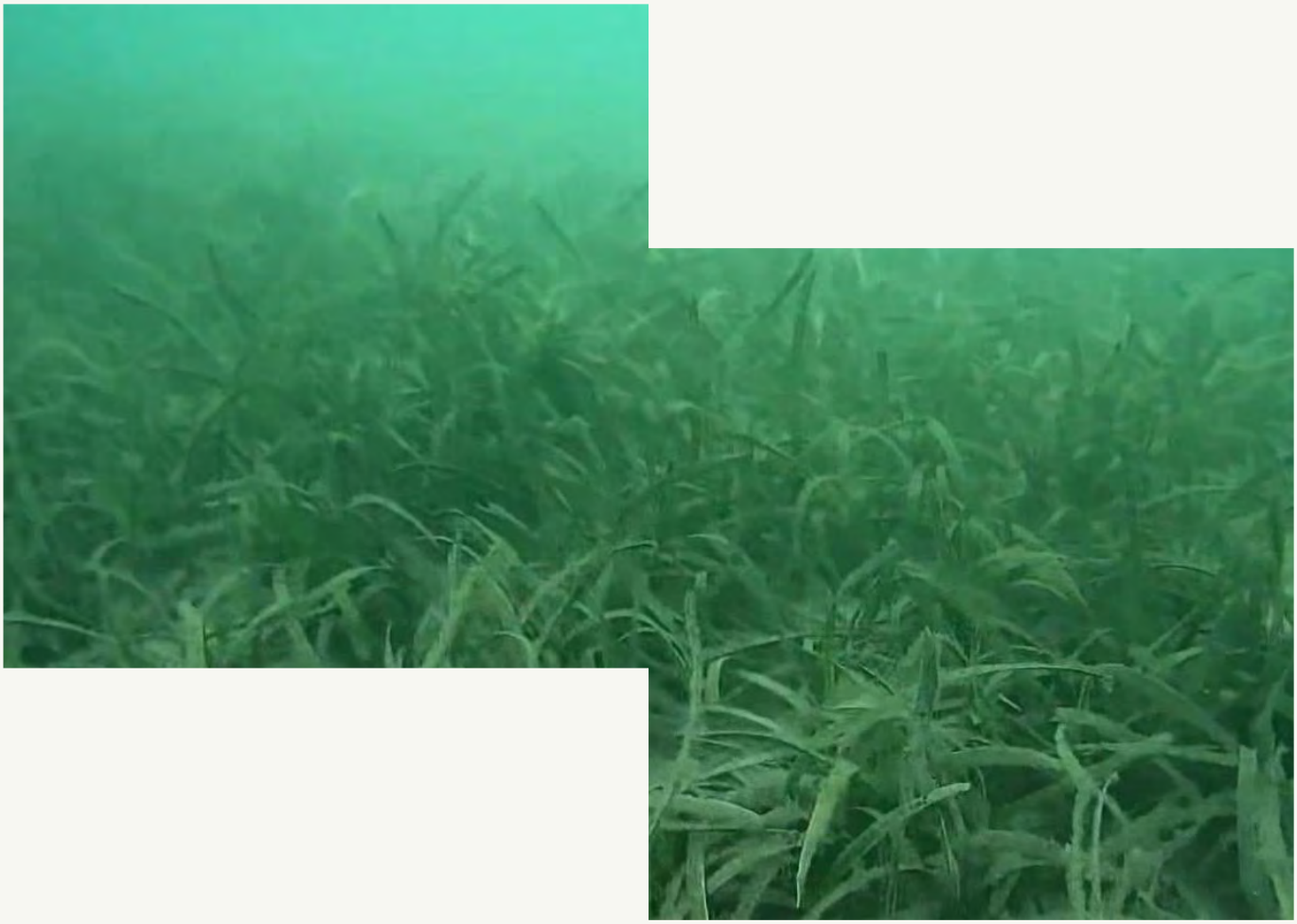

Kamay Ferry Wharves Seagrass Monitoring Program

Construction Monitoring Survey 2 – technical memo

Prepared for Transport for NSW | 29/12/2024

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Document control

Project number	Client	Project manager	LGA
8236	Transport for NSW	Luke Stone	Randwick/Sutherland

Version	Author	Review	Status	Date
D1	Alan Davies Luke Stone	Dr David Cummings	Draft 1	09/10/2024
R1	Luke Stone Dr David Cummings	-	Version 1	11/10/2024
R2	Luke Stone Dr David Cummings	-	Version 2	22/10/2024
R3	Luke Stone	Dr David Cummings	Final	29/11/2024

Glossary and list of abbreviations

Term or abbreviation	Definition
Baseline Surveys	The four Baseline Surveys completed as part of the Kamay Ferry Wharves seagrass pre-construction phase of the Seagrass Monitoring Program
Buffer Area	Temporary construction footprint comprising a 15 metre buffer around the Construction Footprint (permanent)
Construction Survey 1	The first seagrass survey during the construction phase of the Project (summer 2023/24)
Construction Footprint	Permanent construction footprint for the wharf structures
DPIRD	The NSW Department of Primary Industries and Regional Development
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
EIS	Environmental Impact Statement
FM Act	*Fisheries Management Act 1994* (NSW)
Halophila	Seagrass species from the genus *Halophila*, predominantly *Halophila ovalis* but may also include *Halophila decipiens*
IPR	Implementation Reference Panel
MBOS	Marine Biodiversity Offset Strategy
Monitoring sites	Monitoring sites established as part of the Kamay Ferry Wharves seagrass pre-construction phase of the Seagrass Monitoring Program
Niche	Niche Environment and Heritage Pty Ltd
Posidonia	The seagrass species *Posidonia australis*
Potential impact sites	Sites that are monitored to detect potential impacts associated with the project, including sites within the Project Boundary (excluding HZ-K07) and sites within the Buffer Area.

Term or abbreviation	Definition
Potential impact, possible reference sites	Refers to sites that are monitored to detect gradient effects as a result of indirect disturbances during construction on the wider seagrass community (potential impact) but are located outside the Project Boundary (possible reference).
Project	The reinstatement of the ferry wharves at La Perouse and Kurnell in Botany Bay
Project Boundary	Project area as delineated by Transport for New South Wales
Reference sites	Reference sites are identified within the Seagrass Monitoring Program to compare against trends or patterns identified among the potential impact sites. Includes sites within or outside of the Survey Area, and HZ-K07 which is located at the border of the Project Boundary and Survey Area and is considered unlikely to be impacted. As it cannot be established that the reference sites are free from any other sources of impact or stressors, other than the project construction, they cannot be considered 'control' sites. Reference sites are identified within the Seagrass Monitoring Program to compare against trends or patterns identified among the potential impact sites. As it cannot be established that the reference sites are free from any other sources of impact or stressors, other than the project construction, they cannot be considered 'control' sites.
Seagrass Monitoring Program	The Kamay Ferry Wharves seagrass monitoring program
Survey Area	Survey area for the current assessment, incorporating subtidal areas of seagrass habitat within 50-100 metres of the Project Boundary
Shoot (seagrass)	A shoot is considered the section of seagrass from the sheath up and may consist of one or various leaves
TfNSW	Transport for New South Wales
Zostera	The seagrass species *Zostera muelleri*

Table of Contents

1 Introduction

1.1 Project background

Transport for New South Wales (TfNSW) commenced construction of the ferry wharves at La Perouse and Kurnell in Botany Bay (the Project) in mid 2023. The Project was classified State Significant Infrastructure (SSI) under the NSW Planning Framework and is a controlled action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (EPBC Act referral 2020/8825).

The Environmental Impact Statement (EIS) (TfNSW 2021) identified the need for establishment of a Seagrass Monitoring Program that includes Baseline Surveys and is designed to determine construction and operational impacts associated with the Project.

A Marine Biodiversity Assessment Report was prepared as part of the EIS (TfNSW 2021). This report identified that the Project would result in impact to seagrasses, including the *Posidonia australis* (*Posidonia*) population in Botany Bay, listed as an Endangered Population under the *Fisheries Management Act 1994* (FM Act). Impacts on seagrasses will include some direct losses of seagrass within the permanent Construction Footprint and associated temporary 15 metre buffer (Buffer Area) from shading, along with disturbances during construction works and ongoing operation of the wharves and ferries (TfNSW 2021). In addition, a large and significant bed of *Posidonia* seagrass located adjacent to and beyond the Project Boundary at Kurnell is considered of ecological significance to the population in Botany Bay.

1.2 Seagrass Monitoring Program

The purpose of the Seagrass Monitoring Program is to identify any large-scale changes in seagrass composition and areal extent within the Project Boundary and monitor for any changes in the adjacent large bed of *Posidonia* at Kurnell during construction and operation that may be attributable to the Project.

The Seagrass Monitoring Program has been developed to align with the requirements identified within the Marine Biodiversity Offset Strategy (TfNSW 2023, Rev 4) and includes four survey approaches (Table 1).

The Project Boundary for the monitoring surveys encompasses the Construction Footprints and Buffer Areas at Kurnell and La Perouse, as well as a broader area including the known seagrass areal extents in proximity to the Project works and planned operations (Figure 1 and Figure 2).

The Seagrass Monitoring Program to date has included four Baseline Surveys over two years, to establish a sufficient baseline to determine construction and operational impacts (Niche 2023).

This technical memo presents the outcomes of the second seagrass monitoring survey in the Construction phase of the Project ('Construction Survey 2'), completed in winter 2024.

1.3 Project works summary

Key construction activities during winter 2024 included:

- Completion of Piling Works (Install, Adjustments & spoil removal)
- Installation of Berthing Structure Headstocks & Modules
- Concreting of piles
- Installation of pre-cast concrete deck planks
- Installation of in situ Concrete Deck Pours
- Local movement of barges around the site to facilitate the above works

1.4 Aim

The aim of this report is to provide a concise presentation of data collected in this round of monitoring and identify acute indicators of ecological change that may require further investigation or assessment, if any.

The scope of the technical memo is to provide an update on survey results from Construction Survey 2 and is not designed to be a standalone scientific report.

A post construction monitoring report will be prepared following the final Construction survey, which will include analysis of the two Construction surveys and assess changes in the seagrass from the pre-construction monitoring, including consideration of performance indicators recommended in Niche (2023).

Figure 1

Survey Sites and Habitat Mapping Winter 2024 La Perouse

Kamay Ferry seagrass monitoring

Niche PM: Luke Stone
Niche Proj. #: 8236
Client: Transport for NSW

Figure 2

Survey Sites and Habitat Mapping Winter 2024 Kurnell

Kamay Ferry seagrass monitoring

Niche PM: Luke Stone
Niche Proj. #: 8236
Client: Transport for NSW

2 Methods summary

2.1 Overview

Four types/extents of survey area relative to the construction works are defined within the overall area covered by the Seagrass Monitoring Program (Figure 1 and Figure 2) to inform the assessment, as detailed in Table 2.

The Seagrass Monitoring Program is based on the completion of biannual (twice per year) field surveys (two total) during the winter and summer seasons. Each Seagrass Monitoring Program survey is typically undertaken over a period of six to eight weeks depending on the suitability of weather conditions. Surveys completed as part of the Seagrass Monitoring Program and previous habitat and targeted surveys associated with the EIS completed to date, are summarised in Table 3.

The Construction Survey 2 was completed throughout July 2024 and August 2024. Dates for each survey method undertaken are listed in Table 4.

Table 1 Seagrass Monitoring Program survey approaches

Survey	Summary
Seagrass mapping	Seagrass areal extent mapping of seagrass composition and density within the Survey Area
Drop camera surveys	Collection of photo quadrats from within *Halophila* and *Zostera* seagrass beds for quantitative analysis of seagrass composition and density
Posidonia bed monitoring	Diver-based quadrat surveys of seagrass morphology (composition, biomass and condition) in *Posidonia* beds (typically >100 m^2)
Posidonia patch monitoring	Seagrass morphology surveys of smaller *Posidonia* patches (typically <100 m^2).

Table 2 Seagrass Monitoring Program survey area extents

Area	Description
Construction Footprint	Permanent construction footprint for the wharf structures and is the primary area of anticipated direct impacts to seagrass. Direct impacts occurring within the Construction Footprint are likely to be permanent, due to the nature of the structures.
Buffer Area	Temporary construction footprint comprising a 15 m buffer around the Construction Footprint. Direct impacts to seagrass may occur within this area during construction, however no permanent structures will remain post-construction.
Project Boundary	Refers to the Project area as delineated by TfNSW.

Area	Description
Survey Area	Refers to the area of survey for the current assessment, incorporating subtidal areas of seagrass habitat within 50-100 metres of the Project Boundary and including the Construction Footprint and Buffer Area.

Table 3 Seagrass Monitoring Program and previous EIS survey to date

Survey	Season	Survey dates	Reference
EIS survey			
EIS	Winter 2020	June 2020	(Niche 2020a)
EIS	Winter 2020	August – September 2020	(Niche 2020b)
EIS	Summer 2020	December 2020	(Niche 2021b)
Baseline survey (pre-construction)			
Baseline 1	Winter 2021	July – September 2021	Niche (2021a)
Baseline 2	Summer 2022	February – April 2022	Niche (2022a)
Baseline 3	Winter 2022	July – August 2022	Niche (2022b)
Baseline 4	Summer 2022/23	December 2022	Niche (2023)
Construction survey			
Construction 1	Summer 2023/24	December 2023 – February 2024	Niche (2024)
Construction 2	Winter 2024	July -August 2024	This report

Table 4 Construction Survey 2 (winter 2024): seagrass monitoring survey dates

Methodology	Survey date Kurnell	Survey date La Perouse
Seagrass mapping	15/08/2024 and 27/08/2024	22/ 08/2024 and 27/08/2024
Drop camera surveys	07/07/2024	07/07/2024

Methodology	Survey date Kurnell	Survey date La Perouse
Posidonia Bed Monitoring	10/07/2024	11/07/2024
Posidonia Patch Monitoring		

Additional dive surveys and inspections associated with impact observations and rehabilitation works have been completed following the winter (Construction Survey 2) monitoring surveys, with the results of these assessments reported separately (H2O Consulting Group 2024a,b,c,d,e). The results of these separate assessments have been incorporated into the mapping presented in this technical memo. An overview of the findings are also summarised, as relevant to the Seagrass Monitoring Program.

2.2 Field survey methods

The Construction 2 field survey methods are the same as those employed in previous iterations of the Seagrass Monitoring Program during Baseline Surveys and are detailed in Niche (2023). Specific field methods are not repeated in detail in this technical memo.

2.3 Monitoring sites

Monitoring sites are shown for La Perouse in Figure 1, and for Kurnell in Figure 2. All sites are consistent with those applied in Baseline Surveys of the Seagrass Monitoring Program (Table 5), with the exception of *Posidonia* patches within the Buffer Area, which have since been removed and transplanted to new locations (PP-K04, PP-K08, PP-K09, PP-K11).

Table 5 Monitoring sites

Site	Location	Area	Status	Easting (GDA94 MGA56)	Northing (GDA94 MGA56)	Status
Halophila / Zostera monitoring (drop camera)						
HZ-LP01	La Perouse	Project Boundary	Potential impact	336429.98	6237907.4	Current
HZ-LP02	La Perouse	Project Boundary	Potential impact	336516.36	6237871.92	Current
HZ-LP03	La Perouse	Survey Area	Reference	336438.35	6238037.7	Current
HZ-LP04	La Perouse	Survey Area	Reference	336317.97	6238009.92	Current

Site	Location	Area	Status	Easting (GDA94 MGA56)	Northing (GDA94 MGA56)	Status
HZ-K05	Kurnell	Project Boundary	Potential impact	335274.25	6236137.09	Current
HZ-K06	Kurnell	Project Boundary	Potential impact	335344.73	6236180.62	Current
HZ-K07	Kurnell	Project Boundary	Reference	335437.75	6236230.96	Current
HZ-K08	Kurnell	Survey Area	Reference	335164.51	6236149.72	Current
HZ-K09	Kurnell	Project Boundary	Potential impact	335310.06	6236050.64	Current
HZ-K10	Kurnell	Project Boundary	Potential impact	335383.27	6236105.94	Current
Posidonia bed monitoring						
PB-K01	Kurnell	Project Boundary	Potential impact	335263.13	6236095.86	Current
PB-K02	Kurnell	Survey Area	Potential impact, possible reference*	335234.62	6236085.28	Current
PB-K03	Kurnell	Survey Area	Potential impact, possible reference*	335189.91	6236071.11	Current
PB-K04	Kurnell	Outside Survey Area	Reference	335127.2	6236041.22	Current
PB-K05	Kurnell	Survey Area	Potential impact, possible reference*	335315.43	6236006.55	Current

Site	Location	Area	Status	Easting (GDA94 MGA56)	Northing (GDA94 MGA56)	Status
PB-K06	Kurnell	Survey Area	Potential impact, possible reference*	335287.92	6235986.41	Current
PB-K07	Kurnell	Survey Area	Potential impact, possible reference*	335250.49	6235967.27	Current
PB-K08	Kurnell	Outside Survey Area	Reference	335173.89	6235927.58	Current
PB-K09	Kurnell	Project Boundary	Potential impact	335326.24	6236087.61	Current
PB-K10	Kurnell	Project Boundary	Potential impact	335417.71	6236193.76	Current
PB-LP11	La Perouse	Project Boundary	Potential impact	336545.65	6237861.53	Current
PB-LP12	La Perouse	Survey Area	Reference	336578.02	6238082.55	Current
Posidonia patch monitoring						
PP-LP01	La Perouse	Project Boundary	Potential impact	336506.15	6237863.79	Current
PP-LP02	La Perouse	Project Boundary	Potential impact	336533.9	6237847.83	Current
PP-K03	Kurnell	Project Boundary	Potential impact	335367.57	6236122.05	Current
PP-K04	Kurnell	Buffer Area	Potential impact	335346.18	6236109.77	Transplanted
PP-K07	Kurnell	Project Boundary	Potential impact	335340.22	6236069.58	Current

Site	Location	Area	Status	Easting (GDA94 MGA56)	Northing (GDA94 MGA56)	Status
PP-K08	Kurnell	Buffer Area	Potential impact	335355.6	6236062.17	Transplanted
PP-K09	Kurnell	Buffer Area	Potential impact	335366.1	6236071.99	Transplanted
PP-K11	Kurnell	Buffer Area	Potential impact	335370.57	6236060.62	Transplanted

2.4 Limitations to the Seagrass Monitoring Program

The following limitations have been identified for the Seagrass Monitoring Program:

- Seagrass mapping is subject to the accuracy of the GPS-enabled equipment utilised during the surveys (typically ± 5 metres) and dependent on the limitations of aerial photo rectification and registration, which is also limited to the resolution and clarity of the most recent imagery available.
- The construction phase of the Seagrass Monitoring Program defined by TfNSW has not included a winter (June – August 2023) monitoring survey, which would have aligned with the seasonal definition of the Seagrass Monitoring Program and commencement of construction works. This may limit the confidence in attributing potential indicators of impacts during construction works and limit the effectiveness in early detection of any impacts.
- Seagrass area calculations presented in this report are based upon the GDA2020 MGA56 coordinate system. Therefore, there may be minor discrepancies between areas presented in this report and those in Baseline 1, 2 and Construction 1 (Niche 2022a, 2022b), which are based upon the GDA94 MGA56 coordinate system. The area calculations presented in the Baseline 4 report (Niche 2023) should be considered to be the most accurate and up to date presentation of Baseline results.

These factors notwithstanding, the methods of data collection and analysis are considered to be comprehensive and in accordance with the aims of the Seagrass Monitoring Program.

3 Results

3.1 Weather conditions

A significant weather event including powerful easterly swells occurred in April 2024, between Construction 1 and 2 surveys. Transport for NSW reported observations of seagrass wrack on the shoreline at Kurnell following this event.

During the Construction 2 survey period a very large easterly swell occurred between July 28 and 31, resulting in significant waves entering Botany Bay, which wrapped around La Perouse and generated refraction of the Port Botany Breakwater. This resulted in higher than usual wave activity and influence within the Kamay Ferry Project Area at La Perouse.

At Kurnell in particular, exposure to large easterly swells is considered a major driver of temporal changes in seagrasses within the Project Boundary and the adjacent large *Posidonia* bed to the east (Niche 2022b). The results collected during Construction 2 need to be interpreted with consideration to these weather conditions.

3.2 Seagrass distributions

During the Construction 2 surveys, a combined total of 150,464 m^2 of seagrasses was mapped within the combined Survey Areas, Project Boundaries and Buffer Areas at La Perouse and Kurnell (Table 6, Figure 1, Figure 2).

A total of 2609 m^2 of seagrass were mapped within the 15 m Buffer Area at Kurnell and 73 m^2 at La Perouse. Within the Project Boundaries, a total of 29,430 m^2 seagrass were mapped at Kurnell, and 13,016 m^2 at La Perouse. Outside of the Project Boundaries, an additional 84,432 m^2 of seagrass was mapped within the broader Survey Area at Kurnell, and 20,903 m^2 of seagrass at La Perouse.

The majority of seagrass mapped within the Project Boundaries at La Perouse and Kurnell was comprised of *Halophila* and *Zostera / Halophila* beds (Table 6, Figure 1, Figure 2).

Table 6 Areal extent of seagrass types and unvegetated substrata - Construction Survey 2 within the Survey Area, Project Boundary and Buffer Area.

Area	Kurnell (m^2)	La Perouse (m^2)	Total (m^2)
Survey Area			
Posidonia	11	59	70
Posidonia / Halophila	77	34	111
Posidonia / Zostera	1301	0	1301
Posidonia Mixed	34619	295	34914
Zostera	70	210	281
Zostera / Halophila	22695	9046	31741
Halophila	25659	11258	36917
Rock / Rubble / Reef	24333	10459	34791
Sand or Silt	27185	56307	83491

Area	Kurnell (m^2)	La Perouse (m^2)	Total (m^2)
Project Boundary			
Posidonia	26	6	32
Posidonia / Halophila	-	9	9
Posidonia / Zostera	279	-	279
Posidonia Mixed	4549	89	4638
Zostera	59	43	102
Zostera / Halophila	17379	5813	23191
Halophila	7138	7057	14195
Rock / Rubble / Reef	5880	8337	14216
Sand or Silt	11000	40629	51629
Buffer Area - temporary construction footprint (15 m buffer)*			
Posidonia	-	-	-
Posidonia / Halophila	-	-	-
Posidonia / Zostera	-	-	-
Posidonia Mixed	-	-	-
Zostera	63	-	63
Zostera / Halophila	1994	-	1994
Halophila	553	73	626
Rock / Rubble / Reef	1648	1612	3261
Sand or Silt	625	1877	2502

**Survey within the Buffer Area was limited due to the position of active construction operations*

At La Perouse for the Construction Survey 2, areas of *Halophila* and *Zostera* reduced to lower levels than those recorded in Construction 1 in the Buffer Area, Project Boundary and Survey Area, but remained above that recorded in Baseline 4 (Figure 3).

The total area of *Posidonia* seagrasses in the Project Boundary at La Perouse in Construction Survey 2 is lower than Construction Survey 1 (a reduction of 30%) and is the lowest recorded in the Seagrass Monitoring Program to date (Figure 4). A reduction was also observed in throughout the wider Survey Area outside of the Project Boundary in Construction Survey 2 (a reduction of 17%), although the areal extent of *Posidonia* seagrasses recorded in the Survey Area was above that recorded in Baseline Survey 2, indicating that changes in the wider Survey Area may be reflective of background variability measured across the baseline surveys. *Posidonia* seagrass has not previously been recorded in the Buffer Area or Construction Footprint at La Perouse and were not recorded in Construction 2 (Figure 4).

Figure 3 Areal extent of *Halophila* and *Zostera* at La Perouse

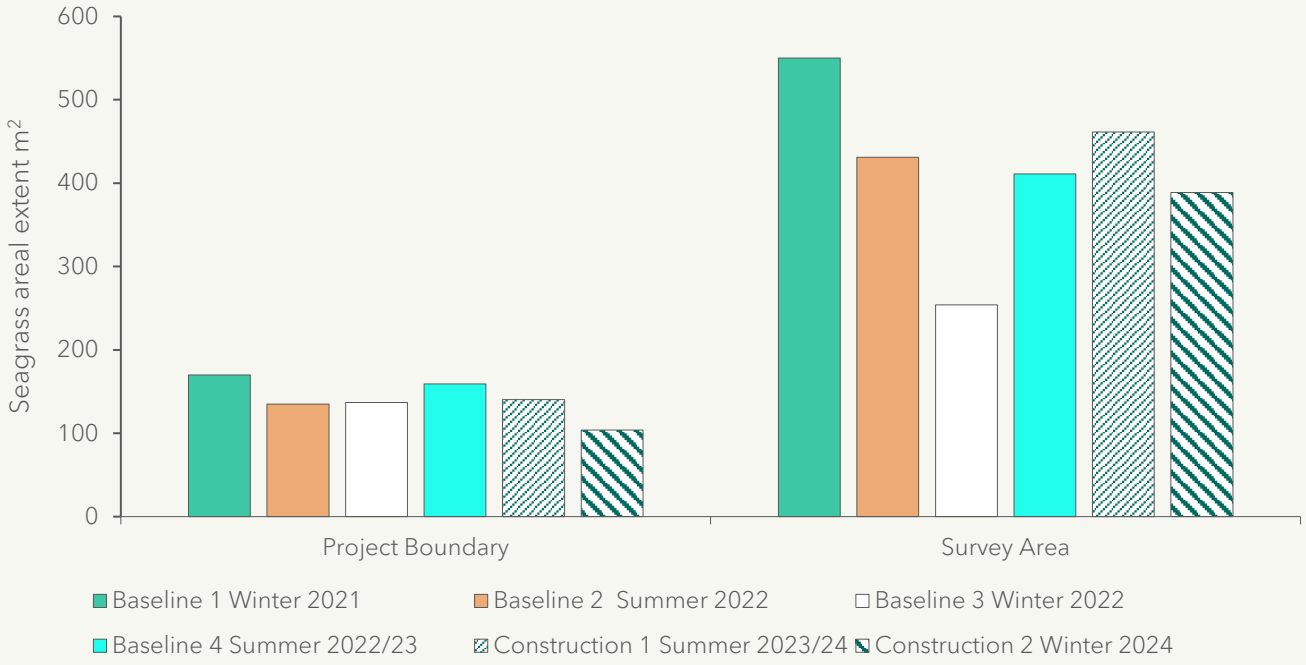


Figure 4 Areal extent of *Posidonia* at La Perouse

At Kurnell, the area of *Halophila* and *Zostera* within the Project Boundary and Survey Area decreased between Construction Survey 1 and Construction Survey 2, although these remained above that recorded in Baseline Survey 4 (Figure 5). The area of these seagrass species recorded within the Buffer Area were slightly below that of Baseline Survey 4. The total area of *Posidonia* seagrasses in the Project Boundary and Survey Area at Kurnell in Construction Survey 2 is slightly higher than in Construction Survey 1 and is comparable to Baseline levels (Figure 6). At Kurnell, no *Posidonia* seagrass was recorded within the Buffer Area, this is a result of the planned removal and transplantation of these seagrasses elsewhere. Direct comparisons over time are limited for the Buffer Area, as the entirety of this area cannot be surveyed due to the construction operations, however the area of seagrasses present are considered to be overall comparable to that recorded in Baseline 4.

Figure 5 Areal extent of *Halophila* and *Zostera* at Kurnell

Figure 6: Areal extent of *Posidonia* at Kurnell

3.3 *Zostera* and *Halophila* seagrasses

The key results for seagrass cover of *Zostera*- and *Halophila*-dominated beds are provided in Table 7 and Figure 7 and can be summarised as follows:

- At Kurnell, at least one species of seagrass was detected at all six of the monitoring sites.
- At La Perouse, at least one species of seagrass was detected at three of the four monitoring sites, no seagrass was recorded at HZ-LP01, as in Construction 1 (Niche 2024) and Baseline 3 (Niche 2023).
- At La Perouse, overall seagrass cover between monitoring sites inside the Project Boundary (HZ-LP01 and HZ-LP02) is lower than that of site HZ-LP03 which is outside the Project Boundary, but similar to HZ-LP04 (also outside) (Figure 7).
- The monitoring sites for *Zostera*- and *Halophila*-dominated beds closer to shore at Kurnell (HZ-K09 and particularly HZ-K10) recorded higher seagrass cover than the sites further from the shore (Figure 7).

The results for sediment cover and turfing algae are presented in Table 8. The key findings include:

- At La Perouse, sediment cover ranged between 53.0% - 91.8% cover. Sediment cover at Kurnell was generally higher, ranging between 60.5% - 95.5% cover.
- Turfing algae was only present, in minor amounts, at two sites each for both La Perouse and Kurnell.

Table 7 Seagrass percentage cover - Construction Survey 2 monitoring

Location	Site	*Halophila*		*Zostera*		*Posidonia*	
		Mean	Standard error	Mean	Standard error	Mean	Standard error
Kurnell	HZ-K05	0.46	0.27	2.82	0.56	0.00	0.00
	HZ-K06	3.79	0.66	0.58	0.29	0.00	0.00
	HZ-K07*	3.08	0.87	1.99	0.60	0.00	0.00
	HZ-K08*	5.62	0.88	0.81	0.32	0.00	0.00
	HZ-K09	4.09	1.41	2.99	1.00	0.00	0.00
	HZ-K10	16.20	1.66	22.92	1.76	0.00	0.00
La Perouse	HZ-LP01	0.00	0.00	0.00	0.00	0.00	0.00
	HZ-LP02	0.56	0.32	0.11	0.11	0.00	0.00
	HZ-LP03*	3.21	0.66	3.54	1.05	0.00	0.00
	HZ-LP04*	0.45	0.27	0.00	0.00	0.00	0.00

**denotes Reference site*

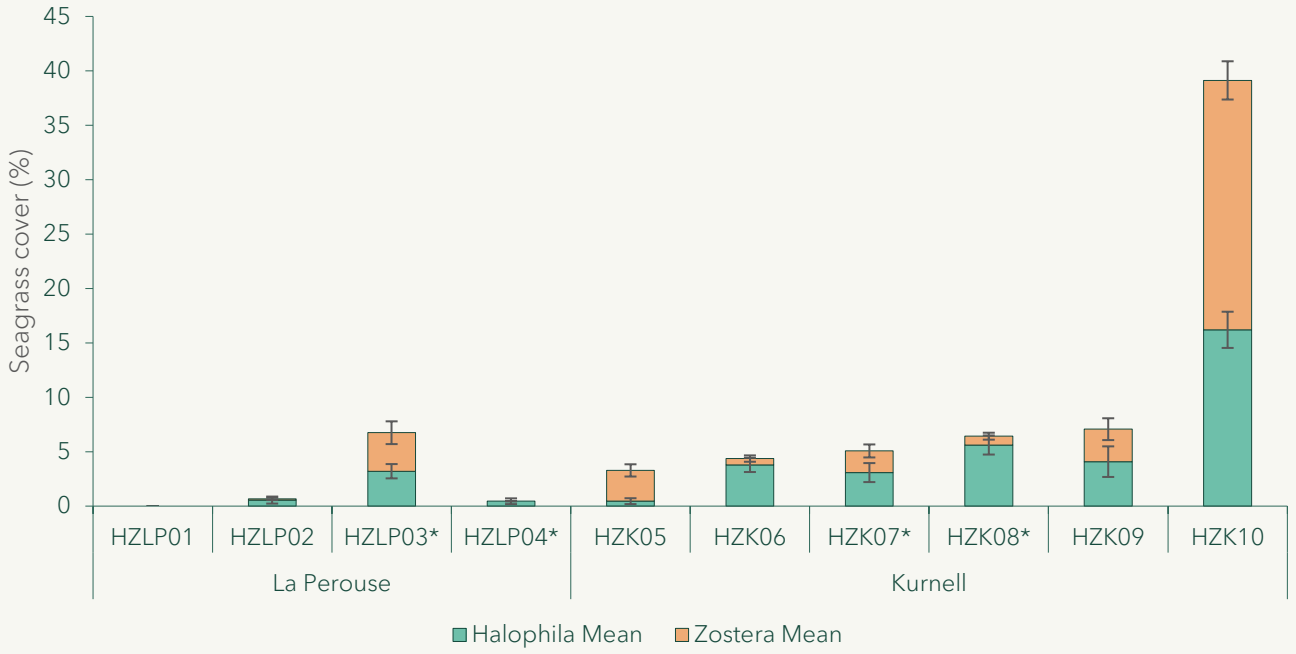


Figure 7 Average (±SE) *Halophila* and *Zostera* seagrasses cover (+/- SE total seagrass cover)

**denotes Reference site*

Table 8 Sediment and turfing algae cover - Construction Survey 2 monitoring

Location	Monitoring site	Factor			
		Turfing algae (TA) (%)		Sediment (SS) (%)	
		Mean	Standard error	Mean	Standard error
Kurnell	HZ-K05	0.00	0.00	96.49	0.57
	HZ-K06	0.00	0.00	95.52	0.67
	HZ-K07*	0.00	0.00	94.70	0.87
	HZ-K08*	0.00	0.00	93.46	0.97
	HZ-K09	0.11	0.11	92.48	2.17
	HZ-K10	0.16	0.16	60.45	1.69
La Perouse	HZ-LP01	0.44	0.46	53.04	3.39
	HZ-LP02	0.35	0.36	82.16	3.68
	HZ-LP03*	0.00	0.00	91.76	1.42
	HZ-LP04*	0.00	0.00	69.12	3.61

**denotes Reference site*

3.4 *Posidonia* seagrasses

3.4.1 Shoot density

The key results from the shoot density surveys at *Posidonia* bed monitoring sites (PB-) and *Posidonia* patch monitoring sites (PP-) (Table 9, Figure 8) are summarised as follows:

- All three species of seagrass were detected at the majority of the monitoring beds and patches:
  - *Posidonia* and *Halophila* was present at all monitoring beds and patches.
  - *Zostera* was absent at monitoring patch PP-LP01 only. *Zostera* has been detected at this site in various densities (including being absent) in Baseline monitoring.
- Average *Posidonia* shoot density in *Posidonia* beds at La Perouse and Kurnell ranged between 7.8 shoots per 0.25 m^2 (PB-K10) and 45.6 shoots per 0.25 m^2 (PB-K07):
  - The highest *Posidonia* densities were recorded at monitoring sites towards the centre of the main *Posidonia* bed at Kurnell (southwest of the Project Boundary), with the smaller *Posidonia* beds to the east of the main *Posidonia* bed and within the Project Boundary recording relatively lower densities.
  - At La Perouse the monitoring site within the Project Boundary (PB-LP11) had a lower *Posidonia* shoot density (9.0 shoots per 0.25 m^2) than the reference site (PB-LP12) (20.4 shoots per 0.25 m^2).

Table 9 Average shoot density - Construction Survey 2 monitoring

Location	Seagrass species	*Halophila* density (0.25 m^2)		*Zostera* density (0.25 m^2)		*Posidonia* density (0.25 m^2)	
		Mean	SE	Mean	SE	Mean	SE
Posidonia beds							
Kurnell	PB-K01	8.2	2.8	9.0	3.7	12.0	2.4
	PB-K02#	31.2	7.5	21.4	4.6	11.4	1.7
	PB-K03#	15.4	3.9	44.6	5.7	13.4	3.1
	PB-K04*	35.4	4.3	27.0	2.6	18.2	2.3
	PB-K05#	38.8	5.4	31.4	3.2	14.6	2.9
	PB-K06#	49.6	6.6	65.2	5.2	16.6	2.5
	PB-K07#	2.6	1.5	1.6	1.0	45.6	3.6
	PB-K08*	20.6	5.8	29.6	7.4	26.4	3.3
	PB-K09	22.2	6.9	35.6	9.1	11.0	2.5
	PB-K10	11.0	6.4	39.4	14.0	7.8	2.6
La Perouse	PB-LP11	19.0	19.0	5.0	5.0	9.0	4.0
	PB-LP12*	1.8	1.8	50.6	23.4	20.4	4.4
Posidonia patches							
Kurnell	PP-K03	29.6	7.5	47.6	9.8	12.4	3.1
	PP-K07	108.8	23.2	78.4	19.6	12.0	1.6
La Perouse	PP-LP01	5.4	1.9	-	-	12.8	1.2
	PP-LP02	13.2	3.8	10.6	4.9	11.4	4.2

*denotes Reference site

#denotes Potential impact, possible reference site

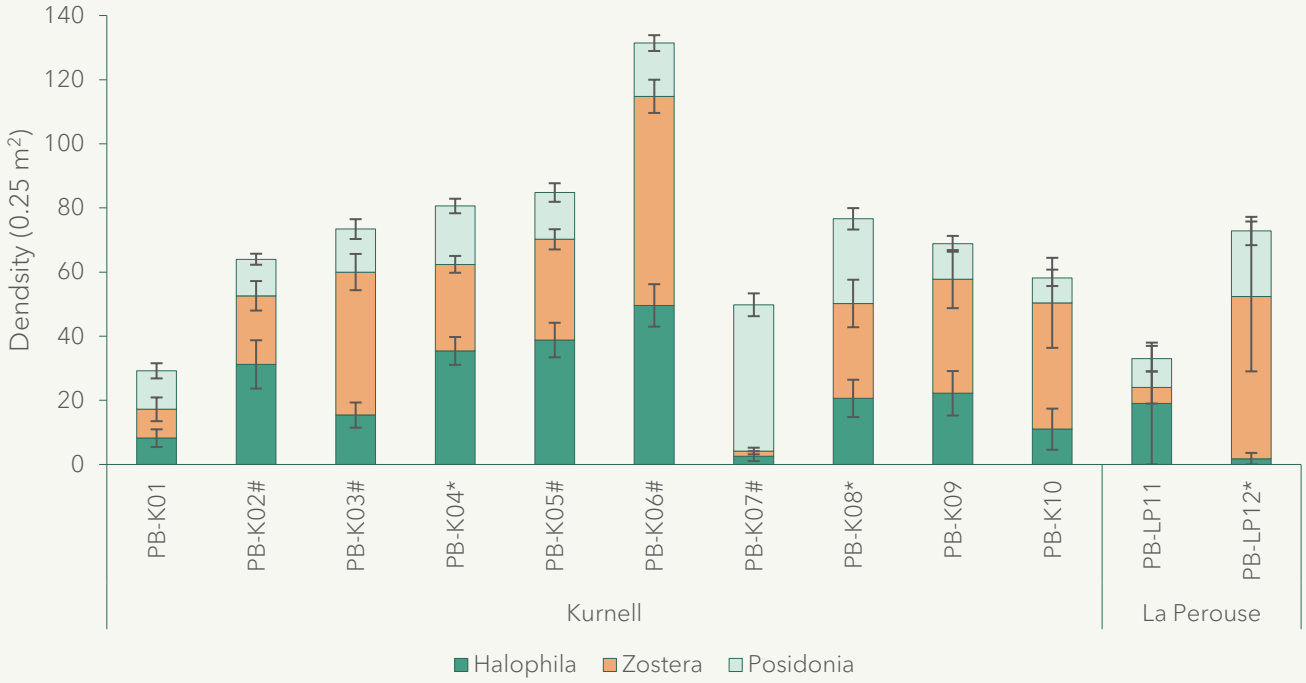


Figure 8 Average (±SE) shoot density of seagrass within the *Posidonia* bed monitoring sites

*denotes Reference site

#denotes Potential impact, possible reference site

Posidonia density has decreased at both monitoring beds at La Perouse between the Construction 1 and Construction 2 surveys. However, the *Posidonia* densities remain higher than the Baseline 4 survey and are comparable to the Baseline 3 survey (Figure 9). Similar trends over time are observed at PB-LP11 (within the Project Boundary) and PB-LP12 (Reference).

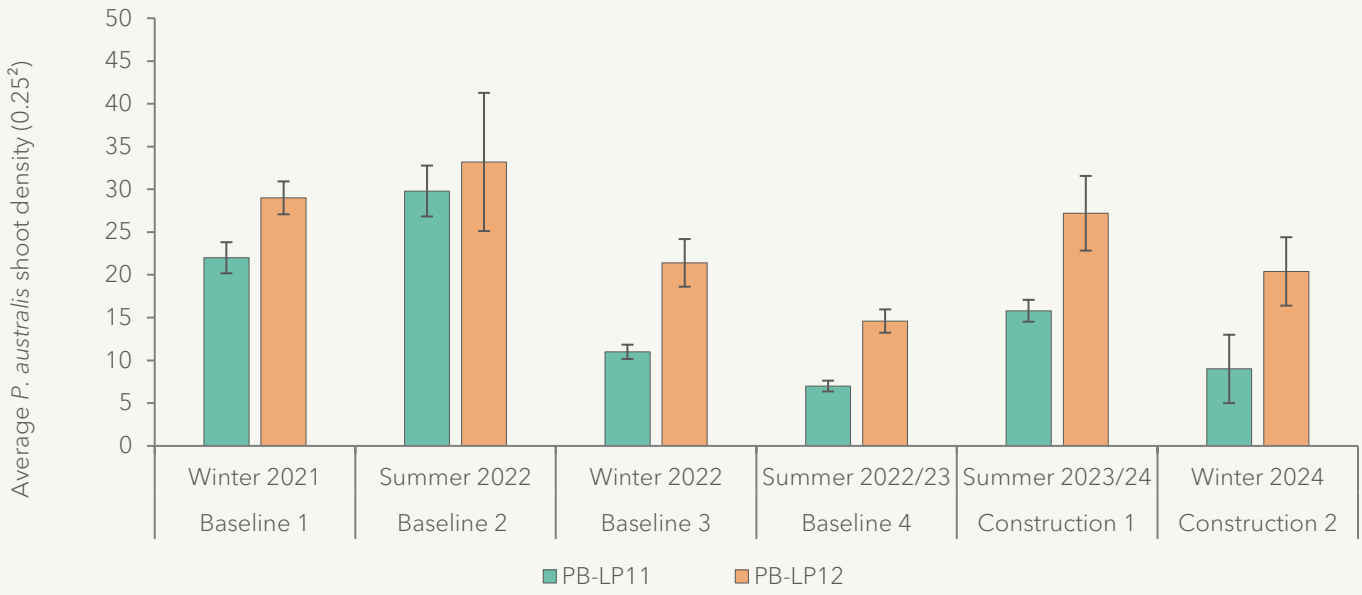
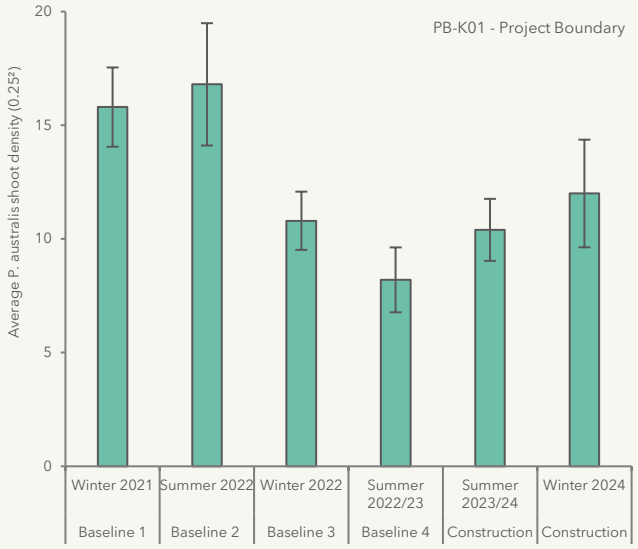
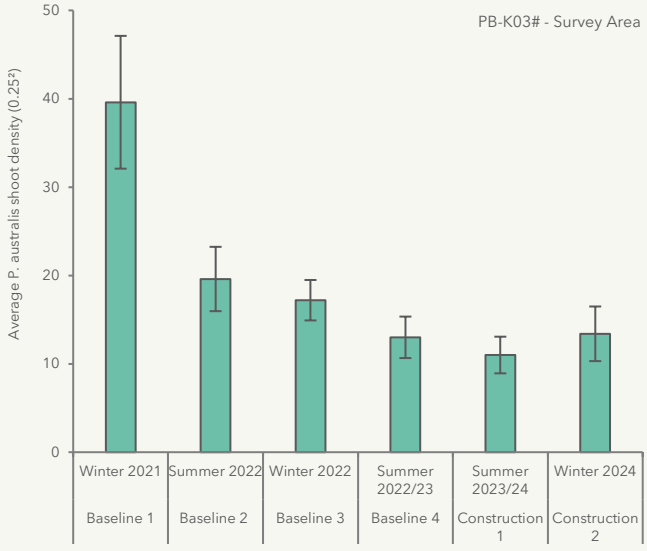


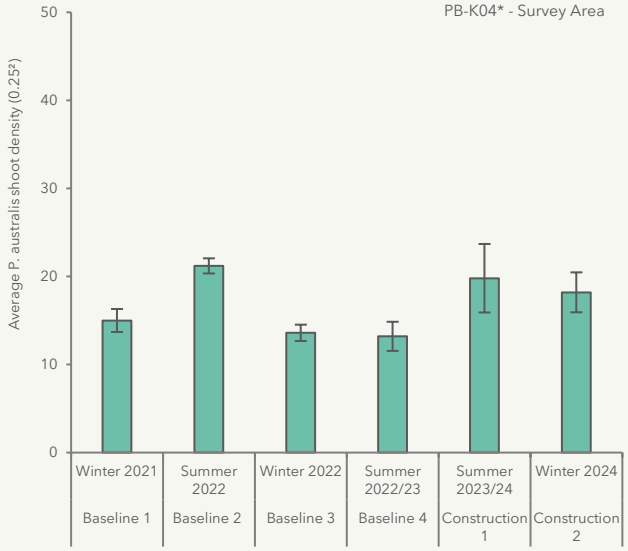
Figure 9 Mean shoot density of *Posidonia* shoots at the La Perouse bed monitoring sites

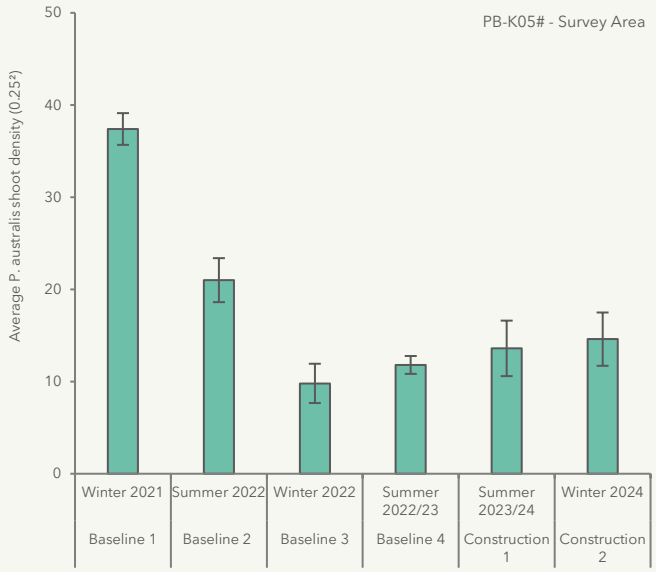
Posidonia density values at the majority of *Posidonia* monitoring beds at Kurnell remain higher than Baseline 4 (Figure 10). Although *Posidonia* density has reduced noticeably at site PB-K08, located outside of the Project Boundary. Of the three sites inside the Project Boundary, two sites showed increased shoot density (PB-K01 and PB-K09) while site PB-K10 showed a decrease since Construction 1. Within the main *Posidonia* bed, sites PB-K01, PB-K02, PB-K03, PB-K04 did not show any visual negative relationship between *Posidonia* density and proximity to the construction footprint. Closer to shore, also within the main *Posidonia* bed, sites PB-K07 and PB-K08 (furthest from the Buffer Area) showed decreases in density, while sites PB-K05 and PB-K06 (closer to the construction footprint) showed increases in shoot density.

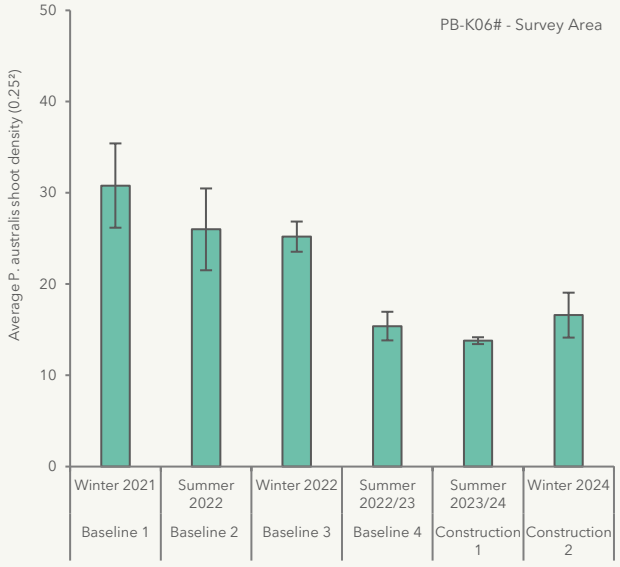

PB-K01 - Project Boundary
Average P. australis shoot density (0.25²)
20
15
10
5
0
Winter 2021
Baseline 1
Summer 2022
Baseline 2
Winter 2022
Baseline 3
Summer 2022/23
Baseline 4
Summer 2023/24
Construction
Winter 2024
Construction

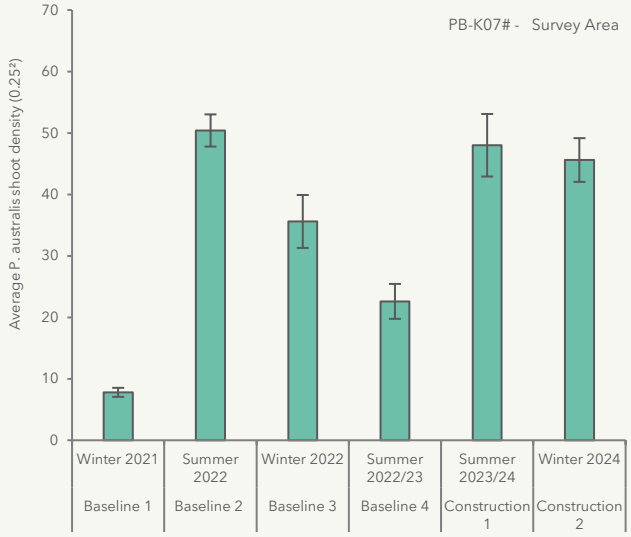

PB-K02# - Project Boundary
Average P. australis shoot density (0.25²)
25
20
15
10
5
0
Winter 2021
Baseline 1
Summer 2022
Baseline 2
Winter 2022
Baseline 3
Summer 2022/23
Baseline 4
Summer 2023/24
Construction 1
Winter 2024
Construction 2

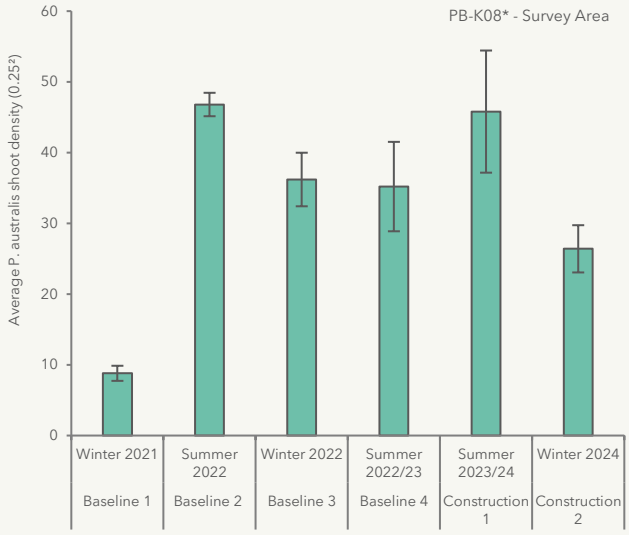

PB-K03# - Survey Area
Average P. australis shoot density (0.25²)
50
40
30
20
10
0
Winter 2021
Baseline 1
Summer 2022
Baseline 2
Winter 2022
Baseline 3
Summer 2022/23
Baseline 4
Summer 2023/24
Construction 1
Winter 2024
Construction 2


PB-K04* - Survey Area
Average P. australis shoot density (0.25²)
50
40
30
20
10
0
Winter 2021
Baseline 1
Summer 2022
Baseline 2
Winter 2022
Baseline 3
Summer 2022/23
Baseline 4
Summer 2023/24
Construction 1
Winter 2024
Construction 2


PB-K05# - Survey Area
Average P. australis shoot density (0.25²)
0
10
20
30
40
50
Winter 2021
Baseline 1
Summer 2022
Baseline 2
Winter 2022
Baseline 3
Summer 2022/23
Baseline 4
Summer 2023/24
Construction 1
Winter 2024
Construction 2


PB-K06# - Survey Area
Average P. australis shoot density (0.25²)
0
10
20
30
40
50
Winter 2021
Baseline 1
Summer 2022
Baseline 2
Winter 2022
Baseline 3
Summer 2022/23
Baseline 4
Summer 2023/24
Construction 1
Winter 2024
Construction 2


PB-K07# - Survey Area
Average P. australis shoot density (0.25²)
0
10
20
30
40
50
60
70
Winter 2021
Baseline 1
Summer 2022
Baseline 2
Winter 2022
Baseline 3
Summer 2022/23
Baseline 4
Summer 2023/24
Construction 1
Winter 2024
Construction 2


PB-K08* - Survey Area
Average P. australis shoot density (0.25²)
0
10
20
30
40
50
60
Winter 2021
Baseline 1
Summer 2022
Baseline 2
Winter 2022
Baseline 3
Summer 2022/23
Baseline 4
Summer 2023/24
Construction 1
Winter 2024
Construction 2

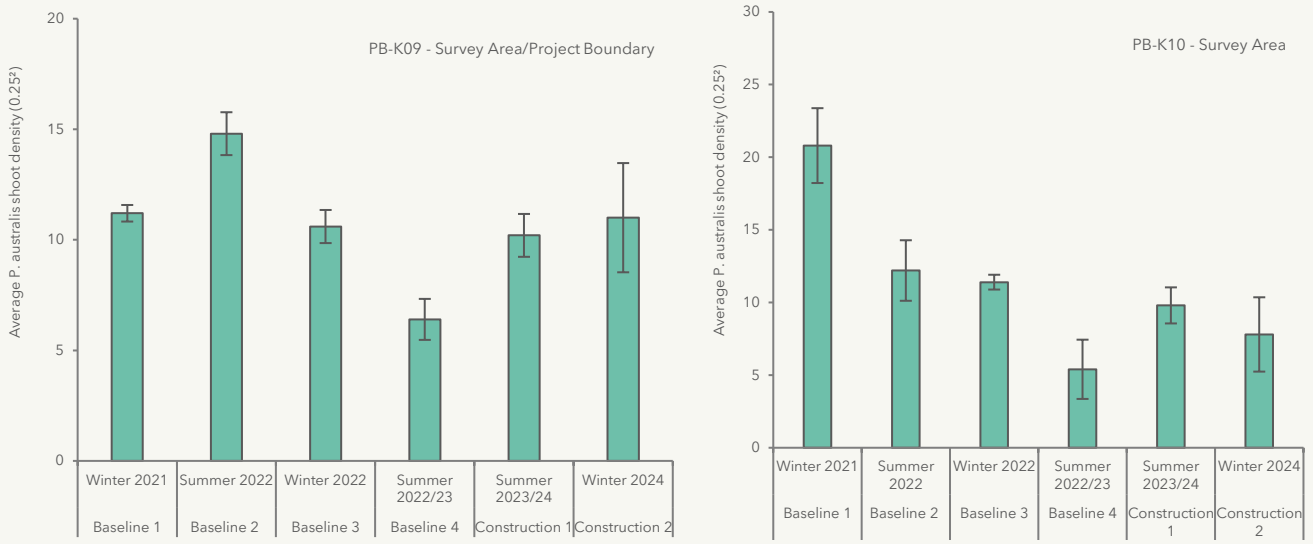


Figure 10 Mean shoot density of *Posidonia* shoots at the Kurnell *Posidonia* bed monitoring sites

**denotes Reference site*

#denotes Potential impact, possible reference site

3.4.2 Leaf length, epiphyte cover and visible sheaths

The key results for leaf lengths in *Posidonia* bed monitoring sites and patches (Table 10) are summarised as follows:

- Average leaf lengths for *Posidonia* at Kurnell, ranged between 20.3 cm (PB-K09) and 31.7 cm (PB-K03). Those monitoring beds with lowest average leaf lengths (PB-K09, PB-K10) are smaller patches that are not connected to the main seagrass bed located to the west of the Construction Footprint (Figure 2), with those sites within this main bed recording relatively higher average leaf lengths (PB-K01, PB-K02, PB-K03, PB-K04, PB-K05, PB-K06, PB-K07, PB-K08).
- Average leaf lengths for *Posidonia* at La Perouse ranged between 26.0 (PB-LP11) and 29.1 (PP-LP02). At the *Posidonia* beds at La Perouse, PB-LP11 (26.0 cm) within the Project Boundary recorded a lower average leaf length than PB-LP12 outside the project boundary (28.1 cm). Although the difference is marginal.
- The average leaf lengths recorded for *Zostera* across both locations ranged between 0.8 (PB-K11) and 13.2 (PB-K03).

The epiphyte cover results (Table 10) show that epiphytic growth was typically higher on *Posidonia* shoots than on *Halophila* or *Zostera*. Epiphyte loads are scored from one (low) to five (high), with high epiphyte loads potentially negatively affecting seagrass. The epiphyte cover scores across the *Posidonia* bed and patch monitoring sites ranged between 3.0 (PP-LP02) and 4.6 (PP-K07, PB-K03) for *Posidonia*. For *Zostera*, the range was between 0.3 (PB-LP11) and 4.4 (PB-K10), while the range for *Halophila* seagrass was between 0.6 (PB-LP11, PB-LP12) and 4.3 (PB-K05).

The average percentage of visible sheaths was found to be highly variable across the sites (Table 10), with some visible sheaths present across all *Posidonia* beds .For *Posidonia* beds, PB-LP11 recorded the highest average percentage of visible sheaths at 72.0%, with PB-K01 recording the lowest (10.4%). The highest average percentage of visible sheaths among these monitoring patches was 94.0% (PP-LP01) and the lowest was 18.2%

(PP-LP02). Greater levels of visible sheafs are an indicator of increased erosional processes within the seagrass bed, with lower levels of visible sheafs potentially indicating increased accretion.

Table 10 Average leaf length, epiphyte cover and visible sheaths (*Posidonia*) - Construction Survey 2 monitoring

Seagrass species	Leaf length (cm)			Epiphytic cover score			Sheath visible (%)
	Zostera	*Posidonia*	*Halophila*	*Zostera*	*Posidonia*	*Halophila*	*Posidonia*
Posidonia beds							
PB-K01	11.0	24.7	3.4	4.3	4.6	4.0	10.4
PB-K02	11.3	28.5	5.2	3.5	3.8	3.9	50.0
PB-K03*	13.2	31.7	4.0	3.5	4.1	3.7	50.0
PB-K04*	10.9	26.7	3.6	3.5	4.3	3.5	20.0
PB-K05	7.3	29.5	5.3	2.3	4.4	3.5	15.0
PB-K06	6.4	29.9	3.7	3.1	4.4	3.2	69.0
PB-K07*	1.5	26.1	2.5	1.0	3.94	1.4	54.0
PB-K08*	10.3	28.0	4.3	3.0	4.3	3.0	52.0
PB-K09	10.0	20.3	4.1	3.7	4.5	3.8	26.0
PB-K10*	7.6	20.9	2.7	4.4	3.5	2.5	55.0
PB-LP11	0.8	26.0	0.6	0.3	3.4	0.6	72.0
PB-LP12*	6.2	28.1	1.0	3.7	4.4	0.6	50.8
Posidonia patches							
PP-K03	12.6	25.6	5.5	4.3	4.2	3.7	51.0
PP-K07	8.0	26.6	3.8	3.9	4.6	4.3	48.6
PP-LP01	0.0	27.0	1.8	0.0	4.4	3.1	94.0
PP-LP02	3.3	29.1	2.1	1.4	3.0	0.9	18.2

**denotes Reference, or possible Reference, site*

3.5 Field observations

3.5.1 Kurnell - PB-K09 (Construction Survey 1)

Fine scale potential impacts to seagrass were identified at one monitoring site in Kurnell during Construction phase 1 monitoring (summer). It was observed that *Posidonia* appeared somewhat disturbed from the anchor lines and potentially the Jack-up Barge legs, along the edge of PB-K09 and the Buffer Area. It was noted that possible impacts at this location may have been unavoidable given the size of construction barges and 15m Buffer Area (Niche 2024).

More recent field observations from the Construction 2 surveys identified that while visually the *Posidonia* still appeared somewhat patchy at this location, the seagrass and benthic conditions appeared to have stabilised in contrast to the last round of survey.

A preliminary review of dive data collected from PB-K09 was undertaken to provide an indication of condition relevant to baseline over time at the time of the Construction 1 survey. Average shoot density of *Posidonia* was within the range of baseline data collected and was greater than in the most recent Baseline 4 (Niche 2024). Further review of the Construction 2 data identifies that average shoot density increased modestly from that recorded in Construction 1 at this site.

The scale of the observation is at too fine a scale to be captured in the seagrass areal mapping, however the quantitative assessment of dive data over time may capture any change in condition. As such, this will be an important monitoring site to examine post-construction.

3.5.2 La Perouse - PB-LP11 (Construction Survey 2)

During Construction 2 surveys conducted on 11/07/2024, the south-western portion of *Posidonia* bed PB-LP11 within the construction boundary at Frenchman's Bay was observed to have been damaged (H2O Consulting Group 2024a). A follow-up dive was done on 23/07/2024 to perform *Posidonia* rehabilitation works (H2O Consulting Group 2024b) directed by TfNSW, with mapping of the bed also being undertaken. The rehabilitation scope was developed in consultation with the Marine Biodiversity Offset Strategy (MBOS) Implementation Reference Panel (IRP).

Following those works, a very large easterly swell impacted on the Sydney Coastline, resulting in significant waves entering Botany Bay, which resulted in higher than usual wave activity at La Perouse. A follow up inspection was completed on 19/08/24, with indicators of significant wave activity and influence on the seabed since the original rehabilitation works in July being observed. As a result, the seabed had not stabilised around the seagrass bed and was notably different to that in July, contributing to significant further disturbance to this *Posidonia* bed (H2O Consulting Group 2024c). This had resulted in the majority of the rehabilitated areas on the south-western fringe of the bed being dislodged with rhizomes exposed or completely lost. Further remediation works were completed during this latest inspection.

A total of 114 m^2 of *Posidonia* seagrass was mapped at PB-LP11 during Construction Survey 1. In Construction Survey 2, this was reduced to a total of 74 m^2 (a reduction of 40 m^2).

It is noted that during the remediation works, several White's Seahorse's (*Hippocampus whitei*), listed as Endangered under the FM Act and EPBC Act, were observed in the seagrass bed utilising habitat on the edge of the damaged area (H2O Consulting Group 2024c). The report concluded that while the remaining seagrass bed provided adequate habitat for the resident White's Seahorses that occur within it, should the areal distribution of seagrass within this bed continue to be eroded, adaptive management solutions would need to be evaluated in consultation with the MBOS IRP..

It has been recommended that as it was unlikely that any further rehabilitation works would provide benefit now the seabed has levelled, recovery monitoring should occur at 3-month intervals (H2O Consulting Group 2024c).

3.5.3 Kurnell - western side of the Kurnell Wharf (Construction Survey 2)

During Construction 2 surveys conducted on 27/09/2024 an area of recent seabed disturbance and notable change in seabed profile was detected while undertaking towed camera survey on the western side of the Kurnell Wharf (H20 Consulting Group 2024d). The area of disturbed seabed was approximately 40 metres west of the mid-section of the wharf under construction. Previous mapping of this area identified the seagrass habitat to be a mixture of *Halophila* and *Zostera*, however *Posidonia* also occurs in close proximity and was observed on live feed to be growing adjacent to the disturbed area. The area was re-inspected by Scientific Divers on 17/09/2024. Four circular to oval scour marks were observed between the PB-K09 and the main *Posidonia* bed (H2O Consulting Group 2024e). The habitat around the scours was observed by the divers to be dominated by *Halophila* and *Zostera* seagrass, however some patchy occurrences of *Posidonia* plants were notable around the scours in this area. These scours also appeared to encroach into the edges of previously mapped areas of *Posidonia*, with some *Posidonia* rhizomes notably exposed and disturbed around the edge of the scours. Furthermore, a notable area of disturbed seagrasses dominated by *Posidonia* was observed to extend approximately 17 m west into the main *Posidonia* bed (H2O Consulting Group 2024e).

H2O Consulting Group (2024e) estimated that between 22 and 43 m^2 of mixed *Posidonia* seagrass were lost as a result of this disturbance, based on in situ observations. An investigation to the potential cause of the seabed disturbance was completed in consultation with the MBOS IRP.

Rehabilitation works were promptly completed around these scours after their identification, including the collection of approximately 170 *Posidonia* fragments, from within the scours, which were delivered to the University of New South Wales (UNSW) holding facility at the Kurnell Desalination Plant for later replanting (H2O Consulting Group (2024e).

Ongoing monitoring of these scours was recommended in consultation with the IRP.

4 Discussion

The winter 2024 (Construction Survey 2) seagrass monitoring survey represents the second monitoring survey of the construction phase of the project and the latest survey since summer 2023/24 (Construction Survey 1). The final Baseline survey in summer 2022/23 (Baseline Survey 4) was completed during a strong and prolonged La Nina weather pattern that impacted seagrasses across both Kurnell and La Perouse, which reduced areal extents and densities of seagrasses at the end of the baseline monitoring period (Niche 2023). The Construction 1 surveys were not subject to these same damaging weather conditions and saw areal extents of seagrasses expanding as part of a general pattern of recovery from these environmental perturbations.

Significant weather events, including powerful easterly swells occurred prior to, and during, the Construction 2 surveys. Exposure to large easterly swells is considered a major driver of temporal changes in seagrasses within the lower reaches of Botany Bay, in particular at Kurnell.

At La Perouse, the total area of *Posidonia* seagrasses in the Project Boundary in Construction Survey 2 was lower than the Construction Survey 1 and Baseline surveys. While a reduction in *Posidonia* extent within the Survey Area outside of the Project Boundary was also observed during this survey at La Perouse, this was similar to variability identified in *Posidonia* distributions measured during the Baseline surveys, and the level of reduction was proportionally lower than that observed in the Project Boundary. Observations of disturbance to *Posidonia* at monitoring bed PB-LP11 within the Project Boundary likely explain the greater reduction of *Posidonia* observed in this area, in addition to background levels of change. Areas of *Halophila* and *Zostera* were also lower than Construction Survey 1 in the Buffer Area, Project Boundary and Survey Area at La Perouse, but remained above those recorded in Baseline 4 and comparable with pre-construction variability.

At Kurnell, the total area of *Posidonia* seagrasses in the Project Boundary and Survey Area at Kurnell in Construction Survey 2 is slightly higher than in Construction Survey 1 and is comparable to Baseline distributions. The area of *Halophila* and *Zostera* within the Project Boundary and Survey Area decreased between Construction Survey 1 and Construction Survey 2, but remained comparable to pre-construction distributions when considering the variability across the Baseline surveys. The areas of these seagrass species recorded within the Buffer Area also reduced in Construction Survey 2, but are comparable with Baseline Survey 4.

Posidonia seagrass has not previously been recorded in the Buffer Area at La Perouse, and was not recorded in Construction 2. At Kurnell, no *Posidonia* seagrass was recorded in the Buffer Area in this survey, as a result of the planned removal and transplantation of these seagrasses elsewhere.

Assessment of the *Posidonia* shoot density data indicated variable results at Kurnell. No visually significant indicators of deterioration within the Project Boundary were observed, with all shoot density results being within the range of Baseline results at all monitoring beds. *Posidonia* shoot density was observed to decrease at both monitoring beds at La Perouse between the Construction 1 and Construction 2 surveys. However, the levels *Posidonia* densities remain higher than those recorded in the Baseline 4 survey at La Perouse.

Observations of fine scale potential impacts to seagrass along the edge of PB-K09 on the outer edge of the Buffer Area previously been identified (Niche 2024). Field observations in the Construction Survey 2 identified a stabilisation of *Posidonia* plants and associated habitat at this location. A preliminary review of dive data collected from PB-K09 identified that the average shoot density of *Posidonia* was within the range of baseline data (Niche 2024) and had increased since Construction Survey 1. These findings suggest a degree of recovery from the initial impact observation, with further assessment of quantitative data to be included in the post-construction monitoring report as relevant. Future areal mapping and quantitative data will determine the extent of these impacts on *Posidonia* seagrasses in close proximity to the works at Kurnell. Therefore, this will be an important post-construction monitoring site to detect longer term impacts as a result of the construction works.

The winter monitoring observation of seagrass disturbance, including *Posidonia* along the western side of the Kurnell Wharf in Construction Survey 2 will need to be considered in future areal mapping and quantitative data assessment.

In conclusion, overall seagrass area extents have decreased in this survey, when compared to the most recent survey (Construction Survey 1 in summer 2023/24). This has been driven primarily by decreases in *Halophila* and *Zostera* seagrasses, with areas of *Posidonia* being relatively stable. Importantly, the levels of seagrass areal extent typically remain above that or comparable to those recorded in Baseline Survey 4 and are observed to occur within both the Survey Area and Project Boundary. This is likely to reflect the effects of the recent powerful easterly swells that have occurred, with the deeper rooted *Posidonia* being more resilient to such environmental perturbations. The exception to this is at La Perouse where declines in *Posidonia* areal extent within the Project Boundary exceed that observed within the Survey Area and have reduced to levels below that recorded in Baseline monitoring. This is likely driven by disturbances observed and described during Construction Survey 2.

A post-construction monitoring report will now be prepared to address data collection over each of the construction monitoring surveys. This report will include more detailed analysis of the ecological data and temporal analysis of trends or change in any ecological indicators to facilitate comparisons between the Baseline and Construction datasets. A particular focus of this report will be to address the performance measures developed in the final baseline monitoring report (Niche 2023).

5 References

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