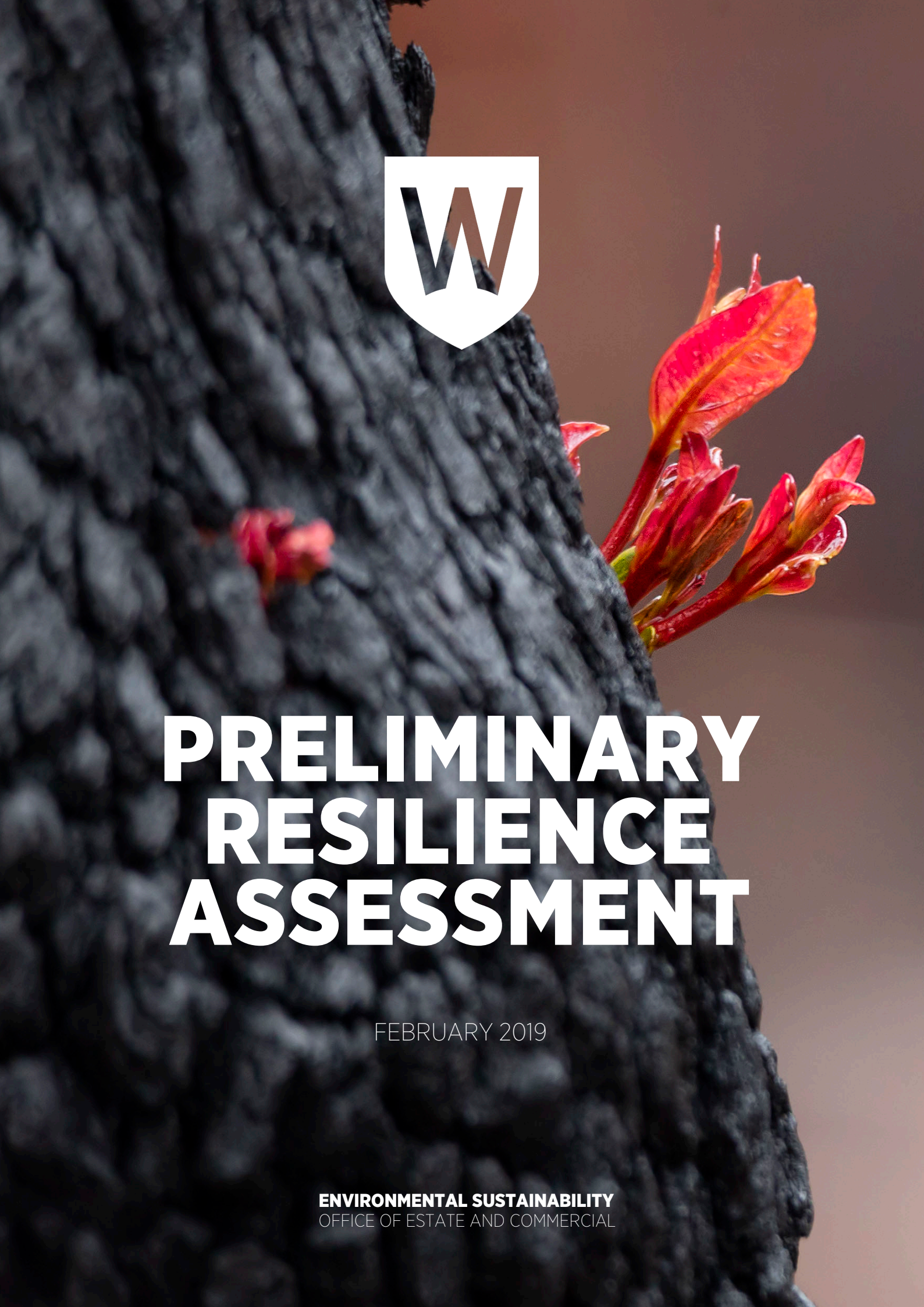


PRELIMINARY RESILIENCE ASSESSMENT

FEBRUARY 2019

ENVIRONMENTAL SUSTAINABILITY
OFFICE OF ESTATE AND COMMERCIAL

CONTENTS

SUMMARY

A key aspect of Resilience Planning is the focus on systemic connectivity, and strategies to mitigate 'cascading failures' (Resilient Sydney 2016). The scope of this preliminary assessment is on climate change risks in relation to our campus infrastructure and the communities of practice who utilise our campuses. However, this scope informs broader social, infrastructure and landscape imperatives due to the ongoing development and role of WSU within Western Sydney. This Preliminary Resilience Assessment summaries key vulnerabilities, current actions and strategies, and opportunities for developing collaboration and strategic activity. The strategy used in the development of this Assessment included

- Compiling and distributing a discussion paper
- Identifying a preliminary infrastructure risk assessment
- Convening campus-based workshops with WSU staff, and
- Compiling this Preliminary Resilience Assessment.

Summary material in the discussion paper (Attachment 1) includes a brief review of: risks, principles and modelling of climate change implications for Western Sydney; resilience planning at a city scale; resilience planning for the property sector; cooling the commons and the university sector. Drawing upon material reviewed, a preliminary risk assessment is presented for infrastructure services at WSU, along with an overview of key strategies and tactics underway. Preliminary recommendations are identified, including:

- Embedding resilience in WSU strategy and planning, through:
  - Building integrated capacities across functional domains of WSU,
  - Embedding integrative concepts, such as Living Labs. in WSU strategy, and
  - Building on Green Star buildings towards Green Star community precincts
- Developing integrative infrastructure strategies and interventions, including:
  - Infrastructure strategies identified in infrastructure risk assessment, and
  - Applying design and operational strategies identified by the Property Council.

Campus based workshops were also undertaken with WSU staff to identify key vulnerabilities, current strategies, and opportunities for collaboration and action. Workshop recommendations were mapped onto the CORE model of sustainable campuses and are presented in summary (curricula, operations, research and engagement). These include:

- Cross-disciplinary opportunities and student recognition
- Broad ranging adaptation opportunities and coordination needs
- Opportunities for integration through Living Lab. initiatives, and
- Communication strategies, and demonstration of best practice on campuses.

1. PRELIMINARY RESILIENCE ASSESSMENT

Shocks and stresses from climate change across Western Sydney are clearly indicated through modelling, including increasing periods of higher temperature, higher bushfire risk, interspersed with increased storm intensity (Dowdy 2015, OEH 2014) (Attachment 1). Consistent with the National Climate Change Resilience and Adaptation Strategy (DEE 2015), key principles in responding to the likely shocks and stresses include:

- Promoting shared responsibility
- Grounded on an evidence-based risk management approach
- Ensuring climate change risks are factored into decisions
- Enabling collaborative values-based choices
- Ensuring we assist the vulnerable, and
- Continue to review decisions and discussions

Western Sydney University campuses are embedded within a range of Council areas, with Council collaboration not just being nice to have, but critical in ensuring WSU's role in urban heat management. Strategies to mitigate urban heat need to be built through regional / multi-jurisdictional partnerships (PCC 2015). The effect of urban heat on health, wellbeing and liveability are well recognised in council strategy documents, such as Penrith City Council's Cooling the City Strategy (2015) and WSROC's Turn Down the Heat: Strategy and Action Plan (2018). Options identified by the Penrith strategy include the following:

- Green infrastructure: designed / natural / innovative
- Water sensitive urban design
- Increased albedo (reflectivity) to reduce heat storage
- Policy and planning controls / Engagement, education

Community behaviour and amenity is also an important critical aspect, as identified in the WSU Cooling the Commons research project (ICS 2016). Community amenity is critical to liveability in the face of urban heat, with urban design and policy needed to support adaptation and an awareness of resident practices, constraints, and aspirations. 'Cool commons' are critical refuges within the built landscape, particularly as refuges in times of extreme heat, and need to be linked with paths, walkways and transport options.

Useful recommendations for responding to climate change risks by property managers have been developed by the NSW Property Council (Attachment 1). With rapid progress of the WSU Western Growth Strategy, WSU has an increasing portfolio of commercial arrangements associated with its campuses. At a broad level, the Property Council suggests organisational strategies to embed climate resilience, including: identifying targets and actions, engaging stakeholders, and measuring progress and demonstration. Collaboration between asset owners can build upon their interdependencies of strengths and weaknesses, and enhance opportunities for coordination with neighbours. A number of adaptation strategies have been recommended by Property Council, such as those for design and operations of Heating Ventilation and Cooling Systems (HVAC), where increasing demands and maintenance costs are a result of higher temperatures and heat waves (PCA 2017).

2. PRELIMINARY RISK ASSESSMENT OF WSU INFRASTRUCTURE SERVICES

A preliminary risk assessment has been prepared for WSU Infrastructure services, broadly interpreting the Resilient Sydney risk assessment process (Attachment 1; Resilient Sydney 2016), considering:

- Critical assets and condition
- Priority shocks and stresses
- Consequence and vulnerability, and
- Adaptation strategies

A summary of this preliminary assessment is presented below in Table 1., along with a description below of strategies already underway to address vulnerabilities and adaptations.

Table 1. Preliminary risk assessment of critical campus assets

CRITICAL ASSETS AND CONDITION	PRIORITY SHOCKS / STRESSES	CONSEQUENCE / VULNERABILITY	ADAPTATION STRATEGY
Electricity and gas supply (HV & LV) – limited peak demand and alternative supplies	• Price increases • Changes in regulatory arrangements • Supply interrupt - storms / bushfire • Demand during periods of heat	• Financial stress • Impacts on business continuity • Excessive peak demand	• Hedging through renewables • Energy efficiency • Research protection measures • Peak demand management
Water supplies and resources – SWC supply, and non- potable sources on HWK, minor egs on PEN, CTN & PTA	• Supply interruption / restrictions • Changes in regulatory arrangements • Drought	• Business continuity • Loss of amenity / assets	• Water harvesting and recycling • Water use efficiency
Building fabric and services – varied age and condition of > 500 buildings plus new portfolio of CBD locations	• Tolerances to heat • Operational tolerances of HVAC • Changes in regulatory arrangements	• Operational flexibility to conditions • Ability to maintain thermal comfort	• Strategic asset planning • Design for thermal tolerance • Energy efficiency • Passive design and landscaping
Research facilities – distributed high intensity controlled environments	• Power supply interruption • Impact on operation during heat • Impact of bushfire, outdoor facilities	• Loss of controlled conditions • Loss of critical data /materials	• Research protection measures • Bush fire mitigation strategies
Outdoor operations (eg farm, environmental assets) –developed on HWK, minimal elsewhere	• Drought / storm surge / flood • Bushfire • Biosecurity incident	• Loss / death of assets • Impacts on animal welfare • Impacts on biodiversity	• Water recycling / resources • Bushfire planning & preparedness • Land and biosecurity management
Public spaces – generally good amenity / condition informed by safety through design	• Thermal comfort during heat • Storm damage • Drought conditions	• Health and safety risks • Loss of amenity	• Precinct design for amenity • Cooling and shading elements • Water harvesting and reuse

3. INITIATIVES UNDERWAY

A broad range of initiatives are already underway which form a strong platform for emerging strategies, as summarised below in relation to the classes of critical assets in Table x.

3.1 Energy (Electricity and gas)

A range of opportunities been implemented over the last few years, including:

- Energy efficiency initiatives have included campus-scale load shedding through a network of Building Management Systems (BMS) at Parramatta campus, a successful trial of voltage optimisation for the L precinct substation at Hawkesbury, and the standard roll-out of BMS, lighting controls and LED lighting.
- Project-based solar PV installations on Hawkesbury (100kW), Parramatta (EHa 40 kW), Kingswood (Building K 35kW), Werrington Park Corporate Centre (25 kW)
- High efficiency solar hot water heating, particularly for pre-heating of central plant at Parramatta (Central Energy Plant and Building EA and EB), Kingswood and the Police Precinct at Hawkesbury.

Current initiatives underway include:

- Review of emerging energy options, including increasing renewables through Power Purchasing Agreements either on or off-site. Peak load reduction is a key strategy for current campus initiatives.
- Planning for a coordinated roll-out of on-site solar PV installations including a ground-based solar farm at Hawkesbury, roof-top PV and multipurpose carpark PV and shade structures across all campuses.
- Installation of a solar PV system and battery storage at Building Z, Kingswood as first step in a solar Living Lab. with Engineering. A pilot carpark solar is planned for the adjacent carpark, to incorporate shade and amenity, and electric car charging bays.

3.2 Water supplies and resources.

Water efficiency and use of alternative non-potable water resources is reasonably well established at WSU. This includes:

- The Hawkesbury Water Recycling Scheme on Hawkesbury Campus, whereby recycled water supplied by Sydney Water Corporation is used for irrigation as part of the Hawkesbury Farm's commercial grazing enterprise and the irrigation of playing fields. The Scheme also incorporates stormwater harvesting, treatment and reuse for grounds irrigation, including the historical precinct and the student residences.
- Stormwater harvesting and reuse is also established at the Campbelltown student residences for landscape irrigation.
- Rainwater harvesting from roof spaces is collected on buildings BA and BB (Werrington South) for toilet flushing and grounds irrigation, Buildings EA and EB Parramatta for toilet flushing, and Building F at Kingswood for grounds irrigation.
- Rainwater harvesting off the roof with storage for re-use is an integral component of the National Protected Cropping Research Facility at Hawkesbury.
- Water efficient fixtures are established in architectural guidelines for building refurbishments.

3.3 Building fabric and services

WSU has now a considerable number of Green Star accredited buildings, along with a range of examples of adaptive reuse of older buildings. Maintenance systems are in place for over 500 buildings across the traditional campuses, along with the new CBD campuses and developments as part of the Western Growth Strategy.

- Green Star accredited buildings include the Parramatta Science Building (6 Star), Liverpool CBD campus (5 Star), The Peter Shergold Building (1PSQ) (5 Star), Kingswood Library (5 star), College Buildings at Nirimba, Kingswood and Bankstown (5 Star) and Werrington Park Corporate Centre (5 Star). Planned builds include Werrington Retail Centre (5 Star) and Bankstown CBD.
- Examples of adaptive reuse include the Female Orphan School, Parramatta campus, and the R precinct buildings at Hawkesbury, including offices and laboratories for the Hawkesbury Institute for Environment (Buildings R2 and L9).

3.4 Research facilities

Infrastructure strategies for research protection are in place for the broad range of research facilities across WSU campuses. These include design elements for particular laboratory uses, service continuity for building facilities, and risk management for external facilities.

- Research protection strategies for building facilities include uninterrupted power supplies and generator backup for critical equipment.
- For the EucFACE facility of Hawkesbury campus a drenching system, supported by the Hawkesbury Bushfire Unit comprising staff with Rural Fire Service Training.

3.5 Outdoor operations (Hawkesbury farm and environmental assets)

On Hawkesbury campus, however, the estate also comprises an area of commercial agricultural operations, teaching and research of horticulture and protected cropping, a significant remnant of Cumberland Plain Bushland, stormwater harvesting and recycled water distribution, and a range of embedded commercial leases of varying uses. Small patches of native vegetation are managed on Parramatta, Kingswood, Bankstown and Campbelltown campuses. Risk management strategies in place include:

- Use of recycled water and harvested stormwater in times of drought or low rainfall.
- Oversight by Campus Security if an emergency or incident arises.
- Restrictions on access and activity by contractors for Total Fire Ban conditions.
- Biosecurity procedures in place for farm and horticultural facilities.
- Land management to reduce risks and enhance preparedness for bushfire.
- Weed management in bushlands though utilisation of bush regeneration strategies.

3.6 Public spaces

For most campuses, the landscapes are maintained for amenity and safety through design. Plant species are chosen for appropriateness to public open spaces in the harsh climate of Western Sydney. Mature trees are maintained through accredited arborists. Steps are underway for established and future campuses to consider the following:

- Building towards precinct amenity relevant to Green Star community accreditation.
- Increasing integrated cooling and shading elements, such as trialling car park solar to contribute to peak load reduction, shading and amenity, accessibility and safety through design.

4. PROPOSED WSU STRATEGIES

4.1 Strategy 1. Embedding resilience in WSU strategy and planning

Continue to develop and embed resilience planning in a manner consistent with WSU strategic values and operational strategies. This will include:

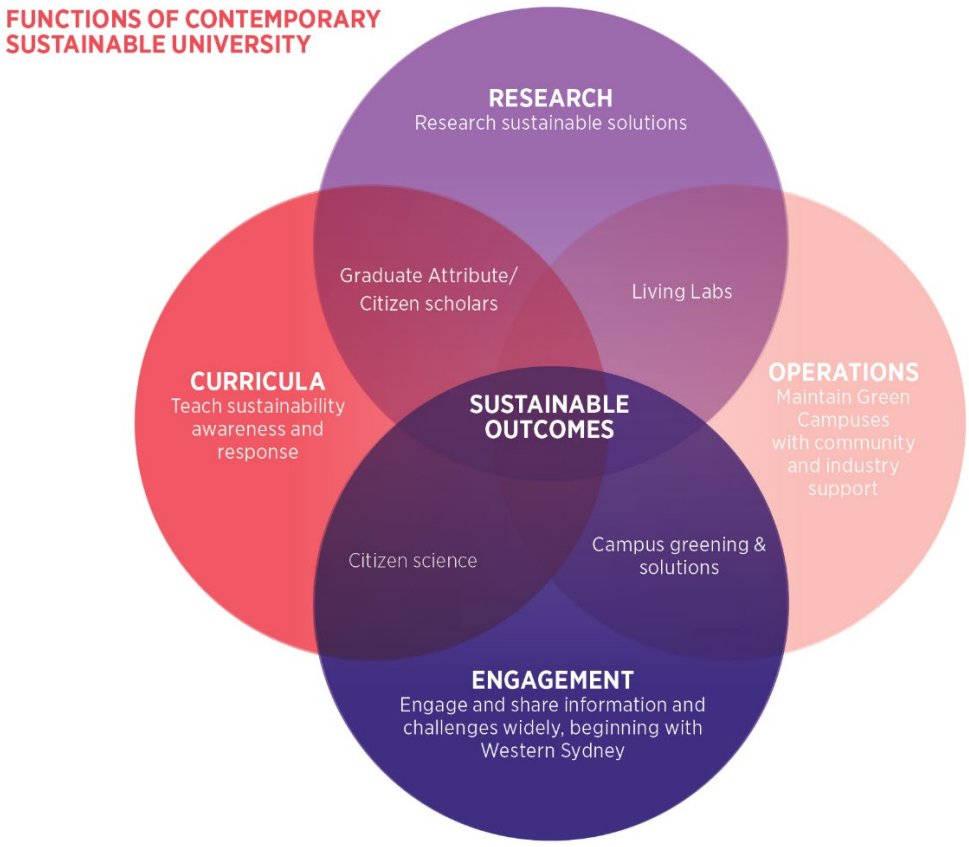
- Building integrated capacities across functional domains of WSU
- Embedding key integrative concepts, such, as Living Labs. in WSU strategy, and
- Building on Green Star accredited buildings towards green star community precincts.

4.1.1 Building integrated capacities across functional domains of WSU

Strengthening WSU as a sustainable university, as represented by the CORE model of sustainability (curricula, operations, research and engagement) (Figure 1), and a particular focus on the overlapping domains of:

- Enhancing the capacities of our graduate attributes as Citizen Scholars
- Promoting opportunities for utilising our campuses as Living Labs.
- Demonstrating best practices through Campus greening and solutions
- And enhancing our role and engagement in Western Sydney through Citizen Science.

Figure 1. Functions of a contemporary sustainable university



Based on Karlin, B., Davis, N. and Matthew, R., GRASP: Testing an Integrated Approach to Sustainability Education, Journal of Sustainability Education, Vol 5, May 2013

4.1.2 Embedding key integrative concepts, such, as Living Labs. in WSU strategy

In addressing the complex issues of resilience to climate change, and the broad role of WSU in Western Sydney, the key integrative capacities outlined in Strategy 1.2 can be linked explicitly with WSU development and commercial strategies.

For example, a recent paper to the WSU Executive outlined the value of leveraging the Living Lab. concept as a framework to underpin precinct strategies, *"positioning the University for the future as an advocate and leader of utilising and developing campuses as integrated learning and development platforms by:*

- *Connecting campuses within the broader precinct strategies developed by local government agencies*
- *Leveraging into future sustainability precincts – i.e. green star buildings to green star precincts*
- *Addressing complex issues facing Western Sydney communities, e.g. urban heat, climate change & resilience of communities and infrastructure,*
- *Enabling replication and variation dependant on location, socio-economic environment and specialist academic context with various precincts in the Western Sydney corridor."*[1]

4.1.3 Building on Green Star buildings towards Green Star community precincts

Building upon the number of Green Star accredited buildings (Section 3.3), these design processes can be used to leverage towards the planning, design and implementation of integrated Green Star community precinct. These will by their nature address:

- Integrated designs for resilience to climate change risks which also address community amenity and accessibility
- As examples of the location dependence above can vary from established campus precincts (e.g. Hawkesbury), repurposing of campuses (e.g. Werrington campuses and integration with Kingswood campus and Werrington Retail Centre), and vertical campuses in shared city precincts (e.g. Parramatta Square, Liverpool and Bankstown campuses).

4.2 Strategy 2. Develop integrative infrastructure strategies and interventions

Interventions should which seek to address multiple symptoms and aspects of climate change risks, i.e. precinct urban design, renewables and energy efficiency, infrastructure design and lifecycle, amenity and cooling, safety through design. These include:

- Infrastructure strategies identified in preliminary risk assessment
- Incorporate design and operational strategies recommended by NSW Property Council
- Incorporation of renewable energy opportunities, and peak load reduction
- Design and operation of infrastructure within a strategic asset planning strategy informed by climate change risks
- Design to address urban heat affects through cooling strategies which provide for community amenity, safety through design and accessibility

[1] Leveraging the Living Lab concept, Strategy development, 11 February 2019.

4.2.1 Infrastructure strategies identified in preliminary risk assessment

Following the preliminary risk assessment of WSU infrastructure services (Section 2), strategies underway and established initiatives include the following:

4.2.1.1 Develop a comprehensive energy strategy, incorporating:

- Hedging energy price uncertainties through increasing renewable energy supplies, both on-site and as an increasing proportion of supply agreements
- Energy efficiency measures from campus to building scales, with key strategies including peak load reduction and redundancy for research protection and critical needs.
- Redundancy in building energy systems for research protection and critical needs
- Peak demand management as a key objective, particularly during periods of extreme heat

4.2.1.2 Water supplies and resources

- Harvesting and utilisation of rooftop rainwater, stormwater and recycled water for appropriate non-potable uses
- Water use efficiency as a standard design principle for fittings, infrastructure and outdoor uses, including non-potable supplies

4.2.1.3 Building fabric and services

- Overarching Strategic Asset Planning framework to inform maintenance and infrastructure renewal, informed by climate change risks
- Design infrastructure for thermal tolerances (re Property Council)
- Energy efficiency through integrated strategies from campus networks to building services
- Passive solar design of buildings and landscapes to promote energy efficiency and amenity

4.2.1.4 Research facilities

- Research protection measures to ensure continuity of services for controlled environments and critical storages
- Bushfire mitigation strategies for outdoor research facilities

4.2.1.5 Outdoor Operations (e.g. farm, environmental assets, bushlands)

- Harvesting and utilisation of recycled water as buffer to rainfall variability
- Strategic bushfire planning and operational procedures for escalation related to risk
- Land management to be consistent with biosecurity requirements

4.2.1.6 Public outdoor spaces

- Landscape and precinct design for amenity, accessibility and safety through design
- Cooling and shade elements, in built form, vegetation and water
- Utilising rainwater and stormwater harvesting and reuse.

4.3 Apply design and operating strategies from NSW Property Council

The NSW Property Council recommendations (Attachment 1) include a range of pragmatic options for the design and operation of HVAC systems, as follows.

4.3.1 Adaptation strategies for increased HVAC demands, maintenance and cost

- Design strategies to reduce dependence on HVAC through passive design ("...natural ventilation, high performing glazing, increased façade and roof insulation, and effective shade structures." (PCA 2017)
- Design and operations to include high efficiency HVAC and controls / monitoring; increased sizing/ test sensitivity to increased temperature scenarios.
- Operations using data analytics for performance feedback, and "...the use of on-site renewable energy systems to offset energy costs" (PCA 2017).

4.3.2 Adaptation strategies for thermal comfort and heat stress

- Design and operations of sizing of HVAC, and permanent shading on northern and western facades
- Operations including improved 'thermal enveloped' (e.g. insulation, glazing, shading, cool roof technologies.
- "Review reliance of infrastructure provided by third parties and understand how extreme heat may trigger failure of infrastructure that impacts / impairs asset". (PCA 2017)
- Design and operation of areas that would be used as indoor / shade refuges through shade, increased reflectance, shading and amenity, and having extreme heat / weather plans.

4.3.3 Adaptation strategies to bushfire and extreme storms

- Design and operate appropriate air quality monitoring and filtration within buildings, along with bushfire risk management as part of emergency procedures.
- Design of critical plant location in relation to extreme storms, along with appropriate landscape selection to reduce debris, potential injury and damage.
- Ensure operations incorporate roof, signage and fixtures can withstand high wind intensity, with plant secured protected or relocated.
- Consider guards on HVAC condensers to protect from hail damage, and hail resistant materials for roofing and glazing.

5. RECOMMENDATIONS EMERGING FROM CAMPUS WORKSHOPS

A broad range of aspects and recommendations emerged from campus workshops, which were broadly mapped onto the CORE model as summarised below and presented in more detail in Attachment 2.

5.1 Workshop recommendations for Curricula

Recommendations raised related broadly to enhancing cross-disciplinary opportunities for engagement of undergraduate and postgraduate students, opportunities for broader student focus and formal recognition of these.

- Cross-disciplinary opportunities mentioned include those relating to:
  - urban heat and cooling strategies across different schools;
  - opportunities across agriculture, environmental management and engineering;
  - demonstration sites on campus for use by architecture, planning and engineering;
  - the Werrington campus development
  - the sub Major in Sustainability, and Masters of Research applied projects.
- Broader student recognition including that relating to: intergenerational student learning; 21C work-based learning and micro-credentialing, and the UN Millennium Fellowships.

A key question raised was how space for experimentation, comparative technology and innovation can be embedded in operational campus situations?

5.2 Workshop recommendations for Operations

Building upon recognition of the impacts of climate change risks a range of adaptation opportunities were identified. Coordination needs were recognised for strategic and operational responses, including integrating teaching and learning as Living Labs.

- Clear impacts on campus users included the need for water conservation, and the critical impacts on the carbon footprint and cost of energy use.
- Broad ranging adaptation opportunities were identified, including:
  - external shade and greenspace;
  - design and orientation of facilities and ESD options,
  - adaptive reuse of building stock and lifecycle management;
  - HVAC options and management of peak energy load;
  - business continuity planning;
  - sustainable land use, community amenity and increased biodiversity;
  - electric and hybrid pool vehicles and car chargers;
  - carbon foot printing and moving towards 100% carbon positive campuses building upon real reductions and resilience measures rather than off-setting;
  - minimising transport between campuses; and
  - procurement policies for corporate responsibility.
- Coordination needs include:

- business continuity, strategic asset planning and resilience planning;
- commitments to SDGs and reporting;
- longer term resilience strategies;
- engagement of research / teaching staff in governance and decision-making.

→ Opportunities for integrating teaching and learning through Living Labs included:

- OEC pilots with 21C students as partners;
- working with industries for research student training and on-campus jobs;
- international partnership opportunities such as medicinal herbs cultivation with Beijing; and
- water supply and recycling options.

5.3 Workshop recommendations for Research

Discussions included the challenges for ongoing operation of research infrastructure, emerging opportunities for multidisciplinary research, and areas of current research which can be enhanced as Living Labs and resilience strategies.

→ Challenges for research infrastructure and operations included: impacts of rainfall variability and biosecurity issues on horticultural / protected cropping research.

→ Opportunities for multidisciplinary research included: engagement of engineering and cultural theorists, health impacts of climate change risks, and challenging assumptions and methodologies underpinning risk rating.

→ Key areas of current research which could be enhanced as Living Labs include:

- Adoption of CO2 enhanced concrete
- Sustainable affordable prefabricated housing, campus housing
- Solar energy: life cycle and performance, and electric car charging
- Green Star projects on campus: life cycle and occupant behaviour
- Mitigation measures and targets
- Integrated energy, water and waste systems
- Benefits of resilience
- Living lab. frameworks and institutional capacity

5.4 Workshop recommendations for Engagement

Key discussion points for engagement included improved alignment and coordination, opportunities for student engagement and Living Labs, and enhanced communication strategies.

→ Improved alignment between operations and teaching

→ Student engagement and Living Labs through:

- Projects, internships, research projects with citizen scholar recognition

→ Communication strategies for resilience and greening the campuses, enhancing:

- Recognition of exceptional activities (e.g. solar car and Millennium Fellowships)
- Internal communication and cross-unit collaboration
- Forums, lunch time information sharing

- Introductions to who's who and what processes in place
- Inductions for buildings, explaining why things are being done
- Orientations to campuses: being on country, being on sustainable campuses

→ Opportunities to demonstrate best practice on campuses

- Encourage public / industry / government to see outstanding facilities
- Increase goodwill and sense of community on campuses
- Recognition / professional development recognition
- Staff / student engagement and sustainable improvements.

ATTACHMENT 1. RESILIENCE PLANNING IN CONTEXT

This first stage of a resilience planning process focuses on risks of climate change to campus infrastructure, and the range of communities of practice within our campuses. Outcomes of this process will seek to complement and inform a number of areas of WSU operations, including the design of our campus assets and precincts, campus operations and maintenance, community engagement, emergency preparedness and response, and business continuity.

Resilience planning is emerging as a common strategy to identify adaptations which address shocks and stresses on our infrastructure and communities. In the case of impacts of climate change for example, those shocks and stresses include extremes of heat and bushfire, storms and flooding. A number of resilience strategies are developing, including that of Resilient Sydney (RS), the Property Council strategy document on climate change risk, and an RMIT benchmark study of resilience planning in Universities.

Proposed Strategy

Building upon these regional initiatives, it is timely for WSU to begin a resilience planning exercise focusing on risks from climate change on our campus assets and infrastructure, and the communities of practice who use our campuses. It is proposed that a staged approach be undertaken, with the following steps resulting in a Stage 1: Preliminary Resilience Assessment. The suggested approach will:

- Adapt the RS methodology, focusing on campus assets and communities of practice.
- Invite involvement of sustainability researchers as a reference group.
- Compile a discussion paper and circulate to reference group and stakeholders.
- Convene campus workshops to add value to the discussion paper.
- Compile feedback, outlining key risks, emerging strategies, and next steps.

Resilience and climate change risks

There is a growing recognition of the need for strategies to address the impacts of chronic stresses, such as climate change, and acute shocks, such as natural disasters, on our critical infrastructure and communities. Urban resilience has emerged as a way of viewing these systemic issues, with a common definition that "...the capacity of individuals, communities, institutions, businesses and systems within a city to survive, adapt and grow no matter what kind of chronic stresses and acute shocks they may experience". (ASBEC quoting 100RC Rockefeller Foundation). In considering how our organisation can contribute to a more resilient society, ASBEC suggested the following principles and key questions:

- "Flexible. Alternative strategies can easily be adopted to deliver critical services, depending on the circumstances.
- Reflective. Past experiences inform future decisions and actions
- Robust. Systems are well-conceived, constructed and managed. Any failure is predictable, safe, and proportionate.
- Inclusive. Broad and meaningful engagement – aiming to create a sense of shared ownership among stakeholders.
- Integrated. Connections between systems and institutions are harnessed to generate multiple benefits.
- Resourceful. Seeking better ways to use existing resources, both in good times and bad.
- Redundant. Spare capacity exists to allow continued functioning even when disrupted." (ASBEC).

Planning and developing strategies for resilience in the face of climate change risks is becoming a common challenge for our governments, cities, businesses and communities. The National Climate Resilience and Adaptation Strategy (DEE 2015) has summarised guiding principles and priorities for national engagement (Table 1). The Strategy outlines the need for the dual approach of mitigation and adaptation to managing a changing climate:

- "Climate change mitigation works to avoid the risks of a changing climate by reducing the emission of greenhouse gases and preventing more severe climate change
- Climate change adaptation works to manage the risks caused by climate change already locked in and from the potential for more severe changes in the future". (DEE 2015)

Table A1.1. Guiding principles (DEE 2015)

Shared responsibility Governments at all levels, businesses, communities and individuals all have important roles to play	**Factor climate risk into decisions** Consider the current climate and future change in all our decisions	**Assist the vulnerable** Support those who are vulnerable to disaster risk and climate change
Evidence-based, risk management approach Apply the best available science	**Collaborative values-based choices** Respect the knowledge and experience of those affected, and involve them in decision-making	**Revisit decisions and outcomes over time** Review actions regularly, look for flexible choices and opportunities

Climate change implications for Western Sydney

Reports of climate change modelling include the Climate Change in Australia Projections: East Coast Cluster Report (CSIRO and BOM 2015), and The Metropolitan Sydney Climate change snapshot (OEH 2015). Details of the East Coast Cluster Report, including the projections used and key modelling outcomes, is provided in Attachment 1.

Regional modelling for Metropolitan Sydney, including the Cumberland Plain to the Blue Mountains has been reported as part of the NSW and ACT Regional Climate Modelling project (NARCliM) (OEH 2014). Western Sydney average summer temperatures are reported as 22-24 OC, with average summer maximum temperatures of 28-30 OC and on average 10-20 hot days per year.

A summary of general monitoring results for the Sydney Metro region, in Table 2, noting that in relation to hot days per year above 35 OC, "The greatest increase is projected for Western Sydney and the Hawkesbury with an additional 5-10 days in the near future, increasing to over 10-20 additional hot days per year by 2070." (OEH 2014)

Table A1.2. Projected climate changes in Metropolitan Sydney (OEH 2014)

PROJECTED TEMPERATURE CHANGES	
Maximum temperatures are projected to increase in the near future by 0.3 – 1.0 OC	Maximum temperatures are projected to increase in the far future by 1.6 – 2.5 OC
Minimum temperatures are projected to increase in the near future by 0.4-0.8 OC	
The number of hot days will increase	The number of cold nights will decrease

PROJECTED RAINFALL CHANGES	
Rainfall is projected to decrease in spring and winter	Rainfall is projected to increase in summer and autumn

PROJECTED FOREST FIRE DANGER INDEX (FFDI) CHANGES	
Average fire weather is projected to increase in spring by 2070.	Severe fire weather days are projected to increase in summer and spring by 2070

Modelling for the East Coast Cluster

The national modelling reported by Dowdy et.al. (2015) is based upon four projections (Representative Concentration Pathways or RCPs) reflecting whether CO2 emissions are curbed through mitigation strategies, as summarised below. Two time periods are used for projections: near future 2020-2039 (2030 as average), and later this century 2080-2099 (2090). Projections used in climate modelling simulations were as follows:

- RCP8.5 - Little curbing of emissions. CO2 concentrations reaching 940 ppm by 2100
- RCP6.0 - Some mitigation strategies, with CO2 conc. reaching 670 ppm by 2100.
- RCP4.5 - Higher early conc. then decline to stabilise at 540 ppm by 2100
- RCP2.6 Low emissions, peaking 2020, the falling to 420 ppm by 2100.

TableA1.3. Key modelling outcomes for the East Coast Cluster (Dowdy et.al. 2015)

Substantial warming in mean, max. and min. temperatures with high confidence in all RCPs for near future, and increasing impact of higher increases later in RCP4.5 and RCP8.5 (e.g. 2.7-4.7 OC increase for RCP8.5 by 2090 compared to 0.8 OC increase recorded between 1910 and 2013).	Increase in temperature., frequency and duration of heat with very high confidence, e.g. for RCP4.5 by 2090 near Brisbane, double number of days >35 OC and triple no. days >40 OC.
Natural variability in annual and seasonal rainfall dominating in near future, with a decrease in winter rainfall and increasing seasonal variability in south with medium confidence by 2090 for RCP4.5 and RCP8.5.	Increasing intensity of heavy rainfall with high confidence, with longer time in drought in 2090 for RCP8.5.
Winter decreases in east coast lows ("southward shift of storms") with medium confidence.	Increased evaporation rates with high confidence by 2090, along with reduced soil moisture with medium confidence.
Harsher fire weather in the future with high confidence.	Increase in sea levels with high confidence, with sea surface temperature warming with high confidence and increasing acidity with high confidence.

Resilience planning at a city scale

The Resilient Sydney project builds upon the 100RC City Resilience Framework: whereby 12 key drivers are used to identify a city's ability to withstand a broad range of shocks and stresses. A broader city resilience approach to climate adaptation and mitigation is the way in which the systemic connectivity of natural and built environment, infrastructure, services and society are considered. Viewing ongoing stresses and potential shocks on the community and economy from this perspective enables new understanding, and "…identifying and managing the potential for cascading failures that create disasters". (Dawson, 2017, Dawson pers. Comm.).

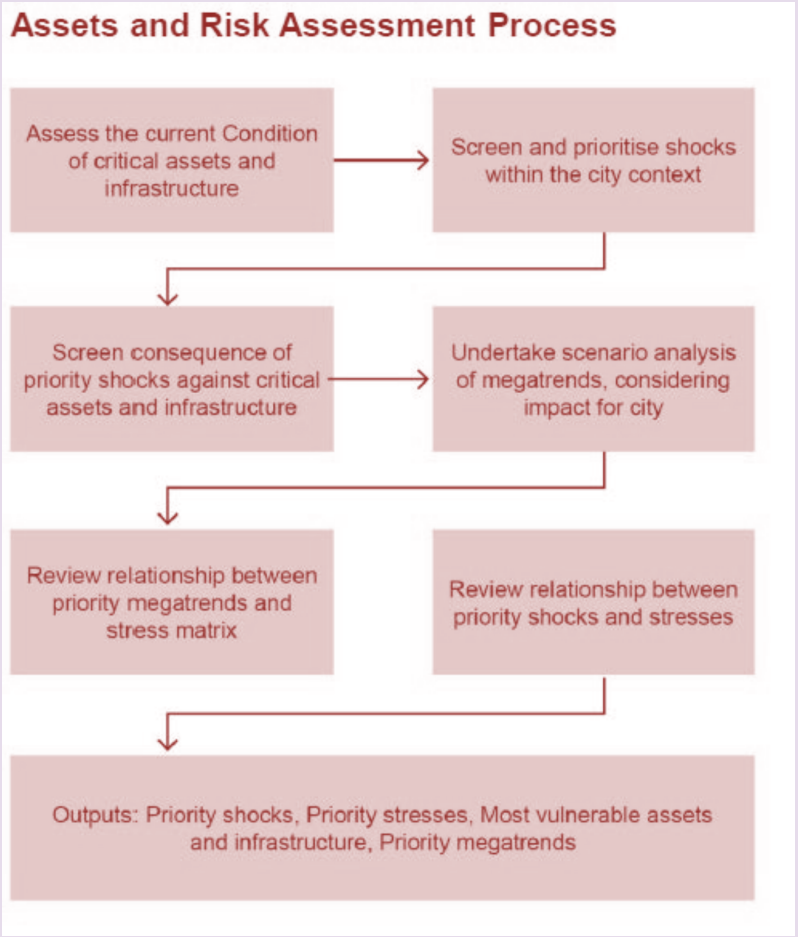
The general resilience approach for cities is to:

- *"Understand: city scale vulnerabilities & community risks;*
- *2. Include: those most affected in the decision;*
- *Diversify: to mitigate risks, collaborate for multiple benefits."* (Dawson 2017, Dawson pers. Comm.).

Application of the global resilience process to the case of Resilient Sydney is reproduced below in Figure A1.1, with additional information on the RS asset and risk assessment methodology below. The methodological strategy proposed for the impact of climate change risks on University infrastructure and communities of practice is to adapt the methodology below.

Figure A1.1. The Resilient Sydney methodology (RS 2016).

Figure A1.2. Resilient Sydney assets and risk assessment process (RS 2016)



Resilience planning for the property sector

The Property Council of NSW has developed guidance for the property industry in relation as building resilience and adaptation to climate change, focusing on the Sydney Metropolitan area. High risks to property and the built environment include "...extreme heat and bushfires, extreme rainfall and flooding, and storm and coastal inundation...". Drivers for the property sector in addressing these risks include issues of increasing insurance costs and access to insurance and operational costs, exposure to reputational damage, and impacts on workforce health and safety. General guidance for the property industry was summarised by the Property Council, with examples below in Table A1.3-5.

Emerging themes identified by the Property Council (PCA 2017) include:

- Developing organisational climate adaptation strategies which reflect commitment to embedding climate resilience across the organisation; identifying targets and actions; engaging and communicating with key stakeholders; and measuring progress and demonstration.
- Contribution of asset owners to city resilience, building upon interdependencies of strengths and vulnerabilities, with opportunities including coordination of neighbouring asset owners and tenants.

Table A1.3. Risk and adaptation opportunities for extreme heat (PCA 2017).

RISK AND IMPACT	CORRESPONDING PROJECT STAGE	ADAPTATION OPPORTUNITIES
Temperature and extreme heat		
Increased average ambient temperatures and heatwave events resulting in greater demand on HVAC systems and increased maintenance and costs	Design	• Reduced dependencies on HVAC systems by considering passive design opportunities such as natural ventilation, high performing glazing, increased façade and roof insulation, and effective shading structures.
	Design & Operations	• Plan, design and install upgrades to provide modern, highly efficient HVAC plant, equipment and controls and actively monitor system operation to ensure ongoing efficiency.
		• Consider the design life of HVAC systems, and where appropriate, increase sizing of HVAC systems to allow for 2030 scenario increased ambient temperatures, or test sensitivity of system sizing to future scenarios.
		• Reviewing the impact of energy efficiency in the context of changing climate. Ensure that climate data used is recent and relevant (i.e. not relying on TRY files from past decades).
	Operations	• Consider the use of data analytics to provide performance insights and instantaneous feedback. • Consider the use of on-site renewable energy systems to offset energy costs.

Table A1.4. Risk and adaptation: extreme heat (PCA 2017).

RISK AND IMPACT	CORRESPONDING PROJECT STAGE	ADAPTATION OPPORTUNITIES
Temperature and extreme heat		
Increased extreme heat days leading to reduced thermal comfort within buildings, particularly where existing HVAC systems and thermal comfort approaches may not be adequate.	Design & Operations	• Consider the design life of HVAC systems, and where appropriate, increase sizing of HVAC systems to allow for increased frequency of heat days or test sensitivity of system sizing to future scenarios.
		• Consider the installation of permanent shade structures or louvres along northern and western facades in order to reduce heat stress.
	Operations	• Ensure that design of HVAC plant allows for an increase in the frequency of extreme heat days over 35O C.
		• Improve thermal comfort in existing assets with an improved "thermal" envelope e.g. wall and roof insulation, double glazed/ low-e windows, external shading and 'cool' roof technology. Ensure that new leasing agreements reduce the liability of an increase in extreme heat days and reduced building performance during extreme heat events.
		• Review tenancy agreements and consider operational practices to plan for an increase number of extreme heat days and how they may affect tenants.
		• Review reliance of infrastructure provided by third parties and understand how extreme heat may trigger failure of infrastructure that impacts / impairs asset.
Increased extreme heat days leading to a greater risk of heat stress and resulting in decreased opportunities to participate in outdoor activities and a higher proportion of people seeking refuge indoors.	Design & Operations	• Provide adequate external shading and areas where refuge can be taken.
		• Integrate materials with a high solar reflectance index to reduce heat build-up.
		• Increase areas of natural landscaping and tree planting – provide increased shading and amenity to public areas through street awnings, drinking water fountains, and access to public amenity.
		• Develop extreme heat event plans to manage increased patronage.
		• Develop plan for people seeking refuge during extreme weather events.

Table A1.5. Risk and adaptation: bushfire and extreme storms (PCA 2017).

RISK AND IMPACT	CORRESPONDING PROJECT STAGE	ADAPTATION OPPORTUNITIES
Bushfire		
Increased bushfire conditions resulting in increased air pollution levels and leading to reduced air quality, smoke penetration into buildings, and ozone related health and safety issues	Design & Operations	• Increased bushfire conditions resulting in increased air pollution levels and leading to reduced air quality, smoke penetration into buildings, and ozone related health and safety issues. Design & Operation
		• Actively monitor air quality and regularly maintain filtration systems.
		• Install enhanced filtration systems where required.
		• Ensure building is well sealed.
		• Develop and implement plans to mitigate smoke ingress e.g. full recirculation mode for air-conditioning systems, closure of windows and doors.
		• Incorporate bushfire risk and policy into emergency plan / procedures.
Extreme storms		
High winds during extreme storms resulting in an increased risk of flying debris causing property damage, health and safety issues and business interruption.	Design	• Consider the location of critical plant and equipment to avoid the likelihood of impact or damage during extreme storm events.
	Design & Operations	• Consider landscaping selection to reduce debris created during strong wind events that could potentially injure people or damage building structures and vehicles.
	Operations	• Ensure fasteners are installed to roof structures, external signage and fixtures so that they can withstand an increased intensity of high winds.
		• Ensure plant located in exposed areas (i.e. on the roof) is secured to prevent debris and damage during storm events.
		• Consider relocation of plant items or implementation of protective coverings to reduce impact and potential damage.
Increased risk of hail damage and inundation of building envelope due to hail build up. Risk of structural overload from hail.	Design & Operations	• Investigate the installation of guards on air conditioning package units to protect condenser coils against damage from an increase in frequency of hail events.

Cooling the city strategy – Penrith

A leading example of a council strategic response is that of Penrith City Council's Cooling the City Strategy (PCC 2015), which addressed the effects of urban heat islands and impacts of increasing heat on community health, wellbeing, and liveability. Priority areas identified for protection against heat included: "bus stops/shelters; public exercise areas; west facing pedestrian areas around schools; main intersections; car parks; footpaths, verges, roads, roundabouts (road reserves)".

Strategies to mitigate urban heat described included those relating to:

- Green infrastructure, defined as "the network of designed and natural vegetation found in our cities and towns, including public parks, recreation areas, remnant vegetation, residential gardens, street trees, community gardens, and innovative and emerging new urban greening technologies such as green roofs and walls" (PCC 2015 citing VCCCAR 2013).
- Water Sensitive Urban Design, i.e. sustainable management through integrated design of the urban water cycle.
- Increased albedo (reflectivity), to reduce the storage of heat.
- Policy and planning controls, and
- Engagement and education.

Consolidating on existing works, tree planting and landscaping was identified as one of the most successful approaches. The regional and multi-jurisdictional nature of heat island problems require building upon partnerships with a range of key stakeholders (PCC 2015).

A recent strategy document is WSROC's (2018) Turn down the heat strategy and action plan. This strategy builds upon an assessment of urban and the impacts on people, the economy and the environment, urban cooling strategies are described including: greening urban areas, cool materials, designing with water, infrastructure adaptation, emergency and health response, education and research. Priority actions are arranged around 5 strategic drivers around which achievable resilience outcomes, along with related targets, strategic alignment and particular actions. Key targets include:

- "Increase multi-sectoral collaboration and investment to deliver more projects to address the impacts of urban heating Western Sydney by 2023.
- Reduce the average peak ambient temperature in Western Sydney by 1.5OC through water, greening and cooling materials strategies by 2023.
- Zero net increase in economic impacts of heatwaves by 2023.
- Zero net increase in morbidity and mortality impacts of heatwaves in Western Sydney by 2023." (WSROC 2018)

Cool commons and community behaviour

The pilot research project Cooling the Commons (ICS 2016) investigated how residents in Western Sydney respond to heat impacts in their day practices, constraints, and their aspirations to improve environmental comfort and wellbeing. Spaces that offer cool respite, or accessible 'cool commons', were used to identify effective ways to guide urban design and public policy which can support grassroots adaptations.

Appreciation of 'residual cool commons' was found to be clear; cool spaces where tree planting or access to river shores was maintained. People are increasingly drawn to 'transgressive cool commons' such as air-conditioned spaces of shopping centres or family restaurants, and use of water features. The key finding related to 'aspirational cool commons' that people would like to see, "...linked to the provision of basic cooling amenities (shade, shelter, water) coupled with the provision of paths and walkways. They were also linked to improved access to water play, parks and pools". (ICS 2016). The need to recognise the context of normative social practises, and support co-design by communities directly affected, was a recommended direction for future research.

Resilience planning in the University sector

In 2015, a benchmarking survey was undertaken by the RMIT Campus Climate Risk & Resilience Project of more than 100 universities and tertiary institutions in Australia and overseas. While more than half had mitigation strategies through emission reduction targets only a small number have or are underway with plans for adaptation, though almost a third steps towards adapting to climate change impacts. Mitigation targets were found to be associated more directly with economic and reputational drivers. Complexity and uncertainty, and expertise uncoordinated with operational planning was found to be common (Kautto et.al. 2016).

Western Sydney University context

As outlined in the introduction, this broad context and the Resilient Sydney methodology will be adapted to address the particular shocks and stresses on campus infrastructure and communities here at Western Sydney University. This builds upon a range of management initiatives underway, which while the majority do not target resilience as such, still do have critical relevance to either adaptation or mitigation strategies. These include, but are not limited to:

- Green Star buildings, such as the 6 Star Green Star Science Building at Parramatta, which incorporate efficiency, building behaviour, and robust amenity in their integrated design. Also, architectural design guidelines for refurbishments which incorporate a number of characteristics relating to efficient and robust design.
- Maintenance planning to minimise reactive efforts, along with emergency response protocols and redundancy measures for potential failures, particularly for critical systems for business continuity and research protection. Condition assessments undertaken for asset portfolio.
- A broad range of energy savings initiatives already underway which contribute to mitigation and adaptation, such as load shedding on Parramatta campus. A comprehensive assessment of current initiatives both on campuses for energy savings, and emerging market opportunities such as a photovoltaic solar farm on Hawkesbury campus, are being increasingly rolled out.
- The coordinated use of non-potable water resources, particularly on Hawkesbury campus where recycled water and stormwater are utilised for farm productivity and landscape amenity, as a demonstration of best practice peri-urban landscape and water cycle management (e.g. Attwater and Derry 2017).

Proposed steps in developing a Preliminary Resilience Assessment

This discussion material is intended as an initial broad introduction to the issues of resilience to infrastructure and communities within our campuses. The review above outlines the general shocks and stresses from climate change risks in Western Sydney, and a range of views on emerging strategies and tactics required. The proposed next steps are to:

1. Distribute the discussion paper to an initial WSU reference group
2. Develop a preliminary format for a workshop with representatives of the reference group, with material and structure based upon an adaptation of the 100RC methodology applied by Resilient Sydney.
3. Convene this workshop with representatives of the reference group.
4. Compile a Preliminary Resilience Assessment based upon this process.

Reference group

This discussion paper will be distributed to a reference group including researchers involved with the Office of DVC (R&I) Sustainability Theme Champions, senior staff who have previously contributed to the Resilient Sydney Project, and staff involved in operational facility management. The discussion paper will also be distributed to key external stakeholders involved in developing resilience strategies.

100RC Methodology used by Resilient Sydney

As outlined in the Resilient Sydney 2016 Preliminary Resilience Assessment, general methodological steps were as follows, (Figure 1 and Attachment 2). Phase 1 comprised the application of a range of tools, including those relating to:

- → University context
  - Critical and vulnerable assets and infrastructure
  - Trends and actions already underway
- → Key shocks, stresses and trends (acute and chronic)
- → Asset and risk assessment process (Attachment 2)
- → Key challenges emerging / discovery area
  - Tactical actions
  - Embedding resilience thinking in campus actions

ATTACHMENT 2. SUMMARY OF CAMPUS WORKSHOPS

Through campus workshops in November 2018, the CORE model was used to map recommendations and suggestions which are summarised in the following sections.

Curricula.

Suggestions relating to curriculum included enhancing cross-disciplinarity in programs, and engagement of undergraduate and postgraduate students, with themes mentioned including:

- Urban heat / cooling teaching opportunity (5 different schools)
- Agricultural, environmental management and engineering as sustainable systems
- Opportunity for a demonstration house at Penrith campus for architecture, town planning and engineering students, and a
- Sub major in Sustainability.

Opportunities for broader student focus and recognition identified included:

- Werrington campus development
- Masters of Research applied projects
- Intergenerational student learning
- 21C work-based learning and micro-credentialing, and
- UN Millennium Fellowships.

One key question raised was the space for experimentation in operational campus situations (Where does it go? learning from failures; testing different techs for same functions, and how this feeds into innovation?).

Operations

Impacts upon campus users of climate change included:

- Water conservation (all impacted)
- Natural and man-made climate change impacts carbon footprint
- High cost of energy use

Adaptation opportunities include:

- External shade options
- HVAC options
- Entire lifecycle of building stock
- Include ESD options as mandatory
- Business continuity planning
- Sustainable land use
- Management of peak load
- Design of facilities – orientation
- Green space – create green canopies

- Adaptive reuse of existing building stock
- Community amenity
- Increase biodiversity
- Plug in electric and hybrid for WSU pool vehicles
  - Fleet of mobile batteries
- 100% renewable carbon positive campus, whole university
- Electric car chargers
- Carbon foot printing to create baseline
- Minimise transport between campuses
- Place-based real reductions and resilience measures rather than off-setting
- Procurement policies for corporate responsibility (e.g. plastic bottles)

A broad range of coordination needs were identified in the workshops, including those related to:

- Coordination with business continuity, strategic asset planning and resilience planning across WSU
- WSU commitment to Sustainable Development Goals
- SDG reporting
- Longer term resilience strategy e.g. 2030, 2050
- Engagement of research and teaching staff in governance / decision-making

A number of opportunities for integrated teaching and research as Living labs were identified,

- OEC develop pilots – students as partners 21C
- Work with companies to establish research projects
  - (e.g. Horticulture company) - research income to WSU; student training and on-campus jobs.
- Chinese Herbal Medicine Cultivation with Beijing University of Chinese Medicine (BUCM) / Chinese Medicine Centre (WSU and BUCM) - benefits / issues: funding, health, community, international partnership
- Water supply and recycling options –Challenges for ongoing research infrastructure identified, include:

Research

Challenges for ongoing research infrastructure identified, include:

- Rainfall variability will affect the S40 water supply and research projects
- Biosecurity issues in WSU's high tech greenhouse

A broad range of opportunities for multidisciplinary research was identified, including:

- Better engagement between engineering & cultural theorists
- Health impact of climate change – input from YHI and health academics
- Challenge assumptions / methodology used to assess climate change, e.g. 1 in 100 flooding is outdated

Key areas of current research which can be enhanced as Living Labs and a way forward include:

- CO2 concrete: Using CO2 and recycled material to produce concrete products that is as strong as virgin concrete and cheaper; long-term direction, WSU can be the leading adopter
- Sustainable affordable housing: using prefabrication; cost and time reduction in production; meet population growth demand; Werrington Estate development
- Solar panels: long-term cost and energy benefits; life cycle and performance
- Green star projects on campus: energy savings; cost savings, emissions reduction; long-term performance; life cycle analysis; occupant behaviour
- Mitigation measures, emissions reduction: reduce CO2 by 2030 (similar as most city councils); ways to reduce CO2 for different sectors.
- Research and demonstration of prefab homes and neighbourhoods to make greener / cheaper construction (current proposal with BuiltSmart)
    - Partnership with Landcom
    - People who occupy homes report data on home performance
- Living labs:
    - Electric car charging, plug in electric and hybrid
    - Champion of best practice
    - Integrated energy, water and waste systems, e.g. FLO systems
    - Research and demonstration of prefab homes
- Benefits of resilience
- Waste – ISF (UTS) & ICS collaboration ? / WSACo
- Living labs sandbox
    - Framework for experimenting, documenting, tracking, building year on year through curriculum and projects (link to MRes projects)
    - Also building institutional capacity, knowledge and memory
- Onsite community and affordable housing
    - Performance of student / staff housing on campus?
    - (concept house village Rotterdam)

Engagement

Improved alignment and coordination was one key theme, with reference to:

- Better alignment between operations and teaching

Opportunities for student engagement and Living Labs. include:

- Engage students to work on projects / Internships / research projects
    - Free
        - The Academy
        - Units of study e.g. Internship and community engagement, 60 hours
        - Citizen scholar awards – volunteering / internships

Enhanced communication strategies were identified as a major opportunity, including:

- Communication strategy for institutional resilience
- Greening the campus…
  - Lecture series, talks, showcase
- Communications strategy
  - We're doing some great things…but we don't know it
    - E.g. solar car and Millennium Fellowships are known about internationally…but not more…
  - Internal communications
    - University website doesn't help us communicate / learn about ourselves
    - Internal promotion of what we've done and what's happening
    - Get this right and it would help cross-unit collaboration
  - Nb my voice survey results
  - It would be worth considering having a forum where staff from units / departments get together to share information, collaborate and celebrate achievements
  - Lunch time sessions
    - Provide opportunities and time to share / engage
    - Who to approach?
    - Knowing the structures of the University and acronyms / who's who
  - PMO, ICT, OEC, Strategic Procurement
- Induction –'how to use this building'
  - Literacy of tech. measures (Louise's west facing sensor example)
  - Telling the stories – qualitative narratives alongside numbers
    - Telling people why we are doing what we're doing
    - Ask for participation
- Orientation
  - To being on country on campus – a sustainable campus "this is how we do things"

Areas of improvement from engagement include:

- Huge amount of green waste from S40 greenhouse, produces 25 tonnes (6/17 to 10/18) donated to food bank; Waste ??? tonnes
  - Paid / Jobs on campus/ Paid internships

Opportunity for demonstrating best practice on our campuses, through:

- Champion of best practice
- Encourage public / industry / govt. to see our outstanding facilities (once they're here)

Opportunities to build upon communication strategy to increase goodwill and sense of community:

- → Investing in goodwill
  - Professional development metrics / points to allow / reward meeting up / sharing ideas/practice/learnings
    - > What's the value?
- → Defining community of practice
- → Staff / student engagement with sustainable outcomes / improvements
  - Behavioural change
  - How to do this well
    - > Autonomy
    - > Ongoing information
    - > Getting people invested in the outcomes

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