BEAL

CONSULTING ENGINEERING & PROJECT MANAGEMENT

REPORT

ENVIRONMENTAL IMPACT MANAGEMENT SERVICES

MANUNGU COLLIERY SURFACE WATER SPECIALIST STUDY

Submitted to:

Brian Whitfield
Block 5 Fernridge Office Park,
5 Hunter Avenue,
Ferndale,
Randburg.
2123, South Africa.

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B196_SurfaceWater SpecialistStudy

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1. INTRODUCTION

Environmental Impact Management Services (EIMS) commissioned BEAL (Pty) Ltd (BEAL) to conduct a surface water specialist study for the proposed expansion of the Manungu Colliery. This report details the results of the study, as well as recommendations emanating from the work done.

1.1 STUDY OBJECTIVES

The study objectives are as follows:

- Baseline hydrological analysis;
- Floodlines and buffer zones;
- Surface water Impact assessment; and
- Review and comment on baseline water quality.

This report constitutes the outcome of the specialist studies undertaken by BEAL on behalf of Manungu, related to the environmental impact of the Manungu Colliery.

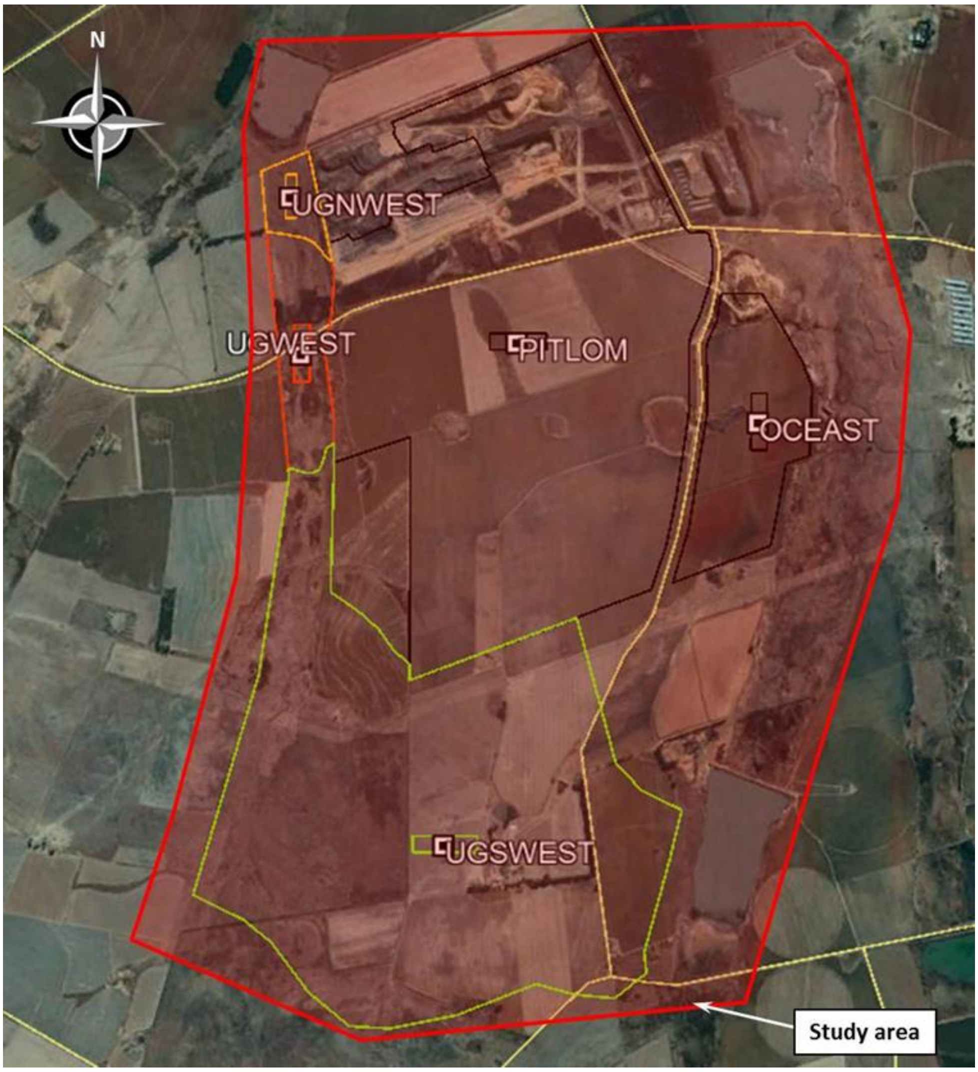


Figure 1: Study areas

1.2 BATTERY LIMITS

The battery limits for the study are confined to the mining rights area unless otherwise specified.

2. REGIONAL SETTING

Manungu colliery is located in the Mpumalanga Province of South Africa. The colliery is located in the upper reaches of the Wilge River catchment. The upper regions of the Wilge River form the catchment of the Bronkhorstspruit Dam

The Wilge River is a tributary of the Olifants River, which feeds the Loskop and Flag Boshielo Dams. The Loskop and Flag Boshielo dams are located downstream of Bronkhorstpruit Dam.

Bronkhorstpruit, Loskop and Flag Boshielo dams and are an important source of domestic, irrigation and industrial water to their surrounding areas. The Olifants River is an international river, flowing through the Kruger National Park and into Mozambique. With the Olifants River flowing through the Kruger National Park, provision for meeting ecological requirements is one of the controlling factors for managing water resources throughout the Olifants River catchment.

The Wilge River catchment measures 4 360 km^2. The mean annual precipitation in this catchment is generally uniform with an average precipitation of approximately 670 mm, varying between 650 mm and 700 mm.

The mean annual evaporation (S-Pan) varies between 1 677 mm in the south western regions of the catchment and 1 800 mm in the north western regions of the catchment.

The natural vegetation in the catchment is predominantly grassland. Extensive irrigated and dry-land agricultural activities are prevalent, along with various forms of livestock farming. Power stations and mining activities occur in the Wilge River catchment, as do a number of small towns. These include Delmas, Bronkhorstspruit, Lionelton, Kendal, and New Largo.

3. LOCAL SETTING

The mining rights area is located in quaternary catchment B20A. It is located approximately 10 km south of Delmas.

Two unnamed tributaries of the Wilge River flow generally in a northerly direction either side of the mining rights area (refer to Figure 1: Study areas). Both tributaries (referred to as Western and Eastern streams in this report) are marked as perennial streams on the Surveyor General's topographical sheets. Both streams were dry during the September 2017 site visit, although subsurface flow cannot be discounted as there were isolated pools in some areas. The two tributaries merge just downstream of the mining rights area. This merged stream flows past the eastern side of Delmas.

4. CATCHMENT DESCRIPTION

The Western and Eastern stream catchments are undeveloped and consists mostly of impacted grasslands and dry land agriculture. The two catchments are not impacted by mining upstream of Manungu Colliery.

The topography is relatively flat. Localised areas have steeper slopes, particularly in the vicinity of the streams. The two streams are dammed with multiple farm dams on each stream. The water courses of the two streams in the mining rights area are reeded in places, but the water courses are generally poorly defined. The flood plains are not well developed.

Two large farm dams are located either side of Manungu Colliery. These dams do not form part of Manungu's property and are being used by the farmers on neighbouring land.

Figure 2: Western Stream

5. BASELINE RAINFALL AND EVAPORATION

5.1 MEAN ANNUAL PRECIPITATION AND EVAPORATION

The mean annual precipitation of the mining rights area is 678 mm. The mean annual evaporation of the mining rights area is 1677 mm (S-Pan). The monthly average rainfall, rainfall days, and evaporation rates are presented in Table 1. The Mpumalanga Highveld has distinct wet and dry seasons. 91% of the mining rights area's mean annual rainfall falls between October and April inclusively. 61% of the area's mean annual evaporation occurs in this period (Midgley et al., 1990).

Table 1: Mean monthly rainfall, rain days and evaporation data for the mining rights area

Month	Ave Rainfall (mm)	Ave rain days	Ave Evaporation (mm S-Pan)
October	67.5	6.8	180.8
November	101.1	10.1	170.6
December	106.9	9.9	187.8
January	119.3	10.3	184.5
February	95.5	8.1	153.8
March	86.0	7.6	151.8
April	41.2	4.7	116.7
May	18.4	2.3	98.3
June	6.1	1.0	79.8
July	5.9	0.8	87.4
August	8.3	1.1	115.7
September	22.4	2.7	149.9
Mean Annual	678		1677

** Note: The sum of the mean monthly rainfall depths does not necessarily equal the mean annual precipitation.*

5.1.1 Climatic water balance

The Department of Water and Sanitation require a climatic water balance that incorporates a list of years which have the wettest six months of the year, either November to April or May to October. In this case November to April is wetter than May to October. The wettest six months between November and April are listed in Table 2.

Table 2: Wettest years between November and April

Rating	Year	Total rainfall between November and April (mm)
Wettest year	1936	1155.0
2nd wettest year	1955	979.8
3rd wettest year	1971	972.5
4th wettest year	1929	963.4
5th wettest year	1996	957.7
6th wettest year	1975	952.6
7th wettest year	1987	924.7
8th wettest year	1909	922.5
9th wettest year	1942	900.3
10th wettest year	1944	898.8

5.1.2 Sources of rainfall data

Daily rainfall data was sourced from the CCWR (Computing Centre for Water Research, Natal University) rainfall database (gauge number 0477309 – Delmas). The gauge is located approximately 9 km north of the mining rights area. The CCWR data that was used contains daily records and patched records between January 1901 and August 2000, or over 99 years. The data is considered representative of the mining rights area and is good quality.

5.1.3 Sources of evaporation data

The mean annual evaporation was sourced from the average evaporation for quaternary catchment B20A, documented in the Water Resources of South Africa, 2005 Study (Middleton and Bailey, 2009). Its monthly distribution was sourced from the Water Resources of South Africa Study data set, zone 4A (Midgley et al., 1990). The data is considered representative of the mining rights area.

5.2 PEAK RAINFALL DATA

5.2.1 Maximum Monthly Rainfall Data

The maximum monthly rainfall data was distilled from the daily rainfall record (discussed in section 5.1.2) and is presented in Table 3.

Table 3: Maximum monthly rainfall data (mm)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
216.6	269.9	243.1	370	333.2	360.5	127	191.8	77.5	79.4	60.7	134.1

5.2.2 Peak 24-hr Rainfall Data

The peak 24-hr rainfall depths are presented in Table 4.

Table 4: Peak 24-hr rainfall depths for the mining rights area

Recurrence Interval (year)	24 hour rainfall depth (mm)
2	55
10	90
20	102
50	116
100	126
200	136

The daily rainfall record, discussed in section 5.1.2, was analysed and the annual maximum series was extracted from the data. This annual maximum series was statistically analysed to determine various T-year recurrence interval 24-hour storm depths. A Log Pearson Type 3 fit was selected as the most appropriate statistical fit. This fit is shown in Figure 3. The rainfall record is long, consists of good data, is representative of the mining rights area, and is suitable to be used to calculate peak rainfall.

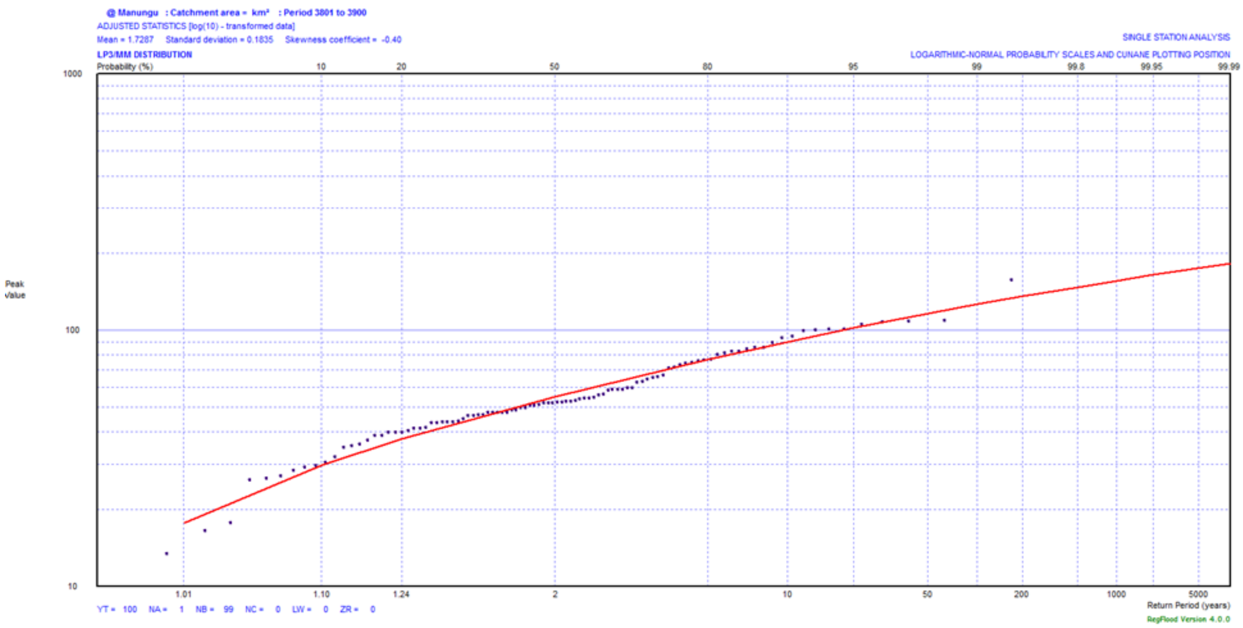


Figure 3: Log Pearson Type 3 statistical fit to the annual maximum series

6. BASELINE HYDROLOGY

6.1 CATCHMENT DELINEATION

The Eastern Stream and the Western Stream catchments measure 938 ha and 6 659 ha respectively. The catchment areas of these two streams were delineated using the Surveyor General's 5m contours. The catchment areas were measured to the two large dams either side of the northern end of the mining rights area. The catchment sizes and catchment boundaries are shown in Figure 4.

The mean annual runoffs for the catchments shown in Figure 5 are listed in Table 5.

Table 5: Mean annual runoff

Stream	Mean annual run-off (Mm^3/a)
Western stream	0.38
Eastern stream	2.71

The mean annual runoff for the quaternary catchments B20A is 25.25 Mm^3 (Middleton and Bailey, 2009). The mean annual runoff values in Table 5 were scaled from the quaternary catchment runoff, based on relative catchment size.

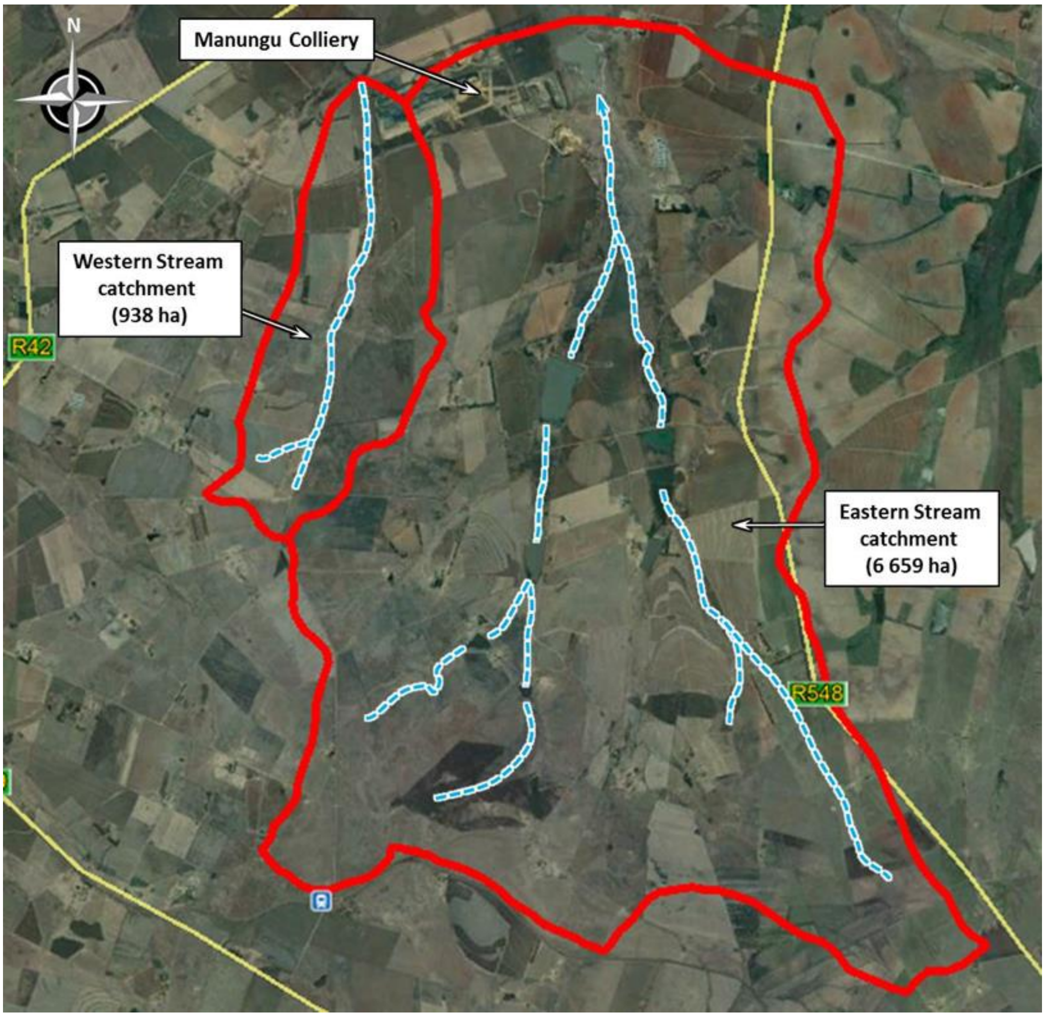


Figure 4: Cachment delineation

6.2 NORMAL DRY WEATHER FLOWS

Due to the small catchment sizes, dry weather flows are likely to be very low and will often be limited to sub-surface flow only. Average dry weather flows appear high but these are influenced by storm flow from occasional winter rainfall events and unseen subsurface flow.

The normal dry weather flows are based on the average monthly flows documented in the Water Resources of South Africa, 2005 Study (Middleton and Bailey, 2009) for quaternary catchment B20A. The flows were scaled based on relative catchment size. The dry weather flows are presented in

Table 6. The dry weather flows have been highlighted in bold text.

Table 6: Normal dry weather flows in m^3/month (highlighted in bold text)

Month	Western stream	Eastern stream
Oct	**17 987 m^3**	**127 652 m^3**
Nov	37 118 m^3	263 429 m^3
Dec	38 805 m^3	275 401 m^3
Jan	54 298 m^3	385 354 m^3
Feb	60 861 m^3	431 929 m^3
Mar	55 345 m^3	392 785 m^3
Apr	34 736 m^3	246 525 m^3
May	26 087 m^3	185 140 m^3
Jun	**19 466 m^3**	**138 148 m^3**
Jul	**15 104 m^3**	**107 191 m^3**
Aug	**11 863 m^3**	**84 193 m^3**
Sep	**9 783 m^3**	**96 434 m^3**

6.3 FLOOD FLOW ANALYSIS

The 50-year and 100-year flood peaks for the two streams were calculated and the results are presented in Table 7. The flood peaks were calculated for the catchments shown in Figure 4.

Table 7: Peak flows in the rivers and streams

Recurrence interval	Western stream	Eastern stream
50-year	50 m^3/s	196 m^3/s
100-year	61 m^3/s	237 m^3/s

The Utility Programs for Drainage software was used to calculate the flood peaks. The Rational Method, Alternative Rational Method, SDF Method and Unit hydrograph Method were used to calculate the flood peaks. The Alternative Rational Method was selected as the most appropriate flood peak to use for both streams.

7. FLOODLINES

7.1 BACKWATER ANALYSIS

The backwater analysis was performed using HEC-RAS. Cross sections for the Eastern and Western streams were taken from 0.5 m contour data supplied by the client.

Both tributaries are small with poorly defined channels in most areas. Some areas have incised channels. The tributaries are generally free of trees and woody vegetation. The channels mostly consist of grasses, sedges and reed beds. The banks are well vegetated, mainly with grasses. A Manning's n of 0.035 was used outside and within the overbank stations.

The flood peaks presented in Table 7 were used to calculate the floodlines. The 50-year and 100-year floodlines are shown in Figure 5.The accuracy of the survey data cannot be verified apart from a visual comparison with landforms visible on Google Earth. This was done. It is assumed that the survey data provided is a true reflection of the topography within the study area. The accuracy of the floodlines is dependent on the accuracy of the survey data.

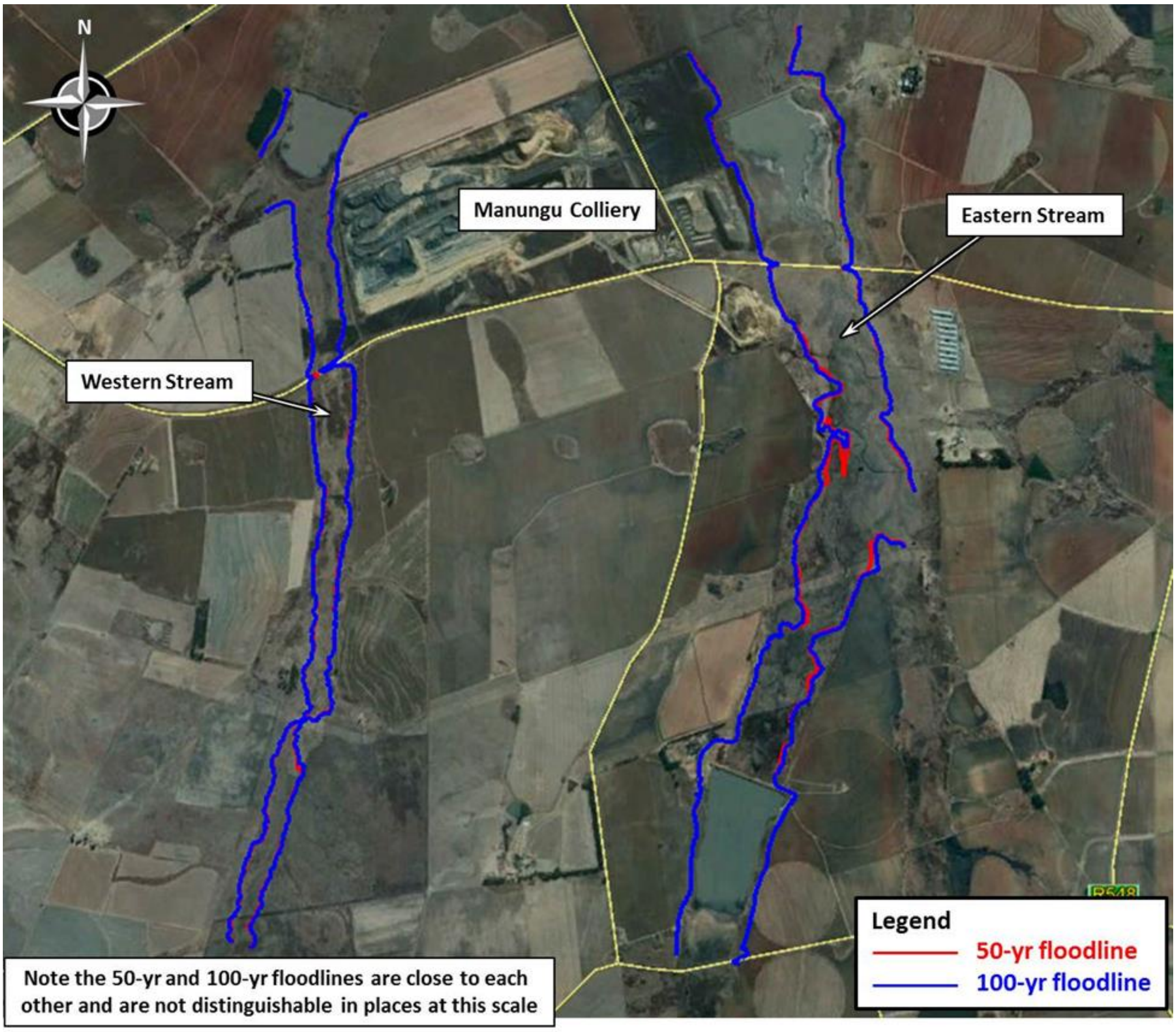


Figure 5: Floodlines

8. BUFFER ZONES

Section 4a of Government Notice 704 (GN 704) of the South African National Water Act states the following: "No person in control of a mine or activity may locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 metres from any watercourse…".

Section 4b of Government Notice 704 of the South African National Water Act states the following: "No person in control of a mine or activity may … carry on any underground or opencast mining, prospecting or any other operation or activity under or within the 1:50 year flood-line or within a horizontal distance of 100 metres from any watercourse…"

Pollution control dams are required as part of the project so Section 4a of GN 704 will apply to these. The surface water buffer zone therefore is the greater of the 100-year floodline or 100 m from the water course. The buffer zones for the Eastern and Western streams are shown in Figure 6.

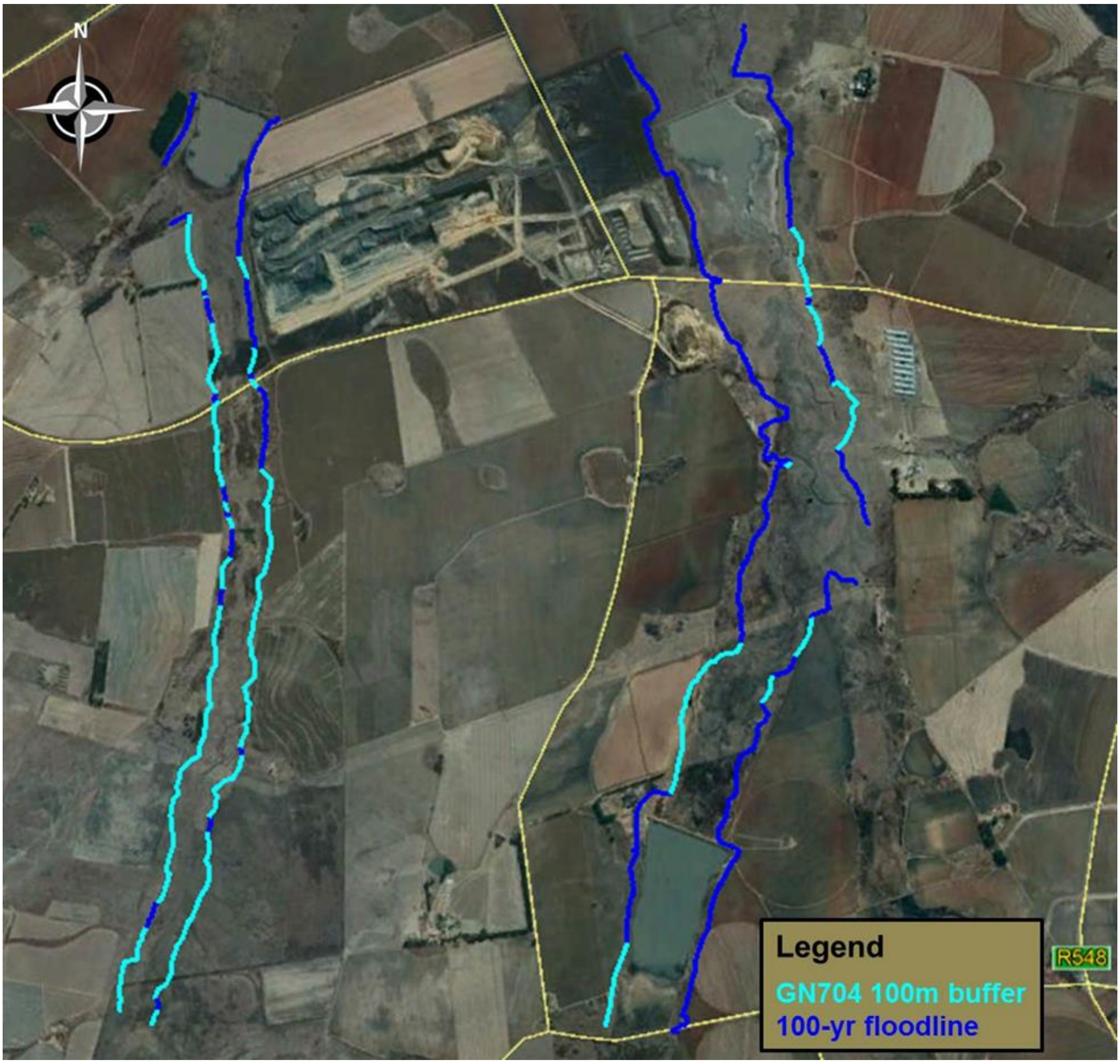
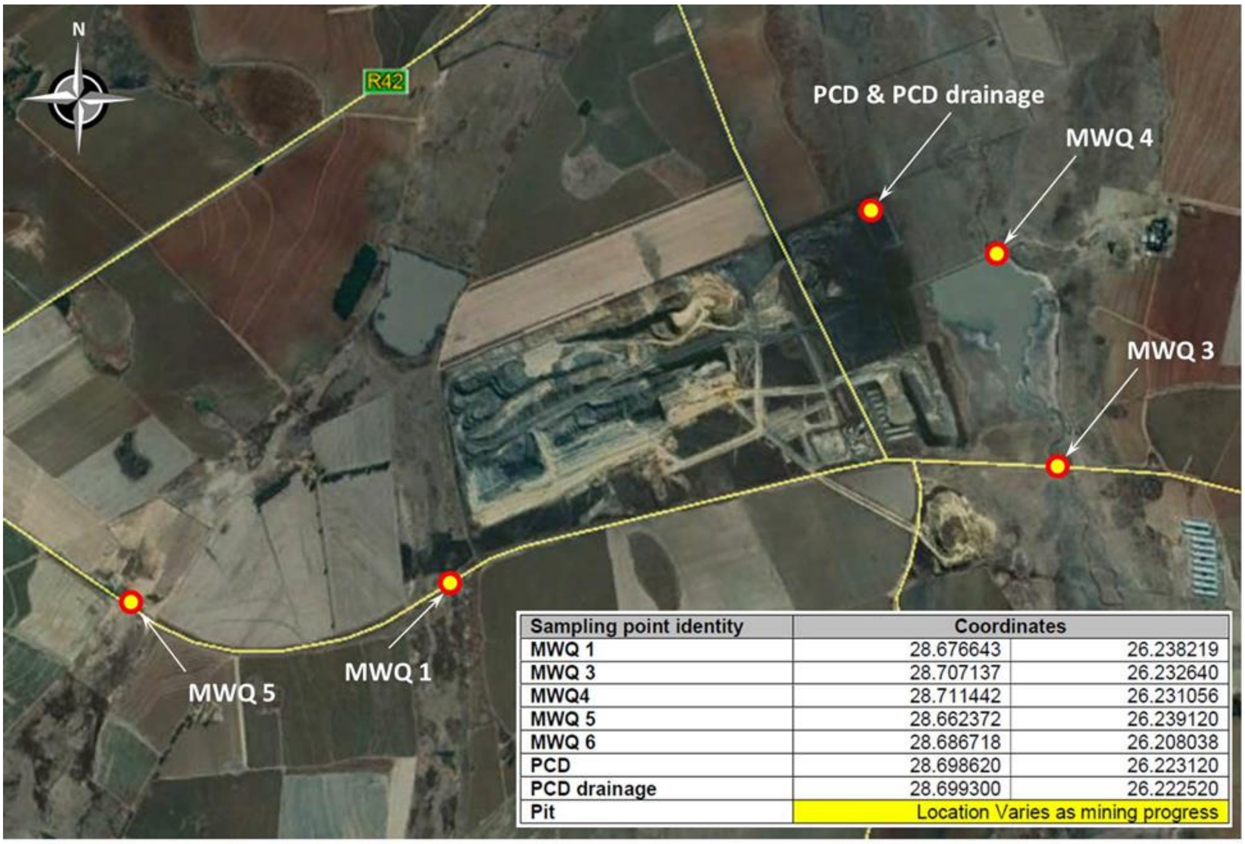


Figure 6: Surface water buffer zones

9. WATER QUALITY

Monthly water quality sampling is done by Philo Environmental Management CC (Philo Environmental) at 8 locations. The sampling locations are shown in Figure 7.



Sampling point identity	Coordinates	
MWQ 1	28.676643	26.238219
MWQ 3	28.707137	26.232640
MWQ4	28.711442	26.231056
MWQ 5	28.662372	26.239120
MWQ 6	28.686718	26.208038
PCD	28.698620	26.223120
PCD drainage	28.699300	26.222520
Pit	Location Varies as mining progress	

Source: Philo Environmental Management CC

Figure 7: Philo Environmental Management CC water quality monitoring locations

Philo Environmental does analysis of the water quality results and extracts of this analysis are included in Appendix A.

The results show poor water quality in the pit and PCD. This is consistent with normal coal mining operations. The upstream water quality monitoring points show no coal mining related impacts, but do show agriculture related impacts. This is consistent with the land use patterns.

10. IMPACT ASSESSMENT

10.1 PROJECT DESCRIPTION

The expansion involves opencast and underground coal mining, the construction of topsoil, hards and softs dumps, and the construction of run of mine stockpile areas. Storm water management infrastructure (diversion channels and pollution control dams) will be constructed.

10.2 METHODOLOGY FOR IMPACT ASSESSMENT

Activities on the proposed expansion project have been taken through an impact assessment prior to and post mitigation measures. The recommended mitigation measures have been included in the impact assessments. Impacts are assessed for the construction, operational, decommissioning and closure phases of the project. The methodology used for the impact assessments is presented below:

Occurrence

- Probability of occurrence (how likely is it that the impact will occur)
- Duration of occurrence (how long impacts will last)

Severity

- Magnitude of impact (the severity of the impact)
- Scale of impact (the extent of the impact).

The following ranking scales were used:

Probability (P)	Duration (D)
5: Definite/don't know 4: Highly probable 3: Medium probability 2: Low probability 1: Improbable 0: None	5: Permanent 4: Long-term (ceases with the operational life) 3: Medium term (5-15 years) 2: Short term (0-5 years) 1: Very short term (0-1 week)
Scale (S)	**Magnitude (M)**
5: International 4: National 3: Regional (within a 100 km radius) 2: Local (within a 5 km radius) 1: Site only 0: None	10: Very high/don't know 8: High 6: Moderate 4: Low 2: Minor

The impact is calculated as: Impact score = (M + D + S) x P. The maximum Impact score is 100. The impact ratings were based on the Impact score and are rated as follows:

- High environmental impact: Impact score between 60 and 100.
- Medium environmental impact: Impact score between 30 and 59.
- Low environmental impact: Impact score between 0 and 29.

10.3 IMPACTS DURING THE CONSTRUCTION PERIOD

10.3.1 Impacts due to topsoil stripping

Impact assessment

During the construction phase, topsoil from all facility footprints will be stripped and stockpiled for future use. This may result in the following impacts:

- Areas that have been stripped of vegetation and topsoil will be prone to erosion. This could lead to increased suspended solids being deposited into the local streams. It is unlikely that impacts will extend beyond the Western and Eastern streams.
- The topsoil stockpile will be prone to erosion prior to it being vegetated. Natural re-vegetation will likely take more than one season to completely cover the topsoil stockpile. The resultant erosion could lead to increased suspended solids being deposited into the Western and Eastern streams.

The affected areas will be relatively small. Erosion impacts will be short term and will cease once the facilities are constructed and the topsoil stockpile is vegetated.

Mitigation

Mitigation of the impacts should include the following:

- Areas that are stripped should be optimised to limit unnecessary stripping.

- Storm water from upslope of the stripped areas should be diverted around these areas to limit the amount of storm water flowing over from these areas.
- The timing of the topsoil stripping should be optimised to limit the time between stripping and construction. Where practical constraints exist and areas need to be left stripped for long periods, contour ploughing or ripping could reduce runoff and hence reduce erosion.
- Dry season construction is preferable where practical.
- Hydro seeding of the topsoil stockpile is recommended to speed up vegetation cover. An appropriate seed mix should be designed by a vegetation specialist.

Residual impact

The residual impacts will likely be low as large flows will wash excess sediment into downstream water systems. These sediment loads are likely to be small in relation to the long-term sediment flows in the Western and Eastern streams.

Cumulative impact

Topsoil stripping will add to sediment loads produced by erosion from upstream agricultural activities. While it occurs, the impact will be significant compared to upstream impacts of similar nature. However, the impact will be temporary and will cease shortly after the dirty water management infrastructure is in place.

Impact rating table

Construction Impact: Topsoil stripping					
Prior to mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
5	2	2	6	50	Medium
Post mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
5	2	2	2	30	Low

10.3.2 Impacts due to construction related pollution

Impact assessment

During the construction phase a significant number of vehicles will be driving around the site. In addition to this, fuels are stored on site and chemicals are used during normal construction activities. This may result in the following impacts:

- If the construction vehicles are poorly maintained hydrocarbon spills could cause pollution if washed off roads by storm water.
- Vehicle wash bays are a common source of hydrocarbon pollutants.
- Leaks from fuel depots could result in surface water pollution.
- Spillage and unsafe storage of chemicals could result in surface water contamination.

The affected areas will be the entire construction site. Spillage impacts will be short term and will cease after the completion of construction. However if soils have become contaminated, this will leach out over a prolonged period.

Mitigation

Mitigation of the impacts should include the following:

- All construction vehicles should be well maintained and inspected for hydrocarbon leaks weekly.
- Wash bay discharge water should flow through an oil separator.
- Fuel depots and refuelling areas should be bunded.
- Chemicals should be stored in a central secure area.
- Regular toolbox talks on the responsible handling of chemicals should be undertaken.

Residual impact

If limited soil contamination occurs, the residual impacts will probably be very low.

Cumulative impact

There are potential sources of hydrocarbon pollutants in the study area. Hydrocarbons are currently not measured in the rivers. It is recommended that hydrocarbon pollutants be measured at least once a quarter in water quality monitoring locations.

Impact rating table

Construction Impact: Construction related pollution					
Prior to mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
3	2	2	4	24	Low
Post mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
2	2	2	4	16	Low

10.4 IMPACTS DURING THE OPERATIONAL PHASE

10.4.1 Impacts due to contaminated water discharge

Impact assessment

Some of the study area should be considered as dirty areas. These areas include the opencast operations, the hards and ROM stockpiles, and any pollution control dams. Storm water and seepage generated from these dirty areas will likely be contaminated and have a detrimental effect on the water quality in the local streams and the Western and Eastern streams. These impacts will be most acute during the dry season when stream flows are low.

The colliery must have an undertaking to comply with Government Notice 704 of the South African National Water Act (Act 36 of 1998). This act limits discharges of contaminated water from mining related activities to less than once in 50 years on average. Storm water from dirty areas must be routed to a dirty water management system, in accordance with Government Notice 704 of the National Water Act (Act 36 of 1998).

Should a legal discharge occur as a result of extreme rainfall conditions, the Western and Eastern streams, and the local streams should have sufficient capacity to dilute poor quality water. The impacts from extreme rainfall conditions should be low and will last for a short duration.

Mitigation

Mitigation of the impacts must include the following:

- Contaminated shallow seepage and storm water run-off must be collected and routed to a lined pollution control dam. The pollution control dam must be sized in accordance with Government Notice 704 of the South African National Water Act.
- The pollution control dam water levels must be constantly monitored. Steps and procedures must be put in place to manage situations where excess water builds up in the pollution control dam.
- The pollution control dam must be operated empty as far as practicable and cannot fulfil the same role as a water storage dam, unless specifically designed to fulfil both purposes.
- Water reuse from the pollution control dam must be maximised.

Residual impact

Based on the assumption that proper management will take place and that infrastructure is adequately sized, the residual impacts will be low. Impacts could occur during the life of the mine.

Cumulative impact

The impacts resulting from contaminated water discharges in accordance with Government Notice 704 of the South African National Water Act, Act 36 of 1998 will result in short term water quality deterioration in the Western and Eastern streams and the local streams.

Impact rating table

Operational Phase Impact: Contaminated water discharge					
Prior to mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
5	4	2	4	50	Medium
Post mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
1	1	2	2	5	Low

10.4.2 Impacts due to leaking or burst dirty water pipes

Impact assessment

Water pipes may transport polluted water between the pollution control dam and other facilities on the proposed colliery. If any of these pipes burst, significant quantities of poor quality water could be pumped into the environment.

Mitigation

Mitigation of the impacts should include the following:

- It is preferable to run the dirty water pipelines through areas already serviced by dirty water systems where possible.
- Pipe lines should be subjected to frequent patrols. An efficient system of reporting should be available to allow the immediate tripping of pumps should a leak be found.

Residual impact

The residual impacts of a pipeline burst could be the contamination of the soil in the location of the burst. Contaminants will continue to be leached into the water systems over a long period (1-5 years) following a pipe burst.

Cumulative impact

Witbank Dam and the local streams are already impacted by mining activities. The impacts resulting from a pipe burst are likely to be similar to existing impacts, and further water quality deterioration will occur.

Impact rating table

Operational Phase Impact: Burst pipes					
Prior to mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
4	3	2	6	44	Medium
Post mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
3	3	1	2	18	Low

10.4.3 Loss of catchment yield

Impact assessment

During the operational phase storm water generated from the proposed mining areas and pollution control dams must be considered as dirty, and must be collected in the dirty water system. This water would have contributed to the flow into the Western and Eastern streams and in the local wetlands. The impounding of this water will result in a small reduction in the yield of the catchment.

If surface subsidence occurs above the underground workings, this will reduce the yield of the Western and Eastern streams and the local wetlands. Runoff from this area would have contributed to the flow in these streams. This water will be intercepted and lost from the surface water system to evaporation and infiltration.

These potential losses is quantified in Table 8.

Table 8: Loss of catchment yield (% of MAR)*

Parameter	Total catchment loss	Impact on Western stream*	Impact on Eastern stream*
Opencast Pit LOM	209 430 m^3/yr	11.6%	6.1%
OCEAST	75 649 m^3/yr	0%	1.2%
UGNWEST (if surface subsidence occurs)	5 739 m^3/yr	1.5%	0%
UGWEST (if surface subsidence occurs)	15 599 m^3/yr	4.1%	0%
UGSWEST (if surface subsidence occurs)	200 692 m^3/yr	24.7%	3.9%

** Note: Impact as % of mean annual runoff*
Refer to Figure 4 *for stream locations.*

Mitigation

As is best practice, dirty areas should be minimised. This will have the dual benefit of smaller dirty water management systems and reduction in catchment yield loss.

The loss of catchment yield due to underground subsidence can be mitigated by preventing subsidence and surface cracking. The mine must commit to adhering to suitable surface subsidence safety factors.

Residual impact

Once the opencast mining areas and the dumps and stockpiles are rehabilitated (assuming proper rehabilitation is done), runoff from these facilities can be returned to the environment. The return water dams can also be removed. The permanent loss of catchment yield is therefore anticipated to be zero to negligible from these areas.

The boxcut will likely remain and contribute to a permanent loss of catchment yield. However, this loss will be small as the boxcut is small.

Cumulative impact

The impact on the Eastern Stream and will be small. The impact on the Western Stream will be significant.

Impact rating table

Operational Phase Impact: Loss of catchment yield					
Prior to mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
4	5	1	1	28	Low
Post mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
4	5	0	0	20	Low

10.4.4 Impacts due to wash bays and workshops

Impact assessment

Organic and nutrient pollution may result from the wash bays and workshop areas. These areas should be bunded and all water should be contained, collected and routed to an appropriate treatment facility. Impacts are likely to be low and will last during the life of the colliery.

Mitigation

Mitigation of the impacts should include the following:

- All drains that collect the wash water and storm water must be maintained regularly. These should be free of debris and silt.
- All diversion canals, trenches and conduits must be designed to convey run-off from a 50-year design storm.
- The wash bays and workshops must be equipped with oil separators to remove hydrocarbons from wash down water.

Residual impact

The residual impacts of the wash bays and workshops will probably be low. The impacts will occur for the life of the mine.

Cumulative impact

There are potential sources of hydrocarbon pollutants in the study area. Hydrocarbons are currently not measured in the rivers. It is recommended that hydrocarbon pollutants be measured at least once a quarter in water quality monitoring locations.

Impact rating table

Operational Phase Impact: Wash bays and workshops					
Prior to mitigation					
Probability	Duration	Scale	Magnitude	Impact score	Impact
2	1	3	4	16	Low
Post mitigation					
Probability	Duration	Scale	Magnitude	Impact score	Impact
1	1	3	4	8	Low

10.4.5Impacts due to vehicle fleet-related pollution

Impact assessment

During the operational phase a significant number of vehicles will be driving around the site. In addition to this, fuels are stored on site and chemicals are used during normal operational activities. This may result in the following impacts:

- If the vehicles are poorly maintained hydrocarbon spills could cause pollution if washed off roads by storm water.
- Vehicle wash bays are a common source of hydrocarbon pollutants.
- Leaks from fuel depots could result in surface water pollution.
- Spillage and unsafe storage of chemicals could result in surface water contamination.

The affected areas will be the entire expansion area. Impacts will be medium term and will cease after the cessation of mining. If soils have become contaminated, this will leach out over a prolonged period.

Mitigation

Mitigation of the impacts should include the following:

- All vehicles should be well maintained and inspected for hydrocarbon leaks weekly.
- Wash bay discharge water should flow through an oil separator.
- Fuel depots and refuelling areas should be bunded.
- Chemicals should be stored in a central secure area. Regular training on the responsible handling of chemicals should be undertaken. If contract plant is being used, responsible handling of chemicals and vehicle maintenance should be a key performance objective of the plant contractor.

Residual impact

If limited soil contamination occurs, the residual impacts will probably be very low.

Cumulative impact

There are potential sources of hydrocarbon pollutants in the study area. Hydrocarbons are currently not measured in the rivers. It is recommended that hydrocarbon pollutants be measured at least once a quarter in water quality monitoring locations.

Impact rating table

Operational Phase Impact: Vehicle fleet related pollution					
Prior to mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
3	2	2	4	24	Low
Post mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
2	2	2	4	16	Low

10.5 IMPACTS DURING THE DECOMMISSIONING PHASE OF THE PROJECT

10.5.1 Impacts due to the removal of surface infrastructure and rehabilitation

Impact assessment

During the decommissioning phase, most impacts will be associated with the removal of surface infrastructure, final pit closure and removal and rehabilitation of the ROM stockpiles and the hards dump. Haul roads will be removed, as will berms and diversion trenches.

During this process, short-term impacts will be moderate, as heavy earth-moving machinery will disturb large areas. Previously vegetated areas may be disturbed which will increase erosion potential. These short-term impacts will give way to long term benefits.

Mitigation

Apart from due diligence care while performing decommissioning tasks, no mitigation is necessary. Due diligence care includes the following:

- Plant should be well maintained to ensure that hydrocarbon spills are minimised.
- Existing roads should be used where possible.
- New disturbed areas should be minimised.

Residual impact

The residual impacts will likely be low as large flows will wash excess sediment into downstream water systems. These sediment loads are likely to be small in relation to the long-term sediment flows in the Western and Eastern streams.

Cumulative impact

Topsoil stripping will add to sediment loads produced by erosion from upstream agricultural activities. While it occurs, the impact will be significant compared to upstream impacts of similar nature. However, the impact will be temporary and will cease shortly after the dirty water management infrastructure is in place.

Impact rating table

Construction Impact: Topsoil stripping					
Prior to mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
5	2	2	6	50	Medium
Post mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
5	2	2	2	30	Low

10.6 IMPACTS AFTER THE CLOSURE PHASE OF THE PROJECT

10.6.1 Impacts due to pit decant

Impact assessment

The groundwater study has not been completed at the time of writing. Whether or not the rehabilitated open cast or underground workings will decant, still needs to be determined. For the surface water impact assessment, a conservative approach is followed and it is assumed that decant may occur from the rehabilitated open cast workings. Should the groundwater study prove that decant will not occur from the rehabilitated open cast workings, this impact assessment will become irrelevant.

After the colliery is closed, contaminated water management becomes passive. Groundwater inflows and recharge through the rehabilitated spoils may create decant from the open cast and underground workings. This decant will be driven by rainfall recharge through the surface and groundwater inflows. The decant water quality is likely to be poor and will contaminate the Western and Eastern streams. Decant flows will likely be seasonal and volumes will be dependent on the quality of rehabilitation done and the degree of surface subsidence. Poor rehabilitation will increase the decant volumes. The water quality is likely to remain poor in the long term (>20 years). Eventually as pollutants are leached out of the workings and natural stratification occurs, the seepage water quality will improve.

Mitigation

Mitigation of the impacts should include the following:

- The rehabilitation work should strive to minimise recharge and maximise run-off.
- A final void could be optimised to evaporate excess pit water.
- Where feasible, materials likely to produce the highest amounts of pollution should be replaced in sections of the pit where they will be permanently flooded, thus preventing oxidation of these materials.
- Should passive mitigation measures not be suitable, active alternatives can be considered such as some form of treatment, prior to release.
- The planned mining method and the commitment to adhering to appropriate safety factors must be made by the mine to prevent surface subsidence.
- Methods to stop or reduce decant volumes could include sealing some areas of the mine workings or leaving some areas unmined to act as a barrier to decant.
- Methods to improve the decant water quality could include flooding of the mining areas, where practical, to reduce oxygen ingress. Routing seepage through lime pits can also improve the water quality if the flows are low enough.

Residual impact

The residual impacts will be dependent on the quality of rehabilitation and the design of the final void. If the quality of rehabilitation is good and the final void is able to balance the inflows, impacts are expected to be negligible. If the rehabilitation quality is poor, impacts could be significant, particularly during the dry season when there is little assimilative capacity in the rivers.

Cumulative impact

If the quality of rehabilitation is good and the void is able to balance the inflows, the cumulative impacts will be negligible. The same will apply if no surface subsidence occurs Should decant occur, the impacts resulting from pit or underground workings decant will result in long term water quality deterioration in the Western and Eastern streams. The impacts resulting from pit decant are likely to result in water quality deterioration will occur in the Western and Eastern streams.

Impact rating table

If mitigation prevents decant, the following table applies:

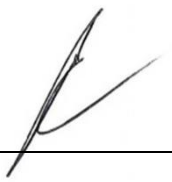
Closure Phase Impact: Pit water decant					
Prior to mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
5	5	3	6	70	High
Post mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
0	0	0	0	0	Low

Should mitigation be unsuccessful and decant occurs, the following table applies:

Closure Phase Impact: Pit water decant					
Prior to mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
5	5	3	6	70	High
Post mitigation					
Probability	**Duration**	**Scale**	**Magnitude**	**Impact score**	**Impact**
5	5	3	4	60	High

11. REFERENCES

- Middleton, B.J. and Bailey, A.K., *Water Resources of South Africa*, 2005 study (WR2005), 2009. WRC Report No TT 382/08.
- Midgley, D.C., Pitman, W.V., Middleton, B.J., *Surface Water Resources of South Africa*, 1990. WRC Report No 298/1.1/94, Volume 1.



Dr Bruce Randell (Pr. Eng.)
Water Resources Engineer

Johann Le Roux
Operational Director

APPENDIX A

Philo Environmental Management Water Quality Analysis

QUARTERLY WATER QUALITY MONITORING REPORT
MAY – JUNE 2017

AUGUST 2017
TSHEDZA MINING RESOURCE (Pty) Ltd
MANUNGU COLLIERY

PHILO ENVIRONMENTAL MANAGEMENT

4.1.2 Monthly Surface Water Quality Results Interpretation – (Compared to SANS 241:2015)

The monthly surface water quality results are compared to the SANS 241-2015 standards and the water quality baseline, to determine the current status of water quality at the Manungu Colliery. It must be noted that the baseline water quality report was conducted before the commencement of mining activities on site and therefore increase of certain variables is permissible and the quality still falls within the SANS 241-2015 standards.

4.1.2.1 MWQ 1

MWQ 1 is located on the western side of the Opencast Pit in the tributary of Stream 1. This point indicates the impacts of activities located upstream of Manungu Colliery. The findings at monitoring point MWQ 1 are as follows:

- The pH concentration is slightly neutral to alkaline, varying from a scale of 7 to 9.
- Very minimal content of Electrical Conductivity (EC) was determined at the monitoring point, however concentrations greater than the Baseline Water Quality report were analyzed during the June 2017 sampling.
- The SANS 241-2015 limit for Total Dissolved Solids is 1200mg/l. All the monthly data indicate good quality when compared to SANS 241-2015 standards and the baseline water quality report.
- Sulphate levels are linked to coal mining and related activities. The variable was detected below the SANS 241-2015 limits and the baseline water quality report.
- There are no limits for Suspended Solids, however increased concentrations were determined in the June 2017 sampling run which were above the baseline water quality report.
- Turbidity was in high concentration for both months when compared to the SANS 241:2015 limit of 1 NTU.
- Some variables as seen in Table 4-1 below are above the SANS 241:2015 standards. Also see Figure 4-1 for non-compliance with SANS 241:2015 standards.

Refer to Table 4-1 Below:

Table 4-1: MWQ 1 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	Norms for Drinking Water according to SANS 241:2015	May-17	Jun-17
EC mS/m	35.933	<170	29.5	37.4
TDS mg/L	202	<1200	150	202
pH	7.903	5-9.7	7.84	7.30
Turbidity NTU	0	<1	18.5	>1000
Ammonium as NH_4 -N mg/L	0.12	<1.5	<0.45	<0.45
Nitrate as NO_3 -N mg/L	0.583	<11	<0.35	<0.35
Sulphate as SO_4 mg/L	23.166	500	16.1	20.4
Chloride as Cl mg/L	15.1	<300	13.6	19.5
Fluoride as F mg/L	0.300	<1.5	0.11	0.17
Magnesium as Mg mg/L	15.566	70	12.5	16.2
Calcium as Ca mg/L	21.466	150	18.4	25.3
Potassium as K mg/L	6.463	50	4.72	6.06
Sodium as Na mg/L	29.366	<200	18.2	27.0
Iron as Fe mg/L	-0.003	2	0.05	0.09
Manganese as Mn mg/L	-0.001	0.4	0.01	0.33
Aluminium as Al mg/L	-0.003	0.3	0.05	0.07
Phosphate (PO_4) mg/L	0.044	0.1	0.04	<0.03
Suspended Solids mg/L	86.666		29.2	3523
Silicon as Si mg/l			1.95	0.74
Total Alkalinity	143.666		110	144
(orange)	Non-compliant with baseline study			
(red)	Non-compliant SANS 241:2015			

	Maximum non-compliant against SANS 241:2015
	Minimum non-compliant against SANS 241:2015

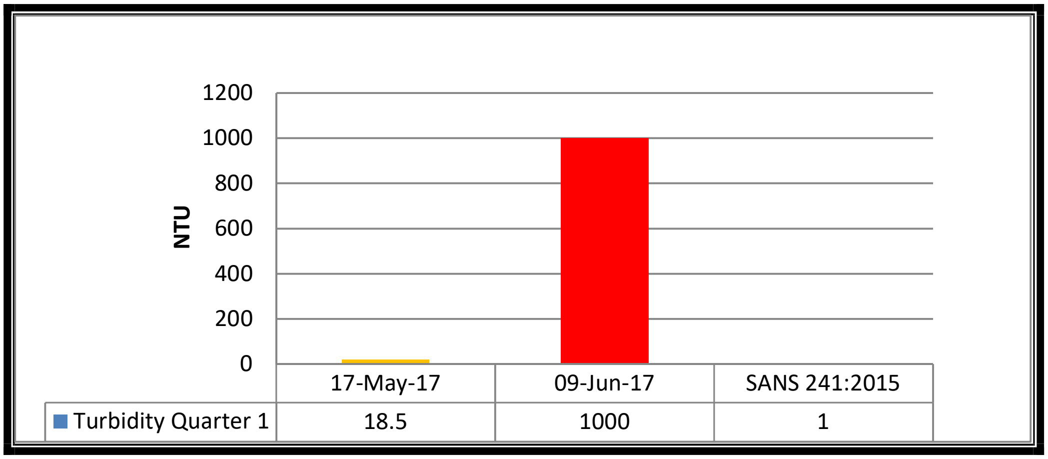


Figure 4—1: Turbidity Non-Compliant

4.1.2.2 MWQ 3

MWQ 3 is located on stream 2 on the eastern side of the Manungu surface infrastructure. This point indicates the impact of activities located upstream of Manungu Colliery. The findings at monitoring point MWQ 3 are as follows:

- Most variables are within the expected SANS standard limits, except Turbidity and Aluminium, which had an average of 372 NTU and 1.33 mg/l respectively. However, when comparing current data to the baseline water quality, a slight deterioration is observed for Total Dissolved Solids, Iron and Phosphate.
- Metals such as Aluminium are dissolved as water percolates through different rock and soil types. Coal sludge, the liquid coal waste produced by mining activities (also known as slurry), contains heavy metals
- Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality. Turbidity is common due to natural geology.
- See Table 4-2 below for all analyzed variables as compared to the baseline water quality results and SANS 241:2015, also Figures 4-2 and 4-3 for non-compliance with SANS 241:2015.

Refer to Table 4-2 Below:

Table 4-2: MWQ 3 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	Norms for Drinking Water according to SANS 241:2015	May-17	Jun-17
EC mS/m	42.65	<170	32.1	34.3
TDS mg/L	242.333	<1200	172	183
pH	8.056	5-9.7	7.58	7.56
Turbidity NTU	0	<1	330	414
Ammonium as NH_4 -N mg/L	0.142	<1.5	<0.45	<0.45
Nitrate as NO_3 -N mg/L	1.121	<11	<0.35	0.51
Sulphate as SO_4 mg/L	45.116	500	34.1	35.3
Chloride as Cl mg/L	26	<300	15.8	16.0
Fluoride as F mg/L	0.540	<1.5	0.47	0.48
Magnesium as Mg mg/L	16.166	70	11.5	12.0
Calcium as Ca mg/L	20.583	150	14.3	15.0
Potassium as K mg/L	11.08	50	10.0	10.8
Sodium as Na mg/L	39.2	<200	24.5	27.7
Iron as Fe mg/L	-0.003	2	1.34	0.23
Manganese as Mn mg/L	0.022	0.4	0.02	<0.01
Aluminium as Al mg/L	0.006	0.3	2.22	0.45
Phosphate (PO_4) mg/L	0.021	0.1	<0.03	<0.03
Suspended Solids mg/L	231		156	206
Silicon as Si mg/l			8.27	3.91
Total Alkalinity	128.766		95.8	104
(orange)	Non-compliant with baseline study			
(red)	Non-compliant SANS 241:2015			

(red)	Maximum non-compliant against SANS 241:2015
(amber)	Minimum non-compliant against SANS 241:2015

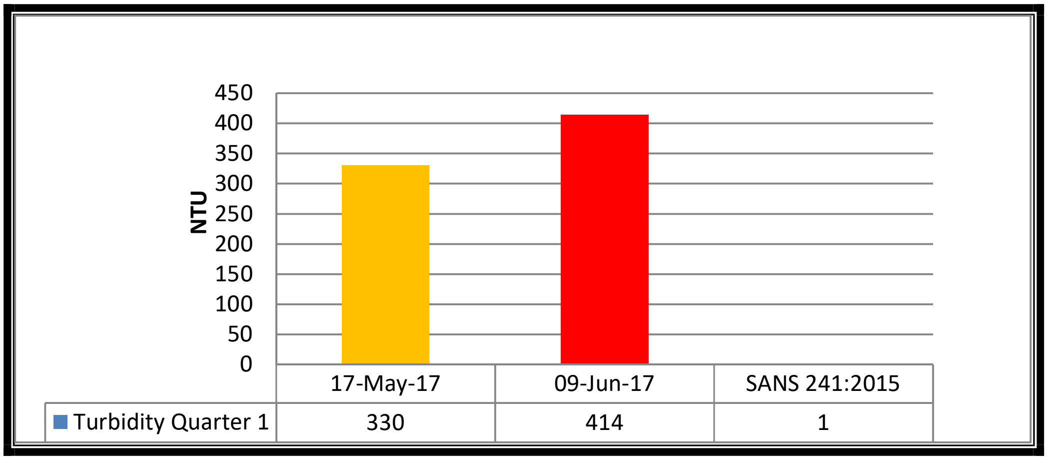


Figure 4—2: Turbidity Non-Compliant

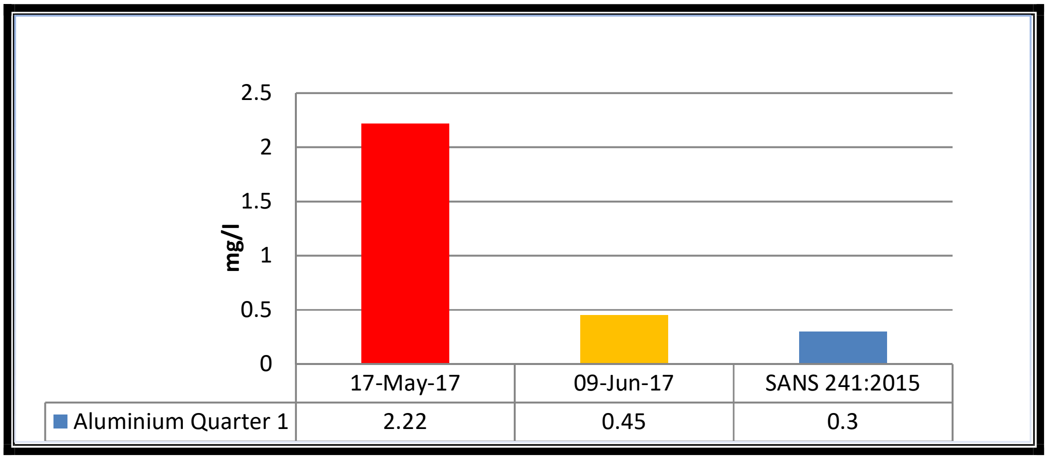


Figure 4—3: Aluminium Non-Compliant

4.1.2.3 MWQ 4

MWQ 4 is located in stream 1, downstream of MWQ 3 and south east of the PCD. The findings at monitoring point MWQ 4 are as follows:

- The concentrations of most variables (marked in orange in Table 4-3) increased and were higher than the baseline water quality data.
- Electrical conductivity was non-compliant as compared to SANS 241:2015 for June 2017 and above the baseline water quality results for both months.
- Total Dissolved Solids has increased as compared to the baseline water quality results but still compliant with SANS 241:2015.
- Ammonia was non-compliant as compared to SANS 241:2015 for June 2017 and above the baseline water quality results for both months.
- Iron was non-compliant as compared to SANS 241:2015 for June 2017 and above the baseline water quality results for both months.
- Turbidity and Manganese had an average of 511.20 NTU and 3.17 mg/l respectively, which are above the SANS 241:2015 limits.
- All metal elements are higher than the Baseline results, which is associated with contamination from earth works involving extraction of coal from the ground.
- See Table 4-3 below for all analyzed variables as compared to the baseline water quality results and SANS 241:2015, also Figures 4-4 to 4-8 for non-compliance with SANS 241:2015.

Refer to Table 4-3 Below:

Table 4-3: MWQ 4 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	Norms for Drinking Water according to SANS 241:2015	May-17	Jun-17
EC mS/m	41.675	<170	144	181
TDS mg/L	234.75	<1200	786	943
pH	8.09	5-9.7	7.44	7.39
Turbidity NTU	0	<1	22.4	>1000
Ammonium as NH_4 -N mg/L	0.043	<1.5	<0.45	4.28
Nitrate as NO_3 -N mg/L	1.16	<11	<0.35	<0.35
Sulphate as SO_4 mg/L	45	500	76.3	5.32
Chloride as Cl mg/L	25.025	<300	152	148
Fluoride as F mg/L	0.548	<1.5	<0.09	0.27
Magnesium as Mg mg/L	15.475	70	38.1	49.8
Calcium as Ca mg/L	19.025	150	51.9	69.7
Potassium as K mg/L	10.617	50	13.3	24.7
Sodium as Na mg/L	36.75	<200	184	200
Iron as Fe mg/L	-0.003	2	0.11	3.27
Manganese as Mn mg/L	-0.001	0.4	1.05	5.29
Aluminium as Al mg/L	0.020	0.3	<0.01	0.22
Phosphate (PO_4) mg/L	0.023	0.1	<0.03	<0.03
Suspended Solids mg/L	328.25		10.0	3277
Silicon as Si mg/l			14.4	11.3
Total Alkalinity	126.1		448	719
(orange)	Non-compliant with baseline study			
(red)	Non-compliant SANS 241:2015			

(red)	Maximum non-compliant against SANS 241:2015
(orange)	Minimum non-compliant against SANS 241:2015
(green)	Compliant

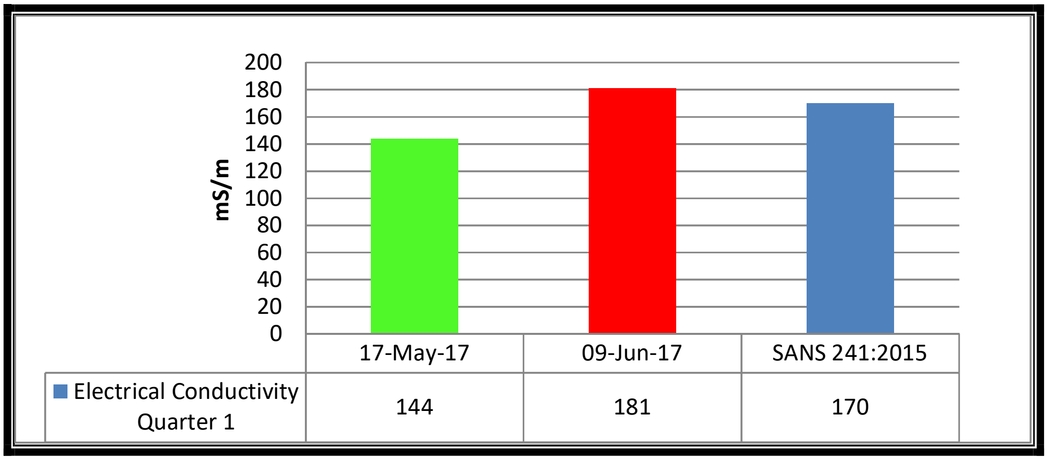


Figure 4—4: Electrical Conductivity Non-Compliant

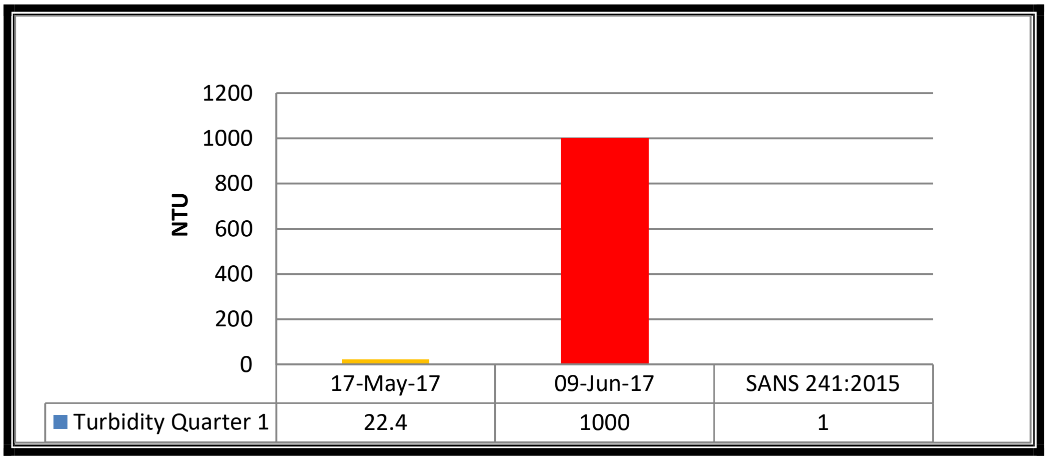


Figure 4—5: Turbidity Non-Compliant

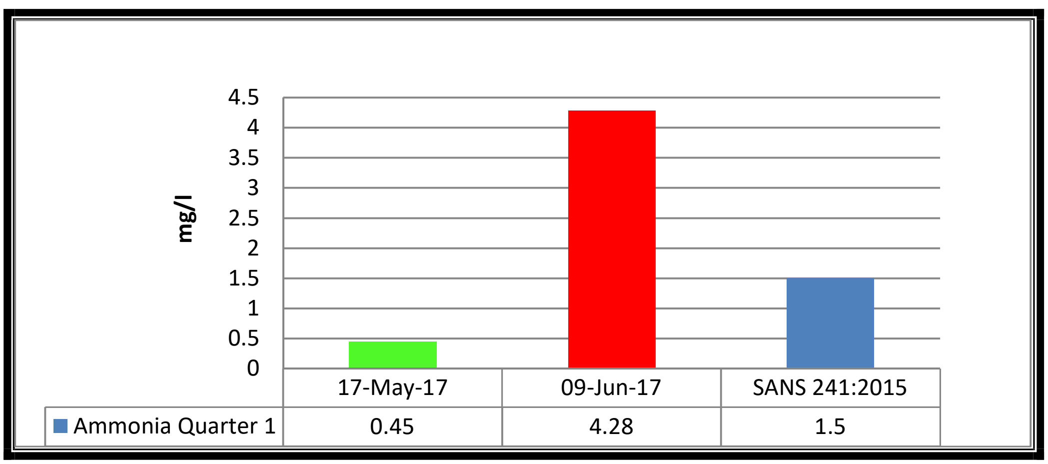


Figure 4—6: Ammonia Non-Compliant

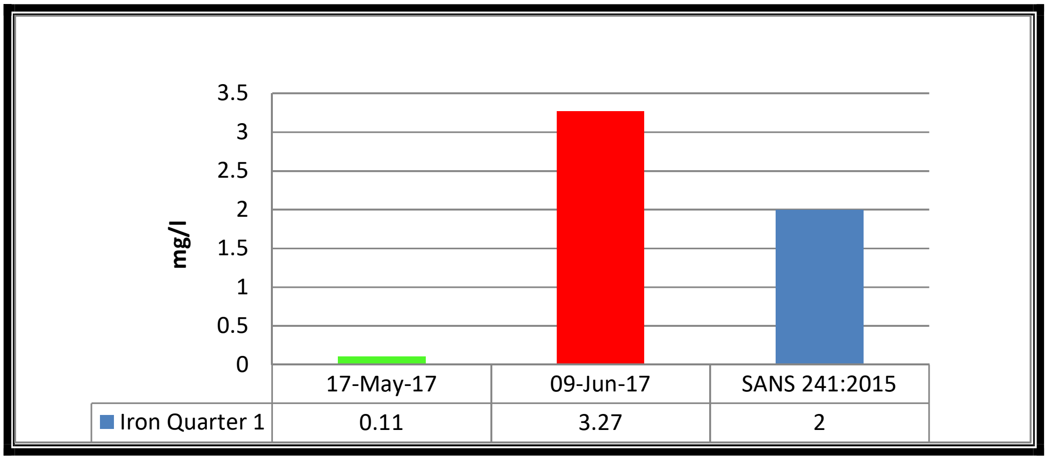


Figure 4—7: Iron Non-Compliant

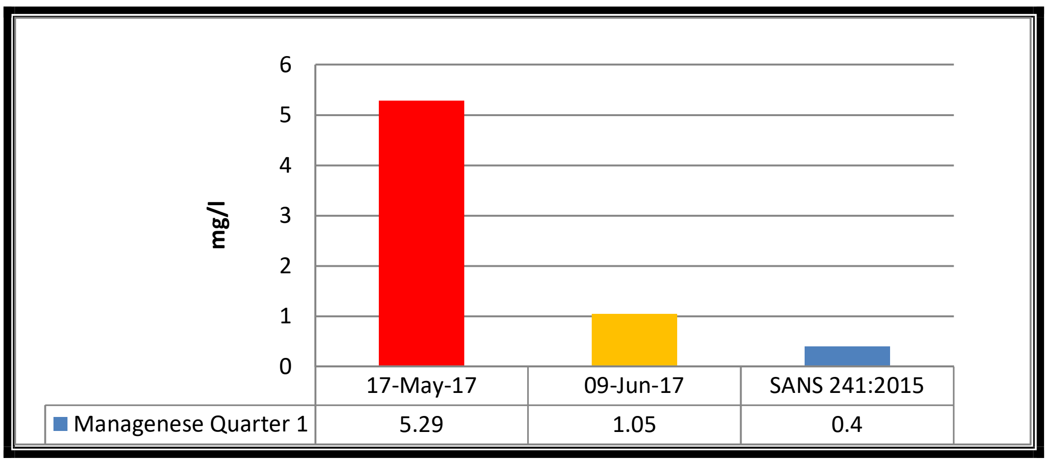


Figure 4—8: Manganese Non-Compliant

4.1.2.4 MWQ 5

MWQ 5 is located in stream 1. Due to the drainage area (Tributary of stream 1) between MWQ 5 and MWQ 1, there is no probability that the activities at Manungu will have an impact on MWQ 5. However, it is necessary to monitor this stream in order to identify the source of impact at MWQ 6. The findings at monitoring point MWQ 5 are as follows:

- According to the standards set by SANS 241-2015, some variables were found to have exceeded the limits, such as Manganese, Turbidity, Aluminuim and Phosphate.
- As indicated earlier in the report there are other activities in the vicinity of the mine not associated with Manungu Colliery. Some of the changes in the variables may not be impacts associated with Manungu operations.
- Rock with high composition of phosphate minerals could result in the increased amount of PO_4 analyzed at this monitoring point.
- Phosphates are added to surface waters by a variety of means. Humans add phosphates to water through industrial and agricultural waste. Fertilizers contain high levels of phosphates and will enter the water by means of runoff and soil erosion. In areas where land and vegetation have been disturbed, soil erosion will increase. This will lead to even more phosphates being washed out of the soil and into the water.
- Phosphates can also come from the excrement of animals living in or near the water.
- Some variables showed an increase when compared to the baseline water quality results.
- See Table 4-4 below for all analyzed variables as compared to baseline water quality results and SANS 241:2015, also Figures 4-9 to 4-12 for non-compliance with SANS 241:2015.

Please refer to Table 4-4 Below:

Table 4-4: MWQ 5 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	Norms for Drinking Water according to SANS 241:2015	May-17	Jun-17
EC mS/m	73.025	<170	32.0	35.7
TDS mg/L	431	<1200	161	166
pH	9.225	5-9.7	7.93	6.85
Turbidity NTU	0	<1	22.1	202
Ammonium as NH_4 -N mg/L	0.119	<1.5	<0.45	1.21
Nitrate as NO_3 -N mg/L	0.262	<11	<0.35	<0.35
Sulphate as SO_4 mg/L	17.417	500	12.4	5.47
Chloride as Cl mg/L	60.025	<300	25.8	30.8
Fluoride as F mg/L	0.421	<1.5	0.12	0.20
Magnesium as Mg mg/L	44.6	70	13.6	13.5
Calcium as Ca mg/L	31.7	150	16.2	16.5
Potassium as K mg/L	10.55	50	9.14	9.45
Sodium as Na mg/L	78.125	<200	18.8	20.1
Iron as Fe mg/L	0.003	2	1.17	0.17
Manganese as Mn mg/L	0.125	0.4	0.13	1.65
Aluminium as Al mg/L	0.003	0.3	1.58	<0.01
Phosphate (PO_4) mg/L	0.185	0.1	0.03	0.23
Suspended Solids mg/L	24.75		19.2	908
Silicon as Si mg/l			4.14	<0.1
Total Alkalinity	306.5		103	109
	Non-compliant with baseline study			
	Non-compliant SANS 241:2015			

	Maximum non-compliant against SANS 241:2015
	Minimum non-compliant against SANS 241:2015
	Compliant

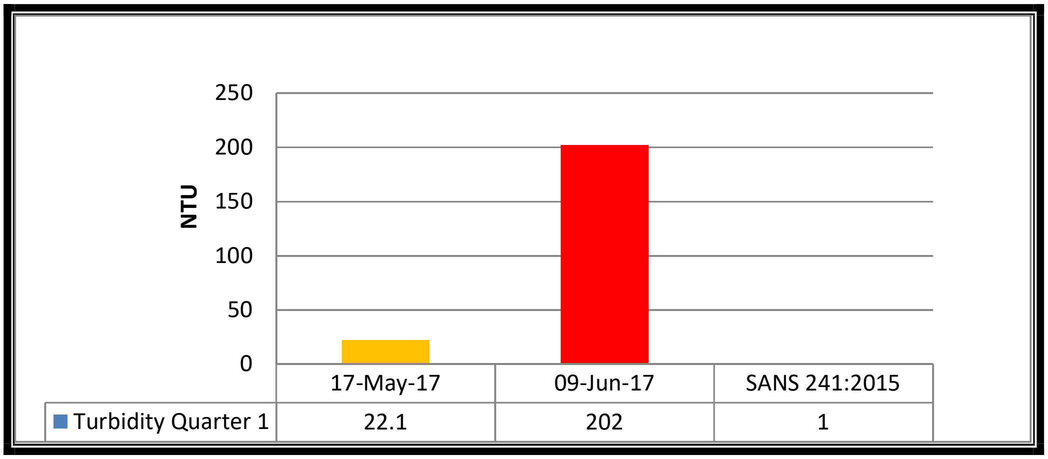


Figure 4—9: Turbidity Non-Compliant

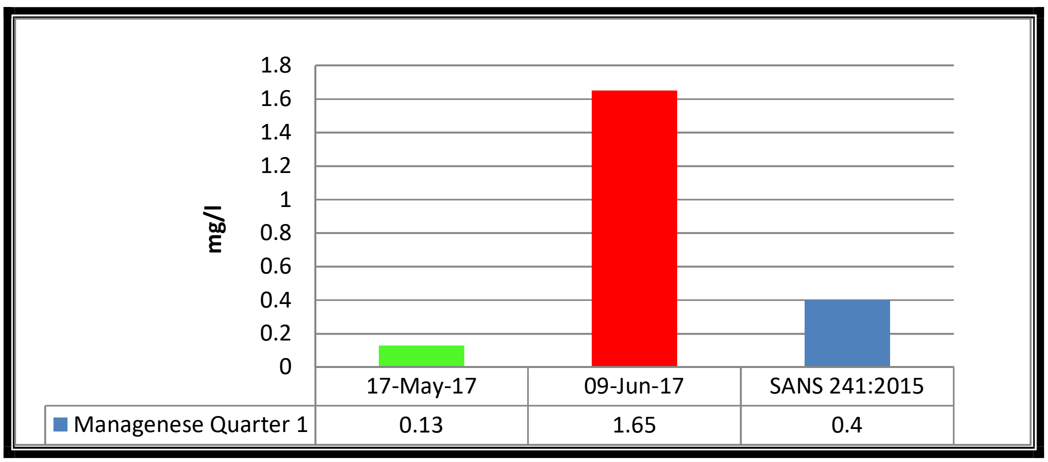


Figure 4—10: Manganese Non-Compliant

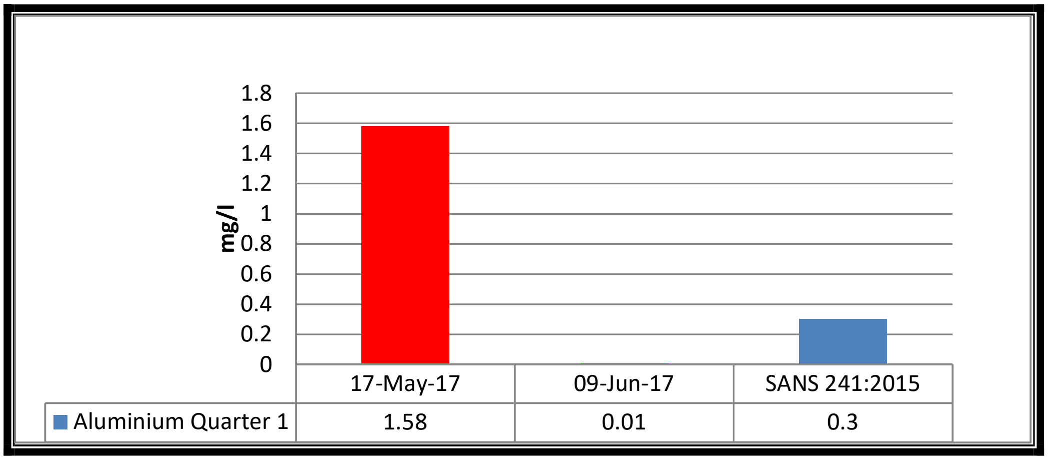


Figure 4—11: Manganese Non-Compliant

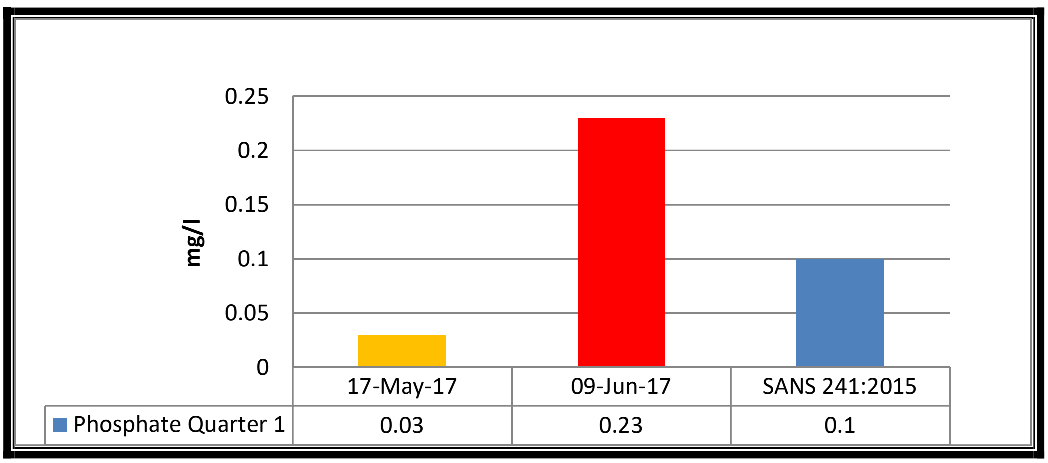


Figure 4—12: Phosphate Non-Compliant

4.1.2.5 MWQ 6

MWQ 6 is located downstream of MWQ 1 and MWQ 3 in stream 1. The findings at monitoring point MWQ 6 are as follows:

- Metals such as Aluminium, Manganese and Iron were above the baseline water quality results but compliant with SANS 241:2015.
- There were some other variables that were above the baseline study such as Chloride, Potassium and Suspended solids.
- Rock with high composition of phosphate minerals could result in the increased amount of PO_4 analyzed at this monitoring point.
- Turbidity had an average of 128.05 NTU for the two months which exceeded the SANS 241:2015 limit.
- See Table 4-5 below for all analyzed variables as compared to the baseline water quality results and SANS 241:2015, also Figure 4-13 for non-compliance with SANS 241:2015.

Refer to Table 4-5 Below:

Table 4-5: MWQ 6 Monthly Quality Results

Analysis Results	Manungu Baseline water results	Norms for Drinking Water according to SANS 241:2015	May-17	Jun-17
EC mS/m	57.5	<170	33.1	43.6
TDS mg/L	290	<1200	176	229
pH	8.32	5-9.7	7.71	7.56
Turbidity NTU		<1	159	97.1
Ammonium as NH_4 -N mg/L	0.069	<1.5	<0.45	<0.45
Nitrate as NO_3 -N mg/L	0.397	<11	0.36	<0.35
Sulphate as SO_4 mg/L	1.63	500	39.9	49.2
Chloride as Cl mg/L	20.5	<300	16.1	20.7
Fluoride as F mg/L	0.32	<1.5	0.14	0.22
Magnesium as Mg mg/L	26.8	70	12.2	17.1
Calcium as Ca mg/L	29	150	17.7	24.3
Potassium as K mg/L	8.37	50	11.0	12.6
Sodium as Na mg/L	43.9	<200	20.5	26.8
Iron as Fe mg/L	0.003	2	0.09	0.05
Manganese as Mn mg/L	-0.001	0.4	0.02	<0.01
Aluminium as Al mg/L	0.003	0.3	0.14	0.13
Phosphate (PO_4) mg/L	0.011	0.1	0.07	0.05
Suspended Solids mg/L	27		56.4	38.0
Silicon as Si mg/l			4.77	2.88
Total Alkalinity	259		93.6	129
(orange)	Non-compliant with baseline study			
(red)	Non-compliant SANS 241:2015			

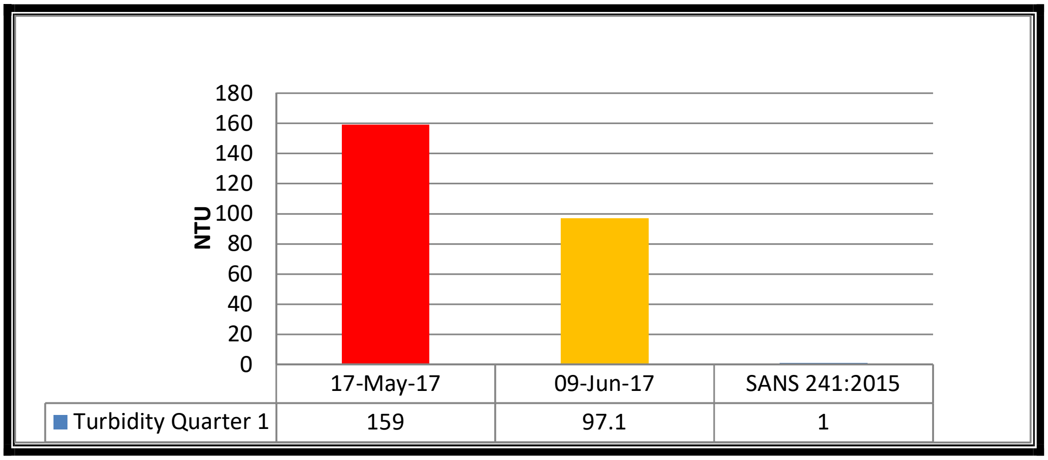


Figure 4—13: Phosphate Non-Compliant

4.1.2.6 Pollution Control Dam (PCD)

The purpose of the Pollution Control dam is to collect contaminated runoff from the dirty water catchment areas. A lined PCD exists at the south eastern boundary of the mining area. The following findings were made at the PCD:

- The Pollution Control Dam is regarded as a dirty water catchment area, to collect dirty run-offs around the mine and poor quality water is expected at this point.
- There was no baseline study conducted before the infrastructure was constructed and therefore water quality for the PCD was only compared to the SANS 241-2015 limits.
- Most variables are within the expected SANS limits, except Turbidity, Nitrates, and Sodium which indicated averages of 118.85 NTU, 56.02 mg/l and 250.06 mg/l respectively for the two months.
- Ammonia also exceeded the SANS 241:2015 limits in May 2017.
- See Table 4-6 below for all analyzed variables as compared to SANS 241:2015, also Figures 4-14 to 4-17 for non-compliance with SANS 241:2015.

Refer to Table 4-6 Below:

Table 4-6: PCD Monthly Water Quality Results

Analysis Results	Norms for Drinking Water according to SANS 241:2015	May-17	Jun-17
EC mS/m	<170	146	156
TDS mg/L	<1200	937	960
pH	5-9.7	8.46	8.49
Turbidity NTU	<1	152	85.7
Ammonium as NH_4 -N mg/L	<1.5	1.89	1.00
Nitrate as NO_3 -N mg/L	<11	56.2	55.8
Sulphate as SO_4 mg/L	500	232	237
Chloride as Cl mg/L	<300	12.1	13.3
Fluoride as F mg/L	<1.5	1.42	1.44
Magnesium as Mg mg/L	70	14.6	17.0
Calcium as Ca mg/L	150	21.5	29.3
Potassium as K mg/L	50	8.39	7.94
Sodium as Na mg/L	<200	249	251
Iron as Fe mg/L	2	0.04	<0.01
Manganese as Mn mg/L	0.4	<0.01	<0.01
Aluminium as Al mg/L	0.3	0.10	<0.01
Phosphate (PO_4) mg/L	0.1	<0.03	<0.03
Suspended Solids mg/L		371	211
Silicon as Si mg/l		6.99	3.45
Total Alkalinity		243	258
	Non-compliant SANS 241:2015		

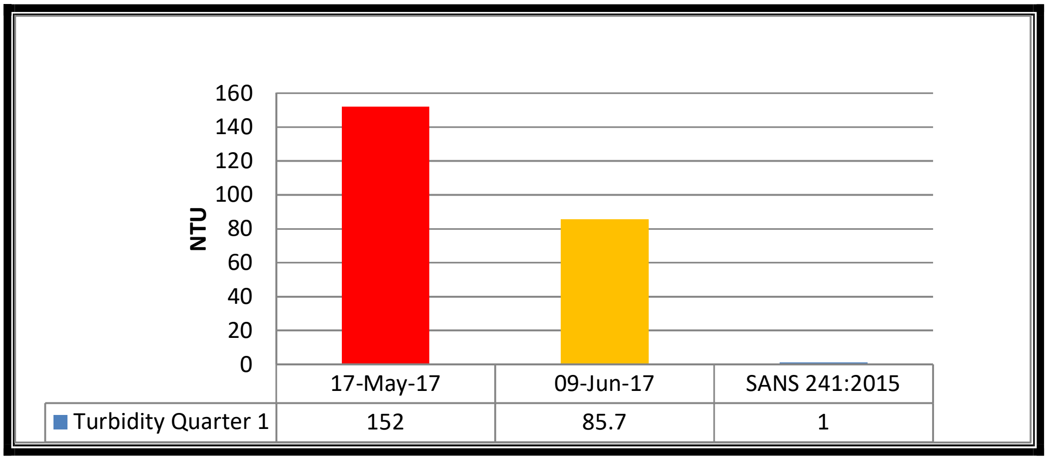


Figure 4—14: Turbidity Non-Compliant

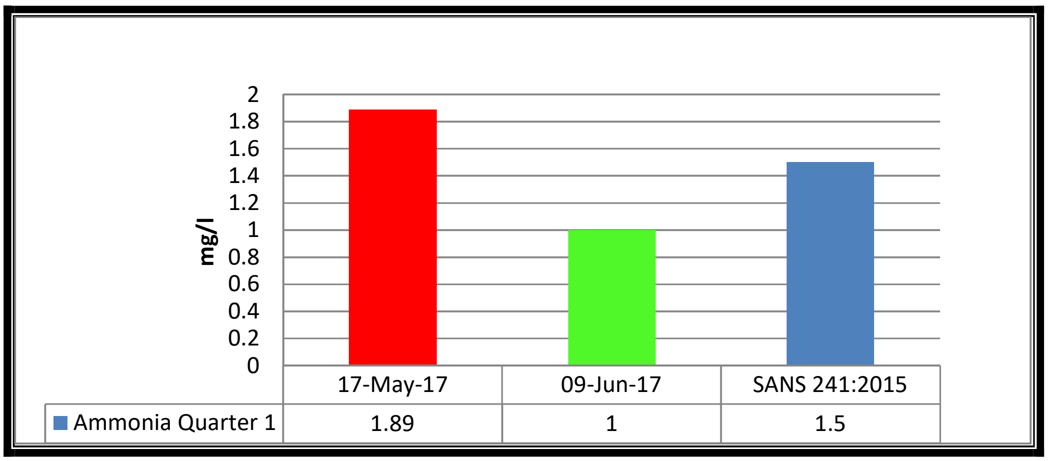


Figure 4—15: Ammonia Non-Compliant

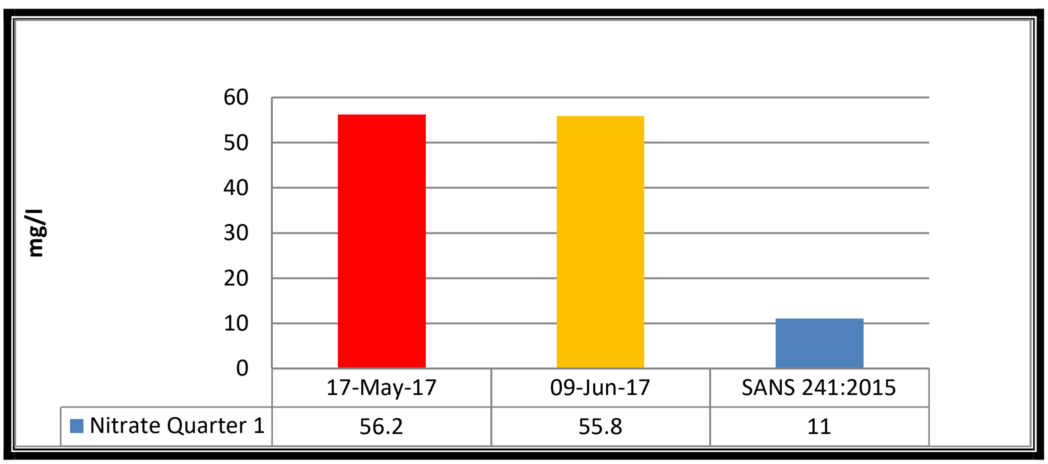


Figure 4—16: Nitrate Non-Compliant

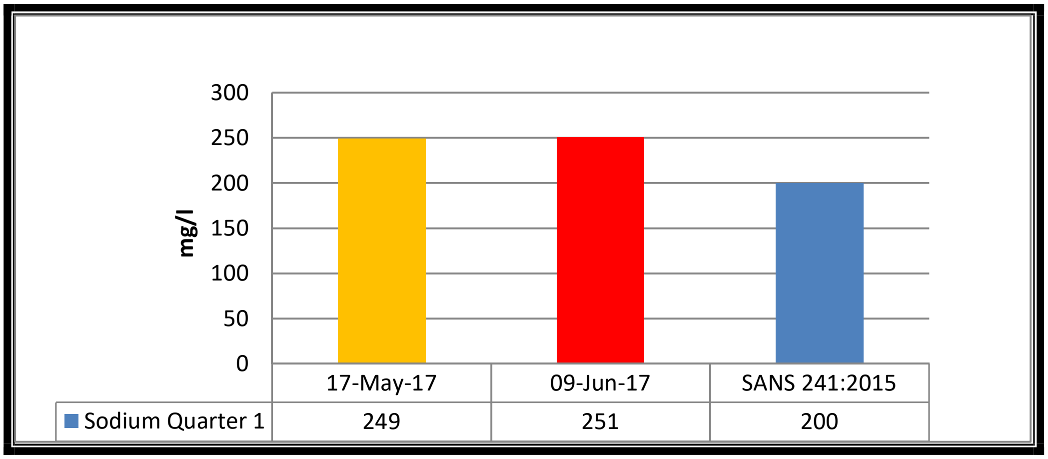


Figure 4—17: Sodium Non-Compliant

4.1.2.7 PCD Drainage

This point is the sump located at the lowest point of the Pollution Control Dam. The following findings were made:

- The PCD Drainage has better water quality when compared to PCD.
- All samples collected fall within the SANS limits except for Turbidity with an average of 8.44 NTU and Aluminium with a level of 0.52 mg/l for May 2017.
- The pH concentration at the PCD Drainage is alkaline, ranging from 8 to 9. The SANS 241-2015 limits ranges from 5 to 9.7.
- TDS falls within the set limit.
- Very low concentrations of Sulphate were noted.
- The concentrations of Suspended Solids are very low at the PCD Drainage monitoring point.
- See Table 4-7 below for all analyzed variables as compared to SANS 241:2015, also Figures 4-18 to 4-19 for non-compliance with SANS 241:2015.

Refer to Table 4-7 Below:

Table 4-7: PCD Drainage Water Quality Results

Analysis Results	**Norms for Drinking Water according to SANS 241:2015**	**May-17**	**Jun-17**
EC mS/m	<170	83.5	85.5
TDS mg/L	<1200	451	461
pH	5-9.7	7.68	7.75
Turbidity NTU	<1	11.2	5.69
Ammonium as NH_4 -N mg/L	<1.5	<0.45	<0.45
Nitrate as NO_3 -N mg/L	<11	1.13	1.20
Sulphate as SO_4 mg/L	500	57.8	59.0
Chloride as Cl mg/L	<300	35.4	37.0
Fluoride as F mg/L	<1.5	0.47	0.43
Magnesium as Mg mg/L	70	21.9	22.5
Calcium as Ca mg/L	150	26.8	28.1
Potassium as K mg/L	50	<0.03	3.71
Sodium as Na mg/L	<200	110	114
Iron as Fe mg/L	2	0.26	0.06
Manganese as Mn mg/L	0.4	0.11	0.04
Aluminium as Al mg/L	0.3	0.52	0.14
Phosphate (PO_4) mg/L	0.1	<0.03	<0.03
Suspended Solids mg/L		8.80	4.40
Silicon as Si mg/l		13.6	12.8
Total Alkalinity		315	318
	Non-compliant SANS 241:2015		

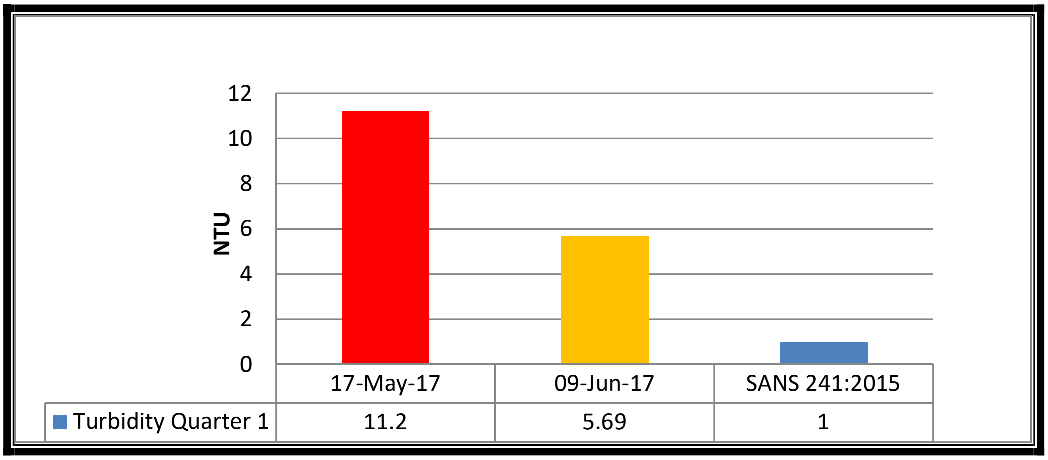


Figure 4—18: Turbidity Non-Compliant

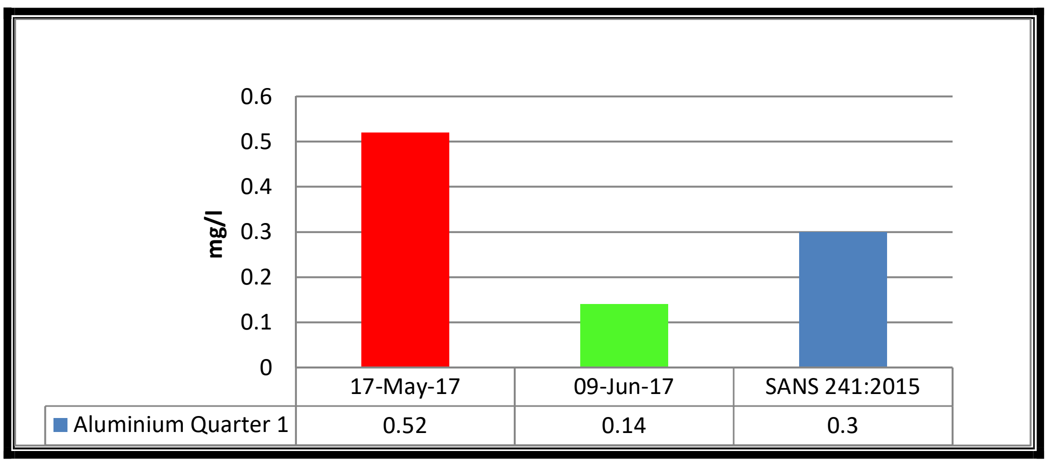


Figure 4—19: Aluminium Non-Compliant

4.1.2.8 Pit Area

A sample is collected at the active Pit which is managed as a dirty water facility. The following findings were made:

- There was no access to sample the Pit Area in May 2017.
- The source of water at the Pit Area is normally groundwater ingress and rainfall. The sampling point is exposed to the ongoing mining activities at Manungu Colliery and thus elevated concentrations will be recorded.
- High concentrations were recorded for Electrical Conductivity, Total Dissolved Solids, Turbidity, Ammonia, Nitrates, Fluoride, Sodium and Aluminium.
- This could possibly be as a result from the explosives used by the mine for blasting as most of them contain ammonium nitrate. Thus the is an increase in Nitrates at the Pit and PCD at the pit area, PCD, b
- Sulphate concentrations for the month of June 2017 were 110 mg/l.
- See Table 4-8 below for all analyzed variables as compared to SANS 241:2015, also Figures 4-20 to 4-27 for non-compliance with SANS 241:2015

Refer to Table 4-8 Below:

Table 4-8: Pit Area Water Quality Results

Analysis Results	Norms for Drinking Water according to SANS 241:2015	May-17	Jun-17
EC mS/m	<170	No Access	235
TDS mg/L	<1200		1523
pH	5-9.7		8.52
Turbidity NTU	<1		18.0
Ammonium as NH_4 -N mg/L	<1.5		7.99
Nitrate as NO_3 -N mg/L	<11		178
Sulphate as SO_4 mg/L	500		110
Chloride as Cl mg/L	<300		15.0
Fluoride as F mg/L	<1.5		2.62
Magnesium as Mg mg/L	70		9.94
Calcium as Ca mg/L	150		10.0
Potassium as K mg/L	50		9.09
Sodium as Na mg/L	<200		412
Iron as Fe mg/L	2		0.15
Manganese as Mn mg/L	0.4		<0.01
Aluminium as Al mg/L	0.3		1.27
Phosphate (PO_4) mg/L	0.1		<0.03
Suspended Solids mg/L			15.2
Silicon as Si mg/l			4.81
Total Alkalinity			256
	Non-compliant SANS 241:2015		

(red)	Maximum non-compliant against SANS 241:2015
(orange)	Minimum non-compliant against SANS 241:2015

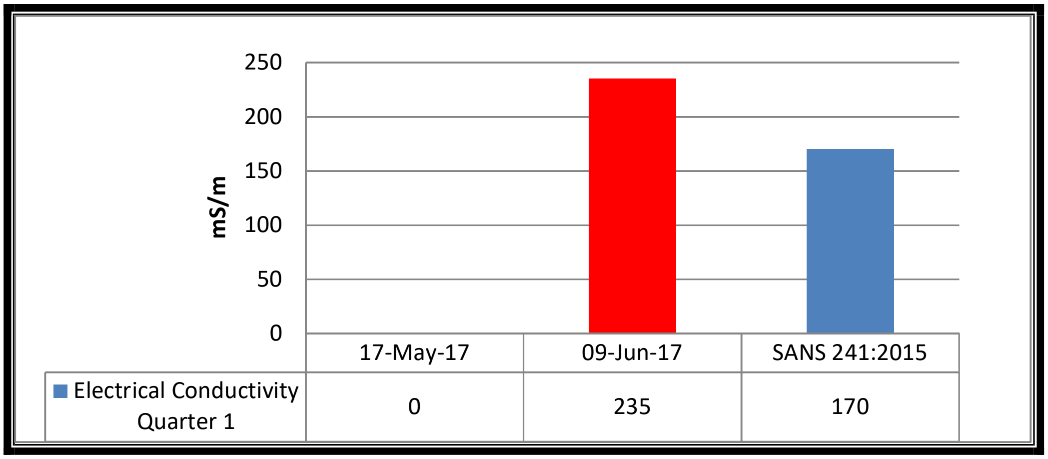


Figure 4—20: Electrical Conductivity Non-Compliant

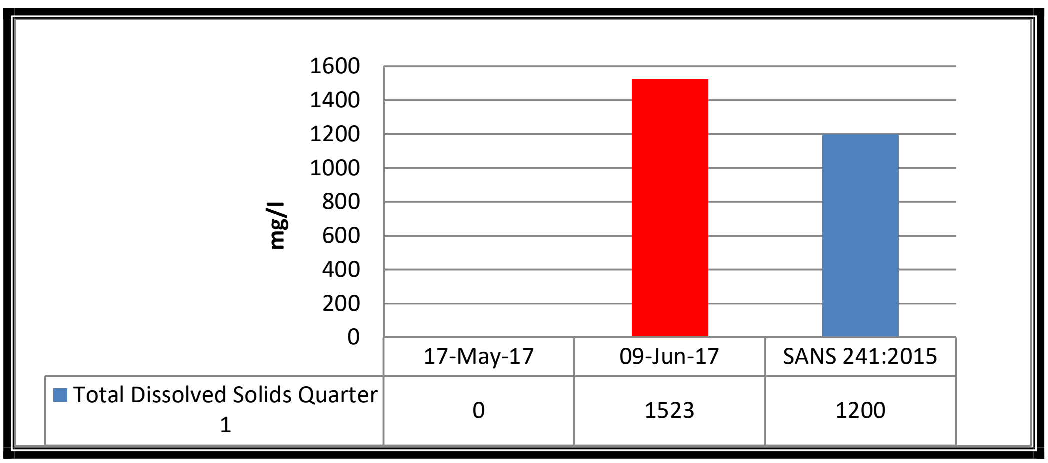


Figure 4—21: Total Dissolved Solids Non-Compliant

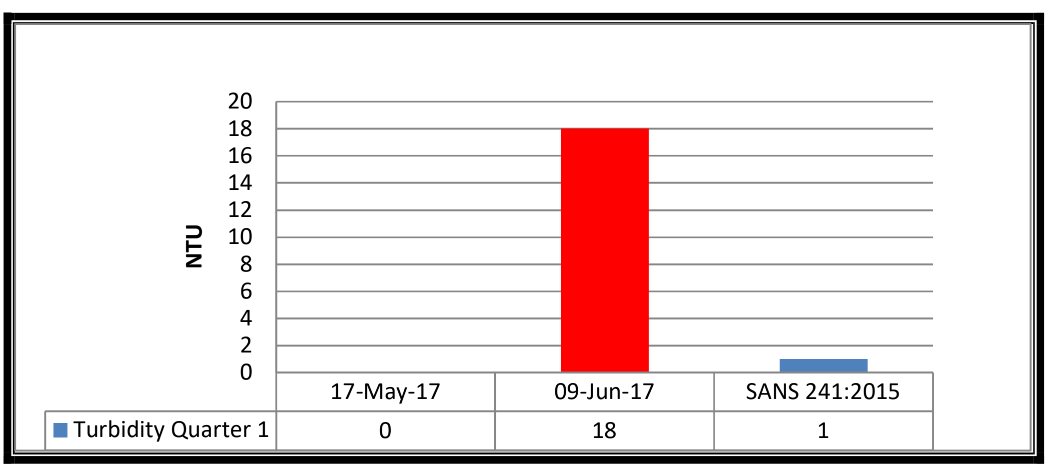


Figure 4—22: Turbidity Non-Compliant

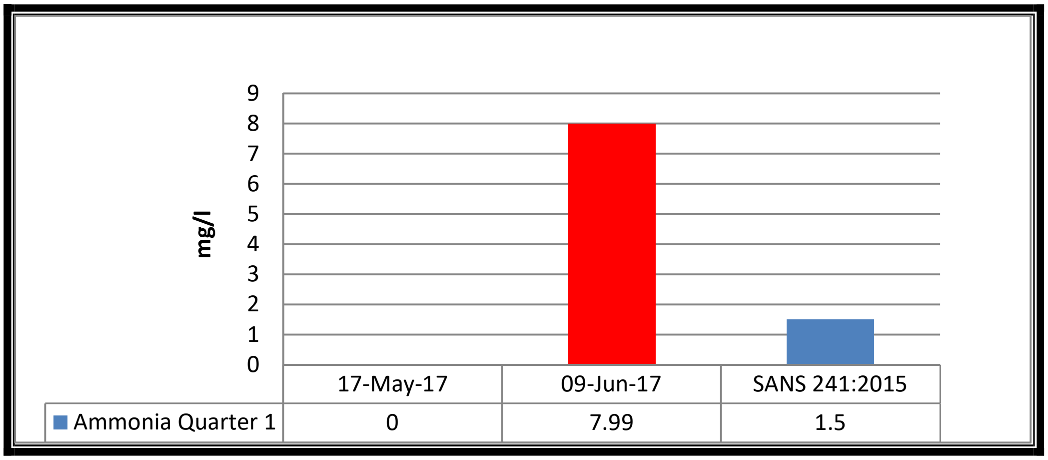


Figure 4—23: Ammonia Non-Compliant

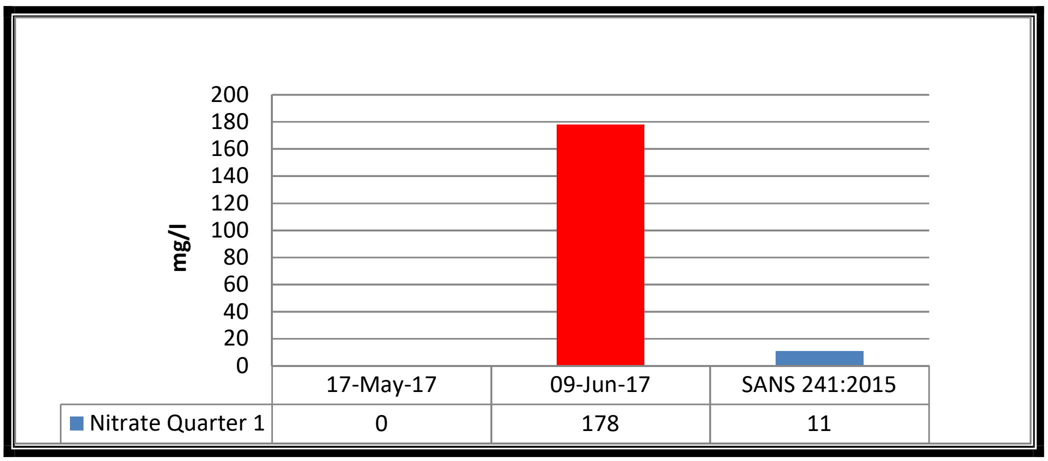


Figure 4—24: Nitrate Non-Compliant

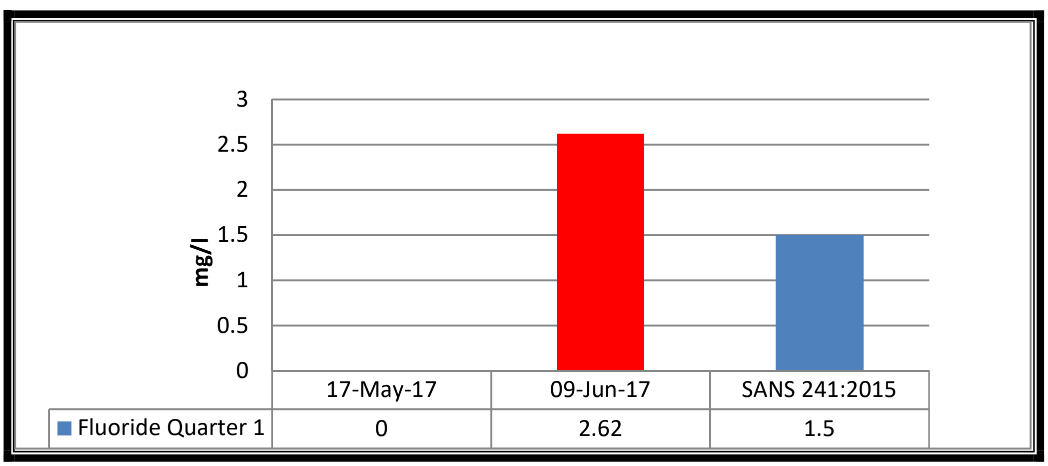


Figure 4—25: Fluoride Non-Compliant

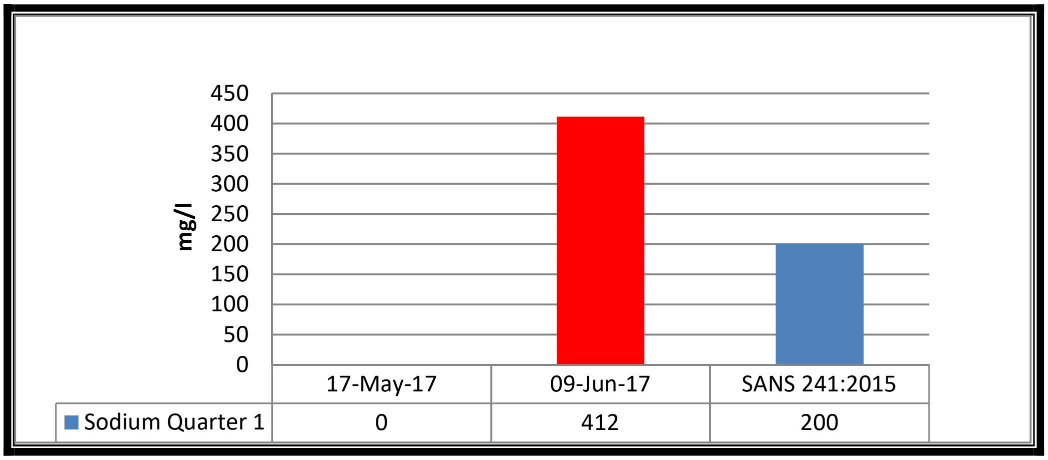


Figure 4—26: Sodium Non-Compliant

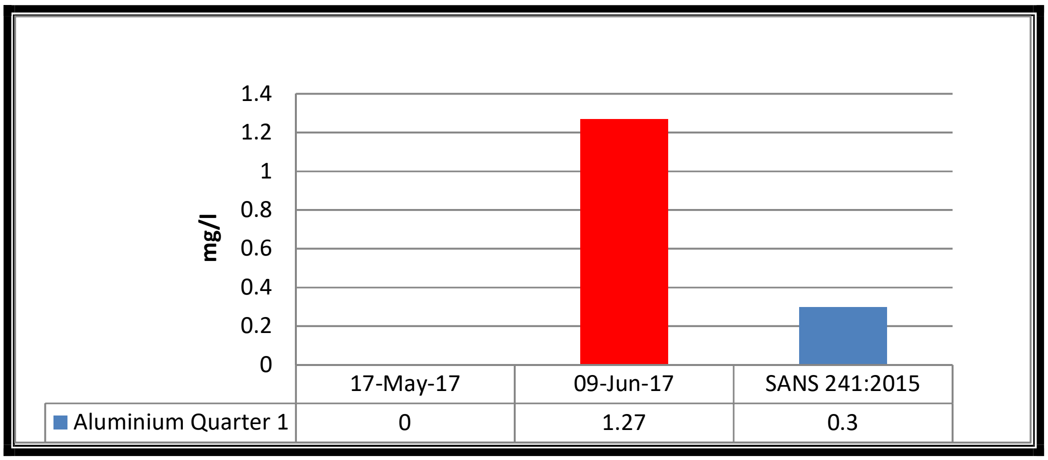


Figure 4—27: Aluminium Non-Compliant

QUARTERLY WATER QUALITY MONITORING REPORT
JULY – SEPTEMBER 2017

OCTOBER 2017
TSHEDZA MINING RESOURCE (Pty) Ltd
MANUNGU COLLIERY

PHILO ENVIRONMENTAL MANAGEMENT

4.1.2 Monthly Surface Water Quality Results Interpretation – (Compared to SANS 241:2015)

The monthly surface water quality results are compared to the SANS 241-2015 standards and the water quality baseline, to determine the current status of water quality at the Manungu Colliery. It must be noted that the baseline water quality report was conducted before the commencement of mining activities on site and therefore the increase of certain variables is permissible, and the quality still falls within the SANS 241-2015 standards.

4.1.2.1 MWQ 1

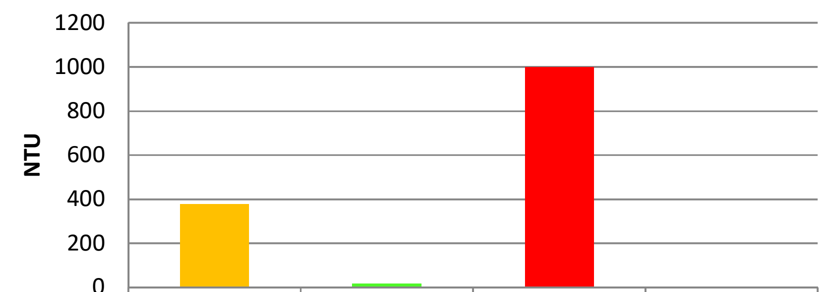
MWQ 1 is located on the western side of the Opencast Pit in the tributary of Stream 1. This point indicates the impacts of activities located upstream of Manungu Colliery. The findings at monitoring point MWQ 1 are as follows:

- The pH concentration was slightly neutral to alkaline, varying from a scale of 7 to 8.
- Very minimal content of Electrical Conductivity (EC) was determined at the monitoring point, however concentrations greater than the Baseline Water Quality report were measured during the three months (July-September).
- Sulphate levels are linked to coal mining and related activities. The variable was detected below the SANS 241-2015 limits as well as the baseline water quality report.
- Turbidity was in high concentration for all three months when compared to the SANS 241:2015 limit of 1 NTU.
- Manganese and iron exceeded the acceptable SANS 241:2015 limits in July and September. These metals may result from surface mining and related activities.
- Some other variables exceeded the SANS 241:2015 standards, as seen in Table 4-1 below. Also see Figure 4-1 to 4-4 for non-compliance with the SANS 241:2015 limits.

Refer to Table 4-1 Below:

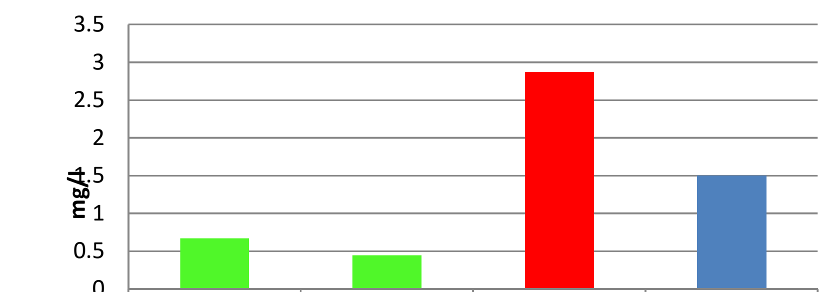
Table 4-1: MWQ 1 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	Drinking Water Standards according to SANS 241:2015	Jul-17	Aug-17	Sep-17
EC mS/m	35.933	<170	45.4	52.0	106
TDS mg/L	202	<1200	251	274	577
pH	7.903	5-9.7	7.07	8.01	7.34
Turbidity NTU	0	<1	378	16.6	>1000
Ammonium as NH_4 -N mg/L	0.12	<1.5	0.67	<0.45	2.87
Nitrate as NO_3 -N mg/L	0.583	<11	<0.35	0.78	<0.35
Sulphate as SO_4 mg/L	23.166	500	18.8	11.1	8.46
Chloride as Cl mg/L	15.1	<300	28.9	47.3	128
Fluoride as F mg/L	0.300	<1.5	0.26	0.13	0.40
Magnesium as Mg mg/L	15.566	70	23.1	22.6	36.9
Calcium as Ca mg/L	21.466	150	29.8	26.8	48.7
Potassium as K mg/L	6.463	50	6.81	10.5	20.9
Sodium as Na mg/L	29.366	<200	30.9	43.9	96.2
Iron as Fe mg/L	-0.003	2	0.02	0.01	4.52
Manganese as Mn mg/L	-0.001	0.4	1.47	<0.01	4.83
Aluminium as Al mg/L	-0.003	0.3	<0.01	<0.01	<0.01
Phosphate (PO_4) mg/L	0.044	0.1	<0.03	<0.03	0.07
Suspended Solids mg/L	86.666		782	16.8	759
Silicon as Si mg/l			1.40	<0.1	1.63
Total Alkalinity	143.666		183	180	374
	Non-compliant with baseline study				
	Non-compliant with SANS 241:2015				



	11-Jul-17	21-Aug-17	14-Sep-17	SANS 241:2015
MWQ1 Quarter 2	378	16.6	1000	1

Figure 4—1: Turbidity Non-Compliant



	11-Jul-17	21-Aug-17	14-Sep-17	SANS 241:2015
MWQ1 Quarter 2	0.67	0.45	2.87	1.5

Figure 4—2: Ammonia Non-Compliant

	11-Jul-17	21-Aug-17	14-Sep-17	SANS 241:2015
MWQ1 Quarter 2	0.02	0.01	4.52	2

Figure 4—3: Iron Non-Compliant

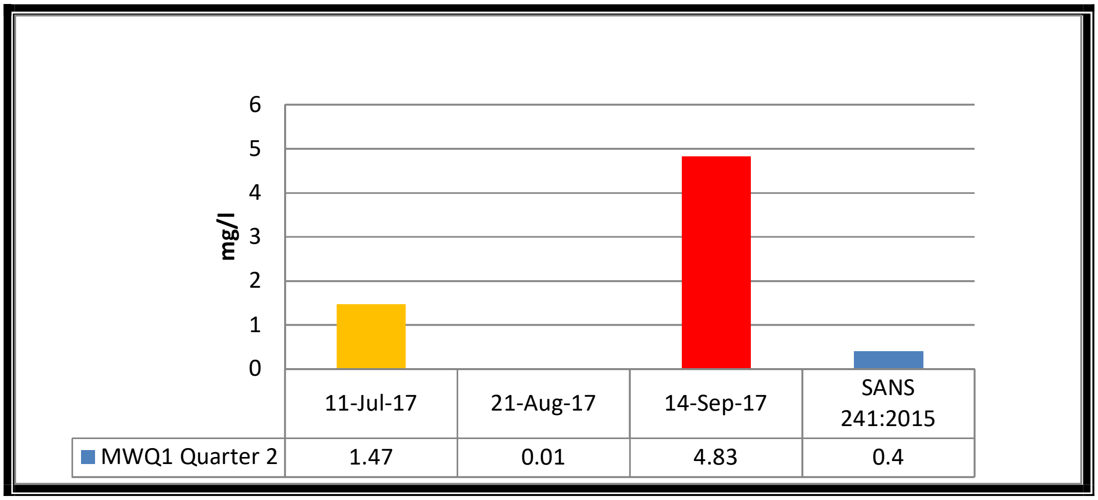


Figure 4—4: Manganese Non-Compliant

4.1.2.2 MWQ 3

MWQ 3 is located in stream 2 on the eastern side of the Manungu surface infrastructure. This point indicates the impact of activities located upstream of Manungu Colliery. The findings at monitoring point MWQ 3 are as follows:

- Most variables were within the expected SANS limits, except Turbidity which had an average of 372 NTU. However, when comparing current data to the baseline water quality, a slight deterioration is observed for some variables.
- Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality. Turbidity is common due to natural geology.
- See Table 4-2 below for all analyzed variables as compared to the baseline water quality results and SANS 241:2015 limits, also see Figure 4-5 for non-compliance with the SANS 241:2015 limits.

Refer to Table 4-2 Below:

Table 4-2: MWQ 3 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	Drinking Water Standards according to SANS 241:2015	Jul-17	Aug-17	Sep-17
EC mS/m	42.65	<170	36.3	40.5	44.1
TDS mg/L	242.333	<1200	212	223	241
pH	8.056	5-9.7	7.40	7.94	7.43
Turbidity NTU	0	<1	428	525	402
Ammonium as NH_4 -N mg/L	0.142	<1.5	0.66	<0.45	<0.45
Nitrate as NO_3 -N mg/L	1.121	<11	0.83	0.89	1.06
Sulphate as SO_4 mg/L	45.116	500	44.9	46.6	55.5
Chloride as Cl mg/L	26	<300	18.7	22.7	23.2
Fluoride as F mg/L	0.540	<1.5	0.55	0.34	0.71
Magnesium as Mg mg/L	16.166	70	14.1	14.2	14.7
Calcium as Ca mg/L	20.583	150	18.4	19.6	21.7
Potassium as K mg/L	11.08	50	10.9	10.8	11.3
Sodium as Na mg/L	39.2	<200	31.8	34.0	35.3
Iron as Fe mg/L	-0.003	2	0.09	0.13	<0.01
Manganese as Mn mg/L	0.022	0.4	0.01	<0.01	<0.01
Aluminium as Al mg/L	0.006	0.3	0.18	0.25	<0.01
Phosphate (PO_4) mg/L	0.021	0.1	<0.03	0.03	0.03
Suspended Solids mg/L	231		168	289	302
Silicon as Si mg/l			3.47	2.93	2.75
Total Alkalinity	128.766		113	117	123
	Non-compliant with baseline study				
	Non-compliant with SANS 241:2015				

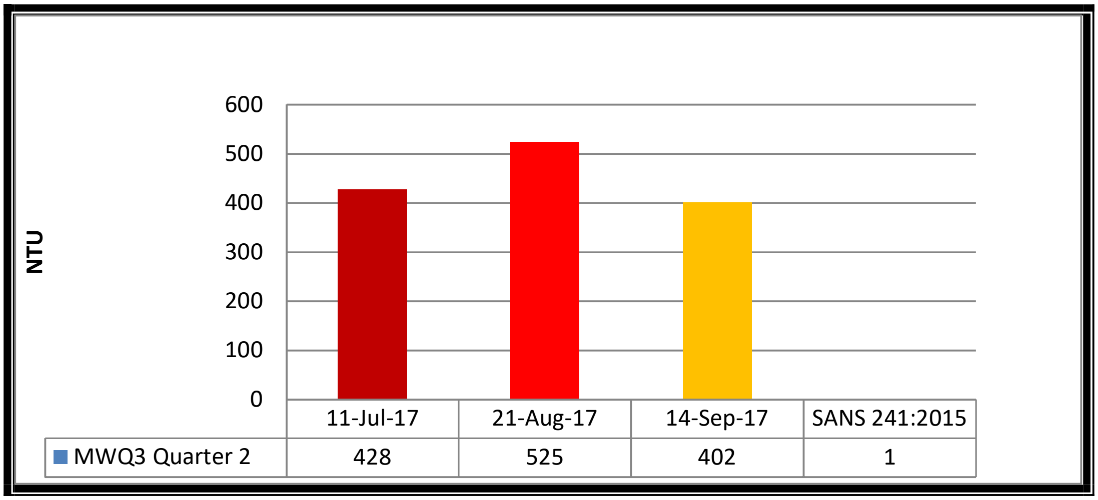


Figure 4—5: Turbidity Non-Compliant

4.1.2.3 MWQ 4

MWQ 4 is located in stream 1, downstream of MWQ 3 and south east of the PCD. The findings at monitoring point MWQ 4 are as follows:

- The concentrations of most variables (marked in orange in Table 4-3) increased and were higher than the baseline water quality data.
- Electrical conductivity was non-compliant compared to the SANS 241:2015 limit for September 2017 and above the baseline water quality results for both July and August.
- Total Dissolved Solids exceeded the limit compared to the baseline water quality results but were still compliant with SANS 241:2015.
- Aluminium was non-compliant compared to the SANS 241:2015 limit for August 2017 and at acceptable levels for the baseline water quality results for July and September.
- Turbidity and manganese both exceed the SANS 241:2015 limits for July and August.
- All metal elements indicated levels that were higher than the Baseline results, which is associated with contamination from earth works involving extraction of coal from the ground.
- Sodium levels indicated non-conformance only for the month of September compared to the SANS 241:2015 limit.
- See Table 4-3 below for all analyzed variables as compared to the baseline water quality results and SANS 241:2015 limits, also see Figures 4-6 to 4-10 for non-compliance with the SANS 241:2015 limits.

Refer to Table 4-3 Below:

Table 4-3: MWQ 4 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	Drinking Water Standards according to SANS 241:2015	Jul-17	Aug-17	Sep-17
EC mS/m	41.675	<170	153	113	172
TDS mg/L	234.75	<1200	861	605	888
pH	8.09	5-9.7	7.31	7.25	7.81
Turbidity NTU	0	<1	126	1001	0.50
Ammonium as NH_4 -N mg/L	0.043	<1.5	<0.45	<0.45	<0.45
Nitrate as NO_3 -N mg/L	1.16	<11	<0.35	<0.35	<0.35
Sulphate as SO_4 mg/L	45	500	3.87	38.7	10.7
Chloride as Cl mg/L	25.025	<300	136	64.4	127
Fluoride as F mg/L	0.548	<1.5	0.23	<0.09	0.22
Magnesium as Mg mg/L	15.475	70	58.8	40.7	48.0
Calcium as Ca mg/L	19.025	150	56.9	56.3	59.8
Potassium as K mg/L	10.617	50	19.8	6.98	12.1
Sodium as Na mg/L	36.75	<200	194	106	216
Iron as Fe mg/L	-0.003	2	0.03	3.93	1.28
Manganese as Mn mg/L	-0.001	0.4	1.88	3.80	<0.01
Aluminium as Al mg/L	0.020	0.3	<0.01	0.57	<0.01
Phosphate (PO_4) mg/L	0.023	0.1	<0.03	<0.03	0.03
Suspended Solids mg/L	328.25		183	1414	<0.4
Silicon as Si mg/l			8.93	8.57	11.6
Total Alkalinity	126.1		649	473	687
(orange)	Non-compliant with baseline study				
(red)	Non-compliant with SANS 241:2015				

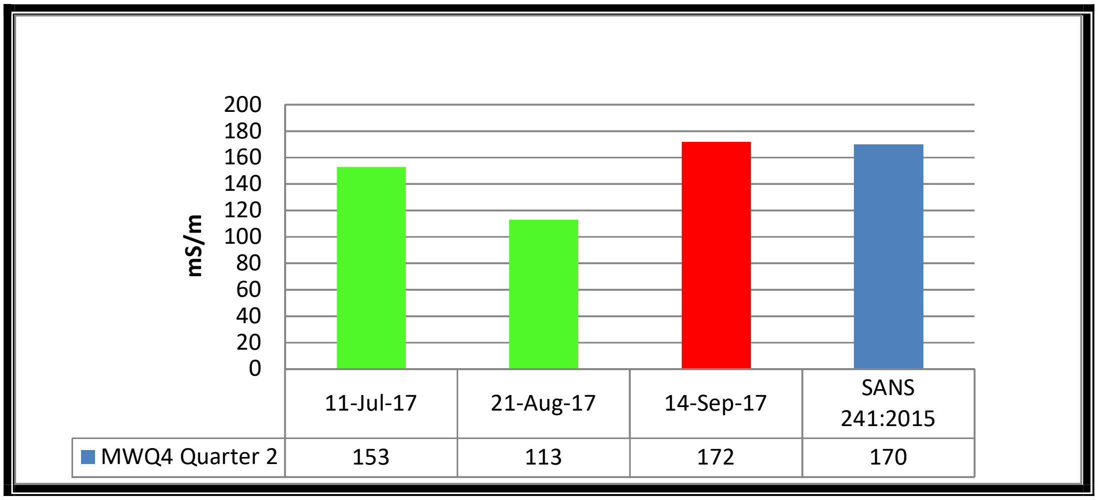


Figure 4—6: Electrical Conductivity Non-Compliant

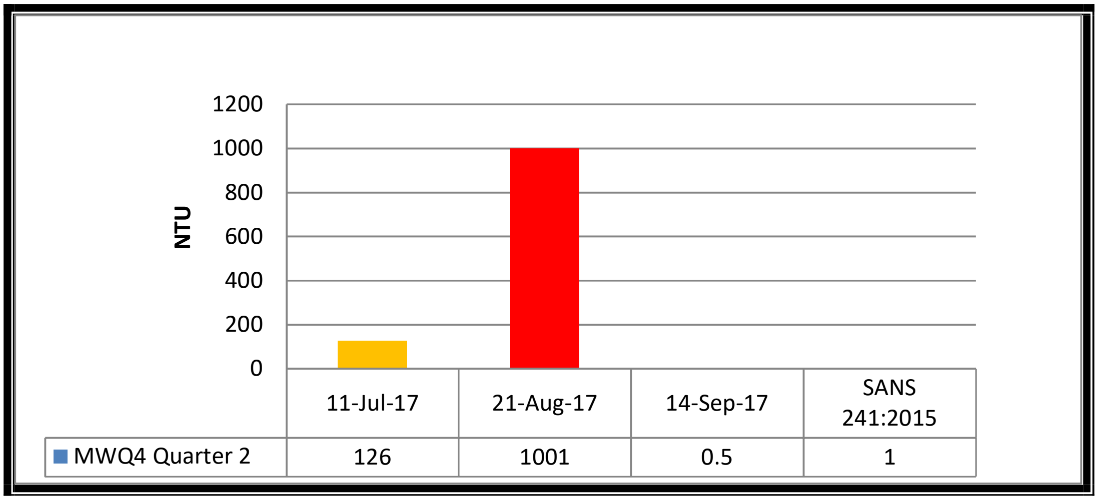


Figure 4—7: Turbidity Non-Compliant

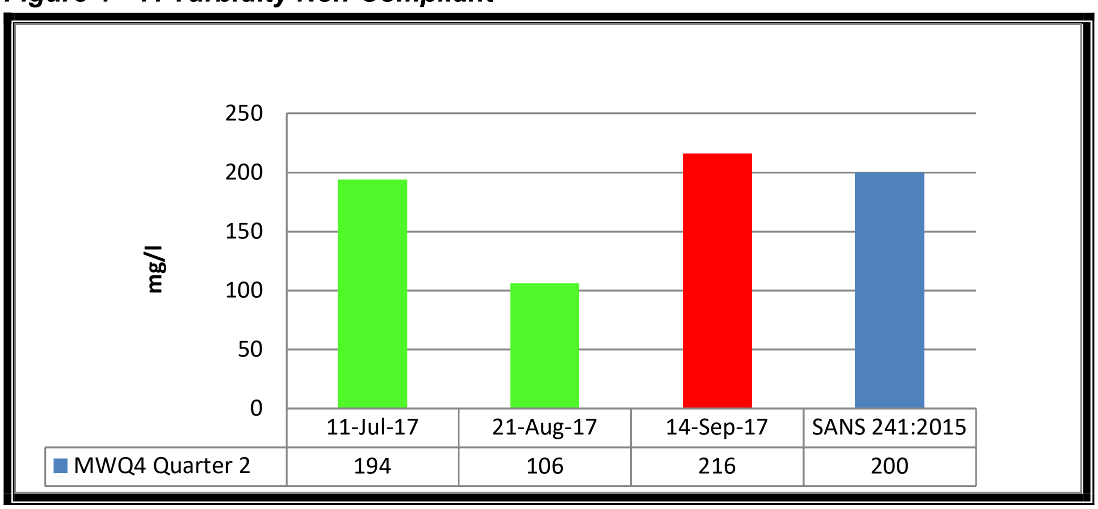


Figure 4—8: Sodium Non-Compliant

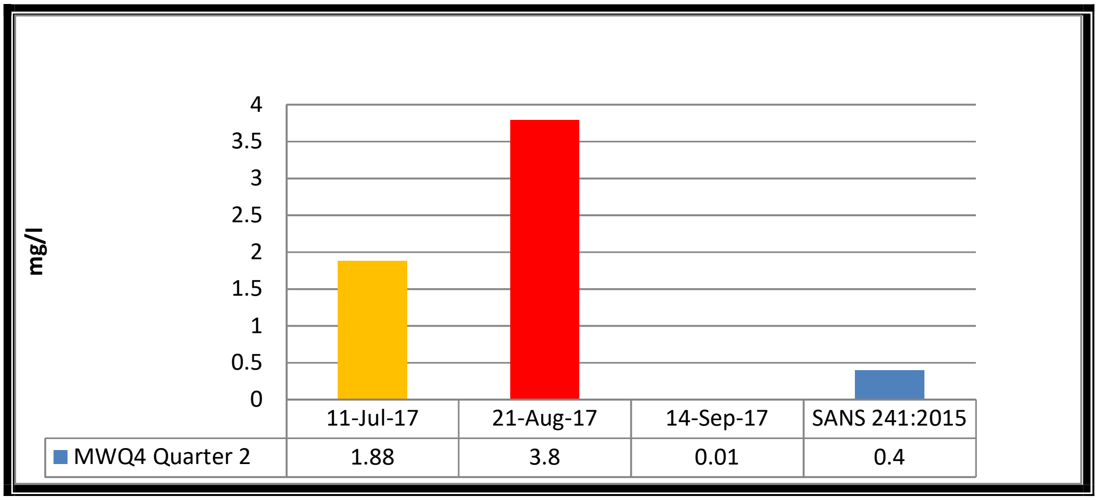


Figure 4—9: Manganese Non-Compliant

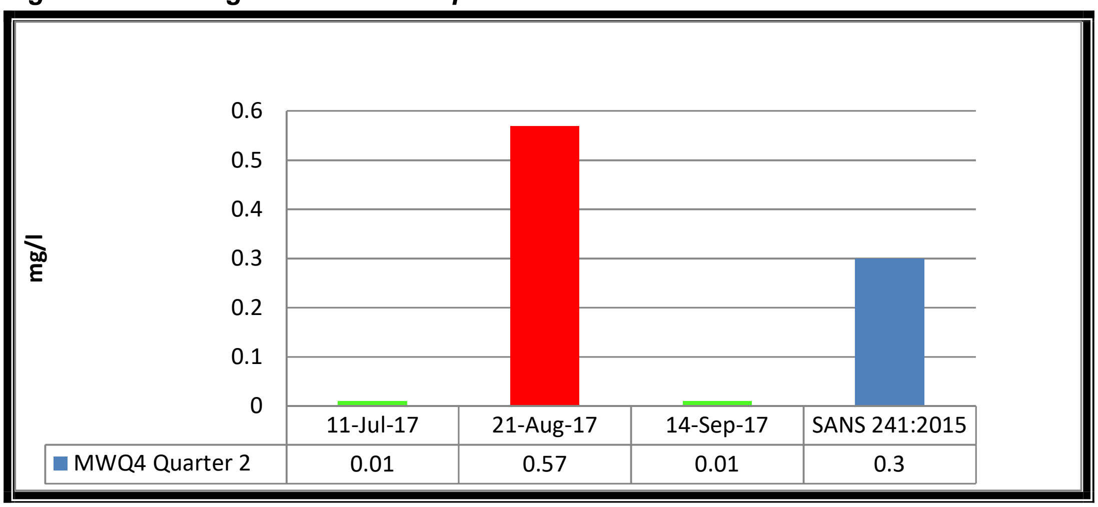


Figure 4—10: Ammonia Non-Compliant

4.1.2.4 MWQ 5

MWQ 5 is located in stream 1. Due to the drainage area (Tributary of stream 1) between MWQ 5 and MWQ 1, there is no probability that the activities at Manungu will have an impact on MWQ 5. However, it is necessary to monitor this stream in order to identify the source of impact at MWQ 6. The findings at monitoring point MWQ 5 are as follows:

- According to the standards set by SANS 241-2015, some variables were found to have exceeded the limits, such as Manganese, Turbidity, Magnesium and Ammonia
- As indicated earlier in the report there are other mining activities in the vicinity of the mine not associated with Manungu Colliery. Some of the changes in the variables may not be impacts associated with the operation at Manungu Colliery.
- Increased Phosphate levels can also result from the excrement of animals living in or near the water.
- Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air.
- Some variables showed an increase when compared to the baseline water quality results.
- See Table 4-4 below for all analyzed variables as compared to baseline water quality results and SANS 241:2015, also see Figures 4-11 to 4-14 for non-compliance with SANS 241:2015.

Please refer to Table 4-4 Below:

Table 4-4: MWQ 5 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	Drinking Water Standards according to SANS 241:2015	Jul-17	Aug-17	Sep-17
EC mS/m	73.025	<170	45.4	51.6	60.4
TDS mg/L	431	<1200	251	251	281
pH	9.225	5-9.7	7.07	8.00	7.62
Turbidity NTU	0	<1	378	39.4	343
Ammonium as NH_4 -N mg/L	0.119	<1.5	0.67	<0.45	3.58
Nitrate as NO_3 -N mg/L	0.262	<11	<0.35	<0.35	<0.35
Sulphate as SO_4 mg/L	17.417	500	18.8	8.54	5.82
Chloride as Cl mg/L	60.025	<300	28.9	50.9	55.6
Fluoride as F mg/L	0.421	<1.5	0.26	0.11	0.53
Magnesium as Mg mg/L	44.6	70	23.1	22.9	97.6
Calcium as Ca mg/L	31.7	150	29.8	23.0	22.3
Potassium as K mg/L	10.55	50	6.81	11.5	12.1
Sodium as Na mg/L	78.125	<200	30.9	32.8	38.1
Iron as Fe mg/L	0.003	2	0.02	<0.01	1.97
Manganese as Mn mg/L	0.125	0.4	1.47	0.1	2.19
Aluminium as Al mg/L	0.003	0.3	<0.01	<0.01	<0.01
Phosphate (PO_4) mg/L	0.185	0.1	<0.03	<0.03	0.32
Suspended Solids mg/L	24.75		782	251	516
Silicon as Si mg/l			1.40	0.34	0.52
Total Alkalinity	306.5		183	169	188
	Non-compliant with baseline study				
	Non-compliant with SANS 241:2015				

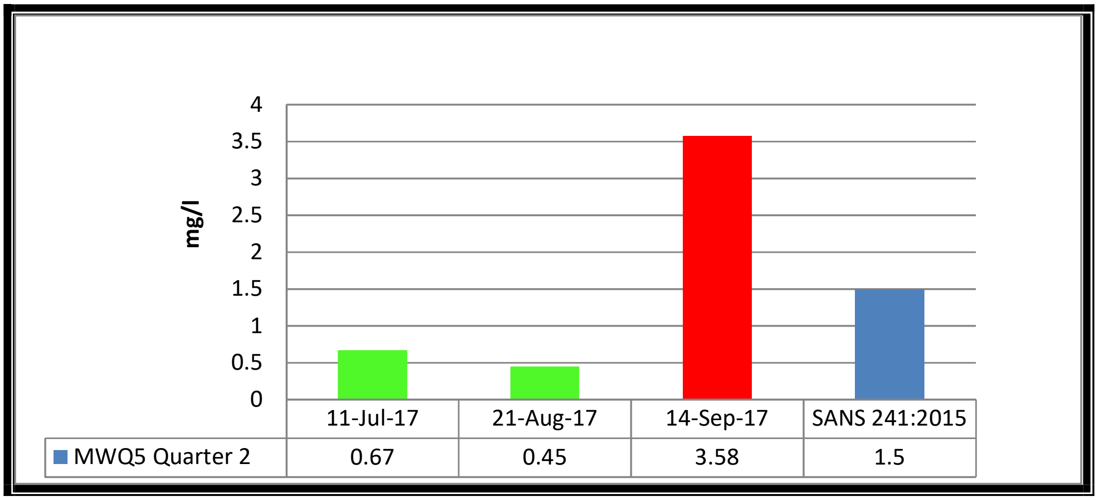


Figure 4—11: Turbidity Non-Compliant

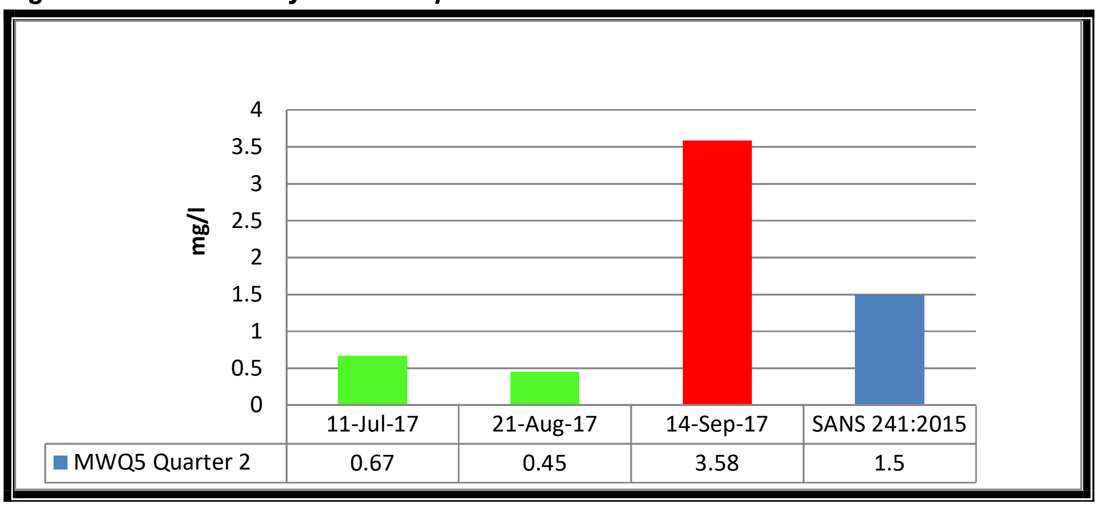


Figure 4—12: Ammonia Non-Compliant

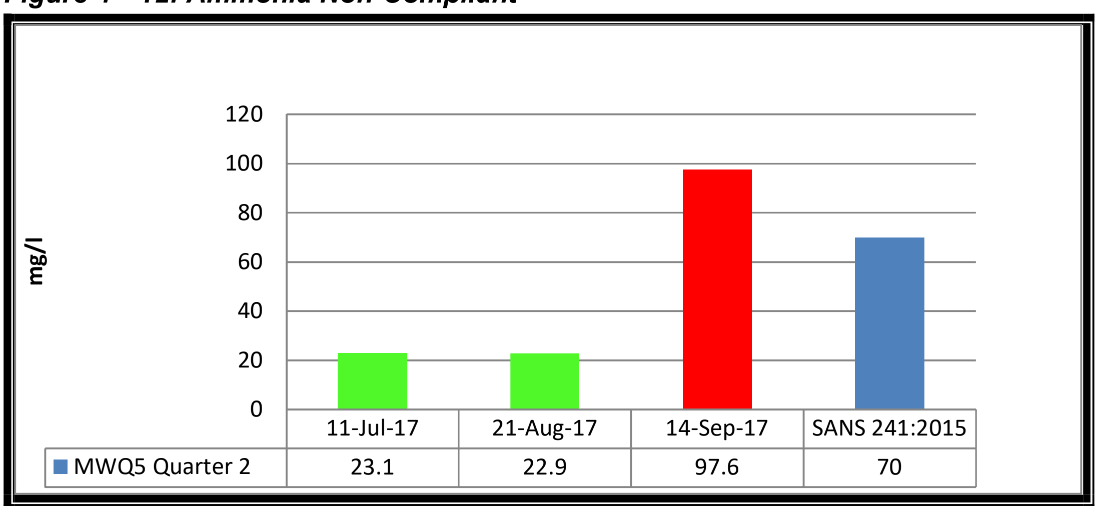


Figure 4—13: Magnesium Non-Compliant

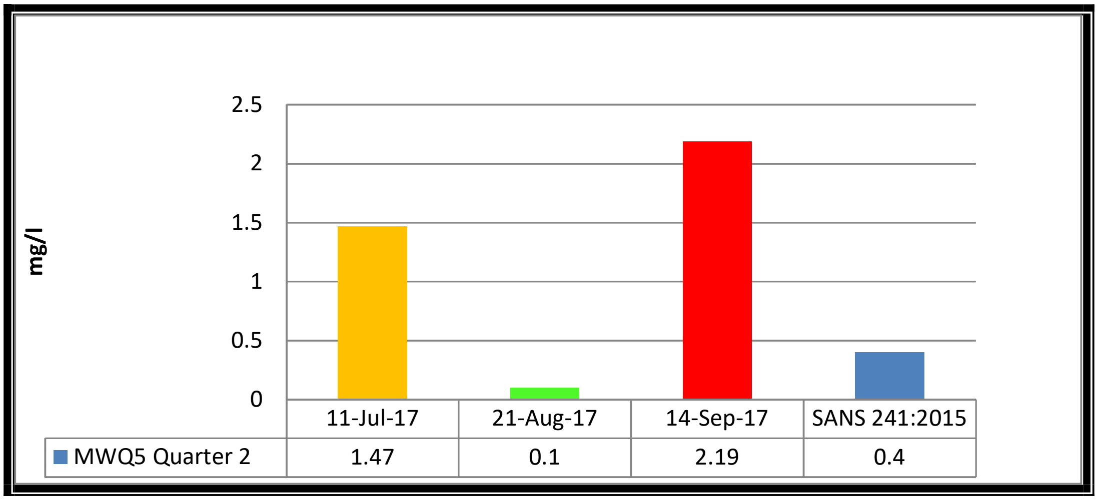


Figure 4—14: Manganese Non-Compliant

4.1.2.5 MWQ 6

MWQ 6 is located downstream of MWQ 1 and MWQ 3 in stream 1. The findings at monitoring point MWQ 6 are as follows:

- Sample point was found to be dry for all 3 months.

Refer to Table 4-5 Below:

Table 4-5: MWQ 6 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	Drinking Water Standards according to SANS 241:2015	Jul-17	Aug-17	Sep-17
EC mS/m	57.5	<170	No water	No water	No water
TDS mg/L	290	<1200			
pH	8.32	5-9.7			
Turbidity NTU		<1			
Ammonium as NH_4 -N mg/L	0.069	<1.5			
Nitrate as NO_3 -N mg/L	0.397	<11			
Sulphate as SO_4 mg/L	1.63	500			
Chloride as Cl mg/L	20.5	<300			
Fluoride as F mg/L	0.32	<1.5			
Magnesium as Mg mg/L	26.8	70			
Calcium as Ca mg/L	29	150			
Potassium as K mg/L	8.37	50			
Sodium as Na mg/L	43.9	<200			
Iron as Fe mg/L	0.003	2			
Manganese as Mn mg/L	-0.001	0.4			
Aluminium as Al mg/L	0.003	0.3			
Phosphate (PO_4) mg/L	0.011	0.1			
Suspended Solids mg/L	27				
Silicon as Si mg/l					
Total Alkalinity	259				
	Non-compliant with baseline study				
	Non-compliant with SANS 241:2015				

4.1.2.6 Pollution Control Dam (PCD)

The purpose of the Pollution Control dam is to collect contaminated runoff from the dirty water catchment areas. A lined PCD exists at the south-eastern boundary of the mining area. The following findings were made at the PCD:

- The Pollution Control Dam is regarded as a dirty water catchment area, to collect dirty run-offs around the mine and poor water quality is expected at this point.
- There was no baseline study conducted before the infrastructure was constructed and therefore water quality for the PCD was only compared to the SANS 241-2015 limits.
- Most variables are within the expected SANS limits, except Electrical Conductivity, Total Dissolved Solids, Fluoride, Turbidity, Nitrates, Phosphate, Aluminium and Sodium.
- See Table 4-6 below for all analyzed variables as compared to SANS 241:2015, also see Figures 4-15 to 4-21 for non-compliance with SANS 241:2015.

Refer to Table 4-6 Below:

Table 4-6: PCD Monthly Water Quality Results

Analysis Results	Drinking Water Standards according to SANS 241:2015	Jul-17	Aug-17	Sep-17
EC mS/m	<170	159	184	224
TDS mg/L	<1200	994	1181	1383
pH	5-9.7	8.31	8.60	8.44
Turbidity NTU	<1	18.5	76.0	38.4
Ammonium as NH_4 -N mg/L	<1.5	0.53	0.80	<0.45
Nitrate as NO_3 -N mg/L	<11	57.8	73.3	63.9
Sulphate as SO_4 mg/L	500	239	278	436
Chloride as Cl mg/L	<300	14.8	17.2	19.7
Fluoride as F mg/L	<1.5	1.68	1.09	2.03
Magnesium as Mg mg/L	70	12.3	11.6	16.0
Calcium as Ca mg/L	150	23.1	20.1	21.8
Potassium as K mg/L	50	7.54	7.04	6.62
Sodium as Na mg/L	<200	280	337	393
Iron as Fe mg/L	2	0.03	<0.01	0.19
Manganese as Mn mg/L	0.4	<0.01	<0.01	0.02
Aluminium as Al mg/L	0.3	0.09	0.02	0.70
Phosphate (PO_4) mg/L	0.1	<0.03	<0.03	<0.03
Suspended Solids mg/L		7.20	92.8	25.4
Silicon as Si mg/l		3.40	3.22	4.93
Total Alkalinity		263	287	339
	Non-compliant with baseline study			
	Non-compliant with SANS 241:2015			

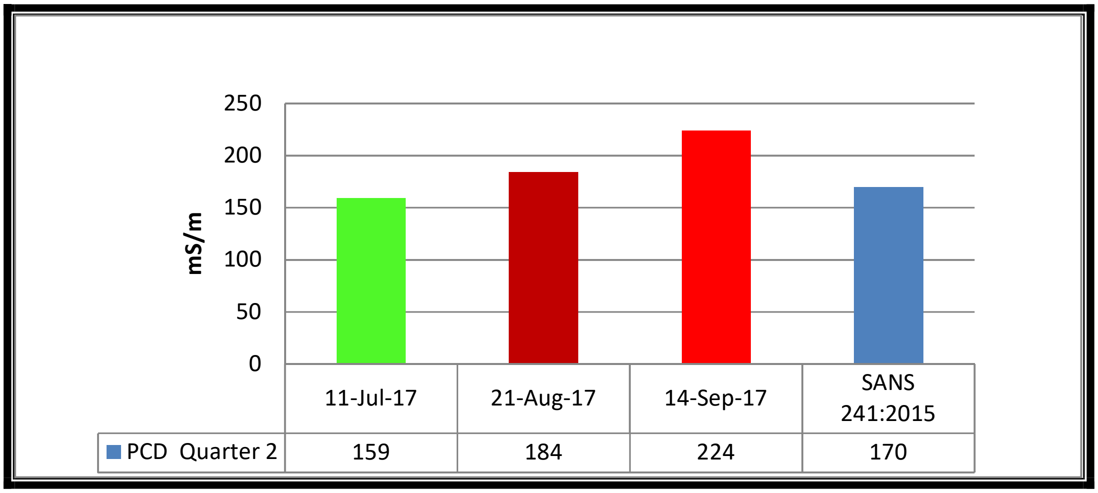


Figure 4—15: Electrical Conductivity Non-Compliant

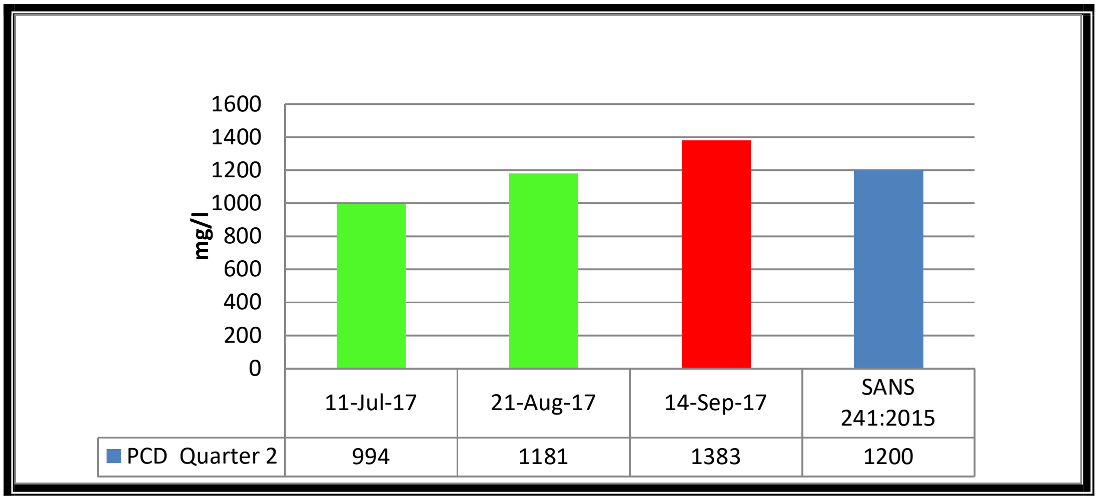


Figure 4—16: Total Dissolved Solids Non-Compliant

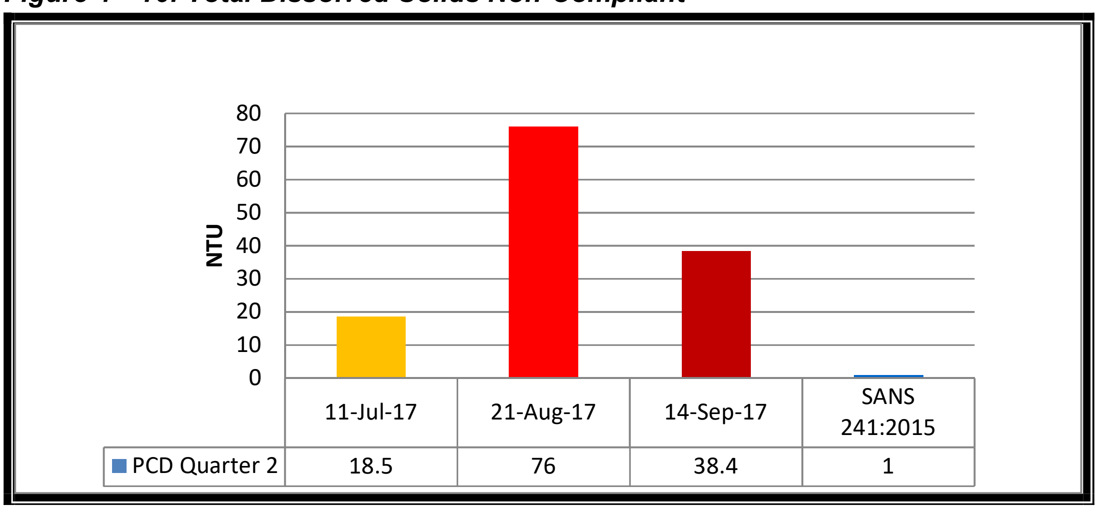


Figure 4—17: Turbidity Non-Compliant

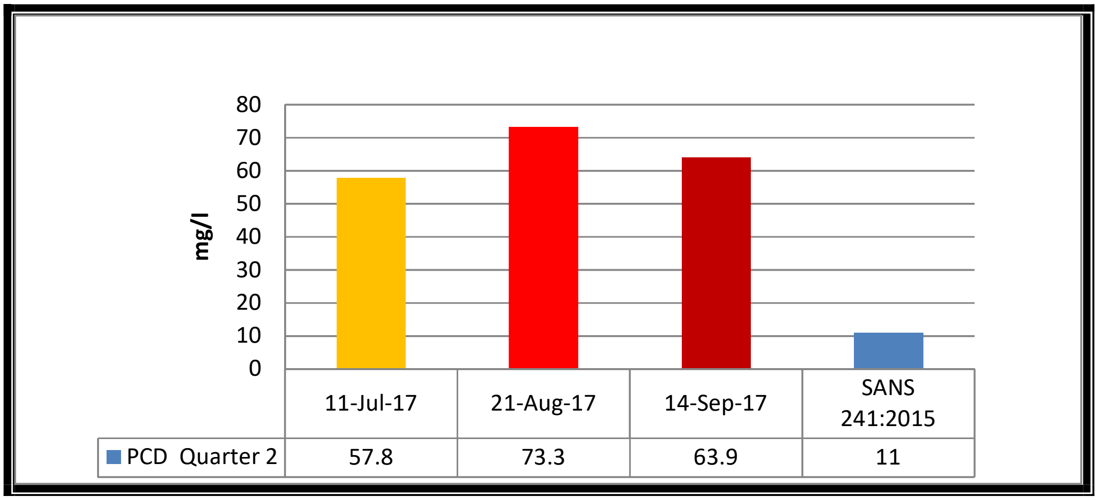


Figure 4—18: Nitrate Non-Compliant

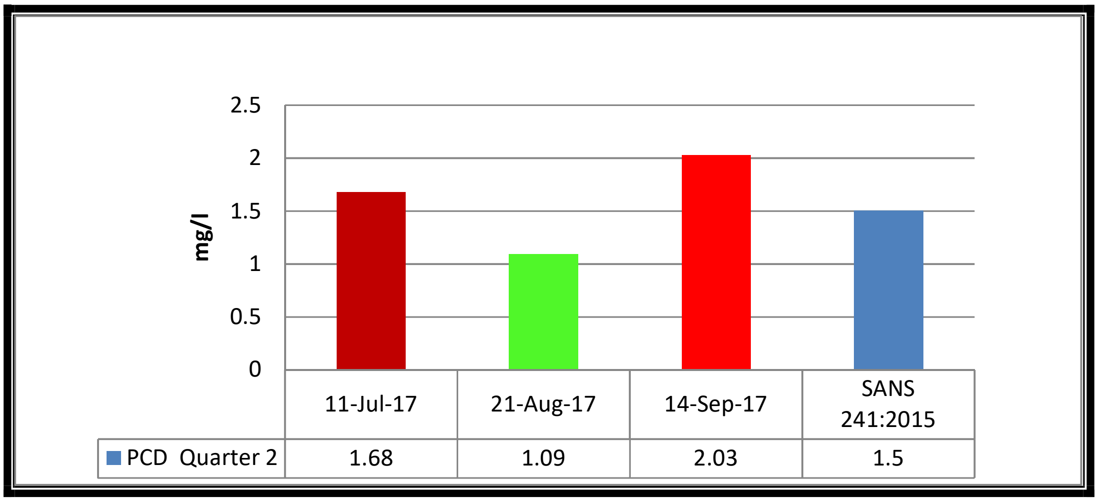


Figure 4—19: Fluoride Non-Compliant

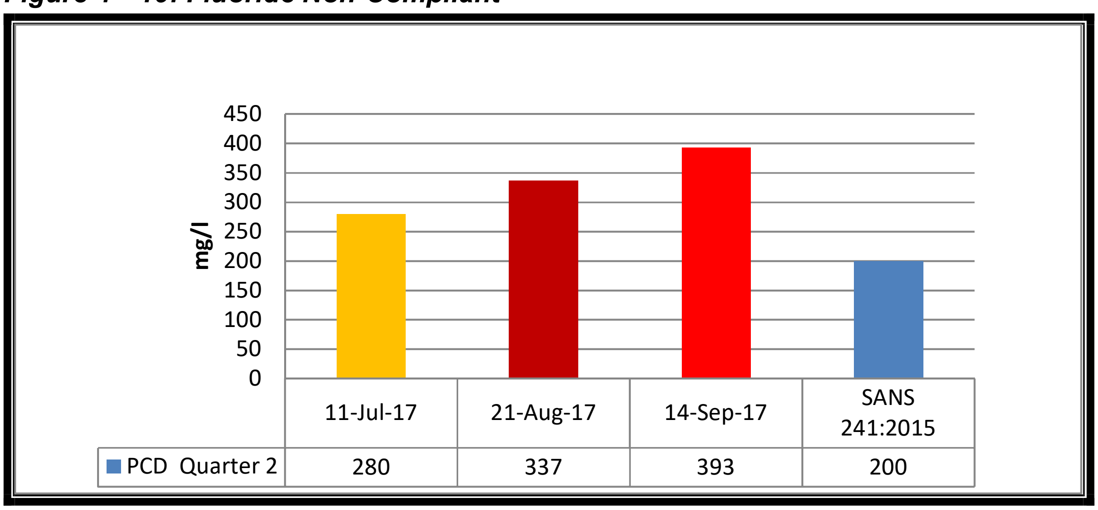


Figure 4—20: Sodium Non-Compliant

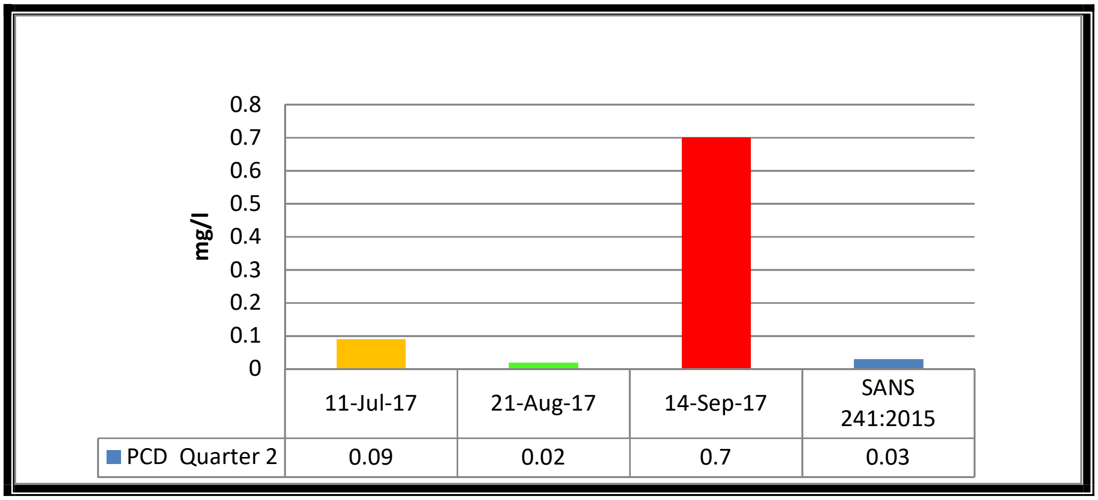


Figure 4—21: Aluminium Non-Compliant

4.1.2.7 PCD Drainage

This point is the sump located at the lowest point of the Pollution Control Dam. The following findings were made:

- The PCD Drainage has better water quality compared to the PCD.
- All samples collected fall within the SANS 241:2015 limits except for Turbidity.
- TDS falls within the set limit of SANS 241:2015.
- The concentrations of Suspended Solids are very low at the PCD Drainage monitoring point.
- See Table 4-7 below for all analyzed variables as compared to SANS 241:2015, also see Figure 4-22 for non-compliance with SANS 241:2015.

Refer to Table 4-7 Below:

Table 4-7: PCD Drainage Monthly Water Quality Results

Analysis Results	Drinking Water Standards according to SANS 241:2015	Jul-17	Aug-17	Sep-17
EC mS/m	<170	86.3	81.2	79.7
TDS mg/L	<1200	489	452	426
pH	5-9.7	7.74	7.67	7.39
Turbidity NTU	<1	9.27	8.16	4.02
Ammonium as NH_4 -N mg/L	<1.5	<0.45	<0.45	<0.45
Nitrate as NO_3 -N mg/L	<11	1.81	2.67	3.27
Sulphate as SO_3 mg/L	500	77.9	67.5	49.7
Chloride as Cl mg/L	<300	38.9	39.1	39.0
Fluoride as F mg/L	<1.5	0.51	0.23	0.56
Magnesium as Mg mg/L	70	25.4	23.8	20.6
Calcium as Ca mg/L	150	33.0	28.8	31.6
Potassium as K mg/L	50	2.77	2.74	2.74
Sodium as Na mg/L	<200	112	105	98.8
Iron as Fe mg/L	2	0.13	0.11	0.02
Manganese as Mn mg/L	0.4	0.03	0.05	0.02
Aluminium as Al mg/L	0.3	0.26	0.20	0.03
Phosphate (PO_4) mg/L	0.1	<0.03	0.03	0.05
Suspended Solids mg/L		4.40	3.20	2.80
Silicon as Si mg/l		12.4	11.7	13.0
Total Alkalinity		317	287	280
(orange)	Non-compliant with baseline study			
(red)	Non-compliant with SANS 241:2015			

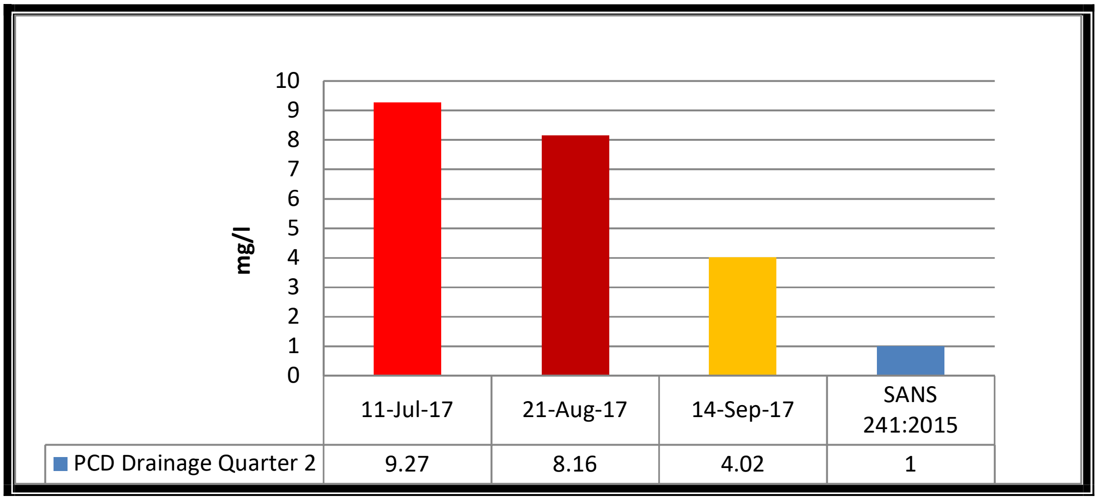


Figure 4—22: Turbidity Non-Compliant

4.1.2.8 Pit Area

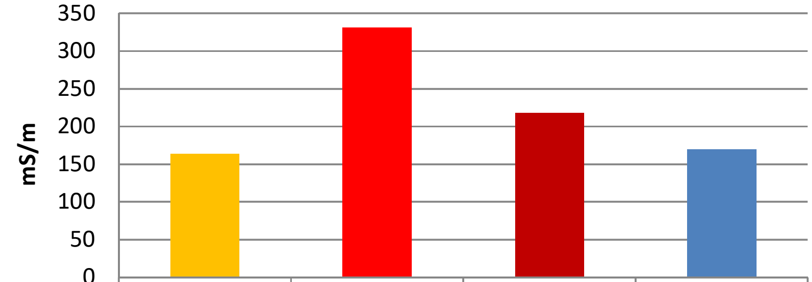
A sample is collected at the active Pit which is managed as a dirty water facility. The following findings were made:

- The source of water at the Pit Area is normally groundwater ingress and rainfall. The sampling point is exposed to the ongoing mining activities at Manungu Colliery and thus elevated concentrations will be recorded.
- High concentrations were recorded for Electrical Conductivity, Total Dissolved Solids, Turbidity, Ammonia, Nitrates, Fluoride, Sodium and Aluminium, Sulphate and Magnesium.
- This could possibly be as a result from the explosives used by the mine for blasting as the explosives contain ammonium nitrate. Thus, there is an increase in Nitrates at PCD at the Pit area.
- See Table 4-8 below for all analyzed variables as compared to SANS 241:2015, also see Figures 4-23 to 4-32 for non-compliance with SANS 241:2015

Refer to Table 4-8 Below:

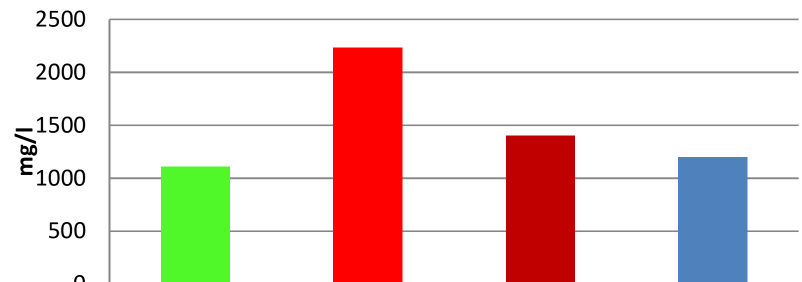
Table 4-8: Pit Area Water Quality Results

Analysis Results	Drinking Water Standards according to SANS 241:2015	Jul-17	Aug-17	Sep-17
EC mS/m	<170	164	331	218
TDS mg/L	<1200	1107	2236	1403
pH	5-9.7	8.61	8.31	8.47
Turbidity NTU	<1	560	19.8	50.2
Ammonium as NH_4 -N mg/L	<1.5	1.39	2.40	2.02
Nitrate as NO_3 -N mg/L	<11	90.9	48.8	26.2
Sulphate as SO_4 mg/L	500	145	1042	521
Chloride as Cl mg/L	<300	17.3	21.2	22.1
Fluoride as F mg/L	<1.5	3.14	0.62	1.53
Magnesium as Mg mg/L	70	3.28	72.9	15.5
Calcium as Ca mg/L	150	6.13	93.6	21.8
Potassium as K mg/L	50	5.40	10.2	9.49
Sodium as Na mg/L	<200	337	688	426
Iron as Fe mg/L	2	0.04	0.39	0.38
Manganese as Mn mg/L	0.4	<0.01	<0.01	<0.01
Aluminium as Al mg/L	0.3	0.12	0.75	1.13
Phosphate (PO_4) mg/L	0.1	<0.03	<0.03	<0.03
Suspended Solids mg/L		217	5.20	33.6
Silicon as Si mg/l		3.62	4.54	7.83
Total Alkalinity		308	331	442
	Non-compliant with baseline study			
	Non-compliant with SANS 241:2015			



	11-Jul-17	21-Aug-17	14-Sep-17	SANS 241:2015
Pit area Quarter 2	164	331	218	170

Figure 4—23: Electrical Conductivity Non-Compliant



	11-Jul-17	21-Aug-17	14-Sep-17	SANS 241:2015
Pit area Quarter 2	1107	2236	1403	1200

Figure 4—24: Total Dissolved Solids Non-Compliant

	11-Jul-17	21-Aug-17	14-Sep-17	SANS 241:2015
Pit area Quater 2	560	19.8	50.2	1

Figure 4—25: Turbidity Non-Compliant

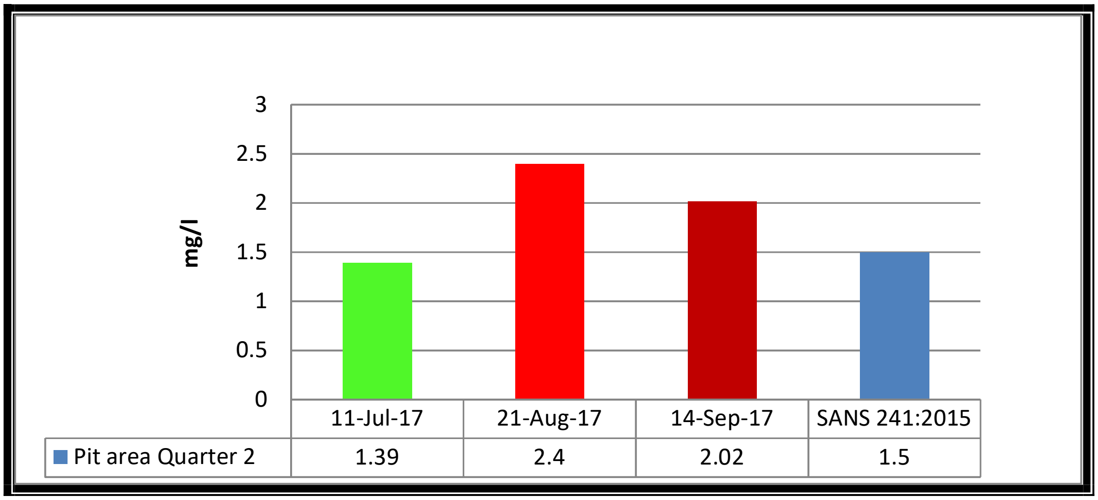


Figure 4—26: Ammonia Non-Compliant

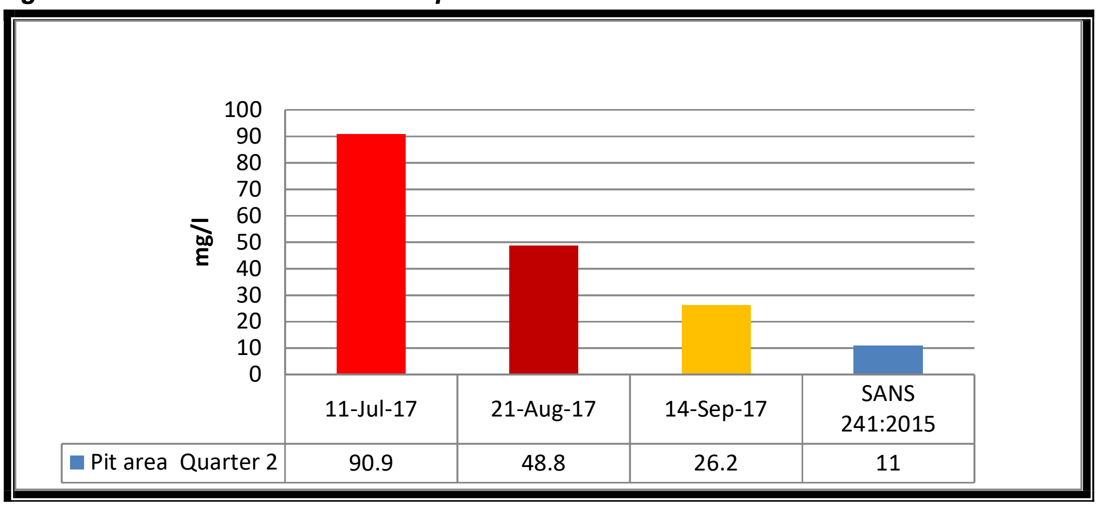


Figure 4—27: Nitrate Non-Compliant

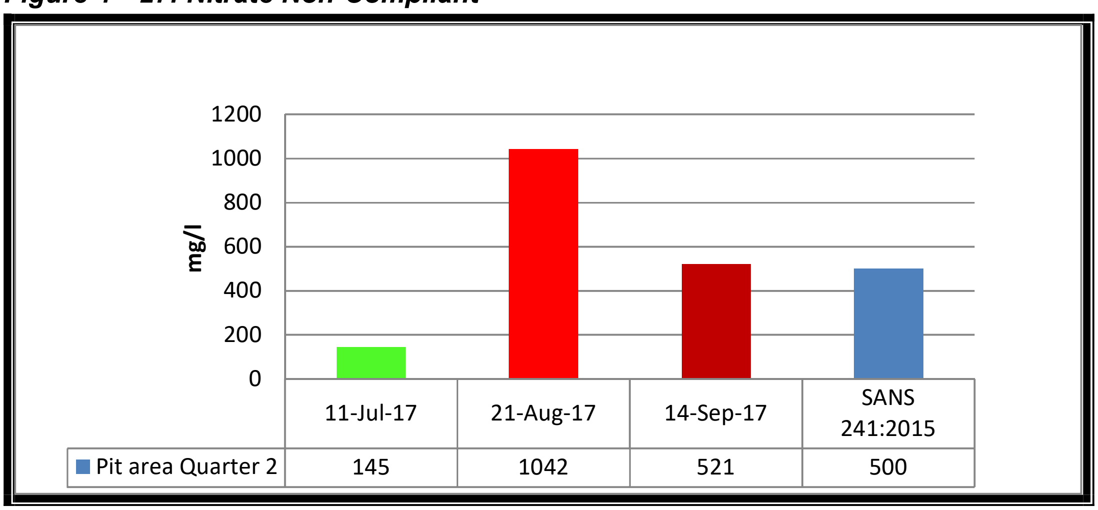


Figure 4—28: Sulphate Non-Compliant

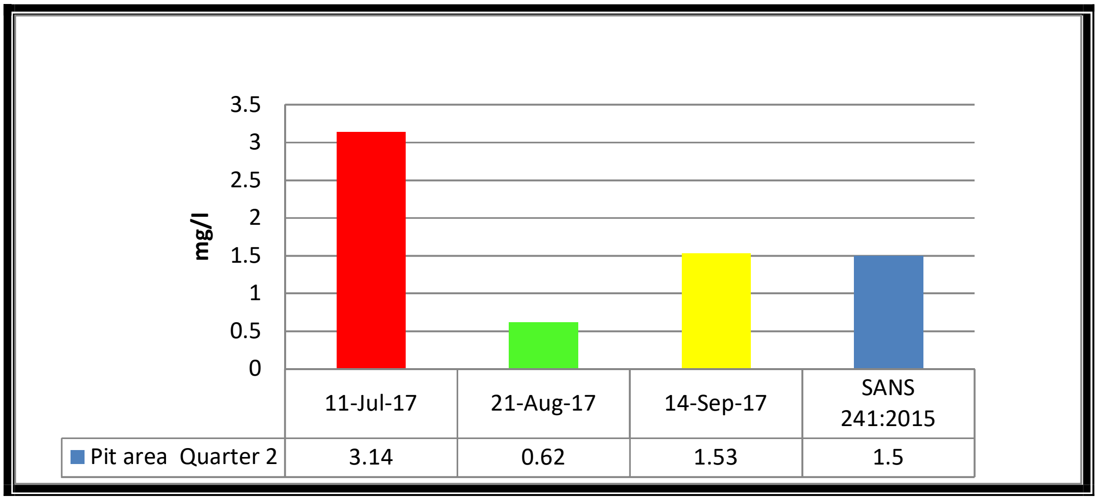


Figure 4—29: Fluoride Non-Compliant

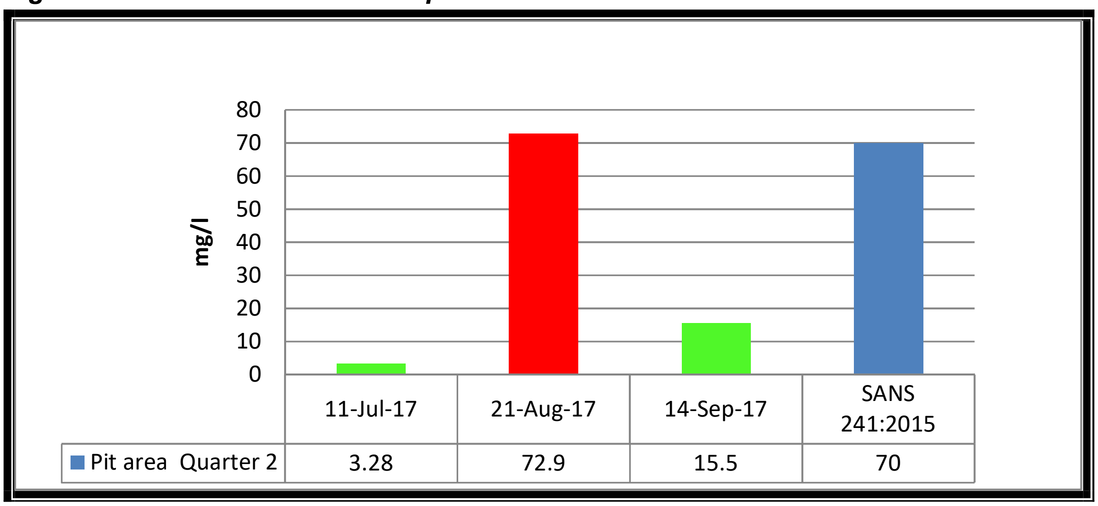


Figure 4—30: Magnesium Non-Compliant

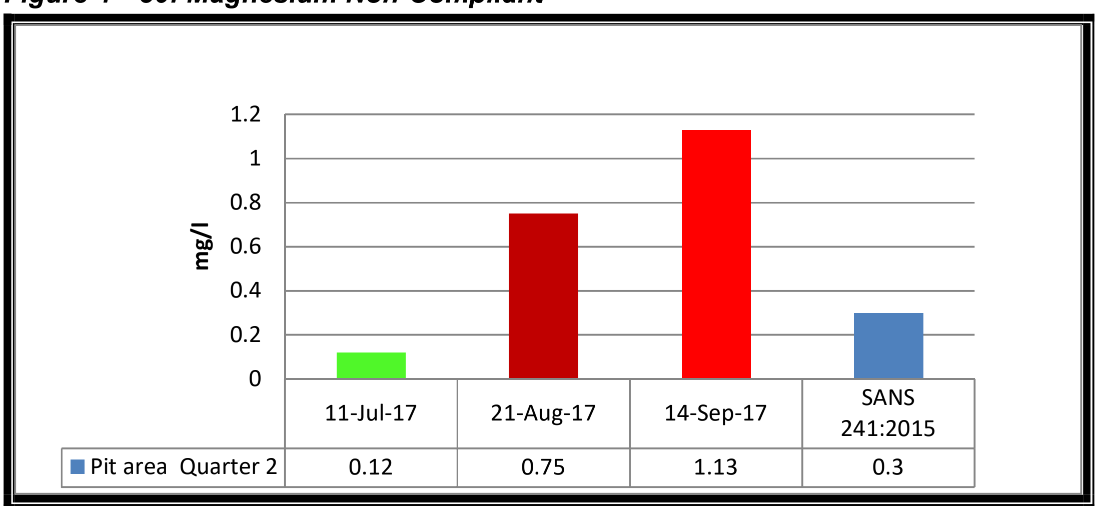


Figure 4—31: Aluminium Non-Compliant

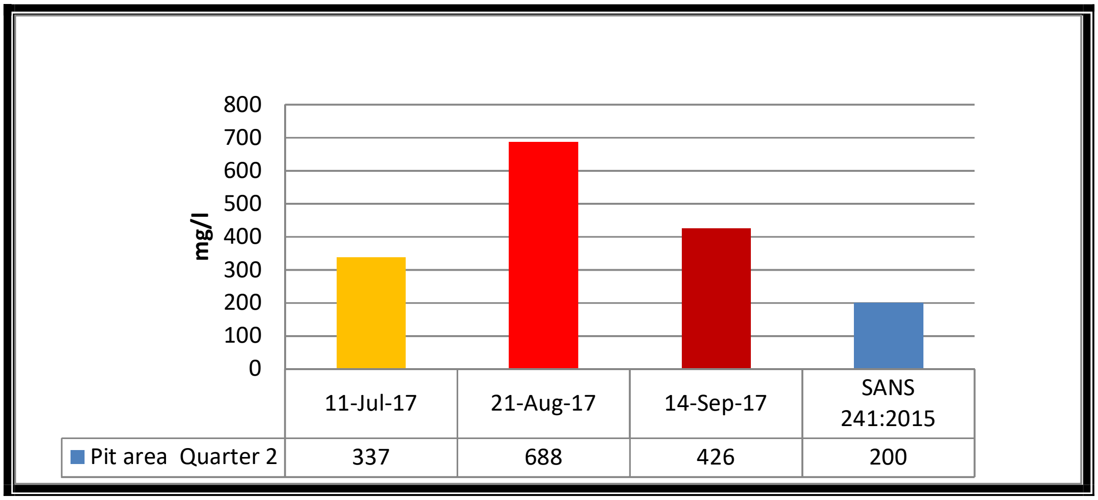


Figure 4—32: Sodium Non-Compliant

QUARTERLY WATER QUALITY MONITORING REPORT
OCTOBER – DECEMBER 2017

JANUARY 2018
TSHEDZA MINING RESOURCE (Pty) Ltd
MANUNGU COLLIERY

PHILO ENVIRONMENTAL MANAGEMENT

4.1.2 Monthly Surface Water Quality Results Interpretation – (Compared to SANS 241:2015)

The monthly surface water quality results are compared to the SANS 241-2015 standards and the water quality baseline, to determine the current status of water quality at the Manungu Colliery. It must be noted that the baseline water quality report was conducted before the commencement of mining activities on site and therefore the increase of certain variables is permissible, and the quality still falls within the SANS 241-2015 standards.

4.1.2.1 MWQ 1

MWQ 1 is located on the western side of the Opencast Pit in the tributary of Stream 1. This point indicates the impacts of activities located upstream of Manungu Colliery. The findings at monitoring point MWQ 1 are as follows:

- Very minimal content of Electrical Conductivity (EC) was determined at the monitoring point during the two sampling months.
- Sulphate levels are linked to coal mining and related activities. The variable was detected below the SANS 241-2015 limit of 500 mg/l.
- Turbidity was in high concentration for the months of November (13.1 NTU) and December (5.81 NTU) when compared to the SANS 241:2015 limit of 1 NTU.
- Manganese exceeded the acceptable SANS 241:2015 limit of 0.4 mg/l with a value of 0.61 mg/l in November. This metal may result from surface mining and related activities.
- Ammonia exceeded the SANS 241:2015 limit of 1.5 mg/l with a value of 1.95 mg/l in November.
- Refer to **Table 4-1** below as well as **Figures 4-1 to 4-3** for non-compliance with the SANS 241:2015 limits.

Table 4-1: MWQ 1 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	SANS 241:2015	Oct-17	Nov-17	Dec-17
EC mS/m	35.933	<170	No Water	17.4	56.1
TDS mg/L	202	<1200		299	306
pH	7.903	5-9.7		6.96	7.17
Turbidity NTU	0	<1		13.1	5.81
Ammonia as NH_4 -N mg/L	0.12	<1.5		1.95	<0.45
Nitrate as NO_3 -N mg/L	0.583	<11		0.46	0.43
Sulphate as SO_4 mg/L	23.166	500		65.1	71.2
Chloride as Cl mg/L	15.1	<300		27.8	31.0
Fluoride as F mg/L	0.300	<1.5		0.3	0.31
Magnesium as Mg mg/L	15.566	70		21.6	18.8
Calcium as Ca mg/L	21.466	150		38	18.6
Potassium as K mg/L	6.463	50		16.9	8.04
Sodium as Na mg/L	29.366	<200		25.9	60.7
Iron as Fe mg/L	-0.003	2		0.32	0.21
Manganese as Mn mg/L	-0.001	0.4		0.61	0.01
Aluminium as Al mg/L	-0.003	0.3		0.06	0.08
Phosphate (PO_4) mg/L	0.044	0.1		0.09	0.18
Suspended Solids mg/L	86.666			18.4	3.20
Silicon as Si mg/l				3.81	13.4
Total Alkalinity	143.666			162	158
(orange)	Non-compliant with baseline study				
(red)	Non-compliant SANS 241:2015				

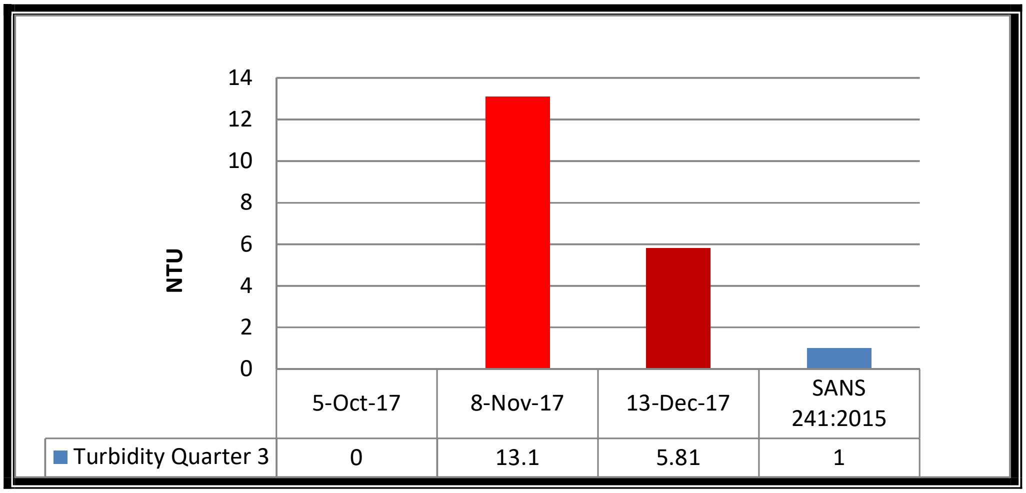


Figure 4-1: Turbidity Non-Compliant

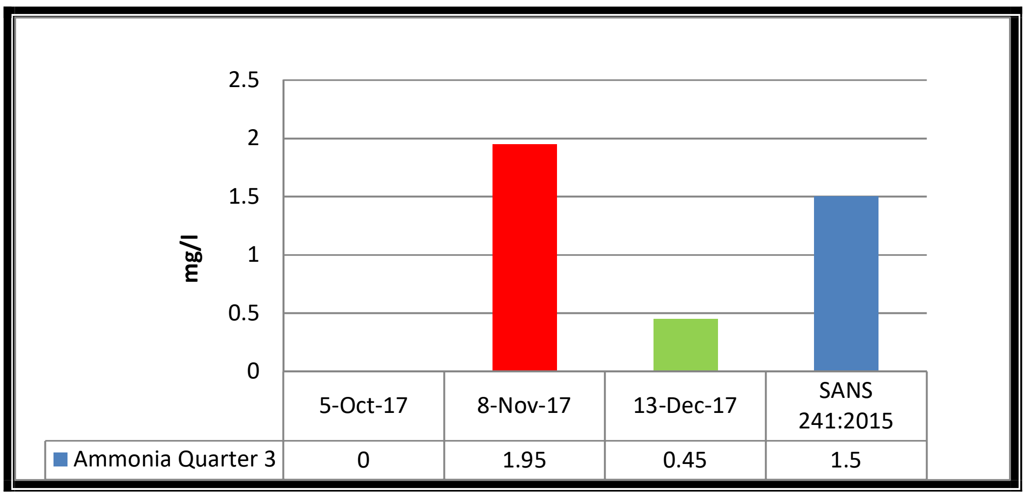


Figure 4-2: Ammonia Non-Compliant

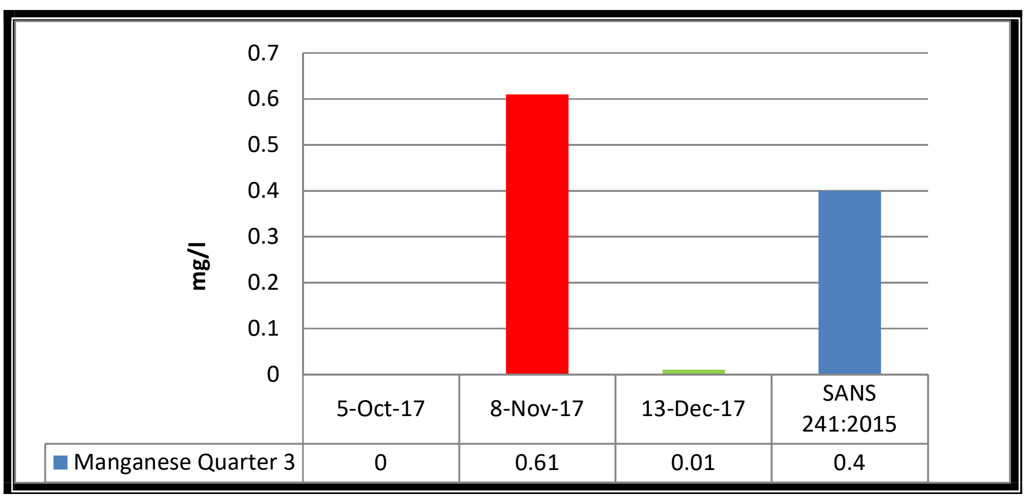


Figure 4-3: Manganese Non-Compliant

4.1.2.2 MWQ 3

MWQ 3 is located in stream 2 on the eastern side of the Manungu surface infrastructure. This point indicates the impact of activities located upstream of Manungu Colliery. The findings at monitoring point MWQ 3 are as follows:

- Most variables were within the expected SANS 241:2015 limits, except Turbidity which had an average of 160.27 NTU for the three months. However, when comparing current data to the baseline water quality, a slight deterioration is observed for some variables.
- Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in the air. The measurement of turbidity is a key test of water quality. Turbidity is common due to natural geology.
- Refer to **Table 4-2** below for all analyzed variables as compared to the baseline water quality results and SANS 241:2015 limits, also see **Figure 4-4** for non-compliance with the SANS 241:2015 limits.

Table 4-2: MWQ 3 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	SANS 241:2015	Oct-17	Nov-17	Dec-17
EC mS/m	42.65	<170	48.1	14.7	28.4
TDS mg/L	242.333	<1200	277	296	306
pH	8.056	5-9.7	7.78	7.74	7.21
Turbidity NTU	0	<1	306	169	5.81
Ammonia as NH_4 -N mg/L	0.142	<1.5	<0.45	<0.45	<0.45
Nitrate as NO_3 -N mg/L	1.121	<11	0.62	0.45	<0.35
Sulphate as SO_4 mg/L	45.116	500	59.8	70.4	42.1
Chloride as Cl mg/L	26	<300	25.9	30.1	13.3
Fluoride as F mg/L	0.540	<1.5	0.87	1.13	0.43
Magnesium as Mg mg/L	16.166	70	17.3	18.7	9.16
Calcium as Ca mg/L	20.583	150	24.8	26.5	12.1
Potassium as K mg/L	11.08	50	14	11.2	9.63
Sodium as Na mg/L	39.2	<200	47	47.5	21.3
Iron as Fe mg/L	-0.003	2	0.04	<0.01	0.11
Manganese as Mn mg/L	0.022	0.4	<0.01	<0.01	0.05
Aluminium as Al mg/L	0.006	0.3	0.06	<0.01	0.15
Phosphate (PO_4) mg/L	0.021	0.1	0.04	0.04	<0.03
Suspended Solids mg/L	231		220	150	172
Silicon as Si mg/l			2.73	1.61	9.23
Total Alkalinity	128.766		141	148	70.4

(orange)	Non-compliant with baseline study
(red)	Non-compliant SANS 241:2015

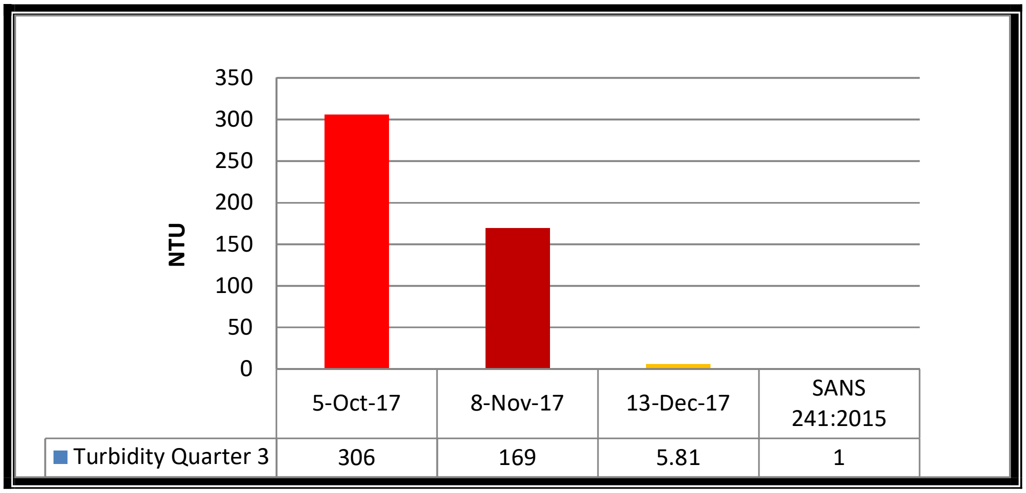


Figure 4-4: Turbidity Non-Compliant

4.1.2.3 MWQ 4

MWQ 4 is located in stream 1, downstream of MWQ 3 and south east of the PCD. The findings at monitoring point MWQ 4 are as follows:

- No water, sampling point was dry.

4.1.2.4 MWQ 5

MWQ 5 is located in stream 1. Due to the drainage area (Tributary of stream 1) between MWQ 5 and MWQ 1, there is no probability that the activities at Manungu will have an impact on MWQ 5. However, it is necessary to monitor this stream in order to identify the source of impact at MWQ 6. The findings at monitoring point MWQ 5 are as follows:

- According to the standards set by SANS 241-2015, some variables were found to have exceeded the limits, these variables include Turbidity and Ammonia.
- Turbidity had an average of 65.6 NTU for these 3 months and Ammonia exceeded the limit in November with a value of 2.7 mg/l.
- As indicated earlier in the report there are other mining activities in the vicinity of the mine not associated with Manungu Colliery. Some of the changes in the variables may not be impacts associated with the operation at Manungu Colliery.
- Some variables showed an increase when compared to the baseline water quality results.
- Refer to **Table 4-3** below for all analyzed variables as compared to the baseline water quality results and SANS 241:2015, also see **Figures 4-5 to 4-6** for non-compliance with SANS 241:2015.

Table 4-3: MWQ 5 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	SANS 241:2015	Oct-17	Nov-17	Dec-17
EC mS/m	73.025	<170	63.9	20.9	57.5
TDS mg/L	431	<1200	327	276	310
pH	9.225	5-9.7	7.69	7.5	7.13
Turbidity NTU	0	<1	74.8	109	13.0
Ammonia as NH_4 -N mg/L	0.119	<1.5	2.7	1.42	<0.45
Nitrate as NO_3 -N mg/L	0.262	<11	0.4	0.45	<0.35
Sulphate as SO_4 mg/L	17.417	500	6.29	18.6	61.8
Chloride as Cl mg/L	60.025	<300	75.3	53.8	42.6
Fluoride as F mg/L	0.421	<1.5	0.45	0.46	0.31
Magnesium as Mg mg/L	44.6	70	29.3	24.4	21.0
Calcium as Ca mg/L	31.7	150	27.3	27.6	21.3
Potassium as K mg/L	10.55	50	12.5	13.2	13.2
Sodium as Na mg/L	78.125	<200	47.1	32.6	51.9
Iron as Fe mg/L	0.003	2	<0.01	0.02	0.37
Manganese as Mn mg/L	0.125	0.4	<0.01	0.08	0.26
Aluminium as Al mg/L	0.003	0.3	0.03	<0.01	0.16
Phosphate (PO_4) mg/L	0.185	0.1	0.04	0.08	0.29
Suspended Solids mg/L	24.75		30.4	224	10.0
Silicon as Si mg/l			1.59	2.63	13.4
Total Alkalinity	306.5		206	168	160
(orange)	Non-compliant with baseline study				
(red)	Non-compliant SANS 241:2015				

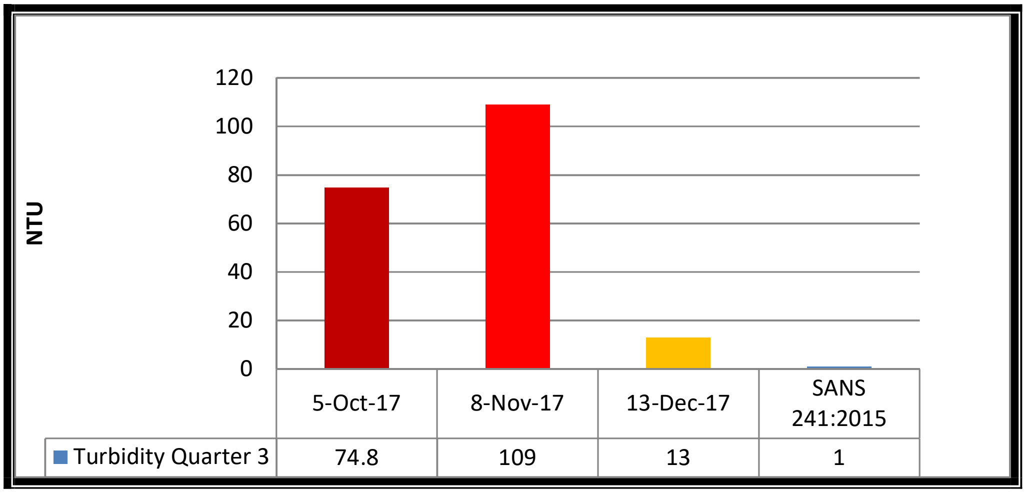


Figure 4-5: Turbidity Non-Compliant

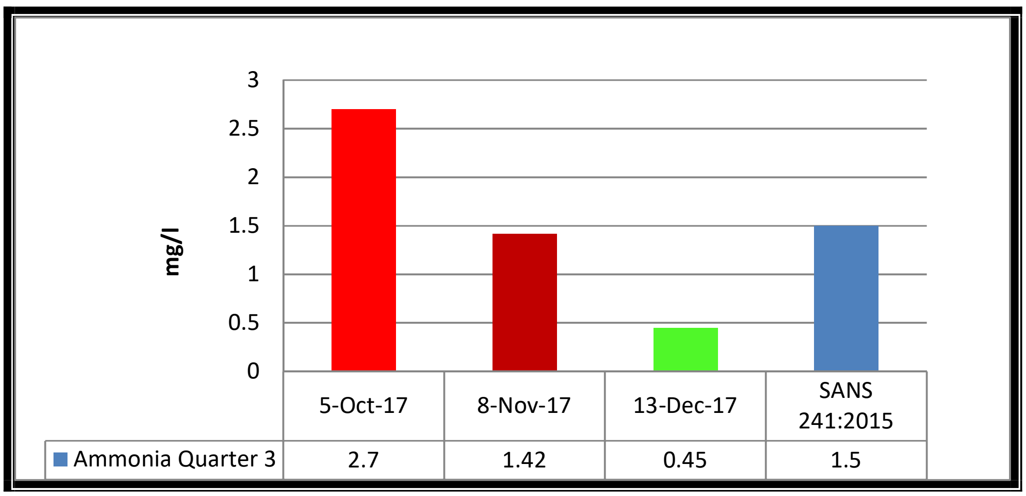


Figure 4-6: Ammonia Non-Compliant

4.1.2.5 MWQ 6

MWQ 6 is located downstream of MWQ 1 and MWQ 3 in stream 1. The findings at monitoring point MWQ 6 are as follows:

- This point was dry in October 2017.
- All variables were within the expected SANS 241:2015 limits, except Turbidity and manganese.
- Turbidity had an average of 157.9 NTU for the two months that this point had water and Manganese exceeded the limit in November with a value of 0.61 mg/l.
- Refer to **Table 4-4** below for all analyzed variables as compared to the baseline water quality results and SANS 241:2015, also see **Figures 4-7 to 4-8** for non-compliance with SANS 241:2015.

Table 4-4: MWQ 6 Monthly Water Quality Results

Analysis Results	Manungu Baseline water results	SANS 241:2015	Oct-17	Nov-17	Dec-17
EC mS/m	57.5	<170	No Water	39.5	32.0
TDS mg/L	290	<1200		207	160
pH	8.32	5-9.7		7.62	7.27
Turbidity NTU		<1		302	13.8
Ammonia as NH_4 -N mg/L	0.069	<1.5		1.46	<0.45
Nitrate as NO_3 -N mg/L	0.397	<11		0.37	<0.35
Sulphate as SO_4 mg/L	1.63	500		28.3	9.81
Chloride as Cl mg/L	20.5	<300		11.3	12.2
Fluoride as F mg/L	0.32	<1.5		0.92	0.32
Magnesium as Mg mg/L	26.8	70		15.4	13.7
Calcium as Ca mg/L	29	150		29.8	14.2
Potassium as K mg/L	8.37	50		11.6	9.10
Sodium as Na mg/L	43.9	<200		18.5	22.6
Iron as Fe mg/L	0.003	2		0.05	0.15
Manganese as Mn mg/L	-0.001	0.4		0.61	<0.01
Aluminium as Al mg/L	0.003	0.3		0.05	0.11
Phosphate (PO_4) mg/L	0.011	0.1		0.12	0.09
Suspended Solids mg/L	27			517	17.2
Silicon as Si mg/l				4.96	13.5
Total Alkalinity	259			145	130

(orange)	Non-compliant with baseline study
(red)	Non-compliant SANS 241:2015

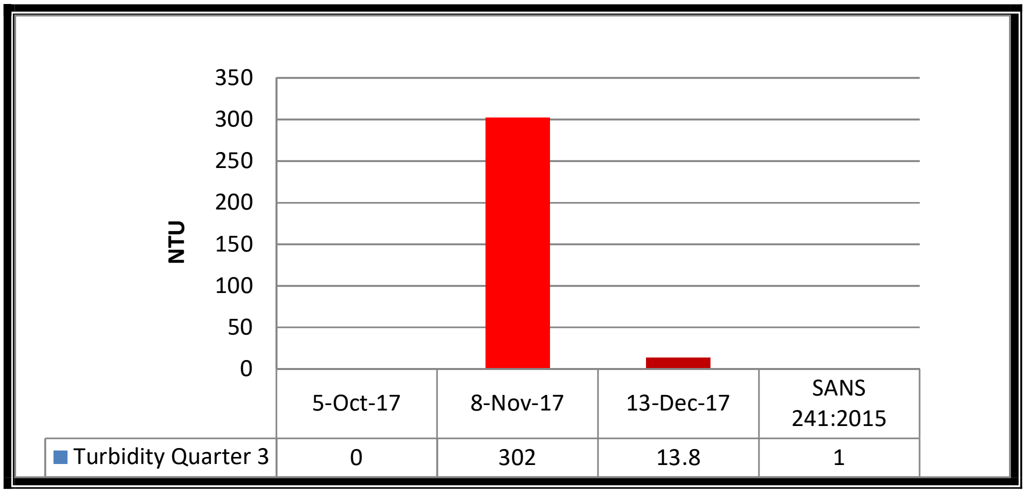


Figure 4-7: Turbidity Non-Compliant

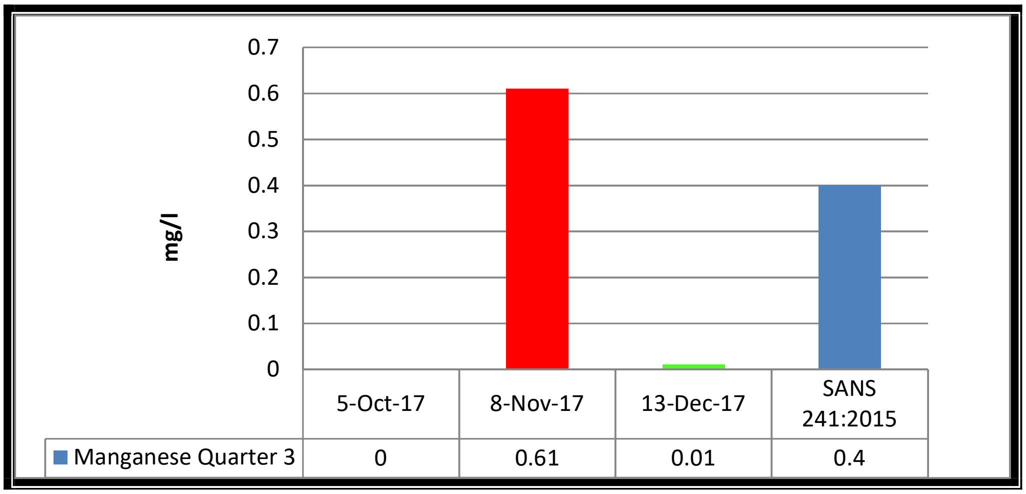


Figure 4-8: Manganese Non-Compliant

4.1.2.6 Pollution Control Dam (PCD)

The purpose of the Pollution Control dam is to collect contaminated runoff from the dirty water catchment areas. A lined PCD exists at the south-eastern boundary of the mining area. The following findings were made at the PCD:

- The Pollution Control Dam is regarded as a dirty water catchment area, to collect dirty run-offs around the mine and poor water quality is expected at this point.
- There was no baseline study conducted before the infrastructure was constructed and therefore water quality for the PCD was only compared to the SANS 241-2015 limits.
- Some of the variables are within the expected SANS limits. Variables exceeding the SANS limits are Electrical Conductivity with an average of 210.67 mS/m, Total Dissolved Solids with an average of 1390.59 mg/l, Fluoride with an average of 1.99 mg/l, Turbidity with an average of 126.33 mg/l, Nitrates with an average of 53.08 mg/l, Aluminium with an average of 1.70 mg/l, Sulphate with an average of 665.54 mg/l and Sodium with an average of 405.62 mg/l.
- Refer to **Table 4-5** below for all analyzed variables as compared to SANS 241:2015, also see **Figures 4-9 to 4-16** for non-compliance with SANS 241:2015.

Table 4-5: PCD Monthly Water Quality Results

Analysis Results	SANS 241:2015	Oct-17	Nov-17	Dec-17
EC mS/m	<170	233	224	175
TDS mg/L	<1200	1535	1536	1101
pH	5-9.7	8.58	8.88	8.33
Turbidity NTU	<1	119	105	155
Ammonia as NH_4 -N mg/L	<1.5	<0.45	<0.45	<0.45
Nitrate as NO_3 -N mg/L	<11	60.2	60.4	38.7
Sulphate as SO_4 mg/L	500	529	559	409
Chloride as Cl mg/L	<300	22.8	21.3	12.2
Fluoride as F mg/L	<1.5	2.15	2.22	1.61
Magnesium as Mg mg/L	70	20.1	12	11.6
Calcium as Ca mg/L	150	23.3	13.8	22.2
Potassium as K mg/L	50	6.9	6.87	4.77
Sodium as Na mg/L	<200	452	450	315
Iron as Fe mg/L	2	0.05	1.57	0.02
Manganese as Mn mg/L	0.4	<0.01	0.02	<0.01
Aluminium as Al mg/L	0.3	0.11	4.98	<0.01
Phosphate (PO_4) mg/L	0.1	0.04	<0.03	<0.03
Suspended Solids mg/L		148	48	169
Silicon as Si mg/l		12.7	12.7	5.19
Total Alkalinity		353	329	256
(orange)	Non-compliant with baseline study			
(red)	Non-compliant SANS 241:2015			

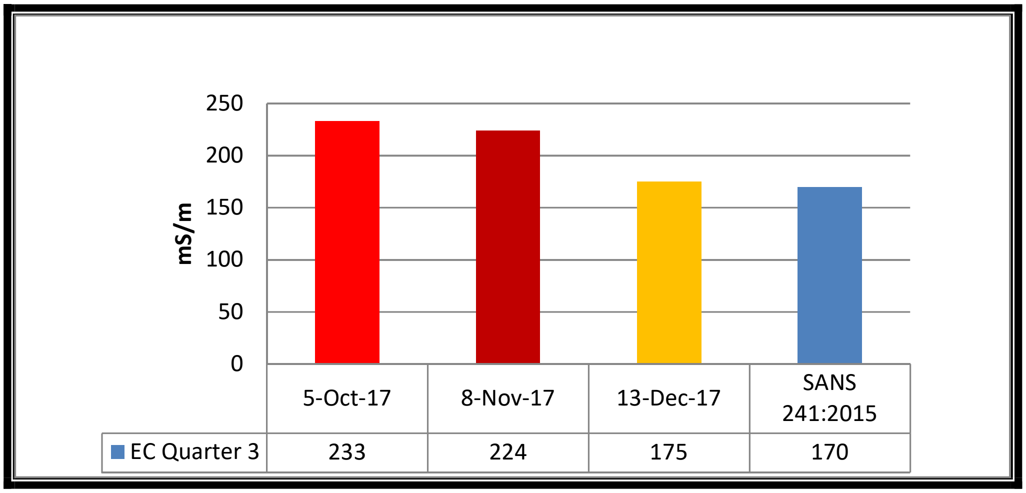


Figure 4-9: Electrical Conductivity Non-Compliant

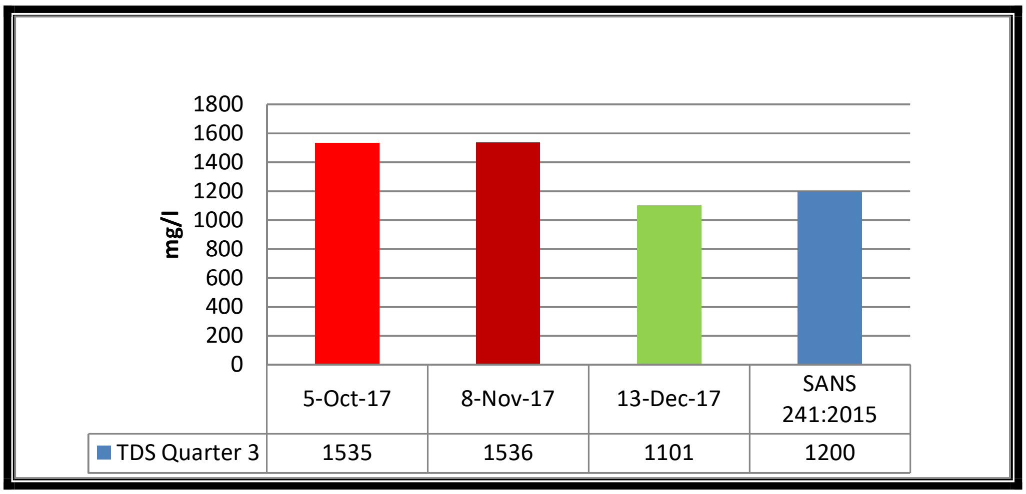


Figure 4-10: Total Dissolved Solids Non-Compliant

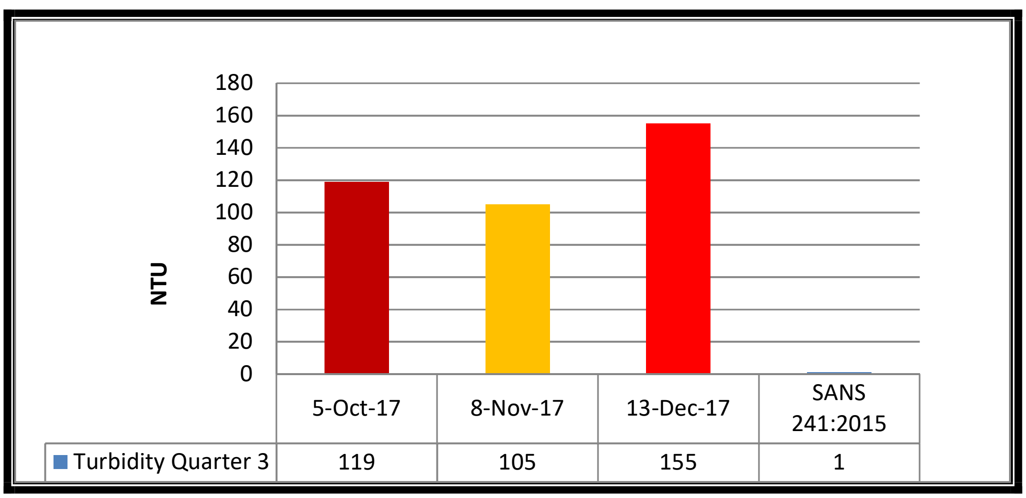


Figure 4-11: Turbidity Non-Compliant

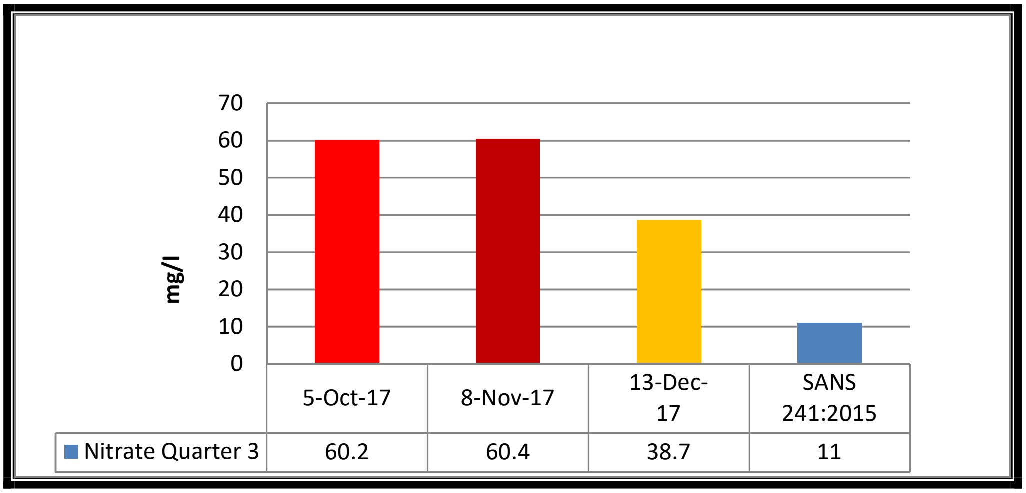


Figure 4-12: Nitrate Non-Compliant

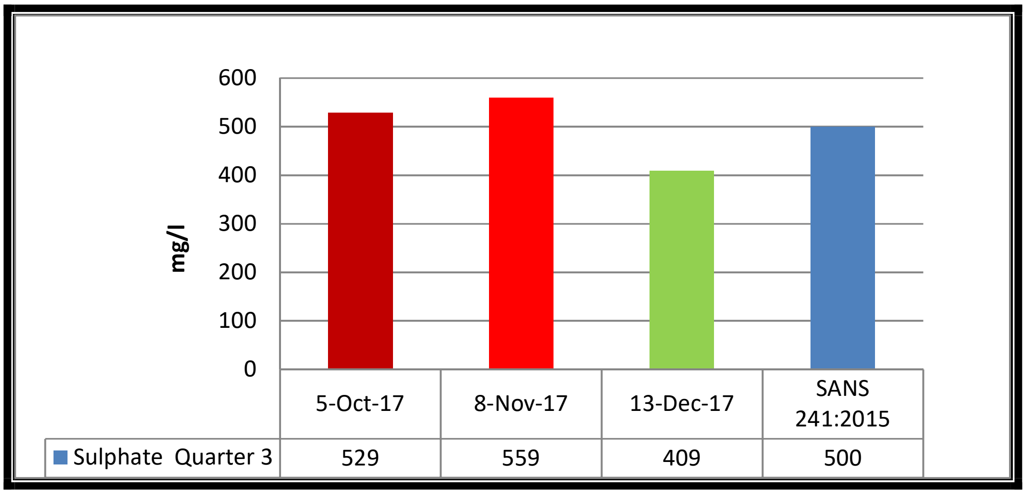


Figure 4-13: Sulphate Non-compliant

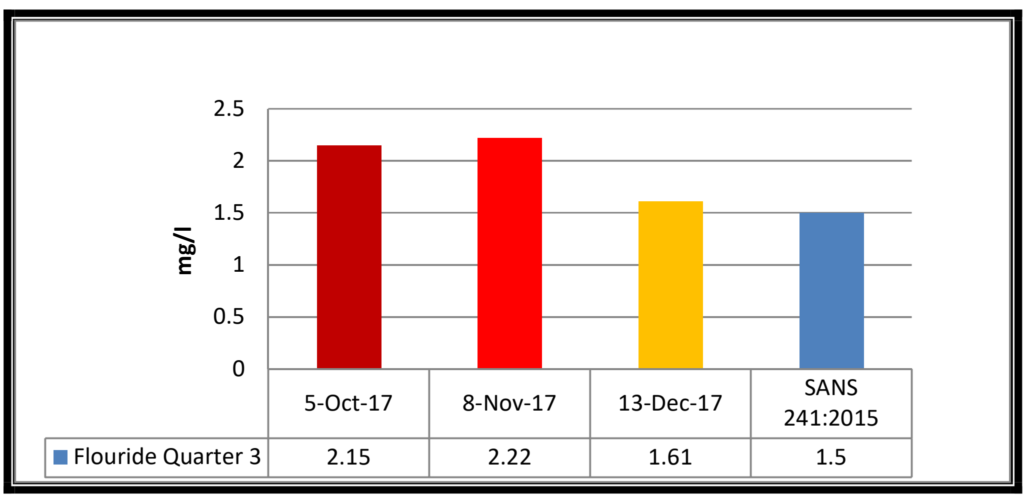


Figure 4-14: Fluoride Non-Compliant

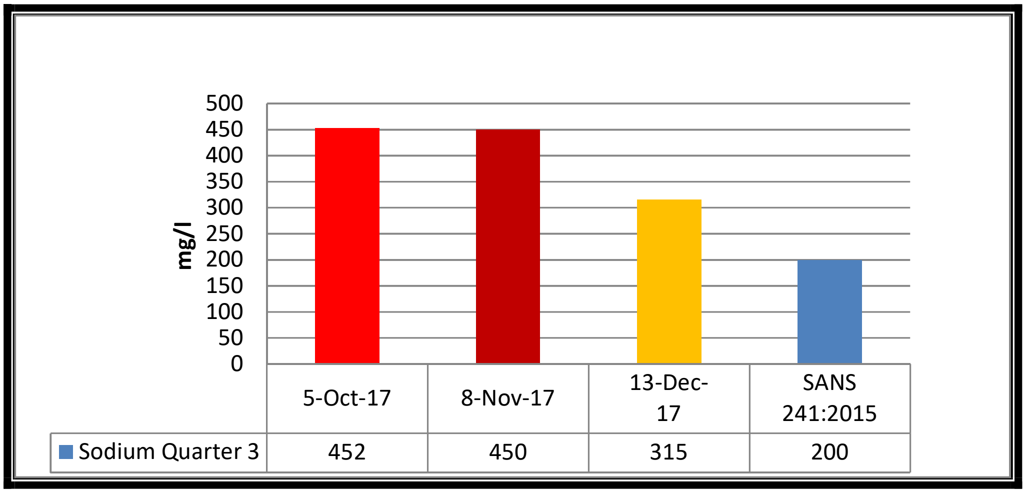


Figure 4-15: Sodium Non-Compliant

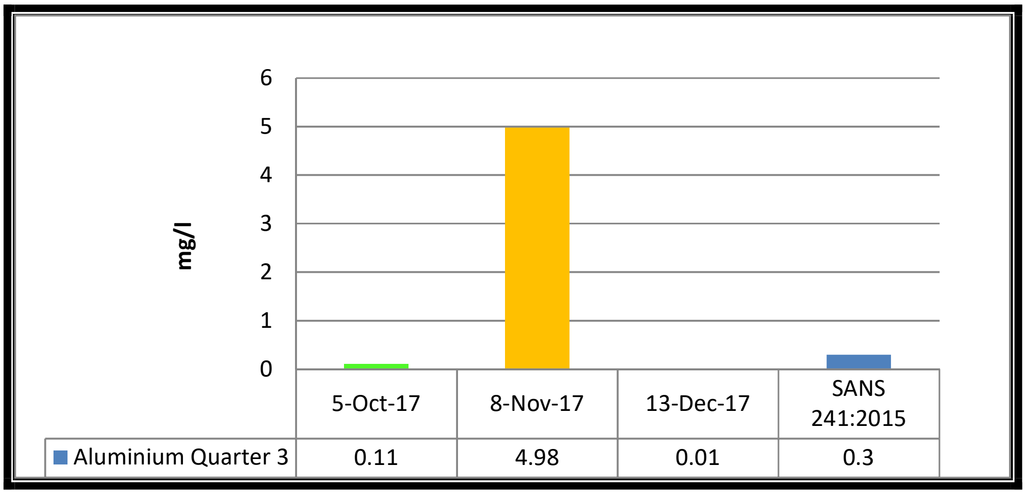


Figure 4-16: Aluminium Non-Compliant

4.1.2.7 PCD Drainage

This point is the sump located at the lowest point of the Pollution Control Dam (PCD). The following findings were made:

- The PCD Drainage has better water quality compared to the PCD.
- All samples collected fall within the SANS 241:2015 limits except for Turbidity with an average of 8.72 NTU and Manganese with an average of 7.25 mg/l for this quarter.
- Total Dissolved Solids falls within the set limit of SANS 241:2015.
- The concentrations of Suspended Solids are very low at the PCD Drainage monitoring point.
- Refer to **Table 4-6** below for all analyzed variables as compared to SANS 241:2015, also see **Figure 4-17 to 4-18** for non-compliance with SANS 241:2015.

Table 4-6: PCD Drainage Monthly Water Quality Results

Analysis Results	SANS 241:2015	Oct-17	Nov-17	Dec-17
EC mS/m	<170	80.3	76	75.3
TDS mg/L	<1200	459	424	416
pH	5-9.7	7.93	8.1	7.52
Turbidity NTU	<1	15.9	5.55	4.71
Ammonia as NH_4 -N mg/L	<1.5	<0.45	<0.45	<0.45
Nitrate as NO_3 -N mg/L	<11	3.16	3.62	3.15
Sulphate as SO_4 mg/L	500	56.3	51.1	55.2
Chloride as Cl mg/L	<300	44.1	36.8	32.8
Fluoride as F mg/L	<1.5	0.66	0.63	0.78
Magnesium as Mg mg/L	70	21.7	19.6	20.0
Calcium as Ca mg/L	150	37.8	30.7	30.3
Potassium as K mg/L	50	3.24	2.46	2.89
Sodium as Na mg/L	<200	107	99.2	94.4
Iron as Fe mg/L	2	<0.01	0.08	0.08
Manganese as Mn mg/L	0.4	21.7	0.02	0.02
Aluminium as Al mg/L	0.3	<0.01	0.18	0.15
Phosphate (PO_4) mg/L	0.1	0.08	0.05	<0.03
Suspended Solids mg/L		20.6	4.4	1.20
Silicon as Si mg/l		<0.1	12.8	14.1
Total Alkalinity		291	279	275

	Non-compliant with baseline study
	Non-compliant SANS 241:2015

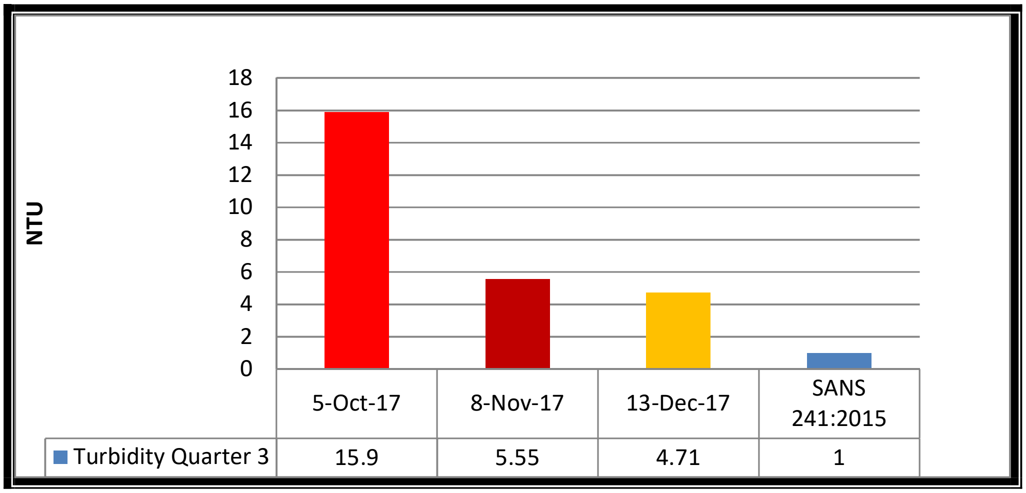


Figure 4-17: Turbidity Non-Compliant

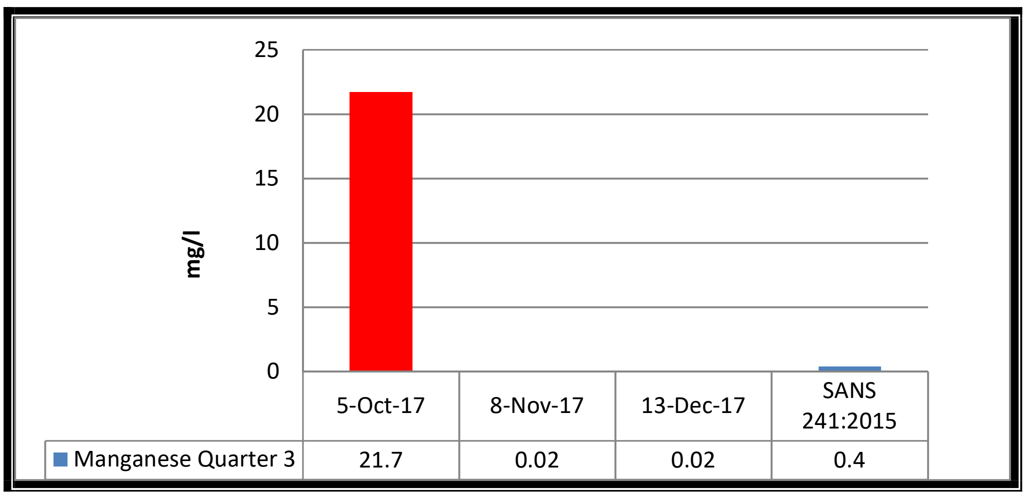


Figure 4-18: Manganese Non-Compliant

4.1.2.8 Pit Area

A sample is collected at the active Pit which is managed as a dirty water facility. The following findings were made:

- Samples could not be taken during the month of October 2017.
- The source of water at the Pit Area is normally groundwater ingress and rainfall. The sampling point is exposed to the ongoing mining activities at Manungu Colliery and thus elevated concentrations will be recorded.
- High concentrations were recorded for Electrical Conductivity, Total Dissolved Solids, Turbidity, Ammonia, Nitrates, Fluoride, and Sodium.
- This could possibly be as a result from the explosives used by the mine for blasting as the explosives contain ammonium nitrate. Thus, there is an increase in Nitrates at the Pit area.
- Refer to **Table 4-**7 below for all analyzed variables as compared to SANS 241:2015, also see **Figures 4-19 to 4-26** for non-compliance with SANS 241:2015.

Table 4-7: Pit Area Water Quality Results

Analysis Results	SANS 241:2015	Oct-17	Nov-17	Dec-17
EC mS/m	<170	No Access	221	179
TDS mg/L	<1200		1449	1155
pH	5-9.7		8.28	8.15
Turbidity NTU	<1		153	1000
Ammonia as NH_4 -N mg/L	<1.5		1.92	2.47
Nitrate as NO_3 -N mg/L	<11		32.6	90.2
Sulphate as SO_4 mg/L	500		517	341
Chloride as Cl mg/L	<300		21	8.82
Fluoride as F mg/L	<1.5		1.85	2.11
Magnesium as Mg mg/L	70		3.37	4.70
Calcium as Ca mg/L	150		4.51	16.5
Potassium as K mg/L	50		4.26	4.62
Sodium as Na mg/L	<200		480	348
Iron as Fe mg/L	2		0.02	0.05
Manganese as Mn mg/L	0.4		<0.01	<0.01
Aluminium as Al mg/L	0.3		0.06	0.07
Phosphate (PO_4) mg/L	0.1		0.03	<0.03
Suspended Solids mg/L			695	7920
Silicon as Si mg/l			4.56	4.38
Total Alkalinity			451	61.4
	Non-compliant with baseline study			
	Non-compliant SANS 241:2015			

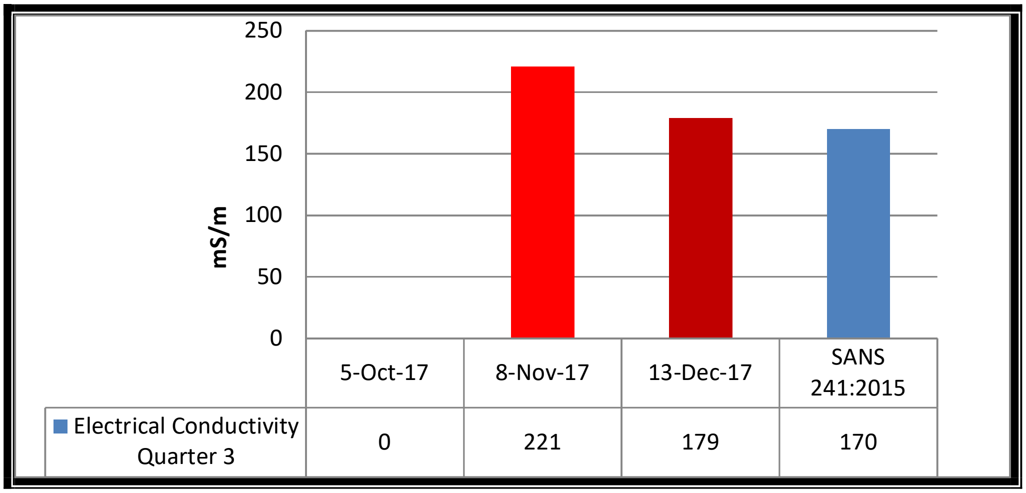


Figure 4-19: Electrical Conductivity Non-Compliant

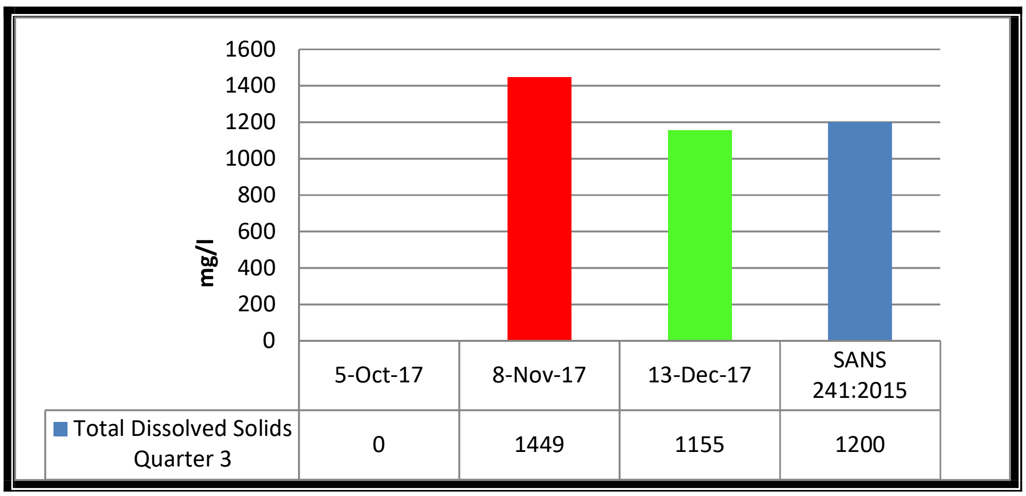


Figure 4-20: Total Dissolved Solids Non-Compliant

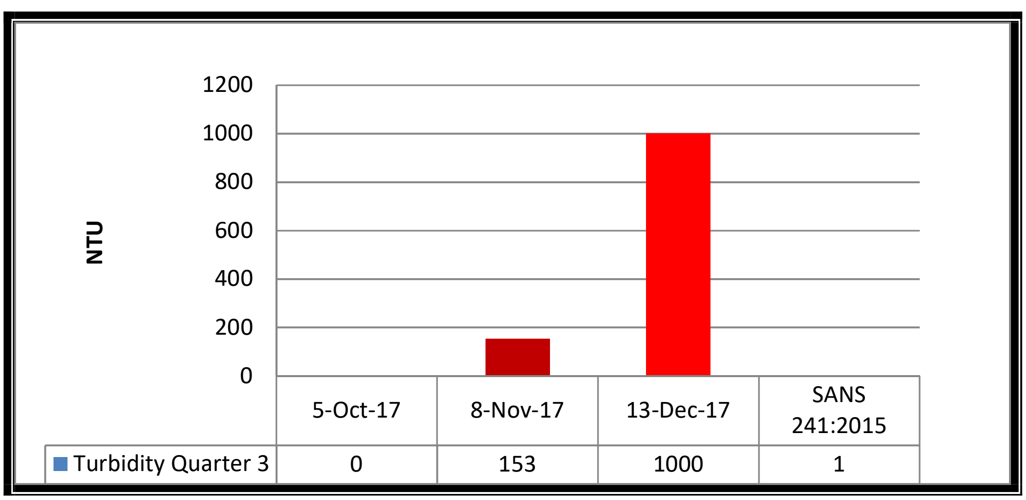


Figure 4-21: Turbidity Non-Compliant

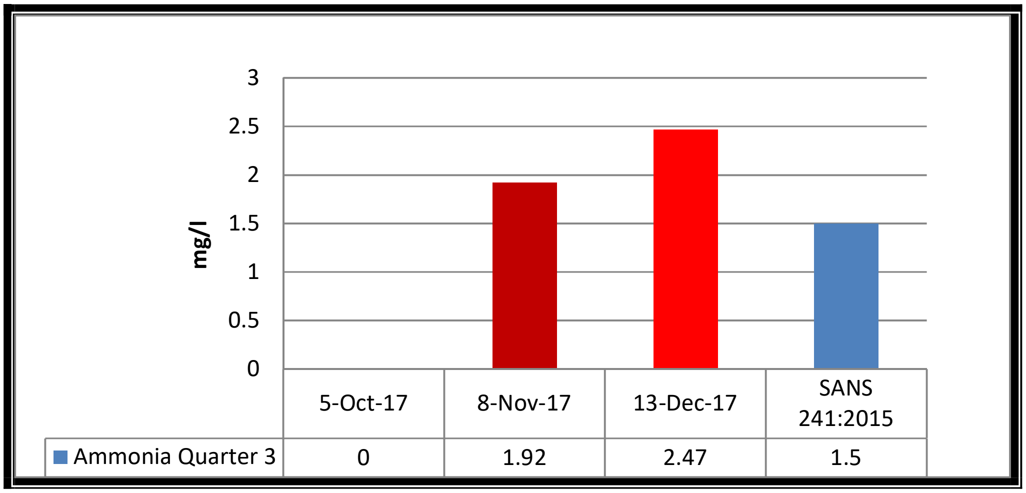


Figure 4-22: Ammonia Non-Compliant

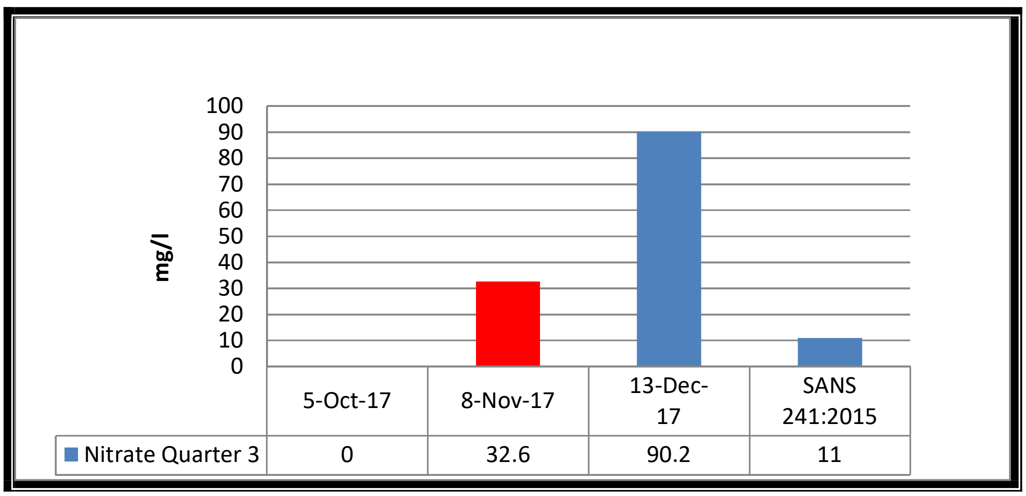


Figure 4-23: Nitrate Non-Compliant

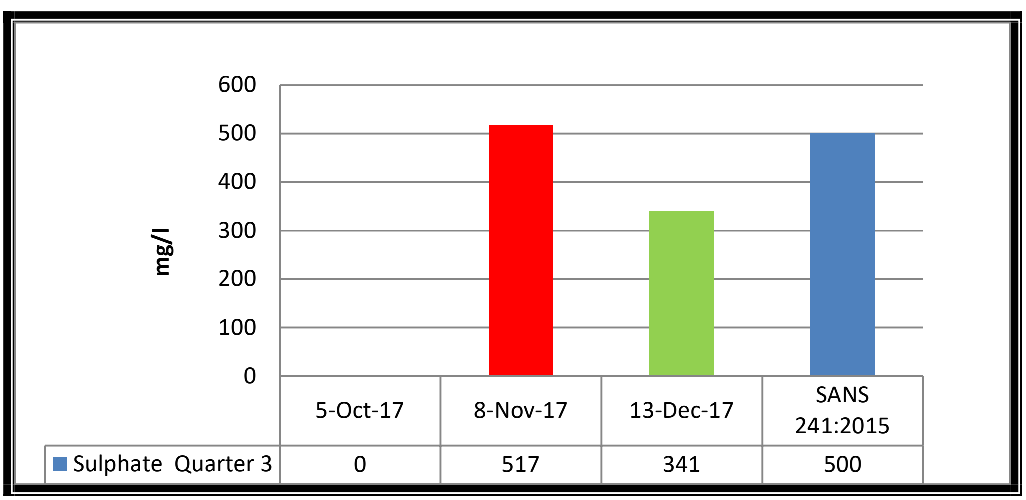
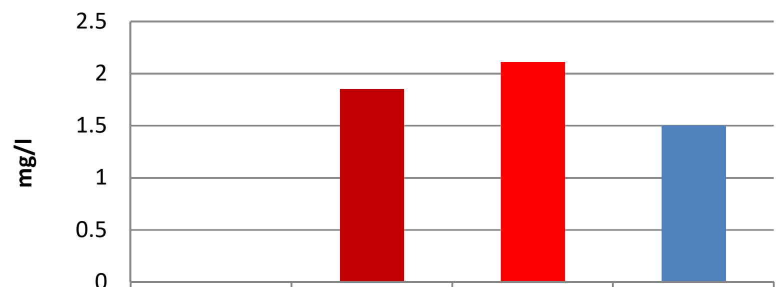
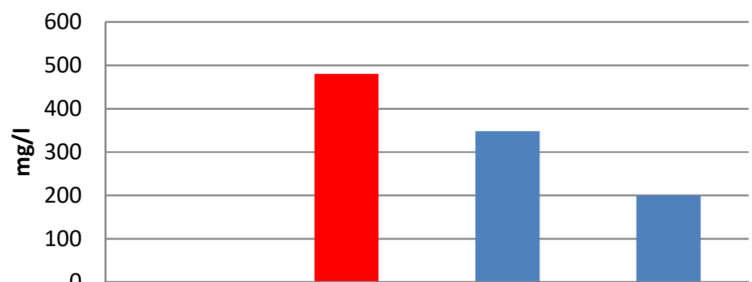


Figure 4-24: Sulphate Non-Compliant



	5-Oct-17	8-Nov-17	13-Dec-17	SANS 241:2015
Fluoride Quarter 3	0	1.85	2.11	1.5

Figure 4-25: Fluoride Non-Compliant



	5-Oct-17	8-Nov-17	13-Dec-17	SANS 241:2015
Sodium Quarter 1	0	480	348	200

Figure 4-26: Sodium Non-Compliant