APPENDIX AA

2 October 2018

The Hon. Gladys Berejiklian
Premier of NSW
Parliament House
Macquarie Street
Sydney NSW 2000

CC: The Hon. Gabrielle Upton, New South Wales Minister for the Environment
CC: The Hon. Niall Blair, New South Wales Minister for Primary Industries
CC: The Hon. Stuart Ayres, New South Wales Minister for Western Sydney

Dear Ms Berejiklian,

We are writing to express our deep concern regarding the *Water NSW Amendment (Warragamba Dam) Bill 2018* that is currently before the NSW Parliament[i]. This amendment will nullify section 153B of the National Parks and Wildlife Act 1974[ii] allowing the temporary dam inundation of two national parks, a world heritage property, a declared Wilderness area, a declared Wild River, a National Heritage site and the Warragamba Special Catchment Area by the proposed 14 metre raising of the Warragamba Dam wall. **We call on you to withdraw the Water NSW Amendment (Warragamba Dam) Bill 2018 from the NSW Parliament, and that plans to raise Warragamba Dam be taken off the table immediately.** Raising Warragamba Dam wall would put the Australian Federal Government in clear contravention to the World Heritage Convention[iii], and would justify placing the GBMWHA on the World Heritage in Danger List.

These natural areas are of the highest conservation value in Australia that should be preserved at all costs. There is yet to be even an environmental assessment completed on the impacts of the proposed dam development. The largest of flood events would inundate up to 4,700 hectares of national parks and 65 kilometres of wilderness streams above the current full storage level of the dam[iv]. Inundation of this nature would result in extensive and irreversible damage to the integrity of the Greater Blue Mountains World Heritage Area (GBMWHA).

In 2000, the Blue Mountains National Park was listed on the World Heritage Register due to its "*exceptional representation of major eucalypt groups", "exceptional diversity of habitats… of the Australian fauna within a single place*" and outstanding ecological integrity[v]. The Warragamba Dam wall raising proposal would have a significant impact on these values, as well as the values for which the parks themselves are gazetted. For example, the nationally threatened Camden White Gum (*Eucalyptus benthamii*)[vi] and the critically endangered Regent honeyeater (*Anthochaera phrygia*)[vii] are two key species whose future existence would be threatened by the dam raising proposal[viii]. At least 25 threatened species are known, or are likely to occur, within the national park estate that would be inundated by the proposal[ix]. Numerous Indigenous cultural heritage sites, belonging to the Gundungurra people of the southern Blue Mountains, are also located within national parks that would be inundated by the dam wall raising. Delicate cave art, rare eucalypt scar trees, dreaming waterholes and marker sites are amongst the cultural heritage sites that would be submerged by a raised dam wall[x]. An Aboriginal Place application was submitted to the NSW

Office of Environment and Heritage by traditional owners earlier this year in a further attempt to protect their cultural sites from the proposal.

It should also be noted that the Blue Mountains National Park Plan of Management explicitly recognises the cultural, National Heritage, scenic, catchment, wilderness, wild rivers and recreational values of the park[xi]. These values would also be degraded by the proposal, most notably through the artificial inundation of the declared Kowmung Wild River and the associated catchment values which protect Sydney's drinking water supply. The proposed Bill seeks to remove the national park lands within the World Heritage Area from being subject to the Blue Mountains National Park Plan of Management. We view this as a retrograde step in the protection of Australia's World Heritage estate.

Several flood mitigation options have been identified as alternatives to raising Warragamba Dam wall, although it appears they will not be adequately investigated during the environmental impact assessment process[xii]. Leading flood and water quality experts believe that mitigating flood risks in the Hawkesbury-Nepean Valley can be achieved through several equally cost-effective alternatives[xiiixiv]. These include managing the existing storage of Warragamba Dam to mitigate floods, significant improvements in downstream evacuation routes, increased ability for flood forecasting, and the adoption of international best practice floodplain development controls in the Hawkesbury-Nepean Valley. **Such options would not cause environmental degradation within the World Heritage Area upstream of Warragamba Dam wall.** It is evident that housing development of downstream floodplains is a key driving factor for the dam wall raising proposal. Infrastructure NSW has said it forecasts an additional 134,000 people to live on downstream floodplains over the next 30 years[xv], more than doubling the existing floodplain population[xvi].

The impacts of temporary inundation caused by the raising of Warragamba Dam wall would significantly degrade the integrity of Blue Mountains National Parks, and therefore the outstanding universal values of the GBMWHA. Because of this, the proposed legislation and the Warragamba Dam raising proposal should be withdrawn. We call on the NSW Government to ensure that any further decisions made regarding flood mitigation in the Hawkesbury-Nepean Valley be informed by the best available scientific advice, and that all impacts on National Park and World Heritage values be avoided.

Yours sincerely,

Peter Garrett AM
Former Minister for the Environment and Arts
Former President of Australian Conservation Foundation

Bob Debus AM
Former NSW Attorney General and NSW Environment Minister

Geoffrey Cousins AM
Former President, Businessman and Environmentalist
Former President, Australian Conservation Foundation

Bruce Gall
Former Director
Queensland National Parks and Wildlife Service

Dr Graeme L. Worboys
(Hon) Associate Professor
Fenner School of Environment and Society, Australian National University

Kim de Govrik
National Parks Area Manager
Kanangra

Professor Richard Kingsford
Professor of Environmental Science
Director of Centre for Ecosystem Science
School of Biological, Earth and Environmental Sciences, University of New South Wales

Sharyn Halls
Gundungurra Elder

Kazan Brown
Gundungurra Traditional Owner

Associate Professor Willem Vervoort
Associate Professor Hydrology and Catchment Management
Sydney Institute of Agriculture, School of Life and Environmental Sciences, the University of Sydney

Dr Carolyn Pettigrew
Former head of Information Services
NSW National Parks and Wildlife Service

Associate Professor Stuart Khan
School of Civil and Environmental Engineering, University of New South Wales

Dr Hayden Washington
Environmental scientist
PANGEA Research Centre, University of New South Wales

Professor Michael Archer
School of Biological, Earth & Environmental Sciences, University of New South Wales

Dr Nikki Thurgate
Research Project Coordinator/Senior Research Fellow
Centre for Freshwater Ecosystems, School of Life Sciences, La Trobe University

Professor Andrew Pitman
Professor of Climate Science, University of New South Wales

Associate Professor Jamie Pittock

Fenner School of Environment and Society, Australian National University

Ross Crates
Postdoctoral Researcher
Fenner School of Environment and Society, Australian National University
Debbie Andrew
Former Senior Project Officer
NSW National Parks and Wildlife Service and Office of Environment and Heritage

Roger Lembit
Ecologist

Michael Doherty
Plant Ecologist
Fenner School of Environment and Society, Australian National University

Emma Spencer
PhD student in Ecology
School of Life and Environmental Sciences, University of Sydney

Michael Jackson
Archaeologist/Cultural Heritage Advisor
Jackson Ward Archaeology

Dr Val Attenbrow
Archaeologist, Research Affiliate
Department of Archaeology, the University of Sydney

Dr Margaret Moussa
Lecturer in Economics
School of Business, Western Sydney University

Janice Wilson
Principal Archaeologist
Umwelt (Australia) Pty Limited

Wendy Goldstein
Lecturer/Director of Master Sustainable Development Program
Department of Environmental Sciences, Macquarie University
Former Head Environmental Education at IUCN Switzerland (1992-2005)

Dr David A. Tierney
Honorary Senior Research Fellow, the University of Sydney

Professor Christopher Dickman
Professor in Terrestrial Ecology
School of Life and Environmental Sciences, the University of Sydney

Associate Professor Mathew Crowther

Associate Professor
School of Life and Environmental Sciences, the University of Sydney

Professor Glenda Wardle
Professor of Ecology and Evolution
School of Life and Environmental Sciences, the University of Sydney

Mick Rodrick
Birdlife Australia

Ian Pulsford
Protected Area and Linking Landscape Specialist

Anne Dickson
President
National Parks Association of NSW

Kate Smolski
Chief Executive Officer
Nature Conservation Council of NSW

Paul Sinclair
Director of Campaigns
Australian Conservation Foundation

Jim Morrison
President
North Coast Environment Council Inc.

Rob Pallin
Paddy Pallin Foundation

Keith Muir OAM
Director
Colong Foundation for Wilderness

Madi Maclean
President
Blue Mountains Conservation Society

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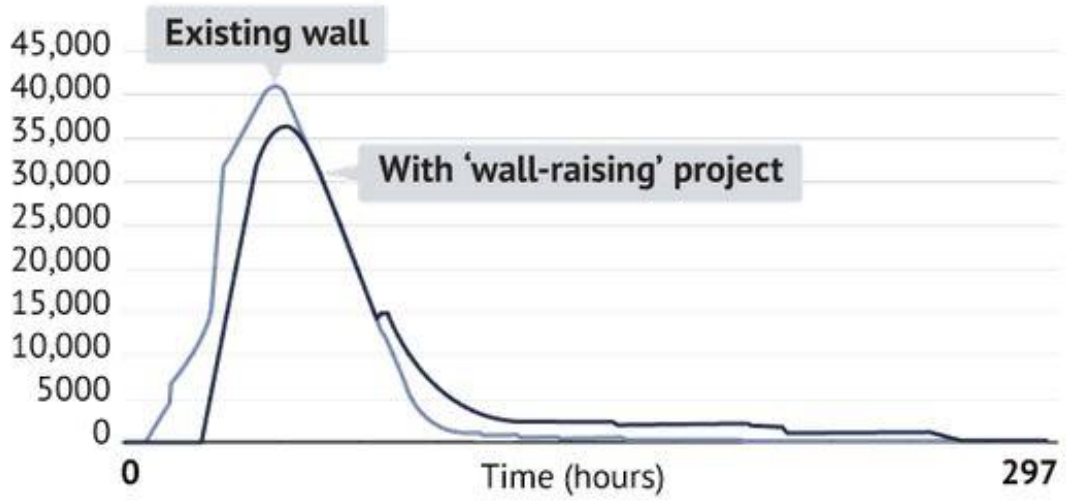
[i] *Water NSW Amendment (Warragamba Dam) Bill 2018 (Cth).* Retrieved from https://bit.ly/2QLj4Sn
[ii] National Parks and Wildlife Act 1974 (Cth) s. 153B. Retrieved from https://bit.ly/2OAVOoB
[iii] UNESCO. (2017). World Heritage Operational Guidelines for the Implementation of the World Heritage Convention, paragraphs 96-98. Retrieved from https://bit.ly/2znvhWr
[iv] WaterNSW. (2016). Prepared by BMT WBM Pty Ltd. Warragamba Dam Raising Preliminary Environmental Assessment, p. 26. Sydney, Australia. Calculated from inundation extents published in Warragamba Dam Raising Preliminary Environmental Assessment. Retrieved from https://bit.ly/2rzXjtz
[v] NSW Office of Environment & Heritage. (2009). Greater Blue Mountains World Heritage Area Strategic Plan. Sydney, Australia. Retrieved from https://bit.ly/2rEX1l6

[vi] Butcher, P.A., Skinner A.K, & Gardiner C.A. (2005). Increased inbreeding and inter-species gene flow in remnant populations of the rare Eucalyptus benthamii. *Conservation Genetics,* 6:213-226.
[vii] Colong Foundation for Wilderness Media Release (2018). Government attempts cover-up of NSW's rarest bird. Retrieved from https://bit.ly/2QQ3RPN
[viii] NSW Department of Planning and Environment. (March 2018). Secretary's Environmental Assessment Requirements (SEARs). Retrieved from https://bit.ly/2znglYy
[ix] WaterNSW. (2016). Prepared by BMT WBM Pty Ltd. Warragamba Dam Raising Preliminary Environmental Assessment, p. 13. Sydney, Australia. Retrieved from https://bit.ly/2rzXjtz
[x] Guardian Australia. (2018). Warragamba dam wall plan 'would flood 50 Aboriginal heritage sites'. Retrieved from https://bit.ly/2G3LAwF
[xi] NSW National Parks and Wildlife Service. (2001). Blue Mountains National Park Plan of Management. Sydney, Australia. Retrieved from https://bit.ly/2PXlCLL
[xii] Pittock, J. (2018). Managing flood risk in the Hawkesbury – Nepean Valley. Alternative options to raising Warragamba Dam wall. Available online https://goo.gl/1BgoUk
[xiii] Ibid
[xiv] Khan, S. (2012). Submission: Inquiry into the adequacy of water storage in NSW. Retrieved from https://bit.ly/2pvgW4N.
[xv] Infrastructure NSW. (2017). Hawkesbury-Nepean Valley Flood Risk Management Strategy, p. 19. . Retrieved from https://bit.ly/2wDd4VL
[xvi] Molino Stewart. (2012). Hawkesbury-Nepean Flood Damages Assessment, p. 32. Prepared for Infrastructure NSW. Sydney, Australia. Retrieved from https://bit.ly/2MXahcH

APPENDIX A

Probable maximum flood event

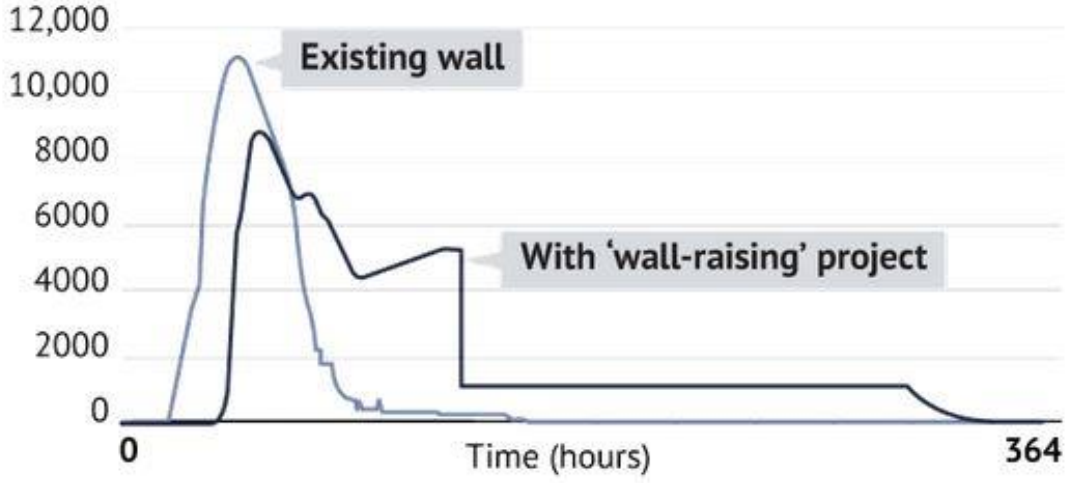
Outflows and discharge (cubic metres per second)



Source: EIS

One-in-500-chance-in-a-year event

Outflows and discharge (cubic metres per second)



Source: EIS

APPENDIX B

DEPARTMENT OF THE ENVIRONMENT AND ENERGY

National Infrastructure Committee Senior Officials Group Meeting

Tuesday, 14 November 2017

Topic/Issue	• NSW Major Infrastructure Projects – EPBC Referrals and Assessments

s22

Warragamba Dam Raising (EPBC 2017/7940)

- WaterNSW proposes to increase the height of the Warragamba Dam Wall at Lake Burragorang (in the Greater Blue Mountains World Heritage Area) by 14 m for flood mitigation.
- The project is being assessed under the Bilateral Agreement with the NSW Government for impacts to World and National Heritage and listed threatened species and communities.

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Warragamba Dam raising (EPBC 2017/7940)

- WaterNSW proposes to raise the height of the Warragamba Dam wall by 14m to provide additional capacity for flood water management to protect downstream urban areas of western Sydney.
- The impact of increased flood water levels within the dam is likely to have extensive and significant impacts on listed threatened species and communities and world and national heritage values of the Greater Blue Mountains World Heritage Area (GBMWHA).
- The delegate is expected to make a controlled action decision shortly, and the project is expected to be assessed under the bilateral agreement with NSW.
- s47C . Under s137 of the EPBC Act the Minister must not act inconsistently with an approved management plan when considering whether or not to grant an approval.

Recent Brief:
Electorate: Hume – Hon Angus Taylor
Assessments SES Contact: Kim Farrant s22 Officer Contact: s22

s22

APPENDIX C

To: Sheikha Haya Rashed Al Khalifa
Chair, World Heritage Committee
7, Place de Fontenoy
75352 Paris CEDEX 07
France

Dr Mechtild Rössler
Director, World Heritage Centre
7, Place de Fontenoy
75352 Paris CEDEX 07
France

Cc. Dr Tim Badman, World Heritage Programme
Peter Shadie, IUCN

Dear Sheikha Haya Rashed Al Khalifa & Dr Mechtild Rössler,

We write to the World Heritage Committee to urgently bring to its attention a proposal by the Government of the State of New South Wales (Australia) to raise the wall of the Warragamba Dam adjacent to the Greater Blue Mountains World Heritage Area (GBMWHA) by 14 meters[1]. The proposal would increase the capacity of the Warragamba Dam, already one of the largest urban water reservoirs in the world, by fifty per cent. The nature of our concerns are as follows:

1. The proposal suggests that airspace added by the raised dam wall would be used to capture floodwaters. Consequently, the greatest impacts will occur between the dam's current full storage level and 14 metres above this, drowning native scleromorphic vegetation and significant cultural heritage sites for up to 5 weeks at a time[2]. However, the largest of flood events could inundate up to 4,700 hectares of wilderness and 65 kilometres of pristine streams above the current full storage level of the dam[3]. (The consequences for natural values recognised in the World Heritage declaration for the Greater Blue Mountains Area are detailed in Appendix A).

[1] WaterNSW 2016, *Warragamba Dam Raising Preliminary Environmental Assessment,* prepared by BMT WBM Pty Ltd, Sydney. Available online: https://bit.ly/2rzXjtz
[2] ibid
[3] ibid

We are alarmed to discover in recent weeks that an environmental impact assessment process is being fast tracked by the New South Wales Government with an intention to sign contracts to begin construction in the 2019/2020 financial year: that is, possibly before the mid 2019 meeting of WHC.

The Federal Government of Australia will have engagement with the environmental assessment but has not so far indicated how it proposes to protect the integrity or authentic values of the GBMWHA during the process.

2. The inundation proposal has never been anticipated in any plan of management associated with GBMWHA. To the contrary, the 2009 Strategic Plan for the GBMWHA expresses the intention of Federal and State Environment Ministers to ensure that:

"Developments and activities with an unknown but potentially significant impact on the World Heritage and other values of the GBMWHA are either modified to minimise the risk of impact on those values or do not proceed". [4]

The area proposed for inundation includes up to 1000 hectares of World Heritage property and 3,700 hectares of land within the adjacent Warragamba Special Area (see Appendix B maps).The GBMWHA and adjacent buffer areas have been some of the most carefully preserved landscapes in Australia, afforded six layers of legislated protection. If the inundation proposal were to proceed the values and integrity of the Greater Blue Mountains World Heritage Area, Blue Mountains National Park, declared Wilderness, a declared Wild River, National Heritage and the Special Catchment Area would be significantly degraded.

Moreover, the land within the Warragamba Special Area was seen explicitly to be essential to the integrity of the adjacent World Heritage Area at the time of nomination in the year 2000. Within two years of the World Heritage listing, the New South Wales Government of the time legislated to include the Warragamba Special Area in Blue Mountains National Park. As part of the legislation the Government also moved to protect the integrity of the whole National Park estate of New South Wales by explicitly banning any inundation activity[5]. This legislation would have to be repealed by the present State Government if the Warragamba Dam wall raising proposal were to proceed.

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[4] NSW Office of Environment & Heritage 2009, *Greater Blue Mountains World Heritage Area Strategic Plan*, Sydney. Available online: https://bit.ly/2rEX1l6

[5] *NSW Government Gazette No. 106*, 28 June 2002, p. 5029 - 5033. Available online: https://bit.ly/2IxRjvh

3. Several flood mitigation options have been identified as alternatives to raising of the Dam wall although it is not clear that they will be adequately investigated during the environmental impact assessment process. A systems management approach that would implement strong downstream floodplain development controls, construction of downstream flood levees, and integrated dam management and climate forecasting have been put forward by respected authorities[6] [7] [8]. However, it is evident that housing development of downstream flood plains is a driving factor for the Dam wall raising proposal[9].

4. We call the attention of the World Heritage Committee to our concern that the environmental impact assessment process is likely to be foreshortened in order to accelerate the inundation proposal toward premature determination. This would deny the precautionary principle and disregard the provisions of the 2009 Strategic Plan for the GBMWHA. Such an approach would also be inconsistent with the provisions of paragraphs 96-98 of the Operational Guidelines for the Implementation of the World Heritage Convention.

We submit that the World Heritage Committee request the Australian Government to provide a comprehensive report on the impact of the Warragamba Dam wall raising within the next year and that it be asked to agree that a moratorium be placed upon any State approval processes until the World Heritage Committee has been able to consider its position upon the proposal at its meeting in mid 2019.

To contact signatories or for further information please do not hesitate to contact wildrivers@colongwilderness.org.au or by phone on +61490010909.

Yours sincerely,

Bob Debus AM
Former NSW Attorney General and NSW Environment Minister

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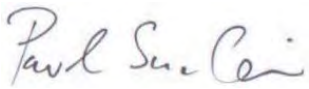
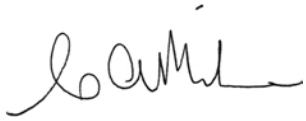
[6] Hawkesbury-Nepean Flood Management Advisory Committee 1997, *Achieving a Hawkesbury-Nepean Floodplain Management Strategy*, Available online: https://bit.ly/2jX8CYR
[7] A. Turner et al (2016), *The potential role of desalination in managing flood risks from dam overflows: the case of Sydney*, Journal of Cleaner Production 135: 342-355
[8] A. Kiem (2018), *Floods don't occur randomly, so why do we still plan as if they do?* The Conversation, Australia. Available online: https://bit.ly/2IbfhNi
[9] Infrastructure NSW 2017, *Hawkesbury-Nepean Valley Flood Risk Management Strategy*, p. 19. Available online: https://bit.ly/2wDd4VL



Paul Sinclair
Director of Campaigns, Australian Conservation Foundation

Prof Brendan Mackey, PhD
Director, Griffith Climate Change Response Program, Griffith University
Great Eastern Ranges Inc, Board Member
Former IUCN Regional Councilor

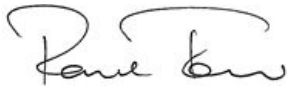
Joan Domicelj AM
Principal Author, Greater Blue Mountains World Heritage Area Nomination
Former ICOMOS Vice-President



Christine Milne
Former IUCN Vice-President

Kazan Brown
Gundungurra Traditional Owner

Dr Bob Brown
President, Bob Brown Foundation



Paul Toni
Conservation Director Sustainable Futures, WWF-Australia

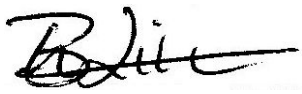
Lyndon Schneiders
National Campaigns Director, The Wilderness Society

Keith Muir
Director, Colong Foundation for Wilderness

Kate Smolski
CEO, Nature Conservation Council of NSW

Alix Goodwin
CEO, National Parks Association of NSW

Roger Lembit
Blue Mountains Ecologist



Harry Burkitt
Colong Foundation for Wilderness

APPENDIX A - Overview of natural & cultural impacts of raising the Warragamba Dam wall

Eucalypt diversity

One of the central reasons for the inscription of the Blue Mountains National Park on the World Heritage List was its diversity of eucalypt species under *Criterion (ix)* of the Natural Criteria for Selection.

"exceptional representation of the major eucalypt groups and aspects of their evolution and radiation" [1]

The Warragamba dam wall raising proposal would have significant impact on the GBMWHA eucalypt diversity. The Wollondilly and Kowmung valley floors represent a very narrow band of fertile grassy woodland on permian sediments. While this habitat constitutes <0.2% of the GBMWHA area, it incorporates a disproportionately large share of the unique GBMWHA eucalypt biodiversity. Of key concern are two threatened eucalypt species, which are regionally restricted to the Wollondilly-Kowmung valley floor.

Eucalyptus benthamii (Vulnerable NSW & Nationally) is globally restricted to two sub-populations. The Nepean sub-population is limited to approx. 300 plants, mostly isolated individuals, and seriously compromised by inbreeding[2]. The Kedumba Valley population by contrast has been considered viable and secure until now. The proposal will destroy approx. 40% of the estimated >6000 individuals[3] of the Kedumba Valley sub-population i.e. 38% of the species global wild population. The species is presently listed as Vulnerable. If the proposal proceeds this species is likely to meet Critically Endangered status under current State, National and International criteria. This species also has cultural significance to the traditional owners of the GBMWHA, including the Gundungurra community.

Eucalyptus glaucina (Vulnerable NSW & Nationally) is predominantly a species of fertile coastal valleys from Newcastle to the Queensland border and was not previously

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[1] NSW Office of Environment & Heritage (2009). Greater Blue Mountains World Heritage Area Strategic Plan. OEH, Sydney. Available online: http://www.environment.nsw.gov.au/research-and-publications/publications-search/greater-blue-mountains-world-heritage-area-strategic-plan

[2] Butcher, P.A., Skinner A.K, & Gardiner C.A. (2005) Increased inbreeding and inter-species gene flow in remnant populations of the rare Eucalyptus benthamii. Conservation Genetics 6:213-226

[3] Bush, D. England N, Han L & Broadhurst L (2016) Domestication and conservation of *Eucalyptus benthamii* and *E. dorrigoensis*. Unpublished presentation by Australian Tree Seed Centre, September 2016

recorded within the GBMWHA. A geographically isolated population of this species is now confirmed in the southern portion of the Wollondilly River floodplain. On preliminary data this species is considered to be of high concern under the proposal.

The proposal would also destroy much of the remaining *Eucalyptus mollucana* of the GBMWHA. While recorded across the southern GBMWHA, recent field work by Western Sydney University & Greater Sydney Local Land Services has clarified that *E. mollucana* is locally restricted to the valley floor permian sediments and replaced by *E. albens* and hybrids on surrounding habitats. While these valley floor *E. mollucana* woodlands are a tiny habitat (<0.2% of the GBMWHA in extent) they protect over 50% of habitat for most threatened woodland fauna of the GBMWHA[4].

A Kedumba Valley *Eucalyptus benthamii*. *Photo: Harry Burkitt*

[4] NSW Office of Environment & Heritage (2007). Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region, Vol 2 Fauna of conservation concern. OEH, Hurstville. Available online: www.environment.nsw.gov.au/threatenedspecies/faunasouthsydney.htm

APPENDIX A - Overview of natural & cultural impacts of raising the Warragamba Dam wall

Habitat diversity

The World Heritage Listing of the Blue Mountains National Park was also provided on the basis of habitat diversity under *Criterion (x)* of the Natural Criteria for Selection.

"exceptional diversity of habitats providing outstanding representation of the Australian fauna within a single place, including 400 vertebrate taxa — 52 native mammals, 265 birds or 33% of the Australian total, 63 reptiles, more than 30 frogs and examples of species of global significance." [5]

One of the key habitats impacted by the proposal is the fertile grassy woodlands of the Burragorang valley floor, including much of the remaining old-growth. While these valley floor *E. mollucana* woodlands on permian sediments are proportionately small (<0.2% of the GBMWHA in extent), they protect over 50% of habitat for most threatened woodland fauna species of the GBMWHA[6]. A number of threatened species are almost entirely restricted in habitat to the immediate surrounds of the current FSL, including Brown Treecreeper, Speckled Warbler, Hooded Robin, Regent Honeyeater, Diamond Firetail and the last wild population of Emu in Greater Sydney[7].

Of particular concern is the Regent Honeyeater, which is currently listed as Critically Endangered (NSW, National & IUCN). The Burragorang Valley floor adjoining the current FSL is the most fertile regional habitat and a key foraging and breeding site for this species. The Regent Honeyeater is a specialist nomad and the regional meta-population relies predominantly on the woodlands of the Capertee, Burragorang flats and Cumberland Plain. The rotational use of these habitats is determinate on the complex, shifting & unpredictable seasonal nectar productivity of these habitats and in a given year and season, the meta-population may favor any one of the regional habitats. As such, impacts in one habitat (e.g. the Burragorang Valley) cannot be offset by improvements in another. The loss of 'nomadic options', being the ability of the

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[5] NSW Office of Environment & Heritage (2009). Greater Blue Mountains World Heritage Area Strategic Plan. OEH, Sydney. Available online: http://www.environment.nsw.gov.au/research-and-publications/publications-search/greater-blue-mountains-world-heritage-area-strategic-plan

[6] NSW Office of Environment & Heritage (2007). Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region, Vol 2 Fauna of conservation concern. OEH, Hurstville. Available online: www.environment.nsw.gov.au/threatenedspecies/faunasouthsydney.htm

[7] NSW Office of Environment & Heritage (2007). Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region, Vol 2 Fauna of conservation concern. OEH, Hurstville. Available online: www.environment.nsw.gov.au/threatenedspecies/faunasouthsydney.htm

meta-population to migrate between core habitats in response to local nectar availability, is a key issue in Regent Honeyeater conservation and of particular concern in relation to the current proposal.

The Regent Honeyeater. *Photo: NSW Office of Environment and Heritage*

Burragorang Emus on Burragorang valley floor, Photo: *Peter Rae (Fairfax)*

APPENDIX A - Overview of natural & cultural impacts of raising the Warragamba Dam wall

Coxs River upstream of present FSL (left) and downstream of the present FSL (right), illustrating the potential additional impact of a raised dam wall on river bank vegetation.

Aboriginal cultural heritage

Numerous Indigenous cultural heritage sites, belonging to the Gundungurra people of the southern Blue Mountains, are located within the regions of the GBMWHA to be inundated by the dam wall raising. Delicate cave art, rare eucalypt scar trees, dreaming waterholes and marker sites are amongst the cultural heritage sites that would be submerged under the raised dam wall. The Indigenous cultural sites surrounding the current FSL of Warragamba dam are both rare and unique, given the destruction of many Gundungurra cultural sites by the initial construction of Warragamba dam in 1960. The association between shelter art and grinding grooves (as seen at the Kerswell Hill Rock Shelter) is rare, with only 5% of shelter art also containing grinding grooves in the region[8].

While the cultural values of the GBMWHA were not specifically endorsed by the World Heritage Committee due to a lack of adequate information available at the time of

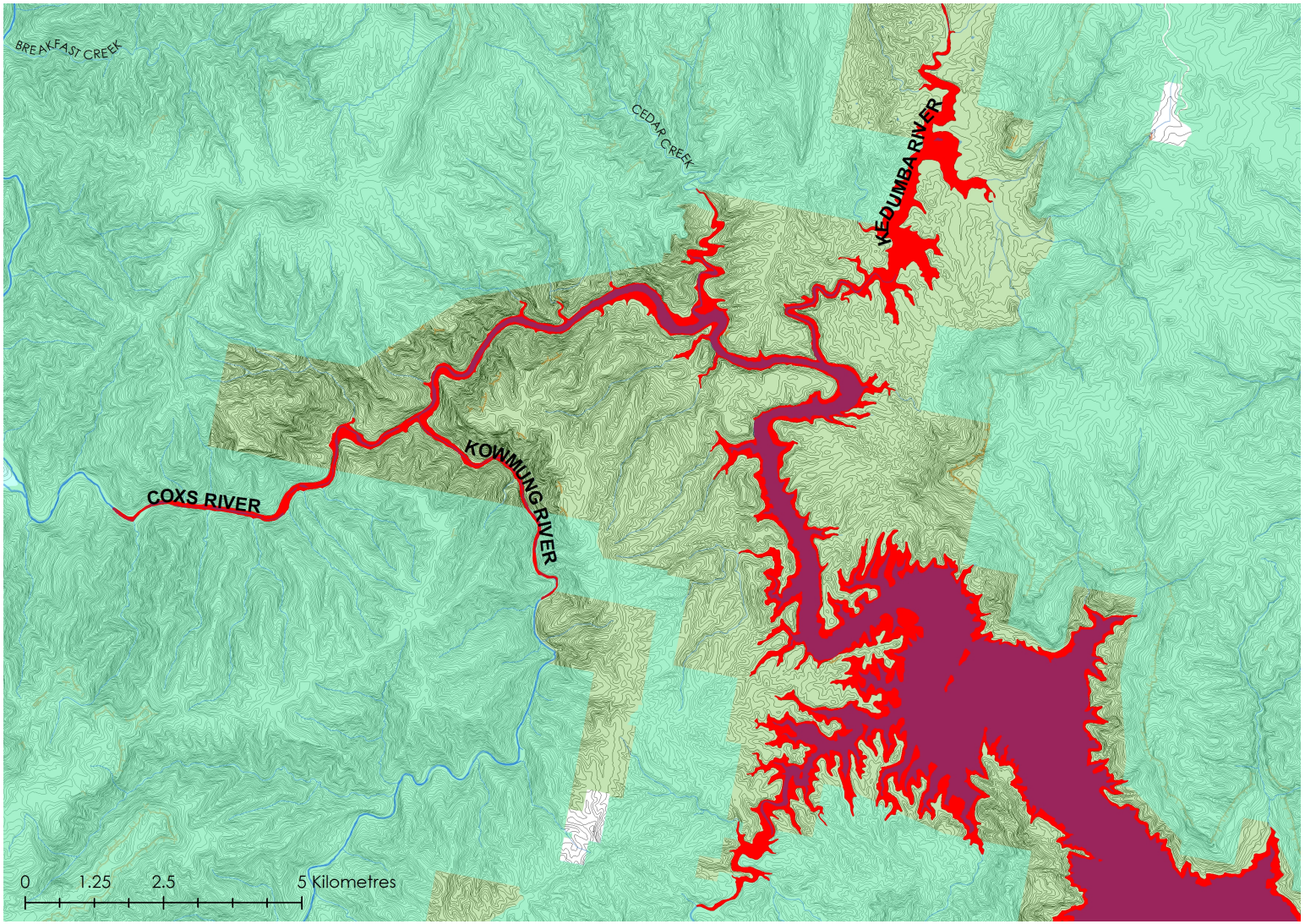
[8] J. McDonald (2008). Dreamtime Superhighway: Sydney Basin Rock Art and Prehistoric Information exchange. ANU E Press, Canberra.

nomination, the 2009 Strategic Plan endorses future inclusion of Indigenous cultural values as part of the GBMWHA listing[9].

Rare Gundungurra artwork in the Kerswell Hill Rock Shelter (above) will be inundated by the raising of Warragamba dam wall. *Photo: Taylor Clarke*

[9] NSW Office of Environment & Heritage (2009). Greater Blue Mountains World Heritage Area Strategic Plan. OEH, Sydney. Available online: http://www.environment.nsw.gov.au/research-and-publications/publications-search/greater-blue-mountains-world-heritage-area-strategic-plan

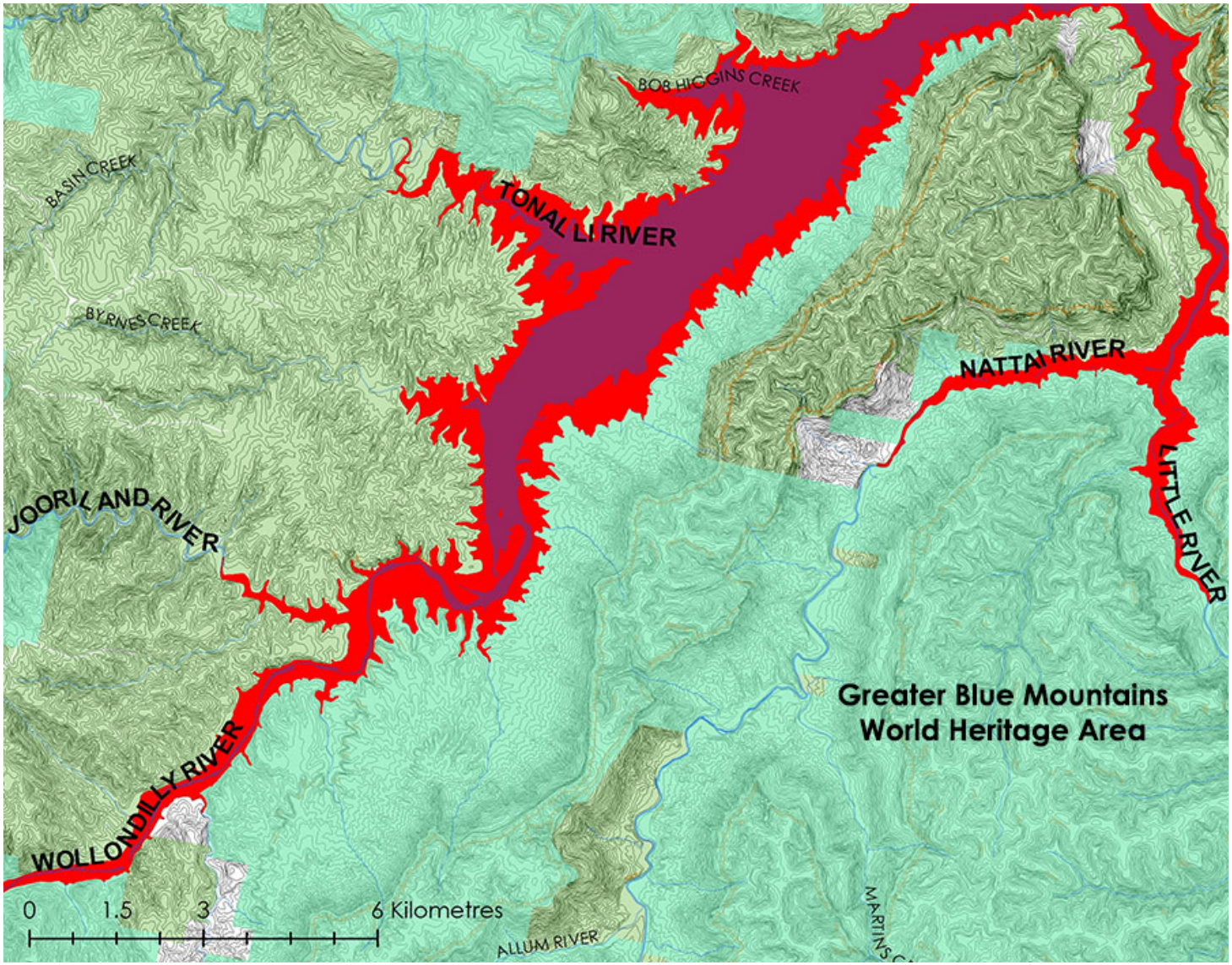
APPENDIX B - Impact-extent maps of Warragamba Dam wall raising



Impact of raised dam on northern arm of Warragamba Dam[1]. Impact extent marked in red.

[1] Based on upstream PMF level of 144 metres AHD after WaterNSW 2016, *Warragamba Dam Raising Preliminary Environmental Assessment,* prepared by BMT WBM Pty Ltd, Sydney. The greatest impacts will occur between the dam's current full storage level and 14 metres above this. Available online: https://bit.ly/2rzXjtz

APPENDIX B - Impact-extent maps of Warragamba Dam wall raising



Impact of raised dam on southern branch of Warragamba Dam (upper Burragorang Valley)[2]. Impact extent marked in red.

[2] ibid

APPENDIX D

United Nations
Educational, Scientific and
Cultural Organization

Organisation
des Nations Unies
pour l'éducation,
la science et la culture

World Heritage **43 COM**

WHC/19/43.COM/7B.Add
Paris, 7 June 2019
Original: English / French

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

CONVENTION CONCERNING THE PROTECTION OF THE WORLD CULTURAL AND NATURAL HERITAGE

WORLD HERITAGE COMMITTEE

Forty-third session

Baku, Republic of Azerbaijan
30 June - 10 July 2019

Item 7B of the Provisional Agenda: State of conservation of properties inscribed on the World Heritage List

SUMMARY

This document contains information on the state of conservation of properties inscribed on the World Heritage List. The World Heritage Committee is requested to review the reports on the state of conservation of properties contained in this document. The full reports of Reactive Monitoring missions requested by the World Heritage Committee are available at the following Web address in their original language: https://whc.unesco.org/en/sessions/43COM/documents

All previous state of conservation reports are available through the World Heritage State of conservation Information System at the following Web address: https://whc.unesco.org/en/soc

Decision required: The World Heritage Committee may wish to adopt the draft Decision presented at the end of each state of conservation report.

AGREED TO 3 July 2018

2. Greater Blue Mountains Area (Australia) (N 917)

Year of inscription on the World Heritage List 2000

Criteria (ix)(x)

Year(s) of inscription on the List of World Heritage in Danger N/A

Previous Committee Decisions see page http://whc.unesco.org/en/list/917/documents/

International Assistance

Requests approved: 0
Total amount approved: USD 0
For details, see page http://whc.unesco.org/en/list/917/assistance/

UNESCO Extra-budgetary Funds

N/A

Previous monitoring missions

N/A

Factors affecting the property identified in previous reports

Potential extension of a mining lease (issue resolved)

Illustrative material see page http://whc.unesco.org/en/list/917/

Current conservation issues

In recent years, particularly 2018 and 2019, the World Heritage Centre received various third party information raising concerns about development proposals in the vicinity of the property and their potential threats to its Outstanding Universal Value (OUV), particularly the construction of the Western Sydney Airport, the Bylong Coal project, the proposal to raise the Warragamba Dam wall and a high-speed transit tunnel.

On 20 December 2018, the State Party responded to letters from the World Heritage Centre and, on 11 April 2019, submitted a report on the state of conservation of the property, available at http://whc.unesco.org/en/list/917/documents/, which provides the following information:

- There is no mining within the property and all mining projects located outside the property have been or are being assessed for their potential impacts on the property under the Environment Protection and Biodiversity Conservation Act (EPBC Act);
- The Bylong Coal Project had been previously assessed and was considered unlikely to have significant impacts on the OUV of the property. This decision was recently reconsidered by the Minister of the Environment, based on newly available information, and it was reaffirmed that the project would not result in significant impacts on the OUV of the property;
- In July 2015, coal fines from the Clarence Colliery collapsed into the Wollangambe River, resulting in pollution within the property. The mining company was prosecuted and requested to pay an environmental compensation, in addition to covering clean-up works. The State Party investigated the incident and remediation works, and concluded that there have been no long-term impacts on the OUV of the property;
- The proposal to raise the Warragamba Dam wall by 14 meters for flood mitigation purposes is being assessed under the EPBC Act and an Environmental Impact Statement (EIS) is being prepared to fully assess potential impacts on the OUV. The State Party reported that the raising

of the wall is expected to increase the frequency and extent of temporary inundation upstream of the dam;

- In October 2018, the New South Wales (NSW) Parliament passed an amendment to the Water NSW Act 2014, exempting the Warragamba Dam from the prohibition to increase temporary inundation in a national park provided for by the NSW National Parks and Wildlife Act 1974. However, this amendment on its own does not constitute an approval for raising of the Warragamba Dam;
- A Strategic Management Framework is being developed and should replace the existing Strategic Plan for the property, as an integrated management instrument;
- In 2016, the construction of the Western Sydney Airport was approved, following the conclusions of the EIS that significant impacts on the OUV of the property were unlikely, but that there might be "some noise impacts on amenity within the property", which should be minimized through the airspace and flight path design. The latter will be subject to a separate assessment under the EPBC Act, expected to be released for public comment in 2021.

Regarding a high-speed transit tunnel project, the State Party provided information to the World Heritage Centre on 15 January 2019 that it was not aware of any serious discussions on the matter and has not received a referral for this proposal under the EPBC Act. The State Party will therefore inform the Committee of any action that may significantly impact the OUV of the property, in accordance with Paragraph 172 of the *Operational Guidelines*.

Analysis and Conclusions of the World Heritage Centre and IUCN

The confirmation provided by the State Party that the EIS for the proposal to raise the Warragamba Dam wall will fully assess all potential impacts on the property's OUV and its other values, including Aboriginal cultural heritage, is welcomed. However, it is noted with concern that both the State Party and the information received by the World Heritage Centre from different third party sources confirm that the raising of the wall will result in the increase of the frequency and extent of temporary inundation in the property. Such inundation of any areas within the property is likely to impact on its OUV. It is therefore recommended that the Committee request the State Party to ensure that, in line with its commitment, all potential impacts on the OUV are assessed in detail by the EIS, which will be submitted to the World Heritage Centre for review by IUCN, prior to taking any final decisions regarding the project. The Committee may also wish to recall Decision **40 COM 7**, para.17, in which it considered that the construction of dams with large reservoirs within the boundaries of World Heritage properties is incompatible with their World Heritage status, and urged States Parties to "*ensure that the impacts from dams that could affect properties located upstream or downstream within the same river basin are rigorously assessed in order to avoid impacts on the Outstanding Universal Value*".

While the State Party's confirmation that no mining occurs within the property and that all mining projects in its vicinity have been or are being assessed for potential impacts on the property is noted, it is of concern that several mining projects exist in the vicinity of the property and that some mining activities have resulted in impacts on the property, as evidenced by the incident at the Clarence Colliery. While the confirmation that no long-term impacts on the property from the incident are expected is noted, it needs to be stressed that, for some projects mentioned in the information submitted by the State Party, such as the Airly Mine Extension Project, potential risks to the OUV have been identified, and the approvals for these projects included conditions that have to be fulfilled in order to minimize risks, such as implementation of a site water management system. It is recommended that the Committee reiterate its position that mineral exploration or exploitation is incompatible with World Heritage status, which is supported by the International Council of Mining and Metals (ICMM) Position Statement of not undertaking such activities within World Heritage properties.

For the South Bates Extension project, the report states that, since the property is not inscribed for its geological values, potential cliff instability resulting from the mining activities would not affect its OUV. However, it should be recalled that the Statement of OUV of the property specifically notes the importance of the geology and geomorphology for providing the physical conditions that support its biological values recognized under criteria (ix) and (x). While some mines were in existence near the property at the time of inscription, it will be important to consider whether the number of mining projects and activities in the vicinity of (or even adjacent to) the property might cumulatively result in any significant impact on its OUV. It should be recalled that this property does not have a formal Buffer Zone, increasing its vulnerability to edge effects. It is therefore recommended that the Committee request the

State Party to undertake an assessment of potential cumulative impacts of existing and planned mining projects in the vicinity of the property.

The information provided by the State Party regarding the Western Sydney Airport is noted, and it is recommended that the Committee request the State Party to submit to the World Heritage Centre a copy of the EIS detailing the anticipated airspace and flight path operations, once available, for review by IUCN.

Finally, it is recommended that the Committee request the State Party to ensure that potential threats to the property from activities outside its boundaries, particularly mining, are fully considered in the development of the Strategic Management Framework.

Draft Decision: 43 COM 7B.2

The World Heritage Committee,

1. *Having examined Document WHC/19/43.COM/7B.Add,*

2. *Recalling Decision **28 COM 15B.15**, adopted at its 28th session (Suzhou, 2004),*

3. *Notes with concern that the State Party recognizes that the proposed raising of the Warragamba Dam wall is expected to increase the frequency and extent of temporary inundation of the property upstream of the dam;*

4. *Considers that the inundation of areas within the property resulting from the raising of the dam wall are likely to have an impact on the Outstanding Universal Value (OUV) of the property, recalls Decision **40 COM 7**, in which it considered that the construction of dams with large reservoirs within the boundaries of World Heritage properties is incompatible with their World Heritage status, and urged States Parties to "*ensure that the impacts from dams that could affect properties located upstream or downstream within the same river basin are rigorously assessed in order to avoid impacts on the OUV*", and requests the State Party to ensure, in line with its commitment, that the current process to prepare an Environmental Impact Statement (EIS) for the proposal fully assesses all potential impacts on the OUV of the property and its other values, including Aboriginal cultural heritage, and to submit a copy of the EIS to the World Heritage Centre for review by IUCN, prior to taking any final decisions regarding the project;*

5. *Also notes with concern that several mining projects exist in the vicinity of or adjacent to the property, and that some mining activities have resulted in impacts on the property, as evidenced by the incident at the Clarence Colliery, and also requests the State Party to undertake an assessment of potential cumulative impacts of all existing and planned mining projects in the vicinity of the property through a Strategic Environmental Assessment (SEA) or a similar mechanism;*

6. *Reiterates its position that mineral exploration or exploitation is incompatible with World Heritage status, which is supported by the International Council of Mining and Metals (ICMM) Position Statement to not undertake such activities within World Heritage properties;*

7. *Notes the information provided by the State Party regarding the Western Sydney Airport proposal and further requests the State Party to submit to the World Heritage Centre a copy of the EIS for the anticipated airspace and flight path operations, once available, for review by IUCN;*

8. *Welcomes the development of a Strategic Management Framework for the property as a new integrated management instrument and requests furthermore the State Party to ensure that potential threats to the property from activities outside its boundaries, particularly mining, are fully considered in the development of this management framework and that the EIS required are carried out in conformity with IUCN's World Heritage Advice Note on Environmental Assessments, with a specific section focusing on the potential impact of the project(s) on the property's OUV;*

9. *Finally requests the State Party to submit to the World Heritage Centre, by **1 December 2020**, an updated report on the state of conservation of the property and the implementation of the above, for examination by the World Heritage Committee at its 45th session in 2021.*

APPENDIX E

GREATER BLUE mountains WORLD HERITAGE AREA
ADVISORY COMMITTEE
PO Box 6 Glenbrook NSW 2773

gbm.worldheritage@environment.nsw.gov.au

Our reference : DOC18/737930

The Chair
Legislative Council Standing Committee on State Development

Via email: state.development@parliament.nsw.gov.au

Dear Chair,

Water NSW Amendment (Warragamba Dam) Bill 2018

The Advisory Committee for the GBMWHA is jointly appointed by the NSW and Commonwealth environment ministers to provide advice on the protection of the GBMWHA and issues concerning surrounding land uses that have the potential to impact on the area.

The Committee has been briefed covering the policy background to the project, the environmental impact assessment process, cultural heritage impact, land use planning, emergency services issues and the views of community organisations.

Please consider the attached correspondence to the NSW and Cwth Ministers for the Environment as our submission to the welcome inquiry in the Water NSW Amendment (Warragamba Dam) Bill 2018.

The Committee has urged the NSW Government to very carefully consider the adverse impacts on the Greater Blue Mountains World Heritage Area when final decisions are being made about the proposed works and alternative courses of action that could alleviate these impacts on this internationally significant area.

If you require further information, please contact our Executive Officer,

Yours sincerely

Bruce Leaver
Chair
Greater Blue Mountains World Heritage Area Advisory Committee

2 October 2018

GREATER BLUE mountains
WORLD HERITAGE AREA
ADVISORY COMMITTEE
PO Box 6 Glenbrook NSW 2773

gbm.worldheritage@environment.nsw.gov.au

Our reference : DOC18/709613

The Hon. Gabrielle Upton MP
Minister for the Environment
GPO Box 5341
Sydney NSW 2001

Via email: office@upton.minister.nsw.gov.au

Dear Minister

Proposed Warragamba Dam works and impact on World Heritage

The Advisory Committee for the GBMWHA is jointly appointed by the NSW and Commonwealth environment ministers to provide advice on the protection of the GBMWHA and issues concerning surrounding land uses that have the potential to impact on the area.

The Committee has been briefed covering the policy background to the project, the environmental impact assessment process, cultural heritage impact, land use planning, emergency services issues and the views of community organisations.

The Committee was working towards input into the EIS process. However, the introduction of the *Water NSW Amendment (Warragamba Dam) Bill 2018* into the NSW Legislative Council on 19 September 2018 has prompted the Committee to exercise its ministerial advice functions and advise you its views in advance of formal input into the EIS.

The Committee raised particular concerns to Water NSW about the impact of inundation on world heritage values, especially Aboriginal cultural heritage, siltation and weed dispersal, and biodiversity impacts.

Outstanding Universal Value and Integrity

The World Heritage listing is based on:

> ***Criterion (ix):*** *The Greater Blue Mountains include outstanding and representative examples in a relatively small area of the evolution and adaptation of the genus Eucalyptus and eucalypt-dominated vegetation on the Australian continent including 177 threatened plant species*
>
> ***Criterion (ix):*** *The site includes an outstanding diversity of habitats and plant communities that support its globally significant species and ecosystem diversity support more than 400 vertebrate taxa (of which 40 are threatened).*

The Committee considers that the proposal will have significant adverse impacts on:

- Biodiversity
- Siltation and weed dispersal
- Wilderness and wild river values
- Aboriginal cultural heritage values
- Aesthetic values
- Management access

Attachment 1 details the Committee's advice in relation to these matters.

The Committee urges the NSW Government to very carefully consider the adverse impacts on the Greater Blue Mountains World Heritage Area when final decisions are being made about the proposed works and alternative courses of action that could alleviate these impacts on this internationally significant area.

If you require further information, please contact our Executive Officer,

Yours sincerely

Bruce Leaver
Chair
Greater Blue Mountains World Heritage Area Advisory Committee

27 September 2018

cc. The Hon. Melissa Price MP, Minister for the Environment

Attachment 1

Advice on impacts on the Greater Blue Mountains World Heritage Area

Biodiversity

The Committee notes the Referral of proposed action (Warragamba Dam Raising (Water NSW) 2017/7940) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) has been determined a controlled action for World Heritage, National Heritage and listed Threatened Species and Communities. The Referral states:

> "The Project has the potential to cause inundation of *Eucalyptus benthamii* and *Hakea dohertyi* populations and Macquarie perch spawning areas for a period of weeks which could impact the overall populations of these species. Inundation could also occur to White Box-Yellow Box, Blakely's Red Gum Grassy Woodland and Derived Native Grassland which could cause both loss of areas occupied by the TEC and the establishment of invasive species. All of these impacts may in turn contribute to an overall impact on the GBMWHA."

While some larger trees of *Eucalyptus benthamii* may survive the inundations, *Hakea* species are likely to be more sensitive and to be killed. Drowning native scleromorphic vegetation in the Threatened box woodlands for up to 5 weeks at a time will kill native vegetation, particularly the groundcover species but not provide conditions necessary for their recovery. Normally native vegetation including Hakea species would re-establish after a bushfire and the seeds would establish in the open high light conditions. However, after a flood event, the dead material and nutrient-rich silt and mud will only promote the establishment of exotic weeds and grasses which will ultimately outcompete any successful native vegetation regrowth seedlings including *Eucalyptus benthamii*. The lush weed areas are likely to attract concentrations of grazing animals, not just macropods but feral pigs, goats, deer and rabbits that will further graze out any successfully establishing native trees and other native vegetation.

The Committee notes that significant populations of the Critically Endangered Regent honeyeater have been identified in the Burragorang Valley and inundation could have a devastating impact on their breeding habitat as their breeding trees such as *Eucalyptus sideroxylo*n are susceptible to waterlogging, and also unlikely to establish in the presence of exotic weed growth.

Siltation and exotic weed dispersal and competition
Depositions of silt will be rapidly colonised by exotic weed species particularly agricultural weeds that grow vigorously in the enriched soil and compete and stop recruitment of native species. At present the areas that will be flooded are relatively undisturbed, but once the weeds have established in a ponding event they will be impossible to remove. Silting will also affect the steeper sandstone slopes which are currently pristine but will collect silt residues following flooding with weed species establishing in the crevices.

All of these impacts may in turn contribute to an overall impact on the GBMWHA.

Wilderness and Wild River values

The Statement of Outstanding Universal Value for the Greater Blue Mountains Area[1] acknowledges that "*Additional regulatory mechanisms, such as the statutory wilderness designation of 65% of the property…further protect the integrity of the GBMA."*

Significant areas of the Kanangra (122,072ha) and Nattai (41,867ha) Wilderness areas, declared under the *Wilderness Act, 1987* will be impacted by the proposal to raise the Warragamba Dam wall, as will parts of the Kowmung River, a Wild River declared under the *NSW National Parks and Wildlife Act 1967*, which will be irreparably silted over.

Section 9 of the *Wilderness Act, 1987* requires management of Wilderness areas "*to restore (if applicable) and to protect the unmodified state of the area and its plant and animal communities."*

And the Kanangra-Boyd Park Plan of Management[2] states:

"There will be two major management emphases for Kanangra-Boyd National Park during the life of this plan:
- implementation of a co-ordinated management strategy with adjacent conservation reserves to enhance their ecological integrity as the largest natural area in eastern New South Wales and to protect their wilderness values; and
- promotion of appropriate land use planning and management amongst relevant land management authorities to ensure the protection of the park's outstanding natural and cultural values from adverse external impacts.

The proposal to raise the Warragamba Dam wall will cause irreparable damage to these extraordinary wilderness areas and wild rivers, protected under legislation.

[1] https://whc.unesco.org/en/list/917
[2] https://www.environment.nsw.gov.au/research-and-publications/publications-search/kanangra-boyd-national-park-plan-of-management

Aboriginal cultural heritage

The Committee expresses deep concern for the Aboriginal cultural heritage of the areas proposed to be inundated. No archaeological surveys were conducted when the Burragorang valley was dammed between 1948 and 1960 and therefore no chance of recovery of that irreplaceable heritage.

Members of the local Aboriginal community have recently advised the Committee that the proponent has only allowed 25 days for archaeological and cultural heritage surveys, yet Lake Burragorang has a foreshore of 354 kilometres. This is not acceptable and the Committee strongly recommends that further, more detailed archaeological surveys be conducted.

The former NSW Minister for the Environment expressed in August 2014 to the former Chair of the Committee and to the former Commonwealth Minister for the Environment his "*strong support for the assessment of the Greater Blue Mountains to consider the important additional values relating to Indigenous and historic cultural values, geodiversity and aesthetic values through their inclusion on the National Heritage List.*"

The Indigenous and other values are currently being assessed by the Australian Heritage Council for inclusion on the National Heritage List as a precursor to potential renomination to the World Heritage List.

The Committee has formally supported the Gundungurra Cultural Landscape – Cox's to Wollondilly Rivers Aboriginal Place nomination under the *National Parks and Wildlife Act 1974.* The Committee acknowledges the significance of the cultural landscape throughout the Gundungurra creation Songline, the journey of Gurangatch and Mirrigan across large tracts of Country that are likely to be inundated should the proposal proceed.

Aesthetic values

The GBMWHA is currently under assessment for inclusion on the National Heritage List for its scenic beauty – aesthetic values. The Statement of OUV stresses that "*the conservation of these associations, together with the elements of the property's natural beauty, contributes to its integrity*."

The Kanangra-Boyd Park Plan of Management states that the "*Service [*NSW National Parks and Wildlife*] will liaise with local councils and other relevant management agencies to minimise the impacts of adjacent developments on the scenic values of the park, with particular emphasis on wilderness viewscapes*."

There is likely to be a negative impact on aesthetic values from planes and various lookouts including McMahons and possibly Echo Point, accessed by millions of visitors annually. These values are a significant element of the regional tourism economy.

Management access

Access to the Special Areas and Yerranderie via Murphy's Crossing and Joorilands will be impacted with inundation which could jeopardise emergency and administration services to these areas which would be required to travel via Oberon.

APPENDIX F

Australia ICOMOS Secretariat
Faculty of Arts & Education
Deakin University
221 Burwood Highway
Burwood Vic 3125
Ph: +61 3 9251 7131
austicomos@deakin.edu.au
www.icomos.org/australia
ABN: 85 073 285 798

17 October 2018

The Hon Gabrielle Upton MP
Minister for the Environment, Minister for Local Government and Minister for Heritage
GPO Box 5341
SYDNEY NSW 2001

By email: vaucluse@parliament.nsw.gov.au

Dear Minister,

Water NSW Amendment (Warragamba Dam) Bill 2018

Australia ICOMOS is writing to you to raise express our concerns in relation to the *Water NSW Amendment (Warragamba Dam) Bill 2018*, which is currently before the Parliament of NSW. We are particularly concerned about the longer term proposal to raise the Warragamba Dam wall by 14 metres, thereby allowing for periodic inundation of parts the Greater Blue Mountains World Heritage Area (GBMWHA) and adjacent areas that are currently being assessed for potential National Heritage values.

Australia ICOMOS (International Council on Monuments and Sites) is a non-government, not-for-profit organisation of cultural heritage professionals formed as a national chapter of ICOMOS International in 1976. Our mission is to lead cultural heritage conservation in Australia by raising standards, encouraging debate and generating innovative ideas. ICOMOS is also an Advisory Body to the UNESCO World Heritage Committee under the World Heritage Convention.

The areas that are affected by the proposed NSW legislation include a World Heritage property, a National Heritage place, two national parks, a declared Wilderness area, a declared Wild River, and the Warragamba Special Catchment Area. The subject area is recognised globally for its biodiversity and rare species and was also originally nominated to the World Heritage List by Australia, with the support of the NSW Government, for cultural and natural values in the 1990s. Parts of the area are currently on the Australian Heritage Council's Priority Assessment List and are being evaluated for a range of potential cultural National Heritage values. It is inappropriate, as a matter of proper process, for the NSW Parliament to be considering enabling legislation that would impact upon established World or National Heritage values or potential National Heritage values.

The proposed dam wall raising could result in the periodic inundation of up to 1,000 hectares of the GBMWHA and 3,700 hectares of national park lands including impacts on eucalypt species, which contribute to the Outstanding Universal value of the GBMWHA, and both known and unknown Aboriginal cultural heritage sites. Australia ICOMOS understands that the cultural heritage survey undertaken as part of the impact assessment for the dam wall project comprised 25 days across a 354 square kilometre section around the shores of Lake Burragorang. This timeframe appears to be manifestly inadequate, either to identify the cultural heritage places which may be affected or to engage appropriately with, or to seek consent from, the relevant Gundungurra Traditional Owners.

Australia ICOMOS therefore advises that:

- The proposed raising of the Warragamba Dam wall has potential to affect the integrity of the GBMWHA and therefore to impact adversely upon the Outstanding Universal Value of this World Heritage property.

- Under Article 4 of the *World Heritage Convention*, Australia is obliged (among other things) to do all it can, using the utmost of its own resources, to identify, protect, and conserve the cultural and natural heritage of GBMWHA – neither the decision making process for the proposed raising of the Warragamba Dam wall nor the pre-emptive proposed NSW enabling legislation comply with these obligations.
- Best practice heritage practice, including the *Burra Charter*, (the Australia ICOMOS Charter for Places of Cultural Significance), requires that the values of a place of cultural significance should be identified prior to decisions which affect those values, and that, while considering and managing other factors, a primary objective should be conservation of those values. The proposed raising of the Warragamba Dam wall, the process for decision making and the proposed NSW legislation do not meet this standard.
- A thorough cultural heritage survey and assessment process, articulation of ALL cultural (and natural) values and completion of the current National Heritage Values assessment should ALL precede any precipitative action in this matter, including particularly the proposed enabling legislation.
- The *Water NSW Amendment (Warragamba Dam) Bill 2018*, represents a potential threat to the GBMWHA, within the meaning of paragraph 179 (b) of the *Operational Guidelines to the World Heritage Convention*.

Given that the draft legislation is currently before the Parliament of NSW, Australia ICOMOS therefore calls on you to intervene urgently to:

1. Withdraw the *Water NSW Amendment (Warragamba Dam) Bill 2018*, from Parliament;
2. Require serious and substantive consideration of alternatives to the proposed raising of the Warragamba Dam wall;
3. Suspend any decision about the proposed raising of the Warragamba Dam wall until the Australian Heritage Council has completely the current Priority Assessment List process;
4. Allow adequate time and resources for further assessment of the proposal, including comprehensive identification of all cultural and natural values that may be affected, and meaningful engagement with Traditional Owners, so as to support a best-practice decision-making process; and
5. Require that, if the proposed raising of the Warragamba Dam wall is to be pursued, the proponent refer that action to the Commonwealth Minister for the Environment, on the basis that it will have a 'significant impact' and should be a 'controlled action' within the meaning of the *Environment Protection Biodiversity Conservation Act 1999* (Cwth).

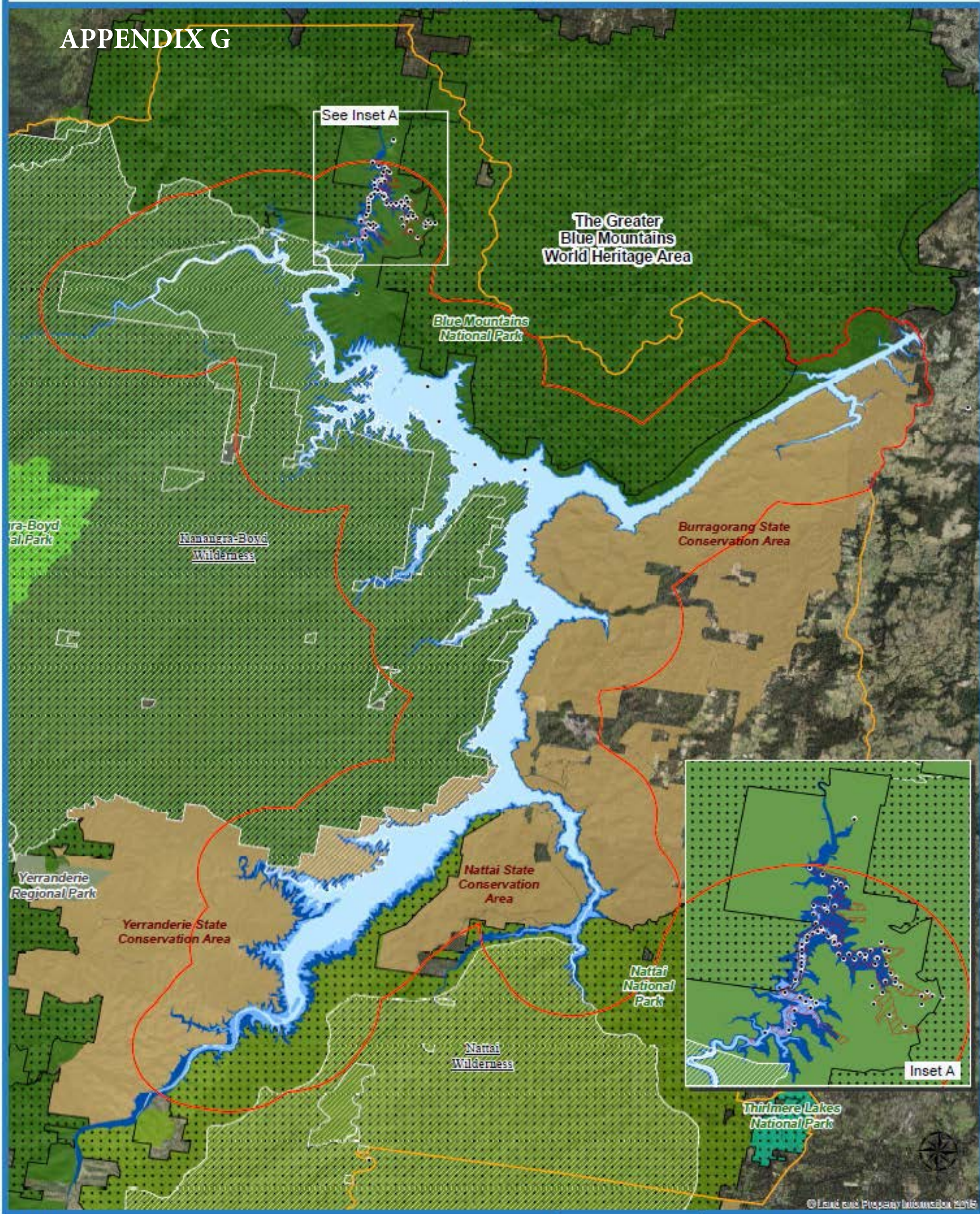
Please note that I have also written to the Commonwealth Minister for the Environment and the ICOMOS Secretariat in Paris regarding this matter. However, Australia ICOMOS is always willing to discuss these concerns further if this would assist you in understanding our position.

Yours faithfully

IAN TRAVERS
President, Australia ICOMOS

14m Dam Raising Warragamba Dam

APPENDIX G



Legend

- Camden White Gum
- Schedule 1 Special Area
- Schedule 2 Special Area
- Burragorang River Flat Forest
- National Parks Declared Wilderness (OEH)
- +14 (FSL@ 116.72m AHD)
- +14 (Crest@ 128.45m AHD)
- +14 (PMF@ 144.41m AHD)
- World Heritage Areas (DE)
- State Conservation Areas
- Yerranderie Regional Park
- Blue Mountains National Park
- Kanangra-Boyd National Park
- Nattai National Park
- Thirlmere Lakes National Park

0 3.25 6.5
Kilometres

Scale 1:170,000

Geographic Coordinate System
Geocentric Datum of Australia 1994

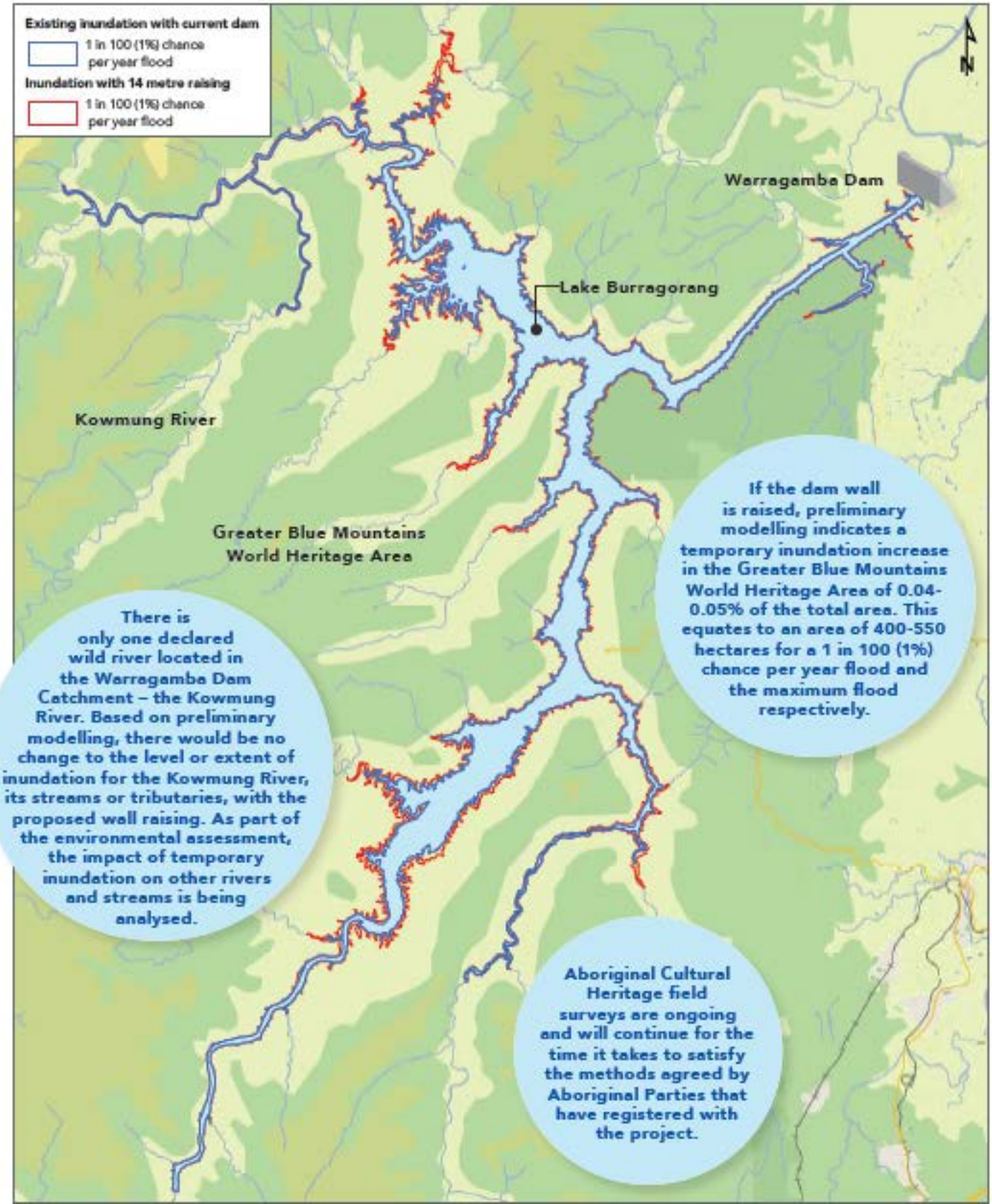
Water NSW
PO Box 1018, Dubbo NSW 2830
Ph: 1300 662 077
PO Box 323, Penrith NSW 2751
Ph: 1300 722 468

Trim Ref: D2016/137466
Created By: Bernie Millynn
Date: 2 December 2016

WaterNSW

Upstream of Warragamba Dam

Currently, when the dam spills, there is inundation upstream of the Warragamba Dam above the full supply level. In raising the dam to create a flood mitigation zone of around 14 metres to reduce the risk to life and property downstream, some additional temporary flooding upstream would occur.



SYDNEY CATCHMENT AUTHORITY

REVIEW OF GATE OPERATIONS AT WARRAGAMBA DAM

Volume 1: FINAL REPORT

SMEC

April 2000

4 RESULTS

4.1 DAM OUTFLOWS AND WATER LEVELS

Peak dam outflows and peak water levels for the H14 and RELEASE procedures are shown in Table 4.1 for a MOL of 116.42 with the auxiliary spillway in place. The results show that the RELEASE gate operating procedure is effective in reducing peak discharges from the dam for events up to the 1:200 AEP event. The reduction for the 1:50, 1:100 and 1:200 AEP events is 32%, 23% and 13% respectively. These events embrace a range of flood events, which contribute a very large portion of the average annual flood damages. The reduction in peak discharge is achieved by engaging surcharge storage and hence peak storage water levels increase. The maximum increase in peak water level is 1.1 m in the 1:100 AEP event. Significantly the gate operating rule has negligible effect on discharge and water level for the PMP design flood.

Table 4.1

Outflows and Flood Levels – MOL 116.42 and Auxiliary Spillway in Place

AEP	H14		RELEASE	
	Outflow (m3/s)	Dam water Level (m AHD)	Outflow (m3/s)	Dam water Level (m AHD)
1:5	2,150	117.3	1,330	117.4
1:10	3,620	117.8	2,390	118.1
1:20	5,630	118.4	3,330	119.1
1:50	7,650	119.4	5,180	120.6
1:100	9,100	121.0	7,010	122.1
1:200	10,900	122.8	9,430	123.5
1:500	13,400	125.0	13,400	125.2
1;1000	15,600	126.8	16,200	127.3
PMF	39,300	130.7	39,200	130.7

4.2 AUXILLIARY SPILLWAY PERFORMANCE

With the auxiliary spillway in place the PMF (24-hour) reaches a maximum water level in the dam of 130.7 m AHD (which is greater than the DCF) for both the H14 procedure and the RELEASE rule and the peak dam discharge in the PMF varies little between the procedures. It is therefore concluded that the auxiliary spillway design requires no modification for the alternative gate operation rules.

Without the auxiliary spillway in place and an MOL of 116.42 m it is estimated that the dam crest is overtopped for a flood with an AEP of 1:6000 when the H14 gate operating rule is applied and a flood with an AEP of 1:5400 for the RELEASE rule. It should be noted that these AEP's have been estimated by interpolating between the 1:1000 and 1:100,000 AEP

APPENDIX H

Warragamba Dam Wall Raising

DRAFT Non-Aboriginal Heritage Impact Assessment

Editorial note: WaterNSW template to be used in next draft

Report to SMEC
September 2018

artefact

Artefact Heritage
ABN 73 144 973 526
Level 4, Building B
35 Saunders Street
Pyrmont NSW 2009
Australia

+61 2 9518 8411
office@artefact.net.au

8.2. Potential impacts to listed sites

8.2.1. Summary of heritage places

The assessment of heritage places within the Referral Area has determined that a total of 1,132 statutory listings are present, which include:

- EPBC Act (18);
    - World Heritage List – 3;
    - National Heritage List – 3;
    - Commonwealth Heritage List – 11;
- NSW Heritage Act (196);
    - State Heritage List – 81;
    - NSW Historic Shipwreck Database – 8;
    - s170 Registers – 86; and
- Local Environment Plans – 939.

In some instances, a single place is represented on several statutory lists, or has its curtilage split and listed more than once. Where curtilages are split, an assessment was undertaken for the entire combined curtilage, thus there are less LEP places in the appendices than noted above.

8.3. World Heritage List

For detailed impact tables, see Appendix 1, which provides an assessment of each place against each flood event assessed and the overall assessment for each place as well as mapping the overall impacts to places.

8.3.1. Greater Blue Mountains Area (WHL Place ID 105127)

8.3.1.1. Physical impact assessment

Impact of the Project to the WHL Greater Blue Mountains Area are noted in the impact tables as having a high impact through the mechanism of this assessment's methodology (Appendix 1). This impact covers areas both upstream and downstream of the dam wall, and is examined in more detail below.

Areas downstream of the dam wall will see a reduction in flood heights and extension of flood duration. The overall impact observed from the six events examined downstream would only affect small areas on the edge of the Greater Blue Mountains Area curtilage around Colo and Colo Heights. The impacts in these areas across the six scenarios are considered to be negligible given the nature of the flood mitigation impact of the Project.

The main impacts to the WHL Greater Blue Mountains Area relate to areas upstream of the dam wall. Around 1,303 hectares of the listed curtilage of the place are within the proposed inundation levels.

These areas of the item's curtilage would be directly impacted through the retention of flood waters at a higher level over an extended period of time. This area would constitute around 0.12% of the item's WHL curtilage. Inundation levels would impact sections of affected streams and rivers within the Greater Blue Mountains Area including Coxs River and Coxs River Arm, Kedumba River, Wollondilly River, Nattai River, Little River and associated creeks.

The diversity and intactness of the habitats and plant communities within the Greater Blue Mountains Area are a key aspect of the property's Outstanding Universal Value, with its habitats and plant communities supporting globally significant species and ecosystem diversity. The proposed increase in inundation levels within affected parts of the Greater Blue Mountains Area would result in permanent environmental changes to the ecosystems and ecology of these areas. ***Editorial note: Integrate findings from Biodiversity Report when available***

Increased inundation levels and duration upstream of the dam wall would additionally impact occupation sites and deposits within the Greater Blue Mountains Area that provide tangible evidence of the place's longstanding Aboriginal connections. As outlined in the description of the property's Outstanding Universal Value, the conservation not only of the natural beauty of the Greater Blue Mountains but also its Aboriginal associations contributes to its integrity and World Heritage values. Impact to Aboriginal sites upstream of the dam wall would therefore diminish the exceptional WHL values of the Greater Blue Mountains Area. ***Editorial note: Integrate findings from Aboriginal Assessment when available***

The Project would result in an overall high direct (physical) impact to the WHL Greater Blue Mountains Area.

8.3.1.2. Visual impact assessment

The Project would result in visual changes to affected portions of the Greater Blue Mountains Area within the raised inundation levels, mainly by way of scarring. ***Editorial note: Integrate findings from Visual Impact Assessment and Biodiversity Report when available***

The Project would result in an overall moderate indirect (visual) impact to the WHL Greater Blue Mountains Area.

Editorial note: Impact to Greater Blue Mountains Area natural and cultural values can only be confirmed in reference to the findings of the Biodiversity Report, Aboriginal Assessment and Visual Impact Assessment.

8.3.1.3. EPBC Major Guideline Questions

The Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (2013) pose a series of questions on the nature of the impact to the heritage values of a World Heritage property or National Heritage Place which are to be considered when assessing the potential impact of a proposed action on items of World or National heritage.

These questions have been considered with reference to the potential impacts associated with the proposed action as follows:

1. *Are there any matters of national environmental significance located in the area of the proposed action (noting that 'the area of the proposed action' is broader than the immediate location where the action is undertaken; consider also whether there are any matters of national environmental significance adjacent to or up/ downstream from the immediate location that may potentially be impacted)?*

Yes, construction of the proposed action would occur both upstream and downstream of the World (and National) Heritage Property. Portions of the World (and National) Heritage Property are located within the proposed increased inundation levels of the Referral Area.

2. *Considering the proposed action at its broadest scope (that is, considering all stages and components of the action, and all related activities and infrastructure), is there potential for impacts, including indirect impacts, on matters of national environmental significance?*

Yes, the proposed action would result in permanent changes within around 1,303 hectares of the Greater Blue Mountains Area, which constitutes around 0.12% of the World (and National) Heritage Property. This includes direct impacts to the natural and cultural values of the Greater Blue Mountains Area, as addressed in the associated Aboriginal Cultural Heritage Impact Assessment and Biodiversity Assessment Report. ***Editorial note: Integrate findings from Biodiversity Report and Aboriginal Assessment when available***

3. *Are there any proposed measures to avoid or reduce impacts on matters of national environmental significance (and if so, is the effectiveness of these measures certain enough to reduce the level of impact below the 'significant impact' threshold)?*

No, there are no proposed measures to avoid or reduce the level of impact to the World (and National) Greater Blue Mountains Area. ***Editorial note: Integrate findings from Biodiversity Report and Aboriginal Assessment when available***.

4. *Are any impacts of the proposed action on matters of national environmental significance likely to be significant impacts (important, notable, or of consequence, having regard to their context or intensity)?*

Yes, the proposed action would result in permanent changes within approximately 0.12% of the World (and National) Heritage Property. This includes impacts to the natural and cultural values of the Greater Blue Mountains Area, as addressed in the associated Aboriginal Cultural Heritage Impact Assessment and Biodiversity Assessment Report. ***Editorial note: Integrate findings from Biodiversity Report and Aboriginal Assessment when available***.

8.3.1.4. Significant Impact Criteria

The Significant Impact Criteria outlined in the *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (2013)* are intended to assist in determining whether the impacts of a proposed action on any matter of national environmental significance are likely to be significant impacts. Table 7.6 presents an assessment against the heritage values for the Greater Blue Mountains Area.

Table 7.6: Assessment against Significant Impact Criteria

Significant Impact Criteria	Impact to Greater Blue Mountains Area
Permanently remove, destroy, damage or substantially alter the fabric of a World Heritage property or National Heritage Place in a manner which is inconsistent with relevant values	Yes
Extend, renovate, refurbish or substantially alter a World Heritage property or National Heritage Place in a manner which is inconsistent with relevant values	No
Permanently remove, destroy, damage or substantially disturb archaeological deposits or artefacts in a World Heritage property or National Heritage Place	Yes
Involve activities in a World Heritage property or National Heritage Place with substantial and/or long–term impacts on its values	Yes
Involve construction of buildings or other structures within, adjacent to, or within important sight lines of, a World Heritage property or National Heritage Place which are inconsistent with relevant values	No

Significant Impact Criteria	Impact to Greater Blue Mountains Area
Make notable changes to the layout, spaces, form or species composition in a garden, landscape or setting of a World Heritage property or National Heritage Place which are inconsistent with relevant values	Yes
Alter the setting of a World Heritage property or National Heritage Place in a manner that is inconsistent with relevant values	No

8.3.2. Australian Convict Sites (Old Great North Road) and buffer zone (WHL Place ID 106209)

8.3.2.1. Physical impact assessment

Impact of the Project to the WHL Australian Convict Sites (Old Great North Road) are noted in the impact tables as having a positive impact through the mechanism of this assessment's methodology (Appendix 1). This is due to a reduction in flood levels across parts of the curtilage closest to the Hawkesbury-Nepean. ***Editorial note: more analysis to be added into next draft***

The Project would result in a positive direct (physical) impact to the WHL Australian Convict Sites (Old Great North Road).

8.3.2.2. Visual impact assessment

It is not anticipated that the Project would result in any visual changes to portions of the Australian Convict Sites (Old Great North Road) within the Referral Area. No changes are proposed within the World (and National) property, and the reduction in flood levels within the item's curtilage that are close to the Hawkesbury-Nepean would minimise future changes to the visual appearance and configuration of the item's fabric.

The Project would result in a neutral indirect (visual) impact to the WHL Australian Convict Sites (Old Great North Road).

8.3.2.3. EPBC Major Guideline Questions

The *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* (2013) pose a series of questions on the nature of the impact to the heritage values of a World Heritage property or National Heritage place which are to be considered when assessing the potential impact of a proposed action on items of World or National Heritage.

These questions have been considered with reference to the potential impacts associated with the proposed action as follows:

1. *Are there any matters of national environmental significance located in the area of the proposed action (noting that 'the area of the proposed action' is broader than the immediate location where the action is undertaken; consider also whether there are any matters of national environmental significance adjacent to or up/ downstream from the immediate location that may potentially be impacted)?*

Yes, the proposed action would occur in proximity to the Australian Convict Sites (Old Great North Road), involving parts of the curtilage closest to the Hawkesbury-Nepean.

2. *Considering the proposed action at its broadest scope (that is, considering all stages and components of the action, and all related activities and infrastructure), is there potential for impacts, including indirect impacts, on matters of national environmental significance?*

No impacts to World Heritage values associated with the Australian Convict Sites (Old Great North Road) are anticipated by the proposed action, with reduction in flood levels in areas close to the World (and National) Heritage Property resulting in a positive outcome.

3. *Are there any proposed measures to avoid or reduce impacts on matters of national environmental significance (and if so, is the effectiveness of these measures certain enough to reduce the level of impact below the 'significant impact' threshold)?*

The proposed action provides flood mitigation that would reduce flood levels in areas of the Hawkesbury-Nepean in proximity to the Australian Convict Sites (Old Great North Road). This would protect the World Heritage values of the property.

4. *Are any impacts of the proposed action on matters of national environmental significance likely to be significant impacts (important, notable, or of consequence, having regard to their context or intensity)?*

No. The proposed action is not expected to impact on matters of national environmental significance.

8.3.2.4. Significant Impact Criteria

The Significant Impact Criteria outlined in the *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (2013)* are intended to assist in determining whether the impacts of a proposed action on any matter of national environmental significance are likely to be significant impacts. Table 7.7 presents an assessment against the heritage values for the Australian Convict Sites (Old Great North Road).

Table 7.7: Assessment against Significant Impact Criteria

Significant Impact Criteria	Impact to Australian Convict Sites (Old Great North Road)
Permanently remove, destroy, damage or substantially alter the fabric of a World Heritage property or National Heritage Place in a manner which is inconsistent with relevant values	No
Extend, renovate, refurbish or substantially alter a World Heritage property or National Heritage Place in a manner which is inconsistent with relevant values	No
Permanently remove, destroy, damage or substantially disturb archaeological deposits or artefacts in a World Heritage property or National Heritage Place	No
Involve activities in a World Heritage property or National Heritage Place with substantial and/or long–term impacts on its values	No
Involve construction of buildings or other structures within, adjacent to, or within important sight lines of, a World Heritage property or National Heritage Place which are inconsistent with relevant values	No
Make notable changes to the layout, spaces, form or species composition in a garden, landscape or setting of a World Heritage property or National Heritage Place which are inconsistent with relevant values	No
Alter the setting of a World Heritage property or National Heritage Place in a manner that is inconsistent with relevant values	No

8.4. National Heritage List

For detailed impact tables, see Appendix 2, which provides an assessment of each place against each flood event assessed and the overall assessment for each place as well as mapping the overall impacts to places.

8.4.1. The Greater Blue Mountains Area (NHL Place ID 105999)

The assessed heritage impacts on the values of the NHL Greater Blue Mountains Area are covered above for its World Heritage listing (refer to Section 7.3). It is noted that a larger portion of the NHL curtilage of the Greater Blue Mountains Area would be impacted by the raised dam levels. Around 1,420 hectares of the NHL curtilage are within the proposed inundation levels, which would constitute around 0.13% of the item's curtilage.

8.4.2. The Greater Blue Mountains Area - Additional Values (NHL Place ID 105696)

The assessed heritage impacts on the values of the NHL Greater Blue Mountains Area – Additional Values are largely consistent with the findings above for its World Heritage listing (refer to Section 7.3).

It is noted, however, that a larger portion of the Additional Values listing would be impacted by the raised dam levels. This is due to the curtilage extending down to the current FSL around the dam. Around 5,774 hectares of the listed curtilage of the Greater Blue Mountains Area – Additional Values are within the proposed inundation levels.

As previously covered, increased inundation levels and duration upstream of the dam wall would result in permanent changes to the ecology of affected areas and would additionally impact Aboriginal sites and places within the Greater Blue Mountains Area. The description of the property's Outstanding Universal Value indicates importance of both the natural and cultural values of the Greater Blue Mountains Area.

Editorial note: Integrate findings from Biodiversity Report and Aboriginal Assessment when available

8.4.3. Great North Road, Wisemans Ferry to Bucketty (NHL Place ID 106318)

The assessed heritage impact on the values of the NHL Great North Road, Wisemans Ferry to Bucketty heritage item are covered above for its World Heritage listing (refer to Section 7.3). The lowering of the flood levels will protect larger elements of the curtilage of the place and result in a generally positive impact. As covered above, this reduction in impact is not considered to be a significant impact under the Significant Impact guidelines and would support the aims of the National Heritage Principles in protecting a place's values. ***Editorial note: more analysis to be added into next draft***

8.5. Commonwealth Heritage List

Impacts to places on the CHL are considered to be neutral across the six scenarios investigated with minor impacts in some events offset by positive impacts in other events. No place on the CHL suffers impacts that would be regarded as significant under the Significant Impact guidelines and the overall neutral impacts are considered to be in line with the Commonwealth Heritage Principles.

Editorial note: more analysis to be added into next draft

For detailed impact tables, see Appendix 3.

APPENDIX I

Donor to Political Party Disclosure Return – Organisations

AEC Australian Electoral Commission

FINANCIAL YEAR 2015-16

Section 305B(1) requires donors to furnish a return within 20 weeks after the end of the financial year. The due date for lodging this return is 17 November 2016.

Completing the Return:

- This return is to be completed byorganisations who made a donation to a registered political party (or a State branch), or to another person or organisation with the intention of benefiting a registered political party.
- This return is to be completed with reference to the *Financial Disclosure Guide for Donors to Political Parties.*
- Further information is available at www.aec.gov.au.
- This return will be available for public inspection from Wednesday 1 February 2017at www.aec.gov.au.
- Any supporting documentation included with this return may be treated as part of a public disclosure and displayed on the AEC website.
- The information on this return is collected under s305B of the*Commonwealth Electoral Act 1918.*

NOTE: This form is for the use of organisations only. Please use the form Donor to Political Party Disclosure Return – Individuals if you are completing a return for an individual.

Details of organisation that made the donation

Name	Waratah Group (Australia) Pty Ltd		
Address	177 Parramatta Road		
	Suburb/Town Auburn	State NSW	Postcode 2144
ABN	87 603 905 808	ACN 603 905 808	

Details of person completing this return

Name	Kenny Zhang		
Capacity or position (e.g. company secretary)	Managing Director		
Postal address	177 Parramatta Road		
	Suburb/Town Auburn	State NSW	Postcode 2144
Telephone number	(02) 8064 2923	Fax number (02) 9748 1050	
Email address	kennyzhang@waratahgroup.com		

Certification

I certify that the information contained in this return and its attachments is true and complete to the best of my knowledge, information and belief. I have made due and reasonable inquiries of the organisation on whose behalf I am authorised to complete this form.

I understand that submitting an incomplete, false or misleading return is an offence under section 315 of the Commonwealth Electoral Act 1918.

Signature  Date 27/03/2017

Enquiries and returns should be addressed to:

Funding and Disclosure
Australian Electoral Commission
Locked Bag 4007
Canberra ACT 2601

Phone: 02 6271 4552
Fax: 02 62937655
Email: fad@aec.gov.au

Office use only
Date received

Part 1a: Other business names

Do you operate or conduct business under any other names?

No ☐

Yes ☐ ▶ List other trading names

Part 1b: Related bodies corporate

Subsection 287(6) of the *Commonwealth Electoral Act 1918* deems bodies corporate related under the provisions of the *Corporations Act 2001* to be a single entity for disclosure purposes. The parent company of the group, therefore, should lodge under its name a return consolidated across the entire group.

Does this return cover any other related bodies corporate?

No ☐

Yes ☒ ▶ List any related bodies corporate **you are lodging on behalf of**

Name	Waratah Paint (Shenzhen) Co. Ltd		
Postal address			
Suburb/town		State	Postcode
ABN		ACN	
Name	Keenfoo Property (Shenzhen) Co. Ltd		
Postal address			
Suburb/town		State	Postcode
ABN		ACN	
Name	Clydesdale Property (Australia) Co. Ltd		
Postal address			
Suburb/town		State	Postcode
ABN		ACN	
Name	Shenzhen Cockatoo Co. Ltd		
Postal address			
Suburb/town		State	Postcode
ABN		ACN	
Name	Shenzhen Waratah Fund Management Co. Ltd		
Postal address			
Suburb/town		State	Postcode
ABN		ACN	
Name	Shenzhen CAN Investment Co. Ltd		
Postal address			
Suburb/town		State	Postcode
ABN		ACN	

Name	Teamwise Investment (HK) Co Ltd		
Postal address			
Suburb/town		State	Postcode
ABN		ACN	
Name	Keenfoo Mining (Heyuan) Co. Ltd		
Postal address			
Suburb/town		State	Postcode
ABN		ACN	
Name	Shenzhen CAN Trading Co. Ltd		
Postal address			
Suburb/town		State	Postcode
ABN		ACN	
Name			
Postal address			
Suburb/town		State	Postcode
ABN		ACN	
Name			
Postal address			
Suburb/town		State	Postcode
ABN		ACN	
Name			
Postal address			
Suburb/town		State	Postcode
ABN		ACN	
Name			
Postal address			
Suburb/town		State	Postcode
ABN		ACN	

If insufficient space, please attach additional sheets.

Part 2: Donations made

Details of **donations** made to a political party **totalling** more than $13 000, between 1 July 2015 and 30 June 2016. If the total of donations made to one political party exceeds the disclosure threshold, all donations made to that political party, regardless of their value, must be disclosed.

For each donation made, the following details must be disclosed:

- Party code* and the address of the political party to which the donation was made
- date each donation was made
- value of each donation made

Party details			Date of donation	Value of donation** (GST inclusive)
Name/Party Code	Liberal Party of Australia, NSW Division (LIB-NSW)		30/06/2016	300,000 .00
Postal address	Locked Bag 2			
Suburb/town	Kings Cross	State NSW Postcode 1340		
Name/Party Code				$ .00
Postal address				
Suburb/town		State Postcode		
Name/Party Code				$ .00
Postal address				
Suburb/town		State Postcode		
Name/Party Code				$ .00
Postal address				
Suburb/town		State Postcode		
Name/Party Code				$ .00
Postal address				
Suburb/town		State Postcode		
Name/Party Code				$ .00
Postal address				
Suburb/town		State Postcode		
Name/Party Code				$ .00
Postal address				
Suburb/town		State Postcode		

If insufficient space, please attach additional sheets. **Total** $ 300,000 .00

*A full list of political parties and their **party codes** is at the end of this form.

****Donation** is a gift within the meaning of Division 4 – Disclosure of donations, in Part XX the *Commonwealth Electoral Act 1918.*

Part 3: Donations received

Details of **donations** of more than $13 000 **received** and used (wholly or partly) to make donations shown in Part 2 of this return. The 'donations received' section of this return applies to a donor:

- who received a donation of more than $13 000 (whether within the 2015-16 financial year or not); **and**
- used that donation, or part of it, to make donations totalling more than $13 000 to a political party in the 2015-16 financial year.

For donations that meet the disclosure criteria above, the following details must be reported:

- full name and address details*** of the person or organisation from whom the donation was received
- date each donation was received
- value or amount of each donation.

Donation received from			Date of donation	Value of donation** (GST inclusive)
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		

If insufficient space, please attach additional sheets.

Total $ Nil .00

** **Donation** is a gift within the meaning of Division 4 – Disclosure of donations, in Part XX of the *Commonwealth Electoral Act 1918*.

***** Name and address details**

- If the gift was from an unincorporated association (other than a registered industrial organisation), the name of the association and the name and addresses of the executive committee members are required.
- If the gift was from a trust, the name of the trust, and the name and addresses of the trustee are required.

Registered Political Party and Branch Codes

CODE	Party / Branch
ALP-ACT	Australian Labor Party (ACT Branch)
ALP-NSW	Australian Labor Party (N.S.W. Branch)
ALP-NT	Australian Labor Party (Northern Territory Branch)
ALP-QLD	Australian Labor Party (State of Queensland)
ALP-SA	Australian Labor Party (South Australian Branch)
ALP-TAS	Australian Labor Party (Tasmanian Branch)
ALP-VIC	Australian Labor Party (Victorian Branch)
ALP-WA	Australian Labor Party (Western Australian Branch)
ALP-FED	Australian Labor Party (ALP)
CLR-NSW	Country Labor Party
DLP-NSW	Democratic Labor Party (DLP) NSW Branch
DLP-QLD	Democratic Labor Party (DLP) – Queensland Branch
DLP-SA	Democratic Labor Party (DLP) of Australia SA Branch
DLP-VIC	Democratic Labor Party (DLP) – Victorian Branch
DLP-WA	Democratic Labor Party (DLP) – WA Branch
DLP	Democratic Labour Party (DLP) of Australia
FFP-QLD	Family First Party – QLD
FFP-SA	Family First Party – SA
FFP-VIC	Family First Party – VIC
FFP	Family First Party
GRN-ACT	Australian Greens, Australian Capital Territory Branch
GRN-NSW	The Greens NSW
GRN-NT	Australian Greens, Northern Territory Branch
GRN-QLD	Queensland Greens
GRN-SA	Australian Greens (South Australia)
GRN-TAS	Australian Greens, Tasmanian Branch
GRN-VIC	The Australian Greens - Victoria
GRN-WA	The Greens (WA) Inc
GRN	Australian Greens
LIB-ACT	Liberal Party of Australia – ACT Division
LIB-NSW	Liberal Party of Australia, NSW Division
LNP-QLD	Liberal National Party of Queensland
LIB-SA	Liberal Party of Australia (S.A. Division)
LIB-TAS	Liberal Party of Australia – Tasmanian Division
LIB-VIC	Liberal Party of Australia (Victorian Division)
LIB-WA	Liberal Party (W.A. Division) Inc.
LIB-FED	Liberal Party of Australia
NAT-SA	National Party of Australia (S.A.) Inc.
NAT-VIC	National Party of Australia – Victoria
NAT-NSW	National Party of Australia – N.S.W.
NAT-WA	National Party of Australia (WA) Inc
NAT-FED	National Party of Australia
SPP	#Sustainable Australia
21ST	21st Century Australia
AJP	Animal Justice Party
AFP-NSW	Australia First Party (NSW) Incorporated
AAPP	Australian Antipaedophile Party
ACH	Australian Christians
CAL	Australian Country Party
CYC	Australian Cyclists Party
ADVP	Australian Defence Veterans Party
AEQ	Australian Equality Party (Marriage)
ALA	Australian Liberty Alliance
AMEP	Australian Motoring Enthusiast Party
PROG	Australian Progressives
ARF	Australian Recreational Fishers Party
ASP	Australian Sex Party
BTA	Bullet Train for Australia
CDP	Christian Democratic Party (Fred Nile Group)
CEC	Citizens Electoral Council of Australia
CRNT	Consumer Rights & No-Tolls
CLP-NT	Country Liberals (Northern Territory)
CM	CountryMinded
DHJP	Derryn Hinch's Justice Party
DLRA	Drug Law Reform Australia
GLT	Glenn Lazarus Team
NMP	Health Australia Party
HEM	Help End Marijuana Prohibition (HEMP) Party
JLN	Jacqui Lambie Network
JMMFP	John Madigan's Manufacturing and Farming Party
KAP	Katter's Australian Party
LDP	Liberal Democratic Party
MAP	Mature Australia Party
XEN	Nick Xenophon Team
NCP	Non-Custodial Parents Party (Equal Parenting)
SOL	Online Direct Democracy – (Empowering the People)
ODR	Outdoor Recreation Party (Stop the Greens)
PUP	Palmer United Party
ONA	Pauline Hanson's One Nation
PIR	Pirate Party Australia
REP	Renewable Energy Party
RUA	Rise Up Australia Party
FUT	Science Party
SPA	Secular Party of Australia
SUN	Seniors United Party of Australia
SFP	Shooters, Fishers and Farmers Party
SMK	Smokers Rights Party
SAL	Socialist Alliance
SEP	Socialist Equality Party
ARTS	The Arts Party
AMHP	The Australian Mental Health Party
VEP	Voluntary Euthanasia Party
FLUX	VOTEFLUX.ORG | Upgrade Democracy!

Links

State Government legislation may place requirements on political donations in addition to federal requirements. Check with your state electoral commission about requirements in your state.

NSW Electoral Commission*
http://www.elections.nsw.gov.au/

Victorian Electoral Commission
http://www.vec.vic.gov.au/

Electoral Commission of Queensland*
http://www.ecq.qld.gov.au/

Western Australian Electoral Commission*
http://www.waec.wa.gov.au/

Electoral Commission of South Australia
http://www.ecsa.sa.gov.au/

Tasmanian Electoral Commission
http://tec.tas.gov.au/

Australian Capital Territory Electoral Commission*
http://www.elections.act.gov.au/

Northern Territory Electoral Commission*
http://www.ntec.nt.gov.au/

*denotes an organisation that operates a funding and disclosure scheme separate from the Commonwealth disclosure scheme as at 30 June 2016.

Donor to Political Party Disclosure Return – Organisations

2017–18 FINANCIAL YEAR

Section 305B(1) requires donors to furnish a return within 20 weeks after the end of the financial year. The due date for lodging this return is 19 November 2018.

Completing the return:

- This return is to be completed by organisations who made a donation to a registered political party (or a state branch), or to another person or organisation with the intention of benefitting a registered political party.
- This return is to be completed with reference to the *Financial Disclosure Guide for Donors to Political Parties*.
- Further information is available at http://www.aec.gov.au/Parties_and_Representatives/financial_disclosure/index.htm.
- This return will be available for public inspection from Friday 1 February 2019 on the AEC website.
- **Any** supporting documentation included with this return may be treated as part of a public disclosure and displayed on the AEC website.
- The information on this return is collected under s 305B of the *Commonwealth Electoral Act 1918*.

NOTE: This form is for the use of organisations only. Please use the form Donor to Political Party Disclosure Return – Individuals if you are completing a return for an individual.

Details of organisation that made the donation

Name	Waratah Group (Australia) Pty Ltd		
Address	177 Parramatta Road		
	Suburb/town Auburn	State NSW	Postcode 2144
ABN	87 603 905 808	ACN 603 905 808	

Details of person completing this return

Name	Kenny Zhang		
Capacity or position (e.g. company secretary)	Managing Director		
Postal address	177 Parramatta Road		
	Suburb/town Auburn	State NSW	Postcode 2144
Telephone number	(02) 8064 2923	Fax number (02)9748 1050	
Email address	kennyzhang@waratahgroup.com		

Certification

I certify that the information contained in this return and its attachments is true and complete to the best of my knowledge, information and belief. I have made due and reasonable inquiries of the organisation on whose behalf I am authorised to complete this form.

I understand that submitting an incomplete, false or misleading return is an offence under section 315 of the Commonwealth Electoral Act 1918.

Signature Date 14 / 19

Enquiries and returns should be addressed to:

Disclosure and Compliance
Australian Electoral Commission
Locked Bag 4007
Canberra ACT 2601

Phone: 02 6271 4552
Fax: 02 6293 7655
Email: fad@aec.gov.au

Office use only
Date received

Part 1a: Other business names

Do you operate or conduct business under any other names?

No ☐

Yes ☐ List other trading names

Part 1b: Related bodies corporate

Subsection 287(6) of the *Commonwealth Electoral Act 1918* deems bodies corporate related under the provisions of the *Corporations Act 2001* to be a single entity for disclosure purposes. The parent company of the group, therefore, should lodge under its name a return consolidated across the entire group.

Does this return cover any other related bodies corporate?

No ☐

Yes ☐ List any related bodies corporate **you are lodging on behalf of**

Name Waratah Paint (Shenzhen) Co. Ltd		
Postal address		
Suburb/town	State	Postcode
ABN	ACN	
Name Keenfoo Property (Shenzen)		
Postal address		
Suburb/town	State	Postcode
ABN	ACN	
Name Clydesdale Property (Australia)		
Postal address		
Suburb/town	State	Postcode
ABN	ACN	
Name Shenzhen Cockatoo Co. Ltd		
Postal address		
Suburb/town	State	Postcode
ABN	ACN	
Name Shenzhen Waratah Fund Management Co. Ltd.		
Postal address		
Suburb/town	State	Postcode
ABN	ACN	

If insufficient space, please attach additional sheets.

Part 1a: Other business names

Do you operate or conduct business under any other names?

No ☐

Yes ☐ List other trading names

Part 1b: Related bodies corporate

Subsection 287(6) of the *Commonwealth Electoral Act 1918* deems bodies corporate related under the provisions of the *Corporations Act 2001* to be a single entity for disclosure purposes. The parent company of the group, therefore, should lodge under its name a return consolidated across the entire group.

Does this return cover any other related bodies corporate?

No ☐

Yes ☐ List any related bodies corporate **you are lodging on behalf of**

Name Shenzhen CAN Investment Co. Ltd		
Postal address		
Suburb/town	State	Postcode
ABN	ACN	
Name Teamwise Investment (HK) Co Ltd		
Postal address		
Suburb/town	State	Postcode
ABN	ACN	
Name Keenfo Mining (Heyuan) Co. Ltd		
Postal address		
Suburb/town	State	Postcode
ABN	ACN	
Name Shenzhen CAN Trading Co. Ltd		
Postal address		
Suburb/town	State	Postcode
ABN	ACN	
Name		
Postal address		
Suburb/town	State	Postcode
ABN	ACN	

If insufficient space, please attach additional sheets.

Part 2: Donations made

Details of **donations**, including **gifts-in-kind,** made to a political party **totalling** more than $13,500, between 1 July 2017 and 30 June 2018. If the total of donations made to one political party exceeds the disclosure threshold, all donations made to that political party, regardless of their value, must be disclosed.

For **each** donation made, the following details must be disclosed:

- party code* and the address of the political party to which the donation was made
- date each donation was made
- value of each donation made.

Party details	Date of donation	Value of donation** (GST inclusive)
Name/party code Liberal Party of Australia, NSW Division (LIB - NSW)	26/7/17	$ 75,000 .00
Postal address Locked Bag 2	27/7/17	$175,000.00
Suburb/town Kings Cross State NSW Postcode 1340		
Name/party code		$ .00
Postal address		
Suburb/town State Postcode		
Name/party code		$ .00
Postal address		
Suburb/town State Postcode		
Name/party code		$ .00
Postal address		
Suburb/town State Postcode		
Name/party code		$ .00
Postal address		
Suburb/town State Postcode		
Name/party code		$ .00
Postal address		
Suburb/town State Postcode		
Name/party code		$ .00
Postal address		
Suburb/town State Postcode		
	Total	$ 250,000 .00

If insufficient space, please attach additional sheets.

*A full list of political parties and their **party codes** is at the end of this form.

****Donation** is a gift within the meaning of Division 4 – Disclosure of donations, in Part XX the *Commonwealth Electoral Act 1918*.

Part 3: Donations received

Details of **donations** of more than $13,500 **received** and used (wholly or partly) to make donations shown in Part 2 of this return. The 'donations received' section of this return applies to a donor:

- who received a donation of more than $13,500 (whether within the 2017–18 financial year or not); **and**
- used that donation, or part of it, to make donations totalling more than $13,500 to a political party in the 2017–18 financial year.

For donations that meet the disclosure criteria above, the following details must be reported:

- full name and address details*** of the person or organisation from whom the donation was received
- date each donation was received
- value or amount of each donation.

Donation received from			Date of donation	Value of donation** (GST inclusive)
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		
Name				$ .00
Postal address				
Suburb/town	State	Postcode		

If insufficient space, please attach additional sheets.

Total $ .00

** **Donation** is a gift within the meaning of Division 4 – Disclosure of donations, in Part XX of the *Commonwealth Electoral Act 1918*.

*** **Name and address details**

- If the gift was from an unincorporated association (other than a registered industrial organisation), the name of the association and the name and addresses of all the executive committee members are required.
- If the gift was from a trust, the name of the trust, and the name and addresses of all the trustees are required.

Registered Political Party and Branch Codes

CODE	Party / Branch
ACP-ACT	Australian Conservatives (ACT)
ACP-NSW	Australian Conservatives (NSW)
ACP-NT	Australian Conservatives (NT)
ACP-QLD	Australian Conservatives (Qld)
ACP-SA	Australian Conservatives (SA)
ACP-TAS	Australian Conservatives (Tas)
ACP-VIC	Australian Conservatives (Vic)
ACP-WA	Australian Conservatives (WA)
ACP	Australian Conservatives
ALP-ACT	Australian Labor Party (ACT Branch)
ALP-NSW	Australian Labor Party (N.S.W. Branch)
ALP-NT	Australian Labor Party (Northern Territory) Branch
ALP-SA	Australian Labor Party (South Australian Branch)
ALP-QLD	Australian Labor Party (State of Queensland)
ALP-TAS	Australian Labor Party (Tasmanian Branch)
ALP-VIC	Australian Labor Party (Victorian Branch)
ALP-WA	Australian Labor Party (Western Australian Branch)
ALP-FED	Australian Labor Party (ALP)
CLR-NSW	Country Labor Party
DLP-NSW	Democratic Labour Party NSW Branch
DLP-QLD	Democratic Labour Party - Queensland Branch
DLP-VIC	Democratic Labour Party - Victorian Branch
DLP-WA	Democratic Labour Party - WA Branch
DLP	Democratic Labour Party
GRN-ACT	Australian Greens, Australian Capital Territory Branch
GRN-NSW	The Greens NSW
GRN-NT	Australian Greens, Northern Territory Branch
GRN-QLD	Queensland Greens
GRN-SA	Australian Greens (South Australia)
GRN-TAS	Australian Greens, Tasmanian Branch
GRN-VIC	The Australian Greens - Victoria
GRN-WA	The Greens (WA) Inc
GRN-FED	Australian Greens
LIB-ACT	Liberal Party of Australia - ACT Division
LIB-NSW	Liberal Party of Australia, NSW Division
LNP-QLD	Liberal National Party of Queensland
LIB-SA	Liberal Party of Australia (S.A. Division)
LIB-TAS	Liberal Party of Australia - Tasmanian Division
LIB-VIC	Liberal Party of Australia (Victorian Division)
LIB-WA	Liberal Party (W.A. Division) Inc
LIB-FED	Liberal Party of Australia
LDP-ACT	Liberal Democratic Party (ACT Branch)
LDP-NSW	Liberal Democratic Party (NSW Branch)
LDP-QLD	Liberal Democratic Party (QLD Branch)
LDP-SA	Liberal Democratic Party (SA Branch)
LDP-VIC	Liberal Democratic Party (Victoria Branch)
LDP-WA	Liberal Democratic Party (WA Branch)
LDP	Liberal Democratic Party
NAT-NSW	National Party of Australia - N.S.W.
NAT-SA	National Party of Australia (S.A.) Inc.
NAT-VIC	National Party of Australia - Victoria
NAT-WA	National Party of Australia (WA) Inc
NAT-FED	National Party of Australia
SPP	#Sustainable Australia
AJP	Animal Justice Party
AFP-NSW	Australia First Party (NSW) Incorporated
APPH	Australian Affordable Housing Party
ACH	Australian Christians
CAL	Australian Country Party
ALA	Australian Liberty Alliance
APEP	Australian People's Party
PROG	Australian Progressives
AWP	Australian Workers Party
XEN	Centre Alliance
CDP	Christian Democratic Party (Fred Nile Group)
CEC	Citizens Electoral Council of Australia
CLP-NT	Country Liberals (Northern Territory)
DHJP	Derryn Hinch's Justice Party
NMP	Health Australia Party
HEM	Help End Marijuana Prohibition (HEMP) Party
IMO	Involuntary Medication Objectors (Vaccination/Fluoride) Party
JLN	Jacqui Lambie Network
KAP	Katter's Australian Party
LAOL	Love Australia or Leave
NCP	Non-Custodial Parents Party (Equal Parenting)
SOL	Online Direct Democracy – (Empowering the People!)
ONA	Pauline Hanson's One Nation
PIR	Pirate Party Australia
RPA	Republican Party of Australia
RUA	Rise Up Australia Party
FUT	Science Party
SPA	Secular Party of Australia
SUN	Seniors United Party of Australia
SFP	Shooters, Fishers and Farmers Party
SAL	Socialist Alliance
SEP	Socialist Equality Party
ARTS	The Arts Party
AMHP	The Australian Mental Health Party
VEP	Voluntary Euthanasia Party
FLUX	VOTEFLUX.ORG | Upgrade Democracy!

Links

State Government legislation may place requirements on political donations in addition to federal requirements. Check with your state electoral commission about requirements in your state.

NSW Electoral Commission*
http://www.elections.nsw.gov.au/

Victorian Electoral Commission
https://www.vec.vic.gov.au/

Electoral Commission of Queensland*
https://www.ecq.qld.gov.au/

Western Australian Electoral Commission*
https://www.elections.wa.gov.au/

Electoral Commission of South Australia*
http://www.ecsa.sa.gov.au/

Tasmanian Electoral Commission
https://www.tec.tas.gov.au/

Australian Capital Territory Electoral Commission*
https://www.elections.act.gov.au/

Northern Territory Electoral Commission*
http://www.ntec.nt.gov.au/

*denotes an organisation that operates a funding and disclosure scheme separate from the Commonwealth disclosure scheme as at 30 June 2018.

ASIC
Australian Securities & Investments Commission

Current & Historical Company Extract

Name: CLYDESDALE PROPERTY DEVELOPMENT GROUP PTY LIMITED
ACN: 169 433 309

Date/Time: 02 September 2018 AEST 10:54:36 PM

This extract contains information derived from the Australian Securities and Investments Commission's (ASIC) database under section 1274A of the Corporations Act 2001.

Please advise ASIC of any error or omission which you may identify.

EXTRACT

CLYDESDALE PROPERTY DEVELOPMENT GROUP PTY LIMITED
ACN 169 433 309

Organisation Details		Document Number
Current Organisation Details		
Name:	CLYDESDALE PROPERTY DEVELOPMENT GROUP PTY LIMITED	2E0503630
ACN:	169 433 309	
ABN:	35169433309	
Registered in:	New South Wales	
Registration date:	07/05/2014	
Next review date:	07/05/2019	
Name start date:	07/05/2014	
Status:	Registered	
Company type:	Australian Proprietary Company	
Class:	Limited By Shares	
Subclass:	Proprietary Company	

Address Details		Document Number
Current		
Registered address:	PKF TAX PTY LTD C/- PKF TAX PTY LTD, Level 8, 1 O'Connell Street, SYDNEY NSW 2000	7E7172554
Start date:	05/08/2015	
Principal Place Of Business address:	C/- PKF TAX PTY LTD, Level 8, 1 O'Connell Street, SYDNEY NSW 2000	7E7172554
Start date:	14/07/2015	
Historical		
Registered address:	SUNNYSIDE ACCOUNTANTS PTY LIMITED, 94 Chandos Street, ST LEONARDS NSW 2065	2E0503630
Start date:	07/05/2014	
Cease date:	04/08/2015	
Principal Place Of Business address:	94 Chandos Street, ST LEONARDS NSW 2065	2E0503630
Start date:	07/05/2014	
Cease date:	13/07/2015	

Contact Address	
Section 146A of the Corporations Act 2001 states 'A contact address is the address to which communications and notices are sent from ASIC to the company'.	
Current	
Address:	GPO BOX 5446, SYDNEY NSW 2001
Start date:	27/06/2017
Historical	
Address:	GPO BOX 5446, SYDNEY NSW 2001
Start date:	29/07/2015
Cease date:	27/06/2017
Address:	PO BOX 294, ST LEONARDS NSW 1590

Start date:	10/11/2014
Cease date:	29/07/2015

Officeholders and Other Roles		Document Number
Director		
Name:	MATTHEW JOHN COLLARD	6E3884377
Address:	120 Second Avenue, MOUNT LAWLEY WA 6050	
Born:	05/10/1973, SYDNEY, NSW	
Appointment date:	29/07/2015	
Name:	KENNY ZHANG	5E5574206
Address:	9a 55 Conduit Road Mid-level Central, Hong Kong	
Born:	22/06/1965, SHANTOU, CHINA	
Appointment date:	07/05/2014	
Previous Director		
Name:	RICHARD MICHAEL PETTY	7E7280827
Address:	62-72 Po Hing Fong, Sheung Wan, Hong Kong	
Born:	23/10/1970, CALGARY, CANADA	
Appointment date:	01/09/2015	
Cease date:	25/05/2017	
Previous Secretary		
Name:	KENNY ZHANG	7E8450998
Address:	8b Block 3 Phase 1, Providence Bay 5, Fochun Road, Taipo, Hong Kong	
Born:	22/06/1965, SHANTOU, CHINA	
Appointment date:	07/05/2014	
Cease date:	25/05/2017	

Share Information

Share Structure

Class	Description	Number issued	Total amount paid	Total amount unpaid	Document number
ORD	ORDINARY	100	100.00	0.00	2E0503630

Members

Note: For each class of shares issued by a proprietary company, ASIC records the details of the top twenty members of the class (based on shareholdings). The details of any other members holding the same number of shares as the twentieth ranked member will also be recorded by ASIC on the database. Where available, historical records show that a member has ceased to be ranked amongst the top twenty members. This may, but does not necessarily mean, that they have ceased to be a member of the company.

Name:	ADVANCED GOAL HOLDINGS LIMITED
Org No.:	166 942 749
Address:	Nova Sage Chambers Po Box 4389 Road Town, Tortola, Virgin Islands, U.s.

Class	Number held	Beneficially held	Paid	Document number
ORD	100	yes	FULLY	2E0503630

Documents

Note: Where no Date Processed is shown, the document in question has not been processed. In these instances care should be taken in using information that may be updated by the document when it is processed. Where the Date Processed is shown but there is a zero under No Pages, the document has been processed but a copy is not yet available.

Date received	Form type	Date processed	Number of pages	Effective date	Document number
07/05/2014	201C Application For Registration As A Proprietary Company	07/05/2014	3	07/05/2014	2E0503630
29/07/2015	484 Change To Company Details 484B Change Of Registered Address 484C Change Of Principal Place Of Business (Address) 484E Appointment Or Cessation Of A Company Officeholder	29/07/2015	3	29/07/2015	7E7172554
08/09/2015	484E Change To Company Details Appointment Or Cessation Of A Company Officeholder	08/09/2015	2	08/09/2015	7E7280827
22/10/2015	384 Notification Of Resol. By Directors Of A Small Pty Company Controlled By A Foreign Coy Which Is Not Part Of Large Group	05/11/2015	1	22/10/2015	029432373
20/10/2016	484A1 Change To Company Details Change Officeholder Name Or Address	20/10/2016	2	20/10/2016	7E8450998
08/06/2017	484E Change To Company Details Appointment Or Cessation Of A Company Officeholder	08/06/2017	2	08/06/2017	7E9134510
09/02/2018	484A1 Change To Company Details Change Officeholder Name Or Address	09/02/2018	2	09/02/2018	6E3884377
14/03/2018	484A1 Change To Company Details Change Officeholder Name Or Address	14/03/2018	2	14/03/2018	5E5574206

*****End of Extract of 3 Pages*****

CERTIFICATE ORDER SUMMARY

Transaction Details

Date:	24/01/2019 12:55
Order No.	55187597
Certificate No:	86050225
Your Reference:	historical6
Certificate Ordered:	NSW LRS - Copy of Dealing - Dealing AI859301
Available:	Y
Size (KB):	32
Number of Pages:	1
Scan Date and Time:	04/09/2014 22:03

Form: 01T
Licence: 05-11-638
Licensee: Softdocs
Baldock Stacy & Niven

TRANSFER

New South Wales
Real Property Act 1900

AI859301R

PRIVACY NOTE: Section 31B of the Real Property Act 1900 (RP Act) authorises the Rec by this form for the establishment and maintenance of the Real Property Act Register. made available to any person for search upon payment of a fee, if any.

STAMP DUTY Office of State Revenue use only (i)

NEW SOUTH WALES DUTY
25-08-2014 0007700683-001
SECTION 18(2)
DUTY $ **********10.00

(A) **TORRENS TITLE** 2/260476

(B) **LODGED BY**

Document Collection Box	Name, Address or DX, Telephone, and Customer Account Number if any	CODES
124E	LLPN : 123820V GlobalX Legal Solutions Pty Ltd Level 3, 175 Castlereagh Street SYDNEY 2000 Ph: 13 5669 Reference (optional): HOY 1626925	T TW

(C) **TRANSFEROR** FRANCIS GEORGE PACE

(D) **CONSIDERATION** The transferor acknowledges receipt of the consideration of $ 45,000,000.00 and as regards the land

(E) **ESTATE** specified above transfers to the transferee an estate in fee simple.

(F) **SHARE TRANSFERRED**

(G) Encumbrances (if applicable):

(H) **TRANSFEREE** CLYDESDALE PROPERTY DEVELOPMENT GROUP PTY LIMITED (ACN 169 433 309)

(I) **TENANCY:**

DATE ..... / ..... / .....

(J) I certify I am an eligible witness and that the transferor signed this dealing in my presence. [See note* below]

Signature of witness:

Name of witness: PENNY LEE DIXON
Solicitor
Address of witness: 44 Martin Place
Sydney

Certified correct for the purposes of the Real Property Act 1900 by the transferor.

Signature of transferor: F Pace

Certified correct for the purposes of the Real Property Act 1900 by the person whose signature appears below.

Signature:

Signatory's name: Stuart Laurence Niven
Capacity: Solicitor for the transferee

off L 882992

(K) The transferee's solicitor certifies that the eNOS data relevant to this dealing has been submitted and stored under eNOS ID No. 638475 Full Name: Stuart Laurence Niven..... Signature: .....

** s117 RP Act requires that you must have known the signatory for more than 12 months or have sighted identifying documentation.*

NSW GOVERNMENT Valuer General

Property number: 2221897

Sale date range: 01/08/2016 to 24/01/2019

Property number	Property address	Title reference	Property area	Sale date	Purchase price
2221897	Heritage, 1270 Richmond Rd, Marsden Park NSW 2765	2/260476	215.1 H	05/12/2016	$138,800,000

NEW SOUTH WALES LAND REGISTRY SERVICES - HISTORICAL SEARCH

SEARCH DATE
24/1/2019 12:42PM

FOLIO: 2/260476

First Title(s): SEE PRIOR TITLE(S)
Prior Title(s): VOL 15062 FOL 63

Recorded	Number	Type of Instrument	C.T. Issue
5/6/1987		TITLE AUTOMATION PROJECT	LOT RECORDED FOLIO NOT CREATED
22/6/1987		AMENDMENT: LOCAL GOVT AREA	
22/6/1987		AMENDMENT: PARISH-COUNTY	
21/9/1987		CONVERTED TO COMPUTER FOLIO	FOLIO CREATED CT NOT ISSUED
14/10/1987	X131440	DEPARTMENTAL DEALING	
26/3/1991	Z539774	MORTGAGE	EDITION 1
20/7/1995	O385929	TRANSFER GRANTING EASEMENT	EDITION 2
20/12/1995	O745641	REQUEST	
12/7/2000	6940863	DEPARTMENTAL DEALING	EDITION 3
26/6/2001	7370576	REJECTED - LEASE	
26/6/2001	7370577	REJECTED - LEASE	
26/6/2001	7370578	REJECTED - LEASE	
26/6/2001	7370579	REJECTED - LEASE	
11/9/2001	7930908	DEPARTMENTAL DEALING TO UPLIFT CT	EDITION 4
2/4/2002	8473657	DISCHARGE OF MORTGAGE	
2/4/2002	8473658	TRANSFER	
2/4/2002	8473660	MORTGAGE	EDITION 5
10/5/2002	8584732	DEPARTMENTAL DEALING	EDITION 6
2/7/2002	8734858	DISCHARGE OF MORTGAGE	
2/7/2002	8734860	MORTGAGE	EDITION 7
2/8/2002	8832992	LEASE	EDITION 8
7/9/2006	AC580733	DISCHARGE OF MORTGAGE	
7/9/2006	AC580734	MORTGAGE	EDITION 9

END OF PAGE 1 - CONTINUED OVER

PRINTED ON 24/1/2019

NEW SOUTH WALES LAND REGISTRY SERVICES - HISTORICAL SEARCH

SEARCH DATE
24/1/2019 12:42PM

FOLIO: 2/260476 PAGE 2

Recorded	Number	Type of Instrument	C.T. Issue
22/3/2012	AG883987	DISCHARGE OF MORTGAGE	EDITION 10
18/6/2014	AI668061	CAVEAT	
1/9/2014	AI859300	WITHDRAWAL OF CAVEAT	
1/9/2014	AI859301	TRANSFER	
1/9/2014	AI859302	MORTGAGE	EDITION 11
5/2/2016	AK196154	CAVEAT	
5/2/2016	AK196164	CAVEAT	
5/2/2016	AK196165	CAVEAT	
5/2/2016	AK196166	CAVEAT	
5/2/2016	AK196167	CAVEAT	
5/2/2016	AK196168	CAVEAT	
4/4/2016	AK327822	DISCHARGE OF MORTGAGE	EDITION 12
12/1/2017	AM44362	WITHDRAWAL OF CAVEAT	
12/1/2017	AM40721	TRANSFER	
12/1/2017	AM40722	MORTGAGE	EDITION 13
15/6/2017	AM478325	DISCHARGE OF MORTGAGE	EDITION 14
7/7/2017	AM520070	MORTGAGE	EDITION 15
18/10/2017	AM770200	WITHDRAWN - CAVEAT	
19/10/2017	AM808696	DISCHARGE OF MORTGAGE	
19/10/2017	AM808697	MORTGAGE	EDITION 16
10/12/2018	AN918715	CAVEAT	
10/12/2018	AN921962	WITHDRAWAL OF CAVEAT	
13/12/2018	AN910221	REQUEST	
13/12/2018	AN910222	LEASE	
13/12/2018	AN910223	LEASE	
13/12/2018	AN910224	LEASE	
13/12/2018	AN910225	LEASE	
14/12/2018	DP1248522	DEPOSITED PLAN	FOLIO CANCELLED

*** END OF SEARCH ***

PRINTED ON 24/1/2019

Order number: 55186165
Your Reference: historical
24/01/19 12:16

NEW SOUTH WALES LAND REGISTRY SERVICES - HISTORICAL SEARCH

SEARCH DATE
24/1/2019 12:16PM

FOLIO: 4/1248522

First Title(s): OLD SYSTEM
Prior Title(s): 2/260476

Recorded	Number	Type of Instrument	C.T. Issue
14/12/2018	DP1248522	DEPOSITED PLAN	FOLIO CREATED EDITION 1

*** END OF SEARCH ***

PRINTED ON 24/1/2019

APPENDIX J
Donor to Political Party Disclosure Return – Individuals

FINANCIAL YEAR 2015-16

Section 305B(1) requires donors to furnish a return within 20 weeks after the end of the financial year.
The due date for lodging this return is 17 November 2016

Completing the Return:

- This return is to be completed by a person who made a donation to a registered political party (or a State branch), or to another person or organisation with the intention of benefiting a registered political party.
- This return is to be completed with reference to the *Financial Disclosure Guide for Donors to Political Parties.*
- Further information is available at www.aec.gov.au.
- This return will be available for public inspection from Wednesday 01 February 2017 at www.aec.gov.au.
- Any supporting documentation included with this return may be treated as part of a public disclosure and displayed on the AEC website.
- The information on this return is collected under s305B of the *Commonwealth Electoral Act 1918*.

NOTE: This form is for the use of individuals only. Please use the form Political Party Disclosure Return-Organisations if you are completing a return for an organisation.

Details of person that made the donation

Name	Garry Rothwell					
Postal address	38 Lower Serpentine Road					
	Suburb/Town	Greenwich	State	NSW	Postcode	2065
Telephone number	0299295000	Fax number				
Email address	grothwell@winten.com.au					

Certification

I certify that the information contained in this return and its attachments is true and complete to the best of my knowledge, information and belief.
I understand that submitting an incomplete, false or misleading return is an offence under section 315 of the Commonwealth Electoral Act 1918.

Signature GWRothwell Date 16/11/2016

Enquiries and returns should be addressed to:
Funding and Disclosure
Australian Electoral Commission
Locked Bag 4007
Canberra ACT 2601

Phone: 02 6271 4552
Fax: 02 6293 7655
Email: fad@aec.gov.au

Office use only
Date received

Part 1: Donations made

Details of **donations** made to a political party **totalling** more than $13,000, between 1 July 2015 and 30 Jun 2016. If the total of donations made to one political party exceeds the disclosure threshold, all donations made to that political party, regardless of their value, must be disclosed.

For each donation made, the following details must be disclosed:

- Party code* and the address of the political party to which the donation was made
- date each donation was made
- value of each donation made.

Party details						Date of donation	Value of donation** (GST inclusive)
Name/Party Code	Liberal Party of Australia					03 Feb 2016	$20,000
Postal address	PO Box 6004						
Suburb/town	KINGSTON	State	ACT	Postcode	2604		

Total $20,000

****Donation** is a gift within the meaning of Division 4 – Disclosure of donations, in Part XX the *Commonwealth Electoral Act 1918*.

Part 2: Donations received

Details of **donations** of more than $13,000 **received** and used (wholly or partly) to make the donations disclosed in Part 1 of this return. The 'donations received' section of this return applies to a donor:

- who received a donation of more than $13,000 (whether within the 2015-16 financial year or not); **and**
- used that donation, or part of it, to make donations totalling more than $13,000 to a political party in the 2015-16 financial year.

For donations that meet the disclosure criteria above, the following details must be reported:

- full name and address details*** of the person or organisation from whom the donation was received
- date each donation was received
- value or amount of each donation.

Donation received from			Date of donation	Value of donation** (GST inclusive)
Name/Party Code				
Postal address				
Suburb/town	State	Postcode		

Total $0

** **Donation** is a gift within the meaning of Division 4 – Disclosure of donations, in Part XX of the *Commonwealth Electoral Act 1918*.

*** **Name and address details**

- If the gift was from an unincorporated association (other than a registered industrial organisation), the name of the association and the name and addresses of the executive committee members are required.
- If the gift was from a trust, the name of the trust, and the name and addresses of the trustee are required.

ASIC
Australian Securities & Investments Commission

Current & Historical Company Extract

Name: WOORONG PARK PTY LIMITED
ACN: 094 493 428

Date/Time: 02 October 2018 AEST 12:33:08 PM

This extract contains information derived from the Australian Securities and Investments Commission's (ASIC) database under section 1274A of the Corporations Act 2001.

Please advise ASIC of any error or omission which you may identify.

EXTRACT

Organisation Details		Document Number
Current Organisation Details		
Name:	WOORONG PARK PTY LIMITED	0E4834953
ACN:	094 493 428	
ABN:	51094493428	
Registered in:	New South Wales	
Registration date:	15/09/2000	
Next review date:	15/09/2019	
Name start date:	15/09/2000	
Status:	Registered	
Company type:	Australian Proprietary Company	
Class:	Limited By Shares	
Subclass:	Proprietary Company	

Address Details		Document Number
Current		
Registered address:	Level 20, 100 Arthur Street, NORTH SYDNEY NSW 2060	030292459
Start date:	09/03/2018	
Principal Place Of Business address:	Level 20, 100 Arthur Street, NORTH SYDNEY NSW 2060	030292459
Start date:	26/02/2018	
Historical		
Registered address:	Level 10, 61 Lavender Street, MILSONS POINT NSW 2061	0E4836288
Start date:	22/09/2000	
Cease date:	08/03/2018	
Registered address:	Level 13, 77 Castlereagh Street, SYDNEY NSW 2000	0E4834953
Start date:	15/09/2000	
Cease date:	21/09/2000	
Principal Place Of Business address:	Level 10, 61 Lavender Street, MILSONS POINT NSW 2061	0E4836288
Start date:	15/09/2000	
Cease date:	25/02/2018	
Principal Place Of Business address:	Level 13, 77 Castlereagh Street, SYDNEY NSW 2000	0E4834953
Start date:	15/09/2000	
Cease date:	15/09/2000	

Officeholders and Other Roles		Document Number
Director		
Name:	GARRY WINTEN ROTHWELL	019386392
Address:	38 Lower Serpentine Road, GREENWICH NSW 2065	
Born:	24/01/1945, SYDNEY, NSW	
Appointment date:	15/09/2000	

Secretary

Name:	GARRY WINTEN ROTHWELL	019386392
Address:	38 Lower Serpentine Road, GREENWICH NSW 2065	
Born:	24/01/1945, SYDNEY, NSW	
Appointment date:	15/09/2000	

Share Information

Share Structure

Class	Description	Number issued	Total amount paid	Total amount unpaid	Document number
ORD	ORDINARY SHARES	100	100.00	0.00	09449342K

Members

Note: For each class of shares issued by a proprietary company, ASIC records the details of the top twenty members of the class (based on shareholdings). The details of any other members holding the same number of shares as the twentieth ranked member will also be recorded by ASIC on the database. Where available, historical records show that a member has ceased to be ranked amongst the top twenty members. This may, but does not necessarily mean, that they have ceased to be a member of the company.

Name: GARRY WINTEN ROTHWELL
Address: 38 Lower Serpentine Road, GREENWICH NSW 2065

Class	Number held	Beneficially held	Paid	Document number
ORD	100	yes	FULLY	019386392

Documents

Note: Where no Date Processed is shown, the document in question has not been processed. In these instances care should be taken in using information that may be updated by the document when it is processed. Where the Date Processed is shown but there is a zero under No Pages, the document has been processed but a copy is not yet available.

Date received	Form type	Date processed	Number of pages	Effective date	Document number
15/09/2000	201C Application For Registration As A Proprietary Company	15/09/2000	3	15/09/2000	0E4834953
15/09/2000	203 Notification Of 203A Change Of Address 203G Change Of Address - Principal Place Of Business	15/09/2000	1	15/09/2000	0E4836288
19/03/2001	316L (AR 2000) Annual Return Annual Return - Proprietary Company	30/03/2001	3	14/03/2001	09449342K

07/01/2002	316L (AR 2001) Annual Return Annual Return - Proprietary Company	23/01/2002	3	20/12/2001	09449342L
06/09/2002	304C Notification Of Change Of Name Or Address Of Officeholder	06/09/2002	1	02/09/2002	0E7615552
17/01/2003	316L (AR 2002) Annual Return Annual Return - Proprietary Company	04/02/2003	3	11/01/2003	09449342M
13/05/2003	304C Notification Of Change Of Name Or Address Of Officeholder	13/05/2003	2	02/05/2003	019180813
21/08/2003	484A Change To Company Details Change Of Officeholder/member Name Or Address	26/08/2003	4	15/08/2003	019386392
20/01/2006	309A Notification Of Details Of A Charge	20/01/2006	28	13/01/2006	022568291
27/10/2008	309A Notification Of Details Of A Charge	28/10/2008	44	21/10/2008	025181729
04/11/2008	350 Certification Of Compliance With Stamp Duties Law By Provisional Charge	05/11/2008	2	04/11/2008	025038598
02/03/2018	484 Change To Company Details 484B Change Of Registered Address 484C Change Of Principal Place Of Business (Address)	05/03/2018	2	05/03/2018	030292459

Annual Return Document List

Year	Return due date	Extended due date	AGM due date	Extended AGM due date	AGM held date	Outstanding
2000	31/01/2001	30/04/2001				no
2001	31/01/2002					no
2002	31/01/2003					no

*****End of Extract of 3 Pages*****

NEW SOUTH WALES LAND REGISTRY SERVICES - TITLE SEARCH

FOLIO: 4/1230408

SEARCH DATE	TIME	EDITION NO	DATE
15/1/2019	9:35 PM	2	5/6/2018

LAND

LOT 4 IN DEPOSITED PLAN 1230408
AT MARSDEN PARK
LOCAL GOVERNMENT AREA BLACKTOWN
PARISH OF ROOTY HILL COUNTY OF CUMBERLAND
TITLE DIAGRAM DP1230408

FIRST SCHEDULE

WOORONG PARK PTY LIMITED

SECOND SCHEDULE (21 NOTIFICATIONS)

1 RESERVATIONS AND CONDITIONS IN THE CROWN GRANT(S) WITHIN THE PART(S) SHOWN SO INDICATED IN THE TITLE DIAGRAM
2 LAND EXCLUDES MINERALS AFFECTING THE PART SHOWN SO INDICATED IN THE TITLE DIAGRAM - SEE VOL 5212 FOL 163
3 S706504 EASEMENT FOR TRANSMISSION LINE AFFECTING THE PART SHOWN SO BURDENED IN THE TITLE DIAGRAM
O726917 EASEMENT VESTED IN NEW SOUTH WALES ELECTRICITY TRANSMISSION
4 DP1078187 RESTRICTION(S) ON THE USE OF LAND REFERRED TO AND NUMBERED (3) IN THE S.88B INSTRUMENT
5 DP1078187 RESTRICTION(S) ON THE USE OF LAND REFERRED TO AND NUMBERED (4) IN THE S.88B INSTRUMENT AFFECTING THE PART(S) SHOWN SO BURDENED IN THE TITLE DIAGRAM
6 DP1078187 RESTRICTION(S) ON THE USE OF LAND REFERRED TO AND NUMBERED (7) IN THE S.88B INSTRUMENT
7 AE313966 MORTGAGE TO MARSDEN PARK CAPITAL PTY LIMITED OF THE PART FORMERLY IN 8-9/1078187
8 DP1178982 EASEMENT FOR SERVICES 7 METRE(S) WIDE APPURTENANT TO THE PART(S) SHOWN SO BENEFITED IN THE TITLE DIAGRAM
DP1225885 EASEMENT RELEASED IN SO FAR AS IT AFFECTS LOT 10 IN DP1178982 AND LOT 5 IN DP1078187
9 DP1178982 EASEMENT FOR SERVICES 7 METRE(S) WIDE AFFECTING THE PART(S) SHOWN SO BURDENED IN THE TITLE DIAGRAM
10 DP1178982 RIGHT OF ACCESS 7 METRE(S) WIDE AFFECTING THE PART(S) SHOWN SO BURDENED IN DP1178982
11 DP1178982 RIGHT OF ACCESS 7 METRE(S) WIDE APPURTENANT TO THE PART(S) SHOWN SO BENEFITED IN THE TITLE DIAGRAM
DP1225885 EASEMENT RELEASED IN SO FAR AS IT AFFECTS LOT 10 IN DP1178982 AND LOT 5 IN DP1078187

END OF PAGE 1 - CONTINUED OVER

SECOND SCHEDULE (21 NOTIFICATIONS) (CONTINUED)
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12 DP1178982 POSITIVE COVENANT AFFECTING THE PART(S) SHOWN SO BURDENED IN THE TITLE DIAGRAM

13 AI563973 PLANNING AGREEMENT PURSUANT TO SECTION 7.6 ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979

AK637766 VARIATION OF PLANNING AGREEMENT

* AN517197 VARIATION OF PLANNING AGREEMENT

14 DP1225885 RESTRICTION(S) ON THE USE OF LAND AFFECTING THE PART(S) SHOWN SO BURDENED IN THE TITLE DIAGRAM

15 DP1225885 POSITIVE COVENANT AFFECTING THE PART(S) SHOWN SO BURDENED IN THE TITLE DIAGRAM

16 AM829243 MORTGAGE TO GLOBAL DEMAND HOLDINGS II LIMITED (SEE AM829244)

17 AM829246 POSTPONEMENT OF MORTGAGE. PRIORITY NOW AM829243 & AE313966

18 DP1230408 RESTRICTION(S) ON THE USE OF LAND REFERRED TO AND NUMBERED (1) IN THE S.88B INSTRUMENT

19 DP1230408 RESTRICTION(S) ON THE USE OF LAND REFERRED TO AND NUMBERED (2) IN THE S.88B INSTRUMENT

* 20 DP1234232 EASEMENT FOR SEWERAGE PURPOSES 3 METRE(S) WIDE AFFECTING THE PART(S) SHOWN SO BURDENED IN DP1234232

* 21 DP1234232 EASEMENT FOR STORMWATER DRAINAGE PURPOSES 2 METRE(S) WIDE AFFECTING THE PART(S) SHOWN SO BURDENED IN DP1234232

NOTATIONS

UNREGISTERED DEALINGS: EC AN986758 PP DP1236022 PP DP1236023 PP DP1236759 PP DP1237734 PP DP1237735 PP DP1238878.

*** END OF SEARCH ***

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APPENDIX K

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The potential role of desalination in managing flood risks from dam overflows: the case of Sydney, Australia

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ABSTRACT

Shifting climate patterns are causing extreme drought and flooding across the globe. This combined with the world's burgeoning population and insatiable thirst for water requires water service providers to think differently about the limited resources they manage. In Australia, the severe drought at the beginning of the century caused dams to fall to record levels. In response, many state governments invested heavily in rain-independent supplies such as desalination to augment and diversify traditional sources. However, extreme rainfall soon followed the drought, filled reservoirs and caused flooding in many locations leaving billions of dollars worth of damage and new water infrastructure standing idle. This is the case in Sydney, where the new desalination plant is still not used and the potential for major flooding has raised concerns over the safety of the large population downstream of the dam. This paper explores the growing need to understand the relationship between drought, flooding and infrastructure optimisation. The paper focuses on Sydney to illustrate the application of a system dynamics model. The new model explores options for raising the dam wall, offering airspace to assist flood protection, in contrast to options to lower the dam full supply level and utilise idle desalination capacity to fill the water security gap created. The illustrative results, using publicly available data, find that by lowering the dam water levels and operating desalination, significant flood protection can be achieved at a similar cost to raising the dam wall. The paper demonstrates the importance of optimising existing and new water resources for multiple purposes and how system dynamics modelling can assist water service providers in these complex investigations.

1. Introduction

In recent years, areas including Australia (Turner et al., 2016), California within the US (Griffin and Anchukaitis, 2014; MWD, 2015), Sao Paulo in Brazil (Carvalho, 2015), many least developed countries in Asia (Miyan, 2015) and parts of China (Zhang and Zhou, 2015), have experienced severe drought. As we look to the future, the long-term effects of climate change are likely to result in a greater frequency of extreme droughts in many regions (IPCC, 2012, 2014). This in combination with significant population rise will put additional pressure on the world's already limited water resources (McDonald et al., 2011). With these increasing pressures on our limited water resources, there is a need for greater use of alternative water supply sources (Gurung and Sharma, 2014).

At the same time more extreme flooding is being observed in many parts of the world and is likely to increase (Huber and Gulledge, 2011; Pittock, 2012; IPCC, 2014). Such flooding has had a significant impact with flood damage constituting approximately a third of the economic losses inflicted by natural hazards worldwide over the past few decades (Berz, 2005).

These extremes have had a significant impact in many countries, with Australia being a prime example of where drought was experienced for over a decade and quickly followed by significant flooding causing loss of life and severe damage (Turner et al., 2016). This combination of extreme droughts and floods and the trend towards increased urbanisation requires water service providers to think differently and to utilise infrastructure in a more productive, efficient and resilient way. Thus moving away from a fragmented

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0959-6526/

Table 1
Key statistics for the main desalination plants in Australia (ATSE, 2012).

Plants	Built	Initial capacity (1×10^6 m^3/a)	Capacity as a % of annual demand in 2009/10	Cost (1×10^6 A$)
Perth I (Kwinana)	2006	45	18	387
Gold Coast[a] (Tugun)	2009	49	25	1200
Sydney[a] (Kurnell)	2010	90	18	1890
Melbourne[a] (Wonthaggi)	2012	150	43	3500
Adelaide[b] (Port Stanvac)	2012	100	80	1830
Perth II[c] (Binningup)	2012	100	40	1400

[a] Standby as at Jan 2015.
[b] Planned standby 2015.
[c] Currently being expanded.

and myopic perspective of water planning and management to a more integrated multi-dimensional systems perspective (Pandit et al., 2015; Turner et al., 2010; Kondili et al., 2010; Fane, 2005).

To help combat water scarcity, the vast opportunities of using desalinated seawater as a resilient rain independent urban water source are now being explored globally, with major focus in the Middle East, China, Australia and South America. This blending of ocean and rain-fed source water adds nuance to water planning and management and requires more sophisticated modelling of options to inform public debate given the major capital and operating costs incurred. There are currently over 18,000 desalination plants worldwide, with a production capacity of over 86 million m^3/day. These plants are located in over 150 countries and supply more than 300 million people.[1] Until recently, the key drawback of desalination plants has been their high energy intensity and associated unit cost (A$/kL) to produce potable water when compared to other available water supply source options. However, recent development in desalination technologies, notably reverse osmosis, has meant that new plants are less energy intensive and have a lower production unit cost, making them viable bulk supply options in large coastal cities.[2]

Water security is one of Australia's greatest issues of concern (Beal et al., 2013). Australia has a vast coastline of 69,000 km (Galloway and Bahr, 1979). Over 85% of the population live in coastal urban areas, with about 50% of the population currently located within 7 km of the shore and as many as 30% within 2 km of the coast (Chen and McAneney, 2006). Desalination has therefore been seen as a huge untapped opportunity for urban water planning over the last decade whilst more traditional water sources (e.g. dams, groundwater and river abstraction) which are often rain-dependent, have fallen short during the worst national drought in Australian recorded history, the “Millennium” drought (Turner et al., 2016). Table 1 identifies the main desalination plants built in Australia since 2006, their capacity and costs.

These assets represent total sunk capital costs in excess of A$10 billion. This high capital outlay places significant pressure on water pricing, which reflects infrastructure investment, and is recognised as being a major contributor to the rapid rise in water supply costs in Australia in recent years (PC, 2011).

Because unusually high rainfall has followed the investment in desalination, all of the desalination plants except Perth are currently on standby (as at 2015). Whilst some plants have been used for a limited time (i.e. Tugun in the Gold Coast predominantly as a backup source during flood events that caused water quality issues), such infrastructure now represents significant stranded assets that are not realising their full potential.[3]

The high rainfall experienced after the drought has caused severe flooding in several areas such as South East Queensland and Sydney. This has caused loss of life and billions of dollars worth of damage resulting in the need for State level inquiries (Queensland Floods Commission of Inquiry, 2012). Similar to the drought situation, much of the discourse on flooding currently focuses on major infrastructure solutions, that is, raising of dam walls to provide airspace to assist in flood protection (DPI, 2014). Whist this does provide a solution this comes at a high cost and does not make best use of the assets at hand, such as idle desalination.

This paper aims to provide an illustrative example of how such desalination plants can be utilised more effectively and assist in optimising the water infrastructure systems we have now. The analysis is based on a system dynamics model (SDM), developed and applied to other water planning illustrative examples in:

- South East Queensland (Sahin et al., 2014a) to explore scarcity pricing; and
- Melbourne (Porter et al., 2014; Sahin et al., 2014b; Scarborough et al., 2015) to explore rain-independent desalination versus more traditional rain-dependent dams in long term planning.

The analysis summarised in this paper focuses on examining how desalination could be used to ensure water security whilst other existing water infrastructure is used to increase flood protection. That is, a desalination plant is used to substitute supply lost if the full supply level (FSL) in the dam is dropped to such an extent that the dam provides both water security and capacity to hold a proportion of flows from flood events, thus reducing the risk of flood damage and assisting in improving evacuation timing. In this illustrative example the SDM uses publicly available information from Sydney and makes a constructive contribution to a contemporary policy problem, that is, exploring the merits (or otherwise) and costs of raising the dam wall to assist with flood mitigation arising from dam overflows due to heavy rain within the catchment versus other options. More broadly the illustrative example helps demonstrate the importance of optimising existing and new water resources for multiple purposes and how system dynamics modelling can assist water service providers in these complex investigations with multiple objectives.

The following sections provide a summary of the Sydney water supply system, current flooding issues and potential options where desalination could be considered to mitigate such flooding. It

[1] http://idadesal.org/desalination-101/desalination-by-the-numbers/ (accessed 29/04/2016).

[2] Desalination power costs have been inflated in public estimates by using expensive wind and solar energy cost estimates, rather than optimised power from the grid. Thus reported Australian desalination unit costs relative to the Middle East raise questions of comparable cost definition, since typically the energy efficiency of Australian plants has been as good as or better than other plants.

[3] Assets are often described as “stranded” when total revenues fail to cover total (fixed and variable) costs. However this does not mean plants should be idle, since marginal costs per ML can and frequently are lower than other sources, creating a need for sound asset optimisation based on marginal cost pricing and revenue generation.

provides details of the SDM used for other cities and modified for the Sydney illustrative example, plus results of the modelling exercise and broader discussion on utilising desalination as part of the mix of water resources of a major city.

2. The Sydney urban water context

Before discussing the SDM and the results of the modelling, a brief outline of the Sydney water supply system is provided along with current flooding issues, recent government flooding investigations and potential options where desalination could be considered.

2.1. Water sources

The greater Sydney water supply system is complex with over 20 dams and a total dam capacity of 2,581,000 ML (WSAA, 2013). Despite being a complex system the 4.2 million people in Sydney and lower Blue Mountains are primarily supplied (80%) by the large Warragamba dam (2,027,000 ML operating capacity) located 65 km west of Sydney. A secondary source, the Tallowa dam 160 km south of Sydney, is the key to the Shoalhaven scheme. Tallowa has a much smaller operating capacity of 7500 ML (available for the Sydney and Illawarra system) but can provide flows into the Upper Nepean dams and Warragamba dam to top up the Sydney and Illawarra systems when Sydney dams reach a trigger level of 75%.[4] This is particularly useful during drought conditions because when the Warragamba catchment suffers from extended low inflows due to dry weather conditions the Shoalhaven catchment often suffers less so.

As part of the Metropolitan Water Plans (MWP) for Sydney, which were first developed in 2004, revised in 2006, and reviewed in 2010 (NSW Office of Water, 2010), a more diverse portfolio has been developed to provide water services to the greater Sydney region. This includes a combination of dams, recycling, extensive water efficiency measures and now desalination.

The Sydney desalination plant has suffered from controversial decision-making outlined below. For this reason, more than any, it provides an interesting illustrative example of how such a desalination plant once constructed, and given relatively low marginal costs, could be used to help optimise the water resources system in a city for multiple purposes. The key criteria for the Sydney bulk water supply system are water security, system reliability, mitigating flood risk, environmental flows to rivers below the dam (not explored here), and acceptable water quality (not explored here).

2.2. The Sydney desalination plant

The Sydney desalination plant began supplying water in early 2010 as part of a 2 year 'defects correction period'. At full capacity it is capable of producing 90 GL/a, approximately 15% of current demand. The current design allows this capacity to be doubled (NSW Office of Water, 2010). However, as indicated earlier it represents one of several desalination plants around Australia that are currently in standby mode. The reasons for individual desalination plants being in standby mode are complex and case specific.

In 2004, the then NSW government committed A$4 million to investigate the potential for desalination in Sydney. In 2005, the technologies and other options such as recycling and potential sites were investigated. By the end of that year, the planning for the plant construction was confirmed. However, in 2006, the plant was put on hold when the government adopted an innovative 'readiness strategy', to build only when dam levels fell below 30%, that is, with the right approvals in place in sufficient time to build the plant before reaching dead storage (White et al., 2006). Whilst formally adopted by multiple stakeholders involved in the MWP process, the readiness strategy (part of a real-options process) was overtaken by political imperative. In early 2007, dam levels were dropping 0.5% per week. Prompted, in part, by concern of storage levels continuing to fall too close to the trigger level of 30% storage within the caretaker period of government,[5] a decision was made to tender for the design, construction and operation of the desalination plant (Giurco et al., 2014).

It has subsequently been acknowledged that if the call to tender for design, construction and operation had been split with hold and review points, the innovative 'readiness' strategy could have been preserved without the full cost of the pre-emptive build. In addition, not signing the full contract when the dam levels were at 57% would have avoided over commitment (PC, 2011) and the A$1.9 billion Sydney desalination plant sitting idle after the 'defects correction period' was complete.

The MWP, which sets out the mix of measures that secure the greater Sydney region water needs into the future is periodically reviewed. The current MWP is under review and should be released in 2015/16. The current plan relies on a mix of dams, recycling (~12%), desalination (~15%) and water efficiency (~25%) (NSW Office of Water, 2010).

As shown in Fig. 1 the existing desalination plant will become operational when total dam storage levels fall below 70% and continue to operate until total storage returns to 80%. As can be seen, after various other measures such as restrictions, construction of a second desalination plant will be triggered when total dam storage levels drop to 30%. Due to the existing infrastructure already in place, such as connecting pipework and roads servicing the plant, the second 90 GL/a desalination plant would likely cost less ~A$1.5 billion.

Another controversial aspect of the desalination plant is that even though the plant is currently in shutdown mode it costs the local utility (Sydney Water Corporation – SWC) customers over A$500,000/day in "availability charges" (IPART, 2011). This is because the plant was sold to private investors, including a Canadian teachers pension plan, for A$2.3 billion on a 50 year lease.[6] The investors are guaranteed an inflation-linked payment of ~A$10 billion from SWC whether the water is used or not. Additional fees such as a re-start fee of A$5.5 million are payable to the investors when the plant is switched on (Malone, 2013). The Independent Pricing and Regulatory Tribunal of NSW (IPART) has reviewed and determined the prices that the owners of the plant (the Sydney Desalination Plant Pty Ltd) can charge customers for the period mid 2012 to mid 2017. These figures range from ~A$500,000/day in long term shutdown mode to A$780,000/day when the plant is in full operation mode (IPART, 2011).

This cost issue highlights the importance of examining opportunities to optimise the system and run the desalination plant full on, idle or under a mixed operating regime.

2.3. Recent flooding investigations

Since the end of the drought investigations concerning the water supply system in Sydney have predominantly focused on flood mitigation issues. These have in part been due to the

[4] http://www.sca.nsw.gov.au/water/visit/warragamba-dam.

[5] That is, between when the state election was to be called and the date of election, a period of six weeks.

[6] http://sydneydesal.com.au/about-sdp/ownership-structure (accessed 29/04/2016).

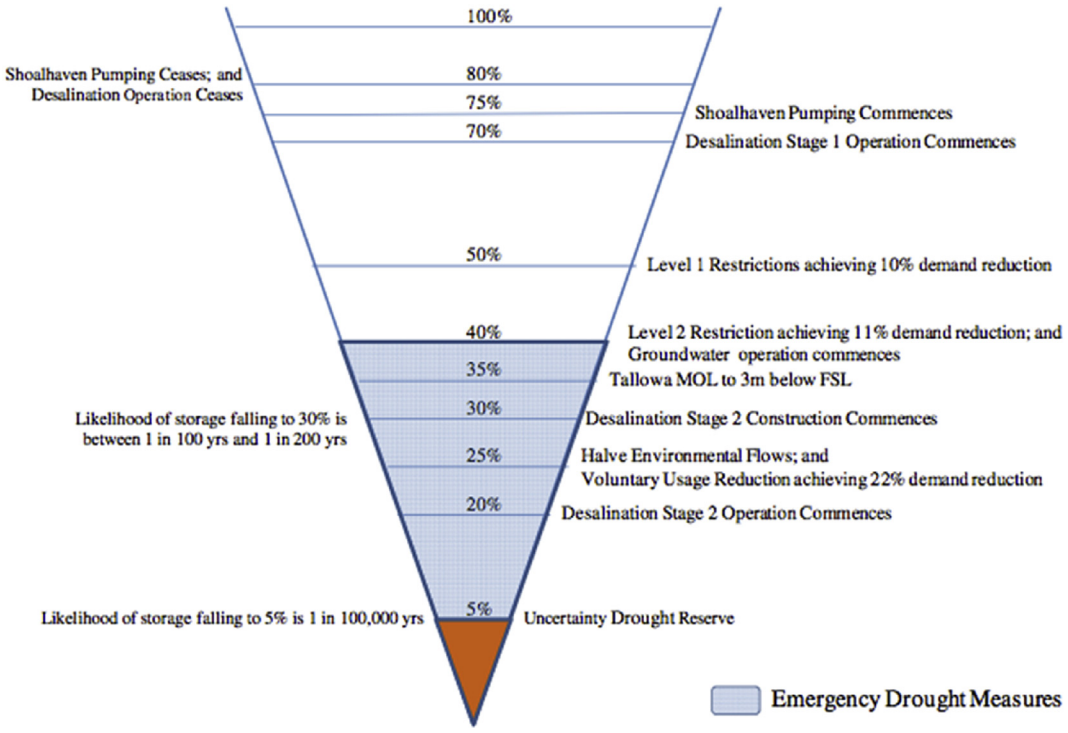

Fig. 1. Sydney's current water supply system operation (SKM, 2011).

extensive flooding experienced in the south east region of Queensland in January 2011 and extensive flooding across south eastern Australia in 2012 which caused the Warragamba dam in Sydney to spill for the first time in 14 years. These experiences have highlighted the need for dams to play both a flood defence role as well as a water security role as the effects of climate uncertainty pan out.

In the floodplain below the Warragamba dam (refer to Fig. 2) resides one of Australia's largest and most diverse local economies with an annual gross regional product of over A$95 billion as at 2010/11 (DPI, 2014). However, within the floodplain approximately 73,000 people are currently living in areas prone to flooding. 13,000 of these are living in homes that could be severely damaged by a 1 in 200 chance per year flood where water levels could rise by 2 m (DPI, 2014). Despite this risk a large proportion of the future new homes and jobs projected in the Strategy for Sydney (NSW Government, 2014) are anticipated to be located within the floodplain. Due to the natural characteristics of the floodplain it is highly susceptible to floods with potential loss of life and property. Fig. 3 shows the vulnerability of the region in terms of flood levels above the typical 1 in 100 flood level (used as the basis for default flood planning) compared to other Australian regions. Typically the probable maximum flood (PMF) in NSW rivers is less than 2 m higher than the 1 in 100 flood level. As can be seen in Fig. 3 at the Richmond–Windsor location on the Warragamba floodplain, this is closer to a staggering 9 m (DPI, 2014).

In Sydney, it is estimated if a severe flood similar to 1867 (estimated to be in the range of a 1 in 200 to 1 in 500 chance per year but considered to be closer to 1 in 500 (DPI, 2014)) occurred today over 45,000 people would need to be evacuated with approximately A$4 billion of damage. The low probability PMF (1 in 100,000 chance per year) would require 73,000 people to be evacuated and put over 20,000 homes at risk of failure (DPI, 2014). In such situations businesses would also be highly affected.

Table 2 shows the number of people and properties affected when estimates were conducted in 2011. These include an estimate of the number of properties that would have a cost of flood damage of greater than A$80,000, which is a "threshold of affordability" above which many households would not be able to afford to recover. The table also contains estimates of direct and indirect flooding event damage. These costs include for example residential, caravans, commercial, motor vehicles, agriculture, roads and bridges, railways, water and sewerage, electricity, telephone, gas and oil, sand and gravel, defence, erosion and emergency services. The direct costs do not include those properties that are likely to "fail" therefore the estimates are considered conservative (Molino Stewart, 2012b).

Due to these significant potential impacts government led investigations in Sydney have primarily centred around (DPI, 2014):

- raising the dam wall at Warragamba by +15 m or +23 m to create flood storage capacity; and
- altering the operation of the dam or lowering the full supply level (FSL) to provide "airspace" to capture and store floodwaters

2.4. Raising the dam wall

The current dam capacity is 2,031,000 ML. Approximately 39% (795,000 ML) of this is above the crest of the main spillway, which is held by the dam's radial gates and drum gate. Due to the tapering shape of the dam a +23 m dam wall extension would provide an enormous 2,800,000 ML of "additional" mitigation "airspace" (Molino Stewart, 2012b). The additional storage would provide flood protection for minor to PMF events. It would not eliminate the need to evacuate the populated floodplains below under more extreme floods (Molino Stewart, 2012a). It would however, reduce the costs of flood damage of which most are associated with greater than a 1 in 100 chance/year and when averaged out over the long term are mainly attributable to floods below a 1 in 500 chance/year as opposed to rarer events (DPI,

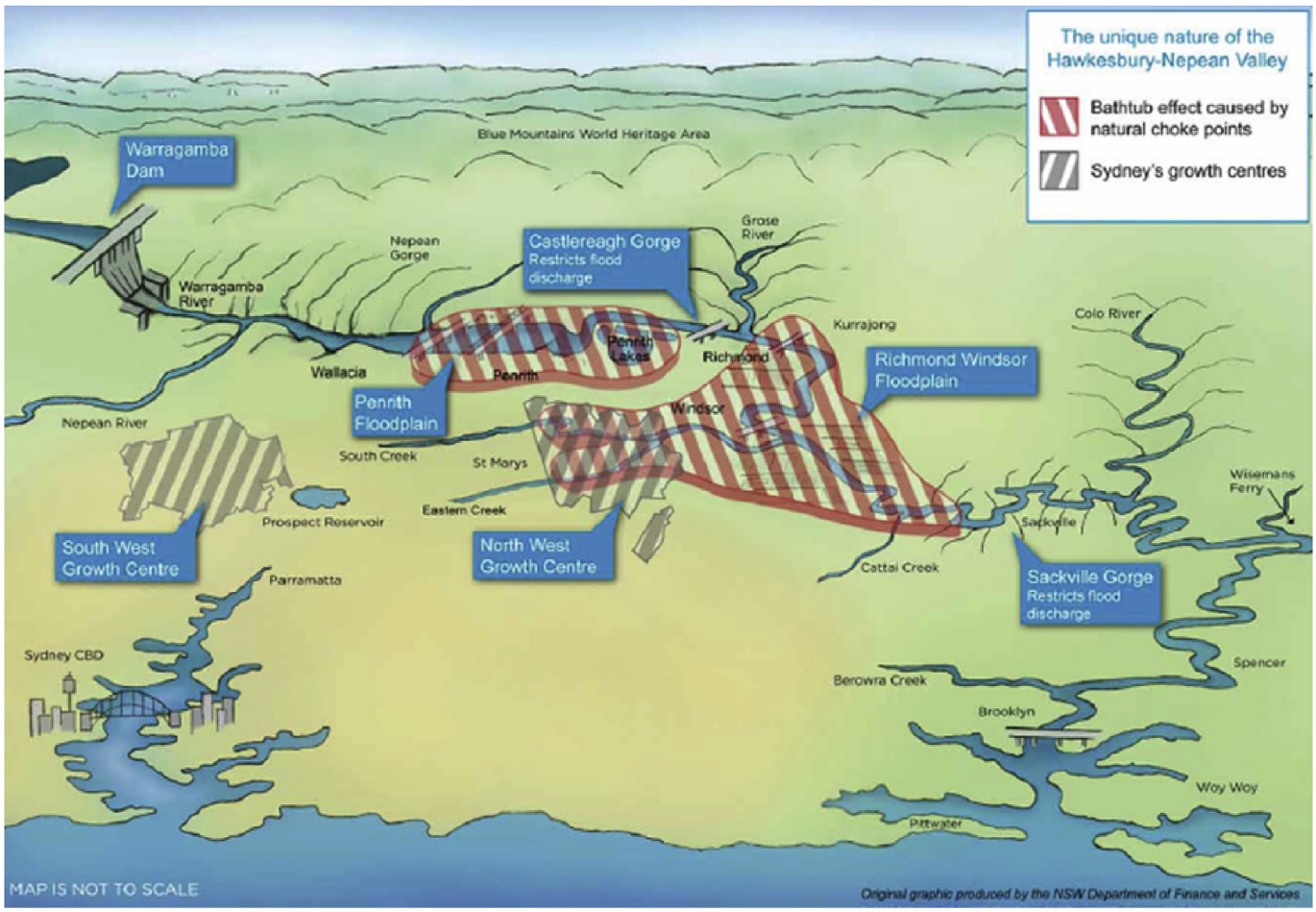

Fig. 2. Probable maximum flood inundation and growth areas downstream of the Warragamba dam (DPI, 2014).

2014). It is also recognised however, that the dam extension would cause significant detrimental environmental damage upstream under more severe events (Molino Stewart, 2012b). This potential damage has not been documented extensively in the public domain and has therefore not been explored in this particular paper.

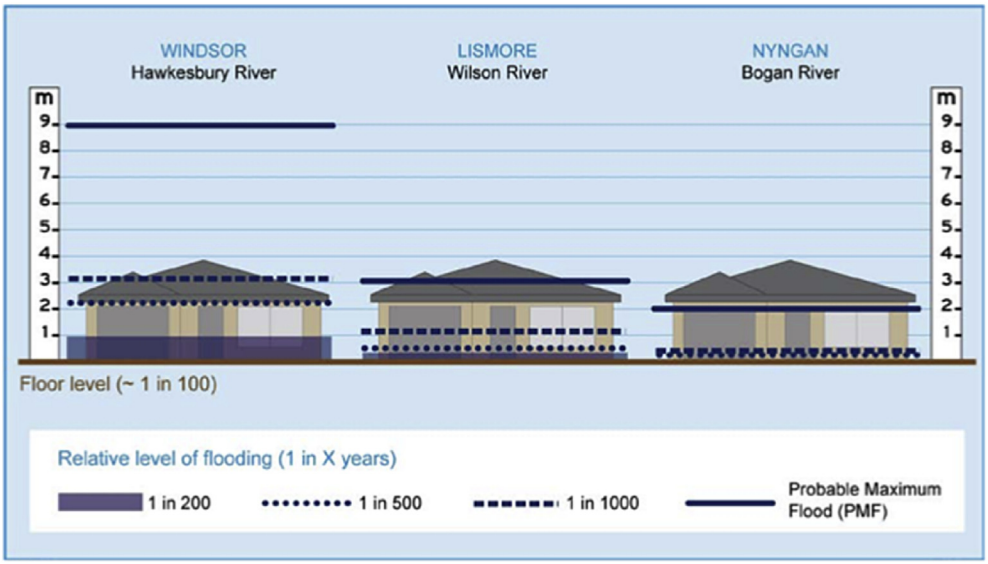

Fig. 3. Probable maximum flood levels for Richmond–Windsor area compared to other NSW rivers (DPI, 2014).

Table 2
Summary of flood events and associated estimated affected population and damage (DPI, 2014; Molino Stewart, 2012b).

Categories of flood risk	Flood size (chance/per year and date of historical flood)	Population at risk[c]		Residential properties as at 2011 with			Estimated event damage[c] (2011 A$ million)		Total no. of people needing evacuation as at 2011
		Residential	Commercial	Above floor flooding	Likely failure[d]	>A$ 80K damage[d]	Direct	Indirect	
Minor (1 in 1 to 1 in 5 chance/year flood)	Once per year March 2012 1 in 2 November 1969								
Moderate (1 in 5 to 1 in 20 chance/year flood)	1 in 5 May 1974 July 1988 June 1975 August 1986	203	0	0	0	0	29	7	
	1 in 10 May 1988 August 1990	394	0	48	0	35	46	10	200
Major (1 in 20 to 1 in 100 chance/year flood)	1 in 20 March 1978 June 1964 November 1961	1308	0	249	0	129	96	15	2400
	1 in 50	1815	596	361	0	190	225	51	7500
Severe (1 in 100 to 1 in 1000 chance/year flood)	1 in 100	13,993	1986	3977	628	3174	981	640	28,000
	1 in 200 June 1867[a,b]	22,226	3710	6931	1258	5344	1752	1264	42,000
	1 in 500	35,006	5206	10,710	3779	8820	3069	2415	48,000
Extreme (1 in 1000 chance/year flood to PMF)	1 in 1000	43,410	8694	14,160	6464	12,748	4381	3506	52,000
	1 in 2000								57,000
	1 in 5000								63,000
	1 in 100,000[b] (PMF)	56,190	1212	19,015	15,516	18,250	6663	5240	73,000

[a] Adjusted for Warragamba dam.
[b] Estimated flows relating to the 1867 flood through the dam in 1867 = 2,200,000–2,600,000 ML and for a PMF > 6,000,000 ML.
[c] Excluding properties requiring rebuild but including residential, commercial, agriculture, infrastructure (e.g. roads) and services (e.g. telephone).
[d] Subsets.

In 2015/16 the government is expected to release cost estimates for the various options identified above. In the absence of these, existing publicly available construction estimates from 1995 inflated to 2011 indicate that raising the dam wall by +23 m could cost ~A$350 million. However, more recent pre-feasibility investigations (and associated press releases) indicate that the costs of options centred around raising the wall between +15 m and +23 m would be closer to between A$0.5 to 1 billion (DPI, 2014; Hasham, 2014).

2.5. Lowering the dam full supply level

Viewing the dam management quite differently, lowering the FSL by up to −12 m would provide up to 795,000 ML of "airspace" for flood storage. The estimated cost to adjust existing pipework to accommodate this is ~A$50 to 70 million. Whilst lowering the FSL by −12 m would incur a cost, lowering the FSL by −5 m would incur little or no cost as the dam frequently satisfactorily operates at this level already. Lowering the FSL by up to −12 m provides potential flood storage capacity, however, it also represents a significant loss in dam capacity, up to 39% (Molino Stewart, 2012b; DPI, 2014).

The government has also considered other combinations of options, such as adjusting the operating conditions of the dam so that water is released prior to a flood to create the flood storage capacity required when potential floods are anticipated. However, the option of releasing dam water prior to a flood has been considered difficult to predict with current metrological data and runs the risk of evacuating the potential community affected when rain and associated floods don't eventuate (DPI, 2014; Molino Stewart, 2012b).

2.6. Potential use of desalination

A scenario that appears to be less explored is where desalination can be used to replace the water security lost if dam levels are dropped to create airspace for flood storage.

Raising the dam by up to +23 m has a high potential cost of up to A$1 billion according to recent prefeasibility estimates, is logistically difficult, is likely to cause adverse environmental impacts upstream of the dam and will not rule out the need to evacuate the population of the floodplain during more extreme floods. Dropping dam levels by up to −12 m, is a low cost option (~A$50 to 70 million) but is almost ruled out by government because water security could drop by up to 39%.

However, the existing trigger levels for the desalination plant could be adjusted and/or the plant turned on when required to fill the security gap and recoup some of the water security lost by dropping the dam FSL at a marginal extra cost above that of the plant standing idle. By doing so the existing water infrastructure in Sydney could potentially be optimised to achieve both water security and a higher level of flood protection – potentially at a lower cost. This is explored below.

3. System dynamics model

Although the Sydney water system is complex and while many of the detailed figures required for such complex modelling are unavailable to the public, a SDM has been developed to explore how desalination in Sydney could potentially be used more

effectively to substitute water lost if the dam FSL was lowered to assist in flood protection. Associated costs and benefits are also explored.

3.1. The system dynamics model (SDM)

As previously mentioned the SDM was first developed and applied in South East Queensland to explore water scarcity pricing (Sahin et al., 2014a). It was subsequently modified for Melbourne to explore rain independent desalination versus more traditional rain dependent dams in long term planning (Sahin et al., 2014b). Further details of the model can be found in these papers (Sahin et al., 2014a, 2014b).

The model has been modified for application in Sydney to explore flood mitigation potential. The SDM, using the Vensim® DSS (Ventana Systems, Inc, 2012) was built by identifying key variables, estimating assumed relationships between these variables and parameterising the relationships. The various components of the model are shown in Fig. 4. The economic component of the modelling, that is, the comparison of costs of the various options considered is currently external to the SDM.

3.2. Options modelled

To test whether using desalination is a viable option for replenishing water lost if the FSL were reduced, a series of options have been explored for a specific inflow-demand projection scenario (detailed below) for the next 25 years (2015–2039). The four key options modelled in the SDM entail either raising the dam wall by +15 m or +23 m or lowering the dam wall by −5 m or −12 m. These options are shown in Table 3 and reflect the kinds of options the government is actually considering.

Existing infrastructure only (EIO) has been modelled to reflect how the dam water levels might react to the inflow-demand projection scenario considered if no changes to the dam wall or FSL were made and no additional desalination (other than the existing desalination plant no.1 – DSP 1 – already in place) was built. Business as usual (BAU) has also been modelled and assumes no change to the dam wall or FSL but that all MWP triggers come into effect (e.g. desalination plant no. 2 – DSP 2 – is triggered to build when the dam levels hit 30% of current capacity and becomes operational when the dam levels hit 20% – refer to Fig. 1).

The four key options modelled (+15 m, +23 m, −5 m and −12 m) all assume that the existing MWP trigger levels for DSP 1 and DSP 2, as shown in Fig. 1, remain in place except for the −12 m option where the current MWP trigger levels for DSP 1 are actually lower than the −12 m option FSL and thus have had to be adjusted. Other key assumptions for the SDM are provided in Table 4.

4. Results

In this section the results of the historical modelled inflows and associated dam levels are shown. This is followed by the outputs for the modelled options in terms of impacts on flooding, requirement for desalination and associated costs over the next 25 years.

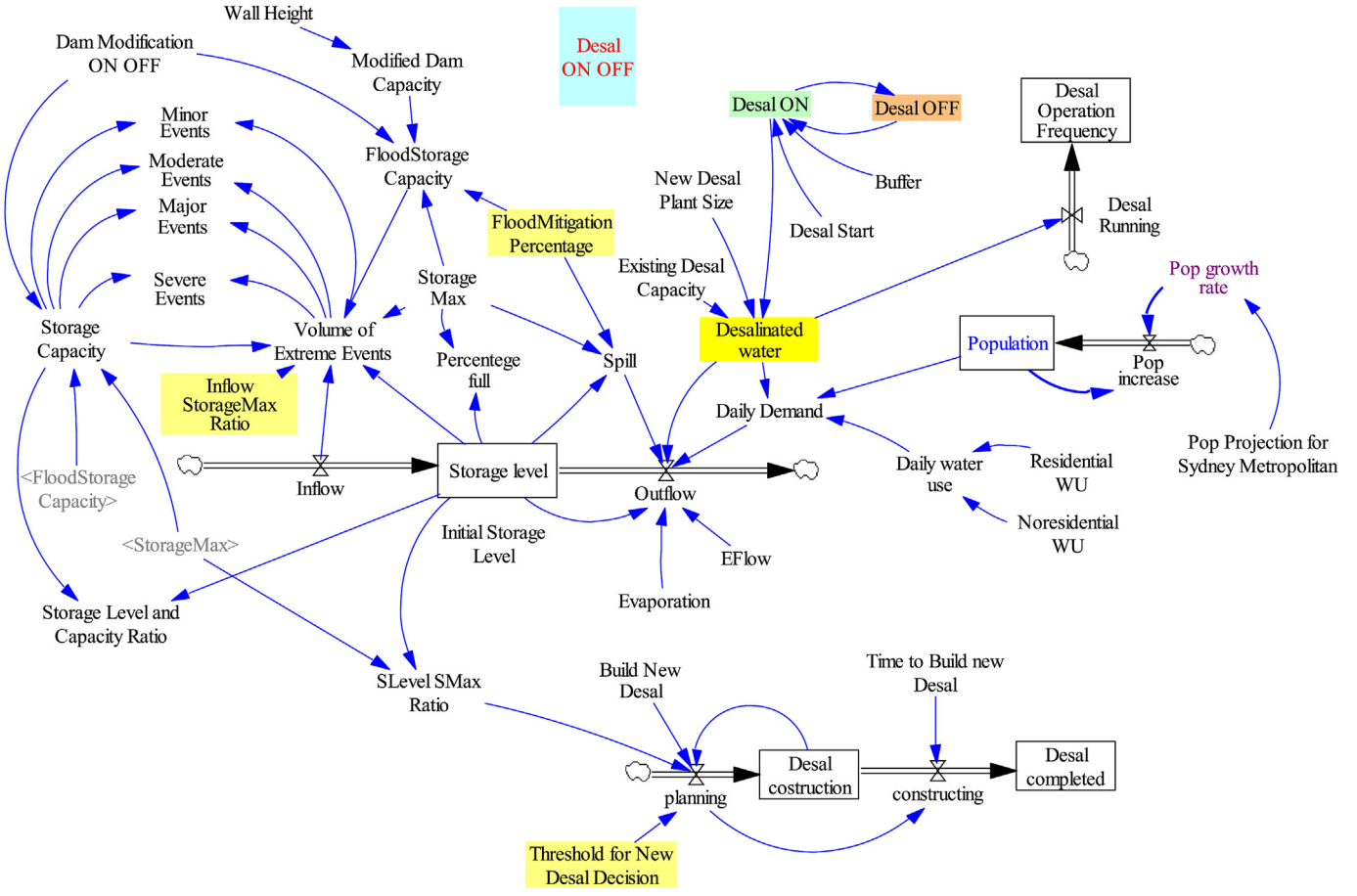

Fig. 4. System dynamics model components in Sydney example.

Table 3
Suite of options modelled.

Options	EIO	BAU	Dam +15 m	Dam +23 m	Dam −5 m	Dam −12 m
Dam modifications						
- Height (m)	N/A	N/A	+15	+23	−5	−12
- Volume change	N/A	N/A	+900	+2800	−405	−795
(GL) for air space			(+45% of airspace)	(+140% of airspace)	(−20% of original capacity)	(−40% of original capacity)
- Cost (A$ billion)	N/A	N/A	0.50	1.00	0.10	0.10
Trigger levels						
Trigger levels for desalination	Same as MWP except DSP 2 not triggered	Same as MWP	Same as MWP	Same as MWP	Same as MWP	Adjusted for DSP 1 -50% on and 60% off of original capacity

EIO – existing infrastructure only.
BAU – business as usual.

4.1. Inflows

Fig. 5 shows how modelled dam levels have varied since 1961. It also shows the frequency and severity of inflows that, depending on the storage levels of the dam, have led to flood events (minor to extreme). As can be seen there appear to be regular cyclical dry periods that have led to low dam levels. These appear to have increased in severity culminating in the Millennium drought during the 2000s where the dam level fell to <35%. The frequency of larger inflow events has significantly decreased over the last two decades leading to few flood events. Due to these dryer conditions the Warragamba dam did not spill over the period 1998–2012.

4.2. Inflow-demand projection scenario

The last 25 years of historical weather patterns, that include flooding and extreme drought periods, have been used here to predict anticipated dam levels and flood events over the next 25 years. The projection period includes increased water demand from the increasing population. Whilst this scenario is only one of thousands of possible scenarios it is a tangible scenario that is valuable in demonstrating the SDM and options considered. Having developed the SDM, further modelling considering multiple inflow-demand projection scenarios and options to assist in exploring system optimisation are planned (but not explored here).

4.3. Modelling outputs

As indicated in Section 2 it is acknowledged by the NSW government, currently investigating flooding issues associated with the Warragamba dam, that raising the dam wall even by +23 m will not rule out the need to evacuate the population of the downstream floodplain or avoid the associated damage and threat to life during more extreme floods. With this in mind Table 5 summarises the modelling results of what could be expected under each of the options modelled with respect to flooding, use of the desalination plants (DSP 1, DSP 2 and potentially additional plants – DSP 3 and DSP 4 – to meet growing demand) and operating and capital infrastructure costs.

5. Discussion

Detailed interpretation and discussion of the results of each option are provided below.

5.1. EIO and BAU

As can be seen from the modelling presented in Table 5 under EIO over the next 25 years (which relies only on the existing infrastructure, that is, the dam and DSP 1) we might expect to see:

- 21 minor, 3 moderate, 6 major and 2 severe events;
- DSP 1 first switched on in 2021 and running 19 of the 25 years modelled;
- DSP 1 repayment and operating costs (total present value costs PV A$4.13 billion); and
- high flood damage costs potentially running into multiple billions of A$ due to the number of potential moderate, major and severe events (refer to Table 2).

As shown in Fig. 6, in this situation the dam levels run critically close to dead storage even with DSP 1 running 19 of the 25 years. This is due to the combination of low inflows and increased demand from the growing population.

Under BAU that assumes construction of DSP 2 and other desalination plants as required under the current MWP trigger levels, we might expect to see:

- 21 minor, 3 moderate, 6 major and 2 severe events;
- DSP 1 first switched on in 2021 and runs 16 of the 25 years modelled;
- DSP 2 construction triggered in 2032 and runs 5 of the 25 years modelled;
- DSP 3 is also needed and construction triggered in 2034 (only 2 years later) because the demand at that time is just too high for the existing desalination plants to satisfy with the depleted dam under the sustained dry conditions;
- DSP 4 is also needed and construction triggered in 2036 (in another 2 years) as the situation remains the same but this desalination plant might not actually be used in the modelling

Table 4
Key assumptions for options modelled.

Variable	Assumption
Weather	Repeat of historical weather patterns over the last 25 years with associated inflows and outflows from Warragamba dam
Population – current	4.28 million
Population – annual growth %	2011–2016 = 1.66% 2016–2021 = 1.67% 2021–2026 = 1.53–1.39% 2026–2031 = 1.39%
Water use	300 L/person/day (residential, non-residential and non-revenue water)
Dam capacity – current	2027 GL/a
DSP capacity – current & future	90 GL/a
DSP 1 repayment costs-fixed	A$200 million/a
DSP 1 operating costs	A$100 million/a
Model time bound	25 years
Time interval of simulation	1 day is used for flood events modelling & 1 year is used for economic analysis
Discount rate	3.5%

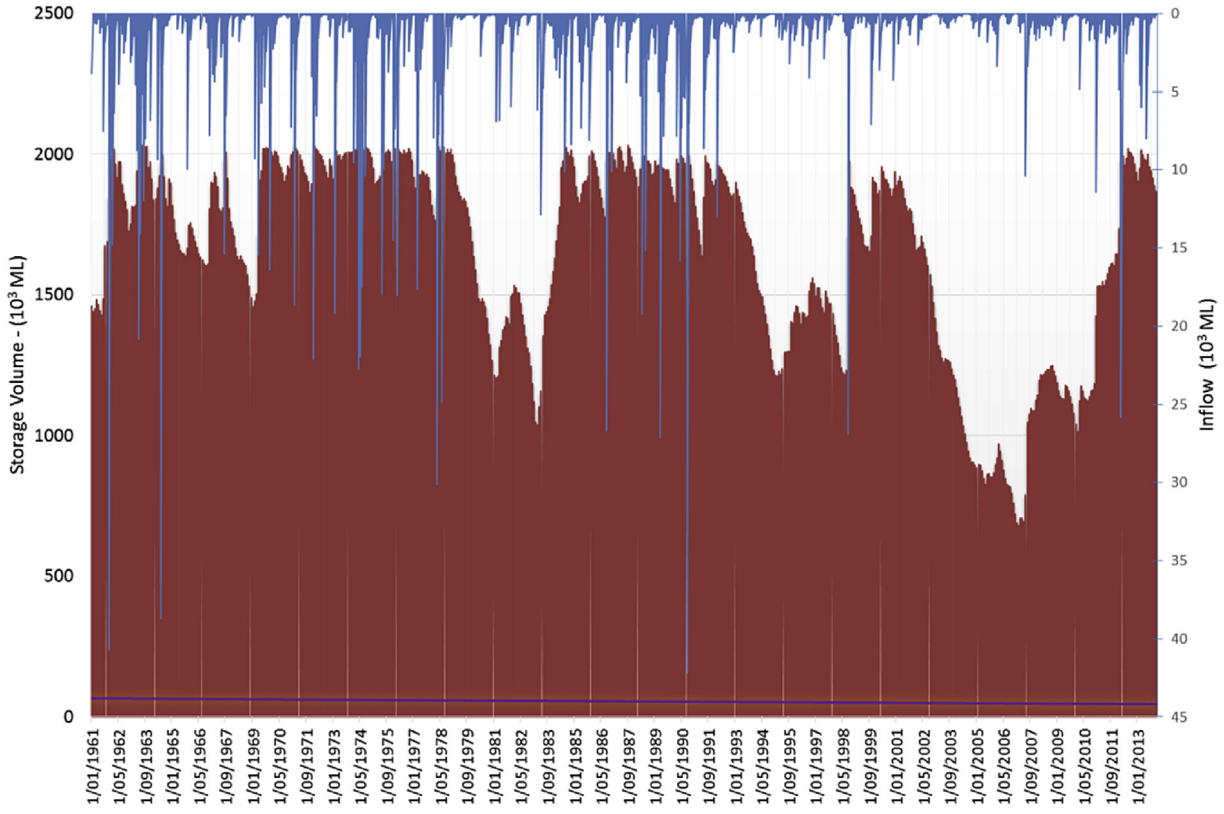

Fig. 5. Historical dam levels and inflows at Warragamba dam.

Table 5
Summary of modelling outputs.

	EIO	BAU	Dam +15 m	Dam +23 m	Dam −5 m	Dam −12 m
Flood events						
- Minor	21	21	0	0	0	0
- Moderate	3	3	0	0	0	0
- Major	6	6	0	0	1	0
- Severe	2	2	0	0	0	0
- Extreme	[a]	[a]	[a]	[a]	[a]	[a]
DSP 1						
- Trigger levels for DSP 1 operation	Same as MWP	Same as MWP	Same as MWP	Same as MWP	Same as MWP	Adjusted to 50% on and 60% off (original capacity)
- No. of years active over next 25 years	19	16	16	16	22	18
DSP 2						
- Trigger levels for DSP 2 construction	N/A	Same as MWP	Same as MWP	Same as MWP	Same as MWP	Same as MWP
- When triggered to build	N/A	2032	2032	2032	2032	2022
- No. of years active over next 25 years	N/A	5	5	5	8	14
DSP 3						
- When triggered to build	N/A	2034	2034	2034	2034	2024
- No. of years active over next 25 years	N/A	3	3	3	6	12
DSP 4						
- When triggered to build	N/A	2036	2036	2036	2036	N/A
- No. of years active over next 25 years	N/A	0	0	0	4	N/A
Costs (PV)						
- Capital dam modifications + DSPs (A$ billion)	N/A	2.19	2.67	3.15	2.19	2.06
- Ongoing costs DSP 1 repayment costs + desalination operating costs (A$ billion)	4.13	4.26	4.26	4.26	4.85	4.97
- Total costs (A$ billion)	4.13	6.45	6.93	7.41	7.04	7.03

EIO – existing infrastructure only.
BAU – business as usual.
BAU assumes MWP trigger levels bring DSP 2 and other DSPs online as required.
[a] No PMF events included in the projection period.

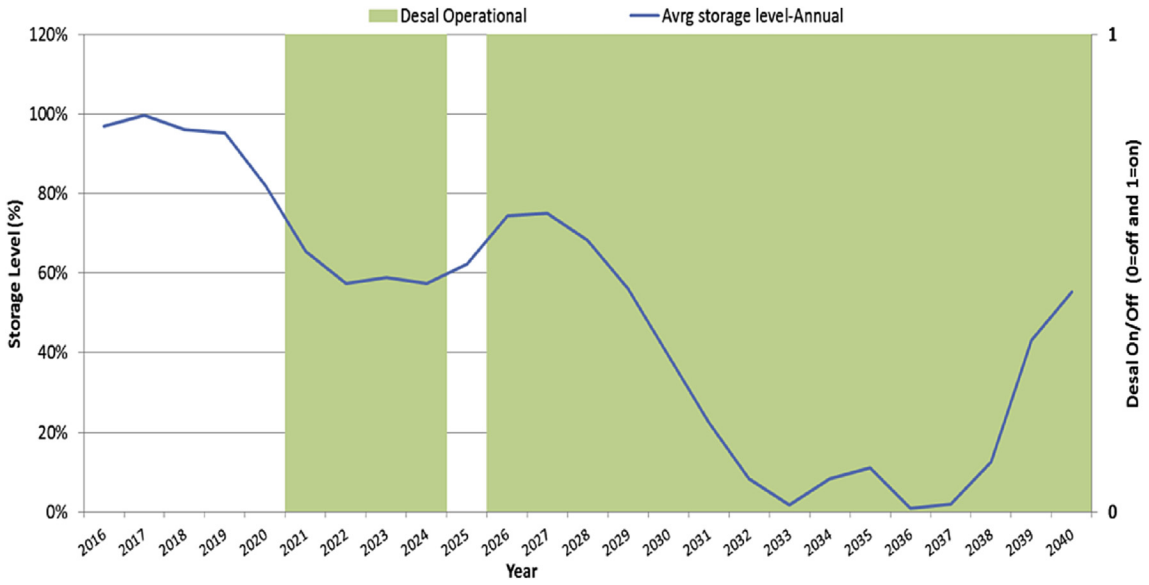

Fig. 6. Existing infrastructure only option projected average dam storage levels and on/off operation of desalination plant 1.

period considered since normal rainfall conditions replenish the dam soon after it is constructed;
- total investment costs of PV A$6.45 billion (capital A$2.19 billion and ongoing A$4.26 billon); and
- high flood damage costs, as above, potentially running into multiple billions of A$ due to the number of potential moderate, major and severe events (refer to Table 2).

As shown in Fig. 7, in this situation the triggering and subsequent use of DSP 2 and other desalination plants as required assists in reducing the risk of the dam running into dead storage and facilitates greater recovery of storage levels but shows the dam still runs critically low.

This suggests that before even considering raising or lowering the dam wall for flood mitigation purposes (that may have implications on the security of supply) that the dam runs the risk of running into dead storage under this scenario (a repeat of the last 25 years of inflows occurs in combination with increased demand due to population rise). To mitigate such a risk additional supply and/or demand options plus adjustment of the dam trigger levels would be required to, for example, provide sufficient time to trigger and then build a desalination plant during low inflows as the population and associated demand grows over time. At current demand levels a trigger of 30% for construction and 20% for operation would be sufficient but in future as demand grows these trigger levels would need to be raised. As identified in Section 3, for the purposes of demonstrating the SDM, the MWP trigger levels have been kept as they are except in the case of the −12 m option which had to be adjusted.

5.2. Options

The four modelled options (+15 m, +23 m, −5 m, −12 m) are used to test how raising the dam wall or lowering the dam FSL can reduce flood risk and associated damage costs and assume that depletion of security of supply is filled by building any number of required additional desalination plants. Of course this may not be the most economically viable solution in reality, as there may be lower cost solutions available. However, for the purposes of demonstrating the use of the SDM such option variables have been constrained.

In all four options (+15 m, +23 m, −5 m, −12 m) the level of flood risk and associated damage costs, in this modelled scenario, is significantly mitigated except for PMF (which has not been modelled) and in the case of the −5 m option where there is a risk of only 1 major flood occurring at the beginning of the 25 year projection period. Such a reduction in the threat of flooding and the associated damage costs is significant and suggests that some form of wall modification to provide flood protection should be undertaken.

5.2.1. Raising the dam wall for flood protection

Raising the dam wall by +15 m or +23 m will not actually affect when the desalination plants are triggered or run compared to BAU as the additional volume is only designated for flood protection purposes (i.e. 'airspace'). In these options we have assumed that the water security shortfall is made up by:

- DSP 1 first switched on in 2021 (the same as BAU) and runs 16 of the 25 years modelled;
- DSP 2 construction is triggered in 2032 and runs 5 of the 25 years modelled;
- DSP 3 is also needed and construction triggered in 2034 (only 2 years later) because the demand at that time is too high for the existing desalination plants to satisfy with the depleted dam under the sustained dry conditions; and
- DSP 4 is also needed and construction triggered in 2036 (in another 2 years) as the situation remains the same but this desalination plant might not actually be used in the modelling period considered since normal rainfall conditions replenish the dam soon after it is constructed.

Cessation of flood damage costs could be achieved for this particular scenario, potentially saving billions of A$ due to the reduction of the number of potential moderate, major and severe flooding events.

Total investment costs for the +15 m and +23 m options are PV A$6.93.billion (A$ 2.67 billion capital plus A$4.26 billion ongoing)

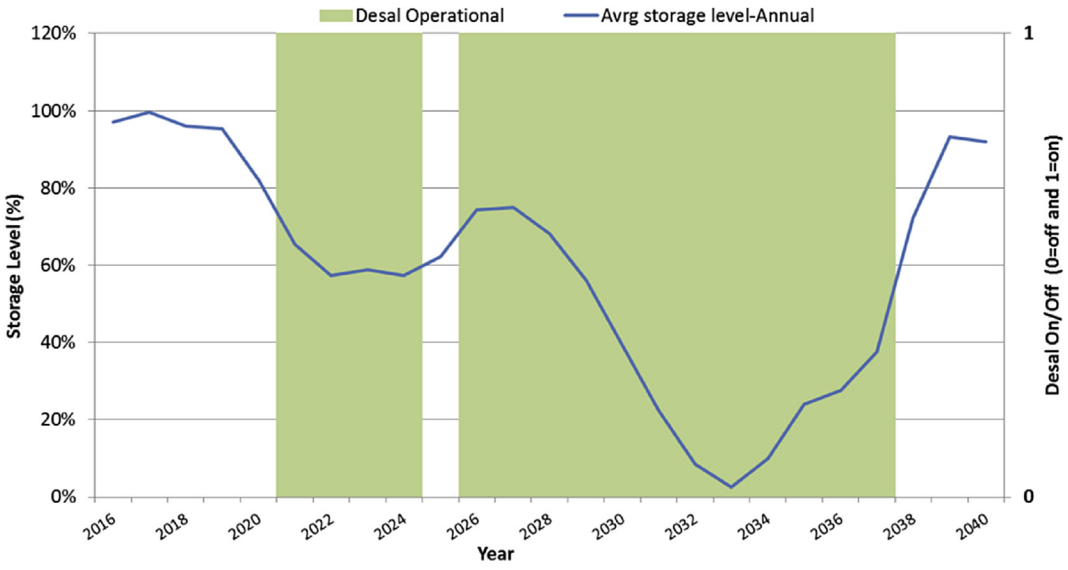

Fig. 7. Business as usual option projected average dam storage levels and on/off operation of desalination plants 1 & 2.

and A$7.41 billion (A$3.15 billon capital plus A$4.26 billion) respectively.

Fig. 8 provides an overview of the average dam storage levels, the extent of operation of the desalination plants and the timing of the construction of the new desalination plants for the BAU, +15 m and +23 m options.

5.2.2. Lowering the dam FSL for flood protection

Lowering the dam FSL by −5 m or −12 m will mean that there is less storage capacity available and potentially lower water security compared to BAU, meaning that more desalination plants may be needed and/or triggered earlier in an extended dry period.

Applying the SDM to the option of lowering the dam FSL by −5 m (−20% by volume) results in the following utilisation and staging of desalination plants:

- DSP 1 first switched on in 2019 (2 years earlier than BAU) and runs 22 of the 25 years modelled;
- DSP 2 construction triggered in 2032 and runs 8 of the 25 years modelled;
- DSP 3 construction triggered in 2034 (only 2 years later) because the population demand at that time is just too high for the depleted dam and desalination plants to sustain under the dry conditions and runs for 6 years of the period modelled; and
- DSP 4 construction triggered in 2036 (in another 2 years) as the situation remains the same but the plant is potentially never actually used in the modelling period since normal rainfall conditions replenish the dam soon after it is constructed.

Virtual cessation of flood damage costs could be achieved for this particular scenario potentially saving billions of A$ due to the reduction of the number of potential moderate, major and severe flooding events.

When comparing the lowered FSL (−5 m) to the option of raising the dam wall for flood protection (i.e. existing dam water storage capacity), there is still a need for a total of four desalination plants (DSP 1–4). The major difference is that they are triggered slightly earlier for the lowered FSL (−5 m) option and utilised more often.

Lowering the dam FSL by −12 m (−39% by volume) was expected to significantly affect the water security compared to BAU and be expected to perform the worst out of the options in terms of security. However, due to the new volume being less than the MWP trigger levels for desalination operation (i.e. triggers of 70%-on and 80%-off according to Fig. 1) the MWP operating rules were adjusted to 50%-on and 60%-off for this specific option. These changes to the dam capacity and MWP trigger levels had a profound influence on the requirement for new desalinated supply. Surprisingly, this scenario of lowering the dam FSL by −12 m meant that fewer desalination plants were required overall as summarised below:

- DSP 1 first switched on in 2019 (2 years earlier than BAU) and runs 18 of the 25 years modelled;
- DSP 2 construction triggered in 2022 (10 years earlier than BAU) and runs 14 of the 25 years modelled;
- DSP 3 construction triggered in 2024 (only 2 years later) and runs 12 of the 25 years modelled; and
- no DSP 4 triggered in the 25 year period modelled.

Cessation of flood damage costs could be achieved for this particular scenario potentially saving billions of A$ due to the reduction of the number of potential moderate, major and severe flooding events.

The total investment costs for the −5 m and −12 m options are PV A$7.04 billion (A$2.19 billion capital plus $A4.85 billion ongoing) and PV A$7.03 billion (A$2.06 billion capital plus A$4.97 billion ongoing) respectively.

5.3. Optimisation

Fig. 9 shows that in the +15 m, +23 m and −5 m options, even with the additional desalination plants DSP 2–4, the dam storage levels become dangerously low. However, because the original MWP triggers are adjusted and DSP 2 & 3 are brought on earlier, the −12 m option provides sufficient security to ride out a drought situation similar to a repeat of the Millennium drought but with an even higher population.

Table 6 provides a summary of the key features of the options modelled. As can be seen significant expenditure is required for BAU to provide security of supply even without modification of the dam for flood management purposes. The +23 m is unsurprisingly the most expensive of the options considered. However,

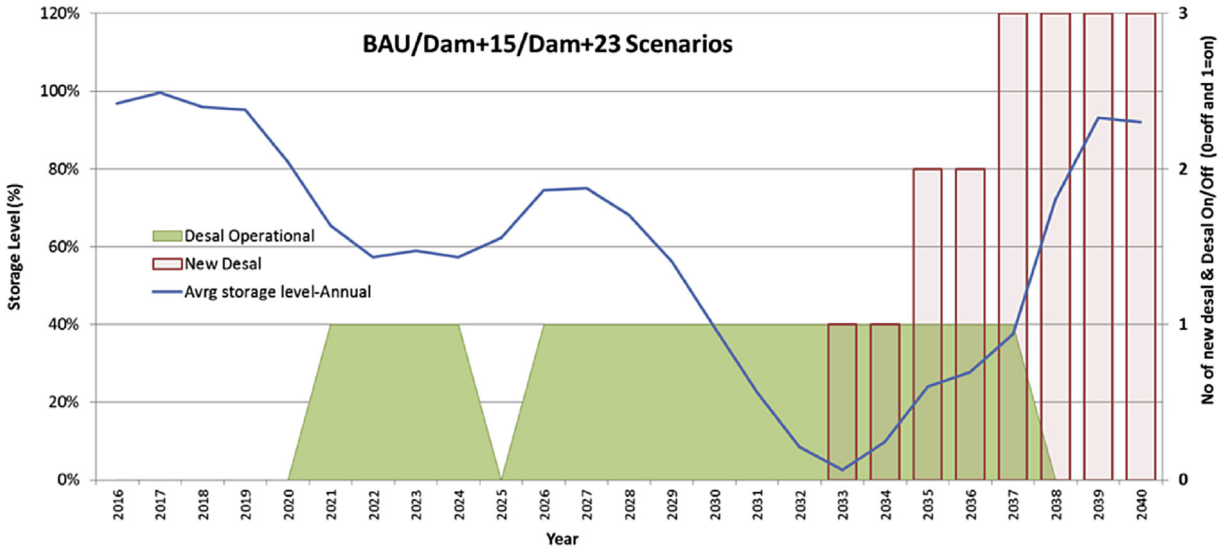

Fig. 8. Summary of dam levels, desalination plants operation and new desalination construction for the business as usual and raising dam wall options.

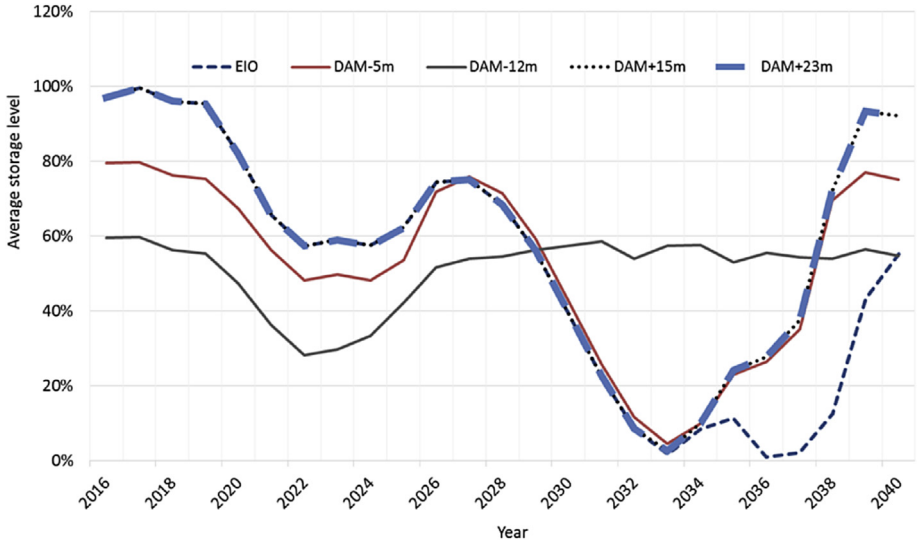

Fig. 9. Projected dam depletion curves for various options (note that the business as usual option follows the same line as +15 m and +23 m but has been omitted for clarity).

the +15 m, −5 m and −12 m options group closely together in terms of total costs but with varying capital and operating expenditure underlying these costs. All four options modelled provide a significant reduction in flood risk.

This brings into sharp focus the question of how to optimise the existing infrastructure to avoid flood risk and maximise security plus call on new supply expansion options when required at the lowest cost to society.

The scenario chosen, that is, inflow projections assuming a repeat of the last 25 years of inflows is repeated with increased demand due to population rise, is just one scenario. The four options chosen to test, which reflect what government have been

Table 6
Summary of the key features of the options modelled.

Options	Trigger level for desal operation	Threshold for new desal construction	Ave storage level (annual)	No of years storage below 40%	No of new desal	Desal operating freq. (years)	Discounted total costs (A$ billion)*
EIO	70%	N/A	50%	9	0	19	4.13
BAU	70%	30%	59%	8	3	16	6.45
+15 m	70%	30%	59%	8	3	16	6.93
+23 m	70%	30%	59%	8	3	16	7.41
−5 m	70%	30%	52%	7	3	22	7.04
−12 m	50%	30%	51%	4	2	18	7.03

Assumed desalination plant size 250 ML/d.
* Includes DSP 1 repayment.

considering, have various sub options that could be examined through extensive sensitivity analysis, including consideration of:

- various storage inflow patterns;
- different population growth rates;
- demand reduction as efficiency and source substitution regulations for new buildings come into effect and urban density intensifies;
- new MWP trigger levels for the use of existing infrastructure and demand management measures as well as when to trigger new supply and demand-side options that will need to change over time; and
- the size of new infrastructure such as desalination.

These along with other variables such as the height to raise the dam or lower the FSL together with additional dam management procedures can be tested to examine how to minimise flooding risk, optimise the use of existing infrastructure and bring on board new options – all at lowest cost to society.

6. Conclusions

This paper explores the potential trade-offs between flood risk and water security, the use of existing and new infrastructure, and the associated cost implications, using a system dynamics model.

In short, the results contrast (i) higher cost options that involve raising the dam wall by +15 m or +23 m to provide "airspace" for potential flood mitigation with (ii) lower cost options that involve lowering the FSL in the dam by −5 m or −12 m to provide potential flood mitigation but at a risk of compromising water security. The results show that under the scenario modelled, that is, a repeat of the last 25 years of inflows but including projected growth and spread of population in vulnerable areas, that under BAU there are likely to be numerous flooding events ranging from minor to severe. These flood events have the potential to cause billions of dollars of damage, lost income and loss of life. With the current development within the dam flood plain this implies that some form of dam wall modification is urgently required to avoid such risk. As raising the dam wall will be logistically challenging, and potentially take several years to construct, reducing the FSL should be considered a viable option.

Even with such flooding over the period examined the EIO option (using DSP 1) and BAU option (triggering the build and use of DSP 2 and additional desalination plants according to the MWP) show that the existing infrastructure cannot cope with the inflow scenario modelled. With the increased demand from the growing population the dam comes dangerously close to dead storage before new inflows replenish supplies. In reality the dams would not reach this point and additional supply and/or demand options would be triggered as required. However, in three of the options modelled (+15 m, +23 m and −5 m) where three additional desalination plants are triggered to replenish security lost due to flood mitigation and/or more extreme climatic conditions – the options still can't cope with the increased population demand and run the risk of reaching dead storage before being replenished by inflows. Surprisingly only the −12 m option, which has a cost comparable to the +15 m and −5 m options, is able to provide both flood protection and water security. This is primarily because the MWP triggers have had to be adjusted to accommodate the 39% loss in dam capacity and brought the need for construction of DSP 2 and DSP 3 forward. Whilst seemingly expensive to do so it provides an effective insurance policy and obviates the need for DSP 4 in the modelling conducted. This option shows that by adjusting the current MWP trigger levels greater optimisation of existing and new infrastructure can be achieved which can potentially mitigate flood risk and water security issues.

Whilst the modelling was conducted with limited publicly available data and the system is inherently complex with distinct interactions and feedback loops, it nevertheless demonstrates the power of such modelling and in the case of the −12 m option, surprising results. With further refinement, the SDM has enormous potential to assist in testing hundreds of different scenarios, options and sub options to help determine the optimal use of existing and new infrastructure for both flood protection and water security. Such tests can also illustrate total cost implications and additional impacts on environmental flows. The illustrative example explores the growing need to understand the relationship between drought, flooding and infrastructure optimisation. It demonstrates the importance of optimising existing and new water resources for multiple purposes and how system dynamics modelling can assist water service providers in these complex investigations as the effects of climate change pan out.

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References

ATSE, 2012. Sustainable Water Management: Securing Australia's Future in a Green Economy (Report). Australian Academy of Technological Sciences and Engineering (ATSE), Melbourne, Victoria.

Beal, C.D., Stewart, R.A., Fielding, K., 2013. A novel mixed method smart metering approach to reconciling differences between perceived and actual residential end use water consumption. J. Clean. Prod. 60, 116–128. http://dx.doi.org/10.1016/j.jclepro.2011.09.007.

Berz, G., 2005. Weather Catastrophes and Climate Change: Is There Still Hope for us? Münchener Rückversicherungs Gesellschaft (Munich Re), Munich, Germany, pp. 1–264.

Carvalho, L., 2015, June 26. Megacity drought: Sao Paolo withers after dry 'wet season'. Conversation. https://theconversation.com/megacity-drought-sao-paulo-withers-after-dry-wet-season-42799 (accessed 29.04.16).

Chen, K., McAneney, J., 2006. High-resolution estimates of Australia's coastal population. Geophys. Res. Lett. 33, L16601. http://dx.doi.org/10.1029/2006GL026981.

Fane, S.A., 2005. Planning for Sustainable Urban Water: Systems-approaches and Distributed Strategies. Institute for Sustainable Futures, University of Technology, Sydney.

Galloway, R.W., Bahr, M.E., 1979. What is the length of the Australian Coast? Aust. Geogr. 14 (4), 244–247. http://dx.doi.org/10.1080/00049187908702768.

Giurco, D.P., Turner, A., Fane, S., White, S.B., 2014. Desalination for urban water: changing perceptions and future scenarios in Australia. Chem. Eng. Trans. 42, 13–18. http://dx.doi.org/10.3303/CET1442003.

Griffin, D., Anchukaitis, K.J., 2014. How unusual is the 2012–2014 California drought? Geophys. Res. Lett. 41, 9017–9023. http://dx.doi.org/10.1002/2014GL062433.

Gurung, T.R., Sharma, A., 2014. Communal rainwater tank systems design and economies of scale. J. Clean. Prod. 67, 26–36. http://dx.doi.org/10.1016/j.jclepro.2013.12.020.

Hasham, N., 2014, March 12. Warragamba Dam wall raising divides experts on $1 billion cost, efficiency. Sydney Morning Herald. http://www.smh.com.au/environment/warragamba-dam-wall-raising-divides-experts-on-1-billion-cost-efficiency-20140311-34kfd.html (accessed 29.04.16).

Huber, D., Gulledge, J., 2011. Extreme Weather and Climate Change. C2ES Center for Climate Change and Energy Solutions, Arlington, VA. http://www.c2es.org/publications/extreme-weather-and-climate-change (accessed 29.04.16).

IPART, 2011. Prices for Sydney Desalination Plant Pty Limited's Water Supply Services for the Period to 30 June 2017, Water – Issues Paper (Report). Independent Pricing and Regulatory Tribunal of New South Wales, Sydney, NSW.

IPCC, 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (Special report of the Intergovernmental Panel on Climate Change). Cambridge University Press, Cambridge, UK and New York, NY.

IPCC, 2014. Freshwater resources. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp. 229–270.

Kondili, E., Kaldellis, J.K., Papapostolou, C., 2010. A novel systemic approach to water resources optimisation in areas with limited water resources. Desalination 250 (1), 297–301. http://dx.doi.org/10.1016/j.desal.2009.09.046.

Malone, U., 2013, September 2013. New South Wales desalination plant deal to cost consumers $10 billion over 50 years. ABC News. http://www.abc.net.au/news/2013-09-27/nsw-desalination-plant-deal-costing-customers-$10-billion/4985168 (accessed 29.04.16).

McDonald, R.I., Green, P., Balk, D., Fekete, B.M., Revenga, C., Todd, M., Montgomery, M., 2011. Urban growth, climate change, and freshwater availability. Proc. Natl. Acad. Sci. U. S. A. 108 (15), 6312–6317.

Metropolitan Water District of Southern California (MWD), 2015. Responding to Drought: Regional Progress Report (An annual report to the California State Legislature on Achievements in Conservation, Recycling, and Groundwater Recharge, Los Angeles, CA).

Miyan, M.A., 2015. Droughts in Asian least developed countries: vulnerability and sustainability. Weather Clim. Extrem. 7, 8–23. http://dx.doi.org/10.1016/j.wace.2014.06.003.

Molino Stewart, 2012a. Hawkesbury-Nepean Flood Damages Assessment – Addendum Report: Answers to Recent Questions (Report prepared for Infrastructure NSW by Molino Stewart Pty Ltd, Parramatta, NSW).

Molino Stewart, 2012b. Hawkesbury-Nepean Flood Damages Assessment – Final Report – Infrastructure NSW (Report prepared for Infrastructure NSW by Molino Stewart Pty Ltd, Parramatta, NSW).

NSW Department of Primary Industries (DPI), Office of Water, 2014. Hawkesbury-Nepean Valley Flood Management Review Stage One – Review Report, NSW.

NSW Government, 2014. A Plan for Growing Sydney (Report). NSW Government Department of Planning and Environment, Sydney, NSW. http://www.planning.nsw.gov.au/~/media/Files/DPE/Plans-and-policies/a-plan-for-growing-sydney-2014-12.ashx.

NSW Office of Water, 2010. 2010 Metropolitan Water Plan. Department of Environment, Climate Change and Water, Sydney, NSW.

Pandit, A., Minné, E.A., Li, F., Brown, H., Jeong, H., James, J.C., Newell, J.P., Weissburg, M., Chang, M.E., Xu, M., Yang, P., Wang, R., Thomas, V.M., Yu, X., Lu, Z., Crittenden, J.C., 2015. Infrastructure ecology: an evolving paradigm for sustainable urban development. J. Clean. Prod. http://dx.doi.org/10.1016/j.jclepro.2015.09.010.

Pittock, B., 2012, February 24. Droughts and flooding rains: climate change models predict increases in both. Conversation. https://theconversation.com/droughts-and-flooding-rains-climate-change-models-predict-increases-in-both-5470 (accessed 29.04.16).

Porter, M.G., Downie, D., Scarborough, H., Sahin, O., Stewart, R.A., 2014. Drought and desalination: Melbourne water supply and development choices in the twenty-first Century. Desalin. Water Treat. 55 (9), 2278–2295. http://dx.doi.org/10.1080/19443994.2014.959743.

Productivity Commission (PC), 2011. Australia's Urban Water Sector (Report no. 55, final inquiry report, Canberra, ACT).

Queensland Floods Commission of Inquiry, 2012. Final Report. Report Prepared for the Queensland Government, Brisbane, QLD. http://www.floodcommission.qld.gov.au/__data/assets/pdf_file/0007/11698/QFCI-Final-Report-March-2012.pdf.

Sahin, O., Siems, R.S., Stewart, R.A., Porter, M.G., 2014a. Paradigm shift to enhanced water supply planning through augmented grids, scarcity pricing and adaptive factory water: a system dynamics approach. Environ. Model. Softw. 1–14. http://dx.doi.org/10.1016/j.envsoft.2014.05.018.

Sahin, O., Stewart, R.A., Porter, M.G., 2014b. Water security pricing and reverse osmosis: a system dynamics approach. J. Clean. Prod. 88, 160–171. http://dx.doi.org/10.1016/j.jclepro.2014.05.009.

Scarborough, H., Sahin, O., Porter, M., Stewart, R., 2015. Long-term water supply planning in an Australian coastal city: dams or desalination? Desalination 358, 61–68. http://dx.doi.org/10.1016/j.desal.2014.12.013.

SKM, 2011. Water Supply System Model and Yield Review 2009/2010 – Volume 1 (Main report prepared by SKM for the Sydney Catchment Authority, Sydney, NSW).

Turner, A., White, S., Chong, J., Dickinson, M.A., Cooley, H., Donnelly, K., 2016. Managing Drought: Learning from Australia (Report). Alliance for Water Efficiency, the Institute for Sustainable Futures, University of Technology Sydney and the Pacific Institute for the Metropolitan Water District of Southern California, the San Francisco Public Utilities Commission and the Water Research Foundation, Sydney, NSW. Retrieved from: http://www.allianceforwaterefficiency.org/AWE-Australia-Drought-Report.aspx.

Turner, A., Willets, J., Fane, S., Giurco, D., Chong, J., Kazaglis, A., White, S., 2010. Guide to Demand Management and Integrated Resource Planning (Report). Institute for Sustainable Futures, University of Technology, Sydney for the National Water Commission and the Water Services Association of Australia, Inc., Sydney, NSW.

Ventana Systems, Inc, 2012. Vensim DSS, Version 6.0b. http://www.vensim.com/.

White, S., Campbell, D., Giurco, D., Snelling, C.M., Kazaglis, A., Fane, S.A., 2006. Review of the Metropolitan Water Plan: Final Report (Report). Institute for Sustainable Futures, University of Technology Sydney, ACIL Tasman and SMEC Australia, Sydney, NSW.

Water Services Association of Australia (WSAA), 2013. Dams Information Pack One. Melbourne, VIC and Sydney, NSW. https://www.wsaa.asn.au/sites/default/files/publication/download/WSAA%20Dams%20Fact%20Sheet%20Information%20Pack.pdf.

Zhang, L., Zhou, T., 2015. Drought over East Asia: a review. J. Clim. 28, 3375–3399. http://dx.doi.org/10.1175/JCLI-D-14-00259.1.

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APPENDIX L

Multi-decadal variability of flood risk

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[1] Recent research has highlighted the persistence of multi-decadal epochs of enhanced/reduced flood risk across New South Wales (NSW), Australia. Recent climatological studies have also revealed multi-decadal variability in the modulation of the magnitude of El Niño/Southern Oscillation (ENSO) impacts. In this paper, the variability of flood risk across NSW is analysed with respect to the observed modulation of ENSO event magnitude. This is achieved through the use of a simple index of regional flood risk. The results indicate that cold ENSO events (La Niña) are the dominant drivers of elevated flood risk. An analysis of multi-decadal modulation of flood risk is achieved using the inter-decadal Pacific Oscillation (IPO) index. The analysis reveals that IPO modulation of ENSO events leads to multi-decadal epochs of elevated flood risk, however this modulation appears to affect not only the magnitude of individual ENSO events, but also the frequency of their occurrence. This dual modulation of ENSO processes has the effect of reducing and elevating flood risk on multi-decadal timescales. These results have marked implications for achieving robust flood frequency analysis as well as providing a strong example of the role of natural climate variability. *INDEX TERMS:* 1821 Hydrology: Floods; 4215 Oceanography: General: Climate and interannual variability (3309); 4522 Oceanography: Physical: El Niño; *KEYWORDS:* Climate variability, El Niño/Southern Oscillation (ENSO), flood frequency, Inter-decadal Pacific Oscillation (IPO), Pacific Decadal Oscillation (PDO), multi-decadal. **Citation:** Kiem, A. S., S. W. Franks, and G. Kuczera, Multi-decadal variability of flood risk, *Geophys. Res. Lett.*, *30*(2), 1035, doi:10.1029/2002GL015992, 2003.

1. Introduction

[2] The quantification and understanding of hydrological variability is of considerable importance for the estimation of flood risk. At present, traditional methods are largely empirical in that annual maximum floods are assumed to be independently and identically distributed [*Franks and Kuczera*, 2002]. Despite the development of rigorous Bayesian frameworks to assess the uncertainty of flood risk estimates, these techniques have not acknowledged the possibility of serial correlation within periods of elevated or reduced flood risk [cf. *Kuczera*, 1999]. However, recent research has highlighted the persistence of multi-decadal epochs of enhanced/reduced flood risk across New South Wales [*Erskine and Warner*, 1988; *Franks*, 2002a, 2002b; *Franks and Kuczera*, 2002]. In particular, *Franks and Kuczera* [2002] demonstrated that a major shift in flood frequency occurred around 1945. Previous authors have noted that the mid-1940's corresponded to a change in both sea surface temperature anomalies as well as circulation patterns [*Allan et al.*, 1995]. *Franks* [2002b] showed that the observed change in flood frequency could be objectively identified as corresponding to this shift in climate parameters. Furthermore, it was shown through the use of a simple index of regional flood risk that the observed shift in flood frequency was statistically significant at the <1% level.

[3] In addition to hydrological observations of changing flood risk, recent climatological studies have also revealed multi-decadal variability in the modulation of the magnitude of El Niño/Southern Oscillation (ENSO) impacts. *Power et al.* [1999] have investigated marked temporal changes in ENSO correlations to Australian rainfall records. The temporal stratification of the rainfall sequences was achieved according to what has been termed the Inter-decadal Pacific Oscillation (IPO). The IPO was defined by anomalous warming and cooling in the Pacific Ocean and is similar to the Pacific Decadal Oscillation or PDO [*Mantua et al.*, 1997; *Franks*, 2002a]. Importantly, *Power et al.* [1999] demonstrated that individual ENSO events (ie. El Niño, La Niña) had stronger impact across Australia during the negative phase of the IPO, implying that there exists a multi-decadal modulation of the magnitude of ENSO events.

[4] The study aims to extend the analysis of *Franks* [2002b] to assess the role of ENSO processes and their multi-decadal modulation, in dictating flood risk across New South Wales (NSW), Australia. In this paper, a derived regional index of flood risk [*Franks*, 2002b] stratified according to ENSO classifications based on the NINO3 index. The index is then further stratified according to the multi-decadal IPO classifications. The stratified flood frequency data are analysed using Bayesian flood frequency analysis to quantify uncertainty on quantiles and thus elucidate the key controls on NSW flood risk.

2. Derivation of a Regional Index

[5] The streamflow data used in this study were obtained from the PINEENA database, developed and managed by the NSW Department of Land and Water Conservation. 40 records spanning 1924 to 1999 were deemed suitable in terms of the length and continuity of record. If the flood gauges were perfectly correlated, treating them as entirely uncorrelated would imply 40 independent records with any inferred change having unwarranted statistical support. To avoid the issue of spatial correlation, the 40 flood records were collapsed into a regional flood index following *Franks* [2002b].

3. Temporal Stratification According to ENSO and IPO Indices

[6] Stratification of the regional flood index record according to ENSO classifications was made using the

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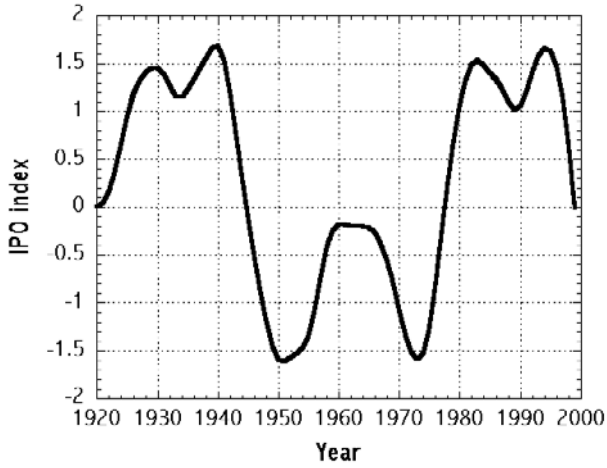

Figure 1. The Inter-decadal Pacific Oscillation (IPO) from 1920 to 1999.

monthly NINO3 index. Every year from 1924 to 1999 was given an ENSO classification based on the six-month October to March average NINO3 value. This method and index combination has previously been demonstrated to be the most robust for the time period being investigated [*Kiem and Franks*, 2001].

[7] The Inter-decadal Pacific Oscillation (IPO) is the coherent pattern of sea surface temperature (SST) variability occurring on inter-decadal time scales over the Pacific Ocean [*Folland et al.*, 1999; *Power et al.*, 1998, 1999; *Allan*, 2000]. In classifying the different IPO phases, *Power et al.* [1999] used the thresholds of ±0.5 to distinguish positive, neutral and negative phases. Figure 1 shows the time series of the IPO over the period of flood data employed in this study. As can be seen, during this period there have been three major phases of the IPO: Two positive phases (IPO > 0.5).

4. Results

[8] The regional flood index was stratified according to El Niño and La Niña extremes, as defined by the NINO3 index. The stratified data were then subjected to a Bayesian flood frequency analysis in order to properly account for parameter uncertainty [*Kuczera*, 1999].

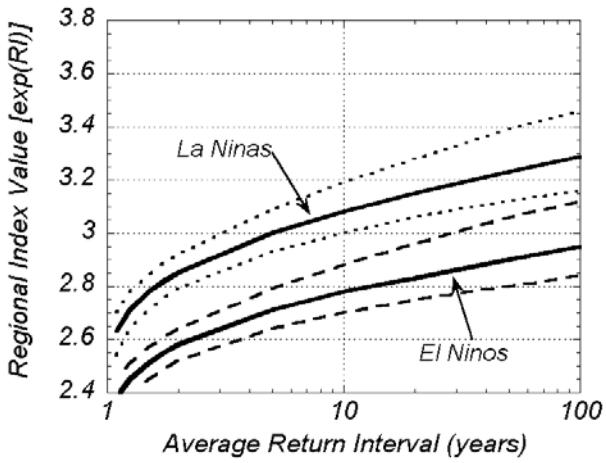

Figure 2. Log-normal expected quantiles and their 90% probability limits (dashed lines) for the regional index under El Niño and La Niña conditions.

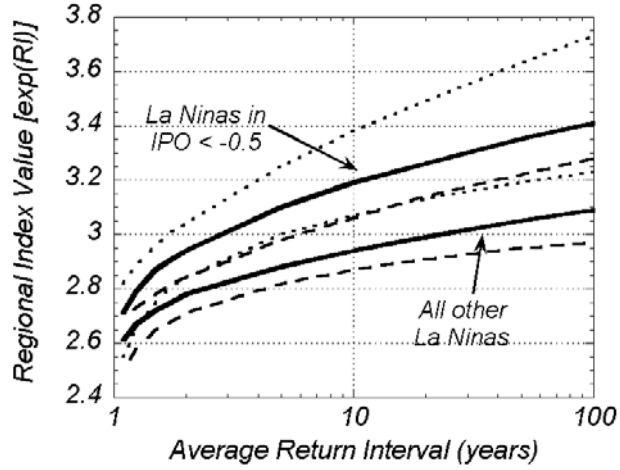

Figure 3. Log-normal expected quantiles and their 90% probability limits (dashed lines) for the regional index under La Niña conditions during the negative IPO phase and La Niña conditions during non-negative IPO phases.

[9] To assess the role of ENSO extremes Figure 2 presents the flood frequency under El Niño and La Niña conditions along with the associated 90% confidence limits. From this plot it can be readily seen that much higher flood risk must be associated with La Niña events as opposed to El Niño. Also immediately apparent is the degree of separation of the confidence limits indicating a highly statistically significant difference between the two ENSO extremes. Although not shown in Figure 2 for the sake of clarity, the flood frequency distribution associated with neutral ENSO events lies between the two extremes.

[10] Given the clear role of La Niña events in flood risk identified in Figure 2, to test the hypothesis that the IPO modulates the magnitude of La Niña events, as suggested by *Power et al.* [1999], a stratification on La Niña under different IPO phases is required. To achieve this test, the regional index is stratified according to La Niña events occurring under negative IPO phase (<-0.5) and then according to La Niña events occurring under neutral and positive IPO phases (>-0.5). Figure 3 shows the resultant flood frequency curves. As can be seen, the frequency curve associated with La Niña events under IPO negative (<-0.5) is markedly higher than the flood frequency associated with all other La Niña events. The 90% quantiles marginally overlap suggesting significant difference between the conditioned distributions.

[11] Finally, given the observed persistence of IPO phases, it is desirable to assess the variability of flood risk under the different IPO phases irrespective of inter-annual ENSO events. Figure 4 shows the flood frequency curves for IPO negative (<-0.5) against non-negative IPO phases. Again, it can be seen that IPO negative phase corresponds to a much increased flood risk when compared to the non-negative phases of IPO. It is therefore clear that monitoring of the multi-decadal IPO phase may provide valuable insight into flood risk on multi-decadal scales, whilst the joint occurrence of inter-annual La Niña

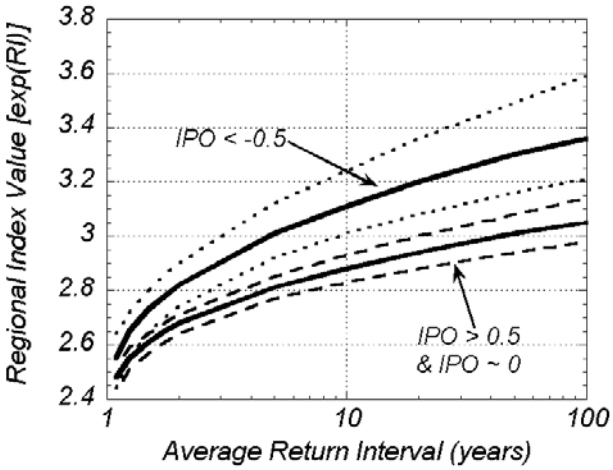

Figure 4. Log-normal expected quantiles and their 90% probability limits (dashed lines) for the regional index under the negative and non-negative IPO phases.

events within the IPO negative phase represents further elevated flood risk.

5. Analysis of ENSO Event Frequency Under Different Multi-Decadal IPO Phases

[12] Given the strong control on flood risk exerted by La Niña events and modulated in their magnitude by multi-decadal IPO processes, it is intuitive to examine the frequency of occurrence of such high magnitude events. Table 1 shows the IPO phases that have occurred between 1924 to 1999, and the frequency of ENSO events under each of these phases. Note that the IPO phases are as defined earlier in this paper (with 1924–43 denoted IPO > 0.5(1) and 1979–97 denoted IPO > 0.5(2)).

[13] Immediately apparent from Table 1, it can be seen that IPO negative phases tend to be biased towards an increased frequency of La Niña events. It therefore appears that the multi-decadal processes as represented by the IPO may modulate the frequency of ENSO events as well as the magnitude of their impact.

[14] To test the statistical significance of the dependence of ENSO event frequency on IPO phase a simple test of proportions was applied [*Hogg and Tanis*, 1988]. It is assumed that the sampling distribution of the proportion of El Niño events occurring within any IPO phase can be approximated by a normal distribution with a mean of p and a variance of $p(1 - p)/n$, where p is the proportion of El Niño events that have occurred within each IPO phase, calculated using $p = y/n$, where y is the number of El Niño events that have occurred and n is the total number of years in the IPO phase being investigated. This was repeated for La Niña and Neutral events.

Table 1. Number of El Niño, La Niña and Neutral Events Occurring Within Each of the IPO Phases

	IPO > 0.5(1)	IPO > 0.5(2)	IPO < −0.5	IPO ~ 0
El Niño	4	6	4	3
La Niña	4	1	10	7
Neutral	12	12	7	6
Total	20	19	21	16

Table 2. Results Obtained When the Frequency at Which El Niño, La Niña and Neutral Events Occur in the Different IPO Phases are Compared

Period being tested		y_1	n_1	p_1	y_2	n_2	p_2	z	p-value
EL NIÑO									
Period 1	Period 2								
IPO > 0.5 (1)	IPO > 0.5 (2)	4	20	0.20	6	19	0.32	0.828	0.204
IPO > 0.5 (1)	IPO < −0.5	4	20	0.20	4	21	0.19	0.077	0.469
IPO < −0.5	IPO > 0.5 (2)	4	21	0.19	6	19	0.32	0.914	0.180
IPO > 0.5 ALL	IPO < −0.5	10	39	0.26	4	21	0.19	0.576	0.282
LA NIÑA									
Period 1	Period 2								
IPO > 0.5 (1)	IPO > 0.5 (2)	4	20	0.20	1	19	0.05	1.376	0.084
IPO > 0.5 (1)	IPO < −0.5	4	20	0.20	10	21	0.48	1.864	0.031*
IPO < −0.5	IPO > 0.5 (2)	10	21	0.48	1	19	0.05	2.996	0.001**
IPO > 0.5 ALL	IPO < −0.5	5	39	0.13	10	21	0.48	2.969	0.001**
NEUTRAL									
Period 1	Period 2								
IPO > 0.5 (1)	IPO > 0.5 (2)	12	20	0.60	12	19	0.63	0.203	0.420
IPO > 0.5 (1)	IPO < −0.5	12	20	0.60	7	21	0.33	1.712	0.043*
IPO < −0.5	IPO > 0.5 (2)	7	21	0.33	12	19	0.63	1.886	0.030*
IPO > 0.5 ALL	IPO < −0.5	24	39	0.62	7	21	0.33	2.085	0.019*

Significance at the <5% and <1% level is represented by * and ** respectively.

[15] In order to determine whether the probability (P_1) of a given ENSO event occurring during one IPO phase was significantly different to the probability (P_2) of the same ENSO event occurring during a different IPO phase the following statistical test was used. Let y_1 represent the number of El Niño events, for example, that occurred in the n_1 years when IPO was positive and y_2 the number of El Niños that occurred in the n_2 years when IPO was negative. A test statistic used to test the hypothesis that P_1 equals P_2 is:

$$z = \frac{|p_1 - p_2|}{\sqrt{p(1-p)(1/n_1 + 1/n_2)}}$$

where $p_1 = y_1/n_1$, $p_2 = y_2/n_2$, $p = (y_1 + y_2)/(n_1 + n_2)$ and $z \sim N(0, 1)$.

[16] Table 2 shows the results obtained when the probability of El Niño, La Niña and Neutral events occurring in different IPO phases were compared. The p-value in Table 2 indicates the probability that the frequency at which a given ENSO event occurs in one IPO phase is equal to the frequency at which the same ENSO event occurs at in a different IPO phase.

[17] Table 2 shows that when the negative IPO phase is compared with the positive IPO phases, the frequency at which La Niña events occur is significantly higher when the IPO is negative. Table 2 also demonstrates that the number of Neutral events that occur when the IPO is positive is significantly higher than when the IPO is negative, indicating a higher rate of occurrence of the ENSO extremes (El Niño or La Niña) when the IPO is negative. Table 2 also shows that no significant difference is observed between the two positive IPO phases in either El Niño, La Niña or Neutral events.

[18] It is therefore apparent from these results that the IPO negative phase, representing cool anomalies in the mid-latitude Pacific Ocean SST, contain a statistically significant

proportion of La Niña events. This indicates a predisposition of the negative (cool) IPO phase towards increased frequency of cool La Niña events. Thus the IPO modulation of flood risk across NSW appears due to its modulation of the magnitude and frequency of strong La Niña events.

[19] This dual modulation has the effect of reducing and elevating flood risk on multi-decadal timescales. Indeed, the 100 year average return interval derived by traditional empirical analysis returns a value of 3.17 for the regional index. However, within the IPO negative phase the regional flood of this magnitude occurs with a return period of 15 years. Given the observed persistence of IPO phases beyond this period, it seems that the '100 year flood' is most likely to occur during this period. Instrumental evidence bears testament to this in the occurrence of clusters of high magnitude floods. This apparent clustering, statistically anomalous under the traditional paradigm, is entirely intuitive within the concept of multi-decadal modulation of ENSO-induced flood extremes.

6. Conclusions

[20] This paper has sought to explain the temporal changes previously observed in NSW flood risk over the period 1924–99. This has been attempted through an analysis of ENSO processes and their modulation via multi-decadal SST as represented through the IPO index. The results have shown that La Niña events predominate the long-term flood risk. Moreover, multi-decadal modulation of ENSO processes result in extended periods of elevated flood risk. This paper has demonstrated that these multi-decadal processes may modulate the frequency of ENSO extremes as well as the magnitude of their impact.

[21] There are a number of important implications associated with these insights;

1. Traditional flood risk where the climate is effectively assumed static is inadequate. Long term flood risk will be under- or over-estimated if the data used for analysis are drawn from a single or unknown combinations of IPO climate state.
2. Persistent periods of IPO negative phases are associated with much elevated flood risk. Given their persistent nature, these high risk periods can be identified through monitoring the IPO index, potentially providing useful guidance for operational flood management and infrastructure maintenance.
3. The observation of the modulation of ENSO extremes also has implications for reservoir management. The observation of increased La Niña events under IPO negative conditions will have significance for recharge of surface reservoirs with preliminary results indicating similar multi-decadal variability in similar multi-decadal variability in drought risk [*Kiem and Franks*, 2002].

[22] Finally, it is worthwhile to note that the results shown here represent one manifestation of natural climate variability. The quantification of hydrological variability represents an integrated measure of natural climate variability. Flood risk is a key hydrological variable in terms of social and economic importance. At present it is unclear whether the multi-decadal modes of sea surface temperature variability are an internal artifact of the ocean-atmosphere system, or forced by external variations in ultraviolet irradiance [*Latif and Barnett*, 1994; *White et al.*, 1997; *Reid*, 2000; *Franks*, 2002a]. In either case, the data presented here might be used as a performance indicator for General Circulation Models that attempt to project the influence of anthropogenic factors on climate. If these models can successfully represent such historic variability in a key hydrological variable, then increased confidence might be placed in the simulation of future, anthropogenically forced climate.

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References

Allan, R. J., ENSO and climatic variability in the last 150 years, in *El Niño and the Southern Oscillation: Multi-scale Variability, Global and Regional Impacts*, edited by H. F. Diaz and V. Markgraf, Cambridge University Press, Cambridge, UK, 3–56, 2000.

Allan, R. J., J. A. Lindesay, and C. J. C. Reason, Multi-decadal variability in the climate system over the Indian Ocean region during the austral summer, *J. Climate*, *8*(7), 1853–1873, 1995.

Erskine, W. D., and R. F. Warner, Geomorphic effects of alternating flood and drought dominated regimes on a NSW coastal river, in *Fluvial Geomorphology of Australia*, edited by R. F. Warner, Academic Press, Sydney, Australia, 223–244, 1988.

Folland, C. K., D. E. Parker, A. W. Colman and R. Washington, Large scale modes of ocean surface temperature since the late nineteenth century, in *Beyond El Niño: Decadal and Interdecadal Climate Variability*, edited by A. Navarra, Springer, Berlin, 73–102, 1999.

Franks, S. W., Assessing hydrological change: Deterministic general circulation models or spurious solar correlation?, *Hydrol. Proc.*, *16*(2), 559–564, 2002a.

Franks, S. W., Identification of a change in climate state using regional flood data, *Hydrol. and Earth System Sci.*, *6*(1), 11–16, 2002b.

Franks, S. W., and G. Kuczera, Flood frequency analysis: Evidence and implications of secular climate variability, *Water Resour. Res.*, *38*(5), doi:10.1029/2001WR000232, 2002.

Hogg, R. V., and E. A. Tanis, *Probability and Statistical Inference*, 3rd Edition, Macmillan Publ., New York, 1988.

Kiem, A. S., and S. W. Franks, On the identification of ENSO-induced rainfall and runoff variability: a comparison of methods and indices, *Hydrol. Sci. J.*, *46*(5), 715–728, 2001.

Kiem, A. S., and S. W. Franks, Multi-decadal variability of drought risk, *Hydrol. Proc.* (*in review*), 2002.

Kuczera, G., Comprehensive at-site flood frequency analysis using Monte Carlo Bayesian inference, *Water Resour. Res.*, *35*(5), 1551–1558, 1999.

Latif, M., and T. P. Barnett, Causes of decadal climate variability over the North Pacific and North America, *Science*, *266*, 634–637, 1994.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis, A Pacific Interdecadal Climate Oscillation With Impacts On Salmon Production, *Bull. Amer. Meteorol. Soc.*, *78*(6), 1069–1079, 1997.

Power, S., T. Casey, C. Folland, A. Colman, and V. Mehta, Inter-decadal modulation of the impact of ENSO on Australia, *Climate Dynamics*, *15*, 319–324, 1999.

Power, S., F. Tseitkin, S. Torok, B. Lavery, R. Dahni, and B. McAvaney, Australian Temperature, Australian Rainfall and the Southern Oscillation, 1910–1992 - Coherent Variability and Recent Changes, *Aust. Met. Mag.*, *47*, 85–101, 1998.

Reid, G. C., Solar variability and the Earth's climate: Introduction and overview, *Space Sci. Rev.*, *94*, 1–11, 2000.

White, W. B., J. Lean, D. R. Cayan, and M. D. Dettinger, Response of global upper ocean temperature to changing solar irradiance, *J. Geophys. Res.*, *102*, 3255–3266, 1997.

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