Draft Final DSS Report

Wetland Prioritisation Decision Support System Great Barrier Reef Catchment

15 May 2006

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Great Barrier Reef Catchment

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"Far better an approximate answer to the right question, which is often vague, than an exact answer to the wrong question, which can always be made precise."

John Tukey, 1962

CONTENTS

APPENDICES

LIST OF ACRONYMS

ABS	Australian Bureau of Statistics
ACTFR	Australian Centre for Tropical Freshwater Research
ASGC	Australian Spatial Geographic Classification
BRS	Bureau of Rural Sciences
C4	Community for Coastal and Cassowary Conservation Inc.
CAMBA	China-Australia Migratory Birds Agreement
CAPAD	Collaborative Australian Protected Areas
CBA	Cost / Benefit Analysis
DEH	Department of the Environment and Heritage
DIW	Directory of Important Wetlands
DNRM	Queensland Government Department of Natural Resources and Mines
DPI&F	Queensland Government Department of Primary Industry and Fisheries
DSS	Decision Support System
EPA	Queensland Government Environmental Protection Agency
ERIN	Environmental Resources Information Network
FNQNRM	Far North Queensland Natural Resource Management Regional Group
GA	Geoscience Australia
GBR	Great Barrier Reef
GBRCWPP	Great Barrier Reef Coastal Wetlands Protection Programme
GBRMPA	Great Barrier Reef Marine Park Authority
GIS	Geographic Information System
HLA	HLA-Envirosciences Pty Limited
ICM	Integrated Catchment Management
JAMBA	Japan-Australia Migratory Birds Agreement
LP	Linear Programming
MCA	Multi-criteria Analysis
MWNRM	Midwest Natural Resource Management Regional Group
NHT2	Natural Heritage Trust funding (round two)
NLWRA	National Land and Water Resources Audit
NRA	Natural Resource Assessments Pty Ltd
NRM	Natural Resource Management
NTT	Native Title Tribunal
ODBC	Open Database Connectivity
PIN	Polygon Identifier Number
PM	Process Models
QLD	Queensland
QLUMP	Queensland Land-use Mapping Project
RE	Regional Ecosystems
RIS	Regional Investment Strategy
SEIFA	Socio-Economic Indices For Areas
UQ	University of Queensland
WPSQ	Wildlife Preservation Society of Queensland

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Primary DSS Testing and Weighting Panel Bill Sawynock (Infofish), Kim Thomas (Cairns LMAC), Rowena Grace (FNQNRM), Patricia Julien (MWNRM), Merike Johnson (Landcare), John Platter (EPA), David Reid (Burdekin Dry Tropics Board), Norm Kippin (Agforce), Simon O'Donnell (DNRM), Murray Whitehead (EPA), Donna Audas (GBRMPA), Vern Veitch (Sunfish / Burdekin Dry Tropics Board), Rachel Allan (Thuringowa City Council), Rebecca Sheppard (DPI&F), Lisa Evans (DEH), Graeme Wolff (ERIN).

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Secondary DSS Testing Panels:
Townsville-Burdekin Coastal Aggregation: Damian Burrows (ACTFR), Tim Perry (Earthworks Environmental Services), David Reid (Burdekin Dry Tropics Board), Murray Whitehead (EPA), Donna Audas (GBRMPA), Rebecca Sheppard (DPI&F), Tony Morrison (EPA), Lisa Evans (DEH).

Tully-Murray Aggregation: Steve McDermott (FNQNRM), Rowena Grace (FNQNRM), Paul Lawrence (DNRM), Alf Hogan (DPI&F), Paul Devine (Cardwell Shire Council), Peter Dore (farmer), Tim Perry (Earthworks Environmental Services), Ron Zamora (WPSQ), Murray Whitehead (EPA), Donna Audas (GBRMPA), Leigh Pentacost (Girringun Aboriginal Corporation), Charles Kinjun (Gulnay), Claude Berin (Girringun Aboriginal Corporation), Peter Lucy (Canegrowers Association), Damon Sydes (Cardwell Shire Council / FNQNRM), Tony Morrison (EPA), Bob Brighton (farmer / C4), Dianna O'Donnell (DPI&F), Dick Camilleri (Tully Sugar), Bill Shannon (FNQNRM), Jane Hosking (DEH).

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The Project Team comprised of:

- Alan Hunter (HLA) – Project Manager
- Abe Francis (Ecoscape / HLA) – DSS development
- Tim Anderson (NRA) – Workshop facilitator
- Jim Tait (Econcern) – Wetland Expert
- Richard Smith (HLA) – GIS analysis / DSS construction

While the project team had specific roles, all members of the team contributed to the direction and development of the DSS.

EXECUTIVE SUMMARY

Concerns about the potential damage to the Great Barrier Reef (GBR) as a result of wetland clearing, altered drainage regimes, and land development has prompted the Australian Government to put into action the Great Barrier Reef Coastal Wetlands Protection Programme (GBRCWPP). The programme aims to develop and implement measures for the long term conservation and management of wetlands in the reef catchments. These measures will be instigated through the strategic allocation of funds directed at wetland restoration and protection projects. Optimal allocation of funding will require the prioritisation of wetlands based on an assessment of a range of complex and interlinked biophysical, social and economic factors. In addition, the rationale and logic driving funding allocation decisions will need to be logical, transparent and clearly account for the choices made to expend public funds.

The development of a wetland decision support system (DSS) has been identified by the Department of the Environment and Heritage (DEH) as a way to strategically prioritise wetlands for investment. The objectives of the DSS are to: *Use biophysical, socio-economic, community capacity and threat data, and expert consultation to identify higher priority wetlands for strategic investment; and to achieve greater accountability and transparency in wetland prioritisation*. This report summarises the outcomes of the development of a wetland DSS for the DEH. Specifically, the report:

- documents the development methodology undertaken to produce the wetland DSS;
- documents the outcomes of the expert and testing workshops conducted over the course of the project;
- includes the Primary and Secondary Wetland DSS tool developed in Microsoft Excel;
- provides instructions on how to operate and use the Wetland DSS tool;
- presents the results of the Initial GBR Wetland prioritisation workshop; and
- provides recommendations on the steps forward with the system.

The development of the wetland DSS involved a number of logical steps that included a review of international and national literature and DSSs, data assessments, data processing, and workshopping with nominated experts and stakeholders. The wetland DSS is based on a multi-criteria assessment method (MCA) to determine wetland priorities and allows different alternatives to be assessed through weighted measurable criteria. Criteria were developed and then assessed and weighted in expert panel workshops. Weighting allowed for value judgements to be made about the criteria and their importance as a contributing factor to be specified when making a decision.

The DSS operates at two scales. The primary DSS prioritises wetland aggregations within the GBR catchments and uses Geographical Information System (GIS) analysis methods to process existing catchment scale datasets. The secondary DSS is used to prioritise individual wetlands using local expert knowledge and GIS analysis. A primary and secondary wetland DSS tool has been developed in separate MS Excel spreadsheets which provides the user with the capacity to view prioritisation results, assign priorities to criteria and, for the secondary DSS, input data for wetland criteria.

The Primary and Secondary DSSs were tested at a series of workshops with regional and local decision makers. The results were then interrogated and feedback received from the participants. The DSSs and associated reports have been externally peer-reviewed and a sensitivity analysis has been undertaken.

With all DSSs, there are strengths and limitations to the system. Often the factor considered a strength can also be considered a limitation. Some of the key strengths of the system include the ability to provide transparency to the decision making process and its inherent flexibility, which allows the system to be applied to multiple management objectives and outcomes. Limitations of the system include the accuracy, availability and relevancy of the criteria data used in the tool. Users must be made aware that the system is designed to support decision making rather than make decisions.

The DSS, as it has been developed, is a powerful tool to assist with prioritising wetland entities for funding. It has been developed with reference to the available data, current NRM frameworks, types of wetlands that exist in Queensland and the different decision makers and stakeholders in the GBR Catchment. Continual improvements to the DSS will need to occur as new data becomes available and as experience grows with using the system.

1 INTRODUCTION

1.1 Project Context

The Australian Government announced, on 13 May 2003, the Great Barrier Reef Coastal Wetlands Protection Programme (GBRCWPP) to be delivered over 5 years, to protect and restore wetlands in catchments adjacent to the Reef lagoon. The GBRCWPP was developed in response to concerns about potential damage to the Great Barrier Reef (GBR) as a result of wetland clearing and drainage, which contributes to increasing levels of sediment, pesticides and nutrients reaching the Reef lagoon. The objective of the programme is to develop and implement measures aimed at the long term conservation and management of wetlands in the GBR Catchment.

The GBRCWPP will also assist in delivering actions under the GBR Water Quality Protection Plan. The selection of wetlands for management intervention must be a logical and transparent decision-making process that is fair and equitable for all parties and clearly accounts for the choices made to expend public funds. Therefore, an initial step for the GBRCWPP is the identification of higher priority wetlands for strategic investment.

A wetland prioritisation process utilising a decision support system (DSS), which incorporates expert consultation, has been developed for the GBRCWPP to achieve greater accountability and transparency in wetland prioritisation. The DSS uses biophysical and socio-economic data to define wetland values, threats and community capacity to assist the prioritisation process. The DSS will be used to make recommendations, but further consultation with regions will take place before funds are invested within the GBR Catchment. The GBR Catchment River Basins are shown on **Figure 1**.

1.2 DSS Aims and Objectives

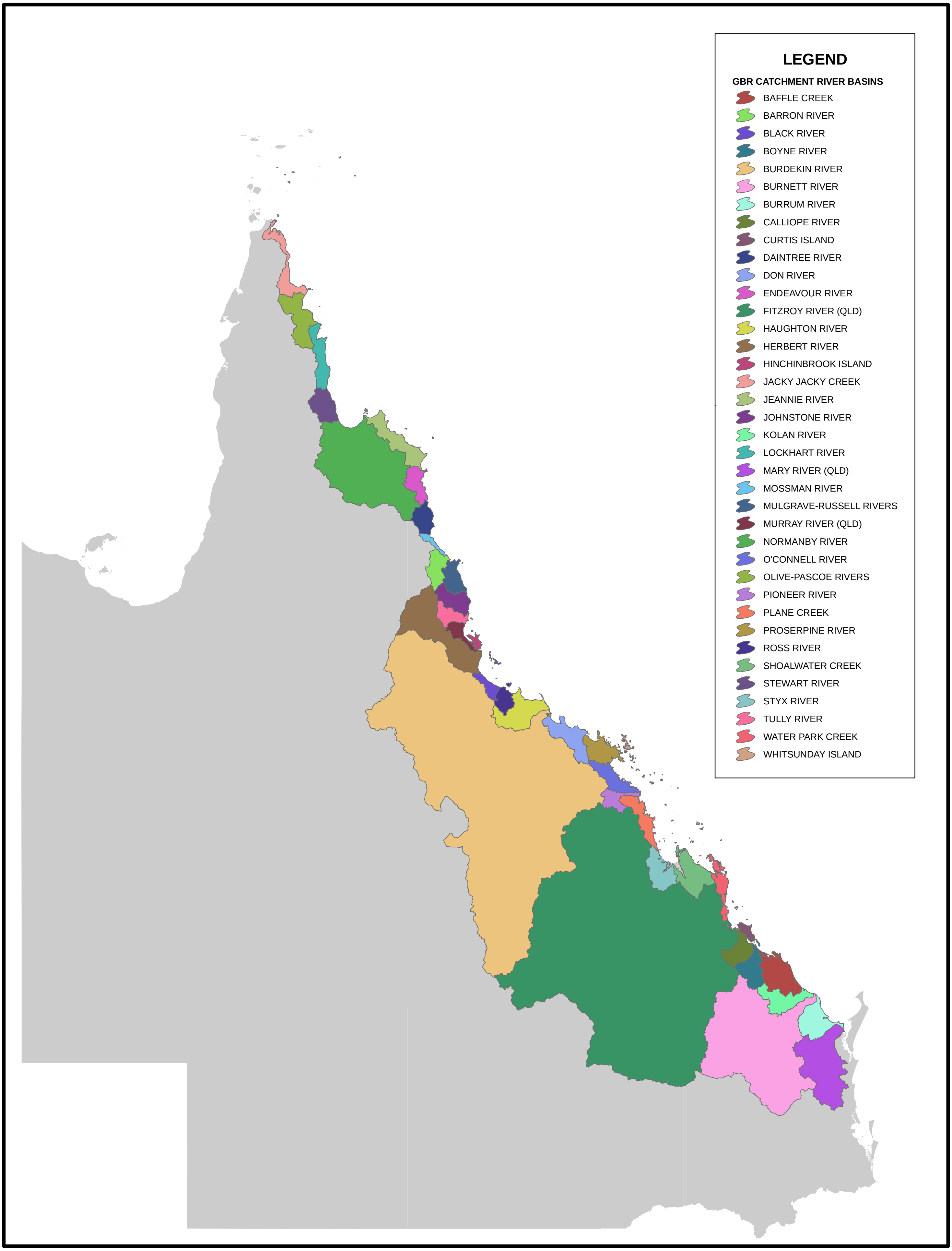
The Wetland Prioritisation Decision Support System for the Great Barrier Reef Catchment is being developed as part of the GBRCWPP. The objective of the GBRCWPP is:

"To develop and implement measures for the long term conservation and management of wetlands in the Great Barrier Reef Catchment"

The GBRCWPP will also assist in delivering actions under the Queensland and Australian Government's *Reef Water Quality Protection Plan.*

A key requirement for prioritising wetlands for investment under the GBRCWPP is to identify wetlands that have a significant role to play in improving water quality entering the reef and wetlands that provide important habitat for native flora and fauna. These significant wetlands will provide the focus for conservation and management initiatives supported by the programme.

The objectives and requirements of the DSS were specified in the terms of reference supplied as part of the project brief. The objectives and requirements are summarised below:



HLA

GBR CATCHMENT RIVER BASINS
Department of the Environment and Heritage
Wetland Prioritisation Decision Support System
GBR Catchment

Source: ERIN

0 50 100 200 300 400 Kilometers

N
Datum WGS 1984

Figure 1

PROJECT NUMBER M600017 | DATE 22 MARCH 2006 | DRAWN A. FRANCIS | VERSION A

A4P_M600017_FIG1_22MAR06

The objectives of the DSS are to:

- Use biophysical, socio-economic, community capacity and threat data and expert consultation to identify higher priority wetlands for strategic investment; and
- Achieve greater accountability and transparency in wetland prioritisation.

The requirements of the DSS are to:

- Use a risk based approach;
- Be robust and based on the best available science;
- Be applicable at different scales;
- Manage data of differing levels of detail for individual wetlands;
- Use different data types e.g. categorical, continuous;
- Integrate biophysical, socio-economic, community capacity and threat considerations;
- Be adaptive as new data and knowledge is made available;
- Allow for defensible and transparent investment decisions;
- Be user friendly;
- Be flexible to cater for different outcomes; and
- Draw on existing data to run.

While the DSS will be used to inform decision makers further consultation with regions will take place before funds are invested within the Great Barrier Reef Catchment. As such, the tool will be used to inform decision makers and ‘support’ decisions rather than be a prescriptive mechanism.

1.3 Background

A technical workshop was held in Townsville in December, 2003 prior to HLA undertaking this project. The workshop was the initial step in the development of a DSS to guide strategic management intervention for Queensland wetlands and its purpose was to consolidate advice from a range of biophysical and socio-economic experts on the requirements of a DSS.

The objectives of the Workshop were as follows (Finlayson, *et al.,* 2004):

1. Develop, test and assess a list of criteria to prioritise wetlands based on current values, pressures, and capacity, including methods to assess values of wetlands (evaluation) and the extent of threats and risks (risk assessment), and capacity of regions to respond;
2. Identify the current knowledge base and gaps, including information on land use and development, population growth, local capacity, biophysical character of wetlands, and social, political and biophysical drivers of change in wetlands;
3. Advise on the development of a decision support system to assist in prioritising interventions, and develop a model scenario to operationalise the use of information from the inventory and assessment (evaluation and risk analyses) steps and considering local capacity to respond; and
4. Advise on a monitoring and evaluation framework and indicators to provide assurance that the operational model is being effectively used and check that initial assumptions about the role/value of priority wetlands is correct, or, where necessary, in need of adjustment.

The major outcomes of the workshop were as follows:

- A broad list of biophysical, socio-economic, and institutional and governance criteria to prioritise wetlands;
- A preliminary identification of knowledge and data gaps;
- Decision rules for initial prioritisation based on agreed criteria and a threat analysis;
- Decision rules for investment; and
- Requirements of a DSS model to prioritise wetlands for strategic intervention.

This workshop represented the initial stages of the project and determined the requirements of the DSS. Additionally, a preliminary list of criteria and associated indicators was compiled from the workshop outcomes. This list was extensive and encompassed social, economic and biophysical aspects of wetland values, threats and capacity. A conceptual model for the DSS was also determined and is shown in **Figure 2**.

The outcomes of this workshop helped to determine the terms of reference for the project, articulated the need for and objectives of a DSS and established a starting-point for determining the criteria associated with the DSS.

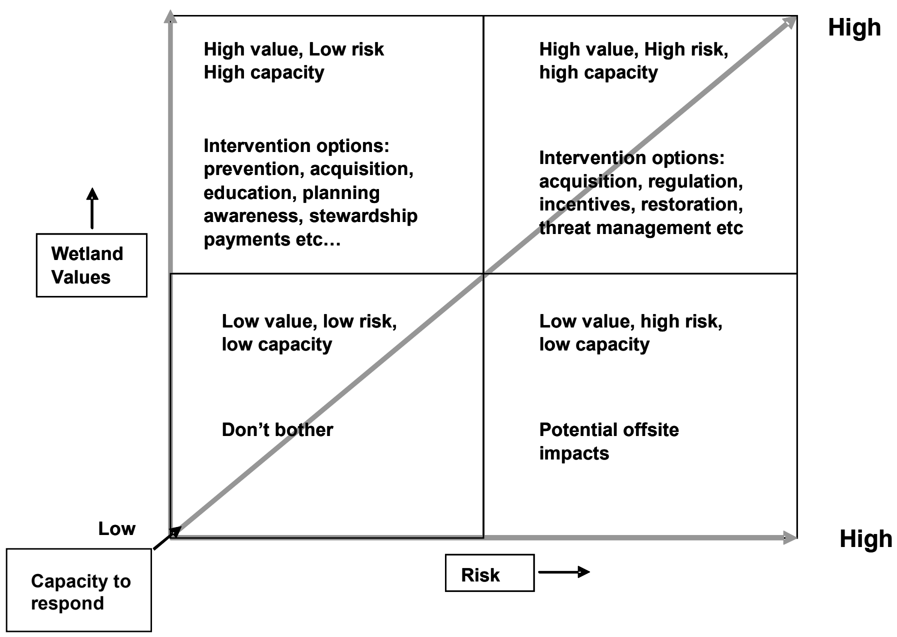


Figure 2: Proposed DSS Conceptual Model for Prioritisation of Wetlands and Intervention, based on Values, Risk & Capacity Criteria Attributes

1.4 Overview of Process

The DSS was developed using a specific and logical procedure. This involved a number of logical steps that included reviews of literature and data as well as a number of expert and stakeholder workshops and externally peer reviewed reports. The DSS development process is illustrated in **Figure 3**.

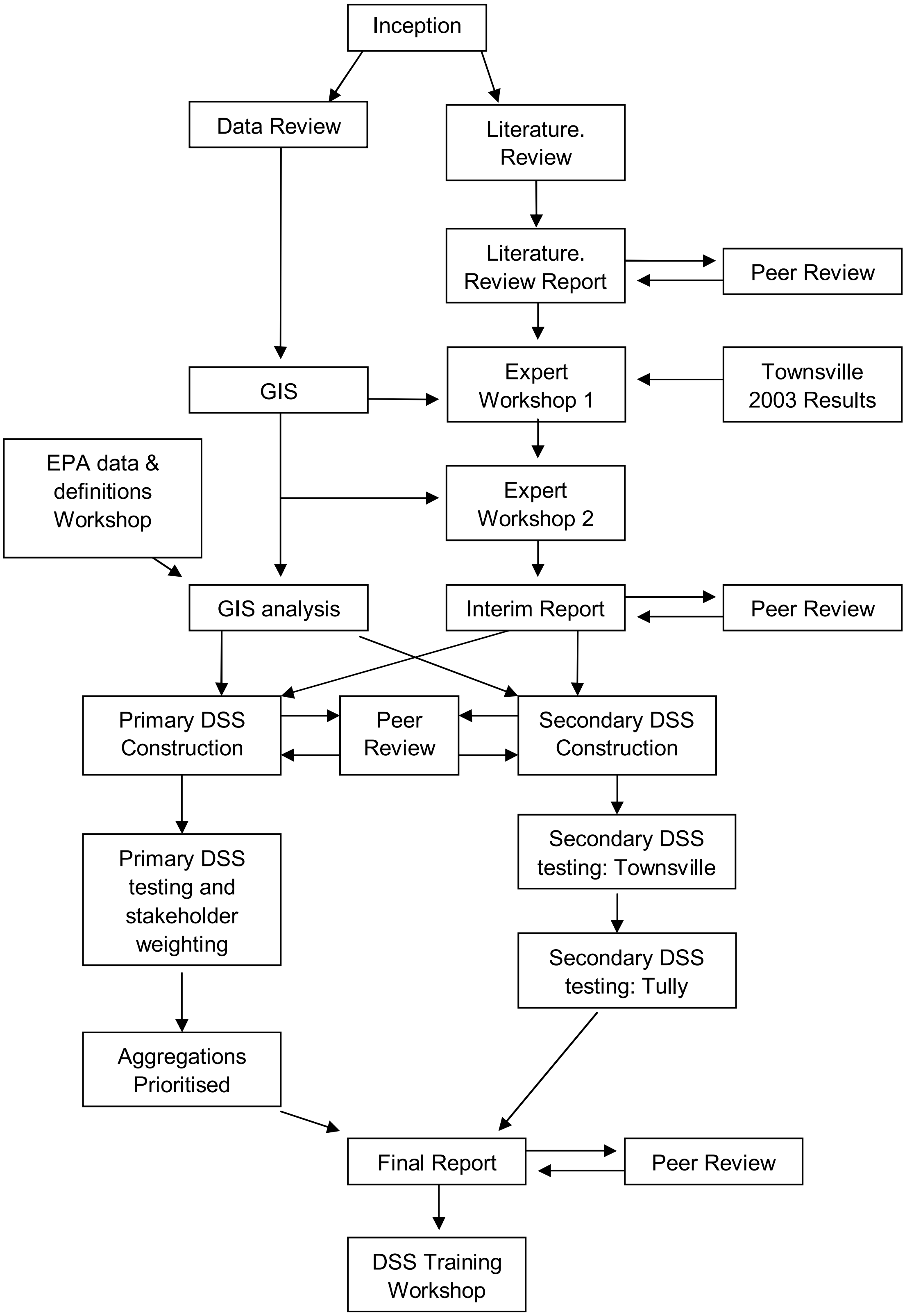


Figure 3: DSS Development Process

2 DECISION SUPPORT SYSTEMS REVIEW

2.1 Introduction

An initial step in developing a DSS for the prioritisation of wetlands in the GBR Catchment was to review the available literature to:

- Ensure that a 'best practice' approach is used and that a full knowledge of the current state of thinking is obtained from national and international sources;
- Determine the suitability of DSS methodologies and associated concepts to the prioritisation of wetlands in the GBR; and
- Identify the potential for the use or modification of existing DSS's to apply to the GBR wetlands.

The review entailed searches of journal databases and obtaining relevant papers, internet searches and downloads, telephone and email discussions with Australian and international DSS practitioners and developers. The detailed outcomes of the literature review are described in HLA-Envirosciences (2005a) and a summary of the outcomes is provided in the section below.

2.2 Definition of a DSS

Holsappe (2003) defined a DSS as follows:

> *"A computer-based system composed of a language system, presentation system, knowledge system and problem-processing system whose collective purpose is the support of decision-making activities"*

DSSs help managers make decisions in situations where human judgment is an important contributor to the problem solving process, but where limitations in human information processing impede decision making (Rauscher, 1995). It is therefore a way to synthesise the available information to make it more readily understandable and able to be used in the decision-making context. Bunnell and Boyland (2003) identified four broad purposes of DSS's with regards to ecosystem management:

1. *Aid Research.* DSSs can identify areas where research needs to be carried out and can also validate previous research with practical management applications.
2. *Guide Management.* The primary function of DSSs is to guide management. The success of this depends on the ability to predict the consequences of management actions.
3. *Convey Knowledge.* Expert knowledge must be conveyed to decision-makers and stakeholders in a transparent way.
4. *Evaluate trade-offs publicly.* The consequences of management actions need to be demonstrated to the public to gain acceptance of the management practices employed.

2.3 DSS Methodologies

Broad DSS methodologies often used for environmental decision support were examined. These were:

- Cost-Benefit Analysis (CBA);
- Process Models (PM);
- Multi Criteria Analysis (MCA); and
- Linear Programming (LP).

These methodologies were compared against the DSS aims (see **Table 1**).

Table 1: Comparative Assessment Of DSS Methodologies

DEH Criteria	CBA	PM	MCA	LP
Uses a risk based approach	No	No	Yes	Yes
Is robust and based on the best available science	Yes	Yes	Yes	Yes
Can be applied at different scales	No	No	Yes	Yes
Can manage with data of differing levels of detail	Yes	Yes	Yes	Yes
Can use different data types e.g. categorical, continuous	No	No	Yes	Yes
Integrates biophysical, socio-economic, community capacity and threat considerations	Not very well	No	Yes	Yes
Is adaptive as new data and knowledge is made available	No	No	Possible	Possible
Allows for defensible and transparent investment decisions	Yes	No	Yes	Not very well
Is user friendly and easy to use	Yes	No	Possible	No
Is flexible to cater for different outcomes	No	Yes	Yes	Yes
Draws on existing data to run	No	Yes	Yes	Yes

A large number of existing DSS tools were also examined to determine if they could be adapted for the GBRCWPP DSS. Of these, three MCA-based tools were identified as potentially suitable, however further examination led to the decision to develop a Microsoft® Excel™ based DSS because it is a widespread application, easily updateable, flexible and a large number of people are familiar with its use.

2.4 Data Review

A comprehensive review of available information, particularly spatial data coverages was also undertaken to determine the existence and availability of information that could be used in the DSS. Following the review, potentially useful data was compiled and further added to during the course of the project. The data review involved:

- An initial review of available literature, reports and datasets by GBRMPA;
- Reviews and metadata searches using online databases (e.g. Australian Spatial Data Directory);

- Discussions with data custodians from Queensland State and Federal Government;
- Discussions with colleagues in similar disciplines; and
- Workshop participation and outcomes.DSS Development

3 DSS DEVELOPMENT

The development of the DSS was undertaken by the project team based on the DSS requirements outlined in Section 1.2 and on the outcomes of a series of five workshops: two expert panel workshops, one stakeholder weighting workshop and two local expert / stakeholder workshops to test the DSS.

The development of the DSS was guided by:

- The DSS requirements;
- The results of the DSS review;
- Discussions during the workshops;
- Discussions with the DEH;
- Discussions within the project team;
- Consultation with external specialists; and
- A review of data quality and availability.

3.1 Definition of Alternative Sets

An early stage of the development process involved the identification and definition of the 'alternatives sets' or 'options' which are the units that are chosen between or ranked in order of priority using the DSS. It became evident that more than one set of alternatives would be required so a two-scale (primary and secondary) approach was proposed by the project team because:

1. Larger scale entities could first be identified / prioritised for further finer scale assessment
2. Data could be utilised according to its appropriate scale, recognising that much available data is likely to be coarse and unsuited to fine scale prioritisation;
3. Different methods could be applied to prioritisation at the two scales including the use of local expert qualitative data for assessment criteria where there is a lack of available GIS data;
4. Local stakeholders could weight finer-scale criteria according to local conditions which gives ownership of the process and more accurate outcomes;
5. It allows more flexibility in funding delivery;
6. It allows measures to be delivered at the appropriate scale, i.e. by grouping wetlands, different management measures could be applied to wetlands individually or as a group.

This approach was proposed at the expert panel workshops and it was agreed by the group to be the most suitable approach. Wetland aggregations were nominated as the most suitable unit at the primary scale because:

- Wetland aggregations listed in the Directory of Important have already been mapped and include most of the important wetland areas currently recognised in Queensland;
- They are of an appropriate scale for GBR Catchment-wide prioritisation;
- They most closely approximate wetland complexes, their boundaries being defined by biophysically related and/or proximally located wetlands; and

- They have been defined using a hierarchical framework with internal sub system elements providing a focus for value definition or management prescription.

It was agreed that aggregation mapping needed to be developed further in the GBR Catchment so that other aggregations, besides those listed in the Directory of Important wetlands, could be considered.

Individual wetlands were identified as the most suitable unit at the secondary scale. The expert panel agreed that the definition of a wetland should follow the EPA definition as follows:

"Areas of permanent or periodic/intermittent inundation, with water that is static or flowing fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6m. To be a wetland the area must have one or more of the following attributes:

i. at least periodically the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their life cycle, or

ii. the substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers, or

iii. the substratum is not soil and is saturated with water, or covered by water at some time.

Examples of wetlands under this definition and within the project scope include:

- Those areas shown as a swamp, lake, marsh, waterhole, wetland, billabong, pool or spring on the latest Sunmap1: 25000, 1:50000, 1:100000 or 1:250000 topographic map;
- Areas defined as wetlands on local or regional maps prepared with the aim of mapping wetlands;
- Wetland associated Regional Ecosystems (RE's) as defined by the Queensland Herbarium;
- Areas containing recognised hydrophytes as provided by the Queensland Herbarium;
- Artificial wetlands such as farm dams; and
- Water bodies not connected to rivers or flowing water such as billabongs and rock pools.

Certain types of wetlands are ineligible for funding under the GBRCWPP. These are

- Riverine and associated riparian wetlands;
- Mangrove wetlands; and
- Seagrass beds.

The above will not be funded through the GBRCWPP as these types of wetlands are funded or are protected through other mechanisms.

The wetland definitions above were endorsed at a workshop of Queensland Government stakeholders on the 19th August, 2005 and the mapping products required were identified.

3.2 System Overview

A Multi-Criteria Analysis (MCA) approach was concluded to be the most appropriate DSS method for supporting prioritisation of wetlands. MCA is a type of DSS that allows different alternatives to be assessed by a set of weighted, measurable criteria. The use of GIS combined with a MCA-based DSS is suited to this application, as existing spatial data can be analysed to create performance values for criteria. Each criterion can then be weighted according to their relative importance to stakeholders. This is a vital part of the decision support process as it allows the physical and/or biological to be considered as well as stakeholder perceptions of the importance of each criterion.

The DSS works at two scales. The Primary DSS prioritises wetland aggregations within the GBR Catchment and all criteria values at this scale are scored using GIS analysis with weighting carried out by stakeholders / decision-makers with visibility over the entire GBR Catchment. Individual wetlands within high priority aggregations are then identified assessed and prioritised by local experts and decision makers using a Secondary DSS. There will therefore be a single primary-scale DSS and a number of Secondary DSSs (one for each aggregation under consideration). This is shown diagrammatically in **Figure 4**.

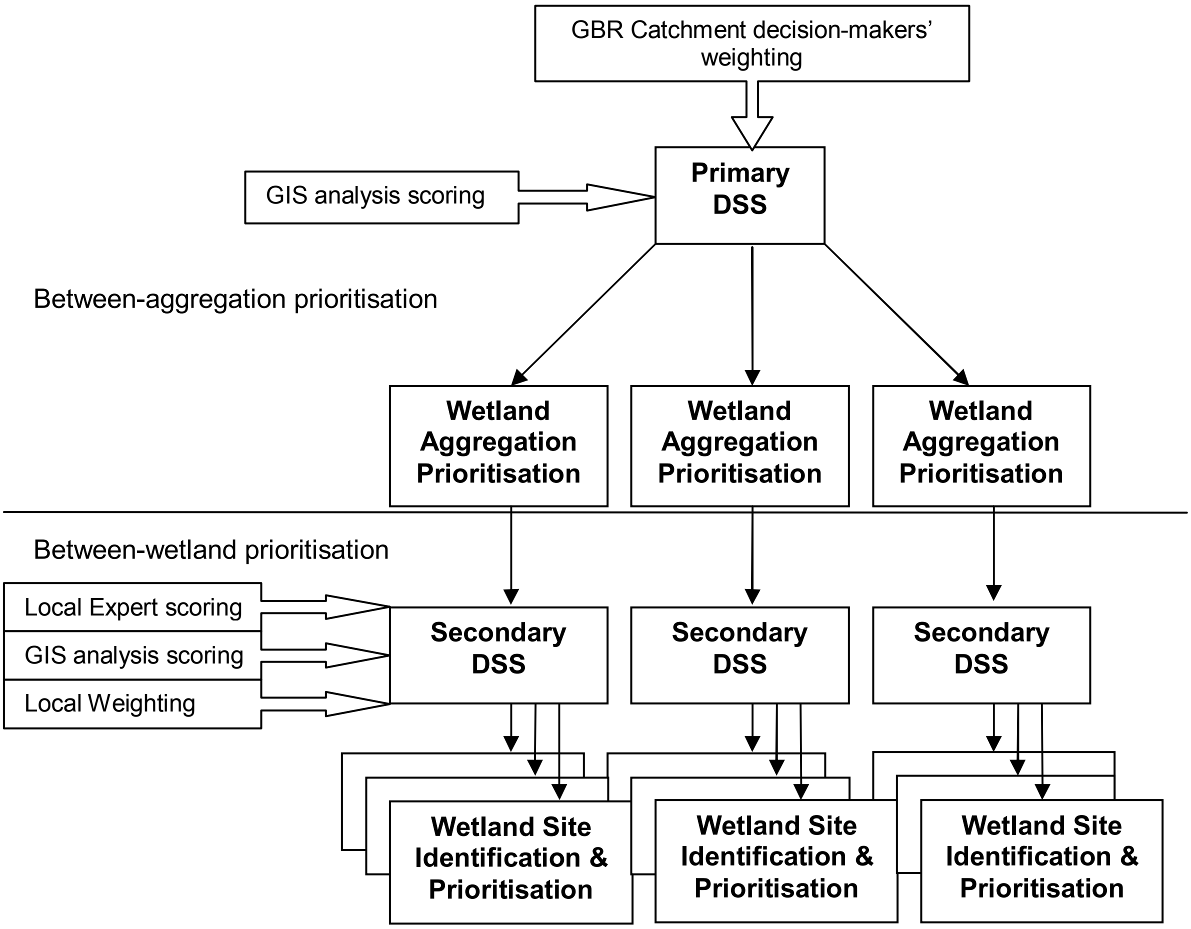


Figure 4: Diagrammatic Representation of DSS

The DSS runs within an Excel spreadsheet with GIS analysis undertaken using ArcGIS 9.1. Currently GIS analysis is undertaken separately and the resulting performance values exported into the Excel workbook, however this process would be simplified through the use of ESRI® Model Builder™ or by building OBDC links with the GIS.

3.3 GBR DSS Structure

Both the Primary and Secondary DSS have been developed in a Microsoft Excel workbook consisting of the following elements (worksheets):

- **Splash Page:** contains basic instructions as well as hyperlinks to detailed instructions and other worksheets in the workbook.
- **Weighting Page:** is where the weightings are entered into the DSS. Overall weights for 'values', 'threats' and 'capacity' are entered in the appropriate columns as are individual criteria weights. This page also has 'dropdown' cells to assign each criteria as a 'cost' or a 'benefit' allowing the user to specify whether a large number for a criteria will help select for the alternative (benefit) or against it (cost) during the analysis.

- **Results Page:** shows the overall results of the MCA once all the scores and weights have been assigned. A button on the worksheet entitled 'sort' ranks the alternatives from highest to lowest. Additionally the ranking for each category is shown in isolation of the others.
- **Results Chart:** shows a graphic representation of the results so that the degree of difference between each of the alternatives can be seen. For example if an alternative scored much higher in the analysis than another, this will be shown in this graph. The data is stacked on top of each other with Values at the bottom, Threats in the middle and Capacity at the top. The sum of the three classes is equivalent to the Overall value.
- **Primary DSS / Secondary DSS:** is the 'engine' of the DSS and contains all the matrices and formulas to carry out the MCA. The appearance of this page will be slightly different depending on whether it is the Primary (aggregations) or Secondary (wetland sites) DSS. Both the Primary and Secondary DSS will have three matrices: an effects matrix, a standardisation matrix and an additive weight matrix. The Secondary DSS has a third matrix to enter the wetland details (name and code) and enter scores for each wetland according to each criterion. It also allows the user to select an average value, which uses the average of all the other entries entered into the Effects Matrix. The Primary DSS does not require data to be entered into this worksheet.
- **GIS Export:** contains all the values for each alternative and criterion, as well as the sum of criteria scores and rank for each alternative in a format suitable for importing to GIS. A button on this worksheet exports this data as a *.csv attribute table which can then be joined to the GIS table of the aggregations or wetlands dataset to show the criteria values and MCA results spatially.
- **GIS Analysis:** is where the values for criteria obtained from GIS analysis are stored. These cells are 'locked' and cannot be edited without a password. Editing of this worksheet is only carried out when major data sources used by the DSS have been updated. The effects matrix gets information from this worksheet to enter criteria values derived from GIS analysis.

3.4 MCA Analysis

The primary/secondary DSS worksheet contains the core calculations and formulae used to prioritise alternate sets. Criteria derived from the workshop process (see Section 4.0) and the set of alternatives are arranged in the effects matrix, standardisation matrix and the additive weights matrix in this worksheet.

The effects matrix is where the scores for each criteria and wetland alternate are entered into the system. Also visible in the effects matrix for the criteria and the wetland alternate set are:

- Values, threats and capacity weights;
- Individual criteria weight;
- Total weight for each criteria; and
- Whether the criteria is set as a benefit or cost.
- These settings are entered through the Weighting page.

The standardisation matrix uses a standardisation method for GIS analysis-derived scores to bring the data into a similar range of values so that the information can be compared across the different criteria. Scores derived through local experts are not standardised as they are derived from specific scales.

The standardisation method for benefits and costs are as follows:

Benefits:

$$\frac{V_i - min(V_j)}{max(V_j) - min(V_j)}$$

Costs:

$$\frac{Max(V_j) - V_i}{max(V_j) - min(V_j)}$$

where V_i is the alternate set score for each criteria.

The standardised scores for each of the sites for each criterion are then multiplied by their associated weights, resulting in an 'Additive Weights Matrix'. The scores are then summed for each site and the sites ranked according to the resulting value. An illustrated example of the process is given in **Figure 5**.

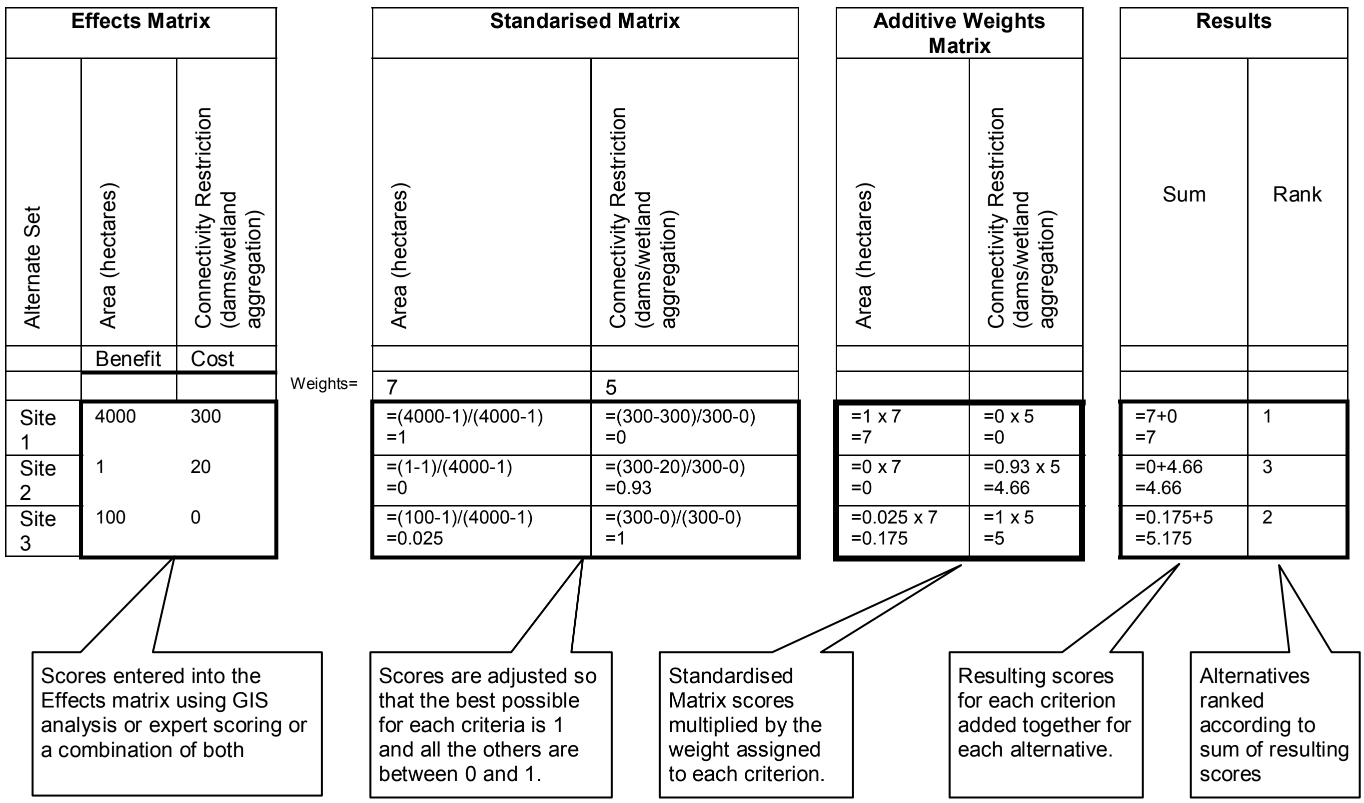


Figure 5: Illustrative Example Of Multi-Criteria Analysis (Additive Weighting) Process

Both the Primary and Secondary DSS use the "additive weighting' method described above to convert the criteria scores, weights and direction to a final rank. This forms the core analysis component of the DSS tool. More detail and illustrations are provided in the User Guides contained in **Appendix 1** (Primary DSS) and **Appendix 2** (Secondary DSS).

The criteria have been grouped into three different categories – 'values', 'threats' and 'capacity'. This has been done for two reasons. The first is to make it easier for participants to weight the criteria so that they need only be compared with other criteria in the same category. The second reason is to enable different weights to be assigned to the categories depending on the specific management objectives without necessarily changing the individual weights for each criterion. Using the DSS to prioritise under different management objectives is explored in greater detail in Section 6.

3.5 Criteria Scoring

3.5.1 Primary DSS Criteria Scoring

The Primary DSS was scored entirely using GIS analysis for the following reasons:

- Datasets available to support criteria analysis are generally more suitable for use at the regional scale rather than the local scale;
- There are a very large number of alternatives at the GBR Catchment scale which would make scoring by hand difficult and time consuming;
- There is little existing data which is consistent, accurate and extensive enough that has not already been incorporated into a spatial dataset; and
- Consistent, accurate and sufficiently extensive expert knowledge for the entire GBR Catchment is unlikely to be obtained.

A number of different analysis metrics were used to score the criteria. The specific analysis steps are described in **Appendix 3**.

Primary DSS criteria definitions and analysis rationale are described in **Appendix 4**. The analysis generally involved the following:

1. Spatial analysis using GIS layers and lookup tables (e.g. Wetland Inventory, QLUMP, Subcatchments)
2. Creating unique polygon identifier numbers (PIN) for each aggregation and summarising the results (adding together all related values) of the above analysis based on PIN.
3. Intersecting with the base layer.
4. Exporting to decision matrix.

3.5.2 Secondary DSS Criteria Scoring

The secondary DSS was primarily scored using expert / local knowledge due to the paucity of consistent, suitable data at that scale. GIS analysis was used to score three of the criteria at this scale.

Most of the criteria for the Secondary DSS are scored using local / expert knowledge in a workshop context. This approach was tested and refined at the secondary DSS testing workshops held in Townsville and Tully. Scoring was done using descriptive definitions based scales for each criterion (see **Appendix 5**). The development of the criteria is the subject of the following chapter.

4 CRITERIA DEVELOPMENT AND ANALYSIS

4.1 Introduction

The criteria for the Primary and Secondary DSSs were developed through a series of workshops composed at various times of Wetland Experts, DSS Experts, State and Federal Government Representatives, industry and NRM stakeholders. The objectives and outcomes of workshop objectives are summarised in **Table 2**.

Table 2: Objectives of GBR Catchment DSS Workshops

Date	Type	Objectives	Achieved?
10/05/05	Expert Panel	Confirm objectives Confirm DSS structure and methods Assess, rationalise and develop criteria from Finlayson *et al.* (2004)	Yes Yes Partly
07/06/05	Expert Panel	Assess, rationalise and develop criteria from Finlayson *et al.* (2004) Group criteria Weight primary criteria	Yes Yes No
19/08/05	Queensland Government	Definitions and mapping requirements of DSS Potential linkages with Qld Gov systems and projects	Yes Yes
13/12/05	Regional Stakeholders	Test primary DSS Weight primary criteria	Yes Yes
22/02/06	Local experts / stakeholders (Townsville)	Test secondary DSS	Yes
17/03/06	Local experts / stakeholders (Tully)	Test secondary DSS	Yes

4.2 Criteria Development

Criteria were developed through the expert panel workshop process and subsequently refined through the DSS testing workshops. The initial expert panel workshop was held in Brisbane at the Queensland EPA to further refine the outcomes of the 2003 workshop and it was attended by experts in the fields of wetland ecology, economics, social science and GIS. The focus of this workshop was to assess the criteria proposed from the Townsville 2003 workshop (Finlayson, 2004) to help establish the set of criteria for the GBR Catchment DSS. To help with this, participants were given background information on the proposed DSS structure and a summary of the existing GIS information available to help score the criteria.

Given there were around 120 criteria proposed at the Townsville 2003 workshop, the overall number of criteria needed to be substantially reduced, both to reduce the amount of analysis required to a feasible level and also to ensure that the DSS was sensitive to weighting. The procedure of assessing and rationalising the Townsville 2003 criteria involved determining whether each criterion was:

- important;
- independent;
- related to the objectives; and
- measurable.

The panel first assessed the importance of each criterion. Criteria considered important and relevant were then examined and if necessary changed so that they were independent (did not overlap with other criteria as much as possible) and measurable. This reduced the overall number of criteria to around 60.

A second expert panel workshop was held in Townsville at the GBRMPA headquarters to further rationalise and group the criteria. Rationalisation was based on the feasibility of measuring each criterion and was based on the review of the available data and further discussion by participants.

Criteria rationalisation followed the decision process outlined in **Figure 6**. Rationalisation was based on the availability and quality of data (including local / expert scoring) and was also used to allocate criteria to the primary or secondary DSS.

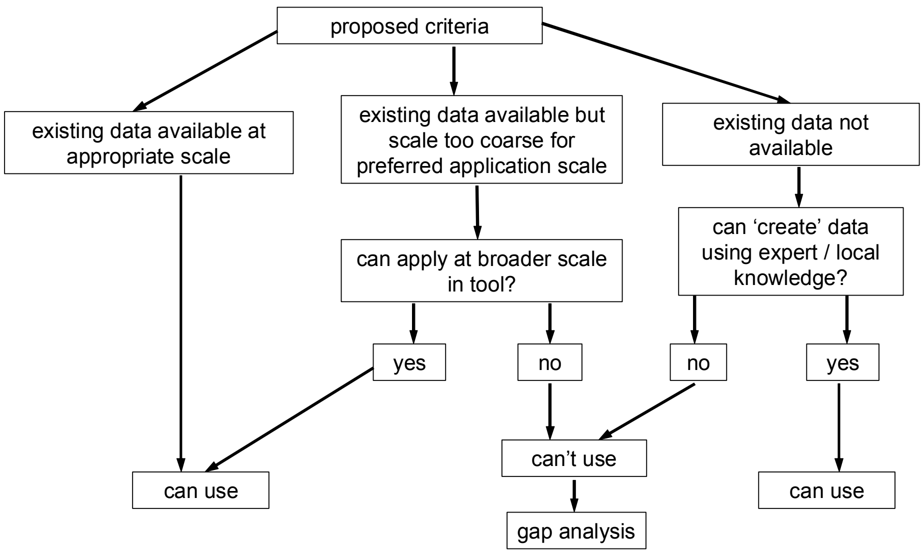


Figure 6: Decision Process To Rationalise Criteria

Grouping and rationalisation was undertaken by the workshop participants in two separate, facilitated groups, biophysical and social/economic, and each group composed of specialists in these fields. It was proposed, discussed and agreed to group the criteria under values, threats and capacity classes. After rationalisation and grouping, the remaining criteria were defined and analysis methods to score the criteria were discussed.

Minor changes were made to the composition and definition of the criteria subsequent to the Expert Panel workshops based on further examination of the quality of the available datasets and through the DSS testing workshops.

Weighting of the Primary DSS Criteria was also to be undertaken at this workshop, however the participants declined as they felt that sensitivity analysis of the criteria should be undertaken first and that participants of a weighting workshop should be composed of regional scale stakeholders.

4.3 Final Criteria Sets

The final criteria sets for the Primary and Secondary DSSs are described below. These have been generated and refined through the process described above and have undergone testing as described in the following chapter.

The primary scale criteria apply to wetland aggregations throughout the entire GBR Catchment. These are shown below in **Table 3**. Definitions of these criteria are described in **Appendix 4**.

Table 3: Primary DSS Criteria

Values	Threats	Capacity
• Vegetation representativeness • Diversity of wetland types • Aggregation area • Proportion remnant vegetation • Fishery habitat value • Detention / retention	• Population density • Population growth • Catchment land-use intensity • Aquatic habitat connectivity restriction • Point source pollution risk • Hydrological change (irrigation)	• Socio-economic disadvantage • Education and occupation • Economic resources • Indigenous land areas • Protected areas

The secondary scale criteria apply to wetland sites throughout the entire GBR Catchment and are shown below in **Table 4**. Definitions of these criteria and the scales used to measure them (where relevant) are described in **Appendix 5**.

Table 4: Secondary DSS Criteria

Values	Threats	Capacity
• Recreation value • Indigenous value • Fishery habitat • Assimilative capacity for nutrients and sediments • Populations of rare or threatened taxa • Vegetation representativeness • Wetland representativeness • Species richness / diversity • Size • Waterbird habitat value • Wetland condition	• Aquatic habitat connectivity restriction • Land-use intensity • Land-use intensification • Weed invasion • Water quality • Point-source pollution • Hydrological change	• Level of protection • Financial incentives • Industry land-use viability • Engagement capacity • Best management practice feasibility

4.4 Criteria Weighting

Criteria weighting is an important part of the MCA process. Weighting allows value judgements to be made about the criteria and their importance as a contributing factor to be specified when making a decision. Different weights can therefore be assigned to criteria depending on the specific decision being made.

Criteria were weighted in a workshop environment. While the criteria for the Primary DSS were originally intended to be weighted during the second expert panel workshop, it was agreed that it should be undertaken by the regional stakeholders and decision-makers. The Primary DSS criteria were therefore weighted at a workshop comprising of regional stakeholder participants. Secondary DSS criteria for two high priority, representative wetland aggregations were subsequently weighted by the local experts / stakeholders at workshops held in these wetland aggregations (see **Table 2**).

Two different weighting methods were trialled at the Regional Stakeholder (Primary DSS) workshop. One method involved weighting each criterion relative to all the other criteria (regardless of category) and the other method involved weighting the categories (values, threats and capacity) and then weighting each criterion within each category relative to the each other. The outcomes of both weighting methods were very similar (see **Figure 7**) however participants found the second method easier because the criteria were broken up into smaller groups and 'like' criteria could be compared with 'like'. The participants voted in preference of the second method and this method was subsequently adopted for both of the secondary testing workshops. The steps involved in weighting are described in **Appendix 1** and **Appendix 2**.

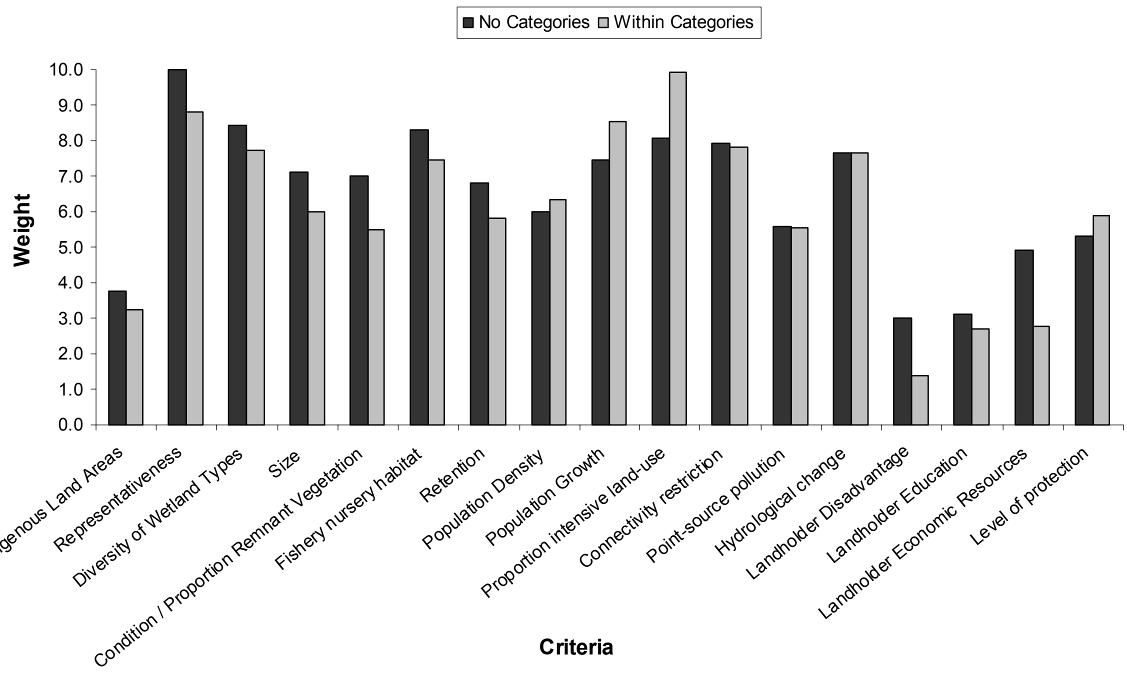


Figure 7: Comparison Between Weighting Regardless Of Weighting (No Categories) And Weighting Within Values, Threats And Capacity Categories (Within Categories)

5 DSS TESTING AND RESULTS

5.1 Introduction

The Primary and Secondary DSSs were tested at a series of workshops. In addition, an external peer review of the primary DSS was conducted. The Primary DSS testing workshop involved assigning weights to the DSS using two methods and selecting the preferred method to produce a prioritised list of aggregations. Critical examination of the criteria, analysis methods and results was also undertaken at this workshop. The Secondary DSS testing workshop involved identifying five or six wetlands which participants were most familiar with, and scoring the criteria using the definitions and scales provided. Comments were recorded and where necessary, changes made to the criteria definitions and scales. Sensitivity analysis of both DSSs was also carried out by plotting the results of different weighting scenarios against the ranking obtained from an equal weighting scenario.

5.2 Primary DSS Testing and Results

The Primary DSS was tested at a workshop with regional stakeholders held in Townsville on the 13th December 2005. As well as testing the Primary DSS, the opportunity was taken to establish weights for the Primary Scale criteria and produce a list of prioritised aggregations. The list and a graph showing value, threat and capacity values are included in **Appendix 6**.

Sensitivity analysis was undertaken on the DSS using the results of the two sets of weighting techniques from the workshop (no categories / categories), equal weights and random weights. The sensitivity analysis involved plotting the ranks obtained from different weighting scenarios against the rank of one weighting scenario, in this case equal weights, and examining the scatter of the points. If there is no discernible pattern, then the criteria are too sensitive to the weights (the criteria are not robust) and the criteria scores have too little influence on the outcome. If there is little or no scatter under different weighting scenarios then the criteria are too robust and value judgements on the criteria have little impact on the results. This is often related to the number of criteria used as well as the arrangement of values for each criterion. Too few criteria often result in the analysis being overly sensitive to different weights, whereas too many criteria result in the weights having little effect on the resulting ranks. The results of the sensitivity analysis are shown in **Figure 8** and show a good balance between sensitivity to different weighting and robustness of the criteria.

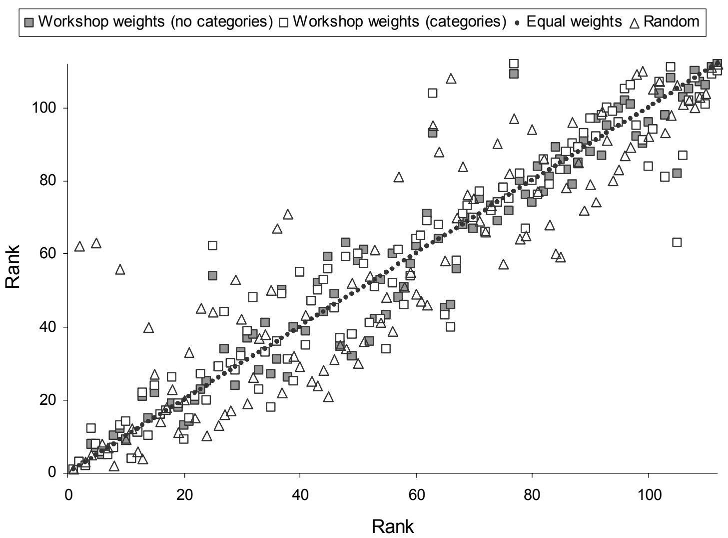


Figure 8: Results of Sensitivity Analysis

5.3 Secondary DSS Testing and Results

Workshops with local experts and decision-makers were undertaken to test the Secondary DSS. Two such workshops were held, the first in Townsville on the 22nd February 2006, and the second was held in Tully on the 17th of March 2006. The DSS was tested by identifying five or six representative wetlands, generating criteria scores for the wetlands and weighting the criteria. Throughout this process, discussion relevant to the DSS and the criteria definitions and associated scales was encouraged and outcomes were noted.

The workshops involved the following:

1. Explanation of DSS Background (presentation)
2. Overview of Criteria (presentation)
3. Identification of test wetlands (interaction) through the following procedure:
    a. All participants nominated wetlands they felt they had enough knowledge of to score criteria;
    b. The wetlands that had the highest number of people with knowledge were added to the DSS
    c. The list was reviewed and if agreed, some wetlands substituted so that the list was representative of the different types and condition of wetlands in the aggregation.
4. Once the test wetlands were identified, the boundaries of these wetlands were identified and the information entered into the DSS. At the initial Townsville workshop, this was done by selecting polygons from the Wetland Inventory and adding them to the DSS using a unique ID. A different method was used at the Tully workshop for two reasons. The first was that the current quality of Wetland Inventory mapping at Tully was poorer (still in development) and second, the participants of the Townsville workshop found that the boundaries defined by the Wetland Inventory, did not match their perceptions of the wetlands boundaries. Wetland boundary identification at the Tully workshop therefore involved identifying and digitising wetland boundaries at the workshop based on directions from the participants.
5. The nominated wetlands were then scored for each criterion by the participants through an interactive process where aspects of the wetland relevant to the criteria were discussed and a score agreed upon through consensus. Where there were uncertainties with the criteria, its definition and score, changes were proposed. The procedure involved considering each wetland for a criterion, before moving on to the next criterion. It was done like this to focus thoughts on the criteria and to ensure true relative sores were assigned to each wetland. Relevant GIS layers (e.g. topography, other water bodies, satellite imagery, cadastre, Regional Ecosystem mapping, protected areas, etc) were available during this process to help participants score the nominated wetlands.
6. Once the wetlands were scored, the criteria were weighted. By this stage the participants had a good understanding of the criteria and weighting was relatively straightforward. Weighting was conducted as follows:
    a. Participants voted for the most important category (values, threats, capacity). This category was then assigned a value of ten.
    b. Participants individually weighted the other categories relative to the most important category. The results for each criterion were averaged and entered into the DSS

   c. Participants then voted for the most important criteria within each category. This was assigned a value of ten and all other criteria were weighted relative to the highest within each category. The results for each criterion were again averaged and entered into the DSS.

7. Once the weights were entered into the DSS, the DSS was run and the results examined. Participants were asked if the results seemed reasonable and further discussion on the results and the process was undertaken.

5.4 Key Outcomes

The outcomes of the DSS testing workshops resulted in refinement of the DSS structure, the criteria and their definitions. Another outcome was participants provided observations on the use and the context of the DSS and this information assisted in the development of the DSS.

5.4.1 Primary DSS Testing Workshop Outcomes

No significant changes were made to the DSS as a result of the Primary DSS workshop apart from some minor bug-fixes for the tool and some minor changes to DSS criteria definitions. The use of the DSS demonstrated that the mechanics of the model worked, and that workshop participants were able to interact with the output of the model (meaning individuals were able to interpret the output and follow the reasoning for the output).

Two different weighting approaches were also tested (weighting criteria regardless of category and weighting within categories) and participants were asked to indicate which approach was preferred. Of the two approaches, weighting within categories was voted as the most preferred by the participants and these weights were used to generate the prioritised list of aggregations. The reason for a preference to the within-category weighting process was that it presented information in smaller subsets, relative to the first weighting process, which some individuals found easier to consider. It also allowed criteria to be considered within their category rather than trying to compare ‘apples with oranges’.

The key observations made by the participants of the Primary DSS workshop are discussed as follows:

Level of understanding

A common theme, irrespective of the weighting method applied, was the need to understand the criteria as defined and assessed for this specific exercise. For example, some participants at this workshop considered that certain criteria could be termed a Threat or a Value. Further, the name given to describe a criteria may imply a definition or assessment capacity that is different to how the criteria is measured (e.g. if good quality data is unavailable).

In order to ensure that all participants have enough understanding of the criteria and assessment used, it is important that adequate time and intellectual resources are allowed to understand the criteria and their relative importance. This was perceived to have been met at the DSS testing workshop, however the participants wanted to point out that this was a very important part of the process.

'Threat' Criteria

One key outcome of the primary DSS workshop resulted in changing of 'threat' criteria from a 'cost' to a 'benefit'. Previously the DSS had considered a high threat as selecting against an alternative, however when the results of the DSS were interrogated, most of the high-priority aggregations were already protected. The participants were of the view that areas with high values and under high threat require the most urgent intervention and therefore should have the highest priority. When this was done the ranked site results were agreed to be more closely aligned with participant's expectations. This conceptual view on the role of threats is supported by recent literature. Hobbs and Kristjanson (2003) outlined a 'triage' approach to prioritising landscapes similar to the prioritisation process used for Emergency Room prioritisation of care where priority is given to patients with the most serious injuries that, with urgent treatment, should recover. Similarly landscapes (or wetlands) that have high values but are under immediate threat should be given the highest priority for 'treatment'.

'Capacity' criteria

The workshop participants were strongly critical of the 'Capacity' criteria and their ability to adequately estimate community capacity. This was not unexpected as it was indicated by the expert panel that very little in the way of data, indicators or relevant information existed at the regional scale. This was also observed in the literature (Smith and Sincock, 2004).

Some participants would have rated Capacity category higher if more appropriate capacity criteria were listed (comments principally related to indicators that reflect community support/capability to engage). The low weighting of the Capacity category and associated criteria was therefore more closely related to the criteria's limited value in describing Capacity as a result of inadequate data rather than a perception that Capacity is unimportant.

The expectation raised by several participants at the Primary DSS workshop that appropriate Primary Scale – ie at the aggregation scale Capacity criteria data existed contradicts the advice provided by the experts assembled thus far. There is also work underway (e.g. Cody, 2004; Fenton, 2004; Nelson, 2004) to develop indicators of capacity. Further effort devoted to researching and determining Capacity criteria for application in the Primary DSS would be beneficial.

There were a number of suggestions for developing datasets to measure capacity. These all involved collating existing datasets throughout the GBR catchment (e.g. consistent data available in local government). Undertaking such collation and assembling it into a consistent dataset is beyond the scope of this study, however the suggestions are listed below for future reference. The data sources included:

- Information about local community groups (e.g. number of active groups);
- Pest management plans prepared by LGAs (particularly in relation to aquatic weeds);
- The total budget each LGA spent on wetlands over a set period of time (e.g. last 5 years);
- Local Government planning scheme classifications for wetland sites; and
- The Regional NRM Group Regional Investment Strategy (RIS) allocation of funding to wetlands.

5.4.2 Secondary DSS Testing Workshops Outcomes

Some changes were made to the DSS based on the Secondary DSS workshops. The majority of these changes were adjustments in the definitions and scales used for criteria in the DSS.

A major change to the Secondary DSS was in the way that wetland entities were entered into the DSS. At the first workshop in Townsville, Wetland entities were entered by selecting polygons from the Wetland Inventory mapping to establish the wetland site. In many cases however, the boundaries of these polygons did not match the participants' perception of the wetland boundaries. While it must be noted at this stage that the Wetland Inventory dataset used were incomplete and untested, it could be envisaged that this was a problem that would be likely to be encountered again even after the Wetland Inventory dataset had been completed.

There are a number of reasons why a wetland defined by the Wetland Inventory may not be considered as a suitable or single wetland 'site' by local stakeholders. For example a wetland may cross tenure boundaries and have different owners and management regimes (ie National Park versus freehold land) which are interpreted by local stakeholders as representing different 'sites' in terms of their management needs or investment potential. Conversely numerous small wetlands defined by wetland inventory mapping that lie within a single property boundary may commonly be aggregated into a single 'site' by local stakeholders on the basis of the property ownership being vested in a single owner and investment needing to be directed accordingly.

As a result of this, a different approach was used at the subsequent testing workshop held in Tully. This involved participants nominating wetland sites and then assisting in drawing boundaries using GIS tools to the satisfaction of all participants. This worked very well and was well received by the participants. It has therefore been included as a feature of the Secondary DSS, although the method of adding wetland sites from the Wetland Inventory has also been retained.

The key observations made by the participants of the Secondary DSS workshops are discussed as follows:

Need for specific objectives

A recurring comment throughout this project, and repeated at both the secondary DSS workshops, is the need to define the objectives of the project for which the DSS tool is being applied. Once the objective(s) is defined, and a common understanding achieved amongst the decision makers who are utilising the DSS tool, then confounding matters, such as determining if a criteria should be considered as a Threat or as a Value, are resolvable. It should also be noted that objectives may alter on depending on their spatial and temporal scale. For example, at a local scale decision makers may have objectives that differ to regional scale, and over time these objectives can change.

Consideration of ineligible wetlands

It was noted that ineligible wetlands (e.g. mangroves) were included in the assessment at the Primary Scale as they were important contributors to wetland processes. It is important however, that the funding delivery mechanisms do not blindly allocate money to aggregations proportional to their ranking without considering the types of wetlands that exist in these aggregations. Some aggregations that scored very highly could be composed almost entirely of ineligible wetlands because their eligibility was not assessed at the aggregation scale.

Need for on-ground outcomes

Some of the participants' introductory comments to the Tully workshop reflected their frustration with 'yet more research' which, based on past experience, rarely resulted in on-ground works. While this was noted, it was also observed that a process such as the DSS was required in order to transparently allocate funding to on-ground works so that the funds could be used in the most efficient way possible.

Additional Criteria Suggestions

Some participants suggested additional criteria be added to the DSS Tool (e.g. criteria to account for the coastal protection function of some wetlands). Most of these criteria suggestions had already been considered by the expert panel and rejected for various reasons, usually because there was insufficient data to measure them. One exception to this was the addition of the 'best management practice feasibility' which was suggested at the Townsville workshop and tested at the Tully workshop.

The following ideas suggested by participants were also noted:

- As was noted at the Primary DSS Workshop, participants needed sufficient time to understand the criteria.
- Participants also stressed the importance of engaging with landholders to avoid a 'them and us' situation.
- Wetlands omitted from this DSS tool on account of being marine (or proximal to marine), for example, should not be lost. The data could be retained and, for example highlighted as being not relevant to the stated objective of this DSS Tool.
- Water quality targets are being compiled for State and Shire (eg Douglas Shire) Water Quality Improvement Plans and these may provide an opportunity to incorporate quantitative data sources into the tool (it should be noted that users of the Secondary DSS can refer to any available sources to assist with scoring criteria which generally employ quasi quantitative descriptive scales in which quantitatively obtained values can be included).

Performance of DSS

Participants at the Secondary DSS Testing Workshops considered the outcome of the DSS Tool analysis of the selected wetlands in a favourable (positive) manner. Some of the comments that supported this outcome were "generally speaking a very good rating of what was expected", "pretty indicative of what was expected", "no gross outliers", and "generally very good".

5.5 Strengths and Limitations of the DSS

The DSS, as it has been developed, is a powerful tool to assist with prioritising wetland entities for funding. It has been developed in recognition of the available data, the current NRM framework, the types of wetlands that exist in Queensland and the different decision-makers and stakeholders in the GBR Catchment. As in any DSS however, there are limitations. Often the same factor that can be considered a strength can also be considered a limitation. For example, the flexibility of the DSS to be able to be used for a number of different types of decisions also means that decision-makers must have a higher level of understanding of the DSS and how it works. It is important therefore that the strengths and limitations of the DSS are explicitly stated and considered when using the DSS to help make decisions. Outlined below are the main strengths and limitations of the DSS.

5.5.1 Strengths

Ability to use data in different formats

One of the key strengths of the DSS is its ability to use a range of different data types. At the Primary scale, different GIS layers are used, and at the secondary scale all types of data can be used to support scoring of the criteria by the local expert panel. This is particularly important as one of the key impediments identified at the start of the project was the view that there was insufficient data to be able to make decisions. While there are certainly areas where additional data would be very beneficial, the DSS in its current format is able to use all the information available including local and expert knowledge.

Ability to work at multiple scales

One of the requirements of the DSS was that it needed to work at multiple scales. The DSS works at two scales which allow different levels of information to be used and decisions made by both regional and local decision-makers. This enhances flexibility of the tool by allowing a hierarchy of decisions to be made at coarse and then finer resolution. For example aggregations can be prioritised by NRM regional bodies through a Primary DSS and then sites within priority aggregations can be identified and prioritised at the local scale by local decision-makers and experts.

Transparency of decision process

The DSS allows decisions to be made in a transparent way. Weightings and other value judgements for the criteria are made explicitly and the mechanisms by which the DSS calculates its results are easily comprehended and to some extent mirror the human decision-making process. Throughout the process the project team often referred to the DSS as a ‘green translucent box’ as opposed to a ‘black box’ meaning that the mechanisms or components, while contained in a computer system, are ‘visible’ and able to be understood. Once the DSS has been run, the results are able to be interrogated at different levels. At a cursory level, the results are presented as a whole and also broken up into values, threats and capacity categories (the results of within-category assessment without the influence of the other categories). Additionally the three matrices are clearly visible and so any alternative’s score for any particularly criteria can be seen in its initial form, standardised and multiplied by the weight assigned to the criteria.

Ownership by decision-makers

By allowing decision-makers to make value judgements about the criteria and to determine if a high value for a criterion supported the objectives or not, a level of ownership is generated by the decision-makers. At the secondary scale this is further enhanced by the ability of the participants to select which wetlands are to be considered and to define wetland boundaries. Ownership of the decision-making process is important as the participants are much more likely to accept the outcomes of the decision-making process. In this way the DSS *supports* decisions rather than *makes* decisions. The only component of the DSS that is unable to be changed is the composition of the criteria, although criteria are able to be removed from the analysis by assigning a weighting of zero. The criteria set were compiled and defined through an exhaustive process using expert knowledge and panel workshops. By providing the criteria set, this process does not need to be repeated and there is also consistency in the assessment. It also ensures that the criteria have all the necessary attributes (are independent, measurable and relevant) and the definitions and scales associated with the criteria are aligned with current thought by experts in the related disciplines.

Flexibility of DSS for different objectives and outcomes

The DSS has been designed to be as flexible as possible and is able to function for a number of different objectives. The flexibility primarily comes from:

- The ability to change criteria weightings both for the criteria categories and the individual criteria;
- The ability to classify each criterion as a 'cost' or 'benefit' whereby a high number for a criterion selects for or against the alternative;
- The ability to delete criteria from the criteria set by setting the weighting to zero; and
- The ability to choose a set of alternatives from a larger set.

The above allows the DSS to be adjusted for different objectives and desired outcomes. A more detailed explanation and examples of using the DSS for different objectives are elaborated on in Section 6. The need for such flexibility is also elaborated on further in Section 5.5.2 *Supporting Decisions rather than Making Decisions.*

Adaptability and Updating

The DSS is able to be updated as datasets are improved or new information is generated. Criteria values generated through GIS analysis can be reanalysed using the analysis steps presented in Appendix 3. Some datasets are used in more than one criterion therefore all criterion depending on the updated dataset must be reanalysed. If the 'base' dataset (aggregations / wetland sites) were to be updated, then the analysis for all the other criteria would also need to be updated.

GIS Support

The use of GIS to generate criteria values and to support the development of criteria through the local / expert panel is an important feature of the DSS. A number of analyses were developed to describe the criteria, though in many cases explicit data was not available so 'surrogates' that were likely to be closely correlated with the actual criteria values needed to be used. The use of GIS data also has limitations, particularly with the use of surrogates as there may be uncertainties or inaccuracies with the datasets and they may be unable to fully describe the criteria for all alternatives. Though the influence of small errors such as this on the overall outcome is small, this consideration needs to be conveyed to participants and decision-maker so that uncertainties can be accounted for when weighting or deciding if a criterion should be excluded. Compound errors can also occur if there are numerous criteria that are dependent on the same dataset which have errors. Datasets which were used in this way in the tool (e.g. Wetland Inventory, QLUMP) were therefore a finer scale than required.

5.5.2 Limitations

Supporting Decisions rather than Making Decisions

While this may not be considered a limitation, it is essential to recognise that the DSS *supports* decisions rather than *makes* decisions. Decisions are supported by incorporating a transparent framework into the decision-making process and by gathering all the available data and putting it into a format that can allow decisions to be made based on that data. One of the criticisms frequently heard at the start of the process was the widely shared belief that there was insufficient data to base a decision on, therefore a DSS was pointless and additional data needed to be collected first. Our reply to this was that a DSS needed to be developed first in order to assess what data was available and what data was lacking so that future research needs could be targeted efficiently and transparently.

The implication of a decision support system is that it aids decisions and cannot make decisions for you. It therefore cannot be used in a regulatory way (although the decisions made by appropriate decision-makers using the DSS can). To this end, the DSS has been developed to be as flexible as possible to ensure that any existing data can be incorporated into the DSS and value judgements on the relative importance of the criteria, associated data and the set of alternatives or options can easily be made. The only area where there is some rigidity is in the criteria make-up as this process has been developed through a series of expert panel workshops and extensively reviewed. The analyses (including qualitative indices) that have been developed to score the criteria are also specific to the criteria themselves and therefore need to be fixed in the DSS.

Being a decision support system, the results must always be examined in the context of the decision being made and the criteria and data used to capture the factors underpinning the decision. The DSS tool has a number of ways to display the data, to interrogate it and to look at the influence of value, threat and capacity categories and associated criteria on the outcome. The resulting overall score for each alternative is graphed in order of rank which can show how much more or less an alternative scored than the other alternatives. Results for value, threat and capacity criteria can also be displayed in isolation of the others in order to observe the influence of these categories on the outcome. The Effects Matrix, Standardisation Matrix and Additive Weight Matrix are also visible and the effects of weighting and standardising on the criteria scores for each alternative can be seen.

Data Accuracy and Relevance

A limitation with the DSS is the accuracy of the data and information used to describe the criteria. As with all computer systems, GIGO (Garbage In – Garbage Out) applies. There is no doubt that there is limited data to describe wetlands and associated attributes in Queensland, however the development of a DSS represents a useful step toward identifying and addressing data deficiencies.

Limitations in the availability and accuracy of the data used to describe criteria have been recognised and taken into consideration during the development of the DSS and has been addressed by:

Extensive searches for available datasets;

- Critical examination of the accuracy and assumptions of available datasets;
- Consideration of data and information availability during final determination of criteria set;
- Development of a 2-scale DSS which enables use of broad-scale GIS data and local studies / local knowledge to score criteria;
- Weights able to reflect decision-maker's confidence in the data as well as importance of criteria; and
- Gap analysis to determine data acquisition and maintenance requirements.

A major difficulty was finding suitable data to measure 'capacity' criteria at the Primary Scale as very little GIS and published data exists to describe NRM capacity. It was therefore necessary to use the Australian Bureau of Statistic's Community Indices for Areas as this is currently the extent of existing indicators to measure capacity at the regional scale (Smith and Sincock, 2004). While indicators applicable at the regional scale are currently being described (e.g. Fenton, 2004; Nelson, 2004) and development is in progress (Cody, 2004), indicators suitable for use in the DSS are not yet available. Once these indicators have been developed they should be incorporated into the DSS.

Funding Allocation

The DSS is able to prioritise aggregations and wetlands for funding allocation under different objectives (e.g. restoration, protection). However it cannot tell the user how much funding needs to be allocated to a particular aggregation or wetland. Criteria and GIS layers can help with estimating funding allocations (e.g. size, condition, tenure etc), however there is currently no mechanism in the tool that will calculate the proportion of funds that need to be allocated to any given area. The need for such a feature is dependent on the type of funding delivery system the DSS will operate within. Such a feature would be needed if funding was allocated purely on the results of the decision-making process at the top level only. If, on the other hand, the DSS was used to support decisions made at multiple levels and as part of a larger planning process, such a feature would be unnecessary. The latter approach to funding delivery is recommended as it will allow a more efficient and robust delivery mechanism as well as greater ownership and therefore endorsement of decisions.

Ineligible Wetlands

Wetlands are not usually separate entities but form part of a larger ecosystem, hence the grouping of wetlands into wetland aggregations. However under the GBRCWPP, some types of wetlands (i.e. marine, mangrove and riverine systems) are ineligible for funding. At the Primary (aggregation) scale, eligibility was not considered because ineligible wetlands may form an important part of the broader wetland ecosystem under consideration. Recognising that works conducted at a wetland site may deliver improved management outcomes for downstream systems, the values of ineligible marine wetlands can potentially influence the values and hence management investment merits of eligible freshwater wetlands.

Within the Primary DSS therefore, there may be aggregations that have been identified as important, that may not be actually comprised of any or very few wetlands eligible for investment. This needs to be explicitly recognised when using the tool and when allocating funding and adds weight to the observations in the previous section on the need for a planning process rather than allocating funds using only the DSS.

Within the Secondary DSS, the set of alternatives (wetland sites) are specified by the participants. This allows the influence of ineligible wetlands to be implicitly considered by the decision-makers. It is therefore important that the decision-makers understand the characteristics of the ineligible wetlands so that these do not become part of the alternatives set while still recognising the importance of ecosystem connections and influence that ineligible wetlands may have on the values and merits of associated eligible wetlands. GIS layers showing the relevant characteristics of the wetlands can also be used to aid participant's understanding of the eligibility of the wetland site under consideration.

Ecosystem Process Linkages and Catchment Context

The issues associated with eligible and ineligible wetlands discussed above raises an important point concerning wetland site alternatives considered by the DSS. The DSS essentially considers wetland alternatives as independent and isolated sites defined by polygons mapped by the community or wetland mapping inventories. In reality wetlands are usually part of an interconnected riverine ecosystem and share biophysical process linkages (i.e. flows and movement of nutrient, sediment, biota etc) with other wetlands based on the catchment context in which they occur.

Recognising catchment process linkages and the influence they have on natural resource condition is the basis for Integrated Catchment Management (ICM). ICM has been used as an important framework for delivering strategic NRM within river basins of coastal Queensland since the 1990's and remains particularly relevant in the case of wetlands. Hence while the DSS can help define the merits of investing in wetlands on the basis of their values, threats and stakeholder capacity it has limited capacity to recognise the strategic merits of individual wetland sites based on their catchment context and process linkages with other systems.

It has not been attempted nor is it considered feasible to develop evaluation criteria that capture the multitude of possible strategic investment merits of wetland sites related to their catchment context. For example, where weed management is the predominant issue for a catchment's wetlands strategic management, considerations may favour investment at upper catchment sites ahead of lower catchment sites. Conversely, a focus on wetland fish habitat and connectivity values may preferentially define lower catchment sites as the most worthy sites for investment. Ultimately the DSS, as its name suggests, is a decision support system and not a decision making system and the strategic investment merits associated with the catchment context of a wetland still need to be considered by decision makers in conjunction with DSS outputs.

Decision-maker Support

While the DSS is user-friendly and can be operated by people with an average knowledge of Microsoft Excel, it is important that use of the DSS takes place in a workshop setting with a facilitator who is familiar with the use of the DSS, techniques, theory and limitations as well as a good understanding of the criteria so that engagement with the decision-makers is achieved. The DSS has been developed and tested in a workshop environment and this has proven to be the most suitable setting for its operation. The participants also need a high level of information on the criteria, their definitions, units of measurement, assumptions and uncertainties.

5.6 Potential DSS Improvements

5.6.1 Data and Criteria Updates

An essential 'improvement' to the DSS is to ensure that the datasets used to score the criteria are the latest available and the remaining data used is still relevant. The production of additional key datasets should also precipitate a review of the criteria set and appropriate changes to the criteria set made. Where this has limited effect on the criteria make-up (one or two criteria) and the benefits are transparent, it may be possible to undertake this with limited expert panel consultation. Larger changes of this nature should only be undertaken in an expert panel environment and only to the extent required.

A major data update should take place once the EPA's Wetland Inventory has been completed (expected to be mid-2006) and following subsequent major updates to the Wetland Inventory and other key dataset. A major review of the 'capacity' criteria should follow the release of capacity indicators by the NLWRA.

5.6.2 Data update features

Given the frequency with which data will need to be updated in the DSS, there would be merit in considering an automated method of analysis for criteria updates, rather than the current step-by-step method. A system of semi-automated updating could be achieved using tools such as ESRI's 'Model Builder' or similar. Model builder is now incorporated into ArcGIS 9 and would be a suitable way to make updating data easier as well as consistent with no risk of misinterpretation of the analysis steps by the operator.

5.6.3 Real-time GIS Linkages

Real-time linkages between the DSS and the GIS would provide considerable enhancement of the DSS. Currently the data from the DSS can be exported and joined to the GIS layer representing the alternative set (aggregations or wetlands). While this is not a difficult task for someone with moderate GIS experience, it is suggested that incorporating 'live' linkages to the DSS would enhance the GIS experience of the workshop facilitation team.

5.7 Current and Future Data Requirements

The current datasets required for operation of the DSS, their related criteria and their custodian(s) are described in **Appendix 7**.

The datasets used in the DSS are:

- Aggregation dataset (currently Queensland DIW)
- User-defined wetland areas
- Regional Ecosystems of Queensland
- Queensland Wetland Inventory
- Nested catchments
- Census data – population density
- ASGC Digital Boundaries
- Queensland Land-use Mapping Project (QLUMP)
- Dams and Weirs in Queensland
- National Pollution Inventory
- Socio-economic indices for areas (SEIFA)
- National Native Title Register
- Registered and Notified Indigenous Land Use Agreements
- Collaborative Australian Protected Areas (CAPAD)

These datasets are generally regularly updated and freely available within the Queensland Government. It is important that the DSS is updated when major updates of these datasets are available.

5.7.1 Aggregations dataset

The aggregations dataset currently used as the alternatives set in the Primary DSS is derived from the Queensland Directory of Important Wetlands (DIW) mapping. This was considered appropriate for the reasons outlined in Section 3.2. While the DIW aggregation dataset is therefore able to be used to support decisions regarding wetland management, it is important that the aggregations dataset be expanded to include all wetlands within the GBR catchment so that they may be considered in the decision-making process.

5.7.2 Collation of data developed through the DSS

Criteria scored in the Secondary DSSs, using the definitions and indexes provided, represents valuable information that should be collated. The development of a database to enter and update the criteria scores from the various Secondary DSSs would be an important step in the achievement of this and should be constructed during the early stages of DSS use.

The development of such a database will enable data and values to be generated during a number of assessment sessions or updated by the panel or individual members as new information comes to hand. Such a database may also enable the prioritisation assessments to be run utilising a comprehensive set of alternate wetland sites drawn from across the entire region.

5.7.3 Data Gaps

The criteria set has been developed in recognition of the quality and availability of data as well as consideration of features of a wetland that are important for prioritisation. It is therefore important to recognise that the development of additional datasets, while not critical to the function of the DSS, may precipitate a re-examination of the criteria set using a similar procedure used to develop the criteria.

At the Primary Scale the datasets used needed to have the following attributes:

1. They needed to consistently extend throughout the entire study area;
2. There was a reasonable expectation that they would be maintained and updated; and
3. They were accurate enough (of fine enough scale) to adequately differentiate between aggregations.

The use of derived datasets (e.g. National Land and Water Resources Audit, Wild Rivers, etc) was also avoided because these may not be repeated and are usually surrogates based on the limited set of extensive datasets available. They are also generally developed on a national scale and may not be developed from datasets unique to Queensland or, if such datasets are used, their accuracy may be degraded to enable consistent comparisons between regions.

Datasets that comply with all three of the above requirements are few because the development of such datasets is usually an enormous undertaking. The time between inception and finalisation of such datasets is
generally very long. The identification of data gaps is therefore difficult as it must also take into account the likelihood of data development occurring within an adequate timeframe for it to be usefully incorporated into the Primary DSS. For example, data relating to water quality for all aggregations in the GBR would be useful but is likely to require too much time and expense to be useful for the Primary DSS. Instead water quality is considered implicitly by other factors such as land-use intensity and point-source pollution. Surrogates are also used where there is a reasonable expectation of a correlation between the surrogate and the desired (but unavailable) datasets. In some cases this assumption has a strong possibility of being violated and these are the areas that data gaps are likely to be found. Such data gaps in the Primary DSS are as follows:

1. **Aggregations Dataset.** The aggregations datasets used in the DSS was derived from the Queensland Directory of Important Wetlands and therefore does not include all wetlands within the GBR. This dataset should be updated as part of the Queensland Wetland Inventory currently being developed.

2. **Capacity Criteria.** The Primary DSS criteria associated with community capacity that have been derived from the ABS's SEIFAs (socio-economic disadvantage, education and occupation and economic resources) have been shown to be correlated with capacity by previous studies, however participants at testing workshops rejected the assumption that these indices were sufficiently correlated with community capacity. This opinion is shared by the authors, however there are currently no other alternative measures of community capacity as it relates to NRM. The development of capacity indices is currently being carried out by the NLWRA and it is recommended that once these are completed, they are incorporated into the DSS.

3. **Aquatic Habitat Connectivity Restriction Criterion.** This criterion is based on the location of dams and weirs in the GBR. This dataset does not differentiate between the type or size of dam or weir and does not include bunds, arguably the biggest source of connectivity restriction. It is therefore likely to have limited correlation with connectivity restriction. While connectivity was regarded as very important, there are currently no better spatial datasets that measure connectivity restriction over the GBR Catchment. Such datasets would be very useful in the DSS and should be developed if possible.

4. **Point-source Pollution Risk.** This criterion is based on the number of pollution source points recorded in the National Pollution Inventory (NPI). While this is likely to be correlated with water contamination, the degree and the importance of the contamination is unknown. Additionally it is unknown whether the pollution is still occurring.

5. **Hydrological Change (Irrigation).** Hydrological changes to wetlands include changes in the timing and volume of supplied flows, surface and groundwater extraction, groundwater rise, bunding and impounding of outflow channels and exclusion of tidal influences. This data is not measured consistently throughout the GBR so the area in the contributing catchment under irrigation was used as a surrogate. This is not an unreasonable assumption, however spatial data depicting the nature, extent and location of structures that contribute to hydrological change would be preferable.

6 USING THE DSS

This chapter discusses the use of the DSS in different contexts and for different objectives. This is not a step-by-step guide as this is already included in **Appendix 1** and **Appendix 2**. Instead it provides the conceptual basis with which the DSS should be used. Given the flexibility of the DSS and its ability to support a number of wetland management decisions with different specific objectives, an understanding of the way the tool works and how the different parameters can be adjusted for different outcomes is essential for correct use of the tool.

6.1 Types of Decisions Supported

Essentially the DSS can help define the merits of investing in the management of wetlands on the basis of their values, threats and stakeholder capacity. As discussed in the previous chapter, the capacity of the DSS is limited by the extent to which the applied evaluation criteria capture the range of considerations that decision makers want to employ in supporting their investment decisions, the availability and quality of data including expert knowledge that is applied to score wetlands against criteria and the appropriateness of weighting applied to those scores.

Other important factors that will affect the successful application of the DSS are the nature of the wetland management that regional stakeholders and decision makers want to invest in and the rationale they want to apply for prioritising investment decisions. These two factors will vary between regions and investment programs and there is no one ‘correct approach’. The DSS has been designed with enough inherent flexibility to support decisions across a wide range of possible wetland management orientations and prioritisation rationales.

While not mutually exclusive, the two key approaches that exist in wetland management are that of protection or restoration. Protective management traditionally involves the declaration of reserves or ‘protected areas’ over public or private land to prevent exploitative uses or impacts affecting contained ecosystems. Protective management is usually considered the most cost effective of nature conservation strategies as it seeks to secure high value assets in good condition from the threat of degrading processes. Restoration lies at the other end of the management spectrum in that it is usually a more costly conservation approach that is applied in the case of degraded ecosystems where degradation associated with threatening processes has already been realised. Although generally more costly, restoration is often a necessary strategy required to conserve wetland species and ecosystems where there has been widespread landscape modification, ecosystem degradation and better conservation options have been lost.

In between the management end-points of high value asset protection and degraded ecosystem restoration there are also a wide range of threat management strategies. These strategies recognise that it is not possible to include all valuable wetland assets within protected areas and that active management of existing threats is required to prevent associated degradation being realised and the need for restoration. One of the primary determinants for selecting appropriate wetland management approaches is the ecological condition status of the regions wetlands. Where a regions option for high value asset protection has been diminished, the relevance and need for threat management and restoration approaches will generally increase. Hence, the relevance of different wetland management objectives will depend on the status of wetland resources and management options available within specific NRM regions.

Investment prioritisation rationales will also vary in response to regional conditions. At the initial primary DSS testing workshop, the default prioritisation rationale presented to the stakeholder panel was that wetland investment priorities were defined by: '*sites with high values, low threats and high community capacity'*. The rationale underpinning this default position was that wetlands need to be valuable to warrant investment. Sites with low threats represent secure investment and that high community capacity is indicative of potentially good on-ground management returns for dollars invested. While the stakeholder panel could see the merits of the default prioritisation rationale for defining good protective management opportunities, the opinion expressed by the majority was that high threats were indicative of a greater urgency for timely management intervention. Additionally, for most regions, wetlands that had high values and low threats were already secured within protected areas. Consequently the investment priority rationale recommended by the stakeholder panel at the primary DSS testing workshop was that wetland investment priorities were defined by: '*sites with high values, high threats and high community capacity'*. These differing investment prioritisation rationales highlight two of a range of prioritisation rationales that are quite legitimate for defining priority wetlands for different management objectives. They also demonstrate the way in which the DSS can be reconfigured based on differing management objectives and situations.

The key point for successful and flexible application of the DSS is that regional stakeholders and decision makers will need to articulate the specific management objectives and investment prioritisation rationales they wish to pursue for wetlands in their region and apply the DSS accordingly. The orientation of funding programs and NRM group Regional Investment Strategies including any preferences toward particular investment strategies i.e. protected area consolidation, ecosystem restoration, threat management (i.e. weed programs) or community capacity building will also be a useful guide to the way in which the DSS should be most appropriately applied. The ways in which the DSS can be configured to serve different wetland management objectives and investment prioritisation rationales is discussed further below.

6.2 Using the DSS for Specific Objectives

As discussed above the DSS can be configured to prioritise wetlands and aggregations according to specific management objectives and investment prioritisation rationales. The two ways in which DSS operation can be manipulated to orientate outputs toward particular management objectives or prioritisation rationales are by:

Choice of score 'direction' i.e. 'benefit' (positive) or 'cost' (negative) for individual criteria or an entire class of criteria (i.e. values, threats, capacity). This has the effect of giving alternatives (wetland aggregations / wetland sites) a higher or lower rank in the prioritisation process on the basis of the individual criteria or class of criteria. When a criterion is designated a 'benefit', a high score for that criterion will contribute to the aggregation / wetland being given a high priority. Conversely, a criterion designated as a 'cost' criterion will result in high scores selecting against that particular aggregation or wetland in the overall priority.

Weighting of criteria classes or individual criteria scores Weighting provides the ability to emphasise the contribution of criteria considered more relevant to specific management objectives, to the overall score obtained by a wetland site during the prioritisation process. Weighting criteria to a value of zero allows the user to omit individual criteria from consideration Weights are therefore a reflection of the importance of each criterion with respect to the specific objectives. Weighting is undertaken for the criteria categories (values, threats and capacity) and for the criteria in each category, relative to the other criteria in that category.

Examples of the potential application of the DSS for identifying priority wetlands under different wetland management objectives and prioritisation rationales are described below.

6.2.1 Protective Management

Protective management is usually considered the most cost effective of wetland conservation strategies as it seeks to secure high value assets in good condition from the threat of degrading processes. Consequently the most logical investment prioritisation rationale to apply when seeking to consolidate wetland protected areas could be to identify '*sites with high values, low threats and high community capacity'*.

In the case of well funded conservation agency acquisition programs, criteria defining community capacity may not be as critical as protected area consolidation programs that depend on collaborative initiatives targeting private land that require the full support of landholders and regional stakeholders. In this case, the capacity criteria may be weighted to zero, or recognising that sites that are already partially or fully protected are not candidate sites for further protected area consolidation, scores obtained by the *Level of Protection* criteria could be set as a cost (negative score direction).

As discussed in section 6.1 (above), while a site with low threats may define a secure investment opportunity for protected area consolidation, sites with high threats may identify higher urgency for timely intervention. The merits associated with setting site threat values as a cost or a benefit will depend on the orientation of protective management planning within a region (i.e. pro-active or reactive), and the availability of alternative sites and funds. Each option may be appropriate within the one region under different protective management programs.

In seeking to meet biodiversity conservation objectives through protective wetland management, it may also be appropriate to apply relatively high weights to criteria values associated with *Populations of Rare or threatened Taxa, Vegetation Representativeness, Wetland Representativeness and Species Richness / Diversity*. Where good ecological condition is considered a prerequisite for protected area acquisition the *Wetland Condition* criteria may also be weighted highly to help define the more pristine sites amongst candidates.

6.2.2 Restoration

The management objectives for a wetland restoration program can span a full spectrum from biodiversity conservation, to fisheries productivity enhancement through to reinstatement of catchment functional values associated with water quality improvement or flood mitigation. Generally all of these objectives are not mutually exclusive though in many instances wetland sites will have distinctive merits in terms of meeting these different objectives. More importantly there are usually major distinctions in what constitutes a suitable wetland candidate site for protective management as opposed to restoration management objectives.

For sites that meet restoration management objectives, ecological condition will generally be poorer, associated values i.e. *Vegetation Representativeness, Species Richness / Diversity* etc lower, and values for threats relatively higher. As described above, restoration is also usually a resource intensive approach to wetland conservation and high stakeholder capacity is required for successful outcomes. Hence suitable wetland restoration candidates may be identified by '*sites with high community capacity, high threats and high values,'* where weighting is preferentially applied to value criteria that are not as dependent on a good existing ecological condition. For example many biodiversity associated values may not remain in a degraded wetland suited for restoration based management and values that relate to a site's potential value once restored i.e. *Size* may more usefully be positively weighted.

Subject to the specific objectives of a restoration program, high weights could also be applied to individual criteria to identify sites most suited to particular restoration objectives. For example:

- The *Recreational Value* criteria weighting could be increased to identify and prioritise sites with community recreational opportunities;
- The *Indigenous Value* criteria weighting could be increased to identify and prioritise sites that help meet Traditional Owner management aspirations;
- The *Fisheries Habitat* criteria weighting could be increased to identify and prioritise sites that contribute to fisheries productivity;
- The *Bird Habitat Value* criteria weighting could be increased to identify and prioritise sites that support bird populations;
- The *Assimilative capacity for nutrients and sediments* criteria weighting could be increased to identify and prioritise sites that provide water quality functions; and
- The *Populations of Rare of Threatened Taxa* criteria weighting could be increased to identify and prioritise sites that provide habitat for rare and threatened species.

Likewise amongst threat criteria, the selective weighting of individual criteria could be use to prioritise sites more suitable to particular restoration programs. For instance:

- The *Fish Passage Connectivity* criteria weighting could be increased to identify and prioritise sites in relation to wetland restoration programs orientated toward fisheries productivity enhancement;
- The *Weed Infestation* criteria weighting could be increased to identify and prioritise sites that are an appropriate focus for weed control programs;
- The *Water Quality* criteria weighting could be increased to identify and prioritise sites where water quality impact mitigation is a priority; and
- The *Hydrological Change* criteria weighting could be increased to identify and prioritise sites where hydrology reinstatement is the focus of wetland restoration strategies.

While it is not possible to identify the full range of DSS configurations that might be utilised for identifying candidate wetland restoration sites, the key point is the inherent application flexibility that can be achieved through increasing or decreasing criteria weights or by changing the score direction (i.e. cost or benefit). In summary, the actual weighting of different criteria under specific management objectives will be relevant to that objective.

6.2.3 Capacity Building

The capacity of regional stakeholders to undertake NRM is often the primary factor impacting the delivery of on ground wetland management outcomes, particularly in the case of more resource intensive activities like restoration. In many regional investment strategies produced by NRM organisations, a high priority has been placed on programmes which seek to build community capacity. The aim of this investment is to improve the ability of local community stakeholders to undertake on-ground management activities and without such community capacity it is difficult to achieve successful outcomes.

Programs that invest in community capacity often have different sources of funding to those that seek to invest directly in on-ground wetland management outcomes and ‘community capacity building’ may not always be an appropriate target for prioritising investment of wetland management funds. The appropriateness of community capacity building objectives within individual wetland management funding programs will determine the appropriate application of weighting to the entire category of capacity criteria and individual criteria.

During project workshops and expert panel consultation the politically incorrect terms of ‘*eco-rationalist’* and *‘eco-socialist’* were coined to define the two investment rationales that may be applied for different levels of community capacity. *'Eco-rationalist'* was applied where sites with high existing community capacity were sought, recognising that such sites promised a more rapid return on investment in terms of wetland management outcomes per dollar invested due to high existing capacity. '*Eco-socialist*' was applied where sites with low community capacity were sought as appropriate sites for investment in community capacity that initially may not return as high a rate of on ground wetland management outcomes, but ultimately represented a good investment in social capital to secure worthwhile management outcomes in the longer term. In both these instances, sites would generally still need to have high wetland values to justify investment.

The merit of low or high threat levels may also be relevant in choosing sites under these contrasting rationales. Generally, beneficial outcomes would be secured more readily where threats are lower, as less ongoing expenditure of management effort is required to mitigate operating threats. To prioritise sites with low threat levels, threat criteria values would be set as costs (negative values). Alternatively, where high levels of threat are considered to elevate the risks associated with forgoing timely management interventions, the beneficial weighting (positive value) of threats is required to prioritise sites for investment.

6.3 Allocating Investment using the DSS

The DSS has been developed to provide a 'framework' that supports wetland management investment decision making that also relies on operator inputs. The DSS does not come with preconceived definitions of appropriate wetland management investment outcomes. Although the set of criteria that can be applied at the primary and secondary scales are fixed, operator flexibility in the definition of eligible alternate site sets, directional criteria valuing, weighting of criteria and the option for the selective omission of criteria via zero weighting provides multifaceted application opportunities that can span the full spectrum of wetland management objectives and prioritisation rationales.

Against the diversity of the DSSs potential applications, it is the consistent and transparent prioritisation of sites based on their attributes once management objectives and prioritisation rationales have been set, that provides the strength and merit of DSS application to investment prioritisation. These aspects of the DSS make it very much a 'bottom up' tool in which regional decision makers are empowered to make consistent and transparently defendable decisions on the basis of regionally targeted investment programs and preferences.

In meeting the strategic investment needs of the catchment-wide GBRCWPP, the Primary DSS operating at the aggregation scale does present some 'top down' prioritisation. However, again outputs are sensitive to operator defined management objectives and associated criteria weighting which are unlikely to become 'fixed' considering the broad range of wetland management objectives embraced by the GBRCWPP.

Ultimately, Primary DSS prioritisation of wetland aggregations will only serve to ensure that the more strategic wetland hotspots within the GBR catchment are the preferred recipients for major wetland program funding. How such investment is pursued at the site scale will depend on regional stakeholder preferences albeit applied in a consistent manner within regions aided by the DSS.

6.4 Defining exceptions

A key part of the flexibility of the DSS tool is the ability to define the area of interest by actively excluding areas of non-interest or exceptions. For example, if aggregation prioritisation is to be undertaken within a particular NRM Region, that region can be selected in the DSS to the exclusion of other regions. When prioritising sites using the Secondary DSS, exceptions are much more difficult to define spatially in an automated fashion, hence the ability of the decision-makers to define wetland site boundaries rather than have the alternative set ‘pre-defined’. This has been seen as necessary for the functional application of the DSS at the site scale, however it brings with it two important considerations that must be taken into account for a successful outcome to be realised.

The first consideration is the exclusion of ineligible areas under the funding delivery program. Though the influence of ineligible areas can be considered implicitly when weighting, these must be actively excluded from the alternative set. For the GBRCWPP, ineligible areas include mangroves, riverine and marine areas. Under some funding programs, tenure may be a consideration so it would be useful to identify areas of public and private land. Other considerations may also be important for the specific objectives under which the tool is used. For example decision-makers may wish to aggregate wetlands that are on the same property into a single wetland ‘site’. With the assistance of relevant GIS or accompanying maps and other appropriate spatial reference material, this can be achieved when the individual sites are being identified. It is very important however, that these considerations and ‘rules’ for defining inclusions and exceptions are clearly documented to form part of the transparency of the decision-making process. It is also important that all participants in the decision-making process have the same understanding of the spatial extents of the wetland sites as defined in the DSS. This can usually be easily achieved in the wetland identification component of the process through brief discussion amongst participants.

The development of guiding principles or ‘rules’ for identification of wetland sites for application by regional stakeholders would serve to limit the variability in applied site definitions and help define interactions with Queensland Wetland Inventory data sets .

The second consideration is that areas nominated as a candidate or considered as part of the alternative set be ground-truthed to ensure that the real attributes of the wetland sites align with the site as it is spatially defined. Additionally, the scores given to each of the criteria for that wetland sites should also be ground-truthed. This is particularly important for wetland sites that have been selected as suitable candidates for funding, but should also be undertaken for low-priority wetlands to ensure that the scores assigned to them were correct. In many cases there may be no ‘local experts’ and decision-makers may be too unfamiliar with the wetlands to be able to assign scores. In these situations the wetland sites should be first identified using the Wetland Inventory data and then a rapid assessment of these sites undertaken using the criteria indices (**Appendix 5**).

6.5 Recommendations and Future Development

The following is a summary of the key recommendations and considerations for use and future development of the DSS:

- Defining wetland management objectives and prioritisation rationales is prerequisite to the appropriate configuration of the inherent flexibility of the DSS to serve decision makers varied needs and should be undertaken as a primary task during the engagement of DSS users. Future development of the DSS could explore the merits of developing set configurations of the DSS that serve different wetland management objectives and prioritisation rationales.
- DSS participants need to be equipped to a level commensurate with the tasks in which they are participating. Resources that will be required, at leat initially in the 'roll out' of the DSS, will include access to expertise and training and the time required to acquire knowledge and skills to allow informed participation.
- Rigorous documentation of process is critical for the consistent application of the DSS, particularly in regard to evidence and references used in local and expert scoring within the secondary DSS. Any changes to the DSS proposed as part of any further development should also be subject to as rigorous a process and documentation as employed in the development of the current DSS.
- The DSS supports decisions rather than makes them and additional management prioritisation information including the catchment context and biophysical process linkages of wetlands needs to be explicitly considered in conjunction with DSS outputs.
- The alternate set of wetland sites for secondary DSS prioritisation need not be limited to a single highly ranked aggregation within a NRM region. Where highly ranked wetland aggregations are juxtaposed, wetland sites across all such aggregations could be considered for secondary prioritisation. There is also an argument for simply applying the secondary DSS to the entire area covered by a NRM region (or local Government area) particularly where decision makers are interested in pursuing a broad range of wetland management objectives and investment programs across the full spectrum of asset protection, threat management, ecosystem restoration and community capacity building NRM strategies.
- The definition of eligible / ineligible wetlands is program specific and should not compromise the inherent flexibility of the DSS which has application for wetland investment prioritisation beyond the GBRCWPP. For the purposes of targeting GBRCWPP expenditure toward eligible wetlands, it would be useful to utilise available data (wetland associated REs, wetland inventory) to classify mapped aggregations in terms of the percentage area of eligible / ineligible wetlands. This information could be used to provide a potentially useful secondary sorting of prioritised aggregations without loosing values defined on the basis of whole aggregation scale attributes.
- Ground-truthing must be undertaken before funding is allocated to a particular site and ideally should be undertaken for all wetland candidates during the prioritisation process. In serving the latter point, the opportunity to utilise secondary DSS criteria scoring for both DSS output ground-truthing and primary wetland site assessment should be explored further.
- As it is practically unfeasible to run an expert panel Secondary DSS assessment workshop across all sites within a region or even a single large wetland aggregation, the development of an interfacing database to capture expert panel outputs is recommended. The development of such a database will enable data and values to be generated during a number of assessment sessions or updated by the panel or

individual members as new information comes to hand. Such a database may also enable the prioritisation assessments to be run utilising a comprehensive set of alternate wetland sites drawn from across an entire region.

- While the definition of 'wetland sites' and their boundaries by regional stakeholders has significant merits, its legitimacy is also prone to be undermined by non-consistent application between sites and aggregations / regions. Development of guiding principles or 'rules' for identification of wetland sites for application by regional stakeholders would serve to limit the variability in applied site definitions and help define interactions with Qld wetland inventory data sets and specify exclusion guidelines for non-wetland areas. Development of automated database querying and scoring of GIS based criteria for stakeholder defined 'wetland sites' is a high priority for further development of the secondary DSS.
- When completed, Queensland wetland inventory data including newly defined aggregations should be incorporated into the Primary DSS and made available for use with the secondary DSS and as per the previous dot point, further explored and developed.
- A plan for the maintenance of the DSS including defined custodian arrangements and ideally a nominated 'champion' should be established to address modifications of the DSS that may need to be implemented as a function of updates of data or the incorporation or removal of criteria.
- The potential to build real time updating linkages between the DSS tool and GIS should be explored further and implemented if feasible.
- Serious consideration should be given to the further development of the DSS into a Web based tool. A password protected Web based interface for the DSS could provide a means of addressing a range of issues identified above including data capture, database functionality, custodianship, version control and real time currency.
- Investment of resources in the maintenance and further development of the DSS will to some degree be governed by the level of use it enjoys for prioritising wetland management investment decisions. Means of ensuring appropriate and ongoing application of the DSS should be explored including the possibility of DSS outputs being a prerequisite for wetland management funding applications.
- With limited modification, the DSS could potentially be applied to other regions including inland drainages such as the Murray Darling Basin or the Gulf of Carpentaria. The use of the existing DSS as a foundation for such developments could provide a cost-effective means of developing decision support for wetland management in other such regions and in doing so provide ongoing impetus for the maintenance and ongoing development of DSS for GBR wetlands.

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APPENDIX 1: Primary DSS User Guide

Overview

The Primary DSS is a Microsoft Excel workbook made up of six worksheets which perform the following functions:

Instructions – a brief instruction page which is hyperlinked to this instruction guide;

Weighting – allows the user to enter and adjust the relative weighting for each criteria used to rank wetlands;

Results – sorts the wetland aggregations based on the standardised and weighted scores calculated in the Primary DSS worksheet;

Results Chart- presents the overall scores for the sorted wetland aggregations in graphical format;

Primary DSS – containing the three performance matrices, this worksheet performs the calculations which convert the raw data for each wetland into standardised and weighted data to allow comparison and ranking of the wetland aggregations; and

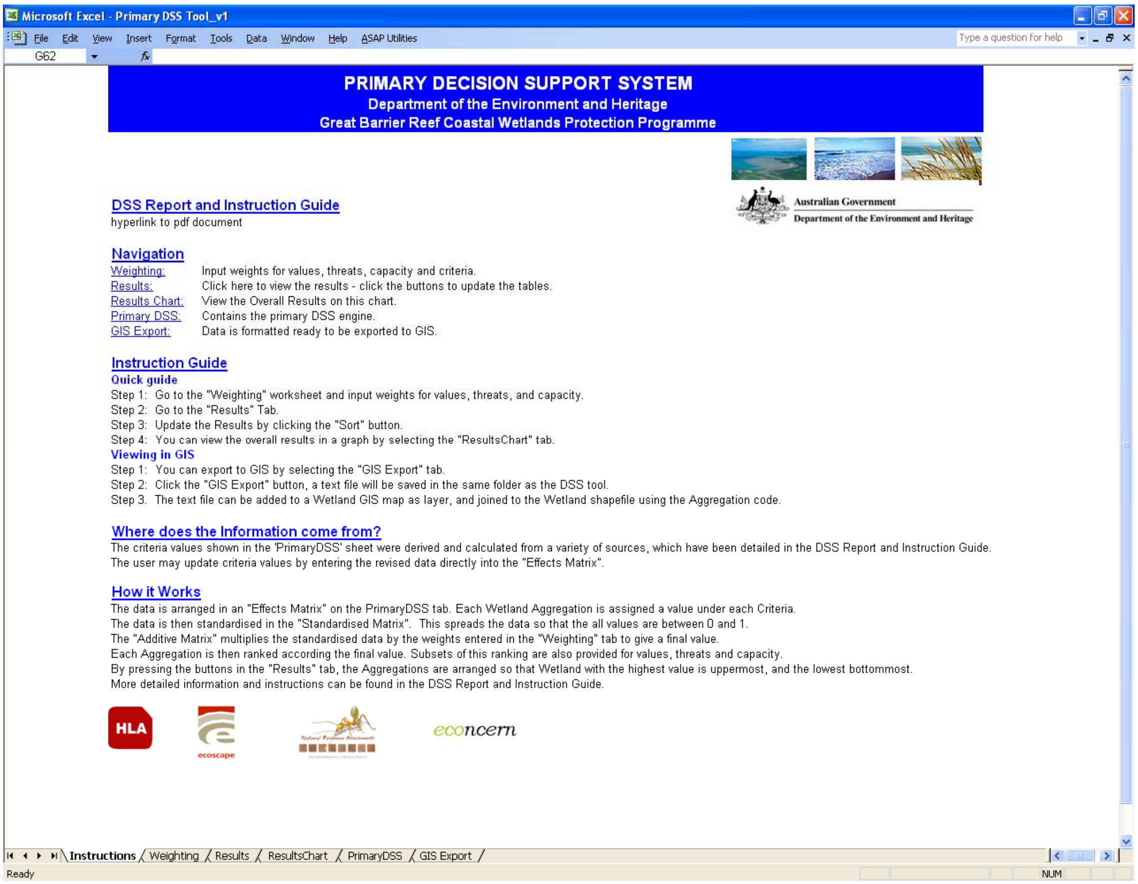
GIS export – converts the data into a format suitable for export to GIS.

Note: In order for the tool to function correctly, 'Macros' must be enabled. This may necessitate reducing the security settings in Excel.

Worksheet Descriptions

Instructions

The "Instructions" worksheet contains brief instructions for operating the Primary DSS. This is the first worksheet that is displayed upon launching the DSS. A 'splash screen' also displays for a few seconds after launch.



Weighting

This worksheet is the main input screen for the DSS user. The worksheet enables the user to enter and adjust the relative weighting for each of the criteria used to assess wetlands. This allows the relative importance of the criterion to be accounted for when ranking wetlands. It also enables the user to determine whether the criterion is considered a cost or a benefit. The weighting should be done in a facilitated workshop environment with the relevant decision-makers and entails the following steps:

1. Setting Objectives – this step involves determining what the objectives are that the aggregations will be prioritised against.
2. Criteria familiarisation – this essential step involves all participants gaining a good understanding of the criteria so that they can make value judgements about their relative importance. The criteria definitions should be referred to during this stage and discussion amongst participants should be encouraged so that everyone has the same understanding of the criteria. Familiarisation should encompass:
    a. the definition and rationale of the criteria;
    b. the datasets the criteria were based on and a brief overview of the GIS analysis involved; and
    c. the units the criteria are measured in.
3. Criteria category weighting – this step involves weighting criteria categories (values, threats and capacity) to determine the relative importance of the criteria categories. There are a number of different ways of weighting. The weighting procedure which has been tested for the DSS involves the following:
    a. Nomination (by vote) of the most important criteria category. This category is then set a weight of 10.
    b. Each participant individually weights the remaining two categories proportional to the most important category. Participants can assign any weight between zero and ten for the remaining criteria categories.
    c. The weights assigned for each category are averaged and entered into the appropriate cells.
4. Criteria weighting – this step is undertaken in the same way as the criteria category weighting except the criteria are weighted relative to each other within each category. The process below is carried out for each criteria category:
    a. Nomination (by vote) of the most important criterion within the category. This criterion is then set a weight of 10.
    b. Each participant individually weights the remaining criteria within the category proportional to the most important category. Participants can assign any weight between zero and ten for the remaining criteria categories.
    c. The weights assigned for each criterion are averaged and entered into the appropriate cells.
    d. The process is repeated for the remaining two categories.
5. Criteria cost / benefit assignment – This step involves determining whether a high number for each of the criteria should be treated as a 'benefit' (high number = high priority) or a 'cost (high number = low priority). The 'default' values have been set and therefore this step is optional and should only be undertaken where very specific objectives have been set and the facilitator and participants have a good understanding of the effect this will have on the outcomes of the DSS.

Clicking on the Criterion name will pop-up a brief explanatory note explaining how the Criterion has been calculated.

Results

The user can sort the Aggregations so that the Wetland Aggregation with the highest value is uppermost and the lowest bottommost, by clicking the “Sort” button in the "Results" worksheet. Each subset (values, threats, capacity, overall score and overall score by region) is found in a separate table in this spreadsheet. Clicking the sort button will sort all five tables.

Results Chart

The results of the overall scores are presented as a graph on the “ResultsChart” worksheet. It is important to note that the graph is linked to the results in the results worksheet, and therefore requires the user to sort the data using the sort button (described above). The data in the chart is stacked on top of each other with Values at the bottom, Threats in the middle and Capacity at the top. The sum of the three classes is equivalent to the Overall value in the ‘Results’ worksheet.

Primary DSS

This worksheet performs the calculations that convert the raw data for each criteria and wetland aggregation into standardised and weighted data to allow comparison and ranking of the wetland aggregations.

Effects Matrix

The scores for each criterion derived from the GIS analysis are arranged in an ‘Effects Matrix’ on the “Primary DSS” tab of the worksheet i.e. each of the wetland aggregations is assigned a value for each of the 17 criteria. Also visible in the effects matrix is the ‘criteria category’ (values, threats and capacity) weight, the ‘individual criteria’ weight, the total weight for each criterion (category weight x individual criteria weight) and an indication of whether a high number is considered to add to (benefit) or detract from (cost) an alternative’s resulting priority.

Scroll Right to view:
Standarised Matrix
Additive Weighting Matrix

DIW Code	Name
QLD001	Abbot Point - Caley Valley
QLD003	Broad Sound
QLD004	Burdekin Delta
QLD005	Burdekin-Townsville Coastal Aggregation
QLD006	Lake Dalrymple
QLD007	Lake Elphinstone
QLD008	Ross River Reservoir
QLD009	Southern Upstart Bay
QLD010	Boggomoss Springs
QLD011	Fairbairn Dam
QLD012	Fitzroy River Delta
QLD013	Fitzroy River Floodplain
QLD014	Hedlow Wetlands
QLD016	Lake Nuga Nuga
QLD017	Northeast Curtis Island
QLD018	Palm Tree and Robinson Creeks
QLD019	Port Curtis

Effects Matrix

	VALUES						THREATS						CAPACITY					Ext	Ext
Value Weight	9						10						6					1	1
Criteria:	Representativeness	Diversity of Wetland Types	Size	Condition / Proportion Remnant Vegetation	Fishery nursery habitat	Retention	Population Density	Population Growth	Proportion intensive land-use	Connectivity restriction	Point-source pollution	Hydrological change	Indigenous Land Areas	Landholder Disadvantage	Landholder Education	Landholder Economic Resources	Level of protection	Ext	Ext
Criteria Weight	10	9	7	6	8	7	6	9	10	8	6	8	4	2	5	5	10	0.0	0.0
Total Weight:	88	77	60	55	75	58	64	85	100	78	55	76	32	14	27	28	59	0.00	0.00
Cost/Benefit:	b	b	b	b	b	b	c	c	c	c	c	c	b	b	b	b	b	b	b
FID																			
0	0.081	2.641	48985759	0.912	25150884	0.025	0.003	0.000	0.015	0	1	0.008	0.000	902	855	930	0.020	1.000	1.000
1	0.080	3.844	959875440	0.913	759059195	0.000	0.052	0.152	0.005	0	2	0.004	0.000	783	734	743	0.341	1.000	1.000
2	0.169	4.877	247936574	0.792	130211627	0.051	0.157	0.000	0.311	0	2	0.305	0.000	984	888	937	0.302	1.000	1.000
3	0.206	4.942	775902906	0.909	406207252	0.130	2.639	0.287	0.262	5	29	0.232	0.000	932	883	911	0.448	1.000	1.000
4	0.376	2.066	305700729	0.977	216259627	0.004	0.001	0.000	0.001	1	1	0.000	0.005	959	890	974	0.000	1.000	1.000
5	0.165	0.093	3003443	0.709	2079947	0.001	0.002	0.000	0.039	0	3	0.000	0.000	929	860	1095	0.000	1.000	1.000
6	0.387	0.000	27816397	0.997	27734821	0.000	2.514	0.283	0.052	1	4	0.004	0.000	999	945	970	0.000	1.000	1.000
7	0.104	2.838	109710366	0.974	80323764	0.069	0.001	0.000	0.013	0	0	0.009	0.000	687	632	688	0.490	1.000	1.000
8	0.214	1.727	3994374	1.000	466946	0.001	0.001	0.000	0.008	0	1	0.004	0.000	1027	938	1003	0.327	1.000	1.000
9	0.594	1.317	153972473	0.703	81689332	0.003	0.003	0.137	0.108	1	6	0.023	0.000	997	927	998	0.000	1.000	1.000
10	0.073	2.923	557265129	0.637	348365331	0.051	4.857	0.086	0.061	2	37	0.006	0.000	762	757	774	0.005	1.000	1.000
11	0.615	3.758	195277989	0.344	17713269	0.010	6.136	0.118	0.052	1	31	0.008	0.000	973	946	942	0.001	1.000	1.000
12	0.509	2.889	111204819	0.063	58847	0.000	0.017	0.358	0.028	0	1	0.007	0.000	1008	958	937	0.000	1.000	1.000
13	0.403	0.716	20697365	0.959	99506	0.014	0.001	0.000	0.085	0	0	0.000	0.000	1075	972	1051	0.039	1.000	1.000
14	0.153	2.468	71135964	0.994	59945563	0.078	0.005	0.000	0.001	0	0	0.000	0.000	926	893	923	0.876	1.000	1.000
15	0.435	3.867	502740472	0.251	40516923	0.010	0.001	0.000	0.011	0	0	0.000	0.000	1028	939	939	0.010	1.000	1.000
16	0.194	4.877	105661057	0.658	51210274	0.000	5.781	0.185	0.008	0	36	0.001	0.073	846	820	866	0.116	1.000	1.000

Standardised Matrix

The data from the Effects Matrix is then standardised in the 'Standardised Matrix'. This standardises the criteria data so that the information from each criteria can be compared. This involves reassigning the values for each criterion so that the data arrange themselves between zero and one. The way this is achieved depends on whether the criterion has been nominated as a 'cost' or a 'benefit'. The standardised score for each criterion is determined by either:

- Standardised Score = (Criterion Score - Minimum Criterion Score) / (Maximum Criterion Score - Minimum Criterion Score) (where the criterion is a benefit); or
- Standardised Score = (Maximum Criterion Score - Criteria Score) / (Maximum Criteria Score - Minimum Criterion Score) (where the criterion is a cost)

For example, QLD005 has a Point Source Pollution (cost) value of 29, with the minimum value in this criterion being 0 and the maximum value being 37, giving a standardised value of 0.216 (i.e. (37 - 29) / (37 – 0) = 0.216)

Scroll Right to view:
Standarised Matrix
Additive Weighting Matrix

DIW Code	Name
QLD001	Abbot Point - Caley Valley
QLD003	Broad Sound
QLD004	Burdekin Delta
QLD005	Burdekin-Townsville Coastal Aggregation
QLD006	Lake Dalrymple
QLD007	Lake Elphinstone
QLD008	Ross River Reservoir
QLD009	Southern Upstart Bay
QLD010	Boggomoss Springs
QLD011	Fairbairn Dam
QLD012	Fitzroy River Delta
QLD013	Fitzroy River Floodplain
QLD014	Hedlow Wetlands
QLD016	Lake Nuga Nuga
QLD017	Northeast Curtis Island
QLD018	Palm Tree and Robinson Creeks
QLD019	Port Curtis

Standardised Matrix

	VALUES						THREATS						CAPACITY					Ext	Ext
Value Weight																			
Criteria:	Representativeness	Diversity of Wetland Types	Size	Condition / Proportion Remnant Vegetation	Fishery nursery habitat	Retention	Population Density	Population Growth	Proportion intensive land-use	Connectivity restriction	Point-source pollution	Hydrological change	Indigenous Land Areas	Landholder Disadvantage	Landholder Education	Landholder Economic Resources	Level of protection	Ext	Ext
Criteria Weight																			
Total Weight:	88.2	77.3	60.2	55	74.7	58.1	63.5	85.3	100	78.2	55.3	76.5	32.3	13.7	27	27.8	58.8	0	0
Cost/Benefit:	b	b	b	b	b	b	c	c	c	c	c	c	b	b	b	b	b	b	b
FID																			
0	0.131	0.531	0.012	0.912	0.033	0.189	1.0	1.0	0.97	1.0	0.973	0.982	0.0	0.798	0.71	0.849	0.02	1.0	1.0
1	0.13	0.773	0.245	0.913	1.0	0.0	0.992	0.707	0.989	1.0	0.946	0.992	0.0	0.692	0.609	0.679	0.341	1.0	1.0
2	0.275	0.981	0.063	0.792	0.172	0.395	0.974	1.0	0.381	1.0	0.946	0.34	0.0	0.87	0.737	0.856	0.302	1.0	1.0
3	0.335	0.994	0.198	0.909	0.535	1.0	0.57	0.448	0.478	0.0	0.216	0.497	0.0	0.824	0.733	0.832	0.448	1.0	1.0
4	0.612	0.416	0.078	0.977	0.285	0.028	1.0	1.0	0.998	0.8	0.973	1.0	0.005	0.847	0.739	0.889	0.0	1.0	1.0
5	0.268	0.019	0.001	0.709	0.003	0.008	1.0	1.0	0.921	1.0	0.919	1.0	0.0	0.821	0.714	1.0	0.0	1.0	1.0
6	0.629	0.0	0.007	0.997	0.037	0.0	0.59	0.455	0.896	0.8	0.892	0.991	0.0	0.884	0.784	0.885	0.0	1.0	1.0
7	0.169	0.571	0.028	0.974	0.106	0.529	1.0	1.0	0.973	1.0	1.0	0.98	0.0	0.607	0.525	0.628	0.49	1.0	1.0
8	0.348	0.347	0.001	1.0	0.001	0.004	1.0	1.0	0.984	1.0	0.973	0.992	0.0	0.908	0.778	0.916	0.327	1.0	1.0
9	0.965	0.265	0.039	0.703	0.108	0.021	1.0	0.737	0.785	0.8	0.838	0.95	0.0	0.882	0.769	0.911	0.0	1.0	1.0
10	0.119	0.588	0.142	0.637	0.459	0.393	0.209	0.835	0.879	0.6	0.0	0.987	0.0	0.674	0.628	0.707	0.005	1.0	1.0
11	1.0	0.756	0.05	0.344	0.023	0.077	0.0	0.772	0.896	0.8	0.162	0.982	0.0	0.86	0.785	0.86	0.001	1.0	1.0
12	0.827	0.581	0.028	0.063	0.0	0.004	0.997	0.31	0.945	1.0	0.973	0.986	0.0	0.891	0.795	0.855	0.0	1.0	1.0
13	0.655	0.144	0.005	0.959	0.0	0.105	1.0	1.0	0.831	1.0	1.0	1.0	0.0	0.95	0.807	0.96	0.039	1.0	1.0
14	0.249	0.497	0.018	0.994	0.079	0.6	0.999	1.0	0.998	1.0	1.0	0.999	0.0	0.819	0.741	0.843	0.876	1.0	1.0
15	0.707	0.778	0.128	0.251	0.053	0.08	1.0	1.0	0.978	1.0	1.0	1.0	0.0	0.909	0.78	0.858	0.01	1.0	1.0
16	0.315	0.981	0.027	0.658	0.067	0.0	0.058	0.644	0.984	1.0	0.027	0.998	0.073	0.748	0.68	0.791	0.116	1.0	1.0

Additive Weighting Matrix

The "Additive Weighting Matrix" multiplies the standardised data by the weights entered in the "Weighting" tab to give a final value. The weighted values are calculated by multiplying the Value, Threat and Capacity data by the criterion weight entered in the Weighting worksheet.

Scroll Right to view:
Standarised Matrix
Additive Weighting Matrix

DIW Code	Name
QLD001	Abbot Point - Caley Valley
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QLD013	Fitzroy River Floodplain
QLD014	Hedlow Wetlands
QLD016	Lake Nuga Nuga
QLD017	Northeast Curtis Island
QLD018	Palm Tree and Robinson Creeks
QLD019	Port Curtis

Additive Weighting Matrix

	VALUES						THREATS						CAPACITY					Ext	Ext
Value Weight																			
Criteria:	Representativeness	Diversity of Wetland Types	Size	Condition / Proportion Remnant Vegetation	Fishery nursery habitat	Retention	Population Density	Population Growth	Proportion intensive land-use	Connectivity restriction	Point-source pollution	Hydrological change	Indigenous Land Areas	Landholder Disadvantage	Landholder Education	Landholder Economic Resources	Level of protection	Ext	Ext
Criteria Weight																			
Total Weight:	88.2	77.3	1	55	74.7	58.1	63.5	85.3	100	78.2	55.3	76.5	1	13.7	27	27.8	58.8	0	0
Cost/Benefit:	b	b	b	b	b	b	c	c	c	c	c	c	b	b	b	b	b	b	b
FID																			
0	11.553	41.082	0.012	50.164	2.476	10.98	63.504	85.29	96.982	78.24	53.796	75.116	0.0	10.94	19.192	23.636	1.197	0.0	0.0
1	11.438	59.785	0.245	50.235	74.714	0.0	62.996	60.276	98.915	78.24	52.301	75.842	0.0	9.491	16.464	18.892	20.06	0.0	0.0
2	24.223	75.849	0.063	43.541	12.817	22.948	61.907	85.29	38.075	78.24	52.301	26.017	0.0	11.938	19.922	23.826	17.753	0.0	0.0
3	29.574	76.86	0.198	49.965	39.983	58.106	36.207	38.186	47.778	0.0	11.955	38.036	0.0	11.302	19.826	23.147	26.366	0.0	0.0
4	53.969	32.13	0.078	53.712	21.286	1.606	63.523	85.29	99.828	62.592	53.796	76.469	0.005	11.626	19.977	24.748	0.0	0.0	0.0
5	23.673	1.441	0.001	39.0	0.205	0.484	63.512	85.29	92.144	78.24	50.807	76.47	0.0	11.268	19.304	27.83	0.0	0.0	0.0
6	55.461	0.0	0.007	54.832	2.73	0.0	37.503	38.777	89.571	62.592	49.313	75.794	0.0	12.12	21.206	24.64	0.0	0.0	0.0
7	14.891	44.138	0.028	53.541	7.906	30.762	63.516	85.29	97.344	78.24	55.29	74.931	0.0	8.333	14.192	17.473	28.83	0.0	0.0
8	30.712	26.855	0.001	54.993	0.046	0.239	63.523	85.29	98.389	78.24	53.796	75.834	0.0	12.461	21.047	25.492	19.212	0.0	0.0
9	85.151	20.484	0.039	38.636	8.041	1.199	63.499	62.822	78.501	62.592	46.324	72.628	0.0	12.093	20.808	25.365	0.0	0.0	0.0
10	10.535	45.459	0.142	35.022	34.29	22.817	13.248	71.198	87.856	46.944	0.0	75.482	0.0	9.24	16.991	19.669	0.296	0.0	0.0
11	88.2	58.454	0.05	18.894	1.744	4.469	0.0	65.844	89.612	62.592	8.966	75.128	0.0	11.803	21.234	23.935	0.072	0.0	0.0
12	72.95	44.929	0.028	3.453	0.006	0.215	63.354	26.476	94.46	78.24	53.796	75.368	0.0	12.226	21.492	23.802	0.0	0.0	0.0
13	57.759	11.134	0.005	52.742	0.01	6.127	63.523	85.29	83.1	78.24	55.29	76.47	0.0	13.039	21.818	26.712	2.312	0.0	0.0
14	21.925	38.394	0.018	54.642	5.9	34.859	63.475	85.29	99.755	78.24	55.29	76.4	0.0	11.232	20.045	23.459	51.49	0.0	0.0
15	62.333	60.151	0.128	13.816	3.988	4.675	63.525	85.29	97.757	78.24	55.29	76.47	0.0	12.473	21.085	23.874	0.616	0.0	0.0
16	27.813	75.857	0.027	36.171	5.041	0.0	3.676	54.938	98.362	78.24	1.494	76.294	0.073	10.261	18.403	22.001	6.842	0.0	0.0

For example, Point Source Pollution has been weighted as 55.29, and QLD005 has a standardised Point Source Pollution value of 0.216. The final value is therefore 55.29 x 0.216 = 11.95.

Ranking

Each Aggregation is then ranked according the final value using the Excel RANK formula. Subsets of this ranking are also calculated for values, threats, capacity and total score by region and can be viewed via the ‘Results’ worksheet.

GIS Export

The user can click the ‘GIS Export’ button to export the data in a format suitable for GIS. A text file of the data will be written to the same location as the Primary DSS Excel file.

Further information

For more information on the DSS Tool, and the Great Barrier Reef Coastal Wetlands Protection Programme go to the DEH website, or contact the GBR Coastal Wetlands Protection Program, Department of the Environment and Heritage, GPO Box 787, CANBERRA ACT 2601.

Appendix 2: Secondary DSS User Guide

Overview

The Secondary DSS is a Microsoft Excel workbook made up of six worksheets which perform the following functions:

Instructions – a brief instruction page which is hyperlinked to this instruction guide;

Weighting – allows the user to enter and adjust the relative weighting for each criteria used to rank wetlands;

Results – sorts the wetlands based on the standardised and weighted scores calculated in the Secondary DSS worksheet;

Results Chart- presents the overall scores for the sorted wetlands in graphical format;

Secondary DSS – containing four performance matrices, this worksheet performs the calculations which convert the raw data for each wetland into standardised and weighted data to allow comparison and ranking of the wetlands; and

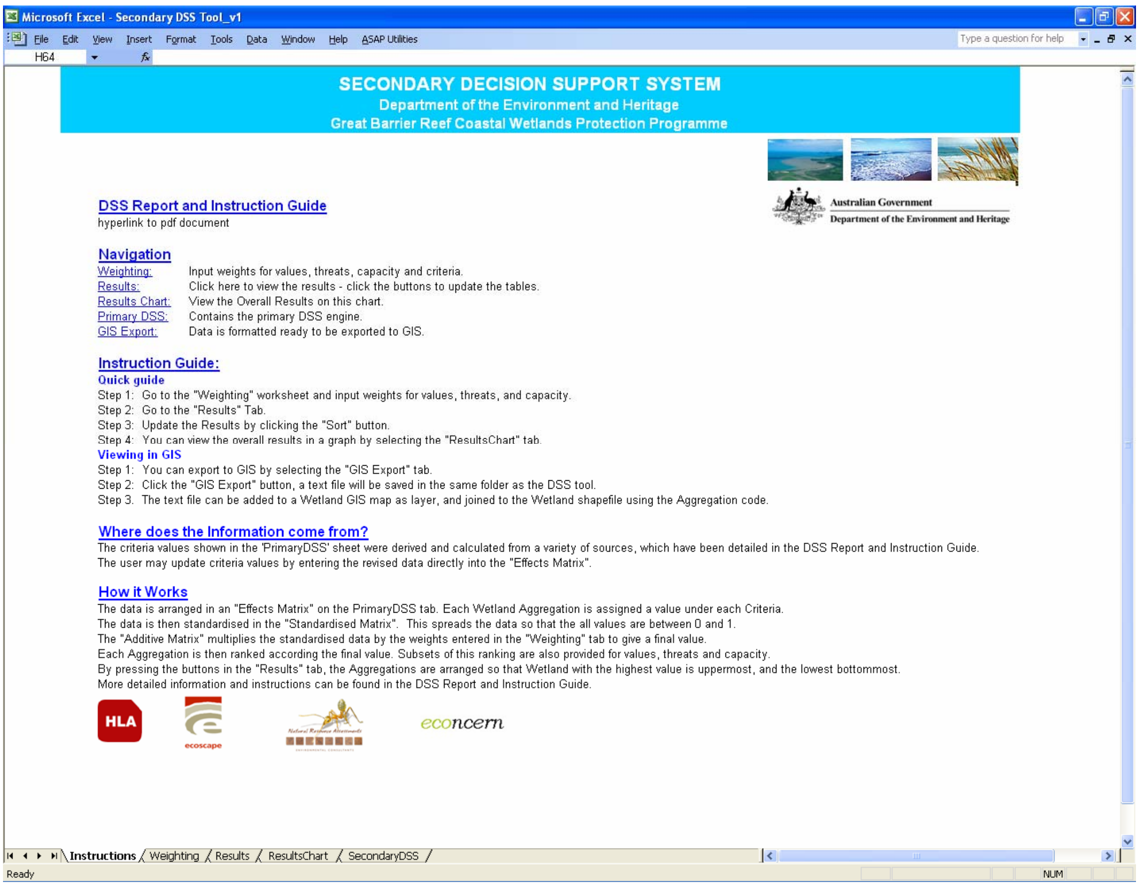
GIS export – converts the data into a format suitable for export to GIS.

Note: In order for the tool to function correctly, 'Macros' must be enabled. This may necessitate reducing the security settings in Excel.

Worksheet Descriptions

Instructions

The "Instructions" worksheet contains brief instructions for operating the Secondary DSS. This is the first worksheet that is displayed upon launching the DSS. A 'splash screen' also displays for a few seconds after launch.



Weighting

This worksheet is the main input screen for the DSS user. The worksheet enables the user to enter and adjust the relative weighting for each of the criteria used to assess wetlands. This allows the relative importance of the criterion to be accounted for when ranking wetlands. It also enables the user to determine whether the criterion is considered a cost or a benefit. The weighting should be done in a facilitated workshop environment with the relevant decision-makers and entails the following steps:

1. Setting Objectives – this step involves determining what the objectives are that the wetlands will be prioritised against.
2. Criteria familiarisation – this essential step involves all participants gaining a good understanding of the criteria so that they can make value judgements about their relative importance. The criteria definitions should be referred to during this stage and discussion amongst participants should be encouraged so that everyone has the same understanding of the criteria. Familiarisation should encompass:
    a. the definition and rationale of the criteria;
    b. the datasets the criteria were based on and a brief overview of the GIS analysis involved; and
    c. the units the criteria are measured in.
3. Criteria category weighting – this step involves weighting criteria categories (values, threats and capacity) to determine the <u>relative</u> importance of the criteria categories. There are a number of different ways of weighting. The weighting procedure which has been tested for the DSS involves the following:
    d. Nomination (by vote) of the most important criteria category. This category is then set a weight of 10.
    e. Each participant individually weights the remaining two categories proportional to the most important category. Participants can assign any weight between zero and ten for the remaining criteria categories.
    f. The weights assigned for each category are averaged and entered into the appropriate cells.
4. Criteria weighting – this step is undertaken in the same way as the criteria category weighting except the criteria are weighted relative to each other within each category. The process below is carried out for <u>each</u> criteria category:
    g. Nomination (by vote) of the most important criterion within the category. This criterion is then set a weight of 10.
    h. Each participant individually weights the remaining criteria within the category proportional to the most important category. Participants can assign any weight between zero and ten for the remaining criteria categories.
    i. The weights assigned for each criterion are averaged and entered into the appropriate cells.
    j. The process is repeated for the remaining two categories.
5. Criteria cost / benefit assignment – This step involves determining whether a high number for each of the criteria should be treated as a ‘benefit’ (high number = high priority) or a ‘cost (high number = low priority). The ‘default’ values have been set and therefore this step is optional and should only be undertaken where very specific objectives have been set and the facilitator and participants have a good understanding of the effect this will have on the outcomes of the DSS.

Clicking on the Criterion name will pop-up a brief explanatory note explaining how the Criterion has been calculated.

Results

The user can sort the Wetlands so that the Wetland with the highest value is uppermost and the lowest bottommost, by clicking the “Sort” button in the "Results" worksheet. Each subset (values, threats, capacity and overall score) is found in a separate table in this spreadsheet.. Clicking the sort button will sort all four tables.

Results Chart

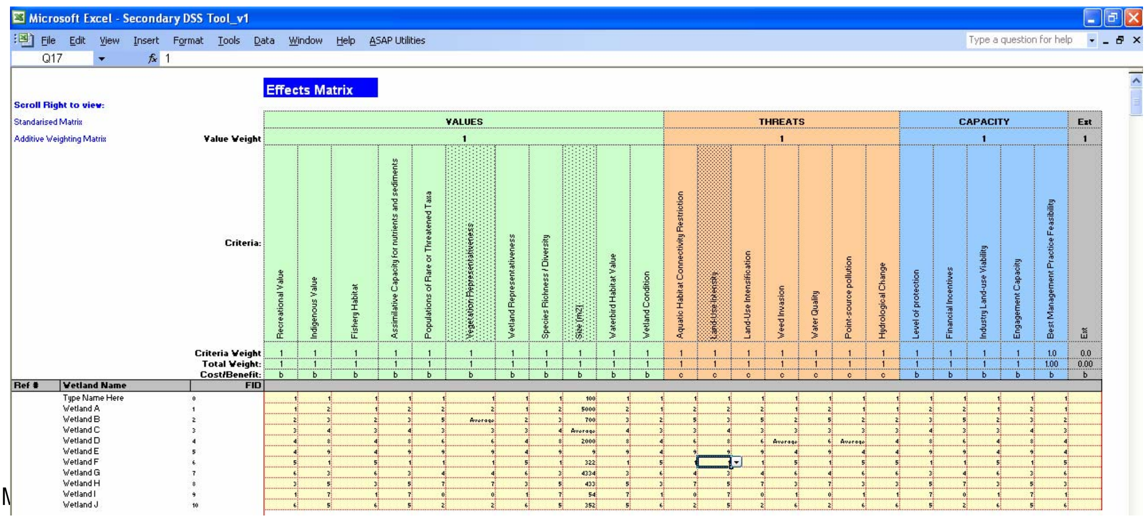
The results are presented as a graph on the “ResultsChart” worksheet. It is important to note that the graph is linked to the results in the results worksheet, and therefore requires the user to sort the data using the buttons using the sort button (described above). The data in the chart is stacked on top of each other with Values at the bottom, Threats in the middle and Capacity at the top. The sum of the three classes is equivalent to the Overall value in the ‘Results’ worksheet.

Secondary DSS

This worksheet allows the user to enter values for each criteria and wetland and converts the entered values into standardised and weighted data to allow comparison and ranking of the wetlands.

Effects Matrix

The user is required to enter a wetland name under the “Wetland Name” column (note that the user must enter a name as text, not a number). By doing so, the data entry fields in the Effects Matrix are revealed. The user can then assign a value of 1 to 10 for each criterion using the drop down list. If the user chooses, they may also select an average value, which uses the average of all the other entries entered into the Effects Matrix (note that this average value will be updated as more data is entered to the matrix). Average values are used when the relevant score for the criterion is unknown. It is proposed that the values for Wetland Size, Vegetation Representativeness, and Land Use Intensity be determined in the facilitated workshop using GIS, and the derived values entered into the tool.

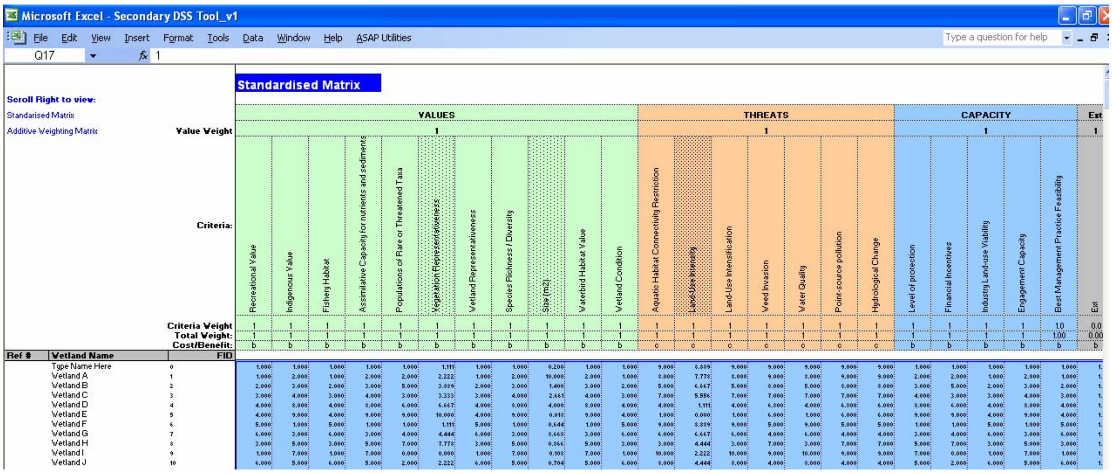


Standardised Matrix

The data from the Effects Matrix for Wetland Size, Vegetation Representativeness and Land Use Intensity are then standardised in the 'Standardised Matrix'. This involves reassigning the values for each criterion so that the data arrange themselves between zero and ten. This enables this data to be compared with the other criteria data, which are all determined by the user to be in the range of between zero and ten (and are therefore already standardised). Standardisation also depends on whether the criterion has been nominated as a 'cost' or a 'benefit'. Cost criteria are inversed by subtracting the value from 10. The standardised score for Wetland Size, Vegetation Representativeness and Land Use Intensity is determined by either:

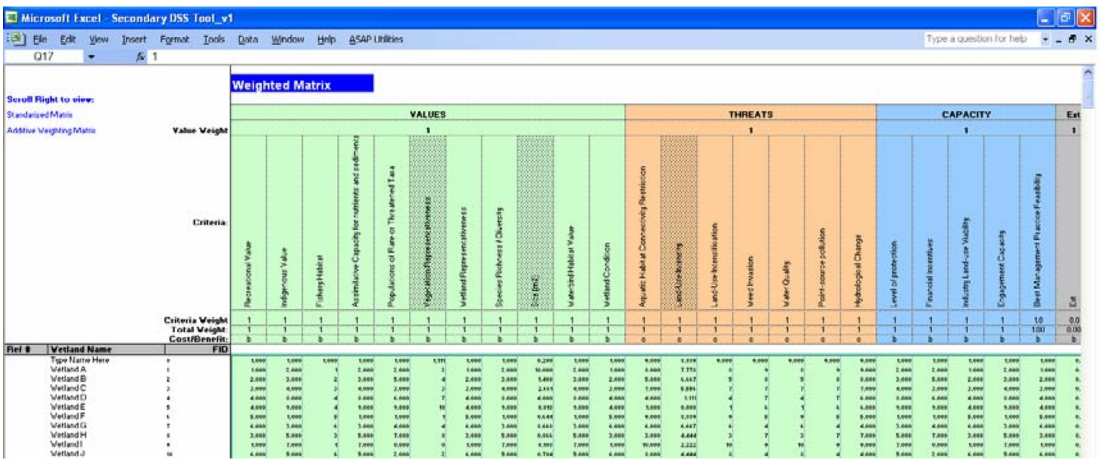
Standardised Score = [(Criterion Score - Minimum Criterion Score) / (Maximum Criterion Score - Minimum Criterion Score)] multiplied by 10 (where the criterion is a benefit); or

Standardised Score = [(Maximum Criterion Score - Criteria Score) / (Maximum Criteria Score - Minimum Criterion Score)] multiplied by 10 (where the criterion is a cost)



Additive Weighting Matrix

The "Additive Weighting Matrix" multiplies the standardised data by the weights entered in the "Weighting" tab to give a final value. The weighted values are calculated by multiplying the Value, Threat and Capacity data by the criterion weight entered in the Weighting worksheet.



Ranking

Each wetland site is then ranked according the final value using the Excel RANK formula. Subsets of this ranking are also calculated for values, threats, capacity and total score by region and can be viewed via the 'Results' worksheet.

GIS Export

The user can click the 'GIS Export' button to export the data in a format suitable for GIS. A text file of the data will be written to the same location as the Secondary DSS Excel file.

Further information

For more information on the DSS Tool, and the Great Barrier Reef Coastal Wetlands Protection Programme go to the DEH website, or contact the GBR Coastal Wetlands Protection Program, Department of the Environment and Heritage, GPO Box 787, CANBERRA ACT 2601.

Appendix 3: Analysis Steps

The following section describes the analysis steps undertaken to calculate the values entered into the Effects Matrix of the Primary DSS.

All spatial datasets were projected onto the Map Grid of Australia, zone 55 datum.

KEY SPATIAL UNITS

Wetland Aggregations

In ArcMap, the GBR catchment layer (sourced from the Great Barrier Reef Marine Park Authority) was dissolved on *Phase_ID*. The DOI wetlands layer (QLD EPA) was then clipped by the derived GBR catchment layer. The derived (clipped) DOI wetlands layer was then dissolved on Wetland Aggregation Code. The resulting layer was then projected as MGA zone 55.

Catchments

A "select by location" query was performed to select catchments (sourced from the Department of the Environment and Heritage) that intersect with the Wetland Aggregation layer (see **Wetland Aggregations** section above). A new layer was created from the selected features. The new layer was intersected with the Wetland Aggregation layer in order to assign Wetland Aggregation ID numbers to each catchment. Area was recalculated, and the data summarised (Sum of Area) by Wetland Aggregation ID to give Catchment Area for each Wetland Aggregation.

RE Types

The RE vegetation mapping layer provided by the QLD EPA was intersected with the Wetland Aggregation layer (see **Wetland Aggregations** section above) and the area of the resulting polygons recalculated. The resulting database file was exported to Excel to perform the calculations outlined below.

RE Units (polygons containing area information) are made up of up to 5 RE Types. RE Types contain the vegetation and wetland information. However, RE Types have no spatial component, only a Percentage Cover of the total RE Unit. For example RE1 may be 55% of the RE Unit, RE2 be 25%, and RE3 20%. In order to calculate an area for each RE type, the area of each RE Unit (polygon) was multiplied by the Percentage Cover value. This basic unit of area was used to determine the criteria of Remnant vegetation, Representativeness, Retention, Diversity and Fish Habitat, by adding the area of certain RE types together and expressing this as a proportion of the total area (all calculations for these criteria were done in Excel).

RE Types were assigned their vegetation and wetland classes based on the Code number attribute and the RE Classification (*RE Code lookup table*). The RE Classification lookup table contained vegetation types, as well as a Wetland classification (Wetland Types), i.e. Estuarine, Riverine, Lacustrine, Palustrine or Floodplain.

Note that for Wetland Aggregations that had no RE data available (e.g. Far North QLD), an average value (average of Wetland Aggregations for the criterion) was used.

CRITERIA

Vegetation Representativeness

RE Type Area was determined as described in **RE Types** section, above, and by performing the following calculations in Excel.

The total RE Remnant Area for each aggregation (sum of RE Type Area) was calculated by excluding the non-remnant vegetation classes ***clear*** (cleared land), ***dist*** (disturbed land), ***plant*** (plantation forest), ***hoop*** (hoop pine), ***sand*** and ***ocean***) from the Excel SUMIF function.

A ratio of current to pre-1750 extent (***RE03:PRE***) was calculated for each RE Type, and was multiplied by the area of each RE to give an area of representative vegetation. The total RE Representative Area for each aggregation (sum of RE Area) was then calculated (excluding the non-remnant vegetation classes ***clear***, ***dist***, ***plant***, ***hoop***, ***sand*** and ***ocean*** from the Excel SUMIF function).

Vegetation Representativeness was then calculated as a percentage (RE Representative Area / RE Remnant Area) and inversed (to give percentage lost as an indication of "rareness"), then added to the tool.

Diversity of Wetland Types

RE Type Area was determined as described in **RE Types** section, above, and by performing the following calculations in Excel.

Diversity of Wetland Types was calculated using a derivative of Simpson's Rule. Each RE Area was squared to give a P_i^2 value. The sum of P_i^2 for each aggregation (sum of RE area) was calculated (excluding the non-remnant vegetation classes ***clear***, ***dist***, ***plant***, ***hoop***, ***sand*** and ***ocean*** from the Excel SUMIF function). This value was then subtracted from 1 to give a diversity value. As diversity for the aggregation is expressed as the inverse of the sum of the P_i^2 values for the REs in an Aggregation, the greater the number of low P_i^2 values (representing smaller proportional areas) for the Aggregation, the higher the Diversity.

The resulting value was then multiplied by the number of Wetland Types (WT), (see **RE Types** section, above) for each aggregation to give a final Diversity value.

[Aggregation Diversity of Wetland Types = $(1 - \sum P_i^2) \times \sum WT$]

Size

The area of each Wetland Aggregation (see **Wetland Aggregations** section, above) was calculated using the ArcMap calculation function.

Proportion Remnant Vegetation

RE Type Area was determined as described in **RE Types** section, above, and by performing the following calculations in Excel.

The total RE Vegetation area for each aggregation (sum of RE Type Area) was calculated by excluding RE types ***sand*** and ***ocean*** from the Excel SUMIF function.

The total RE Remnant Area for each aggregation (sum of RE Type Area) was calculated by excluding the non-remnant vegetation classes ***clear***, ***plant***, ***hoop***, ***sand*** and ***ocean*** from the Excel SUMIF function. The value for ***dist*** was halved and included in the SUMIF function.

Proportion Remnant Vegetation was then calculated as a percentage (RE Remnant Area / RE Vegetation Area), and added to the tool.

Fishery Habitat Value

RE Type Area was determined as described in the **RE Types** section, above, and by performing the following calculations in Excel.

The total Fishery Habitat Value area for each aggregation (sum of RE Type Area) was calculated by including the RE vegetation classes ***water***, ***ocean*** and ***estuary***, and RE wetland classes ***estuarine***, ***riverine*** and ***lacustrine*** in the Excel SUMIF function.

Fishery Habitat Value was then calculated as a percentage (Fish Habitat Area / Wetland Aggregation Area), and added to the tool.

Detention / Retention

RE Type Area was determined as described in **RE Types** section, above, and by performing the following calculations in Excel.

The total RE Wetland Area for each aggregation (sum of RE Type Area) was calculated by summarising (Excel command SUMIF) on wetland classes, ***estuarine***, ***riverine***, ***lacustrine***, ***palustrine*** and ***floodplain***.

A “select by location” query was performed to select catchments that intersect with the Wetland Aggregation layer. A new layer was created from the selected features. The new layer was intersected with the Wetland Aggregation layer in order to assign Wetland Aggregation ID numbers to each catchment. Area was recalculated, and the data summarised (Sum of Area) by Wetland Aggregation ID to give Catchment Area for each Wetland Aggregation.

Detention / Retention was calculated as a percentage (RE Wetland Area / Aggregation Catchment Area), and added to the tool.

Population Density & Social Indicators

SEIFA Population and Indicator data was exported from the SEIFA database (csv file export).

In ArcMap, Population and Indicator fields were added to the Catchment Districts (CD) attribute table. The dbf table was exported to Excel and joined to the Population and Indicator data (Landholder Disadvantage, Education and Economic Resources) using a vlookup based on the CD Code. The CD table was updated with the new values for Population and Indicators.

In ArcMap, an intersection was performed between the updated CD layer and Wetland Aggregation layer, creating a new layer. Area was recalculated for each polygon in the new layer, and then Density calculated as Population / Area (m^2).

The data was then summarised (on Aggregation) to give average Population Density and Indicator data (Landholder Disadvantage, Education and Economic Resources) for each Aggregation, and added to the tool.

Population Growth

In ArcMap, a Population Growth field was added to the QLD Statistical Local Area (SLA) attribute table. The dbf table was exported to Excel and joined to the 'Qld SLA Projected Totals' Excel file (containing population growth data expressed as (2022 - 2005) / 2005) using a vlookup based on the SLA Code. The original SLA dbf table was then updated with the new values for Population Growth.

In ArcMap, an intersection was performed between the updated CD layer and Wetland Aggregation layer, creating a new layer. Area was recalculated for each polygon in the new layer.

The data was then summarised (on Aggregation) to give average Population Growth data for each Aggregation, and added to the tool.

Catchment Land-Use Intensity

In ArcMap, Intensive Landuse was defined by using the Landuse types ***Intensive uses***, ***Production from dryland agriculture and plantations*** and ***Production from irrigated agriculture and plantations*** from the 1999 Landuse data (Queensland Land Use Mapping Program).

An intersection was performed between Intensive Landuse and the Catchment layer. The Area was recalculated, and the data summarised (Sum of Area) by Catchment ID. This data was then joined to the Wetland Catchment layer in order to link the Landuse Area with a Wetland Aggregation ID number. The data was the summarised (Sum of Area), to give LandUse Area and Aggregation Catchment Area.

Catchment Land-Use Intensity in each aggregation was expressed as a percentage (Land Use Area / Aggregation Catchment Area), and added to the tool.

Aquatic Habitat Connectivity Restriction

Dams and Water Storages point data (Geoscience Australia) was buffered at 10km.

A spatial join was performed between the Wetland Aggregation layer and the buffered Dam data to calculate the number of Dams per Wetland Aggregation, with the result added to the tool.

Point-source Pollution Risk

A spatial join was performed between the derived Wetland Catchment layer (see **Catchment Land-Use Intensity** section, above) and National Pollution Inventory point data (EPA). The data was summarised by Catchment and then by Wetland Aggregation to give a count of Pollution Points within the Catchments that intersect with an Aggregation. This result, i.e. number of pollution points per Catchment per Aggregation, was added to the tool.

Hydrological Change

In GIS, the Irrigated Landuse type ***Production from irrigated agriculture and plantations*** was selected from the 1999 Landuse data (Queensland Land Use Mapping Program).

An intersection was performed between selected Irrigated Landuse (above) and the derived Wetland Catchment layer (see **Catchments** section, above). The Area was recalculated, and the data summarised (Sum of Area) by Catchment ID. This data was then joined on the Catchment ID to the Wetland Catchment layer in order to link the Irrigated Landuse Area with a Wetland Aggregation ID number. The data was then summarised (Sum of Area on Aggregation ID), to give Irrigated LandUse Area and Aggregation Catchment Area.

Hydrological Change in each aggregation was calculated as a percentage (Irrigated LandUse Area / Aggregation Catchment Area), and added to the tool.

Indigenous Land Areas

The NTD polygons were merged with the ILUA polygons (both datasets from the National Native Title Tribunal Geospatial Analysis & Mapping Branch) to give a single Native Title layer.

The Native Title layer was intersected with the Wetland Aggregation layer (see **Wetland Aggregations** section, above), and area of the resulting polygons was recalculated. The Area was then summarised on Wetland Aggregation ID (Sum of Area), to give the Native Title Area per Wetland Aggregation, and the result added to the tool.

Protected Areas

The CAPAD layer was dissolved to remove overlapping polygons. The resulting layer represents all protected areas.

The Protected Areas layer was intersected with the Wetland Aggregation layer (see **Wetland Aggregations** section, above), and area of the resulting polygons was recalculated. The Area was then summarised on Wetland Aggregation ID (Sum of Area), to give the area of Protected Areas per Wetland Aggregation, and the result added to the tool.

Appendix 4: Primary DSS Criteria Definitions and Analysis

The following criteria descriptions briefly explain the concepts behind each criterion and the analysis carried out to measure them. They have also been arranged into 'value', 'threat' and 'capacity' categories to group criteria that are related to inherent values that may be attributed to particular wetland aggregations, various sources of threats to wetlands, general wetland values and community capacity for wetland aggregation conservation.

Values Criteria

Vegetation Representativeness

The Representativeness criterion is widely used in the evaluation of candidate areas for biodiversity conservation where the selection of areas that contribute to the full 'representation' of available biotic diversity within reserves is a key tenet of a *Comprehensive, Adequate and Representative* (CAR) protected area network.

The representativeness value of an area is often calculated by comparing the current regional extent of contained vegetation types, or in Queensland's case Regional Ecosystem (RE) types, against their estimated pre-European extent. Regional ecosystems that have been preferentially lost to development are more poorly 'represented' in the post-development landscape and therefore have a greater 'representativeness' value.

Legislation such as Queensland's *Vegetation Management Act, 1999*, often specify policy triggers once the proportion remaining of a given regional ecosystem type falls below a certain percentage (e.g. 30% - 'of concern', 10% - 'endangered'). All RE's, not just wetland associated RE's have been considered for this criterion as terrestrial habitat types within a wetland matrix still contribute to the ecological functional and conservation values of the wetland.

Because the DSS is not a legislative instrument, the actual proportions of pre-European RE extent to current estimated extent remaining is used, in order to retain as much detail in the data as possible. For example, an RE type that has 90% of its pre-1750 extent remaining and an RE type that has 45% of its pre-1750 extent remaining would both be considered "not of concern" under the *Vegetation Management Act*, but in the DSS, inclusion of a RE type with 45% would be considered to contribute more to the representativeness value of a wetland than the RE type with 90% remaining.

The value for this criterion was determined by calculating the ratio of pre-European regional extent to current extent for each RE within a wetland, multiplying these values by the proportional area of each RE's within the aggregation and summing the products.

Diversity of Wetland Types

This criterion examines the diversity of wetland types within a given wetland aggregation. Diversity of wetland types is important as it contributes to the overall biodiversity in the wetland aggregation and the associated provision of a greater range of ecosystem services by the wetland. Two levels of wetland type classification have been utilised in the determination of criterion values: Wetland associated regional ecosystems (REs) and wetland classes (Blackman *et al.,* 1999).

Wetland associated regional ecosystems (REs) are available as a mapped coverage produced by the Qld Herbarium and are essentially regional vegetation types that occur within a wetland landform setting. Wetland landforms occur within a broader set of wetland classes (Blackman *et al.*, 1999) i.e. floodplain, estuarine, riverine, palustarine and lacustarine. The number of wetland associated REs within a wetland aggregation is an obvious measure of its diversity. A large number of different regional vegetation types may occur within a single wetland class i.e. a floodplain. However, we are also interested in the diversity of wetland classes within an aggregation. To integrate both elements of wetland diversity and the diversity of wetland types, this criterion was calculated by determining the diversity of wetland RE types using Simpson's Index of diversity and multiplying this by the number of wetland classes.

Aggregation Area

This criterion measures the land area taken up by the aggregation. An aggregation with a greater area may be considered to have a higher value than a smaller area aggregation as larger areas provide habitat for larger sized populations of biota, incorporate greater diversity of habitat types and associated biodiversity and generate larger magnitude impacts in terms of supplied environmental services.

The values for this criterion were determined by simply calculating the area of each aggregation.

Proportion Remnant Vegetation

This criterion measures the proportion of intact remnant vegetation to cleared land, agriculture and non-native forestry. An aggregation with a greater proportion of cleared land is likely to be in poorer ecological condition and have lower biodiversity and water-quality values than an aggregation that has more native vegetation. The values for this criterion were calculated from the Queensland RE mapping.

The values for this criterion were determined by calculating the proportion of the total wetland aggregation area comprised of RE's categorised as 'remnant' (assigned an RE code). RE's with a classification of 'cleared', 'planted' or 'hoop' (for Hoop Pine plantations) were not included in the assessment of remnant vegetation areas. Areas classified as disturbed were also included in the remnant vegetation calculations, however, the resulting score was divided by two so as to give less weight to these areas.

Fishery habitat value

This criterion provides a coarse measure of the potential value of a wetland aggregation as fish habitat. Wetland classes attributed to wetland associated regional ecosystems mapped by the Queensland Herbarium provide the data for calculating the proportional area comprised of higher value fish habitat wetland classes within an aggregation. Of the range of potential wetland classes that might comprise a wetland aggregation i.e. estuarine, riverine, lacustrine, palustrine and floodplain, the former three will in most instances have greater habitat value to fish than the latter two, although they may have some seasonal importance. Non remnant regional ecosystem areas defined as open water also constitute fish habitat. The fish habitat value criterion is expressed as the total area (ha) of a wetland aggregation comprised of open water and wetland associated REs classed as estuarine, riverine, or lacustrine.

Detention / Retention

This criterion attempts to measure one of the most valued functional values of wetlands which is their ability to improve the quality of water that passes through them to downstream aquatic ecosystems, which in the case of the eastern river basins of Queensland includes the Great Barrier Reef Lagoon. The detention/retention criterion refers to the capacity of a wetland aggregation to 'detain' catchment run off flows and 'retain' associated nutrient and sediment loads. Although there is considerable variability in the operation of this function associated with inflow volumes, rates of run off, vegetation cover and topographic relationships between the wetland and its supplying catchment, the ratio of supplying catchment to receiving wetland area provides a coarse measure of this functional ability that can be derived from currently available data.

The values for this criterion were determined by calculating the proportional area of wetland (as defined by the EPA's Wetland Inventory) within each contributing catchment draining to or within a wetland aggregation. Ratio values obtained for each contributing catchment were weighted by their area and summed to provide a total aggregation functional value.

Threats Criteria

Population Density

Aggregations that have a high population density often results in higher demand for water resources and pressure on wetlands in terms of opportunity costs and overuse as a resource.

The values for this criterion were calculated from ABS population data within CDs (Census Collection Districts). Where an aggregation extended into multiple CD's the average population density was calculated.

Population Growth

High levels of population growth put increased pressure on wetland areas. Population growth usually means increased development and built infrastructure and can also lead to reductions in water quality and land degradation.

The values for this criterion were determined from the *Populations Projections 2002 – 2021* spatial dataset which was based on data from the 2001 National Census. The population within each Census Collection District (CCD) within the aggregation area was averaged to estimate the population growth.

Catchment Land-use Intensity

More intensive patterns of land use are recognised as posing a threat to catchment processes and downstream ecosystems through the generation of altered rates of run off, modified landscape water balance and elevated contaminant loads particularly sediments and nutrients associated with land use practices (NLWRA 2002). In the case of the most intensive forms of land use i.e. urban, industrial, mining, intensive agriculture, contaminant loads can also include chemicals, hydrocarbons and metals.

The intensity of land use within a wetland aggregation's contributing catchment is therefore a very powerful surrogate measure of the catchment based threats a wetland is exposed to and a predictor of its ecological condition.

To measure this criterion the primary land use classes produced by the Queensland Land Use Mapping Project (QLUMP) were allocated to two broad classes.

Intensive - including:

Intensive uses;

Production from dryland agriculture and plantations; and

Production from irrigated agriculture and plantations.

Extensive / Non-Intensive including:

Conservation and natural environments;

Production from relatively natural environments; and

Water.

The values for this criterion were determined by calculating the proportional area of intensive land use within each contributing catchment draining to or within a wetland aggregation. Ratio values obtained for each contributing catchment were weighted by their area and summed to provide a total wetland aggregation land use intensity value.

Aquatic Habitat Connectivity Restriction

Aquatic habitat connectivity within and between coastal wetlands and the marine environment is essential for the maintenance of aquatic biodiversity and fisheries productivity values. The construction of artificial structures such as dams, barrages, weirs and bunded levees impacts on the recruitment and movement of biota to and within wetlands and the maintenance of their salinity and hydrological characteristics. Up to 30% of the freshwater fish community found in tropical Australia has some estuarine life cycle dependency and seasonal hydrology and salinity regimes are essential for the maintenance of most macrophyte communities found in coastal Queensland wetlands. Although the presence of these impacts can only be verified by field investigation, the presence of structures that sever aquatic habitat connectivity within or downstream of a wetland aggregation is a useful coarse measure of potential aquatic habitat connectivity impacts. The values for this criterion have been calculated by counting the number of recorded dams and weirs within 10 km of the wetland aggregation.

Point-source Pollution Risk

Pollution point-sources within a wetland aggregation or its contributing catchment present water quality risks associated with nutrient loading and toxicity associated with other contaminants such as chemicals or metals. While specific information on the nature of points source pollution in terms of its potential for impacts on wetlands is not readily available, the assumption that wetlands are exposed to greater point source pollution risks where there are greater numbers of pollution point sources discharging to them has been considered sufficiently robust to generate a risk index criterion.

Point-source pollution risk was calculated by determining the number of point-source pollution locations recorded within the *National Pollution Inventory* dataset, within the contributing catchments of each aggregation.

Hydrological Change (Irrigation)

Hydrological changes to wetlands include changes in the timing and volume of supplied flows, surface and groundwater extraction, groundwater rise, bunding and impounding of outflow channels and exclusion of tidal influences. Detailed data concerning this range of potential hydrological impacts is not generally available for wetland aggregations, though may be available for more well studied individual wetland sites.

In Australia the largest single driver for hydrological change in river basins and associated wetlands is irrigated agriculture, which generates Australia's largest single consumptive use of water resources (NLWRA 2001). In attempting to identify useful surrogate measures of the potential hydrological changes within a wetland aggregation and its contributing catchments, the proportion of irrigated agriculture landuse within the wetland and its contributing catchments provides a coarse indicator related to the presence of upstream structures required for irrigation, surface and groundwater consumptive use, regulated flows and tailwater volumes.

This criterion was calculated by determining the proportional area of irrigated agriculture land uses mapped by QLUMP in each contributing catchment of the aggregation.

Capacity Criteria

Socio-economic Disadvantage

This criterion is derived from the Australian Bureau of Statistics (ABS) Socio-economic Indices for Areas (SEIFA) derived from the 2001 Census of Population and Housing. The SEIFA indices are derived form a variety of social and economic variables.

The Index of Socio-economic disadvantage is derived from variables such as low income, low educational attainment, high unemployment and jobs in relatively unskilled occupations. A high score for this criterion indicates a low level of disadvantage while a low score indicates a high level of disadvantage. Highly disadvantaged areas are likely to have less capacity to conserve wetland aggregations.

This criterion was calculated by averaging the index values assigned to each Collection District (CD) within the aggregation area.

Education and Occupation

This criterion is derived from the Australian Bureau of Statistics (ABS) Socio-economic Indices for Areas (SEIFA) derived from the 2001 Census of Population and Housing. The SEIFA indices are derived form a variety of social and economic variables.

The Index of education and occupation considers the proportion of people with a higher qualification or employment in a skilled occupation. Urban CDs generally have higher scores on the index than rural, implicitly reflecting the greater availability of jobs with higher incomes, houses with higher price margins and larger houses. Areas with high scores for this criterion are likely to have greater capacity for wetland conservation.

This criterion was calculated by averaging the index values assigned to each Collection District (CD) within the aggregation area.

Economic Resources

This criterion is derived from the Australian Bureau of Statistics (ABS) Socio-economic Indices for Areas (SEIFA) derived from the 2001 Census of Population and Housing. The SEIFA indices are derived form a variety of social and economic variables.

The Index of Economic Resources is based on variables relating to income expenditure and the assets of families, such as family income, rent paid, mortgage repayment and dwelling size. Areas that have greater economic resources are likely to have higher capacity for wetland conservation.

This criterion was calculated by averaging the index values assigned to each Collection District (CD) within the aggregation area.

Indigenous Land Areas

This criterion refers to areas under Native Title or Indigenous Land Use Agreement (ILUA) Areas. This criterion reflects indigenous capacity to conserve wetlands and the likelihood of sympathetic land-uses in these areas.

This criterion was calculated by determining the proportion of the aggregation that is a Registered Native Title area or ILUA area.

Protected Areas

Protected areas (e.g. National Parks, Nature Reserves, etc) are areas that have been set-aside primarily for conservation. There is therefore a very high likelihood that wetlands in these areas are actively conserved and retained in their natural state as far as is possible.

This criterion was calculated from the Collaborative Australian Protected Areas Database (CAPAD). The criteria values were derived by calculating the proportion of the aggregation that is within a protected area.

Appendix 5: Secondary DSS Criteria Definitions and Analysis

The following describes the criteria contained within the secondary DSS. These criteria were defined by a series of expert panel workshops and were selected based on the following requirements:

- Relevance – must relate to DSS objectives;
- Independence – criteria should not be affected by the results of other criteria;
- Measurability – criteria must be able to be measured; and
- Appropriate scale – criteria are relevant to the DSS scale (regional, local).

Criteria are measured either through GIS or local / expert knowledge. The criteria for the Primary Scale DSS were measured entirely using GIS analysis as the number of alternatives (wetland aggregations) and the extent of the study area meant that criteria scoring through the expert panel process was not feasible. Very few (if any) people have the intimate knowledge of all wetland aggregations in the GBR Catchment needed to score the criteria at this level.

For scoring criteria at the secondary DSS level it is a different story. At this scale the resolution of GIS data is generally fairly poor, whereas there are usually people who have a good knowledge of the individual wetlands within the aggregation. The criteria at this level are therefore generally scored using local and expert knowledge, with the exception of three criteria: *Size, Land Use Intensity* and *Vegetation Representativeness* which are scored using GIS.

Criteria scored by local / expert knowledge use a scale from 0-10. Four of the values (10, 7, 3 and 0) are defined, although panel members can choose any value between 0 and 10. A definition of each criterion is also given.

Criteria have been broken up into *Value, Threat* and *Capacity* categories:

- *Value* criteria attempt to measure the inherent values possessed by each wetland;
- *Threat* criteria attempt to measure the threats to wetland values as a whole; and
- *Capacity* criteria attempt to measure the capacity of the community to undertake wetland conservation activities.

These categories help with scoring the criteria by grouping them together. It also allows the DSS to be changed according to different specific management objectives or activities by assigning different weights to the categories as well as providing the ability to change a category from a ‘benefit’ to ‘cost’.

Values Criteria

Recreational Value

This criterion describes the importance of the wetland as a site and resource base for supporting nature based outdoor recreation.

Value	Description	Score
High	Wetland is readily accessible to the public and is a well known and popular nature-based recreation destination with high levels of use. The wetland is managed primarily for nature-based recreation and there are a number of recreational facilities available.	10
Medium	The wetland is a locally popular destination for nature-based recreation and/or it has a very high unrealised potential for nature based recreation. Management of the wetland considers its recreational value though there may be more important management considerations (e.g. conservation, commercial fishing, etc) and broader public knowledge of, or access to, the wetland may be limited.	7
Low	The wetland has some limited existing or unrealised recreational value. The area is not managed for recreation has limited public access and a change in management regime would be required to realise its full recreational potential.	3
None	The area is not accessible to the general public and has no existing or potential recreational values due to existing access or tenure limitations.	0

Indigenous Value

This criterion attempts to provide a relative indicative measure of the importance ascribed to the site by Traditional Owners in terms of cultural values associated with totemic or sacred affiliations, hunting or gathering resource values or sites of historical significance.

Value	Description	Score
High	The wetland is a site of major cultural significance or forms part of a site of major cultural significance.	10
Medium	The wetland is a site of cultural significance or forms part of a site of cultural significance.	7
Low	The wetland has some cultural significance but is not a specifically recognised site.	3
None	The wetland is not considered culturally important by traditional Owners of the area	0

Fisheries Habitat

This criterion measures the relative importance of a site regionally in terms of providing nursery or adult habitat for populations of commercially and/or recreationally important fish species.

Value	Description	Score
High	The wetland represents a regionally significant area of high quality fish habitat permanently or seasonally populated by commercially and/or recreationally important fish species.	10
Medium	The wetland contains locally important areas of suitable fish habitat permanently or seasonally populated by commercially and/or recreationally important fish species.	7
Low	The wetland has ecosystem impacts affecting the quality of its fish habitat values or contains only limited areas of suitable fish habitat permanently or seasonally populated by commercially and/or recreationally important fish species .	3
None	The wetland does not contain habitat suitable for commercially and/or recreationally important fish species or suitable habitat present is not accessible to fish populations due to ecosystem impacts.	0

Assimilative Capacity for nutrients and sediments.

This criterion measures the wetland's ability to improve the quality of water passing through to downstream aquatic ecosystems which, in the case of the eastern river basins of Queensland, includes the Great Barrier Reef Lagoon. This criterion refers to the capacity of a wetland to 'detain' catchment run off flows and 'retain' associated nutrient and sediment loads.

Value	Description	Score
High	The wetland detains sub-catchment scale (or greater) run-off and retains sediment and nutrient loads delivering apparent water quality benefits to downstream ecosystems.	10
Medium	The wetland provides some detention of sub-catchment or local catchment scale run-off and retains sediment and nutrient loads delivering likely water quality benefits to downstream ecosystems.	7
Low	The wetland provides very limited detention of sub-catchment scale run-off or only detains run-off from very small scale catchments providing very limited impact on sediment and nutrient loads delivered to downstream ecosystems.	3
None	The wetland does not detain catchment run-off and/or retained sediment and nutrient loads are too insignificant to deliver measurable water quality benefits to downstream ecosystems.	0

Populations of Rare or Threatened Taxa.

This criterion identifies the relative value of the site for supporting regionally significant populations of rare or threatened flora or fauna listed under State or Commonwealth legislation. Specific species need to be cited by the expert panel to help validate the attributed score.

Value	Description	Score
High	The wetland forms part of the recorded habitat of a regionally significant population of one or more Rare & Threatened species listed under State / Commonwealth legislation.	10
Medium	The wetland is the recorded or confidently predicted habitat of one or more Rare and Threatened species listed under State / Commonwealth legislation however population size is not regionally significant	7
Low	The wetland may provide suitable habitat for at least one Rare and Threatened species listed under State / Commonwealth legislation however its presence has not been confirmed.	3
None	The wetland is not known or predicted to provide suitable habitat for Rare And Threatened species listed under State / Commonwealth legislation.	0

Vegetation Representativeness

The *Vegetation Representativeness* criterion is widely used in the evaluation of candidate areas for biodiversity conservation where the selection of areas that contribute to the full ‘representation’ of available biotic diversity within reserves. This is calculated by comparing the current regional extent of retained Regional Ecosystem (RE) types, against their estimated pre-European extent.

The value for this criterion is determined using GIS by calculating the ratio of pre-European extent to current extent for each RE within a wetland, multiplying these values by the proportional area of each RE’s and summing the products. Because the DSS is not a legislative instrument, the actual proportions of pre-European RE extent to current estimated extent remaining is used rather than arbitrary cut-off values in order to retain as much detail in the data as possible.

Wetland Representativeness

This criterion seeks to capture any ‘representativeness’ value the wetland site has within the region in terms of ‘representing’ a wetland type that has biophysical features or functions largely lost from the 'post-development landscape' due to impacts associated with landscape development and modification. Examples include wetlands typical of landforms highly suitable for, and largely converted to, agriculture. The specific representative features of the wetland need to be cited by the expert panel to help validate the attributed score.

Value	Description	Score
High	The wetland is the best and/or last representative example in the region of a wetland type that has biophysical features or functions which have been historically lost to landscape development and modification.	10
Medium	The wetland is one of a few representative examples in the region of a wetland type that has biophysical features or functions which have been significantly impacted by historical landscape development and modification.	7
Low	The wetland is representative of a wetland type that although still relatively common, has biophysical features or functions which have some level of reduced representation in the post-development landscape.	3
None	The wetland is type that has biophysical features or functions that still have a high level of representation in the post-development landscape.	0

Species Richness / Diversity.

From a biodiversity conservation perspective, wetland sites that support a greater number/diversity of species of any particular faunal or floral group (taxa) have higher value for meeting biodiversity conservation objectives. This criterion seeks to attribute a regionally relative score to wetland sites based on the recognised presence of higher levels of species diversity for one or more taxa. The specific taxa with diverse species representation at the wetland need to be cited by the expert panel to help validate the attributed score.

Value	Description	Score
High	The wetland is known to have regionally high levels of species diversity for more than one major taxa including fish, birds, vascular plants.	10
Medium	The wetland is known to have regionally high levels of species diversity for one major taxa including fish, birds, vascular plants or locally higher levels of species diversity for more than one taxa.	7
Low	The wetland is known or predicted to have locally higher levels of species diversity for one major taxa including fish, birds, vascular plants.	3
None	The wetland is not known or predicted to have locally higher levels of species diversity for major taxa including fish, birds, vascular plants.	0

Size

This criterion measures the total area of the wetland. A wetland with a greater area may generally be considered to have a higher value than a smaller area wetland as larger areas usually provide habitat for larger sized populations of biota, incorporate greater diversity of habitat types and associated biodiversity and generate larger magnitude impacts in terms of supplied environmental services. The values for this criterion are determined using GIS by calculating the area of each defined wetland site.

Waterbird Habitat Value

The habitat value of wetlands to waterbirds is a key element in their contribution to regional biodiversity. This criterion provides an assessment of the waterbird habitat value of a wetland by reference to both the quality of waterbird habitat at the site and the significance of populations supported by it. Note that significant populations may only occur seasonally at the site. The specific waterbird species or groups which populate the wetland need to be cited by the expert panel to help validate the scores greater than ‘low’.

Value	Description	Score
High	The wetland contains good - high quality waterbird habitat and supports nationally or internationally significant populations of waterbirds (i.e. thousands to tens of thousands of birds or 1% of the individuals in a population of one species or subspecies of waterbird or >25% of regional waterbird population).	10
Medium	The wetland contains medium - good quality waterbird habitat and supports regionally important populations (i.e. hundreds - thousands of waterbirds or 0.5% of the individuals in a population of one species or subspecies of waterbird or >10% of regional population.	7
Low	The wetland contains poor – medium quality waterbird habitat and supports regionally small populations of waterbirds (tens to a hundred or less than 10% of regional population)	3
None	The wetland contains poor waterbird habitat and hosts at most only small populations of waterbirds (less than ten).	0

Wetland Condition

This criterion is a measure of the ecological condition of the wetland (considering floristic, faunal, hydrological and geomorphological character) relative to its ‘pristine’ state defined in terms of pre-European development conditions and the level of management inputs required to restore it to a better ecological condition.

Value	Description	Score
High	The wetland is considered to be in ‘near pristine’ condition in terms of its floristic, faunal, hydrological and geomorphological character being little changed from pre-European settlement conditions.	10
Medium	The wetland is considered to be in ‘near natural’ condition though has some apparent changes in terms of its floristic, faunal, hydrological and geomorphological character from pre-European settlement conditions.	7
Low	The wetland is considered to be in a ‘modified’ condition with highly apparent changes to many of its floristic, faunal, hydrological and geomorphological characteristics from pre-European settlement conditions.	3
None	The wetland is considered to be in a ‘completely modified’ condition with its floristic, faunal, hydrological and geomorphological characteristics having little resemblance to pre-European settlement conditions.	0

Threats Criteria

Fish Passage Connectivity Restriction

Aquatic habitat connectivity within and between coastal wetlands and the marine environment is essential for the maintenance of aquatic biodiversity and fisheries productivity values. The construction of artificial structures such as dams, barrages, weirs and bunded levees impacts on the recruitment and movement of biota to and within wetlands and the maintenance of their salinity and hydrological characteristics. Up to 30% of the freshwater fish community found in tropical Australia has some estuarine life cycle dependency. This criterion attempts to quantify the level of downstream connectivity as it relates to fish species.

Value	Description	Score
High	No fish passage between downstream estuarine habitats and wetland exists due to the presence of structures (e.g. dams, weirs, bunds) or catchment conditions (i.e. weeds) impeding all (particularly upstream) movement.	10
Medium	Fish passage between downstream estuarine habitats and wetland affected by structures or catchment conditions and only present during peak flow events i.e. less than 20% of estimated pre-European settlement duration per annum	7
Low	Fish passage between downstream estuarine habitats and wetland affected by structures or catchment conditions but exists for most flow conditions (i.e. 20 - 90% of estimated pre-European settlement duration per annum).	3
None	Fish passage between downstream estuarine habitats and wetland exists for 90-100% of estimated pre-European settlement duration per annum	0

Land Use Intensity

More intensive patterns of land use are recognised as posing a threat to catchment processes and downstream ecosystems through the generation of altered rates of run off, modified landscape water balance and elevated contaminant loads particularly sediments and nutrients associated with land use practices (NLWRA 2002). In the case of the most intensive forms of land use i.e. urban, industrial, mining, intensive agriculture, contaminant loads can also include chemicals, hydrocarbons and metals.

To measure this criterion the primary land use classes produced by the Queensland Land Use Mapping Project (QLUMP) were allocated to two broad classes.

Intensive - including:
Intensive uses;
Production from dryland agriculture and plantations; and
Production from irrigated agriculture and plantations.

Extensive / Non-Intensive including:
Conservation and natural environments;
Production from relatively natural environments; and
Water.

The values for this criterion were determined by calculating the proportion of intensive land-use within the wetland's contributing catchment.

Land Use Intensification

This criteria attempts to capture the relative threat posed to the wetland by actual or potential intensification of land use within its immediate vicinity (1km proximity buffer) or contributing catchment. Land use intensification is defined as any shift toward more extensive patterns of intensive land use including industrial, urban or agricultural cropping uses.

Value	Description	Score
High	Wetland site zoning allows for intensive land-use (urban, industrial, cropping agriculture) on or adjacent to (<0.5 km from wetland perimeter) the wetland or within its contributing catchment and land use intensification capable of affecting the wetland is currently occurring at the site or within its contributing catchment or in close proximity to it (<0.5 km).	10
Medium	Wetland site zoning allows for intensive land-use (urban, industrial, cropping agriculture) on or adjacent to it (within approx 0.5 km of wetland perimeter) or within its contributing catchment and land use intensification capable of affecting the wetland is likely or proposed in the medium term ~ 5yrs.	7
Low	Development potential limited. Intensive land-use (urban, industrial, cropping agriculture) development adjacent to or within approx 0.5 km of wetland perimeter or close enough within its contributing catchment to affect it could only occur with changes to current Shire zoning or, if current plan does allow for such development, opportunities for it actually occurring are very limited.	3
None	No development potential. Wetland site and at least 0.5 km buffer is a protected area or sits within natural resources protection precinct (or equivalent) in Shire plan which does not allow for intensive land-use (urban, industrial, cropping agriculture) within 0.5 km of wetland perimeter **or** proximally located (sufficient to cause impacts) within contributing catchment.	0

Weed Invasion

Invasive weeds are one of the key threats impacting upon the values of both instream aquatic and riparian terrestrial habitats of wetlands within the GBR catchment with consequent impacts to biodiversity, environmental quality, biophysical processes and ecosystem health. This criterion provides a relative qualitative measure of the severity of threat posed to the wetland by existing weed infestations.

Value	Description	Score
High	Major infestation (dominant cover) of invasive weeds within both terrestrial riparian and aquatic habitats with major directly attributable ecosystem impacts being realised.	10
Medium	Major infestation (dominant cover) of invasive weeds within either terrestrial riparian or aquatic habitats or medium infestation in both with measurable ecosystem impacts being realised.	7
Low	Sub-dominant occurrences of invasive weeds within either terrestrial riparian or aquatic habitats with minor ecosystem impacts.	3
None	No apparent weed infestation management issues associated with aquatic or terrestrial riparian habitats.	0

Water Quality

Water quality within wetlands varies enormously naturally. However, catchment or site based impacts on water quality regimes beyond natural variability present the greatest threat to ecosystem health in terms of water quality impacts. This criterion attempts to define the relative risk of the threat posed by water quality to the wetland in terms of chronic, sustained, periodic or no water quality issues affecting ecosystem health.

Value	Description	Score
High	Water quality at the suite is chronically impacted by site conditions or catchment inputs and ambient water quality conditions maintain an unhealthy ecosystem.	10
Medium	Water quality at the wetland is poor in terms of sustained impacts associated with site conditions or catchment inputs and some ambient parameters remain below levels required for maintenance of ecosystem health.	7
Low	Water quality at the wetland is sub-optimal in terms of periodic or seasonal impacts associated with site conditions or catchment inputs with some ambient parameters periodically falling below levels required for maintenance of ecosystem health.	3
None	No water quality issues are known / recognised for the wetland and water quality supports the maintenance of ecosystem health.	0

Point Source Pollution

Pollution point-sources (e.g. sewage treatment plant, intensive animal production facility of sugar mill / heavy industry discharges) within a wetland or upstream of a wetland present water quality risks due to nutrient loading and toxicity associated with other contaminants such as chemicals or metals. This criterion provides a measure of the relative threat posed by point source discharges to the wetland in terms of number of sources, their proximity and apparent associated impact.

Value	Description	Score
High	One or more proximal pollution point source or more than one non-proximal pollution point source located upstream of the wetland with attributable water quality impacts being realised.	10
Medium	A single proximal pollution point source or more than one non-proximal pollution point source located upstream of the wetland with some apparent and attributable water quality impacts being realised.	7
Low	Proximal or non-proximal upstream pollution point sources present but no apparent attributable impacts being realised.	3
None	No known upstream pollution point sources or attributable impacts	0

Hydrological Change

The ecological character of wetlands is largely determined by the hydrological regime that supplies water to them and governs its behaviour within them. Changes to hydrology therefore represent one of the most significant threats confronting wetlands. Hydrological changes to wetlands include changes in the timing and volume of supplied flows, alterations to the heights, fluctuations or recession rates of groundwater levels affected by surface and groundwater extraction or changed recharge rates, bunding and impounding of outflow channels and exclusion of tidal influences. This criterion attempts to capture a relative measure of hydrological change at the wetland based on the magnitude and irreversibility of existing changes at the site.

Value	Description	Score
High	The majority of the habitat characteristics of the wetland are highly modified by hydrological changes within its catchment or on site (i.e. regulated flow regime, impounding, draining, tidal exclusion, changes in groundwater level, seawater intrusion)	10
Medium	Some habitat characteristics of the wetland are modified by hydrological changes within its catchment or on site (i.e. regulated flow regime, impounding, draining, tidal exclusion, changes in groundwater level, seawater intrusion).	7
Low	Habitat characteristics of wetland affected by non-permanent hydrological changes within catchment or on site.	3
None	Habitat conditions of wetland not apparently affected by hydrological changes within catchment or on site.	0

Capacity Criteria

Level of Protection

The extent to which a wetland has been protected by statutory or binding management arrangements is usually indicative of the importance prescribed to the maintenance of its values by government and other stakeholders. Past investments in the protection of a wetland's values by government and other stakeholders usually translates into a greater readiness by same to support ongoing measures to maintain such 'protected' wetland values and therefore provides a measure of capacity for delivering further protective management at the site. This criterion provides a relative measure of such capacity based on the existing level of protection.

Value	Description	Score
High	Wetland forms part of or is adjacent to a protected area under Commonwealth / State legislation and is also covered by one or more international / Commonwealth /State wetland treaty obligations (e.g. Ramsar, JAMBA, CAMBA, World Heritage Area)	10
Medium	Wetland is not part of or adjacent to a formally protected area but occurs on Public tenure land (Council Reserve) and is covered by local Shire plan designations (i.e. Natural Resources Protection Precinct or equivalent) or international / Commonwealth /State treaty obligations (e.g. Ramsar, JAMBA, CAMBA, World Heritage Area) or occurs on private land and is protected by a binding conservation agreement.	7
Low	Wetland occurs on private land and is only 'protected' by non-binding voluntary conservation agreements or similar.	3
None	Wetland not protected by any legislation, treaty obligations, Shire zoning designations or conservation covenants.	0

Financial Incentives

Financial incentives for wetland protection and management provided by government, industry or NRM bodies increase the capacity for delivering wetland management outcomes. This criterion provides a relative measure of such capacity by identifying existing financial incentive schemes and the candidacy of individual wetlands.

Value	Description	Score
High	Wetland site / property are part of a financial incentives program for wetland management.	10
Medium	Wetland site / property are viable candidates for (but not yet part of) a financial incentives program for wetland management.	7
Low	Wetland site / property is only a marginal candidate for a financial incentives program for wetland management.	3
None	Financial incentives do not exist or are not applicable to this wetland.	0

Industry Land-use Viability

Studies that have examined the relationship between the viability of rural industries and the capacity and willingness of landholders for delivering NRM outcomes including habitat management initiatives have generally found that the latter is affected by the profitability of local primary industry. In the case of poor profit margins associated with marginally viable industries, landholder capacity for NRM is generally lower. This criterion attempts to measure the relative capacity of landholders for managing wetland sites based on the viability of the industry the landholders are engaged in.

Value	Description	Score
High	Land use within or surrounding wetland dominated by high viable industry with good profit margins that translate into landholders having a good financial capacity for wetland management activities.	10
Medium	Land use within or surrounding wetland largely dominated by viable industry with profit margins that translate into landholders having some financial capacity for wetland management activities.	7
Low	Land use within or surrounding wetland dominated by marginally viable industry with unreliable profit margins that translate into landholders having limited financial capacity for wetland management activities.	3
None	Land use within or surrounding wetland dominated by non-viable industry that translate into landholders having no financial capacity for wetland management activities.	0

Engagement Capacity

One of the most direct contributions to the capacity of individual landholders and regional stakeholders for delivering wetland management outcomes in recent years has been the substantial investment of community based NRM organisations via Regional Investment Strategies (RIS) developed under NHT2 or the Commonwealth's National Action Plan for salinity and water quality. This criterion attempts to measure this capacity based on the extent to which wetlands generally or the wetland site specifically has been identified as a priority for investment by such organisations.

Value	Description	Score
High	Wetland site is specifically identified as a priority area in the RIS of the regional NRM organisation and/or site landholder(s) and NRM organisation have previously been engaged in delivering on-ground wetland management outcomes at site.	10
Medium	Wetland site is consistent with defined priority work themes or areas identified in the RIS of the regional NRM organisation and/or site landholder(s) have previously responded positively to, or pro-actively approached the regional NRM organisation regarding the prospect for on-ground wetland management works at site.	7
Low	The regional NRM organisation has identified wetland management as a priority area within its RIS but the site has not been specifically identified or the site landholders approached in regard to delivering on-ground wetland management works at the site.	3
None	The regional NRM organisation has not specifically identified wetland management as a priority area within its RIS and/or the site landholder is not supportive of on-ground wetland management works at the site.	0

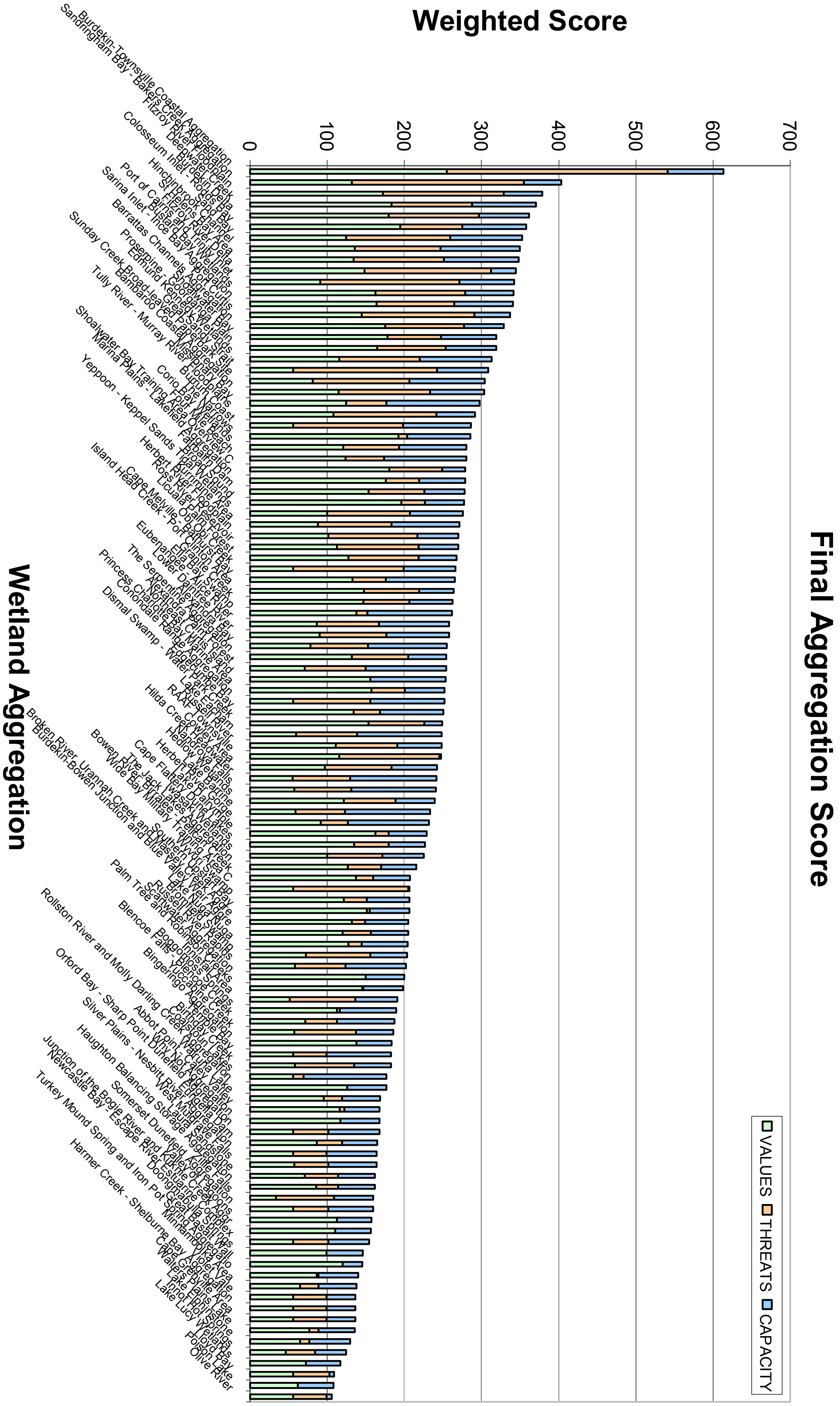
Best Management Practice Feasibility

Best management practice targets for wetland biodiversity and water quality functional values can be usefully and ideally defined in terms of the species populations supported by the wetland and the catchment functions performed by it under pre-European settlement conditions. However, such wetland management targets are often difficult or even impossible to achieve or sustain under current conditions due to catchment development, perennial and pervasive threats (i.e. invasive species) and technical, material, financial and/or human resource and capacity constraints. This criteria attempts to qualitatively assess the feasibility of achieving best management practice in terms of biodiversity and functional value outcomes for a wetland site.

Value	Description	Score
High	Best management practice for wetland biodiversity and water quality functional values can be secured and/or reinstated using available technical, material, financial and human capacity.	10
Medium	Best management practice for wetland biodiversity and water quality functional values can be secured and/or reinstated but require investment of same order of magnitude as existing wetland management programs in technical, material, financial and/or human capacity.	7
Low	Best management practice for wetland biodiversity and water quality functional values cannot be secured and/or reinstated for all values due to insurmountable site constraints /management issues or possibly could be secured and/or reinstated for all values with investment of higher order(s) of magnitude than existing wetland management programs in technical, material, financial and/or human capacity.	3
None	Best management practice for wetland biodiversity and water quality functional values cannot be secured and/or reinstated for any values due to insurmountable site, management issue or capacity constraints.	0

Appendix 6: Prioritised List of Aggregations

Aggregation Ranking Graph



Aggregation Ranking Table

Rank	Sum	Name
1	613.2	Burdekin-Townsville Coastal Aggregation
2	403.0	Sandringham Bay - Bakers Creek Aggregation
3	378.4	Fitzroy River Floodplain
4	370.3	Deepwater Creek
5	362.0	Burdekin Delta
6	357.7	Colosseum Inlet - Rodds Bay
7	352.8	Sand Bay
8	349.5	Hinchinbrook Channel
9	348.1	St Helens Bay Area
10	344.5	Fitzroy River Delta
11	342.2	Port of Cairns and Trinity Inlet
12	341.2	Bustard Bay Wetlands
13	340.5	Sarina Inlet - Ince Bay Aggregation
14	337.3	Port Curtis
15	328.7	Barrattas Channels Aggregation
16	319.4	Shoalwater Bay
17	319.3	Proserpine - Goorganga Plain
18	312.7	Edmund Kennedy Wetlands
19	308.6	Great Sandy Strait
20	304.2	Sunday Creek Broad-leaved Paperbark Site
21	303.0	Bambaroo Coastal Aggregation
22	297.3	Missionary Bay
23	291.4	Tully River - Murray River Floodplains
24	286.0	Burrum Coast
25	285.8	The Narrows
26	280.2	Corio Bay Wetlands
27	280.1	Four Mile Beach
28	279.0	Shoalwater Bay Training Area Overview C
29	278.6	Marina Plains - Lakefield Aggregation
30	278.0	Fairbairn Dam
31	276.9	Broad Sound
32	276.0	Yeppoon - Keppel Sands Tidal Wetlands
33	271.7	Kurrimine Area
34	269.8	Herbert River Floodplain
35	269.8	Ross River Reservoir
36	267.8	Licuala Palm Forest
37	265.9	Obi Obi Creek
38	265.2	Cape Melville - Bathurst Bay
39	263.6	Island Head Creek - Port Clinton Area
40	262.3	Granite Creek
41	261.5	Ella Bay Swamp
42	257.8	Eubenangee - Alice River
43	257.7	Lower Daintree River
44	255.0	Alexandra Bay
45	254.4	The Serpentine Aggregation
46	254.3	Alexandra Palm Forest
47	253.8	Northeast Curtis Island
48	252.4	Princess Charlotte Bay Marine Area
49	251.9	Conondale Range Aggregation
50	250.3	Edgecumbe Bay

Rank	Sum	Name
51	249.0	Dismal Swamp - Water Park Creek
52	248.4	Lake Eacham
53	248.2	Russell River
54	247.6	RAAF Townsville
55	242.0	Cowley Area
56	241.7	Hilda Creek Headwater
57	240.5	Nandroya Falls
58	239.4	Hedlow Wetlands
59	233.7	Lake Barrine
60	231.4	Herbert River Gorge
61	229.0	Lake Dalrymple
62	226.3	Cape Flattery Dune Lakes
63	225.2	Iwasaki Wetlands
64	215.4	The Jack Lakes Aggregation
65	207.4	Bowen River: Birralee - Pelican Creek
66	206.9	Wide Bay Military Training Area C
67	206.9	Wyvuri Swamp
68	206.6	Southern Upstart Bay
69	205.4	Broken River, Urannah Creek and Massey Creek Aggregation
70	204.9	Burdekin-Bowen Junction and Blue Valley Weir Aggregation
71	204.4	Lake Nuga Nuga
72	203.8	Bromfield Swamp
73	201.6	Russell River Rapids
74	199.8	Scartwater Aggregation
75	198.6	Palm Tree and Robinson Creeks
76	190.6	Innisfail Area
77	189.0	Boggomoss Springs
78	187.4	Blencoe Falls - Blencoe Creek
79	185.6	Yuccabine Creek
80	183.8	Bingeringo Aggregation
81	182.9	Temple Bay
82	182.7	Birthday Creek
83	177.2	Coalstoun Lakes
84	176.4	Rollston River and Molly Darling Creek Aggregation
85	168.9	Wairuna Lake
86	168.1	Abbot Point - Caley Valley
87	168.0	Why Not Aggregation
88	167.9	Orford Bay - Sharp Point Dunefield Aggregation
89	164.6	Eungella Dam
90	164.0	Silver Plains - Nesbitt River Aggregation
91	164.0	West Mulgrave Falls
92	161.9	Laura Sandstone
93	161.7	Haughton Balancing Storage Aggregation
94	159.8	Zillie Falls
95	159.3	Somerset Dunefield Aggregation
96	157.4	Valley of Lagoons
97	156.7	Junction of the Bogie River and Kirknie Creek Aggregation
98	154.0	Newcastle Bay - Escape River Estuarine Complex
99	145.9	Doongmabulla Springs
100	145.0	Great Basalt Wall
101	140.3	Turkey Mound Spring and Iron Pot Spring Aggregatio
102	138.1	Minnamoolka Area

Rank	Sum	Name
103	136.8	Violet Vale
104	136.7	Harmer Creek - Shelburne Bay Aggregation
105	136.7	Cape Grenville Area
106	136.1	Walters Plains Lake
107	129.6	Lake Elphinstone
108	124.6	Innot Hot Springs
109	117.4	Lake Lucy Wetlands
110	108.8	Lloyd Bay
111	108.0	Poison Lake
112	105.6	Olive River

Appendix 7: DSS Datasets and Custodians

Primary DSS criteria and relevant datasets

Criteria	Datasets	Custodian
Vegetation representativeness	• Regional Ecosystems of Queensland • Aggregation dataset (currently Queensland DIW)	• EPA • EPA
Diversity of wetland types	• Queensland Wetland Inventory • Aggregation dataset (currently Queensland DIW)	• EPA • EPA
Aggregation area	• Aggregation dataset (currently Queensland DIW)	• EPA
Proportion remnant vegetation	• Regional Ecosystems of Queensland • Aggregation dataset (currently Queensland DIW)	• EPA • EPA
Fishery habitat value	• Queensland Wetland Inventory • Aggregation dataset (currently Queensland DIW)	• EPA • EPA
Detention / Retention	• Nested catchments • Aggregation dataset (currently Queensland DIW)	• NLWRA • EPA
Population Density	• Census data – population density • ASGC Digital Boundaries • Aggregation dataset (currently Queensland DIW)	• ABS • ABS • EPA
Population Growth	• Census data – population density • ASGC Digital Boundaries • Aggregation dataset (currently Queensland DIW)	• ABS • ABS • EPA
Catchment Land-use Intensity	• Queensland Land-use Mapping Project (QLUMP) • Nested catchments • Aggregation dataset (currently Queensland DIW)	• DNRM • NLWRA • EPA
Aquatic habitat connectivity restriction	• Dams and Weirs in Queensland • Aggregation dataset (currently Queensland DIW)	• DNRM • EPA
Point source pollution	• National Pollution Inventory • Nested catchments • Aggregation dataset (currently Queensland DIW)	• EPA • NLWRA • EPA
Hydrological change (Irrigation)	• Queensland Land-use Mapping Project (QLUMP) • Nested catchments • Aggregation dataset (currently Queensland DIW)	• DNRM • NLWRA • EPA
Socio-economic disadvantage	• SEIFA • ASGC Digital Boundaries • Aggregation dataset (currently Queensland DIW)	• ABS • ABS • EPA
Education and occupation	• SEIFA • ASGC Digital Boundaries • Aggregation dataset (currently Queensland DIW)	• ABS • ABS • EPA
Economic Resources	• SEIFA • ASGC Digital Boundaries • Aggregation dataset (currently Queensland DIW)	• ABS • ABS • EPA
Indigenous Land Areas	• National Native Title Register • Registered and Notified Indigenous Land Use Agreements • Aggregation dataset (currently Queensland DIW)	• NTT • NTT • EPA
Protected Areas	• Collaborative Australian Protected Areas (CAPAD) • Aggregation dataset (currently Queensland DIW)	• DEH • EPA

Secondary DSS Criteria and relevant datasets

Criteria	Datasets	Custodian
Wetland Area	• User-defined wetland areas	• N/A
Vegetation Representativeness	• Regional Ecosystems of Queensland • User-defined wetland areas	• EPA • N/A
Land-use Intensity	• Queensland Land-use Mapping Project (QLUMP) • Nested catchments • User-defined wetland areas	• DNRM • EPA • N/A