City of Wanneroo
Coastal Monitoring Report
October 2024

City of Wanneroo

DOCUMENT CONTROL

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1 Introduction

1.1 Coastal Foreshore Monitoring

A long-term coastal monitoring programme has been undertaken by the City of Wanneroo (CoW) since 2014. The purpose of the programme is to evaluate the seasonal, annual and long-term trends in erosion and accretion along the City's coastline. This helps to better inform future coastal management measures, identify key areas requiring future management 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 five (5) beach monitoring sites;
- Hourly automatic photographic monitoring taken at five sites along Quinns Rocks Beach and Yanchep;
- Biannual 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 City's three (3) local wave buoys situated off the coast of Yanchep and Quinns Rocks;
    - Half-hourly wave data from the Department of Transport (DoT) Rottnest Island Wave Station; and
    - Five (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 City's three local wave buoys situated off the coast of Yanchep and Quinns Rocks; and
- Half-hourly wave data from the DoT Rottnest Island Wave Station; and
- Five (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.

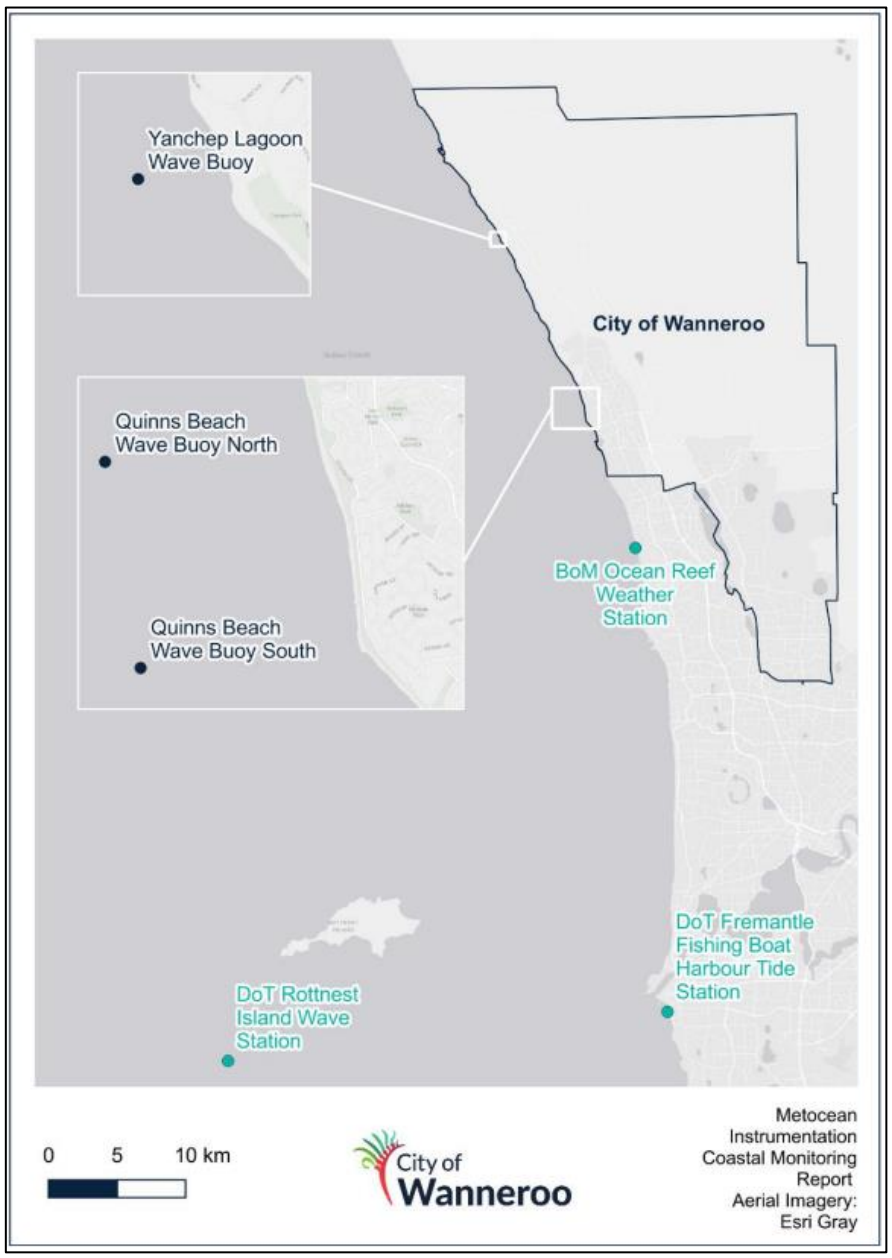


Figure 2-1 Location of Instruments

2.1 Assessment Methodology

The City's local wave buoys were deployed in April 2024 and the University of Western Australia (UWA) have been engaged by the City to service these instruments and provide a wave data set every six (6) months. This data is quality assured and controlled by UWA following best practice guidelines in the line with the Quality Assurance/Quality Control of Real Time Oceanographic Data (QARTOD) standards for in situ wave data. Please note that there was a small gap in the data collected by the Yanchep lagoon Wave Buoy from 23/01/2024 to 30/01/2024 after it was dislodged from its mooring and had to be redeployed.

The data from these instruments is obtained from the DoT and BoM for the annual monitoring period October 2023 to October 2024. The data is assessed using time series and rose plots where trends and major weather events are analysed. The data and all plots are saved in the following folder: \\WCC-SAN\TechOps\Coastal\Coastal_Monitoring\01_DATA\12_-_Metocean_Data\October 2024

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 Local Wave Data

Time series plots of the significant wave height calculated from the total wave spectrum (Hs) for the Yanchep Lagoon Wave Buoy, Quinns Rocks Beach Wave Buoy North and Quinns Rocks Beach Wave Buoy South is presented below in Figure 2-2, Figure 2-3, and Figure 2-4. These wave buoys were deployed on the 25 March 2024 and data was recovered on the 25 September 2024.

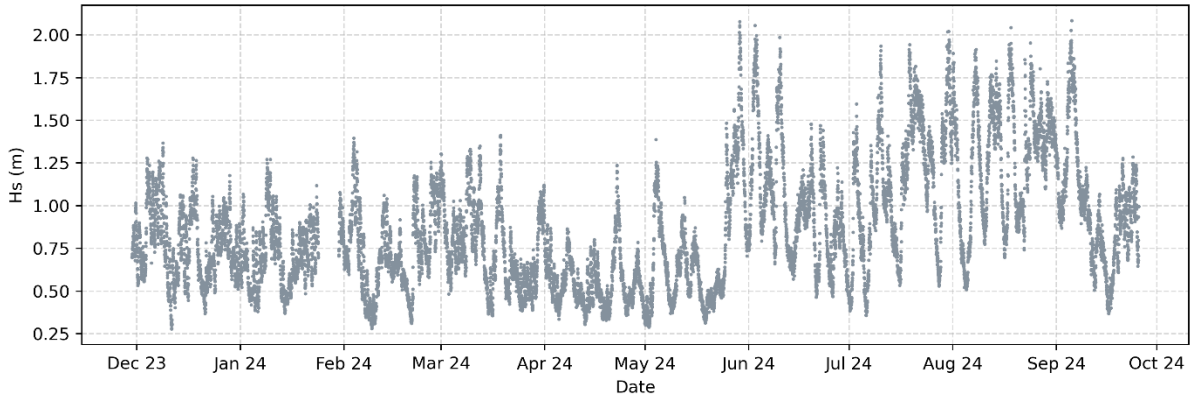


Figure 2-2 Total significant Wave Height (Hs) recorded at the Yanchep Lagoon Wave Buoy from November 2023 to September 2024.

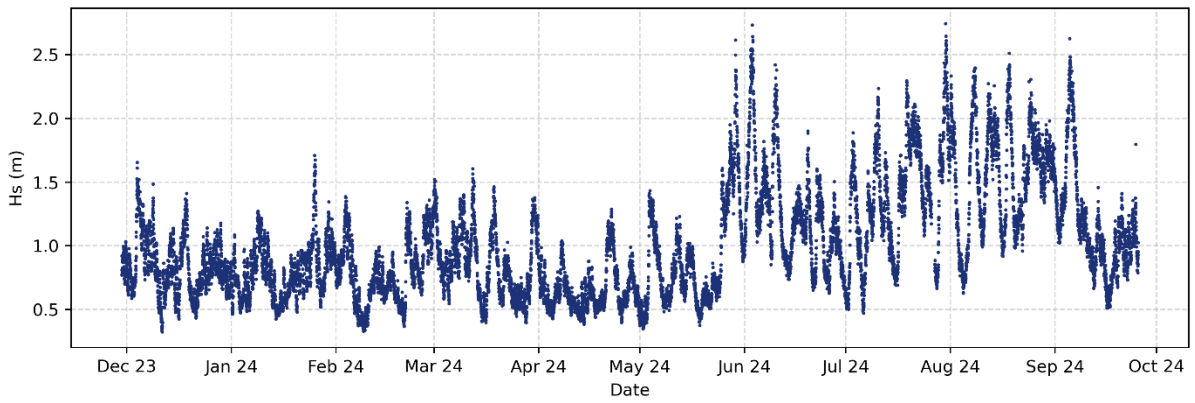


Figure 2-3 Total significant Wave Height (Hs) recorded at the Quinns Rocks Beach Wave Buoy North from November 2023 to September 2024.

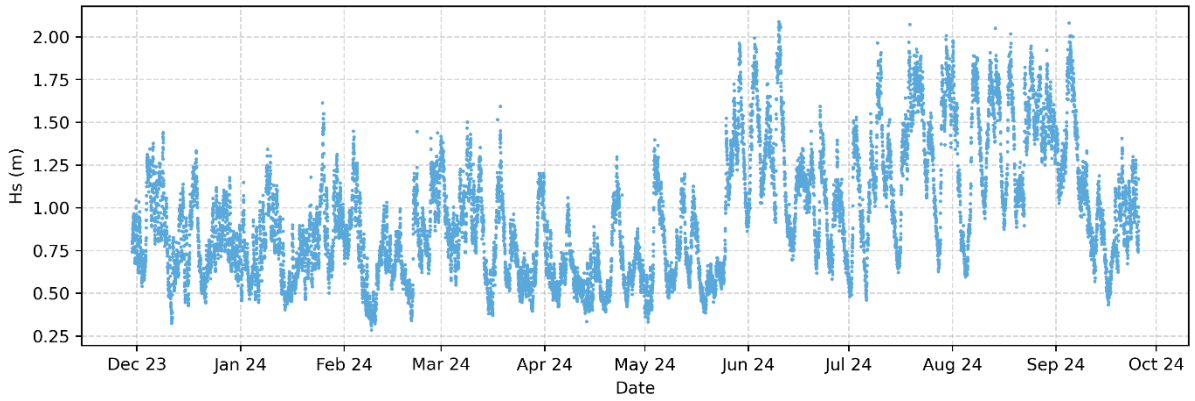


Figure 2-4 Total significant Wave Height (Hs) recorded at the Quinns Rocks Beach Wave Buoy South from November 2023 to September 2024.

The total significant wave height is similar across all three monitoring instruments, with Quinns Rocks Beach Wave Buoy North recording slightly higher readings than Quinns Rocks Beach Wave Buoy South or Yanchep Lagoon Wave Buoy. The plots show typical winter conditions for the region with increasing significant wave height over the winter period with swell conditions dominating. The largest significant wave heights recorded over the year at each site were: 2.74m on 30 July 2024 by Quinns Rocks Beach Wave Buoy North, 2.08m on 05 September 2024 by Quinns Rocks Beach Wave Buoy South, and 2.09m on 10 June 2024 by Yanchep Lagoon Wave Buoy.

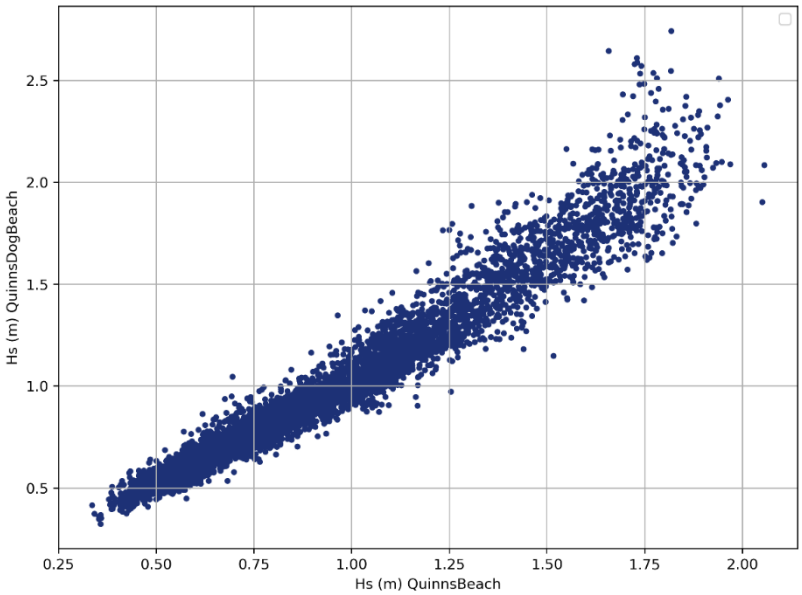


Figure 2-5 Linear correlation of Quinns Rocks North and Quinns Rocks South total significant wave height values

Figure 2-5 presents the linear correlation between the significant wave height (Hs) readings for the Quinns Rocks North Wave Buoy and the Quinns Rocks South Wave Buoy. There is a strong linear correlation between the two datasets (R^2 of 0.9727) for the period of one year. however, the variance in higher wave heights is notably greater.

2.2.2 Study Period

A time series plot of the total significant wave height (Hs) recorded at the Rottnest Island Wave Station from October 2023 to October 2024 is presented below in Figure 2-6.

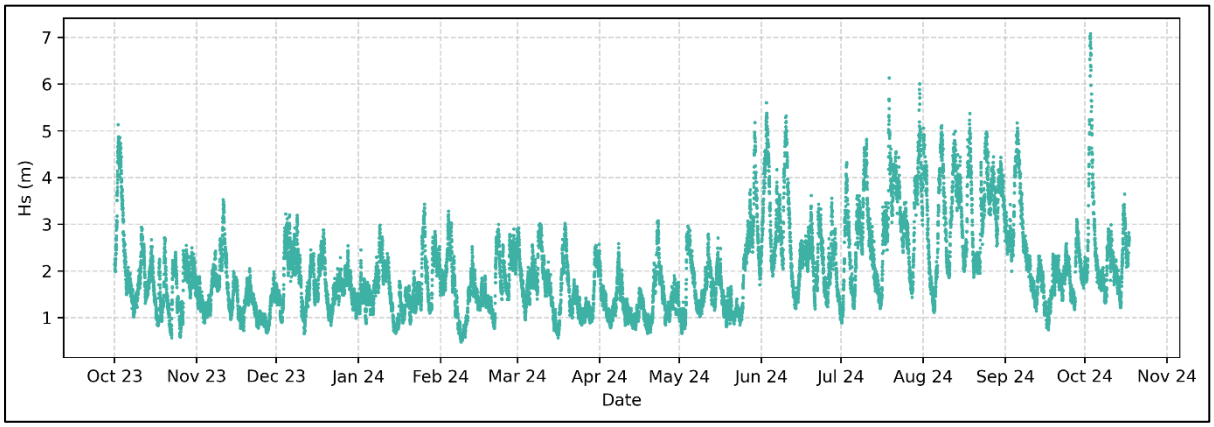


Figure 2-6 Total significant Wave Height (Hs) recorded at the Rottnest Island Wave Station from October 2023 to October 2024

The most notable observations from Figure 2-6 are the storm events that were recorded on the 19th of July 2024, 30th of July 2024, and 03rd of October 2024. These storm events recorded peak significant wave heights of 6.13m, 6.01m and 7.08m respectively. There were more storm events this year compared to 2023, which was a relatively calm year. The 2024 winter period was still calmer than 2022 and 2021. Comparatively, the peak significant wave height for the 2021 and 2022 winter periods were 7.84m and 8.67m, respectively. The calmer winter conditions resulted in minimal storm damage and limited coastal erosion as outlined in Section 3, 4 and 5.

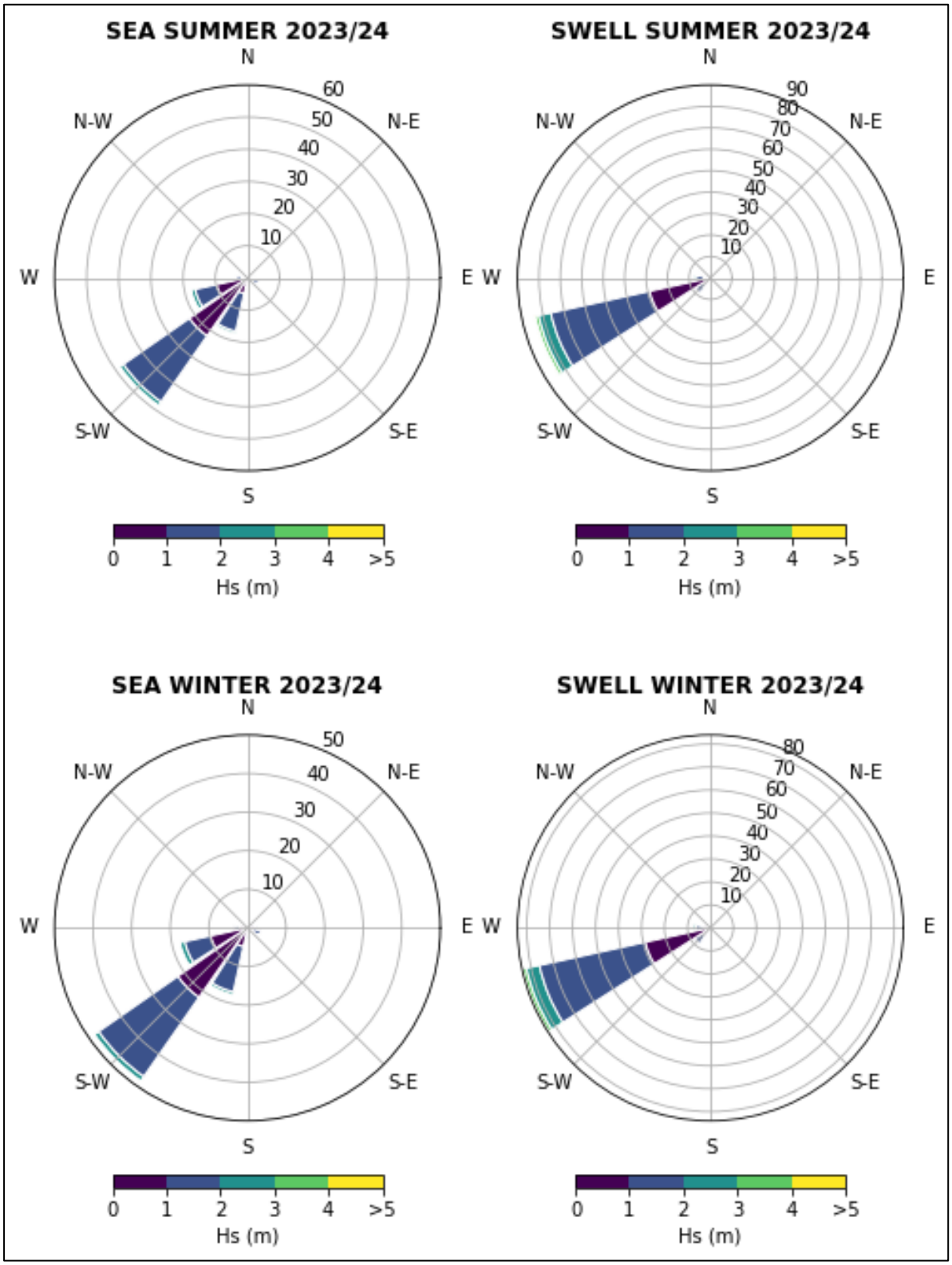


Figure 2-7 *Wind rose plots of sea and swell significant wave heights from the summer season (October 2023 to March 2024) and the winter Season (April to September 2024)*

As seen in Figure 2-7, the wave climate for both the summer and winter periods is characterised by west south westerly waves and as expected, there is an increase in swell height during winter period. Notably, for this study period, wave direction remained consistent for most of the year, with less than 15% readings captured outside of the consistent west south westerly direction.

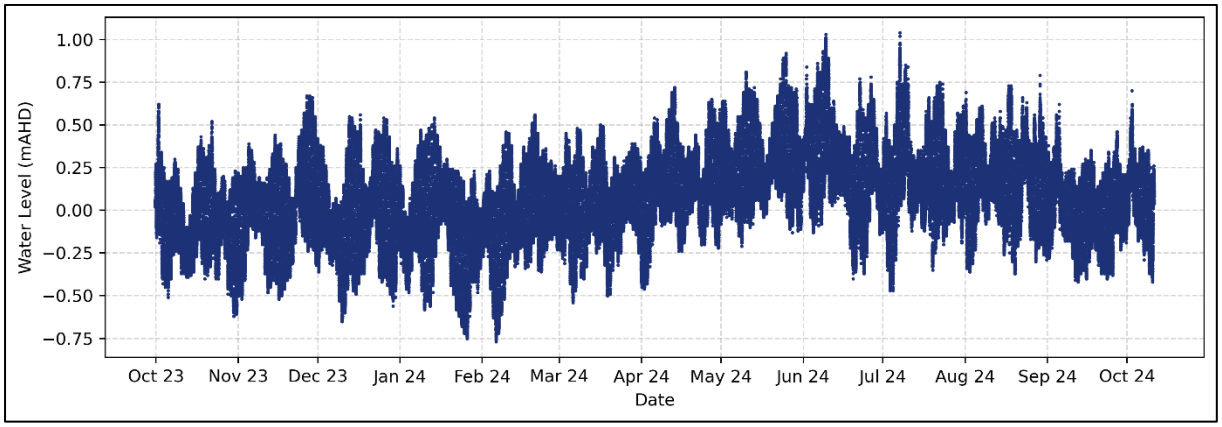


Figure 2-8 Water level (mAHD) recorded at the Fremantle Fishing Harbour Tide Station from October 2023 to October 2024

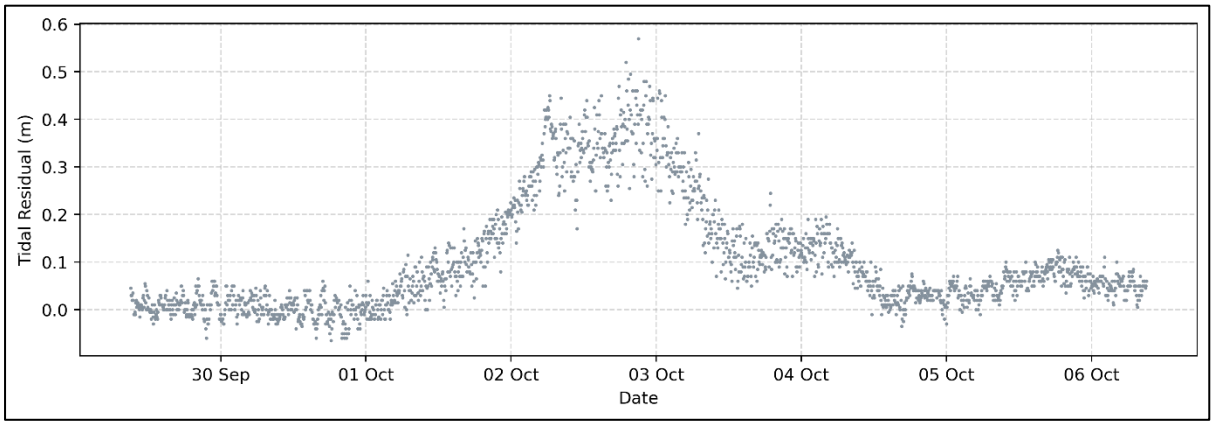


Figure 2-9 Non tidal residual recorded at the Fremantle Fishing Harbour Tide Station during the October 2nd storm event.

Total recorded water level at the Fremantle Tide Station from October 2023 to October 2024 is presented in Figure 2-8. The highest water level recorded was 1.04 mAHD recorded at 09:25AM on 7 July 2024 and the peak non tidal residual (storm surge), 0.57m, was observed on 2 October 2024 at 9:05PM (Figure 2-9). As outlined above, conditions during the 2024 winter period were mild and storm events caused very little damage to infrastructure. Further assessment on the impacts of the winter period is outlined in Section 4, 5 and 6.

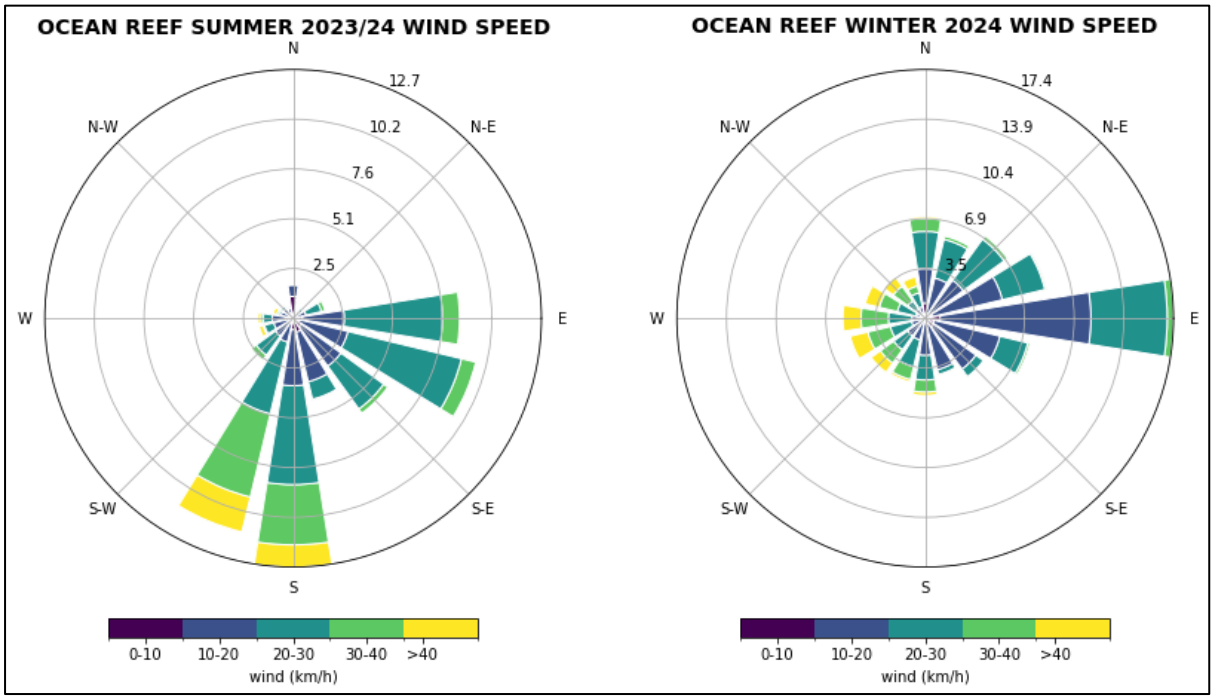


Figure 2-10 Rose plots showing wind speeds recorded during the summer season (October 2023 to March 2024) and the winter season (April to October 2024) at the Ocean Reef Weather Station

As seen in Figure 2-10 , the summer of 2023/24 was largely characterised by strong southerly and south-south westerly winds, which are typical conditions along the West Australian coastline during the summer months. Summer wind conditions were more typical this year with southerly winds more prominent than south-south westerly winds. The winter period was mostly characterised by easterly winds with significant periods of strong westerly winds, which is typical of winter storm events. The wind conditions for the 2024 winter period were less extreme than previous years, with a higher percentage of easterly and north-easterly winds (~30%) with notably fewer strong south westerly wind events. This is consistent with the low wave heights and limited storm damage observed across the monitoring period.

2.2.3 During Monitoring

Manual imagery and aerial surveys for this monitoring period were undertaken between 08 October 2024 and 10 October 2024. The water levels during these monitoring periods are presented below in Figure 2-11.

Most monitoring was undertaken at low tide. Changes in beach volumes are calculated from the area above the waterline so the rising tide will not affect the survey results; however, it is important to note when assessing manual imagery that most images were taken at a water level between –0.3 and 0.0 mAHD.

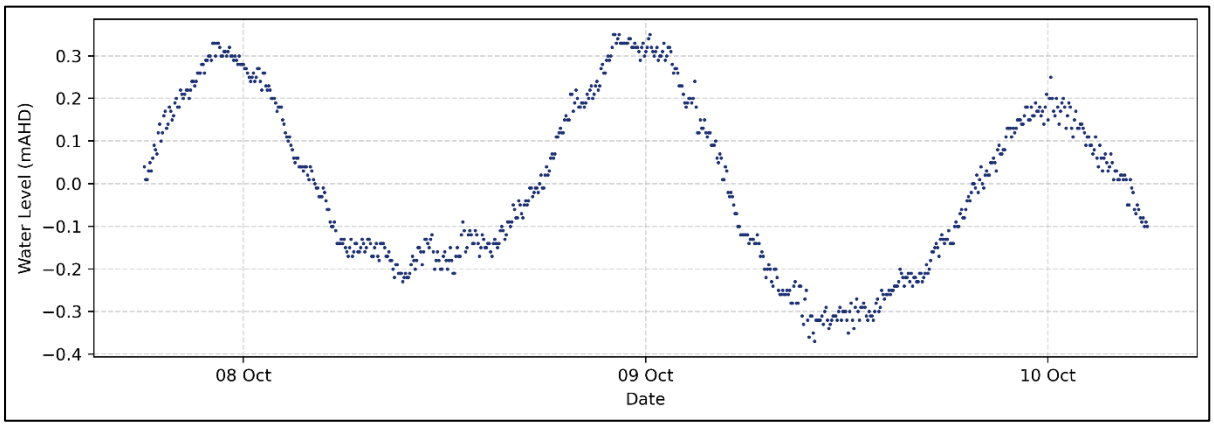


Figure 2-11 Recorded water level during October 2024 monitoring activities

3 Storm Damage

As outlined above in Section 2, the 2024 winter period was relatively calm with only three notable storm events experienced within the study period. With the maximum offshore wave height for the year recorded as 7.08m, the storm damage along the City's coastline was fortunately minimal.

4 Manual Imagery

There are a total of 52 manual imagery beach monitoring sites located in key vulnerable coastal areas along the CoW coastline. The positions of these sites are presented in Figure 4-1 to Figure 4-6. Images are taken biannually in April and October each year to assess seasonal and long-term changes to beach morphology. The October 2024 images are taken by JB Pacific's Coastal Engineer and are taken at the same location and with same field of view as previous years. A detailed description of the methodology for obtaining manual images is outlined in the Coastal Monitoring Inspection Manual CM (Ref #22/89708).

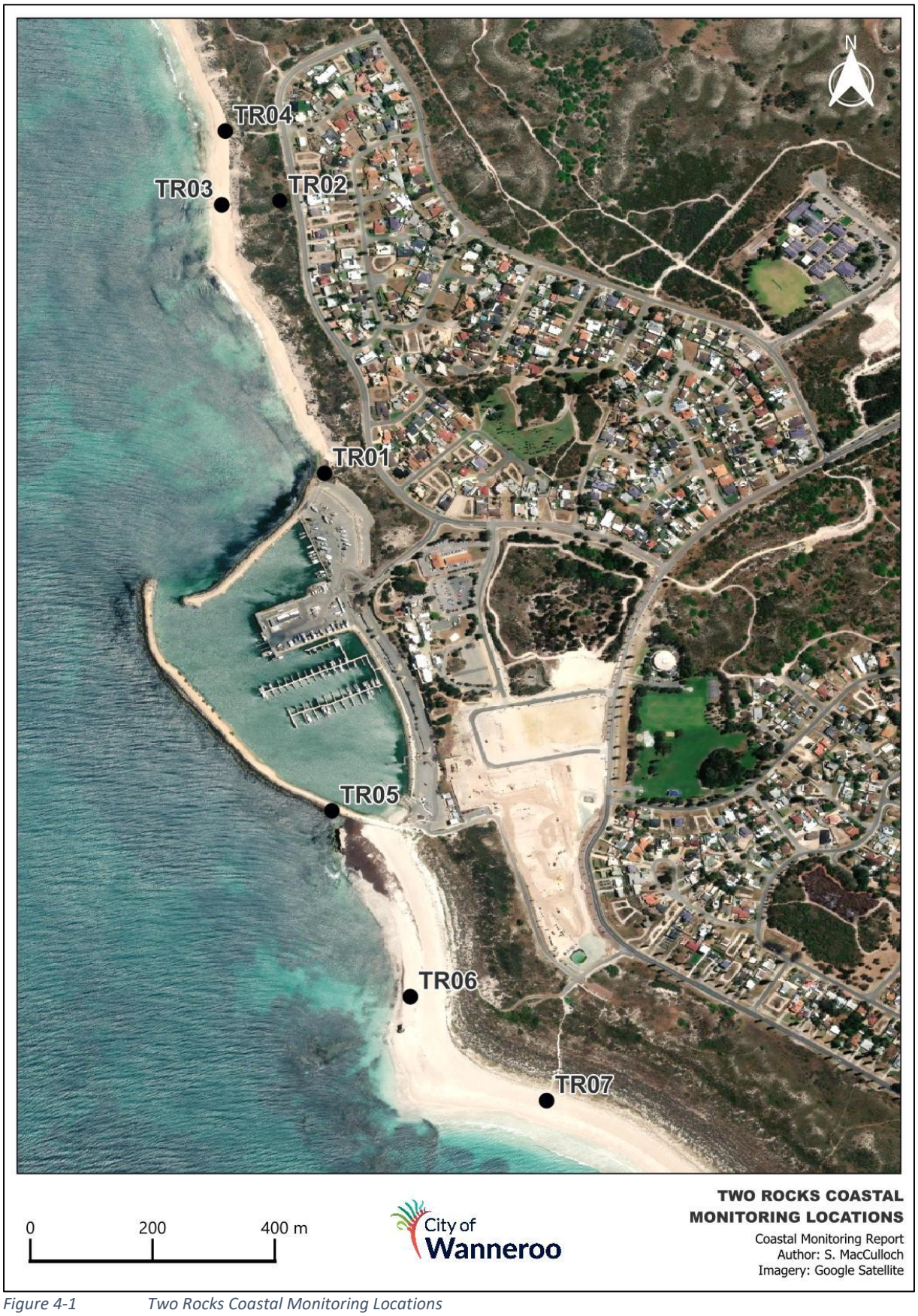


Figure 4-1 Two Rocks Coastal Monitoring Locations

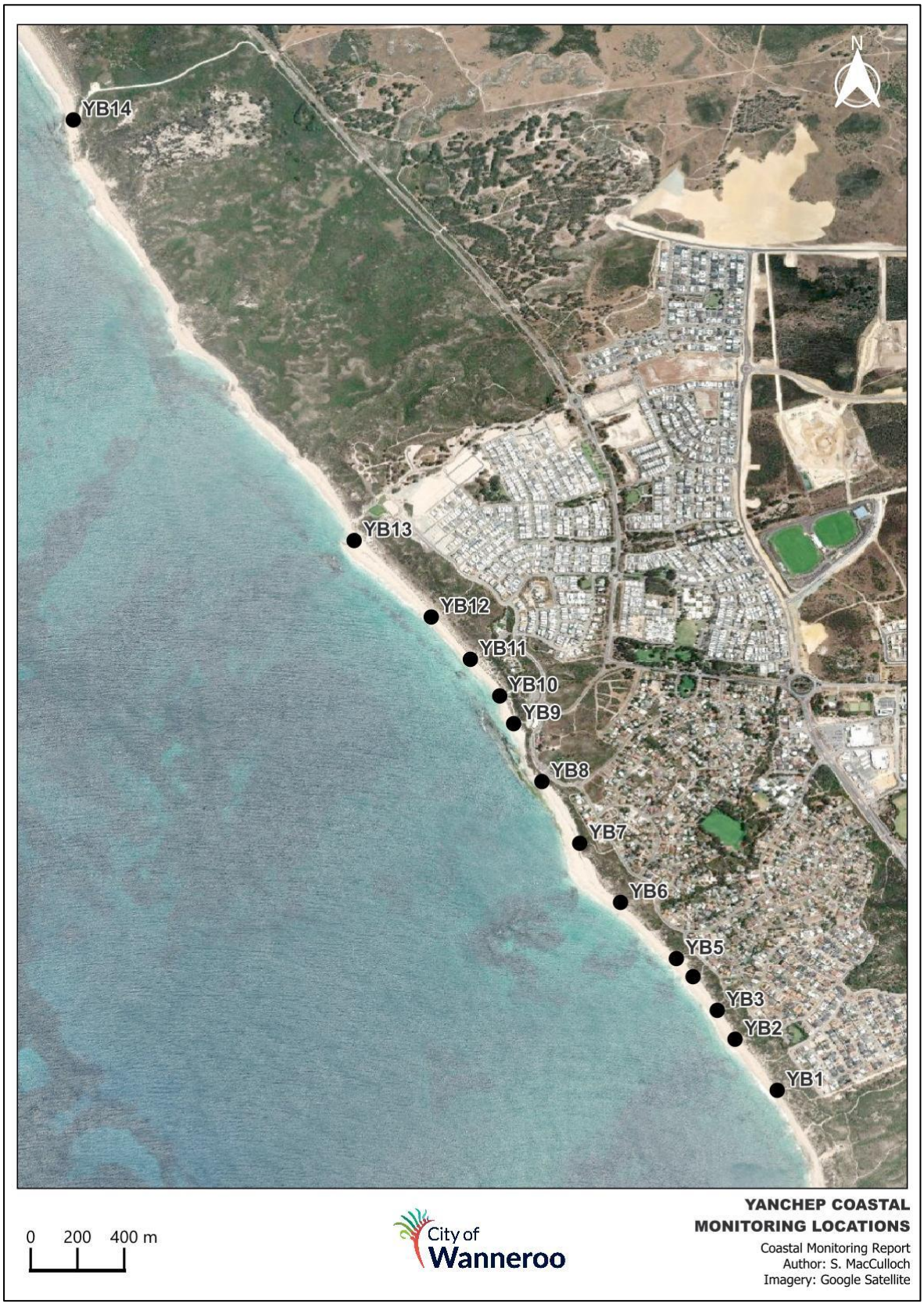


Figure 4-2 Yanchep Coastal Monitoring Locations

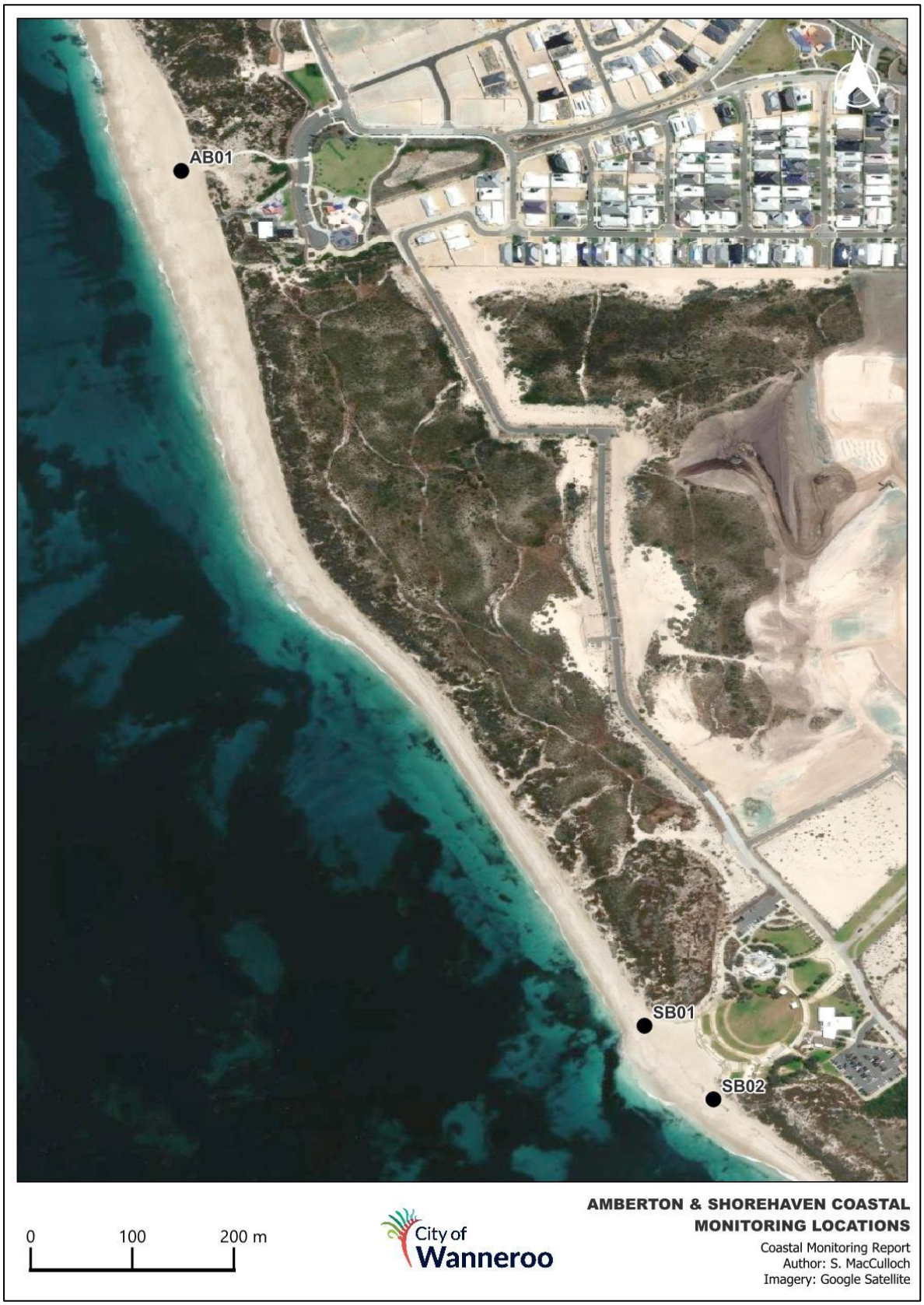


Figure 4-3 Amberton and Shorehaven Coastal Monitoring Locations

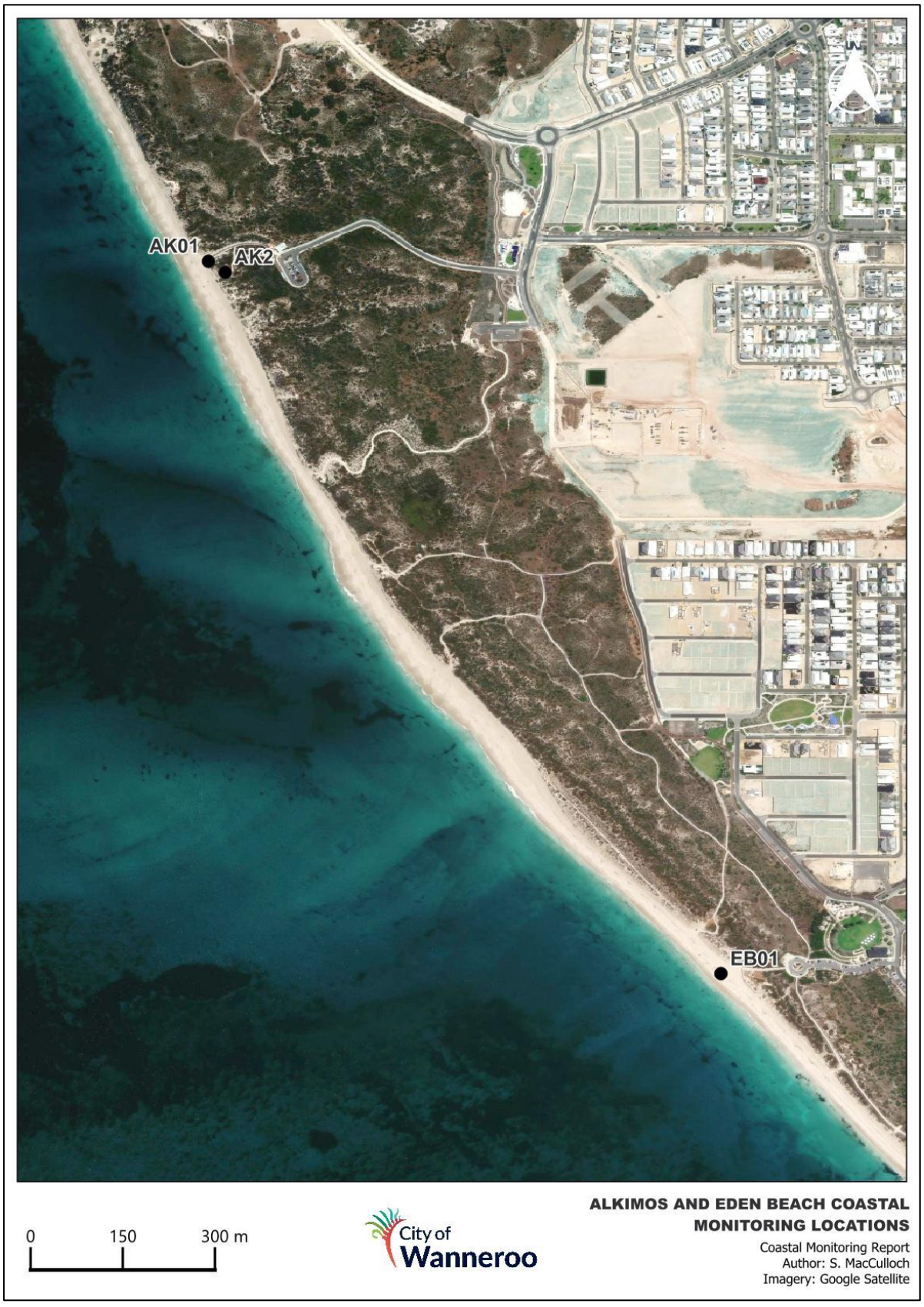


Figure 4-4 Alkimos and Eden Beach Coastal Monitoring Locations

Figure 4-5 Quinns Beach Coastal Monitoring Locations

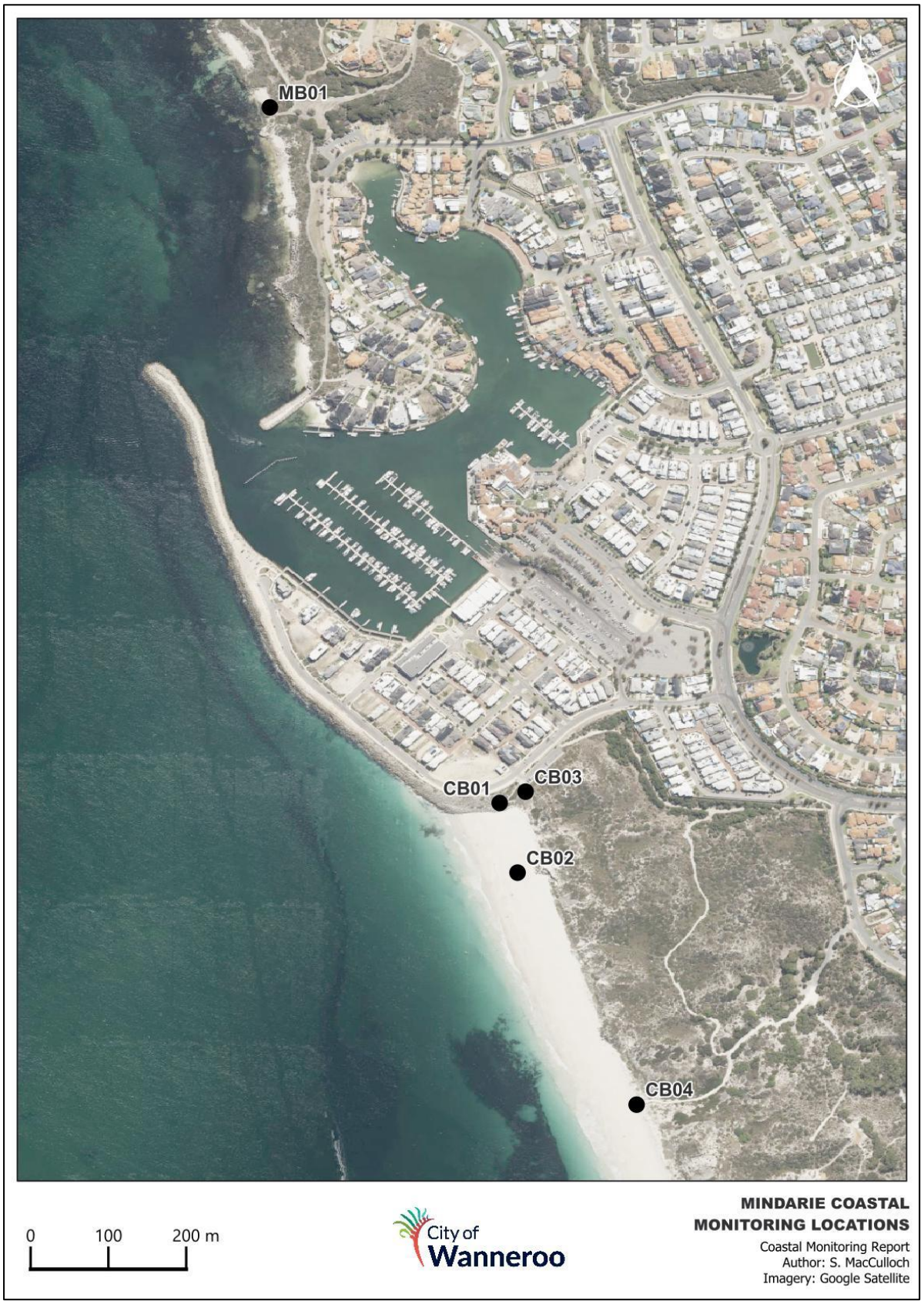


Figure 4-6 Mindarie *Coastal Monitoring Locations*

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 (current year) with April (current year). Annual changes are assessment by comparing current images with images from 12 months earlier. 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	• Increase in beach width; • Notable sand builds up; or • Improvement in dune condition.
No change	• No identifiable change in beach width, slope or dune condition.
Minor Erosion	• Slight or major decrease in beach width; • No impact to dune condition; • Remaining beach is sufficient to protect the dunes or infrastructure that lie landward of the beach.
Major Erosion	• Major decrease in beach width. • Some impact to dune condition. • Remaining beach is NOT sufficient to protect dunes or infrastructure landward of the beach in the event of erosion.

4.2 Results

The severity of beach change and comments are presented in Table 4-1. Images of sites with notably severe beach changes are presented in Table 4-2 to Table 4-9.

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

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Long-term Changes (October 2014 to October 2024)		Long-term Changes (March 2015 to April 2024)	
	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	Accretion	Improvement in beach gradient and volume.	Minor erosion	Slight decrease in beach width with notable minor erosion scarp.	Minor erosion	Minor erosion scarp at the base of the dune.	No change	No notable change to beach condition or dune condition.
B02 UP-COAST	Accretion	Notable increase in beach width	Minor erosion	Slight reduction in beach width.	Minor erosion	Bedrock visible in 2023 suggests a reduction in beach volume however beach width and dune condition appear largely unchanged.	Minor erosion	Bedrock visible in 2023 suggests a reduction in beach volume however beach width and dune condition appear largely unchanged.
B02 DOWN-COAST	Accretion	Notable increase in beach width	Minor erosion	Minor reduction in beach width	Minor erosion	Minor reduction in beach width, but dune is still in good condition.	Minor erosion	Minor reduction in beach width
B03 UP-COAST	Minor erosion	Slight decrease in beach width and erosion scarp at dune base	No change	No notable change in beach width or dune condition.	Minor erosion	Minor erosion at the base of the dunes.	Minor erosion	Slight erosion at the base of the dunes.
B03 DOWN-COAST	Minor erosion	Visible bedrock suggests minor reduction in beach volume	Minor erosion	Slight decrease in beach width with no observable change to the dune condition.	Minor erosion	Visible bedrock suggests minor reduction in beach volume	Minor erosion	Notable degradation in dune condition.
B04 UP-COAST_a	Accretion	Notable increase in beach width	Minor erosion	Slight decrease in beach width noted. No observable impact to dune condition.	Minor erosion	Notable reduction in beach width; however, dune condition is improved with grown vegetation	No change	Location of monitoring has changed due to the relocation of the beach access staircase however beach condition appears unchanged, and the dune condition appears to have improved.
B04 UP-COAST_b	Accretion	Notable increase in beach width and build-up of sand on beach	Minor erosion	Slight decrease in beach width noted. No observable impact to dune condition.	No change	Location of monitoring has changed due to the relocation of the beach access staircase however beach condition appears unchanged, and the dune condition appears to have improved.	No change	Location of monitoring has changed due to the relocation of the beach access staircase however beach condition appears unchanged, and the dune condition appears to have improved.
B04 DOWN-COAST_a	Minor erosion	Visible bedrock suggests minor reduction in beach volume	Minor erosion	Slight decrease in beach width noted. No observable impact to dune condition.	Minor erosion	Visible bedrock suggests minor reduction in beach volume	Minor erosion	Location of monitoring has changed due to the relocation of the staircase however bedrock is now visible in 2024 indicating a loss of beach volume.
B04 DOWN-COAST_b	Accretion	Notable increase in beach width and build-up of sand on beach	Minor erosion	Slight decrease in beach width noted. No observable impact to dune condition.	No change	Location of monitoring has changed due to the relocation of the beach access staircase however beach condition appears unchanged, and the dune condition appears to have improved.	Minor erosion	Location of monitoring has changed due to the relocation of the staircase however bedrock is now visible in 2024 indicating a loss of beach volume.
B05	Major erosion	Significant reduction in beach width	Accretion	Major increase in beach width.	Accretion*	Major increase in beach width.	Accretion*	Major increase in beach width.
B06UP-COAST	Major erosion	Significant reduction in beach width	Accretion	Major increase in beach width.	*Unable to assess, manual imagery capture began in 2021.*			

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Long-term Changes (October 2014 to October 2024)		Long-term Changes (March 2015 to April 2024)	
	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								
B06 DOWN-COAST	Minor erosion	Notable reduction in beach width	Accretion	Major increase in beach width.				
B07 UP-COAST	Minor erosion	Notable reduction in beach width, however, dune is in good condition with grown vegetation	Accretion	Major increase in beach width.	Accretion*	Slight increase in beach width and improvement in dune condition with build up at the base of dune	Accretion*	Major increase in beach width.
B07 DOWN-COAST	Minor erosion	Notable reduction in beach width, however, dune is in good condition with grown vegetation	Accretion	Major increase in beach width.	Accretion*	Major increase in beach width and improvement in dune condition with build up at the base of dune	Accretion*	Major increase in beach width.
*Long-term changes have been assessed through images taken in 2019.								

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

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Mid-term Changes (October 2019 to October 2024)		Mid-term Changes (March 2015 to April 2024)	
	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	Accretion	Notable increase in beach width and build up in beach volume. Dune is in good condition	Minor erosion	Reduction in beach width and slight erosion at the base of the dunes.	Minor erosion	Minor erosion at the base of dune	Minor erosion	Loss of some dune vegetation with erosion scarp at the base of the dunes.
B01 DOWN-COAST	Accretion	Notable increase in beach width and build up in beach volume. Dune is in good condition	Minor erosion	Reduction in beach width and slight erosion at the base of the dunes.	Accretion	Improvement in dune condition with grown vegetation	Minor erosion	Loss of some dune vegetation with erosion scarp at the base of the dunes.
B02 UP-COAST	Accretion	Notable increase in beach width and build up in beach volume. Dune is in good condition	No change	No notable change in beach width or dune condition	Accretion	Slight increase in beach width	Minor erosion	Loss of some dune vegetation with erosion scarp at the base of the dunes.
B02 DOWN-COAST	Accretion	Notable increase in beach width and build up in beach volume. Dune is in good condition	Minor erosion	Slight reduction in beach width.	Minor erosion	Loss of dune vegetation at the base of the dunes.	Accretion	Slight improvement in beach and dune condition.
B03 UP-COAST	Minor Erosion	Minor reduction in beach width and erosion scarp at dune	No change	No notable change in beach width or dune condition	Minor erosion	Notable reduction in beach width	No change	No notable change in beach width or dune condition
B03 DOWN-COAST	Minor Erosion	Slight reduction in beach width. Dune remains in good condition	No change	No notable change in beach width or dune condition	Minor erosion	Slight reduction in beach width	Accretion	Notable increase in beach width.
B04 UP-COAST	Minor Erosion	Slight reduction in beach width. Dune remains in good condition	No change	No notable change in beach width or dune condition	Minor erosion	Loss of dune vegetation at the base of the dunes.	Accretion	Notable increase in beach width.
B04 DOWN-COAST	Minor Erosion	Minor reduction in beach width, however, dune remains in good condition with grown vegetation	Minor erosion	Very slight reduction in beach width.	Minor erosion	Slight reduction in beach width	Minor erosion	Loss of dune vegetation at the base of the dunes.
B05 UP-COAST	Minor Erosion	Minor reduction in beach width and erosion scarp at dune. Visible bedrock suggests a reduction in beach volume	No change	No notable change in beach width or dune condition	Minor erosion	Minor reduction in beach width and erosion scarp at the base of dune	No change	No notable change in beach width or dune condition
B05 DOWN-COAST	Minor Erosion	Notable reduction in beach width	Minor erosion	Very minor reduction in beach width.	Minor erosion	Minor reduction in beach width and loss of vegetation at the base of dune	No change	No notable change in beach width or dune condition

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Mid-term Changes (October 2019 to October 2024)		Mid-term Changes (March 2015 to April 2024)	
	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								
B06 UP-COAST	Accretion	Slight increase in beach width	Minor erosion	Minor reduction in beach width.	Minor erosion	Minor reduction in beach width.	Minor erosion	Notable loss of foredune.
B06DOWN-COAST	Accretion	Notable increase in beach width and gradient	Minor erosion	Minor reduction in beach width.	Minor erosion	Slight reduction in beach width and loss of vegetation at the base of dune.	Minor erosion	Loss of vegetation is evident at the dune toe.
B07 UP-COAST	Major Erosion	Significant reduction in beach width. A visible cliff suggests massive reduction in beach volume and height	Accretion	Significant increase in beach width.	Major Erosion	Significant reduction in beach height and volume	Accretion	Significant increase in beach width.
B07 DOWN-COAST	Major Erosion	Significant reduction in beach width. A visible bedrock suggests massive reduction in beach volume and height	Accretion	Significant increase in beach width.	Minor erosion	Notable reduction in beach height and volume	No change	No notable change in beach width or dune condition
B08 UP-COAST	Major Erosion	Significant reduction in beach width. A visible bedrock suggests massive reduction in beach volume and height	Accretion	Significant increase in beach width.	Minor erosion	Notable reduction in beach width	Accretion	Significant increase in beach width.
B08 DOWN-COAST	Major Erosion	Significant reduction in beach width and volume.	Accretion	Significant increase in beach width.	Minor erosion	Loss of vegetation is evident at the dune toe.	Accretion	Significant increase in beach width.
B09 UP-COAST	Accretion	Slight increase in beach width	Accretion	Improvement in beach gradient.	Minor erosion	Notable reduction in beach width. It is important to note that Nourishment has been undertaken at this site on numerous occasions between 2018 and 2023.	No change	No notable change in beach width or dune condition. Nourishment has been undertaken at this site on numerous occasions between 2018 and 2023.
B09 DOWN-COAST	Minor Erosion	Notable reduction in beach width	Accretion	Improvement in beach gradient and notable increase in beach width at the headland.	Minor erosion	Minor reduction in beach width. It is important to note that Nourishment has been undertaken at this site on numerous occasions between 2018 and 2023.	No change	No notable change in beach width or dune condition. Nourishment has been undertaken at this site on numerous occasions between 2018 and 2023.
B10 UP-COAST	Accretion	Notable increase in beach width	Minor erosion	Notable reduction in beach width. Dunes in similar condition.	Minor erosion	Minor reduction in beach width and	No change	No notable change in beach width or dune condition.
B10 DOWN-COAST	Accretion	Notable increase in beach width	Minor erosion	Notable reduction in beach width. Dunes in similar condition.	Minor erosion	Minor reduction in beach width.	No change	No notable change in beach width or dune condition.
B11 UP-COAST	Accretion	Notable increase in beach width	Minor erosion	Notable reduction in beach width. Dunes in similar condition.	Minor erosion	Minor reduction in beach width	No change	No notable change in beach width or dune condition.
B11 DOWN-COAST	Accretion	Notable increase in beach width and improvement in dune condition	Minor erosion	Notable reduction in beach width. Dunes in similar condition.	Minor erosion	Minor reduction in beach width	Accretion	Slight improvement in beach condition.
B12 UP-COAST	Minor Erosion	Notable reduction in beach width, however, dune remains in good condition	No change	No notable difference in beach or dune condition.	Minor erosion	Minor reduction in beach width; however, dune is in still good condition	No change	No notable change in beach width or dune condition.
B12 DOWN-COAST	Accretion	Notable increase in beach width	Minor erosion	Minor reduction in beach width.	Minor erosion	Notable reduction in beach width	Accretion	Slight improvement in beach condition.
B13UP-COAST	Accretion	Notable increase in beach width	Minor erosion	Notable reduction in beach width.	Minor erosion	Notable reduction in beach width	No change	No notable change in beach width or dune condition.
B13 DOWN-COAST	Major Erosion	Significant reduction in beach width, dune remains in good condition	Accretion	Notable increase in beach width.	Minor erosion	Notable reduction in beach width	Accretion	Significant improvement in beach condition.

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

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Long-term Changes (October 2014 to October 2024)		Long-term Changes (March 2015 to April 2024)	
	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	Major Erosion	Significant reduction in beach width, Minor erosion scarp, visible bedrock suggests reduction in beach volume	Accretion	Notable increase in beach width with some build up at the base of the dunes.	*Unable to* assess - photo *monitoring began in 2021.*			
B01 DOWN-COAST	Major Erosion	Significant reduction in beach width and beach volume. Notable erosion scarp at dune	Accretion	Notable increase in beach width with some build up at the base of the dunes.				

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

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Mid-term Changes (October 2021 to October 2024)		Mid-term Changes (March 2020 to April 2024)	
	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
Shorehaven								
B01 UP-COAST	Accretion	Slight increase in beach width	Minor erosion	Slight reduction in beach width.	Accretion	Slight increase in beach width and improvement in beach condition	Accretion	Slight improvement in beach condition
B01 DOWN-COAST	No change	No notable change in beach width or dune condition.	No change	No notable change in beach width or dune condition.	No change	No notable change in beach width or dune condition.	No change	No notable change in beach width or dune condition.
B02 UP-COAST	No change	No notable change in beach width or dune condition.	No change	No notable change in beach width or dune condition.	No change	No notable change in beach width or dune condition. it is important to note that beach scraping was undertaken, adding a sediment buffer to the dunes in October 2022 not in 2021.	Accretion	Slight improvement in beach condition
B02 DOWN-COAST	Minor erosion	Notable reduction in beach volume based on exposed rock at dune	Minor erosion	Slight reduction in beach width.	Minor erosion	Minor reduction in beach width	No change	No notable change in beach width or dune condition.

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

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Long-term Changes (October 2014 to October 2024)		Long-term Changes (March 2015 to April 2024)	
	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
Alkimos								
B01 UP-COAST	Minor erosion	Slight reduction in beach width, but dunes are in good condition	No change	No notable change in beach width or dune condition.	Unable to assess - photo monitoring began in April 2023.			
B01 DOWN-COAST	Minor erosion	Notable reduction in beach width, but dunes are in good condition	No change	No notable change in beach width or dune condition.				

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

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Long-term Changes (October 2014 to October 2024)		Long-term Changes (March 2015 to April 2024)	
	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	Very slight reduction in beach width.	Minor erosion	Very slight reduction in beach width.	*Unable to* assess - photo *monitoring began in October 2021.*			
B01 DOWN-COAST	Accretion	Notable increase in beach width	Minor erosion	Very slight reduction in beach width.				

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

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Long-term Changes (September 2014 to October 2024)		Long-term Changes (March 2015 to April 2024)	
	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 Rocks Beach								
B01	Accretion	Notable increase in beach width and built up in beach volume.	Minor erosion	Notable reduction in beach width. Dunes still remain in good condition.	Minor erosion	Very minor reduction in beach width; however, dune remains in good condition	Accretion	Notable improvement in dune condition with increased vegetation density.
B03 UP-COAST	Minor erosion	Slight reduction in beach width.	Minor erosion	Very slight reduction in beach width, no impact to dunes.	Minor erosion	Minor reduction in beach width, however, notable erosion at base of dune is observed	No change	No discernible change in beach condition, dunes remain in similar condition.
B03 DOWN-COAST	Minor erosion	Very slight reduction in beach width	Minor erosion	Very slight reduction in beach width, no impact to dunes.	Minor erosion	Minor reduction in beach width.	No change	No discernible change in beach condition, dunes remain in similar condition.
B04 UP-COAST	Minor Erosion	Minor reduction in beach width. Dunes remain in similar condition.	No change	No discernible change in beach width. Dunes remain in similar condition.	Minor erosion	Notable reduction in beach width.	No change	No discernible change in beach condition, dunes remain in similar condition.
B04 DOWN-COAST	Minor Erosion	Minor reduction in beach width. Dunes remain in similar condition.	No change	No discernible change in beach width. Dunes remain in similar condition.	Minor erosion	Notable reduction in beach width; however, dune condition is in good condition	Accretion	Improvement in dune condition with established vegetation.
B06 UP-COAST	Major Erosion	Significant reduction in beach width and notable erosion scarp near sandbags. The reduction in beach volume is also noted.	Accretion	Significant increase in beach width.	Minor erosion	Minor reduction in beach width in 2024 compared to last year; however, the GSC Revetment was under construction in 2014 which makes visual assessment difficult.	Accretion	Slightly wider beach is evident in 2024 however the GSC Revetment was under construction in 2014 which makes visual assessment difficult.
B06 DOWN-COAST	Major Erosion	Significant reduction in beach width and notable erosion scarp near sandbags. The reduction in beach volume is also noted.	Accretion	Significant increase in beach width.	Minor erosion	Minor reduction in beach width in 2024 compared to last year; however, the GSC Revetment was under construction in 2014 which makes visual assessment difficult.	Accretion	Slightly wider beach is evident in 2024 however the GSC Revetment was under construction in 2014 which makes visual assessment difficult.
B07 UP-COAST	Accretion	Slight Increase in gradient. Sand nourishment was undertaken in May 2024 following manual imagery.	Minor erosion	Slight reduction in beach gradient however notably wide beach width.	Accretion	Slight improvement in beach condition. It is important to note that ~75,000 m3 of nourishment has been undertaken at this site since 2013.	Accretion	Slight improvement in beach condition. It is important to note that ~75,000 m3 of nourishment has been undertaken at this site since 2013.

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Long-term Changes (September 2014 to October 2024)		Long-term Changes (March 2015 to April 2024)	
	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 Rocks Beach								
B07DOWN-COAST	Major Erosion	Significant reduction in beach width and notable erosion scarp near sandbags. The reduction in beach volume is also noted.	Accretion	Significant increase in beach width.	Minor erosion	Notable reduction in beach width, however the GSC Revetment was under construction in 2014 which makes visual assessment difficult.	Accretion	Slightly wider beach is evident in 2024 however the GSC Revetment was under construction in 2014 which makes visual assessment difficult.
B09 UP-COAST	Minor Erosion	Extremely minor reduction beach width, dune vegetation remains in good condition. Visible bedrock suggests slight reduction in beach volume	Minor erosion	Extremely minor reduction in beach with, dune vegetation remains in good condition.	Minor erosion	Minor reduction in beach width	Accretion	Notable improvement in dune condition.
B09 DOWN-COAST	Minor Erosion	Notable reduction in beach width and slight erosion scarp at dunes; however, dunes vegetation remains in good condition	Accretion	Notable increase in beach width.	Accretion	Slight increase in beach width and improvement in dune condition with build-up of sand at base of dune	No change	No discernible change in beach condition, dunes remain in similar condition.
B11 UP-COAST	Minor Erosion	Slight reduction in beach width. Dunes remain in good condition.	No change	No discernible change to beach width or dune condition.	No change	No discernible change to beach width or dune condition.	No change	No discernible change in beach condition, dunes remain in similar condition.
B11 DOWN-COAST	Minor Erosion	No dissemble changes in beach width. Slight reduction in beach volume.	No change	No discernible change to beach width or dune condition.	No change	No discernible change to beach width or dune condition.	No change	No discernible change in beach condition, dunes remain in similar condition.
B13 UP-COAST	Accretion	Notable increase in beach width. Sand nourishment was undertaken in May 2024 following manual imagery.	Minor erosion	Slight reduction in beach width however dunes remain in good condition.	Accretion	Notable improvement in dune condition with increased density of dune vegetation. It is important to note that ~25,000m3 of nourishment has been undertaken at this site since 2016, including nourishment that was undertaken in April 2023.	Accretion	Notable improvement in dune condition with increased density of dune vegetation. It is important to note that ~25,000m3 of nourishment has been undertaken at this site since 2016, including nourishment that was undertaken in April 2023.
B13 DOWN-COAST	Minor Erosion	Notable reduction in beach width, dunes remain in good condition.	No change	No discernible change in beach condition. Dunes remain in good condition.	Minor erosion	Minor reduction in beach width; however, improvement in dune condition with grown vegetation.	No change	No discernible change in beach condition, dunes remain in similar condition.
B14 UP-COAST	Minor Erosion	Minor erosion scarp at dune and reduction in beach volume	Minor erosion	Slight reduction in beach width.	Accretion	Slight increase in beach width.	Minor erosion	Notable reduction in beach width.
B14DOWN-COAST	Major Erosion	Significant reduction in beach width and visible bedrocks suggests reduction in beach volume	Accretion	Slight increase in beach width.	Minor erosion	Notable reduction in beach width and visible bedrocks suggests reduction in beach volume; however, it is important to note that beach scraping was undertaken, adding a sediment buffer to the dunes in December 2023.	Minor erosion	Some dune erosion is evident however it is important to note that beach scraping was undertaken, adding a sediment buffer to the dunes in December 2023.
B15 UP-COAST	Minor Erosion	Notable reduction in beach width and beach volume	Minor erosion	Slight reduction in beach height.	Accretion	Notable increase in beach width and beach volume	Minor erosion*	Significant reduction in beach height.

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Long-term Changes (September 2014 to October 2024)		Long-term Changes (March 2015 to April 2024)	
	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 Rocks Beach								
B15 DOWN-COAST	Minor Erosion	Minor reduction in beach width. Dunes remain in similar condition.	Minor erosion	Notable reduction in beach width.	Accretion	Slight increase in beach width.	Minor erosion*	Significant reduction in beach width.
B16 UP-COAST	Minor Erosion	Notable reduction in beach width and notable reduction in beach volume	No change	No discernible change in beach condition. Dunes remain in good condition.	Accretion	Slight increase in beach width	Minor erosion*	Significant reduction in beach width.
B16 DOWN-COAST	Minor Erosion	Notable reduction in beach width.	No change	No discernible change in beach condition. Dunes remain in good condition.	Accretion	Slight increase in beach width and beach volume	Minor erosion*	Significant reduction in beach width.
B17 UP-COAST	Minor Erosion	Minor reduction in beach width. Visible bedrocks suggest reduction in beach volume	Accretion	Slight reduction in beach width, dunes remain in similar condition.	*Unable to* assess - Monitoring *began in 2021.*			
B17 DOWN-COAST	Minor Erosion	Minor reduction in beach width	Accretion	Slight reduction in beach width, dunes remain in similar condition.				

**Long-term changes have been assessed through images taken in 2015.*
***Long-term changes have been assessed through images taken in 2017.*

Table 4-9 Visual observations of beach changes at manual imagery monitoring sites in Mindarie

Photo Monitoring Site	Winter Seasonal Changes (April 2024 to October 2024)		Summer Seasonal Changes (October 2023 to April 2024)		Long-term Changes (October 2014 to October 2024)		Long-term Changes (March 2015 to April 2024)	
	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
Mindarie								
B01	Major Erosion	Significant decrease in beach width with notable minor erosion scarp, and bedrock visible suggests the reduction in beach volume	Accretion	Significant increase in beach width.	Unable to assess – monitoring began in 2020.			
B02 UP-COAST	Major Erosion	Significant decrease in beach width with notable minor erosion scarp, Remaining beach is sufficient to protect dunes and infrastructure	Accretion	Significant increase in beach width.				
B02 DOWN-COAST	Major Erosion	Significant decrease in beach width with notable minor erosion scarp, and bedrock visible suggests the reduction in beach volume	Accretion	Significant increase in beach width.				
B03	Major Erosion	Significant decrease in beach width with notable minor erosion scarp and bedrock visible suggests the reduction in beach volume	Accretion	Significant increase in beach width.				
B04	Minor Erosion	No notable changes in beach width. Slight erosion at the base of the dunes is noted	No change	No discernible change in beach condition.				

4.2.1 Areas Experiencing Major Seasonal Erosion

While assessing seasonal changes, eight areas were identified as having experienced major erosion over the winter months (April 2024 to October 2024). Images of the identified areas experiencing major seasonal erosion are shown below.

4.2.1.1 Yanchep B07 Up-Coast and Down-Coast – Major Erosion, Winter 2024

Yanchep B07 Up-Coast - April 2024

Yanchep B07 Up-Coast - October 2024

Yanchep B07 Down-Coast - April 2024

Yanchep B07 Down-Coast - October 2024

Figure 4-7 Major erosion over winter 2024 at Yanchep B07.

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. There was a significant reduction in beach width over the 2024 winter period with the transport of sediment southward over the winter months resulting in erosion to the north of the headland. Subsequently, however, northward movement of sediment during the summer months results in significant accretion at the site which provides a substantial buffer against early winter storms. While there is major seasonal variation at the site, the long-term assessment suggests that the site has experienced notable reduction in beach volume and height 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 and it is therefore recommended that the site be monitored closely.

4.2.1.2 Yanchep B08 Down-Coast – Major Erosion, Winter 2024

April 2024	October 2024

Figure 4-8 Major erosion over winter 2024 at Yanchep B08 Down-Coast.

The Down-Coast photograph taken at Yanchep site B08 captures the same stretch of coastline captured in the Up-Coast photograph taken at Yanchep site B07 as discussed above in Section4.2.1.1. Yanchep photograph site B08 is situated immediately south of the headland and southward sediment transport over winter 2024 results in erosion at Yanchep site B08.

4.2.1.3 Amberton B01 Down-Coast – Major Erosion, Winter 2024

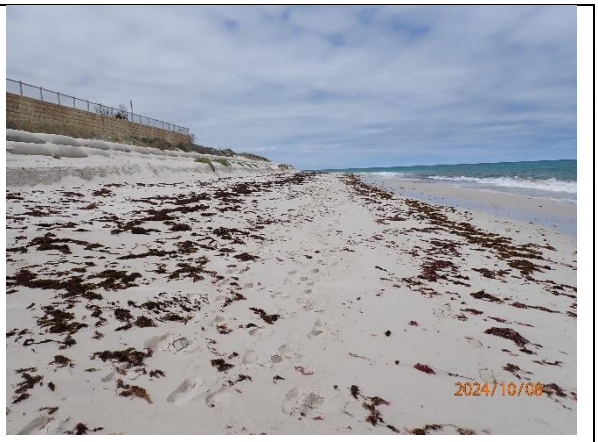
April 2024	October 2024

Figure 4-9 Major erosion over winter 2024 at Amberton B01 Down-Coast.

Significant seasonal erosion with reduction in beach width and erosional scarp at the toe of dune is noted at Down-Coast of Amberton Beach B01 over winter 2024. A Mid-term assessment (2021-2024) of beach also suggests a minor reduction in beach with and erosion at the base of dune compared to the photos taken during October 2021.

4.2.1.4 Quinns RocksB06 and B07 Down-Coast – Major Erosion, Winter 2024

B06 Down-Coast, April 2024



B06 Down-Coast, October 2024

B07 Down-Coast, April 2024

B07 Down-Coast, October 2024

Figure 4-10 Major erosion over winter 2024 at Quinns Rocks Rock B06 and B07 Down-Coast.

A significant reduction in beach width is observed south of Quinns Rocks Groyne One (1) over the 2024 winter period. This is also a result of the southward movement of sediment over the winter period. While the erosion is significant, the coastal management measures implemented at the site including the GSC revetment mean that it is unlikely to be of short-term concern.

4.2.1.5 Mindarie B01 and 02 – Major Erosion, Winter 2024

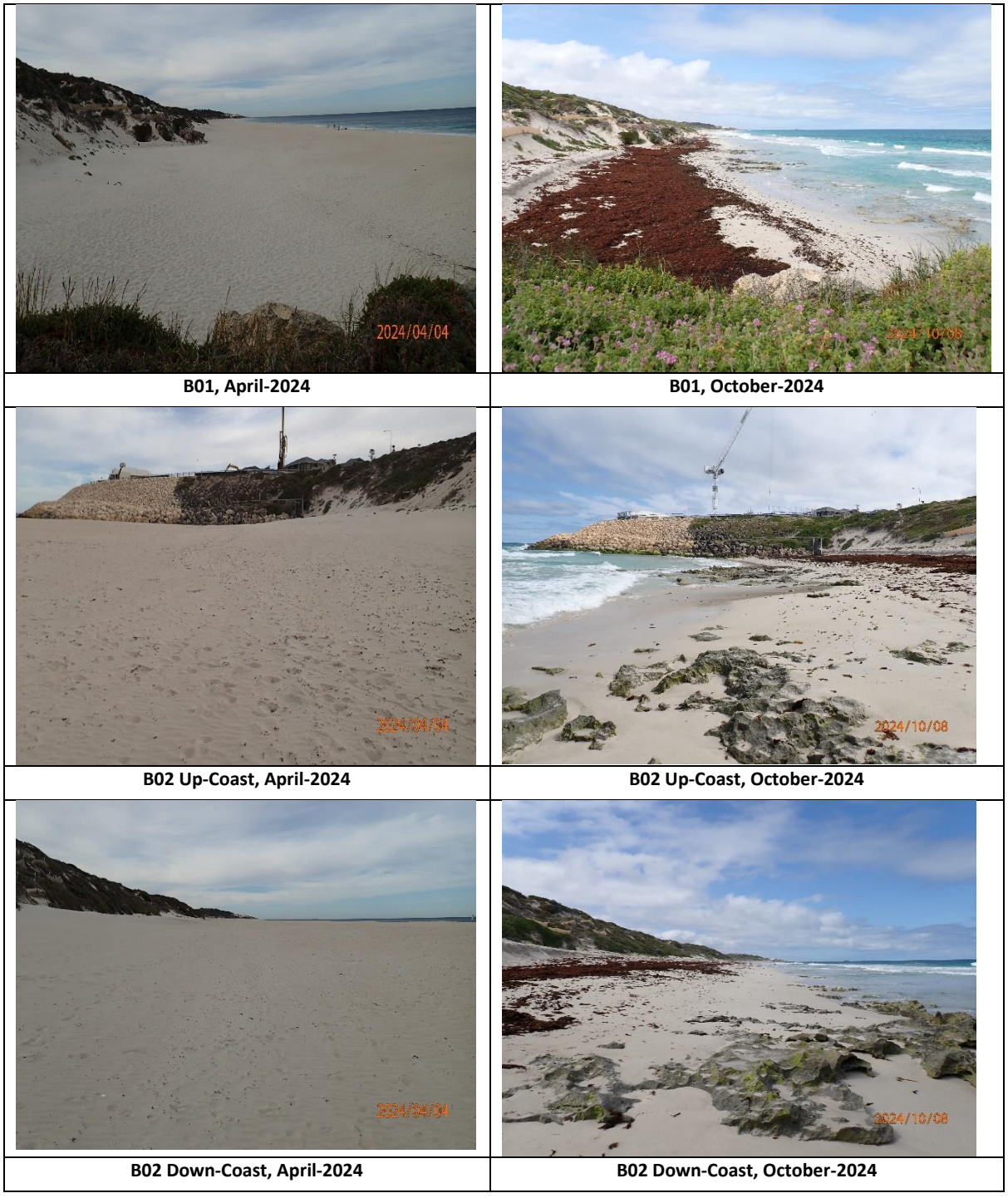


Figure 4-11 Major erosion over winter 2024 at Mindarie B01.

Significant erosion is observed at Clayton's Beach in Mindarie over the 2024 winter period. While the images show some beach remaining in October 2024, 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.

While there is a little infrastructure landward of Clayton's 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.

It is important to note that whilst changes to beach width is minimal at many sites there is still notable erosion at the base of the dunes as a result of this years' winter storms. 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 3.

4.2.2 Areas Experiencing Major Long-Term Change

Long-term trends of erosion and accretion were assessed by analysing photographs taken during the same time period, six years apart, at Two Rocks and Quinns Rocks. While most long-term trends assessed were of minor erosion or accretion at the site, Two Rocks site B05 saw significant, unexpected accretion and long-term erosion is noted at Quinns Rocks site B04.

4.2.2.1 Two Rocks B05 Down-Coast – Long-Term Accretion

October 2019	October 2024

Figure 4-12 Long-term accretion between 2019 and 2024 at Two Rocks B05.

Two Rocks B05 monitoring site is located at South of the beach from Two Rocks Breakwater. As outlined in Section 4.2.1, significant seasonal erosion was identified at the location. However, when assessing long-term changes to the coastline, the site resulted in accretion with wider beach width compared to the photographs taken during similar period in 2019.

4.2.2.2 Quinns Rocks B04 Down-Coast – Long-Term Erosion

September 2014	October 2024

Figure 4-13 Long-term erosion between 2014 and 2024 at Quinns Rocks B04.

Quinns Rocks site B04 Down-Coast show major seasonal and long-term erosion with notable reduction in beach width. Beach width for the site remained wider throughout the period since monitoring started in 2014 until summer 2024. Hence, a notable reduction in beach width has mainly happened during winter season of 2024.

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 completed along the entire CoW coastal corridor including the following areas:

- Two Rocks Beach;
- Yanchep Beach;
- Quinns Rocks Beach; and
- Clayton's Beach.

LiDAR Aerial Surveys can only capture areas above the waterline and when the shoreline has receded, the area of analysis is limited. Therefore, the City engaged MNG to capture an additional 129 nearshore ground based transect surveys to supplement the LiDAR data capture. These surveys are captured at the same time as the LiDAR aerial surveys and extend into the nearshore area, to a maximum water depth of one metre, to collect the data within the nearshore area that is otherwise missed.

These surveys are undertaken six (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 then assessed for changes in beach volume. Note that for this survey technique, this assessment is limited to dry areas landward of the waterline. Seasonal changes (April 2024 to October 2024) and annual changes (October 2023 to October 2024) to beach volume is assessed for each discrete area via difference plots of the two survey surfaces.

The data from ground-based survey transects has been interpolated to estimate changes in beach volume for the nearshore area 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 LiDAR surfaces within each of the study areas. These cross sections are combined with the nearshore ground-based survey transects and compared to earlier cross sections at the same location to further interrogate seasonal and long-term changes to the beach profile.

5.2 Elevation Difference Plots

5.2.1 Seasonal Changes

Plots depicting the difference in elevation between the April 2024 surveys and October 2024 surveys are outputs by MNG.

The change in beach volume between April 2024 and October 2024 is calculated for each of the 12 discrete study areas, the results of which are presented below in Table 5-1.

Table 5-1 Seasonal Net Volume Change of Beach Sections April 2024 – October 2024.

Beach Section	Section Description	Net Volume Change (m^3) October 2023 - April 2024	Net Volume Change (m^3) April 2024 - October 2024
Clayton's Beach Section 1A	Clayton's Beach above the waterline	+26,892	-48,038
Clayton's Beach Section 1B*	Clayton's Beach below the waterline	+31,883	-20,516
Quinns Rocks Section 1A	Quinns Rocks Main Beach - South of Artificial Headland above the waterline	-1,869	-2,386
Quinns Rocks Section 1B*	Quinns Rocks Main Beach – South of Artificial Headland below the waterline	-8,311	+6,491
Quinns Rocks Section 2A	Frederick Stubbs Park and GSC Revetment above the waterline	-764	-8,055
Quinns Rocks Section 2B*	Frederick Stubbs Park and GSC Revetment below the waterline	+8,342	-4,041
Quinns Rocks Section 3A	Frederick Stubbs Carpark, South of Groyne 2 above the waterline	+4,266	-2,572
Quinns Rocks Section 3B*	Frederick Stubbs Carpark, South of Groyne 2 below the waterline	+4,942	-863
Quinns Rocks Section 4A	North of Groyne 2, South of Groyne 3 above the waterline	+1,974	-2,522
Quinns Rocks Section 4B*	North of Groyne 2, South of Groyne 3 below the waterline	+765	-355
Quinns Rocks Section 5A	North of Groyne 3, South of Groyne 4 above the waterline	+1,010	-5,603
Quinns Rocks Section 5B*	North of Groyne 3, South of Groyne 4 below the waterline	+5,925	+1,132
Quinns Rocks Section 6A	North of Groyne 4, Jindalee above the waterline	+28	-4,862
Quinns Rocks Section 6B*	North of Groyne 4, Jindalee below the waterline	-616	+524
Yanchep Section 1A	South of Fisherman's Hollow Beach Access above the waterline	+1,000	-3,190
Yanchep Section 1B*	South of Fisherman's Hollow Beach Access below the waterline	-2,866	4,780
Yanchep Section 2A	South of Headland, North of Fisherman's Hollow Beach Access above the waterline	3,898	-33,866
Yanchep Section 2B*	South of Headland, North of Fisherman's Hollow Beach Access below the waterline	+17,890	-517
Yanchep Section 3A	Yanchep Lagoon above the waterline	-375	+960
Yanchep Section 3B*	Yanchep Lagoon below the waterline	-54	-596
Yanchep Section 4A	South of Capricorn Groyne above the waterline	+5,013	-3,550
Yanchep Section 4B*	South of Capricorn Groyne below the waterline	-1,208	+1,860
Yanchep Section 5A	North of Capricorn Groyne above the waterline	-2,175	-470
Yanchep Section 5B*	North of Capricorn Groyne below the waterline	-3,648	+1,278

Beach Section	Section Description	Net Volume Change (m^3) October 2023 - April 2024	Net Volume Change (m^3) April 2024 - October 2024
Two Rocks Section 1A	South of Two Rocks Marina above the waterline	+14,226	-10,734
Two Rocks Section 1B*	South of Two Rocks Marina below the waterline	+55,778	-34,131
Two Rocks Section 2A	North of Two Rocks Marina above the waterline	-1,451	-6,470
Two Rocks Section 2B*	North of Two Rocks Marina below the waterline	-1,534	+3,429

**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 however volume changes below the waterline are calculated from ground based transects that have 100m separation.*

Overall, there was a decrease in beach volume across the winter 2024 period. The combined net volume changes of the Mindarie, Quinns Rocks, Yanchep and Two Rocks foreshore areas between April 2024 and October 2024 are as follows:

- The one beach section that is assessed within the Mindarie (Clayton's Beach) foreshore areas had an estimated net beach volume loss of 68,884 m^3;
- The six beach sections along the Quinns Rocks foreshore area had an estimated combined net beach volume loss of 23,112 m^3;
- The five beach sections along the Yanchep foreshore area had a combined net beach volume increase of 33,311 m^3; and
- The two beach sections along the Two Rocks foreshore area had a combined net beach volume increase of 47,906 m^3.

These results represent a significant loss in beach volume over the 2024 winter period, particularly along Clayton's Beach, however the volume loss recorded at Clayton's Beach was notably less than the 2022 winter period and slightly more than 2023. Significant seasonal erosion is experienced at this site each year. The extent of beach volume loss within Two Rocks Section 1 is attributed to few small storms events with significant wave height > 5m across 2024 winter. The extent of beach volume loss is considerably larger than previous winter periods. There was, however, a significant increase in beach volume across the summer of 2023/24, particularly along Clayton's Beach and the beach area to the south of Two Rocks Marina. As outlined in Section 2, the 2024 winter period was considered to be a mild winter, with offshore wave heights not exceeding 7.08m and a wave climate characterised by WSW waves. This likely contributed to the net beach volume loss in Quinns Rocks Section 1A as the lack of north-westerly storm events limited the transport of sand southward. 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 – October 2023 to October 2024

Volume change plots depicting the difference in surface elevation between the October 2023 surveys and October 2024 surveys are outputs by MNG.

The change in beach volume over the year, between October 2023 and October 2024, is calculated for each of the 14 discrete study areas, the results of which are presented below in Table 5-2.

Table 5-2 Annual Net Volume Change of Beach Sections October 2023 – October 2024.

Beach Section	Section Description	Net Volume Change (m^3) October 2023 – October 2024
Clayton's Beach Section 1A	Clayton's Beach above the waterline	-38,783
Clayton's Beach Section 1B*	Clayton's Beach below the waterline	+13,194

Beach Section	Section Description	Net Volume Change (m^3) October 2023 – October 2024
Quinns Rocks Section 1A	Quinns Rocks Main Beach - South of Artificial Headland above the waterline	-1,526
Quinns Rocks Section 1B*	Quinns Rocks Main Beach – South of Artificial Headland below the waterline	-166
Quinns Rocks Section 2A	Frederick Stubbs Park and GSC Revetment above the waterline	+3,305
Quinns Rocks Section 2B*	Frederick Stubbs Park and GSC Revetment below the waterline	+1,310
Quinns Rocks Section 3A	Frederick Stubbs Carpark, South of Groyne 2 above the waterline	+1,890
Quinns Rocks Section 3B*	Frederick Stubbs Carpark, South of Groyne 2 below the waterline	-263
Quinns Rocks Section 4A	North of Groyne 2, South of Groyne 3 above the waterline	-126
Quinns Rocks Section 4B*	North of Groyne 2, South of Groyne 3 below the waterline	-936
Quinns Rocks Section 5A	North of Groyne 3, South of Groyne 4 above the waterline	-754
Quinns Rocks Section 5B*	North of Groyne 3, South of Groyne 4 below the waterline	-510
Quinns Rocks Section 6A	North of Groyne 4, Jindalee above the waterline	-5,037
Quinns Rocks Section 6B*	North of Groyne 4, Jindalee below the waterline	-2,745
Yanchep Section 1A	South of Fisherman's Hollow Beach Access above the waterline	-3,158
Yanchep Section 1B*	South of Fisherman's Hollow Beach Access below the waterline	-644
Yanchep Section 2A	South of Headland, North of Fisherman's Hollow Beach Access above the waterline	-2,405
Yanchep Section 2B*	South of Headland, North of Fisherman's Hollow Beach Access below the waterline	-78
Yanchep Section 3A	Yanchep Lagoon above the waterline	-466
Yanchep Section 3B*	Yanchep Lagoon below the waterline	-666
Yanchep Section 4A	South of Capricorn Groyne above the waterline	-1,724
Yanchep Section 4B*	South of Capricorn Groyne below the waterline	-1,870
Yanchep Section 5A	North of Capricorn Groyne above the waterline	-3,487
Yanchep Section 5B*	North of Capricorn Groyne below the waterline	-2,277
Two Rocks Section 1A	South of Two Rocks Marina above the waterline	-2,212
Two Rocks Section 1B*	South of Two Rocks Marina below the waterline	-10,424

Beach Section	Section Description	Net Volume Change (m^3) October 2023 – October 2024
Two Rocks Section 2A	North of Two Rocks Marina above the waterline	-5,194
Two Rocks Section 2B	North of Two Rocks Marina below the waterline	-2,575

It is apparent that there was an overall loss of the beach volume for the City's coastline across the year. It is important to note that as part of the annual beach renourishment program, 7,000 tonnes (~5,700 m^3) of sand was imported in May 2024 for renourishment at Quinns Rocks Sections 3A, 5A, and 6A and 2,000 tonnes (~1,600 m^3) of sand was imported in September 2024 for renourishment at Yanchep Section 3.

The beach volume change maps developed by MNG show that in Quinns Rocks, while there was net volume loss for Sections 1A and 1B, there was a net volume gain of the same order of magnitude for Sections 2A and 2B. As Sections 2A and 2B are situated to the south of Quinns Rocks Groyne One (1), sediment from Sections 1A and 1B were likely transported to Sections 2A and 2B across the summer season, as a result of strong southerly sea breeze events that drive incident wave energy and retained in these sections by Groyne One (1). The mild winter, characterised by WSW waves, likely resulted in limited southward longshore transport which resulted in a net loss of sediment in Quinns Rocks Sections 1A and 1B across the year.

There was a significant reduction in beach volume across the Yanchep coastline for the year, particularly in Yanchep Beach Sections 4 and 5 which are situated to the south of Yanchep Lagoon. The significant seasonal erosion observed within Section 4 of Yanchep Beach following the 2023/24 summer period likely contributed to the overall reduction in beach volume. Yanchep Lagoon Beach is bound by a rock headland to the south which interrupts the longshore transport of sediment during the summer months. By April 2024 monitoring period sediment had begun to move around the headland and build up at the southern end of Yanchep Lagoon Beach, however, it had not moved north before winter with major erosion observed along the northern end of Yanchep Lagoon Beach.

Notably, there was also considerable net loss of beach volume in Two Rocks Section 1A and 1B compared to the previous winter periods. This section is bounded by the Two Rocks Marina to the north, which interrupts longshore sediment transport, trapping sand to the south of the Two Rocks Marina Southern Breakwater. Similarly to Quinns Rocks Sections 2A and 2B, sediment was likely transported to this area across the summer season as a result of summer sea breezes driving incident wave energy and mild winter conditions limited the southerly transport of sediment.

Despite the annual capital renourishment activities, Quinns Rocks Sections 3, 5 and 6 still saw a total reduction of 7419 m^3 in beach volume. This points to the importance of beach renourishment in these areas, without it we would see a significantly larger reduction in beach volume which would cause significant impact to coastal assets and dune systems in these areas.

5.2.3 Long Term Trends

Annual changes in beach volumes have been assessed by the City since 2020. To identify any long-term trends in annual beach volume change, net beach volume change per year, relative to length of coastline, was plotted for each beach section. As nearshore transects were only captured from April 2022 and later, long-term analysis could not be assessed for the nearshore area and therefore it is important to note that these plots only depict annual beach volume change above the waterline. These plots are presented in Figure 5-1, to Figure 5-5 below.

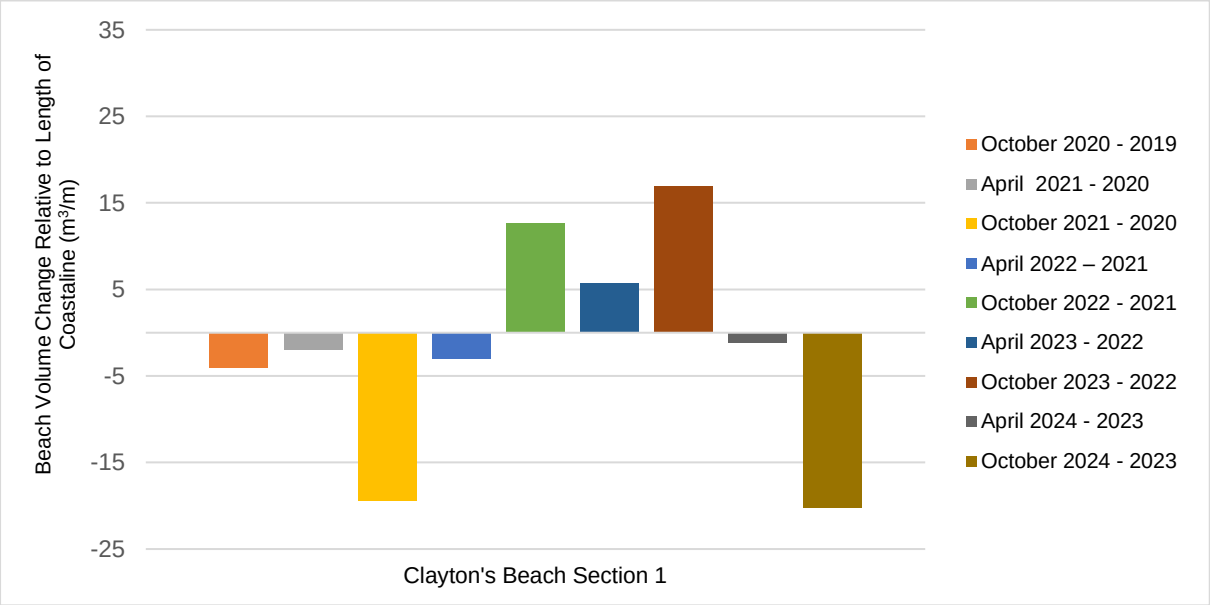


Figure 5-1 *Annual net beach volume changes for Clayton's Beach Section 1.*

The Clayton's Beach Section 1 is situated immediately south of the Mindarie Marina Breakwater, which interrupts the northward longshore sediment transport, trapping sand within the beach section defined by Clayton's Beach Section 1. Figure 5-1 shows that the increase in beach volume along Clayton's Beach observed between October 2021 and October 2023 has been followed by significant erosion over the past year. The net beach volume gain observed during the study periods October 2021 to 2022, April 2022 to 2023 and October 2022 to 2023 is likely attributed to strong sea breezes observed throughout the seasonal summer period. Over the 2023/2024 period there has been an increase in annual net beach volume of 13,194 m^3 in the nearshore section (Clayton's Beach Section 1B), as presented in Table 5-2. However, significant erosion was observed above the water line with annual net beach volume change of -38,783 m^3.

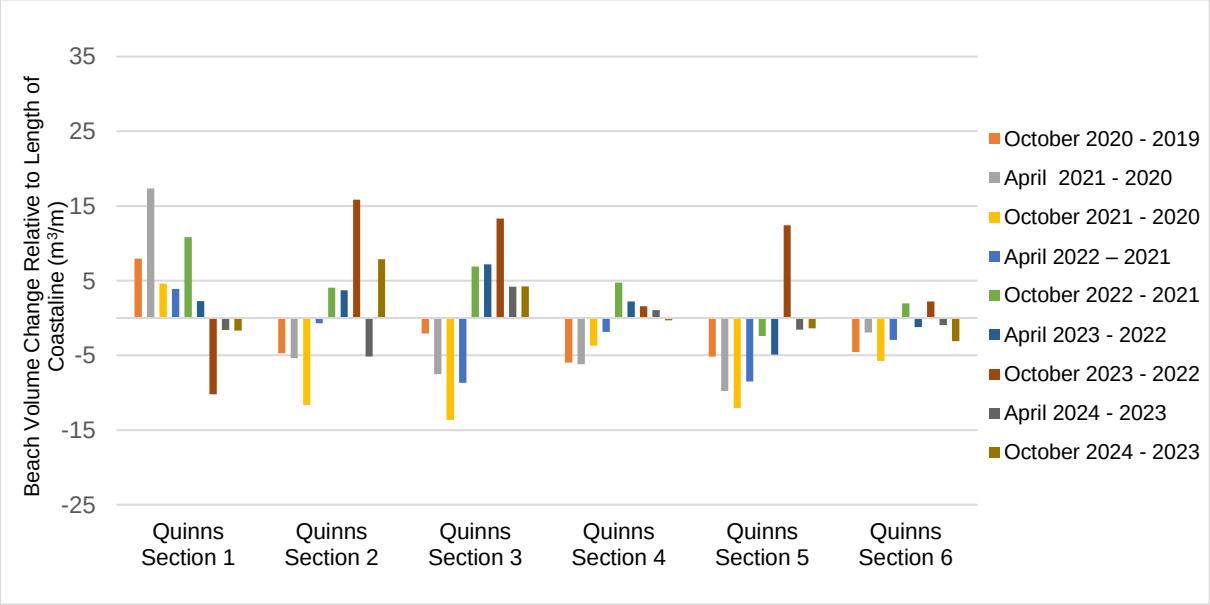


Figure 5-2 *Annual net beach volume changes for Quinns Rocks Section 1,2,3,4,5 and 6.*

Overall, there was limited beach volume change during the monitoring period compared to previous years. Notably, there was a significant beach volume increase in Quinns Rocks Sections 2 during the

study period, reversing the trend from last year. Conversely, a continued erosion trend was observed across Quinns Rocks Section 1. Nourishment works were undertaken within Quinns Rocks Section 3 (3,000 tonnes), Quinns Rocks Section 5 (2,000 tonnes), and Quinns Rocks Section 6 (2,000 tonnes). Figure 5-2 shows a continual reduction in beach volume within Quinns Rocks Section 5, even with the renourishment works. The City has placed approximately 10,000 m^3 of sand within this beach section since 2020 as part of the City's ongoing Beach Renourishment Program and has recently started to undertake regular nearshore beach scraping at this site since 2023. It is recommended that this site continue to be closely monitored as Ocean Drive, associated public infrastructure and residential housing is located less than 100m from the base of the dune and could be impacted by continued coastal erosion.

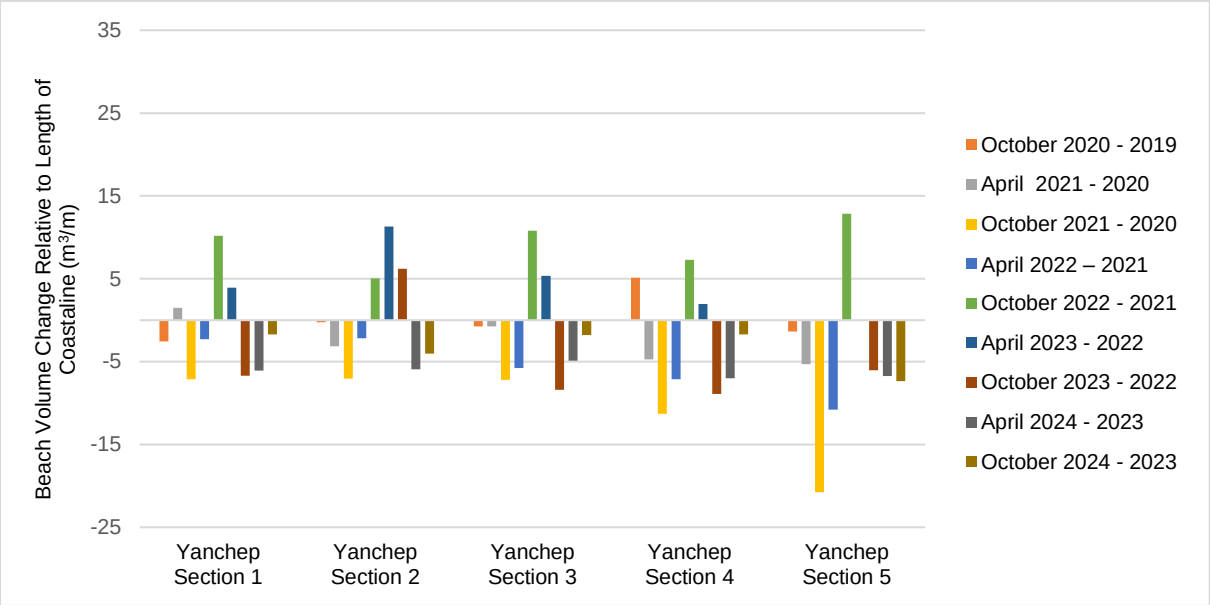


Figure 5-3 Annual net beach volume changes for Yanchep Section 1,2,3,4 and 5.

There was continued loss in beach volume across Yanchep between October 2023 and October 2024 in all sections. It is possible that this is a result of strong summer sea breeze conditions transporting sediment further north, away from the Yanchep coastline, however further analysis is required to better understand sediment transport along the Yanchep coastline. It is anticipated that additional data collection and numerical sediment transport modelling undertaken as part of the Yanchep Coastal Management Study will improve our understanding of sediment transport processes in this area.

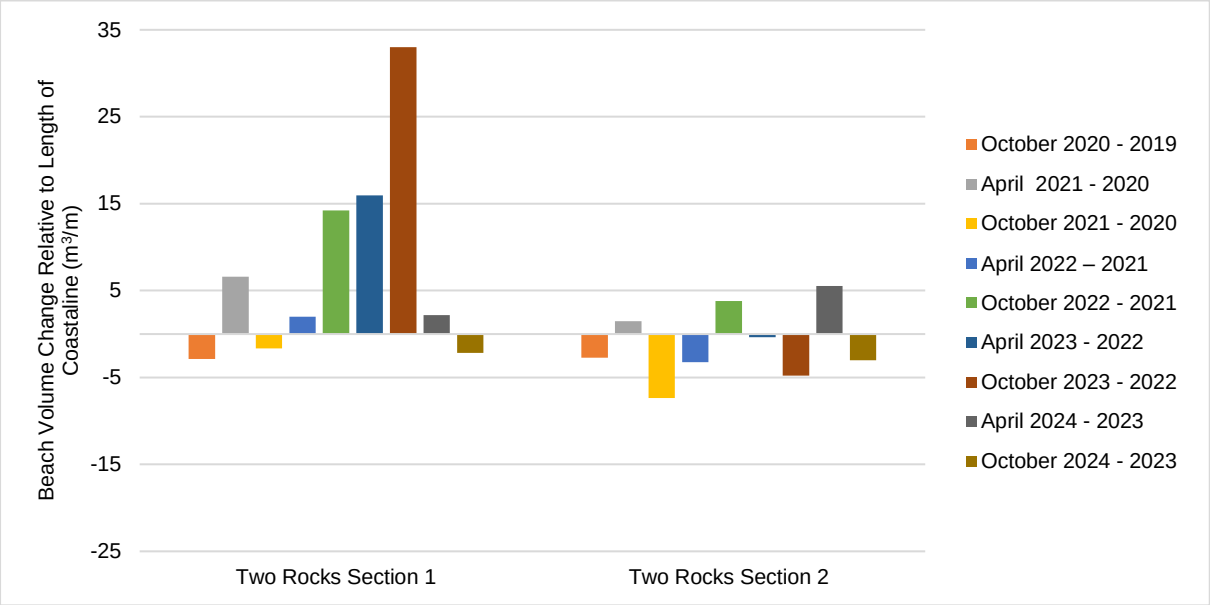


Figure 5-4 Annual net beach volume changes for Two Rocks Section 1 and 2.

For both Two Rocks Sections, as shown in Figure 5-4, there was a minor decrease in beach volume in the period between October 2023 and October 2024. At two Rocks Section 1, this is a notable change in trend from the October 2023 period where considerable increases in beach volume were observed. Accretion here has been attributed to strong summer breeze conditions which transport sand northwards where it is trapped by Two Rocks Marina Southern Breakwater.

5.3 Beach Cross Section Results

5.3.1 Transects with Significant Elevation Difference

The following sites were identified as having significant elevation differences (> 2.0m) between surveys. These areas may not have been identified in manual imagery observations but represent areas of major erosion and are important to identify as part of the coastal monitoring program.
3

5.3.1.1 Yanchep Beach

Cross Section 22 – Manual Imagery Site B07 Up-Coast

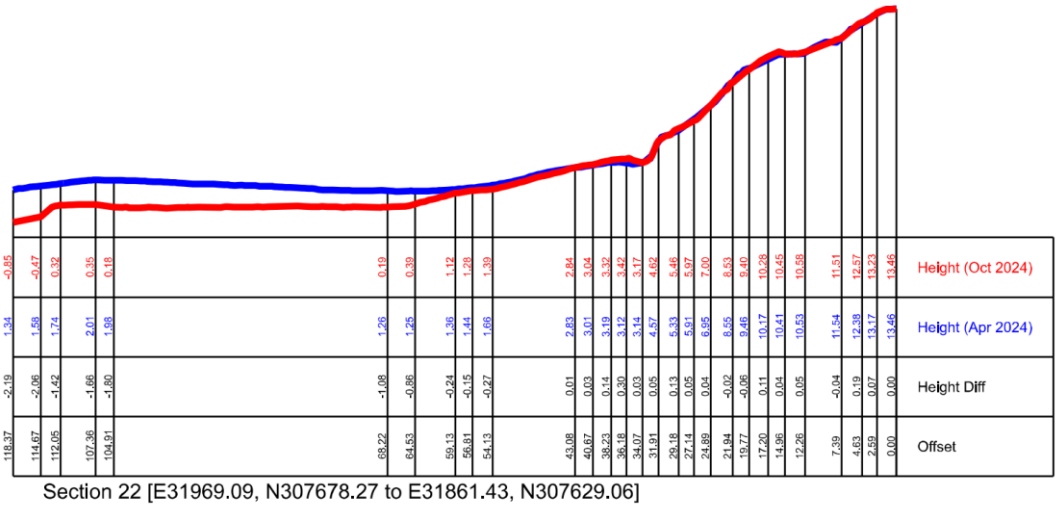


Figure 5-5 Yanchep beach cross section 22 elevation comparison between April 2024 and October 2024 surveys.

Yanchep beach cross-section 22 is situated within the field of view of manual imagery point Yanchep B07 Up-Coast. The cross-sectional survey shows a maximum reduction in elevation of 2.19m between April 2024 and October 2024. This is consistent with manual imagery observations which show a significant reduction in elevation at this stie.

Cross Section 41 – Manual Imagery Site B13 Down-Coast

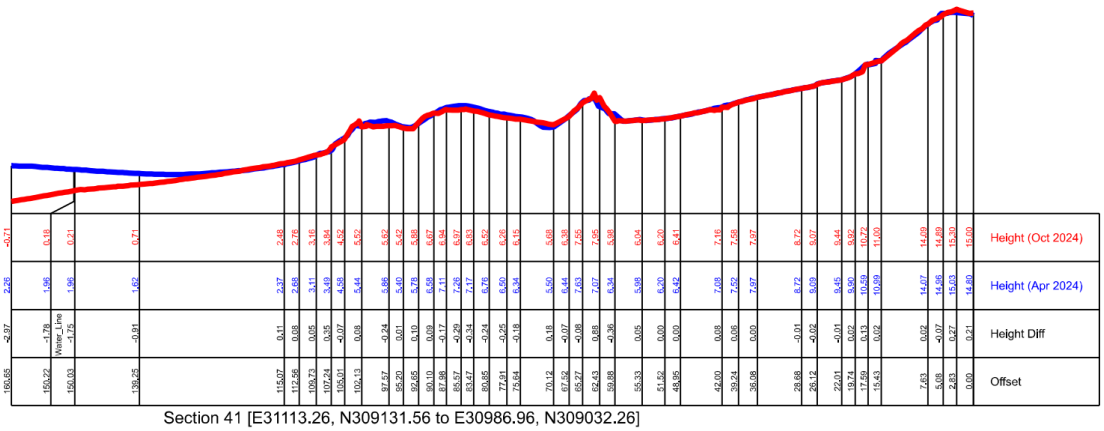


Figure 5-6 Cross section 41 at Yanchep beach, which shows a reduction in beach height of up to 2.99m just below the waterline between April 2024 and October 2024

Yanchep beach cross-section 41 is situated within the field of view of manual imagery point Yanchep B13 Down-Coast. The cross-sectional surveys show a maximum reduction in elevation of 2.99m between April 2024 and October 2024. This is consistent with manual imagery observation which show a significant reduction in beach width.

5.3.1.2 5.3.1.2 Quinns Rocks

Cross Section 14 – Manual Imagery Site B07 Down-Coast

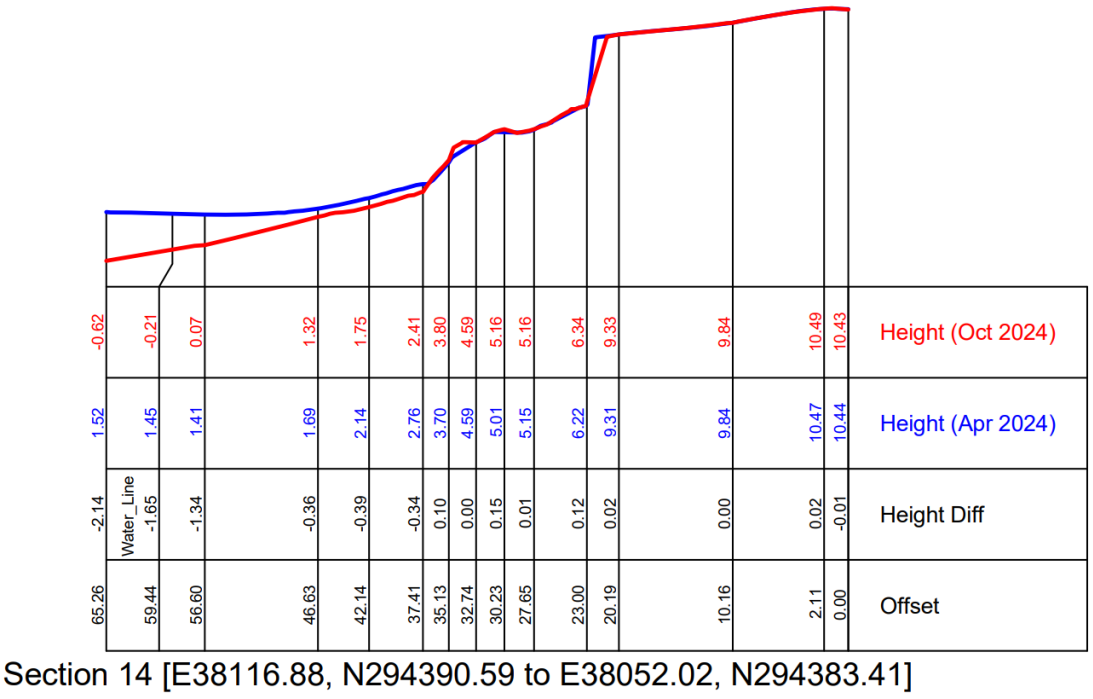


Figure 5-7 Quinns Rocks beach cross section 14 elevation comparison between April 2024 and October 2024 surveys.

Quinns Rocks beach cross-section 14 is situated within the field of view of manual imagery point Quinns Rocks B07 Down-Coast. The cross-sectional survey shows a maximum reduction in elevation of 2.14m. between April 2024 and October 2024. This is consistent with manual imagery observations which show a significant reduction in elevation at this stie.

Cross Section 13 – Manual Imagery Site B06 Down-Coast

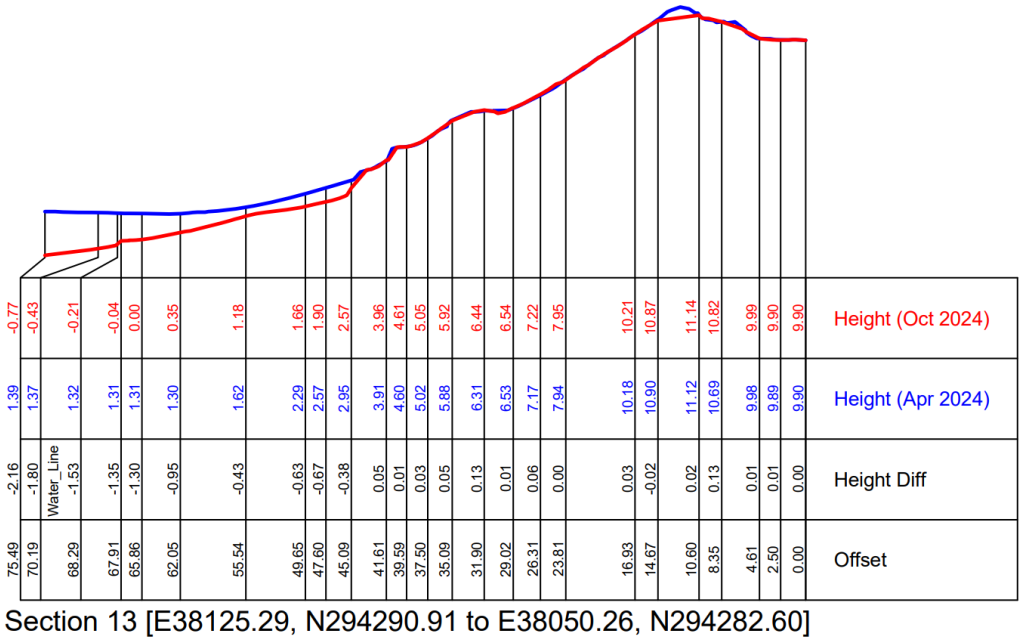


Figure 5-8 Quinns Rocks beach cross section 13 elevation comparison between April 2024 and October 2024 surveys.

Quinns Rocks beach cross-section 13 is situated within the field of view of manual imagery point Quinns Rocks B06 Down-Coast. The cross-sectional survey shows a significant reduction in elevation (max 2.16m) between April 2024 and October 2024. This is consistent with manual imagery observations which show a significant reduction in elevation at this stie.

Cross Section 15 – Manual Imagery Site B06 Down-Coast

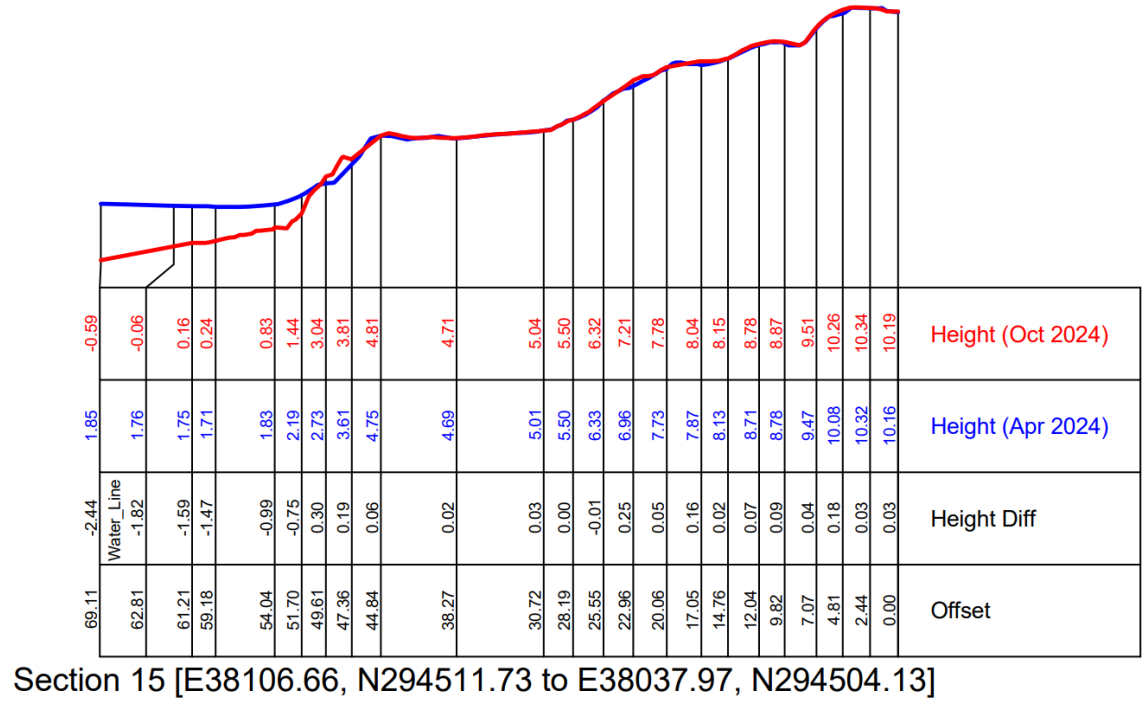


Figure 5-9 Quinns Rocks beach cross section 15 elevation comparison between April 2024 and October 2024 surveys.

The cross-sectional survey shows a significant reduction in beach elevation (2.44m), this is consistent with the seasonal winter trends along this section of beach. The cross-section 15 is situated just to the south of Groyne One (1).

5.3.1.3 Mindarie

Cross Section 19 – Manual Imagery Site B02 Down-Coast

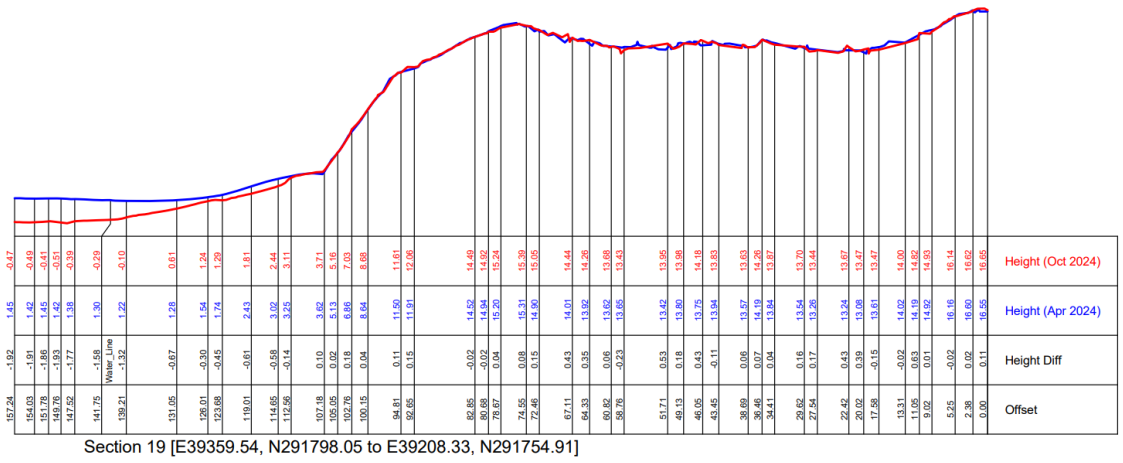


Figure 5-10 Clayton's Beach cross section 19 elevation comparison between April 2024 and October 2024 surveys.

At cross section 19, the surveys show a reduction in beach profile elevation of 1.92m between April 2024 and October 2024. The site is located south of the end of breakwater structure and consistent with manual imagery observations.

5.3.2 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 survey dates. These areas were not identified in manual imagery observations but represent areas of major erosion and are important to mention as part of the coastal monitoring program.

5.3.2.1 Two Rocks

Cross Section 07 – Manual Imagery Site B05 Down-Coast

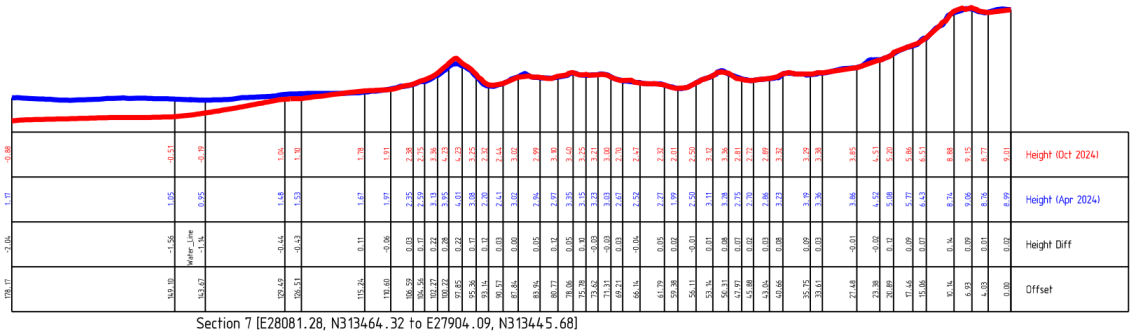


Figure 5-11 Two Rocks beach cross section 07 elevation comparison between April 2024 and October 2024 surveys.

The cross-sectional surveys, plotted in Figure 5-11 show major erosion with 2.04m height difference between April 2024 to October 2024 at an additional site along Two Rocks that were not identified through manual imagery. This site, and the corresponding manual imagery site, is outlined below.

April 2024

October 2024

Figure 5-12 Manual imagery taken at Two Rocks B05 Down-Coast in April 2024 and October 2024

5.3.2.2 Quinns Rocks

Results from beach profile cross-section comparisons show major erosion between April 2024 to October 2024 at an additional site along Quinns Rocks that was not identified through manual imagery. This site, and the corresponding manual imagery, is outlined below.

Cross Section 20 – Manual Imagery Site B09 Down-Coast

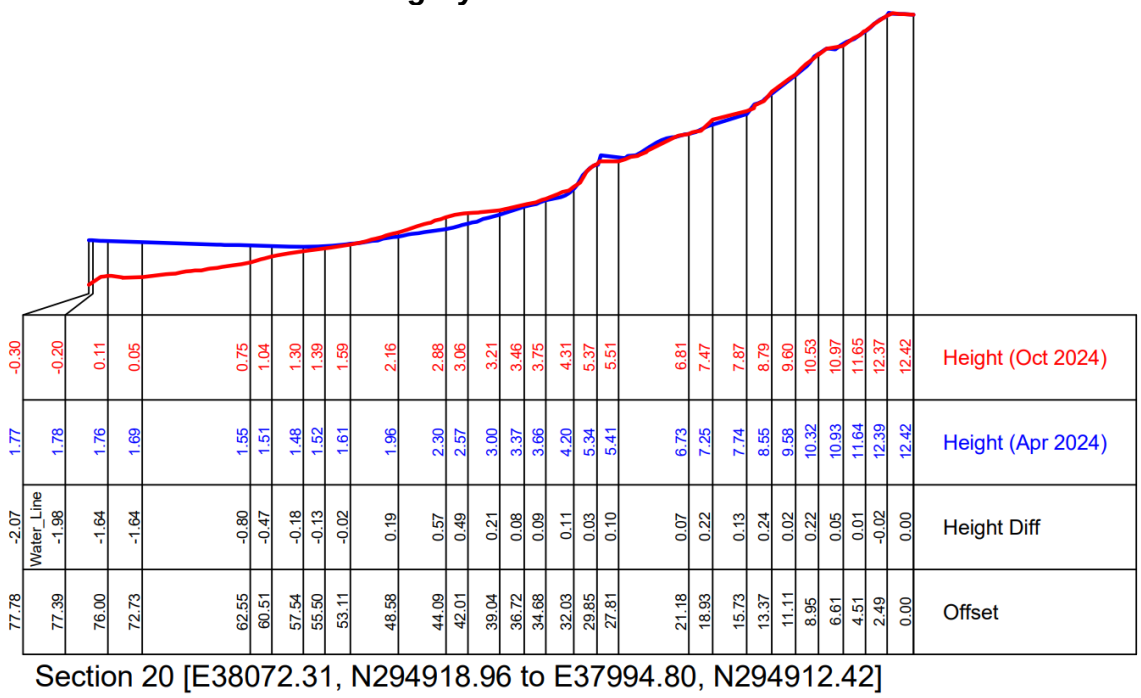


Figure 5-13 Cross section 20 at Quinns Rocks , which shows a reduction in beach height of up to 2.07m just below the waterline between April 2024 and October 2024

The cross-sectional survey data presented in Figure 5-13 shows a significant reduction in the beach height between April 2024 and October 2024 survey. As the reduction in elevation was mostly limited to the beach area close to the waterline, this site was not identified as having experienced major seasonal erosion in manual imagery analysis (Figure 5-14). Erosion at this site is likely a result of mild winter conditions coupled with strong sea breeze conditions which limited southward sediment transport.

Figure 5-14 Manual images taken at Quinns Rocks B09 Down-Coast in April 2024 and October 2024.

6 Remote Monitoring

Five remote monitoring cameras were installed along Quinns Rocks and Yanchep Beach in November 2021. The location and field of view of the cameras was selected to monitor vulnerable sections of the City's coastline, these locations are presented below in Figure 6-1 and Figure 6-2. The 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 between October 2023 and October2024.

Figure 6-1 Quinns Rocks Remote Coastal Monitoring Camera Locations

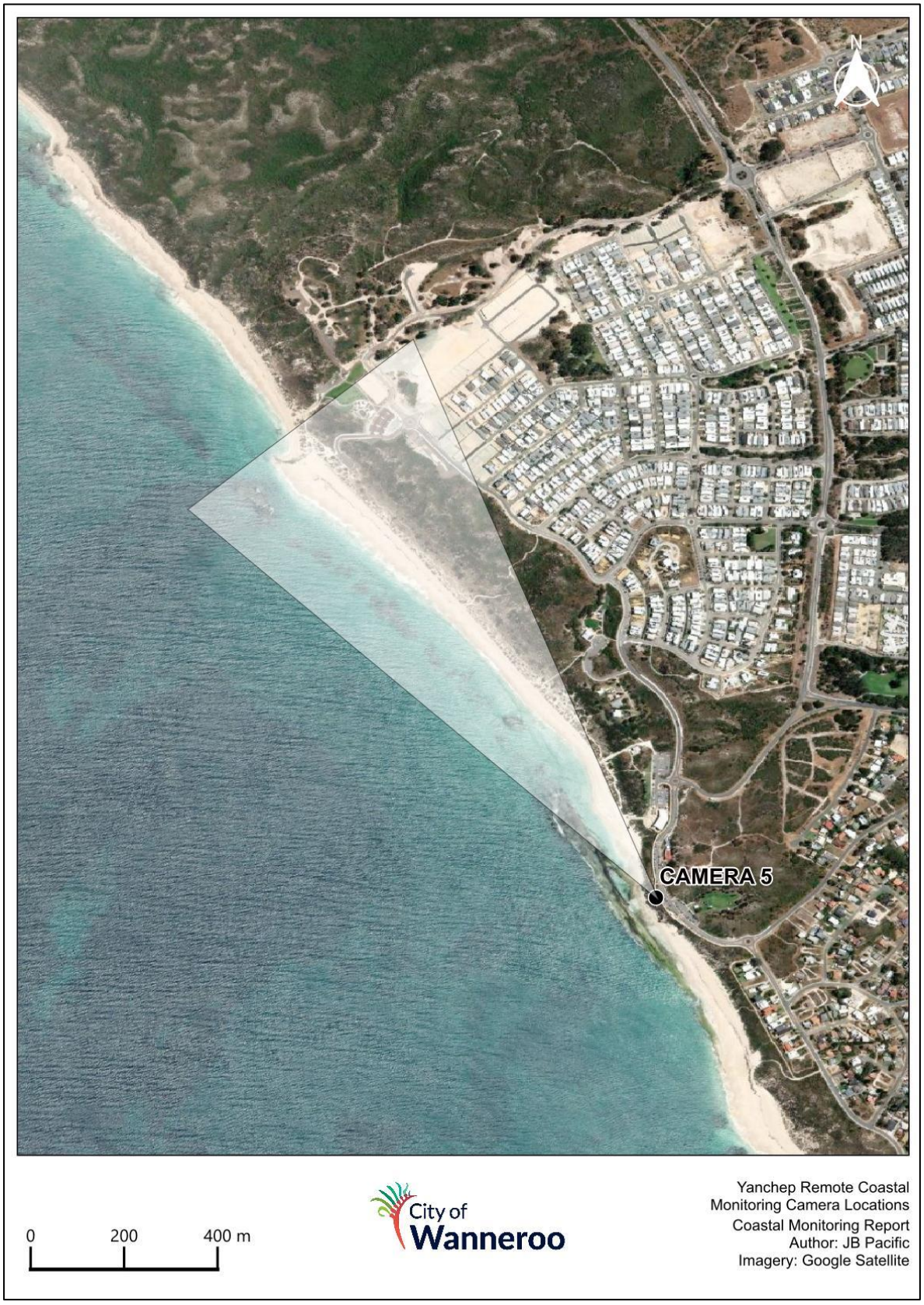
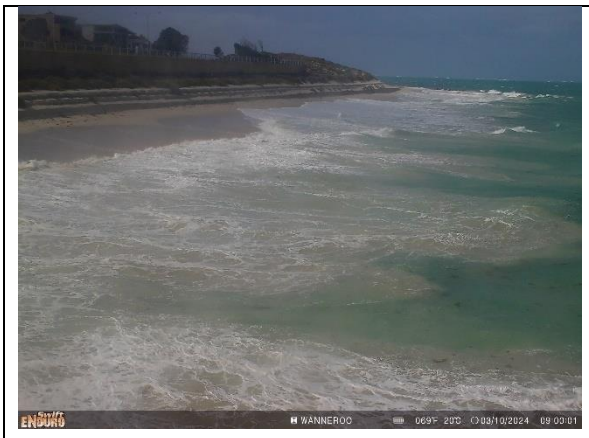


Figure 6-2 Yanchep Remote Coastal Monitoring Camera Locations

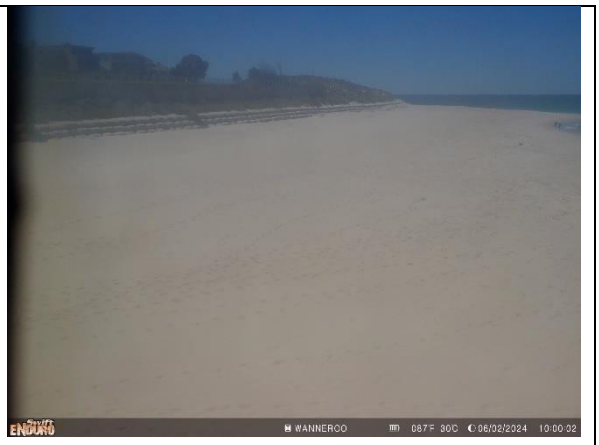
6.1 Quinns Rocks Camera 1

Quinns Rocks Camera One (1) captures the beach immediately south of Groyne One (1), adjacent to the GSC Revetment. Images are taken every hour between 6am and 7pm. In the last monitoring period, there were two gaps in the timeseries data with no imagery collected between 6pm 25 June 2024 to 12:32pm 3 July 2024, and between 7pm 24 August 2024 to 11:40am 9 September 2024.

The time series of images taken from Quinns Camera One (1) between November 2023 and October 2024 shows a wider beach from December 2023 up until May 2024. After May 2024, the beach begins to erode and continues to erode until end of the monitoring period in October 2024. This section of coastline is at its most receded position 3 October 2024, shown in Figure 6-3. Erosion is attributed to winter storms which mobilise sediment away from the beach face and transport sediment southward.



Most receded position – 03 October 2024

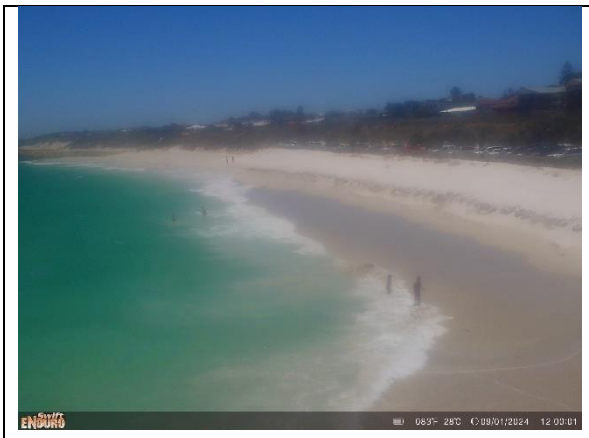


Most accreted position – 06 February 2024

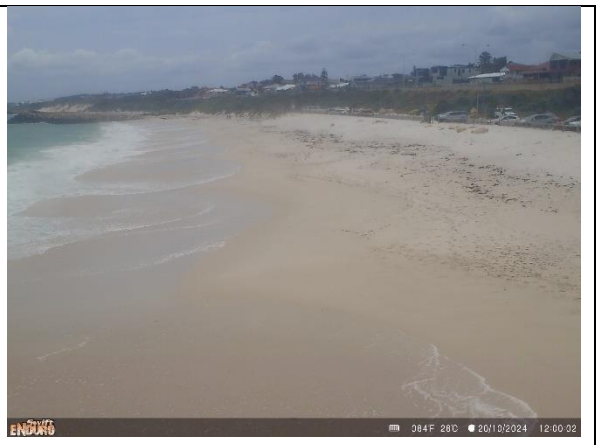
Figure 6-3 Most receded and most accreted shoreline positions to the south of Quinns Rocks Groyne One (1) during the study period.

6.2 Quinns Rocks Camera 2

Quinns Rocks Camera Two (2) captures the beach immediately north of Groyne One (1), adjacent to the Frederick Stubbs Carpark. Hourly images from the camera show the beach eroding over December 2023 throughout January. Accretion of the beach in the summer period is not expected, as prevailing southerly to south-westerly winds generally transport sand north where it is deposited to the south of the Groyne Two (2). It is believed that the build up to the south of Groyne has resulted in bypassing of sand around Groyne and onto the beach, adjacent to the carpark. The city undertook nourishment in front of the carpark in May 2024, where 3000 tonnes of sand was placed at the beach to provide a buffer against the impact of winter storm events and create a safe and accessible beach for the public.



Most receded position – 19 January 2024



Most accreted position – 20 October 2024

Figure 6-4 Most receded and most accreted shoreline positions to the north of Quinns Rocks Groyne One (1) during the study period.

6.3 Quinns Rocks Camera 3

Quinns Rocks Camera Three (3) monitors the beach and dunes to the south of Quinns Rocks Groyne Four (4). Hourly images of the site show slow steady accretion of the beach from the start of the monitoring period until January 2023 where the beach then begins to erode. The most receded shoreline position was observed in October, just following a minor storm event, which resulted in exposure of limestone bedrock on the beach. Beach scraping was undertaken at this site in December 2023 where sand that had built up to the south of Groyne Four (4) was taken from the nearshore and used to create a buffer at the base of the dunes.

Most receded position – 07 October 2024

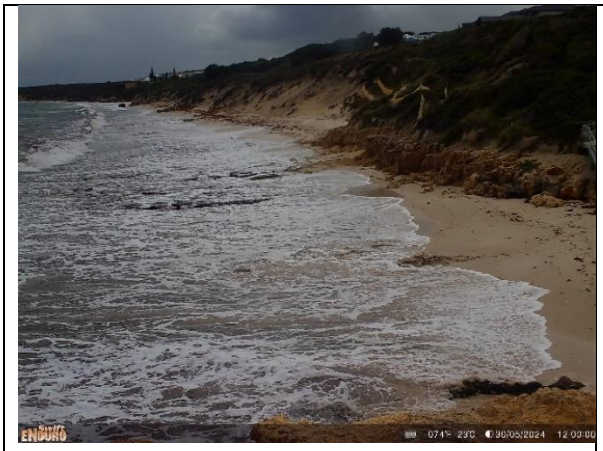
Most accreted position – 22 January 2024

Figure 6-5 Most receded and most accreted shoreline positions to the south of Quinns Rocks Groyne Four (4) during the study period.

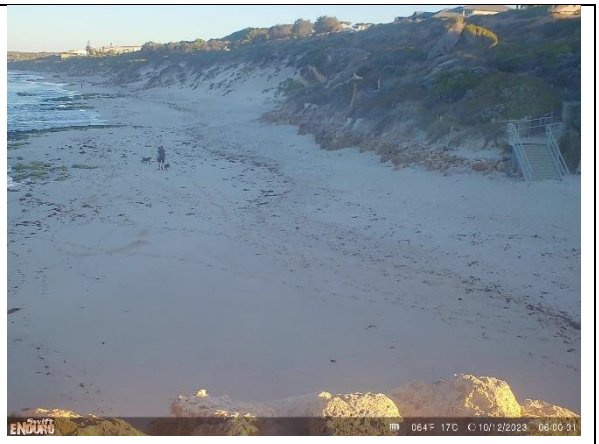
6.4 Quinns Rocks Camera 4

Quinns Rocks Camera Four (4) captures hourly imagery of the beach to the north of Quinns Rocks Groyne Four (4), along the northern Quinns Rocks Dog Beach. The beach was at is most receded position in May 2024 as per Figure 6-6. Seasonal erosion over the summer months is expected in this area as prevailing southerly winds generally transport sand to the north, away from the Groyne. A review of hourly imagery shows the beach building up across the 2024 winter period as north-westerly storm

events transport sand southward where it builds up against the Groyne. Again, this seasonal trend is expected for this site.



Most receded position – 30 May 2024



Most accreted position – 10 December 2023

Figure 6-6 Most receded and most accreted shoreline positions to the south of Quinns Rocks Groyne Four (4) during the study period

6.5 Yanchep Camera

The Yanchep Camera captures hourly images of Yanchep Lagoon Beach, which is bound by a rocky headland to the south and a small rock groyne to the north with a fringing reef system in the nearshore. During the summer the beach is wide and accessible, particularly to the south, however throughout the winter period the beach to the south is eroded by winter storm events that mobilise sediment away from the beach face. The beach was at is most receded position in August 2024 as per Figure 6-7.

Most receded position – 18 August 2024

Most accreted position – 3 May 2024

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

7 Aerial imagery

Aerial imagery obtained from Nearmap and captured during the six-monthly LiDAR Surveys is used to assess changes to 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. Analysis of aerial imagery is limited to the visual assessment of changes to the coastline, which, in this instance, is defined as the shoreline.

During the study period, from October 2023 to October 2024, a total 11 aerial images of the sites were available.

Table 7-1 Date of Aerial Images

Monitoring Date	Imagery Time	Source	Water Level at Time of Monitoring (Fremantle Tide Gauge – mAHD)
04 October 2023	12:19 PM to 12:56 PM	Nearmap	-0.4 to -0.44
07 October 2023	11:13 AM to 1:57 PM	Nearmap	-0.15 to -0.24
17 October 2023	7:00 AM to 3:00 PM	MNG	-0.17 to 0.08
09 December 2023	10:49 AM to 12:22 PM	Nearmap	-0.05 to -0.17
03 February 2024	12:52 PM	Nearmap	0.18
04 February 2024	12:59 PM to 2:44 PM	Nearmap	0.01 to 0.06
06 April 2024	9:38 AM to 11:54 AM	Nearmap	0.25 to 0.26
30 June 2024	1:31 PM to 2:06 PM	Nearmap	-0.06 to -0.07
14 September 2024	9:00 AM to 9:43 AM	Nearmap	0.11 to 0.08
15 September	10:02 AM to 10:49 AM	Nearmap	0.13 to 0.01
08 October 2024	7:00 AM to 4:30 PM	MNG	-0.15 to -0.05

7.1 Assessment Methodology

Similar to the analysis of remote imagery, aerial and satellite imagery is assessed through visual assessment and automatic shoreline tracking.

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 georeferenced and assessed individually.

7.2 Results

For assessment purposes, the coastline has been divided into fourteen discrete areas as outlined in Table 7-2. The most advanced and most receded shoreline position was identified for each discrete area.

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

Area	Most Receded Shoreline Position	Most Advanced Shoreline Position
Clayton's Beach	14 September 2024	03 February 2024
Quinns Rocks Main Beach	14 September 2024	02 December 2023
Quinns Rocks – GSC Revetment	04 October 2023	4 April 2024
Quinns Rocks – Groyne 1 to Groyne 2	04 October 2023	03 February 2024
Quinns Rocks – Groyne 2 to Groyne 3	15 June 2024	02 December 2023
Quinns Rocks – Groyne 3 to Groyne 4	15 June 2024	02 December 2023
Jindalee	27 October 2024	02 December 2023

Area	Most Receded Shoreline Position	Most Advanced Shoreline Position
Eden Beach	15 June 2024	02 December 2023
Shorehaven	15 June 2024	02 December 2023
Eglinton Beach	14 September 2024	03 February 2024
South Yanchep	14 September 2024	03 February 2024
North Yanchep	14 September 2024	02 December 2023
South of Two Rocks Marina	14 September 2024	03 February 2024
North of Two Rocks Marina	06 April 2024	27 October 2024

The most receded shoreline position along several beaches was observed towards the end of the monitoring period in September and October 2024. Sediment deficit is expected at these sites during the winter months. Conversely, beaches that are all situated immediately north of a natural rocky outcrop or piece of hard infrastructure generally had advanced shoreline positions after the winter months (e.g. North of Two Rocks Marina) where sediment was transported southward, building up against any natural rocky headlands or hard infrastructure to the south.

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 for 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.

8 Results and Recommendations

8.1 Seasonal Changes

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

1. **Fisherman's Hollow Beach:** Fisherman's Hollow Beach, south of Yanchep Lagoon, experienced major erosion between April 2024 and October 2024. Seasonal survey cross-section comparisons show a maximum reduction in elevation of 2.19m in 2024 winter. While the dunes appear to be in good condition, 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 recommended that this area is closely monitored moving forward.

2. **North of Two Rocks Marina:** The area immediately north of the Two Rocks Marina experienced major erosion between April 2024 and October 2024. Manual imagery analysis and beach cross section analysis noted a major reduction in beach width. And a reduction of 2.04m in elevation just before the water line.

3. **Quinns Rocks Beach North of Groyne Three (3):** A significant reduction in beach width and major erosion scarp was noted at Quinns Rocks Dog Beach immediately north of Groyne Three (3) in the October 2024 manual images. Beach cross-section analysis noted a drop in elevation of 2.07 m just prior to the water line at this location.

4. **Quinns Rocks Beach GSC Revetment South of Groyne One (1):** Major erosion over 2024 winter period is evident through the manual imagery analysis of the beach immediately south of Quinns Rocks Groyne One (1). Seasonal beach cross sectional analysis also shows a maximum reduction in elevation of 2.14m just before the water line. As this is an area that is known to experience significant erosion annually and has caused major maintenance issues in the past, erosion at this location is not unexpected. The GSC Revetment was constructed in 2014 and prevents coastal erosion effects from impacting infrastructure.

5. **Clayton's Beach:** Clayton's 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. Seasonal erosion is expected at this site each year, with a total beach volume loss of 48038m^3 reported for the 2024 winter period. Major erosion and changes in width were clearly observed at this site via manual imagery. Furthermore, survey cross sections show a reduction of 1.94m between the April and October 2024 surveys.

8.2 Annual Change

Changes in beach volumes between October 2023 and October 2024 were assessed via LiDAR survey elevation difference plots, volume change calculations and cross section transect comparisons undertaken by MNG. Volume change calculations show an overall decrease in beach volume across the coastline between October 2023 and October 2024 in all coastal focus areas.

The major beach volume changes monitored is along Clayton's Beach, Yanchep and Two Rocks beaches. The highest beach volume changes observed at Clayton's Beach with loss of 25,589 m^3 of sand in 2024 winter. Despite the mild winter there was a reduction in beach volume and height within the Fisherman's Hollow beach, which is situated to the south of a significant rocky headland.

While there was overall reduction in beach volumes for all monitored beaches. Over the year, there was a net gain of 6,505 m^3 along the Quinns Rocks coastline however it is important to note that approximately 5,700 m^3 of sand was placed at Quinns Rocks in May 2024 as part of the City's ongoing renourishment program. The gain in beach volume across the year was likely a result of the relatively calm winter conditions where there were less frequent significant erosion events.

8.3 Long-term Changes

Long-term changes to the shoreline were assessed via manual imagery where, in Quinns Rocks and Two Rocks, October 2024 images were compared to images taken at the same location in October 2014, allowing for an assessment of long-term changes of the coastline from up to eight years prior. At Yanchep, the earliest recorded monitoring images were taken in October 2018 and therefore the long-term changes of the coastline can only be assessed from up to five years prior.

One site in Yanchep was identified through manual imagery as having experienced major long-term erosion. The site is situated to the North of Foreshore Reserve. Following significant erosion observed at the site over 2024 winter period, a significantly narrow beach is evident in the image taken in October 2024 with notable reduction in beach elevation.

Long-term trends in erosion and accretion were assessed by analysing historic surveyed net beach volume changes. There has been a notable increase in net beach volume across the Mindarie coastline since October 2021, where strong sea breezes observed throughout the seasonal summer periods likely contributed to increased sand build up at the site. Long-term trends for Quinns Rocks Beach show a significant increase in the beach sections north of the Quinns Rocks Artificial Headland for this study period relative to other years. Despite the calm winter conditions for 2024 there was a considerable loss in beach volume across Yanchep between October 2023 and October 2024. It is possible that this is a result of strong summer Seabreeze conditions transporting sediment further north, away from the Yanchep coastline. There has been a considerable increase in beach volume within Two Rocks Section 1 for the periods assessed between October 2021 and October 2023, but significant loss of sand is observed in October 2024.

8.4 Notable Erosion Events

Due to the relatively calm winter conditions, there were no significant acute erosion events across the 2024 winter period. The most notable winter storm events were observed on the 19th of July and 03rd of October 2024 which recorded a peak significant wave height of 6.13m and 7.08m respectively. While there was some erosion observed across the study period, these storm events did not significantly impact any of the City's coastal assets or dune systems.

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 Beach Renourishment activities during 2024

Date	Renourishment Location	Renourishment Quantity
May 2024	Quinns Rocks Beach, Frederick Stubbs Carpark	3,000 tonnes
May 2024	Quins Dog Beach, North Groyne 3	2,000 tonnes
May 2024	Quinns Rocks Dog Beach, North Groyne 4	2,000 tonnes
September 2024	Yanchep Lagoon	2,000 tonnes

8.6 Recommendations

8.6.1 Automatic Tracking of Shorelines

Five remote monitoring cameras were installed at Quinns Rocks 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 2024/25 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 2024/25 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 the Yanchep Coastal Management Study be completed. This study aims to inform the future long-term management practices for Yanchep Beach and address ongoing erosion and accessibility issues at Yanchep. Additionally, it should address the condition issues and long term functionality of the Capricorn groyne.

8.6.4 Continued Beach Renourishment

It is recommended that beach renourishment continues to be undertaken in vulnerable areas to minimise the impact of erosion on coastal infrastructure and the City's dune systems. It is recommended that the results from this report be utilised to identify areas that require ongoing scheduled renourishment works. As outlined in Section 4.2.1 significant seasonal erosion was experienced at Quinns Rocks Dog Beach, to the north of Groyne Three (3), which impacted beach accessibility and beach amenity. Continued beach renourishment is required along Quinns Rocks Beach to address localised erosion issues.

8.6.5 Continued Beach Scraping

It is recommended that beach scraping be undertaken annually along Quinns Rocks Dog Beach, to the south of Groyne Four (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.

Clayton's beach experience significant changes in beach volumes near breakwater throughout the year. Based on the recent survey data and aerial images, beach scraping is not generally a viable option for the site. However, if conditions are right, i.e. October 2023, accretion at the southern end of the Clayton's Beach could be used to reprofile the erosion northern end of Clayton's Beach.

8.6.6 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.

8.6.7 Review of Quinns Beach Coastal Management Study

It is recommended that Quinns Artificial Headland be included in any future review of coastal management measures at Quinns Beach. The detached rock headland was constructed in 1977 with a primary aim to reduce erosion. Investigations should address structure condition and long-term functionality.

8.6.8 Increased Monitoring and Plan for repairs/upgrade to Mindarie Breakwater Segment 3

It is recommended an increased monitoring of segment 3 of the Mindarie Breakwater following large storms to assess vulnerabilities and determine the need for repairs. Although the segment condition has been assessed as poor, there is little evidence of movement over the past few years suggesting the segment can be monitored for now. Plans for repairs should be put in place, such that if the condition of this segment worsen, remedial action can take place with minimal delay.