COROBRIK LAWLEY FACTORY SITE-WIDE WATER BALANCE REPORT

Project Location: Gauteng, South Africa
Company Name: Corobrik (Pty) Limited - Lawley

Prepared By: CM Eclectic (Pty) Limited

PO Number: Lawley 1103088 OR
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Report Information

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Executive Summary

A steady state site-wide water balance model has been developed using available information to understand the flows at the Lawley Factory during average dry, wet, and average climate conditions. Using available information, a Microsoft Excel spreadsheet model was used to represent the flows within the operational water circuit. The water balance methodology included site verification, water balance modelling, and reporting.

Lawley Factory mines and beneficiates various earth's raw materials and is supported by run of mine stockpiles, offices, wastewater treatment works, brick making plant and workshops. Clay is bench mined by a back-actor from the six quarries belonging to the Lawley operations and transported to stockpiles on site. Current quarrying operations are carried out on an annual basis for approximately three to four months a year during the dry winter months. The limits of the water balance for Lawley are confined to the operation of infrastructure, which comprises:

- Six mining quarries;
- Raw material stockpiles (clay and sand material);
- Clay preparation and brick making factory (clay preparation up to dispatch);
- A water supply borehole
- Support services and infrastructure such as the administration offices, ablutions and change houses, and clinic;
- An onsite sewage treatment plant; and
- A nearby third-party-owned farm is supplied water from the Lawley Factory.

Lawley Factory provided daily records from January 2020 until January 2024 from its three operational water meters in place at the site, two of which record the distribution of borehole water to the farm and the brick-making plant, and the main meter records the total borehole water abstraction. The 2021 to 2023 records were used for this water balance assessment because these were complete and covered all months of the year. Furthermore, two meters are situated at the sewage treatment facilities, one at the inflow, which was not working and one at the outflow final discharge point, which was recorded starting in April 2024 (resulting in a one-month record).

The brick factory operations' water usage prioritised reusing quarry water for dust suppression during the dry months and estimated an average of two tankers of 18 000L capacity are used daily in the dry season. There is no collection dam for stormwater around the production plant, and runoff is discharged to the downstream wetland. Final treated wastewater from the sewage effluent treatment facilities is discharged to the downstream wetland.

There are no rainfall and evaporation records provided by Lawley Factory; therefore, station data from the Department of Water and Sanitation (DWS) and Water Resources of South

Africa 2012 Study (WR2012) are considered. The DWS-managed rain meteorological station Zuurbekom (DWS Reference: C2E007), also referenced by the South African Weather Services (SAWS) as station number 0475528_W, is the nearest station. The mean annual precipitation for the station is 696.9 mm, and the mean annual S-pan evaporation is 1500 mm. The annual rainfall dataset indicated a marginal increase in rainfall over the years and a marginal decrease in evaporation.

Average groundwater inflows are estimated using a 20% recharge percentage of mean annual precipitation for all the Lawley Factory quarries, as no groundwater model estimates exist. For Quarry 5, which is reused at the Lawley Factory for dust suppression in the dry month, 834 m^3/month groundwater inflows are estimated. The groundwater inflows must be updated when Lawley Factory starts undertaking quarry water level measurements.

From the monthly average records for 2021 to 2023, the biggest annual borehole water user is at the various support facilities (offices, clinics, and change houses), followed by the brick-making factory. The lowest volumes (less than 7 000m^3) are supplied to the farm annually.

Although the water balance is based on an average steady state, and it does not consider storage volume in the quarries, which remain dormant when there is no mining (eight to nine months per year). For the current scope, the steady state water balance model and current updates are adequate to capture wet and dry season variations driven by the runoff at the site as well as the reduced December and January water demands. For optimum water management, the following recommendations are proposed:

- Additional water meters/measurement locations are recommended to improve water balance data collection and confidence in the model:
- A meter/ record of the distribution of the potable water, which will be helpful should the Lawley Factory want to investigate water conservation measures if the various water use areas are separated;
- Measurement of dust suppression at the quarry during mining (three to four months per year);
- Periodic estimation of the water level in the quarries will assist in refining the model for groundwater contribution;
- A groundwater model can be used to estimate inflows into the quarries. Once groundwater inflow information is available, and quarry storage volumes can be estimated, the water balance should be updated;
- Any discharge from the site, including the current sewer discharges, should continue to be assessed for water quality and flow recording; and,
- The monthly water meter record keeping should continue.

Declaration of Independence

I, Chenai E Makamure, declare that -

- I act as the independent Hydrology Practitioner;
- I will perform the work relating to the project in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting hydrogeological assessments, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations, and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority and - the objectivity of any report, plan, or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me are true and correct; and
- I will perform all other obligations as expected from a hydrology practitioner regarding the Act and the constitutions of my affiliated professional bodies.

Signature of Specialist	[signature] .
Designation	Principal Hydrologist
Qualification and SACNASP Registration Number	MSc GIS and Earth Observation Integrated Watershed Modelling and Management - Environmental Hydrology; BSc Applied Environmental Science Pr. Sci. Nat 400150/16
Name of company	CM Eclectic (Pty) Ltd

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Table of Acronyms and Abbreviations

Acronym / Abbreviation	**Definition**
DWS	Department of Water and Sanitation
FAO	Food and Agriculture Organisation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
Pr. Sci. Nat	Professional Natural Scientist
SANRAL	South African National Road Agency
SAWS	South Africa Weather Services
WMA	Water Management Area
WR2005	Water Resources of South Africa 2005 Study
WULA	Water Use License Application
WR2012	Water Resources of South Africa 2012 Study

Table of Units

m^3	Cubic metres
m^3/a	Cubic meters per annum
m amsl	Metres above mean sea level
Ha	Hectares
m^2	Square metres
l/day	Litres per day
Km^2	Square kilometres
mm	millimetres
m^3/s	Cubic meters per second
Mcm	Million cubic metres

1 Introduction

1.1 Background

CM Eclectic Pty Ltd (CM Eclectic) was appointed by Corobrik Lawley Factory to prepare a site-wide water balance model and report for the operational brick-making factory and clay mining. The Corobrik Lawley Factory is one of several properties of Corobrik (Pty) Ltd. It is an established quarrying and brick manufacturing operation that has been in operation since the early 1940's while the current factory has been in operation since 1981. The Corobrik Lawley Factory operations are situated on Portion 1 and 2 of the Farm Syferfontein 293 IQ, Portion 88 of the Farm Roodepoort 302 IQ and the Remaining Extent of Portion 47 (a Portion of Portion 2) of the Farm Roodepoort 302 IQ. The study area is located south of Lenasia within the borders of Johannesburg Metropolitan Municipality, Gauteng Province.

A steady state, site-wide water balance model has been developed using available information to understand the flows at the Lawley Factory operational water circuit during average dry and wet seasons.

1.2 Site Process Description Summary

Lawley Factory mines and beneficiates various earth's raw materials and is supported by run of mine stockpiles, offices, sewage treatment works, brick making plant and workshops. Clay is bench mined by a back-actor from the six quarries belonging to the Lawley operations and transported to stockpiles on site. Current quarrying operations are carried out on an annual basis for approximately four months a year during the dry winter months. Rehabilitation of the worked-out sections of the quarries is carried out concurrently with the quarrying operations during the quarrying period by a mining contractor. The quarries are mined for Henly, Redshale, Smactite, Sandy Kaolin, Red Kaolin and Topface clays, and have been named Quarry 1, up to Quarry 6, in no order and presented in Figure 1-1.

The clays are drawn by front end loader from the different stockpiles and pre-blended by volume before being fed into the brick making plant. The pre-blended clays pass through crushers all along the mechanical preparation process, further mixing, and enhancement of the mix takes place. The brick making process also involves the use of coal dust, which is mixed with the clayey soils. Water is added to the material when it passes through the mixers to the extrusion point. At the extrusion point, the stiffness of the mix, as well as the dimensions of the column, is determined and controlled for the next stage of cutting. The cut bricks get loaded onto kiln cars and proceed to a tunnel dryer for final controlled drying to the desired moisture content. The bricks are then fired in the tunnel kilns. Before the bricks are packed, they pass through a de-hacking process, where they are dipped into the water at the dipping station. Once dipped, the bricks are carried by forklift, to the stock bins, ready for dispatch to the customers.

1.3 Scope of Work

A steady state site-wide water balance model has been developed to understand the flows during dry, wet, and average climate conditions. The water balance update is guided by the Department of Water and Sanitation (DWS) Best Practice Guidelines (BPG) G2 – Water and Salt Balances (DWS, 2006). In addition to the Lawley Factory's water balance, which is necessary to inform improvement needs on the operational water management and record keeping, the water balance is also required to fulfil the requirement of a Water Use Licence Application (WULA).

The scope of work comprises the following:

- Define the water circuit, including a review of information on the water meters audit;
- Developing input parameters and operational rules for the water components;
- Develop a monthly average water balance model, which is run for the average wet, dry, and average climatic conditions. This includes analysing the water demand during the operational circuit using water records, as well as understanding makeup water requirements, likelihoods of water shortages and spillage risks; and
- Compile a report on the operational water balance and recommend further work needed to optimise water management and water reporting at the Lawley Factory.

The battery limits of the water balance model are the factory operations and infrastructure, which comprise:

- Six Lawley Factory quarries;
- Clay Stockpiles;
- A water supply borehole;
- The clay processing and brick-making factory and brick stockpiles, and,
- Sewage treatment yard.

Figure 1-1 presents the site infrastructure layout at the Corobrik Lawley site.

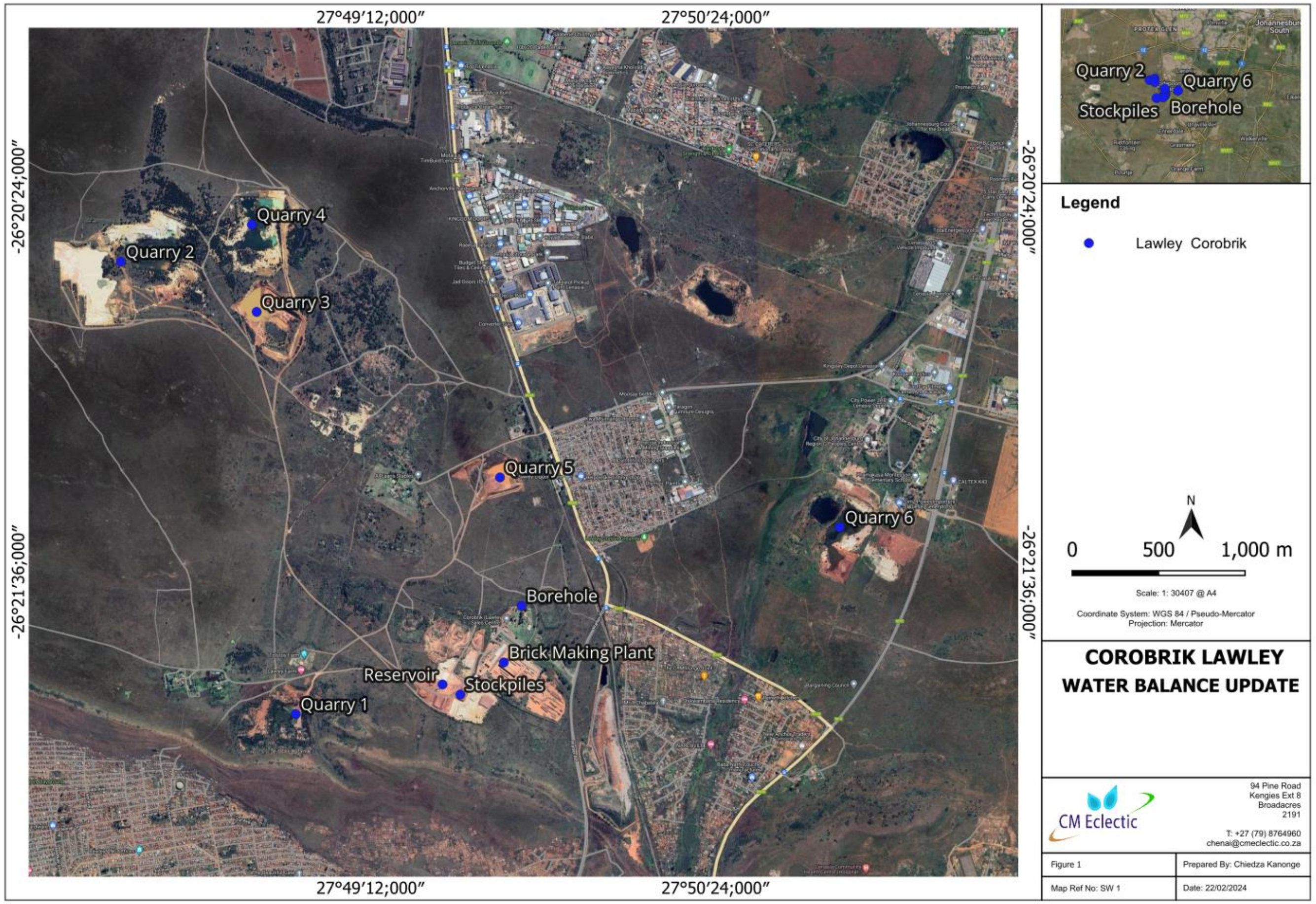

Figure 1-1: Corobrik Lawley Site Layout

2 Water Balance Methodology

2.1 Site Verification

A CM Eclectic Hydrologist visited the Lawley Factory on 9 February 2024 with the following objectives:

- Site walkover – meet key site personnel to discuss water management practices at the site.
- Define the water circuit – improve the understanding of the water schematic flow chart showing the main water components.
- Water meter audit – review of flow metering and water usage monitoring network.
- Preliminary information gathering – obtain hard copies of information, request soft copy information, and establish communication channels for water balance information requirements.

2.2 Water Circuit, Reuse Strategy and Audits

A Microsoft Excel spreadsheet water balance model was developed using available information to represent the water sources and sinks within the operational water circuit. Where information was not available, model inputs and assumptions were based on other applicable studies.

2.2.1 Water Circuit

The modelled water balance circuit of the Corobrik Lawley Factory includes water inflows, losses and transfers for the following aspects of the operation:

- Six mining quarries;
- Raw material stockpiles (clay and sand material);
- Clay preparation and brick making factory (clay preparation up to dispatch); and
- Portable water usage by staff members and onsite sewage treatment plant; and support services and infrastructure such as the clinic.

Water sources (inflows) are as follows:

- Groundwater and stormwater ingress into the quarries;
- Stormwater collected from the dirty catchment (stockpiles area) which is allowed to evaporate; and
- Potable water from the water supply borehole.

Water sinks (losses) through the following:

- Water evaporation from the quarry sump;
- Interstitial lockup in the stockpiles;

- Water loss during the drying and firing processes in the drier and kilns;
- Dust suppression at the stockpiles area, including road dust control;
- Potable water consumption, sewage plant losses and discharge; and,
- Some borehole water is supplied to the nearby farm.

Stormwater, groundwater, and process water are collected within the following storage facilities for reuse including:

- Reservoir for borehole water; and
- Quarry sumps.

The simplified schematic in Figure 2-1 presents the site infrastructure layout at the Corobrik Lawley Factory.

2.2.2 Water Reuse Strategy

The water usage within the brick factory operations prioritised reusing quarry water for onsite dust suppression. However, the Lawley Factory is currently using clean water for the processes from the borehole. There is no collection dam for stormwater at Lawley Factory and from stockpiles; therefore, any stormwater runs off to the downstream wetland system and evaporates. Sewage effluent is disposed of in the downstream wetland system.

2.2.3 Water Meter Audits

There are four of the five meters on site, which are operational at Lawley Factory. The main meter one of which records intake of potable water supplied from a water supply borehole, while the other meters monitor distribution and consumption within Lawley Factory, including wastewater discharge. The non-operational water meter is at the inflow into the onsite sewage treatment facility. Lawley Factory provided the records, and the Hydrologist selected the records from January 2021 to Dec 2023 because these years had complete records that covered all months of the years, for three of the meters with continuous records. The water meter distribution is detailed in Table 2-1.

Table 2-1: Summary of Monitoring meters on site and considered in Water Balance

Meter ID	Monitoring Records Considered	Location in Water Balance
Borehole	January 2021 to Dec 2023	The total borehole abstraction to the reservoir supplying the factory

Meter ID	Monitoring Records Considered	Location in Water Balance
		consumption, farm and brick making
Farm	January 2021 to Dec 2023	Borehole water supplied to the nearby farm from Lawley Factory
Making	January 2021 to Dec 2023	The borehole water used for brick making at the Factory
Sewage Treatment Plant (STP) - Outlet Flow Meter	15 Apr to 15 May 2024 Records	Discharge from the onsite station into the wetland

In addition to the water meters, the numbers and capacity of dust suppression tankers used daily for the roads and stockpiles are recorded.

Currently, there is no monitoring of water accumulating in the quarry and no groundwater model of inflows into the quarries. Furthermore, the network of water meters does not provide records of inflows into the sewage treatment plant, as well as a comprehensive understanding of the internal distribution of potable water consumption (clinic, offices, and ablutions). The meter at the inflows into the sewage treatment facility is currently not working, therefore, records should be kept once it is working. Water meters are recommended to improve data collection at the Lawley Factory as follows:

- A meter to record the distribution of the potable water, which will be helpful should the Factory envisage to investigate water conservation measures;
- Measurement of dust suppression at the quarry during mining (three to four months per year); and
- Periodic estimation of the water level in the quarries will assist in refining the model for groundwater contribution.

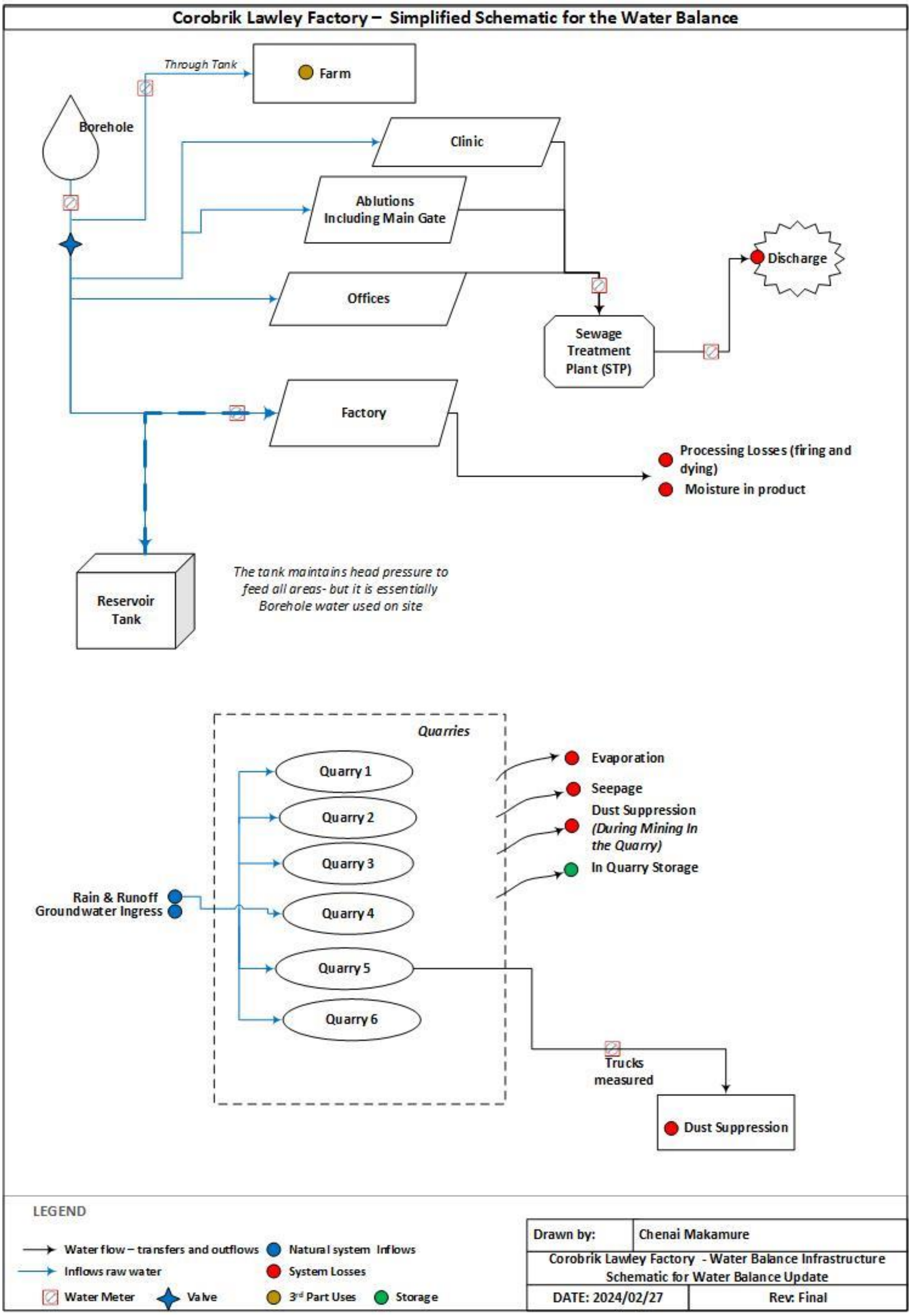

Figure 2-1: Simplified Schematic for Corobrik Lawley Operations

3 Water Balance Assumptions and Input Parameters

This section presents the various input parameters used to model each of the main water components of the water balance. The inputs were determined from available records, and assumptions were made where there were no records. The estimations and assumptions should be updated when additional information becomes available.

3.1 Climate Variables

Lawley Factory sits within the quaternary catchment C22A, and the mean annual precipitation (MAP) determined from the DWS rain gauge station Zuurbekom is 686.6 mm which is comparable to the catchment-wide MAP from the WR2012 of 695mm. An analysis of the rainfall information from the 1959 to 2019 period indicates that the driest year experienced only 405 mm of rainfall and the wettest year experienced 1045 mm of rainfall.

No rainfall and evaporation records are provided from Lawley Factory; therefore, station data from the Department of Water and Sanitation (DWS) and Water Resources of South Africa 2012 Study (WR2012) were considered.

The DWS managed rain meteorological station Zuurbekom (DWS Reference: C2E007)[1] also referenced by the South African Weather Services (SAWS) as station number 0475528_W is the nearest station. The station's Symonds Pan (S-pan) evaporation records and rainfall records adapted for the site are from 1959 to 2019. The station is at the Waterworks Train Station, 7.5 km north of the Lawley Factory.

Table 3-1 presents monthly average rainfall and evaporation for the Zuurbekom Station. A pan coefficient obtained from the WRC's WR90 project is used to convert S-pan evaporation to evaporation from open water such as a dam or pond.

The rainfall evaporation time series presented in Figure 3-1, are used to understand the general trend in rainfall and evaporation, the trendlines show that and shows a marginal increase in rainfall over the years and a marginal decrease in evaporation.

[1] https://www.dws.gov.za/Hydrology/Verified/HyDataSets.aspx?Station=C2E007&SiteDesc=MET Access Date 2024/06/04

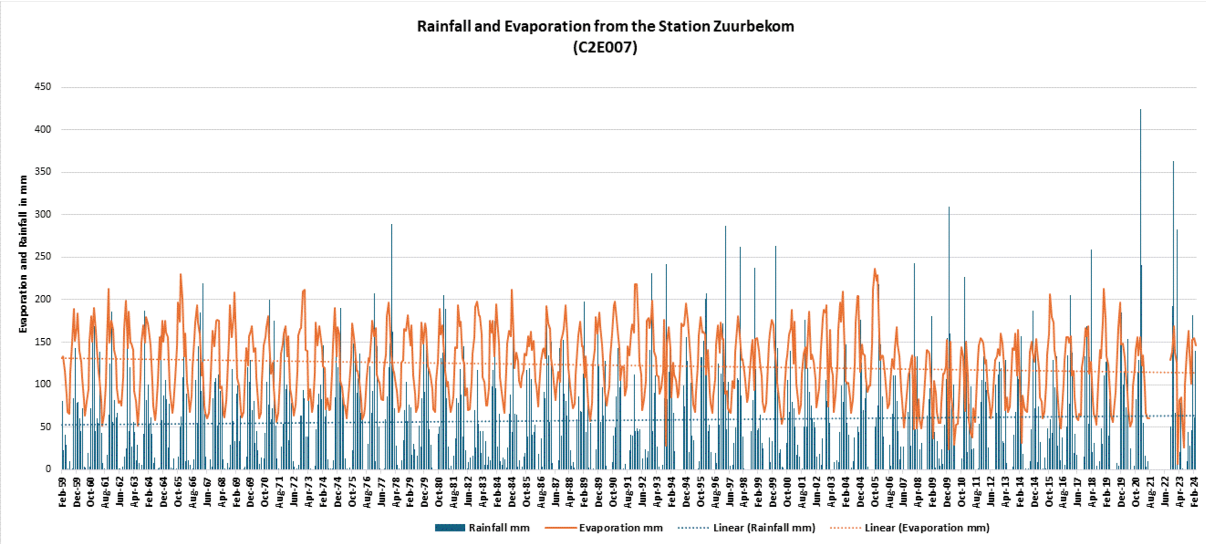

Figure 3-1: Monthly Rainfall and Evaporation at Zuurbekom (C2E007)

Table 3-1: Monthly Average Rainfall and Evaporation – Zuurbekom C2E007

Month	Rainfall (mm)	S-Pan Evaporation (mm)	Pan Coefficient[2]	Open Water Evaporation (mm)
January	129.9	165.9	0.84	139.4
February	95.2	137	0.88	120.6
March	80.3	128.4	0.88	113.0
April	50.9	100.3	0.88	88.3
May	16.6	84.4	0.87	73.4
June	7.2	67.4	0.85	57.3
July	2.8	75.3	0.83	62.5
August	6.5	105.9	0.81	85.8
September	21.2	143.3	0.81	116.1
October	68.7	161.2	0.81	130.6
November	100.5	161.4	0.82	132.3
December	117.1	169.8	0.83	140.9
Total	696.9	1500.3	N/A	1260.1

3.2 Water Meter Records – Water Demands

Lawley provided daily water meter records for the borehole water and its distribution of the meters in Section 2.2.3. Water meter records were for the period from 2020 to 2024 January for the borehole abstraction and distribution meters. Water uses were summarised to provide an average monthly usage based on an average of the records from 2021-2023, for use in the water

[2] Surface Water Resources of South Africa 1990 - Volume 1 Appendices. WRC Report 298/1.1/94

balance and are presented in Figure 3-2. The 2021-2023 period was chosen because it had a full monthly data record.

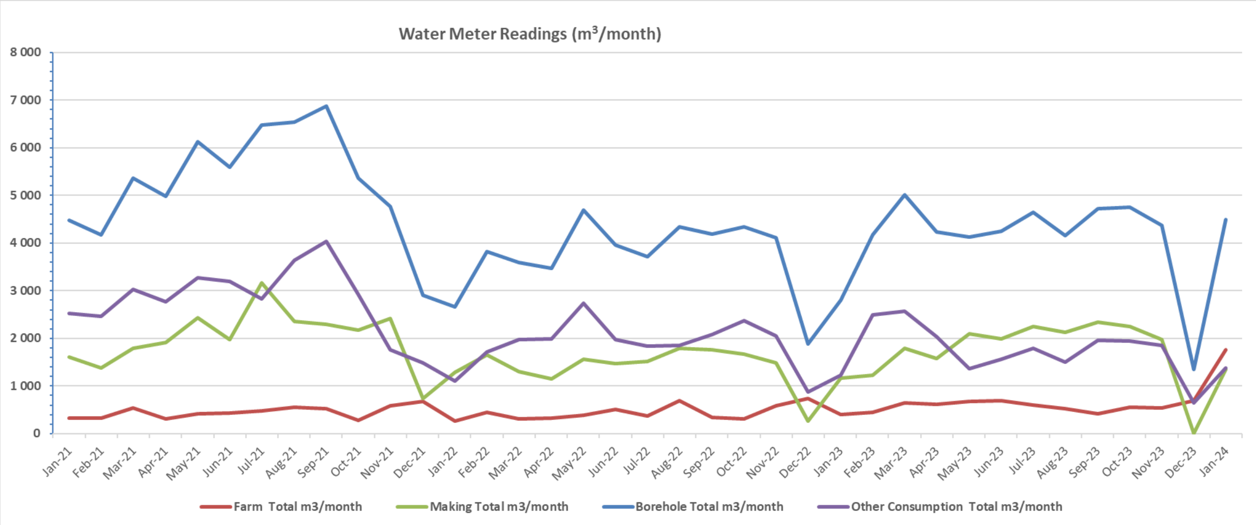

Figure 3-2: Average Monthly Water Meter Records (m^3/month)

The average records used in the water balance model obtained from the 2021 to 2023 data are presented in Table 3-2.

Table 3-2: Water use averages at Lawley Factory

Water Use	Borehole (m^3/month)	Farm (m^3/month)	Making m^3/month	*Other Consumption m^3/month
Jan	3 311.7	333.3	1 354.3	1 624.0
Feb	4 058.3	411.0	1 423.3	2 224.0
Mar	4 654.0	501.7	1 628.3	2 524.0
Apr	4 232.0	421.0	1 545.3	2 265.7
May	4 982.3	494.0	2 030.3	2 458.0
Jun	4 603.3	546.3	1 813.3	2 243.7
Jul	4 947.7	481.7	2 313.3	2 152.7
Aug	5 012.7	589.7	2 092.0	2 331.0
Sep	5 254.7	428.7	2 133.0	2 693.0
Oct	4 823.7	381.3	2 033.0	2 409.3
Nov	4 415.7	569.7	1 959.0	1 887.0
Dec	2 047.7	702.7	341.7	1 003.3
Grand Average	**4 362.0**	**488.4**	**1 722.3**	**2 151.3**

*- calculated difference of total borehole withdrawal and uses at the farm and for brick making at the factory.

Dust suppression for the dry season (May – September) uses a tanker with a capacity of 18 000.0 L/load and a total of two loads per day, thus 828 m^3/month over 23 dust suppression days.

The wastewater discharge from the sewage treatment facility was recorded only from 15 April until 15 May 2024, and the discharge was, 416 m^3/month (13.9 m^3/d)

3.3 Groundwater Ingress

Groundwater ingress rates in the quarries were unavailable; therefore, an estimation method by E Lukas and D. Vermeulen (2015[3]) was used. In the method, the recharge is proportional to the total area and annual rainfall. An average recharge percentage of 20% is assumed for the quarries. The groundwater ingress is kept constant throughout the year. The ingress at Quarry 5 is lower than the estimated demand for dust suppression 36 m^3/day from Quarry 5; however, dust suppression uses accumulated water and is only done during the dry season. The groundwater ingress estimated from the above assumption, presented in Table 3-3, should be verified and adjusted with groundwater models or measurements of water levels in the quarry sumps.

Table 3-3: Estimated Groundwater Ingress

Quarry	Ingress (m^3/d)	Ingress (m^3/month)
Quarry 1	69	2 114
Quarry 2	204	1 238
Quarry 3	49	1 495
Quarry 4	71	2 149
Quarry 5	27	834
Quarry 6	71	2 151

3.4 Stormwater

All footprint areas used in the water balance calculation are based on measurements in Google Earth imagery (2024) and were kept constant for calculating runoff and evaporation losses from the pool areas. There is no stormwater collection and reuse onsite; therefore, no dirty water storage dam is considered. All runoff in the stockpiles yard is lost to evaporation and interstitial storage. The infrastructure footprints are presented in Table 3-4.

Table 3-4: Measures Footprint Estimates

Area	Footprint (m^2)
Quarry 1	182 000.0
Quarry 2	533 007.0
Quarry 3	128 733.0

[3] E. Lukas and D. Vermeulen. 2015. A Management Plan towards the Flooding of an Open-Cast Mine with Adjacent Underground Sections. 10th International Conference on Acid Rock Drainage & IMWA Annual Conference

Area	Footprint (m^2)
Quarry 4	185 000.0
Quarry 5	71 815.0
Quarry 6	185 212.0
Stockpiles	141 500.0
Yards including plant area	140 000.0
Plant	36 000.0

Different runoff ratios were used for the estimation of runoff:

- Quarries = 0.25
- Stockpiles = 0.1
- Plant yard = 0.65

3.5 Model inputs and assumptions summary

The following assumptions for the model inputs apply to the water balance:

- Rainfall-related inflows and evaporation were estimated based on:
    - average values during the dry months of the year (April to September);
    - average values during the wettest months of the year (October to March); and,
    - annual average values.
- Groundwater ingress rates were unavailable; therefore, an average recharge percentage of 20% is assumed and is kept as a constant percentage of annual rainfall.
- Water meter records received from Lawley Factory meters were used.
- Potable water use is assumed to be the difference between the total borehole abstraction and the uses for brick-making supply to the farm.
- All footprint areas are based on measurement in Google Earth, on 2024 imagery and are assumed to be representative.
- Runoff coefficients are constant in each catchment and not influenced by antecedent climatic conditions.
- The sewer treatment plant recovery was estimated based on one month of meter records at the outflow meter.
- Evaporation from the measured quarry sump footprints occurs if there is water in the sumps.
- This water balance model is calculated for only steady-state average wet and dry seasons and does not consider storage; therefore, flow in = flow out.

3.6 Limitations

The water balance limitations include:

- The water balance is based on an average steady state. It does not consider storage volumes. For the current scope, the steady-state water balance model and current updates are adequate to capture wet and dry season variations driven by the runoff at the site.
- Groundwater inflows into the quarries are not quantified, and inflow rates are assumed based on an estimated recharge.
- The model is based on conservative values and assumes that all areas generate runoff.

3.7 Results

Average groundwater inflows are estimated for all the Lawley quarries, and 834 m^3/month is estimated for Quarry 5, which is reused around Lawley brick making plant for dust suppression in the dry months.

From the monthly average records for 2021 to 2023, the biggest borehole water user is at the various support facilities (offices, clinic and change houses), followed by the brick-making factory. The lowest volumes (less than 7 000m^3) are supplied to the farm annually, as shown in Figure 3-3.

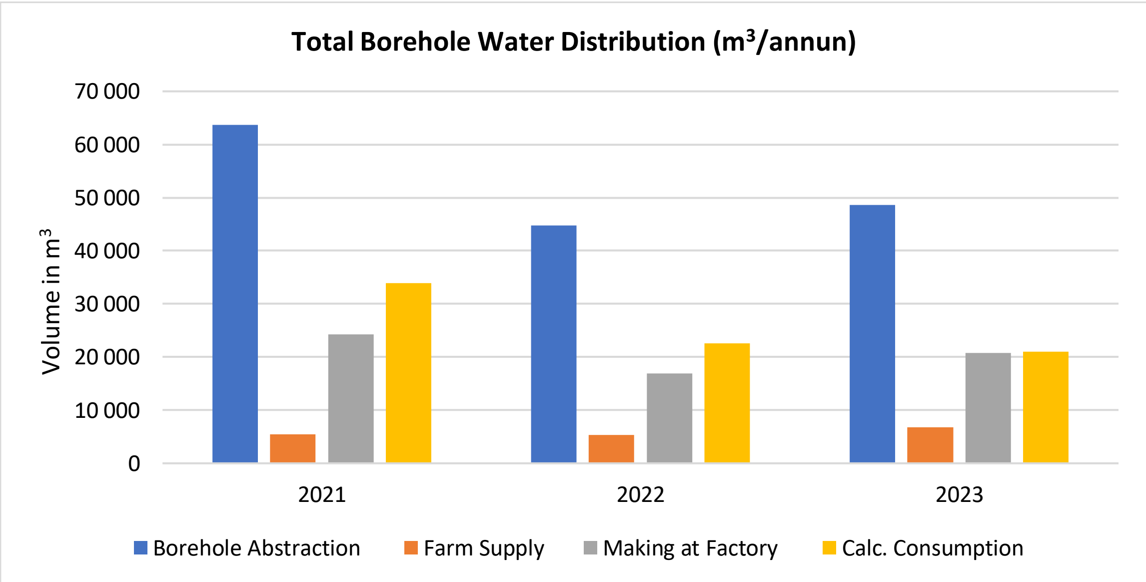

Figure 3-3: Lawley Factory Distribution of Borehole Water

The water abstracted from the borehole for factory uses comprises 86% of the total water used at Lawley Factory, as presented in the pie chart in Figure 3-4. Water from the Quarry 5 is used for dust suppression and comprises 14% of total water used at Lawley Factory in the dry seasons. There is no dust suppression in the wet season, therefore, only borehole water is used for consumption, changehouses and processing. The average volumes of water used in the wet season are lower than in the dry season because December and January, employees take long holiday breaks.

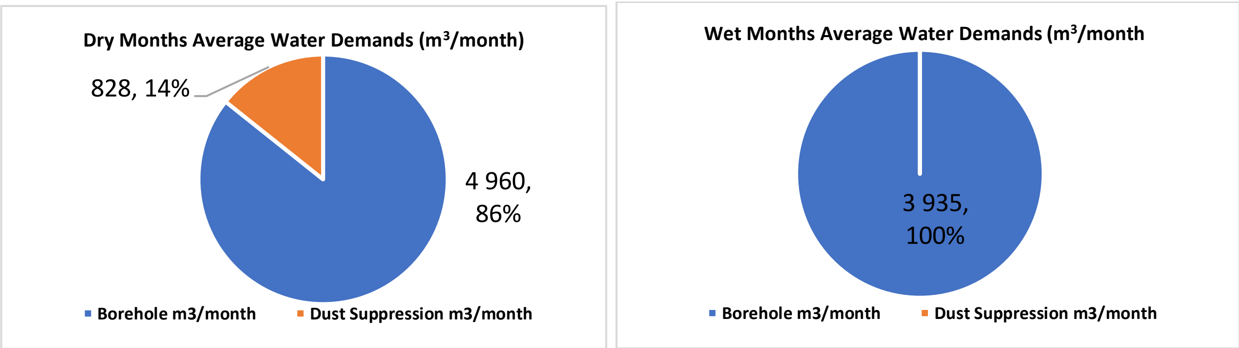

Figure 3-4: Lawley Factory Average Wet and Dry Season Water Sources

Table 3-5, Figure 3-5 through to Figure 3-7 summarise the calculated average wet season, average dry season and average climate conditions water balances, respectively. All three climate conditions indicate a balance in storage for the overall site balance.

Table 3-5: Average Monthly and Annual Water Balance Summary

Facility Name	Water In			Water Out		
	Water Stream	**Quantity (m^3/mon)**	**Quantity (m^3/annum**	**Water Stream**	**Quantity (m^3/mon)**	**Quantity (m^3/annum**
Borehole	Borehole	4 362	52 344	Brick Making Factory	1 722	20 667
				Factory Support Facilities	2 151	25 816
				Farm	488	5 861
		4 362	**52 344**		**4 362**	**52 344**
Factory Support Facilities	Borehole	2 151	25 816	Losses (Leaks, losses, overflow, uses ablutions and offices	1 694	20 324
				Environmental Discharge at STP	416	4 992
				Losses at STP	42	499
		2 151	**25 816**		**2 151**	**25 816**
Brick Making	Brick Making Water	1 722	20 667	Processing losses (firing and drying)	1 722	20 667
	Dust suppression Water	414	4 968	Dust Suppression	414	4 968
		2 136	**25 635**		**2 136**	**25 635**
Stockpiles	Rainfall and runoff	822	9 861	Losses (Evaporation and Interstitial)	822	9 861
		822	**9 861**		**822**	**9 861**
Mining Quarry 5	Rainfall and runoff	417	5 005	In Pit dust suppression, uses and losses	46	557
	Groundwater Ingress	834	10 010	Losses/ Evaporation	363	4 362
				Calculated Stored Water	427	5 128
				Lawley Factory Dust Suppression	414	4 968
		1 251	**15 014**		**1 251**	**15 014**

Facility Name	Water In			Water Out		
	Water Stream	Quantity (m^3/mon)	Quantity (m^3/annum	Water Stream	Quantity (m^3/mon)	Quantity (m^3/annum
Mining Quarries 6	Rainfall and runoff	1 076	12 907	In Pit dust suppression uses and losses	166	1 997
	Groundwater Ingress	2 151	25 815	Losses/ Evaporation	2 893	34 715
				Calculated Stored Water	168	2 010
		3 227	**38 722**		**3 227**	**38 722**
Mining Quarries 4	Rainfall and runoff	1 074	12 893	In Pit dust suppression uses and losses	170	2 044
	Groundwater Ingress	2 149	25 785	Losses/ Evaporation	2 864	34 366
				Calculated Stored Water	189	2 269
		3 223	**38 678**		**3 223**	**38 678**
Mining Quarries 3	Rainfall and runoff	748	8 971	In Pit dust suppression uses and losses	116	1 388
	Groundwater Ingress	1 495	17 943	Losses/ Evaporation	2 011	24 129
				Calculated Stored Water	116	1 397
		2 243	**26 914**		**2 243**	**26 914**
Mining Quarries 2	Rainfall and runoff	3 095	37 145	In Pit dust suppression uses and losses	499	5 985
	Groundwater Ingress	1 238	14 858	Losses/ Evaporation	3 339	40 066
				Calculated Stored Water	496	5 952
		4 334	**52 003**		**4 334**	**52 003**
Mining Quarries 1	Rainfall and runoff	1 057	12 684	In Pit dust suppression uses and losses	194	2 333
	Groundwater Ingress	2 114	25 367	Losses/ Evaporation	1 071	12 853
				Calculated Stored Water	1 905	22 865
		3 171	**38 051**		**3 171**	**38 051**
Total Water Circulation		**26 920**	**323 038**		**26 920**	**323 038**

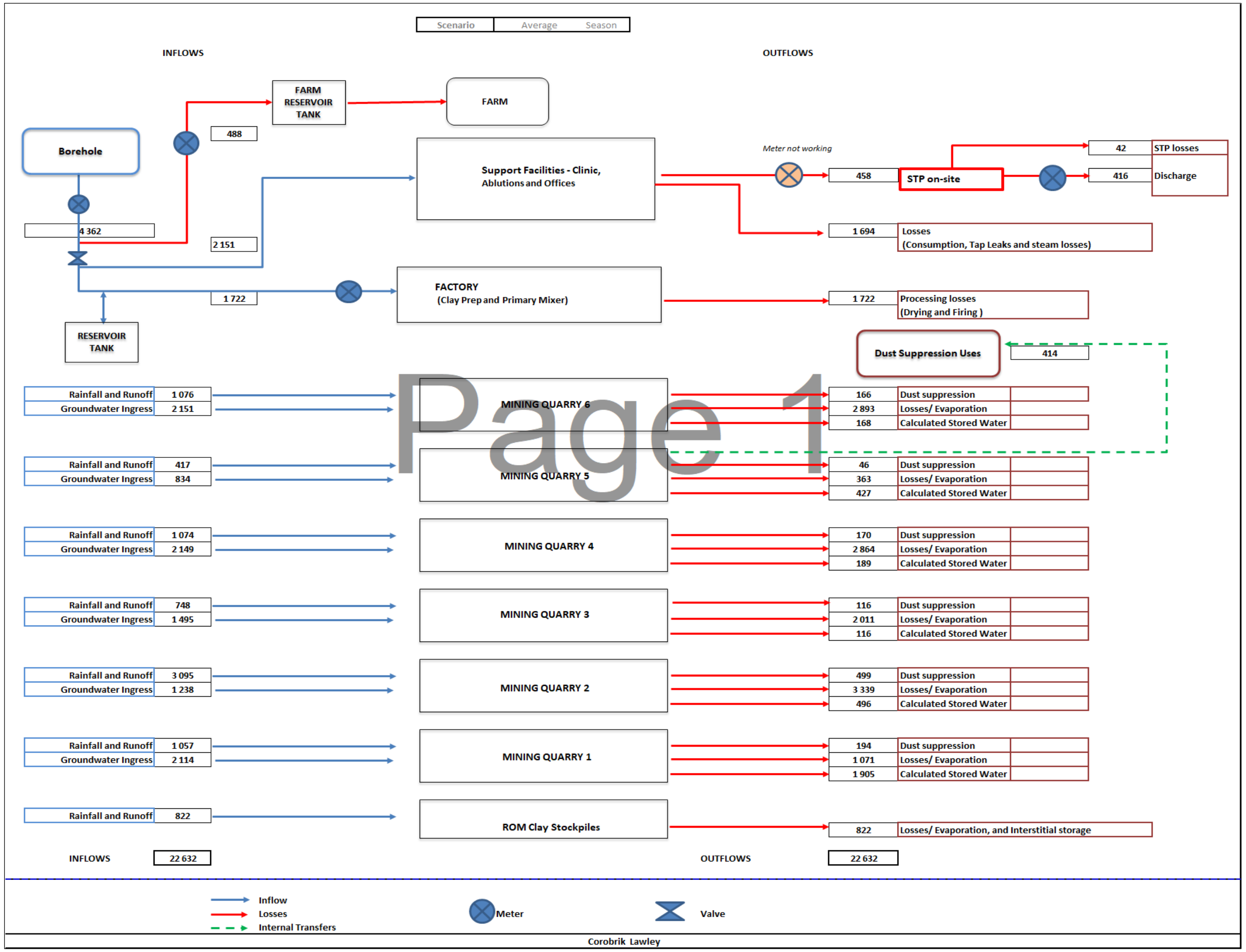

Figure 3-5: Annual Average Water Balance

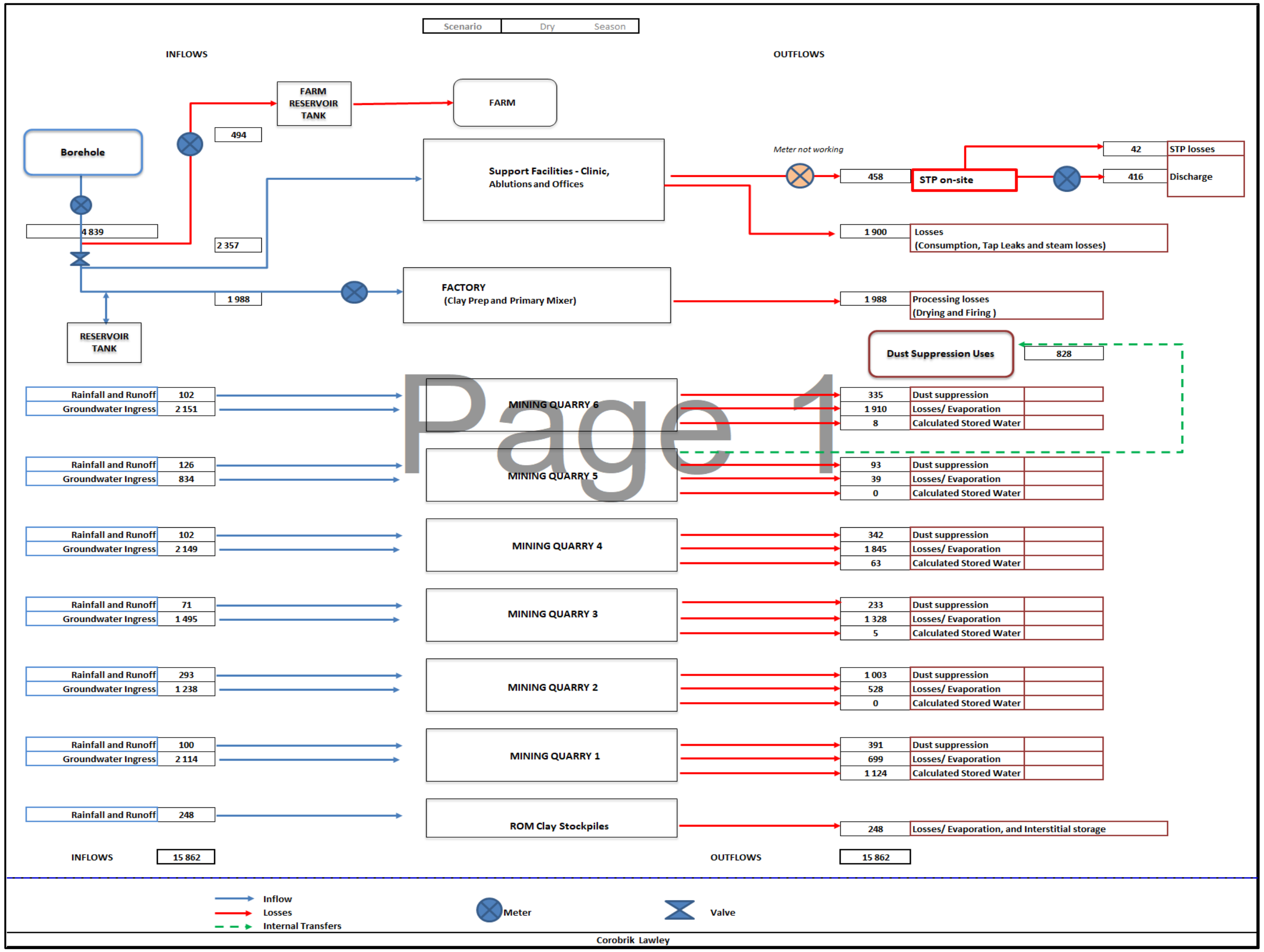

Figure 3-6: Average Dry Season Water Balance

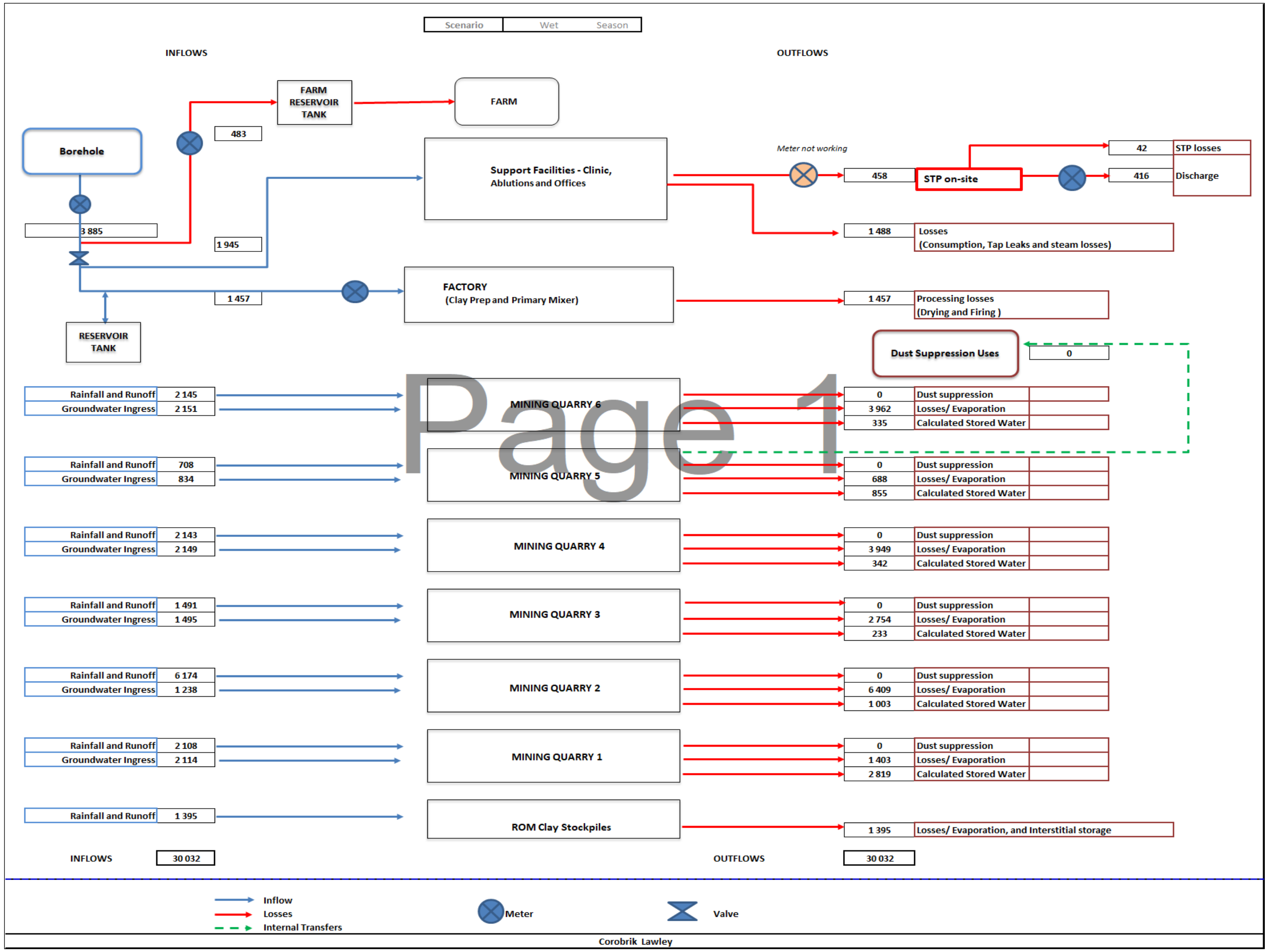

Figure 3-7: Average Wet Season Water Balance

4 Conclusions and Recommendations

A steady state site-wide water balance model has been developed to understand the flows at the Lawley Factory during average dry, wet and average climate conditions using available information. Using available information, a Microsoft Excel spreadsheet model was used to represent the flows within the operational water circuit. The factory operations and infrastructure included in the water balance scope comprise:

- Six mining quarries;
- Raw material stockpiles (clay and sand material);
- Clay preparation and brick making factory (clay preparation up to dispatch);
- A water supply borehole;
- Support services and infrastructure such as the administration offices, ablutions and change houses, and clinic;
- An onsite sewage treatment plant; and
- A nearby third party owned farm is supplied water from the Lawley Factory.

Lawley Factory provided daily records from January 2020 until 2024 January from its three operational water meters in place at the site. Two meters record the distribution of borehole water to the farm and to the brick making plant, and the main meter records the total borehole water abstraction. The 2021 to 2023 records were used for this water balance assessment, as these years had complete records for all months. Furthermore, two meters are situated at the sewage treatment facilities, one at the inflow, which was not working and one at the outflow final discharge point, which had records starting on 15 April 2024.

The brick factory operations' water usage prioritised reusing quarry water for dust suppression during the dry months and estimated an average of two tankers of 18 000L capacity are used daily in the dry season. There is no collection dam for stormwater around the production plant, therefore runoff is discharged to the downstream wetland. Final treated wastewater from the sewage effluent treatment facilities is discharged to the downstream wetland.

The water balance results are presented in tables, graphs, and pie charts. The assessed water balance indicates average operating conditions at Lawley Factory and will suffice for WULA. For optimum water management, the following recommendations are proposed:

- Additional water meters/measurement locations are recommended to improve water balance data collection and confidence in the model:
    - A meter/ record of the distribution of the potable water, which will be helpful should the Lawley Factory want to investigate water conservation measures if the various water use areas are separated;
    - Measurement of dust suppression at the quarry during mining (three to four months per year); and,

    - Periodic estimation of the water level in the quarries will assist in refining the model for groundwater contribution.

- A groundwater model can be used to estimate inflows into the quarries. Once groundwater inflows information is available, and quarry storage volumes can be estimated, the water balance should be updated.
- Any discharge from the site, including the current sewer discharges, should continue to be assessed for water quality and flow recording; and,
- The monthly recording of water meter readings should continue.

Although the water balance is based on an average steady state, and it does not consider storage volume in the quarries, which remain dormant when there is no mining (eight to nine months per year), For the current scope, the steady state water balance model and current updates are adequate to capture wet and dry season variations driven by the runoff at the site as well as the reduced December and January water demands.

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Appendix A: Consultant Details Resume

Chenai E. Makamure (Pr. Sci. Nat)

Principal Consultant

Qualifications and Accreditation

Executive Certificate	2023	New York University - Corporate Sustainability
Pr. Sci Nat	2016	Professional Natural Scientist registered with SACNASP (400150/16)
MWISA	2019	Member Water Institute of Southern Africa (25046)
MSc	2010	Integrated Watershed Modelling and Management - Hydrology
BSc (Hons)	2005	Applied Environmental Science

Expertise

- Hydrological Impact Assessment
- Water Quality Monitoring
- Water and Salt Balance Modelling
- Stormwater Management Plan
- Flood Modelling
- GN704 Auditing
- Water Use licence Audits
- Integrated Water and Waste Management Plans
- Water Liability Assessments
- Water Conservation Water Demand Management Plans
- Sourcing
- Project Planning and Management

Chenai Makamure (Pr. Sci. Nat) holds a BSc In Applied Environmental Science and an M.Sc. Integrated Watershed Modelling and Management - Environmental Hydrology. She has over 16 years of work experience within the water and environmental sectors.

Chenai has broad experience consulting for various industrial sectors - manufacturing, infrastructure, construction, consulting, mining, agriculture, and energy.

Chenai inputs the various stages of project planning (gap analysis, scoping, and impact assessments) and project implementation.

Chenai leads the sourcing and supply of industrial packaging materials for the manufacturing industry.

Chenai possesses excellent interpersonal and communication skills

Chenai is passionate about corporate sustainability and water stewardship and seeks to expand her services into those areas.

Chenai has worked on projects in DRC, Sierra Leone, Liberia, Malawi, Mali, Ghana, South Africa, Zambia, and Zimbabwe.

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