Surface Watercourse Assessment:
Proposed Aggeneys-Paulputs 220kV Transmission Line (Bushmanland, Northern Cape)

Final Specialist Report

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Disclaimer:

This report provides a description of identified sensitive aquatic landscape features (SALF’s), including wetlands, rivers, and dry watercourses, present within the investigated study area. It also provides a concise description of the proposed development and identifies expected project-related impacts and mitigation measures.

This study does not provide detailed descriptions of the geology, soils, climate of the area, hydrology of the aquatic environments, assessments of surface and ground water quality, detailed descriptions of aquatic and terrestrial flora and fauna, or provide a detailed review of the legal constraints associated with potential project related impacts on the environment. It has been assumed for the purposes of this report that these aspects will be the subject of separate specialist studies.
1. INTRODUCTION

SSI was appointed by Eskom Holding Limited to carry out an environmental assessment of a proposed new 220kV transmission line from Aggeneys Substation to approximately 2 km north-northeast of the Paulputs Substation in the Northern Cape. As part of this assessment process, SSI subcontracted Imperata Consulting to carry out an assessment of surface watercourses within the study area. This report forms part of the Basic Assessment Report (BAR).

1.2. Terms of Reference

The following terms of reference are associated with the surface watercourse scoping study:

- The identification of surface watercourses or sensitive aquatic landscape features (in particular wetlands and rivers) present within the study area.
- Emphasis is placed on three route alternatives in the western half of the study area that merge into two alternatives 13.5 km west of Pofadder. The route alternatives are named:
  - Route Alternative 1 (Agg – Paulp)
  - Route Alternative 2 (Agg – Paul N14 2)
  - Route Alternative 3 (Agg – Paul Ex 1)
- Identification and comparison of surface watercourses that overlap with the three route alternatives and their immediate surroundings.
- Recommendations with regards to the least sensitive alignment option from a surface watercourse consideration.
- The identification of potential issues and impacts associated with the proposed development that could negatively affect surface watercourses, as well as appropriate recommendations/mitigation measures.

1.3. General Assumptions and Limitations

1.3.1. General Assumptions

- This study assumes that the project proponents will always strive to avoid, mitigate or offset potentially negative project-related impacts on the environment. It further assumes that the project proponents will seek to enhance potential positive impacts on the environment.
- If there is a change in layout likely to have a potentially highly significant, unavoidable impact on a surface watercourse/sensitive aquatic landscape feature (SALF), the project proponents will commission an additional study to assess the impact(s).

1.3.2. General Limitations

- The focus of this report has been on the SALF’s present in the potential development footprint alternatives within the study area due to the large size of the study area, its linear nature, and time constraints. This incorporated an approximate 2 km wide corridor associated with each route alternative.
- A combined desktop-based and field survey approach was applied to identify potential surface watercourses within the study area and available route alternatives. Available spatial information (GIS shape files) associated with surface watercourses were used to
target survey areas during the fieldwork component. However, not all of the identified watercourse crossings could be investigated during the field survey due to limited time availability, access constrains and the length of the route alternatives that had to be covered (± 97 km).

- In addition, available spatial databases used are not comprehensive in terms of surface watercourse coverage and the results presented are not considered as all-encompassing. However, attempts were made to utilise an inclusive set of surface watercourse spatial databases that included recent wetland-related information.
- Recommendations are presented to help mitigate these constrains prior to construction should the development application be approved.

1.4. Overview of Surface Watercourses (Sensitive Aquatic Landscape Features), Associated Processes and Management Considerations

1.4.1. What are wetlands?

In terms of the Ramsar Convention on Wetlands (Iran, 1971), to which South Africa is a contracting party, "... wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as saltmarshes, mangroves, and seagrass beds, but also coral reefs and other marine areas no deeper than six metres at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs (Ramsar Convention Secretariat 2007).

In South Africa, wetlands are defined as "...land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil" (National Water Act, Act No. 36 of 1998), (NWA). Wetlands are also included in the definition of a watercourse within the NWA, which implies that whatever legislation refers to the aforementioned will also be applicable to wetlands. The types of features included within the definition of a watercourse include:

- "...a river or spring..."
- "...a natural channel in which water flows regularly or intermittently..."
- "...a wetland, lake or dam into which, or from which, water flows..."
- "...any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse..."

In addition, the NWA stipulates that "...reference to a watercourse includes, where relevant, its bed and banks...". This has important implications for the management of watercourses and encroachment on their boundaries, as discussed further on in this document.

The Act defines riparian areas as "...the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas...". Note that
this does not imply that the plant species within a riparian zone must be aquatic, only that the species composition of plant assemblages must be different within the riparian area and adjacent uplands.

In terms of the latest wetland delineation document available from the Department of Water Affairs and Forestry (DWAF), now known as the Department of Water and Environmental Affairs (DWEA), “wetlands must have one of the following attributes” (DWAF 2005):

- **Wetland (hydromorphic) soils** that display characteristics resulting from prolonged saturation.
- The presence, at least occasionally, of **water loving plants (hydrophytes)**.
- A **high water table** that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50 cm of the soil.” (DWAF 2005, p.4)

It follows that the level of confidence associated with a specific area being considered as a wetland is proportionate to the number of confirmed indicators that positively correlate with wetland habitat. Not all indicators are always present within a specific biophysical and land use setting, while not all indicators are always reliable and/or useful under all conditions. The use of additional wetness indicators from different disciplines that are internationally applied therefore adds value and confidence in the identification and delineation of wetland habitats, especially in challenging environments.

1.4.2. Why are wetlands important?
Wetlands are reputed to inter alia:
- Attenuate floods.
- Retain contaminants, nutrients and sediments.
- To facilitate the recharge of groundwater resources.
- Provide an important habitat for aquatic fauna and flora.
- Provide food, building and other materials for a variety of uses.

However, it is important to note that not all wetlands perform all of these functions, and that the potential to perform specific functions depends on the available opportunity, type of wetland and the condition (state) of the wetland system (Kotze et al. 2005; Macfarlane et al. 2008).

1.4.3. Why protect headwaters, arid drainage lines, and small wetlands?
Small drainage lines and other surface watercourses should be afforded the same protection as well defined wetland and larger watercourses, as these systems provide important functions. Some aspects of these features have been listed below:

*Headwater drainage lines*
Headwater drainage lines that only carry storm flow are ephemeral streams or A Section channels that form part of first-order and even second-order streams of rivers, located at the source of drainage line networks. These drainage lines are never or very seldom in connection
with the zone of saturation and they consequently never have base flow (DWAF 2005). They are, however, connected with larger downstream aquatic systems, which make them part of the river continuum concept (NC Division of Water Quality 2005). Ephemeral headwater streams differ from A Section channels in the sense that the former do not always possess a well defined or continuous channel or channel bank along their length. Ephemeral streams therefore encompass A Section drainage lines. Both of these headwater watercourses form part of larger headwater systems, which can be classified into four topographic units (Gomi et al. 2002):

- Hillslopes, which have divergent or straight contour lines with no channelized flow.
- Zero-order basins, which have divergent contour lines and form unchannelised hollows.
- Transitional channels (ephemeral and intermitted channels) have defined banks, as well as discontinuous segments along their length, and emerge out of zero-order basin. They form the headmost definable portion of the channel network (first-order channels) and can have either ephemeral or intermitted flow.
- Well defined first and second-order streams that are continuous with either intermitted or perennial flow.

In addition:

- “...scientists know that headwater streams make up at least 80 percent of the nation’s stream network” (Meyer et al. undated, with reference to the United States of America).
- “Seasonal streams and wetlands are usually linked to the larger network through groundwater even when they have no visible overland connections.” (Meyer et al. undated).
- The role and functions of headwater streams within catchments and their linkages with downstream aquatic systems are not thoroughly understood (Gomi et al. 2002). Recent research, however, ascribes increasing importance to these systems regarding catchment and water resource management (Berner et al. 2008; Dodds & Oaks, 2008).
- Headwater drainage lines are crucial systems for nutrient dynamics as a link between hillslopes and downstream watercourses (Gomi et al. 2002).
- They are directly linked to downstream aquatic systems and have a direct bearing on the health and functioning of these larger systems, especially regarding water quality of downstream aquatic systems (Gomi et al. 2002; Dodds & Oaks 2008).
- The value of headwater functions is normally underestimated due to their inconspicuous nature and numerous occurrences (high density) in the drainage network (Gomi et al. 2002; Berner et al. 2008).
- The large spatial extent of headwater channels in the total catchment area make these systems important sources of sediment, water, nutrients and organic matter for downstream systems (Gomi et al., 2002).
- “Headwater systems are important sources of sediments, water, nutrients, and organic matter for downstream reaches.” (Gomi et al. 2002).
- “Because of their geographical isolation, headwater systems also support genetically isolated species; thus, they support an important component of biodiversity in watersheds.” (Gomi et al. 2002).
Other authors such as Meyer et al. (undated) reported that “small streams” and other wetlands provide the following benefits:
  o Water quality protection.
  o Maintenance of water supply.
  o Flood attenuation.
  o Retention of excess sediments.
  o Maintenance of biological diversity in the landscape.

**Arid drainage lines**

Arid ephemeral streams are also referred to as Washes or Wadis in Arabia, Arroyos in Spanish, and Laagtes in Afrikaans. Laagtes are typically discontinuous channels on a flat topography in dry environments. Washes that lack distinct channel features do often display braided channel configuration referred to as bar and swale topography. Discontinuous streams can also display a stream pattern characterized by alternating erosional and depositional reaches. Some definitions of an arroyo specifically refers to an entrenched arid ephemeral stream with vertical walls (Lichvar & Wakeley, 2004). This definition of an arroyo is consistent with definitions of a gully or donga in South Africa. Ephemeral streams imply that the watercourse only flows briefly in direct response to rainfall in its immediate vicinity and that the channel is at all times isolated from groundwater inputs (Levick et al., 2008).

Extracts in italics were taken from a review article by Lichvar & Wakeley (2004) with related references (own comments are provided in brackets). Information presented here is intended to provide an overview of arid rivers and streams (drainage lines) based on international understanding (also see Section 1.4.5.):

Arid drainage lines can typically include discontinuous, ephemeral, compound, alluvial fan, anastomosing, and single-threaded channels, which vary due to a range of gradients (slopes), sediment sizes, and volumes and rates of discharge. Discontinuous ephemeral stream systems and alluvial fans are most prevalent in, but not restricted to, piedmont settings, while compound channels, anastomosing rivers, and single-thread channels with adjacent floodplains generally occupy the valley bottoms. Ephemeral and intermittent streams are the dominant stream types (drainage lines) in the arid southwestern United States (they are expected to also dominate the drainage network in other arid environments). For example, in Arizona most of the stream networks—96% by length—are classified as ephemeral or intermittent (Beven & Kirby 1993).

The “master variable” responsible for shaping a drainage line is associated with the flow regime of the system, which includes variations and patterns in surface flow magnitude, frequency, duration, and timing (Poff et al., 1997). It follows that the size and shape of a drainage line channel is controlled in large part by the dominant discharge in a particular region (Lichvar & Wakeley, 2004). Fluvial morphology is frequently associated with extreme discharge events; streams and floodplains trap sediments and nutrients in addition to attenuating flood waters (Graf 1988, Leopold 1994).
Arid-land fluvial systems are critically important environments that provide valuable ecological benefits. Arid drainage lines provide inter alia the following ecosystem services (Brinson et al., 1981, Davis et al., 1996, Meyer et al., 2003):

- Convey floodwaters.
- Help ameliorate flood damage.
- Maintain water quality and quantity.
- Provide habitat for plants, aquatic organisms, and wildlife; and determine the physical characteristics and biological productivity of downstream environments.

Limited research had been done on ephemeral and intermitted arid drainage lines in South Africa, particularly systems that are characterized by indistinct or discontinuous channels. No guideline document or other local documentation exists that describes how these arid and often unchanneled drainage lines fit into definitions of what constitutes a watercourses, as defined by the NWA (See Section 1.4.1.). Their protection status as defined in the National Water Act, Act 36 of 1998 remains unclear, as these systems are not expected to always be consistent with the act’s definitions and interpretations of wetlands, rivers (riparian habitat) or natural channels with regular or intermittent flow. Subsequently the value and conservation importance of these systems are also motivated based on international literature. For additional motivation regarding the importance of arid drainage lines also refer to the discussion of Non-channeled drainage lines in arid environments (Section 1.4.5).

Small and isolated wetlands - endorheic pans and flats:

- “Ecologists describe the value of small isolated wetlands by their aggregate role in protecting wetland-dependent species through “source-sink dynamics”. More variable than larger wetlands, each small wetland in an area may fluctuate in the number of individuals of a species it contains; at times a wetland may act as a “sink” when the population of a species dies out locally from that wetland, or it may be a “source” that produces surplus individuals, which can colonize a nearby sink wetland. Populations of a species that are spread over a number of locations are referred to as “metapopulations”, and this source-sink dynamic is crucial to the regional survival of species. A metapopulation of a wetland-dependent species depends on the abundance and proximity of wetlands, rather than a critical size threshold. The disappearance of small wetlands from an area that relies on source-sink dynamics could result in the loss of ecological connectedness and potentially collapse the metapopulations of wetland-dependent species, causing many local extinctions.” (Semlitsch 2000).

- “To protect ecological connectedness and source-sink dynamics of species populations, wetland regulations should focus not just on size but also on local and regional wetland distribution. At the very least, wetland regulations should protect wetlands as small as 0.2 hectares – the lower limit of detection by most remote sensing – until additional data are available to directly compare diversity across a range of wetland sizes.” (Semlitsch 2000).
1.4.4. Do alterations to the hydrological regime matter?
Developments may be associated with a change in the hydrological regime of a drainage line or wetland. The excerpts below indicate what potential effects changes in hydrological regime may have for drainage lines and wetlands:

- “Large, sudden fluctuations in wetland water levels often destroy wetland vegetation, particularly along the wetland edge (Clark 1977). Where wetland vegetation is weakened or destroyed by periods of drought or flooding, native plants give way to weedy, invasive species, invertebrate communities are altered, and wildlife species dependent on these food sources disappear. Increased water level fluctuations caused by increased urbanization have been found to be a major threat to remaining wetlands in the Puget Sound Region, with potential effects on plant succession, habitat, and breeding conditions (Stockdale 1991).”

- “During a survey of aquatic ecosystems in 1989, it was determined that, with regard to non-marine ostracods (Ostracoda, Crustacea), the larger of two temporary pools at Rhino Ridge in the Thomas Baines Nature Reserve near Grahamstown had the highest known biodiversity of any water body in the Eastern Cape. The smaller, adjacent pool contained an as yet undescribed genus of fairy shrimps (Anostraca, Crustacea). A recent visit (November 1993) revealed that a bird observatory had been created at this locality and that the original large temporary pool had changed into a permanent one, consisting of two pools (the original one and one newly dug) connected to each other. The original temporary-pool fauna of both the main and the adjacent pool had been completely eliminated, largely because of the presence of fish which are very efficient predators of temporary pool fauna.” (Martens & de Moor 1995)

1.4.5. Which channels should be regarded as sensitive to flow modification?
In terms of the DWAF channel type classification (DWAF 2005), channels can be assigned to one of three categories. Channel types are separated on the basis of their relationship to the elevation of the water table. A channel types should very seldom (if ever) receive baseflow, C channel types should permanently receive baseflow, while B channel types should receive baseflow in between these two extremes.

**A Section channels**
"The A sections are those headward channels that are situated well above the zone of saturation at its highest level and because the channel bed is never in contact with the zone of saturation, these channels do not carry baseflow. They do however carry storm runoff during fairly high rainfall events but the flow is of short duration because there is no baseflow component. It is important to note that these steep, eroding, headward watercourses do not have a riparian habitat (in terms of the definition in the National Water Act) because they are too steep to be associated with deposition of alluvial (or hydromorphic) soils and are not flooded with sufficient frequency to support vegetation of a type that is distinct from the adjacent land areas." "The A sections are the least sensitive watercourses in terms of impacts on water yield from the catchment. They are situated in the unsaturated zone and in this respect their position in the landscape is little different from nonriparian hillslope positions." (DWAF 2005). However, they often contain a natural
channel in which water flows regularly or intermittently, which is consistent with the National Water Act’s definition of a watercourse (National Water Act, Act No. 36 of 1998).

Non-channeled drainage lines in arid environments
Arid drainage lines often lack distinct channel features or only contain discontinuous channels due to lower annual rainfall, longer rainfall intervals, and low runoff versus infiltration ratio due to greater transmission losses (Lichvar et al., 2004). These arid drainage lines are therefore more common on low gradient topographies (e.g. basins and piedmont plains) with deeper substrates that result in lower energy fluctuations and greater water recharge into the surrounding sand beds and alluvial material during stochastic flow events.

Drainage lines that lack distinct and/or continuous channel features could be interpreted as non-watercourses based on the watercourse definition in the National Water Act (See Section 1.4.3). This definition makes specific mention on the presence of a channel for non-wetland, non-river drainage lines to qualify as a watercourses (Section 1.4.1). However, it is argued that these non-channeled or discontinuously channeled arid drainage lines still form part of the drainage network and are regarded as sensitive drainage line systems due to (Lichvar & Wakeley, 2004):

- “Arid-region drainage line channels, especially those with sandy banks, are often very responsive to large flows and recover slowly from them because of the limited vegetation growth and the large inter-annual variability in peak discharges (Cooke et al. 1993, Tooth 2000).”
- “Nonexistent or poor armoring of ephemeral stream beds (Reid & Laronne 1995) increases the sensitivity of the river channel to a range of flow events and hinders the ability of the river to “hold” any one pattern. Consequently, desert rivers are often in a perpetual state of change—working to recover from a large flood but unable to “heal” completely before the next extreme event widens the channel and renews the process (Cooke et al. 1993, Tooth and Nanson 2000a).”
- “Smaller drainage basins have a greater sensitivity to large floods, especially in arid climates, where stream widths remain largely unchanged for drainage areas exceeding 50 km² due to transmission losses (Wolman and Gerson 1978).”
- “Arid drainage lines display a high sensitivity to change and rarely reach a state of equilibrium (Graf 1988a, Tooth and Nanson 2000a).”

1.4.6. Why are buffers needed to protect wetlands?
Buffers are reputed to provide a number of important benefits. Some of these potential benefits are listed below (based on Castelle et al. 1992):

- Sediment retention.
- Retention of pollutants.
- Lower erosion risk.
- Moderation of flows from uplands into wetlands.
- Provision of faunal habitat.
- Screen a wetland from adjacent developed areas.
- Limitation of direct human impacts on a wetland (e.g. waste disposal and trampling).
It is important to bear in mind that if channelised flows (as opposed to diffuse flows) traverse the buffer, they could largely negate some of the benefits listed above.

1.4.7. What is a floodplain?
For the purposes of this report a distinction has been made between the hydraulic floodplain and the polyphase floodplain (sensu Nanson & Croke 1992). The former represents the elevation of the 1:100 year flood as calculated from modeled runoff. The latter is a geomorphic surface adjacent to the macrochannel. The polyphase floodplain therefore reflects the result of erosion and deposition in the current climatic conditions. Current in this context refers to the Holocene, the period since the end of the Last Glacial Maximum. In a geological context it can be viewed as a dynamic environment where both erosion and deposition takes place. Lateral channel migration can be expected within a floodplain environment, resulting in the reworking of floodplain sediments. Higher lying benches adjacent to the floodplain should therefore represent fluvial terraces that developed under a different set of conditions, possibly a different climatic regime and/or existence at a former lower elevation prior to a period of tectonic uplift.

The polyphase floodplain, from a biophysical processes point of view, can be regarded as a corridor of disturbance with areas at lower elevations subject to more frequent flood disturbance than the areas higher up. Basins (such as areas with closed contour intervals) on the polyphase floodplain could be expected to hold water following flood inundation, after heavy/prolonged rainfall events, or when they intersect the water table or a combination of the aforementioned factors. These basins may represent former channel segments abandoned as a consequence of lateral channel migration and/or incision.

1.4.8. Why are floodplains sensitive to development?
Floodplains may be regarded as sensitive to development in terms of elevated exposure to natural hazards and their importance to biota and ecological processes. Some of the potential development constraints that should be taken into consideration during the planning process have been listed below:

- Floodplains by definition imply that these areas are subject to flooding. No buildings or other infrastructure should therefore be located below the 1:100 year floodline.
- Development on floodplains may compromise the ability of these areas to attenuate floods, by inter alia increasing the area covered by impervious surfaces.
- Floodplains may have shallow water tables, which may present development constraints (e.g. increase the costs of construction).
- Floodplains often represent prime agricultural land suitable for cultivation.
- Floodplains may be associated with a particular vegetation type due to associated climatic or edaphic conditions.
- Floodplains may act as corridors for the dispersal of biological organisms.
1.4.9. What are pediments, alluvial plains, and alluvial fans?
Bates and Jackson (1984) provide the following definitions for pediments and alluvial plains, while other definitions for alluvial fans and piedmont plains are referenced accordingly:

- Pediment - "A broad gently sloping erosion surface or plain of low relief, typically developed by running water, in an arid or semiarid region at the base of an abrupt and receding mountain front; it is underlain by bedrock that may be bare but is more often mantled with a thin discontinuous veneer of alluvium derived from the upland masses and in transit across the surface."

- Alluvial plain - "A plain produced by deposition of alluvium; e.g. a delta plain, flood plain, alluvial fan, or bajada."

- Alluvial fan – "Depositional landform with a conical shape that develops where confined streams emerge from upland areas into zones of reduced stream power" (Lichvar & Wakeley, 2004).
2. PROJECT AND STUDY AREA DESCRIPTION

2.1. Project description

- The proposed development entails the construction of a 220kV transmission line from just north of the Pulpputs Substation to Aggeneys Substation in the Northern Cape.
- The purpose of the proposed additional transmission line between the two substations is to help alleviate current and future network constraints in the Northern Cape. This includes the linkage with the proposed new Pofadder Solar Thermal Plant near Pulpputs Substation.
- Three route alignment corridors were investigated within a larger study area (Figure 1). The larger study area was determined by demarcating a 5 km buffer around the three alignment alternatives, while each of the three alternatives were buffered by 1 km to demarcate their respective corridors. The three route alternative corridors are located in close proximity to one another and generally follow existing infrastructure such as roads (e.g. the N 14 Highway) and the current 220 kV transmission line.
- Each of the route alternatives and their corridors have the following dimensions (Figure 1):
  - Alternative 1 (Agg – Paulp) is approximately 96.41 km long, while its corridor occupies an area of ± 19,571.24 ha.
  - Alternative 2: (Agg – Paul N 14 2) is approximately 96.60 km long, while its corridor occupies an area of ± 19,615.59 ha.
  - Alternative 3: (Agg – Paul Ex 1) is approximately 96.25 km long, while its corridor occupies an area of ± 19,545.16 ha.
- The route alternatives and their corridors have the following orientation (Figure 1):
  - The western portion of the study area contains all three route alternatives from Aggeneys Substation to a merging point 13.43 km west of Pofadder, at a crossing with the N14 Highway.
  - This crossing point is also referred to as the split or merge point in this study and forms the boundary between the western and eastern portions of the study area.
  - Alignment 2 (Agg – Paul N 14 2) merge into Alignment 1 (Agg – PaulP) at this point. The result is only two route alternatives in the eastern portion of the study area towards Pulpputs Substation (Figure 1).
  - The two alignment alternatives follow a similar path as the existing 220 kV line from the merge point towards Pulpputs Substation. The merged alignment 2 & 1 (henceforth only referred to as alternative 1 in the eastern portion of the study area), is closer to the existing 220 KV transmission line compared to route alignment 3.
  - In the western portion of the study area routes 1 & 3 continue to follow a similar path as the existing 220 kV line, while alignment 1 remains closer to the existing structure.
  - The added route 2 (Agg – Paul N 14 2) branches from the split point in a separate direction along the N14 Highway towards Aggeneys Substation (western direction).
2.2. Study area description

2.2.1. Location
The study area is located in the Northern Cape Province in the north-western portion of what is commonly known as Bushmanland. The study area encompasses a 5 km wide area around a proposed new 220 kV transmission line between Paulputs Substation, located approximately 33 km north-northeast of Pofadder, near Konkoonsieskop, to Aggeneys Substation located outside Aggeneys (Figure 1). Other prominent towns in the nearby vicinity include Pella, located north of the study area, with the Orange River located further north (Figure 1).

The three route alternatives follow existing infrastructure, such as the existing 220 kV Eskom transmission line (western and eastern portions of the study area) and the N14 highway (western portion of the study area). Table 1 indicates the coordinates of the start and end point of the proposed new 220 kV transmission line.

Table 1. Generated coordinates of the Aggeneys to Paulputs Substations that form the northeastern and western extremities of the investigated route alternatives.

<table>
<thead>
<tr>
<th>Boundary position</th>
<th>Source</th>
<th>Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start point: North-eastern Extremity (± 2 km north-northwest of Paulputs Substation)</td>
<td>The co-ordinates of the north-eastern extremity of the three alignment alternatives were obtained from a GIS shape file (received from SSI).</td>
<td>-28.8611°S 19.575°E</td>
</tr>
<tr>
<td>End point: Western Extremity (Aggeneys Substation)</td>
<td>The co-ordinates of the western extremity of the three alignment alternative were obtained from a GIS shape file (received from SSI).</td>
<td>-29.2967°S 18.8047°E</td>
</tr>
</tbody>
</table>

2.2.2. Surface hydrology
Surface waters present within the study area intersects five quaternary catchments, all of which drain towards the Orange River and form part of the Lower Orange Water Management Area (WMA) (Table 2). The South African National Spatial Biodiversity Assessment (Driver et al., 2004) indicates that 11 non-perennial and dry rivers overlap with the study area as derived from the DWAF 1:500 000 rivers GIS spatial layer. Ten of these rivers have an Endangered conservation status, while one is regarded as Not threatened. Driver et al. (2004) further associate a Class B or "largely natural" Present ecological state (PES) with all of the eleven rivers.
Figure 1. Illustrates the three route corridor alternatives (each 2 km wide), as well as the main roads, nearest towns and substations (Paulputs Substation is adjacent to the start point in the northeast and Aggeneys Substation is the end point in the west). Drainage lines from the relevant 1:50000 topographic maps are indicated within a 5 km buffer around the route alternatives.
The lack of perennial rivers within the study are can be explained by the low annual rainfall, along with a low mean annual runoff, and a very high mean annual evapotranspiration of greater than 2600 mm across all five quaternary catchments (Table 2). Catchment scale assessments of PES and Ecological importance and sensitivity (EIS) indicate similar results as the National Spatial Biodiversity Assessment for rivers (Table 2). Only quaternary catchment D82C situated around Aggeneys display a lower EIS class.

Table 2. Illustrates the mean annual precipitation (MAP), mean annual runoff (MAR) in million cubic meters (mcm), mean annual evapotranspiration (MAE), Ecological importance and sensitivity (EIS) class, and Present ecological state (PES) class per quaternary catchment as derived from the 2005 water resources of South Africa study (Middleton & Bailey, 2008)

<table>
<thead>
<tr>
<th>Quaternary Catchment</th>
<th>D81E</th>
<th>D81F</th>
<th>D81G</th>
<th>D82A</th>
<th>D82C</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall (MAP)</td>
<td>97 mm</td>
<td>91 mm</td>
<td>102 mm</td>
<td>77 mm</td>
<td>83 mm</td>
<td>90 mm</td>
</tr>
<tr>
<td>Runoff (MAR)</td>
<td>0.77 mcm</td>
<td>0.92 mcm</td>
<td>0.80 mcm</td>
<td>0.38 mcm</td>
<td>0.80 mcm</td>
<td>0.73 mcm</td>
</tr>
<tr>
<td>Evapotranspiration (MAE)</td>
<td>3001 mm</td>
<td>3751 mm</td>
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<td>High</td>
<td>Low/Marginal</td>
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<tr>
<td>PES class</td>
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<td>Class B (Largely Natural)</td>
<td>Class B (Largely Natural)</td>
<td>Class B (Largely Natural)</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

2.2.3. Climate
The climate can best be described as arid with an average annual rainfall of 90 mm across the five quaternary catchments (Table 2). Rainfall occurs mainly during late summer and can continue into autumn, while winter rainfall influences are also known to extend further inland along the lower Orange River Valley (Van Wyk & Smith, 2001). A mean annual temperature of approximately 24°C (Van Wyk & Smith, 2001) is expected due to hot summers and moderate winters. Winter temperatures can drop to below freezing, especially on the higher-lying mountainous areas, but the plains are most commonly frost free (Van Wyk & Smith, 2001).

2.2.4. Geology
The geology of the study area is considered as complex and forms part of the Namaqualand Metamorphic Province. Quartzitic inselbergs associated with the Bushmanland Group are common as intrusive metamorphosed rocks of Mokolian age (Mucina & Rutherford, 2006; Van Wyk & Smith, 2001). Distinct white quartz surface areas occurs as gravel patches on open plains or on the footslopes of inselbergs and other mountainous areas. Mountainous areas further to the east are associated with mafic gneiss and a combination of quartzite-schist that form part of the Hom Subgroup of the Bushmanland Group (Mucina & Rutherford, 2006).

The majority of the study area is overlaid by quaternary sediments in the form of alluvial sands and calcrite that surround the mountain ridges and free standing inselbergs. These quaternary sands include the Koa River Valley and related red dune fields that are considered to be
associated with paleo river systems that formed part of the Orange River. The paleo flow path of the Orange River is also referred to as the Proto-Orange River (Van Wyk & Smith, 2001).

2.2.5. Topography, bio-regions, and biomes
The topography of the study area is highly varied and range from intrusive inselbergs to sandy plains and the red dunes of the Koa River Valley in the south-western extremity of the study area (south of Aggeneys), as well as an outlier dune field near Nongcaise Kop, north-northeast of Pofadder (Figure 1). Other topographic landscape features include gravel dominated plains, dry river beds, and rock-strewn mountains (Van Wyk & Smith, 2001). The topography of the study area ranges between 750 masl to 1160 masl.

The elongated study area also intersects different bio-regions that primarily includes the Bushmanland Bio-region (Nama-Karoo Biome), which is associated with the sandy and gravel plains, as well as the Koa River Valley red dune fields. The Gariep Desert (Desert Biome) forms another bio-region in the eastern portion of the study area, across a ± 16 km area between Pofadder and Paulputs Substation. This desert bio-region is associated with rock strewn mountains areas closer to Pofadder, which form part of the eastern end of the “Groot-Pellaberge” (Figure 1). The mountainous area changes into sheet wash plains further to the north (Mucina & Rutherford, 2006).

The far western portion of the study area overlaps with two prominent inselbergs: “Aggenys se Berge” north of Aggeneys and “Ghaamberg” east of Aggeneys. These two inselbergs are associated with the Richtersveld Bio-region (Succulent Karoo Biome) and borders the existing corridor of linear infrastructure (e.g. the N14 Highway), as well as the proposed route alternatives (Figure 1).

2.2.5. Regional vegetation
The study area overlaps with the Gariep Centre of Endemism (Van Wyk & Smith, 2001) and intersects eight recently described vegetation units across three biomes, all of which have a Least threatened conservation status (Mucina & Rutherford, 2006):

- Desert Biome
  - 11 132.78 ha of Eastern Gariep Plains Desert in the eastern portion of the study area. The habitat includes sloping plains that contrast distinctly from the surrounding mountainous terrain.
  - 6 856.49 ha of Eastern Gariep Rocky Desert in the eastern portion of the study area. The habitat includes rocky mountains and outcrops (ridges) with very sparse, shrub dominated vegetation cover.

- Nama-Karoo
  - 1301.23 ha of Eastern Gariep Broken Veld in the eastern extremity of the study area. The habitat includes hills and low mountains with irregular plains. None of the route alternatives or substations overlap with this vegetation unit.
- 67 275.81 ha of Bushmanland Arid Grassland in the eastern and western portions of the study area. This is the largest vegetation unit within the study area and includes plains with gravel surface areas; more sandy areas can also be present.
- 19 270.58 ha of Bushmanland Sandy Grassland in the eastern and western portions of the study area. This vegetation unit incorporates the Koa River Valley and red dune field near Nongcaip se Kop. The vegetation unit is characterised by deep sandy soils with a dense grass cover.
- 17.55 ha of Bushmanland Vloere in the western extremity of the study area. This vegetation unit is an endorheic (inward draining) system that forms part of the Inland Saline Vegetation Group. It overlaps with none of the route alternatives.

- Succulent Karoo
  - 1 621.12 ha of Aggeneys Vygie Veld in predominately the western portion of the study area, with one outlier in the eastern portion near Pofadder. This vegetation unit can be linked with the white quarts surface areas on open plains and footslopes of inselbergs, and other mountainous areas.
  - 4 691.22 ha of Bushmanland Inselberg Shrubland in the western portion of the study area. The habitat incorporates free standing inselbergs of metamorphic rock that are surrounded by a wide plain of alluvial material. This vegetation unit along with the Aggeneys Vygie Veld form outliers of the Succulent Karoo in an area with transitional summer/winter rainfall. The 2 km wide corridors of route alternatives 1 & 3 overlap with one of the inselbergs (T’Goob se Berg).
3. METHODS

The following methods and approaches were applied as part of the surface watercourse investigation:

- Desktop component
  o The recently completed RSA Wetland Types national spatial database was used to identify potential wetland areas within the study area, route alternatives, and route corridors (Van Deventer et al., 2010).
  o This wetland layer has been formed by combing information from the National Land Cover 2000 data set (NLC 2000), 1:50 000 topomaps and sub national data (Van Deventer et al., 2010).
  o Potential river crossings were identified through the use of the National Spatial Biodiversity Assessment (NSBA) spatial dataset, which is and based on the DWAF 1:500 000 rivers GIS layer (Driver et al., 2004). The GIS layer was obtained via the BGIS website hosted by the South African National Biodiversity Institute.
  o The 1:50000 drainage line spatial dataset of the study area was obtained from the overlapping topographic maps (2918BB, 2918BD, 2919AA, 2919AB, 2919BA, 2919CD, and 2919DC).
  o In addition, areas with higher than average soil moisture conditions were modeled through the Topographic Wetness Index technique (Sørensen et al., 2006).
  o Various existing and one modeled spatial datasets were used to identify the potential presence of watercourses within the study area and route alternatives. It also incorporated a whole spectrum of landscape positions that included headwater settings associated with first and second order streams, as defined by Strahler (1952).
  o Clipped GIS shape files (layers) of intersecting watercourses, route alignments, and route corridors were created to help demarcate potential watercourses systems along each of the route alternatives.

- Field survey component
  o Several of these areas of overlap were investigated during a field survey to identify potential wetlands, rivers and arid (dry) drainage lines along the three route alternatives.
  o It is important to note that not all of the potential watercourse crossings could be investigated due to the linear nature of the project and access constraints (See Section 1.3.2.)
  o The presence of wetlands and riparian habitat were investigated in several of these areas through the procedure described by the Department of Water Affairs (DWA, previously known as DWAF) in their document entitled: “A Practical field procedure for the identification and delineation of wetlands and riparian areas” (DWAF, 2005).
  o However, the use of wetland and riparian habitat indicators as described in the existing delineation guideline (DWAF, 2005) was expected to be of limited use. Lichvar and Wakeley (2006) provide the following reasons why arid drainage lines
will rarely display indicators associated with wetland and riparian watercourses common in more humid areas:

- "Methods for identifying and classifying wetlands for various purposes have generally taken a multi-factor approach based on two or more environmental features or kinds of evidence. Thus, wetland identification and classification rely heavily on hydrology, soil, and vegetative characteristics (Environmental Laboratory 1987, Cowardin et al. 1979, Mitsch and Gosselink 1993, Soil Conservation Service 1994, Tiner 1999, Wakeley 2002)."

- “Unlike most wetlands, the soils in arid stream channels are typically Entisols (i.e., young soils with little horizon development) (Fanning & Fanning 1989), reflecting the dynamics of recent flood events and transport of sediments within the channel. Thus, the use of hydric soils (Natural Resources Conservation Service 2002) or their features for delineating arid streams is limited since these systems rarely develop redoximorphic features.”

- Additional indicators are therefore needed to identify and help delineate dry drainage lines in arid environments. These indicators should be associated with physical evidence of surface flows that will continue to persist long after the flow events ceased. Physical features associated with ordinary high water marks (OHWM) are frequently the result of extreme floods or short-term, high intensity events (Graf 1988; Tooth 2000).

- Examples of appropriate indicators of ordinary high water marks that can be applied to dry watercourses in arid environments and used as part of this study include the presence of drift material, desiccation cracks in silt substrates, channel features such well defined channel banks, knick points (e.g. scour points), and vegetation changes (e.g. distinct changes in species composition and structure), (Lichvar & Wakeley, 2004; Lichvar et al., 2006).

- Vegetation patterns in arid drainage lines can change over short time scales due to destruction and regrowth from flooding events. Consequently climax seres in these environments are limited, but episodic flow event can quickly change the distribution and species composition, and therefore influence the recovery cycle. Consequently, patterns of species composition, age, succession, or physical characteristics can be useful indicators of flooding events in arid drainage lines (Lichvar & Wakeley, 2004).

- Riparian vegetation patterns and processes associated with intermitted rivers and pans in Bushmanland are “of the least studied in the country” (Mucina & Rutherford, 2006). Hence, the use of plant species as indicators of dry watercourses are limited within the study area. Attempts were still made to identify selected species that appeared to be more abundant in drainage line environments that also contained other flow indicators.

- A total of 57 sampling points were investigated in all three the route alternatives and potential watercourse crossings.

- Drainage line crossing distances were measured based on the interpretation of available aerial imagery of these systems and overlaid route alternatives. The
imagery was often of sufficient quality to identify and measure distances between pylons of existing transmission lines in the area.

4. WATERCOURSES IN ROUTE CORRIDORS AND ALIGNMENTS

This section describes sampled field conditions in a selection of drainage line crossings associated with the three route alternatives from Paulputs Substation to Aggeneys Substation. Sampling points were clustered into eleven targeted areas based on results obtained from the existing surface watercourse GIS layers, a modeled Topographic Wetness Index of the study area (Figure 2), and available access.

4.1. Eastern Study Area Portion: Skuitklip/Paulputs Substation to Split Point

4.1.1. Sample Cluster 1: Skuitklip to Paulputs Substation

- Three sample points are located in the eastern extremity of the study area on the Farm Scuit-Klip 92, ± 2 km north-northeast of Paulputs Substation (Table 3; Figure 3).
- No distinct watercourse features, including channel features were identified at any of the three points or in their immediate vicinity.
- Dry drainage lines present in the 1:50 000 topographic dataset were targeted in the area, but no channel features or other ephemeral stream characteristics were identified at any of the three sampling points (Figure 3).
- Darker, linear areas immediately northeast of the sampling points appeared to be associated with an alluvial plain or indistinct washes. This is similar to the findings of Scherman et al. (2010), which indicated alluvial fans in the area.
- These alluvial plains/indistinct washes visible in Figure 3 do not overlap with route alternative 3 and the merged route alternative 1, but do intersect with their corridors.
- No wetlands, natural channels, or riparian habitat were recorded during the field survey in any of the route alternatives within this area.
- As a result all of the route alternatives have a similar sensitivity within this area and appear to avoid encroachment into natural drainage lines.

Table 3. Sample points in sample cluster 1, ± 2 km north-northeast of Paulputs Substation

<table>
<thead>
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</tr>
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</tr>
<tr>
<td>P03</td>
<td>-28.86399695</td>
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</tr>
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</table>
Figure 2. Illustrates a ranged of modeled soil moisture conditions in the study area and route alignment crossing points, based on topographic variation used in the Topographic Wetness Index algorithm. Areas indicated as “Wet” have a greater likelihood of being associated with surface watercourse features.
Figure 3. Illustrates sample cluster 1 (three points) north-northeast of Paulputs Substation with existing watercourse spatial layers.
4.1.2. Sample Cluster 2: Konkonsies

- Three sample points are located in the eastern portion of the study area on the Farm Konkoonsies 91, ± 9.95 km south-southeast of Paulputs Substation (Table 4; Figure 4).
- The area forms an outlier dune field of the paleo Koa River and results in inter-dune basins that can form depressions and flats, as indicated in Figure 4. The indicated depression and valley floor displayed in Figure 5 is derived from the RSA Wetland Types national spatial database (Van Deventer et al., 2010).
- The extent of valley floors and depression appear to be under represented in the existing spatial layers, with more of them present adjacent and between the dunes respectively (Figure 4).
- Inter-dune areas are characterized by different plant species compared to the surrounding areas. Species present include exotic invader Prosopis sp. on the valley floors and an unknown grass species in endorheic inter-dune depressions (Figure 5).
- No distinct obligated hydrophytes were recorded in the area.
- The existing 220kV transmission line is aligned adjacent to route 3; individual pylons appear to avoid the red dunes, but do intersect with valley floors and depressions.
- The red dunes are regarded as unstable environments and should not overlap with pylons.
- Route alternatives 1 & 3 intersect valley floors and an inter-dune depression (south of point P04), (Figure 4 & 5). Limited space is available to avoid other valley floors as they extend east and west of the routes.
- The sensitivity of these valley floors are regarded as low to medium, as surface ponding is expected to be highly infrequent: Each valley floor and inter-dune depression has a small, localised catchment and deep sandy soils that will result in greater infiltration and very low runoff. These systems are therefore expected to have marginal wetness with several years or even decades of no surface ponding.
- The crossing within the inter-dune depression and its associated dunes immediately south of point P04 is approximate 300 m in width and should be avoided or spanned (Figure 4 & 5).
- The two route alternatives in this area are similar in nature and impact, and are therefore expected to have a similar surface watercourse sensitivity.

<table>
<thead>
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<td>P06</td>
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Figure 4. Illustrates sample cluster 2 with existing watercourse spatial layers, additional dry watercourses in the form of inter-dune depressions (e.g. immediately south of point P04) and valley floors.
Figure 5. Top: Illustrates an endorheic inter-dune depression characterised by an unknown short grass species immediately south of point P04; Bottom: Illustrates a valley floor system bordered by red dunes west of sample point P05 and P06, which is characterised by the exotic alien plant species Prosopis sp. in its centre.

4.1.3. Sample Cluster 3: Noncaip se Holte

- Fourteen sample points are located in the eastern portion of the study area on the Farm Nongcaip 142, ± 13.50 km south-southeast of Paulputs Substation (Table 5; Figure 6).
- The area is located south of the red dune field at a confluence of two broad dry drainage lines indicated on the 1:50 000 drainage line dataset (Figure 6).
- The southern drainage line and main branch of the system is known as Noncaip se Holte, which is the more distinct of the two drainage trunks and also incorporates a large catchment area.
- The two drainage systems have discontinuous channels that display braided channel configuration referred to as bar and swale topography that extend across a width of approximately 400-340 m in Noncaip se Holte (Figure 7).
- The width of the second tributary north of the sampling points is narrower and harder to define due to more indistinct channel and flow features. The position of the illustrated drainage lines provide a good approximation of areas more likely to be affected by episodic flooding events (Figure 6).
• No obligated hydrophytes were recorded within the area, but a higher cover abundance of the shrub *Sisyndite spartea* is present in the wash compared to the surrounding areas.

• Noncaip se Holte overlaps with one of the DWAF 1:500 000 rivers GIS layer, which contains a Class B PES value and an Endangered Conservation status (Driver et al., 2004). The dataset also refers to the drainage line as the Kaboep.

• The landowner indicated that Noncaip se Holte has not had a flood event since 1999 (eleven years ago).

• The existing 220kV transmission line positioned east of route 3 manages to span Noncaip se Holte across a width of 340 m, with no pylons present within the drainage line. Pylon positions also don't overlap with indicated drainage lines associated with unnamed tributaries to the north. Pylon positions are located approximately halfway between drainage line areas in this tributary, which is regarded as good practice in this particular crossing setting.

• The width of the Noncaip se Holte increases to the west as a result of the confluence and results in a wider crossing (± 400 m) for route alternative 3 (Figure 6).

• Route alternative 1 has a width cross section of approximately 360 m in Noncaip se Holte, which is considered more favourable compared to route 3.

• No wetlands, natural channels, or riparian habitat were recorded during the field survey in any of the route alternatives within this area. *Bar and swale* features associated with washes (Section 1.4.3.) are, however, present and indicative of arid drainage lines in the area.

**Table 5. Sample points in sample cluster 3, ± 13.50 km south-southwest of Paulputs Substation**

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<tr>
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Figure 6. Illustrates sample cluster 3 with existing watercourse spatial layers (dry watercourses) in a broad wash (Noncaip se Holte) and its northern unnamed tributary that is less well defined and narrower.
4.1.4. Sample Cluster 4: R358 Crossing

- Eight sample points are located in the eastern portion of the study area on the Farm Eyties 144, ± 5 km north-northeast of Pofadder (Table 6; Figure 8 & 9).
- The area is located in a more mountainous area with steeper slopes and shallow soil profiles. Consequently, A-section headwater channels with discontinuous channel features, including banks and scour points, are common due to less infiltration and higher runoff.
- These non-wetland ephemeral drainage lines are well represented by the 1:50000 topographic drainage line network despite the small offset visible on the map (Figure 8 & 9). Trees species such as *Scotia afer* are present within these drainage lines.
- Several of the investigated A-Section headwater drainage lines are considered to be consistent with interpretations of a watercourse as defined in the NWA, based on the presence of natural channels with regular or intermittent flow. This is especially the case in areas with continuous channel lengths, as opposed to areas with discontinuous channel lengths.
- All of the route alternatives intersect headwater watercourses with natural channels in this section (Figure 8 & 9). The affected drainage are however very narrow (typically less than 15 m across) and can easily be spanned via adjacent pylons.
- Route alternatives in the area are therefore expected to have a similar watercourse impact and sensitivity.
Figure 8. Illustrates sample cluster 4 with existing watercourse spatial layers (dry watercourses) as A-section headwater channels.
Figure 9. Illustrates more of sample cluster 4 with existing watercourse spatial layers (dry watercourses) as A-section headwater channels.
Table 6. Sample points in sample cluster 4, ± 5 km north-northeast of Paulputs Substation

<table>
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4.1.5. Sample Cluster 5: Pofadder

- Six sample points are located in the eastern portion of the study area on the Farm Eyties 144, north and west of Pofadder (Table 7; Figure 10 & 11).
- The area is located on a flat plain with shallow soil development due to underlying rock sheets (Figure 10 & 11). A high frequency of A-section headwater channels with distinct to marginal channel features are present throughout the plain (Figure 10 & 11).
- Sample points P57-P60 illustrate that the channel network is more extensive than indicated on the 1:50 000 topographic map drainage line network: New channel features were recorded at these sample points, both upstream and downstream of the N14 highway (Figure 11).
- Trees such as *Acacia karroo* and a *Ozoroa* sp. are associated with these dry and often entrenched drainage lines (arroyo/dongas).
- Three dry river drainage lines from the DWAF 1:500 000 rivers GIS layer are present within the plain and overlap with the two route alternatives. Each of the rivers has a Class B PES value and an Endangered Conservation status (Driver et al., 2004).

Table 7. Sample points in sample cluster 5, immediately north and west of Pofadder

<table>
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Figure 10. Illustrates sample point P56 of sample cluster 4 with existing watercourse spatial layers (dry watercourses) as A-section headwater channels.
Figure 11. Illustrates sample points P57-P61 of sample cluster 4 with existing watercourse spatial layers (dry watercourses) as A-section headwater channels.
Both of the route alternatives intersect headwater drainage lines in the form of natural channels within this section. The affected watercourses are however very narrow (typically less than 15 m across) and can easily be spanned with pylons located outside of watercourses.

However, the close proximity of drainage lines from one another will require careful pylon placement and potentially numerous watercourse road crossings during the construction phase.

Route alternatives in the area are in close proximity to one another and are expected to have a similar watercourse impact and sensitivity. Natural channels with regular or intermittent flow are the only type of surface watercourses within the area.

Figure 12.1 Top: Illustrates shallow soil conditions and exposed bedrock in portions of sample cluster 5; Bottom: Illustrates Ozoroa sp. trees associated with discontinuous and narrow ephemeral drainage lines upstream and downstream of the N14 highway.
4.2. Western Study Area Portion: Split Point to Aggeneys Substation

4.2.1. Sample Cluster 6: T’Goob se Laagte

- Eight sample points are located in the western portion of the study area on the Farm Pella Mission 39, ± 17.25–21.25 km west of Pofadder (Figure 13 & 14; Table 8).
- Sample points are located within a broad non-perennial wash (T’Goob se Laagte) upstream of the N14 crossing.
- The presence of the wash and surrounding dry watercourses correspond with the drainage line network data from the 1:50 000 topographic spatial layer.
- The wash has a width of approximately 400 m in this area while it becomes narrower in the upstream direction, upstream of a confluence with a smaller unnamed wash (Figure 14).
- The 1:50 000 drainage line spatial layer indicates two branches of a dry watercourse near the N14 highway crossing in the sample point cluster (P32-P39). It can, however, be considered as a single, broad wash with alluvial sand that has accumulated in its center and in effect raised the bed of the channel. This would also explain the location of two sets of culverts near the edges of the watercourse (sample points P38 & P39). A red sand dune is also present on the left hand bank of the wash (Figure 13 & 14).
- Dense stands of the grass *Stipagrostis cf. brevifolia* dominate throughout the watercourse in the sampled area and appears to be associated with deep sandy soils.
- Two dry river drainage lines from the DWAF 1:50 000 rivers GIS layer are present within the area and overlap once with route alternative 2, and twice with route alternatives 1 and 3. Each of the rivers has a Class B PES value and an Endangered Conservation status (Driver et al., 2004).
- Route alternative 2 (Agg – Paul N 14 2) crosses T’Goob se Laagte at its broadest section (± 400 m) immediately upstream of the N14 Highway, (Figure 13 & 14).
- Both route alignments 1 and 3 cross further upstream across narrower sections of T’Goob se Laagte, ± 370 m and ± 340 m wide sections respectively.
- The unnamed dry drainage line (wash) tributary, north of T’Goob se Berg, is less distinct and is expected to flow less regularly compared to T’Goob se Laagte.
- Route alternative 3 crosses a ± 275 m wide section of this unnamed wash and alternative 1 an approximately 240 m wide section. Route Alternative 1 crosses the unnamed tributary near a confluence with yet another narrow drainage line.
- The crossing of the existing 220 kV line and T’Goob se Laagte is located immediately south of alternative 1 and is ± 385 m long. The distance between the nearest pylons at this crossing is approximately 530 m. The crossing length of the transmission line through the unnamed tributary is approximately 250 m, while the distance between the nearest pylons is ± 480 m.
- No wetlands, natural channels, or riparian habitat were recorded during the field survey in any of the route alternatives within this area. Recorded Bar and swale features are associated with washes (Section 1.4.3.) and indicative of arid drainage lines in the area.
The three route alternatives have a similar sensitivity: Alternative 2 crosses only one drainage line (wash), but at the widest distance (±400 m). Alternative 1 & 3 crosses two washes, including T’Goob se laagte, but with shorter distances (<400 m).

Table 8. Sample points in sample cluster 5, ± 17.25–21.25 km west of Pofadder

<table>
<thead>
<tr>
<th>Sample Point</th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>P32</td>
<td>-29.13259688</td>
<td>19.17549270</td>
</tr>
<tr>
<td>P33</td>
<td>-29.13272873</td>
<td>19.17528056</td>
</tr>
<tr>
<td>P34</td>
<td>-29.13287516</td>
<td>19.17498467</td>
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<tr>
<td>P35</td>
<td>-29.13294389</td>
<td>19.17453398</td>
</tr>
<tr>
<td>P36</td>
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<td>P37</td>
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<tr>
<td>P38</td>
<td>-29.12909626</td>
<td>19.17635160</td>
</tr>
<tr>
<td>P39</td>
<td>-29.12997527</td>
<td>19.17393853</td>
</tr>
</tbody>
</table>

Figure 13. Illustrates T’Goob se Loop (dry watercourse/wash) at route alternative 2, near the N14 Highway (image taken from the left hand bank of the wash).
Figure 14. Illustrates sample points P32-P39 within T’Goob se Laagte, a broad wash crossing with alternative 2 that is located downstream of confluence with an unnamed wash tributary. The wash becomes narrower in an upstream direction (southeast of the N14 crossing) where it as well as the unnamed tributary are crossed by alternatives 1 and 3.
4.2.2. Sample Cluster 7: Witsand

- Four sample points are located in the western portion of the study area on the Farm Koups Leegte 58, ± 28.45 km west of Pofadder (Figure 15; Table 9).
- Sample points are located within a non-perennial wash near Witsand, along the crossing with alternative 2. The presence of the wash within the area corresponds with the presence of a broad dry watercourse (wash) indicated on the 1:50 000 topographic spatial layer. The same applies to the narrow and less distinct dry drainage lines (Figure 15).
- Dense stands of the grass *Stipagrostis cf. brevifolia* dominate throughout the watercourse in the sampled area and surroundings.
- The dry watercourse is heavily grazed by sheep.
- The National Spatial Biodiversity spatial layer indicates that the wash is associated with a non-perennial river. The river has a class B PES score and an Endangered conservation status (Driver et al., 2004).
- The identified wash also corresponds well with a *Dry water course* indicated in the 1:50 000 drainage line network dataset (Figure 15).
- Route alternative 2 has a crossing length of approximately 200 m through the wash, near the N 14 Highway (Figure 14).
- Route alternatives 1 and 3 have crossing lengths of ± 580 m and 250 m respectively (Figure 15).
- Pylon positions within the narrower dry drainage lines are expected to be avoidable (Figure 15).
- The existing transmission line crosses through a 520 m wide section of the wash in between route alternatives 1 and 3, with one pylon located within the center of the wash. The distance between the two adjacent pylons is ± 460 m to the west and ± 500 m to the east.
- No wetlands, distinct natural channels, or riparian habitat were recorded during the field survey in any of the route alternatives within this area. Recorded *Bar and swale* features are associated with washes (Section 1.4.3.) and indicative of arid drainage lines in the area.
- Route alternative 2 appears to be the most favourable crossing from a drainage line sensitivity consideration, based on the distance of this particular drainage line crossing. Route alternative 3 has a similar sensitivity compared to alternative 2, while alternative 1 is the worst based on the same crossing distance evaluation criteria.

Table 9. Sample points in sample cluster 7, ± 28.45 km west of Pofadder.

<table>
<thead>
<tr>
<th>Sample point</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>P40</td>
<td>-29.15828758</td>
<td>19.10698917</td>
</tr>
<tr>
<td>P41</td>
<td>-29.15826830</td>
<td>19.10754321</td>
</tr>
<tr>
<td>P42</td>
<td>-29.15820250</td>
<td>19.10761538</td>
</tr>
<tr>
<td>P43</td>
<td>-29.15858421</td>
<td>19.10533844</td>
</tr>
</tbody>
</table>
Figure 15. Illustrates sample points P40-P43 within an unnamed dry watercourse (wash) near Witsand.
4.2.3. Sample Cluster 8: Dabbiepoort

- Seven sample points are located in the western portion of the study area on the Farm Aroams 57, ± 12.90 km northeast of Aggeneys Substation (Figure 16; Table 10).

- Sample points are located within a non-perennial arid drainage line upstream of Dabbiepoort. The presence and extent of the wash overlaps partially with a seep wetland indicated in the RSA Wetland Types spatial layer (Van Deventer, 2010), (Figure 16).

- No wetland indicators such as signs of prolonged soil saturation or hydrophytic vegetation were recorded within the drainage line.

- *Bar and swale* features associated with washes (Section 1.4.3.) were, however, present and indicative of an arid drainage. Dark patches of higher vegetation cover is visible in the aerial photograph that are expected to be indicative of flow events and sand deposition. Elongate bare areas in the drainage line appear to be associated with discontinuous swale-like features (Figure 16).

- The 1:50 000 topographic drainage network indicate a discontinuous *Dry water course* located upstream of the sample points that overlap with alternatives 1 & 3. This *Dry water course* is in fact continuous and larger in size, as can be seen in Figure 16.

- The National Spatial Biodiversity spatial layer indicates that the wash is associated with a non-perennial river. The river has a class B PES score and a Not threatened conservation status (Driver et al., 2004). No clearly defined continuous channel is present within the system.

- Route alternative 1 is located parallel to the wash, but only intersects the edge of the wash on its right hand bank. The crossing length within this area is approximately 1 100 m.

- Route alternative 3 is located parallel to the wash and intersects it at two different positions. The upstream intersection is on the edge of the watercourse (left hand bank) and extends for approximately 900 m, while the downstream intersection is closer to the sampling points and cuts across the wash for another 550 m (approximately). The latter crossing incorporates an area with both distinct and indistinct channel features (ordinary high water mark indicators), but the entire crossing distance can potentially still be affected by episodic flooding events (Figure 16).

- The combined drainage line crossing length associated with route 3 is approximately 1450 m in this area.

- Route alternative 2 does not intersect with the wash watercourse, as it is located on the opposite side of the N 14 highway.

- Two existing transmission lines are located immediately southeast of route 1 and therefore miss the unnamed wash completely.
Figure 16. Illustrates sample points P45-P52 within an unnamed arid drainage line (wash) near Dabbiepoort.
• Route alternative 2 appears to be the most favourable from a drainage line sensitivity consideration, as there is no overlap within this particular wash. Route alternative 1 is a distant second best and alternative 3 is the worst based on its combined crossing distance and two crossing points.
• It may be possible to move route alternative 1 further to the east within its corridor so that it no longer overlaps with the wash (Figure 16).

Table 10. Sample points in sample cluster 8, ± 12.90 km northeast of Aggeneys Substation.

<table>
<thead>
<tr>
<th>Sample point</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>P45</td>
<td>-29.21373035</td>
<td>18.91154406</td>
</tr>
<tr>
<td>P46</td>
<td>-29.21356137</td>
<td>18.91186299</td>
</tr>
<tr>
<td>P47</td>
<td>-29.21410158</td>
<td>18.90985644</td>
</tr>
<tr>
<td>P49</td>
<td>-29.21785098</td>
<td>18.90781327</td>
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<tr>
<td>P50</td>
<td>-29.21891087</td>
<td>18.90868449</td>
</tr>
<tr>
<td>P51</td>
<td>-29.21738033</td>
<td>18.90705655</td>
</tr>
<tr>
<td>P52</td>
<td>-29.21692553</td>
<td>18.90722394</td>
</tr>
</tbody>
</table>

4.2.4. Sample Cluster 9: Aggeneys

• One sample point is located in the western portion of the study area on the Farm Aggeneys 56, ± 3.50 km east of Aggeneys Substation and 2.7 m south of the town of Aggeneys (Figure 17; Table 11).
• The sample point is located within a non-perennial wash adjacent to the N 14 highway between route alternatives 1 and 2. The presence of the wash within the area corresponds with the presence of a broad Dry water course indicated on the 1:50 000 topographic drainage line network (Figure 17).
• Route alternative 1 is aligned parallel to the wash along its crossing, with an approximate crossing length of 1350 m.
• Route alternative 2 has a crossing length of approximately 200 m through the wash, on the southern side of the N 14 Highway.
• Route alternative 3 is aligned parallel to the wash, with a crossing length of ± 775 m.
• Two existing transmission lines are located between route alternatives 1 and 3.
• No wetlands, continuous natural channels, or riparian habitat were recorded during the field survey in any of the route alternatives within this area. Recorded Bar and swale features are associated with washes (Section 1.4.3.) and indicative of arid drainage lines.
• Route 2 appears to be the most favourable from a drainage line sensitivity consideration, as it has the shortest crossing within this particular wash. Route alternative 1 is second best, while alternative 3 is the worst based on the same evaluation criteria.

Table 11. Sample points in sample cluster 8, ± 12.90 km northeast of Aggeneys Substation

<table>
<thead>
<tr>
<th>Sample point</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>P55</td>
<td>-29.28133459</td>
<td>18.83943019</td>
</tr>
</tbody>
</table>
Figure 17. Illustrates sample points P45-P52 within an unnamed dry watercourse (wash) south of Aggeneys and east of Aggeneys Substation.
5. POTENTIAL PROJECT-RELATED WATERCOURSE IMPACTS

The issues and impacts below are based on the categories for the assessment of Present Ecological State of wetland systems derived from the DWAF-developed methodology of Duthie (1999) and Kleynhands (1999). Similar issues and impacts are expected to affect arid drainage lines following the implementation of the proposed development.

5.1. Flow Modification
**Potential Causes:** Concentration of surface flow patterns.
**Potential Effects:** Changes to the hydrological regime (e.g. duration, frequency, timing, volume and/or velocity of flows) and hence spatial extent of wetland and river areas and/or hydrological cues for aquatic biota.

Potential project related impacts:
- Alteration of surface flows (surface and subsurface) as a result of crossing structures (running tracks) that function as flow obstructions. These crossings may be envisaged where access and maintenance roads are absent, inadequate or not useable.
- Habitat fragmentation and modified flow patterns within drainage lines and watercourses as a result of surface infrastructure construction (e.g. pylons, stockpiles, vehicle movement and temporary infrastructure in drainage lines).

5.2. Water Quality
**Potential Causes:** Hydrocarbons (e.g. diesel and petrol) polluting drainage lines.
**Potential Effects:** Oxygen depletion, bioaccumulation of toxic compounds in biota, disruption of the endocrine system in biota.

Potential project related impacts:
- Decrease in water quality as a result of refueling of vehicles and machinery in drainage lines.

5.3. Sediment load modification
**Potential Causes:** Loss of vegetation cover (e.g. through vegetation clearing) and erosion of channel bank and/or bed. Erosion is particularly a high risk in erosion prone soils and in drainage lines that lack channel features and are adapted to lower energy environments (e.g. hillslope seepages).
**Potential Effects:** Loss in drainage line habitat, change in vegetation cover, potential increase in turbidity and hence decrease in water quality.

Potential project related impacts:
- Loss of drainage line habitat as a result of erosion related to vegetation clearing for pylon construction.
- Change in substrate conditions (habitat for biota) and erosion damage at road crossings, especially newly created drainage line crossings.
5.4. Canalisation

**Potential Effects:** Lowering of the water table adjacent to the channel and decrease in the frequency of overbank flooding. Channel initiation can also be created in wetland systems that lack channel features.

Potential project related impacts:
- Loss of drainage line habitat as a result of canalization at road crossings.

5.5. Topographic Alteration

**Potential Causes:** Pylon construction, roads, stockpiles, fences and other infrastructure.

**Potential Effects:** Modifies drainage line habitat, change flow patterns and surface ponding.

Potential project related impacts:
- Loss of drainage line area as a result of road construction infrastructure placement (e.g. pylons).
- Road related mortality of migrating/foraging drainage line associated fauna.

5.6. Indigenous vegetation removal

**Potential Causes:** Construction activities in wetlands and riparian habitat (e.g. erection of phylons and the construction of temporary road and watercourse crossings).

**Potential Effects:** Lower flow resistance and hence tendency to attenuate flows, loss of habitat, reduction in accumulation of organic matter, elevated erosion risk.

Potential project related impacts:
- Alteration of watercourse habitat as a result of vegetation removal.
- Aggravation and/or initiation of watercourse erosion features.

5.7. Invasive plant encroachment

**Potential Causes:** Downstream dispersal of exotic plant species, change to a drier hydrological regime. **Potential Effects:** Shading, lowering of the water table, channel incision, loss of habitat.

Potential project related impacts:
- Alteration of species composition of drainage line habitat as a result of the encroachment of alien plant species.
6. DISCUSSION OF DRAINAGE LINE SENSITIVE ROUTE ALTERNATIVES

Each of the three route alternatives can be compared with one another based on available spatial information of overlapping drainage lines, as well as interpretations of drainage line crossing widths in different sections between Paulputs and Aggeneys Substations. Table 12 illustrates the number and combined length of drainage lines within each of the alternative corridors, as well as the number and combined size of drainage line areas (polygons) based on spatial information from the 1:50 000 topographic map set. Table 13 illustrates the individual sensitivity rating of each route alternative per sampled section in the eastern and western portions of the study area (Section 4). The sensitivity rating is based on an interpretation of drainage line crossing widths for each line alternative, focused on the centre line of a specific alternative. Longer drainage line crossings are regarded as less sensitive and have a higher value (weighting) assigned to them, while shorter drainage line crossings are regarded as more sensitive to drainage lines and have a lower value assigned to them (Table 13).

All three route alternatives are located in close proximity to one another along their whole length (Figure 1) and generally have similar drainage line sensitivities (Table 12). A 220kV line typically allows for pylons to be 400 m apart (pers. comm. M Naidoo) and are therefore able to cross the majority of arid drainage lines (e.g. washes) without any major impacts. Crossing distance interpretations and sensitivity rating of similar sections along all three alternatives indicated that alternative 2 (Agg – Paul N 14 2) appears to be the most sensitive crossing option in terms of drainage lines present in the three corridors (Table 12 & 13). Having said that, it could still be possible to also make use of the remaining two alternatives, if modifications are made to their alignments. Specific problem areas that would need to be addressed include: Noncaip se Holte, Witsand, Dabbiepunt en Aggeneys (Section 4). T’Goob se Laagte is the only real area of concern that would need to be addressed if alternative 2 is selected, as alternative 2 would need to span a distance of just over 400 m in this area. The possibility also remains to make use of different sections of the three alternative options in the final route alignment. Section 4 and Table 13 should be used as a sensitivity guide in this regard.

Table 12. Drainage line information from the 1:50 000 topographic map set that overlap with each of the three route alternative corridors (2 km wide).

<table>
<thead>
<tr>
<th></th>
<th>Alternative 1 (Agg - Paulp) corridor</th>
<th>Alternative 2 (Agg - Paul N 14 2) corridor</th>
<th>Alternative 3 (Agg - Paul Ex 1) corridor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length of drainage lines</td>
<td>221.77 km</td>
<td>212.01 km</td>
<td>216.70 km</td>
</tr>
<tr>
<td>Total number of drainage lines</td>
<td>176</td>
<td>166</td>
<td>166</td>
</tr>
<tr>
<td>Total area of drainage line polygons</td>
<td>368.95 ha</td>
<td>253.71 ha</td>
<td>353.59 ha</td>
</tr>
<tr>
<td>Total number of drainage line polygons</td>
<td>6</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>
Table 13. Interpreted drainage line sensitivities based on drainage line crossing distances of route centre lines. Drainage line sensitive crossings are signified by lower values and vice versa.

### Eastern Study Area Portion

<table>
<thead>
<tr>
<th>Sampled cluster</th>
<th>Merged Alignment 1 &amp; 2</th>
<th>Alignment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensitivity rating</td>
<td>Notes</td>
</tr>
<tr>
<td>Skuitklip to Paulputs Substation</td>
<td>0</td>
<td>No distinct drainage lines or watercourses in the area.</td>
</tr>
<tr>
<td>Konkonsies</td>
<td>1</td>
<td>Small inter-dune depressions are avoidable; valley floors have a low to medium sensitivity.</td>
</tr>
<tr>
<td>Noncaipe Holte</td>
<td>0</td>
<td>Widest drainage line crossing is ± 360 m.</td>
</tr>
<tr>
<td>R358 Crossing</td>
<td>1</td>
<td>Similar number and frequency of A section channel crossings</td>
</tr>
<tr>
<td>Pofadder</td>
<td>1</td>
<td>Similar number and frequency of A section channel crossings</td>
</tr>
<tr>
<td><strong>Subtotal 1</strong></td>
<td><strong>3</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Western Study Area Portion

<table>
<thead>
<tr>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity rating</td>
<td>Notes</td>
<td>Sensitivity rating</td>
</tr>
<tr>
<td>T’Goob se Laagte</td>
<td>1</td>
<td>One wide wash crossing of ± 400 m.</td>
</tr>
<tr>
<td>Witsand</td>
<td>1</td>
<td>One wide wash crossing of ± 580 m.</td>
</tr>
<tr>
<td>Dabbiepoort</td>
<td>1</td>
<td>One wash crossing of ± 1100 m</td>
</tr>
<tr>
<td>Aggeneys</td>
<td>3</td>
<td>Combined wash crossing distance of ± 1350 m</td>
</tr>
<tr>
<td><strong>Subtotal 2</strong></td>
<td><strong>6</strong></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>9</strong></td>
<td></td>
</tr>
</tbody>
</table>
7. IMPACT EVALUATION & MITIGATION

7.1. Introduction
This section of the report describes and evaluates the potential impact of the proposed development on the environment. The impact of the development should ideally be assessed in terms of the following development phases:

- Construction Phase
- Operational Phase
- Decommissioning Phase

Limited emphasis will be provided on the decommissioning phase, with most of the attention focused on the construction phase.

7.2. Approach
An impact can be defined as any change in the physical-chemical, biological, cultural and/or socio-economic environmental system that can be attributed to human activities related to alternatives under study for meeting a project need. The significance of the impacts will be determined through a synthesis of the criteria below:

**Temporal Scale.** Defines the significance of the impact at various time scales, as an indication of the duration of the impact.

- Short term: Less than 5 years; many construction phase impacts will be of a short duration.
- Medium term: Between 5 and 15 years.
- Long term: Between 15 and 30 years
- Permanent: Over 30 years and resulting in a permanent and lasting change that will always be there.

**Spatial Scale.** The spatial scale defines physical extent of the impact.

- Individual: This scales applies to person/s in the area.
- Household: This scales applies to households in the area.
- Localised: Small scale impacts, from a few hectares in extent to e.g. the local district area.
- Regional: Provincial.
- National: South Africa.
- International: This scale applies outside of South Africa’s borders.
Severity/Beneficial Rating Scale. The severity scale is used in order to scientifically evaluate how severe negative impacts would be, or how beneficial positive impacts would be on a particular affected system or a particular affected party.

Very severe: An irreversible and permanent change to the affected system(s) or party(ies) which cannot be mitigated. For example, the permanent change to topography resulting from a quarry.

Severe: Long term impacts on the affected system(s) or party(ies) that could be mitigated. However, this mitigation would be difficult, expensive or time consuming or some combination of these. For example, the clearing of forest vegetation.

Moderately severe: Medium to long term impacts on the affected system(s) or party(ies), that could be mitigated. For example constructing a narrow road through vegetation with a low conservation value.

Slight: Medium or short term impacts on the affected system(s) or party(ies). Mitigation is very easy, cheap, less time consuming or not necessary. For example, a temporary fluctuation in the water table due to water abstraction.

No effect: The system(s) or party(ies) is not affected by the proposed development.

Don't know/Can't know: In certain cases it may not be possible to determine the severity of an impact.

Slight beneficial: A short to medium term impact and negligible benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these. For example, a slight increase in the amount of goods available for purchasing.

Moderately beneficial: A medium to long term impact of real benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way. For example a slight improvement in the (local) roads.

Beneficial: A long term impact and substantial benefit to the affected system(s) or party(ies). Alternative ways of achieving this benefit would be difficult, expensive or time consuming, or some combination of these. For example, an increase in the local economy.

Very beneficial: A permanent and very substantial benefit to the affected system(s) or party(ies), with no real alternative to achieving this benefit. For example, the creation of a large number of long term jobs.

Significance scale. The environmental significance scale is an attempt to evaluate the importance of a particular impact. This evaluation needs to be undertaken in the relevant context, as an impact can either be ecological or social, or both.
7.3. Drainage line impact assessment and mitigation

Project-related impacts on drainage line systems and recommended mitigation measures are discussed below for different project phases. The significance of each impact is rated without mitigation measures and with mitigation measures.
<table>
<thead>
<tr>
<th>Impact</th>
<th>Temporal Scale</th>
<th>Spatial Scale</th>
<th>Severity</th>
<th>Significance (without)</th>
<th>Significance (with)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction Phase</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Compaction of drainage line soils</td>
<td>Short term</td>
<td>Localised</td>
<td>Slight</td>
<td>Low</td>
<td>No significance</td>
</tr>
<tr>
<td><strong>Recommendation(s):</strong> Avoid driving on drainage line soils during construction of the powerline. The significance of the impact without mitigation is regarded as low, as identified drainage lines are typically dominated by sandy soils with limited opportunity for compaction.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Surface flow modifications caused by access and maintenance road crossing structures</td>
<td>Long term</td>
<td>Localised</td>
<td>Moderately severe</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Recommendation(s):</strong> Construction of access or maintenance road crossings should not be made through drainage lines. Where this is unavoidable only temporary structures should be used that will be removed at the end of the construction phase. Temporary crossing structures should not concentrate surface flows in such a manner that they pose a risk to scour or headcut formation.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Establishment of a substrate discontinuity and hence dispersal barrier as a result of the construction of a drainage line crossing.</td>
<td>Long term</td>
<td>Localised</td>
<td>Moderately severe</td>
<td>High</td>
<td>No significance</td>
</tr>
<tr>
<td><strong>Recommendation(s):</strong> If the construction of a crossing is unavoidable make sure that substrate continuity is maintained between the drainage line surfaces up and downstream.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Pollution damage a result of construction vehicle refueling and spills in drainage lines</td>
<td>Short term</td>
<td>Localised</td>
<td>Severe</td>
<td>High</td>
<td>No significance</td>
</tr>
<tr>
<td><strong>Recommendation(s):</strong> No refueling of construction vehicles should occur within 30 m of drainage lines. Hydrocarbons should not be stored within 30 m of drainage lines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Loss of drainage line vegetation and habitat as a result of pylon construction</td>
<td>Long term</td>
<td>Localised</td>
<td>Severe</td>
<td>High</td>
<td>No significance</td>
</tr>
<tr>
<td><strong>Recommendation(s):</strong> No pylons should be constructed within any of the drainage lines (i.e. A Section channels, washes and inter-dune depressions).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operational Phase</strong></td>
<td></td>
<td></td>
<td></td>
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<td>6. Accelerated</td>
<td>Long term</td>
<td>Localised</td>
<td>Moderately</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Impact</td>
<td>Temporal Scale</td>
<td>Spatial Scale</td>
<td>Severity</td>
<td>Significance (without)</td>
<td>Significance (with)</td>
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<td>erosion and hence headcut development as a result of a poorly designed crossing structures.</td>
<td></td>
<td>severe</td>
<td></td>
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</tbody>
</table>

Recommendation(s): If the construction of a maintenance crossing is unavoidable make sure that the through flow beneath the crossing (e.g. via culverts or pipes) can accommodate high flows without causing erosion damage, such as scour or headcut development.

7. Encroachment of invasive alien vegetation in response to soil disturbances and deteriorating water quality

<table>
<thead>
<tr>
<th>Temporal Scale</th>
<th>Spatial Scale</th>
<th>Severity</th>
<th>Significance (without)</th>
<th>Significance (with)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long term</td>
<td>Localised</td>
<td>Moderately severe</td>
<td>Moderate</td>
<td>Low</td>
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</tbody>
</table>

Recommendation(s): Powerline infrastructure (e.g. pylons) should be located outside of drainage lines with a buffer of 30 m to avoid edge effects and opportunity for the encroachment of invasive alien plant species, such as *Prosopis* sp. Remove all alien plant infestation from the servitude. This should be a long-term action for the duration of the operation phase.
8. CONCLUSION

- No distinct wetland or river associated riparian habitat overlap with any of the three powerline route alternatives.
- Several arid drainage lines do, however, overlap with the three route alternatives. They include washes, A-Section channels and inter-dune depressions.
- These systems are not typically associated with surface watercourse, apart from the A Section channels, but are still regarded as sensitive landscape features that need to be incorporated into environmental sensitive project layouts with appropriate impact mitigation measures.
- Route alternative 2 is regarded as the most sensitive (appropriate) alignment option for the proposed powerline project based on generally shorter drainage line crossing distances.
- However, the remaining two route alternatives can also still be considered if modifications are made to their respective alignments, in order to reduce drainage line crossing distances. Through this process drainage lines can be spanned, up to 400 m wide sections at a time, and in the process impacts can be avoided.
- An assessment of the Present Ecological State (PES) of observed arid drainage lines are constrained by the scale of the project, as well the absence of an appropriate technique for assessing dry drainage lines. Information from the DWAF 1:500 000 rivers GIS spatial layer does indicate that the larger drainage lines within the study area are associated with a "largely natural" or class B PES score (Driver et al. 2004).
- Driver et al. (2004) also associate an Endangered conservation status with larger drainage lines within the study area. All of these drainage lines were considered as arid washes that lacked distinct channel features.
- The implementation of project-related infrastructures (e.g. roads or pylons) within drainage lines are expected to require an approved water use license as per requirements of the National Water Act, Act 36 of 1998, for impeding or diverting the flow of water in a watercourse. As well as altering the bed, banks, course or characteristics of a watercourse.
- It is recommended that individual drainage line crossings should be demarcated more accurately during a Walk Down Phase once the final route alternative has been selected. This will enable a more accurate identification of sensitive drainage line landscape features for more effective mitigation, as well as potential Water Use License applications where infrastructure construction in drainage lines cannot be avoided.
9. REFERENCES AND SUGGESTED FURTHER READING


