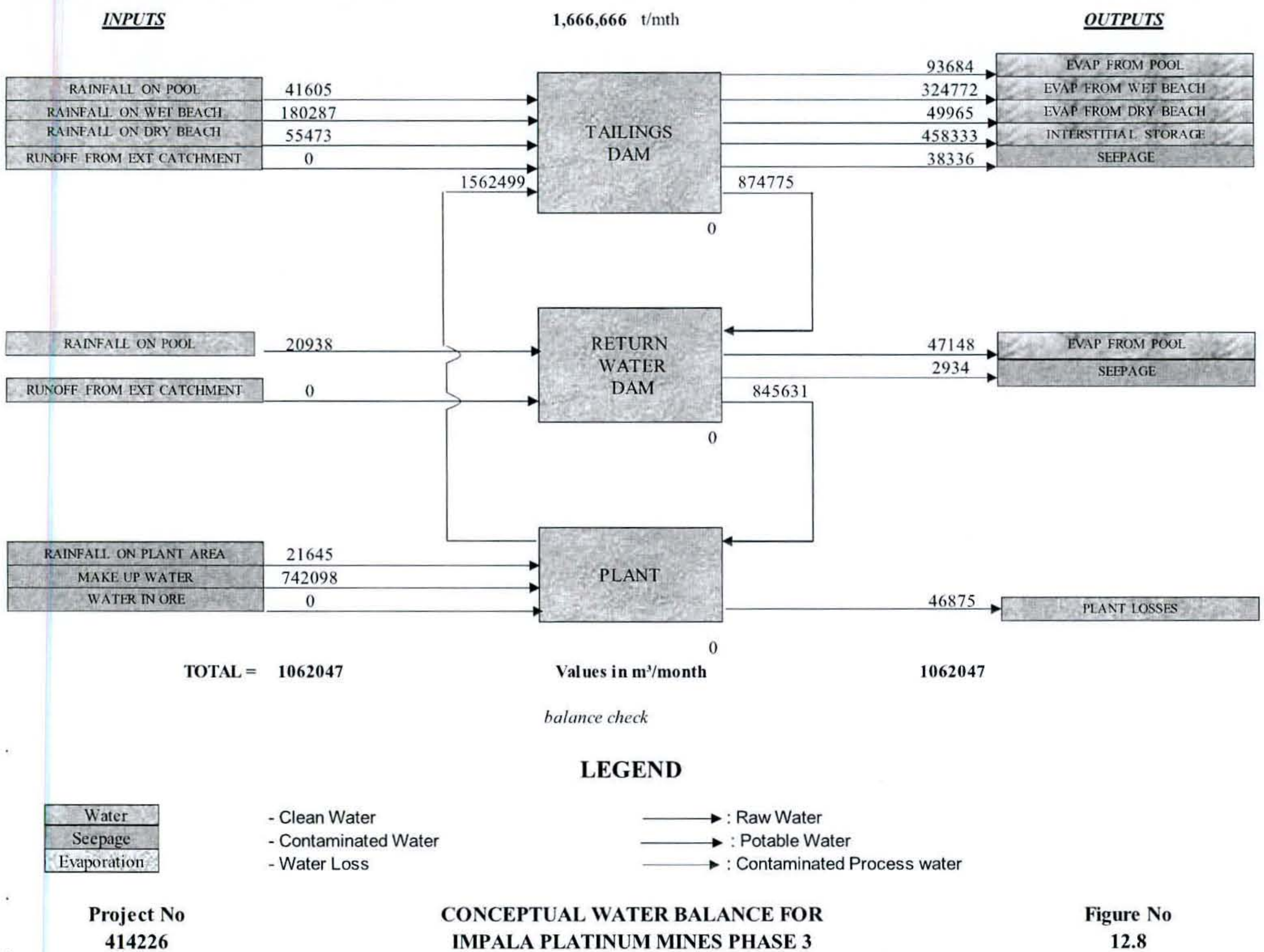


Figure 12-8: Average Monthly Water Balance for Tailings dam No. 5: basin permeability of 2.9e-9m/s

***The average consumption per month is **0.42m^3/t**.

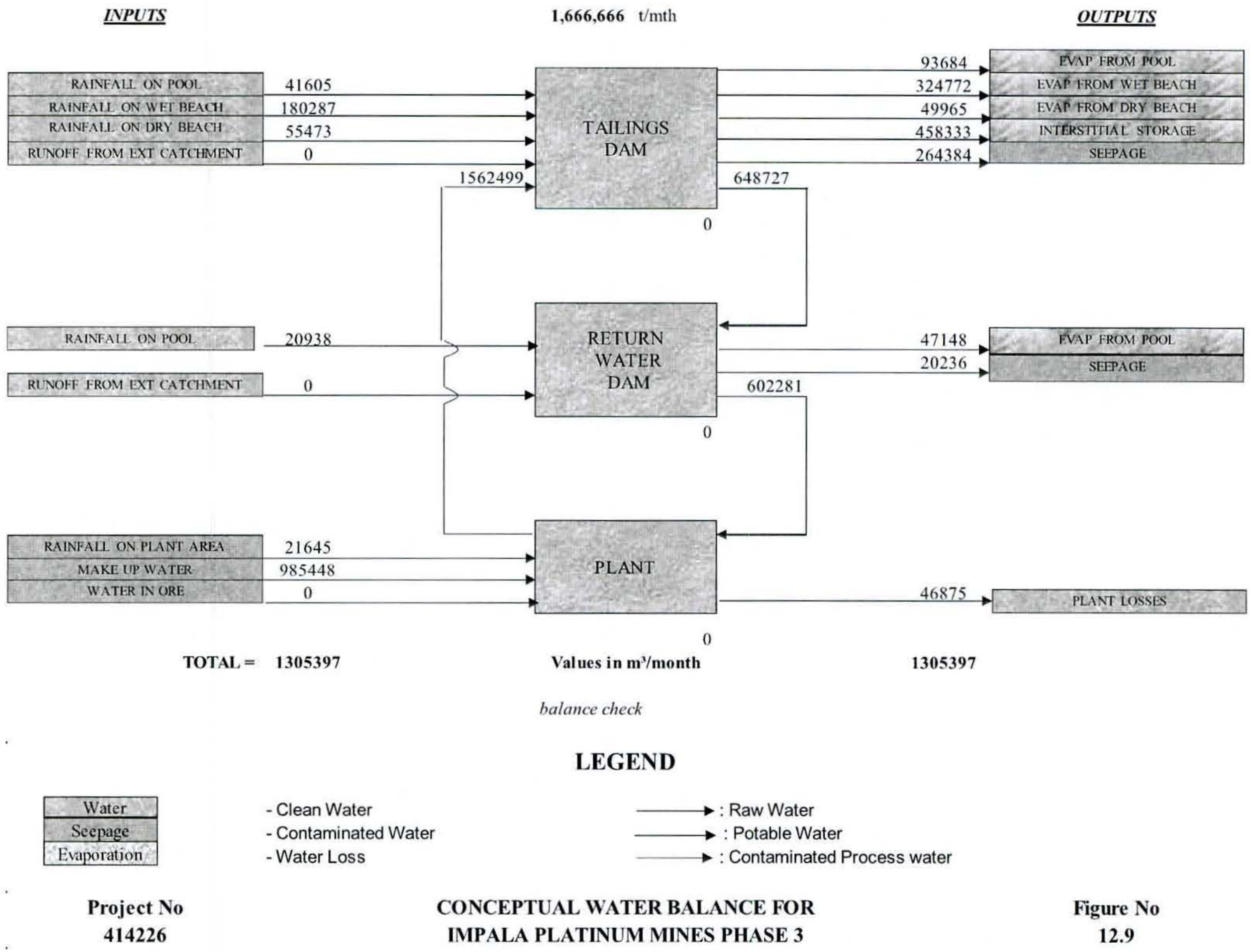


Figure 12-9: Average Monthly Water Balance for Tailings dam No. 5: basin permeability of 2e-8m/s

12.3.2 Conclusion

The following conclusions can be made based on the results of the above-mentioned hydrological assessment work.

- For Tailings dam No. 5 Phase 1 a single Penstock Tower with an intake capacity of 2 m^3/s is required to decant the entire 1:100 year volume of 338,853 m^3.
- The entire storm volume of 338,853 m^3 will take approximately 48 hours to decant, based on the underlying decant pipeline being sized at 1200 mm.
- For Tailings dam No. 5 Phase 2 a single Penstock Tower with an intake capacity of 2 m^3/s is required to decant the entire 1:100 year volume of 412,517 m^3.
- The entire storm volume of 412,517 m^3 for Tailings dam No 5 Phase 2 will take approximately 58 hours to decant, based on the underlying decant pipeline being sized at 1200 mm.
- The time taken to decant the cumulative 1:100 year volume (751,371 m^3) based on the two penstock towers which amounts to an intake capacity of 4 m^3/s, is 53 hours.
- The incremental RWD size for tailings dam No. 5 Phase 1 is 330,000 m^3
- The incremental RWD size for tailings dam No. 5 Phase 2 is 440,000 m^3
- The total Return Water Dam design for tailings dam No. 5 is based on the cumulative size of tailings dam No.5 Phases 1 and 2 which amounts to is 770,000 m^3. The return water dam strategy is as follows. A return water dam with capacity of 770,000m^3 will be provided at the location of RWD 1. A return water dam with capacity of 390,000m^3 will be provided at the location of RWD 2, with the provision that this RWD 2 can be extended, if required to a full capacity return water dam.
- Three clean water diversions are required around the TSF, the first two are located on the northern boundary, whilst the other is located on the south eastern boundary.
- The diversion structures proposed are unlined trapezoidal canals, with depths ranging from 0.5 m to 1 m, and side slopes of 1v:3h.
- Energy dissipaters at the outlets of these channels are required.

13 Return Water Dam

13.1 Tailings dam No. 5 Phase 1

A return water dam for tailings dam No. 5 Phase 1 is to be designed according to the capacity (m^3) outlined in Table 13-1. The dam has been designed in accordance with current South African legislation. The required capacity of the return water facility has been determined based on the fact that it is required to contain the 1:50 year runoff from the tailings dam surface area and the intermediate catchment, as well as the 1:50 year rainfall on the return water dam surface area and the return water dam intermediate catchment. The storage capacity requirement for the return water dam is approximately 330,000 m^3, 800 mm freeboard from the spillway level to the crest is required.

The minimum required storage for the return water dam has been determined and is presented in Table 13-1.

Table 13-1: Storage Requirements for the Return Water Dam

Component	Required Storage (m^3)
1:50 year Rainfall directly onto the dam	17,380
1:50 year catchment runoff	0
1:50 year runoff from tailings dam	284,784
Operating Volume *	27,836
Total RWD Storage (m3) (minimum)	330,000

13.2 Tailings dam No. 5 Phase 2

The return water dam for tailings dam No. 5 Phase 2 is to be sized so that it allows for the remaining capacity required when tailings dam No. 5 is completed. A return water dam for tailings dam No. 5 Phase 2 is to be designed according to the capacity (m^3) outlined in Table 13-2. The dam has been designed in accordance with current South African legislation. The required capacity of the return water facility has been determined based on the fact that it is required to contain the 1:50 year runoff from the tailings dam surface area and the intermediate catchment, as well as the 1:50 year rainfall on the return water dam surface area and the return water dam intermediate catchment. The storage capacity requirement for the return water dam is approximately 770,000 m^3, 800 mm freeboard from the spillway level to the crest is required.

The minimum required storage for the return water dam RWD 1 has been determined and is presented in Table 13-2.

Table 13-2: Storage Requirements for the Return Water Dam RWD 1)

Component	Incremental Phase1	Incremental Phase2	Total Required Storage (m^3)
1:50 year Rainfall directly onto RWD	17,380	23,173	40,553
1:50 year catchment runoff	0	0	0
1:50 year runoff from tailings dam	284,784	392,226	677,010
Operating Volume *	27,836	24,601	52,437
Total RWD Storage (m^3) (minimum)	330,000	440,000	770,000

The minimum required storage volume for RWD 2 is half the capacity of RWD 1 at 390,000 m^3. This return water dam RWD 2 has not yet been designed, but will basically be sized to provide half the capacity of RWD 1, also in terms of footprint considerations, where possible.

13.3 Return Water Dam Basin

The storage capacity provided by the return water dam will be achieved through the construction of the embankment and excavation of the basin to create storage. The site is underlain by 1.3m of soft black turf clay and the average depth to refusal is 2m with a TLB excavator which has the consistency of soft to medium hard rock. Material could be excavated from the dam basin to create the containment walls if no rock fill is available from the mine. The maximum depth of excavation for the return water dam will be around 2m, which mean that drilling and blasting should probably not be required.

13.4 Embankment Construction

The embankment will be constructed out of rock fill or excavated material from the basin, depending on the availability of rock from the mine. The rock fill will be produced by means of a crushing and screening operation to produce a uniformly graded and workable material. The embankment slopes will be 1V:3H. The compaction requirements for the placement of rock fill will take the form of a performance specification that will be developed on site by means of a trial section.

Table 13-3: Return Water Dam Wall RWD 1

Description	Value (Phase 1)	Value (Phase 2)
Crest Elevation	1116.5 mamsl	1116.5 mamsl
Spillway Elevation	1115.7 mamsl	1115.7 mamsl
Maximum Height	9.5 m	7.35 m
Spillway Width	4 m	4 m

Similar details will be prepared for RWD 2 once the final location of RWD 2 has been approved by the full project team including the environmental EIA studies.

13.5 Geomembrane Lining

The liner system comprises of a 2mm thick HDPE primary liner, underlain by a 750 micron cuspated sheet leakage detection layer, a 1.5mm thick HDPE secondary liner and a geofabric bedding layer. A 150mm thick bedding layer will be installed in the basin and up the rock fill side slopes to provide a smooth working surface for the liner installation. A 150mm thick sand layer will be installed in the basin of the dam to keep the liner in place and to prevent it from floating.

13.6 Leakage Collection System

Under the 2mm HDPE primary liner there is a leakage detection layer that enables the detection of possible leaks in the primary liner. Required leakage detection systems can either be a sand drainage layer, a geo-net or a drainage core layer. In this instance, a 750 micron cuspated sheet has been allowed for as the leakage detection layer.

Leakage detection is facilitated by seepage water draining between the primary liner and the 1.5mm HDPE liner (the two liners being kept separate by the leakage detection layer). Any leakage reports to the leakage detection sump. This system effectively forms early warning leakage detection as leakage is detected immediately after a leak occurs in the primary liner and before seepage water can transgress the second and third barriers.

13.7 Long Term Operation of Return Water Dam

During the operation of Tailings dam No. 5 Phase 1, the 440,000m^3 compartment of RWD 1 will be utilised as the return water dam although the volume is larger than required. The 330,000m^3 compartment of RWD 1 will be constructed during the Tailings dam No. 5 Phase 2 construction phase. RWD 2 will be constructed as Part of Phase 2, to its full capacity, also utilizing two compartments.

13.8 Dam safety registration

The storage capacity and the maximum height of the return water dam wall will require the facility to be registered by the DWAE Dam Safety Office. According to the requirements set out by DWAE, the dam will be classified as a Category II facility. The design of the RWD needs to be undertaken by an Approved Professional Person (APP) which conforms to the relevant classification regulation.

14 TSF Features to Reduce Environmental Impact

The Impala tailings dam complex should comply with the EMP and all relevant South African legislation requirements with special focus, but not limited to:

National Environmental Management Act (Act 107 of 1998)

National Water Act (Act No 36 of 1998) and Regulations

Mineral and Petroleum Resource Development Act (Act No 28 of 2002) and Regulations

The Mine Health and Safety Act (Act 29 of 1996)

The TSF will be designed, constructed, operated and closed to high environmental protection standards meeting the requirements of Department of Mineral Resources, Department of Water and Environmental Affairs and the Tailings Management Framework of Impala Platinum Ltd (Implats).

14.1 Tailings dam overall slope angle

The Implats standard for tailings dam overall slope angles is 1v:4h. This will reduce erosion damage as well as promote the establishment of a sustainable vegetation solution. The flatter outer slope angle will also reduce the visual impact of the new TSF.

14.2 Seepage

The bulk of the new tailings dam extension and return water dam extension is underlain by zones of deep weathering. This means that the site is underlain by a thick layer of black turf which could act as a natural clay liner (NCL). The presence of this layer will reduce seepage to the underground. Methods will be investigated during the detailed design phase to moisture condition this layer so that water ingress is further minimised. The slurry density of the tailings material will, if possible, also be increased to reduce potential infiltration.

Allowance was also made in the design for the installation of a main toe drain as well as a sand curtain drain in the tailings dam. These drainage systems will intercept seepage and convey the seepage to the return water dam via the concrete lined solution trench. All of the above mentioned drains will have a 1.5 mm HDPE lining at the bottom to reduce and limit where possible any seepage which could emanate from the respective drains.

SLR Consulting is currently developing a hydrogeological model of the tailings dam complex 4 and 5 to model the development of future seepage flumes. As part of this geohydrological model study, boreholes will be sited to serve at early warning boreholes from a monitoring perspective. These boreholes will be suitably sized and constructed as dewatering boreholes, and can then later, if required, be equipped to extract seepage water at these specific locations to intercept seepage flume development and limit further seepage flume development. The water extracted at these boreholes will either be returned to the RWDs or the tailings dam, depending on the locations of these boreholes.

Figure 14-1 refers. It can be seen that there is an environmentally sensitive area downstream of Phase 2 of Tailings Dam no. 5 development. The following environmental risk reduction measures are proposed:

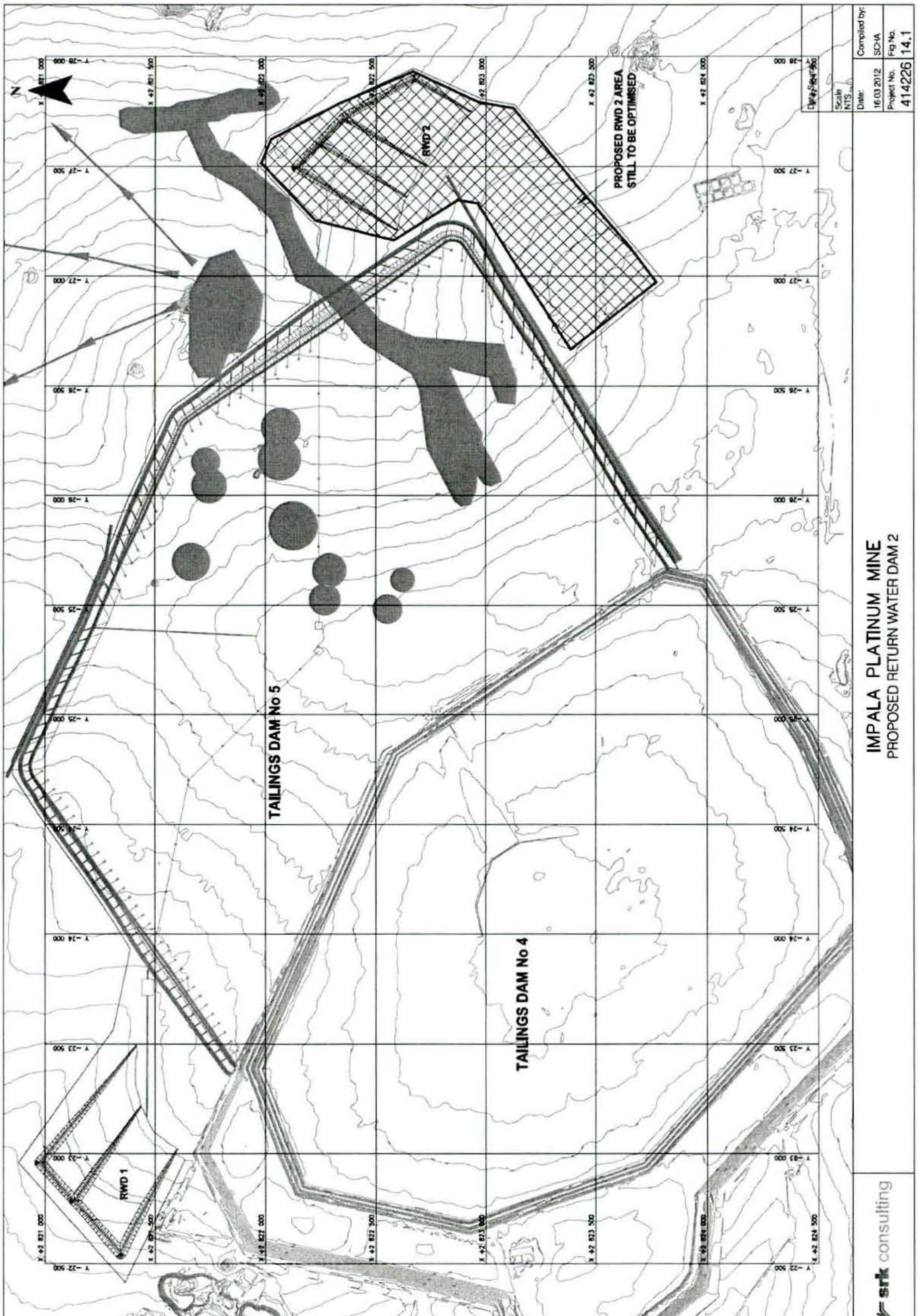
- Just downstream of the tailings dam starter wall, at the low lying area location of this environmentally sensitive area, a deep trench across this low lying area, to refusal of a medium sized excavator will be prepared. This trench will be constructed as a seepage collector drain from the upstream side and all seepage at this location will be able to be monitored for water quality, via the water quality monitoring borehole pipe provided as part of this interceptor drain.
- Provision will be made to either pump this water to the nearby concrete lined solution trench or to gravity feed from this location to the silt trap, if the quality is not suitable for release into the environmentally sensitive area. If the water quality is adequate it will be released to the environmentally sensitive area. These details still have to be designed as part of the detailed design of the tailings dam.

14.3 Siting of RWD 2

Between Phase 2 of the Tailings Dam no. 5 and the RWD 2, there is a small stream channel which is considered an environmental sensitive area (Figure 14-1). The following risk reduction measures will be implemented.

- RWD 2 is a HDPE lined facility, as described above. This RWD facility comprises three components: a silt trap, a RWD and a return water pump station.
- The silt trap is fed by the penstock pipeline from Phase 2 as well as the relevant portions of the solution trench and drains from Phase 2 construction.
- RWD 2 will be located south of the environmental sensitive stream area, so that the penstock pipeline from Phase 2 construction can gravity feed this RWD 2. This penstock pipeline will have to traverse the environmental sensitive area and care will be taken during construction with the construction of the pipeline crossing in this area. It is preferable if this pipeline crossing can be constructed in low rainfall periods, during winter months, as the construction timing can then reduce potential impacts on this environmentally sensitive area.
- As part of this penstock pipeline construction activity the pipes from the solution trench and the drains should be constructed at the same time to reduce environmental impacts. This section of the return water pipelines should also preferably be constructed in this time period.
- RWD 2 will initially be sized to cater for 50% of the management requirements of tailings dam no. 5. As part of the design brief, allowance has to be made to be able to increase the size of this RWD 2, so that there is similar redundancy in the design to the penstock capacities.
- The final location of RWD 2 has not yet been determined, but it will be located to not impact the environmentally sensitive area located directly north of this RWD 2, also be keep outside of the small non-environmentally sensitive stream to the east. A zone of possible locations is shown in Figure 14-1. It is proposed to finally locate the RWD 2 in this zone considering all the known environmental impacts.

Figure 14-1: Proposed RWD 2 location



14.4 Stormwater Diversion

A stormwater system has been allowed for along the southern and north eastern flank of the tailings dam to divert clean run-off away from the tailings dam.

14.5 Return Water Dam

The return water dam extension will be lined with a multiple geomembrane system to reduce seepage. The liner system will include a leakage detection system to detect potential leaks in the primary liner.

14.6 Solution Trench and Silt Trap

Both the solution trench system and silt trap have been designed as concrete structures. The solution trench will be lined with concrete along its entire length. The twin compartment silt trap will also be lined with concrete to prevent seepage to the underground as the silt trap will be filled with silt and water on a continuous basis.

14.7 Dust pollution

On a tailings dam there are two areas where dust can be generated. These two areas are the top of the dam and the side slopes. The management measures for the top of the dam are different from the side slopes.

The most appropriate dust management system for the top of the dam is to keep as much of the beach wet as possible. This can be achieved by paying attention to the cycle times of tailings placement.

It is recommended that 60 to 80% of the beach on top of the dam be kept wet. This wet beach includes the pool area. The cycle time of the tailings placement has to be adjusted to ensure that 60 to 80% of the beach be kept wet at all times.

The most appropriate dust management system for the side slopes of the dam is to pay attention to the vegetation on these slopes. It is recommended that 80% of the side slope area be vegetated in terms of canopy cover. Part of this implication is that the vegetation establishment will have to be kept as close as possible to the top slopes of the dam, i.e. rising green wall concept.

The roads onto and around the tailings dam have to be maintained so that these are not a source of dust development. This will probably mean some form of application of dust suppressant and/or cover with durable gravel. The step in berms could also be capped with slag to reduce dust emanating from the tailings dam further and to protect the berms against erosion.

14.8 Silt transport

As a result of the flow of water over the tailings dam side slopes, some slimes and tailings will be transported to the paddock areas around the tailings dam. These paddock areas require cleaning of tailings when silting occurs. This can be addressed on an annual basis by the tailings dam Operator.

14.9 Tailings characteristics

The potential to increase the slurry density of the tailings material will also be investigated during the detailed design phase. This will result in less water being sent to the TSF as well as less evaporation losses and reduced seepage.

15 Risk Assessment

SRK carried out a risk assessment on the risk of the flow failure and the consequence of flow failure of the proposed Impala New TSF, this includes the existing tailings dam No. 4 and the planned tailings dam No. 5. A fault-event type analysis was adopted. The outcome of the risk assessment will determine whether any risk reduction measures are required and whether physical classifications could be reduced.

15.1 Background of Tailings Dam No. 4

15.1.1 Risk analysis

The probability of occurrence of various modes of failure was calculated at the time of the original design. The associated risk of a loss of life was determined to stand at 10-6 (1 in 1 million) or less. It is recommended that as the techniques in risk analysis are continually improving, the risks associated with the complex should be reviewed on a 5 yearly basis.

15.1.2 Dynamic stability

An investigation was carried out by SRK (Report 118228/61 of December 1993) regarding the stability of the tailings dam under dynamic loading. It was ascertained that the largest seismic event that can result from mining activity corresponds to magnitude 3.5 on the Modified Mercalli Scale (MMS). The maximum credible earthquake for the Rustenburg region has been estimated by the Department of Geological Survey to be magnitude 10 (MMS). Using the above information, a finite difference computer model was developed, for a 50m dam height. The results indicated that for a tailings dam height of 50m, a flow slide failure is very unlikely to occur. Further dynamic stability analyses will be carried out from time to time as deemed appropriate.

15.2 Tailings Dam No. 4 and 5

15.2.1 Fault-event trees

A system failure (e.g. Tailings Dam) is rarely a result of a single cause of failure. The failure is usually a result of a combination of failure events that causes the factor of safety of the system to reduce to below unity (1). A fault-event tree lays out a quantitative evaluation of the probabilities of various failure events leading to the calculation of initiating events which results in failure of the entire system. The objective of a fault tree is to identify and model the various system conditions that can result in the top fault (e.g. catastrophic failure of tailings dam).

In order to establish the correct logic that controls the failure of the system, the faults are not initially given probabilities of occurrence. In this form the fault tree is referred to as a "**cause tree**". When the "**cause tree**" is considered to best reflect the combinations of faults necessary to result in a failure, probabilities are either calculated or assigned to the faults. The probability evaluation within the fault tree are computed by means of **AND** or **OR** gates.

AND gates are used where faults are statistically dependent. If two basic faults, F1 and F2 are statistically dependant, then the probability of the occurrence is represented by;

p{primary fault} = p{F1}*p{F2}

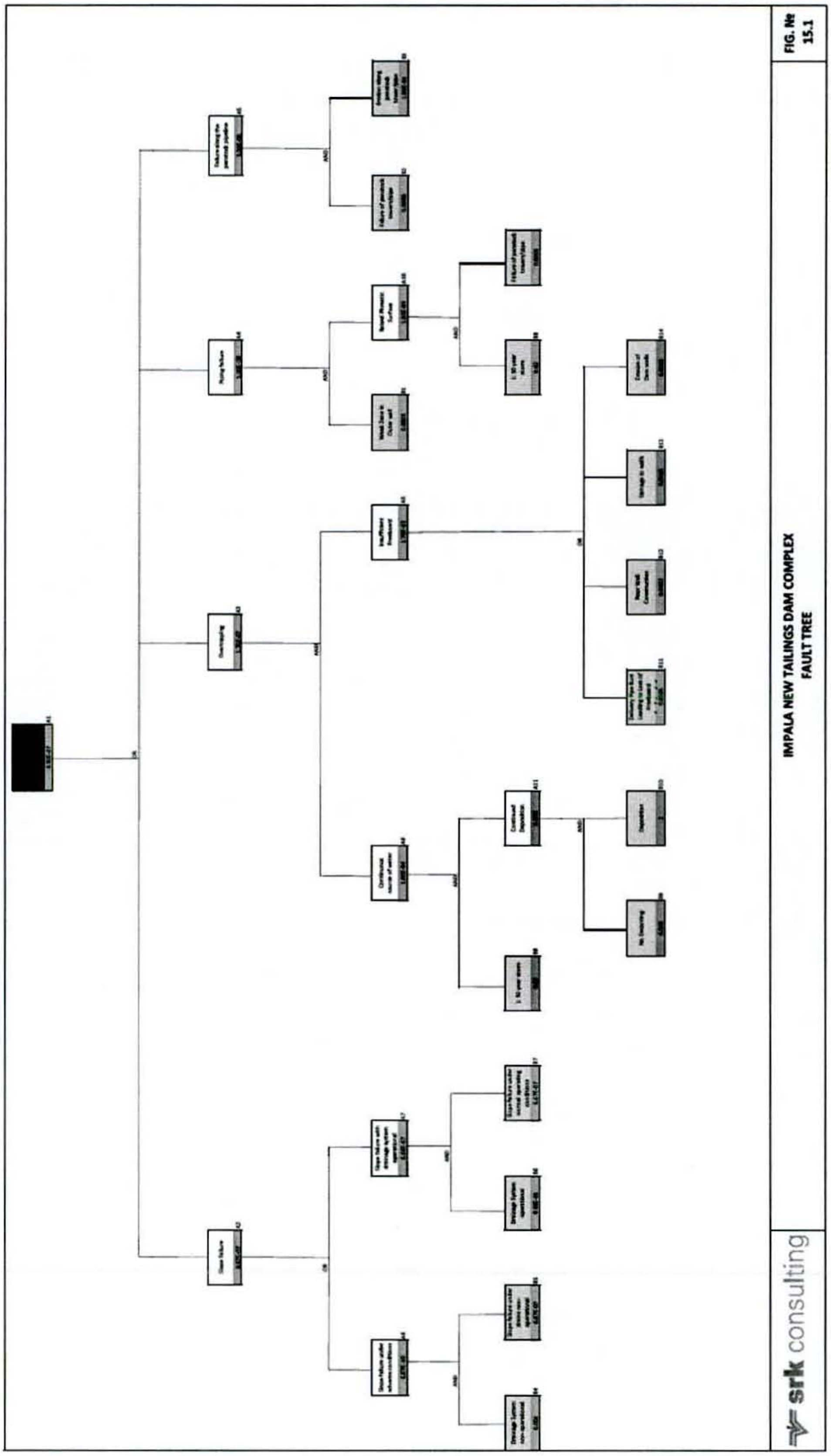
OR gates are used where faults are statistically independent. If two basic faults, F1 and F2 are statistically independent, then the probability of the occurrence is represented by;

P{primary fault} = 1 – (1-p{F1})*(1-p{F2})

Secondary faults that combine and lead to the primary faults are generally caused by one of the following; natural events (earthquakes, hails etc), adverse environmental conditions, operational stress (due to variation in production and human error) and inadequate maintenance.

The fault tree that has been developed for Impala New TSF is shown in Figure 15-1.

Figure 15-1: Fault Tree Analyses



15.2.2 Risk assessment

For a catastrophic flow failure to occur, the dam perimeter slope has to breach.

The two top faults, leading to the major fault are failure of the tailings dam and catastrophic flow of the failed material. In order to cause a catastrophe, both top faults need to occur and they are regarded as statistically dependent. The probability of tailings dam failure is dependent on the occurrence of four primary faults. Primary and secondary faults are summarized on Table 15-1 below:

The following primary faults which may lead to or initiate the failure of the Impala TSF Expansion were identified as:

- Overtopping (erosion failure)
- Slope failure
- Piping failure
- Failure along the penstock pipeline.

Table 15-1: The Primary and Secondary Faults Identified for Impala Tailings Dam

Primary fault	Secondary faults
Overtopping (erosion)	Overtopping occurs due to a continuous source of water and reduction in freeboard. Overtopping continues undetected.
Slope failure	Failure of the outer slope under design conditions (drains operational). Failure of the outer slope under adverse conditions (drains not operation and significant storm event occurs).
Piping failure	Assumes localised weak zone in the outer wall where piping will occur. Raised phreatic surface to trigger piping event.
Failure along the e penstock line	Assumes erosion of the tailings material to the outer wall occurs along the emergency penstock outfall pipelines

The approach adopted to undertake risk assessment is as follows:

Slope stability analyses have been completed at the proposed final height of the New TSF and the probability of slope failure was also analysed. The probability of failure was found to be low and is approximately 6.67×10^{-7} with the drainage system operational.

Fault-event trees have been developed to ascertain the probability of a large scale failure that will result in the release of tailings material. The fault trees were assigned probabilities based on the interpretation of available information and the results of the stability analysis.

15.2.3 Assigned Probabilities

Probabilities have been assigned to each of the faults using the available information or from SRK's experience with the design, operation, monitoring and maintenance of these types of facilities. The values are indicated in Cell (B1, B2, B3 etc). The assigned probabilities and reasoning for each initial fault are listed in

Table 15-2. The cells indicated by Cell (A2, A3, A4 etc) indicate the evaluation of the probabilities which is governed by the "AND" and "OR" gates.

Table 15-2: Assigned Probabilities for the Risk Analyses

Cell No	Assigned Probability	Description	Justification
B1	0.0005	Weak Zone in the outer wall	Regular monitoring and inspections makes weak Zone on the outer wall highly unlikely.
B2	0.0005	Failure of penstock towers/pipes	Failure of the concrete towers/pipes is a remote possibility if penstock rings are not stacked above 25 m height.
B3	0.0001	Erosion along penstock tower/pipe	Seepage paths along the penstock route are a remote possibility to cause erosion of material along the penstock outfall pipe.
B4	0.001	Drainage system non-operational	The probability of a failure of the drainage system is highly unlikely.
B5	0.000000667	Slope failure under drains non-operational	As per the stability analysis.
B6	0.99	Drainage system operation	The probability of the drainage system being operational is (1-p{failure}).
B7	0.0000000667	Slope failure under normal operating conditions	As per the stability analysis.
B8	0.02	1:50 year storm event	A 1: 50 year storm has a probability of 0.02 in occurring in any one year.
B9	0.005	No decanting	It is believed that the chances that decanting activities would not occur are very low.
B10	1.0	Deposition of slurry onto the dam	It is assumed that the risk analysis relates to the dam during active deposition activities and deposition is continuous.
B11	0.0005	Delivery pipe bust leading to loss of freeboard	Pipe breakages leading to erosion is generally not common. The severity of the erosion is a function of the location and configuration of the pipes.
B12	0.0002	Poor wall construction	Poor wall construction is unlikely due to high operational standards.
B13	0.0005	Damage to outer walls	Infrequent and easily repaired.
B14	0.0005	Erosion of dam walls	Easily identified and repaired through ongoing maintenance.

The assignment of probabilities indicated in

Table 15-2 above allows for the probability of a large scale failure that will results in the failure of the dam releasing tailings materials.

It is assumed that when the dam fails, the released material will liquefy and flow. This is an adverse situation whereby the failure would occurs during a storm event and the ground surface conditions over which the tailings will flow is saturated with water, hence the mobility of the tailings is increased due to low viscosity between the tailings and the natural ground.

15.2.4 Sensitivity analysis

A sensitivity analysis was carried out to identify the faults that have the most influence or are likely to contribute more on the probability of failure. A review of fault-event tree analysis showed that the main influential faults in degree of influence are as follows;

Faults B10 relates to the dam during active deposition activities and is a continuous process, hence it is definite that it will occur. Fault B6 relates to the probability of the drainages system being operational. Fault B1 relates to the probability of poor wall construction. This probability rates the supervision on site as wall construction is labour intensive. Fault B8 is a natural event which can happen at any time and cannot be changed through any management action.

Table 15-3: Probability of Occurrence for Contributing Faults

Fault №	**Description**	**Probability of occurrence**
Fault B10	Deposition	1
Fault B6	Drainage system operational	0.99
Fault B1	Weak zone in the outer wall	0.005
Fault B8	1: 50 year storm event	0.02
Fault B4	Drainage system non-operational	0.001

The probability of failure of the Impala New TSF is 8.92×10^{-7} (1: 1121627)

15.2.5 Property and loss of life

If a flow failure occurs the probability of significant damage to property within the zone of influence is a certainty. It must be noted that for the purpose of this investigation it is assumed that a failure of the tailings dam will result in a flow failure.

There are existing agricultural areas, infrastructure and natural stream located to the north west of the Impala Tailings Dam Complex. It is almost certain that a significant damage to this area (property) and possible loss of life will certainly result if a flow failure occurs.

The probability of damage and loss of life is therefore the product of:

Probability of large scale failure: 8.92×10^{-7}

Probability that the realised material will liquefy and flow: 1.00

Probability of damage: 1.00

The overall probability of large scale damage to property and possible loss of life within the zone of influence is therefore 8.92×10^{-7} (1: 1121627).

15.2.6 Comparison with the acceptable probabilities of failure

In order to ascertain the acceptability of the calculated probability of failure of the tailings dam, it is necessary to review what may be considered as acceptable levels of failure (risk) for similar structures under similar conditions. If this risk imposed by the Impala tailings dam complex is higher than what is generally considered acceptable then appropriate action should be taken to reduce the level of risk. It must be noted that a failure of the Impala tailings dam complex does constitute a significant risk to human life, other property (third party), residential areas and environmental impacts on the natural stream within the zone of influence.

Considerable effort has been undertaken by SRK to formulate a framework to determine acceptable levels of failure. The results of this work have been published in a paper "Review of norms for Probability and Risk in Engineering Design" authored by Dr HAD Kirsten (1995). The acceptable life time probabilities of total losses, according to Dr. H Kirsten (1995), vary between 1:15 000 "unlikely to occur" and 1:150 000 "very unlikely to occur".

The fault-event tree analysis for the failure of the Impala tailings complex was analysed and the probability of failure was found to be 8.92 x 10^{-7} (1: 1121627). When these probability is compared to published probability norms, (which are; maximum 6.66 x 10^{-5} and the lower range of 6.67 x 10^{-6} according Kirsten H (2005)), it was found that the probability of failure of Impala Tailings Dam Complex is within the acceptable range of unlikelihood.

There are properties within the Zone of Influence of Impala tailings dam complex. There is a high probability that there will be people within the Zone of Influence if a failure takes place.

HAD Kirsten has established that the acceptable lifetime probability for loss of life of the general population, not engaged in activities with high risk, is 7 x 10^{-5} (Table 6 contained in Kirsten paper). This degree of risk is considered practically impossible.

Using Table 9 contained in Kirsten's paper, it can be seen that the acceptable lifetime probability for loss of life resulting from a slope failure over a long term (40 year) period is 7 x 10^{-4}.

In comparison, the probability of a large scale failure of the Impala New TSF is 8.92 x 10^{-7}. This level of probability should therefore be acceptable as it less than what is considered practically impossible and measures to decrease this probability have therefore not been considered.

However, it is SRK's opinion that possible loss of life that could result from a large scale failure is not acceptable. It is generally not 'good practise' to position infrastructure directly downstream or in proximity to a tailings facility as the dam imposes an involuntary threat on those persons working or residing in the 'zone of influence'. Accordingly, mitigation measures are required to address the consequences of a flow failure. In this manner, the impacts can be managed to reduce the possibility of significant damage and loss of life. A key assumption of all of the above comments is that there will be suitable monitoring vigilance. If this is maintained, then the risks of problems arising will decrease dramatically.

16 Stability Assessment

16.1 Introduction

The objective of assessing the stability of the tailings dam extension was to determine the Factor of Safety (FOS) of the embankment under consideration. Failure of the wall would act as a trigger mechanism resulting in the potential release of large volumes of liquefied slimes and an ensuing flow failure.

The critical section through the tailings dam was analysed. The section reflects the tailings dam at final elevation (1154 m.a.m.s.l) 30 years after commissioning. The impact of possible future expansion on stability has not been evaluated. The positioning of the section is shown in Figure 16-1.

For each section, three different cases were considered:

- Ideal case: The curtain drain and toe drain is functioning to its full potential.
- Worst case: All drains have failed and seepage occurs at the crest of the earth embankment (Starter wall).

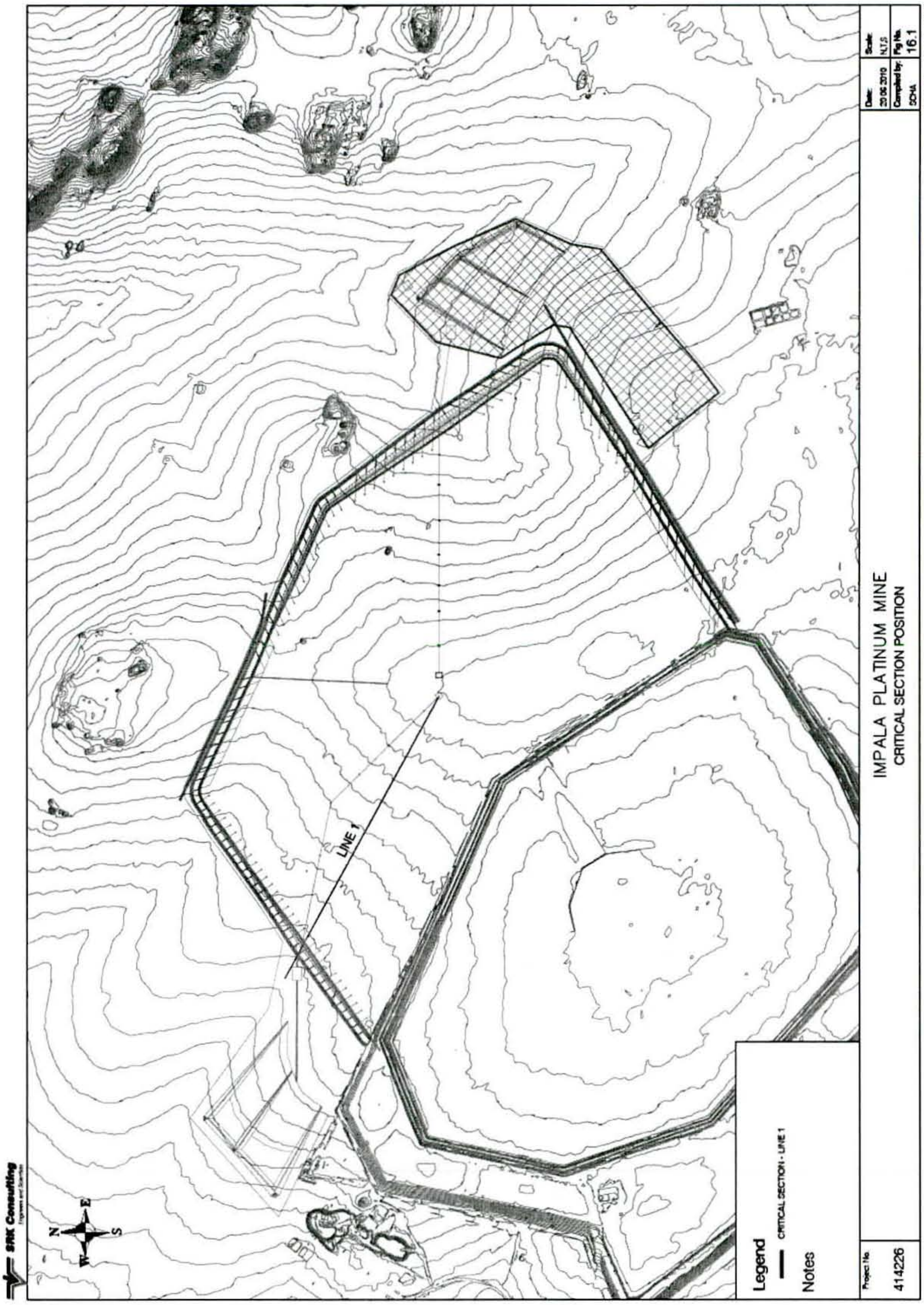
The stability analysis of the Impala tailings dam extension was carried out using a limit equilibrium slope stability software package, Roc Science Slide Version 5. The most critical section has been selected for the analysis as shown in Figure 16-1. SRK selected the soil parameters based on the geotechnical profiles and laboratory test work carried out during the mid life investigation. The material parameters used are summarised in Table 16-1.

The following aspects were taken into consideration and their overall effect on the long term slope stability of the facility.

- The material characteristic of the;
  - Tailings
  - Starter wall
  - Waste rock
  - Underlying foundation
- Selecting three of the most widely used methods of analysis, which are;
  - Bishop simplified
  - Janbu simplified
  - Janbu corrected

A seepage analyses will be undertaken during the next design phase to confirm the toe drain width and make an assessment of the change in phreatic surface within the tailings dam.

Figure 16-1 : Critical Section Through the Dam



16.2 Input Parameters

The foundation and tailings parameters used to determine the critical failure surfaces are given in Table 16-1.

Table 16-1 : Effective Strength Parameters for Stability Evaluation

	Unit Weight (kN/m^3)	Friction Angle (Degrees)	Cohesion (kN/m^2)	Permeability (m/sec)
Tailings Outer Wall	22.7	36	0	$K_s = 2e^{-7}$
Tailings Inner Wall	22	36	0	$K_s = 1e^{-7}$
Starter Wall	18	22	0	$K_s = 1e^{-9}$
Clay	18	22	0	$K_s = 1e^{-9}$
Weathered Rock	20	42	100	$K_s = 1e^{-7}$
Bedrock	26	45	500	$K_s = 1e^{-8}$

16.3 Results

For each section the results are shown in terms of the lowest factor of safety in Table 16-2.

Table 16-2 : Stability Analysis Results

Scenario	Factor of Safety (FoS)	
	Overall Slope	**Local Slope**
Long term – drains operational	2.173	1.503
Long term – drains not operational	1.887	0.846

16.4 Conclusions

All conditions and physical characteristics of the proposed dam are satisfactory and ensure high enough factors of safety against failure for the case of all drains operational. When all the drains are non-operational, the factor of safety against sloughing is 0.8 but the overall slope failure is just above the industry's accepted norm of 1.3. It is therefore important to maintain the overall slope at 1V:4H and to ensure that the curtain and toe drains are fully operational at all times.

17 Preliminary Closure Plan

The closure plan will be developed with suitable consultations with all stakeholders including the communities, stakeholders and authorities.

Planning towards closure, is a dynamic iterative process as a variety of internal and external influences, including political, social, economic and technical, impact on operations with the result that the Mine infrastructure as well as closure requirements may change a number of times during the operation.

It is essential that the rehabilitation of the tailings dam extension be an ongoing item in order to meet the requirements of the DME for closure. It is recommended that a formal vegetation and dust suppression programme be implemented. The closure costing needs to be assessed as part of a separate study as it is not part of the current brief.

18 Construction Phasing

In order to delay capital expenditure for the complex it is proposed that the impoundment be constructed in two phases. The timing of each phase is summarised below:

Phase 1: Construction of Tailings dam No.5 Phase 1 to commence 18 months before excess tonnes from Tailings dam No. 4 need to be deposited onto Tailings dam No. 5 Phase 1. Note that construction preparation work should commence 6 months before the start of construction.

	2011	2012	2012.5	2014	2022.5	2024	2028.5	2030	2037	2040
Existing TSF	Ongoing Deposition								De- Commission Tailings Dam	
Tailings dam No. 5 Phase 1			Start Construction	Commission Tailings dam	Ongoing Deposition					
Tailings dam No. 5 Phase 2					Start Construction	Commission Tailings dam	Ongoing Deposition			
Tailings dam No. 5							Start construction of Penstock towers	Consolidate Tailings Dam No. 5 Phases 1 and 2.		De- Commission Tailings Dam

Table 18-1: Tailings Dam Development Phasing

As part of the construction programme, timing of construction is of utmost importance. It is strongly recommended to start and finish construction in the dry cycle i.e. winter period, as rain delays can be substantial in wet periods.

19 Recommendations

The following should be attended to at the appropriate times:

- Issues that are likely to arise with respect to existing infrastructure:
  - Relocation of power lines.
  - Existing boreholes that need to be sealed.
  - The allocation of surface rights with regards to the section of tailings dam which falls outside of the mine boundary.
- The project progresses to the Detailed Design Phase.

20 Opportunities

During the upfront engineering study, certain aspects related to tailings disposal were identified as areas of opportunities that should be addressed as part of the detail design phase.

These opportunities and planned actions are listed below.

- The disposal of thickened tailings onto tailings dam No. 5 and the eventual consolidated dam is an option to reduce water consumption and improve the overall environmental integrity of the proposed tailings dam(s).

Prepared by

Aréte Schoeman

Technologist

Reviewed by

HAC Meintjes Pr Eng

Partner

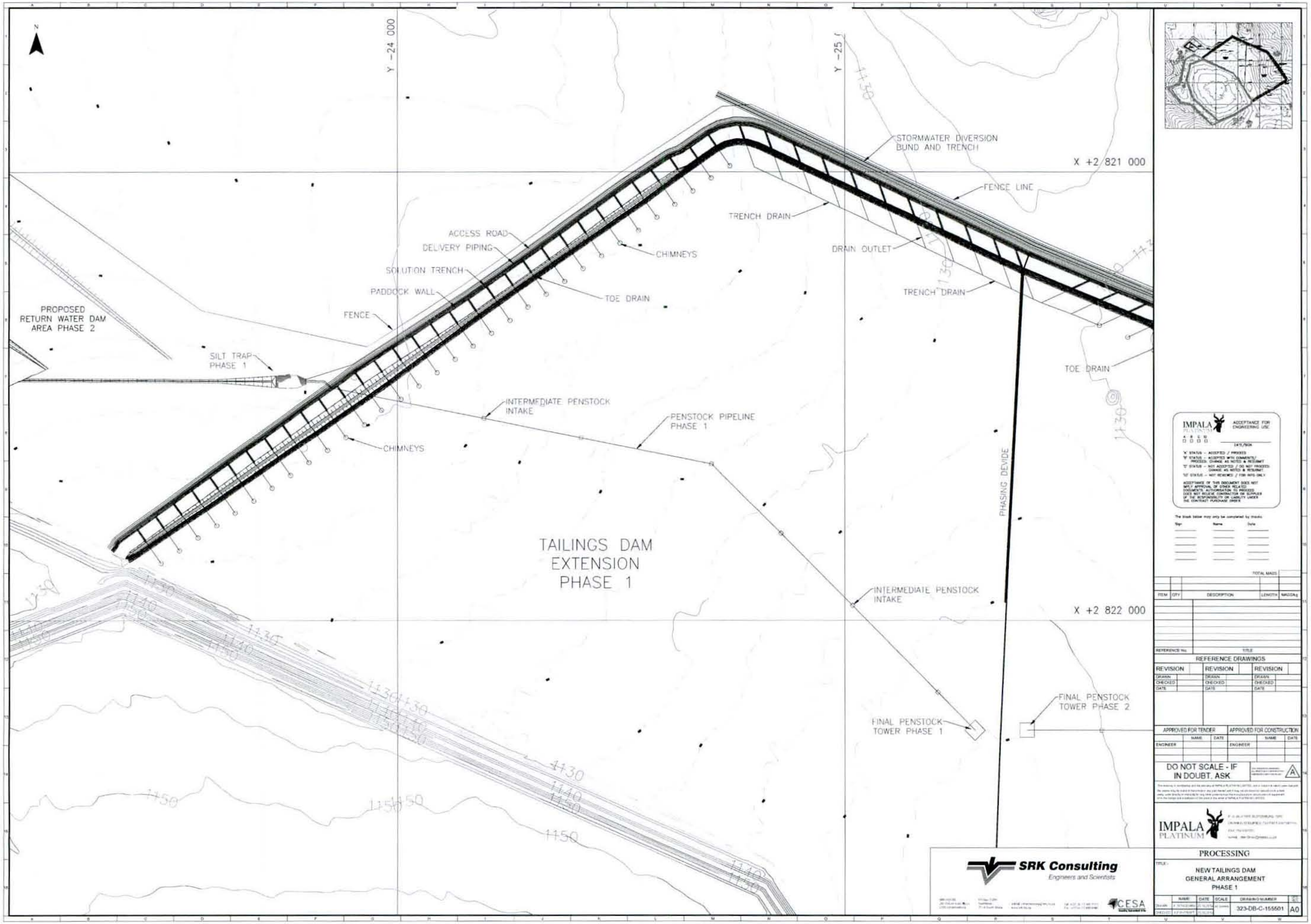
All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

21 References

- Impala Midlife investigation report, SRK Report no. 369694/1 and /2.
- Report on the potential impacts of removing chrome from the UG2 tailings stream on the tailings dam at Marula Platinum mine. SRK Report No. 412074/1
- Pre-feasibility Design Report for the New Tailings Disposal Facility at Impala Platinum Mine, Rustenburg, SRK Report 414226/2, April 2011

Appendices

Appendix 1 Upfront Engineering Drawings



Y -24 000
Y -25 000
X +2 821 000
X +2 822 000
STORMWATER DIVERSION BUND AND TRENCH
FENCE LINE
TRENCH DRAIN
DRAIN OUTLET
TRENCH DRAIN
TOE DRAIN
ACCESS ROAD
DELIVERY PIPING
SOLUTION TRENCH
PADDOCK WALL
FENCE
CHIMNEYS
TOE DRAIN
PROPOSED RETURN WATER DAM AREA PHASE 2
SILT TRAP PHASE 1
INTERMEDIATE PENSTOCK INTAKE
PENSTOCK PIPELINE PHASE 1
CHIMNEYS
PHASING DEVIDE
TAILINGS DAM EXTENSION PHASE 1
INTERMEDIATE PENSTOCK INTAKE
FINAL PENSTOCK TOWER PHASE 2
FINAL PENSTOCK TOWER PHASE 1
1130
1140
1150
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APPROVED FOR CONSTRUCTION
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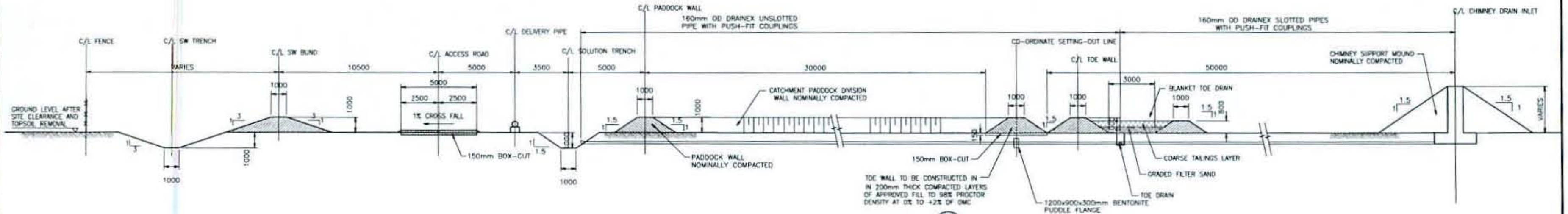
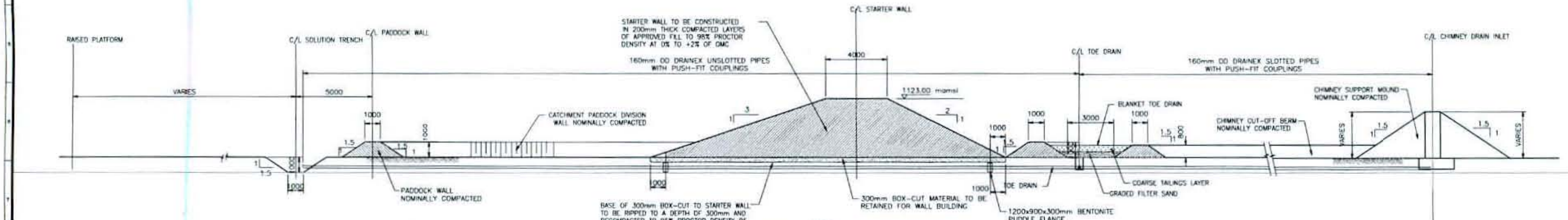
GENERAL ARRANGEMENT
PHASE 1
DRAWING NUMBER
323-DB-C-155501
A0



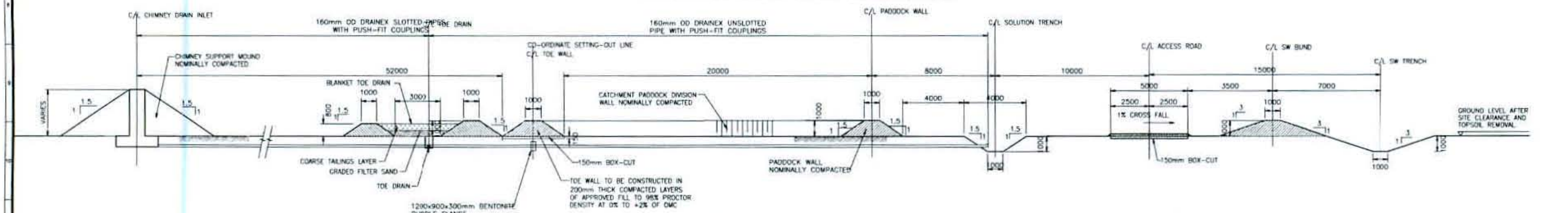
SECTION A
SCALE 1:100 101

TYPICAL SECTION THROUGH TAILINGS DAM WITH TOE WALL AT 1m HEIGHT



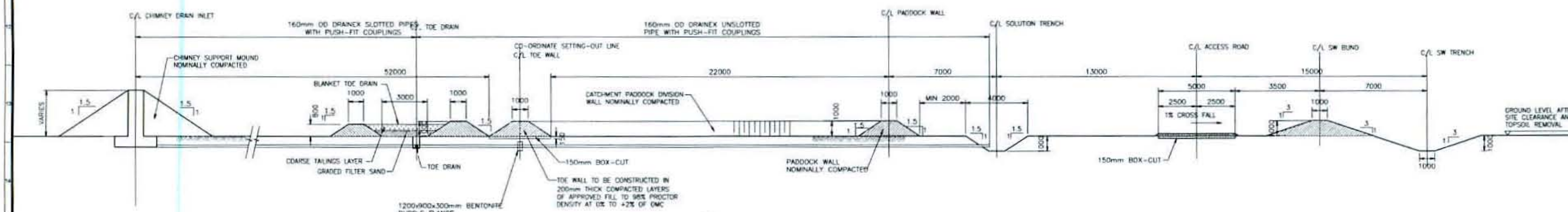
SECTION B
SCALE 1:100 101

TYPICAL SECTION THROUGH TAILINGS DAM STARTER WALL



SECTION C
SCALE 1:100 101

TYPICAL SECTION THROUGH TAILINGS DAM WITH TOE WALL AT 1m HEIGHT



SECTION D
SCALE 1:100 101

TYPICAL SECTION THROUGH TAILINGS DAM WITH TOE WALL AT 1m HEIGHT

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ITEM	QTY	DESCRIPTION	LENGTH	MASS/kg
			TOTAL MASS	

REFERENCE No.	TITLE
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NEW TAILINGS DAM
PHASE 1 EARTHWORKS
TYPICAL SECTIONS & DETAILS SHEET 1 OF 2

DRAWING NUMBER: 323-DB-C-155502 A0

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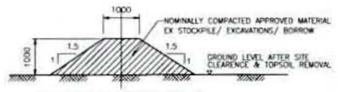
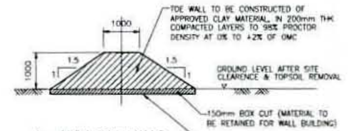


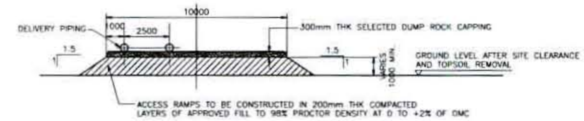
1m HIGH PADDOCK WALLS

SCALE 1:50



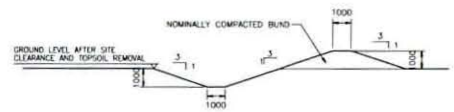
1m HIGH TOE WALLS

SCALE 1:50



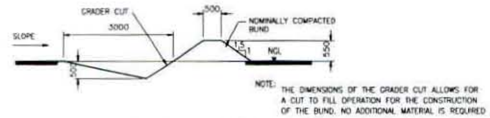
TYPICAL SECTION THROUGH ACCESS RAMPS

SCALE 1:100



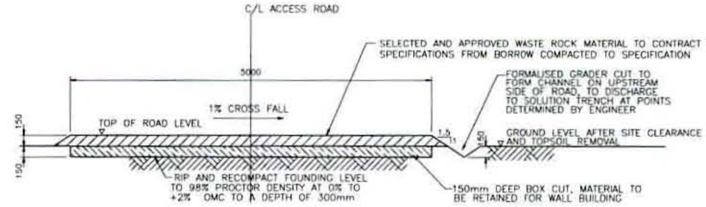
TYPICAL DETAIL OF STORMWATER TRENCH & BUND

SCALE 1:100



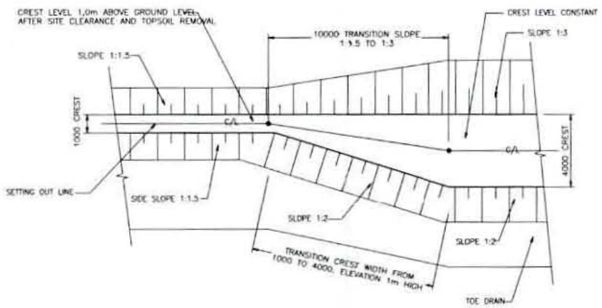
TYPICAL SECTION THROUGH GRADER CUT
STORMWATER TRENCH AND CONTROL BUNDS

SCALE 1:50



SECTION THROUGH ACCESS ROAD

SCALE 1:25



TYPICAL DETAIL OF STARTER WALL TO TOE WALL TRANSITION

SCALE 1:100

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PHASE 1 EARTHWORKS
TYPICAL SECTIONS & DETAILS SHEET 2 OF 2

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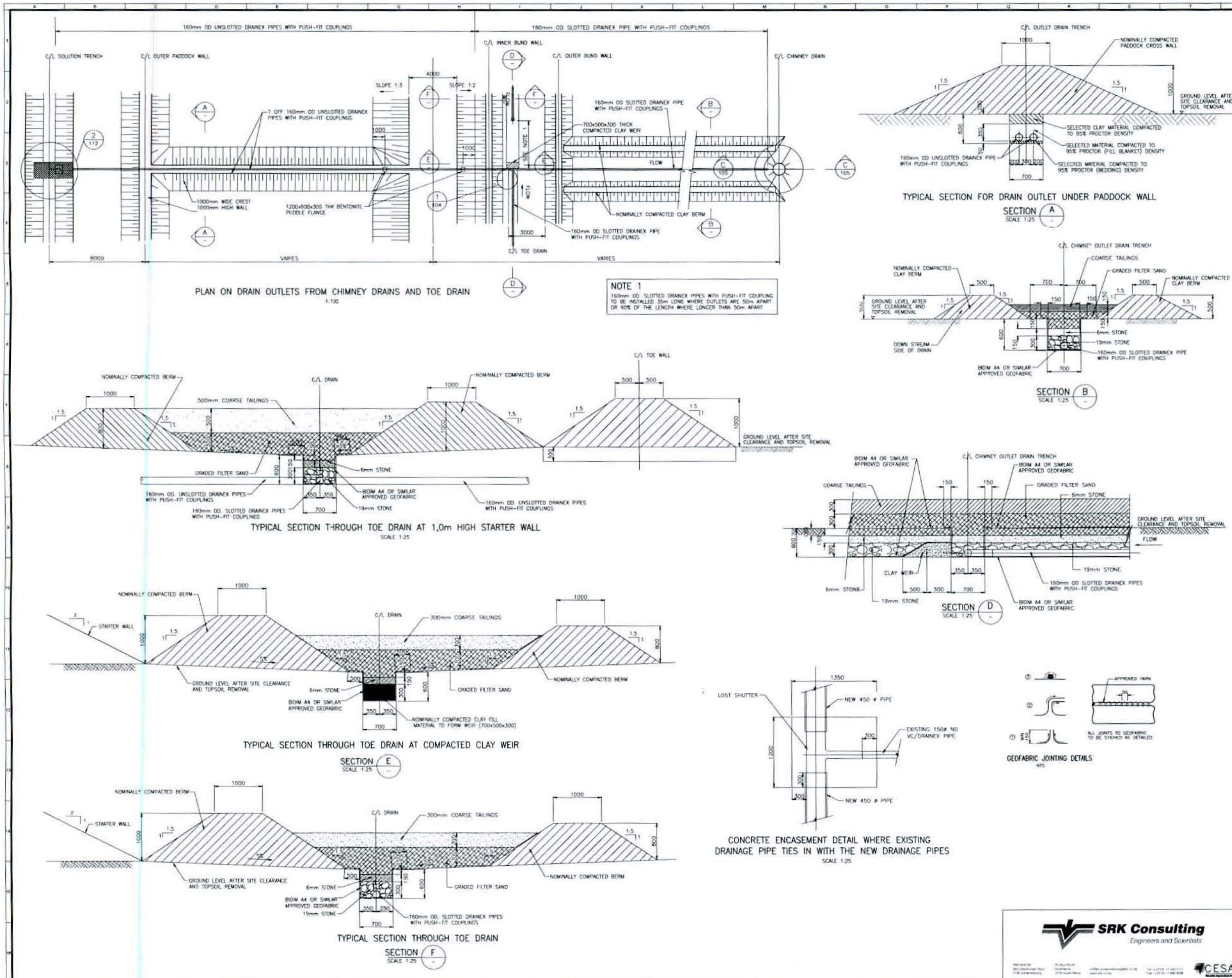

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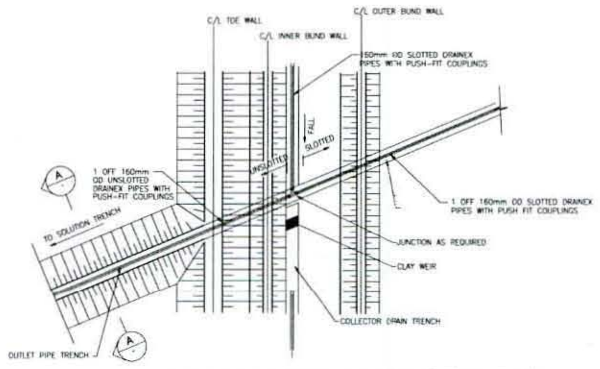
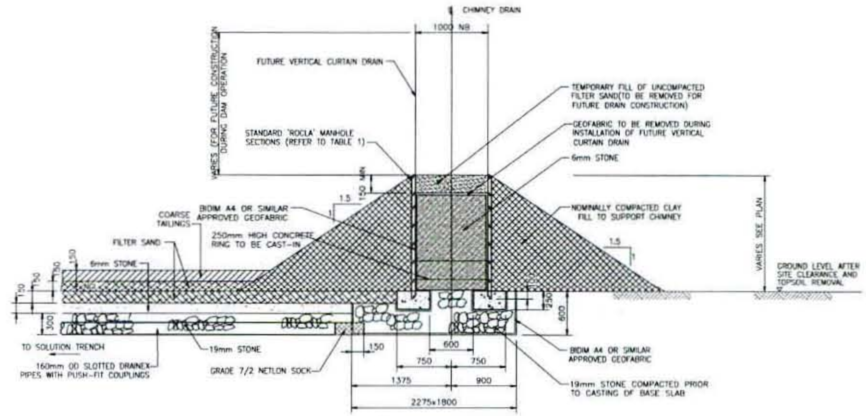


TYPICAL PLAN ON TRENCH DRAIN DETAIL (SAND REMOVED)
SCALE 1:100

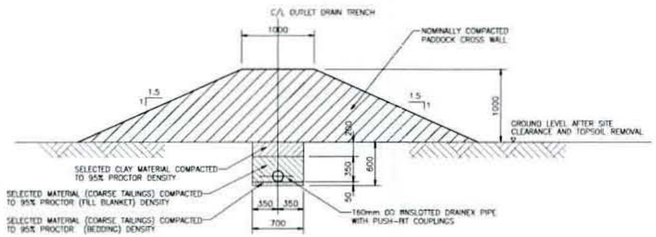


SECTION C
SCALE 1:25 104

CHIMNEY DRAIN

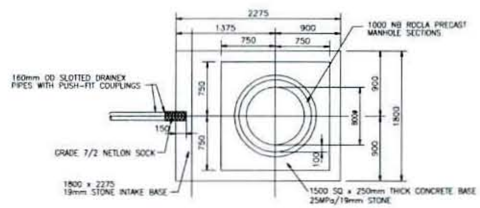
TABLE 1: CHIMNEY SECTION DETAILS

CHIMNEY HEIGHTS (WALL HEIGHT = 968m MAX.CH HEIGHT = 3m)						
CH No.	HEIGHT	G.L.	TOP OF CHIMNEY	0,25m	0,50m	1,00m
CH1	3.00m	962.65	965.65	2	1	2
CH2	3.00m	962.75	965.75	2	1	2
CH3	3.00m	962.85	965.85	2	1	2
CH4	3.00m	962.90	965.90	2	1	2
CH5	3.00m	963.00	966.00	2	1	2
CH6	3.00m	963.20	966.20	2	1	2
CH7	3.00m	963.35	966.35	2	1	2
CH8	3.00m	963.70	966.70	2	1	2
CH9	3.00m	964.20	967.20	2	1	2
CH10	3.00m	964.55	967.55	2	1	2
CH11	3.00m	964.95	967.95	2	1	2
CH12	2.50m	965.40	967.90	2		2
CH13	2.00m	965.80	967.80	2	1	1
CH14	1.50m	966.20	967.70	2		1
CH15	1.50m	966.40	967.90	2		1
CH16–CH29	1.25m	966.60	967.85	14		14
			TOTAL	44	12	41

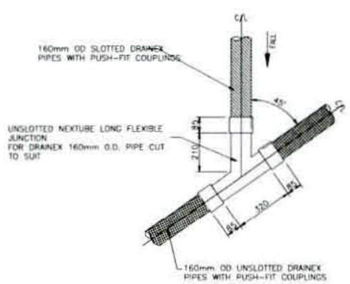


SECTION A
SCALE 1:25

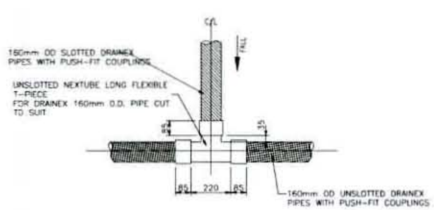
TYPICAL SECTION THROUGH PADDOCK CROSS WALL



TYPICAL PLAN ON CHIMNEY DRAIN BASE (No. 3B CH1 to 3B CH000)
SCALE 1:25



PLAN OF TYPICAL DRAIN OUTLET CONNECTION



PLAN OF TYPICAL DRAIN OUTLET CONNECTION 90°

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PHASE 1
CHIMNEY DRAIN DETAILS

	NAME	DATE	SCALE	DRAWING NUMBER	
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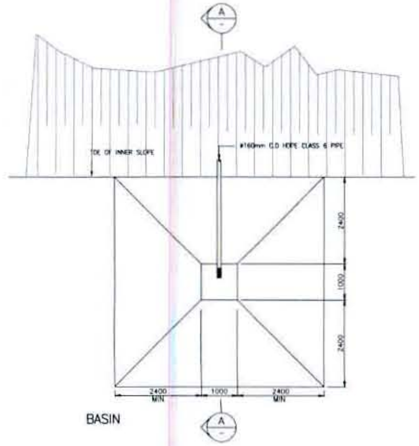
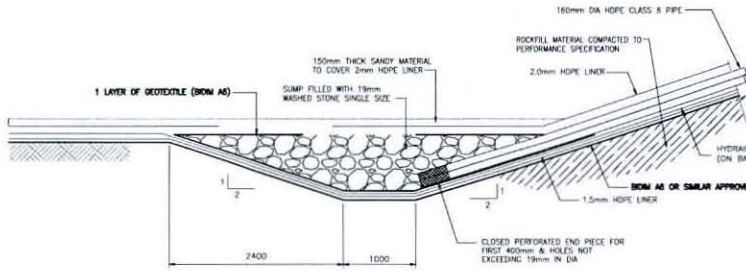
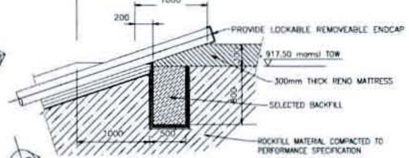


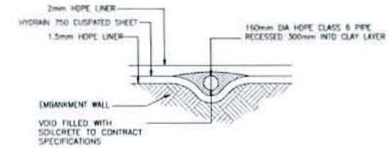
PLAN ON LEAKAGE DETECTION SUMP
SCALE 1:50



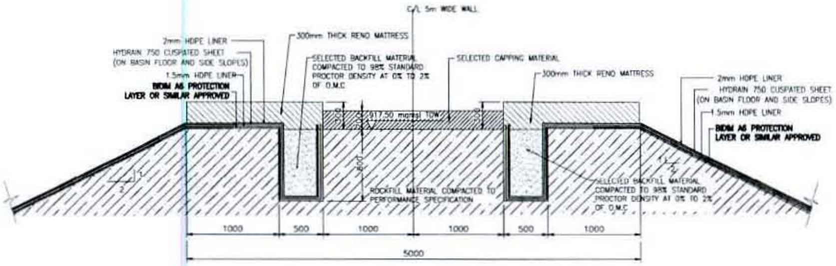
SECTION A–A
DETAIL OF LEAKAGE DETECTION SUMP
SCALE 1:25



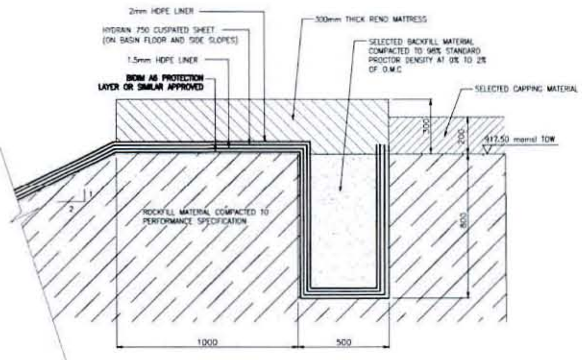
CREST DETAIL OF LEAKAGE DETECTION PIPE



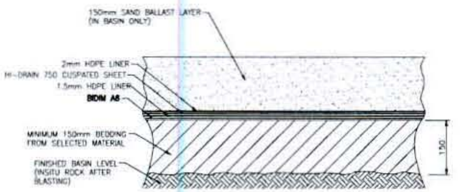
SECTION C–C
SCALE 1:25



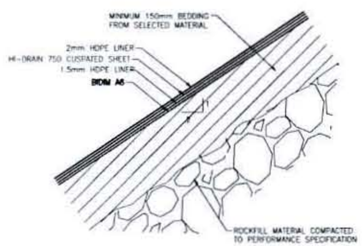
TYPICAL ANCHOR TRENCH DETAIL ON DIVISION WALL WITH 5m CREST
SCALE 1:20



TYPICAL ANCHOR TRENCH DETAIL ON OUTER WALLS
SCALE 1:10



LINER DETAIL–BASIN
SCALE 1:5



LINER DETAIL–SLOPES
SCALE 1:5

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ITEM	QTY	DESCRIPTION	LENGTH	MASS/kg
			TOTAL MASS	

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	REFERENCE DRAWINGS

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DRAWN		DRAWN		DRAWN	
CHECKED		CHECKED		CHECKED	
DATE		DATE		DATE	

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TITLE: NEW RETURN WATER DAM
PHASE 1
LINER DETAILS

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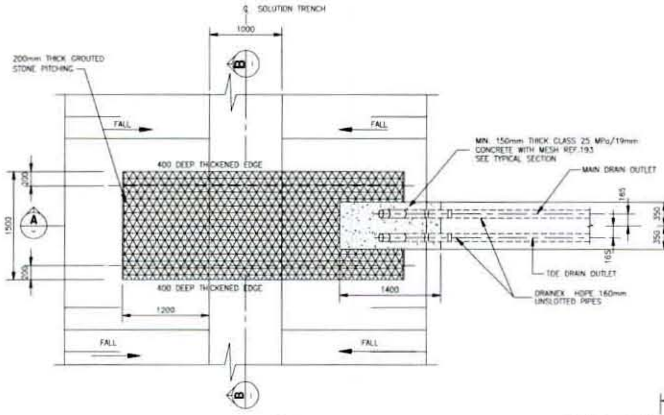
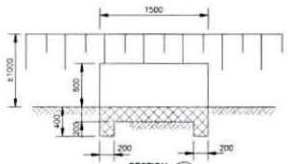
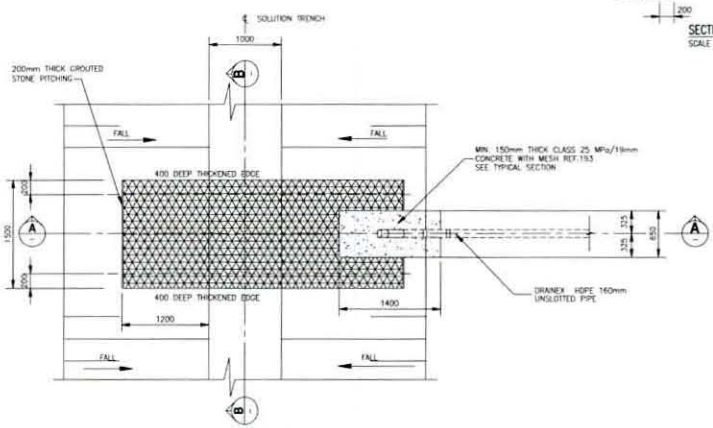


DETAIL 3 SCALE 1:25 104

PLAN ON DOUBLE DRAIN OUTLETS INTO SOLUTION TRENCH

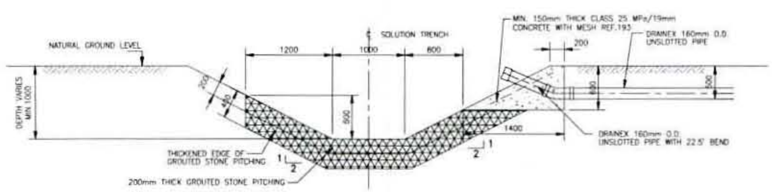


SECTION B SCALE 1:25



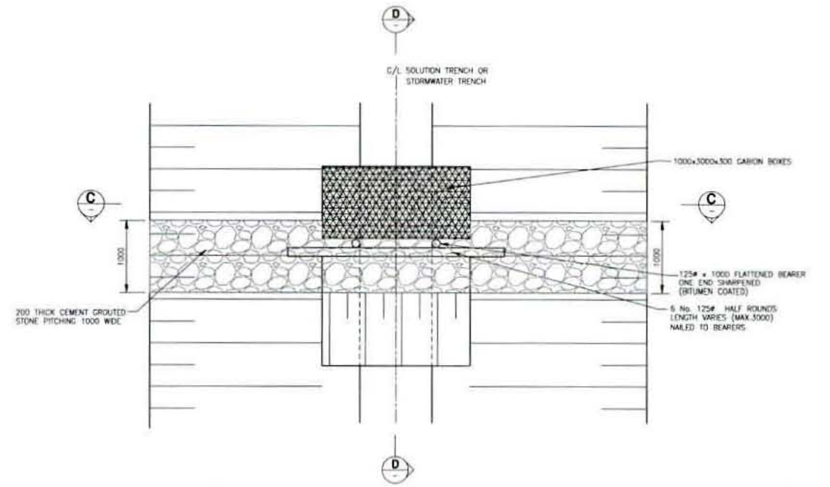
DETAIL 3 SCALE 1:25 104

PLAN ON SINGLE DRAIN OUTLET INTO SOLUTION TRENCH



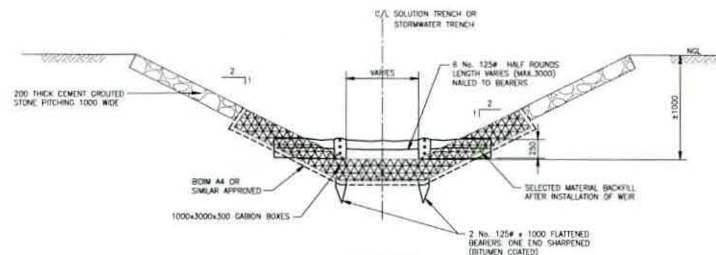
TYPICAL SECTION THROUGH DRAIN OUTLETS INTO SOLUTION TRENCH

SECTION A SCALE 1:25

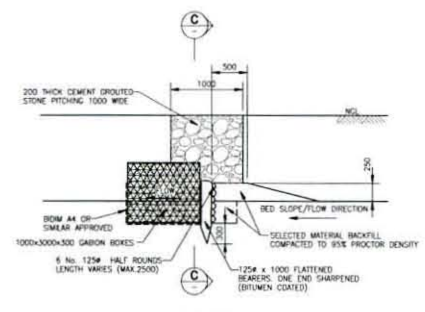


PLAN OF EROSION PROTECTION AT WEIR AND OUTLET PIPE

SCALE 1:25



SECTION C SCALE 1:25



SECTION D SCALE 1:25

IMPALA PLATINUM — ACCEPTANCE FOR ENGINEERING USE

"A" STATUS – ACCEPTED / PROCEED
"B" STATUS – ACCEPTED WITH COMMENTS/ PROCEED. CHANGE AS NOTED & RESUBMIT
"C" STATUS – NOT ACCEPTED / DO NOT PROCEED CHANGE AS NOTED & RESUBMIT
"D" STATUS – NOT REVIEWED / FOR INFO ONLY

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CHECKED		CHECKED		CHECKED	
DATE		DATE		DATE	

APPROVED FOR TENDER	NAME	DATE	APPROVED FOR CONSTRUCTION	NAME	DATE
ENGINEER			ENGINEER		

DO NOT SCALE - IF IN DOUBT, ASK

IMPALA PLATINUM

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PROCESSING

TITLE:-
NEW TAILINGS DAM
PHASE 1
DRAINAGE DETAILS SHEET 2 OF 2

	NAME	DATE	SCALE	DRAWING NUMBER	
DRAWN				323-DB-C-155505	A0
CHECKED					

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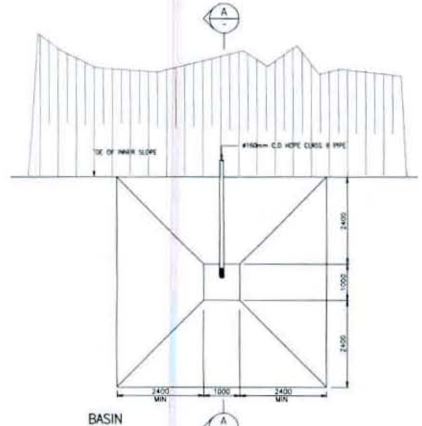
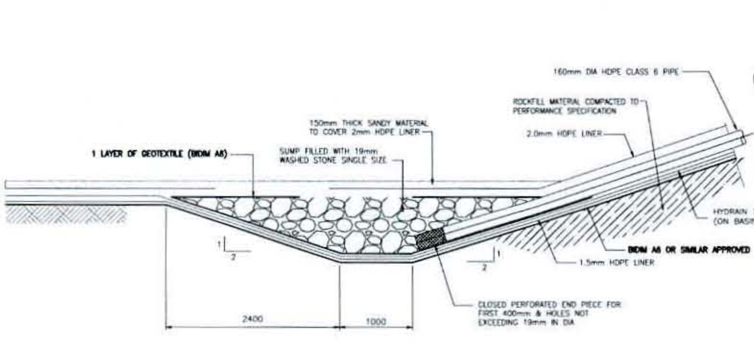


BASIN

PLAN ON LEAKAGE DETECTION SUMP
SCALE 1:50



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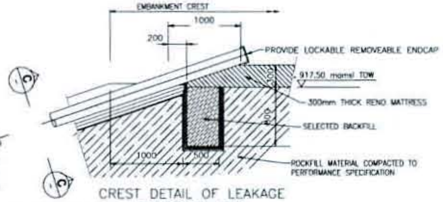
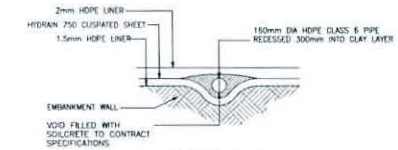
DETAIL OF LEAKAGE DETECTION SUMP
SCALE 1:25



CREST DETAIL OF LEAKAGE DETECTION PIPE



SECTION C-C
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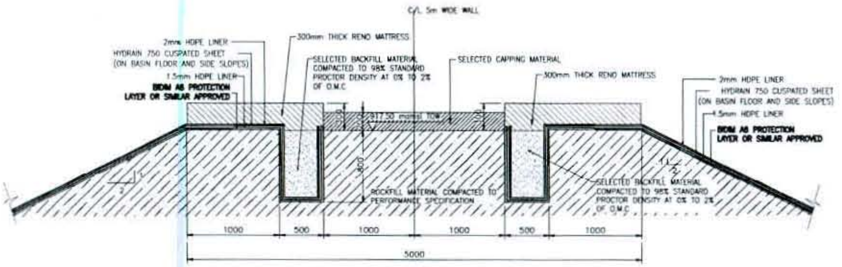
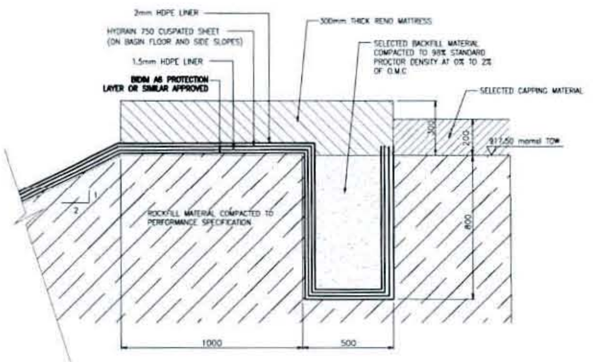
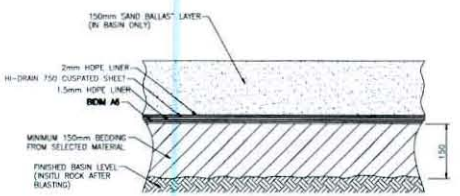


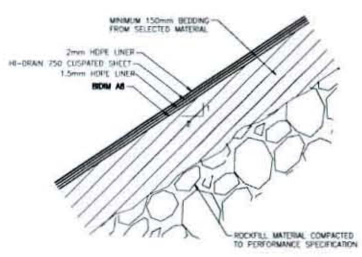
TYPICAL ANCHOR TRENCH DETAIL ON DIVISION WALL WITH 5m CREST
SCALE 1:20



TYPICAL ANCHOR TRENCH DETAIL ON OUTER WALLS
SCALE 1:10



LINER DETAIL-BASIN
SCALE 1:5



LINER DETAIL-SLOPES
SCALE 1:5

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The block below may only be completed by Impala

Sign	Name	Date

TOTAL MASS

ITEM	QTY	DESCRIPTION	LENGTH	MASS Kg

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CHECKED		CHECKED		CHECKED	
DATE		DATE		DATE	

APPROVED FOR TENDER	NAME	DATE	APPROVED FOR CONSTRUCTION	NAME	DATE
ENGINEER			ENGINEER		

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IMPALA PLATINUM

PROCESSING

TITLE:- NEW RETURN WATER DAM
PHASE 1
LINER DETAILS

	NAME	DATE	SCALE	DRAWING NUMBER	
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CHECKED					

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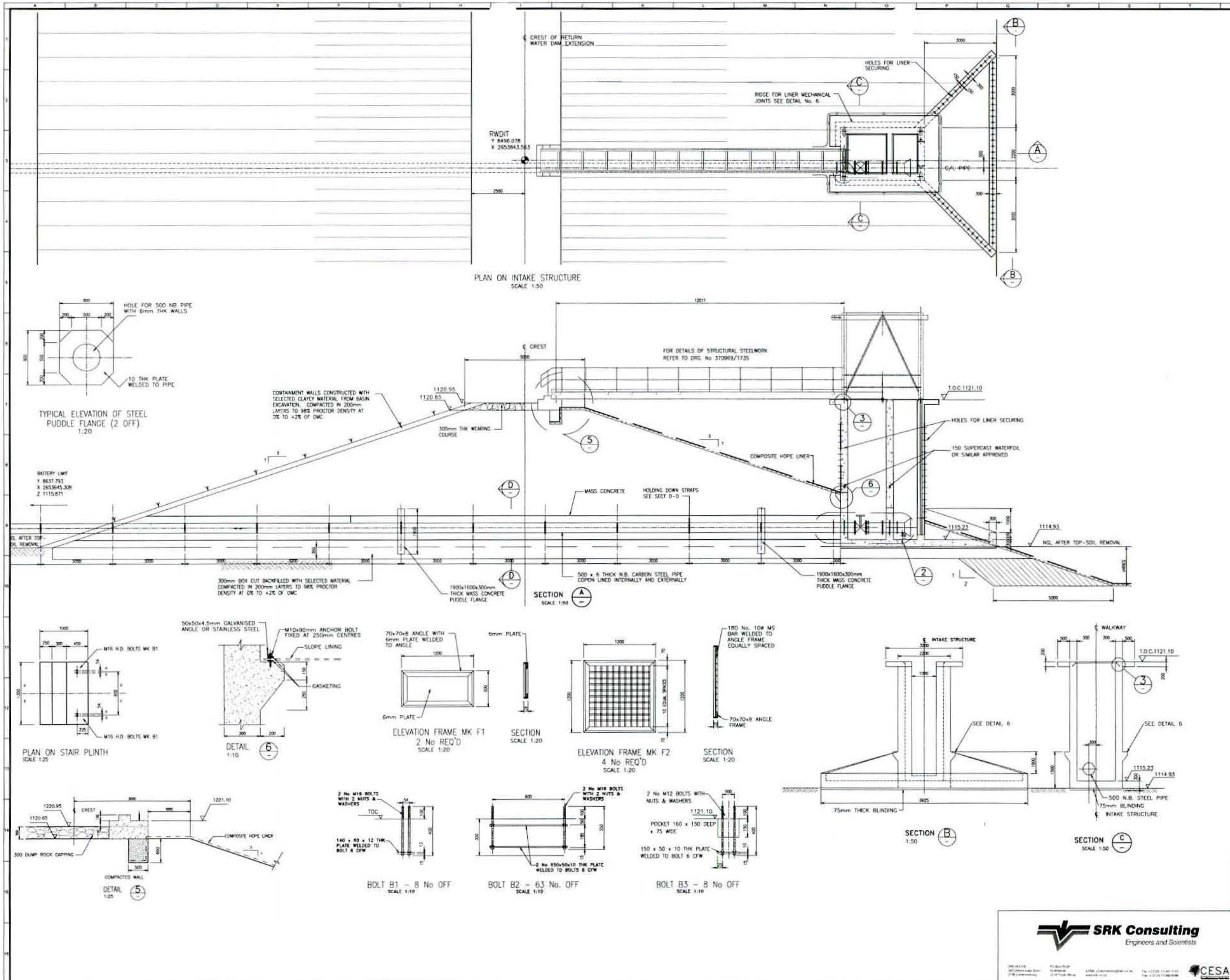

IMPALA PLATINUM — ACCEPTANCE FOR ENGINEERING USE

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ITEM	QTY	DESCRIPTION	LENGTH	MASS Kg

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CHECKED	CHECKED	CHECKED
DATE	DATE	DATE

APPROVED FOR TENDER			APPROVED FOR CONSTRUCTION		
	NAME	DATE		NAME	DATE
ENGINEER			ENGINEER		

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IMPALA PLATINUM

PROCESSING

TITLE:
RETURN WATER DAM
SECTION AND DETAILS
PHASE 1

NAME	DATE	SCALE	DRAWING NUMBER	
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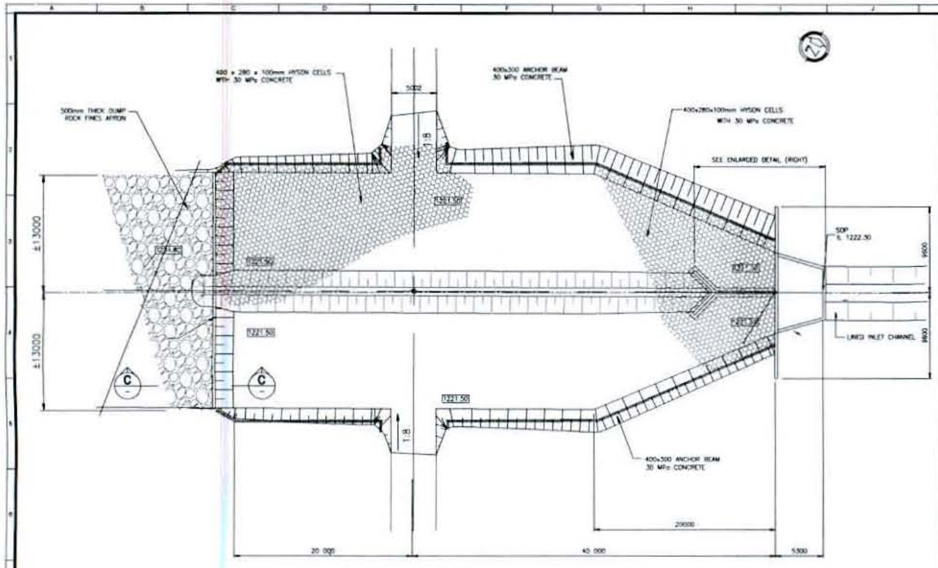
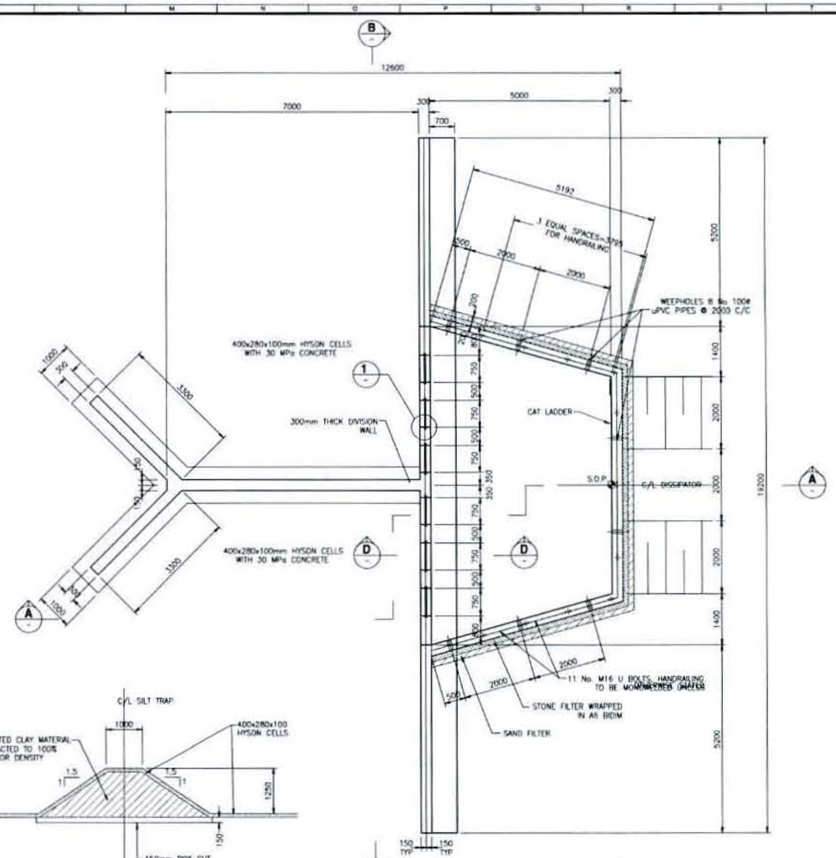


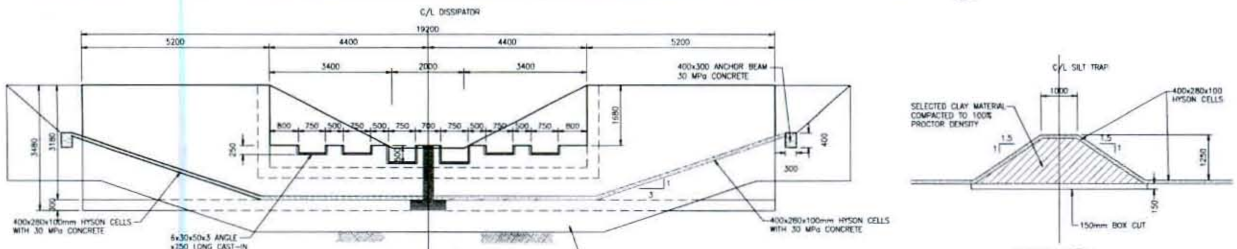
LAYOUT OF SILT TRAP

SCALE 1:200



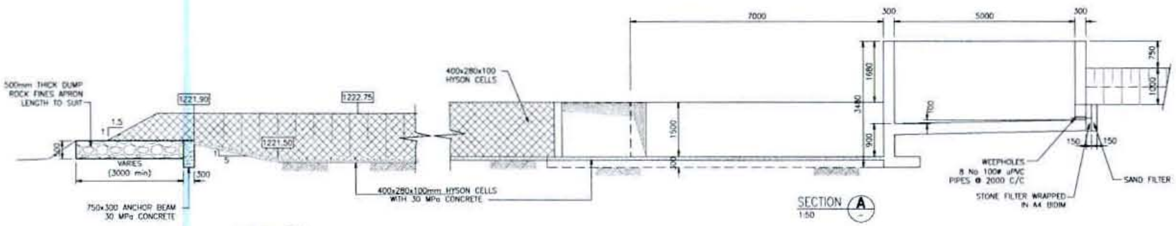
ENLARGED DETAIL AT SILT TRAP INLET

SCALE 1:50



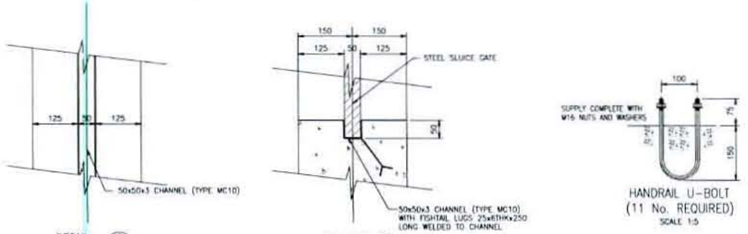
SECTION B 1:50

SECTION E 1:50



SECTION C 1:50

SECTION A 1:50



DETAIL 1 1:5

SECTION D 1:5

HANDRAIL U-BOLT (11 No. REQUIRED) SCALE 1:5

GENERAL NOTES:

ALL CONCRETE WORK TO CONFORM TO THE FOLLOWING – (U.O.N.)

1. ALL CONSTRUCTION WORK TO BE CARRIED OUT IN ACCORDANCE WITH THE CONTRACT SPECIFICATION.
2. ALL DIMENSIONS AND LEVELS TO BE CHECKED BY THE CONTRACTOR ON SITE PRIOR TO COMMENCEMENT OF ANY WORK.THE ENGINEER TO BE INFORMED OF ANY DISCREPANCIES.
3. SETTING OUT SHALL BE CHECKED BY THE SURVEYOR.SHOULD THERE BE ANY SIGNIFICANT DISCREPANCIES, THESE ARE TO BE BROUGHT TO THE ATTENTION OF THE ENGINEER OR HIS REPRESENTATIVE ON SITE.
4. THE SOIL AT FOUNDATION LEVEL MUST BE COMPACTED TO 95% Mod.AASHTO, TESTED AND INSPECTED BY THE ENGINEER BEFORE PLACING THE BLINDING CONCRETE.
5. MIN. CUBE CRUSHING STRENGTH OF CONCRETE TO BE 30 MPa/19 mm AT 28 DAYS.
6. 50mm BLINDING (15 MPa/19 mm) UNDER ALL FOUNDATIONS. U.O.N.
7. ALL FOUNDATION EXCAVATIONS TO BE INSPECTED BY ENGINEER – PRIOR TO CASTING OF BLINDING AND TO BE KEPT DRY AT ALL TIMES.
8. ALL EXPOSED EDGES TO HAVE A 25 x 25 CHAMFER. (U.O.N.)
9. CONCRETE COVER – 50 mm (U.O.N)
10. REINFORCEMENT :
    - SEE BENDING SCHEDULES.
    - R = ROUND MILD STEEL, YIELD STRENGTH 250 MPa.
    - Y = DEFORMED HIGH TENSILE STEEL, YIELD STRENGTH 450MPa.
11. ENGINEER'S INSPECTION:
    - ALL REINFORCEMENT TO BE INSPECTED AND APPROVED BY ENGINEER PRIOR TO CASTING CONCRETE.
12. COMPACTION OF CONCRETE :
    - BY MEANS OF MECHANICAL VIBRATORS ONLY.

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ITEM	QTY	DESCRIPTION	LENGTH	MASS/kg
			TOTAL MASS	

REFERENCE DRAWINGS

REFERENCE No.	TITLE

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DRAWN	DRAWN	DRAWN
CHECKED	CHECKED	CHECKED
DATE	DATE	DATE

APPROVED FOR TENDER	NAME	DATE	APPROVED FOR CONSTRUCTION	NAME	DATE
ENGINEER			ENGINEER		

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IMPALA PLATINUM

PROCESSING

TITLE :
NEW TAILINGS DAM
PHASE 1
SILT TRAP CONCRETE DETAILS

	NAME	DATE	SCALE	DRAWING NUMBER	
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CHECKED					

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Appendix 2 Stability Analysis Output Sheets

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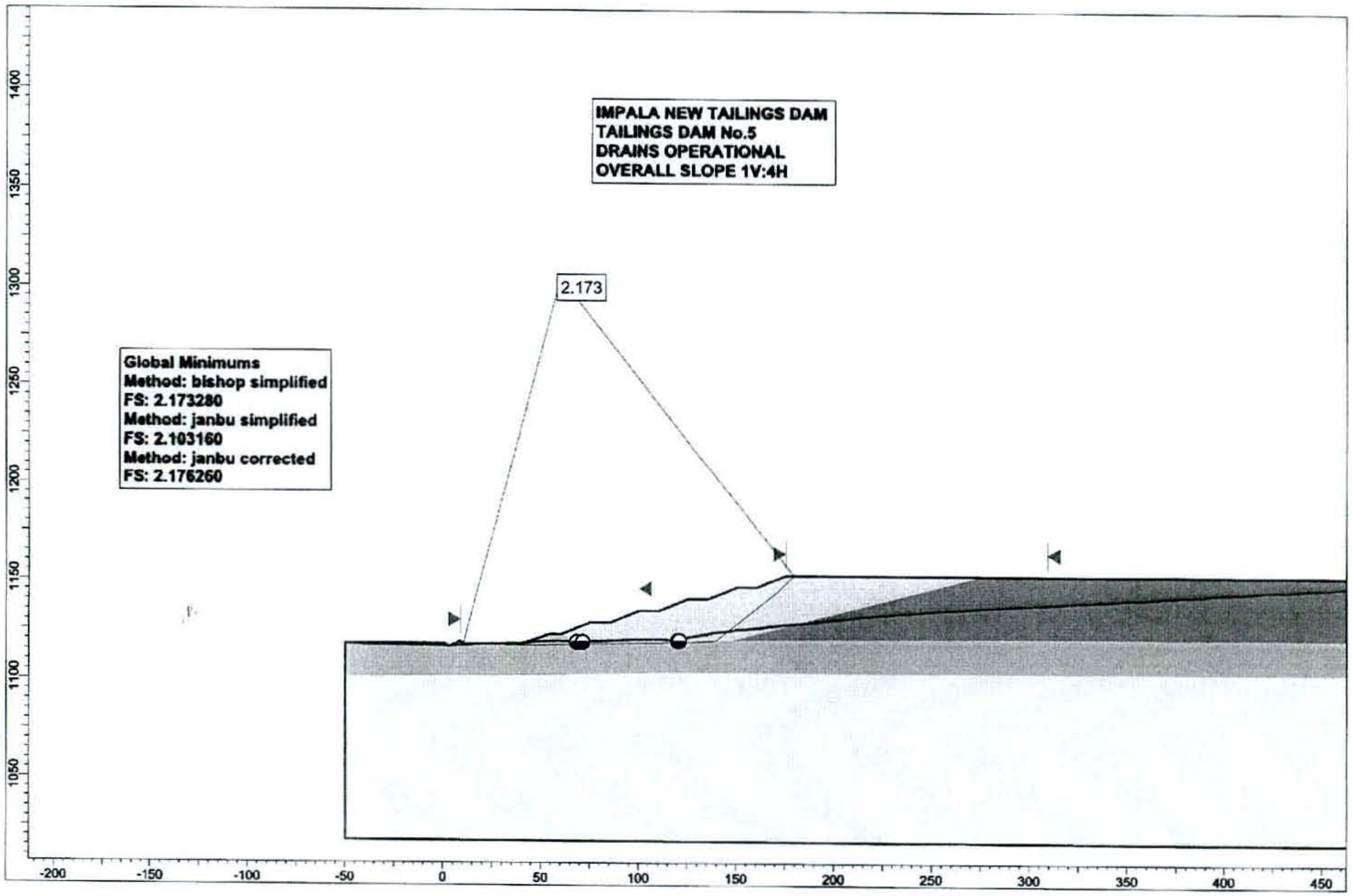

Project No.		Date:	Scale:
	IMPALA PLATINUM MINE	10 01 2011	NTS
414226	STABILITY ASSESSMENT - OVERALL SLOPE	Compiled by: SCHA	Fig No. 2-a

Revision: A Date: 10 01 2011

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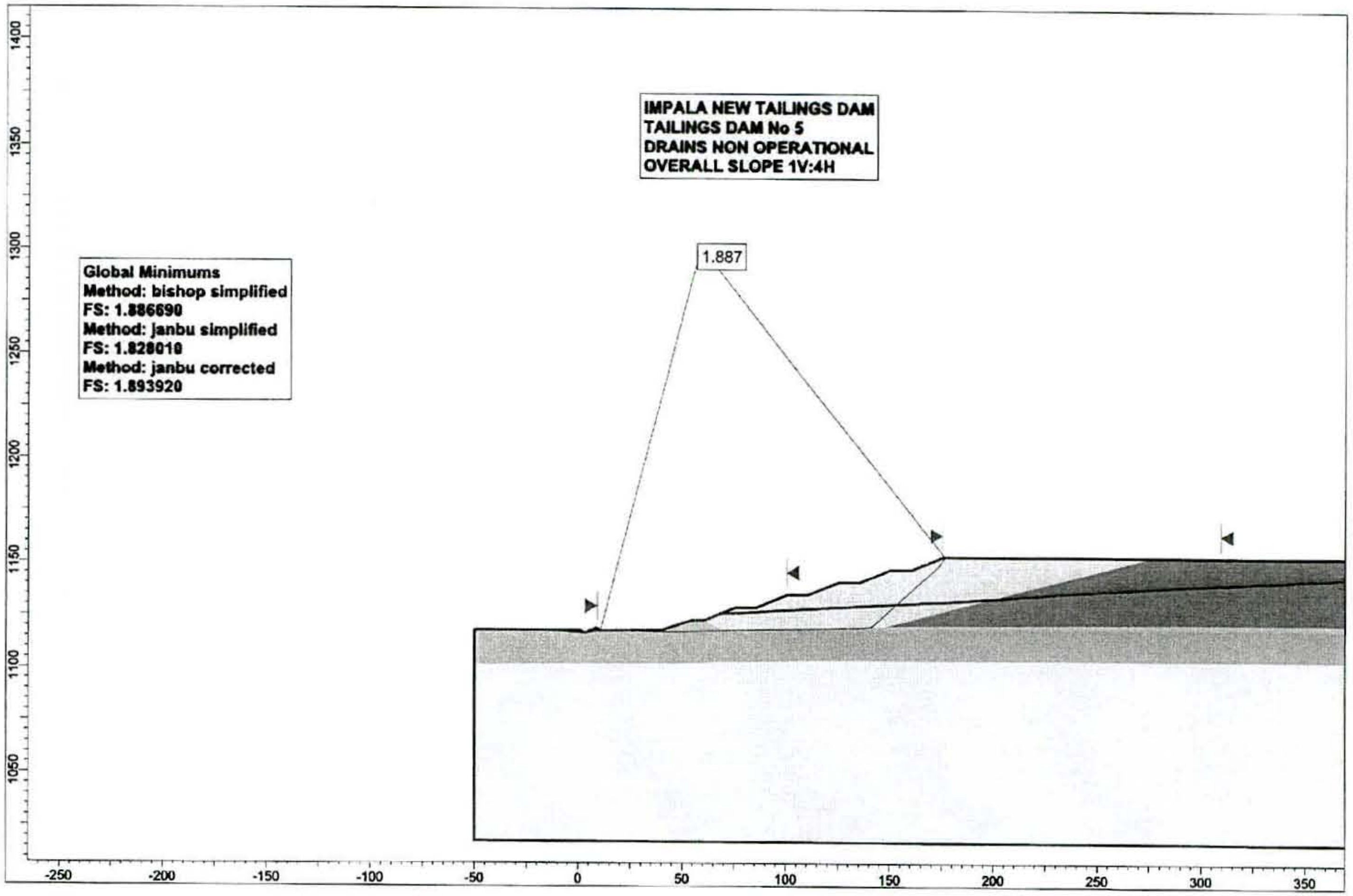

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		Compiled by: SCHA	Fig No. 2-b

Revision: A Date: 10 01 2011

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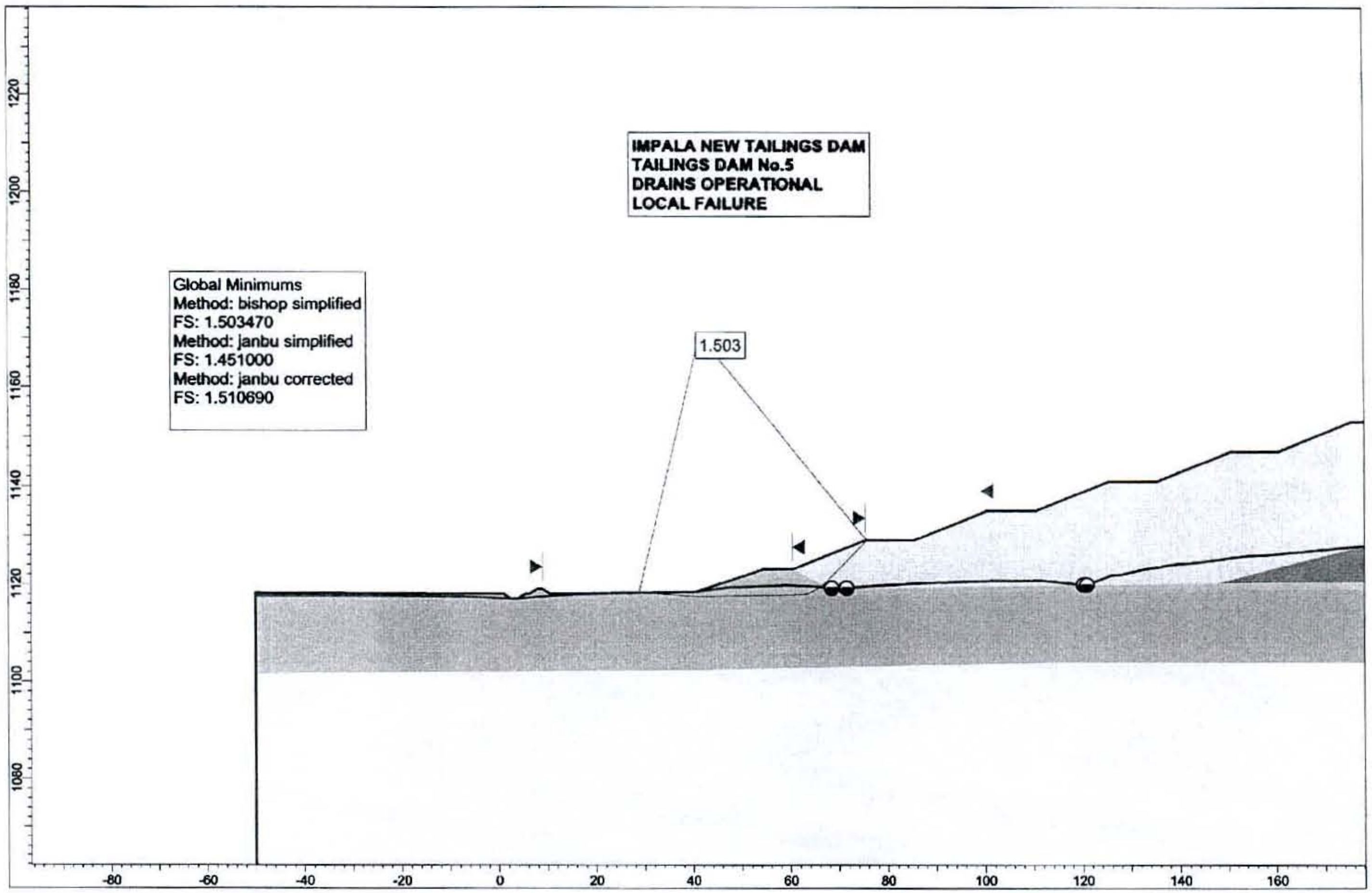

Project No.		Date:	Scale:
	IMPALA PLATINUM MINE	10 01 2011	NTS
414226	STABILITY ASSESSMENT - LOCAL FAILURE	Compiled by: SCHA	Fig No. 2-c

Revision: A Date: 10 01 2011

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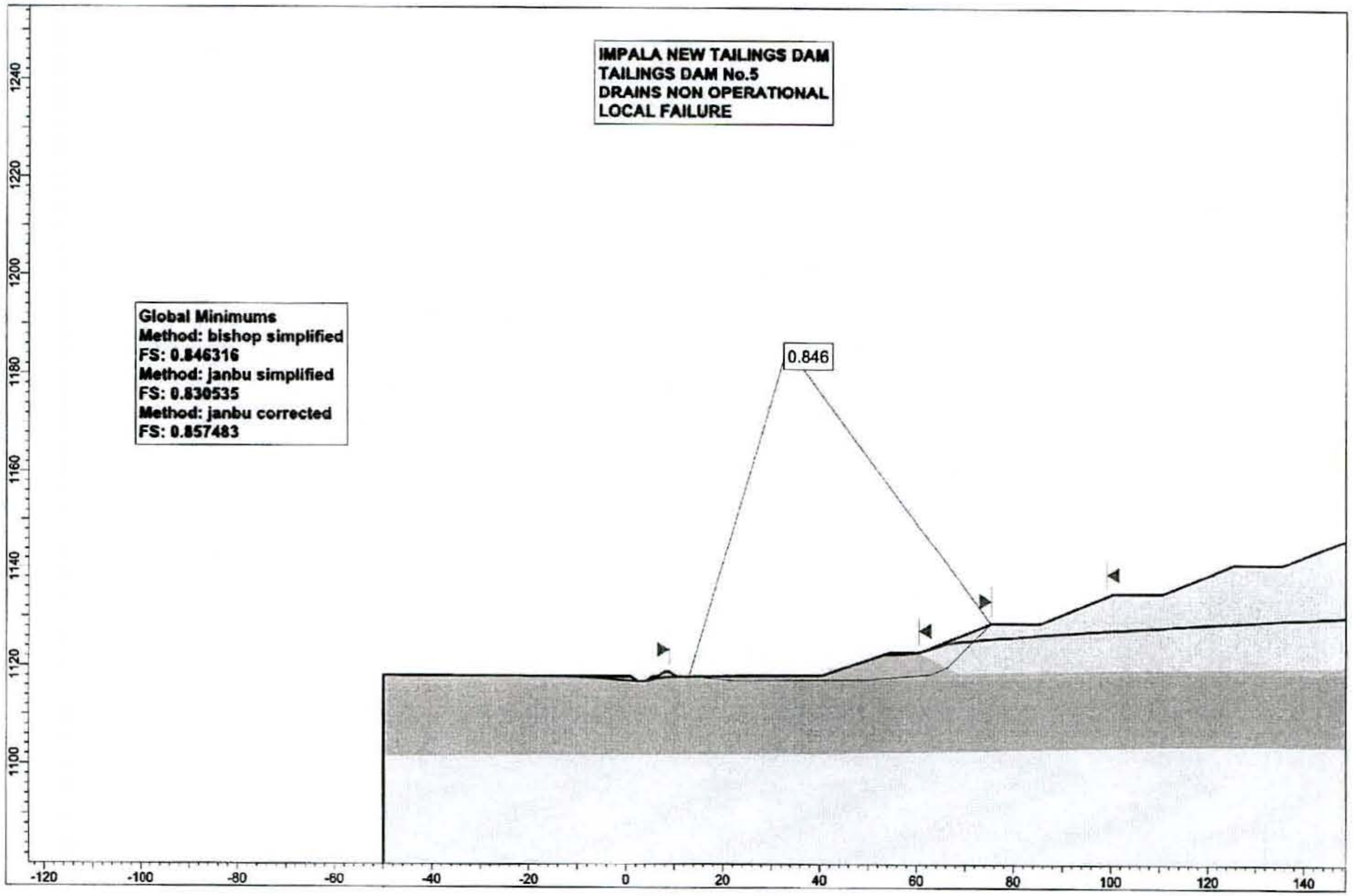

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414226	STABILITY ASSESSMENT - LOCAL FAILURE	Compiled by: SCHA	Fig No. 2-d

Revision: A Date: 10 01 2011

Appendix 3 Geotechnical Investigation Report

Impala Platinum Mine: New Tailings and Return Water Dam

Report Prepared for

Impala Platinum Limited

Report Number 414226/4

Report Prepared by

srk consulting

April 2011

Impala Platinum Mine: New Tailings and Return Water Dam

Impala Platinum Mine

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SRK Project Number 414226/4

April 2011

Compiled by:

DW Warwick Sci Nat
Principal Consultant

Email: DWarwick@srk.co.za

Peer Reviewed by:

Johan Boshoff
Partner

Authors:

Derrick Warwick

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (South Africa)(Pty) Ltd (SRK) by Impala Platinum Limited (Impala). The opinions in this Report are provided in response to a specific request from Mr. H. Smit to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

1 Introduction and Scope of Report

Impala Platinum Mine, near Rustenburg propose extending their existing tailings dam, to provide more flexibility in the operation of the tailings disposal system. The proposed dam is adjacent to the existing No 4 Dam on the north-eastern side. The new tailings dam is approximately 520ha in extent.

The purpose of this geotechnical investigation is to identify the soils and determine their engineering properties with respect to the construction of the TSF and return water dams.

2 Available Information

The following information was consulted during the investigation:

- Un-numbered site drawing of the preliminary layout of the tailings and return water dams.
- 1:250 000 Geological Map 2526 Rustenburg.
- Google Earth images.
- Information from the existing No 4 Tailings dam.

3 Site Description

The Impala Platinum Mine is about 25 km north of Rustenburg via the R565 road to Sun City and 10km north-west of Phokeng. The proposed site of the proposed new tailings disposal facility is immediately north-east of the existing tailings dam and is approximately of the same extent.

The site is largely gently sloping with occasional small rocky hills of gabbro-norite outcrop. Scattered flat outcrops of hard rock gabbro-norite also occur across the site.

The vegetation comprises veld grass and thorn shrubs and trees typical of the Bushveld. The site has a high point in the south-west of 1140m and slopes from this point to the east, west and north-west at about 2%.

4 Geology

The geology of the area comprises gabbro-norite and pyroxenite of the Rustenburg Layered Suite of the Bushveld Complex with sedimentary rocks of the Transvaal Supergroup to the south-west.

The profile at the site generally consists of black turf clay (reworked residual gabbro-norite) about 0.8m to 2.0m thick with an average of 1.4m, overlying highly weathered gabbro-norite, which grades into rock consistency with depth. Zones of apparent pyroxenite with sharp contacts with the gabbro-norite were observed in some test pits.

5 Ground Water

No ground water was observed in any of the test pits, the maximum depth of which was 3.3m (ITPN1 and IST2A).

6 Scope of Work

6.1 Test Pitting

A total of 115 test pits were excavated and profiled according to standard methods.

The pits are numbered and distributed as follows:

- All pits with pre-fix ITP are situated in the proposed new tailings dam area (42 pits);
- Test pits with pre-fix ITPN are for the temporary penstock line (10 pits);
- Test pits with pre-fix IFPN are for the final penstock (4 pits);
- Test pits with pre-fix ISOL are for the solution trench (23 pits);
- Test pits with pre-fix IST are for the silt traps (9 pits);
- Test pits with pre-fix IRWD are for the return water dams (27 pits).

The soil profiles are included in Appendix A. Samples were taken in the test pits and submitted to a soils laboratory for testing.

6.2 Laboratory Testing

Selected disturbed and undisturbed samples were taken for laboratory testing in order to determine the soil properties. The samples were sent to Civilab soils laboratory for foundation indicator, Proctor density test, triaxial, shear box and permeability testing. The results of the laboratory tests are summarised in Table 6 and the detailed results are included in Appendix B.

6.3 Evaluation and Reporting

The results of the field work were evaluated and preliminary conclusions and recommendations were presented in the preliminary report submitted in November 2010. The final evaluation and conclusions are included in this report.

Table 6.1: Summary of Laboratory Test Results

Test pit	Depth (m)	FIND		Grading %				GM	USCS	In situ dry density kg/m3	NMC %	SG	Void ratio	c'	φ'	Proctor		Permeability (m/s)	
		LL%	PI (overall)	Clay	Silt	Sand	Gravel									Density kg/m3	OMC%	In situ	98% proctor
IRWD03	0.5-1.0	71	45(42)	52	23	23	2	0.29	CH	1280	36.6	2.85	1.237	41	7	1333	33.7		1.7E-09
IRWD03	1.6	NP	NP	1	12	53	33	1.75	SM										
IRWD10	0.5	70	48(45)	52	24	23	1	0.27	CH	1348	30.6	2.78	1.060						
IRWD 14	2.1	52	28 (16)	8	16	62	14	1.34	SC										
IRWD 24	0.2-0.5	69	42 (40)	52	26	21	2	0.25	CH										
ISOL01	0.65	56	31(30)	47	25	28	0	0.28	CH										
ISOL10	0.6	79	50(48)	56	27	14	3	0.21	CH	1425	18.4	2.73	0.918	17	9			1.3E-09	
ISOL17	0.5-0.8	74	42(39)	55	22	20	2	0.26	CH	1307	29.4	2.85	1.176	46	10	1347	28.5		5.0E-09
ISOL23A	0.8	70	40 (38)	55	24	17	4	0.28	CH	1097	38.2	2.87	1.610	7	19			1.6E-09	
ITP21	0.55	83	57(54)	62	20	17	2	0.24	CH	1161	33.8	2.76	1.32	4	18			3.1E-10	
ITP40A	0.5-0.8	81	52(50)	54	28	16	2	0.20	CH	1293	31.6	2.65	1.052	17	12	1336	30.2		8.9E-10
ITP43A	0.3-0.6	75	45(41)	52	23	23	2	0.32	CH	1373	27.7	2.71	0.967	25	20	1412	27.7		3.9E-09
ITP50	1.2	78	44(39)	54	22	20	4	0.36	CH	1338	33.5	2.76	1.059						
IFPN1D	0.6	73	45(41)	47	29	20	4	0.35	CH	1142	35.6	2.73	1.333	12	12			1.4E-08	
IFPN2A	0.4-0.7	64	33 (31)	50	25	23	2	0.29	CH	1371	28.0	2.82	1.051	16	24	1397	28.9		4.0E-09
IST1A	0.8	77	44(43)	57	25	16	1	0.17	CH	1360	24.5	2.75	1.021	43	11			2.7E-10	
IST1B	0.5-1.0	80	49(46)	61	17	19	3	0.28	CH	1410	30.5	2.85	1.253	19	14	1309	29.1		1.1E-09
IST1C	2.0	42	23(2)	1	2	29	68	2.57	GW										
IST2A	1.6	57	34(30)	33	44	18	6	0.36	CH										
ITPN2	0.9	72	40 (39)	58	26	16	1	0.16	CH										
	Triaxial - undisturbed																		
	Shearbox - remoulded																		
	Shearbox - undisturbed																		

7 General Geotechnical Evaluation

7.1 Soil Profile

The typical soil profile across the site follows:

0.0m – 0.4m Slightly moist, black, firm, shattered, fissured and slickensided silty clay with roots. Reworked residual norite-gabbro (black turf)

0.4m – 1.3m Moist, black with scattered white specks, firm, fissured and slickensided, silty clay. Reworked residual gabbro-norite (black turf).

1.3m – 1.45m Moist, black speckled white, stiff, some relic layering, clayey sand. Transition zone.

1.45m – 1.8m Slightly moist, mottled off-white and light orange speckled and mottled black, medium dense to dense, relic layering joints, coarse medium and fine sand. Residual gabbro-norite.

1.8m – 2.2m Speckled white dark olive and orange, very close sub-horizontal layering and sub-vertical jointing, highly weathered, gabbro-norite rock ranging with depth from very soft rock to medium hard rock.

The TLB excavator (Hydromek HMK 102B) refused in most test pits.

A dark brown coarsely crystalline rock was intersected in some test pits and had a sharp contact with the country gabbro-norite rock. The rock was interpreted as pyroxenite.

No ground water was intersected.

7.2 Reworked Residual Norite (Black turf clay)

7.2.1 Field Characteristics

The black turf clay profile, shows fissuring and slickensiding, indicating expansion and shrinkage movement in summer and winter respectively. The upper approximately 300mm is also shattered, in which the clay forms granules of aggregated clay, giving the soil a sandy appearance. The fissures often extend to about 1m depth and form receptacles for rain water, causing heave and closing up of the fissures.

The clay is typically separated from the underlying sandy weathered gabbro-norite by a thin zone (about 150mm) comprising clayey and sometimes gravelly sand, which is transitional between the black clay and the light coloured weathered gabbro-norite. The contact between the two soil types is therefore sharp.

The thickness of the black turf varies between 0.95m and 1.7m and the average depth to refusal of the TLB excavator varied from 1.4m to about 2.5m average, with some pits extending to depths of 2.9m and 3.3m (the depth limit of the excavator) without refusing.

7.2.2 Soil Parameters

The black turf clay covering the site is typical of the soil overlying the Rustenburg Layered Suite of the Bushveld Complex, from west of Pretoria to north of Rustenburg. The laboratory test grading results (see Table 6.1) shows the silt and clay proportions ranging between 70% to 85% and Atterberg limits of 56 to 83 for liquid limits and 30 to 50 for plasticity indices of the whole sample. The USCS classification is usually CH. The typical shear strength parameters c' and φ' for this soil are 0kPa and 22° respectively. However, the three consolidated drained triaxial tests carried out on the black turf clay for this investigation showed variable results, with only one (from test pit ITP21) being typical, with c' and φ' values of 4kPa and 18° respectively. The remaining two results from test pit

ISOL10, with c' and φ' values of 17kPa and 9° respectively and test pit IFPN1D with c' and φ' values of 12kPa and 12° respectively were inconclusive.

The Proctor density results range between 1309kg/m^3 to 1412kg/m^3 and optimum moisture content (OMC) 28% to 34%.

Permeability of the undisturbed samples of clay ranged between 1.4E-08 to 3.1E-10 m/sec and of the clay compacted to 98% Proctor density, between 1.1E-09 to 8.9E-10 m/sec. These results are similar, which is not expected, as the in situ material is likely to contain some fissures that are likely to increase the permeability, while such fissures would be broken down during re-moulding to 98% Proctor density, resulting in a decrease in permeability. Although some of the dry density values of the undisturbed samples are relatively low, indicating the possibility of fissures which would be expected to reduce the density compared to a homogeneous sample, most are similar to the Proctor densities. This again indicates the possibility of sample disturbance or testing irregularities.

7.2.3 Uses and Workability

The low permeability of the black turf clay re-moulded to 98% Proctor density indicates that it can be used for starter walls and for lining of the return water dams. Compaction will require the use of sheep foot or grid rollers. Workability will be poor when the moisture content is high, such as in rainy weather when the moisture content is higher than the OMC. Movement of vehicles in such conditions will be difficult and will slow down the earthworks operations.

7.3 Weathered Gabbro-norite

7.3.1 Field Characteristics

The weathered norite, comprising silty sand and gravel grading into rock, is always covered by the black turf clay and will only be exposed in excavations, such as for the solution trenches, silt traps and penstock pipelines and structures. The layering of the Bushveld rocks is apparent in this horizon and together with sub-vertical jointing, forms an orthogonal jointing pattern. The weathered norite was observed in the test pits, to be occasionally intersected by a dark brown coarsely crystalline rock identified as pyroxenite.

7.3.2 Typical Soil Parameters

The weathered gabbro-norite increases in consistency with depth ranging from medium dense to very dense sand and gravel through to rock consistency. The laboratory tests show that the material comprises silty or clayey sand or sandy gravel with USCS classifications of SM, SC or GW respectively.

7.3.3 Excavatability

Excavation of the weathered norite rock should be possible with conventional excavation plant, such as a 30 ton tracked excavator, to about 0.5m deeper than the TLB excavator used for the field investigation.

8 Site Specific Geotechnical Evaluation

8.1 Return Water Dams

The investigation for the return water dams, which will be located in the north-western part of the site, comprised the excavation, profiling and sampling of 27 test pits (labelled IRWD01 to 27). The average thickness of the black turf clay in the area is 1.3m and the average depth to refusal of the

TLB excavator is 2.0m on weathered gabbro-norite with consistency ranging from very soft rock to medium hard rock.

Based on the laboratory grading, Atterberg limits and permeability of compacted samples of the black turf clay, this material can be used for starter embankment walls, but compaction using specialist plant will be required to obtain the specified compaction density. The clay may be used for lining of the return water dams if required. Access and earthworks can be a problem if construction takes place during the rainy season. It may be advisable to adopt a method based specification rather than an end result specification in which a minimum density is specified. The appropriate method should then be determined by field trials.

8.2 Solution Trench

A total of 22 test pits (labelled ISOL01 to ISOL23 (no ISOL04) were excavated along the length of the walls of the proposed new tailings dam on the route of the solution trench in positions shown on Drawing No 414226/---.

The test pit profiles along the route show that average black turf clay thickness is 1.2m and average refusal depth of the TLB excavator was 2.1m on weathered gabbro-norite ranging between very soft rock and medium hard rock. The depth of excavation possible using a large excavator will probably be about 2.5m, but it is possible that hard rock may occur in places along the route and require blasting.

8.3 Silt Traps

Two silt traps are proposed for the TSF, Phase 1 on the north-western boundary of the site (ST1) and Phase 2 on the south-eastern side (ST2). The positions of the test pits at the two silt traps are shown in Figures 1 and 2 at enlarged scale.

Figure 1: ST1

Figure 2: ST 2

Four test pits were excavated at ST1 and the profiles labelled IST1A to IST1D. The average thickness of black turf clay is 1.6m and the depth of refusal of the TLB excavator was 2.6m, but refusal was not reached in test pit ISTC, which was excavated to a depth of 2.9m. The position of silt trap ST1 has been revised and is now about 60m to the west of the above test pits.

Five test pits were excavated at ST2 and the profiles labelled IST2A to IST2E. The average thickness of black turf clay is 1.4m for four of the pits, but in test pit IST2B hard rock norite was almost outcropping with a thin 0.25m cover of black turf clay and in IST2C norite rock occurred at 1.0m depth.

Material identified as residual and weathered pyroxenite was present in test pits IST2A (as dark brownish grey shattered micaceous clayey silt with zones of relic jointed weathered rock below 2.7m) and IST2D (as dark shiny brown coarsely crystalline weathered relic jointed soft rock identified as pyroxenite).

The silt traps can be founded on the weathered gabbro-norite rock. The black turf clay adjacent to foundations and the silt trap walls should be removed and replaced with selected inert backfill, to prevent heave on the vertical faces of the foundations and walls.

Blasting may be required for excavation of the silt traps, especially in the area of test pit IST2B, where hard norite rock was virtually outcropping and IST2C where norite rock occurs from a depth of 1.0m.

8.4 TSF Basin

A total of 43 test pits (labelled ITP01 to ITP43) were excavated within the basin of the proposed TSF to determine the soil properties with respect to wall construction and permeability.

The average black turf clay thickness is 1.4m and average refusal depth of the TLB excavator was 2.1m on weathered gabbro-norite ranging between very soft rock and medium hard rock.

The field soil profiling and laboratory test results show that the properties are typical of the black turf clay. The material can be used for starter walls, but compaction using specialised plant will be required to obtain the specified compaction density. Access and earthworks will be a problem if construction takes place during the rainy season and as indicated in Section 8.1, a method based specification may be required.

8.5 Temporary Penstock Intake Lines

Test pits were excavated along the two temporary penstock intake lines, six pits along the one to the north-west ending at silt trap ST1 (test pits ITPN01 to ITPN06) and the other five pits to the east, ending at silt trap ST2 (test pits ITPN7 to ITPN11).

The average thickness of black turf clay along the north-west line is 1.2m and average refusal depth is 2.3m on hard rock weathered gabbro-norite. However, pits ITPN01 and ITPN03 did not reach refusal at about 3m depth (the excavation depth limit of the TLB excavator). Along the eastern line the average black turf clay thickness is 1.2m and the average refusal depth is 1.8m on weathered gabbro-norite of consistency ranging from very soft rock to hard rock.

If the depth of excavation for the pipelines is greater than the average depths of refusal of the TLB excavator, it may be necessary to blast, although a large tracked excavator should be able to excavate to greater depth than the TLB. The possibility of blasting will be dependent on the depth of the pipeline trenches.

8.6 Final Penstock Towers

A total of 4 test pits were excavated for the final penstock tower positions, two at the Phase 1 western side (IFPN1C and IFPN1D) and two at the Phase 2 eastern side (IFPN2A and IFPN2B). The positions of the test pits are shown in Figure 3 at enlarged scale.

The average black turf clay thickness is 1.0m and average refusal depth of the TLB excavator was 2.6m on weathered gabbro-norite ranging between very soft rock and medium hard rock.

The profiles of test pits IFPN1C and IFPN1D show that the profile is not typical and indicate that the area is probably intruded by a diabase dyke.

It is recommended that rotary cored drilling is carried out at the proposed penstock tower positions to identify more accurately the geological conditions and if these are likely to influence the foundation methods for the towers.

Figure 3: FPN 1

9 Conclusions and Recommendations

- The entire site is underlain by black turf clay which is typical for the Rustenburg area. The clay is highly expansive and it is necessary to take this into account in the design and and construction of the facilities. The average clay thickness is 1.4m and it overlies weathered norite with rock consistency from an average depth of 2.5m, although this does vary from outcrop to greater than 3.3m.

- The relatively low permeability, as determined from the laboratory testing of the black turf clay compacted to 98% Proctor density, indicates that it may be used for construction of starter walls and the lining of the return water dams. However, due to the high plasticity of the clay, specialist compaction plant such as sheeps foot or grid rollers will be required for compaction. Also, the earthworks should if possible take place during the dry season due to the difficult workability of the clay when saturated and difficult access for construction vehicles. A method based specification, which would require field trials, should be considered for the compaction.

- The c' and φ' values determined from the laboratory testing of the clay were inconclusive in two of the three tests. It is recommended that c' and φ' values of 0kPa and 25° be used for design purposes. Since it is considered prudent to be conservative, due to the potential construction problems which are likely to be encountered in the field and the possibility of future soil movement due to seasonal expansion and contraction.

- The depth of excavation required for the silt traps, solution trenches, penstock pipelines and penstock structures will exceed the depths excavated in the present investigation, in which TLB refusal usually occurred at depths between 2m and 3m. The variability of depth of hard rock indicates that it is probable that some blasting of the norite rock will be required from depths ranging between 2m and about 4m. In the few outcrop and shallow rock areas which may occur at the positions of the above structures (such as at the silt trap S2 site, blasting will be required from surface or shallow depth of 1m.

- Further investigation in the form of core drilling is recommended at the final sites of the Penstock Towers, where loads are likely to be high and where settlement should be restricted to the minimum. Two of the test pits for the towers showed the presence of a diabase dyke and, in addition to drilling, trenching using a large tracked excavator is recommended to trace the position of the dyke relative to the structures.

Prepared by

DW Warwick Sci Nat

Principal Consultant

Reviewed by

JCJ Boshoff Pr Eng

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

Appendices

Appendix A Profiles

Appendix B Laboratory Test Results

SRK Report Distribution Record

Report No. 414226/4rev1

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21 April 2011
414226

Department of Water Affairs and Environment
Private Bag X995
Pretoria
0001

Attention: Mr Frans Druyts

Dear Sir

Proposed New Tailings Storage Facility Extensions at Impala Rustenburg and Marula Platinum Mine

Request for Principle Approval of TSF Drainage Design and RWD Liner Design

SRK Consulting has been appointed by Impala Platinum to carry out a feasibility level design and provide professional assistance for the proposed new tailings storage facilities at Impala Rustenburg and Marula Platinum Mine respectively. The Marula Platinum Mine is situated in the Limpopo Province along the R37 regional road.

This letter discusses the drainage and liner features of:

- The Impala Rustenburg TSF Extension
- The Marula Platinum Mine TSF Extension
- Liner system to the storm water catchment and silt dams at the Impala operations in Rustenburg.

1. Impala Rustenburg and Marula Extensions

Refer to Figures 1 and 2 for the general arrangements of the Impala Rustenburg and Marula Platinum TSF's respectively. A cross section indicating the drainage systems can be seen in Figure 3.

The following design features have been incorporated at each TSF extension in order to minimise seepage and reduce environmental impact.

1.1 Under drainage

Drainage of the spigotted tailings wall is of paramount importance. Excess pore water due to underflow build-up is released through the consolidation process. The excess water is then managed by means of an under drainage system designed to induce consolidation of the spigotted tailings material as quickly as possible.

The drainage system for each dam extension consists of a main drain and trench (curtain) drain parallel to the starter walls, placed approximately 50m upstream of the inner toe. An interface drain will be used at the interface between the existing dams and the new tailings dam extension.

The drains will comprise four basic elements:

- Filter sand – in contact with the tailings material
- Filter gravel – in contact with the filter sand (6mm stone)
- Filter gravel – in contact with the 6mm filter gravel (19mm stone)
- Slotted "Drainex" pipe – concentrate and conduct the drained water
- Unslotted "Drainex" pipe – collect the drainage water from the drains to the solution trench.
- 1.5mm HDPE geomembrane lining the drainage trenches.

Each of the drain outlets will decant into a concrete lined solution trench. Water from the solution trench will then flow towards the silt traps where the suspended solids will remain.

1.2 Toe Drain

A toe drain is provided along the full perimeter of the tailings dam on the inside of the starter and toe walls. The toe drain consists of a 600mm deep, 700mm wide trench with two protection berms on each side. The trench, up to the berms is lined with a 1.5mm DHPE lining to prevent any seepage emanating from the drain and to prevent the ingress of fine clay / sand particles into the drain which would lead to eventual clogging of the drain. The drain comprises two 160mmNB slotted Drainex pipes which runs parallel with the starter wall toe. The pipes are surrounded by a 300mm layer of 19mm stone which is overlain by a 150mm layer of 6mm stone and a 150mm layer of graded filter sand inside the trench. On top of the trench another 300mm layer of graded filter sand is placed between the protection bunds with overlaying 300mm coarse grained tailings.

Drain outlets comprising 160NB unslotted Drainex pipes are provided from the toe drain to the solution trench at approximately 50m intervals.

1.3 Chimney and Trench Drains

The chimney drains are constructed with standard 1m diameter Rocla manhole rings filled with 6mm stone. The base of each chimney inlet consists of a concrete base filled with 19mm stone. The outlets from the base of each chimney consists of a 160mmNB slotted Drainex pipe inside the basin of the dam and a 160mmNB unslotted Drainex pipe from the upstream toe of the starter wall to the solution trench. The chimneys are provided at 50m intervals around the dam, and at a position of approximately 50m in from the centre line of the toe drain.

The trench drain is drain is provided along the sections of the tailings dam perimeter to fulfil the needs of a chimney drain in this area.

The trench drain consists of a 600mmNB deep, 700mm wide trench lines with 1.5mm HDPE and also Bidim containing two 160mmNB slotted Drainex pipes. The pipes are surrounded by a 300mm thick layer of 19mm stone which is overlain by a 150mm thick layer of 6mm stone. The Bidim is folded over the 6mm stone and the remaining 150mm of the trench is backfilled with coarse tailings which protrudes 100mm above natural ground level and extends 300mm on either side of the trench and serves as a protection layer.

A layer of Bidim is provided between the 6mm stone and the coarse tailings which is then folded back before installation of the vertical curtain drain. Outlets are provided along the trench drain from one of the 160mmNB slotted Drainex pipes from the trench drain at intervals which follows the contours to the solution trench. The second 160mmNB slotted Drainex pipe leads into the chimney drains at either end of the trench drain.

1.4 Interface Drain

An interface drain system; consisting of a collector drain and an interface drain will be constructed to control the phreatic surface along this interface with the new extension.

An interface vertical drain is provided along the full length of the interface. The existing solution trench will be converted to an interface drain. The trench will be lined with 1.5mm HDPE lining which will prevent any seepage emanating from the drain and the ingress of fine clay/sand particles into the drain which would lead to eventual clogging of the drain.

The drain comprises of two 160mmNB slotted Drainex pipes which run for the total length of the pipe and ends up in the current tailings dam solution trench. The pipes are surrounded by a 300mm layer of 19mm stone which is overlain by a 150mm layer of 6mm stone and a 200mm layer of graded filter sand and a 300mm coarse protection layer on top of the ground level.

1.5 Silt Traps

Two twin compartment concrete lined silt traps have been provided for each new TSF extension. The purpose of the silt trap is to reduce the amount of suspended solids that would otherwise enter the return water dam. The silt trap has been designed with twin compartments in order to facilitate alternate cleaning and operation of each compartment. The flow from the dissipator structure is directed to either one or the other compartment by means of sluice gates.

1.6 Return Water Dam

The return water dam extension in the case of Marula and the new RWD at Impala Rustenburg will be lined with a multiple geomembrane system to reduce seepage. The liner system will include a leakage detection system (750 micron cuspated sheet in between a 1.5mm and 2mm HDPE geomembrane) to detect potential leaks in the 2mm HDPE primary liner.

1.7 Seepage

The bulk of the new tailings dam extension and return water dam extension in both cases is underlain by zones of deep weathering. This means that the site is underlain by a thick layer of black turf which could act as a natural clay liner (NCL). The presence of this layer will reduce seepage to the underground. Methods will be investigated during the detailed design phase to moisture condition this layer so that water ingress is further minimised. The slurry density of the tailings material will also be increased to reduce potential infiltration.

1.8 Tailings Dam overall slope angle

The Implats standard for tailings dam overall slope angles is 1v:4h. This will reduce erosion damage as well as promote the establishment of a sustainable vegetation solution. The flatter outer slope angle will also reduce the visual impact of the new TSF. The TSF at Marula will however have a 1v:3h overall slope due to footprint constraints.

2 Storm water Catchment Dam

Pollution control dams and storm water catchment dams are proposed to be constructed at the UG2 concentrator and 14 shaft. The liner details are presented below and as per the attached figures.

The liner details are as follows:

Catchment dam:

- Abrasion layer of 10mm Hyson cells filled with 25MPa concrete
- Sealmac sealing layer.
- 100mm filter layer including sub-soil drainage layer.
- Secondary Sealmac layer.
- Preparartion layer compacted to 90% MOD AASHTO.

Silt Dam:

- 125mm thick mesh 30 MPa reinforced concrete lining
- 2mm HDPE lining
- 100mm filter layer
- Sealmac layer.
- Preparation layer compacted to 90% MOD AASHTO.

In order to commence with the detailed design of both facilities, we would respectfully like to request the Department to approve the design of the drainage systems and mitigation measures to reduce environmental impact in principle and indicate the latter in writing.

We hope you find the above in order. Should you have any queries, please do not hesitate to contact us.

Yours faithfully,

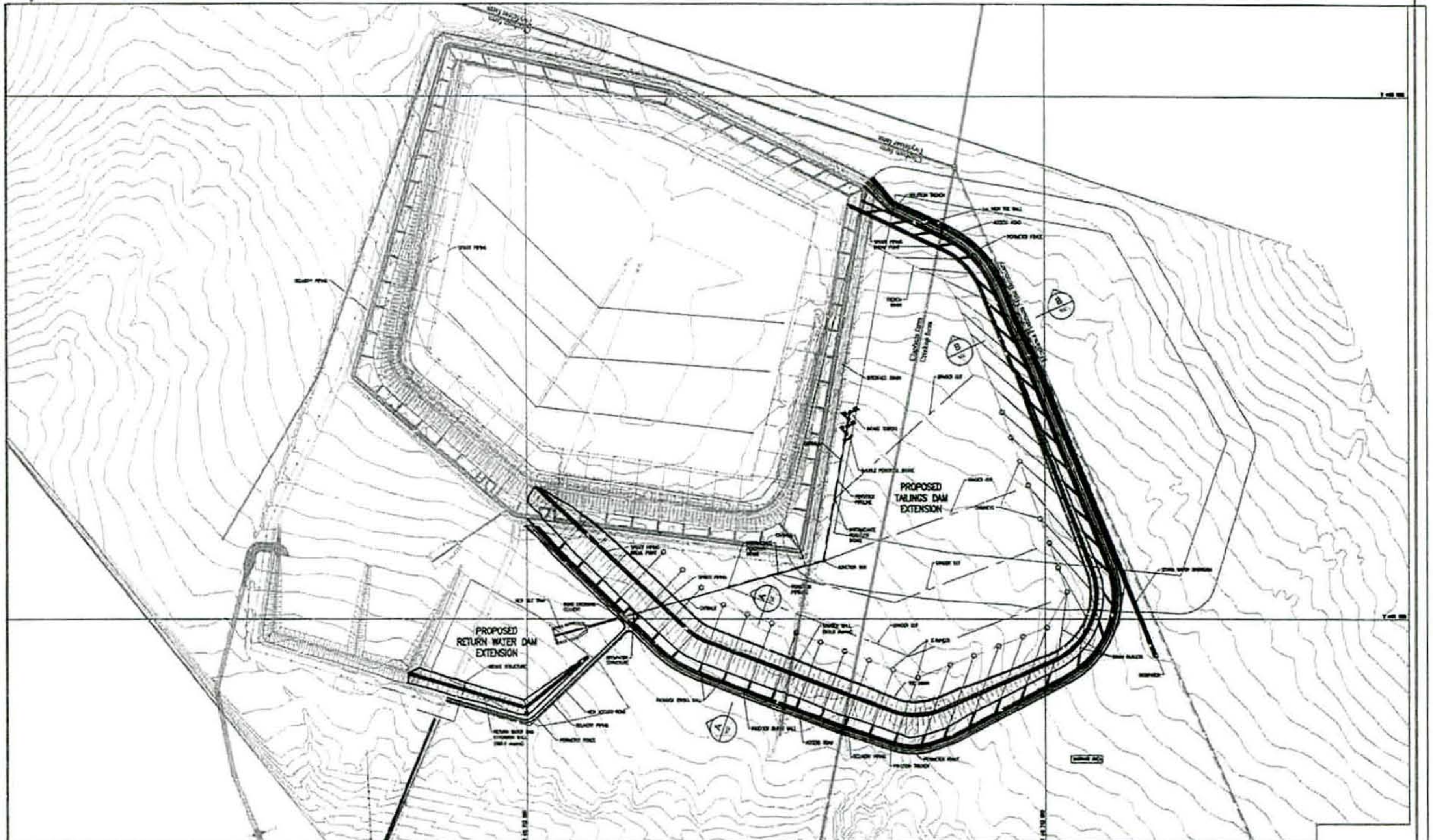
SRK Consulting (South Africa)(Pty)Ltd

A L Schoeman
Geotechnical Engineer

JCJ Boshoff Pr Eng
Partner

Encl.: Figures 1, 2 and 3. Aurecon Figures.

SRK Consulting
Engineers and Scientists



Project No.		Date	Scale
418709	LAYOUT MARULA TAILINGS DAM EXTENSION	30 03 2011	1:1000
		Compiled by: SCHA	Fig No. 1

Revision: A Date: 08 04 2009

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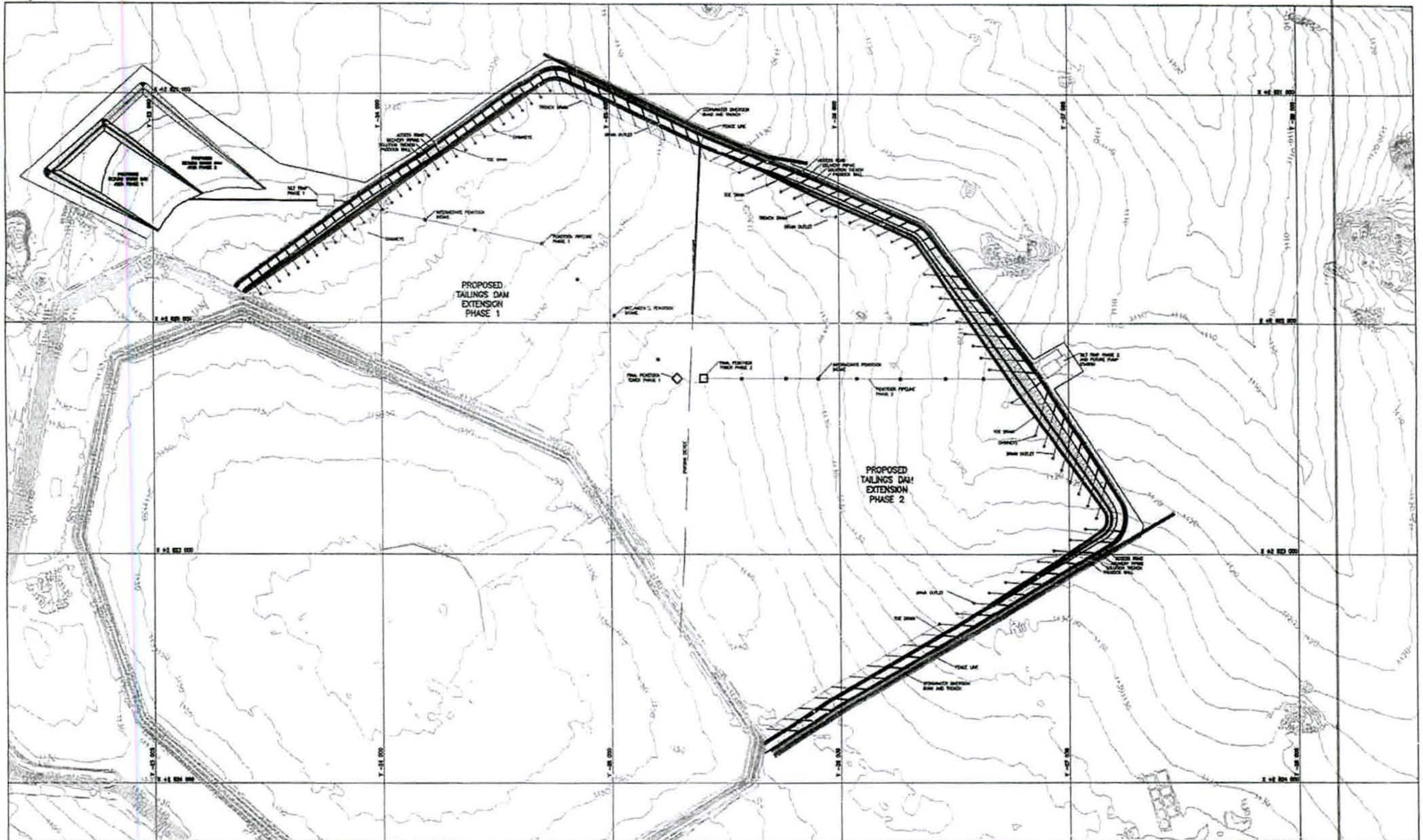

Project No		Date	Scale
414226	IMPALA TAILINGS DAM EXTENSION IMPALA TAILINGS DAM LAYOUT	31 03 2011	NTS
		Compiled by: SCHA	Fig No. 2

Revision: A   Date: 08 04 2009

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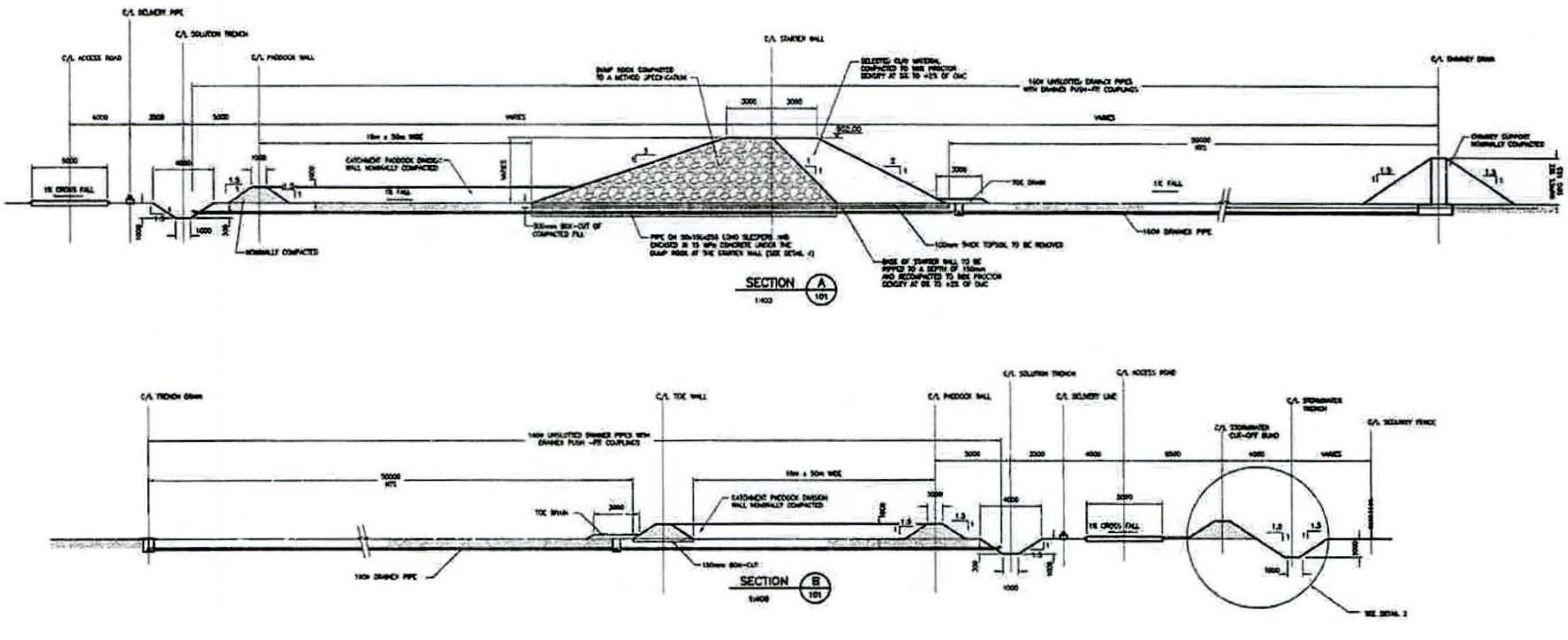
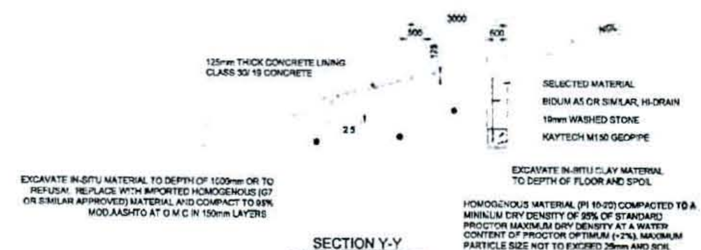


Project No.		Date:	Scale:
418709	TYPICAL SECTION OF TAILINGS DAM WALL MARULA AND IMPALA TAILINGS DAM EXTENSIONS	30 03 2011	1:400
		Compiled by: SCHA	Fig No. 3

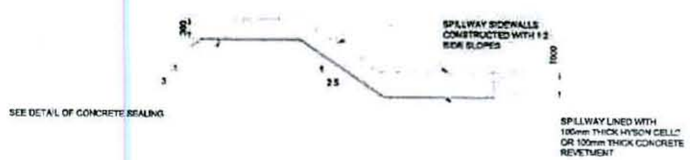
Revision: A Date: 08 04 2009

TYPICAL TRAPEZOIDAL CHANNEL SECTION
N.T.S

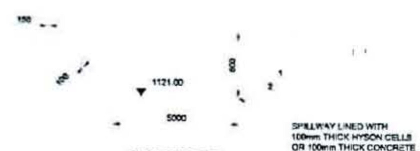
PLAN OF SPILLWAY
N.T.S



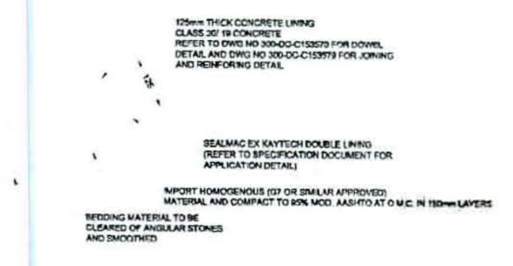
SECTION Y-Y
(CUT EMBANKMENT)
SCALE 1:75



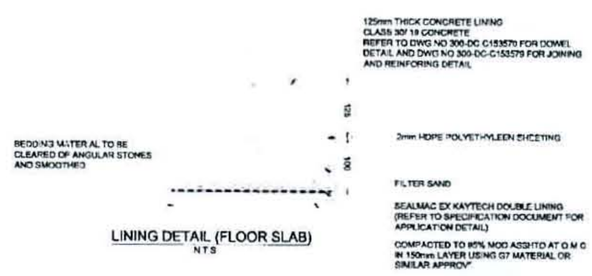
SECTION C-C
N.T.S



SECTION B-B
N.T.S



LINING DETAIL (SIDE SLOPE)
SCALE 1:5



LINING DETAIL (FLOOR SLAB)
N.T.S

FOR INFORMATION

NOTES:

1. SUBSOIL DRAINAGE ACCORDING TO SETTING OUT COORDINATES ON DWG NO 300-DC-C153563

	NAME	SIGNATURE
DRAWN:	M. MARIANO	
CHECKED:	R. GILAU	
DESIGN ENGINEER:	R. GILAU	
LEAD ENGINEER:	J. HEFER	
CLIENT:	H. SMIT	
CONSULT PROJ No:	105090	

aurecon

TOTAL MASS

ITEM	QTY	DESCRIPTION	LENGTH - MASS/kg

REFERENCE No	TITLE
300-DC-C153563	CATCHMENT DAM - SETTING OUT AND SUBSOIL DRAIN
300-DC-C153592	SILT DAM - SETTING OUT AND SUBSOIL DRAIN
300-DC-C153595	WET-WELL DETAIL
300-DC-C153597	SUBSOIL DETAIL

REFERENCE DRAWINGS

REVISION B	REVISION	REVISION
DRAWN	DRAWN	DRAWN
CHECKED	CHECKED	CHECKED
DATE	DATE	DATE

APPROVED FOR TENDER — NAME DATE — ENGINEER

APPROVED FOR CONSTRUCTION — NAME DATE — ENGINEER

DO NOT SCALE - IF IN DOUBT, ASK

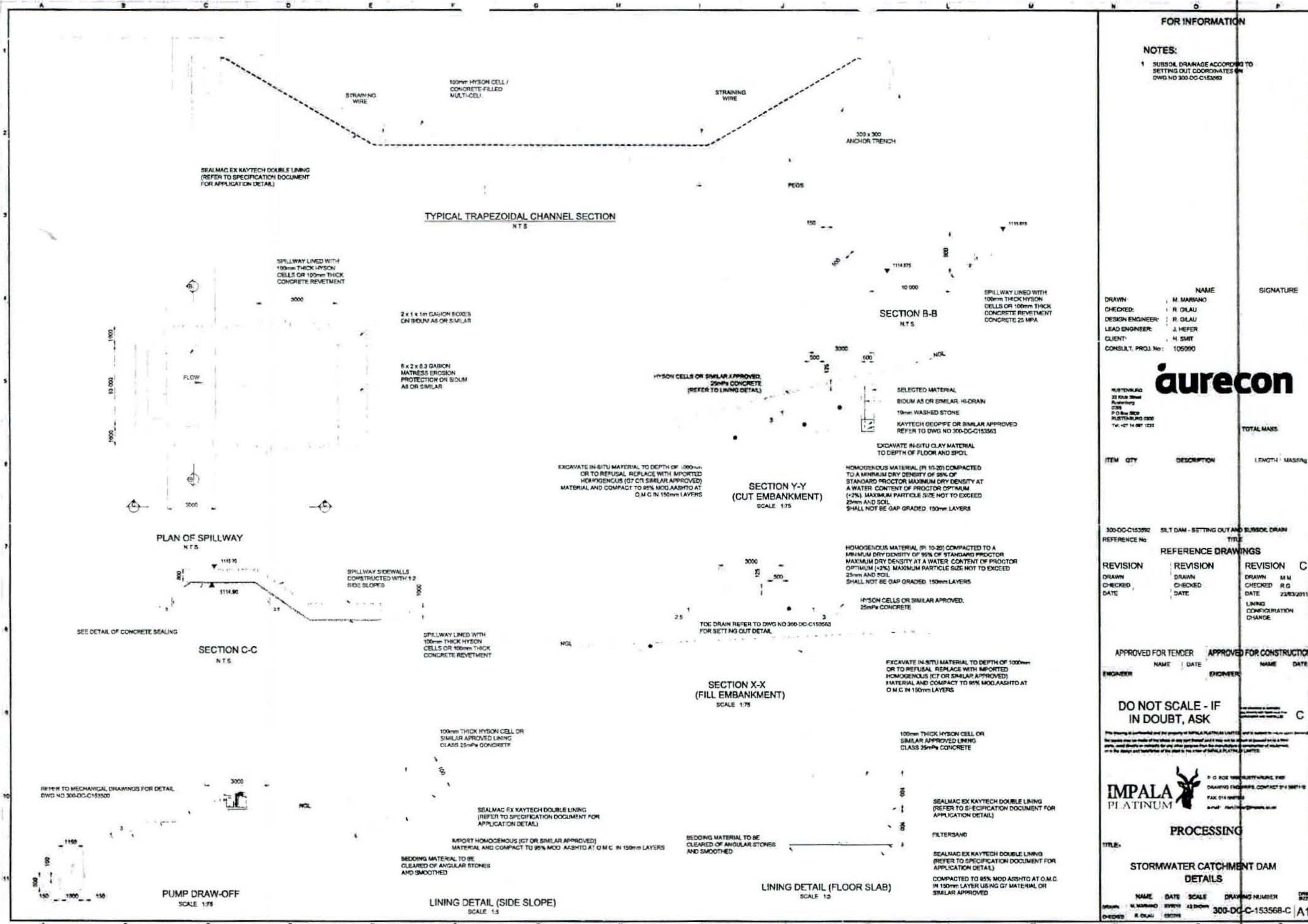
B

IMPALA PLATINUM

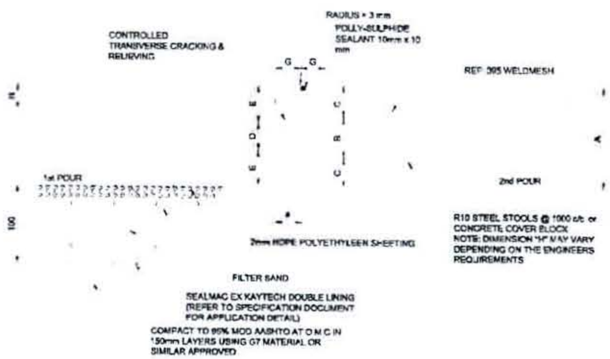
PROCESSING

TITLE: STORMWATER SILT DAM DETAILS

	NAME	DATE	SCALE	DRAWING NUMBER	
DRAWN	M. MARIANO		AS SHOWN	300-DC-C153593	A1
CHECKED	R. GILAU				



TYPICAL TRAPEZOIDAL CHANNEL SECTION
N.T.S
STRAINING WIRE
100mm HYSON CELL / CONCRETE-FILLED MULTI-CELL
STRAINING WIRE
300 x 300 ANCHOR TRENCH
PEGS
SEALMAC EX KAYTECH DOUBLE LINING (REFER TO SPECIFICATION DOCUMENT FOR APPLICATION DETAIL)
SPILLWAY LINED WITH 100mm THICK HYSON CELLS OR 100mm THICK CONCRETE REVETMENT
2 x 1 x 1m GABION BOXES ON BIDUM A6 OR SIMILAR
6 x 2 x 0.3 GABION MATRESS EROSION PROTECTION ON BIDUM A6 OR SIMILAR
FLOW
PLAN OF SPILLWAY
N.T.S
SECTION B-B
N.T.S
SPILLWAY LINED WITH 100mm THICK HYSON CELLS OR 100mm THICK CONCRETE REVETMENT CONCRETE 25 MPA
NGL
HYSON CELLS OR SIMILAR APPROVED, 25mPa CONCRETE (REFER TO LINING DETAIL)
SELECTED MATERIAL
BIDUM A5 OR SIMILAR, HI-DRAIN
19mm WASHED STONE
KAYTECH GEOPIPE OR SIMILAR APPROVED REFER TO DWG NO 300-DC-C153563
EXCAVATE IN-SITU CLAY MATERIAL TO DEPTH OF FLOOR AND SPOIL
EXCAVATE IN-SITU MATERIAL TO DEPTH OF 1000mm OR TO REFUSAL. REPLACE WITH IMPORTED HOMOGENOUS (G7 OR SIMILAR APPROVED) MATERIAL AND COMPACT TO 95% MOD.AASHTO AT O.M.C IN 150mm LAYERS
SECTION Y-Y
(CUT EMBANKMENT)
SCALE 1:75
HOMOGENOUS MATERIAL (PI 10-20) COMPACTED TO A MINIMUM DRY DENSITY OF 95% OF STANDARD PROCTOR MAXIMUM DRY DENSITY AT A WATER CONTENT OF PROCTOR OPTIMUM (+2%). MAXIMUM PARTICLE SIZE NOT TO EXCEED 25mm AND SOIL SHALL NOT BE GAP GRADED. 150mm LAYERS
SPILLWAY SIDEWALLS CONSTRUCTED WITH 1:2 SIDE SLOPES
SEE DETAIL OF CONCRETE SEALING
SECTION C-C
N.T.S
SPILLWAY LINED WITH 100mm THICK HYSON CELLS OR 100mm THICK CONCRETE REVETMENT
HYSON CELLS OR SIMILAR APROVED, 25mPa CONCRETE
TOE DRAIN REFER TO DWG NO 300-DC-C153563 FOR SETTING OUT DETAIL
SECTION X-X
(FILL EMBANKMENT)
SCALE 1:75
EXCAVATE IN-SITU MATERIAL TO DEPTH OF 1000mm OR TO REFUSAL. REPLACE WITH IMPORTED HOMOGENOUS (G7 OR SIMILAR APPROVED) MATERIAL AND COMPACT TO 95% MOD.AASHTO AT O.M.C IN 150mm LAYERS
REFER TO MECHANICAL DRAWINGS FOR DETAIL DWG NO 300-DC-C153500
PUMP DRAW-OFF
SCALE 1:75
100mm THICK HYSON CELL OR SIMILAR APROVED LINING CLASS 25mPa CONCRETE
SEALMAC EX KAYTECH DOUBLE LINING (REFER TO SPECIFICATION DOCUMENT FOR APPLICATION DETAIL)
IMPORT HOMOGENOUS (G7 OR SIMILAR APPROVED) MATERIAL AND COMPACT TO 95% MOD. AASHTO AT O.M.C. IN 150mm LAYERS
BEDDING MATERIAL TO BE CLEARED OF ANGULAR STONES AND SMOOTHED
LINING DETAIL (SIDE SLOPE)
SCALE 1:5
BEDDING MATERIAL TO BE CLEARED OF ANGULAR STONES AND SMOOTHED
LINING DETAIL (FLOOR SLAB)
SCALE 1:5
100mm THICK HYSON CELL OR SIMILAR APPROVED LINING CLASS 25mPa CONCRETE
SEALMAC EX KAYTECH DOUBLE LINING (REFER TO SPECIFICATION DOCUMENT FOR APPLICATION DETAIL)
FILTERSAND
SEALMAC EX KAYTECH DOUBLE LINING (REFER TO SPECIFICATION DOCUMENT FOR APPLICATION DETAIL)
COMPACTED TO 95% MOD AASHTO AT O.M.C. IN 150mm LAYER USING G7 MATERIAL OR SIMILAR APPROVED
FOR INFORMATION
NOTES:
1. SUBSOIL DRAINAGE ACCORDING TO SETTING OUT COORDINATES ON DWG NO 300-DC-C153563
NAME SIGNATURE
DRAWN: M. MARIANO
CHECKED: R. GILAU
DESIGN ENGINEER: R. GILAU
LEAD ENGINEER: J. HEFER
CLIENT: H. SMIT
CONSULT. PROJ. No: 105090
aurecon
TOTAL MASS
ITEM QTY DESCRIPTION LENGTH MASS/kg
300-DC-C153562 SILT DAM - SETTING OUT AND SUBSOIL DRAIN
REFERENCE No TITLE
REFERENCE DRAWINGS
REVISION
REVISION
REVISION C
DRAWN M.M
CHECKED R.G
DATE 23/03/2011
LINING CONFIGURATION CHANGE
APPROVED FOR TENDER
APPROVED FOR CONSTRUCTION
DO NOT SCALE - IF IN DOUBT, ASK
C
IMPALA PLATINUM
PROCESSING
TITLE:
STORMWATER CATCHMENT DAM DETAILS
DRAWING NUMBER
300-DC-C-153568-C
A1



TYPICAL KEY JOINT CONSTRUCTION
N T S

A	B	C	D	E	F	G	H
125 mm	55	35	25	50	40	40	40

TYPICAL WATER TIGHT KEY JOINT
N T S

A	G	H	P	Q	R
125 mm	50	50	200	100	35

CONCRETE NOTES:

ALL CONCRETE WORK SHOWN ON THE DRAWING SHALL COMPLY IN ALL RESPECTS OF DESIGN, MATERIALS AND WORKMANSHIP WITH CODE OF PRACTICE SABS 1200 FOR THE STRUCTURAL USE OF CONCRETE

CONCRETE GRADE (U O N) ... 30MPa/28 DAYS
BLINDING ... 10MPa/

50mm COVER TO REINFORCING
CONCRETE CURED USING AN APPROVED COMPOUND WITH A WHITE PIGMENT

NOTES:

1. CONCRETE TO BE CAST IN 6x3 BLOCKS (MIN)
2. REFER TO DWG NO 300-DC-C153589 FOR DOWEL DETAIL

FOR INFORMATION

	NAME	SIGNATURE
DRAWN:	M MARIANO	
CHECKED:	R. GILAU	
DESIGN ENGINEER:	R. GILAU	
LEAD ENGINEER:	J HEFER	
CLIENT:	H SMIT	
CONSULT. PROJ. No.:	105090	

aurecon

TOTAL MASS

ITEM	QTY	DESCRIPTION	LENGTH	MASS/kg

REFERENCE No.	TITLE:
300-DC-C153589	CATCHMENT DAM CHANNEL DETAIL

REFERENCE DRAWINGS

REVISION	B	REVISION	REVISION
DRAWN		DRAWN	DRAWN
CHECKED		CHECKED	CHECKED
DATE		DATE	DATE

APPROVED FOR TENDER	NAME	DATE	APPROVED FOR CONSTRUCTION	NAME	DATE
ENGINEER			ENGINEER		

DO NOT SCALE - IF IN DOUBT, ASK

B

IMPALA PLATINUM

P O BOX ... RUSTENBURG ...
DRAWING ENQUIRIES, CONTACT 014 ...
FAX 014 ...

PROCESSING

TITLE:-

CENTRAL CONCENTRATION
SILT DAM
KEY JOINT DETAIL

	NAME	DATE	SCALE	DRAWING NUMBER	DRG SIZE
DRAWN	M MARIANO	03/2013	N T S	300-DC-C153579	A1
CHECKED	R. GILAU	03/2013			

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20 December 2011
414226

Mr. G. Van Dyk
Impala Platinum Limited
P O Box 2634
Rustenburg
0300

Attention: Mr. G. Van Dyk

Dear Sir

Addendum to the Impala Tailings Dam Pre Feasibility Report

SRK Consulting has been appointed by Impala Platinum to carry out a pre feasibility level design and provide professional assistance for the proposed new tailings storage facilities at Impala Rustenburg, situated in the North West province.

This letter discusses the environmental items identified during a workshop on 19 October 2011, as follow:

- Concepts for ecosystem functionality.
- Improved Seepage Collection Measures.
- The addition of an additional lined return water dam.

1 Ecosystem functionality

During the environmental workshop Greenco proposed the following item which could be implemented to improve Tailings dam side slopes and Dust control. The respective items are listed below.

1.1 Tailings dam side slopes

Greenco Feedback after Investigation

The new TSF should have slopes not exceeding 15-18° (1:3.5-1:3), provided that slope lengths do not exceed 16-20m and that a serious undertaking is made to maintain vegetation contact cover (LOI) at >60%. The recommended slopes indicate maximum slope at any point, NOT average slope. Slope Angles.

Recommendations

a. The best slopes from a vegetation sustainability and surface stability point of view should not exceed 15-18 degrees (1:3.5-1.3) for any individual slope. Therefore, the overall slope of 1:4 will result in individual slopes that are too steep, unless the step-in widths can be reduced to maintain footprint dimensions.

b. From a closure perspective this will have immense benefits, as vegetation cover and performance will be enhanced, fugitive dust emissions should decrease and the track record of ecosystem development over time will make a very strong case for closure (assuming other latent liabilities such as groundwater contamination, etc., have been addressed).

SRK Application to Design

SRK will reduce the overall slope design of the TSF to 1v:4H with 5m wide step-ins. The slope in between step-ins is then 1v:3.3H, and incorporate above recommendations during the detail design phase.

1.2 Dust Control

Greenco Feedback after Investigation

Slope length and steepness and tailings dam height as well as orientation will have a significant influence on the amount of dust fallout from the TSF.

Recommendations

a. The TSF should preferably be in the wind shadow of the large TSF
b. The TSF should be constructed flatter on an increased footprint (which will also aid in the closure objectives) in order to minimise dust from this facility.
c. The TSF should not be orientated in such a way that it has a slope perpendicular to the dominant wind direction in the are -north west and north east
d. Development within the zone of influence should be refrained from the zone of influence of TSF pertaining to the sand and silt fraction of the dust will be a minimum of 690m from the toe of the TSF (at a height of 30m).
e. Dust management should be budgeted for and money spent accordingly.
f. Vegetation should be kept in an immaculate condition – unused roads should also be vegetated
g. The beach should be kept as wet as possible (if permitted)
h. The operator of the TSF should be trained to operate "dust friendly" and not construct walls on windy days. Speed limits on roadways should be less 30km/hr.
i. It would be in the interest of the TSF from a dust perspective to install a site specific dust suppression system which will aid in the establishment of vegetation and also significantly reduce dust fallout. This is not common practice in the platinum mining industry but is standard in the gold industry. This will significantly reduce the chances of >pm75 and pm10 to be mobilised.
j. The roads should be addressed through slag capping or rock capping but it will only be effective if the side slopes are adequately vegetated – otherwise the erodible fraction of the tailings on the side slope will only cover the slag and rock without any desired effect. In this case, a "dust ditch" can be installed around the TSF which will reduce the chance of dust cover up on the roads.
k. Dust monitoring around the new TSF should be intensified in order to generate dust management data.
l. Dust should be reported on in terms of total environmental load and not monthly fallout as is currently the case.

2 Containment of Contaminant Plumes

The management of plumes emanating from MRD's is complicated by the typically heterogeneous and dual-porosity (fracture network and rock matrices) nature of the underlying aquifers, resulting in frequent failures of traditional plume containment methods.

The following recommendations will inhibit the spread of contaminants away from the TSF site:

a. Build inception trenches close to the perimeter of the TSF sites where the groundwater level is close to the ground surface.
b. Locate scavenger/abstraction boreholes around the TSF perimeter. The scavenger boreholes for pump and treat systems should be located close to the TSF site and in close vicinity to each

other due to the heterogeneous nature and low transmissivity of the shallow weathered aquifer system at Impala. Implement the pump-and- treat system(s) early during the operational phase of the TSF site and continue until the source strength of the contaminant plume reduces to acceptable levels.

c. Induce a 'blast curtain' downstream of the TSF site, ensuring a complete and cost-effective capturing of the plume and prohibiting off-site migration. Blasting is a proven, simple and cost effective method to induce fractures and fragment the rock (i.e. aquifer) around the blasthole, thereby creating zones of high permeability and enhancing borehole yield. The blast curtain can therefore provide a system similar to an interception trench at greater depth and serves to enhance the effectiveness of classical pump-and-treat systems.

The implementation of the above recommendations to intercept the contaminant plume will inhibit the spread of contaminants away from the TSF site and significantly reduce the mass of contaminants released to groundwater and surface water systems.

3 SRK Application to Design

The above recommendations from Greenco, will all have to be addressed during the operational phase of Tailings dam No. 5.

4 Improvement of seepage collection measures

This section has been dealt with in the Pre Feasibility Report and is included below for reference.

4.1 Tailings dam overall slope angle

The Implats standard for tailings dam overall slope angles is 1v:4h. This will reduce erosion damage as well as promote the establishment of a sustainable vegetation solution. The flatter outer slope angle will also reduce the visual impact of the new TSF.

4.2 Seepage

The bulk of the new tailings dam extension and return water dam extension is underlain by zones of deep weathering. This means that the site is underlain by a thick layer of black turf which could act as a natural clay liner (NCL). The presence of this layer will reduce seepage to the underground. Methods will be investigated during the detailed design phase to moisture condition this layer so that water ingress is further minimised. The slurry density of the tailings material will also be increased to reduce potential infiltration.

Allowance was also made in the design for the installation of a main toe drain as well as a sand curtain drain. These drainage systems will intercept seepage and convey the seepage to the return water dam via the concrete lined solution trench. All of the above mentioned drains will have a 1.5 mm HDPE lining at the bottom to prevent any seepage which could emanate from the respective drains.

4.3 Stormwater Diversion

A stormwater system has been allowed for along the southern and north eastern flank of the tailings dam to divert clean run-off away from the tailings dam.

4.4 Return Water Dam

The return water dam extension will be lined with a multiple geomembrane system to reduce seepage. The liner system will include a leakage detection system to detect potential leaks in the primary liner.

4.5 Solution Trench and Silt Trap

Both the solution trench system and silt trap have been designed as concrete structures. The solution trench will be lined with concrete along its entire length. The twin compartment silt trap will also be lined with concrete to prevent seepage to the underground as the silt trap will be filled with silt and water on a continuous basis.

4.6 Dust pollution

On a tailings dam there are two areas where dust can be generated. These two areas are the top of the dam and the side slopes. The management measures for the top of the dam are different from the side slopes.

The most appropriate dust management system for the top of the dam is to keep as much of the beach wet as possible. This can be achieved by paying attention to the cycle times of tailings placement.

It is recommended that 60 to 80% of the beach on top of the dam be kept wet. This wet beach includes the pool area. The cycle time of the tailings placement has to be adjusted to ensure that 60 to 80% of the beach be kept wet at all times.

The most appropriate dust management system for the side slopes of the dam is to pay attention to the vegetation on these slopes. It is recommended that 80% of the side slope area be vegetated in terms of canopy cover. Part of this implication is that the vegetation establishment will have to be kept as close as possible to the top slopes of the dam, i.e. rising green wall concept.

The roads onto and around the tailings dam have to be maintained so that these are not a source of dust development. This will probably mean some form of application of dust suppressant and/or cover with durable gravel. The step in berms could also be capped with slag to reduce dust emanating from the tailings dam further and to protect the berms against erosion.

4.7 Silt transport

As a result of the flow of water over the tailings dam side slopes, some slimes and tailings will be transported to the paddock areas around the tailings dam. These paddock areas require cleaning of tailings when silting occurs. This can be addressed on an annual basis by the tailings dam Operator.

4.8 Tailings characteristics

The potential to increase the slurry density of the tailings material will also be investigated during the detailed design phase. This will result in less water being sent to the TSF as well as less evaporation losses and reduced seepage.

5 Design and allowed for an additional return water dam

A water divide is located approximately in the middle of tailings dam No. 5. The water divide also creates a boundary between the first phase of the project and the second phase of the project. The second phase however has a low point on the north eastern flank, to which all the drains, solution trenches and penstock will report.

The dirty water reporting to this low point will then be pumped to the north western return water dam, to be included into the mine water balance. The original design indicated in the pre feasibility report state that a pump and sump will be installed to pump the water away.

Some environmental risks have been identified, which lead to the design of a second return water dam. If the pump is stolen, the electricity supply is down, the electrical cables are stolen etc. then it will not be possible to pump water back to the other return water dam, which could lead to spilling into the environment, as the sump will not be able to handle all of the water flowing to the low point.
The additional return water dam will allow for more surge capacity and easier management of the decanting water. The return water dam will be designed and in the detail design phase.

If you require any further clarification or assistance, please do not hesitate to contact us.

Yours faithfully,

SRK Consulting (South Africa)(Pty)Ltd

AL Schoeman
Technologist

HAC Meintjes Pr Eng
Partner