Scoping Report 2020/10/08/GHYD

HYROLOGICAL & GEOHYDROLOGICAL SCOPING REPORT FOR THE PROPOSED PROSPECTING OF ALLUVIAL DIAMONDS ALONG THE ORANGE RIVER

November 2020

Prepared for: Ndi Geological Consulting

Document version 1-2 – Draft

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Hydrological & Geohydrological Scoping Report for the Proposed Prospecting of Alluvial Diamonds along the Orange River

10 November 2020

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REPORT DISTRIBUTION LIST

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DOCUMENT HISTORY

Report no	Date	Version	Status
2020/10/08/GHYD	October 2020	1-1	DRAFT
2020/10/08/GHYD	November 2020	1-2	DRAFT FOR PP

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Notations and Terms

Advection is the process by which solutes are transported by the bulk motion of the flowing groundwater.

Anisotropic is an indication of some physical property varying with direction.

Cone of depression is a depression in the groundwater table or potentiometric surface that has the shape of an inverted cone and develops around a borehole from which water is being withdrawn. It defines the area of influence of a borehole.

A ***confined aquifer*** is a formation in which the groundwater is isolated from the atmosphere at the point of discharge by impermeable geologic formations; confined groundwater is generally subject to pressure greater than atmospheric.

The ***Darcy flux***, is the flow rate per unit area (m/d) in the aquifer and is controlled by the hydraulic conductivity and the piezo-metric gradient.

Dispersion is the measure of spreading and mixing of chemical constituents in groundwater caused by diffusion and mixing due to microscopic variations in velocities within and between pores.

Drawdown is the distance between the static water level and the surface of the cone of depression.

Effective porosity is the percentage of the bulk volume of a rock or soil that is occupied by interstices that are connected.

Groundwater table is the surface between the zone of saturation and the zone of aeration; the surface of an unconfined aquifer.

A ***fault*** is a fracture or a zone of fractures along which there has been displacement.

Hydrodynamic dispersion comprises of processes namely mechanical dispersion and molecular diffusion.

Hydraulic conductivity (**K**) is the volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured perpendicular to the area [L/T]. Hydraulic conductivity is a function of the permeability and the fluid's density and viscosity.

Hydraulic gradient is the rate of change in the total head per unit distance of flow in a given direction.

Heterogeneous indicates non-uniformity in a structure.

Karstic topography is a type of topography that is formed on limestone, gypsum, and other rocks by dissolution, is characterised by sinkholes, caves and underground drainage.

Mechanical dispersion is the process whereby the initially close group of pollutants are spread in a longitudinal as well as a transverse direction because of velocity distributions.

Molecular diffusion is the dispersion of a chemical caused by the kinetic activity of the ionic or molecular constituents.

Observation *borehole* is a borehole drilled in a selected location for the purpose of observing parameters such as water levels.

Permeability is related to hydraulic conductivity but is independent of the fluid density and viscosity and has the dimensions L^2. Hydraulic conductivity is therefore used in all the calculations.

Piezo-metric head (ϕ) is the sum of the elevation and pressure head. An unconfined aquifer has a water table and a confined aquifer has a *piezo-metric surface*, which represents a pressure head. The piezo-metric head is also referred to as the hydraulic head.

Porosity is the percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected.

Pumping tests are conducted to determine aquifer or borehole characteristics.

Recharge is the addition of water to the zone of saturation; also, the amount of water added.

Sandstone is a sedimentary rock composed of abundant rounded or angular fragments of sand set in a fine-grained matrix (silt or clay) and more or less firmly united by a cementing material.

Semi-confined / -unconfined aquifers are intermediate between confined and unconfined aquifers. Their confined character is often a result of the heterogeneous nature of the subsurface and have a piezometric surface rather than a water table.

Shale is a fine-grained sedimentary rock formed by the consolidation of clay, silt or mud. It is characterised by finely laminated structure and is sufficiently indurated so that it will not fall apart on wetting.

Specific storage *(S_0),* of a saturated confined aquifer is the volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head. In the case of an unconfined (phreatic, water-table) aquifer, *specific yield* is the water that is released or drained from storage per unit decline in the water-table.

Static water level is the level of water in a borehole that is not being affected by withdrawal of groundwater.

Storativity is the two-dimensional form of the specific storage and is defined as the specific storage multiplied by the saturated aquifer thickness.

Total dissolved solids (TDS) is a term that expresses the quantity of dissolved material in a sample of water.

Transmissivity *(T)* is the two-dimensional form of hydraulic conductivity and is defined as the hydraulic conductivity multiplied by the saturated thickness.

An ***unconfined, water-table*** *or* ***phreatic aquifer*** is different terms used for the same aquifer type, which is bounded from below by an impermeable layer. The upper boundary is the water table, which is in contact with the atmosphere so that the system is open.

Vadose zone is the zone containing water under pressure less than that of the atmosphere, including soil water, intermediate vadose water, and capillary water. This zone is limited above by the land surface and below by the surface of the zone of saturation, that is, the water table.

Water table is the surface between the vadose zone and the groundwater, that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere.

List of Abbreviations

Abbreviation	Description
BPEO	Best Practicable Environmental Option
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMPR	Environmental Management Programme Report
MAMSL	Meter Above Mean Sea Level
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MBDL	Meter Below Datum Level
MBGL	Meter Below Ground Level (i.e. depth)
NEMA	National Environmental Management Act, Act 107 of 1998
NWA	National Water Act, Act 36 of 1998
pH	Measure expressing the acidity or alkalinity of a solution
TDS	Total Dissolved Solids
TWQR	Target Water Quality Range
WUL	Water Use License
WULA	Water Use License Application

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1 INTRODUCTION

1.1 Background

Samara Mining (Pty) Ltd has applied to the Department of Mineral Resources, Springbok Office, for two 'Prospecting Right Applications' (with bulk sampling) to prospect for alluvial Diamonds on the Orange River between Sendlingsdrift and Sanddrift located in the Namaqualand Magisterial District of the Northern Cape Province, South Africa.

The two 'Prospecting Right Applications' have been lodged on the follow areas:

- **NC 30/5/1/1/2/1 (12663) PR** – left (or south eastern) bank of the Orange River, which defines the boundary to Remainder Farm No. 18 with an extent of 690 Ha.
- **NC 30/5/1/1/2/1 (12644) PR** – left (or south eastern) bank of the Orange River, which defines the boundary to Remainder Farm No. 11 with an extent of 987.98 Ha.

AGES has been appointed to do conduct the following specialist assessments:

- Geohydrological & Groundwater Assessment,
- Hydrological & Surface Water Assessment of the river system
- Surface water site assessment: The compilation of a Stormwater Management Plan in order to do a Stormwater design for the proposed prospecting and bulk sampling.

1.2 Description of Proposed Activities

The application is for a prospecting right, with bulk sampling for diamonds from selected alluvial 'pockets' along the bed and banks of the Orange River. The following prospecting and bulk sampling framework were provided as basis to the required assessments:

- The prospecting and bulk sampling of the diamonds will require the excavation of trenches and the processing of the material containing the alluvial diamonds.
- It is expected that ten (10) trenches, approximate dimensions 100 m X 25 m X 4 m, will be required at each of the prospecting sites, however this will be confirmed during the Scoping Phase of the process.
- The stockpiling and processing of the excavated material **may b**e on, or within 50m of the active channel embankment. Diversion and temporary re-alignment of the water course may be required to gain access to the alluvial material for excavation.
- While engineering designs would be required to quantify the diversion activities, hydrologically, the process would include the diversion, abstraction and filtration of the

river water, with release of the clarified water back to the river channel downstream of the workings.

- The processing of the excavated material will involve the use of 8 X 18 feet rotary pans with a minimum and maximum tonnage of 45 and 56 respectively, depending on the Gravel SG.
- The concentrate from the rotary pans will be transferred via conveyor to the diamond recovery process. This will be a two-stage final recovery system utilizing both x-ray (Bourevestnik (BV)) and grease technology, ensuring that any diamonds not recovered by the x-ray sorter will be captured by the grease technology - maximizing recoveries.
- The proposed prospecting is located on the Orange River, in an area historically known for diamond mining - as such no alternative has been investigated for the proposed prospecting area.
- As there are no chemicals used in the process, it is expected that the design of the waste material piles will be based on the use of bedrock and strapping to ensure filtration of water for recycling.
- Water, for use in the processing operations, will be abstracted from the Orange River. A Vacuum Claridisk Filter system will be used to treat all slimes from the scrubber and pan. The treated water will be reused in the scrubber unit, minimizing abstraction volumes.
- The vacuum and filter system will remove the dirt and filter the water back to drinkable standards, either for release back into the Orange River or for supply to local communities if found feasible during the Scoping Phase.
- Further, the waste material – now devoid of diamonds will the used to rehabilitate the excavations in line with environmental guidelines. An engineer will be appointed to design the proposed water impoundments, stock and waste material piles. Tailings and overburden will be backfilled into excavations, followed by topsoil for rehabilitation.
- The positioning of the infrastructure may be on, or within 50m of the active channel embankment. Sites will be finalised once the specialist studies have been completed with the aim of avoiding/minimising impacts on areas of environmental sensitivity.

The proposed flow layout arrangement for the processing and water flow is presented in Appendix A.

2 DETAILS OF THE PROFESSIONAL TEAM

The following team has been appointed by AGES to conduct the specialist assessments requested regarding to the proposed activities.

Name of Scientist:	AGES – Stephan Pretorius (Dr)
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Telephone number:	018 297 6588
Expertise:	PhD - Environmental Sciences, Pr. Sci. Nat., MGSSA

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Telephone number:	018 297 6588
Expertise:	PhD – Geohydrology, Pr. Sci. Nat., MGSSA

Name of Scientist:	AGES – Robert Crosby (Mr)
Physical Address:	45 Cruden Bay Road Greenside, 2193
Telephone number:	010 612 0876
Expertise:	B. Sc. Honours – Geohydrology, Pr. Sci. Nat. - 400215/06, MGSSA

Name of Scientist:	AGES – Pieter Pretorius (Mr)
Physical Address:	88 MC Roode Street Potchefstroom, 2531
Telephone number:	018 297 6588
Expertise:	M. Sc – Environmental Sciences – Geology, Pr. Sci. Nat. - 007303, MGSSA

Name of Scientist:	AGES – Thabiso Katiba (Mr)
Physical Address:	88 MC Roode Street Potchefstroom, 2531
Telephone number:	018 297 6588
Expertise:	B. Sc Honours – Environmental Sciences – Geology, Cand. Sci. Nat. – 128666

Name of Scientist: AGES – Hanneke Pretorius (Mrs)
Physical Address: 88 MC Roode Street
Potchefstroom, 2531
Telephone number: 018 297 6588
Expertise: M. Sc – Town and Regional Planning, Pr Pln – A2494/2017

Name of Engineer: AGES – Karel van Rooyen (Mr)
Physical Address: 88 MC Roode Street
Potchefstroom, 2531
Telephone number: 018 297 6588
Expertise: B. Eng, ECSA Cand. Eng – 201550697

3 LOCATION OF ACTIVITY

3.1 Description of Location

The location of the prospecting and bulk-sampling is along the Orange River, upstream of the world famous Ramsar site- the Orange River Wetland. The Ramsar site is considered to be the second most important estuary in South Africa in terms of conservation status.

The mining is also close to the Richtersveld protected areas that fall under the auspices of the South African National Parks. Figure 1 is a spatial representation of the locality of the proposed activity.

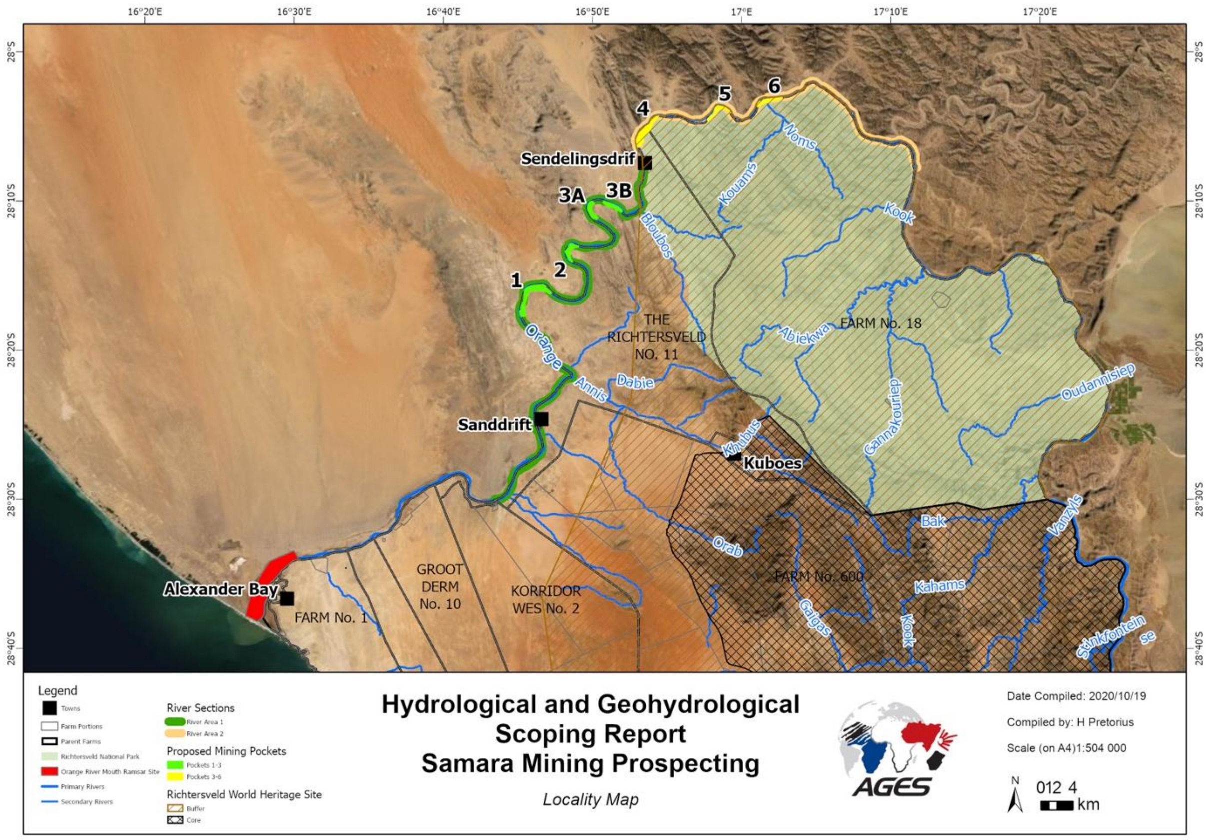

Figure 1: Locality Map

3.1.1 Prospecting Application PR-12663:

This proposed prospecting area is located approximately **3 Km northeast of Sendelingsdrif** in the **Namaqualand Magisterial District** of the Northern Cape Province, South Africa. The proposed prospecting area is within the jurisdiction of the Richtersveld Local Municipality and subsequently the Namakwa District Municipality.

It covers the left (or south eastern) bank of the Orange River, which defines the boundary to Remainder Farm No. 18, with an extent of 690 Hectares.

3.1.2 Prospecting Application PR-12664:

This proposed prospecting area (specifically the proposed pockets) are located approximately **13 km northeast of Sanddrift** (and 11 km southwest of Sendelingsdrift) in the **Namaqualand Magisterial District** of the Northern Cape Province, South Africa. The proposed prospecting area is also within the jurisdiction of the Richtersveld Local Municipality and the Namakwa District Municipality.

It covers the left (or south eastern) bank of the Orange River, which defines the boundary to Remainder Farm No. 11 with an extent of 987.98 Hectares.

3.2 Coordinates of Prospecting Pockets

3.2.1 Prospecting Application PR-12663:

Three pockets, of what is expected to be deeper alluvium, have been identified for prospecting and bulk sampling. The co-ordinates of the centre point for each of the three pockets are:

Pocket 1:	-28.272501°	16.758508°
Pocket 2:	-28.221160°	16.806616°
Pocket 3:	-28.176604°	16.831507°

3.2.2 Prospecting Application PR-12664:

Three pockets, of what is expected to be deeper alluvium, have been identified for prospecting and bulk sampling. The co-ordinates of the centre point for each of the three pockets are:

Pocket 4:	-28.089627°	16.889921°
Pocket 5:	-28.065081°	16.971111°
Pocket 6:	-28.055925°	17.024590°

The proposed prospecting pockets are illustrated in Figure 2.

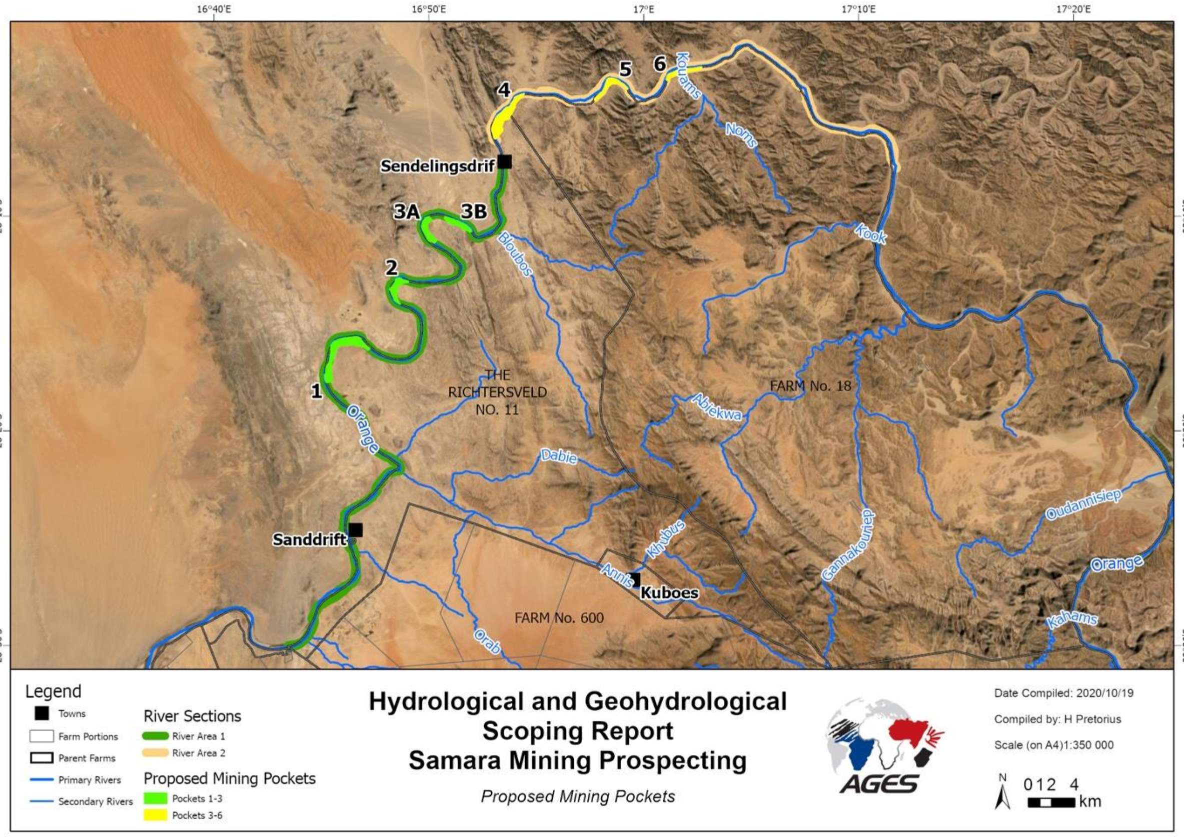

Figure 2: Site Layout – 6 target areas for prospecting and bulk sampling

4 PROPOSED ACTIVITY

Plans for the prospecting and bulk-sampling have not yet been finalised. Provisional indication is that the process will be a 'first of its kind', leading to a 'Pilot' type approach and application during the bulk sampling. Based on the provisional planning, the following proposed activities would have an impact on the groundwater and surface water environment.

4.1 List the Activities

- Excavation of alluvial material from the bed, banks, and various terraces along the Orange River
- Stockpiling the topsoil and overburden to be used as part of the 'temporary' stormwater management infrastructure upgradient of the workings
- Stockpiling of the diamondiferous material from the excavations
- Plant for the screening, concentration, processing and recovery of diamonds from the diamondiferous material
- Water diversion around the excavation site, abstraction and filtration of sediment laden river water from the excavations, and the release of clarified water back to the river channel downstream of the workings
- Stockpiling of the diamond depleted material from the processing plant (waste material) to be used for the continuous rehabilitation of the mined-out excavations
- On-site storage, including fuel and machinery
- Site offices and related infrastructure
- Rehabilitation of the bulk-sample excavations in accordance with environmental guidelines using the diamond depleted material (alluvium) from the processing plant and finally the topsoil from the overburden stockpile

4.2 Description of associated structures and infrastructure related to the development

The required support infrastructure for the alluvial diamond mining will include:

- Ablution facility
- Access roads
- Diesel storage
- Fences

- Office site
- Plant site
- Waste Material stockpile
- Vehicle parking area

4.3 Phases of Development

The proposed mining activities are subdivided into different main phases of the prospecting activities. Each phase consists of different actions and processes with their own related footprints and impacts on the existing environment. Due to the major difference in the proposed activities of each phase, the assessment of the respective impacts will be regarded separately. The various phases in the proposed mining operation considered are defined as:

1. **Construction Phase**: Start-up of operations at the development site in preparation of prospecting and bulk-sampling activities
2. **Operational Phase**: The conditions expected during the active mining phase
3. **Decommissioning & Rehabilitation Phase**: The winding down of activities, the cessation of bulk-sampling, and the Rehabilitation of the excavated and disturbed area
4. **Post-closure Phase**: The "steady-state" conditions, including monitoring following rehabilitation of the site

4.4 Duration of the Activities

The duration of the prospecting and bulk-sampling program has not been finalised. It is expected that this initial phase of bulk-sampling will be completed **within 2 years**.

Based on the results of the prospecting and bulk-sampling, further prospecting may be required, or a mining right will be applied for.

5 POLICY AND LEGISLATIVE CONTEXT / REQUIREMENTS

The following is a broad overview of the relevant policy and legal requirements related to the National Water Act, Act 36 of 1998 applicable to the proposed project.

Table 1: Review of relevant Section 21 Water Uses

National Water Act (Act no. 36 of 1998)
Section 21a – taking water from a resource - Taking (**abstracting**) water from the river, or from boreholes
Section 21c – impeding or diverting the flow of water in a water course - The **diversion** of the water course during the bulk sampling process - The natural flow may also be **impeded** depending on the methodology employed during the prospecting phase
Section 21f – discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit - The clarified water from the filtration process at the prospecting works will be **released to the river** resource
Section 21g – disposing of waste in a manner that may detrimentally impact on a water resource - Topsoil / over burden stockpile - Diamondiferous material stockpile from the bulk- sampling excavation - Diamond depleted stockpile (waste material) from the process plant - Temporary on-site disposal of waste, including Petro-carbons
Section 21i – altering the beds, banks, course or characteristic of a water course - Temporary **altering the course** of the water course - The bulk sampling **excavation** in the 1:100-year flood line (both bed and banks) - The **rehabilitation** of the bed and banks after excavation - The **release of clarified water** (with a lower TSS) into the water course downstream of the workings
GN 704 (GG-20119): Section 26 - Regulation on the Use of Water for Mining and Related Activities Aimed at the Protection or Water Resource. - With excavation and bulk-sampling activities within the 1:100-year flood line, an application for a relaxation of the conditions imposed by GN704 will be required

5.1 Stages at which the competent authority will be consulted

The competent authority will be consulted during:

- Pre-consultation meeting before starting with the project
- Submission of the required 'Technical Reports'
- Site Visit and Liaison during the assessment of the Licence Application

6 INFORMATION SOURCES

The following sources of information were used:

- Topo-Cadastral Map:

  2816 BB, scale 1: 50 000 (digital copy)

  2816 BD, scale 1: 50 000 (digital copy)

  2817 AA, scale 1: 50 000 (digital copy)

- Geological map:

  2816 Alexander Bay, scale 1: 250 000 (digital copy)

- Hydrogeological map series:

  2714 Alexander Bay, scale 1: 500 000

  2718 Upington, scale 1: 500 000

- Remote sensing information:

  GoogleEarth™ image; not to scale (digital image)

  ASTER Satellite Imagery

7 DESCRIPTION OF THE AFFECTED ENVIRONMENT (GEOGRAPHICAL SETTING)

7.1 Land use

Mining and rehabilitation zones have been proposed in the SANPARK's Richtersveld Conservation Development Framework and the project area is characterised by numerous existing mining activities. Figure 3 illustrates the proposed project in context of the mining and rehabilitation zones.

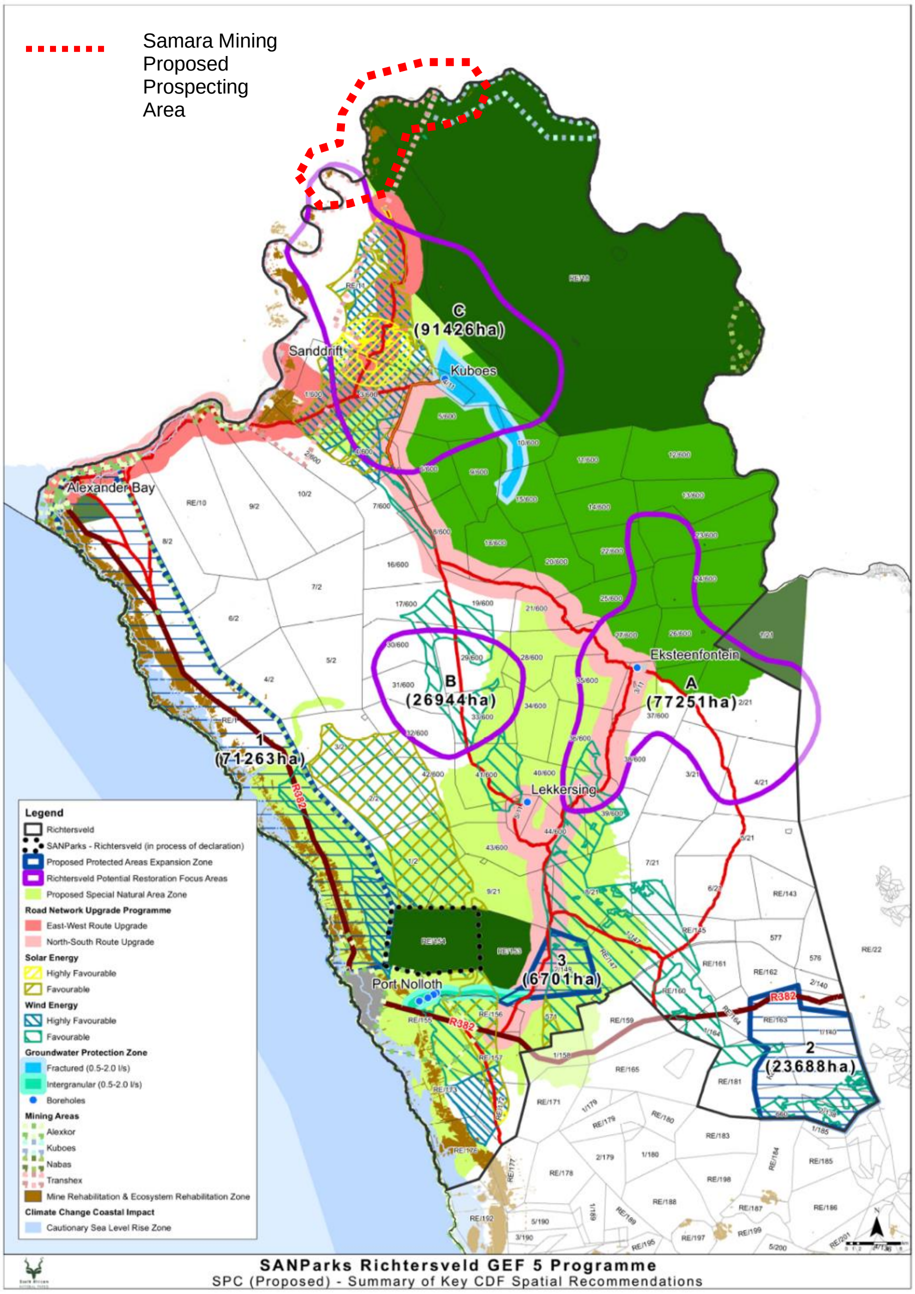

Figure 3: SANParks Richtersveld Conservation Development Framework (Indego Consulting *et al*, 2019)

7.2 Topography and Drainage

The regional topography of the study area classifies as Low Mountains according to ENPAT (2000). More locally, the study area comprises a prominent broad and very gently sloping valley associated with the perennial Orange River that cuts through numerous prominent rocky ridges separated by smaller narrow valleys and lowlands.

The Orange River represents South Africa's largest perennial river that flows mainly West from the prominent highlands of Lesotho in the middle of the sub-continent to its mouth into the Atlantic Ocean at Alexander Bay to the west of the study area. This river forms the border between South Africa and Namibia, and its water is utilized by communities along its course mainly through the Free State, North-West and Northern Cape Provinces of South Africa. The mature downstream portion of the Orange River, in which the study area is located, exhibits a meandering and weakly braided nature. The river enters the study area in the east at an elevation of approximately 36 mamsl, dropping to 18 mamsl in the west over a direct distance of approximately 46 Km. As a result, the river is characterised by low surface flow velocities and deposition of sediments as a result of a very gentle slope (significantly less than 0.5°).

The extreme north-eastern part of the study area is located within Quaternary Catchment (QC) D82J, after which the river flows mainly through QC D82K. The extreme southwestern part falls in QC D82L. The crests of the rocky ridges typically define local watersheds, with the Orange River itself forming the primary surface drainage path towards the west.

7.3 Climate

The study area is located in the Winter Rainfall Season of South Africa, with the regional climatic regime classifying as BWh Arid, Desert, Hot arid according to the Köppen-Geiger Classification System (Conradie, 2012). The available information indicates that the area exhibits a Mean Annual Precipitation (MAP) of **35 mm**, typically in the form of occasional light showers to thunder storms mainly in March and April and extending through the winter season (Figure 3), with a Mean Annual Evaporation (APAN) in excess of 2 600 mm. Rainfall in the area is expected to follow an eight (8) year cycle, ranging from between 0 and 78 mm/year.

Even though precipitation is generally of low intensity, the relatively cohesionless sandy topsoil is prone to scouring by concentrated run off especially in areas exhibiting steep topography. The sandy topsoil throughout the area is highly susceptible to wind-erosion.

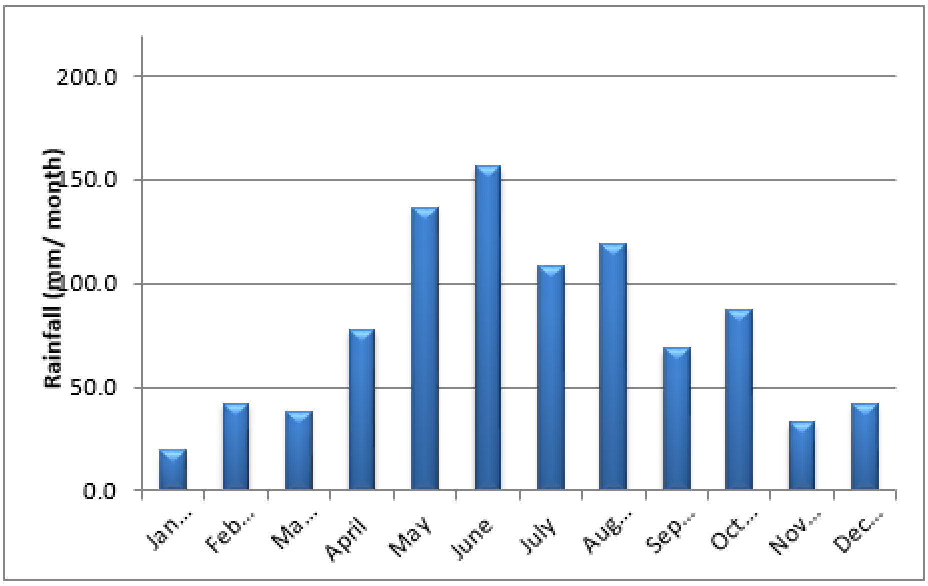

Figure 4: Average rainfall pattern of the study area

7.4 Socio-economic environment

Mining is the dominant economic activity within the Richtersveld Local Municipality. Many of the disadvantaged communities are employed within the mining industry and rely on income from this industry. However, the scaling down of mines and the subsequent decline in the contribution of the mining sector is threatening the employment opportunities for these communities.

8 PLAN OF STUDY

8.1 Aspects to be Assessed by Specialists

The following aspects needs to be considered during the hydrological and geohydrological assessment:

- Current groundwater conditions, groundwater movement, and base flow
- Surface water flow and stormwater management
- Other water users and the impact of bulk-sampling on water use
- The impact of diversion / impeding the river flow
- The impact of changing the water quality by changing the **Total Suspended Solids** (TSS) in the water
  - **TSS may be higher** due to unforeseen breaching of the excavations
  - **TSS may be lower** with clarified water being returned to the river course downstream of the workings

Table 2: Environmental aspects to be assessed

ENVIRONMENTAL ISSUES	POSSIBLE CAUSE	POTENTIAL IMPACTS
	Water quality	
• Pollution of water sources • Pollution by *E. coli* • *Pollution by Petro-carbons* • *Elevated Suspended Solids (TSS)* • Impact on the streams, bed, banks and characteristics of water course • Silt deposition in surface water drainage lines	• Poorly planned and managed sanitation facilities • Spillages of fuel & oil from vehicles during construction • Pollution from solid general waste if not removed regularly • Erosion from area during run-off during heavy rain • Elevated TSS is bulk-sampling excavations are breached • Depleted TSS with filtration of water pre-release	• Changed / **Altered** water quality • Pollution of surface and groundwater • Health risk • Soil degradation • Siltation of aquatic system
	Water quantity	
• Impact on amount of water resources available • Over-use of water allocation • Retarded surface water flow with impeding / diversion of flow	• Water-use during bulk-sampling and processing of diamondiferous material • Mining methods to retard the influx of water flow into the bulk-sampling excavations	• Altered hydraulic characteristics and streamflow • Retarding streamflow during low-flow seasons • Increased evaporation

8.2 Terms of Reference for Specialist Studies

Specialists are to conduct their work in line with the terms of reference as provided for under Regulation 13 of the NEMA EIA Regulations 2014 (GNR 326).

One **Specialist Scoping Report** and one **Impact Assessment Report** will be compiled for the two applications. Where necessary unique impacts based on a specific application area will be highlighted, or if different mitigation measures are required based on the section of the Orange River (either PR-12663 or PR-12664 areas).

Due to restricted timeframes, specialists will focus on preparing a desktop Scoping Report to confirm sensitive areas requiring assessment during the impact phase. Site investigations and a full impact report will be prepared during the EIA phase.

Key deliverables therefore include:

- Scoping Report based on desktop investigations of application areas;
- Field Investigations: January 2021 or earlier;
- Impact Assessment Report – by 5 March 2021
- Attend a feedback workshop with NEC, NDI and Samara;
- Attend Public Participation Meetings during the EIA Phase (if necessary); and
- Address any comments from I&APs relevant to specialist studies

To Note:

- The inclusion in a multidisciplinary team for on-going monitoring and compliance reporting has not been included in this phase of the investigation. The water management and monitoring programme will define the required actions in this regard.

8.3 Scope of Work

The Scope of Works for the required specialist studies is detailed in the sections below.

- Delineate the study area and conduct a literature review on all existing hydrological, geological, and geohydrological information within the study area;
- Identify and screen potential surface and groundwater impacts including potential impacts to existing water users;
- Compile a Hydrological and Geohydrological Scoping Report;
- Conduct a site assessment/terrain assessment for data verification;
- Conceptual modelling of the groundwater flow and hydrological environments;
- Preparation of site sensitivity maps showing surface and groundwater features based on findings of the desktop review and site survey;

- Assess potential impacts on surface and groundwater (quality, quantity, etc.) associated with the prospecting right activities as well as the significance of impacts/risks;
- Assess the impact from the prospecting activities on existing water users;
- Identify any fatal flaws associated with the prospecting activities and method of prospecting from a surface and groundwater perspective;
- Compile a Stormwater Management Plan in support of the water use authorisation;
- Produce geohydrological and hydrological Technical Reports in support of the water use authorisation which is also to highlight key mitigatory and management measures to minimise impacts on affected ground and surface water features;
- Provide a clear mitigation, monitoring plan and action items for effective rehabilitation;
- Compile a surface water and groundwater management plan and monitoring protocol;
- The assessment is to satisfy the requirements of the NEMA EIA Regulations and the NWA WUL Application as well as the relevant MPRDA regulations.

8.3.1 Hydrological

- Form baseline Impact Assessment by:
    - Collation and review of available daily rainfall data;
    - Description of annual and seasonal climatic regimes for local study area based on regional and local climatic data;
    - Description of annual and seasonal surface water regimes (mean annual yield, mean monthly flows, flood flows, low flows) for the local study areas based on regional and local hydrological data;
    - Develop an inventory of water users based on available information;
- Impact Assessment:
    - Potential impacts of prospecting and bulk-sampling on the watercourses within the study area based on the proposed excavation methods
        - It is noted that deviation from proposed bulk-sampling and excavation methods may result in different impacts, which are not contemplated as part of this assessment
    - Potential impacts on hydrological, drainage and land cover changes on surface erosion, sedimentation and flows in river;
    - Potential impacts of erosion and sedimentation on surface water supply and downstream users based on the proposed mining methods;
    - Recommendations for surface water mitigation options to be considered for implementation for adverse effects anticipated (must include cumulative and residual impacts);

- Establish baseline water quality at the site, upstream and downstream;

8.3.2 Geohydrological

- Potential impacts on existing groundwater users;
- Impact on groundwater quality of existing users;
- Develop various mitigation options, if necessary;
- Make a prediction of the impact on the groundwater regime and assess the potential impact of the proposed project activities on the groundwater regime.

8.3.3 Stormwater Management Plan

A Stormwater Management Plan must be developed according to available MAP, rainfall data, catchment area, prospecting infrastructure, surface water drainage lines, and river flow.

To develop the plan, the following information will need to be gathered and tasks conducted:

- Local daily rainfall data will need to be collected and reviewed to determine rainfall statistics;
- Confirm catchment areas;
- Use the proposed project infrastructure layout to identify clean and dirty water areas;
- Set up a design criterion for sizing of stormwater management measures;
- Set up a model to determine the layout and expected peak flow volumes that conveyance structures would need to contain;
- Communicate results to applicant/engineers for design where applicable.

To Note:

- The stormwater management plan does not include the engineering design of the required stormwater structures.

8.4 Public Participation

Information included in this Scoping Report, as well as future EIA reports, will describe the process, the environment of the proposed project as well as the impact assessment of the processes on the environment. The public participation process where the project is presented to interested and affected parties (I&AP) is an important aspect to gain the support and acceptance of the proposed project.

The public participation process and meetings will be facilitated by the Environmental Specialists as part of the Environmental Impact Assessment process. The role of AGES in this process would be to:

- Attend Public Participation Meetings during the EIA Phase, and
- Address any comments from I&APs relevant to specialist studies.

8.5 Outcome of Hydrological and Geohydrological study:

- Geohydrological and Hydrological Scoping Report
- Conceptual Groundwater and Hydrological Model
- Surface water and Groundwater Management Plan and Monitoring Protocol
- Stormwater Management Plan
- Geohydrological and Hydrological Technical Reports and Assessment in support of the WULA

9 METHODOLOGY

The hydrological and geohydrological assessment will be implemented in a phased approach where each successive phase is based on the findings and results from subsequent phases.

9.1 Desk Study

- Review and evaluate existing data and perform a site description on the geology and geohydrology of the site
- Interpretation of remote sensing data to identify possible geological lineaments
- Study area delineation and conceptualising of local hydrological and geohydrological conditions

9.2 Determine the site-specific geological character

- Review and research all the available geological literature and studies conducted in the area
- Terrain assessment and walk-over survey to assess the available information and to map the visible geological features
- Compilation of site-specific geological map

9.3 Determine the site-specific hydro and geohydrological character

- Conduct hydro-census within 1 Km radius of the prospecting site, with documentation of ground- and surface water occurrences, abstraction and end-use, with the taking of up to 3 surface water samples for laboratory testing
- Analyses of ground- and/or surface water samples (up to 3) by reputable water laboratory for suspended solid, macro-chemical- and micro-biological composition
- Compile a list from available information of all the **existing water users** in the area
- Interpretation of results obtained from field work and laboratory tests

9.4 Geo-Physical Survey

- A geophysical survey has <u>not</u> been planned for the hydrological and geohydrological assessment. Detailed geophysical surveys will be planned for the operational phase of the operation.

9.5 Drilling and Siting of Boreholes

- The drilling and development of boreholes will be defined as prerequisites to be implemented during the **operational phase** of the prospecting activities. The development of monitoring boreholes will be sited to characterize the local geological- and geohydrological setting at depth. Any borehole developed for monitoring are to be completed to DWS standards for long-term monitoring purposes.

9.6 Aquifer Testing

- Suitable aquifer tests will be conducted once the monitoring boreholes have been drilled and developed (operational phase). The aquifer tests will be required to determine the hydraulic parameters of the unsaturated- and saturated zones.

9.7 Sampling and Chemical Analysis

- Analyses of surface and groundwater samples by reputable water laboratory for suspended solids, macro-chemical, micro-biological and organic composition

9.8 Water Flow Modelling

9.8.1 Recharge Calculations

- Conceptual surface and groundwater modelling will be compiled. Results will be updated as monitoring borehole data becomes available during the operational phase of the prospecting.

- The conceptual surface water and groundwater model will be used to estimate the groundwater recharge and baseflow in the vicinity of the prospecting sites.

9.8.2 Hydrological Flow

- The conceptual model will be expanded to an analytical surface water model to determine the flood-lines, and the possible changes to the flow regime due to the prospecting and bulk-sampling activities.

9.8.3 Groundwater Availability Assessment

- The availability of groundwater will be based on the results the conceptual model, and the drilling and testing results from the developing of the monitoring boreholes.

10 PREVAILING HYDROLOGICAL AND GEOHYDROLOGICAL CONDITIONS

10.1 Geology

10.1.1 Regional Geology

The lower Orange river basement geology is dominated by rocks of the Richtersveld supergroup. These rocks formed during the middle to late Proterozoic age (2 Ma to 5 Ma). Over time rocky mountain landscape has formed, forcing the Orange river to pierce through the mountains changing directions (meandering), losing energy and depositing minerals. Alluvial diamonds in the study area are a result of transportation of eroded diamonds from kimberlitic sources.

There is already diamond mining taking place in the area by the company named Trans Hex mining. This company has had mining rights since the seventies and over years expanded their area of operation.

10.1.2 Local Geology

- Pocket 1 area is underlain by schist, dolomites, metapelites and arenites rocks of the Kaigas formation with north south strike direction dipping to the west.
- Pockets 2 and 3 are underlain by tillites, dolomites and iron formations of the Hilda sub-group and the Kaigas and Numees formation.
- Much older granites of the Orange River Group underlie Pocket 4 area.

10.2 Acid Generation Capacity

The project area is not dominated by rocks containing sulphides, which have an influence on acid generating capacity. The acid generating capacity of the local geology is low.

10.3 River and Alluvial Systems

The Orange River is south Africa's largest river flowing all the way from Lesotho and used by villages along the way towards the western part of South Africa. The river flows in westward direction towards Alexander bay where it flows into the Atlantic Ocean.

The paleo channels in the study area have been cut off from the present Orange River Valley. Changes in the direction of the river over years has resulted in the remnants in the study area due to river meandering. The deposition of heavy minerals happened where the river lost energy due to change in direction that was caused by obstructions, junctions of cross-channel, rising bedrock etc. Deposits of alluvial diamonds are limited to remnant paleo-channels systems that formed later.

10.4 Hydrogeology

10.4.1 Unsaturated Zone

Portion of the subsurface in which pores are filled by either water or air is called the unsaturated zone. This zone contains natural organisms which have the ability to break down contaminants into secondary products (Hasiniaina et al., 2010). Gneiss, Namaqua metamorphic rocks predominates the unsaturated zones of the study area. The mining site is covered by sand to loamy sand.

10.4.2 Saturated Zone

Pockets 1-3 has fractured and intergranular aquifers and pockets 4 to 6 are characterised by fractured and weathered aquifer. The water table is between 30 and 38 mbgl. The underlying aquifer is regarded as an inter-granular and fractured aquifer, with typical borehole yields ranging from 0.0 - 0.1 l/s. The aquifer has null (zero) contribution to base flow, with null (zero) Average Groundwater Resource Potential (GRA 2012). According to the Vegter Harvest Potential the area is characterised by a resource potential of 500 m3/km^2/annum, with an annual groundwater recharge of 0 - 1 mm.

10.4.3 Hydraulic Conductivity

The hydraulic conductivity of the aquifer where the mining site is proposed is $1x10^1$ – $1x10^{-5}$ and $1x10^1$ – $1x10^{-1}$. These aquifers have **low hydraulic conductivity**.

10.5 Groundwater Levels

Groundwater levels in the study area varies between **30 and 39 mbgl**.

10.6 Groundwater Potential Contaminants

- Petro-chemicals – particularly from heavy machinery
- Increased sediment load (TSS) due to the mining process and disturbance of the alluvium in and along the riverbanks
- Possible e-coli contamination from on-site sanitation

10.7 Groundwater Quality

- Background water quality would be an important baseline for assessing contamination of the groundwater resource.

10.8 Aquifer Characterisation

10.8.1 Groundwater Vulnerability

Groundwater vulnerability is affected by the type of aquifer; the more fractured and the higher permeability of the rock, the higher the vulnerability (Keyser, 1997). The proposed prospecting area has low groundwater vulnerability.

10.8.2 Aquifer Classification

The classification scheme (Parsons, 1995) was created for strategic purposes as it allows the grouping of aquifer areas into types according to their associated supply potential, water quality and local importance as a resource.

Parson’s classification system together with the revised version produced by the Department of Water Affairs and Forestry (DWAF) in 1998 is shown in *Table 3*.

The aquifer at the site is classified as a ***minor aquifer system*** according to both systems.

10.8.3 Aquifer Protection Classification

Groundwater Priority Zones. Due to the reliance on groundwater in most parts of the Richtersveld Local Municipality, all wellhead areas and aquifer yield zones must be protected. On a municipal scale, a Groundwater Management Plan is urgently needed, (Harrison, et al., 2019). The interim measures proposed by the authors are: to place High Yield Aquifer Protection Zones of 250 – 500m around the Kuboes and Port Nolloth aquifers; and to place 50 m wellhead protection zones around boreholes, especially those supplying the Richtersveld towns (Harrison, et al., 2019).

Table 3: Aquifer classification scheme (Parsons, 1995)

Aquifer System	Defined by Parsons (1995)	Defined by DWAF Min Requirements (1998)
Sole Source Aquifer	An aquifer which is used to supply 50 % or more of domestic water for a given area, and for which there are no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.	An aquifer, which is used to supply 50% or more of urban domestic water for a given area for which there are no reasonably available alternative sources should this aquifer be impacted upon or depleted.
Major Aquifer	High permeable formations usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (<150 mS/m).	High yielding aquifer (5-20 L/s) of acceptable water quality.
Minor Aquifer	These can be fractured or potentially fractured rocks, which do not have a high primary permeability or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important both for local supplies and in supplying baseflow for rivers.	Moderately yielding aquifer (1-5 L/s) of acceptable quality or high yielding aquifer (5-20 L/s) of poor-quality water.
Non-Aquifer	These are formations with negligible permeability that are generally regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer as unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and need to be considered when assessing the risk associated with persistent pollutants.	Insignificantly yielding aquifer (< 1 L/s) of good quality water or moderately yielding aquifer (1-5 L/s) of poor quality or aquifer which will never be utilised for water supply and which will not contaminate other aquifers.
Special Aquifer	An aquifer designated as such by the Minister of Water Affairs, after due process.	An aquifer designated as such by the Minister of Water Affairs, after due process.

10.9 Surface water and Groundwater Modelling

10.9.1 Conceptual Water Flow

The Orange River represents South Africa's largest perennial river that flows mainly westwardly from the prominent highlands of Lesotho in the middle of the sub-continent to its mouth into the Atlantic Ocean at Alexander Bay to the west of the study area. This river forms the border between South Africa and Namibia, and its water is utilized by communities along its course mainly through the Free State, North-West and Northern Cape Provinces of South Africa. The mature downstream portion of the Orange River, in which the study area is located, exhibits a meandering and weakly braided nature. The river enters the study area in the east at an elevation of approximately 36 mamsl, dropping to 18 mamsl in the west over a direct distance of approximately 46 Km. As a result, the river is characterised by low surface flow velocities and deposition of sediments as a result of a very gentle slope (significantly less than 0.5°).

The underlying aquifer is regarded as an inter-granular and fractured aquifer, with typical borehole yields ranging from **0.0 - 0.1 l/s**. The aquifer has nul (zero) contribution to base flow, with nul (zero) Average Groundwater Resource Potential (GRA 2012).

According to the Vegter Harvest Potential the area is characterised by a resource potential of 500 m^3/km^2/annum, with an annual groundwater recharge of 0 - 1 mm.

11 GEOHYDROLOGICAL RISK & POLLUTION RISK ASSESSMENT

11.1 Method used to Classify the Risk

An environmental impact is defined as a change in the environment, be it the physical/chemical, biological, cultural and or socio-economic environment. An impact can be related to certain aspects of human activities in this environment and this impact can be either positive or negative. It could also affect the environment directly or indirectly and the effect of it can be cumulative.

The impacts on the groundwater and surface water environment are identified and ranked based on the specialist assessments, site visits applying expert opinion and by using a **matrix** to rate the impacts with and without mitigation measures.

To assess the impacts on the environment, the process will be divided into **four (4)** main phases namely the '**Construction'** phase, the '**Operational**' phase, the '**Decommissioning**' or Rehabilitation phase, and the '**Post Closure'** and Monitoring phase. The activities, products and services present in these phases will be accessed to identify and predict all possible impacts to the hydrological and geohydrological.

In any process of identifying and recognising impacts, one must recognise that the determination of impact significance is inherently an anthropocentric concept, (Duinker and Beanlands, 1986 in DEAT 2002). Thompson (1988, 1990) in DEAT (2002) stated that the significance of an impact is an expression of the cost or value of an impact to society. However, the tendency is always towards a system of quantifying the significance of the impacts so that it is a true representation of the existing situation on site. This will be done by using wherever possible, legal, and scientific standards which are applicable.

In order to ensure uniformity, a standard impact assessment methodology will be utilised so that a wide range of impacts can be compared. The significance of the aspects/impacts of the process will be rated by using a matrix derived from Plomp (2004) and adapted to some extent to fit this process. These matrixes use the consequence and the likelihood of the different aspects and associated impacts to determine the significance of the impacts.

This system derives environmental significance on the basis of the consequence of the impact on the groundwater environment and the likelihood of the impact occurring.
The **consequence** matrix uses parameters like severity, duration and extent of impact as well as compliance to standards. Numerical values of 1 - 5 are assigned to the various parameters.

These values are added together and averaged to determine the overall consequence of the impact / activity. A similar process is followed with the **likelihood** of the impact. This matrix consists of two parameters, namely frequency and probability.

The overall consequence and the overall likelihood are then multiplied to give a numerical value ranging from 1 to 25.

Thus, consequence is calculated as the average of the sum of the ratings of severity, duration and extent of the environmental impact. Likelihood considers the frequency of the activity together with the probability of an environmental impact occurring and allocates a number based on the average of these two factors.

Table 4: Impact Assessment Methodology

SEVERITY of the impact **DURATION** of the impact SPATIAL SCALE (**EXTENT**) of the impact	**Consequence**	**Significance**
FREQUENCY of the ACTIVITY **PROBABILITY** of the OCCURRENCE of the impact	**Likelihood**	

11.2 Determining Consequence

Table 5: Rating of Impact Severity

Assessment and Rating of Impacts Severity	
Rating	**Description**
1	Negligible/ non-harmful / minimal deterioration
2	Minor/ potentially harmful / measurable deterioration
3	Moderate / harmful / moderate deterioration
4	Significant / very harmful / substantial deterioration
5	Irreversible / permanent

Table 6: Rating of Impact Duration

Assessment and Rating of Impacts Duration	
Rating	**Description**
1	Less than 1 month / quickly reversible
2	Less than 1 year / quickly reversible
3	More than 1 year / reversible over time
4	More than 10 years / reversible over time / life of project or facility
5	Beyond life of project of facility / permanent

Table 7: Rating of Impact Extent

Assessment and Rating of Impacts Extent	
Rating	**Description**
1	Within immediate area of activity
2	Surrounding area within project area
3	Beyond project boundary
4	Regional / provincial
5	National / international

Table 8: Rating of Impact Consequence

Determination of Impacts Consequence	
Determination of Consequence (C)	**(Severity + Duration + Extent) / 3**

11.3 Determining the Likelihood

Table 9: Rating of Impact Frequency

Assessment and Rating of Impacts Frequency	
Rating	**Description**
1	Less than once a year
2	Once a year
3	Quarterly
4	Weekly
5	Daily

Table 10: Rating of Impact Probability

Assessment and Rating of Impacts Probability	
Rating	**Description**
1	Almost impossible
2	Unlikely
3	Probable
4	Highly likely
5	Definite

Table 11: Rating of Likelihood

Determination of Likelihood	
Determination of Likelihood (L) =	**(Frequency + Probability) / 2**

11.4 Determining Overall Impact and Environmental Significance

The overall significance of an event on the risk of groundwater pollution is determined using the matrix in Table 12.

Table 12: Significance ratings for negative (top) and positive (bottom) impacts (Plomp, 2004)

Significance	Low -	Low-Medium -	Medium -	Medium-High -	High -
Overall Consequence X Overall Likelihood	1-4.9	5-9.9	10-14.9	15-19.9	20-25

Significance	Low +	Low-Medium +	Medium +	Medium-High +	High +
Overall Consequence X Overall Likelihood	1-4.9	5-9.9	10-14.9	15-19.9	20-25

12 HYDROLOGICAL AND GEOHYDROLOGICAL IMPACTS

12.1 General

The expected project activities required for the prospecting, bulk-sample excavation, and the processing of the diamondiferous material is considered in the context of the risk to the local and regional environment.

Table 13 presents the potential impact and the activities that are expected during prospecting, the phase in which the activities occur, and the environmental significance of the impact.

Table 13: Hydrological and Geohydrological Risk Assessment

Potential Impact	Phase				Activity	Consequence				Likelihood			Significance	
	Construction	Operational	Decommissioning	Post Closure		Severity	Duration	Extent	Consequence	Frequency	Probability	Likelihood	Rating	Classification
Clear vegetation, soil compaction, erosion, contamination and pollution of the local environment (including surface and groundwater)	1	1	1		**Establish, develop, and maintain the site** with access roads, parking, offices, ablution facilities, storage facilities, fences, and the processing plant site	4	3	1	**3**	5	5	**5**	15	M-H
Erosion, increased sediment load during rainfall events, change the paths of local water flow	1	1	1		**Stockpiling the topsoil** and overburden to be used as part of the 'temporary' stormwater management infrastructure upgradient of the workings	3	3	1	**2**	5	5	**5**	10	M
Alter the river course and flow characteristics, increased sedimentation, increased water flow velocity, and or reduced river flow volume		1	1		**Water diversion and impeding of water** flow to limit the ingress of water to the excavations	4	3	3	**3**	5	5	**5**	15	M-H
Altering the beds, banks and characteristics of the water course, increased sediment load during rainfall events (**elevated TSS**)		1	1		**Excavation** of alluvial material from the bed, banks, and various terraces along the Orange River	4	3	4	**4**	5	5	**5**	20	H
Reduction of river flow volumes, change in the water quality (**decreased TSS**)		1	1		**Abstraction and filtration** of sediment laden water from the excavations to be used in the plant with the **release of filtered** / clarified water back to the **river channel** downstream of the workings	4	3	4	**4**	5	5	**5**	20	H
Erosion, increased sediment load during rainfall events, change the paths of local water flow		1	1		**Stockpiling** of the diamondiferous material from the excavations outside of the 1:100-year flood line	3	3	1	**2**	5	5	**5**	10	M
Pollution (including Petro-chemicals), erosion, increased sediment load during rainfall events		1	1		**Operation of the plant** for the screening, concentration, processing and recovery of diamonds from the diamondiferous material	3	3	2	**3**	5	5	**5**	15	M-H
Erosion, increased sediment load during rainfall events, change the paths of local water flow		1	1		**Stockpiling of the diamond depleted material** from the processing plant (***waste material***) to be used for the continuous rehabilitation of the mined-out excavations	3	3	1	**2**	5	5	**5**	10	M
Erosion, increased sediment load, alteration of the water course			1		**Rehabilitation of the bulk-sample excavations** according to environmental guidelines using the diamond depleted material (alluvium) from the processing plant and finally the topsoil from the overburden stockpile	3	4	4	**4**	5	5	**5**	20	H
Degrading of the rehabilitated site, increased erosion, increased sediment load, long-term alteration of the water course	1	1	1	1	On-going **sampling and monitoring** of the groundwater, surface water, and water quality	2	3	4	**3**	3	3	**3**	9	L-M

12.2 Impacts during the Construction Phase

12.2.1 Impacts on Groundwater

- None

12.2.2 Impacts on Surface Water

- Increased localized run-off and flow due to compaction

12.2.3 Impacts on Water Quality

- Possible e-coli contamination from on-site sanitation
- Possible Petro-chemical contamination from machinery
- Increased risk of erosion and sediment load

12.3 Operational Phase

12.3.1 Impacts on Groundwater

- Depressed static water level, and localised dewatering

12.3.2 Impacts on Surface Water

- Change in the localised drainage and flow paths with an increased localized run-off and flow
- Alter the bed, bank, and characteristics of the water course – both **volume** and **velocity**

12.3.3 Impacts of Water Quality

- Possible e-coli contamination from on-site sanitation
- Possible Petro-chemical contamination from machinery
- Increased risk of erosion and sediment load
- Elevated TSS from the excavations, and or a decrease in TSS from the release of clarified return water to the river course

12.4 Decommissioning Phase

12.4.1 Impacts on Groundwater

- Depressed static water level, and localised dewatering

12.4.2 Impacts on Surface Water

- Change in the localised drainage and flow paths with an increased localized run-off and flow
- Alter the bed, bank, and characteristics of the water course – both **volume** and **velocity**

12.4.3 Impacts of Water Quality

- Possible e-coli contamination from on-site sanitation
- Possible Petro-chemical contamination from machinery
- Increased risk of erosion and sediment load
- Elevated TSS from the rehabilitation, and or a decrease in TSS from the release of clarified return water to the river course

12.5 Post Mining Phase

12.5.1 Impacts on Groundwater

- None

12.5.2 Impacts on Surface Water

- Alter the bed, bank, and characteristics of the water course – both **volume** and **velocity**

12.5.3 Impacts of Water Quality

- Increased risk of erosion and sediment load if there is a degrading of the rehabilitation

12.6 Degree to which impacts can be reversed

- The provisional planning is for full rehabilitation of the bulk-sampling excavations using the same material that was excavated.
- The rehabilitation will be according to the environmental guidelines and is to be properly filled and compacted to ‘fully’ restore the beds and banks of the water course.
- Good monitoring and management, good housekeeping on site during all phases of the project, and diligent attention to details during rehabilitation could result in a fully restored site.

13 MONITORING & MANAGEMENT PLAN

13.1 Preamble

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

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

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

Effective water monitoring systems for the prospecting and bulk-sampling consist of the following components:

- Surface water/groundwater quality monitoring system.
- Flow/water level monitoring system.
- Data and information management system.

When designing the monitoring system, the following issues must also be considered:

- Potential or actual water use

- Aquifer or catchment vulnerability
- Water quality of any water discharged or released to the environment
- Toxicity of chemicals
- Potential for seepage or releases
- Quantities and frequency of release to the environment (point and non-point).
- Management measures in place to minimize risk.

13.2 Monitoring Plan for the proposed Prospecting

As part of the water management program at the proposed prospecting and bulk-sampling excavations, it is necessary to understand:

- The changes in groundwater flow/levels within the different excavation pits and to monitor how this change with time.
- The development of a cone of depression and how this extends into the alluvial system over time.
- The pollution and possible sediment loading from the bulk-sampling and to monitor how the pollution changes with time.

The overarching water management action that is of interest for this specific prospecting right and bulk-sampling can, therefore, be defined as:

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

The data requirements are dictated by:

- Area influenced by groundwater dewatering, surface water flow, and flooding.
- Groundwater and surface water abstraction and release points
- Indicators of pollution and changes in water quality from either point or diffuse sources of pollution in relation to the associated pathways

13.3 Monitoring network

A monitoring network will be defined as part of the detailed hydrological and geohydrological assessment of the site. The network will include:

- possible monitoring boreholes both upstream and downstream of the working,
- river sampling points to assess the change in river water quality,
- water volumes – both abstraction and release back to the environment;
- localised rainfall.

13.4 Monitoring Parameters

The identification of the monitoring parameters is crucial and depends on the chemistry of possible pollution sources. The monitoring parameters comprise a set of **physical** and **chemical** parameters, including groundwater levels, cumulative abstraction volumes, predetermined organic and inorganic chemical constituents.

Details of the monitoring and water management plan for each phase of the operation will become clearer as the hydrological and geohydrological assessment are completed.

13.5 Monitoring Frequency

The first monitoring cycle should be conducted **prior to the initiation of the construction** phase in order to confirm the baseline data set as a reference point to evaluate future data.

Subsequent monitoring as part of a multidisciplinary team will be planned and scheduled based on the operational plan and the results of the hydrological and geohydrological assessment. It is noted that different monitoring frequencies may be recommended for the various phases of the prospecting development

13.6 Implementation of the Water Management Plan

The implementation of the groundwater management plan will ensure that the risks identified during the groundwater and surface water risk assessment are addressed and mitigated and that water pollution will be timeously detected so that remedial actions may be implemented. A comprehensive water management plan will be compiled based on the operational plan and the results of the hydrological and geohydrological assessment.

13.7 Data Storage and Reporting

All data must be stored electronically. A backup of the data base must be stored in a safe place. Backups should be made every time the database is updated.

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

14 MITIGATION MEASURES

A number of mitigation measures and management protocol will be defined based on the site-specific assessment and investigation. In general, the following principles apply:

14.1 Short term (Construction & Operational phases) mitigation measures

1. **Site specific mitigation measures** must include at least the following:
   - **Pave and bunded areas** around the workshops
   - **On-site sanitation** must be in accordance to DWS guidelines
   - Surface water from the excavations or groundwater from pits must be pumped to **designed impoundments** for treatment / filtration before reintroduction into the environment.
2. **Runoff from stockpiles** must be contained and pumped to pollution treatment dams for treatment / filtration before being reintroduction into the environment.
3. **Spills** must be cleaned up according to relevant regulations
4. The **Water Management Plan** should be implemented, including the monitoring and assessment of the changes in water levels and water quality.

14.2 Long term (Operational, Decommissioning, & Post-closure) mitigation measures

1. The **Water Management Plan** should be implemented, including the monitoring and assessment of the changes in water levels and water quality.
2. **Runoff from stockpiles** must be contained and pumped to pollution treatment dams for treatment / filtration before being reintroduction into the environment.
3. **Spills** must be cleaned up according to relevant regulations
4. Full and **comprehensive remediation** of all excavations must be done in full compliance with the **environmental guidelines**. Correctly filled and compacted material will ensure that the rehabilitation will, as far as possible, return the excavations to their natural – pre-bulk-sampling state.

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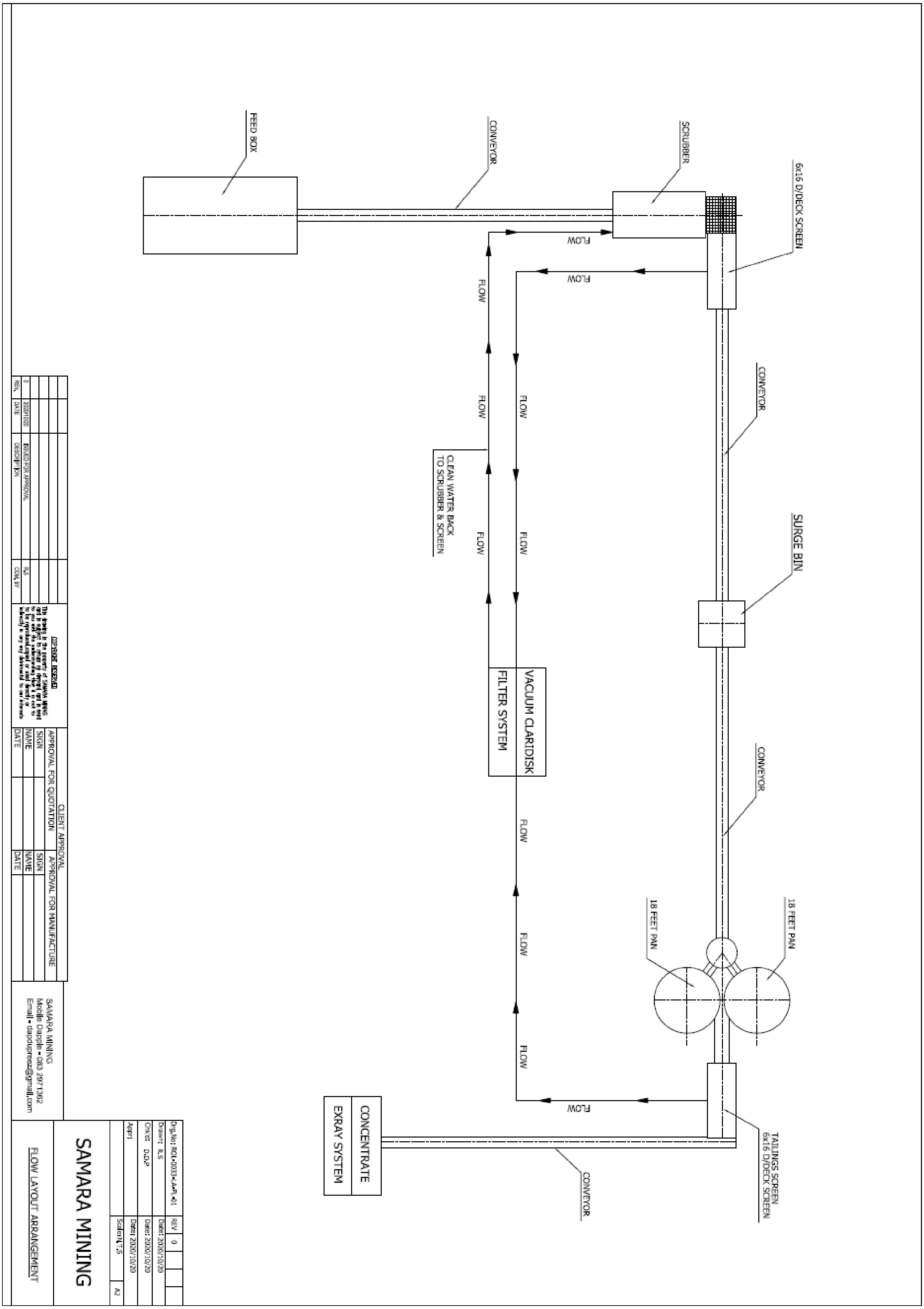
APPENDIX A:

FLOW LAYOUT ARRANGEMENT


FEED BOX
CONVEYOR
SCRUBBER
6x16 D/DECK SCREEN
FLOW
CONVEYOR
SURGE BIN
CONVEYOR
18 FEET PAN
18 FEET PAN
TAILINGS SCREEN
6x16 D/DECK SCREEN
CONVEYOR
CONCENTRATE
EXRAY SYSTEM
VACUUM CLARIDISK
FILTER SYSTEM
CLEAN WATER BACK
TO SCRUBBER & SCREEN
REV. DATE DESCRIPTION
ISSUED FOR APPROVAL
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APPROVAL FOR MANUFACTURE
SIGN
NAME
DATE
SAMARA MINING
SAMARA MINING
FLOW LAYOUT ARRANGEMENT