96	Power lines/Pylons	2842	125.5	N/A
97	Informal Housing	3543	123.6	Complaint
98	Sheds	3237	124.4	Complaint
99	Shed	3508	123.7	Complaint
100	Informal Housing	3114	124.7	Complaint
101	Housing	2854	125.5	Complaint
102	Informal Housing	3339	124.1	Complaint
103	Farm House	530	140.8	Problematic
104	Cement Dam	606	139.6	N/A
105	Informal Housing	2818	125.6	Complaint
106	R33 Road	3428	123.9	N/A
107	Dam	3462	123.8	N/A
108	Shed	3044	124.9	Complaint
109	R33 Road	2416	126.9	N/A
110	Farm House	4144	122.3	Complaint
111	Farmstead	4156	122.3	Complaint
112	Farmstead	4024	122.6	Complaint
113	Orchards	319	145.8	Problematic
114	Hot Houses	4898	120.9	Complaint
115	Farmstead	4671	121.3	Complaint
116	Informal Housing	3266	124.3	Complaint
117	Informal Housing	3634	123.4	Complaint
118	Dam	3396	124.0	N/A
119	Farmstead	4804	121.1	Complaint
120	Informal Housing	5275	120.3	Complaint
121	Dam	2302	127.4	N/A
122	Farmstead	3088	124.8	Complaint
123	Farm House	2283	127.4	Complaint
124	Sheds	2214	127.7	Complaint
125	Sewer Works	2676	126.0	Complaint
126	Mine Activity	2209	127.7	Complaint
127	Graveyard	2804	125.6	Complaint
128	Graveyard	3457	123.9	Complaint
129	Dam	2729	125.9	N/A
130	Dam	1924	128.9	N/A
131	Structure	693	138.3	Problematic
132	Graveyard	3218	124.5	Complaint

7.9.1 Portion 30 Maximum Charge per Delay– 2035kg

Presented are simulations for expected air blast levels from the maximum charge mass for Portion 30. Maximum charge evaluations are shown in the figure below and summary table of outcome given after the charge configuration air blast contour.

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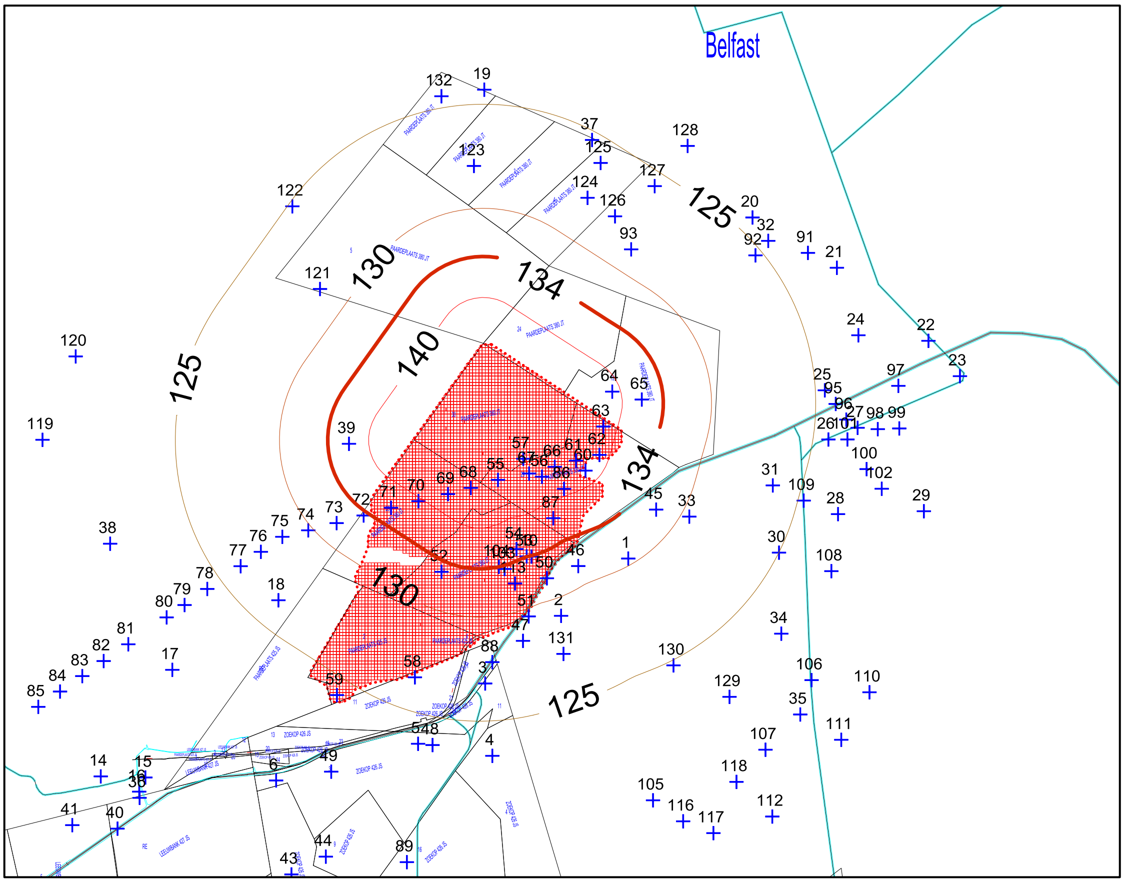

Figure 26: Air blast influence from maximum charge for Portion 30

Table 20: Air blast evaluation for minimum charge for Portion 30

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Shed	1624	130.4	Complaint
2	Informal Housing	1934	128.9	Complaint
3	Farm House	2546	126.5	Complaint
4	Farmstead	3464	123.8	Complaint
5	Railway Substation	3398	124.0	Complaint
6	Buildings/Structures	4563	121.5	Complaint
7	Farmstead	7237	117.7	Acceptable
8	Grain Storage	7036	118.0	Acceptable
9	Dams	6387	118.7	Acceptable
10	Telecom Tower	1109	133.9	N/A
11	Farm House/Hot Houses	8995	116.0	Acceptable
12	Farmstead	7469	117.5	Acceptable
13	Farmstead	6861	118.2	Acceptable
14	Farmstead	5812	119.5	Acceptable
15	Shed	5454	120.0	Complaint
16	Informal Housing	5643	119.8	Acceptable
17	Dam	4219	122.2	N/A
18	Dam	2656	126.1	N/A
19	Siyathuthuka Village Houses	3206	124.5	Complaint
20	Houses	3234	124.4	Complaint
21	Houses	3708	123.3	Complaint
22	Cattle Sales Yard	4515	121.6	Complaint
23	Filling Station	4855	121.0	Complaint
24	Farmstead	3663	123.4	Complaint
25	Sub Station	3141	124.7	Complaint
26	Farmstead	3215	124.5	Complaint
27	Sheds	3565	123.6	Complaint
28	Farmstead	3557	123.6	Complaint
29	Shed	4592	121.5	Complaint

30	Farmstead	3024	125.0	Complaint
31	Farmstead	2667	126.1	Complaint
32	Road	3175	124.6	N/A
33	Farmstead	1809	129.5	Complaint
34	Informal Housing	3617	123.5	Complaint
35	Farmstead	4507	121.6	Complaint
36	School	5702	119.7	Acceptable
37	Dam	2914	125.3	N/A
38	Farmstead	4062	122.5	Complaint
39	Farmstead	830	136.6	Problematic
40	Informal Housing	6181	119.0	Acceptable
41	Farm House	6510	118.6	Acceptable
42	Building/Structure	6552	118.5	Acceptable
43	Farm House	5500	120.0	Acceptable
44	Informal Housing	5118	120.6	Complaint
45	N4 Road	1406	131.7	N/A
46	N4 Road	1464	131.4	N/A
47	N4 Road	2079	128.2	N/A
48	N4 Road	3377	124.1	N/A
49	N4 Road	4113	122.4	N/A
50	Houses	1426	131.6	Complaint
51	Packing Sheds	1806	129.5	Complaint
52	Dam	1233	132.9	N/A
53	Cement Dams	1093	134.0	N/A
54	Farm House	962	135.2	Problematic
55	Dam	159	153.0	N/A
56	Informal Housing	246	148.5	Problematic
57	Farm House	52	165.1	Problematic
58	Farmstead	2600	126.3	Complaint
59	Dam	3240	124.4	N/A
60	Cement Dam	402	143.6	N/A
61	Power lines/Pylon	227	149.3	N/A
62	Power lines/Pylon	453	142.4	N/A
63	Dam	407	143.4	N/A
64	Dam	476	141.9	N/A
65	Farmstead	827	136.6	Problematic
66	Power lines/Pylon	188	151.2	N/A
67	Power lines/Pylon	149	153.7	N/A
68	Power lines/Pylon	123	155.7	N/A
69	Power lines/Pylon	345	145.1	N/A
70	Power lines/Pylon	622	139.3	N/A
71	Power lines/Pylon	880	136.0	N/A
72	Power lines/Pylon	1151	133.6	N/A
73	Power lines/Pylon	1439	131.5	N/A
74	Power lines/Pylon	1762	129.7	N/A
75	Power lines/Pylon	2070	128.3	N/A
76	Power lines/Pylon	2401	127.0	N/A
77	Power lines/Pylon	2714	125.9	N/A
78	Power lines/Pylon	3224	124.4	N/A
79	Power lines/Pylon	3576	123.6	N/A
80	Power lines/Pylon	3851	122.9	N/A
81	Power lines/Pylon	4442	121.7	N/A
82	Power lines/Pylon	4819	121.1	N/A
83	Power lines/Pylon	5149	120.5	N/A
84	Power lines/Pylon	5491	120.0	Acceptable
85	Power lines/Pylon	5827	119.5	Acceptable
86	Informal Housing	490	141.6	Problematic
87	Road	786	137.1	N/A
88	Informal Housing	2281	127.4	Complaint
89	Farm House	4891	120.9	Complaint
90	Farmstead	6042	119.2	Acceptable
91	Houses	3487	123.8	Complaint
92	Informal Housing	2934	125.3	Complaint
93	Labour Housing	2010	128.5	Complaint
94	Informal Housing	7543	117.4	Acceptable
95	Power lines/Pylons	3275	124.3	N/A
96	Power lines/Pylons	3414	124.0	N/A
97	Informal Housing	4072	122.5	Complaint
98	Sheds	3820	123.0	Complaint
99	Shed	4090	122.4	Complaint

100	Informal Housing	3758	123.1	Complaint
101	Housing	3453	123.9	Complaint
102	Informal Housing	4004	122.6	Complaint
103	Farm House	1142	133.6	Problematic
104	Cement Dam	1097	134.0	N/A
105	Informal Housing	4529	121.6	Complaint
106	R33 Road	4294	122.0	N/A
107	Dam	4593	121.5	N/A
108	Shed	3721	123.2	Complaint
109	R33 Road	3094	124.8	N/A
110	Farm House	4947	120.8	Complaint
111	Farmstead	5093	120.6	Complaint
112	Farmstead	5358	120.2	Complaint
113	Orchards	1356	132.1	Complaint
114	Hot Houses	6981	118.0	Acceptable
115	Farmstead	6718	118.3	Acceptable
116	Informal Housing	4930	120.9	Complaint
117	Informal Housing	5230	120.4	Complaint
118	Dam	4758	121.2	N/A
119	Farmstead	4699	121.3	Complaint
120	Informal Housing	4408	121.8	Complaint
121	Dam	2078	128.3	N/A
122	Farmstead	2969	125.1	Complaint
123	Farm House	2245	127.6	Complaint
124	Sheds	2259	127.5	Complaint
125	Sewer Works	2718	125.9	Complaint
126	Mine Activity	2250	127.6	Complaint
127	Graveyard	2843	125.5	Complaint
128	Graveyard	3495	123.8	Complaint
129	Dam	3785	123.1	N/A
130	Dam	3084	124.8	N/A
131	Structure	2402	127.0	Complaint
132	Graveyard	3167	124.6	Complaint

7.10 SUMMARY OF FINDINGS FOR AIR BLAST

The opencast operation was evaluated for expected levels of air blast from future blasting operations. Review of the site and the surrounding installations / houses / buildings showed that structures varied in distances from the opencast pit area.
Complaints from air blast are normally based on the actual effects that are experienced due to rattling of roof, windows, doors etc. These effects could startle people and raise concern of possible damage.

The possible negative effects from air blast are expected to be greater than that of ground vibration. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. This pit is located such that "free blasting" – meaning no controls on blast preparation – will not be possible.

Review of air blast levels with regards to possible concerns on minimum charge mass per delay it is found that the following 8 POI's are considered problematic. These POI's are located such that levels are greater than the allowed limit. These structures range in distance from the pit area to 484m. POI's are 58-Farmstead, 65-Farmstead, 50-Houses, 86-Informal

Housing, 88-Informal Housing, 2-Informal Housing, 56-Informal Housing and 51-Packing Sheds.

The medium charge review showed an increased number of structures / installations that could experience air blast levels greater than the allowed limit. These structures are 3-Farm House, 54-Farm House, 103-Farm House, 57-Farm House, 58-Farmstead, 65-Farmstead, 50-Houses, 86-Informal Housing, 88-Informal Housing, 2-Informal Housing, 56-Informal Housing, 51-Packing Sheds, 5-Railway Substation, 1-Shed and 131-Structure. A total of 15 houses / farm houses / farmsteads or structures. The furthest structure is found 732m from pit edge.

The maximum charge review showed total of 16 installations / structures that are problematic with regards to air blast. Levels are greater than allowed for these structures. These installations are found at 1-Shed, 2-Informal Housing, 3-Farm House, 5-Railway Substation, 33-Farmstead, 50-Houses, 51-Packing Sheds, 54-Farm House, 56-Informal Housing, 57-Farm House, 58-Farmstead, 65-Farmstead, 86-Informal Housing, 88-Informal Housing, 103-Farm House and 131-Structure. The structure furthest away from mining area is located at 1128m from pit boundary.

Portion 30 maximum charge mass per delay showed 7 structures that are of concern. Levels expected are greater than the allowed limits for these installations. The distance to the furthest structure is 1142m. These POI's are 57-Farm House, 54-Farm House, 103-Farm House, 65-Farmstead, 39-Farmstead, 56-Informal Housing and 86-Informal Housing.

In all of the evaluations done it must be remembered that this was done from pit edge. When blasting is done further from the edge – further away from the particular structure the levels will decrease. Air blast is also greatly dependant on stemming length and stemming material. Relative small changes will have influence on the actual levels of air blast experienced. Air blast levels quoted and used is also influenced on meteorological effects. These effects have influence on air blast. The variations are however so great that it is virtually impossible to predict exactly what a specific outcome will be.

Adverse atmospheric conditions that tend to convey or focus air blast:

- Wind velocity and direction
- Temperature inversions in the early to mid-morning, Windless days when warm temperature air exits over colder temperature air on the ground surface and this interface is relatively low in elevation
- Lightly confined blasts, such as parting or secondary blasting
- Air blast may be enhance from ridge to ridge, up to 300% over flat terrain
- Topographic features may enhance air blast down valleys

Detail structure summary will be required to ensure that specific limitations for this area can be applied. Specific structures will dictate the allowed limits for this area.

There are structures very close to the mining boundary and will certainly require specific attention by the client. The lowest charge mass is seen to have possibility of being problematic up to approximately 484m. The ranges will extent to approximately 732m for medium charge and 1128m for maximum charge. This is based on the location of structures and the specific limits applicable.

The air blast levels as projected from the data as recorded on previous occasion from Glisa is certainly indicating greater distance range of possible influence. Levels of influence range from 133dB to 188dB. This makes air blast more problematic than ground vibration.

7.11 FLY-ROCK MODELLING RESULTS AND IMPACT OF FLY ROCK

Review of the factors that contribute to fly rock it is certain that if no stemming control is exerted there will be fly rock. Possible reduction of stemming length to 2.5m for the blast configuration applied could see fly rock up to 484m possible travel for hard rock material. This distance will include important installation / structures such as the roads surrounding the pit and portion 30 area. Figure 27 below shows the relationship burden or stemming length towards expected throw distance. Throw distance considered here on the same level as the free face. Landing level of elements lower than free face could see longer distances. Optimal throw distance is also observed at 45 degree angles of departure. The maximum distance travel of indicated at 484m is indicative of poo stemming control. Careful attention will need to be given to stemming control to ensure that fly rock minimised as much as possible. Consideration will also be required for evacuation of people when blasting operations is done at distances closer than 500m from the private installations.

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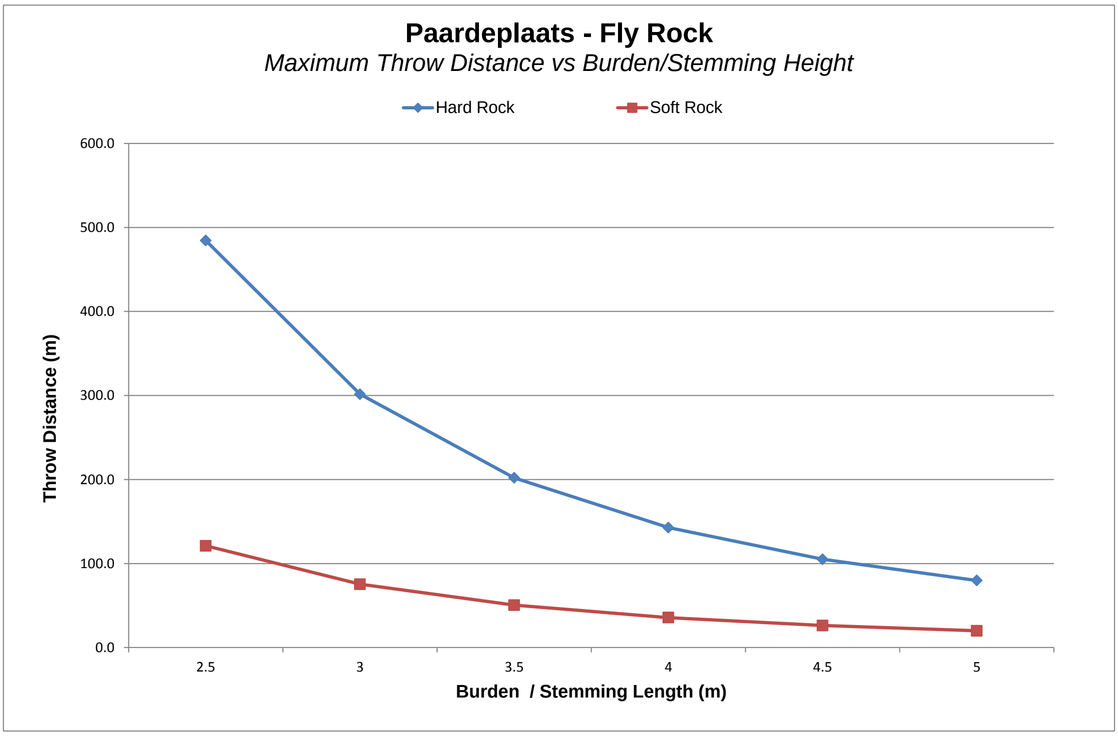

Figure 27: Predicted Fly rock

7.12 NOXIOUS FUMES INFLUENCE RESULTS

The occurrence of fumes in the form the NOx gaseous format is not a given and very dependent on various factors. However the occurrences of fumes should be closely monitored. It is not assumed that fume will travel to any part nearby farm stead but again if anybody is present in the path of cloud travel it could be problematic.

7.13 EVALUATION OF GROUND VIBRATION LEVELS AT WATER WELLS

Specific private boreholes were observed on plans or information provided. The following Table 21 shows list of boreholes that were recorded from hydro census. These water boreholes are located at various portions of the farm Paardeplaats and have different uses.
The borehole locations were reviewed for location with regards to the mining operation and the expected ground vibration levels calculated. The specific expected influence from ground vibration is evaluated.

Table 21: Water Boreholes

Reference	Y	X	Farm	Portion	Uses
HBH1	100010	-2847860	Hadeco	Portion 29, 40	None
HBH2	100008	-2848954	Hadeco	Portion 29, 40	None
HBH3	99346	-2846803	Hadeco	Portion 29, 40	Domestic use (200)
WBH1	98428	-2846188	Paardeplaas	Portion 13	Domestic Use (5 + tourists)
WPBH1	99206	-2849540	Paardeplaas Remainder	Portion 2	Domestic Use (16)

Firstly boreholes were evaluated for the main project area and secondly if only Portion 30 is mined. Figure 28 shows the location of boreholes and projected ground vibration levels with respect to mining of the main project area. Table 22 shows the list of boreholes with the recommended limit and the expected levels of ground vibration at the borehole for the main project area. It must be noted that three of the five boreholes are located inside the mining area and is expected to be destroyed. One borehole is relatively far away at 889m and one is on the border of the mining area.

Figure 29 shows the location of boreholes and projected ground vibration levels with respect to mining of the portion 30 area. Table 23 shows the list of boreholes with the recommended limit and the expected levels of ground vibration at the borehole for the Portion 30 area. The ground vibration levels are evaluated against the allowable limit and outcome provided in the table. Portion 30 mining area will have less influence with all boreholes outside the portion 30 area. All boreholes are at distances from the mining area that influence is not expected except for HBH3 borehole. This borehole is located 134m from portion 30. The expected level of ground vibration is high and will require mitigation.

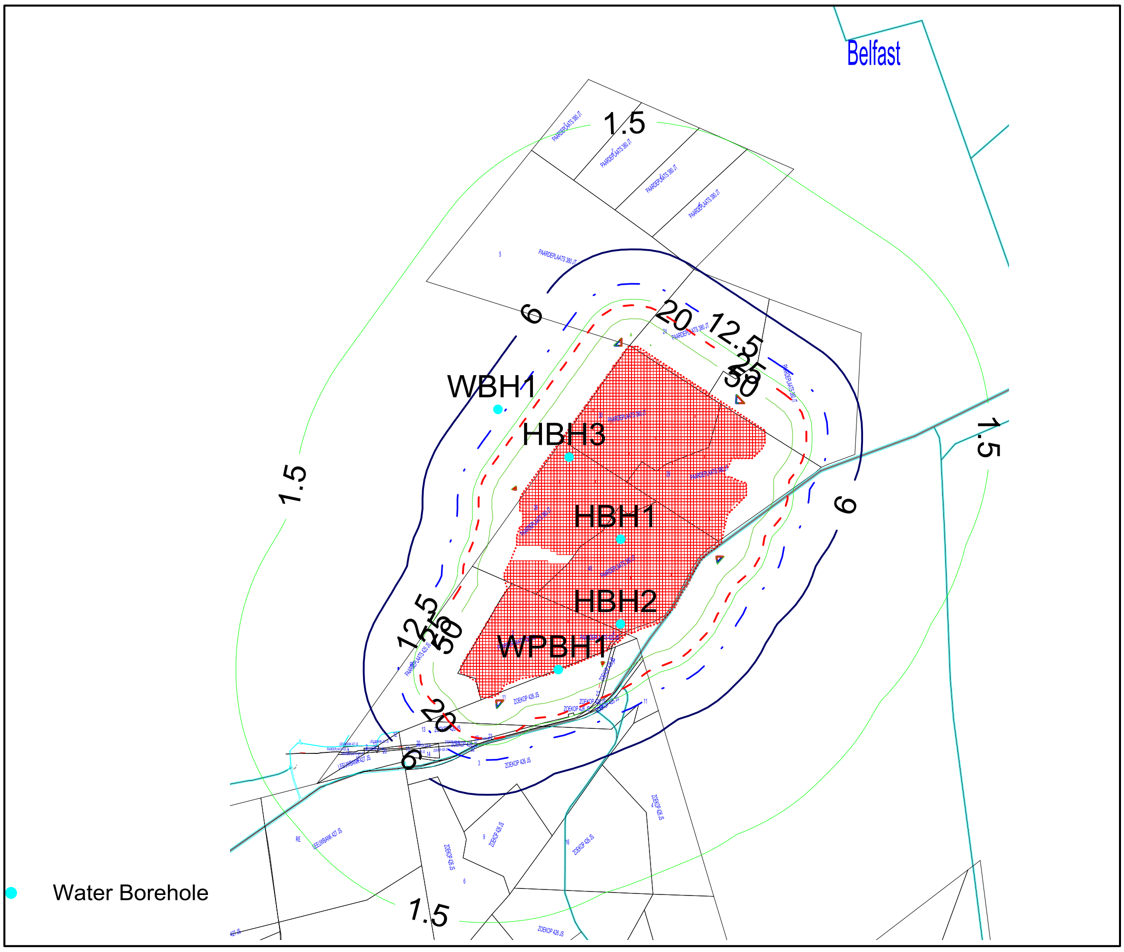

Figure 28: Ground vibration at boreholes for main project area

Table 22: Expected ground vibration levels from main project area at boreholes

Tag	Description	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 30Hz
133	HBH1	50	Inside Mining Area		
134	HBH2	50	Inside Mining Area		
135	HBH3	50	Inside Mining Area		
136	WBH1	50	889	8.0	Acceptable
137	WPBH1	50	15	4020.1	Problematic

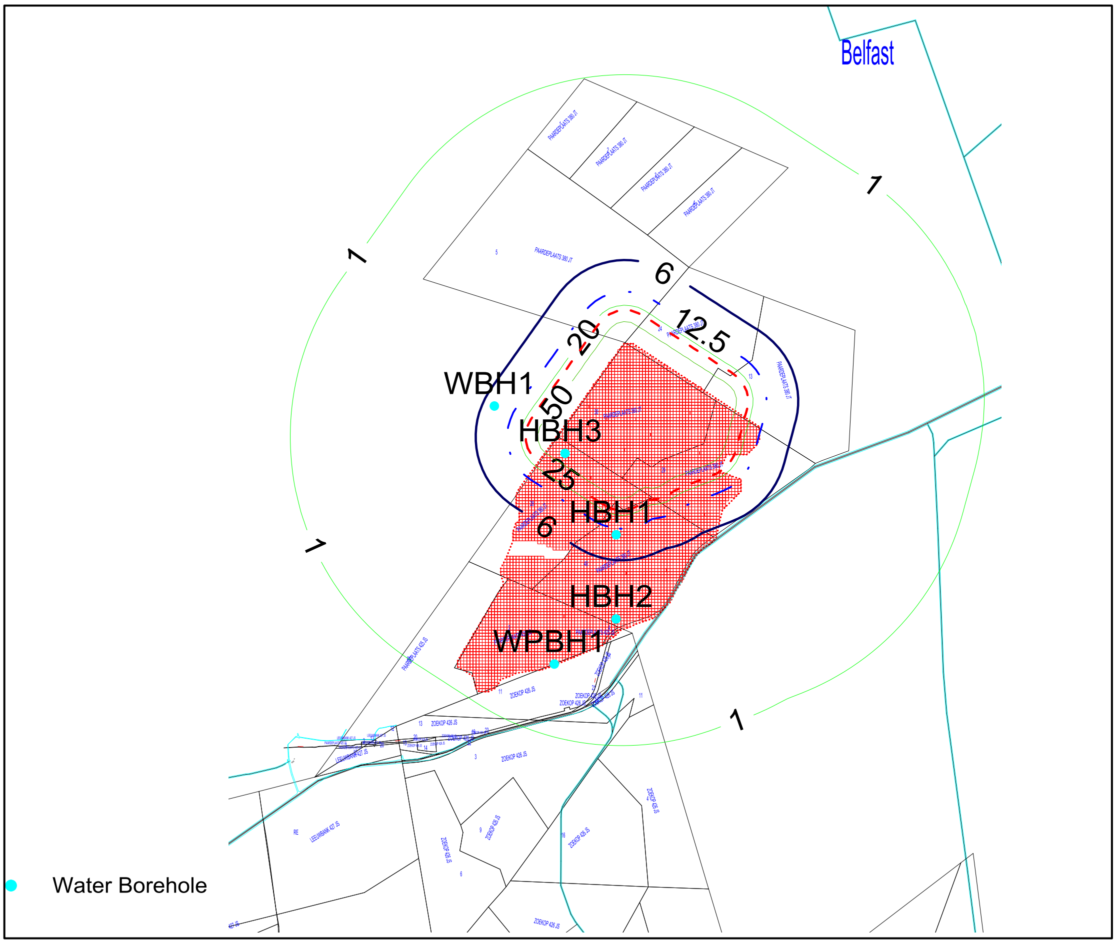

Figure 29: Ground vibration at boreholes for portion 30 area

Table 23: Expected ground vibration levels from Portion 30 at boreholes

Tag	Description	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 30Hz
133	HBH1	50	744	10.4	Acceptable
134	HBH2	50	1836	2.6	Acceptable
135	HBH3	50	134	141.9	Problematic
136	WBH1	50	921	7.5	Acceptable
137	WPBH1	50	2574	1.6	Acceptable

Considering the maximum charge of 2035kg per delay mitigation will be required for the preserving the boreholes in questions. Firstly the charge mass per delay can be reduced or the distance between blast and borehole can be fixed to a minimum. Borehole WPBH1 is however located such that apart from ground vibration ground movement and general mining ground stripping and movement this borehole could be damaged. Table 24 below shows possible mitigation options. At maximum charge a minimum of 275m is required to maintain ground vibration levels within limits and reduction of charge from 2035kg to 500kg could also maintain limits.

Table 24: Mitigation suggestions

Tag	Description	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 30Hz
Main Project area					
137	WPBH1	275	2035	47.4	Acceptable
Portion 30 Area					
135	HBH3	134	500	48.8	Acceptable
135	HBH3	275	2035	47.4	Acceptable

8 POTENTIAL ENVIRONMENTAL IMPACT ASSESSMENT: OPERATIONAL PHASE

The following is the impact assessment of the various concerns covered by this report. The matrix below in Table 25 to Table 30 was used for analysis and evaluation of aspects discussed in this report. The outcome of the analysis is provided in Table 31, Table 32 and Table 33. This risk assessment is a one sided analysis and needs to be discussed with role players in order to obtain a proper outcome and mitigation.

8.1 Method of Assessing Impacts

The impact assessment methodology is guided by the requirements of the NEMA EIA Regulations (2010). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/ likelihood (P) of the impact occurring. This determines the environmental risk. In addition other factors, including cumulative impacts, public concern, and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S).

8.1.1 Determination of Environmental Risk:

The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER).

The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$C = \frac{(E+D+M+R)}{4} \times N$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 25:

Table 25: Criteria for determination of impact consequence.

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary),
	3	Local (i.e. the area within 5 km of the site),
	4	Regional (i.e. extends between 5 and 50 km from the site
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years),
	3	Medium term (6-15 years),
	4	Long term (the impact will cease after the operational life span of the project),
	5	Permanent (no mitigation measure of natural process will reduce the impact after construction).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact

Once the C has been determined the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P (refer to Figure 30). Probability is rated/scored as per Table 26.

Table 26: Probability scoring.

Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur- > 75% probability), or
	5	Definite (the impact will occur),

The result is a qualitative representation of relative ER associated with the impact. ER is therefore calculated as follows:

ER= C x P.

Figure 30: Determination of environmental risk.

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 27.

Table 27: Significance classes.

Environmental Risk Score	
Value	**Description**
< 9	Low (i.e. where this impact is unlikely to be a significant environmental risk),
≥9; <17	Medium (i.e. where the impact could have a significant environmental risk),

≥ 17	High (i.e. where the impact will have a significant environmental risk).

The impact ER will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/ mitigated.

8.1.2 Impact Prioritisation

In accordance with the requirements of Regulation 31 (2)(l) of the EIA Regulations (GNR 543), and further to the assessment criteria presented in Section 8.1.1 it is necessary to assess each potentially significant impact in terms of:

- Cumulative impacts; and
- The degree to which the impact may cause irreplaceable loss of resources.

In addition it is important that the public opinion and sentiment regarding a prospective development and consequent potential impacts is considered in the decision making process.

In an effort to ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact ER (post-mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority / significance issues and impacts. The PF will be applied to the ER score based on the assumption that relevant suggested management/ mitigation impacts are implemented.

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Probability					

Table 28: Criteria for the determination of prioritisation.

Public response (PR)	Low (1)	Not raised as a concern by the I&AP's
	Medium (2)	Issue/ impact raised by the I&AP's
	High (3)	Significant and meaningful response from the I&AP's
Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable / definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable loss of resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in

Table 28. The impact priority is therefore determined as follows:

Priority = PR + CI + LR

The result is a priority score which ranges from 3 to 9 and a consequent PF ranging from 1 to 2 (refer to Table 29).

Table 29: Determination of prioritisation factor.

Priority	Ranking	Prioritisation Factor
= 3	Low	1
3 – 9	Medium	1.5
= 9	High	2

In order to determine the final impact significance the PF is multiplied by the ER of the post mitigation scoring. The ultimate aim of the PF is to be able to increase the post mitigation environmental risk rating by a full ranking class, if all the priority attributes are high (i.e. if an impact comes out with a medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential, significant public response, and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

Table 30: Environmental Significance Rating.

Environmental Significance Rating	
Value	**Description**
< 9	Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
≥9; <17	Medium (i.e. where the impact could influence the decision to develop in the area),
≥ 17	High (i.e. where the impact must have an influence on the decision process to develop in the area).

The significance ratings and additional considerations applied to each impact will be used to provide a quantitative comparative assessment of the alternatives being considered. In addition, professional expertise and opinion of the specialists and the environmental consultants will be applied to provide a qualitative comparison of the alternatives under consideration. This process will identify the best alternative for the proposed project.

8.1.1 Outcome of Impact Rating

The outcome of the impact rating for ground vibration, air blast and fly rock is presented in tables below. The impact ratings are provided for the main project area and portion 30 separately. During construction phase, decommissioning phase and a "no-go" option there is no drilling blasting done and thus no impact yielded in the form of ground vibration, air blast or fly rock. If no blasting is done then no effect yielded. No specific rating tables are submitted for the construction, decommissioning and no-go evaluations.

The following tables show the outcome of the impact ratings for the operational phase firstly for the main project and secondly for portion 30 areas.

Table 31: Ground Vibration Impact Assessment main project area

Impact name:	*Ground Vibration*	
Phase:	*Operational Phase*	
Alternative:	*No Alternatives*	
Description of impact:	*Ground vibration could cause damage to structures and upset community*	
Environmental Risk		
Attribute	**Pre-mitigation**	**Post-mitigation**

Nature of Impact	-1	-1
Extent of Impact	3	3
Duration of Impact	4	4
Magnitude of Impact	3	2
Reversibility of Impact	3	2
Probability	3	2
Environmental Risk (Pre-mitigation)	**-9.75**	
Environmental Risk (Post-mitigation)	**-5.5**	
Degree of confidence in impact prediction:	Medium	
Recommended Mitigation Measures		
The reduction of ground vibration is fundamental in different ways. 1. Detailed blast design for each blast with consideration the effects from blasting i.e. ground vibration and air blast. 2. Calculate expected ground vibration levels for blast to be done and if necessary re-design to reduce change mass per delay, use of electronic initiation of blast, drilling smaller diameter blastholes that will reduce charge per blasthole and per delay.		
Impact Prioritisation		
Public Response	3	
Cumulative Impacts	1	
	2	
Degree of potential irreplaceable loss of resources	2	
Prioritisation Factor	1.5	
Final Significance	**-8.25**	

Table 32: Air Blast Impact Assessment main project area

Impact name:	*Air Blast*	
Phase:	*Operational Phase*	
Alternative:	*No Alternatives*	
Description of impact:	*Air blast could cause damage to structures and induce effects that will upset homeowners*	
Environmental Risk		
Attribute	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1
Extent of Impact	3	3
Duration of Impact	4	4
Magnitude of Impact	4	2
Reversibility of Impact	3	2
Probability	4	2
Environmental Risk (Pre-mitigation)	**-14**	
Environmental Risk (Post-mitigation)	**-5.5**	
Degree of confidence in impact prediction:	Medium	
Recommended Mitigation Measures		
The reduction of air blast is fundamental in different ways. 1. Detailed blast design for each blast with consideration the effects from blasting i.e. ground vibration and air blast. 2. Use of proper stemming lengths of between 25 and 30 blasthole diameters, 3. Use of crushed aggregate of 10% the blasthole diameter as stemming material. 4. Record stemming lengths for each blast and correct if necessary prior to every blast blasted. 5. Monitor each blast done.		
Impact Prioritisation		

Public Response	3
Cumulative Impacts	1
	2
Degree of potential irreplaceable loss of resources	2
Prioritisation Factor	1.5
Final Significance	**-8.25**

Table 33: Fly Rock Impact Assessment main project area

Impact name:	*Fly Rock*	
Phase:	*Operational Phase*	
Alternative:	*No Alternatives*	
Description of impact:	*Fly Rock could cause damage to structures, injure people or animals*	
Environmental Risk		
Attribute	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1
Extent of Impact	3	3
Duration of Impact	4	4
Magnitude of Impact	3	2
Reversibility of Impact	3	2
Probability	3	2
Environmental Risk (Pre-mitigation)	**-9.75**	
Environmental Risk (Post-mitigation)	**-5.5**	
Degree of confidence in impact prediction:	Medium	
Recommended Mitigation Measures		
The reduction of fly rock is fundamental in different ways and similar to air blast control. 1. Detailed blast design for each blast with consideration the effects from blasting i.e. ground vibration and air blast. 2. Use of proper stemming lengths of between 25 and 30 blasthole diameters, 3. Use of crushed aggregate of 10% the blasthole diameter as stemming material. 4. Record stemming lengths for each blast and correct if necessary prior to every blast blasted. 5. Monitor each blast done.		
Impact Prioritisation		
Public Response	3	
Cumulative Impacts	1	
	2	
Degree of potential irreplaceable loss of resources	2	
Prioritisation Factor	1.5	
Final Significance	**-8.25**	

Table 34: Ground Vibration Impact Assessment Portion 30 area

Impact name:	*Ground Vibration*	
Phase:	*Operational Phase*	
Alternative:	*No Alternatives*	
Description of impact:	*Ground vibration could cause damage to structures and upset community*	
Environmental Risk		
Attribute	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1
Extent of Impact	3	3

Duration of Impact	3	3
Magnitude of Impact	3	2
Reversibility of Impact	3	2
Probability	3	2
Environmental Risk (Pre-mitigation)	**-9.0**	
Environmental Risk (Post-mitigation)	**-5.0**	
Degree of confidence in impact prediction:	Medium	
Recommended Mitigation Measures		
The reduction of ground vibration is fundamental in different ways. 1. Detailed blast design for each blast with consideration the effects from blasting i.e. ground vibration and air blast. 2. Calculate expected ground vibration levels for blast to be done and if necessary re-design to reduce change mass per delay, use of electronic initiation of blast, drilling smaller diameter blastholes that will reduce charge per blasthole and per delay.		
Impact Prioritisation		
Public Response	3	
Cumulative Impacts	1	
	2	
Degree of potential irreplaceable loss of resources	2	
Prioritisation Factor	1.5	
Final Significance	**-7.5**	

Table 35: Air Blast Impact Assessment Portion 30 area

Impact name:	*Air Blast*	
Phase:	*Operational Phase*	
Alternative:	*No Alternatives*	
Description of impact:	*Air blast could cause damage to structures and induce effects that will upset homeowners*	
Environmental Risk		
Attribute	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1
Extent of Impact	3	3
Duration of Impact	3	3
Magnitude of Impact	4	2
Reversibility of Impact	3	2
Probability	4	2
Environmental Risk (Pre-mitigation)	**-12**	
Environmental Risk (Post-mitigation)	**-5**	
Degree of confidence in impact prediction:	Medium	
Recommended Mitigation Measures		
The reduction of air blast is fundamental in different ways. 1. Detailed blast design for each blast with consideration the effects from blasting i.e. ground vibration and air blast. 2. Use of proper stemming lengths of between 25 and 30 blasthole diameters, 3. Use of crushed aggregate of 10% the blasthole diameter as stemming material. 4. Record stemming lengths for each blast and correct if necessary prior to every blast blasted. 5. Monitor each blast done.		
Impact Prioritisation		
Public Response	3	
Cumulative Impacts	1	

	2
Degree of potential irreplaceable loss of resources	2
Prioritisation Factor	1.5
Final Significance	**-7.5**

Table 36: Fly Rock Impact Assessment Portion 30 area

Impact name:	*Fly Rock*	
Phase:	*Operational Phase*	
Alternative:	*No Alternatives*	
Description of impact:	*Fly Rock could cause damage to structures, injure people or animals*	
Environmental Risk		
Attribute	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1
Extent of Impact	3	3
Duration of Impact	3	3
Magnitude of Impact	3	2
Reversibility of Impact	3	2
Probability	3	2
Environmental Risk (Pre-mitigation)	**-9**	
Environmental Risk (Post-mitigation)	**-5**	
Degree of confidence in impact prediction:	Medium	
Recommended Mitigation Measures		
The reduction of fly rock is fundamental in different ways and similar to air blast control. 1. Detailed blast design for each blast with consideration the effects from blasting i.e. ground vibration and air blast. 2. Use of proper stemming lengths of between 25 and 30 blasthole diameters, 3. Use of crushed aggregate of 10% the blasthole diameter as stemming material. 4. Record stemming lengths for each blast and correct if necessary prior to every blast blasted. 5. Monitor each blast done.		
Impact Prioritisation		
Public Response	3	
Cumulative Impacts	1	
	2	
Degree of potential irreplaceable loss of resources	2	
Prioritisation Factor	1.5	
Final Significance	**-7.5**	

9 MITIGATIONS

Based on the work done in this report mitigations will be required. Detail mitigation is not calculated at this stage but provided in table below are concepts provided that must be considered for each of the POI's that are considered problematic specific to the Portion 30 area. This mitigation is based on the maximum charge being applied for the area. Table 37 below shows recommended mitigation measures that must be put in place for the mining area.

The reduction of ground vibration is fundamental in different ways.

- Detailed blast design for each blast with consideration the effects from blasting i.e. ground vibration and air blast.
- Calculate expected ground vibration levels for blast to be done and if necessary re-design to reduce change mass per delay, use of electronic initiation of blast, drilling smaller diameter blastholes that will reduce charge per blasthole and per delay.

The reduction of air blast and fly rock is fundamental in different ways.

- Detailed blast design for each blast with consideration the effects from blasting i.e. ground vibration and air blast.
- Use of proper stemming lengths of between 25 and 30 blasthole diameters,
- Use of crushed aggregate with size of 10% the blasthole diameter as stemming material.
- Record stemming lengths for each blast and correct if necessary prior to every blast blasted.
- Monitor each blast done.

Table 37: Mitigation required

POI Description				Pre Mitigation		Post Mitigation			
Tag	**Description**	**Specific Limit (mm/s)**	**Distance (m)**	**Total Mass / Delay (kg)**	**Predicted PPV (mm/s)**	**Total Mass / Delay (kg)**	**Predicted PPV (mm/s)**	**Structure Response @ 10Hz**	**Structure Response @ 30Hz**
57	Farm House	25	52	2035	587.1	30	23.8	Acceptable	Acceptable
68	Powerlines / Pylon	75	123	2035	160.8	700	71.4	Acceptable	Acceptable
67	Powerlines / Pylon	75	149	2035	120.4	1000	70.2	Acceptable	Acceptable
55	Dam	50	159	2035	109.4	700	48.6	Acceptable	Acceptable
66	Powerlines / Pylon	75	188	2035	84.6	1700	73.8	Acceptable	Acceptable
56	Informal Housing	6	246	2035	56.2	100	5.7	Acceptable	Acceptable
86	Informal Housing	6	490	2035	19.7	400	5.7	Acceptable	Acceptable

10 RECOMMENDATIONS

The following recommendations are proposed.

10.1 SAFE BLASTING DISTANCE FROM COMMUNITIES

A minimum recommendation is that a minimum of 500m must be maintained from any blast done. This may be greater but not less. The blaster has a legal obligation concerning the safe distance and he needs to determine this distance.

10.2 EVACUATION

All person animals within 500m from a blast must be cleared and where necessary evacuation must be conducted with all the required pre-blast negotiations.

10.3 ROAD CLOSURE

All roads next to the project area are of concern. Road closure will need to be considered when blasting closer than 500 from the road. The N4 and any service roads will need to be closed for blasting at distances 500m from the pit edge. Local authorities will need to be informed of such requirements and road closure conducted according to authority requirements.

10.4 MONITORING

It is highly recommended that a monitoring program be put in place. This will also qualify the expected ground vibration and air blast levels and assist in mitigating these aspects properly. This will also contribute to proper relationships with the neighbours.

10.5 PHOTOGRAPHIC INSPECTIONS

A base line of structure inspection should be considered for all privately owned structures within 1500m from the mine.

10.6 RECOMMENDED GROUND VIBRATION AND AIR BLAST LEVELS

The following ground vibration and air blast levels are recommended for blasting operations in this area. Table 21 below gives limits for ground vibration and air blast.

Table 38: Recommended ground vibration air blast limits

Structure Description	Ground Vibration Limit (mm/s)	Air Blast Limit (dBL)
National Roads/Tar Roads:	150	N/A
Electrical Lines:	75	N/A
Railway:	150	N/A
Transformers	25	N/A
Water Wells	50	N/A
Telecoms Tower	50	134
General Houses of proper construction	USBM Criteria or 25 mm/s	Shall not exceed 134dB at point of concern but 120 dB preferred
Houses of lesser proper construction	12.5	
Rural building – Mud houses	6	

10.7 BLASTING TIMES

A further consideration of blasting times is when weather conditions could influence the effects yielded by blasting operations. Recommended is not to blast too early in the morning when it is still cool or the possibility of inversion is present or too late in the afternoon in winter as well. Do not blast in fog. Do not blast in the dark. Prevail from blasting when wind is blowing strongly in the direction of an outside receptor. Do not blast with low overcast clouds. These ‘do not’s stem from the influence that weather have on air blast. The energy of air blast cannot be increased but it is distributed differently to unexpected levels where it was not expected.

It is recommended that a standard blasting time is fixed and blasting notice boards setup at various entrance routes that will inform the town’s people of dates of blasting and blast times. Consideration must be given to the school times as pupils use secondary roads that lead to the main road directly across from the project area.

10.8 THIRD PARTY MONITORING

Third party consultation and monitoring should be considered for all ground vibration and air blast monitoring work. Additionally assistance may be sought when blasting is done close to the highways. This will bring about unbiased evaluation of levels and influence from an independent group. Monitoring could be done using permanent installed stations. Audit functions may also be conducted to assist the mine in maintaining a high level of performance with regards to blast results and the effects related to blasting operations.

10.9 WATERWELL MONITORING

A detailed list of water wells must be compiled. Necessary data for each borehole must be logged including, location, condition, qualities, levels etc. Detail of recordings required must be confirmed with the ground water consultant. Ground vibration levels at water wells must be maintained below 50mm/s at surface of well.

11 KNOWLEDGE GAPS

Considering the stage of the project, the data observed was sufficient to conduct an initial study. Surface surroundings change continuously and this should be taken into account prior to any final design and review of this report. This report is based on data provided and international accepted methods and methodology used for calculations and predictions.

12 CONCLUSION

Blast Management & Consulting (BM&C) was contracted as part of Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations in the proposed new opencast mining operation. Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. The report concentrates on the ground vibration and air blast intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500m at least and in some cases further from the mining area considered. The range of structures expected is typical town and farming community with structures that range from well build to informal building style. These include rural type mud house buildings to brick and mortar structures, cement brick structures, and industrial structures. The project area consists mainly of one opencast pit area with option to mine only portion 30.

The project area has possibility of presence of people and farm animals at very close distances to the operations. There are a significant quantity structures in areas around the different pit areas within a 1000m. The N4 national highway is one concern that will need specific attention if the full project will be mined. The N4 is closer than 500m from the project area on the southern side. All animals and people should not be present within 500m from the blasting operations.

Three different charge masses were evaluated. The location of structures around the pit areas are such that even with minimum charge possible influences may be expected. Ground vibration yielded from blasting is expected to be lesser of concern. Air blast did show levels of concern and over distances further than that of ground vibration. There are significant quantities of houses in range where complaints may be expected. Complaints from air blast are normally based on the actual effects that are experienced due to rattling of roof, windows, doors etc. These effects could startle people and raise concern of possible damage.
This pit is located such that “free blasting” – meaning with specific controls on blast preparation – will not be possible.

Specific mitigations were recommended in order to be able to conduct drilling and blasting operations. Specifically will limited charging be required with additional aspects for control of fly rock and management of blasting operations. The concerns raised are in relation to promote good neighbour ship.

This concludes this investigation for Paardeplaats Project. It will be possible to operate this mine in a safe and effective manner provided attention is given to the areas of concern and recommendations as indicated.

13 CURRICULUM VITAE OF AUTHOR

Author joined Permanent Force at the SA Ammunition Core for period Jan 1983 - Jan 1990. During this period I was involved in testing at SANDF Ammunition Depots and Proofing ranges. Work entailed munitions maintenance, proofing and lot acceptance of ammunition. For the period Jul 1992 - Des 1995 Worked at AECI Explosives Ltd. Initially I was involved in testing science on small scale laboratory work and large scale field work. Later on work entailed managing various testing facilities and testing projects. Due to the restructuring of Technical Department I was retrenched but fortunately could take up appointment with AECI Explosives Ltd.'s Pumpable Emulsion explosives group for underground applications. December 1995 to June 1997 I gave technical support to the Underground Bulk Systems Technology business unit and performed project management on new products. I started Blast Management & Consulting in June 1997. Main areas of concern were Pre-blast monitoring, Insitu monitoring, Post blast monitoring and specialized projects.

I have obtained the following Qualifications:

1985 - 1987	Diploma: Explosives Technology, Technikon Pretoria
1990 - 1992	BA Degree, University Of Pretoria
1994	National Higher Diploma: Explosives Technology, Technikon Pretoria
1997	Project Management Certificate: Damelin College
2000	Advanced Certificate in Blasting, Technikon SA

Member: International Society of Explosives Engineers

Blast Management & Consulting has been active in the mining industry since 1997 and work has been on various levels for all the major mining companies in South Africa. Some of the projects where BM&C has been involved are:

Iso-Seismic Surveys for Kriel Colliery in conjunction with Bauer & Crosby PTY Ltd, Iso-Seismic surveys for Impala Platinum Limited, Iso-Seismic surveys for Kromdraai Opencast Mine, Photographic Surveys for Kriel Colliery, Photographic Surveys for Goedehoop Colliery, Photographic Surveys for Aquarius Kroondal Platinum – Klipfontein Village, Photographic Surveys for Aquarius – Everest South Project, Photographic Surveys for Kromdraai Opencast Mine, Photographic Inspections for various other companies including Landau Colliery, Platinum Joint Venture – three mini pit areas, Continuous ground vibration and air blast monitoring for various Coal mines, Full auditing and control with consultation on blast preparation, blasting and resultant effects for clients e.g. Anglo Platinum Ltd, Kroondal Platinum Mine, Lonmin Platinum, Blast Monitoring Platinum Joint Venture – New Rustenburg N4 road, Monitoring of ground vibration induced on surface in Underground Mining environment, Monitoring and management of blasting in close relation to water pipelines in opencast mining environment, Specialized testing of explosives characteristics, Supply and service of seismographs and VOD measurement equipment and accessories, Assistance in protection of ancient mining works for Rhino Minerals (PTY) LTD, Planning, design, auditing and monitoring of blasting in new quarry on new road project, Sterkspruit, with Africon, B&E International and Group 5 Roads, Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Pandora Joint Venture 180 houses – whole village, Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Section : 1000 houses / structures.

BM&C have installed a World class calibration facility for seismographs, which is accredited by Instantel, Ontario Canada as an accredited Instantel facility. The projects describe and discussed here are only part of the capability and professional work that is done by BM&C.

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Paardeplaats Colliery EIA/EMPR

Specialist Study

Hydrology

Final Version

Report Issue	Final version
Aqua Earth Reference Number	
Client Reference	
Title	Specialist Study: Hydrology and Geohydrology

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1 Introduction

1.1 Preamble

Aqua Earth Consulting (AEC) was appointed by Environmental Impact Management Services (EIMS) to carry out an environmental impact assessment (EIA) for the surface water around the proposed mining site at the proposed Paardeplaats Colliery.

Included in the study was the creation of a mine storm water management plan, an assessment of the mine impacts on the surface water quality and quantity, and the creation of a preliminary mine water balance. This report outlines the results of these studies, provides an environmental assessment of the various alternatives and provides recommendations for implementation once the mining activities starts.

Three scenarios were to be considered namely:

Alternative 1 – no mining taking place;

Alternative 2 – mining of the full mining area as per the proposed mining schedule

Alternative 3 – mining of only portion 30

These three alternatives were considered in the final assessment.

The following documentation were taken into account:

- Requirements of the DWAF Government Notice No. 704 (GN – 704) Guideline Document for the Implementation of Regulations on Water Use of Mining and Related Activities Aimed at the Protection of Water Resources:
- DWAF Best Practice Guidelines G1: Stormwater Management (DWAF, 2006); and
- The Water Management for Surface Mines (DWAF, 2008).

These documents support Section 26 of the National Water Act which regulates any activity that may have an impaction a water resource and the conservation and protection of this water resource.

1.2 Declaration of Independence

Aqua Earth was appointed to conduct a specialist groundwater and surface water study as part of the Exxaro NBC Paardeplaats EIA and act as the independent specialists in this application. Aqua Earth will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. Aqua Earth has the expertise in conducting the specialist report relevant to this application and will not engage in conflicting interests in the undertaking of this study.

2 Site characteristics

2.1 Location

The study area lies approximately 65km east of the town of Mhluzi and 7 km west of Belfast in the Mpumalanga Province (Figure 1). It is linked to Mhluzi by the N4 highway. The proposed mining area lies within a farming area and on portions 1, 2, 13, 24, 28, 29 and 30 of the farm Paardeplaats 380JT. It covers a total land area of 1167.65 hectares and contains multi-seam deposits, ranging from 14m to 39m below surface.

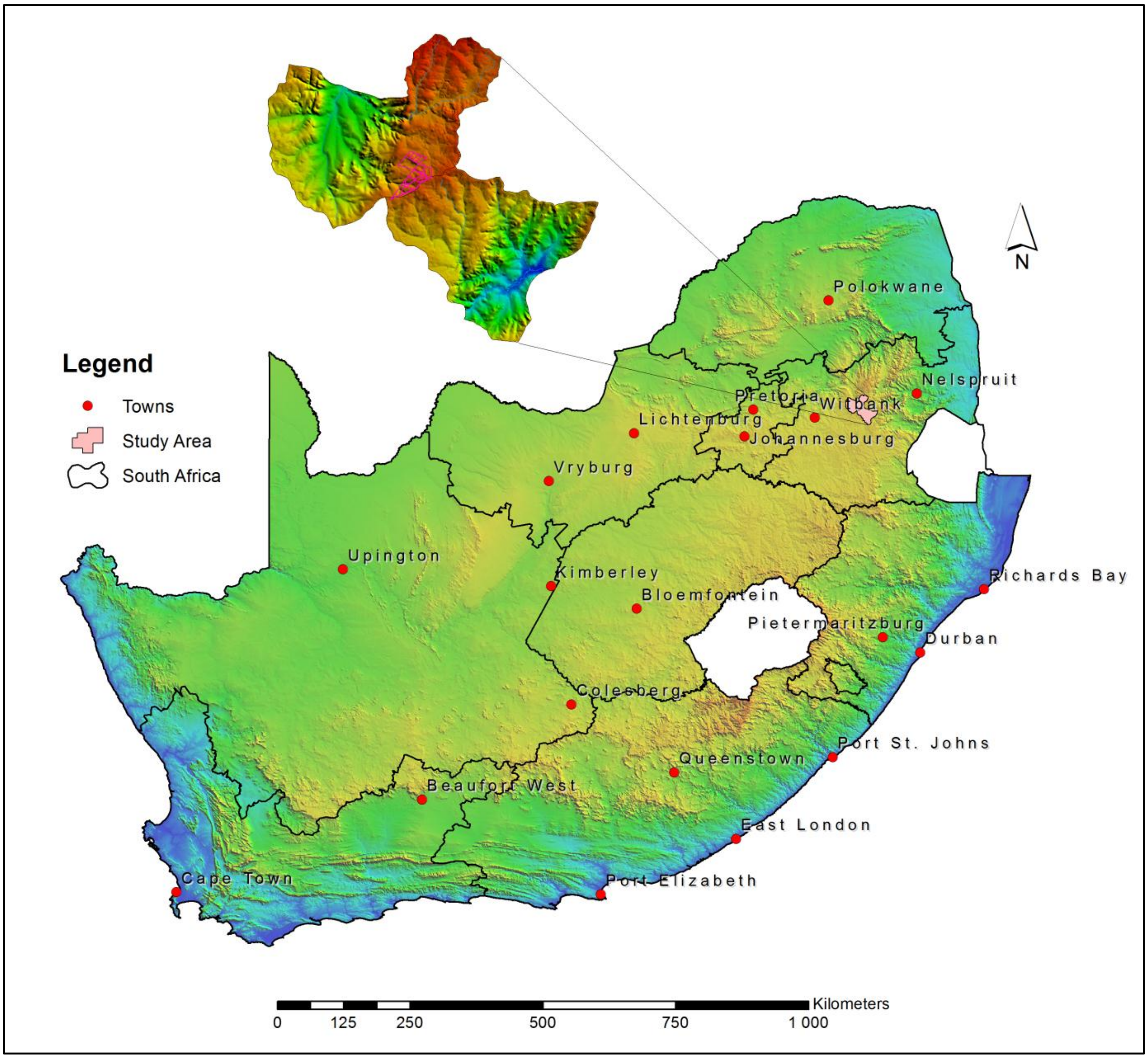


Figure 1: Location of the study area

2.2 Geology

The mine is located in the Karoo Sequence (Vryheid Formation). The Vryheid Formation comprises mudrock, shales, rhythmite, siltstone and fine- to coarse-grained sandstone (pebbly in places). The Formation contains up to five (mineable) coal seams. The different lithofacies are mainly arranged in upward coarsening deltaic cycles. Since the shales are very dense, they are often overlooked as significant sources of groundwater. The permeabilities of these sandstones are also usually very low. The main reason for this is that the sandstones are usually poorly sorted, and that their primary porosities have been lowered considerably by diagenesis. These sedimentary formations have been extensively intruded by dolerite dykes. The regional geological map is shown in Figure 2.

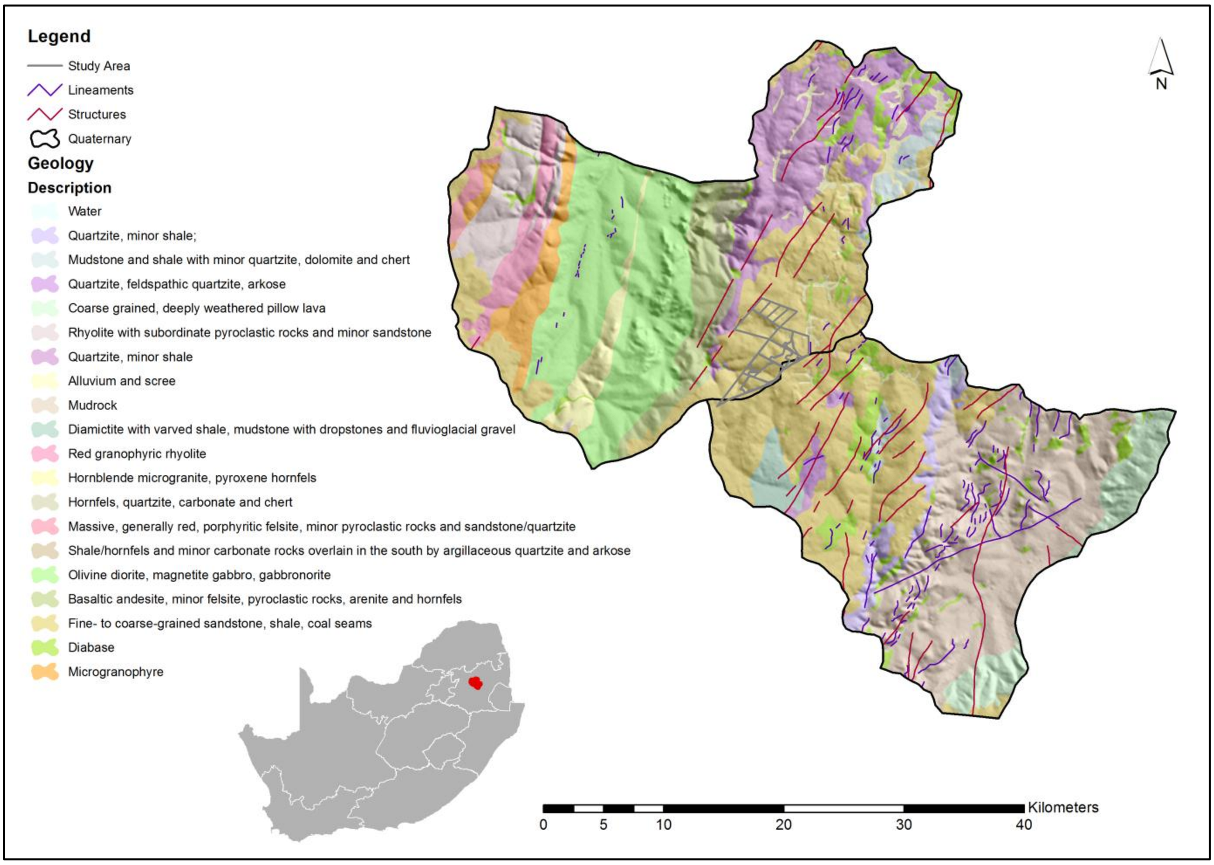


Figure 2: Regional geology

General directions of the regional structures (dykes and faults), are south-southwest to north-northeast for the dykes and east to west for the faults, with some interconnection between faults as a result of north to south faulting. The slip faults were seen as minor faults that occurred as a result of pressure relief and were mainly perpendicular to the main fault strike direction.

2.3 Soils

Terra Africa Consult conducted a soils survey as part of the EMP for Glisa Mine in 2010. A summary of their results is documented in this section as well as soils map for the bigger area depicted in Figure 4. This is given as background information and is useful in understanding the behaviour of surface water over these areas.

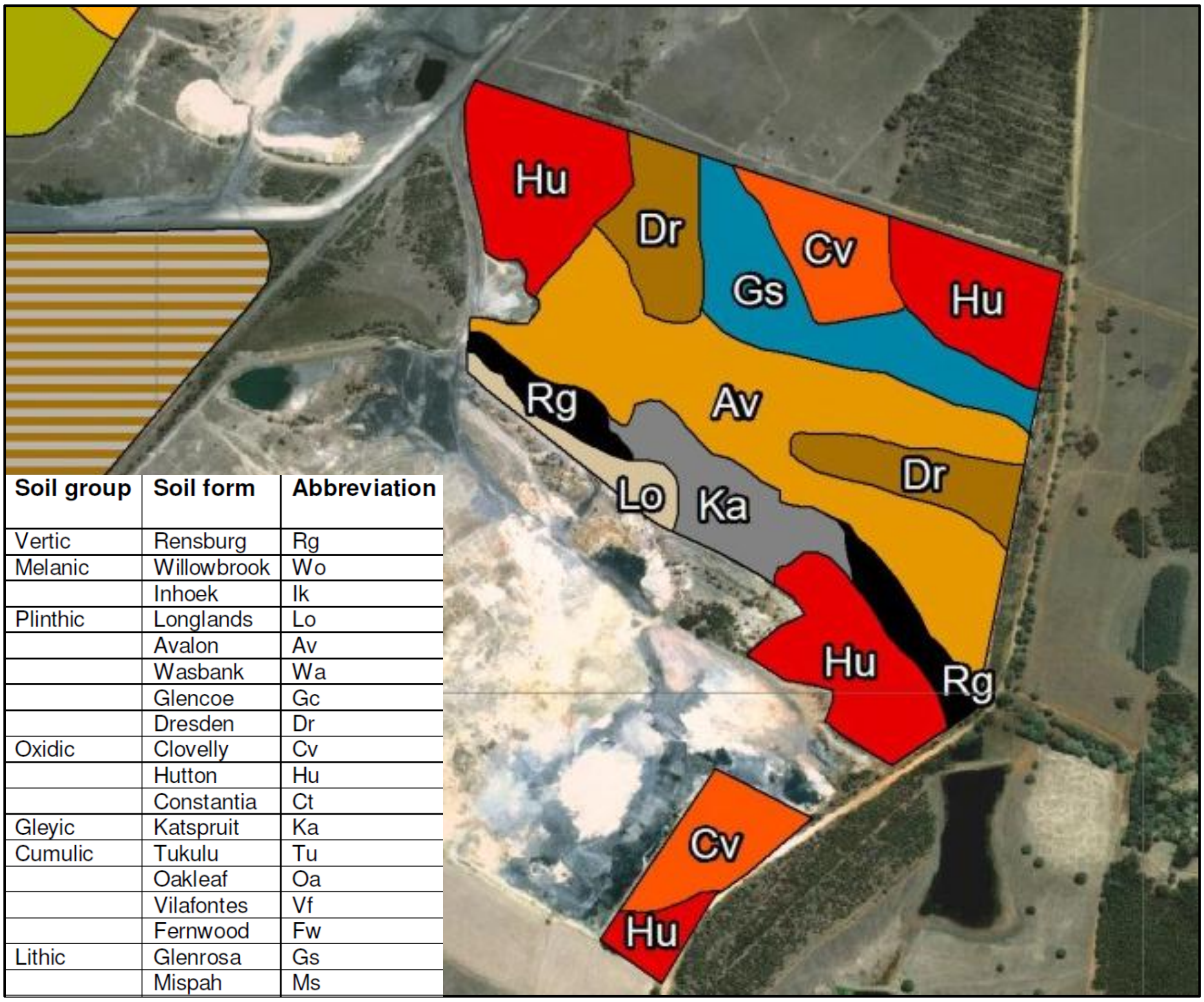
Eight different main soil groups were identified, namely vertic, melanic, gleyic, cumulic, lithic, plinthic, oxidic and anthropic soils. Of the vertic soil group one form (Rensburg) was identified while soil forms in the melanic group are Willowbrook and Inhoek. The Katspruit form was identified in the gleyic soil group and Longlands, Avalon, Glencoe, Wasbank and Dresden forms fall in the plinthic soil group.

Soil forms in the oxidic group are characterized by a red or yellow-brown apedal B-horizon (Hutton, Clovelly and Constantia). The Witbank form is the only soil in the anthropicgroup.

Texture of soil samples taken has generally a high sand content with clay content ranging between 8 – 28% and silt between 14 – 52%.

Soil was chemically analysed at a soil laboratory and found to be very acidic.

The soils found on Portion 30 are shown in Figure 3.



Soil group	Soil form	Abbreviation
Vertic	Rensburg	Rg
Melanic	Willowbrook	Wo
	Inhoek	Ik
Plinthic	Longlands	Lo
	Avalon	Av
	Wasbank	Wa
	Glencoe	Gc
	Dresden	Dr
Oxidic	Clovelly	Cv
	Hutton	Hu
	Constantia	Ct
Gleyic	Katspruit	Ka
Cumulic	Tukulu	Tu
	Oakleaf	Oa
	Vilafontes	Vf
	Fernwood	Fw
Lithic	Glenrosa	Gs
	Mispah	Ms

Figure 3: Detailed map of Soils found on Portion 30 (Terra Africa Consult, 2010)

The soil characteristics are summarised in Table 1.

Table 1: Soil characteristics

Soil group	Properties
Vertic	One soil form (Rensburg) from the vertic group was identified. This soil form consists of a vertic A horizon overlying a G-horizon. The A-horizon is high in clay content and the clay minerals have the capacity to shrink and swell in response to soil moisture changes. The horizon of this form identified is non-calcareous. It is estimated that the vertic horizon contains less than 2% organic carbon.
Plinthic	Plinthic soils consist of an orthic A horizon which grades into a soft or hard plinthic B horizon either directly or indirectly via a yellow-brown a pedal or E horizon. The most important attribute of the presence of plinthite is that it indicates fluctuation of a water table. Soil forms identified from the plinthic group includes Longlands, Avalon and Dresden forms. The Longlands form consists of an orthic A horizon over an E horizon that overlay the soft plinthic B horizon. The Avalon form differs from the Longlands form in that the E horizon is replaced by a yellow brown apedal horizon. This indicates a drier soil profile with less water movement than the Longlands form. The Dresden form is underlain by hard plinthite. The Dresden form has no horizon between the orthic A horizon and the hard plinthic layer.
Oxidic	Oxidic that developed within this group either have a red apedal or yellow-brown apedal horizon underlying an orthic A-horizon. No red structured profiles were identified on this site. The name of this soil groups has been derived from the oxides of iron that accumulate through weathering and colour many soils - uniformly if the conditions are well drained and aerated. The red colour of hematite signifies conditions that are warmer, drier, and less affected by organic matter than those indicated by the yellow-brown colour of goethite. Hematite is the stronger of the two clay pigments and many red soils contain more goethite than hematite. The concept underlying the group is one of relative maturity coupled with free drainage and aeration. Two soil forms were identified that falls within this group i.e. Hutton and Clovelly forms. The well-drained shallow to deep soils of the Hutton form (orthic A horizon over red apedal B over unspecified material) occur in large patches in gently sloping (1 - 2 degrees) midslope positions. Textures are coarse to medium sand to sandy-loam in the topsoil and medium to fine sandy-clay-loam in the subsoil. Structure is weak blocky (dominant) or apedal in all horizons. The Clovelly form is the equivalent of the Hutton form in the red apedal group with unspecified material underneath the yellow-brown apedal horizon.
Gleyic	The overriding property of gleyic soils is the mostly greyish colour which is a manifestation of their tendency to be extremely wet. The soil form identified in this group is the Katspruit form. It consists of an orthic horizon overlying a G horizon. The G horizon is naturally saturated with water for long periods and is dominated by grey colours especially on macro-void and ped surfaces. It has firmer consistence than the overlying horizon. A ferrous-ferric hydroxide is responsible for these blue green colours.
Lithic	In lithic soil forms the solum is dominated by rock or saprolite (weathered rock). These moderately (majority brown), well (red) or poorly (bleached) drained shallow soils of the Glenrosa form occur in a few zones in the survey area. These soils have sandy to sandy-loam texture, while topsoil structure ranges from apedal to weakly blocky. A few small zones of solid rock surrounded by other deeper soil forms have also been delineated.

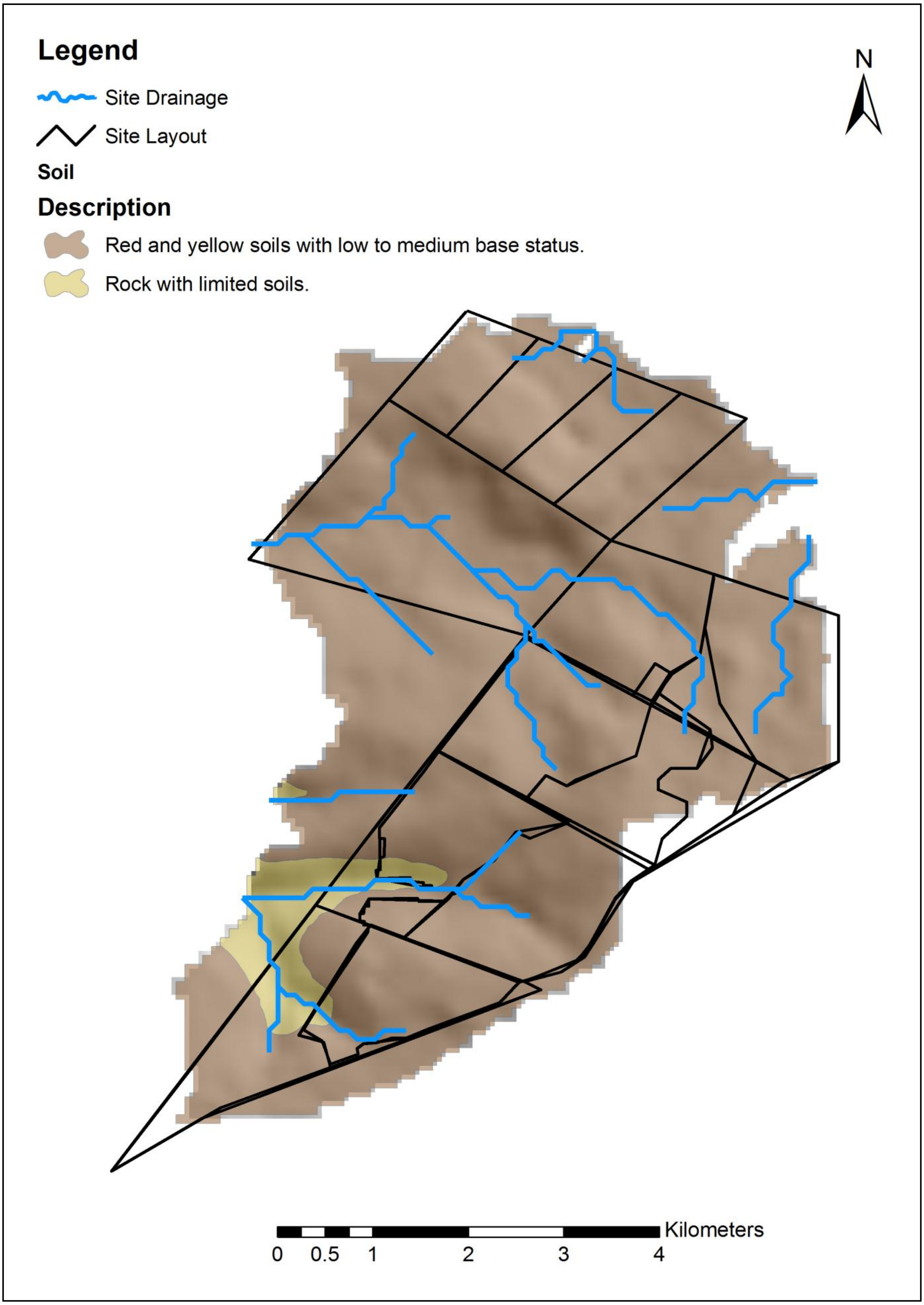


Figure 4: Overview soils map for the full mining area

2.4 Vegetation

The study area is located the Grassland Biome of South Africa, is located across one regional vegetation unit, namely Eastern Highveld Grassland. This regional vegetation unit is classified as endangered.

2.5 Wetlands

Wetland Consulting Services conducted a study in 2011 to assess wetlands within the study area. The location of the wetlands is shown in Figure 5.

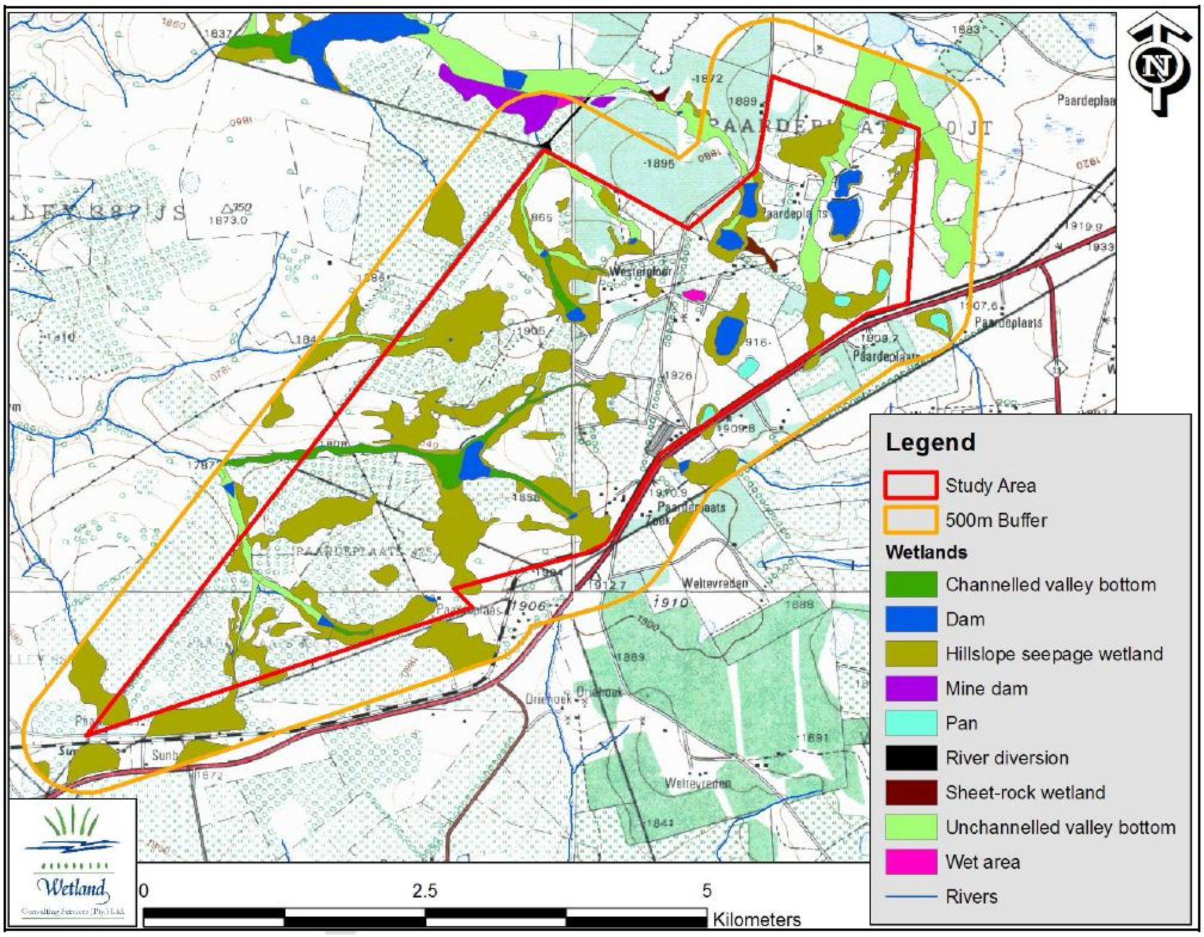


Figure 5: Location of wetlands (WCS, 2011)

The results of the study are summarised as:

All wetlands on site are considered sensitive and, as a result of this, most of the site is considered to be, at best, of low suitability for mining development. This is based on the value of the water that the wetlands represent as well as the requirements of legislation (National Water Act, NEMA, GN704, GN1199 etc.) and other guideline documents (e.g.

Mpumalanga Biodiversity Conservation Plan) which require that all wetlands are considered as sensitive and that any activity within a wetland or within 500m of a wetland requires authorisation. The varying sensitivities ascribed to the wetlands on site, ranging from Restricted to Low Sensitivity, are based on the varying degrees of degradation of the wetlands on site.

Wetlands are connected to many of the streams on site.

2.6 Regional hydrology

The proposed Paardeplaats colliery falls largely within the quaternary catchment B41A, with a small portion falling in catchment X11D. The potentially affected receiving water bodies are the Grootspruit; which flows north into the Steelpoort River; which in turn joins the Olifants River.

The catchments and main surface water bodies are shown in Figure 6. Information concerning the catchments is listed in Table 2.

Table 2: Information concerning quaternary catchments

Catchment	X41A	X11D
Area (km²)	764.5	590
Present ecological status according to Chapter 3 of National Water Act (1998)	B[1]	B
Mean annual runoff (mm/a)	65	88
Groundwater contribution to baseflow (mm/a)	14	45

The elevation of the site ranges between 1500 – 1900mamsl (Figure 6).

[1]Localised low level impacts, but no negative effects apparent. No significant impacts observed.

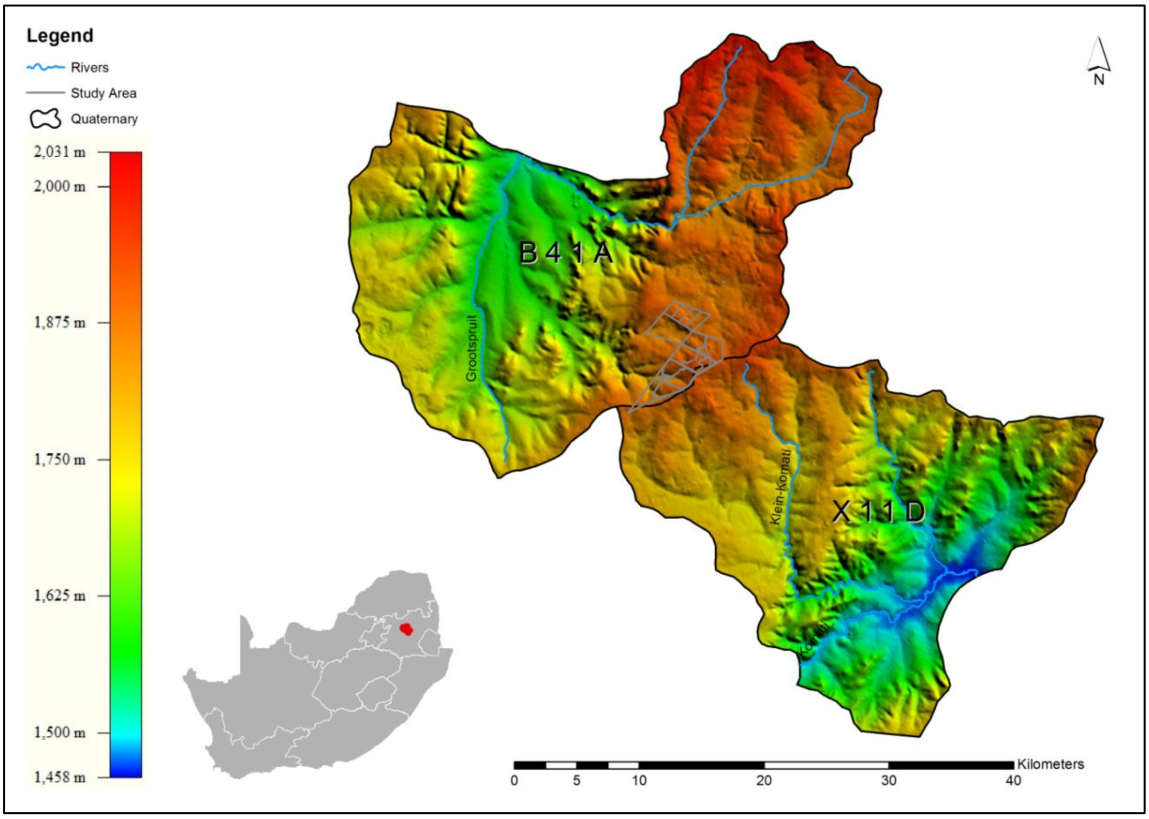


Figure 6: Topography and drainage

There are numerous non-perennial streams on site as shown in Figure 7. There are also nine dams on site.

Local surface water catchments for the full area are shown in Figure 8. From this figure it is clear that that maximum fall in elevation from the highest point on site, situated in the centre of the study towards the lowest point situated in the south western corner is approximately 133m.

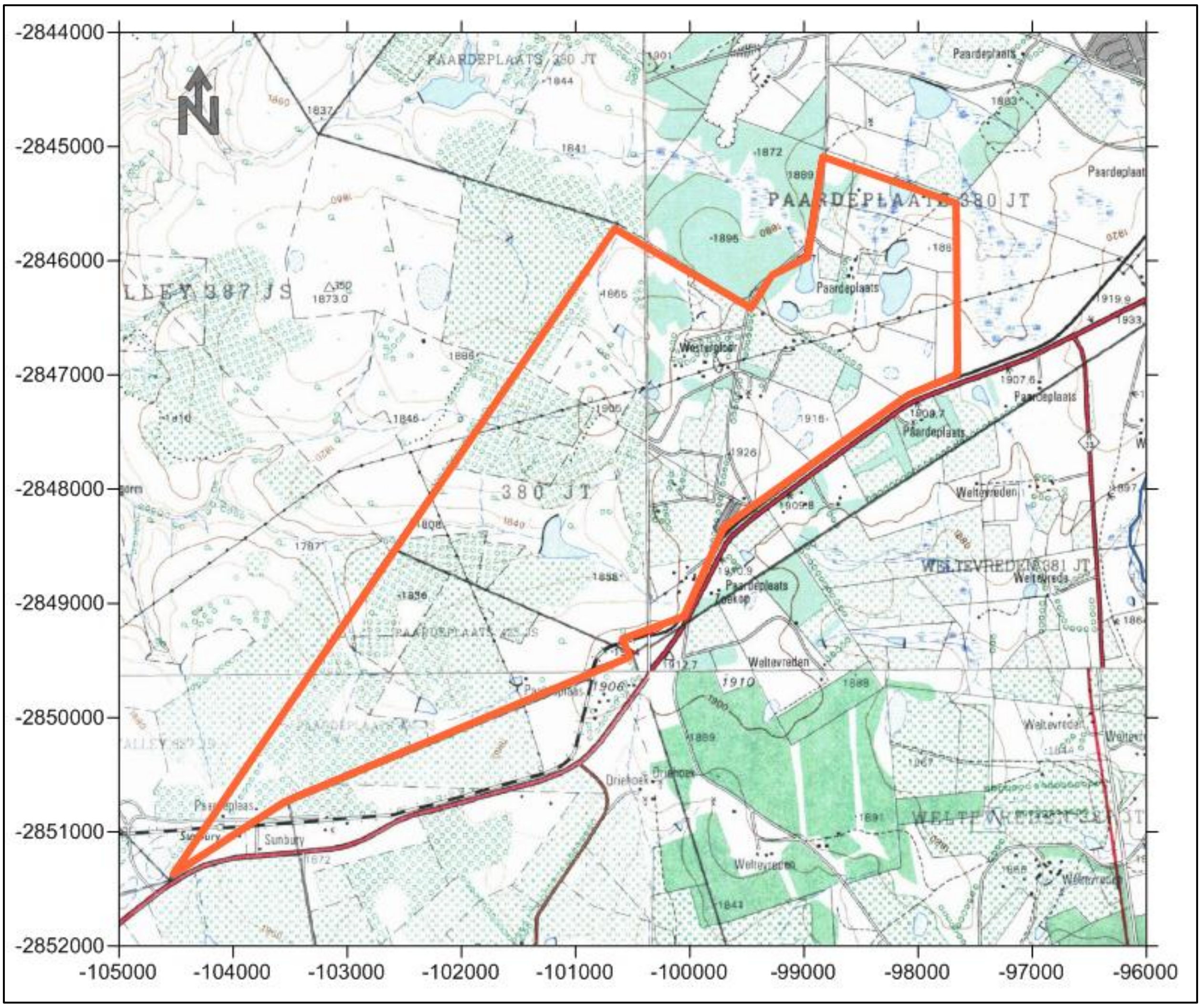


Figure 7: Non-perennial rivers

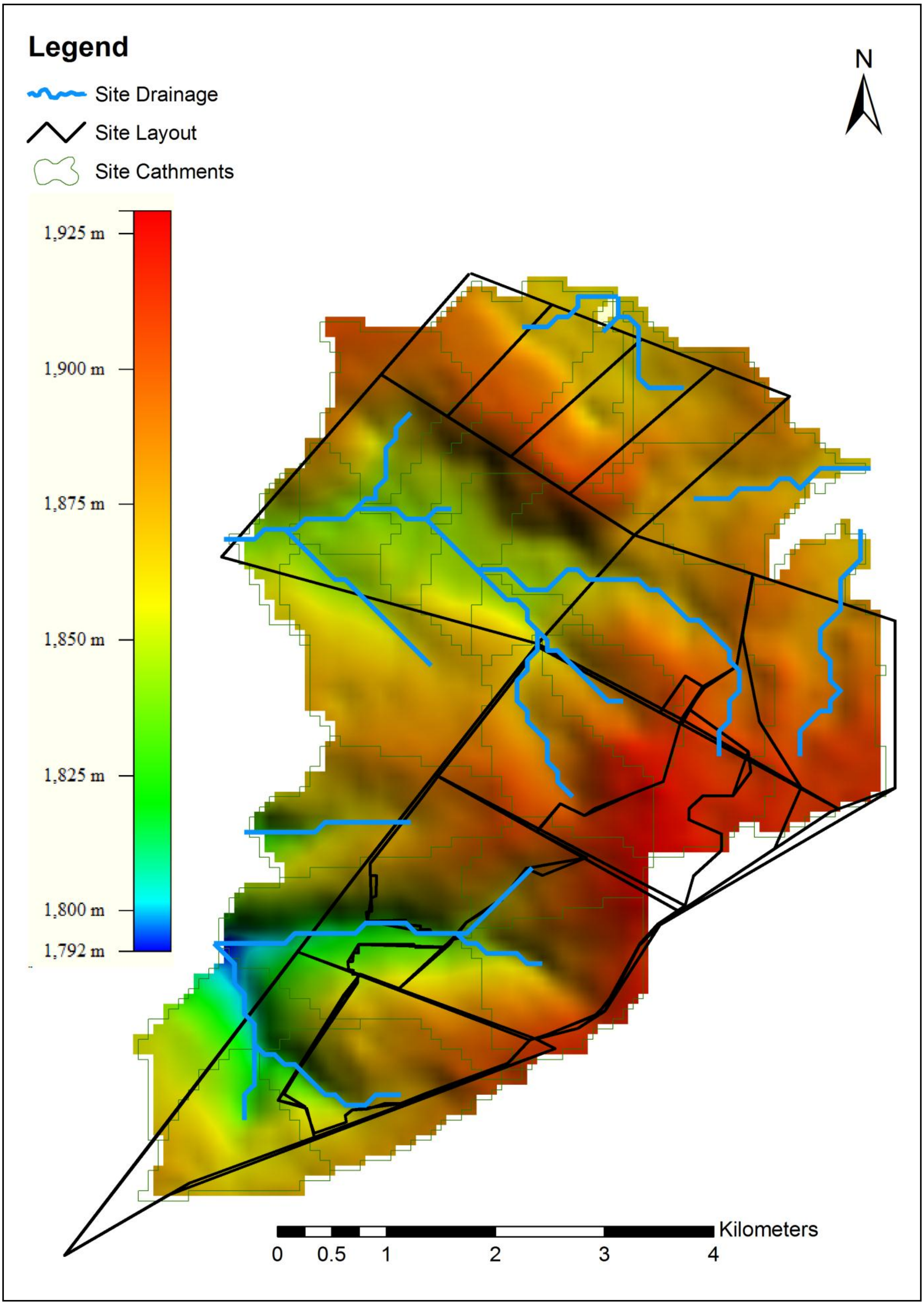


Figure 8: Mining site surface water catchments

2.7 Climate

The regional climate[2] can be described as falling within the Highveld climatic zone, with summer rainfall and cold winters. The average minimum and maximum monthly temperatures are shown in Figure 9.

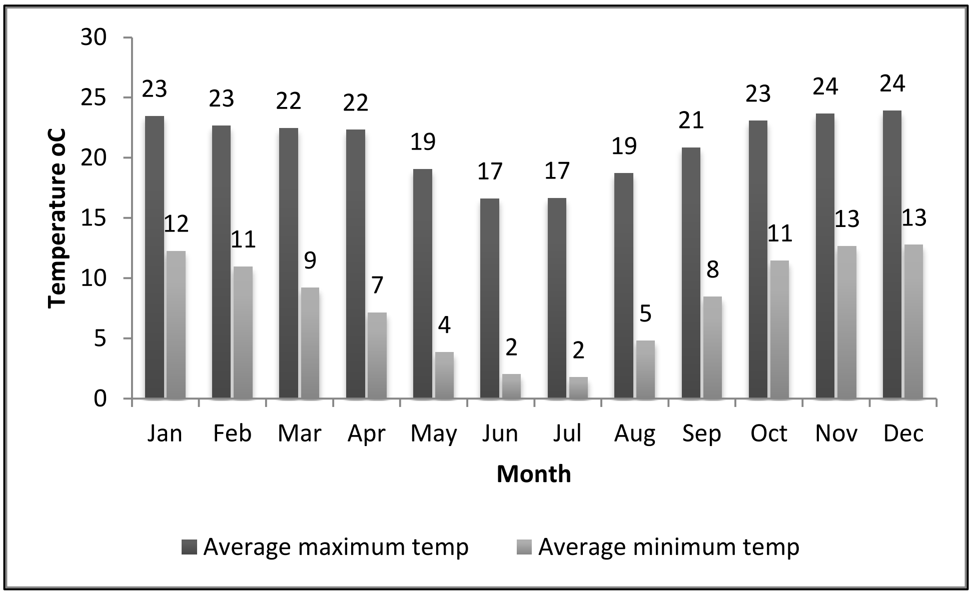


Figure 9: Average temperatures

Belfast lies in the summer rainfall area of South Africa (Figure 10), therefore very little rain occurs in winter, although it is not impossible to have a shower of two during these months. Most of the rainfall occurs in the summer months in the form of thundershowers. Frost occurs regularly in the winter and snow can be expected occasionally. The mean annual rainfall is approximately 750 – 800 mm/a.

[2]The climatic data was provided by worldweatheronline.com

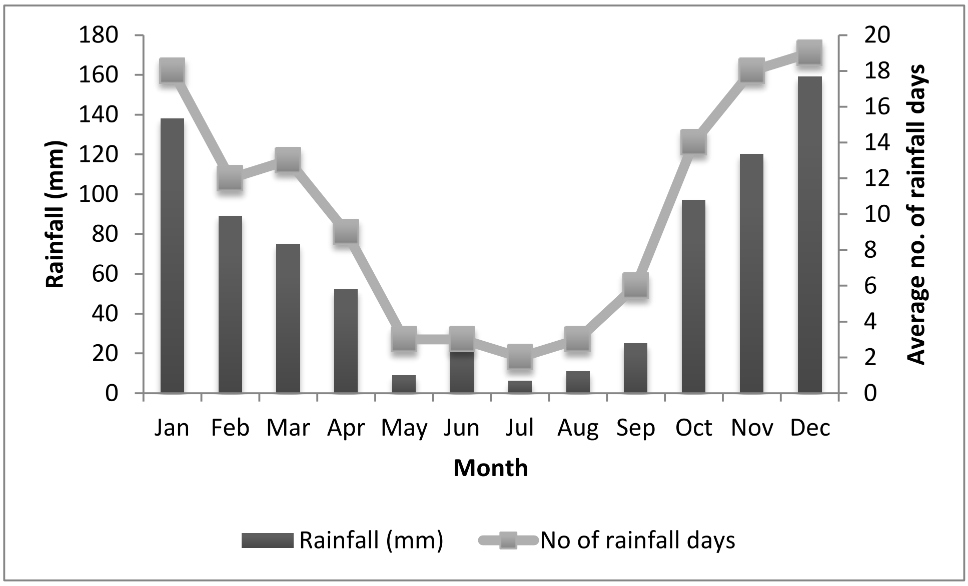


Figure 10: Average monthly rainfall with average number of rainfall days

The mean annual Class A pan evaporation is approximately 1975mm, with the average monthly evaporation shown in Figure 11.

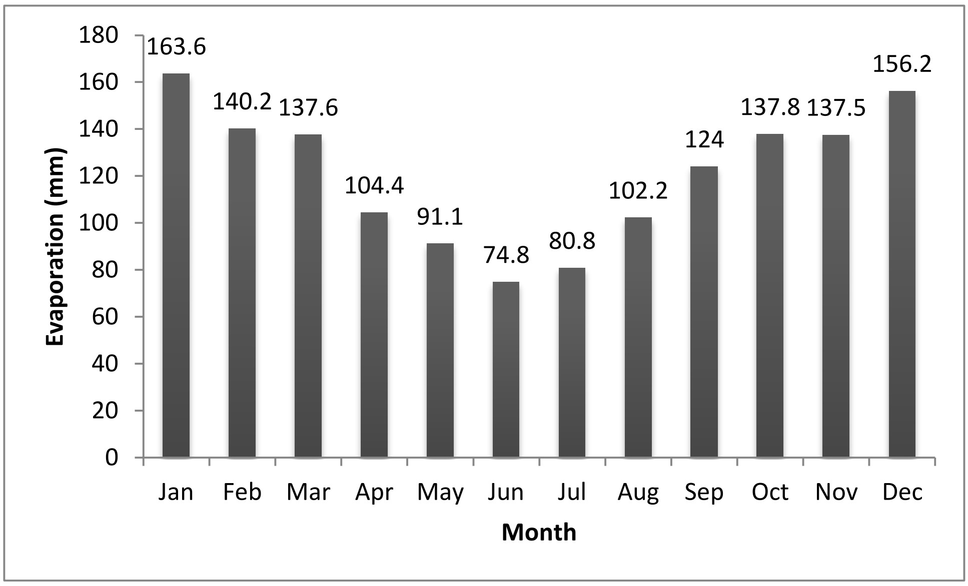


Figure 11: Average monthly class a pan evaporation

3 Background Surface Water Information

3.1 Flow and rain gauging stations

To perform surface runoff modelling rain gauge and flow gauge data is required for calibration purposes. The surface runoff model is done on daily time step as this is the highest resolution rainfall and flow data available. Coarser surface water modelling with regard to time step will not be sufficient for a storm water management plan.

Since no flow and rainfall data is available on site an assessment was done on the closest flow and rainfall station in the vicinity that has daily records available. The list of flow and rain gauges are presented in Table 3 and Table 4 respectively.

Table 3: List of flow gauges

Gauge	Description	Quaternary	Latitude	Longitude
B4H003	Steelpoort River @ Buffelskloof	B41D	-25.029167	29.855556
B4H016	Tonteldoos River @ Mapochsgronde	B41C	-25.278889	29.942500
B4H017	Vlugkraal River @ Mapochsgronde	B41C	-25.230278	29.947500
B4H024	Steelpoort River @ De Hoop Upper	B41D	-25.066667	29.833333

Table 4: List of flow gauges

Gauge	Description	Quaternary	Latitude	Longitude
B1E002	Rondevalley	B12B	-25.925556	29.691389
B1E003	Rondebosch @ Middelburg Dam	B12C	-25.775556	29.545556
B3E002	Loskop Nat. Res. @ Loskop Dam	B32C	-25.413056	29.366389
B3E003	Loskop Nat. Res. @ Loskop Dam	B32A	-25.421389	29.358056
B3E005	Moses River Mouth	B32H	-24.991111	29.351111
B3E006	Loskop Nat. Res. @ Oudestad Exp. Farm	B32H	-25.183889	29.333056
B4E002	Mapochsgronde @ Tonteldoos Dam	B41C	-25.279722	29.941389
B4E003	Buffelskloof @ Buffelskloof Dam	B42G	-24.958333	30.263611
B4E004	Roossenekal	B41C	-25.195556	29.925556
B4E005	De Berg	B41G	-25.225556	30.149722
X1E002	Carolina	X11B	-26.067222	30.116389
X1E003	Nooitgedacht @ Nooitgedacht Dam	X11C	-25.950556	30.078889
X1E006	Vygeboom @ Vygeboom Dam	X11H	-25.883889	30.603889
X2E002	Machadodorp	X21F	-25.667222	30.283056

The geographic positions of the flow gauges are considered together with their respective flow data to delineate a catchment boundary used for the rainfall runoff model. The available flow data for the selected flow gauges are shown in Figure 12. It is clear that that B4H003 has the longest flow record although some suspect flow values are present at 170 m^3/s.

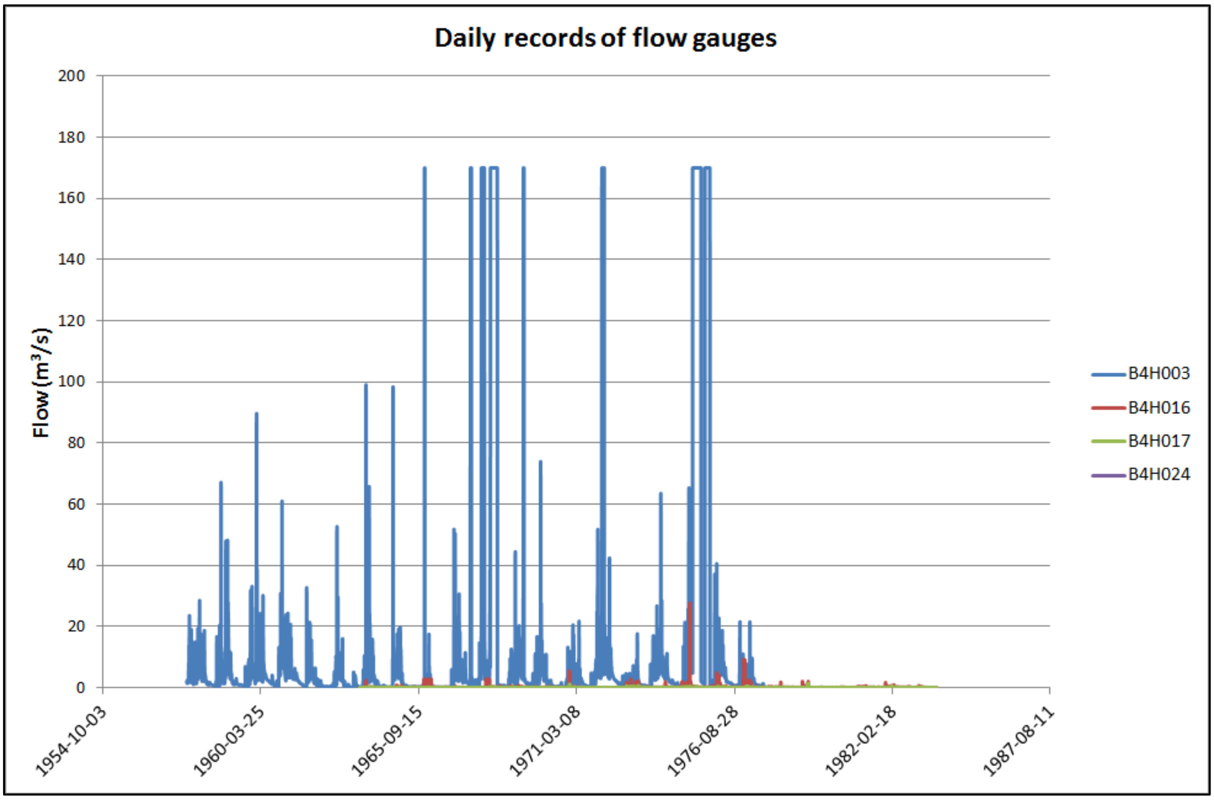


Figure 12: Available flow gauge data

The geographic positions of the flow gauges are presented in Figure 13. B4H003 is an attractive option to use as primary flow gauge to be used for calibration due to the fact that it has the longest flow record and is also the outflow point of a quaternary catchment. The remaining flow gauges can be used for verification purposed.

By using B4H003 as the primary flow gauge, all upstream quaternaries of the study area needs to be included in the catchment delineation as well as all other quaternaries draining to B4H003. This delineation is also presented in Figure 13 and the list of quaternaries considered is as follows:

- B41D
- B41C
- B41B
- B41A

The study area is situated on the B41A catchment boundary with X11D.

The geographic position of rain gauges in the vicinity of the above mentioned quaternaries is shown in Figure 14. The associated rainfall records for all the rain gauges are presented in Figure 15.

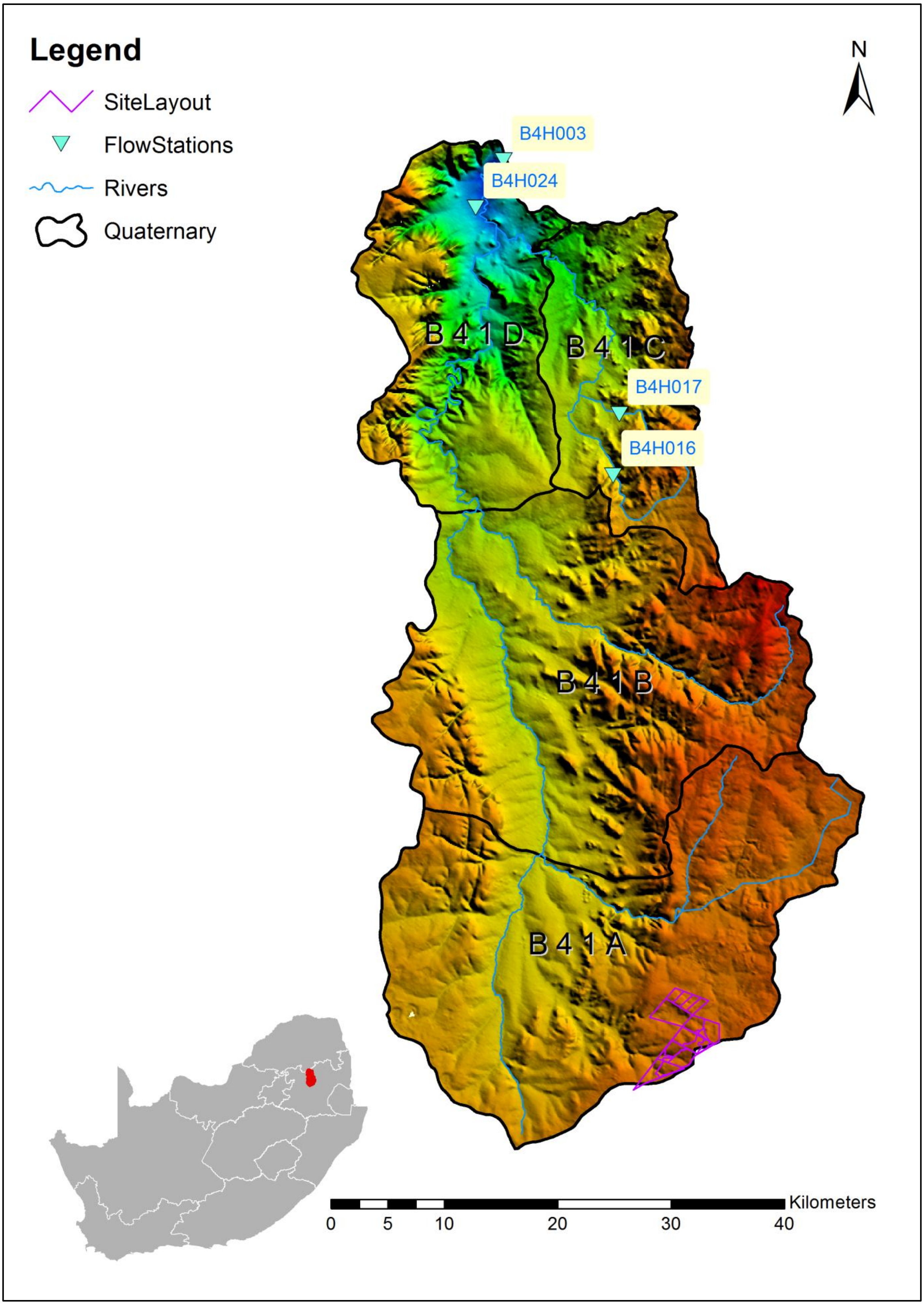


Figure 13: Geographic positions of flow gauges

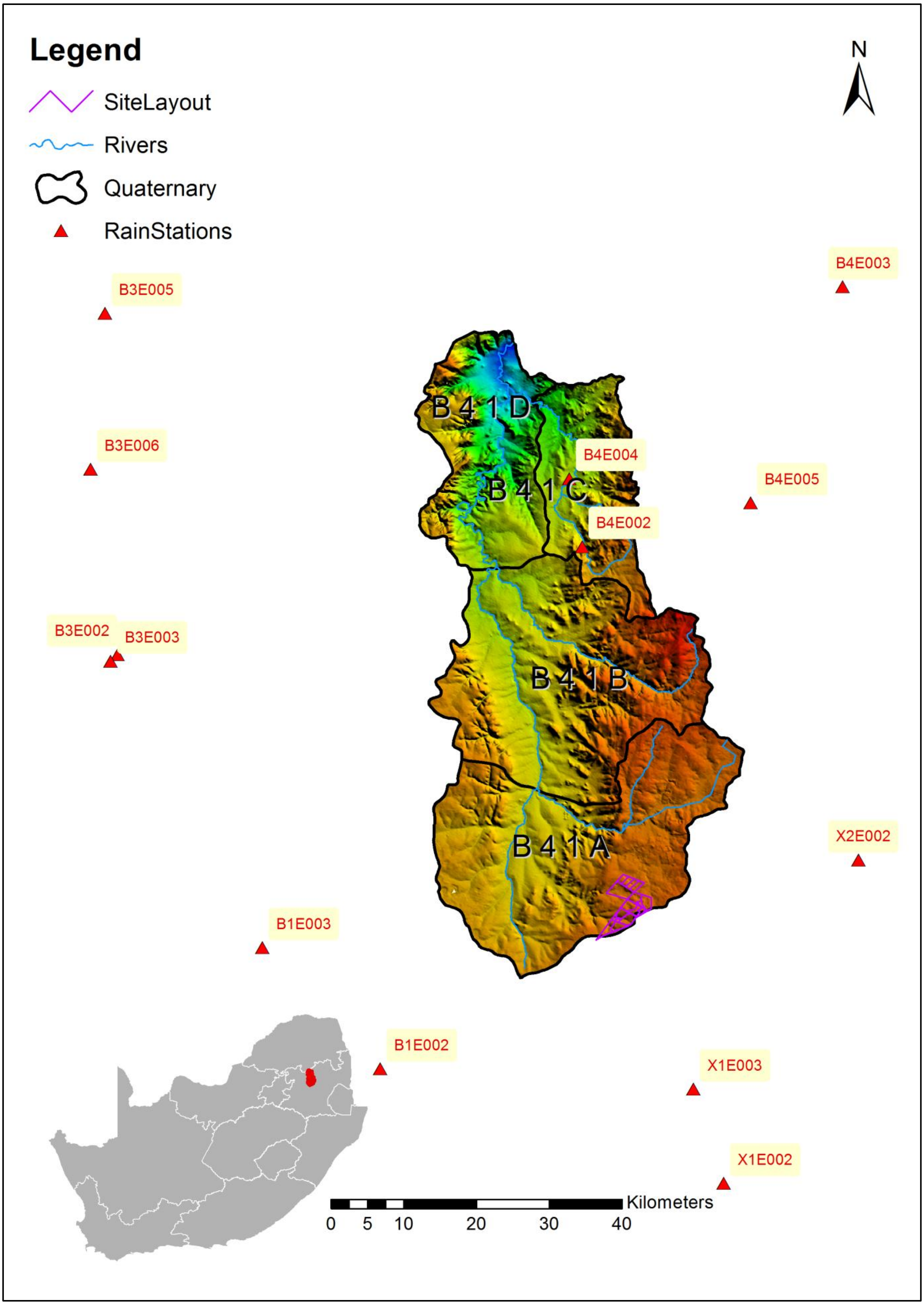


Figure 14: Geographic positions of rain gauges

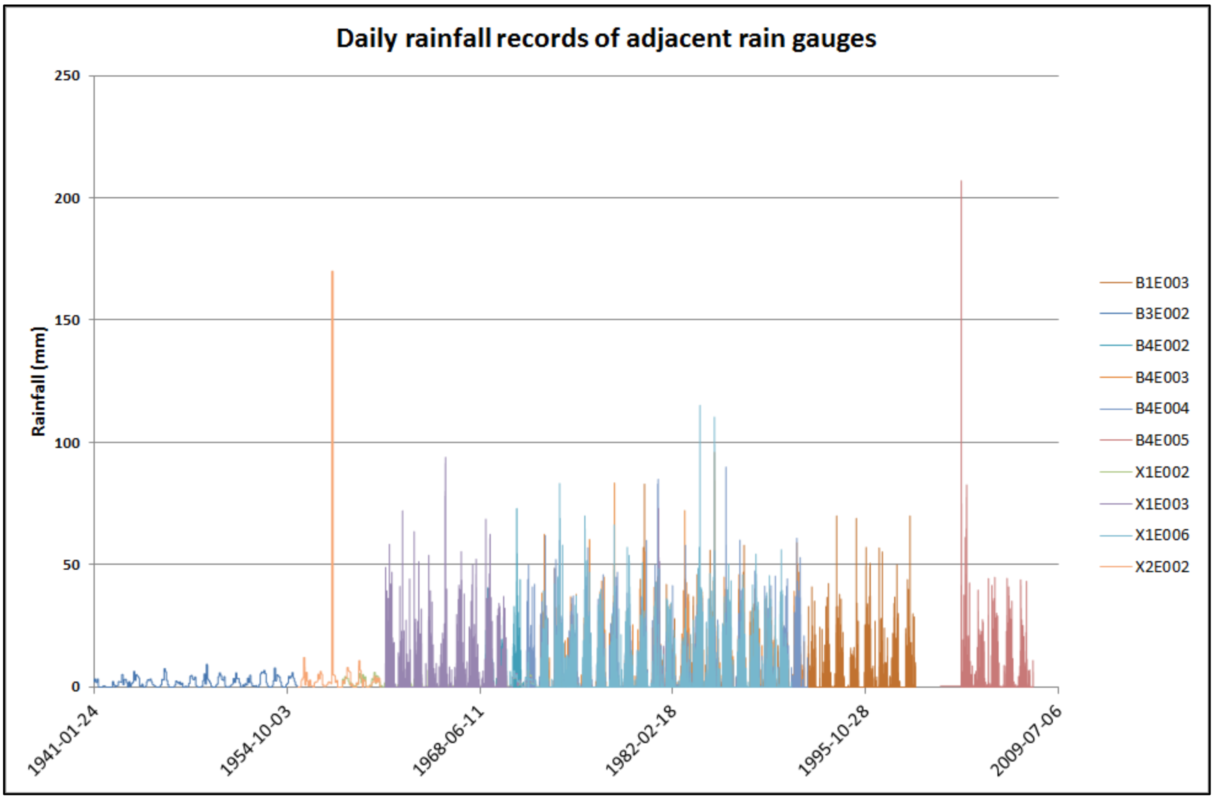


Figure 15: All available rainfall records

The dataset to be used for calibration is chosen where the longest flow and rainfall records overlap. This dataset is shown in Figure 16 where data is available from 1971-10-01 to 1977-08-31. The closest rain gauge (B4E004) to flow gauge B3H004 is used in the calibration.

The additional rainfall station data will be used in the generation of scenarios. It is important from the storm water management plan point of view to present scenarios based on different rainfall sequences from both wet and dry years.

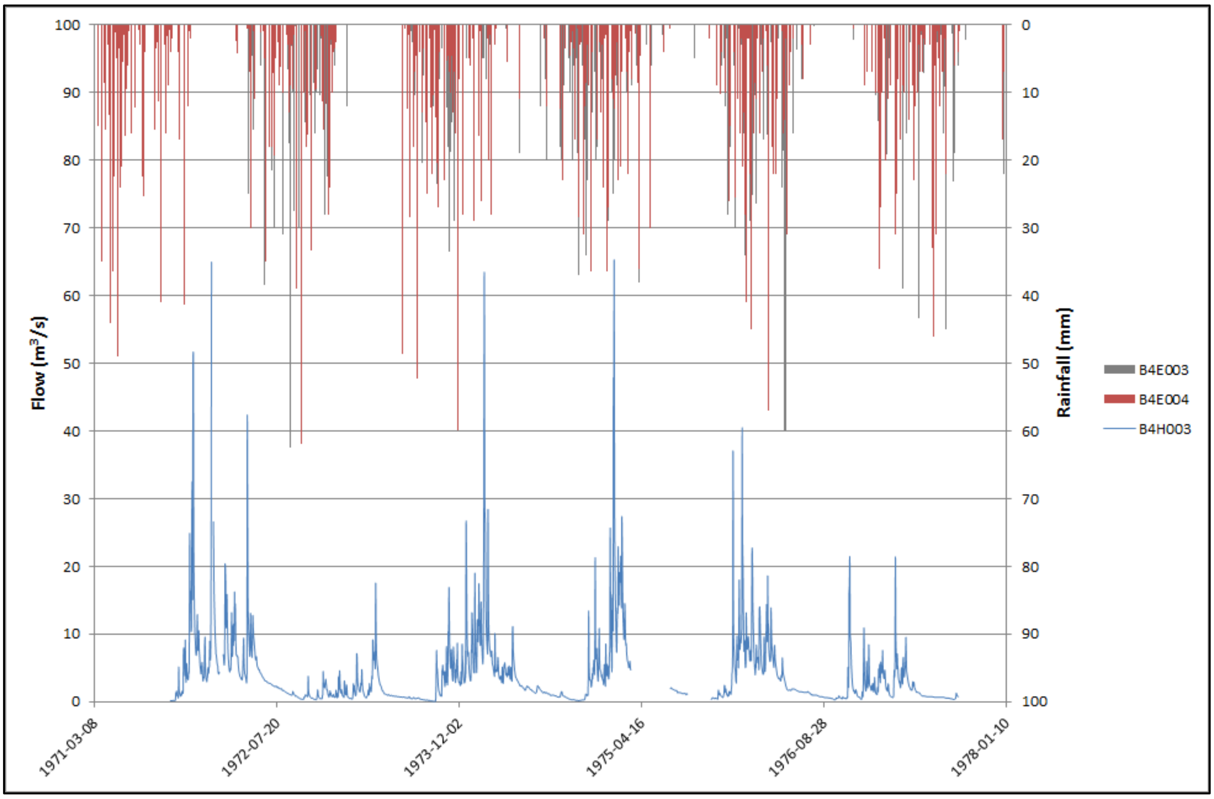


Figure 16: Calibration data set

3.2 Hydrological response units

The delineated catchment is subdivided into hydrological response units (HRUs) as shown in Figure 17. These response units are based on the main drainage line and the flow accumulation criteria selected. This resulted in 11 HRUs which are represented as individual model entities.

Each of the HRU's to be modelled requires certain parameters which are related to the physical catchment. Land cover and the slope are typical parameters required for each HRU.

The catchment land cover and the HRU distribution of the land cover are shown in Figure 18 and Figure 19 respectively. The catchment slope and the HRU slope distribution are shown in Figure 20 and Figure 21 respectively.

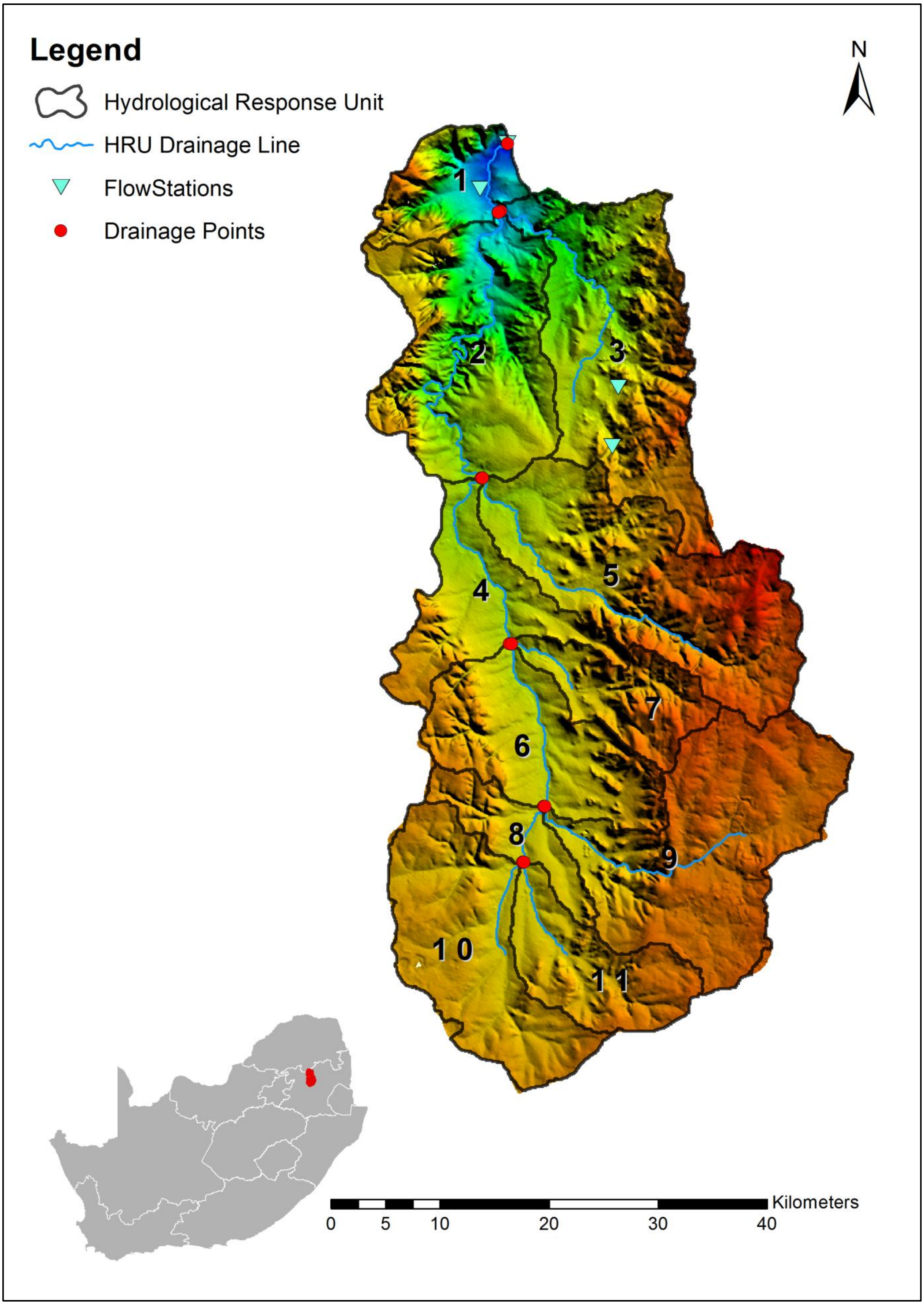


Figure 17: Delineation of hydrological response units

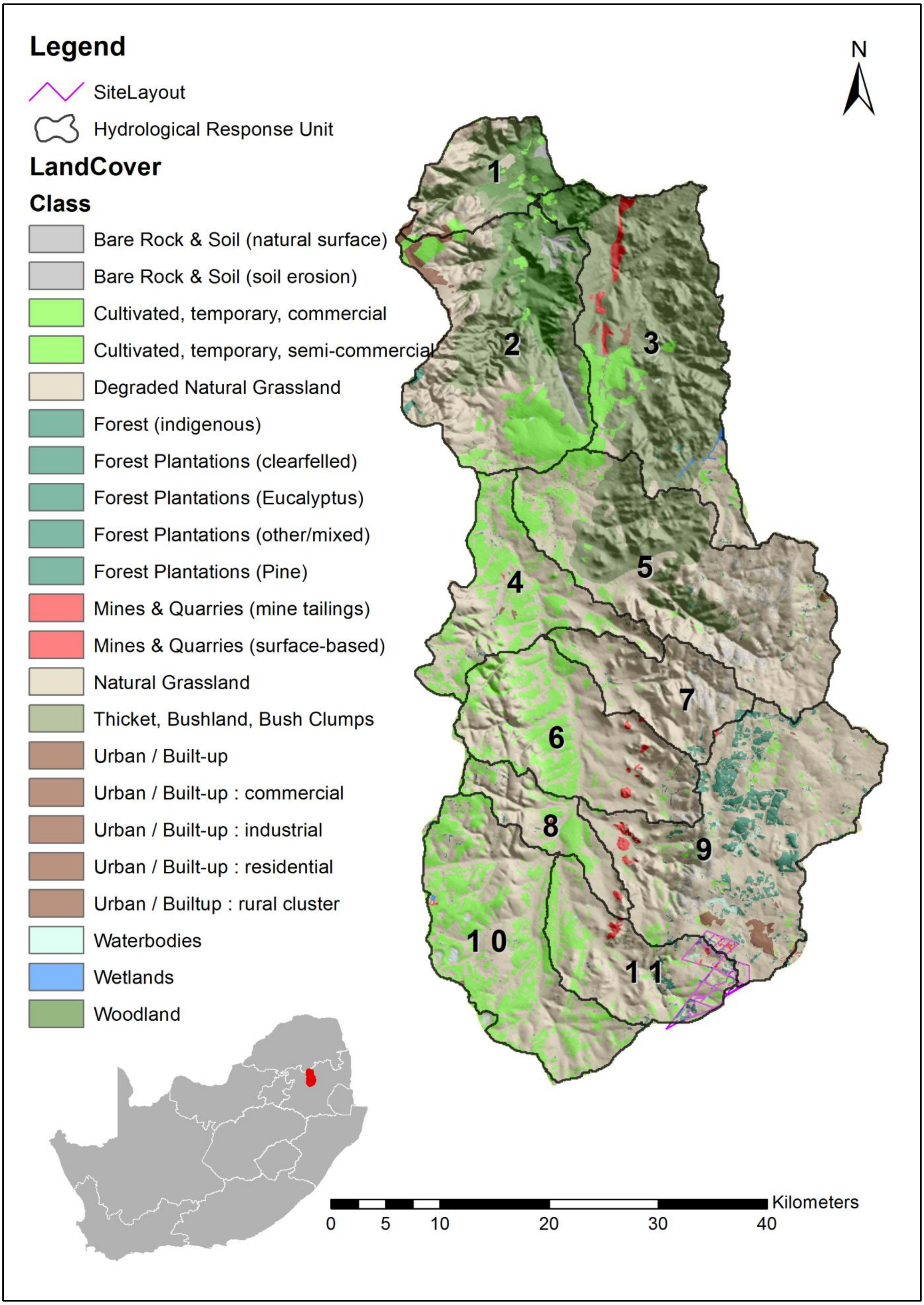


Figure 18: Catchment land cover

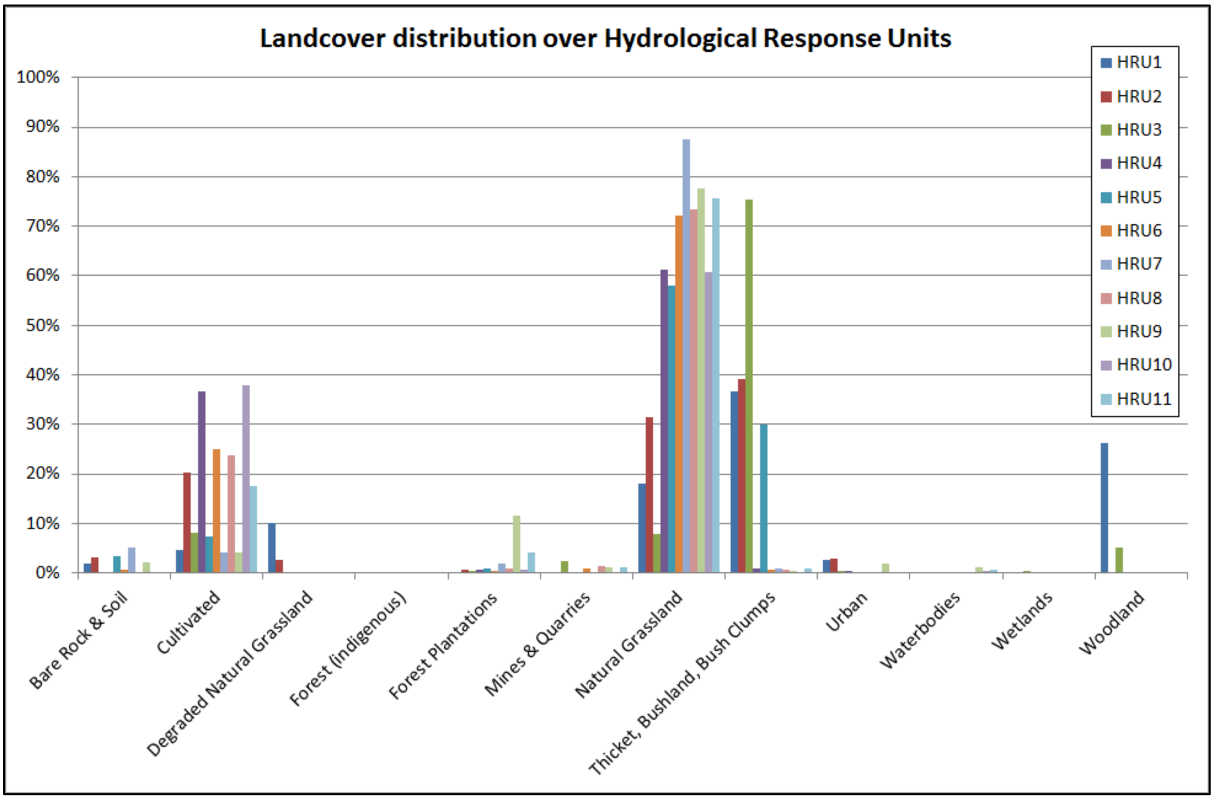


Figure 19: HRU land cover distribution

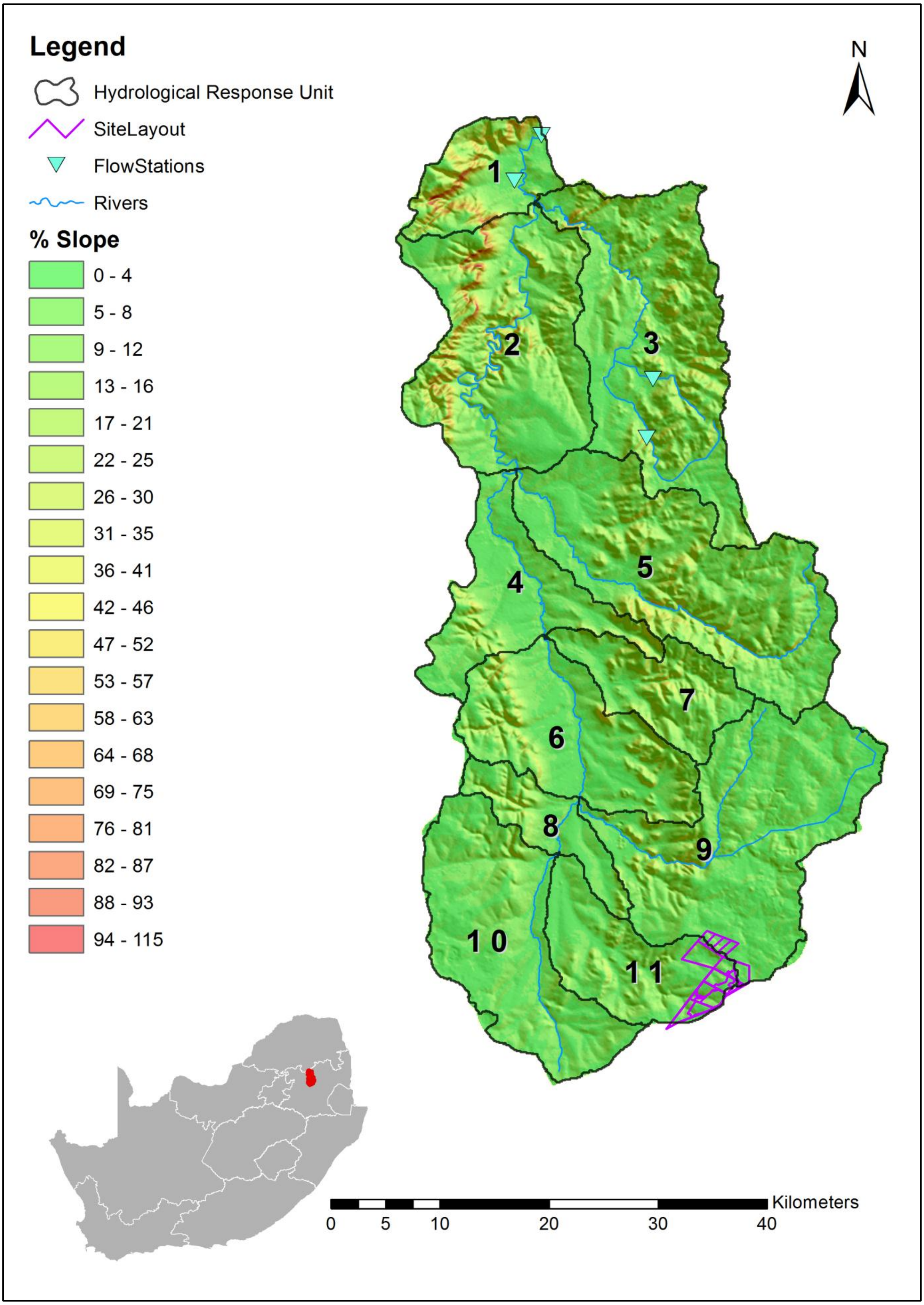


Figure 20: Catchment slope

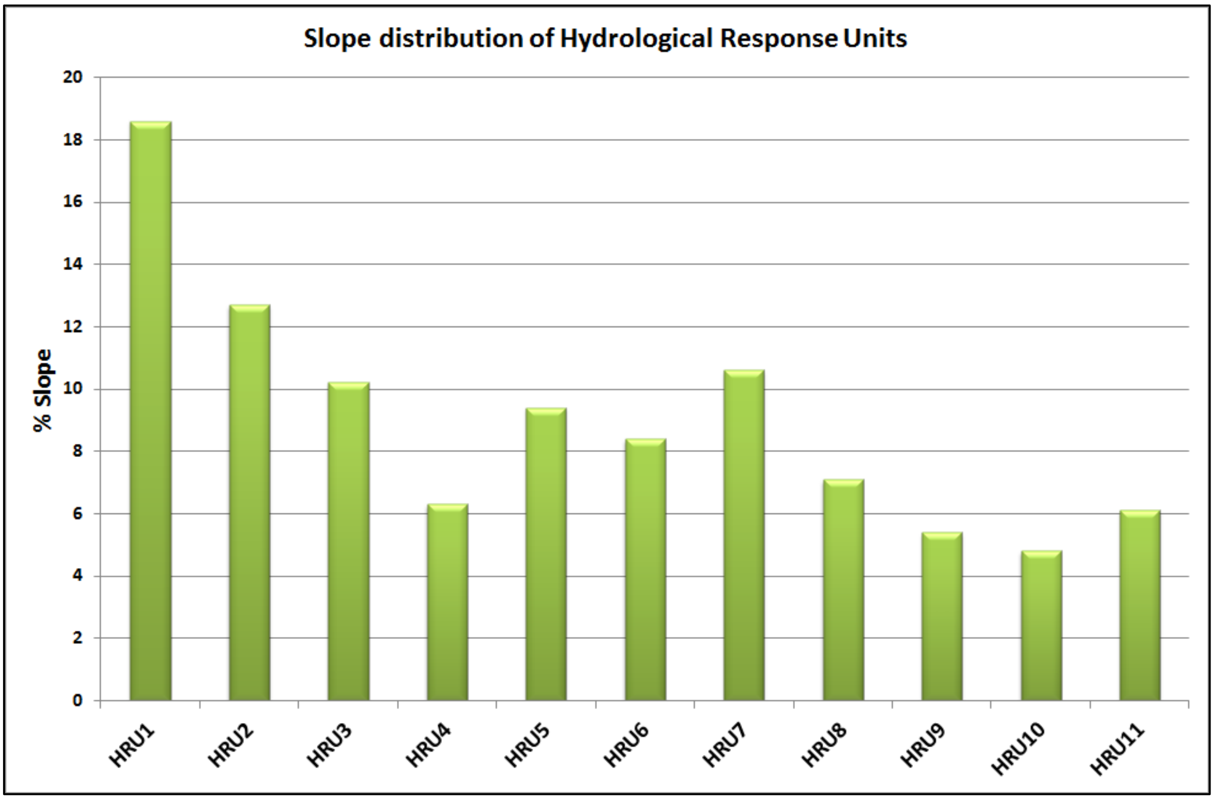


Figure 21: HRU slope distribution

4 Surface water quality

Three hydro census investigations were available namely:

- GCS (2011) hydrocensus for Glisa EMPR
- Aqua Earth hydrocensus August 2012
- Aqua Earth hydrocensus September 2012

Wetland Consulting Services (WCS) conducted wetlands baseline assessment on behalf of Exxaro Glisa Mine for Portions 1, 2, 13, 24, 28, 29 and 30 of the Farm Paardeplaats 380JT during September 2011. The results of study indicated that approximately 27 % of the Paardeplaats study area is covered by wetlands, making up a combined wetland extent of over 338 ha (Table 5). A number of different wetland types were identified, with hill slope seepage wetlands being the dominant wetland type and making up more than 70 % of the wetland area on site. Several dams were also identified within the wetlands, totalling just over 27 hectares.

Table 5 : Areas of different wetland type recorded by GCS during hydrocensus 2010

Wetland	Type Area (ha)	% of wetland area
Channelled valley bottom	20.87	6.17%
Depression/Pan	5.59	1.65%
Hill slope seepage	249.22	73.72%
Unchannelled valley bottom	33.31	9.85%
Sheet-rock wetland	2.05	0.61%
Dams	27.01	7.99

Aqua Earth Consulting (AEC) conducted a hydrocensus in 2012. The hydrocensus included sampling of existing dams and streams located in and around the Mine. Twenty (20) surface water points were located and water samples collected from the surface points and submitted to the accredited laboratory for analyses (Table 6 and Table 7). The surface water monitoring points are indicated in Figure 22.

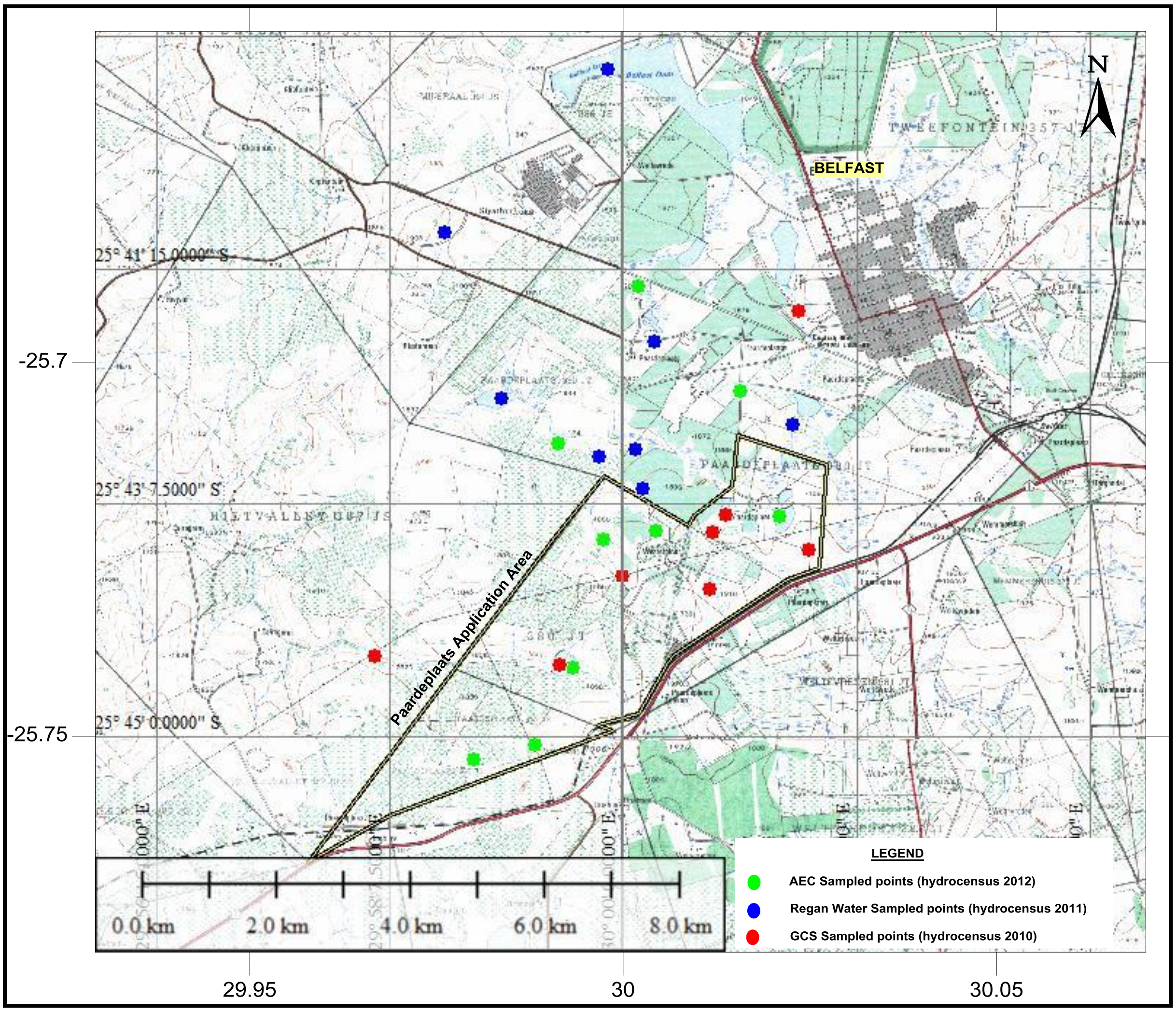


Figure 22: Location of surface monitoring points

Table 6: Hydrocensus data (GCS 2010)

Site Name	Coordinates		Description	Sampled for:
	S	E		
P1	5°42'51.03"	30° 1'20.94"	Farm dam in valley bottom wetland draining into the Langspruit	SASS5, diatoms, water quality
P1A	25°43'29.95"	30° 1'29.46"	Seasonal Depression	SASS5
P2	25°43'13.59"	30° 0'49.60"	Farm dam draining into Glisa Colliery surface right area	SASS5, diatoms, water quality
P3	25°43'22.19"	30° 0'43.36"	Farm dam draining into Glisa Colliery surface right area	Diatoms, water quality
P4	25°43'43.17"	29°59'59.82"	Farm dam in valley bottom wetland, draining into Glisa Colliery surface rights area	SASS5, diatoms, water quality
P5	25°43'49.23"	30° 0'41.72"	Seasonal pan modified into a permanent storage dam	SASS5, diatoms, water quality
P6	25°44'26.95"	29°59'36.08"	Channelised drainage line	Diatoms, water quality
P7	25°44'21.89"	29°58'0.52"	Unnamed tributary of the Steelpoort River, downstream of the study area	Fish, SASS5, diatoms, water quality
P8	25°41'35.14"	30° 1'24.44"	Channelled valley bottom wetland downstream of Paardeplaats as well as the road between Glisa Colliery and Belfast. Drains into the Langspruit	Water quality, Diatoms, Fish

Table 7 : Hydrocensus data (AEC 2012)

Farm Owner	Sample number	Coordinates (WG84) Lat	Long	Time sampled	Date sampled	Use
Stephanie and Victor(Portion 30)	Dam1	25.72357	29.99771	17:20	13.08.2012	Irrigation
Stephanie and Victor(Portion 30)	Dam2	-25.72845	29.999837	11:50	14.08.2012	Irrigation
Stephanie and Victor(Portion 30)	Dam3	-25.722519	30.004467	12:30	14.08.2012	Irrigation
Hadeco	Dam 1	-25.740503	29.991616	08:08	14.08.2012	Irrigation
Willy Pretorius	Dam 1	-25.751196	29.988268	09:59	14.08.2012	Irrigation
Willy Pretorius	Dam 2	-25.753101	29.980048	10:12	14.08.2012	Irrigation
Glisa Mine	Dam 1	-25.710831	29.991267	10:50	15.08.2012	
Glisa Mine	Dam 2	-25.690093	30.000167	11:30	15.08.2012	
Glisa Mine	Dam3	-25.707969	29.978662	12:15	15.08.2012	
Neville Wilke	Dam 1	-25.720521	30.020907	12:50	15.08.2012	Irrigation
Lukas Maseku	Dam 1	-25.70376	30.015664	13:15	15.08.2012	
Nhlupheko Primary School	NPS Dam	-25.76509	E29.95589	08:00	15.08.2012	
--	AEC8 Dam	-28.74101	E30.00848	07:29	15.08.2012	
--	Dam 2	-25.68754	E30.01407	09:23	15.08.2012	
--	Dam1	-25.67329	E30.01621	09:40	15.08.2012	
Masina Farming cc	MF1 Dam	-25.70146	E29.97445	11:59	15.08.2012	
Masina Farming cc	MF2 Dam	-25.68499	E29.96640	13:10	15.08.2012	
Henno	Hdam 1	-25.71694	E30.03543	14:35	15.08.2012	
Exxaro road	Ex Dam 1	-25.70222	E30.037667	15:45	15.08.2012	
Exxaro road (stream)	Ex Dam 2	-25.69597	E30.02480	15:55	15.08.2012	

4.1.1 Chemistry

Chemical results were analysed using the WISH software. Existing monitoring data together with the latest hydrocensus data were compiled into a WISH database. The data included is summarised in Table 8.

Table 8: Chemistry data

Surface sampling points	Locations	pH	EC mS/m	TDS mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Cl mg/l	SO4 mg/l	NO3-N mg/l	F mg/l	Fe mg/l
SVDam1	Portion 30	6.46	19.3	150	3.81	4.89	21.9	10.3	46.7	10.1	0.3	0.178	1.16
SVDam2	Portion 30	7.33	13.1	92	4.23	6.78	12.1	5.75	19.7	4.89	0.35	0.176	0.92
SVDam3	Portion 30	6.6	8	60	2.8	2.45	8.65	5.71	8.81	11.2	0.3	0.238	0.74
HDam 1	Portion 40	7.55	24.1	170	18.2	12.7	9.4	5.1	17.6	50	0.3	0.265	0.05
WPDam 1	Portion 2	6.48	48.7	466	15	10.5	50.6	35.9	119	17.9	0.3	0.441	10.2

WPDam 2	Portion 2	6.79	12.9	114	7.27	5.39	10.1	4.89	13.5	26.6	0.32	0.171	1.01
NWDam1	Portion 13	7.59	8.1	52	4.19	6.35	5.8	1.53	4.08	8.05	0.3	0.266	0.39
LMDam 1	Paardeplaats	7.09	36	282	22.6	18.4	14.7	9.2	20.2	7.19	0.3	0.462	0.17

SANS241:2005

CLASS I: Recommended Operational Limit	5-9.5	<150	<1000	<150	<70	<200	<50	<200	<400	<10	<1	<0.2
CLASS II: Max Allowable/ Acceptable	4.0 - 10.0	150-370	1000 - 2400	150-300	70-100	200-400	50-100	200-600	400-600	10.0 - 20.0	1-1.5	0.2 - 2
Above Class II Limits	10>	370>	24000>	300>	100>	400>	100>	600>	600>	20>	1.5>	2>

WISH supports various illustrative presentations of chemical data. Time series plots are a convenient way in which to understand the changes in water quality over time. All available EC (electrical conductivity) data for the groundwater sites is shown in Figure 23. It is clear from the data that the EC are well below the SANS 241:2005 drinking water guideline. EC is a good global indicator to identify possible problems in most water quality analysis. The data or the major cations are shown in Figure 23 to Figure 30.

Figure 27

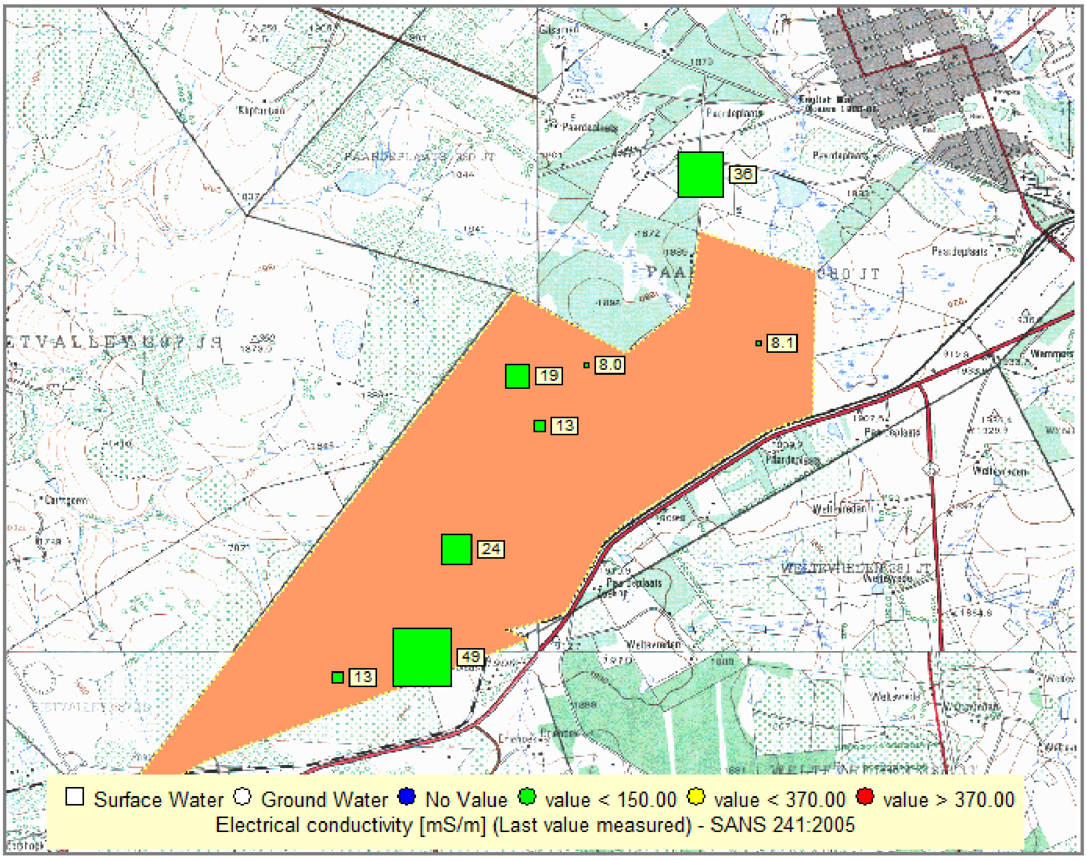


Figure 23: EC data

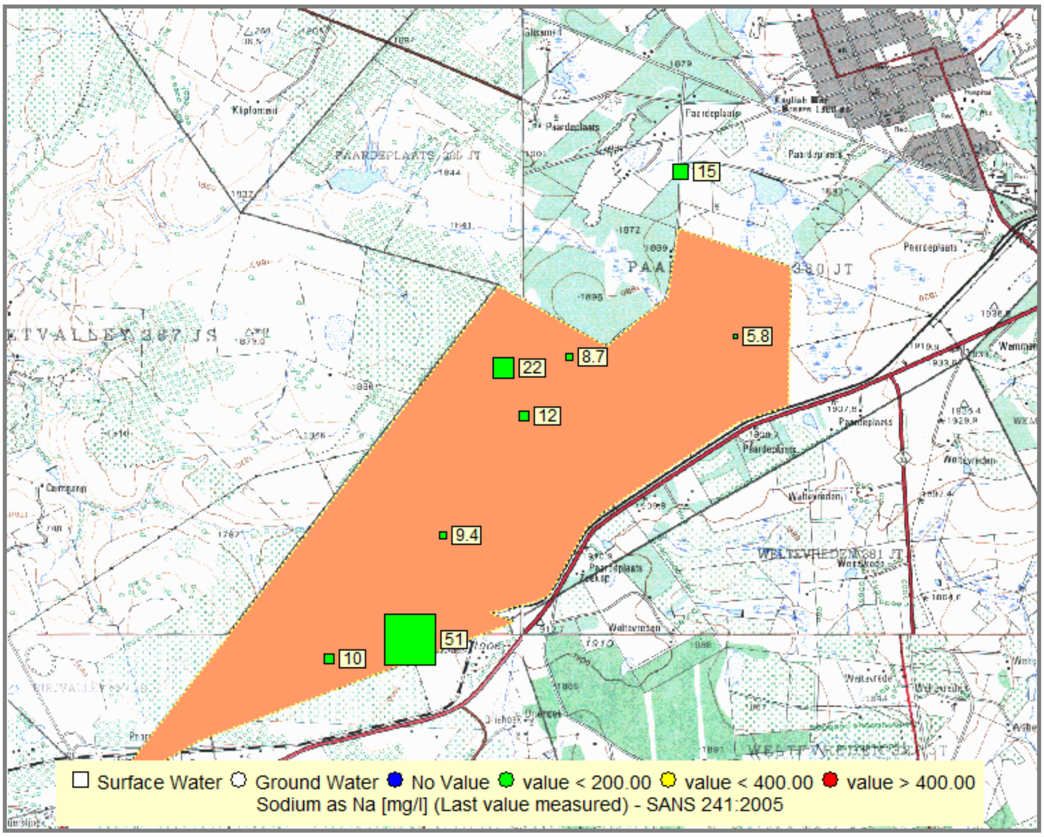


Figure 24: Sodium data

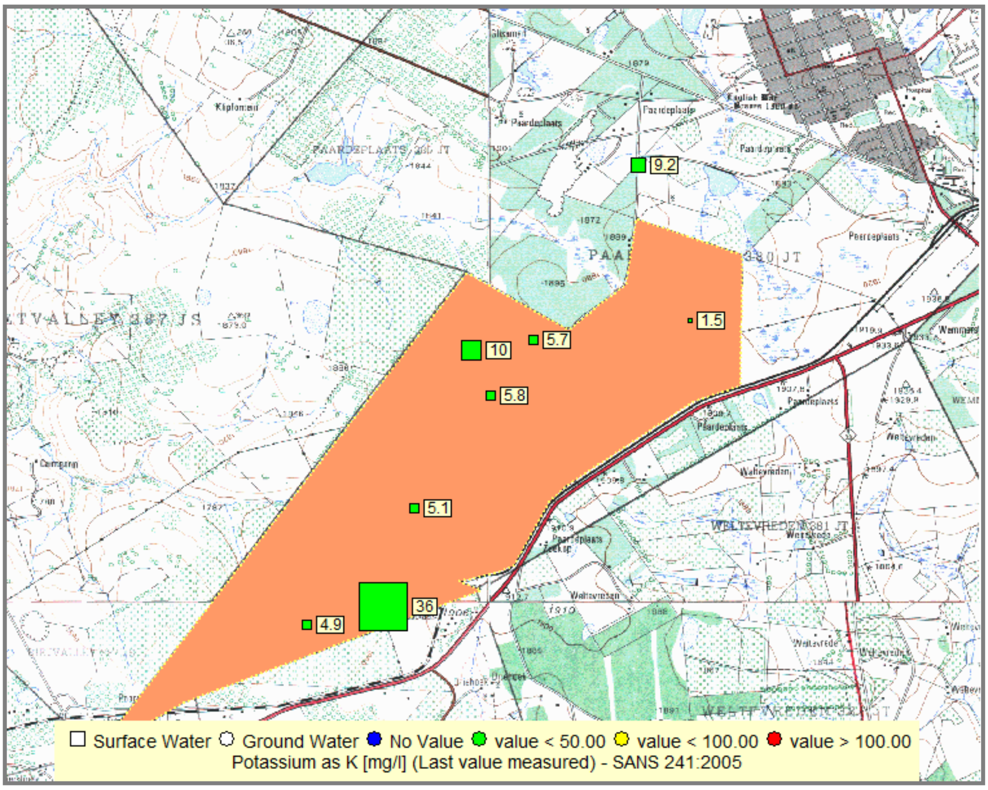


Figure 25: Potassium data

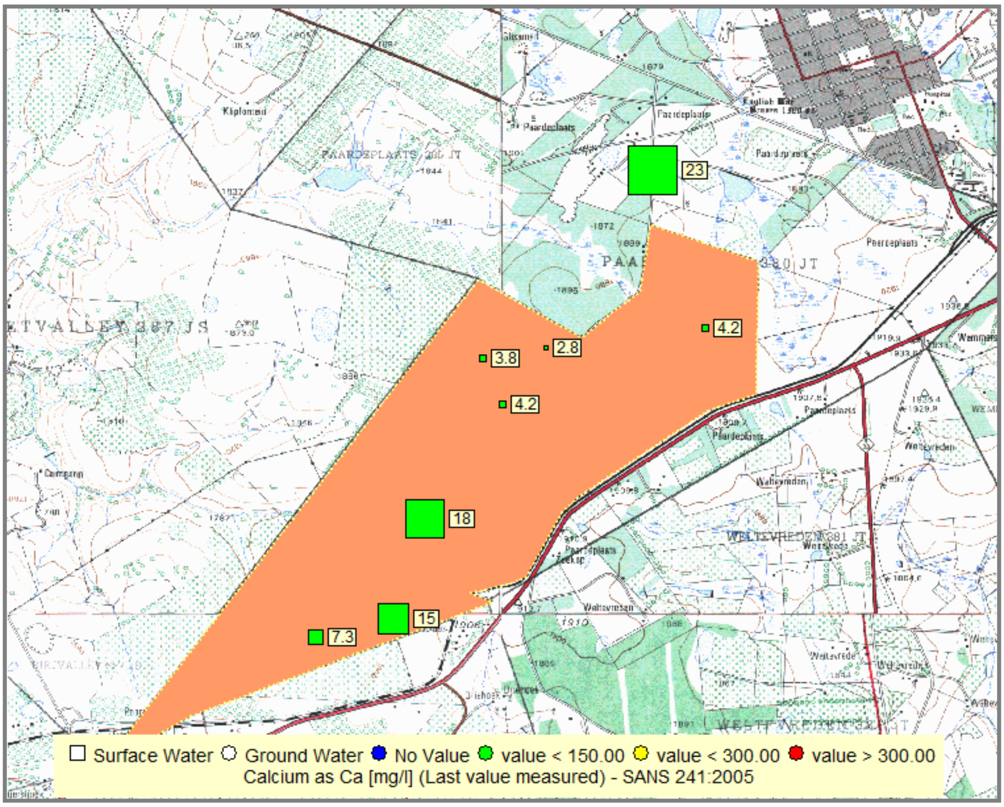


Figure 26: Calcium data

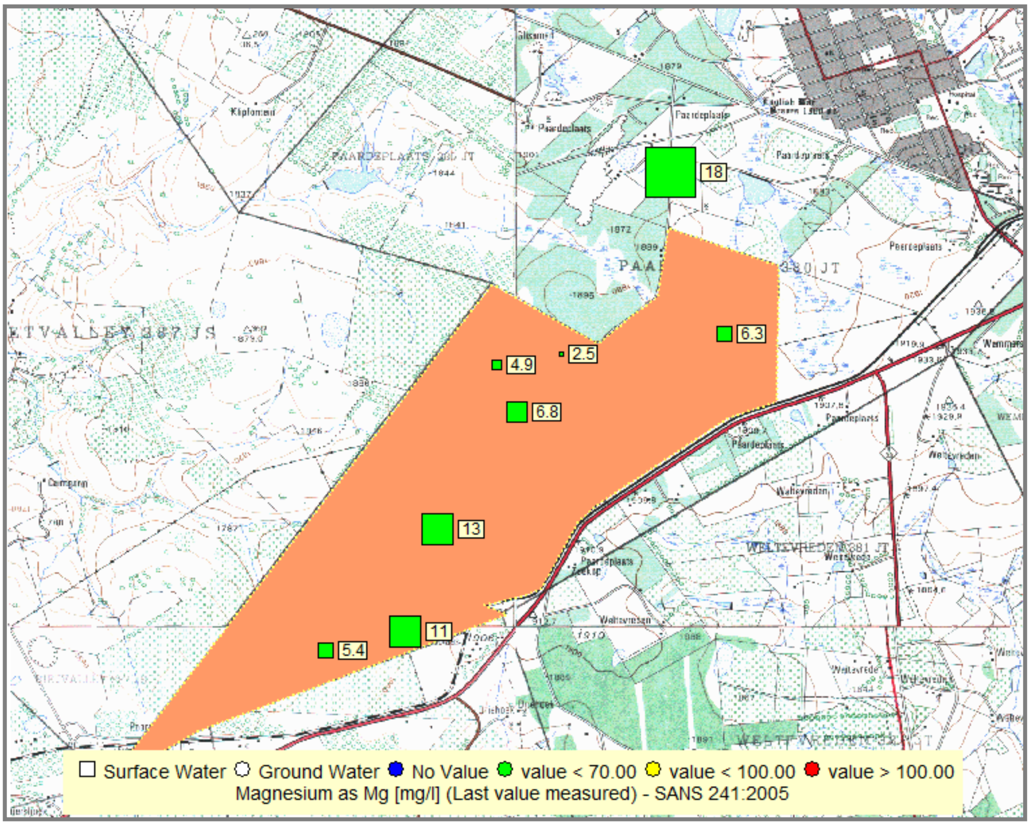


Figure 27: Magnesium data

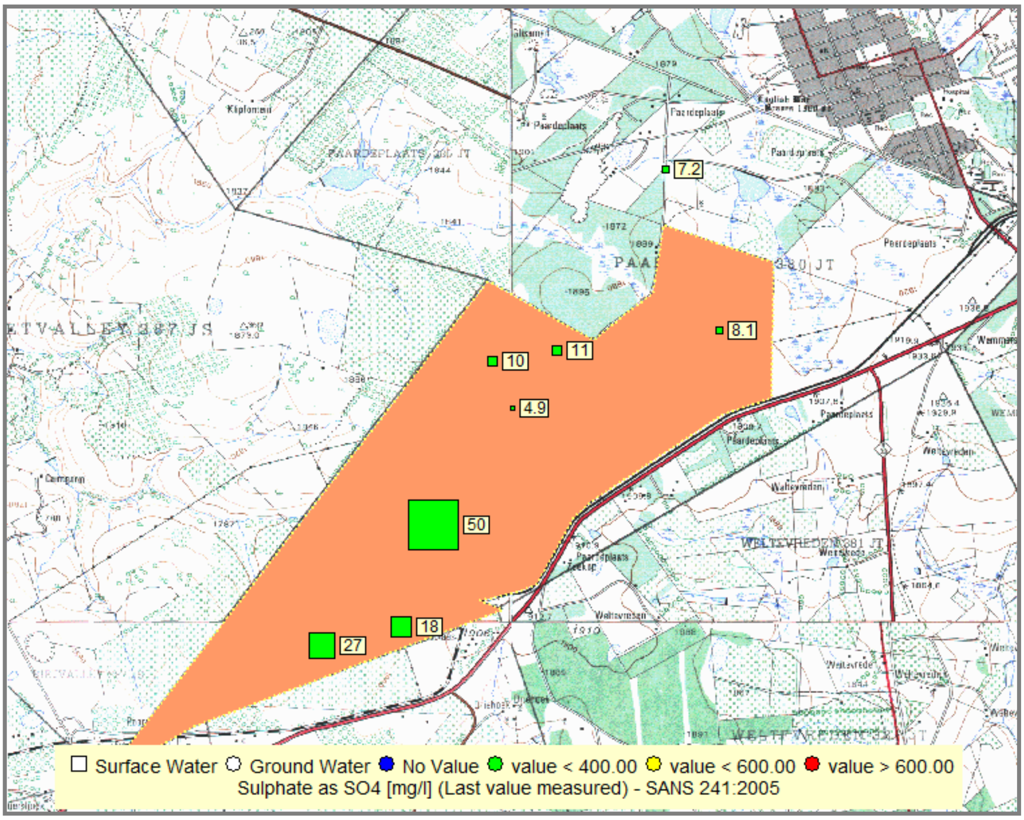


Figure 28: Sulphate data

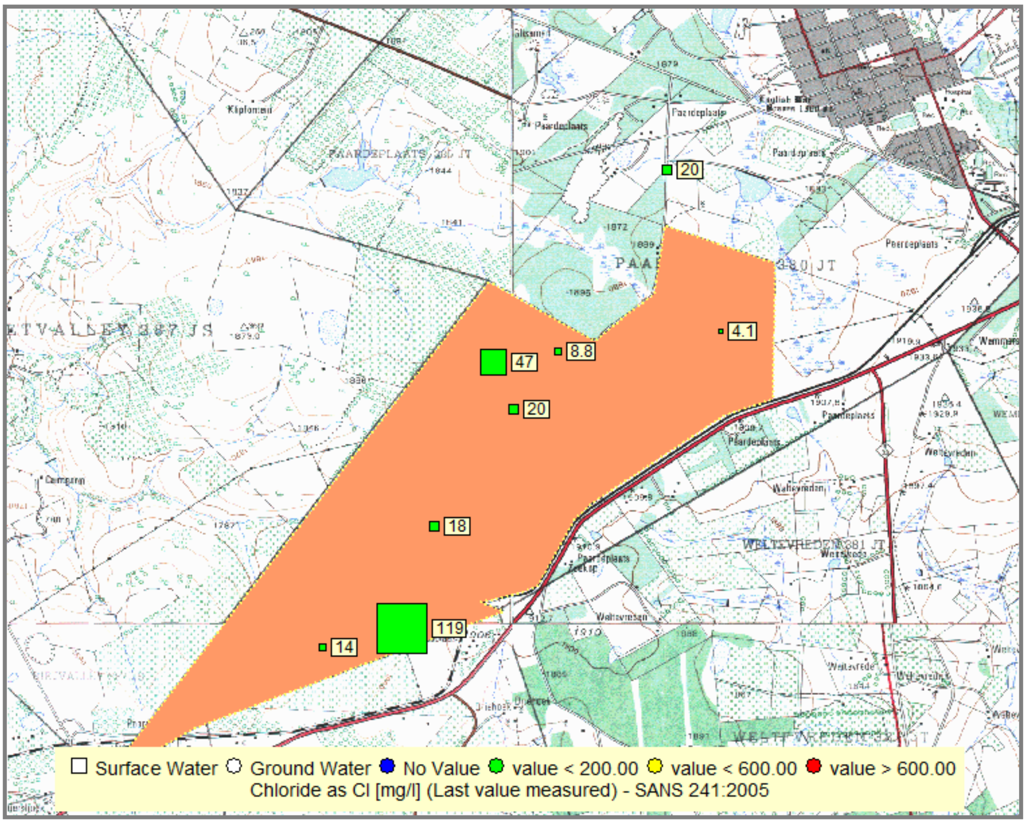


Figure 29: Chloride data

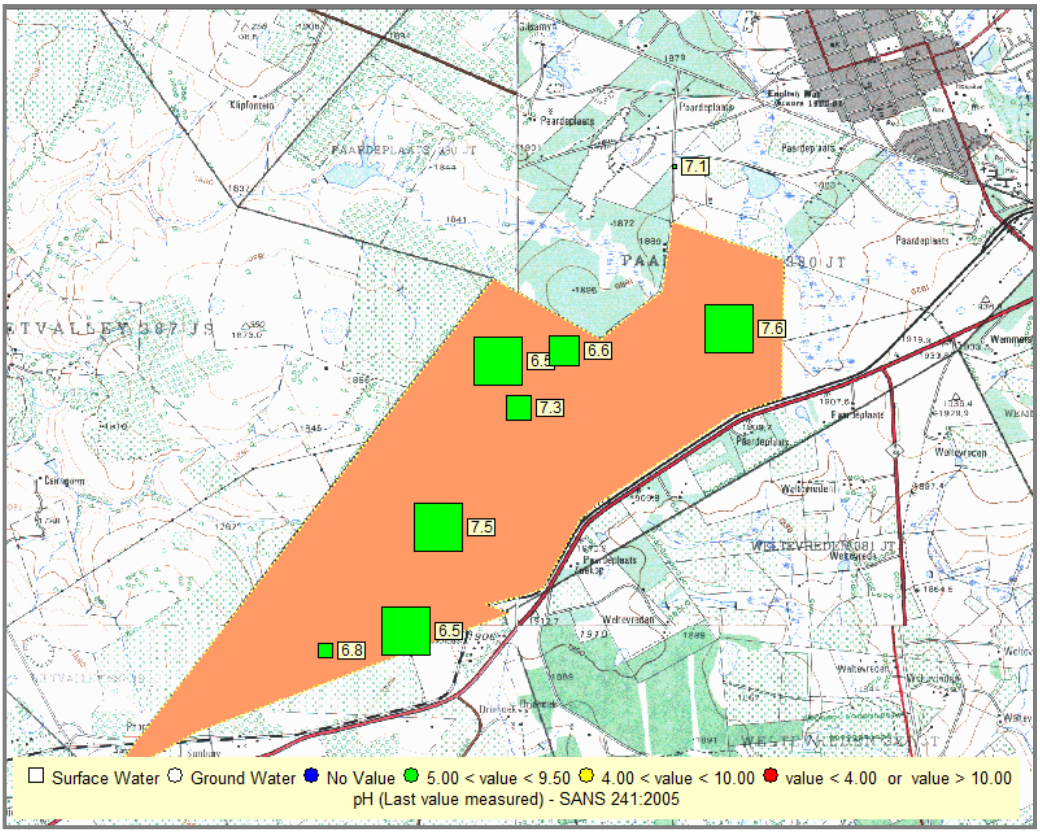


Figure 30: pH data

It is clear from the available data on the major cations and anions that all sites are well below the SANS 241:2005 drinking water guideline.

In terms of other chemical parameters, it is clear that the pH values shown in Figure 30 are within a relatively narrow band of neutral to slightly acidic. Slightly elevated total iron concentrations are also detected in most of the surface water samples.

The pH is important since it is a bulk indicator of changes. These values also limit the mobilisation of metals and as long as pH values remain in this band, metal content should remain low and consequently environmental impacts should be limited by this. It is a known fact that aluminium can mobilise at pH values as high as 10.

A detail explanation on the Piper diagram is provided in Appendix B. The Piper diagram for all the surface samples is shown in Figure 31, with the average data presented. The following associations can be made with the Piper diagram:

- HDam1, WPDam2 : Sodium bicarbonate/chloride waters
- LMDam1, NWDam1, SVDam2 : Calcium/magnesium bicarbonate waters
- SVDam1, SVDam3, WPDam1 : Calcium/sodium sulphate waters

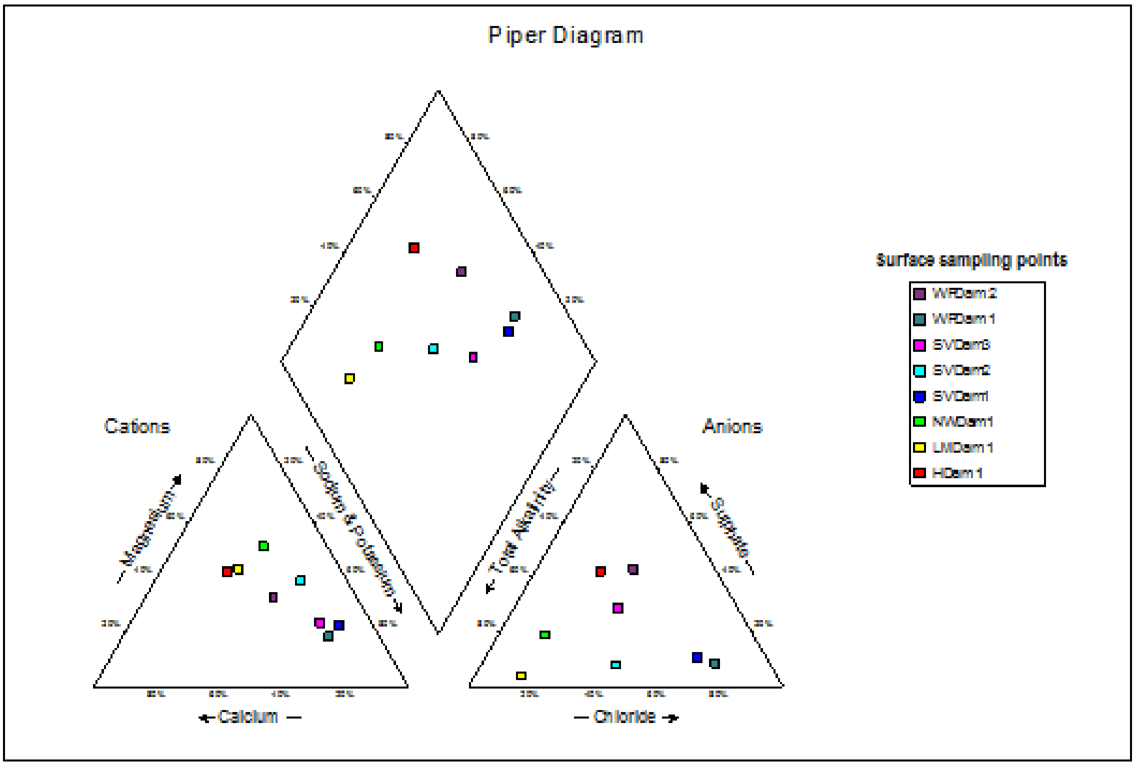


Figure 31: Piper diagram for surface sampling points

5 Surface water Modelling

5.1 Mining activities that can impact surface water (WSP, 2012)

The following changes to the catchment needed to be incorporated into the modelling to account for the change from baseline conditions:

- During mining operations, the mine pit will not contribute to the catchment runoff. The stockpiles should be bermed and lined. As a result, area will not contribute to the catchment runoff.
- Haul roads will increase impervious areas.
- The operations area should have a berm surrounding it, and any surface runoff will be directed into the pollution control dam
- Mining areas will be backfilled with stockpiled material. This material will be re-vegetated
- Decanting from the mine will occur. This water must be treated if necessary before releasing it into adjacent streams.

The rainfall runoff model used is the Stormwater Management Model from the EPA (Environmental Protection Agency of the United States). The model network used for calibration is shown in Figure 32. Once model calibration is achieved the model can be downscaled to the immediate catchment area of the study area to setup the storm water management plan. Detail cross-section information is then used with the design rainfall to generate flood lines to be used in the storm water management plan.

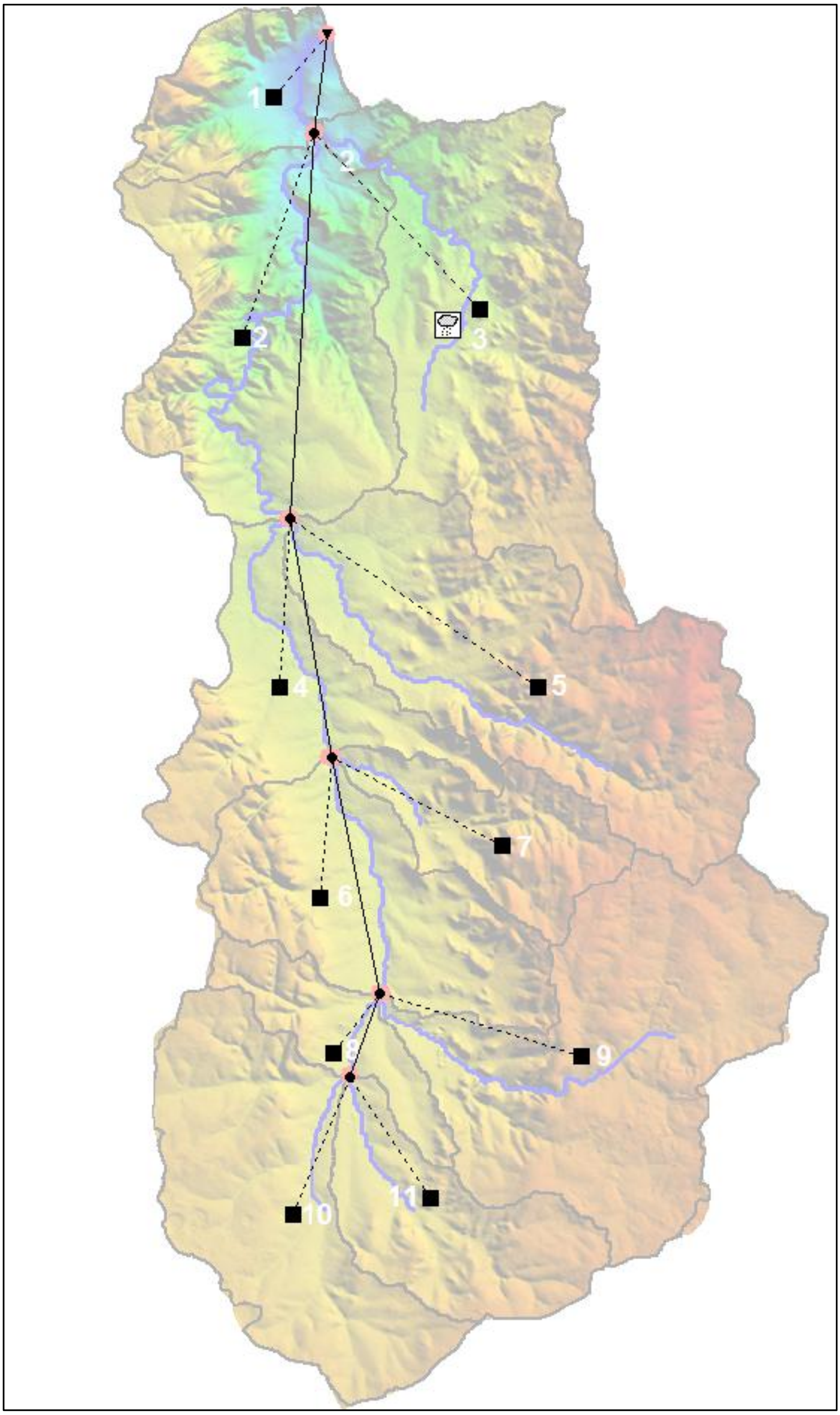


Figure 32: Model network

The resulting calibration of the regional model is shown in Figure 33 and the calibration was done to try and simulate measured peaks as good as possible. The low flow conditions show that the model is overestimating flow somewhat which is not a problem as the peak flows are of importance from a flooding perspective.

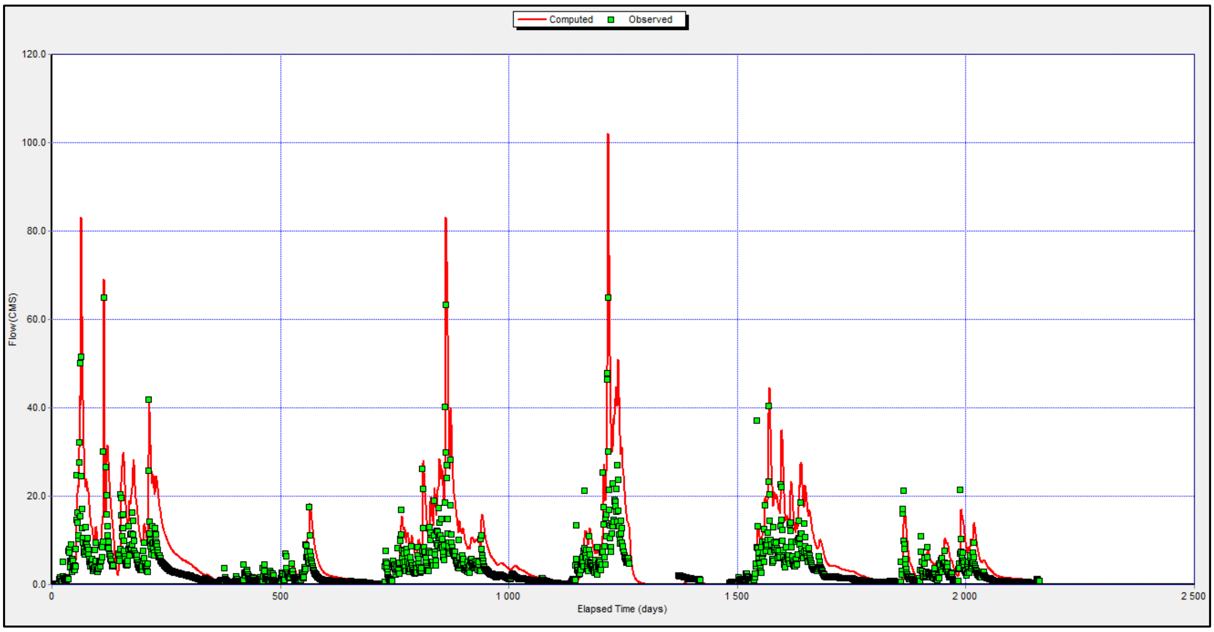


Figure 33: Regional surface water model calibration

The regional model is down scaled to the immediate vicinity of the site (Portion 30) of the proposed mining area as shown in Figure 34.

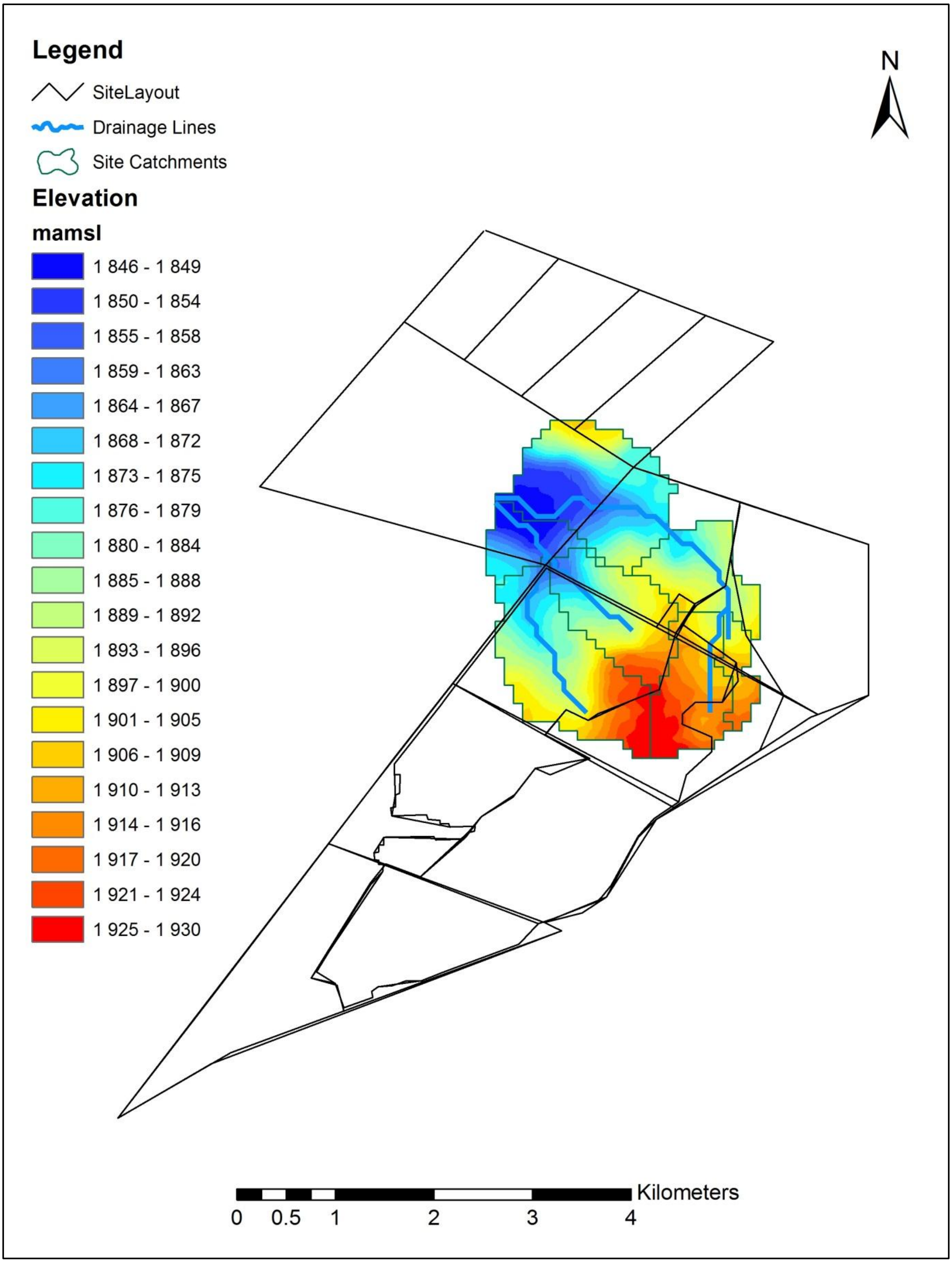


Figure 34: Portion 30 surface water modelling catchments

The representative model network for the site is shown in Figure 35. Note the SRTM 90m data set was used for elevation data.

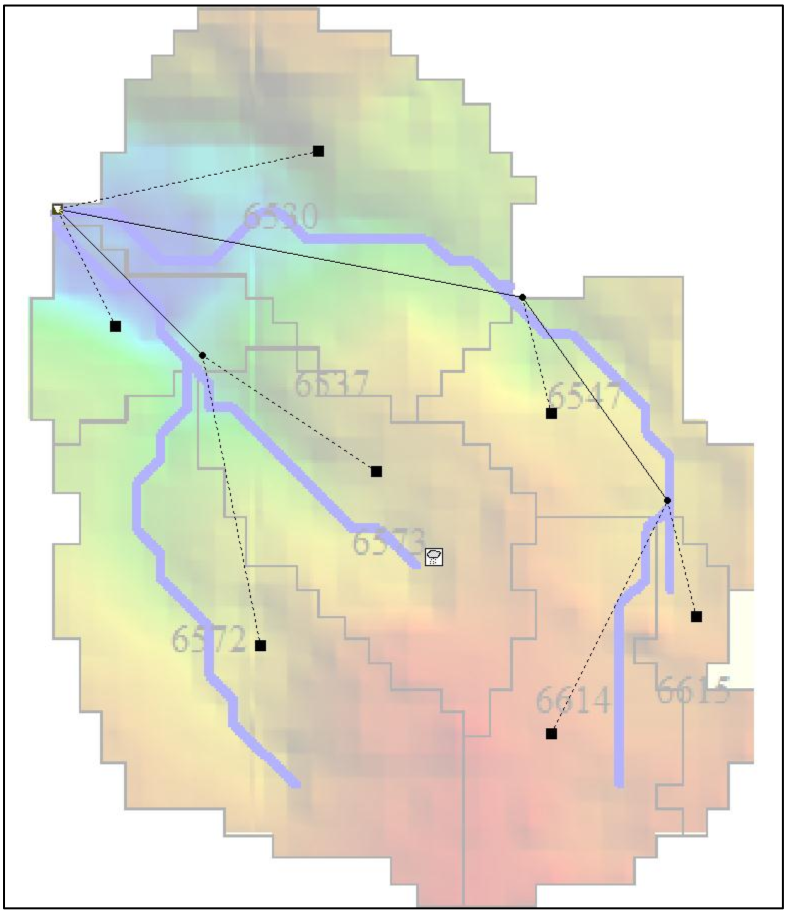


Figure 35: Representative model network around Portion 30

Downscaling of the model network for the bigger mining portion is presented in Figure 36, while the localised catchment for the full mining option (Alternative 2) is presented in Figure 37.

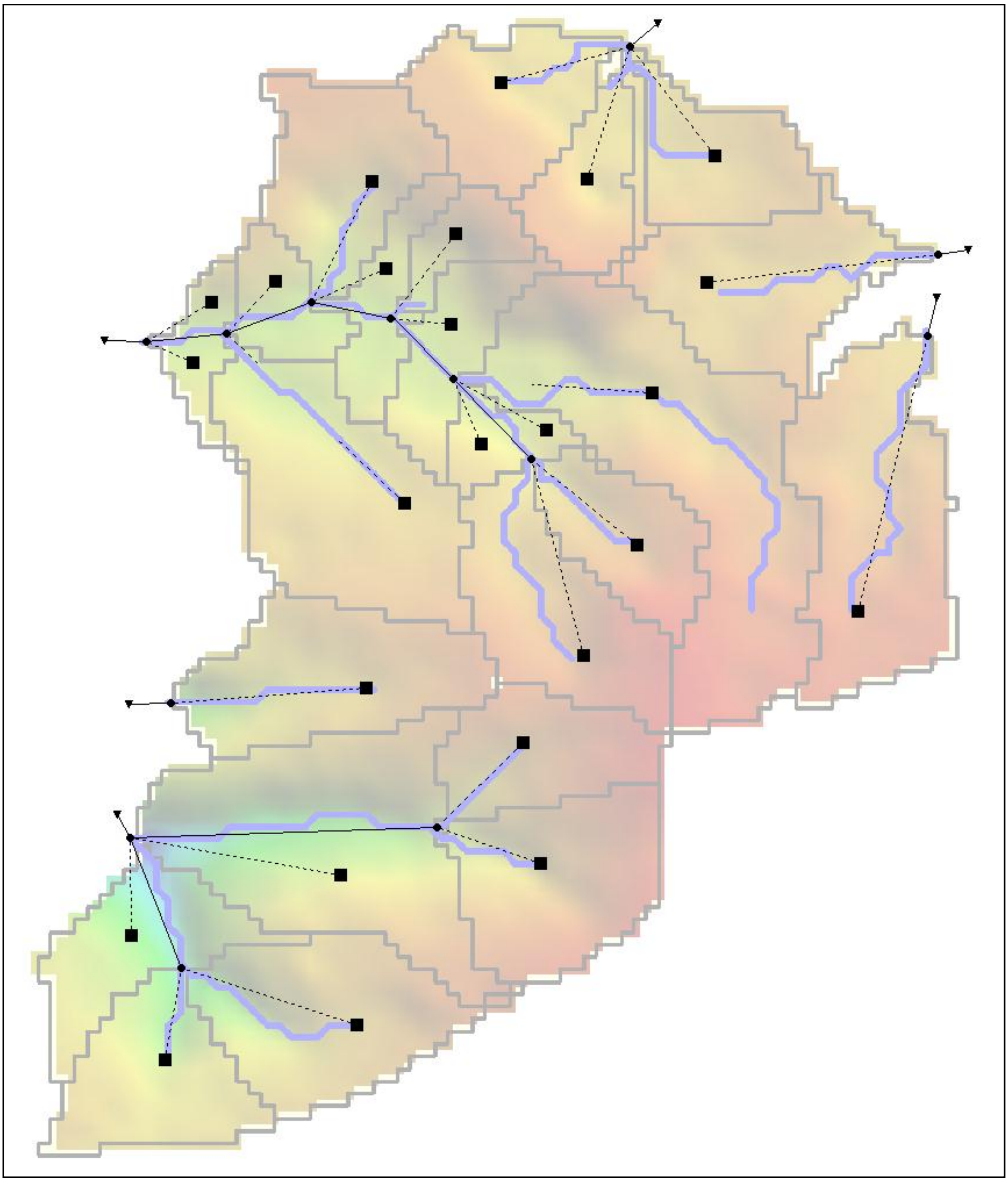


Figure 36: Model network for mining as per schedule (Alternative 2)

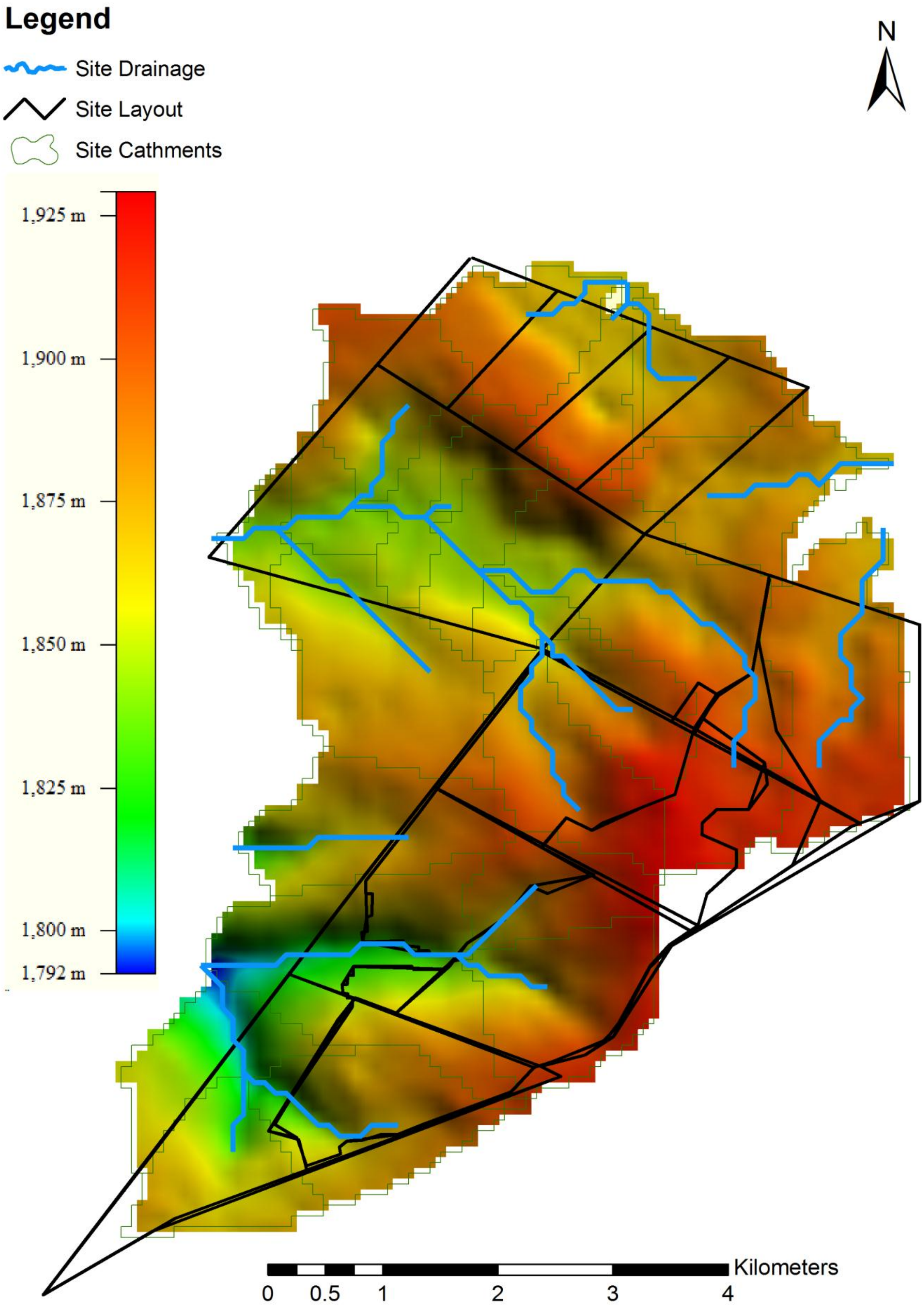


Figure 37: Local catchments for full mining option

Two rain gauges (B4E003 and B4E004) were selected to represent dry and wet conditions for the site. The wet conditions are represented by B4E004 and the dry conditions are represented by B4E003. The simulated flows, at the outflow of the catchment area shown in Figure 35 are presented in Figure 38.

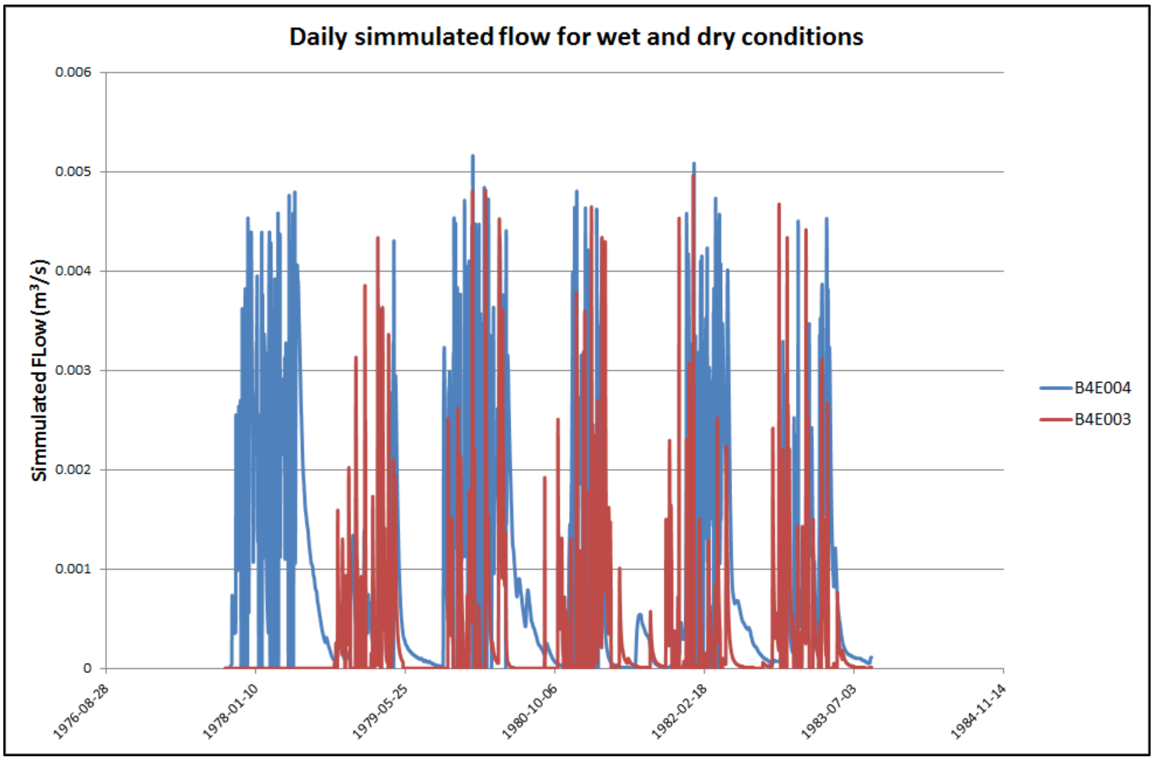


Figure 38: Daily simulated flow for Portion 30 representing wet and dry conditions

The monthly averages for the wet and dry conditions are shown in Figure 39.

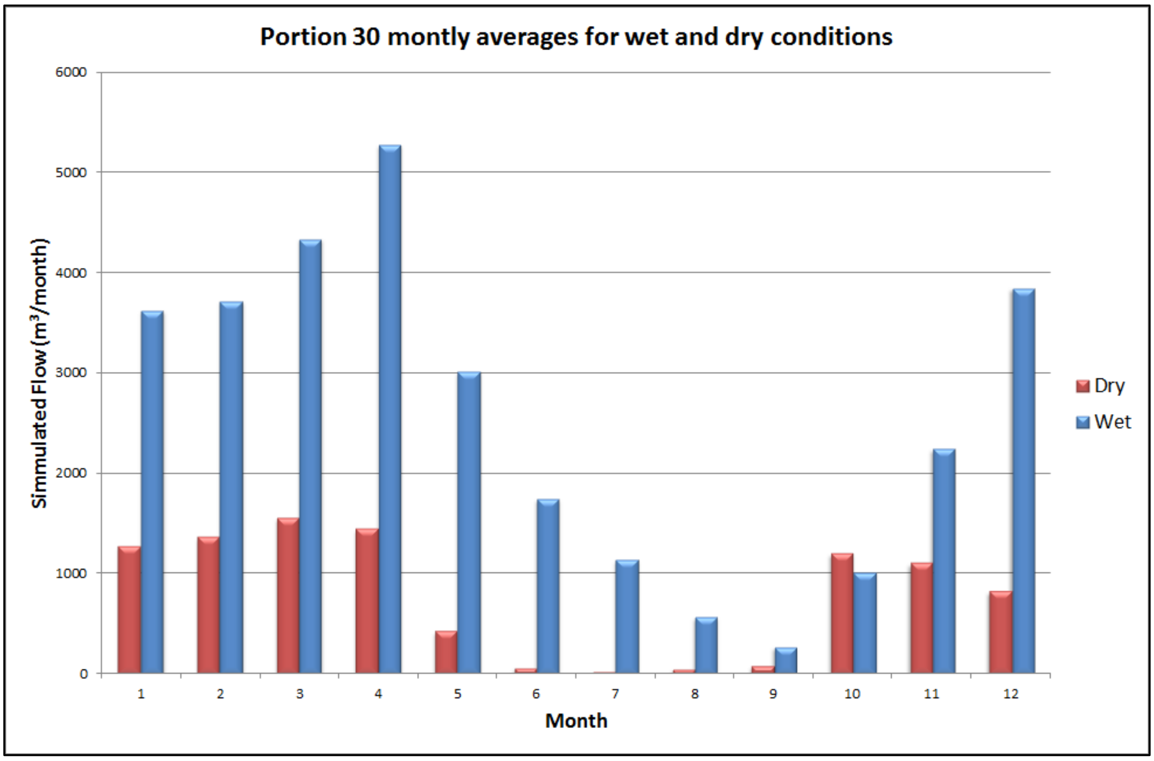


Figure 39: Monthly averages for Portion 30 wet and dry conditions

5.2 Flood Line Calculation

Detail cross-section information is required together with the design rainfall to generate flood lines to be used in the storm water management plan. For the purposes of this document only estimated cross-sections were used for flood line estimation. It is recommended that detail cross-sections be obtained for accurate flood lines.

Design rainfall is used over the site to determine the maximum flood peaks for both the 1:50 and 1:00 year flood events. The design rainfall is presented in Table 9.

Table 9: Design rainfall

Duration	Event 1:50 (mm)	Event 1:100 (mm)
5m	17.7	19.8
10m	25.9	29
15m	32.3	36.1
30m	41	45.9
45m	47.1	52.8
1h	52	58.3
2h	66	74
4h	77.4	86.7
6h	84.9	95.1
8h	90.6	101.5
10h	95.3	106.8

12h	99.4	111.3
16h	106.1	118.9
20h	111.7	125.1
24h	116.4	130.4

The results of the flood peak simulations for the 1:50 and 1:100 year flood events are shown in Figure 40. The maximum flood peak for a 1:50 year event occurs at 12 hour duration (99.4 mm rain) and the maximum flood peak for a 1:100 year event occurs at a 8 hour duration (101.5 mm rain).

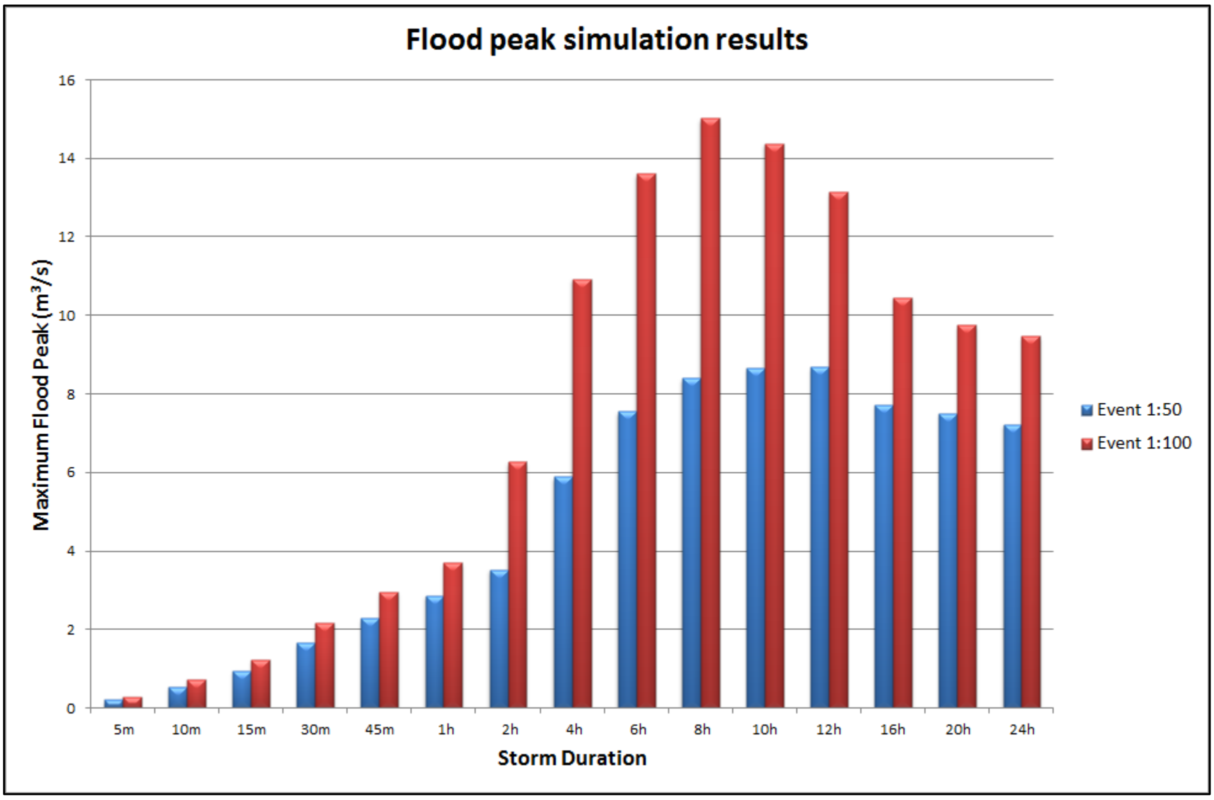


Figure 40: Flood peak simulations

The resultant flood lines calculated for portion 30 are shown in Figure 41 .

Figure 41: Flood Line determined for Portion 30

6 Water Balance

6.1 Water balance principles

The current water balance is very much of a generic nature as no details in terms of consumption and water supply on site is currently available. The water balance is however not to be considered as a once off investigation, but rather an iterative process to be updated as the mine's activities and infrastructures grow.

A water balance rests on a 4 stage process as presented in Figure 42 below.

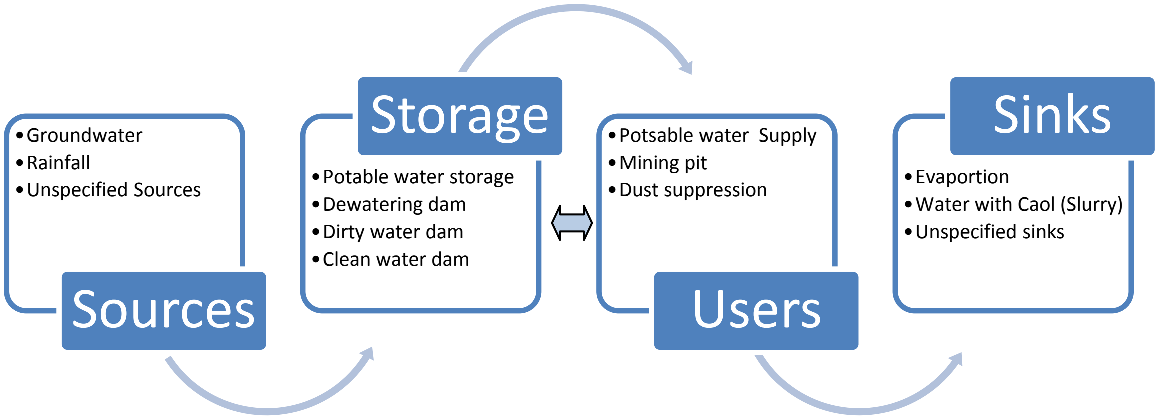


Figure 42: Four stage process in developing a water balance

The water sources to be considered are:

- Groundwater (Both pumped from boreholes and mine ingress)
- Rain water
- Stream or river water

Water users identified for this investigation includes:

- Potable water for mine, plant and office;
- Mine water – opencast
- Dust suppression water
- Process e.g. Beneficiation plant (if installed on site)

Water Storage:

- Potable water
- Pollution control dams or storage of dirty water (water pumped from mine workings, polluted surface run off from mining areas, slurry; etc)
- Sewage

Water sinks:

- Human consumption
- Surface water on coal product
- Discharge to rivers
- Evaporation
- Other discharge

The current water balances are based on available information, and should be considered as an initial water balance, highlighting information gaps and assist in identifying points of metering and monitoring in order to develop a realistic and site specific water balance.

The only detailed information on water requirements, used in the estimation of the monthly average volumes are the volume of water required for dust suppression (120-150m^3/day). Specific usages as summarized in WRC 801/1/01 on generic water balances for South African coal mining industry were also used considering the study site as an open cast mine without beneficiations plants. The average monthly mine production (358333 tonnes) rate used is derived from annual target mine production rate (4.2 to 4.4 million tonnes).

Volumes of Groundwater, Storm water and Evaporation have been estimated using specifics usages calculated from other South Africa coal mines (WRC 801/1/01).

Using information on the average monthly water balance (Table 10) related to mining activities on Blesbok (17 ha) and Block B (8.8 ha) of the GLISA mine, as estimated in the "Environmental Impact Assessment and Environmental Management Plan Report (EIA/EMP 2011)", a water balance is calculated. The calculations include all the above considered sources and sinks. Table 12 and Table 14 show the calculated water balance for alternative 2 (full mining area) and alternative 3 (portion 30) respectively.

Table 10: Summary of monthly GLISA average water balance (Blesbok and Block B : 25.8 ha)

Sources	Average monthly Volume (m^3)	Storage	Use	Sinks	Average monthly Volume (m^3)
Groundwater	26720			Evaporation	54056
Rain (Run-off)	40960			Unspecified sink	36226
Unspecified source	24730			Slurry	5.47
Total	92410				90287.48
Net Balance	2122.52				

6.2 Proposed surface water infrastructure

Based on the available information there are two main water infrastructures that are planned to be used for the the mining options, namely a pollution control dam as well as a dewatering dam. The proposed positions of these two dams are presented in Figure 43 below.

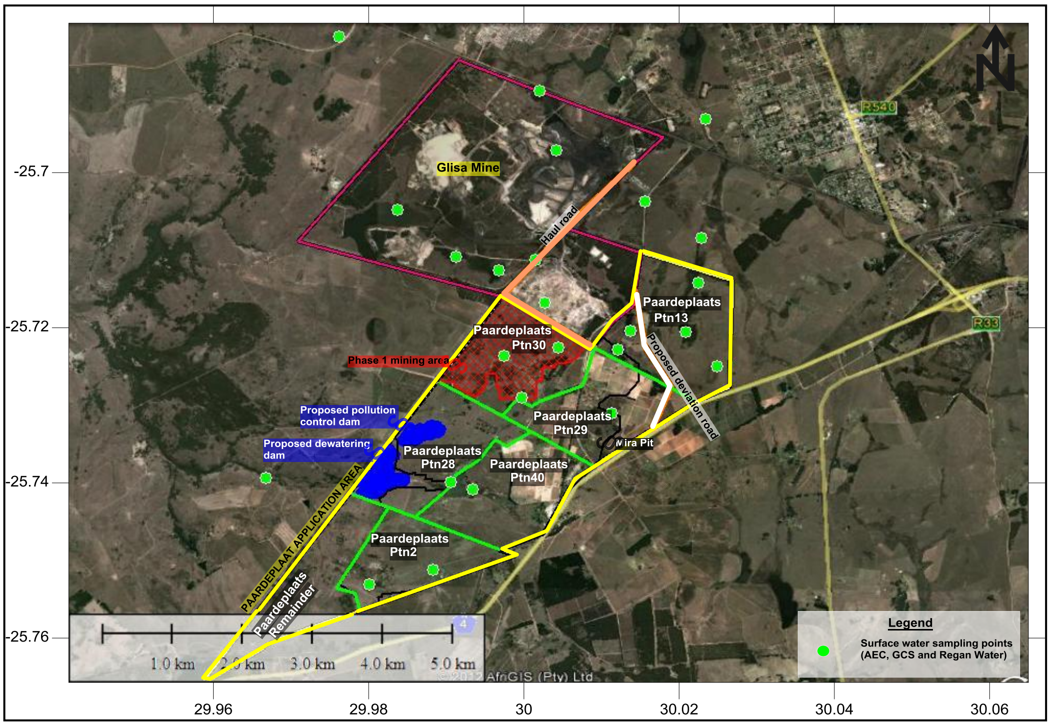


Figure 43: Proposed surface water infrastructure (Alternative 2 and 3)

6.3 Water balance for full mining option (Alternative 2)

A water balance flow diagram has been developed as a preliminary water balance and is presented in Figure 44 while the detailed description for each component is included in

Table 11. This will need to be updated and further developed in consultation with the design engineers once finalization of mine infrastructure and mine plans has been reached.

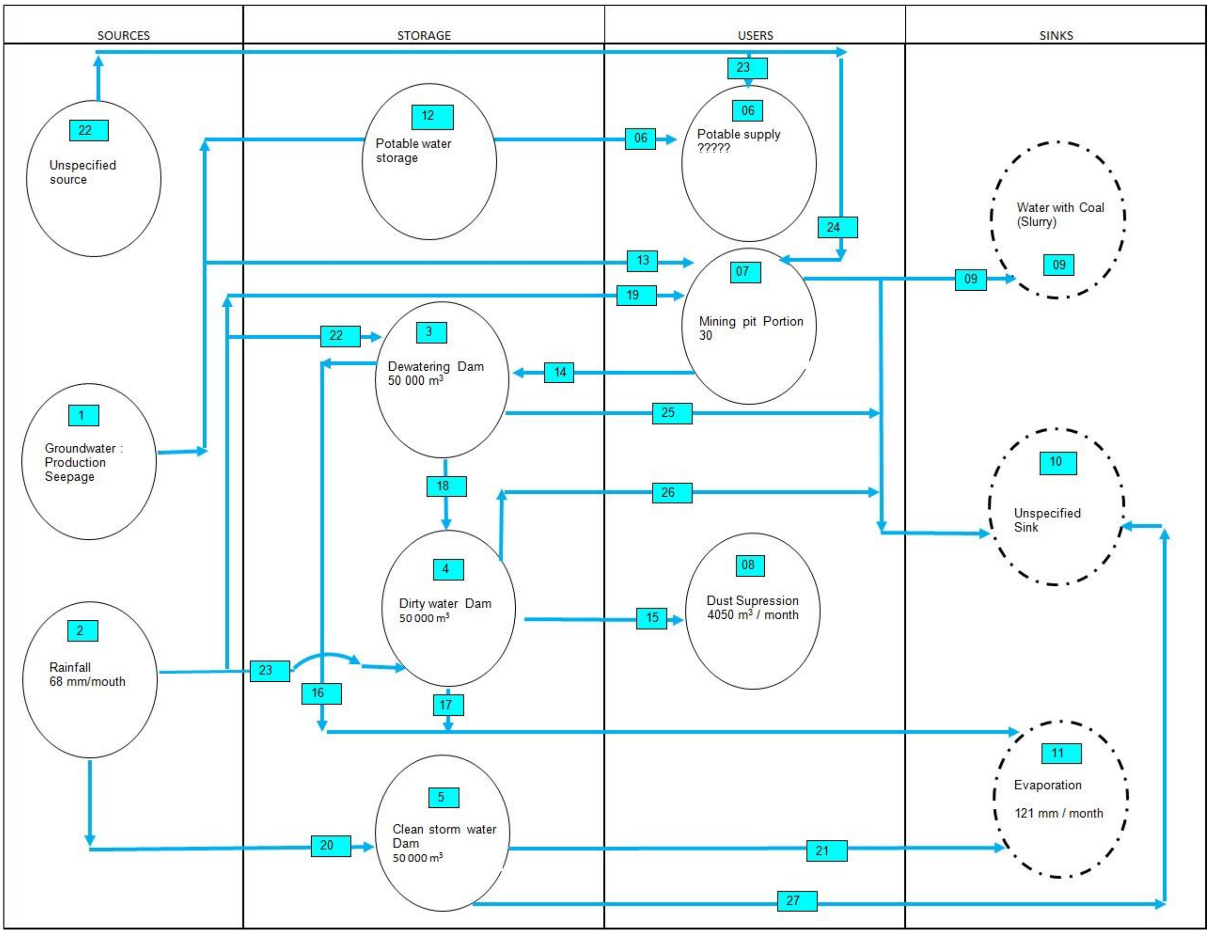


Figure 44: Generic Flow Diagram for Water Balance (Alternative 2)

Table 11: Description of Generic Water Balance Flow diagram for Alternative 2

Stream/Activity number	Description	Specific usage L/t)	Average Volume / Month
1	Total volume of ground water taken in by the mine for all uses, including boreholes production and ground water entering	2.09	748916.67
2	Total rain water taken in by the mine for all uses, including rain into pits, storage dams and stormwater runoff	1.18	422833.33
3	Total volume of water stored in the Dewatering dam		
4	Total volume of water stored in the Dirty water dam		
5	Total volume of water stored in the Clean water dam		
6	Total volume used for human needs	0.11	39416.67
7	Total volume used for mining in the pit area		
8	Total water need for dust suppression		4050000.00
9	Total water associated with slurry		
10	Total water of going to unspecified sink		
11	Total water evaporated from the portion	0.13	46583.33
12	Total Potable water stored		
13	Total volume of groundwater that seep into Open pit Area when operating		
14	Total volume of water pump from Open pit Area (ground water + Run-off water)to the dewatering dam		
15	To test water pump from dirty dam for dust suppression during operation		
16	Total volume of water evaporated from the dewatering dam		
17	Total volume of Dirty water drained to the dirty water dam		
18	Total volume of water pumped from dewatering Dam to the Dirty dam		
19	Total volume of rain water falling directly on the Open pit mining area including upstream run-off water		
20	Total volume of clean water drained to the clean water dam + volume of rain water falling directly on the dam		
21	Total volume of water evaporated from the clean water dam		
22	Total volume of unspecified source water		
23	Total volume of potable water supplied from unspecified sources		

24	Total volume of used in mine pit supplied from unspecified sources		
25	Total volume of water lost from dewatering dam to unspecified sinks		
26	Total volume of water lost from dirty water dam to unspecified sinks		
27	Total volume of water lost from clean water dam to unspecified sinks		

Table 12: Calculated initial Generic Water Balance for alternative 2 (1410 ha)

Sources	Average monthly Volume (m^3)	Storage	Use	Sinks	Average monthly Volume (m^3)
Groundwater	1460279.07			Evaporation	2954223
Rain (Run-off)	2238511.628			Unspecified sink	1979793
Unspecified source	1351523.256			Slurry	299.2562
Total	5050313.953				4934316
Net Balance	115998.4				

6.4 Water balance for mining portion 30 (Alternative 3)

A water balance flow diagram has been developed as a preliminary water balance and is presented in Figure 44 while the detailed description for each component is included in Table 11. This will need to be updated and further developed in consultation with the design engineers once finalization of mine infrastructure and mine plans has been reached.

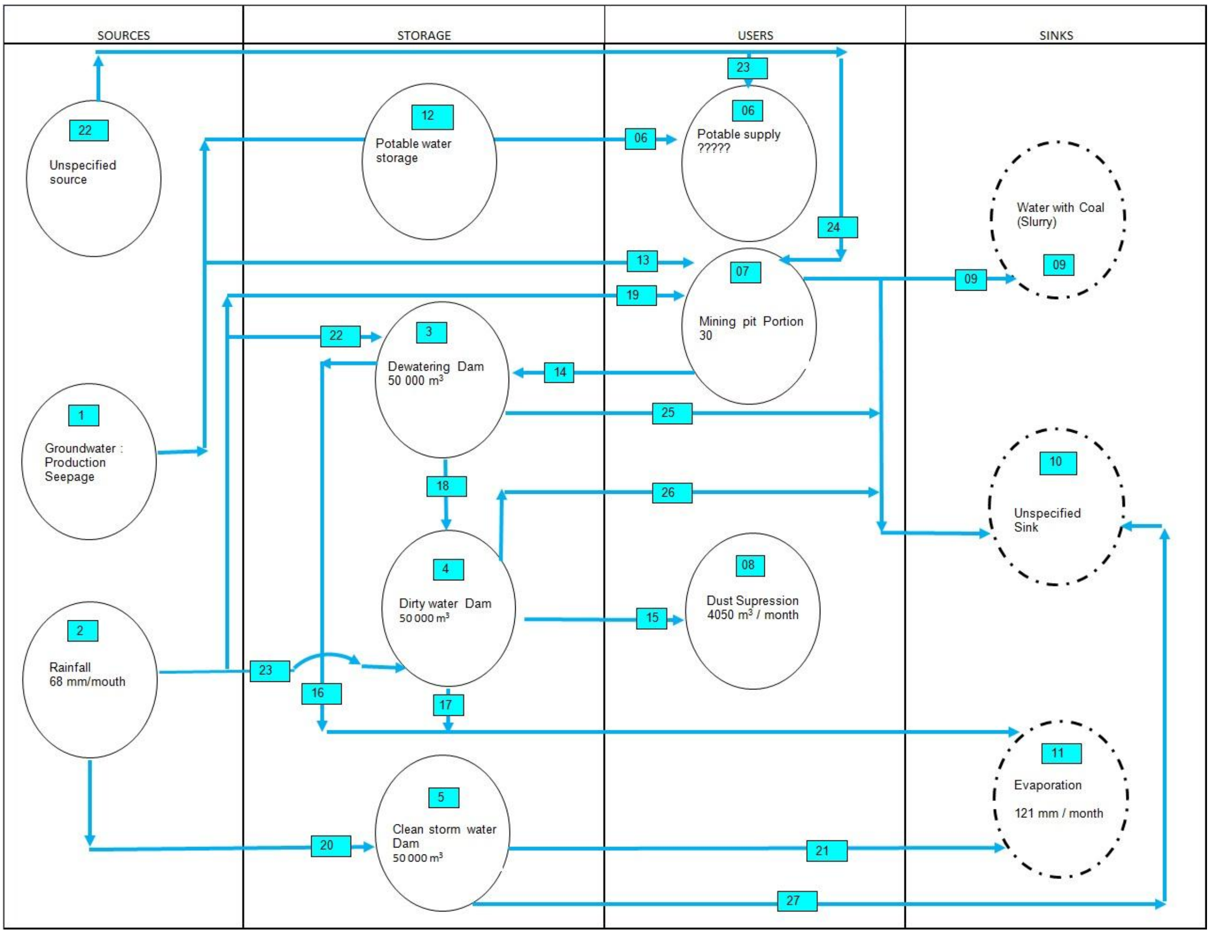


Figure 45: Generic Flow Diagram for Water Balance Alternative 3 (Portion 30)

Table 13: Description of Generic Water Balance Flow diagram for Alternative 3 (Portion 30)

Stream /Activity number	Description	Specific usage L/t)	Average Volume / Month
1	Total volume of ground water taken in by the mine for all uses, including boreholes production and ground water entering	2.09	748916.67
2	Total rain water taken in by the mine for all uses, including rain into pits, storage dams and stormwater runoff	1.18	422833.33
3	Total volume of water stored in the Dewatering dam		
4	Total volume of water stored in the Dirty water dam		
5	Total volume of water stored in the Clean water dam		
6	Total volume used for human needs	0.11	39416.67
7	Total volume used for mining in the pit area		
8	Total water need for dust suppression		4050000.00
9	Total water associated with slurry		
10	Total water of going to unspecified sink		
11	Total water evaporated from the portion	0.13	46583.33
12	Total Potable water stored		
13	Total volume of groundwater that seep into Open pit Area when operating		
14	Total volume of water pump from Open pit Area (ground water + Run-off water)to the dewatering dam		
15	To test water pump from dirty dam for dust suppression during operation		
16	Total volume of water evaporated from the dewatering dam		
17	Total volume of Dirty water drained to the dirty water dam		
18	Total volume of water pumped from dewatering Dam to the Dirty dam		
19	Total volume of rain water falling directly on the Open pit mining area including upstream run-off water		
20	Total volume of clean water drained to the clean water dam + volume of rain water falling directly on the dam		
21	Total volume of water evaporated from the clean water dam		
22	Total volume of unspecified source water		
23	Total volume of potable water supplied from unspecified sources		

24	Total volume of used in mine pit supplied from unspecified sources		
25	Total volume of water lost from dewatering dam to unspecified sinks		
26	Total volume of water lost from dirty water dam to unspecified sinks		
27	Total volume of water lost from clean water dam to unspecified sinks		

Table 14: Calculated initial Generic Water Balance for alternative 3 - portion 30 (195.2 ha)

Sources	**Average monthly Volume (m^3)**	**Storage**	**Use**	**Sinks**	**Average monthly Volume (m^3)**
Groundwater	202160.62			Evaporation	408981.8
Rain (Run-off)	309898.91			Unspecified sink	274082
Unspecified source	187104.49			Slurry	41.42
Total	699164.03				683105.2
Net Balance	16058.78				

7 Stormwater Management Plan (SWMP)

7.1 Preamble

This section is summarized from: Best Practice Guideline - G1: Storm Water Management (2006)

Storm water management and drainage planning are critical components of integrated water and waste management at mining sites. The objectives of a SWMP are site-specific but some general objectives include:

- Protection of life (prevent loss of life) and property (reduce damage to infrastructure) from flood hazards;
- Planning for drought periods in a mining operation;
- Prevention of land and watercourse erosion (especially during storm events);
- Protection of water resources from pollution;
- Ensuring continuous operation and production through different hydrological cycles;
- Maintaining the downstream water quantity and quality requirements;
- Minimizing the impact of mining operations on downstream users;
- Preservation of the natural environment (water courses and their ecosystems).

The complexity of the SWMP depends largely on the size and nature of the mining operation, the characteristics of the hydrological cycle at the site, and the sensitivity of the area in which the mine is located to environmental impacts.

The SWMP must cover the life cycle of the mine from exploration, through construction, operation, decommissioning, and up to post-closure.

7.2 General principles of stormwater management

7.2.1 PRINCIPLE 1: Keep clean water clean

Identify and where possible, maximize areas of the mine that will result in clean storm water runoff as well as infrastructure associated with the mine and ensure that runoff from these areas is routed directly to natural watercourses and not contained or contaminated. Ensure that clean storm water is only contained if the volume of the runoff poses a risk, if the water cannot be discharged to watercourses by gravitation, for attenuation purposes, or when the clean area is small and located within a large dirty area. This contained clean water should then be released into natural watercourses under controlled conditions.

7.2.2 PRINCIPLE 2: Collect and contain dirty water

Ensure the minimization of contaminated areas, reuse of dirty water wherever possible and planning tonsure that clean areas are not lost to the catchment unnecessarily.

Ensure that seepage losses from storage facilities (such as polluted dams) are minimized and overflows are prevented.

Ensure that all possible sources of dirty water have been identified and that appropriate collection and containment systems have been implemented and that these do not result in further unnecessary water quality deterioration.

Ensure that less polluted water or moderately polluted water is not further polluted. Where possible less and more polluted water should be separated. This will assist in the reuse water strategy and improve possibilities for reuse based on different water quality requirements by different mine water uses.

7.2.3 PRINCIPLE 3: Sustainability over mine life cycle

Ensure a commitment from management and staff, including making available adequate human resources band adequate financial resources for both the design and implementation of the SWMP.

Ensure that the SWMP is formulated concurrently with the mine planning and layout of infrastructure and that it takes account of all life cycle phases of the mine from planning through to post-closure.

Identify and quantify the risk of failure of components of the SWMP and the consequences of such failure.

7.2.4 PRINCIPLE 4: Consideration of regulations and stakeholders

Identify items of legislation relevant to the environment and water resources and ensure compliance with these.

Include effective liaison with the Department of Water Affairs, Catchment Management Agencies and all other interested and affected parties.

7.2.5 Considerations for opencast pits

The size of unrehabilitated areas (pit, spoils, and vegetated areas) that produce contaminated runoff should be minimized.

Development of the pit should be planned to promote maximum diversion of clean water. The diversion works may therefore need to be moved as the mine develops.

Rehabilitation should be planned to promote free drainage and to minimize or eliminate ponding of storm water. On-going rehabilitation as mining operations progress is required.

The capacity to rapidly pump water out of the pit into storage dams should be maintained. This will assist in minimizing water quality deterioration due to long-term retention of storm water in contact with materials that may cause water quality deterioration.

7.3 Initial stormwater management plan

As no detailed mine infrastructure and mine plans were available at the time of writing this report. The proposed SWMP will basically state all that needs to be included in the detailed plan and once more information becomes available, the plan must be updated and detail included. Areas that need to be taken into account are discussed in Table 15.

Table 15: Areas that need to be addressed in SWMP

Classification	Area	Comment
Clean water	Undisturbed land area	Regional geology or agricultural practices may contaminate runoff.
	Administrative offices	Generally only suspended solids (SS) to consider
	Tarred roads	Tarred roads are not expected to be contaminated by waste, coal or discard, but may have a run off volume implication.
	Newly rehabilitated areas Clean water dams	SS to be considered
Moderately dirty	Poorly rehabilitated areas	SS and other contaminants to consider
	Roads	If it carries traffic that bears coal, discard, slurry, waste rock, slimes, etc.
Dirty	Workshops and storage yards where oil is handled or ground is covered in fines	Oils, grease and soap, dissolved and suspended contaminants
	Opencast pits	SS and other contaminants to consider
	Residue deposits	Includes coal discard, slurry facilities, slimes dams, waste rock dumps and sand dumps.
	Raw material or product stockpiles	Dissolved and suspended contaminants
	Unrehabilitated areas	Dissolved and suspended contaminants
	Haul roads	Dissolved and suspended contaminants
	Pollution control dams	Depends on contents of dams

Basic issues (WSP, 2011) that must be included are:

7.3.1 Operations area

This area will include stockpiles, roads, workshop, stores and refuelling areas. Pollution sources include runoff from the stockpiles and haul roads spills of hydrocarbons and other chemicals within the workshops, stores and refuelling areas. To limit the impact to surface water bodies, water flow from this area will be directed through earth channels, beams and culverts towards a silt trap just upslope of a pollution control dam. The silt trap will remove suspended solids, while the lined pollution control dam will contain any polluted runoff. The pollution control dam will be kept empty at all times by pumping dirty water into the dewatering dam and through use in dust suppression.

7.3.2 Pollution control dam

The pollution control dam will not overtop for recurrence events up to the 1:50 year event. In addition, the dam embankments will also not overtop for the 1:200 year recurrence event. The dam must be lined with a 1.5mm thick HDPE liner. A sub-surface drainage system will be installed tonsure that all seepage water within the dam area is also collected.

7.3.3 Overburden stockpiles

An erosion containment and dirty water beam must be constructed around the outside of each stockpile. Containment berms must also be constructed perpendicular to the outside berm to ensure that dirty water “coffers” are created. The area between the berms and stockpile will be vegetated to promote rapid evaporation, to reduce ponding within these areas. A 15m wide thickly vegetated “buffer” zone must also be constructed around the outside of berms to contain sediment.

Overburden stockpiles must be separated, with one portion containing carbonaceous waste and the other containing inert materials. The treatment of each of these stockpiles will differ:

- Carbonaceous stockpiles: Surface water will be contained within the stockpile and berms. Groundwater contamination will be prevented by placing a 125mm clay liner at the bottom of the stockpile. Captured water will be lost through evaporation.
- Inert stockpiles: Dirty water will be contained within the stockpile and berms. Surface water seepage through the containment berms can be accommodated, with the provision that siltation is prevented.

7.3.4 Mining area

Dirty water containment berms will need to be constructed around the mine to separate dirty water from clean water. Dirty water should be diverted back into the pit whilst clean water will be directed into the clean water catchment areas.

The pit could be rehabilitated as work progresses. Rehabilitated areas can be vegetated and contour berms will be constructed to slow surface water and to prevent erosion from taking place. It should furthermore be ensured during rehabilitation that buffer zones, containing thick vegetation, are established downstream of the rehabilitated areas. This will ensure that erosion and subsequent sedimentation is minimised. Rehabilitated areas will be classified as clean water areas and the surface water will be released into clean water areas.

Dirty water storage in the pit will be localised in various storage depressions within the pit. This will eliminate the need for a large storage area for capturing the entire pit run-off, which would prevent effective rehabilitation as opencast operations proceed. However, a depression should be made available to hold water transferred from the pollution control dam. This water would be used for dust suppression purposes. The size of the depression would this need to be at least the size of the pollution control dam.

7.3.5 Haul roads

Pit access roads could either traverse rehabilitated or mining areas and may exhibit some pollution potential. Wherever pit access roads traverse rehabilitated areas, small coffer dams, constructed adjacent to the road, are proposed. This will prevent pollution from entering newly defined clean water areas. Coffer dams will also be constructed along the mining areas to prevent a significant amount of surface water from being concentrated at one specific point.

7.3.6 Dewatering dam

Groundwater is expected to decant, decant rates are provided in the groundwater report and the pH is expected to drop. Capturing and returning of decant water a minimum measure should be implemented, while consideration could be given to for the design of a treatment system based on the expected decant volumes and associated water quality.

8 Impact Assessment Methodology

The impact assessment methodology is guided by the requirements of the NEMA EIA Regulations (2010). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/ likelihood (P) of the impact occurring. This determines the environmental risk. In addition other factors, including cumulative impacts, public concern, and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S).

This system derives environmental significance on the basis of the consequence of the impact on the environment and the likelihood of the impact occurring. Consequence is calculated as the average of the sum of the ratings of severity, duration and extent of the environmental impact. Likelihood considers the frequency of the activity together with the probability of an environmental impact occurring. Table 16 to Table 18 describe the process in detail.

8.1 Determining Consequence

The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER).

The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented

by: $C= ((E+D+M+R) \times N)/4$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 16:

Table 16: Aspect rating table

Nature	-1	Negative
	1	Positive
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary),

	3	Local (i.e. the area within 5 km of the site),
	4	Regional (i.e. extends between 5 and 50 km from the site
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years),
	3	Medium term (6-15 years),
	4	Long term (the impact will cease after the operational life span of the project),
	5	Permanent (no mitigation measure of natural process will reduce the impact after construction).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact
Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur- > 75% probability), or
	5	Definite (the impact will occur),

Once the C has been determined the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/ scored as per Table 17.

Table 17: Probability scoring

Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur- > 75% probability), or
	5	Definite (the impact will occur),

The result is a qualitative representation of relative ER associated with the impact.

ER is therefore calculated as follows:

ER= C x P

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
	1	2	3	4	5	
	Probability					

Figure 46: Determination of environmental risk

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 18.

Table 18: Significance classes

Environmental Risk Score	
Value	Description
< 9	Low (i.e. where this impact is unlikely to be a significant environmental risk),
>=9;<17	Medium (i.e. where the impact could have a significant environmental risk),
>= 17	High (i.e. where the impact will have a significant environmental risk).

The impact (ER) will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/ mitigated.

8.1.1 Impact Prioritisation

In accordance with the requirements of Regulation 31 (2) (l) of the EIA Regulations (GNR 543). It is necessary to assess each potentially significant impact in terms of:

- Cumulative impacts;
- and the degree to which the impact may cause irreplaceable loss of resources.

In addition it is important that the public opinion and sentiment regarding a prospective development and consequent potential impacts is considered in the decision making process.

In an effort to ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact ER (post-mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority / significance issues and impacts. The PF will be applied to the ER score based on the assumption that relevant suggested management/ mitigation impacts are implemented. Table 19 provides the criteria for the determination of prioritisation.

Table 19: Criteria for determination of prioritization

Public feedback	1	Low: Issue not raised in public responses
	2	Medium: Issue has received a meaningful and justifiable public response
	3	High: Issue has received an intense meaningful and justifiable public response

Cumulative Impact	1	Low: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikley that the impact will result in spatial and temporal cumulative change.
	2	Medium: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	3	High: Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/ definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable loss of resources	1	Low: Where the impact is unlikely to result in irreplaceable loss of resources.
	2	Medium: Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	3	High: Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).
Degree of Confidence	Low	<30% certain of impact prediction
	Medium	>30 and < 60% certain of impact prediction
	High	>60% certain of impact prediction

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 20. The impact priority is therefore determined as follows:

Table 20 : Impact prioritization

Public response (PR)	Low (1)	Issue/ impact raised in < 30% of responses.
	Medium (2)	Issue/ impact raised in >30% and < 60% of responses.
	High (3)	Issue/ impact raised in >60% of responses.
Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
Irreplaceable loss of	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.

resources (LR)	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

Priority = PR + CI + LR

The result is a priority score which ranges from 3 to 9 and a consequent PF ranging from 1 to 2 (refer to Table 21).

Table 21: Determination of prioritization factor

Priority	Ranking	Prioritisation Factor
= 3	Low	1
3 – 9	Medium	1.5
= 9	High	2

In order to determine the final impact significance the PF is multiplied by the ER of the post mitigation scoring. The ultimate aim of the PF is to be able to increase the post mitigation environmental risk rating by a full ranking class, if all the priority attributes are high (i.e. if an impact comes out with a medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential, significant public response, and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

Table 22: final impact significance

Value	**Description**
< 9	Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
>=9;<17	Medium (i.e. where the impact could influence the decision to develop in the area),
>=17	High (i.e. where the impact must have an influence on the decision process to develop in the area).

The significance ratings and additional considerations applied to each impact will be used to provide a quantitative comparative assessment of the alternatives being considered. In addition, professional expertise and opinion of the specialists and the environmental consultants will be applied to provide a qualitative comparison of the alternatives under consideration. This process will identify the best alternative for the proposed project.

8.2 Key Constraints

The key constraints at this point include:

- Insufficient DEM data to accurately calculate flood lines.
- Detailed mining plans and site infrastructure.
- Limited flow gauge information

8.3 Surface water impact assessment

Surface water impacts identified for both mining options (Alternative 2 and Alternative 3) are exactly the same. The difference between these two sites will be the scale and lateral extend, but the risks remain the same for these options.

8.3.1 Impacts calculated for the full mining area (Alternative 2)

8.3.1.1 Construction phase

The mine is situated in the headwater of the catchments and no major build up of flows is expected to happen, Drainage lines flowing into the mining area will however have to be diverted to prevent clean water from entering the mining area and increase the risk of flooding.

8.3.1.2 Operational phase

There are no perennial streams on site, but increased pit depth of mining will increase the flow from surface water, wetlands and groundwater into the mining areas.

8.3.1.3 Post Closure phase

Decant will happen as presented in the groundwater report. This will impact on the surface water in the catchment where the decant happens. Containment and or treatment might be required by capturing decant water and pumping it back to pollution control dams.

Table 23: Surface water Impact assessment and proposed mitigation measures (full mining option, Alternative 2)

N = Nature; E = Extent, D = Duration; M = Magnitude; R = Reversibility; P = Probability; ES = environmental significance

Potential Environmental Impact	Activity	Environmental Significance score							Recommended mitigation measures
		N	E	D	M	R	P	ES	
Construction phase									
1. ***Re-routing of natural drainage lines***	Natural drainage lines will have to be diverted around the area to be mined as this will increase the risk of flooding if not done. The study area is situated in the headwaters of the catchment and the natural flow is low.	-1	3	5	2	5	5	M	Implementation of storm water management plan.
Operational phase									
2. ***Stream flow depletion***	Once in operation the changing level of the open pit base will create a hydraulic gradient away from the stream which could lead to stream flow depletion. The impact of this will be low as the pit is situated in the headwaters of the catchment.	-1	2	4	3	5	2	M	No mitigation is recommended.
3. Flood risk	Due to the close proximity to drainage lines the risk of flooding exists.	-1	3	1	2	1	3	M	Implementation of storm water management plan.
4. Surface water quality degradation	Normal wash off could affect the stream water quality due to the artificial surface deposits resulting from the mining activity	-1	2	1	2	1	3	M	Implementation of storm water management plan. In particular cut-off trenches to control surface runoff close to pollution sources.
Post-closure phase									
5. ***Impact of decanting mine***	Decanting of the open pit will result in the decant reporting to surface water courses. Decant could lead to deterioration of surface water quality as well as an increase in the sediment load.	-1	4	5	3	5	4	M	Decant is to be captured and pumped to pollution control dams and treated before released.

8.3.2 Impacts calculated for portion 30 (Alternative 3)

8.3.2.1 Construction phase

The mine is situated in the headwater of the catchments and no major build up of flows is expected to happen, Drainage lines flowing into the mining area will however have to be diverted to prevent clean water from entering the mining area and increase the risk of flooding.

8.3.2.2 Operational phase

There are no perennial streams on site, but increased pit depth of mining will increase the flow from surface water, wetlands and groundwater into the mining areas.

8.3.2.3 Post Closure phase

Decant will happen as presented in the groundwater report. This will impact on the surface water in the catchment where the decant happens. Containment and or treatment might be required by capturing decant water and pumping it back to pollution control dams.

Table 24: Surface water Impact assessment and proposed mitigation measures (Portion 30)

N = Nature; E = Extent, D = Duration; M = Magnitude; R = Reversibility; P = Probability; ES = environmental significance

Potential Environmental Impact	Activity	Environmental Significance score							Recommended mitigation measures
		N	E	D	M	R	P	ES	
Construction phase									
6. ***Re-routing of natural drainage lines***	Natural drainage lines will have to be diverted around the area to be mined as this will increase the risk of flooding if not done. The study area is situated in the headwaters of the catchment and the natural flow is low.	-1	3	5	2	5	5	M	Implementation of storm water management plan.
Operational phase									
7. ***Stream flow depletion***	Once in operation the changing level of the open pit base will create a hydraulic gradient away from the stream which could lead to stream flow depletion. The impact of this will be low as the pit is situated in the headwaters of the catchment.	-1	2	4	3	5	2	M	No mitigation is recommended.
8. Flood risk	Due to the close proximity to drainage lines the risk of flooding exists.	-1	3	1	2	1	3	M	Implementation of storm water management plan.
9. Surface water quality degradation	Normal wash off could affect the stream water quality due to the artificial surface deposits resulting from the mining activity	-1	2	1	2	1	3	M	Implementation of storm water management plan. In particular cut-off trenches to control surface runoff close to pollution sources.
Post-closure phase									
10. ***Impact of decanting mine***	Decanting of the open pit will result in the decant reporting to surface water courses. Decant could lead to deterioration of surface water quality as well as an increase in the sediment load.	-1	3	5	3	5	4	M	Decant is to be captured and pumped to pollution control dams and treated before released.

9 Monitoring Plan

9.1 Preamble

A long-term monitoring programme must be developed based on the guideline documented in *Best Practice Guideline G3. Water Monitoring Systems (2007)* available from DWA. These guidelines are summarised and implemented in the proposed monitoring plan.

A monitoring plan is necessary because (DWA, 2006):

- Accurate and reliable data forms a key component of many environmental management actions.
- Water monitoring is a legal requirement
- The most common environmental management actions require data and thus the objectives of water monitoring include the following:
- Development of environmental and water management plans based on impact and incident monitoring (facilitate in decision-making, serve as early warning to indicate remedial measures or that actions are required in certain areas) for the mine and region.
- Generation of baseline/background data before project implementation.
- Identification of sources of pollution and extent of pollution (legal implications or liabilities associated with the risks of contamination moving off site).
- Monitoring of water usage by different users (control of cost and maximizing of water reuse).
- Calibration and verification of various prediction and assessment models (planning for decommissioning and closure).
- Evaluation and auditing of the success of implemented management actions (ISO 14000, compliance monitoring).
- Assessment of compliance with set standards and legislation (EMPs, water use licenses).
- Assessment of impact on receiving water environment.

9.2 General Principals of Monitoring

Monitoring on a mine consists of various components as illustrated by the overall monitoring process (Figure 47). It must be recognized and understood that the successful development and implementation of an appropriate, accurate and reliable monitoring programme requires that a defined structured procedure be followed. A monitoring programme must include the location of all monitoring points (indicated on a map), the type of data to be collected, as well as the data collection (protocol/procedure/methodology, frequency of monitoring and parameters determined, quality control and assurance), management (database and assessment) and reporting procedures. This programme must then be implemented. The results from the monitoring programme should be representative of the actual situation. To ensure that the monitoring programme functions properly, an operating and maintenance programme should be developed and implemented. A data management system is necessary to ensure that data is stored/ used optimally and is accessible to all the relevant users. The monitoring programme must include quality control measures. It is important to note that this programme is dynamic and should change as the mine and water management needs change.

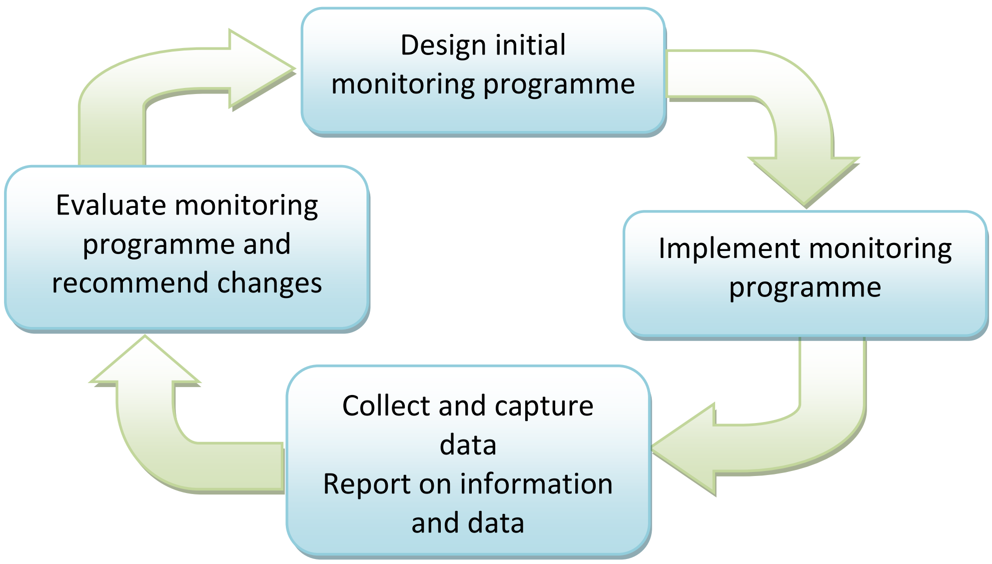


Figure 47: Monitoring process (DWA, 2007)

Effective groundwater monitoring systems on a mine consist of the following components:

- Surface water quality monitoring system.
- Surface water flow monitoring system.
- Data and information management system.

When designing the monitoring system the following issues must also be taken into consideration:

- Potential or actual water use
- Catchment vulnerability
- Toxicity of chemicals
- Potential for seepage or releases
- Quantities and frequency of release to the environment (point and non-point).
- Management measures in place to minimize risk.

9.3 Monitoring Plan for Paardeplaats

9.3.1 Management action

As part of the water management at the Paardeplaats, it is necessary to understand:

- The changes in surface water flow within the mine boundaries and to monitor how this change with time.
- The pollution on the mine and to monitor how the pollution changes with time.

The overarching water management action that is of interest for this specific mine can, therefore, be defined as:

- Develop an understanding of the current surface water flow patterns on the mine and monitor how it changes over time.
- Assess impacts of the changes of these flow patterns on the receiving environment and the performance of associated prevention measures.
- Prevent pollution and thereby protect the receiving water environment.
- Develop an understanding of the current pollution on the mine and monitor how it changes over time.
- Assess performance of pollution prevention measures, i.e. compliance with license conditions and catchment objectives.

9.3.2 Objectives of intended management action

The objectives of the management action are defined as:

- Identify, quantify and monitor surface water flow in the vicinity of the mine.
- Identify, quantify and monitor all point and diffuse pollution sources and associated plumes on the mine.

These objectives must adhere to the requirements of being specific, measurable and feasible.

9.3.3 Data requirements

The data requirements are dictated by:

- Area influenced by changes in surface water flow and associated quality.
- Point and diffuse sources of pollution and associated pathways.

9.3.4 Location of monitoring points

The potential monitoring points are chosen to:

- Determine any changes in surface water flow and quality on the mining property before affecting the down gradient environment.
- Perform a regional surface water screening to ensure that the monitoring points on site are sufficient.

The positions of the proposed monitoring points are presented in Table 25 and Table 26 respectively

Table 25 : Pr0posed surface water monitoring points for Portion 30 (Alternative 3)

SW Points in Portion 30	SW Points outside portion 30
SW Name	WP Dam 1
SV Dam1	WP Dam 2
SV Dam2	HDAm 1
SV Dam3	

Table 26: Proposed surface water monitoring points for full mining option (Alternative 2)

SW Points in Mining Area	SW Points outside Mining Area
SW Name	Dam 1
SV Dam1	MF2 Dam
SV Dam2	MF1 Dam
SV Dam3	Dam2
WP Dam 1	LM Dam
WP Dam 2	Stream Exxaro road
HDAm 1	Dam Exxaro road
Never 1	Hen Dam
	AEC 8 Dam
	NPS Dam
	AEC 12 DS

9.3.5 Parameters to be measured and frequency of measurements

There are two sets of monitoring parameters. A comprehensive analysis must be conducted on surface water points within or close to the mine and a screening analysis must be conducted on surface water points further away. In addition samples must be tested for trace elements once mining commences. The parameters that must be sampled for are listed in Table 27.

Table 27: Sampling parameters

A (Standard set of parameters)	B (Screening parameters)	C (Trace elements)
pH	pH	Ba
EC	EC	As
Ca		Co
Mg		Cr
Na		Ni
K		Pb
Total Alk		Se
F		Sr
Cl		V
NO_2(N)		Zn
NH_4 (N)		Nb
NO_3(N)		Mn
PO_4		Cu
SO_4		Ga
Al		Ge
Fe		Rb
Mn		Y
		Zr
		Sn
		W
		Bi
		Th
		U
		Hg

The frequency and type of sampling is summarised in Table 28.

Table 28: Frequency and type of sampling

Sampling point	Parameter list[3]	Type of sampling	Type of measurement/	Frequency
Surface water points within mine boundaries	A, C*	Grab	Flow	A = Every 4 months C = Once an annum
Surface water points outside mine boundaries	B**	Grab	Flow	Once every 6 months

* If any parameters exceed SANS241-1: 2011 guidelines (or WHO guidelines if no SANS guideline available) then that parameter must become part of list A.

**If any parameters * If any parameters exceed SANS241-1: 2011 guidelines (or WHO guidelines if no SANS guideline available) then that borehole must be sampled according to the A, C list.

IMPORTANT NOTES:

[3] A, B and C are parameters documented in Table 27

Laboratory analysis techniques will comply with SABS guidelines. Laboratories must be accredited.

Once the plant location has been finalised, a borehole must be drilled directly down-gradient of the plant. This borehole must be sampled according to the A, C list of parameters. In addition grease and oil must be sampled for.

9.3.6 Data storage and reporting

Data must be stored electronically. It is suggested that a well-known database such as WISH, Aquabase or Access be used. A backup of the data base must be stored in a safe place. Backups should be made every time the database is updated.

On the completion of every sampling run a monitoring report must be written. Included in the report must be time series trends, Piper and Durov diagrams. These will be used to determine if there are any changes in the system. These changes must be flagged and explained in the report.

It is recommended that Exxaro submit a compliance report to DWA every six months.

10 Final comparison of alternatives

With no mining activities on the area under investigation it could be stated that the current status quo in terms of surface water would be kept in place. The area is situated in the headwater of the two catchments and the risks of flooding, although always present, is not that great due the topographical position of these sites.

The risk involved with mining of the bigger area as well as that of portion 30 only is exactly the same, although the scale will differ. Mining a smaller area will result in impacting a smaller surface water area in only one catchment while mining the full area as per the mining schedule will affect surface in two sub catchments.

11 Recommendations

Based on the results from this assessment the following recommendations are put forward for consideration:

- Once the final decision has been made on mining the monitoring network in terms of surface water monitoring should be revisited and the monitoring points confirmed.
- When more detailed digital elevation data becomes available the model should be re-run to confirm flood lines and confirm surface water management infrastructures. In

this regard topographical surveys like for example a Lidar survey, providing higher density DEM data is strongly recommended.

- The water management plan developed during this study should be considered a baseline and further development thereof should take place in conjunction with the infrastructure development, keeping the water management plan relevant and updated in real time.
- The water balance developed should be considered a baseline water balance and special effort should be made to have sufficient measuring points to collect real data for updating the water balance on a regular basis.

NOISE IMPACT ASSESSMENT OF THE PLANNED PAARDEPLAATS COLLIERY AT BELFAST (eMAKHAZENI) AREA, MPUMALANGA PROVINCE

(October 2012)

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Executive Summary

Exxaro Resources (Pty) Ltd (hereafter referred to as Exxaro) is planning to develop a new mine, the Paardeplaats Coal Mine, in the area two kilometers to the south-west of the town of eMakhazeni (Belfast), Mpumalanga Province. An environmental impact assessment (EIA) was required and was undertaken by Environmental Impact Management Services (Pty) Ltd (EIMS). As part of the EIA, a noise impact assessment has been undertaken by Jongens Keet Associates (JKA). As part of the EIA, a noise impact assessment has been undertaken by Jongens Keet Associates (JKA).

The core study area of the noise impact assessment was taken to be that within the potential noise area of influence of the planned mine. An open cast method of mining is to be employed. The Paardeplaats Project will export its coal to the beneficiation plant at the Glisa Colliery which is located just to the north of the Paardeplaats Project Site.

Environmental Impact Management Services (Pty) Ltd (EIMS) required that three alternatives were to be analysed, namely:

- The mining of only Portion 30 of the coal body in the north-western portion of the site. EIMS named this the Sensitivity Planning Approach Alternative.
- The mining of the entire coal body, named the Maximum Mine Production Alternative.
- The No Go Alternative.

The approach was to determine conservatively the area of potential noise impact, namely that enclosed by the 35dBA noise contour generated by the new Paardeplaats Project. Calculations indicate that the offset of the 35dBA noise contour of the workings at the opencast pit will be of the order of 6100 metres surrounding the edge of the pit.

The main noise sources presently affecting the study area and the noise sources that will continue to affect the area once the mine is commissioned are:

a) Road traffic.
b) Glisa Coal Mine.
c) Middelburg - Nelspruit railway line.
d) General farming activities (not a major source of noise).
e) Air traffic noise at Belfast Aerodrome.

The noise sensitive sites/areas in the study area that are potentially affected by the development of the mine on this site are the residential areas of Belfast, Siyathuthuka, farm houses, farm labourers' residences (including the Hadeco Village), and schools.

In overview, the situation with respect to the existing *noise climate* in the study area was found to be as follows:

i) Residual noise levels at the various farmhouses and farm labourers' dwellings are relatively low (quiet). Daytime ambient conditions across the area range from about 42dBA to 53dBA near the main road. In areas remote from the influence of road traffic noise, the evening conditions range from about 30dBA to 39dBA, while the night-time ambient levels fall even lower to about 25dBA in places. These are acceptable rural residential conditions (SANS 10103).

ii) Residual noise levels at the schools generally meet the noise standards required for educational purposes, namely 50dBA not exceed during school hours.

iii) The existing *noise climate* alongside the main roads is degraded with regard to rural residential living conditions. Residences in some areas are negatively impacted from traffic noise (particularly at night) for up to the following distances from these roads:

a)	National Road N4	-	2300 metres.
b)	Road R33	-	800 metres.
c)	Spitskop Road	-	500 metres.

iv) The Middelburg - Nelspruit railway line is on the southern boundary of the development site, running parallel to and just to the north of the N4 and has very little influence on the ambient noise climate of the study area but has a noise nuisance factor.

v) The residual (existing background) noise levels are relatively low (quiet) in the residential areas of eMakhazeni (Belfast) and in Siyathuthuka.

vi) In general the residual noise levels in the undeveloped areas to the north-west of the proposed development site are low (that is, the areas are very quiet). The noise levels are typically representative of a rural farming area, namely where the average daytime noise levels do not exceed 45dBA and the night-time levels do not exceed 35dBA.

From the findings and observations on site it was considered appropriate to apply the SANS 10103 noise standards and impact criteria to the study area: rural residential standards at the farmhouses and farm labourer residences, suburban residential standards at the residences in Belfast and Siyathuthuka and educational standards at the schools in the study area.

The following were concluded: There are many sectors of the study area that are still extremely quiet and display rural noise climate characteristics. There are also other areas where changes in land use to opencast coal mining have introduced very loud noise sources into the study area thereby degrading the rural noise climate. The construction of the

Paardeplaats Coal Mine will introduce a very loud noise source into an area where a large sector is vulnerable to impact.

The significance rating of the noise impacts at each phase for the three alternatives was found to be as follows:

Alternative	Significance Rating for given Phase			
	Pre-Construction	**Construction**	**Operational**	**Decommissioning**
Sensitivity Planning Approach	Low	Low	Medium	Low
Maximum Mine Production Approach	Low	Low	Medium	Low
No Go	Not applicable	Not applicable	Not applicable	Not applicable

Please note that these ratings do not include the variable in the formula for Public Response but will be incorporated by EIMS at a later stage., Therefore the significance ratings in the table above may change.

Of the two actual mining alternatives, the Sensitivity Planning Approach Alternative will have the least noise impact as it impacts on a smaller area. It has been presumed that all other mining factors are the same for these two alternatives.

There are mitigation measures that may be applied at each of the stages to reduce or prevent noise impact of the new mine.

Contents

APPENDICES

FIGURES

1 INTRODUCTION

1.1 Background

Exxaro Resources (Pty) Ltd (hereafter referred to as Exxaro) is planning to develop a new mine, the Paardeplaats Coal Mine, in the area approximately two kilometers to the south-west of the town of eMakhazeni (Belfast), Mpumalanga Province. The mine development site lies within the jurisdiction of the Nkangala District Municipality and eMmakhazeni Local Municipality (ELM). The Paardeplaats project is located on Portions 28, 29, 30 and 40 of the farm Paardeplaats 380 JT; Remaining Extent (RE) of Portion 2 of the farm Paardeplaats 425 JS; and Portion 13 of Paardeplaats 380JT. The Paardeplaats Project covers an area of approximately 1 415 ha. Refer to Figure 1. The Paardeplaats Project will transport its coal for processing to the existing beneficiation plant at the Glisa Colliery which is located just to the north of the Paardeplaats Project site.

An environmental impact assessment (EIA) was required and was undertaken by Environmental Impact Management Services (Pty) Ltd (EIMS). As part of the EIA, a noise impact assessment has been undertaken by Jongens Keet Associates (JKA). This report documents the findings of the EIA Level Investigation for the proposed development.

EIMS required that three mining alternatives were to be analysed, namely

- The mining of only Portion 30 of the coal body in the north-western portion of the site. EIMS named this the Sensitivity Planning Approach Alternative.
- The mining of the entire coal body, named the Maximum Mine Production Alternative.
- The No Go Alternative.

1.2 Terms of Reference

The terms of reference (TOR) were as follows:

i) A sufficiently detailed quantitative (by measurement) and qualitative assessment was to be undertaken within the area of influence of the planned Paardeplaats Project in order to enable a full appreciation of the nature, magnitude, extent and implications of the potential noise impact. This includes the areas in the colliery study area affected by traffic generated by the mine.

ii) Three mining alternatives were to be analysed (refer to Section 1.1).

iii) The level of investigation was to be that of an EIA.

iv) All aspects of the investigation were to conform to the requirements of relevant environmental legislation and noise standards.

v) The potential impacts of the pre-construction, construction, operational, decommissioning and closure & rehabilitation phases of the project were to be assessed for all three alternatives. The assessment was to indicate the potential cumulative impacts (noise impacts in context of the surroundings).

vi) Where relevant, appropriate noise mitigation measures were to be identified and suggested for inclusion into the EMP.

These issues were based on the Terms of Reference which were provided to Jongens Keet Associates as guidelines for tendering in a document entitled “Appendix 1 Noise Study ToR” (refer to Appendix D).

1.3 Study Area

The core study area of the noise impact assessment is that within the noise area of influence of the planned Paardeplaats Project.