MERCURY - PERSEUS 400 kV TRANSMISSION LINE

SURFACE WATER RESOURCES AND WETLANDS

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EXECUTIVE SUMMARY

Three alternatives alignments for the Mercury – Perseus Transmission line have been identified. This study investigated the surface water resources and wetlands that may be affected by the various alignments. The study area is characterised by various surface water resources. The following wetland types are found on the three alternative alignments:

- Endorheic pans;
- Riverine wetlands;
- Palustrine wetlands;
- Man-made wetlands.

Endorheic pans are important feeding and breeding habitats for various birds, amphibians and invertebrates. These unique habitats need to be preserved, due to the important role they play in the landscape. For this reason the transmission line should be located as far as possible from any pans. The transmission line should not cross the any pans.

Various rivers and streams (both permanent and ephemeral) will be crossed by the different alignments. The crossing sites range from areas with substantial floodplains and riparian zones, to areas characterised by major human impacts, resulting from agricultural activities, the presence of bridges and other transmission lines. Palustrine wetlands that will be crossed are mostly found in association with rivers and streams.
Man made wetlands, although habitat for waterfowl, are less important than the natural wetlands in the study area. The impacts on these wetlands would subsequently also be the least significant.

The construction and operation of this transmission line would have impacts on the surface water resources found in the study area. The significance of these impacts vary from low to medium. The most significant impacts would be related to surface water pollution, erosion, faunal and floral disturbance. Of particular importance is the potential collision of birds with the transmission line, especially in the vicinity of the endorheic pans, rivers, streams and associated floodplains. These wetlands function as important feeding habitats for water birds.

All the anticipated impacts can however be effectively mitigated. These mitigating measures should be incorporated into an Environmental Management Plan. This EMP should be made binding on the client, contractors, subcontractors and their personnel. The EMP should also include an auditing programme for the construction and operational phase.

An analysis of the alternatives was based on the following aspects:

- Number of sensitive wetlands found in close proximity of each alternative;
- The length of the different alternatives;
- The environmental status quo associated with the different alignments.

Based on above aspects Alternative 1 is recommended as the preferred option.

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1. INTRODUCTION

As a signatory to the Ramsar Convention (Convention on Wetlands of International Importance especially as Waterfowl Habitat) South Africa has accepted a number of international obligations in terms of wetland conservation. The National Department of Environmental Affairs and Tourism, which is the responsible authority for the implementation of the Convention in conjunction with other national authorities, is obliged to promote the philosophy of the Ramsar Convention and to encourage the protection and wise use of South Africa's wetlands. In broad terms the Ramsar Convention is based on the protection of wetlands through conservation and wise use. As custodians of these habitats and scarce resources, private landowners and developers are also responsible for the conservation and wise use of wetlands. Practices that result in wetland degradation should be avoided, unless effective mitigating measures can be implemented. This is currently not the standard practice in South Africa, and as a consequence large-scale wetland loss is still taking place through irresponsible development and farming practices.

The issue of wetland degradation is not adequately addressed by merely preventing development within the boundaries of a wetland. Rather, wetland degradation is a catchment-based problem; by reducing water flow and degrading water quality - the lifeblood of wetlands, wetland functioning is severely impeded. Wetland loss is not always a result of on-site impacts, but often results from poor management of the catchment areas feeding the wetland.

South Africa is characterized by rainfall that is both temporally and spatially variable. This temporal variance results in South Africais wetlands being characterized by various ephemeral wetlands. Wetlands are commonly defined as areas with waterlogged soils dominated by emergent vegetation (Davies and Day, 1998). The formal definition of Wetlands according to article 1.1 of the Ramsar Convention is the following:

"*areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.*" In addition article 2.1 of the convention states that wetlands "*may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands*". From this it is clear that this definition extends to a wide variety of habitat types including rivers, shallow coastal waters etc. This definition has been adapted by Cowan (1998) for use under South African conditions and is reflected in Table 1.

Table 1.1. Wetland classification (From Cowan and Van Riet, 1998.).

Marine	**subtidal**	1	sea bays, straits
		2	subtidal aquatic vegetation
		3	coral reefs
	intertidal	4	rocky marine shores, including cliffs, rocky shores
		5	shores of mobile stones and shingle
		6	intertidal mud, sand or salt flats
		7	intertidal marshes
		8	intertidal mangroves
Estuarine	**subtidal**	9	estuarine waters
	intertidal	10	intertidal mud, sand or salt flats
		11	intertidal marshes
		12	intertidal forested wetlands
(Lagoonal)		13	brackish to saline lagoons
INTERIOR WETLANDS			
Endorheic		14	permanent and seasonal, brackish, saline or alkaline lakes
Riverine	**Perennial**	15	rivers and streams including waterfalls
		16	inland deltas
	Seasonal	17	seasonal rivers and streams
		18	riverine floodplains
Lacustrine	**Permanent**	19	permanent freshwater lakes ($\geq$ 8ha)
		20	permanent freshwater ponds, pans ($\leq$ 8ha)
	Seasonal	21	seasonal freshwater lakes ($\leq$ 8ha)
		22	seasonal freshwater ponds, pans ($\geq$ 8ha)
Palustrine	**Emergent**	23	permanent freshwater marshes and swamps
		24	permanent peat-forming freshwater swamps
		25	seasonal fresh water marshes
		26	peatlands and fens
		27	alpine and polar wetlands
		28	springs and oases
		29	volcanic fumaroles
	Forested	30	shrub swamps
		31	freshwater swamp forest
		32	forested peatlands
MAN-MADE WETLANDS			
Aquaculture/mariculture		33	aquaculture ponds
Agriculture		34	irrigated land including rice fields
		35	seasonally flooded agricultural land
Salt exploration		36	salt pans and evaporation pans
Urban/industrial		37	excavations
		38	wastewater treatment areas
Water storage areas		39	reservoirs
		40	hydro-dams

2. BACKGROUND AND BRIEF

The purpose of this study was to assess the wetlands / surface water resources found on the alternative alignments of the Mercury-Perseus Transmission Line proposed between Vierfontein and Dealesville in the north-western Freestate. This entailed the following:

1. A description of the status quo of the wetlands / surface water resources;
2. Identification of sensitive / unique wetlands / surface water resources;
3. Identification of potential impacts on these wetlands / surface water resources;
4. Identification of mitigation measures to preserve these wetlands;
5. Recommendations regarding the most feasible route that will result in the least impacts on the surface water resources.

3. STUDY APPROACH

3.1 Information base (source)

The information used in this study was based on the following:

1. A literature review;
2. A site visit;
3. Professional judgement based on experience gained with similar projects.

3.2 Assumptions

Surface water resources are synonymous as all wetlands in the study area. The definition of wetlands as defined by Cowan and Van Riet (1998) are used in this study and reflected in Table 1. The surface water resources investigated in this assessment was limited to pans, dams, rivers and drainage-line.

3.3 Limitations

Although extensive ground truthing was undertaken, access to all the surface water resources was limited due to the following:

1. The scale of the project;
2. The proposed alignments cross mostly private property onto which, in some instances, no access could be gained;
3. The proposed alignments sometimes crossed inaccessible areas i.e. through agricultural fields. This was further complicated by the heavy rainfall that occurred in the study area during ground truthing, making access roads inaccessible in some instances.

This however did not limit the level and reliability of the information acquired.

3.4 Glossary of terms

Study area: Refers to the entire study area encompassing all the alternative alignments as indicated on the study area map.

Corridor: Refers to a specific alignment as numbered on the study area map (1 – 3)

Alternative alignment: Refers to a specific alignment (1 – 3) with one of the variations (a-b)

Proposed servitude: Refers to the proposed final alignment that the transmission line should follow.

Transmission line: Pylons support the 400 kV transmission line consisting of two steel support structures (supported by guy wires). Transmission lines area suspended between the supports.

Sub-station: A distribution point within the local and national network from which electrical current is rerouted along different power lines as well as distributed to local and municipal networks.

Endorheic: Inward draining.

3.5 List of abbreviations

EIR	Environmental Impact Report
DEAT	Department of Environmental Affair and Tourism
DTEEA	Department of Tourism, Environmental and Economic Affairs
TDS	Total Dissolved Solids
SASS 5	South African Scoring System version 5
ASPT	Average Score Per Taxon
IHAS	Integrated Habitat Assessment
SIC	Stones In Current
SOOC	Stones Out Of Current
ECO	Environmental Control Officer
EMP	Environmental Management Plan

3.6 Methodology

3.6.1 Literature surveys

A detailed literature search was undertaken for the surface water resources in the study area, with the help of the Waterlit database, which is maintained by the Water Research Commission (www.wrc.org.za) in Pretoria and a general internet search.

3.6.2 Ground truthing

Ground truthing entailed a visual assessment of the surface water resources (rivers, pans and dams) found in the study area.

In addition, limited physico-chemical water parameters (conductivity, TDS, pH and temperature) were measured with a hand-held conductivity, pH meter at selected sites.

A limited bio-monitoring assessment was done to determine the ecological state of the Vet and Vals River. This entailed the use of the SASS 5 and IHAS methodology as prescribed by the River Health Programme (http://www.csir.co.za/rhp/).

3.6.2.1 Biomonitoring study

The South African Scoring System version 5 (SASS 5) rapid bioassessment protocol can be used to assess the ecological integrity of a river or stream. The occurrence of different macroinvertebrate families in a river, is used as a measure of the general ecological integrity of the aquatic ecosystem.

SASS 5 has been specifically developed for South African conditions and provides a simple and rapid protocol for biological assessment of water quality. It is therefore ideally suited for assessing impacts of mining, industry and the presence of dams on rivers and streams. SASS 5 has been recommended on a national level in the National Rivers Health Programme as one of the tools for assessing the health of rivers. Due to its national applicability it is therefore recommended that this rapid bioassessment method be used as part of a biomonitoring programme.

SASS 5 is based on a series of assumptions regarding the change in macroinvertebrate assemblages resulting from different levels of environmental degradation. This protocol attempts to quantify the relative quality of a macroinvertebrate community on a specific temporal and spatial scale.

The advantages of SASS5 are its rapidness and the relative ease of us with which it can be used, the simplicity of the results (in the form of two values) and its repeatability. Some of the disadvantages and limitations of SASS5 includes its ability to only indicate water quality problems and not being able to identify reasons for a decline in water quality. The biotope (habitats) availability also affects the final SASS 5 scores, as a lack of habitats can result in less biota being present.

Macroinvertebrates are collected through selective kick sampling. This entails holding a net with a mesh size of 1 mm downstream of an area that is agitated with the feet allowing the animals to drift into it. The following habitats (biotopes) are sampled (if available):

- stones in current (SIC);
- stones out of current (SOOC);
- bedrock;
- gravel;
- sand;
- mud;
- fringing vegetation.

The specific sampling protocol for each biotope is reflected in the SASS 5 score sheet. The contents of the net are tipped into a tray and the different families identified. Each macroinvertebrate family has a specific score depending on the “sensitivity” of the family to environmental degradation. The higher the score, the more sensitive the family. Each family encountered at a site is recorded on a score sheet and all the scores are totalled. The totalled SASS 5 score reflects the integrity of the aquatic ecosystem at that specific site and time.

Due to different macroinvertebrate families carrying different weights (scores), the average score per taxon (ASPT) is used to standardise the scores. The ASPT is generated by dividing the total SASS 5 score by the number of families that were recorded at each site. This prevents that a site that has a high score due to the presence of one or two high scoring families reflecting the same "health" as a site with many low scoring families. The presence of many low scoring families indicates that there is an impact on water quality resulting in only species that are hardy to environmental degradation being present. This is due to the fact that they out-compete the more sensitive species by being better adapted for survival in degraded environments.

Chutter (1998) found that the ASPT is an increasingly unreliable indicator of water quality when SASS 5 scores drop below 50, consequently this score should be interpreted with caution when assessing the biotic integrity of a study area.

Table 3.1. Condition classes for the different Biomonitoring protocols used in this study.

IHAS (%)	SASS 5	ASPT	CONDITION
74-100	>140	>7	Excellent
59-74	100-140	5-7	Good
45-59	60-100	3-5	Fair
30-45	30-60	2-3	Poor
<30	<30	<2	Very Poor

The Integrated Habitat Assessment System (IHAS) have been developed by Peter McMillan of Environmentek (CSIR) in order to integrate a habitat score into the SASS 5 scores, thereby projecting a SASS 5 score to a situation where sampling was done in ideal habitat conditions. This is done because perfect sampling habitat conditions seldom exist (especially in modified environments like Midrand) and sampling has to be done in the available habitats. The original SASS 5 score still stands as the official figure for a specific site. The modified figure is still under development and is only supplementary. It should only be used to compare different sites with different habitat characteristics, or to project values to "ideal" sampling conditions (McMillan, 1998). These modified values are not used in this report.

This habitat scoring system is based on 100 points (or %) and is divided into two sections: the sampling habitat (55 points) and the stream characteristics (45 points). The sampling habitat is further broken down into three sub-sections: Stones in current (20 points), vegetation (15 points) and other habitat / general (20 points). Generally the higher the value, the better the habitat.

4. STUDY AREA

The study area falls within drainage region C of South Africa in the Vaal River catchment (Midgley, Pitman, and Middleton, 1994). The different alignments proposed cross the following quaternary catchments (asterisk indicates catchments with endorheic areas) and are reflected in Figure 1:

- C24B,
- C24J*,
- C70K*,
- C60J*,
- C25C,
- C25B*,
- C25F*,
- C43B*,
- C43C*,
- C43A*,
- C52K*.

From this it is clear that various endorheic areas are found within the study area.

The mean annual rainfall in the study area varies between 300 mm and 600 mm, mean annual S-Pan evaporation varies between 1700 and 2000mm and run-off between 2.5 and 50 mm (Midgley, Pitman, and Middleton, 1994). The study site is situated on soils that have high to medium erodibility (Midgley, Pitman, and Middleton, 1994).

The wetlands found on all three the alternative alignments, are fairly uniform and typical of the western Freestate. The study area is arid towards the south - west, and characterised by thornveld where cattle and game farming is the main activity. Towards the north - east, the area is less arid and characterised by crop production.

4.1. Description of affected environment

Based on the classification system of Cowan and Van Riet (1998), the following wetland types are found in the study area and would be exposed to the anticipated impacts:

- Endorheic – permanent and seasonal, brackish, saline or alkaline lakes, flats, pans and marshes
- Riverine – perennial and seasonal rivers;
- Emergent Palustrine – permanent freshwater marshes and swamps;
- Water storage areas – man made dams.

The endorheic pans are predominantly located in the Dealesville, Bultfontein and Wesselsbron areas. The Vet and Vals River are the main riverine wetlands in the study area. Smaller tributaries to these rivers include the Klein Kalkspruit, Barberslaagte, Dermnspruit, Sandspruit, Otterspruit and Olifantsdrift (Figure 2). Most of these tributaries are perennial. Emergent palustrine wetlands are associated with these rivers, tributaries, drainage lines and the pans. A limited number of dams are also located along the three alternative routes.

4.1.1 Endorheic Pans

Pans, usually have circular or oval shapes, are shallow (less than 3 metres deep) and have a closed drainage system. The major way of water loss is through evaporation, which in part, results in their saline nature (Cowan and Van Riet, 1998). Pans are important waterfowl habitats, especially for migratory birds. According to Cowan and Van Riet (1998), pans can be differentiated into the following:

- *"Salt pans which are dry for most of the time but may contain perennial pools filled by springs;*
- *Temporary pans are also dry for long periods and are moderately saline. They are flooded during the rainy season;*
- *Grass or Diplachne pans are seasonal and dry up in the dry season. They are covered by a thick growth of hygrophilous grasses and other low terrestrial vegetation. Their waters are fresh to slightly saline: and*
- *Reed pans and Sedge pans are temporary or semi-permanent, with dense stands of Phragmites and Cyperaceae."*

In excess of 150 pans occur in the general study area between Dealesville and Vierfontein. The number of pans present on or close to each of the alternative alignments are summarised in Table 1. The size, permanence of water and level of human impact on these pans varies considerably. The pan sizes vary between approximately 300 m^2 and 400 000 m^2. Most of the pans are temporary (Figure 3), although some of the larger pans like the Bultfontein Pan (Figure 4) seem to hold water on a more permanent basis. It is anticipated that this pan would be completely dry during droughts / dry spells. In addition Salt pans, Grass pans (Figure 5) and Reed pans (Figure 6) are also found in the study area. These pans are exposed to various degrees of human impacts including the presence of towns in close proximity of pans (Bultfontein and Wesselsbron), salt mining, agricultural activity (Figure 7), powerlines and roads (Figure 8).

These pans act as an important wildlife habitat, especially for birds, mammal species and invertebrates. The invertebrate component, especially branchiopods like tadpole shrimps, clam shrimps, fairy shrimps etc. found in the endorheic pans, has evolved as a result of the extreme conditions in which they have to survive. These conditions can change from complete desiccation in one instance to completely flooded conditions. Such conditions have resulted in the evolution of very unique animals. The uniqueness of biotic and abiotic components is the main reason for the conservation of these aquatic ecosystem. The major problem these invertebrates have to deal with include the following (Davies and Day, 1998):

1. Growing rapidly enough to be able to reproduce before the pond dries;

2. Surviving the deteriorating conditions in the shrinking pond so as to go on reproducing for as long as possible;
3. Hatching at an appropriate time.

In addition, amphibians like the giant bullfrog (*Pixycephalus adspersus*) occur in temporary pans in the central and western Freestate. According to Mr. Maitland Seaman[1] this species has been recorded in the pans situated in the study area. This species is of particular conservation importance as it is being considered for red data status.

Table 4.1. The number of pans present on or in close proximity (within 1000 metres) to each of the three alternative alignments.

	Dealesville to Wesselsbron	Wesselsbron to Vierfontein	Total
Alternative 1	45	17	62
Alternative 1C	na	none	
Alternative 2	75	21	96
Alternative 2A	6	na	6
Alternative 2B		1	1
Alternative 3	61	28	89

Alternative 1

A total of approximately 62 pans are found on this alternative alignment. This alternative passes approximately 45 pans of various shapes and sizes between Dealesville and Wesselsbron. The largest pan in close proximity to this alternative alignment is Annaspan, approximately 3 kilometres north of Dealesville. A series of smaller pans occur in close proximity to this alternative between Dealesville and Bothaville. Impacts on these pans will be fairly limited due to the presence of existing anthropogenic impacts in the form of existing electrical transmission lines and a gravel road that runs along the largest portion of this alternative alignment (Figure 3).

Between Wesselsbron and Vierfontein this alternative alignment passes approximately 17 pans, in an area that is predominantly used for crop production (Figure 9). No pans are located close to Alternative 1C.

Alternative 2

A total of approximately 96 pans will be passed by this alternative alignment. This alternative will pass approximately 75 pans of various shapes and sizes between Dealesville and Wesselsbron, the largest of which is the Bultfontein Pan (Figure 4). This pan forms part of a pan complex adjacent to Bultfontein. Although this alternative will roughly follow an existing transmission line and be aligned next to the Bultfontein – Wesselsbron road (R719), it will pass more pans in the south western section of the study area

[1] Centre for Environmental Management, University of the Freestate

than alternative 1. In addition it will pass in close proximity to the Bultfontein pan complex, which acts as an important local and regional feeding habitat for flamingos (Figure 4). Impacts of this alternative on the pans will be of more significance than impacts associated with alternative 1, due to the number of pans it will pass and the importance of the Bultfontein pan complex as a feeding ground for flamingos.

Alternative 2A will pass to the north of Bultfontein, thereby circumventing the Bultfontein pan complex. This alternative will be in close proximity of approximately six pans.

Between Wesselsbron and Vierfontein this alternative passes approximately 21 pans. Most of these pans are situated in maize fields but still play an important role as a feeding habitat for birds, mammals and invertebrates. These pans are under more pressure, than those found in the south western part of the study area, due to the proximity of crops and the associated increase in nutrient levels due to the addition of fertilisers.

Alternative 2 B will pass only one pan, but will cross a drainage line at the linkage point with route 1 (Figure 10) in the vicinity of the Vals and Vaal River confluence.

Alternative 3

A total of 89 pans will be passed by this alignment of which 61 pans are situated between Dealesville and Wesselsbron and 28 between Wesselsbron and Vierfontein. The pans on this alignment are also of various shapes and sizes, the largest of which is Annaspan at Dealesville. This alignment has the most salt works, and is further characterised by game farming activities between Dealesville and Wesselsbron.

4.1.2 Rivers and palustrine wetlands.

Riverine wetlands include perennial rivers and streams, inland deltas, seasonal rivers and streams and riverine floodplains (Cowan and Van Riet, 1998). Rivers are exposed to anthropogenic impacts, including water abstraction, pollution, flow reduction due to dams etc. All three alternative alignments cross the Vet and the Vals Rivers as well as a limited number of smaller tributaries and drainage lines. The crossing points, on the Vet and Vals Rivers, are characterised by the presence of a riparian zone and floodplain area. The palustrine wetlands include, but are not limited to, these riparian zones and floodplains. The level of existing impacts on the riparian zones and floodplains at the alternative crossing points differ. The number of rivers that each alternative traverse are summarised in Table 4.2.

Table 4.2. The number of rivers crossed by the three alternative alignments. The number in brackets indicates the ephemeral streams.

	Dealesville to Wesselsbron	Wesselsbron to Vierfontein	Total
Alternative 1	2	3 (2)	5, (2)
Alternative 1C	na		
Alternative 2	1 (1)	3 (2)	4 (3)
Alternative 2A	1	na	1
Alternative 2B	na	1	1
Alternative 3	1 (6)	4 (2)	5, (8)

Table 4.3 reflects limited biomonitoring and physico-chemical water quality results collected during the field survey of February 2003. Due to time constraints only one site was investigated on the Vals River and one on the Vet River. The position of these sampling points is indicated in Figure 2.

Table 4.3. Biomonitoring and limited water quality data for the Vet and Vals River collected during February 2003.

	Vet River (BM 1 in Figure 2)	Vals River (BM 2 in Figure 2)
Physico-chemical water quality		
PH	7.68	8.3
Conductivity (ms/cm)	0.85	0.7
Total Dissolved Solids (ppt)	0.33	0.31
Temperature (^{o}C)	22.8	24.9
Biomonitoring Results		
SASS 5	35 (Poor)	67 (Fair)
Number of families	8	16
ASPT	4.4 (Fair)	4.2 (Fair)
IHAS	43 (Poor)	49 (Fair)

The physico – chemical water quality parameters indicate conditions that would be expected in rivers of the western Free State. These rivers are characterised by high silt loads and subsequent turbidities. The high silt load also resulted in relative high conductivity and TDS levels. The temperature and pH values also reflect expected conditions of typical rivers of the Free State.

The biomonitoring study indicates that the Vet River at the sampling site is in a poor condition, based on the SASS 5 results. The habitat integrity is also poor, based on the IHAS results. The Vals River has fair conditions based on the SASS 5 results and the IHAS results. At both sites major erosion has taken place, resulting in exposed stream banks, with limited vegetation. The level of erosion decreases as one moves further into the riparian zone and associated floodplain. It is important to keep in mind that these results were attained at sites that have been impacted on by human activities in the form of bridges, railway lines and agricultural activities. The sampling habitats were also not ideal as no stone biotopes were available at both sites. Only sand, mud and marginal vegetation was sampled.

Alternative 1

This alignment will cross the Vet River approximately 8 kilometres west of Tierfontein and approximately 20 kilometres west of Wesselsbron (Figure 2). The area is characterised by agricultural activities that includes livestock and crop production. This alternative will run adjacent to the Derm Spruit (Figure 11), which is a tributary of the Vet River. A substantial floodplain area is present at the Vet River crossing point.

The Vals River is crossed adjacent to the confluence with the Vaal River at Balkfontein. There is already an overhead electrical line across the Vals River at this crossing point (Figure 12). The area is further characterised by the presence of a water abstraction and treatment plant and agricultural activities. These human activities have resulted in substantial bush encroachment in the riparian zone at the crossing point.

The Sandspruit is crossed approximately halfway between the Vals and Vet River crossing point (Figure 13). This area is characterised by farming activities, and the crossing point by a marsh with a low level bridge. Approximately four kilometres north-east of the Sandspruit an ephemeral stream is also crossed.

Alternative 2

This alignment will cross the Vet River at Tierfontein, adjacent to an existing railway line and the main tar road between Wesselsbron and Bultfontein (R719). The crossing point is therefore already influenced by anthropogenic activities, which have resulted in substantial bush encroachment, the presence of exotic invader plants in the riparian zone as well as major erosion of the streambanks (Figure 14). A prominent floodplain can also be distinguished in the vicinity of this crossing (Figure 15).

The Sandspruit is crossed at the Schoonspruit station approximately 20 kilometres west of Bothaville (Figure 16). The crossing point is also characterised by the presence of a railway and road bridge.

This alignment will cross the Vals River approximately 10 kilometres, south of Bothaville on the Bothaville – Allanridge Road. The crossing point is characterised by substantial agricultural activities, including intensive maize production.

Alternative 2A will not cross any streams or rivers, but will run adjacent to a drainage line that drains into the Bultfontein pan.

Alternative 3

Approximately 6 ephemeral streams will be crossed between Dealesville and Wesselsbron. Most of these streams drain into pans. These streams are in some instances highly impacted by surrounding agricultural activities. One such stream drains into Annaspan in the Dealesville district. Due to agricultural activities on the sandy soils encountered in this area, major sedimentation of the stream channel has taken place (Figure 17).

This alignment will cross the Vet River approximately 10 kilometres west of Tierfontein. This area is also characterised by livestock keeping and crop production. The riparian zone and floodplain is fairly undisturbed (Figure 18), due to the soils not being optimal for the growth of maize.

The Vals River is crossed by this alignment approximately 10 kilometres south of Bothaville, while the Sandspruit is crossed at Boesmanskop in the vicinity of Allanridge. Both these areas are characterised by intensive maize production. The riparian zone and floodplain at these crossing points have been invaded by exotic vegetation.

4.1.3 Earth Dams

Man-made wetlands in the form of dams have had a profound impact on wetlands in South Africa. Dams change flow patterns in rivers and inundate natural wetland systems.

Earth dams also occur in close proximity to the three alternative alignments. Although the dams have primarily been constructed as a result of the agricultural activities, they do play a role as a wildlife habitat, especially for birds (Figure 19). The number of dams in the study area are summarised in Table 4.4. These dams are all earth dams, usually constructed within a stream or drainage line.

Table 4.4. The number of dams found on the three alternative alignments.

	Dealesville to Wesselsbron	**Wesselsbron to Vierfontein**	**Total**
Alternative 1 **Alternative 1C**	5 earth dams na	7 earth dams	12 earth dams
Alternative 2 **Alternative 2A** **Alternative 2B**	16 earth dams 5 earth dams	6 earth dams na 1 earth dam	22 earth dams 5 earth dams 1 earth dam
Alternative 3	13 earth dams	8 earth dam	21 earth dams

Alternative 1

Approximately 12 earth dams are found on this alternative alignment. Five of these are found between Deaslesville an Wesselsbron, while seven are located between Wesselsbron and Vierfontein. No earth dams are situated in close proximity of Alternative 1C.

Alternative 2

A total of 22 earth dams are found on or in close proximity to this alternative alignment. Sixteen of these are located between Dealesville and Wesselsbron and 6 between Wesselsbron and Vierfontein. Five earth dams are located on Alternative 2A between Dealesville and Wesselsbron, while one is located on Alternative 2B.

Alternative 3

Approximately 21 earth dams are located on this alternative alignment. Thirteen of these are located between Dealesville and Wesselsbron, while eight are located between Wesselsbron and Vierfontein.

5. IDENTIFICATION OF RISK SOURCES

The tables below lists the possible risks and their sources for both the construction and operational phase.

Table 5.1. Risk during construction phase

Possible Risks	Source of the risk
Actually identified risks	
Erosion of stream banks, floodplains and pans	Movement of vehicles. Movement of workforce. Construction method.
Sedimentation of streams and rivers	Movement of vehicles. Movement of workforce. Construction method.
Faunal disturbance.	Movement of vehicles. Workforce activities. Construction activities.
Floral disturbance (riparian zone, floodplains, pan perimeter).	Movement of vehicles. Workforce activities. Construction activities.
Anticipated risks	
Surface water pollution	Oil and fuel spills from construction vehicles. Construction material (i.e. concrete, solvents, paints etc.). Workforce activities.
Faunal disturbance.	Workforce activities.

Floral disturbance (riparian zone, floodplains, pan perimeter).	Workforce activities.
Change in hydrological regime on a micro scale.	Presence of transmission line pylons.

Table 5.2. Risks during operation phase.

Possible Risks	**Source of the risk**
Actually identified risks	
Erosion of stream banks, floodplains and pans	Movement of maintenance vehicles. Movement of maintenance personnel. Maintenance activities.
Sedimentation of streams and rivers	Movement of maintenance vehicles. Movement of maintenance personnel. Maintenance activities.
Faunal disturbance.	Movement of maintenance vehicles. Movement of maintenance personnel. Maintenance activities. Presence of transmission lines.
Floral disturbance (riparian zone, floodplains, pan perimeter).	Movement of vehicles. Movement of maintenance personnel. Maintenance activities. Presence of transmission lines.
Disturbance of hydrological regime (micro scale) in floodplains, riparian zone, pans.	Presence of transmission line pylons
Anticipated risks	
Surface water pollution	Oil and fuel spills from maintenance vehicles. Activities of maintenance personnel. Maintenance activities.

6. IMPACT DESCRIPTION AND ASSESSMENT

Table 6.1: Impacts on study area.

Stage in project lifecycle	Extent	Duration	Intensity	Probability of occurrence/ risk	Significance		Confidence
					WOMM	WMM	
Erosion of stream banks, floodplains and pans	Local	Medium	Medium	Probable	Medium	Low to medium	High
Sedimentation of streams and rivers	Regional	Short	Medium	Probable	Low to medium	Low	Medium
Faunal disturbance.	Local	Short	Medium	Highly Probable	Low to medium	Low to medium	High
Floral disturbance (riparian zone, floodplains, pan perimeter).	Local	Medium	Medium	Highly Probable	Low to medium	Low to medium	High
Surface water pollution	Regional	Short	Medium	Probable	Low to medium	Low to medium	Medium
Disturbance of hydrological regime (micro scale) in floodplains, riparian zone, pans	Local	Short	Medium	Probable	Low to medium	Low to medium	Medium
Erosion of stream banks, floodplains and pans	Local	Long	Medium	Probable	Low to medium	Low	Medium
Sedimentation of streams and rivers	Regional	Long	Medium	Improbable	Low to medium	Low	Medium
Faunal disturbance.	Local	Long	Low	Probable	Low to medium	Low	Medium
Floral disturbance (riparian zone, floodplains, pan perimeter).	Local	Long	Low	Probable	Low to medium	Low	Medium
Disturbance of hydrological regime (micro scale) in floodplains, riparian zone, pans.	Local	Long	Medium	Probable	Low to medium	Low to medium	Medium
Surface water pollution	Regional	Long	Low	Improbable	Low to medium	Low	High

WOMM: Without mitigation measures
WMM: With mitigation measures

6.1 Construction Phase

6.1.1 Erosion of stream banks, floodplains and pans

Access of construction vehicles and construction personnel onto the stream banks, floodplains and pans can result in the onset of erosion. The clearance of vegetation will reduce the capacity of the land surface to retard the flow of surface water, thus decreasing infiltration, and increasing both the quantity and velocity of surface water runoff and erosion. Human activities, which disturb the soil structure, such as the compaction of soil along footpaths and vehicle tracks, and the disturbance of soil structure through movement of soil, can result in increased susceptibility to erosion. Roads and pathways created during the construction phase have the potential to become preferred drainage lines, resulting in gully erosion.

6.1.2 Sedimentation of streams and rivers

Clearance of existing vegetation will expose the upper layers of the soil horizon to soil erosion. The transport of eroded soil into the surface water resources, especially the rivers will impact on water quality. The movement of construction vehicles and personnel, can also result in the onset of erosion and associated sedimentation of streams and rivers. The stockpiling of excavated earth and construction materials can result in contamination of runoff, through erosion of stockpiles.

6.1.3 Faunal disturbance.

During the construction phase, the habitat of the majority of fauna that frequents the construction sites could be damaged or destroyed. Accordingly, these animals can be expected to migrate from the area. As the construction activities will be of relatively short duration and of limited extent, most animals will be able to migrate back. The riparian zone is an important corridor for the movement of wildlife, and as such the construction activities may temporarily impact on the movement of certain faunal species along the riverine corridor. The construction related activities that will result in a deterioration of the water quality, will ultimately influence aquatic species such as macro-invertebrates, fish, amphibians and birds. This impact would however be limited in terms of duration. The construction activities, if not properly managed, can potentially result in a change in the streambed characteristics through sedimentation, litter and construction rubble, which will ultimately result in the disappearance of certain faunal components like fish and macro-invertebrates that require specific habitat conditions. The presence of the transmission line can impact on the birdlife found in and around the pans, especially those that are important feeding habitats for flamingos.

The pans in the western Free State are known for their unique invertebrate composition. Construction activities within the pans or even on the perimeter of pans can expose these unique animals to various impacts, which may jeopardise their chances of survival on a local scale. In addition the confirmed presence of the giant bullfrog (*Pyxicephalis adspersus*) in the pans is an important aspect to be flagged as this red data species has high conservation.

6.1.4 Floral disturbance (riparian zone, floodplains, pan perimeter).

The clearing of vegetation for construction purposes can have a limited impact due to the small footprint that each of the pylons will have. However a small footprint in a sensitive area, for example in a pristine riparian zone can have a major impact on the flora on a local scale. The movement of vehicles through the riparian zone and / or floodplains of rivers and on the perimeter of, or through pans can also result in floral disturbance. Such disturbance can result in the onset of erosion and alien plant invasion.

6.1.5 Surface water pollution

Hydrocarbons-based fuels or lubricants spilled from construction vehicles, construction materials that are not properly stockpiled, and litter deposited by construction workers may be washed into the surface water bodies. Should appropriate toilet facilities not be provided for construction workers at the construction crew camps, the potential exists for surface water resources and surrounds to be contaminated by raw sewerage.

6.1.6 Disturbance of hydrological regime on a micro scale in floodplains, riparian zone and pans

The presence of construction vehicles, personnel and material in floodplains, riparian zones and pans, can result in a local change in flow patterns. This can result in a change in the flow patterns in these areas due to the presence of obstructions (i.e. vehicles, construction material, construction crew camps etc.). Human activities, which disturb the soil structure, such as the compaction of soil along footpaths and vehicle tracks, and the disturbance of soil structure through movement of soil, can also result in a change in the micro scale hydrology.

6.2 Operational Phase

6.2.1 Erosion of stream banks, floodplains and pans

The presence of the transmission line and associated pylons would not result in a substantial increase in erosion during the operational phase. Erosion of streambanks, floodplains and areas around pans, would mainly take place during this phase as a result of the movement of maintenance vehicles and personnel.

6.2.2 Sedimentation of streams and rivers

The presence of the transmission line and associated pylons would not result in a substantial increase in sedimentation of surface water resources. The only sedimentation that may take place would be as a result of erosion associated with the maintenance activities.

6.2.3 Faunal disturbance.

The major faunal disturbance during the operational phase would be the potential collision and / or electrocution of birds. This would especially be the case where the transmission line is aligned in close proximity to pans. Flamingos would be at risk here, as these birds make substantial use of the larger pans as feeding grounds.

Maintenance activities can result in a short-term disturbance of fauna on a local scale. This would however not be highly significant. Maintenance work that entails the use of paints, solvents and concrete, may result in surface water contamination, which may cause harm or death to aquatic invertebrates, fish and birds.

6.2.4 Floral disturbance (riparian zone, floodplains, pan perimeter).

The presence of the transmission line will result in a disturbance of the flora found in the riparian zone, floodplains and to a lesser extend the pans. Clearing of the servitude to prevent fire hazard, will result in floral disturbance. This will however be limited to the footprint area of the servitude. Access roads to the servitude may also need to pass through wetland areas and / or the riparian zone, which will also result in floral disturbance.

6.2.5 Surface water pollution

Maintenance activities may result in limited surface water pollution. The source of this pollution could be oil and fuel spills from maintenance vehicles, construction material i.e. solvents, paint, concrete etc. In addition activities by the work force (i.e. ablution, washing and littering) in the riparian zone and / or floodplains and pans may also result in increased pollution.

6.2.6 Disturbance of hydrological regime (micro scale) in floodplains, riparian zone, pans.

The presence of the pylons in the floodplain, riparian zone and pans, could result in a change in the hydrological regime found within these wetlands. This could result in limited flooding, erosion and changes in the drainage patterns of these wetlands.

7. RECOMMENDED MITIGATION / MANAGEMENT MEASURES

7.1 Construction phase

7.1.1 Erosion of stream banks, floodplains and pans

- Appropriate flow diversion and erosion control structures i.e. earth embankments must be put in place where soil may be exposed to high levels of erosion due to steep slopes, soil structure etc.
- Should a freak storm displace the temporary earth embankments or other erosion control structures, a visual inspection of the channel must be made and any damage be recorded. Any damage and loss of soil resulting from a storm is to be remedied immediately. Should the walls collapse due to construction error, the contractor is to fund the remediation process.

- Stormwater at the construction crew camps must be managed so as to reduce the silt loads in the aquatic system. Measures must be implemented to distribute storm water as evenly as possible to avoid point sources of erosion.
- Construction on steep slopes and in soft or erodable material will require erosion control measures and correct grassing methods.
- All construction areas should be suitably top soiled and vegetated as soon as is possible after construction.
- Disturbed surfaces to be rehabilitated must be ripped, and the area must be backfilled with topsoil or overburden.

7.1.2 Sedimentation of streams and rivers

- To prevent erosion of material that is stockpiled for long periods, the material must be retained in a bermed area.
- All topsoil must be removed and stockpiled on the site.
- The temporary storage of topsoil, inert spoil, fill etc. should be above the 20 year floodline or at least 20 m from the top of the bank of watercourses and pans, whichever is the maximum or as agreed with the ECO.
- Stockpiles should not be higher than 2m to avoid compaction, and single handling is recommended.
- Dust suppression is necessary for stockpiles older than a month – with either water or a biodegradable chemical binding agent.

7.1.3 Faunal disturbance.

- The Contractor shall ensure that all works are undertaken in a manner, which minimises the impact on the local fauna (including aquatic fauna) and shall apply the following specifications with respect to fauna management and protection:
- Under no circumstances shall any animals (wildlife and domestic animals) be handled, removed, killed or interfered with by the Contractor, his employees, his Sub-Contractors or his Sub-Contractors' employees, with the exception of the following fish species, that may be used as a food source:
  - Carp (*Cyprinus carpio*),
  - Bass (*Micropterus salmoides*),
  - Sharptooth Catfish (*Clarias gariepinus*)

  Should any other fish specie be caught, especially yellow fish, these needs to be returned to the river with as little damage as possible.
- The Contractor shall ensure that the work site is kept clean and tidy and free from rubbish, which can result in the interference with aquatic animals.

- The Contractor shall advise his workers of the penalties associated with the needless destruction of wildlife, as set out in the Animals Protection Act (Act 71 of 1962) sec. 2 (fine R2 000 and/or 12 months imprisonment).

7.1.4 Floral disturbance (riparian zone, floodplains, pan perimeter).

- Construction crew camps should not be located within the riparian zone, floodplains of rivers and streams or / adjacent to pans.
- Any wetland and buffer areas should be rehabilitated after construction has been finalised.
- Clearance of indigenous vegetation in the floodplains, riparian zones, pans and other wetlands, must be kept to a minimum.
- Areas of vegetation that are to be protected must be demarcated and cordoned off during construction, preferably using a temporary fence.
- No indigenous vegetation may be collected, or used for firewood.
- Large trees to be retained or transplanted must be marked and protected against damage by construction activities. Wattle trees and other alien invasive trees should be removed where possible.
- The following provisions shall apply with respect to the protection of areas of indigenous vegetation on or adjacent to the construction sites:
    - No indigenous tree or shrub on or adjacent to the construction site shall be felled, lopped, cut or pruned without the prior written approval of the Consulting Engineer or Environmental Control Officer (ECO).
    - No indigenous tree or shrub on or adjacent to the site shall be felled, lopped, cut or pruned until it has been clearly marked for this purpose by the Consulting Engineer or the Environmental Control Officer. The method of marking will be specified by the Consulting Engineer or the Environmental Control Officer, and the Contractor will be informed in writing.

7.1.5 Surface water pollution

- Construction vehicles are to be maintained in good working order, to reduce the probability of leakage of fuels and lubricants.
- A walled concrete platform, dedicated store with adequate flooring or bermed area should be used to accommodate chemicals such as fuel, oil, paint, herbicide and insecticides, as appropriate, in well-ventilated areas.
- Storage of potentially hazardous materials should be above the 100-year flood line, or as agreed with the ECO. These materials include fuel, oil, cement, bitumen etc.
- Sufficient care must be taken when handling these materials to prevent pollution.
- Surface water draining off contaminated areas containing oil and petrol would need to be channelled towards a sump which will separate these chemicals and oils.

- Oil residue shall be treated with oil absorbent such as Drizit or similar and this material removed to an approved waste site.
- Concrete is to be mixed on mixing trays only, not on exposed soil.
- Concrete shall be mixed only in areas, which have been specially demarcated for this purpose.
- All concrete that is spilled outside these areas shall be promptly removed by the Contractor and taken to an approved dumpsite.
- After all the concrete mixing is complete all waste concrete shall be removed from the batching area and disposed of at an approved dumpsite.
- Stormwater shall not be allowed to flow through the batching area. Cement sediment shall be removed from time to time and disposed of in a manner as instructed by the Consulting Engineer.
- All construction materials liable to spillage are to be stored in appropriate structures with impermeable flooring.
- Portable septic toilets are to be provided and maintained for construction crews. Maintenance must include their removal without sewage spillage.
- Under no circumstances may ablutions occur outside of the provided facilities.
- At all times care should be taken not to contaminate surface water resources.
- No uncontrolled discharges from the construction crew camps to any surface water resources shall be permitted. Any discharge points need to be approved by the relevant authority.
- In the case of pollution of any surface or groundwater, the Regional Representative of the Department of Water Affairs must be informed immediately.
- Where construction in close proximity to sewer lines is unavoidable then excavations must be done by hand while at all times ensuring that the soil beneath the sewer lines is not destabilised
- Backfill must be compacted to form a stabilised and durable blanket; and the current load above the sewer lines must at no time be exceeded

7.1.6 Disturbance of hydrological regime (micro scale) in floodplains, riparian zone, pans

- Only a single access road should be used to the construction area.
- The movement of construction vehicles at the construction site should be limited to a specific area.
- Access into the riparian zone and floodplains of rivers and pans should be prevented as far as possible. Where access into these areas is required a preferred route should be determined. No deviation from these routes should be allowed.

- Once the construction of the pylons has been completed and the site cleared of building materials and waste, the ECO must inspect the site and give approval that it is ready for rehabilitation.
- Areas to be rehabilitated should be agreed upon by the ECO, contractor and proponent.

7.2 Operational Phase

7.2.1 Erosion of stream banks, floodplains and pans

- Access by maintenance vehicles and personnel, onto floodplains, pans and streambanks should be limited as far as possible. Should access onto these areas be necessary, only a single access route should be used.
- Access routes should be maintained on a yearly basis. Erosion gullies that may be formed as a result of tracks in the floodplain and stream banks must be filled in with graded rock and covered with topsoil, should the need arise.
- Maintenance personnel should not access floodplains, stream banks and pans, unless required to do maintenance to pylons and the transmission line. All maintenance material should be removed from these areas, once maintenance work is complete.

7.2.2 Sedimentation of streams and rivers

- The presence of the transmission line in the floodplains and riparian zones would not necessary result in an increase in the sedimentation loads in streams and rivers. Sedimentation of streams and rivers can take place as a result of erosion, emanating from maintenance activities as described in 7.2.1.

7.2.3 Faunal disturbance.

- The transmission line should be located as far as possible from pans, to prevent birds colliding with the lines and pylons.
- Bird flappers should be installed on the transmission line, where the line is in close proximity to wetlands used by birds. This would include pans, streams / rivers and dams.
- Maintenance personnel should not disturb fauna, during maintenance of the transmission line.

7.2.4 Floral disturbance (riparian zone, floodplains, pan perimeter).

- Only a single access road should be used during maintenance of the transmission line.
- No access into riparian zones, floodplains and pans should be allowed, unless required for maintenance activities.
- No flora should be disturbed during maintenance of the transmission line.

- Erosion protection of access roads to the powerline should form part of the maintenance schedule.
- No indigenous vegetation may be collected, or used for firewood.
- Maintenance of the servitude by clearing indigenous vegetation in the floodplains, riparian zones, pans and other wetlands, must be kept to a minimum.

7.2.5 Surface water pollution

- Maintenance vehicles are to be maintained in good working order, to reduce the probability of leakage of fuels and lubricants.
- A walled concrete platform, dedicated store with adequate flooring or bermed area should be used to accommodate maintenance chemicals such as fuel, oil, paint, herbicide and insecticides, as appropriate, in well-ventilated areas.
- Storage of potentially hazardous materials should be above the 100-year flood line, or as agreed with the ECO. These materials include fuel, oil, cement, bitumen etc.
- Sufficient care must be taken when handling these materials for maintenance work, to prevent pollution.
- Surface water draining off contaminated areas containing oil and petrol would need to be channelled towards a sump which will separate these chemicals and oils.
- Oil residue shall be treated with oil absorbent such as Drizit or similar and this material removed to an approved waste site.
- Concrete is to be mixed on mixing trays only, not on exposed soil.
- Concrete shall be mixed only in areas, which have been specially demarcated for this purpose.
- All concrete that is spilled outside these areas during maintenance activities shall be promptly removed and taken to an approved dumpsite.
- After all the concrete mixing is complete all waste concrete shall be removed from the batching area and disposed of at an approved dumpsite.
- Stormwater shall not be allowed to flow through the batching area.
- All maintenance materials liable to spillage are to be stored in appropriate structures with impermeable flooring.
- Portable septic toilets are to be provided and maintained for maintenance crews, should long-term maintenance projects commence. Maintenance must include their removal without sewage spillage.
- Under no circumstances may ablutions occur outside of the provided facilities.
- At all times care should be taken not to contaminate surface water resources.
- In the case of pollution of any surface or groundwater, the Regional Representative of the Department of Water Affairs must be informed immediately.

7.2.6 Disturbance of hydrological regime (micro scale) in floodplains, riparian zone and pans

- Only a single access road should be used for maintenance activities.
- The movement of maintenance vehicles should be limited to a specific area.
- Access into the riparian zone and floodplains of rivers and pans should be prevented as far as possible. Where access into these areas is required a preferred route should be determined. No deviation from these routes should be allowed.

8. ALTERNATIVES

The following aspects have been considered to determine the preferred alternative:

- Number of sensitive wetlands found in close proximity of the alternatives.
- The length of the different alternatives;
- The environmental *status quo* associated with the different alignments.

Alternative 1

This alternative has been selected as the most viable option due to the following:

- This alternative will impact on the least number of pans.
- The area is already impact by various human influences, including agricultural activities, existing transmission lines, rail and road bridges.
- The larger pans, that act as important wildlife habitats are not situated in close proximity to this alternative.
- This is the shortest route, and thus implies the least disturbance due to a shorter distance, less pylons and shorter construction time. This may also result in a need for less construction camps and associated impacts.

The use of Option C on this alternative alignment would not result in fewer impacts. This option would only lengthen the route, with subsequent impacts on the footprint and length of construction.

Alternative 2

This is a less preferred alternative due to the following:

- This alternative will be longer, resulting in a longer footprint area and construction time.
- It will pass more pans, which are sensitive areas. Some of the pans that will be found in close proximity to this alternative are important habitats especially for birds. It could therefore negatively influence birds as they approach these pans.
- The crossing points on the rivers are in fairly good condition.
- Limited human-induced activities are found on this alternative alignment.

The use of option A as part of this alignment would prevent bypassing various pans including the Bultfontein pan. This option would however still be longer than option 1.

The use of option B would not change the occurrence of expected impacts substantially.

Alternative 3

This alternative is the least preferred due to the following:

- This alternative will be the longest option, resulting in a longer footprint area and construction time.
- It will pass more pans, which are sensitive areas. Some of the pans that will be found in close proximity to this alternative are important habitats especially for birds. It could therefore negatively influence birds as they approach these pans.
- The crossing points on the rivers are in fairly good condition.
- Relatively less human-induced activities are found on this alternative alignment.

9. DISCUSSION

The study area is characterised by various surface water resources. Four types of wetlands are found along the three alternative alignments:

- Endorheic pans;
- Riverine wetlands;
- Palustrine wetlands;
- Man-made wetlands.

Endorheic pans are important feeding and breeding habitats for various birds, amphibians and invertebrates. These unique habitats need to be preserved, due to the important role they play in the landscape. For this reason the transmission line should be located as far as possible from any pans. No crossing of pans should take place.

Various rivers and streams (both permanent and ephemeral) will be crossed by the different alignments. The crossing sites range from areas with substantial floodplains and riparian zones, to areas characterised by major human impacts, resulting from agricultural activities, the presence of bridges and other transmission lines. Palustrine wetlands that will be crossed are mostly found in association with rivers and streams.
Man-made wetlands, although habitat for waterfowl, are the least important wetlands in the study area. The impacts on these wetlands would subsequently also be the least significant.

The construction and operation of this transmission line would have negative impacts on the surface water resources found in the study area. The significance these impacts would vary between low and medium. The most significant impacts would be related to surface water pollution, erosion, faunal and floral disturbance. Of particular importance is the potential collision of birds with the transmission line, especially in the vicinity of the endorheic pans, which act as important feeding habitats for water birds.

All the anticipated impacts can however be effectively mitigated. These mitigating measures are discussed in detail in Section 7 and should be incorporated into an Environmental Management Plan. This EMP should be binding on the client, contractors, subcontractors and their personnel. The EMP should also include an auditing programme for the construction and operational phases.

An analysis of the alternative was based on the following aspects:

- Number of sensitive wetlands found in close proximity of the alternatives.
- The length of the different alternatives;
- The environmental status quo associated with the different alignments.

Based on above aspects Alternative 1 is recommended as the preferred option.

10. CONCLUSION

Based on this study, Alternative 1 would be the preferred option due to the following:

- This alternative will impact on the least number of pans.
- The area is already impact by various human influences, including agricultural activities, existing transmission lines, rail and road bridges.
- The larger pans, that act as important wildlife habitats are not situated in close proximity to this alternative.
- This is the shortest route, implying the least disturbance due to a shorter distance, less pylons and shorter construction time. This may also results in a need for less construction camps and associated impacts.

The use of Option C on this alternative alignment would not result in fewer impacts but would lengthen the route, with subsequent impacts on the footprint and length of construction.

The anticipated impact can be mitigated to an appropriate level, but this will require an environmental management plan, that is made binding on the client, contractors and their personnel.

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APPENDIX 1: PHOTO PLATES