

REPORT

Deferred Lands Strategic Bushfire Risk Assessment

PREPARED FOR

**Northern Beaches
Council**

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TENRIVERS
Environment. Strategy. Action.

QUALITY STATEMENT

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1 Executive summary

This risk assessment was commissioned to examine the bush fire risk profile of the Deferred Lands area of the Northern Beaches, including parts of Belrose, Oxford Falls and Cromer.

The purpose of this risk assessment is to inform the selection of risk-responsive and appropriate strategic land use planning controls for the Deferred Lands area as part of the formulation of a new Northern Beaches Local Environmental Plan (LEP) and Development Control Plan (DCP).

The primary objectives are to:

- understand and interpret the bush fire risk profile of the Deferred Lands area; and
- identify potential strategic land use planning approaches and controls for including within a new Northern Beaches LEP and DCP.

This report constitutes a Strategic Bush Fire Study for the purposes of Planning for Bush Fire Protection (PBP) 2019.

This risk assessment has adopted best practice techniques for identification of hazard and risk. In particular, a fireline intensity¹ analysis has been adopted to understand and interpret the spatial spread of fire and its intensity and likely behaviour.



Spatial or geographic spread of fire



Intensity of fire

This assists strategic planning considerations through an understanding of where, how intense and how fast fire might occur.

¹ As noted by Leonard et al. (2014) 'at a landscape scale, the preferred metric for indicating the potential severity of these impact mechanisms is fireline intensity. Fireline intensity is a standardised measure of the rate that an advancing head fire would consume fuel energy per unit time per unit length of fire front introduced by Byram (1959)'.

1.1 Hazard

At present, approximately 96.1 per cent of the Deferred Lands area is within 100m of potential bush fire hazard.

When considering only those areas where fireline intensity is modelled to exceed 30,000 kW/m (representing higher hazard and potential risk locations):

- the entirety of the Deferred Lands is within 700m of mapped bush fire hazard;
- 98 per cent of the land is within 400m of mapped bush fire hazard; and
- 71 per cent of the land is within 100m of mapped bush fire hazard.

The interim observations handed down by the 2020 Royal Commission into National Natural Disaster Arrangements identified that 99 per cent of dwellings lost during the 2019-20 'Black Summer' fires were located within 500m of bushland. Under current circumstance, the majority of the Deferred Lands is within 500m of identified hazard.

The final report identified over 80 recommendations, including the need for strategic land use planning processes to consider natural hazard risk.

As it currently stands, a considerably high proportion of the Deferred Lands area is located in close proximity to bushland and is therefore exposed to bush fire hazard and potential risk.

1.2 Risk profile

The existing risk profile of the Deferred Lands area is associated with the high connectivity of fuels at the landscape scale and the area's complex topography, noting the land adjoins Garigal National Park to the north and west. The Deferred Lands area forms part of a broader landscape of contiguous fuel.

A suite of fire weather and hypothetical development scenarios were tested as part of this risk assessment, providing enhanced awareness to inform risk-responsive decision-making which considers a multitude of different scenarios. FFDI 100 is the fire weather threshold required for land use planning purposes in Greater Sydney.



Likelihood
'Likely'
probability of FFDI
100 fire weather



Consequence
'Moderate' to
'Catastrophic' relative
to fire weather



Existing risk exposure in the Deferred Lands is associated with dwellings and businesses on large rural allotments, a substantial number of vulnerable uses and critical infrastructure of regional and national significance.



796
Residents of the Deferred Lands



495
Allotments within the Deferred Lands



436
Estimated dwellings in the Deferred Lands

Based on fireline intensity modelling, the highest risk locations of the Deferred Lands area are evident across multiple scenarios, including under more frequent, lower FFDI conditions.

This includes exposure of existing built form assets, and occupants, to fireline intensities exceeding 30,000 kW/m. In some locations, fireline intensities exceed 40,000 kW/m and 60,000 kW/m.

It is also noted the modelled higher risk areas of the Deferred Lands reflects a level of consistency or alignment with mapped historical fire event impacts which have occurred in the study area.

This risk assessment analyses the nature of existing and potential future risk, such that land use planning controls are identified to avoid, and otherwise mitigate, the potential emergence of unacceptable future risk through inappropriate and incompatible land uses which may otherwise establish.

1.3 Planning considerations

The provisions of Chapter 4 of PBP 2019 have been used to guide the assessment of hazard and potential risk, in accordance with the National Emergency Risk Assessment Guideline (NERAG) framework.

The Deferred Lands area is currently not subject to any zoning provisions pursuant to the current Warringah LEP 2000. Instead, the LEP permits a range of uses in the locality subject to increasingly stringent assessment processes for uses which are generally not considered consistent with the Character Statement for the area.

Planning for the Deferred Lands is also subject to provisions of the broader planning framework, which includes the North District Plan and the strategic intent established by Towards 2040 – Local Strategic Planning Statement. Under these instruments, part of the Deferred Lands is identified as Metropolitan Rural Area (MRA), which is intended to remain non-urban. This effectively limits the range of potential zones and land uses and the application of various state legislation (e.g. State Environmental Planning Policy (SEPP) (Housing for Seniors and People with a Disability) 2004 for this portion of the Deferred Lands area, irrespective of this risk assessment.

The balance area is identified within a future MRA investigation area where the appropriateness of different land uses is to be investigated. This risk assessment is one of a number of studies considering the future MRA investigation area.

There are also a number of SEPPs which may, or may not, be applicable to the Deferred Lands.

An existing risk present within the Deferred Lands is the large number of vulnerable facilities including child care facilities, schools and seniors living facilities. These are referred to under PBP 2019 as Special Fire Protection Purposes (SFPPs).

1.4 Planning options

This risk assessment identifies four (4) potential planning options for Council consideration in regard to how the risk profile of the Deferred Lands area is contemplated by and/or factored into planning instruments.



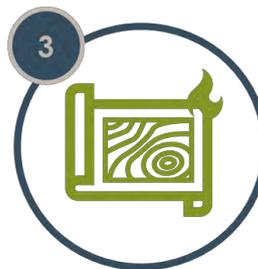
Option 1

Manage bush fire risk largely via reliance upon PBP 2019



Option 2

Land use allocation to avoid areas of highest bush fire risk



Option 3

Combined land use allocation and DCP provisions, including reliance on PBP 2019 provisions and additional controls



Option 4

Zoning based on the protection of environmental values

Planning Option 3 is the preferred approach identified by this risk assessment for Council's consideration.

Planning Option 3 combines a land use approach (intended to inform appropriate zoning allocation) with the adoption of statutory measures (established under PBP 2019 as well as additional

measures) for bush fire risk reduction as part of the formulation of the new Northern Beaches LEP and DCP.

This risk assessment does not nominate a specific zoning. Rather, it specifies the nature of potentially acceptable land uses which may be contemplated in locations with a higher level of exposure to potential risk.

This planning option seeks to avoid the highest potential areas for risk to life and property within the Deferred Lands area, employing a balanced approach which integrates both quantitative and qualitative considerations relating to hazard and risk, whilst identifying moderate hazard areas where statutory mechanisms could be reasonably deployed to mitigate risk to a tolerable level, subject to further, detailed site-based assessment.

Land within the future MRA investigation area which is exposed to potential fireline intensities of 30,000 kW/m or higher (including a 70m flame contact and radiant heat risk exposure buffer) is recommended to form part of the MRA, at a minimum, as part of a suit of planning measures to limit certain land use types and intensification which is likely to increase unacceptable risk.

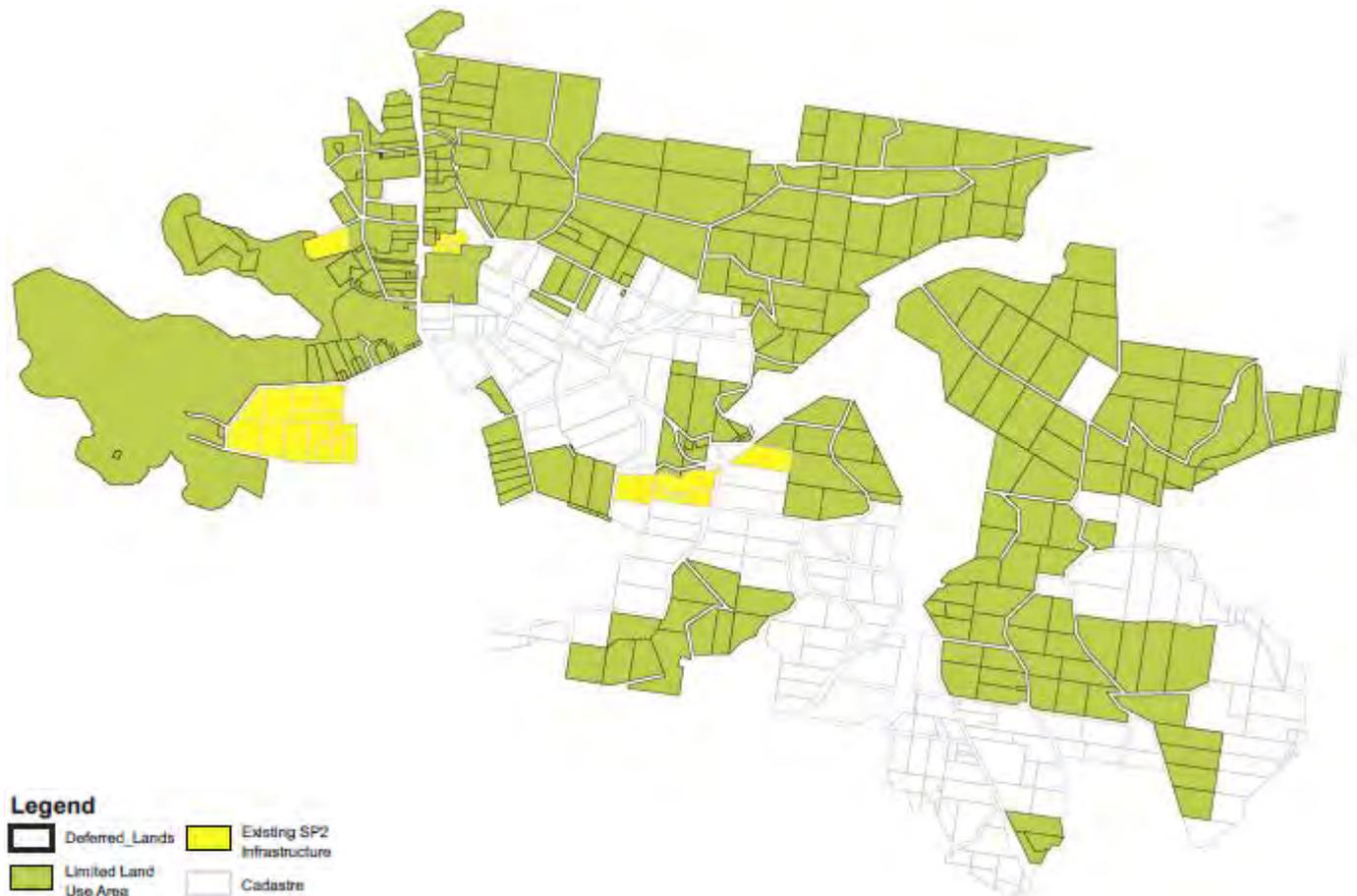


Figure i: Spatial representation of Option 3 and land where expansion and/or intensification is limited

1.5 Recommendations

This risk assessment provides several recommendations for Council's consideration, as follows:

1.5.1 Land use planning recommendations

1. Council considers the planning options identified and, on balance with the range of other planning interests relevant to the Deferred Lands, selects the most desired approach to respond to the nature of bush fire hazard and risk relevant to the Deferred Lands.

- a. Planning Option 3 is the preferred approach of this risk assessment, combining a land use approach (to inform zoning) for the highest hazard areas to limit potential land use permissibility and avoid heightened future risk, with statutory control measures deployed for areas of potentially moderate hazard, subsequent to further planning processes and assessment.
2. Land within the future MRA investigation area which is exposed to fireline intensities of 30,000 kW/m or higher (including a 70m flame contact and radiant heat risk exposure buffer) is recommended to form part of the MRA, at a minimum.
3. Following community and further stakeholder consultation, Council implements its preferred suite of land use controls within the new Northern Beaches LEP and DCP.
4. Council provides a copy of this risk assessment to the Department of Planning, Industry and Environment for its noting.
5. Any lands where future development may be contemplated could be the subject of preliminary structure planning activity which places bush fire responsive urban design at the forefront of the design intent, including the contemplation of strategic asset protection zones, avoiding ad-hoc site-specific approaches.
6. Any planning proposals should include a strategic bush fire study in accordance with the requirements of PBP 2019, and should ideally consider the content of this risk assessment.
7. A clear understanding of the environmental and biodiversity values of the Deferred Lands should be mapped, such that LEP and DCP controls can be considered which limit the damage, loss or fragmentation of environmental assets.
8. Consider the application of Cova's minimum exit requirements for interface communities (at Table 8) when assessing any new development within the Deferred Lands.

1.5.2 Operational recommendations

1. Existing SFPPs should be encouraged to prepare, implement and maintain bush fire management plans. Additional mitigation (i.e. clearing of vegetation) is subject to further assessment. This may be further considered as part of the preparation of the new Northern Beaches Bush Fire Risk Management Plan.
2. All relevant agencies, land managers and land holders, to review and implement, where appropriate, the recommendation identified in the NSW Bush Fire Inquiry Final Report. It is noted that Council has contemplated the findings of the Inquiry as part of the preparation of its new Bushfire Risk Management Plan.
3. Work with NSW RFS to determine the appropriateness of a Neighbourhood Safer Place within Oxford Falls Valley. This may be further considered as part of the preparation of the new Northern Beaches Bush Fire Risk Management Plan.
4. Council may consider forwarding a copy of this report to relevant infrastructure providers with assets in the Deferred Lands area, as information which may assist them to implement any appropriate additional protection measures which may be applicable (such as asset protection zones, radiant heat barriers, etc.).

Northern Beaches Council

Deferred Lands Strategic Bush Fire Risk Assessment

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2 Introduction

This strategic bush fire² risk assessment has been commissioned by Northern Beaches Council (herein referred to as 'Council') to explore and understand the nature of potential bush fire risk associated with the 'Deferred Lands' in parts of Belrose, Oxford Falls and Cromer, pursuant to the *Warringah Local Environmental Plan (WLEP) 2000*.

The intent of this assessment is to inform Council's strategic land use planning approach to the Deferred Lands area, adopting a risk-informed evidence base upon which to consider potential strategic land use planning options.

The process focuses on the identification of acceptable or suitable strategic land use planning approaches and controls for the Deferred Lands area, relative to potential bush fire risk.

It achieves this by adopting risk-based principles to determine appropriately risk-informed zoning and other strategic planning controls.

This approach is required pursuant to the current *Planning for Bush Fire Protection (PBP) 2019* statutory guideline, prepared by the New South Wales Rural Fire Service (NSW RFS), which articulates a suite of bush fire hazard and risk considerations which are required to be appropriately considered as part of strategic planning activities.

This risk assessment adopts a risk-based land use planning lens in critically analysing the magnitude of potential risk likelihood, exposure, vulnerability and consequence having regard to a range of simulated land use scenarios specifically designed to test a variety of risk outcomes, and mitigation and treatment opportunities. This process seeks to inform Council decision making in relation the preparation of a new Northern Beaches Local Environmental Plan (LEP) and Development Control Plan (DCP), having regard to the risk profile of the Deferred Lands area in parts of Belrose, Oxford Falls, and Cromer.

The risk assessment process is based upon that set out by the *National Emergency Risk Assessment Guideline (NERAG)* and in accordance with AS/NZS ISO 31000 – Risk Management, having regard to the critical elements of likelihood, exposure, vulnerability and consequence with consideration of existing and potential future risk exposure framed by an analysis of:

- risks to people;
- risks to property;
- risks to infrastructure;
- environmental risks; and
- economic risks.

This report constitutes a Strategic Bush Fire Study for the purposes of Planning for Bush Fire Protection (PBP) 2019.

² For the purposes of this report, any reference to 'bushfire' as opposed to the legislated term of 'bush fire' is in reference to specific organisational or document names.

3 Background

The impetus for this work relates to preparation of a new planning framework for the Northern Beaches. This includes a Local Strategic Planning Statement (LSPS), Local Environmental Plan (LEP) and Development Control Plan (DCP). In March 2020 the LSPS was released following public comment. The LSPS includes a number of priorities, principles and actions that are relevant to this strategic bush fire risk assessment.

The Warringah LEP 2000 is the current relevant planning instrument for the area. It does not include any land use zones but rather, controls development through assessment against locality statements. In 2006, Council was required to prepare a 'Standard Instrument' LEP pursuant to which, the former Warringah Council undertook a comprehensive process to prepare its Standard Instrument LEP, leading to the formulation of the Warringah LEP 2011.

In 2011 the Minister of Planning 'deferred' land in parts of Belrose, Oxford Falls and Cromer from the Warringah LEP 2011, in response to stakeholder concerns regarding the adequacy of consultation during the preparation of the 2011 planning instrument.

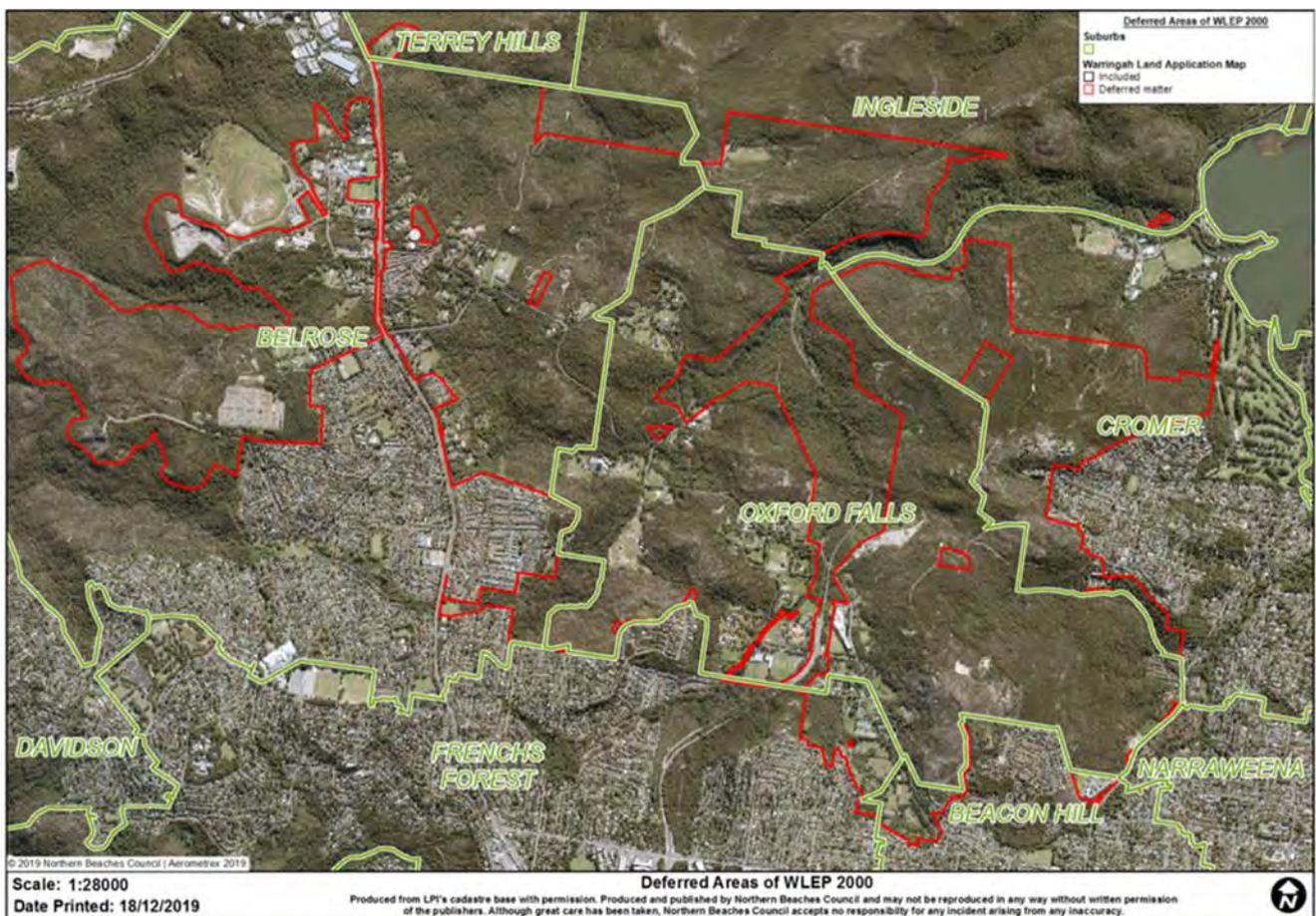


Figure 1 - Deferred Lands area pursuant to the Warringah LEP 2000 (Source: Northern Beaches Council, 2020)

In 2012, Council resolved to undertake the first of two stages of a strategic review of the Deferred Lands area in partnership with the former Department of Planning and Environment (now Department of Planning, Industry and Environment). Stage 1 of the review involved the transfer of the Deferred Lands area in parts of Belrose, Oxford Falls and Cromer into the Warringah LEP 2011. Stage 2 of the review involved the consideration of the future urban development potential for the area.

Following completion of Stage 1 of the review, Council resolved in 2015 to proceed with a Planning Proposal, generally in accordance with the Department's direction. The Planning Proposal was submitted to the Department in April 2015 for a Gateway Determination, which was issued in 2017 subject to a number of conditions including completing Stage 2 of the Strategic Review. This involved the preparation of a number of studies, including a bush fire hazard assessment, to help determine future development potential for the area.

In early 2018 Council resolved to request that the Minister for Planning determine that the Planning Proposal for Oxford Falls Valley and Belrose North should not proceed on a number of grounds. On 5 May 2020 the Department of Planning, Infrastructure and Environment, as delegate of the Minister for Planning and Public Spaces, determined that the Planning Proposal should not proceed.

The LSPS commits to resolving the future zoning of the Deferred Lands as part of the new LEP. It also identifies a suite of technical studies that will inform planning controls.

This strategic bush fire risk assessment of the Deferred Lands area will form an important input to the new planning controls for the deferred lands. It is acknowledged this new planning framework responds to recent amendments to the *Environmental Planning and Assessment Act 1979* (EP&A Act) and the release of the *Greater Sydney Region Plan – A Metropolis of Three Cities* (Regional Plan) and the *North District Plan* (District Plan) by the Greater Sydney Commission in March 2018.

Under the LSPS the Deferred Lands area is identified as 'Metropolitan Rural Area' (MRA) and 'Future MRA investigation area', subject to further studies, including this assessment.

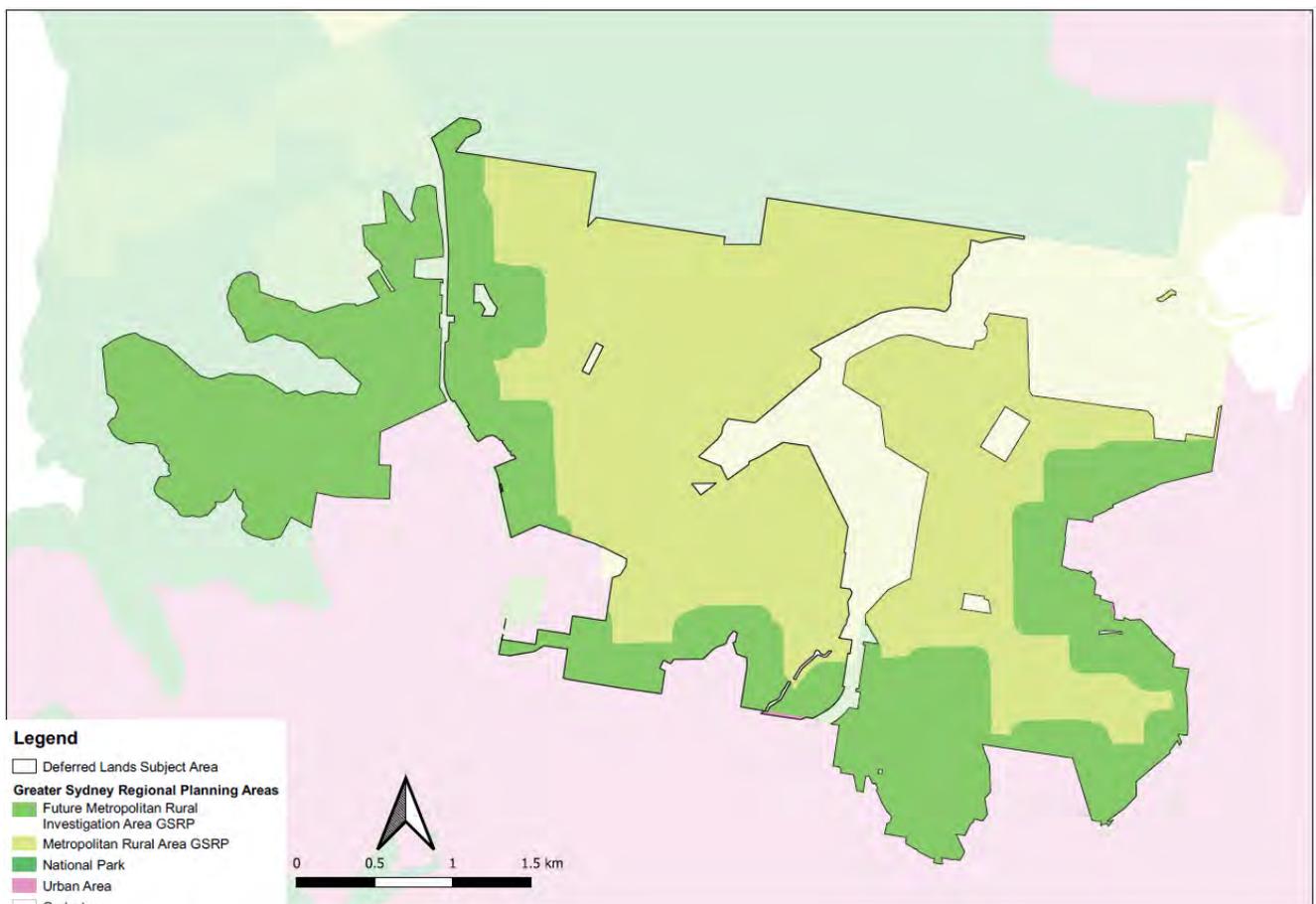


Figure 2 - MRA and Future MRA Investigation Areas as per the North District Plan

3.1 Risk assessment scope

The assessment has been carried out in consultation with Northern Beaches Council and the NSW RFS, and prepared in accordance with the current PBP 2019 statutory guideline, and Planning Ministerial Direction 4.4 – Planning for Bush Fire Protection (pursuant to Section 9.1(2) of the EP&A Act 1979).

The purpose of this landscape-scale strategic risk assessment is to recommend land use planning controls for the area under the new Northern Beaches LEP and DCP which respond to the bush fire risk profile of the area. The assessment includes (at a minimum):

- an overview of the legislative, governance, biophysical, climatic, land use and socio-economic context of the Deferred Lands area;
- a review of past, current and future data on bush fire behaviour and management;
- a review of relevant ecological and environmental data;
- the identification of the exposure and vulnerability of the Deferred Lands to risk from bush fire events, including fire run analysis;
- the identification of key resilience factors to bush fire;
- an examination of the adequacy of existing measures to address bush fire risk now and into the future, including e.g. asset protection zone impacts versus risks to loss of valued bushland and biodiversity, and implications for evacuation;
- a review of the probability and consequences of major bush fire events including consideration of impacts on people, property, vulnerable land-uses, infrastructure, the environment, and the economy; and
- the identification of actions to reduce bush fire risk now and into the future, with specific recommendations for future land use planning provisions including LEP and DCP controls that balance effective bush fire management and protection with the ecological value of the Deferred Lands.

Key components of the project scope, as articulated by Council, include the following:

- the assessment is approached and prepared generally in accordance with PBP 2019, demonstrating best practice risk-based land use planning for bush fire, and sets the benchmark against which future strategic planning proposals are assessed, having specific regard to Section 4 relating to strategic planning and in particular an assessment against Section 4.1 and table 4.2.1;
- in the context of PBP 2019 and relevant Ministerial Direction 4.4 Planning for Bush Fire Protection, identify the suitability of special fire protection purpose developments in the Deferred Lands area including the appropriateness of current and potential future permissible uses under relevant State Environmental Planning Policies (SEPP's) for Medium Density Housing, Seniors Housing and Boarding Houses; and
- Preparation of a bush fire risk evacuation map for potential inclusion in relevant State Environmental Planning Policies, including:
 - State Environmental Planning Policy (Housing for Seniors or People with a Disability) 2004 (Schedule 1);
 - State Environmental Planning Policy (Affordable Rental Housing) 2009;
 - State Environmental Planning Policy (Exempt and Complying Development Codes) 2008, and in particular the Low Rise Medium Density Housing Code; and

- State Environmental Planning Policy (Educational Establishments and Child Care Facilities) 2017.

3.2 Assumptions and exclusions

The following assumptions and exclusions apply to this risk assessment:

- it is assumed the evidence sources utilised to inform this risk assessment are accurate and up-to-date, and can be reasonably relied upon for the purposes of its application;
- this risk assessment is not a bush fire management plan;
- it may offer options or recommendations for Council consideration as part of strategic land use planning processes pursuant to its obligations under PBP 2019. It does not make any decisions in relation to land use;
- it is assumed a range of other planning-related issues are likely to be taken into account as **part of Council's consideration of the observations made by this risk assessment**;
- this risk assessment seeks to analyse the extent of bush fire risk relevant to the Deferred Lands area with respect to the existing situation and potential future risk, based upon a series of simulated hypothetical land use scenarios. This assessment makes no inference as to the probability of any scenario coming to fruition;
- the scenarios adopted for the purpose of this assessment are hypothetical only, designed to test a range of potential future land use combinations and the associated risk profiles, mitigation options and residual risk profiles to **determine potential 'optimal' options having regard to bush fire risk**; and
- this assessment does not incorporate any traffic modelling or analysis with regard to bush fire emergency evacuation, and remains qualitative in this regard only.

4 Risk assessment methodology

In order to appropriately inform strategic land use planning controls, a bush fire risk assessment is necessary in order to examine potential bush fire risk and opportunity for risk-responsive planning controls for the Deferred Lands area.

4.1 Objectives and priorities

The objectives and priorities of this risk assessment are:

1. the delivery of *risk-informed land use planning* policy, strategy and statutory controls to underpin the new LEP and DCP for the Deferred Lands area, having regard to the extent of potential bush fire risk and protection of ecological values;
2. the *quantification of risk* across the Deferred Lands area to formulate policy and strategy responses across the spectrum of:
 - o avoid;
 - o mitigate;
 - o accept; and
 - o transfer.
3. the identification of any *potential acceptable or tolerable risk opportunities* where development could be considered subject to statutory provisions. This includes understanding how land management and other bush fire protection measures can be undertaken to facilitate potential development having regard to risk to life;
4. to understand the magnitude of risk relative to certain land uses, particularly *special fire protection purposes (SFPP's)* and, **the impact of such uses on the ability to implement certain land and fuel management approaches or demand/reliance placed on bush fire protection measures;** and
5. the relevant *strategic planning responses or options* which may be considered in response to the above matters.

4.1.1 Principles

The principles of this risk assessment seek to serve as the foundation which guide the approach and implementation of methodologies. This risk assessment is:

- evidence-based;
- stakeholder-led, guided by specialist expertise;
- locally contextualised;
- fit-for-purpose;
- both quantitative and qualitative in assessment;
- guided by measurable benchmarks to **appropriately determine 'acceptable risk'**;
- transparent to ensure integrity of process;
- in alignment with the strategic planning requirements of *Planning for Bush Fire Protection 2019*; and
- undertaken to give effect to the North District Plan and Council's Local Strategic Planning Statement.

4.2 Risk assessment process

As established above, this risk assessment process is undertaken through the specific lens of risk-based land use planning and using the processes outlined by the *National Emergency Risk Assessment Guidelines* (NERAG) published by the Australian Institute for Disaster Resilience (AIDR) as well as AS/NZS ISO 31000: 2018 Risk management: principles and guidelines (ISO 31000), refer to Figure 3 below original set out by the Peer Review Assessment Report dated February 2018.

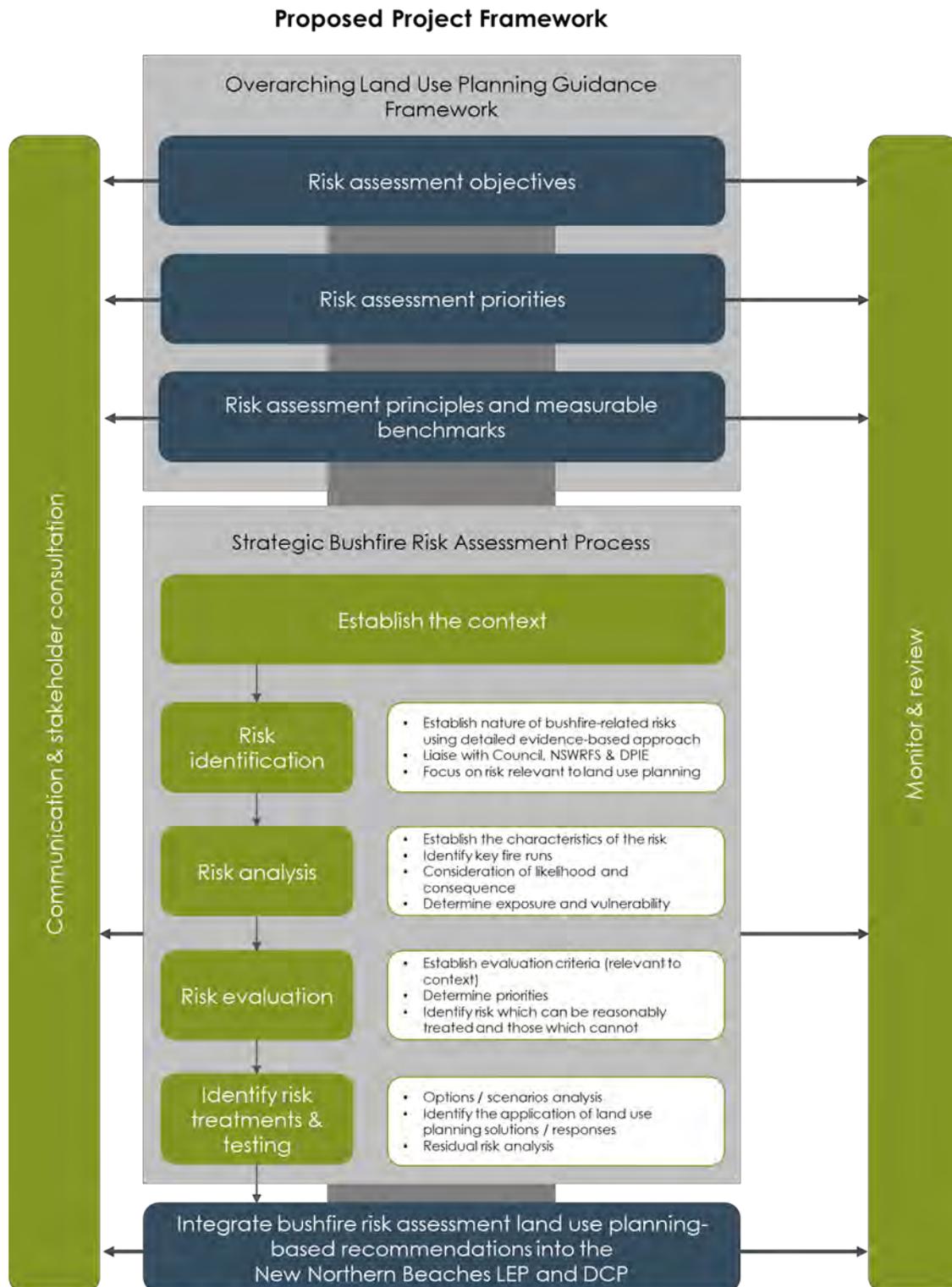


Figure 3 - The strategic bush fire risk assessment framework

How risk is considered by strategic land use planning processes accords with the NERAG framework, but attracts different procedures than are otherwise applied in emergency operational contexts. This is an important distinction to make. This is largely due to the focus of emergency management operations which maintain a different focus than does strategic land use planning.

The AIDR Land Use Planning for Disaster Resilient Communities Handbook identifies *how risk management procedures are applied in strategic land use planning contexts*, outlined below.

Risk management procedure	Land use planning procedure
Establishing the context	Visioning, overarching desired futures
Risk assessment	Analysis of the circumstances and problems/opportunities
Selection of risk treatment options	Identification of planning alternatives, and evaluation and selection of them
Risk treatment implementation	Planning implementation
Ongoing communication and consultation	Communication and consultation
Ongoing monitoring and review	Monitoring effects and adjusting

Figure 4 - Parallels between land use planning and risk management procedures (AIDR, 2020)

This risk assessment also incorporates an integrated and multi-disciplinary approach to the consideration and quantification of bush fire risk. The purpose of this landscape-scale strategic risk assessment is to recommend land use planning controls for the area under the new Northern Beaches LEP and DCP.

This risk assessment adopts a strategic land use planning approach to bush fire resilience. As such, it is necessary to consider the multitude of disciplines and mitigation approaches that combined, give rise to bush fire resilience. Thus, this risk assessment process maintains strong regard to aspects of the disaster management cycle and links them to broader social, economic, environmental and settlement systems.

This approach fundamentally recognises that it is not the role of strategic land use planning to necessarily avoid or reconcile all aspects of risk, but to contemplate the magnitude of risk under varying scenarios to consider how the quantum of mitigation measures may reduce risk exposure, or not, and whether such risk can reasonably be expected to limit risk to life, property and the environment to an acceptable or tolerable level.

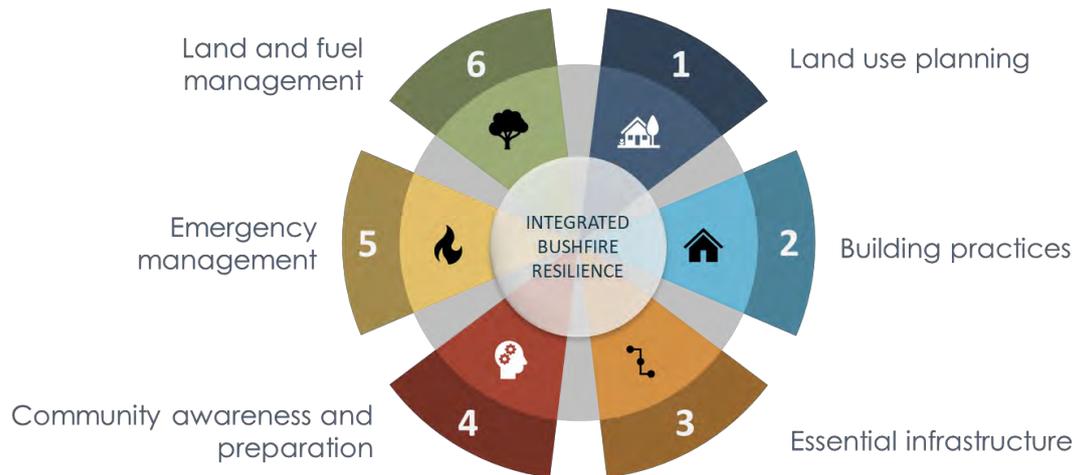


Figure 5 - An integrated approach to community bush fire resilience

4.3 Project technical stakeholders

Having regard to the planning-related purpose of this risk assessment, Northern Beaches Council is the project sponsor, in close consultation with the NSW RFS. Both stakeholders were involved extensively throughout the process.

A schedule of milestone stakeholder meetings were established at the outset of the assessment to gauge input, direction and feedback from the technical stakeholder group.

The ultimate end-users remain the core priority of this assessment, including both existing and potential future residents within and adjoining the Deferred Lands area in of parts of Belrose, Oxford Falls and Cromer.

An overview of the technical stakeholder meetings is outlined below.

Project phase / milestone	Date	Description
Project inception	25 June 2020	Project inception meeting to discuss project management and schedule. Brief overview of intended methodologies, data requirements and background information.
Risk context phase	16 July 2020	This meeting reviewed previous actions and data collation to inform the work. The meeting also focussed on the contextual analysis of the risk assessment with a particular focus on the identified risk acceptability criteria.
Risk identification	31 July 2020	An overview of the preliminary bush fire behaviour modelling at FFDI 116 was provided. Risk identification was discussed, including particular assets within the area.
Risk analysis phase	27 August 2020	Presentation of fireline intensity mapping to project stakeholders across various fire

		weather and land use scenarios, considering the magnitude of geographic or spatial impact, as well as impact of intensity to identify higher risk areas.
Risk evaluation and treatments	11 September 2020	These meetings focussed on detailed discussions in relation to the identified strategic planning risks, the evaluation of these risks and the planning-based measures identified in response.
	16 September 2020	
	22 September 2020	
	28 September 2020	
Risk assessment finalisation	2 December 2020	Project stakeholder review of draft risk assessment, with a focus on permissible land uses, and project finalisation.

4.4 Planning for Bush Fire Protection 2019

In March 2020 the current PBP 2019 came into statutory effect. One of the key additions to the current PBP 2019 which sets it apart from previous editions is a new chapter on strategic planning, which aims to ensure that bush fire risk is appropriately considered as part of strategic planning activities, having regard to the nature of potential risk rather than mere compliance with bush fire protection measures.

The application of strategic provisions is only relevant following the strategic consideration of landscape risk, and where that level of risk is determined by governments to be satisfactorily acceptable or tolerable. *The mere ability to meet statutory controls for bush fire protection does not inherently determine the appropriateness of land use in the face of potential risk.*

Section 4 of PBP 2019 establishes *strategic principles for the exclusion of inappropriate development* which guide how the strategic consideration of bush fire risk is to be integrated into strategic planning processes. These include:

- the development area is exposed to a high bush fire risk and should be avoided;
- the development is likely to be difficult to evacuate during a bush fire due to its siting in the landscape, access limitations, fire history and/or size and scale;
- the development will adversely effect other bush fire protection strategies or place existing development at increased risk;
- the development is within an area of high bush fire risk where density of existing development may cause evacuation issues for both existing and new occupants; and
- the development has environmental constraints to the area which cannot be overcome.

In order to assess the above, PBP 2019 requires a strategic bush fire study to assess the matters outlined at the table below, as a minimum. PBP 2019 provides that where strategic issues cannot be resolved, the proposal cannot comply with PBP 2019.

Table 1 - PBP 2019 strategic bush fire study assessment requirements

Issue	Detail	Assessment considerations
<i>Bush fire landscape assessment</i>	A bush fire landscape assessment considers the likelihood of a bush fire, its potential severity and intensity and the potential impact on life and property in the context of the broader surrounding landscape.	<ul style="list-style-type: none"> • The bush fire hazard in the surrounding area, including: <ul style="list-style-type: none"> ○ Vegetation ○ Topography ○ Weather • The potential fire behaviour that might be generated based on the above; • Any history of bush fire in the area; • Potential fire runs into the site and the intensity of such fire runs; and • The difficulty in accessing and suppressing a fire, the continuity of bush fire hazards or the fragmentation of landscape fuels and the complexity of the associated terrain.
<i>Land use assessment</i>	The land use assessment will identify the most appropriate locations within the masterplan area or site layout for	<ul style="list-style-type: none"> • The risk profile of different areas of the development layout based on the above landscape study; • The proposed land use zones and permitted uses; • The most appropriate siting of different land uses based on risk profiles within the site (i.e. not locating development on ridge tops, SFPP development to be located in lower risk areas of the site); and

	the proposed land uses.	<ul style="list-style-type: none"> The impact of the siting of these uses on APZ provision.
<i>Access and egress</i>	A study of the existing and proposed road networks both within and external to the masterplan area or site layout.	<ul style="list-style-type: none"> The capacity for the proposed road network to deal with evacuating residents and responding emergency services, based on the existing and proposed community profile; The location of key access routes and direction of travel; and The potential for development to be isolated in the event of a bush fire.
<i>Emergency services</i>	An assessment of the future impact of new development on emergency services.	<ul style="list-style-type: none"> Consideration of the increase in demand for emergency services responding to a bush fire emergency including the need for new stations/brigades; and Impact on the ability of emergency services to carry out fire suppression in a bush fire emergency.
<i>Infrastructure</i>	An assessment of the issues associated with infrastructure and utilities.	<ul style="list-style-type: none"> The ability of the reticulated water system to deal with a major bush fire event in terms of pressures, flows, and spacing of hydrants; and Life safety issues associated with fire and proximity to high voltage power lines, natural gas supply lines etc.
<i>Adjoining land</i>	The impact of new development on adjoining landowners and their ability to undertake bush fire management.	<ul style="list-style-type: none"> Consideration of the implications of a change in land use on adjoining land including increased pressure on BPMs through the implementation of Bush Fire Management Plans.

4.5 Acceptable risk criteria and benchmarking

The determination risk acceptability or tolerance is essential in the consideration of appropriate risk-informed strategic planning, land use allocation and development controls which are needed to respond to the nature and potential level of risk, as part of the contemplation of LEP and DCP controls.

It must be noted that risk levels vary across the landscape, thus a place-based approach is required which considers specific locations across the study area.

The following table outlines the risk acceptability / tolerability benchmarks against which risk is to be analysed and evaluated, relative to different risk treatment options. It is informed by the strategic bush fire study requirements outlined at Section 4.4.

Table 2 - Acceptable risk benchmarks against which strategic planning residual risk is measured

PBP 2019 strategic issue	Acceptability benchmarks	Relevant risks
<i>Bush fire landscape assessment</i>	The context of landscape, fire history, likelihood / probability and fire behaviour and intensity is considered and potential consequences can be avoided, mitigated, transferred or accepted	Life risk Property risk Environmental risk
	Valued habitat, environmental values, assets, corridors and functions are maintained	Environmental risk Property risk
<i>Land use assessment</i>	Various land use scenarios are contemplated to examine and assess the potential impact of different fire behaviour intensities and mitigation measures	Life risk Property risk Infrastructure risk Economic risk
	Balancing environmental values and land use allocation incorporates consideration of disaster risk reduction	Property risk Life risk Economic risk
	Special fire protection purposes are strategically considered in terms of appropriateness in bush fire prone areas	Life risk
	The planning outcome is capable of facilitating local Neighbourhood Safer Places, community refuges or evacuation centres within the area for shelter in place options	Life risk
<i>Access and egress</i>	Strategic planning is capable of facilitating appropriate and effective evacuation, based on key assumptions	Life risk
	The evacuation ability of existing residents or occupants is not worsened	Life risk
<i>Emergency services</i>	Increased demand on emergency services is avoided or reasonably mitigated	Life risk Property risk
<i>Infrastructure</i>	Essential, community and strategic infrastructure avoids high risk exposure	Property risk Infrastructure risk

	The water supply network is protected from or avoids exposure to bush fire attack which may compromise its function, including pump stations and other assets	Property risk Infrastructure risk
<i>Adjoining land</i>	Ongoing land management and hazard reduction implications are considered	Environmental risk

4.5.1 Risk-based strategic land use planning

The context assessment demonstrates the extensive policy and regulatory framework in place at national, State and local levels which set the expectation for disaster risk reduction, and the role of strategic risk-based land use planning in avoiding loss, and contributing toward resilient communities.

As per the National Strategy for Disaster Resilience and Productivity Commission Report into Natural Disaster Funding, land use planning is perhaps the most potent policy lever in addressing potential future disaster risk. This is further evidenced by the focus on land use planning within recent inquiries and Royal Commissions.

This being the case, a risk-based land use planning lens approach allows for the consideration of bush fire risk to be embedded within decision-making processes, informed by an evidenced-based picture of both current and future potential bush fire risk.

The function of strategic planning is to investigate whether certain land use actions *should* occur, and the consequences of land use allocation into the future. This is markedly distinct to statutory planning processes which take place following a determination of strategic appropriateness. Such statutory processes therefore focus on establishing *how* a land use action can occur, once deemed appropriate or acceptable.

5 Risk assessment context

Pursuant to NERAG and AS/NZS ISO 31000, the essential first stage of any natural hazard risk assessment process is establishing the context to understand the policy and regulatory environment, the physical environment, weather and climatic trends and event history (AIDR, 2017).

This section articulates:

- the current regulatory environment in place regarding both natural hazard risk assessments and bush fire protection planning in NSW;
- the existing settlement pattern of parts of Belrose, Oxford Falls, Cromer and surrounds;
- the relevant environmental, built environment and social factors which are relevant to the consideration of bush fire risk within the Deferred Lands area and surrounding landscape; and
- the nature of the bush fire hazard landscape and relevant fire history of the locality.

5.1 Current locality and landscape context

The Deferred Lands area which incorporates parts of Belrose, Oxford Falls and Cromer is located on Sydney's Northern Beaches. The Deferred Lands area covers approximately 1,400ha and is predominantly represented by native vegetation and bushland, with scattered cleared areas subject to various land uses. Land parcels within the Deferred Lands area are relatively large with land ownership including the Metropolitan Local Aboriginal Land Council (MLALC), Crown Land, various private landholders, infrastructure providers and government agencies.

The majority of existing land uses encompass large lot residential activities, with a range of additional land uses also present. These include two major telecommunications facilities for Telstra and Optus which support international networks, schools, places of worship, isolated industrial-related activities, child care centres, aged care and seniors living facilities, a range of recreational facilities and a major electrical station on Ralston Avenue in Belrose North.

The area is situated to the north of Frenchs Forest in the vicinity of Wakehurst Parkway and Forest Way, and bound by Garigal National Park to the north and west. It is also bound by the residential suburbs of Cromer, Narrabeena, Beacon Hill, Oxford Falls, Frenchs Forest, Belrose and Belrose North. The area straddles the Narrabeen and Middle Harbour catchments. Wakehurst Parkway generally follows Middle Creek, which forms part of the Narrabeen catchment and is subject to high flood risk. The waterway corridor divides the Deferred Lands area along Wakehurst Parkway.

Wakehurst Parkway is a significant arterial route which traverses the area, linking North Narrabeen with Frenchs Forest. Warringah Road and Forest Way are also major transport arteries, providing north-south and east-west connectivity.

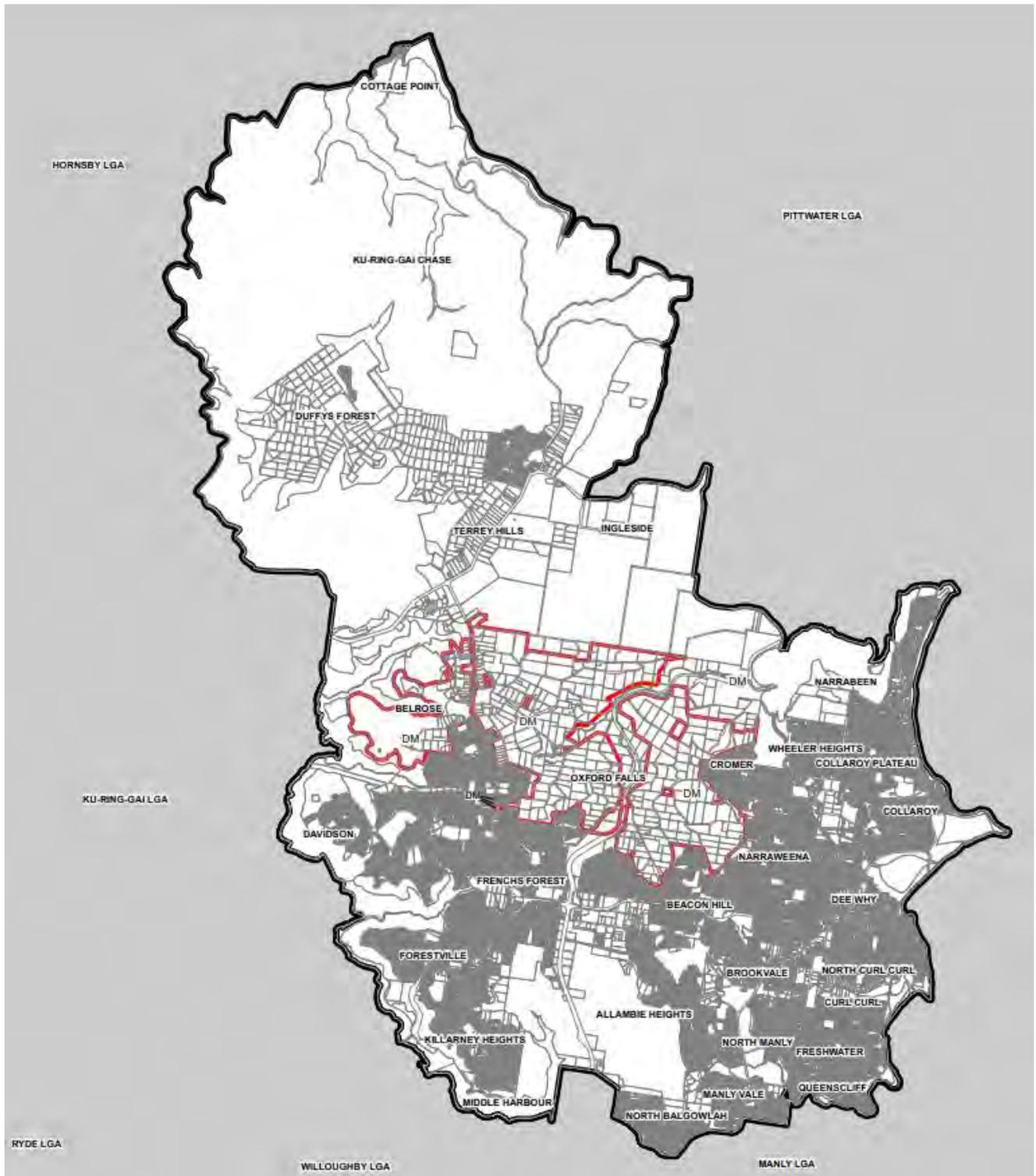


Figure 6 - Former Warringah Local Government Area and Deferred Lands area outlined in red as per the Land Application Map contained within the Warringah LEP 2000 (Source: Former Warringah Council, 2013)

5.2 Potential future land use and development context

This assessment seeks to provide the relevant bush fire risk considerations to inform the potential future land use intent for the Deferred Lands area as part of the new Northern Beaches LEP and DCP. Notwithstanding this, there remain a number of existing approved development applications

throughout the area, as well as a number of larger-scale opportunities requiring further strategic planning contemplation.

These approvals and opportunities remain relevant to this assessment insofar as they:

- introduce new residents to the study area;
- augment the nature of land uses and built form within the study area; and
- alter the natural environment, removing natural vegetation and changing topography.

All approved but not currently constructed developments within the Deferred Lands area is considered as part of this assessment.

In addition to the above are a range of 'Planning Assessment Commission' (PAC) investigation sites within the area, which were determined 'unsuitable' a decade ago, but which were identified as potential opportunities into the future, pending further technical investigation. These site are also relevant to consider, having regard to the more strategic-level impact they may derive having regard to the points made above. To this end, identified PAC investigation sites are also contemplated by this assessment.

Other potential future development that may be complying or exempt development under State Environmental Planning Policies (SEPPs) are excluded from this assessment.

5.3 Policy and regulatory context

This section provides an overview of the policy and regulatory context and frameworks relating to bush fire protection in New South Wales, as relevant to the Deferred Lands area.

These key instruments demonstrate a 'line of sight' with respect to the cascading relevance from legislation and regulation, to national best practices instruments, previous inquiries, risk assessments and studies as well as leading Australian and international fire and risk research.

5.3.1 National policy settings and guidance materials

The national policy landscape relating to natural hazard risk management maintains a strong focus on implementation of the **United Nations' Sendai Framework** through improving the understanding of risk across all sectors and all levels of government, stakeholders and the community through a shared responsibility for building resilient communities. In particular:

- given the alignment with the Sendai Framework, there is naturally a focus on understanding risk, sharing risk information and using improved technologies to understand risk;
- there is a focus on understanding risks to the social, built, economic and natural environments;
- there is a strong focus on building 'disaster resilient communities' by improving the community's understanding of risk and their vulnerabilities, and taking a shared responsibility approach in building resilience to natural hazards such as bush fire;
- planning is presented in the *National Strategy for Disaster Resilience* as an important element of shaping disaster resilient communities;
- efforts and resources should be targeted to priority disaster risks and mitigation opportunities, and exposure to unreasonable risks from hazards avoided or suitable arrangements to minimise risks implemented;
- with regards to recovery and rebuilding, there is a focus on considering the appropriateness of rebuilding in the same location, or rebuilding to a more resilient standard to reduce future risks;
- many of the *National Disaster Risk Reduction Framework* strategies apply to the planning sector;

- the *National Climate Resilience and Adaptation Strategy* not only aligns with the premise that resilience building is a shared responsibility and that there is a need for an evidence-base, risk management approach, but also identifies the importance of factoring climate change into decisions through collaborative and values-based choices and the need to revisit decisions and outcomes regularly;
- ***Profiling Australia's Vulnerability*** brings to the forefront the importance of understanding the relationship between community values and vulnerabilities, including the vulnerabilities of systems that communities rely on, to strengthen resilience. It identifies that trade-offs need to be made between social, built, economic and natural environment factors at the local level when making decisions, and that incentives need to be embedded to guide decision making;
- the *National Emergency Risk Assessment Guidelines (NERAG) Handbook* produced by the Australian Institute for Disaster Resilience provides a nationally consistent approach to risk assessment and prioritisation to support the implementation of strategy. It provides a contextualised, emergency-related risk assessment methodology consistent with *AS/NZS ISO 31000: 2018 Risk management – principles and guidelines*;
- pursuant to the *National Construction Code* and *Building Code of Australia*, development on land within a designated Bush Fire Prone Area is required to be assessed against and comply with the construction requirements of *Australian Standard AS3959-2018 – Construction of Buildings in Bushfire Prone Areas*. A designated Bush Fire Prone Area is established by the Bush Fire Prone Land Map prepared pursuant to Section 10.3 of the Environmental Planning and Assessment Act 1979 and designated by the Commissioner of the NSW RFS;
- of particular relevance in the incorporation of natural hazards and risk into planning processes, the Australian Institute for Disaster Resilience *Land Use Planning for Disaster Resilient Communities Handbook* provides a summary of regulatory instruments, spatial instruments and assessment processes and their role in disaster resilience, aligned with the Planning Institute of Australia's *National Land Use Planning Guidelines for Disaster Resilient Communities*; and
- the *Evacuation Planning Handbook* prepared by the Australian Institute for Disaster Resilience provides a suite of considerations for evacuation planning, using the five nationally-recognised stages of the evacuation process. The Handbook articulates the relevant aspects of community-level evacuation planning which are to be considered as part of evacuation planning processes.

5.3.2 State-based policy and regulation

The state-wide policy and regulatory environment relating to natural hazard risk management and bush fire protection maintains a strong focus on protection of life, property and the environment. This is aligned with the state's commitment to enhancing the quality of life of the people of NSW. Those aspects of the state-wide policy and regulatory framework which contribute to this includes:

- reducing climate change impacts on health and wellbeing, with a focus on enabling communities and individuals to be better prepared and providing long-term and coordinated efforts to increase the resilience through the *NSW Climate Change Framework*;
- the principles for emergency management under the *NSW State Emergency Management Plan (EMPLAN)* align with national approaches, including those related to continuous improvement, information sharing, understanding an all-hazards approach, building local capacity and ensuring community engagement. EMPLAN articulates the roles and

responsibilities as part of the NSW Emergency Management Arrangements. It also includes the bush fire sub-plan;

- the *Emergency Risk Management Framework* (ERMF) acknowledges that there is a need for a greater focus on disaster mitigation to reduce expenditure on recovery, and the strengths of existing approaches related to current hazard specific approaches (such as for bush fire);
- one of the guiding principles of the ERMF focuses mitigating and effectively responding to risks through emergency risk management to protect the safety and wellbeing of NSW communities, with outcome 3 specifically related to integrating emergency risk management into land-use planning, infrastructure, strategic planning and asset management;
- the *State Level Emergency Risk Assessment* (SLERA) undertaken by the former Office of Emergency Management (now Resilience NSW) identifies the vital role of the state and local governments in planning for and managing sustainable development through increasing the resilience of communities through prevention and mitigation with improved land use planning provisions for mitigation, and response and recovery;
- the State Infrastructure Strategy includes a strategic direction for resilience which calls for resilience to be embedded in strategic land use planning through a natural hazard policy supported by a broader strategic process to embed resilience in planning;
- the *NSW Critical Infrastructure Resilience Strategy* underlines the need to consider the resilience of infrastructure when planning for new development, as early in the process as possible, which leads to decreased interruptions, reduced recovery times, more rapid restoration and commensurate benefits for the community;
- the *Environmental Planning and Assessment Act 1979* (EP&A Act) regulates planning in NSW and relates to planning for bush fire protection. This includes regulating mapping for bush fire prone areas, compliance with PBP 2019 and the regulation of integrated development. It also includes provisions for Councils to prepare and make local strategic planning statements to set out the 20 year vision for land use in local areas;
- the EP&A Act gives the Minister power to direct a local government to exercise its functions of preparing an LEP in accordance with principles in a direction;
- *Ministerial Direction 4.4 – Planning for Bush Fire Protection* finds its head of power at section 9.1 of the EP&A Act. It applies where a planning authority prepares a planning proposal that will affect or is close to bush fire prone land. The Direction aims to protect life, property and the environment from bush fire hazards, by discouraging the establishment of incompatible land uses, and encourage sound management of bush fire prone areas;
- it requires, amongst other things, that a planning proposal must have regard to PBP 2019 and it must introduce controls that avoid placing inappropriate developments in hazardous areas;
- the *Rural Fires Act 1997* creates the Bush Fire Coordinating Committee (BFCC), a statutory body representing the Crown which is responsible for planning in relation to bush fire prevention and co-ordinated bush firefighting. The BFCC is responsible for advising the Commissioner on bush fire prevention, mitigation and coordinated suppression. The Act also incorporates the provisions for the *10/50 vegetation clearing scheme* pursuant to Section 100R;
- the BFCC must constitute Bush Fire Management Committees (BFMCs) which may prepare a Bush Fire Risk Management Plan. The Act also sets in place the regulatory environment which guides bush fire response, hazard reduction processes, fire danger periods and total fire ban provisions. Division 8 of the Act deals with development of bush fire prone land;
- the Warringah Pittwater Bush Fire Management Committee in 2008 produced the *Warringah Pittwater Bush Fire Risk Management Plan* which relates to the study area. The purpose of this plan is to identify community assets at risk and provide a five-year program

of coordinated multi-agency treatments to reduce the risk of bush fire to these assets, having regard to the principles of ecologically sustainable development;

- the BFMC is underway with the preparation of a new *Northern Beaches Bush Fire Risk Management Plan*, at the time this report was prepared. This new plan is intended to replace the two existing 2010 plans for Warringah Pittwater and Manly, Mosman and North Sydney. This approach will provide a unified bush fire risk management plan for the entire Northern Beaches. As per advice from NSW RFS, this land use planning-based risk assessment utilises the content of the existing 2010 bush fire risk management plan, being that which was in place and adopted at the time of writing. It is likely that whilst the tools utilised to inform the bush fire risk management plan may be consistent with those utilised by this risk assessment, the outputs may differ. This is likely to occur where inputs are altered, different assumptions are utilised and also noting the bush fire risk management plan is for the express purpose of mitigation and preparedness in an emergency management context, whereas the methodologies employed by this risk assessment are for the solitary purpose of informing strategic land use planning;
- part of the study area is identified by the *Cromer, Oxford Falls and Beacon Hill Community Protection Plan* prepared by the NSW RFS. This includes a bush fire preparation map and bush fire survival map;
- the *PBP 2019* statutory guideline establishes the strategic planning and development assessment requirements which are relevant to bush fire prone land across NSW. It requires strategic planning processes to consider the nature of potential bush fire risk to consider key strategic issues, and to determine if development is inappropriate in its risk context;
- a number of *State Environmental Planning Policies* or SEPPs are relevant, being environmental planning instruments which relate to matters of State or regional planning significance. SEPPs can override LEPs and can allow or prohibit development in certain areas or zones. Relevant SEPPs include, for example:
 - State Environmental Planning Policy (Housing for Seniors or People with a Disability) 2004 (now excluded from Metropolitan Rural Areas by the State Government as per the 2020 exemption amendment);
 - State Environmental Planning Policy (Affordable Rental Housing) 2009;
 - State Environmental Planning Policy (Exempt and Complying Development Codes) 2008 (which includes the Low Rise Medium Density Housing Code);
 - State Environmental Planning Policy (Educational Establishments and Child Care Facilities) 2017;
 - State Environmental Planning Policy (Infrastructure) 2007; and
 - State Environmental Planning Policy (Aboriginal Land) 2019.
- several regional-level planning instruments guide the strategic planning approaches adopted by local governments in the Greater Sydney region. These include *The Greater Sydney Region Plan - A Metropolis of Three Cities* (Region Plan) and the *North District Plan*.

5.3.3 Local policy, regulation and strategies

5.3.3.1 Existing and current local instruments

The existing local planning context relevant to the Northern Beaches Council area incorporates not only local environmental planning instruments but a number of strategies which guide Council decision-making. Together these include:

- The Northern Beaches Council forms part of the 33 Councils party to *Resilient Sydney – A Strategy for City Resilience 2018*. It highlights key risks to Sydney's resilience, including the

top three risks being heat, severe storm and bush fire. 35 Actions are listed to address acute shocks such as bush fire. The Strategy broadly promotes a people centred city, where place-based planning considers vulnerability and resilience as a first step when planning for (and with) local communities;

- the *Warringah LEP 2000*, which is the current statutory local planning instrument for this area. It does not include any land use zones but controls development through assessment against locality statements;
- the *Warringah DCP 2000 (Amendment 4)* which applies to land to which the *Warringah LEP 2000* applies. The DCP provides detailed planning and design guidelines to support the planning controls identified within the *Warringah LEP 2000*. The content of the *Warringah DCP 2000* largely relates to the preservation of trees and bushland vegetation;
- as required under the State provisions, the certified *Northern Beaches Bush Fire Prone Land Map* is currently in place relative to the study area;
- the bush fire prone land map is to identify land that is at risk from bush fire attack (Bush Fire Prone Area) and acts as a legislative trigger for additional planning and development controls. Planning processes, including strategic planning activities, and development (if deemed acceptable from a strategic planning risk perspective) in these areas must comply with the provisions of PBP 2019 and AS3959-2019;
- a number of site-specific fire regime management plans are in place for Council-owned land and reserves across the Council area. These plans articulate the fire management measures required in terms of prescribed burns, manual fuel load treatment, asset protection zone management, etc.;
- a Local Emergency Management Committee is established for the Northern Beaches, pursuant to the NSW Emergency Management Arrangements with representation from Council as well as all relevant combat agencies and support agencies. The focus of this committee is on the prevention of, preparation for, response to and recovery from emergencies which impact the community;
- the 2017 *Northern Beaches Local Emergency Management Plan* defines roles and responsibilities of responders and community partners, informs disaster management responses at region and State levels and outlines the nature of support provided by the Committee. The Plan identifies bush fire as an 'Extreme' risk in the Council area, and highlights Oxford Falls Valley and Garigal National Park as specific areas of potential bush fire threat;
- Council also maintains a number of locally-relevant policies and strategies including, for example:
 - Community Strategic Plan 2018-2028;
 - Local Strategic Planning Statement – Towards 2040;
 - Bushland policy and bushland and biodiversity strategies;
 - Climate change policy and environment and climate change strategy;
 - Flood risk management policy and catchment creek and lagoon strategies;
 - Geotechnical risk management;
 - Stormwater control policy;
 - Waterways and riparian land policy;
 - Environmental sustainability policy;
 - Tree preservation policy; and
 - Road reserve management policy.

5.3.3.2 Future planning framework

Northern Beaches Council is in the process of formulating a new consolidated Northern Beaches LEP and DCP which brings together the four existing LEPs and four DCPs of the former Councils which were amalgamated in 2016. As part of this process:

- Council's first Local Strategic Planning Statement (LSPS) came into effect on 26 March 2020;
- the purpose of the LSPS is to provide the 20 year vision for land use in the local area. It also gives effect to the regional and district plan based on local characteristics and opportunities, and Council's priorities identified by the Community Strategic Plan 2018-2028;
- the **LSPS 'Toward 2040'** will inform the development of Council's new LEP and DCP as well as broader policies and strategies, and the assessment of planning proposals for changes to Council's planning controls;
- the LSPS establishes a series of directions which are informed by the North District Plan (District Plan). These include:
 - landscape;
 - efficiency;
 - resilience;
 - infrastructure and collaboration;
 - people;
 - housing;
 - great places;
 - connectivity; and
 - jobs and skills.
- the LSPS established a suite of planning priorities underpin the above directions. These include for example, healthy and valued coasts and waterways, protected and enhanced bushland and biodiversity, protected Metropolitan Rural Area, a low carbon community with high energy, water and waste efficiency and adaptation to the impacts of natural and urban hazards and climate change;
- the LSPS notes the Council area is particularly vulnerable to natural hazards including bush fire, and as the climate changes exposure to these hazards will increase. It notes that efforts to increase resilience in the community and natural and built environments is necessary;
- the majority of the study area is identified within the LSPS as a *MRA* and *future MRA investigation area*. The LSPS notes that:
 - *'under the North District Plan, further urban development is not consistent with the values of the MRA – this constitutes a clear State-level direction to avoid housing growth in these areas. Parts of Oxford Falls (south), Cromer Heights (west) and Belrose North, are not currently identified as part of the MRA in the Greater Sydney Region Plan but share many of its traits and characteristics. Council has identified this land area as 'Future MRA investigation area', and will work with the Greater Sydney Commission to assess its suitability for inclusion in the MRA when the Greater Sydney Region Plan is reviewed.*

Using the precautionary principle, Council will apply the principles and actions in this priority to these lands until that review is complete'.

- the LSPS incorporates a suite of principles and actions to guide strategic land use planning across the Northern Beaches. These include (but are not limited to):
 - P4 principle – *ensure development is not intensified in areas where there is unacceptable risk to human life and property from hazards such as bush fire;*
 - P8 principles – *within high risk areas, avoid developments that rely on performance-based solutions, are difficult to evacuate or would be occupied by at-risk members of the community, avoid intensification of development, inappropriate development and incompatible land uses in areas exposed to natural and urban hazards; and reduce risk to life and property;*
- the LSPS also identifies a suite of actions, including the preparation of a structure bush fire risk assessment to guide future strategic planning. Council is progressing with background studies to inform the development of consolidated LEP and DCP instruments for the Northern Beaches, of which this risk assessment forms part.

5.4 Royal Commissions and inquiries

Over the years, more than 51 inquiries have been conducted in relation to bush fire between 2009 and 2017, resulting in over 811 recommendations. This is considerable in comparison to the number of flood-related inquiries conducted over the same period at just 15, yielding 328 recommendations. This includes Royal Commissions and independent, audit, agency, Coronial and Parliamentary inquiries (BNHCRC, 2019).

Aspects relevant to this risk assessment are as follows:

- the 2020 *Royal Commission into National Natural Disaster Arrangements* handed down its findings during the preparation of this risk assessment. This Royal Commission follows the 'extreme' bush fire season of 2019-20 in Australia which resulted in loss of life, property, wildlife and environmental destruction;
- the Terms of Reference for the Royal Commission included land use planning as a key aspect of focus, along with a range of other matters such as hazard reduction, disaster management and response, recovery and Indigenous cultural burning
- interim observations of the Royal Commission were handed down in late August 2020. From a land use planning perspective, the report identifies that 99 per cent of destroyed or damaged residential buildings during the 2019-20 fire season in Australia were within 500m of identified bush fire prone land. 74 per cent of those buildings were constructed prior to the introduction of AS3959 (Commonwealth of Australia, 2020). The full report is expected to be handed down in late October 2020;
- the findings of the Royal Commission seek to mandate the consideration of natural hazard risk as part of land use planning processes;
- in 2020 the NSW Government commissioned an independent expert inquiry into the 2019-20 bush fire season, with a focus on the provision of advice to NSW ahead of the next bush fire season. Again, land use planning is identified as a focus within the Inquiry Terms of Reference which cited the Inquiry would include '*consideration of land use planning and management and building standards, including appropriate clearing and other hazard reduction, zoning, and any appropriate use of indigenous practices*';
- the *Final Report of the NSW Bushfire Inquiry* were handed down in August 2020. Bush fire resilience featured prominently, including the need to advance strategic land use planning processes and calibration of risk consideration within such processes. The Inquiry also recommends the preparation of a State Bush fire Policy, similar to the Flood Planning Areas

Policy, to assist in guiding strategic planning processes for bush fire resilience across the State;

- the *Victorian Bushfires Royal Commission* (VBRC) which concluded in 2010 after the Black Saturday fires of 7 February 2009 also contemplated the role of land use planning in bush fire disaster risk reduction. Of the 67 recommendations made by the VBRC, 18 recommendations related specifically to land use planning;
- the inclusion of planning-related findings as a result of inquiries dates back to the 1939 *Royal Commission (the Stretton) report* which identified a clear need to incorporate bush fire risk considerations into policy, including planning;
- similar observations and findings are made across other Royal Commission and Inquiry reports, over the decades across the country. One of the key challenges for planning in this regard is the continued expansion or encroachment of urban areas into bushland and scrub areas. In 1984, following the Ash Wednesday fires in Victoria and South Australia, two reports identified specific planning-based measures for bush fire risk reduction. Many of these measures continue to form the basis of risk treatment today, at the property level;
- more recent NSW-based inquiries include the 2014 Coronial Inquest into the Warrumbungle Bush Fire, the inquiry into the 2013 Blue Mountains Bush Fire, the 2014 Parliamentary Inquiry into the Wambelong fire and the 2018 Bega Valley Fires Independent Review. Each of these has shaped the continued evolution of policy and disaster management arrangements;
- the 2014 *Productivity Commission Inquiry into National Disaster Funding Arrangements* identified a range of recommendations, with key observations including the governments over-invest in post-disaster reconstruction and under-invest in resilience and mitigation to limit the impact of risk and disaster, and that regulations affecting the built environment have a significant influence on the exposure and vulnerability of communities to natural hazards. While building regulations have generally been effective, there is a need to transparently incorporate disaster risk management into land use planning; and
- in terms of inquiries within the spatial context of the Northern Beaches, the *Coronial Inquiry into the cause and origins of the bush fires occurring in New South Wales between 31 December 1993 and 14 January 1994* had regard to the Cottage Point fire which started on 7 January 1994. Over a period of several days this fire event moved south and burnt through areas of the Deferred Lands as well as other parts of the Northern Beaches, totally 231ha in total. This event remains one of the most significant fire events in the area in recent history.

5.5 Bush fire risk and land use planning research

An extensive evidence-base of academic research is available in Australia which informs policy approaches as well as operational approaches. A considerable base of land use planning and bush fire specific research has been conducted, particularly following Black Saturday in 2009, as well as events which have occurred over recent years including the Wye River and Tathra fires.

Key bodies of research include:

- the *Community Preparedness and Responses to the 2017 New South Wales Bushfires* research paper reviewed the reactions of the NSW community when faced with threat from a bush fire emergency. The research revealed that even when notified, the at-risk community tends to remain where they are to observe the bush fire for themselves, adopting a 'wait and see' approach. Despite a change in focus on warning messaging since the 2009 Black Saturday fires for catastrophic events, most people still do not intend to leave before there is a fire on such days (Whittaker & Taylor, 2018);
- *Planning and Bushfire Risk in a Changing Climate* examines the role of urban and regional planning in relation to bush fire risk in Australia. The research provides a deeper understanding of the contribution of urban and regional planning to managing fire risk

throughout Australia. Differing perceptions of fire and various planning responses by States and Territories provide a rich policy environment for multiple sectors to consider. Added to this complexity are expanding urban areas across Australia and the challenges of continuing urban development in regions that are already experiencing environmental change and predictions of an even hotter environment and an increased potential for fire risk. A key finding is the need for a more integrated approach to planning for fire risk that better connects planners with emergency management (Norman et al. 2014);

- the Australian Business Roundtable for Disaster Resilience and Safer Communities, together with Deloitte Access Economics, released the report *Building Resilience to Natural Disasters in our States and Territories* in 2017. At 2017, the total cost of disasters across NSW was \$3.6bn per year. This is forecast to escalate to \$10.6bn per year by 2050 having regard to direct and indirect tangible costs as well as intangible costs. NSW also receives the second-highest allocation of Commonwealth resilience funding. From a social perspective, bush fire life loss, injury, homelessness and persons affected registers as the second highest type of disaster cause, after heatwave, and higher than flood. Mainstreaming resilience into planning, land use and building requirements is identified as a key strategy in embedding resilience in decision-making but noting also that land use planning systems are yet to fully embrace their role in mitigating the risks to loss of life, property damage and destruction of vital infrastructure arising from natural hazards (Deloitte Access Economics, 2017);
- the 2020 report *Integrated Urban Planning for Natural Hazard Mitigation* identifies that risk modelling for urban edge development remains relatively limited in Australia, and that it is common for future growth area identification processes to progress significantly, well before adequate risk assessment. The inclusion of critical decision criteria, requirements for scenario testing, allocation of roles and establishment of suitable forums can significantly improve future growth risk assessments. The report identifies a suite of findings to assist in frontload risk considerations into strategic planning activities (March et al. 2020); and
- the 2019 paper entitled ***Future Risk Framework: Understanding tomorrow's risk and what we can do to reduce it*** notes the continuous increases over time in disaster risk due to factors such as climate change, population growth, economic development and an ageing population. The paper presents structure risk framework comprising four main steps to quantify future risk. These steps include the exploration of drivers of future risk, development of plausible future scenarios, parameterisation of scenarios and simulation of impact of scenarios to develop an increased understanding of future risk. The progresses assessment from more of a qualitative approach to one which is more quantitative in nature (Riddell et al. 2019).

5.6 Overview of bush fire attack mechanisms

This section provides a brief overview of the bush fire attack mechanisms which may impact upon life, property and the environment.

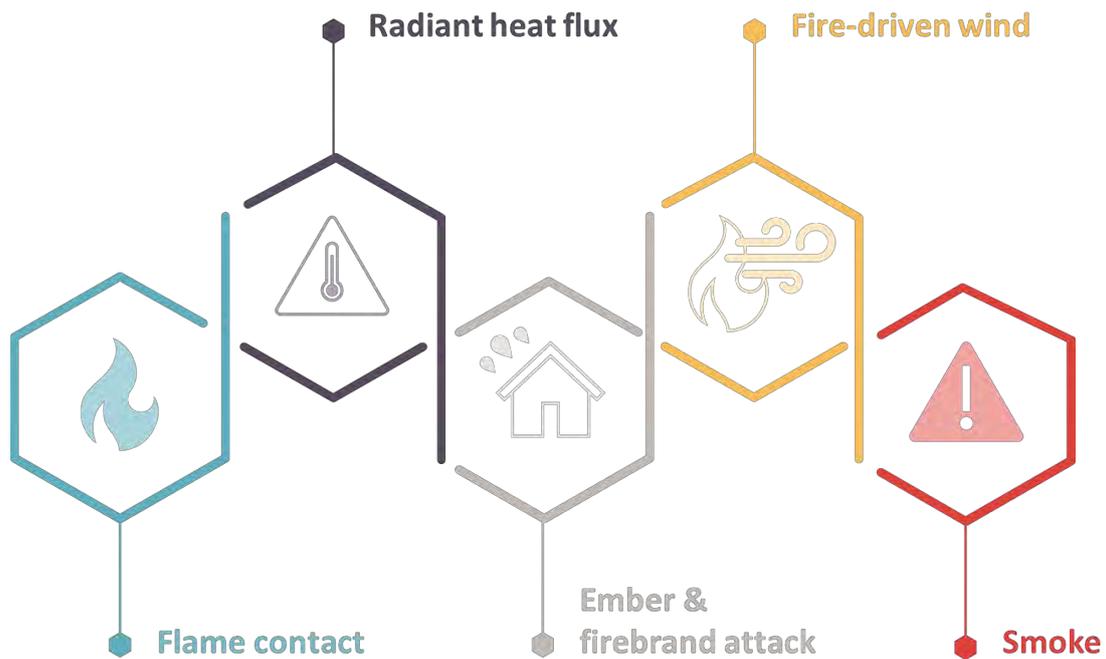


Figure 7 - Bush fire attack mechanisms

- *flame contact* refers to flame contact from fire, where the flame which engulfs burning vegetation comes in to contact with buildings, assets or people. It is estimated that between 10 to 20 per cent of buildings lost to bush fire occur as a direct result of flame attack (CSIRO, 2014);
- *radiant heat flux* is the heat energy released from the fire front which radiates to the surrounding environment. It remains one of the leading causes of fatalities due to bush fire. In terms of impacts on buildings, radiant heat can pre-heat materials making them susceptible to ignition, can cause non-piloted ignition to certain materials at specific temperatures and can severely damage and melt materials. Radiant heat can also damage building materials such as window glazing, allowing openings into a building through which embers may enter. Radiant heat impact is an especially important factor in building-to-building ignition. The figure below outlines the observed effects of radiant heat exposure for persons and buildings;

Radiant heat flux kW/m ²	Observed effect
1	Maximum for indefinite skin exposure
3	Hazardous conditions, firefighters expected to operate for a short period (10 minutes)
4.7	Extreme conditions, firefighters in protective clothing will feel pain after 60 seconds of exposure
6.4	Pain after 8 seconds of skin exposure
7	Likely to be fatal to unprotected person after exposure for several minutes
10	Critical conditions, firefighters not expected to operate in these conditions although they may be encountered. Considered to be life threatening in less than 60 seconds in protective equipment. Fabrics inside a building could ignite spontaneously with long exposure.
12.5 (BAL-12.5)	Volatiles from wood may be ignited by pilot after prolonged exposure. Standard float glass could fail during the passage of a bushfire.
16	Blistering of skin after 5 seconds
19 (BAL-19)	Screened float glass could fail during the passage of a bushfire.
29 (BAL-29)	Ignition of most timbers without piloted ignition (3 minutes of exposure) during the passage of a bushfire. Toughened glass could fail.
40+	Flame zone – exposure to direct flame contact from fire front

Figure 8 - The effects of radiant heat (Source: NSW RFS, 2006)

- *ember and firebrand attack* relates to the convective forces of bush fire which raises burning embers into the atmosphere on prevailing winds, depositing them to the ground ahead of the fire front to spark spot fires (also referred to as spotting). Firebrands are typically larger items of burning material such as bark which can also stay alight for some time, and can be more dangerous to humans. Ember attack will usually occur ahead of the arrival of the fire front. Embers attack the vulnerabilities of buildings and is estimated to cause between 80 and 90 per cent of building loss as a result of bush fire (CSIRO, 2014);
- the convective forces of bush fire typically result in strong to gale force *fire driven winds* which can, on occasion, lead to building damage. The typical effects of fire driven wind include the conveyance of embers, damage from branches and debris hitting the building and breaking windows; and
- *smoke* emission remains a secondary effect of bush fire and is one which is typically not addressed by bush fire assessments but is a relevant aspects of risk assessment. This is for two reasons, the first relates to the potentially severe impact of smoke emission on the human respiratory system. Toxic smoke emission can occur, particularly where buildings, furnishings, materials and the insides of vehicles are ignited or exposed to extreme radiant heat (i.e. materials start to melt). Secondly. It can reduce visibility which can result in challenging evacuation conditions.

5.7 Deferred Lands bush fire hazard context

The following sections set out the nature of the bush fire hazard context relating to the Deferred Lands areas which includes parts of Belrose, Oxford Falls and Cromer.

For the purposes of the risk assessment, the Deferred Lands area is divided into three separate precincts. These precincts include:

- *Western precinct* – west of Forest Way;
- *Central Precinct* – bound to the west by Forest Way and to the east by Wakehurst Parkway; and
- *Eastern precinct* – east of Wakehurst Parkway to Cromer and Narraweena.

These precincts do not alter the landscape-wide approach to bush fire behaviour modelling or assessment of landscape-scale risk. Rather, the purpose of identifying precincts assists in communicating the risk context specific to different areas of the Deferred Lands.

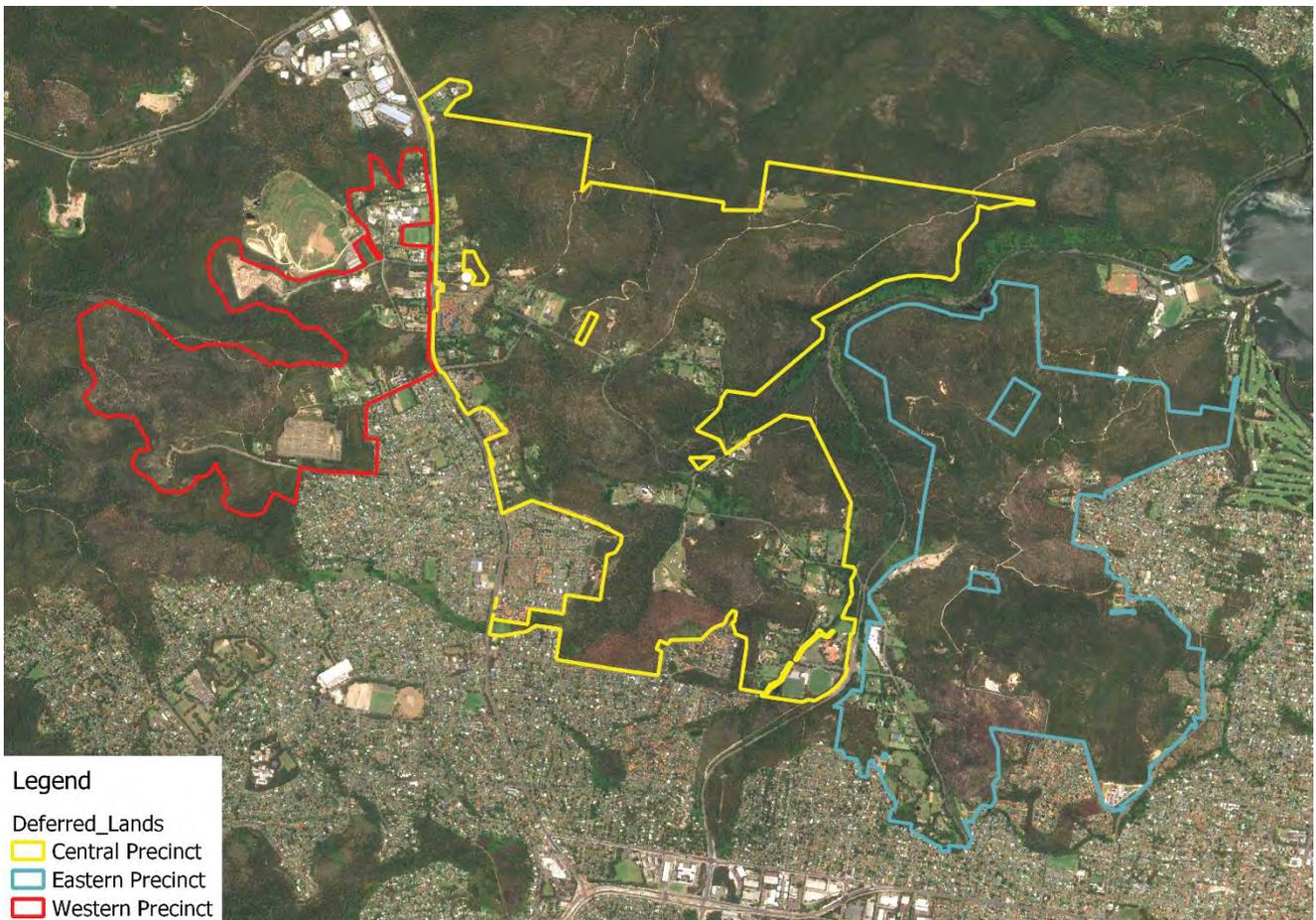


Figure 9 - Overview of Deferred Lands precincts

5.7.1 Bush fire prone land

The new Northern Beaches Bush Fire Prone Land map was certified by the Commissioner of the NSW RFS in August 2020. An excerpt of this map is provided below.

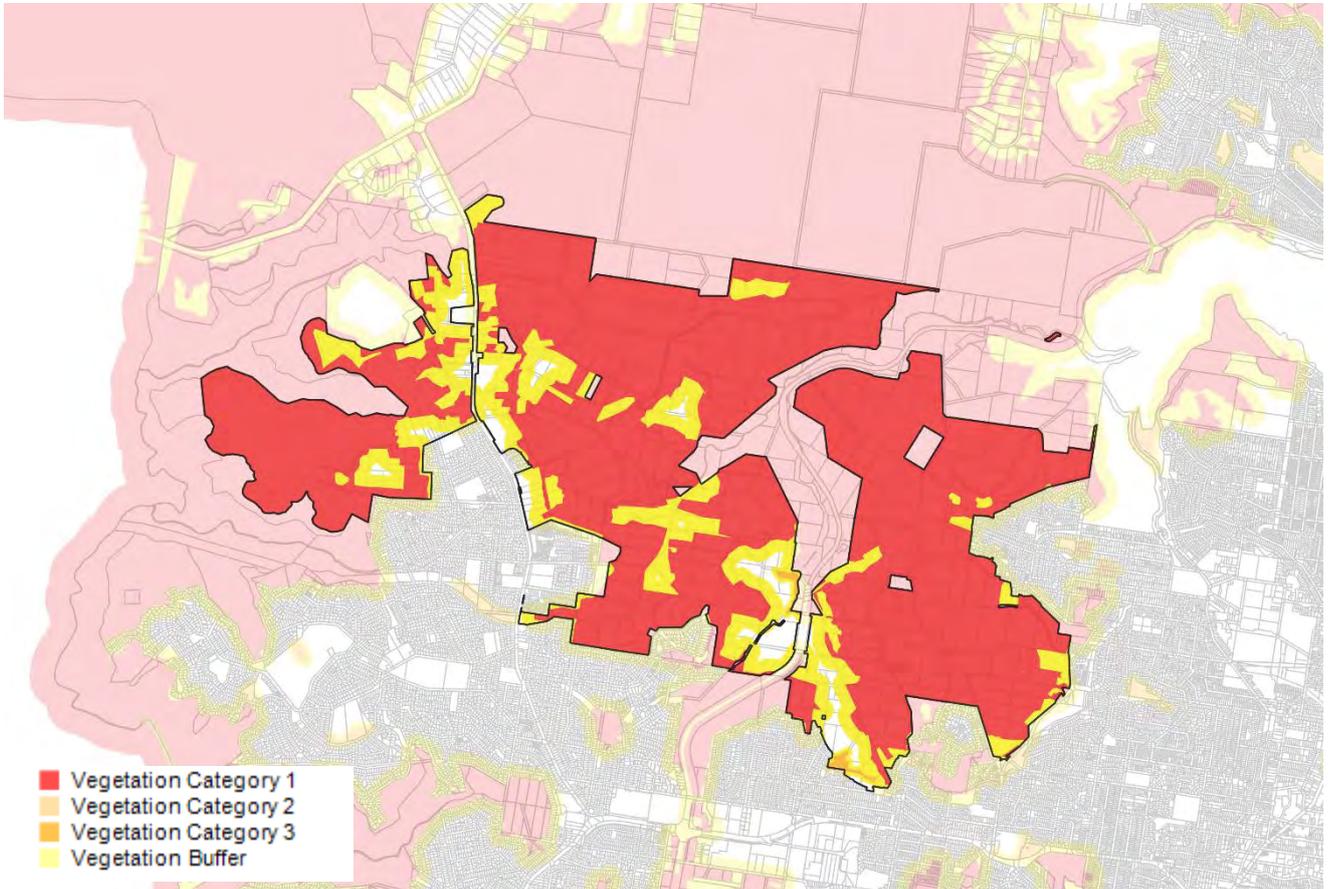


Figure 10 - Extract of the certified Northern Beaches Bush Fire Prone Land map (Source: Northern Beaches Council, 2020)

5.7.2 Fire weather

It is important to understand the influence of fire weather with regard to how it can affect bush fire risk levels on a daily, weekly or seasonal basis.

In most parts of NSW, hot-air fire wind is typically generated by north to north-westerlies and cool-air fire wind is generated by south-westerlies which are prevalent during the State's annual fire season which extends from October to March but varies year-on-year due to macro-climatic conditions. Other fire weather conditions must also be contemplated such as preceding weather conditions (such as low rainfall or drought), air temperature and relative humidity. If the area has been subject to drought or low rainfall for a period of time, vegetation health tends to deteriorate with increased leaf drop, curing and drying. This contributes to increased ground fuel loads and general ignition susceptibility. Prolonged dry periods also reduce soil moisture content.

The Forest Fire Danger Index (FFDI) is a commonly used method to readily advise the community of the likely ability of fire suppression based on fire weather, which is used to inform the Fire Danger Rating (FDR) System which guides the communication of bush fire warnings across Australia, refer to the following figure. It is noted, the FDR system is currently being revised and a new FDR will replace that outlined at the figure below in the near future, across Australia.

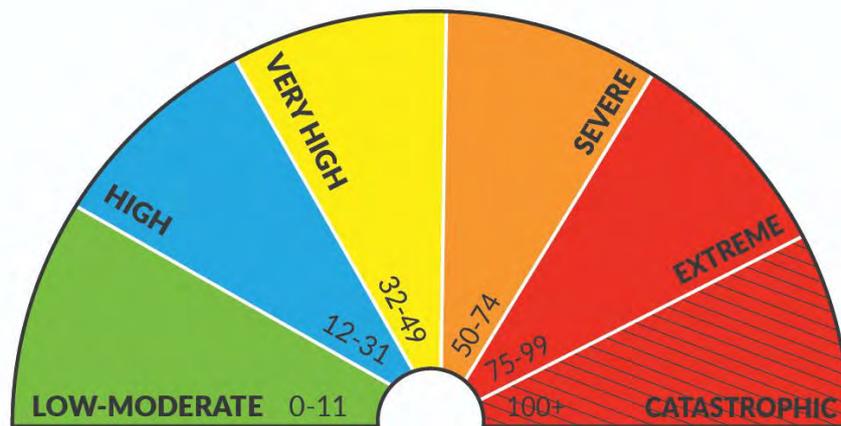


Figure 11 - Fire danger ratings and corresponding FFDI values

The Deferred Lands area is within the Greater Sydney fire weather region, pursuant to the NSW RFS fire weather regions mapping.

In Greater Sydney, a FFDI of 100 is adopted for both land use planning and building construction purposes. This recognises that, on occasion fire weather across this area reaches (and may exceed) Catastrophic FDR level. This has been generally equivalent to a 2 per cent annual exceedance probability (AEP) event (sometimes referred to as a 1 in 50 year annual return internal fire weather event).

A 'generalised extreme value' (GEV) analysis has been undertaken, using 40+ years of daily FFDI data recorded at both the Sydney Airport and Richmond weather stations. The daily FFDI values recorded at Sydney Airport are routinely higher than those recorded at Richmond. For the purposes of this risk assessment, the Sydney Airport data is adopted.

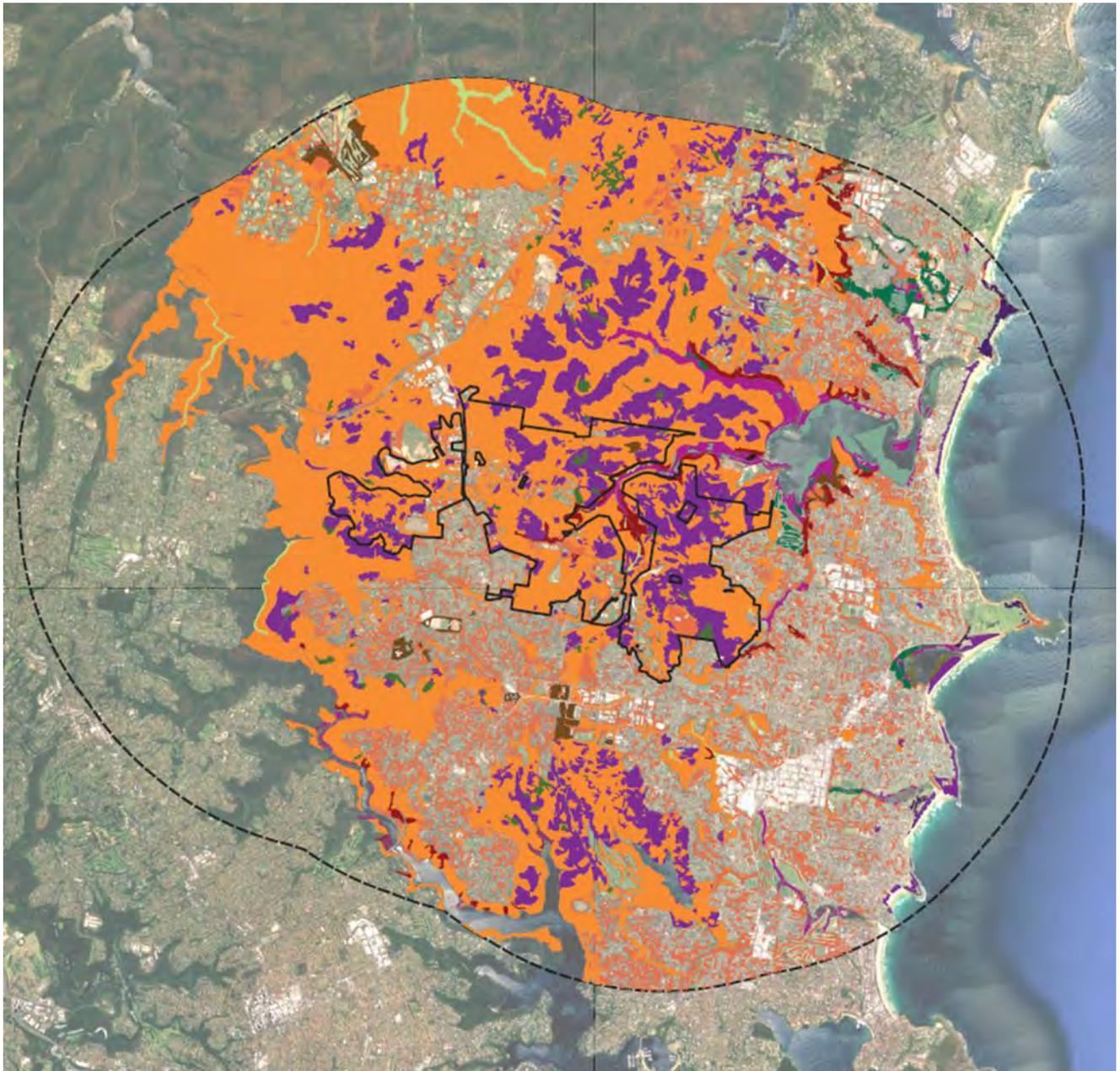
The GEV analysis indicates a 1 in 50 year fire weather event for Sydney is more accurately identified at 116, and a 1 in 200 year fire weather event at FFDI 134. This is also similar to the FFDI recorded in parts of Victoria on Black Saturday, though noting localised FFDI's in Victoria on that day may be as high as 185.

NSW RFS states that during Catastrophic fire weather, leaving early is the only option for survival and homes are not designed to withstand fires in Catastrophic conditions.

A detailed analysis of fire weather history and annual exceedance probabilities (AEP) is provided at the 'Risk Identification' section of this report as part of the risk likelihood and probability analysis.

5.7.3 Vegetation communities

Fuel load and arrangement represents a considerable component in dictating to a large degree the behaviour of fire in terms of intensity, rate of spread and flame height. Different vegetation groups yield very different fire behaviour and intensity by virtue of their characteristics such as density, arrangement and fuel loads. Vertical and horizontal continuity of fuels is also a considerable factor. Vegetation characteristics guide estimates on how quickly fire might spread and the likely fire behaviour and intensity which may occur.



Legend

5kmBuffer

Deferred_Lands_Area1

Vegetation and Fuel Loads

Saline Wetlands

Mangrove Swamps

Saltmarshes

Seagrass Meadows

Heathlands

Coastal Headland Heaths

Sydney Coastal Heaths

Wet Sclerophyll Forests

North Coast Wet Sclerophyll Forests

Northern Hinterland Wet Sclerophyll Forests

Forested Wetlands

Coastal Floodplain Wetlands

Coastal Swamp Forests

Eastern Riverine Forests

Grasslands

Maritime Grasslands

Rainforests

Littoral Rainforests

Northern Warm Temperate Rainforests

Freshwater Wetlands

Coastal Freshwater Lagoons

Coastal Heath Swamps

Dry Sclerophyll Forests

Coastal Dune Dry Sclerophyll Forest

Sydney Coastal Dry Sclerophyll Forests

Low Hazard/Other

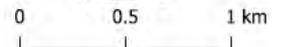


Figure 12 - Vegetation communities within five kilometres of the Deferred Lands area

The data used to inform the vegetation communities is drawn from:

- a compilation of Council vegetation mapping datasets; and
- Sydney Metro Catchment Management Area Vegetation Mapping (OEH, 2016).

Within 5 kilometres of the Deferred Lands area, the predominant vegetation communities, in accordance with 'Keith Formations' include:

- Sydney coastal dry sclerophyll forests;
- Sydney coastal heath; and
- to a lesser degree, pockets of North Coast Wet Sclerophyll forests.

Small pockets of other vegetation communities are also present. Pursuant to Table A1.12.8 of PBP 2019, the primary vegetation communities are converted into standardised vegetation formations as set out at the following table.

Table 3 - Predominant vegetation communities relevant to the Deferred Lands area

Vegetation	Formation	Surface and elevated fuel load (t/ha)	Overall fuel load including bark and canopy (t/ha)
Sydney coastal dry sclerophyll forests	Forest (wet and dry sclerophyll)	22	36.1
North Coast Wet Sclerophyll forests	Forest (wet and dry sclerophyll)	22	36.1
Sydney coastal heath	Tall heath	36.9	36.9

5.7.4 Topography

The topography of the Deferred Lands is characterised by incised waterways, valleys and ridge-top plateaus which combine to create a complex area of terrain in some locations.

Council's 2019 LiDAR digital elevation model was utilised for this topographic analysis.

In the western precinct, land rises considerably from waterways which drain to the Middle Harbour catchment further to the west. As such, the area of Belrose North is quite elevated, flanking a ridgeline which is generally represented by Forest Way.

In the central precinct, land falls away from the Forest Way ridgeline and into Oxford Falls Valley. The various waterways which flow into Narrabeen Lagoon including Middle Creek, Oxford Creek, Snake Creek and Deep Creek, have over time carved the undulating topography of the central precinct, which includes steep topography in some locations. Most existing development in the central precinct is situated on the valley floor.

The terrain of the eastern precinct is of a similar character to the central precinct, with a quite prominent ridge extending north from Red Hill Reserve, falling to valley areas to the east and west. The land rises again to the north, to the immediate west of the Maybrook Retirement Village. The topography of the balance of the precinct is rugged and substantially undulating.

This topography continues north into Garigal National Park.

The complex terrain features of the Deferred Lands area and surrounding lands likely produces quite localised fire behaviour characteristics as winds navigate the meandering slopes of the area.

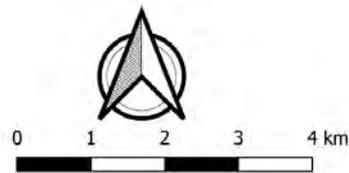
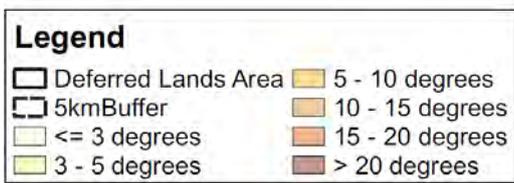


Figure 13 - Topographical context within 5 kilometres of the Deferred Lands area

5.7.5 Landscape and localised fire hazard

Two types of hazard are relevant in terms of bush fire including:

- landscape hazard – where large expanses of bushland are located in immediate proximity to, and may traverse, urban periphery suburbs/townships; and
- localised hazard – most commonly associated with fragmented areas of vegetation larger than 1 hectare in size, including vegetated waterway corridors and remnant bushland patches.

These two types of hazard present different types of fire behaviour, fire intensity and potential rate of spread characteristics.

Fireline intensity mapping has been prepared for the Deferred Lands area and surrounding landscape for a distance of 5 kilometres, in order to understand the potential transfer of fire both spatially (geographical extent) as well as its potential intensity (energy emission).

The fireline intensity mapping for the area under westerly and north westerly wind conditions at FFDI 100 is represented below, FFDI being the fire weather threshold for land use planning purposes, established by PBP 2019.

This mapping demonstrates the Deferred Lands area is largely subject to landscape-scale fire, at present. Smaller patches and corridors are subject to potential localised hazard, given the extent of spotting behaviour and ember attack likely to occur at FFDI 100 in the Warringah-Pittwater region.

Fireline intensity is a measure of fire intensity at the fire front. It is measured as the amount of energy released per metre width of the fire edge (CSIRO, 2013).

It is a function of fuel characteristics (vegetation types, structures, arrangements and quantity) and relationship with fire weather which influences potential rate of spread.

Fireline intensity mapping has been undertaken for a range of fire weather scenarios, and land use scenarios. These are included at Appendices A, B and C, and discussed in further detail at Section 7 of this report.

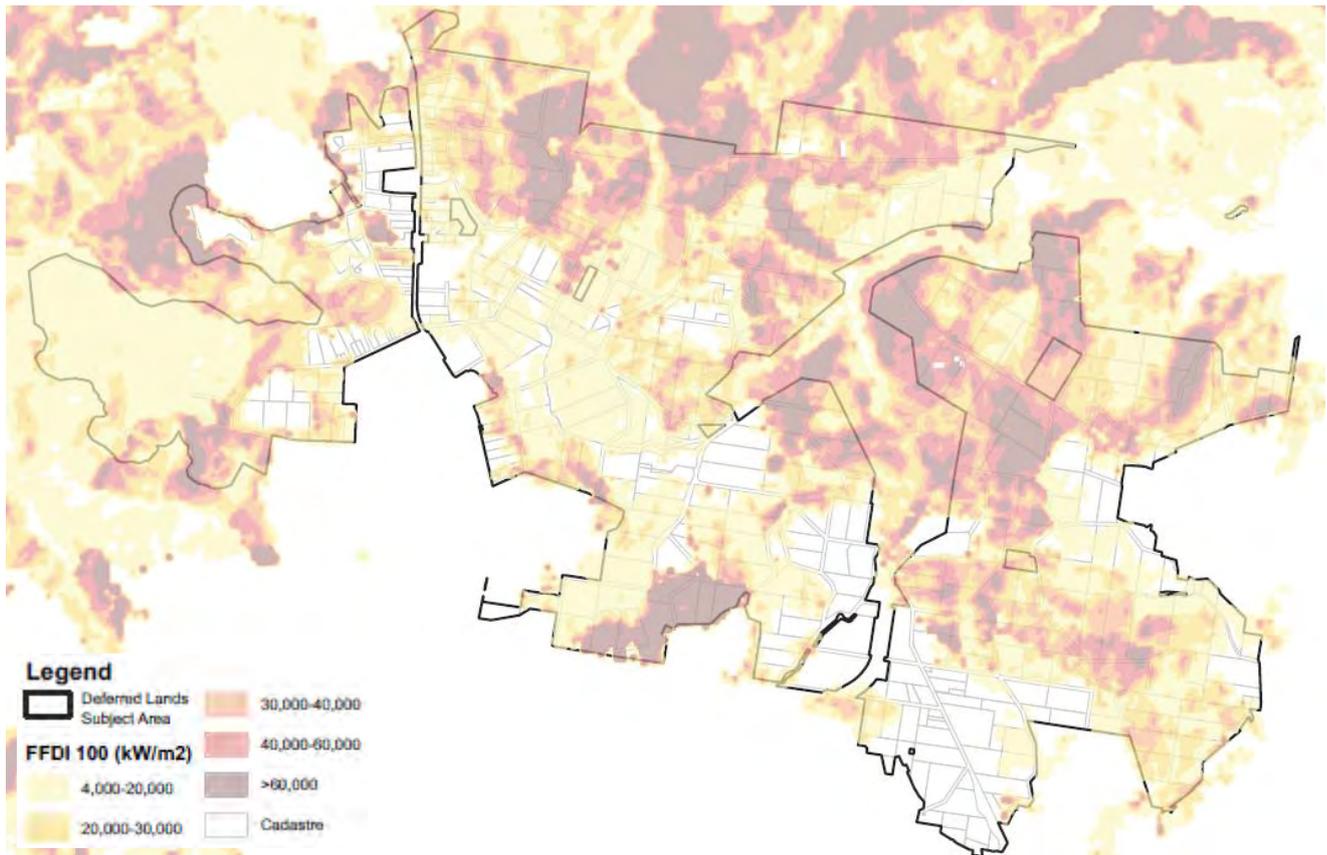


Figure 14 - Fireline intensity mapping for fire weather of FFDI 100 under north westerly wind conditions based on current vegetation

5.7.6 Primary fire runs

This section identifies the nature of the primary fire runs relevant to each precinct within the Deferred Lands area.

5.7.6.1 Western precinct primary fire runs

The northern interface of the western precinct at Belrose North is largely framed by Fireclay Gully which forms part of Garigal National Park and the former recycling centre, now a mountain bike track facility, north of Challenger Drive. It is bound by Middle Harbour Creek to the west and Frenchs Creek to the south.

Key fire runs relevant to the western precinct of the Deferred Lands area stem from the west, north and north-west areas of Garigal National Park. An ignition within Garigal National Park or further afield in Ku-ring-gai Chase National Park is likely to transition toward the western precinct on a westerly and north-westerly fire wind including flame front transition as well as spotting from ember attack. These winds are likely on days of elevated fire danger.

The new mountain bike track facility provides a fire break, of sorts, to existing and potentially vulnerable facilities within Belrose North, from a north-westerly fire run however, it is noted the cleared area in this location is fragmented whilst is likely to enable the fire front, spotting and ember attack to traverse the landscape toward Forest Way and possibly beyond.

On a westerly-driven fire wind, Fireclay Gully has the potential to convey fast-moving fire from the west, toward Forest Way, with vegetation connectivity providing the ability for fire run transition directly to Forest Way. In elevated fire danger conditions, fire in this location could possibly jump Forest Way to continue in an easterly direction into the central precinct, or Oxford Falls.

The topography of Fireclay Gully is such that a fire run in this location would likely increase dramatically in rate of spread and intensity along the gully banks to the north and south noting

major infrastructure facilities, educational facilities and other development is located on the ridge areas of Fireclay Gully.

A similar situation exists to the south, along Frenchs Creek which incorporates a deep gully which transitions into urban residential at Belrose.

There is also the potential for propagation from the north east, depending upon fire wind conditions and it is noted this occurred during the 1994 Cottage Point fire which impacted the Belrose North area.



Figure 15 - Indicative key fire runs relative to the western precinct (Source: Base map derived from Google Earth, 2020)

5.7.6.2 Central precinct primary fire runs

The central precinct is framed to the north by Garigal National Park, Forest Way to the west and Wakehurst Parkway and Middle Creek to the east.

The primary fire run relevant to the central precinct is from the north, through Garigal National Park. Secondary fire runs are possible from the north-west and west, should fire overrun Forest Way and continue into Oxford Falls, or via spotting activity generated from the north-west or west.

Secondary fire runs are also possible from the east, on a northerly or north-easterly win, and possible on a south-easterly. These winds tend to be cooler in nature this close to the coastline than those which drive hot-dry westerly fire winds and may be of a lower intensity than those driven on westerly fire winds however, preceding drought, rainfall and fuel moisture conditions may vary across seasons to increase the threat of such events.

The existing fuel connectivity of the central precinct is relatively intact with a low level of fragmentation, likely to enable fire to transition across the landscape relatively unabated by firebreaks, asset protection zones, road corridors or the like.



Figure 16 - Indicative key fire runs relative to the central precinct (Source: Base map derived from Google Earth, 2020)

5.7.6.3 Eastern precinct primary fire runs

The eastern precinct is bound to the west by Wakehurst Parkway and to the east by the urban suburbs of Cromer and Narraweena. The Sydney Academy of Sport and Recreation is located to the immediate north, and the urban area of Beacon Hill frames the precinct to the south.

The primary fire runs relative to the eastern precinct are likely to originate from the north and north-west, where fire may run out of Garigal National Park to the south, and including the transition of fire from the central precinct or further afield to the north-west. Spotting from ember attack generated to the north and north-west are likely to be a key aspect of fire activity within the eastern precinct.



Figure 17 - Indicative key fire runs relative to the eastern precinct (Source: Base map derived from Google Earth, 2020)

5.7.7 Fire history

Over recorded history, the area has endured a number of fire events of relatively regular frequency.

Across the Northern Beaches, fire events have been recorded as far back as the 1890's, with events occurring in 1918, 1928, 1939, a particularly intense run of multiple events between the years of 1942 and 1957, 1967, 1971 and 1972 (Macleod, 1996).

On 16 December 1979 a state of emergency was declared as a fire front extending 12 kilometres in width burned through the areas of Terrey Hills, Ingleside, Duffys Forest, Mona Vale, Elanora Heights, Cromer and Forestville, claiming over 100ha of bushland and six homes over a three day period (Macleod, 1996). The context of settlement is appropriate to consider, noting the area was not developed to the extent that it is today.

The Garigal National Park Fire Management Strategy identifies a recent history of significant fire events within the national park occurring in 1987, 1991, 1994, 2001 and 2003. It notes most fires within the national park have been ignited by human activities, in particular arson. No recorded lightning ignitions had occurred in the national park prior to 2006 (Department of Environment and Conservation NSW, 2006).

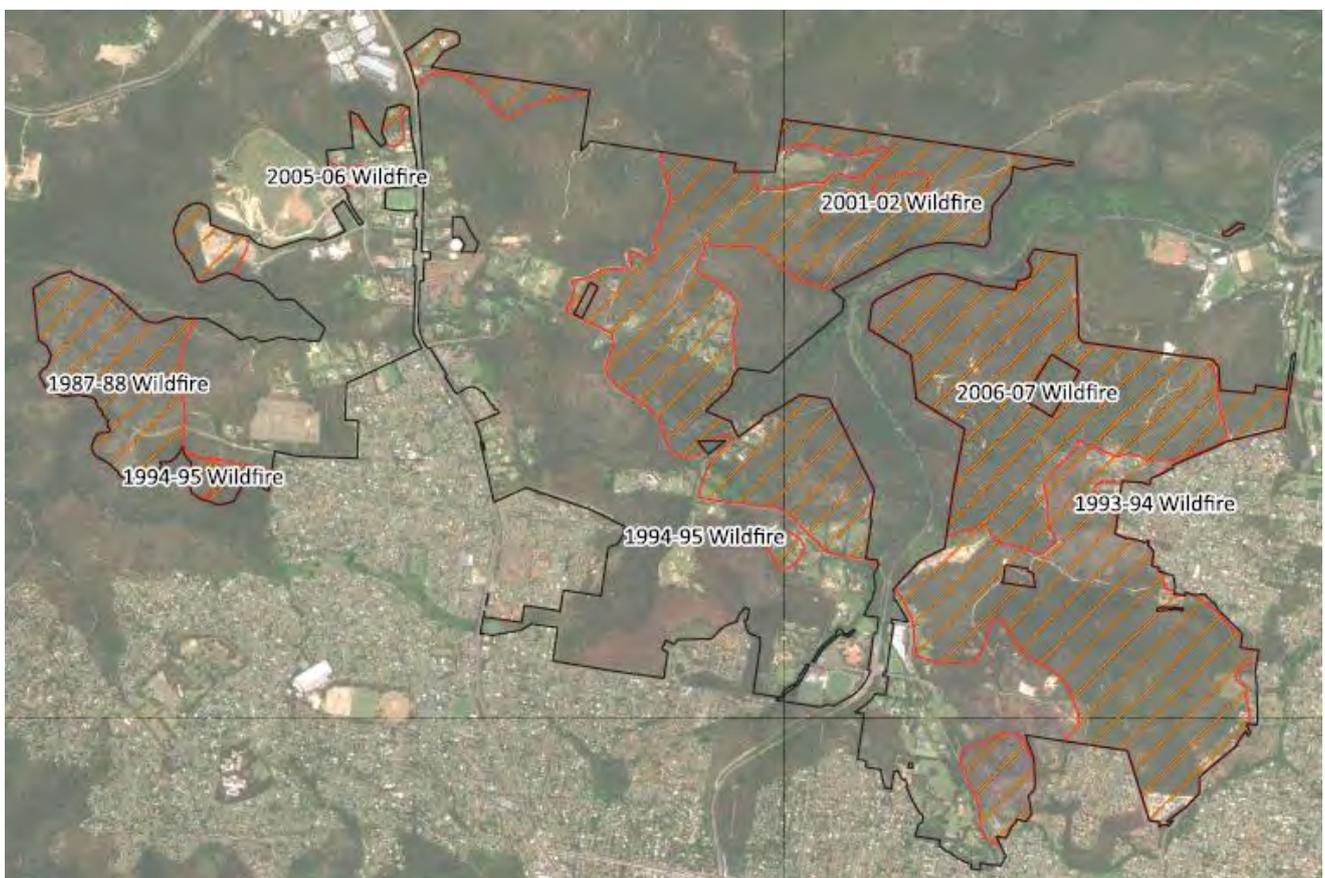


Figure 18 - Fire scar mapping across the Deferred Lands area based upon available data

In early January 1994, fire weather conditions developed as a result of little summer rainfall, high temperatures (37-38 degrees Celsius), low relative humidity (as low as 20 per cent) with a gusting north-westerly wind (Macleod, 1996). An ignition occurred at Cottage Point in the late afternoon of 7 January 1994. The cause of the ignition could not be determined, however the fire burnt in a south-easterly direction, driven on a hot, dry north-westerly fire wind.

On the first day Cottage Point was isolated almost immediately and the fire had spread 6.5 kilometres in three and a half hours, reaching the area of Bayview a short time later (Macleod, 1996).

The following day, the fire expanded substantially, and it is on this day the fire transitioned across Ingleside and into Bayview, Warriewood, Elanora Heights and Terrey Hills. This included the transition of the fire front across existing golf courses to the south of Ingleside which are typically low fuel environments. Over the next two days, the fire continued to advance through to Oxford Falls and burning out Garigal National Park (Macleod, 1996).

No life was lost in the Warringah Pittwater fires, however more broadly across NSW that day four people lost their lives as multiple fires impacted various communities. In total, the Cottage Point fire burned through 231ha in Warringah Pittwater. 27 houses and two units were destroyed along with damage to a further 60 houses and four units along with a host of other items such as caravans, trailers, boats, garages, machines, etc. (Macleod, 1996; Hiatt et al. 1995).

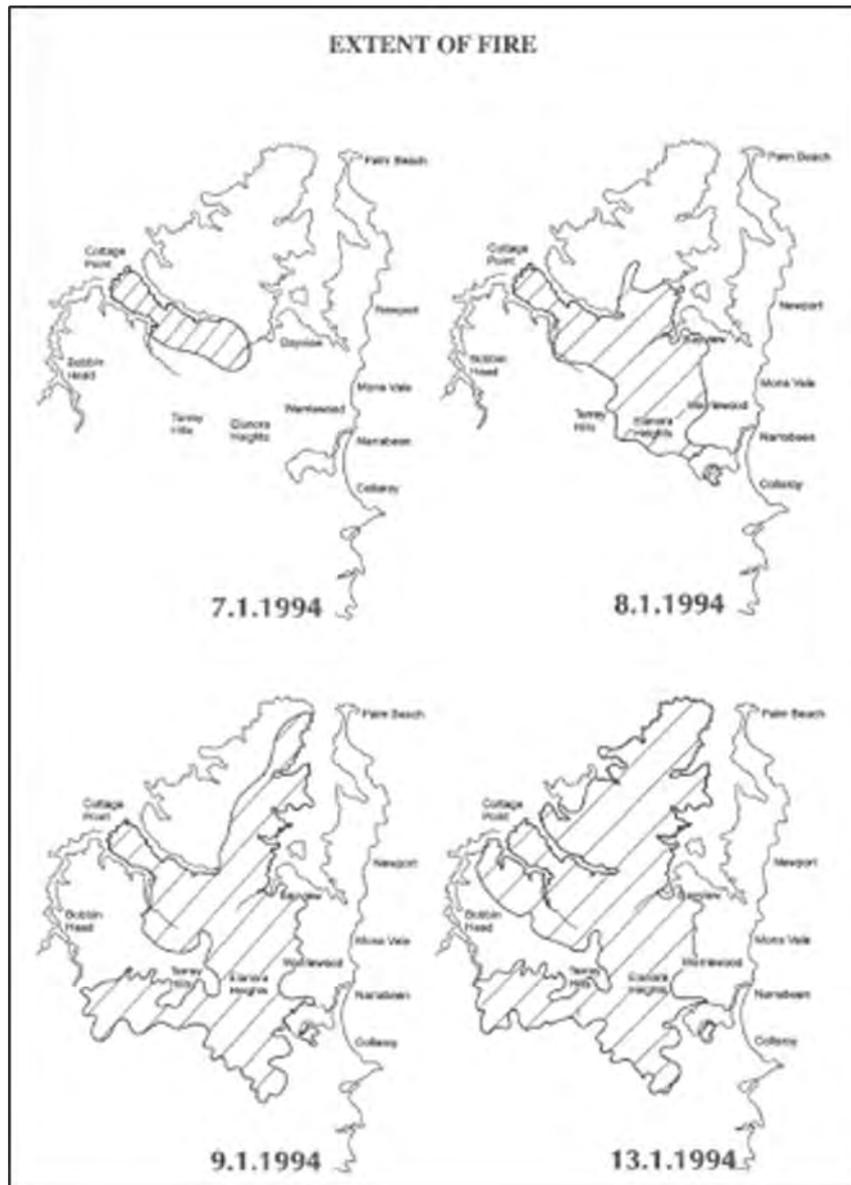


Figure 19 - Illustration of fire spread 7-13 January 1994 (Source: Macleod, 1996)

Two key observations are drawn from the 1994 with respect to the Deferred Lands area, these include:

1. Urban property loss has occurred in the area, in fuel reduced areas; and
2. The Deferred Lands area is part of a broader known 'fire path' pursuant to previous events.

6 Risk identification

In accordance with NERAG, it is critical that all risks of interest are identified and acknowledged (AIDR, 2017). The following section considers the relevant risk elements of:

- likelihood or probability;
- consequence, as a function of exposure and vulnerability; and
- possible strategic land use planning and associated cascading risks.

Risk level is a function of the likelihood or probability of a certain event, multiplied by consequence which is a function of exposure and vulnerability (minus tolerability). The Land Use Planning for Disaster Resilient Communities Guideline released by the AIDR, forming part of a larger suite of Handbooks which includes NERAG, identifies the following matrix of risk levels, across a graduated spectrum from very low to extreme. This matrix reflects that of NERAG.

The following sections articulate the qualitative aspects of this risk identification process, of relevant consideration.

LIKELIHOOD	CONSEQUENCE LEVEL				
	INSIGNIFICANT	MINOR	MODERATE	MAJOR	CATASTROPHIC
ALMOST CERTAIN	Medium	Medium	High	Extreme	Extreme
LIKELY	Low	Medium	High	Extreme	Extreme
UNLIKELY	Low	Low	Medium	High	Extreme
RARE	Very low	Low	Medium	High	High
VERY RARE	Very low	Very low	Low	Medium	High
EXTREMELY RARE	Very low	Very low	Low	Medium	High

Figure 20 - NERAG risk matrix (AIDR, 2020)

6.1 Likelihood analysis

There are two broadly accepted approaches to the interpretation of event likelihood or probability relating to natural hazards and these include the annual recurrence interval (ARI) and annual exceedance probability (AEP). The ARI is commonly used to refer the number of years which may pass before an event of a given magnitude may occur.

This approach is no longer considered an appropriate method to communicate risk likelihood, given there is a percentage chance each year that an event of a given magnitude may occur. Hence the current accepted use of AEP which note for example that an event considered to be of a 1 in 50 year event magnitude has an approximate 2 per cent chance of occurring in any given year. This explains more readily how two higher magnitude (less likely) events can occur multiple times within a short time period.

The table below translates the NERAG risk likelihood levels into fire weather event ARI and AEP values.

Table 4 - Fire weather risk likelihood levels and associated ARI and approximate AEP values

NERAG risk likelihood level	Probability of fire weather		
	Annual recurrence interval (ARI)	Approximate annual exceedance probability (AEP)	Equivalent FFDI
Almost certain	Almost annual event	100%	62
Likely	1 in 20 year fire weather event	5%	100
Unlikely	1 in 50 year fire weather event	2%	114
Rare	1 in 100 year fire weather event	1%	124
Very rare	1 in 200 year fire weather event	0.5%	134
Extremely rare	1 in 500 year fire weather event	0.2%	148

In Greater Sydney, a FFDI of 100 is adopted for both land use planning and building construction purposes. This recognises that, on occasion fire weather across this area reaches (and may exceed) Catastrophic FDR level.

Over time, NSW coastal areas are likely to experience alterations to historic fire weather trends (Douglas, 2017).

However, additional fire weather scenarios are also considered by this risk assessment, including more frequent, lower FFDI events as well as higher FFDI events which are rarer in probability but still possible.

A 1 in 200 year fire weather event at FFDI 134 is referenced by this risk assessment. This is also similar to the FFDI recorded in parts of Victoria on Black Saturday (Teague et al. 2010; Leonard & Bianchi, 2012), though noting localised FFDI's in Victoria on that day may be as high as 185.

Noting the 1994 Cottage Point fire occurred under circa FFDI 62 conditions (as recorded at the weather station however, locally the FFDI may have been higher), lower FFDI events can give rise to serious bush fire events and impacts, and are also more frequent and thus, higher in likelihood. The pre-conditioning of the landscape from preceding drought conditions can enhance the impact of fire in lower FFDI conditions (Bradstock et al. 2009).

The fire weather scenarios adopted for the purposes of this risk assessment include:
 FFDI 62 – representative of the fire weather recorded during the January 1994 Cottage Point fire;
 FFDI 100 – the fire weather threshold adopted for planning and building in Greater Sydney;
 FFDI 114 – representative of a 2 per cent AEP or 1 in 50 year fire weather event; and
 FFDI 134 – equivalent of a 1 in 200 year fire weather event (climate change scenario).

6.1.1 Influence of climate change on fire weather

The 2019-20 fire weather season was record breaking for NSW. On 12 November 2019, a catastrophic fire danger warning was issued for Greater Sydney, the first of three 7-day State of Emergency declarations were issued for NSW in November, December and January.

In 2020 the Bureau of Meteorology issued a Special Climate Statement detailing the climatic factors which contributed to dangerous fire weather conditions in the 2019-20 fire season, confirming large areas of Australia had their highest accumulated FFDI for December in 2019. It also notes 2019 had

the highest December accumulated FFDI for Australia as a whole, continuing the pattern seen in the spring period across NSW.

From a climate perspective, the Metropolitan Sydney Climate Change Snapshot (Office of Environment and Heritage, 2014) which is based on NSW and ACT Regional Climate Modelling (NARClIM) data provides the following:

- maximum temperatures are projected to increase between 2020-2039 by 0.3-1.0 degree Celsius and by 1.6-2.5 degrees Celsius between 2060-2079;
- minimum temperatures are also projected to increase over the above periods;
- the number of hot days will increase and the number of cold nights will decrease;
- rainfall is projected to decrease over spring and winter periods, but projected to increase over summer and autumn periods; and
- both average and severe fire weather days are projected to increase in summer and spring by 2070 (affecting both the peak risk season as well as the prescribed burn periods).

The impact of climate change on fire weather is complex. It is not as simply as an elevated FFDI, but involves a likely increased frequency of both higher fire danger days, as well as more frequent fire danger days more generally. Longer fire seasons which start earlier and extend over a longer period are projected (Douglas, 2017), with a cascading impact on fuel reduction opportunities in cooler months.

The work of Douglas (2017) notes 'the moving 20 year GEV₅₀ shows a trend to more severe fire weather conditions, however the changes range from subtle to pronounced (across NSW). These results have implications for adaptation in future land use decision making'.

Catastrophic fire weather events may be rare in nature, and fires in these conditions can be considered as outliers when compared with the frequency of lower FFDI events. However, it remains the responsibility of strategic land use planning to consider the risks associated with higher magnitude and rarer events. In flood risk management this is often referred to as the probable maximum flood.

The 1 in 200 year FFDI of 134 is adopted as the climate-adjusted fire weather scenario for the purposes of this risk assessment

6.1.2 Factors of ignition probability

Likelihood, and particularly the likelihood of consequence (as opposed to event consequence) is a factor of fire weather event likelihood, fuel availability and ignition. Fire weather event likelihood and fuel classifications are addressed above.

In terms of ignition, the Warringah Pittwater BFRMP identifies the area experiences an average of 48 bush fires per year, of which fire events every five to seven years can be expected to be major events'.

Ignition probability is intrinsically tied to the fire conditions of the day, which vary greatly across a single season. Probability of ignition can be forecast as a function of fire weather, preceding rainfall, humidity, elevation, vegetation and fuel moisture which is interfaced with lightning probability and / or human-caused factors like population interface, road density and electrical infrastructure (BNHCRC, 2015).

As a result of a changing climate, ignition probability will likely increase. From a land use planning perspective, increased fire danger days are considered to also represent high ignition probability days as the chances of fire in the landscape are dramatically increased due to the ignition sensitivity of the landscape.

6.1.3 Likelihood assessment

Having regard to the above, and the statements contained with the Warringah Pittwater BFRMP, the likelihood of extreme fire weather in and around the Deferred Lands area is considered 'almost certain', having regard to the spectrum of likelihood presented in the above table. FFDI 100 fire weather events could be considered 'likely' noting these events, over recorded history, are infrequent but have occurred.

6.2 Consequence analysis

This section outlines the identified potential risk consequence of fire of varying magnitudes relating to the Deferred Lands area.

Risk consequence is a function of *exposure* and *vulnerability* (minus tolerability). Tolerability is addressed later in this report.

The following identification of potential risk consequence aligns with the PBP 2019 strategic bush fire study requirements with the addition of specific elements. The risk identification process as it relates to risk consequence analyses the following:

- the *bush fire landscape* and its interface with the community;
- *land use*, property and risk to special fire protection purposes;
- *evacuation* ability;
- risk to *emergency services*;
- *infrastructure* risk, including cascading risk from loss of or damage to critical infrastructure;
- *environment* and land management risk; and
- *economic* risk.

6.2.1 Bush fire landscape

The NSW RFS Bush Fire Survival Maps for Cromer, Oxford Falls Valley and Beacon Hill (noting Belrose North lies outside this area) have been prepared based on an 'extreme' Fire Danger Rating (FFDI 75-99) and are contained within the Community Protection Plan.

These maps demonstrate the majority, if not all, of the Deferred Lands area which has been mapped is subject to flame contact, radiant heat or ember attack (NSWRFS, 2015).

Under 'Extreme' conditions under current circumstances, all of the area is exposed to at least one form of bush fire attack.

The small proportion of the area subject only to ember attack, as it currently exists, includes very little land. Most of this land is in private ownership and is unlikely to represent a safe location for evacuation. The Bush Fire Survival Maps indicate that under these conditions, leaving early is the only option. Staying and defending even a well-prepared property is not advised by the NSWRFS (2015).

The Deferred Lands area is comprised largely of expansive areas of vegetation of limited fragmentation.

The vegetation classes, key fire runs and topography are set out in the contextual analysis section of this report.

6.2.1.1 Demographics and risk to life

From a social perspective, bush fire life loss, injury, homelessness and persons affected registers as the second highest type of disaster cause, after heatwave, and higher than flood (Deloitte Access Economics, 2017).

The Deferred Lands area maintains a resident population of approximately 796 people, and 436 dwellings (ABS, 2016; Geoscience Australia, 2020). From a demographic perspective, approximately 19.7 per cent of the current resident population is aged 65 or over compared with an average of 18.7 per cent for NSW and a national average of 16.9 per cent (ABS, 2016; Geoscience Australia, 2020).

The number of existing seniors living and aged care facilities within the area may or may not factor into the demographic characteristics of the Deferred Lands area, depending upon how the 2016 Census accounted for such uses. Mobility associated with this demographic can be considerably constrained. The ability to evacuate large proportions of potentially vulnerable persons is a key consideration.

Table 5 - Characteristics of the Deferred Lands area

Deferred Lands area	
Residents	796 approx.
Area (ha)	1,406.1
Allotments/Properties	495 approx.
Dwellings	436 approx.

Table 6 - Demographic snapshot of the Deferred Lands population

Element	Deferred Lands area*	NSW
65 years and older	19.7%	18.7%
14 years and under	21.5%	18.5%
Median age	42 years	38 years
Persons with disability	4.1%	5.4%
Dwellings without a vehicle	8.9%	9.2%
Low income	39.4%	44.9%
Households where non-English language is spoken	7.4%	12.5%

* Based on 2016 ABS Census data for the Statistical Areas (SA2) for Cromer and Frenchs Forest-Belrose

Table 7 - Snapshot of Indigenous population within the Deferred Lands area

Element	Deferred Lands area*	NSW
Indigenous population	1.3%	2.9%

* Based on 2016 ABS Census data for the Statistical Areas (SA2) for Cromer and Frenchs Forest-Belrose

Having regard to the above demographic analysis, the population of the Deferred Lands area does not exhibit any particular, statistically-significant differences from the NSW State averages.

In 2012, the CSIRO in conjunction with the former Bushfire Corporative Research Centre undertook a comprehensive study into matters of both life and house loss across utilising over 110 years (1901-2011) of data across 260 bush fire events (Blanchi et al. 2012). Over this period, a total of 825 known civilian and firefighter fatalities have occurred (Blanchi et al. 2012).

Important findings of this seminal research are as follows:

- it is evident that fire weather and proximity to forest are very strong contextual drivers for defining the potential for fatalities to occur;
- 85 per cent of fatalities occur within 100m of bushland;
- 50% of all recorded fatalities have occurred on days exceeding FFDI 100 (most fatalities occur as a result of infrequent but high magnitude events);
- late evacuation is the most common activity persons were engaged in at time of death (30.3 per cent) followed by sheltering inside a structure (24.8 per cent) and defending a property outside (22.4 per cent);
- for those instances where sufficient data is available with respect to fatalities occurring during the act of evacuation, most were trapped on roads by either fallen trees or become bogged, the remainder having run off the road due to poor visibility as a result of smoke conditions;
- in terms of location of fatal exposure, 50 per cent occurred out in the open (including persons found outside structures and outside vehicles), 28 per cent occurred inside structures and in events where FFDI exceeded 100, fatalities within structures represented over 75 per cent of life loss;
- the percentage of fatalities within structures appears to be increasing over time, mostly attributed to the 2009 Victorian Bushfires where 118 of the 173 fatalities occurred inside a structure;
- during the 2009 Victorian Bushfires, findings demonstrate that most of those persons who lost their lives 'could not respond appropriately to the risk the bush fire presented' on that day;
- increasing percentages of fatalities occurring within structures in later fires (1965-2011) were persons aged 65 and over, as well as those with physical and / or mental disability;
- most fatalities occur between the hours of 3pm and 9pm – when FFDI is at its peak (3pm) and when summer cool-change winds occur. 90 per cent of fatalities occur immediately after afternoon wind changes;
- 41.9 per cent of fatalities which occurred from 1965 to 2011 'were aware of the fire with enough time to save their lives; had a fire plan and were following intended actions which were ineffective', with 21.8 per cent who also had enough time to save their lives but either had no fire plan or that plan was not followed, and includes persons who were 'waiting to see'. 10.9 per cent were unaware of a fire and only realised when it was too late, and a further 10.7 per cent were either children or adults following the instructions of another person. 6.1 per cent were either physically or mentally incapable of implementing an effective survival strategy (Blanchi et al. 2012).

Identified potential risks

Potential risks identified, relevant to the bush fire landscape, demographics and risk to life may include:

1. continuous connectivity of landscape fuels and known fire paths and fire runs into the Deferred Lands area;
2. areas of considerable fireline intensity adjacent to and within the Deferred Lands area; and
3. fragmented land ownership which increases the difficulty to manage fire trail networks and implement fuel reduction, and landholder ability and willingness to manage fuel loads on private land.

It is necessary to assess the magnitude of risk associated with these identified potential risks, and this is expanded upon in the following sections of the report.

6.2.2 Land use, property and special fire protection purposes

The nature of land uses across the Deferred Lands area is currently comprised of rural, large lot residential, infrastructure facilities and mixed uses including educational, commercial, places of worship and public lands.

The Deferred Lands area is currently not subject to zoning pursuant to the Warringah LEP 2000. Instead, the LEP permits a range of uses in the locality subject to increasingly stringent assessment processes for uses which are generally not considered consistent with the Character Statement for the area.

A number of special fire protection purposes are located within the area, these are covered in more detail in the sections that follow.

As per the bush fire landscape assessment of risk, the connectivity of fuels across the Deferred Lands landscapes is largely intact, with low levels of fragmentation. Urban development currently exists at the edges of the Deferred Lands area, and adjoining urban development within surrounding suburbs. Fire has previously occurred across substantial areas of the Deferred Lands.

Many properties may maintain site-specific asset protection zones. These may be in accordance with older versions of PBP, noting the 2019 version further expands the asset protection zone requirements for several vegetation communities, or they may instead comply with the 10/50 policy.

Some properties do not appear to maintain any asset protection zones around existing buildings.

The Bush Fire Survival Map for Comer, Oxford Falls and Beacon Hill yield the following observations:

- the majority of the Deferred Lands area (as it currently exists) is subject to a combination of flame impact, radiant heat exposure and ember attack;
- only small pockets throughout the study area are identified as subject to only ember attack, and these areas are already developed (at least to an extent);
- under the conditions identified to prepare these maps, early evacuation is the only appropriate option and this is articulated by NSW RFS (2015). Very limited areas exist in the area in which safe shelter and defence could occur without posing a risk to life as a result of flame impact or radiant heat;
- pursuant to the findings of the BNHCRC 2017 research (refer to information below) into community attitudes and awareness, only 12 per cent of persons surveyed in that instanced stated they would 'leave early' before a fire / ignition was obvious (Whittaker & Taylor, 2018);
- having regard to a 2012 study of life and house loss in 260 bush fire events across Australia conducted by the CSIRO, late evacuation is the most common activity persons were engaged in at time of death (30.3 per cent) followed by sheltering inside a structure (24.8 per cent) and defending a property outside (22.4 per cent) (Blanchi et al. 2012). However, this was not the case on Black Saturday, where approximately 14 per cent lost their life on the road attempting to evacuate and 69 per cent of the 173 persons who lost their life that day were passively sheltering within a building (as opposed to actively defending) (Teague et al. 2010);

- There are non-residential activities within the study area which periodically serve large numbers of people (i.e. schools, places of worship, seniors living facilities, disability services and the like) which may experience difficulty in evacuation due to their location and/or the nature of potential occupants (i.e. children).

Pursuant to the District Plan, the majority of the Deferred Lands area is identified in either the Metropolitan Rural Area (MRA). The land use intent derived by the District Plan is for non-urban activities. The LSPS identifies an additional future MRA investigation area, where lands may be considered for inclusion as part of the MRA.

The future MRA investigation area incorporates large parts which exhibit similar characteristics to the MRA and are currently non-urban in nature.

The CSIRO, in conjunction with the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC), remain among the leading property loss research agencies in Australia, having produced a multitude of reports, studies and tools to assist in developing a solid evidence base to support policy-level decision-making.

With respect to property loss, CSIRO studies have found that approximately 98 per cent of all building loss has been found to occur on days when the FFDI exceeded 45 (Blanchi & Lucas, 2010). In events where the FFDI exceeds 50, fire suppression at any part of a fire line is virtually impossible due to the intensity and unpredictable behaviour of a fire (Leonard & Blanchi, 2012).

Land use planning, building design, fuel management, strategic intervention of fire brigades and community preparedness are the only effective defence mechanisms available once the FFDI has exceeded 50 (Blanchi & Lucas, 2010; Leonard & Blanchi, 2012).

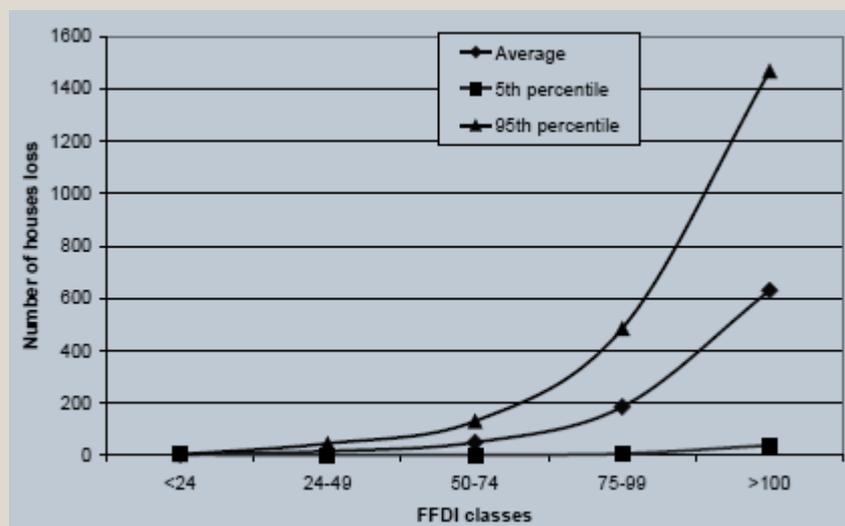


Figure 21 - Average house losses for different FFDI classes (Source: Leonard & Blanchi, 2012)

Extensive property loss research reveals that approximately 80 per cent of property loss occurs within 100m of the bushland interface, with the full extent of loss typically occurring within circa 700m of the bushland interface in urban contexts (Leonard & Blanchi, 2012; McAneney & Chen, 2004 and Ahern & Chladil, 1999). This is particularly relevant given recent bush fire events across the world which have penetrated urban areas.

6.2.2.1 Seniors living and disability services

Several seniors living, aged care, retirement and disability support facilities are located within the Deferred Lands area. These facilities include:

- Glenaeon retirement community on Forest Way;

- Uniting Wesley Gardens Belrose;
- Willandra Bungalows;
- Maybrook Retirement Village; and
- Marston Living Beacon Hill.

The Deferred Lands area also adjoins existing facilities located outside of the study area boundary including the Belrose Country Club Retirement Village on Forest Way.

Approximately four development approvals also exist that relate to seniors living in the Deferred Lands area, several of which were refused by Council but approved by the NSW Land and Environment Court.

These approvals are included within the land use scenarios informing this risk assessment.

6.2.2.2 Child care

There are a number of child care facilities within the Deferred Lands area including:

In the western precinct:

- Papilio Early Learning in Belrose; and
- Convent Christian School Early Learning in Belrose;

In the central precinct:

- Uniting Forest Preschool at Belrose; and
- Oxford Falls Early Learning Centre on Oxford Falls Road.

No child care facilities are currently identified within the eastern precinct.

Outside of school care may also be provided at existing educational facilities within the area which are combined with broader educational services.

6.2.2.3 Schools

A number of education facilities are currently situated within the Deferred Lands area.

In the western precinct, the following schools are identified:

- Kamaroi Rudolf Steiner School;
- Covenant Christian School Sydney;
- Yanginanook School;
- John Colet School; and
- Leonis Academy.

In the central precinct, the following schools are identified:

- St Pius College - Treacy Education Centre; and
- Christian City Church College / C3 College.

In the eastern precinct, the following schools are identified:

- Oxford Falls Grammar School.

The bush fire management and emergency management plans for these facilities is of utmost importance to ensure the safety of students and staff. It is noted that part of the annual bush fire

season coincides with annual school summer holidays from late December to the end of January. However, the balance of school terms occurs within the annual bush fire season.

In 2019-2020, educational facilities were closed on catastrophic fire danger days.

Schools are particularly vulnerable facilities due to the nature of the occupants and their young age. These characteristics give rise to challenges in evacuation, and stress experienced by students, staff and families in an emergency.

Noting the existing scale of special fire protection purposes already located within the Deferred Lands area, the continued intensification of educational facilities within the Deferred Lands area should ideally be avoided.

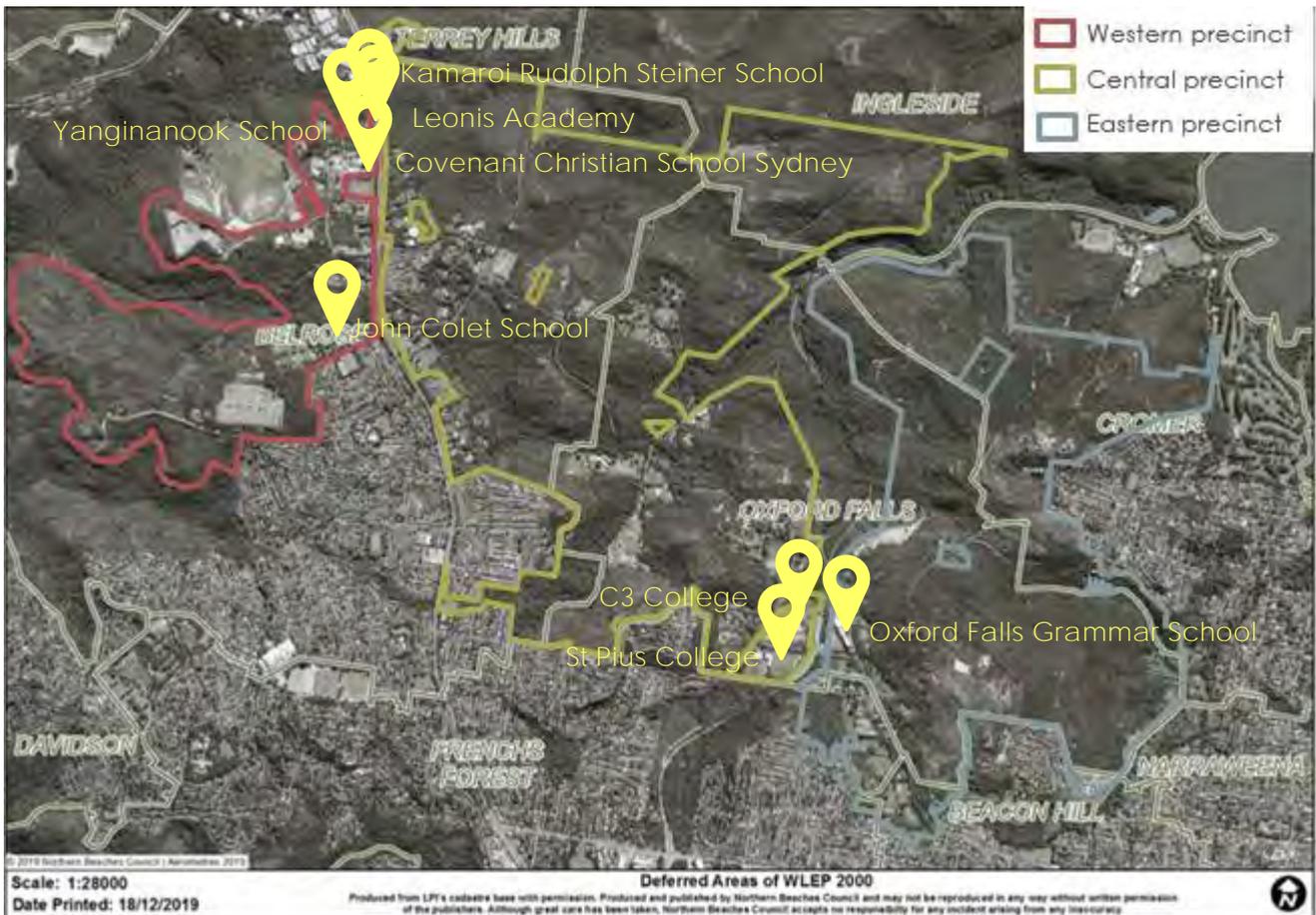


Figure 22 - Location of existing educational facilities within the Deferred Lands area

Identified potential risks

Potential risks identified, relevant to the land use, property and vulnerable uses may include:

1. the exposure of existing SFPP uses within the Deferred Lands area;
2. the potential for new or expansion of existing SFPP uses within the Deferred Lands area;
3. a zoning rationale which does not respond to risk;
4. a settlement pattern which exposes property (and occupants) to unacceptable or intolerable risk; and
5. the potential for property loss from fire occurring within or adjacent to the Deferred Lands area.

It is necessary to assess the magnitude of risk associated with these identified potential risks, and this is expanded upon in the following sections of the report.

6.2.3 Evacuation ability (access and egress)

Planning for bush fire evacuation is an immensely difficult task. Unlike flood and other events, bush fire events are not a 'known quantity'. There is no surety in when or where an ignition may occur, the direction it may spread, the extent of possible ember attack, etc.

The impact of smoke and limited visibility in emergency situations, coupled with wind impact, can lead to issues on the road network as residents attempt to evacuate. The exposure of motorists to potential flame contact and radiant heat are also key considerations

Evacuation planning processes can also inadvertently presuppose that the intended location in which one seeks to evacuate to, and the pathway to get there, is safer than from which they came.

The extent of warning time and ability to evacuate to safety (including the aspects of access and egress) represent the most fundamental characteristics which determine risk to life in a land use planning context.

There are three key elements of relevance to land use planning:

1. The extent of warning time available (window of evacuation opportunity);
2. How the settlement pattern supports / enables:
 - a. separation from hazard sources;
 - b. limits urban penetration of fire by built form; and
 - c. the act of community evacuation (processes); and
3. Evacuation destinations (designated evacuation centre or Neighbourhood Safer Place [NSP]).

Whilst it is the preference of emergency management in Australia that persons evacuate to the home of friends or family – which is certainly not contended by this risk assessment – it is the role of land use planning to allocate land and identify planning-based measures to enable strategic decisions to be made in the future with regard to evacuation facilities and NSPs.

Thus, whilst such formalised evacuation locations may not be the preference of emergency and disaster managers, land use planning should not inadvertently void the option or require retrofitting to community infrastructure at a later date as a result of limited-range strategic planning.

AIDR Handbook 4: Evacuation Planning provides guidelines and considerations for developing community evacuation plans underpinned by an all-hazards approach. It uses the nationally recognised five stages of the evacuation process as a framework for planning an evacuation (AIDR, 2017).

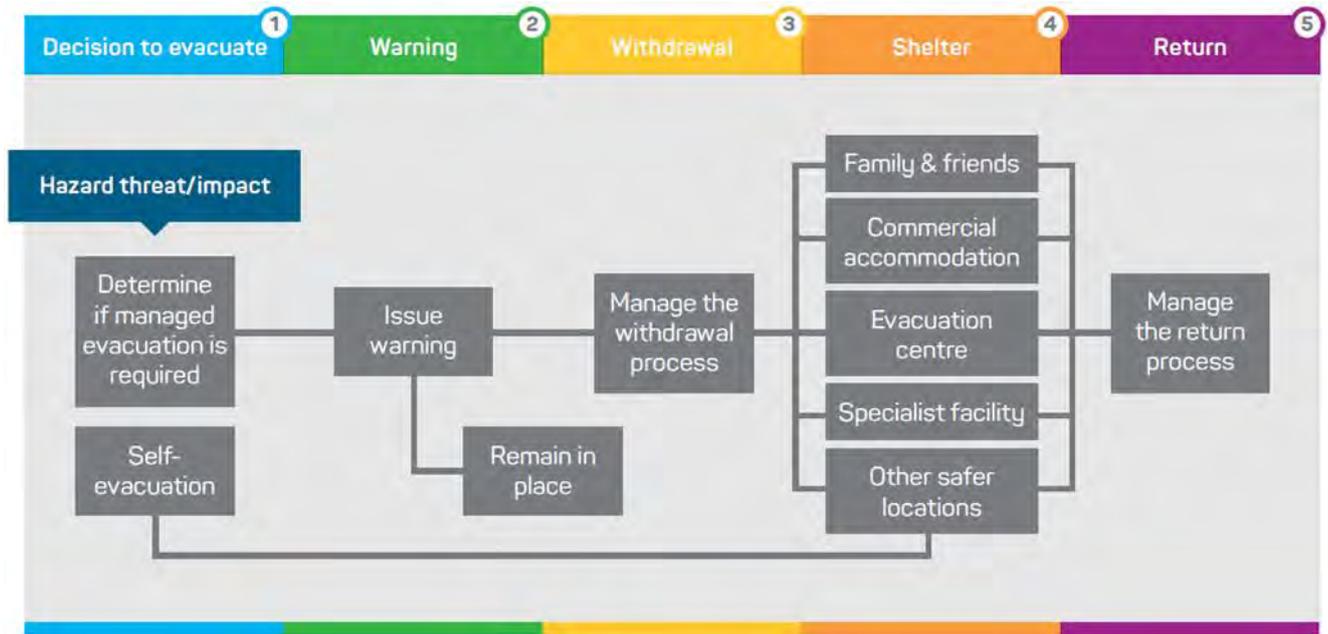


Figure 23 - The five stage evacuation process (Source: AIDR, 2017)

Research by Cova (2005) provides indicative 'community egress' parameters which identifies the maximum preferred number of dwellings and corresponding minimum number of road exits or egress points to facilitate emergency evacuation in the event of bush fire. It remains a generalised approach which can be used to guide new development, or identify existing pinch points within a community.

Table 8 - Cova's proposed minimum exits for interface communities (Source: Cova, 2005)

Number of dwellings	Minimum number of exiting roads	Maximum number of dwellings per exit
1-50	1	50
51-300	2	150
301-600	3	200
601+	4	-

Based on the connections of the existing road network throughout the Deferred Lands area, capacity of the road network may not be a particular issue, though this would require further traffic analysis to accurately determine.

The challenges associated with the existing road network largely relate to:

- the proximity of roadside vegetation to the roadway;
- potential for flame contact and radiant heat exposure along the network;
- potential for reduced visibility coupled with narrow rural and unsealed roads; and
- the capacity of Forest Way and Wakehurst Parkway, southbound.

Identified potential risks

Potential risks identified, relevant to the ability to evacuate may include:

1. potential for risk to life from an inability to evacuate to a safer location.

It is necessary to assess the magnitude of risk associated with these identified potential risks, and this is expanded upon in the following sections of the report.

6.2.4 Emergency services

The Northern Beaches Hospital is located to the immediate south of the Deferred Lands area, at the corner of Wakehurst Parkway and Warringah Road.

A number of NSW RFS Brigades are located in the region, two of which are within the Deferred Lands area. These include the Beacon Hill Rural Fire Brigade and the Belrose Rural Fire Brigade. Other brigades are located to the north and include Warringah, Terrey Hills, Coal and Candle and Ingleside, as well as Davidson Rural Fire Brigade to the west.

A Fire and Rescue NSW fire station is located to the south at Forestville.

Risk consequence in relation to emergency services is twofold. Firstly, is the consideration of increasing reliance or burden placed on emergency services during events. This relates to the defence of persons and property, communication with and management of communities in an emergency and the resources required. The second is the ability for fire suppression within urban bushland interface environments. This is directly related to urban exposure and settlement pattern.

Emergency services are also impacted in other ways, such as impost on the Ambulance service to assist with evacuation of vulnerable residents, including that of seniors living facilities. This is a critical consideration given the bed to ambulance ratio which exists, and the inability to service the demand placed on services during an emergency.

Such facilities are expected to maintain robust emergency management and evacuation plans which avoid unnecessary impost on emergency services for facility evacuation.

In addition to the above is consideration of the Northern Beaches Hospital to the south of the Deferred Lands area, at Frenchs Forest and the potential impact of a fire event and added pressure placed on hospital resources during a bush fire emergency.

Identified potential risks

Potential risks identified, relevant to emergency services may include:

1. demand on fire services for property protection during an event, when resources may not necessarily be available; and
2. the settlement pattern inappropriately limits or otherwise frustrates the ability for fire services to suppress fire by limiting access to the hazard interface.

It is necessary to assess the magnitude of risk associated with these identified potential risks, and this is expanded upon in the following sections of the report.

6.2.5 Infrastructure

The Deferred Lands area comprises a number of critical and essential infrastructure assets. For the purposes of this risk assessment, special fire protection purposes (including educational facilities) are addressed separately.

6.2.5.1 Water supply and sewer

Water supply is one of the key bush fire protection measures identified by NSW RFS in PBP 2018.

Access to water supply within the Deferred Lands area includes access to reticulated services in some areas, with other areas reliant upon static water supply. Mains water supply is provided through much of Belrose North, within the road reserve of Oxford Falls Road and a number of lower road reserves.

A reservoir is located to the east of Forest Way within the central precinct, to the rear of the Belrose Rural Fire Brigade facility. A water treatment plan and pumping station is located on the eastern

side of Forest Way, in the northern extent of the central precinct. A water pumping station is also located on the northern side of Wyatt Avenue, near its intersection with Forest Way.

There are sewer pumping stations located:

- 170A Morgan Road, Belrose in the central precinct;
- Por 199 Morgan Road, Belrose in the central precinct;
- south of Barnes Road in the eastern precinct.

6.2.5.2 Road networks

The study area is traversed by several key road corridors including Forest Way and Wakehurst Parkway. Other key roads include Oxford Falls Road and Morgan Road.

Forest Way is a four lane arterial extending from Warringah Road in the south to Mona Vale Road in the north. Wakehurst Parkway is a dual lane road which traverses bushland toward the centre of the Deferred Lands area, extended from Warringah Road in the south to North Narrabeen.

Consideration of risk relating to road infrastructure is generally associated with permitting safe evacuation rather than direct impact on the road itself however, damage can occur as a result of traffic accidents, tree falls and melting pavement as a result of bush fire attack.

The above routes are supplemented by a network of local road which extend through the area.

6.2.5.3 Telecommunications

Telecommunications is also essential during emergency situations however, often telecommunications towers and assets can come under attack, presenting a level of risk during an event.

The Deferred Lands area is largely serviced by an overhead telecommunications network with additional fibre optic cable availability. These fibre optic cables traverse the area along the Oxford Falls Road reserve. The NBN is available within the area.

In order to function during emergencies, the NBN must be powered both at the source and at the node (i.e. at either end of the connection). If a power source fails at one end, the NBN connection will cease to operate. NBN Co has developed emergency systems and processes during times of emergency and disaster but this does remain an emergency management issue for consideration.

Telecommunications towers are located near the study area. The entire Deferred Lands is also identified to be covered by Telstra mobile coverage, according to its coverage mapping.

Beyond domestic telecommunications, several major satellite telecommunications facilities are located within the study area, within Oxford Falls and Belrose North operated by Telstra and Optus. These facilities provide essential telecommunications services to broad areas of Australia, and across a diversity of platforms. Each facility maintains an extensive bush fire management plan.

6.2.5.4 Electricity

The Transgrid Sydney East 330 kilovolt substation is located on Ralston Avenue in Belrose North. It is a critical transmission supply point for power distribution to Sydney, the substation supplies Ausgrid substations across a geographical range spanning between Mt Coolah – North Sydney – Mosman – Belrose, including the Ausgrid substation at Royal North Shore Hospital. The de-energisation of the Sydney East substation may result in a widespread blackout affecting a significant area of north-eastern Sydney, having significant impacts to residents, businesses and public infrastructure/services (Transgrid, 2018).

In its submission on a Ralston Avenue planning proposal in 2018 (which was subsequently rejected), Transgrid identified that de-energising the facility would be an unlikely mitigation strategy in the

event of fire. Rather, the facility maintains specific, fit-for-purpose bush fire protection measures to assist the facility to operate in potential emergency.

Approximately 10 kilometres of electricity transmission lines traverse the area (Geoscience Australia, 2020). At present during an event, the existing pole and wires network is likely to be impacted.

6.2.5.5 Gas utilities

Gas infrastructure and bush fire are at obvious odds and thus, it is important the treatment of gas utilities is undertaken with the potential threat of bush fire in mind.

No data in relation to any existing gas utilities network within the area could be located at the time of this assessment.

Identified potential risks

Potential risks identified, relevant to infrastructure supply and asset safety may include:

1. potential impact of bush fire on critical infrastructure assets and networks within the Deferred Lands area, and those located external to the study area, and the cascading or flow-on impacts of loss of or damage to critical infrastructure networks and/or assets.

It is necessary to assess the magnitude of risk associated with these identified potential risks, and this is expanded upon in the following sections of the report.

6.2.6 Environmental and land management risk

The Deferred Lands area is one of Sydney's largest unreserved and largely privately owned areas of bushland that stretches across the Oxford Falls Valley west from Narrabeen Lagoon to Belrose and Frenchs Forest (Northern Beaches Council, 2020). This area represents a substantial regional connectivity corridor across the local government area.

The study area is known habitat for a range of threatened plant species including significant populations of *Grevillea caleyi*, *Persoonia hirsuta* subsp. *hirsuta*, *Eucalyptus camfieldii* and *Genoplesium bauera*.

6.2.6.1 Catchments

The area broadly falls across two catchments including the Narrabeen catchment and the Sydney Harbour catchment. The Narrabeen catchment incorporates a number of waterways which find their headwaters in the Deferred Lands area including Middle Creek, Wheeler Creek, Oxford Creek and Snake Creek. These waterways flow into the sensitive Narrabeen Lagoon.

With large tracts of the Narrabeen catchment comprising natural bushland, waterway and riparian assets, fragmentation of the area and continued urban encroachment is one of the catchment's greatest risks from an environmental perspective. This is underpinned by the unique values and characteristics of the Narrabeen Lagoon, which set it apart from other coastal lagoons.

In this regard, incremental land clearing, changing land uses and uncontrolled recreational activity are not only current threats, but have the potential to translate to significant cumulative loss and degradation of a regionally significant natural environment, over time. Terrestrial impacts could result in cascading impacts on the water quality of the system and Narrabeen Lagoon, which can lead to consequences for the wildlife which rely upon the complex ecological functions of the system, and a loss of biodiversity.

Similar characteristics and challenges exist for the Frenchs Creek and the Sydney Harbour catchment, where waterways discharge into North Harbour. One of the key issues in this area, including Belrose North, is urban stormwater run-off and its impacts on water quality.

Further investigations into the environmental values of the Deferred Lands is required, and intended to be delivered as part of Council's forward program to inform the development of the new LEP and DCP.

From a policy perspective, whilst clearing in interface environments is typically required to site new development, it is often accompanied by an intent to retain as much vegetation as possible to avoid costly *biodiversity offsets*.

It is also necessary to retain key vegetation corridors and patches of bushland where valued ecological communities remain. These approaches, whilst intentioned to protect important ecological values and functions can also inadvertently enable fire to easily propagate within urban areas.

This continues to represent a significant *policy conflict* at the strategic level between demand for growth and retention of environmental assets and vegetation, which can manifest in a higher level of risk exposure for new communities at the bushland interface.

6.2.6.2 Land and fuel management

Land and fuel management within the Deferred Lands area and its surrounds is complex, by nature of the fragmentation of land ownership and land use, as well as the fire regimes associated with different vegetation communities.

In terms of land tenure throughout the BFRMP area (which remains larger in extent than just the Deferred Lands area, land management responsibility is varied and includes:

Table 9 - Land tenure of the Warringah Pittwater BFRMP Area (Source: NSWRF, 2010)

Land Manager	% of BFRMP Area
National Parks & Wildlife Service	40
Department of Lands	5
Local government	16
Private	35
All other	4

To the north and west, the Deferred Lands is flanked by Garigal National Park which is subject to its own land management requirements, including bush fire management and mitigation provisions. This is articulated by the Garigal National Park Fire Management Strategy. Balancing the management of fire risk in any landscape is required alongside consideration of the impact of over or under burning, in terms of risk to ecological communities. Burning too frequently, or not often enough, can result in significant impacts on ecology and potential fire behaviour.

It is significant to note that prescribed burning, or hazard reduction burning, is not a panacea for the management of bush fire risk. In fact, evidence demonstrates the effect of prescribed burning on reducing fire intensity in more extreme conditions is uncertain. Rather, it is one of a broad suite of bush fire risk management measures which should be employed across a landscape.

The Garigal National Park Fire Management Strategy identifies a series of fire management zones, and identifies the processes and strategies to be employed to mitigate the risk of fire within the national park, and its risk to adjacent areas. The Deferred Lands area is identified to encompass assets requiring protection.

Land and fire risk management on Crown Lands, Council-owned land and across private land is the responsibility of the land owner. Some activities are exempt and do not require permit, whilst other activities will require approval from assessing authorities.

Identified potential risks

Potential risks identified, relevant to environmental and land management risk may include:

1. local and State government responsibilities for fuel load management and hazard reduction on an annual basis are increased; and
2. potential for environmental loss or damage as a result of clearing to achieve asset protection.

It is necessary to assess the magnitude of risk associated with these identified potential risks, and this is expanded upon in the following sections of the report.

6.2.7 Economic risk

Approximately 183 registered businesses exist or operate within the Deferred Lands area (Geoscience Australia, 2020).

At 2017, the total cost of disasters across NSW was \$3.6 billion per year. This is forecast to escalate to \$10.6 billion per year by 2050 having regard to direct and indirect tangible costs as well as intangible costs (Deloitte Access Economics, 2017). NSW also receives the second-highest allocation of Commonwealth resilience funding (2013/14 – 2016/17) at \$31 million, including \$2.3 million from the national bush fire mitigation fund and \$1.5 million from the mechanical fuel load reduction trials program (Deloitte Access Economics, 2017). Funding from the national bush fire mitigation fund is matched by the NSW Government.

Early estimates of the costs of the 2019-20 Australia bush fires has been estimated at approximately \$100 billion, incorporating both tangible and intangible costs (Read & Denniss, 2020).

Deloitte Access Economics (2017) estimated the tangible impact of the Victorian Black Saturday bush fires at \$3.1 billion in 2015 dollars, with intangible costs at more than \$3.9 billion.

Governments of all levels are increasingly exposed to economic risks stemming from bush fire and other disaster events. Understanding risk exposure and investing in building resilience to reduce disaster risk are key opportunities to reduce the magnitude of potential loss.

6.2.7.1 Recovery and reconstruction

Geoscience Australia (2020) estimates the potential reconstruction cost of property loss within the Deferred Lands area at \$199 million, with a contents value of approximately \$28.2 million.

The cost of damage or loss to public assets, critical infrastructure and essential services extends beyond the above amount and can translate into extended recovery timeframes which can also extend beyond bush fire impacts to communities.

6.2.7.2 Insurance

The Insurance Council of Australia identifies that approximately 1 in 20 properties across Australia are not insured, approximately 70 per cent of properties are under-insured and about two-thirds of renters do not have contents insurance (Wynne, 2017).

One of the critical issues in this regard is that 'insured value' should not just cover the construction or purchase price, but must take into account current building standards, demolition, potential asbestos removal and site clean-up. The recent 2019-20 New South Wales Bushfire Inquiry identified that costs to re-build to new standards could be as high as an additional \$100,000 (Owens & O'Kane, 2020).

Identified potential risks

Potential risks identified, relevant to economic risk may include:

1. local government is exposed to increased economic risk for mitigation, reconstruction and recovery.

It is necessary to assess the magnitude of risk associated with these identified potential risks, and this is expanded upon in the following sections of the report.

6.2.8 Summary of risk identification

The following table provides a summary of the potential risks identified for the Deferred Lands area, relative to the threat of bush fire.

Table 10 - Summary of identified potential risks

Potential risk identified for the Local Plan area
Risk category – bush fire landscape, demographics and risk to life
1. continuous connectivity of landscape fuels and known fire paths and fire runs into the Deferred Lands area
2. areas of considerable fireline intensity adjacent to and within the Deferred Lands area
3. fragmented land ownership which increases the difficulty to manage fire trail networks and implement fuel reduction, and landholder ability and willingness to manage fuel loads on private land
Risk category - land use, property and vulnerable uses
1. the exposure of existing SFPP uses within the Deferred Lands area
2. the potential for new or expansion of existing SFPP uses within the Deferred Lands area
3. a zoning rationale which does not respond to risk
4. a settlement pattern which exposes property (and occupants) to unacceptable or intolerable risk
5. the potential for property loss from fire occurring within or adjacent to the Deferred Lands area
Risk category – ability to evacuate
1. potential for risk to life from an inability to evacuate to a safer location
Risk category – emergency services
1. demand on fire services for property protection during an event, when resources may not necessarily be available
2. the settlement pattern inappropriately limits or otherwise frustrates the ability for fire services to suppress fire by limiting access to the hazard interface
Risk category – infrastructure supply and asset safety
1. potential impact of bush fire on critical infrastructure assets and networks within the Deferred Lands area, and those located external to the study area, and the cascading or flow-on impacts of loss of or damage to critical infrastructure networks and/or assets
Risk category – environmental and land management

1. local and State government responsibilities for fuel load management and hazard reduction on an annual basis are increased; and
2. potential for environmental loss or damage as a result of clearing to achieve asset protection

Risk category - economic

1. local government is exposed to increased economic risk for mitigation, reconstruction and recovery

6.2.9 Consequence levels

The following table provides an overview of relevant land use planning risk consequence criteria. Each hypothetical land use scenario informing this risk assessment is assessed in terms of likelihood and consequence to identified the resultant risk profile, including the assessment of residual risk following possible land use risk mitigation.

Fireline intensity is adopted for the purposes of consideration of risk consequence on the basis of modelled geographic spread and energy release (intensity).

Table 11 - Land use planning bush fire risk consequence criteria based on McAneney, 2009

NERAG risk consequence level	Exposure	Consequence vulnerability
Catastrophic	Land and communities within 100m of mapped fireline intensity exceeding 30,000kW/m	<p>Nil to very little separation from the hazard exposes persons, property and assets to flame contact and extreme radiant heat flux</p> <p>Compliance with PBP 2019 statutory bush fire protection measures and AS3959 construction is unlikely to be sufficient to withstand bush fire attack</p> <p>Property loss, asset loss and fatalities are highly likely</p> <p>Evacuation networks are exposed to flame contact and extreme radiant heat</p>
Major	Land and communities within 100-200m of mapped fireline intensity exceeding 30,000kW/m	<p>Limited separation from the hazard exposes persons, property and assets to potential flame contact and significant radiant heat flux</p> <p>Compliance with PBP 2019 statutory bush fire protection measures and AS3959 construction may not be sufficient to withstand bush fire attack</p> <p>Property loss, asset loss and fatalities are likely</p> <p>Evacuation networks are likely to be exposed to bush fire attack and may not support last minute influx of traffic</p>
Moderate	Land and communities within 200-400m of mapped fireline intensity exceeding 30,000kW/m	<p>Separation from the hazard may expose persons, property and assets to potential flame contact, radiant heat flux and/or ember attack</p> <p>Compliance with PBP 2019 statutory bush fire protection measures and AS3959 construction may or may not assist property to withstand bush fire attack</p> <p>Property loss, asset loss or damage may occur. Fatalities and/or serious injuries may occur</p> <p>Evacuation networks may be exposed to bush fire attack and may experience delays or queuing due to last minute influx of traffic</p>

<p style="text-align: center;">Minor</p>	<p>Land and communities within 400-700m of mapped fireline intensity exceeding 30,000kW/m</p>	<p>Separation from the hazard may limit exposure of persons, property and assets to potential flame contact. Exposure to radiant heat flux and ember attack may occur</p> <p>Compliance with PBP 2019 statutory bush fire protection measures and AS3959 construction may assist property to withstand bush fire attack</p> <p>Property damage and asset damage may occur. Small numbers of losses may be experienced. Injuries to persons may occur</p> <p>Evacuation networks may be exposed to a level of bush fire attack and may experience delays or queuing due to last minute influx of traffic</p>
<p style="text-align: center;">Insignificant</p>	<p>Land and communities more than 700m of mapped fireline intensity exceeding 30,000kW/m</p>	<p>Separation from the hazard is likely to avoid exposure of persons, property and assets to potential flame contact, with minimal exposure to radiant heat flux. Ember attack may occur</p> <p>Compliance with PBP 2019 statutory bush fire protection measures and AS3959 construction is likely to assist property to withstand bush fire attack</p> <p>Property damage and asset damage may occur. Injuries to persons may occur</p> <p>Evacuation networks may experience short-term delays due to last minute influx of traffic</p>

6.3 Existing risk profile

At present, the existing risk profile of the Deferred Lands area is ostensibly associated with the high connectivity of fuels and complex topography.

Noting the land adjoins Garigal National Park to the north and west, the Deferred Lands area forms part of a broader landscape of contiguous fuel.

At present, approximately 96.1 per cent of the Deferred Lands area is within 100m of potential bush fire hazard.

When considering only those areas where fireline intensity is modelled to exceed 30,000kW/m (representing higher risk locations), the entirety of the Deferred Lands is within 700m, 98 per cent of the land is within 400m and 71 per cent of the land is within 100m. This is based on a filtering approach to remove patches of higher fireline intensity of less than one hectare. This approach is adopted in order to reduce risk of over-estimation of bushfire behaviour in very small locations. Filtering of small patches and corridors of vegetation more generally, is an approach which forms an accepted part of the existing bush fire hazard mapping methodology for NSW.

Overall, *the existing risk profile ranges in scale from potentially moderate to catastrophic*, having regard to the bush fire risk consequence criteria at Table 6, noting the risk profile varies across the Deferred Lands.

7 Risk analysis

7.1 Methodology

The risk analysis component of this land use planning-based risk assessment involves several discrete methodologies. Broadly, the risk analysis is informed by:

- preparation of fireline intensity mapping for a series of fire weather scenarios (derived from bush fire behaviour modelling), with a focus on a planning-based design scenario of FFDI 100 on west and north-westerly winds (as the primary fire driven winds);
- consideration of a series of land use scenarios selected to hypothetically consider changes to landscape fire behaviour under different land use conditions;
- preparation of risk exposure mapping based on a primary loss extent (representing the spatial extent of 85 per cent life loss and 80 per cent house loss from bush fire in Australia) relevant to the fire weather and hypothetical land use scenarios selected; and
- data interrogation of the above spatial or geographic extent of fire, as well as fire intensity to examine current and potential future risk relative to different fire weather and hypothetical land use conditions.

A discussion of overall risk is subsequently provided on the basis of observations drawn from the above data analysis process and findings.

Testing hypothetical possible scenarios is required in order for strategic land use planning processes to adequately assess risk (March et al. 2020 and Riddell et al. 2019).

In the past, it has been common for strategic planning processes for growth area identification to progress significantly, well before adequate risk assessment. As identified by March et al. 2020, this sequencing has placed pressure on later stages of land rezoning, scheme (LEP) formulation and amendment, and development assessment processes.

The inclusion of critical decision criteria, requirements for scenario testing, allocation of roles and establishment of suitable forums can significantly improve future growth risk assessments' (March et al. 2020).

In Victoria, recent BNHCRC-funded research to support planning agencies identified as part of its recommendations that planning panels in Victoria which assess planning scheme amendment proposals (equivalent to LEP amendments in NSW) should be required to consider risk scenarios in urban planning processes (March et al. 2020).

This research is considered to inform best practice approaches for the consideration of natural hazard risks in strategic land use planning practices, and is adopted as part of the methodology informing this risk assessment.

7.1.1 Fire weather event scenarios

Fire weather is a key driver of the potential magnitude of fire behaviour. As identified as part of the consideration of risk likelihood, the fire weather scenarios considered for the purposes of this risk assessment are outlined below.

The fire weather scenarios adopted for the purposes of this risk assessment include:
 FFDI 62 – representative of the fire weather recorded during the January 1994 Cottage Point fire;
 FFDI 100 – the fire weather threshold adopted for planning and building in Greater Sydney;
 FFDI 114 – representative of a 2 per cent AEP or 1 in 50 year fire weather event; and

FFDI 134 – equivalent of a 1 in 200 year fire weather event (climate change scenario).

7.1.2 Hypothetical land use scenarios

This risk assessment seeks to analyse the extent of bush fire risk relevant to the Deferred Lands area with respect to the existing situation and potential future risk, based upon a series of simulated hypothetical land use scenarios. This assessment makes no inference as to the appropriateness or otherwise, or the probability of any land use scenario used for the purposes of this assessment coming to fruition.

A scenario-based approach to the assessment of potential risk enables insight into the potential changes in fire behaviour in response to different fuel and weather scenarios. This helps to inform robust decision-making, having contemplated a range of factors.

The *hypothetical land use scenarios* utilised for testing of potential future growth outcomes to inform Council's consideration of relevant LEP and DCP controls include:

- Scenario 1* – existing land use planning cadastre and vegetation communities;
- Scenario 2* – amended land use planning cadastre for identified Planning Assessment Commission (PAC) sites for which reduced fuels are blanket applied (to reflect urban land use); and
- Scenario 3* – existing land use planning cadastre and vegetation communities within higher risk areas, with reduced fuels applied to moderate risk areas.

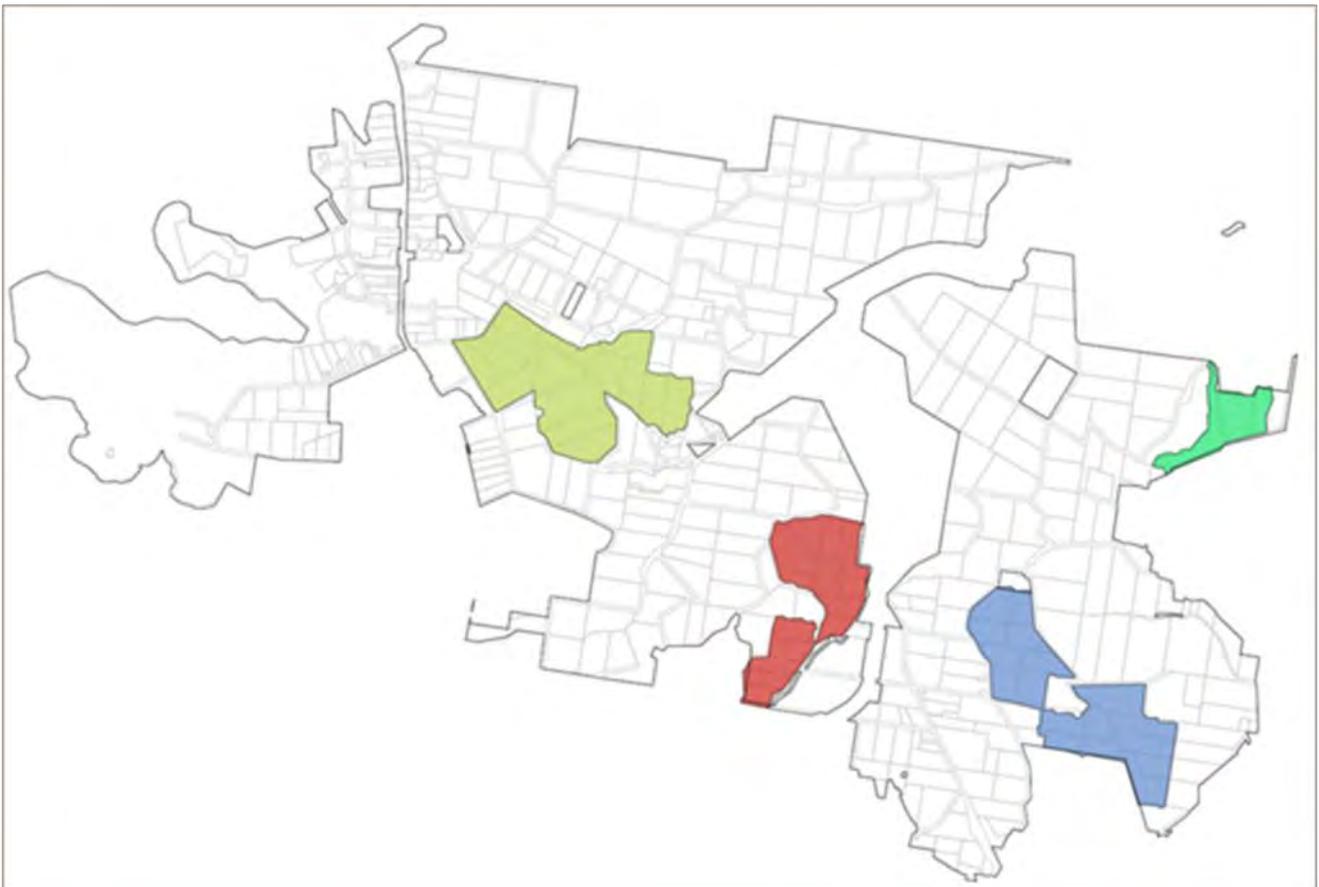


Figure 24 - Previously identified potential PAC sites

7.1.2.1 Caveats

In relation to Scenario 2 in particular, this assessment does not assess the appropriateness or otherwise of these potential planning projects. It provides no commentary on the particulars of these potential planning projects. It takes no position in relation to the assessment of these potential planning projects.

Rather, these sites are identified to provide a potential, plausible consideration of the impact of different planning proposals on landscape-scale fire behaviour across the Deferred Lands area.

It is likely these projects encompass detail at a granularity this assessment does not and cannot consider, nor is it intended to do so. For example, it is likely these sites may include vegetation retention and rehabilitation which is not contemplated by the blanket reduction of fuels applied in these areas as part of the scenario approach adopted for the purposes of this assessment.

In addition to the above, bush fire behaviour modelling does not necessarily translate to linear increases in bush fire behaviour. As such, it is not the case that data trends will necessarily always escalate in line with increased FFDI, on the basis of the dynamic nuances of the range of data inputs under varying conditions.

7.1.3 Fireline intensity assessment

Fireline intensity mapping has been prepared for the Deferred Lands area and surrounding landscape for a distance of 5 kilometres, in order to understand the potential transfer of fire both spatially (geographical extent) as well as its potential intensity (energy emission) across the Deferred Lands area.

As noted earlier, fireline intensity is a measure of fire intensity at the fire front. It is measured as the amount of energy released per metre width of the fire edge (CSIRO, 2013).

Fireline intensity mapping has been undertaken for each fire weather scenario, and each hypothetical land use scenario. These are included at Appendices A, B and C. This was completed utilising the potential bush fire intensity classes and corresponding potential fireline intensities as per the table below.

It is critical to note that pursuant to research conducted by Tolhurst, dwelling loss rates are observed to increase where fireline intensity exceeds 30,000kW/m. As noted earlier, increased house loss is also observed in events where FFDI exceeds 50. Direct firefighting is not possible where fireline intensity exceeds 3,500 kW/m.

Table 12 - Potential bush fire intensity classes and corresponding potential fireline intensity ranges (Source: Leonard et al. 2014)

Potential bush fire intensity classes	Potential fireline intensity
Very high	40,000+kW/m
High	20,000-40,000kW/m
Medium	4,000-20,000kW/m
Low	0-4,000kW/m

It is important to note that for some aspects of the risk analysis undertaken by this assessment, mapped fireline intensity up to 4,000kW/m has been removed from the dataset as this class is considered sufficiently low that it not necessarily be considered as part of the risk profile for examination for strategic land use planning purposes.

As noted by Leonard et al. (2014) 'at a landscape scale, the preferred metric for indicating the potential severity of these impact mechanisms is fireline intensity. Fireline intensity is a standardised measure of the rate that an advancing head fire would consume fuel energy per unit time per unit length of fire front introduced by Byram (1959)'.

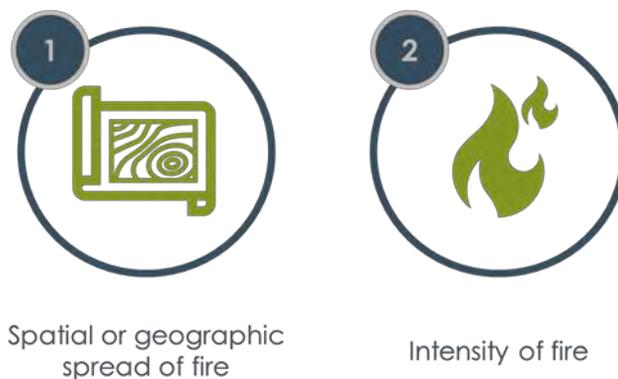
Leonard et al. (2014) goes on to provide that 'one of the main benefits of the fireline intensity metric is that it can be used to estimate the potential flame length (e.g. Byram, 1959; Alexander and Cruz 2012) and thus the radiant heat expected at various distances from potentially hazardous vegetation. Radiant heat measures can in turn be used to estimate required minimum distance from hazardous vegetation needed to afford safety levels to people and/or buildings (e.g. Cheney, Gould et al. 2001; Zárate, Arnaldos et al. 2008; Siggins, Newnham et al. 2013). Fireline intensity can also be used to derive estimates of flame length, radiant heat and other fire metrics'.

With any modelling, there are certain limitations which must be considered. The bush fire behaviour modelling (Phoenix RapidFire) used to assist in deriving and testing fireline intensity may not reflect actual fire spread, as this is particularly sensitive to minor shifts in fire weather, fuel accumulation, etc. and this is potentially amplified in conditions beyond FFDI 100.

Irrespective, event modelling for any natural hazard is a meaningful and necessary process to understand and contemplate different event situations and their relative impact from a landscape and land use perspective.

7.1.4 Risk exposure

Across the Deferred Lands area, risk exposure pursuant to fireline intensity fluctuates as a function of two critical elements:



Understanding the landscape spread of fire is equally as significant as understanding the intensity of the fire across the landscape, which devolves into an understanding of potential rates of spread under varying fire weather conditions relative to location of ignition.

This assists strategic planning considerations through an understanding of where, how intense and how fast fire might occur.

Mapping of risk can only illustrate risk exposure to an extent, it can only illustrate so much. It does not consider the human, social, environmental or economic dimensions of risk. Qualitative assessment of risk exposure mapping completes the holistic assessment.

To this end, the drawing of conclusions relying strictly on mapping to the exclusion of qualitative risk consideration is inappropriate. This risk assessment provides both a quantitative and qualitative appraisal of potential risk exposure and consequence in order to understand the relevant strategic land use instruments and controls which may be considered.

Potential risk exposure and vulnerability is examined in two ways:

1. potential existing risk; and
2. potential future risk.

As identified above, a series of fire weather scenarios are considered by this assessment. First and foremost however, is the FFDI 100 fire weather scenario which is the identified fire weather threshold for planning in the Greater Sydney region.

This risk assessment focusses on the FFDI 100 scenario but draws upon observations from other fire weather scenarios for comparative purposes.

The basis for the risk exposure analysis is summarised at the table below.

Table 13 - Data inputs and methodology for risk exposure mapping and data analysis

Potential existing risk	Potential future risk
Current settlement pattern (current planning cadastre)	Current settlement pattern (current planning cadastre)
2019 LiDAR digital elevation model	2019 LiDAR digital elevation model
Sydney Metro Catchment Management Area Vegetation Mapping (OEH, 2016)	Adjusted Sydney Metro Catchment Management Area Vegetation Mapping (OEH, 2016), transitioning specified areas to low fuel status, equivalent to urban areas
FFDI 62 fire weather	FFDI 62 fire weather
FFDI 100 fire weather	FFDI 100 fire weather
FFDI 114 fire weather	FFDI 114 fire weather
FFDI 134 fire weather	FFDI 134 fire weather
Nil patch or corridor filtering	Nil patch or corridor filtering
Fireline intensity mapping to determine spatial/geographic spread and intensity of fire	Fireline intensity mapping to determine spatial/geographic spread and intensity of fire
Spatial exposure extents (based on upper extent of 80 per cent dwelling loss and fatalities) for: <ul style="list-style-type: none"> • potential flame contact exposure • radiant heat exposure • primary ember attack exposure 	Spatial exposure extents (based on upper extent of 80 per cent dwelling loss and fatalities) applied for: <ul style="list-style-type: none"> • potential flame contact exposure • radiant heat exposure • primary ember attack exposure
100m primary loss risk extent	100m primary loss risk extent
700m secondary loss risk extent	700m secondary loss risk extent
Fire intensity exposure	Fire intensity exposure

Critical to the analysis of risk, existing Australian research reveals that 80-90 per cent of property loss occurs within 100m of the bushland interface, with the full extent of loss typically occurring within circa 700m of the bushland interface in urban contexts (Leonard & Bianchi, 2012; McAneney & Chen, 2004 and Ahern & Chladil, 1999). This is particularly relevant given recent bush fire disasters across the globe which have penetrated urban areas.

Additionally, comprehensive data interrogation performed by CSIRO demonstrates that 85 per cent of bush fire fatalities in 260 events from 1901 to 2011 have occurred within the first 100m of the bushland interface, including persons attempting to evacuate (Blanchi et al. 2012).

To this end, the 100m primary loss risk extent is relevant to both property loss and fatalities due to bush fire in Australia.

The interim observations handed down by the National Natural Disaster Arrangements Royal Commission following the 2019-2020 'Black Summer' fire season identified that almost all of the dwellings lost during those events were located within 500m of bushland.

On the basis of the above, the analysis of risk considers life and property exposure to the various bush fire attack mechanisms (flame contact, radiant heat and ember attack) within a primary loss risk extent of 100m, and a secondary loss extent of 700m from the bushland interface which represents the full or maximum extent of loss observed to date in Australia.

Table 14 - Indicative distances between hazardous vegetation and loss from bush fire for severe events (Source: Leonard et al. 2014, Leonard & Bianchi, 2009, McAneney et al. 2009, Ahern & Chladil, 1999)

Bush Fire Attack Mechanism	Typical upper distance for 80% of all house losses (m)	Typical upper distance for house ignition from forest (m)	Maximum reach (km)
Primary ember attack	100	700	10
Radiant heat exposure	70	160	Unknown
Flame exposure	50	100	Unknown

Potential risk exposure mapping is included at Appendix D, for all fire weather and hypothetical land use scenarios.

7.2 Precinct risk exposure analysis

The following sections provide a synopsis of the analysis of risk exposure, established by observations of spatial or geographical fire extent and fire intensity across the Deferred Lands area relative to the fire weather and hypothetical land use scenarios examined.

7.2.1 Western precinct

The western precinct has seen several historical planning proposals, including a rezoning proposal for land north of Ralston Avenue at Belrose which was the subject of considerable bush fire hazard and risk assessment. In 2017 Council resolved not to proceed with rezoning, following which the (former) Department of Planning and Environment referred the matter to the Independent Planning Commission, which eventually rejected the proposal on the basis of the extent of bush fire risk, risk to human life and biodiversity outweighed the potential benefit.

The western precinct today includes a number of potentially vulnerable facilities including several educational facilities, a major telecommunications facility and the Sydney North Substation and the Sydney North – Sydney East 330 kV transmission lines operated by TransGrid.

Under FFDI 100 fire weather conditions:

- approximately 82 per cent of the western precinct is subject to potential fireline intensity exceeding a minimum 4,000 kW/m; and
- more than 99 per cent of the precinct is exposed to potential flame contact, radiant heat and ember attack;

Under a more frequent fire weather event of FFDI 62:

- fireline intensity exposure is present across approximately 76 per cent of the precinct area; and
- the application of potential flame contact, radiant heat and ember attack exposure expands the area of potential risk to over 98 per cent of the precinct.

As such, even more frequent but lower intensity events may still present risk to almost the entire precinct, from a spatial or geographical extent of potential fire spread.

This is largely driven by the expansive interface the precinct shares with Garigal National Park, as well as the proximity of Ku-ring-gai Chase National Park. Potential ignitions to the north, north-west or west may see potential fire runs into the western precinct. Extensive spotting behaviour driven by extensive ember attack may occur in the precinct in more extreme-scale events.

As evidenced at section 5.7.7. of this report, previous fire events have occurred in parts of the precinct over recent years. However, the extent of historical fire advancing toward the current location of Forest Way, as identified as possible by the fireline intensity mapping for various fire weather scenarios, cannot be determined based on available data.

The impact of hypothetical land use scenarios for approved development or potential future PAC sites is negligible in terms of the nature of hazard and risk relevant to the western precinct, as none are located within the precinct or situated such that they yield in discernible change to bush fire behaviour.

In terms of potential fire intensity of a fire weather event of FFDI 100, several pockets of high and very fireline intensity are modelled to potentially occur on the basis of mapped vegetation and the digital elevation model. The following is observed:

- approximately 20 per cent of the precinct is modelled to a potential exposure of less than 4,000 kW/m;
- approximately 60 per cent of the precinct is modelled as potentially subject to fireline intensities of between 4,000 kW/m to 30,000 kW/m; and
- approximately 9 per cent of the precinct is modelled as potentially subject to fireline intensities between 30,000 kW/m and 40,000 kW/m, 7.7 per cent exposure between 40,000 kW/m and 60,000 kW/m and approximately 5.8 percent above 60,000 kW/m.

In more extreme, but less frequent events, up to FFDI 134 the modelled fireline intensities increase but only by a few percentage points. The full suite of both spatial/geographic and intensity data analysis tables are presented at Appendix F for each fire weather and hypothetical land use scenario, across each precinct.

From a land use planning perspective, the confluence of the geographic risk and intensity risk extents is fundamental. Key insights relevant to the western precinct include:

- the western precinct is identified in its entirety within the future MRA investigation area pursuant to the District Plan;
- pockets of the precinct are modelled as potentially exposed to very high fireline intensity;
- the adjoining mountain bike park to the north-west may perform a mitigating function to a degree, however very high fireline intensity continues to the modelled within the western precinct for almost the entire area around the mountain bike park;
- the existing recycling centre in the western extent of the precinct may comprise materials which may also provide fire fuel, noting this facility is exposed to very high fireline intensity to the north-west, west and south. This could augment the modelled transition of fire within the western precinct, both in terms of geographic spread as well as potential intensity. In the longer term, any future transition of land use of this site will require risk-based consideration;

- major electricity and telecommunications infrastructure facilities may be exposed to a level of risk however, this may be currently contemplated by existing emergency management mitigation plans and procedures for such facilities;
- there are a number of educational facilities along the Forest Way corridor within the precinct, which likely require specific consideration in terms of mitigation and evacuation; and
- Forest Way would likely perform a critical evacuation function for the western precinct in the end of fire threat, with most if not all movement constrained to the southbound direction toward Frenchs Forest.

7.2.2 Central precinct

The central precinct is the largest of the three precincts forming the Deferred Lands area. The northern area of the precinct encompasses areas of complex topography, and intact vegetation which is not overly fragmented. It is this area which also adjoins Garigal National Park.

The fire history of the area establishes it as a known fire path, either associated with ignitions occurring within the precinct, or running out of the national park to the north.

Land adjoining the eastern side of Forest Way has been historically developed, and includes four seniors living facilities. The Belrose Fire Brigade is also located on the eastern side of Forest Way, with a water reservoir situated nearby. Other notable land uses include a major Telstra telecommunications facility, and several educational facilities including schools and child care facilities.

A portion of the precinct has been historically cleared, including land south of Oxford Falls Road and west of Wakehurst Parkway.

Under FFDI 100 fire weather conditions:

- approximately 83 per cent of the western precinct is subject to potential fireline intensity exceeding a minimum 4,000 kW/m; and
- more than 97 per cent of the precinct is exposed to potential flame contact, radiant heat and ember attack;

Under a more frequent fire weather event of FFDI 62:

- fireline intensity exposure is present across approximately 63 per cent of the precinct area; and
- the application of potential flame contact, radiant heat and ember attack exposure expands the area of potential risk to over 89 per cent of the precinct.

In terms of the influence of approved development and the potential future development of any PAC sites, depending upon the treatment of fuels internal to these locations (i.e. the retention of vegetated corridors and patches of bushland), the risk of fire across the landscape will require careful consideration.

Vegetation retained within urban developments can invite fire into such locations, referred to as urban fire intrusion. This occurred in Canberra in the 2003 fire event which saw fire intrusion occur up to 700m within suburban areas.

Another consideration is the location of these areas within a broader risk landscape, surrounded by bushland and the ability to evacuate.

In terms of potential fire intensity of a fire weather event of FFDI 100, several large areas of high and very fireline intensity are modelled to potentially occur on the basis of mapped vegetation and the digital elevation model. The following is observed:

- approximately 17 per cent of the precinct is modelled to a potential exposure of less than 4,000 kW/m;

- approximately 50 per cent of the precinct is modelled as potentially subject to fireline intensities of between 4,000 kW/m to 30,000 kW/m; and
- approximately 10 per cent of the precinct is modelled as potentially subject to fireline intensities between 30,000 kW/m and 40,000 kW/m, 11 per cent exposure between 40,000 kW/m and 60,000 kW/m and approximately 11 percent above 60,000 kW/m.

The approved development and reduced fuel PAC sites hypothetical land use scenarios appear only to alter fireline intensities at the lower end of the spectrum. In this regard, whilst these sites, for the most part, avoid potentially higher fireline intensity areas of the precinct, they may remain directly adjacent to areas where high and very high fireline intensity may occur. This risk assessment is not intended to critique these sites or their future development, however it does provide a landscape-scale understanding of potential risk for Council and other stakeholders to consider in strategic planning processes.

In more extreme, but less frequent events, up to FFDI 134 the modelled fireline intensities increase. As is the case across the Deferred Lands area, these increases occur by only a few percentage points however the spatial or geographic rate of spread and extent of risk exposure remain at the higher end of the spectrum, across multiple land use scenarios.

The full suite of both spatial/geographic and intensity data analysis tables are presented at Appendix F for each fire weather and hypothetical land use scenario, across each precinct.

From a land use planning perspective, the confluence of the geographic risk and intensity risk extents is fundamental. Key insights relevant to the central precinct include:

- the majority of the central precinct is identified as MRA, with areas in the west and south of precinct identified within the future MRA investigation area;
- large areas of the precinct are identified as subject to potential high and very high fireline intensity. This is largely evident in the northern area of the precinct, driven in combination by complex topography, limited fragmentation of substantial fuel loads and the influences of fire weather from the north and north-west;
- other areas of potential high and very high fireline intensity occur:
 - to the immediate west of the Wakehurst Parkway road reserve, north of Aroona Road;
 - north of existing residential development on Harstaf Close, Laurie Place and Childs Circuit (development is located outside the Deferred Lands area); and
 - at the headwaters of Oxford Creek, adjacent to Corymbia Circuit.
- there are a number of potentially vulnerable facilities which adjoin Forest Way and Wakehurst Parkway, both of which are key evacuation routes for the Deferred Lands area and surrounds. These facilities will continue to require consideration in terms of mitigation and evacuation;
- most existing development is located in the southern to central area of the precinct and along Forest Way; and
- Wakehurst Parkway is flanked by vegetation to the south of the Deferred Lands area.

7.2.3 Eastern precinct

The eastern precinct is bound to the east and south by the suburbs of Cromer, Narraweena and Beacon Hill, and to the west by Wakehurst Parkway. The boundary of the Deferred Lands area stops short of meeting Wakehurst Parkway to the north.

Wakehurst Parkway separates the eastern precinct from Garigal National Park however, the road reserve is not a particularly wide firebreak and tree canopies extend over the roadway.

Similar to the central precinct, the complex terrain and connectivity of high fuel loads gives rise to large areas of modelled high and very high fireline intensity in the northern half of the precinct which extends south.

Land along Oxford Falls Road has been historically cleared and developed. The majority of land uses are large lot residential in nature, interspersed with some commercial activities including outdoor sport and recreation and rural industry. Oxford Falls Grammar School is located to the east of Wakehurst Parkway.

Under FFDI 100 fire weather conditions:

- approximately 77 per cent of the western precinct is subject to potential fireline intensity exceeding a minimum 4,000 kW/m; and
- more than 92 per cent of the precinct is exposed to potential flame contact, radiant heat and ember attack;

Under a more frequent fire weather event of FFDI 62:

- fireline intensity exposure is present across approximately 62 per cent of the precinct area; and
- the application of potential flame contact, radiant heat and ember attack exposure expands the area of potential risk to over 81 per cent of the precinct.

Of each of the precincts, the spatial or geographic spread of fire is lowest in the eastern precinct however, on a percentage basis the proportion of the precinct which is exposure to hazard and risk remains relatively high.

At FFDI 100 approximately 36 per cent of the precinct is subject to potential fireline intensity above 30,000 kW/m which is the highest proportion of each of the precincts in terms of exposure to high and very high potential fireline intensity. Thus, whilst spatial/geographic extent of fire might be comparably less than the other precincts to an extent, it is highest for exposure to extreme fire intensity.

Two PAC sites are identified in the eastern precinct, one in the area of Red Hill Reserve and the other to the west of Cromer Gold Course. Both sites adjoin areas modelled at high and very high potential fireline intensity.

The full suite of both spatial/geographic and intensity data analysis tables are presented at Appendix F for each fire weather and hypothetical land use scenario, across each precinct.

From a land use planning perspective, the confluence of the geographic risk and intensity risk extents is fundamental. Key insights relevant to the eastern precinct include:

- the majority of the eastern precinct is identified as MRA, with areas in the south and east of precinct identified within the future MRA investigation area;
- large areas of the precinct are identified as subject to potential high and very high fireline intensity. This is largely evident in the northern area of the precinct and extending south, driven in combination by complex topography, limited fragmentation of substantial fuel loads and the influences of fire weather from the north and north-west;
- the eastern precinct is identified as exposed to a higher extent of hazard and risk, principally relating to fireline intensity, than the other precincts of the Deferred Lands area although all precincts are highly exposed, including under lower but more frequent FFDI conditions;
- the south-western area of the precinct is exposed to a lower level of hazard and risk in both spatial/geographic spread and fireline intensity contexts, but remains within proximity to the bushland interface and may be vulnerable to ember attack; and

- high and very high potential fireline intensity may occur in proximity to Oxford Falls Grammar School which may need to be further contemplated in terms of mitigation and evacuation for the facility.

7.3 Metropolitan Rural Area and Future MRA Investigation Area

Pursuant to the District Plan, the Deferred Lands area is partially incorporated within the MRA. The LSPS further identifies a future MRA investigation area comprising lands which may be considered by Council for inclusion as part of the MRA. Consistent with the extent of existing exposure relevant to the precincts, when divided by these boundaries the extent of potential exposure remains high.

It is however slightly lower for the future MRA investigation area, at 93 per cent, compared with the MRA at 98.8 per cent when contemplating combined flame contact, radiant heat and ember attack at FFDI 100.

At FFDI 62 and at FFDI 134, the extent of the areas potential exposed does fluctuate but not by any significant margin.

8 Risk evaluation

The risk evaluation considers the findings of the risk analysis against the identified potential risks established at Section 6 of this assessment, for each of the strategic bush fire study elements required by Chapter 4 of PBP 2019. These elements are addressed through the headings below.

This section focuses on the considerations and opportunities for risk likelihood/consequence reduction relative to the identified strategic risks.

8.1 Bush fire landscape, demographics and risk to life

Identified potential risks

Potential risks identified, relevant to the bush fire landscape, demographics and risk to life may include:

1. continuous connectivity of landscape fuels and known fire paths and fire runs into the Deferred Lands area;
2. areas of considerable fireline intensity adjacent to and within the Deferred Lands area; and
3. fragmented land ownership which increases the difficulty to manage fire trail networks and implement fuel reduction, and landholder ability and willingness to manage fuel loads on private land.

8.1.1 Continuity of landscape fuels

As demonstrated by the risk analysis and exposure assessment, the ability for fire transition throughout the Deferred Lands area is present.

Potential ignition sources are diverse and may involve natural or human-caused ignitions. Ignitions may impact the Deferred Lands in a number of ways:

- propagation and transition of fire front;
- spot ignitions from ember attack from the north, north-west or west;
- ember attack, generally.

Radiant heat, fire-driven wind and smoke are also likely features of the above.

The Deferred Lands at present forms part of the broader landscape of bushland and fuels. This is unlikely to change in any substantial manner having regard to the current MRA designation for much of the area, pursuant to the District Plan which is non-urban in character.

External to the Deferred Lands to the north and west, this landscape continues as part of Garigal National Park and into Ku-ring-gai Chase National Park. To the south and east however, fuel continuity is broken by the urban environment.

Previous fire events have transitioned into the Deferred Lands area from the north and west, largely due to the connectivity of landscape-scale fuels. Land and fuel management practices are currently in place across the area managed by Council, NSW RFS and the National Parks and Wildlife Service.

From a strategic planning perspective however, the primary policy response is to avoid intensification of development in inappropriate locations where high bush fire risk exposure is likely, where evacuation may be difficult and where environmental constraints cannot be overcome (NSW RFS, 2019).

This translates to the consideration of appropriate LEP and DCP controls which avoids high risk outcomes, and introduces tools to assist tolerable risk outcomes. This is expanded further in Section 9.

8.1.2 Exposure to fireline intensity and risk to life

Further to the continuity of landscape fuels, the Deferred Lands area includes a number of areas where high and very high fireline intensities are likely in a fire event.

It is significant to note the marginal difference between higher fireline intensities under different fire weather conditions. These areas remain key higher risk locations in almost all fire weather scenarios. This is largely a product of fuel load and complex topography.

The risk to life and property in these locations is likely to be elevated. As previously noted, fireline intensities exceeding 30,000kW/m generally correspond with increased property loss. This is equally relevant to the consideration of life loss where research demonstrates that community members largely continue to adopt a 'wait and see' approach, and an appetite to defend.

The two figures below demonstrate the modelled fireline intensity at FFDI 100 under north-westerly wind conditions, subject to existing vegetation, noting the following:

- fireline intensity under 4,000 kW/m has been removed from the figure on the left, and only incorporates fireline intensities above this threshold; and
- fireline intensity below 30,000 kW/m has been removed from the figure on the right, and only incorporates fireline intensities above 30,000 kW/m.

Below 4,000 kW/m, fireline intensity is substantially low. This does not necessarily translate to 'no risk' or an absence of risk or hazard, but its scale is generally limited in terms of strategic planning consideration.

The figure on the right focusses on the higher fireline intensity areas, above 30,000 kW/m.

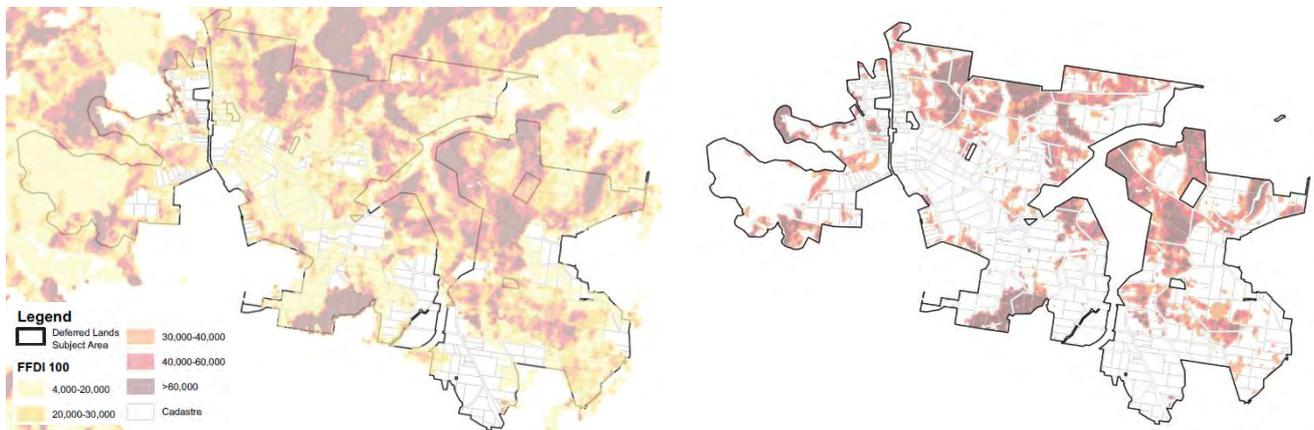


Figure 25 - Fireline intensity mapping at FFDI 100 under north westerly wind conditions for existing vegetation

The figure on the right demonstrates those areas of the Deferred Lands which are potentially susceptible to higher modelled fire intensity. From a risk perspective, the impact of potential flame contact and radiant heat exposure extends beyond these areas for a proximate distance of 70m having regard to Table 14 of this document.

These higher fireline intensity areas of the Deferred Lands should ideally be considered as part of the application of LEP and DCP controls, including zoning, to avoid high risk to life and risk to property outcomes.

8.1.3 Fragmented land ownership

The fragmentation of land ownership throughout the Deferred Lands presents considerable challenges in the strategic application of hazard reduction at a landscape-scale, such as tenure-blind burning and fire trail continuity and access for management.

The ability or willingness of landholders to implement property-based hazard reduction and land management practices to reduce risk and limit fire propagation across landholdings remains a further challenge. The 2020 NSW Bushfire Inquiry identifies the increasing responsibility of landowners in hazard reduction on private land.

For Council-owned land, Council is underway with the preparation of a Bush Fire Management Policy for the Northern Beaches.

8.2 Land use, property and vulnerable uses

Identified potential risks

Potential risks identified, relevant to land use, property and vulnerable uses may include:

1. the exposure of existing SFPP uses within the Deferred Lands area;
2. the potential for new or expansion of existing SFPP uses within the Deferred Lands area;
3. a zoning rationale which does not respond to risk;
4. a settlement pattern which exposes property (and occupants) to unacceptable or intolerable risk; and
5. the potential for property loss from fire occurring within or adjacent to the Deferred Lands area.

8.2.1 Exposure of existing SFPP uses

The Deferred Lands area currently incorporates a significant number of Special Fire Protection Purposes (SFPPs), otherwise known as vulnerable uses. These activities include a number of primary and secondary schools, child care operations and seniors living activities.

A number of facilities, particularly those in proximity to Forest Way, are potentially exposed to modelled higher levels of fireline intensity by virtue of the primary fire runs associated with this area of the Deferred Lands.

Other facilities are located in Oxford Falls Valley, and adjoining the existing urban area of Cromer in the very eastern area of the Deferred Lands. Both areas are potentially vulnerable to moderate fireline intensity (up to 30,000 kW/m), and adjoin areas where higher fireline intensity is modelled.

Whilst this remains an existing risk issue, it is necessary to ensure planning controls do not inadvertently continue to increase the risk profile of these activities. Two key considerations in this regard involve the ability to evacuate, and the consideration of potential land management measures to increase existing mitigation. These measures are unlikely to prevent bush fire attack but may provide additional time redundancy for evacuation procedures with a focus on slowing fire advancement.

8.2.2 Future SFPP uses

The addition of further SFPPs in the Deferred Lands area is somewhat attenuated by changes recently made to the Seniors Living SEPP by the Department of Planning, Industry and Environment. The current SEPP now prohibits seniors living developments from establishing within MRAs. Notwithstanding, it is acknowledged that landowners are still permitted to seek seniors living developments under the Warringah LEP 2000 in some areas of the Deferred Lands.

Generally, SFPPs should be avoided within the MRA extent of the Deferred Lands area due to the magnitude of exposure to hazard and the vulnerability of such facilities and residents.

In relation to the future MRA investigation area, there remain large expanses of modelled fireline intensities exceeding 30,000 kW/m. These areas also impact potential evacuation networks. One of the key issues with SFPPs is the lack of private vehicle access for evacuation which places direct demand on emergency services to manage evacuation for individual facilities.

Further intensification of SFPPs within the future MRA investigation area, including new facilities or expansion of existing uses involving increased persons on-site, should not be sustained by LEP or DCP controls. This aligns with the LSPS which focuses growth within existing centres.

8.2.3 Zoning rationale is responsive to bush fire risk

The Deferred Lands area is not currently subject to any zoning requirements under WLEP 2000. It is understood the area is subject to a significant history of dialogue in relation to its zoning.

Given the majority of the Deferred Lands area is within the MRA, the intention set by the District Plan and Council's LSPS is for this area to remain non-urban. This inherently limits the nature of zoning which can be contemplated, irrespective of this study. The future MRA investigation area may involve more flexibility however, its bush fire risk profile also requires consideration.

One of the primary intents of this assessment is to provide an evidence base for the quantification of potential bush fire risk, and support the risk-informed consideration of potential zoning.

This is a statutory requirement or obligation of Council, pursuant to Chapter 4 of PBP 2019.

Based on fireline intensity analysis, there are areas of the Deferred Lands which are modelled to potentially exceed 30,000 kW/m, including areas which are modelled to exceed 60,000 kW/m, under FFDI 100 fire weather conditions. In these locations, it is not only a factor of the spatial extent of higher fireline intensity, but its impact on surrounding lands which are also exposed to potential extreme fire behaviour.

Zoning is a spatial planning tool which can and should be deployed to avoid and/or mitigate potential risk to life (AIDR, 2020 and PIA, 2016). It can achieve this by limiting and directing the nature of land uses, and therefore, persons present, in higher risk locations. This is not a new approach, and has been used for some time in avoiding and mitigating flood and coastal risk to communities, for example.

Another example is the approach adopted in 2012 by Ku-ring-gai Council, where a rigorous zoning approach to identified higher risk evacuation locations was recommended and deployed by its standard instrument LEP.

In the case of the Deferred Lands, some locations should be considered for more stringent zoning requirements on the basis of potential risk to life from extreme bush fire intensity and activity. This is largely a function of the nature of existing vegetation characteristics, and complex terrain.

The fireline intensity modelling completed by this study reflects higher risk locations which mirror primary fire runs experienced in historical bush fire events which have impacted the Deferred Lands area. To an extent, this verifies the veracity of the modelling approach conducted³, demonstrating key relationships between fuel characteristics, topography and fire weather.

Pursuant to the above, a high risk evacuation model to inform zoning, such as that adopted by Ku-ring-gai Council, is not adequate in the situation of the Deferred Lands. The difference being the context of the settlement pattern which varies greatly between the two situations. In Ku-ring-gai, the identified higher risk evacuation locations are considerably constrained by the urban context of the settlement pattern. This is not the case for the Deferred Lands which encompasses a more rural character and settlement pattern, comprising comparatively larger allotment sizes.

To this end, whilst potential evacuation issues could possibly be addressed via changes to the broader settlement pattern of the Deferred Lands (i.e. provision of new road infrastructure), the limiting factor continues to be exposure to potentially high fireline intensity. Irrespective of

³ Whilst a level of modelling accuracy may be qualitatively identified having regard to historic fire events, the limitations of modelling must still be recognised, as addressed earlier in this report.

evacuation capability, exposure to such high fireline intensities may pose a considerable risk to human life which evacuation networks and statutory controls cannot overcome.

Pursuant to Chapter 4 of PBP 2019, it is these higher risk instances and locations which are required to be identified by local governments (and others involved in strategic planning processes), such that effective land use planning controls can be implemented to support community resilience by avoiding the unnecessary exposure of persons to intolerable risk.

8.2.4 Potential settlement patterns

Where combined planning, building, land management, landscaping and disaster management processes can effectively mitigate risk exposure to a tolerable level, statutory tools and controls can be implemented.

Structure planning is an additional tool, following the allocation of appropriate risk-responsive land use zoning, which can be implemented to limit and mitigate risk exposure.

Ad hoc site-specific structure planning can lead to lost opportunities for the implementation of strategic risk reduction measures. This is inherently driven by the site-specific focus of planning proposals which are not necessarily required to contemplate the context of the site in the broader landscape. This further underpins the critical role of strategic planning processes.

To avoid ad hoc development, Council may consider a structure planning approach in response to zoning of the Deferred Lands area, enabling strategic mitigation (i.e. evacuation networks, strategic fire breaks, fire trail networks, open space networks to provide asset protection, etc.) to be factored into urban design approaches for resilient settlement patterns within the future MRA investigation area, where applicable.

8.2.5 Potential for property loss

The current planning framework inherently accepts a level of property loss risk, enabling development to occur within identified bush fire prone areas but limiting exposure to 29 kW/m².

This level of risk tolerance is driven by a number of complex, competing issues such as desire to live in vegetated areas, desire to retain valued ecological assets, the ability to implement mitigation measures to respond to a level of risk, etc.

Research and inquiry findings to date indicates that construction of buildings to AS3959 standard provides a potential greater level of building survival compared with those which are not, however it is not a guarantee. In addition to AS3959 construction, planning controls are likely to be part of the suite of factors influencing building survivability. The interim findings of the 2020 National Natural Disaster Arrangement Royal Commission identified that 99 per cent of dwellings which were damaged or lost during the 'Black Summer' fires were located within 500m of bushland. 74 per cent of the dwellings lost were constructed prior to the introduction of AS3959 (Commonwealth of Australia, 2020).

Approximately 26 per cent of dwellings constructed to AS3959 standard were lost during the 'Black Summer' fires of 2019-20 in Australia, most of those in NSW.

Existing Australian research reveals that 80-90 per cent of property loss occurs within 100m of the bushland interface, with the full extent of loss typically occurring within circa 700m of the bushland interface in urban contexts (Leonard & Bianchi, 2012; McAnaney & Chen, 2004 and Ahern & Chladil, 1999).

Accordingly, the assessment and construction requirements of AS3959 extend 100m from classified vegetation.

Whilst construction to AS3959 standards does not guarantee against property loss, evidence from the 2020 Royal Commission and other investigations (such as the Wye River and Separation Creek fire building loss assessment completed by CSIRO, and building loss assessment undertaken following the 2018 Tathra fire in New South Wales) identifies potential improved property survival rates of

buildings constructed to AS9395 standards, where occupants have not otherwise altered the building to a non-compliant status following building certification.

The existing dwelling density identified by the WLEP 2000 is a maximum of one dwelling per 20 hectares. This was largely established to maintain the rural character of the Deferred Lands area but does and has worked to limit the intensification of residential activity within higher hazard areas, effectively limiting potential exposure. However this does not prevent potential intensification of uses on existing allotments. This can only be achieved by limiting the range of permissible uses within the area. Typically this is achieved through zoning.

8.3 Ability to evacuate

Identified potential risks

Potential risks identified, relevant to the ability to evacuate may include:

1. potential risk to life from an inability to evacuate to a safer location.

The Deferred Lands area is currently serviced by two arterial routes being Forest Way and Wakehurst Parkway. Key internal collector routes include Oxford Falls Road, Morgan Road and roads within the western precinct which include Wyatt Avenue and Challenger Drive.

The local road network extends from these key routes.

The Deferred Lands area currently comprises approximately 495 allotments, serviced by the existing road network. Some local roads are unsealed, and many are flanked by roadside vegetation. Historical subdivision of Crown Land in the area has led some allotments to require access via easement, without immediate access to the gazetted road network.

Within the Deferred Lands, Forest Way is a key evacuation route connecting with Mona Vale Road to the north and Warringah Road at Frenchs Forest to the south. In a fire event, it is likely traffic will evacuate south on Forest Way. The route is largely urbanised and thus, protected from higher levels of bush fire attack, though smoke, wind and ember attack may still be present.

Forest Way is four lanes in width, two lane each way. It is divided by a centre median which is vegetated with low level ground covers. Several intersections are located along the route within the Deferred Lands, as well as a series of emergency turnarounds across the centre median. It is also possible for contraflow to be managed in an emergency on Forest Way, as Forest Way may be closed to the north in an event, requiring all traffic to travel south. For land uses on the western side of Forest Way, contraflow arrangements would enable traffic to move immediate south. Irrespective, the centre median facilitates U turns, and is also low enough to enable vehicles to drive over it to travel south, if needed be.

The road network in the western precinct, feeding onto Forest Way may be exposed to potential bush fire attack however, time to evacuate may avoid potential human exposure.

Wakehurst Parkway is a two lane route which connects Warringah Road in the south with Pittwater Road to the north-east, on the northern Side of Narrabeen Lagoon. It is flanked by dense vegetation within the Deferred Lands area, as well as the north and south. The route is likely to be closed to the north in a fire event, as it traverses the southern side of Garigal National Park.

South of the Deferred Lands, the road reserve is highly vegetated. It is possible that spot fires, flame contact and radiant heat exposure may limit the function of this evacuation route in an emergency based on potential for exposure to flame contact and radiant heat. Oxford Falls Road offers an alternative route, linking to Iris Street in the south which flows to Warringah Road. Wakehurst Parkway does connect with Forest Way via Oxford Falls Road and Morgan Road however, this route is meandering and steep in locations, moving north-east which traverses identified higher fireline intensity locations and as such, may not be a desirable option if bush fire attack is already occurring within the Deferred Lands area.

From a mitigation perspective, roadside vegetation management along Wakehurst Parkway to reduce potential for bush fire attack exposure could be considered. It is however noted that roadside vegetation forms a major wildlife corridor, and the Wakehurst Parkway road reserve is outside the Deferred Lands area.

From a road capacity perspective, the Deferred Lands currently comprises approximately 495 allotments. A traffic engineering analysis may need to be undertaken to fully explore evacuation capacity.

Cova's minimum evacuation exit points and relationship with the number of dwellings serviced by particular roads should guide the consideration of any potential future development within the Deferred Lands (and beyond, elsewhere in bush fire prone areas across the Northern Beaches).

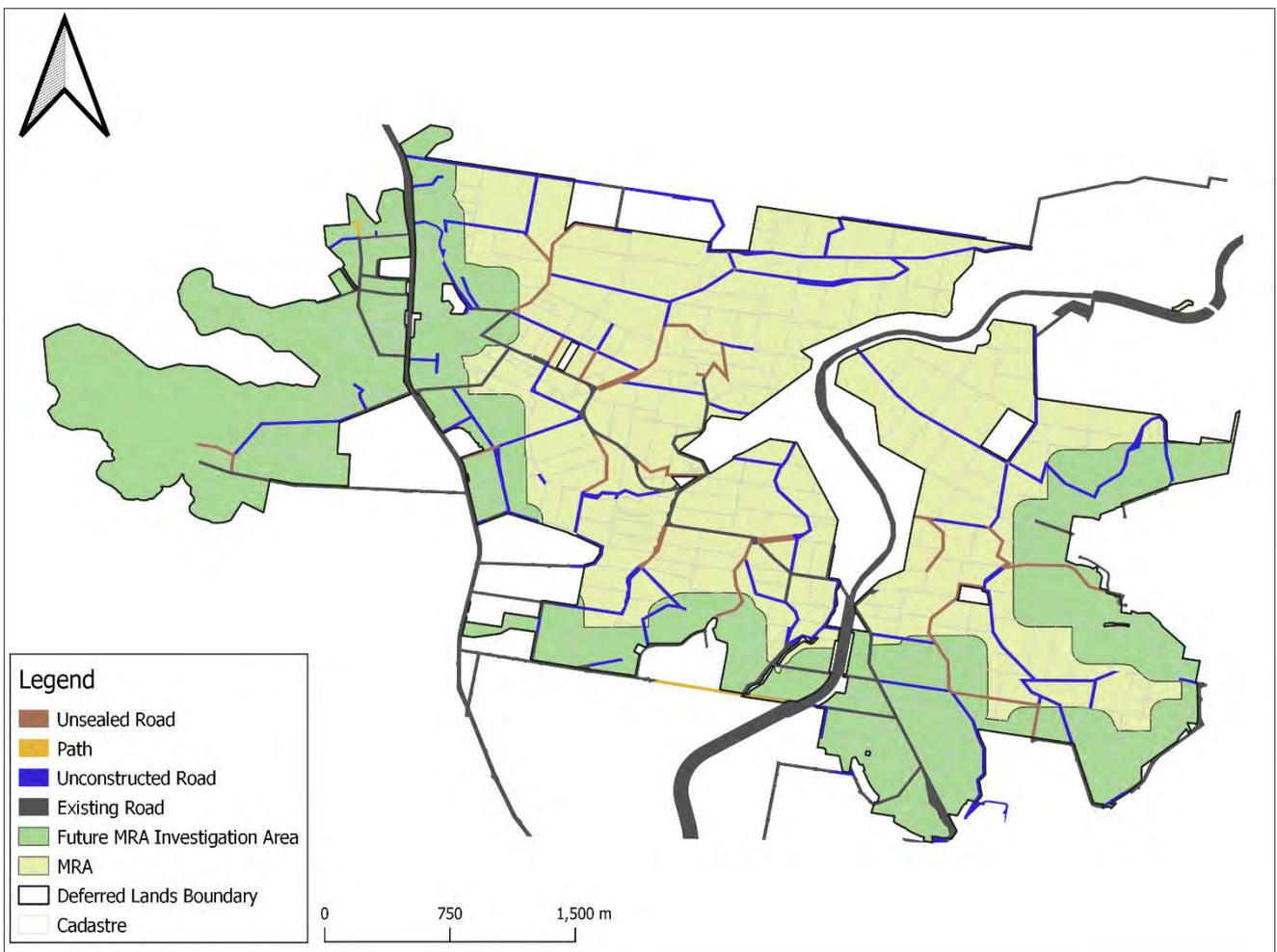


Figure 26 - Existing constructed and unconstructed road network

8.4 Emergency services

Identified potential risks

Potential risks identified, relevant to emergency services may include:

1. demand on fire services for property protection during an event, when resources may not necessarily be available; and

2. the settlement pattern inappropriately limits or otherwise frustrates the ability for fire services to suppress fire by limiting access to the hazard interface.

8.4.1 Demand on fire services

Both the existing and any future density envisaged by the LEP and DCP within the Deferred Lands area inherently involves population in an area of bush fire hazard.

Increasing the demand placed on emergency services can be mitigated, however this is only possible in low and moderate fireline intensity areas. In areas of higher fireline intensity, the statutory measures of PBP 2019 may be insufficient to enable emergency services to safely operate. This is due to the impact of prevailing fire winds driving increased behaviour in these areas, the complexity of the terrain in these areas, and extreme radiant heat profile associated with higher fireline intensity.

In these locations, emergency services may not be able to undertake property defence, depending upon the conditions due to firefighter safety.

8.4.2 Impact of settlement pattern on ability to suppress

Whilst this assessment does not contemplate any settlement pattern, LEP and DCP controls may give rise to the expansion of the settlement pattern in some locations where risk is acceptable or tolerable.

To this end, it may be the case that risk-informed master planning is undertaken in these locations once the preferred zoning rationale is adopted, capable of mitigating potential risk. This will assist to ensure residual risk transfer to emergency services is as low as reasonably practicable. It will also ensure that any intensification of development in the Deferred Lands area is contemplated and designed collaboratively and strategically, avoiding ad hoc outcomes where strategic mitigation can instead be implemented.

8.5 Infrastructure supply and asset safety

Identified potential risks

Potential risks identified, relevant to infrastructure supply and asset safety may include:

1. potential impact of bush fire on critical infrastructure assets and networks within the Deferred Lands area, and those located external to the study area, and the cascading or flow-on impacts of loss of or damage to critical infrastructure networks and/or assets.

Infrastructure services are located within the Deferred Lands area to support existing uses. In addition, the area also accommodates a number of large-scale strategic critical infrastructure operations in both electricity and telecommunications. Other assets both within and around the Deferred Lands area will likely be drawn upon to service existing and any new residents.

Infrastructure providers with existing assets in the Deferred Lands maintain comprehensive risk management procedures, and employ risk reduction and mitigation measures.

New infrastructure within the area can mitigate risk for example, by locating essential services underground. This is largely the expectation of new development in hazard prone areas.

This does not necessarily mean the Deferred Lands area will not be impacted by potential infrastructure service disruption during an emergency event, however infrastructure protection is increased which generally enables a more timely return of essential services should they be disrupted.

8.6 Environmental and land management

Identified potential risks

Potential risks identified, relevant to environmental and land management risk may include:

1. local and State government responsibilities for fuel load management and hazard reduction on an annual basis are increased; and
2. potential for environmental loss or damage as a result of clearing to achieve asset protection.

8.6.1 Demand on government resources for land management

The existing context of the Deferred Lands already requires considerable fuel load and land management requirements both internally and externally. This extends well beyond government agencies to land owners who are equally required to manage fuel loads on private property within the Deferred Lands.

Hazard reduction and land management is an impost on local and State government. This is not a new risk, as this need currently exists. The risk profile in relation to land management could potentially escalate to protect any new development.

Council, and likely the National Parks and Wildlife Service and NSW RFS are required to incorporate the cost of annual fuel load, weed and land management into its operational budgets for environmental assets as part of Council's broader environmental network. Increased land use activity in the area are likely to increase these costs and responsibilities more broadly.

The ability for application of prescribed burning in some locations throughout the Deferred Lands area may prove challenging on the basis of fragmented land ownership, slope, vegetation type and proximity of development and infrastructure.

8.6.2 Risk of environmental damage or loss

Much of the Deferred Lands has previously been mapped by the NSW Government as being among the 'highest' and 'very high' areas for native flora conservation priorities in the Sydney Metropolitan Area. Much of the area is further mapped as being High Environmental Value lands as part of the NSW Government Architect – North District Green Grid. Additional biodiversity studies continue however, the environmental values of the Deferred Lands is a significant factor in the stewardship of the landscape, and a considerable planning matter in its own right, irrespective of bush fire hazard and risk considerations.

A clear understanding of the environmental and biodiversity values of the Deferred Lands should be mapped, such that LEP and DCP controls can be considered which limit the damage, loss or fragmentation of environmental assets. The Deferred Lands is situated at the headwaters of two catchments, the impacts on which can extend far beyond the bounds of the Deferred Lands. As such, the environmental considerations of land uses within the Deferred Lands is a separate strategic planning matter in its own right.

8.7 Economic

Identified potential risks

Potential risks identified, relevant to economic risk may include:

1. local government is exposed to increased economic risk for mitigation, reconstruction and recovery.

Development within hazard prone areas inherently involves potential economic risk for ongoing mitigation, and possibly for reconstruction and recovery should an event occur.

In this case the new LEP and DCP have the opportunity to incorporate proactive measures to mitigate potential risk exposure and ensure any residual risk is as low as reasonably practicable. This

does not necessarily avoid potential economic risk altogether, but it can set in place appropriate provisions to limit risk through a suite of combined measures.

9 Risk mitigation and treatment analysis

This risk treatment analysis focuses only on those aspects of bush fire risk reduction which are relevant to strategic land use planning. This is contemplated having regard to:

- existing risk;
- future risk; and
- residual risk.

It is recognised a suite of other mitigation and management measures are applicable to bush fire risk reduction however, the purpose of this risk assessment is to assist Council with risk-informed approaches for the formulation of LEP and DCP controls, relevant to the Deferred Lands area.

Notwithstanding this, a range of other risk reduction opportunities are identified, and included for consideration at Section 9.7 below.

The following suite of mitigation measures are available for consideration on a spectrum of risk treatment. From a land use planning perspective, the transfer or acceptance of risk without mitigation or avoidance is not an appropriate planning response. Thus, these elements are not capable of consideration outside the bounds of residual risk management.

The mitigation measures outlined below represent varying levels of effectiveness, and can be strengthened by multiple measures acting in concert to reduce risk exposure. It is noted none have been tested from a cost benefit analysis perspective.

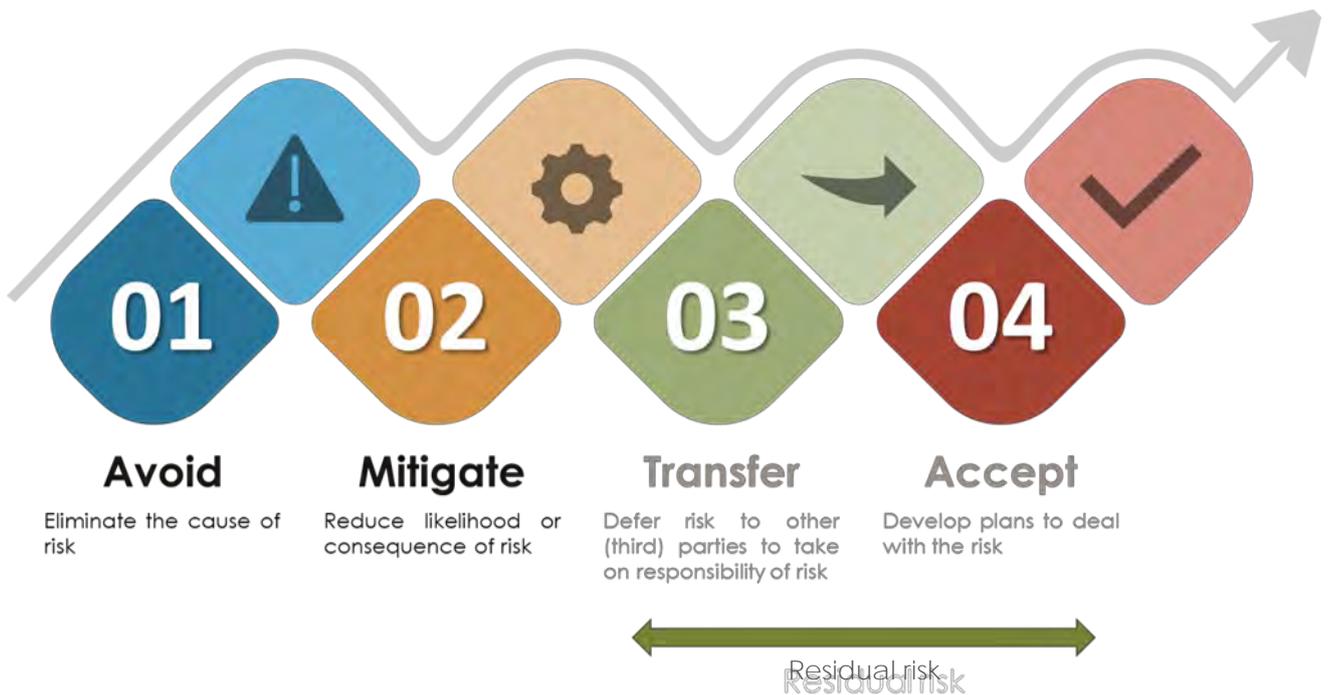


Figure 27 - Spectrum of risk treatment relevant to land use planning

9.1 Consideration of broader planning framework requirements

In considering the potential risk-informed planning options relevant to the Deferred Lands area, the broader planning framework must be considered, having regard to its provisions and limitations.

Those aspects of the broader planning framework relevant to the Deferred Lands area include:

- a large area of the Deferred Lands is identified within the Metropolitan Rural Area (MRA) pursuant to the District Plan. Under the LSPS and pursuant to the requirements of the District Plan, this area of the Deferred Lands is intended to *remain non-urban*.
- the above *limits the range of potential zones and land uses* which can be considered for this portion of the Deferred Lands area, *irrespective of this risk assessment*.
- the balance of the Deferred Lands area is identified within the future MRA investigation area under the LSPS. This means *further investigation* into the nature of potential land uses within this area is required, one aspect of which is exposure to potential bush fire hazard and risk. The potential suite of zones and land uses in this area may be more flexible than for land within the identified MRA, however this depends upon a range of studies, this assessment being only one of a range of broader planning considerations for this area. However, exposure to hazards and consideration of risk to life are higher-order considerations.
- land uses within the Deferred Lands area are subject to the provisions of a range of SEPPs.
- amendments to the *Housing for Seniors or People with a Disability SEPP* implemented by the State government in 2020 now precludes the ability for establishment or expansion of such land uses within identified MRAs.
- the *Exempt and Complying Development Codes SEPP* enables some types of residential, commercial and industrial development to occur within bush fire prone areas, but not for development outcomes of BAL-40 or higher.
- the *Aboriginal Lands SEPP* is relevant to land identified under the SEPP and enables the making of development delivery plans for land owned by Local Aboriginal Land Councils. This SEPP currently does not apply to the Northern Beaches, but it may do so into the future.
- the *Educational Establishment and Child Care Facilities SEPP* supports the development of such facilities and enables specified development. In bush fire prone areas, the SEPP requires a notice to be provided to NSW RFS, and consideration of any response to the notice. It can also enable development on adjoining State lands under certain circumstances. Limitations exist for any development of BAL-40 or higher.
- the *Affordable Rental Housing SEPP* potentially enables some forms of residential development in certain zones under certain circumstances. Section 46B sets out the development standards for bush fire prone land.

The relevance of these requirements and provisions is discussed further, relative to each planning option below.

9.2 Overview of options

This assessment identifies four (4) potential planning options for Council consideration in regard to how the risk profile of the Deferred Lands area is contemplated by and/or factored into planning instruments.

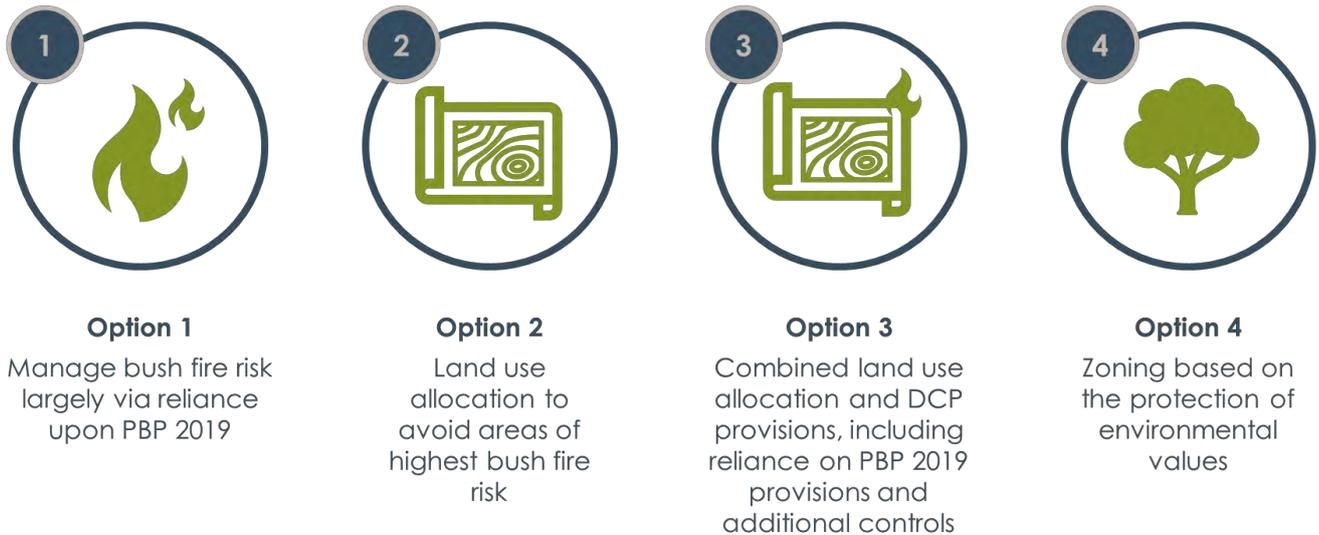


Figure 28 - Summary of planning control options

The potential planning options for consideration are outlined in detail below.

9.3 Planning option 1 – reliance on statutory PBP 2019 provisions

This planning option relies on the implementation of statutory protection measures including PBP 2019, and can include specific provisions including within the new DCP.

This option is characterised by:

- no specific risk-responsive zoning approach is applied. Instead, the zoning rationale is driven by the requirements for MRA lands (non-urban zoning), and other planning considerations for land identified in the future MRA investigation area;
- bush fire risk is not avoided or mitigated through zoning, but addressed via compliance with statutory protection measures or controls;
 - this relies upon the existing statutory provisions of the broader planning framework (including SEPPs) and their linkages to PBP 2019. This may or may not be supplemented by specific DCP provisions for the entire local government area, or the Deferred Lands area in particular; and
- the potential formulation of a bush fire risk overlay (in addition to the certified bush fire prone lands map for the Northern Beaches) which can be used to guide the trigger of LEP and/or DCP controls, and which could also identify land exposed to higher fireline intensity or at evacuation risk, which limits the application of certain SEPPs, if so desired.

9.3.1 Statutory LEP and DCP controls

Potential LEP and/or DCP controls for consideration include:

- retention of existing assessment triggers for compliance with PBP 2019, and subsequently with AS3959-2018 – Construction of buildings in bushfire prone areas. This is an existing legislative requirement under the EP&A Act and is a mandatory requirement;
- embedding Cova's minimum exit requirements for interface communities (at Table 8) within the DCP for subdivision development, to aid evacuation planning and assessment;
- requirements for the provision of underground electricity and other essential infrastructure networks and services for new development;

- inclusion of a bush fire risk overlay map within the LEP (separate from the certified bush fire prone lands map) which can be used to trigger specific controls. This map could be informed by fireline intensities⁴. The controls which could be triggered by such an overlay include:
 - minimum dwelling or allotment densities to limit populations in specific areas or locations, irrespective of zoning;
 - minimum lot sizes or depth to width ratios in certain areas or locations;
 - the minimum lot size or landholding required for dwellings in the Deferred Lands area is currently 20 hectares under the WLEP 2000. This may be retained for land within the MRA;
 - land within the future MRA investigation area may be subject to more flexible density provisions, where not exposed to fireline intensities above 30,000 kW/m.
 - locations where future subdivision is not supported on the basis of bush fire hazard or risk;
 - locations where specific SEPPs are not intended to apply.
- the preparation of LEP and DCP controls for industrial, tourism and major infrastructure utilities development in bush fire prone areas (in addition to the provisions of PBP 2019) such as mandatory asset protection zones specific to such developments (PBP 2019 provides asset protection zone requirements for residential and SFPPs, but does not include provisions for industrial, tourism or major infrastructure activities); and
- controls relating to the provision of private bush fire shelters (i.e. bunkers), if so desired⁵, where in contemplation of Section 8.3.3 of PBP 2019 and the requirements of the EP&A Act.

In relation to vegetation clearing, as a general rule pursuant to PBP 2019, new development should be sited away from hazardous vegetation without the need for clearing to achieve sufficient bush fire protection.

9.3.2 Benefits and limitations

Compliance with, or the intended ability to comply with, the statutory controls of PBP 2019 does not necessarily infer risk is acceptable or tolerable. This is clearly identified at Chapter 4 of PBP 2019 which requires the strategic consideration of risk as part of the formulation of new LEPs and DCPs.

Currently statutory measures only require an assessment of landscape for 150m surrounding a site. The strategic bush fire study provisions also do not identify any distance for which the required landscape assessment should be undertaken.

A distance of five kilometres is adopted for the purposes of this assessment. As such, the insights in relation to the resultant bush fire behaviour relative to different fire weather conditions would not otherwise be sufficiently understood at the development assessment stage to enable potential higher risk implications to be avoided.

The application of statutory measures as outlined above can and should be incorporated into the new LEP and DCP, irrespective of the zoning rationale.

⁴ Outside of the Deferred Lands area, a hybrid approach could be adopted which also considers potential bush fire evacuation risk.

⁵ Private bush fire shelters are private last resort refuges and cannot guarantee survival. Shelters should not be contemplated in lieu of any aspect of compliance with relevant statutory requirements and PBP 2019.

However, this planning option considered in isolation of zoning to avoid or mitigate potential future risk in the Deferred Lands area would not apply the potential full range of land use planning tools to respond to existing hazard and future risk.

This option also does not contemplate the types of land uses which might establish within the Deferred Lands area, relative to potential bush fire risk in the manner which zoning can. This could potentially result in the establishment of incompatible or inappropriate land use activities which may increase the risk profile of the area.

9.4 Planning option 2 – land use allocation to avoid potential highest risk areas

This planning option relies on the identification of appropriate and inappropriate land uses (and densities) relative to bush fire hazard and potential risk, to contribute toward informing a zoning approach which seeks to avoid higher risk outcomes. This risk assessment focuses on the nature of appropriate land uses, rather than the identification of specific zones. A separate body of work is underway to inform the zoning approach of the new Northern Beaches LEP.

This option is characterised by:

- the identification of land use types and densities which are appropriate in different areas of the Deferred Lands, on a basis of exposure to hazard and potential risk;
- **the ability to inform Council's zoning** approach for lands with the potential to experience or be exposed to fireline intensities exceeding 30,000 kW/m⁶ at FFDI 100⁷ under north-westerly wind conditions;
 - the above is informed, via this risk assessment, by an understanding of fireline intensity and modelled bush fire behaviour at lower and higher FFDIs through the contemplation of multiple fire weather scenarios to inform comprehensive risk analysis at FFDI 100; and

9.4.1 Consideration of land use policy

In order to contemplate the nature of acceptable land uses within high bush fire risk locations, existing policy positions articulated across a number of relevant instruments must first be contemplated, namely:

- the policy position outlined at section 4.1 of PBP 2019 identifies the need for strategic planning to avoid development where exposed to a high bush fire risk;
- Objective 37 of the District Plan which seeks to ensure exposure to natural and urban hazards is reduced, noting that 'placing development in hazardous areas or increasing the density of development in areas with limited evacuation options increases risk to people and property';
- The LSPS includes principles which involve shaping decisions for future bushland and biodiversity management around the consequences of climate change, including the need for increased bush fire risk mitigation. It also notes the majority of land within the MRA and future MRA investigation area is either bush fire prone or surrounded by bush fire prone land, and that protection of human life and property from bush fire is a major planning concern for the area.

From a land use policy perspective, the intent for the MRA portion of the Deferred Lands is to remain non-urban in nature and avoiding an increase in development density in areas of high bush fire risk.

9.4.2 Acceptable land uses and densities

In order to inform Council's approach to zoning allocation across the Northern Beaches, a range of acceptable land uses and density provisions are identified below, relative to high bush fire risk in a relatively undeveloped area of the Northern Beaches as it currently stands.

⁶ As noted earlier in this assessment, research identifies that house loss increases substantially at exposure to 30,000 kW/m of fireline intensity or higher. House loss is an important factor in consideration of potential risk to life.

⁷ The identified fire weather region of Greater Sydney attracts a planning threshold of FFDI 100 pursuant to PBP 2019.

As part of the amalgamation of four (4) separate LEPs and DCP instruments into one consolidated planning framework for the Northern Beaches, Council is required to adopt a consistent methodology in relation to zoning across the local government area. This means the Deferred Lands cannot be considered in isolation of other parts of the Northern Beaches.

To this end, the land uses identified below represent those which may be considered acceptable in areas of the Deferred Lands which are exposed to fireline intensities exceeding 30,000 kW/m.

In contemplating the range of potentially acceptable land uses within those areas subject to increased fireline intensity, the existing provisions of the Warringah LEP 2000, including Character Statements for the area, as well as the State's Standard Instrument LEP provisions in relation to land uses, have been considered.

The list of potentially acceptable land uses below is consistent with the Standard Instrument LEP suite of land uses.

Table 15 - List of potentially acceptable land uses within areas exposed to fireline intensities exceeding 30,000k kW/m within the Deferred Lands

Acceptable land uses* (specific to consideration of bush fire hazard and risk) where compliance with PBP 2019 can be achieved on a site-specific basis
<ul style="list-style-type: none"> • Agricultural uses (including aquaculture and intensive plant agriculture) • Farm buildings (where associated with an existing use) • Forestry • Dwelling houses (where complying with WLEP 2000 density provision of one dwelling per 20 hectares) • Secondary dwelling (where associated with an existing dwelling) • Home business and home occupation (where associated with an existing dwelling) • Sewerage systems and water supply systems • Helipads • Roads • Signage (where associated with an existing use) • Boat launching ramps and jetties • Environmental facilities • Recreation areas • Recreation facilities (outdoors) • Cemetery • Environmental protection works and flood mitigation works

* other relevant land use planning considerations apply (such as restrictions on vegetation clearing) which may otherwise prevent these uses within the Deferred Lands area.

In terms of residential density, the existing Warringah LEP 2000 identifies a maximum density of one (1) dwelling per 20 hectares. In the area identified as subject to fireline intensity exceeding 30,000 kW/m (depending upon which spatial extent rationale is selected from those outlined below), this density provision should continue to be maintained.

9.4.3 Spatial extent rationale

Three (3) methodologies are identified to inform the spatial extent to which the above land uses and Council's zoning approach may be applied in response to the highest risk areas of the Deferred

Lands, in a manner which seeks to limit and avoid increased risk exposure. These are set out as follows.

Any uses which are not listed above are considered inappropriate within that area identified as subject to fireline intensity exceeding 30,000 kW/m. A series of options which establishes the spatial extent of this area is outlined below.

However, it is noted Council may augment the nature of permissible uses as part of its zoning rationale for the area.

9.4.3.1 Approach A – coarse

The ‘coarse’ approach involves the identification of all allotments, based upon the existing planning cadastre, where:

- a) modelled fireline intensities of 30,000 kW/m or higher, under FFDI 100 conditions are observed; and
- b) within 70m⁸ of modelled fireline intensities of 30,000 kW/m or higher, under FFDI 100 conditions are observed.

The land identified in green at the figure below identifies those areas where modelled fireline intensities of 30,000 kW/m or higher are observed, irrespective of the proportion of land which is affected. This represents a conservative approach.



Figure 29 – Spatial representation of land subject to Approach A

⁸ Accounting for 50m flame contact buffer and 70m radiant heat exposure buffer beyond that area subject to modelled fireline intensities of 30,000 kW/m or higher as established by research contained at Table 14.

9.4.3.1.1 Benefits and limitations

The coarse approach is conservative, and does not reflect the qualitative attributes of lands which may have broader contextual considerations which should be taken into account. For example, this approach does not discriminate between large areas of increased fireline intensity and very small pockets (less than 1 hectare) where this may occur.

This approach, whilst the most rigorous, potentially overstates the spatial extent of those areas subject to modelled higher fireline intensity.

9.4.3.2 Approach B – filtered

Building on from the coarse approach, the 'filtered' approach removes:

- small pockets (less than 1 hectare in size) of modelled fireline intensity of 30,000 kW/m or higher; and
- where less than 30 per cent of the allotment is subject to combined modelled fireline intensity of 30,000 kW/m or higher, including the 70m flame contact and radiant heat risk extent which is applied.

This approach avoids capturing small pockets of increased fireline intensity which may occur throughout moderate fireline intensity areas. It also avoids the inclusion of allotments which, based on size and proportion (30 per cent) of the area, may be subject to only a limited level of higher fireline intensity exposure.

Where more than 30 per cent of an allotment is subject to increased fireline intensity, the ability to satisfy bush fire mitigation provisions on-site to an acceptable level is likely to be considerably compromised.

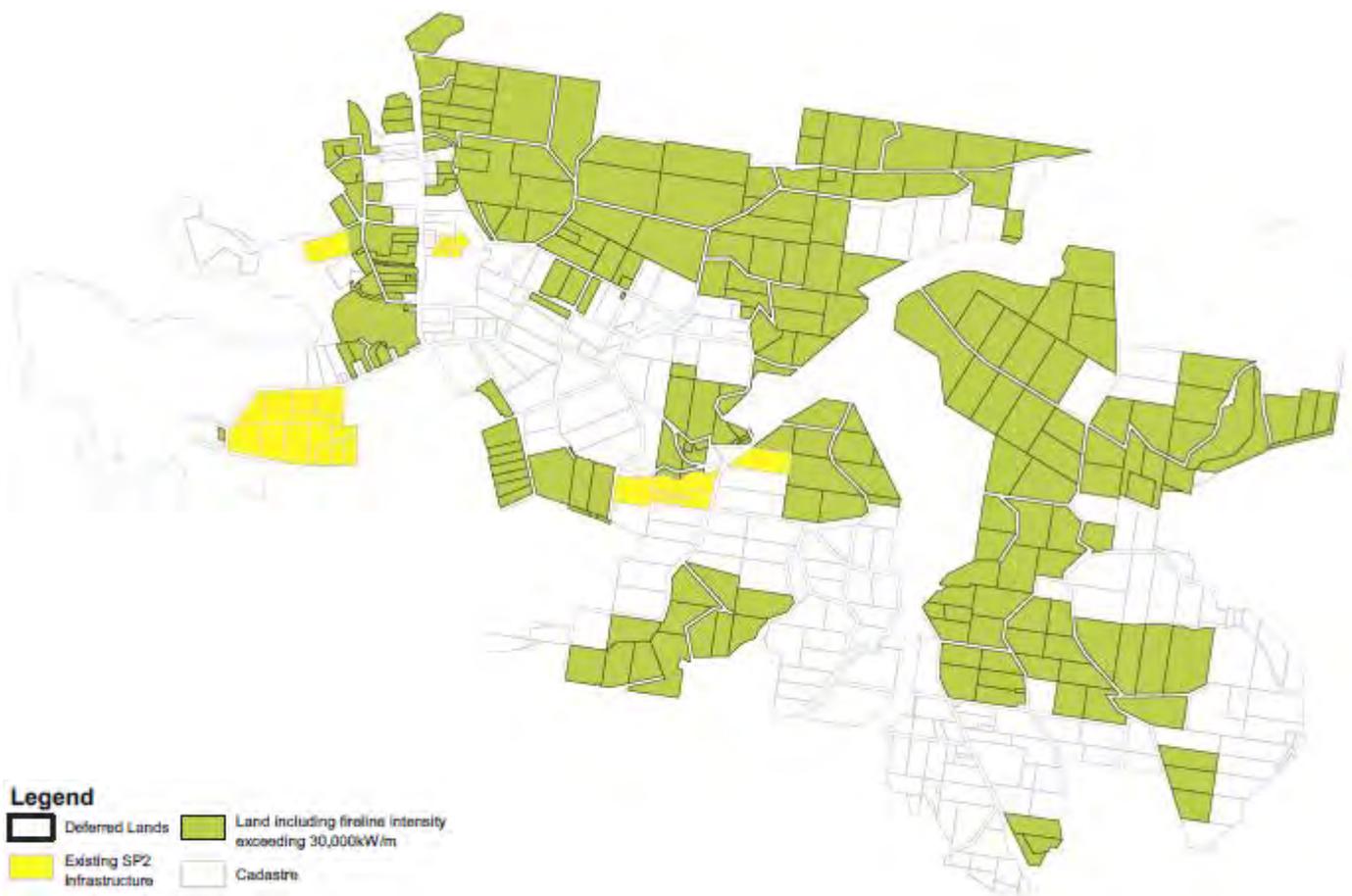


Figure 30 – Spatial representation of land subject to Approach B

9.4.3.2.1 Benefits and limitations

The filtered approach potentially amplifies certain areas of risk exposure by avoiding the qualitative consideration of other aspects of risk, such as ability to evacuate, areas which are entirely or substantially surrounded by higher fireline intensities, areas adjoining steep topography where fire behaviour is likely to make upslope runs, etc.

Large allotments in the western precinct do not meet the criteria, despite having been previously analysed in considerable detail in relation to the planning constraints relating to these site(s). This is merely reflective of the limitation of GIS-based analytics and highlights the need and value of qualitative evaluation and assessment.

9.4.3.3 Approach C – evaluated

Having regard to the limitations of the coarse and filtered approaches, the evaluated approach incorporates qualitative analysis based on a suite of criteria to contemplate the nature of bush fire risk which cannot be explicitly identified by GIS-based analysis.

This includes factors of:

- the nature of immediate or adjacent hazard and risk;
- the potential for isolation; and
- the ability to evacuate.

9.4.3.3.1 Evaluated approach criteria

The criteria for inclusion for risk-responsive zoning as part of the 'evaluated' approach include lands:

1. where 30 per cent or more⁹ of site area is mapped as subject to modelled fireline intensity of 30,000 kW/m or higher;
2. within the 70m flame contact and radiant heat risk buffer surrounding modelled fireline intensity of 30,000kW/m or higher;
3. which are completely surrounded by areas modelled to experience potential fireline intensity exceeding 30,000kW/m where evacuation is likely to be seriously challenged due to surrounding bush fire behaviour;
4. which are significantly surrounded by areas modelled to experience potential fireline intensity exceeding 30,000kW/m where evacuation is likely to be significantly constrained due to surrounding bush fire behaviour;
5. which adjoin areas modelled to experience potential fireline intensity exceeding 30,000 kW/m where the lands are upslope on a ridgeline where rate of spread will increase significantly;
6. where the location of core habitat¹⁰ and where modelled fireline intensity exceeding 30,000 kW/m limits the ability for site-based egress to the road network, significantly constraining the ability to evacuate balance areas of the land; and
7. lands which have been the subject of historical and extensive bush fire risk analysis where development applications and or planning proposals have been subsequently refused on the basis of unacceptable bush fire risk exposure which is unable to be appropriately mitigated.

⁹ Where more than 30 per cent of an allotment is subject to increased fireline intensity, the ability to satisfy bush fire mitigation provisions on-site to an acceptable level is likely to be considerably compromised.

¹⁰ Pursuant to Council's draft core habitat mapping data.

Land which does not reflect these criteria is considered to constitute moderate hazard and potential risk.

On the basis of the above, the 'evaluated' approach to risk-responsive land use planning is illustrated below. The zoning rationale itself is to be considered separately by Council, having regard to the land uses identified above and the need for consistency in zoning allocation methodologies across the Northern Beaches.

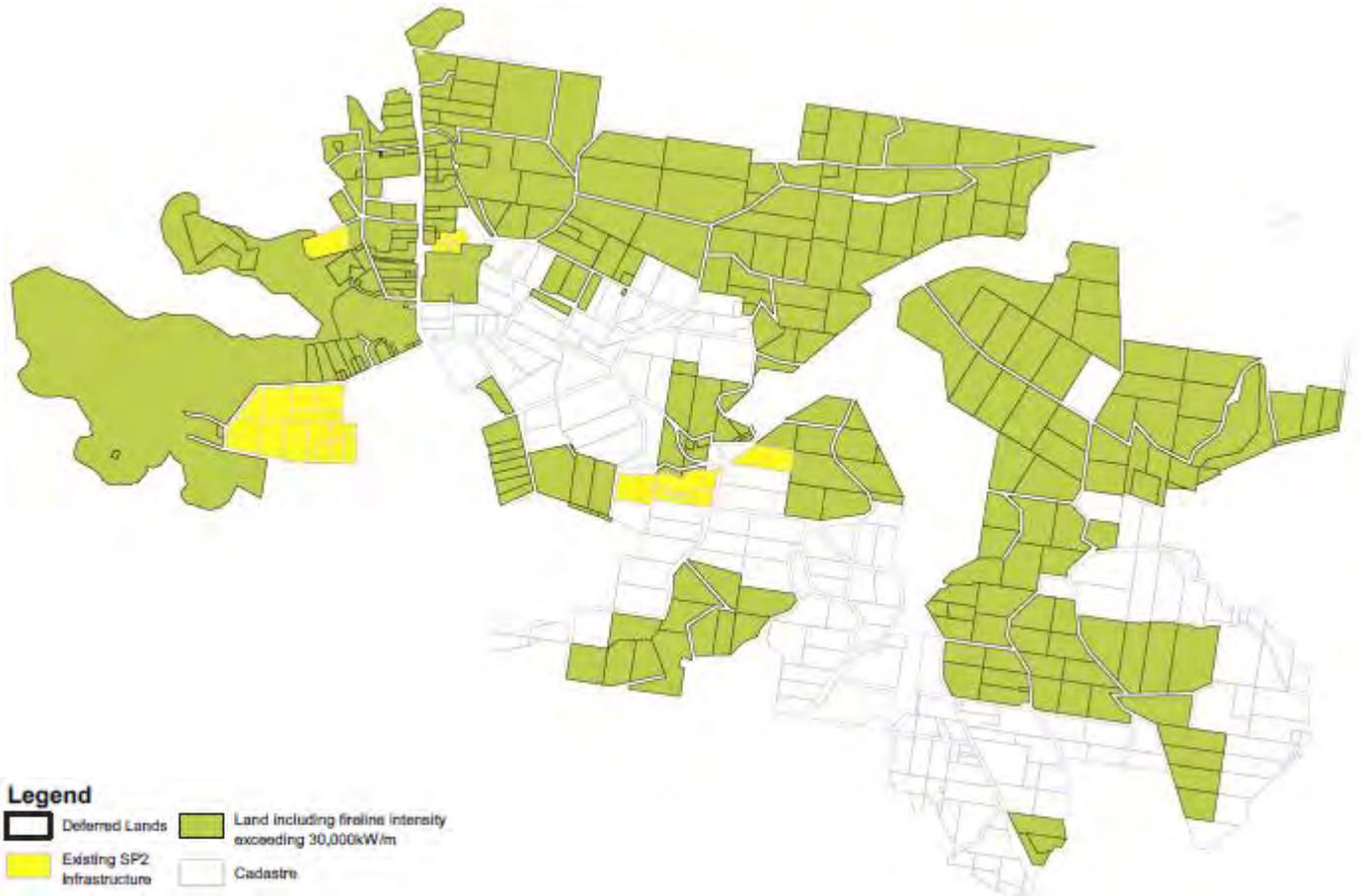


Figure 31 – Spatial representation of land subject to Approach C

9.4.3.3.2 Benefits and limitations

The 'evaluated' approach provides a combined quantitative and qualitative analysis of hazard and potential for risk, to identify land uses and inform the zoning rationale which responds to the highest risk areas of the Deferred Lands.

The 'evaluated' approach, along with the other identified approaches, does not infer those areas which are not identified in green are not subject to bush fire risk. Rather, these may be areas where compliance with statutory mechanisms could be considered. That is to say, these areas present 'moderate' risk profiles and are likely to be adequately mitigated via the application of PBP 2019 provisions.

9.5 Planning option 3 – combination of options 1 and 2C

This planning option combines a land use approach (which is ultimately intended to inform Council's zoning approach in the area) with the adoption of statutory measures to provide a holistic approach to bush fire risk reduction as part of the formulation of the new Northern Beaches LEP and DCP.

For the purposes of this planning option, the 'evaluated' approach is the preferred strategic planning response identified by this risk assessment, providing a multi-layered, comprehensive and calibrated suite of controls.

This option is characterised by:

- the combination of the 'evaluated' spatial extent rationale for land uses (to inform zoning) which provides a quantitative and qualitative appraisal of hazard to limit potential future risk, and
- statutory measures embedded within the new LEP and DCP, including the requirement to comply with the provisions of PBP 2019.

This planning option represents the most holistic option for risk treatment, having regard to the spectrum of potential strategic planning treatments. It seeks to avoid the highest potential areas for risk to life and property within the Deferred Lands area, employing a balanced approach which integrates both quantitative and qualitative considerations relating to hazard and risk, whilst identifying moderate hazard areas where the implementation of statutory controls are likely to be capable of acceptable implementation.

This option is the planning approach recommended for consideration by this risk assessment.

9.5.1 Combined risk-responsive land use allocation and statutory controls

Strategic policy should use spatial tools to avoid development in higher risk locations, and orient development opportunity to those areas with a lower risk profile, where bush fire protection measures can satisfactorily mitigate the risk to a tolerable or acceptable level.

It does not remove risk, but rather adopts a 'measures in combination' approach from a strategic planning perspective, focussed on limiting (to that degree possible) existing and future potential risk profiles within a tolerable threshold.

To this end, strategic planning determines the appropriateness of land uses and if development should occur, setting in place controls which direct appropriate and compatible land uses having regard to hazard constraints and risk profiles. Statutory controls can then direct how appropriate and compatible land uses might occur, where applicable.

A combined land use (zoning) and statutory control planning approach provides a fully calibrated approach to the formulation of LEP and DCP controls which respond to existing and potential future risk within the Deferred Lands area.

It provides a transitional area between lands of highest existing hazard and potential future risk, and existing urban development. It achieves this by:

- identifying potentially acceptable land uses to inform a zoning approach in those areas of highest hazard to limit potential future risk by expansion of inappropriate and incompatible land uses;
- limiting the extent of potential population expansion in the area reliant upon the existing road network for emergency evacuation;
- identifying moderate hazard areas where potential for non-urban activities on large allotments could be explored, and where statutory mechanisms could be reasonably

deployed to mitigate risk to a tolerable level, subject to further, detailed site-based assessment; and

- mitigating, to that extent practicable, the exposure of existing urban land uses within the Deferred Lands area which includes a considerable number of SFPPs via the articulation of land uses and associated zonings to provide a strategic transition area.

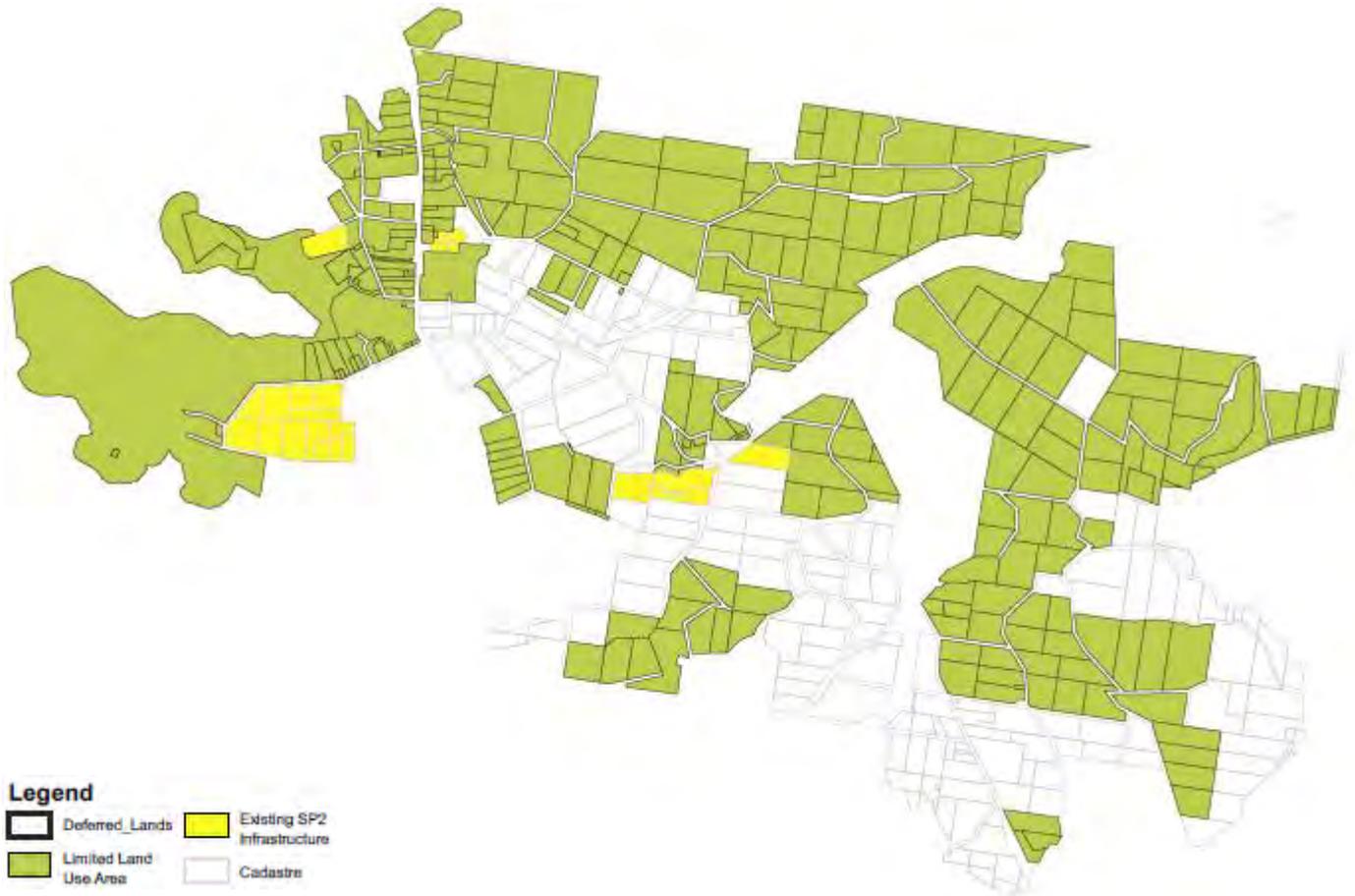


Figure 32 - Spatial representation of Option 3 and land where expansion and/or intensification is limited (the same map as presented at Figure 31)

Land within the future MRA investigation area which is exposed to fireline intensities of 30,000 kW/m or higher (including a 70m flame contact and radiant heat risk exposure buffer) is recommended to form part of the MRA, at a minimum, as a mechanism to limit land uses which could be further supplemented by an appropriate zoning rationale.

An analysis of exposure for this scenario has been undertaken, with data included at Appendix F.

9.5.2 Benefits and limitations

This approach limits land use permissibility in those areas which present the highest potential hazard and therefore, potential for increased risk to life. This approach enables the ability for Council to enact the full suite of strategic planning tools from spatial approaches such as land use acceptability and zoning through to statutory measures for moderate hazard locations where risk may be mitigated, pending detailed mitigation and assessment.

This approach can signal the land use intent for limited development in those areas identified as highly exposed, in response to bush fire hazard and risk.

Planning option 3 is a balanced approach, which focuses a land use response only for those areas where risk to life is a concern. This is intended to inform Council's approach to zoning. This recognises

the potential ability for statutory controls to potentially mitigate hazard and potential risk in balance locations.

It must be recognised, not all risk can be avoided and mitigated, hence the applicability of a suite of other bush fire protection measures which also apply beyond the role of strategic land use planning.

This also does not infer that planning proposals or development applications within locations identified as subject to more moderate levels of hazard and potential risk will or should necessarily be approved by any assessing authority.

9.6 Planning option 4 – zoning based on protection of environmental values

This planning option relies on the identification of relevant zoning which is driven by environmental protection as the primary consideration for land use acceptability.

This option is characterised by:

- adopting a zoning approach which is based upon the identification of environmental values and assets which are to be protected by limiting incompatible land uses. Exposure to potential bush fire hazard may be a secondary consideration;
- broader environmental planning framework requirements may also apply, such as the Koala Habitat Protection SEPP; and
- identification of land for environmental protection and where resultant controls on development should apply.

9.6.1 Zoning rationale

The zoning rationale is primarily driven by environmental protection in the first instance. Bush fire hazard and risk may still be contemplated as a secondary consideration, and this may occur through the application of zoning objectives.

This approach may also be supplemented by the inclusion of statutory controls identified as part of planning option 1, but zoning is largely directed by other values rather than bush fire hazard and risk exposure.

9.6.2 Benefits and limitations

This option enables the specific identification of environmental values which are to be protected, making the Council's expectations in relation to land fragmentation and clearing unambiguous.

This provides certainty in relation to how statutory controls could be implemented, informed by a clear understanding of the limits of potential clearing Council might accept in order to cite development to comply with PBP 2019 and any statutory controls introduced into the new LEP and DCP.

This approach does not necessarily limit the nature of land uses which might seek to occur within the bush fire prone lands area of the Deferred Lands. This could potentially result in the establishment of incompatible or inappropriate land use activities which may increase the risk profile of the area.

At the time this report was prepared, biodiversity studies for the Deferred Lands area were ongoing.

9.7 Other risk reduction mitigation opportunities

In addition, the planning-related options identified above, a number of other mitigation opportunities may also be contemplated by Council, outlined below.

- any lands where future development may be contemplated could be the subject of preliminary structure planning activity which places bush fire responsive urban design at the forefront of the design intent, including the contemplation of strategic asset protection zones, avoiding ad-hoc site-specific approaches;
- any planning proposals should include a strategic bush fire study in accordance with the requirements of PBP 2019, and should ideally consider the content of this risk assessment;
- there are currently no Neighbourhood Safer Places within the Deferred Lands area. Having regard to the assessment criteria for Neighbourhood Safer Places, future land uses could contemplate the establishment of a Neighbourhood Safer Place (place of last resort) in the Oxford Falls Valley area of the Deferred Lands, in consultation with NSW RFS;

- confirm with all SFPPs within the Deferred Lands area, working with NSW RFS and Fire & Rescue NSW that appropriate emergency management and evacuation arrangements are in place;
- consider the exposure of existing community infrastructure assets within the Deferred Lands area, including water pumping stations and implement any appropriate additional protection measures which may be applicable (such as asset protection zones, radiant heat barriers, etc.); and
- consider working alongside and encourage all relevant agencies, land managers and land holders, to review and implement, where appropriate, the recommendation identified in the NSW Bush Fire Inquiry Final Report.

10 Testing mitigation for risk acceptability

The assessment below highlights the opportunities for mitigation measures to achieve acceptable or tolerable risk, tested against the risk acceptability criteria which align with the objectives of the strategic bush fire study required by NSW RFS, as well as the criteria which define 'inappropriate development' in bush fire prone areas.

The assessment of acceptable risk assumes adoption of the recommendations contained throughout this assessment, summarised at Section 11 which follows.

10.1 Assessment of risk acceptability criteria

The below assessment relates specifically to Planning Option 3 (land use (zoning) and statutory measures) identified by this risk assessment, as the preferred planning approach to respond to potential bush fire risk in the Deferred Lands.

Table 16 - Summary assessment of acceptability of risk treatments relative to Planning Option 3

PBP 2019 strategic issue	Acceptability benchmarks
<p><i>Bush fire landscape assessment</i></p>	<p>Benchmark 1 – The context of landscape, fire history, likelihood / probability and fire behaviour and intensity is considered and potential consequences can be avoided, mitigated, transferred or accepted</p>
	<p><i>Summary assessment</i></p> <p>This assessment is supported by fireline intensity analysis to understand both the spatial spread of fire, and its behaviour or intensity, under various fire weather conditions.</p> <p>This assessment identifies a combination of land use (to inform zoning) and statutory planning measures to avoid and mitigate hazard and risk, limiting the extent of residual risk transfer or acceptance. This approach does not guarantee against loss or damage but seeks to limit the extent of risk transfer to a point that is as low as reasonably practicable via strategic land use planning.</p>
	<p>Benchmark 2 – Valued habitat, environmental values, assets, corridors and functions are maintained</p>
	<p><i>Summary assessment</i></p> <p>The planning options identified focus on the formulation of LEP and DCP controls to respond to existing hazard and potential future risk.</p> <p>The nature of this aspect of strategic planning does not infer any development will necessarily occur that will result in a negative impact on highly valued landscapes, but instead seeks to design provisions to avoid and mitigate potential risk. As such, the controls identified by this assessment do not incorporate any requirements for clearing.</p>
<p><i>Land use assessment</i></p>	<p>Benchmark 3 – Various land use scenarios are contemplated to examine and assess the potential impact of different fire behaviour intensities and mitigation measures</p>

	<p><i>Summary assessment</i></p> <p>Several fire weather and hypothetical development scenarios are contemplated by this assessment, providing enhanced awareness to inform risk-responsive decision-making which considers a multitude of different scenarios.</p> <p>It is evident from this approach the highest risk locations of the Deferred Lands area are evident across multiple scenarios, including under more frequent, lower FFDI conditions. This enables the formulation of LEP and DCP controls with respect to a spectrum of potential hazard and risk.</p> <p>It is also noted the modelled higher risk areas of the Deferred Lands reflects a level of consistency with mapped historical fire event impacts.</p>
	<p>Benchmark 4 – Balancing environmental values and land use allocation incorporates consideration of disaster risk reduction</p>
	<p><i>Summary assessment</i></p> <p>The planning options identified focus on the formulation of LEP and DCP controls to respond to existing hazard and potential future risk.</p> <p>Planning Option 3 seeks to avoid increased risk by seeking to limit inappropriate and incompatible land uses in higher risk locations, and orient development opportunity to those areas with a lower risk profile, where bush fire protection measures can satisfactorily mitigate the risk to a tolerable or acceptable level.</p>
	<p>Benchmark 5 – Special fire protection purposes are strategically considered in terms of appropriateness in bush fire prone areas</p>
	<p><i>Summary assessment</i></p> <p>The Deferred Lands area currently comprises a considerable number of SFPPs.</p> <p>Further SFPPs within the Deferred Lands area should be seriously contemplated in advance, having regard to the existing number of vulnerable facilities already established in the area which is likely to place considerable pressure on emergency services during an event. In addition, access and egress is also likely to be impacted by further addition of SFPP facilities.</p> <p>Ideally, the further proliferation of SFPPs within the Deferred Lands area is avoided.</p>
	<p>Benchmark 6 – The planning outcome is capable of facilitating local Neighbourhood Safer Places, community refuges or evacuation centres within the area for shelter in place options</p>
	<p><i>Summary assessment</i></p> <p>There are currently no Neighbourhood Safer Places within the Deferred Lands area.</p> <p>Having regard to the assessment criteria for Neighbourhood Safer Places, future land uses could contemplate the establishment of a Neighbourhood Safer Place (place of last resort) in the Oxford Falls Valley area of the Deferred Lands, in consultation with NSW RFS.</p>
<p><i>Access and egress</i></p>	<p>Benchmark 7 – Strategic planning is capable of facilitating appropriate and effective evacuation, based on key assumptions</p>

	<p><i>Summary assessment</i></p> <p>The Deferred Lands area currently comprises approximately 495 allotments, serviced by the existing road network. Not all properties are improved by a dwelling.</p> <p>Evacuation to safer locations is required to be considered as part of any future planning proposals, including consideration of the road network beyond the site boundaries. This is central to the completion of strategic bush fire studies.</p> <p>In so far as this assessment goes, the preferred planning option involves zoning and statutory LEP and DCP controls. These planning controls do not change or introduce any provisions which potentially impact the existing evacuation situation of the Deferred Lands.</p> <p>Benchmark 8 – The evacuation ability of existing residents or occupants is not worsened</p> <p><i>Summary assessment</i></p> <p>The preferred planning option involves the identification of appropriate land uses (to inform zoning) and statutory LEP and DCP controls. These planning controls do not change or introduce any provisions which potentially impact the existing evacuation situation of the Deferred Lands.</p>
<p><i>Emergency services</i></p>	<p>Benchmark 9 – Increased demand on emergency services is avoided or reasonably mitigated</p> <p><i>Summary assessment</i></p> <p>A key tenet of the preferred planning option is to avoid potential increased risk to life exposure, which includes consideration of the safety of frontline emergency services and firefighters.</p> <p>Increased demand on emergency services can be mitigated, however this is only possible in low and moderate fireline intensity areas. In areas of higher fireline intensity, the statutory measures of PBP 2019 may be insufficient to enable emergency services to safely operate.</p> <p>The preferred planning option responds to this by seeking to limit the range of land use permissibility within higher risk locations of the Deferred Lands area.</p>
<p><i>Infrastructure</i></p>	<p>Benchmark 10 – Essential, community and strategic infrastructure avoids high risk exposure</p> <p><i>Summary assessment</i></p> <p>Existing infrastructure is currently located in potentially higher risk areas of the Deferred Lands. It is understood these facilities maintain comprehensive emergency management and mitigation plans.</p> <p>Any new infrastructure should be located in areas where exposure to higher fireline intensities can be avoided, and mitigation measures can be implemented in accordance with PBP 2019.</p> <p>Benchmark 11 – The water supply network is protected from or avoids exposure to bush fire attack which may compromise its function, including pump stations and other assets</p>

	<p><i>Summary assessment</i></p> <p>Existing infrastructure is currently located within the Deferred Lands. Existing facilities should be assessed in terms of potential exposure and relevant mitigation measures to address potential exposure should be implemented.</p> <p>Any new infrastructure should be located in areas where exposure to higher fireline intensities can be avoided, and mitigation measures can be implemented in accordance with PBP 2019.</p>
<i>Adjoining land</i>	<p>Benchmark 12 – Ongoing land management and hazard reduction implications are considered</p>
	<p><i>Summary assessment</i></p> <p>This assessment considers the existing future need for ongoing land and fuel load management activities to mitigate hazard.</p> <p>The preferred planning approach does not avoid the need for ongoing land and fuel management both within and external to the Deferred Lands area. This is a responsibility of land owners and land managers which exists outside of planning processes, but for which planning must have regard.</p>

10.2 ‘Inappropriate development’ criteria assessment

Chapter 4 of PBP 2019 identifies that strategic planning should provide for the exclusion of inappropriate development in bush fire prone areas. The criteria for which is as follows:

1. the development area is exposed to a high bush fire risk and should be avoided;
2. the development is likely to be difficult to evacuate during a bush fire due to its siting in the landscape, access limitations, fire history and/or size and scale;
3. the development will adversely effect other bush fire protection strategies or place existing development at increased risk;
4. the development is within an area of high bush fire risk where density of existing development may cause evacuation issues for both existing and new occupants; and
5. the development has environmental constraints to the area which cannot be overcome.

On the basis of the analysis conducted by this assessment, those areas identified to require a specific land use response pursuant to Planning Option 3 and the ‘evaluated’ approach, are those areas to which the above criteria apply.

The planning approach identified by this risk assessment seeks to limit inappropriate and incompatible land uses in the highest risk areas of the Deferred Land.

Balance areas may be subject to a moderate level of risk where statutory mitigation measures may effectively treat hazard and potential risk, subsequent to detailed assessment via planning proposal and development assessment processes.

11 Synthesis of recommendations

This section summarises the key recommendations of this risk assessment.

11.1 Land use planning recommendations

1. Council considers the planning options identified and, on balance with the range of other planning interests relevant to the Deferred Lands, selects the most desired approach to respond to the nature of bush fire hazard and risk relevant to the Deferred Lands.
 - a. Planning Option 3 is the preferred approach of this risk assessment, combining a land use approach (to inform zoning) for the highest hazard areas to limit potential land use permissibility and avoid heightened future risk, with statutory control measures deployed for areas of potentially moderate hazard, subsequent to further planning processes and assessment.
2. Land within the future MRA investigation area which is exposed to fireline intensities of 30,000 kW/m or higher (including a 70m flame contact and radiant heat risk exposure buffer) is recommended to form part of the MRA, at a minimum.
3. Following community and further stakeholder consultation, Council implements its preferred suite of land use controls within the new Northern Beaches LEP and DCP.
4. Council provides a copy of this risk assessment to the Department of Planning, Industry and Environment for its noting.
5. Any lands where future development may be contemplated could be the subject of preliminary structure planning activity which places bush fire responsive urban design at the forefront of the design intent, including the contemplation of strategic asset protection zones, avoiding ad-hoc site-specific approaches.
6. Any planning proposals should include a strategic bush fire study in accordance with the requirements of PBP 2019, and should ideally consider the content of this risk assessment.
7. A clear understanding of the environmental and biodiversity values of the Deferred Lands should be mapped, such that LEP and DCP controls can be considered which limit the damage, loss or fragmentation of environmental assets.
8. Consider the application of Cova's **minimum exit requirements for interface communities** (at Table 8) when assessing any new development within the Deferred Lands.

11.2 Operational recommendations

1. Existing SFPPs should be encouraged to prepare, implement and maintain bush fire management plans. Additional mitigation (i.e. clearing of vegetation) is subject to further assessment. This may be further considered as part of the preparation of the new Northern Beaches Bush Fire Risk Management Plan.
2. All relevant agencies, land managers and land holders, to review and implement, where appropriate, the recommendation identified in the NSW Bush Fire Inquiry Final Report. It is noted that Council has contemplated the findings of the Inquiry as part of the preparation of its new Bushfire Risk Management Plan.
3. Work with NSW RFS to determine the appropriateness of a Neighbourhood Safer Place within Oxford Falls Valley. This may be further considered as part of the preparation of the new Northern Beaches Bush Fire Risk Management Plan.
4. Council may consider forwarding a copy of this report to relevant infrastructure providers with assets in the Deferred Lands area, as information which may assist them to implement

any appropriate additional protection measures which may be applicable (such as asset protection zones, radiant heat barriers, etc.).

12 Conclusions

This risk assessment considers the extent of potential bush fire hazard and risk relevant to the Deferred Lands area of the Northern Beaches which includes parts of Belrose, Oxford Falls and Cromer.

This risk assessment has been undertaken through the lens of risk-based land use planning to critically analyse the extent of bush fire hazard and risk exposure in both existing and potential future contexts. On the basis of the NERAG framework, this risk assessment report has analysed the extent of landscape-scale fire risk to evaluate the quantum of risk issues of relevance from a strategic land use planning perspective.

To this end, this risk assessment addresses the observations of the 2020 NSW Bushfire Inquiry in relation to the need for consideration of risk as part of strategic land use planning processes, and assesses the elements require of strategic bush fire studies pursuant to Chapter 4 of PBP 2019.

Overall and having regard to the policy provisions of PBP 2019, this risk assessment identifies a suite of strategic land use planning controls for contemplation as part of the formulation of a new Northern Beaches LEP and DCP, taking a risk-informed approach.

Whilst risk may not be avoided in entirety, the controls identified provide the ability for risk-informed structure planning to appropriately address residual risk through planning, design, and construction processes, aided by supplementary measures.

In recognition of the above, several recommendations are identified for consideration moving forward.

13 Glossary of terms

This section defines those core terms and concepts which are adopted throughout the body of this report.

Risk – a risk is created when a hazard interacts with an area of social, built environment, economic or environmental value. There are a number of direct and indirect losses associated with natural hazards. These losses include:

- loss of life and/or injury;
- physical suffering;
- emotional suffering;
- damage to property;
- reduced productivity;
- degraded environment;
- loss of species and habitats;
- impact on resources such a water supply;
- damaged infrastructure;
- weakened economy;
- destabilised community cohesion, political situations; and
- reduced quality of life.

The degree of risk presented by that interaction will depend on the likelihood and consequence of the hazard occurring.

Risk may be defined as the chance of something happening, in a specified period of time that will have an impact on values or objectives. It is measured in terms of likelihood and consequence.

Risk-based land use planning – the strategic consideration of natural hazard risk and mitigation in informing strategic land use planning activities.

Hazard – a hazard is any source of potential harm or a situation with a potential to cause loss. A hazard is therefore a contributing factor of risk.

Risk assessment – a systematic process of evaluating the potential risks that may be involved in a projected activity or undertaking, having regard to factors of likelihood, exposure, vulnerability, consequence and tolerability.

Residual risk – the risk that remains after risk mitigation or treatment (i.e. through risk avoidance, reduction/ mitigation, transfer or retention/acceptance) has been applied to reduce the potential consequences.

Likelihood – the probability or chance of an event occurring. Likelihood may be represented as a statistical probability (such as an Annual exceedance probability), annual return interval or where this is not possible, it can be represented qualitatively using measures such as 'likely', 'possible' and 'rare'.

Consequence – an impact on the natural, economic, built or social environments as a result of the hazard. The consequences are influenced by the vulnerability of elements at risk, by the exposure of elements at risk to the hazard, and by the characteristics of the hazard.

Exposure – the state of having little to no protection from a hazard, or harm.

Vulnerability – the degree of susceptibility, minus resilience, of the community and environment to hazards.

Tolerance - a level of measure of risk acceptability which assists in defining risk appetite.

Bush fire attack mechanisms – the various ways in which a bush fire can impact upon people and property and cause loss or damage. These mechanisms include flame contact, radiant heat exposure, ember attack, fire winds and smoke.

Acceptable risk – that level of risk that is sufficiently low that society is comfortable with it. Society does not generally consider expenditure in further reducing such risks justifiable.

Unacceptable risk – a level of risk that is so high that requires risk treatment measures whatever their cost, or the elimination of the risk which is not always possible.

Primary loss extent – that extent, measured in distance from a landscape-scale hazard source, which reflects the majority of life and property loss from bush fire events in Australia.

Mitigation – measures taken in advance of a disaster aimed at decreasing or eliminating its impact on society and environment.

Special Fire Protection Purpose (SFPP) – as per the definition adopted by PBP 2019 for vulnerable facilities including seniors living, schools and child care facilities.

As Low as Reasonably Practicable – a risk management concept known as the ALARP Principle, this is applied to define boundaries between risks that are generally intolerable, tolerable or broadly acceptable.

Resilience - the ability of people, property and infrastructure within our communities to adapt over time in a manner that minimises the governance, social, economic and environmental burden in responding to, and recovering from, the changing effects of natural hazard stresses and shocks.

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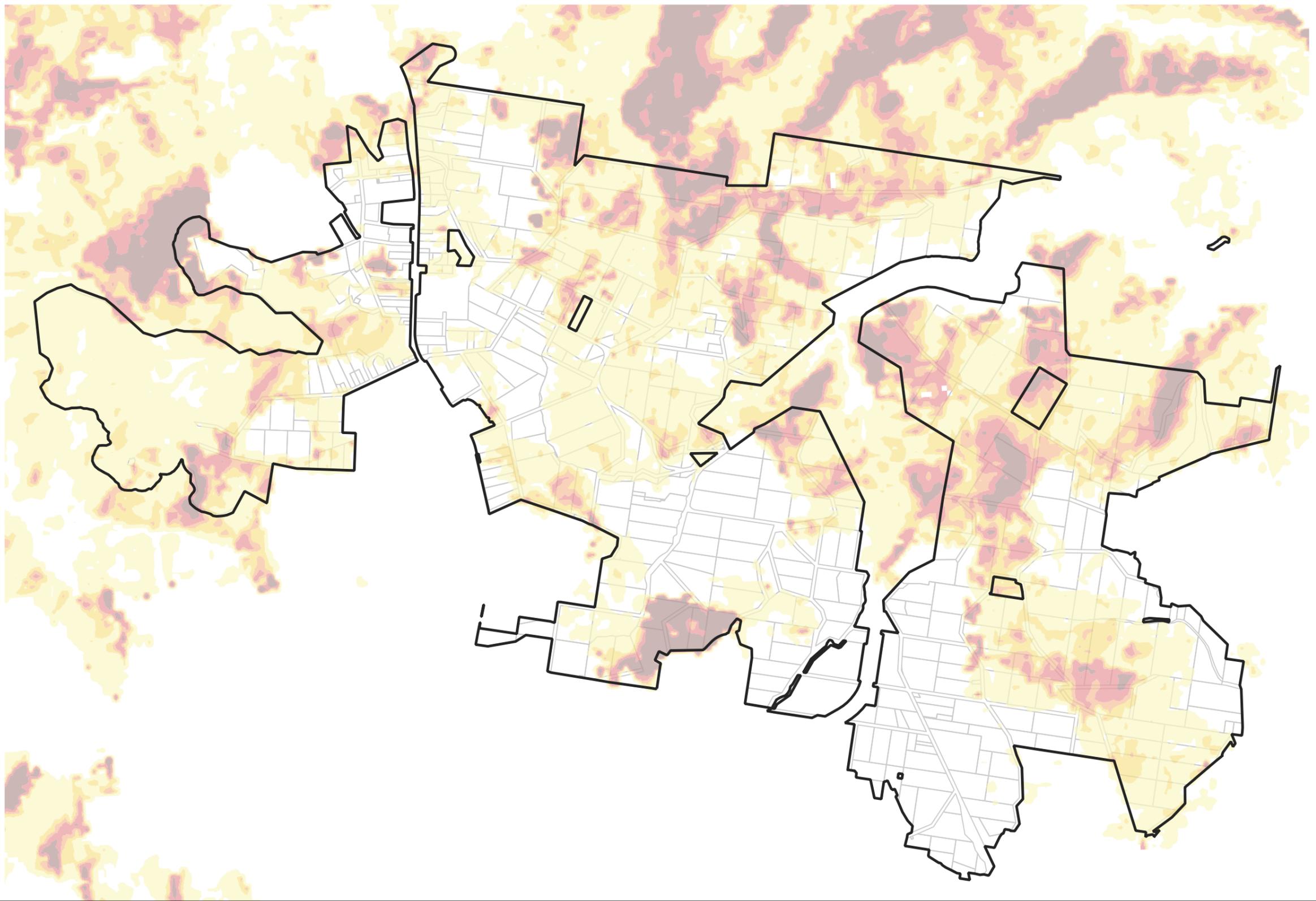
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APPENDICES



Appendix A Scenario-based fireline intensity mapping (Scenario 1 – existing)



Legend

Deferred Lands Subject Area

FFDI 62

- 4,000 - 20,000
- 20,000 - 30,000
- 30,000 - 40,000
- 40,000 - 60,000
- >60,000
- Cadastre

ORIGINAL SIZE A3



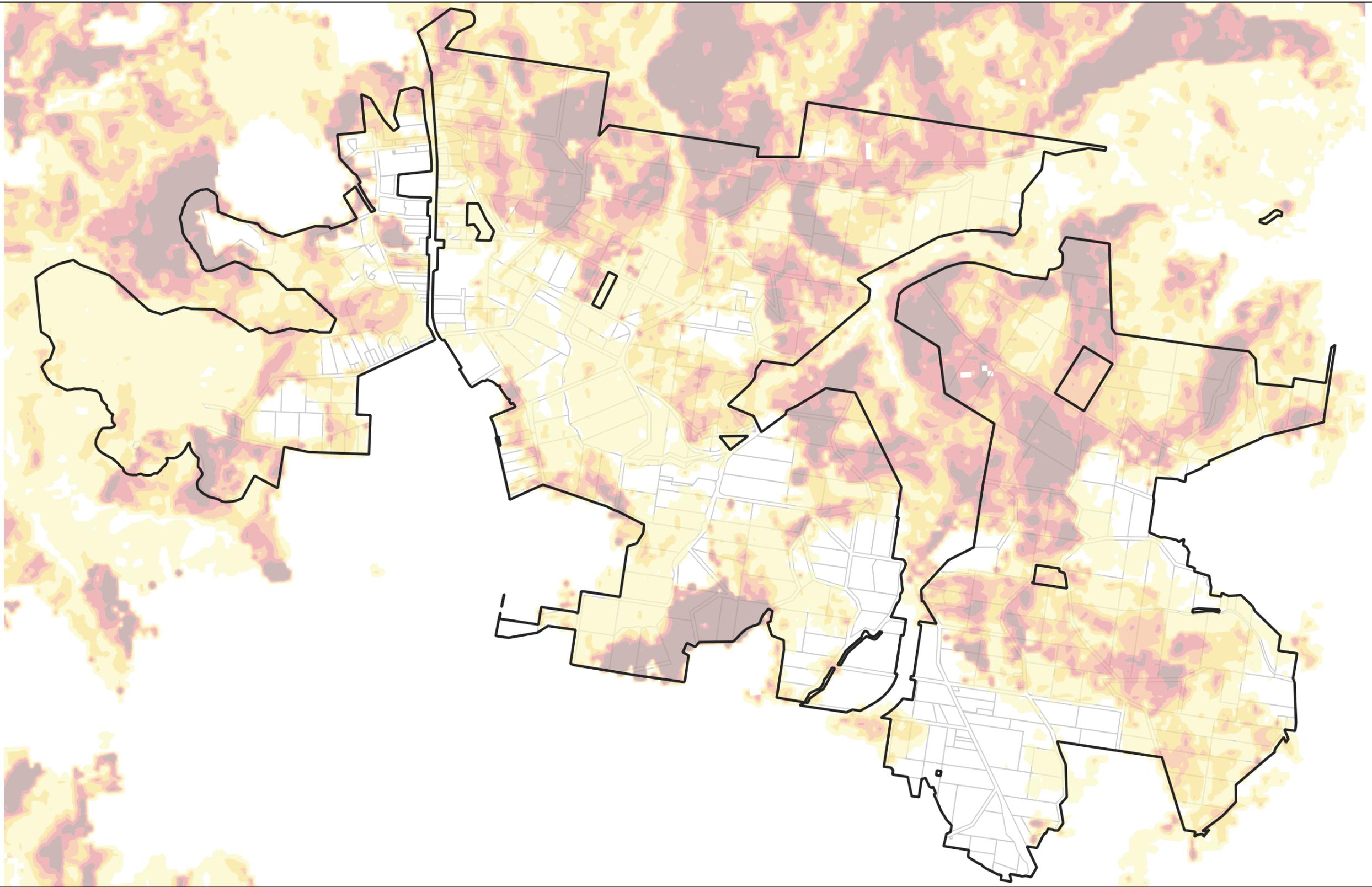
Rev	Description	Drawn	Checked	Date
A	FFDI 62	FR		19/08/2020

Forest Fire Danger Index 62

PROJECT: NBC Deferred Lands Bush Fire Risk	
LOCATION: Northern Beaches Council	
CLIENT: Northern Beaches Council	
Local Authority: Northern Beaches Council	Drawn: FR



Scale: 1:23 @ A3
 Drawing no: FFDI 62.1.1



Legend

Deferred Lands Subject Area

FFDI 100

4,000-20,000

20,000-30,000

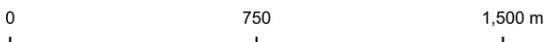
30,000-40,000

40,000-60,000

>60,000

Cadastre

ORIGINAL SIZE A3



Scale 1:21.5 - Lengths are in Kilometers



Rev	Description	Drawn	Checked	Date
A	FFDI 100 - no reduced fuel	FR		23/08/2020

Forest Fire Danger Index 100 - no fuel reduction

PROJECT: NBC Deferred Lands Bush Fire Risk

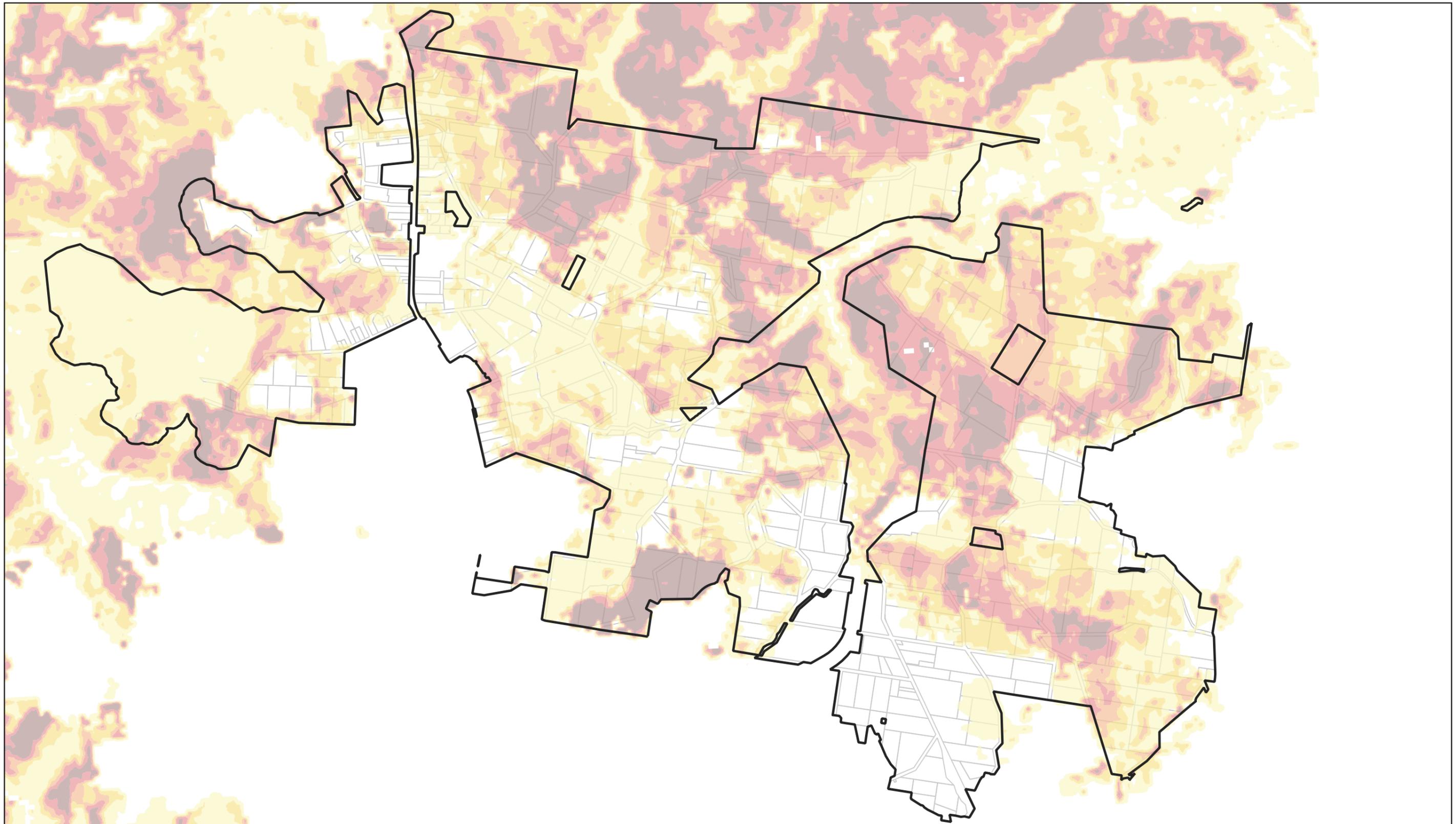
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CLIENT: Northern Beaches Council

Local Authority: Northern Beaches Council Drawn: FR



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Drawing no: FFDI 100.1.1



Legend

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	FFDI 134 4,000-20,000		40,000-60,000
	20,000-30,000		>60,000
	Cadastre		

ORIGINAL SIZE A3

0 750 1,500 m

Scale 1:21.5 - Lengths are in Kilometers



Rev	Description	Drawn	Checked	Date
A	FFDI 134 - no reduced fuel	FR		23/08/2020

Forest Fire Danger Index 134 - no fuel reduction

PROJECT: NBC Deferred Lands Bush Fire Risk

LOCATION: Northern Beaches Council

CLIENT: Northern Beaches Council

Local Authority: Northern Beaches Council

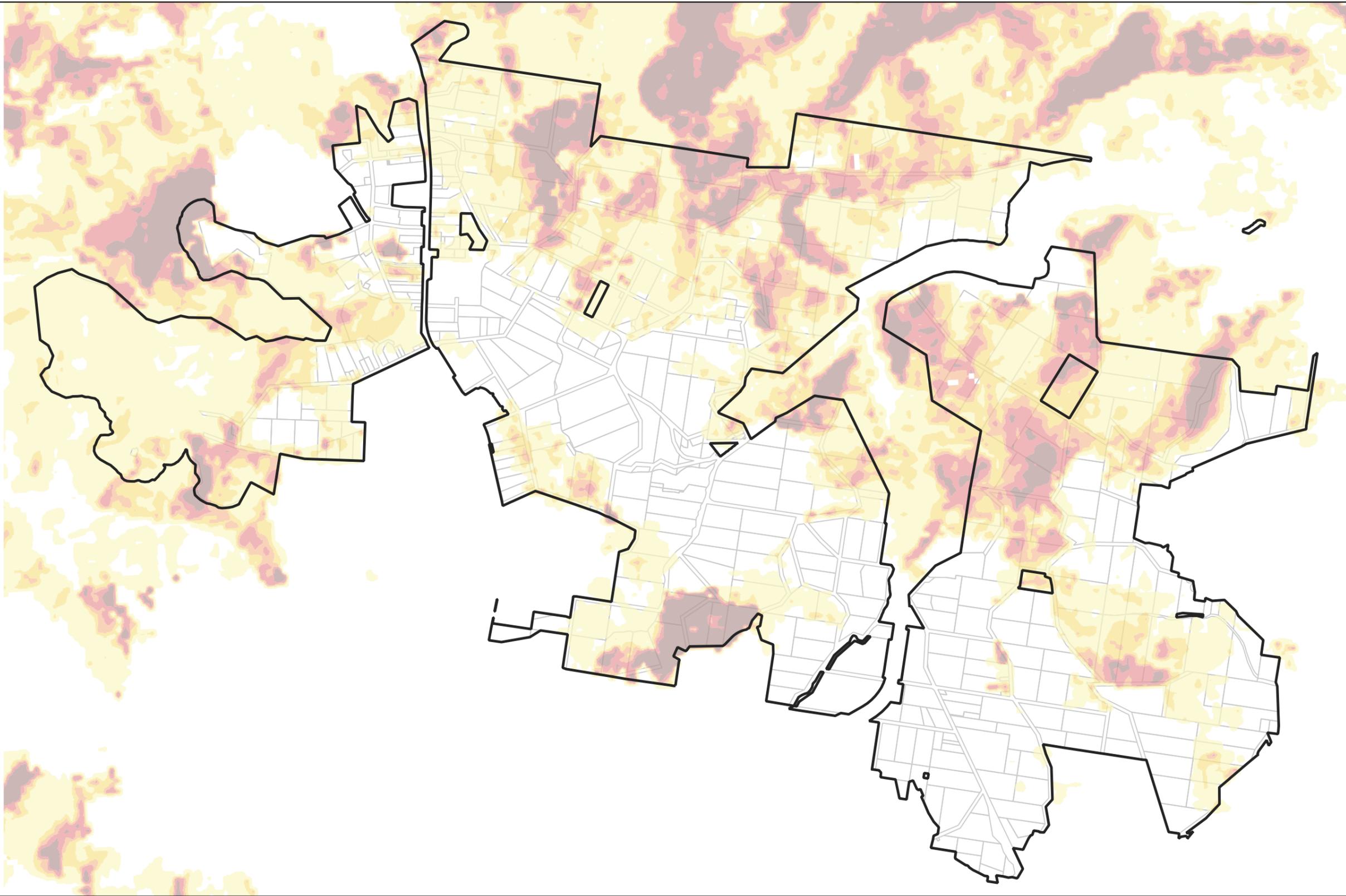
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Scale: 1:21.5 @ A3

Drawing no: FFDI 134.1.1

Appendix B Scenario-based fireline intensity mapping (Scenario 2 – PAC site fuel reduction)



Legend

Deferred Lands Subject Area

FFDI 62

4,000 - 20,000

20,000 - 30,000

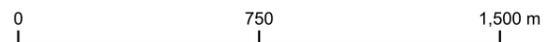
30,000 - 40,000

40,000 - 60,000

>60,000

Cadastre

ORIGINAL SIZE A3



Scale 1:2 - Lengths are in Kilometers



Rev	Description	Drawn	Checked	Date
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Forest Fire Danger Index 62 with Reduction

PROJECT: NBC Deferred Lands Bush Fire Risk

LOCATION: Northern Beaches Council

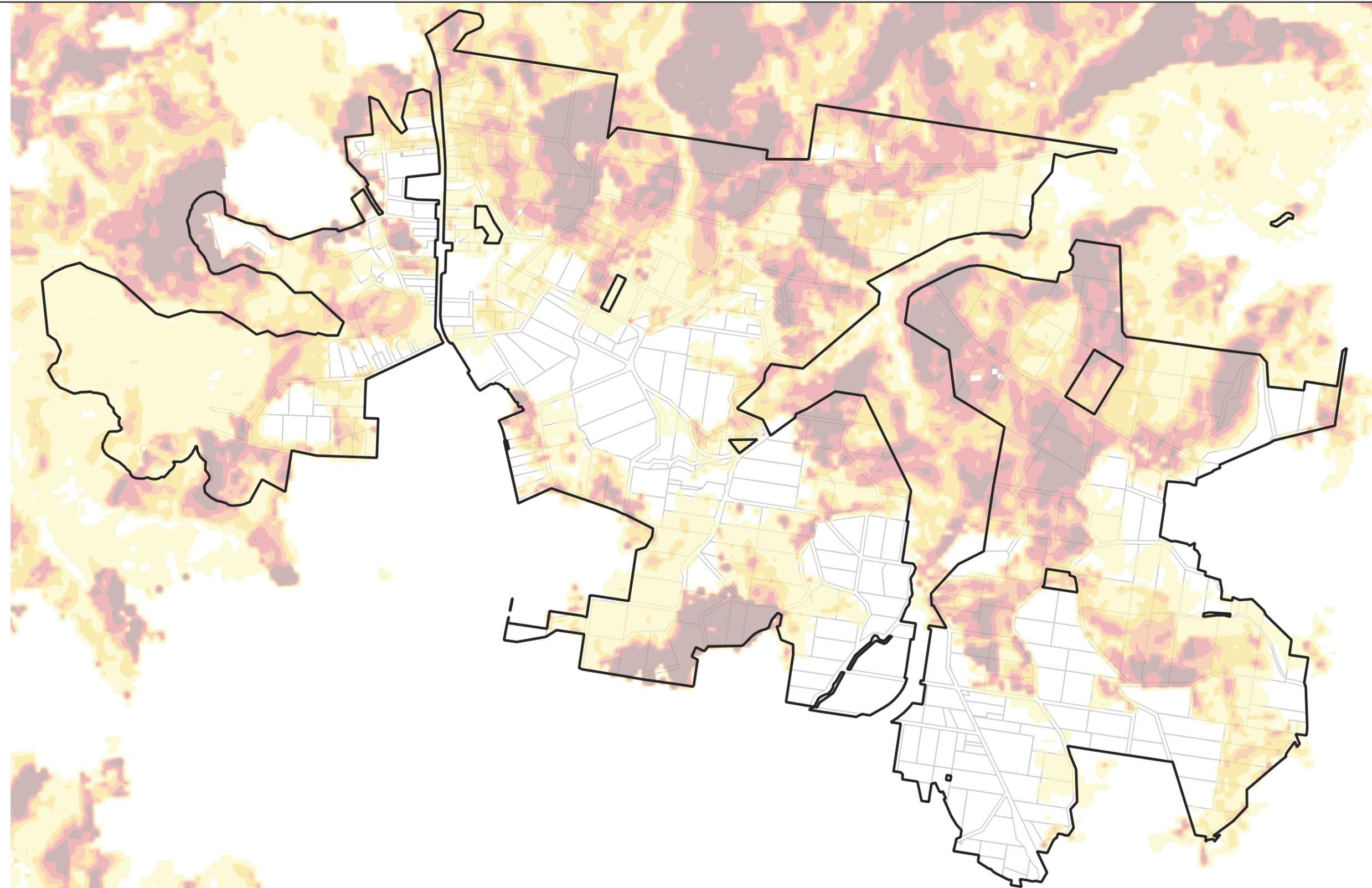
CLIENT: Northern Beaches Council

Local Authority: Northern Beaches Council Drawn: FR




Scale: 1:22 @ A3

Drawing no: FFDI 62.1.2



Legend

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	4,000-20,000		40,000-60,000
	20,000-30,000		>60,000
	Cadastre		

ORIGINAL SIZE A3



Scale 1:21.5 - Lengths are in Kilometers



Rev	Description	Drawn	Checked	Date
A	FFDI 100 - with reduced fuel	FR		23/08/2020

Forest Fire Danger Index 100 - with fuel reduction

PROJECT: NBC Deferred Lands Bush Fire Risk

LOCATION: Northern Beaches Council

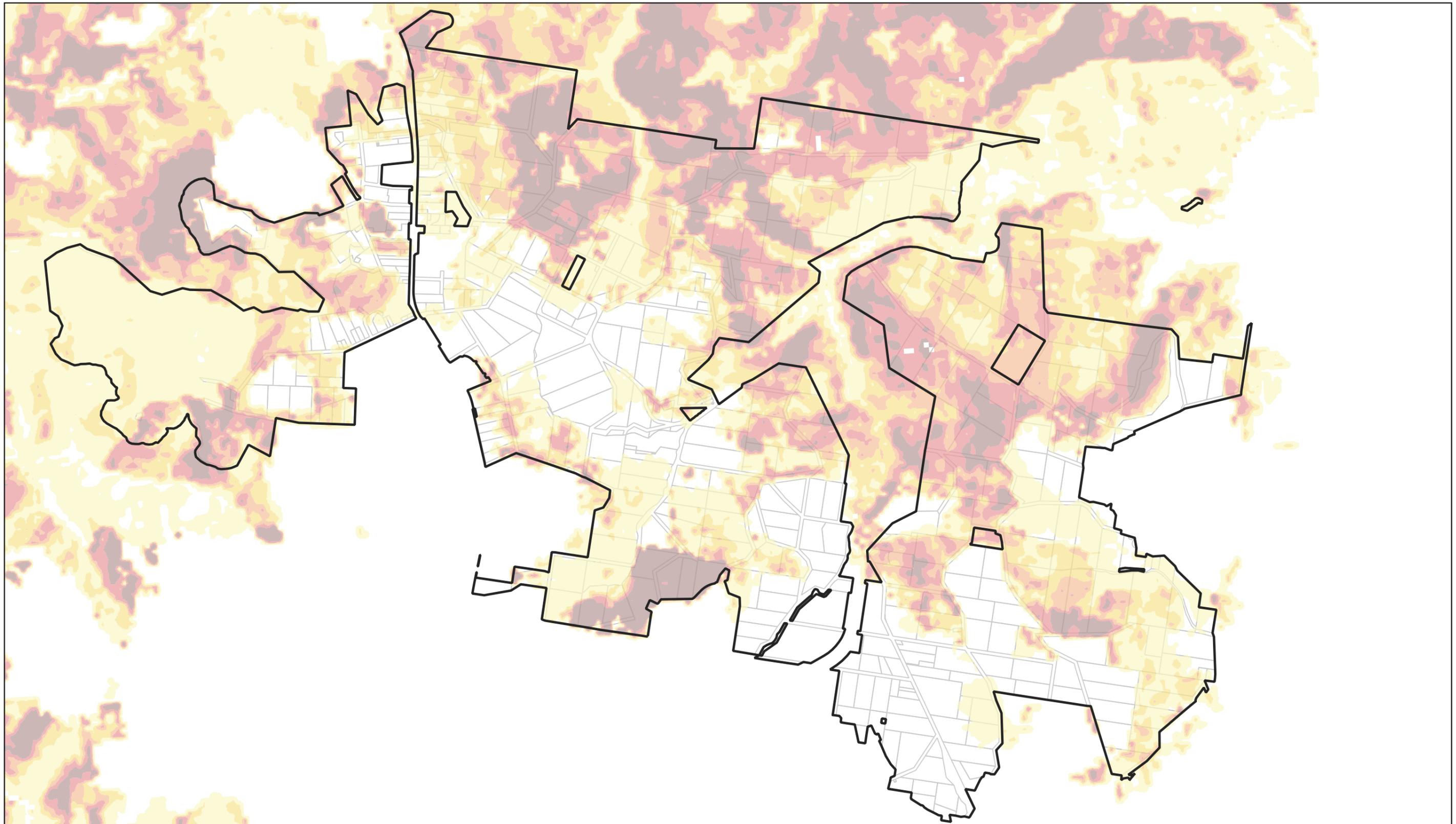
CLIENT: Northern Beaches Council

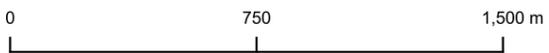
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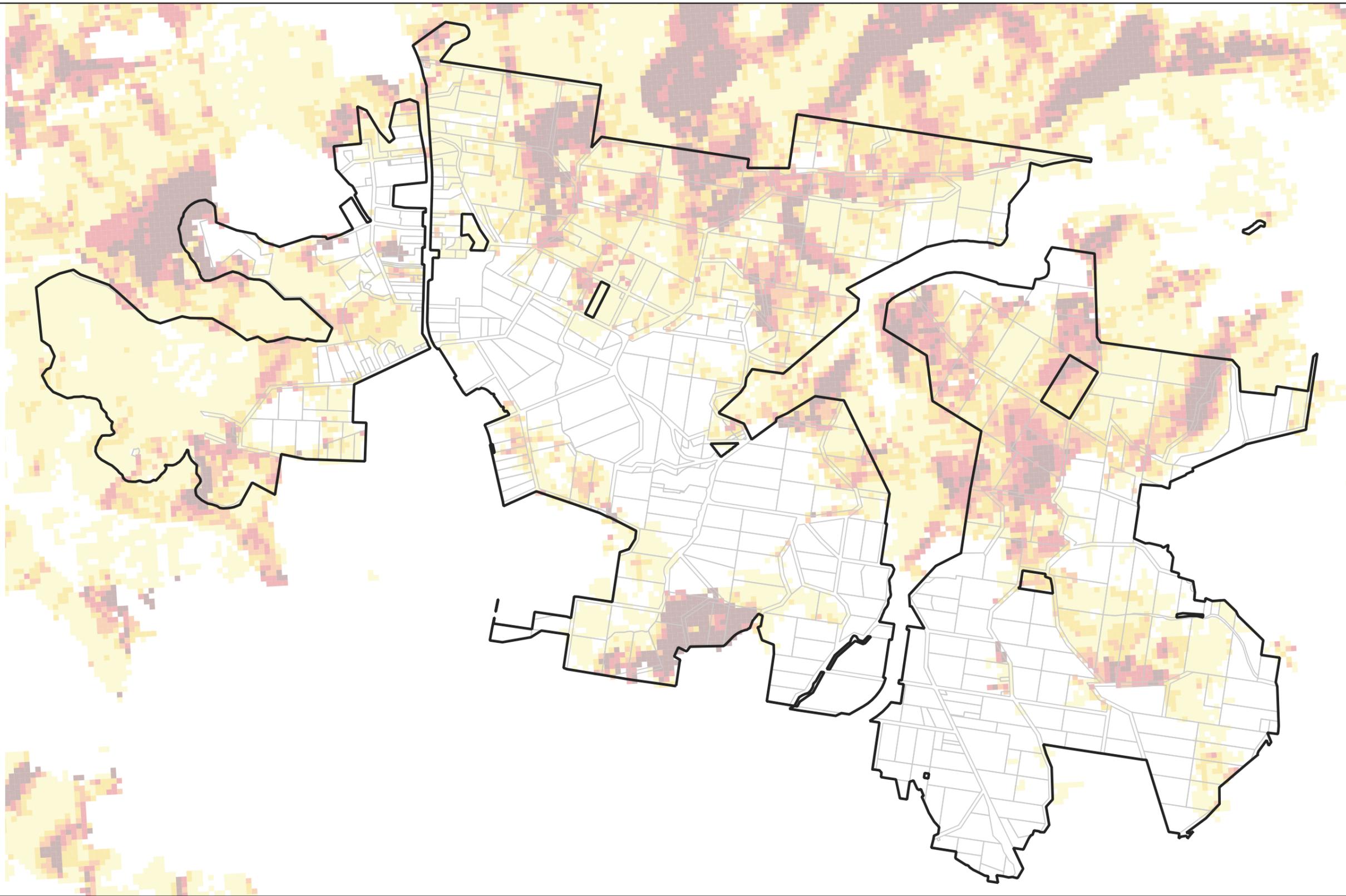
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Drawing no: FFDI 100.1.2



Legend  Deferred Lands Subject Area FFDI 134  4,000-20,000  20,000-30,000  30,000-40,000  40,000-60,000  >60,000  Cadastre	ORIGINAL SIZE A3  Scale 1:21.5 - Lengths are in Kilometers 	<table border="1"> <thead> <tr> <th>Rev</th> <th>Description</th> <th>Drawn</th> <th>Checked</th> <th>Date</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>FFDI 134 - with reduced fuel</td> <td>FR</td> <td></td> <td>23/08/2020</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Rev	Description	Drawn	Checked	Date	A	FFDI 134 - with reduced fuel	FR		23/08/2020											<p align="center">Forest Fire Danger Index 134 - with fuel reduction</p> <p>PROJECT: NBC Deferred Lands Bush Fire Risk</p> <p>LOCATION: Northern Beaches Council</p> <p>CLIENT: Northern Beaches Council</p> <p>Local Authority: Northern Beaches Council Drawn: FR</p>	 
		Rev	Description	Drawn	Checked	Date																		
A	FFDI 134 - with reduced fuel	FR		23/08/2020																				
				Scale: 1:21.5 @ A3 Drawing no: FFDI 134.1.2																				

Appendix C Scenario-based fireline intensity mapping (Scenario 3 – zoning-based fuel reduction)



Legend

- Deferred Lands*Subject Area
- 30,000 - 40,000
- 4,000 - 20,000
- 40,000 - 60,000
- 20,000 - 30,000
- >60,000
- Cadastre

ORIGINAL SIZE A3

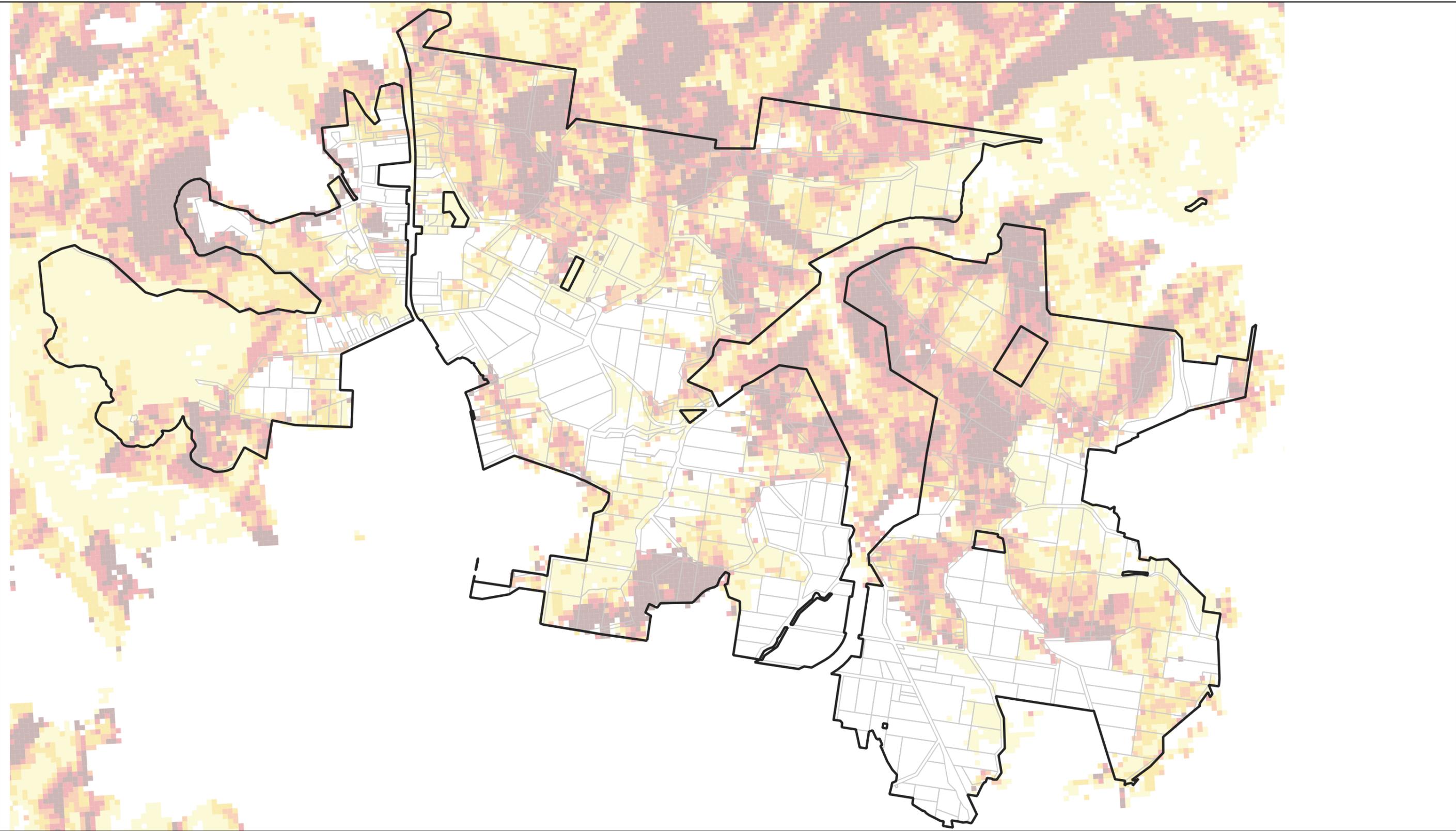


Rev	Description	Drawn	Checked	Date
A	FFDI 62	FR		11/12/2020

Forest Fire Danger Index 62 with Reduction	
PROJECT: NBC Deferred Lands Bush Fire Risk	
LOCATION: Northern Beaches Council	
CLIENT: Northern Beaches Council	
Local Authority: Northern Beaches Council	Drawn: FR



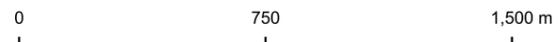
Scale: 1:22 @ A3
 Drawing no: FFDI 62.1.3



Legend

Deferred Lands Subject Area	30,000 - 40,000
FFDI 100 (kW/m2)	40,000 - 60,000
4,000 - 20,000	>60,000
20,000 - 30,000	Cadastre

ORIGINAL SIZE A3



Scale 1:21.5 - Lengths are in Kilometers



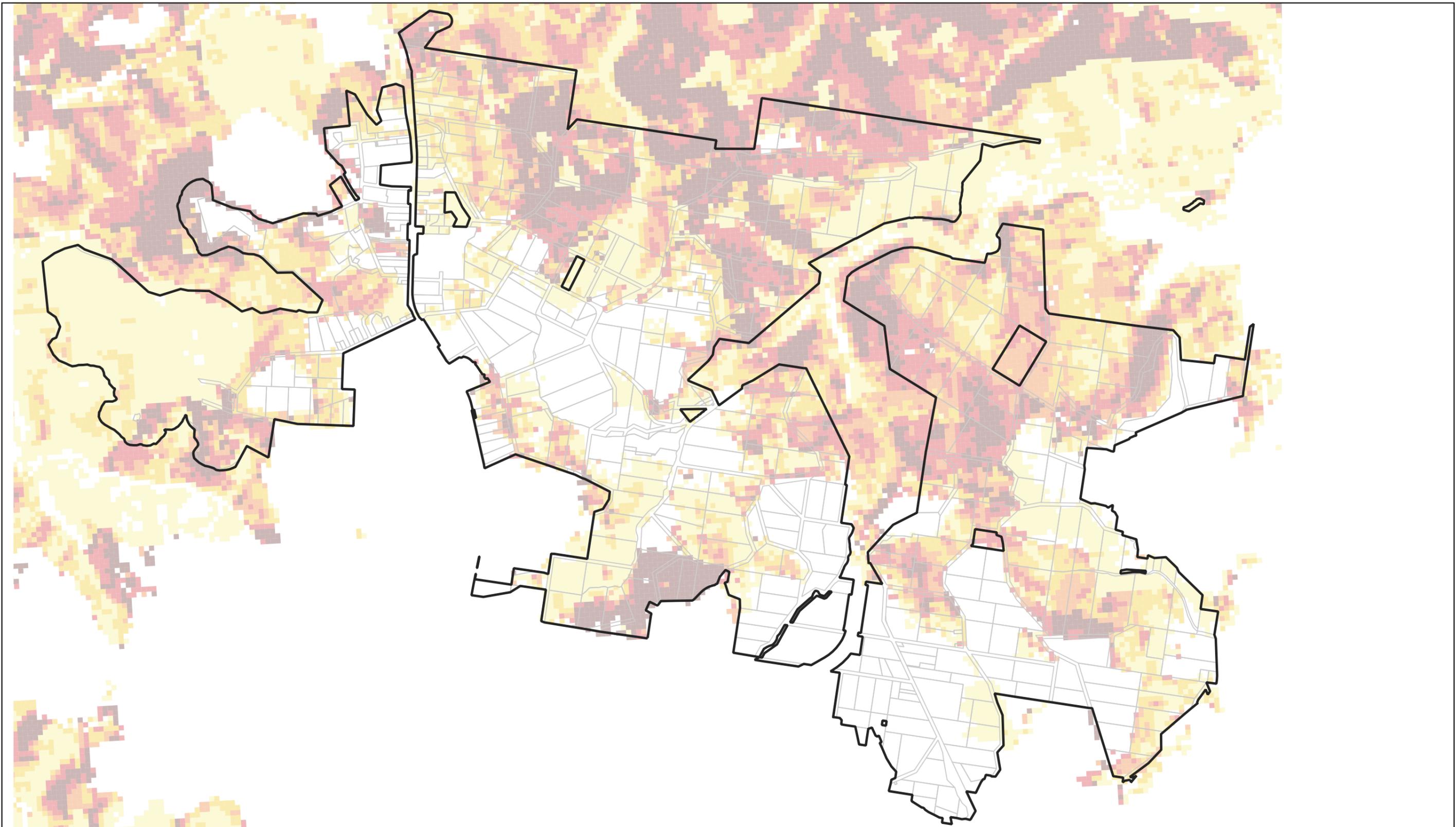
Rev	Description	Drawn	Checked	Date
A	FFDI 100 - with reduced fuel	FR		11/12/2020

Forest Fire Danger Index 100 - with fuel reduction

PROJECT: NBC Deferred Lands Bush Fire Risk	
LOCATION: Northern Beaches Council	
CLIENT: Northern Beaches Council	
Local Authority: Northern Beaches Council	Drawn: FR



Scale: 1:21.5 @ A3
Drawing no: FFDI 100.1.2.2



Legend

	Deferred Lands Subject Area		30,000 - 40,000
	FFDI 134 (kW/m ²)		40,000 - 60,000
	4,000 - 20,000		>60,000
	20,000 - 30,000		Cadastre

ORIGINAL SIZE A3



Scale 1:21.5 - Lengths are in Kilometers



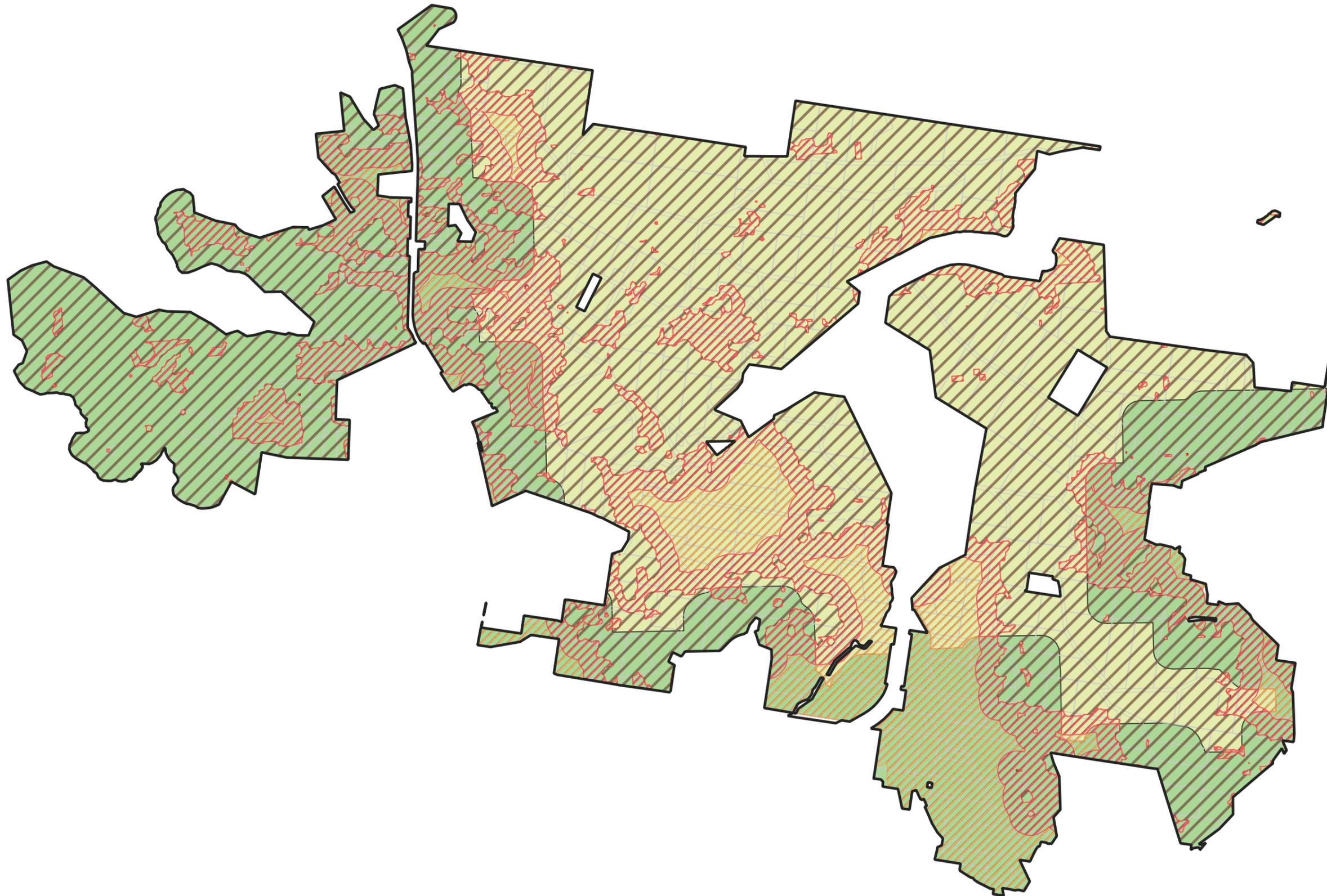
Rev	Description	Drawn	Checked	Date
A	FFDI 134 - with reduced fuel	FR		14/12/2020

Forest Fire Danger Index 134 - with fuel reduction

PROJECT: NBC Deferred Lands Bush Fire Risk	
LOCATION: Northern Beaches Council	
CLIENT: Northern Beaches Council	
Local Authority: Northern Beaches Council	Drawn: FR
Scale: 1:21.5 @ A3	
Drawing no: FFDI 134.1.2.1	



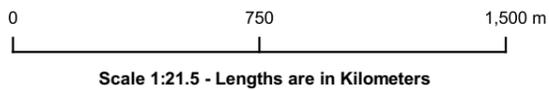
Appendix D Scenario-based risk exposure mapping



Legend

	Deferred Lands Subject Area		Future Metropolitan Rural Area
	FFDI 62 Fire Line Intensity Area		Metropolitan Rural Area
	100m Buffer		Cadastre
	700m Buffer		

ORIGINAL SIZE A3

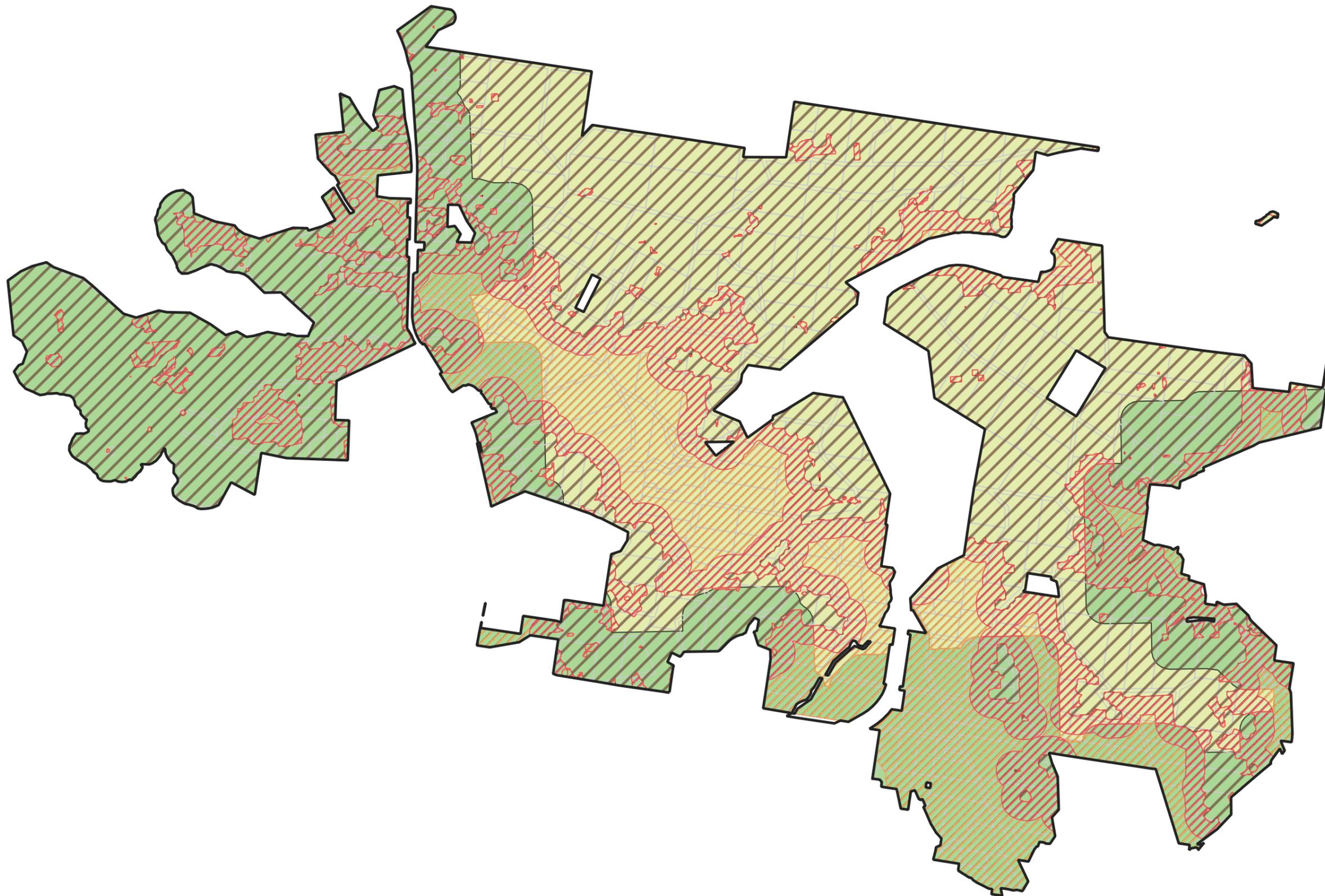


Rev	Description	Drawn	Checked	Date
A	FFDI 62 - no reduced fuel	FR		23/08/2020

Forest Fire Danger Index 62 - no fuel reduction	
PROJECT:	NBC Deferred Lands Bush Fire Risk
LOCATION:	Northern Beaches Council
CLIENT:	Northern Beaches Council
Local Authority: Northern Beaches Council	Drawn: FR



Scale: 1:21.5 @ A3
Drawing no: FFDI 62.5.1



Legend

	Deferred Lands Subject Area		Metropolitan Rural Area
	FFDI 62 Fire Line Intensity Area		Future Metropolitan Rural Area
	100m Buffer		Cadastre
	700m Buffer		

ORIGINAL SIZE A3

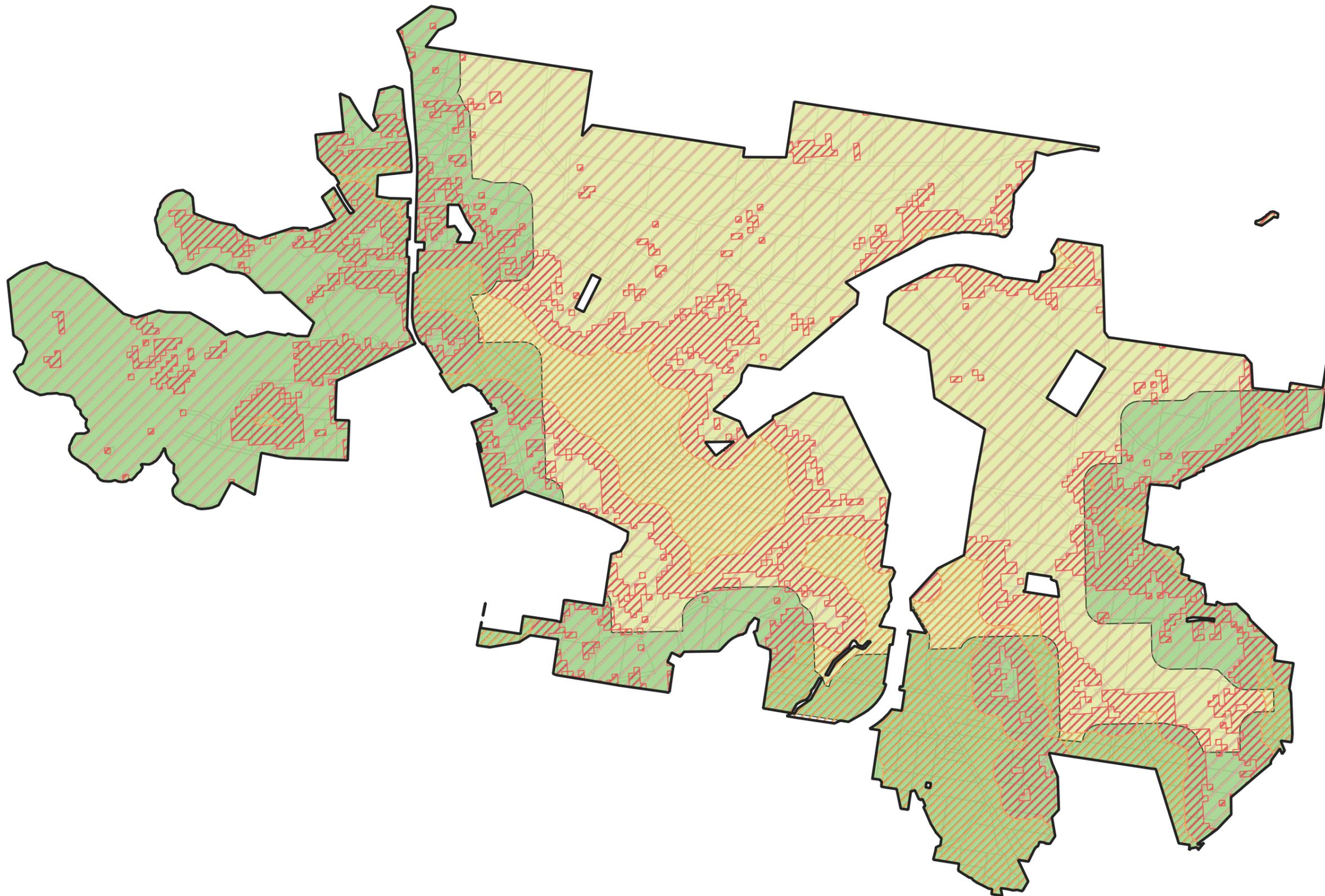


Rev	Description	Drawn	Checked	Date
A	FFDI 62 - with reduced fuel	FR		23/08/2020

Forest Fire Danger Index 62 - with fuel reduction	
PROJECT:	NBC Deferred Lands Bush Fire Risk
LOCATION:	Northern Beaches Council
CLIENT:	Northern Beaches Council
Local Authority: Northern Beaches Council	Drawn: FR



Scale: 1:21.5 @ A3
 Drawing no: FFDI 62.5.2



Legend

	Deferred Lands Subject Area		Future Metropolitan Rural Area
	FFDI 62 (kW/m2) Fire Line Intensity Area		Metropolitan Rural Area
	100m Buffer		Cadastre
	700m Buffer		

ORIGINAL SIZE A3

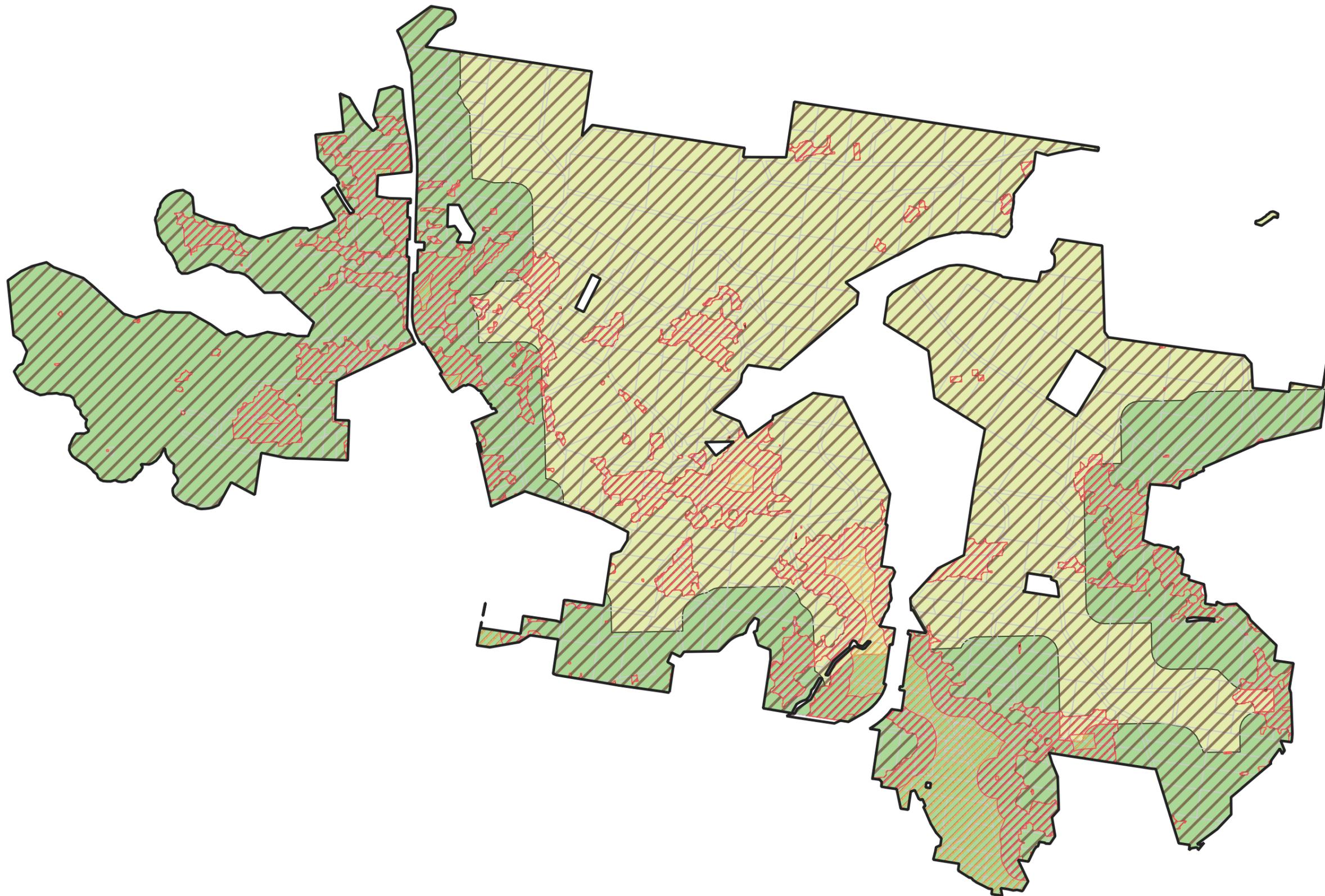


Rev	Description	Drawn	Checked	Date
A	FFDI 62 - with reduced fuel	FR		14/12/2020

Forest Fire Danger Index 62 - with fuel reduction	
PROJECT:	NBC Deferred Lands Bush Fire Risk
LOCATION:	Northern Beaches Council
CLIENT:	Northern Beaches Council
Local Authority: Northern Beaches Council	Drawn: FR



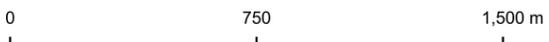
Scale: 1:21.5 @ A3
 Drawing no: FFDI 62.5.2.1



Legend

	Deferred Lands Subject Area		Future Metropolitan Rural Area
	100m Buffer		FFDI 100 Fire Line Intensity Area
	700m Buffer		Cadastre
	Metropolitan Rural Area		

ORIGINAL SIZE A3



Scale 1:21.5 - Lengths are in Kilometers



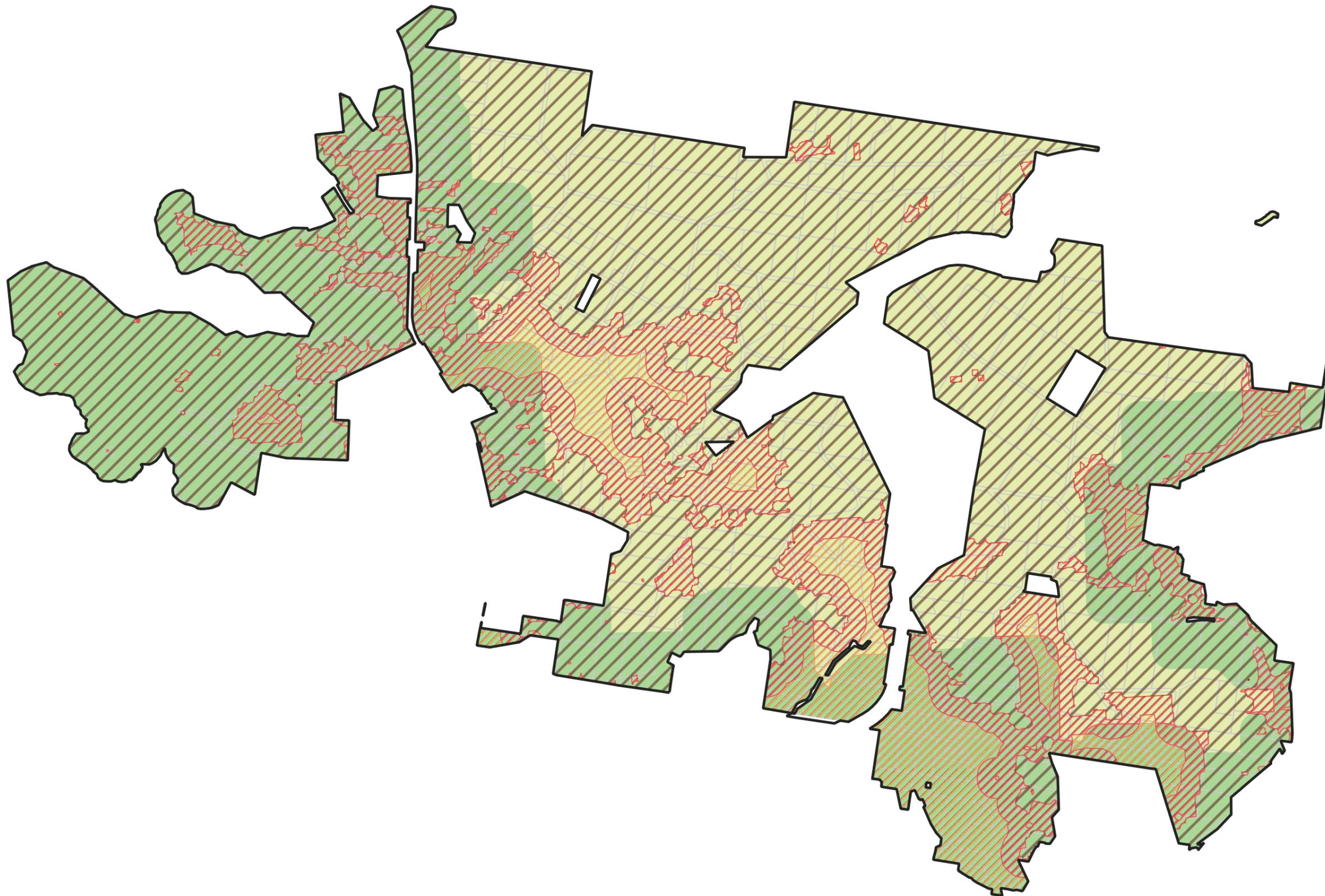
Rev	Description	Drawn	Checked	Date
A	FFDI 100 - no reduced fuel	FR		23/08/2020

Forest Fire Danger Index 100 - no fuel reduction

PROJECT: NBC Deferred Lands Bush Fire Risk	
LOCATION: Northern Beaches Council	
CLIENT: Northern Beaches Council	
Local Authority: Northern Beaches Council	Drawn: FR



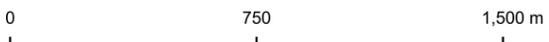
Scale: 1:21.5 @ A3
Drawing no: FFDI 100.5.1



Legend

	Deferred Lands Subject Area		Future Metropolitan Rural Area
	100m Buffer		FFDI 100 Fire Line Intensity Area
	700m Buffer		Cadastre
	Metropolitan Rural Area		

ORIGINAL SIZE A3



Scale 1:21.5 - Lengths are in Kilometers



Rev	Description	Drawn	Checked	Date
A	FFDI 100 - with reduced fuel	FR		23/08/2020

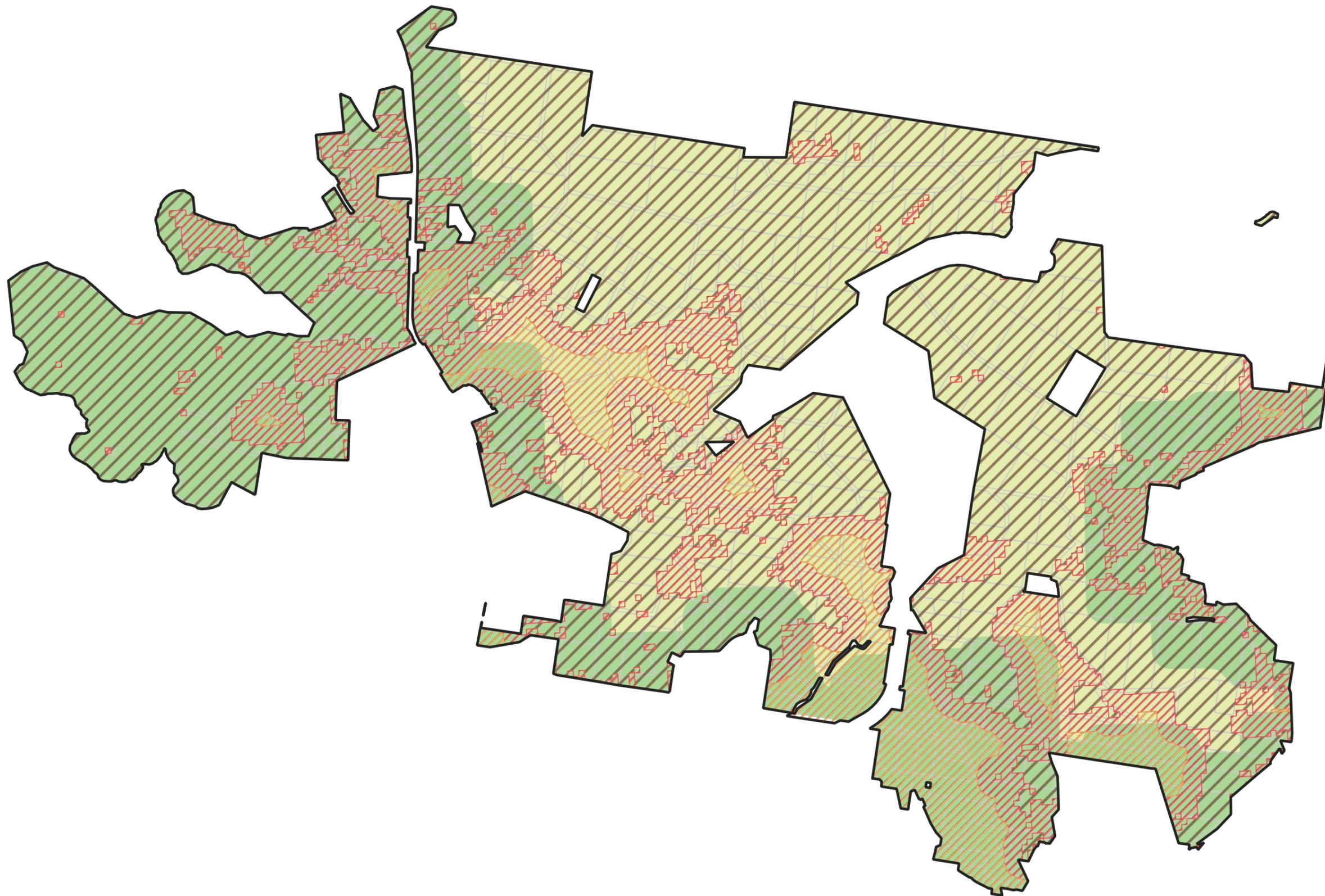
Forest Fire Danger Index 100 - with fuel reduction

PROJECT: NBC Deferred Lands Bush Fire Risk	
LOCATION: Northern Beaches Council	
CLIENT: Northern Beaches Council	
Local Authority: Northern Beaches Council	Drawn: FR



Scale: 1:21.5 @ A3

Drawing no: FFDI 100.5.2



Legend

	Deferred Lands Subject Area		Future Metropolitan Rural Area
	FFDI 100 (kW/m2) Fire Line Intensity Area		Metropolitan Rural Area
	100m Buffer		Cadastre
	700m Buffer		

ORIGINAL SIZE A3



Scale 1:21.5 - Lengths are in Kilometers



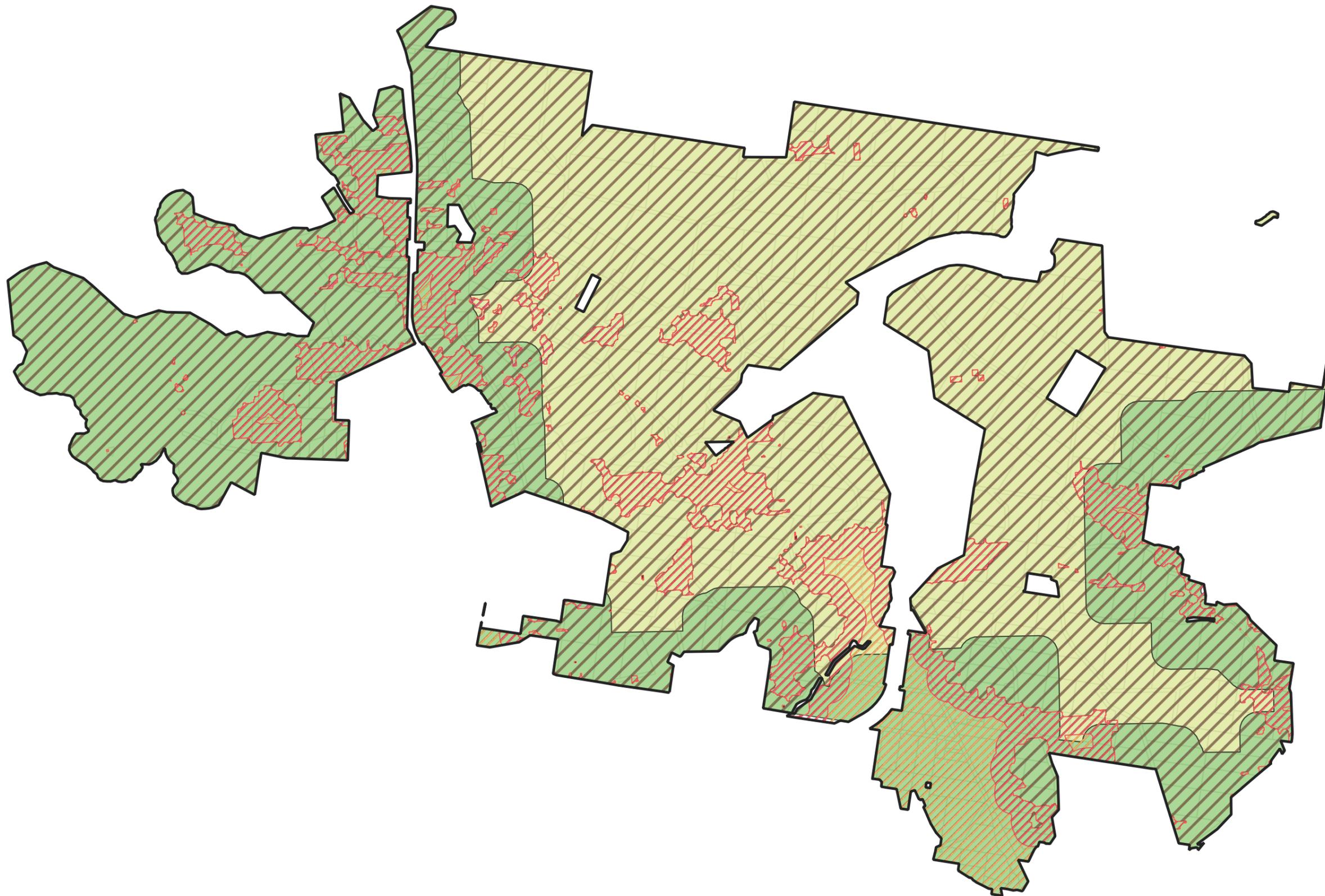
Rev	Description	Drawn	Checked	Date
A	FFDI 100 - with reduced fuel	FR		14/12/2020

Forest Fire Danger Index 100 - with fuel reduction

PROJECT: NBC Deferred Lands Bush Fire Risk	
LOCATION: Northern Beaches Council	
CLIENT: Northern Beaches Council	
Local Authority: Northern Beaches Council	Drawn: FR



Scale: 1:21.5 @ A3
Drawing no: FFDI 100.5.2.1



Legend

	Deferred Lands Subject Area		Metropolitan Rural Area
	FFDI 134 Fire Line Intensity Area		Future Metropolitan Rural Area
	100m Buffer		Cadastre
	700m Buffer		

ORIGINAL SIZE A3

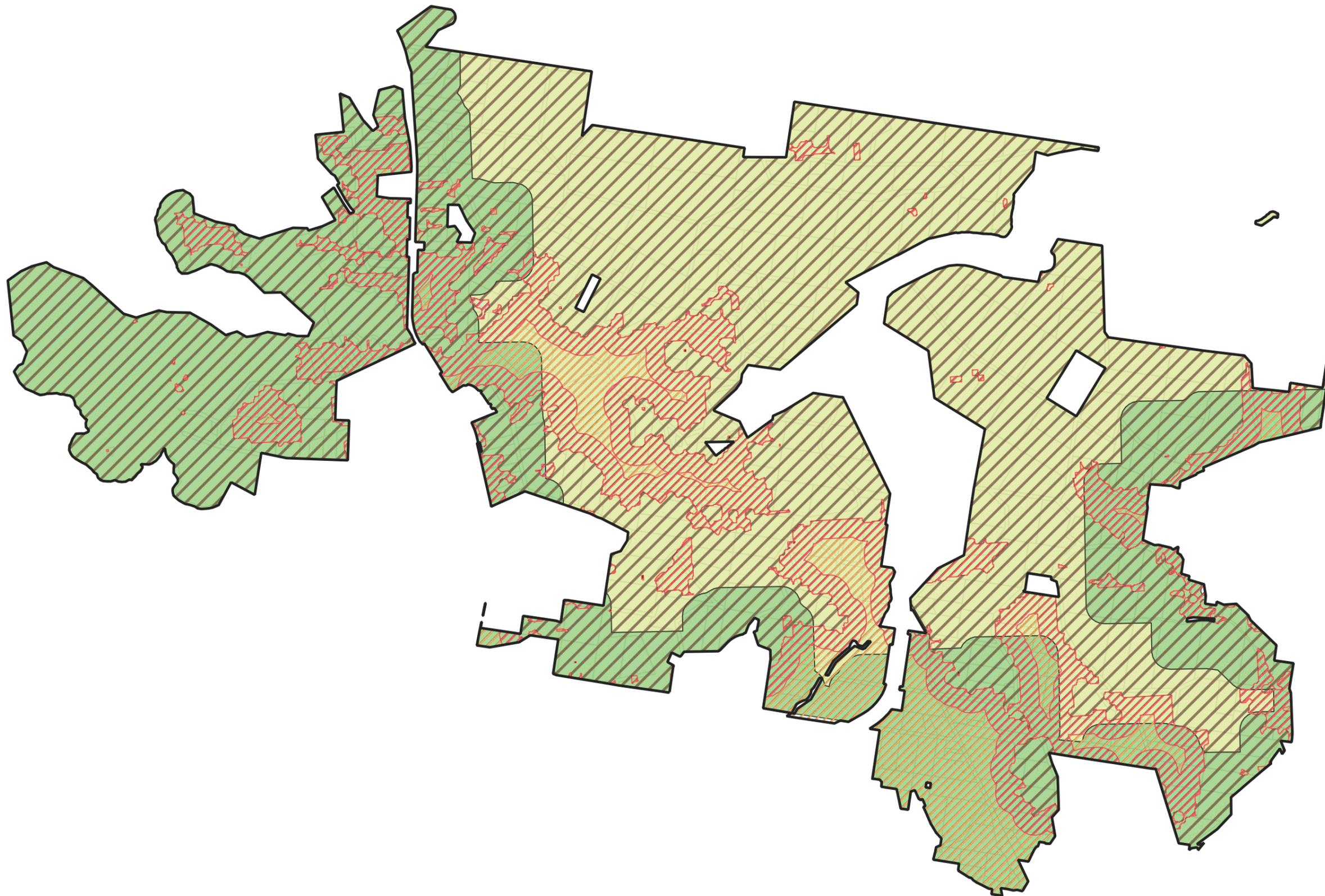


Rev	Description	Drawn	Checked	Date
A	FFDI 134 - no reduced fuel	FR		23/08/2020

Forest Fire Danger Index 134 - no fuel reduction	
PROJECT:	NBC Deferred Lands Bush Fire Risk
LOCATION:	Northern Beaches Council
CLIENT:	Northern Beaches Council
Local Authority: Northern Beaches Council	Drawn: FR



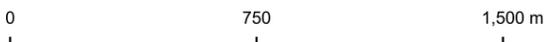
Scale: 1:21.5 @ A3
 Drawing no: FFDI 134.5.1



Legend

	Deferred Lands Subject Area		Metropolitan Rural Area
	FFDI 134 Fire Line Intensity Area		Future Metropolitan Rural Area
	100m Buffer		Cadastre
	700m Buffer		

ORIGINAL SIZE A3



Scale 1:21.5 - Lengths are in Kilometers

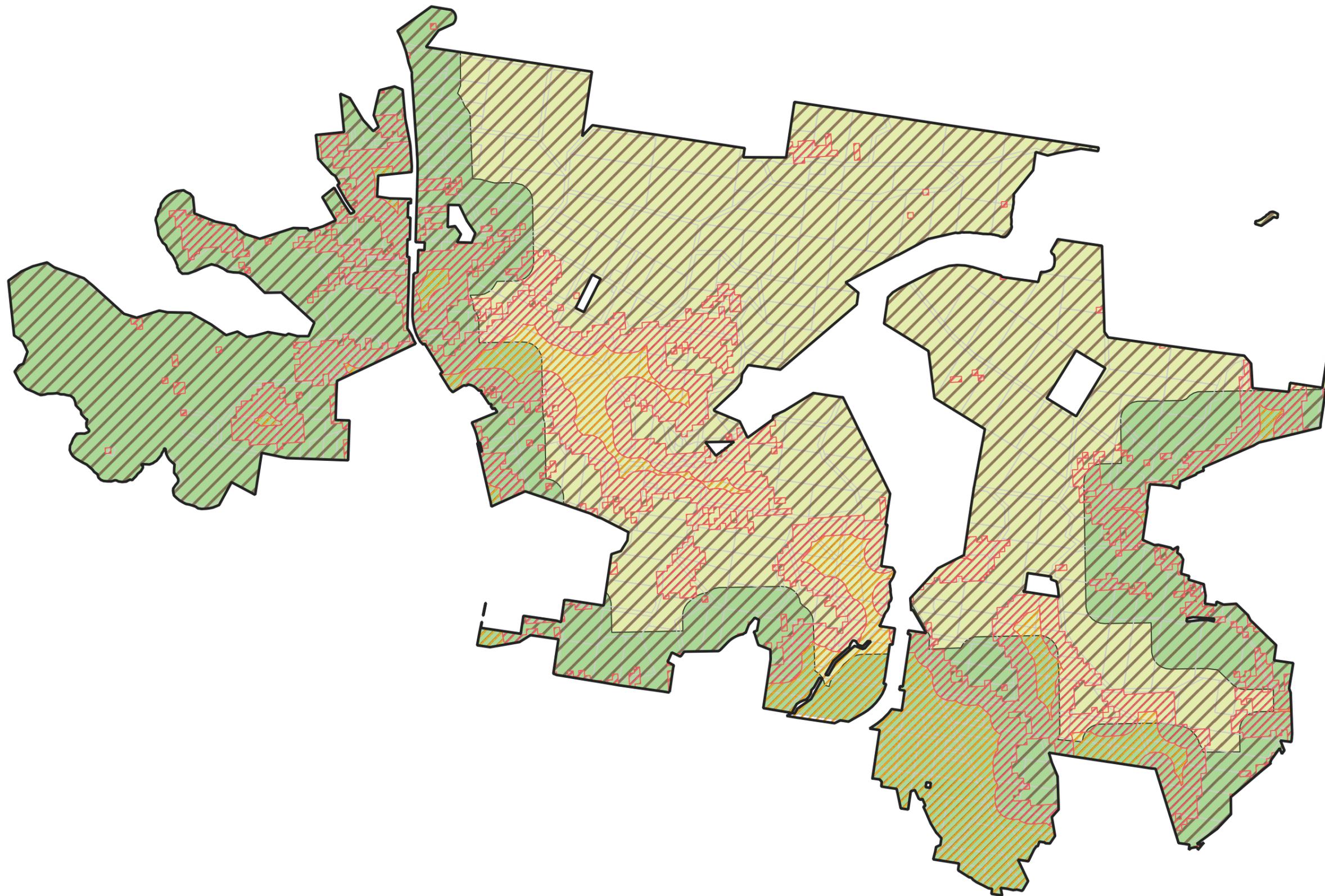


Rev	Description	Drawn	Checked	Date
A	FFDI 134 - with reduced fuel	FR		23/08/2020

Forest Fire Danger Index 134 - with fuel reduction	
PROJECT:	NBC Deferred Lands Bush Fire Risk
LOCATION:	Northern Beaches Council
CLIENT:	Northern Beaches Council
Local Authority: Northern Beaches Council	Drawn: FR



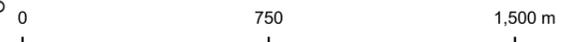
Scale: 1:21.5 @ A3
Drawing no: FFDI 134.5.2



Legend

	Deferred Lands Subject Area		Future Metropolitan Rural Area
	100m Buffer		Metropolitan Rural Area G
	700m Buffer		Cadastre
	FFDI 134 (kW/m2) Fire Line Intensity Area		

ORIGINAL SIZE A3



Scale 1:21.5 - Lengths are in Kilometers



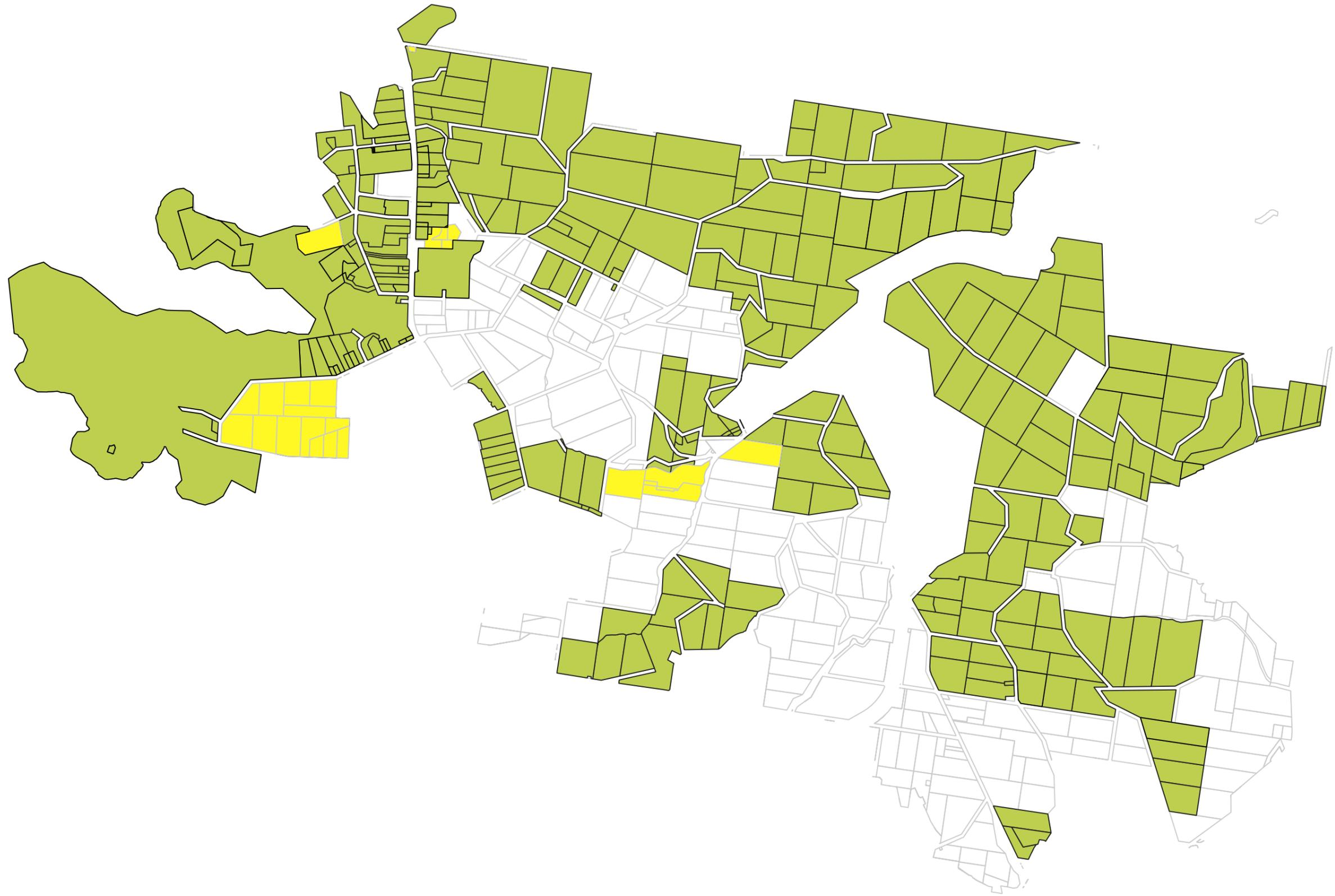
Rev	Description	Drawn	Checked	Date
A	FFDI 134 - with reduced fuel	FR		14/12/2020

Forest Fire Danger Index 134 - with fuel reduction	
PROJECT:	NBC Deferred Lands Bush Fire Risk
LOCATION:	Northern Beaches Council
CLIENT:	Northern Beaches Council
Local Authority:	Northern Beaches Council
Drawn:	FR



Scale: 1:21.5 @ A3
Drawing no: FFDI 134.5.2.1

Appendix E Option 3 zoning rationale map



Legend

	Deferred Lands		Limited Land Use Area
	Existing SP2 Infrastructure		Cadastre

ORIGINAL SIZE A3



Rev	Description	Drawn	Checked	Date
A	FFDI 100 - Option 3	FR		24/11/2020

Option 3 - Zoning Rationale	
PROJECT:	NBC Deferred Lands Bush Fire Risk
LOCATION:	Northern Beaches Council
CLIENT:	Northern Beaches Council
Local Authority: Northern Beaches Council	Drawn: FR



Meridian
Urban



TENRIVERS

Scale: 1:21.5 @ A3

Drawing no: C.1

Appendix F Risk exposure analysis datasets

Total Deferred Lands

1. Spatial / geographic extent of fire (percentage of total Deferred Lands area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	64.9%	80.9%	79.5%	81.5%
Potential flame contact exposure	15.8%	11.3%	10.3%	9.9%
Radiant heat exposure	3.6%	2.0%	1.9%	1.8%
Primary ember attack exposure	4.0%	1.9%	2.0%	1.6%
Total affected land	88.3%	96.1%	93.7%	94.8%

SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	59.0%	71.7%	70.6%	72.5%
Potential flame contact exposure	14.9%	13.2%	12.7%	12.2%
Radiant heat exposure	3.9%	3.0%	3.0%	3.0%
Primary ember attack exposure	4.6%	3.4%	3.5%	3.5%
Total affected land	82.4%	91.3%	89.8%	91.2%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	55.9%	68.2%	67.5%	68.6%
Potential flame contact exposure	17.3%	15.7%	14.9%	14.5%
Radiant heat exposure	3.9%	3.2%	3.2%	3.1%
Primary ember attack exposure	4.7%	3.6%	3.7%	3.8%
Total affected land	81.8%	90.7%	89.3%	90.1%

2. Intensity of fire extent (percentage of total Deferred Lands area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	29.4%	17.0%	20.3%	17.5%
Fireline intensity 4,000-20,000 kW/m	37.5%	32.3%	26.7%	30.6%
Fireline intensity 20,000-30,000 kW/m	10.4%	16.3%	14.3%	16.1%
Fireline intensity 30,000-40,000 kW/m	6.4%	11.1%	9.7%	10.9%

Fireline intensity 40,000-60,000 kW/m	6.5%	11.2%	12.1%	13.0%
Fireline intensity >60,000 kW/m	4.2%	10.0%	16.7%	11.0%

SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	41.0%	23.3%	26.6%	24.4%
Fireline intensity 4,000-20,000 kW/m	30.8%	27.2%	22.9%	26.7%
Fireline intensity 20,000-30,000 kW/m	10.8%	13.8%	12.5%	13.7%
Fireline intensity 30,000-40,000 kW/m	6.2%	9.8%	8.4%	9.9%
Fireline intensity 40,000-60,000 kW/m	6.2%	10.8%	10.9%	12.0%
Fireline intensity >60,000 kW/m	5.0%	10.0%	15.8%	10.2%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	44.1%	31.8%	32.5%	31.4%
Fireline intensity 4,000-20,000 kW/m	28.2%	23.2%	19.4%	22.5%
Fireline intensity 20,000-30,000 kW/m	10.0%	12.1%	11.1%	12.9%
Fireline intensity 30,000-40,000 kW/m	6.2%	9.9%	8.2%	9.7%
Fireline intensity 40,000-60,000 kW/m	6.2%	11.5%	11.4%	11.7%
Fireline intensity >60,000 kW/m	5.3%	11.5%	17.3%	11.9%

Metropolitan Rural Area

1. Spatial / geographic extent of fire (percentage of MRA area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	71.9%	88.3%	87.0%	89.7%
Potential flame contact exposure	14.0%	8.1%	8.1%	7.2%
Radiant heat exposure	3.1%	1.2%	1.5%	1.1%
Primary ember attack exposure	3.3%	1.1%	1.6%	1.0%
Total affected land	92.3%	98.7%	98.2%	99.0%

SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
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Hazard area	65.4%	78.5%	76.7%	79.5%
Potential flame contact exposure	12.8%	11.3%	11.1%	10.5%
Radiant heat exposure	3.4%	2.6%	2.9%	2.6%
Primary ember attack exposure	4.0%	3.0%	3.5%	3.1%
Total affected land	85.6%	95.4%	94.2%	95.7%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	62.8%	75.8%	74.8%	76.8%
Potential flame contact exposure	14.7%	13.0%	12.8%	12.1%
Radiant heat exposure	3.4%	2.8%	2.9%	2.8%
Primary ember attack exposure	4.1%	3.3%	3.5%	3.4%
Total affected land	85.0%	94.9%	94.1%	95.0%

2. Intensity of fire extent (percentage of MRA area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	27.9%	11.5%	12.9%	10.2%
Fireline intensity 4,000-20,000 kW/m	36.6%	28.6%	23.2%	26.6%
Fireline intensity 20,000-30,000 kW/m	12.5%	17.3%	14.7%	17.1%
Fireline intensity 30,000-40,000 kW/m	8.7%	13.6%	10.7%	13.7%
Fireline intensity 40,000-60,000 kW/m	9.3%	15.5%	15.2%	17.7%
Fireline intensity >60,000 kW/m	4.9%	13.3%	23.1%	14.6%

SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	34.7%	18.5%	20.2%	17.4%
Fireline intensity 4,000-20,000 kW/m	28.4%	23.1%	18.3%	22.0%
Fireline intensity 20,000-30,000 kW/m	13.4%	14.9%	13.3%	14.7%
Fireline intensity 30,000-40,000 kW/m	8.4%	12.3%	9.5%	12.7%
Fireline intensity 40,000-60,000 kW/m	9.0%	14.9%	13.9%	16.7%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity >60,000 kW/m	6.1%	13.4%	21.8%	13.4%
Fireline intensity 0-4,000 kW/m	37.2%	24.2%	25.5%	23.2%
Fireline intensity 4,000-20,000 kW/m	26.6%	20.3%	16.1%	19.1%
Fireline intensity 20,000-30,000 kW/m	12.2%	12.5%	11.4%	13.6%
Fireline intensity 30,000-40,000 kW/m	8.5%	12.2%	9.3%	12.1%
Fireline intensity 40,000-60,000 kW/m	8.9%	15.4%	14.3%	16.1%
Fireline intensity >60,000 kW/m	6.5%	15.5%	23.7%	15.8%

Future Metropolitan Rural Area (MRA) Investigation Area

1. Spatial / geographic extent of fire (percentage of future MRA investigation area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	56.7%	72.1%	70.7%	71.7%
Potential flame contact exposure	18.0%	15.1%	13.0%	13.1%
Radiant heat exposure	4.3%	2.8%	2.3%	2.6%
Primary ember attack exposure	4.8%	2.9%	2.4%	2.4%
Total affected land	83.8%	92.9%	88.4%	89.8%

SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	51.5%	63.7%	63.5%	64.2%
Potential flame contact exposure	17.4%	15.6%	14.6%	14.3%
Radiant heat exposure	4.5%	3.4%	3.2%	3.4%
Primary ember attack exposure	5.3%	3.9%	3.6%	4.0%
Total affected land	78.7%	86.6%	84.9%	85.9%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	47.9%	59.2%	58.8%	59.0%
Potential flame contact exposure	20.3%	18.9%	17.5%	17.5%

Radiant heat exposure	4.5%	3.6%	3.5%	3.6%
Primary ember attack exposure	5.4%	4.0%	3.5%	4.4%
Total affected land	78.1%	85.7%	83.3%	84.4%

2. Intensity of fire extent (percentage of future MRA investigation area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	31.2%	23.5%	29.1%	26.1%
Fireline intensity 4,000-20,000 kW/m	38.6%	36.8%	31.0%	35.2%
Fireline intensity 20,000-30,000 kW/m	8.1%	15.0%	13.8%	14.8%
Fireline intensity 30,000-40,000 kW/m	3.6%	8.1%	8.5%	7.7%
Fireline intensity 40,000-60,000 kW/m	3.2%	6.2%	8.3%	7.3%
Fireline intensity >60,000 kW/m	3.2%	6.1%	9.1%	6.7%

SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	48.5%	29.0%	34.1%	32.7%
Fireline intensity 4,000-20,000 kW/m	33.6%	32.1%	28.5%	32.2%
Fireline intensity 20,000-30,000 kW/m	7.8%	12.6%	11.7%	12.6%
Fireline intensity 30,000-40,000 kW/m	3.6%	6.9%	7.1%	6.5%
Fireline intensity 40,000-60,000 kW/m	2.9%	6.1%	7.4%	6.4%
Fireline intensity >60,000 kW/m	3.6%	6.0%	8.8%	6.5%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	52.1%	40.8%	41.2%	41.0%
Fireline intensity 4,000-20,000 kW/m	30.1%	26.7%	23.3%	26.5%
Fireline intensity 20,000-30,000 kW/m	7.4%	11.7%	10.8%	12.2%
Fireline intensity 30,000-40,000 kW/m	3.5%	7.2%	7.0%	6.8%
Fireline intensity 40,000-60,000 kW/m	3.0%	6.9%	8.0%	6.3%
Fireline intensity >60,000 kW/m	3.8%	6.7%	9.7%	7.2%

Western Precinct

1. Spatial / geographic extent of fire (percentage of Western Precinct area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	75.9%	82.4%	82.7%	82.9%
Potential flame contact exposure	17.0%	13.9%	13.7%	13.2%
Radiant heat exposure	3.0%	1.9%	1.9%	2.1%
Primary ember attack exposure	2.7%	1.4%	1.4%	1.4%
Total affected land	98.6%	99.6%	99.7%	99.6%

SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	76.7%	82.5%	82.7%	82.9%
Potential flame contact exposure	16.5%	13.9%	13.7%	13.2%
Radiant heat exposure	2.9%	1.9%	1.9%	2.2%
Primary ember attack exposure	2.5%	1.4%	1.4%	1.4%
Total affected land	98.6%	99.7%	99.7%	99.7%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	71.9%	77.0%	76.9%	77.1%
Potential flame contact exposure	20.1%	18.0%	17.0%	17.3%
Radiant heat exposure	3.1%	2.5%	2.7%	2.6%
Primary ember attack exposure	2.8%	1.9%	2.3%	2.2%
Total affected land	97.9%	99.4%	98.9%	99.2%

2. Intensity of fire extent (percentage of Western Precinct area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	23.9%	17.4%	17.1%	17.0%
Fireline intensity 4,000-20,000 kW/m	51.3%	44.8%	39.8%	43.2%

Fireline intensity 20,000-30,000 kW/m	11.4%	15.1%	15.3%	14.8%
Fireline intensity 30,000-40,000 kW/m	5.5%	9.1%	9.4%	8.7%
Fireline intensity 40,000-60,000 kW/m	4.6%	7.7%	9.1%	9.2%
Fireline intensity >60,000 kW/m	3.1%	5.8%	9.0%	7.1%

SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	23.3%	17.4%	17.1%	16.9%
Fireline intensity 4,000-20,000 kW/m	51.3%	44.8%	39.8%	43.2%
Fireline intensity 20,000-30,000 kW/m	12.3%	15.1%	15.4%	14.8%
Fireline intensity 30,000-40,000 kW/m	5.7%	9.1%	9.5%	8.7%
Fireline intensity 40,000-60,000 kW/m	4.2%	7.7%	9.1%	9.1%
Fireline intensity >60,000 kW/m	3.2%	5.8%	9.0%	7.1%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	28.1%	23.1%	23.1%	22.9%
Fireline intensity 4,000-20,000 kW/m	46.8%	38.5%	33.9%	37.4%
Fireline intensity 20,000-30,000 kW/m	11.3%	14.7%	14.2%	14.8%
Fireline intensity 30,000-40,000 kW/m	5.3%	8.2%	8.6%	7.9%
Fireline intensity 40,000-60,000 kW/m	4.8%	8.1%	9.8%	8.4%
Fireline intensity >60,000 kW/m	3.7%	7.4%	10.3%	8.5%

Central Precinct

1. Spatial / geographic extent of fire (percentage of Central Precinct area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	63.3%	82.9%	81.6%	84.2%
Potential flame contact exposure	18.0%	11.3%	10.8%	10.1%
Radiant heat exposure	4.0%	1.8%	2.0%	1.6%
Primary ember attack exposure	4.4%	1.7%	2.1%	1.5%

Total affected land	89.7%	97.7%	96.5%	97.4%
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SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	59.5%	72.4%	70.5%	73.5%
Potential flame contact exposure	13.6%	12.5%	12.5%	11.8%
Radiant heat exposure	3.5%	3.0%	3.2%	3.0%
Primary ember attack exposure	4.4%	3.7%	4.1%	3.8%
Total affected land	81.0%	91.6%	90.3%	92.1%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	56.5%	69.1%	67.9%	70.0%
Potential flame contact exposure	16.0%	14.8%	14.8%	13.8%
Radiant heat exposure	3.4%	3.2%	3.3%	3.2%
Primary ember attack exposure	4.3%	3.9%	4.2%	4.1%
Total affected land	80.3%	90.9%	90.3%	91.1%

2. Intensity of fire extent (percentage of Central Precinct area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	34.7%	17.0%	18.3%	15.6%
Fireline intensity 4,000-20,000 kW/m	38.2%	34.4%	28.7%	32.6%
Fireline intensity 20,000-30,000 kW/m	8.9%	16.0%	15.5%	15.7%
Fireline intensity 30,000-40,000 kW/m	5.9%	10.4%	9.1%	9.5%
Fireline intensity 40,000-60,000 kW/m	5.6%	11.1%	11.0%	12.7%
Fireline intensity >60,000 kW/m	4.8%	11.0%	17.3%	13.7%

SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	40.5%	23.5%	25.4%	22.4%
Fireline intensity 4,000-20,000 kW/m	30.8%	27.1%	22.3%	25.9%

Fireline intensity 20,000-30,000 kW/m	10.3%	14.0%	13.6%	13.2%
Fireline intensity 30,000-40,000 kW/m	6.2%	9.7%	7.9%	8.8%
Fireline intensity 40,000-60,000 kW/m	5.8%	10.8%	10.0%	12.2%
Fireline intensity >60,000 kW/m	6.5%	10.9%	16.6%	13.3%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	43.5%	30.9%	32.1%	30.0%
Fireline intensity 4,000-20,000 kW/m	28.4%	23.4%	19.3%	22.4%
Fireline intensity 20,000-30,000 kW/m	9.5%	11.5%	11.6%	12.2%
Fireline intensity 30,000-40,000 kW/m	6.3%	9.8%	8.0%	8.0%
Fireline intensity 40,000-60,000 kW/m	5.8%	12.0%	10.2%	12.0%
Fireline intensity >60,000 kW/m	6.6%	12.4%	18.7%	15.2%

Eastern Precinct

1. Spatial / geographic extent of fire (percentage of Eastern Precinct area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	61.9%	77.2%	74.9%	76.7%
Potential flame contact exposure	12.0%	10.2%	8.0%	7.9%
Radiant heat exposure	3.5%	2.2%	1.7%	1.8%
Primary ember attack exposure	4.1%	2.5%	2.0%	2.0%
Total affected land	81.5%	92.1%	86.6%	88.4%

SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	49.7%	65.4%	74.9%	65.9%
Potential flame contact exposure	16.1%	13.9%	12.4%	12.4%
Radiant heat exposure	4.9%	3.5%	3.2%	3.3%
Primary ember attack exposure	5.9%	4.0%	3.8%	4.0%
Total affected land	76.6%	86.8%	94.3%	85.6%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Hazard area	47.4%	62.7%	62.3%	62.5%
Potential flame contact exposure	17.7%	16.0%	14.1%	14.2%
Radiant heat exposure	4.8%	3.5%	3.2%	3.4%
Primary ember attack exposure	5.9%	3.9%	3.8%	4.2%
Total affected land	75.8%	86.1%	83.5%	84.3%

2. Intensity of fire extent (percentage of Eastern Precinct area)

SCENARIO 1 – EXISTING	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	24.2%	16.9%	24.8%	20.3%
Fireline intensity 4,000-20,000 kW/m	29.7%	23.3%	17.6%	21.6%
Fireline intensity 20,000-30,000 kW/m	12.3%	17.2%	11.9%	17.2%
Fireline intensity 30,000-40,000 kW/m	7.5%	13.0%	10.7%	14.1%
Fireline intensity 40,000-60,000 kW/m	8.7%	13.1%	15.1%	15.1%
Fireline intensity >60,000 kW/m	3.8%	10.6%	19.7%	8.8%

SCENARIO 2 – LOW FUEL PAC SITES	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	50.3%	26.0%	32.9%	31.0%
Fireline intensity 4,000-20,000 kW/m	20.9%	18.9%	15.8%	19.8%
Fireline intensity 20,000-30,000 kW/m	10.8%	13.0%	9.6%	14.0%
Fireline intensity 30,000-40,000 kW/m	6.6%	10.3%	8.6%	12.0%
Fireline intensity 40,000-60,000 kW/m	7.8%	12.4%	13.1%	12.9%
Fireline intensity >60,000 kW/m	3.6%	10.8%	17.9%	7.3%

SCENARIO 3 – PLANNING OPTION 3	FFDI 62	FFDI 100	FFDI 114	FFDI 134
Fireline intensity 0-4,000 kW/m	52.6%	37.3%	37.7%	37.5%
Fireline intensity 4,000-20,000 kW/m	18.9%	15.6%	12.5%	15.3%
Fireline intensity 20,000-30,000 kW/m	10.2%	11.7%	8.8%	13.0%

Fireline intensity 30,000-40,000 kW/m	6.6%	10.9%	8.4%	12.8%
Fireline intensity 40,000-60,000 kW/m	7.5%	12.4%	13.9%	12.6%
Fireline intensity >60,000 kW/m	4.2%	12.2%	18.7%	8.7%

