

KELVIN POWER STATION

Quarterly Report:

November/December 2024 Biomonitoring and Toxicity Testing

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1. Introduction & Objectives

1.1 Background

This report represents the fourth quarterly survey of the 2024 biomonitoring programme, dealing with the biomonitoring (second biannual survey) conducted in November 2024 and the toxicity testing results (fifth quarterly survey) based on the December 2024/January 2025 sampling events. In addition, the temporal trends are also updated and presented in this report where deemed applicable. The biomonitoring assessment protocols include DEEEP (Direct Estimation of Ecological Effect Potential) lethal/sub-lethal toxicity water testing, chronic sediment contact toxicity testing, and SASS5 (macroinvertebrate assessments) assessments.

Clean Stream has designed and performed a biological monitoring program for Kelvin power station (KPS) on a quarterly basis since 1999 which complies with the Department of Water Affairs (DWS) licencing requirements (see Table 1 for a list of recent monitoring surveys and reports, released since 2006). This monitoring program is continuously being reviewed and refined to meet the needs of the client (KPS) as well as its water use licence and the latest scientific standards. In line with this approach, the biomonitoring program was further refined for the 2015 monitoring period (beginning with report KEL-B-15). The ash investigation was downscaled to include only one round of sediment testing per year. The final effluent (Eff) sample's toxicity testing was upgraded from screening to definitive. Toxicity was previously detected in this sample and it is the standard DEEEP approach to do definitive toxicity testing on samples that are not from natural river sources.

As of July 2024, the Pollution Control Dams, namely the Return Water Dam (RWD), Ash Dam, and Desilting Dam are included for toxicity testing. Toxicity testing was limited to one trophic organism on a screening level for the July 2024 samples in an attempt to reach compliance within the set out time, however toxicity testing will in future be conducted on a definitive level (with a minimum of three test organisms).

This report provides a detailed discussion of the second biomonitoring survey and refers to the fifth toxicity testing survey for the year of 2024, and is therefore part of the continuation of the biological monitoring programme as refined during the 2015 surveys. Any single report should not be interpreted in isolation but reference should be made to previous survey reports where applicable and to maintain an overall view of the biomonitoring programme. Where relevant, reference is also made to results gained during previous surveys.

Direct Estimation of Ecological Effect Potential (DEEEP)

The National Water Act (Act no. 36 of 1998) implemented an approach known as the DEEEP protocol as a means of circumventing the shortcomings of direct toxicant monitoring. This protocol consists of a battery of tests to directly assess lethal (acute) and sub-lethal (chronic) toxicity, using test organisms from a range of trophic levels.

South African Scoring System (SASS) Version 5

"The assessment of biota in rivers is a widely recognised means of determining the condition or health of rivers. Benthic macroinvertebrates, in particular, are recognised as valuable organisms for bioassessments, due largely to their visibility to the naked eye, ease of identification, rapid life cycle often based on the seasons and their largely sedentary habits." – *Dickens and Graham, 2002*

Table 1: List of most recent surveys and their corresponding report numbers.

Annual program	Month, quarter and report number of surveys			
	Quarter 1	Quarter 2	Quarter 3	Quarter 4
2006		Apr-06	Aug-06	Dec-06
		KEL-B-06	KEL-C-06	KEL-A-07
2007	Feb-07	May-07		Oct-07
	KEL-B-07	KEL-C-07		KEL-D-07
2008	Feb-08	Jun-08	Sep-08	Dec-08
	KEL-A-08	KEL-B-08	KEL-C-08	KEL-D-08
2009	Apr-09	Jun-09	Sep-09	Dec-09
	KEL-A-09	KEL-B-09	KEL-C-09	KEL-D-09
2010	Mar-10	Jun-10	Aug-10	Nov-10
	KEL-A-10	KEL-B-10 & KEL-C-10	KEL-D-10	KEL-E-10 & KEL-F-10
2011	Feb-11	May-11	Aug-11	Nov-11
	KEL-A-11	KEL-B-11	KEL-C-11	KEL-D-11
2012	Mar-12	Jun-12		Dec-12
	KEL-A-12	KEL-B-12		KEL-C-12
2013	Apr-13	Jun-13	Sep-13	Dec-12
	KEL-A-13	KEL-B-13	KEL-C-13	KEL-D-13
2014	Feb-14	May-14	Sep-14	Oct-14 & Nov-14
	KEL-A-14	KEL-B-14	KEL-C-14	KEL-D-14 & KEL-A-15
2015	Feb-15	May-15	Aug-15	Oct-15
	KEL-B-15_Tox	KEL-C-15	KEL-D-15_Tox	KEL-E-15
2016	Feb-16	May-16	Aug-16	Nov-16
	KEL-A-16_Tox	KEL-B-16	KEL-C-16_Tox	KEL-D-16
2017	Feb-17	May-17	Aug-17	Nov-17
	KEL-A-17_Tox	KEL-B-17	KEL-C-17_Tox	KEL-D-17
2018	Feb-18	Jun-18	Aug-18	Dec-18
	KEL-A-18_Tox	KEL-B-18	KEL-C-18_Tox	KEL-D-18
2019		Jun-19	Aug-19	Nov-19
		KEL-A-19	KEL-B-19_Tox	KEL-C-19
2020	Feb-20	May-20		
	KEL-A-20_Tox	KEL-B-20		
2021	Apr-21	Jun-21	Aug-21	Nov-21
	KPS-A-21_Tox	KEL-B-21 & KPS-B-21_Tox	KPS-C-21_Tox	KEL-D-21 & KPS-D-21_Tox
2022	Apr-22	Jun-22	Sep-22	Nov-22
	KPS-A-22_Tox	KEL-B-22 & KPS-B-22_Tox	KPS-C-22_Tox	KEL-D-22 & KPS-D-22_Tox
2023	Mar-23	Jun-23	Aug-23	Nov-23
	KPS-A-23_Tox	KEL-B-23 & KPS-B-23_Tox	KPS-C-23_Tox	KEL-D-23 & KPS-D-23_Tox
2024	Mar-24	May-24 & Jul-24	Sep-24	Dec-24
	KPS-A-24_Tox	KEL-B-24; KPS-B-24_Tox; KPS-C-24_Tox	KPS-D-24_Tox	KEL-D-24 & KPS-E-24_Tox

Key: Months in green/italic font = not correlating with calendar quarters. Such surveys still functional, as monitoring quarters for the specific year's program, in terms of licencing requirements. Not correlating to calendar quarters due to either weather or valid logistical reasons.

1.2 Objectives of the Biomonitoring Programme

The main objective of this biomonitoring programme is to identify and quantify any potential impacts of the Kelvin power station on the biotic integrity of the receiving water body (Modderfonteinspruit) by means of the following:

- Spatial comparisons of biotic integrity (based on macroinvertebrates, SASS5) of the Modderfonteinspruit up- and downstream from potential Kelvin power station impacts.
- Spatial cumulative impact analyses to include other users for a distance of 4km downstream from Kelvin power station.
- Temporal analyses of results to determine the trajectory of change in terms of biotic integrity of the receiving water body and upstream catchment. Temporal analyses will facilitate the

assessment of cumulative impacts (in reference to the data collected up to date for sites K1 and K2) over time. Note should be taken that temporal analyses are only possible from 1999 (and not before) when the biomonitoring program was initiated.

- The verification of the potential non-Kelvin power station impacts derived from the upstream catchment and the cumulative impact of all users for a distance of 4 km downstream.
- Lethal/sub-lethal environmental risk classification of Kelvin power station effluents on the biota of the receiving water body (by means of toxicity analyses).
- Lethal/sub-lethal environmental toxicity risk classification of the Modderfonteinspruit both upstream and downstream from Kelvin power station (by means of toxicity analyses). This serves to illustrate the toxicity contribution (cumulative impact) from the industrial area upstream from the power station.

The above-mentioned objectives will be instrumental in the gauging of environmental management effectiveness and assist in the recommendation of mitigating measures to negate any adverse impacts that may originate at Kelvin power station. It will furthermore meet the needs of environmental monitoring in terms of the latest licencing requirements.

The continuation of toxicity testing on the Modderfonteinspruit, both upstream and downstream from (before and after) the introduction of Kelvin power station effluents, as performed since the last quarter of 2007, will be maintained. This adds the benefit of illustrating the toxicity level (risk) associated with the water from the industrial area upstream from the power station, excluding potential power station impacts. It has also shown at times that the power station effluents lowered the toxicity risk by means of dilution of this polluted water from the upstream industrial area.

2. Study Area & Schedule of Activities

2.1 Study area

Biomonitoring localities were selected to be easily accessible and representative of as many habitats as possible. The Modderfonteinspruit is the primary receiving water body via a natural drainage line (named Effluent Stream for the purposes of this report) that originates within Kelvin power station (KPS) grounds (Figure 1). The reach of the Modderfonteinspruit that forms part of the study area also receives impacts from industrial and residential areas as well as a golf course (Figure 1). Licensing conditions refers to monitoring of impacts to the Edenvale Spruit (Figure 2), however, no known KPS effluent directly enters the Edenvale Spruit, and clarification should be sought as to the exact localities of the streams/rivers (Edenvale Spruit or other) referred to in the licensing conditions and amendment should be sought if necessary.

Four biomonitoring sampling sites were selected in the Modderfonteinspruit. One site was selected to be upstream (K1) and another to be downstream (K2) from water entering the Modderfonteinspruit from Kelvin power station via the Effluent Stream (Table 2; Figure 1). The Effluent Stream is not ideally suited to SASS5 biomonitoring, given its small size and fairly shallow water. Given that the Effluent Stream originates within KPS, there is no available upstream (control) site for comparative biomonitoring. Two more downstream sites (K3 and K4) in the Modderfonteinspruit were also included since the June 2010 survey to assess the potential cumulative impact for a distance of a few additional kilometres downstream. Refer to Appendix 3 for photographs of the individual biomonitoring sites.

Four stream sites were selected for toxicity testing. The first two are sites K1 and K2 as explained above. Two more toxicity sites were selected within the Effluent Stream draining from the power station towards the Modderfonteinspruit. The upstream site (site Eff) was selected within the power station boundaries to be inclusive of only potential impacts originating from the power station. An additional site (site Eff-plus) was included (since the June 2009 survey) downstream within the Effluent Stream, just before its confluence with the Modderfonteinspruit. This was done to address concerns pertaining to increasing development within the industrial area and a probable increase in non-Kelvin power station related impacts on the water quality.

within this stream. By comparing the upstream and downstream sites within the Effluent Stream, a clear indication can be observed regarding non-Kelvin power station impacts that may be adding to the toxicity risk in the Modderfonteinspruit. This monitoring strategy also enhances the cumulative impact assessment of the monitoring programme.

Additionally, as of July 2024, the Pollution Control Dams, namely the Return Water Dam (RWD), Ash Dam, and Desilting Dams are included for toxicity testing (Table 2; Figure 1). These facilities are tested on a definitive level, allowing the estimation of safe dilution factors should a release (accidental or planned) take place. Planned releases should, however, always be conducted within licencing conditions as set out by the Integrated Water Use License (IWUL).

Table 2: Latitude/Longitude, site description, protocols applied and frequency of application at the different monitoring sites.

Monitoring site	Description	Biomonitoring protocols		GPS coordinates	
		Protocol	Frequency per annum	Latitude (South)	Longitude (East)
K1	Upstream (from Kelvin Power Station effluent) site in the Modderfonteinspruit.	SASS5 and in-situ water quality	Six-monthly	S26.119475°	E 28.173828°
		Toxicity (acute screening water)	Quarterly		
		Toxicity (direct sediment contact)	Annual		
K2	Downstream (from Kelvin Power Station effluent) site in the Modderfonteinspruit.	SASS5 and in-situ water quality	Six-monthly	S 26.109192°	E 28.168992°
		Toxicity (acute screening water)	Quarterly		
		Toxicity (direct sediment contact)	Annual		
K3	Approximately 1km downstream from site K2, on the Modderfontein golf course in the Modderfonteinspruit.	SASS5 and in-situ water quality	Six-monthly	S 26.103308°	E 28.1658°
		Toxicity (acute screening water)			
		Toxicity (direct sediment contact)			
K4	Approximately 2km downstream from K3, directly downstream from an instream pollution control dam in the Modderfonteinspruit.	SASS5 and in-situ water quality	Six-monthly	S 26.095919°	E 28.151933°
		Toxicity (acute screening water)			
		Toxicity (direct sediment contact)			
Eff	Effluent stream within the power station boundary.	SASS5 and in-situ water quality		S 26.121806°	E28.183108°
		Toxicity (definitive testing water)	Quarterly		
		Toxicity (direct sediment contact)			
Eff-plus	Effluent stream, downstream from the power station, just upstream from confluence with Modderfonteinspruit	SASS5 and in-situ water quality		S 26.118978°	E 28.174103°
		Toxicity (acute screening water)	Quarterly		
		Toxicity (direct sediment contact)	Annual		
RWD	Pollution control facility - return water dam			S 26.120857°	E 28.183835°
		Toxicity (definitive testing water)	Quarterly		
Ash Dam	Pollution control facility			S 26.119063°	E 28.189330°
		Toxicity (definitive testing water)	Quarterly		
Desilting Dam	Pollution control facility			S 26.121652°	E 28.189947°
		Toxicity (definitive testing water)	Quarterly		

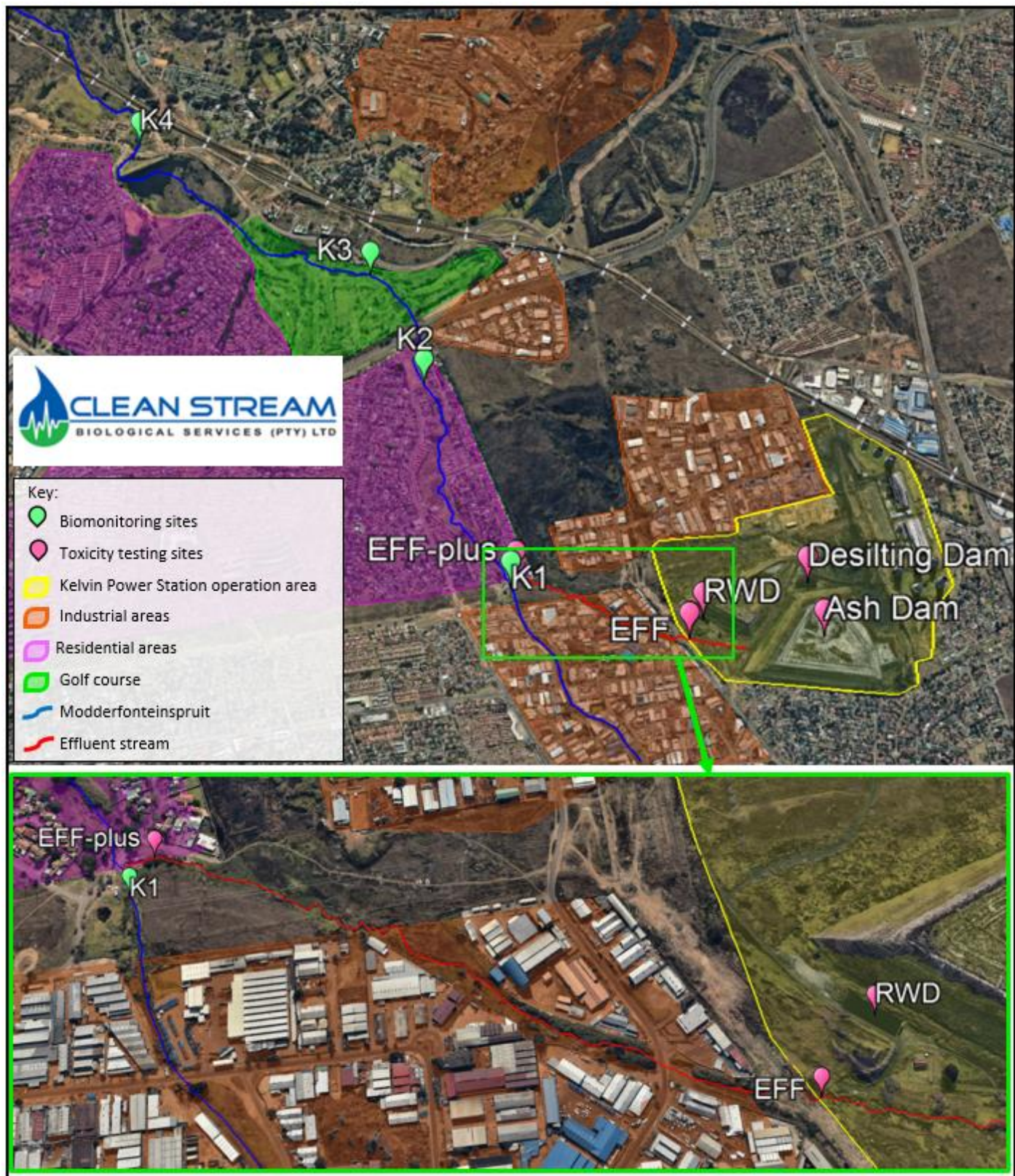


Figure 1: Map indicating position of monitoring sites, the power station, golf course, industrial areas and residential areas.

11.2 BIOMONITORING

- 11.2.1 An Aquatic Scientist approved by the Regional Head must establish a monitoring programme for the following indices: Invertebrate Habitat Assessment System (IHAS) and the latest SASS (South African Scoring System). Sampling must be done once during the summer season and once during the winter season, annually, to reflect the status of the river upstream and downstream of the industrial activities.
- 11.2.2 Toxicity testing to be performed on the effluent leaving the site at the desilting dams, the secondary channel and effluent entering the Edenvale Spruit on a quarterly basis in order to determine the risks to the receiving environment. The data gathered in the investigation must be reported annually during July of each year to the Regional Chief Director. If any toxicity levels as specified is exceeded, the Licensee must institute an investigation to determine the cause of toxicity.
- 11.2.3 Toxicity testing must be conducted quarterly on the wastewater stream from the Ash Dam and Return Water Dam when returned back to the Power Station for use as process water.
- 11.2.4 The Licensee shall participate in any initiative such as Direct Estimation of Ecological Effect Potential (DEEEP) to determine the toxicity of complex tailings waste discharges. Both acute and chronic toxicity must be addressed and at least three taxonomic groups must be present when toxicity tests are performed.
- 11.2.5 The Licensee shall determine the accumulative impact due to both past and present activities on the Edenvale Spruit and the Modderfontein Spruit.
- 11.2.6 Analysis shall be carried out in accordance with methods prescribed by and obtainable from the South African Bureau of Standards (SABS), in terms of the Standards Act, 1982 (Act 30 of 1982).
- 11.2.7 The methods of analysis shall not be changed without prior notification to and written approval by the Minister.

Figure 2: Excerpt from the IWUL biomonitoring requirements.

2.2 Annual schedule of monitoring and reporting activities

Please refer to Table 3 below for the schedule of monitoring activities, performed and scheduled for the 2024 monitoring period. All planned monitoring activities were conducted during the May 2024 survey. The toxicity testing samples from the PCDs were only collected in July 2024, and performed on a low level of confidence, with only a single of at least three trophic levels required to achieve a high level of confidence included with the results. Future surveys will include at least three levels of testing.

Table 3: Annual Kelvin biomonitoring, toxicity and ash impact assessment scheduling – 2024.

Kelvin Biomonitoring and toxicity classification (planned quarterly activities)				
Item	Survey 1 - Mar 2024	Survey 2 - May/Jul 2024	Survey 3 - Sep 2024	Survey 4 - Nov/Dec 2024
SASS5 surveys		completed		completed
In-situ water quality assessments		completed		completed
DEEEP - Toxicity analyses				
<i>Daphnia magna</i> screening/definitive toxicity testing	completed	completed	completed	completed
<i>Poecilia reticulata</i> screening/definitive toxicity testing	completed	completed	completed	completed
<i>Allivibrio fischeri</i> screening/definitive toxicity testing	completed	completed	completed	completed
6 day chronic <i>Heterocypris incongruens</i> (OSTRCOD) sediment contact screening test				completed
Electronic toxicity reports - DEEEP hazard classification	completed	completed	completed	completed
Detailed reports (SASS5 and toxicity integration and cumulative temporal analyses)		completed		completed

4. Results and Discussion

4.1 *In-situ* Water Quality

Temporal trends in electrical conductivity (EC) levels are included as of May 2024 (Figure 3b). Linear trends were fitted to data collected since December 2018 to assess long-term variation in the salinity (EC) of the biomonitoring sites. The temporal trends will assist in identifying reaches (between monitoring sites) of concern and also in guiding mitigation measures.

4.1.1 November 2024 survey results

Surface flow was moderate at moderate at site K1, decreasing to low at site K2, and again increasing to moderate at sites K3 and K4 during the November 2024 survey. The water was clear at sites K1 and K2, but slightly turbid at site K3 and K4. Although turbidity was not particularly high during the current survey, some previous surveys have reflected turbid water along this reach of the Modderfonteinspruit. High turbidity detrimentally impacts on biotic integrity by clogging the gills of filter feeders and hindering visual predation. High turbidity can also increase the bioavailability of toxins adsorbed to suspended sediment particles. Exotic vegetation, including poplar (*Populus* sp.), black wattle (*Acacia mearnsii*), bluegum (*Eucalyptus* sp.), and bugweed (*Solanum mauritianum*), continues to impact several of the monitoring sites (Plate A). A pipe draining effluent of an unknown source into the Modderfonteinspruit at site K2 remains of concern (Plate B). Site K2 is also impacted by bank erosion (and subsequent sedimentation) (Plates B and C). Sedimentation was also noted at sites K3 and K4 during the November 2024 survey. Algal proliferation was again noted at all four Modderfonteinspruit sites in November 2024, and is likely due organic enrichment (sewage pollution) (Plate C). Signs of organic enrichment, such as low dissolved oxygen (DO) concentrations and algal proliferation, have been noted in this reach during several recent surveys. Although unrelated to KPS, the observed evidence of sewage contamination should be reported to the relevant authorities as a matter of urgency as it constitutes an environmental safety hazard.

Electrical conductivity (EC) values were sourced from the toxicity testing laboratory results and the *in-situ* records, where relevant. Electrical conductivity (EC) levels increased (deteriorated) markedly between sites K1 (56.6 mS/m) and K2 (109.8 mS/m) in November 2024 (Table 4; Figure 3a), indicating inputs of salts along this reach. Indeed, temporal data clearly reflect that salinity consistently increases between these sites, and while a stable trend is reflected for site K1, an increasing (deteriorating) trend is shown for site K2 (Figure 3b). Toxicity testing samples have shown that salinity is consistently considerably higher in the Effluent Stream (represented by sites Eff and Eff-plus) than the receiving Modderfonteinspruit (as represented by site K1), confirming the Effluent Stream (carrying potential KPS impacts) as a source contributing to the salt load of the Modderfonteinspruit (Figure 3b). Most surveys have reflected that industrial activities did not lead to an increase in salinity of the Effluent Stream (Eff to Eff-plus), however it is again noted that the June 2021 survey reflected likely impacts from industrial development as the EC levels increased towards the more downstream site, Eff-plus (Figure 3b). Temporal data are reflecting trends of increasing salinity at both site Eff and Eff-plus, with the increasing trend at site Eff-plus likely a response to the upstream increase as seen at site Eff (Figure 3b). Bank erosion remains a notable impact at site K2 and the regularly observed sedimentation of the stream may have contributed in part to the increase in EC between sites K1 and K2 during some recent surveys. It is reiterated that Kelvin Power Station's environmental staff should take steps to mitigate any potential contributions to the increased salinity of the Modderfonteinspruit, especially given the higher salinity consistently recorded in the Effluent Stream during recent surveys.

Salinity decreased (improved) between site K2 (109.8 mS/m) and site K3 (96.4 mS/m) in November 2024, but increased (deteriorated) slightly towards site K4 (104.0 mS/m) (Table 4; Figure 3a). Most recent surveys have shown spatial improvement or stability along this reach (K2 to K4), however a few surveys (e.g. June 2023 and June 2021) have reflected an increase (deterioration) in salinity along this reach (especially between sites K3 and K4) (Figure 3b), showing that industrial/residential areas do impact on the Modderfonteinspruit from time to time. A trend of increasing salinity is displayed for sites K2, K3, and K4,

with the increasing trend at the two latter sites likely being a result of the increasing trend at site K2 which is in turn at least in part attributable to the inflow of the Effluent Stream with its higher salinity (Figure 3b).

As in May 2024, the November 2024 survey showed that the pH values from all Modderfonteinspruit sites were within the target water quality pH range for fish health, which is between 6.5 and 9.0 (DWAF, 1996) (Table 4; Figure 4), and should not be limiting to aquatic fauna.

The dissolved oxygen (DO) concentration measured above the median guideline (> 5 mg/l, as set by Kempster *et.al.*, 1980) at all four Modderfonteinspruit sites during the November 2024 survey (Table 4; Figure 5), and would not have limited aquatic biota at these sites. This reflects improvement at site K1 compared to the May 2024 survey when the DO concentration at this sites measured below the median guideline level. Low DO concentrations have been observed at several Modderfonteinspruit monitoring sites over recent surveys, but the scenario is generally already present at site K1 (upstream of potential KPS impacts) and appears unrelated to KPS activities. Sewage contamination is believed to be underlying the low DO concentrations, with other signs of sewage pollution, such as algal proliferation, supporting this notion.



Plate A: Exotic vegetation as photographed at sites K1 (left), Eff-plus (middle), and K4 (right) in May 2024.



Plate B: Culvert draining unknown effluent into Modderfonteinspruit at site K2 (left) as photographed in May 2024. Sheer banks and bank erosion at site K2 (middle) as recorded in May 2024.



Plate C: Algae and sedimentation as seen at site K2 (left) and algal proliferation as seen at site K3 (right) in November 2024. Signs of organic enrichment (sewage) are regularly noted along this reach of the Modderfonteinspruit.

Table 4: In-situ water quality variables measured at the time of sampling at the selected biomonitoring sites (2024-11).

Monitoring site	EC (mS/m)	pH	Oxygen saturation (%)	Dissolved oxygen (mg/l)	Water temp (°C)	Turbidity (visual)	Flow (visual)
K1	56.6	6.7	157.0	10.0	22.5	Clear	Moderate
K2	109.8	6.6	176.0	10.0	21.3	Clear	Low
K3	96.4	6.7	103.4	6.6	23.8	Slightly turbid	Moderate
K4	104.0	7.0	170.0	8.7	25.5	Slightly turbid	Moderate

Value outside guideline levels

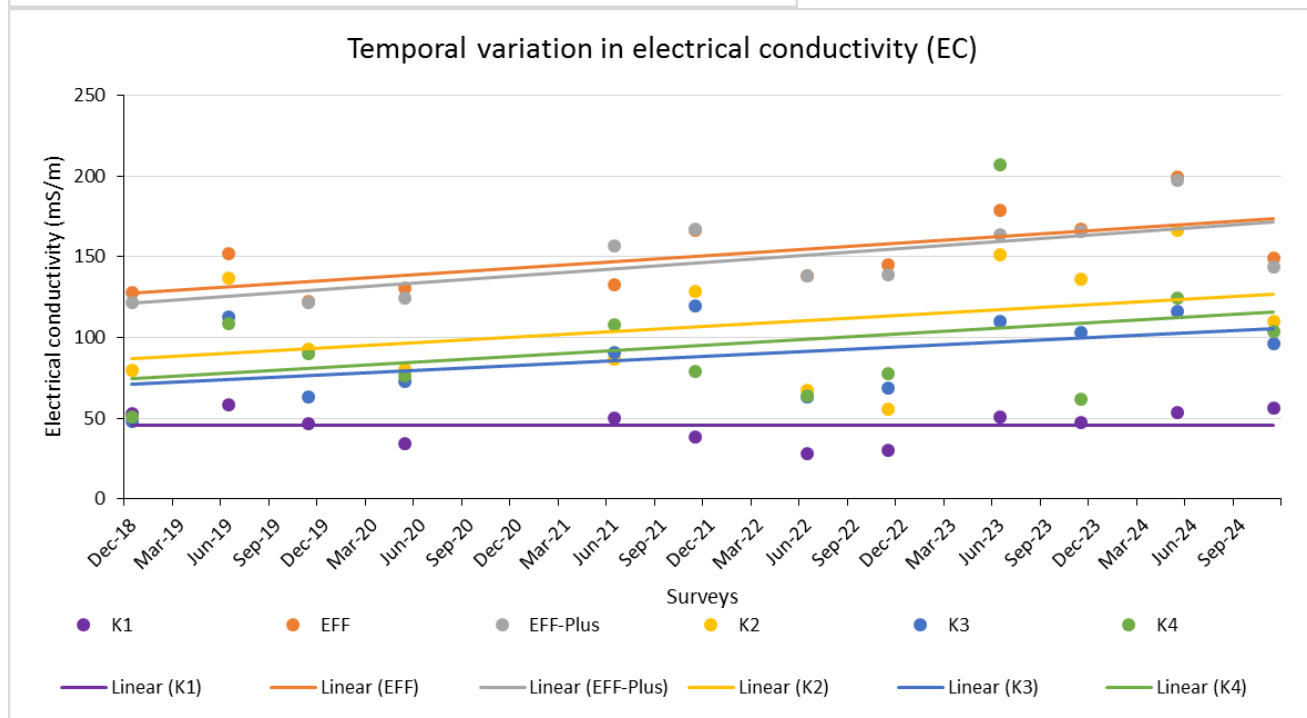
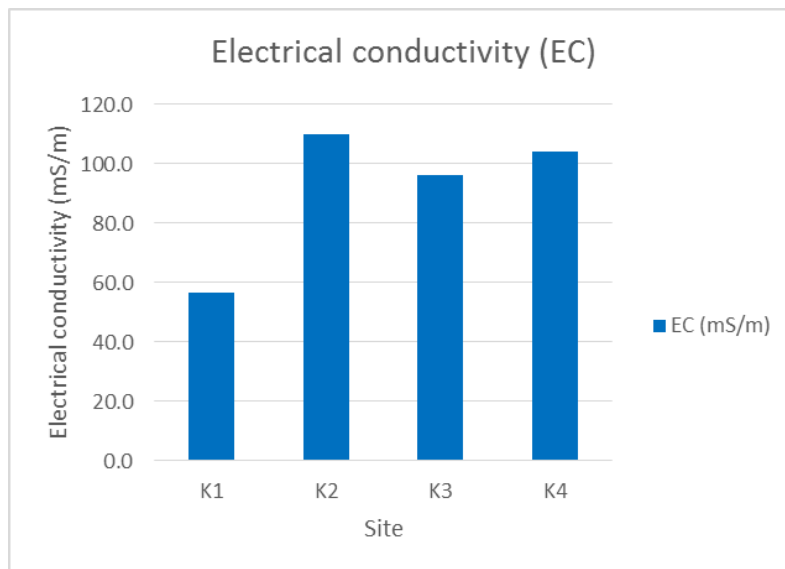


Figure 3 a-b: (a: top) Electrical Conductivity (EC) values recorded at the different monitoring sites during the November 2024 survey. (b: bottom) Temporal trends in salinity (EC) as measured in-situ or obtained from toxicity testing samples and ranging from December 2018 to November 2024.

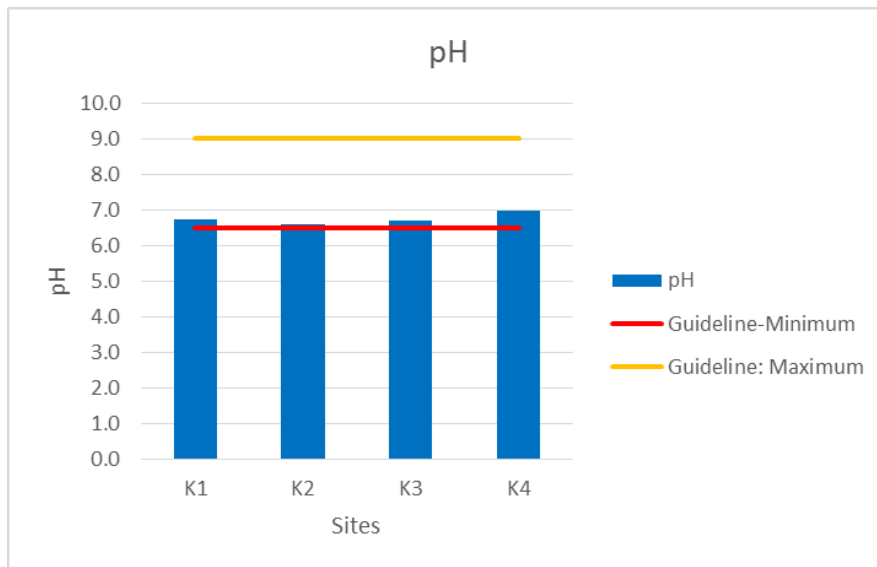


Figure 4: pH values recorded at the different monitoring sites during the November 2024 survey.

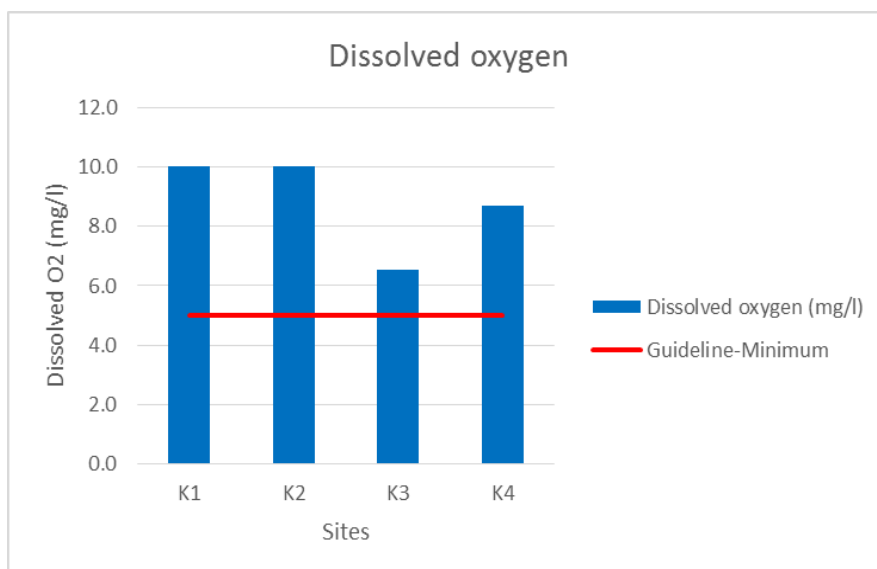


Figure 5: Dissolved oxygen (DO) levels recorded at the different monitoring sites during the November 2024 survey.

4.2 Environmental toxicity testing

As per SANAS requirements, the toxicity testing report was produced independently by BiotoxLab (Pty) Ltd. All results contained in this section are therefore sourced from the BiotoxLab report which is submitted as an Addendum (separate PDF file).

As of July 2024, the three PCDs, namely RWD, Ash Dam, and Desilting Dam are also included for toxicity testing, however testing was limited to screening on a bacterial level only. All three PCDs are now scheduled for definitive toxicity testing. See Table 5 below for details of samples taken and analyses requested for the December 2024/January 2025 sampling events.

Table 5: Analyses requested and description for the different samples, including sampling and delivery dates.

Sample name	Sampling date	Sample type (water, sediment, product etc)	Sampled by	Delivery date	Delivered by	Additional comments (sample description or deviations)	Oxygenation required for sample, please tick (lab use): ✓ ✗ N/A	Tests requested - Marked with X									
								Screening	Definitive	Water							Sediment
										<i>Daphnia magna</i>	<i>Poecilia reticulata</i>	<i>Aliivibrio fischeri</i>	<i>Selenastrium capricornutum</i>	<i>Spirodela polyrriza</i>	Phyto seeds	Ostracod	
K1	2024.12.13	Water & Sediment	Clean Stream	2024.12.13	Clean Stream	Particles present	N/A	X		X	X	X					X
K2	2024.12.13	Water & Sediment	Clean Stream	2024.12.13	Clean Stream	Particles present	N/A	X		X	X	X					X
EFF Plus	2024.12.13	Water & Sediment	Clean Stream	2024.12.13	Clean Stream	Particles present	N/A	X		X	X	X					X
EFF	2025.01.09	Water	CSBS	2025.01.09	CSBS	Particles present	N/A		X	X	X	X					
Ash Dam	2025.01.09	Water	CSBS	2025.01.09	CSBS	Particles present	N/A		X	X	X	X					
Desilting Dam	2025.01.09	Water	CSBS	2025.01.09	CSBS	Particles present	N/A		X	X	X	X					
RWD	2025.01.09	Water	CSBS	2025.01.09	CSBS	Particles present	N/A		X	X	X	X					

Screening = 100% (undiluted) sample tested only

Definitive = Series of sample dilutions tested to enhance classification accuracy and to determine safe dilution

Lethal or sub-lethal toxicity testing (as applied for this assessment) is applied by exposing biota to water sources in order to determine the potential risk of such waters to the biota/biological integrity of the receiving water bodies and the environment. A risk category is determined based on the percentage of mortalities (lethal) or inhibition (sub-lethal) of the exposed biota. It is important to note that the hazard classification is based on the standardised battery of selected test biota and therefore represents the risk/hazard towards similar biota in the receiving aquatic environment. The toxicity hazard is therefore in terms of the aquatic biotic integrity and does in no way represent toxicology towards humans or other mammals.

All of the toxicity samples are tested on either a screening or a **definitive**¹ level. The frequency of testing is determined by the level of toxicity. If toxicity levels increase, it may become relevant and useful to increase the frequency of testing. The frequency and type of toxicity testing (screening vs. definitive) required will be revised annually based on the outcome of the specific year's assessment.

The toxicity unit (TU) for each test performed is calculated as 100% (full strength effluent expressed as percentage) divided by the effective concentration or LC₅₀ expressed as percentage sample dilution (e.g. *Daphnia magna* and *Poecilia reticulata* lethal toxicity tests) and EC₅₀ (e.g. *Aliivibrio fischeri* bioluminescent test) (Tonkes & Baltus, 1997). If there is insufficient toxicity in a sample to allow for the determination of an EC₅₀/LC₅₀ value, then a toxicity unit of <1 will be assigned to the sample.

¹ Definitive = A definitive toxicity test refers to the exposure of test organisms to both the 100% concentration as well as a range of dilutions, generally used to determine the risk of a pollution source that may have a toxicity effect on the receiving water body (such as effluents and PCD's). The range of dilutions are therefore useful in the event that the 100% sample concentration presents lethal toxicity, and allows for the determination of a safe dilution factor, to negate toxicity effects on the receiving water bodies.

Toxicity Units:

Toxicity Unit	Conclusion/Description
<1	Limited to no toxicity
1 – 2	Negligibly toxic
2 – 10	Mildly toxic
10 – 100	Acutely toxic
> 100	Highly toxic

A risk/hazard category is determined by using a hazard classification system developed by Persoone *et al.* (2003) whereby one can classify sites using the toxicity data of the non-diluted samples. The percentage effect (PE) of toxicity (mortalities, growth inhibition, luminescence inhibition) is used to rank the sample into one of five classes based on the highest toxic response obtained in at least one of the tests applied.

Hazard classification system for natural water samples:

Class	Symbol	Hazard rating	PE	Percentage effect
I	☺	No lethal/sub-lethal hazard	≤10/20%	None of the tests show a toxic effect (i.e. an effect value that is significantly higher than that noted in the controls)
II	☹	Slight lethal/sub-lethal hazard	10/20% ≤ PE < 50%	A statistically significant (P < 0.05) PE is reached in at least one test, but the effect level is below 50%
III	☹☹	Lethal/sub-lethal hazard	50% ≤ PE < 100%	The 50% effect level is reached or exceeded in at least one test but the effect level is below 100%
IV	☹☹☹	High lethal/sub-lethal hazard	PE 100% in at least one test	The 100% effect is reached or exceeded in at least one test
V	☹☹☹☹	Very high lethal/sub-lethal hazard	PE 100% in all tests	The 100% effect is exceeded in all the tests

Hazard classification system for effluent/waste samples:

Class	Symbol	Hazard rating	PE	Percentage effect
I	☺	No lethal/sub-lethal hazard	≤10/20%	None of the tests show a toxic effect (i.e. an effect value that is significantly higher than that noted in the controls)
II	☹	Slight lethal/sub-lethal hazard	10/20% ≤ PE < 50%	A statistically significant (P < 0.05) PE is reached in at least one test, but the effect level is below 50% (TU < 1)
III	☹☹	Lethal/sub-lethal hazard	50% ≤ PE < 100%	The 50% effect level is reached or exceeded in at least one test but the effect level is below 100% (1 ≤ TU < 10)
IV	☹☹☹	High lethal/sub-lethal hazard	PE 100% in at least one test	The 100% effect is reached exceeded in at least one test (10 ≤ TU < 100)
V	☹☹☹☹	Very high lethal/sub-lethal hazard	PE 100% in all tests	The 100% effect is reached or exceeded in all the tests applied (TU ≥ 100)

EP (Percentage effect) = an effect measured either as mortality or inhibition (depending on the type of test). A >10% effect is regarded as slight lethal toxicity for *Daphnia*, *Poecilia* while a >20% effect is regarded as slight sub-lethal toxicity for *Aliivibrio*. A 50% effect is regarded as a lethal/sub-lethal toxicity for all the tests (*Daphnia*, *Poecilia*, *Aliivibrio*).

Each sample is furthermore weighted according to its relative toxicity level (out of 100%). Higher values indicate that more of the individual tests indicated toxicity within a specific class.

Weight score allocation for each test type:

Score	Category
0	No significant toxicity effect
1	Significant toxicity effect < PE50
2	Toxicity effect > PE50 but < PE100
3	The PE100 is reached

Class weight score calculated as follows:

Class weight score = $(\sum \text{all test scores})/n$ where n is the number of tests performed

Class weight score % = $(\text{class score}) / (\text{maximum class weight score}) \times 100$

4.2.1 Water toxicity testing: December 2024 and January 2025

The December 2024 water sample representing the upstream Modderfonteinspruit site, **K1**, tested as posing a slight lethal environmental toxicity hazard (**Class II**) based on the 33% vertebrate mortality effect noted (Table 6). This comprises an increase in toxicity hazard compared to the September 2024 survey when the sample from this site showed no lethal/sub-lethal environmental toxicity hazard (Class I) (*report CSBS-KPS-D-24_Tox*). Given that site K1 is the upstream (control) site, the slight toxicity hazard recorded in December 2024 is unrelated to KPS.

Snapshot of conditions

It is important to note that water toxicity testing provides only a snapshot of the conditions prevailing at the time of sampling and does not allude to hazards prior to or after sampling.

The toxicity hazard of the Modderfonteinspruit decreased towards site **K2**, with the December 2024 water sample of this site showing no lethal/sub-lethal environmental toxicity hazard (**Class I**) (Table 6). Site K2 is located in the Modderfonteinspruit downstream of potential KPS impacts (via the Effluent Stream). The December 2024 toxicity sampling event therefore showed no increase in the toxicity hazard class (in fact showing a decrease) of the Modderfonteinspruit after inclusion of potential KPS impacts via the inflow of the Effluent stream. The September 2024 sample from site K2 also reflected no lethal/sub-lethal environmental toxicity hazard (Class I), and the September 2024 survey also showed no increase in toxicity hazard along this reach.

Site **Eff** represents the Effluent Stream inclusive of potential power station impacts, but excluding industrial impacts. A slight lethal environmental toxicity hazard (**Class II**) was allocated to the latest sample from site Eff, based on the toxicity effects noted on the dilutions of the sample (Table 6). A safe dilution factor of 13% was calculated for the sample (i.e. 13 parts Eff water diluted with 87 parts 'clean' water should be sufficient to negate toxicity effects for these trophic levels should this water reach the natural environment) (Table 6). A Class II hazard (slight sub-lethal hazard) was also assigned to the September 2024 sample from site Eff. These findings reflect a continued improvement in toxicity hazard for site Eff compared to the November 2023 survey (very high lethal toxicity hazard – Class V) (*report CSBS-KPS-D-2023_Tox*) as well as some previous surveys. Nonetheless, even a slight toxicity hazard is of concern in the natural environment, and KPS's environmental staff should closely monitor the scenario and take steps to mitigate any potential KPS related impacts.

Site **Eff-plus** is the downstream site in the Effluent Stream and inclusive of potential power station impacts as well as industrial impacts. No lethal/sub-lethal environmental toxicity hazard (**Class I**) was detected for the latest sample from this site, reflecting a decrease in the toxicity hazard of the Effluent Stream compared to the slight hazard (Class II) recorded for the upstream site (Table 6). This shows that, based on the most recent findings, industrial (and or other) impacts along the Effluent stream did not lead to an increase in toxicity hazard of this stream, with the toxicity hazard in fact decreasing towards the downstream site. A decrease in toxicity hazard (Class II to I) was also seen from site Eff to Eff-plus based on the September 2024 samples.

No known KPS impacts occur downstream of site K2 and sites K3 and K4 are generally not included for toxicity testing. However, site K3 and K4 were included for toxicity testing in June 2022, at which time the toxicity hazard remained stable in the Modderfonteinspruit, with the samples from site K3 and site K4 similarly posing a slight sub-lethal environmental toxicity hazard (Class II). This showed that industrial/residential impacts between sites K2 and K3, as well as between sites K3 and K4, did not lead to an increase in toxicity hazard of the Modderfonteinspruit at the time of the June 2022 survey.

A slight lethal environmental toxicity hazard (**Class II**) was detected for the January 2025 sample from the **Ash Dam** based on the toxicity effects noted on the dilutions of the sample (Table 6). A safe dilution factor of 6% was calculated for the sample (i.e. 6 parts Ash Dam water diluted with 94 parts 'clean' water) (Table 6). This constitutes a decrease in toxicity hazard for the Ash Dam compared to the September 2024 survey when a Class III hazard (lethal/sub-lethal hazard) was recorded for the sample from this site.

The January 2025 sample from the **Desilting Dam** showed a slight sub-lethal environmental toxicity hazard (**Class II**) based on the bacterial light emission inhibition effect noted for the dilutions of this sample (Table 6). **No safe dilution factor** could be established for the sample from this site (up to 0.78% dilution of the sample). A sub-lethal hazard (Class III) was assigned to the September 2024 sample from the Desilting Dam.

A sub-lethal environmental toxicity hazard (**Class III**) was allocated to the January 2025 sample from the Return Water Dam (**RWD**) based on the 69% (TU=1.2) bacterial light emission inhibition effect observed following testing (Table 6). A safe dilution factor of 62% was calculated for the sample from this site (i.e. 62 parts RWD water diluted with 38 parts 'clean' water) (Table 6). A Class III hazard was similarly assigned to the September 2024 sample from the RWD (although no safe dilution factor could be established on that occasion).

The toxicity hazards recorded for the PCDs highlights the need for continued and definitive toxicity testing. Such testing is a valuable management tool to monitor and, if needed, timeously mitigate hazards related to these sources.

It should still be noted that, during the November 2016 survey a leaking pipe spilled milky water directly downstream of site K1 into the Modderfonteinspruit. It appeared that this source is non-KPS related and toxicity testing was performed with this water to put into context the possible impact related to this source of contamination. A very high aquatic hazard (**Class V**) was revealed during testing, which was probably related to the low oxygen content of this liquid (see Report KEL-D-16_Tox for detailed toxicity testing results).

Table 6: Toxicity results and hazard classification for selected water samples pertaining to the Kelvin Power Station study area (2024-12 and 2025-01).

	Results	K1	K2	EFF Plus	EFF	Ash Dam	Desilting Dam	RWD
Water quality	Test date yy/mm/dd	2025.01.06	2025.01.06	2025.01.06	2025.01.10	2025.01.10	2025.01.10	2025.01.10
	pH @ 25°C (NA)	8.1	8.3	7.9	8.8	9.9	9.1	10.1
	EC (Electrical conductivity) (mS/m) @ 25°C (NA)	42.9	151.2	143.6	149.3	204.2	139.7	176.7
	Dissolved oxygen (mg/l) (NA)	8.5	8.7	9.2	7.3	7.3	7.0	7.5
A. fischeri (bacteria) (A)	Test started on yy/mm/dd	2025.01.13	2025.01.13	2025.01.13	2025.01.21	2025.01.21	2025.01.22	2025.01.22
	*30min inhibition (-) / stimulation (+) (%)	39	19	11	34	14	22	-69
	EC/LC20 (30 mins)	*	*	*	n.r	n.r	n.c	62
	EC/LC50 (30 mins)	*	*	*	n.r	n.r	n.r	85
	Toxicity unit (TU) / Description	no sub-lethal hazard	no sub-lethal hazard	no sub-lethal hazard	<1	<1	<1	1.2
D. magna (waterflea) (A)	Test started on yy/mm/dd	2025.01.06	2025.01.06	2025.01.06	2025.01.13	2025.01.13	2025.01.13	2025.01.13
	*48hour mortality rate (-%)	0	0	0	0	0	0	0
	EC/LC10 (48hours)	*	*	*	n.r	n.r	n.r	n.r
	EC/LC50 (48hours)	*	*	*	n.r	n.r	n.r	n.r
	Toxicity unit (TU) / Description	no lethal hazard	no lethal hazard	no lethal hazard	<1	<1	<1	<1
P. reticulata (guppy) (A)	Test started on yy/mm/dd	2025.01.09	2025.01.09	2025.01.09	2025.01.20	2025.01.20	2025.01.20	2025.01.20
	*96hour mortality rate (-%)	-33	-8	0	0	-8	0	0
	EC/LC10 (96hours)	*	*	*	13	6	n.r	n.r
	EC/LC50 (96hours)	*	*	*	n.r	n.r	n.r	n.r
	Toxicity unit (TU) / Description	S.D.O.T.H	no lethal hazard	no lethal hazard	<1	<1	<1	<1
Minimum acceptable effect level/ Estimated safe dilution factor (%) [for definitive testing only]		N/A	N/A	N/A	13	6	<1	62
Overall classification - Hazard class***		Class II - Slight lethal hazard	Class I - No lethal/sub-lethal hazard	Class I - No lethal/sub-lethal hazard	Class II - Slight lethal hazard	Class II - Slight lethal hazard	Class II - Slight sub-lethal hazard	Class III - Sub-lethal hazard
Weight (%)		33	0	0	33	33	33	33

Key:

% = for definitive testing, only the 100% concentration (undiluted) sample mortality/inhibition/stimulation is reflected by this summary table. The dilution series results are considered for EC/LC values and Toxicity unit determinations

n.r. = not relevant, i.e. the 100% concentration caused less than 10/20/50% (effective concentration) mortalities or inhibition

n.c. = not calculable, although the 100% concentration showed no significant light emission inhibition effect such slight effects were observed on other dilutions of the sample, and could not be diluted out up to a 0.78% dilution of the sample

* = EC/LC values not determined, definitive testing required if a hazard was observed and persists over subsequent sampling runs

S.D.O.T.H = Some degree of lethal/sub-lethal toxic hazard based on this single test organism, refer to overall hazard classification, which takes into account the full battery of test organisms.

*** = The overall hazard classification takes into account the full battery of tests and is not based on a single test result. Note that the overall hazard classification is expressed as both lethal (*Daphnia* & *Poecilia*) and sub-lethal (*Alivibrio*) levels of toxicity

Weight (%) = relative toxicity levels (out of 100%), higher values indicate that more of the individual tests indicated toxicity within a specific class

site/sample name shaded in purple = screening test

site/sample name shaded in orange = definitive test

4.2.2 Temporal variation of water toxicity hazards

For the purpose of determining long-term (temporal) trends, the toxicity results for the power station effluents have been included since 2002 and the results obtained at the river sites are included since October 2007. The results in Figure 6 are representative of the hazard class as per DEEEP classification, after consideration of all organism group tests for each survey.

From the long-term trends, it is clear that a marked decrease in toxicity of the power station effluent as well as the stream site has occurred over the first half of the study, however, toxicity hazards detected during some recent surveys have led to increasing trends displayed at some sites (Figure 6).

Toxicity hazards have varied greatly at the upstream site (K1), ranging between a lethal/sub-lethal environmental toxicity hazard (Class III) and no lethal/sub-lethal environmental toxicity hazard (Class I) (Figure 6). This is indicative of a catchment with largely varying water quality with intermittent discharges, which has clearly been polluted to varying degrees (as detected since October 2007 with inclusion of toxicity testing at this site). The long-term polynomial temporal trend at site K1 show a trend of decreasing (improving) toxicity towards 2015, however a trend of increasing (deteriorating) toxicity is displayed thereafter (Figure 6).

Toxicity hazards have similarly varied at the downstream site (K2), mostly ranging between a slight lethal/sub-lethal environmental toxicity hazard (Class II) and no lethal/sub-lethal environmental toxicity hazard (Class I), however increasing for the first time to lethal/sub-lethal environmental toxicity hazard (Class III) during the June 2019 survey (Figure 6). A Class III toxicity hazard was again recorded for this site in June 2023 and August 2023 (Figure 6). The temporal trend is one of increasing toxicity since 2015, and although the hazard at K2 has generally been lower than (or similar to) that at site K1, toxicity hazard at site K2 surpassed that at site K1 during the June 2019, February 2021, June 2021, April 2022, and August 2023 surveys (Figure 6). Although the present survey (December 2024) reflected a decrease in hazard from site K1 to K2, the spatial increases seen during some previous surveys **highlight the importance of close monitoring.**

The toxicity hazard for site Eff has improved considerably since September 2005, generally fluctuating between slight lethal/sub-lethal toxicity hazard (Class II) and no lethal/sub-lethal toxicity hazard (Class I) with the long-term trend showing a significant decrease (improvement) up to 2015 (Figure 6). However, following 2015, a trend of increasing toxicity hazard is displayed for site Eff and the **Class V** hazard (very high lethal hazard) recorded for this site in November 2023 reflects further **notable and rapid deterioration** at this site (Figure 6). The November 2023 survey constituted the first record of a Class V hazard for site Eff over the study period to date. Although the four subsequent surveys showed only a slight toxicity hazard (Class II), **KPS's environmental staff should nonetheless closely monitor the scenario and timeously implement mitigation measures if needed.**

Apart from the **Class IV** hazard recorded during the August 2010, June 2021, and August 2021 surveys, site Eff-plus has also generally varied between a slight lethal/sub-lethal toxicity hazard (Class II) and no lethal/sub-lethal toxicity hazard (Class I) (Figure 6). The long-term temporal trend reflected an overall decreasing trend in toxicity hazard after inclusion of site Eff-plus in 2009, however, toxicity hazards recorded in 2021 (Class IV during two surveys) and 2023 (Class III during two surveys) resulted in a sharply increasing (deteriorating) toxicity trend displayed for site Eff-plus (Figure 6). It is encouraging to note that inclusion of the four most recent surveys has resulted in a decreasing trend again being reflected for site Eff-plus (Figure 6). Nonetheless, close monitoring is considered prudent.

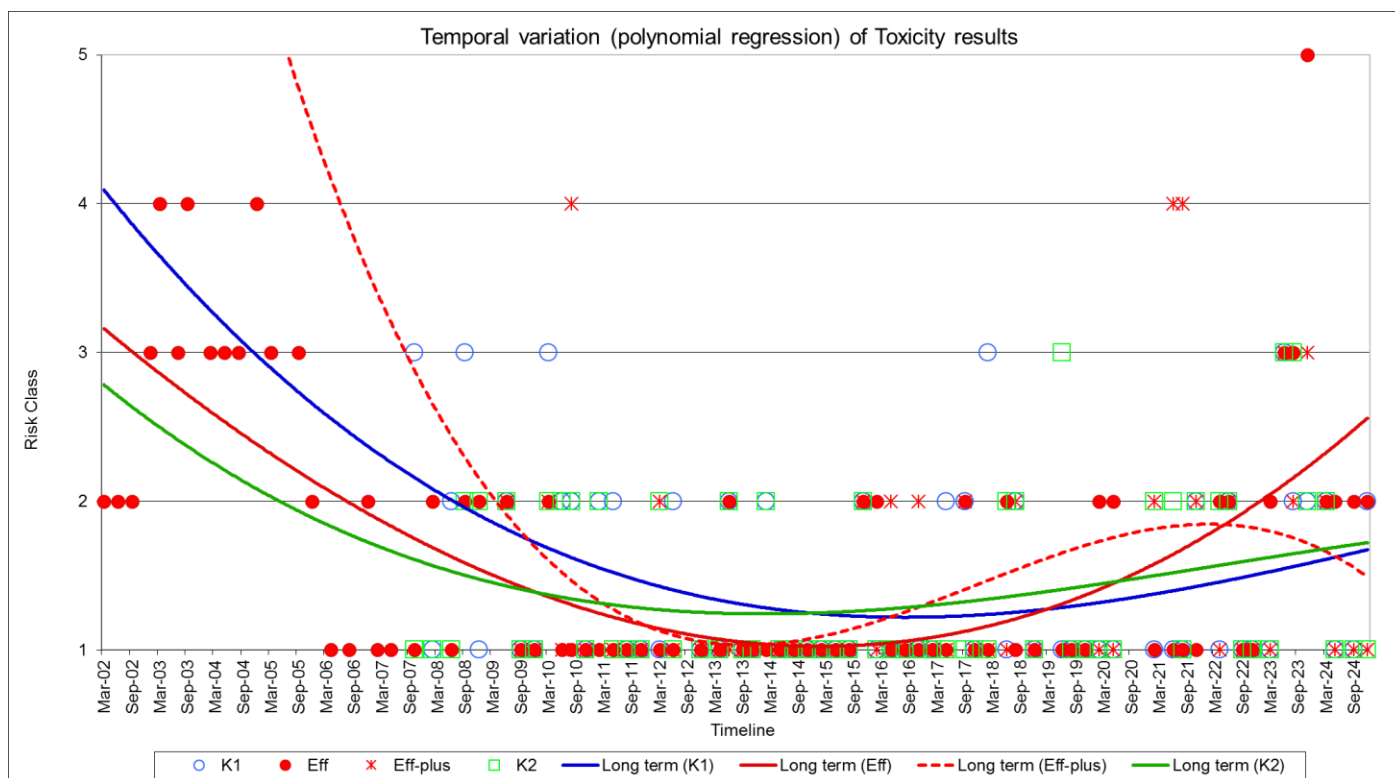


Figure 6: Long and medium-term trends in acute toxicity (2002 – 2024).

4.2.3 Chronic sediment toxicity testing

Chronic sediment toxicity testing was initially included in the biomonitoring programme in order to gain insight pertaining to the potential impact of ash deposition within the sediments of the Effluent Stream and the Modderfonteinspruit. Sediment toxicity testing was thereafter retained within the routine biomonitoring programme (on a once yearly basis) to serve as an early warning system of potentially increased chronic toxicity levels that may be related to ash discharge from the power station.

During 2014, sediment toxicity analyses revealed that the chronic hazards decreased spatially from K1 (upstream from the ash spill) to K2 (downstream from the ash spill). The sediments of the Modderfonteinspruit, upstream from the spill, measured a “chronic toxicity hazard” (Class III). The sediments within the effluent stream and the downstream Modderfonteinspruit (both clearly containing spilled ash) measured “no chronic hazard” (Class I). This is a clear indication that, although significant amounts of ash were present within the downstream sediments, the spill had clearly not resulted in an increased toxicity hazard within the sediments. The opposite trend was observed during the 2010 ash spill assessment (report KEL-F-10), when a spatial increase in chronic sediment toxicity was indeed observed.

Sediment toxicity testing is conducted once per annum and took place during the fourth quarter survey (present survey) of 2024.

The December 2024 sediment samples from both site K1 and K2 showed a slight lethal environmental toxicity hazard (Class II) based on the 20% and 27% ostracod mortalities recorded for the samples respectively (Table 7). These findings show that the toxicity hazard of the sediment in the Modderfonteinspruit remained stable between sites K1 and K2 and therefore did not reflect impacts from KPS or industrial activities along this reach (via the Effluent stream). Indeed, the December 2024 sediment sample from the downstream Effluent Stream site, Eff-plus, reflected no lethal/sub-lethal environmental toxicity hazard (Class I) (Table 7). The November 2023 survey similarly did not reflect impacts to the sediment toxicity hazard of this reach, in fact showing a decrease in hazard from site K1 (Class II) to site K2 (Class I) (reports KEL-D-23 and CSBS-KPS-D-23_Tox). The findings of the December 2024 survey therefore comprise an increase in hazard for

site K2 compared to November 2023, however as no spatial increase in hazard was recorded this is likely attributable to upstream (non-KPS impacts). Nonetheless, close monitoring is warranted.

Similar to the sediment toxicity testing findings, the December 2024 water toxicity testing findings reflected no impacts to water toxicity hazard of this reach of the Modderfonteinspruit (K1: Class II and K2: Class I). However, sediment toxicity testing reflected a slight hazard (Class II) at site K2 in contrast to water toxicity testing that reflected no hazard (Class I) at this site (Tables 6 and 7). Sediment particles may become suspended during times of higher flow and this could lead to increased bioavailability of toxins adsorbed to particles. The findings also highlight the importance of conducting both water- and sediment toxicity testing.

Table 7: Toxicity results and hazard classification for selected sediment samples pertaining to the Kelvin Power Station study area (2024-12).

	Results	K1	K2	EFF Plus
<i>Heterocypris incongruens</i> (Ostrocod) (A)	Date test performed	2025.01.09	2025.01.09	2025.01.09
	*144hour inhibition (-) / stimulation (+) (%)	-17	5	-5
	144hour mortality rate (% relative to control)	-20	-27	0
	Description	S.D.O.T.H	S.D.O.T.H	no lethal/sub-lethal hazard
Overall classification - Hazard class		Class II - Slight lethal hazard	Class II - Slight lethal hazard	Class I - No lethal/sub-lethal hazard

* = The sub-lethal toxicity interpretation relies on the inhibition/stimulation result of this test. The lethal toxicity interpretation relies on mortalities.

S.D.O.T.H = Some degree of toxicity hazard, refer to overall hazard classification

4.3 SASS5 (Aquatic macroinvertebrates)

The South African Scoring System (Version 5) is a site-specific index, which, together with an associated habitat index (biotope suitability index) gives a general perspective of the biotic integrity (based on macroinvertebrates) and the impact of water quality on the biotic integrity of the specific sites (Thirion *et.al.*, 1995; Dickens and Graham, 2001). The biotope suitability index takes into account the suitability of the different sampled biotopes in terms of quality and availability. It thereby firstly assesses whether the total SASS5 scores of two sites are directly comparable by matching the total biotope suitability scores. In the event that the total biotope suitability scores are largely different this would imply that the total SASS5 scores should not be compared, but instead the most comparable SASS biotope scores. The most comparable SASS biotope scores are identified by comparing the various individual biotope suitability scores. In addition to the biotope suitability index, the Integrated Habitat Assessment System, version 2 (IHAS) was also applied and included for the purpose of macroinvertebrate specific habitat descriptions (Table 8).

Average score per taxon (ASPT) values are also very useful in the assessment and comparison of biotic conditions at different sites. According to field trials assessed by Dickens and Graham (2001), the ASPT score was less variable than total SASS5 scores when conducted within a given river reach by different operators, considering all biotopes. ASPT scores are therefore included in the discussion below.

Table 8: Integrated Habitat Assessment (IHAS) description of the different biomonitoring sites.

Sampling Habitat	K1		K2		K3		K4	
	Desc	Score	Desc	Score	Desc	Score	Desc	Score
Stones In Current (SIC)								
Total length of white water rapids (ie: bubbling water) (in meters)	none	0	none	0	0-1	1	none	0
Total length of submerged stones in current (run) (in meters)	0-2	1	none	0	0-2	1	0-2	1
Number of separate SIC area's kicked	2-3	2	0	0	2-3	2	2-3	2
Average stone sizes kicked (in cm's)	2-20	4	none	0	2-20	4	2-20	4
Amount of stone surface clear (in %)	0-25	1	n/a	0	0-25	1	0-25	1
Protocol: time spent actually kicking SIC's (in mins)	<1	1	none	0	<1	1	<1	1
SIC score (max 20)		9		0		10		9
Vegetation (VEG)								
Length of fringing vegetation sampled (banks) (in meters)	2	4	2	4	2	4	2	4
Amount of aquatic vegetation/algae sampled (in square meters)	none	0	none	0	none	0	none	0
Fringing vegetation sampled in	mix	5	pool	3	mix	5	pool	3
Type of veg. (percent leafy as apposed to stems/shoots)	1-25	2	1-25	2	1-25	2	1-25	2
Veg score (max 15)		11		9		11		9
Other Habitat / General (O.H.)								
Stones Out Of Current (SOOC) sampled (in square meters)	>0.5-1	2	>0.5-1	2	>0.5-1	2	>0.5-1	2
Sand sampled (in minutes)	under	1	0-0.5	2	>0.5-1	3	0-0.5	2
Mud sampled (in minutes)	0-0.5	2	0-0.5	2	0.5	3	0-0.5	2
Gravel sampled (in minutes)	none	0	none	0	none	0	none	0
Bedrock sampled (all = no SIC, sand, gravel)	some	1	some	1	some	1	some	1
Algal presence (m ²)	>1-2sqm	2	>1sqm	3	>2sqm	0	>2sqm	0
Tray identification	correct	3	correct	3	correct	3	correct	3
O.H. score (max 20)		11		13		12		10
Sampling habitat totals (max 55)		31		22		33		28
Stream Condition								
Physical								
River make up	2 mix	4	2 mix	4	3 mix	5	2 mix	4
Average width of stream (in meters)	>2-5	5	>5-10	2	>2-5	5	>5-10	2
Average depth of stream (in meters)	0.5	4	>0.5-1	3	>0.5-1	3	>0.5-1	3
Approximate velocity of stream	mix	5	mix	5	mix	5	mix	5
Water colour	clear	5	clear	5	discoloured	3	discoloured	3
Recent disturbances	other	3	other	3	other	3	other	3
Bank/Riparian vegetation	mix	4	mix	4	mix	4	mix	4
Surrounding impacts	other	3	other	3	other	3	other	3
Left bank cover (rocks and vegetation) (in %)	51-80	1	81-95	2	51-80	1	51-80	1
Right bank cover (rocks and vegetation) (in %)	51-80	1	81-95	2	51-80	1	51-80	1
Stream condition total (max 45)		35		33		33		29
Total IHAS score (%)		66		55		66		57

4.3.1 November 2024 survey results

The November 2024 integrated habitat assessment system (IHAS) scores reflected that habitat was adequate (>65%) at site K1 (66%) but decreased to below adequate at site K2 (55%) (Table 8). The IHAS scores improved towards site K3 (66%) and again decreased slightly towards site K4 (57%) (Table 8). Total biotope availability and suitability similarly decreased slightly from site K1 (7) to site K2 (5) (Table 9; Figure 7). Total biotope availability and suitability improved towards site K3 (9) and decreased marginally towards site K4 (8) (Table 9; Figure 7).

The November 2024 survey reflected low macroinvertebrate diversity along this reach of the Modderfonteinspruit, with only ten, seven, nine, and 11 taxa (families) recorded at sites K1, K2, K3, and K4 respectively (Appendix 2). As during previous surveys, hardy taxa with a low to very low requirement for unmodified water quality dominated this reach. No taxa with a high requirement for unmodified water quality were recorded and only a single taxon (Aeshnidae) with a moderate requirement was sampled (only sampled at site K1) (Appendix 2). These findings point to very poor water quality persisting in this reach of the Modderfonteinspruit. It must be noted that low taxa diversity reduces confidence in the ASPT and biotope-specific comparisons and the total SASS5 score is considered the better indicator. The below results must be interpreted with this limitation in mind.

The November 2024 survey reflected a poor total SASS5 score of 36 (and ASPT of 3.6) for site K1 (Table 9; Figure 7), and shows that deteriorated biotic conditions are already present in the Modderfonteinspruit upstream of potential KPS impacts, as has also been the case during previous surveys. The December 2024 toxicity testing results supported the notion of deteriorated conditions upstream of potential KPS impacts with a slight hazard (Class II) recorded for the sediment and water samples from this site (Section 4.2). Signs of sewage contamination is also regularly recorded at this site (as well as other sites along this reach) (Section 4.1). Although unrelated to KPS, the scenario should nonetheless be reported to the relevant authorities as it is a source of environmental degradation.

In November 2024, the total SASS5 score and ASPT decreased between site K1 (36 and 3.6) and K2 (22 and 3.1) with slightly poorer habitat potentially contributing in part to the decrease (Table 9; Figure 7). The GSM biotope was directly comparable and comparison of the SASS5 score of this biotope (K1: 3 and K2: 10) did not point to water quality impacts (Table 9; Figure 8), however as mentioned before the low SASS5 findings reduces confidence in biotope-specific comparisons. Water toxicity testing (based on December 2024 samples) showed downstream improvement with a decrease in hazard from site K1 (Class II) to K2 (Class I), while the sediment toxicity hazard remained stable (Class II at both sites) (Section 4.2). Additionally, no water or sediment toxicity hazard (Class I) was recorded at the downstream Effluent Stream site, Eff-plus (carrying potential KPS and non-KPS impacts). However, *in-situ* measurements showed a marked increase in salinity, indicating that water quality impacts may also have contributed to the decrease in biotic integrity towards site K2 (Section 4.1). The Effluent Stream has regularly been identified as a source of increased salts in the Modderfonteinspruit. Therefore, although habitat differences likely played a role and toxicity testing showed no spatial increase in hazard, *in-situ* measurements show that water quality impacts may have contributed to the decrease in biotic integrity seen

ASPT and low taxa diversity

“ASPT becomes an unreliable indicator of river health at very low SASS5 Scores, since a single taxon with a medium or high sensitivity weighting can increase the ASPT considerably.” – Dallas, 2007

Indicator taxa

Taxa with a high or moderate requirement for unmodified water quality can be seen as indicator taxa as they will likely be the first to disappear should further water quality deterioration take place.

Dragonfly nymphs belonging to the family Aeshnidae were the only taxa with a moderate requirement for unmodified water quality sampled during the November 2024 survey.

Aeshnidae nymph



Source: Aquatic Invertebrates of SA Rivers

along this reach (K1 to K2) of the Modderfonteinspruit in November 2024. KPS's environmental staff should closely monitor the scenario and implement mitigating measures if needed, especially given the high toxicity hazards recorded in the Effluent Stream during various previous surveys. It must also be noted that several other users impact on this reach of Modderfonteinspruit, indeed a pipe that potentially contains sewage water flows into the Modderfonteinspruit at site K2 (SASS5 sampling is conducted upstream of this pipe, however impacts related to backflow cannot be excluded).

The November 2024 SASS5 findings are in contrast to that of the May 2024 and November 2023 surveys which did not detect further deterioration in biotic conditions along this reach (K1 to K2) (*reports KEL-B-24 and KEL-D-23*). The total SASS5 score had improved at site K1 when comparing the May 2024 (24) and November 2024 (36) findings. In contrast, the total SASS5 score at site K2 had decreased slightly (29 to 22) over this period, further highlighting the need for close monitoring. Biotic conditions remain very poor at both sites. Also refer to the next section on temporal trends.

The total SASS5 score remained fairly stable while the ASPT decreased slightly from site K2 (22 and 3.1) to K3 (24 and 3.7) in November 2024 (Table 9; Figure 7). The absence of a spatial improvement in biotic integrity despite better habitat (IHAS- and biotope availability and suitability scores) at site K3 (Tables 8 and 9), is suggestive of water quality deterioration. Comparison of the SASS5 scores of the most comparable biotopes (Stones and Vegetation) did not provide conclusive insights regarding potential water quality related impacts to the macroinvertebrates of this reach (Table 9; Figure 8). *In-situ* measurements in contrast showed improvement in water quality in terms of a decrease in salinity towards site K3 (Section 4.1), however it may be that variables not included in the *in-situ* range played a role. The November 2024 SASS5 findings suggested that water quality related impacts to the biotic integrity of this reach (K2 to K3) of the Modderfonteinspruit (industrial/residential areas) cannot be ruled out. It is reiterated that there are no known further KPS impacts downstream of site K2.

The SASS5 findings of the November 2024 survey are in line with those of the May 2024 and November 2023 surveys which similarly reflected possible water quality related impacts to the biotic integrity of this reach (K2 to K3) of the Modderfonteinspruit. The total SASS5 score at site K3 had remained fairly stable when comparing the May 2024 (22) and November 2024 (24) surveys.

A very slight improvement in total SASS5 score and ASPT was seen between site K3 (24 and 2.7) and K4 (32 and 3.9), despite similar to marginally poorer habitat at site K4 (Tables 8 and 9; Figure 7). However, total biotope availability and suitability was similar enough to allow direct comparison of the total SASS5 score which is therefore suggestive of slight water quality improvement towards site K4 (Table 9; Figures 7 and 8). *In-situ* measurements did not reflect major water quality differences between sites K3 and K4, although salinity did increase (deteriorate) very slightly (Section 4.1). It may also be that improvement in water quality variables outside the *in-situ* range played a role. The November 2024 SASS5 findings thus reflect that activities (non-KPS) along this reach did not negatively impact the biotic integrity of the Modderfonteinspruit, in fact showing a marginal improvement in biotic integrity towards site K4.

The May 2024 SASS5 findings similarly showed improvement in biotic integrity towards site K4 (more pronounced improvement than during the present survey), and the November 2023 SASS5 findings also detected no detrimental impacts along this reach. Comparison of the May 2024 and November 2024 surveys showed that the total SASS5 score had decreased (48 to 32) at site K4. Also refer to the next section on temporal trends.

Overall, biotic integrity remained fairly similar/ decreased slightly in the Modderfonteinspruit in November 2024 when comparing the most upstream (K1) and most downstream (K4) sites in the study area. However, biotic integrity remains poor at all Modderfonteinspruit sites and close monitoring remains warranted.

Table 9: SASS5 and ASPT index scores as well as individual biotope suitability scores at the different monitoring sites (2024-11).

Monitoring site	SASS5 score	ASPT	SASS5-score per biotope			Biotope availability and suitability (Scores)			
			SASS _{Stones}	SASS _{Vegetation}	SASS _{GSM}	Stones	Vegetation	GSM	Combined
K1	36	3.6	17	25	3	3	2	2	7
K2	22	3.1	5	21	10	2	1	2	5
K3	24	2.7	13	17	9	3	2	4	9
K4	32	2.9	13	27	9	4	2	2	8

Key:

ASPT - Average Score Per Taxon S-Stones Veg-Vegetation GSM-Gravel, sand & mud

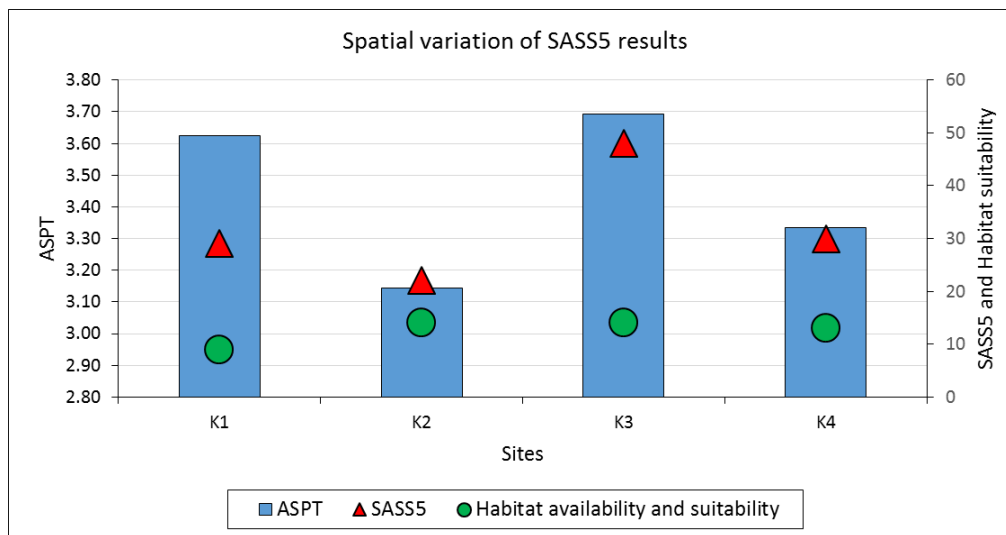


Figure 7: SASS5, ASPT and total biotope suitability scores at the different biomonitoring sites (2024-11).

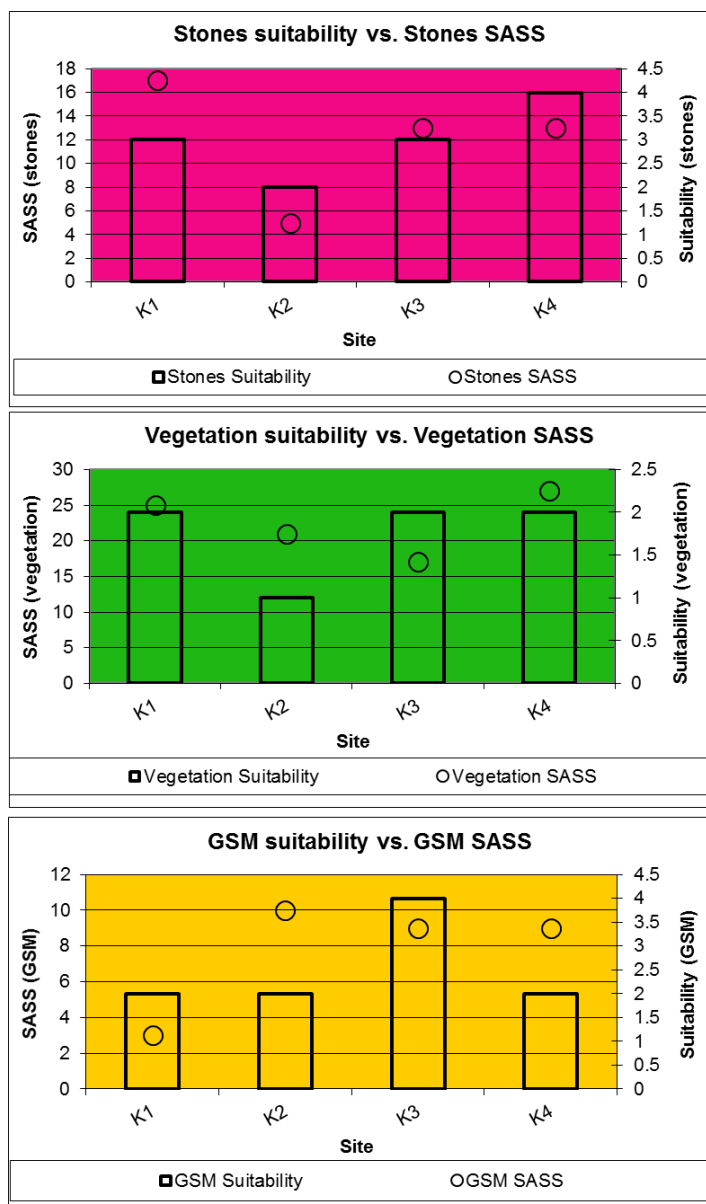


Figure 8: SASS biotope and biotope suitability & availability scores at the different monitoring sites.

4.3.2 Long-term trends (2002 – 2024)

Over the period since the inception of the application of the SASS5 index (March 2002) to the present (November 2024), no consistent trend in downstream improvement or deterioration between sites K1 and K2 could be established, however the SASS5 score is generally slightly better at site K2, downstream of potential KPS impacts (Figure 9). There was a high level of variation in SASS5 scores at both sites over the period between 2002 and 2024, reflecting fluctuating conditions. The long term (entire study period) trends (polynomial regression) have shown improvement in biotic conditions at sites K1 and K2 (although still considered poor) over much of the study period (Figure 9). Recent surveys are now reflecting an improving trend at site K1 while the trend at site K2 appears to be stabilizing (Figure 9). This reversal of the previously observed negative trend to a positive one and then in the case of site K2, a stable one, over recent years, is encouraging, but should be monitored closely in future to timeously initiate mitigation, should this trend become negative again. Although most surveys to date have not reflected spatial deterioration towards site K2, cognisance must also be taken of the decrease in total SASS5 score seen towards site K2 during a few surveys (e.g. November 2024 and June 2023).

Temporal trends of SASS5 scores at sites K3 and K4 are also included, as the database is deemed to be sufficiently populated since inclusion of these sites as of 2013. Biotic integrity has mostly been higher at the most downstream site (K4), however, a few recent surveys (e.g. the June 2019, June 2021, and June 2022 surveys) have shown a sharp decrease in biotic integrity at site K4 (Figure 9). It is also noticeable that biotic integrity generally improves from site K2 to both sites K3 and K4. This illustrates that the cumulative effect of all users upstream from K4 does not lead to a decrease in biotic integrity. However, recent data show that the trend is still, overall, improving at sites K1 and K2, while deteriorating notably at site K3 (Figure 5). A deteriorating trend was recently also observable for site K4, however inclusion of recent surveys have resulted in an improving trend being displayed (Figure 9) The deteriorating trend at site K3 (and previously at site K4) is a probable indication of increasing impacts originating between sites K2 and K3 (and previously also site K4), since approximately 2015. It is noted that KPS has no known sources of impact downstream from K2. The recent temporal deterioration is therefore non-KPS related.

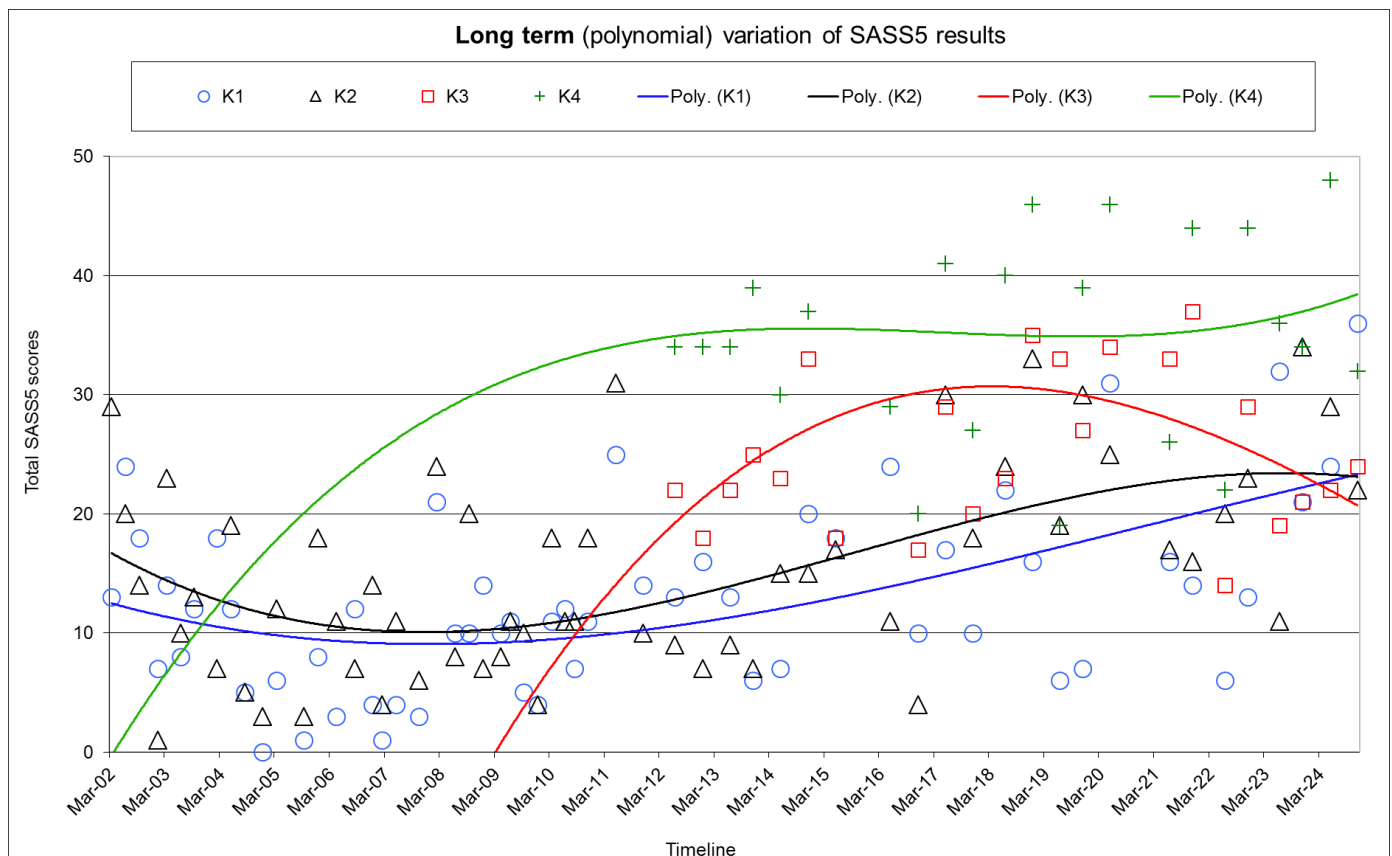


Figure 9: Long term (polynomial trends) variation in SASS5 scores since inception of the biomonitoring programme.

5. Conclusions & Recommendations

After interpretation of relevant data, the following conclusions and recommendations can be made based primarily on the November 2024 biomonitoring and the December 2024/January 2025 toxicity testing surveys, with strong emphasis also on the other recent surveys. It also includes historic reference to the biomonitoring programme (temporal variation):

- **Lethal/sub-lethal DEEEP Toxicity testing:**

- As of July 2024, toxicity testing is also performed on three Pollution Control Dams, namely the Return Water Dam (RWD), Ash Dam, and Desilting Dam. Toxicity testing of these sources is conducted on a definitive level.

- A slight lethal or sub-lethal environmental toxicity hazard (Class II) was detected for the January 2025 samples from the Ash Dam and the Desilting Dam. A safe dilution factor of 6% was calculated for the sample from the Ash Dam (i.e. 6 parts Ash Dam water diluted with 94 parts 'clean' water), however **no safe dilution factor** could be established for the sample from the Desilting Dam. A sub-lethal environmental toxicity hazard (Class III) was allocated to the January 2025 sample from the Return Water Dam (RWD), with a safe dilution factor of 62% calculated for the sample from this site (i.e. 62 parts RWD water diluted with 38 parts 'clean' water). **The toxicity hazards recorded for the PCDs highlights the need for continued and definitive toxicity testing. Such testing is a valuable management tool to monitor and, if needed, timeously mitigate hazards related to these sources.**
- A slight lethal environmental toxicity hazard (Class II) was assigned to the water sample from the upstream Modderfonteinspruit site, K1. The toxicity hazard decreased towards site K1, the sample of which showed no lethal sub/lethal environmental toxicity hazard (Class I), and the Effluent Stream (carrying potential KPS and other impacts) did not result in an increase in toxicity hazard of the receiving Modderfonteinspruit, at the time of sampling.
- A slight lethal environmental toxicity hazard (Class II) was detected for the sample from site Eff (Effluent Stream site inclusive of potential power station impacts, but excluding industrial impacts). A safe dilution factor of 13% was calculated for the sample (i.e. 13 parts Eff water diluted with 87 parts 'clean' water). Although the four most surveys have reflected only a slight hazard at this site, it is again noted that Class V and III hazards have on occasion been recorded for this site and close monitoring remains prudent.
- The water toxicity hazard decreased towards the downstream Effluent Stream site, Eff-plus (inclusive of potential power station- as well as industrial impacts), with the sample from this site showing no lethal/sub-lethal environmental toxicity hazard (Class I), and thus showing no increase in the toxicity hazard of the Effluent Stream due to industrial development.
- Temporal data show that toxicity levels at the upstream site (K1) ranged between a lethal/sub-lethal environmental toxicity hazard (Class III) and no lethal/sub-lethal environmental toxicity hazard (Class I), with the long-term polynomial temporal trend decreasing (improving) towards 2015, however an increasing (deteriorating) trend is displayed thereafter. Toxicity levels at the downstream site (K2) mostly ranged between a slight lethal/sub-lethal environmental toxicity hazard (Class II) and no lethal/sub-lethal environmental toxicity hazard (Class I), however increasing for the first time to a lethal/sub-lethal environmental toxicity hazard (Class III) during the June 2019 survey and again during the June 2023 and August 2023 surveys. The temporal trend is one of increasing toxicity since 2015, and although toxicity at site K2 has generally been lower than (or similar to) that at site K1, toxicity at K2 surpassed that at K1 during the June 2019, February 2021, June 2021, April 2022, and August 2023 surveys. Although the present survey (December 2024) reflected a decrease in hazard from site K1 to K2, the spatial increases seen during some previous surveys **highlight the importance of close monitoring.**
- The toxicity hazard for site Eff has improved (decreased) considerably between 2005 and 2015. However, following 2015, a trend of increasing toxicity hazard is displayed for site Eff, with the **Class V hazard** (very high lethal hazard) recorded in November 2023 reflecting further notable and rapid deterioration at this site. Although the four subsequent surveys showed only a slight toxicity hazard (Class II), **KPS's environmental staff should further investigate and timeously implement mitigation measures.** Apart from the **Class IV** hazard recorded during the August 2010, June 2021, and August 2021 surveys, site Eff-plus has also generally varied between slight lethal/sub-lethal environmental toxicity hazard (Class II) and no lethal/sub-lethal environmental toxicity hazard (Class I). The long-term temporal trend at site Eff-plus reflected an overall decreasing trend in toxicity hazard at site Eff-plus after its inclusion in 2009, however, f toxicity hazards recorded in 2021 (Class IV during two surveys) and 2023 (Class III during two surveys) resulted in a sharply increasing (deteriorating) toxicity trend displayed for site Eff-plus. It is encouraging to note that inclusion of the four most recent surveys has resulted in a decreasing trend again being reflected for site Eff-plus.
- **Chronic sediment toxicity testing (December 2024 survey):**
 - *Sediment toxicity testing is done annually during the fourth quarter survey (current survey):*

- During 2014, sediment toxicity analyses revealed that the chronic hazards decreased spatially from K1 (upstream from the ash spill) to K2 (downstream from the ash spill). The sediments of the Modderfonteinspruit, upstream from the spill, measured a “chronic toxicity hazard” (Class III). The sediments within the effluent stream and the downstream Modderfonteinspruit (both clearly containing spilled ash) measured “no chronic hazard” (Class I). This is a clear indication that, although significant amounts of ash were present within the downstream sediments, the spill has clearly not resulted in an increased toxicity hazard within the sediments. The opposite trend was observed during the 2010 ash spill assessment (report KEL-F-10), when a spatial increase in chronic sediment toxicity was indeed observed.
- The December 2024 sediment samples from both site K1 and K2 showed a slight lethal environmental toxicity hazard (Class II), and therefore did not reflect impacts from KPS or industrial activities along this reach (via the Effluent stream). The slight hazard recorded at for the sediment sample from site K2 is in contrast to the water sample from this site that showed no toxicity hazard (Class I) – this highlights the value of conducting both water- and sediment toxicity testing.
- **SASS5 Protocol:**
 - As during previous surveys, biotic integrity, as measured by the SASS5 macroinvertebrate protocol, was poor throughout the study area, reducing the confidence in the ASPT and biotope-specific comparisons and rendering the total SASS5 score the better indicator of biotic integrity.
 - In November 2024, the total SASS5 score and ASPT decreased between site K1 (36 and 3.6) and K2 (22 and 3.1) with slightly poorer habitat potentially contributing in part to the decrease. Assessment of the most comparable biotope did not point to water quality impacts and toxicity testing (water and sediment) did not show an increase in hazard towards site K2. However, *in-situ* measurements showed a marked increase in salinity, indicating that water quality impacts may also have contributed to the decrease in biotic integrity towards site K2. Indeed, a spatial increase in salinity is consistently observed towards site K2 and the Effluent Stream has regularly been identified as a source of increased salts along this reach of the Modderfonteinspruit. The November 2024 findings therefore showed that biotic integrity decreased towards site K2 and although habitat differences likely played a role, water quality impacts (increased salts via the Effluent stream) may also have contributed. Although other impacts also occur along this reach (notably potential sewage pollution via a entering the Modderfonteinspruit just downstream of K2), **KPS’s environmental staff should closely monitor the scenario** and implement mitigating measures if needed.
 - The total SASS5 score remained fairly stable while the ASPT decreased slightly from site K2 (22 and 3.1) to K3 (24 and 3.7) in November 2024. The lack of improvement in biotic integrity despite better habitat at site K3 is suggestive of water quality deterioration. Assessment of the most comparable biotopes did not provide conclusive insights regarding potential water quality related impacts to the macroinvertebrates of this reach. *In-situ* measurements in contrast showed improvement in water quality in terms of a decrease in salinity towards site K3, however it may be that variables not included in the *in-situ* range played a role. The November 2024 SASS5 findings suggested that water quality related impacts to the biotic integrity of this reach (K2 to K3) of the Modderfonteinspruit (industrial/residential areas) cannot be ruled out. It is reiterated that there are no known further KPS impacts downstream of site K2.
 - A very slight improvement in total SASS5 score and ASPT was seen between site K3 (24 and 2.7) and K4 (32 and 3.9), despite similar to marginally poorer habitat at site K4. The slightly better biotic integrity at site K4 may point to water quality improvement, although *in-situ* measurements did not reflect major water quality differences between sites K3 and K4 (other than a very slight increase in salinity). However, it may also be that improvement in water quality variables outside the *in-situ* range played a role. The November 2024 SASS5 findings thus reflected that activities (non-KPS) along this reach did not negatively impact the biotic integrity of the Modderfonteinspruit, in fact showing a marginal improvement in biotic integrity towards site K4.
 - Overall, biotic integrity remained fairly similar/ decreased slightly in the Modderfonteinspruit in November 2024 when comparing the most upstream (K1) and most downstream (K4) sites in the study area. Biotic integrity remains poor at all Modderfonteinspruit sites and close monitoring remains warranted.

- Although there has been considerable temporal variation at both sites K1 and K2, the SASS5 score has **generally been slightly better at site K2**, downstream of potential KPS impacts. Additionally, the long term trends have shown improvement in biotic conditions at sites K1 and K2 over much of the study period. Recent surveys are now reflecting an **improving trend at site K1** while the **trend at site K2 appears to be stabilizing**. Close monitoring remains warranted.
- Biotic integrity is almost always higher at the most downstream site (K4) than at site K3, however, a few recent surveys have shown a sharp decrease in biotic integrity at site K4. It is also noticeable that biotic integrity generally improves from site K2 to both sites K3 and K4. This illustrates that the cumulative effect of all users upstream from K4 has not lead to decreased biotic integrity. Recent data, however, show that the trend is still improving at sites K1 and K2, while **deteriorating notably site K3**. A deteriorating trend was recently also observable for site **K4**, however inclusion of recent surveys have resulted in an **improving trend being displayed**. The deteriorating trend at site K3 (and previously at site K4) is a probable indication of **increasing impacts** originating between sites K2 and K3 (and previously K4), since approximately 2015. It is again noted that KPS has no known impacts downstream of site K2 and any deterioration noted between sites K2 and K4 is therefore non-KPS related.

Evidence of sewage contamination along the reach of the Modderfonteinspruit included in the study has been observed during a number of recent surveys. Indeed, the DO concentration was below the guideline level at site K1 in May 2024 and at all Modderfonteinspruit sites in November 2023, despite moderate surface flow and thus ample physical aeration. In November 2024, the DO concentration met the lower guideline level at all sites, however signs of sewage contamination (such as algal proliferation) is still prevailing. Although unrelated to KPS, the scenario should nonetheless be reported to the relevant authorities as it is a source of biotic deterioration and also poses an environmental health risk.

It is recommended to continue with the current monitoring format, with inclusion of definitive toxicity testing for the three PCDs on a quarterly basis. Clarification should be sought regarding licensing conditions referring to the monitoring of impacts to the Edenvale Spruit as no known KPS effluent directly enters the Edenvale Spruit, with the Modderfonteinspruit being the primary receiving water body of potential KPS impacts via a natural drainage line (referred to as the Effluent Stream for the purposes of this report). As a standard monitoring requirement, the integrated water user licence (IWUL) should always be consulted and considered, if amended, when continuing with, or entering into a new monitoring period.

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Appendices

Appendix 1: Methodology applied during this biomonitoring assessment.

1. Aquatic invertebrate assessment: South African Scoring System, Version 5.

Benthic macro-invertebrate communities of the selected sites were investigated according to the South African Scoring System, version 5 (SASS5) approach (Dickens & Graham, 2001). This method is based on the British Biological Monitoring Working Party (BMWP) method and has been adapted for South African conditions by Dr. F. M. Chutter (Thirion *et al.*, 1995). The SASS method is a rapid, simple and cost effective method, which has progressed through four different upgrades/versions. The current upgrade is Version 5, which is specifically designed to comply with international accreditation protocols.

Sample Collection

An invertebrate net (30 x 30cm square with 1mm mesh netting) was used for the collection of the organisms. The available biotopes at each site were identified on arrival. Each of the biotopes was sampled by different methods explained later (samples should not be collected when the river is in flood).

The biotopes were combined into three different groups, which were sampled and assessed separately:

a) Stone (S) Biotopes:

Stones in current (SIC) or any solid object: *Movable stones of at least cobble size (3 cm diameter) to approximately 20 cm in diameter, within the fast and slow flowing sections of the river.* Kicksampling is used to collect organisms in this biotope. This is done by putting the net on the bottom of the river, just downstream of the stones to be kicked, in a position where the current will carry the dislodged organisms into the net. The stones are then kicked over and against each other to dislodge the invertebrates (kicksampling) for ± 2 minutes.

Stones out of current (SOOC): *Where the river is still, such as behind a sandbank or ridge of stones or in backwaters.* Collection is again done by the method of kicksampling, but in this case the net is swept across the area sampled to catch the dislodged biota. Approximately 1 m² is sampled in this way.

Bedrock or other solid substrate: Bedrock includes stones greater than 30cm, which are generally immovable, including large sheets of rock, waterfalls and chutes. The surfaces are scraped with a boot or hand and the dislodged organisms collected. Sampling effort is included under SIC and SOOC above.

b) Vegetation (VG) Biotopes:

Marginal vegetation (MV): *This is the overhanging grasses, bushes, twigs and reeds growing on the edge of the stream, often emergent, both in current (MvegIC) and out of current (MvegOOC).* Sampling is done by holding the net perpendicular to the vegetation (half in and half out of the water) and sweeping back and forth in the vegetation (± 2 m of vegetation).

Submerged vegetation (AQV): *This vegetation is totally submerged and includes Filamentous algae and the roots of floating aquatics such as water hyacinth.* Sampled by pushing the net (under the water) against and amongst the vegetation in an area of approximately one square meter.

c) Gravel, Sand and Mud (GSM) biotopes:

Sand: *This includes sandbanks within the river, small patches of sand in hollows at the side of the river or sand between the stones at the side of the river.* This biotope is sampled by stirring the substrate by shuffling or scraping of the feet, which is done for half a minute, whilst the net is continuously swept over the disturbed area.

Gravel: *Gravel typically consists of smaller stones (2-3 mm up to 3 cm).* Sampling similar to that of sand.

Mud: *It consists of very fine particles, usually as dark-collared sediment.* Mud usually settles to the bottom in still or slow flowing areas of the river. Sampling similar to that of sand.

d) Hand picking and visual observation:

Before and after disturbing the site, approximately 1 minute of "hand-picking" for specimens that may have been missed by the sampling procedures was carried out.

Sample preparation

The organisms sampled in each biotope group were identified and their relative abundance also noted on the SASS5 datasheet.

SASS-Habitat Assessment

The IHAS scores were supplemented with biotope suitability and availability scores. This scoring system was adapted to consider the importance of different biotopes by applying a site-specific weighting to each biotope score, based on the natural prevalence and therefore relative (to other biotopes) ability to harbour macro-invertebrates. Importance (and weightings) of biotopes are influenced by among others, natural geomorphology, ecoregions, stream order, riparian vegetation, river gradient and other applicable natural site-specific features. The final weighted site-specific suitability score is expressed as a percentage, and merely used to compare the overall habitat compatibility of different sites, and therefore gives an indication whether total SASS5 scores could be compared to indicate on improved/deteriorated biotic conditions. In addition specific biotopes (Stones, Vegetation and Gravel/Sand/Mud) suitability scores were surmised to determine which SASS-biotope scores are most comparable (from site to site) in the event that total SASS scores are not comparable (from site to site).

Appendix 2: Tables

Table A1: SASS5 analysis including macroinvertebrate families sampled at the different sites (2024-11).

Taxon	Common name	K1				K2				K3				K4			
		Stones	Veg	GSM	Total	Stones	Veg	GSM	Total	Stones	Veg	GSM	Total	Stones	Veg	GSM	Total
Oligochaeta	Aquatic earthworms	A	A	B	B	-	-	B	B	B	B	B	C	B	B	-	B
Leeches	Leeches	B	A	-	B	B	A	A	B	A	B	-	B	-	B	-	B
Baetidae 1 sp.	Small minnow flies	B	-	-	B	-	A	A	A	-	-	-	-	-	A	-	A
Baetidae 2 spp.	Small minnow flies	B	-	-	B	-	-	-	-	B	-	-	B	-	-	-	-
Coenagrionidae	Damselflies	-	A	-	A	-	A	-	A	-	-	-	-	-	-	-	-
Aeshnidae	Dragonflies	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	-
Belostomatidae*	Giant water bug	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	A
Corixidae*	Water boatmen	-	-	-	-	-	-	-	-	-	A	A	A	A	B	B	C
Notonectidae*	Back swimmers	-	-	-	-	-	-	-	-	-	-	-	-	-	A	1	A
Pleidae*	Pigmy backswimmers	-	-	-	-	-	-	-	-	-	A	-	A	-	-	-	-
Hydropsychidae 1sp.	Caseless caddisflies	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	A
Dytiscidae (adults*)	Predacious diving beetles	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	A
Ceratopogonidae	Biting midges	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Chironomidae	Midges	B	B	C	C	B	B	B	B	B	B	B	C	B	B	B	B
Culicidae*	Mosquitoes	-	1	-	1	-	-	-	-	-	A	-	A	-	-	-	-
Muscidae	House flies	-	1	-	1	-	-	-	-	B	-	-	B	-	-	1	1
Simuliidae	Black flies	A	-	-	A	-	A	-	A	-	-	-	-	-	-	-	-
Physidae*	Pouch snails	-	-	-	-	-	A	-	A	-	B	A	B	B	B	-	B
Total SASS5 score		17	25	3	36	5	21	10	22	13	17	9	24	13	27	9	32
No. of families		5	8	2	10	2	6	4	7	5	7	4	9	5	9	4	11
ASPT		3.40	3.13	1.50	3.60	2.50	3.50	2.50	3.14	2.60	2.43	2.25	2.67	2.60	3.00	2.25	2.91
Total IHAS																	
IHAS - Habs sampled																	
IHAS - Stream condition																	

Appendix 3: Site photos of biomonitoring sites (last two surveys)



Plate 1: Upstream view of site K1 (2024-11)



Plate 2: Downstream view of site K1 (2024-11)



Plate 3: Upstream view of site K1 (2024-05)



Plate 4: Downstream view of site K1 (2024-05)



Plate 5: Upstream view of site K2 (2024-11)



Plate 6: Downstream view of site K2 (2024-11)

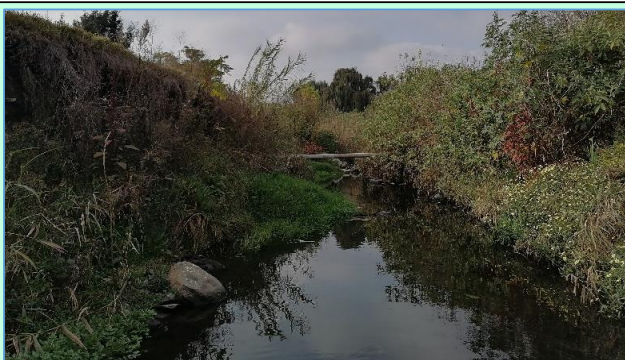


Plate 7: Upstream view of site K2 (2024-05)



Plate 8: Downstream view of site K2 (2024-05)



Plate 10: Upstream view of site K3 (2024-11)



Plate 11: Downstream view of site K3 (2024-11)



Plate 6: Upstream view of site K3 (2024-05)

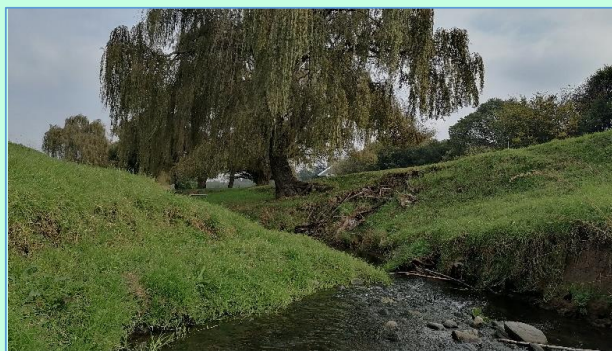


Plate 13: Downstream view of site K3 (2024-05)



Plate 14: Upstream view of site K4 (2024-11)



Plate 15: Downstream view of site K4 (2024-11)



Plate 16: Upstream view of site K4 (2024-05)



Plate 17: Downstream view of site K4 (2024-05)

Addendum 1: Toxicity test report/s (BiotoxLab)
(submitted as separate PDF document/s)