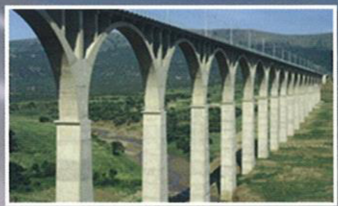
Jeffares & Green

CONSULTING ENGINEERS

KLIPKOP TO LEHATING POWERLINE

FLOODLINE STUDY



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KLIPKOP TO LEHATING POWERLINE

FLOODLINE STUDY

April 2016

REVISION 02

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1 INTRODUCTION

Jeffares & Green (Pty) Ltd (J&G) were appointed by Eskom to undertake floodline studies for drainage lines in the area of the proposed Klipkop-Lehating 132 kV Double Circuit Chickadee powerline (± 14km in length). The location of the proposed powerline is between the new Lehating Substation and the existing Klipkop Substation, Northern Cape Province. Based on a site visit undertaken in June 2015 and topographical maps of the study area, the only drainage line requiring a floodline study is the Kuruman River.

Three alternative powerline alignment corridors were previously investigated as part of this study (**Revision 01**), namely; **Alternative 1**, **Alternative 2** and **Alternative 3**. The results of this study and other assessments undertaken for the greater project resulted in Alternative 3 being the preferred option. However, Ntsimbintle Mining, who have mining operations in the study area, have indicated that the centre line of Alternative 3 will have an impact on their future mining operations. Ntsimbintle Mining subsequently provided two additional deviation options, namely; **Alternative 3A** and **Alternative 3B**. Eskom have indicated that their preferred alignment route is 3B.

The following report presents the methodologies used and results obtained for the floodline study. The report also discusses the feasibility of the additional routes in the context of design flood events on the Kuruman River.

2 SITE DESCRIPTION

The location of the study site is indicated in **Figure 2-1** with a site plan depicting the five alternative powerline alignments presented in **Figure 2-2**. The study area is located in the Northern Cape Province, approximately 12 km north-west of the town, Hotazel. The catchment area is predominantly rural, and consists of the Quaternary Catchments D41J, D41K, D41L and part of D41M.

J&G conducted a site assessment on the 23nd of June 2015. The objective of this site visit was to assess topographical, soil and land cover characteristics of the project area. These site characteristics form the basis for understanding the hydrology and hydraulic modelling. **Photographs 1** and **2**, taken during the site visit, indicate arid nature of the study area as well as the general characteristics of the Kuruman River reach where the floodline study was undertaken.

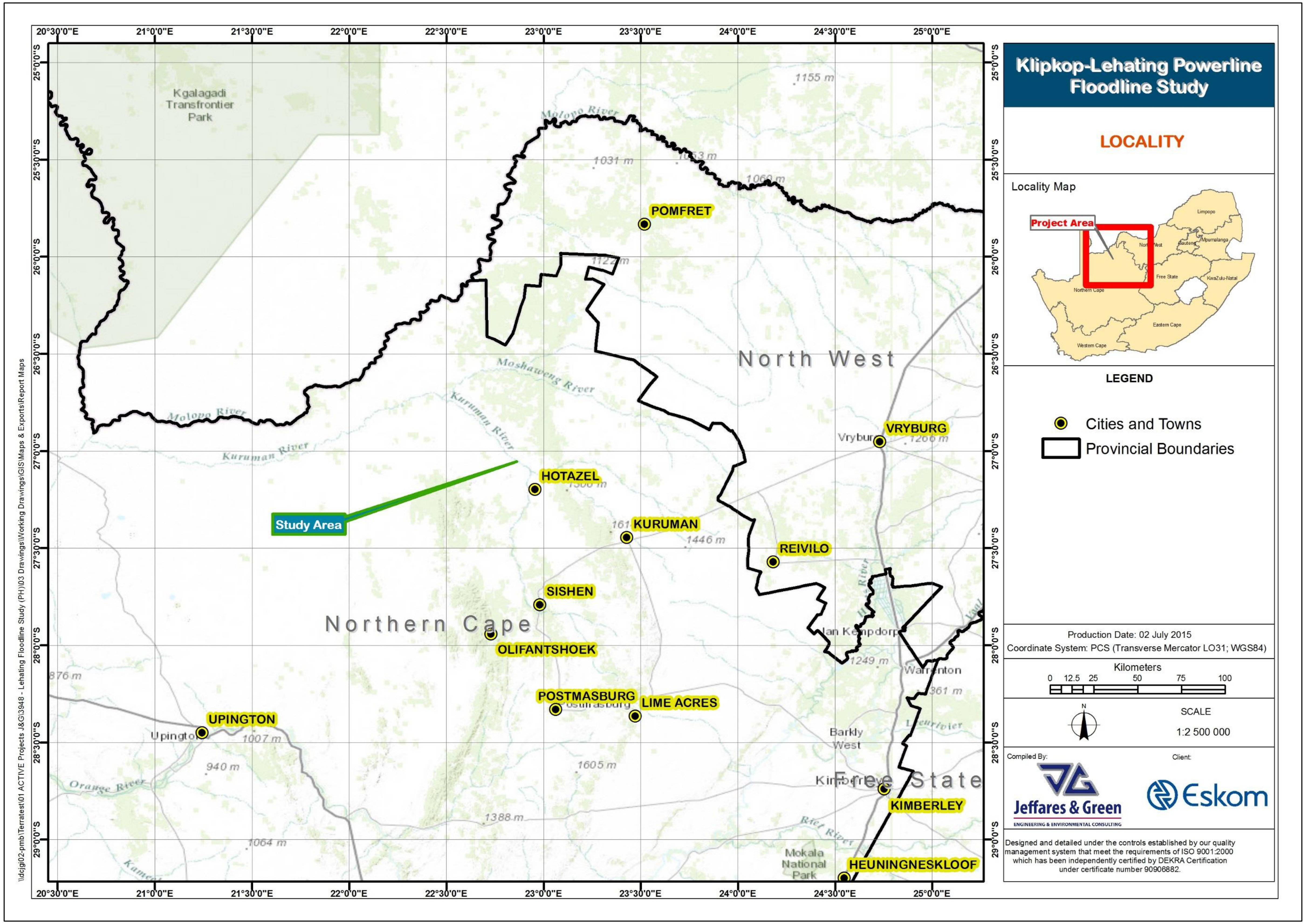

Figure 2-1 Klipkop-Lehating Powerline Floodline Study Locality Plan

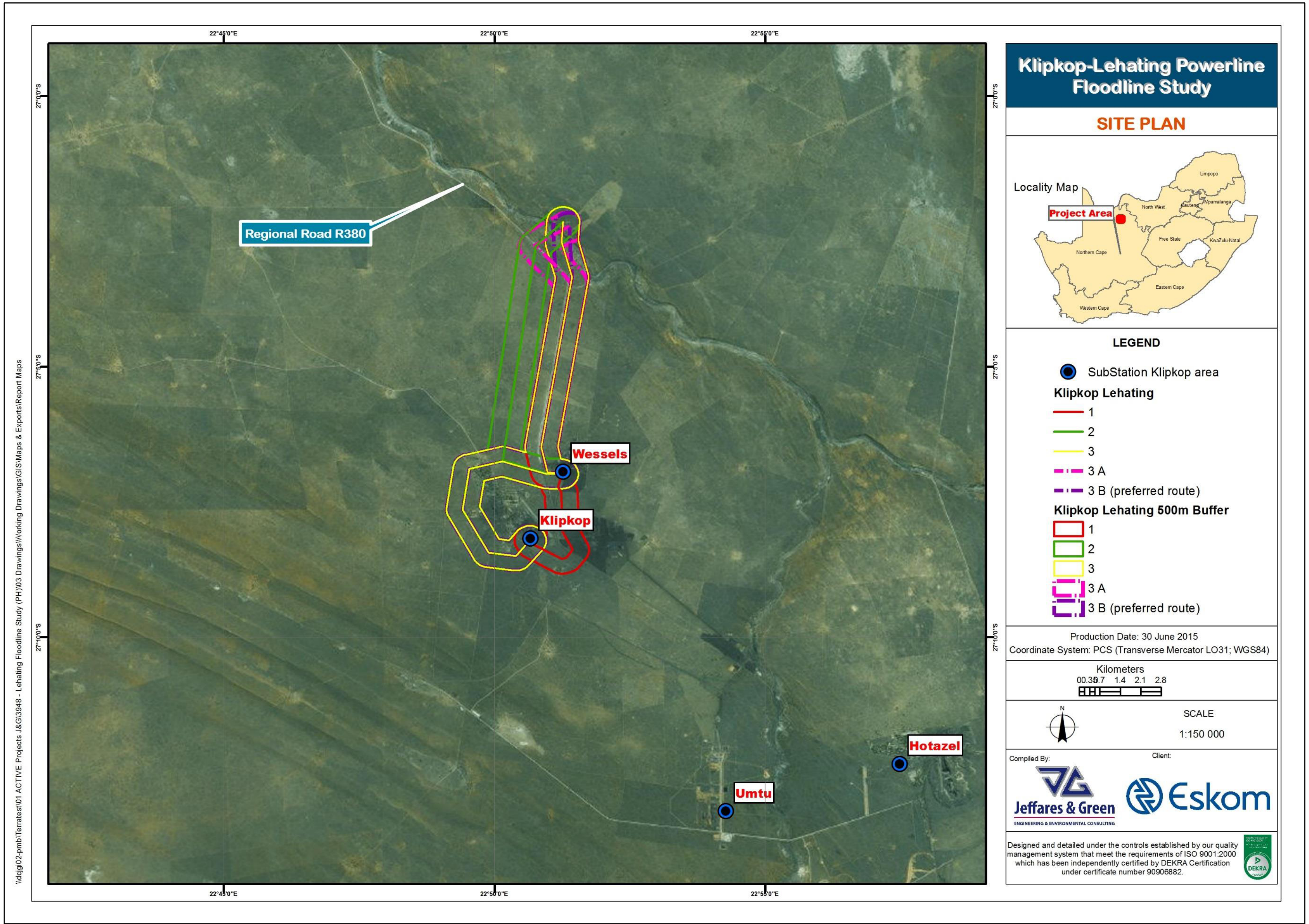

Figure 2-2 Klipkop-Lehating Powerline Floodline Study Site Plan

Photograph 1 and 2 Depiction Kuruman River in the Vicinity of the Project Area

3 DESIGN FLOOD ESTIMATION

The methodology used to calculate the design flood values, and the hydraulic model used to simulate the resultant floodlines, are discussed in the following sub-sections.

3.1 Peak Discharge Calculation Methodology

The methodology used for the peak discharge calculation depends largely on the size of the contributing catchment areas. In the case of this floodline study, the catchment area is large (**13 891 km^2**). Based on the catchment size, and the lack in reliable gauged data within the contributing catchment area, the Unit Hydrograph Method was used for the design flood calculations in this study.

3.1.1 Unit Hydrograph Method

The Unit Hydrograph method is based on regional analyses of historical data, and is independent of personal judgement. The results are reliable, although some natural variability in the hydrological occurrences is lost through the broad regional divisions and the averaged form of the hydrographs (SANRAL, 2006). A detailed description of the method is available in Report 1/72 of the Hydrological Research Unit (Pitman and Midgley, 1971).

The catchment variables used in the Unit Hydrograph Method are presented in **Table 3-1**. The resultant peak discharge values are presented in **Table 3-2**.

Table 3-1 Unit Hydrograph Catchment Parameters

Catchment Variable	Kuruman River
Catchment Area (km^2)	13 891
Length of Longest Water Course (km)	130
Distance to Catchment Centroid (km)	72
Catchment Mean Annual Precipitation (mm)	340
Veld Type Zone	6
Lag Time (hours)	14.7
Catchment Index	160 523
Coefficient (Ku)	0.265

Table 3-2 Unit Hydrograph Peak Discharge Calculation Results

Catchment	Peak Discharge (m^3/s) (Years)		
	1:20	1:50	1:100
Kuruman River	593	912	1 274

The design flood results obtained using the Unit Hydrograph Method were verified using Regional Flood Frequency Analysis (RFFA) Method. A comparison of the design flood results are presented in **Table 3-3**. It can be seen that the Unit Hydrograph Method results compare well to the Görgens (2007) Joint Peak-Volume (JPV) method using K-Region and Veld Zone pooling groups. It is therefore concluded that the results obtained using the Unit Hydrograph Method are acceptable.

Table 3-3 Results Comparison

Method	1:20 year	1:50 year	1:100 year
Unit Hydrograph	593	912	1 274
JPV Veld Zone	591	822	1 023

3.1 Floodline Delineations

3.2.1 Hydraulic modelling

The HEC-RAS Model (US Army Corp of Engineers) was used to undertake the 2-dimensional hydraulic modelling to determine the extent of the 1:20, 1:50 and 1:100 year return period flood events. Spatial information consisting of a digital elevation model (DEM) at a resolution of 30 metres was used for the hydraulic modelling. The DEM was converted by ArcMAP to allow for elevations and other topology to be extracted from the DEM utilising HEC-GeoRAS (an ArcMAP 9.3 extension that links directly with the hydraulic model). This data was subsequently exported into the HEC-RAS model for hydraulic modelling of the previously calculated peak discharge values.

The roughness of the channel and floodplain surfaces needs to be accounted for within the hydraulic model. In this case, Manning's n values (Chow, 1959) were used to describe the surface roughness within HEC-RAS. Land cover information for this purpose was obtained from the Department of Agriculture and Environmental Affairs (DAEA) South African National Landcover (2013 - 2014) Dataset compiled by GeoTerraImage (Pty) Ltd. **Table 3-7** presents the general Manning's n values for the river reach and the surrounding floodplain that was modelled.

Table 3-4 Manning's n Values used in the Hydraulic Modelling (Chow, 1959; GeoTerraImage, 2014)

Manning's n	Description
0.02	Bare non-vegetated areas
0.02	Erosion
0.035	Grassland
0.04	Low Shrubland
0.06	Thicket/dense bush

3.1.2 Results

The floodline delineations are based on a DEM with a 30 metre resolution. This is considered course, especially in terms of floodline delineation requirements and results in is less accurate floodline delineations. The reasons for this are illustrated in **Figure 3-1**, where it is evident that detail in the cross-sectional information is lost due to coarse spatial information (red line). Detailed spatial information (purple line) represents the actual cross-sectional topography (blue line) far more accurately. Therefore the resultant floodlines, based on more detailed spatial information, would be more accurate. It should, however, be noted that for the purposes of this project (construction of powerlines), high level floodlines based on a DEM with a 30 metre resolution is sufficient. It is recommended that a detailed survey of the project site is undertaken if the more detailed floodlines are required. The resultant delineated floodlines for the study are presented in **Figure 3-2** (at a high scale) and **Figure 3-3**.

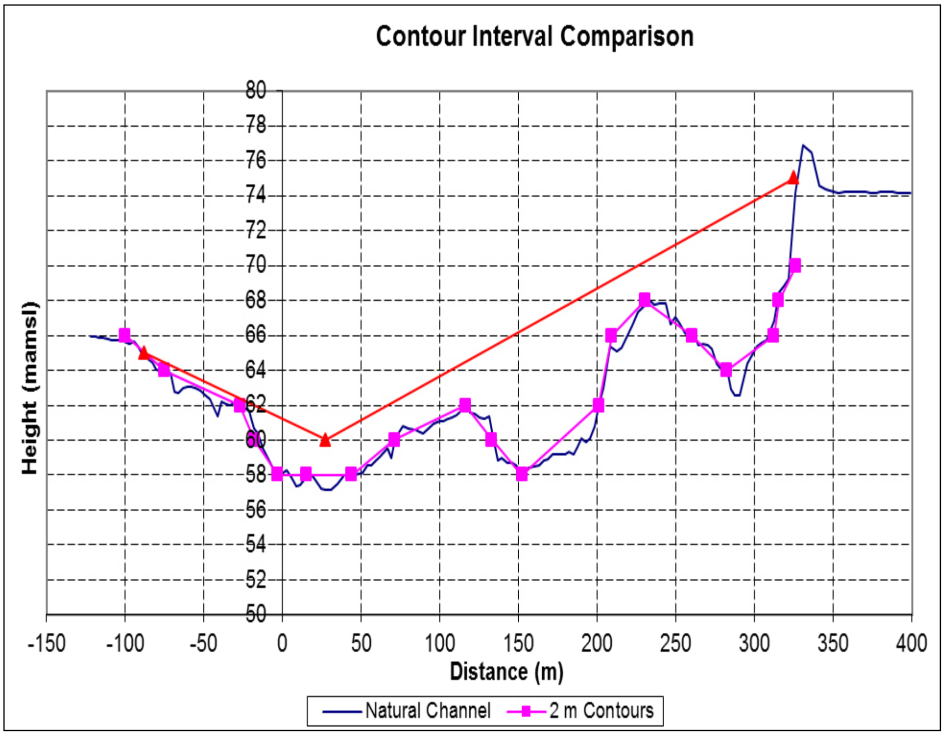

Figure 3-1 Illustration of Contour Information Representation (example)

The results of this study indicate that no existing infrastructure is at risk of inundation by the 1:20, 1:50 and 1:100 year design flood events (*cf*. **Figure 3-3**). However, The Regional Road R380 is at risk of inundation approximately 2.5 km downstream of the development site.

As is expected, the alignments of the five alternatives are inundated. There are no significant differences between the inundation extents of Alternatives 1, 3 and 3B. The inundation extent of the Alternative 2 and 3A appears to be somewhat less by comparison. This is thought to be as a result of the reduced length of the alignment through the Kuruman River (i.e. the orientation of the alignments with respect to the Kuruman River). It is understood that Eskom's preferred route is Alternative 3B.

Based on the findings of the study, it is thought that there will be no significant limitations should this Alternative be selected for the project's future development. However, consideration of the limitations associated with the simulated extents of the 1:20, 1:50 and 1:100 year design flood events should be made.

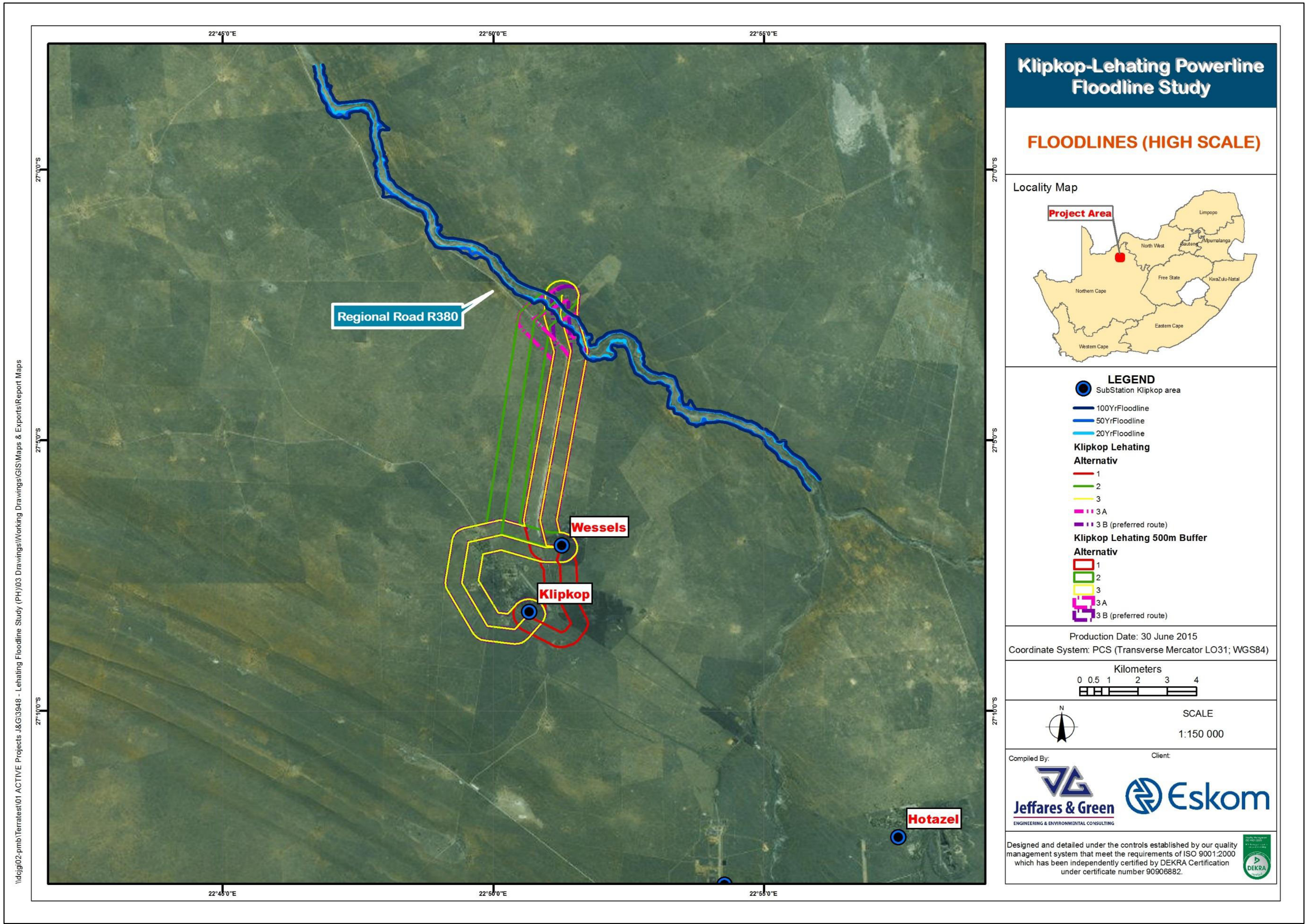

Figure 3-2 Klipkop-Lehating Powerline 1:20, 1:50 and 1:100 Year Floodline Delineation Results (High Scale)

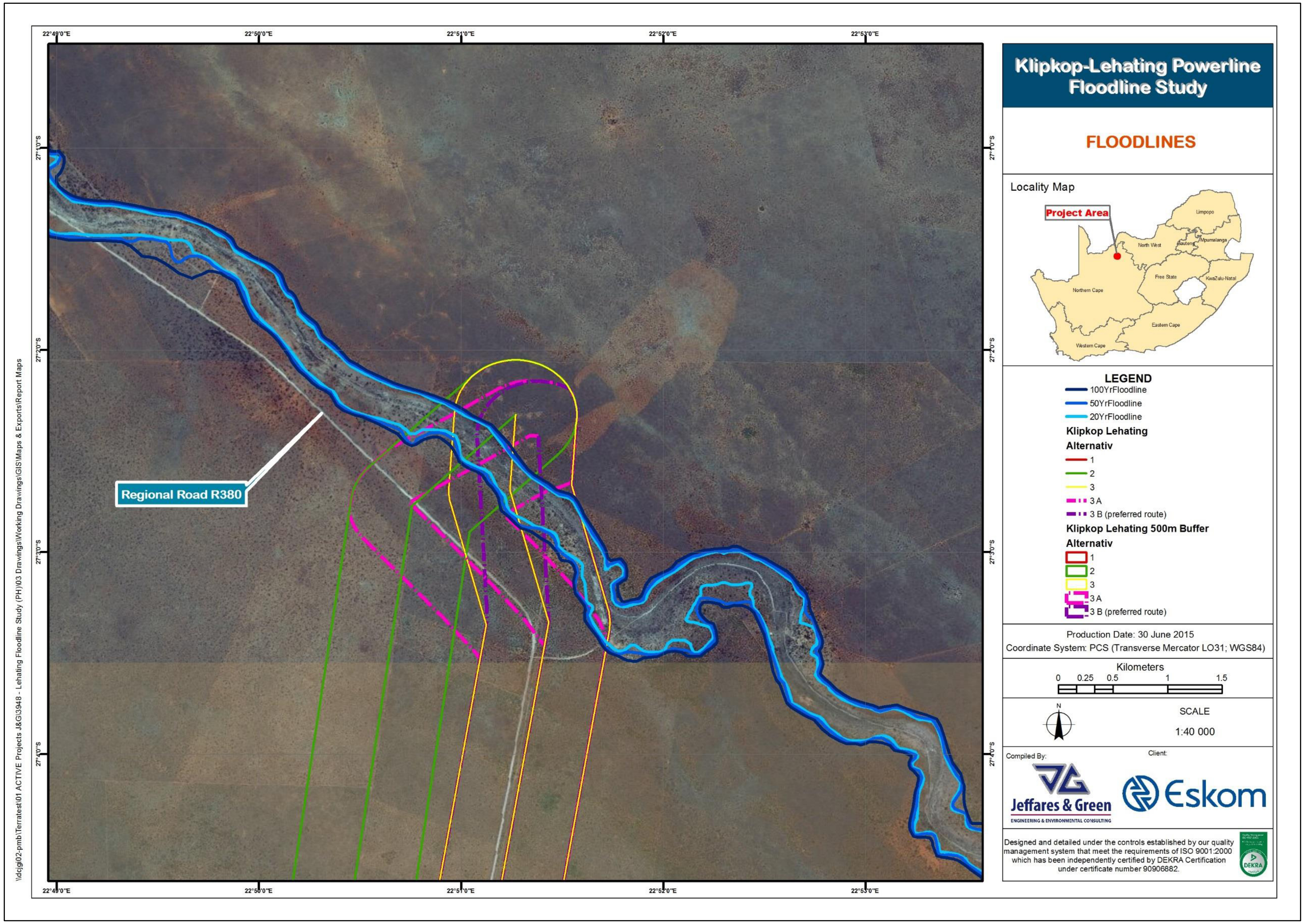

Figure 3-3 Klipkop-Lehating Powerline 1:20, 1:50 and 1:100 Year Floodline Delineation Results

4 CONCLUSION

A floodline study was undertaken for a section of the Kuruman River in the vicinity of the proposed Klipkop-Lehating 132 kV Double Circuit Chickadee powerline. The study area is located approximately 12 km north-west of Hotazel, Northern Cape Province.

The 1:20, 1:50 and 1:100 year return period design flood peak discharge values were calculated for the Kuruman River using the Unit Hydrograph Method. The extents of the corresponding floodlines were determined through hydraulic modelling using the HEC-RAS model. This model provided high water flood levels associated with the calculated design flood peak discharge values.

The resultant floodlines where plotted using GIS. The results indicated that the 1:20, 1:50 and 1:100 year floodlines range from approximately 217 m (1:20 year flood) wide to 456 m (1:100 year flood) wide in the vicinity of the development site. The floodline results indicated that portions of the proposed powerline alternative routes fall within the delineated floodlines. This is expected for the reason that the five proposed alignments cross the Kuruman River. The inundation of powerline Alternatives 2 and 3A is less extensive than Alternatives 1, 3 and 3B due to the orientation of the alignment in relation to the Kuruman River.

It should be noted that the floodlines presented in this study are based on a DEM with a resolution of 30 metres. The level of detail available using spatial data of this resolution is limited and the resultant floodlines are therefore considered high level. However, the high level floodline delineations are considered sufficient for the purposes of the construction of powerlines.

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