- From a geochemical/pollution risk potential, the waste rock may safely be used as an erosion protection material to protect the TSF side slopes from water erosion and dust generation. It could also be used for other applications such as road building or terrace formation (subject to suitability from an engineering viewpoint).

7.2 GEOTECHNICAL INVESTIGATION OF THE TSF SITE

A geotechnical investigation of the TSF site was undertaken in April 2011 by Hoppe Engineering Services (contracted by AMEC) - see Appendix B. The geotechnical laboratory tests on the samples obtained from the site investigation are shown in Appendix C.

7.2.1 GEOTECHNICAL INVESTIGATION METHODOLOGY

A total of 13 test pits in the vicinity of the proposed TSF (and return water facilities) were excavated using a TLB wheeled backhoe (TP17 to TP29). For each of the different materials encountered in the test pits (excluding topsoil), a 40kg representative sample was taken for laboratory testing purposes. All the test pits were logged, photographed and the pit location captured by GPS. Furthermore, a tray sample for each test pit was collected for offsite reference purposes by Metago.

7.2.2 GEOTECHNICAL INVESTIGATION RESULTS

The average depth of the 13 test pits excavated was 1.4m, and all test pits were excavated to refusal depth. Only 1 test pit was excavated deeper than 2 m. The shallowest test pit was 0.5 m (TP19) and the deepest 3.0 m (TP27). All the test pits were dry, and no ground water was encountered.

Based on the logging results, the generalised soil profile of the site consists of either:

- 0.65 m topsoil (varies from 0.4 m to 0.9 m), directly underlain by hard quartz feldspar,
  or
- 0.85 m topsoil (varies from 0.6 m to 1.0 m), underlain 0.6 m silty sand material (varies from 0.4 m to 1.1m), underlain by hard gneiss sandstone conglomerate.

Two bulk samples of material were taken from test pit 22 (at 1.2 m depth) and test pit 27 (at 1.5 m depth).

Based on the geotechnical laboratory test work:

- The silty sand material from test pit 22 is classified according to the Unified Soil Classification System (USCS) as SC material (Clayey sand (with small percentage of fines)).
- The weathered quartz feldspar from test pit 27 is classified according to the USC as GP-GC material (Poorly graded gravel (little or no fines)).

- The moisture density tests (Mod AASHTO) of the SC and GP-GC materials yielded a maximum material density of 2195 kg/m^3 (at 6.9%) and 1874 kg/m^3 (at 13.8%) respectively. These results are within the expected USCS ranges for such materials (namely, 2000 ± 250 kg/m^3 and 1900 ± 300 kg/m^3).
- The effective shear strength tests (Consolidated undrained triaxial) of the SC material provided a cohesion of 13 kPa and a friction angle of 33 degrees. The friction angle is within the expected USCS range for a SC material (namely, 32 ± 4 degrees). The recommended cohesion for a SC material according to the USCS is 0.
- The effective shear strength tests (Consolidated undrained triaxial) of the GP-GC material provided a cohesion of 25 kPa and a friction angle of 34 degrees. The friction angle is within the expected USCS range for a GP-GC material (namely, 34±4 degrees). The recommended cohesion for a GP-GC material according to the USCS is 0.
- The permeability tests (Constant head) of the SC material yielded an average permeability of 1.1×10^{-6} m/s. This result is not within the expected USCS range for such material (namely, 1×10^{-8} to 1×10^{-10} m/s), but is within the expected USCS range for SM material (namely1 $\times 10^{-5}$ to 1×10^{-8} m/s). SM materials are classified according to USCS as: Silty sands with a small percentage of fines.
- The permeability tests (Constant head) of the GP-GC material yielded an average permeability of 1.1×10^{-9} m/s. The USCS range for such material is extremely wide (namely, 1×10^{-3} to 1×10^{-10} m/s), and the result for the test did fall within this range.
- The various dispersive tests (Crumb, double hydrometer and pinhole) indicated that both materials may be 'dispersive' or erodible (a more accurate term since the process of dispersion is mechanical and not physio-chemical).

7.2.3 GEOTECHNICAL INVESTIGATION CONCLUSIONS

The following conclusions have been drawn from the geotechnical investigation:

- The SC materials exhibit high strength and high load bearing characteristics. This material is ideal as wall building, foundation and road construction material.
- The material classified according to the USCS as SC materials, could also be classified as SM materials – the classification criteria is marginal, and it has no bearing on the overall expected performance of the material.
- The GP-GC materials exhibit high strength and high load bearing characteristics. This material is good for foundation and road construction material.
- The recommended shear strength values for the Insitu SC materials (to be used in the stability analysis) are cohesion = 0 kPa and effective friction angle = 30 degrees. The effective friction angle can be increased to 32 degrees for the starter wall (i.e. compacted SC material).

- The permeability and the potential 'dispersiveness' or 'erodability' of the SC (and GP-GC) materials indicate that these materials are not preferable for water retaining structures.

7.3 STAGE CAPACITY RELATIONSHIP AND SIZING OF STARTER EMBANKMENT

The derived stage capacity curves for the proposed TSF are presented in Appendix D. A schematic diagram indicating the tailings deposition strategy is presented in Figure 7-1.

The information presented in the stage capacity curves and schematic diagram can be summarized as follows:

- The maximum allowable rate of rise (RoR) for the proposed TSF is 1.0 m/year.
- The TSF will consist of two paddocks (an upper and lower paddock). Strategic tailings deposition in the upper paddock is required to reduce the RoR in the lower paddock i.e. tailings deposition in the lower paddock will be limited to the maximum RoR of 1.0 m/year and the difference in the tailings stream will be deposited in the upper paddock (RoR < 1.0 m/year). This approach will ensure that upper and lower paddocks consolidate in approximately 21 to 24 years.
- The TSF has a total volumetric capacity (up to 984.0 mamsl) of approximately 65,719,100 m^3 which is sufficient to accommodate the total production volume of 63,990,000 m^3 (127,980,000 tonnes, at the assumed average in-situ density of 2.0 t/m^3).
- The lower and upper starter walls will be constructed to an elevation of 955.0 and 966.0 mamsl respectively with wall heights, measured from the lowest point along the outer toe, of 9 m and 6 m.
- Tailings deposition will commence in the lower paddock, up to the starter wall crest elevation, at the maximum production rate of 355,500 tonnes/month for a period of 18 months (1.5 years).
- The tailings stream will then be split between the lower and upper paddocks such that a RoR of 1.0 m/yr is maintained in the lower paddock (Refer to Figure 7-1 and Table 7-1 for the target depositional rates and periods). The lower and upper paddocks are expected to consolidate after 288 months (24 years) or sooner (particularly if there are significant periods of reduced tailings deposition i.e. less than 355,500 tonnes/month).
- The total tailings stream will then be deposited on the total available surface (basin) area up to the 30 year LOM. The final height of the TSF is 38m.

The anticipated target production rates used to develop the stage capacity curves are presented in Table 7-1 below.

TABLE 7-1: TARGET DEPOSITIONAL RATES AND PERIODS

Date	Period (Months)	Average Monthly Tailings Tonnage		
		Lower Paddock	Upper Paddock	Total for TSF
Months 1 to 18	18	355,500	0	355,500
Months 19 to 28	10	180,000	175,500	355,500
Months 29 to 40	12	210,000	145,500	355,500
Months 41 to 52	12	240,000	115,500	355,500
Months 53 to 64	12	270,000	85,500	355,500
Months 65 to 85	21	300,000	55,500	355,500
Months 86 to 256	171	295,000	60,500	355,500
Months 257 to 288	32	288,000	75,500	355,500
Months 289 to 360	72	355,500		355,500

7.4 Water Balance

A monthly water balance model has been developed based on the average monthly climatic data and operating conditions to determine average monthly inflows and outflows of water from the ore processing plant, TSF and return water dam (RWD) / stormwater dam (SWD).

Since the Moonlight Project area is particularly water scarce, and hence the water demand of the TSF critical, both the conservative tailings tonnage (355,500 dry tonnes per month (tpm)) and the anticipated tailings tonnage (274,260 dry tpm) have been assessed.

7.4.1 Water Balance Methodology

The design information, rainfall data and stormwater runoff assumptions used in the monthly water balance are shown in Tables 7-2, 7-3 and 7-4.

TABLE 7-2: MONTHLY WATER BALANCE DATA FOR 355,500 TPM TAILINGS

Facility	Information Used
Tailings Storage Facility (TSF)	• Total catchment area = 2,343,815 m^2 (LOM basin) and 629,712 m^2 (LOM slopes). • Supernatant pool area = 500,952 m^2 (with 100% runoff) • Dry tailings area = 1,523,480 m^2 (with 50% average runoff) • Wet tailings area = 319,368 m^2 (with 100% average runoff) • Evaporation water losses = 127,754 m^3 / month (during average months) = 140,259 m^3 / month (during wet months) = 81,283 m^3 / month (during dry months) • Seepage water losses = 4,500 m^3 / month • Interstitial lock-up water losses = 91,043 m^3 / month (or 31% of total incoming slurry water)
Return Water Dam (RWD) & Stormwater Dam (SWD)	• Total catchment area = 1,718,127 m^2 • RWD/SWD area = 329,945 m^2 (with 100% runoff) • Veld, road servitude and TSF paddocks etc. = 1,388,182 m^2 (with 30% runoff) • Evaporation water losses = 28,270 m^3 / month (during average months) = 54,771 m^3 / month (during wet months) = 12,696 m^3 / month (during dry months) • Seepage water losses = 2,102 m^3 / month (during average months, SWD storing some water) = 5,749 m^3 / month (during wet months, SWD storing significant amount of water) = 575 m^3 / month (during dry months, SWD mainly empty)

TABLE 7-3: MONTHLY WATER BALANCE DATA FOR 274,260 TPM TAILINGS

Facility	Information Used
Tailings Storage Facility (TSF)	• Total catchment area = 1,804,738 m^2 (LOM basin) and 484,878 m^2 (LOM slopes). • Supernatant pool area = 385,734 m^2 (with 100% runoff) • Dry tailings area = 1,173,080 m^2 (with 50% average runoff) • Wet tailings area = 245,914 m^2 (with 100% average runoff) • Evaporation water losses = 98,371 m^3 / month (during average months) = 107,999 m^3 / month (during wet months) = 62,588 m^3 / month (during dry months) • Seepage water losses = 3,465 m^3 / month • Interstitial lock-up water losses = 70,103 m^3 / month (or 31% of total incoming slurry water)
Return Water Dam (RWD) & Stormwater Dam (SWD)	• Total catchment area = 1,322,958 m^2 • RWD/SWD area = 254,058 m^2 (with 100% runoff) • Veld, road servitude and TSF paddocks etc. = 1,068,900 m^2 (with 30% runoff) • Evaporation water losses = 21,768 m^3 / month (during average months) = 42,174 m^3 / month (during wet months) = 9,776 m^3 / month (during dry months) • Seepage water losses = 1,619 m^3 / month (during average months, SWD storing some water) = 4,427 m^3 / month (during wet months, SWD storing significant amount of water) = 443 m^3 / month (during dry months, SWD mainly empty)

Note: There is no preliminary design information for a TSF to cater for 274,260 dry tpm tailings. Therefore, in order to generate site specific data for the 274,260 dry tpm tailings water balance, a multiplication factor of 0.77 has been applied to the 355,500 tpm tailings data (i.e. 0.77 = 274,260 divided by 355,500). This assumption is considered accurate enough for preliminary design purposes.

TABLE 7-4: CLIMATIC DATA USED IN THE MONTHLY WATER BALANCE

Month	Marnitz Weather Station (A5E001)	
	Average Rainfall Depth (mm)	**Average Lake Evaporation (mm)**
January	84.5	177.4
February	67.5	142.1
March	45.6	149.7
April	34.6	115.2
May	6.9	96.2
June	3.2	78.4
July	1.4	89.8
August	2.7	120.4
September	10.4	155.3
October	33.4	184.4
November	62.5	178.4
December	66.7	166.2
TOTAL	**419.4**	**1653.6**
Month	**Average Rainfall Depth (mm)**	**Average Lake Evaporation (mm)**
Average (Mar to Apr) (Sep to Oct)	31.0	151.2
Wet Season (Nov to Feb)	70.3	166.0
Dry Season (May to Aug)	3.6	96.2

7.4.2 WATER BALANCE RESULTS

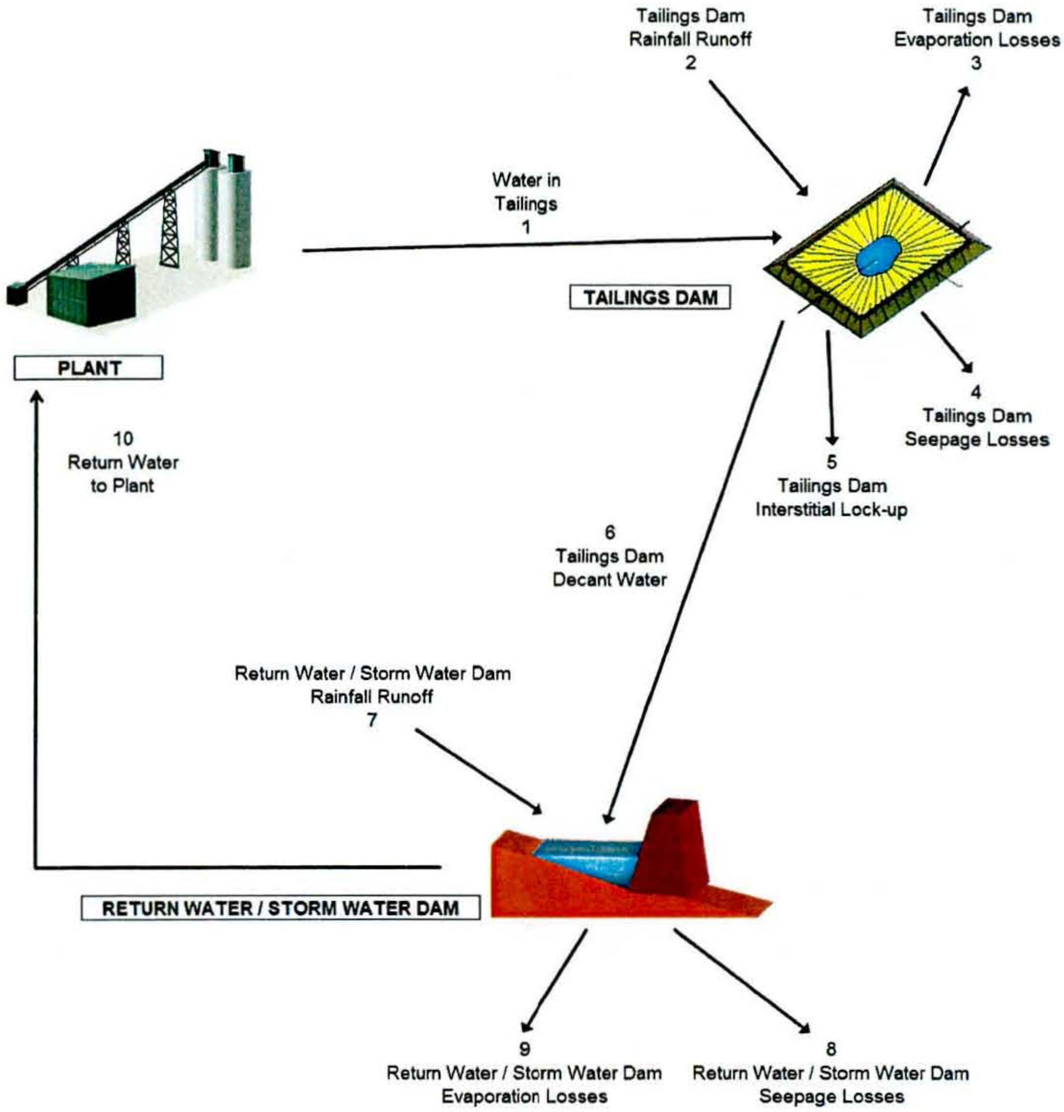
Figures 7-2 and 7-3 show the monthly inflows and outflows from the ore processing plant, TSF and RWD / SWD for the average monthly, driest monthly (this results in the maximum water demand) and wettest monthly (this results in the minimum water demand) conditions respectively.

The bulk make-up water required at the ore processing plant for 355,500 tpm tailings is expected on average to be:

- 176,068 m^3/month or roughly 60% (typically 4 months of the year – average conditions),
- 110,496 m^3/month or roughly 38% (typically 4 months of the year – wet season conditions), and
- 181,293 m^3/month or roughly 62% (typically 4 months of the year – dry season conditions)

Therefore, the annual bulk make-up water required for 355,500 tpm tailings is 1,871,428 m^3 or roughly 53.4%.

FIGURE 7-2: MONTHLY WATER BALANCE FOR THE MOONLIGHT TSF (355,500 TPM TAILINGS)

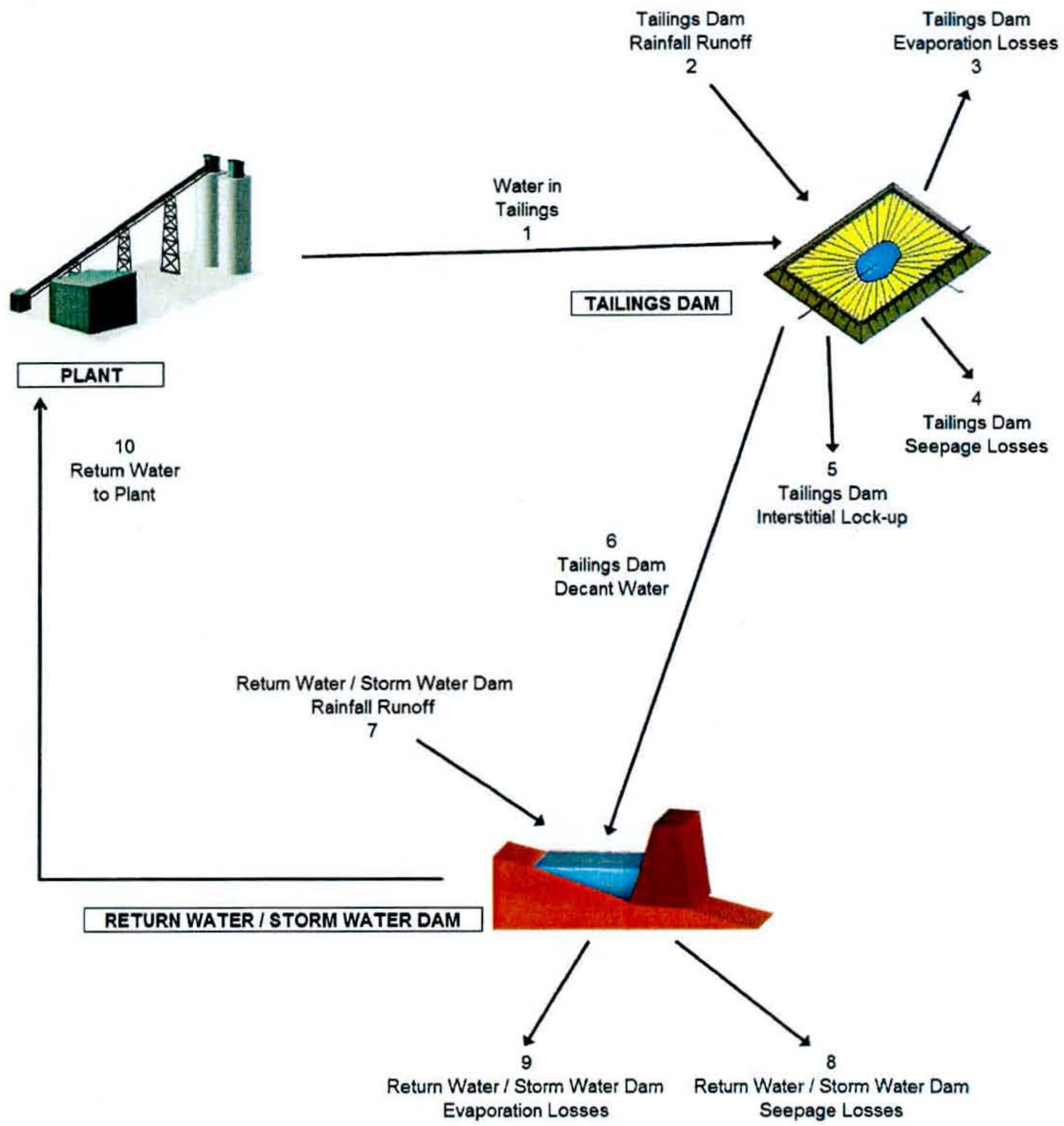


STREAM No.	1	2	3	4	5	6	7	8	9	10	% of Water in Tailings (1) returned to Plant (10)
Average, 4 months, (March to April) and (September to October)	291 874	49 044	127 754	4 500	91 043	117 621	28 467	2 012	28 270	115 806	40%
Maximum, 4 months, (November to February)	291 874	111 220	140 259	4 500	91 043	167 292	74 606	5 749	54 771	181 378	62%
Minimum, 4 months (May to August)	291 874	5 695	81 283	4 500	91 043	120 744	3 108	575	12 696	110 581	38%
											46.6%

All quantities are in m^3/month

Total bulk make-up water (m^3) 1 871 428 per year
53.4%

FIGURE 7-3: MONTHLY WATER BALANCE FOR THE MOONLIGHT TSF (274,260 TPM TAILINGS)



STREAM No.	1	2	3	4	5	6	7	8	9	10	% of Water in Tailings (1) returned to Plant (10)
Average, 4 months, (March to April) and (September to October)	225 174	37 764	98 371	3 465	70 237	90 865	21 919	1 549	21 768	89 467	40%
Maximum, 4 months, (November to February)	225 174	85 639	108 000	3 465	70 237	129 111	57 447	4 427	42 174	139 958	62%
Minimum, 4 months (May to August)	225 174	4 386	62 588	3 465	70 237	93 269	2 393	443	9 776	85 444	38%

46.6%

All quantities are in m^3/month

Total bulk make-up water (m^3) 1 442 613 per year
53.4%

For comparison purposes, the bulk make-up water required at the ore processing plant for 274,260 tpm tailings is expected on average to be:

- 135,707 m^3/month or roughly 60% (typically 4 months of the year – average conditions),
- 85,216 m^3/month or roughly 38% (typically 4 months of the year – wet season conditions), and
- 139,730 m^3/month or roughly 62% (typically 4 months of the year – dry season conditions)

Therefore, the annual bulk make-up water required for 274,260 tpm tailings is 1,442,613 m^3 or roughly 53.4% (i.e. same percentage as before).

7.4.3 Sizing of the Return Water Dam and Stormwater Dam

The RWD and SWD have been sized to satisfy the requirements of Regulation 704 of the National Water Act of 1998 No. 56, which states that the facilities should be designed to "not spill more than once in every 50 years".

The sizing of the RWD and SWD has therefore been calculated based on the "average condition" water balance results (from the 355,500 tpm tailings water balance) plus the runoff from the 1:50 year storm event, namely:

- Average monthly water inflow into RWD and SWD (from Figure 7-1) = 117,621 m^3, plus
- 1-in-50 year stormwater runoff from TSF basin = 248,385 m^3, plus
- 1-in-50 year stormwater runoff from TSF slopes and surrounding area = 114,815 m^3, plus
- 1-in-50 year stormwater runoff from RWD and SWD = 51,801 m^3

The total storage capacity of the RWD and SWD is therefore 532,624 m^3 (say 535,000 m^3) to full supply / spill level.

7.5 Seepage Analyses

Seepage analyses were carried out on the final profile of the proposed TSF (for 355,500 tpm tailings) to ascertain the effect of toe drains and inner blanket drains on the phreatic surface, and to estimate the expected seepage flux into the foundations. The seepage analyses were undertaken using the program SEEP/W (2008). The analyses are described in detail in Appendix E.

7.5.1 SEEPAGE ANALYSIS CONCLUSIONS

The following conclusions were drawn from the seepage analyses:

- Seepage from the TSF footprint will most likely range from 148 m^3/day (i.e. 4,440 m^3/month, under normal operating conditions) to 840 m^3/day (i.e. 25,200 m^3/month, under abnormal operating conditions).
- Under normal operating conditions, the underdrains play a role in reducing the seepage flux to the foundations, as well as, ensuring that the phreatic surface does not daylight on the outer slopes of the TSF.
- The drain configuration shown on Metago drawing no. T020-04-002 and 003 are considered suitable in terms of controlling the position of the phreatic surface.
- The seepage analyses have shown that a combination of a 10 m wide blanket drain and 5 m wide toe drain should effectively control the phreatic surface within the TSF.

7.5.2 SEEPAGE ANALYSIS RECOMMENDATIONS

The following recommendations are made for the detailed design phase of the TSF

- The permeability of the near surface foundation soils and tailings should be confirmed through laboratory testing and/or field infiltration tests.
- Predicted seepage losses need to be confirmed once the infiltration testing is complete.
- Drain functionality should be monitored throughout the life of the TSF. Separation of the blanket drain and toe drain collection pipes is therefore recommended to assist with diagnosis of a drain malfunction.
- Piezometric heads and drainage volumes must be monitored at least monthly to ensure safe operating phreatic surface conditions.
- During the detailed design phase, transient analysis should be carried out to assess the time it takes for the phreatic surface under normal operating conditions within the TSF to respond to abnormal conditions.

7.6 STABILITY ANALYSES

Stability analyses were carried out on the final profile of the proposed TSF (for 355,500 tpm tailings) using the program SLOPE/W (2004). The analyses are described in detail in Appendix E.

7.6.1 STABILITY ANALYSIS CONCLUSIONS

The following conclusions were drawn from the stability analyses:

- The factor of safety (FOS) is acceptable for both the normal (FOS = 2.128 and 2.125 for 35% and 75% pool sizes respectively, and the underdrains operational) and abnormal (FOS = 1.971 and 1.561 for 35% and 75% pool sizes respectively, and the underdrains non-operational) conditions as it is greater than the recommended FOS of 1.3.
- The non-operation of the underdrains results in the phreatic surface daylighting on the slopes of the TSF, which will significantly increase the likelihood of sloughing on the outer TSF slopes. Also the possibility of a piping failure of the TSF (i.e. internal erosion of tailings between the supernatant pool and the outer TSF slope) significantly increases.

7.6.2 STABILITY ANALYSIS RECOMMENDATIONS

The following recommendations are made for the detailed design phase of the TSF

- The supernatant pool should be minimised at all times through the provision of adequately sized off-dam water storage facilities, and ensuring proper functioning of the underdrains and the decant system.
- The likely range of tailings material and insitu foundation strength parameters need to be determined so that a probabilistic and sensitivity analysis can be undertaken.

8 SUMMARY DESCRIPTION OF THE TSF

8.1 SIZING AND LAYOUT

The TSF has been designed to operate as two separate paddocks during the first 21 to 24 years life of mine because of the high tailings deposition tonnages (i.e. the elevation of the lower paddock will only "catch up" to the elevation of the upper paddock towards the last 6 to 9 years of operation).

The advantages to having a TSF divided into two paddocks, upper and lower, are:

- Reducing the height of the main starter wall i.e. reduces the rate of rise by alternating tailings deposition between the two areas, and
- Phasing of the construction works, and hence having a tailings storage area (lower paddock) ready to receive tailings earlier (i.e. during the stages of plant commissioning etc.).

The size and layout of the TSF is depicted in drawing no.'s T020-04-002 (TSF General Arrangement) and T020-04-101 (LOM General Arrangement), copies of which are included in Appendix F of this report.

Key features of the sizing and layout of the facility are:

- The footprint area of the TSF is approximately 312 ha (including perimeter road, solution trench and paddock area) with the return water dam and stormwater dam having a footprint of approximately 38.5 ha.
- The final elevation of the TSF at LOM (at the end of year 30) will be 984 mamsl (maximum height of 37.5 m).

A layout of the TSF and associated infrastructure showing the major components of the system is presented in Figure 8-1. The components of the facility are described briefly below.

8.2 TAILINGS AND RETURN WATER PIPELINE ROUTES

The tailings delivery and return water pipeline route is shown in Figure 8-2. The pipelines will most likely be steel and will be supported on concrete sleepers. There are no river crossings or non-perennial stream crossings along the pipeline route. In the event of a pipe leak, any pollution will be limited to the immediate area surrounding the leak, and will effectively be contained.

8.3 TAILINGS DELIVERY SYSTEM

Deposition of the tailings will be carried out using a conventional spigot delivery system. Spigot deposition is suited to the anticipated tailings characteristics, climatic conditions and topography associated with the Moonlight site.

The tailings delivery system will comprise the following piping elements with the associated valves and fittings:

- A steel delivery pipeline (350 to 400 mm ND) that conveys tailings from the ore processing plant to the toe of the starter wall for the upper paddock;
- A steel spigot pipeline (350 to 400 mm ND) along the length of the upper and lower starter walls, that discharges tailings in the two deposition areas (upper and lower paddocks).

A schematic representation of the tailings delivery pipeline (to be designed by AMEC) is shown in Figure 8-2. It should be noted that the required pumping capacity and exact pipeline details will be addressed during the bankable feasibility and/or detailed design phase of the TSF.

8.4 STARTER EMBANKMENT

Given that the tailings will be spigotted, the TSF will require a compacted starter embankment/wall when rates of rise are high and self-building with tailings is difficult from both an operational and stability point of view. Once a rate of rise of 1.0 m/year or less is attained, "self-building" with the tailings using the upstream method of TSF development can be employed.

Construction by the upstream method is made possible by the material characteristics and the local climatic conditions which result in rapid drying and consolidation of the tailings and the resulting attainment of good tailings shear strengths within a short period of time after placement.

At a tailings deposition rate of 355 500 dry tonnes per month, the required elevation of the main (lower) starter wall is 955 mamsl (9 m maximum height), and 966 mamsl (6 m maximum height) for the upper starter wall. The stage capacity curves for the TSF are presented in Appendix D. See drawing T020-04-003 for details of the main (lower) starter wall and upper paddock starter wall.

8.5 UNDERDRAINAGE SYSTEM

The design of the underdrainage system for the TSF is based on two sets of drains:

- The toe drains, which are coincident with the inside edge of the starter wall at the downstream end of the TSF; and

- The inner blanket drains, which run parallel to the toe drains, approximately 100 m from the toe.

The function of the drains is to maintain or improve the stability of the TSF slopes. The placement and performance of the drains with respect to the functioning has been modelled as part of the seepage and stability analysis (see Appendix E).

Based on the design and analysis, the preferred approach to the construction of an underdrainage system (see drawing T020-04-003) is to make use of:

- A 5 m wide toe drain constructed at the inside edge of the starter wall;
- A 10 m wide inner elevated blanket drain constructed on top of a compacted earth platform 1,0 m above the natural ground level with 2.5 m wide slots every 50 m to allow tailings and water to migrate through to the inside area of the TSF basin;
- Spigotting (deposition) of total tailings over the underdrains during commissioning.

Once the TSF is operational, the toe and blanket drains will be extended around the entire perimeter of the TSF (mainly between months 12 (i.e. year 1) and 66 (i.e. year 5.5) for the lower paddock area, and between months 24 (i.e. year 2) and 66 for the upper paddock area). See LOM general arrangement – drawing T020-04-101 for details.

8.6 DECANT SYSTEM

A central decant system connects the upper and lower paddocks and consists of the following:

- A buried concrete spigot and socket outfall pipeline with a number of intermediate penstock intakes (see drawing T020-04-030). The penstock towers of decommissioned intermediate intakes are sealed with steel plates and concrete.
- Side inlets at the intermediate intake structures to facilitate easy migration of the pool to the intake structure. Once the tailings level exceeds the operational level of the side inlets, the inlet at the top of the intake structure is commissioned with the use of concrete rings (and the side inlets decommissioned). The side inlets of decommissioned intermediate intakes will be blocked with steel plates and concrete.
- An energy dissipator at the outfall pipeline outlet (see Drawing T020-04-032) from where decant water flows into a concrete lined solution trench which in turn conveys water into the concrete lined silt trap (see Drawing T020-04-033).

In the lower paddock, ten intermediate decants will be commissioned during the life of the TSF. The first four intermediate decants will be decommissioned, whilst the remaining six decants will be used for the life of the facility (upto 984 mamsl). Refer to drawing T020-04-002 for the positions of the decants, and to drawing T020-04-102 for the LOM Section, and Table 8-1 below.

In the upper paddock, the three intermediate decants will be commissioned and decommissioned during the life of the TSF.

TABLE 8-1: DECANT COMMISSIONING AND DECOMMISIONING DETAILS

Decant No.	Commissioned (mamsl)	Decommissioned (mamsl)	Height of Tower (m)
Lower Paddock			
1	947.0	955.0	8.0
2	948.5	960.0	11.5
3	950.5	965.0	14.5
4	950.5	965.0	14.5
5*	953.5	984.0 (LOM)	30.5
6*	953.5	984.0 (LOM)	30.5
7*	956.0	984.0 (LOM)	28.0
8*	956.0	984.0 (LOM)	28.0
9	959.0	984.0 (LOM)	25.0
10	959.0	984.0 (LOM)	25.0
Upper Paddock			
11	960.5	966.0	5.5
12	962.0	972.0	10.0
13	963.5	977.5	14.0

* The height of the penstock towers exceeds the recommended maximum height of 25m. These decants may therefore require concrete bases that protrude 3 to 5.5 m above the ground. This will be confirmed during the bankable feasibility and/or detailed design phase of the TSF.

The decant system has been sized according to following assumptions:

- The outfall pipe must be designed to decant the 1:50 year storm off the TSF within 4 days; and
- The concrete lined solution trench is to provide for the 1:50 year 24-hr storm event from the depositional area.

8.6.1 OUTFALL PIPE CAPACITY

The outfall pipe capacity is based on decanting the 1:50 year storm off the TSF within 4 days. The decant system for both paddocks comprise two distinct components:

- Vertical penstocks consisting of 0.6 m stacked fibre reinforced asbestos cement penstock rings, which convey the water from the pond of supernatant water on top of the TSF to ground level, and
- A concrete spigot and socket pipe in a trench approximately 1.85 m below natural ground level, which conveys the supernatant water towards the RWD.

Table 8-2 presents the capacity calculations for both components of the system.

For decanting the 1:50 year storm within 4 days, 3 to 4 penstocks are required. For the outfall pipe, a nominal diameter of 0.6 m is specified (internal diameter of 0.585 m).

TABLE 8-2: DECANT SYSTEM PIPING CAPACITY

Moonlight TSF Requirements	
1:50 Year flood (mm)	157
Drainage Period (days)	4
Drained area (m^2)	2,343,815
Flood volume (m^3)	248,385
Required Discharge (m^3/s)	0.719
Penstock Design	
Height of Water above Inlet (m)	0.15 to 0.20
Standard Penstock Diameter (m)	0.6
Single Penstock Capacity (m^3/s)	0.335 m^3/s (at 0.25 m head) 0.220 m^3/s (at 0.15 m head)
Number of Penstocks Required	3 to 4
Outfall Pipeline Design	
Pipe slope (1 in)	90
Internal Diameter (m)	0.585
Manning's n	0.011
Discharge for Assumed Diameter (m^3/s)	0.750

8.6.2 SOLUTION TRENCH CAPACITY

The solution trench dimensions are based on the capacity to convey the design discharge in Table 8-2 and the practicality of cleaning the trench in the event that silting occurs. With respect to keeping the channel silt free, a 1m deep concrete lined trapezoidal channel has been specified with 1V: 1.5H side slopes. The half-full capacity of the channel (using Manning's equation, assuming a slope of 1:150, which is the flattest section) is then 2.192 m^3/s (see Table 8-3), which is significantly greater than the required 1.340 m^3/s flood discharge (i.e. 4 x 0.335 m^3/s).

TABLE 8-3: SOLUTION TRENCH CAPACITY

Open Channel Flow Calculation	
Depth (m)	1.0
Breadth (m)	1.0
side slopes (1V : X H)	1.5
Channel Slope 1 : X	150
Flow Area (m^2)	0.875
Manning's n	0.015
Discharge for Specified Geometry (m^3/s)	2.192

8.7 RETURN WATER SYSTEM

The return water system will consist of the following:

- A silt trap that is fed by the solution trench,
- A HDPE lined dam (return water dam, RWD) with a capacity of 193,000 m^3,
- An unlined dam (stormwater dam, SWD) with a capacity of 356,000 m^3,
- A return water pumping station; and
- The return water pipeline (100 to 150 mm NB steel pipe), which coveys water from the return water pump station to the ore processing plant.

The advantage of the system is that the risk of seepage and groundwater contamination is limited i.e. only from the SWD. It is well known that return water dams are the single biggest contributor to seepage and ground water contamination in a TSF complex due to the increased driving heads and the relatively pervious foundations of such facilities.

The silt trap is designed to remove (or "settle out") particles that are 0.025 mm (or larger) from the decant water at a flow rate of 0.25 m^3/s. For the silt trap to operate successfully, a retention time of 27 minutes is required for the smallest particles (0.025 mm) to settle from the water surface to below the spillway level (0.15 m) i.e. the total volume of water stored in the silt trap, under a flow rate of 0.25 m^3/s, will be approximately 400 m^3.

To ameliorate the risk of drowning in the lined RWD, nylon ropes (or equivalent) fastened to anchor blocks at 100m centres around the dam will be provided. Furthermore, the RWD and SWD are fenced off to prevent any unauthorised access and to prevent livestock from drinking the water in the dams.

8.8 SURFACE WATER MANAGEMENT

Surface water management for the tailings facility entails limiting any pollution caused by the erosion of tailings from the side slopes and top surface of the TSF. Also, any surface water (considered to be contaminated) will be kept separate from clean (uncontaminated) surface water runoff.

The stormwater management is separated into the following distinct areas:

- The depositional area inside the TSF;
- The side slopes of the TSF; and
- Areas outside of the complex that drain towards the facility.

Stormwater that falls on the depositional area inside the TSF reports to the supernatant pool, there it mixes with process water and is handled as such, through the decant system, described in Section 8.6.

During any rainfall event, stormwater on the side slopes present two design challenges:

- The volume of water, which is classed as polluted water as it is in contact with deposited tailings; and
- The volume of deposited tailings that is eroded by the stormwater.

The volume of water that falls on the side slopes is retained, together with the eroded solids, in catchment paddocks that run around the TSF at its toe. Stormwater will be drained from the catchment paddocks into the solution trench. The catchment paddocks are designed to trap the tailings eroded from the side slopes (i.e. act as a settling facility) and will have to be routinely cleaned out. The tailings cleaned out from the catchment paddocks will be deposited in the basin of the TSF.

Stormwater that would normally flow through the TSF area from the upstream catchment is diverted around the tailings facility by stormwater diversion berms and channels (i.e. material excavated for the diversion channel is used to construct the berm) running around the upstream perimeter of the TSF where any inflows might occur. The stormwater diversion berms are specified as trapezoidal compacted earthfill berms that are either 1.5 m or 3.2 m wide at the crest, and 0.9 m or 1.2 m high with 1V:1.5H side slopes. Similarly, the adjacent diversion channels are either 1.5 m or 3.2 m wide at the base, and 0.9 m or 1.2 m deep with 1V:1.5H side slopes. The two differing sizes of the berms/channels are due to the different upstream catchment areas for each diversion.

Further details of stormwater management is described in "Hydrological Assessment and Stormwater Management Plan for the Proposed Moonlight Iron Ore Mine" (Metago Project T020-02, Report No. 6: Final, May 2011) that is appended with the overall EMP document for the Moonlight Project.

8.9 MONITORING PROGRAMME

During the life of the facility, various elements will be monitored daily, weekly and monthly to ensure the integrity and safety of the TSF complex. Monitoring elements as a minimum will include:

Tailings storage facility:

- Daily monitoring to include:
  - Position and size of the supernatant pool;
  - Condition of slurry delivery pipes, valves etc.
  - Decanting of clear supernatant water;
  - Safety around and general condition of penstock intakes and catwalk; and
  - Safe access to all areas of the TSF.

- Weekly and/or monthly monitoring to include:
  - Adequacy of pool freeboard;
  - Presence of erosion gulleys on outer walls, trenches, berms, culverts, pipeline supports etc. following periods of significant rainfall;
  - Presence of seepage;
  - Evidence of settlement and/or cracking on walls;
  - Condition of fences, access gates and signage;
  - Location of the phreatic surface;
  - Assessment of slope stability;
  - Functioning of underdrains; and
  - Incidence of tailings layering.
- Quarterly groundwater monitoring, typically: EC, TDS, pH, Ca, Cl, F, Mg, NO_3, K, Na, SO_4, Zn, Sb, Cd, Cr, Cu, Fe, Mn, Ni, Se, *Total Coliform Bacteria, E.coli*, alkalinity, and hardness.

Return water dam:

- Daily monitoring to include:
  - Water levels; and
  - Operation of pumps, pump motor control system and flow rates.
- Monthly monitoring to include:
  - Dipping of leak detectors to check integrity of HDPE liner;
  - Physical inspection for damage to HDPE liner;
  - Presence of seepage, erosion damage, wall movement/bulging/subsidence, vegetation on outer slope, condition of riprap, condition of spillways;
  - Condition of fences, access gates, signage, safety ropes, life rings; and
  - General condition of silt trap, cleaning and removal of silt required.
- Monthly surface water monitoring, typically: EC, TDS, pH, Ca, Cl, F, Mg, NO_3, K, Na, SO_4, Zn, Sb, Cd, Cr, Cu, Fe, Mn, Ni, Se, *Total Coliform Bacteria, E.coli*, alkalinity, and hardness
- Quarterly groundwater monitoring (as per the TSF), typically: EC, TDS, pH, Ca, Cl, F, Mg, NO_3, K, Na, SO_4, Zn, Sb, Cd, Cr, Cu, Fe, Mn, Ni, Se, *Total Coliform Bacteria, E.coli*, alkalinity, and hardness.

8.10 Contingency Plans

8.10.1 Tailings Storage Facility

The following situations, all of which could adversely affect slope stability of the TSF, may arise that will require contingency plans:

- An increase in the elevation of the phreatic surface;

- A blocked drain outlet that may lead to the above;
- A blockage or failure of the decant outfall pipeline or penstock intake structure;
- Extreme rainfall and/or failure of the upstream stormwater diversion berms;
- Excessive seepage noted on sidewalls.

In each case, the problem will be investigated and, where necessary, remediation measures will need to be put in place timeously. Remediation may range from a simple repair to a designed engineering solution that ensures the ongoing integrity of the tailings storage facility.

In the event that a significant increase in groundwater pollution is indicated by one or more of the monitoring boreholes, the source would need to be identified and appropriate measures put in place to prevent further pollution and to control the pollution plume if necessary (e.g. seepage interception system).

8.10.2 RETURN WATER AND STORMWATER DAMS

The following adverse operational conditions may occur at the RWD/SWD that need to be planned for:

- The water level of the dam is above what is considered acceptable, as determined by the climatic water balance;
- The pumps that convey water to the process plant break down, implying that there is no way of maintaining the water level within acceptable limits.
- A power failure rendering the pumps inoperable.

If the water level in the dam is above what is considered acceptable, the following courses of action could be taken:

- Excess water could be pumped to the process water and stormwater dams within the MPC;
- Excess water could be pumped back to the TSF, if there is sufficient capacity; or
- As a last resort, water could be discharged to the environment. DWAF will be informed should such an action be required.

A pump breakdown will be countered by a back up pump that can be commissioned timeously and operated while the primary pump is repaired and reinstalled.

A power failure of short duration (less than 24 hours) does not pose a significant risk to the operation of the return water dam but if the duration is greater than 24 hours, a generator may be necessary if the water level approaches or is greater than what is considered acceptable.

9 SUMMARY DESCRIPTION OF THE PREPARATORY WORKS

The preparatory works required for the TSF and associated water dams and infrastructure are shown on the preliminary drawings in Appendix F of this report and are described briefly below.

9.1 TAILINGS STORAGE FACILITY

The TSF preparatory works will include:

- A compacted main starter wall with a maximum height of 9 m;
- A compacted upper containment wall with a maximum height of 6 m;
- 1.5 m high catchment paddocks downstream of the main starter wall and upper containment wall (along the TSF perimeter);
- Toe drains at the base of the main starter wall which are 5 m wide comprising suitably graded sand and stone with drain pipes;
- Blanket drains (10 m wide) located approximately 100 m from the inside toe of the starter wall;
- Two HDPE drain outlet pipes (160 mm NB), approximately every 50 m that accept effluent from the toe drains and blanket drains separately;
- A concrete spigot and socket penstock outfall pipe (600 mm NB) buried in a trench which discharges into the solution trench;
- Thirteen intermediate penstock inlets (600 mm NB) located along the spigot and socket outfall pipe;
- Timber catwalks from the main starter wall and upper containment wall to the first two intermediate penstock inlets;
- A concrete energy dissipater structure at the exit of the penstock pipeline;
- A 1 m deep concrete lined solution trench along the length of the main starter wall which accepts the seepage and decant water from the drains, catchment paddocks and the penstock pipeline;
- A silt trap (with a volumetric capacity of approximately 400 m^3) immediately upstream of the return water dam (RWD), accepting water from the solution trench;
- A HDPE lined RWD (193,000 m^3 capacity) with spillway to the stormwater dam (SWD);
- An unlined SWD (356,000 m^3 capacity) with spillway and an unlined trench diverting water to the downstream areas (in the event of overtopping);
- A return water pump station (to be designed by others);
- A 4m wide waste rock road around the perimeter of the TSF;
- A barbed wire perimeter fence with access gates around the perimeter of the whole TSF;
- A 2.4 m high security fence and access gates around the RWD and SWD;
- An east and west topsoil stockpile area, 25 ha each with a perimeter silt containment berm; and
- An upstream stormwater diversion berm/channel that directs clean surface water run off away from the TSF and RWD/SWD.

9.2 SOURCING CONSTRUCTION MATERIALS (EARTHFILL) FOR THE TSF

Based on the geotechnical investigation it has been determined that the average topsoil thickness is about 650 to 850 mm. Prior to the commencement of construction activities; some topsoil (for rehabilitation purposes) needs to be removed and stockpiled. It is currently estimated that the total volume of topsoil to be stripped, at 0.3 m depth, over the entire TSF area (from tailings storage facility, return water dam, stormwater dam, access road etc. footprints) is approximately 1,050,000 m^3.

Topsoil stockpiles exceeding 2 m in height can result in adverse biochemical reactions such as the accumulation of ammonium and anaerobic conditions at the base of the pile that decrease the quality of the stockpiled topsoil as a growth medium material. Therefore to minimise the decrease in the quality of the stockpiled topsoil, the footprint of the topsoil stockpile would need to be about 50 ha (for 1,050,000 m. The surface of the topsoil stockpile will be shaped in such a way that rain water will not pond on top of the stockpile (i.e. dome shaped).

Topsoil will be sourced from the stockpile during the life of mine operations for the ongoing rehabilitation of the outer slopes of the TSF (and final rehabilitation of the top surface at closure). If required, nutrients and/or fertilizers will be added to the topsoil material to correct any adverse biochemical reaction that may have occurred within the material.

Based on the preliminary geotechnical investigation and laboratory testing it has been determined that the residual silty sand material is suitable for the construction of the following:

- Main starter wall;
- Upper containment wall; and
- Catchment berms and paddocks.

The construction of the main starter wall and upper containment paddock will require approximately 211,750 m^3 and 271,150 m^3 of earthfill (silty sand material). The construction of the RWD and SWD will require approximately 72,350 m^3 of earthfill (preferably clayey material). The construction of the access roads will require approximately 15,000 m^3 of earthfill (gravel material / weathered rock). The construction of the rip-rap layer in the SWD will require 5550 m^3 of waste rockfill (unweathered).

The bulk of the all earthworks material will be sourced from the excavation of the open pit. Additional wall building material is also available from minor excavation works in the RWD. Careful material selection from excavations in the open pit area will hopefully yield material that has a higher clay content, that will be used in the construction of the RWD and SWD walls (preferable to the residual silty sand material). A follow up geotechnical investigation during the bankable feasibility study and/or detailed design phase of the TSF will be undertaken to attempt to source better wall building material for the RWD and SWD.

Careful material selection during the open pit development operations will therefore be required to ensure that:

- Suitable silty sand material is allocated for TSF wall construction,
- Suitable clayey/silty material is allocated for RWD / SWD wall construction (if available), and
- Suitable hard rock is allocated for rip-rap in the SWD,
- Suitable weathered material is allocated for access road construction and
- Topsoil and any unsuitable/excess pit material is stockpiled separately.

10 METHOD OF OPERATION AND TSF DEVELOPMENT

The major part of the tailings facility operations relates to the delivery and placement of tailings onto the TSF and formation of the outer walls. The deposition operation comprises of two distinct sub-operations, namely start-up/drain covering and routine operations.

The covering of the drains with suitable material while at the same time preventing the washing away or damage of the filter sand drain is vital to the successful operation and integrity of the TSF in the longer term. The TSF operator will be required to take extra care of drain covering at all times.

Deposition is to commence at the lowest points of the TSF directly against the starter wall and rise up-contour as the level of the tailings in the basin rises with time. The tailings is to be placed in a manner to ensure that a beach is formed which results in the formation of supernatant/decant water pool around the decant inlets and away from the sides of the starter wall. Decant water is not allowed to pond or pool within 20m of the toe drain or the blanket drain at any time during the TSF commissioning, start up and routine operations.

The tailings will be deposited via a 350 to 400 mm NB steel spigot pipeline along the length of the starter walls (main starter wall and upper paddock containment wall). Once the tailings has reached the elevation of the starter walls, tailings deposition will cycle from one end of the spigot pipeline to the other to allow the formation of bund walls for the continual raising of the spigot pipeline. Discard material (from the process plant) and/or dried tailings material will be used for building the outer bund walls.

The TSF will be developed by the upstream method of tailings deposition. The rate of rise of the TSF is limited to 1.0 m/year or less to ensure that the deposited tailings sufficiently dries and consolidates, and has sufficient shear strength to support additional newly placed tailings material. Simultaneous tailings deposition in the upper and lower areas of the TSF will be for the first 21 to 24 years life of mine, after which it is expected that the two paddocks will consolidate to form one paddock (approximately between 975 and 977.5 mamsl). See Figure 7-1.

Decanting will be via the intermediate penstock inlets throughout the life of the TSF. In the lower paddock, ten intermediate decants will be commissioned during the life of the TSF. The first four intermediate decants will be decommissioned, whilst the remaining six decants will be used for the life of the facility (upto 984 mamsl). In the upper paddock, the three intermediate decants will be commissioned and decommissioned during the life of the TSF. The final height of the penstock towers will range from 5.5 m to 30.5 m.

Where the height of the penstock towers exceeds the recommended maximum height of 25m, these decants may require concrete bases that protrude as much as 5.5 m above the ground. The need for concrete bases at some of the intermediate decants will be confirmed during the bankable feasibility and/or detailed design phase of the TSF. Further details regarding the intermediate decants are given in Chapter 8.6, and the positions and elevations shown on Drawings T020-04-002 and T020-04-102.

The supernatant pools (in the upper and lower paddocks) are expected to migrate from the starter walls up-contour along the penstock outfall pipeline route. The intermediate intakes will be sealed as the pool sufficiently migrates past these intakes structures. The decanted pool water discharges via the penstock outfall pipeline into an energy dissipator structure, from where decant water flows into a concrete lined solution trench which in turn conveys water into the concrete silt trap. The silt trap discharges water directly into the HDPE lined RWD.

Water collected in the RWD (and SWD) will be pumped back to the ore processing plant. The RWD and SWD dam will need to be managed such that the dam has capacity to absorb the 1:50 year storm event at all times (i.e. the SWD must be kept empty as much as practically possible). In the event of the design capacity of the SWD being exceeded, excess water will be released via a lined spillway to the environment.

11 CLOSURE, REHABILITATION AND AFTERCARE ISSUES

The closure and rehabilitation plan comprise a series of activities both during and after the operational phase. The closure and rehabilitation plan described below is of a conceptual nature only, and presumes that the TSF will remain as a permanent on-surface facility (i.e. alternative closure options such as in-pit disposal at LOM has not been considered at this stage).

11.1 CLOSURE OBJECTIVES

The closure objectives for the TSF are as follows:

- To achieve chemical and physical stability,
- To make the TSF site safe,
- To protect surface and groundwater resources from loss of utility value or environmental functioning, and
- To limit the rate of emissions to the atmosphere (including particulate matter and salts) to the extent that degradation of the surrounding properties and soils does not occur.

11.2 REHABILITATION DURING OPERATIONS

The following ongoing rehabilitation activities should be carried out in conjunction with the operation of the TSF:

- Ongoing amelioration of the tailings and the establishment of vegetation on the side slopes as the elevation of the TSF increases. To assist with the establishment of the vegetation an irrigation system will most likely be required, use being made of water from the RWD,
- The step-in berms on the side slopes will need to be engineered to contain and control stormwater runoff from the side slope, and
- As older step-ins berms become redundant and are no longer required as access roads, the step-ins can be dozed over and the side slopes reshaped to a 1V:4H continuous slope, covered with a 0.5 m thick layer of waste rock cladding and pockets of vegetation (shrubs and grasses) established at 50 no. /ha (i.e. roughly a 14 m x 14 m spacing).

11.3 DECOMMISSIONING ACTIVITIES AT CESSATION OF OPERATIONS

At the end of the operational life of the facility the following decommissioning activities will be required (refer to Figure 11-1):

- Top Surface of TSF:
    - Remove spigot pipelines and pipe supports,
    - Seal penstock intakes and decant pipeline,

- Push up perimeter berm, 15 m crest width, 1.5 m high covered with 0.5 m thick layer of rock,
- Push up paddock berms, 3 m crest width, 1.5 m high covered with 0.5 m thick layer of rock, at 50 m centre-to-centre spacing,
- Cover inside of paddocks with 0.3 m thick topsoil layer (not on berms), and
- Establish vegetation cover inside paddocks (not on berms).

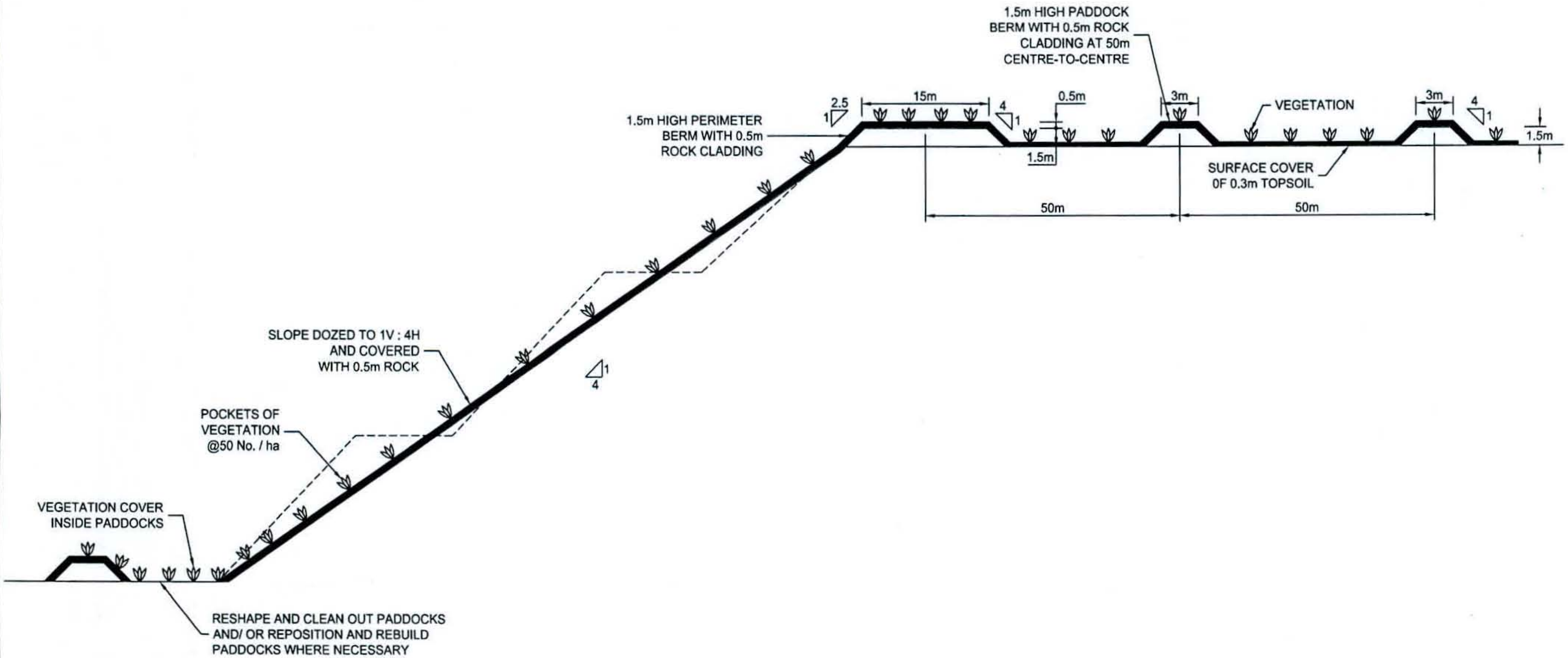
- Side Slopes of TSF:
  - Rock clad access roads (0.5 m thick rock wearing course) and establish sufficient stormwater drainage measures,
  - Doze over remaining step-ins and reshape side slopes to 1V:4H continuous slope, and
  - Rock clad remaining side slopes with 0.5 m thick rock layer and establish pockets of vegetation at 50 no./ha.
- Toe and surrounding area of TSF:
  - Remove delivery and return water pipelines and pipe supports,
  - Reshape and clean out the paddocks and solution trench,
  - Re-establish vegetation cover all around and inside paddocks, and
  - Reshape the flood protection berms
- Water Dams:
  - Demolish and dispose of pump station and associated infrastructure at the return water dam and stormwater dam,
  - Demolish and dispose of silt trap, energy dissipator, concrete lined trenches and other concrete infrastructure,
  - Widening and/or cleaning out of spillways, and
  - Remove and dispose of HDPE liner within return water dam.

11.4 AFTERCARE REQUIREMENTS

On completion of the final closure measures an aftercare programme has to be implemented to ensure that the closure measures are robust, have performed adequately and that no further liabilities arise. The aftercare period is normally not less than 5 years but can extend into decades depending on the physical and chemical characteristics of the facility. In the case of the Moonlight TSF, with relatively inert iron ore tailings, a period of 6 years is considered reasonable.

The typical aftercare requirements would include:

- The monitoring of closure measures to ascertain that vegetation has been successfully established where it is feasible, and earthworks have not been impaired in anyway (which would then require follow up remediation).
- Monitoring of the drop in the phreatic surface and the quantity and quality of the seepage from the underdrains followed by underdrain outlet closure.



SCHEMATIC CROSS-SECTION THROUGH TSF AT CLOSURE

Metago Environmental Engineers (Pty) Ltd *Consulting Engineers & Scientists*	MOONLIGHT IRON ORE PROJECT PROPOSED NEW TAILINGS STORAGE FACILITY 'CHEMATIC CROSS-SECTION THROUGH TSF CLOSURE	MAY '11 T020-04	FIGURE 11-1

- Topsoiling and vegetation of the surface of the TSF in the area of the pool (which may have been too wet to work on at closure).
- Weed and invasive species control (spraying, cutting and removing).
- Fertilising, topdressing, seeding and planting of bare wash-away areas.
- Maintenance of vegetation, which would include:
  - Cutting and baling (stimulates horizontal vegetation growth rather than vertical growth), and
  - Establish and maintain firebreaks to protect re-vegetated areas still vulnerable.
- Erosion control (fill in gulleys, erect catch nets, repairing berms and wash-away areas).
- Clean-out debris / fine material deposited in toe paddocks.
- Evaluate and audit of rock cladding and cover integrity and effectiveness, which would include:
  - Erosion protection of the cladding and underlying tailings material, and
  - Dust reduction / elimination.
- Evaluate and audit vegetation rehabilitation, which would include:
  - Forage value,
  - Soil fertility,
  - Species composition, and
  - Soil loss.

The six year aftercare period has been sub-divided into three years of active maintenance and three years of passive maintenance (i.e. where maintenance activities have decreased and monitoring frequency declined).

12 EXPENDITURE

12.1 CONSTRUCTION EXPENDITURE

The capital costs for the facility are estimated in Table 12-1. The estimate has been based on a preliminary schedule of quantities, and the rates used have been taken from recently priced bills of quantities for various tailings storage facilities.

The following cost qualifications apply to the construction cost estimate:

- Pipeline sizes are preliminary and require further design for final costing.
- Concrete decant towers to accommodate penstocks greater than 25 m in height have been excluded.
- All mechanical and electrical items associated with the TSF and return water pumpstation have been excluded.
- The return water pumpstation (structure and equipment) has been excluded.
- Free haul distance is assumed to be 2 km and no overhaul is anticipated for embankment and return water dam construction.
- Overhaul for topsoil has been excluded.

TABLE 12-1: CAPITAL EXPENDITURE FOR CONSTRUCTION

Description		Quantity	Unit	Rate	Total	% of Total
TAILINGS STORAGE FACILITY						
Clear Site		4 720 000	m^2	R 0.65	R 3 068 000.00	2.81%
Remove Top Soil (300mm)		1 416 000	m^3	R 18.00	R 25 488 000.00	23.35%
Main Starter Wall (Lower Paddock)	- Box Cut	24 150	m^3	R 15.00	R 362 250.00	0.33%
	- Base Prep	48 300	m^2	R 1.60	R 77 280.00	0.07%
	- Wall Building	212 000	m^3	R 25.00	R 5 300 000.00	4.86%
Upper Starter Wall (Upper Paddock)	- Box Cut	42 000	m^3	R 15.00	R 630 000.00	0.58%
	- Base Prep	84 000	m^2	R 1.60	R 134 400.00	0.12%
	- Wall Building	271 150	m^3	R 25.00	R 6 778 750.00	6.21%
Toe Drain		2 740	m	R 1 790.00	R 4 904 600.00	4.49%
Toe Drain Outlets		3 640	m	R 80.00	R 291 200.00	0.27%
Blanket drain		2 380	m	R 1 950.00	R 4 641 000.00	4.25%
Blanket Drain Outlets		5 550	m	R 80.00	R 444 000.00	0.41%
Decant - Pipeline - Concrete Encased		145	m	R 3 400.00	R 493 000.00	0.45%
Decant - Pipeline - No encasement		1 900	m	R 1 800.00	R 3 420 000.00	3.13%
Decant – Inlets		13	No.	R 30 000.00	R 390 000.00	0.36%
Energy Dissipator		1	No.	R 75 000.00	R 75 000.00	0.07%
Timber Catwalks and Structures		1	SUM	R 1 000 000.00	R 1 000 000.00	0.92%

Timber - Steel Cage	13	No.	R 4 000.00	R 52 000.00	0.05%
Solution Trench (concrete lined)	5 400	m	R 3 000.00	R 16 200 000.00	14.84%
Stormwater Diversion Berm	5 350	m	R 100.00	R 535 000.00	0.49%
Silt Trap	1	SUM	R 820 000.00	R 820 000.00	0.75%
Paddocks	3 900	m	R 18.00	R 70 200.00	0.06%
Access Roads	13 000	m^2	R 60.00	R 780 000.00	0.71%
Access Road Crossings	3	SUM	R 35 000.00	R 105 000.00	0.10%
Tailings - Pipeline	1	SUM	R 5 000 000.00	R 5 000 000.00	4.58%
Gates	2	No.	R 9 000.00	R 18 000.00	0.02%
Perimeter Fence	2 680	m	R 290.00	R 777 200.00	0.71%
Sub Total (TSF)			**Sub Total A**	**R 81 854 880.00**	75.00%
RETURN WATER & STORMWATER DAM					
Excavation	234 850	m^3	R 20.00	R 4 697 000.00	4.30%
Base Preparation - Base	155 370	m^2	R 2.00	R 310 740.00	0.28%
- Wall	229 190	m^2	R 1.30	R 297 947.00	0.27%
Wall Building	72 350	m^3	R 25.00	R 1 808 750.00	1.66%
HDPE Lining	139 200	m^2	R 35.00	R 4 872 000.00	4.46%
A5 Geofabric	139 200	m^2	R 10.00	R 1 392 000.00	1.28%
A6 Geofabric	241 200	m^2	R 12.00	R 2 894 400.00	2.65%
Outlet Trench	570	m^3	R 40.00	R 22 800.00	0.02%
Embankment Rip-rap	11 050	m^2	R 70.00	R 773 500.00	0.71%
RWD Spillway	1	No.	R 35 000.00	R 35 000.00	0.03%
SWD Spillway	1	No.	R 80 000.00	R 80 000.00	0.07%
Steel Outlet Pipe OD 300	130	m	R 1 400.00	R 182 000.00	0.17%
Sub Total (RWD and SWD)			**Sub Total B**	**R 17 366 137.00**	15.91%
Contingency (10% of Sub Total A + B)				**R 9 922 101.70**	9.09%
Total (excl. VAT)				**R 109 143 118.70**	100.00%

12.2 OPERATIONAL EXPENDITURE

The TSF operations management cost has been estimated to be R1.50 per tonne of tailings (excluding VAT). This estimate typically includes tailings deposition costs, ongoing TSF maintenance and expansion costs (excluding significant piping, mechanical and electrical expansion costs). This estimate would need to be verified by a specialist TSF operations contractor.

The construction of the toe drains (3,400 m), blanket drains (2,270 m), drain outlets (7,000 m) and paddocks (4,450 m) along the perimeter of the TSF during the life of mine has been costed using the rates in Table 12-1. The total cost of these works is R 11,152,600 (excluding VAT).

The provision of mandatory monitoring and ongoing documentation reviews and updates (e.g. annual design reports, monitoring reports, operations manual, code of practise, closure liability etc.) by independent professional persons (engineers and/or scientists) is estimated to be R 1,000,000 per annum (excluding VAT).

The rehabilitation and closure fund provisions are included under decommissioning expenditure.

12.3 CLOSURE EXPENDITURE

The financial provision calculation for closure of the tailings complex has been based on guidelines drawn up by the Department of Minerals and Energy (DME), "*Guideline Document for the Quantum of Closure-Related Financial Provision Provided by a Mine*" (January 2005). The financial provision, which is required by in terms of Section 41 of the Mineral and Petroleum Resources Development Act (MPRDA), (Act 28 of 2002), is a monetary value placed in a dedicated trust fund (in terms of Section 10(1)(cH) of the Income Tax Act, 1962) by Turquoise Moon to cover the environmental liability that would be incurred at closure of the facility.

Following the DME guideline, the following steps are applicable:

- The mining operations consist of an open pit that mines iron ore, which is further processed to produce a magnetite concentrate.
- The facility would have a risk ranking of A (high risk) since it is classified as a large base metal mine (greater than 10,000 tonnes per month).
- The area's sensitivity criteria (biophysical, social and economic) is classed as Medium.
- As the facility is still in the design phase and limited information is available, the "rules-based" approach will be used.

Further details and explanation as to the DME (now DMR) process for calculating the closure liability is provided in the "Calculation of the Financial Closure Liability associated with the Moonlight Iron Ore Mine" that is appended with the overall EMP document for the Moonlight Project.

The calculation of the closure cost is presented in Table 12-2, the DME template for the "rules-based" approach. The unit (Master) rates for each closure component given in the template has been inflated by 50.1% (CPI index) to account for escalation since January 2005.

The financial provision required by Turquoise Moon for the closure and rehabilitation of the Moonlight TSF is currently estimated to be R 68,990,023 (excluding VAT) at the LOM (i.e. after 30 years of operation and ongoing rehabilitation work, at the current predicted tailings deposition rates).

TABLE 12-2: FINANCIAL PROVISION FOR CLOSURE

CALCULATION OF THE QUANTUM								
Area	*Turquoise Moon - Tailings Storage Facility*							
No.	Description:	Unit:	Operational Area	A Quantity	B Master rate	C Multiplication factor	D Weighting factor 1	E=A*B*C*D Amount (Rands)
				Step 4.5	Step 4.3	Step 4.3	Step 4.4	
1	Dismantling of processing plant & related structures (incl. overland conveyors & power lines)	m^3	N/A	0.00	R 10.24	1	1	R 0.00
2 (A)	Demolition of steel buildings & structures	m^2	N/A	0.00	R 142.57	1	1	R 0.00
2 (B)	Demolition of reinforced concrete buildings & structures	m^2	N/A	0.00	R 210.11	1	1	R 0.00
3	Rehabilitation of access roads	m^2	TSF Area	49 855.00	R 25.51	1	1	R 1 271 955.10
4 (A)	Demolition & rehabilitation of electrified railway lines	m	N/A	0.00	R 247.63	1	1	R 0.00
4 (B)	Demolition & rehabilitation of non electrified railway lines	m	N/A	0.00	R 135.07	1	1	R 0.00
5	Demolition of housing &/or administration facilities	m^2	N/A	0.00	R 285.15	1	1	R 0.00
6	Opencast rehabilitation including final voids & ramps	ha	N/A	0.00	R 145 124.46	0.52	1	R 0.[illegible]
7	Sealing of shafts, adits & inclines	m^3	N/A	0.00	R 76.54	1	1	R 0.0[illegible]
8 (A)	Rehabilitation of overburden & spoils	ha	N/A	0.00	R 99 651.13	1	1	R 0.00
8 (B)	Rehabilitation of processing waste deposits & evaporation ponds (basic, salt producing waste)	ha	SWD & RWD	39.21	R 124 113.68	1	1	R 4 866 993.81
		ha	TSF - Basin	213.73	R 124 113.68	1	1	R 26 526 642.30
		ha	TSF - Side Slopes	65.67	R 0.00	1	1	R 0.00
8 (C)	Rehabilitation of processing waste deposits & evaporation ponds (acidic, metal-rich waste)	ha	N/A	0.00	R 360 484.95	0.80	1	R 0.00
9	Rehabilitation of subsided areas	ha	N/A	0.00	R 83 442.81	1	1	R 0.00
10	General surface rehabilitation	ha	Surrounding Areas of TSF (already rehabilitated)	37.40	R 0.00	1	1	R 0.00
		ha	Top Soil Stockpile	48.94	R 78 940.50	1	1	R 3 863 663.93
		ha	Concrete Areas	2.61	R 78 940.50	1	1	R 205 753.68
11	River diversions (to be decommissioned)	ha	N/A	0.00	R 78 940.50	1	1	R 0.00
12	Fencing	m	TSF Area	0.00	R 90.05	1	1	R 0.00
13	Water management	ha	N/A	0.00	R 30 015.40	0.67	1	R 0.00
14	2 to 3 years of maintenance & aftercare	ha	Operational TSF & Surrounding Areas	412.55	R 10 505.39	1	1	R 4 333 966.50
15 (A)	Specialist study (Water pollution potential study)	SUM	All Areas	0.00	R 500 000.00	1	1	R 0.00
15 (B)	Specialist study (Overall quantified risk assessment)	SUM	All Areas	0.00	R 300 000.00	1	1	R 0.00
15 (C)	Concrete Slabs & Light Structures	m^2	Silt Trap	1 153.20	R 130.00	1	1	R 149 916.00
		m^2	Energy Dissipator	108.00	R 130.00	1	1	R 14 040.00
		m^2	Solution Trench	24 803.20	R 130.00	1	1	R 3 224 416.[illegible]
							Sub Total 1 (Sum of items 1 to 15 Above)	R 44 457 347
16	Preliminary and general	12.5% of Subtotal 1				**Weighting factor 2 (step 4.4)**	1.05	R 5 835 026.84
17	Administration & supervision costs	6.0% of Subtotal 1						R 2 667 440.84
18	Engineering drawings & specifications	2.0% of Subtotal 1						R 889 146.95
19	Engineering & procurement of specialist work	2.5% of Subtotal 1						R 1 111 433.68
20	Development of a closure plan	2.5% of Subtotal 1						R 1 111 433.68
21	Final groundwater modeling							
							Sub Total 2 (Subtotal 1 plus sum of management & administrative items, 1 to 6 above)	R 56 071 829.30
22	Contingency	10.0% of Subtotal 1						R 4 445 734.73
							Sub Total 3 (Subtotal 2 plus contingency)	R 60 517 564.03
23	VAT	14.0% of Subtotal 3						R 8 472 458.96
							GRAND TOTAL FOR TSF (Subtotal 3 plus VAT)	R 68 990 023.00

13 CONCLUSIONS

Predictive Methods, Assumptions and Uncertainties

1) The predictive methods and tools used in the analyses and preliminary design of the TSF are considered best practise, and are based on the legislative requirements (especially the MPRDA), as well as, industry established standards and guidelines, namely: SANS 10286:1998, "*Code of Practise for Mine Residue*" and the Chamber of Mines of South Africa, 1996, "*Guidelines for Environmental Protection – The Engineering Design, Operation and Closure of Metalliferous, Diamond and Coal Residue Deposits*".

2) All underlying assumptions made throughout the analyses and preliminary design of the TSF have been conservative (i.e. presenting the worst case) until such time that it can be proven otherwise. Wherever possible, these assumptions have also been based on similar TSF operations and/or design philosophies.

3) Uncertainties regarding any information provided and/or used in the analyses and preliminary design of the TSF have been highlighted and recommendations have been made that will need to be addressed during the bankable feasibility design phase, detailed design phase and/or operations phase of the TSF.

Design Criteria

4) The TSF described in this report has been designed, up to a preliminary level, to accommodate an average of 355,500 dry tonnes of tailings per month for a period of 30 years. This tailings production figure is considered worst case, assuming a 65% conversion of ROM production to tailings. [The best case assumes a 50% conversion of ROM production to tailings, or 274,260 dry tonnes of tailings per month].

5) The expected particle size distribution of the tailings indicates that the tailings is likely to dry slowly, crack extensively and erode easily. Also, the tailings is expected to be slow draining and relatively impermeable.

Site Selection

6) Site A (see Figure 5-1) is the preferred site from the point of view of the physical and biological environment, social aspects, technical issues and economics.

TSF Classification

7) Based on the safety classification criteria the TSF has been classified as a medium hazard facility.

8) Based on the environmental classification criteria the TSF has been classified as having no potentially significant impact on groundwater and a potentially significant impact on air quality.

9) In the managed scenario (i.e. ongoing contaminant plume modelling, the construction of a downstream seepage interception system (if required) and continuous rehabilitation and re-vegetation of the TSF), the TSF impacts on air and groundwater can all be managed to low significance. In this scenario there is little potential for significant impact on the environment.

Geochemical Investigation

10) The potential for acid generation is extremely limited (since there is a minimal percentage of pyrite in the ore body) and considering that there is also some alkalinity available, the tailings is unlikely to be acid generating.

11) It is unlikely that there will be leaching of any metals of environmental concern from the tailings.

12) The tailings will contain amphibolites in the form of actinolite. Testwork on the actinolite has confirmed that this material is non-fibrous, and does not pose any health risks for workers or communities exposed to this mineral. [Fibrous forms of actinolite have implications for the respiratory health of workers and communities exposed to the mineral].

13) At closure, the possibility of attaining a level of biodiversity and vegetation cover on the TSF similar to that of the surrounding undisturbed land exists, provided that measures are put in place to deal with other factors such as tailings erodability, moisture retention characteristics, microbial activity and the low nutrient levels present in the tailings.

14) The waste rock may safely be used as an erosion protection material to protect the TSF side slopes from water erosion and dust generation.

Geotechnical Investigation

15) The generalised soil profile at the TSF area consists of either:

   - 0.65 m topsoil (varies from 0.4 m to 0.9 m), directly underlain by hard quartz feldspar, or
   - 0.85 m topsoil (varies from 0.6 m to 1.0 m), underlain 0.6 m silty sand material (varies from 0.4 m to 1.1m), underlain by hard gneiss sandstone conglomerate.

16) The silty sand material (SC, according to the USCS) is ideal as wall building, foundation and road material.

17) The weathered quartz feldspar (GP-GC, according to the USCS) is good for foundation and road construction material.

18) No clay or clayey materials were identified during the preliminary geotechnical investigation.

19) To minimise the disturbance of the shallow insitu materials in the TSF basin (and hence reduce seepage), it is recommended that the bulk of all TSF earthworks material be sourced from the excavation of the open pit. Careful material selection from the open pit area may also yield clayey material that is better suited for the construction of the RWD and SWD embankments.

Stage Capacity

20) The maximum allowable rate of rise (RoR) for the proposed TSF is 1.0 m/year.

21) The TSF has a volumetric capacity (up to 984 mamsl) of approximately 65,719,000 m^3 which is sufficient to accommodate the total production volume of 63,990,000 m^3 (127,980,000 tonnes, at the assumed average in-situ density of 2.0 t/m^3).

22) The TSF will consist of two paddocks (an upper and lower paddock). Strategic tailings deposition in the upper paddock is required to reduce the RoR in the lower paddock i.e. tailings deposition in the lower paddock will be limited to the maximum RoR of 1.0 m/year and the difference in the tailings stream will be deposited in the upper paddock (RoR < 1.0 m/year). This approach will ensure that upper and lower paddocks consolidate in approximately 21 to 24 years.

23) The lower and upper starter walls will be constructed to an elevation of 955.0 and 966.0 mamsl respectively with wall heights, measured from the lowest point along the outer toe, of 9 m and 6 m.

24) Tailings deposition will commence in the lower paddock, up to the starter wall crest elevation, at the maximum production rate of 355,500 tonnes/month for a period of 18 months (1.5 years). The tailings stream will then be split between the lower and upper paddocks such that a RoR of 1.0 m/yr is maintained in the lower paddock (Refer to Figure 7-1 and Table 7-1 for the target depositional rates and periods).

25) The lower and upper paddocks are expected to consolidate after 288 months (24 years) or sooner (particularly if there are significant periods of reduced tailings deposition i.e. less than 355,500 tonnes/month). The total tailings stream will then be deposited on the total available surface (basin) area up to the 30 year LOM.

26) The final height of the TSF will be 38m (at 984 mamsl).

Water Balance

27) The bulk make-up water required at the ore processing plant for 355,500 tpm tailings is expected on average to be:

- 176,068 m^3/month or roughly 60% (typically 4 months of the year – average conditions),
- 110,496 m^3/month or roughly 38% (typically 4 months of the year – wet season conditions), and
- 181,293 m^3/month or roughly 62% (typically 4 months of the year – dry season conditions)

Therefore, the annual bulk make-up water required for 355,500 tpm tailings is 1,871,428 m^3 or roughly 53.4%.

28) At 355,500 tpm tailings, the total storage capacity of the RWD and SWD needs to be 535,000 m^3 to full supply / spill level (to cater for the 1 in 50 year storm event as stipulated by the requirements of Regulation 704 of the National Water Act of 1998).

29) For comparison purposes, the bulk make-up water required at the ore processing plant for 274,260 tpm tailings is expected on average to be:

- 135,707 m^3/month or roughly 60% (typically 4 months of the year – average conditions),
- 85,216 m^3/month or roughly 38% (typically 4 months of the year – wet season conditions), and
- 139,730 m^3/month or roughly 62% (typically 4 months of the year – dry season conditions)

Therefore, the annual bulk make-up water required for 274,260 tpm tailings is 1,442,613 m^3 or roughly 53.4% (i.e. same percentage as before).

Seepage Analysis

30) At 355,500 tpm tailings, the seepage from the TSF footprint will most likely range from 148 m^3/day (i.e. 4,440 m^3/month) to 840 m^3/day (25,200 m^3/month).

31) Under normal operating conditions the underdrains play a role in reducing the seepage flux to the foundations, as well as, ensuring that the phreatic surface does not daylight on the outer slopes of the TSF.

32) A combination of a 10 m wide blanket drain and 5 m wide toe drain should effectively control the phreatic surface within the TSF.

Stability Analysis

33) The factor of safety (FOS) is acceptable for both the normal (FOS = 2.128 and 2.125 for 35% and 75% pool sizes respectively, and the underdrains operational) and abnormal (FOS = 1.971 and 1.561 for 35% and 75% pool sizes respectively, and the underdrains non-operational) conditions as it is greater than the recommended FOS of 1.3.

34) The non-operation of the underdrains results in the phreatic surface daylighting on the slopes of the TSF, which will significantly increase the likelihood of sloughing on the outer TSF slopes. Also the possibility of a piping failure of the TSF (i.e. internal erosion of tailings between the supernatant pool and the outer TSF slope) significantly.

Surface Water Management

35) There are no perennial or non-perennial streams at (or near to) the TSF site. This is due to the overall Moonlight site being located on a watershed, as well as the aridity of the region. Significant catchment areas upstream of the Moonlight site are consequently not present, while the dominant flow regime within the site is that of overland flow (and not channel flow).

36) Clean stormwater from the upstream catchment area of the TSF is diverted around the TSF by a stormwater diversion berm and channel.

Summary Description of the TSF

37) The footprint area of the TSF is approximately 312 ha (including perimeter road, solution trench and paddock area) with the return water dam and stormwater dam having a footprint of approximately 38.5 ha.

38) The pipelines will most likely all be steel and supported on concrete plinths where necessary. The tailings delivery and spigot pipelines approximately 350 to 400 mm ND. The return water pipeline is approximately 100 to 150 mm ND.

39) The toe drains will be 5 m wide. The blanket drains (approximately 100m from the toe drains) will be 10 m wide.

40) The decanting of supernatant (and storm) water will be via penstocks with 600 mm diameter concrete or fibre reinforced asbestos cement rings. The outfall pipeline will be a 600 mm concrete spigot and socket pipe.

41) The solution trench (1m deep and 1m wide at the base) around the perimeter of the TSF will be concrete lined.

42) The return water dam will be HDPE lined, with a capacity of 193,000 m^3. The stormwater dam will be unlined with a capacity of 356,000 m^3.

Closure and Rehabilitation

43) Decommissioning and reclamation activities will be focused primarily on the completion of the rock cladding to the side slopes of the TSF and access roads, removal of pipelines, sealing of penstocks, construction of berms and the creation of vegetation cover to minimise long term erosion and dust emissions.

44) Aftercare will be concerned primary with monitoring of the rock cladding and topsoil cover, and the establishment of sustainable vegetation. An aftercare period of 6 years is considered reasonable for relatively inert magnetite tailings material.

Cost Estimate

45) The estimated cost of constructing the facility is R 109.1 million (excl. VAT).

46) The ongoing operating costs are roughly estimated at:

- R 1.50 (excl. VAT) per tailings tonne deposited (i.e. R 192 million over the 30 year life of mine). This rate per tonne needs to be confirmed by a qualified tailings dam operator.
- R 11.1 million (excl. VAT) for ongoing LOM construction expenditure (toe and blanket drains, drain outlets and paddocks around the TSF).
- R 1 million (excl. VAT) per year for the associated external monitoring costs for the TSF (i.e. R 30 million over the 30 year life of mine).

47) The closure cost associated with the TSF is estimated to be R 69 million (excl. VAT).

48) The combined overall cost for the TSF is therefore estimated to be R 411.2 million (excl. VAT).

14 RECOMMENDATIONS

The following recommendations arise from this study that will need to be addressed during the detailed design phase and operation phase of the TSF:

Design Criteria

1) Verification of the production rates, tailings and slurry characteristics, particle size distribution, specific gravity, in-situ density, void ratio, rate of rise etc. to confirm that the current TSF design is fit for purpose.

Geochemical Investigation

2) Leach tests on representative tailings samples should be undertaken to confirm that there is unlikely to be any leaching of metals of environmental concern.

Geotechnical Investigation

3) A follow up geotechnical investigation is required to attempt to source better wall building material for the RWD and SWD (i.e. clay or clayey material).

Seepage Analysis

4) The permeability of the near surface foundation soils and tailings should be confirmed through laboratory testing and/or field infiltration tests during the detailed design phase.

5) Predicted seepage losses need to be confirmed once the infiltration testing is complete.

6) Drain functionality should be monitored throughout the life of the TSF. Separation of the blanket drain and toe drain collection pipes is recommended to assist in diagnosis of a drain malfunction.

7) Piezometric heads and drainage volumes must be monitored at least monthly to ensure safe operating phreatic surface conditions.

8) During the detailed design phase, transient analysis should be carried out to assess the time it takes for the phreatic surface under normal operating conditions within the TSF to respond to abnormal conditions.

Stability Analysis

9) The supernatant pool should be minimised at all times through the provision of adequately sized off-dam water storage facilities, and ensuring proper functioning of the underdrains and the decant system.

10) The likely range of tailings material and insitu foundation strength parameters needs to be determined so that a probabilistic and sensitivity analysis can be undertaken. .

11) The TSF side slope must be developed at 1V:4H or flatter.

Closure and Rehabilitation

12) Ongoing amelioration of the tailings and the establishment of vegetation on the side slopes as the elevation of the TSF increases should be carried out. To assist with the establishment of the vegetation an irrigation system will most likely be required, use being made of water from the RWD,

13) The step-in berms on the side slopes will need to be engineered to contain and control stormwater runoff from the side slope, and

14) As older step-ins berms become redundant and are no longer required as access roads, the step-ins should be dozed over and the side slopes reshaped to a 1V:4H continuous slope, covered with a 0.5 m thick layer of rock cladding and pockets of vegetation (shrubs and grasses) established at 50 no. /ha (i.e. roughly a 14 m x 14 m spacing).

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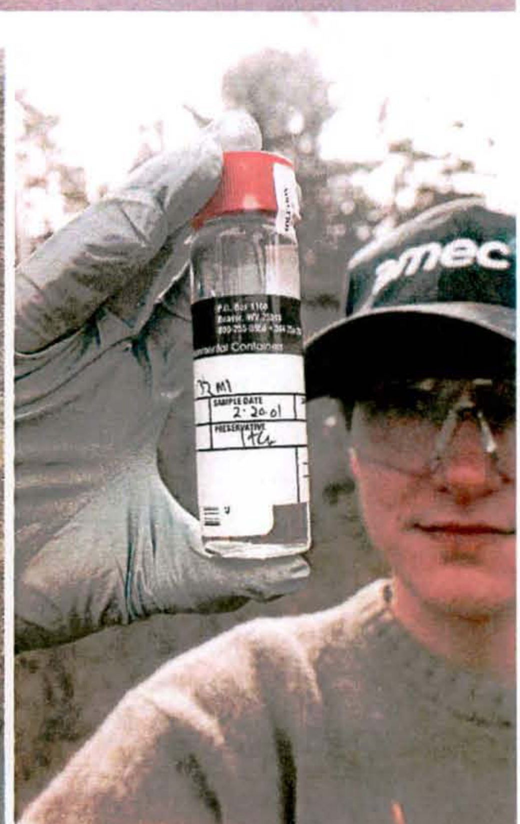
Metago Environmental Engineers (Pty) Ltd

APPENDIX A: GEOCHEMICAL CHARACTERISATION OF THE TAILINGS MATERIAL

"***Waste Characterisation Report***", AMEC Earth & Environmental UK Ltd., Report A029-11-R1090, June 2011.

Moonlight Iron Ore Project
Waste Characterisation Report
Ferrum Crescent (PTY) Ltd., South Africa





Submitted to

Ferrum Crescent PTY Ltd.

Submitted by

AMEC Earth & Environmental

REPORT ISSUE FORM

Client Name	**Ferrum Crescent (Pty) Ltd.**		
Project Name	**Moonlight Iron Ore**		
Report Title	**Waste Characterisation Report**		
Document Status & Issue No.	**Final**	Issue No.	**4**
Issue Date	**17 June 2011**		
Document Reference	**7879010029**	**A029-11-R1090**	
Author	**M. A. Diaz**	Signature & Date	
Reviewer	**Steve Sibbick**	Signature & Date	
Project Manager Approval	**Pier Chiti**	Signature & Date	

DISCLAIMER

EXECUTIVE SUMMARY

AMEC has been retained by Ferrum Crescent PTY Ltd to assist in the development of the Bankable Feasibility Study (BFS) for the Moonlight Iron Ore Project located in the Republic of South Africa. The Moonlight Deposit lies about 150 km northwest of Polokwane and eight kilometres south of Marnitz, a hamlet on Highway N11, which leads to the Botswana border-crossing at Tom Burke, 25 km to the northwest.

As part of the feasibility study the characterisation of future waste from the operation and the likely water quality at the open pit after closure are considered significant issues.

The Moonlight Deposit is located in the Central Zone of the Archaean Limpopo Mobile Belt (LMB) and next to the Phalala Shear Zone. The main rocks types are gneiss, granulite, quartzite, marble and banded iron formation (BIF) of the Beit Bridge Complex. The Central Zone of the LMB is characterized by high-grade regional methamorphism and intense deformation.

Groundwater levels in the region generally vary between 13 and 33 metres below ground level (mbgl) with an average depth of 17 mbgl.

The main ore is coarse grained magnetite. At and near the surface, the magnetite is often totally oxidised to hematite, goethite and limonite. The gangue minerals consist of essentially quartz (20-64%) with varying amounts of K-feldspar (0-5%), calcite (0-5%), actinolite and hornblende (<5%) and plagioclase (<5%). Minor accessory minerals include talc, chlorite, epidote and very rare garnet, clay minerals, apatite and grunerite.

Tailings chemical analyses taken from a metallurgical variability study conducted by MINTEK from South Africa indicate that the Total Sulphur content on the 48 samples was at most 0.05% indicating that these tailings have no to very limited potential for acid generation. The future tailings sample composition indicates that the tailings will contain more silica and iron than the average Earth's crust composition with a lower proportion of Mg, Al, Ca, Ti and K. This suggests that is unlikely that there will be any metal leachability issues.

A total of 45 samples of waste rock were selected taking into consideration the main lithologies that will become the future waste rock as well as the spatial distribution of the deposit. The samples were subjected to Acid Base Accounting and paste pH determination. The results indicate a very limited driving force for acid generation due to the lack of significant quantities of sulphides.

Finally, it was concluded that the lack of sulphides and the semi-arid environment make it likely that on closure there will not be any significant generation of acidity from the pit walls.

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1.0 INTRODUCTION

1.1 General

AMEC has been retained by Ferrum Crescent PTY Ltd to assist in the development of the Bankable Feasibility Study (BFS) for the Moonlight Iron Ore Project located in the Republic of South Africa.

Figure 1 shows the location of the project.

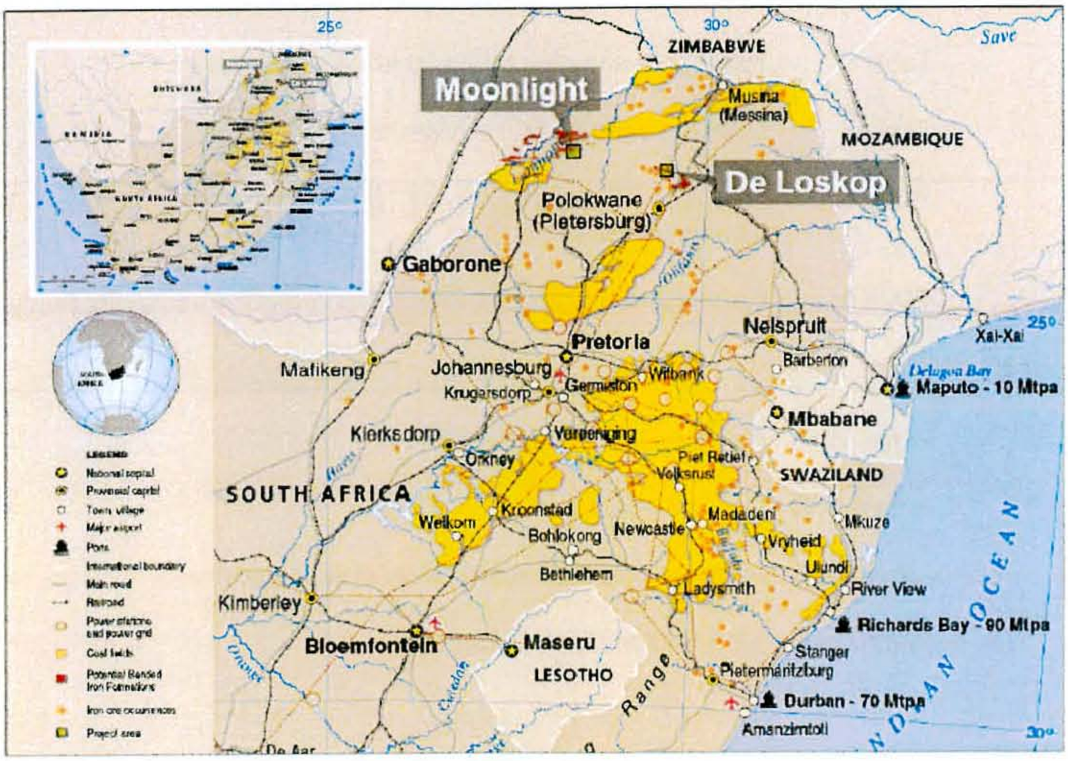

Figure 1 Project location map

Source of Map: Continental Resources Management PTY Ltd

The project consists of:

- Development of an open pit to extract the resources
- Beneficiation plant to process the ore to market requirements
- Development of disposal facilities for the waste rock and tailings
- Transportation of the concentrate to suitable port facilities, and

- Ancillary infrastructure such as access roads, transmission lines, etc. to support the operation.

As part of the feasibility study the characterisation of future waste from the operation and the likely water quality at the open pit after closure are considered significant issues. The purpose of the present report is to address these issues. In preparing this report AMEC has relied on testwork cited in this report and the available literature, mainly comprising the following:

- ISCOR Ltd. "The Moonlight Low-Grade Iron ore Deposit – Geological Report" No date.
- ProMet Engineers "CPR Moonlight PIG Iron Project Report C5465-RP- 004 Rev P4"; July 2010.
- MinTek "Variability Scoping Testwork of Ferrum Crescent's Moonlight Project", 27 September 2010.
- Metago Environmental Engineers (PTY) Ltd. "Environmental Scoping Report for the Proposed Moonlight Iron Ore Project – Report No. 2", Metago Project No. TO20-02, February 2011.

1.2 The Setting

The Moonlight Deposit lies about 150 km northwest of Polokwane and eight kilometres south of Marnitz, a hamlet on Highway N11, which leads to the Botswana border-crossing at Tom Burke, 25 km to the northwest (Figure 1). The Moonlight exploration area is 53 km^2 and comprises three farms: Moonlight, Gouda Fontein and Julietta.

The Project area's terrain is "fairly" flat with undulations, rocky outcrops and occasional hills. Vegetation is consistent with typical "Limpopo province Bushveld scrub" or low level scrub veldt.

Livestock farming is the predominant activity in the Project area.

1.2.1 Geology

The Moonlight Deposit is located in the Central Zone of the Archaean Limpopo Mobile Belt (LMB) and next to the Phalala Shear Zone (Figure 2)

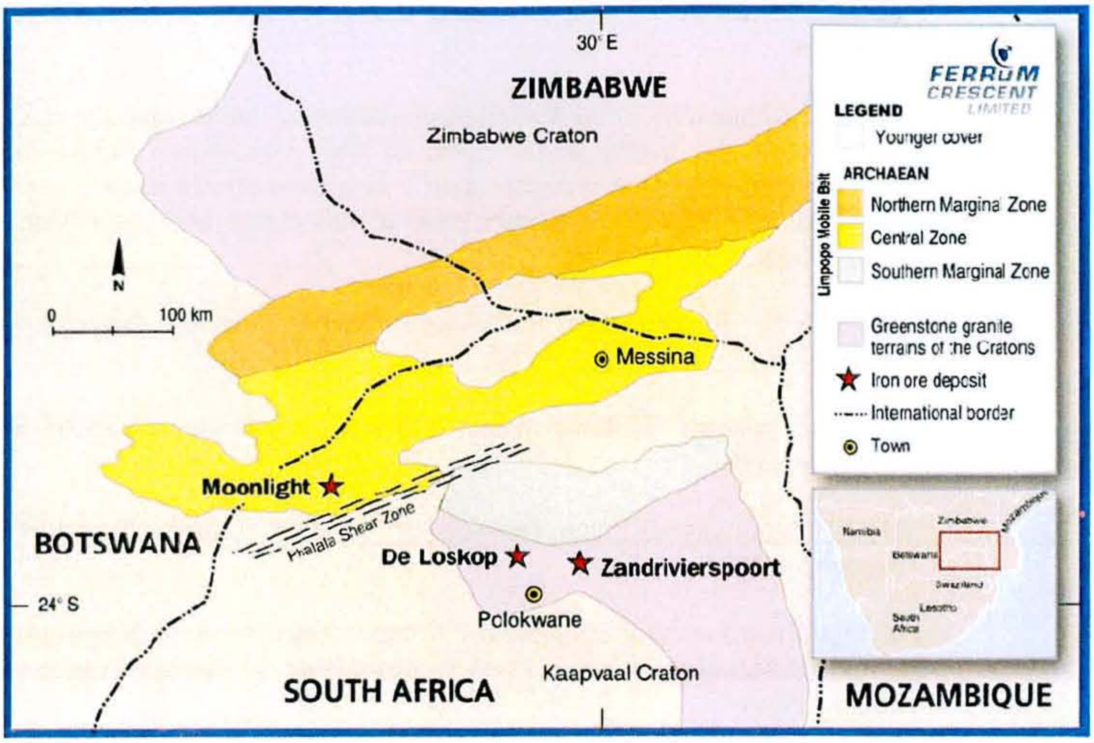

Figure 2. Regional Geological Setting, after du Plessis et al.

The main rocks types are gneiss, granulite, quartzite, marble and banded iron formation (BIF) of the Beit Bridge Complex. The Central Zone of the LMB is characterized by high-grade regional metamorphism and intense deformation.

The Moonlight area is very flat and is largely covered by Tertiary alluvium, sand and calcrete. Apart from uncommon meta-BIF outcrops, the only other outcrops consist of limestone and minor granulites. Except for an inferred down-faulted block containing the basal formations of the Permian-Jurassic Karoo (Pretorious 1992), which occur on the southern portion of Moonlight and further south, only rocks of the LMB occur in the Moonlight area.

Generally, the BIF is markedly less weathered and oxidised than the rest of the rock sequence.

1.2.2 Hydrogeology

The underground water resources are used by the agricultural community as the area has a Lowveld semi-arid climate. It is understood that numerous state water boreholes have been drilled in the area without any success.

The Moonlight project area falls within the Polokwane Plateau groundwater region. Fresh unweathered rock such as that of the Limpopo Belt has very low primary porosity, permeability and storage capacity. The possible occurrence of groundwater is thus related to secondary hydrogeological properties developed from the processes of weathering, faulting, fracturing and the influence of intrusive structures.

Groundwater levels in the region generally vary between 13 and 33 metres below ground level (mbgl) with an average depth of 17 mbgl. Groundwater flow is expected to be towards the drainage system.

From literature review and regional databases checked by Metago Environmental Engineers (pty) Ltd., the natural groundwater quality in the basement aquifers is generally suitable for human consumption, although elevated salinities, nitrates or trace elements (fluoride) concentrations render selected natural water qualities detrimental to human health.

1.2.3 Ore Mineralogy

The main ore is coarse grained magnetite. At and near the surface, the magnetite is often totally oxidised to hematite, goethite and limonite. Alteration and oxidation of the magnetite decrease fairly rapidly downwards, with the result that the iron minerals are highly magnetic (maghemite) within a few metres of the surface.

Hematite is also found at depth far below the weathered zone, as a subordinate to very minor mineral with the magnetite. The hematite was probably formed during metamorphism under slightly oxidising conditions. The gangue minerals consist of essentially quartz (20-64%) with varying amounts of K-feldspar (0-5%), calcite (0-5%), actinolite and hornblende (<5%) and plagioclase (<5%). Minor accessory minerals include talc, chlorite, epidote and very rare garnet, clay minerals, apatite and grunerite (Badenhorst 1992).

The average in situ chemistry of the Moonlight orebody is shown in Table 1. It is worth noting that sulphur occurs in trace amounts.

Table 1 Summary of in situ chemical analysis of Moonlight deposit

Major oxide or element	Formula	Percentage (%)
Iron (total)	Fe(total)	33.8
Silicon Oxide	SiO_2	44.7
Aluminum Oxide	Al_2O_3	1.20
Potassium oxide	K_2O	0.10
Phosphorus	P	0.04
Manganese	Mn	0.06
Titanium Oxide	TiO_2	0.16
Calcium Oxide	CaO	1.90
Magnesium Oxide	MgO	2.60
Chromium Oxide	Cr_2O_3	0.03

Ferrum Crescent submitted samples from the oxidised and fresh mineralization, composited from RC drill chips from its 2008 drilling campaign to AMMTEC Ltd for mineralogical determination by Quantitative Automated Mineralogical Analysis (QEMSCAN). Table 2 shows a summary of the results:

Table 2. QEMSCAN Results of Composite Samples of Mineralization		
Mineral	**Oxidised (Mass %)**	**Fresh (Mass %)**
Magnetite	**14.4**	**37.4**
Hematite	**39.5**	**2.7**
Goethite	**0.1**	**0.1**
Quartz	**42.5**	**42**
Feldspar	**1.4**	**4.9**
Smectite/ Talc	**1.5**	**4.6**
Amphibole	**0.6**	**3.9**
Other	**0.1**	**1.4**

Quartz and iron minerals are the main phases of the mineralization.

1.3 Acid Rock Drainage (ARD)

One important problem associated with mining minerals which might be sulphide related is the potential for acid rock drainage (ARD) to occur. ARD takes place when reactive sulphides come into contact with oxygen and water in the presence of iron/sulphur oxidising bacteria and there is insufficient or ineffective alkaline material to stop the oxidation reaction or to neutralise its products. ARD is a dynamic and spatial problem and occurs if the acidity generated is higher than the neutralisation capacity of the system at any stage of the life cycle of the natural phenomenon of sulphide oxidation. The term ARD is applied to the resulting leachate, seepage or drainage.

The two main sulphide minerals associated with ARD are the gangue minerals pyrite and pyrrhotite. Pyrite is relatively abundant and is not usually recovered in the processing of ore. When pyrite and pyrrhotite are not recovered or oxidised in the processing of the ore they may become the source of acidity. Carbonate-bearing rock (e.g. limestone) and reactive silicates usually provide the naturally occurring neutralisation capacity of the system.

Acidic drainage is generated according to the following three overall equations:

$$2FeS_2 + 7O_2 + 2H_2O \xrightarrow{bacteria} 2FeSO_4 + 2H_2SO_4; \qquad (1)$$

$$4FeSO_4 + 2H_2SO_4 + O_2 \xrightarrow{bacteria} 2Fe_2(SO_4)_3 + 2H_2O; \qquad (2)$$

$$FeS_2 + Fe_2(SO_4)_3 \rightarrow 3FeSO_4 + 2S. \qquad (3)$$

The neutralisation aspect of the problem is usually represented by the following equation:

$$H_2SO_4 + CaCO_3 + H_2O \rightarrow CaSO_4.2H_2O + CO_2. \quad (4)$$

Equations 1 to 4 represent, in very general terms, the basic chemistry of ARD, however its manifestation can vary depending on the physical and mineralogical characteristics of the material, method of disposal and the local climatic conditions. It is due to the interactions of these factors that ARD is considered a site-specific problem. In some cases even when the material is not ARD generating there might be a problem of leachability of trace elements. This is usually assessed by using short-term leachability tests.

The quality of the drainage from waste rock dumps is particularly influenced by the particle size distribution of the materials deposited in the dump. The fine particles have a disproportionate influence on the quality of the drainage and therefore particular care should be taken when predicting future drainage quality from a waste rock dump.

In the case of the Moonlight deposit the presence of sulphide minerals is very limited.

2.0 APPROACH TO THE STUDY

Figure 3 illustrates the sequence of methods and techniques used during the investigation in order to achieve confidence in the predictions and any mitigation measures justified.

2.1 ACID BASE ACCOUNTING (ABA)

ABA is usually the first step in the prediction and evaluation of ARD. In general, ABA aims to determine on one hand the acid generation potential (directly related to the sulphide content of the sample) and on the other hand, the neutralization potential. By comparing these two values, samples may be classified as either potentially acid generating, lying within a zone of uncertainty, or unlikely to generate ARD. ABA can be considered to be equivalent to characterising the chemical thermodynamics of a system, i.e. ABA indicates what can happen but it does not guarantee that it will happen and if it happens it does not indicate when or at what speed it will occur. If a sample is potentially acid generating then in order to confirm whether a sample will generate ARD and to what degree of intensity, kinetic testing is necessary.

There are a considerable number of methods available to carry out ABA. Experience has shown that those methods using the calculation of acid generation based on total sulphur and/or the neutralization potential of every alkalinity generating material in the sample are more prone to misclassify the sample into the wrong category. The method chosen here for ABA testing is the "Modified ABA" (Lawrence and Wang, 1997) which is considered (on the basis of comparative testwork) to provide a more realistic value for the acid and neutralization potentials. The method is described in Appendix A.

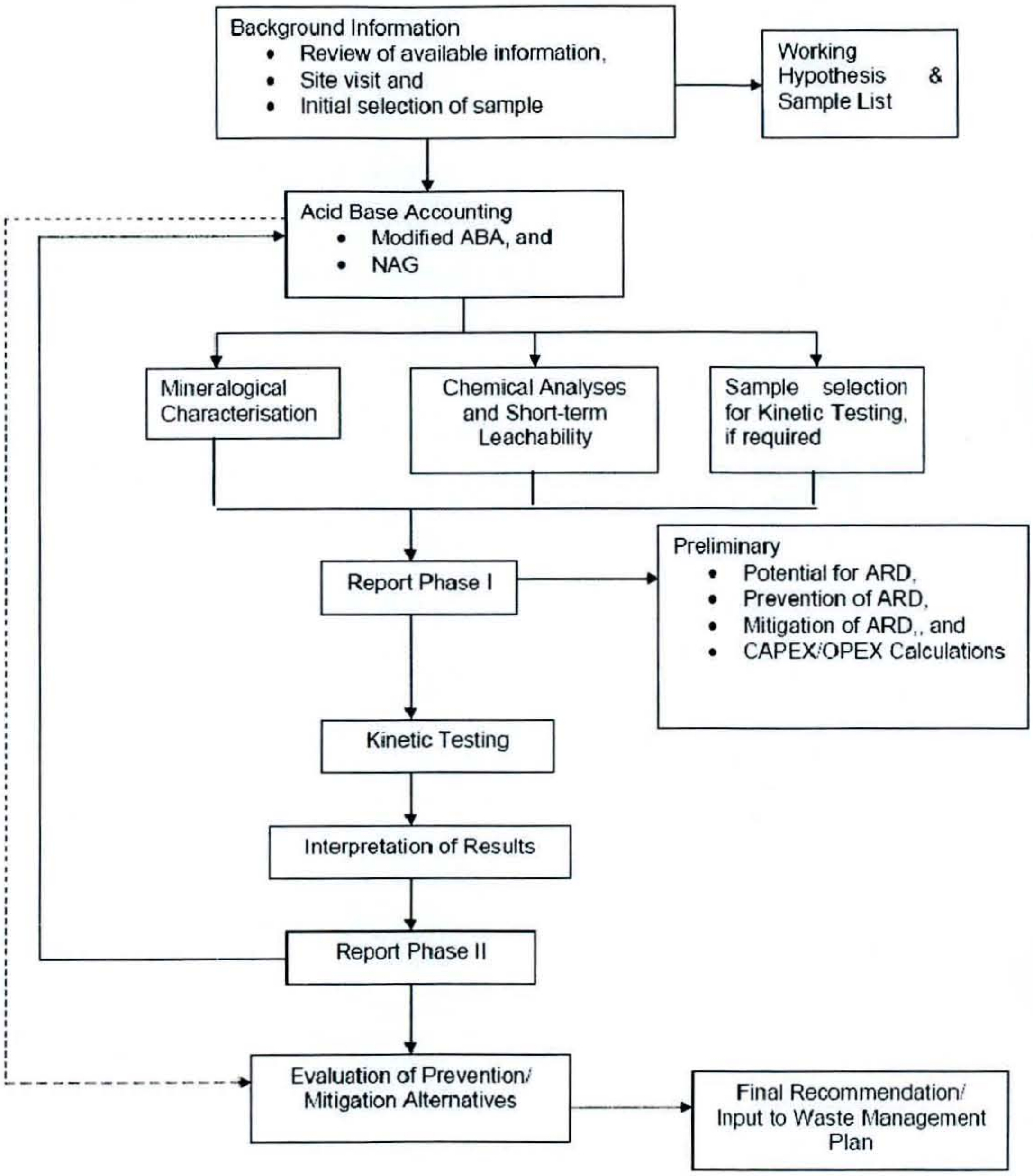

Figure 3. General Methodology of Waste Characterisation

Two parameters are usually calculated to classify material in terms of ARD. These are as follows:

- the net neutralisation potential (NNP) which is neutralisation potential (NP) minus the acid potential (AP); and

- the neutralisation potential ratio (NPR) which is the NP divided by the AP.

The Acid Base Accounting screening criteria adopted in this interpretation are mainly those recommended by the British Columbia Ministry of Employment and Investment of Canada and reproduced in Table 3. The AP and NP are expressed in the same unit which is kg $CaCO_3$/tonne of material. In this section the word "acidity" denotes the presence of mineral acidity (free hydrogen ions) in the sample. Most life processes in natural waters are seriously impaired if the pH lies outside the range 4.5 to 10.3. If the pH of water falls below 4.5 this indicates the presence of mineral acidity (that is, if any further hydrogen ions are added, from whatever process, these hydrogen ions will remain as such in solution). Acidity is the result of the acid potential being realised.

Table 3: Acid-Base Accounting Screening Criteria – NPR

Potential for ARD	Initial NPR	Comments
Likely	< 1:1	Likely ARD generating.
Possibly	1:1 to 2:1	Possibly ARD if NP is insufficiently reactive or is depleted at a faster rate than sulphides.
Low	2:1 to 4:1	Not potentially ARD generating unless significant preferential exposure of sulphides or extremely reactive sulphides in combination with insufficiently reactive NP.
None	> 4:1	No further testing is required unless material is going to be used as a source for alkalinity.

An alternative screening criteria is the Net Neutralization Potential (NNP) as shown in Table 4.

Table 4: Acid-Base Accounting Screening Criteria – NNP

NNP (kg $CaCO_3$/t)	Potential for ARD	Comments
<-20	Potentially acid generating	Equivalent to Likely
Between –20 and +20	Zone of uncertainty	Equivalent to Possibly/Low
>+20	Not potentially acid generating	Equivalent to None

The NNP criteria are more relevant to samples with sulphide content of less than 1% and a relative low or negative NP.

2.2 MINERALOGICAL CHARACTERISATION

Mineralogical characterisation would be carried out on selected samples in order to determine whether the NP obtained from the ABA tests is reactive or not and also the type of sulphide and matrix of the sample. Mineralogical characterisation is an important tool and a check on the interpretation of the static and kinetic testing (if these are performed). The mineralogical characterisation for Ferrum Crescent project consists of X-ray fluorescence (XRF) to provide a whole rock analysis.

2.3 SHORT-TERM LEACHABILITY TEST

The purpose of short-term leachability tests should be to provide an indication of the mobility of various metals when the waste is exposed to a leaching agent. The leaching agent can simulate either acidic or alkaline environments. Some of these tests can be used to classify the samples into hazardous or not hazardous using criteria developed by regulators, e.g. BC Waste Management Act, Canada or the US Environmental Protection Agency. If the sample is classified as hazardous, then there are specific regulations governing their disposal. In this study the Synthetic Precipitation Leaching Procedure (SPLP) developed by the US EPA is used. Details of the procedure can be found in Appendix A. These results are an indication of the metal leachability potential of the samples.

The waste characterisation program is iterative, adjusted to the characteristics of the waste and can be stopped whenever the objectives of the characterisation are met.

3.0 MINE MATERIALS CHARACTERISATION

3.1 ROCK TYPES

The complex deformation history, high degree of recrystallisation during a long period of regional metamorphism and the absence of marker bands are major constraints on the compilation of a typical lithostratigraphic section. However, typical sections for the northern and southern portions of the project area have been compiled. In general the meta-BIF is associated with leucocratic quartzfeldspathic gneisses, granulite, amphiboilite, some intrusive pegmatite and lenticular ultramafic bodies which contain small amounts of chromite. Pyrite is an accessory mineral associated with the gneiss and granulite lithologies. In terms of waste characterisation, the following sub-sections describe relevant lithologies.

3.1.1 Granulite (GRAN)

The term granulite is used to describe a wide variety of granoblastic rocks and refers to white-pinkish coloured, xenomorphic metamorphic rocks. These rocks consist of essentially quartz and feldspar with various amounts of dark minerals as aggregates which tend to give the rock a mottled texture. See Plate 1.

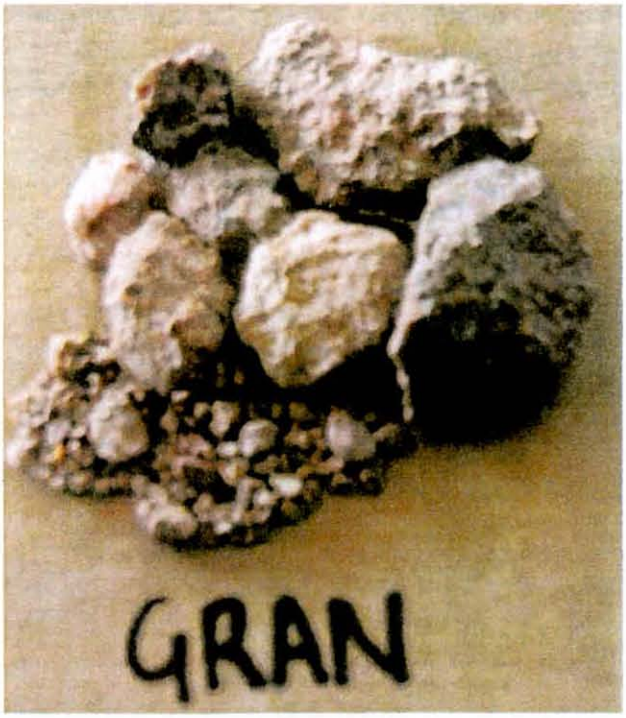

Plate 1. Granulite lithology at Moonlight Iron Ore project.

The plagioclase has undergone some sericitization and perthitic microcline and graphic textures are characteristics of the granulite. Isolated almandine crystals of various grain sizes are found in layers of essentially leucocratic granulites. Accessory minerals are zircon, apatite and pyrite.

3.1.2 Quartzfeldspathic gneiss (GNS)

Gneiss is the major rock type in the prospect area. These gneisses comprise various associated rocks which are mainly characterised by quartz-feldspathic mineral assemblages and a gneissic texture defined by well orientated mafic minerals. The mineral assemblages comprise microcline, plagioclase and orthoclase feldspar and quartz. Accessory minerals are apatite, allanite, magnetite, zircon and pyrite. On the basis of the dominant mafic minerals, the leucogneisses can be subdivided into granite gneiss with chlorite as the dominant mafic mineral, hornblende gneiss, biotite gneiss and garnet gneiss. The gneisses are typically medium to finely crystalline, grey to pinkish in colour and well banded and foliated. Banding as seen in the rock is most probably the result of metamorphic differentiation and/ or shear associated foliations. No primary, sedimentary structures can be observed. When weathered, the colours diverge to a dirty-white or brownish-red colour.

Alteration processes of the mineral assemblages include sericitisation of the feldspars, partial chloritization of biotite and hornblende and to a lesser extent the replacement of biotite and hornblende with epidote. Augen textures are common and consist of quartz and feldspar. In garnet gneiss the garnets (almandine) can be disseminated, form the foliation and are often also confined by the foliation. The inclusion of augens and garnets suggests pre-syntectonic development of garnet and the augens.

A second group of quartzfeldspathic gneisses which are characterised by the absence of foliation, occur in the project area and is thought to be mobilised anatectic leucocratic gneisses. These leucogneisses are typically medium to coarsely crystalline and display a distinguishing massive and homogeneous granitic character.

Plate 2. Quartzfeldspathic lithology at Moonlight Iron Ore project.

3.1.3 Amphibolite (AMP)

The amphibolite is a dark green to black coloured, medium to coarse grained rock consisting of idioblastic hornblende, xenoblastic plagioclase feldspar and some minor accessory quartz. The amphibolite occurs as massive, conformable interbanded units of various thickness within the rest of the supra crustal rocks. Hornblende and biotite are the primary minerals in the amphibolites associated with the gneisses and granulites. A green amphibolite which consists of actinolite and hastingsite is common in the magnetite quartzite. The precursors are thought to be igneous rocks which could have been sheet-like intrusions before metamorphism.

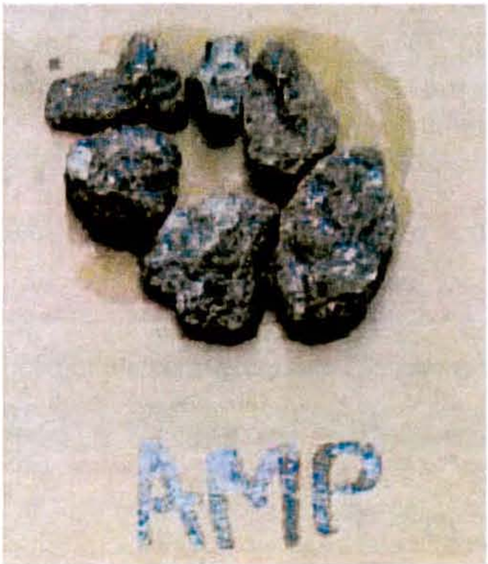

Plate 3. Amphibolite lithology at Moonlight Iron Ore project.

3.1.4 Ultramafic Bodies

Lens shaped ultramafic bodies of various sizes occur above, interbedded and below the meta-BIF. These bodies comprise essentially serpentinite with lesser amounts of amphibolite, metapyroxinate and chromitite. Originally the ultramafic bodies consisted of intrusive layered magmatic bodies of peridotitic or pyroxenitic assemblage that has been metamorphosed and tectonically highly deformed.

The serpentinite is essentially antigorite with minor lizardite and chrysotile within a fine grained groundmass of carbonate. The preference of anitgorite serpentinite over lizardite serpentinite suggests high amphibolite to granulite facies metamorphism. The presence of carbonate in the groundmass as well as calcite veins suggests that carbonization followed sepertinization. Minor diopside, magnesium chromite, chlorite, magnetite and hematite are common in the serpentinites. Talc can be seen as joint-filling and pseudomorphs of pyroxenite.

The amphibolite is a green coloured, coarse crystalline rock consisting of essentially actinolite, diopside and talc with minor amounts of calcite, chlorite and magnetite.

The chromitite occurs as inconsistent, lenticular bodies and bands within sepertinites. The chromitite is without structure, is dark-grey to black and fine grained with a sugary texture. The chromitite is thought to be part of a layered magmatic body or bodies of peridotitic or pyroxenitic assemblage that have been metamorphosed and tectonically highly deformed. In this layered intrusion the chromitite probably occurred as layers and after metamorphism and tectonism remained as lens shaped bodies.

3.1.5 Pegmatites (PEG)

Pegmatites and aplites occur as intrusive veins in all of the rocks in the project area, also in the meta-BIF. However, these veins do not seem to crosscut the ultramafic units. The pegmatites and aplites vary in thickness from 0.1 to 15 m and commonly crosscut the regional foliation. The pegmatites are typically very coarsely crystalline with a pinkish colour and consist of K-feldspar, plagioclase and quartz. Some occurrences have minor hornblende, biotite and magnetite.

3.1.6 Meta-BIF

The meta-BIF comprises dark grey, medium to coarse crystalline rocks, which primarily consist of disseminated magnetite, lesser hematite and quartz. When weathered the meta-BIF exhibits a reddish brown colour, caused by secondary hematite, limonite and lesser goethite weathering products. The BIF is interbedded with leucocratic quartzfeldspathic gneiss, granulite, amphibolite, some intrusive pegmatites and lenticular ultramafic bodies which contain some chromitite lenses.

A secondary type of meta-BIF is also found in the project area, and is generally referred to as the Gradation Zone meta-BIF. This meta-BIF is fine to medium crystalline, with well differentiated alternating thin bands of magnetite, quartz and lesser amphibolite.

Faults with only minor lateral movements are frequently found on the contact between the meta-BIF and its country rocks. The faults are probably caused by the difference in competency between the two rock types. Often the faults are associated with the presence of ultramafic bodies. Weathering generally goes down to a depth of 50 m. Usually, the BIF is markedly less weathered and oxidised than the rest of the sequence. Hardly any foliation is recognisable and it is impossible to define primary sedimentary structures conclusively.

3.1.7 Dyke (AN-DI)

Only one relatively thin doleritic dyke was intersected in the central portion of the Julietta farm. From previous drilling on Moonlight, it is known that a thick "diabase" dyke has been intersected. This diabase is greenish, with red K-feldspar phenocrysts and is finely crystalline. The primary mineral is albite with lesser augite, clinopyroxene, K-feldspar, chlorite, magnetite, amphibole and quartz. Epidote and quartz veins are found in the rock. Along joints, epidote replaces the diabase. Chemically this rock plots in the andesite-diorite field.

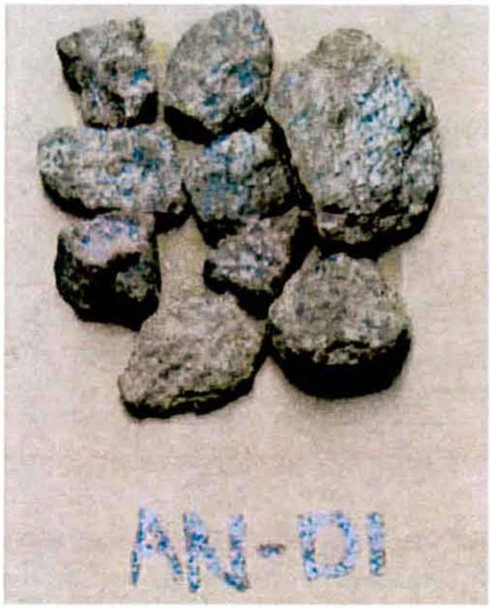

Plate 4. Amphibolite lithology at Moonlight Iron Ore project.

Table 5 below shows the major oxides composition for the various lithologies at the Moonlight deposit.

Table 5: Weighted Chemical Average for the various lithologies

	Fe	FeO	SiO_2	Al_2O_3	Mn	TiO_2	CaO	MgO	K_2O	P	Cr_2O_3	V_2O_5	RD
Garnet gneiss	5.06	3.68	66.68	13.16	0.06	0.53	2.10	2.71	2.63	0.04	0.02	0.03	2.64
Granite gneiss	5.29	3.51	66.88	12.91	0.08	0.49	2.34	2.00	3.01	0.06	0.03	0.04	2.64
Biotite gneiss	7.02	3.56	61.18	13.53	0.08	0.55	3.94	3.36	1.66	0.03	0.02	0.03	2.61
Pegmatite	7.59	4.73	60.64	13.53	0.27	0.46	3.94	2.68	3.05	0.09	0.02	0.03	2.73
Hornblende gneiss	9.34	5.99	53.59	12.82	0.16	0.64	6.44	6.95	1.44	0.09	0.05	0.06	2.76
Chromitite	9.80	n.d.	10.92	11.65	0.18	0.17	0.14	18.19	0.02	0.01	43.50	0.12	n.d.
Serpentinite	10.56	6.32	48.82	7.23	0.17	0.49	4.72	14.03	0.50	0.07	1.23	0.04	2.75
Amphibolite	14.57	9.27	46.44	8.92	0.20	0.57	5.18	11.28	0.84	0.07	0.17	0.05	2.89

3.2 SAMPLING AND ANALYSIS

It is proposed to carry out the waste characterisation testing programme in two overall phases. Phase I will use available materials from previous drilling campaigns while Phase II (if required) will use samples from the 2011 campaign to confirm the initial findings and ensure that every area in the deposit has been tested

In Phase I a total of 45 samples were obtained to represent the main lithologies of the project. The following table indicates the number of samples taken from each lithology.

Table 6. Number of samples taken by lithology Phase I

Lithology	Number of samples	Fresh	Oxidised
Magnetite quartzite	13	4	9
Granulite	11	3	8
Gneiss	10	3	7
Amphibole	5	3	2
Andesite-Diorite	6	4	2

All samples will be subjected to ABA and paste pH and selected samples will additionally be subjected to NAG test, XRF and short term leaching. Appendix B contains the list of the samples tested including the borehole identification and a map of their location.

4.0 RESULTS

4.1 REVIEW OF AVAILABLE INFORMATION AND TESTING RESULTS

4.1.1 Climate

The region climatic type is classified as "Lowveld semi-arid". Most rainfall occurs during the summer with temperatures in the low 30s. Winters are cold at night with temperatures less than 10°C. Average rainfall is 435 mm (range 350 to 580 mm) and peak rainfall occurs in December/ January. Winds are predominantly from the east all year around, averaging between 5 and 10 m/s. Table 7 below shows the average rainfall and evaporation for the Guage station at Marnitz, the closest station to the project.

Table 7. DWAF Guage A5E001- Marnitz

Month	Rainfall	Evap (Lake)
Jan	84.5	177
Feb	67.5	142
Mar	45.6	150
Apr	34.6	115
May	6.9	96
Jun	3.2	78
Jul	1.4	90
Aug	2.7	120
Sep	10.4	155
Oct	33.4	184
Nov	62.5	178
Dec	66.7	166
Totals	419.4	1651

In general, it is expected that evaporation will be higher than precipitation through the majority of the year. The data in Table 7 suggest that drainage from waste rock dumps will not occur under average conditions from May to September.

4.1.2 Tailings Facility

Ttailings will be deposited as slurry with a very slow rate of rise (1 m per year). Considering the climatic characteristics of the project area it is expected that the tailings will drain and desiccate with the exception of the deposition area.

The Moonlight deposit contains limited amounts of pyrite mainly as an accessory minerals as discussed in Section 3.1. Table 8 below indicates that pyrite will be concentrated in the tailings.

Table 8: Magnetic attractability of some minerals relevant to magnetite concentrations

Minerals	Relative Attractability	Classification
Iron*	100.00	Strongly magnetic
Magnetite	40.18	
Pyrrhotite	6.69	Weakly magnetic
Hematite	1.32	
Zircon	1.01	
Garnet	0.40	Nonmagnetic
Quartz	0.37	
Pyrite	0.23	
Dolomite	0.22	
Apatite	0.21	
Chalcopyrite	0.14	
Calcite	0.03	

*Iron taken as standard with a relative attractability of 100

MinTek carried out a metallurgical variability study on 48 samples from the Moonlight deposit to determine the beneficiation limits. The head analysis of the samples indicates that the maximum total sulphur percentage is 0.21% (it is assumed that this was determined by X-ray fluorescence) and this occurs in only 6 samples. The samples were subject to Davis Tube testing and the magnetics and non-magnetics analysed for total Sulphur by LECO amongst other parameters and elements. .

Table 9 shows the chemical analysis of the produced tailings from a variability study on the Moonlight ore carry out by MINTEK of South Africa and they are compared against the average earth's concentration for the different oxides.

The percentage of pyrite in the tailings has been determined to below 0.05% total sulphur by LECO. Apatite, calcite, dolomite and garnet will also report to the tailings. These minerals are able to release alkalinity to neutralize any potential acidity. On balance it can be concluded that the potential for acid generation is extremely limited and that there is some available alkalinity in the system and therefore it can be concluded that the Moonlight tailings are unlikely to generate acidity.

Table 9: Davis Tube Testwork – 1/2

Description	MgO	Al_2O_3	Fe(Total)	SiO_2	CaO	TiO_2	V_2O_6	Cr_2O_3	MnO	K_2O	P_2O_5	LOI	S	Na	K
	%	%	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm
Ave Earth's Crust	3.45	15.22	2.17	59.07	5.1	1.03				3.11	0.3				
E0467 non mags	0.08	4.00	18.60	60.60	0.74	0.08	<0.05	<0.05	<0.05	0.91	0.09	3.18	0.02	0.24%	0.68%
E044 non mags	1.89	0.62	11.10	74.70	0.77	0.08	<0.05	<0.05	0.21	0.10	0.17	1.48	0.05	662	937
E0194 non mags	4.54	3.39	8.89	68.00	2.76	0.20	<0.05	0.13	0.07	0.39	0.10	4.73	0.01	0.33%	0.33
E0025 non mags	1.03	1.07	10.40	76.60	0.29	0.08	<0.05	0.06	<0.05	0.06	0.10	1.9	0.02	370	750
E0276 non mags	1.66	2.97	6.36	79.60	0.70	0.13	<0.05	<0.05	<0.05	1.15	0.12	1.97	0.02	0.27%	0.81%
E0356 non mags	0.25	2.34	9.49	76.70	0.25	0.17	<0.05	<0.05	<0.05	0.70	<0.05	2.5	0.02	247	1.76%
E0085 non mags	4.49	3.10	14.60	63.00	1.78	0.14	<0.05	0.16	0.05	0.51	0.10	3.67	0.02	0.17%	0.39%
E0482 non mags	1.06	2.84	17.30	64.70	0.54	0.29	<0.05	<0.05	<0.05	1.17	0.18	1.65	0.01	0.39%	0.84%
E0028 non mags	2.98	3.46	9.14	71.90	0.85	0.37	<0.05	0.10	0.11	0.39	0.14	3.55	0.01	0.17%	0.33%
E0301 non mags	0.36	2.82	7.92	78.60	0.29	0.26	<0.05	0.08	<0.05	0.20	<0.05	2.98	0.02	365	0.17%
E0352 non mags	<0.05	1.21	26.20	57.70	<0.05	0.14	<0.05	0.06	<0.05	0.08	0.06	1.92	0.02	69.8	675
EO483 non mags	1.59	8.77	4.83	68.60	1.59	0.29	<0.05	<0.05	0.10	4.82	<0.05	1.41	0.01	0.89%	2.94%
E0492 non mags	0.18	1.80	22.50	61.10	0.31	<0.05	<0.05	0.11	<0.05	0.71	0.12	1.93	0.02	0.17%	0.485
E0397 non mags	1.57	1.56	7.91	78.30	0.99	0.13	<0.05	<0.05	<0.05	0.07	0.17	2.72	0.04	0.24%	709
E0035 non mags	1.02	5.81	7.87	73.90	0.44	0.31	<0.05	0.14	<0.05	0.20	<0.05	4.45	0.01	0.13%	0.14%
E0042 non mags	2.63	1.26	15.10	69.80	0.55	0.14	<0.05	0.07	<0.05	0.16	0.11	1.87	0.01	753	0.12%
E0026 non mags	2.05	0.80	18.80	66.10	0.48	0.12	<0.05	0.06	<0.05	<0.05	0.09	2.02	0.01	353	247
E0493 non mags	0.85	8.50	4.88	74.30	0.91	0.18	<0.05	<0.05	0.07	2.68	0.11	1.79	0.01	1.14%	1.85%
E0031 non mags	1.09	1.67	23.60	59.50	0.64	0.12	<0.05	0.05	0.06	0.48	0.13	1.58	0.01	0.17%	0.33%

Table 9: Davis Tube Testwork – 2/2

Description	MgO	Al_2O_3	Fe(Total)	SiO_2	CaO	TiO_2	V_2O_6	Cr_2O_3	MnO	K_2O	P_2O_5	LOI	S	Na	K
	%	%	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm
Ave Earth's Crust	3.45	15.22	2.17	59.07	5.1	1.03				3.11	0.3				
E0257 non mags	10.40	4.04	7.46	65.90	2.80	0.77	<0.05	0.15	0.15	0.30	0.13	3.12	0.04	0.27%	0.24%
E0302 non mags	1.85	0.99	7.10	82.70	0.70	0.12	<0.05	006	0.08	0.07	<0.05	1.47	0.01	332	527
E0262 non mags	3.35	0.53	4.22	84.00	2.56	0.10	<0.05	<0.05	<0.05	<0.05	0.21	0.92	0.02	0.14%	465
E0466 non mags	0.34	1.93	19.70	64.60	0.39	0.08	<0.05	0.07	<0.05	0.39	0.10	3.1	0.01	9.12	0.27
E0275 non mags	2.62	1.00	10.10	77.60	0.69	0.09	<0.05	<0.05	<0.05	<0.05	0.16	1.81	0.01	223	286
E0484 non mags	0.63	2.05	14.40	70.70	0.50	0.13	<0.05	<0.05	0.08	0.71	0.07	1.69	0.02	0.15%	0.49%
E0246 non mags	0.24	8.87	5.68	71.30	0.31	0.27	<0.05	<0.05	<0.05	2.99	<0.05	2.15	0.01	1.39	2.17%
E0263 non mags	3.46	0.61	4.51	78.10	3.00	0.15	<0.05	<0.05	<0.05	0.08	0.20	1.17	0.02	0.17%	718
E0255 non mags	5.12	4.72	6.68	72.20	1.12	0.32	<0.05	0.11	0.12	0.73	0.09	2.97	0.02	0.31%	0.53%
E0022 non mags	3.83	4.44	7.21	70.30	0.66	0.30	<0.05	0.43	0.07	0.30	<0.05	4.01	0.01	756	0.22%
E0361 non mags	0.59	2.04	29.00	49.70	0.96	2.14	<0.05	<0.05	0.13	0.23	0.20	0.94	0.01	0.27%	0.16%
EO401 non mags	2.06	0.19	21.20	63.00	1.20	0.25	<0.05	<0.05	<0.05	<0.05	0.32	0.77	0.02	0.12%	124
E0304 non mags	1.01	0.68	23.70	61.50	0.76	0.06	<0.05	<0.05	<0.05	0.33	0.11	0.96	0.01	887	0.21%
E0487 non mags	1.06	4.27	6.68	77.70	0.97	0.10	<0.05	<0.05	0.06	1.46	0.13	1.52	0.02	0.41%	1.01%
E0087 non mags	10.50	5.99	6.56	65.00	2.75	0.32	<0.05	0.40	0.14	0.85	0.08	4.16	0.02	0.28%	0.54%
E0311 non mags	<0.05	0.39	32.10	49.90	<0.05	0.06	<0.05	0.05	<0.05	<0.05	<0.05	0.82	0.02	74.2	158
E0272 non mags	1.35	3.57	7.37	75.70	0.29	0.18	<0.05	0.13	<0.05	0.19	<0.05	3.17	0.02	390	35.2
E0354 non mags	<0.05	5.45	8.30	72.80	0.18	0.34	<0.05	<0.05	<0.05	1.89	<0.05	2.66	0.01	0.26%	1.39
E0306 non mags	0.13	<0.05	21.20	65.70	0.27	<0.05	<0.05	<0.05	<0.05	<0.05	0.13	0.84	0.01	312	49.5
E0312 non mags	0.08	0.45	22.00	63.60	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1.44	0.01	80	167

The composition of the future tailings as shown in Table 9 indicates that the tailings will contain more silica and iron than the average Earth's crust composition with proportionately less Mg, Al, Ca, Ti and K. Considering the lack of driving force for acid generation and that silica and iron will be the main phases it can be concluded that is unlikely that there will be metal leachability of metals of environmental concern.

The possibility of dust emissions when the tailings become desiccated cannot be discounted. Other potential issue related to the tailings is that the amphibolites will report to the tailings. The amphibolite at Moonlight is reported as actinolite. There are fibrous and non fibrous forms of actinolite. The fibrous form of actinolite has implications for the respiratory health of workers and communities exposed to the mineral. Therefore the first step to understand the issue is to characterise some samples. Six samples were selected by Mineral Corporation Consultancy (Pty) Ltd. From the chips collected during Phase I campaign and containing amphibolites. The six samples were sent to Department of Earth Sciences, Royal Holloway College, university of London for characterisation. The samples were characterised paying particular attention to the presence of any fibrous (asbestiform) amphiboles. This was carried out by visual observation under a binocular microscope and supplemented by X-ray diffraction (XRD) analysis and qualitative chemical analysis of the amphibole. The conclusions of the study are summarised as:

- The mineralogy of the six 'amphibolite' samples is dominated by quartz, amphibole, talc, biotite and magnetite, and lesser chlorite, kaolinite and goethite.
- Weathering has tended to break the amphibole down and replace it by talc.
- Although amphiboles are abundant (particularly in the unweathered samples), they have a prismatic habit and would not be classified as asbestiform. The chemical composition and X-ray diffraction data also demonstrate that the amphiboles are a common variety hornblende (pargasite).
- The samples show no evidence of the presence of any fibrous minerals.

The full report of the amphibolites characterisation can be found in Appendix C.

4.1.3 Waste Rock Dump

Section 3.1 indicates that units that will become waste rock contain pyrite as an accessory mineral. In addition, apatite, dolomite and garnet occur as accessory minerals. Calcite is present in most lithologies albeit in a limited quantity.

A selection of 45 samples was subjected to Acid Base Accounting (ABA) and paste pH. The results are summarized in Table 10 (Appendix C contains the factual report from SGS). Figure 4 shows the graphs of the five samples that contain Total Sulphur higher than detection limit in terms of Net Neutralization Potential. The results (Appendix D) show that Total Sulphur for most of the samples is below 0.1% and only 3 samples have a Total Sulphur between 0.1 to 0.2%. The low level of sulphur indicates that there is a very limited driving force for acid generation. The lowest paste pH is 6.2 and most of the samples have a paste pH > 8. These pH measurements are consistent with samples with limited sulphide content. The low Neutralization Potential (for the great majority of samples) suggests that the calcite is not widespread. Figure 4 shows that only three samples would be classified as uncertain (Table 4) but considering that a Total Sulphur value is being used this make the result conservative and even if the Total Sulphur values were to be realized in terms of creating acidity, the magnitude would be very limited.

The combination of lack of pyrite (or pyrite present at low concentration), and some limited neutralization potential indicates that if any drainage is generated from the waste rock dumps, it is unlikely that this will be acidic.

Table 10. Summary of Acid Base Accounting and Paste pH Determination for Moonlight Samples

Sample	Borehole ID	Total S	NP	Paste pH	AP	NNP
		%	kg CaCO3/ t		kg CaCO3/ t	kg CaCO3/ t
U0892	FCL004	<0.01	4.9	8.2		
U0951	FCL004	<0.01	4.1	8.4		
U0924	FCL004	0.13	36	8.7	4.1	31.9
U0018	FCL005	<0.01	0.89	8.7		
U0111	FCL006	<0.01	3.8	8.4		
B1611	FCL007	0.12	17	9.1	3.8	13.3
B1635	FCL007	0.11	8.8	8.4	3.4	5.4
B1574	FCL007	<0.01	5.7	8.1		
B1105	FCL008	<0.01	3.5	8.9		
U0232	FCL011	<0.01	2.5	8.1		
U0484	FCL013	<0.01	7.8	8.9		
U0483	FCL013	<0.01	5.1	8.7		
U0486	FCL013	0.08	52	8.8	2.5	49.5
U0547	FCL029	<0.01	9.9	9.1		
U0553	FCL015	<0.01	3.0	9.3		
U0166	FCL017	<0.01	9.9	8.3		
U0593	FCL018	<0.01	5.1	8.4		
U0584	FCL018	<0.01	1.2	8.2		
B1145	FCL019	<0.01	3.0	8.4		
B1191	FCL019	<0.01	6.7	8.8		
B1197	FCL019	<0.01	20	9.2		
E0466	FCL022	<0.01	1.9	8.2		
E0493	FCL027	<0.01	4.3	8.2		
E0505	FCL028	<0.01	1.4	7.8		
E0504	FCL29	<0.01	2.2	8.4		
E0503	FCL29	<0.01	2.7	8.3		
E0476	FCL031	<0.01	2.5	8.0		

Table 10. Summary of Acid Base Accounting and paste pH Determination for Moonlight Samples (Cont)						
Sample	Borehole ID	Total S	NP	Paste pH	AP	NNP
		%	kg CaCO3/ t		kg CaCO3/ t	kg CaCO3/ t
E0293	FCL039	<0.01	4.6	8.4		
E0182	FCL046	<0.01	4.3	7.9		
E0101	FCL056	<0.01	2.7	7.5		
E0097	FCL056	<0.01	2.2	7.7		
E0128	FCL058	<0.01	4.6	8.3		
E0132	FCL058	<0.01	7.8	8.9		
E0308	FCL067	<0.01	1.4	6.4		
E0327	FCL068	0.08	7.0	9.1	2.5	4.5
E0415	FCL069	<0.01	11	9.4		
E0564	FCL070	<0.01	170	9.4		
E0351	FCL071	<0.01	0.36	6.7		
E0354	FCL071	<0.01	0.89	6.2		
E0342	FCL072	<0.01	7	9.1		
E0297	FCL077	<0.01	1.7	7.8		
E0306	FCL077	<0.01	3.3	7.7		
E0457	FCL081	<0.01	2.2	7.6		
E0523	FCL083	<0.01	35	8.7		
E0525	FCL083	<0.01	14	8.9		

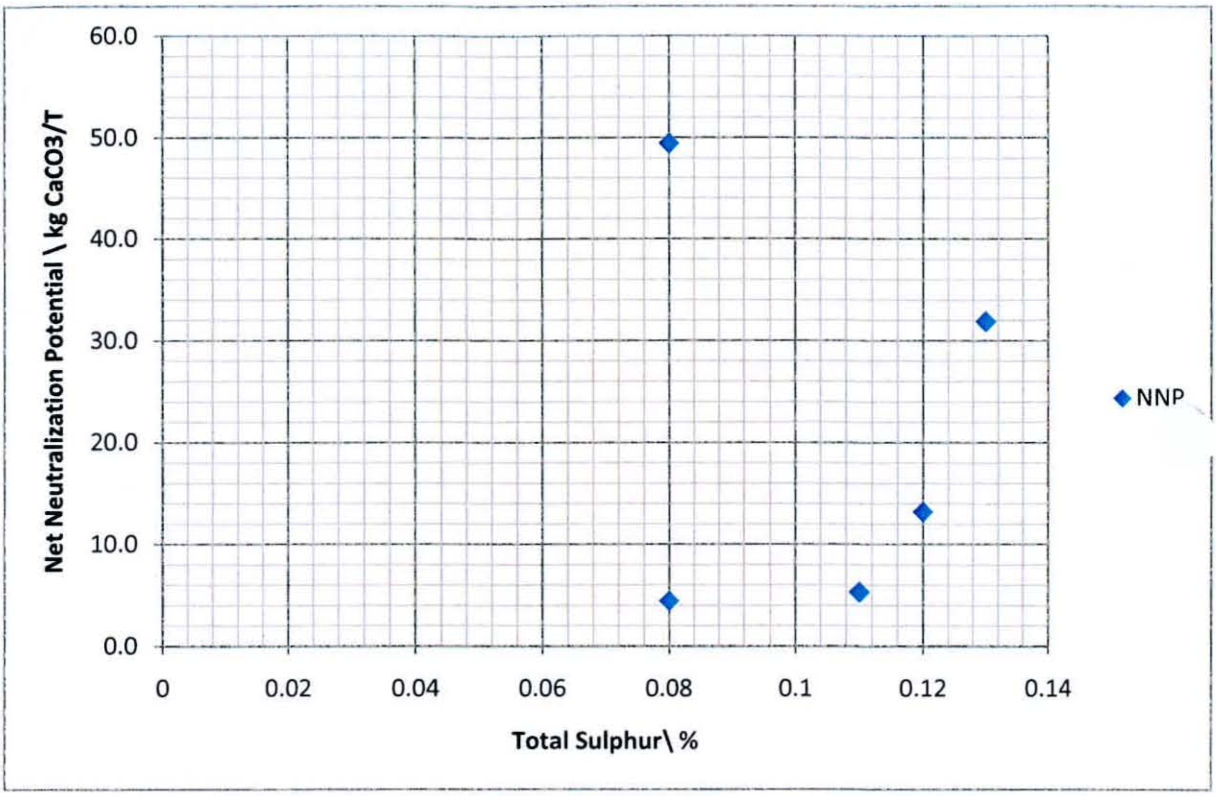

Figure 4. NNP representation for samples with Total Sulphur Above Detection Limit

4.1.4 Open Pit

At this stage it is not possible to provide a definitive indication of the likely water quality of a pit lake on closure. In fact it is not possible at present to determine whether a significant pit lake will be generated. However, a few general conclusions can be reached based on the lithology of the deposit and the leaching potential of these lithologies:

- The weathered zone is not going to generate acidity as if any sulphide was present in the past it has already been oxidised
- The fresh material left in the pit wall is likely to have a very small amount of sulphide present (See Table 10); however considering that sulphides are accessory minerals to start with, it is highly unlikely that any acidity will be generated.

5.0 CONCLUSIONS

The low level of sulphides present in the waste rock, pit walls and tailings indicate that it is unlikely that any significant amount of acid generation will take place because there is no driving force for this to occur.

Aspect / studies	Adequacy of predictive methods and tools used	Adequacy of underlying assumptions	Uncertainties in information provided
Geochemical waste characterisation	The methodology and techniques used in this study follow international best practice as found in the Guidelines from the British Columbia Ministry of Employment and Investment of Canada	The underlying assumptions were consistent and adequate with the type of deposit in this study and within the limits of the methods used.	There is always some degree of uncertainty in any study; however the results presented are consistent with this type of deposit

APPENDICES

APPENDIX A

Acid Base Accounting Method

The Modified Acid Base Accounting Procedure
(Lawrence and Wang, 1997)

Sample Preparation

The sample should pass 60 mesh.

Determination of "Fizz Factor"

Add a few drops of 25% HCl to 1 to 2g of pulverized sample on a watch glass. Observe the degree of reaction and assign a fizz rating of none, slight, moderate or strong.

Method for Neutralisation potential

- Weigh about 2.00g of pulverized sample (to 4 places of decimal) into a sample bottle and add about 90 ml. of distilled water.

- Add a known volume of standardised acid (1.0 N HCl in standard method but 0.1 N HCl is more accurate to use) according to the fizz rating previously given to the sample. (See Table below). This is time zero or T = 0. If using 0.1 N HCl multiply the volumes below by 10.

Fizz Rating	Volume of 1.0 N HCl (ml)	
	At T = 0	At T = 2
None	1.0	1.0
Slight	2.0	1.0
Moderate	2.0	2.0
Strong	3.0	2.0

- Place the bottles on the reciprocating shaker and leave to shake for 2 hours. T= 2. Add the second aliquot of acid according to the table above.

- Replace on shaker and leave to shake for a further 20 hours. T = 22.

- At T = 22 remove the bottles from the shaker and measure the pH of the solutions. If the pH is greater than 2.5 add a measured amount of acid to bring the pH down to between 2.0 and 2.5. If the pH is below 2.0 then too much acid was added at T = 2 and the test will have to be redone at lower acid concentration.

- Replace the bottles back on the shaker for a further 2 hours.

- At T = 24, terminate the test and add distilled water to the bottle or flask to bring the volume to approximately 125 mL. Measure and record the pH, making sure it is in the required range of 2.0 to 2.5..

- Titrate the content of the bottle or flask to a pH of 8.3 using certified or standardized 0.5 N or 0.1N NaOH.

- The Modified NP in Kg CaCO3/t is as follows:-

$$NP = \frac{[(N \times V_{mls\ HCl}) - (N \times V_{mls\ NaOH}) \times 50]}{\text{Weight of Sample (g)}}$$

The acid generating potential is then calculated on the basis of the Sulphide – sulphur content (AP = S= x 31.25).
Sulphide - sulphur is typically determined as the difference between total sulphur and sulphate – sulphur.

Reference

Modified Acid Base Accounting Procedure, R.W. Lawrence and Y. Wang. 4th International Conference on Acid Rock Drainage. May 31 – June 6, 1997 Vancouver, B.C. Canada. p.464.

Appendix B

List of Waste Rock Samples

Appendix C

Mineralogical Characterization of Amphibolite Samples

MINERALOGICAL CHARACTERIZATION OF SIX AMPHIBOLITE SAMPLES

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For: AMEC Earth and Environmental

Ashford

Kent

UK

Executive summary

1) The mineralogy of the six 'amphibolite' samples is dominated by quartz, amphibole, talc, biotite and magnetite, and lesser chlorite, kaolinite and goethite.

2) Weathering has tended to break the amphibole down and replace it by talc.

3) Although amphiboles are abundant (particularly in the unweathered samples), they have a prismatic habit and would not be classified as asbestiform. The chemical composition and X-ray diffraction data also demonstrate that the amphiboles are a common variety hornblende (pargasite).

4) The samples show no evidence of the presence of any fibrous minerals.

Aim

To characterise the mineral phases present in six samples of amphibolite, paying particular attention to the presence of any fibrous (asbestiform) amphiboles. This was carried out by visual observation under a binocular microscope and supplemented by X-ray diffraction (XRD) analysis and qualitative chemical analysis of the amphibole.

Samples

Each sample consisted of approximately 30g of granular material (size up to 0.5cm). Further details of the samples can be found in the attached appendix.

Sample no.	State	BHID	From (m)	To (m)
B1387	Fresh	FCL001	115	116
B1611	Fresh	FCL007	104	105
B1614	Fresh	FCL007	116	117
U0341	Weathered	FCL010	13	14
U0232	Weathered	FCL011	15	16
U0403	Weathered	FCL014	50	51

Visual observation

The samples were disaggregated lightly in a mortar and pestle to separate the individual mineral grains. They were then viewed using a binocular microscope.

The sample images are presented in Figures 1 to 6, and clearly show the presence of minerals such as quartz (glassy and transparent), amphibole (green), biotite mica (brownish plates), magnetite (opaque, octahedral) and red-brown iron oxide.

Where green amphibole is present, it shows only a slight elongation with a small length:width ratio. Most grains are either 'blocky' or slightly prismatic in shape. **No fibrous minerals have been observed.**

Four of the samples contain abundant amphibole, but the weathered samples U0341 and U0403 contain almost none of this mineral.

Figure 1: View of sample B1387 (Field of view 16mm across)

Figure 2: View of sample B1611 (Field of view 8mm across)

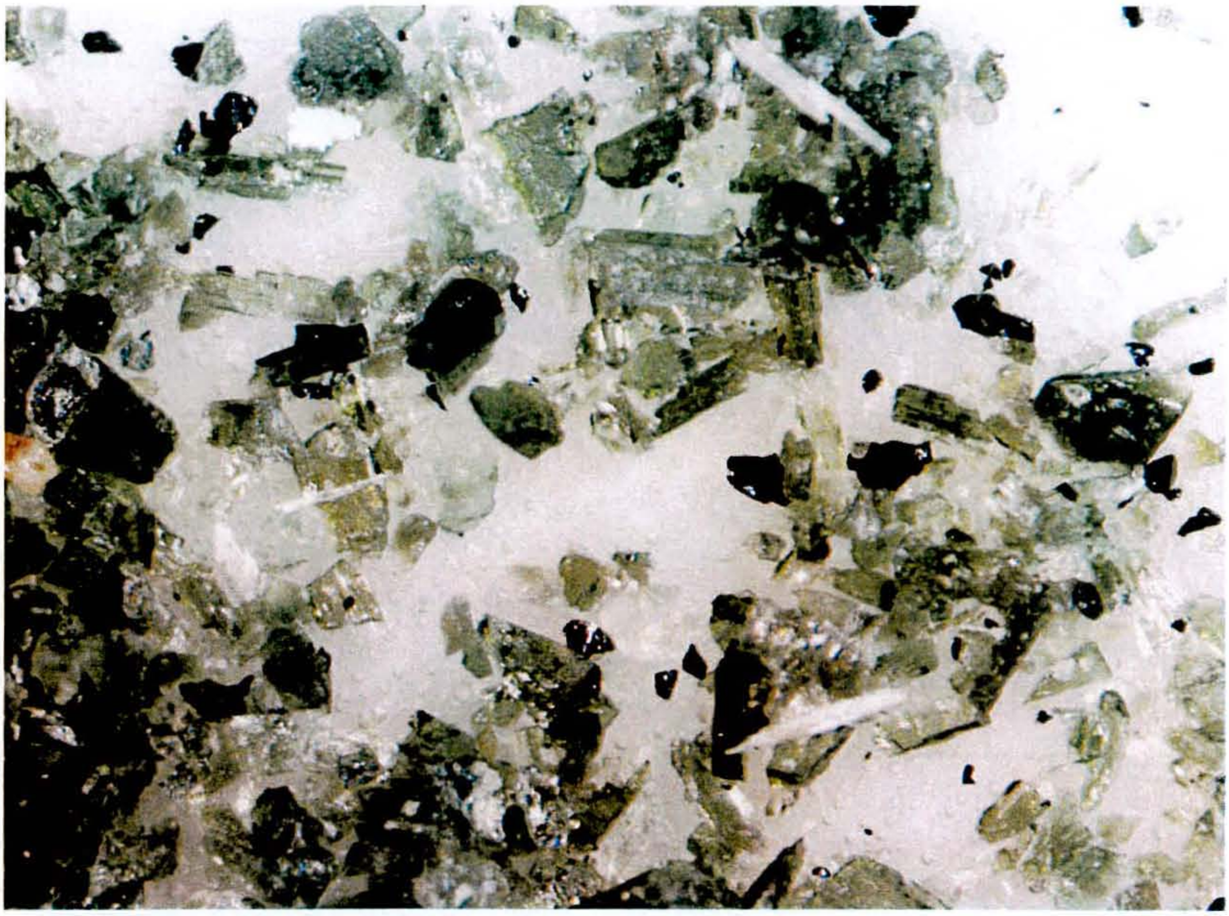

Figure 3: View of sample B1614 (Field of view 8mm across)

Figure 4: View of sample U0341 (Field of view 8mm across)

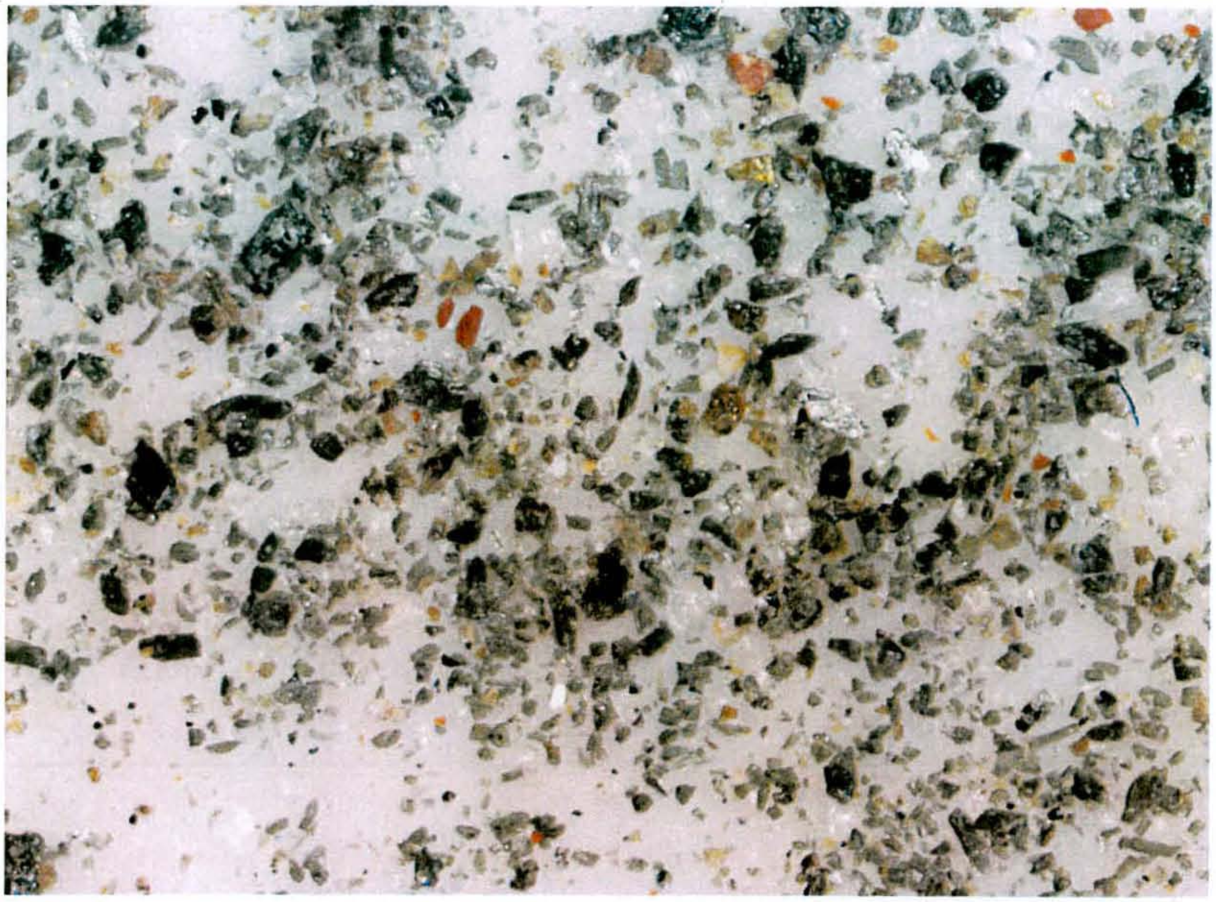

Figure 5: View of sample U0232 (Field of view 16mm across)

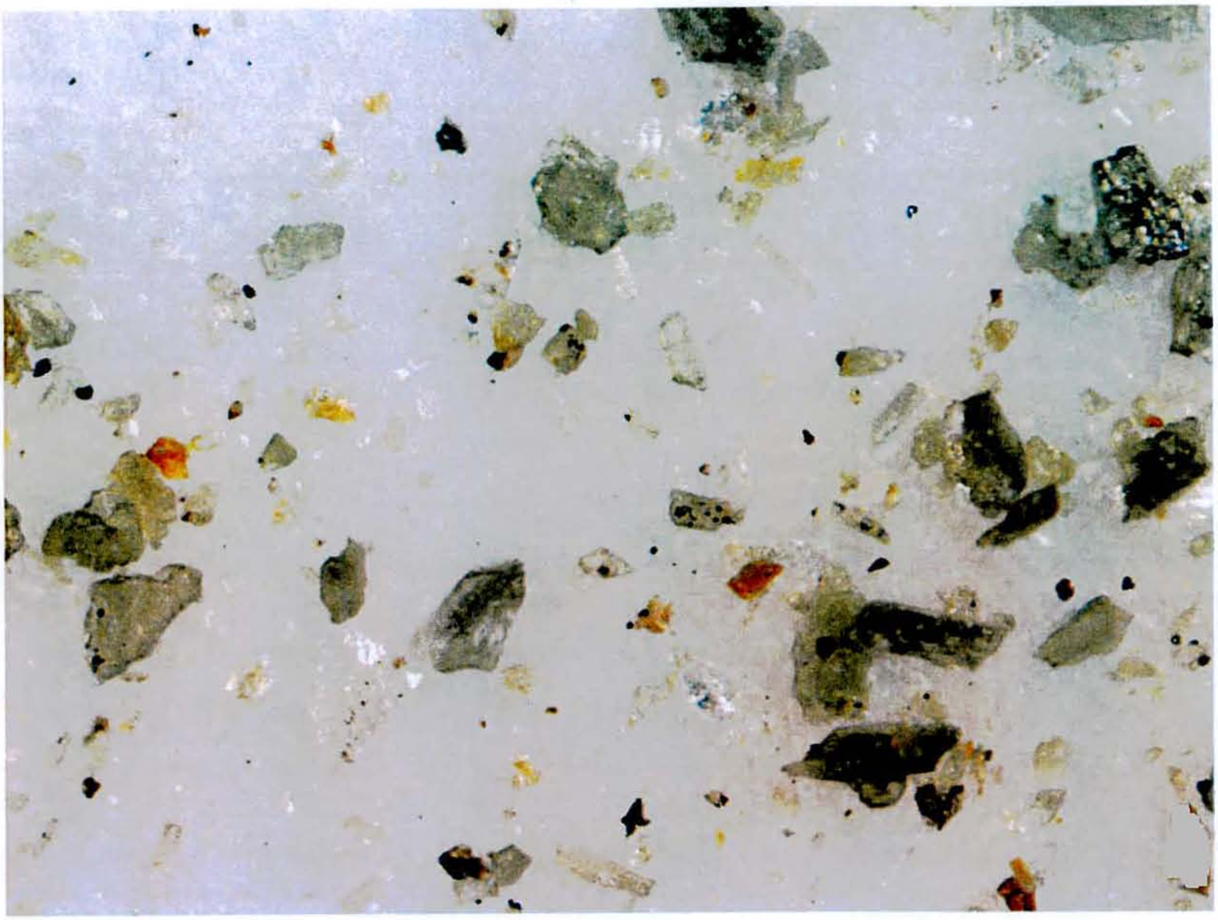

Figure 6: View of sample U0403 (Field of view 8mm across)

XRD analysis

XRD analysis was used to confirm the nature of the amphibole present in the samples. A representative portion of each sample was manually ground to a fine powder using a ceramic mortar and pestle. The powder was packed into a recessed plastic holder and preferred orientation was minimised. The samples were analysed using a Philips X-ray diffractometer (PW3710) scanning from 4° to 60° 2θ. The generator was set at 40kV and 40mA, and the operation was controlled using Philips PC-APD software. Peak identification was enabled using the PDF/ICCD database.

The traces for the six samples are presented in Figures 7 to 12, along with peak markers for the main minerals present.

The XRD analysis confirms the visual observations, but also indicates that **the amphibole is the variety pargasite (a relatively common variety of 'hornblende').** (Labelled as 'pargasi' on the XRD peak database).

Talc is abundant in several samples and the traces for U0341 and U0403 clearly show that this mineral has totally replaced the original amphibole (confirming the visual observation of these two samples).

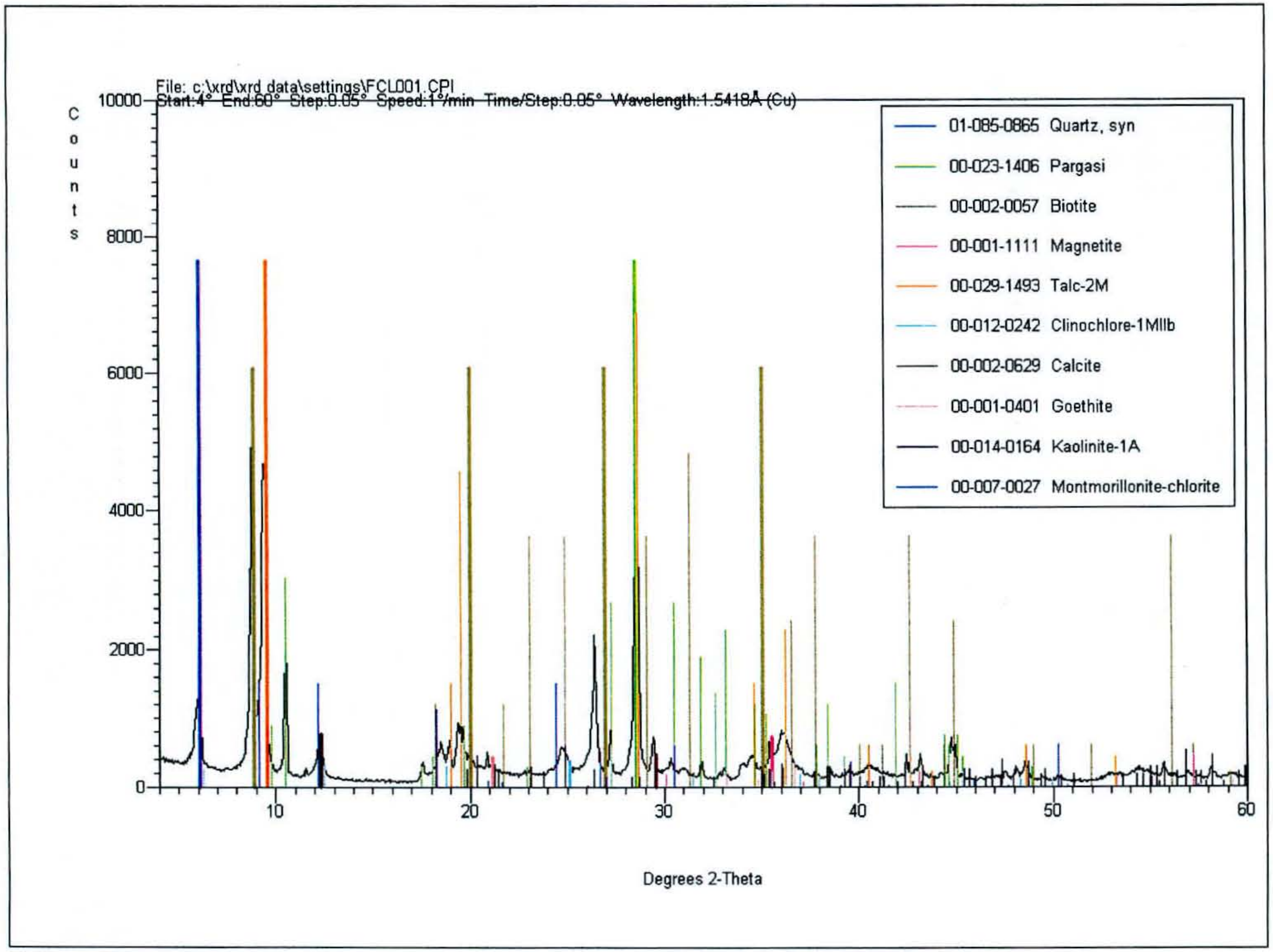

Figure 7: XRD trace for sample B1387, with markers for the dominant minerals present

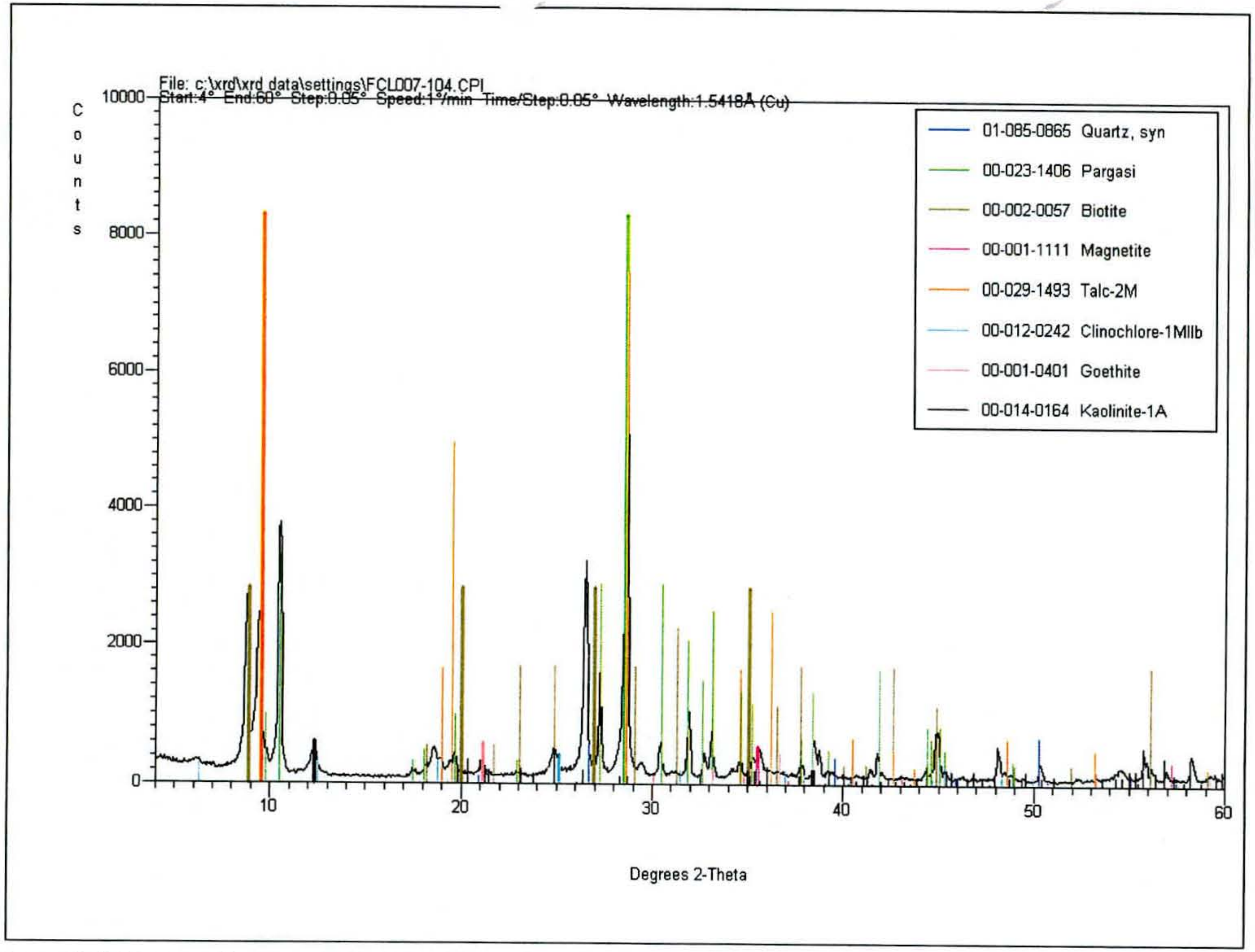

Figure 8: XRD trace for sample B1611, with markers for the dominant minerals present

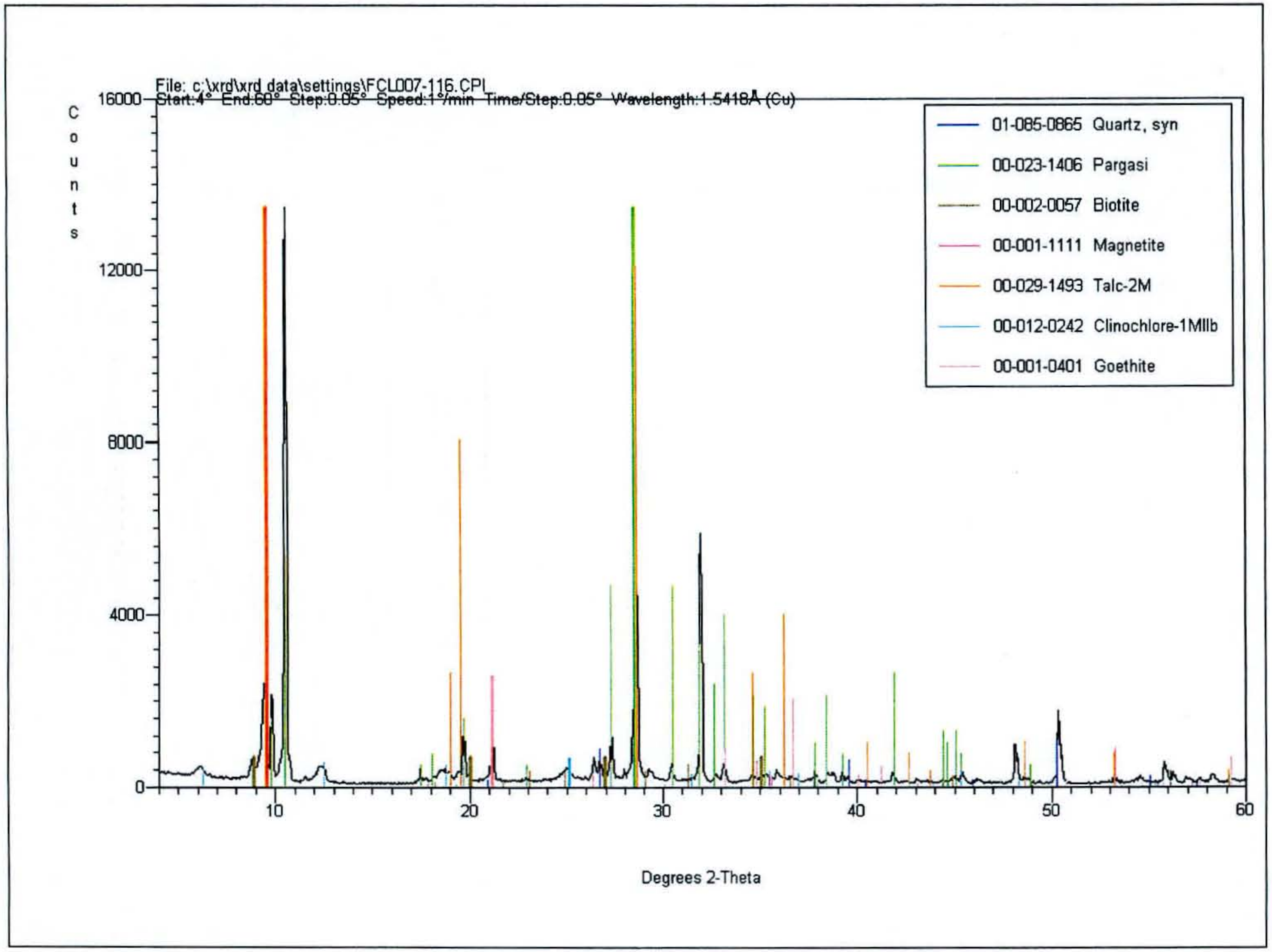

Figure 9: XRD trace for sample B1614, with markers for the dominant minerals present

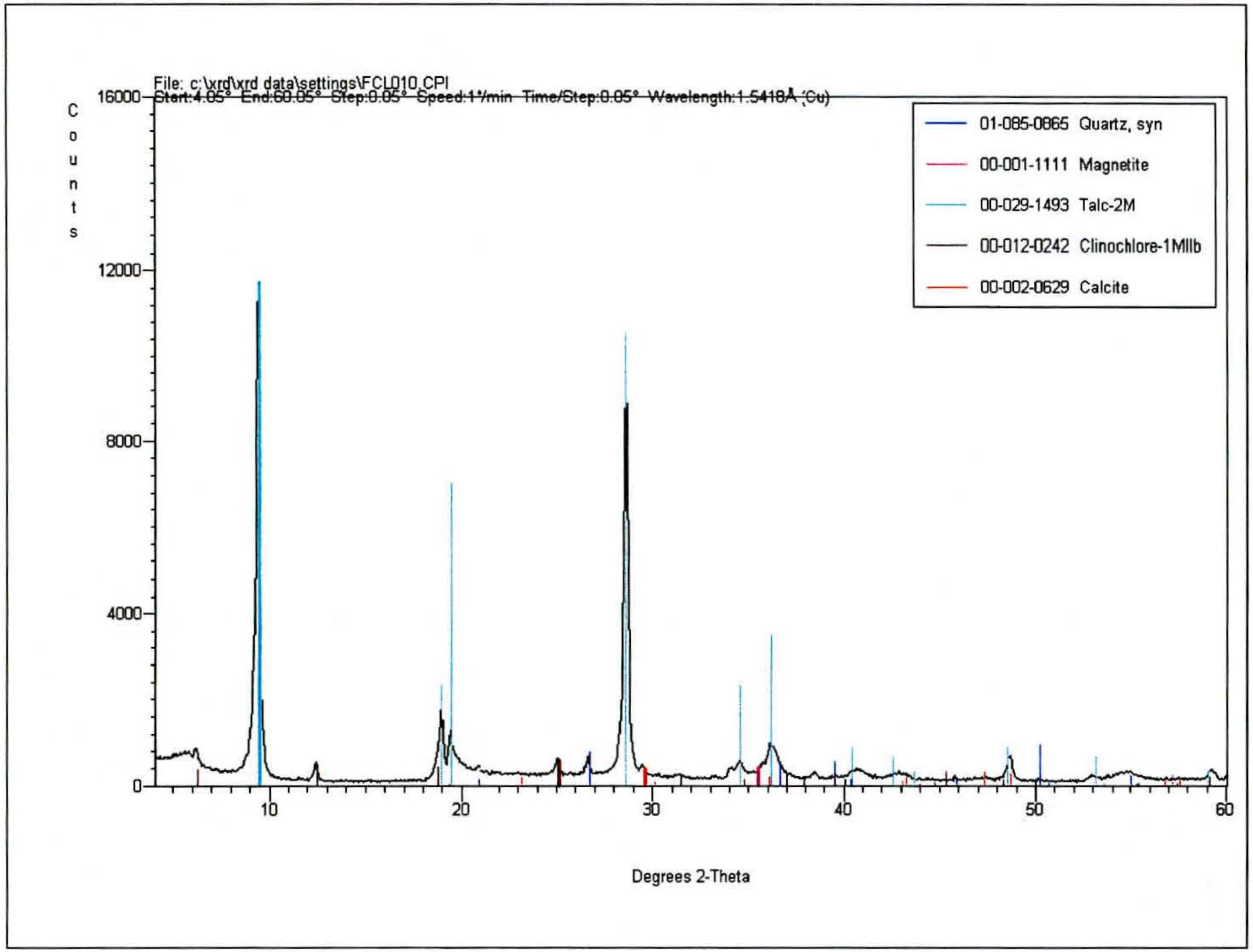

Figure 10: XRD trace for sample U0341, with markers for the dominant minerals present

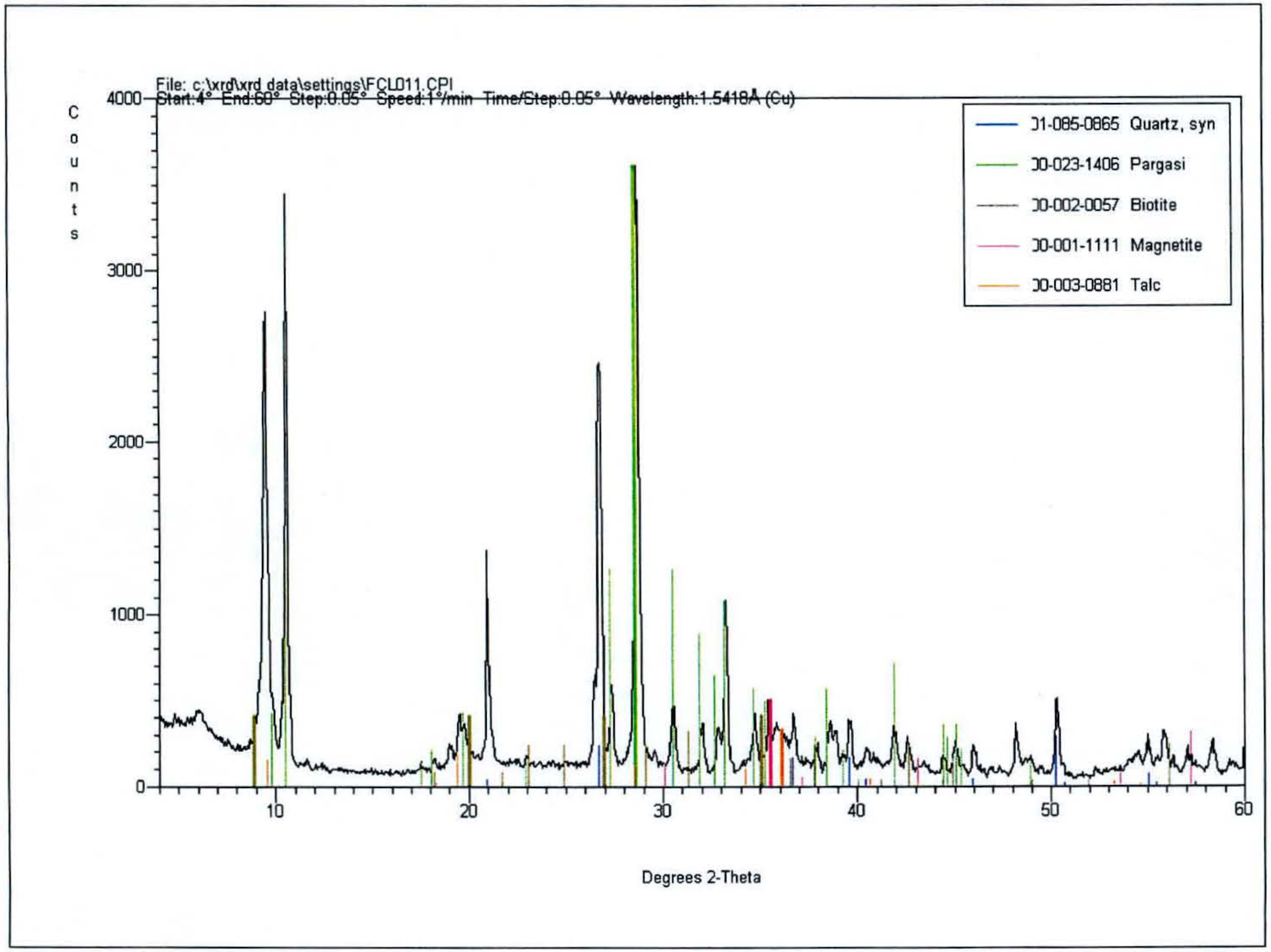

Figure 11: XRD trace for sample U0232, with markers for the dominant minerals present