SAXON HEAVY MINERALS (Pty) Ltd

HEAVY MINERAL SANDS PROJECT, MITCHELL'S BAY, NORTHERN CAPE

SURFACE AND GROUNDWATER ASSESSMENT

Dr. J. Hattingh
Creo Design Pty (Ltd)
PO Box 932
Stellenbosch, 7599

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Surface and Groundwater Resources

Introduction

The SAXON Heavy Mineral Sand prospecting project ("the project area") is situated in the coastal zone between Hondeklip Bay and the mouth of the Spoeg River some 10km south of Hondeklip Bay. The west coast of Namaqualand falls in the tropical desert, arid, hot climatic region of South Africa, according to the Koeppen classification. The climate of this area is controlled by altitude, topography and distance from the sea. Climatological data for the project area (i.e. precipitation, evaporation and temperature) were received from the South African Weather Bureau, Computing Centre for Water Research and data from the WR90 publication of Midgeley *et al.* (1994).

Surface water

The mean annual precipitation (MAP) varies from 44 mm in the coastal zone area to 480 mm in the Kamies Mountains some 70km east of the project area. Higher rainfall in the higher lying areas is a result of orographic rainfall. Rainfall mostly occurs during the winter months and thus falls within the Mediterranean climate zone of Southern Africa. High incidences of fog days on the West Coast of South Africa contribute significant moisture to the coastal areas of Namaqualand.

The average annual evaporation rate for this area is measured at 1,900mm and the combined effect of low rainfall and high evaporation rates result in extremely dry conditions. The monthly distribution of average daily maximum temperatures shows that the average midday temperatures for Hondeklip Bay range from 20.6°C in July to 27.5°C in January. The region is the coldest during July when the mercury drops to 8.3°C on average during night time.

From September to early April, late morning to afternoon south-westerly winds can reach gale force velocities in excess of 70km/h. North-westerly winds are the dominant wind in winter when cold fronts reach the coast from the southern Atlantic Ocean. Occasional hot, dry easterly katabatic winds, locally known as "berg winds", in winter can result in drastic temperature increases during these events reaching 40°C and resulting in extreme temperature variations of up to 30°C.

Data obtained from the Springbok weather station shows that a large variation in rainfall over the last 120-year period prevails. A plot of the annual rainfall over the period minus the MAP over the period (217 mm) shows an oscillation between wet and dry years seems to exist with a quasi-12 year return period. The wet and dry cycles have a significant impact on groundwater recharge. Periods of above average rainfall will contribute much more to recharge than the drier periods.

On a larger time scale major rainfall periods occurred between 1913-1918, 1939-1943, 1950-1955 and 1992-1997 lasting for 5 to 6 years. At the start of 1992 an 83-year return period of excessive rainfall (since ~1909) was observed peaking during the 1996-1997 seasons. These high rainfall periods produced several flood events. The main flood event occurred during the 1997 season, however, higher rainfall was recorded the previous year. The last although smaller wet spell was experienced during 2008 to 2011.

The prospecting area falls within Water Management Area (WMA) 6 – Lower Orange, and straddles the catchment divide between quaternary catchments F40D and F40F (DWAF 2004) (Table 1).

Table 1: Catchment data for the Spoeg and Swartlintjies River systems.

Catchment	Gross Area (km^2)	Mean Annual Evaporation (MAE) (mm)	Mean Annual Precipitation (MAP) (mm)	Mean Annual Runoff (MAR) (mm)	MAP-MAR RESP	NET MAR (10^6m^3)	Gross MAR (10^6m^3)	Coefficient of Variation (CV)
F40D	741	1900	123	0.4	6	0.2	0.3	1.343
F40F	682	1900	118	0.4	6	0.2	0.3	1.358

Catchment F40D to the north of the site and drained by the Swartlintjies River
Catchment F40F to the south of the site and drained by the Spoeg River

The natural mean annual runoff of all the coastal catchments in the WMA, which stretch some 285km from Strandfontein in the south to Alexander Bay at the mouth of the Orange River in the north, is estimated to be 24 million cubic metres (Mm^3). All rivers in the area except the Orange River are ephemeral / episodic, and flow only sporadically in response to high rainfall events, mostly in their upper catchments, remote from the coast, where annual rainfall exceeds 400mm. As a result, available reliable yield from surface water sources in all the coastal catchments is estimated to be zero, while reliable yield from groundwater from the catchments is estimated to be a total of 3 Mm^3/a.

Spoeg River

The South African National Biodiversity Institute (SANBI) National Wetland Classification system, classifies the Spoeg River as an Inland system falling within the Western Coastal Belt Ecoregion. According to the National Freshwater Ecosystem Priority Areas (NFEPA) database (2011), the Spoeg River and its tributaries are considered to be valley floor wetland features. The Spoeg River is indicated as a channelled valley bottom wetland feature which is in a good condition (Class AB).

The Spoeg River flows from east to west just south of the project area without transecting it (Figure 1). The mouth of the Spoeg River is situated 19 km south of Hondeklip Bay and 47 km north of the Groen River mouth (1:50 000 Sheet 3017 AD; 1:250 000 Topographical Sheet 3017). The total catchment area is 682 km^2 and the total river length from the Kamiesberg in the catchment to the mouth is approximately 95 km (1:250 000 Topographical Sheet 3017). The mean annual rainfall in the upper reaches of the catchment ranges between 200 and 400 mm, whilst in the lower reaches it varies from 40 to 100 mm (Le Roux and Ramsey 1979; Heydorn and Tinley 1980).

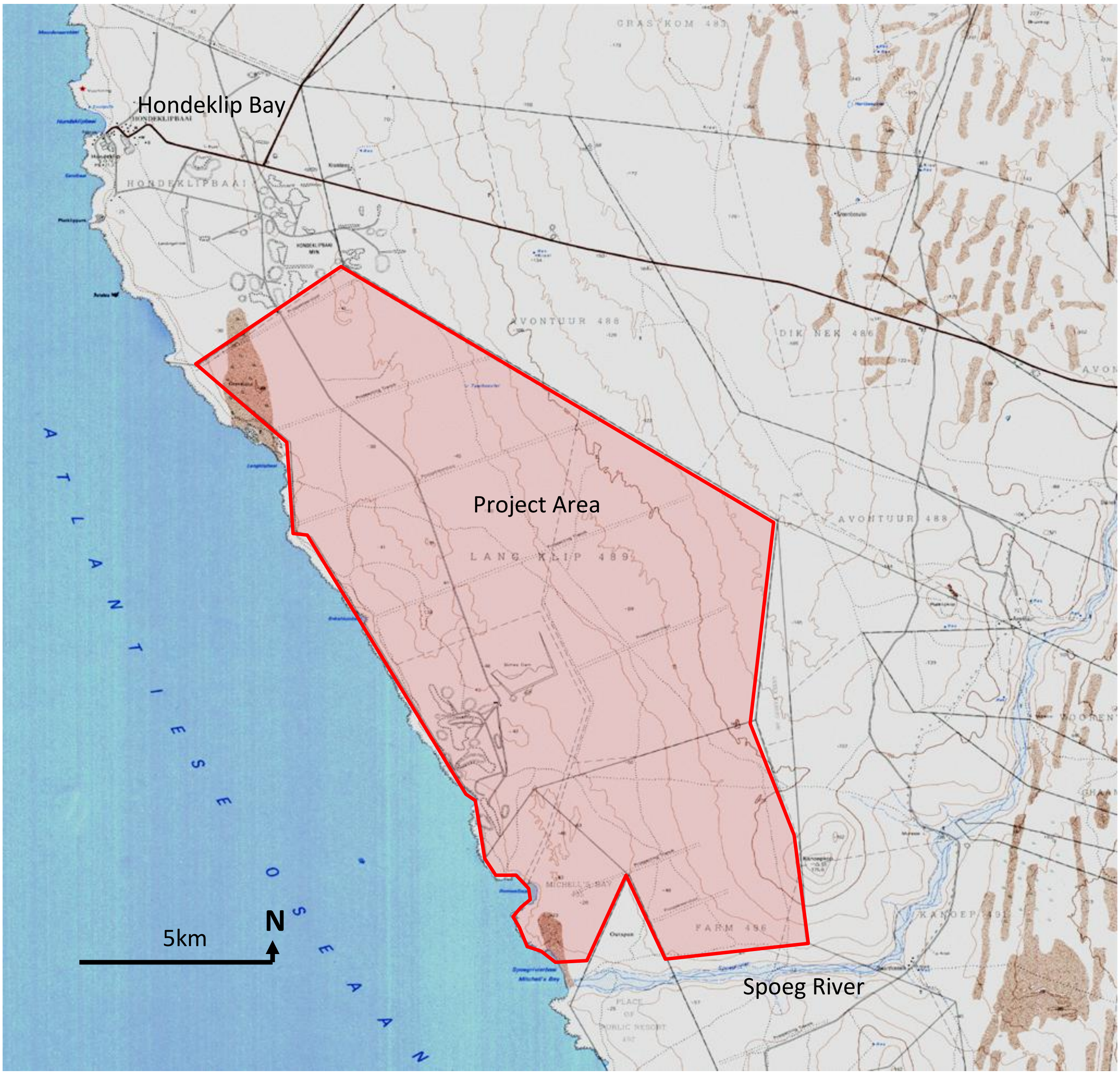

Figure 1: Surface water at the project area

Rainfall in arid areas produces sporadic runoff that seldom reaches the valley bottom. Rainfall in topographically distinct areas will be higher in areas of higher altitude (orographic effect). Bare rock outcrops produces runoff under most rainfall conditions and only infiltrates once it reaches alluvial or colluvial cover.

There is no recorded information on flood history, but the nature of the river and the valley through which it flows indicate that strong flood flows have occurred in the past. The nature of the riverbed vegetation suggests that there had been no flooding in recent times. Fine brown silt covers much of the riverbed, but in the last 2 to 3 km, this is largely overlain by sands. The nature of the vegetation suggests availability of underground water and it is probable that there is considerable underground flow in the sandy riverbed. A meandering flow channel is indicated along the length of the estuary by the predominant occurrence of the sedge Juncus kraussii.

The ephemeral Spoeg River has a relatively small catchment area and probably only flows into the sea at times of extreme rain storm events in the catchment. As the dune covered catchment readily absorbs the run-off, the mouth does not appear to be subject to heavy fluvial sediment deposition. This can be seen from aerial photography of the Spoeg, particularly that taken soon after heavy rainfall e.g. Job No. 12 of 1943. The older dune plumes on the northern banks of the estuary have probably originated from the river-borne sands being blown northwards out of the riverbed by the predominant south-westerly winds. These winds predominate in the summer months when there is very little rainfall and most rivers in Namaqualand are dry. The positions of these dune plumes probably reflect periods when sandblows were possible due to dying off of vegetation in the river bed.

Despite low annual runoff totals in arid regions, peak flood discharges are often high in periods of peak rainfall. This was the case during the 1997 rainy season when the rainfall for the period was extremely high in the higher lying regions of the area. The drainage system of the Spoeg River catchment shows a large variation in drainage characteristics, channel width, depth, Groundwater Recharge Assessment of the Basement Aquifers of Central Namaqualand sediment thickness, drainage density and the development of river terraces. Negligible soil cover exists in the tributaries, a major pathway of direct groundwater recharge. In the lower lying areas the alluvial thickness' increase due to the change in topography (i.e. decrease in gradient) and the concomitant decrease in sediment transport.

Rivers in semi-arid to arid regions generally show a decrease in discharge volume downstream as a result of mainly evaporation and infiltration into the alluvium and channel boundaries. In the coastal rivers such as the Spoeg River, for example, most of the water flows along the base of the alluvial aquifer and is stored in the channel banks during the drier months.

Spoeg River mouth and estuary

The Spoeg River enters the Atlantic Ocean immediately south of the project area through a small estuary. The water surface area in the estuary as measured from satellite imagery, was estimated at approximately 1, 3 ha. However, the lower valley area with evidence of estuarine vegetation up to 3 km from the mouth is approximately 53 ha as measured from satellite imagery. A buffer zone of at least 600m was set between the project area and the northern limit of the estuary (Figure 2).

A well developed longitudinal dune cordon blocks the surface water flow from the estuary to the ocean on an almost permanent basis. This dune only gets breached during exceptional short lived flood events with minimum return period of 12 to 15 years.

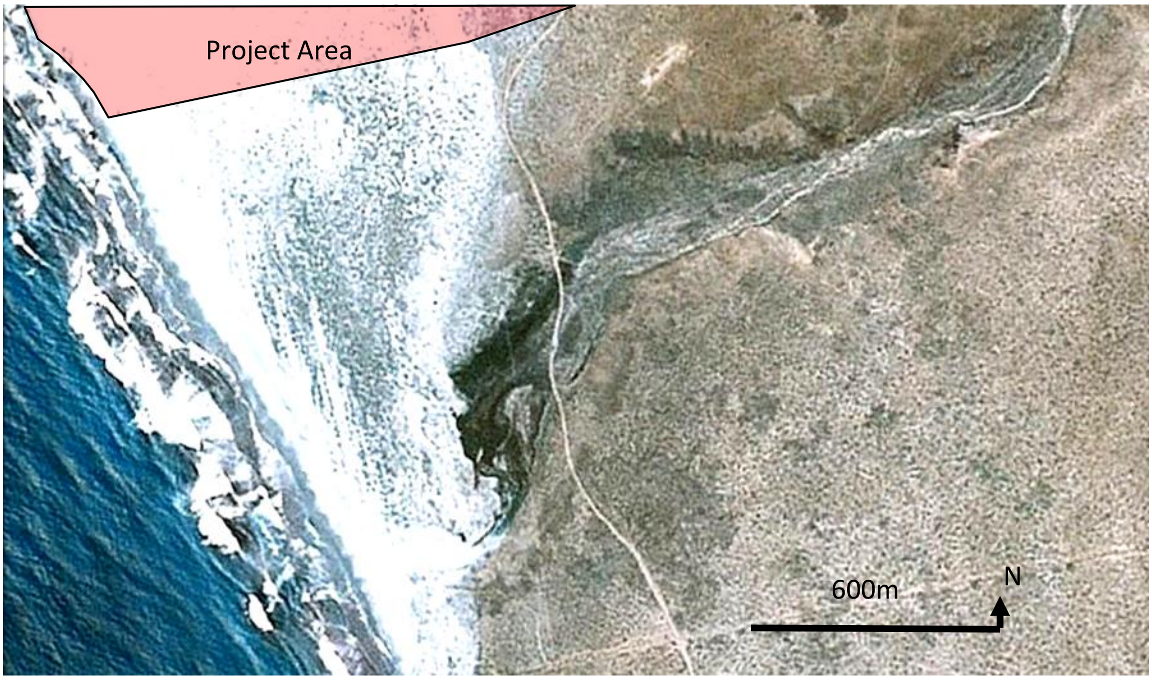

Figure 2: Spoeg River estuary with the 600m buffer zone between the river and the project area.

There is a long straight valley in the upper estuary area, with an almost flat floor and steeply sloping sides, particularly in the southern bank. Cliffs form the northern bank in the Kliphuis farm area. A wandering channel which probably carries low flow water can be observed clearly. The width of the valley varies from 100 to 400 m. Generally, the water depth in the estuary is greater than 1 m and the channel width from 6 to 10 m. This gives a tidal range between MLWS and MHWS of 1,57 m and between Lowest Astronomical Tide and Highest Astronomical Tide of 2,24 m (South African Tide Tables 1980). These values represent a typical no-flow situation which is likely to be prevalent in this estuary for prolonged periods. Overtopping of the sandbar by storm waves during high-tide conditions, may influence the salinity, as would rare instances of river flow. Under the circumstances it seems obvious that groundwater seepage must be responsible for maintaining water levels and also for imparting at least some measure of stability to the physico-chemical characteristics of this system and furthermore, that the groundwater must be of relatively low salinity. This was confirmed by elevated salinity observed in pools in the riverbed by in the Spoeg. Here salinities ranging from 6 parts per thousand, to 31 parts per thousand were measured by Heydorn & Grindley (1981). It can be assumed that the replenishment of low salinity water through groundwater seepage probably gives this system its unusual ability to support a wide diversity of plant and animal life, either permanently or at least for prolonged periods in the arid environment of the Namaqualand coast.

Groundwater

Introduction

The geological conditions at the project area comprise an uncomplicated arrangement of aquifers and related hydrological units. The hydrogeology of the Namaqualand coastal area consists of unconsolidated surface deposits and crystalline basal aquifers. The surface aquifers are host to intergranular aquifers. These aquifers have low yield due to the presence of fine and clayey materials and are dependent on rainfall for recharge. Major recharge events generally occur every 12 to 15 years and natural draw down occurs between periods of recharge. The crystalline basal aquifers are fracture aquifers comprising joint sets and fault systems with higher yield potential.

Groundwater is one of the most important water sources in the Namaqualand region. It plays a major role in the provision of water to urban and rural areas. Groundwater extraction impacts on the natural rate of draw down. Indications are that presently boreholes at Garies, Kamieskroon, Hondeklip Bay and Koingnaas are at levels lower than observed in 1990. Where aquifers have been de-watered, this may lead to surface instability. The alteration of aquifer structure arising from de-watering could limit the possibility for future recharge.

Groundwater quality in the Lower Orange WMA ranges from good to unacceptable, the latter due to contamination by total dissolved solids, nitrates and fluorides caused by pollution from agriculture, lack of sanitation and algal blooms. Areas of high nitrate concentration have been measured at Garies and the surrounding areas.

Groundwater on a regional scale generally flows towards the coast and there is usually little connection between surface water flows and the groundwater aquifer, mainly due to low quantities of surface water. There are therefore not many aquifer dependent ecosystems in the project area and it is likely that groundwater contamination does not pose a major risk to floral and faunal communities.

The aquifers on site can be divided into two main units as follows:

1. Unconsolidated primary aquifer:

This aquifer consists of the surface aeolian sands, marine sands and basal grits and conglomerates overlying the granitic bedrock. The presence of damp sands and minor mud at the base of a number of exploration boreholes, most notably in areas corresponding to topographic lows in the surface of the bedrock, are indicative of a minor concentration of groundwater in the north western part of the project area. Although minor kaolinisation and cementation from the weathering of the feldspars in the underlying granite and gneiss exists, the unit is generally unconsolidated and relatively permeable. The unit has a relatively high clay content constituting some 20% of the overall volume on average with local values up to 35%. The undulating nature of the bedrock contact means that only local perched aquifers with limited aerial extent may form, separated by palaeo-highs in the bedrock contact.

2. Fractured secondary aquifer:

This aquifer underlies the primary aquifer and comprises predominantly fractured bedrock within gneiss and granitic, which underlie the site. The bedrock geology consists of high-grade metamorphic rocks of the Namaqua-Natal Mobile Belt, which are generally massive and highly deformed. The topography of the bedrock contact with the overlying weathered material has been shown to correspond with structures in the bedrock such as faults and fractures, which are generally oriented north-north-west – south-south-east, northeast - south-west and west-north-west - east-south-east. Although significant groundwater flow may be encountered in faults and fracture zones, overall storativity is likely to be very limited with a resultant decrease in long-term sustainability of abstraction, particularly at the relatively high rates that would be required for production. Based on the apparent depths of drilling, it is clear that all the water boreholes in the area are drilled into fracture or fault zones in the bedrock.

Aquifer characterisation

Due to the low potential of appreciable ground water yield in the area, ground water has been ruled out as a source of water for prospecting at the project area. Historic exploration and mining indicated the presence of a thick layer of weathered bedrock material with elevated proportions of kaolinite clay between the upper aeonian sands aquifer and the lower fractured bedrock aquifer. This relatively impermeable layer probably may act as an aquitard, which restricts water flow between the two aquifers and, importantly, influences the volume and rate of seepage from backfilling operations to the groundwater resource.

Geologically there are no distinct structural or lithological boundaries within the site, and as a result it is assumed that the Spoeg River to the south act as a boundary to flow in this direction. High ground to the east acts as a watershed for surface water, and is assumed to coincide with the boundary between groundwater units, while the Atlantic Ocean to the west acts as a natural boundary. The proximity of the site to the coastline, and the surface elevation of the bedrock and groundwater levels, does pose a risk of seawater intrusion as a result of groundwater abstraction.

Groundwater Recharge and Discharge

Groundwater recharge in the area is approximately 2% of mean annual precipitation. It is expected that actual recharge may be less than this figure owing to the relatively high levels of evaporation in the area. However, for the purposes of determining contribution of recharge to the aquifers, the value is not considered unrealistic. The relatively high clay content of the unconsolidated aquifer serves to retard vertical flow and may result in a significant reduction in recharge. It is thought that the recharge to the fractured rock aquifer is more regionally sourced than locally, due to the retarded vertical flow of infiltrating rainwater. The retardation is a result of both the high evaporation in the area, and the aquitard effect of the weathered, kaolinite-rich weathered bedrock contact zone. This recharge occurs in the topographically higher areas to the east of the site with the resultant high head causing flow to the west. Lateral recharge of groundwater from the east follows the overall topographic gradient towards the Atlantic Ocean. The ephemeral Spoeg River probably act as a losing stream as is common in arid zones, but more detailed data from groundwater elevations around the riverbeds is required to determine this.

Infiltration and evapotranspiration are related to water table depth. Recharge is related to the distribution of rainfall into infiltration, runoff and evapotranspiration. Recharge will be less if the water table is deep and higher when water tables are shallow in arid to semi-arid areas. Evapotranspiration will dominate under both cases but will be significantly higher if the water table is close to the surface. When the water table is shallow, infiltration reaches the saturated zone fairly fast, so that most of the individual rainfall events correspond to isolated infiltration events with small time lags. As the depth to groundwater increases the potential for rainfall to percolate to the saturated zone decreases.

Groundwater flow and depth

Groundwater levels on site vary from 40m below surface (Primary Aquifer) along the seaward western boundary of the site, and more than 90m below surface up gradient topographically towards the eastern border (Secondary Aquifer). According to DWAF's Groundwater Resource Assessment Phase 2 project (2005), the average groundwater depth in the quaternary catchment F40F is approximately 48 mbgl.

On a regional scale, groundwater flow is from east to west, flowing towards the Atlantic Ocean. On a local scale, groundwater flows from the project area towards the Spoeg River in the south where flow emanates from the watersheds and flows towards the river channels.

Groundwater quality

According to DWAF (1995) the area surrounding the project area may be classified as a poor aquifer region, which means that it can be described as having a low to negligible yielding aquifer system of moderate to poor water quality. The EC in the area ranges between 300 and 1 000 mS/m immediately around the project area.

Groundwater potential

The area has a yield ranging from < 0.1 L/s just south of Hondeklip Bay to 0.1 – 0.5 L/s east of the project area. Abstraction by the Koiingnaas Mine is reportedly ± 216,000 m^3/annum (D. Visser, Pers Comm).

Prospecting Work Plan

Prospecting will comprise mapping, surface sampling and drilling. Drilling will either be conducted by a truck-mounted RC drill rig or by a hand-held engine-powered auger drill. Approximately 175 RC drill holes are anticipated to be drilled on a 100m by 100 m grid to a maximum depth of approximately 40m each. The RC drill uses compressed air that raises the drilled material to the surface for sampling purposes. The hand-held auger has a 30cm core barrel at the end of the drill rods that holds the sediment sample.

Drilling is proposed to take place in two 1-month periods separated by an analysis phase. The first phase of drilling will require the drilling of approximately 175 drill holes, followed by a second round of infill drilling of some 87 holes if required. It is anticipated that the drill rig will require between two and three hours to complete drilling activities on each drill site.

Drill samples of some 50kg per hole will be collected from the drilled material for submission to an external laboratory for chemical and mineralogical analysis. Drill results are recorded in a database that serves as the primary data set needed for mapping and 3D geological and resource modeling.

Assessment of impacts

Impacts on surface water

Impacts relating to surface water are assessed for the exploration period only (Table 1).

Impacts on groundwater

Impacts relating to groundwater are assessed for the exploration period only (Table 2).

Comment on impacts

No ground- or surface water will be used during prospecting. No impacts are anticipated.

Mitigation and management

During the drilling phase all fuels and oils (hydrocarbons) of all types must be stored on impermeable surfaces with appropriately-sized containment bunds and grease traps. Traps must be regularly cleaned. The same applies to chemicals of all types must be stored on impermeable surfaces in secure and bunded designated storage areas. Vehicle repairs, servicing and refuelling must be done only in designated areas with impermeable surfaces with appropriately-sized containment bunds and grease traps. Drip trays have to be installed under all engines and compressors during drilling. Spill kits must be available at all locations where chemicals of hydrocarbons are stored, handled or used, and spills must be cleaned up immediately in accordance with an established protocol appropriate to the material in question. All vehicle track and drill locations must be rehabilitated immediately after vacating the specific drill site.

Description of impact	Extent	Duration	Intensity	Significance without mitigation	Significance with mitigation	Probability	Confidence
Channel inundation and loss of instream habitat	**Local**	**Long Term**	**Low**	**L**	**VL**	**Highly probable**	**M**
Habitat disturbance	**Regional**	**Long Terms**	**Low**	**M**	**L**	**Probable**	**M**
Habitat Fragmentation	**Regional**	**Long terms**	**Low**	**M**	**L**	**Probable**	**M**
Drill works, disturbance of dunes causing erosion triggers	**Local**	**Short term**	**Low**	**VL**	**L**	**Highly Probable**	**M**

Table 1: Impact ratings on surface water

Description of impact	Extent	Duration	Intensity	Significance without mitigation	Significance with mitigation	Probability	Confidence
Hydrocarbon spills	**Local**	**Long Term**	**Low**	**L**	**VL**	**Highly probable**	**M**
Habitat disturbance	**Regional**	**Long Terms**	**Low**	**M**	**L**	**Probable**	**M**
Habitat Fragmentation	**Regional**	**Long terms**	**Low**	**M**	**L**	**Probable**	**M**
Drill works, disturbance of subsurface permeability and groundwater flow	**Local**	**Short term**	**Low**	**VL**	**N/A**	**Highly Probable**	**M**

Table 2: Impact ratings on ground water

Conclusions

This ground and surface water assessment cover the prospecting phase of the Saxon Heavy Minerals (Pty) Ltd project in terms of baseline ground and surface water data for the area. A large part of the project area has been mined extensively during the past 60 years. This allowed for the establishment of a very good survey record of conditions relating to the ground and surface water situation at the project area.

It is proposed that a 600m buffer zone is established between the Spoeg River and the prospecting area in order to avoid any disturbance that might cause interference with the natural flow of ground water or to generate dust that might impact the water body at the Spoeg River estuary. This no go area will have to cover the entire affected reach of the river from the mouth and have to include the estuary and the northern river valley up to the eastern limit of the project area. No prospecting activity may impact on the Spoeg River estuary and the riparian zones and the no-go areas and must therefore be strictly enforced. This will eliminate any possible impacts on both surface and ground water in these areas. Exploration over the entire area will be limited to the unconsolidated primary aquifer where drilling will be done to an average depth of 40m below surface.

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