Wetland and Riparian Assessment for sand mining operations along the banks of the Sand River on the Farm De Klerkskraal situated near Theunissen, Free State Province.

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DECLARATION OF INDEPENDENCE

DPR Ecologists and Environmental Services is an independent company and has no financial, personal or other interest in the proposed project, apart from fair remuneration for work performed in the delivery of ecological services. There are no circumstances that compromise the objectivity of the study.

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Executive Summary

The sand mining operations will mostly affect the banks and floodplain of the Sand River, though a sand pump in the river will also affect the main channel. The mining operations will consist of a mining right application which is situated on the farm De Klerkskraal which is situated approximately 30 km to the north of the small town of Theunissen (Appendix A: Map 1). The proposed mining operations will entail the excavation of sand from the floodplain and banks of the river while a sand pump within the main channel will be use to extract sand from the riverbed. This will also require the construction of a stockpiling area, sand screen, settling ponds and attenuation areas. The extent and nature of the mining operations are anticipated to have several significant impacts on the river and its associated floodplain and wetland areas mainly associated with sedimentation and loss of aquatic and riparian habitat. The study area consists of a length of approximately 5 km section of the Sand River extending approximately 200 meters to either side of the river. The study area includes both the northern and southern banks of the river as well as large portions of the riparian zone and has an approximate extent of 230 hectares. Several lateral stream systems flowing into the river and a few backwater floodplain wetlands were also included within the assessment. The banks of the Sand River are, for the most part, still intact and largely natural with few noticeable impacts.

The study area consists mainly of the Sand River and its banks (Appendix A: Map 1 & 2). However, in order to provide an accurate assessment of the study area and the affected section of the Sand River the assessment will include delineation of wetland areas associated with the river, such as floodplain wetland backwaters, delineation of the riparian zone or floodplain situated within the proposed study area or mining right application area as well as an overview of lateral streams and drainage lines flowing into the river. This comprehensive assessment and delineation will include both the southern and northern banks although due to the inaccessibility of the north western banks, data from the surrounding area will be extrapolated for this portion.

Soil samples (Appendix C) reliably indicated that wetland conditions along the Sand River at the site is confined to the marginal and lower zones with perennial zones of wetness being present at the water's edge and the marginal zone, decreasing into a seasonal zone of wetness in the lower zone and with wetland conditions being absent from the upper zone of the river (Appendix A: Map 2). The riparian zone of the river extending along both the northern and southern floodplain of the river is quite extensive. The soils within this riparian zone contain fine silty soils (a consequence of historical flood deposition) but it was devoid of wetland conditions. Furthermore, a few backwater floodplain wetlands also occurs within the riparian zone. These are visible as shallow depressions, forming backwater systems and in all of these areas both soils and vegetation indicated at least seasonal wetland conditions. Soil samples taken within several of the lateral drainage lines or seasonal streams indicated the clear presence of wetland conditions, at least for those portions of the streams situated within the proposed mining area (Appendix C). The wetland conditions associated with the banks of the Sand River and lateral streams can be characterised as a channel wetland system (SANBI 2009). Where wetland conditions occur in the floodplain of the Sand River, small backwater depressions have formed and these wetland conditions can be regarded as forming a floodplain wetland (SANBI 2009).

Sand River main channel and banks (Appendix A: Map 1 & 2)

River systems can be divided into different riparian zones within the lateral section of the system. These riparian zones represent the banks of a river and can be distinguished in terms of their geomorphology and vegetation structure. The same applies to the affected section of the Sand

River in the study area. The marginal zone within the Sand River as it occurs within the study area is well defined and easily identifiable. It is relatively narrow in most areas, varying between 1 to 5 meters and is inundated annually during flooding. The majority of this zone seems to be largely natural on both the southern and northern banks. The lower zone along the Sand River can also be clearly defined and is easily visible as a definite and steep increase in slope over a short distance where after it levels off into the upper zone. In small sections of the river, especially where lateral streams flow into the river and an alluvial fan occurs and the marginal zone is broader the lower zone extends over a larger distance. The lower zone is largely natural within the study area but is affected by the current sand mining area. The upper zone along the Sand River is clearly visible as a decrease in slope and an increase in the woodland component. The majority of the upper zone, and the riparian thicket it supports, is still intact.

Floodplain or riparian zone of the Sand River (Appendix A: Map 2)

The floodplain or riparian zone of the Sand River along the section in the study area is extensive. It is very broad in most areas and covers the entire extent of the proposed mining areas, i.e. 200 meters in width on both the northern and southern banks. The delineation of the floodplain and edge of the riparian zone within the proposed mining area was determined by using a combination of soil sampling, vegetation composition and topography and is considered to give an accurate description of it.

Backwater areas forming floodplain wetlands (Appendix A: Map 2)

The floodplain or riparian zone of the Sand River is largely devoid of wetland conditions. However, a few backwater wetland areas has formed and here wetland conditions are clearly present. These floodplain wetlands are fairly easily distinguishable from the surrounding riparian thicket. All of these areas form a very shallow depression where, consequently, surface water now accumulates and saturated soil condition form. Soil samples contained quite clear indication of seasonal wetland conditions and also further aided in the identification and delineation of these floodplain wetlands.

Lateral streams and drainage lines flowing into the Sand River (Appendix A: Map 2)

There are numerous small drainage lines and seasonal streams that drain from the terrestrial surroundings, across the floodplain and into the Sand River on the site. All of these, irrespective of their size, will transport surface water after rainfall events and they should therefore also be taken into consideration in this assessment. Soil samples taken within these small watercourses indicated that they all contain significant wetland conditions, at least in those portions of the watercourses that occur within the proposed mining area. Vegetation along these lateral watercourses also confirmed riparian conditions along all of them, while the main channel also contained at least some obligate wetland vegetation.

The largest impact on the study area is the construction of large upstream containment dam in the Sand River. These impacts alter the flooding regime and the functioning and habitat of the river and floodplains. An Index of Habitat Integrity (IHI) was conducted along the Sand River within the study area (Appendix D). The results of the IHI indicated that the Sand River has an Instream IHI of category C: Moderately Modified and Riparian IHI of category C: Moderately Modified. This is largely due to the change in flooding regime and disturbance/transformation of the habitat. The Sand River and associated wetlands and floodplains are considered to be somewhat modified by historical and current impacts. The EI&S of the floodplains associated with the Sand River has been rated as being Moderate. The floodplain wetlands along the Sand River in the study area are clearly not affected by many impacts. A WET-Health determination was undertaken for one of the larger backwater areas to serve as representative for the floodplain wetland areas along the study area (Appendix D). The results of the WET-Health indicated an overall Present Ecological State of Category B: Largely Natural. Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. This is considered relatively accurate given the few impacts affecting it.

A Risk Assessment for the proposed sand mining operations along the Sand River has been undertaken according to the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E).

The sand mining operations will entail the excavation of sand from the banks and floodplain of the river. Sand is continuously deposited along the banks of the river by flooding events. These sands are exposed along the lower zone when the river is at its baseflow level. It is largely these sands that will be excavated by the mining operations by means of excavators and transported by means of a small dirt access road to stockpiling areas in the floodplain. Impacts associated with this will include modification of the geomorphology, loss of some of the riparian vegetation, contributing toward increased sedimentation of the river and causing local modification and de-stabilisation of the bank. Given the large extent of the proposed mining right area (approximately 230 hectares) this may potentially result in high impacts. In order to limit this impact it is recommended that sand excavation areas be limited to an extent of 5 hectares at a time. Sand should be excavated, processed and the area rehabilitated before moving to a new sand mining area. If this mining method is maintained, the risk is anticipated to remain moderate. This is however subject to comprehensive mitigation and rehabilitation measures being implemented.

An additional mining method which is also being considered entail the pumping of sand from the main channel by means of a sand pump, associated infrastructure and an access road along the riverbank. The main impacts associated with this will be removal of sand from the channel which will affect geomorphology, affecting the aquatic fauna dependant on the sandy habitat and causing local modification of the bank. If these extraction areas are limited to the 5 hectares sand excavation site and to one extraction point at a time, the extent of the impact should be limited and confined to the site (5 hectare area). The risk is therefore only anticipated to remain moderate.

The sand which is excavated from the main channel, banks and floodplain will be transported via the small access roads to a stockpiling area located in the floodplain. Should sand extraction by a pump also be implemented this will also include settling ponds. The most prominent impacts associated with these areas are the removal of riparian vegetation and disturbance of the soil surface. Other likely impacts will include increased sediment washing into the river and likely flooding of the stockpiling area during large floods. The anticipated risk is however anticipated to remain moderate.

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Wetland Assessment

1. Introduction

1.1 Background

Natural vegetation is an important component of ecosystems. Some of the vegetation units in a region can be more sensitive than others, usually as a result of a variety of environmental factors and species composition. These units are often associated with water bodies, water transferring bodies or moisture sinks. These systems are always connected to each other through a complex pattern. Degradation of a link in this larger system, e.g. tributary, pan, wetland, usually leads to the degradation of the larger system. Therefore, degradation of such a water related system should be prevented.

Though vegetation may seem to be uniform and low in diversity it may still contain species that are rare and endangered. The occurrence of such a species may render the development unviable. Should such a species be encountered the development should be moved to another location or cease altogether.

South Africa has a large amount of endemic species and in terms of biological diversity ranks as one the ten highest in the world. This has the result that many of the species are rare, highly localised and consequently endangered. It is our duty to protect our diverse natural resources.

South Africa's water resources have become a major concern in recent times. As a water scarce country we need to manage our water resources sustainably in order to maintain a viable resource for the community as well as to preserve the biodiversity of the system. Thus, it should be clear that we need to protect our water resources so that we may be able to utilise this renewable resource sustainably. Areas that are regarded as crucial to maintain healthy water resources include wetlands, streams as well as the overall catchment of a river system.

It is well known that sand mining operations have several detrimental impacts on the environment. These impacts are numerous but the most pronounced impacts are associated with the excavation of large amounts of earth materials, the storage and disposal thereof and the sedimentation associated with it especially where mining takes places near watercourses. This usually causes degradation of waterways due to sedimentation as well as the transformation of the vegetation and ecosystem on the site.

As a result of the above it is necessary to determine the extent of water sources and any associated wetland conditions in the study area and the likelihood that operations may impact on them.

The sand mining operations will mostly affect the banks and floodplain of the Sand River, though a sand pump in the river will also affect the main channel. The mining operations will consist of a mining right application which is situated on the farm De Klerkskraal which is situated approximately 30 km to the north of the small town of Theunissen (Appendix A: Map 1). The proposed mining operations will entail the excavation of sand from the floodplain and banks of the river while a sand pump within the main channel will be use to extract sand from the riverbed. This will also require the construction of a stockpiling area, sand screen, settling ponds and attenuation areas. The extent and nature of the mining operations are anticipated to have several significant impacts on the river and its associated floodplain and wetland areas mainly, associated with sedimentation and loss of aquatic and riparian habitat. The study area consists of a length of approximately 5 km section of the Sand River extending approximately 200 meters to either side of the river. The study area includes both the northern and southern banks of the river as well as large portions of the riparian zone and has an approximate extent of 230 hectares. Several lateral stream systems flowing into the river and a few backwater floodplain wetlands were also included within the assessment. The banks of the Sand River are, for the most part, still intact and largely natural with few noticeable impacts.

A site visit was conducted on 1 to 2 March 2022. The study area included approximately 5 km section of the Sand River including both the northern and southern banks and lateral watercourses flowing into the river. The study also included the delineation of the riparian zone within the floodplain of the river within the proposed 200-meter corridor on both the northern and southern banks proposed for mining operations. The survey was undertaken during late summer after heavy rains and after heavy flooding of the river. This has resulted in the inundation of the banks of the river and the consequent deposition of large volumes of sediment and loss of riparian vegetation in this zone. This is considered a limitation of the study. In order to augment data obtained, the results of a similar study in this area (2017) will be utilised to provide a more accurate description of the riparian vegetation. In addition, species identification of the upper and floodplain zones were optimal and an active hydrological regime also enabled accurate delineation of the riparian zones, wetland areas and floodplain.

The report together with its recommendations and mitigation measures should be used to minimise the impact of the proposed mining operations.

1.2 The value of biodiversity

The diversity of life forms and their interaction with each other and the environment has made Earth a uniquely habitable place for humans. Biodiversity sustains human livelihoods and life itself. Although our dependence on biodiversity has become less tangible and apparent, it remains critically important.

The balancing of atmospheric gases through photosynthesis and carbon sequestration is reliant on biodiversity, while an estimated 40% of the global economy is based on biological products and processes (Johnson 2005).

Biodiversity is the basis of innumerable environmental services that keep us and the natural environment alive. These services range from the provision of clean water and watershed services to the recycling of nutrients and pollution. These ecosystem services include:

- Soil formation and maintenance of soil fertility.
- Primary production through photosynthesis as the supportive foundation for all life.
- Provision of food, fuel and fibre.
- Provision of shelter and building materials.
- Regulation of water flows and the maintenance of water quality.
- Regulation and purification of atmospheric gases.
- Moderation of climate and weather.
- Detoxification and decomposition of wastes.
- Pollination of plants, including many crops.
- Control of pests and diseases.
- Maintenance of genetic resources.

1.3 Value of wetlands and watercourses

Freshwater ecosystems provide valuable natural resources, which contributes toward economic, aesthetic, spiritual, cultural and many recreational values. Yet the integrity of freshwater ecosystems in South Africa is rapidly declining in recent times. This crisis is largely a consequence of a variety of challenges that are practical (managing vast areas of land to maintain connectivity between freshwater ecosystems), socio-economic (the need to utilise these recourses between different stakeholders, i.e. individuals, communities, corporate and industrial) and institutional (Implementing appropriate governance and management). Water affects every activity and aspiration of human society and sustains all ecosystems.

Freshwater ecosystems provide many of our fundamental needs, enable important regulating ecosystem services, supports functional faunal and floral communities:

- Water for drinking and irrigation
- Food such as fish and water plants.
- Building material such as clay and reeds.
- Preventing floods and easing the impacts of droughts.
- Remove excess nutrients and toxic substances from water
- Rivers, wetlands and groundwater systems maintain water supplies and buffer the effects of storms, reducing the loss of life and property to floods.
- Riverbanks help to trap sediments, stabilise
- river banks and break down pollutants draining from the surrounding land.

1.4 Details and expertise of specialist

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South African Council for Natural Scientific Professions No. (400284/13) (Ecological Science).

Membership with relevant societies and associations:

- South African Society of Aquatic Scientists (SASAQS0091)
- South African Association of Botanists
- South African Wetlands Society (3SLY4IG4)

Expertise:

- Qualifications: B.Sc. (Hons) Botany (2008), M.Sc. in Vegetation Ecology (2012) with focus on ephemeral watercourses.

- Vegetation ecologist with over 10 years experience of conducting ecological assessments.
- Founded DPR Ecologists & Environmental Services (Pty) Ltd in 2016.
- Has conducted over 200 ecological and wetland assessments for various developments.
- Regularly attend conferences and courses in order to stay up to date with current methods and trends:

  2017: Kimberley Biodiversity Symposium.
  2018: South African Association of Botanists annual conference.
  2018: National Wetland Indaba Conference.
  2019: SASS5 Aquatic Biomonitoring Training.
  2019: Society for Ecological Restoration World Congress 2019.
  2019: Wetland rehabilitation: SER 2019 training course.
  2020: Tools For Wetlands (TFW) training course.

2. Scope and limitations

- To provide a description of watercourses, wetlands and riparian vegetation included within the study area.
- Identify watercourses including rivers, streams, pans and wetlands and determine the presence of wetland conditions within these systems.
- Where wetland conditions have been identified the classification of the wetland system will be given.
- To identify possible negative impacts that could be caused by the mining operations.
- To evaluate the present state of the wetlands and riparian vegetation in close proximity to the operations. The importance of the ecological function and condition will also be assessed.
- Determine the Present Ecological State (PES) and Ecological Importance & Sensitivity (EIS) for the watercourses in close proximity to operations.
- Conduct a risk assessment and determine the likelihood that watercourses and wetlands will be adversely affected by the development.

2.1 Riparian Vegetation

Aspects of the riparian vegetation that will be assessed include:

- The vegetation types of the region with their relevance to the study area.
- The overall status of the riparian vegetation along the wetlands and watercourses in the study area.
- Species composition with the emphasis on dominant-, rare- and endangered species.
- Presence of wetland conditions and riparian vegetation using obligate wetland and riparian species.

The amount of disturbance present on the study area assessed according to:

- The amount of grazing impacts.
- Disturbance caused by human impacts.
- Other disturbances.

2.2 Wetlands and watercourses

Aspects of the wetlands and watercourses that will be assessed include:

- Identification of watercourses including rivers, streams, pans and wetlands.
- Determine the presence of wetland conditions and riparian vegetation using obligate wetland and riparian species.
- Describe watercourses and wetlands and importance relative to the larger system.
- Conduct habitat integrity assessment of watercourses to inform the condition and status of these systems.

2.4 Limitations

- Some geophytic or succulent species may have been overlooked due to a specific flowering time or cryptic nature.
- Although a comprehensive survey of the site was done it is still likely that several species were overlooked.
- Due to time constraints only limited soil sampling could be done.

- The lateral watercourses flowing into the Sand River in the study area are seasonal in nature and do not contain an aquatic component (including invertebrates and fish species).
- Smaller drainage lines may have been overlooked where a distinct channel or riparian vegetation is absent.
- Due to the large extent of the study area only spot surveys of watercourses were undertaken.
- The Sand River has recently (January 2022) experienced quite substantial flooding which has caused inundation of the marginal and lower zones as well as the deposition of large volumes of sediment. This has caused flood disturbance of the river and the loss of riparian vegetation and this hampers the description within these zones. Accurate delineation was however still possible by utilising soil sampling and an approximate description of the vegetation in these zones can be provided by utilising results obtained during previous studies (2017).
- Access to the north western riverbank, riparian zone and floodplain of the river was limited and delineation is based on data obtained from adjacent areas and extrapolated to this portion.
- The assessment will be limited to the assessment of the banks of the Sand River, riparian vegetation, any associated wetland conditions, floodplain, riparian zone and any other associated watercourses and wetlands but will not include assessment of the aquatic component and hydrology of the watercourses.

3. Methodology

3.1 Several literature works were used for additional information.

General ecology:

- Red Data List (Raymondo *et al.* 2009).
- Vegetation types (Mucina & Rutherford 2006).
- NBA 2018: South African Inventory of Inland Aquatic Ecosystems (SAIIAE).
- NBA 2018 Technical Report: Inland Aquatic (Freshwater) Realm.
- National Freshwater Ecosystem Priority Areas 2011 (NFEPA).
- Strategic Water Source Areas 2018 (SWSA).
- SANBI (2011): List of threatened ecosystems.
- NEM:BA: List of threatened ecosystems and Threatened Or Protected Species (TOPS).
- Biodiversity Plan Free State Province (2018).

Vegetation:

- Red Data List (Raymondo *et al.* 2009).
- Vegetation types (Mucina & Rutherford 2006).
- Field guides used for vegetation and riparian species identification (Bromilow 1995, 2010, Coates-Palgrave 2002, Fish *et al* 2015, Gerber *et al* 2004, Gibbs Russel *et al* 1990, Grifiths & Picker 2015, Manning 2009, Retief & Meyer 2017, Van Ginkel *et al* 2011, Van Ginkel & Cilliers 2020, Van Oudtshoorn 2004, Van Wyk & Malan 1998, Venter & Joubert 1985).

Wetland methodology, delineation and identification:
Department of Water Affairs and Forestry 2004, 2005, 2008, Collins 2006, Duthie 1999, Kleynhans *et al* 2008, Marnewecke & Kotze 1999, Macfarlane, Ollis & Kotze 2020, Ollis *et al* 2013, Nel *et al* 2011, SANBI 2009.

3.2 Survey

The site was assessed by means of transects and sample plots. Observation w.r.t. the general ecology of the area includes:

- Noted species include rare and dominant species.
- The broad vegetation types present at the site were determined.
- The state of the environment was assessed in terms of condition, grazing impacts, disturbance by humans, erosion and presence of invader and exotic species.
- The state of the habitat was also assessed.

In order to provide a visually representative overview of the results obtained from the survey, site sensitivity mapping will also be done. This should indicate the relative importance of different ecological elements on the site as obtained from the survey. In general, these levels of sensitivity will include:

- Low Sensitivity – normally confined to areas that are completely transformed from the natural condition or degraded to such an extent that they are no longer representative of the natural ecosystem. Such areas will also no longer contain any ecological processes of importance relative to the surrounding areas, i.e. in some instances such as watercourses which are completely transformed but still provide important ecological functions, a low level of sensitivity will not apply.

- Moderate Sensitivity – normally applicable to areas that are still natural and therefore does still have some ecological importance but which do not contain elements of high conservation value and are not essential to the continued functioning of surrounding areas. Areas of Moderate Sensitivity usually require some mitigation but can be developed without resulting in high impacts.

- High Sensitivity – areas of high sensitivity contain one or more ecological elements which are considered of high conservation value. Such areas are normally preferred to be excluded from a development but where this is not possible, will require comprehensive mitigation and is also likely to result in high impacts.

- Very High Sensitivity – these areas are critical to the continued functioning of the ecosystem on and around the site. Development of such areas normally represent a fatal flaw and should be excluded from development. No manner of mitigation is able to decrease the anticipated impact in these areas.

All rivers, streams, pans and wetlands were identified and surveyed where they occurred in the study area. These systems were determined by use of topography (land form and drainage pattern) and riparian vegetation with limited soil sampling (Appendix B & C). The following outlines the process applied during the on-site survey in order to obtain all required data:

- Perform desktop overview of the study area utilising available resources (Section 3.1). From the desktop overview identify the different landscape forms, possible wetland areas, watercourses and their relative flow patterns. Using this information, identify transects and sample plots for possible on-site survey. This should be both representative of the wetland or watercourse as a whole but should also include any prominent or significantly unique features.
- Possible sites identified during the desktop overview should be surveyed on-site. Where access is not possible or where desktop features are considered poor representatives of the wetland or watercourse the survey site or transect should be moved to another location, without compromising a comprehensive overview of the system.
- Where a lateral transect is taken of a watercourse this is done from the water's edge, across the marginal, lower and upper zones and extended across the floodplain until the edge of the riparian zone is reached.
- Where a transect is taken of a wetland system, this should preferably be taken across the entire wetland at its widest part or where it is most relevant to the proposed development, from the terrestrial surroundings, across the temporary, seasonal and perennial zones across the wetland.
- Soil samples are taken at 10 meter intervals along the survey transect, or where a distinct transition into a different zone is observed.
- A survey of the plant species within each distinct riparian or wetland zone is undertaken and includes the identification of obligate wetland species, riparian species, terrestrial species, exotic species and the general species composition and vegetation structure which allows for an accurate description of the watercourse or wetland.
- Visual survey of the general topography which substantiates the presence of riparian zones and wetland forms.

- Other general observations include any impacts observed, the overall ecosystem function, presence of fauna, surrounding land uses and the overall condition of the watercourse or wetland.
- Data is recorded by means of photographs with GPS coordinates taken at all relevant soil sampling sites and borders of riparian and wetland zones.

Data obtained during the on-site survey is utilised to provide the following information on the system:

- Desktop overview and assimilation of information on the likely impacts and functioning of the wetland system.
  - Review all available spatial data and resources in order to provide an estimate of the likely impacts and condition of the wetland or watercourse system.
- Confirm the presence of the wetland or watercourse system and provide an estimate of its borders.
  - The border of wetland conditions or the edge of the riparian zone will be confirmed by using soil sampling, obligate wetland vegetation and topography. This will also include the delineation of any temporary, seasonal or perennial zones of wetness along wetlands and the marginal, lower, upper and riparian zones along watercourses.
- Provide a description of the wetland or watercourse.
  - Provide the hydrogeomorphic setting of the wetland, a longitudinal profile which will aid in determining the erodibility of the wetland and provide an overall description of the wetland and impacts affecting it.
  - Provide a general description of the lateral zonation of the watercourse banks including the marginal, lower, upper and riparian zones and a description of the riparian vegetation along the banks of the watercourse. This will also include the description of any impacts or modification of the watercourse.
- Assess the current condition of the wetland or watercourse.
  - Utilising information obtained from the assessments listed above, determine the condition of this portion of the wetland by applying the WET-Health 2 tool.
  - Utilising information obtained from the assessments listed above, determine the condition of the relevant section of the watercourse by applying the Index of Habitat Integrity (IHI) tool.
- Utilising all of the information obtained from the assessment, provide recommendations to mitigate anticipated impacts that the development will have.

The following guidelines and frameworks were also used to determine the presence of the rivers, streams, pans and wetlands in the study area:

- Department of Water Affairs and Forestry. 2005. A practical field procedure for identification and delineation of wetlands and riparian areas. Edition 1. Department of Water Affairs and Forestry, Pretoria.
- Marnewecke & Kotze 1999. Appendix W6: Guidelines for delineation of wetland boundary and wetland zones. In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

The following guidelines and frameworks were used to determine the sensitivity or importance of these identified watercourses or wetlands in the study area:

- Nel *et al.* (2011). Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.

- Government of South Africa. 2008. National Protected Area Expansion Strategy for South Africa 2008: Priorities for expanding the protected area network for ecological sustainability and climate change adaptation. Government of South Africa, Pretoria.

- Duthie, A. 1999. Appendix W5: IER (floodplain and wetlands) determining the Ecological Importance and Sensitivity (EIS) and Ecological Management Class (EMC). In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

These guidelines provide the characteristics which can be utilised to determine if a wetland or watercourse is present and also aids in determining the boundary of these systems.

The following were utilised to inform the condition and status of watercourses:

- Kleynhans, C.J., Louw, M.D. & Graham, M. 2008. Module G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity. Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 377-08.

The following were utilised to inform the condition and status of wetlands:

- Macfarlane, D.M., Ollis, D.J. & Kotze, D.C. 2020. WET-Health (Version 2.0): a refined suite of tools for assessing the present ecological state of wetland ecosystems. WRC Report No. TT 820/20.

A Risk Assessment will be conducted for the proposed development in or near watercourses and wetlands in accordance with the Department of Water & Sanitation’s requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use.

3.3 Criteria used to assess sites

The following criteria is also applied during the site survey to further inform the general sensitivity and conservation value of the site or specific elements on the site. These criteria were used to assess the site and determine the overall status of the environment.

3.3.1 Vegetation characteristics

Characteristics of the vegetation in its current state. The diversity of species, sensitivity of habitats and importance of the ecology as a whole.

Habitat diversity and species richness: normally a function of locality, habitat diversity and climatic conditions.
Scoring: Wide variety of species occupying a variety of niches – 1, Variety of species occupying a single nich – 2, Single species dominance over a large area containing a low diversity of species – 3.

Presence of rare and endangered species: The actual occurrence or potential occurrence of rare or endangered species.
Scoring: Occurrence actual or highly likely – 1, Occurrence possible – 2, Occurrence highly unlikely – 3.

Ecological function: All plant communities play a role in the ecosystem. The ecological importance of all areas though, can vary significantly e.g. wetlands, drainage lines, ecotones, etc.
Scoring: Ecological function critical for greater system – 1, Ecological function of medium importance – 2, No special ecological function (system will not fail if absent) – 3.

Degree of rarity/conservation value:
Scoring: Very rare and/or in pristine condition – 1, Fair to good condition and/or relatively rare – 2, Not rare, degraded and/or poorly conserved – 3.

3.3.2 Vegetation condition

The sites are compared to a benchmark site in a good to excellent condition. Vegetation management practises (e.g. grazing regime, fire, management, etc.) can have a marked impact on the condition of the vegetation.

Percentage ground cover: Ground cover is under normal and natural conditions a function of climate and biophysical characteristics. Under poor grazing management, ground cover is one of the first signs of vegetation degradation.
Scoring: Good to excellent – 1, Fair – 2, Poor – 3.

Vegetation structure: This is the ratio between tree, shrub, sub-shrubs and grass layers. The ratio could be affected by grazing and browsing by animals.
Scoring: All layers still intact and showing specimens of all age classes – 1, Sub-shrubs and/or grass layers highly grazed while tree layer still fairly intact (bush partly opened up) – 2, Mono-layered structure often dominated by a few unpalatable species (presence of barren patches notable) – 3.

Infestation with exotic weeds and invader plants or encroachers:
Scoring: No or very slight infestation levels by weeds and invaders – 1, Medium infestation by one or more species – 2, Several weed and invader species present and high occurrence of one or more species – 3.

Degree of grazing/browsing impact:
Scoring: No or very slight notable signs of browsing and/or grazing – 1, Some browse lines evident, shrubs shows signs of browsing, grass layer grazed though still intact – 2, Clear browse line on trees, shrubs heavily pruned and grass layer almost absent – 3.

Signs of erosion: The formation of erosion scars can often give an indication of the severity and/or duration of vegetation degradation.
Scoring: No or very little signs of soil erosion – 1, Small erosion gullies present and/or evidence of slight sheet erosion – 2, Gully erosion well developed (medium to large dongas) and/or sheet erosion removed the topsoil over large areas – 3.

3.3.3 Faunal characteristics

Presence of rare and endangered species: The actual occurrence or potential occurrence of rare or endangered species on a proposed site plays a large role on the feasibility of a development. Depending on the status and provincial conservation policy, presence of a Red Data species or very unique and sensitive habitats can potentially be a fatal flaw.
Scoring: Occurrence actual or highly likely – 1, Occurrence possible – 2, Occurrence highly unlikely.

3.4 Biodiversity sensitivity rating (BSR)

The total scores for the criteria discussed in section 3.3 were used to determine the biodiversity sensitivity ranking for the sites. On a scale of 0 – 30, five different classes are described to assess the biodiversity of the study area. The different classes are described in the Table 1:

Table 1: Biodiversity sensitivity ranking

BSR	BSR general floral description	Floral score equating to BSR class
Totally transformed (5)	Vegetation is totally transformed or in a highly degraded state, generally has a low level of species diversity, no species of concern and/or has a high level of invasive plants. The area has lost its inherent ecological function. The area has no conservation value and potential for successful rehabilitation is very low.	29 – 30
Advanced Degraded (4)	Vegetation is in an advanced state of degradation, has a low level of species diversity, no species of concern and/or has a high level of invasive plants. The area's ecological function is seriously hampered, has a very low conservation value and the potential for successful rehabilitation is low.	26 – 28
Degraded (3)	Vegetation is notably degraded, has a medium level of species diversity although no species of concern are present. Invasive plants are present but are still controllable. The area's ecological function is still intact but may be hampered by the current levels of degradation. Successful rehabilitation of the area is possible. The conservation value is regarded as low.	21 – 25
Good Condition (2)	The area is in a good condition although signs of disturbance are present. Species diversity is high and species of concern may be present. The ecological function is intact and very little rehabilitation is needed. The area is of medium conservation importance.	11 – 20
Sensitive/Pristine (1)	The vegetation is in a pristine or near pristine condition. Very little signs of disturbance other than those needed for successful management are present. The species diversity is very high with several species of concern known to be present. Ecological functioning is intact and the conservation importance is high.	0 - 10

4. Wetland Assessment

For the purpose of this report the general ecology of the study area will first be discussed followed by a discussion of the watercourses and wetland systems.

4.1 Ecology and description of the study area

Refer to the list of species encountered on the site in Appendix B.

The sand mining operations will mostly affect the banks and floodplain of the Sand River, though a sand pump in the river will also affect the main channel. The mining operations will consist of a mining right application which is situated on the farm De Klerkskraal which is situated approximately 30 km to the north of the small town of Theunissen (Appendix A: Map 1). The proposed mining operations will entail the excavation of sand from the floodplain and banks of the river while a sand pump within the main channel will be use to extract sand from the riverbed. This will also require the construction of a stockpiling area, sand screen, settling ponds and attenuation areas. The extent and nature of the mining operations are anticipated to have several significant impacts on the river and its associated floodplain and wetland areas mainly associated with sedimentation and loss of aquatic and riparian habitat. The study area consists of a length of approximately 5 km section of the Sand River extending approximately 200 meters to either side of the river. The study area includes both the northern and southern banks of the river as well as large portions of the riparian zone and has an approximate extent of 230 hectares. Several lateral stream systems flowing into the river and a few backwater floodplain wetlands were also included within the assessment. The banks of the Sand River are, for the most part, still intact and largely natural with few noticeable impacts.

According to Mucina & Rutherford (2006) the area consists of Highveld Alluvial Vegetation (AZa 5) (Appendix A: Map 1). This vegetation type is currently listed as being of Least Concern (LC) within the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004). It is a widespread vegetation type and not currently subjected to any pronounced development pressures. It is also associated with alluvial plains associated with larger lowland rivers and was also confirmed by the current survey.

The Free State Province Biodiversity Management Plan (2015) has recently been published and has identified areas which are essential to meeting conservation targets for specific vegetation types, i.e. Critical Biodiversity Areas. The site in question is listed as being an Ecological Support Area (ESA) 1. Areas identified as and ESA 1 are associated with the immediate catchment of the Sand River and functions in support of this large watercourse. This functioning and support should therefore be retained as far as possible.

The main channel, banks and floodplain of the Sand River, which forms the main study area for the proposed mining, is largely still intact and natural (Appendix A: Map 1). A small, existing sand mine of approximately 5 hectares being the only significant impact in the area. This mining area has mostly resulted in the removal of riparian vegetation, modification of the riverbanks and transformation of the geomorphology. This will also be taken into consideration for the proposed mining operations and should provide an indication of the type of impacts that this would result in. The floodplain or riparian zone of the river is extensive along the entire section of the study area. The riparian zone is dominated by thicket with fine alluvial sediments, also confirming the extent of this zone. It is doubtful if flooding will still be able to extend along the entire breadth of the riparian zone, mostly as a result of the upstream Allemanskraal Dam which acts as a flood regulator. This is also considered to have a significant impact on the natural functioning of the flooding regime of the river. The study area is being utilised as grazing for domestic livestock which leads to a moderate level of overgrazing and trampling but is not regarded as having a large impact on the riparian vegetation and river itself. A few small dirt tracks transect the area but are few and small and do not have any significant impact. It would seem that the study area is therefore still largely intact and affected by only a few impacts, the current sand mining area being the most significant.

The vegetation structure along the banks of the river varies considerably, mostly as a result of the variety of habitats and diverse geomorphology along the riverbanks. The surrounding riparian zone is dominated by a fairly dense riparian thicket with interspersed herblands and grassland (Appendix B). Along the upper zone or bank of the river, a dense riparian thicket dominated by tall trees are prominent. Vegetation along the lower and marginal zones of the river bank is subjected to annual flooding and is therefore dominated by a variety of hygrophilous grasses, herbaceous plants, sedges and reeds. Exotic weeds are also abundant along these portions of the river bank. A more detailed description of the vegetation along the river will be provided within the wetland assessment section of the report.

The topography is closely associated with the Sand River and its functioning. The surrounding topography outside the application area is dominated by alluvial plains which also forms part of the historical floodplain of the river (Appendix A: Map 1). These plains also have a gradual and gentle slope toward the river. Within this alluvial floodplain, being dominated by fine, silt sediments, several drainage lines and stream systems have become incised into the terrain and form prominent watercourses in the study area. The banks of the river consist of an elevated upper zone, dominated by riparian thicket with a gentle slope, which then transitions into the steep sloped lower zone (the banks of the river). The lower zone again levels off into the marginal zone along the main channel of the river. Altitude varies from 1300 m to 1275 m and should illustrate the gradual slope from the surrounding alluvial plain areas toward the river.

The site and the surrounding area is situated in a region experiencing moderate rainfall, with cold, dry winters and warm summers. Climate for the site can be extrapolated from rainfall and evaporation data from the weather station C4E009 (Zeebrugge@Sand-Vet). The site is located in an area with a rainfall of between 500 mm and 600 mm per annum with an average of 508.7 mm per year. Rainfall occurs largely as summer rainfall with a mean annual evaporation of between 1600 and 1799 mm/annum. The surface water runoff in the area is therefore not significantly high which results in a relatively low runoff for the area of between 20 - 50 mm according to a study by the Water Research Commission. As a result wetlands are uncommon in the area although several wetland areas are associated with the floodplain of the Sand River and the drainage lines and seasonal streams transecting the floodplain of the river.

The study area is situated on geology associated with the Volksrust Formation. The Volksrust Formation of the Ecca Group in the vicinity of Theunissen is dominated by underlying mudrock. However, the site and surroundings are dominated by quite deep alluvial deposits consisting of fine sand and silt soils. This is also one of the main drivers of the vegetation composition of the area. Along the northern banks of the river areas of dolerite outcrops were also encountered.

Pioneer weeds and exotics are abundant in the study area, especially along the banks of the river (Appendix B). The river is subjected to a natural disturbance regime as a result of annual flooding. As a result, this promotes the establishment of these exotic weeds along the banks of the river.

As indicated, the proposed mining area is still largely natural with the current sand mining area being the most significant current impact. Current mining causes the removal of riparian vegetation, modification of the riverbanks and transformation of the geomorphology. This also provides an indication of the type of impacts that proposed mining would have.

Figure 1: Aerial view of the area prior to the current mining (Google Earth 2012) compared to the current condition (Google Earth 2021) which illustrates the likely impacts which will be caused by proposed mining operations.

Figure 2: Surrounding terrestrial areas are dominated by a well-developed grassland which transitions into a much more denser thicket vegetation within the floodplain or lower lying alluvial plains associated with the river.

Figure 3: The alluvial plain associated with the floodplain of the river, is dominated by a dense ticket vegetation structure.

Figure 4: The Sand River along the study area contains a broad main channel with steep banks.

Figure 5: View of one of the larger lateral streams transecting the study area and flowing into the Sand River.

Figure 6: Along the riparian zone of the river a few distinct floodplain wetlands have also formed.

Figure 7: Current sand mining along the banks of the river does clearly cause significant impacts which will require comprehensive mitigation.

4.2 Wetland and Watercourses Assessment

4.2.1 Introduction

The study area consists mainly of the Sand River and its banks (Appendix A: Map 1 & 2). However, in order to provide an accurate assessment of the study area and the affected section of the Sand River the assessment will include delineation of wetland areas associated with the river, such as floodplain wetland backwaters, delineation of the riparian zone or floodplain situated within the proposed study area or mining right application area as well as an overview of lateral streams and drainage lines flowing into the river. This comprehensive assessment and delineation will include both the southern and northern banks although due to the inaccessibility of the north western banks, data from the surrounding area will be extrapolated for this portion. The affected section of the Sand River and different aspects as indicated above will be discussed below.

As indicated, the proposed mining area will consist of approximately a 5 km section along the banks of the Sand River extending approximately 200 meters to either side and which is situated approximately 30 km to the north of the town of Theunissen in the Free State Province (Appendix A: Map 1). Mining operations will entail the excavation of sand from the banks and floodplain of the river but may also include the pumping of sand from the riverbed. Associated with the mining operations will also be a stockpile area, sand screen, settling ponds and associated infrastructure and structures. In order to provide a detailed description of the river it is necessary to delineate and assess the banks of the river, including the different zones, i.e. marginal, lower and upper zones and the differing vegetation composition and structure along these zones. The presence of wetland conditions and their borders should be determined, this will also include any wetland areas within the floodpain such as backwater wetland areas. Above the banks of the river (upper zone) a floodplain is also present and represents the riparian zone of the river which also needs to be described and its location within the study area/mining application area determined. From the surrounding terrestrial catchment, several watercourses, some forming quite substantial seasonal streams, drain into the river. They therefore also form a part of the Sand River system, will be affected by proposed mining and will also influence the functioning of the Sand River. These lateral stream systems therefore also need to be included in this assessment.

The term watercourse refers to a river, stream, wetland or pan. The National Water Act (NWA, 1998) includes rivers, streams, pans and wetlands in the definition of the term watercourse. This definition follows:

Watercourse means:

- A river or spring.
- A natural channel in which water flows regularly or intermittently.
- A wetland, lake or dam into which water flows.
- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

Riparian habitat is an accepted indicator of watercourses used to delineate the extent of wetlands, rivers, streams and pans (Department of Water Affairs and Forestry 2005).

The Sand River has been listed as a third order watercourse and therefore forms a large lowland river system. The classification of stream orders from 1 to 3 can be illustrated by means of the Strahler 1952 classification:

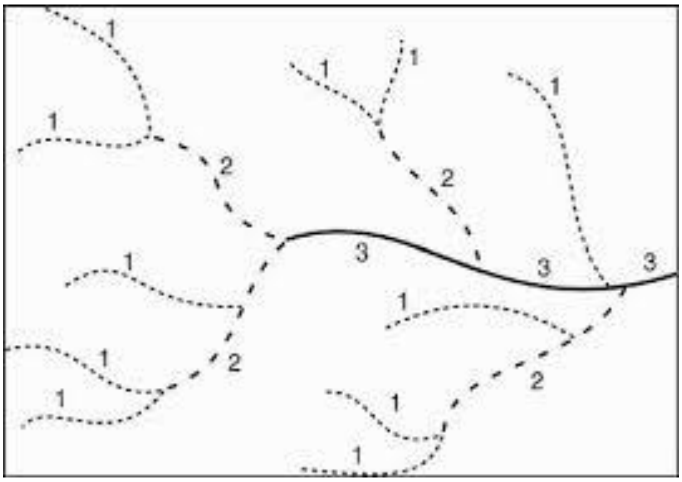

Figure 8: The classification of stream orders from 1 to 3 (Strahler 1952)

4.2.2 Wetland and riparian indicators

Obligate wetland vegetation was utilised to determine the presence and border of wetland conditions along the banks of the river, as well as within its floodplain, lateral stream systems and any wetland areas situated within the floodplain. Due to time constraints and the extent of the study area soil samples were only taken by lateral transects along the banks and floodplain of the river with only a few selected samples taken within the lateral stream systems flowing into the river and the backwater floodplain wetland areas. Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils (Appendix C).

Soil samples reliably indicated that wetland conditions along the Sand River at the site is confined to the marginal and lower zones with perennial zones of wetness being present at the water’s edge and the marginal zone, decreasing into a seasonal zone of wetness in the lower zone and with wetland conditions being absent from the upper zone of the river (Appendix A: Map 2). This was also clearly reflected within the vegetation composition along the banks.

The riparian zone of the river extending along both the northern and southern floodplain of the river is quite extensive. The vegetation type here, Highveld Alluvial Vegetation, also confirm the deposition of silty soils through the historical flooding of the river. Though flooding may not necessarily extend over the riparian zone it does still contain the characteristics of a floodplain and is therefore still regarded as forming part of the riparian zone of the river. The soils within this riparian zone contain fine silty soils (a consequence of historical flood deposition) but it was devoid of wetland conditions. The soil samples indicated fine silty soils with a high sand content and vegetation was dominated by riparian thicket and confirmed that the floodplain forms part of the riparian zone of the river and although flooding will occur only very infrequently it is inevitable that flooding will occur at some time. Furthermore, a few backwater floodplain wetlands also occurs within the riparian zone. These are visible as shallow depressions, forming backwater systems and in all of these areas both soils and vegetation indicated at least seasonal wetland conditions.

Soil samples taken within several of the lateral drainage lines or seasonal streams indicated the clear presence of wetland conditions, at least for those portions of the streams situated within the proposed mining area (Appendix C). It is clear that these systems discharge annually from runoff generated in the surrounding catchment, but is also being inundated when floods within the Sand River push up into the lateral streams. The soil samples also confirm that soil saturation and the period of inundation is sufficient to create wetland conditions. These wetland conditions are however confined to the main channel of these watercourses with their banks consisting of riparian vegetation and forming part of the riparian zone.

These wetland soil indicators were also confirmed in all of these areas by the presence of obligate wetland species. Obligate wetland species are confined to wetlands and cannot occur in conditions outside of these systems. As a result, where they occur, wetland conditions can be considered to occur. Riparian vegetation was also utilised to delineate the riparian zones along the river.

4.2.3 Classification of wetland systems

The wetland conditions identified along the banks of the Sand River as well as the lateral drainage lines and streams flowing into it can be classified into a specific wetland type.

The wetland conditions associated with the banks of the Sand River and lateral streams can be characterised as a channel wetland system (SANBI 2009):

“An open conduit with clearly defined margins that (i) continuously or periodically contains flowing water, or (ii) forms a connecting link between two water bodies. Dominant water sources include concentrated surface flow from upstream channels and tributaries, diffuse surface flow or interflow, and/or groundwater flow. Water moves through the system as concentrated flow and usually exits as such but can exit as diffuse surface flow because of a sudden change in gradient. Unidirectional channel-contained horizontal flow characterises the hydrodynamic nature of these units. Note that, for purposes of the classification system, channels generally refer to rivers or streams (including those that have been canalised) that are subject to concentrated flow on a continuous basis or periodically during flooding, as opposed to being characterised by diffuse flow (see unchannelled valley-bottom wetland). As a result of the erosive forces associated with concentrated flow, channels characteristically have relatively obvious active channel banks. An active channel is a channel that is inundated at sufficiently regular intervals to maintain channel form and keep the channel free of established terrestrial vegetation. These channels are typically filled to capacity during bankfull discharge (i.e. during the annual flood, except for intermittent rivers that do not flood annually).”

This accurately describes the banks of the Sand River as well as lateral streams flowing into it (Appendix A: Map 2). The wetland conditions are confined to the main channel of these systems which experience surface flow either seasonally or perennially. Here wetland conditions are most prominent along the main channel and decrease in distance from the channel.

Where wetland conditions occur in the floodplain of the Sand River, small backwater depressions have formed and these wetland conditions can be regarded as forming a floodplain wetland (SANBI 2009):

"A floodplain wetland and lowland river floodplain: the mostly flat or gently sloping wetland area adjacent to and formed by a lowland floodplain river and subject to periodic inundation by overtopping of the channel bank of the river. The location of the wetland adjacent to the river in the lowland floodplain zone is the key criterion for distinguishing a floodplain wetland from a channelled valley-bottom wetland. Water and sediment input to floodplain wetland areas is mainly via overtopping of a major channel, although there could be some overland or subsurface flow from adjacent valley side-slopes (if present). Water movement through the wetland is dominantly horizontal and bidirectional, in the form of diffuse surface flow and interflow, although there can be significant temporary containment of water in depressional areas (within which water movement is dominantly vertical and bidirectional). Water generally exits as diffuse surface flow and/or interflow, but infiltration and evaporation of water from a floodplain wetland can also be significant, particularly if there are a number of depressional areas within the wetland."

This accurately described the wetland conditions which occur within the floodplain of the Sand River (Appendix A: Map 2). While wetland conditions are clearly present within the main channel and forms a channel wetland system, those wetland conditions adjacent to the Sand River are clearly a result of the floodplain and there forming a floodplain wetland.

4.2.4 Description of watercourses

The proposed mining operations will mostly affect the banks of the Sand River and the adjacent floodplain or riparian zone (Appendix A: Map 1 & 2). The description of the affected section of the river will be divided into the main channel and banks, the floodplain or riparian zone (including backwater wetland areas) and the lateral watercourses flowing into it.

Obligate wetland vegetation was also used to determine the presence of wetland conditions. Obligate wetland species are confined to wetlands and are only able to occur in wetlands. They are therefore reliable indicators of wetland conditions. Field observations over time as well as the following sources were used to determine FW and OW species:

- Marnewecke, G. & Kotze, D. 1999. Appendix W6: Guidelines for delineation of wetland boundary and wetland zones. In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

- DWAF. 2008. Updated manual for the identification and delineation of wetlands and riparian areas, prepared by M.Rountree, A.L. Batchelor, J. MacKenzie and D. Hoare. Stream Flow Reduction Activities, Department of Water Affairs and Forestry, Pretoria, South Africa.

Sand River main channel and banks (Appendix A: Map 1 & 2)

River systems can be divided into different riparian zones within the lateral section of the system. These riparian zones represent the banks of a river and can be distinguished in terms of their geomorphology and vegetation structure. The same applies to the affected section of the Sand River in the study area. These zones are as follows:

The marginal zone is the lowest zone and is always present in river systems while the other two zones may not always be present. The zone is situated from the water level at low flow, if present, up to the features that are hydrologically activated for the most of the year (Figure 18 & 19). The marginal zone within the Sand River as it occurs within the study area is well defined and easily identifiable. It is relatively narrow in most areas, varying between 1 to 5 meters and is inundated annually during flooding. Along the majority of the affected river section the marginal zone is only one meter in width, however, this may increase to about 5 meters in areas where lateral streams flow into the river and form alluvial sediment fans along the river bank. Previous studies (2017) in the area indicates a dense riparian and sedge layer. However, due to recent prolonged flooding and inundation, most of the vegetation in the marginal zone has either been removed, buried by sediment deposition or succumbed after being submerged for a long period. This also provides an indication of the manner in which the riparian vegetation in this zone functions, it is adapted to a disturbance regime whereby periodic large floods cause disturbance and removal of the vegetation and whereafter the vegetation will undergo a period of succession until the next large flood causes removal of the vegetation. Almost the entire marginal zone is considered a perennial zone of wetness, indicating that soil saturation occurs throughout the year as a result of the zone being situated at the water's edge. The majority of this zone seems to be largely natural on both the southern and northern banks.

As indicated, the majority of vegetation within the marginal zone has been removed by recent flooding. The scant vegetation that has been able to survive include the semi-aquatic fern *Equisetum ramosissimum,* the hygrophilous grass, *Paspalum distichum,* the wetland sedges, *Cyperus marginatus* and *Cyperus longus* and the common reed, *Phragmites australis.* It is was also notable that the riparian tree, *Salix mucronata*, was able to the withstand the flooding of the marginal zone, one of the few trees able to do this. When this survey was compared to previous surveys (2017) the species composition was found to much the same although the abundance was much lower, having been decreased by flooding and inundation. The abundance of the wetland plants will now steadily increase again over the following seasons. It was however notable that exotic weeds observed previously were now completely absent. These establish as a response to flooding but are not in any way adapted to inundation and are quickly removed during floods. They will however undoubtedly re-establish in time.

Figure 9: The marginal zone (red) is quite narrow. Note that recent flooding has almost completely removed the riparian vegetation in this zone.

Figure 10: Another view of the marginal zone (red). This is the shape it has for the majority of this river section, only broadening significantly where alluvial fans occur. Note it is quite narrow and almost all riparian vegetation has been removed by recent flooding.

Figure 11: Another view of the marginal zone (red), which clearly illustrates its shape along this river section.

The lower zone is characterised by seasonal features and extends from the marginal zone up to an area of marked elevation. This area may be accompanied by a change in species distribution patterns. The lower zone consists of geomorphic features that are activated on a seasonal basis (Figure 18 & 19). The lower zone along the Sand River can also be clearly defined and is easily visible as a definite and steep increase in slope over a short distance where after it levels off into the upper zone. The lower zone is inundated less frequently and only during larger flooding events as has recently occurred at the site. In small sections of the river, especially where lateral streams flow into the river and an alluvial fan occurs and the marginal zone is broader the lower zone extends over a larger distance and the increase in slope and elevation is more gradual. It is also clearly defined by a grass layer but with many obligate wetland plants as well. This can also be explained by the flooding of the lower zone. Large-scale flooding has a disturbance effect whereby vegetation is removed and allows for vegetation to re-establish through an ongoing cycle which is well known in river systems. Trees are also being affected most by flooding due to their increased volume presented to floods. Grasses, sedges and the like growth forms are much better adapted to flooding and able to withstand being uprooted to a much better degree. As a result the marginal and lower zones contain almost no trees whereas the upper zone is dominated by trees. The lower zone is largely natural within the study area but is affected by the current sand mining area.

The current survey indicated that vegetation loss due to the recent flood was much less within the lower zone. However, when compared with previous surveys in this area it is notable that the percentage vegetation cover was much higher prior to flooding. Vegetation establishment will continue over time until it is again as dense as prior to the flood. The zone contains a higher species diversity than the marginal zone but with several grass species still being dominant. Dominant grasses include *Cynodon dactylon, Panicum coloratum, Digitaria eriantha, Setaria sphacelata, Setaria pallide-fusca, Eragrostis lehmanniana* and *Sporobolus fimbriatus*. This is a mixture of terrestrial grasses and facultative wetland species and indicates a decrease in the moisture regime and wetland condition from the water's edge up the banks of the river. However, obligate wetland sedges and other growth forms are also still abundant and also confirms that wetland conditions remain present in the lower zone. These include sedges such as *Cyperus fastigiatus, Cyperus marginatus* and *Cyperus longus*. As with the marginal zone, the lower zone is also subjected to frequent flooding and the consequent disturbance caused by this. As a result, exotic weeds are also abundant in this zone and include *Xanthium strumarium, Verbena bonariensis, Conyza bonariensis, Opuntia lindheimerii, Sesbania punicea, Cenchrus incertus* and *Tamarix ramosissima.* Where the lower zone contains extensive sandy areas, clumps of the indigenous tree, *Salix mucronata*, was also observed. As previously indicated, the lower zone is completely devoid of trees and shrub, except for this small tree. It has adapted to flooding and prolonged submergence and the survey has also confirmed that these have been able to survive the recent flooding. Scattered specimens of the protected geophyte, *Crinum bulbispermum*, also occur along the banks in the lower zone. This species still retains a significant conservation value and should be avoided by the proposed mining operations.

Figure 12: The lower zone (red) of the river bank has a steep slope, is easily discernible and has a clear border with the upper zone (edge of riparian thicket). Note also a considerable loss of riparian vegetation due to recent flooding.

Figure 13: The lower zone (red) varies in width along the section and may be narrow on one bank, while being broad on the opposite.

Figure 14: Some portions contain a very broad lower zone with extensive sands and these areas are also likely to be affected by the proposed sand mining.

Figure 15: Where the lower zone contains extensive sandy areas, clumps of the indigenous tree, *Salix mucronata*, was also observed.

The upper zone is characterised by ephemeral features as well as the presence of both riparian and terrestrial species. The zone extends from the lower zone to the riparian corridor. The upper zone contains geomorphic features that are hydrologically activated on an ephemeral basis (Figure 18 & 19). The upper zone along the Sand River is clearly visible as a decrease in slope and an increase in the woodland component. The tree species are able to attain height and age due to the deep root systems still able to access the higher moisture levels and as flood disturbance in the upper zone is much less the trees are allowed to grow old without being removed by flood damage. The riparian tree species within the upper zone is dominated by *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn), Searsia pyroides (Taaibos), *Celtis africana* (White Stinkwood) and *Diospyros lycioides* (Bluebush) which then also indicate the border of the upper zone. Underneath this tree layer an undergrowth is present which is adapted to shaded habitats formed by the tree layer. The shade loving grass, *Setaria verticillata* is especially abundant. Shrubs include *Lycium hirsutum, Artemisia afra, Asparagus cooperi* and *Asparagus larcinus*. Though disturbance caused by flooding is much less in this zone, other disturbances are still present and is substantiated by the presence of several exotic weeds and invasive species. These include the weeds, *Bidens bipinnata, Tagetes minuta, Achyranthes aspera* and the invasive tree species, *Eucalyptus camaldulensis, Populus deltoides* and *Fraxinus americana*. The majority of the upper zone, and the riparian thicket it supports, is still intact.

Figure 16: The border between the upper- and lower zones (red) is easily visible where the slope levels off and the riparian thicket starts.

Figure 17: The upper zone is clearly visible as dense riparian thicket. Note also that while recent flooding had removed much of the vegetation within the lower and marginal zones, the upper zone remains largely intact.

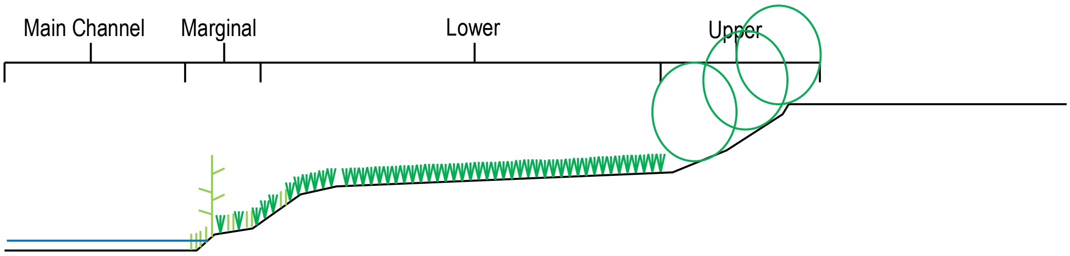

Figure 18: Illustration showing the different riparian zones of the Sand River in the study area. This illustrates the broadening of the zones in areas where alluvial fans occur. These are also the portions most likely to be targeted for sand excavation.

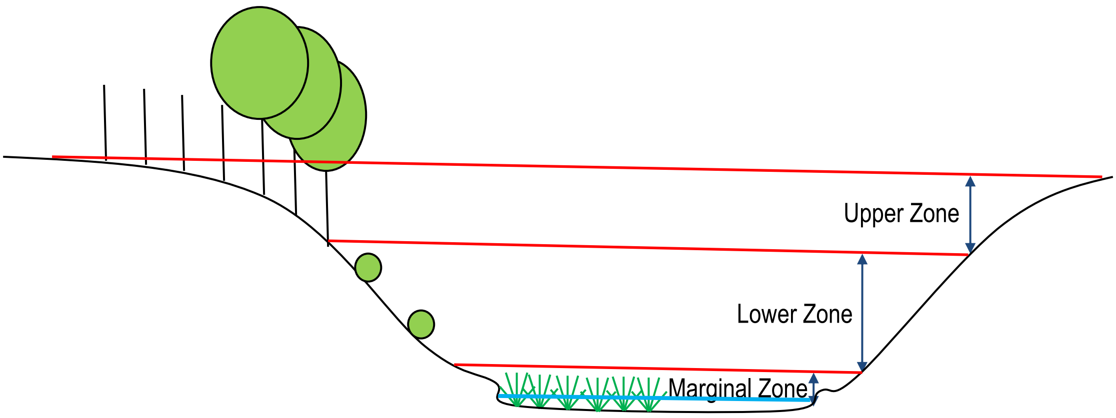

Figure 19: Illustration showing the different riparian zones of the of Sand River in the study area. This illustrates the steep banks occurring in some portion of the river, especially along the northern banks. Note the narrow marginal zone and steep lower zone.

Figure 20: Aerial view of the riverbank zonation (Google Earth 2021) (Blue – Marginal, Yellow – Lower, Red – Upper Zone). This represents the majority of the riverbank zonation along the affected section. Note a widely varying lower zone with alluvial sand deposits present in many areas.

Figure 21: Aerial view of the riverbank zonation (Google Earth 2018) (Blue – Marginal, Yellow – Lower, Red – Upper Zone). Where lateral streams flow into the river they cause the formation of alluvial fans and broadening of the marginal and lower zones.

Floodplain or riparian zone of the Sand River (Appendix A: Map 2)

The floodplain or riparian zone of the Sand River along the section in the study area is extensive. It is very broad in most areas and covers the entire extent of the proposed mining areas, i.e. 200 meters in width on both the northern and southern banks.

Delineation of the floodplain or riparian zone could not be easily determined, since alluvial deposition has occurred over an extensive area. It is however certain that almost the entire mining area consists of the riparian zone with only a few small portions clearly consisting of surrounding terrestrial habitats. The delineation of the floodplain and edge of the riparian zone within the proposed mining area was determined by using a combination of soil sampling, vegetation composition and topography and is considered to give an accurate description of it.

Soil samples taken within the floodplain indicate the general absence of wetland conditions, which is also confirmed by the vegetation composition. The soils indicate a high silt content without any prominent gravel or stone component, which is characteristic of floodplains and also confirms the presence of the riparian zone. A high sand content was also present in most areas.

Topography with the floodplain or riparian zone is dominated by a relatively flat, alluvial plain which extends over a larger area and is readily distinguished from the surrounding terrestrial areas which is visible as a slight elevation.

Soil samples and topography aid in delineation of the riparian zone, however, the vegetation composition is the most prominent indicator and provides the most accurate delineation of the riparian zone. The floodplain or riparian zone is dominated by a low shrub layer, scattered trees and well-developed riparian thicket. The dense shrub/tree layer is dominated by *Vachellia karroo, Lycium hirsutum, Asparagus larcinus, Ziziphus mucronata* and *Gymnopsoria buxiifolia*. This assemblage of tree and shrubs are quite characteristic of riparian thicket vegetation. A poorly developed grass layer, dominated by pioneer species is also interspersed in this shrub layer. These include *Aristida congesta, Eragrostis lehmanniana, Cynodon dactylon, Pogonarthria squarrosa* and *Urochloa mosambicensis*. The facultative grass, *Panicum coloratum*, also occur in areas of higher moisture regime. The fine silty soils in the riparian zone also promotes the establishment of a few succulent species such as *Mestoklema tuberosum* and *Delosperma* cooperi. Exotic weeds are also common and include *Zinnia peruviana, Bidens bipinnata, Schkuhria pinata, Opuntia humifusa, Conyza bonariensis* and *Cyllindropuntia imbricata*.

Figure 22: The alluvial floodplain or riparian zone along the Sand River is relatively distinct as a flat plain dominated by riparian thicket.

Figure 23: The riparian thicket can be quite dense in most areas.

Figure 25: Surrounding terrestrial areas are dominated by a well-developed grassland which transitions into a much more denser thicket vegetation within the floodplain or lower lying alluvial plains associated with the river.

Backwater areas forming floodplain wetlands (Appendix A: Map 2)

As indicated the floodplain or riparian zone of the Sand River is largely devoid of wetland conditions. However, a few backwater wetland areas has formed and here wetland conditions are clearly present.

These floodplain wetlands are fairly easily distinguishable from the surrounding riparian thicket. All of these areas form a very shallow depression where, consequently, surface water now accumulates and saturated soil conditions form. These floodplain wetlands are now mostly fed by runoff from the surrounding catchment but it is most likely that they would also have been fed by overtopping of the main channel into the floodplain prior to the construction of the upstream Allemanskraal Dam. This dam acts as a flood regulator and the floodplain of the river would now be flooded on a very infrequent basis, if ever.

The topography of these wetland areas, a shallow depression, does allow for quite easy delineation of these wetland areas. Furthermore, soil samples contained quite clear indications of seasonal wetland conditions and also further aided in the identification and delineation of these floodplain wetlands.

As indicated, these floodplain wetland areas are fairly easily discernible and this is also the case for the vegetation within these areas. Where the surrounding floodplain is dominated by riparian thicket, these backwater wetland areas are dominated by hygrophilous grasses and obligate wetland sedges. This further aids in distinguishing these wetland areas. Hygrophilous grasses include the facultative species such as *Setaria sphacelatum, Echinichloa holubii* and *Pancium coloratum*. Obligate wetland sedges also dominated and include *Cyperus longus, Cyperus* *difformis* and *Cyperus marginatus*. Other herbaceous and graminoid plants which are abundant and are most often associated with areas with a high moisture regime include *Alternanthera sessilis, Cyperus indecorus, Isolepis sp.* and *Salola rabienana*. These backwater wetlands are all still natural but does also contain several exotic weeds such as *Verbena bonariensis, Xanthium strumarium* and *Schkuhria pinata*.

Table 2: Summary of backwater floodplain wetlands (Map 1 & 2).

Watercourse	Position of crossing
#1 Western floodplain wetland	S 28.142277°, E 26.657987°
#2 North western floodplain wetland	S 28.139611°, E 26.661827°
#3 Eastern poorly defined floodplain wetland	S 28.137296°, E 26.684077°
#4 Eastern poorly defined floodplain wetland	S 28.136626°, E 26.691238°
#5 Eastern floodplain wetland	S 28.132651°, E 26.694400°

Figure 26: View of one of the backwater floodplain wetland areas which clearly forms a shallow depression in the landscape.

Figure 27: The vegetation within these floodplain wetland areas are also dominated by hygrophilous grasses and sedges which clearly differentiates it from the surrounding riparian thicket.

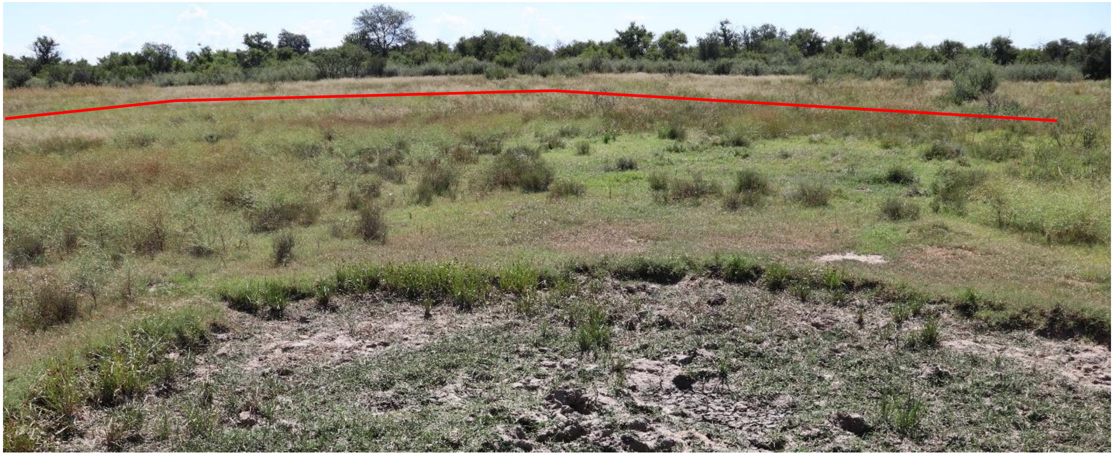

Figure 28: Not all of these floodplain wetlands are as easily defined but contain at least patches where wetland conditions are clearly present.

Lateral streams and drainage lines flowing into the Sand River (Appendix A: Map 2)

As previously indicated, there are numerous small drainage lines and seasonal streams that drain from the terrestrial surroundings, across the floodplain and into the Sand River on the site. All of these, irrespective of their size, will transport surface water after rainfall events and they should therefore also be taken into consideration in this assessment.

The following brief description of the functioning of these stream systems should indicate their sensitivity and relevance to the proposed mining operations.

Non-perennial rivers are systems in which surface flow stops and may disappear for some period of most years (Uys & Keeffe 1997). This is true for all of the lateral stream systems flowing into the river at the site. Floods are essential to the existence, productivity and interactions of many biotic elements in seasonal ecosystems. The longitudinal transfer must play a vital role where any deliverance of moisture may serve to supplement available resources. Floods transfer materials laterally and longitudinally, but more importantly, water triggers ecosystem processes (Jacobsen 1997). Floods have also been shown to play an important role in structuring riparian communities. Different plant species differ in their ability to withstand or regenerate after major floods (Stromberg, Lite & Dixon 2010). From the above it should be clear that flooding is essential to the continued and natural functioning of the seasonal watercourses in the study area. It is also a real occurrence during the annual cycle of these watercourses and will occur annually in the seasonal systems. This should therefore also be taken into consideration where mining operations along the banks of the Sand River and floodplain will be influenced by these lateral watercourses. The above description should give a general idea of the functioning of the small lateral watercourses within the study and should also serve to indicate that although they may seem small and flow only occur sporadically they still have a complex functioning which provides several unique ecosystem services. They should consequently still be considered as sensitive systems, should be avoided by any proposed mining operations and an applicable buffer zone retained around these streams.

Soil samples taken within these small watercourses indicated that they all contain significant wetland conditions, at least in those portions of the watercourses that occur within the proposed mining area. They form clearly defined channel wetland systems, the same as the Sand River. Vegetation along these lateral watercourses also confirmed riparian conditions along all of them, while the main channel also contained at least some obligate wetland vegetation. Soil samples also confirmed the presence of wetland conditions.

The study area contains a multitude of these stream and smaller drainage lines and only a representative sample of these were surveyed. These systems are all similar in terms of their geomorphology, vegetation composition and functioning and assessment of a few of these systems should therefore provide an accurate description of all of these lateral watercourses. These watercourses flowing through the floodplain and into the Sand River all contain a well-defined main channel and is dominated by a riparian shrub layer along the banks with a variety of riparian grasses and wetland sedges along the main channel and banks. The main channel and banks contain a variety of grasses with the smaller systems containing terrestrial species but which also often occur in riparian vegetation. Riparian grasses which dominated include *Cynodon dactylon, Digitaria eriantha, Sporobolus fimbriatus, Panicum coloratum, Setaria sphacelatum, Echinchloa holubii* and *Setaria pallide-fusca*. However, in all of these systems, at least some obligate wetland vegetation were noted. These included sedges such as *Cyperus longus, Cyperus dastigiatus* and wetland grasses such as *Leptochloa fusca*. Other aquatic or semi-aquatic plants also included *Marsilea farinosa, Mimulus gracilis, Ranunculus multifidus, Conyza podocephala, Alternanthera sessilis* and *Persicaria lapathifolia*. A protected and rather uncommon plant, *Kniphofia ensifolia*, also occurs along these watercourses and is of significant conservation value. Riparian trees and shrubs are also abundant along these smaller watercourses and include *Vachellia karroo, Diospyros lycioides, Asparagus larcinus, Searsia pyroides* and *Ziziphus mucronata*. Exotic weeds are also quite common along these small watercourses and include *Bidens bispinosa, Xanthium strumarium* and *Verbena bonariensis*.

Table 3: Summary of lateral streams and drainage lines (Map 1 & 2).

Watercourse	Position of crossing
#1 Large stream along western border	S 28.145726°, E 26.650782°
#2 Small western drainage line	S 28.143700°, E 26.653049°
#3 Small western drainage line	S 28.141498°, E 26.662887°
#4 Large western stream system	S 28.141230°, E 26.665105°
#5 Small central drainage line	S 28.139496°, E 26.670037°
#6 Small western drainage line	S 28.138924°, E 26.659085°
#7 Large central stream system	S 28.137550°, E 26.667190°
#8 Large central drainage line	S 28.135598°, E 26.672126°
#9 Small central drainage line	S 28.138894°, E 26.674167°
#10 Small central drainage line	S 28.140412°, E 26.676099°
#11 Large central eroded stream system	S 28.144245°, E 26.678915°
#12 Large central stream system	S 28.140339°, E 26.682780°
#13 Small eastern stream system	S 28.132643°, E 26.683387°
#14 Small eastern stream system	S 28.136138°, E 26.689180°
#15 Small eastern drainage line	S 28.134184°, E 26.689116°
#16 Small eastern drainage line	S 28.134232°, E 26.691491°
#17 Small eastern drainage line	S 28.131851°, E 26.690946°
#18 Small eastern drainage line	S 28.130689°, E 26.693261°

Figure 29: The study area contains many large stream systems which clearly flow on a seasonal basis.

Figure 30: Clear wetland conditions are also prominent along the majority of these seasonal stream systems.

Figure 31: One of the drainage systems in the central portion of the study area is characterised by high amounts of natural erosion. All of the streams and drainage lines will also be susceptible to increased erosion should mining have any impact on them.

Figure 32: Smaller drainage lines are less prominent but nonetheless contain at least some wetland conditions.

4.3.5 Water quality and comparison with background values

Comprehensive water quality analysis has been undertaken by an accredited laboratory (refer to Appendix G for the complete report). These results were also compared against previous samples (2020 & 2021) in order to indicate the trend of water parameters. In terms of bacteriological values, the Sand River contains fairly high values of coliforms and *E.coli*. This is however not regarded as a result of sewage discharge from a Waste Water Treatment Works but may be linked to smaller localised ablution facilities along the river as well as from livestock grazing along the river and the resulting manure that enters the river.

These bacteriological values indicate that the water is not suitable for consumption but do not pose a significant risk for full contact recreation as recommended by the South African Water Quality Guideline.

Table 3: Summary of bacteriological results of the water in the Sand River at the proposed sand mining area taken in March 2022 (counts/100ml).

Determinant	Units	SANS 241:2015	Risk	August 2020	March 2021	Site1 Upstream (March 2022)	Site2 Downstream (March 2022)
Heterotrophic / Standard plate count	CFU/ml	< 1000	Operational	**540**	**>30 000**	**>1000**	**>1000**
Total coliforms	CFU/100 ml	10	Operational	**300**	**>1 500**	**>2420**	**>2420**
Faecal coliforms	CFU/100 ml	0		**62**	**250**	**249**	**326**
E. coli	CFU/100 ml	0	Acute Health Micro	**30**	**160**	**517**	**727**

Results indicate that the water quality contains high levels of bacteriological contamination but which is unlikely to be linked to untreated sewage being discharged into the river.

The risk to on-site mining personnel is however still low in terms of full contact during operational processes but is however unsuitable for consumption. Potable water for the operational personnel should therefore not be sourced from the river.

In terms of the chemical water quality parameters the water within Sand River seem to fall within the excepted standards. High levels of turbidity during the current sampling may be a result of the recent flooding of the river.

According to diatom sampling results (Appendix G: Koekemoer 2022) the Sand River at the site is characterised by poor biological water quality with significant nutrient and organic loads. In addition, high salt concentrations are notable which may be a consequence of the upstream diamond mining operations.

Table 4: Guideline for faecal coliforms and somatic coliphages to be used for full contact recreation (counts/100ml) (DWA 1996).

Faecal coliform target guideline range	Effects
0-150	Negligible risk of gastro-intestinal effects is expected. It should, however, be noted that while the presence of faecal indicators indicates a possible risk to health, the absence of indicators does not guarantee the absence of risk. The postulated range should not be exceeded by the geometric mean or median count over a period of three months. Whenever possible, this three month period should coincide with seasons to allow detection of seasonal variation in water quality.
150-600	A slight risk of gastro-intestinal illness is indicated at faecal coliform levels which occasionally fall in this range. The risk increases if geometric mean or median levels are consistently in this range. This range should not be exceeded by the geometric mean or median of fortnightly samples collected over a three month period.
600-2000	Noticeable gastro-intestinal health effects may be expected in the population of swimmers and bathers. Some health risk exists if single samples fall in this range, particularly if such events occur frequently.
>2000	As the faecal coliform level increases above this limit, the risk of contracting gastrointestinal illness as a result of full contact recreation increases. The volume of water which needs to be ingested in order to cause adverse effects decreases as the faecal coliform density increases.
Coliphages target guideline range	**Effects**
0-20	Negligible risks of sewage pollution and of enteric virus infection are indicated. It should be noted that, as for all indicators, the absence of the indicator does not necessarily guarantee the absence of indicated pathogens. This range should not be exceeded by the geometric mean or median of fortnightly samples collected over a period of three months. Preferably this three month period should coincide with seasons to allow detection of seasonal variation in water quality.
20-100	A slight risk of sewage pollution and of virus infection is indicated. The risk is increased if geometric mean or median levels frequently fall in this range but is probably minimal if only isolated instances are recorded. This range should not be exceeded by the geometric mean or median of fortnightly samples collected over a three month period.

>100	Significant sewage pollution and health risks may be expected if geometric mean or median coliphage levels commonly exceed this limit. Risks increase as occurrences of high coliphage levels increase in frequency and extent.

4.3.6 Condition and importance of the affected watercourses

The determination of the condition of the Sand River, associated floodplain and lateral watercourses in the study area will be based on an overall determination of the Index of Habitat Integrity (IHI) (Appendix D). Due to the numerous lateral streams and drainage lines situated along the floodplain of the Sand River a determination of the Index of Habitat Integrity (IHI) will be limited to an overall IHI of the Sand River. All of the lateral watercourses drain into the Sand River within the study area and therefore forms part of one system, located in close proximity to each other, are affected by the same impacts, located within the riparian zone of the Sand River, situated in the same environmental setting and will all affect the same downstream section of the Sand River (Appendix A: Map 2). Therefore, one IHI will be conducted to represent the overall condition for the Sand River in the study area. This is considered to give a good representation of the condition of the system within the study area which will be affected by the proposed mining operations. The IHI will be taken as representative of the Present Ecological State (PES) of this system.

In addition, the backwater floodplain wetland areas occurring adjacent to the main channel of the river, although part of this system, also functions independently from it to a large degree. In order to provide a further indication of the condition of these floodplain wetland areas, a WET-Health determination will be done for one of the larger floodplain wetlands to serve as a representative of these wetland systems. The WET-Health will be taken as representative of the Present Ecological State (PES) of this system (Appendix D).

Table 4 refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers relative to the natural or close to the natural reference condition. The purpose of the EcoClassification process is to gain insights and understanding into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river (Kleynhans & Louw 2007).

Table 5 refers to the Ecological Importance and Sensitivity (EIS) of wetlands. "Ecological importance" of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. "Ecological sensitivity" refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The Ecological Importance and Sensitivity (EIS) provides a guideline for determination of the Ecological Management Class (EMC).

Table 4: Ecological categories for Present Ecological Status (PES).

Ecological Category	Description
A	Unmodified, natural
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.

C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominately unchanged.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem function has occurred.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Critically/Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

Table 5: Ecological importance and sensitivity categories.

Ecological Importance and Sensitivity Category (EIS)	**Range of Median**	**Recommended Ecological Management Class**
Very High Floodplains that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4	A
High Floodplains that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3	B
Moderate Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2	C
Low/marginal Floodplains that are not ecologically important and sensitive at any scale. The biodiversity of these floodplains is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1	D

According to Kleynhans (2000) a desktop assessment of the Sand River in the study area and which will be affected by mining operations is considered to have a PES of Category C: Moderately Modified. More recent desktop assessments (Van Deventer *et al* 2018) also confirm this assessment. On-site observation indicate that this is relatively accurate as this study has also calculated the river as having a PES of Category C: Moderately Modified. Despite this the system still provides vital services including water transportation, flood dissipation, wetland and riparian habitat and support of ecological processes. The system should still be regarded as sensitive with a very high conservation value and mining should endeavour to keep impacts on it to a minimum.

The majority of rivers in South Africa are already in an altered condition. The section of the Sand River within the study area is also considered to be moderately modified by several impacts. The flood dynamics of the river has been altered to a large degree by the construction of a large containment dam, the Allemanskraal Dam, upstream. The dam results in impacts associated with abstraction for various uses including consumption, irrigation and industrial uses as well as to allow for flood control in downstream areas. The Allemanskraal Dam has influenced the frequency and magnitude of flooding which is part of the natural system. These structures now regulate the magnitude and frequency of floods in the river. As a result thereof the flooding of the floodplain within the upper zone does no longer take place at the same regular intervals and magnitude. This was also evident during recent high rainfall where flooding could be regulated and controlled by opening and closing of the sluices of the Allemanskraal Dam. Floods are essential to the existence, productivity and interactions of many biotic elements of the riparian community. Large floods influence the geomorphology of the riparian zone as well as sediment dynamics. Floods have also been shown to play an important role in structuring riparian communities. Different plant species differ in their ability to withstand or regenerate after major floods. As floods alter the species composition of a community, invariably the ecosystem functions are also altered, especially where shifts occur in plant functional types. It is therefore evident that a reduction in flood frequency and magnitude will have a definite effect and alteration of riparian communities.

Impacts and land use in the surrounding catchment as well as riparian areas are numerous and cause significant modification of the Sand River. The area is subjected to extensive gold mining operations. This type of mining has several highly deleterious impacts including acid mine drainage. This will undoubtedly also affect the river. The current sand mining activities itself also has several impacts on the river. These impacts are currently localised and still contained within a small area, but may become more extensive as mining is expanded. This will undoubtedly contribute to the sediment load of the river. The increased sediment leads to impacts such as sedimentation of unique bedrock communities, a decrease in instream and marginal macrophytes and impacts on the aquatic community. Centre-pivot irrigation takes place along the river in upstream and downstream areas. In addition, dryland crop cultivation is also extensive in the surrounding catchment. This will impact on the river as a result of fertiliser runoff and enrichment, pesticides and other impacts associated with commercial irrigation. Due to the clearing of natural vegetation the surface runoff velocity will increase and groundwater infiltration will decrease. This will increase erosion and consequently sediment load in the river. An impact associated with crop irrigation will also be a decrease in baseflow of the river. Water abstraction for irrigation from the river will decrease the amount of baseflow and alter the flow regime in the river and will increase zero flows. The river also flows through the urban area of Virgina and surroundings and the impacts associated with the urban area will include increase runoff and refuse in the river. The towns waste water treatment works also releases effluent into the river which is likely to affect the water quality of the river to some degree depending on the operation of the works. Most of the impacts or land uses described above also require to varying degrees, abstraction from the river. Though most of these do not require large volumes by themselves, though cumulatively, large volumes of water is being abstracted from the river contributing to considerable decreases in flow volumes. This also has a large impact on the natural flow regime of the river.

According to previous desktop assessments (Kleynhans 2000, Van Deventer *et al* 2018) those floodplain wetlands that had been identified along the Sand River is considered to have a PES of Category A/B: Natural to Largely Natural. The current survey indicates this to be somewhat overestimated though they do remain largely natural. A few impacts has resulted in a low level of modification to these floodplain wetland areas. A few small dirt tracks adjacent to these wetland areas would have a low impact in terms of flow modification. Overgrazing and trampling by domestic livestock was also notable in these wetland areas and this would also contribute an additional low impact on these systems. Coupled with this are also foraging excavations by the invasive Warthog (*Phacochoerus africanus*) which is not native to the grassland biome and can cause significant disturbance in natural areas. The main impact on these floodplain wetlands will be the change in their hydrology. Historically, these floodplain wetlands would have been fed to a significant degree by the overtopping of the river channel during flooding. However, due to flood control by the upstream Allemanskraal Dam this rarely, if ever, still occurs. These floodplain wetlands are now almost exclusively fed by runoff and groundwater inflow from the surrounding catchment. From the above, it is clear that though these floodplain wetlands are still largely natural their condition would have been altered to some degree.

Figure 33: Aerial images from 1944 clearly indicate the area to still be largely natural without any significant modifications (National Geo-Spatial Information).

Figure 29: A more recent aerial image (Google Earth 2021) also indicates that the river and immediate surroundings remain largely unchanged, a small sand mine and nearby agricultural fields being the only significant change.

The Sand River and its associated floodplains are considered a third order watercourse. This is also due to the Sand River being a large lowland river. The quaternary catchment of this area is C42L. The largest impact on the study area is the construction of large upstream containment dam in the Sand River. These impacts alter the flooding regime and the functioning and habitat of the river and floodplains. An Index of Habitat Integrity (IHI) was conducted along the Sand River within the study area (Appendix D). The results of the IHI indicated that the Sand River has an Instream IHI of category C: Moderately Modified and Riparian IHI of category C: Moderately Modified. This is largely due to the change in flooding regime and disturbance/transformation of the habitat. The Sand River and associated wetlands and floodplains are considered to be somewhat modified by historical and current impacts.

The floodplain wetlands along the Sand River in the study area are clearly not affected by many impacts. A WET-Health determination was undertaken for one of the larger backwater areas to serve as representative for the floodplain wetland areas along the study area (Appendix D). The results of the WET-Health indicated an overall Present Ecological State of Category B: Largely Natural. Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. This is considered relatively accurate given the few impacts affecting it.

The EI&S of the floodplains associated with the Sand River has been rated as being Moderate: Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains are not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers. The riparian habitat associated with the river does not have a significant diversity of species. Diversity is also affected by numerous exotic weeds which form dense patches in areas. Diversity of habitats is considered moderate due to the variety in the vegetation structure varying from grassland to thicket. It is considered unlikely that the site will provide a significant feeding or migratory site for wetland species. Despite this it must be kept in mind that watercourses such as the Sand River provide a much richer system in terms of habitat and feeding ground when seen in comparison to most terrestrial ecosystems. Due to relatively low levels of diversity and uniformity of the river it will only be moderately sensitive to changes in hydrological regime and water quality changes. The extensive floodplain will play a moderate role in flood storage, energy dissipation and particulate removal. The protected status of the river must still be considered as high as it is a major river providing vital services. The ecological integrity of the river is moderate as it has been affected by several upstream impacts.

4.2.7 Buffer zone determination

As indicated in previous sections, the Sand River, its floodplain, lateral drainage lines and backwater wetland areas provide several vital ecological services and it is important that operations not result in further impacts on them. The operations should therefore exclude and avoid these watercourses and wetlands (Appendix A: Map 2). The main channel of the Sand River, the associated wetland conditions occurring along the marginal and lower zones, all lateral drainage lines and backwater wetland areas are all regarded as being of very high sensitivity. These areas should be treated as no-go areas and should be avoided, as far as possible by the proposed sand mining operations. This will not be possible where sand is excavated from the lower zone or where sand pumping is done from the main channel. In these instances, the operational area (stockpile area, sand screen, settling dams and all other associated structures and infrastructure) should at least be located outside these areas of high sensitivity.

In addition, a suitable buffer for these areas of very high sensitivity can be provided by using the Buffer Zone Tool for the Determination of Aquatic Impact Buffers and Additional Setback Requirements for Wetland Ecosystems (2014) (Appendix F). This determination was also done in conjunction with Macfarlane *et al* (2014). It should be noted however that the buffers determined by this model only caters for wetland systems and impacts associated with diffuse-source surface runoff. As a result the buffer was determined only for the backwater wetland systems, although this buffer should also be applied to the river channel, associated wetland conditions and lateral stream systems. By using the above tools a suitable buffer of 38 meters from the edge of the floodplain wetland areas and the wetland conditions along the Sand River main channel and lateral stream systems has been determined (Appendix A: Map 2).

The main channel of the Sand River, wetland conditions along the banks, lateral stream systems and floodplain wetland areas are all regarded as having a very high sensitivity (Appendix A: Map 2). The 38 meter buffer zone is also regarded as having a high sensitivity. The portions of the floodplain outside this 38 meter buffer is still regarded as having a moderate sensitivity but impacts here will be more easily manageable. As a result, mining operations should aim to avoid all areas regarded as having a very high and high level of sensitivity, while focussing operations in areas with moderate sensitivity. This may however not be possible where sand excavation takes place from the lower zone or banks of the river and where sand is pumped from the main channel. In such instances, the operational area (stockpile area, sand screen, settling dams and all other associated structures and infrastructure) should at least be located outside these areas of high sensitivity. It remains however apparent that sand mining operations will result in several significant impacts on the Sand River.

4.3 Risk Assessment

A Risk Assessment for the proposed sand mining operations along the Sand River has been undertaken according to the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). Activities which will be implemented by the sand mining operations and which may affect the Sand River include the extraction (via pump and float) of sand from the main channel, an access road and pump structure along the bank, excavation of sand from the banks of the river and a processing and stockpile area in the floodplain of the river.

The sand mining operations will entail the excavation of sand from the banks and floodplain of the river. Sand is continuously deposited along the banks of the river by flooding events. These sands are exposed along the lower zone when the river is at its baseflow level. It is largely these sands that will be excavated by the mining operations by means of excavators and transported by means of a small dirt access road to stockpiling areas in the floodplain. Impacts associated with this will include modification of the geomorphology, loss of some of the riparian vegetation, contributing toward increased sedimentation of the river and causing local modification and de-stabilisation of the bank. Given the large extent of the proposed mining right area (approximately 230 hectares) this may potentially result in high impacts. In order to limit this impact it is recommended that sand excavation areas be limited to an extent of 5 hectares at a time. Sand should be excavated, processed and the area rehabilitated before moving to a new sand mining area. If this mining method is maintained, the risk is anticipated to remain moderate. This is however subject to comprehensive mitigation and rehabilitation measures being implemented. This should include amongst others; limiting the extraction areas and access roads in terms of extent as well as the number of access points, implementing consecutive rehabilitation in order to preserve the integrity of the system, adequate management of topsoil, prevention of erosion and sedimentation and continuous eradication of exotic weeds. Comprehensive rehabilitation will also have to be implemented after mining has ceased.

An additional mining method which is also being considered entail the pumping of sand from the main channel by means of a sand pump, associated infrastructure and an access road along the riverbank. The main impacts associated with this will be removal of sand from the channel which will affect geomorphology, affecting the aquatic fauna dependant on the sandy habitat and causing local modification of the bank. If these extraction areas are limited to the 5 hectares sand excavation site and to one extraction point at a time, the extent of the impact should be limited and confined to the site (5 hectare area). The risk is therefore only anticipated to remain moderate. Mitigation which should be implemented to limit the impact should include restricting sand extraction points to only one point at a time and rehabilitating the extraction site immediately when the pump is moved to another location along the site. Adequate rehabilitation of the bank and eradication of exotic weeds will also have to be implemented.

The sand which is excavated from the main channel, banks and floodplain will be transported via the small access roads to a stockpiling area located in the floodplain. Should sand extraction by a pump also be implemented this will also include settling ponds. The most prominent impacts associated with these areas are the removal of riparian vegetation and disturbance of the soil surface. Other likely impacts will include increased sediment washing into the river and likely flooding of the stockpiling area during large floods. The anticipated risk is however anticipated to remain moderate. Adequate mitigation which should be implemented to reduce the risk as described should include implementing an adequate storm water management system which should protect the stockpiling area from flooding and should prevent erosion and sediment from being washed into the river. Correct topsoil management should also be implemented which should include removal of topsoil in all areas where disturbance will occur, i.e. truck turning areas, stockpile area, etc. and replacing topsoil in disturbed areas when rehabilitation is undertaken. Adequate rehabilitation and eradication of exotic weeds will also have to be implemented when mining has been completed.

Moderate Risks: Risk and impact on watercourses are notable and require mitigation measures on a higher level.

For the complete risk assessment please refer to Appendix E.

No.	Phases	Activity	Aspect	Impact	Risk Rating	Confidence level	Control measures
1	Mostly Operational Phase but also limited during rehabilitation	Sand mining operations	Excavation of sand from the riverbank and floodplain including associated access roads.	Sand will be excavated from the banks or lower zone and floodplain by excavators which will result in removal of riparian vegetation, modification of the geomorphology, sedimentation of the river and similar impacts associated with the access road.	**M**	**4**	The excavation of sand will result in permanent alteration of the geomorphology of the banks and floodplain, but provided that adequate rehabilitation is undertaken the condition of the river will not be decreased and its functioning can also remain relatively intact. Mining areas should also be limited to an extent of 5 hectares at a time. As long as adequate rehabilitation and mitigation is implemented the impacts should also largely be confined to the immediate vicinity of the site (5 hectares at a time). The risk should remain moderate and adequate mitigation should be implemented. Mitigation should include limiting the extent (5 hectares) and number of excavation sites and implementing consecutive rehabilitation. Exotic weed eradication will also be an important management aspect.

	Mostly Operational Phase but also limited during rehabilitation		Extraction of sand from the main channel including pump infrastructure and access road.	Sand will be extracted from the main channel by a pump which will entail removal of material from the riverbed, a pump and associated infrastructure and an access road along the riverbank.	**M**	**4**	The extraction of sand is not anticipated to have any permanent or long lasting impacts on the river. It will however cause alteration of the geomorphology and affect the biota at the site but should not affect adjacent areas. The risk should remain moderate and adequate mitigation should be implemented. Mitigation should include limiting the extraction points to only one at a time and when moving the pump to another location the disturbed area should first be adequately rehabilitated. This should include the bank of the river and any access road.
	Mostly Operational Phase but also limited during rehabilitation		Stockpiling areas and associated activities	Sand excavated and pumped from the main channel, banks and floodplain will be transported to a stockpiling area in the floodplain which will require vegetation removal and disturbance of the soil surface.	**M**	**4**	Given the large extent of the proposed mining right area (approximately 230 hectares) this may potentially result in high impacts. In order to limit this impact it is recommended that sand excavation areas be limited to an extent of 5 hectares at a time. Sand should be excavated, processed and the area rehabilitated before moving to a new sand mining area. If this mining method is maintained, the risk is anticipated to remain moderate. The clearance of vegetation and disturbance of the soil surface may however cause significant impacts if correct mitigation is not implemented. The stockpiling may increase sediment load and turbidity within the river and the correct storm water management system should be implemented to prevent this. It will also be important to implement adequate rehabilitation of the stockpiling area. This should include correct topsoil management and prevention of exotic vegetation establishment.

5. Biodiversity Sensitivity Rating (BSR)

Habitat diversity and species richness:
Habitat diversity in the study area is considered relatively high. The area contains riparian thicket, floodplain, lateral stream systems, reed beds, aquatic habitat and backwater wetlands in the floodplain. The surrounding terrestrial habitats being dominated by grassland also contribute significantly toward habitat and species diversity. The habitat diversity is therefore regarded as high, though despite this, species diversity remains moderate.

Presence of rare and endangered species:
No rare or endangered species were encountered in the area and it is also not known to contain such species. A few protected species had been observed in the surrounding areas and may also be likely to occur on the site (Appendix B). These include *Ammocharis coranica, Kniphofia ensifolia* and *Crinum bulbispermum.*

The majority of these species are relatively widespread and common and therefore not of exceptionally high conservation value. However, as protected species all of them still retain some conservation significance.

Ecological function:
The ecological function of the study area and surroundings are still fairly natural and intact though the river itself is moderately modified, mostly by upstream impacts. has been altered to a significant degree. The site functions as habitat for a variety of fauna, supports a specific vegetation type and contain numerous watercourses, including the Sand River, performing important functions in terms of water transportation, wetland and riparian habitats and bio-remediation. Natural vegetation still dominated the area, though a low level of disturbance is still evident (Appendix A: Map 1). As a result, the habitat provided for fauna is still largely intact and given the fact that watercourses are able to sustain a higher bioload and much more diverse faunal population, it further increases the importance of its ecological function. The Sand River, its floodplain, lateral stream system and backwater wetland areas provide numerous vital ecosystem functions and consequently the overall ecological function of the area must be regarded as high.

Degree of rarity/conservation value:
According to Mucina & Rutherford (2006) the area consists of Highveld Alluvial Vegetation (Aza 5) and is listed as being of Least Concern (LC) within the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Appendix A: Map 1). It is a widespread vegetation type and not currently subjected to any pronounced development pressures. The conservation value of the vegetation type would therefore be relatively low.

All watercourses including the Sand River, floodplain, backwater wetland areas and lateral stream systems are considered sensitive ecosystems and their conservation value must therefore be considered as relatively high (Appendix A: Map 1 & 2).

Percentage ground cover:
The region is characterised by a moderate climate and consequently would also sustain a moderate percentage vegetation cover. This was still the case in the study area and the percentage vegetation cover is regarded as unmodified.

Vegetation structure:
The study area is situated within Highveld Alluvial Vegetation which is characterised by riparian thicket, herblands and flooded grassland. This is certainly still the case for the study area though historical aerial images indicate a substantial increase in the thicket component. Overall the vegetation structure is therefore regarded as moderately modified.

Infestation with exotic weeds and invader plants:
Several weed species occur on the site predominately associated with the Sand River, especially the lower one but also being prominent in the floodplain. Overall the study area is therefore considered to a contain a moderate infestation by weeds and invasive species (Appendix B).

Degree of grazing/browsing impact:
Grazing by domestic stock is moderate. Grazing by domestic livestock was evident over the entire study area and significant trampling were noted on the banks of the river and therefore overgrazing is regarded as at least moderate.

Signs of erosion:
Due to the slope, sandy soils and drainage lines in the area it is subjected to moderate erosion. However, this erosion is considered as part of the natural ecosystem but is being exacerbated by the land use in the region (agriculture, trampling) and is also evident where dirt tracks and gravel roads cross over lateral watercourses.

Terrestrial animals:
Due to the presence of the Sand River, a perennial water source, it is considered important habitat for numerous mammal species. The area also provides various habitats and a high degree of ecosystem resources and it is considered likely that a diverse mammal population inhabits the area. The survey also noted a diversity of different animals inhabiting the area.

Table 6: Biodiversity Sensitivity Rating for the Sand River mining area.

	Low (3)	Medium (2)	High (1)
Vegetation characteristics			
Habitat diversity & Species richness			1
Presence of rare and endangered species		2	
Ecological function			1
Uniqueness/conservation value			1
Vegetation condition			
Percentage ground cover			1
Vegetation structure		2	
Infestation with exotic weeds and invader plants or encroachers		2	
Degree of grazing/browsing impact		2	
Signs of erosion		2	
Terrestrial animal characteristics			
Presence of rare and endangered species		2	
Sub total	0	12	4
Total		16	

6. Biodiversity Sensitivity Rating (BSR) interpretation

Table 7: Interpretation of Biodiversity Sensitivity Rating.

Site	Score	Site Preference Rating	Value
Sand River mining area	16	Good Condition	2

7. Discussion and conclusions (Appendix A: Map 1 - 5)

The area for the proposed mining of the banks and floodplain of the Sand River is regarded as being in a relatively good condition. This is based largely on the characteristics of the ecosystem, i.e. conservation value, ecological function and importance of the ecosystem as well the condition of the area which is largely still natural and unmodified.

The sand mining operations will mostly affect the banks and floodplain of the Sand River, though a sand pump in the river will also affect the main channel. The mining operations will consist of a mining right application which is situated on the farm De Klerkskraal which is situated approximately 30 km to the north of the small town of Theunissen (Appendix A: Map 1). The proposed mining operations will entail the excavation of sand from the floodplain and banks of the river while a sand pump within the main channel will be use to extract sand from the riverbed. This will also require the construction of a stockpiling area, sand screen, settling ponds and attenuation areas. The extent and nature of the mining operations are anticipated to have several significant impacts on the river and its associated floodplain and wetland areas mainly associated with sedimentation and loss of aquatic and riparian habitat. The study area consists of a length of approximately 5 km section of the Sand River extending approximately 200 meters to either side of the river. The study area includes both the northern and southern banks of the river as well as large portions of the riparian zone and has an approximate extent of 230 hectares. Several lateral stream systems flowing into the river and a few backwater floodplain wetlands were also included within the assessment. The banks of the Sand River are, for the most part, still intact and largely natural with few noticeable impacts.

As indicated, the proposed mining area is still largely natural with the current sand mining area being the most significant current impact. Current mining causes the removal of riparian vegetation, modification of the riverbanks and transformation of the geomorphology. This also provides an indication of the type of impacts that proposed mining would have.

The study area consists mainly of the Sand River and its banks (Appendix A: Map 1 & 2). However, in order to provide an accurate assessment of the study area and the affected section of the Sand River the assessment will include delineation of wetland areas associated with the river, such as floodplain wetland backwaters, delineation of the riparian zone or floodplain situated within the proposed study area or mining right application area as well as an overview of lateral streams and drainage lines flowing into the river. This comprehensive assessment and delineation will include both the southern and northern banks although due to the inaccessibility of the north western banks, data from the surrounding area will be extrapolated for this portion.

Soil samples (Appendix C) reliably indicated that wetland conditions along the Sand River at the site is confined to the marginal and lower zones with perennial zones of wetness being present at the water's edge and the marginal zone, decreasing into a seasonal zone of wetness in the lower zone and with wetland conditions being absent from the upper zone of the river (Appendix A: Map 2). This was also clearly reflected within the vegetation composition along the banks. The riparian zone of the river extending along both the northern and southern floodplain of the river is quite extensive. Though flooding may not necessarily extend over the riparian zone it does still contain the characteristics of a floodplain and is therefore still regarded as forming part of the riparian zone of the river. The soils within this riparian zone contain fine silty soils (a consequence of historical flood deposition) but it was devoid of wetland conditions. Furthermore, a few backwater floodplain wetlands also occurs within the riparian zone. These are visible as shallow depressions, forming backwater systems and in all of these areas both soils and vegetation indicated at least seasonal wetland conditions.

Soil samples taken within several of the lateral drainage lines or seasonal streams indicated the clear presence of wetland conditions, at least for those portions of the streams situated within the proposed mining area (Appendix C). It is clear that these systems discharge annually from runoff generated in the surrounding catchment, but is also being inundated when floods within the Sand River push up into the lateral streams. The soil samples also confirm that soil saturation and the period of inundation is sufficient to create wetland conditions. These wetland conditions are however confined to the main channel of these watercourses with their banks consisting of riparian vegetation and forming part of the riparian zone (Appendix A: Map 2).

The wetland conditions associated with the banks of the Sand River and lateral streams can be characterised as a channel wetland system (SANBI 2009). The wetland conditions are confined to the main channel of these systems which experience surface flow either seasonally or perennially. Where wetland conditions occur in the floodplain of the Sand River, small backwater depressions have formed and these wetland conditions can be regarded as forming a floodplain wetland (SANBI 2009).

Sand River main channel and banks (Appendix A: Map 1 & 2)

River systems can be divided into different riparian zones within the lateral section of the system. These riparian zones represent the banks of a river and can be distinguished in terms of their geomorphology and vegetation structure. The same applies to the affected section of the Sand River in the study area. These zones are as follows:

The marginal zone is situated from the water level at low flow, if present, up to the features that are hydrologically activated for the most of the year (Figure 18 & 19). The marginal zone within the Sand River as it occurs within the study area is well defined and easily identifiable. It is relatively narrow in most areas, varying between 1 to 5 meters and is inundated annually during flooding. The majority of this zone seems to be largely natural on both the southern and northern banks.

The lower zone is characterised by seasonal features and extends from the marginal zone up to an area of marked elevation. The lower zone consists of geomorphic features that are activated on a seasonal basis (Figure 18 & 19). The lower zone along the Sand River can also be clearly defined and is easily visible as a definite and steep increase in slope over a short distance where after it levels off into the upper zone. The lower zone is inundated less frequently and only during larger flooding events as has recently occurred at the site. In small sections of the river, especially where lateral streams flow into the river and an alluvial fan occurs and the marginal zone is broader the lower zone extends over a larger distance. The lower zone is largely natural within the study area but is affected by the current sand mining area.

The upper zone is characterised by ephemeral features as well as the presence of both riparian and terrestrial species. The zone extends from the lower zone to the riparian corridor. The upper zone contains geomorphic features that are hydrologically activated on an ephemeral basis (Figure 18 & 19). The upper zone along the Sand River is clearly visible as a decrease in slope and an increase in the woodland component. The majority of the upper zone, and the riparian thicket it supports, is still intact.

Floodplain or riparian zone of the Sand River (Appendix A: Map 2)

The floodplain or riparian zone of the Sand River along the section in the study area is extensive. It is very broad in most areas and covers the entire extent of the proposed mining areas, i.e. 200 meters in width on both the northern and southern banks.

Delineation of the floodplain or riparian zone could not be easily determined, since alluvial deposition has occurred over an extensive area. It is however certain that almost the entire mining area consists of the riparian zone with only a few small portions clearly consisting of surrounding terrestrial habitats. The delineation of the floodplain and edge of the riparian zone within the proposed mining area was determined by using a combination of soil sampling, vegetation composition and topography and is considered to give an accurate description of it.

Backwater areas forming floodplain wetlands (Appendix A: Map 2)

As indicated the floodplain or riparian zone of the Sand River is largely devoid of wetland conditions. However, a few backwater wetland areas has formed and here wetland conditions are clearly present.

These floodplain wetlands are fairly easily distinguishable from the surrounding riparian thicket. All of these areas form a very shallow depression where, consequently, surface water now accumulates and saturated soil condition form. The topography of these wetland areas, a shallow depression, does allow for quite easy delineation of these wetland areas. Furthermore, soil samples contained quite clear indication of seasonal wetland conditions and also further aided in the identification and delineation of these floodplain wetlands.

Lateral streams and drainage lines flowing into the Sand River (Appendix A: Map 2)

As previously indicated, there are numerous small drainage lines and seasonal streams that drain from the terrestrial surroundings, across the floodplain and into the Sand River on the site. All of these, irrespective of their size, will transport surface water after rainfall events and they should therefore also be taken into consideration in this assessment.

Soil samples taken within these small watercourses indicated that they all contain significant wetland conditions, at least in those portions of the watercourses that occur within the proposed mining area. They form clearly defined channel wetland systems, the same as the Sand River. Vegetation along these lateral watercourses also confirmed riparian conditions along all of them, while the main channel also contained at least some obligate wetland vegetation.

The largest impact on the study area is the construction of large upstream containment dam in the Sand River. These impacts alter the flooding regime and the functioning and habitat of the river and floodplains. An Index of Habitat Integrity (IHI) was conducted along the Sand River within the study area (Appendix D). The results of the IHI indicated that the Sand River has an

Instream IHI of category C: Moderately Modified and Riparian IHI of category C: Moderately Modified. This is largely due to the change in flooding regime and disturbance/transformation of the habitat. The Sand River and associated wetlands and floodplains are considered to be somewhat modified by historical and current impacts. The EI&S of the floodplains associated with the Sand River has been rated as being Moderate.

The floodplain wetlands along the Sand River in the study area are clearly not affected by many impacts. A WET-Health determination was undertaken for one of the larger backwater areas to serve as representative for the floodplain wetland areas along the study area (Appendix D). The results of the WET-Health indicated an overall Present Ecological State of Category B: Largely Natural. Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. This is considered relatively accurate given the few impacts affecting it.

As indicated in previous sections, the Sand River, its floodplain, lateral drainage lines and backwater wetland areas provide several vital ecological services and it is important that operations not result in further impacts on them. The operations should therefore exclude and avoid these watercourses and wetlands (Appendix A: Map 1). The main channel of the Sand River, the associated wetland conditions occurring along the marginal and lower zones, all lateral drainage lines and backwater wetland areas are all regarded as being of very high sensitivity. These areas should be treated as no-go areas and should be avoided, as far as possible by the proposed sand mining operations. A suitable buffer of 38 meters from the edge of the floodplain wetland areas and the wetland conditions along the Sand River main channel and lateral stream systems has also been determined (Appendix A: Map 1). The 38 meter buffer zone is also regarded as having a high sensitivity. The portions of the floodplain outside this 38 meter buffer is still regarded as having a moderate sensitivity but impacts here will be more easily manageable. As a result, mining operations should aim to avoid all areas regarded as having a very high and high level of sensitivity, while focussing operations in areas with moderate sensitivity. This may however not be possible where sand excavation takes place from the lower zone or banks of the river and where sand is pumped from the main channel. In such instances, the operational area (stockpile area, sand screen, settling dams and all other associated structures and infrastructure) should at least be located outside these areas of high sensitivity. It remains however apparent that sand mining operations will result in several significant impacts on the Sand River.

A Risk Assessment for the proposed sand mining operations along the Sand River has been undertaken according to the Department of Water & Sanitation’s requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E).

The sand mining operations will entail the excavation of sand from the banks and floodplain of the river. Sand is continuously deposited along the banks of the river by flooding events. These sands are exposed along the lower zone when the river is at its baseflow level. It is largely these sands that will be excavated by the mining operations by means of excavators and transported by means of a small dirt access road to stockpiling areas in the floodplain. Impacts associated with this will include modification of the geomorphology, loss of some of the riparian vegetation, contributing toward increased sedimentation of the river and causing local modification and de-stabilisation of the bank. Given the large extent of the proposed mining right area (approximately 230 hectares) this may potentially result in high impacts. In order to limit this impact it is recommended that sand excavation areas be limited to an extent of 5 hectares at a time. Sand should be excavated, processed and the area rehabilitated before moving to a new sand mining area. If this mining method is maintained, the risk is anticipated to remain moderate. This is however subject to comprehensive mitigation and rehabilitation measures being implemented. This should include amongst others; limiting the extraction areas and access roads in terms of extent as well as the number of access points, implementing consecutive rehabilitation in order to preserve the integrity of the system, adequate management of topsoil, prevention of erosion and sedimentation and continuous eradication of exotic weeds. Comprehensive rehabilitation will also have to be implemented after mining has ceased.

An additional mining method which is also being considered entail the pumping of sand from the main channel by means of a sand pump, associated infrastructure and an access road along the riverbank. The main impacts associated with this will be removal of sand from the channel which will affect geomorphology, affecting the aquatic fauna dependant on the sandy habitat and causing local modification of the bank. If these extraction areas are limited to the 5 hectares sand excavation site and to one extraction point at a time, the extent of the impact should be limited and confined to the site (5 hectare area). The risk is therefore only anticipated to remain moderate. Mitigation which should be implemented to limit the impact should include restricting sand extraction points to only one point at a time and rehabilitating the extraction site immediately when the pump is moved to another location along the site. Adequate rehabilitation of the bank and eradication of exotic weeds will also have to be implemented.

The sand which is excavated from the main channel, banks and floodplain will be transported via the small access roads to a stockpiling area located in the floodplain. Should sand extraction by a pump also be implemented this will also include settling ponds. The most prominent impacts associated with these areas are the removal of riparian vegetation and disturbance of the soil surface. Other likely impacts will include increased sediment washing into the river and likely flooding of the stockpiling area during large floods. The anticipated risk is however anticipated to remain moderate. Adequate mitigation which should be implemented to reduce the risk as described should include implementing an adequate storm water management system which should protect the stockpiling area from flooding and should prevent erosion and sediment from being washed into the river. Correct topsoil management should also be implemented which should include removal of topsoil in all areas where disturbance will occur, i.e. truck turning areas, stockpile area, etc. and replacing topsoil in disturbed areas when rehabilitation is undertaken. Adequate rehabilitation and eradication of exotic weeds will also have to be implemented when mining has been completed.

8. Recommendations

- The main channel of the Sand River, wetland conditions along the banks, lateral stream systems and floodplain wetland areas are all regarded as having a very high sensitivity and should wherever possible, be excluded from mining operations (Appendix A: Map 2).
    - A 38 meter buffer zone around these areas is also regarded as having a high sensitivity and should also be excluded from operations (Appendix A: Map 2).
    - Mining operations should aim to avoid all areas regarded as having a very high and high level of sensitivity, while focussing operations in areas with moderate sensitivity.
    - This may however not be possible where sand excavation takes place from the lower zone or banks of the river and where sand is pumped from the main channel. In such instances, the operational area (stockpile area, sand screen, settling dams and all other associated structures and infrastructure) should at least be located outside these areas of high sensitivity.
    - The backwater floodplain wetlands and lateral stream systems do not contain sand resources and would not be desirable for mining (Appendix A: Map 2). They should therefore be excluded from any mining operations or activities and treated as no-go areas.

- The exotic species occurring on the site must be eradicated as mining progresses (Appendix B). It is also recommended that the eradication of exotic species be rigidly maintained and form part of the management of the mining process.

- The following mitigation measures are recommended where mining activities will impact on the Sand River or its floodplain (Appendix A: Map 1):

    - The sand excavation areas should be limited to an extent of 5 hectares at a time. Sand should be excavated, processed and the area rehabilitated before moving to a new sand mining area.
    - Only one pump, including infrastructure and access road, should be utilised at any time and the site rehabilitated immediately after moving the pump to another location along the site.
    - Any disturbance of the riverbank should be adequately rehabilitated which must include re-instatement of the natural topography, replacement of topsoil, prevention of erosion and monitoring and eradication of problematic weeds and invasives.
    - Where disturbance of the banks or floodplain takes place the removal of vegetation must be kept to a minimum.
    - Implementing consecutive rehabilitation in order to preserve the integrity of the system.
    - Keeping disturbance of the marginal zone and steep banks of the river to a minimum.
    - The stockpile area is situated within the floodplain and requires the removal of vegetation. Where disturbance of the soil surface will occur the topsoil should first be removed and stored on site and should be utilised once rehabilitation of the site takes place.

  - Adequate storm water management measures should be implemented and should include diverting storm- and floodwater around the stockpile and excavation areas and preventing sediment and silt from entering the river.
  - As the stockpile areas and several of the sand excavation areas are located in the floodplain and along the riverbanks they will also be affected by annual flooding and the necessary precautions should therefore be taken to ensure that floodwaters is diverted around them by means of berms.
  - Where excavation of sand takes place within the floodplain and along the riverbanks the rehabilitation should endeavour to re-instate a geomorphology which will form part of a functional system and should refrain from leaving excavations or pits.
  - Due to the high abundance of exotic weeds currently on the site it will be difficult to keep the site weed-free. Seeding of bare areas with indigenous pioneer grasses should be considered as this will provide competition for exotic species.

- The hunting, capturing and trapping of fauna should be prevented by making this a punishable offense during the mining operations.

- No littering must be allowed and all litter must be removed from the site.

- Monitoring of mining and compliance with recommended mitigation measures must take place.

- After mining has ceased all construction materials should be removed from the area.

- Comprehensive rehabilitation should undertaken after mining has ceased. This should include re-instatement of the natural topography as far as possible, replacing topsoil in disturbed areas, prevention of erosion and monitoring and eradication of exotic invasive species.

- The proposed mining operations will result in significant impacts on the banks and main channel of the river. A comprehensive monitoring programme should therefore be followed to quantify impacts and recommend mitigation. Such monitoring should include quarterly water quality sampling, sediment release (turbidity), Index of Habitat Integrity and SASS5 or a combination thereof.

- Mining operations within 100 meters or within the floodplain of the river and within 500 meters of wetland areas will require authorisation from DWS.

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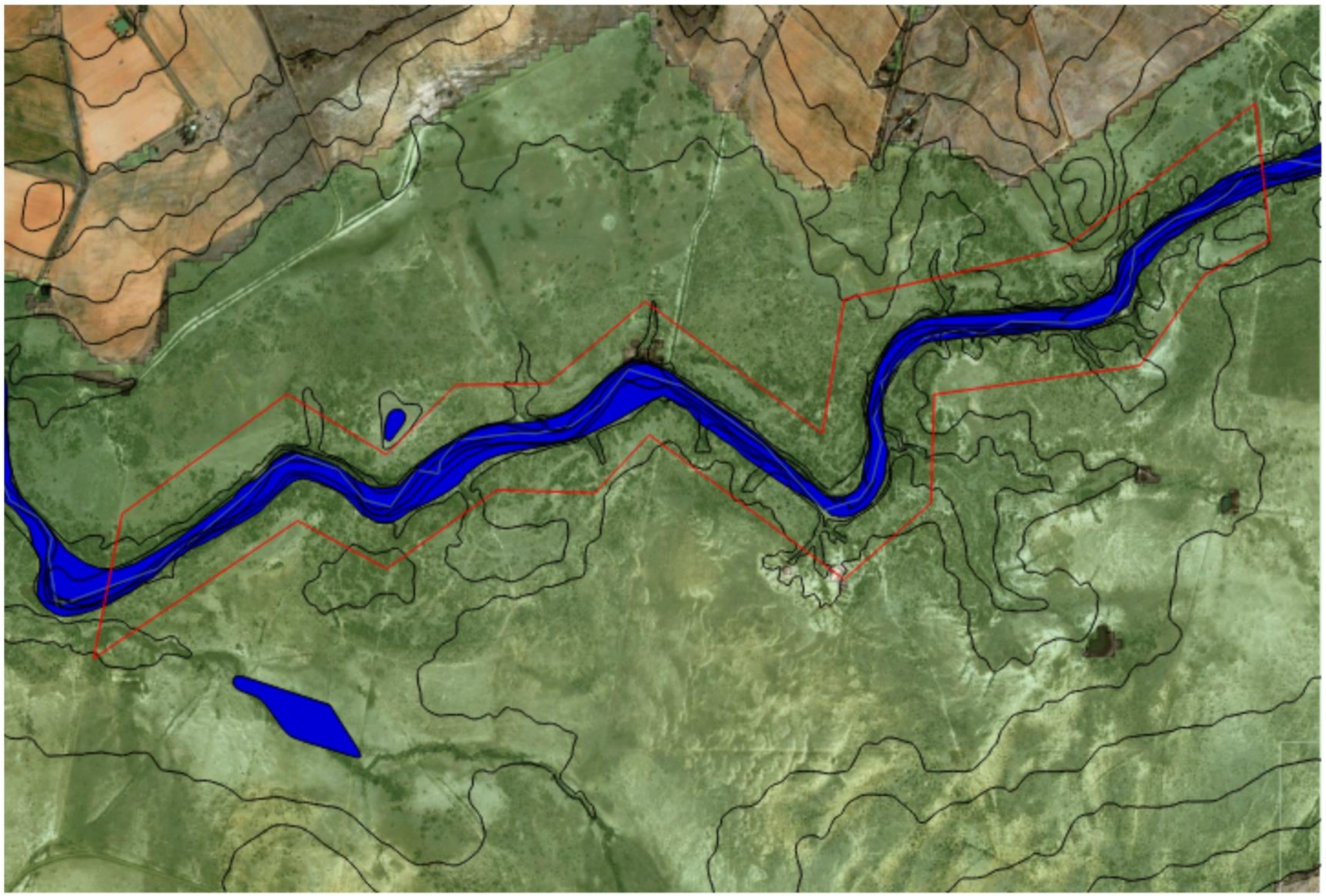
Annexure A: Maps

Wetland delineation map for the proposed sand mining operations along the banks of the Sand River on the Farm De Klerkskraal situated near Theunissen, Free State Province.



Preparred for:
Greenmined Environmental
Baker Square
Somerset West
7130

Legend:

- Application area
- 5-meter contours
- Highveld Alluvial Vegetation
- National Wetland Map 5

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:30 000

DPR Ecologists
Contact Darius van Rensburg at:
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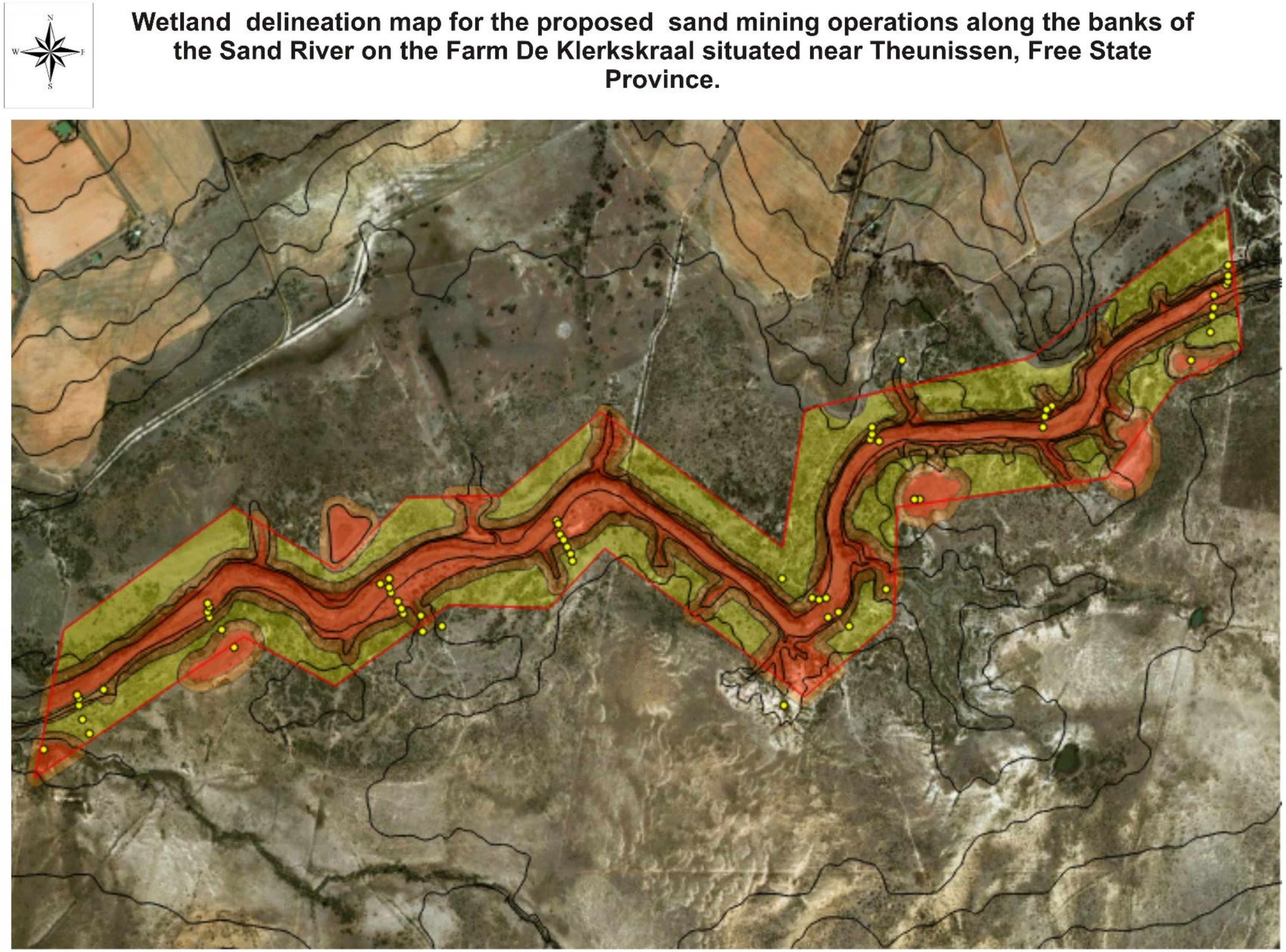
P.O. Box 12726, Brandhof, 9324
Tel: 083 410 0770

Map 1: General ecology map of the proposed sand mining operations along the Sand River on the Farm De Klerkskraal near Theunissen. The areas of remaining natural vegetation, consisting of Highveld Alluvial Vegetation has been indicated and it is clear that the area still consists largely of natural vegetation, at least on and around the proposed site. Note transformation of the natural vegetation to the north as a result of agriculture. The National Biodiversity Assessment 2018: Wetland Map 5 also indicates the larger wetland systems in the area. Note that the Sand River is also regarded as a wetland system and confirmed by the on-site delineation. Smaller wetland areas are however not indicated and was only identified by the on-site survey. Contours of the area also indicate the location of smaller lateral stream systems and also indicate a very broad alluvial floodplain along the section of the river.

Wetland delineation map for the proposed sand mining operations along the banks of the Sand River on the Farm De Klerkskraal situated near Theunissen, Free State Province.



Map 2: Wetland delineation map of the proposed sand mining operations along the Sand River on the Farm De Klerkskraal near Theunissen. Areas delineated as wetland areas include the Sand River, the marginal and lower zones forming the banks, lateral streams draining into the river and backwater floodplain wetland areas situated adjacent to the river. These areas are all considered to be of Very High sensitivity and should be avoided, this may not be possible for sand excavation which will in most instances occur along the banks of the river. A 38 meter buffer has also been determined around these wetland areas which is regarded as being of High sensitivity and should also be avoided, especially by the processing and stockpiling areas. The riparian zone along the floodplain of the river is regarded as being of Moderate sensitivity and mining operations should, as far as possible, be concentrated in these areas, this is especially applicable to the processing and stockpiling areas and associated structures and infrastructure which should only be located in these areas of Moderate sensitivity.

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Somerset West
7130

Legend:

- Application area
- Wetland conditions - Very High Sensitivity
- 38 meter buffer from wetlands - High Sensitivity
- Riparian zone - Moderate Sensitivity
- Sampling sites

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:30 000

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Appendix B: Species list

Species indicated with an * are exotic.

Protected species are coloured orange and Red Listed species red.

Species	Growth form
**Achyranthes aspera*	Herb
**Bidens bipinnata*	Herb
**Cenchrus incertus*	Grass
**Cirsium vulgare*	Herb
**Conyza bonariensis*	Herb
**Conyza canadensis*	Herb
**Cyllindropuntia imbricata*	Succulent
**Eucalyptus camaldulensis*	Tree
**Fraxinus americana*	Tree
**Opuntia humifusa*	Succulent
**Oputia lindheimeri*	Succulent
**Populus deltoides*	Tree
**Schkuhria pinata*	Herb
**Sesbania punicea*	Shrub
**Tagetes minuta*	Herb
**Tamarix ramosissima*	Tree
**Verbena bonariensis*	Herb
**Xanthium strumarium*	Herb
**Zinnia peruviana*	Herb
Alternanthera sessilis	Herb
Amaranthus sp.	Herb
Ammocharis coranica	Geophyte
Aristida congesta	Grass
Artemisia afra	Shrub
Asparagus cooperi	Shrub
Asparagus larcinus	Shrub
Celtis africana	Tree
Chenopodium album	Herb
Clematis brachiata	Climber
Commelina africana	Herb
Commelina livingstonii	Herb
Commicarpus pentandrus	Herb
Conyza podocephala	Herb
Crinum bulbispermum	Geophyte
Cynodon dactylon	Grass
Cyperus difformis	Sedge
Cyperus fastigiatus	Sedge
Cyperus indecorus	Sedge
Cyperus longus	Sedge
Cyperus marginatus	Sedge

Delosperma cooperi	Succulent
Digitaria eriantha	Grass
Diospyros lycioides	Shrub
Echinochloa holubii	Grass
Equisetum ramosissimum	Fern
Eragrostis lehmanniana	Grass
Gomphocarpus fruticosus	Herb
Gymnosporia buxiifolia	Shrub
Heliotropium lineare	Herb
Isolepis sp.	Sedge
Kniphofia ensifolia	Geophyte
Ledebouria revoluta	Geophyte
Leptochloa fusca	Grass
Lycium hirsutum	Shrub
Manulea buchneroides	Herb
Marsilea farinosa	Fern
Mestoklema tuberosum	Succulent
Mimulus gracilis	Herb
Panicum coloratum	Grass
Paspalum dilatatum	Grass
Paspalum distichum	Hrass
Pentzia incana	Dwarf shrub
Pergularia daemia	Climber
Persicaria lapathifolia	Herb
Phragmites australis	Reed
Pogonarthria squarrosa	Grass
Ranunculus multifidus	Herb
Rhychosia totta	Creeper
Rhynchosia caribaea	Creeper
Salix mucronata	Tree
Salsola rabieana	Dwarf shrub
Searsia pyroides	Shrub
Setaria pallide-fusca	Grass
Setaria sphacelatum	Grass
Setaria verticillata	Grass
Sporobolus fimbriatus	Grass
Urochloa mosambicensis	Grass
Vachellia karroo	Tree
Ziziphus mucronata	Tree

Appendix C: Soil Samples Methodology

Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to confirm the wetland conditions in the study area. Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils.

Soil samples have been taken along ten transects across the banks and floodplain of the Sand River on both the northern and southern banks and many of the lateral streams and backwater floodplain wetland areas have also been sampled. The following results will only illustrate five of these transects on order to illustrate a representative sample of data collected.

Within wetlands the hydrological regime differs due to the topography and landscape. For instance; a valley bottom wetland would have a main channel that is below the water table and consequently permanently saturated, i.e. permanent zone of wetness. As you move away from the main channel the wetland would become dependent on flooding in order to be saturated. As a result along this hydrological regime areas of permanent saturation, seasonal and temporary saturation would occur. At some point along this gradient the saturation of the soil would be insufficient to develop reduced soil conditions and therefore will not be considered as wetland.

Within wetland soils the pores between soil particles are filled with water instead of atmosphere. As a result available oxygen is consumed by microbes and plantroots and due to the slow rate of oxygen diffusion oxygen is depleted and biological activity continues in anaerobic conditions and this causes the soil to become reduced.

Reduction of wetland soils is a result of bacteria decomposing organic material. As bacteria in saturated soils deplete the dissolved oxygen they start to produce organic chemicals that reduce metals. In oxidised soils the metals in the soil give it a red, brown, yellow or orange colour. When these soils are saturated and metals reduced the soil attains a grey matrix characteristic of wetland soils.

Within this reduction taking place in the wetland soils there may be reduced matrix, redox depletions and redox concentrations. The reduced matrix is characterised by a low chroma and therefore a grey soil matrix. Redox depletions result in the grey bodies within the soil where metals have been stripped out. Redox concentrations result in mottles within the grey matrix with variable shape and are recognised as blotches or spots, red and yellow in colour.

Soil wetness indicator is used as the primary indicator of wetlands. The colour of various soil components are often the most diagnostic indicator of hydromorphic soils. Colours of these components are strongly influenced by the frequency and duration of soil saturation. Generally, the higher the duration and frequency of saturation in a soil profile, the more prominent grey colours become in the soil matrix.

Coloured mottles, another feature of hydromorphic soils, are usually absent in permanently saturated soils and are at their most prominent in seasonally saturated soils, becoming less abundant in temporarily saturated soils until they disappear altogether in dry soils (Collins 2005).

The following soil wetness indicators can be used to determine the permanent, seasonal and temporary wetness zones. The boundary of the wetland is defined as the outer edge of the temporary zone of wetness and is characterised by a minimal grey matrix (<10%), few high chroma mottles and short periods of saturation (less than three months per year). The seasonal zone of wetness is characterised by a grey matrix (>10%), many low chroma mottles and significant periods of wetness (at least three months per year). The permanent zone of wetness is characterised by a prominent grey matrix, few to high chroma mottles, wetness all year round and sulphuric odour (rotten egg smell). According to convention hydromorphic soil must display signs of wetness within 50 cm of the soil surface (DWAF 2005).

Table 1: Soil samples taken along a lateral transect of the Sand River banks at the western end of the study area – southern banks (S 28.143891°, E 26.652039°).

	
Soil sample taken within the marginal zone of the southern riverbank. A prominent grey matrix with prominent mottling indicate a permanent zone of wetness. Wetland conditions are therefore present.	Soil sample taken in the lower zone of the southern riverbank. A grey matrix (<10%) is present with prominent mottling and is therefore indicative of a seasonal zone of wetness.
	
Soil sample taken in the upper zone of the southern riverbank. A grey matrix and mottling is clearly absent and wetland conditions are therefore no longer present. Soils consist of fine sands with a uniform colouration.	Soil sample taken within the floodplain of the southern riverbank. Wetland conditions are clearly absent. Silty soils are present being indicative of alluvial floodplain.

Table 2: Soil samples taken along a lateral transect of the Sand River banks in the central portion of the study area –southern banks (S 28.138005°, E 24.670240°).

	
Soil sample taken in the floodplain of the southern banks. Soil has a high sand content, no grey matrix is present mottling is absent and this indicates no wetland conditions present in this area.	Soil sample taken in the upper zone/floodplain of the river. Soil has a high sand content, no grey matrix is present mottling is absent and this indicates no wetland conditions present in this area.
	
Soil sample taken in the upper zone/floodplain of the river. Soil has a high sand content, no grey matrix is present mottling is absent and this indicates no wetland conditions present in this area.	Soil sample taken on the banks/lower zone of the river. No discernible grey matrix is present although a low degree of mottling is present. This is considered as the border of wetland conditions.

	
Soil sample taken on the banks/lower zone of the river. A sudden and prominent grey matrix is present, no mottling is present and is indicative of a permanent zone of wetness.	Soil sample taken on the banks/lower zone of the river. A prominent grey matrix is present, few mottles are present and is indicative of a permanent zone of wetness.
	
Soil sample taken at the water edge/marginal zone of the river. A prominent grey matrix is present with no discernible mottling but a sulphuric odour. The areas is considered as part of the permanent zone of wetness.	

Table 3: Soil samples taken along a lateral transect of the Sand River banks in the central portion of the study area – northern and southern banks (S 28.141272°, E 26.680593°).

	
Soil sample taken within the marginal zone of the southern riverbank. A prominent grey matrix (>10%) is present with prominent mottling and is therefore indicative of a seasonal zone of wetness.	Soil sample taken in the lower zone of the southern riverbank. A prominent grey matrix (>10%) is present with prominent mottling and is therefore indicative of a seasonal zone of wetness.
	
Soil sample taken in the upper zone of the southern riverbank. A grey matrix and mottling is clearly absent and wetland conditions are therefore no longer present. Soils consist of fine sands with a uniform colouration..	Soil sample taken within the marginal zone of the northern riverbank. A prominent grey matrix with prominent mottling indicate a permanent zone of wetness. Wetland conditions are therefore present.

	
Soil sample taken in the lower zone of the northern riverbank. A grey matrix (<10%) is present with prominent mottling and is therefore indicative of a seasonal zone of wetness.	Soil sample taken in the upper zone of the northern riverbank. A grey matrix and mottling is clearly absent and wetland conditions are therefore no longer present. Soils consist of fine sands with a uniform colouration.
	
Soil sample taken within the floodplain of the northern riverbank. Wetland conditions are clearly absent. Silty soils are present being indicative of alluvial floodplain.	

Table 4: Soil samples taken along a lateral transect of the Sand River banks in the eastern portion of the study area –northern banks (S 28.135343°, E 26.682507°).

	
Soil sample taken within the marginal zone of the northern riverbank. A prominent grey matrix with prominent mottling indicate a permanent zone of wetness. Wetland conditions are therefore present.	Soil sample taken in the lower zone of the northern riverbank. A grey matrix (<10%) is present with prominent mottling and is therefore indicative of a seasonal zone of wetness.
	
Soil sample taken in the upper zone of the northern riverbank. A grey matrix and mottling is clearly absent and wetland conditions are therefore no longer present. Silty soils are present being indicative of alluvial floodplain.	Soil sample taken within the floodplain of the northern riverbank. Wetland conditions are clearly absent. Soils consist of fine sandy soils with uniform colouration.

Table 5: Soil samples taken along a lateral transect of the Sand River banks in the eastern portion of the study area – northern and southern banks (S 28.130459°, E 26.695232°).

	
Soil sample taken within the marginal zone of the southern riverbank. A prominent grey matrix (>10%) is present with prominent mottling and is therefore indicative of a seasonal zone of wetness.	Soil sample taken in the lower zone of the southern riverbank. A grey matrix (<10%) is present with prominent mottling and is therefore indicative of a seasonal zone of wetness.
	
Soil sample taken in the upper zone of the southern riverbank. A grey matrix and mottling is clearly absent and wetland conditions are therefore no longer present. Soils consist of fine sands with a uniform colouration..	Soil sample taken within the floodplain of the northern riverbank. Wetland conditions are clearly absent. Soils consist of fine sands with a uniform colouration..

	
Soil sample taken within the marginal zone of the northern riverbank. A prominent grey matrix with prominent mottling indicate a permanent zone of wetness. Wetland conditions are therefore present.	Soil sample taken in the lower zone of the northern riverbank. A grey matrix (<10%) is present with prominent mottling and is therefore indicative of a seasonal zone of wetness.
	
Soil sample taken in the upper zone of the northern riverbank. A grey matrix and mottling is clearly absent and wetland conditions are therefore no longer present. Soils consist of fine sands with a uniform colouration.	Soil sample taken within the floodplain of the northern riverbank. Wetland conditions are clearly absent. Silty soils are present being indicative of alluvial floodplain.

Table 6: Soil samples taken within several of the lateral watercourses draining into the Sand River in the study area.

	
Soil sample taken in one of the larger stream in the western portion of the site (S 28.141230°, E 26.665105°). A grey matrix and mottling is evident and at least seasonal wetland conditions are present.	Soil sample taken in one of the smallest drainage lines on the site (S 28.143700°, E 26.653049°). A grey matrix is not prominent though feint is cealry discrinible. This indicates that even the smallest drainage lines still contain at least some wetland conditions.
	
Soil sample taken in one the larger stream systems in the eastern portion of the site (S 28.140339°, E 26.682780°). A prominent grey matrix and feint mottling indicates a permanent zone of wetness. Wetland conditions are clearly present.	Soil sample taken in one of the largest streams in the western portion of the site (S 28.145726°, E 26.650782°). A prominent grey matrix and feint mottling indicates a permanent zone of wetness. Wetland conditions are clearly present.

Table 7: Soil samples taken within several of the floodplain wetland areas situated adjacent to the Sand River.

	
Soil sample taken in a floodplain wetland in the western portion of the site (S 28.142277°, E 26.657987°). A grey matrix and mottling is evident and at least seasonal wetland conditions are present.	Soil sample taken in a floodplain wetland in the central portion of the site (S 28.137296°, E 26.684077°). A prominent grey matrix and feint mottling clearly indicate the presence of wetland conditions. Note also the exceedingly high clay content.
	
Soil sample taken in a floodplain wetland in the eastern portion of the site (S 28.132651°, E 26.694400°). A grey matrix and mottling is evident and at least seasonal wetland conditions are present.	

Appendix D: Index of Habitat Integrity (IHI)/WET-Health Summary

For the complete IHI please contact the author of this report.

ASSESSMENT UNIT INFORMATION	
ASSESSMENT UNIT INFORMATION	
UPPER LATITUDE	S 28.130116
UPPER LONGITUDE	E 26.671057
UPPER ALTITUDE	1277m
LOWER LATITUDE	S 28.144366
LOWER LONGITUDE	E 26.651099
LOWER ALTITUDE	1275
SURVEY SITE (if applicable)	Sand River
SITE LATITUDE (if applicable)	
SITE LONGITUDE (if applicable)	
SITE ALTITUDE (if applicable)	
WMA	Middle Vaal
QUATERNARY	C42L
ECOREGION 2	11_8
DATE	01/03/2022
RIVER	Sand River
TRIBUTARY	
PERENNIAL (Y/N)	**Y**
GEOMORPH ZONE	**LOWLAND**
WIDTH (m)	**>15**

INSTREAM IHI	MRU
Base Flows	-2.0
Zero Flows	1.0
Floods	-1.5
HYDROLOGY RATING	**1.4**
pH	2.0
Salts	2.5
Nutrients	1.5
Water Temperature	1.5
Water clarity	1.5
Oxygen	2.0
Toxics	1.5
PC RATING	**1.7**
Sediment	1.5
Benthic Growth	1.5
BED RATING	**1.5**
Marginal	2.0
Non-marginal	1.5
BANK RATING	**1.8**
Longitudinal Connectivity	2.0
Lateral Connectivity	1.5
CONNECTIVITY RATING	**1.8**
INSTREAM IHI %	**67.9**
INSTREAM IHI EC	**C**
INSTREAM CONFIDENCE	**2.8**

RIPARIAN IHI	MRU
Base Flows	-1.5
Zero Flows	1.0
Moderate Floods	-1.0
Large Floods	-2.0
HYDROLOGY RATING	**1.4**
Substrate Exposure (marginal)	2.0
Substrate Exposure (non-marginal)	2.0
Invasive Alien Vegetation (marginal)	2.0
Invasive Alien Vegetation (non-marginal)	2.0
Erosion (marginal)	1.0
Erosion (non-marginal)	1.0
Physico-Chemical (marginal)	1.5
Physico-Chemical (non-marginal)	1.5
Marginal	2.0
Non-marginal	2.0
BANK STRUCTURE RATING	**2.0**
Longitudinal Connectivity	1.5
Lateral Connectivity	1.5
CONNECTIVITY RATING	**1.5**
RIPARIAN IHI %	**66.2**
RIPARIAN IHI EC	**C**
RIPARIAN CONFIDENCE	**3.7**

Wetland Attributes

The information in this sheet must be captured before continuing with any other aspects of the assessment. Not capturing all the information required will lead to errors in the spreadsheet calculations, which will prevent a final outcome being obtained.

Wetland Name	Sand River Backwaters
Assessment Unit Name / No.	1
Assessor	Darius van Rensburg
Date of Assessment	01/03/2022
HGM Type (Basic)	Floodplain wetland FP
HGM Type (Refined)	Floodplain wetland FP
Conceptual model	Water and sediment inputs from the topographically defined catchment are assumed to emanate primarily from the catchment upstream of the wetland, with limited lateral inputs. A weighting of 90% is therefore allocated to the assessment of hydrological, geomorphic and water quality impacts in the upstream catchment whereas impacts associated with lateral inputs only contribute 10% to final catchment impact scores.
Wetland size (Ha)	1.8
Upslope catchment size (Ha)	39.4
Quaternary Catchment[1]	C42L
MAR (Mm3)	12.4
MAR per unit area (m3/Ha)	83.0
MAP (mm)	483
PET (mm)	1780
MAP:PET ratio	0.3
Vulnerability Factor	1.0
Hydrogeological Type Setting[2]	Other
Connectivity of wetland to a regional aquifer	No connection
Change in groundwater levels in the regional aquifer	
Water quality of regional aquifer	
Channel characteristics (if present)	
Natural wetness regimes	Dominated by seasonally saturated soils
Broad vegetation attributes	Domainted by oblagte wetland grasses and sedges, uniform and with low species diversity. Exotic weeds are abundant.
Number of dams in the catchment	0
Average surface area of dams (m2)	0
Perimeter of wetland (m)	628
Perimeter-to-area ratio (m/ha)	348.9
Down-slope length of wetland (m)	265
Elevation change over length (m)	1
Longitudinal Slope (%)	0.4%
Propensity to erode (Category)[3]	Very low
Propensity to erode (Score)	1.0
Dominant sediment accumulation process	Clastic

WET-Health Level 2 assessment: PES Summary

This worksheet provides an overall summary of the WET-Health Assessment that can be used for reporting purposes

	Wetland PES Summary			
Wetland name	**Sand River Backwaters**			
Assessment Unit	**1**			
HGM type	Floodplain wetland			
Areal extent (Ha)	1.8 Ha			
Unadjusted (modelled) Scores				
PES Assessment	**Hydrology**	**Geomorphology**	**Water Quality**	**Vegetation**
Impact Score	2.4	0.3	0.4	2.0
PES Score (%)	76%	97%	96%	80%
Ecological Category	**C**	**A**	**A**	**C**
Combined Impact Score	1.4			
Combined PES Score (%)	86%			
Combined Ecological Category	**B**			
Hectare Equivalents	1.5 Ha			
Confidence (modelled results)	RATE-TO-HIGH: Field-based assessment including information about the regional a			

Appendix E: Risk Assessment Matrix

RISK MATRIX (Based on DWS 2015 publication: Section 21 c and I water use Risk Assessment Protocol)

Risk to be scored for construction and operational phases of the project. MUST BE COMPLETED BY SACNASP REGISTERED PROFESSIONAL MEMBER REGISTERED IN AN APPROPRIATE FIELD OF EXPERTISE

					Severity																
No.	Phases	Activity	Aspect	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorph+Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures
1	Mostly Operational Phase but also limited during rehabilitation	Sand mining operations	Excavation of sand from the riverbank and floodplain including associated access roads.	Sand will be excavated from the banks or lower zone and floodplain by excavators which will result in removal of riparian vegetation, modification of the geomorphology, sedimentation of the river and similar impacts associated with the access road.	1	3	4	3	2.75	3	3	8.75	5	3	5	3	16	140	M	80	The excavation of sand will result in permanent alteration of the geomorphology of the banks and floodplain, but provided that adequate rehabilitation is undertaken the condition of the river will not be decreased and its functioning can also remain relatively intact. Mining areas should also be limited to an extent of 5 hectares at a time. As long as adequate rehabilitation and mitigation is implemented the impacts should also largely be confined to the immediate vicinity of the site (5 hectares at a time). The risk should remain moderate and adequate mitigation should be implemented. Mitigation should include limiting the extent (5 hectares) and number of excavation sites and implementing consecutive rehabilitation. Exotic weed eradication will also be an important management aspect.
	Mostly Operational Phase but also limited during rehabilitation		Extraction of sand from the main channel including pump infrastructure and access road.	Sand will be extracted from the main channel by a pump which will entail removal of material from the riverbed, a pump and associated infrastructure and an access road along the riverbank.	2	3	2	3	2.5	3	3	8.5	5	3	5	3	16	136	M	80	The extraction of sand is not anticipated to have any permanent or long lasting impacts on the river. It will however cause alteration of the geomorphology and affect the biota at the site but should not affect adjacent areas. The risk should remain moderate and adequate mitigation should be implemented. Mitigation should include limiting the extraction points to only one at a time and when moving the pump to another location the disturbed area should first be adequately rehabilitated. This should include the bank of the river and any access road.

	Mostly Operational Phase but also limited during rehabilitation		Stockpiling areas and associated activities	Sand excavated and pumped from the main channel, banks and floodplain will be transported to a stockpiling area in the floodplain which will require vegetation removal and disturbance of the soil surface.	1		3		2		2		2	3	3		8		5	3	5	3		16	128	M	80	Given the large extent of the proposed mining right area (approximately 230 hectares) this may potentially result in high impacts. In order to limit this impact it is recommended that sand excavation areas be limited to an extent of 5 hectares at a time. Sand should be excavated, processed and the area rehabilitated before moving to a new sand mining area. If this mining method is maintained, the risk is anticipated to remain moderate. The clearance of vegetation and disturbance of the soil surface may however cause significant impacts if correct mitigation is not implemented. The stockpiling may increase sediment load and turbidity within the river and the correct storm water management system should be implemented to prevent this. It will also be important to implement adequate rehabilitation of

Appendix F: Buffer Zone Determination

Name of Assessor	Darius van Rensburg	Project Details	De Klerkskraal Sand Mine	Date of Assessment	01/03/2022

Step 1: Define objectives and scope of assessment and determine the most appropriate level of assessment

Level of assessment	Site-based

Step 2: Map and categorize water resources in the study area

Approach used to delineate the wetland boundary?	Site-based delineation	Wetland type	Floodplain

Step 3: Refer to the DWA management objectives for mapped water resources or develop surrogate objectives

Present Ecological State	B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
Ecological importance & sensitivity	Medium	Features that are considered to be ecologically important and sensitive at a local scale. The functioning and/or biodiversity of these features is not usually sensitive to anthropogenic disturbances. They typically play a small role in providing ecological services at the local scale.
Management Objective	Maintain	

Step 4: Assess the risks from proposed developments and define mitigation measures necessary for protecting mapped water resources in the study area

Assess threats of planned activities on water resources and determine desktop buffer requirements

Proposed development / activity	Sector	Mining	This class comprises all mining-related activities including surface and sub-surface mining, quarrying and dredging for the extraction of minerals or materials, including sand and stone.
	Sub-Sector	Low-risk quarrying operations	Quarrying operations of minerals with a low water quality risk to water resources. These include: Attapulgite (Special clays), Calcrete, Clays, Dolerite, Kyanite, Mica, Norite (Dimension stone), Pyrophyllite, Quartzite (Dimension Stone and abrasive), Sand and Gravel, Siltstone Fines, Soil, Bentonite (Special clays), CaC03, Diatomaceous Earth, Feldspar, Graphite, Lime (Produced from limestone), Mineral Aggregates, Phosphate Rock, Quartz, Rare earths, Shale, Silica, Talc, Calcite, Dolomite, Fullers Earth, Kaolin, Montmorillonite, Pumice, Quartzite, Salt, Siltstone (Dimension Stone), Vermiculite

Climatic factors	MAP Class	401 - 600mm	Rainfall Intensity	Zone 2

Overall size	**Size of the wetland relative to (as a percentage of) its catchment**	**Average slope of the wetland's catchment**	**The inherent runoff potential of the soil in the wetland's catchment**	**The extent to which the wetland (HGM) setting is generally characterized by sub-surface water input**
0.5-5 ha	Intermediate (6-10%)	<3%	Moderately high	Low (Floodplain)
Perimeter to area ratio	**Vulnerability of the HGM type to sediment accumulation**	**Vulnerability of the site to erosion given the site's slope and size**	**Extent of open water, particularly water that is naturally clear**	**Sensitivity of the vegetation to burial under sediment**
Low (<500 m per ha)	Floodplain wetland	Low (Vulnerability score <2)	Low (0.5-3%)	Moderately low
Peat versus mineral soils	**Inherent level of nutrients in the landscape: is the wetland and its catchment underlain by sandstone?**	**Sensitivity of the vegetation to increased availability of nutrients**	**Sensitivity of the vegetation to toxic inputs, changes in acidity & salinization**	**Natural wetness regimes**
Mineral	No	Low (e.g. tall and dense vegetation with low natural diversity)	Low (e.g. low natural diversity)	Dominated by seasonally saturated soils
Natural salinity levels	**Level of domestic use**	**Mean Annual Temperature**	Note: See the guideline document for further information on the rationale for indicator selection and how these attributes affect the sensitivity of wetlands to lateral inputs.	
Naturally low saline levels	Low	Zone 4 (18.2 - 19.5 Deg C)		

Appendix G: Diatom Results

DEKLERKSKRAAL - DIATOM RESULTS

MARCH 2022

Authored by: Shael Koekemoer, Koekemoer Aquatic Services

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KOEKEMOER AQUATIC SERVICES

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1. BACKGROUND

Diatoms have been shown to be reliable indicators of specific water quality problems such as organic pollution, eutrophication, acidification and metal pollution, as well as for general water quality. Diatoms are commonly employed in monitoring efforts as sensitive biological indicators to determine the anthropogenic impact on aquatic ecosystems, and have for a long time been used in bio-assessments (Kasperovičienė and Vaikutienė, 2007). As benthic diatom assemblages are sessile they are exposed to water quality at a site over a period antecedent to sampling. They therefore indicate recent as well as current water quality (Philibert *et al*., 2006). Diatoms (as a biological response variable) are included in biomonitoring as it provides additional information on the water quality assessment in terms of current pollution levels and possible trends in physical chemical variables. Diatoms also provide a general description of the water quality related habitat specifications linked to ecologically sensitive species requirements. Diatom-based water quality indices for riverine ecosystems have been implemented in South Africa since 2004 as there is a measurable relationship between water quality variables such as pH, electrical conductivity, phosphorus and nitrogen, and the structure of diatom communities as reflected by diatom index scores, allowing for inferences to be drawn about water quality (Taylor, 2004; De la Rey *et al*. 2004).

The specific water quality tolerances of diatoms have been resolved into different diatom-based water quality indices, used around the world. Most indices are based on a weighted average equation (Zelinka and Marvan, 1961). In general, each diatom species used in the calculation of the index is assigned two values; the first value (s value) reflects the tolerance or affinity of the particular diatom species to a certain water quality (good or bad) while the second value (v value) indicates how strong (or weak) the relationship is (Taylor, 2004). These values are then weighted by the abundance of the particular diatom species in the sample (Lavoie *et al*., 2006; Besse, 2007). The main difference between indices is in the indicator sets (number of indicators and list of taxa) used in calculations (Eloranta and Soininen, 2002). These indices form the foundation for developing computer software to estimate biological water quality. OMNIDIA (Lecointe *et al*., 1993) is one such software package; it has been approved by the European Union and is used with increasing frequency in Europe and will be used for this study.

1.1 AIMS AND OBJECTIVES

The aim of the diatom sampling and analysis is to provide biological water quality information for conditions on the day of biological component sampling regarding the aquatic health and functioning of the aquatic system, and providing additional input to the physico-chemical component of the study as a response variable. The overall objective of this report is to assess the impacts of anthropogenic activities on the Present Ecological State of the receiving aquatic ecosystem

1.2 TERMINOLOGY

Several key ecological terms used in South African diatomology are summarised in Table 1.1 for the meaningful reading and understanding of the diatom results.

Table 1.1 Diatoms: Key ecological terms Taylor *et al*. (2007a)

Trophy	
Dystrophic	Rich in organic matter, usually in the form of suspended plant colloids, but of a low nutrient content.
Oligotrophic	Low levels or primary productivity, containing low levels of mineral nutrients required by plants.
Mesotrophic	Intermediate levels of primary productivity, with intermediate levels of mineral nutrients required by plants.
Eutrophic	High primary productivity, rich in mineral nutrients required by plants.
Hypereutrophic	Very high primary productivity, constantly elevated supply of mineral nutrients required by plants.
Mineral content	
Very electrolyte poor	< 50 µS/cm
Electrolyte-poor (low electrolyte content)	50 - 100 µS/cm
Moderate electrolyte content	100 - 500 µS/cm
Electrolyte-rich (high electrolyte content)	> 500 µS/cm
Brackish (very high electrolyte content)	> 1000 µS/cm
Saline	6000 µS/cm
Pollution (Saprobity)	
Unpolluted to slightly polluted	BOD <2, O_2 deficit <15% (oligosaprobic)
Moderately polluted	BOD <4, O_2 deficit <30% (β-mesosaprobic)
Critical level of pollution	BOD <7 (10), O_2 deficit <50% (β-ά-mesosaprobic)
Strongly polluted	BOD <13, O_2 deficit <75% (ά-mesosaprobic)
Very heavily polluted	BOD <22, O_2 deficit <90% (ά-meso-polysaprobic)
Extremely polluted	BOD >22, O_2 deficit >90% (polysaprobic)

2. METHODS

2.1 SAMPLING AND ANALYSIS

Epilithic[1] and/or Epiphytic[2] substrate was sampled as outlined in Taylor *et al*. (2007a). Diatom samples were taken at the site by scrubbing the substrate with a small brush and rinsing both the brush and the substrate with distilled water.

Preparation of diatom slides followed the Hot HCl and $KMnO_4$ method as outlined in Taylor *et al.* (2007a). A Nikon Eclipse E100 microscope with phase contrast optics (1000x) was used to identify diatom valves on slides. The aim of the data analysis was to count 400 diatom valves to produce semi-quantitative data from which ecological conclusions can be drawn (Taylor *et al*., 2007a). This range is supported by Prygiel *et al.* (2002), Schoeman (1973) and Battarbee (1986) as satisfactory for the calculation of relative abundance of diatom species. Nomenclature followed Krammer and Lange-Bertalot (1986-91). Diatom index values were calculated in the database programme OMNIDIA (Lecointe *et al.*, 1993) for epilithon data in order to generate index scores to general water quality variables.

2.2 DIATOM BASED WATER QUALITY SCORE

The European numerical diatom index, the Specific Pollution sensitivity Index (SPI) was used to assign biological water quality Ecological Categories (ECs) and associated water quality classes. Classes based on the class limits provided in Table 2.1. Other indices housed within the OMNIDIA programme used to characterise biological water quality included:

- Biological Diatom Index (BDI): Primarily a practical index, as it treats morphologically related taxa as one group and composes so-called associated taxa eliminating species that are difficult to identify.
- The ecological characterisation of diatom species based on Van Dam *et al.* (1994): Includes the preferences of 948 freshwater and brackish water diatom species in terms of pH, nitrogen, oxygen, salinity, humidity, saprobity and trophic state.
- Trophic Diatom Index (TDI) (Kelly and Whitton, 1995): This index provides the percentage pollution tolerant diatom valves (PTVs) in a sample and was developed for monitoring sewage outfall (orthophosphate-phosphorus concentrations), and not general stream quality. The presence of more than 20% PTVs shows significant organic impact.
- Valve deformities were also noted as it is an indication of possible metal toxicity that may be present within the system. According to Luís *et al*. (2008) several studies on metal polluted rivers have shown that diatoms respond to perturbations not only at the community but also at the individual level with alteration in cell wall morphology. In particular, size reduction and frustule deformations have been sometimes associated with high metal concentrations. The general threshold for the occurrence of valve deformities in a sample is usually considered between 1 - 2% and is regarded as potentially hazardous (Taylor, *pers. comm*.).

[1] Diatoms growing on rock or stone surfaces.
[2] Diatoms growing on macrophytic surfaces.

Table 2.1 Class limit boundaries for the SPI index applied in this study

Interpretation of index scores		
Ecological Category (EC)	**Class**	**Index Score (SPI Score)**
A	High quality	18 - 20
A/B		17 - 18
B	Good quality	15 - 17
B/C		14 - 15
C	Moderate quality	12 - 14
C/D		10 - 12
D	Poor quality	8 - 10
D/E		6 - 8
E	Bad quality	5 - 6
E/F		4 - 5
F		<4

3. RESULTS AND DISCUSSION

A summary of the diatom results are provided in Table 3.1 and a species list is provided in Appendix A. Species contributing 5% or more to the total count were classified as dominant.

Table 3.1 Summary of diatom results

Site	No species	SPI score	Class	Category	PTV (%)	Deformities (%)
US	40	5.7	Bad quality	**E**	21.5	0
DS	26	6.4	Poor quality	**D/E**	9.5	0

3.1 US

In March 2022 the SPI score was 5.7 (E Ecological Category) and the biological water quality was bad and ecologically unacceptable (Table 3.1). Diatom data suggested that organic load and nutrient levels were moderate while salinity concentration was high and problematic. Further analysis of the various indices within OMNIDIA suggested general pollution levels were critical.

Dominant species had a preference for deteriorated water quality with high nutrient levels organic load and salinity concentration and included *Cyclotella atomus*, *Navicula recens*, *Eolimna subminuscula*, and *Nitzschia palea*. Most of these species are key indicator species of sewage effluent. The centric diatom *Cyclotella atomus* occurred at highest abundance and occurs in the plankton of electrolyte rich waters (Taylor *et al*., 2007b). *Navicula recens* is found in large eutrophic rivers with elevated electrolyte content as well as brackish waters and tolerant to critical levels of pollution (Taylor *et al*., 2007b). *Nitzschia palea* is typical of phosphate enriched or organically polluted waters. It is an obligate nitrogen heterotroph and hyper eutrophic species that tolerates low levels of DO and prefers large concentrations of organic and inorganic nutrients and indicates organic sediment impairment (Teply and Bahls, 2006). According to Davey *et al*. (2008) this species has an optimum filterable Phosphorus between 0.35 and 1 mg/L, and can tolerate a broad range of phosphorus concentrations. The sub-dominance of *Craticula accomoda* further suggested that the main impact on biological water quality was sewage effluent as this key indicator is characteristic of high levels of pollution, found in strongly organically polluted waters, in particular effluent from sewage treatment works (Taylor *et al*., 2007b). No valve deformities were noted suggesting that metal toxicity was below detection limits, with limited bio-availability.

3.2 DS

In March 2022 the SPI score was 6.4 (D/E Ecological Category) and the biological water quality was poor, reflecting slight improvement from upstream (Table 3.1). Diatom data suggested that organic load and nutrient levels were moderate and improved from upstream while salinity concentration was still high and problematic. Further analysis of the various indices within OMNIDIA suggested general pollution levels were critical.

Dominant species at the downstream site were similar to US with *Cyclotella atomus*, *Navicula recens*, and *Nitzschia palea* occurring at highest abundance and suggesting that sewage effluent was still the main impact on the site. *Cyclotella atomus* increased in abundance reflecting an increased gradient of salinity concentration between sites. While the abundance of *Nitzschia palea* and *Navicula recens* remained stable between sites, the general abundance of species with a preference for higher nutrient levels and organic load decreased at lower abundance levels, reflecting the slightly improved biological water quality conditions. No valve deformities were noted suggesting that metal toxicity was below detection limits, with limited bio-availability.

4. CONCLUSIONS

The sites situated in the Deklerkskraal is characterised by poor biological water quality. While elevated nutrient and organic loads impact the sites, these variables decrease at the downstream site. However, high salinity concentration is the main impact on both sites with no improvement noted at the downstream site.

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6. APPENDIX A: DIATOM SPECIES LIST

List of diatom species collected during March 2022 in the Deklerkskraal where red indicates dominant species, yellow indicates moderately abundant species and green reflects species occurring at low abundance.

Species	US	DS
Aulacoseira granulata (Ehrenberg) Simonsen		2
Craticula accomoda (Hustedt) Mann	8	1
Craticula molestiformis (Hustedt) Lange-Bertalot	6	
Cyclostephanos dubius (Fricke) Round	1	
Cyclotella atomus Hustedt	194	279
Cyclotella meneghiniana Kützing	1	1
Eolimna minima (Grunow) Lange-Bertalot	2	
Eolimna subminuscula (Manguin) Moser Lange-Bertalot & Metzeltin	23	6
Gomphonema parvulum (Kützing) Kützing	9	4
Gyrosigma scalproides (Rabenhorst) Cleve	1	
Mayamaea agrestis(Hustedt) Lange-Bertalot	3	
Mayamaea atomus (Kützing) Lange-Bertalot	2	
Mayamaea atomus var. permitis (Hustedt) Lange-Bertalot	4	3
NAVICULA J.B.M. Bory de St. Vincent	1	
Navicula cryptocephala Kützing		
Navicula erifuga Lange-Bertalot	1	
Navicula libonensis Schoeman		
Navicula microcari Lange-Bertalot	1	
Navicula recens (Lange-Bertalot) Lange-Bertalot	74	66
Navicula reichardtiana Lange-Bertalot		
Navicula rostellata Kützing	1	1
Navicula schroeteri var. *symmetrica* (Patrick) Lange-Bertalot	12	
Navicula tripunctata (OF Müller) Bory		
Navicula veneta Kützing	6	3
Navicula viridula Kützing Ehrenberg		
NITZSCHIA A.H. Hassall	6	1
Nitzschia draveillensis Coste & Ricard	2	
Nitzschia frustulum (Kützing) Grunow	5	1
Nitzschia inconspicua Grunow abnormal form		
Nitzschia irremissa Cholnoky		1
Nitzschia palea (Kützing) W. Smith	34	24
NUPELA W. Vyverman & P. Compere		6
Staurosira elliptica (Schumann) Williams & Round	1	
Surirella crumena Brebisson		1
Synedra tenera W.Smith		
Tryblionella calida (Grunow) D.G. Mann	1	
Tryblionella hungarica (Grunow) D.G. Mann	1	
Total Count	**400**	**400**

Appendix H: Water Quality Report

iWATER

KNOWLEDGE TO ENVIRONMENTAL SOLUTIONS

WATER QUALITY REPORT

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