indicative cost estimates for inspections (GST exclusive)

Facility	Level 1 Inspection Cost	Level 2 Inspection Cost	Level 3 Inspection Cost
Barge ramp and boat ramp	Professional fee: $2,500 to $3,000 Expenses: $1,000 to $2,000 Total: $3,500 to $5,000	Professional fee: $6,000 to $7,500 Expenses: $1,000 to $2,000 Dive team: $0 to $10,000 Total: $7,000 to $19,500	Cost can be small to over $50,000.
Pontoon	Professional fee: $4,000 to $5,000 Expenses: $2,000 to $4,000 Total: $6,000 to $9,000	Professional fee: $6,000 to $7,500 Expenses: $2,000 to $4,000 Dive team: $5,000 to $10,000 Total: $13,000 to $21,500	Cost can be small to over $50,000.
Jetty	Professional fee: $6,000 to $7,500 Expenses: $3,000 to $4,000 Total: $9,000 to $11,500	Professional fee: $10,000 to $12,500 Expenses: $3,000 to $4,000 Dive team: $5,000 to $10,000 Total: $18,000 to $26,500	Cost can be small to over $100,000 depending on length and complexity of the jetty
Walls	Professional fee: $6,000 to $7,500 Expenses: $3,000 to $4,000 Total: $9,000 to $11,500	Professional fee: $10,000 to $12,500 Expenses: $3,000 to $4,000 Dive team: $5,000 to $10,000 or Multi beam survey: $20,000 to $30,000 Total: $18,000 to $46,500	Cost can be small to over $50,000.
Underwater	Inspection level	Professional fee: $10,000 to $12,500	Professional fee and expenses depend on

Facility	Level 1 Inspection Cost	Level 2 Inspection Cost	Level 3 Inspection Cost
observatories	not applicable	Expenses: $3,000 to $4,000 Dive team: $5,000 to $10,000 Total: $18,000 to $26,500	scope of inspection, testing and analysis required
Pipes		Professional fee: $10,000 to $12,500 Expenses: $3,000 to $5,000 Dive team: $5,000 to $10,000 Total: $18,000 to $27,500	Professional fee and expenses depend on scope of inspection, testing and analysis required Cost is highly dependent on individual pipeline size, configuration and site constraints. Cost can be $50,000 to over $100,000. In some cases, it will prove more cost effective to remedy or replace any possible deficiencies than to undertake a Level 3 assessment.

Inspection for cables also involve testing. Indicative cost for landside inspections and testings for high voltage and low voltage cables are provided in table 47 and table 48 respectively.

Table 47. Indicative cost for high voltage cable inspection (excl. GST)

Type	Indicative Cost	Notes
Inspection	$1,000 per cable	Inspection of point on land where cable comes out of ground
Testing	$5,000 per cable	Testing in substation on land

Table 48. Indicative cost for low voltage cable inspection – Landside only (excl. GST)

Type	Indicative Cost
Monthly RCD test	Nil (undertaken by facility owner)
Inspection and limited testing including RCD	Professional fee: $1000-$3000 Expenses: $500
Inspection and full testing including RCD	Professional fee: $2000-$5000 Expenses:$1000

SUMMARY OF ISSUES

In preparing this paper, a number of issues were identified and discussed in table 49.

Table 49. Summary of issues

No.	Issue	Discussion
1	DTMR bridge inspection manual and training course might not be appropriate for marine structures	There is no specific training course for marine structures inspection in Australia such as this course in Canada: You can view the training course on the Epic Training Centre website. The relevant course in Australia is specifically on corrosion can be viewed on the Corrosion training website. The Ports Australia (2014) provides a comprehensive guideline for wharf structures, which can be considered as for high value properties. This manual also provides 3 Levels of hierarchy inspection, similar to DTMR (2004) manual. However, this manual may not suit small facilities The intent of the DTMR (2004) and the associated courses could be adopted and applied for marine structures. There are a number of service providers that conduct bridge inspection courses to the DTMR (2004) manual such as IPWEA, Informa and ARRB. A number of councils and private property owners in Queensland have adopted the DTMR (2004) manual and inspection Levels for marine structures inspection.
2	Inspection guidelines for underwater observatories	Based on research of publicly available literature, there is no specific guidelines for inspections of underwater observatories. This kind of structures are special high risk structures. The structural designers should consider and document inspections and maintenance in the whole of life design principles. The frequency to be assessed on case by case basis in discussions with the facility owner and with a risk assessment. Different built form may require different inspection regime.
3	Professional liability	Inspectors should be covered by appropriate Professional Liability and Public Indemnity insurances so that staffs are not personally liable for claims.
4	Availability of as-built drawings	If as-built drawings are not available, details of the facility should be measured and recorded during the first Level 1 inspection and updated with following inspections. This will help in planning for future inspections. GBRMPA could possibly consider requiring that as-built information is provided as part of applying for continuation of an existing permit.
5	Cost of inspections	The cost estimate could vary substantially for work in remote areas. The cost also depends on the scale and complexity of the facility as well as the level of deterioration (how many deficiencies need to be examined and recorded).
6	Inspection frequency	The inspection frequency suggested is based on Arup's experience working in the marine environment and providing inspection services to marine asset owners. There is option to relook in detail and suggest recommended and maximum intervals, but owners will go for the least required. Therefore, it will be a burden to GBRMPA to assess case by case basis.
7	Level 1 inspection allows the inspector to provide recommendation to close the facility if	For serious issues identified in a Level 1 inspection, the inspector is allowed to close the facility if required and recommend a Level 2 inspection to be undertaken.

No.	Issue	Discussion
	required (excluding pipes and cables)	
8	Level 3 inspection scope and cost (excluding pipes and cables)	Level 3 inspections scope is determined from a Level 2 inspection. It can be a small inspection for a particular issue to a very detail assessment of the whole structure. The Level 2 inspector will recommend Level 3 inspection scope. Therefore the cost to undertake a Level 3 inspection can only be determined after a Level 2 inspection.
9	Marine growth	Where facilities are not maintained free from marine growth, dive inspections can take a lot of effort and time to clean a small surface for inspection. It may only provide the opportunity to inspect that particular area but may not provide enough information on the condition of the whole structure. For this reason, it is important that inspections or compliance audits occur with enough frequency to 'catch' instances where marine growth is not being appropriately managed and removed.
10	Inspections for underwater observatories	There may not be many RPEQ experienced in underwater observatory structures. There may be concerns regarding liability for signing off for these type of high risk structures. Inspections should also consider internal inspection and take into account the requirements of 'confined space' if applicable.
11	Inspection after an significant event	It is suggested that a Level 1 inspection (Level 2 for underwater observatory and pipelines) to be carried out after a significant event. This type of inspection can be organised and undertaken quickly. The inspector can recommend a higher Level inspection if required or provide advice to shut down the facility pending further investigation.
12	Leave in place decommissioned facility	Facilities that have been decommissioned and determined to be best left in place need to consider in detail the liability aspects as liability may be transferred to GBRMPA.
13	Decommissioning and removal	It is suggested that GBRMPA request from the facility owners for a decommissioning and removal plan for all facilities in the Marine Park (where appropriate) as part of the permit assessment process. The decommissioning and removal should be considered in the design and construction of the facilities. It is important to have this plan established earlier on so that the facility can be removed as required to reduce risks in the Marine Park. This can be considered a risk mitigation option.

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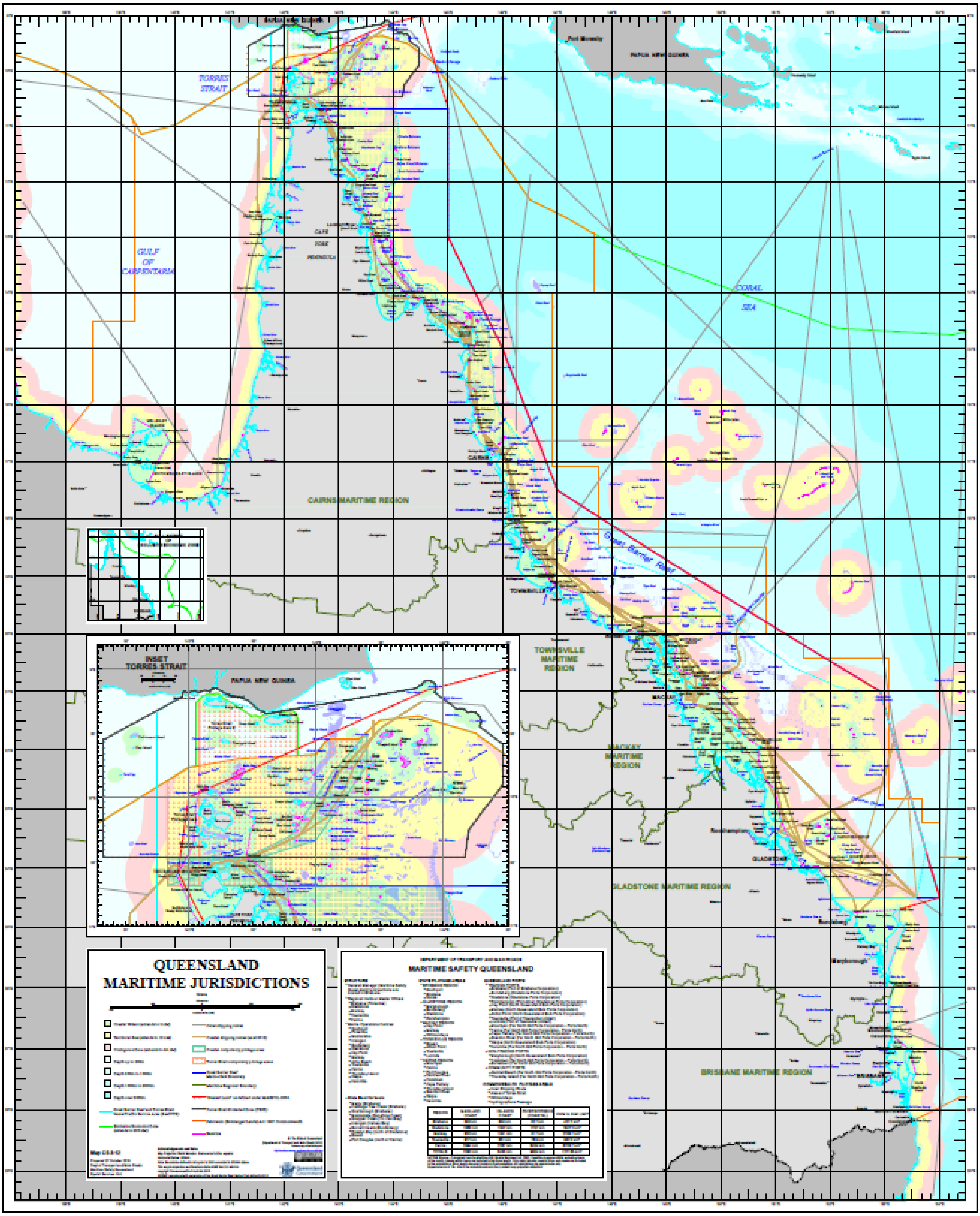
Appendix A

Queensland Maritime Jurisdictions Map


QUEENSLAND
MARITIME JURISDICTIONS
MARITIME SAFETY QUEENSLAND
TORRES STRAIT
GULF OF CARPENTARIA
CORAL SEA
Great Barrier Reef
CAPE YORK PENINSULA
CAIRNS MARITIME REGION
TOWNSVILLE MARITIME REGION
MACKAY MARITIME REGION
GLADSTONE MARITIME REGION
BRISBANE MARITIME REGION
INSET TORRES STRAIT
PAPUA NEW GUINEA
CAIRNS
TOWNSVILLE
MACKAY
GLADSTONE