Climate Change Impact Assessment

Proposed Development of the Granger Bay Precinct and Reclamation of Land at the V&A Waterfront in Cape Town, Western Cape

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Infinity Environmental

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srk consulting

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Proposed Development of the Granger Bay Precinct and Reclamation of Land at the V&A Waterfront in Cape Town, Western Cape

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Executive Summary

This Climate Change Impact Assessment (CCIA) evaluated the current climate conditions, natural-hazard exposure and future climate risks for the proposed Granger Bay land-reclamation and mixed-use development at the Cape Town Victoria and Alfred (V&A) Waterfront. The assessment draws on long-term meteorological datasets, oceanographic modelling, global and regional climate projections, and hazard-mapping tools to determine potential vulnerabilities and climatic adaptation needs.

Baseline Climate and Ocean Conditions

The project site currently experiences a mild coastal climate with clear seasonal rainfall and temperature patterns. Mean monthly temperatures range from 12.7-16.6 °C in winter and from 17.3-22.5 °C in summer, with a recorded extreme maximum of 39.8 °C. Heatwaves have increased in frequency, with six heatwave events occurring annually post-2020 relative to a long-term average of ~2.5 heatwaves per year.

The site can expect a mean annual precipitation (MAP) of 821.5 mm. 78.8% of the MAP falls between April and September, with July being the wettest month (July receives ~142 mm, 17.3% of the MAP). Rainfall variability indicates El Niño/La Niña influences, with historic annual totals ranging from 466 mm to 1 138 mm.

Winds predominantly originate from the south-southeast and average 6 m/s.

The marine environment is moderated by the semi-enclosed nature of Granger Bay. Hydrodynamic modelling shows wave heights of 1–2.75 m in typical storm conditions, with isolated >3.75 m height zones near the Dolos Revetment during extreme events.

Natural-Hazard Baseline and Key Risks

Flooding, coastal flooding, storm surge, drought and wildfires emerge as the most relevant regional natural hazards. Risks to the site as a result of these natural hazards are summarised below:

- **Flooding** is the most common recorded natural hazard in the Western Cape, accounting for **44.4% of disasters since 1980**. The site is currently at medium risk of inland flooding and at very high risk of coastal flooding risk due to its shoreline position.
- **Storm surge** occurs frequently, with regional projections showing modest increases in surge height by 2050, and local bathymetry contributing to higher winter storm exposure.
- **Drought** frequency is increasing, with biannual drought occurrence since 2015 and strong evidence of future intensification.
- **Wildfire risk** is high regionally; however, the immediate project site is fully urbanised and coastal and therefore is at low risk of direct exposure.
- **Coastal erosion** is low for some parts of the Waterfront due to engineered protections, but the overall risk increases with the projected increases in sea level rise and storm activity.

Projected Climate Changes

Climate change projections indicate substantial warming, drying, and sea level rise as follows:

- **Temperature:** Mean, minimum, and maximum temperatures are projected to increase by up to 1.4 °C by the 2060s and by up to 3.3 °C by 2100 under high-emission scenarios.
- **Rainfall:** MAP is projected to decline by up to 11.7% by the 2060s and by up to 25.6% by 2100, with fewer very wet days and lower 1-day maximum rainfall. This increases drought risk and reduces the risk of inland flooding.
- **Sea level:** The sea level is expected to rise by 0.3 m by the 2060s and by 0.7 m by 2100.
- **Ocean conditions:** Sea-surface temperature and acidity will increase, elevating the corrosion potential of marine and inland infrastructure.

Impacts Identified

The dolosse implemented as part of the development will reduce the possibility of coastal flooding, coastal erosion and wave-related infrastructure damage. Although the dolosse will also reduce wave impact pressures on the coastline, saltwater intrusion is more a function of sea level rise. This risk will be imposed on the region, and the proposed development will have little impact. It should, however, be noted that the development could, through the implementation of water conservation projects, reduce the impact anticipated by reducing its net water demand.

Other low significance risks to the proposed development include:

- Construction-phase delays from wave action, storm surge, and high shear stresses[1].
- Drought-related water availability constraints.
- Drought-related groundwater extraction and the projected sea level rise increasing the potential for saltwater intrusion — If the development reduces its net water demand, this risk becomes a positive impact.
- Increased possibility of corrosion due to the projected increases in ambient and ocean temperatures and reduction in ocean pH.

Recommendations

Mitigation measures that can be implemented to reduce the impacts associated with the climate physical risks identified include:

- Rainwater storage for the extended dry periods anticipated.
- The implementation of greywater recycling in new homes and offices, where feasible, to reduce potable water consumption.
- Consideration of alternative water sources should the risk of reduced water availability be realised.

[1] The shear stress acting on the seabed that is produced by the oscillatory motion of surface waves. It is the result of interactions between waves and sediment and causes sediment transport, erosion and/or deposition.

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (South Africa) (Pty) Ltd (SRK) by Infinity Environmental. The opinions in this Report are provided in response to a specific request from Infinity Environmental to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this Report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

List of Abbreviations

AR6	-	Sixth Assessment Report
CCIA	-	Climate Change Impact Assessment
CCKP	-	Climate Change Knowledge Portal
CGMs	-	Climatic Gridded Models
CMIP6	-	The Sixth Phase of the Coupled Model Intercomparison Project
CO_2	-	Carbon Dioxide
CPs	-	Consulting Practices
CSIR	-	Council for Scientific and Industrial Research
DFFE	-	Department of Forestry, Fisheries and the Environment
DWS	-	Department of Water and Sanitation
EIA	-	Environmental Impact Assessment
ESMs	-	Earth System Models
FAO	-	United Nations Food and Agricultural Organisation
FIRMS	-	Fire Information for Resource Management
GHG	-	Greenhouse Gas
GWLs	-	Global Warm
IPCC	-	Intergovernmental Panel on Climate Change
MERRA2	-	Modern-Era Retrospective analysis for Research and Applications, Version 2
NASA	-	The National Aeronautics and Space Administration
NEMA	-	National Environmental Management Act
NOAA	-	National Oceanic and Atmospheric Association
PGA	-	Peak Ground Acceleration
Pr	-	Precipitation / Rainfall
QDM	-	Quantile Delta Mapping
QM	-	Quantile Mapping
RH	-	Relative Humidity
SAAQIS	-	South African Air Quality Information System
SAWS	-	South African Weather Service
SPI	-	Standardised Precipitation Index
SRK	-	SRK Consulting (South Africa) (Pty) Ltd
SSP	-	Shared Socio-economic Pathway
Temp	-	Temperature
UNDRR	-	United Nations Disaster Risk Reduction
V&A	-	Victoria and Alfred
WD	-	Wind Direction
WS	-	Wind Speed

1 Introduction

1.1 Background

An Environmental Impact Assessment (EIA) is required for the proposed reclamation of land for mixed-use development, and construction of coastal defence infrastructure at Granger Bay in the Cape Town V&A Waterfront. SRK Consulting (South Africa) (Pty) Ltd (SRK) has been appointed to undertake the Climate Change Impact Assessment (CCIA) that will inform the EIA.

1.2 Project Team

SRK Global is the overarching company of the SRK Group of companies and is the global investment vehicle for employee shareholders. Established in South Africa in 1974, SRK has, over the years, grown into a large consulting practice with a broad client base worldwide. SRK Group Consulting Practices (CPs) employ approximately 1 700 professionals operating from more than 45 established offices on 6 continents.

SRK's integration of services and global base has raised its reputation in technical advice, feasibility studies, due diligence, and confidential internal reviews.

SRK made available an experienced team to fulfil the requirements of the scope of work up to and including the finalised Report. This includes quality review to ensure the products met the requirements of the scope of work and the client's needs. Staff included in the project team is detailed in Table 1-1 below. Curriculum vitae for each member of the project team can be made available upon request.

Table 1-1: Project Team

Name	Designation	Role
Philippa Burmeister Pr.Sci.Nat / Reg.EAP	Partner/ Principal Scientist	Project Manager and Technical Review.
Joss Cahi	Hydrologist	Climate baseline and projections, meteorological data processing, impact assessment and reporting.
Gareth v.d. Walt	Chemical Engineer	

SRK's independence is ensured by the fact that it is strictly a consultancy organisation, not holding equity in any project and with ownership primarily by staff. This permits its consultants to provide clients with conflict-free and objective support on crucial issues.

Neither SRK nor any of the authors of this Report have any material present or contingent interest in the outcome of this Report, nor do they have any pecuniary or other interest that could be reasonably regarded as being capable of affecting their independence or that of SRK.

SRK's fee for completing this assessment is based on its normal professional daily rates plus reimbursement of incidental expenses. The payment of that professional fee is not contingent upon the outcome of the Report.

1.3 Scope and Structure of the Report

This report includes an assessment of climate change risks associated with the Victoria and Alfred (V&A) Waterfront and includes:

- An overview of the proposed development to contextualise the study;
- A review of applicable international and local standards, guidelines and requirements that inform the approach to the assessment;
- An overview of the approach, assumptions and limitations associated with the assessment;
- Reporting of natural hazards and site-specific climate baseline data;

- Regional and site-specific projections for climatic changes;
- Identification of potential site-specific risks associated with the climatic changes;
- An assessment of the risks aligned to the methodology provided by Infinity Environmental; and
- Recommended actions to be implemented to address the risks identified.

2 Project Description

The proposed Granger Bay development includes the reclamation of land for mixed-use development, and construction of coastal defence infrastructure. The project site is west of the Cape Town V&A Waterfront and is located between the Western Dolos Revetment and the Granger Bay Small Craft Harbour, also known as the Waterclub (refer to Figure 2-1).

Figure 2-1: Proposed Project Location

3 Requirements

The EIA for the proposed development will be undertaken in terms of South African Legislation. Specifically, the EIA Regulations (Government Notice R982 in Government Gazette No. 38282 on December 4, 2014) under the National Environmental Management Act No. 107 of 1998 (NEMA). The EIA regulations require the assessment of the impacts associated with a project. Like all other specialist studies, while Appendix 6 of the regulations specifies specialist study requirements, it does not dictate the approach to GHG quantification or climate change modelling. This is determined based on the project's requirements.

The Department of Forestry, Fisheries and the Environment (DFFE) published a draft guideline for consideration of climate change implications in environmental authorisations on the 25th of October 2025. This guideline sets out the minimum requirements for integrating climate change considerations into applications for environmental authorisations, atmospheric emission licenses, and waste management licenses. It requires that EIAs systematically address greenhouse gas (GHG) emissions, climate change mitigation and adaptation strategies, and climate-resilient planning. The guideline ensures that all relevant applications evaluate the potential impacts of climate change on the proposed activity, and the activity's overall contribution to climate change.

South Africa's Climate Change Act (No. 22 of 2024), signed into law in July 2024 and proclaimed into effect on March 17th, 2025, establishes a framework for a coordinated national response to climate change, including mitigation and adaptation strategies. While the Act does not prescribe requirements for CCIAs in terms of EIAs, it highlights the need to consider both mitigation and adaptation when assessing the risks and impacts of climate change.

South Africa's National Environmental Management: Air Quality Act (39/2004): National Greenhouse Gas Emission Reporting Regulations (GNR40762), mandates the annual reporting of GHG emissions for entities listed in Annexure 1 of the regulations.

4 Approach

The development, based on discussions via email on Monday, the 8th of September 2025, does not appear to form part of Annexure 1 of the GHG Emission Reporting Regulations. Furthermore, no significant sources of GHG emissions in terms of this legislation were identified based on the project description. The quantification of GHG emissions has therefore been excluded from this assessment.

Given the nature of the development, it is at risk from, or vulnerable to, climatic changes. The assessment therefore focusses on the identification of climate physical risks using a desktop review of climatic changes that are then assessed to identify adaptation strategies for inclusion in the design.

4.1 Climate Baseline

Observed meteorological data was downloaded from:

- National Oceanic and Atmospheric Association (NOAA) stations identified within a 200 km radius of the project site — Five stations were identified.
- The Higgovale Cape Town Department of Water and Sanitation (DWS) meteorological station.
- The South African Air Quality Information System (SAAQIS) stations closest to the project site (the Maitland, Bothasig and Goodwood-NAQI stations).

The locality of these meteorological stations and their approximate distance from and elevation difference relative to the project site is presented in Table 4-1 as an indication of spatial representativity. A map of the project site that indicates the meteorological stations used for this assessment follows in Figure 4-1.

Table 4-1: Meteorological Station Locality

Source	Station Name / ID	Latitude (°)	Longitude (°)	Distance from Site (km)	Elevation Difference (m)
NOAA	TABL.MTN MOLTENO RSV	-33.93	18.42	2.42	+23
	CAPE TOWN FIRE STATION	-33.93	18.43	2.58	+21
	TABLE.MTN PLATTEKLIP	-33.95	18.42	4.64	+231
	ROYAL OBSERVATORY	-33.93	18.48	6.03	+5
	TABLE.MTN WOODHEAD TUNNEL	-33.98	18.38	8.79	+135
DWS	Higgovale Cape Town	-33.94	18.41	3.67	+122
SAAQIS	Maitland	-33.92	18.52	8.97	+11
	Bothasig	-33.86	18.54	12.25	+21
	Goodwood-NAQI	-33.90	18.57	13.30	+30

Data Source: Maxar Imagery	
Scale 1:115,000	
Projection: UTM	Datum: WGS84
Central Meridian/Zone: Zone 34S	
Date: 26/02/2026	Compiled by: CAHJ
Project No. 624717	Fig No. 4-1

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CCIA - GRANGER BAY PRECINCT AND LAND RECLAMATION AT THE V&A WATERFRONT IN CAPE TOWN

PROJECT SITE AND METEOROLOGICAL STATION LOCALITY

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4.1.1 Data Availability

The meteorological parameters available and data record periods for each of the meteorological stations presented in Table 4-1 is presented in Table 4-2. All data obtained from the SAAQIS stations was downloaded on the 12th of November 2025. The meteorological parameters available included precipitation/rainfall (Pr), temperature (Temp), wind speed (WS), wind direction (WD) and relative humidity (RH)

Table 4-2: Meteorological Data Available

Station Name / ID	Meteorological Parameters	Data Record Period	Data Recovery (%)
TABL.MTN MOLTENO RSV	Pr	01/09/1887 – 30/09/1997	99.97
CAPE TOWN FIRE STATION	Pr	01/10/1882 – 29/02/1972	100.00
TABLE.MTN PLATTEKLIP	Pr	01/04/1882 – 31/01/1987	99.96
ROYAL OBSERVATORY	Pr	01/01/1850 – 30/11/1997	96.92
TABLE.MTN WOODHEAD TUNNEL	Pr	01/10/1906 – 30/11/1997	82.56
Higgovale Cape Town	Pr	01/01/1981 – 31/12/2021	81.65
Maitland	WS, WD, Temp, RH	01/03/2021 – 12/11/2025	• WS & WD: 89.35 • Temp: 63.91 • RH: 88.94
Bothasig	WS, WD, Temp, RH	01/05/2015 – 12/11/2025	• WS & WD: 46.74 • Temp: 45.31 • RH: 44.92
Goodwood-NAQI	WS, WD, Temp, RH	01/05/2015 – 12/11/2025	• WS & WD: 57.08 • Temp: 52.82 • RH: 54.64

4.1.2 Data Processing

Historical baseline conditions were established for the period 1981 to 2024. Observed baseline data from the Higgovale Cape Town DWS station (Pr data) and Maitland SAAQIS station (WS, WD, Temp and RH data) was selected to represent the site since these meteorological stations offered the highest data recoveries for the baseline period assessed. Data from the Higgovale DWS station was screened to remove duplicates (repeating dates). Meteorological data from the Maitland SAAQIS station was screened to remove any irregularities including:

- Wind speeds above 37.7 m/s (135.72 km/h) (The highest wind speed recorded at the Cape Point during a severe storm in April 2024);
- Wind directions above 360°;
- Extremely low temperatures (Temperatures below -1°C, i.e., the lowest temperature recorded in Cape Town);
- Extremely high temperatures (Temperatures above 42.4°C, i.e., the highest official temperature recorded by the South African Weather Service (SAWS) in Cape Town); and
- Relative humidities above 100%.

4.1.3 Bias Correction

Modelled meteorological data from climatic gridded models (CGMs) was downloaded and used to patch the data gaps identified in the baseline period (no Pr data was available after 2021 and no WS, WD, Temp and RH data was available prior to March 2021). Data was downloaded from CHIRPS, ERA5, ERA5-Land, PERSIANN and MERRA2.

This modelled data (raw data) was bias corrected using a script developed by SRK using the programming language "R". Two bias correction methods were employed, namely:

- **Quantile Mapping (QM)**: A bias correction method that matches historical model quantiles to observed quantiles and is good at removing systematic biases. This method can, however, alter or inflate the magnitude of extremes.
- **Quantile Delta Mapping (QDM)**: An improved version of QM that accounts for the changes (deltas) between future and historical model quantiles and preserves the relative changes projected by raw models, reducing distortion. This method can, however, introduce biases that preserve changes in standard deviation.

The modelled data downloaded from ERA5-Land and bias-corrected using QDM preserved the trends of the observed Pr and mean, minimum and maximum temperature data the best. Raw (un-bias corrected) MERRA2 WS, WD and RH data correlated well with the observed data. The final patched climate baseline dataset therefore consists of observed and QDM-corrected ERA5-Land Pr and Temp data and observed and raw MERRA2 RH, WS and WD data.

4.2 Natural Hazards

As per the United Nations Disaster Risk Reduction (UNDRR) office's request, the terminology refers to natural hazards rather than natural disasters. The susceptibility of the project site to natural hazards, including flooding (inland and coastal), storm surge, fires/wildfires, droughts, earthquakes, coastal erosion, landslides, and tsunamis, was assessed using data (where available) from:

- The World Bank's Climate Change Knowledge Portal (CCKP).
- The Council for Scientific and Industrial Research (CSIR)'s Green Book Municipal Risk Tool.
- NASA's Landslide Susceptibility Map and Global Landslide Catalog.
- NASA's Fire Information for Resource Management System (FIRMS).
- The Global Earthquake Model's Seismic Hazard Map.
- ThinkHazard, a web-based tool allowing for the consideration of the impacts natural hazards may have on projects.
- Scientific Papers:
  - Tsunami Hazard Assessment of Coastal South Africa Based on Mega-Earthquakes of Subduction Zones (Kijko et. al., 2017).
  - Global projections of storm surges using high-resolution CMIP6 climate models (Muis et. al., 2023).

4.3 Climate Change Projections

4.3.1 Shared Socio-Economic Pathways

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. It provides regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. The IPCC recently released the Sixth Assessment Report (AR6). AR6 consists of contributions by three Working Groups as follows:

- Working Group I - The Physical Science Basis, released 9 August 2021.
- Working Group II - Impacts, Adaptation and Vulnerability, released 28 February 2022.

- Working Group III - Mitigation of Climate Change, released 4 April 2022.

The IPCC assesses and communicates climate change, risks that may arise from potential impacts of climate change, as well as human responses to climate change. These risks are assessed taking climatic impact-drivers and low-likelihood, high-impact outcomes into account.

The AR6 considers five new emission scenarios that illustrate climate response to a broader range of GHG, land-use and air pollutant futures. These scenarios start in 2015, are associated with a contribution to global surface temperature, form the basis of climate model projections of changes in the climate system, and include:

- Shared Socio-economic Pathway (SSP) 1-1.9 and SSP 1-2.6 – scenarios with very low and low GHG emissions and carbon dioxide (CO_2) emissions declining to net zero around or after 2050, followed by varying levels of net negative CO_2 emissions.
- SSP 2-4.5 – CO_2 emissions remain around current levels until the middle of the century.
- SSP 3-7.0 and SSP 5-8.5 – high and very high GHG emissions, roughly double that of current levels by 2100 and 2050.

The IPCC's AR6 translates scenario-based climate projections into Global Warming Levels (GWLs) by aggregating the Earth System Models (ESMs) response to GWLs for different scenarios. A key outcome of the assessment is the Working Group I Atlas that allows interrogation of the regional information and responses projected by the models. The identification of climate change projections was undertaken using the Working Group I Interactive Atlas (based on the sixth phase of the Coupled Model Intercomparison Project (CMIP6)).

4.3.2 Data Sources

The World Bank CCKP provides climate-related information, data and tools at a country, province and watershed level to inform regional climatic changes based on CIMP6. Regional climate change projections were obtained from the World Bank CCKP. CCKP projections are determined relative to the historic period 1995-2014. Although the CCKP reports projections for four SSPs, i.e., SSP 1-2.6, SSP 2-4.5, SSP 3-7.0 and SSP 5-8.5, only the projections for SSP 1-2.6 (the best-case scenario) and SSP 5-8.5 (the worst-case scenario) are presented.

The regional data available from the CCKP was supplemented with projections for the City of Cape Town from the CSIR's Green Book Municipal Risk Tool. The Green Book disaggregates projections by municipal regions in South Africa and documents the vulnerability of said regions to climate change. Projections from The Green Book are determined relative to the period 1961-1990 and reported for SSP 2-4.5 and SSP 5-8.5.

More detailed site-specific climate change projections were obtained from the IPCC's Interactive Atlas. A 100 km resolution was used to determine projections relative to the historic period (1995-2014) for four different SSPs, i.e. SSP 1-2.6, SSP 2-4.5, SSP 3-7.0 and SSP 5-8.5.

4.3.3 GCM Variability

CIMP6 coordinates experiments on coupling computer-based models of the Earth's climate. CMIP6's dataset is an ensemble of projections from 35 different models and four SSPs. One of the biggest challenges in climate change projections is explaining the inherent variation in possible scenarios. Unlike civil design approaches that design structures for specific events with fixed values (e.g., a 1:100-year storm event), climate change projections present ranges defined by various GCMs and meteorological projections. This fixed-value definition loses significance in the context of climate change projections considering up to 35 models, where most of the design values are not fixed but are in fact ranges defined by every GCM and every possible meteorological projection. Since this assessment is intended to inform the EIA and not the management of the port as a whole, it was considered appropriate to make use of the P50 median values of the 35 models. P50 median values were used considering the inherent variability in which some models overpredict extremes and other models underpredict extremes[2]. The process of selecting individual models is extremely time consuming and costly and would therefore be appropriate for a large-scale project, for instance, the whole of Cape Town, but not for a single EIA.

4.4 Impact Assessment Methodology

Impacts have been identified for the construction, operation and decommissioning (where appropriate) phases of the project. The impacts have considered the cumulative impact of climate change on the environment and the development.

The impacts identified have been assessed in terms of the impact assessment methodology supplied by Infinity Environmental on the 21st of November 2025. This methodology aligns with the Department of Environmental Affairs and Tourism's (now referred to as DFFE) Guideline 5. This included rating the impacts in terms of the following to determine significance:

- Spatial extent.
- Intensity.
- Duration.
- Reversibility.
- Irreplaceability.
- Probability.

The definitions applicable to the rating of significance are detailed in Appendix A.

For **significant impacts, mitigation measures have been identified**. The mitigation measures have been identified in line with the mitigation hierarchy – i.e., **avoid, minimise, restore and offset**. For negative impacts, the measures aim to avoid or reduce the impact. For positive impacts, the measures aim to augment the impact. The recommendations summarise the proposed mitigation measures for the impacts assessed and include any requirements for monitoring, or where appropriate, limits or targets to be achieved.

Where mitigation measures are required, a post mitigation significance rating has also been provided.

5 Assumptions and Limitations

5.1 Climate Baseline

Monitored precipitation data from the DWS station was available between 1981 and 2021. Monitored temperature, relative humidity and wind speed and direction data was available from the Maitland SAAQIS station between 2021 and 2025. Since both of the monitored datasets were incomplete considering the baseline period chosen (1981-2024), CGM data was used to create a complete dataset. Modelled data is known to underpredict extremes weather events and may under/over-predict rainfall.

[2] P50 median values are considered a "middle ground" between P90's (high extreme values) and P10's (low, and often, underestimated projections).

5.2 Ocean Baseline

Sea temperature, residual circulation, wave height and shear stress[3] data was obtained from the modelling completed by PRDW Port and Coastal Engineers for the project site in 2023. This data is based on two six-week modelling periods (a summer-autumn monitoring period, and a winter-spring monitoring period). The two six-week monitoring periods were insufficient to establish a long-term climate baseline to inform the CCIA. These short-term models (one-two weeks) are used for operational, day-to-day forecasting of physical conditions like currents, waves and storm surges. The modelling results from PRDW Port and Coastal Engineers undertaken in 2023 were therefore used in conjunction with additional baseline information and projection data available from the CIMP6 as above.

5.3 Natural Hazards

No monitored data was available that indicated the project site's susceptibility to natural hazards. Data was therefore obtained from the sources listed in Section 4.2. Although the accuracy of this data is influenced by the assumptions made for hazard susceptibility modelling, the assumptions for and performance of the remote sensing undertaken, and the number and severity of the disasters reported, it offers the best proxy in the absence of onsite data.

5.4 Climate Change Projections

Climate change projections are limited by the inherent variations between the different GHG emission scenarios and climatic models. As above, this assessment made use of P50 median values and does not present the variation between models. The variability between models is caused by various sources of uncertainty (model structure, parameterisations, coarse resolution, scenario choice, etc.). Near-term signals can be masked by internal variability, and climatic extremes may be under/mis-represented. Downscaling raw data to a site-specific scale relies heavily on observational data quality, may not capture local microclimates and complex topography accurately, and carries the risk of altering the trends of the raw data, decreasing the accuracy of projections. Despite these limitations, the tools available provide insight to inform the identification of climatic risks and the measures required to adapt to these should they arise.

PRDW's January 2025 Wave Modelling Report and the sea level rise projections presented therein were used as a comparative reference to assess the climate physical risks identified that may impact the coastline and associated infrastructure. This Report was still a draft when reviewed.

6 Climate Baseline

6.1 Temperature

The temperature data presented in this section was obtained from the Maitland SAAQIS station and patched with QDM-corrected data from ERA5-Land.

The monthly mean temperatures (minimum, average and maximum) for the project site are presented in Figure 6-1. February is the warmest month, recording mean minimum and maximum temperatures of 18.5°C and 22.5°C, respectively. July is the coldest month, recording mean minimum and maximum temperatures of 12.7°C and 15.8°C, respectively.

[3] The shear stress acting on the seabed that is produced by the oscillatory motion of surface waves. It is the result of interactions between waves and sediment and causes sediment transport, erosion and/or deposition.

The absolute minimum and extreme maximum temperatures recorded for the 1981 to 2024 period are presented in Figure 6-2. The highest extreme temperature recorded, 39.8°C, was recorded in January. Since the absolute lowest temperature recorded (0.4ºC in March) exceeded 0 °C, no frost days (days with temperatures below 0°C) occurred.

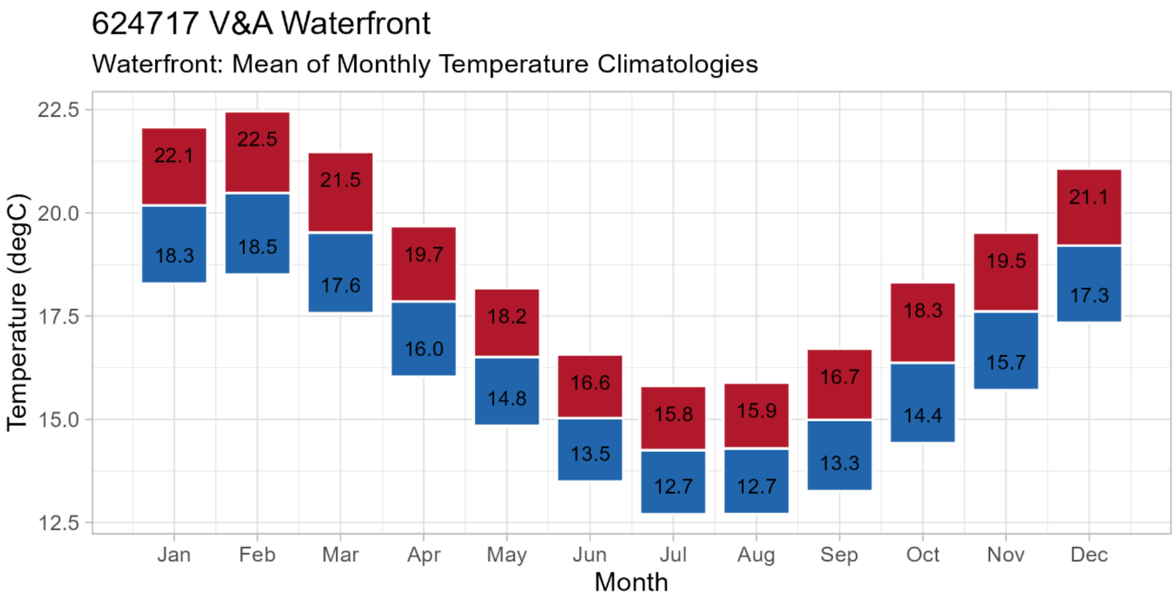


Figure 6-1: Monthly Mean Temperatures

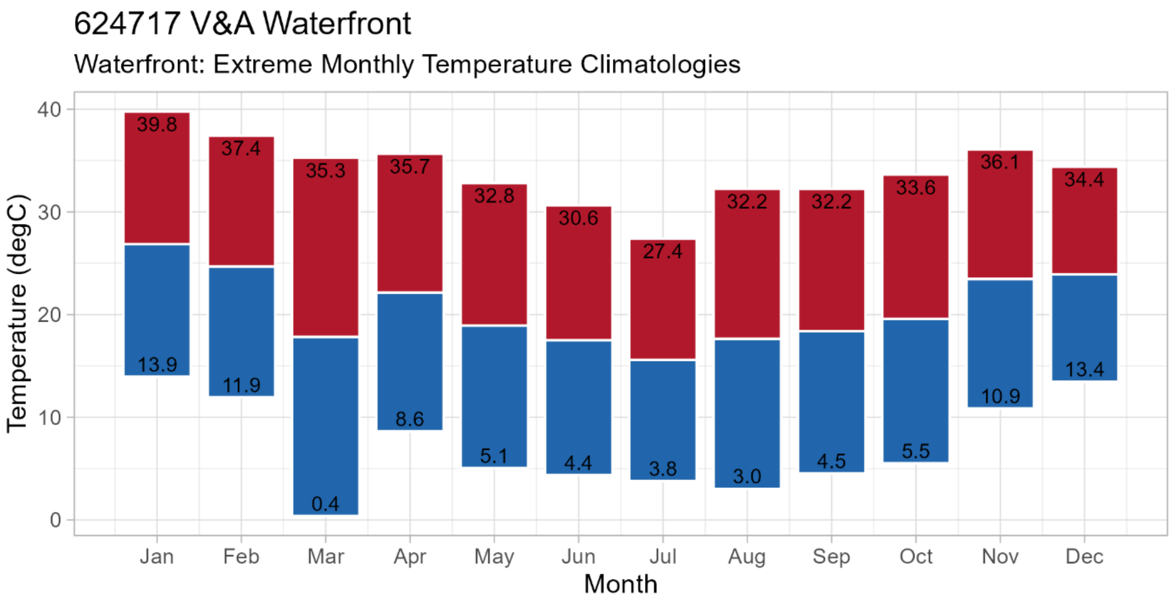


Figure 6-2: Absolute Minimum and Extreme Maximum Temperatures

A heatwave is defined as a period of prolonged high surface temperatures relative to the average. Heatwaves for this study were classified as **a period of more than five consecutive days where the daily maximum temperature exceeds the average annual maximum temperature by 5°C**. The number of heatwaves for the baseline period is presented in Figure 6-3, and the average number of annual heatwaves, 2.5, is indicated by the red line. Based on this data, the V&A Waterfront can expect at least two heatwaves annually and has experienced six heatwaves annually post 2020 (A concerning trend indicating an increase in the number of extremely hot periods).

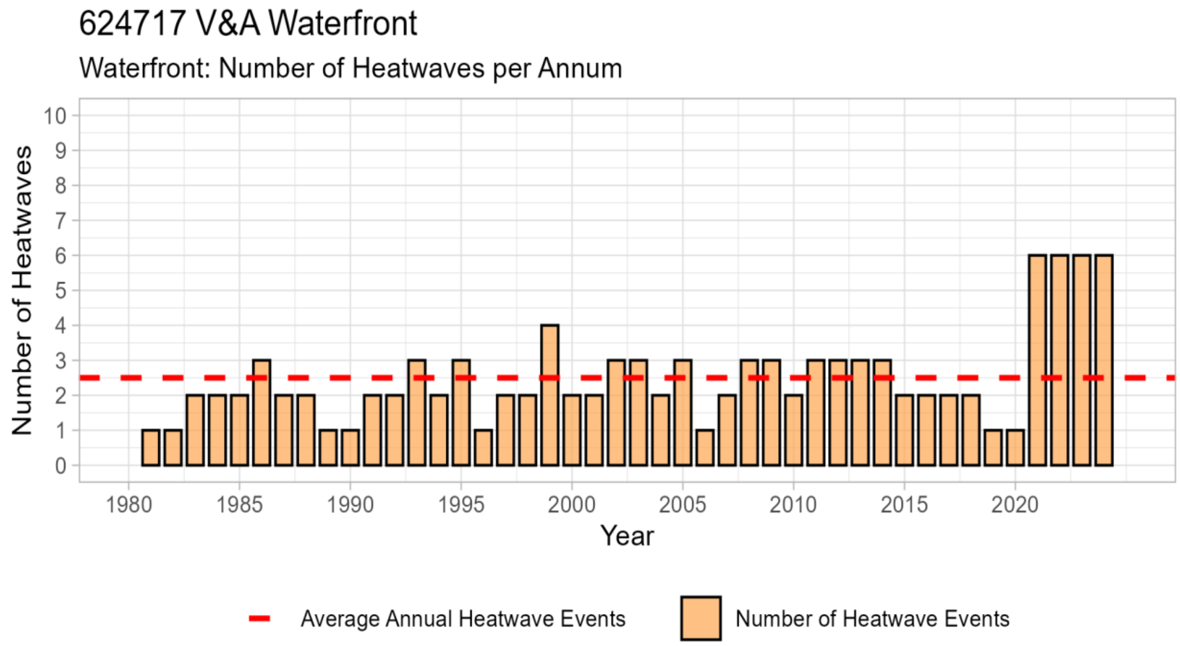


Figure 6-3: Number of Heatwaves During the Baseline Period

6.2 Rainfall

The rainfall data presented in this section was obtained from the Higgovale Cape Town DWS station and patched with QDM-corrected data from ERA5-Land. The baseline mean annual precipitation (MAP) was calculated to be 821.5 mm (refer to Table 6-1 and Figure 6-4).

Table 6-1: Monthly Precipitation and MAP (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAP (1981–2024)
19.3	18.8	31.7	66.4	105.0	137.8	141.8	118.5	77.7	41.4	35.0	28.0	821.5

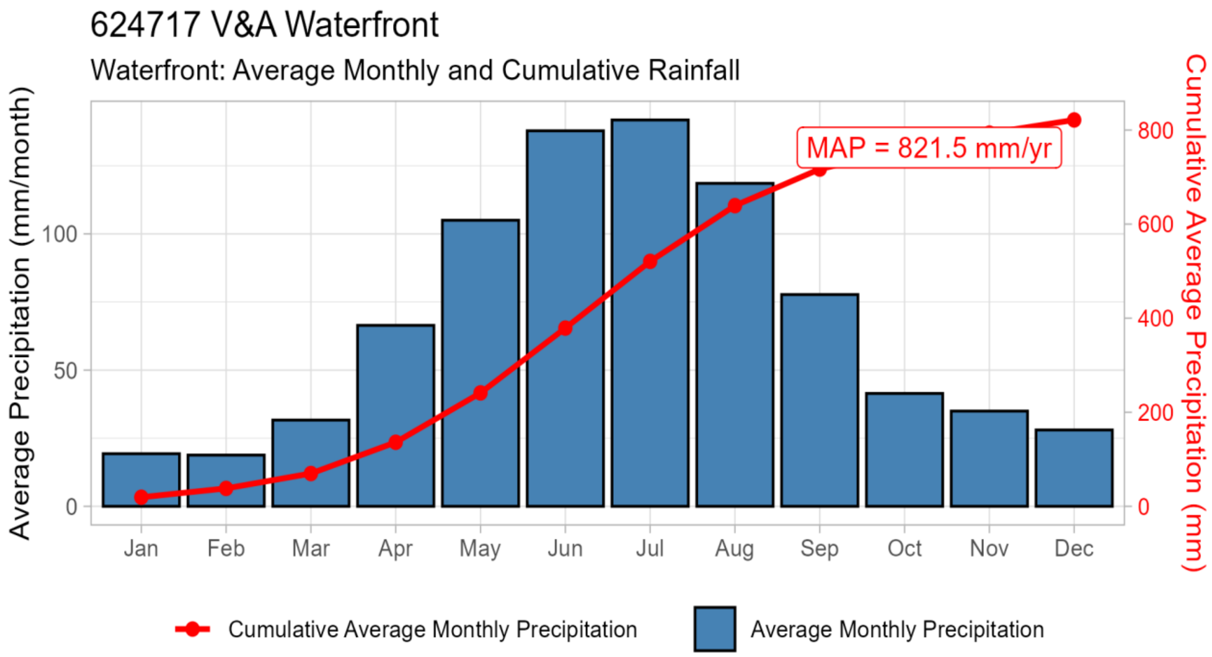


Figure 6-4: Mean Monthly and Annual Precipitation

Based on the data presented in Table 6-1 and Figure 6-4:

- 78.8% of the MAP falls between April and September.
- July is the wettest month, with an average rainfall of 141.8 mm (17.3% of the MAP), followed by June (137.8 mm – 16.8% of the MAP).
- February is the driest month, with an average rainfall of 18.8 mm.
- All months experience rainfall, however, rainfall steadily tapers down after July and ramps after March. This highlights the possibility of droughts towards the end of the year and flooding towards the end of Autumn and mid-Winter.

An annual rainfall plot follows in Figure 6-5 to indicate the variation in rainfall throughout the baseline period. The MAP (821.5 mm) is indicated by the red dashed line. Oscillations in the amount of rainfall observed indicate potential observed La Niña and El Niño effects. The lowest amount of rainfall reported, 466.2 mm, was reported in 2022, and the highest amount of rainfall reported, 1 137.5 mm, was reported in 2013.

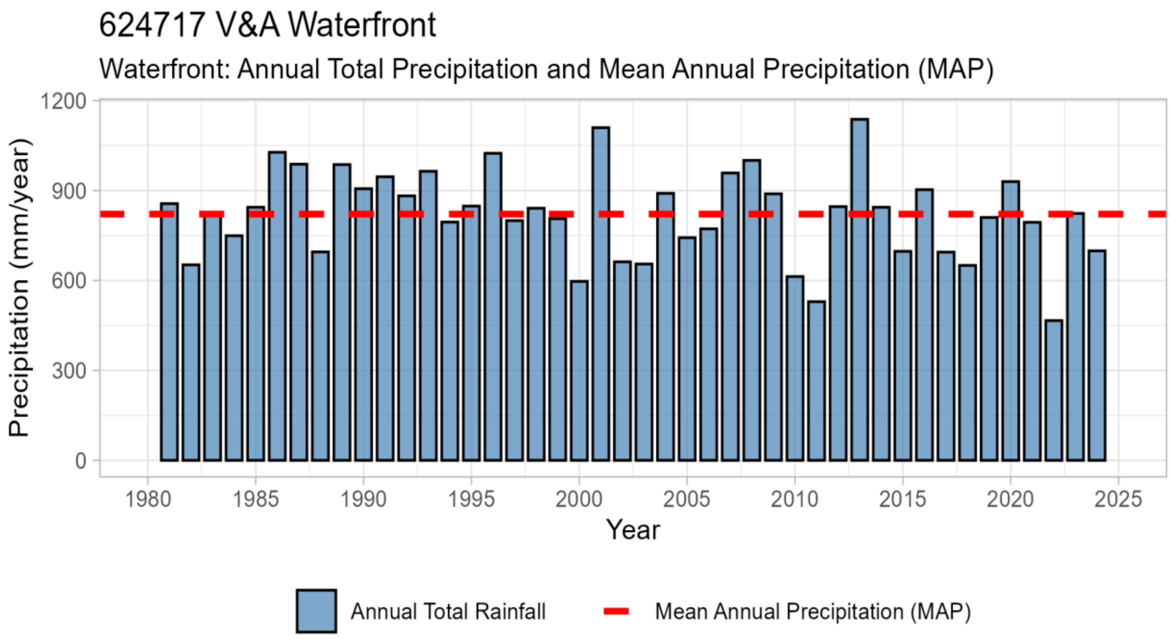


Figure 6-5: Annual Rainfall Plot for the Baseline Period

The number of rain event days per year is presented in Figure 6-6. The average number of rain event days, 80 days, is indicated by the red line. The number of rain event days observed annually oscillates about this average, with potential observed La Niña and El Niño effects. The lowest number of rain event days was recorded in 1999 (61 days), while the highest number of rain event days noted, 110 days, was recorded in 2023.

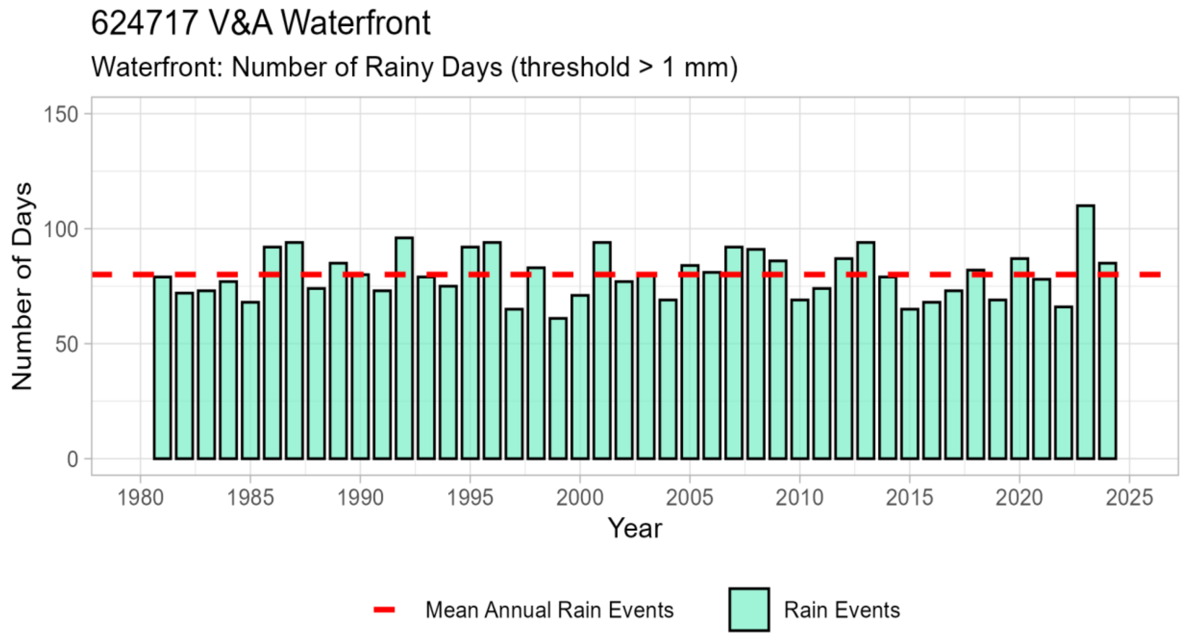


Figure 6-6: Number of Rain Event Days

A precipitation anomaly illustrating the change in rainfall for the baseline period compared to the reference period[4] (1985-2014) averages is presented in Figure 6-7. The maximum decrease in rainfall from the reference period, 130.9 mm, occurred in June 2002. The most extreme positive anomaly (increase), 175.1 mm, was observed in June 1994. This anomaly also highlights the probability of drought within the drier months (October to March) with slight decreases in rainfall at the start of the wet period (in April, May and June).

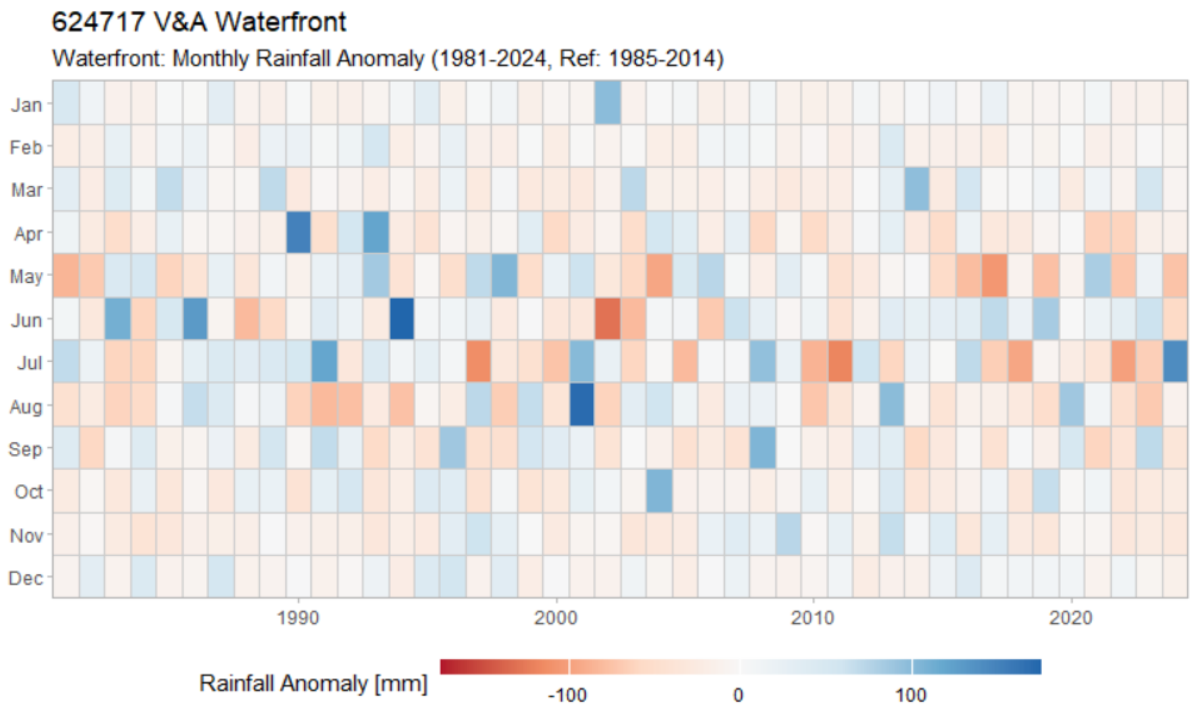


Figure 6-7: Annual Precipitation Anomaly

[4] A reference period represents a historical average against which the monthly values for each year can be compared to demonstrate changes in monthly rainfall.

6.3 Wind Speed and Wind Direction

Although wind speed data was available from the Maitland SAAQIS station, a complete, hourly data record is required to generate wind roses. Hourly wind speed and wind direction data for the period 01 January 2022 to 12 November 2025 was obtained from the MERRA2 CGM and used as a proxy.

Figure 6-8 presents the wind speed classification for the project site based on the Beaufort Wind Scale. Winds are predominantly categorised as either being a moderate breeze (wind speeds between 5.5 and 7.9 m/s approximately 30% of the time) or a gentle breeze (wind speeds between 3.4 and 5.4 m/s approximately 29% of the time).

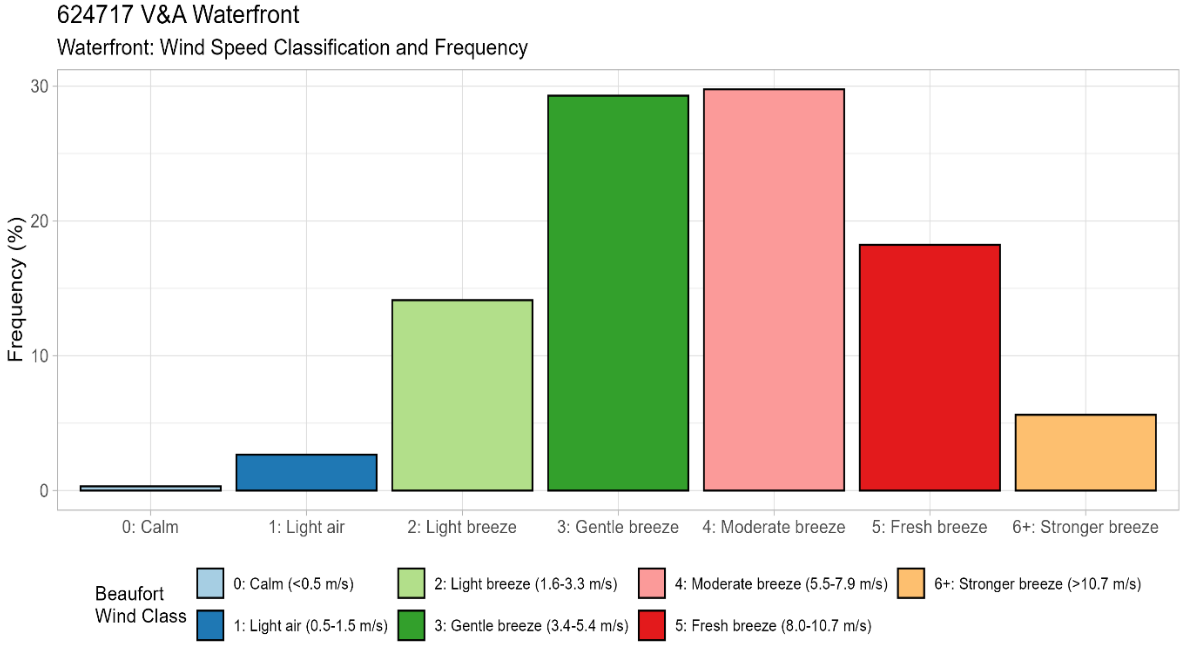


Figure 6-8: Beaufort Wind Classification (01 January 2022 - 31 December 2024)

Winds average 5.97 m/s and generally originate from the south-southeast and southeast with minor occurrences from the south, southwest, west and northwest (refer to Figure 6-9).

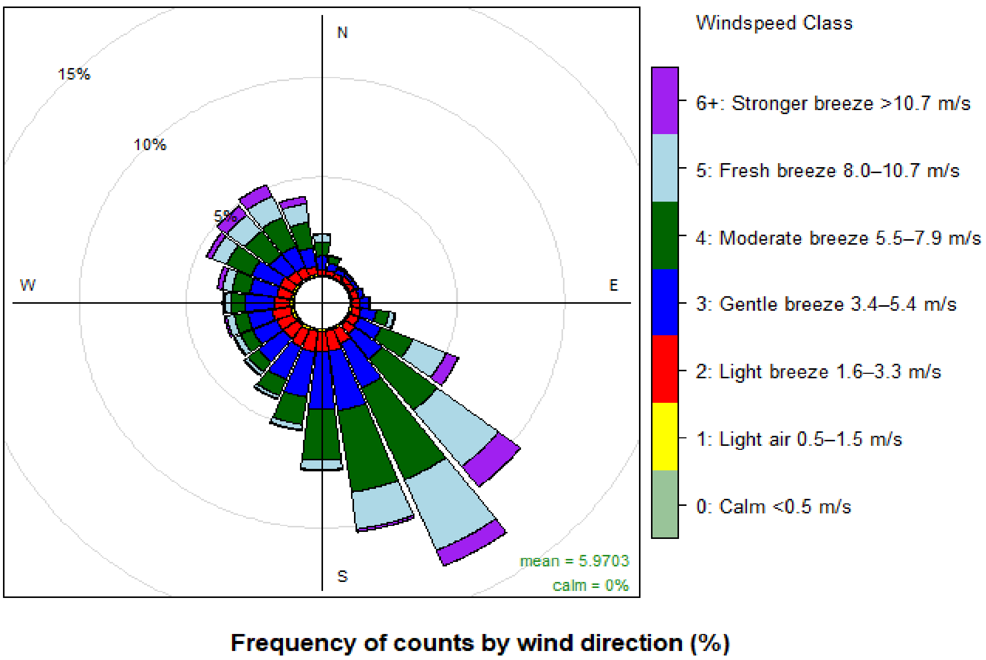


Figure 6-9: All-Hours Wind Rose

Daytime winds (winds experienced between 06h00 and 18h00) and nighttime winds (winds experienced between 18h00 and 23h00) are presented in Figure 6-10 and Figure 6-11, respectively. Winds expected during these periods originate from similar directions as that of the full period. Daytime and nighttime winds average 6.05 m/s and 6.16 m/s, respectively.

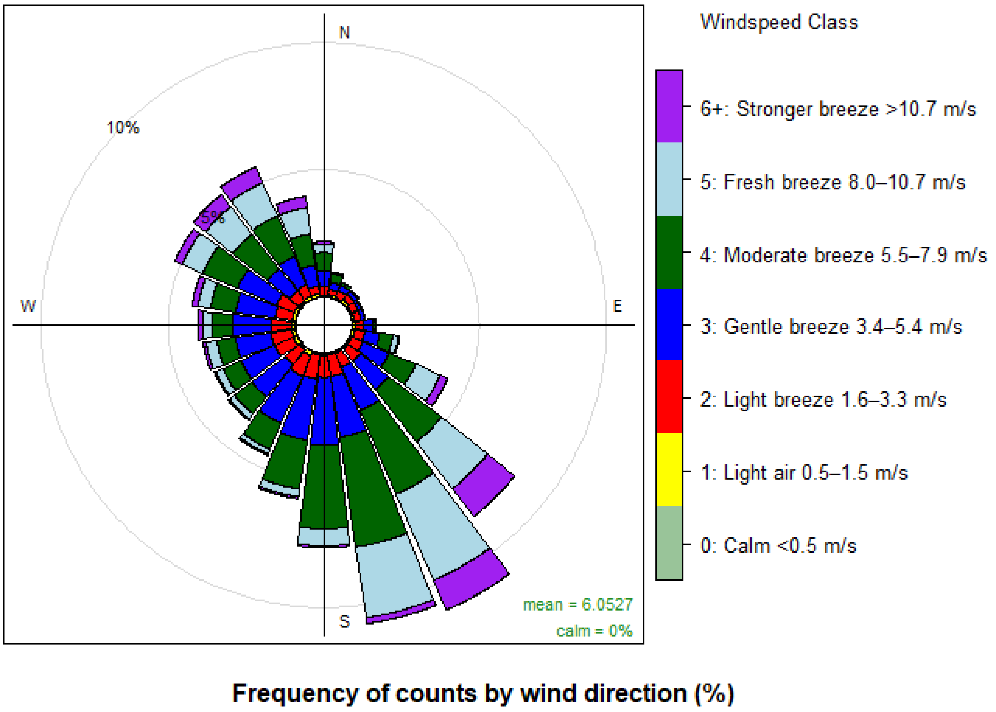


Figure 6-10: Daytime Wind Rose

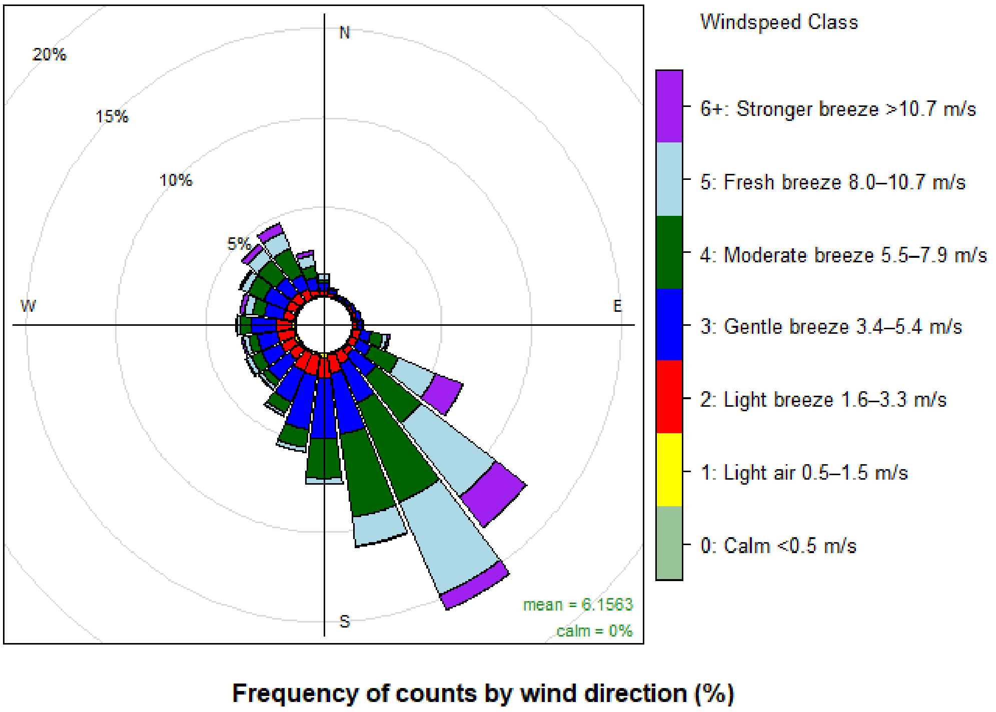


Figure 6-11: Nighttime Wind Rose

Early morning winds (winds experienced between 00h00 and 06h00) average 5.68 m/s and predominantly originate from south-southeast, with minor occurrences from the northwest, west, southwest and south (refer to Figure 6-12).

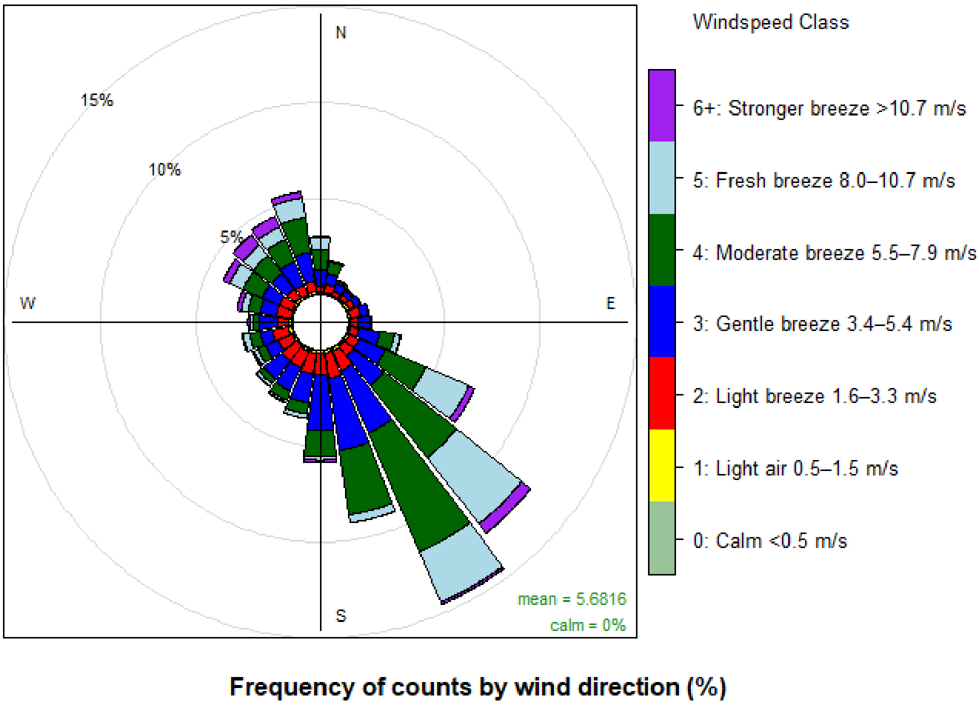


Figure 6-12: Early Morning Wind Rose

6.4 Relative Humidity

Humidity governs the increasing likelihood of heavier rainfall and more dangerous heatwaves. The relative humidity presented in this section was sourced from the Maitland SAAQIS station and patched with raw data from the MERRA2 CGM.

Monthly average relative humidity data is presented in Figure 6-13 Although humidity is at its highest in May (80.5%) and at its lowest in December (77.5%), all months present average relative humidities close to the average (78.3%). Very low variation in relative humidity is noted.

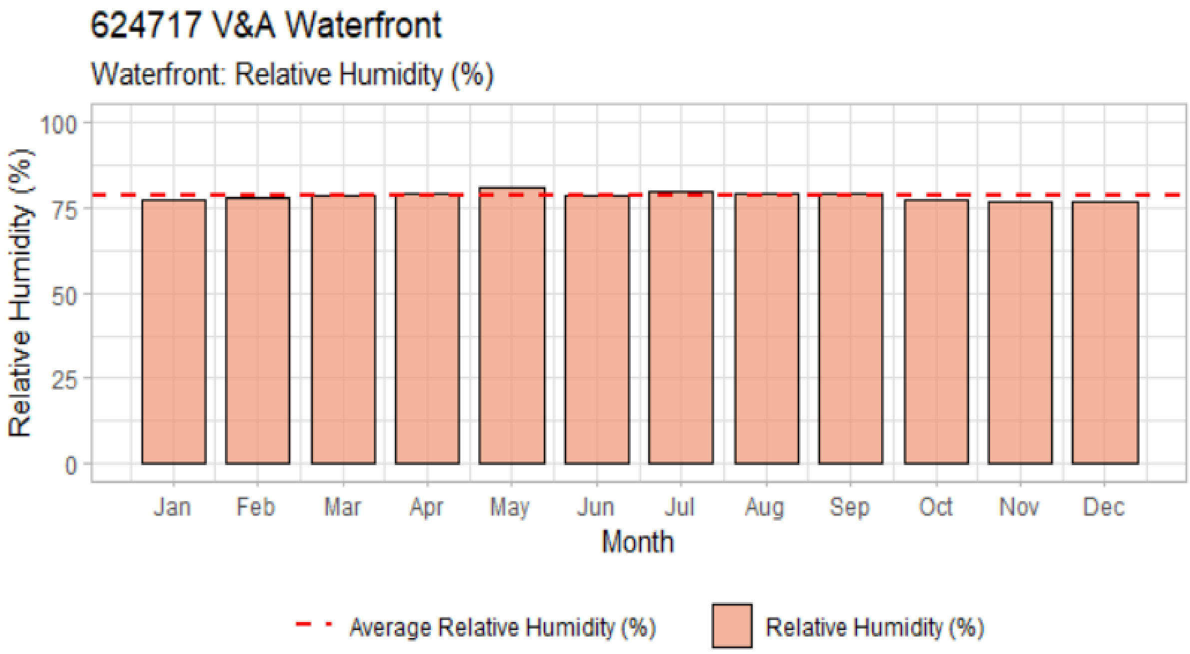


Figure 6-13: Monthly Average Relative Humidities

Average annual relative humidities for the dataset are presented in Figure 6-14. The annual average relative humidity for the baseline period, 78.3%, is indicated by the red dashed line. Almost all of the years prior to 2021 had average relative humidities above or close to the average. All of the years post and including 2021 had relative humidities below the average. The lowest average annual relative humidity recorded during the baseline period, 72.3%, was recorded in 2022.

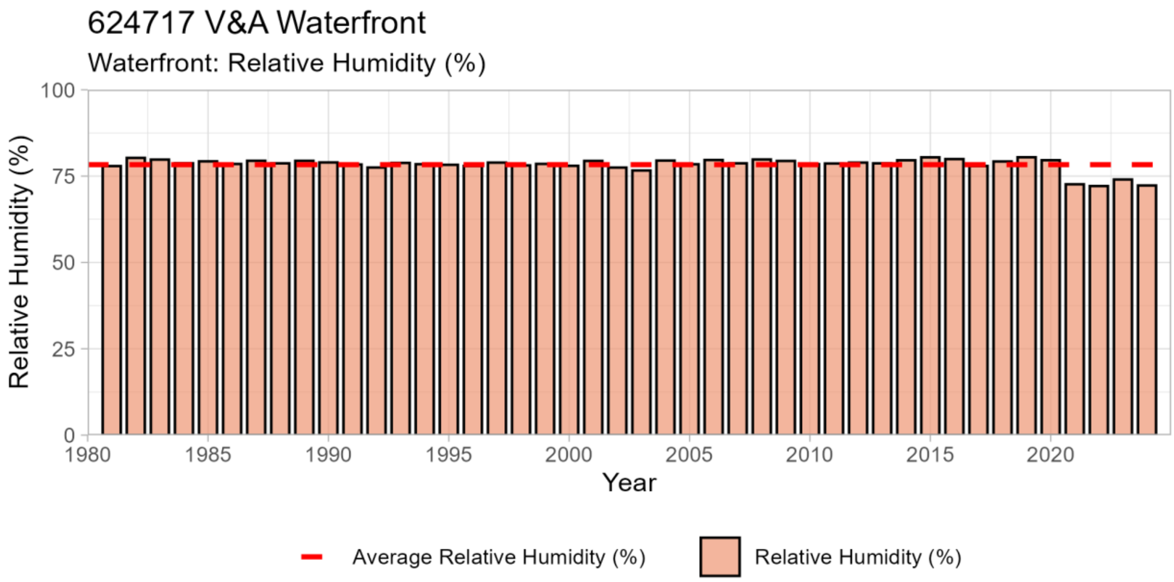


Figure 6-14: Annual Average Relative Humidities

7 Ocean Baseline

All information presented in the following subsections was extracted from the Wave and Hydrodynamic Modelling Study compiled by PRDW Port and Coastal Engineers for the proposed Granger Bay Development in August 2023. Refer to Figure 2-1 for a locality map of the proposed development zone.

7.1 Sea Temperature

The maximum (99th percentile) surface seawater temperature figures presented in the PRDW Report for the summer and autumn months (December to May) indicate that seawater temperatures in the Granger Bay Small Craft Harbour fall between 17.25°C at the mouth of the harbour and >21°C further inland. Sea temperatures around the proposed Granger Bay Development Zone average 17°C (refer to Figure 3-7 in the 2023 PRDW Report).

The maximum (99th percentile) surface seawater temperature figures presented for the winter and spring months (June to November) indicate that seawater temperatures in the Granger Bay Small Craft Harbour fall between 16.50°C at the mouth of the harbour and 18°C further inland. Sea temperatures around the proposed Granger Bay Development Zone average 16.25°C (refer to Figure 3-8 in the 2023 PRDW Report).

7.2 Residual Circulation

The residual circulatory currents experienced during the summer and autumn months are presented in Figure 3-5 of the 2023 PRDW Report. Based on the data:

- Move towards the shoreline, rotate clockwise and move towards the harbour mouth in a northwesterly direction.
- Result in low current speeds within the small craft harbour and near the shoreline of the Granger Bay Development (speeds below 0.005 m/s).

- Mix/Interact at the harbour mouth, resulting in current speeds of between 0.010 and 0.030 m/s.
- Move westwards through the proposed Granger Bay Development Zone at speeds between 0.005 and 0.015 m/s.

The residual circulatory currents experienced during the winter and spring months are presented in Figure 3-6 of the 2023 PRDW Report. Based on the data:

- Generally avoid the harbour and proposed development zone and move directly westwards.
- Result in low current speeds within the small craft harbour and majority of the proposed development zone (Majority of the area experiences current speeds below 0.005 m/s).
- Mix/Interact slightly at the harbour mouth, resulting in speeds of up to 0.020 m/s.
- Circulate clockwise and anticlockwise within the proposed development zone at speeds of up to 0.015 m/s.

7.3 Wave Height

Wave heights were modelled for 1-year, 1-month summer, and 1-month winter return period storms. Based on the modelling undertaken for a:

- **1-year storm (Figure 3-10 of the 2023 PRDW Report)**:
  - The harbour experiences wave heights between 0.75 and 1.75m.
  - Although, the majority of the proposed development zone experiences wave heights between 0.25 and 2.75 m, wave circulation in the southeastern pocket of the proposed development zone (near the Dolos Revetment) creates isolated points of extreme wave height (heights >3.75 m).
  - Wave heights exceed 3.75 m out at sea and reach heights of between 2.25 and 2.75 m when entering the development zone.
- **1-month summer storm (Figure 3-11 of the 2023 PRDW Report)**:
  - The harbour generally experiences very small waves (heights below 0.25 m).
  - The majority of the proposed development zone area experiences waves with heights between 0.25 and 1 m.
  - The circulation and wave impacts experienced near the Dolos Revetment results in waves with heights of up to 2 m.
- **1-month winter storm (Figure 3-12 of the 2023 PRDW Report)**:
  - The harbour experiences waves between 0.75 and 1 m.
  - The circulation and wave impacts experienced near the Dolos Revetment results in waves with heights of up to 3.5 m.
  - The majority of the wave heights experienced in the proposed development zone fall between 1.25 and 2.25 m.

7.4 Wave-Induced Bed Shear Stress

High shear stresses result in areas that are predominantly sandy. Low shear stresses prevent silt and sand from being resuspended and result in muddier areas[5]. Shear stresses were modelled for 1-year, 1-month summer, and 1-month winter return period storms. Based on the modelling undertaken for:

- **1-year storms (Figure 3-13 of the 2023 PRDW Report)**:
  - The harbour experiences the lowest shear stresses and is expected to be muddier than the rest of the area.

[5] According to the PRDW Report, shear stresses exceeding 0.2 N/m^2 cause resuspension of mud and bed sand.

  - Shear stresses in the proposed development zone exceed 3 N/m^2 near in the southeastern pocket, near the Dolos Revetment and fall between 0.3 and 2 N/m^2 throughout the rest of the area.
- **1-month summer storms (Figure 3-14 of the 2023 PRDW Report)**:
  - The maximum shear stress experienced in the harbour area is 0.2 N/m^2.
  - Shear stresses in the proposed development zone fall between 0.05 and 0.2 N/m^2, barring the area near the Dolos Revetment, which experiences stresses of up to 0.3 N/m^2.
  - The majority of the area experiences low shear-stresses and is expected to be muddy.
- **1-month winter storms (Figure 3-15 of the 2023 PRDW Report)**:
  - The harbour area generally experiences shear stresses between 0.03 and 0.2 N/m^2.
  - Shear stresses in the proposed development zone fall between 0.2 and 2 N/m^2, barring the area near the Dolos Revetment, which experiences stresses of up to 3 N/m^2.

8 Natural Hazards

GDIS data from the World Bank's CCKP indicates that floods, storms, droughts and earthquakes affected the Western Cape between 1980 and 2018 (refer to Figure 8-1). Floods are the most common natural hazard, constituting 44.4% of the natural disasters reported, followed by extreme storms (refer to Table 8-1). Further detail on risk and prevalence of specific natural hazards follows in the subsections below.

Figure 8-1: Natural Disasters in the Western Cape (CCKP)

Table 8-1: Total Natural Disasters in the Western Cape (CCKP)

Disaster	Total Documented (1980-2024)	Overall Contribution (%)
Floods	12	44.4
Storms	11	40.7
Droughts	3	11.1
Earthquakes	1	3.7

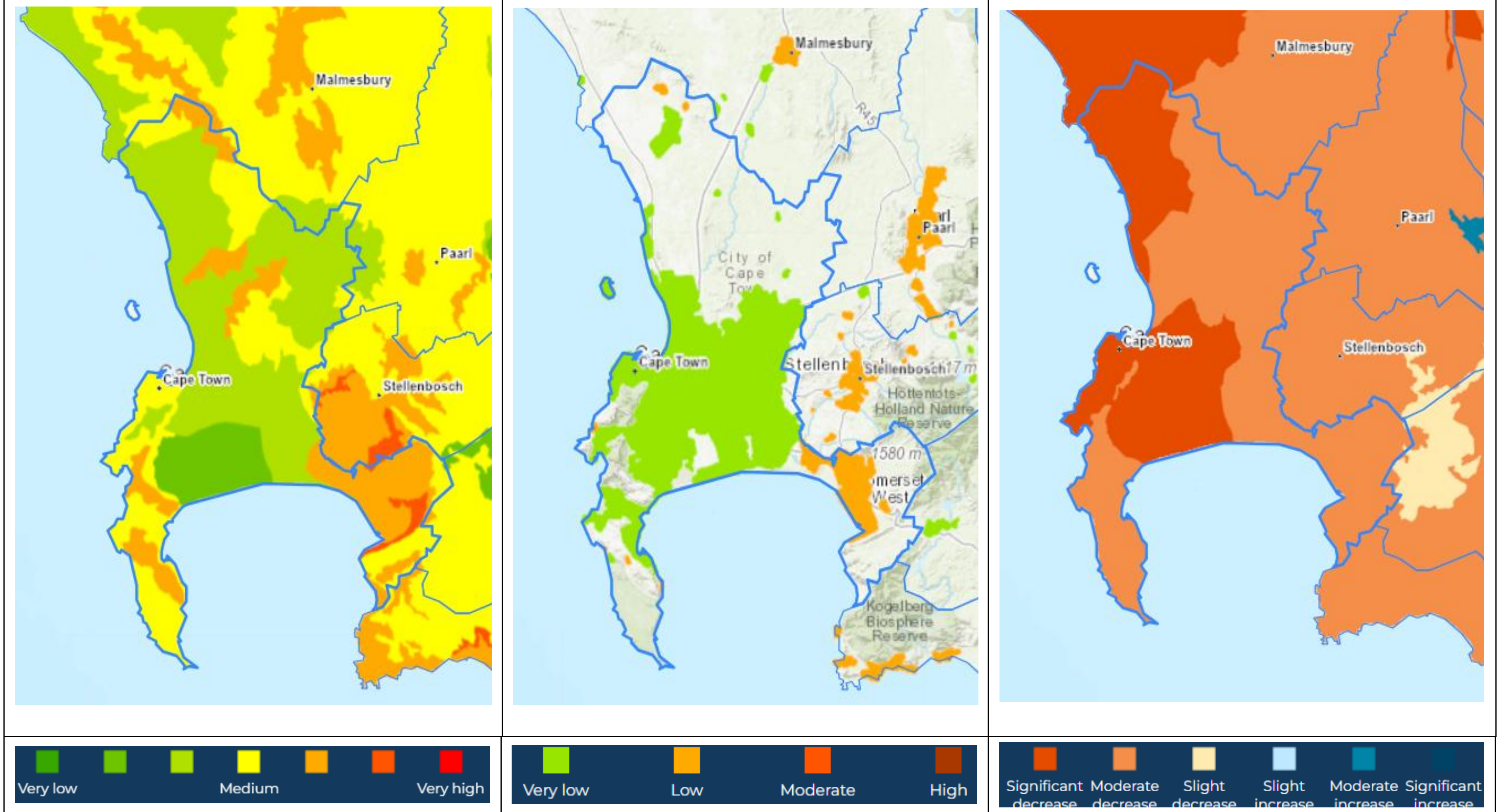
8.1 Flooding

The World Bank CCKP indicates that 51 flood events occurred in South Africa between 1980 and 2024. It highlights that the number of flood events reported annually has increased significantly (21 out of the 51 flood events documented occurred between 2019 and 2024). The highest number of flood events documented in a single year, 8 flood events, occurred in 2022.

The CSIR's Green Book indicates that the project location is at medium risk of floods currently. Areas to the south, east and northeast of the project site at medium to high risk of floods (refer to Figure 8-2 A). 2050 projections indicate a significant decrease in the number of extreme rainfall days that will be experienced on and around the project site in tandem with a very low projected increase in flood exposure (refer to Figure 8-2 B and Figure 8-2 C). With a projected extreme rainfall value of 0.715, majority of the Western Cape is expected to experience moderate to significant decreases in the number of extreme rainfall days experienced[6].

The Green Book also indicates that the project site is at very high risk of coastal flooding currently (refer to Figure 8-3 A). Although 2050 projections indicate that more areas will be at risk of coastal flooding (refer to Figure 8-3 B), Cape Town remains at moderate risk of coastal flooding, and it is anticipated that the project site will still be at very high risk of coastal flooding.

[6] A calculated regional extreme rainfall value >1 indicates an increase in extreme daily rainfall, whilst values below 1 denote decreases. The lower the value, the more significant the decrease.



A: CURRENT FLOOD EXPOSURE	B: PROJECTED FLOOD EXPOSURE (2050)	C: PROJECTED CHANGE IN EXTREME RAINFALL DAYS (2050)

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Figure 8-2: Flood Exposure - Cape Town and V&A Waterfront

0 | Very low risk | Low risk | Medium risk | High risk | Very high risk

A: CURRENT COASTAL FLOOD EXPOSURE – PROJECT SITE AND REGION

Very low | Low | Moderate | High | Not exposed

B: PROJECTED COASTAL FLOOD EXPOSURE

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COASTAL FLOOD EXPOSURE

Project No. 624717

Figure 8-3: Coastal Flood Exposure - Cape Town and V&A Waterfront

8.2 Storm Surge

A total of 34 extreme storms were documented in South Africa between 1980 and 2024. Eleven extreme storms occurred in the Western Cape between 1980 and 2018. The highest number of storms documented in a single year, four storms, was documented in 2002. Although there is no distinct trend in the number of storms documented annually, a notable increase in the number of storms has been observed between 2010 and 2024 (19 storms were documented between 1980 and 2009, but 15 were documented between 2010 and 2024, with two documented annually in 2021, 2023 and 2024) – refer to Figure 8-4.

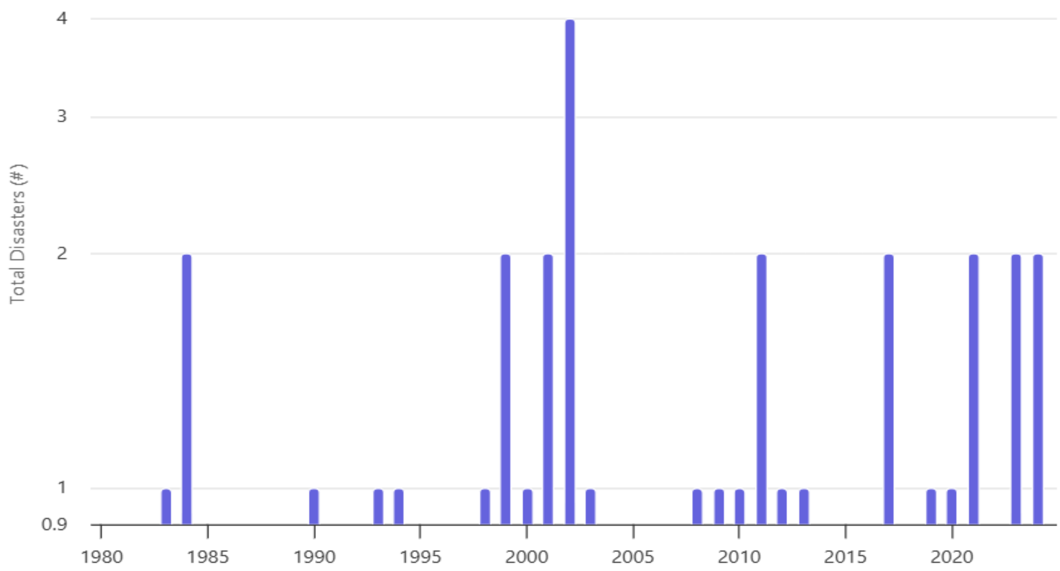


Figure 8-4: Number of Extreme Storms noted in South Africa (CCKP)

Although there has been an increase in the number of extreme storms noted, a research paper compiled by Muis *et al*, (2023) indicates that storm surge heights expected along the coast of the WSAF (West-Southern-Africa) Region are projected to increase by up to 0.05 m between 2021 and 2050 from an ensemble median height of between 0.4 and 0.8 m for a 10-year return period.

8.3 Droughts

The CCKP indicates that ten droughts were documented across South Africa between 1980 and 2024 and that three of these occurred in the Western Cape. Six of these occurred prior to 2005 (in 1982, 1986, 1988, 1991, 1995 and 2004), and four occurred between 2015 and 2021 (in 2015, 2017, 2019 and 2021) – refer to Figure 8-5. The biannual occurrence of droughts since 2015 relative to full period highlights the increased prevalence of droughts in the region.

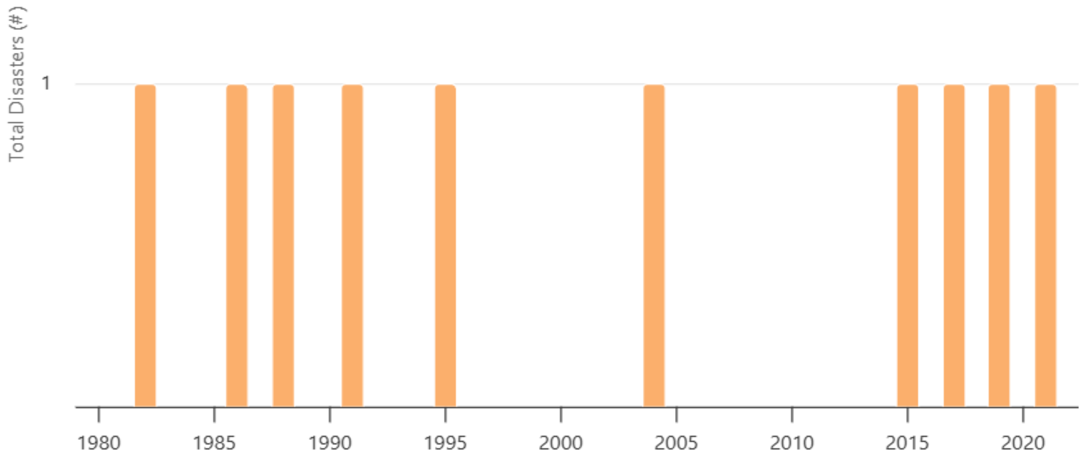
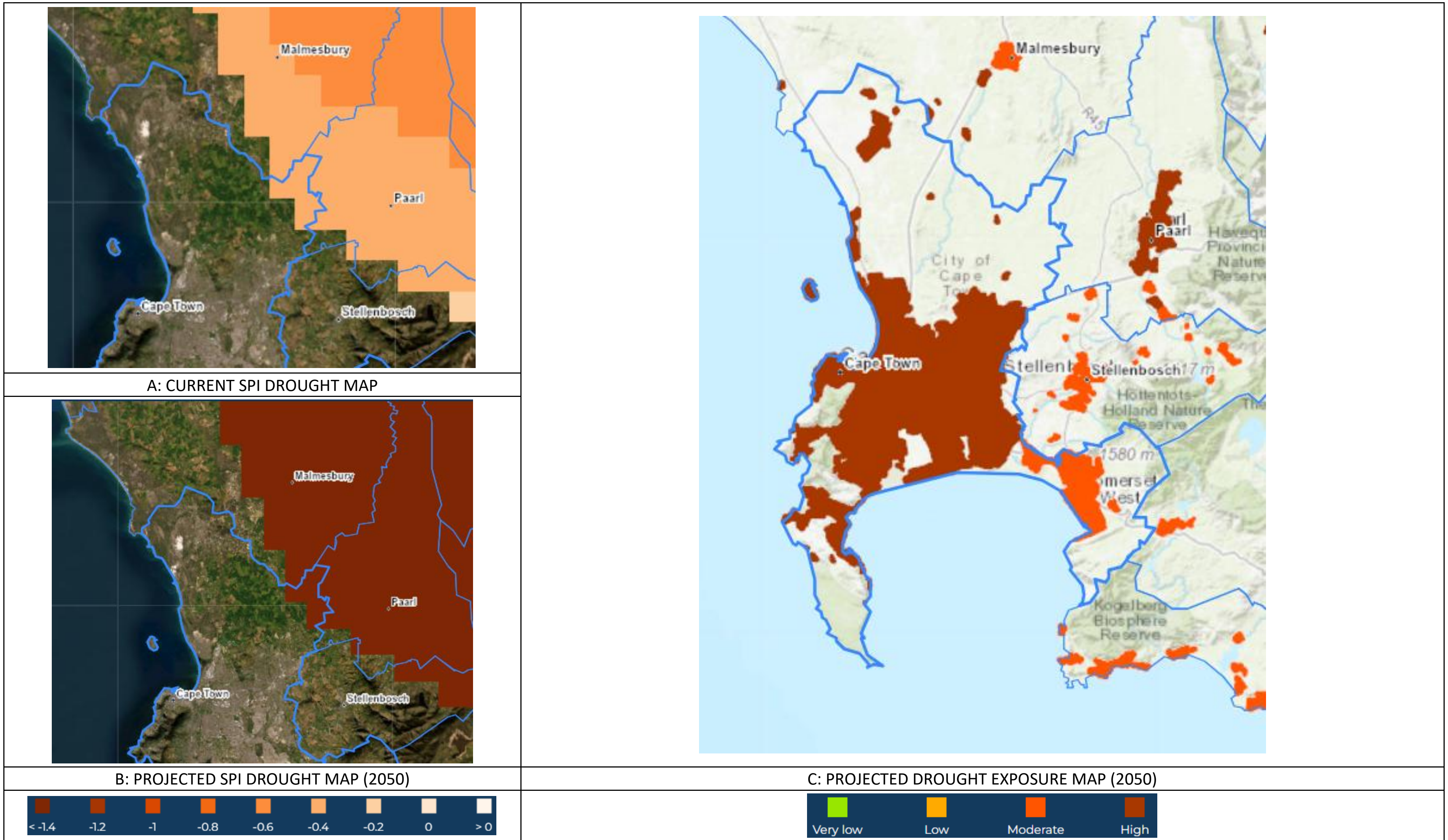


Figure 8-5: Drought Occurrences in South Africa (CCKP)

The Green Book indicates that Malmesbury, Paarl and other areas northeast of Cape Town and Stellenbosch are currently at low to moderate risk of drought (Figure 8-6 A). The projected standardised precipitation index (SPI) map (Figure 8-6 B) indicates that the number of drought cases experienced in the region will increase significantly by 2050. The projected drought exposure map (Figure 8-6 C) indicates that the risk of drought exposure in Cape Town will be high by 2050. Although the SPI index map does not analyse Cape Town and the V&A Waterfront specifically, it is likely, given the projected drought exposure map, that the V&A Waterfront and surrounding area may experience similar SPI index changes to that of Malmesbury and other inland areas.



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SPI AND DROUGHT EXPOSURE

Project No. 624717

Figure 8-6: Drought Susceptibility - Cape Town and V&A Waterfront

8.4 Earthquakes

The Global Seismic Hazard Map (Version 2023.1) indicates that the west coast of South Africa is at very low risk of seismic activity, whilst inland areas in Gauteng (Johannesburg) and north of Bloemfontein in the Free State are at low-moderate risk of seismic activity (refer to Figure 8-7 and the project location in Cape Town indicated by the purple demarcation symbol). This is confirmed by:

- Historical data collated in the CCKP, which indicates that four earthquakes occurred in South Africa between 1980 and 2024 (one in 1990, 1997, 2005 and 2014 - Figure 8-8).
- A ThinkHazard Assessment of the City of Cape Town, which indicates that the susceptibility of the City of Cape Town to earthquakes is very low (a <2% chance of a potentially damaging earthquake occurring in the next 50 years).

Peak Ground Acceleration (PGA) refers to the acceleration a mass on the ground would experience due to gravity in the event of an earthquake. Higher PGA values indicate the possibility of more severe earthquakes, and therefore, structural damage.

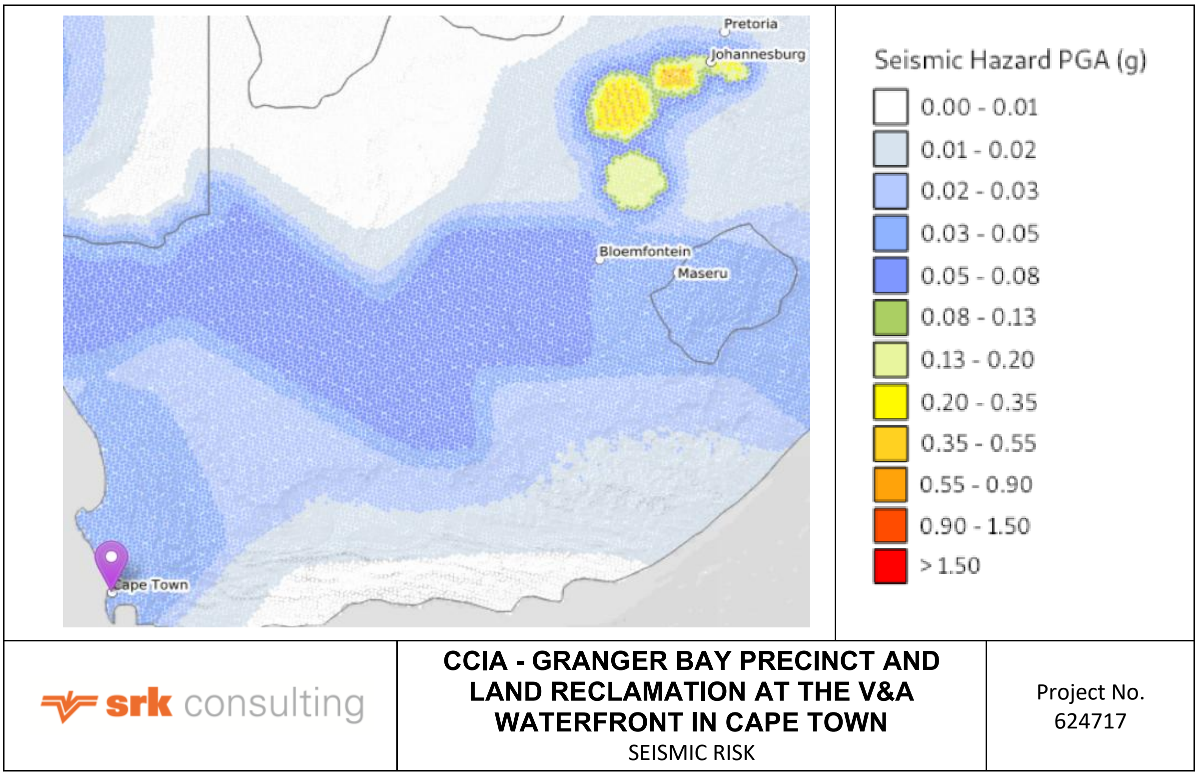


Figure 8-7: Seismic Risk - Southern Africa

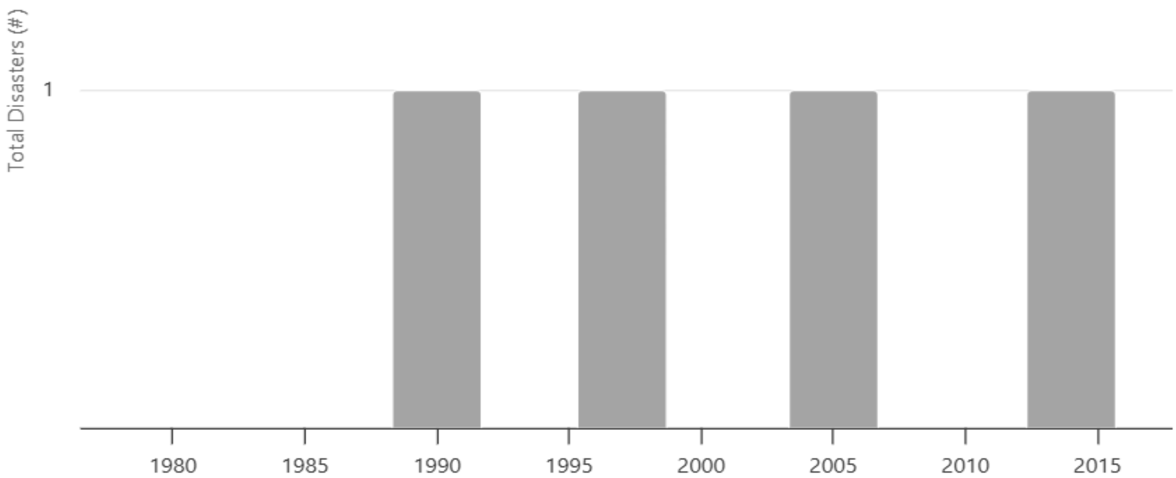


Figure 8-8: Seismic Activity and Earthquakes in South Africa (CCKP)

8.5 Fires/Wildfires

Rising temperatures and reduced humidity create favourable conditions for fires in regions already prone to drought. Human activities, including domestic fuel/solid waste burning, fuel storage and transport, controlled burning, material storage, etc., could exacerbate fire risk in built-up areas by creating isolated ignition points that allow fires to spread. This is highlighted by:

- The Green Book, which indicates that the City of Cape Town is:
  - Highly susceptible to population growth pressure.
  - The most vulnerable municipality in South Africa in terms of environmental conflict (the conflict between preserving the natural environment and accommodating growth pressures – population growth, urbanisation and economic development).
- A ThinkHazard Assessment, which indicates that wildfire[7] risk in the region is **high** — Wildfire risk is high in the case of weather patterns that are likely to support a significant wildfire that could result in both life and property loss once every two years.

NASA's FIRMS documents 539 fire reports between 2012 and 2025 (41 high, 39 low and 459 nominal confidence reports[8]). These fire reports were grouped by month and are presented in Table 8-2 and Figure 8-9 to indicate fire occurrence trends. The data indicates that fires are uncommon between May and September and ramp up in October, January and April. However, based on the definitions for low, nominal and high confidence reports (refer to the footnote below), and the fact that the region is highly urbanised, some of the reports documented may be the result of temperature anomalies caused by domestic fuel/solid waste burning, controlled burning and/or industrial activities.

Table 8-2: Monthly Grouped Fire Reports, 2012-2025 (NASA's FIRMS)

Month	No. of Confidence Reports			Total No. of Reports
	High	Medium	Low	
January	7	11	90	**108**
February	1	13	63	**77**
March	6	4	33	**43**
April	9	1	74	**84**
May	0	0	5	**5**
June	0	0	5	**5**
July	0	0	4	**4**
August	0	0	7	**7**
September	0	0	3	**3**
October	14	3	96	**113**
November	1	2	33	**36**
December	3	5	46	**54**
Total	**41**	**39**	**459**	**539**

[7] The World Bank has adopted the United Nations Food and Agricultural Organisation (FAO)'s definition for wildfires. According to the FAO, a wildfire is an unplanned and uncontrolled vegetative fire that could impact socioeconomic and environmental factors.

[8] Low confidence daytime fires are typically associated with areas of sun glint and lower relative temperature anomaly in the mid-infrared channel.

Nominal confidence fires are those free of potential sun glint contamination during the day and marked by strong (>15 K) temperature anomaly in either day or nighttime data.

High confidence fires are associated with day or nighttime saturated pixels.

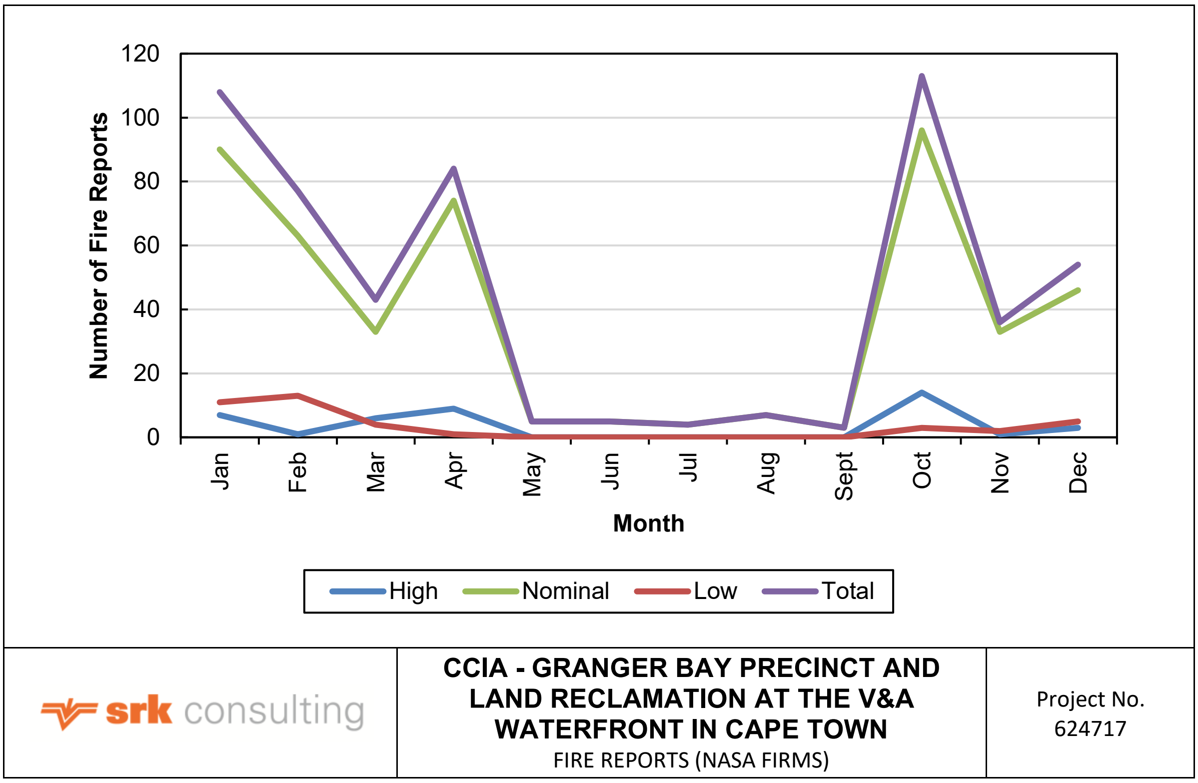
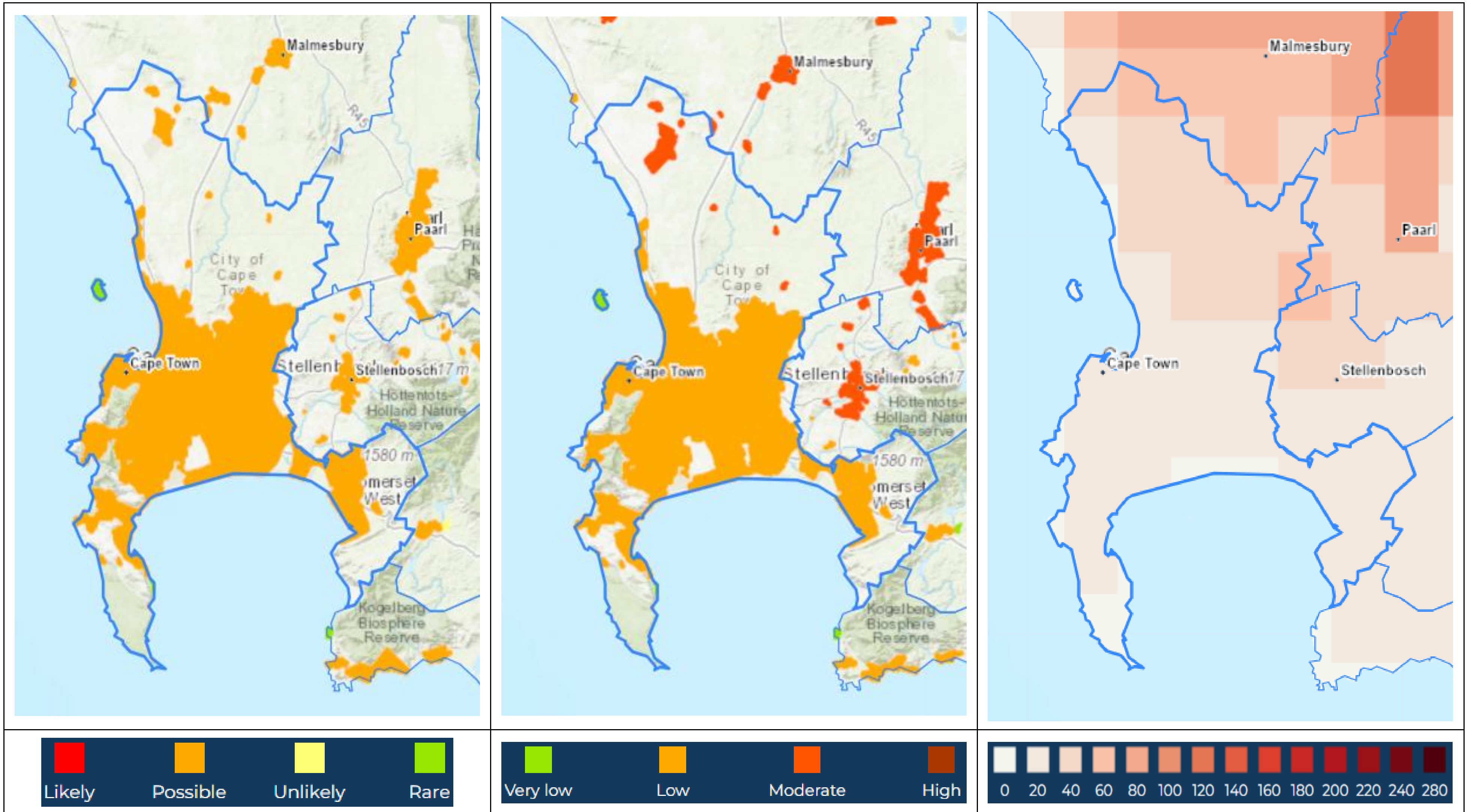


Figure 8-9: Monthly Grouped Fire Reports in Cape Town, 2012-2025 (NASA's FIRMS)

The CCKP indicates that 11 wildfires were reported across South Africa between 1991 and 2024 (Figure 8-10) and that three of these occurred in the Western Cape. The highest number of wildfires reported in a single year (two) occurred in 2001. No trend pertaining to the occurrence of wildfires in the region was identified.

Figure 8-10: Wildfires in South Africa (CCKP)

The Green Book indicates that the likelihood of wildfires occurring in the region currently is possible (Figure 8-11 A). 2050 projections indicate a low increase in wildfire exposure in Cape Town (Figure 8-11 B) with a slight increase in the number of fire danger days noted around the project site (Figure 8-11 C). Wildfire exposure and the projected increase in the number of fire danger days worsens to the northeast, inland of the project site.



A: CURRENT WILDFIRE EXPOSURE	B: PROJECTED WILDFIRE EXPOSURE (2050)	C: PROJECTED FIRE DANGER DAYS (2050)

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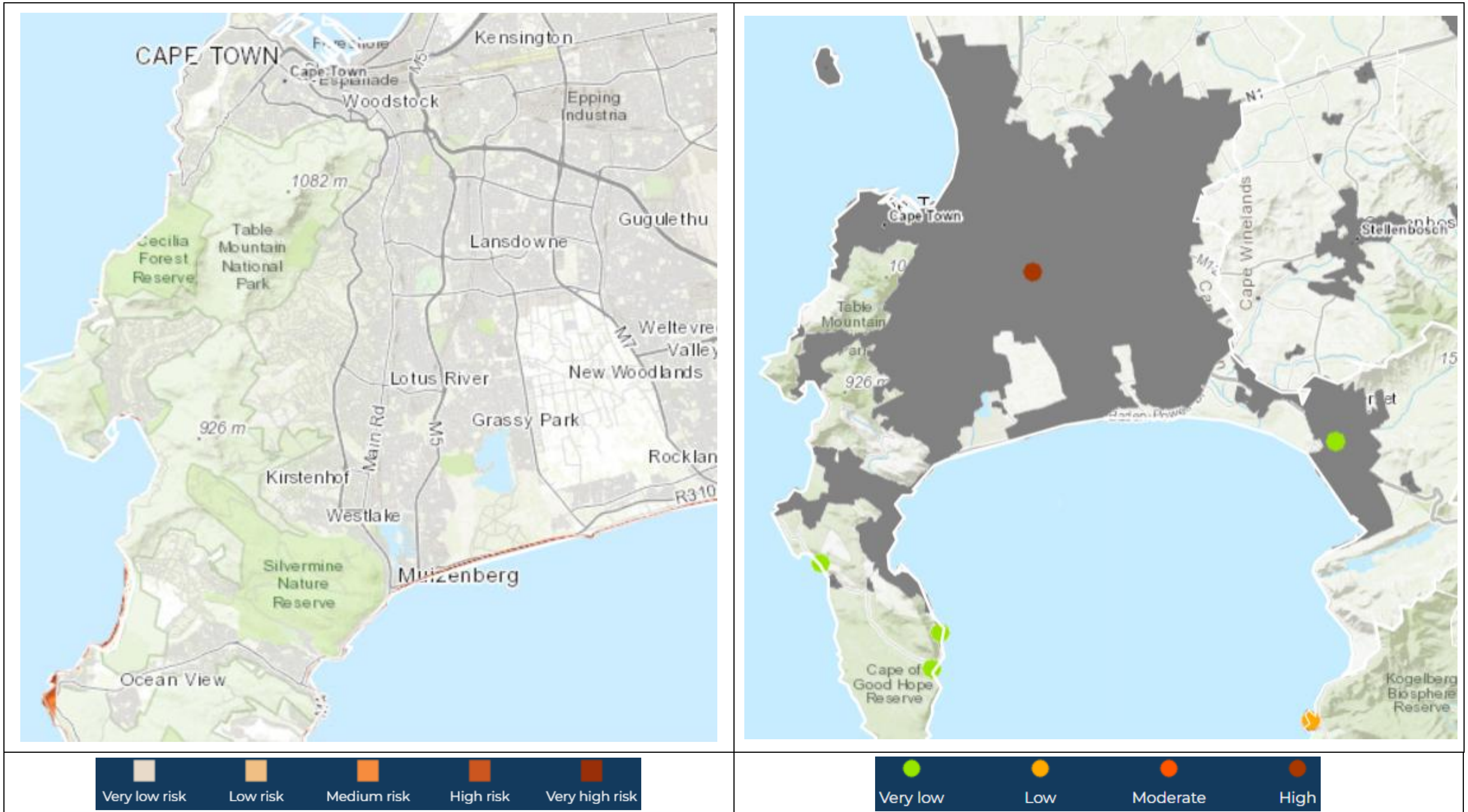
Figure 8-11: Wildfire Exposure and Fire Danger Days - Cape Town and V&A Waterfront

8.6 Coastal Erosion

Areas to the north (Bloubergstrand), south (Ocean View) and southeast (Muizenberg) of the project site are at high to very high risk of coastal erosion – refer to Figure 8-12 A. 2050 projections indicate that majority of the structures in Cape Town near the coastline are highly susceptible to, and at risk of, coastal erosion, which will be exacerbated during extreme storms.



A: CURRENT COASTAL EROSION	B: PROJECTED COASTAL EROSION

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Figure 8-12: Coastal Erosion - Cape Town and V&A Waterfront

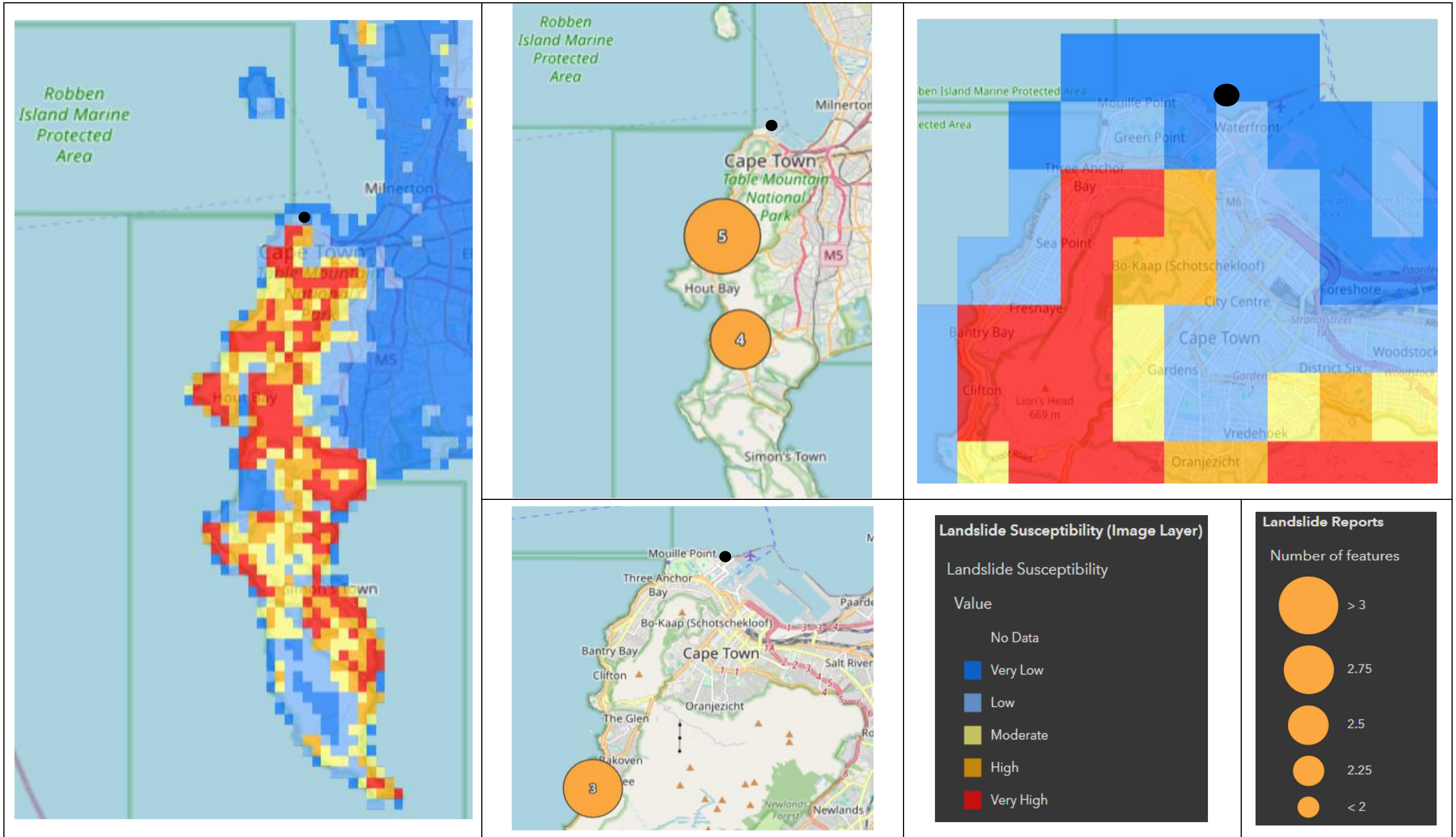
8.7 Landslides

Although NASA's Global Landslide Catalog indicates that 12 landslides were reported in the Western Cape, only nine of these were reported within the bounds of the City of Cape Town. Reports include:

- One on the east coast, directly east of the M76 (Boynes Drive).
- Seven on the M6 (Victoria Road) – one near Chapman's Peak, two to the west of Noordhoek Peak, one southeast of Hanging Meadow, one northwest of Kronendal Retirement Village, and two further to north, directly east of Kroeëlbaai.
- One southeast of the M6, to the south of Barley Bay Bus Stop.

None of these landslide reports were documented near the project site (denoted by the black dot in Figure 8-13). Furthermore, although NASA's Landslide Susceptibility Map indicates that a vast majority of the western coast of Cape Town is at moderate to very high risk of landslide events, the V&A Waterfront is considered to be at very low to low risk of landslide events.

An assessment undertaken using ThinkHazard also indicates that the susceptibility of the project site and region to landslides is low (The rainfall patterns, terrain slope, geology, soil, land cover and earthquake susceptibility (discussed above) indicate that localised landslides are uncommon).



srk consulting	**CCIA - GRANGER BAY PRECINCT AND LAND RECLAMATION AT THE V&A WATERFRONT IN CAPE TOWN** LANDSLIDE REPORTS AND OVERALL LANDSLIDE SUSCEPTIBILITY	Project No. 624717

Figure 8-13: Landslide Reports and Overall Landslide Susceptibility – Cape Town and V&A Waterfront

8.8 Tsunami

ThinkHazard indicates that a tsunami could hit Cape Town's coastline once every 500 years. Realistic and worst-case tsunami amplitude modelling conducted by Kijko, Smit, Papadopoulos and Novikova in 2017 also indicated the possibility of *relatively small tsunamis that do not represent a significant risk* to South Africa's eastern and western coastlines.

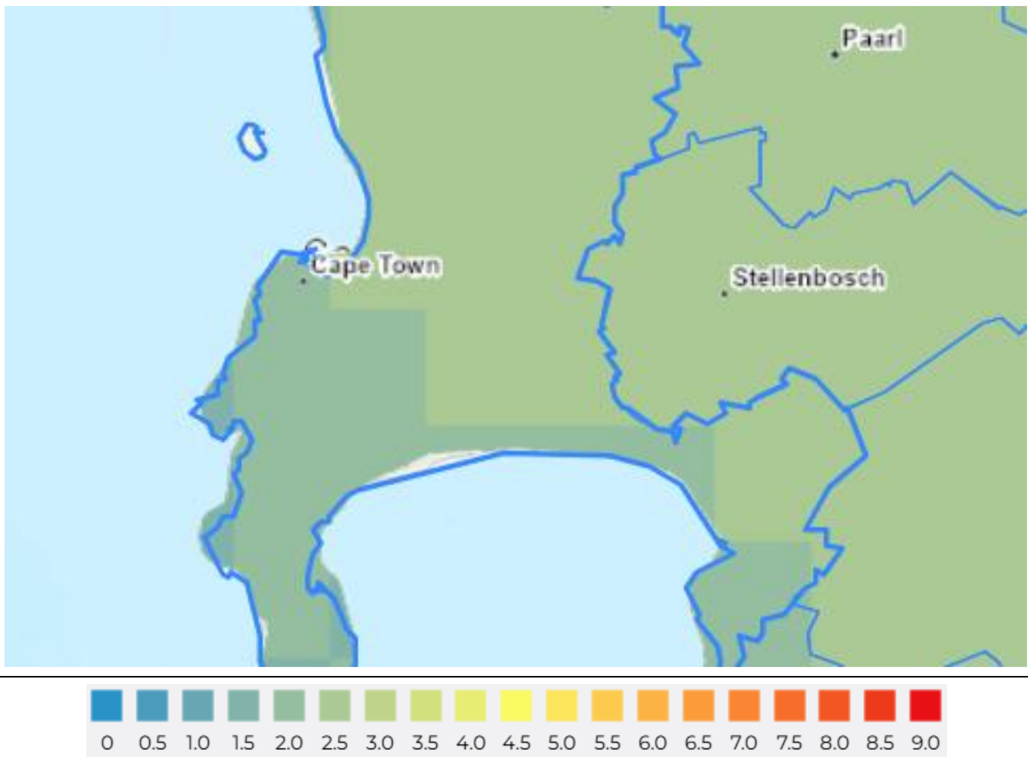
9 Climate Change Projections

9.1 Regional

Regional climate change projections were obtained from the World Bank's CCKP and supplemented with 2050 projections from The Green Book.

9.1.1 Temperature

The Green Book indicates that the City of Cape Town is anticipated to experience mean temperature increases of between 1 and 2.5 °C (refer to Figure 9-1).



srk consulting	CCIA - GRANGER BAY PRECINCT AND LAND RECLAMATION AT THE V&A WATERFRONT IN CAPE TOWN MEAN TEMPERATURE PROJECTIONS (GREEN BOOK)	Project No. 624717

Figure 9-1: Mean Temperature Projections (Green Book)

The average (mean) daily temperature changes (minimum, average and maximum) for the region under SSP 1-2.6 and SSP 5-8.5 are presented in Table 9-1 (CCKP data). Average minimum, mean and maximum temperatures in the region are projected to increase by up to 3.77 °C, 3.91 °C and 4.11 °C by the end of the century, respectively, under SSP 5-8.5. The absolute minimum and extreme maximum temperature changes for the region are also projected to increase under the same SSPs (refer to Table 9-2 (CCKP data)). The absolute minimum and extreme maximum temperatures under SSP 5-8.5 are projected to increase by up to 3.10 °C and 4.26 °C, respectively, by the end of the century.

Table 9-1: Average Temperature Changes for the Region (CCKP)

Decades	SSP 1-2.6						SSP 5-8.5					
	Avg. Min Temperature		Avg. Temperature		Avg. Max Temperature		Avg. Min Temperature		Avg. Temperature		Avg. Max Temperature	
	°C	%	°C	%	°C	%	°C	%	°C	%	°C	%
2001-2010	0.04	0.32	0.02	0.13	0.02	0.09	0.04	0.32	0.02	0.13	0.02	0.09
2011-2020	0.21	1.93	0.25	1.45	0.26	1.13	0.22	1.98	0.23	1.33	0.23	1.00
2021-2030	0.49	4.50	0.52	3.03	0.56	2.40	0.56	5.15	0.60	3.54	0.65	2.81
2031-2040	0.70	6.42	0.74	4.32	0.77	3.33	0.90	8.22	0.98	5.76	1.04	4.48
2041-2050	0.87	7.96	0.94	5.51	1.01	4.38	1.28	11.72	1.34	7.87	1.42	6.12
2051-2060	0.88	8.06	0.95	5.58	1.00	4.31	1.75	16.01	1.84	10.82	1.94	8.38
2061-2070	0.92	8.43	0.99	5.82	1.08	4.66	2.25	20.51	2.33	13.69	2.42	10.44
2071-2080	0.90	8.24	1.01	5.90	1.08	4.66	2.75	25.09	2.87	16.84	2.98	12.86
2081-2090	0.90	8.18	1.01	5.92	1.11	4.80	3.35	30.55	3.48	20.40	3.60	15.55
2091-2100	0.84	7.67	0.94	5.53	1.05	4.54	3.77	34.42	3.91	22.96	4.11	17.77

Table 9-2: Absolute Minimum and Extreme Maximum Temperature Changes for the Region (CCKP)

Decades	SSP 1-2.6				SSP 5-8.5			
	Minimum Temperature		Maximum Temperature		Minimum Temperature		Maximum Temperature	
	°C	%	°C	%	°C	%	°C	%
2001-2010	-0.05	-9.25	0.08	0.22	-0.05	-9.25	0.08	0.22
2011-2020	0.21	41.29	0.26	0.74	0.18	36.23	0.28	0.79
2021-2030	0.28	55.42	0.52	1.47	0.36	72.54	0.71	1.99
2031-2040	0.42	83.88	0.86	2.41	0.68	135.22	1.07	3.02
2041-2050	0.64	128.06	1.01	2.86	0.96	190.75	1.62	4.57
2051-2060	0.65	128.46	1.11	3.12	1.21	240.70	2.11	5.95
2061-2070	0.73	144.38	1.13	3.20	1.77	351.74	2.62	7.40
2071-2080	0.74	147.76	1.15	3.23	2.22	442.49	3.09	8.72
2081-2090	0.67	132.84	1.20	3.38	2.66	528.46	3.61	10.19
2091-2100	0.72	143.78	1.00	2.82	3.10	617.61	4.26	12.03

Note: SSP refers to Shared Socioeconomic Pathway

9.1.2 Rainfall

A precipitation anomaly indicating the projected seasonal changes to rainfall in the region under SSP 5-8.5 (the worst-case emissions scenario) is presented in Figure 9-2 (CCKP data). The data presented indicates that the region will become drier in the near-term (by the 2040s) and increasingly so by the end of the century, with precipitation anomalies reaching up to -10 mm between May and November.

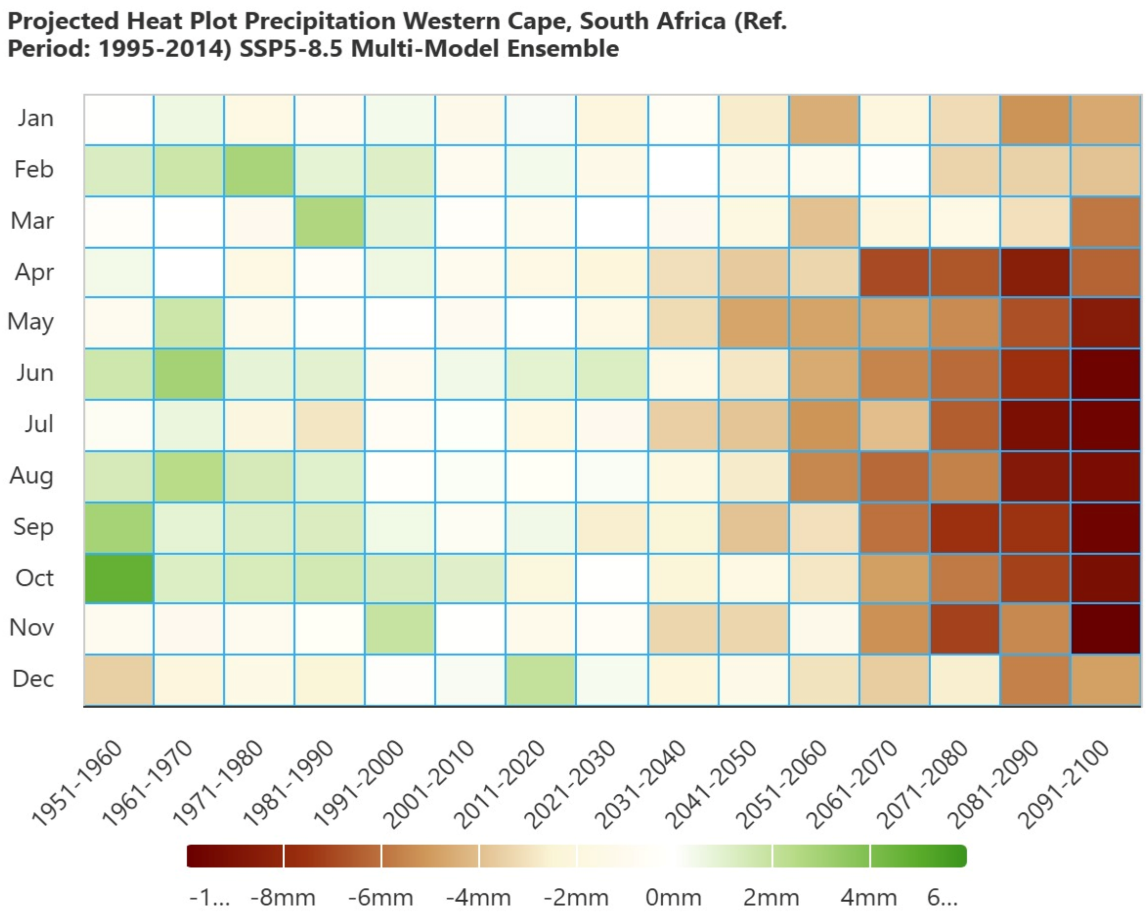
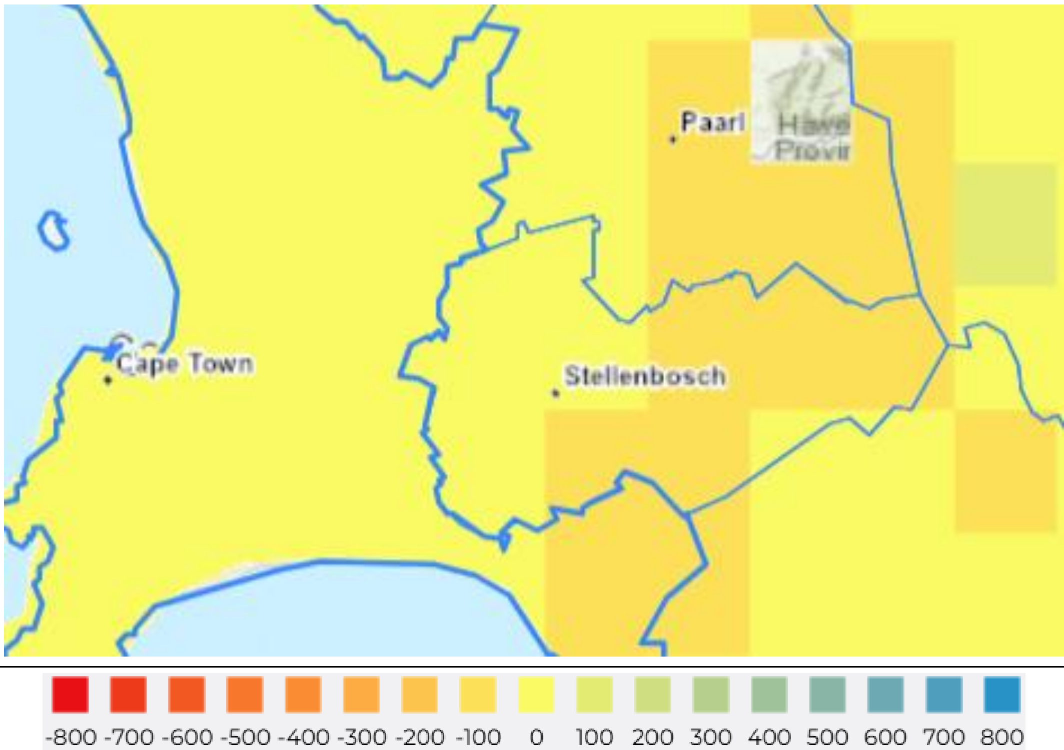


Figure 9-2: Average Precipitation Anomaly - Western Cape (CCKP)

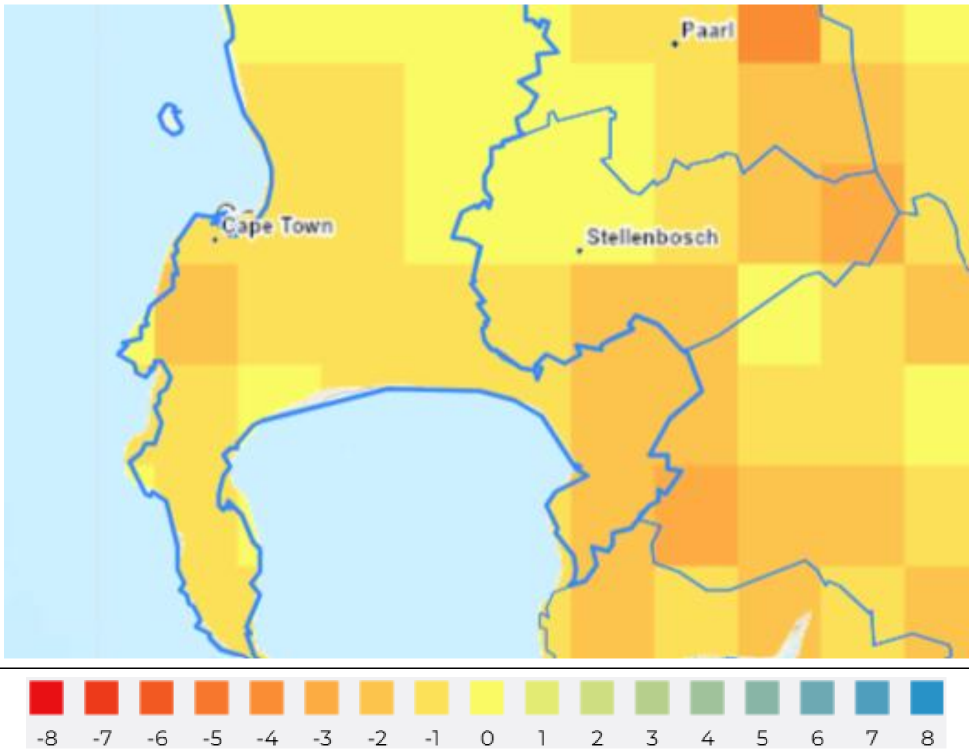
The Green Book indicates that the City of Cape Town is anticipated to experience MAP decreases of between 0 and 100 mm (refer to Figure 9-3) and decreases in the number of very wet days of between 0 and 3 days (refer to Figure 9-4). These projections coincide with the precipitation anomaly presented above, which indicates monthly precipitation reductions of between 2 mm and 6 mm by the 2050s.

The average (mean) rainfall changes, 1-day maximum rainfall changes and changes in the number of very wet days (days with rainfall exceeding 20 mm) documented by the CCKP for SSPs 1-2.6 and 5-8.5 are presented in Table 9-3. MAP is expected to decrease by up to 82.53 mm by the end of the century under SSP 5-8.5. Although some decadal periods project increases in 1-day maximum rainfall and the number of very wet days, neither SSP 1-2.6 nor SSP 5-8.5 project increases in MAP between 2001 and 2100. This further indicates that the region will become drier, highlighting the probability of droughts and challenges of water availability.



srk consulting	**CCIA FOR LAND RECLAMATION AT V&A CCIA - GRANGER BAY PRECINCT AND LAND RECLAMATION AT THE V&A WATERFRONT IN CAPE TOWN** MEAN PRECIPITATION PROJECTIONS (GREEN BOOK)	Project No. 624717

Figure 9-3: Mean Precipitation Projections (Green Book)



srk consulting	**CCIA - GRANGER BAY PRECINCT AND LAND RECLAMATION AT THE V&A WATERFRONT IN CAPE TOWN** VERY WET DAY PROJECTIONS (GREEN BOOK)	Project No. 624717

Figure 9-4: Very Wet Day Projections (Green Book)

Table 9-3: Mean Precipitation, 1-Day Maximum Precipitation and No. of Very Wet Day Changes for the Region (CCKP)

Decades	SSP 1-2.6						SSP 5-8.5					
	Avg. Precipitation		1-Day Maximum Rainfall		No. of Very Wet Days		Avg. Precipitation		1-Day Maximum Rainfall		No. of Very Wet Days	
	mm	%	mm	%	Days	%	mm	%	mm	%	Days	%
2001-2010	-0.68	-0.19	-0.15	-0.69	0.00	0.14	-0.68	-0.19	-0.15	-0.69	0.00	0.14
2011-2020	-5.00	-1.40	-0.02	-0.09	-0.03	-2.82	1.64	0.46	0.36	1.66	0.03	2.68
2021-2030	-8.93	-2.49	0.19	0.85	0.01	1.04	-7.27	-2.03	0.21	0.94	-0.02	-1.85
2031-2040	-3.91	-1.09	0.67	3.09	0.05	4.83	-16.35	-4.56	0.23	1.04	-0.01	-0.86
2041-2050	-15.09	-4.21	0.26	1.17	-0.02	-1.85	-22.73	-6.34	0.46	2.11	-0.04	-3.56
2051-2060	-16.44	-4.59	-0.25	-1.13	-0.07	-6.27	-35.25	-9.84	-0.15	-0.67	-0.12	-10.42
2061-2070	-19.21	-5.36	0.21	0.98	-0.03	-2.93	-43.42	-12.12	0.15	0.68	-0.12	-10.60
2071-2080	-20.59	-5.75	0.21	0.94	-0.01	-0.95	-52.70	-14.71	-0.36	-1.64	-0.17	-15.65
2081-2090	-21.28	-5.94	-0.07	-0.30	-0.04	-3.74	-70.58	-19.70	-1.03	-4.72	-0.30	-27.20
2091-2100	-24.39	-6.81	-0.05	-0.23	-0.06	-5.55	-82.53	-23.03	-1.14	-5.22	-0.35	-31.80

9.2 Local (Site-Specific)

The climate change projections for the site were determined relative to the historic baseline (1995-2014) and are separated into three time periods, i.e., the short-term (2021-2040), medium-term (2041-2060) and long-term (2081-2100).

9.2.1 Temperature

The average (mean) daily temperature changes (minimum, average and maximum) for the project site are presented in Table 9-4 to Table 9-6. The extreme maximum and minimum temperature changes anticipated follow in Table 9-7.

All SSPs project increases in ambient temperatures (both average and extreme), with average temperatures (minimum, average and maximum) projected to increase by up to 1.4 °C by the 2060s and by up to 3.3 °C by the end of the century. Extreme minimum temperatures are projected to increase by up to 1.3 °C by the 2060s and by up to 3.2 °C by the end of the century. Extreme maximum temperatures are projected to increase by up to 1.5 °C by the 2060s and by up to 3.3 °C by the end of the century.

Table 9-4: Projected Average Minimum Temperature Changes (IPCC AR6)

Scenario	Short-Term (°C)	Medium-Term (°C)	Long-Term (°C)
SSP 1-2.6	0.53	0.80	0.83
SSP 2-4.5	0.53	1.01	1.62
SSP 3-7.0	0.58	1.20	2.55
SSP 5-8.5	0.64	1.35	3.27

Table 9-5: Projected Average Mean Temperature Changes (IPCC AR6)

Scenario	Short-Term (°C)	Medium-Term (°C)	Long-Term (°C)
SSP 1-2.6	0.57	0.88	1.00
SSP 2-4.5	0.54	1.04	1.66
SSP 3-7.0	0.61	1.25	2.64
SSP 5-8.5	0.66	1.40	3.30

Table 9-6: Projected Average Maximum Temperature Changes (IPCC AR6)

Scenario	Short-Term (°C)	Medium-Term (°C)	Long-Term (°C)
SSP 1-2.6	0.52	0.82	0.84
SSP 2-4.5	0.53	1.05	1.66
SSP 3-7.0	0.57	1.23	2.61
SSP 5-8.5	0.63	1.37	3.28

Table 9-7: Projected Extreme Minimum and Maximum Temperature Changes (IPCC AR6)

Scenario	Minimum Temperature (°C)			Maximum Temperature (°C)		
	Short-Term	Medium-Term	Long-Term	Short-Term	Medium-Term	Long-Term
SSP 1-2.6	0.51	0.74	0.84	0.56	0.83	0.81
SSP 2-4.5	0.51	0.98	1.53	0.55	1.00	1.63
SSP 3-7.0	0.59	1.16	2.48	0.51	1.22	2.54
SSP 5-8.5	0.65	1.29	3.17	0.73	1.47	3.27

9.2.2 Rainfall

The anticipated changes in MAP, 1-day maximum rainfall and very wet days (days with precipitation above 20 mm) are presented in Table 9-8 to Table 9-10. All SSPs indicate decreases in daily precipitation, 1-day maximum rainfall and the number of very wet days in the medium to long-term. Based on the data presented:

- MAP is projected to decrease by up to 11.7% by the 2060s and by up to 25.6% by the end of the century.
- 1-Day maximum rainfall is expected to decrease by up to 3.5% by the 2060s and by up to 8.4% by the end of the century.
- The number of very wet days is projected to decrease by 0.87 days by the end of the century.

This highlights the probability of droughts in the region and coincides with:

- The monthly and decadal precipitation changes projected by the CCKP (refer to Figure 9-2);
- The flood exposure map and extreme rainfall day projections presented by The Green Book (refer to Figure 8-2); and
- The projected drought exposure map and changes in standard precipitation presented by The Green Book (refer to Figure 8-6).

Table 9-8: Projected MAP Changes (IPCC AR6)

Scenario	Short-Term (%)	Medium-Term (%)	Long-Term (%)
SSP 1-2.6	-2.18	-6.51	-6.60
SSP 2-4.5	-2.28	-8.10	-10.72
SSP 3-7.0	-3.62	-10.67	-21.81
SSP 5-8.5	-4.88	-11.65	-25.61

Table 9-9: Projected 1-Day Maximum Rainfall Changes (IPCC AR6)

Scenario	Short-Term (%)	Medium-Term (%)	Long-Term (%)
SSP 1-2.6	-0.20	-2.10	-1.13
SSP 2-4.5	2.35	-2.81	-0.75
SSP 3-7.0	-0.66	-3.51	-6.95
SSP 5-8.5	-3.37	-2.40	-8.35

Table 9-10: Projected Very Wet Day Changes (IPCC AR6)

Scenario	Short-Term (Days)	Medium-Term (Days)	Long-Term (Days)
SSP 1-2.6	-0.01	-0.13	-0.11
SSP 2-4.5	0.11	-0.23	-0.23
SSP 3-7.0	-0.07	-0.21	-0.54
SSP 5-8.5	-0.17	-0.36	-0.87

9.2.3 Wind Speed

The anticipated changes in mean daily wind speeds are presented in Table 9-11. Based on the data presented, the wind speed changes that can be anticipated are negligible (a maximum increase of 0.08 m/s (0.29 km/h) by the end of the century under SSP 3-7.0).

Table 9-11: Projected Mean Daily Wind Speed Changes (IPCC AR6)

Scenario	Short-Term (m/s)	Medium-Term (m/s)	Long-Term (m/s)
SSP 1-2.6	-0.00	-0.02	-0.02
SSP 2-4.5	-0.01	0.00	0.00

Scenario	Short-Term (m/s)	Medium-Term (m/s)	Long-Term (m/s)
SSP 3-7.0	0.05	0.04	0.08
SSP 5-8.5	0.01	0.02	0.06

9.2.4 Sea Level Rise

The anticipated changes in sea level around the project site are presented in Table 9-12. The sea level around the project site (and region) is expected to increase by up to 0.3 m by the 2060s and by up to 0.7 m by the end of the century. These projections coincide with the coastal flood exposure projections and coastal erosion susceptibility projections presented by The Green Book (refer to Figure 8-3 and Figure 8-12), highlighting the possibility of infrastructure being impacted and coastal erosion being exacerbated.

Table 9-12: Projected Sea Level Rise Changes (IPCC AR6)

Scenario	Short-Term (m)	Medium-Term (m)	Long-Term (m)
SSP 1-2.6	0.1	0.2	0.4
SSP 2-4.5	0.1	0.2	0.5
SSP 3-7.0	0.1	0.2	0.6
SSP 5-8.5	0.1	0.3	0.7

9.2.5 Storm Surge

Storms are already a common natural hazard in the region and account for 40.7% of the historic documented disasters (refer to Table 8-1). The PRDW Report indicates that maximum wave heights currently exceed 3.75 m during a 1-year storm, that wave heights of up to 2 m occur during a 1-month summer storm, and that wave heights of up to 3.5 m occur during a 1-month winter storm.

Muis *et al*, (2023) indicates that storm surge heights along the coast of the WSAF (West-Southern-Africa) Region are projected to increase by up to 0.05 m between 2021 and 2050, and IPCC projections indicate marginal wind speed increases in the medium-term and long-term (Table 9-11); and a sea level rise of up to 0.3 m in the medium-term and up to 0.7 m in the long-term (Table 9-12).

Based on this data, it was inferred that:

- Storm surge wave heights in the near future would be higher during the winter and spring months.
- Storm surge wave heights would increase proportionally to the sea level rises anticipated.
- Wave speeds recorded during a storm would remain fairly constant.

9.2.6 Coastal Erosion

Wave heights of 3.5 m are currently reported at the coastline for 1-month winter storms (refer to Section 7.3). The Green Book indicates that the development zone is currently at high risk of coastal flooding and erosion and projects that the region will remain at high risk of coastal flooding and erosion in 2050 (refer to Figure 8-3 and Figure 8-12). The sea level around the proposed development zone is also expected to rise by up to 0.3 m in the medium-term (refer to Table 9-12). This, and the fact that wave-induced shear stresses already reach 3 N/m^2 in winter and spring[9], indicates that the expected increase in wave heights would increase the surface area exposed to impact corrosion.

[9] According to the PRDW Report, shear stresses exceeding 0.2 N/m^2 cause resuspension of mud and bed sand.

9.2.7 Sea Surface Temperature

The anticipated changes in sea surface temperature are presented in Table 9-13. Sea surface temperatures are projected to increase by up to 0.93 °C by the 2060s and by up to 2.21 °C by the end of the century. This, and the projected sea level increases presented in Table 9-13, highlight the increased corrosion risk imposed on infrastructure around the project site[10].

Table 9-13: Projected Sea Surface Temperature Changes (IPCC AR6)

Scenario	Short-Term (°C)	Medium-Term (°C)	Long-Term (°C)
SSP 1-2.6	0.40	0.67	0.79
SSP 2-4.5	0.41	0.75	1.24
SSP 3-7.0	0.35	0.83	1.78
SSP 5-8.5	0.46	0.93	2.21

9.2.8 Ocean pH

The anticipated changes in the pH of the ocean around the project site are presented in Table 9-14. Based on the data presented, the ocean around the project site is expected to become slightly more acidic. This, coupled with the projected increases in sea surface temperature and sea level presented above, indicates the possibility of increased corrosion in and around the project site and the Western Cape's coastline.

Table 9-14: Projected Ocean pH Changes (IPCC AR6)

Scenario	Short-Term	Medium-Term	Long-Term
SSP 1-2.6	-0.1	-0.1	-0.1
SSP 2-4.5	-0.1	-0.1	-0.2
SSP 3-7.0	-0.1	-0.1	-0.3
SSP 5-8.5	-0.1	-0.1	-0.3

9.2.9 Ground Water Salinisation

Any seawater entering the freshwater contained in aquifers will increase groundwater salinity and may render the water unusable. A literature review was conducted as part of this study to determine if any work had been conducted to model the extent of sea water intrusion possible.

Extended dry periods strip water from vegetation and soils in a region and reduce the amount of water available for domestic and industrial use. Groundwater usage may increase during these dry periods to compensate.

The baseline precipitation anomalies generated for the last decade indicate that the amount of rainfall experienced in the drier months (October to March) remained relatively unchanged and that reductions in rainfall occurred at the start of the wet period (between April and June) - refer to Figure 6-7. Droughts were reported biannually between 2015 and 2021 (refer to Figure 8-5), and the CSIR's Green Book projects an increase in drought exposure in the region and around the project site by 2050 (refer to Figure 8-6). This highlights the possibility of an extension of the dry period in the near-term future.

[10] Higher temperatures increase the amount of kinetic energy particles in aqueous solution have, thereby increasing their overall surface reactivity. The natural salinity of seawater, coupled with increasing temperatures, increases the rate of ion transfer (conductivity), thereby increasing the rate of corrosion of metal structures submerged (or in contact with) seawater.

The region's coastline and the project site are currently exposed to (and projected to be exposed to) coastal erosion and coastal flooding with increases in mean sea level. Excessive water usage from aquifers during the anticipated extended dry period will lower the water table and create a pressure imbalance that allows dense seawater to push inland. Sea level rise can also increase the pressure exerted on coastal aquifers naturally, further highlighting the likelihood of groundwater intrusion. Sea level rise will, however, impact the region, regardless of whether the proposed development is established.

10 Impact Identification

The proposed development will be established in Granger Bay and is expected to exist well into the long-term future. Based on the information currently available, it is unclear whether decommissioning is planned / will occur. Impacts associated with the decommissioning phase of the project were therefore not assessed. Should decommissioning be planned for, or occur in, the medium to long-term, impacts will need to be identified and assessed accordingly.

Although the region is currently at medium risk of inland flooding (refer to Section 8.1), the projected decreases in MAP, extreme rainfall and number of extreme rainfall days, coupled with the projected drought exposure map (refer to Table 9-8, Table 9-9, Table 9-10 and Figure 8-6) reduce the possibility and extent of inland flooding in the medium to long-term future. The proposed Granger Bay Development is also located near the coastline and is therefore more likely to be impacted by coastal flooding. The impact of inland flooding during the operational phase of the development was therefore not assessed.

The following risks were identified based on the current baseline:

Construction Phase

- High wind speeds and associated storm surge in the area delaying construction and damaging equipment.
- High shear stresses impacting the settling of the sand and concrete used for construction, delaying project completion.

The following climate physical risks and opportunities were identified based on the current baseline and the climate change projections anticipated:

Operational Phase

- The proposed development prevents high wind speeds and associated storm surge in the area damaging established infrastructure.
- The proposed development reduces the risk of the projected increase in sea level, coupled with the high wind speeds and shear stresses experienced, increasing the potential for coastal flooding.
- The proposed development reduces the risk of the projected increase in sea level, coupled with the high wind speeds and shear stresses experienced, increasing the potential for coastal erosion.
- Reduced water availability and increased temperatures in the region increasing the likelihood of fires starting offsite and spreading to Granger Bay, damaging infrastructure (a highly urbanised area experiencing extended dry periods with less water available for firefighting).
- The project's effect on the reduction in water availability increasing the use of freshwater from aquifers. This, coupled with the projected increases in sea level (refer to Table 9-12), increases the potential for groundwater intrusion and therefore, groundwater salinisation.
- The reduction in water availability impacting the development should water not be available to sustain the development during operations.
- Reduction in ocean pH and increased sea level and temperatures (refer to Table 9-12, Table 9-13 and Table 9-14), coupled with the high wind speeds experienced, increasing the potential for, and rate of, physical and chemical corrosion.
- The projected increases in mean temperatures (refer to Table 9-4, Table 9-5 and Table 9-6) and reduction in ocean pH increasing the potential for, and rate of, chemical corrosion inland.

11 Impact Assessment

A discussion of the construction and operational phase risk significance ratings is presented in the following subsections. A full ranking table of the climate physical risks identified with associated mitigation measures, Table 11-1, follows.

11.1 Construction Phase

As per Sections 6.3, 7.3, 7.4 and 8:

- The project site already experiences wind speeds between 3.4 and 7.9 m/s (12.2 to 28.44 km/h) 60% of the time.
- Wind speeds averaging 6.05 m/s (21.8 km/h) are noted during the day.
- The majority of the proposed development is expected to experience wave heights between 0.25 and 2.75 m during a 1-year storm. Some isolated areas near the Dolos Revetment experience extreme wave heights (wave heights >3.75 m).
- Circulation and wave impacts near the Dolos Revetment result in wave heights of up to 2 m during a 1-month summer storm and wave heights of up to 3.5 m during a 1-month winter storm.
- High shear stresses that cause mud and bed sand resuspension are experienced near the Dolos Revetment during a 1-year storm and 1-month winter storm.
- Storms and associated storm surges are the second-most common natural hazard in the region.
- A notable increase in the number of extreme storms has been noted between 2010 and 2024, with two documented annually in 2021, 2023 and 2024.

The climatic changes anticipated are unlikely to impact the construction phase of the project considering the majority of changes are only anticipated to occur post-2030. The construction of the Granger Bay Development could, however, be delayed as a result of the shear stress influences and wave impacts experienced at certain times of the year and in certain areas of the proposed development zone. Any equipment damage and delays noted during construction would occur in the short-term and could be easily mitigated. The contractors would have the technology and financial means to address any issues noted, resulting in very low significance ratings.

11.2 Operational Phase

The region is currently at risk of wildfires and has experienced ten droughts between 1980 and 2024. 2050 projected SPI and drought exposure maps indicate that the number of drought cases experienced in the region will increase significantly and that Cape Town will be highly susceptible to drought. Regional sea temperatures are expected to increase by up to 0.9 °C by the 2060s and by up to 2.2 °C by the end of the century. All SSPs indicate that the ocean will become slightly more acidic.

The project site:

- Currently experiences mean monthly temperatures ranging between 12.70 and 22.50 °C. Average minimum, mean and maximum temperatures are projected to increase by up to 1.35 °C, 1.40 °C and 1.37 °C, respectively, by the 2060s.
- Is expected to experience at least two heatwaves annually.
- Receives an average of 821.5 mm of rainfall annually, with 78.8% of the total MAP falling between April and September. The projections, however, indicate that MAP will decrease by 11.7% by the 2060s and by up to 25.6% by the end of the century. The precipitation anomaly also indicates that negligible changes in rainfall during the drier months (October to March) and a decrease in rainfall at the start of the wet period (between April and June) is already being observed.
- Is projected to experience decreases in the amount 1-day extreme rainfall and number of very wet days of up to 3.5% and 0.4 days, respectively, by the 2060s.
- Currently experiences wind speeds between 3.4 and 7.9 m/s (12.2 to 28.44 km/h) 60% of the time. Negligible changes are anticipated in the medium to long-term.

- Will have to adapt to a projected sea level rise of up to 0.3 m in the medium-term and 0.7 m in the long-term.
- Will experience significant wave heights near the Dolos Revetment during 1-year and 1-month winter storms (refer to Figure 3-10 and Figure 3-12 in the 2023 PRDW Report). The Granger Bay Development will, however, significantly reduce the wave heights experienced near the shoreline and create isolated points of significant wave heights that are nowhere near the shoreline. This will reduce the potential for and magnitude of coastal erosion and coastal flooding.
- Currently experiences shear stresses that cause resuspension of mud and bed sand. The Granger Bay Development will, however, significantly reduce the shear stresses experienced. This will reduce the potential for and magnitude of coastal erosion.

11.2.1 Impacts

High wind speeds and associated storm surge mitigated by the proposed development:

Since wind speeds are unlikely to change in the medium to long-term future and Granger Bay Development will decrease the shear stresses and wave heights experienced near the shoreline, it is expected that wave-related infrastructure damage (due to wave impacts and erosion) will be mitigated by the development.

The sea level rise projected, coupled with high wind speeds and erosion rates increase the potential for coastal flooding/erosion that will be mitigated by the proposed development:

The sea level around the coastline is projected to increase by up to 0.3 m in the medium-term and by up to 0.7 m by the end of the century. PRDW's January 2025 Wave Modelling Report indicates a projected sea level rise of 0.43 m by 2074 and that overtopping would only occur during an extreme storm (a 475-year case). The potential for significant flooding depths against landslide structures therefore remains in the case of extreme storms (refer to Figure 5-18 of the 2025 PRDW Report). The proposed development will, however, address climate change risks since the dolosse proposed have been designed taking current climate change projections up to 2074 into account. The majority of the wave impacts experienced in the development zone will therefore be reduced.

Increased abstraction from freshwater aquifers during the dry period, coupled with the projected increases in sea level, resulting in increased potential for saltwater intrusion:

The V&A Waterfront uses water from aquifers to reduce its municipal water demand (borehole water is normally used for irrigation, hard surface cleaning and flushing toilets). Increased drought susceptibility and extended dry periods will result in increased groundwater abstraction to meet regional water demands. Although the proposed development will reduce coastline wave heights and shear stresses, and therefore, wave impact pressure, the sea level rise projected (an increase in the range of 0.2 - 0.7 m) will affect the entire coastline. The hydraulic pressure that will be exerted on the coastline as a result of the projected sea level increases is more likely to influence the extent of saltwater intrusion than the proposed development's abstraction. This impact is therefore considered low, negative prior to mitigation. Rainwater storage and greywater recycling projects will reduce abstraction. Should the proposed development reduce its water demand, it could have a low, positive impact post-mitigation.

11.2.2 Risks to the Proposed Development

Reduced water availability during extended dry periods reducing water availability for the development:

Increased drought susceptibility and extended dry periods may reduce water availability for the development. Water conservation projects will build resilience for the development by reducing water demand. Should this risk be realised, it may be necessary to consider alternative water sources — A desalination plant already exists and operates within the V&A Waterfront, and this plant could be expanded to accommodate the full development of Granger Bay. Desalination, however, requires significant amounts energy, imposes its own environmental impacts (brine discharge, which could exacerbate any potential saltwater intrusion). It is therefore not considered a sustainable solution amidst increasing urbanisation and a potentially extending dry period. The risk, however, is rated low considering it is site specific and short-term. The development also has the financial means to build resilience should the risk be realised and is therefore not considered vulnerable.

Reduced water availability and increased regional temperatures could result in fires starting offsite and spreading to the proposed development:

The project site is approximately 900 m away from the nearest natural vegetation susceptible to wildfires (Signal Hill). Although fires (and wildfires) can spread through urbanised areas, the V&A Waterfront and proposed development are not considered to be at risk of fires and wildfires – very low significance.

The projected changes in ocean pH and the average oceanic and ambient temperatures increasing the potential for corrosion:

The average ambient temperatures and ocean temperature are projected to increase for all SSPs. The ocean is also projected to become slightly more acidic in the medium and long-term. This highlights the potential for increased chemical corrosion of metals submerged in seawater and exposed to the ambient sea air. Since the projected decreases in ocean pH are low, it is unlikely that evaporation will increase the rate of chemical corrosion enough to result in structural faults inland. The materials (metals) used for construction in saltwater environments are also normally treated (anodised) to resist corrosion. This resulted in low significance ratings for the in-water and inland corrosion impacts.

Table 11-1: Impact Assessment

Phase	Impact	Spatial Extent	Intensity	Duration	Reversibility	Irreplaceability	Probability	Mitigation Measures	Significance (Risk Status)	
									Without Mitigation	With Mitigation
Construction	High wind speeds and associated storm surge delays construction and/or damages equipment.	Site-specific	Low	Short-Term	Moderate	Replaceable	Probable	---	Very Low (-)	---
	High shear stress impacts the settling of sand, concrete, etc. used for construction, delaying completion.	Site-specific	Medium	Short-Term	Moderate	Replaceable	Highly Probable	---	Low (-)	---
Operational	The proposed development prevents high wind speeds and associated storm surge in the area damaging established infrastructure.	Site-specific	Medium	Permanent	High	Replaceable	Highly Probable	---	Medium (+)	---
	The proposed development reduces the risk of the projected increase in sea level, coupled with the high wind speeds and shear stresses experienced, increasing the potential for coastal flooding.	Site-specific	High	Permanent	High	Replaceable	Highly Probable		Medium (+)	---
	The proposed development reduces the risk of the projected increase in sea level, coupled with the high wind speeds and shear stresses experienced, increasing the potential for coastal erosion.	Site-specific	High	Permanent	High	Replaceable	Highly Probable		Medium (+)	---
	Reduced water availability increasing the use of freshwater from aquifers, coupled with the increases in sea level. This increases the potential for groundwater intrusion, and therefore, salinisation. The development will have minimal impact on this regional impact of climate change.	Site-specific	Low	Long-Term	Permanent	Moderate	Probable	• Rainwater storage for the extended dry period. • Greywater recycling.	Low (-)	Low (+)
	Increased drought susceptibility and extended dry periods may reduce water availability for the development.	Site Specific	High	Short-Term	Low	Moderate	Probable	• Rainwater storage for the extended dry period. • Greywater recycling. • Consideration of alternative water sources should this risk be realised.	Low (-)	Low (-)
	Reduced water availability and increased temperatures in the region may increase the likelihood of fires starting offsite and spreading to Granger Bay, damaging infrastructure.	Site-specific	Low	Temporary	High	Replaceable	Improbable	---	Very Low (-)	
	The reductions in ocean pH and increased sea level and sea temperature, coupled with the high wind speeds already experienced, may slightly increase the potential for, and rate of, physical and chemical corrosion.	Site-specific	Medium	Permanent	Moderate	Replaceable	Probable	---	Low (-)	---
	The projected increases in mean temperatures and reduced ocean pH may slightly increase the potential for inland chemical corrosion.	Local	Low	Permanent	Moderate	Replaceable	Probable		Low (-)	---

12 Conclusion and Recommendations

This CCIA has evaluated the current climatic conditions, natural-hazard exposure and future climate risks for the proposed Granger Bay land reclamation and mixed-use development at the Cape Town V&A Waterfront.

The project site currently experiences a mild coastal climate with clear seasonal rainfall and temperature patterns. Flooding, storm surge, drought and wildfires were identified as the most relevant regional natural hazards. Although inland flooding poses a significant risk to the region, it does not pose a risk to the project (it is situated on the coastline). The project site is also removed from natural vegetation and is therefore at low risk of wildfires. The possibility of coastal flooding, storm surge and drought, however, remains.

Local climate change projections indicate that the site will become warmer and receive less rainfall, increasing the overall risk of drought. The mean sea level, sea-surface temperature and ocean acidity are also expected to increase, increasing the potential for coastal flooding, storm surge-related damage and corrosion.

The project will contribute to reducing the risks of long-term exposure to storm surge and sea level rise, and therefore, coastal flooding and coastal erosion — The dolosse implemented as part of the development will reduce the possibility of coastal flooding, coastal erosion and wave-related infrastructure damage.

Drought-related groundwater abstraction and the projected sea level rise could increase the potential for saltwater intrusion. While this remains a risk to the region, the proposed development's abstraction will have little impact. The development could, however, through the implementation of water conservation projects, reduce the regional impact anticipated by reducing its net water demand.

The following changes could pose a risk to the development:

- Increased drought susceptibility and extended dry periods may reduce water availability for the development — The development is considered resilient to this climate physical risk but could reduce per capita water requirements via water efficiency measures.
- Increased corrosion potential due to the projected increases in ambient and ocean temperatures and reduction in ocean pH – low risk.

Since none of the negative impacts or risks identified have a significance rating above low, mitigation measures are not required. However, should the following mitigation measures be practical, they would contribute in a small way to addressing regional climate risks and resilience:

- Rainwater storage for the extended dry periods anticipated.
- The implementation of greywater recycling in new homes and offices, where feasible, to reduce potable water consumption.
- Consideration of alternative water sources should the risk of reduced water availability be realised.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

13 References

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Appendices

Appendix A: Impact Assessment Methodology

Ratings are provided in terms of the following criteria in accordance with the methodology and associated definitions:

- **Spatial extent** – The size of the area that will be affected by the impact:
  - Site specific;
  - Local (<2 km from site);
  - Regional (within 30 km of site);
  - National; or
  - International (e.g. Greenhouse Gas emissions or migrant birds)
- **Intensity** – The anticipated severity of the impact:
  - High (severe alteration of natural systems, patterns or processes);
  - Medium (notable alteration of natural systems, patterns or processes); or
  - Low (negligible alteration of natural systems, patterns or processes).
- **Duration** – The timeframe during which the impact will be experienced:
  - Temporary (less than 1 year);
  - Short-term (1 to 6 years);
  - Medium-term (6 to 15 years);
  - Long-term (the impact will cease after the operational life of the activity); or
  - Permanent (mitigation will not occur in such a way or in such a time span that the impact can be considered transient).
- **Reversibility of the Impacts** - the extent to which the impacts are reversible assuming that the project has reached the end of its life cycle (decommissioning phase):
  - High reversibility of impacts (impact is highly reversible at end of project life);
  - Moderate reversibility of impacts;
  - Low reversibility of impacts; or
  - Impacts are non-reversible (impact is permanent).
- **Irreplaceability of Resource Loss caused by impacts** – the degree to which the impact causes irreplaceable loss of resources assuming that the project has reached the end of its life cycle (decommissioning phase):
  - High irreplaceability of resources (project will destroy unique resources that cannot be replaced);
  - Moderate irreplaceability of resources;
  - Low irreplaceability of resources; or
  - Resources are replaceable (the affected resource is easy to replace/rehabilitate).

Using the criteria above, the impacts where further assessed in terms of the following:

- **Probability** –The probability of the impact occurring:
  - Improbable (little or no chance of occurring);
  - Probable (<50% chance of occurring);
  - Highly probable (50 – 90% chance of occurring); or
  - Definite (>90% chance of occurring).
- **Significance** – Will the impact cause a notable alteration of the environment?
  - Low to very low (the impact may result in minor alterations of the environment and can be easily avoided by implementing appropriate mitigation measures, and will not have an influence on decision-making);
  - Medium (the impact will result in moderate alteration of the environment and can be reduced or avoided by implementing the appropriate mitigation measures, and will only have an influence on the decision-making if not mitigated); or

  - High (the impacts will result in major alteration to the environment even with the implementation on the appropriate mitigation measures and will have an influence on decision-making).
- **Status** – Whether the impact on the overall environment will be:
  - Positive - environment overall will benefit from the impact;
  - Negative - environment overall will be adversely affected by the impact; or
  - Neutral - environment overall not be affected.
- **Confidence** – The degree of confidence in predictions based on available information and specialist knowledge:
  - Low;
  - Medium; or
  - High.

Appendix B: Risk Assessment Tables

Table B - 1: Pre-Mitigation Climate Physical Risk Rankings

Phase	Impact No.	Impact	Spatial Extent	Intensity	Duration	Reversibility	Irreplaceability	Risk Rating	Probability	Risk Significance	Risk Status	Confidence
Construction	1	High wind speeds and associated storm surge delaying construction and damaging equipment.	Site Specific	Low	Short-Term	Moderate	Replaceable	**Low**	Probable	**Very Low**	Negative	Medium
	2	High shear stresses impacting the settling of the sand, concrete, etc. used for construction, delaying project completion.	Site Specific	Medium	Short-Term	Moderate	Replaceable	**Low**	Highly Probable	**Low**	Negative	Medium
Operational	3	The proposed development prevents high wind speeds and associated storm surge in the area damaging established infrastructure.	Site Specific	Medium	Permanent	High	Replaceable	**Medium**	Highly Probable	**Medium**	Positive	Medium
	4	The proposed development reduces the risk of the projected increase in sea level, coupled with the high wind speeds and shear stresses experienced, increasing the potential for coastal flooding.	Site Specific	High	Permanent	High	Replaceable	**Medium**	Highly Probable	**Medium**	Positive	Medium
	5	The proposed development reduces the risk of the projected increase in sea level, coupled with the high wind speeds and shear stresses experienced, increasing the potential for coastal erosion.	Site Specific	High	Permanent	High	Replaceable	**Medium**	Highly Probable	**Medium**	Positive	Medium
	6	Reduced water availability increasing the use of freshwater from aquifers. This, coupled with the increases in sea level increases the potential for groundwater intrusion, and therefore, salinisation.	Site Specific	Low	Long-Term	Permanent	Moderate	**Medium**	Probable	**Low**	Negative	Medium
	7	Increased drought susceptibility and extended dry periods reducing water availability for the development.	Site Specific	High	Short-Term	Low	Moderate	**Medium**	Probable	**Low**	Negative	Medium
	8	Reduced water availability and increased temperatures in the region increasing the likelihood of fires starting offsite and spreading to Granger Bay, damaging infrastructure.	Site Specific	Low	Temporary	High	Replaceable	**Low**	Improbable	**Very Low**	Negative	High
	9	The reductions in ocean pH and increased sea level and sea temperature, coupled with the high wind speeds already experienced, increasing the potential for, and rate of, physical and chemical corrosion.	Site Specific	Medium	Permanent	Moderate	Replaceable	**Medium**	Probable	**Low**	Negative	Medium
	10	The projected increases in mean temperatures and reduced ocean pH increasing the potential for inland chemical corrosion.	Local	Low	Permanent	Moderate	Replaceable	**Medium**	Probable	**Low**	Negative	Medium

Table B - 2: Post-Mitigation Climate Physical Risk Rankings

Impact No.	Mitigation Measures	Spatial Extent	Intensity	Duration	Reversibility	Irreplaceability	Risk Rating	Probability	Risk Significance	Risk Status	Confidence
6	• Rainwater storage for the extended dry period. • Greywater recycling.	Site Specific	Low	Long-Term	Permanent	Moderate	**Medium**	Improbable	**Low**	Positive	Medium
7	• Rainwater storage for the extended dry period. • Greywater recycling. • Consideration of alternative water sources should this risk be realised.	Site Specific	Medium	Short-Term	Low	Moderate	**Medium**	Probable	**Low**	Negative	Medium