8/14/2025

Kelvin Power Station: 2024/25 Water and Salt Balance Update Study

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Title	Kelvin Power Annual Water and Salt Balance – 2024/2025 Update
Reference Number	
Issue	1
Date	August 2025
Classification	Privileged
Document Status	First

EXECUTIVE SUMMARY

Kelvin Power Pty Ltd (Kelvin) appointed Dihlashana Consulting Corporation to conduct the 2024/2025 water and salt balances update study for its operation in Kelvin. This station operates under the Water Use Licence Number 03/A21C/FGH/1110, File No. 16/2/7/A210J/B1, issued on 24 June 2011 (2011 WUL) by the Department of Water and Sanitation (DWS). Part of the conditions of this WUL requires that changes to the plant infrastructure, operating philosophy, water use, and demands, together with the concentration of salt loads within the water reticulation network, are updated annually. These changes aim to address uncertainties and gaps to facilitate integrated water management at the power station and the broader context of ensuring that water within the plant is used effectively and efficiently.

The power station is on the property Zuurfontein 331IR, Erf Re 82, in the City of Ekurhuleni, in the Gauteng Province of South Africa. The mean annual rainfall experienced within the region is estimated to be 720 mm and the S-Pan evaporation is 1690 mm/annum.

A water Process Flow Diagram (PFD) within the Kelvin was updated based on the 2024/25 operations and incorporated the information derived during the site visit. The average daily and monthly database of the flow meters for the plant covering the period July 2024 to June 2025 was used to guide the indicators of the water use, deficiencies and losses within the plant. These data were also used to update the water and salt balance, which was upscaled from daily to monthly and annual averages.

The key findings from the study include:

- Kelvin operation uses about 17 925 m^3/day from Rand Water Board and Northern Wastewater Treatment Works (NNWTW). About 4% (78 m^3/day) accounts for systematic losses from the Demin Plant (B-Station), while 73% (1 305 m^3/day) is used at the Power Plant, and 22% (399 m^3/day) is recovered from the Ash Handling Facility. This water is mainly used to operate the Demin and Power Plant, as well as for general services.
- The overall water balance indicated that a daily average volume of 17,925 m^3 of water is required to run the current operations at Kelvin. Of this volume, 78 m^3/day accounts for losses, while 1 305 m^3/day is used at the Power Plant, 399 m^3/day is recovered from the Ash Handling Facility and the rest is distributed from B-Stations Forebays to the Power Plant and for General Services.

- Results show that the overall 2024/25 water balance has less than 1% error difference between the inflows (33 058 m^3/day) and outflows (33 059 m^3/day) of the system. Of these inflows, approximately 14% (4 686 m^3/day) remains unaccounted for, and it is assumed that this inflow is lost at the ash handling facility to achieve a balance.
- Average salt balance calculations, based on the Sulphates (SO_4) concentration data, show that Kelvin Power Station generates a daily salt load of 3 198 kg from an inflow of 1 168 kg/day. This indicates that about 2 020 kg/day is generated within the plant site. Water quality data shows that the station generates salts that elevate electronic conductivity in the downstream areas, which is non-compliant with the water use license limits.

Recommendations include:

- Optimising flow meters to be operational for maximum collection of flow data from various components (with more emphasis on the Ash Handling Facility) to improve the future water and salt balance model.
- Implement the Plant site water conservation and demand management plan to reduce facility wastewater, monitor flow circulation within the cooling towers, and implement efficient stormwater management to enhance recycling of on-site water.
- Verify meter placement in the SCADA systems is commensurate with the actual location on-site and address meter calibration findings to facilitate consistent and valid flow data.

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LIST OF ACRONYMS

AHS	Ash Handling System
BPGs	Best Practice Guidelines
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Evaporation
MW	Megawatt
m^3	Cubic metre
NWA	National Water Act
NWRS	National Water Resources Strategy
PFD	Process Flow Diagram
RWB	Rand Water Board
SAWS	South African Weather Services
SCADA	Supervisory Control and Data Acquisition
SO_4	Sulphate
WMA	Water Management Area
WTW	Wastewater Treatment Works
WUL	Water Use Licence
Yr	Year

CONSULTANTS DETAILS

Company	Dihlashana Consulting Corporation (Pty) Ltd	
	Compiled by: Sbongiseni Mazibuko Category Professional Membership • SACNASP: *Pr.Sci.Nat*	**Approved By: Dipitseng Manamela** Category Professional Membership • SACNASP: Pr. Sci. Nat • National Association of Clean Air (NACA) • Network for Industrially Contaminated Land in Vaal (NICOLA)
Qualifications	• MSc (Hydrology)	• MSc. (Environmental Sciences) • Programme and Project Management • Management Advanced Programme • Certificate in Safety Management • BP COW Training
Experience	10 yrs. experience in surface water-related problems.	20 yrs. In Environmental and Safety Management in the oil industry and government departments.
Expertise	• Field data collection and interpretation • Flood hydrology • Stormwater Management • Water balances • Water resources assessments	• Project Management • Phase I and II site assessments at various retail sites • Sub-surface clearance, installing monitoring wells using a hand auger, soil sampling, low flow groundwater sampling for BTEX and various metals. • Soil screening, classification and removal • Surface Water Sampling for hydrocarbon contamination • Report Writing

DECLARATION OF INDEPENDENCE

I, *Sbongiseni Mazibuko*, as duly authorised representative of Dihlashana Consulting Corporation (Pty) Ltd., hereby confirm my independence as well as that of Dihlashana Consulting Corporation and declare that neither I nor Dihlashana Consulting Corporation have any business, financial, or personal, or other interest other than fair remuneration for work performed. I further declare that there is no conflict of interest in compiling this report.

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1 INTRODUCTION

Kelvin Power (Pty) Ltd (Kelvin) appointed Dihlashana Consulting Corporation to update the existing water and salt balance study of its Kelvin Power Station located in the Gauteng Province of South Africa. This coal power station is operating under Water Use Licence (WUL) Number 03/A21C/FGH/1110, File No. 16/2/7/A210J/B1, issued on 24 June 2011 (2011 WUL), by the Department of Water and Sanitation (DWS) in terms of the National Water Act, Act 36 of 1998 (NWA). Part of the compliance conditions of this license requires that Kelvin update its SWB annually to address changes to the infrastructure, operations and a larger scope of optimising water use within the station.

This study, therefore, aims to incorporate all water uses within the power plant infrastructure by using the measured monthly flow volumes from flow meters covering the period 01 July 2024 to 30 June 2025. The ultimate goal is to evaluate the state of compliance, identify gaps and challenges, as well as to formulate water use mitigation measures aimed at ensuring that effective and efficient use is achieved while protecting the water resources in the area, as envisaged in the 3rd edition of the South African National Water Resources Strategy (NWRS).

1.1 Background

The Kelvin Power site is located at property Zuurfontein 331IR, Erf Re 82, in the City of Ekurhuleni Metropolitan area (Figure 1-1) in the Gauteng Province, and its footprint stretches across the boundary of quaternary catchments A21C and A21A, which drains to the Jukskei River of the Limpopo Water Management Area (WMA).

Operations in Kelvin include a 13-unit coal-fired plant with a total capacity of 600 MW. Built between 1957 and 1969, the plant was initially developed and operated by the City of Johannesburg until its sale to a private company in 2001. Kelvin Power is among the few coal-fired power stations in South Africa that are not owned by Eskom. It comprises two independent stations: A-Station (currently being decommissioned) and B-Station. A-Station began commercial power generation on March 27, 1957, with six 30 MW generators and 11 chain grate boilers. The newer B-Station features seven 60 MW generators and seven PF-type boilers.

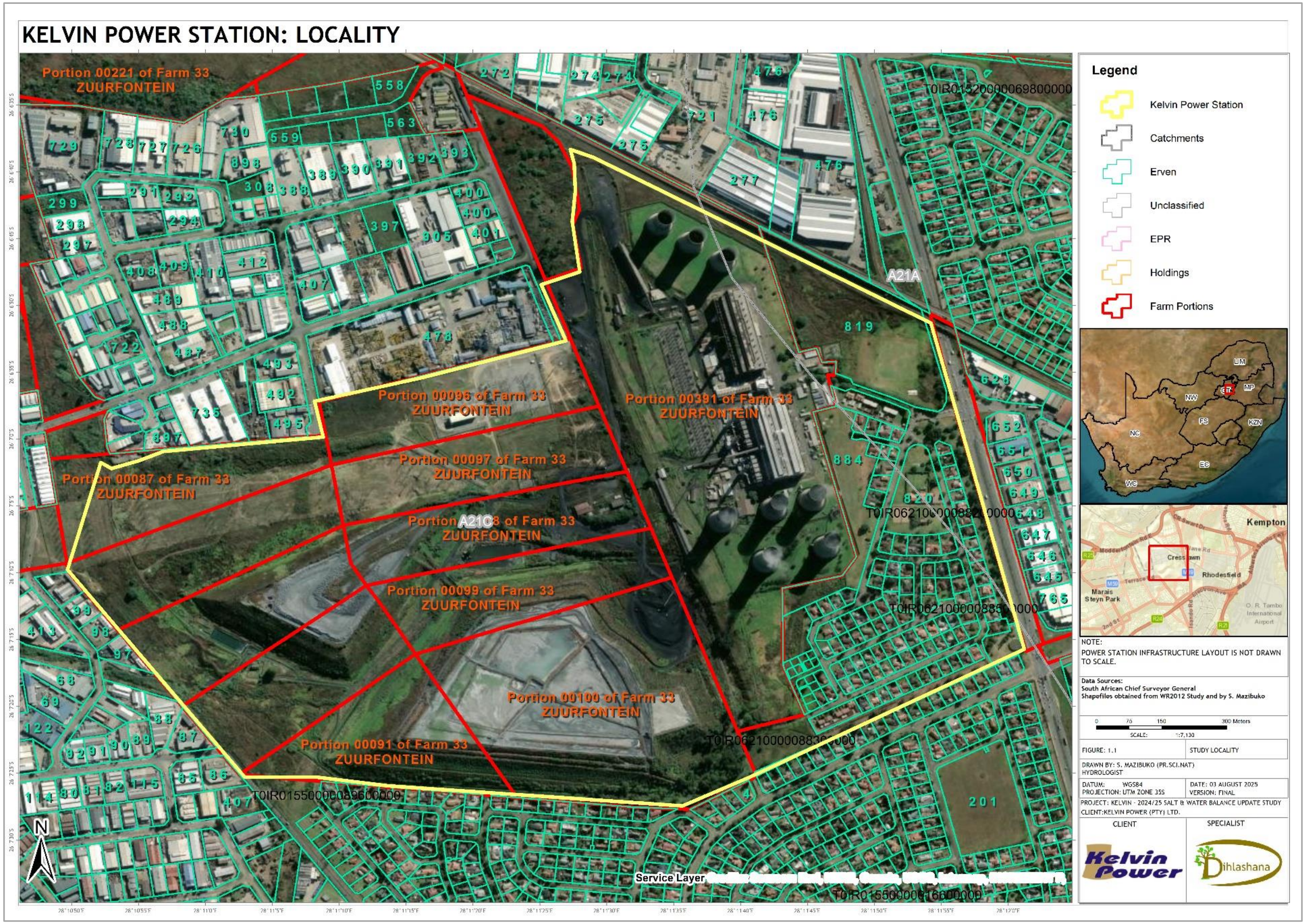

Figure 1-1: Study locality

2 SCOPE OF WORK

The scope of work for the water and salt balance study was defined as follows:

1. Site Visit, Information Sourcing and Data Collection;
    - A site visit to identify all plant site components and their relativeness to water flow processes,
    - Acquisition and review of relevant information and data, and
    - Review the applicable regulations and guidelines concerning the water and salt balances for water use licensing.
2. Update Local Hydrology Update;
    - Collect and extend a record of rainfall to update the expected overland surface runoff and catchment losses calculations, and
    - Hydrometeorological data analysis.
3. Update the Current Water and Salt Balance Model;
    - Collate updated flow meter data across the plant site
    - Update the water and salt balance model.
4. Average Water and Salt Balance Calculations;
    - Calculate average annual, monthly, and daily water balances based on the client-approved water PFD.
    - Update waste loads in compliance with the WUL
5. Reporting;
    - Reporting on the study's findings, including the conclusions and recommendations for future updates that will improve the confidence level of the water balance.

3 METHODOLOGY

3.1 Review of Existing Water Balance and Site Assessment

The existing water and salt balance studies and surface water quality monitoring data were reviewed to revive the understanding of the Kelvin site's water reticulation system and associated water demands. This was followed by a site visit conducted on the 15th of July 2025 to assess the plant site conditions and verify the water management infrastructure and reticulation status quo.

3.2 Receiving Environment

The general catchment, climate and hydrology setting of the study site were summarised using data derived from the previous studies, the 2012 South African Water Resources Study database (WR2012) (Bailey & Pitman, 2015) with over a 90-year record and the rainfall data from the rain gauge station is representative of the power station site. The combination of these was used to derive the average Mean Annual Precipitation (MAP), Mean Annual Evaporation (MAE) and natural Mean Annual Runoff (MAR) for the quaternary catchment to which the power plant belongs. Statistical analysis of these data was aimed at providing historical insights into the long hydroclimatic behaviour of the Kelvin site and enabling the calculation of the potential evaporation on the open water storage facilities. Although changes in climatic regimes and the frequency of hydrological extremes caused by climate change are acknowledged, it was assumed that the analysis of the long-term records was representative of the known climatic regimes for the study site.

3.3 Applicable Legislation

The National Water Act of 1998 (Act No. 36 of 1998) (NWA) was developed to ensure the protection of water resources in South Africa. The NWA recognises that water resource management aims to achieve the sustainable use of water for the benefit of all users. Following the provisions of the National Water Act (No. 36 of 1998) (NWA), all “water uses“ must be licensed with the Competent Authority (i.e., the Regional Department of Water and Sanitation (DWS) or the relevant Catchment Management Agency (CMA) where applicable). The DWS is responsible for the effective and efficient management of water resources to ensure sustainable economic and social development while also protecting water resources in accordance with the NWA. DWS is also responsible for evaluating and issuing licenses pertaining to water use (i.e., Water Use Licenses (WULs)).

3.4 Water and Salt Balances

Insights into water sources, flow links and storages within the power station site were derived from the information obtained during the site visit, previous relevant studies ((Dihlashana, 2024) and water flow meter data provided by Kelvin personnel. The water flow links were presented as a water Process Flow Diagram (PDF), which was drafted based on understanding the 2024 Kelvin operational philosophy and the client's input relative to the plant.

Kelvin personnel provided information and data on water sources and authorised/source volumes, water quality records, plant water use estimates, production data, potable water use, and the records of the disposed water. These provided insights into estimating the monthly and/or annual water demands for the plant site and the salt load within different components of the power plant circuits. Water flow quantities between various plant components were linked to guide the representation of the water flow processes and the calculation of the overall average power plant's water and salt balances. This study did not include plant components that have been disconnected for the reporting period.

A Microsoft Excel spreadsheet-based average water and salt balance model was developed and updated in accordance with the DWS Best Practice Guidelines (BPG) G2: Water and Salt Balances (DWAF, 2006). The spreadsheet indicates the flow of water quantities of different components and accounts for all estimates of losses within the plant station site, which is treated as a closed water system. Water balance calculations were based on the prevailing local hydrologic conditions relating to rainfall, evaporation, and runoff in the calculations. Other water volumes were based on reasonable assumptions that were made in line with the Power Plant's operational philosophy, where there were information and data gaps.

3.5 Best Practice Guidelines

Kelvin's WUL conditions include that a detailed and accurate water and salt balances study be conducted annually, and its standard must meet DWS Best Practice Guidelines for Water and Salt Balances (DWAF, 2006). This implies that a balance update study should be dynamic, considering seasonal changes and incorporating changes in, among other things, water storage levels. Principles used in this study include:

- Dynamic water balances based on variable climate inputs should include all inflows and outflows from any power plant activity. Water balances must also reflect surface and subsurface interconnections with the water resource in the location of the plant study area.

- The water balance should incorporate accurately measured volumes of water abstracted, used, or discharged at any point in the power plant. Water uses may include process water intake for supporting plant operations, cooling, domestic, portable, outflows to and return water from waste management facilities and water abstracted from the power station.
- Water balances should incorporate accurate values determined from suitable measurements of flows or modelling of rainfall, runoff, groundwater seepage and evaporation. Where flow is not monitored, a calculated water balance should be determined through mass balance calculations.
- Measures taken to manage the flow of water should have clear objectives and account for current and future mining situations.

4 GENERAL CLIMATE AND METEOROLOGICAL ANALYSIS

4.1 Climate

Located on a flat urbanised landscape, Kottek *et al*. (2006) classified the climatic conditions surrounding the Kelvin Power Station site as a warm and temperate climatic zone. The area experiences hot, wet summers and dry, cold winters with a localised average maximum and a minimum of 27°C and 6°C, respectively. Figure 4-1 shows Kempton Park's long-term average minimum and maximum temperatures.

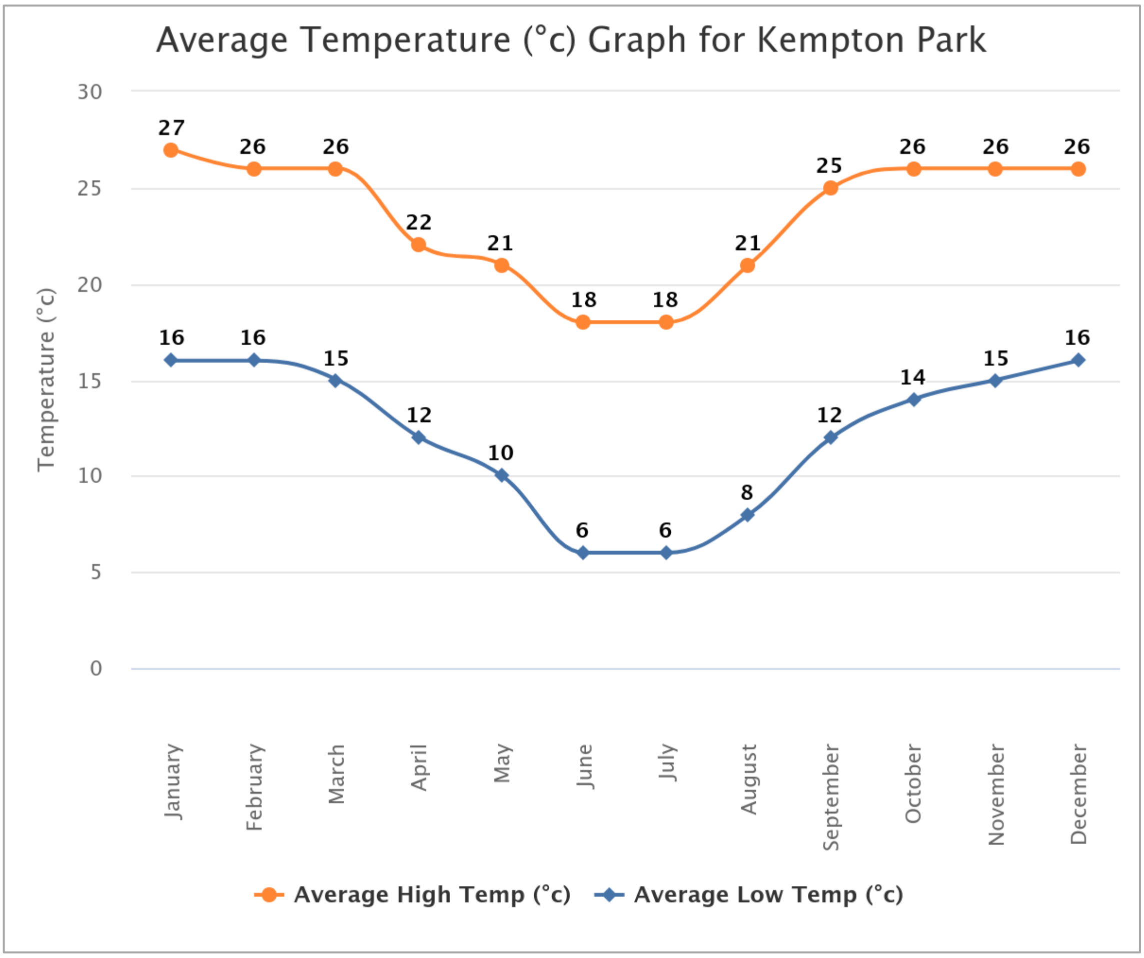

Figure 4-1: Average temperatures for the study site represented by Kempton Park station (source: WorldWeatherOnline, 2025)

Convective storms during summer dominate the regimes of the area with infrequent cold fronts. Convective storms result from prevalent weather conditions reaching a maximum of 35°C, while winters are relatively dry and have high evaporative demands. The mean annual evaporation across the area of the power station is approximately 1 700 mm and the calculated mean rainfall based on the historical record from the SAWS station of 683 mm/annum, based on the interpolated rain gauge stations in the area (Bailey & Pitman, 2015).

4.2 Average Rainfall

The South African Weather Services (SAWS) station 0476246W, located at 26°6.048'S and 28° 8.986'E, is the closest station to Kelvin with the most reliable daily rainfall record (64% reliability) from 1920 to 2000. Rainfall data from 2000 to 2022 was updated by simulating the observed rainfall using empirical statistical models to describe the behaviour of the daily rainfall. Additional rainfall data records from 2023-2024 were received from Kelvin Power and SAWS. The average annual rainfall from 1920 to 2000 is 724 mm; for 1920 – 2024, it is 866 mm. The monthly statistics of rainfall data and its graphical representation are given in Table 4-1 and Figure 4-2. Generally, the patterns show that December and January receive the highest rainfall, followed by the rest of the season.

Table 4-1: Monthly rainfall statistics

Rainfall (mm)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Total
Minimum	66	47	118	214	273	210	311	309	259	122	117	71	2117
10%	23	21	64	127	184	168	192	171	150	92	46	16	1255
30%	3	7	22	77	137	138	142	123	109	60	23	7	847
Average	7	7	24	67	112	113	129	101	89	46	19	8	720
70%	0	0	8	41	79	84	101	73	58	26	3	0	472
90%	0	0	0	21	40	57	67	48	38	8	0	0	278
98%	0	0	0	15	17	29	44	16	18	2	0	0	142
Maximum	0	0	0	14	10	25	42	14	10	0	0	0	113

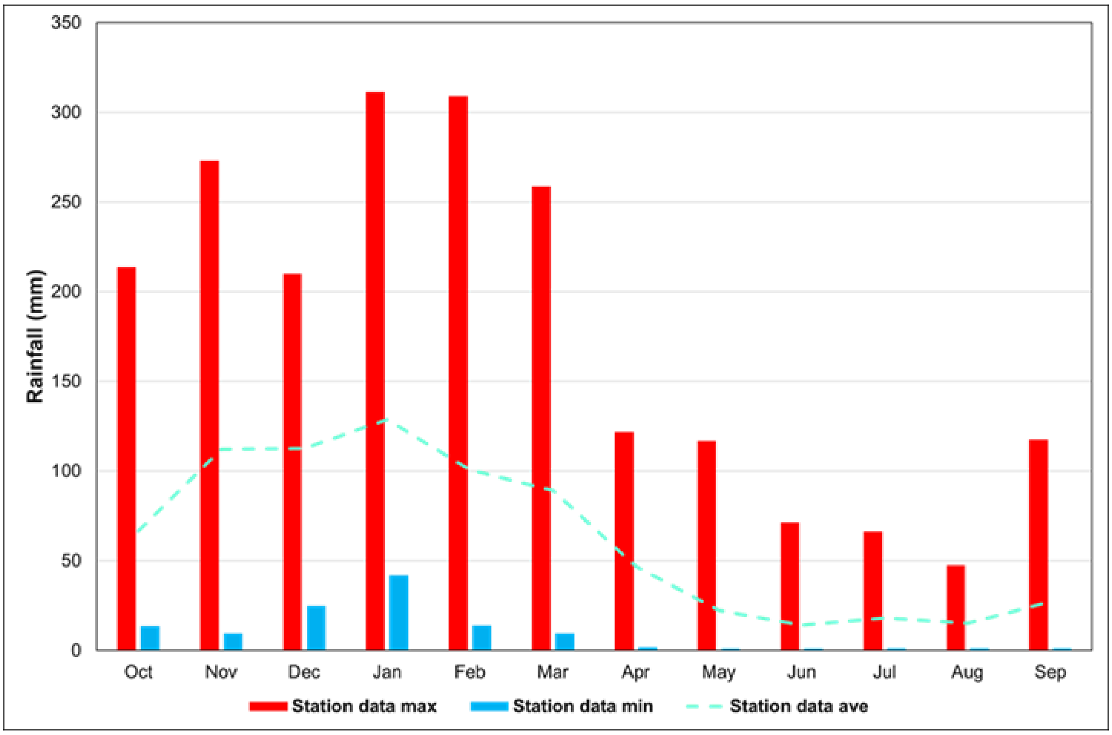

Figure 4-2: Average monthly rainfall

4.3 Evaporation Patterns

Evaporation estimations for the study site are based on the South African Water Resources Study WR2012 (Bailey & Pitman, 2015), which combined all the regions that experience similar evaporation demands and losses using the ground-based s-pan stations. Based on that, the Mean Annual Evaporation (MAE) for the areas surrounding the plant is 1 700 mm and predominantly higher during the dry month of July. These patterns suggest that open water bodies within the plant site have higher water losses, which, if not properly planned, can reduce the availability of recovered water from the ash slurry. Compared with the local evaporation A-pan station (A2E009), the A-Pan evaporation estimated MAE at 2 208 mm, resulting in a lower S-Pan evaporation for the region of 1 690 mm. The comparison of monthly evaporation patterns for the study site is graphically presented in Figure 4-3.

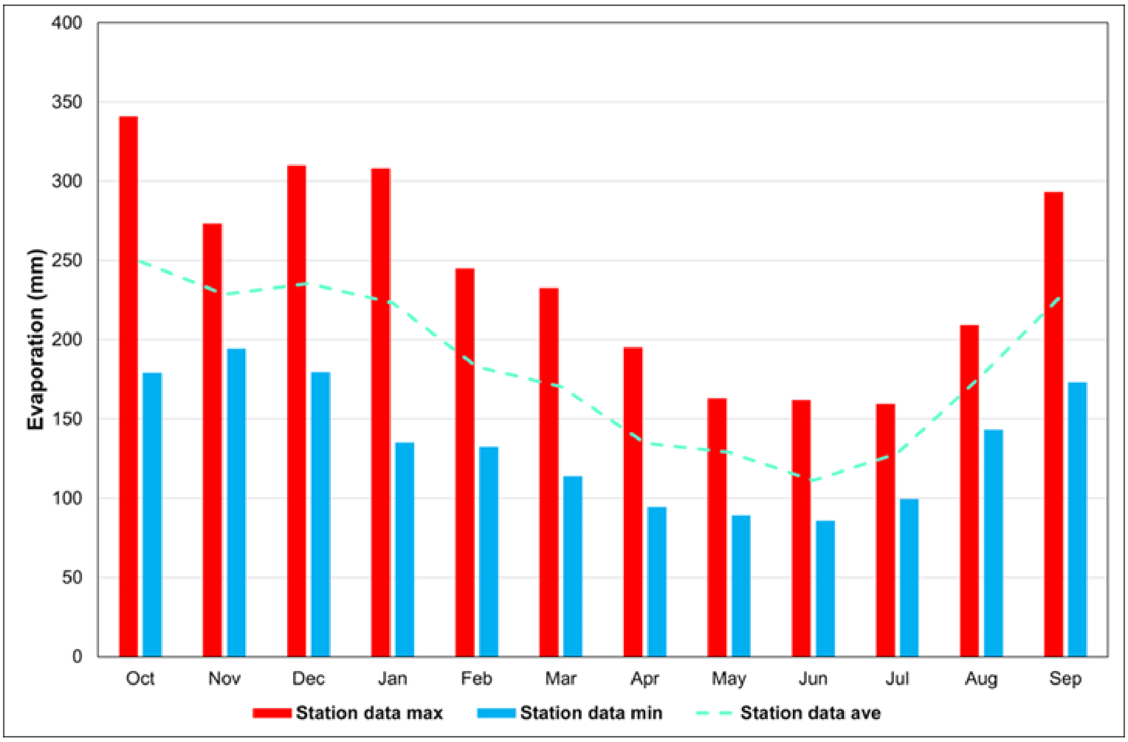

Figure 4-3: Average monthly evaporation

5 WATER PROCESS FLOW DIAGRAM AND PLANT DATA

5.1 Process Flow Diagram

In line with the DWS's BPG, understanding the water systems' boundaries and the layout of the water circuits is essential when updating the water and salt balances. The water flow processes within Kelvin for the 2024 period are presented as a Process Flow Diagram (PFD), shown in Figure 5-1. A PFD was drafted to create insights into all water-linked flows and storages within Kelvin's existing and operational infrastructure and water requirements. These components align with the central Supervisory Control and Data Acquisition (SCADA) system used in the plant site operations. The diagram distinguishes circuits and meters relevant to the level at which the water balance models the system. The green flowmeters indicate the data provided; internal circuits within the plant were not modelled. The following assumptions and information were made to calculate average water and salt balances:

- The Rand Water Board (RWB) and the Northern Wastewater Treatment Works (NWTW), situated 2 km outside Diepsloot, supply raw water to Kelvin to support operations. Raw water from RWB is demineralised before being used for steam generation in the boilers and domestic purposes throughout the station. The existing power plant includes the still operational B-Station, which comprises seven 60 MW steam turbines and eight pulverised coal boilers. On the other hand, NWTW water is used to cool the condensate and perform tasks such as ash quenching, ash slurrification, and general services.

- Most of the ash water recycled and reused in the Ash Handling System (AHS) comes from the Desilting dam, which overflows into the Ash Return Water dam. Water from this dam is pumped to the ash water buffer reservoir, which is used for various functions, including efficiently clearing ash accumulation in the ash hoppers, conveying ash in the sluiceway to the ash slurry sump and dust suppression on haul roads. Water is pumped from the ash slurry sump as a slurry by ash transfer pumps to the Ash Dam. In the Ash Dam, the ash particles settle, and the water is decanted via a penstock into a sump before discharging back into the ash return water dam.

- The secondary and main channels collect runoff from the coal stockpile area, routed with stormwater. The main channel diverts flow to either the Desilting dam or the ash return water dam for reuse in the AHS or directs it to the effluent channel to be discharged into the Modderfonteinspruit. The secondary channel discharges directly into the Modderfonteinspruit.

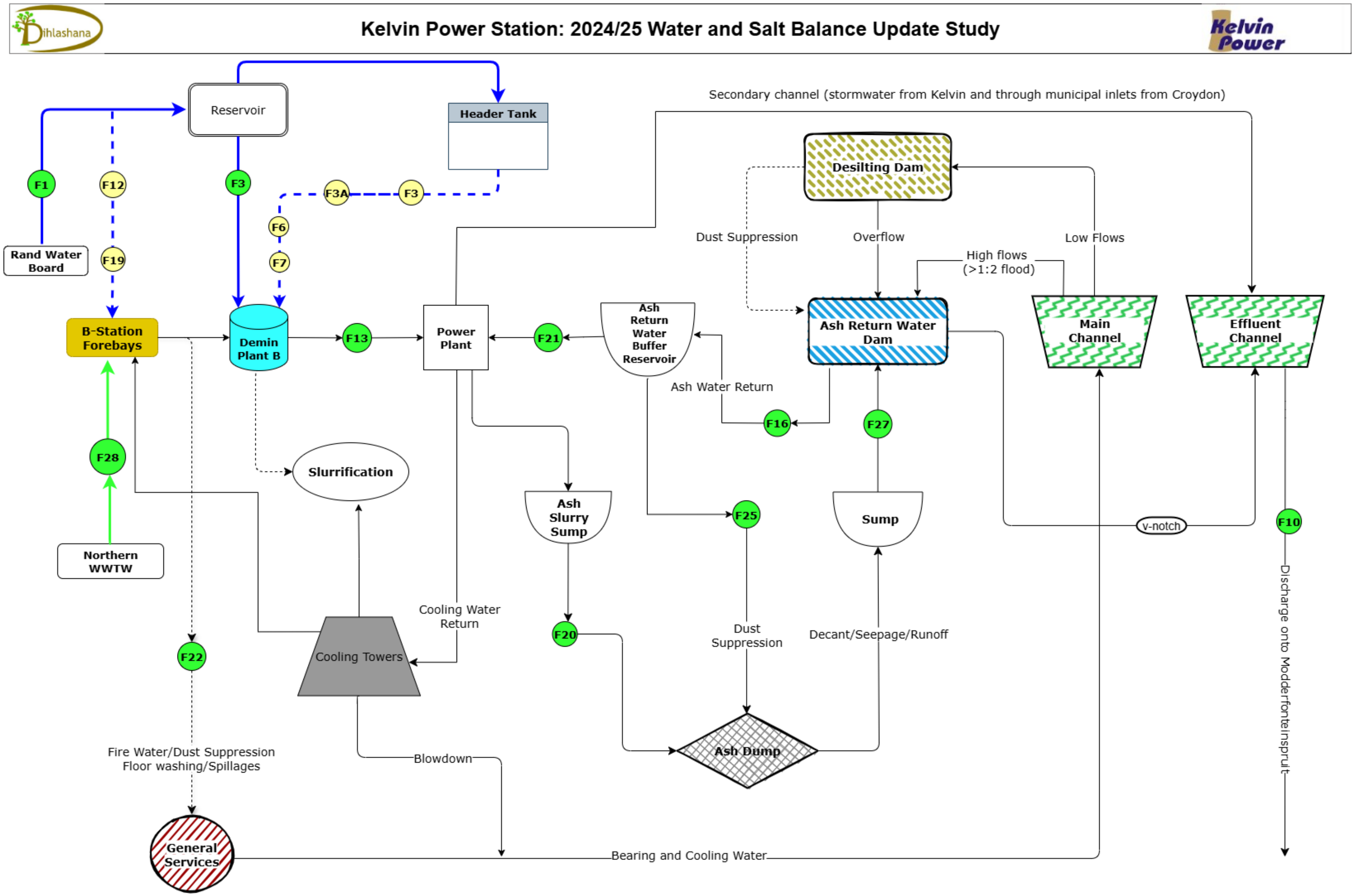

Figure 5-1: Water Process Flow Diagram for 2024/25 Kelvin Power Station infrastructure layout and operations

5.2 Plant Data

5.2.1 Modelled Plant Components

The power station operations comprise the following infrastructure:

- A-Station and B-Station Forebays,
- Plant: Demin and Power plant,
- Rand water reservoir,
- Header tank,
- Cooling towers,
- Ash return buffer reservoir,
- Ash slurry sump,
- Ash dump,
- Sump,
- Ash Return Water dam,
- Desilting dam, and
- Main and Effluent channel.

5.2.2 Input Data and Constraints

Table 5-1 details key input variables and constants used to calculate the water balance. The key assumptions made include the following:

- Seepage is based on a permeability of 6.32 x 10^{-5}m/s.
- The evaporation rate from the Cooling Towers was based on the operation of only four circulation pumps. Each circulation pump is rated at a 9 766 m^3/hr flow at a temperature differential of 11,5°C. The resulting in a combined evaporation loss accounting to 449.236 m^3/hr.
- Modern cooling towers are designed to minimise drift losses, typically maintaining drift rates between 1% and 2% of the circulating water flow. A drift rate of 1% was assumed for the B-Station cooling towers.
- Flow water measurements in the main channel are done using an installed v-notch, with its water level (m) recorded twice daily. These data are converted to daily water flow volume using the flow equation for this notch, the dimensions of which are provided in Annexure 10.2.
- The calculation for potable water demand is based on a year-round schedule and assumes a daily consumption of 70 litres per person for an average of 714 on-site employees.

Table 5-1: Assumptions used in the water balance

Water Storage Facilities	Area (m^2)
Return water dam	1 998
Desilting Dam	5 615
Ash Dam A	132 000
Runoff catchment extent	**Area (m^2)**
Main channel	28 000
Ash dam	14 500
Slurry Characteristics	
Tonnage	20.9 t/hr
Slurry density	1.01 t/m^3
Specific gravity	1.05
Volume water	1 908 m^3/day
Ash Dam	
Area of ash dam A	132 000
Seepage rate (m/s)	6.32×10^{-5}
Interstitial storage	235 m^3/day
Evaporation of wet beach (factor)	0.7
Evaporation of dry beach (factor)	0.4
% pool	5
%wet beach	15
%dry beach	80

5.3 Plant Water Use Data

The water balance model of the current infrastructure was updated to simulate the current water uses. This update focused on improvements to the accuracy of the water balance in terms of representing actual water reticulation, management and the accuracy of input and variable data. All data and information required as inputs into the water balance model were provided by Kelvin personnel. A larger proportion of the water uses included in this study is currently metered. Some water uses were calculated based on the available water meter data associated with the use. Metered data used to develop the water balance and the meters that may be responsible for the identified uncertainties are presented in Table 5-2.

Table 5-2: Flow meter readings and descriptions used in this study

Meter ID	Description	From	To	Average flow (m^3/day)
F1	Supply from RWB to the Reservoir	RWB	Reservoir	2 076
F2	NNWTW supply to the Station Forebays	NWTW	B-Station forebays	1 921
F3	RWB supply to the Header Tank	Header Tank	Demin Plant	1 414
F7	Supply from the header tank to the Demin at	Header Tank	B-Station Demin	368
F10	Final effluent into the Modderfonteinspruit	Final effluent	Modderfonteinspruit	6 768
F14	Supply from the Demin to the Plant	Station Demin	Plant	1 305
F19	Supply from RWB to the B-Station Forebays	RWB	B-station forebays	5 141
F22	Supply from the cooling towers for use as	Cooling tower	Slurrification	789

6 WATER BALANCE ANALYSIS

Figure 6-1 presents the results of the daily water balance model results based on the 2024/25 data, while monthly and annual balances are also shown in Figure 6-2 and Figure 6-3. The results present the key input, storage variable, which shows the water balance input and output volumes. The model simulation results present Kelvin station's inflow, outflow and water storage volumes. The overall water balance shows a less than 1% error difference between the inflows (33 058 m³/day) and outflows (33 059 m³/day) of the system. Explanations of the water balance results for the main components are summarised in the sub-sections below.

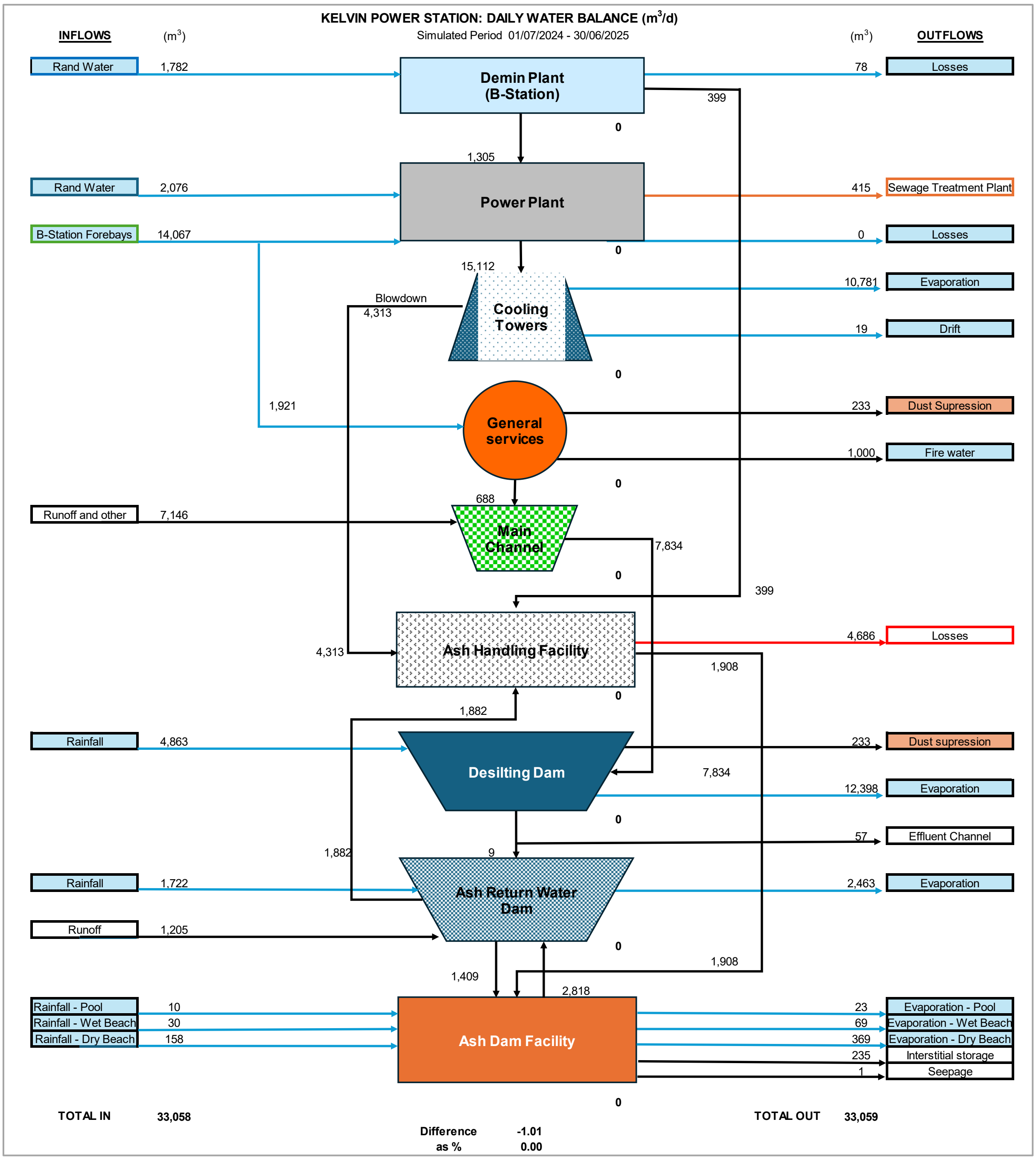

Figure 6-1: Average daily water balance

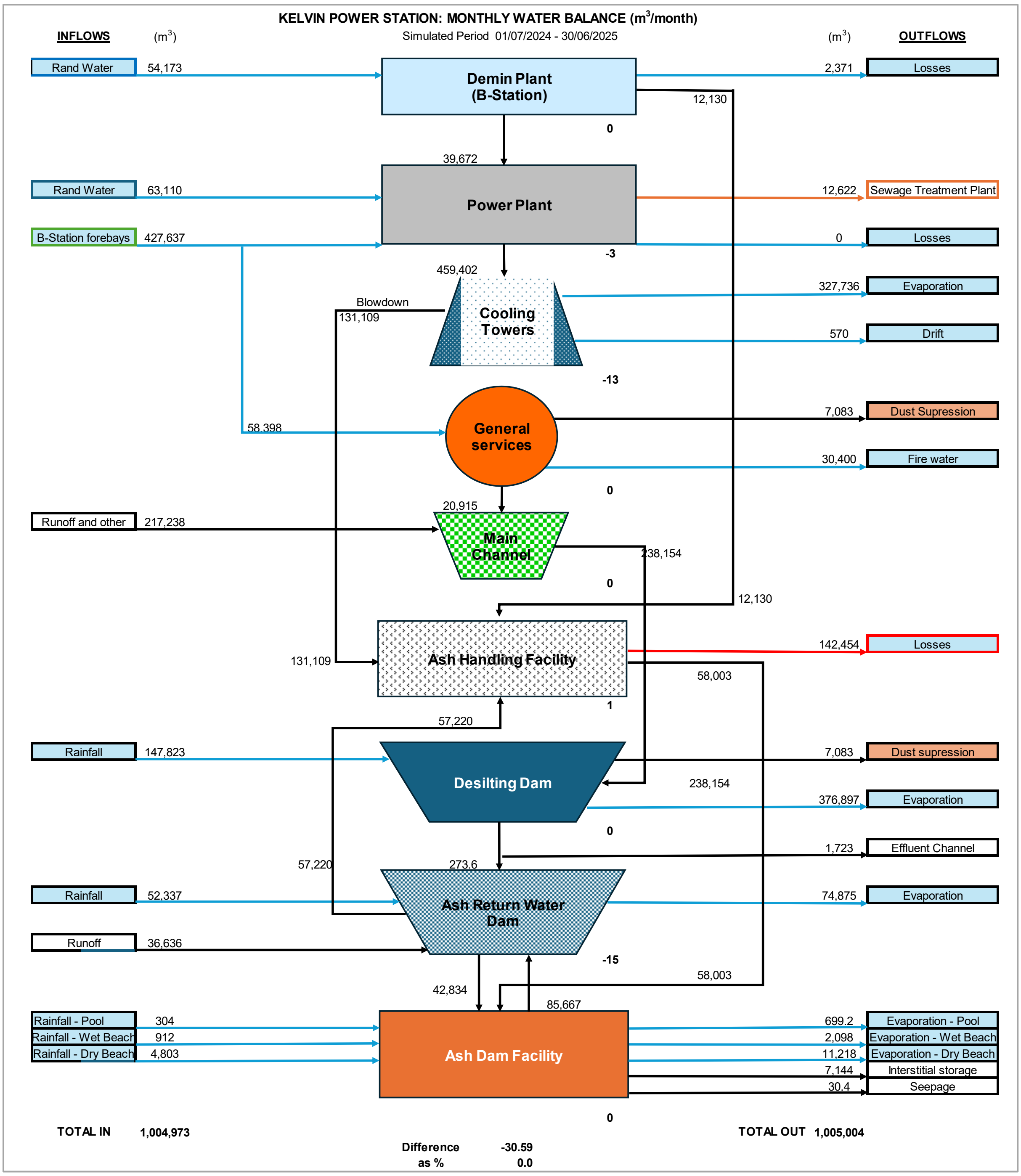

Figure 6-2: Average monthly water balance

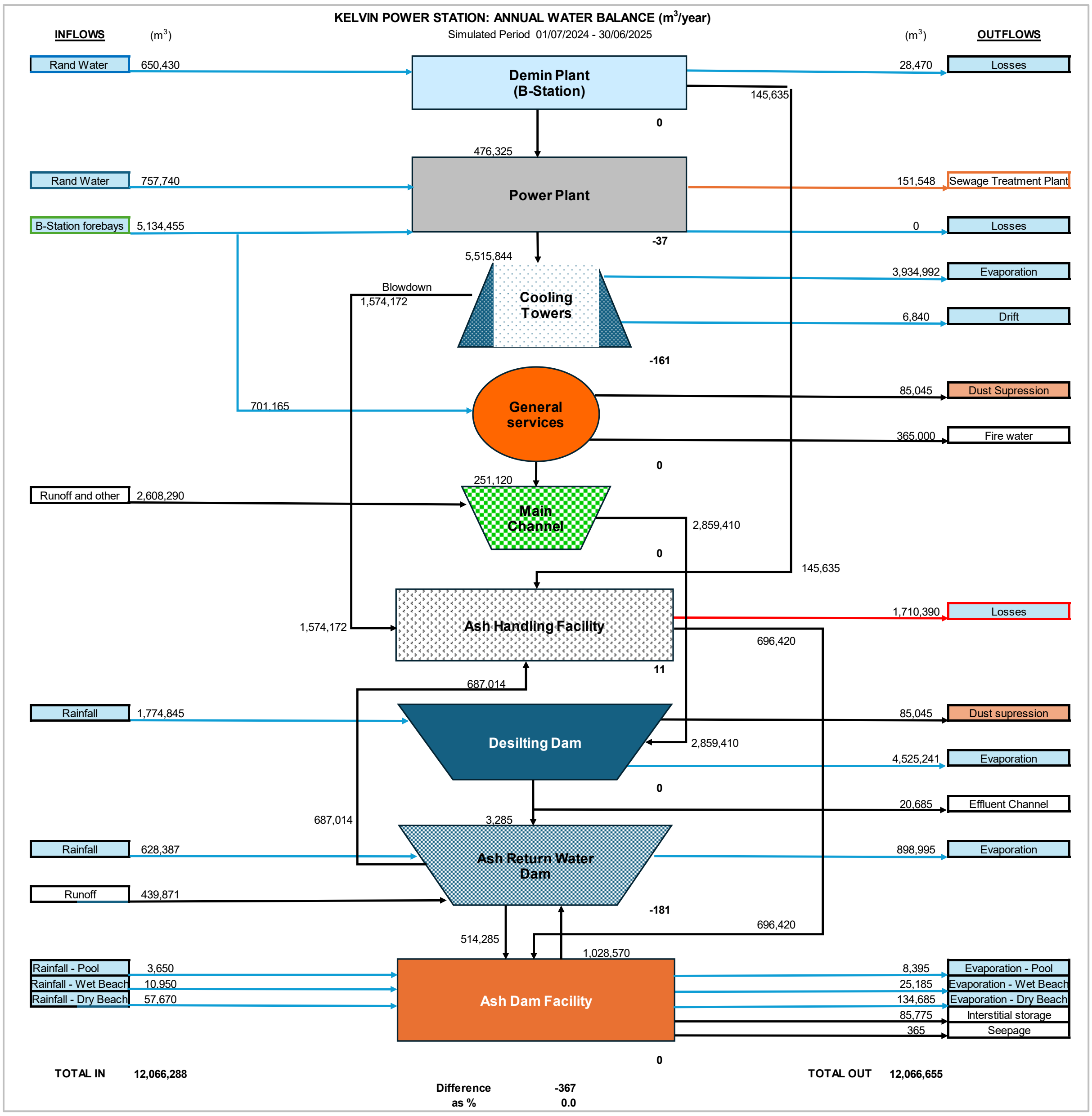

Figure 6-3: Average annual water balance

6.1 Demin Plant (B-Station)

Demin Plant receives an estimated inflow of 1 782 m^3/day (equivalent to 650 430 m^3/yr) from Rand Water. An estimated 4% of this inflow (78 m^3/day) is lost during the demineralisation process, and 399 m^3/day (22%) is discharged as regeneration water in the Ash Handling Facility. This makes 1 305 m^3/day (73%) of available water for use in the Power Plant.

6.2 Power Plant

Kelvin Power Plant receives an average of 2 076 m^3/day (about 757 740 m^3/yr) of potable water from Rand Water, of this amount, about 20% (415 m^3/day) is lost through sewage. Additionally, the Northern WWTW supplies (through B-Station Forebays), on average, 14 067 m^3/day for use in the cooling towers. This is equivalent to 5 134 455 m^3/yr of which approximately 73% of this inflow is needed as make-up water for the cooling towers.

6.3 Cooling Towers

A total of five (5) active cooling towers were operational for the reporting period. On average, 15 112 m^3/day (5 515 844 m^3/yr) is needed as make-up water for the cooling towers to dissipate the excess heat produced during power generation. Of this, an estimated 4 313 m^3/day is discharged as blowdown water to the ash handling system for reuse, while 10 781 m^3/day is lost through evaporation, based on the operation of four circulation pumps.

6.4 Ash Handling Facility

This facility receives an estimated average inflow of 6 594 m^3/day. The slurry transported to the ash dam is estimated to have a volume of water amounting to 1 908 m^3/day. There is an amount of 4 686 m^3/day that is unaccounted for. It is assumed that this flow is lost in the process.

6.5 Desilting Dam

The main channel contributes the largest inflow to the desilting dam, estimated at 7 834 m^3/day. Over 90% of this inflow, or 12 398 m^3/day, is lost via evaporation. Some of this volume of water is predominantly generated on the plant site as stormwater runoff due to paved surfaces.

6.6 Ash Return Water Dam

The return water dam receives an estimated total inflow of 2 936 m^3/day for on-site reuse. Of this, 1 882 m^3/day (64%) is estimated to be recycled in the Ash handling facility.

6.7 Ash Dam

The ash dam's total flow averages 3 515 m^3/day. Around 80% of the inflow, approximately 2 818 m^3/day, is decanted into the ash return water dam for on-site reuse. In comparison, the remaining 20% is lost through evaporation and seepage around the plant area.

7 SALT BALANCE ANALYSIS

Salt balances for the Kelvin Power Station site were undertaken to understand the volume of salt loads within its water circuit. A water balance model update discussed in the above section was used to route the salt load based on the water quality analysis for various components. The model simulated these loads (Sulphates) to estimate the average daily, monthly and annual salt balances. Daily salt load results are presented in Figure 7-1 while others are given in Appendix 10.1. Results show a generation of loads from the plant to the environment.

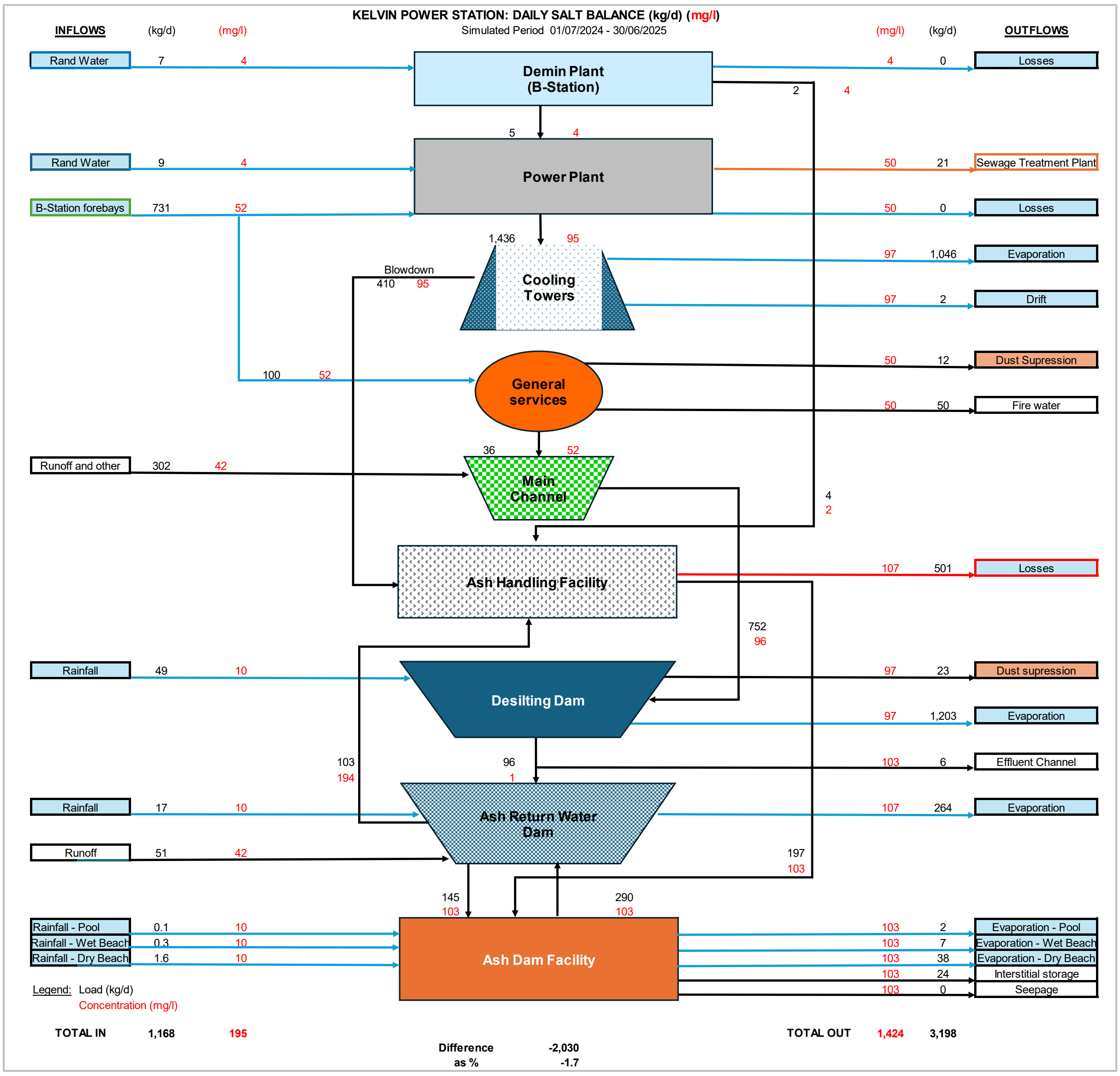

Figure 7-1: Average daily salt balance

7.1 Water Use Licence Limit

Table 7-1 shows the average water quality results for the year 2024/2025 compared with the WUL requirements. The exceedance is highlighted in red in the table.

Table 7-1: Water quality limits

Variable	Secondary channel	Desilting dam	Ash Seepage	Tower B	Northern Waste Treatment Works	Croydon	Effluent	Upstream of Modderfonteinspruit	Downstream of Modderfonteinspruit	WUL Limit
pH	8.23	8.4	**10.43**	7.95	7.16	7.71	8.93	8.71	8.42	5.0 - 9.5
Electrical Conductivity [EC] (µS/cm)	**1 261**	**1 650**	**1 660**	**2 167**	**727**	**613**	**1 644**	**1 598**	**1 255**	115
Sulphate (SO_4) mg/ℓ	92	96	103	95	52	52	104	100	92	200
Chloride (Cl) mg/ℓ	**120**	**167**	**183**	**252**	69	44	**168**	**151**	**118**	103.4
Sodium (Na) mg/ℓ	17	26	24	30	11	7	21	25	20	49.5
Magnesium (Mg) mg/ℓ	**289**	**144**	35	**198**	**68**	**169**	**104**	**111**	**131**	61.6
Calcium (Ca) mg/ℓ	**138**	**243**	**253**	**324**	90	73	**274**	**263**	**209**	100
Nitrate (NO_3) mg/ℓ	6	**23**	**12**	**34**	**10**	**7**	**15**	**15**	**12**	6
Fluoride (F) mg/ℓ	**0.6**	**1.4**	**0.5**	**3.4**	**1.1**	**1**	**1.7**	**2.9**	**1.1**	0.3
Suspended Solids mg/ℓ	5	24	8	43	22	13	14	15	10	40
F. Coli CFU/mℓ	695			3 492	400 628	32 946	2 029			

The table shows that there are high levels of concentration of salts within the Kelvin Power Station, which contributes to elevated values of Electrical Conductivity in Modderfonteinspruit. It is evident from most of the sampled components of the power station that they are not compliant with the limits set in the WUL issued for Kelvin.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The following findings were derived from this study:

- Raw water to supply the Kelvin operation is sourced from Rand Water and Northern Wastewater Treatment Works and was measured to account for 17 925 m^3/day. It was calculated that about 4% of this water is lost through systematic losses, which equates to 78 m^3/day (28 740 m^3/yr). This water is mainly used to operate the Demin and Power Plant, as well as for general services.

- The overall water balance indicated that a daily average volume of 17,925 m^3 of water is required to run the current operations at Kelvin. Of this volume, 4% (78 m^3/day) accounts for losses, while 73% (1 305 m^3/day) is used at the Power Plant. It was calculated that 22% (399 m^3/day) is recovered from the Ash Handling Facility. An estimated average daily volume of water recovered from the Ash Return Water Dam to the Ash Handling Facility was calculated to be 1 882m^3/day (~687 014 m^3/yr).

- Results show that the overall 2024/25 water balance has less than 1% error difference between the inflows (33 058 m^3/day) and outflows (33 059 m^3/day) of the system. Of these inflows, approximately 14% (4 686 m^3/day) remains unaccounted for, and it is assumed that this inflow is lost at the ash handling facility to achieve a balance.

- Average salt balance calculations were based on the established water balance model, which was used to route salt load, applying Sulphates (SO_4) concentration data for monitored components. Results show that Kelvin Power Station, on average, generates a daily salt load of 3 198 kg from an inflow of 1 168 kg/day. This indicates that about 2 020 kg/day is generated within the plant site. Water quality data shows that the station generates salts that elevate electronic conductivity in the downstream areas, which is non-compliant with the water use license limits.

8.2 Recommendations

Recommendations derived from the study include:

- The Ash Handling Facility required more metered values to calibrate the facility better

- It is also recommended that flow meters be operational for maximum collection of flow data from various components to improve the future water and salt balance model.

- Implement the Plant site water conservation and demand management plan to reduce facility wastewater and monitor flow circulation within the cooling towers.

- Implement efficient stormwater management plans to enhance the collection of recovered water from the Ash Dam and reduce groundwater recharge.
- Verify meter placement in the SCADA systems is commensurate with the actual location on-site and address meter calibration findings to facilitate consistent and valid flow data.

9 REFERENCES

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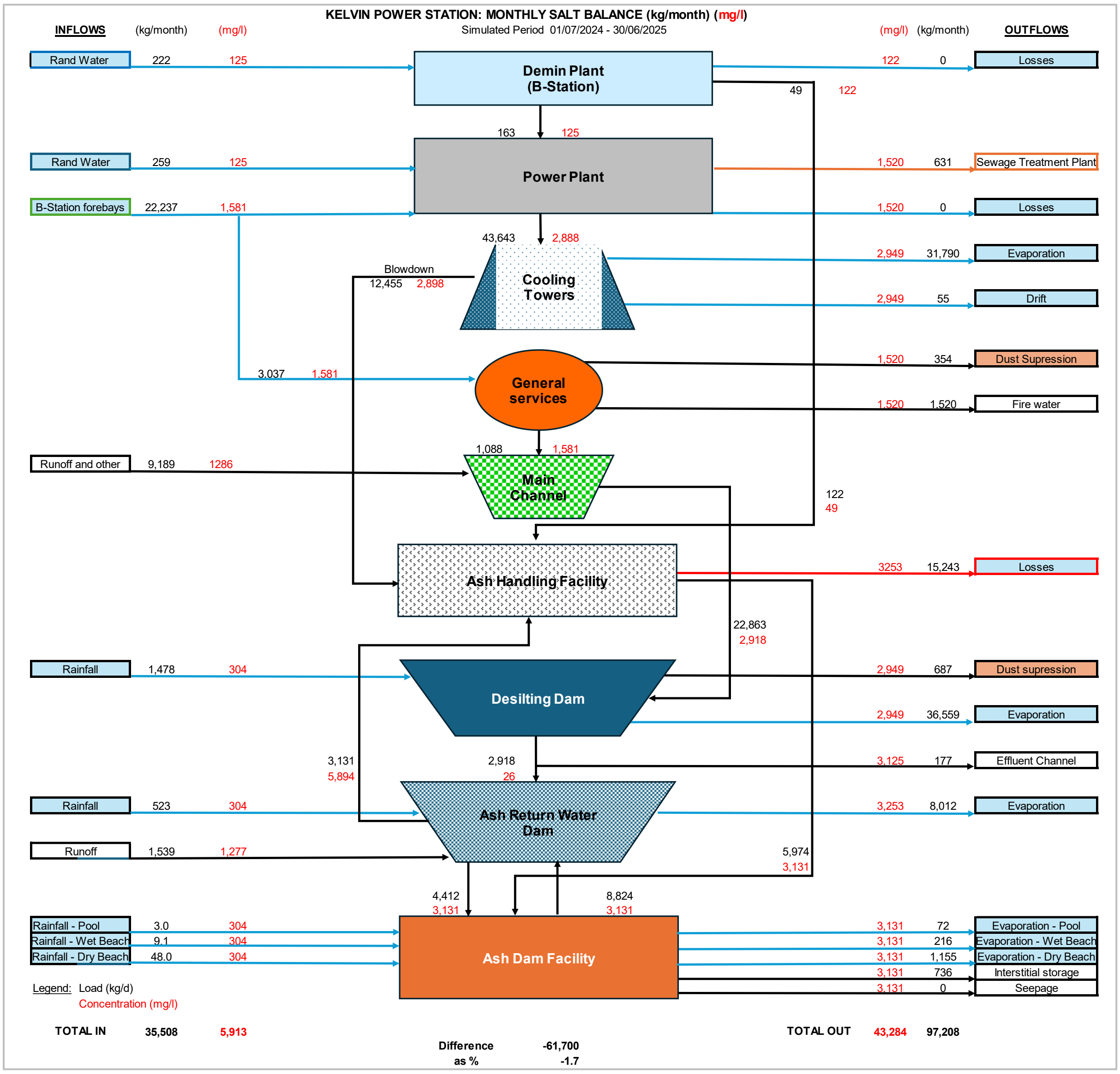
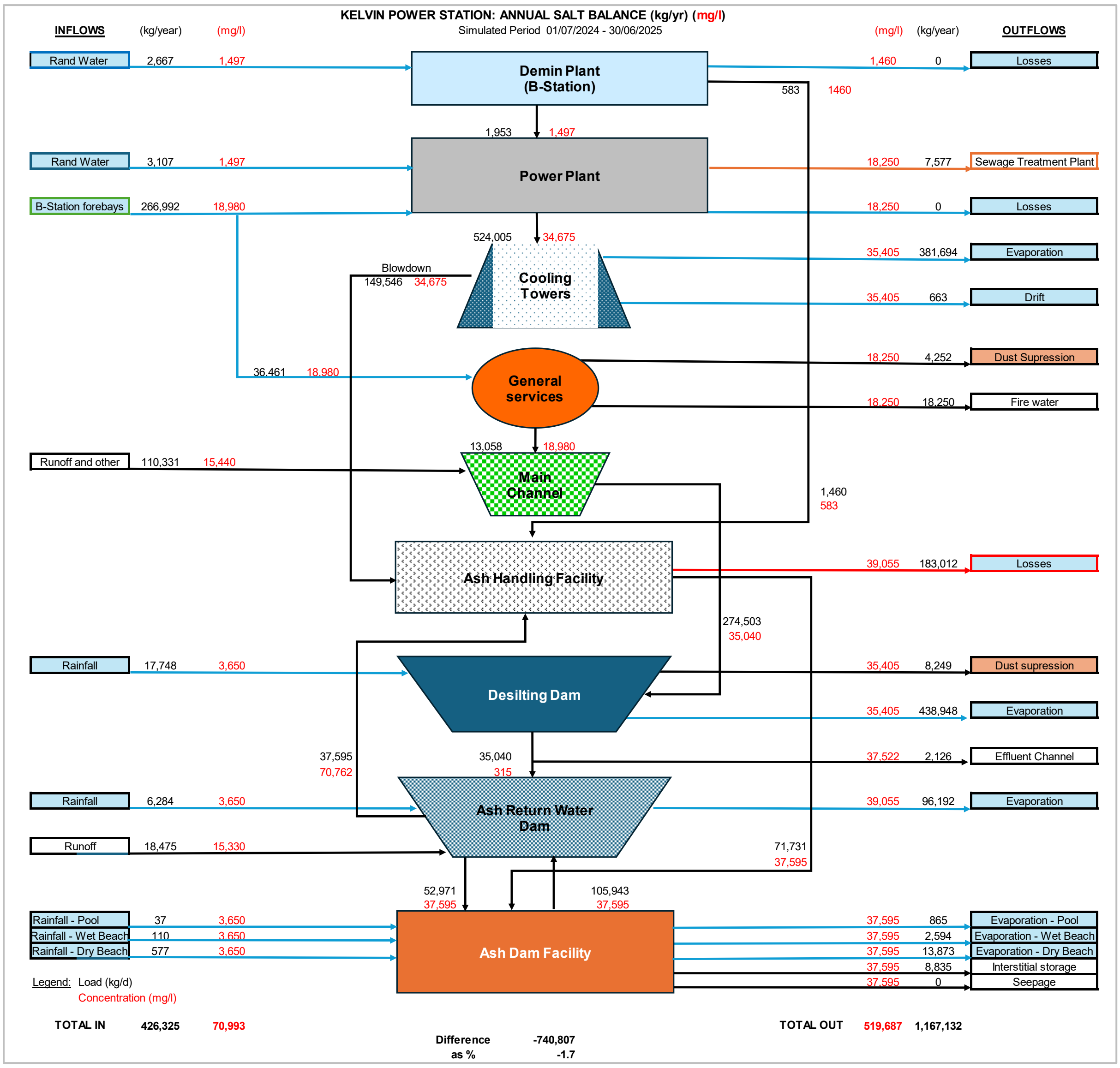
10 APPENDIX

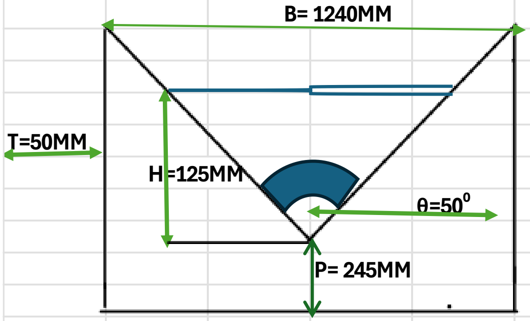
10.1 Water Quality – Monthly and Annual Salt Balances



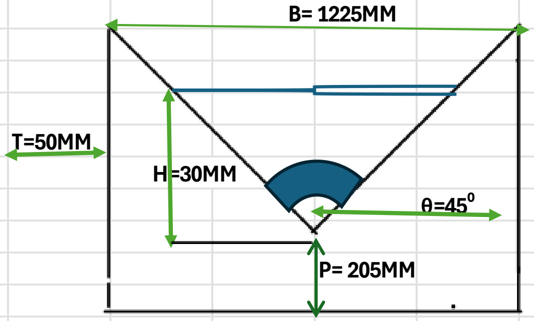

KELVIN POWER STATION: ANNUAL SALT BALANCE (kg/yr) (mg/l)
Simulated Period 01/07/2024 - 30/06/2025
INFLOWS (kg/year) (mg/l)
Rand Water 2,667 1,497
Rand Water 3,107 1,497
B-Station forebays 266,992 18,980
Runoff and other 110,331 15,440
Rainfall 17,748 3,650
Rainfall 6,284 3,650
Runoff 18,475 15,330
Rainfall - Pool 37 3,650
Rainfall - Wet Beach 110 3,650
Rainfall - Dry Beach 577 3,650
Demin Plant (B-Station)
1,953 1,497
583 1460
Power Plant
524,005 34,675
Cooling Towers
Blowdown 149,546 34,675
36,461 18,980
General services
13,058 18,980
Main Channel
1,460 583
Ash Handling Facility
274,503 35,040
Desilting Dam
37,595 70,762
35,040 315
Ash Return Water Dam
71,731 37,595
52,971 37,595
105,943 37,595
Ash Dam Facility
(mg/l) (kg/year) OUTFLOWS
1,460 0 Losses
18,250 7,577 Sewage Treatment Plant
18,250 0 Losses
35,405 381,694 Evaporation
35,405 663 Drift
18,250 4,252 Dust Supression
18,250 18,250 Fire water
39,055 183,012 Losses
35,405 8,249 Dust supression
35,405 438,948 Evaporation
37,522 2,126 Effluent Channel
39,055 96,192 Evaporation
37,595 865 Evaporation - Pool
37,595 2,594 Evaporation - Wet Beach
37,595 13,873 Evaporation - Dry Beach
37,595 8,835 Interstitial storage
37,595 0 Seepage
Legend: Load (kg/d)
Concentration (mg/l)
TOTAL IN 426,325 70,993
TOTAL OUT 519,687 1,167,132
Difference -740,807
as % -1.7

10.2 V-notch dimensions

V- NOTCH 2 PARAMETERS



V- NOTCH 1 PARAMETERS



KEY SYMBOLYS/ WORDS

KEY SYMBOLYS	MEANING
B	Channel depth/ width
T	Weir Thickness
H	Water Head
P	V-notch heigt
θ	Angle of v-Notch

V-NOTCH AREAS

V-NOTCH 1	**V-NOTCH 2**
A=0,74	A=1,05