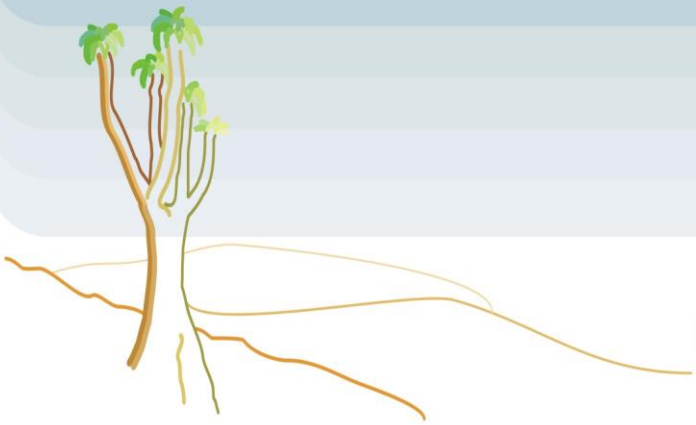
APPENDIX D_2

Ecological Report



DPR
Ecologists & Environmental Services

Report on the ecological and wetland assessment of the proposed construction of a bulk water transfer pipeline in the Roodewal Small Holdings, Bloemfontein, Free State Province.

August 2019

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DECLARATION OF INDEPENDENCE

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

Report Version	**Final 1.0**		
Title	**Report on the ecological and wetland assessment of the proposed construction of a bulk water transfer pipeline in the Roodewal Small Holdings, Bloemfontein, Free State Province.**		
Author	**DP van Rensburg (Pr.Sci.Nat)**		**Aug'19**

Executive Summary

The proposed pipeline will be constructed from the Renosterspruit, will pass through the Roodewal Small Holdings, and will join the tarred road at the north eastern border of the small holdings (Map 1). The pipeline will form part of the main water provision for the city and as such will function as transport for treated waste water to the purification plant at the Maselspoort Dam and from there back to Bloemfontein for re-use. The pipeline will cross peri-urban, transformed and natural areas, several watercourses will also be crossed by the pipeline. The assessment will include two alternative pipeline routes as well as a small additional third deviation (Map 1). Both pipeline route will have an estimated length of 5 km.

Route 1 (Southern Route)

The southern pipeline route alternative contains sections which has been modified and transformed significantly from the natural condition and these portions are consequently of relatively low conservation value. However, several large portions of relatively natural vegetation still remain, especially in the eastern section of the pipeline (Map 1). Consisting of Bloemfontein Dry Grassland, a Threatened Ecosystem, and highly likely containing protected species, these sections should be regarded as sensitive and having a significant conservation value (Map 2). The condition of the vegetation in these sections do however seem to be somewhat degraded along the border fences which should decrease the impact the proposed pipeline will have. Adequate mitigation will however be required which should include minimising the disturbance footprint and conducting a walkthrough survey to identify and mark protected species along the pipeline route. It is recommended that any protected plant specimens which will be affected by the pipeline construction should be removed and transplanted adjacent to the pipeline in an area of suitable and similar habitat. Permits must be obtained for those specimens to be transplanted.

Route 2 (Northern Route)

The vegetation along the northern pipeline route has mostly been transformed from the natural condition with only a few remnant patches of natural vegetation remaining and these also not in a good condition (Map 1). The vegetation along the route is therefore no longer considered to consist of the threatened Bloemfontein Dry Grassland (Map 2). This alternative pipeline route should therefore result in a significantly lower impact than the southern alterative. However, there is still a low likelihood of protected species occurring along the patches of remnant natural vegetation and a walkthrough survey of at least these sections should be undertaken to identify and mark protected species. Should any protected species be identified which will be affected by the pipeline construction they should be removed and transplanted adjacent to the pipeline in an area of suitable and similar habitat. Permits must be obtained for those specimens to be transplanted.

Both pipeline routes cross the same two small seasonal stream systems and these will be the subject of this study (Map 1 & 2).

From the description of the riparian vegetation of both stream systems it is clear that obligate wetland vegetation is present along both and therefore clearly indicate the presence of wetland conditions. These are more pronounced along the eastern stream, a much larger system. Exotic vegetation indicate varying degrees of disturbance at all points of crossing although in

both instances the crossings along the northern pipeline route is indicative of more disturbances than the crossings along the southern pipeline route.

The small seasonal stream systems which will be affected by the pipeline is still natural to some extent but has been significantly modified by several impacts which is mostly associated with the surrounding small holding land uses and infrastructure such as roads. An Index of Habitat Integrity (IHI) was conducted and indicated that the watercourses have an Instream IHI of Category C: Moderately Modified and Riparian IHI of Category C/D: Moderately to Largely Modified (Appendix C).

The EI&S of the two small stream systems 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 two pipeline routes will cross the two affected stream systems twice for each alternative (Map 1 & 2). This is then a total of four crossing points.
The proposed pipeline will result in several significant impacts on these watercourses. The material being transported by the pipeline being treated water, will have a negligible impact should leaks or spillages occur into watercourses. This is therefore not considered a likely impact. The installation of the pipeline will however 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. It is further recommended that the aboveground installation of the pipeline on pylons at crossings be done as far as possible as this will cause less disturbance. 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 (Appendix B). 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 and crossing of watercourses 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 D). The excavation of trenches and removal of riparian vegetation is considered to have a moderate risk in terms of the watercourse crossings whilst the crossing of watercourses by means of pylon construction is considered to be of lower risk as the footprint and disturbance of watercourses will be lower.

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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 Renosterspruit, will pass through the Roodewal Small Holdings, and will join the tarred road at the north eastern border of the small holdings (Map 1). The pipeline will form part of the main water provision for the city and as such will function as transport for treated waste water to the purification plant at the Maselspoort Dam and from there back to Bloemfontein for re-use. The pipeline will cross peri-urban, transformed and natural areas, several watercourses will also be crossed by the pipeline. The assessment will include two alternative pipeline routes as well as a small additional third deviation (Map 1). Both pipeline routes will have an estimated length of 5 km.

A site visit was conducted on 27 June 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 site survey was conducted during winter and consequently species identification was not easy though is still considered adequate to give a good representation of the area.

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.
Some animal species may not have been observed as a result of their nocturnal and/or shy habits.
Access could not be gained to large portions of the pipeline route and could therefore not be assessed directly with assessment based on estimates and nearby areas considered to be similar.
The Renosterspruit crossing was assessed during previous studies and was therefore not included in this assessment.

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 (Child *et al* 2016, 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.

Watercourses and wetlands 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

According to Mucina & Rutherford (2006) the area consists of Bloemfontein Dry Grassland (Gh 5). Bloemfontein Dry Grassland is listed as a Threatened Ecosystem with a status of Vulnerable (VU) (National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)) (Map 2). Large portions of this grassland has been transformed by dryland crop cultivation and urbanisation.

The pipeline routes fall within an Ecological Support Area 2, 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. This also indicates the mostly transformed nature of the area along which the proposed pipeline routes are situated.

The proposed pipeline will be constructed from the Renosterspruit, will pass through the Roodewal Small Holdings, and will join the tarred road at the north eastern border of the small holdings (Map 1). The pipeline will form part of the main water provision for the city and as such will function as transport for treated waste water to the purification plant at the Maselspoort Dam and from there back to Bloemfontein for re-use. The pipeline will cross peri-urban, transformed and natural areas, several watercourses will also be crossed by the pipeline. The assessment will include two alternative pipeline routes as well as a small additional third deviation (Map 1). Both pipeline routes will have an estimated length of 5 km.

In order to provide a more detailed description of the respective pipeline routes so that their conditions can be better assessed the two different main routes will be assessed separately from here on in the report.

Route 1 (Southern Route)

The southern route is dominated by undulating terrain with a substantially higher degree of remaining natural vegetation present. The route will cross the tarred Maselspoort road and will mostly avoid roads, being situated along the border of small holdings. Several large natural areas occur to the south of the pipeline route (Map 1 & 2).

The western portion of this route is located within the small holdings and although portions of natural vegetation remain they have been degraded to such an extent as not being good representative samples of the natural vegetation type. The small holdings entail intensive stock farming, crop cultivation and general disturbance associated with small-scale farming activities. The eastern portion of this route also contains extensive disturbance but also large areas of comparative natural grassland. Here the pipeline route exits the small holdings and is bordered to the south by extensive natural areas but to the north by small holdings (Map 1). A large historical borrow pit is situated along the pipeline route and is therefore a transformed portion. The eastern portion bordering the pipeline route to the south is however still largely natural and is confirmed by available spatial data indicating it is still forming part of the Bloemfontein Dry Grassland, a Threatened Ecosystem (Map 2).

The following description of the terrestrial vegetation along this pipeline route should also give a good indication of the condition it is in. Naturally this area should consist of Bloemfontein Dry

Grassland, a vegetation type characterised by a dominant grass layer, often dominated by the climax grass, *Themeda triandra*, but also a prominent dwarf shrub component with a diversity of geophytic species. The western portion of this pipeline route situated in the small holdings has however been altered to a significant extent. The grass layer has been much diminished and dwarf karroid shrubs are dominant in many areas. Dominant dwarf shrubs include *Lycium horridum, Pentzia incana, Rosenia humilis, Felicia muricata* and *Chrysocoma* ciliata. Where a grass layer is still present these are often dominated by pioneer species such as *Chloris virgata, Eragrostis lehmanniana* and *Aristida congesta*. However, there are still areas containing patches of climax *Themeda triandra*, which indicates that remnants of the natural vegetation type is still present and it is highly likely that protected species of conservation value will still be present here.

As mentioned the eastern section of this pipeline route is situated in an area consisting of natural vegetation. Access to this section could however not be provided and only limited sampling was undertaken here. From this sampling the following assumptions could be made. The area consists of a dominant grass layer with the climax grass, *Themeda triandra* dominating and thus indicating that the vegetation is still largely natural. Patches of dwarf karroid shrubs are still present but not prominent and therefore further substantiate that the vegetation is still largely natural. A few geophytic species were also observed, including *Eriospermum porphyrium* and *Colchicum longipes*. It is therefore also highly likely that protected species may occur along this section. It was however also noted that the border between the small holdings and natural areas to the south contained significant levels of disturbance most likely as a result of the edge effect often present along borders between degraded and natural areas. The impact that the pipeline will have should therefore be limited as long as the disturbance footprint is kept to a minimum and confined to the small strip along the border fence. As a result of disturbance several pioneer herbaceous species are prominent along the border and include *Salvia verbenaca, Senecio consanguineus, Arctotis arctotheca, Chenopodium album* as well as the exotic weed, *Alternanthera pungens*. An old borrow pit also occurs in the eastern section of the pipeline route which is consequently associated with significant transformation of the natural vegetation. Here dolerite outcrops are also abundant and as a result several tree species have also established here including *Vachellia karroo, Searsia lancea* as well as an exotic invasive tree, *Melia azedarach.*

In conclusion, the southern pipeline route alternative contains sections which has been modified and transformed significantly from the natural condition and these portions are consequently of relatively low conservation value. However, several large portions of relatively natural vegetation still remain, especially in the eastern section of the pipeline. Consisting of Bloemfontein Dry Grassland, a Threatened Ecosystem, and highly likely containing protected species, these sections should be regarded as sensitive and having a significant conservation value (Map 1 & 2). The condition of the vegetation in these sections do however seem to be somewhat degraded along the border fences which should decrease the impact the proposed pipeline will have. Adequate mitigation will however be required which should include minimising the disturbance footprint and conducting a walkthrough survey to identify and mark protected species along the pipeline route. It is recommended that any protected plant specimens which will be affected by the pipeline construction should be removed and transplanting adjacent to the pipeline in an area of suitable and similar habitat. Permits must be obtained for those specimens to be transplanted.

Route 2 (Northern Route)

The northern route is dominated by undulating terrain with most of the natural vegetation having been transformed previously or in a quite degraded condition (Map 1). Remnant patches of natural vegetation are present but overall not in a good condition. The route will be situated to the north of the tarred Maselspoort road and will also be mostly situated adjacent to an existing gravel road. This also further decreases the condition of the vegetation along the route. This pipeline route also contains a small alternative deviation but will be discussed as a whole as it does not contain any elements different from the rest of the pipeline route.

The pipeline route is situated in its entirety in the Roodewal Small Holdings and does not border on any significant natural areas (Map 1). The survey indicated that small remnants of the natural grassland are present but evidently not in a good condition. The remainder of the pipeline route has been degraded to such an extent as not being good representative samples of the natural vegetation type. The small holdings entail intensive stock farming, crop cultivation and general disturbance associated with small-scale farming activities. Spatial data also confirms that the natural vegetation type, Bloemfontein Dry Grassland, is considered transformed along this pipeline route (Map 2).

The following description of the terrestrial vegetation along this pipeline route should also give a good indication of the condition it is in. Naturally this area should consist of Bloemfontein Dry Grassland, a vegetation type characterised by a dominant grass layer, often dominated by the climax grass, *Themeda triandra*, but also a prominent dwarf shrub component with a diversity of geophytic species. This has however been altered along the majority of the pipeline route. The grass layer has been much diminished and dwarf karroid shrubs are dominant in many areas. Dominant dwarf shrubs include *Lycium horridum, Pentzia incana, Rosenia humilis, Felicia muricata, Hertia pallens, Salsola rabieana* and *Chrysocoma* ciliata. A few pioneer herbaceous species has also become prominent with *Nidorella resedifolia*, forming dominant patches in some areas. Other prominent herbaceous species also include *Senecio consanguineus* and *Osteospermum scariosum*. The small geophyte, *Moraea pallida*, is abundant. This species is unpalatable and even poisonous to stock and proliferates where overgrazing occurs as along the pipeline route. Overgrazing and disturbance of the grass layer has also resulted in the increased establishment of shrubs and trees, especially the tree, *Vachellia karroo*, and shrub, *Asparagus larcinus*. A few exotic weeds has also established due to the degraded condition and include *Datura ferox* and *Opuntia humifusa*. The latter also being a serious invasive and forms extensive clumps in this area. As mentioned, the natural grass layer is much diminished. However, the climax grass, *Themeda triandra* is still present in a few areas where remnants of the natural vegetation remain. Where a grass layer is still present these are often dominated by pioneer species such as *Chloris virgata, Eragrostis lehmanniana, Tragus koelerioides, Cynodon dactylon* and *Aristida congesta*.

In conclusion, the vegetation along the northern pipeline route has mostly been transformed from the natural condition with only a few remnant patches of natural vegetation remaining and these also not in a good condition (Map 1). The vegetation along the route is therefore no longer considered to consist of the threatened Bloemfontein Dry Grassland (Map 2). This alternative pipeline route should therefore result in a significantly lower impact than the southern alternative. However, there is still a low likelihood of protected species occurring along the patches of remnant natural vegetation and a walkthrough survey of at least these sections should be undertaken to identify and mark protected species. Should any protected species be identified which will be affected by the pipeline construction they should be removed

and transplanted adjacent to the pipeline in an area of suitable and similar habitat. Permits must be obtained for those specimens to be transplanted.

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 (Map 1 & 2).

Both pipeline routes will cross the Renosterspruit near the western extreme. This point of crossing has been assessed by previous studies and has therefore not been included in this assessment.

Both pipeline routes cross the same two small seasonal stream systems and these will be the subject of this study (Map 1 & 2).

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.

Within the western portions of both the northern and southern routes a small seasonal stream is being crossed (Map 1 & 2). The stream system is heavily degraded by numerous impacts and is not in a good condition. The point of crossing along the northern route could be assessed directly but access to the southern point of crossing was not possible and was surveyed a short distance upstream. Vegetation at both points will be discussed together and differences indicated where observed. The stream contains a dense grass layer in the main channel and is dominated by the riparian grass, *Cynodon dactylon*. It is however not a good indicator of wetland conditions. Clumps of the obligate wetland grass, *Diplachne fusca*, is however common and does reliably indicate the presence of wetland conditions in the stream. Along the banks of the stream scattered trees, *Vachellia karroo*, and shrubs, *Asparagus larcinus*, occur and are also a natural component of riparian vegetation in this region. The exotic riparian weed, *Phyla nodiflora*, is also common in the main channel. The southern point of crossing contains much fewer impacts than the northern crossing and does consequently not contain a significant infestation of exotic species. The northern crossing is however heavily degraded and numerous exotic weeds and invasives occur which include *Sphaeralcea bonariensis, Plantago lanceolata, Malva parviflora, Argemone ochroleuca, Bidens bipinnata, Pyracantha angustifolia, Opuntia humifusa* and *Alternanthera pungens*.

The eastern portions of both the northern and southern pipeline routes contain a larger but still seasonal stream system which is again crossed by both routes (Map 1 & 2). The stream is also considered affected by several impacts though somewhat less than the western stream. Again, the point of crossing along the northern route could be assessed directly but access to the southern point of crossing was not possible and was surveyed a short distance downstream. Vegetation at both points will be discussed together and differences indicated where observed. A dense grass cover is again present in the main channel. The riparian grass, *Cynodon dactylon* is also present but to a lesser extent and the obligate wetland grass species, *Diplachne fusca* is more abundant along this stream. Due to the larger size of the stream, pools and areas of higher moisture regime are present and are able to sustain more wetland species which include *Eleocharis sp., Setaria sphacelata, Persicaria lapathifolia* and *Cyperus longus*. These therefore indicate clear and extensive wetland conditions along this stream system. Along the banks of the stream scattered trees, *Vachellia karroo*, and shrubs, *Asparagus larcinus*, occur and are also a natural component of riparian vegetation in this region. Other herbaceous species occurring in the floodplain of the stream include *Moraea pallida, Indigofera daleoides, Scabiosa columbaria, Falkia oblonga* and *Cymbopogon pospischillii*. Both points of survey contained an existing road crossing which degrades the stream and riparian vegetation although the southern point of crossing (which could not be directly assessed) does not contain a road crossing and it is anticipated to be in a much better condition with few or no exotic species. Exotic weeds and invasive species observed included *Verbena bonariensis, Plantago lanceolata, Phyla nodiflora, Sphaeralcea bonariensis* and *Gleditsia triacanthos*.

From the description of the riparian vegetation of both stream systems it is clear that obligate wetland vegetation is present along both and therefore clearly indicate the presence of wetland conditions. These are more pronounced along the eastern stream, a much larger system. Exotic vegetation indicate varying degrees of disturbance at all points of crossing although in both instances the crossings along the northern pipeline route is indicative of more disturbances than the crossings along the southern pipeline route.

4.3 Assessment of watercourses

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

Both the northern and southern pipeline routes will both cross two small seasonal stream systems. Both stream systems drain into the Renosterspruit, in close proximity to each other, are mostly affected by the same impacts, are similar in their morphology and function and will affect the same downstream section. They will therefore be mostly be discussed as a whole and differences discussed where applicable.

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:

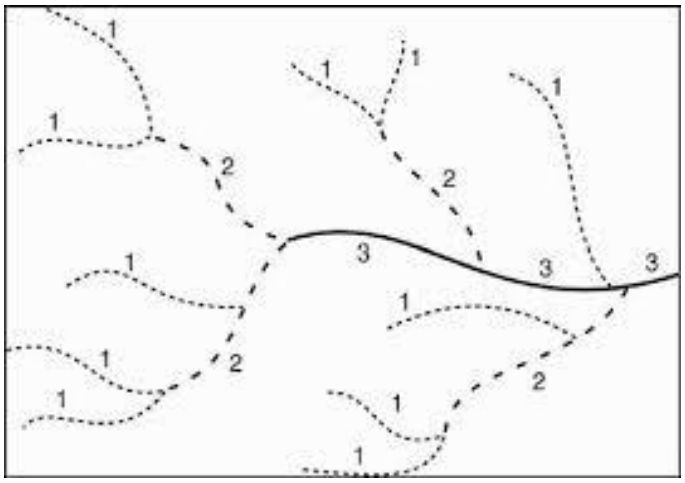


Figure 1: The classification of stream orders from 1 to 3 (Strahler 1952)

Stream systems can be divided into different riparian zones within the lateral section of the system. 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 natural in terms of geomorphology and riparian vegetation, except for the western crossing of the northern pipeline route. Erosion is significant at all crossings and is a consequence of the surrounding land use. Refuse and litter is also present at all crossings. The flow and flooding regime would still be natural although modified to a significant degree, mostly be obstruction such as roads and infrastructure but also due to the surrounding land uses.

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 both streams contains a gradual but still steep slope and is subjected to annual flooding. This zone is also natural though significantly modified.

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 both streams levels off and contains a gradual slope. It is flooded very infrequently and is dominated by a short grass layer with scattered trees and shrubs but all being terrestrial species.

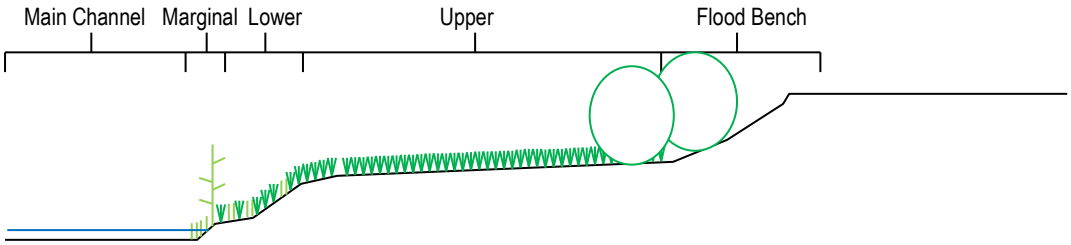


Figure 2: Illustration showing the different riparian zones of the two stream systems being crossed by the northern and southern pipeline alternatives.

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 affected stream systems 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 both pipeline alternatives will be based on an overall determination of the Index of Habitat Integrity (IHI) (Appendix C). Both stream systems drain into the Renosterspruit, in close proximity to each other, are mostly affected by the same impacts, are similar in their morphology and function and will affect the same downstream section. As a result, one IHI will be conducted to represent the overall condition of these stream systems. This is considered to give a good representation of their condition as both watercourses drain into the Renosterspruit and will affect the same downstream area. The IHI will be taken as representative of the Present Ecological State (PES) of these systems.

The small seasonal stream systems which will be affected by the pipeline is still natural to some extent but has been significantly modified by several impacts which is mostly associated with the surrounding small holding land uses and infrastructure such as roads. An Index of Habitat Integrity (IHI) was conducted and indicated that the watercourses have an Instream IHI of Category C: Moderately Modified and Riparian IHI of Category C/D: Moderately to Largely Modified (Appendix C).

The EI&S of the two small stream systems 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 two pipeline routes will cross the two affected stream systems twice for each alternative. This is then a total of four crossing points. A short description of each crossing point will be provided.

Table 4: Description of the specific points of crossing by the proposed pipeline alternatives over the two small stream systems (Map 1 & 2).

Watercourse name:	**Coordinates of crossing:**	**Order:**
#1 Unnamed stream system (Route 1 – Southern Pipeline)	S 29.098819°, E 26.341101°	Second Order
Description of watercourse at point of crossing: A small seasonal stream system in the western portion of the southern pipeline route. Access to the exact point of crossing could not be provided and a point a short distance upstream was surveyed. The stream at this point is considered still natural to a significant degree. It is located within an area of small holdings and also has its origin in this area. It will therefore be affected by land use associated with these small holdings. Concentrated livestock farming will be one of the most significant impacts. This will cause trampling and overgrazing which will decrease the vegetation cover and increase erosion and sedimentation of the stream. Manure will also contribute to increased nutrients. Areas of dryland crop cultivation is also visible and this will further contribute to a decrease in vegetation cover and an increase in sediment load. Impacts associated with fertiliser, herbicide and pesticide use is also likely. There are also numerous gravel roads, dirt tracks and low water crossings over this stream which will also result in significant impacts. The main impact is the obstruction this causes to flow and flooding and will therefore alter the natural flow and flooding regime of the stream. The stream contains a clearly defined main channel although a quite extensive and not clearly defined floodplain is also present. Though small the stream clearly contains obligate wetland vegetation but mostly confined to the main channel and absent from the floodplain.		

View of the small stream with the point of survey (red) and the actual point of crossing indicated (yellow). Note the grass dominated main channel and apparent natural surroundings.

View of the culver crossing of the stream. This will clearly affect the natural flow and flooding regime of the stream.

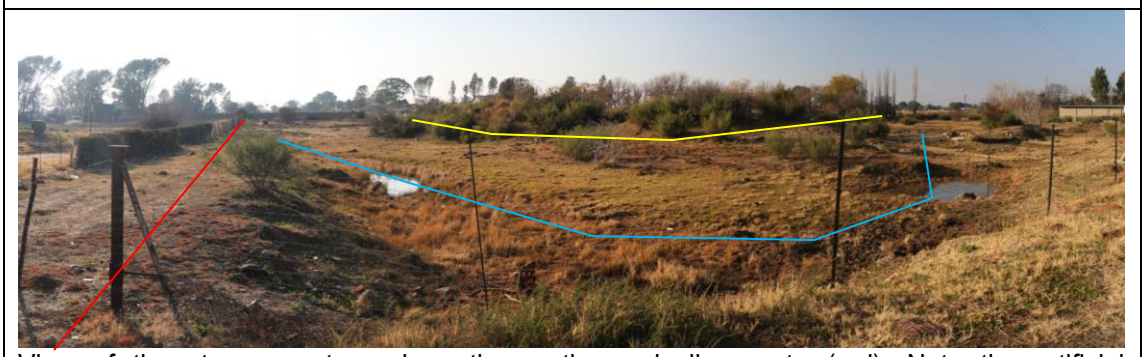
Watercourse name:	**Coordinates of crossing:**	**Order:**
#2 Unnamed stream system (Route 2 – Northern Pipeline)	S 29.094865°, E 26.337133°	Second Order

Description of watercourse at point of crossing:

This is the same stream system as discussed in Crossing #1 but crossed by the Northern Pipeline route. The point of crossing is located approximately 600 meters downstream of Crossing #1 and impacts here have cumulated to become much more significant.

The stream system at this point becomes much more modified then the upstream section. In addition to impacts as discussed for the same stream under Crossing #1 the stream is also affected by crossing by the tarred road, an artificial impoundment and canalisation. The stream is being crossed by the tarred Maselspoort road, a busy road, causing significant disturbance of the stream. A small artificial impoundment has also been constructed in the stream which will have a significant impact on the flow and flooding regime and geomorphology of the stream. The survey also indicated that the riparian vegetation has been significantly altered as a result. Downstream of the dam the stream is also canalised passed an orchard which significantly alters the stream further. The stream at this crossing is significantly degraded and modified.

The stream contains a clearly defined main channel but which has evidently been modified by impacts as described. The vegetation in the stream is degraded but obligate wetland vegetation is still present.



View of the stream system along the northern pipeline route (red). Note the artificial impoundment (yellow) and stream flowing from it. This area is clearly degraded and the stream heavily modified.

View of the floodplain of the stream. Note dense infestation by the exotic *Opuntia humifusa* (red).

View of the culvert at the crossing (red) with the canalised section of the stream inbetween orchards and crop fields.

Watercourse name:	**Coordinates of crossing:**	**Order:**
#3 Unnamed stream system (Route 1 – Southern Pipeline)	S 29.084928°, E 26.362107°	Second Order

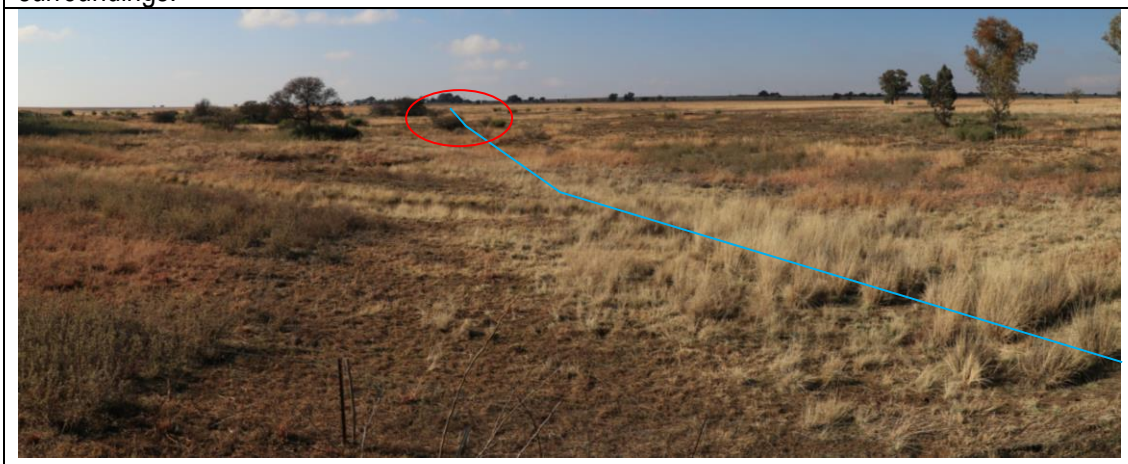
Description of watercourse at point of crossing:

The small seasonal stream system in the eastern portion of the southern pipeline route. Access to the exact point of crossing could not be provided and a point 400 meters downstream was surveyed. The impacts here were much more significant than the actual point of crossing and should be taken into consideration.

The stream at this point is considered still natural to a significant degree. The majority of the stream is situated within a natural area utilised for livestock farming. The impacts on it here will therefore be limited. Livestock overgrazing will however contribute to trampling which will decrease the vegetation cover and increase erosion and sedimentation of the stream. Manure will also contribute to increased nutrients. A small portion of dryland cropfileds also occurs in the catchment of the stream which will have some impact associated with fertiliser, herbicide and pesticide use. The impacts on the stream are however limited and should indicate that it is in a relatively good condition at this point of crossing.

The stream contains a clearly defined main channel although a quite extensive and not clearly defined floodplain is also present. The stream is significant and contains a prominent obligate wetland vegetation component although mostly confined to the main channel.

View of the stream with the actual point of crossing indicated (red). Note the largely natural surroundings.



Another view of the stream with the actual point of crossing indicated (red). Again note the comparative natural condition of the stream.

Watercourse name:	**Coordinates of crossing:**	**Order:**
#4 Unnamed stream system (Route 2 – Northern Pipeline)	S 29.082766°, E 26.353049°	Second Order

Description of watercourse at point of crossing:

This is the same stream system as discussed in Crossing #3. The point of crossing is located approximately 1 km downstream of Crossing #3 and impacts here have cumulated to become more significant, decreasing the condition of the stream in comparison to Crossing #3.

The stream system at this point becomes more modified though not significantly different than the upstream section. Additional impacts at this crossing point include crossing by the tarred road and a small artificial impoundment. The stream is being crossed by the tarred Maselspoort road, a busy road, causing significant disturbance of the stream. A small artificial impoundment has also been constructed in the stream which will have a significant impact on the flow and flooding regime and geomorphology of the stream. The stream at this crossing is therefore decreased in condition though only considered moderately modified.

The stream contains a clearly defined main channel although a quite extensive and not clearly defined floodplain is also present. The stream is significant and contains a prominent obligate wetland vegetation component although mostly confined to the main channel.

View of the stream downstream of the point of crossing. Note the relatively natural environment, though significantly modified by surrounding small holdings.

View of the culvert over the stream at the point of crossing. This also contributes to modification of the flow and flooding regime and ponding upstream of the culvert.

View of the stream upstream of the point of crossing. Note clear ponding caused by the road crossing. The flood bench is also quite visible here (red).

4.4 Anticipated impacts on watercourses

The two affected small stream systems are both affected by several impacts though not considered to such an extent as to cause modification beyond a moderate level. However, it is also clear that the stream crossings along the southern pipeline route (Route 1) is in a much better condition than the stream crossing along the northern pipeline route (Route 2). As far as

the anticipated impacts of the pipeline are concerned the northern pipeline route will therefore result in a lower level of impacts and is therefore preferred over the southern route.

Impacts on the two streams are mostly associated with the surrounding small holdings, their land uses, and numerous road crossings (Map 1). The road crossings, especially the Maselspoort tarred road, 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 Roodewal Small Holdings will also result in impacts associated with peri-urban areas including altered storm water velocity and volumes and pollutants. The small holdings are also associated with concentrated agricultural activities which will also contribute some impacts to these watercourses. Dryland and irrigated cropfields and concentrated livestock farming will result in decreased vegetation cover and consequently increased surface runoff and erosion leading to increased sediment load within watercourses. Clearing of fields to plant crops disturbs the soil surface and decreases vegetation cover which in turn increases runoff velocity and erosion which increases the sediment load within these watercourses. Together with the runoff also occurs the runoff of herbicide, pesticide and fertiliser residue and contributes pollutants and increases the nutrient level within these watercourses. Livestock farming will also decrease the vegetation layer, trampling will disturb the soil surface and increased runoff and sediment load will result. In addition, manure will increase the nutrient load within watercourses.

The proposed pipeline will result in several significant impacts on these watercourses. The material being transported by the pipeline being treated water, will have a negligible impact should leaks or spillages occur into watercourses. This is therefore not considered a likely impact. The installation of the pipeline will however 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. It is further recommended that the aboveground installation of the pipeline on pylons at crossings be done as far as possible as this will cause less disturbance. 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 (Appendix B). 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 and crossing of watercourses 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. The excavation of trenches and removal of riparian vegetation is considered to have a moderate risk in terms of the watercourse crossings whilst the crossing of watercourses by means of

pylon construction is considered to be of lower risk as the footprint and disturbance of watercourses will be lower.

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 D.

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.

4.6 Overview of terrestrial mammals (actual & possible)

Both pipeline route alternatives are situated in a degraded habitat and consequently it is considered unlikely that this area will support a significant mammal population. Small, widespread and abundant species adapted to disturbed environments is however still likely to occur.

Signs and tracks of mammals identified along the pipeline routes included the following:

Shallow foraging excavation and a small borrow of an unidentified mammal were noted although the species could not be established.

Soil mounds of the Common Molerat (*Cryptomys hottentotus*) are abundant. This is a generalist species common in peri-urban areas and consequently not of high conservation value.

Burrows and scat of the Yellow Mongoose (*Cynictis penicillata*) also occur near the old borrow pit. This species is also widespread and common and will vacate the area once construction commences.

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 routes 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 mammals. 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:

Route 1 (Southern Route)
Habitat diversity along the pipeline route is moderate. The route consists predominately of grassland with large portions still being intact and natural. The two streams also contribute significantly to habitat diversity. Due to lack of access the species diversity could not be adequately determined but is estimated as moderate.

Route 2 (Northern Route)
The route is situated entirely within the small holdings and without extensive natural areas which is therefore considered to have a relatively low habitat diversity. The two stream systems do contribute to habitat diversity but not sufficient to significantly increase this. As a result the species diversity is also considered relatively low.

Presence of rare and endangered species:

Route 1 (Southern Route)
It is considered unlikely that the route will contain any exceptionally rare or endangered species although the immediate area is known to contain several protected species and given the large portions of natural vegetation remaining along this route is highly likely to still occur here. These species include *Crinum bulbispermum, Eucomis autumnalis*, *Ammocharis coranica, Haemanthus montanus,* and *Brunsvigia radulosa.* Adequate mitigation should include conducting a walkthrough survey to identify and mark protected species along the pipeline route. It is recommended that any protected plant specimens which will be affected by the pipeline construction should be removed and transplanted adjacent to the pipeline in an area of suitable and similar habitat. Permits must be obtained for those specimens to be transplanted.

Route 2 (Northern Route)
Only small patches of natural vegetation remain along this route and the likelihood of protected species occurring is much lower. However, there is still a low likelihood of protected species occurring along the patches of remnant natural vegetation and a walkthrough survey of at least these sections should be undertaken to identify and mark protected species. Should any protected species be identified which will be affected by the pipeline construction they should be removed and transplanted adjacent to the pipeline in an area of suitable and similar habitat. Permits must be obtained for those specimens to be transplanted.

Ecological function:

Route 1 (Southern Route)
The ecological function along this route is modified to a significant degree. However, the eastern portion containing large areas of natural vegetation will be more intact than the western, transformed portion. The functioning of the small streams along this route is also much more natural both in terms of water transportation and habitat.

Route 2 (Northern Route)
The ecological function along this route has been transformed for the most part and only remnant patches of natural vegetation remain. The functioning of the two stream systems is also more modified here than along the southern route. However, the functioning of

watercourses remain highly important to the continued functioning and service provision to downstream areas and should therefore still be regarded as sensitive.

Degree of rarity/conservation value:

Route 1 (Southern Route)

According to Mucina & Rutherford (2006) the area consists of Bloemfontein Dry Grassland (Gh 5). Bloemfontein Dry Grassland is listed as a Threatened Ecosystem with a status of Vulnerable (VU) (National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)) (Map 2). The portions of remaining natural vegetation along this route therefore has a relatively high conservation value.

The two small stream systems are also mostly intact, further increasing the conservation value.

Route 2 (Northern Route)

According to Mucina & Rutherford (2006) the area consists of Bloemfontein Dry Grassland (Gh 5). Bloemfontein Dry Grassland is listed as a Threatened Ecosystem with a status of Vulnerable (VU) (National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)) (Map 2). The vegetation along this route is however mostly transformed and the natural vegetation type no longer present. This significantly decreases the conservation value.

The two small stream systems are also significantly more degraded along the route. In spite of this all the watercourses remain sensitive and have a significant conservation value.

Percentage ground cover:

Route 1 (Southern Route)

The percentage ground cover has been significantly modified, especially in the western portion where it is relatively low. However, the eastern, natural portion, is still considered to contain a relatively high percentage grass cover.

Route 2 (Northern Route)

Land use, especially livestock overgrazing, along this route has considerably decreased the percentage vegetation cover and is considered to be relatively low.

Vegetation structure:

Route 1 (Southern Route)

The vegetation structure is still intact in the eastern, natural grassland portion, but modified to a significant degree in the western portion.

Route 2 (Northern Route)

The vegetation structure has been significantly modified, mostly by an increase in tree and shrub establishment but is still considered to be moderately modified.

Infestation with exotic weeds and invader plants:

Route 1 (Southern Route)

A significant level of infestation by exotic weeds is present, especially along the western portion, but still regarded as only moderate.

Route 2 (Northern Route)
This route contains large patches of invasive species with exotic weeds abundant in many areas.

Degree of grazing/browsing impact:

Route 1 (Southern Route)

Overgrazing is relatively high in the western, small holdings, portion and decreases in the eastern portion where stocking levels are lower.

Route 2 (Northern Route)
This route is confined to the small holdings where overgrazing is relatively high.

Signs of erosion:

Route 1 (Southern Route)

Erosion is considered moderate. Impacts in the area decrease the vegetation cover which in turn leads to moderate levels of sheet erosion.

Route 2 (Northern Route)
Erosion is also considered moderate, though may be somewhat higher than the southern route.

Terrestrial animals:

Both pipeline route alternatives are situated in a degraded habitat and consequently it is considered unlikely that this area will support a significant mammal population. Small, widespread and abundant species adapted to disturbed environments is however still likely to occur.

Table 5: Biodiversity Sensitivity Rating for the proposed southern pipeline alternative (Route 1).

	Low (3)	Medium (2)	High (1)
Vegetation characteristics			
Habitat diversity & Species richness		2	
Presence of rare and endangered species		2	
Ecological function		2	
Uniqueness/conservation value		2	
Vegetation condition			
Percentage ground cover		2	
Vegetation structure		2	
Infestation with exotic weeds and invader plants or encroachers		2	
Degree of grazing/browsing impact		2	
Signs of erosion		2	
Terrestrial animal characteristics			
Presence of rare and endangered species	3		
Sub total	3	18	0
Total		21	

Table 6: Biodiversity Sensitivity Rating for the proposed northern pipeline route (Route 2).

	Low (3)	Medium (2)	High (1)
Vegetation characteristics			
Habitat diversity & Species richness	3		
Presence of rare and endangered species	3		
Ecological function		2	
Uniqueness/conservation value		2	
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		2	
Terrestrial animal characteristics			
Presence of rare and endangered species	3		
Sub total	18	8	0
Total		26	

6. Biodiversity sensitivity rating (BSR)

Table 7: Interpretation of Biodiversity Sensitivity Rating.

Site	Score	Site Preference Rating	Value
Southern pipeline route (Route 1)	21	Degraded	3

Table 8: Interpretation of Biodiversity Sensitivity Rating.

Site	Score	Site Preference Rating	Value
Northern pipeline route (Route 2)	26	Advanced Degraded	4

7. Discussion and conclusions

According to Mucina & Rutherford (2006) the area consists of Bloemfontein Dry Grassland (Gh 5). Bloemfontein Dry Grassland is listed as a Threatened Ecosystem with a status of Vulnerable (VU) (National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)) (Map 2). Large portions of this grassland has been transformed by dryland crop cultivation and urbanisation.

The pipeline routes fall within an Ecological Support Area 2, 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. This also indicates the mostly transformed nature of the area along which the proposed pipeline routes are situated.

The proposed pipeline will be constructed from the Renosterspruit, will pass through the Roodewal Small Holdings, and will join the tarred road at the north eastern border of the small holdings (Map 1). The pipeline will form part of the main water provision for the city and as such will function as transport for treated waste water to the purification plant at the Maselspoort Dam and from there back to Bloemfontein for re-use. The pipeline will cross peri-urban, transformed and natural areas, several watercourses will also be crossed by the pipeline. The assessment will include two alternative pipeline routes as well as a small additional third deviation (Map 1). Both pipeline route will have an estimated length of 5 km.

Route 1 (Southern Route)

The southern route is dominated by undulating terrain with a substantially higher degree of remaining natural vegetation present. The route will cross the tarred Maselspoort road and will mostly avoid roads, being situated along the border of small holdings. Several large natural areas occur to the south of the pipeline route (Map 1 & 2).

The southern pipeline route alternative contains sections which has been modified and transformed significantly from the natural condition and these portions are consequently of relatively low conservation value. However, several large portions of relatively natural vegetation still remain, especially in the eastern section of the pipeline (Map 1). Consisting of Bloemfontein Dry Grassland, a Threatened Ecosystem, and highly likely containing protected species, these sections should be regarded as sensitive and having a significant conservation value (Map 2). The condition of the vegetation in these sections do however seem to be somewhat degraded along the border fences which should decrease the impact the proposed pipeline will have. Adequate mitigation will however be required which should include minimising the disturbance footprint and conducting a walkthrough survey to identify and mark

protected species along the pipeline route. It is recommended that any protected plant specimens which will be affected by the pipeline construction should be removed and transplanted adjacent to the pipeline in an area of suitable and similar habitat. Permits must be obtained for those specimens to be transplanted.

Route 2 (Northern Route)

The northern route is dominated by undulating terrain with most of the natural vegetation having been transformed previously or in a quite degraded condition. Remnant patches of natural vegetation are present but overall not in a good condition. The route will be situated to the north of the tarred Maselspoort road and will also be mostly situated adjacent to an existing gravel road (Map 1). This also further decreases the condition of the vegetation along the route. This pipeline route also contains a small alternative deviation but will be discussed as a whole as it does not contain any elements different from the rest of the pipeline route.

The vegetation along the northern pipeline route has mostly been transformed from the natural condition with only a few remnant patches of natural vegetation remaining and these also not in a good condition (Map 1). The vegetation along the route is therefore no longer considered to consist of the threatened Bloemfontein Dry Grassland (Map 2). This alternative pipeline route should therefore result in a significantly lower impact than the southern alterative. However, there is still a low likelihood of protected species occurring along the patches of remnant natural vegetation and a walkthrough survey of at least these sections should be undertaken to identify and mark protected species. Should any protected species be identified which will be affected by the pipeline construction they should be removed and transplanted adjacent to the pipeline in an area of suitable and similar habitat. Permits must be obtained for those specimens to be transplanted.

Both pipeline routes will cross the Renosterspruit near the western extreme. This point of crossing has been assessed by previous studies and has therefore not been included in this assessment.

Both pipeline routes cross the same two small seasonal stream systems and these will be the subject of this study (Map 1 & 2).

From the description of the riparian vegetation of both stream systems it is clear that obligate wetland vegetation is present along both and therefore clearly indicate the presence of wetland conditions. These are more pronounced along the eastern stream, a much larger system. Exotic vegetation indicate varying degrees of disturbance at all points of crossing although in both instances the crossings along the northern pipeline route is indicative of more disturbances than the crossings along the southern pipeline route.

The determination of the condition of the watercourses along both pipeline alternatives will be based on an overall determination of the Index of Habitat Integrity (IHI) (Appendix C). Both stream systems drain into the Renosterspruit, in close proximity to each other, are mostly affected by the same impacts, are similar in their morphology and function and will affect the same downstream section. As a result, one IHI will be conducted to represent the overall condition of these stream systems. This is considered to give a good representation of their condition as both watercourses drain into the Renosterspruit and will affect the same downstream area. The IHI will be taken as representative of the Present Ecological State (PES) of these systems.

The small seasonal stream systems which will be affected by the pipeline is still natural to some extent but has been significantly modified by several impacts which is mostly associated with the surrounding small holding land uses and infrastructure such as roads. An Index of Habitat Integrity (IHI) was conducted and indicated that the watercourses have an Instream IHI of Category C: Moderately Modified and Riparian IHI of Category C/D: Moderately to Largely Modified (Appendix C).

The EI&S of the two small stream systems 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 two pipeline routes will cross the two affected stream systems twice for each alternative (Map 1 & 2). This is then a total of four crossing points.

Table 9: Summary of watercourses and the position of the pipeline crossing (Map 1 & 2).

Watercourse	Position of crossing
#1 Unnamed stream system (Route 1 – Southern Pipeline)	S 29.098819°, E 26.341101°
#2 Unnamed stream system (Route 2 – Northern Pipeline)	S 29.094865°, E 26.337133°
#3 Unnamed stream system (Route 1 – Southern Pipeline)	S 29.084928°, E 26.362107°
#4 Unnamed stream system (Route 2 – Northern Pipeline)	S 29.082766°, E 26.353049°

The proposed pipeline will result in several significant impacts on these watercourses. The material being transported by the pipeline being treated water, will have a negligible impact should leaks or spillages occur into watercourses. This is therefore not considered a likely impact. The installation of the pipeline will however 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. It is further recommended that the aboveground installation of the pipeline on pylons at crossings be done as far as possible as this will cause less disturbance. 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 (Appendix B). 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 and crossing of watercourses 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 D). The excavation of trenches and removal of riparian vegetation is considered to have a moderate risk in terms of the watercourse crossings whilst the crossing of watercourses by means of pylon construction is considered to be of lower risk as the footprint and disturbance of watercourses will be lower.

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.

- Due to a lower level of disturbance and the presence of large portions of intact and Threatened Blowmfontein Dry Grassland along the southern pipeline route (Route 1) the norther pipeline route is preferred (Map 1 & 2). Where this is not possible and the southern route is used, the following additional mitigation should be implemented:

    - The condition of the vegetation along the border fences is more degraded and the construction footprint should be minimised and retained within this area.
    - A walkthrough survey should be conducted by a qualified botanist/ecologist to identify and mark protected species along the pipeline route. It is recommended that any protected plant specimens which will be affected by the pipeline construction should be removed and transplanted adjacent to the pipeline in an area of suitable and similar habitat. Permits must be obtained for those specimens to be transplanted.

- 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 along the pipeline route as listed in Table 9 (Map 1 & 2).

- 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.

- 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.

- It is recommended that the aboveground installation of the pipeline on pylons at crossings be done as far as possible 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 construction period within and adjacent to watercourses must 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.

- 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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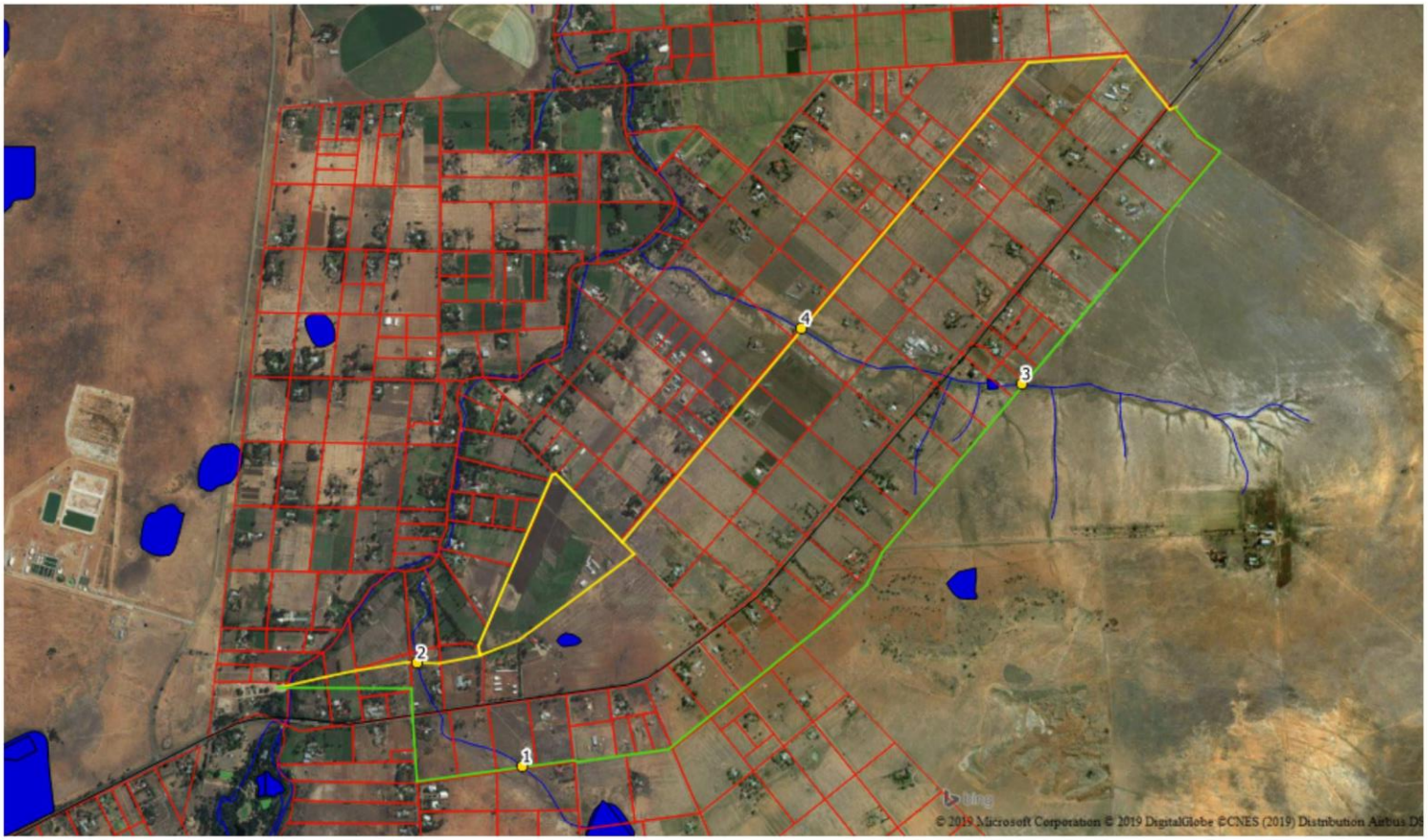
Annexure A: Maps and Site photos

Locality map for the proposed bulk water transfer pipeline in the Roodewal Small Holdings, Bloemfontein, Free State Province.



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Westdene
9301

Legend:
- Road network
- Watercourses
- Small Holdings
- Points of crossing
- Southern Pipeline (Route 1)
- Northern Pipeline (Route 2)
- Wetlands and impoundments

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:15 000

DPR Ecologists
Contact Darius van Rensburg at:
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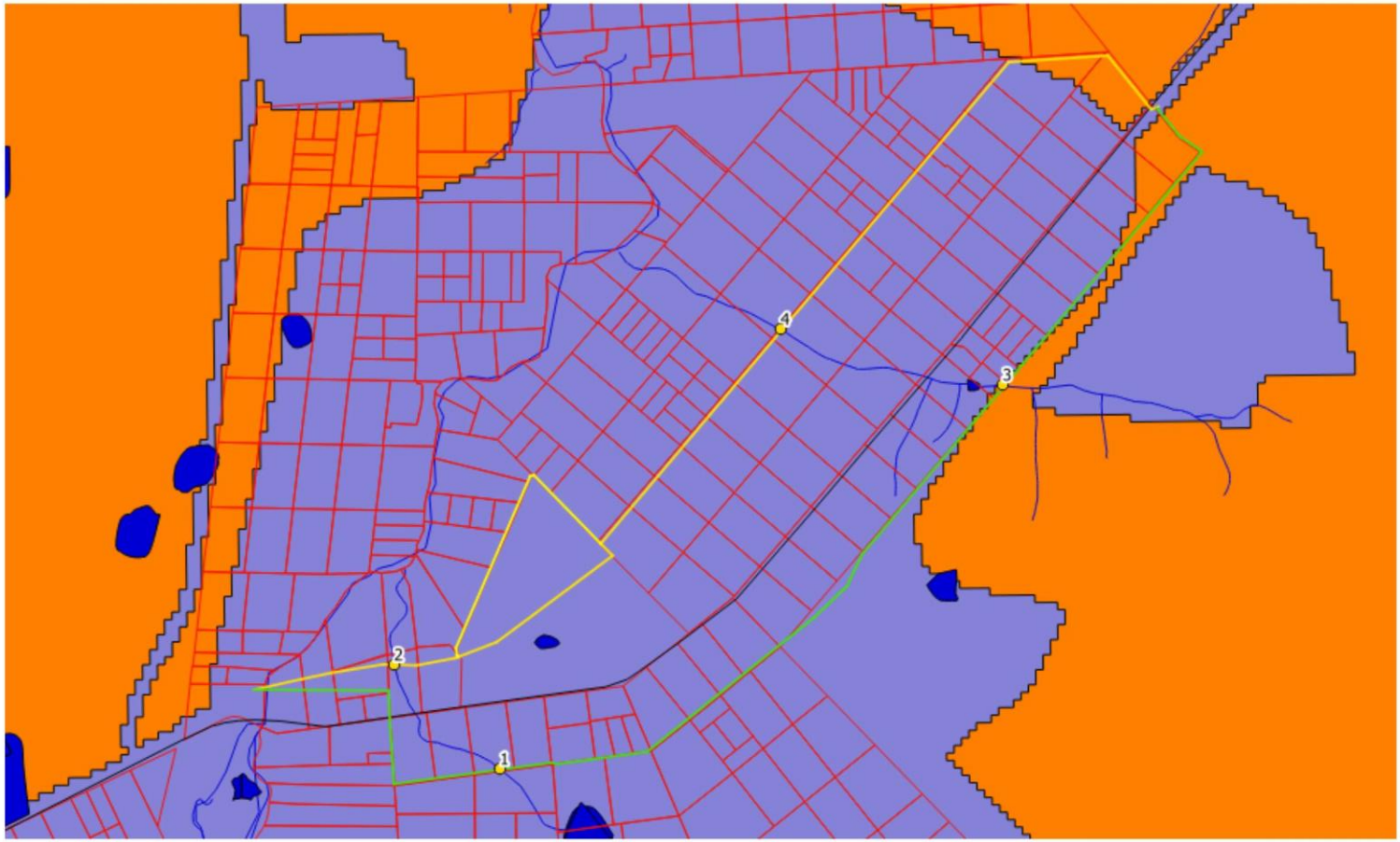
Tel: 083 410 0770

Map 1: Locality map of the proposed bulk water transfer pipeline in the Roodewal Small Holdings, Bloemfontein. The two affected small streams as well as the points of crossing by the two pipeline alternatives are indicated. It should also be clear that the northern alternative is situated in a much more transformed area as apposed to the southern route which contains extensive natural areas along the north east.

General ecology map for the proposed bulk water transfer pipeline in the Roodewal Small Holdings, Bloemfontein, Free State Province.



Preparred for:
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9 Barnes Street
Westdene
9301

Legend:
- Road network
- Watercourses
- Small Holdings
- Points of crossing
- Southern Pipeline (Route 1)
- Northern Pipeline (Route 2)
- Threatened Ecosystems
- Wetlands and impoundments
- Bloemfontein Dry Grassland

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:15 000

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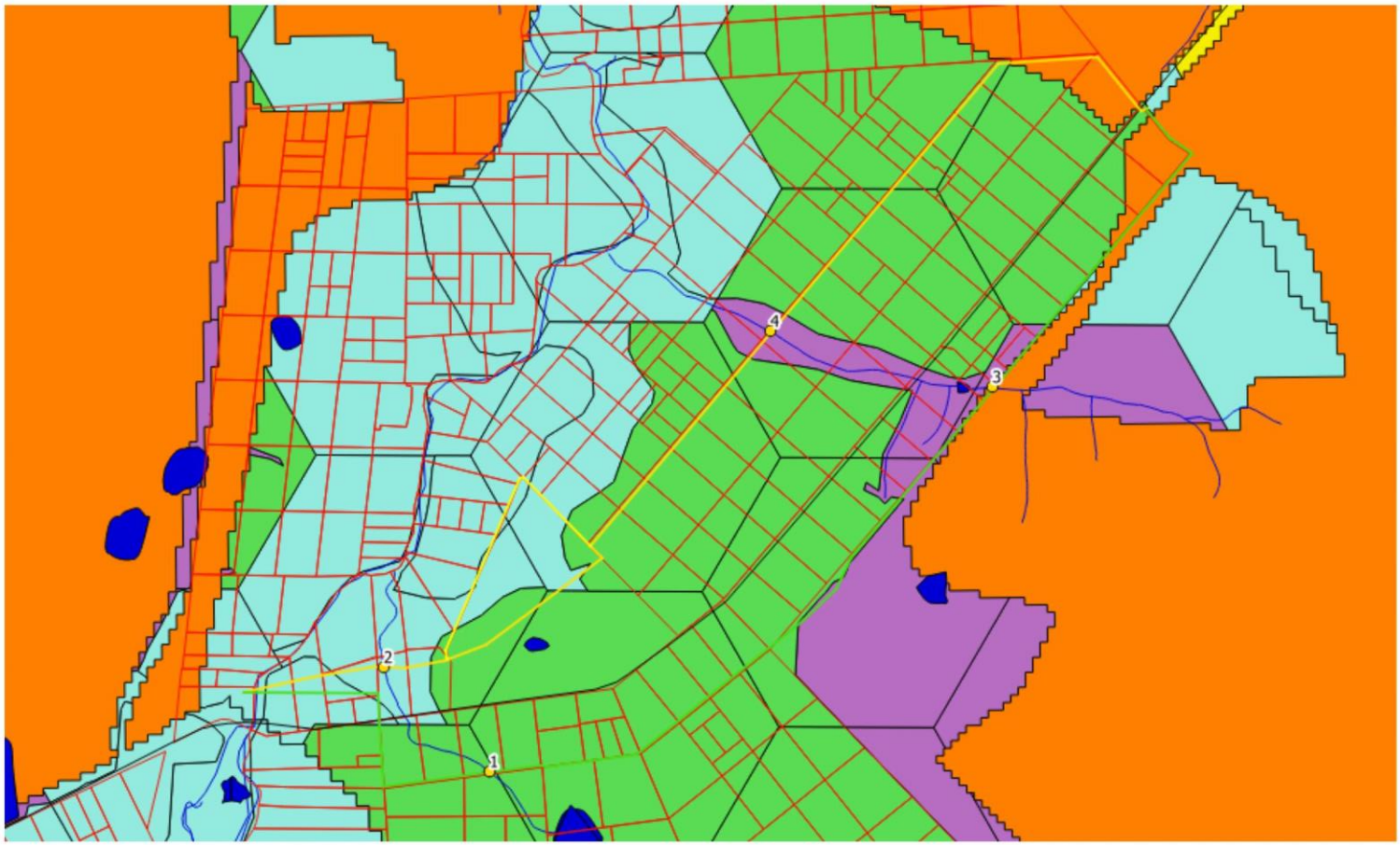
Map 2: General ecology map of the proposed bulk water transfer pipeline in the Roodewal Small Holdings, Bloemfontein. The respective pipeline alternatives and points of crossing of the two small stream systems are indicated. Portions of remaining natural vegetation, which are also regarded as being part of a Threatened Ecosystem, is also indicated. Note that these portions are mostly confined to the eastern portions of the Southern Pipeline alternative.

Free State Biodiversity Plan map for the proposed bulk water transfer pipeline in the Roodewal Small Holdings, Bloemfontein, Free State Province.



Preparred for:
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Westdene
9301

Legend:
- Road network
- Watercourses
- Small Holdings
- Points of crossing
- Southern Pipeline (Route 1)
- Northern Pipeline (Route 2)
- Threatened Ecosystems
- Wetlands and impoundments
- Critical Biodiversity Area 1
- Critical Biodiversity Area 2
- Ecological Support Area 1
- Ecological Support Area 2
- Degraded
- Other

Map Information

Spheroid: WGS 84

Quantum GIS

Scale: 1:15 000

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Map 3: Biodiversity Plan map of the proposed bulk water transfer pipeline in the Roodewal Small Holdings, Bloemfontein. Note that the Northern Pipeline alternative is mostly situated in a Degraded category whilst the Southern Pipeline alternative consists of Degraded, Other and Ecological Support Area 2 categories.

Figure 1: View of the environment along the Northern Pipeline alternative (Route 2). Note that the natural grassland is diminished and a vegetation structure dominated by dwarf karroid shrubs and trees have become established.

Figure 2: View of a portion of the Northern Pipeline alternative (Route 2). Large portions along this route consists of old agricultural fields dominated by weeds and pioneer herbs.

Figure 3: The vegetation along the Northern Pipeline alternative (Route 2) is evidently heavily degraded.

Figure 4: Remnant patches of the natural vegetation area however still present along the Northern Pipeline alternative (Route 2).

Figure 5: View of another remnant patch of natural vegetation along the Northern Pipeline alternative (Route 2) at the eastern border of the route.

Figure 6: View of the western portion along the Southern Pipeline alternative (Route 1). Patches of natural vegetation also remain here though the small holdings cause significant degradation of the vegetation.

Figure 7: As mentioned in Fig. 6 the natural vegetation along the western portion of the Southern Pipeline alternative (Route 1) has been significantly degraded as clearly indicated here.

Figure 7: The eastern portion along the Southern Pipeline alternative (Route 1) clearly still consists of natural grassland though its condition could not be accurately assessed due to lack of access.

Figure 8: The remaining natural vegetation along the Southern Pipeline alternative (Route 1) does however seem to more disturbed along the bordefences.

Figure 9: Tracks and signs of mammals along the pipeline routes include; on the left, numerous soil mounds of the Common Molerate (*Cryptomys hottentottus*) and on the right, scat of the Yellow Mongoose (*Cynictis penicillata*).

Appendix B: Likely invader weed species

Invader weed species along the pipeline routes may not be limited to these species but these are considered to be the most likely and significant invaders to occur. Additional sources should be consulted to confirm invader weed species as well as the best method to eradicate them.

According to the Conservation of Agricultural Resources Act, No. 43 of 1983 any Category 1 declared plants must be controlled by the land user on whose land such plants are growing.

	***Cirsium vulgare*** **Scotch Thistle/Skotse Dissel** **Type**: Weed **Category**: 1 Mechanical removal is effective to control this weed. Cutting should be done below soil level and no leaves should remain.
	***Argemone ochroleuca*** **Mexican Poppy** **Type**: Weed **Category**: 1 Mechanical removal by hand is effective against this weed. Several chemicals have also been registered for control: 2, 4-D, 2, 4-DB, dicamba, diuron, fluroxypyr, hexazinone, isoproturon, karbutilate, MCPA, picloram and terbutryn.
	***Verbena bonariensis/Verbena officinalis*** **Purple Top/Vervain/Blouwaterbossie** **Type:** Weed **Category:** Proposed 1b When young, weed can easily be controlled by mechanical removal by hand or with broadleaf weed herbicides. When mature plants are tough and more tolerant to herbicides.

Xanthium strumarium
Large cocklebur/Kankerroos

Type: Weed
Category: 1

Mechanical removal by hand is effective to control this weed. Cutting is not recommended as this leads to re-sprouting.

Several chemicals have also been registered for control: bromoxynil, metribuzin, cyanazine/atrazine, bendioxide, MCPB, MCPA-K and 2,4-D(A), (T), (I).

Solanum eleagnifolium
Silver-leaf Bitter Apple/Satansbos

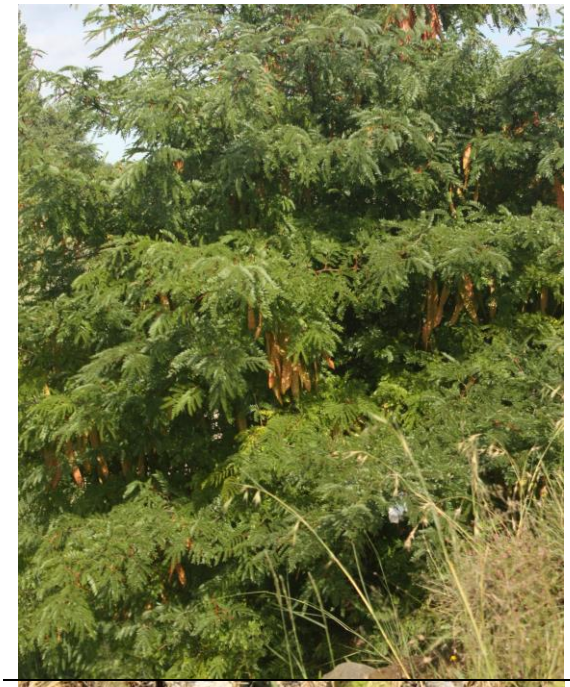
Type: Wees
Category: 1

Chemical control is most effective for control of this weed. Garlon 4 (triclopyr) is the only registered herbicide for control.

Datura ferox
Large thorn-apple/Grootstinkblaar

Type: weed
Category: 1

Mechanical removal by hand is effective for this weed.



Gleditsia triacanthos
Honeylocust/Soetpeulboom

Type: Invader
Category: 1

The species is not easily controlled by mechanical removal but is susceptible to herbicides used as cut-stump or basal bark treatments.

Opuntia humifusa
Creeping Prickly Pear

Type: Weed
Category: 1

Mechanical control is effective for single specimens. All parts of the plant must be removed and burned.

Chemical is most effective control method. Monosodium methanearsonate (MSMA) and glyphostae must be injected into the stem as concentrated solutions.

Nicotiana glauca
Wild Tobacco/Tabakboom

Type: Weed
Category: 1

Mechanical control is effective when specimens are still small.

There are no specific herbicides registered for it, but it should be susceptible to the usual herbicides

Pyracantha angustifolia
Firethorn/Branddoring

Type: Invader
Category: 1

Several herbicides are known to be effective. These include Round-up, Starane, Access, Grazon, Garlon and Brush Off.

The method of application depends on the herbicide used.

Appendix C: Index of Habitat Integrity (IHI) Summary

ASSESSMENT UNIT INFORMATION	
ASSESSMENT UNIT INFORMATION	Roodewal Pipeline
UPPER LATITUDE	S 29.098807
UPPER LONGITUDE	E 26.341049
UPPER ALTITUDE	1337 m
LOWER LATITUDE	S 29.082870
LOWER LONGITUDE	E 26.352897
LOWER ALTITUDE	1334 m
SURVEY SITE (if applicable)	
SITE LATITUDE (if applicable)	
SITE LONGITUDE (if applicable)	
SITE ALTITUDE (if applicable)	
WMA	Upper Orange
QUATERNARY	C52F
ECOREGION 2	11_10
DATE	27/06/2019
RIVER	Seasonal streams
TRIBUTARY	Renosterspruit
PERENNIAL (Y/N)	**N**
GEOMORPH ZONE	**FOOTHILL**
WIDTH (m)	**2-15**

METRIC GROUP	RATING	CONFIDENCE
HYDROLOGY MODIFICATION	1.7	2.0
PHYSICO-CHEMICAL MODIFICATION	1.3	3.0
BED MODIFICATION	2.0	4.0
BANK MODIFICATION	2.0	3.0
CONNECTIVITTY MODIFICATION	2.0	4.0
INSTREAM IHI%	64.6	
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	1.42	3.00
BANK STRUCTURE MODIFICATION	2.61	4.00
CONNECTIVITY MODIFICATION	1.84	4.00
RIPARIAN HABITAT INTEGRITY (%)	59.15	
CATEGORY	C/D	
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	1.0
Floods	-2.0
HYDROLOGY RATING	**1.7**
pH	1.0
Salts	1.5
Nutrients	1.5
Water Temperature	1.0
Water clarity	2.0
Oxygen	1.0
Toxics	1.0
PC RATING	**1.3**
Sediment	2.0
Benthic Growth	2.0
BED RATING	**2.0**
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 %	**64.6**
INSTREAM IHI EC	**C**
INSTREAM CONFIDENCE	**3.2**

	MRU
RIPARIAN IHI	
Base Flows	-1.5
Zero Flows	1.0
Moderate Floods	-1.5
Large Floods	-1.5
HYDROLOGY RATING	**1.4**
Substrate Exposure (marginal)	2.0
Substrate Exposure (non-marginal)	3.0
Invasive Alien Vegetation (marginal)	2.0
Invasive Alien Vegetation (non-marginal)	2.0
Erosion (marginal)	2.0
Erosion (non-marginal)	2.0
Physico-Chemical (marginal)	1.5
Physico-Chemical (non-marginal)	3.0
Marginal	2.0
Non-marginal	3.0
BANK STRUCTURE RATING	**2.6**
Longitudinal Connectivity	2.0
Lateral Connectivity	1.5
CONNECTIVITY RATING	**1.8**
RIPARIAN IHI %	**59.1**
RIPARIAN IHI EC	**C/D**
RIPARIAN CONFIDENCE	**3.7**

Appendix E: Risk Assessment Matrix

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

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

					Severity																	
No.	**Phases**	**Activity**	**Aspect**	**Impact**	**Flow Regime**	**Physico & Chemical (Water Quality)**	**Habitat (Geomorph+Vegetation)**	**Biota**	**Severity**	**Spatial scale**	**Duration**	**Consequence**	**Frequency of activity**	**Frequency of impact**	**Legal Issues**	**Detection**	**Likelihood**	**Significance**	**Risk Rating**	**Confidence level**	**Control Measures**
1	All Phases	Installation of bulk water transport pipeline through watercourses.	Excavation and backfilling of trenches	Excavation of trenches will impeded flow while trenches are open. Disturbance of the bed and banks will promote sedimentation.	**3**	**2**	**2**	**1**	**2**	**1**	**3**	**6**	**2**	**2**	**5**	**2**	**11**	**66**	**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.	1	2	3	3	2.25	1	3	6.25	2	2	5	2	**11**	**68.75**	**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 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	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.