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Design, development and implementation of NEDS

Redland City Council

24 November 2011

Stage 1 - Review of Literature and Initiatives

Natural Environment Decision System

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Natural Environment Decision System

Prepared for

Redland City Council

Prepared by

AECOM Australia Pty Ltd
Level 8, 540 Wickham Street, PO Box 1307, Fortitude Valley QLD 4006, Australia
T +61 7 3553 2000 F +61 7 3553 2050 www.aecom.com
ABN 20 093 846 925

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Prepared by Fiona Duncan, Vlatka Varagic and Antoine Burdett

Reviewed by Phillip Hawes, Con Lokkers, Susan Korrel and Jo Chambers (BAAM)

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Table of Contents

Abbreviations 1
Executive Summary 3
1.0 Review of Planning Strategies and Initiatives 4
1.1 Introduction 4
1.2 Review of Planning Legislation and Policy Documents 4
2.0 Review of Existing Systems 16
2.1 Local and State Government Initiatives 16
2.2 Local, National and International Initiatives and Case Studies 21
2.3 GIS Technology Review 27
3.0 Review of RCC Current Systems 29
3.1 Introduction 29
3.2 Overview 29
3.3 Review 30
4.0 Recommendations 32
4.1 Key Findings from Review 32
4.2 GIS Technologies Recommended for NEDS 33
References 34
Appendix A – Documentation Reviewed A
Appendix B – AECOM Review Synthesis B
Appendix C – SWOT Summary C

Abbreviations

Acid Sulphate Soils	ASS
Australian Height Datum	AHD
Biodiversity Assessment and Mapping Methodology	BAMM
Biodiversity Development Offset Area	BDOA
Biodiversity Planning Assessments	BPA
Comprehensive, Adequate and Representative	CAR
Decision Support System	DSS
Decision Support Tool	DST
Department of Environment and Resource Management	DERM
Department of Local Government and Planning	DLGP
Digital Cadastral Database	DCDB
Enterprise License Agreement	ELA
Enterprise Resource Planning	ERP
Environment Protection and Biodiversity Conservation Act 1999	EPBC Act
Environmental Inventory	EI
Environmental Inventory Stage 4	EI4
Environmental Protection Act 1994	EP Act
Identified Koala Broad Hectare Areas	IKBHA
Integrated Development Assessment System	IDAS
Integrated Geodatabase	IG
Koala Assessable Development Area	KADA
Land-use and land-cover change	LUCC
Light Detection and Ranging	LIDAR
Local Government Area	LGA
Markov Chain Monte Carlo	MCMC
Multiple Criteria Analysis	MCA
National Estuarine Research Reserve	NERR
Natural Environment Decision Support System	NEDS
Nature Conservation Act 1992	NC Act
North American Datum of 1983	NAD83
Pine Rivers and Koala Coast Priority Koala Assessable Development Areas	PKADA
Property Maps of Assessable Vegetation	PMAV
Redland City Council	RCC
Redland Planning Scheme	RPS
Regional Ecosystems	RE
SEQ Natural Resource Management Geographical Information System	SEQ NRM GIS

South East Queensland Koala Protection Area	SEQKPA
South East Queensland Koala State Planning Regulatory Provision	SEQ Koala SPRP
South East Queensland Natural Resource Management Plan 2009–2031	SEQ NRM Plan
South East Queensland Regional Plan 2009-2031	SEQRP
South East Queensland State Planning Regulatory Provision	SEQ SPRP
Spatial Database Engine	SDE
Spatial Information Management	SIM
Spatial Information Systems	SIS
Sustainable Planning Act 2009	SP Act
Universal Transverse Mercator	UTM
Visual Basic for Applications	VBA

Executive Summary

This report presents findings and recommendations as a result of a review of literature and current systems in accordance with the requirements of Stage 1 of the Natural Environment Decision Support System (NEDS) project. It is critical that an understanding is gained of the relevant local, regional and state strategies and policies presently used by decision makers particularly those elements that relate to environmental and land-use planning.

This review outlines the role and function of each of the key relevant documents within Queensland's planning framework. Biodiversity conservation initiatives contained within these documents have been assessed to understand how the strategies and policies could impact the NEDS.

AECOM's key findings are:

- Automation is required to ensure consistent and repeatable processes allowing defensible results. Processes should be auditable and transparent.
- Ensure policy is closely linked to spatial extents – i.e. need to be able define extents on ground to ensure enforceability.
- Ensure design is flexible to allow for future changes in legislation etc.
- Interpretation of outputs is critical; they must be easily understood and comprehended, but should based on sound scientific foundations.
- Data quality is critical. Good decisions can only be based on sound data. This is in-line with Redland City Council's data focused approach, i.e. "get the data right".
- GIS has become a critical tool to support businesses with growing acceptance at management levels.
- Decision factors, weightings, inputs and criteria need to be clearly defined, i.e. the business rules (scientific foundations) to apply to NEDS. Redland City Council (RCC) must ensure appropriate stakeholders within the business are engaged to derive and agree on these criteria.
- Keep it Simple (where possible) – for ease of maintenance and extendibility. Ensure NEDS is extendable and future proofed (flexible and adaptable to change).
- Apply lessons learnt by RCC; use natural boundaries as foundation layers for NEDS and only incorporate Digital Cadastral Database (DCDB) in the final stages.

1.0 Review of Planning Strategies and Initiatives

1.1 Introduction

As part of the review of NEDS and environmental inventory (EI) processes and initiatives throughout the region, state and country, it is important that an understanding is gained of the relevant local, regional and state strategies and policies that inform various elements of mapping and decision making for land-use planning. This section provides a high level review of the role and function of each of the key relevant documents within Queensland's planning framework that were investigated as part of the NEDS review process.

This review has covered the following documents:

- South East Queensland Regional Plan 2009-2031 (SEQRP) and South East Queensland State Planning Regulatory Provision (SEQ SPRP)
- SPP 2/10 – South East Queensland Koala Conservation
- South East Queensland Koala State Planning Regulatory Provision (SEQ Koala SPRP)
- Vegetation Management Framework
- Coastal Protection and Management Act 1995 (Coastal Act)
- Queensland Government Environmental Offsets Policy
- Department of Environment and Resource Management (DERM) Protected Areas Mapping
- SEQ Biodiversity Planning Assessments (SEQ BPA)
- SEQ Natural Resource Management Plan 2009-2031 and SEQ NRM Atlas
- Redland Planning Scheme 2006 (RPS)
- Redland City Council Biodiversity Strategy 2008-2012.

A brief description and outline of the role and function of each of these documents has been provided in the following table. In addition to this, consideration has been given to the relevance of each document for the NEDS project. As the project continues to progress it is possible that these implications will change and evolve with the findings; it is therefore recommended that prior to completing the project that a review of this section is undertaken and updated where necessary.

1.2 Review of Planning Legislation and Policy Documents

1.2.1 South East Queensland Regional Plan 2009-2031 and South East Queensland State Planning Regulatory Provision

Description, Role and Function	Data Sources
The SEQRP was released by the Queensland Government in July 2009. The primary purpose of the regional plan is to provide a sustainable growth management strategy for South East Queensland to the year 2031. The SEQRP and SEQ SPRP are statutory instruments under the *Statutory Instruments Act 1992*. They are also planning instruments under the *Sustainable Planning Act 2009* (SP Act). They have a direct effect in their own right and indirect effect through the amendment and alignment of local government planning schemes and state plans and policies. The SEQRP requires that local government prepare local nature conservation strategies that identify local biodiversity values, including terrestrial and aquatic biodiversity, ecological corridors and threatening	**Legislative Policy Applicability** SP Act **Administrating Authority** Department of Local Government and Planning (DLGP) **General Use** Regulatory provisions within the SEQRP trigger the need for certain developments to meet specific codes. The SEQRP categorises all land as one of three regional land use categories, which provide the spatial context for the regulatory provisions: - Regional Landscape and Rural Production Area - Urban Footprint

Description, Role and Function	Data Sources
processes. It also instructs local government to set local targets and performance indicators that have the capacity to be integrated with State of Region reporting.	- Rural Living Area. These classifications have impacts on biodiversity conservation and the requirements of some development applications. Regulatory mapping is also provided for "areas of ecological significance" and "major koala population and habitats". Recent modifications to the SEQRP and SPRP associated with the adoption of the SPP 2/10 – South East Queensland Koala Conservation, allow the State Government to declare a Biodiversity Development Offset Area (BDOA) for koala conservation purposes, which also has additional statutory implications for development applications. **Availability** The regulatory mapping as described above is available from the DLGP. The mapping within the SEQRP is a holistic mapping exercise, providing an overarching framework for development in South East Queensland. The methodology employed in these maps is not made clear in the document as it is informed by other policy documents.

1.2.2 SPP 2/10 – South East Queensland Koala Conservation

Description, Role and Function	Data Sources
SPP 2/10 is a statutory instrument of the SP Act which informs land use planning undertaken by state and local government, and infrastructure providers in South East Queensland. The Policy ensures that koala and koala habitat conservation measures are reflected in planning decisions. Planning decisions made in the SEQ Koala Protection Area (SEQKPA) – the seven eastern local government areas of South East Queensland – must include strategies and measures to respond to potential conflicts between achieving koala conservation objectives and development.	**Legislative Policy Applicability** SP Act **Administering Authority** DERM/ relevant local government **General Use** The policy is to be expressed in local planning instruments, structure plans and master plans, and may have regard to maps of DERMs SEQ KPA (koala habitat area) KHVs (koala habitat values) as mapped for the SEQKPA. For Redland City Council the habitat values shown on the SEQ KPA KHVs are the same as the Maps of Assessable Development Area Koala Habitat Values that are statutory under the SPRP. In conjunction with the Koala SPRP, the SPP also allows the planning minister to declare an area to be a Biodiversity Offset Area (BDOA) for koala conservation purposes. **Availability** Mapping supporting SPP2/10 was generated through the South East Queensland Koala Habitat Assessment and Mapping Project. This mapping and associated methodology is provided directly to local governments by DERM.

1.2.3 South East Queensland Koala Conservation State Planning Regulatory Provision

Description, Role and Function	Data Sources
The Koala SPRP is a state planning instrument that applies to the priority areas of the Pine Rivers and Koala Coast Priority Koala Assessable Development Areas (PKADA). The SEQ Koala SPRP supersedes the South East Queensland Koala State Planning Regulatory Provisions (Feb 2010). The SEQ Koala SPRP requires assessable development activities within PKADA to minimise their impacts on koalas. Depending upon the development type and koala habitat type, requirements may include: - Avoiding, minimising or offsetting the clearing of non-juvenile koala habitat trees - Site design that provides safe koala movement opportunities as appropriate to the development type and habitat connectivity values of the site - Construction practices that do not increase the risk of death or injury to koalas - Sequential clearing of native vegetation - The presence of a koala spotter when clearing of koala habitat trees is undertaken. clearing of koala habitat trees is undertaken.	**Legislative Policy Applicability** SP Act **Administering Authority** DERM **General Use** The SEQ Koala SPRP regulates assessable development at the development assessment stage with mapping and associated codes, through the Integrated Development Assessment System (IDAS) process. The SEQ Koala SPRP defines and maps koala habitat values within assessable development areas. The mapping identifies: - PKADA - Koala Assessable Development Area (KADA) - Koala habitat value category - Bushland habitat (low-high value) - Suitable for rehabilitation habitat (low-high value) - Other areas of value (low-high value) - Generally not suitable. The SEQ Koala SPRP also includes Identified Koala Broad Hectare Areas (IKBHA) as defined in Schedule 3 of the SPRP. RCC contains two IKBHA at Kinross Road and South East Thornlands. These areas have further implications for undertaking development and preparing structure plans. **Availability** Mapping in the SPRP was generated through the South East Queensland Koala Habitat Assessment and Mapping Project. This mapping and associated methodology is provided directly to local governments by DERM.

1.2.4 Vegetation Management Framework

Description, Role and Function	Data Sources
The State Policy for Vegetation Management documents the Queensland Government's policy on vegetation management, defining the principles that underlie the policy, its desired outcomes, and how these are to be achieved. The policy aims to ensure: - Conservation of biodiversity - Maintenance of ecological processes - Clearing does not cause land degradation - Management of the environmental effects of	**Legislative Policy Applicability** *Vegetation Management Act 1999* (VM Act), *Environmental Protection Act 1994* (EP Act), *Nature Conservation Act 1992* (NC Act) and SP Act. **Administering Authority** DERM **General Use** Under the SP Act, state and local governments use the IDAS for all development assessment. “Regional

Description, Role and Function	Data Sources
clearing - Reduction of greenhouse gases - Balanced decision-making - Support for regional communities. It consolidates the overarching objectives of Queensland's vegetation management framework comprised of legislation, a state policy, regional vegetation management codes, an offsets policy, a regrowth vegetation code, and 'material change of use' and 'reconfiguring a lot' policies.	Ecosystems" (RE) mapping may trigger the need for development to meet specific codes. The classification of REs is used for vegetation management under the VM Act in determining environmentally sensitive areas under the EP Act and has also been used by the Commonwealth government to ensure the conservation of biodiversity under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Additional information contained on the maps includes regrowth, Property Maps of Assessable Vegetation (PMAV) and essential habitat, which are areas identified by DERM as essential habitat for a species of wildlife listed as endangered, vulnerable, or near threatened under the NC Act. ***Material change of use/reconfiguring a lot policies*** Remnant vegetation clearing associated with a proposed material change of use or a reconfiguration of a lot application may be referred to DERM as a "concurrence agency" through the IDAS process. Relevant material change of use and reconfiguration of a lot policies are used to undertake this assessment. ***Regional vegetation management codes*** Clearing of remnant vegetation shown on an RE map or remnant map requires a development approval unless the clearing is for an exempt activity. DERM uses regional vegetation management codes to assess applications for clearing native vegetation. Each regional vegetation management code contains performance requirements for each application type or relevant purpose under the vegetation management framework. ***Regrowth vegetation management codes*** Clearing of regrowth vegetation shown on DERMs regrowth vegetation map requires notification to DERM and a statement of compliance with the relevant Regrowth Vegetation Code. ***Clearing applications*** All applications to clear vegetation require a property vegetation management plan (PVMP). A PVMP provides DERM with the information needed to make a decision on a vegetation clearing application. A property map of assessable vegetation (PMAV) may be prepared by a landholder to "lock in" and/or correct vegetation mapping within a property and replace RE and regrowth maps for determining the location of vegetation that is assessable or notifiable under the VM Act. **Availability** Information shown on the RE Map, Remnant Map and Essential Habitat Map includes current data, which is contained under the *VM Act* and the *Vegetation*

Description, Role and Function	Data Sources
	Management Regulation 2000. This information is freely available from DERM. The Queensland Herbarium is the lead agency for vegetation survey and mapping in Queensland and has established an internationally recognised methodology for vegetation survey and mapping. The methodology used in this mapping can be obtained from DERM or from: Neldner, V.J., Wilson, B. A., Thompson, E.J. and Dillewaard, H.A. (2005) *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland*. Version 3.1. Updated September 2005. Queensland Herbarium, Environmental Protection Agency

1.2.5 Coastal Management

Description, Role and Function	Data Sources
As required by the *Coastal Protection and Management Act 1995* (Coastal Act), the State Coastal Management Plan outlines directions for effective protection and management of the coastal zone. Regional coastal management plans describe how the coastal zone should be managed and identify the coastal management districts in particular regions. Regional coastal management plans implement the State Coastal Management Plan's policy framework at the regional level and identify key coastal sites requiring special management within the region. South East Queensland is subject to a regional coastal management plan.	**Administering Authority** DERM **General Use** The coastal plans have the effect of State planning policies (SPPs) under the *Sustainable Planning Act 2009* and are required to be considered during the making or amending of local government planning schemes or in the assessment of development applications until such time as local government planning schemes have been signed off by the planning minister as appropriately reflecting the coastal plans. **Availability** The South East Queensland Regional Coastal Management Plan is available on the DERM web site, as are maps of key coastal sites and supporting documentation.

1.2.6 Queensland Government Environmental Offsets Policy

Description, Role and Function	Data Sources
The Queensland government environmental offsets policy (QGOP) ensures that offsets are used consistently and transparently across the State, as a last line of environmental preservation response. It provides principles and guidelines for applying and developing more detailed 'specific-issue' offsets policies for important environmental values, such as: • Policy for Vegetation Management Offsets. • Queensland Biodiversity Offsets Policy. • Offsets for Net Gain of Koala Habitat is South East	**Policy for vegetation management offsets** Administered by DERM, this policy is applied to development assessable under the VM Act where, under Regional Vegetation Management Codes, offsets may be a means of meeting relevant performance requirements. Offsets must meet specific vegetation offsets criteria as set out within the policy. **Policy for biodiversity offsets** Administered by DERM, the purpose of the biodiversity offsets policy is to increase the long-term protection

Description, Role and Function	Data Sources
Queensland Policy. • Mitigation and Compensation for Works or Activities Causing Marine Fish Habitat Loss It should be noted that these offset policies are not independent of each other, for example an offset under the Policy for Vegetation Management Offsets may also satisfy part or all of the offsets required under the Queensland Biodiversity Offsets Policy.	and viability of the state's biodiversity where residual impacts from a development, on an area possessing State significant biodiversity values, cannot be avoided. The policy provides the framework to ensure that there is no net loss of biodiversity and applies to developments subject to the *Sustainable Planning Act 2009, Environmental Protection Act 1994, Nature Conservation Act 1992* and *Transport Infrastructure Act 1994.* The policy is administered by DERM. **Policy for koala habitat offsets** The objective of the Offsets for Net Gain of Koala Habitat in South East Queensland Policy is to ensure that environmental offsets for unavoidable impacts on higher quality koala habitat contribute to a net gain in bushland koala habitat in South East Queensland by 2020. The policy is applied when determining koala habitat offsets for: • applications for development assessed against the requirements of the Koala SPRP where an offset is required under the provisions of the Koala SPRP. • a local planning instrument (including local government planning schemes, structure plans, master plans, neighbourhood plans and other local area plans) within the SEQ KPA to achieve a net include in bushland habitat within the planning area as requirement by SPP 2/10: Koala Conservation in South East Queensland. • applications for community infrastructure designations within the SEQ KPA as required by the provisions of SPP 2/10. • Queensland government supported community infrastructure activities within the SEQ KPA as required by the State Government Supported Community Infrastructure Koala Conservation Policy. **Offset measures for marine fish habitat loss** Administered by DEEDI, offset measures for marine fish habitat loss are agreed measures to balance the remaining or residual impact of approved losses triggered by fisheries development approvals assessed under the provisions of the *Fisheries Act 1994* and *Integrated Planning Act 1997*.

1.2.7 DERM Protected Areas Mapping

Description, Role and Function	Data Sources
DERM has an advice agency role under the IDAS in relation to the following areas: - Wetlands - Conservation estate - Acid sulphate soils - Places on the Queensland Heritage Register.	**Legislative Policy Applicability** SP Act 2009, NC Act 1992*, Forestry Act 1959, Marine Parks Act 2004, Recreation Area Management Act 1988* and World Heritage Convention **Administering Authority** DERM **General Use** Under the SP Act*,* state and local governments use the IDAS for all development assessment. "Referrable areas" mapping may trigger the need for development to meet specific codes. These triggers are those under Schedule 7 of the *Sustainable Planning Regulation 2009*. ***Wetlands (DERM)*** DERM is a concurrence agency for wetlands identified as 'wetland protection areas' on the map of referable wetlands. The map of referable wetlands available from the DERM web site identifies the location of wetland management areas and Great Barrier Reef (GBR) wetland protection areas across Queensland. Development triggers for wetlands include: - Reconfiguring a lot if: • any part of the land is situated wholly or partly within a wetland management area; and • the reconfiguration results in more than six lots being created, or any lot resulting from the reconfiguring is less than 5 ha. - Material change of use, other than for a domestic activity, if any part of the land is situated wholly or partly within a wetland management area. ***Conservation Estate (DERM)*** The conservation estates for which DERM has an advice agency role are identified on the map of referable areas. Information shown on the map includes current data for conservation estate (Protected areas, recreation areas, state marine parks, World Heritage Areas and Brisbane Forest Park), QLD Heritage Register, roads, cadastral boundaries and towns. Development triggers for conservation estates include: - Reconfiguring a lot, which results in more than 10 lots or any lot less than 5 ha, or material change of use for urban purposes, where any part of the lot is situated in, or within 100 m of: • a protected area, forest reserve, critical

Description, Role and Function	Data Sources
	habitat or area of major interest (NC Act) • a State forest or timber reserve (*Forestry Act 1959*) • a marine park (*Marine Parks Act 2004*) • a recreation area (*Recreation Area Management Act 1988*) or • a World Heritage area (World Heritage Convention). ***Acid Sulphate Soils (ASS) (DLGP)*** Areas that may have potential ASS are regulated by the *State Planning Policy 2/02 Planning and Managing Development Involving Acid Sulphate Soils (ASS)*, which is administered by DLGP. Mapping at 1:100 000 scale has been completed in South East Queensland, from the New South Wales border to Noosa. The maps identify where development must meet additional conditions to avoid the impacts of ASS. Development triggers for ASS are as per the State Planning Policy and associated guidelines, including where development involves: - excavating more than 1,000 m³ below 5 metres Australian Height Datum (AHD) where the natural ground level is less than 20 metres AHD; or - using more than 1000 m³ of material as fill (with an average depth of 0.5 metre or greater, at or below 5 metres AHD where the natural ground level is equal to or less than 5 metres AHD). ***Adjacent to places on the Queensland Heritage Register (DERM)*** DERM can impose conditions on development at or near a place contained on the heritage mapping. This mapping is used by DERM to help identify development that could impact on heritage outcomes and to place appropriate conditions to mitigate impacts. Development triggers for lots adjacent to places on the Queensland Heritage Register include: - Reconfiguring a lot if the lot shares a common boundary with a registered place under the *Queensland Heritage Act 1992*. - Material change of use, other than for a domestic activity, if the lot shares a common boundary with a protected area or registered place under the *Queensland Heritage Act 1992*. **Availability** Referable areas mapping is freely available from DERM, including layers for conservation estates, registered heritage sites and referable wetlands. Various methodologies were used to prepare this data.

1.2.8 SEQ Biodiversity Planning Assessments

Description, Role and Function	Data Sources
BAMM is currently used by DERM to generate BPA. The BAMM provides a consistent approach for assessing biodiversity values at a landscape scale in Queensland. BPAs are used by DERM, other government departments, local governments and members of the community in a range of planning and decision making processes.	**Legislative Policy Applicability** Not Applicable **Administrating Authority** DERM **General Use** The BAMM is applied in two stages. The first stage uses existing data to assess ecological concepts such as rarity, diversity, fragmentation, habitat condition, resilience, threats, and ecosystem processes in a uniform and reliable way across a bioregion. The second stage relies more upon expert opinion to refine the results of the first stage and identify features such as wildlife corridors and areas with special biodiversity value. The final BPA is a powerful Decision Support Tool (DST) that can be comprehensively interrogated through a GIS platform and is supported by expert panel reports. **Availability** BPAs have been completed for a number of bioregions within Queensland, including South East Queensland. The BAMM is based on vegetation mapping from the Queensland Herbarium and analysis of biodiversity values by expert panels. Mapping is freely available from DERM.

1.2.9 SEQ Natural Resource Management Plan 2009-2031 and SEQ NRM Atlas

Description, Role and Function	Data Sources
The South East Queensland Natural Resource Management Plan 2009–2031 (SEQ NRM Plan) is a strategic document, designed to connect a wide range of existing plans, strategies and actions to better coordinate the management of natural resources in SEQ. The plan includes desired quantifiable targets for NRM in SEQ under the following themes: - Air and Atmosphere - Coastal and Marine - Land - Nature Conservation - Regional Landscape Areas - Water. The SEQ NRM Plan relies on the SEQ Natural Resource Management Atlas (SEQ NRM Atlas) to provide an understanding of the spatial dimensions of	**Legislative Policy Applicability** Not Applicable **Administrating Authority** DERM **General Use** The SEQ NRM Atlas contains regional maps that describe the current condition and extent of the environment and natural resource assets in SEQ. This allows the calculation of a benchmark from which corresponding targets can be made and achievements measured. The SEQ NRM Atlas is used for the following purposes: - As a forward planning tool (e.g. to inform preparation of local government planning schemes and State Government policy, corporate plans, property plans and natural resource

Description, Role and Function	Data Sources
each NRM area and desired targets. The SEQ NRM Atlas contains maps of the targets showing where natural assets are in SEQ at present and where activity should occur spatially to achieve each target.	management program efforts) - As a decision-making tool for natural resource managers - For the monitoring and evaluation of resource conditions and trends - For the identification of data compatibility and/or gaps. Local government planning can reflect SEQ NRM Plan targets to effectively address NRM outcomes by coordinating approaches with other local governments and agencies in SEQ. The SEQ NRM Atlas targets can also assist in establishing more tangible performance standards for new development. As there are no specified levels of achievement for the targets required by either the SEQRP or the SEQ NRM Plan, the level and type of response to targets will be determined by each local government. Further information on how to incorporate NRM targets into planning schemes and DSTs can be found in: *Implementing SEQ Regional NRM Plan Targets through Planning Schemes: A Decision Support Tool for South East Queensland Local Government Planners.*(Department of Infrastructure and Planning (DIP), Department of Environment and Resource Management (DERM), Burnett Mary Regional Group, 2010) **Availability** The Atlas acts as a central point for the collation of a variety of study outputs. The data is contained within the SEQ Natural Resource Management Geographical Information System (SEQ NRM GIS). Associated GIS data is not readily available to the general public. However, relevant mapping and data may be requested from the SEQ Regional Coordination Group within DERM by RCC. As a variety of information sources are collated within the Atlas, a range of data sets and methodologies used to inform the Atlas.

1.2.10 Redland Planning Scheme 2006 (RPS)

Description, Role and Function	Data Sources
The RPS, enacted 30 March 2006, provides a framework for managing development in a way that advances the overarching purpose of the *Integrated Planning Act 1997* (IPA) (now SP Act) to achieve ecological sustainability. The RPS includes “Planning Scheme Policy 4 – Ecological Impacts”. The policy is applicable to numerous habitat overlays and specific development application situations as described opposite,	**Legislative Policy Applicability** The RPS is a statutory planning instrument originally contained within the IPA and now contained within the SP Act. **Administrating Authority** RCC **General Use**

Description, Role and Function	Data Sources
particularly when a development is likely to result in adverse impact on ecological values or is located in an area with significant ecological values. The policy's purpose is to: - Set out the requirements for the preparation and submission of technical reports, including an Ecological Assessment Report, associated with some development applications - Provide information relating to management of ecological impacts of development under the planning scheme.	The RPS regulates the approval of development within the Redlands LGA through the IDAS process, using overlay maps and codes relevant to each land zoning. Overlays for habitat, waterway and coastal protection are in the form of: - Habitat Protection Overlay – Bushland Habitat - Habitat Protection Overlay – SEQ Regional Plan – Interim Guideline: Koalas and Development - Waterways, Wetlands and Moreton Bay Overlay. Material change of use and development applications are code assessable under the Habitat Protection Overlays. The purpose of the Habitat Protection Overlays is to ensure that development protects and provides for the long-term management and improvement of environmental values. In addition to the land use codes and overlays, Structure Plan Areas (i.e. South East Thornlands Structure Plan Overlay) can also be designated under the local planning scheme. These plans can be used to target the coordinated assessment of the ecological features for development applications within a particular area. The RPS also works in tandem with other legislation to ensure that necessary referrals agency assessment is triggered through the development application process. **Availability** Environmental Inventory Stage 4 (EI4) mapping was used as a basis for allocation of the Conservation Zone, Environmental Protection Zone and Habitat Protection Overlays in the RPS. This mapping is an earlier, simpler and more robust version of the Common Nature Conservation Classification System and the SEQ BAMM.

1.2.11 Redland City Council Biodiversity Strategy 2008-2012

Description, Role and Function	Data Sources
The RCC Biodiversity Strategy acts as the head of power and dictates the broad goals for management of the City's natural environment. The City's program for biodiversity outlines objectives to plan, design, deliver and regulate activities to protect and restore the quality and quantity of biodiversity in the Council area. Long term objectives include protecting, maintaining and enhancing the health of the City's bushland, vegetation, koalas and native wildlife. This document drives the conservation goals of Council and the management of reserves.	**Legislative Policy Applicability** Not Applicable **Administrating Authority** RCC **General Use** The protection of biodiversity within Redlands is based upon a combination of enforcement of statutory laws (Commonwealth, State and Local), education and extension programs, RPS, management plans and partnerships, and private stakeholder initiatives. The biodiversity strategy aims to bring these initiatives together to protect the Redland LGA's biodiversity. It

Description, Role and Function	Data Sources
	achieves this by providing an action plan which outlines key objectives, actions and outcomes to be undertaken by various stakeholders. **Availability** Not Applicable

2.0 Review of Existing Systems

GIS is used to store and collate information that can be used to answer questions and aid decision making processes. The analysis method selected to provide an answer will depend on the type of question asked. Action can then be taken based on the results of the analysis.

This review will present a variety of initiatives dealing with environmental problem solving; demonstrating the diversity of GIS technology. It is evident as a result of this review that the collection, analysis and storage of spatial information are critical elements of any environmental project or operation, regardless of its scale.

GIS technology is exceptionally capable of providing assistance in the decision-making process for a variety of fields across an organisation. GIS can amalgamate data and provide decision makers with a powerful tool to collect knowledge from disciplines as diverse as ecology, infrastructure, planning, transportation, utilities, and others. To aid readability and comprehension, the review has been structured into the following sections:

- Local and state government initiatives
- Local, national and international initiatives and case studies
- GIS technology review.

Refer to Appendix B for a full synopsis of the interviews discussed in the sections below and subsequent SWOT analysis.

2.1 Local and State Government Initiatives

2.1.1 Gold Coast City Council

The following assessment is a result of an interview with three key members of the Natural Areas Management Unit from the Gold Coast City Council (Christian, Robson, & Taylor, 2011).

Natural Areas Management Unit and Relationship to Corporate Spatial Information Systems Team

The Unit has approximately 30 people divided into three groups:

- Operations
- Planning
- Restoration (ecological).

The Senior Ranger is currently completing a Masters degree in Spatial Ecology, and whilst his role is primarily a Ranger, he has been undertaking geospatial work for the unit.

The corporate Spatial Information Systems (SIS) Team are seen as a service provider. There is an apparent disconnect between the Natural Areas Management Team and SIS team. It is perceived that the SIS Team has limited spatial analysis capabilities. Generally, the Natural Areas Management Team outsources spatial analysis work to third parties if they do not have the ability to undertake the work within the unit.

It was indicated that the Unit sees RCC as a leader (along with Brisbane) in forward thinking environmental management and GIS.

Conservation Planning and GIS

The current approach in conservation design and management has been fragmented across the Council. Consistency in managing coastal to world heritage rainforest conservation is seen as a challenge.

There is a strong focus on systematic conservation planning tools.

- Light Detection and Ranging (LIDAR) has been utilised on various initiatives including bushfire hazard mapping. Combined with aerial and satellite imagery, data is used to inform the planning scheme. LIDAR has been used primarily for vegetation structure to support management of vegetation thickening. Council would like to move to fire simulation and modelling and has been investigating tools developed by the University of Melbourne such as VISTA and PHOENIX, products which allow predictive modelling and hazard control.
- From a decision support perspective, Council have also been investigating use of products developed by the University of Queensland. These include MARXMAN (reserve design software used for forest development) and ZONATION (a raster based product used for complex problem solving, which is however not seen as

user-friendly). These tools are based on a scientific (maths) foundation with success linked to the quality of input data.

GIS and Technology

Council currently utilises MapInfo-based GIS products and are about to migrate to the ESRI GIS technology (by May 2012). MapInfo is used for limited spatial analysis; however, the unit is starting to use raster analysis tools (currently Vertical Mapper) to aid in problem-solving. It is perceived that ESRI will bring the extra functionality such as raster analysis.

The technology environment is changing in Council over the next two years. Apart from the move to ESRI; the Council is also migrating to a new Enterprise Resource Planning (ERP) system based on SAP, which will also be utilised for asset management.

ESRI Australia's Dekho product will be used as the web mapping tool and a possible integration between GIS and SAP will be considered. No scripting (for process automation) has been undertaken in MapInfo; however, it is expected in the future that ModelBuilder will be utilised once ESRI products are available.

Data is managed by the SIS team and is tightly controlled.

Biggest Challenge

Nine management plans have been developed for conservation management, which have lead to an unmanageable number of actions to prioritise, action, and assign. The unit indicated to AECOM that they need to address the following:

- Budget and resource constraints
- Mechanisms to prioritise actions
- Arrangement of reserves to get value for money against conservation targets.

All actions are very specific (detailed rather than broad) and require considerable effort to implement. The unit suggested a better balance is required.

2.1.2 Sunshine Coast Regional Council

The following assessment is a result of an interview with the Manager, Spatial Information Management (SIM) of Sunshine Coast Regional Council along with three of his key team members (Browne, Derby, Clewett, & King, 2011).

Biodiversity Planning

The Council's immediate planning concerns are around biodiversity and connectivity across the regional network, and REs and other vegetation related layers as core datasets. The current Biodiversity Strategy was published two years ago.

A new planning scheme exists, which necessities the need for refinement to planning areas. It is currently in a draft format and focuses on core linkages and habitat areas.

Vegetation has been mapped at a fine scale (including trees, waterways) across the region using LIDAR technology with the net result of 20% more of the region mapped as REs. The output is a raster based model; however, a vector output has also been generated for information dissemination and underpins biodiversity planning policy moving forward.

Council completes a "Biodiversity Report Card" every two to three years. This involves significant spatial analysis, defining where Council is and where they are moving to.

Structure of SIM Team

As a result of the amalgamation of three councils the SIM team consists of 35 staff across the following four units:

- Land Information (e.g. parcels, property ownership)
- Assets (e.g. drainage, roads, parks)
- Systems (e.g. GIS, asset management)
- Geospatial Information (e.g. information to support planning).

This amalgamation has enabled access to a broad and diverse range of skills including eight analyst/programmers capable of geoprocessing (two at an advanced level), all with advanced spatial skills. This

means that the team is in a position where they can utilise the full capabilities of GIS and assist in complex problem-solving. Skills also include Dot Net, Visual Basic for Applications (VBA) and Microsoft Access, therefore anything from simple queries through to more complex analysis and advanced scripting can be performed.

The SIM Team is positioned under the Chief Information Officer (CIO) and alongside the IT section; hence a close relationship exists between SIM and IT and this is seen as a positive outcome.

The CIO is responsible for records, systems, infrastructure, administration/governance and the project office.

Architecture

The Council has an Enterprise License Agreement (ELA) with ESRI that provides them access to all ESRI based software and tools. The current standard is version 10 with all desktop licenses at this version; however, upgrades of SDE from 9.x to 10 are still in progress. Some licenses of MapInfo still remain, but are being phased out.

From a data point of view, spatial data is made available for consumption through ArcGIS Services, although a significant challenge was the integration of legacy data from three councils, i.e. the process to migrate into a regional wide dataset was complex due to data being across various scales and criteria.

From a geoprocessing standpoint, Model Builder is predominantly used with some Python scripting also employed.

IBM Maximo is used for asset management, with the Council in the process of rolling out version 7. A Flex-based interface is used to integrate back into Maximo, although at a rudimentary level.

Current Approaches, Issues, Opportunities

Due to a change in culture at Council, GIS is now seen as an integral part of planning and Council business. This has enabled Council to leverage the power of GIS and this has resulted in a change in the way business is engaging the GIS team, e.g. a significant increase in meetings has been experienced, with GIS frequently being involved in business planning. The demand from Council for GIS involvement has recently grown steeply.

A large amount of information from previous field surveys exists. These data were captured for biodiversity and planning purposes; however, it has not been stored in a coordinated fashion and is unintegrated. An area of improvement was identified for better integration of information and linkages to information systems.

A strict metadata process and standard exists for versioning/historical data aligned with business process. The need to follow defined methods and standards is slowly filtering through the organisation.

The team is currently looking at custodianship and ownership of data. They are in the process of facilitating relevant business units to take ownership of the data they are responsible for, with GIS providing the necessary tools to enable update of the data, thus empowering users. The net goal is to move responsibility for the datasets back to business units that are responsible for them.

The SIM unit is pointing clients toward a self-service model. Although only internal at present they are exploring options for external clients, through:

- Data as a service
- Analysis as a service.

Value is seen to be added through high-end analysis as opposed to the supply of more traditional paper maps only, i.e. tools and facilities can be provided to add more value, such as field work.

Geoprocessing

The team strongly advocates the use of geoprocessing for automation. An example given was a task of processing 150,000 land parcels for a particular analytical study, leaving only eight percent requiring some level of manual intervention/assessment by planners after automated processing and rules were applied.

For audit, traceability and transparency, a level of attribution is made as a result of business process/workflow, e.g. the use of “updated automatically” or “user over-ride by planning decision” is recorded against each data object.

Geoprocessing utilises both raster and vector based analysis, with only ESRI tools being utilised at present with the use of grids.

2.1.3 Department of Environment and Resource Management

The following assessment is a result of an interview with the Senior GIS Analyst of the Nature Refuge and Sustainable Communities division (Hempel, 2011) and Steven Howell of the Biodiversity Assessment Unit (Howell, 2011) within DERM. Also referenced is the framework developed by Vlatka Varagic (Varagic, 2010) for streamlining the nature refuge gazettal process adopted by DERM as a central part of the Nature Refuge Program.

The purpose of this interview was to:

- Ascertain DERM's approach to the application of GIS technology in support of environmental management
- Consider the strengths, weaknesses, and impacts of policy
- Identify relevant considerations and/or opportunities for consideration in the development of NEDS by RCC.

Biodiversity Assessment Unit

The BAMM has been adopted by DERM to enable a consistent approach for assessing biodiversity and generating BPAs. BAMM presents raw and synthesised data regarding biodiversity to a broad range of users, optimising the use of existing information. BAMM is used to advise a range of planning and decision-making processes.

The complexity of the data and communicating it effectively are seen as significant challenges, especially given that the expectations of the public, to have immediate access to the data, have increased due to currently available products such as Google Maps and Google Earth. It should be noted however that people do not recognise the implications of data currency, representation and positional accuracy that technologies such as Google have.

To alleviate this, DERM have instigated a number of initiatives such as:

- Staff training
- Website improvement
- Better presentation of data
- An email address for data users to post questions
- Information (datasets) made available through a centralised website site for immediate access.

In addition, ArcGIS Explorer (a tool for disseminating spatial information similar to ArcReader) has been utilised as a data visualisation and navigation tool to include on data CD's for some data products.

The GIS architecture is consistent across DERM; ESRI is used as the primary suite of software tools. A new license agreement is now in place for three years with ESRI. There is also some utilisation of open source GIS software.

The geodatabase is utilised as the core data management and storage framework, physically implemented as a File Geodatabase. Use of a File Geodatabase maintains simplicity whilst allowing storage of large datasets. Given the limited need for multi-user editing (one to two users) the limitations of multi-user editing of a File Geodatabase is not seen as an issue.

Model Builder is used for geoprocessing as a primary tool to streamline repetitive tasks, with Python scripting being incorporated where required, e.g. complex control logic such as looping. Due to available skills, some data processing and manipulation is done in Microsoft Excel and/or Access as well as older scripts written in ArcInfo Modelling language (AML); however, AML support is limited and questionable in the long term.

In models and scripts, standard data operations are applied, such as buffering, intersections, unions, clip etc. Data is also exported to Excel for pivot table reports.

The following items were raised as issues and considerations for future success:

- Education of the IT department to understand GIS data can be large and ideally the network needs to move large datasets (e.g. 2GB) around.
- It is critical to ensure expertise is made available to support and maintain the system, given its development cost and substantial maintenance requirements.

- Keep it simple, so technology and processing power is available to support most needs.
- Ensure appropriate people (subject matter experts) are available to consult and contribute when deriving criteria to support processing models (such as weightings and filtering tables). DERM achieve this through formal workshops with expert panels and moderators.

Nature Refuge | Sustainable Communities

GIS Framework for Streamlining the Nature Refuge Gazettal Process

The Nature Refuge Program has grown at a much faster rate than anticipated from less than 100,000 hectares of nature refuges in 1994 to 2,100,000 hectares in 2010. The GIS system has been a major factor in maintaining an effective administration throughout this growth. The Nature Refuge Branch now has the capability to perform various system inventory searches, from basic database work (such as deriving the exact number of nature refuge properties that are located within a specific bioregion) to providing answers to questions about the negative impacts on conservation. The new feature classes that are generated facilitate effective investigative data analysis. The geodatabase model developed adds rich GIS functionality, providing the capability to store, query, and manipulate geographic information. It provides the ability to leverage data relationships and enforces topological integrity, creating savings in customisation and productivity. The advanced functions of ArcGIS included in the geodatabase design facilitate building spatial system models. The GIS system supports the decision-making process, provides visual evidence for reporting purposes and offers a way to streamline work procedures. When interrogated it supplies answers, offering decision makers the ability to challenge impacts on the environment.

Specific advantages of the GIS framework include:

- GIS environment enables boundaries and internal zones of nature refuges to be spatially referenced.
- GIS digital database maintains accurate spatial data for storage, retrieval, research and analysis.
- GIS analysis is able to be performed on validated data for performance reporting, future analysis growth of the program and fiscal management.
- Data custodianship of spatial data has elevated the awareness of and the importance of the program.
- The GIS functionality has elevated and streamlined the delivery of data, which has been seamlessly integrated into similar DERM environments to improve the protection of land of high environmental value in Queensland.

Conservation and Biodiversity Planning

DERM are looking to apply an approach known as Comprehensive, Adequate and Representative (CAR) to conservation planning in the Queensland, based on a bioregional framework as a result of both commonwealth and state based policy.

Biodiversity is being quantified with targets at different scales catering for fauna, environmental condition and land tenure.

Biodiversity and habitat protection are often dependent on land tenure, with freehold and leased land forming legally binding arrangements and these can inhibit protection. In SEQ there is a pressure for land development; however, there is still a need to maintain natural connectivity in the landscape. While Council zoning highlights areas for future development it will require negotiation to ensure adequate biodiversity protection is maintained.

A significant concern for DERM is the relationship between offsets policies and the focus on major urban development. The current requirement is for a developer to offset environmental impacts; the desired result being a ‘no loss’ or ‘net gain’ of biodiversity. Although providing offsets is an important policy, it can present challenges such as quantifying impact areas, determining appropriate offsets (i.e. is there sufficient gain, can the offset area replace what is lost), compliance and obtaining suitable offset sites in developed areas.

Changes to government policy, legislation and budget allocation can create difficulties for consistency in biodiversity conservation planning. Another significant challenge is balancing the requirements of development, tourism, agriculture, and mining with the requirements of biodiversity conservation.

Relationship between Councils and State Government

There is a significant quantity of spatial and non-spatial data to draw from; however, DERM indicate a need for stronger relations between councils and state government. DERM have indicated to AECOM that RCC has worked well on these issues, with significant biodiversity with coastal forest areas still intact i.e. balancing population support with good outcomes in terms of conservation.

GIS and Technology

There is a strong connection between policy and spatial context. That is, there is a need to take into account connectivity and/or scale when developing policy. Policy needs to be definable on the ground so it is enforceable.

DERM are well resourced in spatial technologies; utilising Spatial Database Engine (SDE) databases and a corporate ESRI license with full access to ESRI tools. Python is used for all geoprocessing tools along with VBA code. Tools are automated and therefore repeatable and enable/enforce repeatable outcomes that are defensible. The ESRI software suite is the same technology in use by RCC.

It was indicated that there is currently a lack of raster-based GIS approaches, as current geoprocessing relies on vector arithmetic such as intersects and unions; however, raster analysis can be more powerful. Raster maps are inherently well suited to mathematical modelling and quantitative analysis. Vector data often requires extensive data cleaning for effective analysis and is processing intensive, e.g. as a result of requiring conversion to a topological structure (Buckley, 1997).

People

Acceptance of and recognition of the importance of spatial information and technologies is increasing in DERM.

2.2 Local, National and International Initiatives and Case Studies

2.2.1 Biophysical and System Approaches for Simulating Land-Use Change

Lee, Huang and Chan (2008) inspired by land-use and land-cover change (LUCC) projects, examined complex land-use change systems and embarked on developing a land-use change model. Previously, various models had been created to simulate land-use change, but no biophysical approach that could identify material and energy flows in a land-use change system existed. In order to develop spatial system models that could simulate land change, programming was needed to combine system dynamics with GIS software. Therefore, due to the difficulties in dealing with spatial interactions and integrating different software programs, costs and the required advanced programming skills, spatial system models had not received much attention nor had they been applied widely. To overcome methodological disadvantages of spatial system modelling the study presented a new procedure that used GIS in modelling a spatial system. To simulate land-use change, an example was utilized to demonstrate the capabilities of Model Builder in GIS software.

The study explored the biophysical perspective of land-use change to identify material and energy flows during land-use change. The study integrated different Spatial Analyst functions into a spatial system model in Model Builder. Model Builder in ArcGIS is an interface used to create models. It is an object-oriented environment that formalizes procedures for processing GIS data and other spatial analysis actions. The objectives of spatial system models are not to develop spatial forecasting models, but to design explanatory models for analysis. Improvements for spatial system models were developed to solve the problems associated with spatial homogeneity and simplified spatial interactions. The proposed procedure, which utilises Model Builder in ArcGIS, was presented and tested using a 10×10 cell space with three scenarios to demonstrate the feasibility of the procedure and the explanatory power of the model.

2.2.2 Mapping Invasive Wetland Plants in the Hudson River National Estuarine Research Reserve using Quickbird Satellite Imagery

The Laba et al.(2007) study involved mapping invasive wetland plants in the Hudson River National Estuarine Research Reserve (NERR) using QuickBird satellite imagery. The NERR program tracks changes in ecological resources of representative estuarine ecosystems and coastal watersheds. Utilising high spatial resolution satellite imagery, plant communities and invasive plants within the Hudson River were mapped. The images were rectified and geo-referenced to the Universal Transverse Mercator (UTM) coordinate system and the North American Datum of 1983 (NAD83). The image processing component involved classification of the imagery to distinguish areas of different dominant vegetation. Using the ERDAS Imagine software package and a maximum-likelihood classification, 20 land-cover maps were produced.

GPS was used to collect points along plot boundaries and data concerning the immediate environment was collected and recorded. Onscreen digitising was used to produce field plots of the GPS points and field data. Conventional contingency tables and a fuzzy set analysis served as a basis for accuracy assessments. The accuracy figures assessed by the contingency tables were 73.6%, 68.4%, 67.9% and 64.9%. Fuzzy assessment tables had even higher estimates for map accuracies figures (83%, 75%, 76% and 76%) suggesting that high-resolution satellite imagery offers huge potential for mapping of invasive plant species (Laba, et al., 2007).

2.2.3 Collaborative Decision-making Processes for Maintaining Biodiversity: Two Australian Case Studies

Pettit and Pullar (2004) observed two Australian case studies, which focused on land-use planning and biodiversity issues. They examined the application of two modelling approaches, which endeavoured to integrate mapping with multiple criteria decision-making techniques. Case Study 1 dealt with urban areas, while Case Study 2 focused on a regional context.

Case Study 1 - Urban Biodiversity in the City of Darebin

The City of Darebin is 1 of 31 councils comprising metropolitan Melbourne. Preserving and enhancing green systems is critical not only for sustaining and improving the quality of life of urban residents but also for conserving biodiversity. Certain areas with environmental and cultural significance in the City of Darebin required protection including native grasslands, waterways and significant remnant vegetation.

Prior to the urban green system scenarios being formulated a geodatabase was created. Datasets included:

- Green systems data – open spaces, waterways and water areas
- Biodiversity data – flora, ecological vegetation classes, threatened fauna
- Cultural heritage data – registered heritage sites
- Planning scheme and land parcel (cadastral) data.

A number of buffering and union GIS operations were performed on these data layers. The resultant datasets were used to construct the geodatabase for importing into ‘what if’ analysis.

Land suitability analysis was undertaken using a weighted linear combination (WLC), multiple criteria analysis (MCA) model, based on the sieve mapping overlay technique.

The MCA model applied was a simple mathematical procedure that multiplied each decision factor’s rating by the overall weighting of importance assigned by the user and then performed an additive operation, combining all suitability factors, to derive a final potential cost surface, also known as a suitability map. By using this simple MCA technique the underlying mathematical model is easily understood by most planners, decision-makers and ultimately the community.

The land suitability analysis module enabled multiple decision factors to be synthesised in order to determine the relative suitability of different locations for a particular land use.

Category		Considered suitability factors and ratings							
Factors		Fauna	Flora	Open space	Water features	Heritage	EVC	Land Use	
Factor weight		3	3	3	3	-	-	2	
Buffers (m)	0-25	5	5	3	5	-	-	Park	5
	25-50	5	4	3	4	-	-	bus	2
	50-75	5	3	2	3	-	-	ind	2
	75-100	5	2	2	2	-	-	infra	3
	Outside	1	1	1	1	-	-	res	2

Table 1 Suitability Factors and Ratings (Pettit and Pullar, 2004)

These weightings and ratings, combined with permissible land use conversion values, were used to formulate the urban green space scenario.

The advantages of this land suitability approach to urban green systems scenario modelling are:

- The approach is objective and effective
- Decision factors can be clearly defined and adjusted to objectives
- Transparency in processing enables scenarios to be easily formulated
- Results can be examined spatially with suitability maps and reports
- Weightings and ratings can easily be adjusted.

The disadvantages are:

- Jurisdictional boundaries impose a constraint (example: Darebin and Merri Creeks flow through three councils); therefore, consistent land use management practices need to be in place across the councils
- This approach does not consider social and economic dimensions pertaining to surrounding land uses.

Case Study 2: Modelling Ecoregions in Queensland

Ecoregions define recognisable areas that represent broad environmental and landscape structures. They play a significant role in decision-making and legislation and it is therefore essential they are represented in an objective and scientifically defensible manner.

A project was undertaken between the state Environmental Protection Agency and the University of Queensland (Pullar, Low Choy, & Rochester, 2004) to develop an ecosystem classification that combined expert (qualitative) knowledge from ecologists and (quantitative) data analysis of environmental data.

Qualitative forms of knowledge included:

- Rules of thumb
- Expert advice
- Scientific publications and reports.

These were converted to quantitative data in a rigorous statistical model. The Bayesian modelling approach supports the inclusion of this knowledge as *informative priors*, which is balanced with hard data in the model result.

Information elicitation is a procedure of transforming knowledge into probability statements for informative priors and this was carried out through a workshop. Geographical descriptions for ecoregions were obtained and analysed against measurable environmental data such as climatic, terrain and soil data. The experts then interactively explored and adjusted environmental data distributions and their confidence in them to conform to their opinions of ecoregions. This information was transformed into probability distributions and an overall weight was given for this prior information.

A GIS application was written for elicitation of ecoregion classifications. The three main components of the system are:

1) An exploratory interface for users to select areas that define ecoregions by querying locations and attributes (biotic and landscape categorical variables)
2) A data visualisation tool that allows users to adjust the abiotic variables used to characterise these ecoregions
3) A Markov Chain Monte Carlo (MCMC) simulation algorithm that uses a Gibbs sampling technique [Gilks et al., 1996] to classify ecoregions as density mixture distributions.

2.2.4 Chester, Delaware and Montgomery Counties Regional Watershed Improvement Project

AECOM is in the process of developing a GIS-based DST to identify priority areas for investment in watershed improvements (Chapman, 2011). The DST will allow for an objective assessment of the issues facing the project area and provide consistency in prioritising watershed improvement.

This initiative commenced in May 2011 and is scheduled for completion in mid-2012.

Objectives

Two main objectives were identified:

1) Identify and prioritize areas where the Partnership could assist in design and construction of priority regional watershed improvement projects.

2) Assist local entities in regional watershed planning.

Approach

The approach involves centralising watershed data for three county regions and will:

- Provide objective assessment of existing conditions and issues facing the project area
- Provide consistent decision-making approach for the region
- Facilitate discussion of watershed issues and solutions
- Identify priority regional projects
- Support regional coordination, fundraising and project definition efforts
- Be made available to stakeholders to allow others to continue to use, update, or enhance.

DST Architecture

Figure 1 depicts the model (Schematic Process Flow Chart) utilised by the DST.

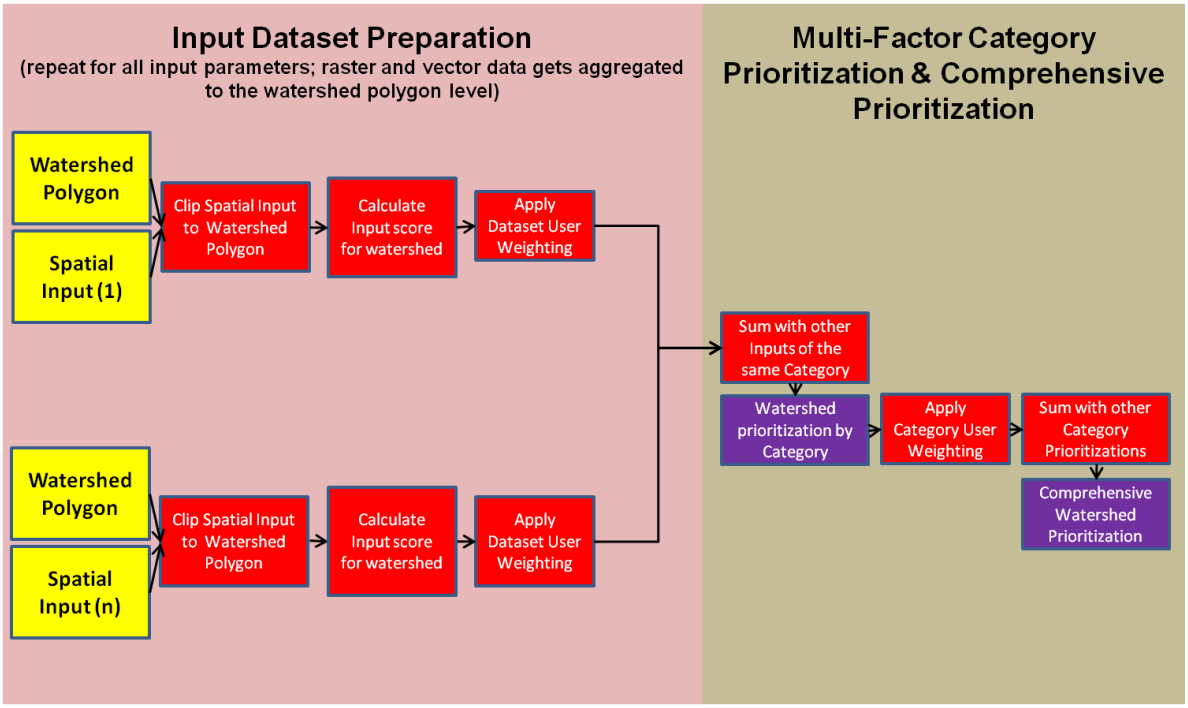

Figure 1 Schematic Process Flow Chart

The architecture is based on the ESRI software platform. Specifically, an ArcGIS extension was developed that:

- Allows users to define analysis extent and resolution
- Allows users to define input datasets and weighting factors
- Automates computations/prioritisations
- Assists in viewing and interpretation.

All input datasets are stored in a geodatabase with the focus being on spatial regional datasets with comprehensive coverage and allows:

- Simple weighting
- Combining with other datasets.

2.2.5 Decision Support System for the National Historic Trails System in the Western United States

AECOM has developed a Decision Support System (DSS) for the National Historic Trails System in the western United States (Ensley, 2011). The site holds a vast amount of GIS data that AECOM has created or downloaded as well as field collected data from AECOM and subcontractors. There is also a large amount of non-GIS data on the site.

The National Historic Trails Inventory project involved AECOM working with the US Bureau of Land Management to describe and document archaeological and visual resources of 600 miles of historic trails and significant sites. These are the historic wagon routes used by the settlers of the American west. The DSS site developed for this project is not a true interactive GIS map, but more of a data clearinghouse. The site holds everything from GIS base data and maps to field-collected archaeological data to project documents and reports.

From a GIS perspective, this involves the building of geoprocessing models to generate calculations to compare possible route alternatives based on environmental impacts and costs associated with permitting. This normally starts with an opportunities and constraints analysis. The numbers are used to generate matrices for comparing route alternatives side by side. Formulas have been developed that rank the routes side by side so that they can be compared by ranks.

The system provides results that can be used to answer policies and regulations related to infrastructure development.

2.2.6 Research on Distributed GIS Process Modelling and Integration

The paper by Jia, Jiang, Sun and Wei (Jia, Jiang, Sun, & Wei, 2008) provides a discussion on rapid application development for GIS software in relation to process modelling and workflow. The paper's goal is focused on the development of GIS software that is location-oriented and decision support based. It goes into detail on matters relating to process engineering and advanced software development; however, makes a number of high level points that AECOM feel are pertinent to RCC.

GIS is said to support the dynamic nature of process-oriented modelling and analysis. Process models within GIS can take the abstract definition of required processing/analysis to solve spatial problems.

An example given was a process model that takes a number of datasets as input (soil, vegetation, imagery, elevation) and analyses/processes the data through digital elevation reconstruction, slope gradient analysis and spatial interpolation, combining this with a mathematical model (e.g. soil erosion, vegetation evolution, precipitation) to predict precipitation, soil erosion, vegetation cover change etc. The concept of taking spatial input datasets, applying processing based on sound scientific models and producing output datasets that enable well informed decisions is the key point to be taken from this.

From the perspective of process management it is perceived that GIS can meet the following requirements:

- Support for both asynchronous and parallel activities
- Collaboration among parallel events
- Articulation of the order of activities
- Definition of pre-requisite activities
- Description of structures such as processes, sub-processes, tasks, sub-tasks etc
- Description of data inputs and outputs.

Process modelling is said to be based on professional knowledge relating to the spatial problem to be solved and includes three aspects:

- Building the model
- Applying principles and methods specific to the spatial problem to be solved
- Management, operation and improvement of the model in the actual environment.

When solving a specific problem, the paper recommends that not only should all parameters be included, but also the unnecessary or impossible activities and tasks should be cut, thus obtaining the real operational process. The implication to RCC is that processes should be reduced to the simplest form and unnecessary data/processing removed. A key to this is requirement specification (Phase 2).

Models can be tested for validity to find any shortcomings, to ensure that continuous improvements can be made. This enables an iterative cycle of improvement. Two phases are referred to:

1) Modelling phase: including geographic information modelling tools

2) Operational phase: including platforms(s) to run models/workflow.

Architecturally, the following layers are referred to:

- Presentation Layer (user interface)
- Process Logic Layer
- Data Interface Layer (data query and optimization)
- Data Layer (data storage – e.g. File Geodatabase).

This is sound and in terms of RCC, the user interface would be through ESRI GIS tools capable of running models such as ArcMap, given NEDS is a tool for the GIS team to synthesise outputs.

The key message from the paper is that process modelling is the basis of process automation. To achieve this, one must research the data model suitable for the process, develop the process model and establish the integrated operational environment to integrate with GIS (Jia, Jiang, Sun and Wei, 2008).

2.2.7 Computers, Environment and Urban Systems

The paper by Zhou, Regnauld and Roensdorf (2009)) describes a data model for logging map generalisation process information to facilitate data authentication in a multi-representation spatial database. The key message is the ability to audit process and provide traceability.

Consistency among different data products is often poor, e.g. map productions are on different scales, maintained separately (i.e. collected data is not reused effectively). A recommended solution to this problem is to manage and integrate all source data for various products into a single repository, thus any maps are generated from generalisation from data in this repository. This is referred to as a multi-representational database and accommodates data from different sources in an integrated way. One representation in the source data can serve multiple depictions in different products.

The quality of a map or spatially derived output depends on quality of the source data (accuracy, completeness) and nature of applied processes.

The paper shows how linkages between features (pre- and post-processing) can be tracked in both directions. This enables traceability of derived features back to the source data. To enable bi-directional traceability, the paper refers to a “generalisation log” to record relevant information on parameters, procedures and any data mapping rules required. A data model capable of recording such a log is provided in the paper and can be realised into a relational database structure/schema.

Two approaches are referred to for populating a multi-representation spatial database:

1) Matching and linking features at different resolutions from existing data

2) Generalising a large scale (detailed) dataset to derive multiple representations.

A generalisation process is said to be modelled at various levels of granularity of functional decomposition and requires balance between complexity and expressive power of the model, the goal being to produce a human-readable model that can be easily coded in the modelling environment. In RCC’s case this will be Model Builder and if required Python. The key message therefore is to ensure a solution that is easily supported and maintained.

Transformation from source to target is rarely achieved in a single step, rather there are often many steps with intermediate states of data, thus a number of operations to the data need to be recorded.

A number of approaches for versioning (data and functional elements) are documented in the paper:

- Data side: changes to source data will create new versions of features in the dataset(s). These changes are propagated to the target dataset through appropriate processes. Feature versioning adds a temporal

dimension to the data. Depictions of real world phenomena in the past which could be of value may be retrieved.

- Functional side: processes, parameters, precedence etc may change over time. The complexity of functional versioning means that even if the source data remains unchanged, functional versioning may still create new versions of target features (Zhou, Regnauld, & Roensdorf, 2009).

2.2.8 Other Reference Material

1) An Index of Regional Sustainability: A GIS-based MCA DSS for progressing sustainability (Graymore, Wallis, & Richards, 2009)

   This paper focuses on sustainability assessment at the regional scale by building a sustainability index that considers the interactions occurring between and within the systems. It has been included as an information only item, i.e. a detailed synthesis has not been conducted. Refer to the Appendix A for a copy of the paper.

2) Spatial Decision System for the Westernport Region Victoria (Pelizaro & McDonald, 2006)

   This system utilises a number of models that are interlinked through a cascade of their results. One set of model results are used as input into the next in a modelling chain. The system derives a set of socio-economic-environmental measures (performance indicators), such as land use, nutrient and sediment concentration in water (water quality measures), and other relevant indicators for coastal and bay ecosystems. This article has been included as an information only item, i.e. a detailed synthesis has not been conducted. Refer to the Appendix A for a copy of the paper.

2.3 GIS Technology Review

2.3.1 Geodatabase Fundamentals

A geodatabase is a collection of geographic datasets, designed to store, query, and manipulate geographic information and spatial data. It provides the ability to leverage data relationships, enforce data integrity and create intelligent features. In terms of environmental data, vector data is stored as point, line and polygon geometry data type with an associated spatial reference system (ESRI, 2006).

Understanding geodatabase elements is important for building a sound design (Arctur & Zeiler, 2004). Vector data is stored in a geodatabase as thematic layers otherwise known as *feature classes*. Environmental data and associated (fixed) base layers are stored in a geodatabase as a collection of geographic features with the same polygon geometry type. They are generally grouped together within a feature dataset with the same coordinate system to model geospatial relationships between them.

Geodatabases have the advantage of being able to store feature classes within a feature dataset so geospatial relationships can be modelled between the feature classes, enabling more advanced GIS analysis. Topology can be introduced to manage the spatial relationships between feature classes in the feature dataset. A geodatabase supports an approach to modelling spatial objects by incorporating their behaviour while supporting different types of key relationships between them. A collection of rules and relationships can be applied to the datasets to assist in accurately modelling their geometric relationships (Arctur & Zeiler, 2004).

Examples of environmental feature classes include:

- Nature refuges
- Digital Cadastral Database (DCDB)
- Estate boundaries
- Remnant vegetation
- Regrowth vegetation
- Biodiversity planning assessment areas
- Local government administrative boundaries
- Mining (exploration permits, coal, mineral, petroleum etc).

As an example, Zhou et al. (2007) used GIS technology to analyse the offshore marine placer gold deposits at Nome, Alaska. The primary task of the GIS project underpinning this was the building of geodatabases. The

digital data was in different formats, so two relational geodatabases were created to store and integrate the information. The Integrated Geodatabase (IG) was used for data management, information queries and to serve as a warehouse to store various geological data such as borehole, bedrock geology, surface geology and geochemical data. The second geodatabase (R2.5DG) was generated based on the IG and was used to estimate gold resources, define orebody boundaries and perform grade interpolation. The R2.5DG facilitated data management, retrieval and integration and was used to perform advanced analysis tasks such as queries, geostatistical and numerical modelling (Zhou, Chen, Li, Luo, & Huang, 2007).

RCC currently utilise the ESRI suite of GIS software and make effective use of geodatabases in support of council's spatial needs. Continued use of geodatabases as a spatial data management platform is a logical choice for NEDS.

Geodatabase: Modelling and Managing Spatial Data

The following documents and podcast have been reviewed:

- The Geodatabase: Modelling and Managing Spatial Data ArcNews winter 2008/2009 (ESRI, 2008/2009)
- Working with the Geodatabase ESRI White paper 2002 (ESRI, 2002)
- An overview of the GDB and five reasons why you should use it, ESRI Podcast (ESRI, 2007).

All three sources had a similar view that geodatabases are the industry standard data model for ArcGIS. All sources focused on File Geodatabase (one of the physical implementation options for deploying a geodatabase without the requirement for significant infrastructure) and the multi-user geodatabase using ArcSDE.

A benefit of a File Geodatabase is that it does not limit NEDS in any way, as ArcGIS geodatabase solutions are scalable and transportable, therefore allowing an easy migration path to an ArcSDE environment.

A geodatabase was released with Version 8 of the ArcGIS suite of products and since then has been the primary and preferred data model for ArcGIS. Today geodatabases are a fundamental component of the ArcGIS software and are easily integrated into Desktop, ArcGIS Server, as well as other non-ESRI information systems and allow for streamlined workflows that are time- and cost-effective.

There are many benefits to using a geodatabase. Those that relate to RCC include:

- Geodatabases are a more robust and extendable data model compared to shapefiles and coverages. Coverages and shapefiles do not take advantage of new technologies.
- It enables GIS data (spatial and attribute) to be centrally managed. Storing the data in one central location allows easy management and access for GIS users and eliminates silos of information. There are many different data types supported by geodatabases with tools to easily migrate data.
- Geodatabases can store large datasets. NEDS requires a range of different datasets that vary in size.
- Data entry and editing is more efficient. By applying constraints to the data, a high level of data integrity can be maintained. Default values, subtypes and domains are all ways that this can be achieved.
    - Subtypes - Define categories for features.
    - Domains – Set legal values that can be inputted for a field. This limits the possibility of error while editing.
- Geodatabases allow information to be integrated with other IT systems as needed. As an example, RCC have a loose integration between IBM Maximo for Asset Management and Red-e-map, allowing a rudimentary level of integration that allows geographic visualisation of asset data for users, a capability not inherently available or utilised in the Maximo environment.
- Geodatabases can be scaled to use ArcSDE technology in order to provide additional capability at an enterprise (multi-user) level not available in other geodatabase implementations (such as personal or file), e.g. versioning, replication and archiving (refer to figure below). The NED's geodatabase will therefore have the ability to scale to a multi-user database should RCC require it.

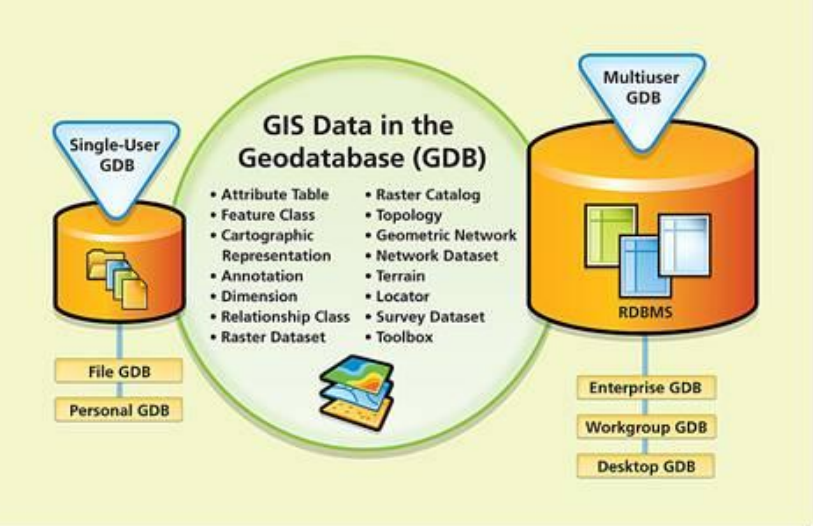

Figure 2 ESRI 2008/2009 The Geodatabase: Modelling and Managing Spatial Data

3.0 Review of RCC Current Systems

3.1 Introduction

The following review is a result of an interview with the RCC GIS Manager on 3 October 2011 and consolidated comments received from a variety of GIS users within Council. The purpose of this review was to ascertain strengths and weaknesses of RCC's current application of GIS technology in support of environmental management and identify opportunities for consideration in the development of NEDS. Refer to Appendix B for a full synopsis of the interview and subsequent SWOT analysis.

3.2 Overview

3.2.1 History

RCC currently has a mapped database containing the EI of habitats and their relative ecological functions and significance. The current database is a single ESRI shapefile with considerable associated documentation. Conservation Management Areas (CMAs) within the shapefile are currently prioritised into four categories of conservation significance (Priority, Major, General and Enhancement) and are assigned functional roles (Habitat, Corridor, Tidal, Patch etc).

Current EI mapping represents historical information that remains a valuable resource to inform the planning and management of ecologically significant areas in the Redland LGA.

3.2.2 Current Technology

RCC currently utilises the following suite of software to deliver GIS services to the council and public:

- Microsoft Windows XP Build 2600 SP3 (PC operating system)
- ArcGIS Desktop 9.2 SP6 (GIS desktop software)
- ArcSDE 9.2 on SQL Server 2000 and 2005 (Enterprise RDBMS with ESRI based spatial engine)
- Microsoft .Net application linked to ArcIMS 9.2 (for RediMap web-based GIS)
- Microsoft Source Safe (for version management of scripts, database views, etc).

3.3 Review

3.3.1 Geodatabase

RCC have a number of SDE databases spread across both staging/editing and published environments. These form the physical implementation of the corporate geodatabase infrastructure. Batch jobs are run automatically on a frequent basis, which updates the published environments, e.g. weekly updates. The advantage is that published environments are disposable; i.e. they can be easily recreated should they be corrupted in any way. The geodatabase also contains a number of static layers defining planning scheme rules/zoning.

For the purposes of NEDS, a File Geodatabase has been identified as a suitable implementation option, with the flexibility to be incorporated into an SDE based enterprise database in the future should that be a requirement.

Current SDE geodatabases avoid feature datasets, topologies and relationship classes as spatial data does not conform to the rigidity imposed by those fixed structures and they are too difficult to manage within RCC's SDE. This will not have any implications on the design of the geodatabase for NEDS as it will be a File Geodatabase and a data repository dedicated to NEDS and therefore such facilities as topology, relationship classes or feature datasets can be incorporated as required.

3.3.2 Internal Processes and Standards

RCC has strong and well developed processes including strict naming standards based on a hierarchic level of three character mnemonics.

Microsoft Source-Safe is used to manage versioning, e.g. for database views, scripts etc. It is envisaged this would be a suitable repository to be manage the NEDS AECOM deliverable and associated components.

A strong culture has been built on spatial information and is now considered a critical aspect of the business and is strongly entrenched in RCC asset management business processes.

Technology

Advice from RCC is that current GIS software will not be upgraded in the short term. An upgrade of the ESRI-based GIS environment from version 9.2 has been estimated to be 24 months away. The current focus of RCC is on getting the data right.

GIS Tools are kept relatively simple and intuitive. Geoprocessing tools use Model Builder and very little Python scripting is used.

NEDS development will therefore be restricted to only the functionality that is available within the current RCC GIS software versions (as opposed to using features or functionality contained in subsequent versions of the ESRI software suite not currently in use by RCC). This should not impact NEDS development and will ensure any tools that are developed function within the RCC software version (9.2) as well as the current ESRI software version (10.x) available in the market. This will ensure that NEDS is future proofed, but will not take advantage of any new features in version 10.x.

3.3.3 NEDS Scope

Output from NEDS will be used to generate layers in Redimap or its next incarnation, and will consist of layers representing both Conservation Value and Enhancement Potential (at various scales). These outputs will in turn be used to create policy through a human decision-making process. NEDS will not determine policy, rather it will provide information to decision makers in order to make informed decisions and policy. A spatial expression of policy will be created by RCC and used to disseminate information internally and externally, such as layers in Redimap for land-use planning.

RCC require a toolset that is extensible and future-proof. This will be a design goal of NEDS and enforced via a "keep it simple" philosophy. NEDS's outputs need to be comprehensible, i.e. readily understood and easily interpreted.

3.3.4 Current Environmental Inventory

The current EI is a single ESRI shape file that is now locked in time, i.e. it can't be disaggregated, rather it is a current expression of policy and provides an interpretation of values.

Advice from RCC is that the cadastre was used as a base (starting point), which turned out to be a mistake as it has resulted in a highly fragmented dataset of CMAs. RCC indicate it would be a better approach to use natural boundaries (phenomena that do not change unlike the cadastre) and intersect/apply the DCDB as the final step in the process only. This will be factored into the design of NEDS to ensure the same issues do not happen again and that NEDS outputs are flexible and extendable.

RCC GIS Skills

The GIS team has largely been assembled through restructure, with people having a variety of backgrounds and skills.

The team has recently lost its analyst/programmer but has gained a spatial data coordinator. It has three focuses, namely operational management, data management and systems development. A business case is being developed for an additional analyst/programmer position; however, the team does have the ability to maintain the current set of geoprocessing tools. One of the team has recently attended a Python programming course.

The team now has the security of having permanent staff and this has cleared up one of RCC's biggest threats to GIS capability.

It is AECOM's view that RCC therefore have adequate skills to be able to operate and maintain NEDS at an appropriate level.

3.3.5 RCC Current Utilisation of GIS

The following uses of GIS for environmental planning have been articulated and are relevant requirements to be considered for incorporation into NEDS:

- Identification of constraints and opportunities for development and identification of areas for conservation/enhancement (i.e. habitat to be protected, 'gaps' in linkages between habitat that should be enhanced to provide for wildlife corridors), and opportunities for infrastructure provisions (i.e. road network and recreational open space). Spatial data has assisted in informing design criteria for future development; including waterway buffers, drainage requirements, and fauna treatments to facilitate road crossings.
- Predictive GIS mapping of waterway management units as a tool to set priorities for annual work programs and report progress.

A number of issues and ideas were also raised by users of GIS:

- Existing system is not capable of update, hence information is out of date and layers are incompatible with different resolutions. This is an artefact of the current EIv4. It was also indicated that the EIv4 cannot be interrogated for detailed information and that categories are not easy to interpret.
- For dissemination of information within RCC a preference was raised to 'save' a view or work session and forward that for people to access via Redimap (rather than producing a simple screen capture). This has no implications for NEDS, but is a consideration for RCC internal GIS processes.
- Good quality maps are produced; however, mapping products are not always used to their fullest potential due to a range of internal factors and the currency of the data which quickly changes over time. The implications for NEDS are for RCC to ensure currency of input data and for AECOM to develop geoprocessing tools that enable input datasets to be easily updated.
- Of significant importance is the upcoming RPS review (which will run over the next few years). A comprehensive tool is required that collates existing data and provides a consistent, transparent, repeatable methodology for making land use decisions across the city (i.e. zoning and overlay decisions). This is consistent with current NEDS design intent.
- In forming policy and understanding the effects of policy, it is seen as important to be able to test the spatial impact of policy change before approval. The implication to NEDS is the ability to cater for the application of "what-if" scenarios.

4.0 Recommendations

4.1 Key Findings from Review

A SWOT summary in the format of a table is included in Appendix C. The key findings are:

- Use automation to ensure consistent and repeatable processes – e.g. re-runnable geoprocessing routines allow defensible results. Ensure transparency and auditability in repeatable processes, which allows consistent results to be achieved.
- Keep geoprocessing models in a single unified environment for ease of maintenance, flexibility, training and extensibility. Ensure NEDS is extensible and future proofed (flexible and adaptable to change).
- Ensure policy is closely linked to spatial extents – i.e. need to be able define extents on ground to ensure enforceability.
- Ensure design is flexible to allow future changes in legislation etc.
- Spatially link DSS to allow a co-ordinated approach to policy development and promote data and model integration through a common special reference and visual environment for what-if analysis.
- Interpretation of outputs is critical – they must be easily understood and comprehended and based on sound scientific foundations.
- Ensure architectural separation (decoupling) of data management from model management in user interface.
- Data quality is critical. Good decisions can only be based on sound data. This is in-line with RCC's data focused approach, i.e. "get the data right" and "garbage in = garbage out".
- GIS is a critical part of the toolsets used across all projects. Acceptance is growing of spatial technologies as a critical aspect of technology in supporting business activities. This is very much the case with RCC.
- Decision factors, weightings, inputs, criteria, etc need to be clearly defined, i.e. the business rules (scientific foundations) to apply to NEDS.
- Allow for weightings/criteria/input data to be adjusted and models rerun to enable different scenarios or to apply different temporal data sources.
- Ensure all stakeholders are involved in development of NEDS, especially criteria, weightings etc.
- Integrate non-spatial data/information with GIS to combine geographical data with multiple criteria decision models and produce maps that show the ranking of options. This will enable a visual (spatial) representation of policy.
- NEDS may require development (scripting) outside of Model Builder, as it is unlikely that it alone will handle all cases. However, use of scripting should be minimised to keep the solution as simple as possible and therefore easy to maintain.
- Apply strong naming convention across datasets, scripts, models/processes database views etc.
- Spatial culture is strong in RCC. Management already recognises spatial information and technology as a critical tool to support all aspects of the business.
- Lessons Learnt - Ensure use of natural boundaries as foundation layers for NEDS and only incorporate DCDB in the final stages.
- DERM ecological spatial data (e.g. REs, regrowth vegetation, wetland management areas, essential habitat, biodiversity planning assessment mapping) may provide a useful starting point for development of foundation layers. However, the 1:100,000 scale of DERM mapping may compromise the value of these datasets for use at the local scale.
- Outputs from NEDS must be easily understood (comprehensible) as they will be required to support policy development.

In conclusion, the GIS discipline is subject to fast-paced technology changes, therefore regular upgrades to software and hardware are crucial. Another key obstacle is that the technologies require the user to learn the system's complex language.

GIS can manage data and information, but it is generally not smart enough to do all the work. Many operations in GIS require human involvement (Chen & Tan, 2008). Therefore, a lack of adequate and in-depth training could be a limitation to successfully building on the research design.

Cartography is an integral part of GIS and the design of a map is a complex process (ESRI, 2004)). GIS users may be highly skilled in performing spatial analysis, but if they do not know how to effectively communicate those results through map presentation, they risk producing dangerously misleading maps.

4.2 GIS Technologies Recommended for NEDS

It is evident from the review that the current ESRI GIS technology suite utilised by RCC is an appropriate platform on which NEDS can be built and operated effectively. ESRI software is one of the industry's best-of-breed and is utilised for environmental management and other causes world-wide. It is recommended; however, that RCC ensure an upgrade of its software versions is planned for an appropriate time in the future to maintain currency and support and to utilise new features that could enhance NEDS in the future.

4.2.1 Geodatabase

The geodatabase is the most suitable data management repository to fulfil the requirements of NEDS. The physical implementation of this will be managed as a File Geodatabase. This complies with the RCC GIS environment and enables simplicity of deployment whilst being flexible and adaptable for future incorporation into enterprise DBMS environments utilising SDE in the future should this be a requirement of RCC.

4.2.2 Geoprocessing

Geoprocessing is a common process in GIS. It allows the creation of new data from altered or informed extracts from existing data to help solve problems. Data in NEDS will need to be run through geoprocessing tools to answer defined questions about the biodiversity of an area. These tools can be built from a combination of different sources by utilising tools available within ESRI's ArcTool box.

The core of NEDS will be a set of automated geoprocessing tools (to generate required outputs) that can be run by the RCC GIS Team in a manner that ensures consistent and repeatable outcomes are achieved through a transparent and auditable process.

The primary tool to achieve this will be Model Builder, a core part of the functionality contained within the ESRI software for scripting and automating geoprocessing. This environment is highly graphical and intuitive in nature; however, has potential limitations due to its simplicity. AECOM intend to use Model Builder to its fullest capacity, while recognising that Python scripting may be required for more complex geoprocessing.

Python is a scripting language utilised by ESRI to enable complex logic to be built into geoprocessing tools. Use of Python will be minimised. Where incorporated, AECOM will ensure an appropriate level of documentation is included within the scripts to ensure maintainability by RCC. It is understood that RCC have a limited level of expertise in Python but are looking to recruit these skills in the future.

4.2.3 Spatial Data Management

Appropriate metadata will be incorporated into NEDS at all three levels, namely input datasets, geoprocessing tools, and outputs. This will ensure appropriate lineage (traceability) can be ascertained from NEDS outputs back to the input datasets.

4.2.4 Technology Refresh

Apart from the initial upgrade of the GIS environment to the latest ESRI software version, AECOM suggest ongoing planning allows for an appropriate budget to ensure a technology refresh (update) at a minimum of every two years to allow for ongoing developments and improvements in technology and ensure RCC can maintain its GIS environment to current standards.

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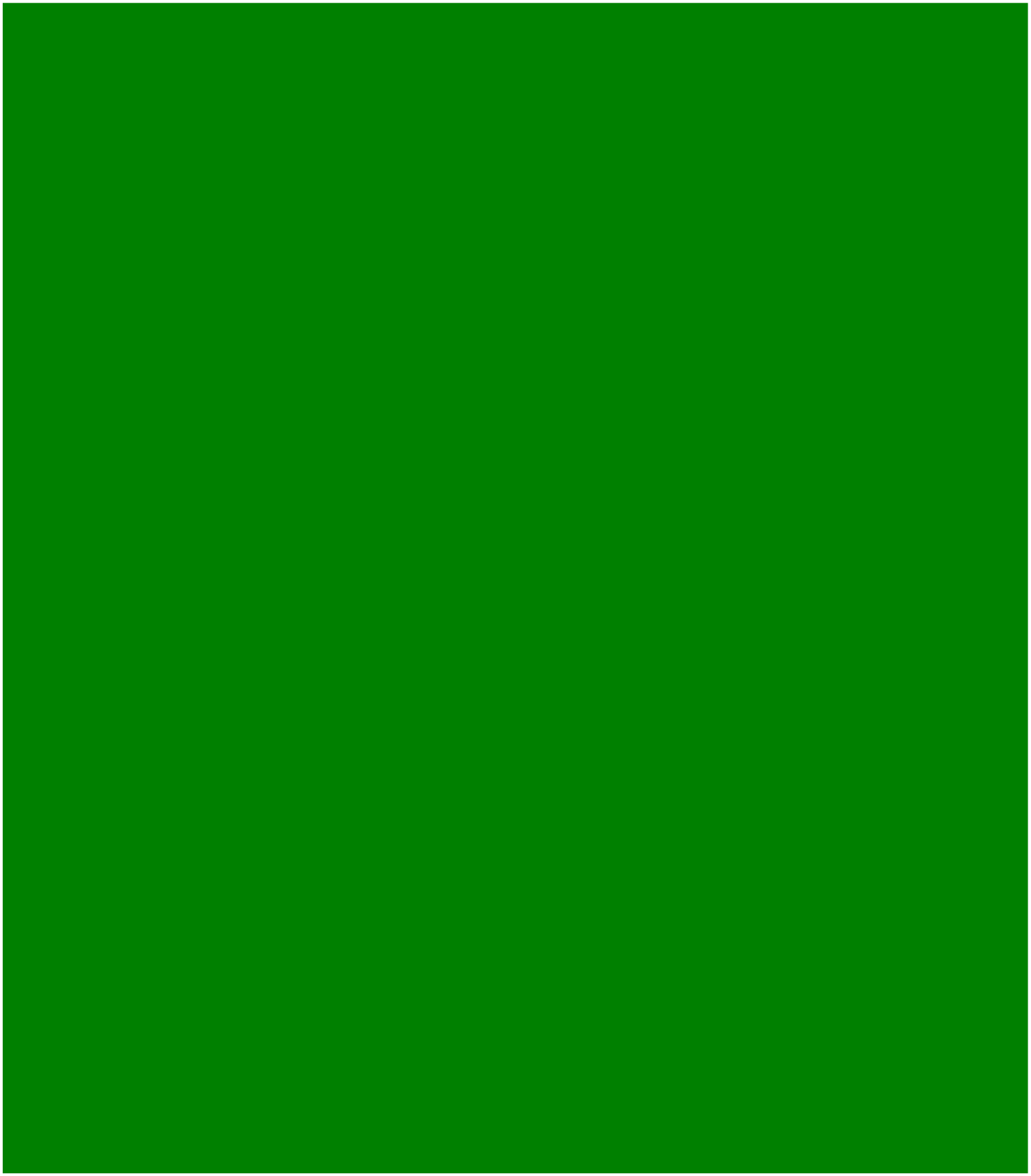
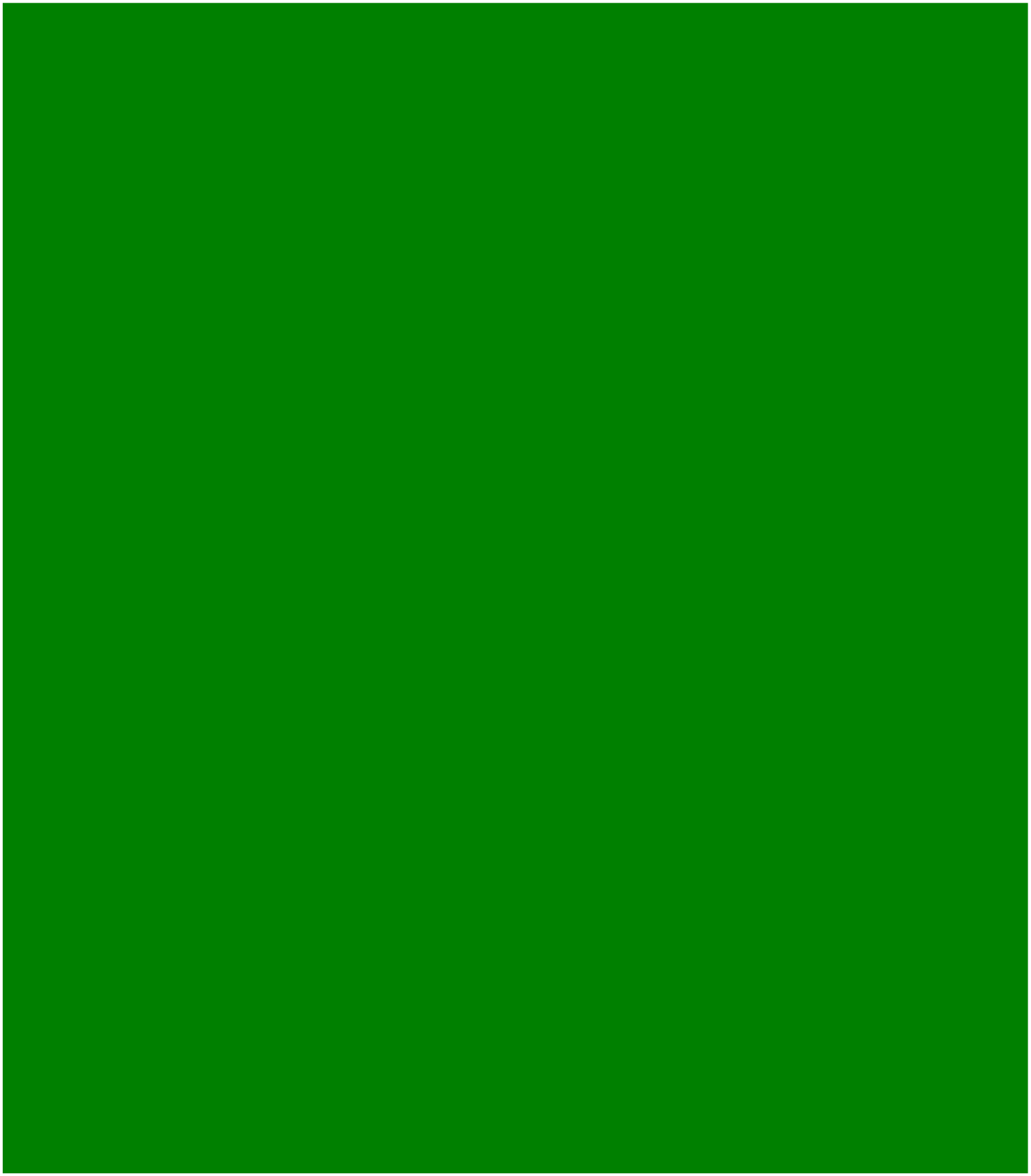
Appendix A – Documentation Reviewed

Appendix B – AECOM Review Synthesis



Appendix C – SWOT Summary