Appendix U

Climate Change Assessment

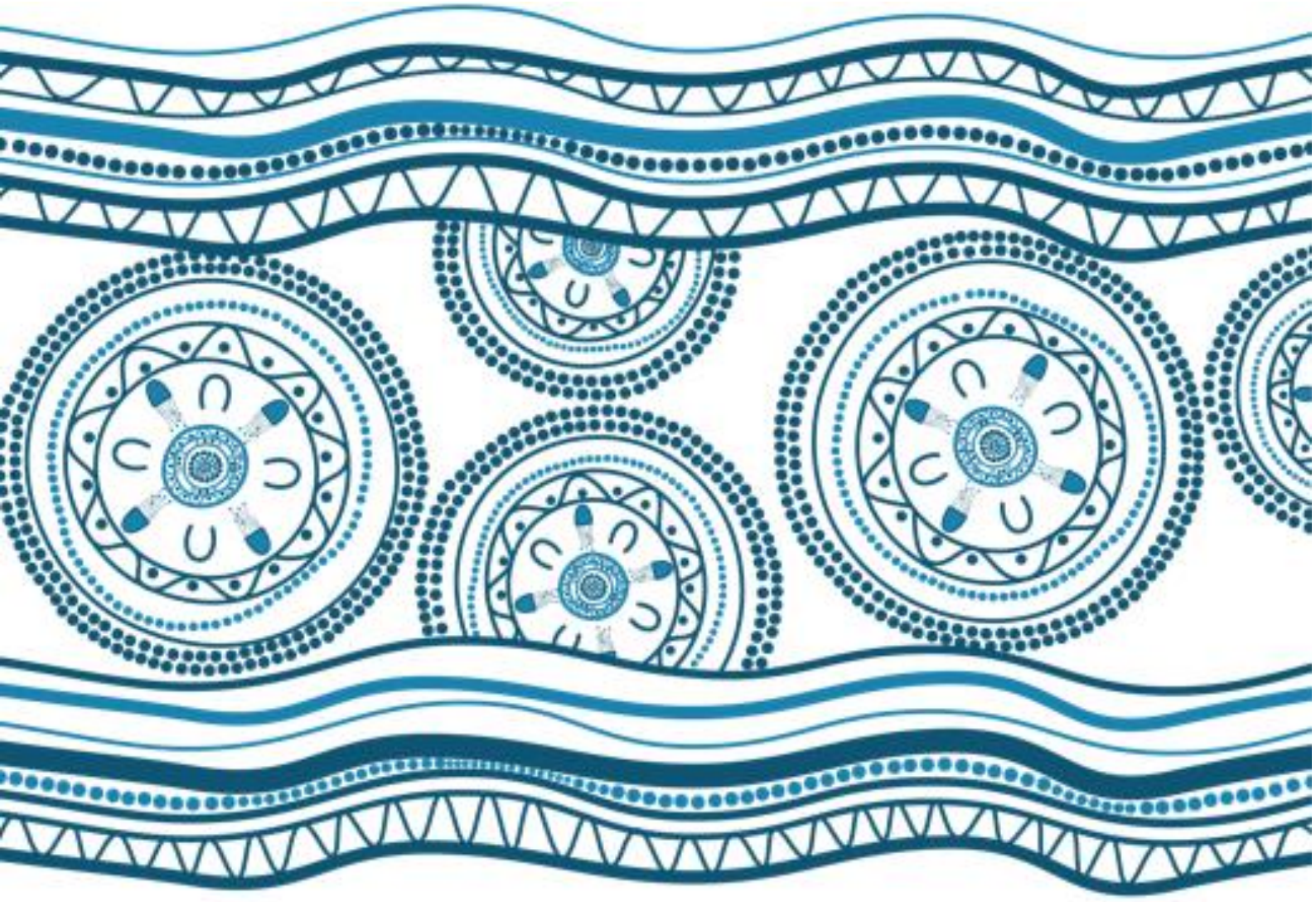

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Table 1 provides the results of a climate change risk assessment workshop that was carried out for the Kamay Ferry Wharves Project on 6 August 2020 (refer to Chapter 19 (Climate change) of the EIS for details about the methodology for this workshop).

Table 1: Climate change risk assessment workshop results

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
Cuttings, embankments, retaining walls (connection of wharves on land)									
Increased annual average rainfall	Erosion / degradation of supporting / surrounding soil structures	Unlikely (L4)	Minor (C5)	D – Low					
	Increase loading on retaining structures	Unlikely (L4)	Minor (C5)	D – Low					
Increased extreme rainfall events and flooding	Landslides, slope failures and embarkment instability / failure	Unlikely (L4)	Minor (C5)	D – Low					
	Increased erosion	Unlikely (L4)	Minor (C5)	D – Low					
	Stress and damage to retaining walls	Unlikely (L4)	Minor (C5)	D – Low					
Increased annual mean temperature	Increased stress and deterioration of materials (eg cracks)	Unlikely (L4)	Minor (C5)	D – Low					
	Erosion / degradation of supporting / surrounding soil structures	Unlikely (L4)	Minor (C5)	D – Low					
Increased extreme temperature	Increased stress and deterioration of materials (eg cracking)	Unlikely (L4)	Minor (C5)	D – Low					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
events (number of hot days over 35ºC)	Erosion / degradation of supporting / surrounding soil structures	Unlikely (L4)	Minor (C5)	D – Low					
Storms and strong winds	Increased stress and deterioration of materials (eg cracking)	Likely (L3)	Minor (C5)	C – Medium					
	Inundation of low-lying areas, erosion and effects on coastal defences	Likely (L3)	Minor (C5)	C – Medium					
Sea level rise	Increased stress and deterioration of materials (eg cracking)	Likely (L3)	Minor (C5)	C – Medium					
	Inundation of low-lying areas, erosion and effects on coastal defences / abatement / seawalls	Likely (L3)	Minor (C5)	C - Medium					
Bushfires	Direct heat and fire damage to support infrastructure	Unlikely (L4)	Minor (C5)	D – Low					
Ferry wharves (landing freeboard, wharf approach levels, pile depths)									
Increased annual average rainfall	Erosion / degradation of supporting / surrounding soil structures	Unlikely (L4)	Minor (C5)	D – Low					
	Impact on users and staff comfort during operations	Likely (L3)	Moderate (C4)	C - Medium					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
Increased extreme rainfall events and flooding	Increased stress and deterioration of materials (eg cracking)	Unlikely (L4)	Minor (C5)	D – Low					
	Increased risk of slips and falls for passengers along concrete jetty and entranceways	Very likely (L2)	Severe (C2)	A -Very high	Concrete slip resistant finish. Mesh flooring slip resistant. Mesh allows water flow through.	Maintenance schedule. Regular water blasting	Very unlikely (L5)	Severe (C2)	C - Medium
	Impact on utilisation of wharves	Very likely (L2)	Minor (C5)	C – Medium					
Annual increased mean temperature	Impact on structural integrity associated with movement at expansion joints due to extreme temperatures	Unlikely (L4)	Moderate (C4)	C – Medium					
Increased extreme temperature events (number of hot days over 35ºC)	Reduction of structural integrity as a result of temperature stress on materials	Unlikely (L4)	Moderate (C4)	C - Medium					
	Impact on users and staff comfort during operations	Very likely (L2)	Severe (C2)	A -Very high	Waiting area roofing. Wind or weather protection over jetty lengths.	-	Very likely (L2)	Severe (C2)	C - Medium

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
					Retention of existing shelter at Kurnell.				
	Impact on utilisation of wharves	Very likely (L2)	Minor (C5)	C – Medium					
Storms and strong winds	Increased maintenance requirements	Likely (L3)	Minor (C5)	C - Medium					
	An increase in erosion of shorelines and damage to near shore assets	Very likely (L2)	Severe (C2)	A -Very high	Shoreline protection is out of scope	Geotech considerations at detailed design.	Very unlikely (L5)	Severe (C2)	C - Medium
	Impact to substations, electronic and communication systems and other equipment vulnerable to storm and lightning damage impacting energy supply, communications and emergency response management etc	Likely (L3)	Moderate (C4)	C - Medium					
	Passenger comfort and safety	Likely (L3)	Major (C3)	B - High	Sheltered waiting area, seating, non-slip surfaces and handrails	Maintenance schedule	Unlikely (L4)	Major (C3)	C - Medium
	Localised storm surge and impacts of associated water elevation	Likely (L3)	Minor (C5)	C - Medium					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
	Damage to infrastructure (flooring, substructure, roofing)	Very likely (L2)	Major (C3)	B - High	Sea level rise (RCP8.5) and increased wave heights considered in wharf design. Fibreglass reinforced plastic mesh deck. Substructure is marine grade coated steel (epoxy coating).	Roof structure wind impact to be assessment	Unlikely (L4)	Major (C3)	C - Medium
	Damage to secondary infrastructure (balustrades, signage/information boards)	Very likely (L2)	Moderate (C4)	B - High	Stainless steel used. Secondary elements designed for easy replacement.	Replacement if necessary.	Unlikely (L4)	Moderate (C4)	C - Medium
Sea level rise	Damage to infrastructure (due to increased water levels and wave heights)	Very likely (L2)	Severe (C2)	A -Very high	Sea level rise (RCP8.5) and increased wave heights considered in wharf design	Designed for deconstruction	Very unlikely (L5)	Severe (C2)	C - Medium
	Limit access to wharves (staff, customers and also maintenance/repairs)	Likely (L3)	Minor (C5)	C - Medium					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
	Erosion and effects on coastal defences	Likely (L3)	Minor (C5)	C - Medium					
	Increased swell and wave action at wharves with increased water depths exacerbating erosion and other impacts	Very likely (L2)	Severe (C2)	A – Very high	Sea level rise (RCP 8.5) and increased wave heights considered in wharf design	Deck level consideration for wave load.	Very unlikely (L5)	Severe (C2)	C - Medium
	Change in daily tidal levels affecting operability of fixed boarding levels	Likely (L3)	Moderate (C4)	C – Medium					
	Structure exposed to increased levels of chloride attack on concrete	Likely (L3)	Moderate (C4)	C – Medium					
	Wave overtopping	Likely (L3)	Moderate (C4)	C – Medium					
	Coastal & tidal inundation	Likely (L3)	Moderate (C4)	C – Medium					
Bushfires	Direct heat and fire damage to supporting infrastructure	Unlikely (L4)	Moderate (C4)	C – Medium					
	Limited access to the wharves, in particular Kurnell due to restrictions to Kurnell	Unlikely (L4)	Moderate (C4)	C - Medium					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
	Botany Bay National Park								
Increased CO_2	Ocean acidification and the effects on vessels and infrastructure	Unlikely (L4)	Moderate (C4)	C - Medium					
	Increased risk of carbonation (concrete cracking)	Likely (L3)	Major (C3)	B - High	Preliminary durability assessment taken.	Review concrete mix and do carbonation modelling for concrete mix.	Unlikely (L4)	Major (C3)	C - Medium
Ferry services									
Increased extreme rainfall events and flooding	Cancelled services due to safety	Unlikely (L4)	Moderate (C4)	C – Medium					
	Passenger health and safety	Likely (L3)	Moderate (C4)	C – Medium					
	Safety and wellbeing of maintenance workers at risk due to increased infrastructure instability.	Likely (L3)	Moderate (C4)	C – Medium					
	Increased size and quantity of debris in water	Likely (L3)	Minor (C5)	C – Medium					
Increased annual mean temperature	Safety and wellbeing of employees and maintenance workers	Likely (L3)	Moderate (C4)	C – Medium					
	Safety and wellbeing of passengers	Likely (L3)	Moderate (C4)	C - Medium					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
Increased extreme temperature events (number of hot days over 35ºC)	Safety and wellbeing of employees and maintenance workers	Likely (L3)	Major (C3)	B - High		Vessels will have internal seating, so staff can operate vessels without being exposed to continuous outdoor heat. Additional mitigation measures may be developed by Operator.	Very unlikely (L5)	Major (C3)	C - Medium
	Passenger health, comfort and safety e.g. dehydration, heat stroke	Likely (L3)	Major (C3)	B - High		Vessels will have internal seating, so passengers can travel without being exposed to continuous outdoor heat. Additional mitigation measures may be developed by Operator.	Very unlikely (L5)	Major (C3)	C - Medium
Storms and strong winds	Cancelled services due to passenger comfort and safety during crossing	Likely (L3)	Moderate (C4)	C - Medium					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
	Delays, cancellations & reliability implications to network due to speed restrictions	Likely (L3)	Minor (C5)	C - Medium					
	Decreased visibility for ferry drivers as a result of extreme weather events impacting operations including services and journey time	Likely (L3)	Minor (C5)	C - Medium					
	Increased navigational safety risk with other vessels	Very unlikely (L5)	Moderate (C4)	D – Low					
	Impacting the ability to berth vessels and utilise wharves	Likely (L3)	Major (C3)	B - High	Berth orientated to face predominate wave direction. Modelling undertaken (Baird) showed that passenger comfort will be governed by crossing (not at berth).	Operator procurement specification. Design accounts for this with different landings. If sea level rise is great, the number of landing decreases.	Unlikely (L4)	Severe (C2)	C - Medium

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
					End user requirements: useable 90-95% of time. Specialist modelling has been undertaken which showed that passenger comfort is governed by crossing. Fixed structure levels have been set to be suitable for current and future sea level rise levels	Appropriate fenders and mooring points			
Sea level rise	Increased maintenance requirements including frequency of maintenance and cost as a result of sea level rise	Likely (L3)	Moderate (C4)	C – Medium					
	Cumulative impacts and increased exposure of assets to storms and	Likely (L3)	Moderate (C4)	C - Medium					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
	strong winds as sea level rises								
Bushfires	Delays or cancellations due to bushfires	Unlikely (L4)	Moderate (C4)	C – Medium					
	Delays and cancellations due to bushfires or bushfire warnings	Unlikely (L4)	Moderate (C4)	C - Medium					
	Decreased visibility for ferry drivers as a result of bushfire smoke	Unlikely (L4)	Minor (C5)	D – Low					
Surface drainage									
Increased annual average rainfall	Damage to drainage infrastructure due to an increase in erosion of shorelines and damage to near shore assets	Unlikely (L4)	Minor (C5)	D – Low					
Increased extreme rainfall events and flooding	Storm water drain inundation leading to increased pressures on drainage capacity and impacting operations	Likely (L3)	Moderate (C4)	C – Medium					
	Local flooding	Likely (L3)	Moderate (C4)	C – Medium					
Increased annual mean temperature	Damage to infrastructure and associated leakage as a result of stress on drainage infrastructure	Very likely (L2)	Minor (C5)	C - Medium					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
Increased extreme temperature events (number of hot days over 35°C)	Damage to infrastructure and associated leakage as a result of stress on drainage infrastructure	Very likely (L2)	Minor (C5)	C - Medium					
Storms and strong winds	Damage to drainage infrastructure due to an increase in erosion of shorelines and damage to near shore assets	Unlikely (L4)	Minor (C5)	D – Low					
	Local flooding	Likely (L3)	Moderate (C4)	C - Medium					
Sea level rise	Damage to drainage infrastructure	Unlikely (L4)	Minor (C5)	D – Low					
	Local flooding	Likely (L3)	Moderate (C4)	C - Medium					
Bushfires	Direct heat and fire damage to supporting infrastructure	Unlikely (L4)	Moderate (C4)	C - Medium					
Utilities (power supply; telecommunications; sewer; water)									
Increased extreme rainfall events and flooding	Damage to power supply infrastructure, service disruption and safety risk.	Likely (L3)	Moderate (C4)	C - Medium					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
Increased annual mean temperature	Overload and/or interruption to mains power impacting service provision and the customer experience e.g. signal failure and/or reduced functionality	Unlikely (L4)	Minor (C5)	D – Low					
	Degradation of wiring	Unlikely (L4)	Minor (C5)	D – Low					
Increased extreme temperature events (number of hot days over 35°C)	Overload and/or interruption to mains power impacting service provision and the customer experience e.g. signal failure and/or reduced functionality	Unlikely (L4)	Minor (C5)	D – Low					
	Degradation of wiring	Unlikely (L4)	Minor (C5)	D – Low					
	Decrease in efficiency and heat related damage.	Unlikely (L4)	Minor (C5)	D – Low					
Storms and strong winds	Potential damage to power supply system	Likely (L3)	Moderate (C4)	C – Medium					
	An increase in erosion of shorelines and damage to near shore assets	Likely (L3)	Moderate (C4)	C – Medium					
	Impact to substations, electronic and	Unlikely (L4)	Moderate (C4)	C - Medium					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
	communication systems and other equipment vulnerable to storm and lightning damage impacting energy supply, communications and emergency response management etc								
	An increase in frequency of extreme wind above thresholds known to correspond to damage to assets, electricity network and overhead cables (usually from flying debris)resulting in asset damage and power failure	Unlikely (L4)	Moderate (C4)	C – Medium					
Sea level rise	Potential damage to power supply system due to inundation	Likely (L3)	Moderate (C4)	C – Medium					
Bushfires	Direct heat and fire damage to supporting infrastructure	Unlikely (L4)	Moderate (C4)	C - Medium					
Signage									

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
Increased extreme rainfall events and flooding	Increased flood risk and damage to electrical and ancillary infrastructure.	Unlikely (L4)	Minor (C5)	D – Low					
	Impact comms and power resulting in increased cost to cover repair and durability	Unlikely (L4)	Minor (C5)	D – Low					
Increased annual mean temperature	Extreme temperatures could cause damage and the faster deterioration of materials	Unlikely (L4)	Minor (C5)	D – Low					
Increased extreme temperature events (number of hot days over 35°C)	Heat related damage and material deterioration would have variable impacts on the reliability, functionality and speed of signalling and communication equipment.	Unlikely (L4)	Minor (C5)	D – Low					
	Increase in maintenance frequency and operating costs due to number of hot days cracking	Unlikely (L4)	Minor (C5)	D – Low					
	People burning themselves on hot metallic infrastructure	Unlikely (L4)	Minor (C5)	D – Low					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
Storms and strong winds	Impact to substations, electronic and communication systems and other equipment vulnerable to storm and lightning damage impacting energy supply, communications and emergency response management etc	Unlikely (L4)	Minor (C5)	D – Low					
	An increase in frequency of extreme wind above thresholds known to correspond to damage to assets, electricity network and overhead cables (usually from flying debris)resulting in asset damage and power failure	Unlikely (L4)	Minor (C5)	D – Low					
	Damage to comms and power supply	Unlikely (L4)	Minor (C5)	D – Low					
Bushfires	Direct heat and fire damage to supporting infrastructure	Unlikely (L4)	Minor (C5)	D – Low					
Soft landscaping									

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
Increased annual average rainfall	Increased maintenance requirements	Likely (L3)	Moderate (C4)	C - Medium					
Increased extreme rainfall events and flooding	The projected periodic extreme hot, dry and wet periods would increase the potential for damage to landscaping features and plantings	Likely (L3)	Moderate (C4)	C - Medium					
	Impact to water sensitive urban design	Likely (L3)	Moderate (C4)	C - Medium					
	Erosion	Likely (L3)	Moderate (C4)	C - Medium					
Increased annual mean temperature	Increased watering / maintenance requirements	Likely (L3)	Minor (C5)	C – Medium					
Increased extreme temperature events (number of hot days over 35°C)	Increased evidence of dry limbs becoming a hazard to assets, materials and public / staff safety	Likely (L3)	Moderate (C4)	C - Medium					
	Side plants that are more exposed to heat than centrally planted ones overheat (edge effect) and die	Likely (L3)	Moderate (C4)	C - Medium					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
	Increase in maintenance / replacement costs, including limitation in water access / supply	Likely (L3)	Minor (C5)	C - Medium					
	Reduced human comfort at wharves and therefore reduced amenity and risk of health impacts	Unlikely (L4)	Moderate (C4)	C - Medium					
Storms and strong winds	Damage and erosion of soft landscaping	Likely (L3)	Moderate (C4)	C - Medium					
Sea level rise	Damage and inundation to soft landscaping	Unlikely (L4)	Moderate (C4)	C - Medium					
	Salinity levels	Unlikely (L4)	Moderate (C4)	C - Medium					
Bushfires	Dry vegetation increasing the bushfire safety risk	Likely (L3)	Moderate (C4)	C - Medium					
Waterside approach and surrounds (sediments, depths and siltation)									
Increased annual average rainfall	Increased size and quantity of debris in water	Unlikely (L4)	Minor (C5)	D – Low					
Increased extreme rainfall events and flooding	Increased size and quantity of debris in water	Likely (L3)	Minor (C5)	C - Medium					
	Altered sediment transportation and movement	Unlikely (L4)	Minor (C5)	D – Low					

Climate variable	Potential climate change impact	Likelihood	Consequence	Risk rating	Existing mitigation measures	Potential mitigation measures	Mitigated likelihood	Mitigated consequence	Residual risk
Storms and strong winds	Altered sediment transport and sedimentation / accumulation	Likely (L3)	Major (C3)	B - High	Study on sediment movement at Kurnell (Cardno Assessment). Minimal ling shore sand movement	Appropriate monitoring during asset life to assess changes.	Unlikely (L4)	Major (C3)	C - Medium
	Surrounding area buffer zone for ferry mooring, approach and potential failure of mooring	Likely (L3)	Moderate (C4)	C - Medium					
Sea level rise	Increased erosion and elevation of sediment scour	Unlikely (L4)	Minor (C5)	D – Low					