



Reef infrastructure guidelines: tourist pontoons

IR Kapitzke, MJ Matheson, TA Hardy

James Cook University



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- Australian Institute of Marine Science
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- Great Barrier Reef Research Foundation
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FOREWORD

The Great Barrier Reef Marine Park Authority (GBRMPA) is very pleased with the co-operative approach between CRC Reef researchers, the tourism industry and managers that led to the successful completion of *Reef Infrastructure Guidelines: Tourist Pontoons*.

There is a diversity of infrastructure, including pontoons, marinas, groynes, underwater observatories, boat ramps, cables, artificial reefs, stinger nets, navigation aids, aquaculture facilities and a floating hotel that have been proposed or have been permitted in the Great Barrier Reef Marine Park (GBRMP). Tourist pontoons, anchored on outer reefs, are large, popular facilities and are the focus of these guidelines. The first tourist pontoon was a simple, barge-like structure that was permitted in 1983 at John Brewer Reef offshore from Townsville. There are now approximately 20 large pontoon-type facilities that have been permitted to operate in the GBRMP; they are spread between Agincourt Reef offshore from Port Douglas to Lady Musgrave Island. Pontoon design has evolved. Modern pontoons are purpose-built, multi-level structures in excess of 50 metres long. The largest floating structure that has been permitted in the GBRMP was the Four Seasons Floating Hotel.

There have been some environmental problems with installation and operation of pontoons. In some cases, there were negative impacts on the coral and fish near the pontoons. A major concern has been the risks associated with direct and indirect damage to the environment from a pontoon sinking or breaking free from its moorings in bad weather or cyclonic conditions.

Previously, GBRMPA advocated a precautionary approach to minimise the risk of damage from structures to the GBRMP. The Authority developed a policy that required all structures to be certified by an engineer to withstand category 4 cyclones. However, this policy was criticised by the tourism industry and designers as being too conservative and difficult to implement. GBRMPA responded by initiating discussions with experts on engineering who were developing an alternative approach based on the location of the structure, acceptable risk of failure and structure design life. These discussions were initiated in 1994 with the CRC for Ecologically Sustainable Development of the Great Barrier Reef (which later became CRC for the Great Barrier Reef World Heritage Area or CRC Reef) and in the intervening year there have been numerous staff changes, conference papers, meetings, field trips, reviews and several awards for excellence.

A challenge for all projects is to successfully integrate science and management. I believe that we have been very successful in this objective because of good communication between industry, science and management. The *Reef Infrastructure Guidelines* will form the basis of the GBRMPA's policy for structures in the GBRMP. The guidelines have been designed to provide new and existing operators, designers and managing agencies a 'World's Best Practice' framework and protocol to develop tourist pontoon projects from the concept phase, through feasibility, design and installation, to monitoring and operation.

The guidelines are a lengthy, detailed document and GBRMPA will be directly involved in communicating their importance to the tourism industry and the broader community.

Dr Adam Smith
Manager, Environmental Impact Management
Great Barrier Reef Marine Park Authority (GBRMPA)

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Mr Ross Kapitzke

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1 INTRODUCTION

	Summary
1.1	Purpose and scope
1.2	History of pontoon development in the Great Barrier Reef Marine Park
1.3	Modern tourist pontoon installations
1.4	Using these <i>Guidelines</i> in tourist pontoon planning, design and implementation
1.5	Recommended reading

Summary

- Tourism *operators/proponents, designers* and environmental *managers* should use this chapter to gain an overview of tourist pontoon development in the Great Barrier Reef region.
- Tourist pontoon facilities must provide for the protection and wise use of the natural environment. They must withstand severe tropical cyclones, meet stringent structure, function and safety requirements, protect cultural heritage, and mitigate impacts on the Reef.
- These *Guidelines* provide a systematic planning, design and implementation procedure to meet the multipurpose requirements for new or upgraded tourist pontoon projects.
- The *Guidelines* provide a framework and procedure for tourism operators/proponents and designers to undertake a development, and they provide a basis for managers and reviewers to assess the proposed projects.

The Great Barrier Reef region, comprising the Great Barrier Reef (GBR) and adjoining mainland coastline and continental islands, has great natural, cultural, aesthetic and economic importance for Australia (Figure 1.1). From a conservation viewpoint, declaration of the Great Barrier Reef World Heritage Area (GBRWHA) in 1981 provided recognition of its outstanding universal value and integrity as a self-perpetuating ecological system. Placement on the register of the National Estate in 1982 further recognised the special values of the Reef for the present community and for future generations in Australia. From a development viewpoint, the region is one of Australia's premier tourist destinations, it supports major fishing and shipping industries, and it encompasses a wide range of infrastructure within and adjacent to the Great Barrier Reef Marine Park (GBRMP).



Figure 1.1 The Great Barrier Reef Region

Source: State of the Great Barrier Reef World Heritage Area (GBRMPA 1999)

Infrastructure developments such as marinas, jetties, tourist pontoons and moorings in coastal, island and offshore environments in the GBR region must be carefully undertaken within this context of conservation and development. The objectives for management of the Reef are to balance its protection and wise use, and to provide for ecologically sustainable development. That is, Reef management aims to protect natural values and ecological processes, whilst providing for a range of uses that are consistent with the conservation of these natural features and processes.

The demand for sustainability within the Great Barrier Reef region applies particularly to the planning, design and implementation of offshore facilities such as tourist pontoons. These pontoons are semi-permanently moored floating structures supporting tourist activities, operated by shore-based tour companies, and normally located at outer reef sites. They must withstand harsh environmental loading such as severe tropical cyclones, and meet stringent requirements for structure, function and safety. Designs must also protect cultural heritage, and mitigate impacts on the sensitive coral reef environment.

Limited guidance has historically been available for the planning, design and implementation of reef and coastal infrastructure projects such as tourist pontoons. Tourist pontoons are unconventional installations, for which design criteria for tropical cyclone loading, and mooring configuration and design techniques have not been clearly established. Few designers have the relevant experience and expertise with this type of facility, and limited information is available on design inputs for winds, waves etc. The requirements for reef facilities differ from those applying in many other marine environments. Standardised coastal engineering analyses and assumptions may not apply to coral reefs, which are living substrates with unusual growth patterns that respond to wave action, currents, cyclones and other climatic variables (Plate 1.1).



Plate 1.1 The coral reef environment: Lady Musgrave Island Reef

The CRC Reef Research Centre (CRC Reef) was established in 1993 through the Australian Government's Cooperative Research Centres Program. CRC Reef is a knowledge-based partnership of coral reef managers, researchers and industry, whose purpose is to address and to develop approaches to sustainable development in the region.

These *Reef Infrastructure Guidelines: Tourist Pontoons* have been developed by CRC Reef to meet the needs of tourism operators, who own and operate tourist pontoons in the Marine Park, as well as the needs of the Great Barrier Reef Marine Park Authority (GBRMPA), which manages and regulates development activities in the region (Box 1.1). An interdisciplinary approach is used, embracing the fields of coastal and ocean engineering, environmental science and conservation management.

Box 1.1 Activities involved in development of Reef Infrastructure Guidelines: Tourist Pontoons

- assessment of reefal and coastal processes and environmental conditions for the GBR
- analysis of natural processes and environmental conditions that affect infrastructure development on the Reef
- analysis of infrastructure response and behaviour when subjected to severe climatic conditions and environmental loading such as during tropical cyclones
- evaluation of infrastructure design layouts and configuration for sustainable development
- development of a project planning and design methodology to account for physical, biological and socio-economic factors
- examination of case study projects in the region
- collaboration with marine park managers, tourism industry operators, designers, and researchers

1.1 Purpose and scope

These *Guidelines* have been prepared to assist tourism operators/proponents, designers, managers and reviewers in the planning, design, implementation, monitoring and management of tourist pontoon projects on the GBR (Box 1.2). They provide *proponents* and *designers* with a basis for understanding and applying sound engineering and environmental practice to pontoon development in coral reef regions. They also provide a basis for *environmental managers* in GBRMPA and other agencies, and expert *reviewers* engaged by GBRMPA, to apply these consistent principles when evaluating and assessing projects.

Both the experienced operator, who already has one or more pontoons in operation, and the not-so-experienced operator, who is proposing a pontoon development for the first time, will use these *Guidelines*. Planners and designers involved in these projects should have a good understanding of the requirements for development of structures in the marine environment, and previous experience with coral reefs in particular. Individual users, trained in engineering, naval architecture, ecology and conservation management etc., will require specialist input in areas outside their expertise.

Box 1.2 Objectives for Reef Infrastructure Guidelines: Tourist Pontoons

- Present an approach to planning and design in the coral reef environment that acknowledges function and safety requirements, as well as protection of coral reef ecosystems, and maintenance of social and cultural values.
- Provide a framework and procedure for tourism operators, developers or their representatives to undertake a tourist pontoon development on the GBR.
- Provide technical guidance for trained professionals (eg. engineers, environmental scientists, ecologists), with specialist input as required, to undertake the planning, design, implementation and monitoring of a tourist pontoon project.
- Provide a basis for management and regulatory agency staff and expert reviewers to assess proposed projects.
- Provide a reference document for policy makers, tourism operators, consultants, researchers, trainers, educators, students, contractors and others involved in infrastructure development in the coral reef environment.

The complexities of natural systems do not allow rigid rules or completely deterministic procedures for infrastructure development projects such as tourist pontoons to be set down in a cookbook type of approach. Prescriptive guidance is neither achievable nor appropriate because of the variety of conditions and circumstances encountered. The approaches and techniques presented here complement, but do not substitute for, professional experience or judgement based on site-specific evaluation and design. They are not intended as a design code requirement or standard. The characteristics of some complex projects may require more comprehensive investigation and design approaches than those outlined here. On the other hand, provided

conservative approaches are used and no adverse consequences and effects are likely to result, investigation and design methods for simple projects may be abridged in order to keep these costs low in relation to overall project costs. Users should understand the full scope of issues and procedures involved in pontoon projects and should approach the planning and design activities in a manner appropriate to the particular project.

The *Guidelines* are not intended to prevent enterprising and innovative solutions. Alternative approaches and techniques will be considered, but pontoon operators and designers should recognise that innovative alternatives may require greater investment of resources in research and development to demonstrate their suitability. Techniques may change over time as a result of new research, proven methods and modern technology. The *Guidelines* provide for this. For example, the information on hydrodynamic design and modelling presented in Chapter 5 and in the *Atlas of Tropical Cyclone Waves in the Great Barrier Reef* (Hardy et al. 2001) may be updated as hydrodynamic modelling results are developed. A more sophisticated dynamic mooring design approach may be introduced as an alternative to the simplified method presented in Chapter 7, and improved mooring and anchor systems may be developed as alternatives to those described in Chapters 7 and 8.

These *Guidelines* apply both to new tourist pontoon developments and to existing facilities that are to be upgraded or retrofitted to meet updated requirements. The document may also be used as a guide for other, smaller pontoon-type structures, such as swim platforms, helicopter pontoons, and floating decks for reef and jetty access, which are often used in the Reef environment in conjunction with the tourist pontoons. Many of the principles and details presented here for planning, design and implementation will apply to such auxiliary structures, even though their function, configuration and detail differ from tourist pontoons. Although developed for tourist pontoons on the Great Barrier Reef, much of the *Guideline* material will be relevant to other Reef facilities and coastal developments, and to other areas in the wider Pacific region and beyond.

1.2 History of pontoon development in the Great Barrier Reef Marine Park

Various structures such as boat harbours, jetties and underwater observatories existed within or adjacent to the GBRMP at the time of its declaration in 1975. Since the early 1980s, GBRMPA has grappled with the need for a comprehensive policy to manage new infrastructure developments and to regulate existing facilities. Over this period GBRMPA has progressively developed draft policies and guidelines for installations such as pontoons, mariculture, marinas, artificial reefs and sewage outfalls. Guideline users (project proponents, designers and marine park managers), however, have sought updated guidelines that can be applied to all infrastructure development applications. These calls for new guidelines have been heightened by the complex technical issues involved in infrastructure developments, the failure of several structures, an increase in the number of development applications, and the need for streamlining of, and consistency in, assessment.

A number of proposals were put forward in the early 1980s to develop stable, permanently moored tourism facilities on the Reef. The intent was to enhance visitor experience to the outer reef and to relieve pressures on the reef islands, which were under considerable stress from high levels of visitation. (The first tourist pontoon was installed on John Brewer Reef near Townsville in 1983.) These early installations were relatively simple platforms, providing activities such as snorkelling, scuba diving, fish feeding and glass-bottomed boat trips.

The *Four Seasons Floating Hotel* (FSFH) was installed on John Brewer Reef in 1988 as a major pontoon-type venture. Serious attempts were made to adequately consider environmental conditions in design, but few relevant planning and regulatory instruments to guide assessment of this type of offshore structure were available at the time. The venture folded after only a few years of operation, due to poor commercial performance and some technical inadequacies. Nevertheless, the project helped in developing an understanding of the requirements for design and installation of offshore structures on the Reef. It also provided a major milestone in policy development for tourism facilities on the Reef by addressing such things as the uncertainties surrounding the legal status of offshore structures located outside, what was at that time, Australia's three nautical mile declared territorial sea.

The tourist pontoon concept from the 1980s has subsequently grown to the point where a large proportion of first time and return visitors to the GBR now see the Reef from pontoons located from Lady Musgrave Island near Bundaberg to the Agincourt reefs near Port Douglas. Concerns raised by environmental groups, who initially opposed some aspects of the early installations, have largely been resolved, and pontoons have developed into bigger and more complex structures as a result of increasing markets, competitive innovation and technological advances.

Nevertheless, a number of installations have failed in some way, leading either to damage to the structure or to environmental damage to the coral reef in the immediate vicinity. One of the first attempts at a purpose-made pontoon installation (*Fantasy Island* on John Brewer Reef) sank at its moorings shortly after installation in 1988 and was salvaged from the reef after more than 18 months. Over the ensuing decade, a number of pontoons and ancillary facilities broke free from their moorings and were grounded on nearby reefs, damaging coral colonies and causing visual scars. Mooring chains have shifted, damaging coral colonies under and adjacent to the pontoon facilities in many installations. Operators, designers and managers have improved their understanding of technical aspects of the installations by examining the failures, and this has been reflected in some way through revised policies and guidelines for pontoon facilities.

In spite of this, many of the fundamental issues relating to design loading and criteria, and mooring design methods have remained unresolved. Draft pontoon guidelines, introduced by GBRMPA in 1989 and subsequently modified in 1991 and 1992, adopted a simple, precautionary approach. The *Draft Guidelines* stipulated a conservative Category 4 tropical cyclone design criterion to guard against failure or excessive movement of the moorings, which might endanger passenger or shipping safety or damage coral at the site. GBRMPA justified the conservative design criteria on the basis of the high value of the installations, their potential liability for human life and property losses resulting from mooring failure, and their obligation to protect the environmental integrity and the natural and cultural resources of the GBRWHA. GBRMPA further justified the conservative criteria on the basis of the uncertainties in hydrodynamic design, and difficulties in the accurate determination of wind-wave characteristics and design loadings in the coral reef environment.

On the other hand, many marine park tourism industry pontoon operators and designers have considered the design criteria to be excessive both in terms of safety and environmental protection, claiming that the criteria for pontoon mooring safety are not consistent with those for terrestrial installations. With regard to environmental protection of the reef, they have claimed it is futile to provide such conservative criteria for pontoon-related damage when the reef itself is damaged by cyclonic conditions. The argument here is that it is inconsistent and over rigorous to further limit the damage caused by the mooring chains for the same event.

Pontoon operators and marine park managers have improved practices for environmental protection of the pontoon site through monitoring programs, which have examined the effects of the pontoons on the local coral and fish populations. Whereas the first attempts to monitor the potential impacts of pontoons were initiated by tour guide companies in the 1980s, monitoring programs have since become obligatory for new pontoon projects.

1.3 Modern tourist pontoon installations

Modern tourist pontoons (Plate 1.2) are normally located on outer reef sites up to 60km from the coast. Serviced by fast catamarans, the typical large pontoon, takes up to 450 visitors per day, making a 1.5 to 2.5 hour journey from the coast, and staying 3 to 4 hours at the pontoon.

Pontoon facilities, structures and mooring arrangements have changed significantly over time. Whereas the first pontoons were simple, barge-like structures less than 20 metres long with very basic facilities such as covered areas and tables, the latest pontoons are purpose-made, multi-level structures in excess of 50 metres long. Improvised mooring systems on the original installations, incorporating chains attached to miscellaneous concrete and steel anchors, are now replaced with elaborate systems, carefully configured to protect the coral substrate. Difficulties in berthing experienced by service craft at the original pontoons have generally been alleviated at the new installations.

Modern tourist pontoons provide a range of activities, including snorkelling, scuba diving, underwater viewing, fish feeding, reef viewing and guided reef walks (Plate 1.3). In addition to the pontoon structure and moorings, the pontoon installation usually includes a variety of ancillary craft and facilities (Plate 1.4, Box 1.3). Dedicated access platforms are provided for scuba diving and snorkelling, and detached platforms are often provided for helicopters and seaplanes. As well as providing a berthing facility for the transit vessels, the pontoons house semi-submersible craft, glass-bottomed boats and dive tenders.



Plate 1.2 Tourist pontoon: Great Adventures, Norman Reef



Plate 1.3 Pontoon activities: snorkelling



Plate 1.4 Pontoon installation on the Great Barrier Reef
Source: State of the Great Barrier Reef World Heritage Area (GBRMPA 1999)

Box 1.3 Typical auxilliary craft and facilities

- catamaran for day trip service from coastal ports
- miscellaneous service craft (eg. dive tender, runabout, research vessel)
- semi-submersible craft
- swim pontoon
- helicopter and pontoon
- seaplane
- single point moorings for service craft

Aesthetics and physical comfort are important features for tourist pontoons, as they are for all recreational facilities located in coral reef areas. Structures must provide access to the surrounding water and coral, and the facilities must be easily installed and, under present Marine Park regulations, must be able to be completely removed. Floating platforms are most suitable for this purpose as they provide good access to the water, are installed in their complete condition and can be readily removed or relocated.

Extensive facilities are commonly built into the pontoon structure (Box 1.4). The most recently installed structures are multi-level platforms with underwater observatories, barbecue and dining areas, freshwater showers and overnight accommodation for caretaker staff. The components, layout and configuration of a pontoon installation depend on the function of the facility and the characteristics of the site (Chapter 6). Layout planning for pontoon installations has been refined in recent large projects, such as the Agincourt III pontoon near Port Douglas. Quicksilver Connections used an integrated resort-planning approach for this project, creating a physical model of the site and structure to assist in project planning and design (Plate 1.5).



Plate 1.5 Model of Quicksilver tourist pontoon for Agincourt Reef

Box 1.4 Pontoon facilities commonly provided

- docking facilities for craft (catamaran, semi submersible, miscellaneous)
- access platforms for snorkelling
- access platforms for scuba diving (introductory and experienced)
- underwater observatory
- catering area (barbeque, food preparation, food storage, servery)
- dining and lounge areas
- tables and seating areas
- souvenir and sales area
- sun deck
- canopy and sun awnings
- freshwater showers
- change rooms
- machinery space
- storage facilities (diving equipment, souvenirs, galley equipment)
- fresh water tanks
- grey water holding tanks
- overnight accommodation
- communication facilities and other instrumentation
- access ramps and stairwells
- miscellaneous protection devices (eg. bird netting)

If they are appropriately designed and managed, tourist pontoons are likely to have minimal adverse impact on the Reef. At the same time, they offer many benefits for reef-based tourism activities, providing effectively for high demand and high intensity use. They provide enhanced visitor appreciation compared with other offshore tourism operations, and an unparalleled opportunity for tourists to view and learn about the Reef. The comparatively unobtrusive nature of the large capacity installations causes conceivably less disturbance to a 'wilderness experience' than a large number of smaller vessels or structures.

Very few sites are available, however, in any particular area on the GBR that meet the strict criteria for suitability for pontoon installations. Protection of these sites is vital to the continued viable operation of the facility. Site selection criteria for pontoons are based on Marine Park policy and management provisions, as well as, operational, safety and customer considerations (Chapter 6). The characteristics of the pontoon site not only affect operational viability, but also constrain the design and construction of the installation. Sites may differ markedly in exposure to winds, waves and currents; in water depth and foundation conditions; and in coral cover and condition. These factors affect, for example, mooring type, configuration and capacity.

The type and configuration of the pontoon moorings and anchors are governed not only by the site characteristics, but also by the need to withstand tropical cyclonic loadings and to satisfy operating conditions (Chapters 6 to 8). Pontoons are normally located in shallow water, typically less than 20 metres deep. Prevailing weather conditions are predominantly calm, but severe conditions occur during tropical cyclones. The pontoons are moored over and adjacent to corals, hence the moorings and anchors must be strategically placed. Coral is sometimes relocated to provide clearance for mooring lines and anchors. This is a fragile environment, which may be subject to damage during installation and operation.

A multi-point mooring system, comprising a mooring line and anchor connected to each of, at least, four points on the pontoon, has conventionally been used. Various supplementary *cyclone mooring* arrangements, such as a single-point, cyclone swing mooring connected to the primary multi-point mooring system, have been employed for extreme conditions in some installations. This system usually incorporates lightweight mooring lines that hold the pontoon aligned into the prevailing winds under normal conditions. These lines are designed for release during cyclone conditions, allowing the pontoon to weathervane off the single-point mooring line and align with the cyclonic wind, sea, swell and current forces.

Various alternative *cyclone mooring* arrangements have been considered, in which the pontoon would be moved to an adjacent deep water sheltered mooring site prior to the onset of excessive weather conditions. Under this system, a manually operated winch or an automatic system would be used to relocate the pontoon to and from the cyclone mooring. It is not logistically possible to mobilise craft at short notice to rehook the pontoon to alternative moorings at the site, or to relocate the pontoon back to the mainland through rough seas.

The mooring lines and anchors for the multi-point mooring system usually comprise a conventional heavy mooring chain attached to one or more anchors on the seabed for each mooring leg. Conventionally, dumper blocks, clump weight sinkers and line buoys have been used in an attempt to dampen the dynamic effects of the mooring forces on the anchors and to reduce the likelihood of the mooring lines coming in contact with and damaging the corals. Recent modelling studies have shown that the manner in which dumper blocks and buoys have been used in the past has rendered them somewhat ineffective under severe conditions, exacerbating reef damage caused by movements of mooring lines (Chapter 7). More effective use of dumper blocks is required, in conjunction with heavier chains and consideration of innovative systems incorporating elastic elements (eg. bungy cords).

Various anchor types are used in the coral reef environment, including the dead weight, drag embedment, grouted screw and driven pin cluster anchors. Anchor types must be carefully chosen to provide the capacity appropriate to the environmental loading and substrate condition, to suit the ecological conditions, and to minimise construction disturbance. Various anchor types and methods for anchor design are discussed in Chapter 8.

Although only moored floating pontoon systems have conventionally been used on the GBR, fixed systems mounted on piles or caissons on the sea floor could be considered. To alleviate excessive forces on the structure from wave action associated with tide and storm surge induced water level fluctuations, the underside of these platforms would need to be six metres or more above low tide levels. Such a structure would require substantial foundations and would significantly detract from the amenity value of the Reef. A variation to this, which allows the structure to jack up and down with water levels, would be expensive and difficult to construct, operate and maintain in the harsh offshore environment. A possible compromise would be to fix most of the structure well above water levels, with a smaller adjustable (or floating) portion that would be lowered (or float) to cater for water-based recreation. Although offering security under adverse wave conditions, with reasonable foundation requirements, this type of facility has many drawbacks related to the poor visual impact, access difficulties to the water-based activities area, and generally poor amenity value in the marine environment.

One configuration that may provide for structural integrity while meeting the requirements for environmental protection, amenity and recreation access, is to moor a floating pontoon to fixed piers or caissons with short elastic mooring lines. This arrangement would avoid long mooring lines and minimise the area of the seabed affected, while complying with the need for flexible mooring systems, which withstand severe loading conditions.

1.4 Using these *Guidelines* in tourist pontoon planning, design and implementation

These *Guidelines* provide the framework and procedures for development of a tourist pontoon project from the *concept phase*, through *feasibility*, *design* and *installation*, to *monitoring* and *operation* (Box 1.5). The document helps tourism *operators/proponents*, *designers*, *reviewers*, *environmental managers* and other users to:

- understand the concept of sustainable development, and thus provide both for human use and for protection of natural ecosystem function
- understand the marine environment (in particular, the coral reef) and how it relates to pontoon installations
- follow a systematic project planning, design and implementation procedure meeting multi-purpose requirements

Box 1.5 Framework, procedures and elements presented and described in these *Guidelines*

- the prevailing *policy, legislative and management regime* for reef facilities
- a project *planning, design and implementation procedure*
- *guiding principles* for planning, design and implementation
- planning and design *steps and tasks*
- planning and design *tools*
- *techniques* for implementation of the facility and its components
- best practice *guides* and *checklists*
- *references* to relevant literature for detailed procedures or parameter values
- *examples* to illustrate analysis and evaluation

Chapter 2: Sustainable infrastructure development on the Great Barrier Reef provides tourism *operators/proponents*, *designers* and environmental *managers* with an overview of sustainability as it applies to tourist pontoon projects in the GBR. The core principles for sustainable development are presented, and the prevailing policy, legislative and management regime for the GBR is outlined. The desired approaches to multiple objective planning and design, project management and stakeholder consultation are presented.

Chapter 3: Project planning, design and implementation presents a 10-Step procedure, incorporating four phases from (1) *Concept*, through (2) *Feasibility*, and (3) *Implementation*, to (4) *Operation, monitoring and review*. The procedure provides a common basis for *proponents*, *designers* and *managers* to use in the planning, design and implementation of a tourist pontoon project. The GBRMPA permit assessment process is outlined and the manner in which this fits into the planning, design and implementation procedure is described. A summary of the component planning and design steps and tasks within each of the project phases is provided for *designers* and *managers*; the relevant personnel, planning and design tools, input and output data and other information are described, and links with other sections of the *Guidelines* are established.

Chapter 4: Site investigation and characterisation is an integral part of project planning, design and implementation, providing a framework for assessment of site conditions, and outlining site investigations that the *proponents* and *designers* may undertake. The likely data sources and methods of acquisition are described for each of the principal data areas that may be needed, and likely data acquisition needs through various phases of the project are noted.

Chapter 5: Design environmental loads outlines the environmental loading conditions that apply for a pontoon facility, and provides **designers** with a basis for determining design load components resulting from waves, winds and water levels. A risk-based approach is presented as the basis for **proponents, designers** and **managers** to determine the appropriate loading conditions associated with tropical cyclones. The manner in which the design loads are used in subsequent chapters to ensure the adequacy of the pontoon mooring system, the structural integrity of the pontoon elements, and the overall stability, buoyancy and safe operation of the facility is explained.

Chapter 6: Pontoon siting, layout and configuration provides the basis for **proponents, designers** and **managers** to determine the site, layout and configuration of the pontoon facility, which must meet multi-purpose requirements related to function, safety, environmental protection and amenity. The scope and method of the tasks, the objectives and criteria to be met, and the relevant personnel, planning and design tools, input and output data and other information are described.

Chapter 7: Mooring design presents detailed procedures for **designers** to use in the selection and design of the pontoon mooring systems, which is one of the most technically demanding and complex tasks covered in these *Guidelines*. Using design load data from Chapter 5, and based on the siting, layout and configuration features selected from Chapter 6, methods of analysis are described for determining forces and movements in the mooring system and for designing mooring components.

Chapter 8: Anchor design is to be used by **designers** in the selection and design of the anchors to be incorporated into the pontoon mooring system. Site data, design loading, siting, layout, configuration, and mooring design information from Chapters 4, 5, 6 and 7 are used to determine anchor loads and to assess capacities for various anchor types and configurations.

Chapter 9: Pontoon body and ancillary facilities provides basic information for **proponents** and **designers** to use in the configuration, design and specification of the pontoon body and other miscellaneous aspects of the pontoon facility. Principles and recommended practice for selection and design of materials, coatings, storage vessels, waste management and other facilities are provided.

Chapter 10: Pontoon installation, operation, maintenance and monitoring provides a guide for **operators, designers** and **managers** to use in post-design aspects of the pontoon project. The scope and provisions for installation, operation and maintenance are presented, and the manner in which these aspects are incorporated into project planning and design tasks and management plans is described. The requirements for monitoring both the facility and the environment throughout the above phases are also described.

The *Guidelines* address major issues and limitations that have conventionally applied to planning, design, implementation, maintenance and monitoring practices in tourist pontoon projects. The major issues identified by tourism operators, designers, managers, researchers and others, and the manner in which they are addressed in this document are summarised in Box 1.6. Further detail is provided in subsequent chapters.

Box 1.6 Major issues in pontoon planning, design, implementation, maintenance and monitoring	
Issue	How addressed in these Guidelines
Inadequate links between policy and practice to ensure sustainability for pontoon projects.	Links between policy, legislation and management planning, and project planning, design and implementation are established in the framework for sustainable infrastructure development (Chap 2).
Uncertain path of project assessment by GBRMPA.	The systematic planning, design and assessment procedure clearly outlines project requirements and provides an early indication of project suitability (Chap 3).
Inadequate project management for integration of planning, design and implementation activities by proponents and designers.	The integrated planning, design and implementation procedure reduces project delays and overall costs (Chaps 2, 3 & 4).
Incomplete consideration of multiple project purposes related to function, safety, environmental protection and amenity, by proponents, designers and GBRMPA managers.	Multiple project objectives are achieved through an interdisciplinary approach and the systematic procedure for project planning, design and implementation (Chaps 2, 3 & 4).
Over-conservative and irrational design criteria for tropical cyclone loadings.	A risk assessment approach is used to define design criteria for prevailing and severe conditions (Chap 5).
Inadequate calculation of the intensity of environmental loads due to winds, waves and currents.	Designers will use the <i>Atlas of Tropical Cyclone Waves in the Great Barrier Reef</i> for waves, and simplified approaches for winds and currents (Chap 5).
Deficient analysis and design of pontoon moorings.	A conservative but simplified approach is presented and reference is made to more sophisticated approaches if warranted (Chap 7).
Inadequate construction supervision and maintenance provisions for structural components.	Improved specification and quality control for installation, site testing and maintenance (Chap 10).

1.5 Recommended reading

Atlas of Tropical Cyclone Waves in the Great Barrier Reef. Available at:

<http://tsunami.jcu.edu.au>

Great Barrier Reef Marine Park Authority. 1994. *A 25 year Strategic Plan for the Great Barrier Reef World Heritage Area*.

Great Barrier Reef Marine Park Authority. 1999. *State of the Great Barrier Reef World Heritage Area*.

Hardy TA, McConochie JD, Mason LB. 2001. Great Barrier Reef Tropical Cyclone Wave Database. In *Proceedings of Coasts and Ports Conference 2001*. Institution of Engineers Australia.

Inglis GJ. 1996. Science and tourism infrastructure on the Great Barrier Reef: Learning from experience or just 'muddling through?'. In *Proceedings of The Great Barrier Reef Science, Use and Management, A National Conference*, Townsville, November 1996, pp. 319-333.