100 year Floodlines for Rivers along the Silimela Power line Route

Prepared by: SAZI Environmental Consulting
June 2016

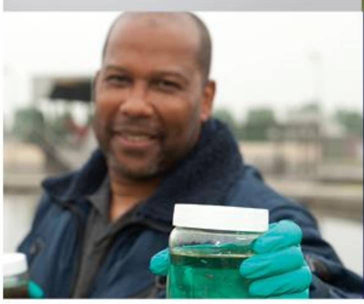

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TABLE OF CONTENTS

1 INTRODUCTION 1
1.1 AIMS OF THE STUDY 1
1.2 ASSUMPTIONS AND LIMITATION 1
2 LEGAL FRAMEWORK... 2
3 METHODOLOGY FOR ASSESEMENT 3
3.1 DESKTOP ASSESSMENT... 3
4 POTENTIAL IMPACTS 4
5 FLOODLINE ASSESSMENTS 6
5.1 APPROACH AND METHODS... 6
5.1.1 Limitations and Assumptions 6
5.2 DELINEATED CATCHMENTS 6
5.3 PEAK FLOW ESTIMATES 8
5.3.1 Empirical Method... 8
5.4 FLOOD HYDRAULIC MODELING METHODOLOGY 9
5.4.1 Hec-Ras Software 9
5.4.2 Model development and assumptions 9
5.5 DISCUSSION OF RESULTS... 10
6 CONSTRUCTION RELATED IMPACTS... 13
7 STORM WATER MANAGMENT 14
7.1 SEDIEMENT AND EROSION RISK ASSESSMENT 14
7.1.1 Sediment control measures 16
7.2 TOWERS LOCATED IN CLOSE PROXIMITY TO 100 YEAR FLOODLINES........... 16
8 GENERAL MITIGATION MEASURES... 18
8.1 REHABILITATION 18
8.2 ROLES AND RESPONSIBILITIES 19
9 CORRECTIVE AND PREVENTATIVE ACTION... 20
10 SURFACE WATER MONITORING PROGRAM... 21
11 REFERENCES... 22

LIST OF FIGURES

Figure 1: Catchments for the Rivers (Elands and Moses) that crosses the power line route…. 7
Figure 2: 100 year floodline for the Elands River along the power line route.......................... 11
Figure 3: 100 year floodline for the Moses Rivers along the power line route 12

LIST OF TABLES

Table 1: Catchment Peak flows (m^3/s) determined by the Empirical methods.......................... 8
Table 2: Sheet flow sediment control techniques.. 16
Table 3: Roles and responsibilities 19
Table 4: Preliminary surface water monitoring program.. 21

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EXECUTIVE SUMMARY

SAZI Environmental Consulting was commissioned by Eskom Holdings SOC Limited to conduct a surface water assessment, for the proposed construction of a new Silimela transmission power line. This Surface Water assessment will identify all surface water features that may be potentially impacted by the project or associated activities. The surface water assessment will establish feasible mitigation measures that can be implemented to prevent and/or minimise the potential impacts.

Surface water features (rivers/streams, dams, pans and wetlands) are a very important component of the natural environment, as they are typically characterised by high levels of biodiversity and are critical for the sustaining of human livelihoods through the provision of water for drinking and other human uses. They are sensitive features of the natural environment, and pollution or degradation of rivers/streams can result in a loss of biodiversity, as well as an adverse impact on the human users which depend on the resource to sustain their livelihoods. As such surface water resources and wetlands are specifically protected under the National Water Act, 1998 (Act No. 36 of 1998) and generally under the National Environmental Management Act, 1998 (Act No. 107 of 1998). It is in this context that the potential impact of the proposed development on surface water features has been assessed.

The main surface water potential impacts of constructing the power line have been identified as well as the mitigation measures to help prevent and/or minimise the impacts.

Construction activities can cause the following surface water impacts:

- Reduction of surface water quality due to introduction of chemicals/hydrocarbons from leakages, oil spills etc;
- Inadequate storm water management and soil stabilisation measures in cleared areas could lead to erosion that may lead to siltation of nearby watercourses; and
- The natural flow of water within the watercourses may be impeded. This would alter the hydrology of the watercourse and potentially affect the hydraulic characteristics of channel.

The proposed power line project should implement the following measures:

- The rivers and wetlands along the power line route are naturally narrow and can be spanned; no towers must be placed within the boundaries of any wetland or within the riparian zone of any watercourse, which should ensure a 32 meter water buffer from the stream centre line.
- The clearing of riparian vegetation has been identified to be a potential cause of localised impact on watercourses and rivers, thus clearing of riparian vegetation should be limited as far as possible.

1 INTRODUCTION

SAZI Environmental Consulting was commissioned by Eskom Holdings SOC Limited to conduct a surface water assessment, for the proposed construction of the Silimela power line, in the Limpopo Province. The surface water assessment will identify all surface water features that may be potentially impacted by the project or associated activities. The surface water assessment will further establish feasible mitigation measures that can be implemented to prevent and/or minimise the potential impacts.

The proposed power line route crosses two perennial rivers (i.e. Elands and Moses) based on a desktop assessment of the 1:50 000 topographical maps.

1.1 AIMS OF THE STUDY

The aims of the study are to:

- Identify all surface water (rivers/streams, pans, dam or wetlands) along the proposed power line alignments that could potentially be impacted by the development;
- Assess the impacts of the proposed development on these suitable surface water features, and suggest suitable mitigation measures, if relevant, to ameliorate or remove these predicted impacts; and
- Recommend any further studies required during the design phase of the project.

1.2 ASSUMPTIONS AND LIMITATION

The floodline analysis was undertaken at a desktop level, which can only be used for environmental impact purposes and the integrated water use license application for indicative proximity of the proposed route. No contour data was made available, where 5 m contour data were used to perform the analysis (not accurate for the purpose) and no ground surveys where undertaken by SAZI as access to the site was not organized by the Client. Therefore these floodlines cannot be considered accurate and may be considered conservative (i.e greater in extent than what the floodline may actually be). Therefore, the floodlines can only be considered as an indicative specifically for environmental purposes, only.

Only surface water features along the proposed alignment of the power line have been assessed as part of this study; the study does not include an assessment of the wider catchments within which the surface water resources along the line alternatives are located. Furthermore, attenuation features (such as dams) within the catchments have not be considered in these analysis allow for a conservative estimate in the peak flows.

2 LEGAL FRAMEWORK

In accordance with the requirements of the National Environmental Management Act (Act 107 of 1998) (NEMA) and the National Environmental Management Waste Act (Act 59 of 2008) (NEMWA), Eskom, requires prior approval i.e. Environmental Authorisation (EA) from the Competent Authority, in this case the Department of Environmental Affairs (DEA) to undertake the proposed new power line. Furthermore, a water use license will be required in terms of the National Water Management Act (Act 36 of 1998) (NWA). Due to water resources identified in close proximity to the proposed power line, which may trigger the following water uses as listed in Section 21 of the National Water Act, 1998 (Act No.36 of 1998) (NWA):

c) Impending or diverting the flow of water in a watercourse; and

i) Altering the bed, banks, course or characteristics of a watercourse.

In terms of the National Water Act (Act 36 of 1998), 100 year floodlines need to be determined before establishment of proposed power line as highlighted from an extract of the National Water Act below:

In compilation of the surface water specialist report other water related legislation and guidelines are also applied namely the Department of Water Affairs (DWA) Best Practice Guidelines (BPGs) series (2006).

3 METHODOLOGY FOR ASSESSEMENT

3.1 DESKTOP ASSESSMENT

The baseline surface water assessment was carried out in three phases namely:

- A desktop study to characterise the site, identify surface water features and to conduct hydrological characterisation;
- An indicative floodline assessment; and
- A report compilation.

The report identifies all potential impacts resulting from the proposed power line development and associated activities that may affect the surface water features. These impacts specifically relate to surface water features i.e. Elands and Moses Rivers. The report will also propose mitigation measures to either ensure that the identified potential impact does not materialise, or to ameliorate/limit the impact to acceptable levels have been stipulated.

4 POTENTIAL IMPACTS

Transmission power lines are not typically associated with impacts on surface water resources within non-woody environments, as the power lines do not have a physical footprint over the length of the power line other than the footprint of each tower position. As the lines are strung above the ground and as the towers are spread approximately 200m apart, most wetlands and rivers are able to be spanned by the power lines and thus avoid from being physically affected. Power lines can however be associated with impacts on surface water resources if the towers are placed within a river or wetland, or in wooded settings if they cross the riparian zone of a surface water feature (most relevant in this context). The process of constructing the power line can also cause impacts on surface water resources when vehicles drive in the footprint area during construction phase, especially if certain mitigation measures and procedures are not followed. These potential surface water quality and quantity impacts were determined and are explained in greater detail below.

- Towers/ electricity pylons are large structures and are require foundations in order for the structures to remain standing. The process of excavating the foundations would disturb the substrate and entail the removal of soil and vegetation from parts of the footprint, as well as the potential damage to vegetation due to the movement of construction machinery in the vicinity.
- If towers are constructed within a surface water feature, this activity could potentially adversely affect the soil and vegetation through the compaction of saturated soils, the trampling, smothering or removal of wetland vegetation and the resultant exposure of soils that could result in their desiccation and subsequent erosion thereby reducing the quality of water on the stream.
- The presence of concrete, as well as machinery which may leak hydrocarbon (fuel) into the surface water feature could result in the introduction of pollutants into the feature.
- The movement of heavy construction machinery into the surface water feature, especially wetlands, could result in the alteration of the sub-surface hydrology by creating conduits for the movement of water in the wetland.
- The placing and construction of a tower in a surface water feature would also require a licence from the Department of Water Affairs and Forestry as this activity would fall under one of the specified water uses under Section 21 of the National Water Act:

(i) altering the bed, banks, course or characteristics of a watercourse.

- The natural rivers affected in the study area are generally narrower than 200 meters including riparian zone and the riparian zone is mostly grass and small shrubs/tress with no woody vegetation, thus able to be spanned without the water course/wetland being physically affected.

5 FLOODLINE ASSESSMENTS

The objective of the assessment was to determine the 1:100 year floodline at the rivers and streams that cross the power line route, respectively. The floodlines will be used as part of the environmental impact assessment and integrated water use license application, where this assessment will present the proximity of the proposed pylons to the delineated floodline. It must be emphasised that this was desktop study; therefore the assessment can only be considered as an indicative floodline and specifically for environmental purposes, only.

5.1 APPROACH AND METHODS

The approach adopted in the study is summarised below;

- The catchment areas was delineated using 5 m contour data;
- A flood peak analysis was undertaken to determine the 100 year recurrence interval flood peaks for the respective rivers/streams;
- The HEC-RAS backwater programme was used to determine the surface water elevations for the 1:100 year flood peaks; and
- The floodlines were plotted on the available maps.

5.1.1 Limitations and Assumptions

The following limitations and assumptions were made in this specialist assessment;

- No flow or rainfall data against which the runoff calculations could be calibrated were available. The runoff volumes were therefore calculated theoretically;
- Since no flow data was available for estimation of the roughness coefficients, the Manning's n coefficient were estimated by comparing the vegetation and nature of the channel surfaces to the published data. These were considered to be 0.035 and 0.03 respectively;
- No attenuation features where considered in the peak flow analysis therefore the peak flow estimates would be conservative.

5.2 DELINEATED CATCHMENTS

The delineated catchments of the relevant rivers that cross the power line are illustrated in Figure 1. It can be seen that catchments extend of significant areas.

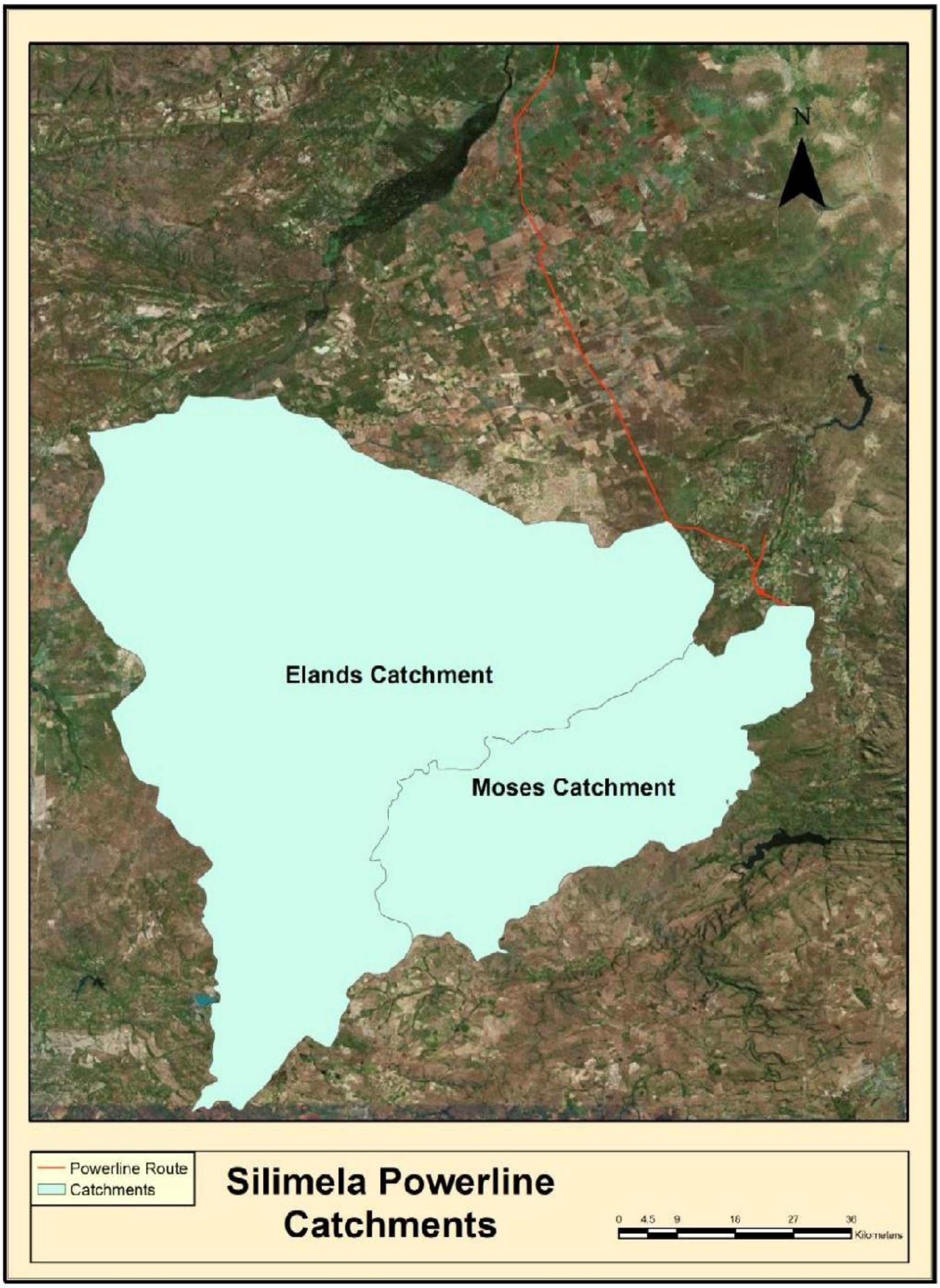

Figure 1: Catchments for the Rivers (Elands and Moses) that crosses the power line route

5.3 PEAK FLOW ESTIMATES

5.3.1 Empirical Method

The empirical methods are mainly applicable for larger catchments in extent of 100 km^2. The reliability of empirical methods depends largely on the realistic demarcations of comparable flood producing areas. Parameters for every region are based on historical data from the same region. Catchment characteristics and the peak flow estimates derived from the Empirical methods are presented in Table 1 below.

Table 1: Catchment Peak flows (m^3/s) determined by the Empirical methods

Catchment	Area (km^2)	Peak Flow (m^3/s)
Elands	4770	1650
Moses	1500	780

5.4 FLOOD HYDRAULIC MODELING METHODOLOGY

The following section details the approach and the methods used in the development of a hydraulic model for the purposes of defining the 1:100 year flood extents.

5.4.1 Hec-Ras Software

HEC-RAS 4.1.0 was used for the purposes of modelling the flooding resulting from a 1:100 year rainfall event. Hec-Ras is designed to perform one-dimensional hydraulic calculations. This was further used to define the channel and banks within the model. No site visit was undertaken to confirm the data used in the hydraulic analysis and this was considered to be the best available contour data at the time of the study. A default Manning's *n* value of 0.03 and 0.035 was used in defining the roughness for the channel and banks (Chow, 1959).

The peak flows used in the hydraulic model were calculated in Section 5.3. Peak flows and inflow boundaries have been calculated based upon an understanding of the catchment, the delineation of the respective catchment. The locations of the inflow boundaries within the hydraulic model are conservative in that the estimates for each of the catchments are placed at the start of each catchment river reach as represented by the hydraulic model, illustrated in Appendix A1. Consequently, flows in the headwaters of the catchments are overestimated; this is considered standard practice when undertaking hydraulic modelling of floodlines.

5.4.2 Model development and assumptions

The absence of any river structures and implementation of a steady state model meant that the Hec-Ras model developed was stable.

A number of assumptions have been made in undertaking the hydraulic modelling. These assumptions have been made in the context of the study and are considered appropriate in view of the level of detail required and the existing site conditions.

The key assumptions include:

- The Manning's *n* value used is considered suitable for use in the 100 year return periods modelled, as well as in representing both the channel and banks.
- A steady state model has been used to define flooding. The use of a steady state model, assumes that the area of interest is sensitive to peak flows rather than flood volume. Due to the topography of the site, peak flows are expected to be suitable for defining flood extents.

5.5 DISCUSSION OF RESULTS

The100 year floodline results of the hydraulic modelling are presented in Figure 2 and Figure 3, respectively where the floodline extent for the 1:100 year events where mapped.

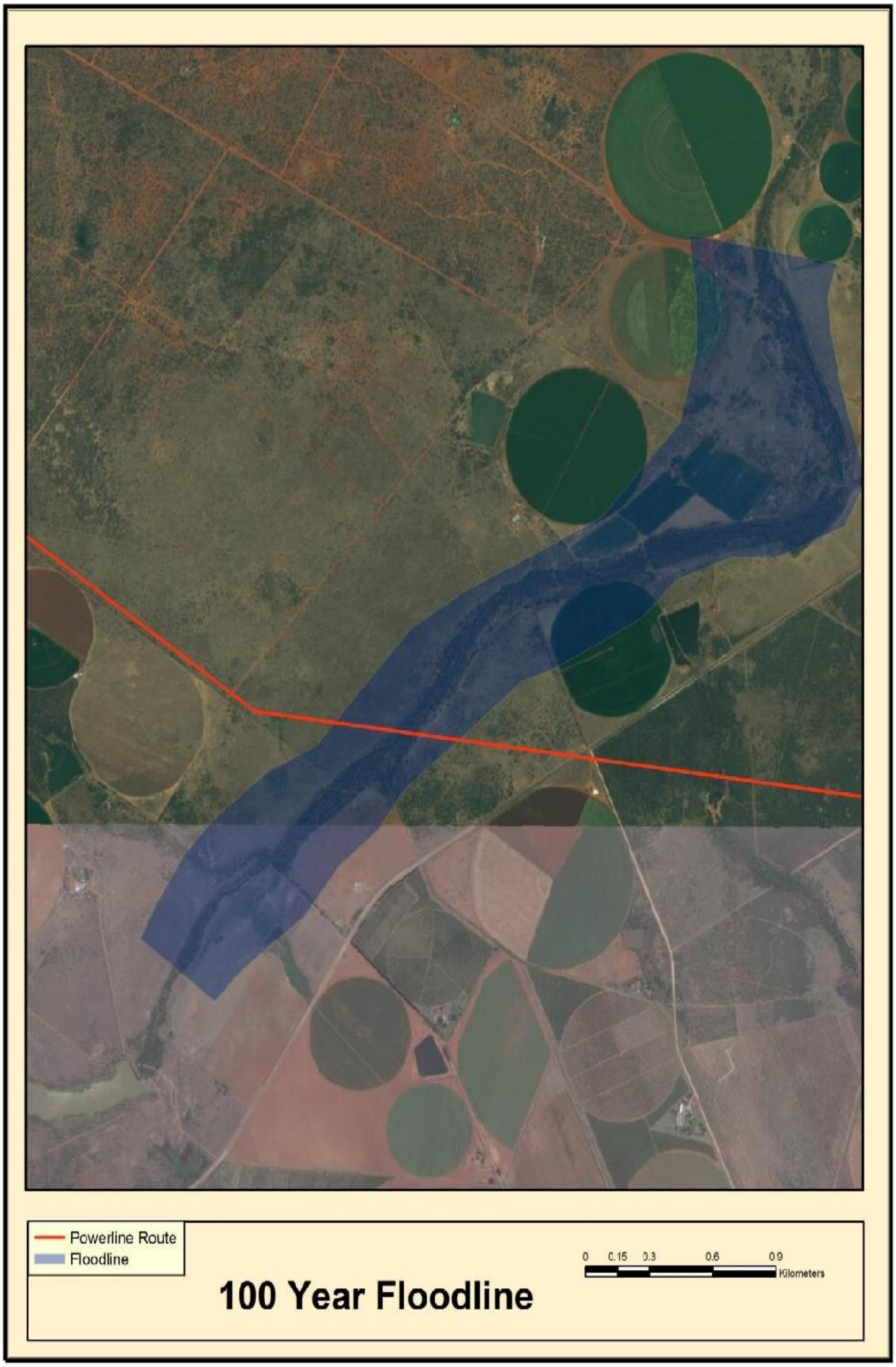

Figure 2: 100 year floodline for the Elands River along the power line route

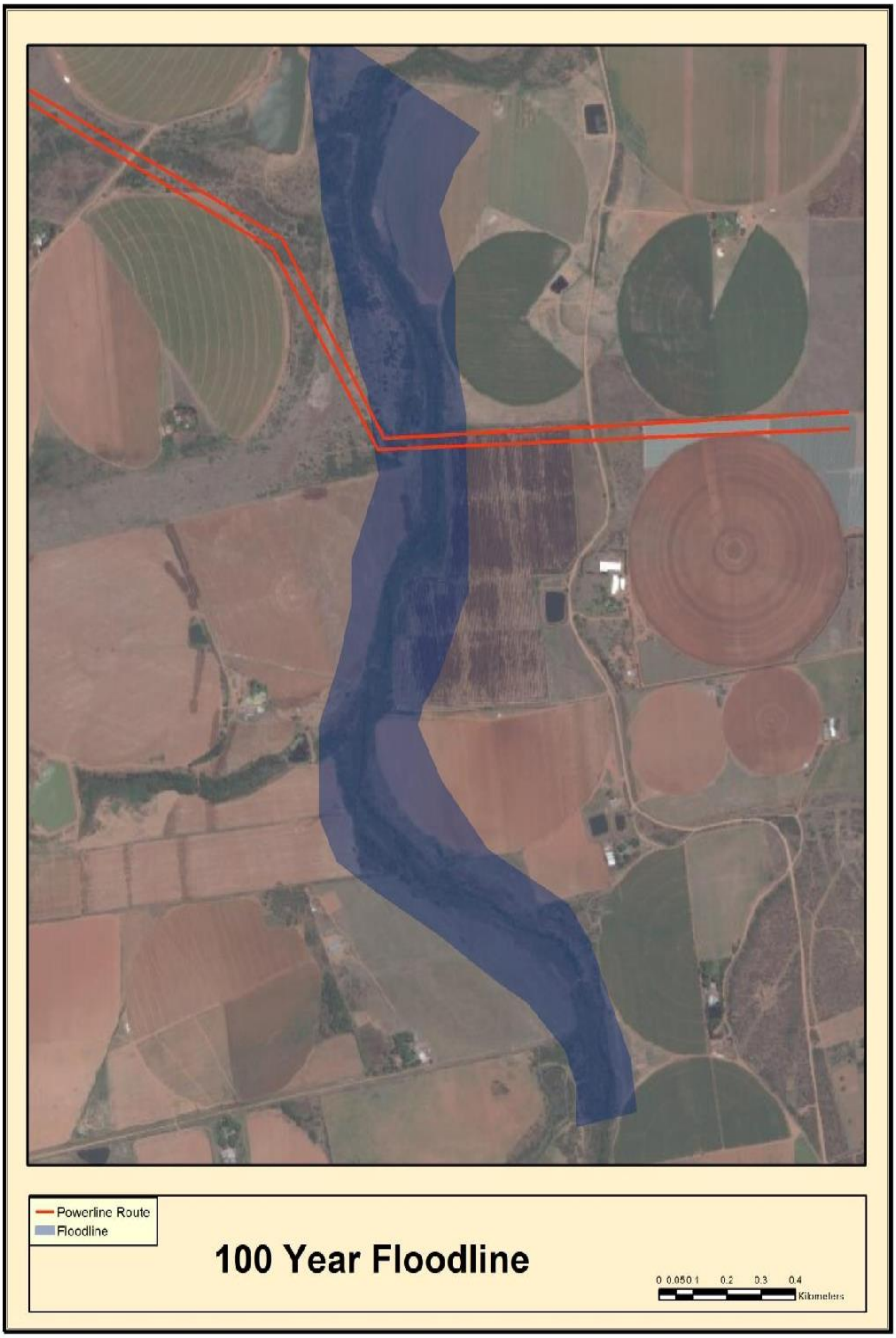

Figure 3: 100 year floodline for the Moses Rivers along the power line route

6 CONSTRUCTION RELATED IMPACTS

No towers are placed within any stream/wetlands and delineated 100 year floodlines. However, the activities of constructing the power line could potentially impact surface water resources. A number of activities, especially those relating to the access of construction vehicles along the alignment of the power line being constructed can result in damage to/impact on surface water resources. Construction vehicles and machinery that move along the alignment of a power line during construction would typically cross streams and drainage lines. Access route across these surface water resources may need to be constructed should existing access for vehicles not exist (this is often the case as power lines can run in undisturbed settings in which there is little human infrastructure). Accordingly the following impacts on surface water can result from construction activities along the power line servitude:

- The uncontrolled interaction of construction workers with watercourses that could lead to the pollution of the water in these drainage systems. Examples of this may be the washing of equipment in water within the watercourse, dumping of construction material into the drainage system, etc;
- Leakage of hazardous materials including chemicals and hydrocarbons such as fuel, and oil, which could potentially enter nearby surface water resources through storm water flows;
- The incorrect mixing (batching) of cement could lead to siltation and contamination of watercourses;
- Inadequate storm water management and soil stabilisation measures in cleared areas could lead to erosion that may lead to siltation of nearby watercourses;
- The creation of new access roads for construction traffic across watercourses may lead to the erosion of banks and disturbance of riparian vegetation that may trigger the further development of gulley (donga) erosion thereby reducing the quality of water; and
- Construction of accesses across watercourses may impede the natural flow of water (especially if access is required across flowing water). This would alter the hydrology of the watercourse and potentially affect the quality of water at some downstream water users.

7 STORM WATER MANAGMENT

The storm water measures best suited for the tower sites during construction are established from significant risk of impacts. The major risks identified during construction are presented in Section 6, which over an area that spans $10m^2$. The associated land disturbances will be an increase in sediment within the runoff to the rivers and streams and result generally in a decrease in water quality. The general storm water management strategy would comprise of five phases;

- Phase 1: Analysis of the main erosion and sedimentation hotspots across the respective tower site locations ,
- Phase 2: Design of the action plan based on the risk assessment;
- Phase 3: Implementation of the action plan;
- Phase 4: Continual monitoring and assessment of action plan;
- Phase 5: Implementation of supplemental contingency plans, if required.

7.1 SEDIMENT AND EROSION RISK ASSESSMENT

Erosion risk assessment provides an indicator tool to determine the sediment control and erosion control. The quantitative erosion risk for the sites would be conducted by the Revised Universal Soil Loss Equation (RUSLE). RUSLE aims to predict the potential long term average soil loss rate from a given site based on the following parameters.

$$\mathbf{A = K \times R \times LS \times P \times C}$$

Where: A is the predicted soil loss per area,

K is the soil erodibility factor,

R is the rainfall erosivity factor,

LS is the slope length/gradient factor,

P is the erosion control practice factor,

C is the ground cover and management factor.

Based on these factors it can be established that risks of sediment and erosion from the sites are generally of a low significant. This is mainly attributed to the small area that is being disturbed and the gentle slope gradients (since they are within the floodline flat areas will be prevalent).

Within the RUSLE, the C and P factors are used to describe management of the site with respect to reducing soil loss. The C factor measures the combined effect of the interrelated cover and management variables adopted over the sites. It also represents the non-structural methods for controlling erosion (i.e. covering exposed areas). The P factor measures the combined effect of the support practices and management variables. P factor is reduced by practices that reduce both the velocity of runoff and the tendency of runoff to flow directly downhill from the tower site area. It also represents structural methods for controlling erosion.

The soil characteristics would play a major role in the establishment of a storm water and erosion management plan. The soils would establish suitability of proposed measures. However, since the proposed sites are located generally in flat areas, the risk of erosion is lowered significantly. There are no tower locations which are considered as hotspots for the storm water and erosion measures for this proposed route. During construction runoff from above the site clearing should not enter onto the work areas. The areas are relatively flat therefore; the runoff would be expected to be sheet flow. The risks are associated with low risk therefore recommended that non-structural sediment control measures be considered. Best practice erosion management techniques for various erosion risk ratings would require minimum sediment and erosion control measures.

7.1.1 Sediment control measures

Since flat slopes reduce potential runoff onto the tower sites, when flow does occur it will be in the form of sheet flow. The suitably identified sheet flow control techniques are presented in the Table 2, which are in an order of risk significance.

Table 2: Sheet flow sediment control techniques

Technique	Typical Use
Filter sock	Suitable for the sites located close to the streams
Filter berm	Suitable for the tower exposed cleared areas. Suitable for the stockpiles. Capture of finer (sand/silt) sediments.
Mulch berm	Suitable for these proposed activities
Sediment Fence	Preferred type of sediment fence when placed adjacent critical habitats such as waterways. Short duration construction sites likely to experience only a few storm events

7.2 TOWERS LOCATED IN CLOSE PROXIMITY TO 100 YEAR FLOODLINES

Construction activities within the drainage lines have the potential to generate sediment plumes within the work area. Sediment released from a clearance site into streams can cause an increase in both turbidity and bed load sediment. During the construction of towers within drainage lines two sources of water flow will need to be managed. Firstly, flows passing through the tower construction area, and secondly lateral flows consisting of local storm water runoff flowing towards the channel. Practical measures need to be employed to convey the lateral inflow of storm water runoff around or through the tower area in a non-erosive manner. This inflow of 'clean' water should not mix with any 'dirty' water generated within the work area. The diversion of lateral inflow will be required in the following cases:

- When rainfall is expected or likely;
- Lateral inflows are likely to flow over exposed soil or cause bank erosion within the tower construction area; and
- Material stockpiles on the side of the streams which may wash into the streams.

The primary objectives when clearing within drainage lines include:

- Timing of works to coincide with periods of no/low flow and a low probability of significant rainfall;
- Staging of works to divert stream flows around tower construction area;
- Stockpiles should be positioned above flood levels with appropriate sediment control measures installed; and
- Rapid rehabilitation and stabilisation of river channel and banks.

Once the method of construction, sequencing and timing of works is known for all activities occurring in close proximity to the streams a review of the risks posed will need to be conducted prior to commencing any works.

8 GENERAL MITIGATION MEASURES

There are a number of general mitigation measures that are specified for all river and wetland crossings.

- The river and streams impacted along the power line are naturally narrow extent and can be spanned; no towers must be placed within the boundaries of any stream and wetland or within the riparian zone of any watercourse.
- The clearing of riparian vegetation has been identified to be a potential cause of localised impact on watercourses and rivers, thus clearing of riparian vegetation should be limited as far as possible.
- All rivers, wetlands and watercourses and their associated riparian zones should be treated as highly sensitive areas, and be strictly maintained as no-go' areas, except in the case of construction activities such as stringing of the lines and clearing of vegetation. No lay down areas should be placed within riparian corridors, and no construction right of ways should be created through or across watercourses (other than where existing roads access or cross watercourses). In that case, the existing roads and bridges should be used to move construction vehicles across the watercourse.
- Where surface water is encountered within rivers or watercourses, this should not be utilised for abstraction, or washing of equipment, etc. in order to minimise the risk of pollution of the water by construction activities. All abstraction of water from any surface water feature must be authorised as prescribed by the National Water Act and be subject to the provisions of any water use licence or general authorisation.
- No temporary roads or construction accesses must be constructed through any wetland or other surface water feature.

8.1 REHABILITATION

The primary objectives are to establish a self-sustaining vegetation cover or return the site back to original conditions. Re-vegetation should be completed within the timeframes depending on erosion risk. If works are likely to be suspended for an extended period, stabilisation of exposed areas will also be required within the specified timeframes.

8.2 ROLES AND RESPONSIBILITIES

The roles and responsibilities are presented Table 3.

Table 3: Roles and responsibilities

Role	Responsibility
Project Manager	■ Overall responsibility of ESC implementation; ■ Notify the Environmental Manager immediately of any Non-compliance with proposed measures; ■ Ensure the prompt implementation of measures to mitigate erosion and sediment generation;
Project Engineer	■ Provide design information as required; ■ Inspect ESC installation and maintenance; ■ Inspect offsite impacts and management;
Site Supervisor	■ Monitor daily rainfall; ■ Notify Environmental Manager when runoff generating rainfall occurs in the previous 24 hours; ■ Maintain current records of rainfall, extreme runoff onto site, water quality, treatment practices, discharge volumes;
Environmental Manager	■ Conduct in-situ monitoring; ■ Collect and submit samples to laboratory, if incidents occur and monitoring is required; ■ Collate results and prepare reports as required; ■ Conduct site inspections and audits as required; ■ Conduct site inspections and audits as required; ■ Prepare audit reports; ■ Provide advice regarding management measures and site improvement;
All Site Personnel	■ Report any damage to measuring devices and any potential or actual impacts to the resources

9 CORRECTIVE AND PREVENTATIVE ACTION

An environmental incident with respect to the management measures is defined as any occurrence where sediment is released from the site, whether controlled or uncontrolled, or where storm water is released (controlled) from tower site which does not meet the water quality requirements.

All incidents and non-conformances are to be reported and investigated and corrected in accordance with the management plan to ensure effective soil and water quality management practices at all times. Best practice site management requires all measures to be inspected by the Contractors nominated representative at least daily when rain is occurring, of sufficient intensity and duration to cause onsite runoff off the tower areas.

Inspection must be in line with the following:

- Daily site inspections (during periods of runoff producing rainfall);
- All drainage, erosion and sediment control measures;
- Occurrences of excessive sediment deposition (whether on-site or off-site); and
- All the tower site discharge points.

Weekly site inspections (even if work is not occurring on-site)

- All drainage, erosion and sediment control measures;
- Occurrences of excessive sediment deposition (whether on-site or off-site);
- Occurrences of construction materials, litter or sediment placed, deposited, washed or blown from the site, including deposition by vehicular movements;
- Litter and waste receptors; and
- Material storage facilities (Oil, fuel and chemical) Prior

to anticipated runoff producing rainfall

- All drainage, erosion and sediment control measures; and
- All temporary flow diversion and drainage works

Following runoff producing rainfall

- All drainage, erosion and sediment control measures;
- Occurrences of excessive sediment deposition (whether on-site or off-site);

- Occurrences of construction materials, litter or sediment placed, deposited, washed or blown from the site, including deposition by vehicular movements; and
- Occurrences of excessive erosion, sedimentation, or mud generation around the site and/or material storage areas.

10 SURFACE WATER MONITORING PROGRAM

The requirements of a surface water quality monitoring program are subject to an Environmental Management Plan as stipulated within the various project conditions of approval. At preliminary level surface water monitoring presented in Table 4 outlines possible requirements for with respect to management plans.

Table 4: Preliminary surface water monitoring program

Requirement	Sampling to be performed
Analytes	As per EMP At a minimum ▪ pH, Turbidity, Dissolved Oxygen (DO), Electrical Conductivity (EC), Temperature (°C)
Monitoring Locations	As per EMP At a minimum ▪ Downstream of tower sites, ▪ Drainage discharge points, ▪ Within identified sediment settling points
Timing	As per EMP At a minimum on any day when storm water runoff discharges from the tower sites.
Methodology	Samples are to be collected by suitably qualified personal and submitted to an SANS accredited laboratory for analysis. Sample collection must be defined in the EMP.

11 REFERENCES

Chow, V.T., 1959, *"Open-Channel Hydraulics"*, McGraw-Hill, New York