# City of Wanneroo Coastal Monitoring Report April 2023







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# **1** Introduction

A long-term coastal monitoring program has been undertaken by the City of Wanneroo (CoW) since 2014. The purpose of the program is to evaluate the seasonal, annual and long-term trends in erosion and accretion along the City's coastline. This helps to better inform coastal management decisions, identify key areas with future management requirements and to provide data for future coastal hazard studies.

At present, the coastal monitoring programme involves the acquisition and assessment of the following data sets.

- Biannual manual images taken at 49 beach monitoring sites;
- Hourly automatic photographic monitoring taken at five sites along Quinns Beach and Yanchep;
- 6 monthly LiDAR aerial surveys undertaken across all vulnerable areas;
- Aerial imagery taken across the entire CoW coastline;
- Metocean conditions including:
  - Half-hourly wave data from the Department of Transport (DoT) Rottnest Island Wave Station;
  - Half-hourly wind data from the Ocean Reef Weather Station; and
  - o 5-minute water level data from the DoT Fremantle Fishing Boat Harbour Tide Station.

This document outlines the methodology and results obtained from the seasonal and long-term assessments of coastline changes at priority locations along the CoW coastline.



# 2 Metocean Conditions

Metocean conditions including wave and water level data are assessed as part of the coastal monitoring program. Data is obtained from the following instrumentation managed by the Department of Transport (DoT) and the Bureau of Meteorology (BoM):

- Half-hourly wave data from the DoT Rottnest Island Wave Station;
- 5-minute water level data from the DoT Fremantle Fishing Boat Harbour Tide Station; and
- Half-hourly wind data from the Ocean Reef Weather Station.

Locations of these instruments are presented in Figure 2-1.





# 2.1 Assessment Methodology

The data from these instruments is obtained from the DoT for the annual monitoring period April 2022 to April 2023. The data is assessed using time series and wave rose plots where trends and major weather events are analysed.

The metocean conditions at the time of manual photographic monitoring is noted and used to interpret qualitative observations from visual assessments of photo comparison (both seasonal and long term).

# 2.2 Results

# 2.2.1 Annual

A time series plot of the total significant wave height (Hs) recorded at the Rottnest Island Wave Station from April 2022 to April 2023 is presented below in Figure 2-2.





The most notable observations from Figure 2-2 are the storm events that were recorded on the 24<sup>th</sup> of May 2022, 13<sup>th</sup> of June 2022 and the 3<sup>rd</sup> of August 2022. The storm that resulted in the most significant infrastructure damage and erosion along the City's coastline occurred on the 3<sup>rd</sup> of August 2022 which had a peak total significant wave height of 8.67m which was recorded at 2:09 AM on 3<sup>rd</sup> August 2022.





March 2023) and the winter Season (April to September 2022)

As seen in Figure 2-3, the wave climate for both the summer and winter periods is characterised by west south westerly waves and, as expected, there is a significant increase in swell height during the winter period. Wave direction across the year was typically recorded from a WSW direction.





Figure 2-4 Water level (mAHD) recorded at the Fremantle Fishing Harbour Tide Station from April 2022 to April 2023.



*Figure 2-5* Storm surge recorded at the Fremantle Fishing Harbour Tide Station during the August 3<sup>rd</sup> storm event.

Total recorded water level at the Fremantle Tide Station for April 2022 to April 2023 is presented in Figure 2-4. The highest water level recorded was 1.01 mAHD recorded at 1:15PM on 23rd of May 2022 and the peak storm surge (0.83m) was observed on the 2nd of August at 3:30AM. The winter storm that extended over three days at the beginning of August 2022 was characterised by an extended storm surge and high significant wave heights. This resulted in significant erosion and infrastructure damage to Mindarie Breakwater, Frederick Stubbs Staircase, Queenscliffe Dog Beach Dune System, Jindalee Staircases and Amberton Beach Access Ways. Further details of the storm damage are outlined in Section 3.





Figure 2-3 Rose plots showing wind speeds recorded during the summer season (October 2022 to March 2023) and the winter season (April to September 2022).

As expected, the summer of 2022/23 was largely characterised by strong southerly and south-south westerly winds, which are typical conditions along the West Australian coastline during the summer months. Notably, this year, south-south westerly winds were more prominent than southerly winds and a larger percentage of winds over 40km/h were recorded than previous years. The winter period was mostly characterised by easterly winds with significant periods of strong westerly winds, which is typical of winter storm events.

# 2.2.2 During Monitoring

Manual imagery and aerial surveys for this monitoring period were undertaken between 12 April 2023 and 19 April 2023. The water levels during these monitoring periods are presented below in Figure 2-6.







Manual imagery was undertaken on 12 April and 19 April 2023 and it important to note when assessing manual imagery that the maximum water level on 12 April was significantly higher (0.6mAHD) than that observed on 19 April (0.25mAHD). It is important to note when assessing manual imagery that most images were taken at a water level between -0.0 and 0.6 mAHD.



# 3 Storm Damage

As outlined above in Section 2, a number of storm events occurred during the 2022 winter period. The most notable of which was the storm event that occurred between the 1<sup>st</sup> and the 4<sup>th</sup> of August which resulted in significant infrastructure and dune damage as outlined in Table 3-1.

Table 3-1 Examples of major infrastructure and dune damage caused by winter storms.

Damaged Asset	Damage	Action Taken by the City	Photograph of the asset following actions
Mindarie Breakwater and adjacent road infrastructure		Immediately following the August storm event, the road was cleaned and any debris was removed. Complete asset upgrade/renewal works began in February 2023.	



Damaged Asset	Damage	Action Taken by the City	Photograph of the asset following actions
Frederick Stubbs GSC Revetment, Quinns Rocks	2622/08/04	Some of the geotextile sand containers (GSCs) were buried shortly after being dislodged from the revetment. The GSCs that could be recovered were removed from the beach. Any additional repair works will be investigated if the structure begins to slump.	NUMINESS:
Beach Access Staircase, Quinns Beach		The base of the beach access staircase at Quinns Rocks was damaged following the August storms. A contractor was engaged to repair the decking and fixings.	



Damaged Asset	Damage	Action Taken by the City	Photograph of the asset following actions
Dune and Wind Break Fencing, Quinns Dog Beach		The wind break fencing was repaired. The City completed beach scraping at this site in February 2023 following a significant build up of sand over the summer months. Sand was moved from the built-up beach to the base of the dunes to provide a buffer for this dune system prior to winter storm events.	
Amberton Beach Access Pathway		This asset is currently managed and maintained by the Amberton Beach Residential Development. The Developer has undertaken localised renourishment at the site and installed geotextile sand containers at the base of the pathway to limit future scour.	2020/04/19



Damaged Asset	Damage	Action Taken by the City	Photograph of the asset following actions
Northern Fisherman's Hollow Twin Beach Access, Yanchep		Natural Area Consulting Management Services were engaged to install an extension to the staircase. They began works in April 2023 and expect to complete works by the end of May 2023.	
Southern Fisherman's Hollow Beach Access, Yanchep		The southern staircase at Fisherman's Hollow was undermined following a significant erosion event. The City have backfilled underneath the staircase to ensure safe access.	



Damaged Asset	Damage	Action Taken by the City	Photograph of the asset following actions
Yanchep Lagoon Beach Access, Yanchep	2022/708/04	The City undertook reactive beach renourishment at Yanchep Lagoon in September 2022 to provide a safe beach for beach users. Further details of the nourishment are outlined in <b>Section 8.5</b> .	2022/09/30



# 4 Manual Imagery

There are a total of 49 manual imagery beach monitoring sites located in key vulnerable coastal areas along the CoW coastline. The position of these sites is presented in Figure 4-1 to Figure 4-4. Images are taken 6 monthly in April and October each year to assess seasonal and long-term changes to beach morphology. Images are taken by CoW's Project Manager – Coastal and are taken at the same location and with same field of view each time.























# 4.1 Assessment Methodology

Manual imagery is assessed via visual comparison. Images, once taken, are filed individually for each monitoring site allowing for an effective analysis of long-term and seasonal beach changes.

Seasonal changes are assessed by comparing the images taken in April (current year) with October (previous year) and October (previous year) with April (previous year). Long-term changes are assessed by comparing current images with the earliest images taken at the same time of year for each monitoring location.

Comments are made on the severity of beach changes observed at each monitoring site following the visual assessment. The severity of beach change is based upon the definitions as defined in Table 4-1.

Table 4-1 Severity of Beach Change Definitions

Accretion	<ul> <li>Increase in beach width;</li> <li>Notable sand build up; or</li> <li>Improvement in dune condition.</li> </ul>
No change	<ul> <li>No identifiable change in beach width, slope or dune condition.</li> </ul>
Minor Erosion	<ul> <li>Slight or minor decrease in beach width;</li> <li>Slight or nil impact to dune condition; and</li> <li>Remaining beach is sufficient to protect the dunes or infrastructure that lie landward of the beach.</li> </ul>
Major Erosion	<ul> <li>Major decrease in beach width;</li> <li>Some impact to dune condition; and</li> <li>Remaining beach is not sufficient to protect dunes or infrastructure landward of the beach in the event of erosion.</li> </ul>

# 4.2 Results

The severity of beach change and comments are presented in Table 4-2, Table 4-3, Table 4-4, Table 4-5, Table 4-7 and Table 4-8.

Images of sites with notably severe beach changes are presented in Section 4.2.1.



Table 4-2 Visual observations of beach changes at manual imagery monitoring sites in Two Rocks

	Summer Seasonal Changes		Winter Seasonal Changes		Long-term Changes		Long-term Changes		
Photo Monitoring Site	(Octobe	r 2022 to April 2023)	(April 202	22 to October 2022)	(Marc	h 2015 to April 2023)	(Octobe	r 2014 to October 2022)	
5	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	
Two Rocks									
B01	Minor erosion	Slight reduction in beach width. Bedrock exposed.	Accretion	Increase in beach width however notable erosion at the base of the dunes.	Major erosion	Dune condition is very poor and significant erosion at this location was noted in survey results. Please note however that the FOV of imagery does not allow for an accurate assessment of erosion.	Major erosion	Dune condition is very poor and significant erosion at this location was noted in survey results. Please note however that the FOV of imagery does not allow for an accurate assessment of erosion.	
B02 UP-COAST	Minor erosion	Slight reduction in beach width.	Accretion	Increase in beach width.	Minor erosion	Notable reduction in beach width.	No change	No notable change in dune condition. Increased beach width.	
B03 UP-COAST	Minor erosion	Slight reduction in beach width.	Accretion	Increase in beach width with erosion notable at the base of the dunes.	Minor erosion	Notable reduction in beach width and slight erosion at the base of the dunes.	Minor erosion	Slight erosion at the base of the dunes.	
B03 DOWN-COAST	Minor erosion	Slight reduction in beach width.	Accretion	Increase in beach width.	Minor erosion	Notable reduction in beach width and slight erosion at the base of the dunes.	Minor erosion	Slight erosion at the base of the dunes.	
B04 UP-COAST	Major erosion	Notable reduction in beach width with erosion scarp. Dunes remain in good condition.	Accretion	Increase in beach width with established dune vegetation.	Minor erosion	Notable reduction in beach width with a significant erosion scarp.	Minor erosion	Slight erosion at the base of the dunes.	
B04 DOWN-COAST	Major erosion	Notable reduction in beach width with erosion scarp. Dunes remain in good condition.	Accretion	Significant increase in beach width with established dune vegetation.	Minor erosion	Notable reduction in beach width with a significant erosion scarp.	Accretion	Slight increase in beach width.	
B05	Accretion	Significant increase in beach width.	Minor erosion	Reduction in beach width.	Accretion**	Significant increase in beach width noted.	Accretion*	Significant increase in beach width noted.	
B06 UP-COAST	Accretion	Significant increase in beach width.	Minor erosion	Slight reduction in beach width with no observed impact on dunes.					
B06 DOWN-COAST	Accretion	Notable increase in beach width.	Minor erosion	Slight reduction in beach width with slight impact to the base of dunes.	Unable to assess, manually imagery capture began in 2021.				
B07 UP-COAST	Accretion	Significant increase in beach width.	Minor erosion	Slight reduction in beach width with no observed impact on dunes.	Accretion*	Significant increase in beach width noted.	No change*	No notable change in dune condition. Increased beach width.	
B07 DOWN-COAST	Accretion	Significant increase in beach width.	Minor erosion	Slight reduction in beach width with no observed impact on dunes.	Accretion*	Significant increase in beach width noted.	Minor erosion*	Slight decrease in beach width noted.	

\*Long-term changes have been assessed through images taken in 2019.

\*\* Long-term changes have been assessed through images taken in 2020.



Table 4-3 Visual observations of beach changes at manual imagery monitoring sites in Yanchep

	Summer Seasonal Changes (October 2022 to April 2023)		Winter Seasonal Changes (April 2022 to October 2022)		Mid-term Changes (April 2019 to April 2023)		Mid-term Changes (October 2018 to October 2022)	
Photo Monitoring Site	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Yanchep								
B01 UP-COAST	Minor erosion	Reduction in beach width. Dunes remain in good condition.	Accretion	Slight increase in beach width.	Minor erosion	Very minor erosion at the base of the dunes.	No change	No notable change in beach width or dune condition.
B01 DOWN-COAST	Minor erosion	Reduction in beach width. Dunes remain in good condition.	Accretion	Notable increase in beach width.	Minor erosion	Very minor erosion at the base of the dunes.	No change	No notable change in beach width or dune condition.
B02 UP-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Slight increase in beach width.	Minor erosion	Very minor erosion at the base of the dunes.	Minor erosion	Notable erosion at the base of the dunes.
B02 DOWN-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Significant increase in beach width.	Minor erosion	Notable erosion at the base of the dunes.	Minor erosion	Notable erosion at the base of the dunes.
B03 UP-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Slight increase in beach width.	Minor erosion	Notable erosion at the base of the dunes.	Minor erosion	Notable erosion at the base of the dunes.
B03 DOWN-COAST	Minor erosion	Notable reduction in beach width.	Minor erosion	Notable erosion at the base of the dunes.	Minor erosion	Notable erosion at the base of the dunes.	Minor erosion	Notable erosion at the base of the dunes.
B05 UP-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Minor erosion	Very minor reduction in beach width.	Minor erosion	Reduction in beach width and notable erosion at the base of the dunes.	No change	No notable change in beach width or dune condition.
B05 DOWN-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Slight increase in beach width.	Minor erosion	Reduction in beach width and notable erosion at the base of the dunes.	Minor erosion	Notable erosion at the base of the dunes.
B06 UP-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Slight increase in beach width.	Minor erosion	Significant erosion at the base of the dunes.	Minor erosion	Notable erosion at the base of the dunes.
B06 DOWN-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Slight increase in beach width.	Minor erosion	Significant erosion at the base of the dunes.	Minor erosion	Notable erosion at the base of the dunes.
B07 UP-COAST	Accretion	Significant increase in beach width.	Major erosion	Significant reduction in beach width and erosion at the base of the dunes.	No change	No notable change to dune or beach condition.	Minor erosion	Notable erosion at the base of the dunes.
B07 DOWN-COAST	Accretion	Significant increase in beach width.	Major erosion	Significant reduction in beach width.	No change	No notable change to dune or beach condition.	Minor erosion	Notable reduction in beach height and erosion at the base of the dunes.
B08 UP-COAST	Accretion	Slight increase in beach width.	Minor erosion	Reduction in beach width with erosion at the base of the dunes.	Accretion	Slight improvement in beach condition and beach width.	No change	No notable change in beach width or dune condition.
B08 DOWN-COAST	Accretion	Slight increase in beach width.	Minor erosion	Reduction in beach width.	Accretion	Slight improvement in beach condition and beach width.	Minor erosion	Notable erosion at the base of the dunes.
B09 UP-COAST	Major erosion	Significant reduction in beach width.	Accretion	Significant increase in beach width	Minor erosion	Notable reduction in beach width and dune condition. Noting the significant volume of nourishment that has been undertaken at this site.	No change	No notable change in beach width or dune condition. Both images were taken following renourishment.
B09 DOWN-COAST	Accretion	Slight increase in beach width. Particularly notable around the headland.	Accretion	Slight increase in beach width.	No change	No notable change in beach width or dune condition. Noting the significant volume of nourishment that has been undertaken at this site.	No change	No notable change in beach width or dune condition. Both images were taken following renourishment.
B10 UP-COAST	Major erosion	Significant reduction in beach width and notable damage to the dunes.	Accretion	Notable increase in beach width.	Minor erosion	Significant erosion at the base of the dunes.	No change	No notable change in beach width or dune condition. Both images were taken following renourishment.



	Summer Seasonal Changes		Winter Seasonal Changes		Mid-term Changes		Mid-term Changes	
Dhata Manitarin a Oita	(Octobe	r 2022 to April 2023)	(April 2022 to October 2022)		(April 2019 to April 2023)		(October 2018 to October 2022)	
Photo Monitoring Site	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Yanchep								
B10 DOWN-COAST	Minor erosion	Notable reduction in beach with.	Accretion	Significant increase in beach width as a result of nourishment	Major erosion	Significant erosion of the dunes. Limited beach width.	No change	No notable change in beach width or dune condition. Both images were taken following renourishment.
B11 UP-COAST	Major erosion	Significant reduction in beach width and notable damage to the dunes.	Accretion	Increase in beach width and improvement of dune condition.	Minor erosion	Reduction in beach width and erosion evident at the base of the dunes.	Minor erosion	Notable erosion at the base of the dunes.
B11 DOWN-COAST	Major erosion	Significant reduction in beach width and notable damage to the dunes.	Accretion	Increase in beach width and improvement of dune condition.	Major erosion	Significant erosion of the dunes. Limited beach width.	Minor erosion	Notable erosion at the base of the dunes.
B12 UP-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Increase in beach width and improvement of dune condition.	Minor erosion	Notable reduction in beach width and very minor erosion at the base of the dunes.	Accretion	Increase in beach width and build up at the base of the dunes.
B12 DOWN-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Increase in beach width and improvement of dune condition.	No change	No notable change in beach width or dune condition.	Accretion	Increase in beach width and build up at the base of the dunes.
B13 UP-COAST	Minor erosion	Slight reduction in beach width. Dunes remain in good condition.	Accretion	Increase in beach width and improvement of dune condition.	Minor erosion	Dune erosion is evident.	No change	No notable change in beach width or dune condition.
B13 DOWN-COAST	Minor erosion	Notable reduction in beach width. It is important to note that there was a storm surge of 0.2m during the April monitoring period which led to higher waterlines throughout the monitoring period.	Accretion	Increase in beach width and improvement of dune condition.	Minor erosion	Minor erosion is evident at the base of the dunes.	Minor erosion	Erosion is evident at the base of the dunes.



#### Table 4-4 Visual observations of beach changes at manual imagery monitoring sites in Amberton

Dhota Manitaring Cita	Seasonal Changes (October 2022 to April 2023)		Seasonal Changes (April 2022 to October 2022)		Long-term Changes		Long-term Changes		
Photo Monitoring Site	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	
Amberton									
B01 UP-COAST	Accretion	Notable improvement in dune condition.	Minor erosion	Reduction in beach width and erosion evident at the base of the dunes.					
B01 DOWN-COAST	Accretion	Notable improvement in dune condition.	Minor erosion	Reduction in beach width and significant erosion at the base of the dunes.	- Unable to assess – photo monitoring began in 2021.				

#### Table 4-5 Visual observations of beach changes at manual imagery monitoring sites in Shorehaven

	Seas (Octobe	sonal Changes r 2022 to April 2023)	Seas (Octobe	sonal Changes r 2021 to April 2022)	Long-term Changes		
Photo Monitoring Site	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Se
Shorehaven							
B01 UP-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Notable increase in beach width.			
B01 DOWN-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Notable increase in beach width.			onitori
B02 UP-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Notable increase in beach width.	Unable to asse		JIIIOII
B02 DOWN-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Notable increase in beach width.			

#### Table 4-6 Visual observations of beach changes at manual imagery monitoring sites in Eden

Dhota Manitaring Site	Seasonal Changes (October 2022 to April 2023)		Seasonal Changes (April 2022 to October 2022)		Long-term Changes		Long-term Changes	
Photo Monitoring Site	Severity of Beach Change	Beach Change Comments	Severity of Beach Change Beach Change Comments		Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Eden								
B01 UP-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Increase in beach width.	– Unable to assess – photo monitoring began in October 2021.			
B01 DOWN-COAST	Minor erosion	Notable reduction in beach width. Slight erosion at the base of the dunes.	Accretion	Increase in beach width.				

Long-term Changes				
everity of Beach Change	Beach Change Comments			
ng began in 2020.				



Table 4-7 Visual observations of beach changes at manual imagery monitoring sites in Quinns Rocks

	Seasonal Changes (October 2022 to April 2023)		Seasonal Changes (April 2022 to October 2022)		Long-term Changes (April 2014 to April 2023)		Long-term Changes (November 2013 to October 2022)	
Photo Monitoring Site	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Quinns Beach	•	•			·	•	•	•
B01	Major erosion	Notable reduction in beach width with notable erosion at the base of the dunes.	Accretion	Notable increase in beach width.	Accretion	Slight increase in beach width and improvement of dune condition and width.	Accretion	Slight increase in beach width and improvement of dune condition.
B03 UP-COAST	No change	No notable reduction in beach width. Dunes remain in good condition.	Accretion	Increase in beach width.	Accretion	Slight increase in beach width and improvement in dune condition.	Minor erosion	Slight reduction in beach width dunes in similar condition.
B03 DOWN-COAST	Minor erosion	Slight reduction in beach width. Dunes in good condition.	Accretion	Notable increase in beach width.	Minor erosion	Slight reduction in beach width.	Minor erosion	Slight reduction in beach width dunes in similar condition.
B04 UP-COAST	No change	No notable change in beach width. Dunes remain in similar condition.	No change	No notable change in beach width. Dunes remain in similar condition.	Minor erosion	Slight reduction in beach width.	Minor erosion	Slight reduction in beach width dunes in similar condition.
B04 DOWN-COAST	No change	No notable change in beach width. Dunes remain in similar condition.	No change	No notable change in beach width. Dunes remain in similar condition.	Minor erosion	Slight reduction in beach width.	Minor erosion	Slight reduction in beach width dunes in similar condition.
B06 UP-COAST	Accretion	Significant increase in beach width.	Major erosion	Significant reduction in beach width.	Minor erosion	Notable reduction in beach width however as the GSC was being constructed in 2014 which makes it difficult to assess the extent of erosion.	Minor erosion	Notable reduction in beach width however as there was no GSC revetment in 2013 it makes it difficult to assess the extent of the erosion.
B06 DOWN-COAST	Accretion	Significant increase in beach width.	Major erosion	Significant reduction in beach width.	Minor erosion	Notable reduction in beach width however as the GSC was being constructed in 2014 which makes it difficult to assess the extent of erosion.	Minor erosion	Notable reduction in beach width however as there was no GSC revetment in 2013 it makes it difficult to assess the extent of the erosion.
B07 UP-COAST	Minor erosion	Notable erosion in front of the carpark however there is still a significant beach in front of the revetment.	Accretion	Notable increase in beach width noting that sand nourishment was undertaken in April following manual imagery.	No change	No change in beach condition. It is important to note that $70,000 \text{ m}^3$ of nourishment has been undertaken at this site since 2013.	No change	No change in beach condition. It is important to note that 70,000 m <sup>3</sup> of nourishment has been undertaken at this site since 2013.
B07 DOWN-COAST	Accretion	Significant increase in beach width.	Major erosion	Significant reduction in beach width.	Minor erosion	Notable reduction in beach width however as there was no GSC revetment in 2014 it makes it difficult to assess the extent of the erosion.	Minor erosion	Notable reduction in beach width however as there was no GSC revetment in 2013 it makes it difficult to assess the extent of the erosion.
B09 UP-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Notable increase in beach width.	Accretion	Notable improvement in dune condition.	Accretion	Notable improvement in dune condition.
B09 DOWN-COAST	Accretion	Notable increase in beach width.	Minor erosion	Slight reduction in beach width and notable erosion at the base of the dunes.	Minor erosion	Notable reduction in beach width and slight reduction in dune width.	Minor erosion	Notable erosion at the base of the dunes.
B11 UP-COAST	No change	No notable change in beach condition. Dunes remain in good condition.	Minor erosion	Slight reduction in beach width to the south of the groyne.	Minor erosion	Reduction in dune width.	Minor erosion	Notable erosion at the base of the dunes.
B11 DOWN-COAST	No change	No notable change in beach condition. Dunes remain in good condition.	Accretion	Slight increase in beach width.	No change	Dunes are in a similar condition.	No change	Dunes are in a similar condition.
B13 UP-COAST	Major erosion	Significant reduction in beach width and notable erosion at the base of the dunes.	Accretion	Significant increase in beach width.	Minor erosion	Notable reduction in beach width with notable erosion at the base of the dunes.	Minor erosion	Notable reduction in beach width and minor erosion at the base of the dunes.
B13 DOWN-COAST	Accretion	Increase in beach width and improvement in dune condition.	Minor erosion	Decrease in beach width.	Minor erosion	Notable erosion at the base of the dunes.	Minor erosion	Notable erosion at the base of the dunes. Nourishment was undertaken in April 2022.
B14 UP-COAST	Minor erosion	Notable reduction in beach width.	Accretion	Notable accretion with increase in beach width.	Minor erosion	Notable reduction in beach width.	Minor erosion	Notable erosion at the base of the dunes.



	Seasonal Changes (October 2022 to April 2023)		Seasonal Changes (April 2022 to October 2022)		Long-term Changes (April 2014 to April 2023)		Long-term Changes (November 2013 to October 2022)	
Photo Monitoring Site	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments
Quinns Beach	Quinns Beach							
B14 DOWN-COAST	Accretion	Improvement in dune condition as a result of beach scraping works undertaken in February 2023.	Minor erosion	Notable reduction in beach width with erosion notable at the base of the dunes.	Minor erosion	Notable reduction in beach width.	Minor erosion	Notable erosion at the base of the dunes.
B15 UP-COAST	Minor erosion	Notable reduction in beach width.	Accretion	Slight increase in beach width.	Minor erosion*	Notable reduction in beach width.	Minor erosion**	Some notable erosion at the base of the dunes.
B15 DOWN-COAST	Minor erosion	Notable reduction in beach width. Dunes remain in good condition.	Accretion	Notable increase in beach width.	Minor erosion*	Notable reduction in beach width.	Accretion**	Notable accretion at the base of the dunes.
B16 UP-COAST	No change	No notable change in dune condition.	Minor erosion	Slight reduction in beach width.	Minor erosion*	Significant reduction in beach width.	Accretion**	Increase in beach width.
B16 DOWN-COAST	No change	No notable change in dune condition.	Minor erosion	Notable decrease in beach width.	Minor erosion*	Significant reduction in beach width.	Accretion**	Increase in beach width.
B17 UP-COAST	Accretion	Slight increase in beach width.	Minor erosion	Notable reduction in beach width and erosion at the base of the dunes.	Unable to economy Manitaring bagan in 2021			
B17 DOWN-COAST	Accretion	Slight increase in beach width.	Minor erosion	Notable reduction in beach width and erosion at the base of the dunes.	Unable to assess – Monitoring began in 2021.			

\*Long-term changes have been assessed through images taken in 2015. \*\*Long-term changes have been assessed through images taken in 2014.

Table 4-8 Visual observations of beach changes at manual imagery monitoring sites in Mindarie

Dhata Manitaring Site	Seasonal Changes		Sea (April 20	sonal Changes 022 to October 2022)	Lor	ng-term Changes	
Photo Monitoring Site	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Severity of Beach Change	Beach Change Comments	Se
Mindarie			-				
B01	Accretion	Significant increase in beach width. Noting that there was a significant storm surge during the monitoring period which resulted in a high-water line.	Major erosion	Significant reduction in beach width with notable erosion at the base of the dunes.			
B02 UP-COAST	Accretion	Significant increase in beach width and improvement in dune condition. Noting that there was a significant storm surge during the monitoring period which resulted in a high-water line.	Major erosion	Significant reduction in beach width with notable erosion at the base of the dunes.			
B02 DOWN-COAST	Accretion	Significant increase in beach width and improvement in dune condition. Noting that there was a significant storm surge during the monitoring period which resulted in a high-water line.	Major erosion	Significant reduction in beach width with notable erosion at the base of the dunes.		Unable to assess – mo	onitorin
B03	Accretion	Significant increase in beach width and improvement in dune condition. Noting that there was a significant storm surge during the monitoring period which resulted in a high-water line.	Major erosion	Significant reduction in beach width with notable erosion at the base of the dunes.			
B04	Minor erosion	Slight reduction in beach width.	Accretion	Slight increase in beach width.			

Long	-term Changes
everity of Beach Change	Beach Change Comments
ng began in 2020.	



## 4.2.1 Areas Experiencing Major Seasonal Erosion

While assessing seasonal changes, four areas were identified as having experienced major erosion over the summer period (October 2022 to April 2023) and three areas were identified as having experienced major erosion over the winter months (April 2022 to October 2022). Images of the identified areas experiencing major seasonal erosion are shown below.

# Two Rocks B04 – Major Erosion, Summer 2022/23



Figure 4-6

Major erosion over summer 2022/23 at Two Rocks B04.

Significant seasonal erosion was identified via manual imagery along northern Two Rocks beach, adjacent to the Sovereign Drive Beach Access Staircase. This site is situated within the Coastal Erosion Hotspot '21 – Two Rocks Northern Coast'. While seasonal erosion is identified at this site each year, major erosion is uncommon. The site is situated to the north of the Two Rocks Marina which interrupts the summer longshore sediment transport resulting in a narrow beach following the summer months.



# Yanchep B09 UP-COAST, B10 UP-COAST and B11 – Major Erosion, Summer 2022/23



Figure 4-7

Major erosion over summer 2022/23 along Yanchep Lagoon Beach.



Significant seasonal erosion was identified at Yanchep Lagoon Beach following the 2022/23 summer period. Yanchep Lagoon Beach is bound by a rock headland to the south which interrupts the longshore transport of sediment during the summer months. By the April 2023 monitoring period sediment had begun to move around the headland and build up at the southern end of Yanchep Lagoon Beach (Figure 4-7) however the major erosion was observed along the northern end of the beach.

# Quinns B01 UP-COAST – Major Erosion, Summer 2022/23



Figure 4-8 Major erosion over summer 2022/23 at Quinns B01 Up-Coast.

Quinns Beach site B01 is situated at the southern end of Quinns Beach and captures the beach area to the north of the rocky headland that is situated between Quinns Beach and Mindarie. Seasonal erosion is experienced at this site each year due to the seasonal northward movement of sand, away from the headland, however major seasonal erosion is uncommon at this site. The beach has eroded to the dune area with some notable vegetation loss.

# Quinns B13 UP-COAST – Major Erosion, Summer 2022/23



Figure 4-9

Major erosion over summer 2022/23 at Quinns B13 Up-Coast.

Quinns B13 manual imagery site is located at the base of Quinns Groyne 3. Significant seasonal erosion is experienced at this site each year following northward movement of sediment, away from the groyne, during the summer months. The City undertook renourishment at this site in May 2023, following the monitoring period, where 4,000 tonnes of sand was placed to protect the dune system from the impacts of winter storm events. While seasonal erosion is experienced at this site each year, there is evidence showing that sediment is contained within this section of beach and nearshore area by the groyne field (October 2022 Coastal Monitoring Report, City of Wanneroo).



# Yanchep B07 Up-Coast and Down-Coast – Major Erosion, Winter 2022



Figure 4-10 Major erosion over winter 2021 at Yanchep B07 Up-Coast and Down-Coast.

The beach captured in the photographs taken up-coast and down-coast at the Yanchep monitoring location B07 is bounded by a headland to the north and south. There was a significant reduction in beach width over the 2022 winter period with the transport of sediment southward over the winter months, bypassing the southern headland and feeding the beach area to the south, resulting in erosion at the site. Northward movement of sediment during the summer months resulted in significant accretion at the site which provided a substantial buffer against early winter storms. While there are major seasonal changes at the site, the long term manual imagery assessment suggests that the site has experienced very minor erosion since the start of monitoring in 2019. It is important to note, however, that residential houses and road infrastructure are in close proximity to the site and could, in future, be susceptible to the effects of coastal erosion. It is therefore recommended that the site be monitored closely.



# Quinns B06 and B07 Down-Coast – Major Erosion, Winter 2022



Figure 4-11 Major erosion over winter 2021 at Quinns B06 Up-Coast, Down-Coast and Quinns B07 Down-Coast.

Major seasonal erosion is experienced adjacent to the GSC and Rock Revetment at Quinns Rocks each year. The area is bound by Quinns Groyne 1 to the north and the Artificial Headland to the south. As presented in Figure 4-11 significant erosion was experienced over the 2022 winter period with very little beach remaining adjacent to the GSC Revetment. While seasonal erosion happens in the area each year, the GSC Revetment provides sufficient protection to adjacent assets and park land. The area will continue to be monitored and the GSC Revetment will continue to be assessed to ensure that it continues to function adequately as a coastal protection structure.



# Mindarie B01, B02 and B03 – Major Erosion, Winter 2022



Figure 4-12 Major erosion over winter 2021 at Mindarie B01, B02 and B03.

Significant erosion was observed at Clayton's Beach in Mindarie over the 2022 winter period. While the images show some beach remaining in October 2022, images taken at site B01 and B02 show



significant impact to the base of the dunes at Clayton's Beach. Clayton's Beach experiences significant seasonal erosion and accretion each year however, there was significant dune erosion in 2021 which left the area vulnerable to further erosion in 2022. While there is little infrastructure landward of Claytons Beach it is recommended that the area be closely monitored in future coastal monitoring reports and if significant erosion continues coastal management measures should be investigated for the area.

Dune volume loss is significant in some areas which is often not captured effectively through manual imagery. Dune volume loss is more effectively assessed through survey results as outlined in **Section 5.3**.

## 4.2.2 Areas Experiencing Major Longer Term Erosion

Two sites in Yanchep were identified through manual imagery as having experienced major erosion in the last four years of monitoring. These sites, which are outlined below in Figure 4-9, are situated to the north of Yanchep Lagoon.

# Yanchep B10 Down-Coast and B11 Down-Coast – Major Erosion



Figure 4-13 Significant long-term erosion at Yanchep Beach, north of Yanchep Lagoon.

Yanchep monitoring sites B10 and B11 are situated along the northern portion of the Yanchep Lagoon Beach. As outlined in Section 4.2.1 significant seasonal erosion was identified at Yanchep Lagoon Beach following the 2022/23 summer period which, when assessing long term changes to the coastline, resulted in major erosion at this site. Survey results (Section 5.2.3) also show a significant reduction in beach volume at this site between April 2019 and April 2023.


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#### Two Rocks B01 Up-Coast – Major Erosion



Figure 4-14 Significant long-term erosion at Two Rocks, north of the Two Rocks Marina.

Two Rocks monitoring site B01 is situated at the base of the northern breakwater and captures the beach immediately north of the Two Rocks Marina. While the field of view at this site makes it difficult to identify major erosion at this site, long term major erosion is evident in survey results and aerial imagery. The coastline captured in imagery taken at Two Rocks site B01 is classified as a Coastal Erosion Hotspot (Seashore Engineering, 2019).



# 5 LIDAR and Ground Based Transect Surveys

Both LiDAR aerial surveys and nearshore ground based transect surveys are undertaken by MNG Surveyors including all post processing and analysis. LiDAR surveys are captured along the entire CoW coastal corridor including, and in between, the following areas:

- Two Rocks Beach;
- Yanchep Beach;
- Quinns Rocks Beach; and
- Claytons Beach.

129 nearshore ground based transect surveys are captured around the same time as the LiDAR aerial surveys. These surveys extend into the nearshore area, to a maximum water depth of one meter, to collect the data within the nearshore area that is otherwise missed in LiDAR surveys due to constraints. LiDAR Aerial Surveys can only capture areas above the waterline and when the shoreline has receded, the area of available data for analysis is limited.

These surveys are undertaken 6 monthly in April and October each year, in line with the timing of manual photographic monitoring.

## 5.1 Assessment Methodology

14 discrete study areas within the overall survey area are assessed for changes in beach volume. Seasonal changes (October 2022 to April 2023) and annual changes (April 2022 to April 2023) to beach volume is assessed for each discrete area via difference plots of the two survey surfaces.

The data from ground based survey transects have been interpolated to estimate the changes in beach volume in areas below the waterline which is illustrated in the elevation difference plots. It is important to note that these volumes are estimates only.

129 beach cross sections are extracted from the aerial survey profiles within each of the study areas. These cross sections are combined with the nearshore ground based survey transects and compared to earlier cross sections to further evaluate the extent of seasonal and long term erosion or accretion at each transect location.

For this monitoring period, longer-term changes to beach volumes have been assessed for each of the 14 discrete study areas as well as an additional three study areas that capture the City's remaining coastline. The long-term beach volume changes are assessed via difference plots of the October 2018 to October 2022 and April 2019 to April 2023 surveys. An additional 50 beach cross sections were extracted from the aerial profiles in the additional three study areas that capture the City's remaining coastline. These cross sections show the four-year changes to the coastline in these areas.

## 5.2 Elevation Difference Plots

#### **5.2.1 Seasonal Changes**

Plots depicting the difference in elevation between the October 2022 surveys and April 2023 surveys are output by MNG. These plots are presented in **Appendix A**.

The change in beach volume between October 2022 and April 2023 is calculated for each of the 14 discrete study areas, the results of which are presented below in Table 5-1.



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<b>T</b> <i>i i i i</i>	o		~	( ) (	o
l able 5-1	Seasonal Net	Volume	Change	of Beach	Sections.

Beach Section	Section Description	Winter Net Volume Change October 2022 – April 2022	Summer Net Volume Change April 2023 – October 2022
Claytons Section 1A	Clayton's Beach, Mindarie above the waterline	-36,220 m <sup>3</sup>	+44,270 m <sup>3</sup>
Claytons Section 1B*	Clayton's Beach, Mindarie below the waterline	-52,828 m <sup>3</sup>	+51,329 m <sup>3</sup>
Quinns Section 1A	Quinns Main Beach – South of Artificial Headland above the waterline	+371 m <sup>3</sup>	+2,432 m <sup>3</sup>
Quinns Section 1B*	Quinns Main Beach – South of Artificial Headland below the waterline	+8,653 m <sup>3</sup>	-11,580 m <sup>3</sup>
Quinns Section 2A	Frederick Stubbs Park and GSC Revetment above the waterline	-8,807 m <sup>3</sup>	+9,592 m <sup>3</sup>
Quinns Section 2B*	Frederick Stubbs Park and GSC Revetment below the waterline	-13,182 m <sup>3</sup>	+14,156 m <sup>3</sup>
Quinns Section 3A	Frederick Stubbs Carpark, South of Groyne 2 above the waterline	-1,599 m <sup>3</sup>	+5,290 m <sup>3</sup>
Quinns Section 3B*	Frederick Stubbs Carpark, South of Groyne 2 below the waterline	-2,977 m <sup>3</sup>	+1,520 m <sup>3</sup>
Quinns Section 4A	North of Groyne 2, South of Groyne 3 above the waterline	-1,265 m <sup>3</sup>	+1,744 m <sup>3</sup>
Quinns Section 4B*	North of Groyne 2, South of Groyne 3 below the waterline	-930 m <sup>3</sup>	-163 m <sup>3</sup>
Quinns Section 5A	North of Groyne 3, South of Groyne 4 above the waterline	-3,896 m <sup>3</sup>	-1,065 m <sup>3</sup>
Quinns Section 5B*	North of Groyne 3, South of Groyne 4 below the waterline	+4,533 m <sup>3</sup>	-2,804 m <sup>3</sup>
Quinns Section 6A	North of Groyne 4, Jindalee above the waterline	-8,710 m <sup>3</sup>	+5,687 m <sup>3</sup>
Quinns Section 6B*	North of Groyne 4, Jindalee below the waterline	-2,914 m <sup>3</sup>	+26 m <sup>3</sup>
Yanchep Section 1A	South of Fisherman's Hollow Beach Access above the waterline	+2,906 m <sup>3</sup>	+1,534 m <sup>3</sup>
Yanchep Section 1B*	South of Fisherman's Hollow Beach Access above the waterline	+3,170 m <sup>3</sup>	-2,459 m <sup>3</sup>
Yanchep Section 2A	South of Headland, North of Fisherman's Hollow Beach Access above the waterline	+41 m <sup>3</sup>	+6,470 m <sup>3</sup>
Yanchep Section 2B*	South of Headland, North of Fisherman's Hollow Beach Access below the waterline	-19,248 m <sup>3</sup>	+21,101 m <sup>3</sup>
Yanchep Section 3A	Yanchep Lagoon above the waterline	+2,439 m <sup>3</sup>	-1,183 m <sup>3</sup>
Yanchep Section 3B*	Yanchep Lagoon below the waterline	+3,571 m <sup>3</sup>	-219 m <sup>3</sup>
Yanchep Section 4A	South of Capricorn Groyne above the waterline	-7,382 m <sup>3</sup>	+4,114 m <sup>3</sup>
Yanchep Section 4B*	South of Capricorn Groyne below the waterline	+2,930 m <sup>3</sup>	-6,005 m <sup>3</sup>
Yanchep Section 5A	North of Capricorn Groyne above the waterline	+911 m <sup>3</sup>	-614 m <sup>3</sup>
Yanchep Section 5B*	North of Capricorn Groyne below the waterline	-928 m <sup>3</sup>	-3,355 m <sup>3</sup>



Beach Section	Section Description	Winter Net Volume Change October 2022 – April 2022	Summer Net Volume Change April 2023 – October 2022
Two Rocks Section 1A	South of Two Rocks Marina above the waterline	-15,764 m <sup>3</sup>	+32,197 m <sup>3</sup>
Two Rocks Section 1B*	South of Two Rocks Marina below the waterline	-14,555 m <sup>3</sup>	+19,630 m <sup>3</sup>
Two Rocks Section 2A	North of Two Rocks Marina above the waterline	-7,225 m <sup>3</sup>	+3,116 m <sup>3</sup>
Two Rocks Section 2B*	North of Two Rocks Marina below the waterline	+5,910 m <sup>3</sup>	-2,731 m <sup>3</sup>

\*These values are interpolated from the results of the ground based transects and are an estimate of the volume changes below the waterline. The volume changes above the waterline are calculated from LiDAR surveys that have a resolution of +10 points per square meter whereas these volume changes are calculated from ground based transects that are approximately 100m apart.

Overall, there was an increase in beach volume across the 2022/23 summer period. The combined net volume changes of the Mindarie, Quinns, Yanchep and Two Rocks foreshore areas are as follows:

- The one beach section that is assessed within the Mindarie foreshore area had an estimated net beach volume gain of 95,599 m<sup>3</sup> between October 2022 and April 2023;
- The six beach sections along the Quinns foreshore area had an estimated combined net beach volume gain of 24,835 m<sup>3</sup> between October 2022 and April 2023;
- The five beach sections along the Yanchep foreshore area had an estimated combined net beach volume gain of 19,384 m<sup>3</sup> between October 2022 and April 2023; and
- The two beach sections along the Two Rocks foreshore area had an estimated combined net beach volume gain of 52,212 m<sup>3</sup> between October 2022 and April 2023.

While these results represent an overall increase in beach volume over the 2022/23 summer period there was a significant reduction in beach volume across the winter period of 2022. However, in Mindarie, Yanchep and Two Rocks there was a greater net volume gain over the summer period than there was net volume loss in winter 2022. For Quinns Beach, however, the total net beach volume loss in winter 2022 (30,723 m<sup>3</sup>) was not gained back over the summer.

Areas with significant seasonal changes in beach volume were consistent with manual imagery observations. It is important to note that the areas below the waterline are an estimate however the data does provide an improved understanding of how sediment is transported locally within these beach segments.

#### 5.2.2 Annual Changes – April 2022 to April 2023

Elevation difference plots depicting the difference in surface elevation between the April 2022 surveys and April 2023 surveys are output by MNG.

The change in beach volume over the year is calculated for each of the 14 discrete study areas, the results of which are presented below in Table 5-2.

Beach Section	Section Description	Net Volume Change April 2023 – April 2022
Clayton Section 1A	Clayton's Beach above the waterline	+11,065 m <sup>3</sup>
Clayton Section 1B*	Clayton's Beach below the waterline	-5,988 m <sup>3</sup>
Quinns Section 1A	Quinns Main Beach – South of Artificial Headland above the waterline	+2,035 m <sup>3</sup>
Quinns Section 1B*	Quinns Main Beach – South of Artificial Headland below the waterline	-3,909 m <sup>3</sup>

Table 5-2 Annual Net Volume Change of Beach Sections April 2023 – April 2022.



Beach Section	Section Description	Net Volume Change April 2023 – April 2022
Quinns Section 2A	Frederick Stubbs Park and GSC Revetment above the waterline	+1,549 m <sup>3</sup>
Quinns Section 2B*	Frederick Stubbs Park and GSC Revetment below the waterline	+816 m <sup>3</sup>
Quinns Section 3A	Frederick Stubbs Carpark, South of Grovne 2 above the waterline	+3,211 m <sup>3</sup>
Quinns Section 3B*	Frederick Stubbs Carpark, South of Grovne 2 below the waterline	+546 m <sup>3</sup>
Quinns Section 4A	North of Groyne 2, South of Groyne 3 above the waterline	+943 m <sup>3</sup>
Quinns Section 4B*	North of Groyne 2, South of Groyne 3 below the waterline	-1,397 m <sup>3</sup>
Quinns Section 5A	North of Groyne 3, South of Groyne 4 above the waterline	-2,638 m <sup>3</sup>
Quinns Section 5B*	North of Groyne 3, South of Groyne 4 below the waterline	-2,293 m <sup>3</sup>
Quinns Section 6A	North of Groyne 4, Jindalee above the waterline	-1,989 m <sup>3</sup>
Quinns Section 6B*	North of Groyne 4, Jindalee below the waterline	-3,911 m <sup>3</sup>
Yanchep Section 1A	South of Fisherman's Hollow Beach Access above the waterline	+7,284 m <sup>3</sup>
Yanchep Section 1B*	South of Fisherman's Hollow Beach Access below the waterline	-2,689 m <sup>3</sup>
Yanchep Section 2A	South of Headland, North of Fisherman's Hollow Beach Access above the waterline	+6,747 m <sup>3</sup>
Yanchep Section 2B*	South of Headland, North of Fisherman's Hollow Beach Access below the waterline	+2,517 m <sup>3</sup>
Yanchep Section 3A	Yanchep Lagoon above the waterline	+1,393 m <sup>3</sup>
Yanchep Section 3B*	Yanchep Lagoon below the waterline	+3,102 m <sup>3</sup>
Yanchep Section 4A	South of Capricorn Groyne above the waterline	+1,937 m <sup>3</sup>
Yanchep Section 4B*	South of Capricorn Groyne below the waterline	-8,570 m <sup>3</sup>
Yanchep Section 5A	North of Capricorn Groyne above the waterline	+7 m <sup>3</sup>
Yanchep Section 5B*	North of Capricorn Groyne below the waterline	-765 m <sup>3</sup>
Two Rocks Section 1A	South of Two Rocks Marina above the waterline	+16,351 m <sup>3</sup>
Two Rocks Section 1B*	South of Two Rocks Marina below the waterline	+12,555 m <sup>3</sup>
Two Rocks Section 2A	North of Two Rocks Marina above the waterline	-651 m <sup>3</sup>
Two Rocks Section 2B*	North of Two Rocks Marina below the waterline	-2,777 m <sup>3</sup>

\*These values are interpolated from the results of the ground based transects and are an estimate of the volume changes below the waterline. The volume changes above the waterline are calculated from LiDAR surveys that have a resolution of +10 points per square meter whereas these volume changes are calculated from ground based transects that are approximately 100m apart.

The combined net volume changes of the Mindarie, Quinns, Yanchep and Two Rocks foreshore areas for the year are as follows:

• The one beach section that is assessed within the Mindarie foreshore area had an estimated net beach volume gain of 5,077 m<sup>3</sup> between April 2022 and April 2023;



- The six beach sections along the Quinns foreshore area had an estimated combined net beach volume loss of 7,037 m<sup>3</sup> between April 2022 and April 2023;
- The five beach sections along the Yanchep foreshore area had an estimated combined net beach volume gain of 10,963 m<sup>3</sup> between April 2022 and April 2023; and
- The two beach sections along the Two Rocks foreshore area had an estimated combined net beach volume gain of 25,478 m<sup>3</sup> between October 2022 and April 2023.

It is apparent that there was a significant gain in beach volume across the year in all areas aside from Quinns Beach. It is important to note that as part of the annual beach renourishment programme, 9,000 tonnes (~6,500 m<sup>3</sup>) of sand was placed in April 2022 for renourishment at Quinns Sections 3A and 5A. Additionally, in response to the erosion caused by the 2022 winter storms, reactive beach renourishment works were also undertaken at Yanchep Section 3, where 2,693 tonnes (~1,750 m<sup>3</sup>) was placed in September 2022.

## 5.2.3 Long-Term (4 Year) Changes

Elevation difference plots depicting the difference in surface elevation between the October 2022 and October 2018 surveys and the April 2023 and April 2019 survey were output by MNG.

The change in beach volume over the four years is calculated for each of the 14 discrete study areas, the results of which are presented below in Table 5-3.

Beach Section	Section Description	Four Year Net Volume Change October 2022 – October 2018	Four Year Net Volume Change April 2023 – April 2019
Claytons Section 1A	Clayton's Beach, Mindarie above the waterline	+7,159 m <sup>3</sup>	+17,597 m <sup>3*</sup>
Claytons Section 1B*	Clayton's Beach, Mindarie below the waterline	+746 m <sup>3</sup>	-5,893 m <sup>3</sup>
Quinns Section 1A	Quinns Main Beach – South of Artificial Headland above the waterline	+27,016 m <sup>3</sup>	+17,414 m <sup>3</sup>
Quinns Section 1B*	Quinns Main Beach – South of Artificial Headland below the waterline	+79 m <sup>3</sup>	+1,912 m <sup>3</sup>
Quinns Section 2A	Frederick Stubbs Park and GSC Revetment above the waterline	-3,403 m <sup>3</sup>	+3,283 m <sup>3</sup>
Quinns Section 2B*	Frederick Stubbs Park and GSC Revetment below the waterline	-2,408 m <sup>3</sup>	-183 m <sup>3</sup>
Quinns Section 3A	Frederick Stubbs Carpark, South of Groyne 2 above the waterline	-4,066 m <sup>3</sup>	-3,212 m <sup>3</sup>
Quinns Section 3B*	Frederick Stubbs Carpark, South of Groyne 2 below the waterline	-603 m <sup>3</sup>	-1,299 m <sup>3</sup>
Quinns Section 4A	North of Groyne 2, South of Groyne 3 above the waterline	-3,251 m <sup>3</sup>	-2,576 m <sup>3</sup>
Quinns Section 4B*	North of Groyne 2, South of Groyne 3 below the waterline	-72 m <sup>3</sup>	-48 m <sup>3</sup>
Quinns Section 5A	North of Groyne 3, South of Groyne 4 above the waterline	-13,025 m <sup>3</sup>	-12,772 m <sup>3</sup>
Quinns Section 5B*	North of Groyne 3, South of Groyne 4 below the waterline	-1,491 m <sup>3</sup>	-1,462 m <sup>3</sup>
Quinns Section 6A	North of Groyne 4, Jindalee above the waterline	-11,336 m <sup>3</sup>	-12,205 m <sup>3</sup>

Table 5-3 4-Year Net Volume Change of Beach Sections April 2023 – April 2019 and October 2022 – October 2018.



Beach Section	Section Description	Four Year Net Volume Change October 2022 – October 2018	Four Year Net Volume Change April 2023 – April 2019
Quinns Section 6B*	North of Groyne 4, Jindalee below the waterline	-351 m <sup>3</sup>	-6,261 m <sup>3</sup>
Yanchep Section 1A	South of Fisherman's Hollow Beach Access above the waterline	+12,734 m <sup>3</sup>	+6,289 m <sup>3</sup>
Yanchep Section 1B*	South of Fisherman's Hollow Beach Access above the waterline	+334 m <sup>3</sup>	-2,621 m <sup>3</sup>
Yanchep Section 2A	South of Headland, North of Fisherman's Hollow Beach Access above the waterline	+4,649 m <sup>3</sup>	+5,989 m <sup>3</sup>
Yanchep Section 2B*	South of Headland, North of Fisherman's Hollow Beach Access below the waterline	+113 m <sup>3</sup>	-2,356 m <sup>3</sup>
Yanchep Section 3A	Yanchep Lagoon above the waterline	+3,257 m <sup>3</sup>	+3,846 m <sup>3</sup>
Yanchep Section 3B*	Yanchep Lagoon below the waterline	-285 m <sup>3</sup>	+281 m <sup>3</sup>
Yanchep Section 4A	South of Capricorn Groyne above the waterline	+2,835 m <sup>3</sup>	-1,537 m <sup>3</sup>
Yanchep Section 4B*	South of Capricorn Groyne below the waterline	+1,182 m <sup>3</sup>	-7,497 m <sup>3</sup>
Yanchep Section 5A	North of Capricorn Groyne above the waterline	-5,424 m <sup>3</sup>	-5,240 m <sup>3</sup>
Yanchep Section 5B*	North of Capricorn Groyne below the waterline	+272 m <sup>3</sup>	-732 m <sup>3</sup>
Two Rocks Section 1A	South of Two Rocks Marina above the waterline	+33,856 m <sup>3</sup>	+50,529 m <sup>3</sup>
Two Rocks Section 1B*	South of Two Rocks Marina below the waterline	+226 m <sup>3</sup>	+2,506 m <sup>3</sup>
Two Rocks Section 2A	North of Two Rocks Marina above the waterline	-8,311 m <sup>3</sup>	-15,207 m <sup>3</sup>
Two Rocks Section 2B*	North of Two Rocks Marina below the waterline	-2 m <sup>3</sup>	-2,109 m <sup>3</sup>

\*Please note that the elevation difference plots captured significant fill within the foreshore that was undertaken as part of the Catalina Estate Development in Mindarie and this has impacted the results.

The combined net volume changes of the Mindarie, Quinns, Yanchep and Two Rocks foreshore areas over the past four years are as follows:

- The one beach section that is assessed within the Mindarie foreshore area had an estimated net beach volume <u>gain</u> of 7,905 m<sup>3</sup> between October 2018 and October 2022 and a net <u>gain</u> of 11,704 m<sup>3</sup> between April 2019 and April 2023;
- The six beach sections along the Quinns foreshore area had an estimated combined net beach volume loss of 12,914 m<sup>3</sup> between October 2018 and October 2022 and a net loss of 17,409 m<sup>3</sup> between April 2019 and April 2023;
- The five beach sections along the Yanchep foreshore area had an estimated net beach volume gain of 19,667 m<sup>3</sup> between October 2018 and October 2022 and a net loss of 3,578 m<sup>3</sup> between April 2019 and April 2023; and
- The two beach sections along the Two Rocks foreshore area had an estimated combined net beach volume gain of 25,769 m<sup>3</sup> between October 2018 and October 2022 and a net gain of 35,719 m<sup>3</sup> between April 2019 and April 2023.

Quinns Beach continues to have a net reduction in beach volume while other areas, particularly Two Rocks, had a significant net gain in beach volume. It is important to note that Quinns Beach continues to have a net beach volume loss despite approximately 50,000m<sup>3</sup> of nourishment sand that has been



placed along Quinns Beach since October 2018 as part of the City's ongoing Beach Renourishment Program.

While the 4-year comparison taken from the October surveys show a net beach volume gain along Yanchep Beach over the four-year period, the comparison taken from the April surveys show a net beach volume loss along the Yanchep foreshore. Major erosion was noted along the northern end of Yanchep Lagoon Beach (Yanchep Section 4) over the 2022/23 summer period (see Section 4.2.1) which has likely resulted in the significant volume loss within this area. The elevation difference plots show that the most significant areas of volume loss are within the dune areas in Yanchep Section 4 and Section 5, north Yanchep Lagoon Beach, which is consistent with manual imagery observations.

The change in beach volume over the four years was also calculated for the additional areas along the City's coastline. The remaining coastline was divided up into an additional three discrete study areas, the results of which are presented below in Table 5-4.

Table 5-4 4-Year Net Volume Change of Additional Beach Sections April 2023 – April 2019 and October 2022 – October 2018.

Beach Section	Section Description	Three Year Net Volume Change October 2022 – October 2019	Four Year Net Volume Change April 2023 – April 2019
Eden & Alkimos	Spanning from the south of Eden Beach to the north of Alkimos Beach.	-26,584 m <sup>3</sup>	-28,365 m <sup>3</sup>
Amberton & Shorehaven	Spanning from the south of Shorehaven Beach, past Amberton Beach to the north.	-16,513 m <sup>3</sup>	-9,141 m³
The Spot	The foreshore area between Yanchep north and Two Rocks south.	+99,706 m <sup>3</sup>	+146,838 m <sup>3</sup>

The results show a significant increase in volume along the foreshore area between Yanchep and Two Rocks. While the results for Two Rocks Section 1 show a net increase in beach volume, the increase between Yanchep and Two Rocks represents a significant trend in accretion in this area. Elevation difference plots of the area show that most of the volume gain is between the Two Rocks Marina and the rocky headland situated at 'The Spot' surf break between Two Rocks and Yanchep.

The results also show a significant net reduction in volume along the Eden, Alkimos, Amberton and Shorehaven residential development areas. While most of this coastline remains undeveloped, a number of sites are currently being developed by private land developers, it is important that the extent of beach volume loss in these area be accounted for in any future developments.

## 5.3 Beach Cross Section Results

Beach cross sections of areas that were identified as having experienced major erosion in the manual imagery analysis (**Section 4.2**) were analysed to assess the extent of erosion experienced in these areas. The results are presented below.





#### 5.3.1 Two Rocks B04 – Major Erosion, Summer 2022/23



Two Rocks beach cross-section 17 is situated within the field of view of manual imagery point 'Two Rocks B04 Up-Coast and Down-Coast'. The cross section shows a maximum height difference of 2.64m between surveys, just below the water line. The results of the cross section are consistent with manual imagery observations and show a significant reduction in elevation at this site.



#### 5.3.2 Yanchep B09, B10 and B11– Major Erosion, Summer 2022/23

Figure 5-2 Yanchep cross section 32 elevation comparison between April 2023 and October 2022 surveys.

Cross section 32 is one of a number of cross-sections that are situated within the field of view of manual imagery sites B09, B10 and B11. The cross-sectional survey results show a maximum elevation difference of 1.95m between surveys and a recession of the dunes, which is consistent with manual imagery observations that show major erosion along this area between October 2022 and April 2023.





#### 5.3.3 Quinns Rocks B01– Major Erosion, Summer 2022/23



Quinns Beach cross-section 1 is situated within the field of view of manual imagery point 'Quinns Rocks B01'. The cross section shows a maximum reduction in elevation of 2.55m between the April 2023 and October 2022, just below the water line. The results of the cross section are consistent with manual imagery observations and show a significant reduction in elevation at this site.

# 5.3.4 Quinns Rocks B13 Up-Coast – Major Erosion, Summer 2022/23



Figure 5-4

Quinns beach cross section 29 elevation comparison between October 2022 and April 2023 surveys.



Quinns beach cross-section 29 is situated within the field of view of manual imagery point 'Quinns Rocks B13 Up-Coast'. Figure 5-4 shows a significant reduction in elevation (2.17m) between the October 2022 and April 2023 surveys which is consistent with the major seasonal summer erosion that was identified at the site through manual imagery analysis (**Section 4.2.1**). Significant seasonal summer erosion is common at this site as strong sea breeze conditions promote the northward transport of sediment, away from Quinns Groyne 3.

#### 5.3.5 Yanchep B07 Up-Coast and Down-Coast – Major Erosion, Winter 2022



Section 21 [E32020.00, N307577.30 to E31928.96, N307535.69]

Figure 5-5 Yanchep Beach cross section 21 elevation comparison between April 2022 and October 2022 surveys.

Yanchep Beach cross section 21 is situated within the field of view of manual imagery point 'Yanchep B07 Up-Coast' where significant erosion was observed between April and October 2022 in manual imagery. While levels above the water line show only a minor drop in elevation, levels below the water line show quite a significant reduction in elevation, with the maximum height difference between the April and October 2022 survey was 2.04m. These results outline the benefits of undertaking additional ground based nearshore survey transects as the results from these surveys can capture areas of significant erosion that is otherwise not captured through LiDAR Aerial Surveys. The results from this cross section are consistent with manual imagery observations.





## 5.3.6 Quinns B06 Down-Coast – Major Erosion Winter 2022

Figure 5-6 Quinns Beach cross section 13 elevation comparison between April 2022 and October 2022 surveys.

Quinns Beach cross section 13 is situated within the field of view of manual monitoring point 'Quinns B06 Down-Coast'. The elevation difference presented in Figure 5-6 shows quite significant erosion at the site over the winter period, between April and October 2022, which is consistent with manual imagery observations. The most significant drop in elevation (1.72m) was recorded at the waterline. This area experiences significant seasonal erosion each year, as sediment builds up southward of Quinns Groyne 1 in the summer months and erodes in the winter months as sand moves southward.



## 5.3.7 Quinns B07 Down-Coast and B06 Up-Coast – Major Erosion Winter 2022



Figure 5-7 Quinns Beach cross section 14 elevation comparison between April 2022 and October 2022 surveys.

Quinns Beach cross section 14 is situated within the field of view of both Quinns manual imagery sites 'B07 Down-Coast' and 'B06 Up-Coast'. The cross section shows a significant drop in elevation between April and October 2022, where the maximum recorded elevation difference was 2.56m. The significant elevation difference recorded between April and October 2022 is consistent with manual imagery observations at the site (**Section 4.2**).

# 5.3.8 Mindarie B01, B02 Up-Coast & B03 - Major Erosion Winter 2022



Figure 5-8 Mindarie cross section 20 elevation comparison between April 2022 and October 2022 surveys.

Mindarie cross section 20 is situated within the field of view of Mindarie manual imagery sites 'B01', 'B02 Up-Coast' and 'B03'. The elevation difference between April 2022 and October 2022 shows



significant erosion at the site which is consistent with the manual imagery observations outlined in **Section 4.2.1**. Additional to Quinns Beach cross section 14 and Yanchep Beach cross section 21, the most significant elevation difference (2.36m) was recorded below the water level, demonstrating the importance of nearshore ground based transects for assessing the extent of erosion at the site. Significant seasonal erosion is also experienced at this site each year as the beach is bound by the Mindarie Breakwater to the north which interrupts the longshore sediment transport.

#### **5.3.9 Additional Transects with Significant Elevation Difference**

A number of transects, additional to those identified through manual imagery, were identified as having significant elevation difference (greater than 2.0m) between surveys. These areas were not identified in manual imagery observations but represent areas of major erosion and are important to identify as part of the coastal monitoring program.

#### 5.3.9.1 Quinns

Results from the cross section comparisons show major erosion between April 2022 to April 2023 at an additional site along Quinns Beach that was not identified through manual imagery. This site, and the corresponding manual imagery site, is outlined below.

#### Cross Section 32 – Manual Imagery Site B14 Down-Coast





Cross section 32 at Quinns Beach which shows dune recession of 3m between April 2023 and April 2022.



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Figure 5-10 Manual images taken at Quinns B14 Down-Coast.

The cross section presented in Figure 5-9 indicates a significant recession of the dune face between the April 2022 survey and the April 2023 survey. This was not identified in manual imagery (Figure 5-10) as the dune face is not a main focus of the manual imagery field of view and recession in the dune face is difficult to interpret using manual imagery alone. Beach scraping was undertaken at this location in February 2023 to build-up the base of the dune system and protect the site from the impacts of winter storms. Despite this, there was still a significant recession of the upper dune face over the past 12 months.



#### 5.3.9.2 Yanchep

Figure 5-11 Additional Yanchep cross section 41 that experienced major erosion between April 2022 and April 2023 surveys.

The results from cross section 41 along Yanchep Beach show a significant drop in elevation of the beach profile between April 2022 and April 2023. This site is located immediately south of Capricorn Groyne and is not within the field of view of formal manual imagery sites. The area was noted as having experienced major erosion in October 2022 while on site where considerable dune erosion had exposed a historical beach access staircase.

## 5.4 Notable Long-Term Cross Section Changes

Several areas with significant elevation difference (greater than 2.0m) between October 2019 and October 2022 as well as April 2019 and April 2023 were identified. These cross sections show the sites that have experiences significant erosion over the past four years.



#### Eden Beach Cross-Section 6 and 8



Section 6 [E36334.08, N298664.06 to E36261.44, N298612.39]

Figure 5-12 Cross section 6 at Eden Beach which shows dune recession of approximately 8m between April 2019 and April 2023.





Eden Beach cross section 6 is situated to the north of Eden Beach, just south of Eden Beach Access Way 3 and Eden Beach cross section 8 is located adjacent to Eden Beach Access Way 4. The crosssections show a significant reduction in elevation (maximum 6.08m) and a dune recession of almost 8m between the April 2019 and April 2023 surveys. There is no manual imagery site at this location. This foreshore area is still managed by a private land developer and this information has been passed on to the current land manager. Significant erosion was noted at this site by Land Development following a Practical Completion Meeting in early 2023.



#### **Amberton Cross-Section 11**



Figure 5-14 Cross section 11 at Amberton Beach which shows dune recession of 3m between October 2019 and April 2023.

Amberton cross-section 11 is situated to the south of the Amberton Residential Development and is not within the field of view of any manual imagery sites. The cross-section comparison shows a significant reduction in elevation between the October 2022 and October 2019 surveys representing major erosion at this site. This area is yet to be developed.

#### **Amberton Cross-Section 20**





Amberton cross-section 20 is located approximately 1.2km north of the Amberton Residential Development and is not within the field of view of any manual imagery sites. The cross-section comparison shows a significant reduction in elevation between the October 2022 and October 2019 surveys representing major erosion at this site however this area is yet to be developed.

#### The Spot Cross-Section 7



Figure 5-16 The Spot beach cross-section 7 October 2019 to October 2022 elevation difference.

The Spot cross-section 7 is situated to the south of the rocky headland between Yanchep and Two Rocks. The cross-section comparison shows a significant reduction in elevation between the October 2022 and October 2019 surveys representing major erosion at this site however this area is yet to be developed.

![](_page_54_Picture_0.jpeg)

# 6 Remote Monitoring

Five remote monitoring cameras were installed along Quinns and Yanchep Beach in November 2021. The location and field of view of the cameras was selected to monitor vulnerable sections of the City coastline, these locations are presented below in Figure 6-1 and Figure 6-2. These cameras take photos hourly between the hours of 7:00 and 18:00. Timelapse videos were created for each camera to assess morphological changes to the coastline for the study period.

![](_page_54_Picture_4.jpeg)

Figure 6-1

Quinns Rocks Remote Coastal Monitoring Camera Locations.

![](_page_55_Picture_0.jpeg)

![](_page_55_Picture_2.jpeg)

Figure 6-2

Yanchep Remote Coastal Monitoring Location.

![](_page_56_Picture_0.jpeg)

## 6.1 Quinns Camera 1

Quinns Camera 1 captures the beach immediately to the south of Groyne 1, adjacent to the GSC Revetment. There were technical issues with this camera during the study period and, unfortunately, the camera was not operational between October 2022 and April 2023. The time series of images taken from Quinns Camera 1 between April 2022 and October 2022 show steady erosion of the site during this period, with the most accreted position identified to be at the start of the monitoring period. Significant seasonal erosion is experienced at this site each year and manual imagery monitoring suggests that following October 2022, there was significant accretion at the site between October 2022 and April 2023.

![](_page_56_Picture_4.jpeg)

 Most receded position – 30 July 2022
 Most accreted position – 6 April 2022

 Figure 6-3
 Most receded and most accreted shoreline position to the south of Quinns Groyne 1 during the study period.

## 6.2 Quinns Camera 2

Quinns Camera 2 captures the beach immediately north of Groyne 1 in Quinns Rocks, adjacent to the Frederick Stubbs Carpark. Following the renourishment that was undertaken in April 2022, hourly imagery shows the beach area adjacent to the carpark steadily accreting over the winter period, with some discrete erosion events. In November, this beach area begins to erode with northward longshore transport depositing sand to the south of Groyne 2. Steady erosion of the beach area immediately adjacent to Frederick Stubbs Carpark continues up until late January 2023 where sediment transported from the beach to the south of Groyne 1 bypasses around the Groyne and is deposited on the beach.

![](_page_57_Picture_0.jpeg)

![](_page_57_Picture_2.jpeg)

 Most receded position – 30 January 2023
 Most accreted position – 18 August 2022

 Figure 6-4
 Most receded and most accreted shoreline position to the north of Quinns Groyne 1 during the study period.

## 6.3 Quinns Camera 3

Quinns Camera 3 monitors the beach and dunes to the south of Quinns Groyne 4. At the start of the monitoring period, April 2022, the beach is wide and the dunes are in fair condition. The beach is steadily eroding between April and October 2022 with a number of major erosion events in May and August 2022 causing dune recession and loss of beach. The most receded shoreline position was observed just after the August storm event, which resulted in significant dune erosion at the site and exposure of limestone bedrock on the beach. There was considerable erosion at this site prior to the August storm event which left the beach and dunes vulnerable to impacts of the storm. The beach area begins steadily accreting from October 2022 as summer wind conditions drive northward longshore transport. The most accreted beach position was identified to in March 2023.

![](_page_57_Picture_6.jpeg)

 Most receded position – 4 August 2022
 Most accreted position – 6 March 2023

 Figure 6-5
 Most receded and most accreted shoreline position to the south of Quinns Groyne 4 during the study period.

![](_page_58_Picture_0.jpeg)

## 6.4 Quinns Camera 4

There was little beach area to the north of Quinns Groyne 4 at the start of the monitoring period, in April 2022 which left little defence to the effects of the early May 2022 storm event. After May, the beach area begins to steadily accrete as sediment is transported southward during the winter months and builds up against Quinns Groyne 4. The beach continues accreting until December 2022, at which point northward longshore sediment transport driven by summer sea breezes leaves a narrow beach by the end of the monitoring period.

![](_page_58_Figure_4.jpeg)

 Most receded position – 20 May 2022
 Most accreted position – 13 December 2022

 Figure 6-6
 Most receded and most accreted shoreline position to the north of Quinns Groyne 4 during the study period.

## 6.5 Yanchep Camera

Notably, at Yanchep Lagoon, both the most accreted and eroded position during the study period was observed during winter 2022. There was a notable build-up of the beach area to the south of the Lagoon from December 2022 to March 2023, this is likely a result of longshore sediment transport, driven by prevailing southerly winds, moving sand from Fisherman's Hollow Beach to the south, bypassing the headland, depositing on Yanchep Lagoon Beach. Notably, this summer, there was significant erosion along the northern portion of Yanchep Lagoon Beach, as outlined in Section 4.2.1. It is possible that this is a result of higher wind speeds were observed over the 2022/23 summer period (Section 2.2).

At the end of the study period there is significant build-up to the south of Yanchep Lagoon Beach with an eroded beach to the north.

![](_page_59_Picture_0.jpeg)

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![](_page_59_Picture_2.jpeg)

 Most receded position
 - 12 August 2022
 Most accreted position
 - 7 June 2022

 Figure 6-7
 Most receded and most accreted shoreline position at Yanchep Lagoon Beach.

![](_page_60_Picture_0.jpeg)

# 7 Aerial Imagery

Aerial imagery obtained from Nearmap and taken during the 6 monthly LiDAR Surveys is used to assess changes of the CoW coastline.

The improved temporal resolution of aerial imagery allows us to assess the condition of the coastline throughout the year, unlike manual imagery where we are limited to only two snapshots in time. However, analysis of aerial imagery is limited to assessing the changes to the coastline, which in this instance, is defined as the coastal vegetation line.

During the study period, from April 2022 to April 2023, a total of ten aerial images of the sites were available.

Monitoring Date	Monitoring Time	Source	Water Level at Time of Monitoring (Fremantle Tide Gauge – mAHD)
4 April 2022	12:29 PM to 4:01 PM	MNG	0.12 to 0.47 mAHD
15 April 2022	9:53 AM	Nearmap	0.17 mAHD
28 May 2022	Unknown	Nearmap	-0.05 to 0.64 mAHD
1 October 2022	09:33 AM	Nearmap	-0.22 mAHD
3 October 2022	10:30 AM to 4:30 PM	MNG	-0.36 to -0.19 mAHD
4 December 2022	9:20 AM to 10:14 AM	Nearmap	0.00 to
25 February 2023	9:40 AM to 3:08 PM	Nearmap	0.11 to 0.30 mAHD
23 April 2023	10:20 AM to 3:20 PM	Nearmap	0.36 to 0.71 mAHD
29 April 2023	10:35 AM	Nearmap	0.16 mAHD

Table 7-1 Date of Aerial Images

## 7.1 Assessment Methodology

Similar to the analysis of remote imagery, aerial and satellite imagery is assessed through visual assessment. Visual assessment allows for the identification of major erosion or accretion periods and is used to determine the most advanced and receded shoreline position during the observation period. Visual assessment also allows for the identification of additional vulnerable coastline areas that may require more detailed assessment into the future. Images obtained throughout the observation period are all loaded into QGIS software, georeferenced and assessed individually. Images are saved and can be viewed in the following folder:

## 7.2 Results

For assessment purposes the coastline has been divided into fourteen discrete areas as depicted in Table 7-2. The most advanced and most receded shoreline position was identified for each discrete area. For the purposes of this analysis the shoreline has been classified as the waterline and it is important to incorporate water level at the time of monitoring.

![](_page_61_Picture_0.jpeg)

Area	Most Receded Shoreline Position	Most Advanced Shoreline Position
Clayton's Beach	01 October 2022	25 February 2023
Quinns Main Beach	28 May 2022	14 January 2023
Quinns – GSC Revetment	01 October 2022	14 January 2023
Quinns – Groyne 1 to Groyne 2	28 May 2022	14 January 2023
Quinns – Groyne 2 to Groyne 3	28 May 2022	14 January 2023
Quinns – Groyne 3 to Groyne 4	28 May 2022	11 December 2022
Jindalee	29 April 2023	14 January 2023
Eden Beach	28 May 2022	11 December 2022
Shorehaven	23 April 2023	11 December 2022
Eglinton Beach	23 April 2023	25 February 2023
South Yanchep	01 October 2022	25 February 2023
North Yanchep	23 April 2023	01 October 2022
South of Two Rocks Marina	01 October 2022	25 February 2023
North of Two Rocks Marina	23 April 2023	04 December 2022

Table 7-2 Most advanced and receded shoreline positions as identified through aerial imagery review.

Some areas experienced the most receded and advanced shoreline positions outside of the survey periods (April and October). This indicates that while seasonal assessment of beach volume changes as detailed in **Section 5.2.1** are indicative, they do not necessarily capture the total seasonal beach volume change of each area. Further assessment of satellite, aerial and remote imagery allows for the identification of the most appropriate time for surveys to capture the most accurate seasonal changes in beach volumes. However, what is most appropriate for some areas will not necessarily be most appropriate for other areas of the coast and it is important to understand that these results simply allow us to assess whether the volume changes calculated are accurate or are an underestimation of the actual seasonal volume changes.

![](_page_62_Picture_0.jpeg)

# 8 Results and Recommendations

## 8.1 Seasonal Changes

Areas that experienced major seasonal erosion during the study period were identified via manual imagery and the analysis of beach cross-sections. These areas are as follows.

- 1. <u>Two Rocks Beach North:</u> Major erosion was identified along Two Rocks Beach North, adjacent to the Sovereign Drive Beach Access Way, between October 2022 and April 2023 via manual imagery. The survey cross-section comparisons show a drop in elevation of 2.64m between the October 2022 and April 2023 surveys. This site is situated within a coastal erosion hotspot and seasonal erosion is experienced at this site each year.
- 2. <u>Yanchep Lagoon Beach North:</u> Significant seasonal erosion was identified along an area of approximately 200m at Yanchep Lagoon Beach, to the north of the beach access way. Seasonal survey cross-section comparisons show a maximum reduction in elevation of 1.95m between the October 2022 and April 2023 LiDAR surveys. It is possible that the extent erosion at this site over the summer period was caused by higher than average wind speeds and sea wave action. Wind data captured at the Ocean Reef Weather Station confirmed a higher percentage of winds exceeding 40km/h over the summer 2022/23 period than in previous years.
- 3. <u>Fisherman's Hollow Beach:</u> Fisherman's Hollow Beach, south of Yanchep Lagoon, experienced major erosion between April 2022 and October 2022. Below the waterline, a maximum elevation difference of 2.04m was recorded at cross section 21. It is important to note that residential houses and road infrastructure are in close proximity to the site and could, in future, be susceptible to the effects of coastal erosion. There is however, significant seasonal accretion each year at this site and long-term elevation difference plots results show a net gain in beach volume at this site between October 2018 and October 2022. It is recommended that this area is closely monitored moving forward.
- 4. Quinns Beach North of Groyne 3: A significant reduction in beach width and major erosion scarp was noted at Quinns Dog Beach, immediately north of Groyne 3, in April 2023 manual imagery. Beach cross-section analysis noted a drop in elevation of 2.17m just below the water line at this location. However, renourishment was undertaken at this location in late April 2023, after monitoring, in response to the eroded beach conditions which improved beach usability at the site and provided a buffer for erosion that resulted from the subsequent winter storms.
- 5. <u>Quinns Beach South of Groyne 2:</u> There was a significant net increase in beach volume of approximately 6,800m<sup>3</sup> within Quinns Beach Section 3, which is situated between Groyne 1 and Groyne 2. This highlights the effectiveness of Quinns Groyne 2 in capturing sand within this beach compartment. The significant increase in volume during the summer months provides a buffer against the effects of winter storm events.
- 6. Quinns Beach GSC Revetment South of Groyne 1: A major reduction in beach width over winter 2022 was noted in the manual imagery review of the beach immediately south of Quinns Groyne 1. There was very little remaining beach in October 2022 and wave impact to the GSC revetment over winter caused minor damage to the structure. This is an area that is known to experience significant seasonal erosion annually and has caused major maintenance issues in the past. The GSC Revetment was constructed in 2014 and despite the minor damage sustained from the 2021 and 2022 storm events, the structure works effectively in protecting adjacent coastal infrastructure. It also important to note that while there was significant erosion at this location over the winter period, there was net gain in beach volume of approximately

![](_page_63_Picture_0.jpeg)

23,000m<sup>3</sup> across the summer period. Significant seasonal erosion is observed at this site each year however Quinns Groyne 1 and the GSC Revetment work to protect infrastructure and capture sediment in this compartment during the summer months.

- 7. <u>Quinns Beach South:</u> During the 2022/23 summer period there was significant erosion at Quinns Beach South. Manual imagery shows a wide beach in October 2022 and a very narrow beach in April 2023, with loss of dune vegetation. Analysis of survey cross sections at this site show a reduction in elevation of 2.55m between October 2022 and April 2023. While seasonal erosion is expected at this site as sediment is transported northward, away from the headland immediately south of this site, major seasonal erosion is uncommon. However, it is important to note that long-term survey analysis show a net increase of beach volume at this site between 2018 and 2023 which is likely due to higher than average winter storm activity and subsequent southward transport of sediment.
- 8. <u>Clayton's Beach, Mindarie:</u> Claytons Beach in Mindarie is bound by the Mindarie Breakwater to the north which interrupts longshore transport leading to significant seasonal erosion over the winter months. While seasonal erosion is expected at this site each year, the extent of erosion has been considerably greater in winter 2021 and 2022 than in previously recorded years. The estimated net beach volume change over winter 2022 for this site was 89,048 m<sup>3</sup> with manual imagery and survey results showing significant impact to the dune condition. It is also important to note that there is significant seasonal accretion at this site each year, during the summer months, as sand builds up to the south of the breakwater. There was an increase in beach volume of 95,599 m<sup>3</sup> between October 2022 and April 2023, exceeding the volume loss that was observed over the 2022 winter period.

## 8.2 Annual Change

Changes in beach volumes between April 2022 and April 2023 were assessed via LiDAR survey elevation difference plots, volume change calculations and cross section transect comparisons undertaken by MNG. Volume change calculations show an increase in beach volume across the coastline between April 2022 and April 2023 in all suburbs, aside from Quinns Rocks.

Over the year, there was a net loss of 12,914 m<sup>3</sup> along the Quinns Rocks coastline despite approximately 6,500 m<sup>3</sup> of sand being placed at Quinns Rocks in April 2022 as part of the City's ongoing renourishment program. This points to the importance of beach renourishment in Quinns Rocks, without it we would see a significantly larger reduction in beach volume which would cause significant impact to coastal assets and limit the accessibility and usability of the beach.

The most notable areas of beach volume gain are within Two Rocks where the total estimated net beach volume increase within Two Rocks Section 1 (south of the Two Rocks Marina) was 28,906 m<sup>3</sup>.

Survey cross section results outline additional areas that experienced significant erosion between April 2022 and April 2023. The survey results from Quinns Dog Beach, to the south of Groyne 4, show an approximate 3m recession of the dune face between the April 2022 and the April 2023 surveys. This was not identified in the manual imagery (site Quinns B14 Down-Coast) as the dune face is not the main focus of the image and recession in the dune face is difficult to interpret using manual imagery alone. This highlights the importance of utilising multiple data sets when undertaking coastal monitoring. Beach scraping was undertaken at this site in February 2023 to build-up the base of the dune system and to create a buffer from the impacts of winter storms.

![](_page_64_Picture_0.jpeg)

## 8.3 Long-term Changes

As the five-year contract with survey contractor MNG concluded in April 2023, additional long-term analysis was requested so that changes to beach conditions could be assessed across the contract period which spanned between October 2018 and April 2023.

Overall, results indicate that there has been a net gain in beach volume across all suburbs aside from Quinns Rocks. Net beach volume change calculations for all beach sections within Quinns Rocks, aside from Quinns Beach Section 1 (Quinns Beach South), show a net reduction in beach volume between October 2018 and October 2022. Elevation difference plots show a net increase in beach volume along Quinns Beach South over the past four years, which is consistent with past annual imagery assessments.

Between April 2019 and April 2023 the six beach sections along the Quinns foreshore area had an estimated combined net beach volume loss of 17,409 m<sup>3</sup>. It is important to note that Quinns Beach continues to be subject to erosion despite significant beach renourishment that has been undertaken at the site since 2018. Again, this highlights the importance of the City's Renourishment Program, without ongoing renourishment continued coastal erosion would result in damage to infrastructure and issues with beach accessibility.

While there was an overall net gain in beach volume along the Two Rocks foreshore area, there was a net loss within Two Rocks Section 2 (north of the Two Rocks Marina) over the four-year period. Between April 2019 and April 2023 there was a net loss of 17,316 m<sup>3</sup>. This site was identified as a Coastal Erosion Hotspot within the Department of Planning Lands and Heritage's Assessment of Coastal Erosion Hotspots in Western Australia (2019) and a Coastal Management Options Assessment will be undertaken for this site in the near future. At present, there are no assets that are at risk of impact by coastal erosion at this site and the site will continue to be closely monitored moving forward.

The net beach volume changes for the Yanchep foreshore area calculated between April 2019 and April 2023 are quite different to the results from those calculated between October 2018 and October 2022. Overall, the five beach sections along the Yanchep foreshore area had an estimated net beach volume gain of 19,667 m<sup>3</sup> between October 2018 and October 2022 and a net loss of 3,578 m<sup>3</sup> between April 2019 and April 2023. The net beach volume loss between April 2019 and April 2023 is likely a result of the major erosion along the northern Yanchep Lagoon Beach that occurred over the 2022/23 summer period. Note that although the overall long term beach volume change along the Yanchep coastline is not significant over the last 5 years, ongoing localised erosion continues to cause issues with beach accessibility, beach functionality and excessive coastal maintenance requirements.

In addition to the four suburbs that are regularly assessed as part of the regular survey capture and analysis, long-term changes were also assessed for the City's remaining coastline, which was divided into three areas. Of these three areas, there was a net beach volume loss at the southern two areas, Eden & Alkimos and Amberton & Shorehaven. There are a number of private land developments in construction along this section of foreshore which, once complete, will be under the management of the City of Wanneroo. It is important that the extent of erosion along these sections of coastline is understood by all private land developers and coastal managers.

The third additional site, which contains the foreshore area between Yanchep and Two Rocks, had a significant net increase in beach volume of 146,838 m<sup>3</sup> between April 2019 and April 2023. Elevation difference plots show that gain in beach volume is largely within the beach area situated between the rocky headland to the south of the popular surf break 'The Spot', and the Two Rocks Marina.

![](_page_65_Picture_0.jpeg)

## 8.4 Notable Erosion Events

A number of notable erosion events occurred during the study period between May and August 2022 which resulted in damage to coastal infrastructure. The most notable of which was the storm that occurred on the 3<sup>rd</sup> of August 2022 which resulted in significant erosion at Clayton's Beach, Quinns Dog Beach, Amberton and Yanchep Beach and also impacted a number of coastal infrastructure assets with damage to the Mindarie Breakwater, Frederick Stubbs GSC Revetment, Jindalee Staircase, Amberton Beach Access Ramp and Staircase. Most areas that experienced significant erosion in August 2022 had an already receded shoreline which was exacerbated by the August storm event.

## 8.5 Renourishment Activities

The location, date and quantity of renourishment activities along the coastline within the past 12 months is outlined in the table below.

Table 8-1 Renourishment locations and quantities within the study period.

Date	Renourishment Location	Renourishment Quantity
April 2022	Quinns Beach, adjacent to Frederick Stubbs Carpark	4,000 tonnes
April 2022	Quinns Beach, north of Groyne 3	4,000 tonnes
September 2022	Yanchep Lagoon	2,693 tonnes

An additional 9,000 tonnes of sand was placed along Quinns Beach in April 2023 as part of the City's ongoing renourishment program.

## 8.6 Recommendations

## 8.6.1 Automatic Tracking of Shorelines

Five remote monitoring cameras were installed at Quinns and Yanchep in November 2021. Remote monitoring cameras allow for the continuous assessment of the coastline, particularly in areas where continued coastal erosion is experienced. It is recommended that the methodology for automatic shoreline tracking be finalised for 2023/24 so that hourly data can be quantified. Automatic shoreline tracking can be used with imagery obtained from remote monitoring cameras to track the shoreline across the study period and estimate changes in beach volume.

## 8.6.2 Automatic Vegetation Line Tracking in Aerial Imagery

The City is in the process of developing a methodology for the automatic detection of vegetation lines in satellite and aerial imagery It is recommended that this methodology be finalised in 2023/24 as it will facilitate quantitative analysis of satellite and aerial imagery. This will allow for the long term analysis of coastline changes as historic Aerial Imagery of the City's coastline has been captured since 1965.

## 8.6.3 Yanchep Study to Inform Coastal Management

It is recommended that, similar to the Quinns Beach Long-Term Coastal Management Study, a Yanchep Beach Coastal Management Study be undertaken to inform the future long-term management practices for Yanchep Beach. Yanchep Beach is one of the City's most popular beaches and is subject to significant seasonal and annual erosion. Sections of the Yanchep Coastline have also been identified as vulnerable coastal locations within the City's Coastal Hazard Risk Management and Adaptation Plan (CHRMAP). Additionally, there was significant erosion along the northern portion of Yanchep Lagoon Beach across the 2022/23 summer period. There are a number

![](_page_66_Picture_0.jpeg)

of residential properties in close proximity to this dune system and it is important to investigate future coastal management actions to address these risks.

#### 8.6.4 Continued Beach Renourishment

It is recommended that beach renourishment continues to be undertaken in vulnerable areas to minimise the effects of erosion on coastal infrastructure. It is recommended that the results from this report be utilised to identify areas that require ongoing scheduled renourishment works. As outlined in Section 5.2.3 there has been a net beach volume loss of approximately 15,000m<sup>3</sup> along Quinns Beach between 2018 and 2023 despite the placement of approximately 50,000m<sup>3</sup> of nourishment. Continued beach renourishment is required along Quinns Beach to address localised erosion issues.

As outlined in Section 5.2.3 there was considerable accretion along the coastline between 'The Spot' Surf Break and the Two Rocks Marina Southern Breakwater over the last four years. It is recommended that this location be investigated as a potential future sand source for nourishment although it is important to note that the site is currently inaccessible and major upgrades would be needed in order to implement this option.

#### 8.6.5 Continued Beach Scraping

It is also recommended that beach scraping be undertaken annually along Quinns Dog Beach, to the south of Groyne 4, during periods of significant accretion. This will continue to improve the condition of the dune system and provide a buffer against the impact of winter storms. It is also recommended that the City investigate additional sites where beach scraping could be implemented to limit the impacts of erosion.

#### 8.6.6 Procurement of Nearshore Wave Buoys

It is recommended that wave buoys be procured by the City to enable site specific analysis of metocean conditions. Wave data from the Department of Transport Rottnest Island Wave Station is currently used to analyse metocean conditions for the City's Coastal Monitoring Program. Site specific data will allow more accurate and effective analysis of coastal changes as the local wave climate is significantly different to the Rottnest Island wave climate and can vary considerably along the City's coastline.

#### 8.6.7 Additional Photographic Monitoring Locations

It is recommended that additional photographic monitoring locations be added to the manual imagery monitoring sites to ensure that areas impacted by significant erosion are being monitored by the City moving forward. As outlined in Section 5.3.9 there are a number of sites, particularly within the Eden Beach Development and Amberton Beach Development areas that have been subject to significant erosion over the past five years and it is recommended that these sites be monitored more frequently moving forward.

## 8.6.8 Renewal of the Two Rocks Marina Northern Breakwater

The dune system immediately north of the Two Rocks Marina Northern Breakwater has been subject to significant ongoing erosion since the construction of the Marina. Over this period, the condition of the Northern Breakwater has deteriorated considerably. It is recommended that the condition of this Breakwater be formally assessed and the structure be renewed/repaired where required. While the structure is under the management of the Department of Transport (DoT), the City will work with the DoT to manage this process.

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# **APPENDIX A – ELEVATION DIFFERENCE PLOTS**

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