Scoping Study

eReefs Work Package 2 – Interoperable data and information systems

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eReefs is a collaborative project that will contribute to the protection and preservation of the Great Barrier Reef. It forms the first step in building comprehensive coastal information systems for Australia.

Using the latest technologies to collate data, and develop new and integrated modelling, eReefs will produce powerful visualisation, communication and reporting tools. This information will benefit government agencies, reef managers, policy makers, researchers, industry and local communities.

The Work Package 2: Interoperable Data and Information Systems component of eReefs is tasked with implementing standardised information handling infrastructure and with developing interoperable data transfer systems, model orchestration engines and water quality data standards to operationalise eReefs.

Work Package 2 will ensure that data products developed through other eReefs Work Packages and resultant eReefs composite datasets will be accessible to eReefs users and the general public through international open standards for data formats and transfer methods.
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Collaborators

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Executive summary

This scoping study has been prepared as a key initial deliverable for Work Package 2. It defines the business drivers for the eReefs system in sufficient detail to allow the subsequent design phase to proceed. The team expects that, as the scope of eReefs itself evolves, this document will be updated as the project proceeds.

The project team is using a methodology that uses reference models to describe the components of the information infrastructure and how they interact in meeting the business needs. The reference models used in this study, and to be used subsequently in the design phase are the RM-ODP (Reference Model for Open Distributed Processing) and its derivative the WRON-RM (Water Resources Observation Network Reference Model).

The RM-ODP defines an information system by way of 5 viewpoints: 1. enterprise – the who and why; 2. information – the what; 3. computation – the how; 4. engineering – the where; and 5. technology – using what. Business requirements and scope are detailed in the enterprise viewpoint and this document is structured accordingly.

The WRON-RM defines an information system that facilitates the provision and support of additional use cases when required. This is one of the high level goals for eReefs, to efficiently support new use cases without large-scale, costly redesign. WRON-RM is therefore considered as a critical input for this study.

The requirements gathering process was undertaken using a review and interview methodology. Documentation relevant and available to the team was reviewed and included as an input to this study. This was complemented by interviews with eReefs stakeholders. From this material, the major stakeholders and their interests have been identified along with high level use cases. The review and analysis has not been comprehensive, but rather sufficient to provide information for the project team to proceed into the next phase of Work Package 2, the infrastructure design.

This study states a number of non-functional requirements, which range from a set of architectural principles (derived from the WRON-RM), to enumerating existing systems which are relevant in one way or another to eReefs. The National Plan for Environmental information (NPEI) is the major system of relevance to eReefs and this is described in some detail. An explicit goal of the eReefs project is that it participate in the National Environmental Information Infrastructure (NEII).

In addition to the listing of existing infrastructure, a list of existing data products and their purpose has also been defined. This list will allow the design team to consider the broad range of information types when specifying information and service interfaces, in the information and computation viewpoints.
1 Background

1.1 The eReefs concept

eReefs is an information system concept with the goal of fundamentally changing the way the Great Barrier Reef is managed. It will be achieved by bringing together data, models, visualisations, reports and decision support tools in a distributed information system. It will span the whole of the Great Barrier Reef.

eReefs will not be a single information and management system in the traditional sense of an information system. eReefs is an integrated “system of systems” that spans the entire Reef and areas that affect the Reef - from paddock to catchment, estuary, reef lagoon and ocean.

The objectives therefore of eReefs are:

- To provide integrated, comprehensive and defensible information and forecasting capability as the basis for a decision-making system for the Reef
- To create a communication tool via the eReefs visualisation layer to enable information and decisions to be conveyed to a range of different audiences for regulatory, advocacy, governance and general user/consumer purposes.

The diagram below, courtesy of the GBRF, presents a conceptual description of the eReefs system. Note, that a key requirement is the integration of a large and diverse set of data sources, delivering into modelling and forecasting systems, which are then used as core tools for decision support and management. The conceptual model is divided into functional layers, which are akin to a traditional N-Layer architecture used widely in information system design. The layers of note are: data layers (Data Assimilation, Data Capture, Data Acquisition); business layers (Data Integration, modelling and forecasting); and Presentation layers (reporting and visualisation).
1.2 Information Systems

It is regarded as best practice to describe an information system using a reference model. The Organization for the Advancement of Structured Information Standards (OASIS) defines a reference model\(^1\) as an abstract framework to understand the relationship between the different components and entities of a system.

The Reference Model used for this Scoping Study is the ISO/IEC 10746 Reference Model for Open Distributed Processing (RM-ODP) (ISO, 1998)\(^2\). The eReefs design is further informed by the Water Resources Observation Network Reference Model (WRON-RM) [WRON-RM].

The RM-ODP provides a system description based on five viewpoints, each from a different system perspective. The viewpoints are:

1. **Enterprise** - describes the business needs/drivers for the information system. It defines who the stakeholders are and their interest in the system. It is also the viewpoint where other requirements are described, including non-functional requirements.
2. **Information** - describes what information flows around the system.
3. **Computational** - describes how the service interfaces are defined and interact. This is usually a list of services, together with a description of the interfaces used.
4. **Engineering** - describes where the various components of the system are located physically (topology)

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\(^1\) Oasis: [https://www.oasis-open.org/\]. See the following for Reference Model definitions: [https://www.oasis-open.org/committees/soa-rm/faq.php](https://www.oasis-open.org/committees/soa-rm/faq.php)

\(^2\) The standard, in 4 parts, is freely downloadable from the International Organization for Standardization at: [http://standards.iso.org/ittf/PubliclyAvailableStandards/index.html](http://standards.iso.org/ittf/PubliclyAvailableStandards/index.html)

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Figure 1 Conceptual diagram of eReefs system functional layers

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5. **Technology** - describes what specific components are required to perform the required system functionality

The RM-ODP and, following its pattern the WRON-RM, expects system design to progress through viewpoints in order, each one allowing for finer implementation detail in sequence.

1.3 **Scoping Study - Enterprise Viewpoint with additions**

This scoping study is equivalent to the Enterprise Viewpoint of the RM-ODP with additional information about existing components of eReefs. It describes the business requirements of the interoperable data infrastructure required to support the eReefs vision as well as the infrastructure already built or inherited from other projects.

The study is being prepared concurrently with the project activities, which presents difficulties in producing a comprehensive analysis of requirements in a timeframe which is useful to the dependant activities.

This document references other viewpoints of RM-ODP, but developing these will follow this work when the team moves into the design phase of the project.

1.4 **Methods**

Information for this study has been collected primarily by reviewing existing material relating to eReefs and undertaking interviews with a number of stakeholders (these are documented in Appendix A) which have then been synthesised into this document. The study also references work undertaken previously to define a similar infrastructure to support water resource management (WRON-RM). Where appropriate, we have drawn from that work as much of it is relevant to eReefs.
2 Enterprise Viewpoint

2.1 Overview

The Enterprise Viewpoint within RM-ODP focuses on the business purpose, scope and policies for the system from a system behaviour perspective. It describes the business requirements and in some cases, how to meet them. It is from these requirements that the high level Information and Computational Viewpoints can be developed.

The Enterprise Viewpoint also describes the relationship between this system and other relevant external systems and any associated non-functional requirements.

Section 2.2 lists the Business requirements for eReefs, Section 2.4 identifies and discusses the key architectural principles and requirements underlying the development of eReefs, and Section 2.5 identifies the principle system use cases for eReefs.

In the viewpoints following the Enterprise Viewpoint, the roles, components and information artefacts required to meet the requirements described here are further defined. Specifically, the Information Viewpoint identifies the nature of the information required to realise eReefs as an information distribution framework. The Computational Viewpoint defines the components that users will expect to interact with and how these relate to each other. In the Engineering Viewpoint, the business needs are transformed into an engineering solution design that addresses issues such as deployment, size and robustness. Finally, the Technical Viewpoint identifies the technical issues that must be validated in order to implement the eReefs architecture that is flexible enough to allow multiple technical platforms to co-exist and evolve. This is necessary as it is recognised that eReefs must provide a viable solution for the existing technical platforms and skills capacity of the various stakeholder communities.

2.2 Business Requirements for eReefs

2.2.1 ARTICULATED BUSINESS REQUIREMENTS

A key element of the Enterprise Viewpoint is to describe the business environment in which eReefs will exist and, in particular, the elements of this environment that have a direct effect on architectural choices.

The key business requirements that inform eReefs and which the project is required to deliver over the next 5 years are:

1. expanded and improved monitoring data through the application of the latest in measurement technologies and data delivery tools (e.g. mobile and Internet tools);
2. a suite of new and integrated bio-physical simulation models across paddock, catchment, estuary, Reef lagoon and ocean;
3. a framework to explore the impact of multiple factors such as temperature, nutrients, turbidity and pH, and to communicate this impact to the Reef stakeholders;
4. an interactive visual picture of the health of the Reef and its component parts, accessible to all; and
5. citizen science initiatives to engage the broader community on the health of the Reef — contributing monitoring information and learning about the Reef

2.2.2 GBRF GOALS

The Great Barrier Reef Foundation document\(^4\) to clarify the purpose of eReefs adds some additional insight to the planned purpose and requirements for eReefs and the high level use cases. This document states the main goal of eReefs is to quantify and assess water quality issues impacting the reef, though there is a recognition that eReefs will support other applications such as:

- coral-bleaching assessment and prediction,
- oil-spill dispersion prediction,
- and information to guide the tourism industry.

It goes further to state: “In broad terms, four end-use cases can be defined:

1. **Scenarios** – including land practice change and climate change
2. **Reporting** – including Reef Report Cards and State of Environment
3. **Incident Response** – including oil spills and ship groundings
4. **Forecasting** – including bleaching events, flood & storm predictions and water temperature forecasts for tourism and fisheries

These use-cases require varying combinations of hind cast, near real-time (NRT) and predictive products from both catchment and receiving water models as well as in-situ monitoring inputs.”

2.2.3 STRATEGIC GOALS

In addition to the specific business requirements listed in the eReefs initial documents related above, it is intended that there is potential for eReefs’ processes and products to be used for applications beyond the GBR and that it should be a project of national significance\(^5\). Two methods are employed to ensure this:

1. eReefs is a NPEI technical feasibility demonstration pilot project (see Section 3.1.1) and
2. that eReefs uses best-practice standardised data formats and procedures to allow for maximal interoperability but also employs architecture that allow for future format and standard adoption where possible.

From these two methods regarding the eReefs Strategic Goals, it follows that it is a business requirement that eReefs is compliant with NPEI nodes and that eReefs follow principles of Implementation Neutrality and other architectural principles stipulated in the WRON-RM.

2.3 Stakeholders, their interests and responsibilities

The list below enumerates the primary stakeholders of the eReefs system. Following the list, a brief description of the stakeholder’s anticipated interests and responsibilities is given. It is expected that the stakeholders themselves will contribute to future implementations of these descriptions in documents other than this report.

Primary eReefs stakeholders:

1. Great Barrier Reef Marine Park Authority (GBRMPA)
2. Australian Institute of Marine Science (AIMS)
3. The Bureau of Meteorology (BoM)
4. Queensland Government (QG):
   - Department of Premier and Cabinet (DPC)

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\(^5\) From “eReefs Value Proposition”, internal eReefs Project oversight committee documentation, March 2011.
● Department of Science, Information Technology, Innovation and the Arts (DSITIA)
● Department of Environment and Heritage Protection (DEHP)
● Department of Natural Resources and Mines (DNRM)
5. Commonwealth Science and Industry Research Organisation (CSIRO)
6. Great Barrier Reef Foundation (GBRF)
7. Federal Department of Sustainability, Environment, Water, Population and Communities (SEWPaC)
8. Natural Resource Management regional bodies in the GBR catchment areas (NRM Boards)
9. The general public as reef users

2.3.1 STAKEHOLDER INTERESTS

GBRMPA

It is anticipated that the initial reef management use cases of eReefs will come from GBRMPA staff as GBRMPA is the operational organisation entrusted with day-to-day reef management.

The GBRMPA interests are around the new data visualisations or visualisations of new combinations of datasets that eReefs will add to existing data sets. Specific GBRMPA interests articulated through specific GBRMPA user stories do exist but the overall interest is in seeing the eReefs value-add to existing data sets through their increased interoperability and new visualisations.

AIMS

AIMS conducts tropical marine research associated with the Great Barrier Reef and therefore its interest is less in day-to-day data access and visualisation and more in accessing data from longer time spans in order to understand reef processes. AIMS interests therefore are catered for through powerful eReefs component dataset access and dataset interoperability and less through visualisations.

BoM

The Bureau of Meteorology has a mandate to implement environmental intelligence products and services offered under the framework of the National Plan for Environmental Information. In addition to this, the BoM also has specific motivations for the implementation of specific datasets used by eReefs but also used for other purposes. One example of this is the DSITIA wave and tide data. Currently this data is ingested by the BoM for use by their National Tidal Centre and this interest in wave and tide datasets will continue regardless of eReefs. Consequently, data interoperability will feature as a major interest area for the BoM as they are dependent on external datasets they need to continue to access beyond the life of eReefs.

DPC, DSITIA, DEHP and DNRM

It has been problematic to join DERM/DSITIA’s interests and those of other eReefs stakeholders due to large differences their target reporting regimes. DERM/DSITIA is primarily interested in hind cast, year-long and very long-term datasets where as other eReefs stakeholders are interested in near-real time views of reef data.

One of the interests that DSITIA has in eReefs is in the delivery of current DSITIA and other QG sensory data as interoperable Web Services. Some existing projects such as TERN are already operating in part of this space and QG broadly supports such moves as this will lead to better data access for a multitude of projects including many outside eReefs.

DPC, as well as a general interest in eReefs, has a direct interest in the Report Card Automation part of eReefs. This automation should reduce the time taken between the end of field readings and the delivery of a report card that both DPC and other can use generate reef policy from.
CSIRO
As the primary research provider to facilitate eReefs, CSIRO’s main interests are in seeing the design and deployment of innovative ways of delivering, fusing and presenting reef data as well as the refinement and operationalisation of existing CSIRO models within the BoM. Through these enhanced models and new interoperability, CSIRO researchers aim to consume eReefs datasets for research in a manner similar to that of AIMS researchers.

GBRF
GBRF is the funding coordinator and one of the main eReefs partners. Their interest in eReefs is as a whole system that enhances the ability of operational agencies, such as GBRMPA, in achieving the GBRF’s mission to “identify, shape, fund and oversee research that will underpin protection and preservation of coral reefs”. Due to GBRF’s role in linking Australian business, research, philanthropy and policy, GBRF has an interest in seeing systems developed within eReefs that allow a wide range of data users but also data and infrastructure contributors. This may be realised in private sector components of the eReefs architecture.

SEWPaC
As the Federal agency for the environment, SEWPaC is leading the National Plan for Environmental Information (NPEI) initiative which aims to bring together all Australia’s efforts in national environmental information, building and maintaining this critical information infrastructure for the future. eReefs, along with the Information Platform for Bioregional Assessments is an NPEI ‘node’ and thus must conform to standards expected to be used by NPEI. As one of the first NPEI nodes, eReefs will act as a pathfinder with SEWPaC watching progress to inform further work.

NRM Boards
NRM boards within the GBR catchments will both provide data to and can be expected to take data from eReefs. It can be expected that there are a range of interests and skillsets available within the various NRM boards so minutely defining their interests without wider consultation is not appropriate. Engagement with the NRM boards will mostly progress through the QG and GBRF.

The general public
The general public needs to be considered a primary stakeholder in the eReefs project as the eReefs public documentation refers to the project as supporting the reef’s “industry and local communities”. We anticipate that certain visualisations of eReefs data, such as water quality, may be instantly useful to local communities and industry and may be used to manage their activities on the reef such as directing diving tours away from areas of low visibility.

2.4 Architectural Requirements and Principles for eReefs

There are a number of design constraints on the eReefs system that arise from the broader context within which eReefs must operate over a considerable period of time. These requirements stem from the necessity to support multiple stakeholders across two tiers of government and the private sector and the need for a flexible infrastructure capable of addressing emerging issues within the domain and exploiting new approaches, tools and data as they become available.

This long-term view characterises Open Distributed Systems – which can be upgraded or extended component-by-component and consequently has a lifetime expectancy at least an order of magnitude greater than individual technologies. This contrasts with ‘stovepipe’ or ‘warehouse’ approaches that tend

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6 http://www.barrierreef.org/Whoweare.aspx
to live only as long as the shortest lived of the technology platform, resourcing for data management processes, governance arrangements and client needs for centralised access.

The following sections describe architectural requirements and principles that eReefs, informed by the WRON-RM, needs to aspire to.

### 2.4.1 IMPLEMENTATION NEUTRALITY

Implementation neutrality is an attribute of an information system whereby components and interactions are specified in a way that does not dictate any particular implementation solution. Therefore, eReefs system will not assume particular technologies for implementation, as much as it is practically possible, (thus it is neutral with respect to specific platforms of implementation) but rather assume that derived implementations will change and evolve over time, while allowing eReef compatible systems to continue to function.

It is recognised that in some cases technologies are currently ‘locked in’ or ‘non-implementation neutral’ and form some sub-components of the eReefs system. Therefore, part of Work Package 2’s scope is to work out how best to translate or facilitate the translation of data from these systems into forms that can then be further transformed into current best practice interoperable formats.

An example is the use of netCDF for the delivery of remote sensing and model data. This technology also includes specific profiles such as netCDF-CF, which are defined with a particular implementation in mind. netCDF-CF is a best practice standard for sharing climate data and the BoM are moving towards using netCDF-CF for most of the datasets that it delivers that are of interest to eReefs. Given the comprehensive nature of CF-compliant datasets metadata, eReefs may be able to implement interoperable Open Geospatial Consortium (OGC) compliant data delivery by establishing a service layer on top of the netCDF-CF data layer.

**Recommendation 2.4.1:** WP2 team must advise and assist other eReefs work packages on how already implemented subcomponents, implemented using non eReefs approaches can be made eReefs compliant.

### 2.4.2 TIMELINESS, TRANSPARENCY, TRACEABILITY

The WRON-RM requires that end users be provided confidence in the information they are using through the provision of transparent and traceable data products in a timely fashion. For eReefs, this requirement shall be met through the reporting of provenance of data products. As such, eReefs Interoperable Data-Infrastructure Reference Model (eReefs-IDIRM) must consider, at least in summary, the internal processes affecting eReefs datasets and not just the final form of the products.

**Recommendation 2.4.2:** The eReefs-IDIRM must consider how the processing of datasets may change over time and what metadata needs to be reported to ensure that such changes are understood by end users or downstream systems if they affect data interpretation. This would be by way of an architecture that was amenable to the inclusion of a provenance system at a suitable point in time.

### 2.4.3 SCALABILITY

The eReef systems need to be future-proofed as much as possible. Ensuring the architecture can be scaled-up to accommodate new and different datasets, information flow and software developments, while minimising ‘private contracts’ is crucial to ensuring sustainability and scalability. eReefs is expected to have

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8 Being “CF-Compliant” means adhering to the NetCDF Climate and Forecast Metadata Convention, see [http://cf-pcmdi.llnl.gov](http://cf-pcmdi.llnl.gov)

9 A ‘private contract’ is an arrangement between two or more parties for the transfer of data that does not follow open, standard protocols. Private contracts may establish the simplest one-off method for data delivery but do not build in robustness, transparency or adaptability. Private contracts
a long life and the volume of data within eReefs may grow substantially in that time as more base datasets become automatically available and increase in resolution. Additionally, visualisation and data delivery systems can expect to be polled for data slices right from the start of the eReefs project.

**Recommendation 2.4.3:** The eReefs-IDIRM defined architecture should allow for growth of data and use.

### 2.4.4 SIMPLICITY

eReefs is a complex project that both end users and eReefs staff with specific areas of interest may not be able to conceptualise easily. There is a danger that this complexity could prevent use and efficient development within the building phase of the project. In aiming to embody the WRON-RM’s principle of simplicity so that eReefs is “as understandable as possible to its audience, and is simple enough to manage” [WRON-RM, p29], WP2 needs to consider delivering several levels of documentation that describe the project’s information architecture as a whole.

One of these levels will be for dataset producers and users. Another should allow non-technical system end users to understand the sorts of data products that they may be able to use in an interoperable fashion or request someone else to make available to them. It is not required of end users to understand the principles of interoperability, as data management may not be their area of expertise. It is important, however, that they be able to understand what datasets are potentially interoperable as these datasets may indicate requirements for which the proposed system architecture does not cater, but may be possible with minor additional work.

In general, the information systems themselves should be as simple as possible, while still meeting the eReef stakeholder requirements. Complex systems such as those required by the eReefs strategy, can only be technically sustained after the initial project development phase (when the budget available for continued operation is reduced) by ensuring re-use of established technology and standards wherever possible.

### 2.4.5 ADEQUATE DESCRIPTION

eReefs component subsystems need to be designed to deliver sufficient metadata to enable use of data and processes from those subcomponents without prior knowledge of their workings. This means more than just specifying query formats, as in some cases provenance information is required in order to sufficiently interpret data.

Some eReefs datasets are currently operational and do not include this information. For other subsystems which are currently being or will be operationalised, currently also they will not have the required metadata. These systems need to be made compliant with eReefs approaches and as per recommendation 2.4.1, the WP2 team will provide advice to and assist the broader eReefs project on how this might be done.

### 2.4.6 SEMANTIC ROBUSTNESS

Metadata definitions and vocabularies of terms needed for the correct interpretation of eReefs datasets must themselves be agreed to or be mapped to equivalent terms elsewhere defined and used in order to establish agreed point of commonality between stakeholders. In most cases this will mean adhering to international standards and definitions but in some cases it may mean creating new mappings between metadata systems where mappings currently do not exist and where the existing systems are already embedded and cannot be changed.

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may work and may even work well but they are not to be tolerated as they limit access to those privy to the contract, they lock in particular technologies and are liable to cease and be unable to be resurrected when organisational change occurs.
Recommendation 2.4.6: Since the main goal of eReefs is to “quantify and assess water quality issues impacting the reef”, it is imperative that eReefs-IDIRM attend specifically to water quality data and metadata requirements. Consistent with the overall approach of the eReefs systems, it is proposed that this be implemented existing using the international data formats such as WaterML2.0.

Appendix C: Data exchange format for water quality data investigates technical aspects of this issue.

2.4.7 NO PRIVATE CONTRACTS

Transparency, perceived objectivity, scalability and sustainability all require that the information is interoperable between multiple systems – the interoperability framework. This requires that no component is dependent on a private contract – that is, an agreement between two parties that input data, model outputs or software processing will be available in some private format, at some private location, available in some private way.

Existing systems tend to be built on ‘private contracts’, usually internal to an organisation. The information platform will need to identify these and where possible propose alternative, more sustainable approaches.

Of specific interest here to WP2 are assumptions about data interoperability. Interactions between distinct components of the eReefs system cannot operate under Private Contracts even if these systems exist within the same agency or are the subject of existing interagency agreements as this will potentially prevent future organisations accessing data at current and future subsystem delivery points.

Recommendation 2.4.7: To avoid the proliferation of hidden private contracts between eReefs subsystems particularly when they are entirely contained within a single agency, the eReefs-IDIRM should specify a compliance framework for testing the compliance of such systems and components.

2.4.8 GOVERNANCE

Ongoing governance of the eReefs information system is crucial to ensuring a return on investment. The stakeholders need to be engaged in the governance process, however eReefs must be able to evolve to meet priorities, changing technical environments and future data and tool availability. This evolution must be enabled without creating an unmanageable set of issues for the individual stakeholders.

WP2 must deliver a flexible architecture that can be re-purposed within reason. In general the best method to address this will be in ensuring standards compliance across data products and a prohibition on private contracts as discussed above.

Recommendation 2.4.8: eReefs-IDIRM must make recommendations as to how new services are to be added or deprecated i.e. how the system will evolve gracefully, by the provision of a governance roadmap.

2.5 eReefs Use Cases

Typically in software systems design, formalised Use Cases are collected and used to determine system functions or, more correctly, system/external actor interactions. Use Cases specify system user (human or machine) intent, not detailed action (Cockburn, 2006).

Not all of eReefs Use Cases have been, or can yet be collected due to the evolving possibilities of data access, which the new system will facilitate. For this reason, specific Use Cases have been sought out where they have been articulated in previous eReefs work, and there are several supply sources for them. In
addition, more generic Use Cases, based on predicted classes of use and informed by both the WRON-RM and recent USGS work\textsuperscript{10}, have been included to focus WP2 scope as much as possible.

### 2.5.1 USE CASE SOURCES

The following are sources of both generic and specific use cases:

- **The WRON-RM.** It provides generic system Use Cases through ‘key perspectives’ that facilitate the operation and maintenance of distributed computing systems in general.
- **Existing processes** that consume existing data sources that form part of eReefs. These Use Cases must not be broken by eReefs.
- **eReefs Existing Documentation.** eReefs project public documentation lists both generic and specific deliverables that can be rephrased as Use Cases.
- **eReefs User Reference Group User Stories.** eReefs management has assembled a list of User Stories from the eReefs User Reference Group. Some of the stories amount to generic Use Cases and some to more specific ones.
- **eReefs Work Package 4: Data Delivery.** WP4’s distinct parts provide generic Use Cases for data access and some specific Use Cases such as Reef Report Card access.
- **Perceived Stakeholder Requirements.** Generic Use Cases may be ascribed to eReefs stakeholders that have not yet been articulated through the User Reference Group. In some cases WP2 staff, due to better knowledge of eReefs systems, may be able to perceive a potential Use Case of interest to a stakeholder that is not yet perceived by that stakeholder..
- **External systems.** There exist systems external to eReefs that may become system Actors and will thus generate eReefs Use Cases. Currently the Atlas of Living Australia (ALA) is one such external system\textsuperscript{11}, TERN\textsuperscript{12} another and IMOS\textsuperscript{13} yet another..
- **Citizen Science groups.** eReefs contains a Citizen Science element that is currently in a scoping phase. Specific Use Cases from that project element are not available for this Scoping Study but generic Use Cases can be estimated by WP2 staff.

**Watchpoint 2.5.1.a:** WP2 team needs to stay engaged with the Citizen Science component of eReefs collaborative project and where possible ensure that the emerging approaches are consistent with eReefs-IDIRM.

**Watchpoint 2.5.1.b:** WP2 needs to stay engaged with the User Reference Group as further definitions of the end-user User Requirements become available.

### 2.5.2 GENERIC USE CASES

The generic Use Cases considered here are the six key system Use Cases listed in the WRON-RM (WRON-RM, p.iv). Adapting them for use with eReefs, they are:

1. **End User** - the process of accessing information through eReefs
2. **Data Provision** - the process of contributing data to eReefs
3. **Functionality Provision** - the process of contributing data processing services to eReefs
4. **Enablement and Governance** - the processes of controlling various components of eReefs
5. **Cross-business Domain Integration** - the processes enabling integration with other frameworks
6. **System Maintenance** - the processes associated with maintaining eReefs


\textsuperscript{11} http://www.ala.org.au/

\textsuperscript{12} http://tern.org.au/

\textsuperscript{13} http://www.imos.org.au/
2.5.3 SPECIFIC USE CASES

Specific Use Cases from the Use Cases sources listed above can be placed within these 6 generic categories. Table 1 below lists a few specific Use Cases derived from the User Stories (one user story may have generated more than one Use Case) along with their WRON-RM-defined generic Use Case (column “2nd Level Generic UC”) and WRON-RM-defined 6 key system Use Cases (column “Top Level UC”) listed above.

Note: The eReefs internal document “User Stories List” is required for cross-referencing the Use Cases in Table 1 below to particular, numbered, User Stories. Since this document is not public, each specific Use Case and its User Story number should just be taken to indicate distinct Use Cases which are sufficiently explained for the purposes of understanding here in the column “Actor: Specific Implementation”.

Table 2 lists a few other User Cases from eReefs Existing Documentation, Existing Processes, Work Package 4, Perceived Stakeholder Requirements, External Systems and Citizen Science grouped in a fashion similar to Table 1. Table 5 and
Table are extended versions of Table 1 and Table 2 respectively.

Table 1 User Story-derived Use Cases grouped by top level (WRON-RM) generic Use Cases (system Use Cases)

<table>
<thead>
<tr>
<th>Source (Story No)</th>
<th>Actor: Specific implementation</th>
<th>2nd Level Generic UC</th>
<th>WRON-RM Top Level UC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Tourist operator: View current sediment plume maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>GBRMPA User: View forecast sediment plume maps</td>
<td>End User predicted data access</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>GBRMPA User: View WQ timeseries for selected points from past, current and predicted loads maps</td>
<td>End User: data access, data discovery</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>GBRMPA User: View WQ timeseries beyond threshold mask for selected points from past, current and predicted loads maps</td>
<td>End User: data access, data discovery</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>GBRMPA User: View WQ timeseries for selected points from past, current and predicted loads maps for different predicted scenarios</td>
<td>End User predicted data access</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>This UC is for the Use Case. WP4 Report Card which has not been assessed here, see Section 3.3 for further details.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>22</td>
<td>QG: fuse river discharge, marine WQ maps sources and static target maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>SEWPaC: fuse river discharge, marine WQ maps sources and static target maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>eReefs: showcase eReefs product set</td>
<td>End User data discovery</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>GBRMPA: fuse NRT hydrodynamic visualisations with static risk maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>GBRMPA: fuse river loads with NRT hydrodynamic visualisations with static risk maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>GBRMPA: fuse fishing data with eReefs data</td>
<td>Data Provision: Create data resource, Implement profile</td>
<td>2</td>
</tr>
<tr>
<td>29</td>
<td>GBRMPA: compare land use trends with WQ map timeseries and 3rd party fish data</td>
<td>End User: data access Data Provision: Create data resource, Implement profile</td>
<td>2</td>
</tr>
<tr>
<td>54</td>
<td>QG: compare/fuse WQ trends with other data</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>55</td>
<td>eReefs: create and deploy new data sources</td>
<td>Data Provision: create data resource, Implement profile, Publish resource, Manage resource lifecycle</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>GBRMPA User: View WQ timeseries for selected points from past, current and predicted loads maps for different predicted scenarios</td>
<td>End User predicted data access</td>
<td>1</td>
</tr>
</tbody>
</table>

From Table 1 and its extended version Table 5, it can be seen that the majority of User Story-derived Use Cases are about eReefs data consumption although several Use Cases require data ‘mash-ups’ with non-eReefs datasets. Some of these datasets, for example fish counts, may become part of eReefs in future phases of work through Citizen Science initiatives.

Table 2 Other Use Cases grouped by top level (WRON-RM) generic Use Cases (system Use Cases)
While the Use Cases listed in Table 2 and its extended version Table 6, are much fewer in number than those in Table 1/5, they may and even should constitute a much larger proportion of the total set of Use Cases to be considered by WP2. They are more diverse in nature regarding their generic classifications and originate from many of the identified Use Case Sources (see Section 2.5.1).

### 2.5.4 USE CASE DISCUSSION

#### Scope of Use Cases

Bounds around the eReefs Use Cases are currently set by the scope of eReefs project as a whole as defined in the *eReefs Collaboration Agreement* signed by all partners in November 2011. The whole-of-project scope is:

1. The development and routine implementation of data and model interoperability standards and tools;
2. The delivery of marine water quality products based on near real time remote sensing (water quality dashboard);
3. The development and delivery of ‘Citizen Science’ applications;
4. The establishment of the monitoring, modelling and reporting infrastructure required to operationalise the eReefs System;
5. Integration with catchment models;
6. Real time received water quality models;
7. A model orchestration engine to integrate models;
8. Reporting and visualisation tools for standard and customised reporting.

While currently it is easy to determine whether some Use Cases do or do not fit within the above scope, there appears to be some distance between the eReefs scope and the current and expected future resources of eReefs. This means Use Cases may be articulated that, although within scope, are not technically feasible. Additionally, not expressly listed in the project scope above is any direction regarding the integration of eReefs with the NEII (see Section 3.1.1) thus Use Cases supporting the use of eReefs with NEII is technically not within scope.

It is expected that the eReefs project scope and thus the bounding scope for Use Cases will be further articulated in eReefs communication documents in late 2012 and early 2013.

**Watchpoint 2.5.4.a:** WP2 must continue to watch for scope changes in future eReefs project documentation.

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Formulation of Use Cases

Overall, the Use Cases listed here are not sufficiently formalised and detailed to begin software system design. Even though a Scoping Study such as this does not require complete Use Case articulation, it is hard to extract sensible Use Case candidates from some of the more general user stories.

Use Case Sources

Although seven sources of Use Cases have been identified (see Section 2.5.1), many Use Cases that the authors perceive will be critical to eReefs have not been forthcoming from some of them, even informally. For example, there are very few Use Cases from the External Systems source and yet it imperative that eReefs be able to interacts with many external systems such as TERN, other NPEI nodes and also other standardised environmental data systems, such as the Atlas of Living Australia etc.

Generic Use Cases

The Top and Second level generic Use Cases articulated in the WRON-RM are incomplete as of WRON-RM Version 0.1 [WRON-RM]. That document gives no breakdown of the Enablement and Governance, Cross-business Domain Integration or System Maintenance generic use cases as it does for End Use, Data Provision and Functionality Provision. It is therefore not possible to undertake a detailed analysis of Use Cases within these un-detailed categories to the same extent as the detailed ones and thus complete the reference model analysis.

Recommendation 2.5.4.b: The WP2 team must investigate further articulations of RM-ODP derivative RMs created since the WRON-RM v0.1 and the AWRIS\(^{15}\) system which implements much of the WRON-RM’s theory in order to better understand the breadth of Use Cases that can be expected in these generic Use Case categories.

Summary

From even the most cursory distillation of informal Use Cases from some of the Use Case sources, it is obvious that eReefs has a more-than usually difficult user requirements scope. eReefs is building new infrastructure to support a range of new Use Cases, mainly around new or developed data product access, but it also has product legacy, external systems and future systems interconnections to manage and the even more challenging requirement that eReefs evolves to allow resources development and addition.

To facilitate specific actions by WP2 and to constrain scope, specific Use Cases need to be articulated and actioned otherwise it is impossible to know where WP2’s work will end.

Recommendation 2.5.4.c: The eReefs-IDRIM should specify a methodology for subsequent use case capture and inclusion of those requirements into the eReefs system. This methodology will be applied on subsequent phases of the eReefs project expanding the capability so that it can deliver on those identified needs. The additional use cases captured by this methodology must:

a. be bounded by continued consideration of eReefs goals.
b. consider how Use Cases in the Enablement and Governance, Cross-business Domain Integration and System Maintenance generic Use Case categories should be handled or if Reference Models beyond the WRON-RM are needed
c. consult with the full range of Use Case sources.
d. provide templates or direction to Use Case providers that enable them to return usefully formulated Use Cases
e. list lodged Use Cases from all sources and actions against them so that they may be an ongoing reference for the project.

3 Existing Infrastructure

3.1 Relevant external systems

eReefs exists in an environment where there are both many agencies supplying and using data and also many communities standardising data sets for interoperability. Some of these communities and standardisation projects use formats and systems that are of particular relevance to their community only. eReefs cannot afford to do this and must instead ascribe to the most widely supported formats and processes if it is to be relevant to as large a number of communities as possible. This means that work converting specific communities’ particular data formats and processes into more general formats and processes is core business for Work Package 2.

Some of the relevant systems external to eReefs are:


- **BlueLINK** – [http://www.bom.gov.au/bluelink/](http://www.bom.gov.au/bluelink/) a $15m project to deliver ocean forecasts for the Australian region. BlueLINK is already operational and its systems are ‘locked in’. BlueLINK provides inputs into the eReefs hydrodynamic models.


- **NCRIS/IMOS** – [http://imos.org.au/](http://imos.org.au/) the National Collaborative Research Infrastructure Strategy’s Integrated Marine Observing System. IMOS is designed to be a fully-integrated, national system, observing at ocean-basin and regional scales, and covering physical, chemical and biological variables.

- **NCRIS/TERN** – [http://tern.org.au/](http://tern.org.au/) Terrestrial Ecosystem Research Network. The Terrestrial Ecosystem Research Network (TERN) is an overarching and integrated network designed to serve ecosystem research in Australia. TERN’s ACEF16 project shares staff with eReefs and is interested in similar data and access to it using standardised data formats. eReefs needs to coordinate activity with TERN.

- **NMOC** – the BoM’s National Meteorological Operations Centre. This is the Centre that will ultimately operationalise BoM output products.

- **NPEI** – [http://www.environment.gov.au/npei/index.html](http://www.environment.gov.au/npei/index.html) The National Plan for Environmental Information. This initiative brings together all our efforts in national environmental information, building and maintaining this critical information infrastructure for the future. eReefs will be an NPEI node and thus will have to conform to NPEI specifications.

- **Reef Atlas** ([http://www.aims.gov.au/docs/research/research-highlights/reef-atlas.html](http://www.aims.gov.au/docs/research/research-highlights/reef-atlas.html)) The vision for the Atlas is that it will be a knowledge repository containing data, maps and information on topics relevant to the GBR and its catchments. Relations between eReefs’ static datasets and those of the Reef Atlas need consideration.

- **Reef Plan** - ([http://reefplan.qld.gov.au](http://reefplan.qld.gov.au)) Is a collaborative program of coordinated projects and partnerships designed to improve the quality of water in the Great Barrier Reef though improved land management in reef catchments. eReefs will be extremely relevant to the Reef Plan and should consider its needs in design.

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Of these systems, the NPEI most directly affects eReefs design.

**Recommendation 3.1.a:** WP2 team to create an index of the data types, exchange formats and, most importantly, the level of standards-compliant, service-delivered data adoption used by the major external systems relevant to eReefs as a reference for eReefs’ technical teams and users.

**Recommendation 3.1.b:** expectations of eReefs’ function should be sought from the external systems’ stakeholders through a WP2 workplan in collaboration with eReefs project management to ensure good relations. This should involve detailing External System Use Cases.

### 3.1.1 The National Plan for Environmental Information (NPEI)

The Bureau of Meteorology was tasked in 2011 to develop a plan for improving access to environmental information across Australia. This plan, known as the National Plan for Environmental Information (NPEI), will propose a framework to address the many institutional and jurisdictional barriers to accessing information as well as provide a technical infrastructure through which access will be achieved.

The National Environmental Information Infrastructure (NEII) is still in its infancy. However, some early work has been undertaken to describe at a very high level, the key concepts and components. Figure 2: High level architecture for NEII lists some of these components.

When complete, the NEII technical documentation will provide enough information to allow potential NEII contributors to participate in NPEI. Such participation will be achieved through implementing NEII nodes.

![Figure 2: High level architecture for NEII](from pers. com. with Dr Andrew Woolf, BoM)

To assess the technical feasibility, the NPEI program is supporting a series of pilots of which eReefs is one.
Another NPEI pilot project is the Bioregional Assessment (BRA) Information Platform being funded by the Office of Water Science (OWS) which is an office within the Australian government’s Department of Sustainability, Environment, Water, Population and Communities (SEWPAC). This project will initially implement two NEII Nodes (Water and Geosciences) and build client tools to access information required to support the Bioregional Assessment process. A high level architecture of Phase 1 for this project is shown in Error! Reference source not found..

A core technology of the NEII Nodes for the BRA Information Platform project will be the Spatial Information Services Stack (SISS). SISS is a suite of tools based on open standards, built specifically for supporting the sharing of information between multiple organisations. It has been deployed in multiple Australian Government agencies and research organisations and is used with a range of data types. As SISS is built on open source technologies such as GeoServer and GeoNetwork others are encouraged to utilise the stack and assist in its development. Key capabilities of SISS are:

- Spatial data services, features and maps
- Timeseries observation data, features and observations
- Cataloguing services providing an ISO19115 metadata profile for discovery
- Vocabulary services to enable data integration

Recommendation 3.1.1.a: WP2 must ensure eReefs is compliant with the NPEI.
Recommendation 3.1.1.b: eReefs should aim for the maximal reuse of the technologies to be used by NEII, especially SISS.

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17https://www.seegrid.csiro.au/wiki/Siss/WebHome

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3.2 Existing eReefs datasets

For eReefs, significant components of the infrastructure anticipated for its use already exist and are in differing stages of operationalisation. Most of these components have well established Use Cases and functional requirements for projects outside eReefs. This Scoping Study lists the major datasets from existing infrastructure components and, taking the justification of their existing formats as a given, details the implications for WP2 work needed for their use within eReefs.

The eReefs project is being implemented through four Work Packages. Work Package 2: Interoperable Data and Information Systems, is responsible for this Scoping Study and for the overall eReefs architecture. Work Package 4: Reporting and Visualisation handles the final eReefs data and information delivery. Work Package 1: Enhancing existing monitoring efforts and Work Package 3: Operational Catchment and Marine Modelling are the project components that have so far generated or obtained the majority of the eReefs infrastructure Key Artefacts.

Infrastructure for one of Work Package 4’s sub-projects, the Reef Report Card, has existing infrastructure similar to that of its anticipated final form that has already been implemented for the Health-e-Waterways Report Card\(^{18}\). This document is not able to identify a sustainable and scalable mechanism to deliver inputs to the Reef Report Card due to a lack of knowledge of the Report Card project’s own scope. It is expected this will become apparent shortly with the release of the Report Card project’s own Scoping Study.

Table 3 summarises existing eReefs datasets (models or data sources) and their individual input and output data streams. Following the table, notes are given on each individual data streams in Section 3.2.1 (Input) and Section 3.2.2 (Output). WP2 scope, regarding existing datasets, is given in Section 3.2.3.

Table 3 Summary of existing information exchange infrastructure, formats and status by Work Package (next page)

\(^{18}\) See [http://www.health-e-waterways.org/reportcard](http://www.health-e-waterways.org/reportcard) for the online SEQ Health-e-waterways report card
<table>
<thead>
<tr>
<th>WP</th>
<th>Dataset Name</th>
<th>Dataset Location</th>
<th>In/Out</th>
<th>Datum/Data Name</th>
<th>Source/Destination</th>
<th>Format(s)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Continuous Water Quality Monitoring</td>
<td>DERMS</td>
<td>Out</td>
<td>River Gauge Data</td>
<td>DERM (<a href="http://watermonitoring">http://watermonitoring</a>. derm.qld.gov.au/host.htm)</td>
<td>HTML/text fixed format files FTP dump</td>
<td>Operational</td>
</tr>
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<tr>
<td>1</td>
<td>Operational Marine Remote Sensing</td>
<td>BoM (NMOC)</td>
<td>In</td>
<td>MODIS imagery</td>
<td>BoM MODIS base stations</td>
<td>MODIS raw data</td>
<td>Operational</td>
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<td></td>
<td>Operational in Dec 2012/Feb 2013</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ocean Colour maps</td>
<td>BoM public web</td>
<td>OpenDAP THREDDS netCDF 4 (CF)</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td>ReefTemp</td>
<td>BoM public web</td>
<td>OpenDAP THREDDS netCDF 4 (CF)</td>
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<td></td>
<td>Operational in Dec 2012/Feb 2013</td>
</tr>
<tr>
<td>3</td>
<td>Hydrodynamics</td>
<td>BoM (NMOC)</td>
<td>In</td>
<td>River gauge data</td>
<td>DERM (<a href="http://watermonitoring">http://watermonitoring</a>. derm.qld.gov.au/host.htm)</td>
<td>HTML/text fixed format files FTP dump</td>
<td>Operational</td>
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<td></td>
<td>ACCESS-G (ocean circulation)</td>
<td>BoM subscription list</td>
<td>netCDF 3 netCDF 4</td>
<td>Operational Sep 2012</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ACCESS-R</td>
<td>BoM subscription list</td>
<td>netCDF 3 netCDF 4</td>
<td>Operational Sep 2012</td>
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<td></td>
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<td></td>
<td></td>
<td>Wave &amp; tide</td>
<td>BoM</td>
<td>-</td>
<td>Internally modelled</td>
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<td></td>
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<td>measurements</td>
<td>DERM</td>
<td>DERM</td>
<td>Tide: yearly delivered to BoM's NTC, Wave, so far unknown</td>
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<td>Altimetry &amp; Sea</td>
<td>BoM</td>
<td>MODIS</td>
<td>Outputs from WP1</td>
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<td></td>
<td>surface Temp</td>
<td>DERM</td>
<td>DERM</td>
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<td>Hydrodynamic model</td>
<td>CSIRO now (Aug 12)</td>
<td>OpenDAP THREDDS netCDF 4 (CF)</td>
<td>Dec 2012</td>
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<tr>
<td></td>
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<td></td>
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<td>output layers</td>
<td>BoM public web (Dec '12)</td>
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<td><strong>3</strong></td>
<td>Sediment, BGC</td>
<td>BoM (NMOC)</td>
<td>In</td>
<td>River sediment &amp; nutrient loads</td>
<td>DERM</td>
<td>FTP</td>
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<td><strong>3</strong></td>
<td>Integrated RWQ Model</td>
<td>BoM (NMOC)</td>
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<td>In</td>
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<td><strong>3</strong></td>
<td>CONNIE2</td>
<td>CSIRO</td>
<td>Potential</td>
<td>Ocean circulation</td>
<td>CSIRO public web</td>
<td>netCDF behind the scenes, web graphics on top</td>
<td>Operational, requires continuous hydrodynamic model outputs as inputs</td>
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<tr>
<td></td>
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<td></td>
<td>Out</td>
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<tr>
<td><strong>4</strong></td>
<td>Reef Report Card inputs(^{19})</td>
<td>QG-DAFF</td>
<td>In</td>
<td>Land practice data</td>
<td>Manual entry</td>
<td>Word/Excel</td>
<td>Current</td>
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</tr>
<tr>
<td><strong>4</strong></td>
<td>reef Report Card outputs(^{20})</td>
<td>UQ then QG</td>
<td>Out</td>
<td>Reef Report Card online</td>
<td>Automatic delivery to web</td>
<td>HTML (PDF to be phased out)</td>
<td>As per Report Card Scoping Study</td>
</tr>
</tbody>
</table>

\(^{19}\) This information is taken from Version 2.0 of the Automated Reef Report Card: Scoping, Requirements and Preliminary Design Study by Jane Hunter & Andre Gerber

\(^{20}\) As above.
3.2.1 INPUT DATASET DESCRIPTIONS

River Gauge Data

Currently river gauge data for all the GBR catchments are available online at http://watermonitoring.derm.qld.gov.au/host.htm and also internally within the BoM’s forecast system (AIFS).

The Terrestrial Ecosystem Research Network (TERN)’s Australian Coastal Ecosystem Facility (ACEF) also requires access to the river gauge and other data. WP2 will work with ACEF and the appropriate Queensland government departments to ensure proposed data delivery strategies meet eReef requirements. Emphasis will be on establishing mechanisms that use existing data delivery strategies that can be deployed and sustained by the data custodians.

The continuous monitoring datasets of interest to eReefs are:

1. Point source discharge data (DSITIA)
2. Estuarine and Marine EHMP Water Quality data (DSITIA / Healthy Waterways)
3. Central Queensland Ambient Water Quality Monitoring Data (DSITIA)
4. Surface Water Ambient Network (DSITIA). This includes river loads.
5. Wave monitoring (DSITIA)
6. Storm tide monitoring (DSITIA)

The river monitoring point locations as used by Queensland Government do not necessarily match those suited for use with the hydrodynamic modelling. Establishing appropriate monitoring point translations, such as between the Australian Hydrological Geospatial Fabric (Geofabric)21 and Queensland Government locations, will be required.

Watchpoint 3.2.1.a: WP2 should work with TERN and its subcomponents (ACEF: Jonathan Hodge, AusCover: Matt Paget, data synthesis in general: Siddeswara Guru) to facilitate compatibility.

Watchpoint 3.2.1.b: The provision of river gauge data from QG to CSIRO is currently done using non-standard methods. Delivery of this data using eReefs standards compliant methods is of high priority and should be scheduled as soon as possible and the eReefs team, including WP2 should facilitate this.

Recommendation 3.2.1.c: WP2 should reference all geospatial feature indexes against an eReefs geofabric which references the Australian Hydrological Geospatial Fabric22.

Recommendation 3.2.1.d: WP2 implementation team should work with QG to enable the reporting of gauge and WQ data with against eReefs Geofabric Contracted Catchment identifiers, rather than local catchment identifiers or names.

MODIS Imagery

Currently raw MODIS data from Australia’s MODIS receiver stations is converted to MODIS imagery and stored at either the National Computing Infrastructure (NCI) or at the BoM. Centrally stored MODIS data is used as inputs to WP1’s remote sensing processes, which receive the raw MODIS data and deliver processed and reprojected data products.

MODIS data in its raw form appears not to be relevant to WP2 interoperability work. Processed imagery is of interest to eReefs and is listed below in ReefTemp and Ocean Colour data stream outputs.

The MODIS data source will soon be replaced with data from a new satellite, VIIRS, which will entail a substantial replacement of the whole processing chain used for derived products and such sensor changes can be expected to be on going.

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**Recommendation 3.2.1.e:** The eReefs-IDIRM should allow for the future delivery of MODIS-equivalent imagery from successor satellites ensuring continued use of this imagery within eReefs.

**Citizen Science Data**

Currently little is known about the form of the Citizen Science data. It is expected that several volunteer groups will engage with the GBRF so that initiatives regarding citizen science data collection, processing, QA and storage may be delivered to the many citizen science groups already working on the reef.

Such initiatives will store data using a Telstra or Microsoft provided cloud storage facility. Some visualisation may occur through Microsoft’s EyeOnEarth platform\(^\text{23}\).

Citizen Science data in its currently loosely scoped form cannot be considered in this Scoping Study to WP2 interoperability work at this stage.

**Watchpoint 3.2.1.f:** WP2 team keep an open dialogue with WP1 and other Citizen Science components of eReefs to ensure the interoperability of datasets through standards compliance when they become available.

**ACCESS-G**

The Bureau of Meteorology’s (BoM) ACCESS-G global numerical weather prediction model data\(^\text{24}\) is required as an input into the hydrodynamic modelling component of eReefs. This data supplies boundary conditions for the hydrodynamic models. Data from this model is available publicly with subscription from the BoM in netCDF and compressed text grid formats. This data is used by many projects as well as by eReefs.

This input data set does not require further consideration by WP2 unless WP2 wishes to address the conversion of netCDF into other data formats.

**ACCESS-R**

The Bureau of Meteorology’s (BoM) ACCESS-R regional numerical weather prediction model data\(^\text{25}\) is required as an input into the hydrodynamic modelling component of eReefs. This data supplies boundary conditions for localised components of the hydrodynamic models. Data from this model is available publicly with subscription from the BoM in netCDF and compressed text grid formats.

This input data set does not require further consideration by WP2 unless WP2 wishes to address the conversion of netCDF into other data formats.

**Wave and tide measurements**

Currently CSIRO’s 4km and 1km hydrodynamic modelling, uses modelled wave and tide data for the boundary conditions. It is expected that future refinements of these models, or their replacements within the BoM, will require near-real-time measured data from QG and private (ports) monitoring networks.

Currently, sea level data (tide) is currently delivered to the BoM’s National Tide Centre on an ad-hoc basis with a sub-hourly time-step through an FTP data transfer. This data is used to check the tide models but is not directly used by the models. The National Tide Centre is currently negotiating an agreement with Ports Australia to receive high-resolution NRT data. Progress on this needs investigation.

**Watchpoint 3.2.1.g:** when higher resolution tide data is made available to the BoM, it should be delivered through service architecture. If the data is not for public consumption, service architecture with appropriate security should be used.

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\(^\text{23}\) [http://watch.eyeonearth.org/](http://watch.eyeonearth.org/)


Wave data is delivered from QG to the BoM’s Marine Observations Unit at hourly or sub-hourly intervals and is displayed online both on QG websites and on BoM websites. But it is displayed in graph form only (i.e. not raw data form). Raw data cannot be delivered due to issues surrounding paying for the data. Much of the wave data comes from 3rd party suppliers, mainly port authorities. QG is happy for the BoM to use the wave data for internal processes and for limited, graph, display but not for public data delivery.

According to the QG (DNRM) manager of wave monitoring, the existing wave monitoring network does not have sufficient number of stations for effective use by the BoM’s possible future hydrodynamic model implementations on the GBR. DNRM is therefore interested in additional sources of funding to help them acquire more wave monitoring buoys.

**Recommendation 3.2.1.h:** eReefs should address the private contract between QG and the BoM and aim for service data delivery. If data in its raw form is not to be made available to the public, a security layer should be implemented as with tide data above.

Near-real-time wave and tide data are some of the datasets to be delivered through TERN/ACEF (see ‘River Gauge Data’ above).

**Watchpoint 3.2.1.i:** WP2 needs to ensure that the information infrastructure design is made available to TERN.

**Recommendation 3.2.1.j:** The eReefs-IDIRM should consider the delivery of private data delivery using standardised service data services with additional security layers.

**Altimetry & Sea Surface Temperature**

These datasets are consumed by the hydrodynamic model and are delivered to it internally from the BoM’s satellite data feeds. Altimetry data is NASA’s Jason-2 satellite data calibrated with Australian ocean height sensors and Sea surface Temperature (SST) data from several satellite sources calibrated with sea temperature sensors in Australian waters.

These input data sets are used by many projects outside eReefs, of particular note is the use the Group for High Resolution Sea Surface Temperature (GHRSSST) makes of SST data as they standardise SST processes.

SST data is also an input to ReefTemp which forms part of the Water Quality Dashboard.

**Recommendation 3.2.1.k:** Since altimetry and SST data are delivered to projects outside eReefs, for example to the GHRSSST, and since they are also core eReefs data sets, those data need to be delivered as standardised services rather than as ‘private contracts’. Service delivery will reduce both the effort of delivering the data to multiple locations shortly (GHRSSST & eReefs) and potentially further locations in the future as well as the risk of new services wishing to use the data facing unacceptable delivery establishment costs. This delivery should be done once and done correctly. WP2 must document current processes in more detail and determine a roadmap to standardisation.

**Recommendation 3.2.1.l:** It is unclear if SST data used by different eReefs projects, particularly ReefTemp & WP3, is the same data. WP2 needs to convene a meeting between WP1 & WP3 to reach clarity.

**River sediment loads data**

Currently the sediment and BCG models are not able to automatically retrieve river sediment and loads data from QG departments. Empirical relationships between river flow data (available publicly online, see River Gauge Data above) and loads are used, based on historical loads data, to estimate loads. It is expected that some GBR catchments will soon see high-frequency loads monitoring equipment installed for other projects and data from them that may become available online through TERN with a timing to be

advised after this Scoping Study’s release (Oct, 2012). There is also recent CSIRO work that increases the accuracy of estimating loads from flows (Kuhnert, 2012), techniques which may be adopted where high-frequency load monitoring is not implemented.

It is expected that loads data will be acquired through various means for the various catchments and, at this stage, it seems unlikely that a unified loads data collection approach will be able to be implemented. (Robson, 2012).

Loads data is also affected by the same monitoring point mismatch that affects flow data.

**Recommendation 3.2.1.m:** The eReefs-IDIRM design should allow delivery of measured and computed loads data referenced to Geofabric catchments and ensure that effort by TERN to place data online, when they occur, use both service and standards best practice and Geofabric referencing.

### Reef Report Card Inputs

Eight input data streams are listed by the Reef Report card Scoping, Requirements and Preliminary Design Study, as are the data collectors and the locations for that data. The Report indicates the format of these non-real time data streams and details how these data streams will be delivered to the future Report Card Content Management System (CMS) through the work of the Automated Reef Report Card eReefs Work Package 4 subcomponent.

At this stage, it is not clear if the input data streams for the Report Card are amenable to standards-based delivery. It appears that both currently, and in the future ideal situation as outlined in the Report, the data consists of Word and Excel reports which will be manually uploaded into a CMS for operation within a business workflow (manual QA, approvals, editing) that contains some automated components. This appears to preclude automated data transfers for these streams.

**Watchpoint 3.2.1.n:** At the time of writing this study, the reef report card data and system are out of scope for including in the eReefs-IDRIM.

### Other data stream inputs

Many data stream inputs either assumed by eReefs members to be within eReefs or likely to be so due to their nature exist, for example the AIMS ocean weather station network.

**Recommendation 3.2.1.o:** WP2 more formally require of the other WP’s that they list not only their current data inputs and outputs but also potential future inputs.

**Recommendation 3.2.1.p:** WP2 must seek clarification from eReefs project management regarding changing project scope which determines Use Cases boundaries. This will determine which particular data streams need to be considered.

**Recommendation 3.2.1.q:** eReefs-IDIRM must make data format recommendations and data ingestion processes clear that are in line with NPEI expectations and publicly available in order to allow data streams not explicitly catered for in the initial eReefs project to be able to be handled/ingested in the future.

### 3.2.2 OUTPUT DATASET DESCRIPTIONS

### Ocean Colour Maps

These maps are generated from processed MODIS data and will eventually use data from VIIRS, the MODIS successor. Product generation operationalisation is now in progress at the BoM.

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**Recommendation 3.2.2.a:** WP2 must ensure that the delivery formats already chosen for the operational datasets (CF-compliant netCDF etc.) are both best practice within their community and are able to be translated into best practice formats used by the general community.

**ReefTemp**

ReefTemp is a data portal product displaying sea-surface temperature maps, indicating areas of possible reef bleaching risk. Prior to June 2012, ReefTemp was an experimental product hosted at CMAR in Hobart and used operationally by the BoM; however at the time of writing the BoM is actively redeveloping the product to enhance its capabilities and increase its maintainability. The update "ReefTemp Next Generation" product will be incorporated into eReefs through WP1. GBRMPA have identified several deficiencies in the existing ReefTemp product, including limitations in interpretation and visualisation of SST (and derivative) datasets, lack of availability of, and inability to visualise, historical SST data, inability to use newer, higher-resolution datasets, and issues dealing with gap-filling and data unavailability due to cloud cover.

**Recommendation 3.2.2.b:** Data quality and governance arrangements for ReefTemp need to be formalised within the eReefs project lifetime. WP2 must work with WP1 & WP4 to ensure that governance for ReefTemp and its parent, the Marine Water Quality Dashboard, are finalised within Phase 1.

**MS EyeOnEarth**

“Eye on Earth is a ‘global public information network’ for creating and sharing environmentally relevant data and information online through interactive map-based visualisations. The overall goal is to improve the environment by sharing information and knowledge.”

“...It uses ESRI’s ArcGIS Online cloud services coupled with Windows Azure and Microsoft SQL Azure, and it hosts the data in the Environmental Data Store. The network’s user interface enables the easy creation and sharing of map-based services, translating complex scientific data into accessible, interactive and visual web services...”

If the EyeOnEarth system is used for Citizen Science data, WP2 will only be dealing with data delivery from the Azure cloud. In principle, WP2 can use Azure or other cloud storage of data, but it does require that the data is accessible in standards compliant formats via standards compliant methods.

**Recommendation 3.2.2.c:** WP2 must work with the GBRF to ensure that the citizen science component of eReefs is compatible with the eReefs-IWDIRM.

**Hydrodynamic model output layers**

The outputs from CSIRO’s SHOC model are currently netCDF3 (soon to be netCDF4) files delivered through a THREDDS server. Regardless of whether BoM operationalise the hydrodynamic model using the same underlying models, it is assumed that the output formats will remain the same.

**Recommendation 3.2.2.d:** WP2 must require that the Bureau and the CSIRO WP3 team outline the output formats of the hydrodynamic model as expected to be implemented.

**Reef Report Card Outputs**

The Reef Report card is automatically generated from input data streams but does not rely on, or deliver, NRT data. It will deliver geospatial data via GeoServer and Google Earth.

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Other output datasets

The full extent of eReefs data outputs are not yet known and will change with changing requirements over time.

Recommendation 3.2.2.e: In addition to specifying formats for specific, existing eReefs data output streams, eReefs-IDIRM needs to specify which standards and formats are to be used for other data streams if they are to be considered eReefs data streams.

3.2.3 SCOPE DERIVED FROM EXISTING DATASETS

Since all the forms of potentially useful eReefs ‘data mashups’ are not known and cannot be known due to changing requirements over time, WP2 needs to allow maximal interoperability between existing eReefs datasets and new eReefs datasets as they become available.

Spatial compatibility

Many of the datasets in and relevant to eReefs are spatial in nature and thus, for maximal interoperability, spatially consistent frames of reference must be employed among them. Different coordinate system use by eReefs products may be fairly easily catered for through re-projecting data, however, agreement on topological features is harder to achieve.

Watchpoint 3.2.3.a: To ensure spatial compatibility, and enable correct integration, eReefs should have available both terrestrial and coastal geofabrics.

Recommendation 3.2.3.b: WP2 must document the spatial coordinate systems used by th various eReefs datasets and models and estimate a timeframe and cost for conversion to or a translation of reference to the AHGF and its derivatives.

Data formats

Many of the existing datasets use well-known data formats but some of these formats, while seeing wide community acceptance, are not recognised standards-compliant formats. Of note are CF-compliant netCDF & non-CF-compliant netCDF in both netCDF v3 & netCDF v4 formats, HTML, XML and text tables on the web and GIF and other web animations.

Recommendation 3.2.3.c: It is proposed that WaterML 2.0 is used for water-related timeseries data.

Data delivery

Service data delivery is necessary to conform to the RM-ODP and WRON-RM. Currently some existing datasets are delivered publicly are delivered through ‘FTP dumps’, through HTTP as web pages

Data definitions

Metadata definitions used among eReefs datasets need to be either the same or translatable so that meaning can be determined consistently across all eReefs products. These definitions also need to be interoperable with the NPEI and with existing, authoritative, BoM datasets.

Recommendation 3.2.3.d: eReefs consortium create or coordinate vocabulary services that provide authoritative definitions for data and metadata terms used by data providers within eReefs. Vocabulary service reuse should occur if such services that can be authoritative for eReefs from external projects already exists (such as NPEI or BoM vocabulary services). WP2 will need to initiate activity with the CSIRO IPBA team and also the Bureau’s vocabulary staff.

Data discoverability

The datasets here are hosted by a number of organisations and are delivered in a diverse set of ways. WP2 needs to ensure that, in addition to specific eReefs products that allow eReefs dataset discovery and use
(such as a possible WP4 portal) datasets can also be located and accessed through a general index. This index should be as non-prescriptive as possible regarding how it presents its entries and should itself be a dataset presented as a service which can be consumed elsewhere.

**Recommendation 3.2.3.e:** eReefs consortium create a catalogue of data and services for data and service discovery and use. WP2 will need to initiate activity with the CSIRO IPBA team to standardise the catalogue efforts with others working under the NPEI auspices and also the Bureau’s vocabulary staff.
4 Proposed eReefs System Architecture

The following diagram, tendered as an initial information system architecture for eReefs, based on requirements as seen at this point in time by WP2. It is expected that this diagram will be adapted and extended over time as eReefs work progresses.

Figure 4 eReefs Proposed Information Architecture as seen by WP2

Figure 4 depicts a Data-to-Decision transition on the y-axis that is similar to the y-axis in Figure 1, but also reflects an N-tiered software architecture\(^\text{31}\) and is very close to the common Data-Information-Knowledge-Wisdom transition found in many cognitive sciences’ knowledge classifications\(^\text{32}\). The x-axis lists current resources, applications, services and known decisions but indicates the possibility of more being added. The links between Applications – Services and Services – Decisions are deliberately marked with m:n cardinality to indicate that multiple Applications feed multiple Services and likewise multiple Services feed multiple Decisions.

The set of **Mediators** indicated in the Integration cloud of the diagram and the format/service forms indicated as linking Resources to the Integration cloud will absorb most of WP2’s attention throughout.

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eReefs. WP2 attention will also be paid to the backlink from Applications to Resources whereby combinations of Applications can be re-issued as new, derived, Resources.
5 Recommendations

5.1 Collected Recommendations

Recommendations here are collected from all other points in this document.

**Recommendation 2.4.1:** WP2 team should advise other eReefs work packages on how already implemented subcomponents, implemented using non eReefs approaches can be made eReefs compliant.

**Recommendation 2.4.2:** The eReefs-IDIRM must consider how the processing of datasets may change over time and what metadata needs to be reported to ensure that such changes are understood by end users or downstream systems if they affect data interpretation. This would be by way of an architecture that was amenable to the inclusion of a provenance system at a suitable point in time.

**Recommendation 2.4.3:** The eReefs-IDIRM defined architecture should be allow for growth of data and use.

**Recommendation 2.4.6:** Since the main goal of eReefs to “quantify and assess water quality issues impacting the reef”, it is imperative that eReefs-IDIRM attend specifically to water quality data and metadata requirements. Consistent with the overall approach of the eReefs systems, it is proposed this be implemented existing using the international data formats such as WaterML2.0. Appendix C: Data exchange format for water quality data investigates technical aspects of this issue.

**Recommendation 2.4.7:** To avoid the proliferation of hidden private contracts between eReefs subsystems particularly when they are entirely contained within a single agency, the eReefs-IDIRM should specify a compliance framework for testing the compliance of such systems and components.

**Recommendation 2.4.8:** eReefs-IDIRM must make recommendations as to how new services are to be added or deprecated i.e. how the system will evolve gracefully, by the provision of a governance roadmap.

**Watchpoint 2.5.1.a:** WP2 team needs to stay engaged with the Citizen Science component of eReefs collaborative project and where possible ensure that the emerging approaches are consistent with eReefs-IDIRM.

**Watchpoint 2.5.1.b:** WP2 needs to stay engaged with the User Reference Group as further definitions of the end-user User Requirements become available.

**Watchpoint 2.5.4.a:** WP2 must continue to watch for scope changes in future eReefs project documentation.

**Recommendation 2.5.4.b:** The WP2 team must investigate further articulations of RM-ODP derivative RMs created since the WRON-RM v0.1 and the AWRIS system which implements much of the WRON-RM’s theory in order to better understand the breadth of Use Cases that can be expected in these generic Use Case categories.

**Recommendation 2.5.4.c:** The eReefs-IDIRM should specify a methodology for subsequent use case capture and inclusion of those requirements into the eReefs system. This methodology will be applied on subsequent phases of the eReefs project expanding the capability so that it can deliver on those identified needs. The additional use cases captured by this methodology must:

1. be bounded by continued consideration of eReefs goals.
2. consider how Use Cases in the **Enablement and Governance, Cross-business Domain Integration** and **System Maintenance** generic Use Case categories should be handled or if Reference Models beyond the WRON-RM are needed.

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c. consult with the full range of Use Case sources.
d. provide templates or direction to Use Case providers that enable them to return usefully formulated Use Cases
e. list lodged Use Cases from all sources and actions against them so that they may be an on-going reference for the project.

Recommendation 3.1.a: WP2 team to create an index of the data types, exchange formats and, most importantly, the level of standards-compliant, service-delivered data adoption used by the major external systems relevant to eReefs as a reference for eReefs’ technical teams and users.

Recommendation 3.1.b: expectations of eReefs’ function should be sought from the external systems’ stakeholders through a WP2 workplan in collaboration with eReefs project management to ensure good relations. This should involve detailing External System Use Cases.

Recommendation 3.1.1.a: eReefs-IDIRM must ensure eReefs is compliant with the NEII.

Recommendation 3.1.1.b: eReefs should aim for the maximal reuse of the technologies identified as part of NEII such as SISS.

Watchpoint 3.2.1.a: WP2 should work with TERN and its subcomponents (ACEF: Jonathan Hodge, AusCover: Matt Paget, data synthesis in general: Siddeswara Guru) to facilitate compatibility.

Watchpoint 3.2.1.b: The provision of river gauge data from QG to CSIRO is currently done using non-standard methods. Delivery of this data using eReefs standards compliant methods is of high priority and should be scheduled as soon as possible and the eReefs team, including WP2 should facilitate this.

Recommendation 3.2.1.c: WP2 should reference all geospatial feature indexes against an eReefs geofabric which references the Australian Hydrological Geospatial Fabric.

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Watchpoint 3.2.1.g: when higher resolution tide data is made available to the BoM, it should be delivered through service architecture. If the data is not for public consumption, service architecture with appropriate security should be used.

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Watchpoint 3.2.1.i: WP2 needs to ensure that the information infrastructure design is made available to TERN.

Recommendation 3.2.1.j: The eReefs-IDIRM should consider the delivery of private data delivery using standardised service data services with additional security layers.

Recommendation 3.2.1.k: Since altimetry and SST data are delivered to projects outside eReefs, for example to the GHRSST, and since they are also core eReefs data sets, those data need to be delivered as standardised services rather than as ‘private contracts’. Service delivery will reduce both the effort of delivering the data to multiple locations shortly (GHRSST & eReefs) and potentially further locations in the

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**Recommendation 3.2.1.m:** The eReefs-IDIRM design should allow delivery of measured and computed loads data referenced to Geofabric catchments and ensure that effort by TERN to place data online, when they occur, use both service and standards best practice and Geofabric referencing.

**Recommendation 3.2.1.n:** At the time of writing this study, the reef report card data and system are out of scope for including in the eReefs-IDIRM.

**Recommendation 3.2.1.o:** WP2 more formally require of the other WP’s that they list not only their current data inputs and outputs but also potential future inputs.

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**Recommendation 3.2.1.g:** In addition to specifying formats for specific, existing eReefs data output streams, eReefs-IDIRM needs to specify which standards and formats are to be used for other data streams if they are to be considered eReefs data streams.

**Watchpoint 3.2.3.a:** To ensure spatial compatibility, and enable correct integration, eReefs should have available both terrestrial and coastal geofabrics.

**Recommendation 3.2.3.b:** WP2 must document the spatial coordinate systems used by the various eReefs datasets and models and estimate a timeframe and cost for conversion to or a translation of reference to the AHGF and its derivatives.

**Recommendation 3.2.3.c:** It is proposed that WaterML 2.0 is used for water-related timeseries data.

**Recommendation 3.2.3.d:** eReefs consortium create or coordinate vocabulary services that provide authoritative definitions for data and metadata terms used by data providers within eReefs. Vocabulary service reuse should occur if such services that can be authoritative for eReefs from external projects already exists (such as NPEI or BoM vocabulary services). WP2 will need to initiate activity with the CSIRO IPBA team and also the Bureau’s vocabulary staff.

**Recommendation 3.2.3.e:** eReefs consortium create a catalogue of data and services for data and service discovery and use. WP2 will need to initiate activity with the CSIRO IPBA team to standardise the catalogue efforts with others working under the NPEI auspices and also the Bureau’s vocabulary staff.

**Recommendation Appendix C:**
1. Establish a vocabulary resolution service for returning further information on relevant NetCDF ‘tokens’ and WaterML2.0 URIs:

   Further enabling the resolution of the content of the NetCDF responses will increase the usefulness of the NetCDF data outside immediate users and facilitate establishing interoperable WaterML web-based services;

2. Develop a mapping between the NetCDF hydrology datasets and WaterML:

   A NetCDF to WaterML mapping will allow data providers to deliver stored NetCDF hydrology data as WaterML to the broader eReef community. Encouraging data providers to establish WaterML services, rather than only NetCDF services, ensures the delivery of comprehensive metadata in standard ISO formats;

3. Develop a set of best practices that allows WaterML time-series to be represented as NetCDF documents.

   This is a longer term goal that will ensure software applications and archives that are dependent on NetCDF standards are able to access services based on WaterML.

Recommendation Appendix D:

- Extend and validate WaterML 2.0 and/or Observations and Measurements for water quality data, suitable for use within the eReefs project;
- Evaluate sensor description language for describing water quality sensor metadata for WaterML 2.0.
- Map WaterML2 water quality observation metadata to netCDF metadata ‘tokens’ (see Appendix C);
- Reconcile water quality support in WaterML2.0 with WDTF 1.x or WDTF 2.x through input into WDTF implementation.

5.2 Note on Recommendations

Some of the recommendations/watchpoints in Section 5.1 will lead to specific actions and others will lead to WP2 staff following general principles for action and other are issues which have scope for the eReefs initiative. It is left to further WP2 work to accept, reject or alter the various recommendations and their subpoints. It is recommended that the recommendation numbering (Recommendation x.x.x) be retained in further documents to allow traceability.
## Glossary

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>AIMS</td>
<td>Australian Institute of Marine Science</td>
</tr>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
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<tr>
<td>BoM</td>
<td>Australian Bureau of Meteorology</td>
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<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation</td>
</tr>
<tr>
<td>DEHP</td>
<td>Queensland Government’s Department of Environment and Heritage Protection (partial successor to from DERM)</td>
</tr>
<tr>
<td>DERM</td>
<td>Queensland Government’s Department of Environment and Resource Management (now split into successors)</td>
</tr>
<tr>
<td>DNRM</td>
<td>Queensland Government’s Department of Natural Resources and Mines (partial successor to from DERM)</td>
</tr>
<tr>
<td>DSITIA</td>
<td>Queensland Government’s Department of Science, Information Technology, Innovation and the Arts (partial successor to from DERM)</td>
</tr>
<tr>
<td>eReefs-IDIRM</td>
<td>eReefs Interoperable Data-Infrastructure Reference Model</td>
</tr>
<tr>
<td>GBR</td>
<td>Great Barrier Reef</td>
</tr>
<tr>
<td>GBRF</td>
<td>Great Barrier Reef Foundation</td>
</tr>
<tr>
<td>GBRMPA</td>
<td>Great Barrier Reef Marine Park Authority</td>
</tr>
<tr>
<td>JCU</td>
<td>James Cook University</td>
</tr>
<tr>
<td>netCDF</td>
<td>A flexible self describing data model and API for sharing climate and remote sensed data</td>
</tr>
<tr>
<td>NPEI</td>
<td>National Plan for Environmental Information</td>
</tr>
<tr>
<td>NEII</td>
<td>National Environmental Information Infrastructure</td>
</tr>
<tr>
<td>OASIS</td>
<td>Organization for the Advancement of Structured Information Standards</td>
</tr>
<tr>
<td>OGC</td>
<td>Open Geospatial Consortium</td>
</tr>
<tr>
<td>QG</td>
<td>Queensland Government</td>
</tr>
<tr>
<td>RM-ODP</td>
<td>Reference Model for Open Distributed Processing</td>
</tr>
<tr>
<td>THREDDS</td>
<td>Thematic Realtime Environmental Distributed Data Services</td>
</tr>
<tr>
<td>UQ</td>
<td>University of Queensland</td>
</tr>
<tr>
<td>Web Service</td>
<td>A method of communication between two devices over the internet. Used in contracts to local file access.</td>
</tr>
<tr>
<td>WFS</td>
<td>OGC compliant Web Feature Service</td>
</tr>
<tr>
<td>WCS</td>
<td>OGC compliant Web Coverage Service</td>
</tr>
<tr>
<td>WPS</td>
<td>Standards Compliant spatial data delivery web services (Web Processing Service)</td>
</tr>
<tr>
<td>WRON</td>
<td>Water Resources Observation Network</td>
</tr>
</tbody>
</table>
References


# Appendix A Interactions with Key Stakeholders

## Table 4 Interviews with Key Stakeholder organisation personnel

<table>
<thead>
<tr>
<th>Date</th>
<th>Meeting</th>
<th>People</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012-05-29</td>
<td>SSIMR Usergroup</td>
<td>Nick &amp; Lindsay</td>
<td>Contact formally, ask about SASS contact post SSIMR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Redlich</td>
<td>Contact formally</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bernie Fitzpatrick</td>
<td>Contact formally, ask about Citizen Science</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nyssa Henry Suzanne Long</td>
<td>Contact formally, ask about DERM data access from TERM (with J.Hodge)</td>
</tr>
<tr>
<td>2012-06-13</td>
<td>Hobart Visit</td>
<td>Nick &amp; Mike Herzfeld</td>
<td>Meet again at GBRF meeting on 21/06. Explained the hydrodynamic modelling needs. Pointed to Farhan Rizwi as the person understanding best the technical requirements of the ROAM/Tryke model.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Farhan Rizwi</td>
<td>- Farhan is enabling the continuous running of Tryke</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ed King</td>
<td>- oTryke currently creates an Inputs dir and an Outputs dir per run</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Andreas Schiller</td>
<td>- it is possible for Farhan to log inputs for provenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Farhan understands and wishes to implement standards-based outputs from the model.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- He would be the appropriate person to list data formats, requirements etc for WP1</td>
</tr>
<tr>
<td>2012-06-22</td>
<td>Citizen Science</td>
<td>Teresa Fyffe</td>
<td>GBRMPA to lead Citizen Science initiative</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>First meeting of all Citizen Science groups on reef 2 weeks ago</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Microsoft &amp; Telstra are involved</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Telstra is interested in technology and in providing cloud services</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Microsoft interested in providing Azure cloud services with an eyenearth front end (<a href="http://eyenearth.cloudapp.net">http://eyenearth.cloudapp.net</a>)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Meeting with Telstra technical next week</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Meeting with Microsoft in 2 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(notes from GBRF email, 31/08: the first meeting for all Citizen Science groups took place in mind August. There have been preliminary discussions with several GBRF corporate contacts regarding their potential involvement including Microsoft Research. Discussions with Microsoft Research have explored the possibility of using a Eye-on-earth front end supported by Azure cloud services. Discussions with GBRF corporate partners will continue in coming months)</td>
</tr>
<tr>
<td>2012-07-09</td>
<td>DERM SSIMR Team</td>
<td>Lindsay Redlich, Bernie Fitzpatrick</td>
<td>They indicated John Bennet &amp; John Mullins are more appropriate to give insight into scientifically what DERM delivers and can deliver. SSIMR is ending and they are not in a position to deliver ongoing model output (or input raw data) datasets from the SSIMR server.</td>
</tr>
<tr>
<td>2012-07-10</td>
<td>WP1</td>
<td>Jonathan Hodge</td>
<td>- descriptions of the DERM data collection architecture</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- TERN is requesting, through ACEF, access to many of the data streams that are of interest to eReefs (see letter from A. Steven to DERM)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- SEQI TOR? will promote the use of standardised WS datasets</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- point source emissions (water treatment) are a DERM dataset of interest to eReefs</td>
</tr>
<tr>
<td>Date</td>
<td>Name</td>
<td>Notes and Content</td>
<td>Details</td>
</tr>
<tr>
<td>------------</td>
<td>---------------------------</td>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td>2012-07-10</td>
<td>Chris Carol, John Bennet, Nyssa Henry, and Ken Brook</td>
<td>WQ needs for eReef are similar to those of SEQ. John Bennet provided a document entitled “An Assessment of Background Knowledge and Available Data, and Recommendations for Field Studies, to Support RWQM V3 Implementation and Calibration.” (my assessment of this document is that, since the authors of it are mostly within the eReef project, WP2 need not delve into it in detail).</td>
<td>Suggested actions for more info: - Marine Monitoring Program: see GBRMPA - Modelling: see SEQ Data Repo - apply to join the Project Data User Group (via Bernie Fitzpatrick)</td>
</tr>
</tbody>
</table>
• In-situ boat monitoring data from AIMS
The last point seems to have been arranged through a ‘private contract’ whereby AIMS agreed to, and has, given irregularly measured ship voyage data to WP3. K W-A says that much of the AIMS data they want is available from AIMS online but that is has been easier for her and her colleagues to request a data dump from AIMS rather than use the online query system.

<table>
<thead>
<tr>
<th>2012-08-28</th>
<th>BoM</th>
<th>Mikhail Entel &amp; Tony Baxter (phone)</th>
<th>Current wave &amp; tide QG &amp; ports data delivery to the BoM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Future data delivery of above.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Join Tsunami Early Warning Centre’s radar buoys</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(comments included in Scoping Study existing datasets section on wave &amp; tide data)</td>
</tr>
</tbody>
</table>
Appendix B  Extended Use Case tables
Table 5 User Story-derived Use Cases grouped by top level (WRON-RM) generic Use Cases (system Use Cases)

<table>
<thead>
<tr>
<th>Source (Story No.)</th>
<th>Actor: Specific implementation</th>
<th>2nd Level Generic UC</th>
<th>WRON-RM Top Level UC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Tourist operator: View current sediment plume maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>GBRMPA User: View forecast sediment plume maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>GBRMPA User: View WQ timeseries for selected points from past, current and predicted loads maps</td>
<td>End User: data access, data discovery</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>GBRMPA User: View WQ timeseries beyond threshold mask for selected points from past, current and predicted loads maps</td>
<td>End User: data discovery, data access</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>GBRMPA User: View modelled outputs of WQ for different land management scenarios</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>GBRMPA User: Calibrate eReefs WQ model outputs using Marine Monitoring Program data</td>
<td>Functionality provision: Publish web service or Cross business domain integration</td>
<td>3 or 5</td>
</tr>
<tr>
<td>7</td>
<td>GBRMPA User: View NRT flood plume maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>GBRMPA User: View predicted flood plume maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Not able to be termed a Use Case</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>GBRMPA User: View WQ timeseries for selected points from past, current and predicted loads maps</td>
<td>End User: data discovery, data access</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>GBRMPA User: View past catchments’ WQ contribution maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>GBRMPA User: View WQ timeseries for selected points from past, current and predicted loads maps for different predicted scenarios</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>GBRMPA User: View WQ timeseries for selected points from past, current and predicted loads maps for different predicted scenarios</td>
<td>End User predicted data access</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>This is a report card Use Case. WP4 Report Card has not been assessed in this report. See Section 3.3 for further details.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>GBRMPA User: View NRT WQ maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>GBRMPA User: View predicted WQ maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>GBRMPA User: View NRT WQ maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>GBRMPA User: View predicted WQ maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>QG/Public: Access latest Report Card using up-to-date data</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>QG: view pollutant plumes fused with land usage maps and river discharge</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>QG: view changing land use and changing pollutant plumes to establish correlation</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>QG: showcase eReefs product set and differences with previous reef-related product set</td>
<td>End User data discovery</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>QG: compare latest visualisations with previous visualisations</td>
<td>Data Provider: Implement profiles</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>QG: view WQ timeseries of WQ maps</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>QG: view WQ timeseries of WQ maps</td>
<td>End User: data</td>
<td>1</td>
</tr>
</tbody>
</table>

This particular Use Case will see pre-European modeled loads loaded in a similar way to predicted modeled loads.
<table>
<thead>
<tr>
<th></th>
<th>Work Package</th>
<th>Description</th>
<th>Data Provision &amp; End User Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>QG: fuse river discharge, marine WQ maps sources and static target maps</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>SEWPaC: fuse river discharge, marine WQ maps sources and static target maps</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>eReefs: showcase eReefs product set</td>
<td>End User data discovery</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>GBRMPA: fuse NRT hydrodynamic visualisations with static risk maps</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>GBRMPA: fuse river loads with NRT hydrodynamic visualisations with static risk maps</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>GBRMPA: fuse fishing data with eReefs data</td>
<td>Data Provision: Create data resource, Implement profile</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>GBRMPA: fuse tourism data with eReefs data</td>
<td>Data Provision: Create data resource, Implement profile</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>GBRMPA: compare land use trends with WQ map timeseries and 3rd party fish data</td>
<td>End User: data access, Data Provision: Create data resource, Implement profile</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>GBRMPA: view hydrodynamic models fused with CONNIE2 and fused with static risk maps</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>QG: fuse WQ map timeseries with 3rd party COTS map timeseries</td>
<td>End User: data access, Data Provision: Create data resource, Implement profile</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Public: showcase eReefs datasets</td>
<td>End User data discovery &amp; data access</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Ports: view NRT hydrodynamic transport maps</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>GBRMPA: fuse static land use/costal use maps with WQ map timeseries</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>GBRMPA: compare WQ and other target maps</td>
<td>End User data discovery &amp; data access</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>QG: compare loads and hydrodynamic scenarios</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>QG: compare multi dataset scenarios</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>QG: view hydrodynamic &amp; WQ NRT maps</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Public: list &amp; access all eReefs data</td>
<td>End User data discovery &amp; data access</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>AIMS: view past BCG model outputs as maps timeseries</td>
<td>End User data discovery &amp; data access</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>GBRMPA: view NRT hydrodynamics and compare to risk maps</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>GBRMPA: view NRT hydrodynamics and compare to risk maps</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Ports: view NRT/forecast hydrodynamics</td>
<td>End User: data access</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>End User: data access, Data provision, Implement profile</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>44</td>
<td>QG: fuse NRT hydrodynamics transport with point source data with particular properties</td>
<td>End User: data access, Data provision, Implement profile</td>
<td>1 &amp; 2</td>
</tr>
<tr>
<td>45</td>
<td>GBRMPA: view NRT/forecast hydrodynamics</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>46</td>
<td>Public: fuse Citizen Science data with eReefs datasets</td>
<td>End User data discovery, data access, Data provision, Implement profile</td>
<td>1 &amp; 2</td>
</tr>
<tr>
<td>47</td>
<td>BoM: export large eReefs datasets in NPEI-compliant forms</td>
<td>Cross business domain integration</td>
<td>5</td>
</tr>
<tr>
<td>48</td>
<td>GBRMPA: contribute data layers of habitat destruction then fuse with eReefs map timeseries</td>
<td>Data provision: create data resource, Implement profile, End User data access</td>
<td>2 &amp; 1</td>
</tr>
<tr>
<td>49</td>
<td>GBRMPA: view Report Card</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>50</td>
<td>GBRMPA: export reports the World Heritage Commission</td>
<td>Cross business domain integration</td>
<td>5</td>
</tr>
<tr>
<td>51</td>
<td>GBRMPA: show GBR usage interactions</td>
<td>Cross business domain integration</td>
<td>5</td>
</tr>
<tr>
<td>52</td>
<td>Public: fuse Citizen Science data with eReefs datasets</td>
<td>End User data discovery, data access, Data provision, Implement profile</td>
<td>1 &amp; 2</td>
</tr>
<tr>
<td>53</td>
<td>GBRMPA: view hydrodynamic transport of larvae (BGC)</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>54</td>
<td>QG: compare/fuse WQ trends with other data</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>55</td>
<td>eReefs: create and deploy new data sources</td>
<td>Data provision: create data resource, Implement profile, Publish resource, Manage resource lifecycle</td>
<td>2</td>
</tr>
<tr>
<td>Source</td>
<td>Actor: Specific implementation</td>
<td>2nd Level Generic UC</td>
<td>WRON-RM Top Level UC</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------</td>
<td>----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>eReefs existing documentation</td>
<td>General User: Interact with a visual picture of the Reef and its component parts</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>Work Package 4</td>
<td>General User: Select compatible eReefs datasets for joint visualisation</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>Coastal &amp; Ocean Services Use Statements</td>
<td>Search and Rescue: NRT hydrodynamics fused with BoM weather</td>
<td>End User: data access, Data Provision: Implement profile</td>
<td>1 &amp; 2</td>
</tr>
<tr>
<td>Coastal &amp; Ocean Services Use Statements</td>
<td>Post: view wave and tide predictions</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>Coastal &amp; Ocean Services Use Statements</td>
<td>Fisheries: view NRT WQ to determine appropriate fishing locations</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>Coastal &amp; Ocean Services Use Statements</td>
<td>Fisheries: fuse fish movement data with eReefs data to avoid bycatch</td>
<td>End User: data access, Data Provision: Create data resource, Implement profile</td>
<td>1 &amp; 2</td>
</tr>
<tr>
<td>Coastal &amp; Ocean Services Use Statements</td>
<td>Fisheries: fuse fish movement data with eReefs data to identify potential fishing zones</td>
<td>End User: data access, Data Provision: Create data resource, Implement profile</td>
<td>1 &amp; 2</td>
</tr>
<tr>
<td>NPEI</td>
<td>NPEI systems: access data using NPEI formats &amp; services</td>
<td>Cross business domain integration</td>
<td>5</td>
</tr>
<tr>
<td>TERN</td>
<td>TERN systems: access data using open standards, best practice formats &amp; services</td>
<td>Cross business domain integration</td>
<td>5</td>
</tr>
<tr>
<td>eReefs contract</td>
<td>BoM Staff: maintain eReefs operational systems</td>
<td>System maintenance</td>
<td>6</td>
</tr>
<tr>
<td>eReefs contract</td>
<td>AIMS, CSIRO: maintain eReefs operational systems</td>
<td>System maintenance</td>
<td>6</td>
</tr>
<tr>
<td>eReefs contract</td>
<td>New eReefs partner organisation's staff: maintain eReefs operational systems</td>
<td>System maintenance</td>
<td>6</td>
</tr>
<tr>
<td>BoM</td>
<td>BoM Staff: manage eReefs datasets when inputs evolve</td>
<td>Data provision: manage resource lifecycle</td>
<td>2</td>
</tr>
<tr>
<td>BoM</td>
<td>BoM Staff: add newly generated data sources to eReefs listings</td>
<td>Data Provision: create data resources, publish resource</td>
<td>2</td>
</tr>
<tr>
<td>eReefs contract</td>
<td>CSIRO: add new tools to eReef systems</td>
<td>Functionality provision: publish tool description, publish web service</td>
<td>3</td>
</tr>
<tr>
<td>eReefs contract</td>
<td>CSIRO, AIMS: add new data services to eReef systems</td>
<td>Data provision: all</td>
<td>2</td>
</tr>
<tr>
<td>Existing BoM Requirement</td>
<td>Public: access multi-source WQ information</td>
<td>End User: data access</td>
<td>1</td>
</tr>
<tr>
<td>Work Package 4</td>
<td>General User: create a derived visualisation and publish it for</td>
<td>End User: data access</td>
<td>1 &amp; 2</td>
</tr>
</tbody>
</table>


Work Package 2 Scoping Study | 52
| Work Package 4 | General User: overview all of eReefs data sources | End User Data discovery | 1 |
| Work Package 4 | General User: access NRT & historical hydrodynamic visualisations | End User Data discovery, data access | 1 |
Appendix C  netCDF – WaterML 2.0 Integration

BACKGROUND (AFTER [PALMER])

Network Common Data Format (NetCDF)\(^{37}\) is a set of APIs, libraries and self-describing machine-independent data formats, commonly used in climatology, meteorology and oceanography applications for array-oriented data. NetCDF is used as an input/output format for many scientific software applications, as well as for archival storage and data exchange. A considerable amount of existing eReef data transfer is currently carried out using the NetCDF format, either as NetCDF 3 or NetCDF 4 (See Table 3 Summary of existing information exchange infrastructure, formats and status by Work Package (next page))

\(^{37}\)http://www.unidata.ucar.edu/software/netcdf/
<table>
<thead>
<tr>
<th>WP</th>
<th>Dataset Name</th>
<th>Dataset Location</th>
<th>In/Out</th>
<th>Datum/Data Name</th>
<th>Source/Destination</th>
<th>Format(s)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Operational: 12 hour data delivery for flows &amp; temp, ad hoc (monthly) delivery for in-situ WQ measurement available by October '12</td>
</tr>
<tr>
<td>1</td>
<td>Operational Marine Remote Sensing</td>
<td>BoM (NMOC)</td>
<td>In</td>
<td>MODIS imagery</td>
<td>BoM MODIS base stations</td>
<td>MODIS raw data</td>
<td>Operational</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td>Operational in Dec 2012/Feb 2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Out</td>
<td>Ocean Colour maps</td>
<td>BoM public web</td>
<td>OpenDAP THREDDS netCDF 4 (CF)</td>
<td>Operational in Dec 2012/Feb 2013</td>
</tr>
<tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Out</td>
<td>Reeftemp</td>
<td>BoM public web</td>
<td>OpenDAP THREDDS netCDF 4 (CF)</td>
<td>Operational in Dec 2012/Feb 2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Hydrodynamics</td>
<td>BoM (NMOC)</td>
<td>In</td>
<td>River gauge data</td>
<td>DERM (<a href="http://watermonitoring.derm.qld.gov.au/host.htm">http://watermonitoring.derm.qld.gov.au/host.htm</a>)</td>
<td>HTML/text fixed format files FTP dump</td>
<td>Operational</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In</td>
<td>ACCESS-G (ocean circulation)</td>
<td>BoM subscription list</td>
<td>netCDF 3 netCDF 4</td>
<td>Operational Sep 2012</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>In</td>
<td>ACCESS-R</td>
<td>BoM subscription list</td>
<td>netCDF 3 netCDF 4</td>
<td>Operational Sep 2012</td>
</tr>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In</td>
<td>Wave &amp; tide measurements</td>
<td>BoM</td>
<td>-</td>
<td>Internally modelled</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DERM</td>
<td></td>
<td>Tide: yearly delivered to BoM's NTC, Wave, so far unknown</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In</td>
<td>Altimetry &amp; Sea surface Temp</td>
<td>BoM</td>
<td>MODIS</td>
<td>Outputs from WP1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Out</td>
<td>Hydrodynamic model output layers</td>
<td>CSIRO now (Aug '12)</td>
<td>OpenDAP THREDDS netCDF 4 (CF)</td>
<td>Dec 2012</td>
</tr>
<tr>
<td></td>
<td>Work Package 2 Scoping Study</td>
<td>56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Sediment, BGC (NMOC)</th>
<th>BoM</th>
<th>In</th>
<th>River sediment &amp; nutrient loads</th>
<th>DERM</th>
<th>FTP</th>
<th>Currently generated empirically within the model. Soon to be updated with regular WG data from QG, ultimately, to be delivered from DERM for some catchments where continuous WQ instruments are installed (approx Dec 2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Internal CSIRO transfer, Internal BoM transfer</td>
<td>BGC</td>
<td>BGC modelling not finalised to take place within BoM. Currently an internal CSIRO process</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seagrass mangrove extent maps</td>
<td>DERM or AIMS</td>
<td>One-off transfer</td>
<td>Currently a ‘private contract’ for one-off data delivery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hydrodynamic model output layers</td>
<td>BoM</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>As per Hydrodynamics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ocean circulation</td>
<td>AIMS</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Operational, requires continuous hydrodynamic model outputs as inputs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paddock monitoring</td>
<td>QG-DAFF</td>
<td>Manual entry</td>
<td>Word/Excel</td>
<td>Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Catchment Indicators</td>
<td>QG-DAFF</td>
<td>Manual entry</td>
<td>Word/Excel</td>
<td>Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Catchment Loads</td>
<td>QG-NRM</td>
<td>Manual entry</td>
<td>Word/Excel/CSV</td>
<td>Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inshore Water Quality</td>
<td>AIMS</td>
<td>Manual entry</td>
<td>Excel (derived data)</td>
<td>Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seagrass extent</td>
<td>AIMS</td>
<td>Manual entry</td>
<td>Unspecified, assumed Excel</td>
<td>Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inshore Coral Reef Health</td>
<td>AIMS JCU</td>
<td>Manual entry</td>
<td>Unspecified, assumed Excel</td>
<td>Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flood Plume Dynamics</td>
<td>AIMS JCU</td>
<td>Manual entry</td>
<td>Unknown</td>
<td>Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reef Report Card online</td>
<td>UQ then QG</td>
<td>Automatic delivery to web</td>
<td>HTML (PDF to be phased out)</td>
<td>As per Report Card Scoping Study</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The WaterML standard\textsuperscript{38} provides a consistent conceptual model for hydrological time-series data. The WaterML model is a specialisation of the Open Geospatial Consortium (OGC) Observation and Measurements (O&M) standard. The model is designed to allow delivery of rich and complex data and metadata. WaterML is expressed as UML with an XML encoding of the conceptual model part of the standard.

As the conceptual models underpinning WaterML and NetCDF are not readily compatible, an OGC discussion paper [Palmer] investigated the possible uses of NetCDF as a representation of WaterML time-series data.

**ISSUES**

Although NetCDF is an efficient and well-used data exchange format with established client software, it has a number of limitations. Two that severely restrict interoperability are the use of ‘tokens’ for standard terms and the limited capacity of NetCDF to deliver metadata.

Standard terms in NetCDF documents tend to be tokens, words or phrases connected by underscores. As an example, the equivalent to “good quality” in NetCDF would be a token such as ‘quality_good’. In contrast, an example standard term in WaterML is the http-URL ‘\texttt{http://www.opengis.net/WaterML/2.0/def/quality/good}’ which resolves to a semantic description of the meaning of “good quality”. The use of http-URLs as terms in WaterML allows resolving the terms via a vocabulary service into more usable information, such as definitions, foreign language equivalents, hierarchical relationships and the like. A key outcome of the eReefs strategy should be the capacity to resolve relevant NetCDF tokens into meaningful vocabulary terms.

WaterML enables the delivery of rich dataset metadata through the ISO19115 standard, as well as individual observation metadata through O&M. In addition to the result itself, which may be a measurement (e.g. 3.45m) or categorical (e.g. Cloudy), the observation contains extensive contextual information about the nature of the observation. In NetCDF metadata attributes can be attached to the arrays, or to the dataset as a whole, with a range of conventions for encoding data and attributes for the purposes of consistent data exchange.

In order to increase the usefulness of NetCDF data to the eReefs project, the following three activities are to be undertaken:

**Recommendation Appendix C:**

4. **Establish a vocabulary resolution service for returning further information on relevant NetCDF ‘tokens’ and WaterML URIs:**

   Further enabling the resolution of the content of the NetCDF responses will increase the usefulness of the NetCDF data outside immediate users and facilitate establishing interoperable WaterML web-based services;

5. **Develop a mapping between the NetCDF hydrology datasets and WaterML:**

   A NetCDF to WaterML mapping will allow data providers to deliver stored NetCDF hydrology data as WaterML to the broader eReef community. Encouraging data providers to establish WaterML services, rather than only NetCDF services, ensures the delivery of comprehensive metadata in standard ISO formats;

6. **Develop a set of best practices that allows WaterML time-series to be represented as NetCDF documents.**

   This is a longer term goal that will ensure software applications and archives that are dependent on NetCDF standards are able to access services based on WaterML.

\textsuperscript{38} \url{http://www.opengeospatial.org/projects/groups/waterml2.0swg}
Appendix D Exchange format for water quality data

LONG-TERM GOAL

WaterML2.0 is an emerging international standard, based on the ISO Observations and Measurements standard (O&M), for the transfer of water information. WaterML2.0 Part 1 has recently been approved for publication by OGC after a two-year development process. WaterML2.0 deals with regular time series data, and does not cater for water quality observations that are a result of a laboratory (ex-situ) analysis. In particular, metadata that is usually expected to accompany ex-situ sampled observations relating to sampling method, sample treatment and laboratory analysis is missing. This capability is an essential requirement for eReefs. This work item will provide that functionality.

OBJECTIVES

- Extend and validate WaterML 2.0 and/or Observations and Measurements for water quality data, suitable for use within the eReefs project.
- Evaluate sensor description language for describing water quality sensor metadata for WaterML 2.0.
- Map WaterML2 water quality observation metadata to netCDF metadata ‘tokens’ (see Appendix B)
- Reconcile water quality support in WaterML2.0 with WDTF 1.x or WDTF 2.x through input into WDTF implementation

METHODS

This activity will use OGC standards and procedures to extend WaterML2.0 and/or Observations and Measurements to support water quality observations. Much of the abstract work has been completed already and is detailed in the Observations and Measurements 2.0 specification. This needs to be profiled and then, if appropriate, incorporated in an extended WaterML2.0.

This approach – developing a profile of O&M – is emerging as a standard methodology in the design of observation data systems in earth and environmental sciences. O&M provides a domain-neutral terminology for observation metadata. For specialized use within an application domain it is necessary to introduce constraints on, or extensions to, the generalized classes: observed property, feature of interest, observation procedure, and result type. This methodology has been applied in a number of domains, including geoscience, aeronautical information, ecosystem observations.

The first task of this activity will be to undertake a survey of user requirements to determine the additional metadata required for eReefs. This will become the primary input for the design exercise to follow, which will:

- Assess the outputs of the BoM’s National Water Quality Metadata and Standards investigations
- Use UML to profile Observations and Measurements or extend WaterML2.0 to support water quality
- Generate the required XML schema
- Test the transfer of water quality for eReefs using the developed profile or extension

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39 OGC specifications are constructed in sets (classes) of testable requirements, with dependencies to formalize the re-use of existing requirements classes. Hence, a more specialized standard is built incrementally from more basic existing elements.

• Communicate the profile or extension to peers through the OGC process via an OGC discussion or best practice paper.

INPUTS

The primary input for this work will be a requirements gathering exercise to determine the metadata that is required for the effective sharing of water quality data, ensuring that the integrity of data is maintained. Additional inputs will be the Observation and Measurements, and WaterML2.0 conceptual models and schema.

This work will rely on the availability of the SolidGround and FullMoon toolset that has been developed within WIRADA for assisting with the translation of the conceptual model to an XML schema.

OUTPUTS

Outputs of the activity will include:

• UML conceptual model to support water quality observations.
• XML schema which can be used to transfer water quality observations between systems as part of the eReefs project.
• Best practice paper reporting on the work, which is to be presented and released through the OGC.

OUTCOMES

The outcome of this work will be the development and availability of a transfer standard for the exchange of water quality observations between systems required for the eReefs project. The work also will benefit other organisations in Australia and internationally where the accurate transmission of water quality observations using open standards is required.

This work may also be the first work building standards that can be used across terrestrial hydrology, estuarine and ocean domains.

Recommendation Appendix D:

• Extend and validate WaterML 2.0 and/or Observations and Measurements for water quality data, suitable for use within the eReefs project;
• Evaluate sensor description language for describing water quality sensor metadata for WaterML 2.0.
• Map WaterML2 water quality observation metadata to netCDF metadata ‘tokens’ (see Appendix C);
• Reconcile water quality support in WaterML2.0 with WDTF 1.x or WDTF 2.x through input into WDTF implementation.