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URBANISATION PRESSURES & FLOOD RISK

Gawler River Catchment & Regional Development

Graeme Riddell, Hedwig van Delden, Holger Maier
The University of Adelaide, Australia
Research Institute for Knowledge Systems, the Netherlands

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INTRODUCTION

Adelaide is built on a natural floodplain and as such is at constant threat of inundation from flood waters. The risk from flooding is a significant threat to South Australia, with it being the State's most costly natural hazard. In 2017 the State's average annual damages from flooding were approximated at $32 million (Burns et al., 2017). It is also estimated that 8,500 properties are vulnerable to a 1-in-100-year event (as of 2010).

Flood risk is a complex interaction between many dynamic and interrelated processes, and can be considered as the combination of the flood hazard itself (its depth, extent, and velocity can all be considered), along with the assets and values exposed to the hazard and the vulnerabilities of these. This can be considered as the 'risk triangle' (Crichton, 1999).

Each of these factors is also subject to change with time. Flood hazard is impacted by climate change via various mechanisms including changing intensity and frequency of rainfall events, along with impacts on vegetation and antecedent moisture (van Aalst, 2006; Alfieri et al., 2015). The exposure and vulnerability of the region is also changing with increased economic productivity and residential demands for land, along with different building codes and personal resilience (Koks et al., 2015; Mazzorana et al., 2012).

There are also interactions between the components of flood risk such as the impact of urbanisation in a floodplain – increasing the number of exposed assets and increasing runoff, along with new developments and changing building codes influencing the vulnerability of buildings in a floodplain. This report will specifically highlight the interaction between new development in a region and its flood risk in the Gawler River floodplain.

As exposure increases driven by the need to meet economic and population demands for land, catchments become increasingly urbanised and hence impermeable. This reduces the ability for the landscape to manage the risk of pluvial flooding, as natural surfaces are replaced with more impermeable surfaces (like concrete or asphalt) leading to increased runoff.

This report will look at the probability of urbanisation in the Gawler River floodplain in comparison to areas subject to inundation and of high flood hazard.

To achieve this the Metronamica land use model (www.metronamica.nl) was applied to the region and calibrated to incorporate the local context and conditions appropriately. This model was then used to consider scenarios for the region's growth (economic and population) to 2050 to consider the location and likelihood of urbanisation and its relationship to flood hazard.

This is done to highlight the value of considering changes in urbanisation and flood risk, however it should be noted this modelling is performed as proof-of-concept and should not be used for any planning or investment decision.

OBJECTIVES

This report has the following objectives:

- Show results of the developed land use model, and its ability to simulate land use change into the future;
- Perform Monte-Carlo simulation to show the areas likely to urbanise that are in land subject to inundation in the Gawler River floodplain;
- Highlight the importance of considering dynamic exposure in flood risk management.

STUDY AREA

The land use model area considered is the Greater Adelaide region of South Australia. This is as defined by the Australian Bureau of Statistics (ABS) and classified as the Greater City Centre Statistical Area (GCCSA) of Adelaide, South Australia.

Figure 1 shows the region as defined by its included local government areas (LGAs). The region is approximately 326,000ha and encompasses 27 LGAs.

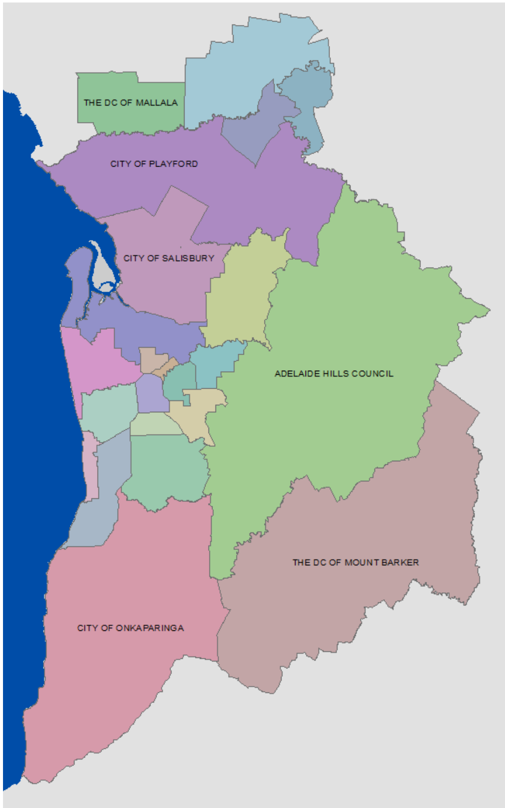

FIGURE 1 - GREATER ADELAIDE, GREATER CITY CENTRE STATISTICAL AREA

The analysis on flood risk however focusses on the Gawler River catchment in the North of Adelaide. Figure 2 shows the Gawler River Floodplain Management Authority region included within the model area, which is a combination of six local councils; Adelaide Hills Council, City of Playford, Light Regional Council, Barossa Council, Town of Gawler and Adelaide Plains Council.

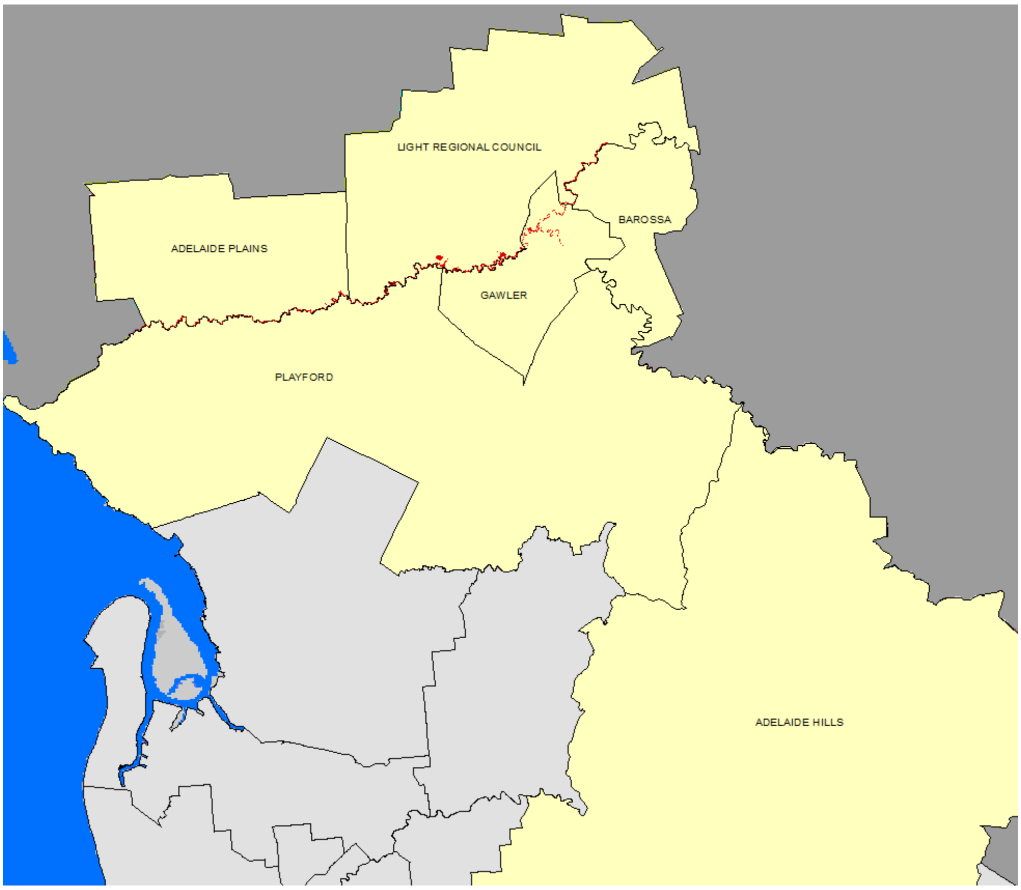

FIGURE 2 - GAWLER RIVER FLOODPLAIN MANAGEMENT AUTHOIRTY AREA, AND THE GAWLER RIVER

METHODOLOGY

The following sections will provide details on the below listed aspects of the study:

- Land use modelling approach
- Land use model development
- Land use data and parameters
- Flood modelling
- Baseline scenario considered

METRONAMICA LAND USE MODELLING APPROACH

The primary goal of METRONAMICA is to explore the effects of (alternative) policy options on the quality of the socio-economic and physical environment and, with this information at hand, to stimulate and facilitate awareness building, learning, and discussion prior to the decision-making proper. To this end, the system combines autonomous developments with policy-induced changes to form integral pictures of possible futures for the area modelled and evaluates their relative value on the basis of social, economic and ecological criteria. It does not seek to provide the highest levels of detail on separate economic, ecological or social dimensions, rather it aims to deal with our living environment as an integrated entity. Although this means losing some detail, the benefit of the approach is the strong integrative and interactive nature of the resulting system, in which highly dynamic, autonomous processes play a key role.

The motor driving the spatial changes in METRONAMICA is fueled by socio-economic developments. The model allocates economic activities and population by means of a Cellular Automata (CA) based land use model (White and Engelen, 1993; van Delden et al., 2011a; RIKS, 2017). To that effect, the modelled area is represented as a mosaic of grid cells typically representing a parcel of land covering, depending of the type of application and the desired spatial detail, anything from 25x25 m to 1000x1000 m. Each cell is modelled dynamically and together the cells constitute the changing land use pattern of the city, region or country. In principle, it is the relative attractiveness of a cell as viewed by a particular spatial agent, as well as the local constraints and opportunities that cause cells to change from one type of land use to another and to experience an increase or decrease of activity levels. The demands for activity and land per region drive the model from the national and regional level, while the local competition for space determines which activities will be allocated and hence which land use demands will be met.

Four local drivers determine the activity levels of a cell as well as whether a piece of land is taken in by a particular land use (as shown in Figure 3):

1. **Physical suitability.** Suitability is represented in the model by one map per modelled activity. The term suitability is used here to describe the degree to which a cell is fit to support a particular activity. It is a composite measure, using an overlay of GIS maps, to determine the physical, ecological and environmental appropriateness of cells. Factors

used are typically: elevation, soil quality and stability, agricultural capacity, air quality, noise pollution, etc.

2. **Zoning or institutional suitability.** Zoning too is characterized by one map per activity. It is a composite measure based on master plans and planning documents available from the national, regional or local planning authorities including among others ecologically valuable and protected areas, protected culturescapes, buffer areas, urban expansion plans etc. For the various plans an interpretation can be made if these are restricting activities, allowing activities under certain conditions, not providing any limitations to activities or even stimulating them.

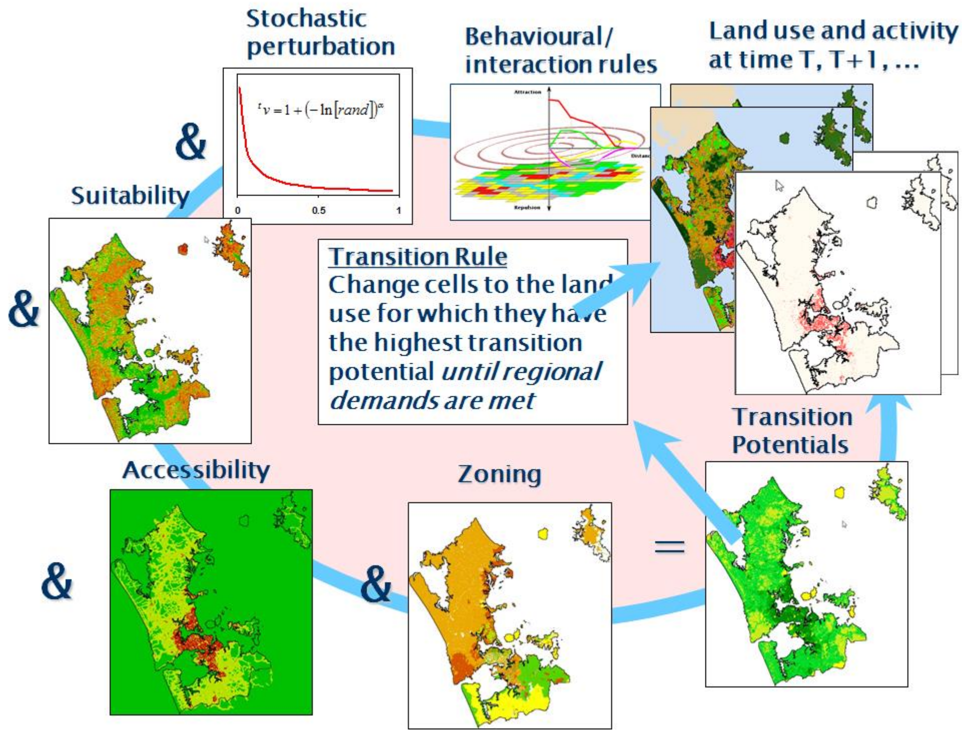

FIGURE 3 – ELEMENTS DETERMINING THE DYNAMICS AT THE LOCAL LEVEL (APPLICATION AUCKLAND, RESOLUTION IS 1 HA)

3. **Accessibility.** The accessibility for each land use function is calculated in the model relative to the infrastructure networks, consisting of the road network, the railways and railway stations, the navigable waterways, the irrigation channels, etc. It is an expression of the ease with which an activity can fulfil its needs for access to infrastructure and/or mobility in a particular cell. It accounts for the distance of the cell to the nearest link or node on each of the infrastructure elements, the importance and quality of that link or node, and the needs of the particular activity to be close to these elements.

4. **Human behaviour.** While the above three elements are introduced in the model to determine the non-homogeneous nature of the physical space within which the land use dynamics unfold, there is a fourth and important aspect, namely the dynamic impact of activities and land uses in the area immediately surrounding a location. This is no longer the domain of abstract planning, rather that of the reality on the ground representing the fact that the presence of complementary or

competing activities and land uses is of great significance for the quality of that location and thus for its appeal to particular activities. For each location, each cell that is, the model assesses the quality of its neighbourhood. For each activity, a set of rules determines the degree to which it is attracted to, or repelled by, the other functions present in the neighbourhood, which also includes the location itself. The strength of the interactions as a function of the distance separating the different functions within the neighbourhood, is articulated in these rules. If the attractiveness is high enough, the function will try to occupy the location, if not, it will look for more attractive places. New activities and land uses invading a neighbourhood over time will thus change its attractiveness for activities already present and others searching for space. This process explains the decay of a residential neighbourhood due to the invasion by industrial or commercial activities, as well as the gentrification and revival of decayed neighbourhoods initiated by the arrival of a new type of residents, or economic activities, few high quality functions like parks, exclusive office buildings, high-end condominiums, etc. These rules determine the interactions between the different functions: the inertia, the push and pull forces, and economies of scale, the economic and political power to actually occupy the locations of highest interest.

On the basis of these four elements, the model calculates for every simulation step the transition potential for each cell and activity. In the course of time and until regional demands are satisfied, cells will change to the land use function for which they have the highest transition potential. Consequently, the transition potentials reflect the pressures exerted on the land and, together with the simulated land use dynamics, constitutes important information for those responsible for the design of sound spatial planning policies.

Monte-Carlo Simulation

The stochastic perturbation shown in Figure 1, simulates the effect of unpredictable occurrences, and is considered within the neighbourhood effect. Monte-Carlo simulation is a method to analyse a series of possible outcomes. The analysis involves the generation of a multitude of outcomes with small differences that are eventually aggregated. In METRONAMICA terms this means a series of land use maps is generated that are a little different since they are computed using a stochastic (random) term. From these maps the likelihood is computed that a cell will take a specific land use. Hence if a cell will become residential in 23 out of 50 runs, it will get a value for residential of 0.46 (23 / 50).

Monte-Carlo simulation is therefore used to consider probability of urbanisation by taking the cumulative probability a non-urban land use class transitions to an urban land use class over the simulation period. 100 runs were simulated for this analysis.

MODEL DEVELOPMENT

Metronamica model development includes the application, calibration and validation of the model to the region of interest. Application involves making conceptual choices regarding the selection of input data, the land use classification, the spatial resolution, the area extent and the time horizon. It furthermore requires preparing the input data and setting up the model for the selected region. Calibration entails the parameterisation of the model, while validation encompasses the assessment of the parameters, the model's behaviour and the results calculated.

An overview of the Metronamica application, calibration and validation procedure is provided below:

1. As part of the data analysis the current situation and historic developments are analysed. This includes analysing the temporal change in total area surface for various land uses as well as the change in landscape structure. Regarding the latter, metrics such as the clumpiness index (McGarigal, 2014) and the rank size distribution (Gabaix, 1999) are used in conjunction with a visual inspection of the developments. Furthermore, the enrichment factor is used to analyse the over- and underrepresentation of certain land uses in the neighbourhood of changed land uses (Van Vliet et al, 2013).

2. Model set-up includes a set of choices relevant for setting up the model to a specific region and context. In CA-based land use modelling main choices are related to the decision on the area extent, the applied resolution and the selection of land use classes to be modelled, where finding a balance between providing additional information and creating a false sense of accuracy is often a crucial point of discussion (Van Delden et al, 2011b).

3. During the calibration, parameter values are set and fine-tuned and subsequently the model is assessed on its behaviour and results, frequently over a historic calibration period. Difficulties in calibrating CA-based land use models mainly relate to the large number of parameters that need to be set, the limited availability of time series of land use maps, and finding objective ways to assess the quality of the calibration. Regarding the latter, progress has been made over the past years, which has resulted in the use of neutral models to act as a benchmark for quality assessment (Hagen-Zanker and Lajoie, 2008), together with the use of objective measures to complement the more subjective visual assessment. To assess the quality of the calibration we take into account the predictive accuracy, which is the ability of the model to accurately simulate actual land use patterns; and the process accuracy, the extent to which the modelled processes are consistent with real world processes (Brown et al, 2005). Main indicators used for assessing the quality of the calibration are indicators for location agreement, such as Fuzzy Kappa (Hagen-Zanker, 2009) and Fuzzy Kappa Simulation (Van Vliet et al 2013); indicators for landscape structure agreement, such as the clumpiness index (McGarigal, 2014), the fractal dimension (Chen,

2011), the rank size distribution (Gabaix, 1999), and the enrichment factor (Van Vliet et al, 2013); and visual inspection.

4. During the validation, the model's behaviour and results, based on the parameters settings obtained during the calibration, are assessed over a data set independent from the one used as part of the calibration. This usually results in an evaluation of the model's behaviour over a different historic period; although other independent data sets are equally valid (see e.g. Van Vliet et al 2010). Assessment criteria are the same as for the calibration.

5. Finally, the model is tested and evaluated on its long-term behaviour, which includes a long-term simulation with the calibration parameters, a number of tests with extreme scenarios to assess the robustness of the model, a number of tests to assess the sensitivity of model results on small changes to the parameter settings and some tests to assess the impact of the main perceived uncertainties.

METRONAMICA DATA & PARAMETERS

Data used within the development, calibration and validation of the Metronamica model for Greater Adelaide are split between the model components of Metronamica – land use, accessibility, suitability and zoning.

Each section below will outline the data used for each and the way the data has been processed to be included within the model.

Land Use

Human behaviour is analysed within the model using historical land use maps and considering the changes between them. This is used to calibrate the inertia of a land use and its relative attractiveness to other uses.

For Greater Adelaide four land use maps were used for the calibration and validation of Metronamica, 2006, 2013, 2015 and 2016.

These generalised land use maps were sourced from data.sa.gov.au.

Files:

landuse_2006.shp
landuse_2013.shp
landuse_2015.shp
landuse_2016.shp

Maps were 'clipped' to the region of interest (see Figure 1).
For standardisation purposes and to minimise data errors across time slices, the land protected under the National Parks & Wildlife Act were over-laid each map, as were airport areas and reservoirs (extracted from landuse_2013.shp).

Table 1 and 2 show the mapping of Generalised Land Use Descriptions in 2006 and 2013 to the included land use class for the model.

TABLE 1 & 2 - GENERALISED LAND USE DESCRIPTIONS AND MODELLED LAND USE IN METRONAMICA FOR 2006 (LEFT – TABLE 1) AND 2013 (RIGHT – TABLE 2)

2006 Description	Modelled Land Use
Agriculture	Agriculture
Commercial	Commercial
Education	Public institutions including education
Food_Industry	Industry
Forestry	Forest
Golf	Recreation
Horticulture	Horticulture
Livestock	Livestock
Mine_Quarry	Mine and quarry
Nonprivate_ resid	Residential
Pub_Institution	Public institutions including education
Recreation	Recreation
Reserve	Forest
Residential	Residential
Ret_Commercial	Commercial
Rural_resid	Rural residential
Util_Industry	Industry
Vacant	Vacant
Vacant_Resid	Vacant

2013 Description	Modelled Land Use
Agriculture	Agriculture
Airport	Airport
Commercial	Commercial
Education	Public institutions including education
Food_Industry	Industry
Forestry	Forest
Golf	Recreation
Horticulture	Horticulture
Infrastructure	Infrastructure
Livestock	Livestock
Mine_Quarry	Mine and quarry
Nonprivate_ resid	Residential
Pub_Institution	Public institutions including education
Recreation	Recreation
Reserve	Reserve
Reservoir	Reservoir
Residential	Residential
Ret_Commercial	Commercial
Rural_resid	Rural residential
Util_Industry	Industry
Vacant	Vacant
Vacant_Resid	Vacant

NB: 2015 and 2016 follow the same mapping as 2006.

The totals for land across the modelled land uses are shown in Table 3.

TABLE 3 – TOTAL LAND USE PER METRONAMICA CLASSIFICATION 2006 - 2016

Index	Metronamica Land Use	Area Totals (ha)			
		2006	2013	2015	2016
0	Vacant	13333	9558	10043	10346
1	Forest	22726	30401	30693	29131
2	Residential	42475	43425	43851	44188
3	Rural residential	78443	81816	82377	83813
4	Commercial	3669	4208	4170	4288
5	Public institutions including education	6431	6204	6283	6224
6	Recreation	7618	5179	5158	5155
7	Industry	6190	5864	6324	6318
8	Agriculture	27941	25672	26128	26011
9	Horticulture	33038	33390	32928	32689
10	Livestock	60703	56188	55314	55168
11	Airport	1171	1173	1173	1172
12	Infrastructure	8928	10067	8761	8697

13	Reservoir	5434	5409	5437	5436
14	Mine and quarry	6930	6476	6390	6394

Metronamica defines land uses with a type relating to how it is modelled, and an explanation of these types is given below, Table 4.

TABLE 4 – LAND USE TYPES CONSIDERED WITHIN METRONAMICA

Type	**Description**
Vacant (passive dynamic)	Classes that only change as a result of other land use dynamics. Typically abandoned land or natural land use types are modelled as vacant state, since they are available for other land uses or the result of the disappearance of other land use functions.
Function (active dynamic)	Land use classes that are actively modelled, like residential or industry. Functions change dynamically as the result of the demands for land and the local dynamics.
Feature (static)	Land use classes that don't change in the simulation, like water bodies or airports. However, they do influence the dynamics of the function land uses, and thus their location.

Land uses are also classified by their environmental and social-economic group for the calculation of spatial indicators. Environmental groups include – *forest, natural (non-forest), urban* and *other*. Social-economic groups include – *recreation, residential, work* and *other*.

The land use type and the environmental and social-economic group of each land use class modelled within Metronamica for Greater Adelaide, is shown in Table 5.

TABLE 5 – LAND USE CLASSIFICATION AND GROUPINGS FOR GREATER ADELAIDE METRONAMICA APPLICATION

Index	**Name**	**Type**	**Environmental Group**	**Social-Economic Group**
0	Vacant	Vacant	Natural (non-forest)	Other
1	Forest	Vacant	Forest	Recreational
2	Residential	Function	Urban	Residential
3	Rural residential	Function	Urban	Residential
4	Commercial	Function	Urban	Work
5	Public institutions including education	Function	Urban	Work
6	Recreation	Function	Natural (non-forest)	Recreational
7	Industry	Function	Urban	Work
8	Agriculture	Function	Natural (non-forest)	Other
9	Horticulture	Function	Natural (non-forest)	Other
10	Livestock	Function	Natural (non-forest)	Other
11	Airport	Feature	Urban	Other
12	Infrastructure	Feature	Urban	Other
13	Reservoir	Feature	Natural (non-forest)	Other
14	Mine and quarry	Feature	Other	Other

15	Sea	Feature	Natural (non-forest)	Other
16	Land outside Greater Adelaide	Feature	Other	Other

Accessibility

Accessibility typically relates to the infrastructure networks that enable an activity to meet its mobility and access needs.

For the Greater Adelaide model seven types of accessibility were considered as inputs to the model:

- Road network
- Rail network
- Rail stations
- Tram network
- Tram stops
- Bus stops

Each transport network was sourced from data.sa.gov.au and processed for the Greater Adelaide model extent.

South Australia adopts a road classification with an eight-level hierarchy. The SA road network was simplified to three classes in the model application, reflecting its significance to the mobility needs of the land use activities. The re-classification is shown in Table 6.

TABLE 6 – SA ROAD HIERARCHY LINKED TO METRONAMICA ROAD TYPES

SA Road Hierarchy	Modelled Road Network Classes
Highway	HWY / FWY
Freeway	
Arterial Road	SUB / ARTERIAL
Sub-Arterial Road	
Collector Road	LOCAL
Local Road	
Track – 2 wheel drive	
Track – 4 wheel drive	Removed

Adelaide’s six suburban rail lines, along with 81 stations are included within the model, along with bus stops and the Adelaide – Glenelg Tram line and stops.

Suitability

Suitability relates to the physical characteristics of the land to support an activity in that cell.

Slope was used as a consideration for the development of urban land uses such as industrial, commercial and residential land. Slope is included in the model as the average slope across the 100m cell derived from Geoscience

Australia's Shuttle Radar Topography Mission (SRTM) Digital Elevation Model Version 1. (http://www.ga.gov.au/metadata gateway/metadata/record/gcat_72759)

For agricultural, horticultural and livestock land uses, land use potential as modelled by the Department of Environment, Water and Natural Resources (DEWNR) was included. This land use potential uses soil and land attributes impacting on productivity and management requirements of different crops (Rowland et. al., 2016).

Factors considered in this land use potential include:

- Soil type
- Topography
- Waterlogging / salinity / drainage
- Chemical barriers to root growth
- Soil depth / water storage
- Soil fertility
- Soil physical conditions
- Erosion potential

For further details please see (Rowland et. al., 2016).

Land use potential maps for the below agricultural crops are associated with the respective land use classes following the classification on (https://www.environment.sa.gov.au/Knowledge_Bank/Information_data/soil-and-land/assessing-land-use-potential, accessed 5/05/2017).

TABLE 7 – LAND USE POTENTIAL MAPPING LINKED TO MODELLED LAND USE CLASSES

Agriculture	**Horticulture**	**Livestock**
Barley	Almonds	Dryland lucerne
Canola	Apples	Dryland lucerne (acid soil tolerant varieties)
Chickpeas	Brassicas	Irrigated lucerne
Faba beans	Carrots	Dryland grazing.
Field peas	Cherries	Dryland phalaris
Lentils	Citrus	Dryland perennial ryegrass
Lupins	Grape vines	Irrigated perennial ryegrass (high value)
Oats	Grape vines (mechanically harvested)	Dryland strawberry clover
Triticale	Olives	Summer fodder
Wheat	Onions	
Durum wheat	Pears	

Each map of land use potential is classified across 10 classes, based on the potential.

TABLE 8 – LAND USE POTENTIAL CLASSIFICATION

Value	Proportion of land with moderate to high potential	Most common potential class
Aa	More than 60%	High potential (mostly Class 1)
Ab	More than 60%	Moderately high potential (mostly Class 2)
Ac	More than 60%	Moderate to high (mixed)
Ad	More than 60%	Moderate potential (mostly Class 3)
B	30-60%	Low to high potential (mixed)
C	10-30%	Moderately low to low potential (mixed)
D	1-10%	Moderately low to low potential (mixed)
Ea	Less than 1%	Moderately low potential (mostly Class 4)
Eb	Less than 1%	Low potential (mostly Class 5)
X	-	-

Five classes – as referenced in the above table – are also used to classify the quality of land use potential following FAO 1976.

TABLE 9 – LAND USE POTENTIAL CLASS DESCRIPTION

Class	Potential	Description
1	High potential	Land with high productive potential and requiring no more than standard management practices to sustain productivity.
2	Moderately high	Land with moderately high productive potential and / or requiring specific, but widely accepted and used, management practices to sustain productivity.
3	Moderate	Land with moderate productive potential and / or requiring specialized management practices to sustain productivity.
4	Moderately Low	Land with marginal productive potential and / or requiring very highly specialized management skills to sustain productivity.
5	Low	Land with low productive potential and /or permanent limitations which effectively preclude its use.
X	Not applicable	Not applicable (urban, lakes, reservoirs, evaporation pans, quarry, etc.).

The classification shown in Table 9 is considered in the model by transforming its land use potential to a suitability value, Table 10, and the maximum suitability value across all agricultural crops taken per land use (agriculture, horticulture, livestock) in a particular cell. This makes the assumption that a decision is made to cultivate the most appropriate crop in that cell.

TABLE 10 – LAND USE POTENTIAL CLASS TO MODELLED SUITABILITY VALUE

Class	Suitability Value
Aa	0.9875
Ab	0.9625
Ac	0.9375
Ad	0.9125
B	0.8625
C	0.8
D	0.7625

Ea	0.7525
Eb	0.75125
X	0.75

Zoning

Several zoning plans are included within the model and determine whether a particular land use is actively stimulated, allowed, weakly restricted or strictly restricted in a location.

Six zoning strategies are included within the model in its initial set up.

- National Parks & Wildlife Areas
- Development categories
- Parklands
- Vacant residential areas
- Metropolitan Open Space System
- Major project status (Buckland Park Township)

See Appendix for details regarding how each zoning plan was considered within the model impacting on function land use classes.

Each zone can have one of 5 influences on development of a land use in a cell, Table 11 outlines these states and how they are numerically included in the calculation of the transition potential.

TABLE 11 – ZONING STATUS DESCRIPTION FOR METRONAMICA ZONE CLASSES

Zoning status	Description	Numerical value
Actively stimulated	Specific category encourages development of a specific land use function – numerical zoning value >1	1.5
Allowed	Specific category allows development of a specific land use function, has no influence over transition potential – numerical zoning value =1	1
Weakly restricted	Specific category discourages but does not fully restrict development of a specific land use function – numerical zoning value 0 < X < 1	0.5
Strictly restricted	Specific category fully restricts the development of a specific land use function, turning the transition potential to 0 – numerical zoning value = 0	0
Unspecified	Specific category does not influence a specific land use function or that no information for that category is available	-

Calibration, Validation and Evaluation

A simplified procedure was followed for the calibration, validation and evaluation of the model.

As part of the BNHCRC project (2014-2017 Decision support system for assessment of policy and planning investment options for optimal natural hazard mitigation) a set of five exploratory scenarios was developed to explore future (land use) dynamics, see Riddell et al. (2016). For this study we have taken the scenario that resembles a business as usual scenario, and which aligns with assumptions from the 30 Year Plan for Greater Adelaide. In this scenario, the interaction rules representing human behaviour were to the extent possible set based on historic developments as obtained from land use maps. They were then complemented based on assumed behaviour in the scenario and expert judgement.

The assessment of the quality of the model's behaviour, resulting from these settings as well as the settings described in the previous paragraphs, focused on its ability to simulate plausible long-term futures and was done based on expert judgement.

FLOOD MODELLING

Gawler River Floodplain Mapping (2015) was provided by DEWNR under Creative Commons Licence.

Depth maps included:

- 200 year average return interval
- 100 year average return interval
- 50 year average return interval

Original modelling was undertaken by Australian Water Environments.

Associated report: *Gawler River Floodplain Mapping Report,* Version 2.2, 2015, Australian Water Environments.

BASELINE SCENARIO

For the baseline scenario used within this analysis land demands were sourced from various reports used in the development of the Greater Adelaide Plan.

Table 12 highlights initial land use demands used for the baseline scenario for entire Greater Adelaide model region

TABLE 12 – LAND USE DEMANDS 2016 – 2050 FOR BASELINE SCENARIO

Land use	Initial Demand, 2016 (Ha)	Final Demand, 2050 (Ha)
Residential	44,188	50,223
Rural Residential	83,813	89,848
Commercial	4,308	4,764
Public Institutions including Education	6,235	6,435
Recreation	5,219	5,413
Industry	6,318	7,582
Agriculture	25,974	22,109
Horticulture	32,522	31,055
Livestock	54,474	46,893

Values derived from:

Housing and Employment Land Supply Program – 2012 Monitoring Report.

Population Projections for South Australia and Statistical Divisions 2011 – 2041, DPTI, September 2015.

Considering the medium population growth scenario for the Adelaide statistical area which projects a population of 1,535,308 by 2041 (increase of 329,152 from 2011 base year).

2004 – 2010 Residential demolition and resubdivision report, Adelaide Statistical Division, DPTI, February 2014.

Greater Adelaide Economy and Employment – Background Technical Report (Final Report), SGS Economics & Planning (for Planning SA), September 2008.

Buckland Park Township Inclusion

The proposed major project – Buckland Park Township – was incorporated into the model by including a specific zoning layer actively stimulating Residential, Rural Residential, Commercial, Public Institutions including Education, land use functions from 2020 onwards.

Changes to the road network were also included, matching proposed roads under the Buckland Park Township Proposed Master Plan (Version 6).

The initial land use map (as specified in Section 3.3.1) was adapted to reflect the changed land use from Agricultural and Horticultural land use functions to Vacant in preparation of the Buckland Park Township, along with certain established developments of Commercial and Public Institutions including Education, reflecting the Buckland Park Township Proposed Master Plan (Version 6).

RESULTS

The Monte-Carlo simulation was performed for 100 runs, with a simulation period from 2016 to 2050.

The resultant raster maps with range [0,1] for urban land uses (Commercial. Industry, Public institutions including education, Residential, and, Rural residential) were summed, to show the cumulative probability of a cell transitioning from a non-urban to urban land use.

The following figures show the cumulative probability with the mapped inundation depths for various average return intervals.

Figure 4: Gawler River, Urban Land Use Change (2016 - 2050), 1 in 50 ARI Flood Inundation

Figure 5: Gawler River, Urban Land Use Change (2016 - 2050), 1 in 100 ARI Flood Inundation

Figure 6: Gawler River, Urban Land Use Change (2016 - 2050), 1 in 200 ARI Flood Inundation

KEY FINDINGS

From the modelling shown in Figure 4-6 some key findings can be summarised:

- There is significant 'spill' in the North-West corner of the region, comparing 1in50 (Figure 4) to 1in100 (Figure 5) and 1in200 (Figure 6) which sees increased exposure to low probability urbanisation areas.
- Several areas with high probability of urbanisation are exposed to flooding in all return periods, especially in Adelaide Plains. This development should therefore be considered high risk, and mitigation strategies devised.
- Development south of the Gawler River in Playford is similarly consistently exposed to flooding from modelled return periods and should be treated as high risk.
- Buckland Park Township exhibits a high probability of urbanisation, which is to be expected given zoning and infrastructure developments. The development however appears to be minimally exposed to return periods modelled. There is also a high likelihood that this development reduces exposure in other areas within the study-region by concentrating development.
-

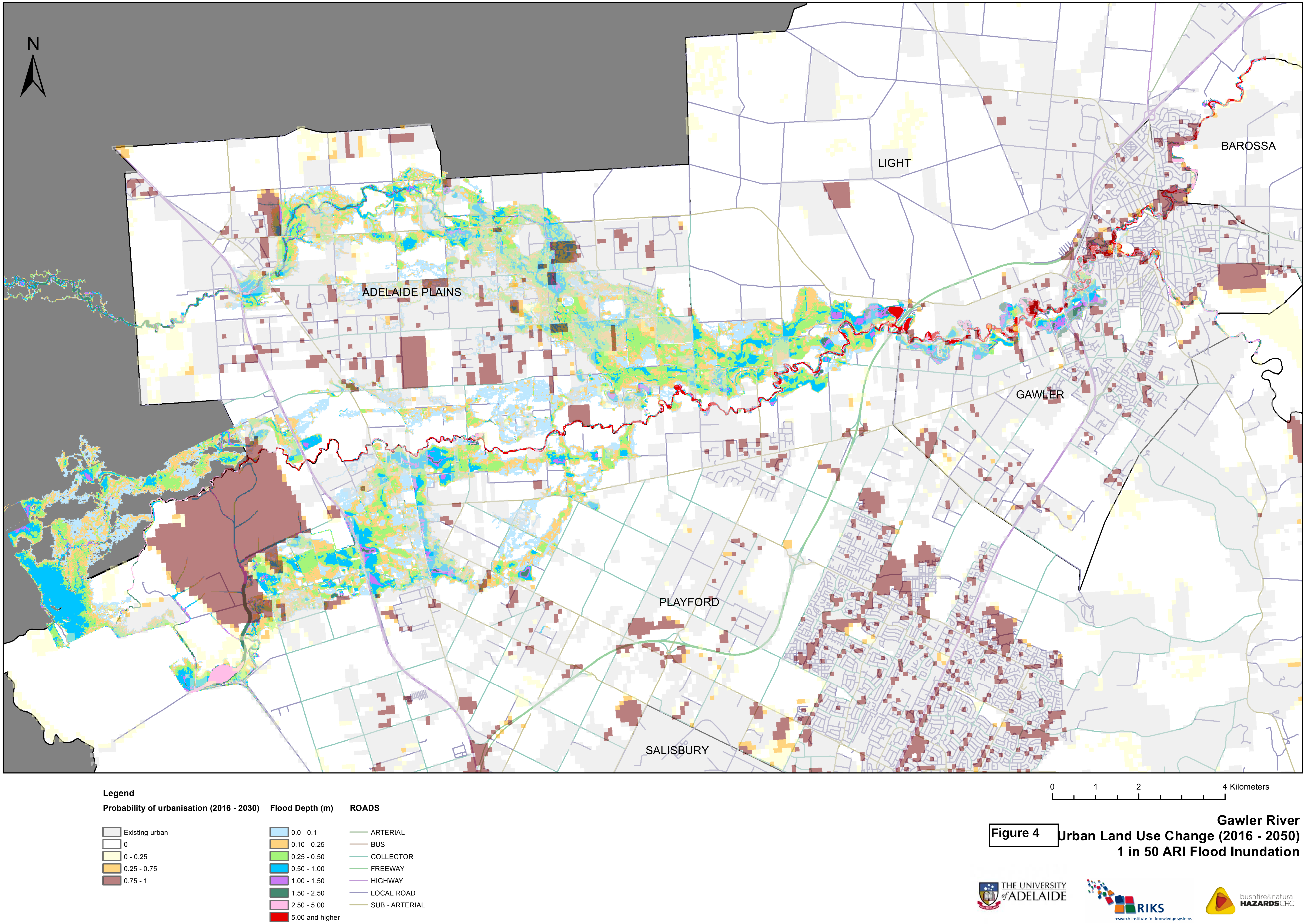

Figure 4

Gawler River
Urban Land Use Change (2016 - 2050)
1 in 50 ARI Flood Inundation

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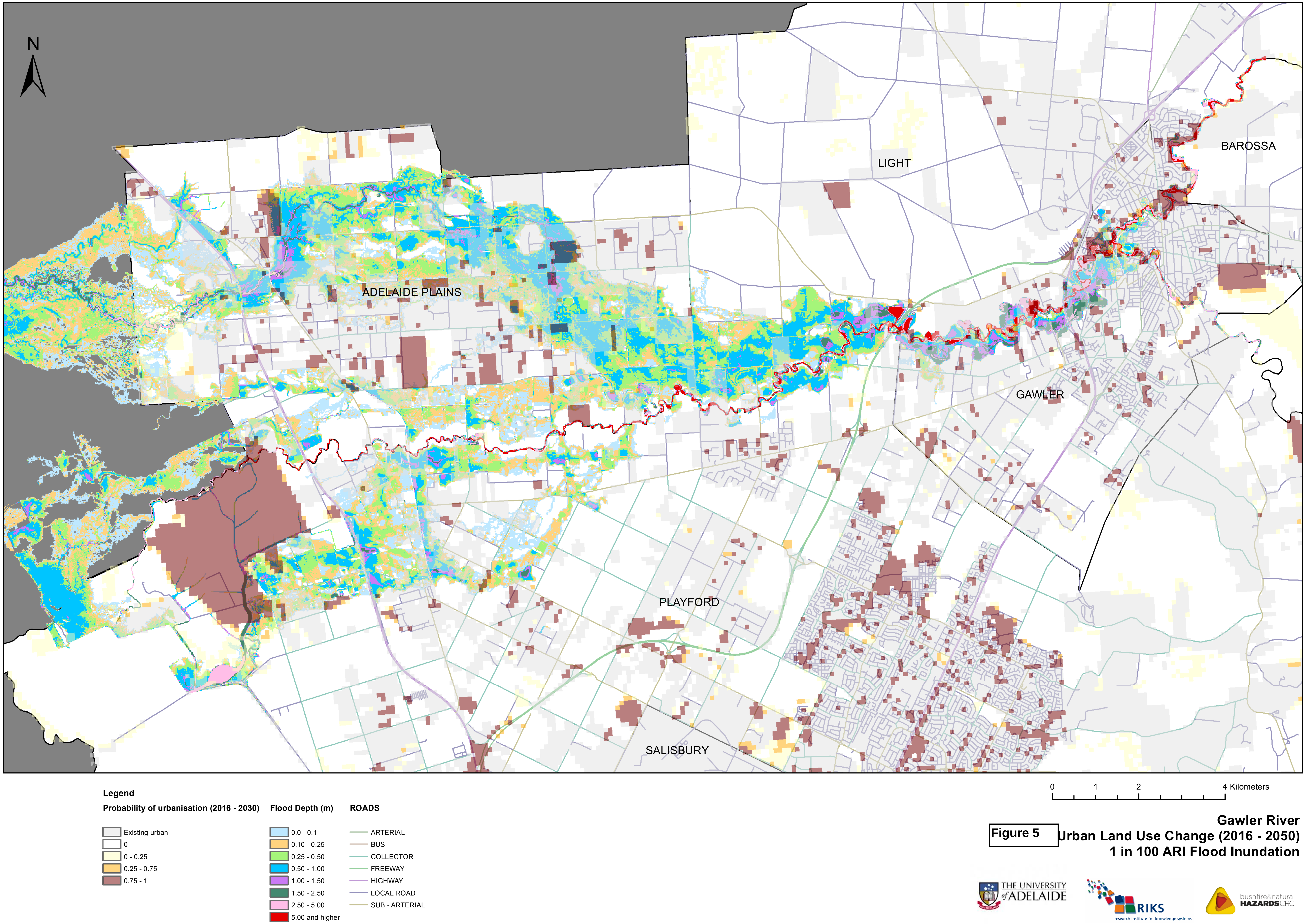

Figure 5 Gawler River
Urban Land Use Change (2016 - 2050)
1 in 100 ARI Flood Inundation

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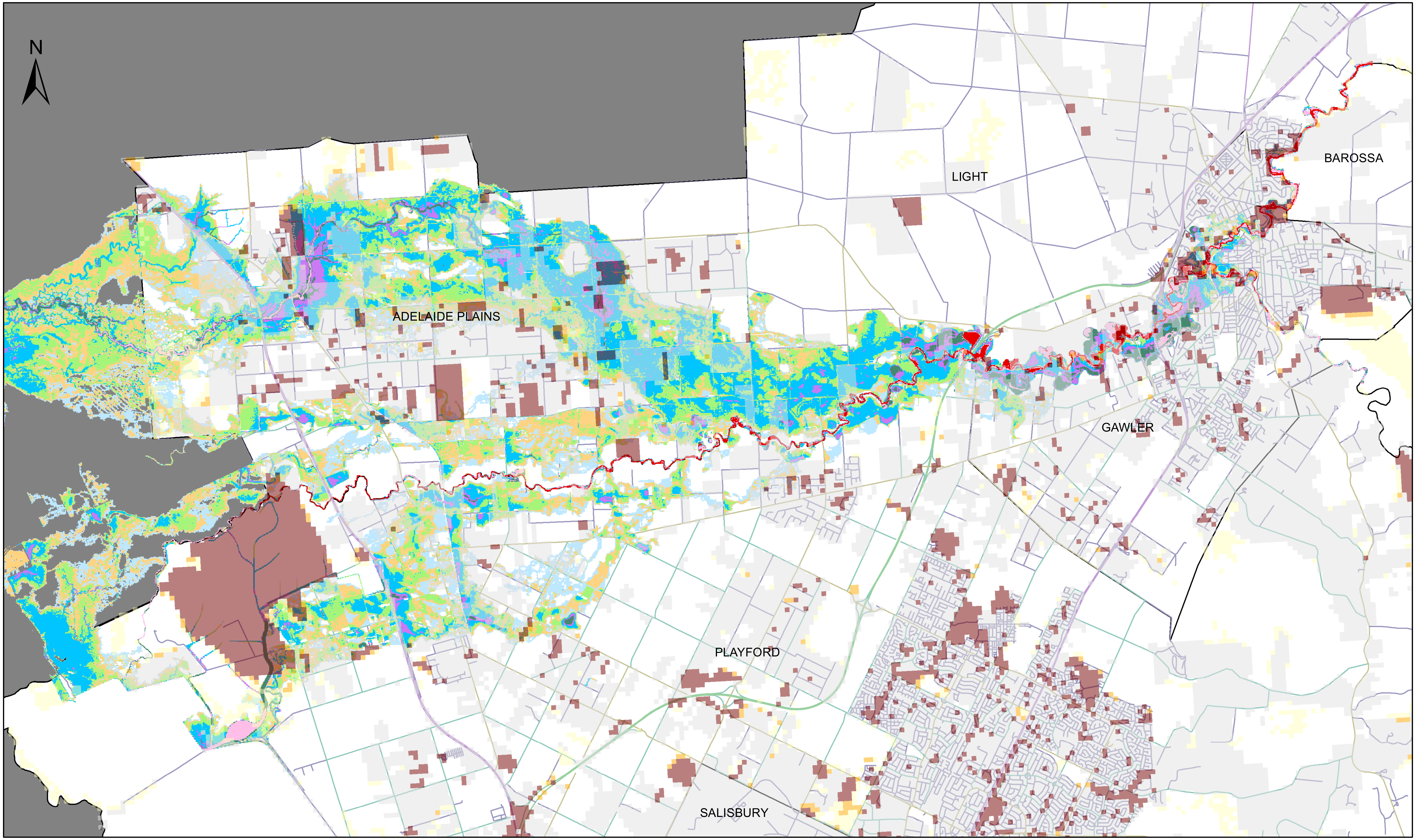

Legend

Probability of urbanisation (2016 - 2030)	Flood Depth (m)	ROADS
Existing urban	0.0 - 0.1	ARTERIAL
0	0.10 - 0.25	BUS
0 - 0.25	0.25 - 0.50	COLLECTOR
0.25 - 0.75	0.50 - 1.00	FREEWAY
0.75 - 1	1.00 - 1.50	HIGHWAY
	1.50 - 2.50	LOCAL ROAD
	2.50 - 5.00	SUB - ARTERIAL
	5.00 and higher	

Figure 6

Gawler River
Urban Land Use Change (2016 - 2050)
1 in 200 ARI Flood Inundation

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CONCLUSIONS

This report highlights the consideration of exposure modelling for flood risk understanding and subsequent management. The Monte-Carlo simulation of urbanisation in the Gawler River Floodplain shows the area most likely to be urbanised (developed from natural to urban land uses) between 2016 and 2050. This enables an improved understanding of where the risk from flooding is likely to increase in the future due to increased runoff and value of exposed assets.

By analysing modelling of both the flood hazard and development patterns in the region, planners and risk professionals can gain a greater understanding of where the 'hotspots' of flood risk will be, and which land is more or less suitable to allow for development. With continued use of this modelling approach the impact of development restrictions, as well as potential / proposed development areas can be tested in terms of their interaction with flood hazards.

Future flood modelling can also be updated by considering likely development patterns and areas by updating the hydrological model assuming levels of permeability for future urban areas. This will enable improved understanding of the impact of urbanisation on flood extent and depth, and provide a broader consideration of development in the floodplain in terms of its impact on flood risk.

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APPENDIX

		Residential	Rural Residential	Commercial	Industry	Public Institutions including Education	Agriculture	Horticulture	Livestock
National Parks & Wildlife Areas	Policy enacted	Strictly restricted	Strictly restricted	Strictly restricted	Strictly restricted	Strictly restricted	Strictly restricted	Strictly restricted	Strictly restricted
Parklands	Policy enacted	Strictly restricted	Strictly restricted	Strictly restricted	Strictly restricted	Strictly restricted	Strictly restricted	Strictly restricted	Strictly restricted
Vacant Residential	Policy enacted	Actively stimulated	Actively stimulated	Weakly restricted	Weakly restricted	Weakly restricted	Unspecified	Unspecified	Unspecified
Metropolitan Open Space System	Policy enacted	Weakly restricted	Weakly restricted	Weakly restricted	Strictly restricted	Weakly restricted	Unspecified	Unspecified	Unspecified
	Conservation	Weakly restricted	Weakly restricted	Weakly restricted	Strictly restricted	Unspecified	Unspecified	Unspecified	Unspecified
	Environmental Constraint	Weakly restricted	Weakly restricted	Weakly restricted	Strictly restricted	Unspecified	Unspecified	Unspecified	Unspecified
	Residential	Allowed	Allowed	Allowed	Weakly restricted	Allowed	Unspecified	Unspecified	Unspecified
	Country Township	Allowed	Allowed	Allowed	Weakly restricted	Allowed	Unspecified	Unspecified	Unspecified
	Rural Living	Allowed	Allowed	Allowed	Weakly restricted	Allowed	Unspecified	Unspecified	Unspecified
	Historic Residential	Allowed	Allowed	Weakly restricted	Strictly restricted	Unspecified	Unspecified	Unspecified	Unspecified
	Hills Face Zone	Allowed	Allowed	Allowed	Weakly restricted	Unspecified	Unspecified	Unspecified	Unspecified
	Rural	Allowed	Allowed	Allowed	Strictly restricted	Unspecified	Unspecified	Unspecified	Unspecified
	Deferred Urban	Actively stimulated	Allowed	Actively stimulated	Allowed	Unspecified	Unspecified	Unspecified	Unspecified
	Mixed Uses	Allowed	Weakly restricted	Allowed	Allowed	Unspecified	Unspecified	Unspecified	Unspecified
Development Categories	Miscellaneous	Allowed	Unspecified	Allowed	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified
	Commercial	Weakly restricted	Unspecified	Actively stimulated	Weakly restricted	Unspecified	Unspecified	Unspecified	Unspecified
	Community Facilities	Unspecified	Unspecified	Allowed	Weakly restricted	Unspecified	Unspecified	Unspecified	Unspecified
	Watershed Protection	Unspecified	Weakly restricted	Strictly restricted	Strictly restricted	Unspecified	Unspecified	Unspecified	Unspecified
	Industrial	Unspecified	Weakly restricted	Allowed	Allowed	Unspecified	Unspecified	Unspecified	Unspecified
	Industry	Unspecified	Weakly restricted	Allowed	Allowed	Unspecified	Unspecified	Unspecified	Unspecified
	Infrastructure	Unspecified	Weakly restricted	Allowed	Allowed	Unspecified	Unspecified	Unspecified	Unspecified
	Open Space	Unspecified	Allowed	Weakly restricted	Strictly restricted	Unspecified	Unspecified	Unspecified	Unspecified
	Primary Production - Mining	Unspecified	Unspecified	Allowed	Strictly restricted	Unspecified	Unspecified	Unspecified	Unspecified
	Recreation	Unspecified	Unspecified	Allowed	Weakly restricted	Unspecified	Unspecified	Unspecified	Unspecified
	Special Use	Unspecified	Unspecified	Weakly restricted	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified