Appendix G.7

CONCEPTUAL STORMWATER MANAGEMENT PLAN

TECHNICAL MEMO

TO	R-Bay Properties	FROM	M Baloyi
DATE	**06 June 2023**	**CONFIDENTIALITY**	**Confidential**
SUBJECT	**Richards Bay Warehousing Complex Conceptual Stormwater Management Plan**		

INTRODUCTION

WSP Group (Ltd) Pty (WSP) has been Requested by R-Bay Properties to develop a Conceptual Stormwater Management Plan (SWMP) for their new Warehousing Complex in Pietermaritzburg, KwaZulu-Natal. The purpose of this study is to manage stormwater runoff from the site catchment area by diverting it away from key infrastructure and sizing diversion channels to fulfil the requirements of the National Water Act (Act 36 of 1998), particularly, the Government Notice 704 (GN704).

This technical memorandum summarises the model inputs and assumptions used to develop the SWMP as well as the results.

MODEL INPUTS

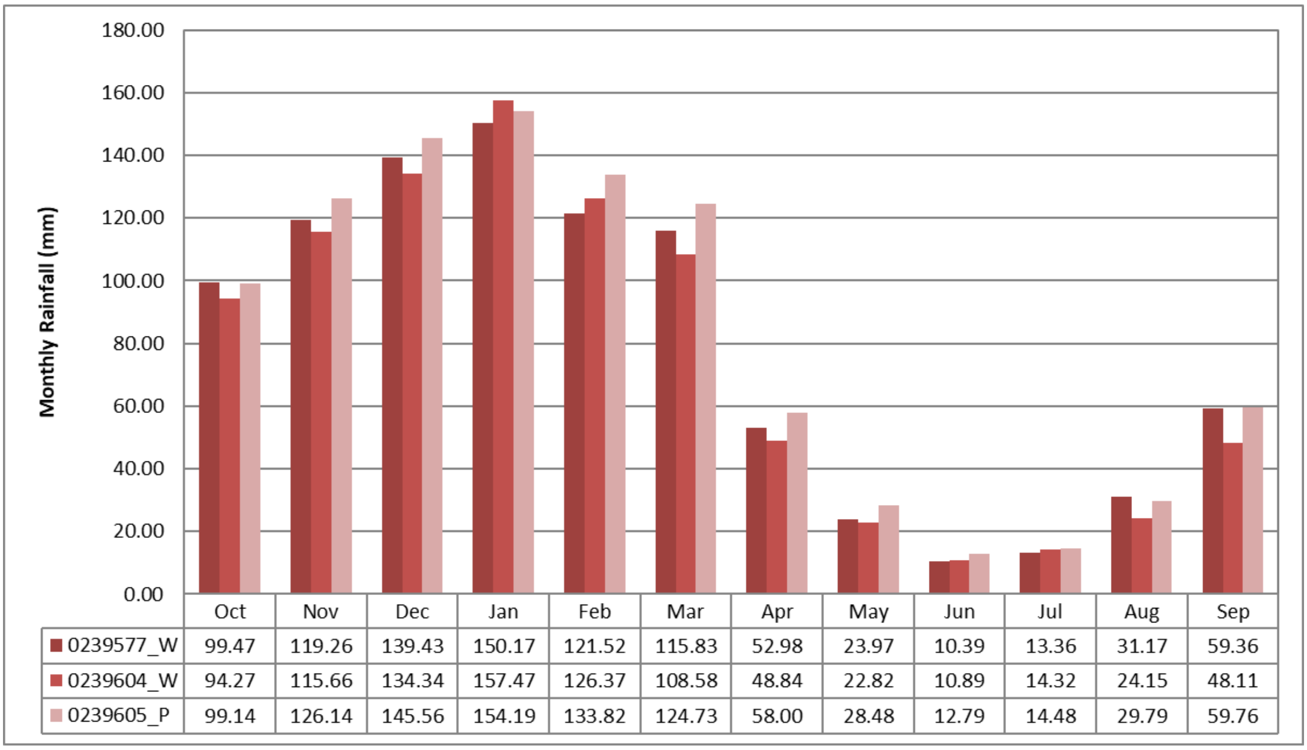
The following information was used to develop the SWMP for the new R-Bay Warehousing Complex.

Climate Data

Historic climate data around the project site were sourced from the Daily Rainfall Extraction Utility. Three climate stations were selected and analysed to determine the most suitable station to be used in this study. These stations were selected based on their reliability, rainfall record length as well as proximity to the study site. The station properties are presented in Table 1 below. The monthly rainfall distribution for these stations is shown in Figure 1

Table 1: Rainfall Station Properties

Station Number	Station Name	Distance From Site	Record	Recorded Period	Reliability	MAP	Coordinates	
		km	Years	From – To	%	mm	Lat	Long
0239577 W	Pietermaritzburg (PUR)	6.4	48	1 Dec 1949 – 28 Feb 1997	100	936.9	29.36	30.26
0239604 W	Allerton (VET)	8.8	89	31 May 2001 – 1 July 1917	58	905.8	29.35	30.21
0239605 P	Botanic Gardens - PMB	8.8	82	1 Jan 1907 - 30 Nov 1989	94	986.9	29.35	30.21



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0239577_W	99.47	119.26	139.43	150.17	121.52	115.83	52.98	23.97	10.39	13.36	31.17	59.36
0239604_W	94.27	115.66	134.34	157.47	126.37	108.58	48.84	22.82	10.89	14.32	24.15	48.11
0239605_P	99.14	126.14	145.56	154.19	133.82	124.73	58.00	28.48	12.79	14.48	29.79	59.76

Figure 1: Average monthly rainfall for the R-Bay new Warehousing complex

Figure 2 illustrates the cumulative plots of rainfall for the three stations analysed. This is done to check for irregularities and anomalies that may have occurred during the recorded rainfall period. All three stations seem to follow a similar trend with only a slight change in trend noted at the 0239604_W (Allerton (VET)) station.

The 0239605_P (Botanic Gardens – PMB) rainfall station was selected for use in this study due to its high data reliability and long record period.

Figure 3 shows the daily rainfall for the 0239605_P (Botanic Gardens – PMB) rainfall station. It is noted that the station experienced a large storm in January of 1947 and September of 1987 with rainfall depths of 247 mm and 222 mm, respectively.

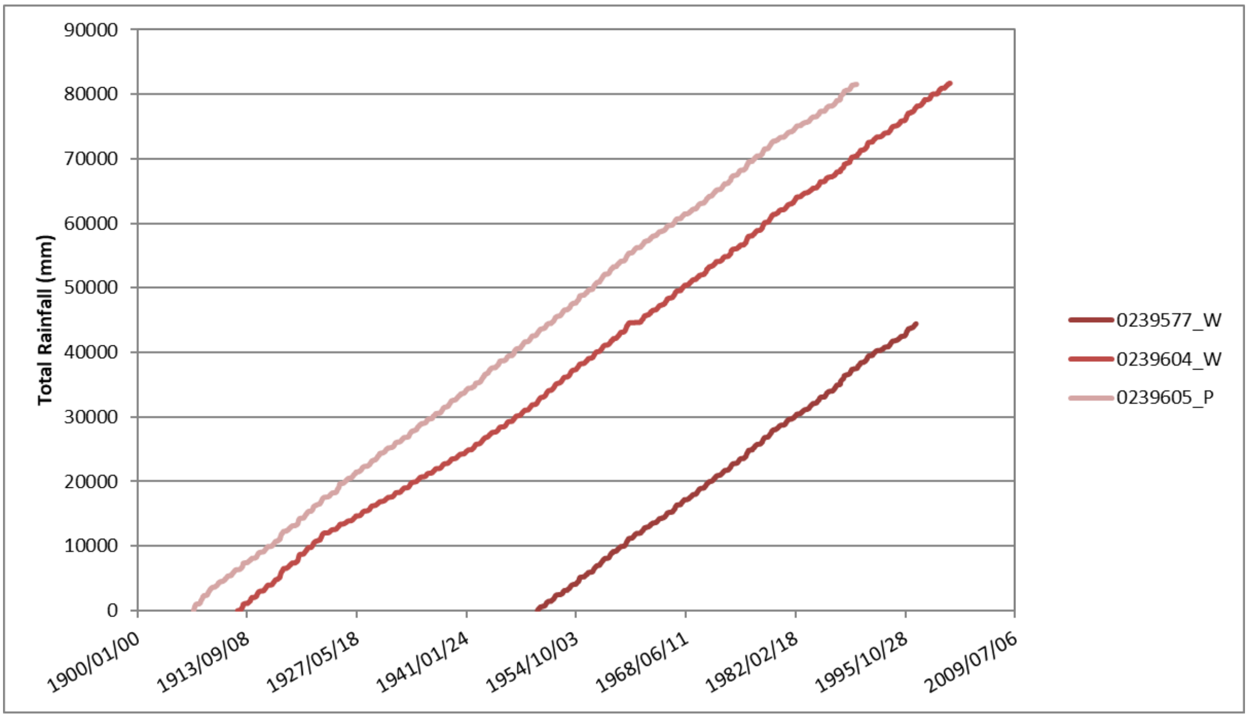


Figure 2: Cumulative rainfall for the rainfall stations near the R-Bay New Warehousing complex

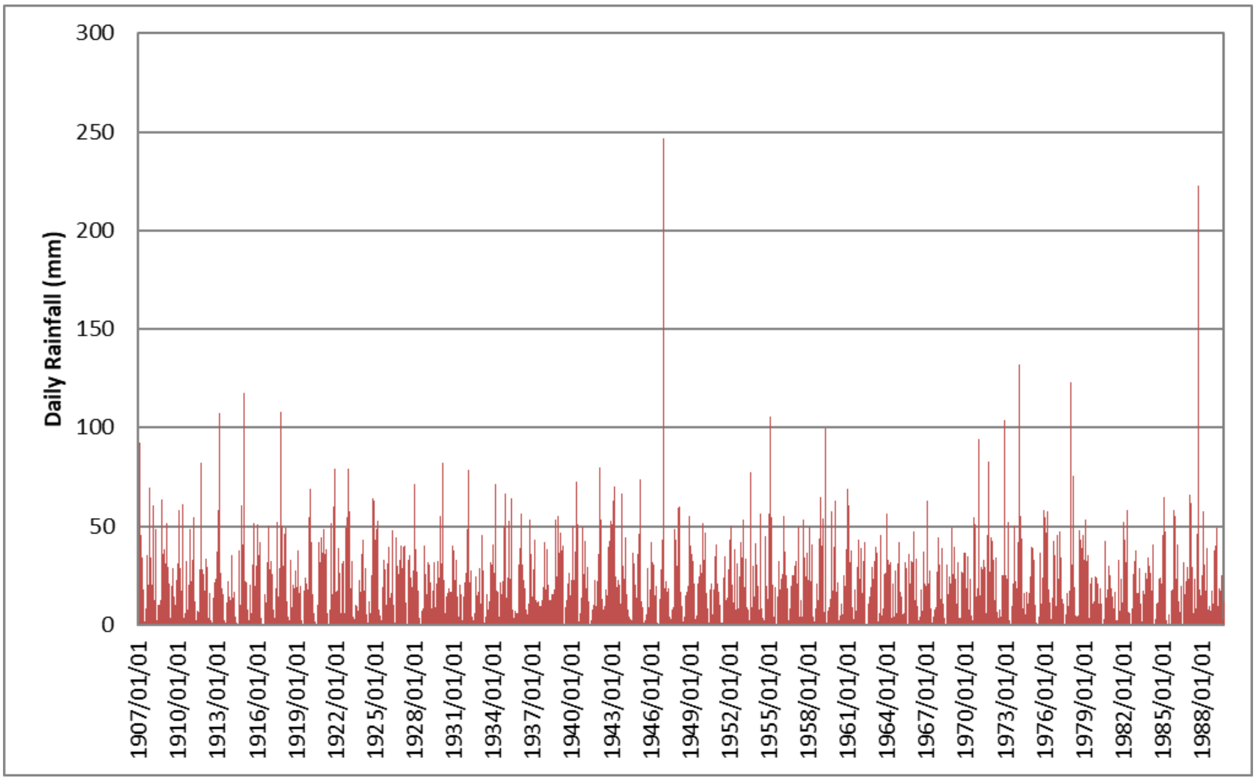


Figure 3: Daily rainfall for the Botanic Gardens – PMB rainfall station

Figure 4 shows the annual rainfall for each year compared to the Mean Annual Precipitation (MAP) of the combined rainfall record. The MAP appears to be in a similar range as the other two stations.

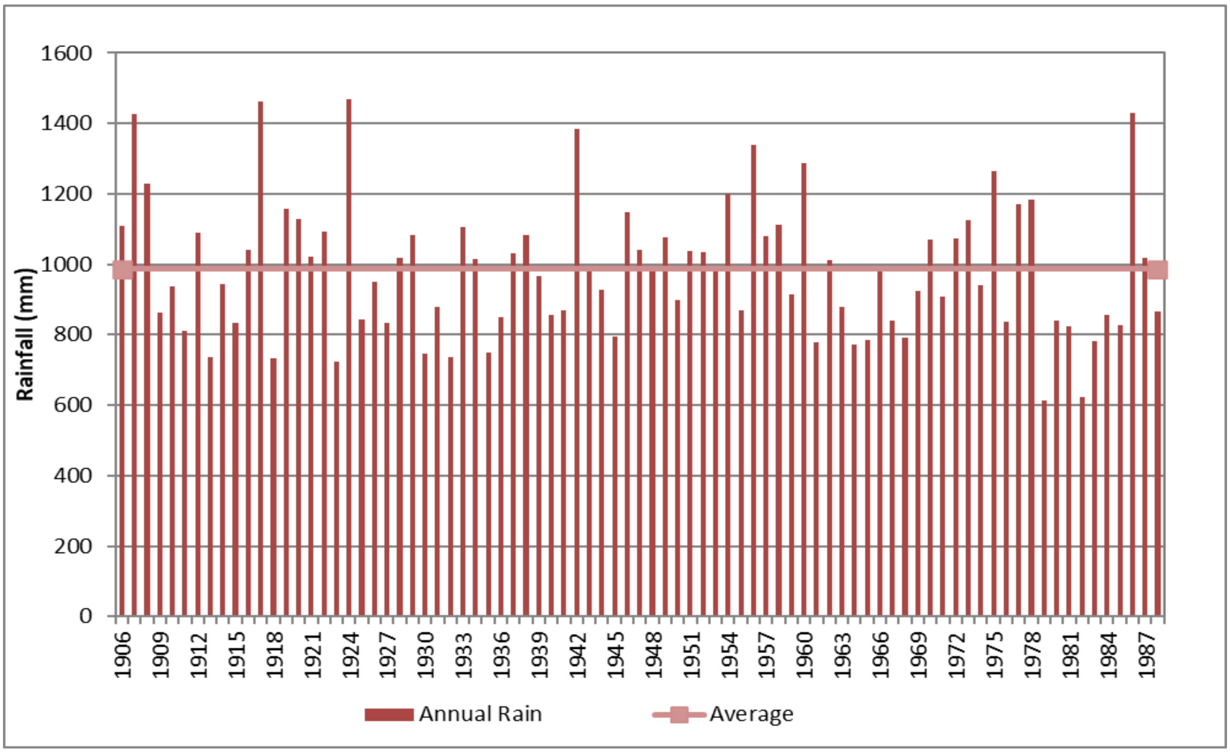


Figure 4: Annual rainfall depth for the Botanic Gardens – PMB rainfall station

Figure 5 shows the monthly rainfall boxplot for station 0239605_P (Botanic Gardens – PMB). A boxplot shows the variations of observed monthly rainfall totals in a five-number summary. This includes the 1st percentile, 25th percentile, 50th percentile, 75th percentile and 99th percentile, of the observed monthly rainfall records. The higher rainfall occurs between September and March while very little rain falls between April and August.

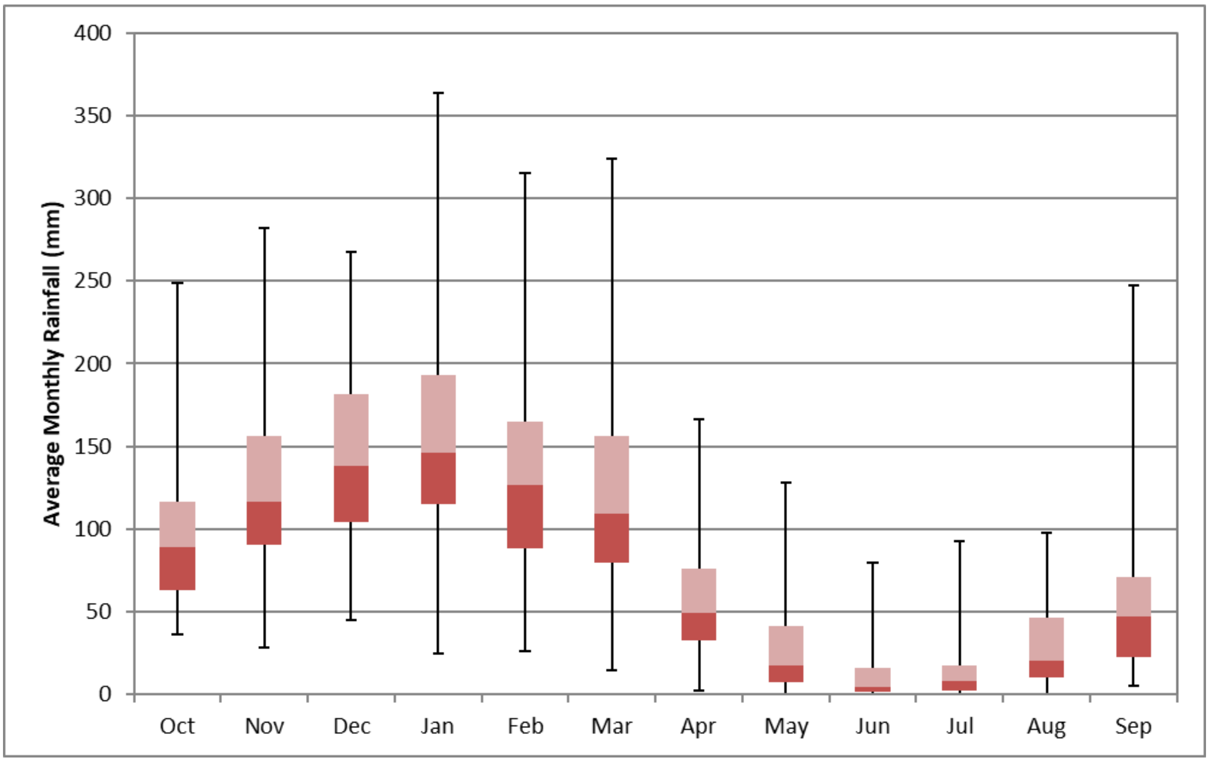


Figure 5: Monthly rainfall depth box plot for the Botanic Gardens – PMB rainfall station

The 5th, 50th and 95th percentiles of the annual rainfall totals for the rainfall station are presented in Table 2. Figure 6 shows the cumulative distribution function of the annual rainfall totals measured at the Botanic Gardens – PMB station.

Table 2: 5th, 50th and 95th percentile on the annual rainfall totals

Station Name	5th Percentile	50th Percentile	95th Percentile
Botanic Gardens – PMB	735	957	1382

Figure 6 shows the following occurrences in the area based on the rainfall data collected at the Botanic Gardens – PMB rainfall station.

- 95% of sample observations indicate that the area will experience an annual rainfall of 735 mm or more.
- 50% of sample observations indicate that the area will experience an annual rainfall of 957 mm or more.
- 5% of sample observations indicate that the area will experience an annual rainfall of 1382 mm or more.

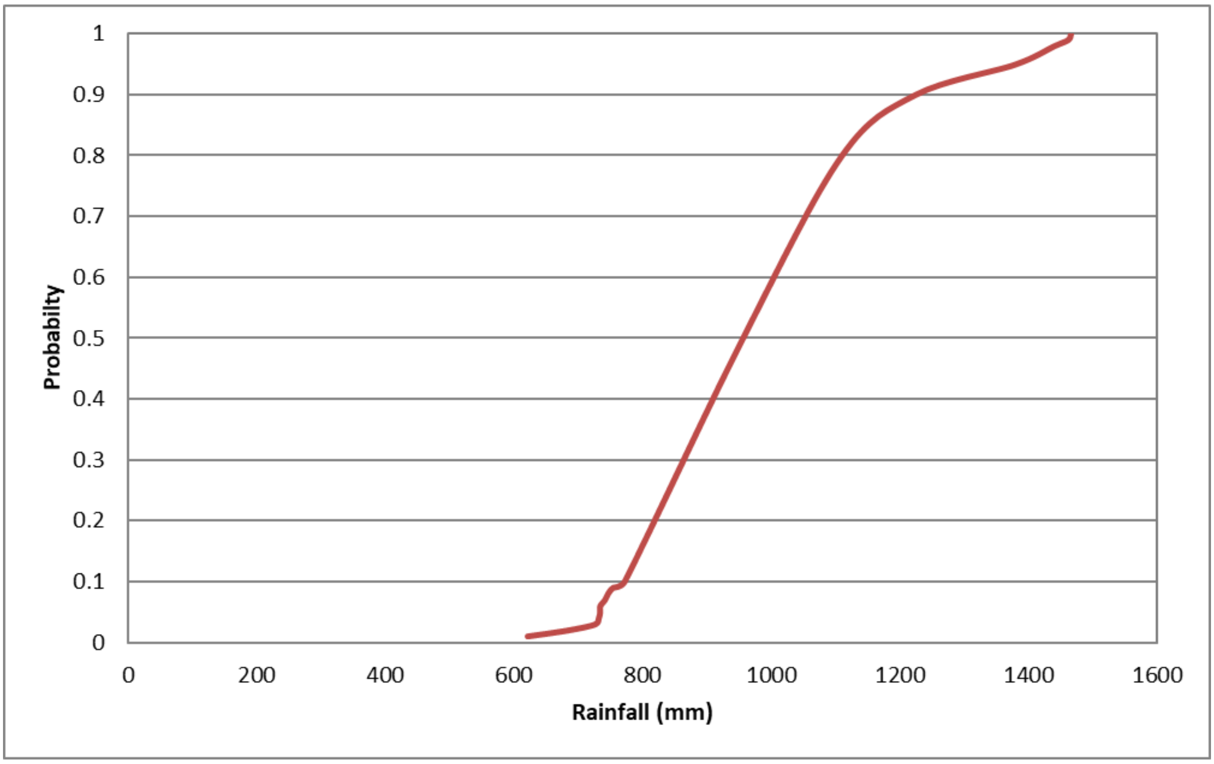


Figure 6: Exceedance probability distribution for the Botanic Gardens – PMB rainfall station

Storm Depth Recurrence Periods

Probability distributions were fitted to the annual maximum rainfall depths measured at the Botanic Gardens - PMB station in order to determine the likely magnitude of storm events for various recurrence intervals. The Log Pearson Type III distribution was found to fit the data best. The daily rainfall depths for the wet season were then converted to 24-hour rainfall depths using the 1981 ratio of 1.11 (Adamson, 1981). Table 3 and Figure 7 presents the storm depths for the different Annual Exceedance Probability (AEP) based on this fitted distribution.

Table 3: 24-Hour rainfall depths for the different AEP in mm/day

Annual Exceedance Probability (AEP)	1:2	1:5	1:10	1:20	1:25	1:50	1:100	1:200
Daily rainfall Depth (mm)	57	81	102	126	135	166	204	248
24 Hour Rainfall Depth (mm)	63	90	113	140	150	185	226	276

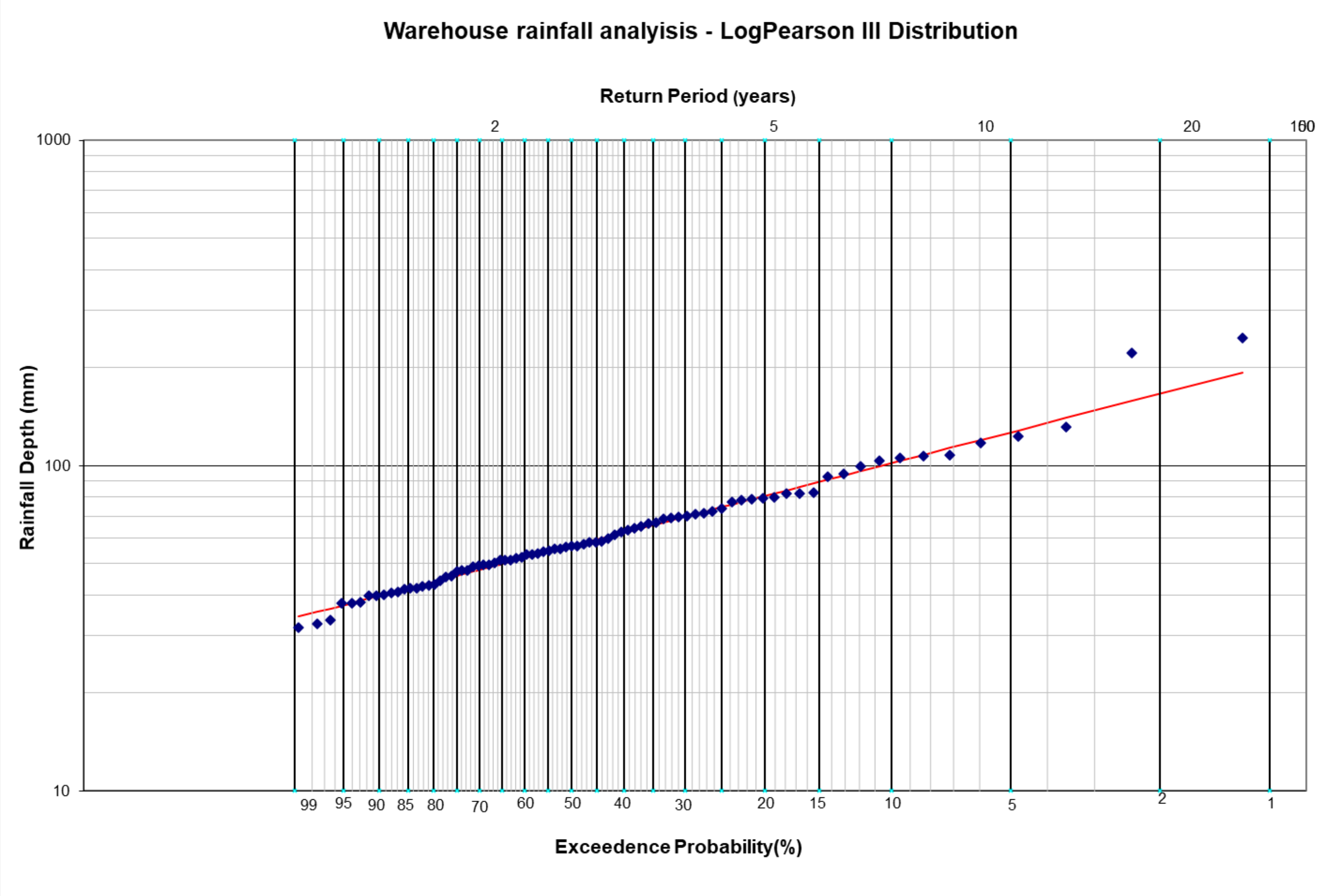


Figure 7: Log Pearson III distribution for the Botanic Gardens – PMB rainfall station

Modelling

The PCSWMM® (refer www.chiwater.com) commercial software package, developed by Computational Hydraulics International (CHI) was used as the analysis model. PCSWMM® is a dynamic rainfall-runoff simulation model used for single event or long-term simulation of runoff quantity. The runoff component of SWMM operates on a collection of sub-catchment areas that receive precipitation and simulate runoff overland and underground through a system of pipes, channels, storage and treatment devices, pumps, and regulators.

PCSWMM tracks the quantity of runoff generated within each sub-catchment, and the flow rate, flow depth and quality of water in each pipe and channel during a simulation period comprised of multiple time steps.

RAINFALL-RUNOFF MODEL INPUT PARAMETERS

The following assumptions were made for the hydrologic and hydraulic input parameters:

Table 4: Model Input Parameters

Parameter	Input used in model	Comment
Pervious/Impervious Surface	Paved catchments and roofs assumed 100 % impervious and vegetated areas assumed 95 % pervious	
Manning's N roughness coefficients for catchments	Asphalt paved areas: 0.011 Grass cover: 0.15 Corrugated iron roof: 0.024	
Soil Type and Infiltration Method	Sandy Loam, the Modified Green Ampt infiltration method was used as the infiltration method in the model with the following properties: Avg. Capillary Suction Head: 110.1 mm Hydraulic Conductivity: 21.8 mm/hr Initial Moisture content deficit: 0.358	The Green-Ampt method is a function of the soil suction head, porosity, hydraulic conductivity, and time used to estimate infiltration into the soil
Cross-sectional profile of channels evaluated	Trapezoidal	
Manning's roughness coefficients for diversion channels	Asphalt: 0.013 Concrete: 0.015	
Flood type used in Model	South African SCS 24-hour Type 3	Based on the location of the site. Figure 8 below shows the hyetograph for the 1:50 year 24-hour storm event
Design rainfall depth	185 mm	Refer to Table 3 above

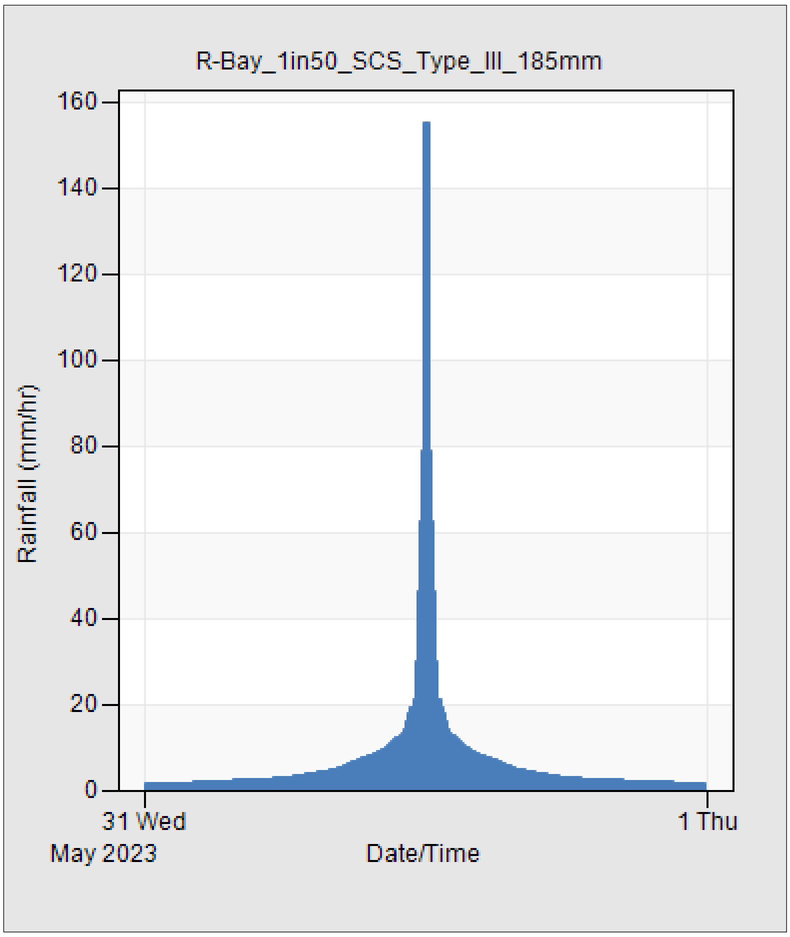


Figure 8: 1 in 50-year storm event

RAINFALL-RUNOFF MODEL RESULTS

Stormwater Management Plan Description

R-Bay Properties requires a storm water management plan to divert storm water runoff from the New Warehouse Development catchment. The design criteria adopted for the analysis and design of the storm water management system will follow the guiding principles of Regulation No.704 dated 4 June 1999, gazetted by (then) Department of Water Affairs and Forestry under the National Water Act, Act No.36 of 1998 (GN704) as this regulation applies to mining activities.

The guideline principles state the following:

- Separate clean and dirty water systems:
- Demarcation of dirty water footprint areas
- Delineation of upstream catchment areas that would naturally drain into dirty water areas.
- Estimation of peak flood runoff from relevant catchments
- Design of drains, diversion channels and berms to prevent clean water from entering dirty water areas.
- Control and contain dirty water runoff:
- Design of drains and berms to prevent dirty water from leaving dirty water areas.
- Design appropriately sized SWDs that will not spill into a clean water system more than once in 50-years.

Figure 9 shows the conceptual SWMP for the New Warehouse. The catchments areas were delineated into sub-catchments based on the site topography. Survey data of 5-meter interval contours was sourced from the National Geo-spatial Information (NGI) Mapping and Aerial Imagery site and used for the study site. The runoff from the entire site catchment is assumed to be clean with no contaminants in the water. The paved catchment is assumed to have an Asphalt lining. The clean runoff from the paved catchment area is diverted into channels along the perimeter on the south-western boundary wall of the site, as well as behind the northern parking bay into the nearest municipal stormwater system.

The new warehouse roof is assumed to be corrugated iron with its runoff being collected in a gutter system reporting to the nearest perimeter channel. The runoff from the grassed catchment will report to a second northern perimeter channel that connects to a channel reporting to the municipal stormwater system.

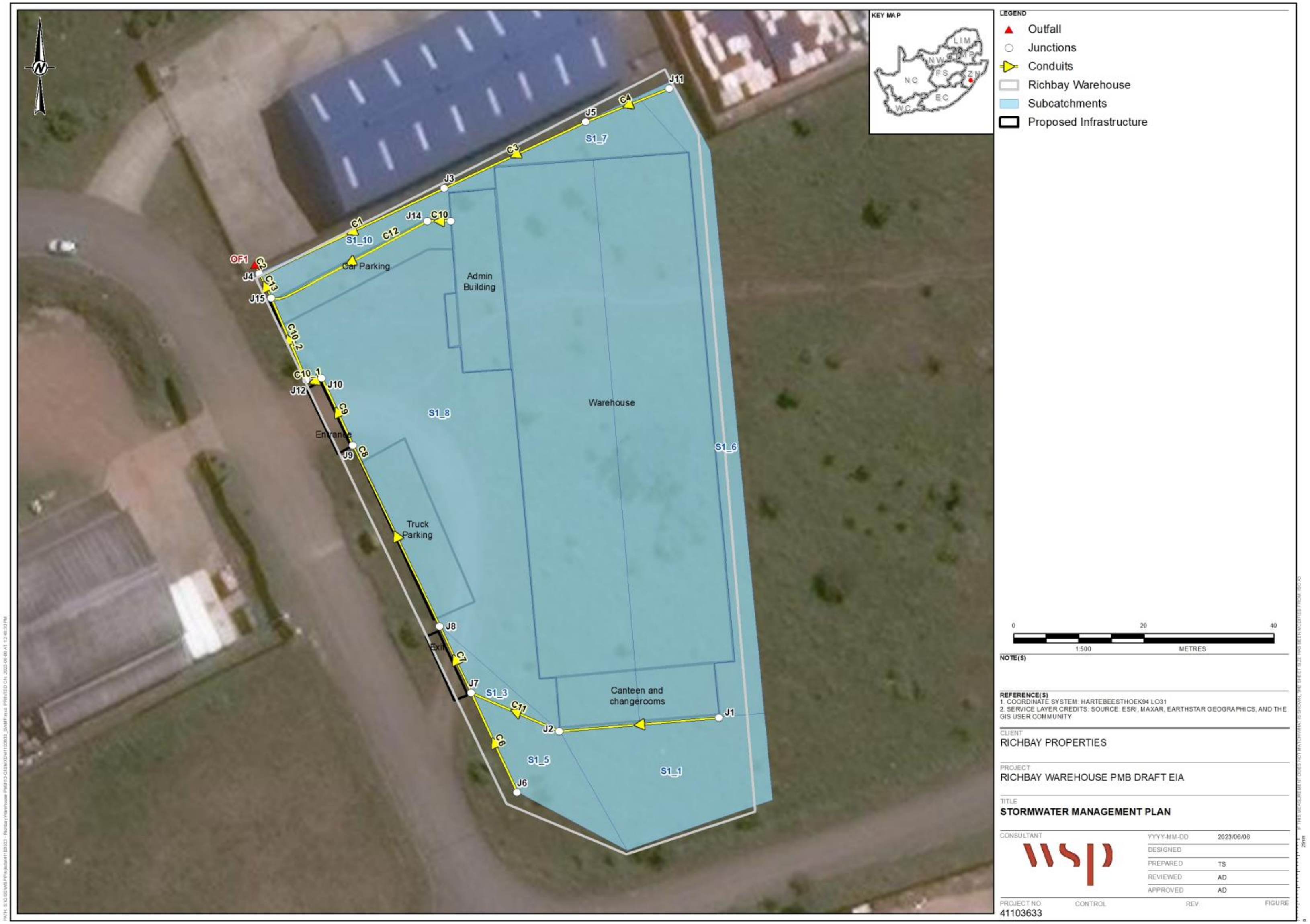


Figure 9: R-Bay Properties New Warehouse SWMP

Sub-catchment Parameters

The sub-catchment characteristics used in the model are shown in Table 5 below.

Table 5: Sub-catchment characteristics

Name	Area (m^2)	Slope (%)	Impervious (%)
S1_1	456	4.5	100
S1_10	138	3.8	2
S1_3	55	5.6	100
S1_5	190	5.3	100
S1_6	393	4.0	100
S1_7	163	3.2	2
S1_8	1 444	4.4	100
S1_2	1 279	1.0	100
S1_4	1 291	1.0	100
S1_11	215	1.0	100

Sub-catchment Model Outputs

The computed flood peaks and runoff volumes for the sub-catchments on site are presented below in Table 6

Table 6: Computed Flood Peaks

Name	Runoff Volume (ML)	Peak Runoff (m^3/s)	Runoff Coefficient
S1_1	0.08	0.02	0.999
S1_10	0.01	0.01	0.24
S1_3	0.01	0.01	0.999
S1_5	0.04	0.01	0.999
S1_6	0.31	0.07	0.999

S1_7	0.01	0.01	0.24
S1_8	0.27	0.06	0.999
S1_2	0.24	0.06	0.999
S1_4	0.24	0.06	0.999
S1_11	0.04	0.01	0.999

Channel Sizing

Table 7 shows the channel dimensions and computed velocities for each channel for a 1 in 50-year recurrence interval 24-hour storm event.

Table 7: Channel Sizes

Name	Length (m)	Roughness	Depth (m)	Bottom Width (m)	Side Slope (V:H)	Max. Flow (m^3/s)	Max. Velocity (m/s)	Max Full depth (m)	Min Freeboard (m)
C1	31.4	0.014	0.5	0.5	1:2	0.15	0.84	0.20	0.31
C10	3.6	0.015	0.3	0.3	1:3	0.06	1.18	0.10	0.21
C10_1	2.7	0.015	0.3	0.3	1:5	0.03	1.38	0.05	0.26
C10_2	13.7	0.015	0.3	0.3	1:5	0.03	0.82	0.07	0.24
C11	14.8	0.015	0.3	0.3	1:3	0.02	1.29	0.04	0.46
C12	26.9	0.015	0.3	0.3	1:3	0.06	1.17	0.10	0.21
C13	4.2	0.015	0.3	0.3	1:5	0.09	0.64	0.15	0.15
C2	1.5	0.014	0.5	0.5	1:2	0.24	1.18	0.22	0.29
C3	24.0	0.014	0.5	0.5	1:2	0.08	0.75	0.27	0.23
C5	24.6	0.015	0.3	0.3	1:3	0.02	1.05	0.05	0.45
C6	16.9	0.015	0.3	0.3	1:5	0.01	0.58	0.03	0.27
C7	11.3	0.015	0.3	0.3	1:5	0.03	1.37	0.04	0.26

C8	30.8	0.015	0.3	0.3	1:5	0.03	1.33	0.04	0.26
C9	11.3	0.015	0.3	0.3	1:5	0.03	1.41	0.04	0.26
C4	13.8	0.014	0.5	0.5	1:2	0.07	1.26	0.09	0.42

RECOMMENDATIONS

- Frequent maintenance is recommended on the diversion channels at least once before the wet season and once during the wet season.

REFERENCES

Adamson, P. (1981). *South African Storm Rainfall.* October 1981: Department of Environment Affairs .