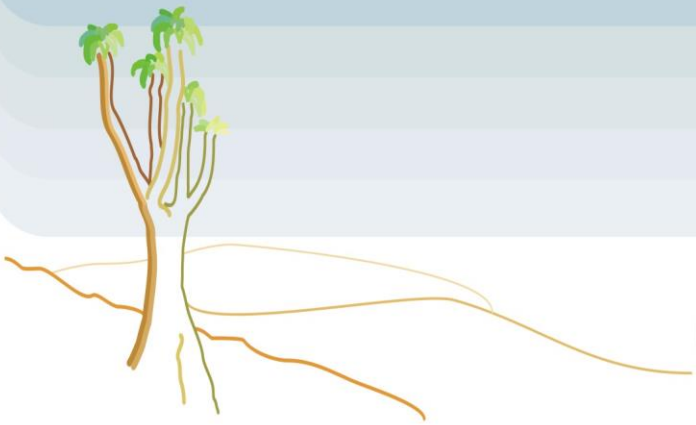
APPENDIX D_2

Ecological Report



DPR
Ecologists & Environmental Services

Report on the ecological and wetland assessment of the proposed construction of a bulk water transfer pipeline from the Cyferfonteindam to the town of Senekal, Free State Province.

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Prepared by:

Darius van Rensburg
Pr.Sci.Nat. 400284/13
T 083 410 0770
darius@dprecologists.co.za
P.O. Box 12726 | 61 Topsy Smith Street
Brandhof | Langenhovenpark
9324 | 9300

Prepared for:
MDA Environmental Consultants
9 Barnes Street
Westdene
9301

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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Title	**Report on the ecological and wetland assessment of the proposed construction of a bulk water transfer pipeline from the Cyferfonteindam to the town of Senekal, Free State Province.**		
Author	**DP van Rensburg (Pr.Sci.Nat)**		**Mar'19**

Executive Summary

The topography along the pipeline route consists of undulating plains sloping toward the Sand River with a prominent sandstone hill in the town. The pipeline roughly follows the Sand River and is situated along the eastern bank (Map 1). The pipeline differs considerably in terms of land use and vegetation cover along the route. The northern portion from the Cyferfonteindam to the Koekemoers Rekwest Small Holdings is primarily situated within an agricultural area. The natural vegetation has largely been transformed by dryland crop cultivation with only small portions of natural vegetation remaining. The central portion of the pipeline route is situated within the urban area of Senekal and here disturbance is high and natural vegetation has mostly been transformed, except for the prominent hill which although degraded still consists largely of natural vegetation. The pipeline section to the south and west of the town is situated in close proximity to the urban area of Matwabeng and here disturbance and transformation of the natural vegetation is also high.

As can be deduced from the vegetation description along the pipeline route the majority of vegetation has been transformed with portions of natural vegetation remaining though also disturbed to some degree. Those portions consisting of remaining natural vegetation adjacent to the road reserve may de degraded to some extent but should still be regarded as having a significant conservation value. The natural grassland is situated within the Eastern Free State Clay Grassland, a Threatened Ecosystem, and therefore of high conservation value (Map 2). In this portion the construction of the pipeline should keep the footprint and clearance of vegetation to a minimum. The sandstone hill situated in the town of Senekal also contains elements of high conservation value. Areas of exposed sandstone represent a unique habitat and contains areas similar to vernal pools. Furthermore, and of higher sensitivity is the steep southern slope which contains a dense tree and shrub cover. The footprint and clearance of vegetation should also be kept to a minimum in these areas. Furthermore, the pipeline should also be installed on top of the soil surface or semi-imbedded much the same as the existing pipeline. In addition to the above, these areas contain several protected species (Appendix C). Where any of the geophytic species will be affected the necessary permits should be obtained to transplant them to adjacent areas.

The pipeline route crosses several watercourses of which the majority are seasonal streams and drainage lines and occurs within close proximity to the Sand River (Map 1 & 2). The only significant watercourse along the pipeline route is the Sand River and although it will not be crossed by the pipeline it will occur within close proximity to it. Furthermore, all the affected watercourses drain into this river and is therefore taken as representative of all the watercourses being crossed.

The Sand River and associated tributaries which will be affected by the pipeline is still natural to a significant extent although moderately modified by large impacts associated with dryland crop cultivation and urban development. An Index of Habitat Integrity (IHI) was conducted and indicated that the watercourses have an Instream and Riparian IHI of Category C: Moderately Modified. A summary of these results are included in Appendix D.

The EI&S of the Sand River and associated tributaries 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 is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.

The Sand River and affected tributaries has been affected by several significant impacts which has caused moderate modification of these systems. The river has been affected by two large off-channel storage dams and associated weirs which would undoubtedly have altered the flow and flooding regime. The extensive agricultural crop cultivation and urban area of Senekal has also contributed significant impacts on water quality, sediment load and geomorphology of the river.

The pipeline will roughly follow the Sand River and although it will not cross the river, will occur in close proximity to it. The pipeline will therefore not have any direct impacts on the river but may affect it indirectly. The installation of the pipeline will require the removal of vegetation, disturbance of the soil surface and excavation of material. This will form a source of sediment which may be washed into the river and increase the sediment load. The storage of stockpiles should therefore occur outside the floodplain of the river and stockpiles protected against erosion. Stockpiles and materials should also be placed in the sequence; watercourse-trench-stockpile. This will ensure that sediment is kept away from the watercourse and the trench acts as barrier. The pipeline may also occur within the floodplain of the river in some areas. It is evident that the floodplain is subjected to significant erosion. As a result the pipeline installation may increase the erosion potential and it is therefore important that adequate mitigation be implemented to prevent any erosion from taking place. Adequate monitoring and remediation of erosion should be implemented.

Where the tributaries require crossing by the pipeline more substantial impacts will result. The installation of the pipeline will result in the disturbance of the bed and banks of the watercourses. This in turn will promote erosion, prevent the banks from stabilising and lead to increased sedimentation of the watercourses. As a result disturbance of the banks should be kept to a minimum and erosion remediated where it occurs. Removal of vegetation should also be kept to a minimum. The disturbance caused by construction will also cause susceptible conditions for further establishment of exotics. It is therefore recommended that weed eradication be initiated at the crossing sites prior to construction and continued until rehabilitation of the pipeline route has been completed. When excavating in watercourses the upper 30 cm, or topsoil, should be removed together with the vegetation and stored as sods on the site. These should then be replaced on top of the installed pipeline. Subsoil should be used as backfilling and not as top dressing. Only removed sods and topsoil should be utilised to rehabilitate the bed and bank surface. The soil surface should also be re-instated to the virgin soil level and not depressed or elevated as this will promote erosion and cause flow barriers. After rehabilitation any excess soil or material should be removed and disposed of at a registered disposal facility. Installation of the pipeline through the watercourses should preferably be undertaken during the winter months (July to September) when baseflow will be at its lowest level.

A Risk Assessment for the proposed pipeline, crossing of watercourses as well as sections of pipeline which will be located in close proximity to the Sand River has been undertaken according to the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). Where tributaries are being crossed by the pipeline by means of the excavation of trenches and removal of riparian vegetation the risk is considered to be moderate whilst the crossing of tributaries by means of pylon construction is considered to be of lower risk as the footprint and disturbance of watercourses will be lower. Where the pipeline will occur within the floodplain or in close proximity to the Sand River the risk is considered as low as long as adequate mitigation is implemented.

Table of contents

Ecological and wetlands assessment

1. Introduction

1.1 Background

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

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

South Africa has a large amount of endemic species and in terms of biological diversity ranks among the top ten 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.

Water is essential and crucial to the survival of all living organisms as well as ecosystem processes. This also applies to the survival of humans as we need daily intake of water. We, as humans, also utilise water for a range of other daily tasks and it is considered an essential component of our daily lives. It is therefore necessary for a community to have easy access to a potable water supply. The provision of water to a community must therefore take priority.

The proposed pipeline will be constructed from the Cyferfonteindam situated approximately 8 km north of Senekal and will connect to the Senekal Dam to the south of the town via several reservoirs on top of a prominent hill in town (Map 1). The completed pipeline will have an approximate length of 15 km. The pipeline will function in the bulk transportation of potable water. The pipeline will be situated within urban, natural and cultivated areas and will cross a few small watercourses and will also be situated in close proximity to the Sand River.

A site visit was conducted on 18 March 2019. The route of the pipeline was surveyed by means of a drive-through and sample plots at watercourses and portions of remaining natural vegetation. The survey was conducted in autumn after ample rain and is considered to give an accurate representation of the vegetation on the site as well as active hydrological processes which ensures accurate identification and delineation.

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 development.

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.

2. Scope and limitations

- To evaluate the present state of the vegetation and ecological functioning of the area proposed for the pipeline development.
- To identify possible negative impacts that could be caused by the proposed construction of a pipeline.
- Identify and assess the watercourses being crossed by the pipeline including associated wetlands and ascertain condition and status therefore and recommend mitigation.
- 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.
- A list of species that may occur in the region (desktop study).

2.3 Watercourses

Aspects of the watercourses that will be assessed include:

- Identification of watercourses including rivers, streams, pans and wetlands.
- Describe condition and status of watercourses 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

Several bulbous and herbaceous species may have finished flowering or has not yet flowered and these may have been overlooked or not identifiable.
Due to time constraints, only limited surveys of watercourses were done and concentrated on more significant watercourses.
Due to the length of the pipeline and numerous watercourses being crossed, assessment of the condition of the watercourses were limited to perennial systems, indicating the overall condition of watercourses in the area.
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.

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, Retief & Meyer 2017, Van Ginkel *et al* 2011, Van Oudtshoorn 2004, Van Wyk & Malan 1998, Van Wyk & Van Wyk 1997, Venter & Joubert 1985).

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

Terrestrial fauna:
Field guides for species identification (Smithers 1986a).

3.2 Survey

The site was assessed by means of transects and sample plots.

Noted species include rare and dominant species.
The broad vegetation types present on 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.

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.

The Sand River, associated wetlands and watercourses were identified and surveyed where they were crossed by the pipeline or occurred in close proximity to it.
These systems were delineated by use of topography (land form and drainage pattern) and riparian vegetation.
The following were used to determine and delineate the rivers, streams, pans and wetlands:

- 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, 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.

The following were used to determine the sensitivity or importance of these identified watercourses:

- Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., Van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L. and Nienaber, S. (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.

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.

A Risk Assessment will be conducted for the crossing of watercourses by the pipeline 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

Several 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 and wetland assessment

4.1 Ecology and description of environment

Refer to the species list in Appendix B.

According to Mucina & Rutherford (2006) the area consists of Eastern Free State Clay Grassland (Gm 3) and Central Free State Grassland (Gh 6). Of these the latter is listed as being of Least Concern (LC) whilst the former is listed as being Vulnerable (VU) and therefore a Threatened Ecosystem according to the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (Map 2). Both are affected by transformation to some extent as a result of crop cultivation, urban areas and dam construction but only the latter to such an extent as to be listed a Threatened Ecosystem. Large portions of the natural vegetation along the pipeline has been transformed by crop cultivation and urban development. The pipeline route falls within an Ecological Support Area 2 category with small areas of Degraded and Other categories under the Free State Province Biodiversity Management Plan (2015) (Map 3). Although these are not Critical Biodiversity Areas they still function in ecological support of natural areas.

The topography along the pipeline route consists of undulating plains sloping toward the Sand River with a prominent sandstone hill in the town. The pipeline roughly follows the Sand River and is situated along the eastern bank (Map 1). The slope along the pipeline route therefore generally slope from east to west and toward the river. This does not take the prominent hill into account where the slope and gradient varies considerably. The entire pipeline route is situated within the catchment of the Sand River although the river itself is not being crossed by the pipeline it is situated in close proximity to it (approximately 30 – 100 m). However, all affected watercourses along the pipeline route drain into it.

The pipeline differs considerably in terms of land use and vegetation cover along the route. The northern portion from the Cyferfonteindam to the Koekemoers Rekwest Small Holdings is primarily situated within an agricultural area. The natural vegetation has largely been transformed by dryland crop cultivation with only small portions of natural vegetation remaining. The central portion of the pipeline route is situated within the urban area of Senekal and here disturbance is high and natural vegetation has mostly been transformed, except for the prominent hill which although degraded still consists largely of natural vegetation. The pipeline section to the south and west of the town is situated in close proximity to the urban area of Matwabeng and here disturbance and transformation of the natural vegetation is also high.

The mean annual rainfall for Senekal is given as 638 mm. Temperatures range from an average of 21.6°C in January to an average of 8.3°C in July.

The underlying geology of the region consists of mudstones and sandstone of the Adelaide Formation (Beaufort Group). Sandstone outcrops, resistant to weathering, form isolated hills and ridges.

The following paragraphs gives a description of the terrestrial vegetation along the pipeline route. Riparian vegetation associated with watercourses and wetlands will be discussed in the following section (Section 4.2).

The terrestrial vegetation around the Ceferfonteindam is dominated by indigenous vegetation although mostly pioneer species and the natural vegetation here has been altered to a significant degree. Dominant grasses include the pioneer species *Aristida congesta* and *Chloris virgata*. Dwarf karroid shrubs, also indicative of a degraded grass layer where they are abundant, include *Felicia muricata* and *Pentzia incana*. The pioneer herb, *Nidorella resedifolia*, is also common. *Bidens bipinnata*, an exotic weed, is also common. The vegetation around the dam is clearly degraded, although mostly indigenous species.

The section (approximately 2 km long) to the south of the dam is situated along the gravel road but outside the road reserve and although it is consequently still degraded, still consists of natural vegetation. This portion is also situated within Eastern Free State Clay Grassland, a Threatened Ecosystem, which is therefore of a high conservation value (Map 2). The portion immediately adjacent to the fenceline is notably degraded most likely due to a variety of impacts and which may include, firebreaks, grading of the vegetation for firebreaks, historical clearing of the vegetation associated with the road building activities and dirt tracks along the border fence. As a result the natural vegetation structure is modified to a significant degree and a dwarf karroid shrub component is dominant. Although dwarf karroid shrubs are natural to the vegetation type in the area they become dominant only where disturbance is high, otherwise a grass layer dominates. Dominant dwarf karroid shrubs include *Chrysocoma ciliata, Selago densiflora, Ruschia hamata* and *Stoebe vulgaris*. Grass species are still abundant but notably lower than dwarf karroid shrubs. These include *Eragrostis lehmanniana, E. curvula, E. obtusa, Aristida congesta, Sporobolus fimbriatus, Themeda triadra* and *Cymbopogon pospischillii*. This is a mixture of climax and pioneer species which indicates natural grassland, but which is evidently degraded to some extent. This is also affirmed by a few exotic weeds including *Verbena tenuisecta* and *Schkuhria pinata*. They are however not abundant. Other abundant herbs include *Hibiscus pusillus, Berkheya macrocephala, Crabbea acaulis* and *Solanum supinum*. A single geophyte was observed, *Hypoxis angustifolia*, but is a widespread and common species not of significant conservation value. However, due to limited surveying it is still likely that protected or Red Listed species may occur in this section. As can be deduced the vegetation immediately adjacent to the fenceline is significantly degraded. Being situated within a Threatened Ecosystem it is however still considered to have a high conservation value and the footprint of the construction of the pipeline in this section should be kept to a minimum.

Associated with the above described section of the pipeline route but located adjacent to the Sandspruit is a small area where sandstone outcrops occur. This often creates a unique habitat and may also often contain species of conservation importance. Grasses adapted to shallow soils dominate and include *Aristida diffusa, Triraphis andropognoides* and *Cymbopogon pospischillii*. Herbs are abundant and include *Haplocarpha scaposa, Berkheya onopordifolia, Dicoma anomala, Scabiosa columbaria, Delosperma cooperi* and *Hermannia depressa*. The dwarf shrub, *Stoebe vulgaris*, is also common. No protected or Red Listed were observed but due to limited surveying it is still likely that such species may occur here. As for the previous section the footprint of the pipeline construction should be kept to a minimum.

The section to the south of the above described remaining natural areas is situated within dryland crop cultivation, small holdings and adjacent to the urban area of Senekal. The majority of natural vegetation has therefore been transformed by these land uses (Map 1 & 2). Significant portions of remaining natural vegetation do still occur but will be discussed separately. Furthermore, small patches of natural grassland are also present but as can be expected heavily degraded and not well representative of the natural vegetation type. These areas are therefore considered to have a low conservation value. Grasses still dominate these

areas and include *Eragrostis gummiflua, E. curvula, Digitaria eriantha, Aristida congesta, Hyparrhenia hirta, Sporobolus fimbriatus* and *Cymbopogon pospischillii*. This species assemblage is indicative of a degraded grass layer. The shrub, *Asparagus larcinus,* is also abundant and also indicates a transformation of the grass layer which should, under natural conditions, be devoid of shrubs and trees. Exotic weeds are common and dominate in certain areas and these include *Sorghum halepense, Tagetes minuta, Bidens bippinata, Verbena tenuisecta, Amaranthus hybridis* and *Datura stramonium*.

As mentioned, portions of natural vegetation also occur within the above section of agricultural fields and transformed portions. The vegetation here is much the same as the previously discussed section adjacent to the road reserve. The vegetation is notably degraded from the natural conditions by a variety of likely impacts which may include firebreaks, grading of the vegetation for firebreaks, historical clearing of the vegetation associated with the road building activities and dirt tracks along the border fence. The vegetation structure and species composition is much the same as the previously discussed section of remaining natural vegetation and will only be discussed in brief here. The grass layer is dominated by *Digitaria eriantha, Chloris virgata, Themeda triandra, Eragrostis curvula* and *Aristida congesta*. This is again a mixture of climax and pioneer species which indicates natural grassland, but which is evidently degraded to some extent. Dwarf karroid shrubs are also prominent and include *Pentzia incana, Felicia muricata* and *Nolletia ciliaris*. The shrub, *Asparagus larcinus*, is also common, especially along the fenceline and is also an indicator of the modification of the vegetation structure. Exotic weeds and invasive succulents are also common and a consequence of the degradation of the vegetation along the fenceline. These include *Verbena tenuisecta, Cyllindropuntia imbricata, Opuntia ficus-indica* and *Conyza bonariensis*. A common occurrence is also windrows and clumps of the exotic tree, *Eucalyptus camaldulensis*. Despite the degraded condition of the vegetation along the fenceline a protected geophyte, *Ammocahris coranica*, also occurs as scattered specimens. It is a widespread species not considered rare but is still listed as a protected species in the Free State Province and therefore of significant conservation value (Appendix C). It does however transplant easily and due to the small footprint of the pipeline it is unlikely that a large portion of the population will be affected. It is recommended that permits be obtained to transplant any specimens which will be affected by the pipeline.

The pipeline section to the south of the above described portion is situated within the urban area of Senekal and adjacent to the urban development of Matwabeng. Consequently the natural vegetation is almost completely transformed in this area and will therefore not be discussed any further. However, within Senekal a prominent sandstone hill is located with several water reservoirs on top (Map 1). The pipeline will also connect to these and will therefore traverse the slopes and plateau of this hill. Being surrounded by urban areas the vegetation and ecology of the hill is significantly degraded but still retains largely natural elements of low disturbance and high conservation value. These areas include the southern, wooded slope, cliff edge and small vernal pools. The plateau of the hill is dominated by a shorter grass layer with exposed sandstone rock sheets. Rock sheets are largely devoid of pools although small areas similar to vernal pools do occur. On these exposed rocky sheets dwarf plants dominate and include dwarf grasses such as *Oropetium capense* and *Microchloa caffra*, dwarf succulents including *Chasmatophyllum musculinum, Ruschia hamata* and *Crassula lanceolata* and the sedge *Cyperus rupestris*. Around these rock sheets taller grasses dominate in shallow soils and include *Eragrostis lehmanniana, E, gummiflua, Aristida congesta, Hyparrhenia hirta* and *Brachiaria eruciformis*. The south facing cliff and slope of the hill is dominated by a dense tree and shrub cover and is considered the most sensitive element of

the hill. Dominant trees and shrubs include *Kiggelaria africana, Celtis africana, Diospyros lycioides, Gymnosporia buxiifolia, Heteromorpha arborescens* and *Searsia burchellii*. Of these *C. africana* (White Stinkwood) is also listed as a protected species and should any specimens require removal the necessary permits will have to be obtained. Herbs and ferns are also abundant in the shady understorey and include *Dicliptera leistneri, Cheilanthes hirta, Cineraria erodioides* and *Pellaea calomelanos*. The large geophyte, *Erythrina zeyheri*, is scattered on the slope and is also listed as a protected species which is not common (Appendix C). Should any specimens be affected by the pipeline permits should be obtained to transplant them to adjacent areas where they will not be affected. The exposed sandstone rock sheets and especially the wooded slope of the hill is considered sensitive habitats and it is recommended that where the pipeline transects these areas it be placed on top of the soil surface or semi-imbedded much the same as the existing pipeline. The construction footprint should be kept to a minimum here and as little as possible vegetation removed.

As can be deduced from the vegetation description along the pipeline route the majority of vegetation has been transformed with portions of natural vegetation remaining though also disturbed to some degree. Those portions consisting of remaining natural vegetation adjacent to the road reserve may de degraded to some extent but should still be regarded as having a significant conservation value. The natural grassland is situated within the Eastern Free State Clay Grassland, a Threatened Ecosystem, and therefore of high conservation value (Map 2). In this portion the construction of the pipeline should keep the footprint and clearance of vegetation to a minimum. The sandstone hill situated in the town of Senekal also contains elements of high conservation value. Areas of exposed sandstone represent a unique habitat and contains areas similar to vernal pools. Furthermore, and of higher sensitivity is the steep southern slope which contains a dense tree and shrub cover. The footprint and clearance of vegetation should also be kept to a minimum in these areas. Furthermore, the pipeline should also be installed on top of the soil surface or semi-imbedded much the same as the existing pipeline. In addition to the above, these areas contain several protected species (Appendix C). Where any of the geophytic species will be affected the necessary permits should be obtained to transplant them to adjacent areas.

4.2 Description of vegetation along watercourses

This section will give a description of the riparian vegetation along the watercourses and wetlands affected by the pipeline.

Where FW or OW is indicated it refers to Facultative or Obligate Wetland species. A facultative wetland species is often associated with wetlands but is also able to occur in non-wetland areas. 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.

The Cyferfonteindam is an artificial and off-channel storage dam and artificial wetland conditions has established along its shore. As a result a fringe of relatively low diversity riparian vegetation has established along its shore and is dominated by obligate wetland species, *Juncus effusus* and *Leptochloa fusca* as well as facultative wetland species, *Setaria sphacelata* and *Panicum coloratum*.

Form the dam the pipeline will be situated in close proximity (varying between 30 to 100 meters) to the Sand River (Map 1 & 2). This will mostly be situated outside the floodplain. The floodplain of the river contains significant erosion and a clearly defined flood bench which are considered natural to a large extent but most probably affected by surrounding land use to some extent. Vegetation in the floodplain consists of a sparse grass layer with a significant dwarf karroid shrub component and scattered trees and shrubs. Grass species include *Digitaria eriantha, Setaria sphacelata, Hyparrhenia thamba, Paspalum dilatatum, Eragrostis lehmanniana* and *Aristida congesta.* This contains a mixture of facultative wetland species and pioneer grasses which is considered indicative of a slightly higher moisture regime as well as disturbance associated with the erosion and sparse vegetation cover. Dwarf karroid shrubs include *Lycium cinerium* and *Salsola rabieana* and is associated with the floodbench where runoff is higher and moisture gradient lower. Scattered trees and shrubs associated with the floodplain and riparian thicket include *Searsia lancea, S. pyroides, Vachellia karroo, Diospyros lycioides* and *Asparagus larcinus*. The succulent herb, *Delosperma cooperi*, is also abundant in the floodplain. Several exotic weeds are also abundant in the floodplain as a result of the disturbance regime and include *Verbena tenuisecta, V. bonariensis, Tagetes minuta* and *Commelina benghalensis*. The banks of the river is dominated by a tree layer with reeds, sedges and other wetland vegetation dominating. Numerous exotic tree species are also present. Exotic trees include *Salix babylonica, S. fragilis, Tamarix chinensis, Populus x canescens* and *Robinia pseudoacacia*. Wetland vegetation along the banks and water's edge include reedbeds, *Phragmites asutralis,* Bulrush, *Typha capensis,* Sedges, *Cyperus marginatus,* hygrophilous grasses, *Leptochloa fusca* and a few semi-aquatic herbs and shrubs such as *Berula erecta* and *Gomphostigma virgatum*. The vegetation associated with the banks of the river are clearly indicative of wetland conditions but do not extend into the floodplain and floodbench. Exotic trees are also abundant in areas and cause significant disturbance of the natural vegetation. The floodplain contains significant erosion and a clear floodbench but is considered largely natural and part of the flood-pulse disturbance regime associated with all rivers.

The portion of pipeline situated along the fenceline bordering the road reserve in the northern section of the pipeline situated in between agricultural cropfields contains a few very indistinct drainage lines and wetland areas. These are all modified to a large degree mostly as a result of the agricultural crop fields, crossing by the gravel road and artificial impoundments. Vegetation along these systems are dominated by terrestrial species indicating their small size and include *Eragrostis curvula, E. lehmanniana* and *Panicum coloratum*. Due to the disturbance in these areas the presence of exotic species are also abundant and include *Verbena tenuisecta, Conyza bonariensis, Eucalyptus camaldulensis* and *Bidens bipinnata*. Obligate wetland species are however also present in some areas and indicate that these areas do contain some wetland conditions and functions as watercourses. These species include *Leptochloa fusca* and *Cyperus esculentus* with riparian species such as *Conyza podocephala* and *Vachellia karroo* also being present. The protected geophyte, *Ammocahris coranica*, also forms

significant colonies in some areas. It is a widespread species not considered rare but is still listed as a protected species in the Free State Province and therefore of significant conservation value (Appendix C). It does however transplant easily and due to the small footprint of the pipeline it is unlikely that a large portion of the population will be affected. It is recommended that permits be obtained to transplant any specimens which will be affected by the pipeline.

The portion of the pipeline situated within the urban area of Senekal and adjacent to Matwabeng crosses a few smaller streams and occurs in close proximity to the Sand River (Map 1 & 2). As can be expected the riparian vegetation here is heavily degraded as a result of the urban area. Smaller watercourses within the urban area is dominated by exotic vegetation such as *Melia azedarach, Bidens bipinnata, Pennisetum clandestinum, Cirsium vulgare, Tagetes minuta* and *Gleditsia triacanthos*. The indigenous shrub, *Asparagus larcinus*, is also abundant. Obligate wetland vegetation is still present and includes *Leptochloa fusca, Cyperus longus* and *Paspalum distichum*. The Sand River itself also contains a heavily degraded floodplain dominated by terrestrial species as well as several exotic weeds. Exotic weeds include *Xanthium spinosum, Datura stramonium, Pennisetum clandestinum, Cirsium vulgare, Pantago lanceolata* and *Sesbania punicea*. A sparse grass layer is also prominent in the floodplain and include *Hyparrhenia hirta, Cynodon dactylon, Digitaria eriantha, Aristida congesta, Sporobolus fimbriatus, Eragrostis lehmanniana, Aristida congesta* and *Themeda triandra*. This is a mixture of pioneer and climax species. Trees and shrubs are scattered and clearly affected by removal for firewood. These include *Asparagus larcinus* and *Diospyros lycioides*. Vegetation along the water's edge and banks of the river is still dominated by obligate wetland vegetation and include *Cyperus longus, C. marginatus, Leptochloa fusca, Berula erecta* and *Gomphostigma virgatum*. The protected geophyte, *Crinum bulbispermum*, is also present as scattered specimens along the riverbank. The species should remain unaffected as long as the pipeline route remains in the floodplain and adjacent terrestrial environment.

From the description of the riparian vegetation above, the following conclusions can be made. The vegetation long the Sand River is degraded to varying degrees. The portion to the south of the Cyferfonteindam, including the Sand River and Sandspruit, is least degraded although numerous exotic trees along the riverbank does lead to significant degradation. The floodplain in this portion contains significant, but natural, erosion with the riparian vegetation largely natural although some exotic weeds are present. The indistinct drainage lines and wetland areas situated in the agricultural cropfields portion is heavily modified and visibly degraded and contains numerous exotic species. The portion of the Sand River adjacent to the urban areas of Senekal and Matwabeng is heavily degraded, much more so than the northern section. The riparian vegetation here still contains a natural vegetation structure and species composition although this has been altered significantly by the removal of trees and shrubs and a much higher proportion of exotic weeds and invaders occur.

4.3 Assessment of watercourses

Watercourses being crossed by the pipeline will be discussed below (Map 1 & 2).

Although several crossings of watercourses take place all of these drain into the Sand River and this system and its tributaries will therefore be discussed as a whole, i.e.:

- The Sand River.
- A few indistinct drainage lines and wetland areas.

- The Sandspruit.
- A few smaller drainage lines.

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

Watercourse means:

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

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

The classification of stream orders from 1 to 3 can be illustrated by means of the Strahler 1952 classification:

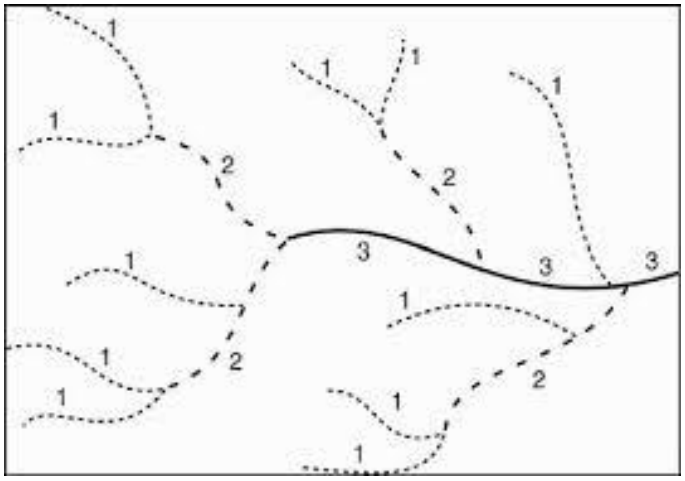


Figure 1: The classification of stream orders from 1 to 3 (Strahler 1952)

The pipeline route crosses several watercourses of which the majority are seasonal streams and drainage lines and occurs within close proximity to the Sand River (Map 1 & 2). The only significant watercourse along the pipeline route is the Sand River and although it will not be crossed by the pipeline it will occur within close proximity to it. Furthermore, all the affected watercourses drain into this river and is therefore taken as representative of all the watercourses being crossed.

Stream systems can be divided into different riparian zones within the lateral section of the system. The Sand River along the pipeline route will be discussed. These zones are as follows:

The marginal zone is the lowest zone and is always present in river systems while the other two zones may not always be present. The zone is situated from the water level at low flow, if present, up to the features that are hydrologically activated for the most of the year (Figure 2).

The marginal zone is still relatively natural though somewhat degraded and especially along the section adjacent to the urban areas.

The lower zone is characterised by seasonal features and extends from the marginal zone up to an area of marked elevation. This area may be accompanied by a change in species distribution patterns. The lower zone consists of geomorphic features that are activated on a seasonal basis (Figure 2). The lower zone of the Sand River contains a relatively steep but short slope and subjected to annual flooding. The zone is much more noticeably degraded along all portions of the pipeline route. Erosion is problematic especially along the urban areas and infestation by exotic trees is prominent in the northern section. The lower zone in the northern section contains a prominent riparian thicket of trees and shrubs which is largely absent in the southern section.

The upper zone is characterised by ephemeral features as well as the presence of both riparian and terrestrial species. The zone extends from the lower zone to the riparian corridor. The upper zone contains geomorphic features that are hydrologically activated on an ephemeral basis (Figure 2). The upper zone of the Sand River levels off but still contains a significant slope. It is flooded very infrequently and is dominated by a shorter grass layer with scattered trees and shrubs. The zone is largely natural in the norther section but noticeably degraded along the southern section adjacent to urban areas.

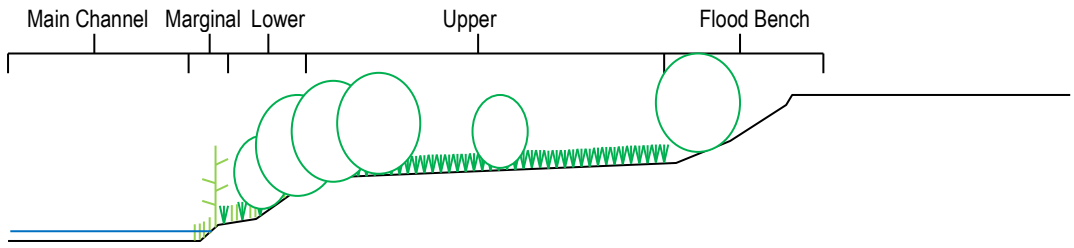


Figure 2: Illustration showing the different riparian zones of the Sand River along the pipeline route. The occurrence of trees and shrubs in the lower zone is most prominent in the northern section and largely absent along the southern section.

Table 2 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 3 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 2: 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 3: Ecological importance and sensitivity categories.

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

The Sand River, associated tributaries and drainage lines were delineated by use of topography (land form and drainage pattern) and riparian vegetation. The following guidelines and frameworks were used to determine and delineate the watercourses:

- 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 determination of the condition of the watercourses along the pipeline route will be based on an overall determination of the Index of Habitat Integrity (IHI). The Sand River, associated tributaries and drainage lines all form part of one system in the study area and located in close proximity to each other, are affected by much the same impacts and also affect the same downstream portions (Map 1 & 2). As a result, one IHI will be conducted to represent the overall condition of the Sand River and its affected tributaries. This is considered to give a good representation of the condition of this system as all affected watercourses and wetlands drain into the Sand River and will affect the same downstream area. The IHI will be taken as representative of the Present Ecological State (PES) of these systems.

According to Kleynans (2000) a desktop assessment of the Sand River and tributaries affected by the pipeline is considered to have a PES of Category C: Moderately Modified. On site observations indicate that this is relatively accurate as this study has also calculated the Sand River as having a PES of Category C: Moderately Modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominately unchanged. The system therefore still provides vital functions including water transportation, storm water, instream and riparian habitat and groundwater recharge. The entire system should therefore still be considered as sensitive and the proposed development should not lead to any further alteration to it.

The Sand River and associated tributaries which will be affected by the pipeline is still natural to a significant extent although moderately modified by large impacts associated with dryland crop cultivation and urban development. An Index of Habitat Integrity (IHI) was conducted and indicated that the watercourses have an Instream and Riparian IHI of Category C: Moderately Modified. A summary of these results are included in Appendix D.

The EI&S of the Sand River and associated tributaries 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 is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.

The pipeline route will roughly follow the Sand River and in a few areas, it will occur in close proximity to it. Several smaller tributaries will also be crossed by the pipeline. All of these areas will be summarised below.

Table 4: Description of the specific points of crossing by the proposed pipeline route as well as areas where the pipeline will be situated in close proximity to the Sand River (Map 1 & 2).

Watercourse name:	**Coordinates of crossing:**	**Order:**
#1 Sand River	S 28.241128°, E 27.657396°- S 28.243721°, E 27.655869°	Sand River - Second Order

Description of watercourse at point of crossing:

A section of the pipeline route (approximately 300 m) to the south of the Cyferfonteindam will be situated in close proximity to the Sand River (approximately 40 m from the main channel and within the floodplain).

The river is still natural to a large extent in this area although affected by several significant impacts. The surrounding crop fields will contribute to several impacts. These clear the natural vegetation and significantly contributes to increased runoff velocity which in turn increases erosion and sedimentation of watercourses. Also associated with this is fertiliser, pesticide and herbicide runoff and its effect on water quality. The Cyferfonteindam and associated weir will also have a high impact on the baseflow of the river as well as the flooding regime. The river along this section also contains numerous exotic trees which dominate in some areas. This decreases species diversity and degrades the available habitat. It is also likely to affect the baseflow as a result of high evapotranspiration. These significant impacts causes at least moderate modification of the river and associated tributaries.

The river and tributaries contain clearly defined main channels and the floodplain contains a clear floodbench which simplifies determination of the border of the floodplain. Significant erosion gullies occur in the floodplain but is considered mostly natural though somewhat exacerbated by surrounding land use. Obligate wetland vegetation is dominant along the main channel but mostly confined to it and absent from the floodplain.

View of the main channel of the Sand River.

View of the floodplain of the Sand River. Note the extensive erosion gullies, considered to be mostly natural.

View of the main channel of the Sand River. Note that riparian trees in this area is dominated by exotic *Populus x canescens*.

Watercourse name:	**Coordinates of crossing:**	**Order:**
#2 Drainage line – Small tributary of Sand River	S 28.251780°, E 27.656937°	First Order

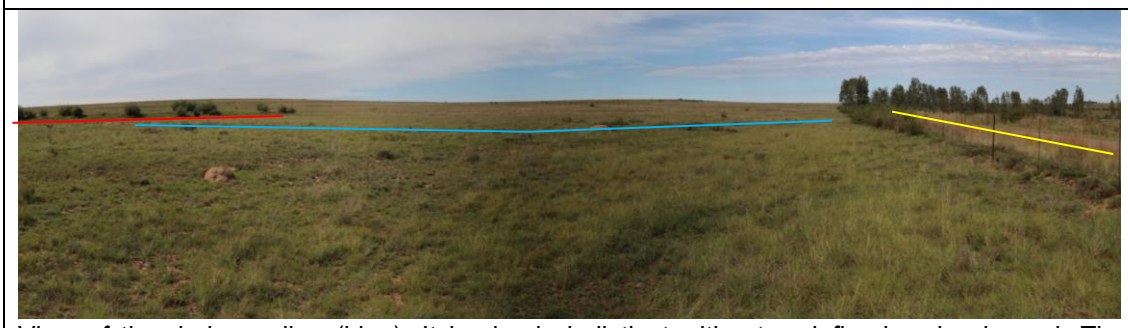
Description of watercourse at point of crossing:

This crossing will occur approximately 1 km to the south of the Cyferfonteindam along the gravel road but outside the road reserve and along the fencline. The crossing consists of a small drainage line which does not have a defined main channel and consequently its borders are ill defined. An artificial impoundment is located immediately upstream which also further modifies its morphology, complicating its delineation.

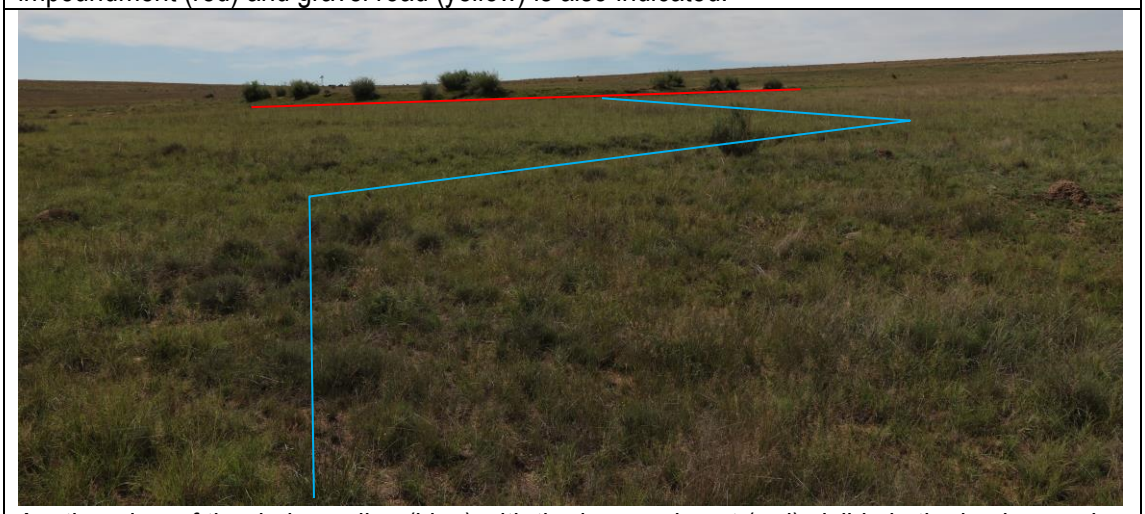
The drainage line is modified to a large degree by a few large impacts. The catchment of the drainage line is situated in the portion of remaining natural grassland and therefore the impacts of erosion, surface runoff and contribution of any fertilisers would be absent. However, an artificial impoundment immediately upstream of the point of crossing causes significant modification of the flow- and flooding regime of the drainage line. The drainage line seeps from the impoundment and this also causes heavy modification of the geomorphology of the drainage line. The crossing of the gravel road also leads to significant modification of the drainage line. This causes retardation of flow and modifies the flow- and flooding regime

further.

The drainage line contains a few obligate wetland species including grasses and sedges and indicates that although it is small, some wetland conditions do occur. The drainage line is devoid of a clearly defined channel although wetland conditions are clearly present and is therefore considered a valley-bottom wetland without a channel.



View of the drainage line (blue). It is clearly indistinct without a defined main channel. The impoundment (red) and gravel road (yellow) is also indicated.



Another view of the drainage line (blue) with the impoundment (red) visible in the background.

Watercourse name:	**Coordinates of crossing:**	**Order:**
#3 Sandspruit – Significant tributary of Sand River	S 28.264831°, E 27.650774°	First Order

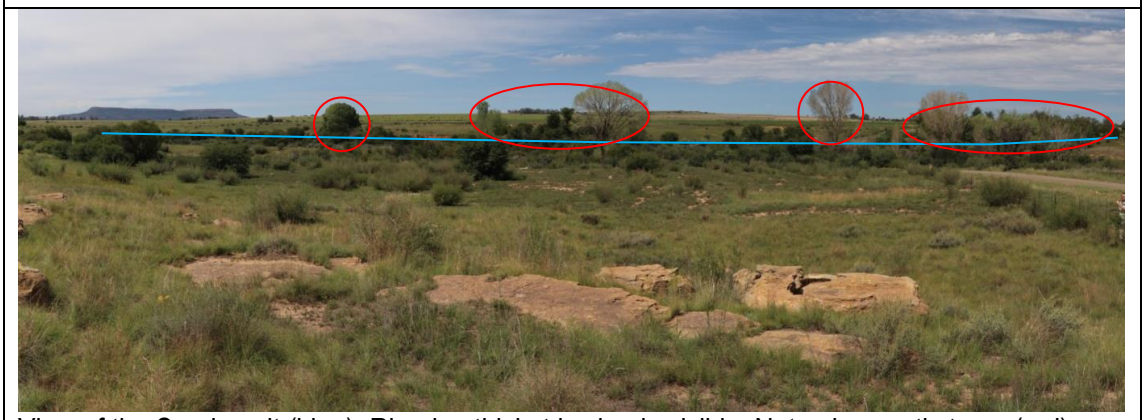
Description of watercourse at point of crossing:

The pipeline will cross the Sandspruit a significant and large tributary of the Sand River approximately 400 meters upstream of its confluence.

The stream is still natural to a large extent and only affected by a few significant impacts. The surrounding crop fields will contribute to several impacts. These clear the natural vegetation and significantly contributes to increased runoff velocity which in turn increases erosion and sedimentation of watercourses. Also associated with this is fertiliser, pesticide and herbicide runoff and its effect on water quality. It is also relatively free of any large artificial impoundments and its flow- and flooding regime would therefore still be largely natural. The stream does contain quite a substantial infestation by several exotic tree species. This decreases species diversity and degrades the available habitat. It is also likely to affect the baseflow as a result of high evapotranspiration. The crossing of the gravel road will also lead to some modification of the stream. This causes retardation of flow, while pylons contribute to

scouring and will modify the flow- and flooding regime to some degree. These impacts do cause some modification of the stream.

The stream has a clearly defined main channel and the floodplain contains a clear floodbench which simplifies determination of the border of the floodplain. Significant erosion was noted in the floodplain but is considered mostly natural though somewhat exacerbated by surrounding land use. Obligate wetland vegetation is dominant along the main channel but mostly confined to it and absent from the floodplain.



View of the Sandspruit (blue). Riparian thicket is clearly visible. Note also exotic trees (red).

The main channel of the Sandspruit clearly indicates that it is a large and significant watercourse. Note the large exotic tree in the background.

View of the gravel road and bridge over the Sandspruit. This will clearly have some impact in terms of flooding and scouring.

Watercourse name:	**Coordinates of crossing:**	**Order:**
#4 Drainage line – Small tributary of Sand River	S 28.285490°, E 27.640992°	First Order

Description of watercourse at point of crossing:

This crossing will occur approximately 2.5 km to the north of the urban edge of Senekal and within the Koekemoers Rekwest Small Holdings. The crossing consists of a very small drainage line but with a clear channel and which is considered heavily modified.

The drainage line is heavily modified and clearly affected by numerous significant impacts. The catchment of the drainage line is situated within agricultural cropfields which affects it heavily in terms of increased runoff velocity which in turn increases erosion and sedimentation of watercourses. Also associated with this is fertiliser, pesticide and herbicide runoff and its effect on water quality. A road crossing and the small holdings also cause flow barriers and alter the flow regime considerably. These also cause some diversion of the flow pattern of this drainage line.

The drainage line is dominated by terrestrial species with a few facultative wetland grasses and indicates that wetland conditions are largely absent. It also indicates the small size of the drainage line. It does contain a clearly defined, though small, main channel.

View of the drainage line (blue). It is clearly heavily degraded. Note row of exotic *Eucalyptus camaldulensis* trees.

Watercourse name:	**Coordinates of crossing:**	**Order:**
#5 Drainage line – Small tributary of Sand River	S 28.297726°, E 27.637011°	First Order

Description of watercourse at point of crossing:

This crossing will occur approximately 1 km to the north of the urban edge of Senekal and within the Koekemoers Rekwest Small Holdings. The crossing consists of a drainage area without a clearly defined channel and situated near the origin of several drainage areas. These all combine where the pipeline crossing will take place.

The drainage line is modified to a large degree by a few large impacts. The catchment of the drainage line is situated in the portion of remaining natural grassland and therefore the impacts of erosion, surface runoff and contribution of any fertilisers would be absent. However, several artificial impoundments immediately upstream of the point of crossing causes significant modification of the flow- and flooding regime of the drainage line. These impoundments also modify the geomorphology of the drainage line. The crossing of the gravel road also leads to significant modification of the drainage line. This causes retardation of flow and modifies the flow- and flooding regime further.

The drainage line contains a few obligate wetland species including grasses and sedges and indicates that although it is small, some wetland conditions do occur. The drainage line is devoid of a clearly defined channel although wetland conditions are clearly present and is therefore considered a valley-bottom wetland without a channel.

View of the drainage line (blue). It is clear that a defined channel is absent.

View of the drainage line (blue). Note a significant colony of the protected geophyte, *Amocharis coranica*.

Watercourse name:	**Coordinates of crossing:**	**Order:**
#6 Seasonal stream - Small tributary of the Sand River	S 28.328599°, E 27.624824°	First Order

Description of watercourse at point of crossing:

This crossing will take place along the southern border of Senekal and near the industrial area of the town. A small stream will be crossed which is highly degraded and heavily modified by amongst others an increased effluent from the industrial area.

The stream is heavily modified and degraded. Vegetation associated with it is heavily degraded and modified and dominated by exotic species. The flow regime is considered as highly modified by the urban development of Matwabeng and small industrial development which increased effluent substantially and this in turn modifies the flow regime and consequently geomorphology of the stream to a large extent.

The stream is clearly defined with a prominent main channel and as a result of increased effluent is anticipated to have an almost perennial flow. Being dominated by exotic vegetation obligate wetland vegetation is largely absent although it is still highly likely that wetland conditions will be present although artificial to a large extent due to the increased baseflow.

View of the seasonal stream which has clearly been degraded.

View of the main channel of the stream which is clearly modified by increased effluent. Note also the crossing by existing pipeline.

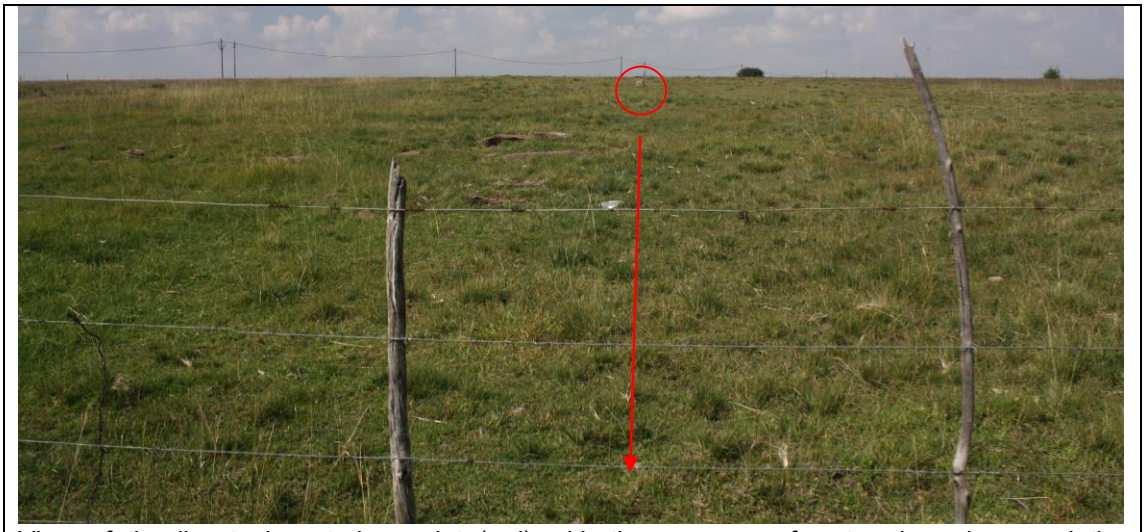
Watercourse name:	**Coordinates of crossing:**	**Order:**
#7 Artificial wetland	S 28.333916°, E 27.622869°	N/A

Description of watercourse at point of crossing:

A wetland area has formed as the result of livestock watering point which is dysfunctional and causing continuous leaking of water. Moisture seeps downslope from east to west and accumulates adjacent to a railway line. The wetland conditions which has formed is clearly of artificial nature.

The wetland area is completely artificial and is in itself a modification and impact on the environment.

The borders of the artificial wetland is not well defined, mostly as a result of its artificial nature. Obligate wetland vegetation has however become established and indicate that artificial wetland conditions has formed.



View of the livestock watering point (red) with the seepage of water downslope and the formation of artificial wetland conditions.

View of the artificial wetland area and accumulation of moisture adjacent to the railway line.

Watercourse name:	**Coordinates of crossing:**	**Order:**
#8 Sand River	S 28.339652°, E 27.621821° -S 28.344653°, E 27.621958°	Second Order

Description of watercourse at point of crossing:

A section of the pipeline route (approximately 700 m) adjacent to the urban area of Matwabeng will be situated in close proximity to the Sand River (approximately 40 m from the main channel and within the floodplain).

As can be expected, the urban area has caused considerable impacts on the river in this area. The urban area will considerably increase effluent in terms of storm water runoff. This will have an influence on the flow regime of the river. Coupled with a poor drainage system and sewer network this will also have a significant impact on water quality. A portion of the floodplain is also being utilised for illegal dumping of soil, rubble and general waste which has a high impact on the river. Overgrazing by domestic stock and trampling has caused a decrease in vegetation cover and this visibly increases erosion. This then also further increases the sediment load in the river. Trampling is also evident on the banks of the river.

The river contains a clearly defined main channel and floodbench although activities such as illegal dumping and erosion complicates the boundary of the floodplain. Significant erosion gullies occur in the floodplain which is considered a natural feature of this river although visibly exacerbated by the current impacts. Exotic vegetation is abundant and dominates in some areas. Obligate wetland vegetation is dominant along the main channel but mostly confined to it and absent from the floodplain.

View of the illegal dumping in the floodplain. The location of the river is indicated (red).

View of the main channel of the river.

Dense algal mats indicate high nutrient levels and poor water quality.

Trampling and refuse is evident along the riverbank (red).

Watercourse name:	**Coordinates of crossing:**	**Order:**
#9 Sand River	S 28.349737°, E 27.619922° -S 28.352771°, E 27.621321°	Second Order

Description of watercourse at point of crossing:

A section of the pipeline route (approximately 400 m) to the south of the urban area of Matwabeng and adjacent to the Senekal Dam will be situated in close proximity to the Sand River (approximately 40 m from the main channel and 15 m from the floodplain).

The section is located upstream from the previous #5 and therefore much less degraded by the urban area. It is however still affected by several large impacts. The Senekal Dam and associated weir will also have a high impact on the baseflow of the river as well as the flooding regime. Overgrazing by domestic stock and trampling has caused a decrease in vegetation cover and this visibly increases erosion. This then also further increases the sediment load in the river. Trampling is also evident on the banks of the river.

The river contains a clearly defined main channel and the floodplain contains a clear floodbench which simplifies determination of the border of the floodplain. Significant erosion gullies occur in the floodplain which is considered a natural feature of this river although visibly exacerbated by overgrazing and trampling. Exotic vegetation is abundant but do not dominate. Obligate wetland vegetation is dominant along the main channel but mostly confined to it and absent from the floodplain.

View of the river (red) with the floodbench clearly visible (blue).

View of the main channel of the river. High levels of trampling is clearly present (red).

Erosion is clearly being exacerbated by overgrazing and trampling.

4.4 Current and anticipated impacts on watercourses

The Sand River and affected tributaries has been affected by several significant impacts which has caused moderate modification of these systems. The river has been affected by two large off-channel storage dams and associated weirs which would undoubtedly have altered the flow and flooding regime. The extensive agricultural crop cultivation and urban area of Senekal has also contributed significant impacts on water quality, sediment load and geomorphology of the river.

The storage dams, Cyferfonteindam and Senekal Dam, abstracts water from the main channel and in so doing decreases the baseflow of the river which alters the flow regime significantly. The weirs associated with these dams also act as flow barriers, and although not as significant as an in-channel storage dam, would also cause retardation of flow and obstruct flooding events and would therefore impact on the flow and flooding regime of the river.

Another flow obstruction, though not nearly to the same extent is the few bridge- and road crossings of the river and its tributaries. These act as flow barriers retarding flow and in so doing altering the flow and flooding regime. They also contribute pollutants in the form of runoff from the road surface.

The area is subjected to extensive dryland crop cultivation, especially along the northern section of the pipeline route, and this would undoubtedly also contribute significant impacts on the river (Map 1). These fields clear the natural vegetation and significantly contributes to increased runoff velocity which in turn increases erosion and sedimentation of watercourses. Also associated with this is fertiliser, pesticide and herbicide runoff and its effect on water quality.

The northern section of the pipeline route also contains numerous exotic trees which dominate in some areas. This decreases species diversity and degrades the available habitat. It is also likely to affect the baseflow as a result of high evapotranspiration.

The urban developments of Senekal and Matwabeng has numerous significant impacts on the river (Map 1). The urban environment leads to a decrease in vegetation cover, an increase in paved surfaces and generation of storm water and effluent. Consequently this alters the flow regime of the river to a significant extent. This effluent is also of poor quality and in turn leads to poor water quality in the river, increased nutrient levels and consequently dense algal mats and a modified aquatic community. Rubbish dumping is also problematic and especially a portion of the river (Table 4: #5) where extensive soil, rubble and refuse dumping takes place in the floodplain causes significant impacts on the river.

Also associated with the urban area of Matwabeng is high utilisation as communal grazing. The river and surrounding catchment is subjected to high levels of overgrazing. This significantly decreases vegetation cover which in turn increases runoff velocity and erosion which increases the sediment load within the Sand River. Trampling will also disturb the soil surface and further increase sediment load in the river. In addition, manure will increase the nutrient load within the river.

The proposed pipeline will result in several significant impacts on the Sand River and its affected tributaries. The material being transported by the pipeline being potable water, will

have a negligible impact should leaks or spillages occur into watercourses. This is therefore not considered a likely impact.

The pipeline will roughly follow the Sand River and although it will not cross the river, will occur in close proximity to it. The pipeline will therefore not have any direct impacts on the river but may affect it indirectly. The installation of the pipeline will require the removal of vegetation, disturbance of the soil surface and excavation of material. This will form a source of sediment which may be washed into the river and increase the sediment load. The storage of stockpiles should therefore occur outside the floodplain of the river and stockpiles protected against erosion. Stockpiles and materials should also be placed in the sequence; watercourse-trench-stockpile. This will ensure that sediment is kept away from the watercourse and the trench acts as barrier. The pipeline may also occur within the floodplain of the river in some areas. It is evident that the floodplain is subjected to significant erosion. As a result the pipeline installation may increase the erosion potential and it is therefore important that adequate mitigation be implemented to prevent any erosion from taking place. Adequate monitoring and remediation of erosion should be implemented.

Where the tributaries require crossing by the pipeline more substantial impacts will result. The installation of the pipeline will result in the disturbance of the bed and banks of the watercourses. This in turn will promote erosion, prevent the banks from stabilising and lead to increased sedimentation of the watercourses. As a result disturbance of the banks should be kept to a minimum and erosion remediated where it occurs. Removal of vegetation should also be kept to a minimum. The disturbance caused by construction will also cause susceptible conditions for further establishment of exotics. It is therefore recommended that weed eradication be initiated at the crossing sites prior to construction and continued until rehabilitation of the pipeline route has been completed. When excavating in watercourses the upper 30 cm, or topsoil, should be removed together with the vegetation and stored as sods on the site. These should then be replaced on top of the installed pipeline. Subsoil should be used as backfilling and not as top dressing. Only removed sods and topsoil should be utilised to rehabilitate the bed and bank surface. The soil surface should also be re-instated to the virgin soil level and not depressed or elevated as this will promote erosion and cause flow barriers. After rehabilitation any excess soil or material should be removed and disposed of at a registered disposal facility. Installation of the pipeline through the watercourses should preferably be undertaken during the winter months (July to September) when baseflow will be at its lowest level.

4.5 Risk assessment

A Risk Assessment for the proposed pipeline, crossing of watercourses as well as sections of pipeline which will be located in close proximity to the Sand River has been undertaken according to the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use. Where tributaries are being crossed by the pipeline by means of the excavation of trenches and removal of riparian vegetation the risk is considered to be moderate whilst the crossing of tributaries by means of pylon construction is considered to be of lower risk as the footprint and disturbance of watercourses will be lower. Where the pipeline will occur within the floodplain or in close proximity to the Sand River the risk is considered as low as long as adequate mitigation is implemented.

Moderate Risks: Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Licence required.

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

For the complete risk assessment please refer to Appendix E.

No.	Phases	Activity	Aspect	Impact	Risk Rating	Confidence level	Control measures
1	All Phases	Installation of bulk water transport pipeline through watercourses.	Excavation and backfilling of trenches	Excavation of trenches will impede flow while trenches are open. Disturbance of the bed and banks will promote sedimentation.	**M**	**4**	Control measures which can be utilised to decrease the risk include the following. Installation of pipelines during winter months when seasonal systems will not contain a baseflow and flow regime alteration will be minimal. Correct backfilling and using the removal of sods as rehabilitation.
			Removal of riparian vegetation	Removal of riparian vegetation will promote erosion and sedimentation of watercourses. Disturbance and removal of vegetation will create conditions susceptible to the establishment of exotic weeds.	**M**	4	Adequate rehabilitation and replacement of sods to decrease rehabilitation period. Adequate weed control to prevent establishment of weeds and promote establishment of indigenous riparian vegetation.
			Construction of pipeline pylons	Construction of pylons will cause limited disturbance of the bed and banks which will also promote erosion and sedimentation but will be less than the excavation of trenches. Removal of vegetation will be more limited than trench excavation. Pylons will form a obstruction to flow which will be low as long as pylon footprints are small.	**L**	4	Pylons will have a smaller footprint and require less disturbance of vegetation and the soil profile and will therefore entail a lower risk.
2	All Phases	Installation of bulk water transport pipeline in close proximity to the Sand River.	Removal of vegetation, excavation and backfilling of trenches.	The installation of the pipeline will require the removal of vegetation, disturbance of the soil surface and excavation of material. This will form a source of sediment which may be washed into the river and increase the sediment load.	**L**	4	It is unlikely that this will result in significant impacts. however, the storage of stockpiles should occur outside the floodplain of the river and protected against erosion. Stockpiles and materials should also be placed in the sequence; watercourse-trench-stockpile. This will ensure that sediment is kept away from the watercourse and the trench acts as barrier. Adequate erosion measures, monitoring and remediation of erosion should be implemented.

4.6 Overview of terrestrial mammals (actual & possible)

The southern portion of the pipeline route which is situated within and in close proximity to the urban areas of Senekal and Matwabeng will not contain a viable mammal population due to the transformation of habitat and human activities. The northern section of the pipeline route will contain natural areas although large portions has also been transformed by dryland crop cultivation which will also alter the mammal population to a significant degree. Furthermore, the layout of a large portion of the pipeline adjacent to the gravel road will further decrease the mammal population size likely to be affected. The Sand River which is situated in close proximity to portions of the pipeline route will however sustain a significant and varied mammal population.

It is not anticipated that the pipeline development will have a high impact on the mammal population as a result of the largely altered mammal population along the majority of the pipeline route as well as the relatively small footprint of the pipeline.

The only factor that would have a high impact on the mammal population would be the hunting, capturing and trapping of mammal. This must be strictly prohibited.

In addition, open trenches may act as pitfall traps to mammals, reptiles and amphibians and trenches should be daily monitored for trapped animals which should be removed promptly.

List of some Red Data terrestrial mammals that could occur in the region:

South African Hedgehog	*Atelerix frontalis*
Aardwolf	*Proteles cristatus*
African Wild Cat	*Felis lybica*
Small-Spotted Cat	*Felis nigripes*
Bat-Eared Fox	*Otocyon megalotis*
Striped Weasel	*Poecilogale albinucha*

5. Ecological description of affected area

Habitat diversity and species richness:
Habitat diversity is relatively high and represented by a varied topography including undulating plains, a prominent sandstone hill as well as the Sand River, floodplain and associated tributaries. As a result of the variety of habitat the species diversity is also considered relatively high.

Presence of rare and endangered species:
Several protected species were observed along the pipeline route (Appendix C). No endangered or Red Listed species were observed but it is still possible that such species may be present. The presence of protected, rare and endangered species is therefore considered as moderate.

Ecological function:
The ecological functioning of the Sand River and its affected tributaries has been moderately modified though still intact and provide ecological services in terms of water transportation, storm water, instream and riparian habitat and groundwater recharge. The majority of natural vegetation along the pipeline route has been transformed by dryland crop cultivation and urban development and together with this the ecological function has also been altered to a large degree. Portions of remaining natural still sustain the threatened Eastern Free State Clay Grassland and these areas therefore still have an important ecological function (Map 2).

Degree of rarity/conservation value:
According to Mucina & Rutherford (2006) the area consists of Eastern Free State Clay Grassland (Gm 3) and Central Free State Grassland (Gh 6). Of these the latter is listed as being of Least Concern (LC) whilst the former is listed as being Vulnerable (VU) and therefore a Threatened Ecosystem according to the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (Map 2). Both are affected by transformation to some extent as a result of crop cultivation, urban areas and dam construction but only the latter to such an extent as to be listed a Threatened Ecosystem. Large portions of the natural vegetation along the pipeline has been transformed by crop cultivation and urban development. The pipeline route falls within an Ecological Support Area 2 category with small areas of Degraded and Other categories under the Free State Province Biodiversity Management Plan (2015) (Map 3). Although these are not Critical Biodiversity Areas they still function in ecological support of natural areas. The conservation value of the small portions of remaining natural vegetation can therefore be considered to be high.

The Sand River and affected tributaries remain highly sensitive in spite of their moderately modified character and therefore has a high conservation value.

Percentage ground cover:
The overall percentage ground cover is considered to be relatively low. Removal of vegetation for dryland crop cultivation as well as urban expansion has transformed a large portion of the pipeline route.

Vegetation structure:
The vegetation structure of those portions of remaining natural vegetation is still largely natural although exotic trees do modify this where they dominate. Portions of urban development and crop cultivation has however transformed the vegetation structure where this has taken place.

Infestation with exotic weeds and invader plants:
Exotic weeds and invaders are common along the pipeline route and dominate in several areas where disturbance has been highest (Appendix B).

Degree of grazing/browsing impact:
Overgrazing and browsing is high, especially along the communal grazing areas in the southern section of the pipeline route. The remainder of the pipeline route is subjected to moderate levels of overgrazing. Trampling is also evident, especially in the southern section of the pipeline route.

Signs of erosion:
Erosion gullies are common and extensive in many areas along the Sand River. This is considered a largely natural component of this river system but has however been exacerbated by increased runoff from cultivated area and overgrazing and especially in the southern section of the pipeline route erosion has been significantly increased.

Terrestrial animals:
The southern portion of the pipeline route which is situated within and in close proximity to the urban areas of Senekal and Matwabeng will not contain a viable mammal population due to the transformation of habitat and human activities. The northern section of the pipeline route will contain natural areas although large portions has also been transformed by dryland crop cultivation which will also alter the mammal population to a significant degree. Furthermore, the layout of a large portion of the pipeline adjacent to the gravel road will further decrease the mammal population size likely to be affected. The Sand River which is situated in close proximity to portions of the pipeline route will however sustain a significant and varied mammal population.

Table 5: Biodiversity Sensitivity Rating for the proposed pipeline.

	Low (3)	Medium (2)	High (1)
Vegetation characteristics			
Habitat diversity & Species richness			1
Presence of rare and endangered species		2	
Ecological function		2	
Uniqueness/conservation value			1
Vegetation condition			
Percentage ground cover	3		
Vegetation structure		2	
Infestation with exotic weeds and invader plants or encroachers	3		
Degree of grazing/browsing impact	3		
Signs of erosion	3		
Terrestrial animal characteristics			
Presence of rare and endangered species		2	
Sub total	12	8	2
Total		22	

6. Biodiversity sensitivity rating (BSR)

Table 6: Interpretation of Biodiversity Sensitivity Rating.

Site	Score	Site Preference Rating	Value
Senekal pipeline	22	Degraded	3

7. Discussion and conclusions

According to Mucina & Rutherford (2006) the area consists of Eastern Free State Clay Grassland (Gm 3) and Central Free State Grassland (Gh 6). Of these the latter is listed as being of Least Concern (LC) whilst the former is listed as being Vulnerable (VU) and therefore a Threatened Ecosystem according to the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (Map 2). Both are affected by transformation to some extent as a result of crop cultivation, urban areas and dam construction but only the latter to such an extent as to be listed a Threatened Ecosystem. Large portions of the natural vegetation along the pipeline has been transformed by crop cultivation and urban development. The pipeline route falls within an Ecological Support Area 2 category with small areas of Degraded and Other categories under the Free State Province Biodiversity Management Plan (2015) (Map 3). Although these are not Critical Biodiversity Areas they still function in ecological support of natural areas. The conservation value of the small portions of remaining natural vegetation can therefore be considered to be high.

The topography along the pipeline route consists of undulating plains sloping toward the Sand River with a prominent sandstone hill in the town. The pipeline roughly follows the Sand River and is situated along the eastern bank (Map 1). The pipeline differs considerably in terms of land use and vegetation cover along the route. The northern portion from the Cyferfonteindam to the Koekemoers Rekwest Small Holdings is primarily situated within an agricultural area. The natural vegetation has largely been transformed by dryland crop cultivation with only small portions of natural vegetation remaining. The central portion of the pipeline route is situated within the urban area of Senekal and here disturbance is high and natural vegetation has mostly been transformed, except for the prominent hill which although degraded still consists largely of natural vegetation. The pipeline section to the south and west of the town is situated in close proximity to the urban area of Matwabeng and here disturbance and transformation of the natural vegetation is also high.

As can be deduced from the vegetation description along the pipeline route the majority of vegetation has been transformed with portions of natural vegetation remaining though also disturbed to some degree. Those portions consisting of remaining natural vegetation adjacent to the road reserve may de degraded to some extent but should still be regarded as having a significant conservation value. The natural grassland is situated within the Eastern Free State Clay Grassland, a Threatened Ecosystem, and therefore of high conservation value (Map 2). In this portion the construction of the pipeline should keep the footprint and clearance of vegetation to a minimum. The sandstone hill situated in the town of Senekal also contains elements of high conservation value. Areas of exposed sandstone represent a unique habitat and contains areas similar to vernal pools. Furthermore, and of higher sensitivity is the steep southern slope which contains a dense tree and shrub cover. The footprint and clearance of vegetation should also be kept to a minimum in these areas. Furthermore, the pipeline should also be installed on top of the soil surface or semi-imbedded much the same as the existing pipeline. In addition to the above, these areas contain several protected species (Appendix C).

Where any of the geophytic species will be affected the necessary permits should be obtained to transplant them to adjacent areas.

The pipeline route crosses several watercourses of which the majority are seasonal streams and drainage lines and occurs within close proximity to the Sand River (Map 1 & 2). The only significant watercourse along the pipeline route is the Sand River and although it will not be crossed by the pipeline it will occur within close proximity to it. Furthermore, all the affected watercourses drain into this river and is therefore taken as representative of all the watercourses being crossed.

The determination of the condition of the watercourses along the pipeline route will be based on an overall determination of the Index of Habitat Integrity (IHI). The Sand River, associated tributaries and drainage lines all form part of one system in the study area and located in close proximity to each other, are affected by much the same impacts and also affect the same downstream portions (Map 1 & 2). As a result, one IHI will be conducted to represent the overall condition of the Sand River and its affected tributaries. This is considered to give a good representation of the condition of this system as all affected watercourses and wetlands drain into the Sand River and will affect the same downstream area. The IHI will be taken as representative of the Present Ecological State (PES) of these systems.

According to Kleynans (2000) a desktop assessment of the Sand River and tributaries affected by the pipeline is considered to have a PES of Category C: Moderately Modified. On site observations indicate that this is relatively accurate as this study has also calculated the Sand River as having a PES of Category C: Moderately Modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominately unchanged. The system therefore still provides vital functions including water transportation, storm water, instream and riparian habitat and groundwater recharge. The entire system should therefore still be considered as sensitive and the proposed development should not lead to any further alteration to it.

The Sand River and associated tributaries which will be affected by the pipeline is still natural to a significant extent although moderately modified by large impacts associated with dryland crop cultivation and urban development. An Index of Habitat Integrity (IHI) was conducted and indicated that the watercourses have an Instream and Riparian IHI of Category C: Moderately Modified. A summary of these results are included in Appendix D.

The EI&S of the Sand River and associated tributaries 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 is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.

Table 7: Summary of watercourses and the position of the pipeline crossing (Map 1 & 2).

Watercourse	Position of crossing
#1 Sand River	S 28.241128°, E 27.657396°- S 28.243721°, E 27.655869°
#2 Drainage line – Small tributary of Sand River	S 28.251780°, E 27.656937°
#3 Sandspruit – Significant tributary of Sand River	S 28.264831°, E 27.650774°
#4 Drainage line – Small tributary of Sand River	S 28.285490°, E 27.640992°
#5 Drainage line – Small tributary of Sand River	S 28.297726°, E 27.637011°
#6 Seasonal stream - Small tributary of the Sand River	S 28.328599°, E 27.624824°
#7 Artificial wetland	S 28.333916°, E 27.622869°
#8 Sand River	S 28.339652°, E 27.621821° - S 28.344653°, E 27.621958°
#9 Sand River	S 28.349737°, E 27.619922° - S 28.352771°, E 27.621321°

The Sand River and affected tributaries has been affected by several significant impacts which has caused moderate modification of these systems. The river has been affected by two large off-channel storage dams and associated weirs which would undoubtedly have altered the flow and flooding regime. The extensive agricultural crop cultivation and urban area of Senekal has also contributed significant impacts on water quality, sediment load and geomorphology of the river.

The proposed pipeline will result in several significant impacts on the Sand River and its affected tributaries. The material being transported by the pipeline being potable water, will have a negligible impact should leaks or spillages occur into watercourses. This is therefore not considered a likely impact.

The pipeline will roughly follow the Sand River and although it will not cross the river, will occur in close proximity to it. The pipeline will therefore not have any direct impacts on the river but may affect it indirectly. The installation of the pipeline will require the removal of vegetation, disturbance of the soil surface and excavation of material. This will form a source of sediment which may be washed into the river and increase the sediment load. The storage of stockpiles should therefore occur outside the floodplain of the river and stockpiles protected against erosion. Stockpiles and materials should also be placed in the sequence; watercourse-trench-stockpile. This will ensure that sediment is kept away from the watercourse and the trench acts as barrier. The pipeline may also occur within the floodplain of the river in some areas. It is evident that the floodplain is subjected to significant erosion. As a result the pipeline installation may increase the erosion potential and it is therefore important that adequate mitigation be implemented to prevent any erosion from taking place. Adequate monitoring and remediation of erosion should be implemented.

Where the tributaries require crossing by the pipeline more substantial impacts will result. The installation of the pipeline will result in the disturbance of the bed and banks of the watercourses. This in turn will promote erosion, prevent the banks from stabilising and lead to increased sedimentation of the watercourses. As a result disturbance of the banks should be

kept to a minimum and erosion remediated where it occurs. Removal of vegetation should also be kept to a minimum. The disturbance caused by construction will also cause susceptible conditions for further establishment of exotics. It is therefore recommended that weed eradication be initiated at the crossing sites prior to construction and continued until rehabilitation of the pipeline route has been completed. When excavating in watercourses the upper 30 cm, or topsoil, should be removed together with the vegetation and stored as sods on the site. These should then be replaced on top of the installed pipeline. Subsoil should be used as backfilling and not as top dressing. Only removed sods and topsoil should be utilised to rehabilitate the bed and bank surface. The soil surface should also be re-instated to the virgin soil level and not depressed or elevated as this will promote erosion and cause flow barriers. After rehabilitation any excess soil or material should be removed and disposed of at a registered disposal facility. Installation of the pipeline through the watercourses should preferably be undertaken during the winter months (July to September) when baseflow will be at its lowest level.

A Risk Assessment for the proposed pipeline, crossing of watercourses as well as sections of pipeline which will be located in close proximity to the Sand River has been undertaken according to the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). Where tributaries are being crossed by the pipeline by means of the excavation of trenches and removal of riparian vegetation the risk is considered to be moderate whilst the crossing of tributaries by means of pylon construction is considered to be of lower risk as the footprint and disturbance of watercourses will be lower. Where the pipeline will occur within the floodplain or in close proximity to the Sand River the risk is considered as low as long as adequate mitigation is implemented.

8. Recommendations

- After construction of the pipeline the area must be rehabilitated. This includes removal of all construction material. Excavated rock may not be left in heaps and must be removed or distributed evenly over the terrain to represent a natural environment. Compacted areas must be ripped. Construction roads not being utilised afterwards must be rehabilitated.

- Problematic weeds must be eradicated where these establish on the constructed pipeline route (Appendix B). The watercourse crossings especially should be monitored for establishment of weeds.

- The route must be inspected for erosion due to construction. This is particularly relevant where watercourses or slopes are involved. Where erosion is evident this must be remedied.

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

- Portions consisting of remaining natural vegetation adjacent to the road reserve is situated within the Eastern Free State Clay Grassland, a Threatened Ecosystem, and therefore of high conservation value (Map 2). In these areas the construction of the pipeline should keep the footprint and clearance of vegetation to a minimum.

- The sandstone hill in the town of Senekal contains elements of high conservation value (Map 1). The footprint and clearance of vegetation should also be kept to a minimum in these areas. Furthermore, the pipeline should also be installed on top of the soil surface or semi-imbedded much the same as the existing pipeline.

- Remaining natural vegetation contain several protected species (Appendix C). Where any of the geophytic species will be affected the necessary permits should be obtained to transplant them to adjacent areas. Where protected trees require removal for the installation of the pipeline permits should also be obtained to do so.

- No hunting, harming, capturing or trapping of fauna must be allowed and this must be strictly prohibited.

- Open trenches may act as pitfall traps to mammals, reptiles and amphibians and trenches should be daily monitored for trapped animals which should be removed promptly.

- 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.

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

- The necessary authorisations must be acquired from Department of Water Affairs (DWA) as well as the Department of Environmental Affairs (DEA) for the crossing of

the watercourses or where they occur in close proximity along the pipeline route as listed in Table 7 (Map 1 & 2).

- Where the pipeline is constructed in close proximity to the Sand River the storage of stockpiles should occur outside the floodplain of the river and stockpiles protected against erosion. Stockpiles and materials should also be placed in the sequence; watercourse-trench-stockpile. This will ensure that sediment is kept away from the watercourse and the trench acts as barrier.

- The floodplain of the Sand River is prone to erosion and therefore monitoring and remediation of erosion is especially important where the pipeline is constructed in close proximity to it.

- Installation of the pipeline through watercourses should preferably be undertaken during the winter months (July to September) when baseflow will be at its lowest level.

- When excavating in watercourses the upper 30 cm, or topsoil, should be removed together with the vegetation and stored as sods on the site. These should then be replaced on top of the installed pipeline. Subsoil should be used as backfilling and not as top dressing. Only removed sods and topsoil should be utilised to rehabilitate the bed and bank surface. The soil surface should also be re-instated to the virgin soil level and not depressed or elevated as this will promote erosion and cause flow barriers. After rehabilitation any excess soil or material should be removed and disposed of at a registered disposal facility.

- Where possible it is recommended that the aboveground installation of the pipeline on pylons at crossings be done as this will lead to less disturbance.

- Where excavation takes place within watercourses, the excavated material should be stored outside the floodplain of the watercourse as soils will be washed into the main channel when placed within the stream.

- Where aboveground installation of the pipeline is done, the structure should be of sufficient design and strength to withstand flood damage.

- The watercourse bed and bank morphology should also be re-instated as far as possible, which will also speed up the stabilisation of the bed and banks.

- Where steep banks occur and erosion is evidently problematic it is recommended that geotextiles be utilised to stabilise soils. Available options include contouring, berms, gabions and geotextile netting.

- Construction within the watercourses will require blocking of active flow. This should be done by blocking only half of the channel for construction whilst the remaining half is allowed to maintain flow. The timeframe for construction through watercourses should also be kept to a minimum.

- The construction footprint along the watercourses should be kept to a minimum.

- Removal of vegetation along watercourses should also be kept to a minimum.

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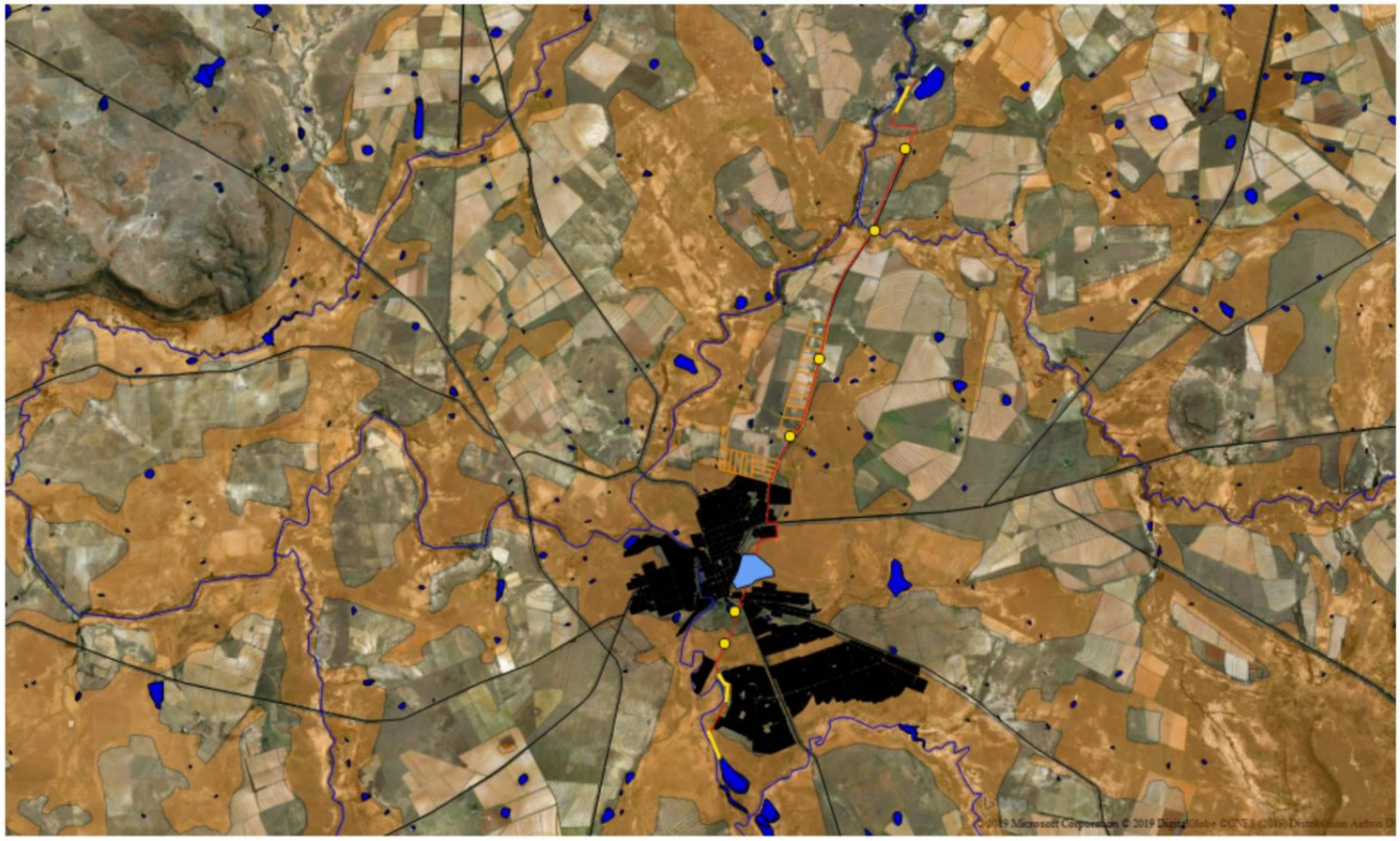
Annexure A: Maps and Site photos

Layout map for the proposed bulk water transfer pipeline from the Cyferfonteindam to the town of Senekal, Free State Province.



Preparred for:
MDA Environmental Consultants
9 Barnes Street
Westdene
9301

Legend:
- Road network
- Watercourses
- Pipeline route
- Small Holdings
- Urban Areas
- Wetlands and impoundments
- Threatened Ecosystems
- Sandtsone hill
- Points of crossing
- Pipeline in close proximity

Map Information

Spheroid: WGS 84

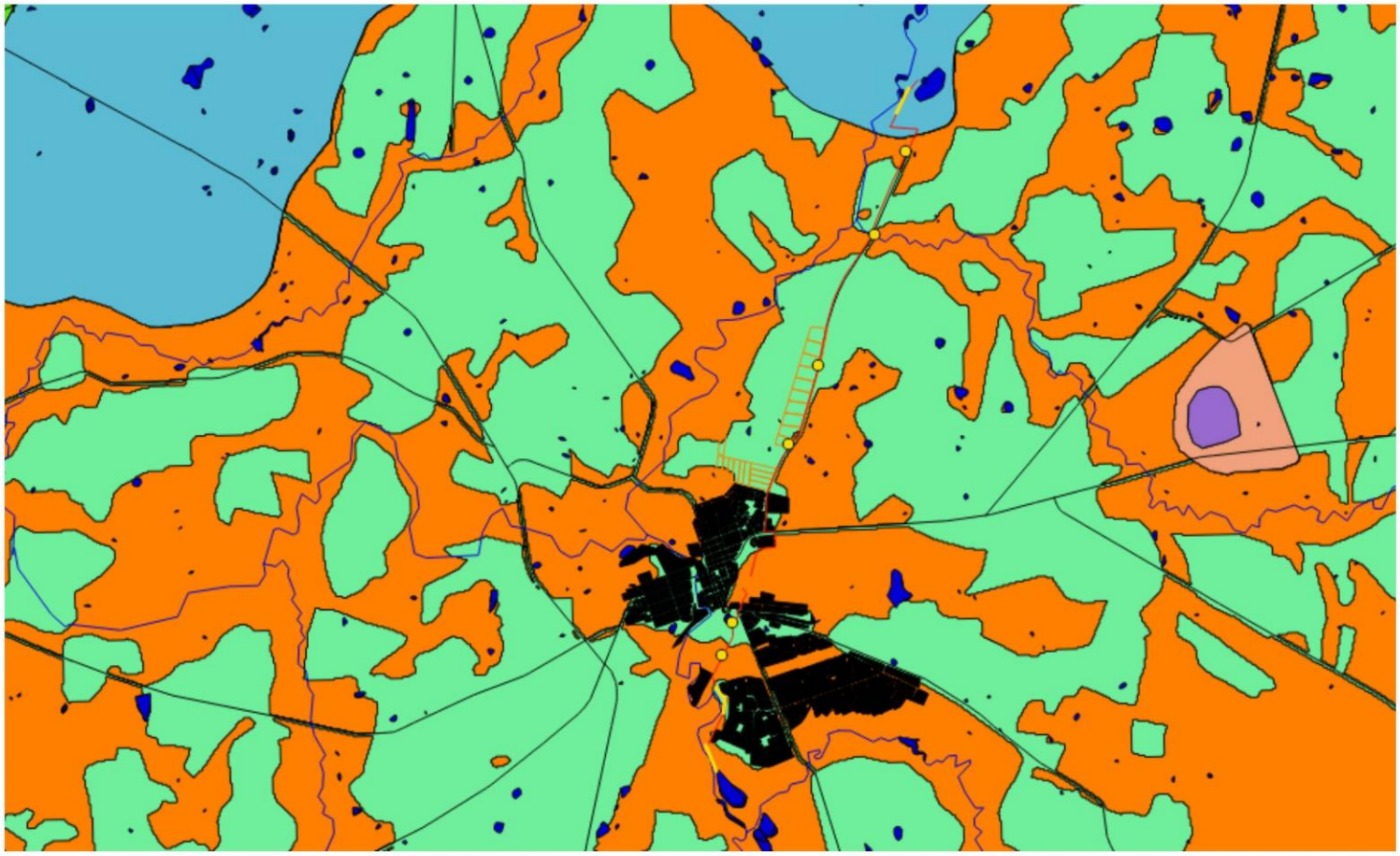
Quantum GIS

Scale: 1:70 000

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

Map 1: Layout map of the proposed bulk water transfer pipeline from the Cyferfonteindam to the town of Senekal. The points of crossing as well as where the pipeline occurs in close proximity to the Sand River is indicated. The prominent sandstone hill in the town is also indicated. Note the extensive agricultural crop fields in the region which has resulted in transformation of the natural grassland.

General ecology map for the proposed bulk water transfer pipeline from the Cyferfonteindam to the town of Senekal, Free State Province.



Preparred for:
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9 Barnes Street
Westdene
9301

Legend:
- Road network
- Watercourses
- Pipeline route
- Small Holdings
- Urban Areas
- Wetlands and impoundments
- Threatened Ecosystems
- Eastern FS Clay Grassland
- Central Free State Grassland
- Points of crossing
- Pipeline in close proximity

Map Information

Spheroid: WGS 84

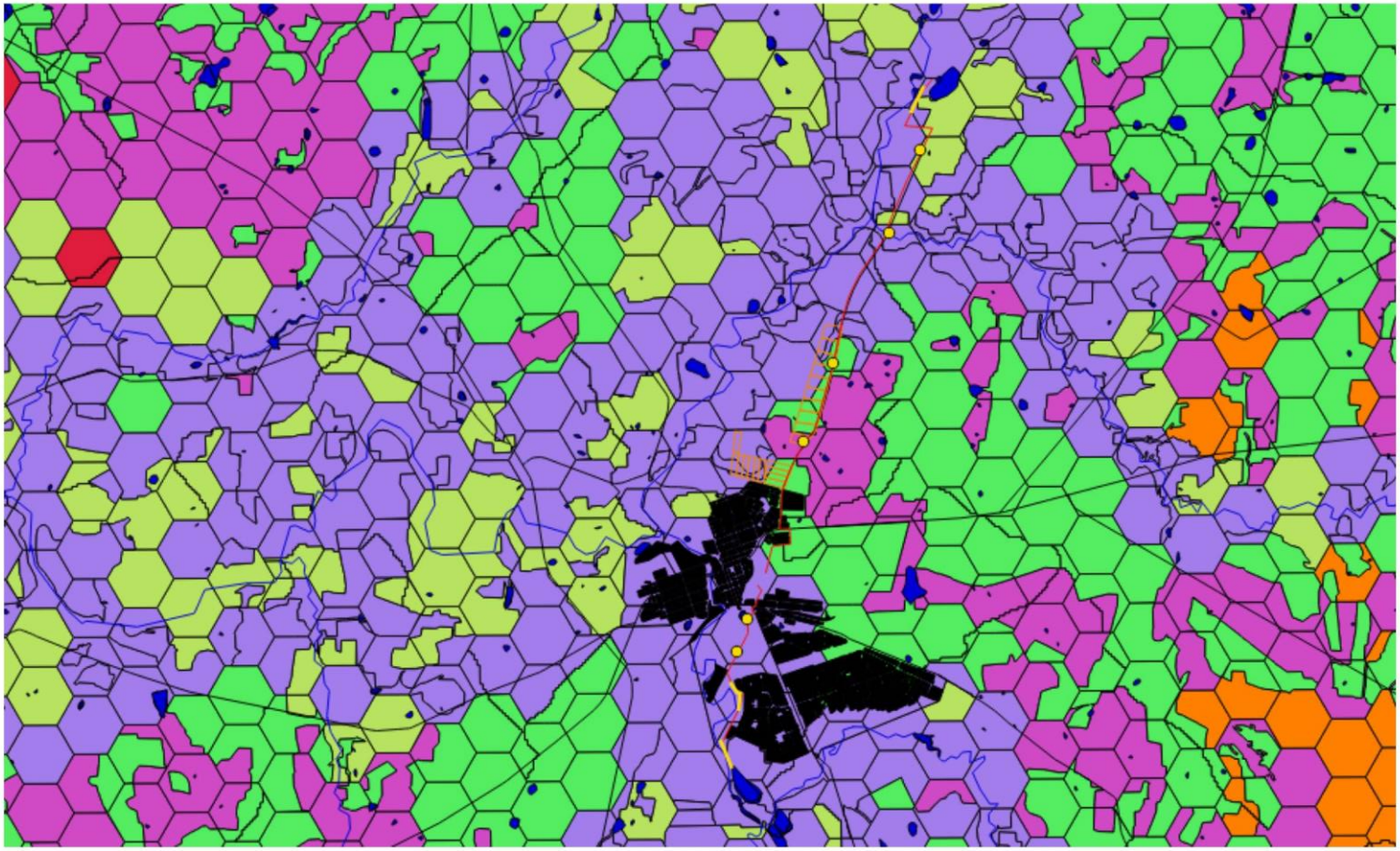
Quantum GIS

Scale: 1:70 000

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

Map 2: General ecology of the proposed bulk water transfer pipeline from the Cyferfonteindam to the town of Senekal. The points of crossing as well as where the pipeline occurs in close proximity to the Sand River is indicated. Note the proximity to the urban area of Senekal. Areas of remaining Threatened Ecosystem, i.e. Eastern Free State Clay Grassland is also indicated. Portions around the town are however already transformed and only in the northern section does portions of the natural grassland remain.

Free State Biodiversity Plan map for the proposed bulk water transfer pipeline from the Cyferfonteindam to the town of Senekal, Free State Province.



Preparred for:
MDA Environmental Consultants
9 Barnes Street
Westdene
9301

Legend:
- Road network
- Watercourses
- Pipeline route
- Small Holdings
- Urban Areas
- Wetlands and impoundments
- Critical Biodiversity Area 1
- Critical Biodiversity Area 2
- Ecological Support Area 1
- Ecological Support Area 2
- Degraded
- Other
- Points of crossing
- Pipeline in close proximity

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:70 000

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

Map 3: Biodiversity Plan map of the proposed bulk water transfer pipeline from the Cyferfonteindam to the town of Senekal. The pipeline is mostly situated within an Ecological Support Area 2 with small areas within Other and Degraded categories.

Figure 1: Panorama of the Cyferfonteindam at the northern end of the pipeline route.

Figure 2: View of the portion of remaining natural vegetation south of the Ceyferfonteindam. The approximate location of the pipeline adjacent to the fenceline is indicated (red). Note the dominance by dwarf karroid shrubs indicating a degraded grass layer.

Figure 3: Another view of the portion of remaining natural vegetation where it is clear that a narrow strip adjacent to the fenceline is visibly degraded.

Figure 4: Large portion of the pipeline route (red) has been transformed by crop cultivation.

Figure 5: View of the water reservoirs on top of the sandstone hill where the pipeline will connect to.

Figure 6: View of the southern slope of the sandstone hill. Note the densely wooded slope.

Figure 7: View of an existing pipeline along the slope of the hill. The current proposed pipeline should be installed along the same method where with regards to the sandstone hill, i.e. on top of the soil surface or semi-imbedded.

Figure 7: Grassland portions around the urban areas are mostly transformed from the natural condition and no longer considered as part of the threatened Eastern Free State Clay Grassland.

Figure 8: View of the pump station at the Senekal Dam where the pipeline will connect to the system.

Figure 9: Panorama of the Senekal Dam at the southern end of the pipeline route.

Appendix B: Species list

Species indicated with an * are exotic.

Protected species are coloured orange and Red Listed species red.

Species	Growth form
**Achyranthes aspera*	Herb
**Amaranthus hybridis*	Herb
**Bidens bipinnata*	Herb
**Cirsium vulgare*	Herb
**Commelina benghalensis*	Herb
**Conyza bonariensis*	Herb
**Cotoneaster franchetii*	Shrub
**Cyllindropuntia imbricata*	Succulent
**Datura ferox*	Herb
**Datura stramonium*	Herb
**Eucalyptus camaldulensis*	Tree
**Gleditsia triacanthos*	Tree
**Melia azedarach*	Tree
**Opuntia ficus-indica*	Succulent
**Opuntia humifusa*	Succulent
**Pennisetum clandestinum*	Grass
**Plantago lanceolata*	Herb
**Populus x canescens*	Tree
**Robinia pseudoacacia*	Tree
**Salix babylonica*	Tree
**Salix fragilis*	Tree
**Schkuhria pinata*	Herb
**Sesbania punicea*	Shrub
**Sorghum halapense*	Grass
**Tagetes minuta*	Herb
**Tamarix chinensis*	Tree
**Verbena bonariensis*	Herb
**Verbena tenuisecta*	Herb
**Xanthium spinsoum*	Herb
Ammocharis coranica	Geophyte
Aristida congesta	Grass
Aristida diffusa	Grass
Artemisia afra	Shrub
Asparagus larcinus	Shrub
Barleria macrostegia	Herb
Berkheya macrocephala	Herb
Berkheya onopordifolia	Herb
Berula erecta	Herb
Brachiaria eruciformis	Grass
Celtis africana	Tree

Chasmatophyllum musculinum	Succulent
Cheilanthes hirta	Fern
Chenopodium album	Herb
Chloris virgata	Grass
Chrysocoma ciliata	Dwarf shrub
Cineraria erodioides	Herb
Commelina africana	Herb
Conyza podocephala	Herb
Crabbea acaulis	Herb
Crassula lanceolata	Succulent
Crinum bulbispermum	Geophyte
Cymbopogon pospischillii	Grass
Cynodon dactylon	Grass
Cyperus esculentus	Sedge
Cyperus longus	Sedge
Cyperus marginatus	Sedge
Cyperus rupestris	Sedge
Delosperma cooperi	Succulent
Dianthus basuticus	Herb
Dicliptera leistneri	Herb
Dicoma anomala	Herb
Dicoma macrocephala	Herb
Digitaria eriantha	Grass
Diospyros lycioides	Shrub
Eragrostis curvula	Grass
Eragrostis gummiflua	Grass
Eragrostis lehmanniana	Grass
Eragrostis nindensis	Grass
Eragrostis obtusa	Grass
Eragrostis superba	Grass
Erythrina zeyheri	Geophyte
Felicia fillifolia	Dwarf shrub
Felicia muricata	Dwarf shrub
Gomphocarpus fruticosus	Herb
Gomphostigma virgatum	Dwarf shrub
Gymnosporia buxiifolia	Shrub
Haplocarpha scaposa	Herb
Helichrysum nudifolium	Herb
Hermannia depressa	Herb
Heteromorpha arborescens	Tree
Heteropogon contortus	Grass
Hibbiscus pusillus	Herb
Hyparrhenia hirta	Grass
Hyparrhenia thamba	Grass
Hypoxis angustifolia	Geophyte
Hypoxis hemerocallidae	Geophyte

Ipomoea oblongata	Creeper
Juncus effusus	Rush
Kiggelraria africana	Tree
Ledebouria luteola	Geophyte
Ledebouria marginata	Geophyte
Leptochloa fusca	Grass
Lycium cinerium	Dwarf shrub
Micrchloa caffa	Grass
Moraea palida	Geophyte
Nidorella resedifolia	Herb
Nolletia ciliaris	Dwarf shrub
Oropetium capense	Grass
Osteospermum muricatum	Dwarf shrub
Panicum coloratum	Grass
Paspalum dilatatum	Grass
Paspalum distichum	Grass
Pellaea callomelanos	Fern
Pentzia incana	Dwarf shrub
Phragmites australis	Reed
Pollichia campestris	Dwarf shrub
Raphionacme hirsuta	Geophyte
Ruschia hamata	Succulent
Salsola rabieana	Dwarf shrub
Salvia verbenaca	Herb
Scabiosa columbaria	Herb
Searsia burchellii	Tree
Searsia dentata	Shrub
Searsia lancea	Tree
Searsia pyroides	Tree
Selago densiflora	Herb
Setaria sphacelata	Grass
Setaria verticillata	Grass
Solanum supinum	Herb
Sporobolus fimbriatus	Grass
Stoebe vulgaris	Dwarf shrub
Teucrium trifidum	Herb
Themeda triandra	Grass
Trachyandra laxa	Geophyte
Triraphis andropogonoides	Grass
Typha capensis	Bulrush
Ursinia nana	Herb
Vachellia karroo	Tree
Vigna vexillata	Creeper

Appendix C: Protected species on the site

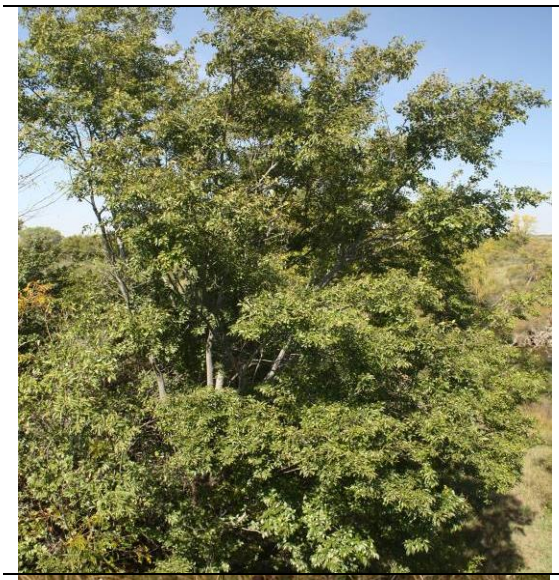
Protected species on the site may not be limited to these species but these species have identified on and around the site. Additional sources should be consulted to confirm the presence of protected species.

Ammocharis coranica
Seeroogblom/Ground Lily

Protected in the Free State Province

National Red List Status: **Least Concern (LC)**

Remove this species if present and transplant to a suitable area where no disturbance will take place.



Celtis africana
White Stinkwood/Witstinkhout

Protected in the Republic of South Africa

National Red List Status: **Least Concern (LC)**

Obtain permits to remove specimens which will be affected by construction.

Crinum bulbispermum
Orange River Lily/Oranjerivierlelie/Vleilelie

Protected in the Free State Province

National Red List Status: **Declining**

Where they will be affected by construction permits should obtained to remove them and transplant them to an adjacent area where they will not be affected. Plants only flower for a short period after which they may be difficult to identify in which case an ecologist should be consulted.

Erythrina zeyheri
Ploughbreaker/Ploegbreeker

Protected in the Free State Province

National Red List Status: **Least Concern (LC)**

Remove this species if present and transplant to a suitable area where no disturbance will take place. Transplants easily. Will not be visible during winter months. Also take note that this species has an exceptional underground tuber.

Raphionacme hirsuta
False Gentian/Khadiwortel

Protected in the Free State Province

National Red List Status: **Least Concern (LC)**

Remove this species if present and transplant to a suitable area where no disturbance will take place. Transplants easily. Will not be visible during winter months. Also take note that this species has an exceptional underground tuber.

Appendix D: Index of Habitat Integrity (IHI) Summary

ASSESSMENT UNIT INFORMATION	
ASSESSMENT UNIT INFORMATION	Senekal Bulk Water Pipeline
UPPER LATITUDE	S 28.242259
UPPER LONGITUDE	E 27.655622
UPPER ALTITUDE	1443 m
LOWER LATITUDE	S 28.354383
LOWER LONGITUDE	E 27.620480
LOWER ALTITUDE	1437 m
SURVEY SITE (if applicable)	Sand River
SITE LATITUDE (if applicable)	
SITE LONGITUDE (if applicable)	
SITE ALTITUDE (if applicable)	
WMA	Middle Vaal
QUATERNARY	C42D
ECOREGION 2	11_3
DATE	02/05/2018
RIVER	Sand River
TRIBUTARY	Sandspruit
PERENNIAL (Y/N)	**Y**
GEOMORPH ZONE	**FOOTHILL**
WIDTH (m)	**>0-2**

METRIC GROUP	RATING	CONFIDENCE
HYDROLOGY MODIFICATION	2.1	2.0
PHYSICO-CHEMICAL MODIFICATION	1.5	3.0
BED MODIFICATION	1.8	4.0
BANK MODIFICATION	2.0	3.0
CONNECTIVITTY MODIFICATION	2.0	4.0
INSTREAM IHI%	62.6	
CATEGORY	C	
CONFIDENCE	3.2	

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	2.08	3.00
BANK STRUCTURE MODIFICATION	1.80	4.00
CONNECTIVITY MODIFICATION	1.50	4.00
RIPARIAN HABITAT INTEGRITY (%)	63.50	
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	-2.0
Zero Flows	2.0
Floods	2.5
HYDROLOGY RATING	**2.1**
pH	1.0
Salts	1.5
Nutrients	2.0
Water Temperature	1.5
Water clarity	1.5
Oxygen	1.5
Toxics	2.0
PC RATING	**1.5**
Sediment	2.0
Benthic Growth	1.5
BED RATING	**1.8**
Marginal	2.0
Non-marginal	2.0
BANK RATING	**2.0**
Longitudinal Connectivity	2.0
Lateral Connectivity	2.0
CONNECTIVITY RATING	**2.0**
INSTREAM IHI %	**62.6**
INSTREAM IHI EC	**C**
INSTREAM CONFIDENCE	**3.2**

	MRU
RIPARIAN IHI	
Base Flows	-2.0
Zero Flows	2.0
Moderate Floods	2.0
Large Floods	2.5
HYDROLOGY RATING	**2.1**
Substrate Exposure (marginal)	1.0
Substrate Exposure (non-marginal)	2.0
Invasive Alien Vegetation (marginal)	1.0
Invasive Alien Vegetation (non-marginal)	3.0
Erosion (marginal)	1.0
Erosion (non-marginal)	2.0
Physico-Chemical (marginal)	1.5
Physico-Chemical (non-marginal)	3.0
Marginal	1.5
Non-marginal	3.0
BANK STRUCTURE RATING	**1.8**
Longitudinal Connectivity	1.5
Lateral Connectivity	1.5
CONNECTIVITY RATING	**1.5**
RIPARIAN IHI %	**63.5**
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

No.	Phases	Activity	Aspect	Impact	Severity: Flow Regime	Severity: Physico & Chemical (Water Quality)	Severity: Habitat (Geomorph+Vegetation)	Severity: Biota	Severity	Spatial scale	Duration	Consequence
1	All Phases	Installation of bulk water transport pipeline through watercourses.	Excavation and backfilling of trenches	Excavation of trenches will impede flow while trenches are open. Disturbance of the bed and banks will promote sedimentation.	2	2	2	1	1.75	1	3	5.75
			Removal of riparian vegetation	Removal of riparian vegetation will promote erosion and sedimentation of watercourses. Disturbance and removal of vegetation will create conditions susceptible to the establishment of exotic weeds.	1	2	2	2	1.75	1	3	5.75
			Construction of pipeline pylons	Construction of pylons will cause limited disturbance of the bed and banks which will also promote erosion and sedientation but will be less than the excvataion of trenches. Removal of vegetation will be more limited than trench excavation. Pylons will form a obstruction to flow which will be low as long as pylon footprints are small.	1	1	1	1	1	1	3	5
2	All Phases	Installation of bulk water transport pipeline in close proximity to the Sand River.	Removal of vegetation, excavation and backfilling of trenches.	The installation of the pipeline will require the removal of vegetation, disturbance of the soil surface and excavation of material. This will form a source of sediment which may be washed into the river and increase the sediment load.	1	2	1	2	1.5	2	1	4.5

Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures
2	**2**	**5**	**2**	**11**	**63.25**	**M**	**4**	Control measures which can be utilised to decrease the risk include the following. Installation of pipelines during winter months when seasonal systems will not contain a baseflow and flow regime alteration will be minimal. Correct backfilling and using the removal of sods as rehabilitation.
2	2	5	2	**11**	**63.25**	**M**	4	Adequate rehabilitation and replacement of sods to decrease rehabilitation period. Adequate weed control to prevent establishment of weeds and promote establishment of indigenous riparian vegetation.
2	2	5	2	**11**	**55**	**L**	4	Pylons will have a smaller footprint and require less disturbance of vegetation and the soil profile and will therefore entail a lower risk.
1	1	5	1	**8**	**36**	**L**	4	It is unlikely that this will result in significant impacts. however, the storage of stockpiles should occur outside the floodplain of the river and protected against erosion. Stockpiles and materials should also be placed in the sequence; watercourse-trench-stockpile. This will ensure that sediment is kept away from the watercourse and the trench acts as barrier. Adequate erosion measures, monitoring and remediation of erosion should be implemented.