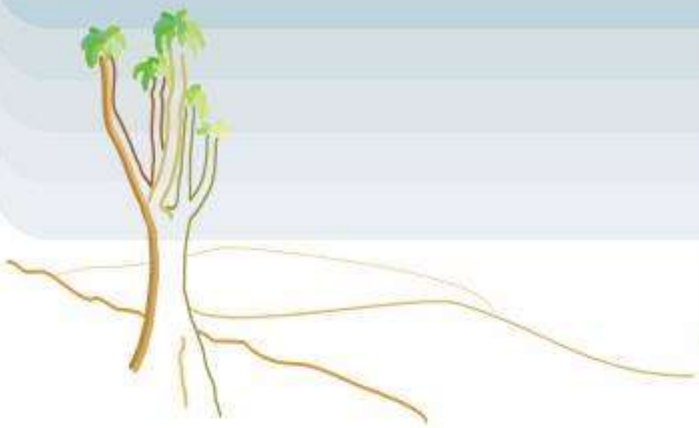

DPR
Ecologists & Environmental Services

Report on the ecological and wetland assessment for the proposed Harmony Joel PV solar development 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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Author	**DP van Rensburg (Pr.Sci.Nat)**		**Jan'23**

Executive Summary

The study area is situated between the towns of Theunissen (approximately 20 km) and Virginia (approximately 15 km) and within the Joel Gold mining operations. The study area is fairly large with an approximate extent of 200 hectares and dominated by thicket, of which a large portion are considered riparian thicket associated with the Doring River adjacent to the site (Appendix A: Map 1). The majority of the site still consists of natural vegetation without previous modification although mining operations situated on and around the site do result in transformation of the surroundings.

From the description of the area it is clear that the site still consists of natural vegetation with only small portions of it having been transformed. The natural vegetation types in the area, Highveld Alluvial Vegetation and Central Free State Grassland are both only listed as being of Least Concern and is therefore not of high conservation value (Appendix A: Map 1). The area is also listed an Ecological Support Area and therefore the area is not essential to meeting conservation targets but forms part of the functioning of the Doring River adjacent to the site (Appendix A: Map 2). The site would therefore have an overall Moderate level of sensitivity (Appendix A: Map 4). However, the Doring River itself is considered a highly sensitive system but which will be discussed in detail in the wetland assessment section of the report (Appendix A: Map 3). It would also be important to accurately determine the 1:100 year floodline of the river and exclude it from development or where development encroaches into the floodline of the river, that the necessary flood protection structures be implemented.

The development will therefore result in the loss of natural vegetation but which is considered to have only a moderate conservation value. The development would therefore still result in significant impacts but which is unlikely to exceed moderate values. The areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative transformation. The proposed solar development would therefore not result in a high cumulative impact though would certainly contribute toward the overall cumulative transformation of the area.

Signs and tracks of mammals are present on the site but notably less when compared to the natural condition. This is most likely a consequence of the proximity of the mining operations and frequent human activities in the area. Being dominated by natural vegetation the site itself will therefore still have capacity for a natural mammal population though the actual mammal population will be smaller and dominated by generalist species. Rare and endangered mammals are often reclusive and avoid areas in close proximity to human activities and are also dependant on habitat in pristine condition. Such species are therefore considered unlikely to occur in the area though the Doring River may still provide suitable habitat for Cape Clawless Otter (*Aonyx capensis*) though should remain largely unaffected by the development as long as the development footprint is kept outside the 1:100 year floodline of the river.

The surface water features of the study area is dominated by the Doring River which is situated adjacent to the site along its eastern, northern and western borders and may in some areas occur in close proximity to it (Appendix A: Map 1 & 3). Associated with the Doring River is an extensive floodplain which may also extend onto the site (Appendix A: Map 3). This is also dependent on the 1:100 year floodline of this watercourse. Within this floodplain an area of temporary saturation has also been identified which forms part of a floodplain wetland area although observed wetland conditions are only of a temporary nature and this area is therefore not clearly defined. The river itself is a tributary of the Sand River and is therefore a smaller

system though still significant. It is regarded as perennial or nearly so, flowing for the most part of the year. The river also drains a large catchment which seems to be largely natural and the river should therefore be in a quite good condition, however, immediate upstream gold mining operations does seem to significantly contribute toward poor water quality which is likely to have a significant affect on it. The assessment will therefore be based on the Doring River and its associated floodplain.

The vegetation survey indicated that obligate wetland vegetation occurs along the banks of the Doring River but does not extend into the floodplain. The floodplain of the river is dominated by alluvial clays which, although they do not contain wetland conditions, are clearly a consequence of alluvial deposition after flooding and which confirms the presence of an extensive floodplain. However, a portion in the north eastern corner of the site contains a grassy floodplain where Facultative Wetland grasses dominate and which therefore indicates a temporary wetland zone. This was also confirmed by soil samples which confirmed temporary soil saturation. The wetland conditions associated with the main channel and banks of the Doring River can be characterised as a channel wetland system while the wetland areas forming within the floodplain in the north east of the site can be categorised as a floodplain wetland (SANBI 2009).

The determination of the condition of the watercourses and wetlands on the site will consist only of the Doring River. From the impacts affecting the river it should be clear that the Doring River is still largely natural though being affected by a few large impacts which does result in significant modification. An Index of Habitat Integrity (IHI) was conducted for the river system itself and indicated that it has an Instream IHI of Category B/C: Largely Natural to Moderately Modified and Riparian IHI of Category C: Moderately Modified (Appendix D). This is considered accurate given the still largely natural catchment and unregulated flow while mining will still contribute significant impacts on it. The EI&S of the Doring River has been rated as being Moderate.

A Risk Assessment for the proposed solar facility which will affect the Doring River and associated floodplain 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). Aspects of the development that may have an impact on the surface water features of the site include, construction of the solar facility in close proximity to the Doring River and floodplain and also possibly encroaching into the floodplain of the river.

The Doring River situated adjacent to the solar development is still a largely natural system and therefore regarded to have a high conservation value (Appendix A: Map 3). The proposed development should therefore not contribute any new impacts to it or modify it in any significant way. The river and associated floodplain should therefore be completely excluded from the development and should not encroach into the riparian zone of the river as delineated. Furthermore, the exact border of the floodplain should be determined by a 1:100 year floodline determination. The development should, as far possible, refrain from encroaching into the 1:100 year floodline of the river.

In the event that the development is unable to avoid the floodplain and 1:100 year floodline of the river there is a likelihood that the development may become flooded at some time (Appendix A: Map 3). This may occur only very infrequently but will still result in significant impacts and consequently in this instance the anticipated risk will be moderate.

The impact significance has been determined and should development take place without mitigation it is anticipated that the majority of impacts will be moderate while the impact on the Doring River may be fairly high. Adequate mitigation may however significantly reduce these impacts though several will remain moderate. This is also dependant on the development excluding the 1:100 year floodline of the Doring River.

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Ecological and wetland assessment.

1. INTRODUCTION

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 plant diversity ranks third 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.

In order to better manage our water resources several guidelines and research sources have been developed. Amongst these are the National Freshwater Ecosystem Priority Areas for South Africa 2011 (NFEPA).

The human population has become a power-hungry system where non-renewable resources are being utilised at an alarming rate. These resources are nearing depletion and are often associated with some form of pollution (air-, water-, atmospheric pollution). The unlimited use of these non-renewable resources is not sustainable. In recent times people have become aware of this and are attempting to alleviate this by using renewable energy sources. This has become increasingly popular and are commonplace in many first world countries. Recently it has come to light that South Africa is optimally situated for solar power production. The use of solar power will alleviate the pressure experienced by Eskom, will reduce carbon emissions and will promote the use of renewable energies. The development of solar facilities should be encouraged. Solar parks do have their disadvantages. These include the use of fertile soil for power production rather than food supply and the disturbance and removal of natural vegetation.

The study area is situated between the towns of Theunissen (approximately 20 km) and Virginia (approximately 15 km) and within the Joel Gold mining operations. The study area is fairly large with an approximate extent of 200 hectares and dominated by thicket, of which a large portion are considered riparian thicket associated with the Doring River adjacent to the site (Appendix A: Map 1). The majority of the site still consists of natural vegetation without

previous modification although mining operations situated on and around the site do result in transformation of the surroundings.

A site visit was conducted on 15 June 2022. The entire footprint of the proposed development area, including terrestrial and riparian areas, was surveyed over the period of one day. The site survey was conducted during early winter and though vegetation was in the process of going dormant, late rains and light frost to date did allow for adequate vegetation identification and an active hydrological regime was present. This ensured accurate identification of watercourses and wetlands.

For the above reasons it is necessary to conduct an ecological and wetland assessment of an area proposed for development.

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

1.1 Background of the development

The following summary has been provided by the applicant and provides a brief description of the planned development:

Free Gold Harmony (Pty) Ltd (a subsidiary of Harmony Gold Mining Company Ltd) is looking to supplement its energy supply by implementing Photovoltaic (PV) generation, aiding their transition to a more sustainable and environmentally friendly energy mix.

The development of a solar photovoltaic (PV) facility with a generating capacity of up to 18MW is proposed 900m north east of the Harmony Joel operations, approximately ~20km north east of the town of Theunissen within the Masilonyana Local Municipality and within the Lejweleputswa District Municipality, Free State Province. The PV facility is located on Portion 0 of the Farm Leeuwbult 580. The solar PV development will be known as Harmony Joel Solar PV Facility.

The preferred site for the project is on a property which is privately owned by the Mine and are available for the proposed project, and is therefore deemed technically feasible by the project developer for such development to take place.

A project site[1] considered to be technically suitable for the development of the solar PV facility, with an extent of approximately 1000ha, was identified. A development area[2] of ~220ha was demarcated within this project site and allows an adequate footprint (~47ha)[3] for the installation of a solar PV facility with a contracted capacity of up to 18MW, while allowing for the avoidance of environmental site sensitivities.

The infrastructure associated with the 18MW solar PV facility will include:

[1] The project site comprises the affected properties for that identified area within which the development area and development footprint are located. It is the broader geographic area assessed as part of the EIA process, within which direct effects of the proposed project may occur. The project site is ~920ha in extent.

[2] The development area is that identified area where the 18MW PV facility is planned to be located. This area has been selected as a practicable option for the facility, considering technical preference and constraints. The development area is ~220ha in extent.

[3] The development footprint is the defined area (47ha) located within the development area) where the PV panel array and other associated infrastructure for the Harmony Joel Solar PV facility is planned to be constructed. This includes the actual footprint of the facility, and the area which would be disturbed.

» PV modules and mounting structures
» Inverters and transformers a SCADA room, and maintenance room
» Cabling between the project components, to be laid underground where practical
» Access roads, internal roads and fencing around the development area.
» Temporary and permanent laydown areas and O&M buildings.
» Grid connection solution including an on-site facility substation, switching station, to be connected to the Shafts 1 & 2 HJ Joel Mining Substation via an overhead power line (located ~830m south west of the development footprint).

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.

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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Professional registration:
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.
2022: National Wetland Indaba Conference

2. SCOPE AND LIMITATIONS

- To evaluate the present state of the vegetation and ecological functioning of the area proposed for the solar development.
- To identify possible negative impacts that could be caused by the proposed clearing of vegetation and establishment of solar development.
    - Severity relates to the nature of the event, aspect or impact to the environment and describes how severe the aspects impact on the ecosystem.
    - Duration refers to the amount of time that the environment will be affected by the event, risk or impact, if no intervention e.g. remedial action takes place.
    - Extent refers to the spatial influence of an impact.
    - Frequency refers to how often the specific activity, related to the event, aspect or impact, is undertaken.
    - Probability refers to how often the activity/event or aspect has an impact on the environment.
- 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 evaluate the present state of the wetlands and riparian vegetation in close proximity to the site. 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 Vegetation

Aspects of the vegetation that will be assessed include:

- The vegetation types of the region with their relevance to the proposed site.
- The overall status of the vegetation on site.
- Species composition with the emphasis on dominant-, rare- and endangered species.

The amount of disturbance present on the site assessed according to:

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

2.2 Fauna

Aspects of the fauna that will be assessed include:

- A basic survey of the fauna occurring in the region using visual observations of species as well as evidence of their occurrence in the region (burrows, excavations, animal tracks, etc.).

- The overall condition of the habitat.

2.3 Wetlands and watercourses

Aspects of the wetlands that will be assessed include:

- Identification and delineation 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 perennial systems to inform the condition and status of watercourses.

2.4 Limitations

- Due to the season of the survey several bulbs, seasonal herbs and subterranean succulents may have been overlooked as leaves and flowers may be absent due to their seasonal or deciduous nature.
- Although a comprehensive survey of the site was done it is still likely that several species were overlooked.
- Smaller drainage lines may have been overlooked where a distinct channel or riparian vegetation is absent.
- The area is dominate by alluvial soil deposits which complicates the delineation of the riparian zone and floodplain of the river and an additional 1:100 year floodline determination should be undertaken.
- Due to time constraints only limited surveys of wetlands were done.
- Some animal species may not have been observed as a result of their nocturnal and/or shy habits.

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.
- NBA 2018 Technical Report Volume 1: Terrestrial 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 species identification (Bromilow 1995, 2010, Coates-Palgrave 2002, Fish *et al* 2015, Gerber *et al* 2004, Gibbs-Russell *et al* 1990, Griffiths & Picker 2015, Manning 2009, Moffett 1997, Pooley 1998, 2003, Retief & Meyer 2017, Van Ginkel & Cilliers 2020, Van Ginkel *et al* 2011, Van Oudtshoorn 2004, Van Wyk & Malan 1998, Van Wyk & Van Wyk 1997, Venter & Joubert 1985).

Terrestrial fauna:

- Field guides for species identification (Smithers 1983, Child *et al* 2016, Cillié 2018).

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.

Ecological aspects surveyed and recorded includes:

- The overall ecology of an area including the diversity of species, uniformity or diversity of habitats and different vegetation communities.

- Identification and delineation of distinct vegetation communities ad habitats and the ecological drivers responsible for these distinct communities, i.e. soil, geology, topography, aspect, etc.
- A comprehensive plant species survey including the identification of protected, rare or threatened species.
- Any ecological process or function which is important to the ecosystem including ecological drivers such as fire, frost, grazing, browsing, etc. and any changes to these processes.

Animal species were also noted as well as the probability of other species occurring on or near the site according to their distribution areas and habitat requirements.
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. ECOLOGICAL OVERVIEW OF THE SITE

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

4.1 Overview of ecology and vegetation types

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

According to Mucina & Rutherford (2006) the immediate surroundings consist of Central Free State Grassland (Gh 6). The vegetation type is currently listed as being of Least Concern (LC) according to the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (Appendix A: Map 2). Although it is quite heavily affected by transformation for dryland crop cultivation, it is not yet considered as severe enough to be regarded a Threatened Ecosystem. Remaining natural areas of this vegetation type will therefore not have a high conservation value, however, elements of conservation concern may still be present in natural areas. However, the site is also situated adjacent to the Doring River and from the survey it was also evident that the vegetation on the site is much more representative of the Highveld Alluvial Vegetation (AZa 5) type which is associated with riparian areas. This vegetation type is also listed as being of Least Concern (LC) which will also be taken into account in the assessment of the site.

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 for the proposed solar development is listed as being an Ecological Support Areas 1 & 2 (ESA 1 & 2) (Appendix A: Map 3). This indicates that the area is not essential to meeting conservation targets but forms part of the functioning of the Doring River adjacent to the site and as a result does provide important functions in the support of this system. A Critical Biodiversity Area 2 (CBA 2) is situated to the west of the site and marginally intersects with the western border of the site. This CBA 2 is associated with surrounding natural grassland of Vaal-Vet Sandy Grassland, an Endangered vegetation type though the marginal portion extending into the study area overlaps with the existing mining plant and is therefore not relevant to the development.

The study area is situated between the towns of Theunissen (approximately 20 km) and Virginia (approximately 15 km) and within the Joel Gold mining operations. The study area is fairly large with an approximate extent of 200 hectares and dominated by thicket, of which a large portion are considered riparian thicket associated with the Doring River adjacent to the site (Appendix A: Map 1). The majority of the site still consists of natural vegetation without previous modification although mining operations situated on and around the site do result in transformation of the surroundings.

As previously stated, the study area is still largely natural (apart from the portion occupied by the mining operations) (Appendix A: Map 1). The study will largely focus on these areas of remaining natural vegetation with the mining plant only discussed in overview. This is also confirmed by the National Biodiversity Assessment (2018) which indicates the site to still consist of natural Central Free State Grassland. The site is however also situated adjacent to the Doring River and the vegetation structure is much better affiliated with Highveld Alluvial Vegetation (Aza 5) which is a riparian vegetation type and dominated by riparian thicket which is quite prominent on the site. The site is fairly uniform and dominated by a mosaic of fairly

dense thicket and open grassland and will be discussed as a whole. A small portion in the central portion of the site is clearly transformed and associated with a historical tailings dump but has a limited extent of approximately 5 hectares and is the only prominently transformed area of the site (apart from the existing mining plant).

Figure 1: The study area is generally dominated by fairly dense thicket vegetation with a well-developed grass layer also being present.

Figure 2: A historical tailings dump in the central portion of the site is the only significant transformation of the natural portion of the study area.

The Doring River is situated adjacent to the site along the eastern, northern and western borders and may in some areas occur in close proximity to it and is therefore also relevant to the development (Appendix A: Map 1). Associated with the Doring River is an extensive floodplain which may also extend onto the site (Appendix A: Map 3). This is also dependent on the 1:100 year floodline of this watercourse. Within this floodplain an area of temporary saturation has also been identified which forms part of a floodplain wetland area although observed wetland conditions are only of a temporary nature and this area is therefore not clearly defined. These areas will all be assessed in detail in the wetland assessment section of the report.

Figure 3: The Doring River is situated adjacent to the site and is a fairly large watercourse.

Figure 4: A grass dominated floodplain wetland areas is also associated with the Doring River.

The main impacts affecting the area is associated with the mining operations here (Appendix A: Map 1). The plant itself covers a fairly large area which is completely transformed, associated with the mining plant is also a network of infrastructure which includes roads, dirt tracks and pipelines which contributes toward transformation. Along the east of the plant and centrally within the study area is a prominent tailings dump which also completely transforms the footprint of approximately 5 hectares both in terms of vegetation and topography. This transformation is however of limited extent and the majority of the area still consists of natural vegetation. The area is also being utilised as grazing for domestic livestock and this also contributes toward at least a moderate level of overgrazing and trampling. It should be clear that though significant transformation is caused by the mining operations, the majority of the site is still in a natural condition.

Figure 6: Impacts in the study area (red) are largely associated with the existing mining operations (yellow) with a tailings dump (blue) also situated in the central portion of the site. Overall the site is however dominated by natural vegetation (Google Earth 2022).

In general, the surface topography is still largely intact except for those areas consisting of mining operations as well as the tailings dump. The natural topography in the area consists of a plain but with a gentle slope towards the Doring River situated adjacent to the site. In closer proximity to the river, the slope also increases and erosion gullies and uneven terrain also become more prominent.

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 Doring 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.

As previously indicated, the terrestrial component of the study area is fairly uniform and dominated by thicket vegetation with interspersed grassland layer. The study area will therefore be discussed as a whole and elements of conservation value indicated where these were observed.

The majority of the site still consists of natural vegetation which is dominated by a fairly dense thicket vegetation while a well-developed grass layer is also prominent (Appendix A: Map 1). The density of thicket also varies over the site with the northern portion being densest. The survey has indicated that though a moderate level of disturbance is present the vegetation is still natural. Available resources indicate the area to consist of Central Free State Grassland which is characterised by undulating plains dominated by grassland while lower lying areas may be affected by increased encroachment by the tree, *Vachellia karroo*, where overgrazing and trampling occurs (Mucina & Rutherford 2006). This was also found to be the case for this site. However, the lower lying areas along the rivers in this region, such as the Doring River, is normally dominated by Highveld Alluvial Vegetation. This vegetation type is characterised by flat topography with riparian thickets dominated by *Vachellia karroo,* accompanied by seasonally flooded grassland and disturbed herblands often dominated by exotic weeds (Mucina & Rutherford 2006). Again, this is also a very good description for the site. We can therefore conclude that the area consists of a mixture of Central Free State Grassland and Highveld Alluvial Vegetation which may also have been affected by increased encroachment of *Vachellia karroo* as a result of overgrazing and trampling. This sets a good baseline for the description of the site on which the following vegetation composition is based.

The thicket layer is dominated to a large degree by *Vachellia karroo* (Sweetthorn) and as discussed in the previous paragraph, this is a natural component of the vegetation though may have increased in density due to previous overgrazing and trampling. Other trees and shrubs also common within this thicket vegetation also include *Diospyros lycioides, Ziziphus mucronata, Searsia pyroides, Asparagus larcinus* and *Searsia lancea*. These species are often also associated with riparian conditions and is likely associated with the floodplain of the Doring River. Associated with the understorey beneath these trees are also plants adapted to shade such as the grass, *Setaria verticillata* The grass layer interspersed in the thicket layer is also dense and dominated by a variety of grasses which include climax grasses such as *Themeda triandra, Cymbopogon pospischillii, Eragrostis chloromelas, Digitaria eriantha, Fingerhuthia africana* and *Themeda triandra* while pioneer grasses are also common and include *Aristida congesta, Chloris virgata, Eragrostis echinochloide, Melinis nerviglumis* and *Eragrostis gummiflua*. This is indicative of a natural grass layer but with a level of disturbance also present which is characteristic of the vegetation type in the area but is also a consequence of overgrazing and trampling by domestic livestock. It is also notable that a few riparian grasses which are listed as Facultative Wetland grasses are also abundant in the area. These include *Panicum coloratum, Setaria sphacelatum* and *Cynodon dactylon*. This also indicates the presence of a floodplain and areas of higher moisture regime where a shallow groundwater table may be present. It will therefore also be important for the development to undertake a 1:100 floodline determination in order for the development to remain outside the floodplain of the river or implement sufficient mitigation to offset the impact. A significant herbaceous component is also imbedded within the grass layer and include species such as *Nidorella resedifolia, Solanum incanum, Blepharis subvolubilis, Gomphocarpus fruticosus, Hermannia depressa, Sebaea pentandra, Salvia verbenaca* and *Arctotis arctotoides*. Many of these are also pioneer species and while they are characteristic of the local vegetation type, they also indicate a low level of disturbance. The Highveld Alluvial Vegetation type in this region is also associated with a prominent geophytic component (plants with underground storage organs) and this was also the case for the site. Geophytic species observed include *Moraea pallida, Oxalis depressa, Boophone distichia, Eriospermum porphyrium, Colchicum burkei, Eucomis autumnalis, Bulbine abyssinica* and *Chlorophytum sp.* Of these, *B. distichia* and *E. autumnalis* are also listed as protected in the Free State Province and are therefore of significant conservation value. Where the development will affect these species, permits will also have to

be obtained and affected plants transplanted to adjacent areas where they will remain unaffected. A few small specimens of the protected Wild Olive Tree (*Olea europaea* subsp. *africana*) also occur on the site and permits will also have to be obtained to remove these. As indicated, some disturbance is present in the area and the natural vegetation type is also characterised by the establishment of some weeds. As a result, several exotic weeds are present on the site and include *Bidens bipinnata, Tagetes minuta, Conyza bonariensis, Opuntia humifusa, Xanthium spinosum, Verbena bonariensis* and *Verbena tenuisecta*. Where degradation is evident, such as the tailings dump on the site, more invasive plants have also established such as *Melia azedarach, Tamarix chinensis* and *Cortaderia selloana*.

The vegetation on the site is clearly still natural and is mostly affiliated with Highveld Alluvial Vegetation though it does also contain elements of Central Free State Grassland (Appendix A: Map 1). Both of these vegetation types are however listed as being of Least Concern (LC) and does not significantly contribute toward the site's conservation value. Though natural, the vegetation on the site also contains a significant degree of disturbance. The site also does not contain a significant species diversity and does not contain elements of high conservation value. However, as a natural area it must retain at least a Moderate level of sensitivity (Appendix A: Map 4).

Figure 7: The thicket vegetation on the site can become quite dense in some areas and is characteristic of Highveld Alluvial Vegetation type.

Figure 8: Areas of open grassland is also present and is then more characteristic of Central Free State Grassland.

Figure 9: A panorama of the site clearly illustrates the mosaic vegetation pattern of thicket and open grassland.

Conclusions

From the description of the area given above it is clear that the site still consists of natural vegetation with only small portions of it having been transformed. The natural vegetation types in the area, Highveld Alluvial Vegetation and Central Free State Grassland are both only listed as being of Least Concern and is therefore not of high conservation value (Appendix A: Map 1). The area is also listed as an Ecological Support Area and therefore the area is not essential to meeting conservation targets but forms part of the functioning of the Doring River adjacent to the site. The site would therefore have an overall Moderate level of sensitivity (Appendix A: Map 4). However, the Doring River itself is considered a highly sensitive system but which will be discussed in detail in the wetland assessment section of the report (Appendix A: Map 3). It would also be important to accurately determine the 1:100 year floodline of the river and exclude it from development or where development encroaches into the floodline of the river, that the necessary flood protection structures be implemented.

The development will therefore result in the loss of natural vegetation but which is considered to have only a moderate conservation value. The development would therefore still result in significant impacts but which is unlikely to exceed moderate values. The areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative transformation. The proposed solar development would therefore not result in a high cumulative impact though would certainly contribute toward the overall cumulative transformation of the area.

The remaining natural vegetation on the site is generally fairly uniform and species diversity remain moderate over the entire site. There are however still a few protected plant species and these also retain a significant conservation value (Appendix B). Where the protected geophytic species, *Boophone distichia* and *Eucomis autumnalis* will be affected by the development, permits will have to be obtained and affected plants transplanted to adjacent areas where they will remain unaffected. A few small specimens of the protected Wild Olive Tree (*Olea europaea* susp. *africana*) also occur on the site and permits will also have to be obtained to remove these. Areas of high disturbance also contains several exotic plant species of which a few are also well known invasive and problematic plants such as *Melia azedarach, Tamarix chinensis* and *Cortaderia selloana* (Appendix B). These will also pose a risk of spreading into surrounding

natural areas, especially as construction of the solar development will increase disturbance in the area (Appendix B). The proposed development will also have to implement a comprehensive monitoring and eradication programme to ensure that invasive plant species are removed from the area and prevented from re-establishing.

Figure 10: Protected plant species observed on the site include *Boophone distichia* (Left) and *Eucomis autumnalis* (Right). These are both geophytic species which are also deciduous.

4.2 Overview of terrestrial fauna (actual & possible)

Signs and tracks of mammals are present on the site but notably less when compared to the natural condition. This is most likely a consequence of the proximity of the mining operations and frequent human activities in the area. Being dominated by natural vegetation the site itself will therefore still have capacity for a natural mammal population though the actual mammal population will be smaller and dominated by generalist species. Rare and endangered mammals are often reclusive and avoid areas in close proximity to human activities and are also dependant on habitat in pristine condition. Such species are therefore considered unlikely to occur in the area though the Doring River may still provide suitable habitat for Cape Clawless Otter (*Aonyx capensis*) though should remain largely unaffected by the development as long as the development footprint is kept outside the 1:100 year floodline of the river.

Wetland and riparian habitats also generally provide a higher abundance of resources and subsequently are also able to sustain a diverse and large mammal population (Appendix A: Map 3). This will also be the case for the Doring River adjacent to the site. It is therefore also important that this system not be affected by the development. As long as the development footprint is kept outside the 1:100 year floodline of the river, the impact on the mammal population along the river should remain low.

The mammal survey of the site was conducted by means of active searching and recording any tracks or signs of mammals and actual observations of mammals. From the survey the following actual observations of mammals were recorded:

- Soil mounds of the Common Molerat (*Cryptomys hottentotus*) were common in most areas of the study area. This is a widespread species which has even become adapted to urban areas. It is a generalist species anticipated to occur in this area.

- Scat and burrows of Yellow Mongoose (*Cynictis penicillata*) occur in the study area. This species is widespread and common and found in most natural or disturbed habitats.

- Several burrows of small mammals were noted which could not be identified but do indicate a significant mammal population in the area.

- Observation of a Steenbok (*Raphicerus campestris*). This species is widespread but confined to fairly natural or agricultural areas and generally avoid urban areas.

- An active burrow of Aardvark (*Orycteropus afer*) occurs in the study area. This is also a fairly widespread and common species but is highly reclusive and is also listed as a protected species and is therefore of significant conservation value.

These species identified on the site indicate only a moderate species diversity of largely widespread and generalist species and is indicative of a modified natural mammal population. A similar mammal population should also be able to re-establish in the solar development footprint after construction has taken place.

The most significant impact on mammals anticipated on the site itself is primarily concerned with the loss and fragmentation of available habitat. Transformation of the natural vegetation on the site will result in a decrease in the population size as available habitat decreases. As indicated, the site does still consist of natural vegetation though it is still fairly uniform and with moderate habitat diversity and consequently the mammal population is also not anticipated to be diverse. The impact on the loss of habitat would therefore be significant but is unlikely to exceed high values. In addition, extensive natural areas still remain in the surroundings into which mammals on the site can move to without resulting in high habitat pressures.

It is also considered likely that several mammal species were overlooked during the survey and it may also be likely that other rare and endangered species may be present on the site.

Construction itself may also affect the mammal population and care should therefore be taken to ensure none of the faunal species on site is harmed. The hunting, capturing or harming in any way of mammals on the site should not be allowed. Voids and excavations may also act as pitfall traps to fauna and these should continuously be monitored and any trapped fauna removed and released in adjacent natural areas.

Mammals species likely to occur on the site has been determined by means of FitzPatrick Institute of African Ornithology (2022).

Table 2: Red Listed mammals occurring or likely to occur in the study area (Child *et al* 2016).

Scientific name	Common name	Status
Mystromys albicaudatus	African White-tailed Rat	**Vulnerable (VU)**
Damaliscus lunatus lunatus	(Southern African) Tsessebe	**Vulnerable (VU)**
Hippotragus equinus	Roan Antelope	**Endangered (EN)**
Hippotragus niger niger	Sable Antelope	**Vulnerable (VU)**

Kobus leche	Lechwe	**Near Threatened (NT)**
Pelea capreolus	Vaal Rhebok	**Near Threatened (NT)**
Felis nigripes	Black-footed Cat	**Vulnerable (VU)**
Hyaena brunnea	Brown Hyena	**Near Threatened (NT)**

The survey has indicated that though the mammal population will consist largely of widespread, generalist species, there remains a low likelihood that some of these Red Listed species may occur in the area.

Table 3: Likely mammal species in the region.

Family	Scientific name	Common name	Status
Bathyergidae	*Cryptomys hottentotus*	Southern African Mole-rat	Least Concern
Bovidae	*Aepyceros melampus*	Impala	Least Concern
	Alcelaphus buselaphus	Hartebeest	Least Concern
	Antidorcas marsupialis	Springbok	Least Concern
	Connochaetes gnou	Black Wildebeest	Least Concern
	Connochaetes taurinus taurinus		Least Concern
	Damaliscus lunatus lunatus	(Southern African) Tsessebe	**Vulnerable**
	Damaliscus pygargus phillipsi	Blesbok	Least Concern
	Hippotragus equinus	Roan Antelope	**Endangered**
	Hippotragus niger niger	Sable Antelope	**Vulnerable**
	Kobus ellipsiprymnus ellipsiprymnus		Least Concern
	Kobus leche	Lechwe	**Near Threatened**
	Oryx gazella	Gemsbok	Least Concern
	Pelea capreolus	Vaal Rhebok	**Near Threatened**
	Raphicerus campestris	Steenbok	Least Concern
	Redunca arundinum	Southern Reedbuck	Least Concern
	Redunca fulvorufula	Mountain Reedbuck	Least Concern
	Sylvicapra grimmia	Bush Duiker	Least Concern
	Syncerus caffer	African Buffalo	Least Concern
	Taurotragus oryx	Common Eland	Least Concern
	Tragelaphus angasii	Nyala	Least Concern
	Tragelaphus scriptus	Bushbuck	Least Concern
	Tragelaphus strepsiceros	Greater Kudu	Least Concern
Canidae	*Canis mesomelas*	Black-backed Jackal	Least Concern
	Vulpes chama	Cape Fox	Least Concern
Cercopithecidae	*Chlorocebus pygerythrus*	Vervet Monkey	Least Concern
Equidae	*Equus quagga*	Plains Zebra	Least Concern

Felidae	*Felis nigripes*	Black-footed Cat	**Vulnerable**
Giraffidae	*Giraffa giraffa giraffa*	South African Giraffe	Least Concern
Herpestidae	*Cynictis penicillata*	Yellow Mongoose	Least Concern
	Herpestes sanguineus	Slender Mongoose	Least Concern
	Suricata suricatta	Meerkat	Least Concern
Hippopotamidae	*Hippopotamus amphibius*	Common Hippopotamus	Least Concern
Hyaenidae	*Hyaena brunnea*	Brown Hyena	**Near Threatened**
	Proteles cristata	Aardwolf	Least Concern
Hystricidae	*Hystrix africaeaustralis*	Cape Porcupine	Least Concern
Leporidae	*Lepus capensis*	Cape Hare	Least Concern
	Lepus saxatilis	Scrub Hare	Least Concern
Muridae	*Aethomys namaquensis*	Namaqua Rock Mouse	Least Concern
	Gerbilliscus brantsii	Highveld Gerbil	Least Concern
	Mastomys coucha	Southern African Mastomys	Least Concern
	Rhabdomys dilectus	Mesic Four-striped Grass Rat	Least Concern
	Rhabdomys pumilio	Xeric Four-striped Grass Rat	Least Concern
Mustelidae	*Ictonyx striatus*	Striped Polecat	Least Concern
Nesomyidae	*Mystromys albicaudatus*	African White-tailed Rat	**Vulnerable**
Sciuridae	*Xerus inauris*	South African Ground Squirrel	Least Concern
Suidae	*Phacochoerus africanus*	Common Warthog	Least Concern
Thryonomyidae	*Thryonomys swinderianus*	Greater Cane Rat	Least Concern
Viverridae	*Genetta genetta*	Common Genet	Least Concern

From historical records (Table 3) it is evident that the area contains a large amount of mammals and numerous Red Listed mammals. Of these the larger antelope are however historical records and would only be found within conservation areas, they are not of consequence to the development. The smaller Red Listed mammal species may still occur in the area, including the Black-footed Cat (*Felis nigripes*), Brown Hyena (*Hyaena brunnea*), and African White-tailed Rat (*Mystromys albicaudatus*). These species are considered somewhat unlikely to occur in the area though this likelihood cannot be completely discounted and the anticipated impact will remain moderate.

A note should also be made of the Sungazer Lizard (*Smaug giganteus*). This is a highly endangered reptile known to occur in the sandy grassland habitats of this region. The survey also specifically targeted this species but was found to be absent from the area. The habitat on the site is also unsuitable for this species while its distribution range is also situated to the north of the site. It is therefore not relevant to this development.

Figure 11: Tracks and signs of mammals on the site include from top to bottom; Scat and scratchings of a Yellow Mongoose (*Cynictis penicillata*), Burrow of an unidentified small rodent, a Steenbok (*Raphicerus campestris*) and burrow of an Aardvark (*Orycteropus afer*).

4.3 Wetland Assessment

4.3.1 Introduction

The surface water features of the study area is dominated by the Doring River which is situated adjacent to the site along its eastern, northern and western borders and may in some areas occur in close proximity to it (Appendix A: Map 1 & 3). Associated with the Doring River is an extensive floodplain which may also extend onto the site (Appendix A: Map 3). This is also dependent on the 1:100 year floodline of this watercourse. Within this floodplain an area of temporary saturation has also been identified which forms part of a floodplain wetland area although observed wetland conditions are only of a temporary nature and this area is therefore not clearly defined. The river itself is a tributary of the Sand River and is therefore a smaller system though still significant. It is regarded as perennial or nearly so, flowing for the most part of the year. The river also drains a large catchment which seems to be largely natural and the river should therefore be in a quite good condition, however, immediate upstream gold mining operations does seem to significantly contribute toward poor water quality which is likely to

have a significant affect on it. The assessment will therefore be based on the Doring River and its associated floodplain.

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.

The classification of stream orders from 1 to 3 can be illustrated by means of the Strahler 1952 classification. The Doring River is considered a second order watercourse, flowing into the Sand River to the north which is a third order system.

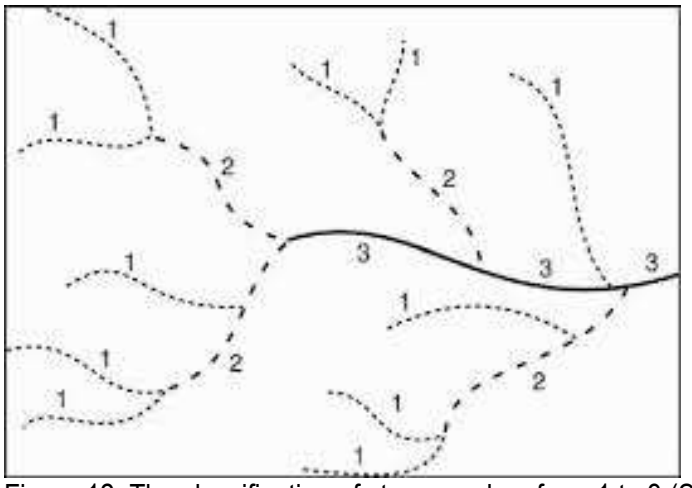


Figure 12: The classification of stream orders from 1 to 3 (Strahler 1952).

4.3.2 Wetland indicators

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 Doring River and associated floodplain was delineated by use of topography (land form and drainage pattern) and obligate wetland vegetation with limited soil sampling (Appendix C). Due to time constraints and the extent of the study area soil samples were only taken along a few lateral transects of the Doring River to confirm the presence of wetland conditions (Appendix A: Map 3). The following guidelines and frameworks were used to determine and delineate the watercourses 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.

Obligate wetland vegetation was utilised to determine the presence and border of wetland conditions (Appendix B). Due to time constraints soil samples were only taken along a few transects of the Doring River and its associated floodplain. Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils (Appendix C).

The vegetation survey indicated that obligate wetland vegetation occurs along the banks of the Doring River but does not extend into the floodplain. The floodplain of the river is dominated by alluvial clays which, although they do not contain wetland conditions, are clearly a consequence of alluvial deposition after flooding and which confirms the presence of an extensive floodplain. However, a portion in the north eastern corner of the study area contains a grassy floodplain where Facultative Wetland grasses dominate and which therefore indicates a temporary wetland zone. This was also confirmed by soil samples which confirmed temporary soil saturation.

4.3.3 Classification of wetland systems

The wetland conditions associated with the Doring River as well as its floodplain can be classified into a specific wetland type.

The wetland conditions associated with the main channel and banks of the Doring River 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 channel of the river system. The wetland conditions are confined to the main channel which experiences surface flow on a perennial basis (Appendix A: Map 3). Here wetland conditions are most prominent along the main channel and decrease in distance from the channel.

The wetland areas forming within the floodplain of the Doring River situated in the north east of the site can be categorised as 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 description fits the wetland conditions in the north eastern portion of the floodplain well (Appendix A: Map 3). Here, a flat grassy area adjacent to the main channel contains temporary saturation which leads to the establishment of temporary wetland conditions. The river is situated within surrounding plains and though hills and ridges occur to the north, it still forms part of a lowland system, also confirmed by the lowland Sand River situated to the north. This floodplain wetland area also contains a very flat topography, one of the main criterions of a floodplain wetland. This floodplain portion is most probably fed largely by overland flow though overtopping into the floodplain will occur on a very infrequent basis, i.e. during 1:100 year flooding events. The floodplain wetland discharges by diffuse flow though erosional features at its north western end also indicate concentrated flow toward the river.

4.2.4 Description of watercourses and wetlands

The study area is dominated by the Doring River which occurs along the eastern, northern and western borders of the site (Appendix A: Map 3). An extensive floodplain is also present. A short description of the Doring River and floodplain wetland area will be provided below.

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.

- Van Ginkel, C.E. & Cilliers, C.J. 2020. Aquatic and wetland plants of Southern Africa. Briza Publications, Pretoria.

Table 4: Description of the individual watercourses and wetlands which forms part of the study area (Appendix A: Map 3) (FW – Facultative wetland species, OW – Obligate wetland species, * - Exotic species).

Watercourse name:	**Coordinates of sampling:**	**Flow regime:**
#1 Doring River – a mostly perennial and prominent watercourse	S 28.243091°, E 26.834375° S 28.248495°, E 26.820406°	Perennial

Description of watercourse at the site:

A lateral transect to the north and west of the site along the floodplain and to the main channel was taken for the Doring River. This provides a fairly good description of the banks of the river, the floodplain and the current impacts affecting the system.

The river is still fairly natural, especially when considering the catchment which is still largely natural. However, the main channel does indicate at least some contamination caused by upstream seepage of mining areas. The likelihood that the Joel, Beatrix and Oryx mines are causing pollution of the Doring River has also been confirmed by DWS (2015). Other lesser impacts in the area include a few dirt tracks that act as obstructions to surface flow and trampling caused by domestic livestock which leads to a decrease in riparian vegetation and increased sedimentation of the river. These impacts will contribute to at least some modification of the system.

The river contains a clearly defined, fairly deep main channel with distinct riparian zonation. It follows a meandering flow pattern though generally flows from south east to north west. The river also drains into the Sand River approximately 20 km to the north west of the site. The channel of the river is prominent and fairly wide at approximately 8 meters. An extensive floodplain is situated along the river though the exact border could not be accurately determined. The area is dominated by alluvial soils and thicket which all indicate the presence of a riparian zone though the exact border of the floodplain should be determined by a 1:100 year floodline determination. Toward the north east of the site the floodplain also contains temporary wetland conditions which indicate the presence of a floodplain wetland. Also refer to Section 4.3.5 for a description of the current impacts on the stream. The development should, as far possible, refrain from encroaching into the 1:100 year floodline of the river and where it will not be possible to completely avoid the floodline of the river, that the necessary flood protection structures be implemented.

Obligate wetland vegetation dominates along the main channel, which include a variety of sedges, rushes and grasses in the marginal zone while dense aquatic vegetation may also be present in some portions of the stream. Dense algal mats were also notable and may be a consequence of increase nutrient inflow caused by upstream impacts. The lower zone is also dominated by many obligate wetland plants such as sedges and grasses with terrestrial plants being largely absent. This indicates wetland conditions extending up the banks of the river. The upper zone also contains some obligate wetland plants though terrestrial species are quite abundant and dominates in many areas. This indicates a decrease in the moisture regime in the upper zone which contains only a temporary zone of wetness. Riparian trees and shrubs dominate in the upper zone while being absent in the other zones. However, the floodplain is dominated by thicket which is fairly dense overall. Here terrestrial plants dominate though it was noted that patches of higher moisture regime do also contain facultative wetland grasses

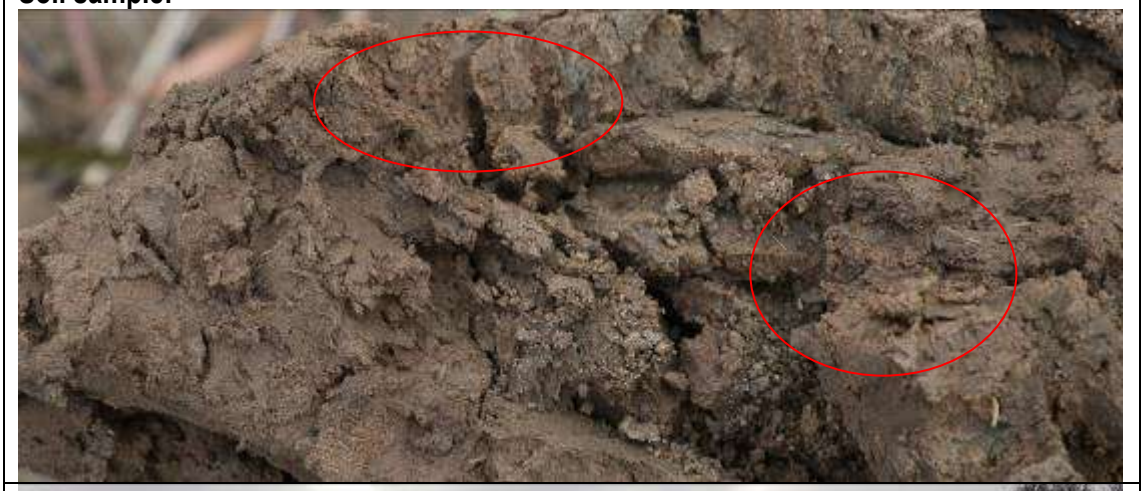
which indicate a higher moisture regime in the floodplain. Overall, the species composition along the river and floodplain is in a relatively natural condition although exotic weeds are also quite abundant. This is however to be expected within the riparian thicket. The system is therefore still considered to largely natural although some disturbance is evident. The border between the floodplain or riparian zone and the surrounding terrestrial areas are not well defined with the area being dominated by alluvial clay soils. The approximate floodplain has been delineated though a 1:100 year floodline determination should also be undertaken to accurately determine the extent that flooding may occur.

Dominant plant species:
Riverbanks: *Artemisia afra, Imperata cylindria* (OW), *Equisetum ramosissimum* var. *ramosissimum, Cyperus marginatus* (OW), *Celtis africana, Pergularia daemia, Typha capensis* (OW).

Floodplain: *Berkheya radula, Setaria verticillata, Gomphocarpus fruticosus, Cynodon dactylon, Ziziphus mucronata, Setaria sphacelata* (FW), *Diospyros lycioides, Vachellia karroo, Salsola rabieana, Microloma aramatum, Kalanchoe rotundifolia.*

Protected plant species:
Pergularia daemia, Microloma armatum.

Soil sample:



The Doring River contains a prominent and fairly wide channel with steep banks.

Dense riparian thicket is clearly present in the floodplain though the border with the surrounding terrestrial areas are not well defined.

Flooding within the river can be extensive during the riany season, here indicated by the level of flood debris in trees (red).

Dense algal mats in the main channel indicate high levels of nutrients which may be consequence of upstream mining impacts.

Watercourse name:	**Coordinates of sampling:**	**Flow regime:**
#2 Floodplain wetland – Area of temporary saturation in the north east of the site	S 28.248697°, E 26.835987° S 28.250044°, E 26.836936°	Temporary

Description of watercourse:

The north eastern portion of the site contains a flat area adjacent to the Doring River which is dominated by facultative wetland grasses and indicates at least temporary saturation during the rainy season. This indicates the presence of a floodplain wetland area. It forms a part of the Doring River but is included separately here in order to give a specific description of this area. It is not a prominent wetland area and is border with surrounding thicket habitats is not well defined though the floodplain wetland itself is still clearly differentiable from the surroundings. This floodplain wetland has an elongated form and drains into the Doring River via an erosion feature in the floodplain. This gulley erosion is a common feature along the watercourses in this region and is still considered as a natural feature. The floodplain wetland has an approximate length of 480 meters. The floodplain wetland is imbedded within the surrounding thicket vegetation but is clearly differentiated from it in that it is almost devoid of trees and shrubs (a possible consequence of temporary saturation) while it is dominated by facultative wetland grasses. This also confirms at least temporary wetland conditions. It will also form part of the floodplain of the river and it is recommended that this portion be completely excluded from development.

The floodplain wetland is a completely flat area situated within the floodplain, adjacent to the river and corresponds well with the characteristics of a floodplain wetland. Vegetation also consists of facultative wetland grasses and therefore indicate at least temporary saturation though it is clear that prominent wetland areas are not present. Soil samples also indicate soils with a very high clay content and with feint mottling also being visible. This also confirms the presence of temporary wetland conditions.

Dominant plant species:

Setaria sphacelata (FW), *Panicum coloratum* (FW).

Protected plant species:

None observed.

Soil sample:

The floodplain wetland clearly do not contain prominent wetland conditions but is dominated by dense facultative grasses which indicate a temporary zone of saturation. Note also the absence of trees and shrubs.

The floodplain wetland also drains into the Doring River via an erosional feature at the north western end.

4.3.5 Condition and importance of the affected watercourse

The determination of the condition of the watercourses and wetlands on the site will consist only of the Doring River. The aim is to provide an overall overview of the condition of the Doring River in the study area. Determination of the condition will be based on an overall determination of the Index of Habitat Integrity (IHI) (Appendix D). This will also take into account upstream impacts as well as impacts within the catchment. This is considered to give a good representation of the condition of this river. The IHI will be taken as representative of the Present Ecological State (PES) of the river system at the site.

Table 5 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 6 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 5: 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 6: Ecological importance and sensitivity categories.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very High Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications.	>3 and <=4	A
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications.	>2 and <=3	B
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications.	>1 and <=2	C
Low/marginal Wetlands that are not ecologically important and sensitive at	>0 and <=1	D

any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications.		

According to previous desktop assessments (Kleynhans 2000, Van Deventer *et al* 2018) the Doring River near the site is considered to have a PES varying from Category D: Largely Modified according to the former to Category B: Largely Natural according to the latter assessment. This does indicate the desktop uncertainty with regards to the condition of the system. The more recent desktop assessment (Van Deventer *et al* 2018) is considered the more accurate of the two as it is similar to the results of the current assessment. It is evident that the river system provides vital services including water transportation, storm water, wetland and riparian habitats and groundwater recharge. The entire system should therefore still be considered as sensitive and the impact caused by solar development should be prevented as far as possible. It is therefore recommended that the exact border of the floodplain should be determined by a 1:100 year floodline determination. The development should, as far possible, refrain from encroaching into the 1:100 year floodline of the river and where it will not be possible to completely avoid the floodline of the river, that the necessary flood protection structures be implemented.

As indicated above, the Doring River is still considered to be fairly natural though it is affected by a few significant impacts. A summary of the impacts will be provided in the following paragraphs.

The upstream catchment of the river is largely intact and affected by only a few significant impacts. The river contains no significant impoundments upstream of the site and is therefore still largely unregulated. A few small cropfields are notable in the floodplain and catchment upstream of the site and these will have some impact on the functioning of the river. These cultivated areas will contribute to a fairly low degree towards the removal of the natural vegetation layer, which in turn promotes runoff while decreasing infiltration and this again results in higher erosion rates, which increases both the inflow into the river system, as well as the sediment load within the river. Coupled with this will also be fertiliser runoff, which will increase the nutrient load in the river. Other smaller impacts which will also affect the river include a few low water dirt road crossings which will act as flow obstructions, will result in retardation of flow and consequently will impact on the flow and flooding regime of the river. Trampling by domestic livestock will also contribute toward a decrease riparian vegetation and higher sediment loads within the river.

Figure 13: The catchment of the Doring River is clearly still largely natural though note some agricultural fields upstream as well as a few road crossings (Google Earth 2022).

The immediate surroundings upstream of the site does contain several gold mining areas and this is considered to have several significant impacts on the river. Several areas contain oxidation ponds and containment ponds associated with the mining operations and it is also highly likely that seepage from these areas will enter the Doring River. This also seems to be affecting the water quality within the river which contain dense algal mats and a chemical smell. This has also been identified as a highly likely source by the Department of Water and Sanitation (2015) which has recommended prioritising water quality sampling downstream of the Joel, Beatrix and Oryx mines to determine and monitor the extent of contamination.

Figure 14: Oxidation and containment ponds are highly likely to seep into and affect the water quality of the Doring River.

Figure 15: The main channel contains dense algal mats which are indicative of a high nutrient content and also has a chemical smell indicating likely contamination.

From the above described impacts it should be clear that the Doring River is still largely natural though being affected by a few large impacts which does result in significant modification. An Index of Habitat Integrity (IHI) was conducted for the river system itself and indicated that it has an Instream IHI of Category B/C: Largely Natural to Moderately Modified and Riparian IHI of Category C: Moderately Modified (Appendix D). This is considered accurate given the still largely natural catchment and unregulated flow while mining will still contribute significant impacts on it.

The EI&S of the Doring 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.

4.3.6 Risk Assessment

A Risk Assessment for the proposed solar facility which will affect the Doring River and associated floodplain 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). Aspects of the development that may have an impact on the surface water features of the site include, construction of the solar facility in close proximity to the Doring River and floodplain and also possibly encroaching into the floodplain of the river.

The Doring River situated adjacent to the solar development is still a largely natural system and therefore regarded to have a high conservation value (Appendix A: Map 3). The proposed development should therefore not contribute any new impacts to it or modify it in any significant way. The river and associated floodplain should therefore be completely excluded from the development and should not encroach into the riparian zone of the river as delineated. Furthermore, the exact border of the floodplain should be determined by a 1:100 year floodline determination. The development should, as far possible, refrain from encroaching into the 1:100 year floodline of the river. The river and associated floodplain should also be regarded as no-go areas and no construction or operational activities including stockpiling, clearing, laydown areas, vehicle movement or any other associated activities should occur in or near this

system. As long as this is implemented successfully, the anticipated risk on the Doring River should remain low. Furthermore, although it should not be directly affected, it may however still be indirectly affected by the development, most probably as a result of increased runoff from the panels and an increased sediment load. Erosion is therefore also probable. The development will therefore have to design and implement a comprehensive storm water management system in order to manage runoff and prevent erosion which will affect the river system.

In the event that the development is unable to avoid the floodplain and 1:100 year floodline of the river there is a likelihood that the development may become flooded at some time (Appendix A: Map 3). This may occur only very infrequently but will still result in significant impacts and consequently in this instance the anticipated risk will be moderate. In order to mitigate these impacts flood protection structures will have to be erected such as flood berm around the perimeter of the development.

Low Risks: Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated.

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

Mitigation as recommended as well as any additional mitigation recommended by other specialist studies should be implemented in order to alleviate the risks on the wetland systems in the area.

For the complete risk assessment please refer to Appendix E.

No.	Phases	Activity	Aspect	Impact	Risk Rating	Confidence level	Control measures
1	Mostly Construction Phase but also during operation	Construction of a solar facility.	The Doring River and associated floodplain situated adjacent to the solar footprint may be affected by the proposed development	The construction of the facility may encroach into the floodplain or riparian zone which will directly affect or may also impact on the catchment of the river which will then have an indirect impact on it.	**L**	**80**	Provided that the solar footprint does not encroach into the 1:100 year floodline or floodplain and these areas are treated as no-go areas, the anticipated risk should remain low. The development may however still have an indirect impact in terms of runoff and erosion and a comprehensive storm water management system should be implemented in order to manage runoff and prevent erosion which will affect the river system.
	Mostly Construction Phase but also during operation	Construction of a solar facility	Where construction encroaches into the floodplain or 1:100 year floodline it will have an increased impact on the Doring River.	Construction below the 1:00 year floodline will make the development susceptible to periodic flooding which will have a significantly higher impact on the river.	**M**	**80**	In order to mitigate the risk of flooding flood protection structures will have to be erected such as flood berm around the perimeter of the development.

5. ANTICIPATED IMPACTS

Anticipated impacts that the development will have is primarily concerned with the loss of habitat and species diversity but will also include impacts on the Doring River situated adjacent to the study area (Appendix A: Map 1 - 4).

The following impacts on the ecosystem, ecology and biodiversity will be assessed:

- Loss of vegetation and consequently habitat and species diversity as a result.
- Loss of protected, rare or threatened plant species.
- Impacts on watercourses, wetlands or the general catchment.
- The impact that the development will have on exotic weeds and invasive species, both current and anticipated conditions.
- Any increased erosion that the development may cause.
- Fragmentation of habitat, disruption of ecological connectivity and -functioning in terms of the surrounding areas.
- Impacts that will result on the mammal population on and around the site.
- Any significant cumulative impacts that the development will contribute towards.

Solar PV developments usually entail the removal of surface vegetation and may also involve modification of the surface topography. This therefore has a large impact in terms of the loss of vegetation, vegetation type and consequently habitat. As indicated from the discussion of the study area, it is still largely dominated by natural vegetation though a degree of disturbance is notable. The loss of natural vegetation, habitat and species diversity is therefore inevitable. However, the natural vegetation types in the area, Highveld Alluvial Vegetation and Central Free State Grassland are both only listed as being of Least Concern and is therefore not of high conservation value (Appendix A: Map 1). The area is also listed as an Ecological Support Area and therefore the area is not essential to meeting conservation targets but forms part of the functioning of the Doring River adjacent to the site. The site would therefore have an overall Moderate level of sensitivity (Appendix A: Map 4). The development will therefore result in the loss of natural vegetation but which is considered to have only a moderate conservation value. The development would therefore still result in significant impacts but which is unlikely to exceed moderate values.

The remaining natural vegetation on the site is generally fairly uniform and species diversity remain moderate over the entire site. There are however still a few protected plant species and these also retain a significant conservation value (Appendix B). Where the protected geophytic species, *Boophone distichia* and *Eucomis autumnalis* will be affected by the development, permits will have to be obtained and affected plants transplanted to adjacent areas where they will remain unaffected. A few small specimens of the protected Wild Olive Tree (*Olea europaea* susp. *africana*) also occur on the site and permits will also have to be obtained to remove these. Provided that this mitigation is successfully implemented, the anticipated impact should remain moderate to low.

The Doring River and associated floodplain and wetland areas are situated adjacent to the site and it remains likely that they will be affected by the proposed development. Solar developments are well known to have significant impacts on surface water features as a result of the rain shadow caused by the panels and the coupled runoff and infiltration patterns, erosion caused by these runoff patterns and disruption of surface watercourses. The Doring River and its associated floodplain should therefore be excluded from the development and the

necessary mitigation implemented to ensure no indirect impacts affect the river system. Development in close proximity (within 100 meters of riparian and within 500 meters of wetland areas) to the Doring River will require authorisation from DWS. Refer to the risk assessment (Section 4.3.7) for a more detailed discussion on the likely risks and impacts that the development will have on this river system. Should it be possible to avoid the 1:100 year floodline of the Doring River the anticipated impact will remain low, however, where the development encroaches into the floodplain of the river the impacts will be considerably higher.

As was observed during the survey of the study area, those portions of high disturbance also contains several exotic plant species of which a few are also well known invasive and problematic plants such as *Melia azedarach, Tamarix chinensis* and *Cortaderia selloana* (Appendix B). Without mitigation, these will also pose a risk of spreading into surrounding natural areas, especially as construction of the solar development will increase disturbance in the area (Appendix B). The proposed development will also have to implement a comprehensive monitoring and eradication programme to ensure that invasive plant species are removed from the area and prevented from re-establishing. It is therefore recommended that weed control be judiciously and continually practised. Monitoring of weed establishment should form a prominent part of management of the development area. Where category 1 and 2 weeds occur, they require removal by the property owner according to the Conservation of Agricultural Resources Act, No. 43 of 1983 and National Environmental Management: Biodiversity Act, No. 10 of 2004.

As indicated, because solar PV developments result in the removal of vegetation, this reduces infiltration and promotes runoff. Coupled with the rain shadow caused by panels and the resulting dripline, this increases runoff and erosion. This may also have a moderate impact on the Doring River adjacent to the site. In order to reduce this impact, the development should implement a comprehensive storm water management system which should ensure that the surface runoff patterns are retained as is, especially pertaining to solar panels, and that the development does not contribute toward increased surface flow, erosion and any impacts on downslope areas.

The region around the study area, especially to the east of it, is still dominated by extensive natural areas and consequently ecosystem functions, habitat fragmentation and the disruption of ecosystem processes is still fairly low. However, the proposed development will also require the transformation of a significant portion consisting of thicket and grassland in fairly good condition and will therefore result in significant habitat loss and fragmentation. This will however be limited to the study area since the surroundings are still dominated by natural vegetation. However, the study area is still listed as an Ecological Support Area 1 (ESA) and aids in the functioning of the adjacent Doring River in terms of ecological connectivity and aids in preserving the integrity of the system. The development may therefore still affect this functioning of the river and adequate mitigation as indicated should still be implemented, i.e. the implementation of a comprehensive storm water system and exclusion of the 1:100 year floodline of the river. The development will also result in the loss of some natural vegetation which would contribute to at least a moderate impact in terms of habitat fragmentation and the loss of ecosystem processes.

The most significant impact on mammals anticipated on the site itself is primarily concerned with the loss and fragmentation of available habitat. Transformation of the natural vegetation on the site will result in a decrease in the population size as available habitat decreases. As indicated, the site does still consist of natural vegetation though it is still fairly uniform and with

moderate habitat diversity and consequently the mammal population is also not anticipated to be diverse. The impact on the loss of habitat would therefore be significant but is unlikely to exceed high values. In addition, extensive natural areas still remain in the surroundings into which mammals on the site can move to without resulting in high habitat pressures. Construction itself may also affect the mammal population and care should therefore be taken to ensure none of the faunal species on site is harmed. The hunting, capturing or harming in any way of mammals on the site should not be allowed. Voids and excavations may also act as pitfall traps to fauna and these should continuously be monitored and any trapped fauna removed and released in adjacent natural areas.

As previously indicated, the areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative transformation. The proposed solar development would therefore not result in a high cumulative impact though would certainly contribute toward the overall cumulative transformation of the area.

The impact significance has been determined and should development take place without mitigation it is anticipated that the majority of impacts will be moderate while the impact on the Doring River may be fairly high. Adequate mitigation may however significantly reduce these impacts though several will remain moderate. This is also dependant on the development excluding the 1:100 year floodline of the Doring River.

Please refer to Appendix G for the impact methodology.

Nature: **Loss of vegetation and consequently habitat and species diversity as a result.**			
Impact description: Solar PV developments usually entail the removal of surface vegetation and may also involve modification of the surface topography. This therefore has a large impact in terms of the loss of vegetation, vegetation type and consequently habitat. As indicated from the discussion of the study area, it is still largely dominated by natural vegetation though a degree of disturbance is notable. The loss of natural vegetation, habitat and species diversity is therefore inevitable. However, the natural vegetation types in the area, Highveld Alluvial Vegetation and Central Free State Grassland are both only listed as being of Least Concern and is therefore not of high conservation value (Appendix A: Map 1). The area is also listed as an Ecological Support Area and therefore the area is not essential to meeting conservation targets but forms part of the functioning of the Doring River adjacent to the site. The site would therefore have an overall Moderate level of sensitivity (Appendix A: Map 4).			
	Rating	**Motivation**	**Significance**
Prior to Mitigation			
Duration	5	Permanent transformation of vegetation	**Moderate Negative (55)**
Extent	1	Limited development footprint	
Magnitude	5	Moderate conservation value	
Probability	5	Impact is unavoidable	
Mitigation/Enhancement Measures			
Mitigation: The loss of natural vegetation, habitat and species diversity is inevitable and no significant mitigation will decrease the anticipated impact. However, the site is considered to have an overall Moderate level of sensitivity (Appendix A: Map 4). The development will therefore result in the loss of natural vegetation but which is considered to have only a moderate conservation			

value. The development would therefore still result in significant impacts but which is unlikely to exceed moderate values.			
Post Mitigation/Enhancement Measures			
Duration	5	Permanent transformation of vegetation	**Moderate Negative (55)**
Extent	1	Limited development footprint	
Magnitude	5	Moderate conservation value	
Probability	5	Impact is unavoidable	
Cumulative impacts: As previously indicated, the areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative transformation. The loss of vegetation, habitat and species diversity would therefore not result in a high cumulative impact though would certainly contribute toward the overall cumulative transformation of the area.			
Residual Risks: As indicated from the discussion of the study area, it is still largely dominated by natural vegetation though a degree of disturbance is notable. The loss of natural vegetation, habitat and species diversity is therefore inevitable.			

Nature: **Loss of protected, rare or threatened plant species.**			
Impact description: The remaining natural vegetation on the site is generally fairly uniform and species diversity remain moderate over the entire site. There are however still a few protected plant species and these also retain a significant conservation value (Appendix B). Where the protected geophytic species, *Boophone distichia* and *Eucomis autumnalis* will be affected by the development, permits will have to be obtained and affected plants transplanted to adjacent areas where they will remain unaffected. A few small specimens of the protected Wild Olive Tree (*Olea europaea* susp. *africana*) also occur on the site and permits will also have to be obtained to remove these. Provided that this mitigation is successfully implemented, the anticipated impact should remain moderate to low.			
	Rating	**Motivation**	**Significance**
Prior to Mitigation			
Duration	5	Permanent loss of protected species	**Moderate Negative (42)**
Extent	1	Limited development footprint	
Magnitude	8	High likelihood for the loss of protected species	
Probability	3	Only a few protected species known to occur on the site and therefore probability is moderate	
Mitigation/Enhancement Measures			
Mitigation: Where the protected geophytic species, *Boophone distichia* and *Eucomis autumnalis* will be affected by the development, permits will have to be obtained and affected plants transplanted to adjacent areas where they will remain unaffected. A few small specimens of the protected Wild Olive Tree (*Olea europaea* susp. *africana*) also occur on the site and permits will also have to be obtained to remove these.			
Post Mitigation/Enhancement Measures			
Duration	5	Permanent loss of protected	**Moderate Negative**

		species	**(30)**
Extent	1	Limited development footprint	
Magnitude	4	Loss of fewer protected species, provided mitigation is successfully implemented	
Probability	3	Probable that at least some protected species will be lost	
Cumulative impacts: As previously indicated, the areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative transformation. The loss of protected would therefore not result in a high cumulative impact though would certainly contribute toward the overall cumulative loss of protected species in the area.			
Residual Risks: Despite comprehensive mitigation (dependant on this mitigation being successfully implemented) a residual loss of some protected species is still unavoidable.			

Nature: **Impacts on watercourses, wetlands or the general catchment.**			
Impact description: The Doring River and associated floodplain and wetland areas are situated adjacent to the site and it remains likely that they will be affected by the proposed development. Solar developments are well known to have significant impacts on surface water features as a result of the rain shadow caused by the panels and the coupled runoff and infiltration patterns, erosion caused by these runoff patterns and disruption of surface watercourses. The Doring River and its associated floodplain should therefore be excluded from the development and the necessary mitigation implemented to ensure no indirect impacts affect the river system. Development in close proximity (within 100 meters of riparian and within 500 meters of wetland areas) to the Doring River will require authorisation from DWS. Refer to the risk assessment (Section 4.3.7) for a more detailed discussion on the likely risks and impacts that the development will have on this river system. Should it be possible to avoid the 1:100 year floodline of the Doring River the anticipated impact will remain low, however, where the development encroaches into the floodplain of the river the impacts will be considerably higher.			
	Rating	**Motivation**	**Significance**
Prior to Mitigation			
Duration	5	Permanent transformation of the Doring River and riparian zone	**High Negative (90)**
Extent	3	Spill over of impacts into downstream areas	
Magnitude	10	Direct impact on the river system	
Probability	5	Impact is unavoidable	
Mitigation/Enhancement Measures			
Mitigation: Should it be possible to avoid the 1:100 year floodline of the Doring River the anticipated impact will remain low, however, where the development encroaches into the floodplain of the river the impacts will be considerably higher. Where the development remains outside the 1:100 year floodline of the river it should not be directly affected, however, it may still be indirectly affected by the development, most probably			

as a result of increased runoff from the panels and an increased sediment load. Erosion is therefore also probable. The development will therefore have to design and implement a comprehensive storm water management system in order to manage runoff and prevent erosion which will affect the river system.

In the event that the development is unable to avoid the floodplain and 1:100 year floodline of the river there is a likelihood that the development may become flooded at some time (Appendix A: Map 3). This may occur only very infrequently but will still result in significant impacts. In order to mitigate these impacts flood protection structures will have to be erected such as flood berms around the perimeter of the development.

Post Mitigation/Enhancement Measures

Duration	5	Permanent transformation of the catchment of te river	**Moderate Negative (33)**
Extent	2	Development footprint remains outside the 1:100 year floodline of the river	
Magnitude	4	Impacts on the river still significant	
Probability	3	Impact probability is moderate	

Cumulative impacts:

As previously indicated, the areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative impacts on the Doring River. The clearance of vegetation and resulting impacts on the river would therefore not result in a high cumulative impact though would certainly contribute toward the overall condition of the river.

Residual Risks:

Where the development remains outside the 1:100 year floodline of the river it should not be directly affected, however, it may still be indirectly affected by the development, most probably as a result of increased runoff from the panels and an increased sediment load. Erosion is therefore also probable.

Nature:

The impact that the development will have on exotic weeds and invasive species, both current and anticipated conditions.

Impact description: As was observed during the survey of the study area, those portions of high disturbance also contains several exotic plant species of which a few are also well known invasive and problematic plants such as *Melia azedarach, Tamarix chinensis* and *Cortaderia selloana* (Appendix B). Without mitigation, these will also pose a risk of spreading into surrounding natural areas, especially as construction of the solar development will increase disturbance in the area (Appendix B). The proposed development will also have to implement a comprehensive monitoring and eradication programme to ensure that invasive plant species are removed from the area and prevented from re-establishing. It is therefore recommended that weed control be judiciously and continually practised. Monitoring of weed establishment should form a prominent part of management of the development area. Where category 1 and 2 weeds occur, they require removal by the property owner according to the Conservation of Agricultural Resources Act, No. 43 of 1983 and National Environmental Management: Biodiversity Act, No. 10 of 2004.

	Rating	**Motivation**	**Significance**
Prior to Mitigation			
Duration	4	Long-term infestation	**Moderate Negative**

Extent	3	Spreading of infestation into neighbouring areas	**(52)**
Magnitude	6	Infestation of surrounding natural areas	
Probability	4	Impact is highly likely	
Mitigation/Enhancement Measures			
Mitigation: It is recommended that weed control be judiciously and continually practised. Monitoring of weed establishment should form a prominent part of management of the development area. Where category 1 and 2 weeds occur, they require removal by the property owner according to the Conservation of Agricultural Resources Act, No. 43 of 1983 and National Environmental Management: Biodiversity Act, No. 10 of 2004.			
Post Mitigation/Enhancement Measures			
Duration	3	Limited duration if monitoring and eradication is maintained	**Moderate Negative (30)**
Extent	1	Limiting extent through monitoring and eradication	
Magnitude	6	Limited but unavoidable infestation	
Probability	3	Moderate probability remains	
Cumulative impacts: As previously indicated, the areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative transformation. The increase in terms of infestation by exotic weeds and invasive species would therefore not result in a high cumulative impact though would certainly contribute toward the overall cumulative infestation of the area.			
Residual Risks: Without mitigation this will significantly increase the establishment of exotics and is likely to spread into the surrounding areas.			

Nature: **Any increased erosion that the development may cause.**			
Impact description: As indicated, because solar PV developments result in the removal of vegetation, this reduces infiltration and promotes runoff. Coupled with the rain shadow caused by panels and the resulting dripline, this increases runoff and erosion. This may also have a moderate impact on the wetland systems adjacent to the site. In order to reduce this impact, the development should implement a comprehensive storm water management system which should ensure that the surface runoff patterns are retained as is, especially pertaining to solar panels, and that the development does not contribute toward increased surface flow, erosion and any impacts on downslope areas.			
	Rating	**Motivation**	**Significance**
Prior to Mitigation			
Duration	5	Permanent modification of surface topography	**Moderate Negative (56)**
Extent	3	Spreading of erosion into neighbouring areas	
Magnitude	6	Limited magnitude due to the flat topography	
Probability	4	Highly likely to take place	
Mitigation/Enhancement Measures			

Mitigation: In order to reduce this impact, the development should implement a comprehensive storm water management system which should ensure that the surface runoff patterns are retained as is, especially pertaining to solar panels, and that the development does not contribute toward increased surface flow, erosion and any impacts on downslope areas.			
Post Mitigation/Enhancement Measures			
Duration	5	Permanent modification of surface topography	**Low Negative (20)**
Extent	1	Limiting extent through storm water management	
Magnitude	4	Limited magnitude due to the flat topography	
Probability	2	Unlikely to occur as long as storm water management is maintained	
Cumulative impacts: As previously indicated, the areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative transformation. The increase I erosion would therefore not result in a high cumulative impact though would certainly contribute toward the overall cumulative erosion if the development is able to successfully implement a storm water management system.			
Residual Risks: Erosion may also have a significant impact on the Doring River adjacent to the site.			

Nature: **Fragmentation of habitat, disruption of ecological connectivity and -functioning in terms of the surrounding areas.**			
Impact description: The region around the study area, especially to the east of it, is still dominated by extensive natural areas and consequently ecosystem functions, habitat fragmentation and the disruption of ecosystem processes is still fairly low. However, the proposed development will also require the transformation of a significant portion consisting of thicket and grassland in fairly good condition and will therefore result in significant habitat loss and fragmentation. This will however be limited to the study area since the surroundings are still dominated by natural vegetation. However, the study area is still listed as an Ecological Support Area 1 (ESA) and aids in the functioning of the adjacent Doring River in terms of ecological connectivity and aids in preserving the integrity of the system. The development may therefore still affect this functioning of the river and adequate mitigation as indicated should still be implemented, i.e. the implementation of a comprehensive storm water system and exclusion of the 1:100 year floodline of the river. The development will also result in the loss of some natural vegetation which would contribute to at least a moderate impact in terms of habitat fragmentation and the loss of ecosystem processes.			
	Rating	**Motivation**	**Significance**
Prior to Mitigation			
Duration	5	Permanent loss and fragmentation of habitat	**Moderate Negative (48)**
Extent	2	Limited loss of natural areas	
Magnitude	5	Moderate impact on the functioning of the Doring River	
Probability	4	Highly likely to take place	

Mitigation/Enhancement Measures			
Mitigation: The development may still affect this functioning of the river and adequate mitigation as indicated should still be implemented, i.e. the implementation of a comprehensive storm water system and exclusion of the 1:100 year floodline of the river (Section 4.3.7).			
Post Mitigation/Enhancement Measures			
Duration	5	Permanent loss and fragmentation of habitat	**Moderate Negative (36)**
Extent	2	Limited loss of natural areas	
Magnitude	5	Moderate impact on the functioning of the Doring River	
Probability	3	Lower probability if adequate mitigation is implemented	
Cumulative impacts: As previously indicated, the areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative transformation. The proposed solar development would therefore not result in a high cumulative impact though would certainly contribute toward the overall cumulative transformation of the area and therefore habitat fragmentation and the disruption of ecosystem services.			
Residual Risks: The area is largely still dominated by natural vegetation in fairly good condition and it is unavoidable that the development will result in transformation of a significant portion of natural vegetation and consequently the residual impact on habitat fragmentation and the loss of ecosystem processes would remain significant.			

Nature: **Impacts that will result on the mammal population on and around the site.**			
Impact description: The most significant impact on mammals anticipated on the site itself is primarily concerned with the loss and fragmentation of available habitat. Transformation of the natural vegetation on the site will result in a decrease in the population size as available habitat decreases. As indicated, the site does still consist of natural vegetation though it is still fairly uniform and with moderate habitat diversity and consequently the mammal population is also not anticipated to be diverse. The impact on the loss of habitat would therefore be significant but is unlikely to exceed high values. In addition, extensive natural areas still remain in the surroundings into which mammals on the site can move to without resulting in high habitat pressures. Construction itself may also affect the mammal population and care should therefore be taken to ensure none of the faunal species on site is harmed.			
	Rating	**Motivation**	**Significance**
Prior to Mitigation			
Duration	4	Limited to a semi-permanent impact if some vegetation re-establishes within the development	**Moderate Negative (48)**
Extent	2	Limited loss of natural areas	
Magnitude	6	Moderate given the uniform population diversity	
Probability	4	Fairly high since the impact is largely unavoidable	
Mitigation/Enhancement Measures			

Mitigation: Construction itself may also affect the mammal population and care should therefore be taken to ensure none of the faunal species on site is harmed. The hunting, capturing or harming in any way of mammals on the site should not be allowed. Voids and excavations may also act as pitfall traps to fauna and these should continuously be monitored and any trapped fauna removed and released in adjacent natural areas.			
Post Mitigation/Enhancement Measures			
Duration	4	Limited to a semi-permanent impact if some vegetation re-establishes within the development	**Moderate Negative (48)**
Extent	2	Limited loss of natural areas	
Magnitude	6	Moderate given the uniform population diversity	
Probability	4	Fairly high since the impact is largely unavoidable	
Cumulative impacts: As previously indicated, the areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative transformation. The proposed solar development would therefore not result in a high cumulative impact though would certainly contribute toward the overall cumulative transformation of the area and therefore a loss of mammal habitat.			
Residual Risks: Transformation of the indigenous vegetation on the site will result in a decrease in the mammal population size as available habitat decreases.			

Cumulative impact:

As previously indicated, the areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative transformation. The proposed solar development would therefore not result in a high cumulative impact though would certainly contribute toward the overall cumulative transformation of the area.

	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	2	3
Duration	4	4
Magnitude	6	8
Probability	4	4
Significance	**Moderate (48)**	**Moderate (60)**
Status (positive or negative)	Negative	Negative
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resources?	No	Yes
Can impacts be mitigated?	Yes – but limited	Yes – but limited
Confidence in findings: High		
Mitigation: The cumulative impact is unlikely to be easily mitigated. Decreasing the total development footprint should allow for a decrease in the cumulative impact though the cumulative impact is still anticipated to remain significant.		

6. BIODIVERSITY SENSITIVITY RATING (BSR)

Habitat diversity and species richness:
The site itself is dominated by a mosaic of thicket and grassland and represents a moderate habitat diversity. As a result, species diversity on the site also fairly uniform and does not exceed moderate values (Appendix B). The Doring River and its banks significantly contribute toward habitat and species diversity but does not form part of the development footprint.

Presence of rare and endangered species:
The remaining natural vegetation on the site is generally fairly uniform and species diversity remain moderate over the entire site. There are however still a few protected plant species and these also retain a significant conservation value (Appendix B). These include *Boophone distichia, Eucomis autumnalis* and *Olea europaea* subsp. *africana*.

Ecological function:
The ecological function of the site is still largely intact though some modification, mostly of the surroundings are present. The site functions as habitat for a variety of fauna, supports specific vegetation types and also function in support of the Doring River adjacent to the site (Appendix A: Map 1). The river itself also maintains several vital functions such as water transportation, wetland and aquatic habitats and bio-remediation and it is therefore crucial that the development not affect this functioning. This should be obtainable as long as the development does not encroach into the riparian zone of 1:100 year floodline.

The surrounding mining transformation contributes to the modification of the functioning of the site as habitat for fauna though the site itself does still support the natural vegetation type. Overall the ecological functioning of the site is considered moderately modified.

Degree of rarity/conservation value:
The natural vegetation types in the area, Highveld Alluvial Vegetation and Central Free State Grassland are both only listed as being of Least Concern and is therefore not of high conservation value (Appendix A: Map 1).

According to the Free State Province Biodiversity Management Plan (2015) the site for the proposed solar development is listed as being an Ecological Support Areas 1 & 2 (ESA 1 & 2) (Appendix A: Map 2). This indicates that the area is not essential to meeting conservation targets but forms part of the functioning of the Doring River adjacent to the site and as a result does provide important functions in the support of this system.

From the above the site does not seem to have a high conservation value, however, it is clear that the Doring River provides vital services including water transportation, storm water, wetland and riparian habitats and groundwater recharge and therefore has a very high conservation value. As long as the development, refrains from encroaching into the 1:100 year floodline of the river it should not affect the conservation of it (Appendix A: Map 3).

Overall the site is therefore considered as having a moderate conservation value.

Percentage ground cover:
The percentage vegetation cover on the site is still largely natural though disturbances on and adjacent to the development area such as tailings and mining operations does influence the natural vegetation cover.

Vegetation structure:
The vegetation types in the area is characterised by grassland and thicket habitats both which are well represented on the site. However, an increased establishment of thicket, especially the *Vachellia karroo* trees are likely and therefore a moderate modification of the vegetation structure is considered likely.

Infestation with exotic weeds and invader plants:
The site contains a moderate establishment of exotic weeds which include *Bidens bipinnata, Tagetes minuta, Conyza bonariensis, Opuntia humifusa, Xanthium spinosum, Verbena bonariensis* and *Verbena tenuisecta* (Appendix B). Where degradation is evident, such as the tailings dump on the site, more invasive plants have also established such as *Melia azedarach, Tamarix chinensis* and *Cortaderia selloana*. These are also well known invasive and problematic plants.

Degree of grazing/browsing impact:
The area is being utilised as grazing for domestic livestock and significant levels of overgrazing and trampling were also noted. It is however still considered to remain at moderate levels.

Signs of erosion:
Signs of erosion is common, though are for the most part still regarded as natural. This includes natural gulley erosion within the floodplain of the Doring River. This natural erosion has however been moderately increased by the on-site impacts, notably trampling by domestic livestock.

Terrestrial animals:
Signs and tracks of mammals are present on the site but notably less when compared to the natural condition. This is most likely a consequence of the proximity of the mining operations and frequent human activities in the area. Being dominated by natural vegetation the site itself will therefore still have capacity for a natural mammal population though the actual mammal population will be smaller and dominated by generalist species. Rare and endangered mammals are often reclusive and avoid areas in close proximity to human activities and are also dependant on habitat in pristine condition. Such species are therefore considered unlikely to occur in the area though the Doring River may still provide suitable habitat for Cape Clawless Otter (*Aonyx capensis*) though should remain largely unaffected by the development as long as the development footprint is kept outside the 1:100 year floodline of the river.

Wetland and riparian habitats also generally provide a higher abundance of resources and subsequently are also able to sustain a diverse and large mammal population (Appendix A: Map 3). This will also be the case for the Doring River adjacent to the site. It is therefore also important that this system not be affected by the development. As long as the development footprint is kept outside the 1:100 year floodline of the river, the impact on the mammal population along the river should remain low.

Table 7: Biodiversity Sensitivity Rating for the proposed solar development.

	Low (3)	Medium (2)	High (1)
Vegetation characteristics			
Habitat diversity & Species richness		2	
Presence of rare and endangered species		2	
Ecological function		2	
Uniqueness/conservation value		2	
Vegetation condition			
Percentage ground cover			1
Vegetation structure		2	
Infestation with exotic weeds and invader plants or encroachers	3		
Degree of grazing/browsing impact		2	
Signs of erosion		2	
Terrestrial animal characteristics			
Presence of rare and endangered species		2	
Sub total	3	16	1
Total		20	

7. BIODIVERSITY SENSITIVITY RATING (BSR) INTERPRETATION

Table 8: Interpretation of Biodiversity Sensitivity Rating.

Site	Score	Site Preference Rating	Value
Harmony Joel PV Solar	20	Good Condition	2

8. DISCUSSION AND CONCLUSION (Appendix A: Map 1 - 4)

The site proposed for PV solar development has been rated as being in a Good Condition. The site is largely still dominated by natural vegetation and which is still fairly intact. The site itself is however fairly uniform with a moderate species diversity and consists of vegetation types with a relatively low conservation value (Appendix A: Map 1 - 4). The Doring River situated adjacent to the site does have a high conservation value and is considered highly sensitive but as long as development does not encroach into the riparian zone and 1:100 year floodline of the river, it should remain largely unaffected by the development (Appendix A: Map 3).

The study area is situated between the towns of Theunissen (approximately 20 km) and Virginia (approximately 15 km) and within the Joel Gold mining operations. The study area is fairly large with an approximate extent of 200 hectares and dominated by thicket, of which a large portion are considered riparian thicket associated with the Doring River adjacent to the site (Appendix A: Map 1). The majority of the site still consists of natural vegetation without previous modification although mining operations situated on and around the site do result in transformation of the surroundings.

According to Mucina & Rutherford (2006) the immediate surroundings consist of Central Free State Grassland (Gh 6). The vegetation type is currently listed as being of Least Concern (LC) according to the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (Appendix A: Map 2). Although it is quite heavily affected by transformation for dryland crop cultivation, it is not yet considered as severe enough to be regarded a Threatened Ecosystem. Remaining natural areas of this vegetation type will therefore not have a high conservation value, however, elements of conservation concern may still be present in natural areas. However, the site is also situated adjacent to the Doring River and from the survey it was also evident that the vegetation on the site is much more representative of the Highveld Alluvial Vegetation (AZa 5) type which is associated with riparian areas. This vegetation type is also listed as being of Least Concern (LC) which will also be taken into account in the assessment of the site.

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 for the proposed solar development is listed as being an Ecological Support Areas 1 & 2 (ESA 1 & 2) (Appendix A: Map 2). This indicates that the area is not essential to meeting conservation targets but forms part of the functioning of the Doring River adjacent to the site and as a result does provide important functions in the support of this system. A Critical Biodiversity Area 2 (CBA 2) is situated to the west of the site and marginally intersects with the western border of the site. This CBA 2 is associated with surrounding natural grassland of Vaal-Vet Sandy Grassland, an Endangered vegetation type though the marginal portion extending into the study area overlaps with the existing mining plant and is therefore not relevant to the development.

As previously stated, the study area is still largely natural (apart from the portion occupied by the mining operations) (Appendix A: Map 1). The study will largely focus on these areas of remaining natural vegetation with the mining plant only discussed in overview. This is also confirmed by the National Biodiversity Assessment (2018) which indicates the site to still consist of natural Central Free State Grassland. The site is however also situated adjacent to the Doring River and the vegetation structure is much better affiliated with Highveld Alluvial Vegetation (Aza 5) which is a riparian vegetation type and dominated by riparian thicket which

is quite prominent on the site. The site is fairly uniform and dominated by a mosaic of fairly dense thicket and open grassland and will be discussed as a whole. A small portion in central portion of the site is clearly transformed and associated with a historical tailings dump but has a limited extent of approximately 5 hectares and is the only prominently transformed area of the site (apart from the existing mining plant). The Doring River is situated adjacent to the site along the eastern, northern and western borders and may in some areas occur in close proximity to it and is therefore also relevant to the development.

From the description of the area it is clear that the site still consists of natural vegetation with only small portions of it having been transformed. The natural vegetation types in the area, Highveld Alluvial Vegetation and Central Free State Grassland are both only listed as being of Least Concern and is therefore not of high conservation value (Appendix A: Map 1). The area is also listed an Ecological Support Area and therefore the area is not essential to meeting conservation targets but forms part of the functioning of the Doring River adjacent to the site (Appendix A: Map 2). The site would therefore have an overall Moderate level of sensitivity (Appendix A: Map 4). However, the Doring River itself is considered a highly sensitive system but which will be discussed in detail in the wetland assessment section of the report (Appendix A: Map 3). It would also be important to accurately determine the 1:100 year floodline of the river and exclude it from development or where development encroaches into the floodline of the river, that the necessary flood protection structures be implemented.

The development will therefore result in the loss of natural vegetation but which is considered to have only a moderate conservation value. The development would therefore still result in significant impacts but which is unlikely to exceed moderate values. The areas surrounding the site does still contain fairly extensive natural portions though mining operations and agricultural transformation does contribute toward a moderate degree of cumulative transformation. The proposed solar development would therefore not result in a high cumulative impact though would certainly contribute toward the overall cumulative transformation of the area.

The remaining natural vegetation on the site is generally fairly uniform and species diversity remain moderate over the entire site. There are however still a few protected plant species and these also retain a significant conservation value (Appendix B). Where the protected geophytic species, *Boophone distichia* and *Eucomis autumnalis* will be affected by the development, permits will have to be obtained and affected plants transplanted to adjacent areas where they will remain unaffected. A few small specimens of the protected Wild Olive Tree (*Olea europaea* susp. *africana*) also occur on the site and permits will also have to be obtained to remove these. Areas of high disturbance also contains several exotic plant species of which a few are also well known invasive and problematic plants such as *Melia azedarach, Tamarix chinensis* and *Cortaderia selloana*. These will also pose a risk of spreading into surrounding natural areas, especially as construction of the solar development will increase disturbance in the area (Appendix B). The proposed development will also have to implement a comprehensive monitoring and eradication programme to ensure that invasive plant species are removed from the area and prevented from re-establishing.

Signs and tracks of mammals are present on the site but notably less when compared to the natural condition. This is most likely a consequence of the proximity of the mining operations and frequent human activities in the area. Being dominated by natural vegetation the site itself will therefore still have capacity for a natural mammal population though the actual mammal population will be smaller and dominated by generalist species. Rare and endangered mammals are often reclusive and avoid areas in close proximity to human activities and are

also dependant on habitat in pristine condition. Such species are therefore considered unlikely to occur in the area though the Doring River may still provide suitable habitat for Cape Clawless Otter (*Aonyx capensis*) though should remain largely unaffected by the development as long as the development footprint is kept outside the 1:100 year floodline of the river.

The most significant impact on mammals anticipated on the site itself is primarily concerned with the loss and fragmentation of available habitat. Transformation of the natural vegetation on the site will result in a decrease in the population size as available habitat decreases. As indicated, the site does still consist of natural vegetation though it is still fairly uniform and with moderate habitat diversity and consequently the mammal population is also not anticipated to be diverse. The impact on the loss of habitat would therefore be significant but is unlikely to exceed high values. In addition, extensive natural areas still remain in the surroundings into which mammals on the site move to without resulting in high habitat pressures.

The surface water features of the study area is dominated by the Doring River which is situated adjacent to the site along its eastern, northern and western borders and may in some areas occur in close proximity to it (Appendix A: Map 1 & 3). Associated with the Doring River is an extensive floodplain which may also extend onto the site (Appendix A: Map 3). This is also dependent on the 1:100 year floodline of this watercourse. Within this floodplain an area of temporary saturation has also been identified which forms part of a floodplain wetland area although observed wetland conditions are only of a temporary nature and this area is therefore not clearly defined. The river itself is a tributary of the Sand River and is therefore a smaller system though still significant. It is regarded as perennial or nearly so, flowing for the most part of the year. The river also drains a large catchment which seems to be largely natural and the river should therefore be in a quite good condition, however, immediate upstream gold mining operations does seem to significantly contribute toward poor water quality which is likely to have a significant affect on it. The assessment will therefore be based on the Doring River and its associated floodplain.

The vegetation survey indicated that obligate wetland vegetation occurs along the banks of the Doring River but does not extend into the floodplain. The floodplain of the river is dominated by alluvial clays which, although they do not contain wetland conditions, are clearly a consequence of alluvial deposition after flooding and which confirms the presence of an extensive floodplain. However, a portion in the north eastern corner of the site contains a grassy floodplain where Facultative Wetland grasses dominate and which therefore indicates a temporary wetland zone. This was also confirmed by soil samples which confirmed temporary soil saturation. The wetland conditions associated with the main channel and banks of the Doring River can be characterised as a channel wetland system while the wetland areas forming within the floodplain in the north east of the site can be categorised as a floodplain wetland (SANBI 2009).

The determination of the condition of the watercourses and wetlands on the site will consist only of the Doring River. The aim is to provide an overall overview of the condition of the Doring River in the study area. Determination of the condition will be based on an overall determination of the Index of Habitat Integrity (IHI) (Appendix D). This will also take into account upstream impacts as well as impacts within the catchment. This is considered to give a good representation of the condition of this river. The IHI will be taken as representative of the Present Ecological State (PES) of the river system at the site.

From the impacts affecting the river it should be clear that the Doring River is still largely natural though being affected by a few large impacts which does result in significant modification. An Index of Habitat Integrity (IHI) was conducted for the river system itself and indicated that it has an Instream IHI of Category B/C: Largely Natural to Moderately Modified and Riparian IHI of Category C: Moderately Modified (Appendix D). This is considered accurate given the still largely natural catchment and unregulated flow while mining will still contribute significant impacts on it. The EI&S of the Doring River has been rated as being Moderate.

A Risk Assessment for the proposed solar facility which will affect the Doring River and associated floodplain 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). Aspects of the development that may have an impact on the surface water features of the site include, construction of the solar facility in close proximity to the Doring River and floodplain and also possibly encroaching into the floodplain of the river.

The Doring River situated adjacent to the solar development is still a largely natural system and therefore regarded to have a high conservation value (Appendix A: Map 3). The proposed development should therefore not contribute any new impacts to it or modify it in any significant way. The river and associated floodplain should therefore be completely excluded from the development and should not encroach into the riparian zone of the river as delineated. Furthermore, the exact border of the floodplain should be determined by a 1:100 year floodline determination. The development should, as far possible, refrain from encroaching into the 1:100 year floodline of the river. The river and associated floodplain should also be regarded as no-go areas and no construction or operational activities including stockpiling, clearing, laydown areas, vehicle movement or any other associated activities should occur in or near this system. As long as this is implemented successfully, the anticipated risk on the Doring River should remain low. Furthermore, although it should not be directly affected, it may however still be indirectly affected by the development, most probably as a result of increased runoff from the panels and an increased sediment load. Erosion is therefore also probable. The development will therefore have to design and implement a comprehensive storm water management system in order to manage runoff and prevent erosion which will affect the river system.

In the event that the development is unable to avoid the floodplain and 1:100 year floodline of the river there is a likelihood that the development may become flooded at some time (Appendix A: Map 3). This may occur only very infrequently but will still result in significant impacts and consequently in this instance the anticipated risk will be moderate. In order to mitigate these impacts flood protection structures will have to be erected such as flood berm around the perimeter of the development.

The impact significance has been determined and should development take place without mitigation it is anticipated that the majority of impacts will be moderate while the impact on the Doring River may be fairly high. Adequate mitigation may however significantly reduce these impacts though several will remain moderate. This is also dependant on the development excluding the 1:100 year floodline of the Doring River.

9. RECOMMENDATIONS

- The Doring River, associated floodplain and any wetland areas has been identified as highly sensitive and should be completely excluded from the development and should not encroach into the riparian zone of the river as delineated (Appendix A: Map 3).

    - The exact border of the floodplain should also be determined by a 1:100 year floodline determination.
    - The river and associated floodplain should also be regarded as no-go areas and no construction or operational activities including stockpiling, clearing, laydown areas, vehicle movement or any other associated activities should occur in or near this system.

- The following recommendations and mitigation measures should be implemented in order to manage any residual impacts on the Doring River (Appendix A: Map 3):
    - The development should design and implement a comprehensive storm water management system in order to manage runoff and prevent erosion which will affect the river system and associated floodplain.
    - The storm water management system should include design of erosion prevention structures such as soakaways, attenuation areas and dissipation structures.
    - All structures and mitigation measures should be maintained throughout the lifetime of the development.
    - Where development encroaches into the riparian zone or 1:100 year floodline of the river, appropriate flood protection structures should be erected.
    - It will be important to implement a monitoring programme so that any changes to the Doring River can be identified quickly before it leads to irreversible changes. This monitoring programme should include, at least during the construction phase, a bi-annual biomonitoring of the affected river which should include Index of Habitat Integrity and water quality sampling. This should be conducted by a suitable qualified wetland specialist.
    - The necessary authorisations should be obtained from the Department of Water and Sanitation (DWS) where any construction occurs within 500 meters from the edge of any of the delineated watercourses or wetlands in the study area.

- The survey has confirmed the presence of a few protected species (Appendix B). These consist of a few geophytic species and a tree species. The following recommendations should be followed for protected species:

    - Where protected Wild Olive Tree (*Olea europaea* susp. *africana*) will be affected by the development, permits should be obtained from the relevant authority to remove them.
    - Where protected geophytic species, *Boophone distichia* and *Eucomis autumnalis* will be affected by development, permits should be obtained and these transplanted to adjacent areas where they will remain unaffected.
    - These species are cryptic and inconspicuous and it is recommended that a walkthrough survey be conducted prior to an area being cleared. This should include identification and marking of all protected plants in such an area and should be performed by an ecologist or botanist.

    - The transplanting of these species should be overseen by an ecologist, botanist or other suitably qualified person.
    - Monitoring of the success of establishment should also be undertaken.

- Construction may affect the mammal population and care should therefore be taken to ensure none of the faunal species on site is harmed. The hunting, capturing or harming in any way of mammals on the site should not be allowed.

- Voids and excavations may also act as pitfall traps to fauna and these should continuously be monitored and any trapped fauna removed and released in adjacent natural areas. This should include mammals, reptiles and amphibians.

- In the event of poisonous snakes or other dangerous animals encountered on the site an experienced and certified snake handler or zoologist must remove these animals from the site and re-locate them to a suitable area.

- Due to the susceptibility of disturbed areas, it is recommended that weed control be judiciously and continually practised. Monitoring of weed establishment should form a prominent part of management of the development area and should be extended into the operational phase.

- Adequate monitoring of weed establishment and their continued eradication must be maintained (Appendix B). Where category 1 and 2 weeds occur, they require removal by the property owner according to the Conservation of Agricultural Resources Act, No. 43 of 1983 and National Environmental Management: Biodiversity Act, No. 10 of 2004.

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

- Construction should be confined to the site footprint and should not encroach into adjacent areas. This is specially relevant to the riparian zone and 1:100 year floodline of the Doring River.

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

- Monitoring of construction including weed establishment and erosion should take place.

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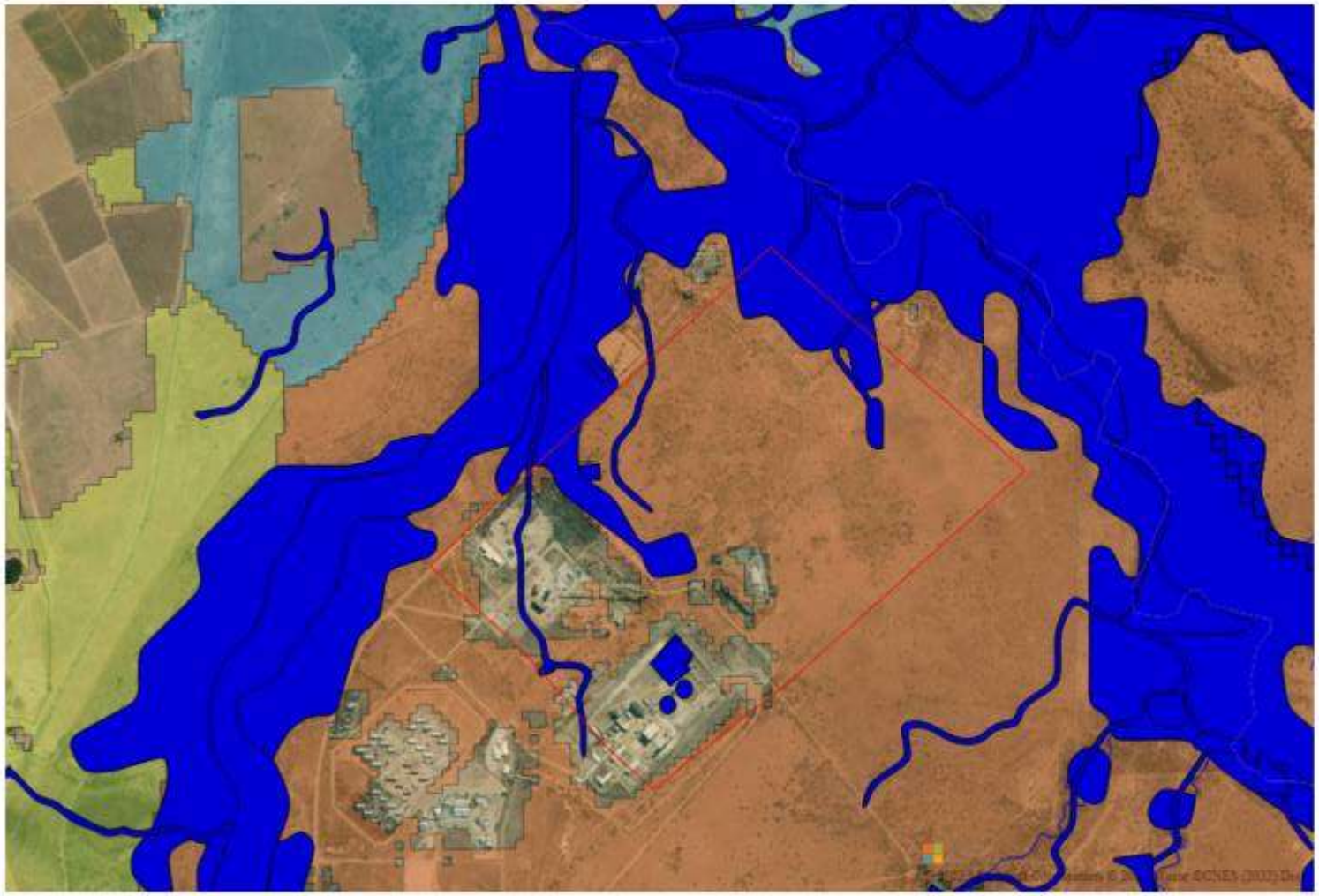
Annexure A: Maps

Locality map for the proposed Harmony Joel PV solar development situated in Theunissen, Free State Province.



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Sunninghill
2157

Legend:

- Study area
- Watercourses
- NFEPA Wetlands
- Vaal-Vet Sandy Grassland
- Highveld Alluvial Vegetation
- Central Free State Grassland

Map Information

Spheroid: WGS 84

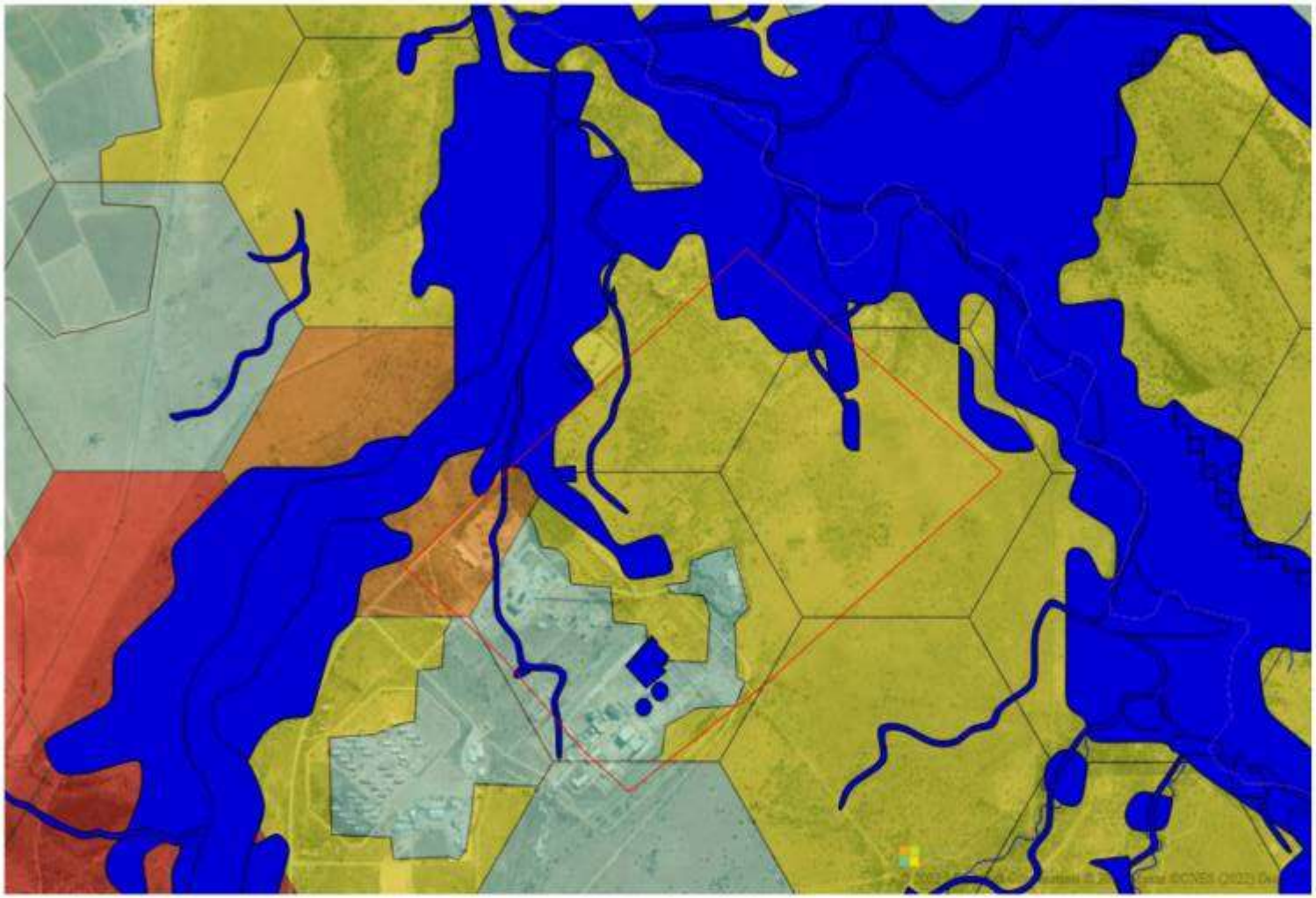
Quantum GIS

Scale: 1:25 000

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

Map 1: Locality map of the proposed Harmony Joel PV solar development near the town of Theunissen. The area still consists largely of natural vegetation with the mining operations resulting in the only prominent areas of transformation. The site itself is indicated as Central Free State Grassland though the survey has indicated a high affinity with Highveld Alluvial Vegetation and the site can be considered as a mosaic of the two vegetation types. Neither of these vegetation types as listed as Threatened Ecosystems. The probability of watercourses and wetlands in the area is also indicated and it is clear that extensive wetland and floodplain areas has been indicated, associated with the Doring River. The onsite survey has however provided more accurate delineation of these areas (Map 3).

Free State Biodiversity Plan map for the proposed Harmony Joel PV solar development situated near Theunissen, Free State Province.



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Legend:

- Study area
- Watercourses
- NFEPA Wetlands
- Critical Biodiversity Area 1
- Critical Biodiversity Area 2
- Ecological Support Area 1
- Ecological Support Area 2
- Degraded
- Other

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:25 000

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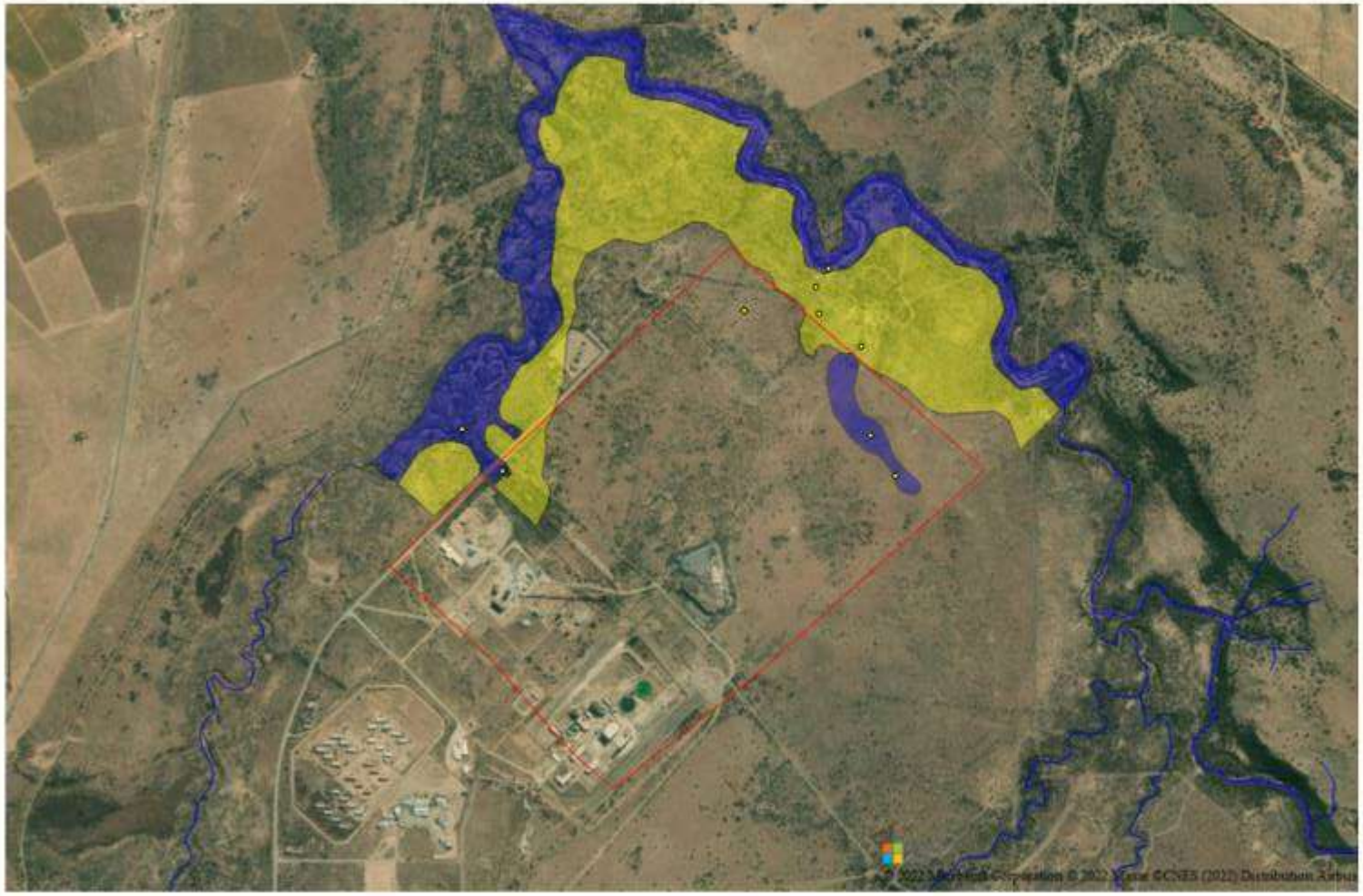
Map 2: Free State Biodiversity Plan map of the proposed Harmony Joel PV solar development near the town of Theunissen. The area is largely being regarded as an Ecological Support Area 1 and 2 which functions in support of the Doring River and protects the integrity of the river. A small portion of Critical Biodiversity Area 2 is visible in the west but which is associated with the adjacent areas of remaining Vaal-Vet Sandy Grassland which is not present on the site and therefore not relevant to the development.

Wetland delineation map for the proposed Harmony Joel PV solar development situated near Theunissen, Free State Province.



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Legend:

- Study area
- Watercourses
- Delineated Wetland Areas
- Riparian Zone
- Wetland sampling points

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:25 000

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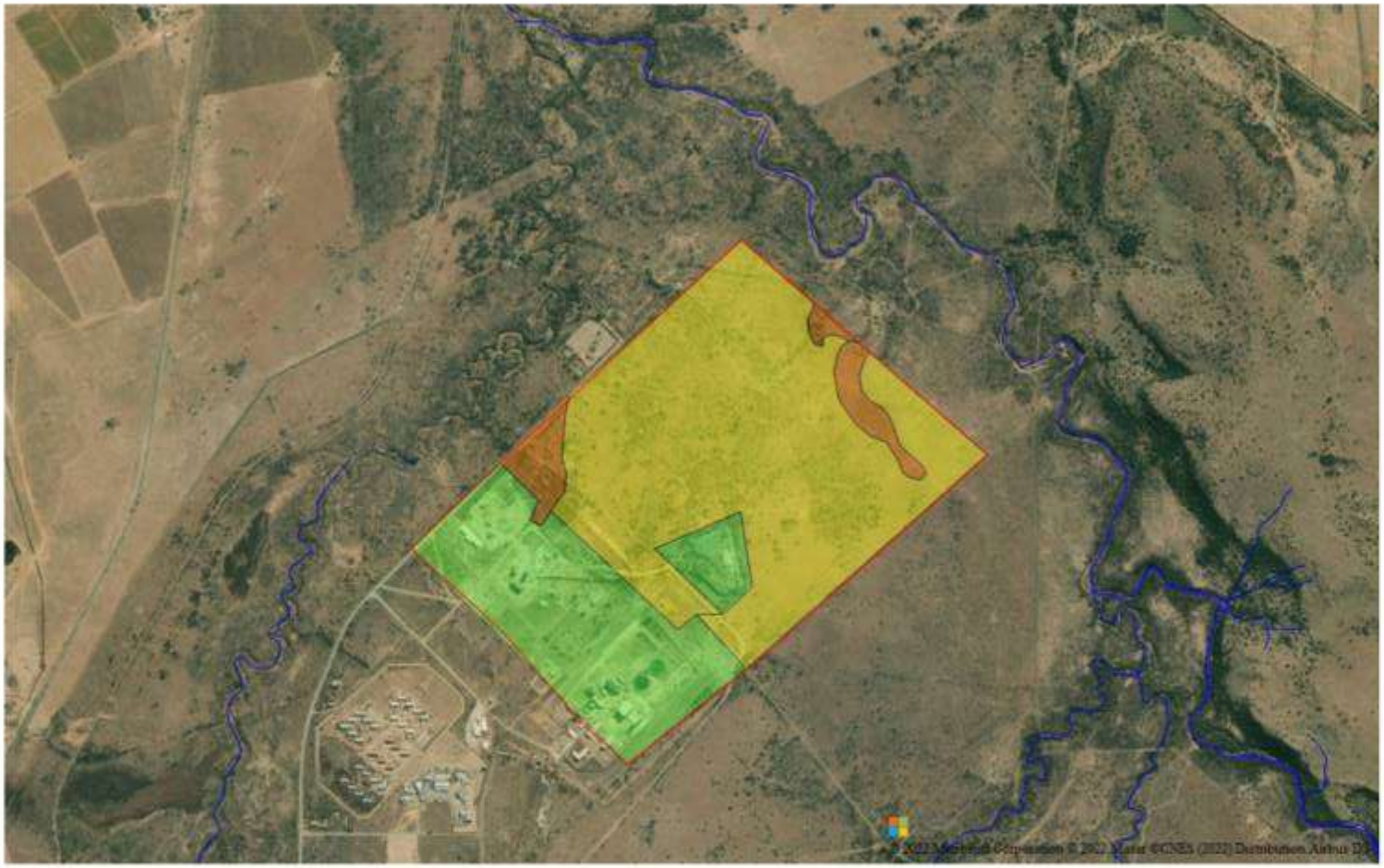
Map 3: Wetland delineation map of the proposed Harmony Joel PV solar development near the town of Theunissen. The Doring River is situated adjacent to the site with the main channel delineated and forming a channel wetland system while a temporary floodplain wetland is also situated in the eastern portion of the site. The river is also associated with an extensive riparian zone which is also indicative of the floodplain of the river. The delineation is however difficult owing to the dominance of alluvial soils and thicket vegetation and may not be accurate. As a result it is also recommended that a 1:100 year floodline determination be undertaken to accurately determine the area which will periodically be affected by flooding.

Sensitivity map for the proposed Harmony Joel PV solar development situated near Theunissen, Free State Province.



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Legend:

- Study area
- Very High Sensitivity
- High Sensitivity
- Moderate Sensitivity
- Low Sensitivity

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:25 000

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Map 4: Sensitivity map of the proposed Harmony Joel PV solar development near the town of Theunissen. Areas regarded as having a High Sensitivity are associated with the floodplain, wetland areas and riparian zone of the Doring River situated adjacent to the site. These areas should be avoided as far as possible by the development. The accuracy of these delineated areas should also be augmented by a 1:100 year floodline determination. The majority of the site still consists of natural vegetation and though it is not listed as a Threatened Ecosystem and does not contain elements of high conservation value it must still be regarded as at least of Moderate Sensitivity. Those areas having been transformed by mining operations (including a tailings dump) is clearly transformed from the natural condition and cannot be regarded as having a significant conservation value and these areas are considered to be of Low Sensitivity.

Appendix B: Species list

Species indicated with an * are exotic.

Protected species are coloured orange and Red Listed species red.

Species	Growth form
**Bidens bipinnata*	Herb
**Conyza bonariensis*	Herb
**Cortaderia selloana*	Grass
**Melia azedarach*	Tree
**Opuntia humifusa*	Succulent
**Tagetes minuta*	Herb
**Tamarix chinensis*	Tree
**Verbena bonariensis*	Herb
**Verbena tenuisecta*	Herb
**Xanthium spinosum*	Herb
Antizoma angustifolia	Herb
Arctotis arctotoides	Herb
Aristida congesta	Grass
Artemisia afra	Shrub
Asparagus larcinus	Shrub
Berkheya radula	Herb
Blepharis subvolubilis	Herb
Boophone distichia	Geophyte
Bulbine abyssinica	Geophyte
Celtis africana	Tree
Chloris virgata	Grass
Chlorophytum sp.	Geophyte
Colchicum burkei	Geophyte
Cymbopogon pospischillii	Grass
Cynodon dactylon	Grass
Cyperus marginatus	Sedge
Delosperma cooperi	Succulent
Digitaria eriantha	Grass
Diospyros lycioides	Shrub
Equisetum ramosissimum var. *ramosissimum*	Fern
Eragrostis chloromelas	Grass
Eragrostis echinochloidea	Grass
Eragrostis gummiflua	Grass
Eriospermum porphyrium	Geophyte
Eucomus autumnalis	Geophyte
Fingerhuthia africana	Grass
Gomphocarpus fruticosus	Herb
Hermannia depressa	Herb
Hyparrhenia hirta	Grass

Imperata cylindrica	Grass
Kalanchoe rotundifolia	Succulent
Melinis nerviglumis	Grass
Microloma armatum	Dwarf shrub
Moraea pallida	Geophyte
Nidorella resedifolia	Herb
Olea europaea subsp. *africana*	Tree
Oxalis depressa	Geophyte
Panicum coloratum	Grass
Pentzia incana	Dwarf shrub
Pergularia daemia	Climber
Salsola rabieana	Dwarf shrub
Salvia verbenaca	Herb
Searsia lancea	Tree
Searsia pyroides	Shrub
Sebaea pentandra	Herb
Setaria verticillata	Grass
Setraria sphacelata	Grass
Solanum incanum	Herb
Themeda triandra	Grass
Typha capensis	Bulrush
Vachellia karroo	Tree
Ziziphus mucronata	Tree

Appendix C: Soil Samples

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 taken at approximately 10 meter intervals. Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils.

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).

Appendix D: Index of Habitat Integrity (IHI)

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

ASSESSMENT UNIT INFORMATION	
ASSESSMENT UNIT INFORMATION	
UPPER LATITUDE	S 28.248495°
UPPER LONGITUDE	E 26.820406°
UPPER ALTITUDE	1340m
LOWER LATITUDE	S 28.243091°
LOWER LONGITUDE	E 26.834375°
LOWER ALTITUDE	1336m
SURVEY SITE (if applicable)	Doring River
SITE LATITUDE (if applicable)	
SITE LONGITUDE (if applicable)	
SITE ALTITUDE (if applicable)	
WMA	Middle Vaal
QUATERNARY	C42K
ECOREGION 2	11_8
DATE	15/06/2022
RIVER	Doring River
TRIBUTARY	Sand River
PERENNIAL (Y/N)	Y
GEOMORPH ZONE	LOWLAND
WIDTH (m)	2-15

METRIC GROUP	RATING	CONFIDENCE
HYDROLOGY MODIFICATION	0.6	1.7
PHYSICO-CHEMICAL MODIFICATION	1.5	1.1
BED MODIFICATION	1.0	4.0
BANK MODIFICATION	1.0	3.0
CONNECTIVITTY MODIFICATION	1.0	4.0
INSTREAM IHI%	79.8	
CATEGORY	B/C	
CONFIDENCE	2.8	

HABITAT INTEGRITY CATEGORY	DESCRIPTION	RATING (% OF TOTAL)
A	Unmodified, natural.	90-100
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.	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
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.	0-19

METRIC GROUP	RATING	CONFIDENCE
HYDROLOGY	0.75	3.00
BANK STRUCTURE MODIFICATION	1.70	4.00
CONNECTIVITY MODIFICATION	1.00	4.00
RIPARIAN HABITAT INTEGRITY (%)	75.45	
CATEGORY	C	
CONFIDENCE	3.67	

HABITAT INTEGRITY CATEGORY	DESCRIPTION	RATING (% OF TOTAL)
A	Unmodified, natural.	90-100
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.	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
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.	0-19

	MRU
INSTREAM IHI	
Base Flows	-1.0
Zero Flows	0.5
Floods	-0.5
HYDROLOGY RATING	**0.6**
pH	2.0
Salts	2.0
Nutrients	1.0
Water Temperature	1.0
Water clarity	1.5
Oxygen	1.5
Toxics	1.5
PC RATING	**1.5**
Sediment	1.0
Benthic Growth	1.0
BED RATING	**1.0**
Marginal	1.0
Non-marginal	1.0
BANK RATING	**1.0**
Longitudinal Connectivity	1.0
Lateral Connectivity	1.0
CONNECTIVITY RATING	**1.0**
INSTREAM IHI %	**79.8**
INSTREAM IHI EC	**B/C**
INSTREAM CONFIDENCE	**2.8**

	MRU
RIPARIAN IHI	
Base Flows	-1.0
Zero Flows	0.5
Moderate Floods	-0.5
Large Floods	-1.0
HYDROLOGY RATING	**0.8**
Substrate Exposure (marginal)	1.0
Substrate Exposure (non-marginal)	2.0
Invasive Alien Vegetation (marginal)	1.0
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	1.5
Non-marginal	2.0
BANK STRUCTURE RATING	**1.7**
Longitudinal Connectivity	1.0
Lateral Connectivity	1.0
CONNECTIVITY RATING	**1.0**
RIPARIAN IHI %	**75.4**
RIPARIAN IHI EC	**C**
RIPARIAN CONFIDENCE	**3.7**

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 Construction Phase but also during operation	Construction of a solar facility.	The Doring River and associated floodplain situated adjacent to the solar footprint may be affected by the proposed development	The construction of the facility may encroach into the floodplain or riparian zone which will directly affect or may also impact on the catchment of the river which will then have an indirect impact on it.	1	2	1	1	1.25	1	1	3.25	2	2	5	3	12	39	L	80	Provided that the solar footprint does not encroach into the 1:100 year floodline or floodplain and these areas are treated as no-go areas, the anticipated risk should remain low. The development may however still have an indirect impact in terms of runoff and erosion and a comprehensive storm water management system should be implemented in order to manage runoff and prevent erosion which will affect the river system.
	Mostly Construction Phase but also during operation	Construction of a solar facility	Where construction encroaches into the floodplain or 1:100 year floodline it will have an increased impact on the Doring River.	Construction below the 1:00 year floodline will make the development susceptible to periodic flooding which will have a significantly higher impact on the river.	2	3	2	1	2	3	2	7	3	3	5	2	13	91	M	80	In order to mitigate the risk of flooding flood protection structures will have to be erected such as flood berm around the perimeter of the development.

Appendix F: Impact methodology

Direct, indirect and cumulative impacts associated with the projects must be assessed in terms of the following criteria:

- The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
- The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high):
- The **duration**, wherein it will be indicated whether:
  - the lifetime of the impact will be of a very short duration (0–1 years) – assigned a score of 1;
  - the lifetime of the impact will be of a short duration (2-5 years) - assigned a score of 2;
  - medium-term (5–15 years) – assigned a score of 3;
  - long term (> 15 years) - assigned a score of 4; or
  - permanent - assigned a score of 5;
- The **magnitude**, quantified on a scale from 0-10, where 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
- The **probability** *of occurrence*, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1–5, where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
- the **significance**, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
- the **status**, which will be described as either positive, negative or neutral.
- the degree to which the impact can be reversed.
- the degree to which the impact may cause irreplaceable loss of resources.
- the *degree* to which the impact can be *mitigated.*

The **significance** is calculated by combining the criteria in the following formula:

S=(E+D+M)P

S = Significance weighting
E = Extent
D = Duration
M = Magnitude
P = Probability

The **significance weightings** for each potential impact are as follows:

- < 30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),

» 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),
» > 60 points: High (i.e. where the impact must have an influence on the decision process to develop in the area).

Assessment of impacts must be summarised in the following table format. The rating values as per the above criteria must also be included. Complete a table and associated ratings for **each** impact identified during the assessment.

<u>Example</u> of Impact table summarising the significance of impacts (with and without mitigation)

Nature: **[Outline and describe fully the impact anticipated as per the assessment undertaken]**			
Impact description: The impact will occur due to added pressure on the availability of housing located in the local community. This may contribute to increased levels of competition in the temporary housing market.			
	Rating	**Motivation**	**Significance**
Prior to Mitigation			
Duration	Short-term (1)	The construction period will last for less than one year	**Low Negative (18)**
Extent	Local (1)	Pressure will only be added on the local municipality to provide housing for outsourced construction workers	
Magnitude	Low (4)	The increase in demand for affordable accommodation should not be extensive as workers will primarily be sourced from the local communities.	
Probability	Probable (3)	The possibility of the impact on the provision of affordable accommodation is very low	
Mitigation/Enhancement Measures			
Mitigation: "Mitigation", means to anticipate and prevent negative impacts and risks, then to minimise them, rehabilitate or repair impacts to the extent feasible. • Provide a description of how these mitigation measures will be undertaken keeping the above definition in mind.			
Post Mitigation/Enhancement Measures			
Duration	Short-term (1)	Pressure will only be added on the local municipality to provide housing for outsourced construction workers.	**Low Positive (8)**
Extent	Local (1)	The increase in demand for affordable accommodation should be mitigated if external construction crews are provided with onsite accommodation.	
Magnitude	Minor (2)	The possibility of the impact on the	

		provision of affordable accommodation is very low.	
Probability	Improbable (2)	A reduced amount of pressure will be added on the local municipality to provide housing for outsourced construction workers.	
Cumulative impacts: "Cumulative Impact", in relation to an activity, means the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity, that in itself may not be significant, but may become significant when added to existing and reasonably foreseeable impacts eventuating from similar or diverse activities.			
Residual Risks: "Residual Risk", means the risk that will remain after all the recommended measures have been undertaken to mitigate the impact associated with the activity (Green Leaves III, 2014).			

Assessment of Cumulative Impacts

As per requirements of the EIA Regulations, specialists are required to assess the cumulative impacts. In this regard, please refer to the methodology below that will need to be used for the assessment of Cumulative Impacts.

"Cumulative Impact", in relation to an activity, means the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity, that in itself may not be significant, but may become significant when added to existing and reasonably foreseeable impacts eventuating from similar or diverse activities[4].

The role of the cumulative assessment is to test if such impacts are relevant to the proposed project in the proposed location (i.e. whether the addition of the proposed project in the area will increase the impact). This section should address whether the construction of the proposed development will result in:

» Unacceptable risk
» Unacceptable loss
» Complete or whole-scale changes to the environment or sense of place
» Unacceptable increase in impact

The specialist is required to conclude if the proposed development will result in any unacceptable loss or impact considering all the projects proposed in the area.

Example of a cumulative impact table:
Nature: Complete or whole-scale changes to the environment or sense of place (example)

Nature: **[Outline and describe fully the impact anticipated as per the assessment undertaken]**		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**

[4] Unless otherwise stated, all definitions are from the 2014 EIA Regulations, as amended, GNR 326

Extent	Low (1)	Low (1)
Duration	Medium-term (3)	Long-term (4)
Magnitude	Minor (2)	Low (4)
Probability	Improbable (2)	Probable (3)
Significance	**Low (12)**	**Low (27)**
Status (positive or negative)	Negative	Negative
Reversibility	High	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes
Confidence in findings: High.		
Mitigation: "Mitigation", means to anticipate and prevent negative impacts and risks, then to minimise them, rehabilitate or repair impacts to the extent feasible. Provide a description of how these mitigation measures will be undertaken keeping the above definition in mind.		