APPLICATION TO CONSTRUCT THE LOWER KRUISVALLEI HYDROELECTRIC POWER GENERATION PLANT ON A PORTION OF THE FARM MIDDELVALLEI 130 AND ON A PORTION OF THE FARM KRUISVALLEI 190, NEAR BETHLEHEM, FREE STATE

REPORT ON AGRICULTURAL IMPACT ASSESSMENT
FEBRUARY 2018

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1. INTRODUCTION

Zevobuzz (Pty) Ltd intends to develop a hydro-electric power generation scheme in the Ash River in the Bethlehem Magisterial District, Free State Province. The proposed development will take place on the border of the farm portions Kruisvallei 190 and Middelvallei 130. The hydro-electric power generation scheme will consist of two hydro plants; the Lower Kruisvallei (LK) Scheme and the Middle Kruisvallei (MK) Scheme. This report only considers the LK Scheme.

Mayborn (Pty) Ltd is the owner of the farm Kruisvallei 190. Zevobuzz (Pty) Ltd is a new entity formed by an Italian Renewable independent power producer (IPP), Building Energy SpA, for the sole purpose of developing the hydro potential of the farm. An agreement was reached with the owner and occupants of the farm Middelvallei 130, to enable Zevobuzz (Pty) Ltd to develop a part of the hydroelectric power generation scheme on the farm Middelvallei 130.

The Ash River is fed by the Trans Caledon Transfer Tunnel, which transfers water from the Katse Dam high up in the Maluti Mountains in Lesotho. Being very predictable, this is one of the greatest small hydro resources in the country, allowing for conditions perfectly suited to electricity production. In addition (also a result of the flow regulation), comprehensive information on current and future flow is available, making the potential highly predictable.

A basic impact assessment is being undertaken for authorisation of the proposed facility and an agricultural impact assessment has been conducted as part thereof.

2. SPECIALIST DETAILS

This report was prepared by an independent agricultural consultant:

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He has 43 years of experience in planning and managing natural resources to ensure optimal utilisation, without exploiting such resources to the detriment of future generations.

Mr Lubbe has spent the past 15 years as a soil consultant, doing mainly soil surveys, terrain classification and agricultural potential studies. Reports include a variety of maps and GIS aspects, which play a significant role in these surveys and studies.

Mr Lubbe has 17 years of experience as a lecturer in agricultural engineering subjects at the Tshwane University of Technology, teaching Soil Conservation Techniques I, II and III, which dealt with the surveying, design and drawing of soil conservation structures; Farm Planning, which dealt with optimal resource utilization and Agricultural Mechanization, which dealt with the implements and machinery used to mechanize farming.
His first ten years in the agricultural environment he spent on the survey, design and supervising the construction of soil conservation structures in the agricultural field, mainly for farm planning.

A full curriculum vitae is attached as Appendix A.

CR Lubbe is not a subsidiary or in any way affiliated to Zevobuzz (Pty) Ltd, nor does he have any interest in secondary developments that may arise from the authorisation of the proposed project.

The site investigation was conducted in winter, on 24 and 25 July 2017, during the dry season. There are no crops on cultivation land, which enables a better assessment of drainage patterns. This is important for rehabilitation after construction and decommissioning and serves as a benchmark for mitigation measures.

3. SCOPE AND PURPOSE OF STUDY

The purpose of the study was to:

- Establish the agricultural potential of the site that is to be leased on long-term basis from the existing farms;
- Estimate the potential and existing arability and carrying capacity of the study area;
- Establish the availability and condition of the existing agricultural resources and agricultural infrastructure;
- Describe past and current agricultural practices/activities on the site;
- Identify indications of possible constraints; and
- Consider and evaluate possible impacts on the existing agricultural resources and activities.

4. APPROACH AND METHODOLOGY

4.1. Approach

The approach to the study was:

- To identify and describe the existing agricultural environment;
- To identify and describe the risks and possible impacts of the proposed project on the agricultural environment;
- To assess the severity of the possible impacts;
- To consider alternatives to avoid the impacts; and
- To identify and describe mitigation measures to avoid or reduce the impacts of the project on the existing agricultural environment.
4.2. Desktop Study
A desktop study was conducted to review existing data and literature sources.

The desktop review provided a baseline agricultural and land use profile, focusing on the specific geographical area potentially impacted by the proposed project.

As far as regional information is concerned, this is primarily a desktop-based study. Climatic conditions, land uses, land type, and terrain are readily available from literature, GIS information and satellite imagery.

4.3. Field Survey
A field survey was carried out on 24 and 25 July 2017, and aimed at verifying the information obtained from the desktop study and obtaining further information about the site and its immediate surroundings. This, inter alia, included a soil survey.

4.4. Impact identification
Potential impacts of the proposed project on agriculture were identified and assessed. Particular attention was paid to the following issues:

- The possibility of permanent loss of high potential agricultural land;
- Impairment of land capability due to construction; and
- Analysis of erosion risk because of altered drainage patterns and potential for poor rehabilitation in erosion-sensitive areas.

5. ASSUMPTIONS AND UNCERTAINTIES
A study of this nature will inherently contain various assumptions and limitations.

As far as regional information is concerned, this is primarily a desktop-based study. Many adjustments were made to infer climatic conditions, land uses, land type and terrain by extrapolating from available land use data, GIS information and satellite imagery.

Notwithstanding these limitations, the site-specific field studies confirmed most of the desktop findings and it can be noted with confidence that the findings provide sufficient detail to inform the agricultural impact assessment reported in this document.

6. DESCRIPTION OF PROPOSED PROJECT
Zevobuzz (Pty) Ltd intends to develop a hydroelectric power generation scheme comprising of two plants, including Lower Kruisvallei and Middle Kruisvallei, in the Ash River on a portion of the farm Kruisvallei 190 and a portion of the farm Middelvallei 130, Bethlehem Magisterial District, Free State Province. This report addresses the Lower Kruisvallei (LK) Scheme, and a second report will address the Middle Kruisvallei (MK) Scheme. However, the two sites for part of the same hydroelectric scheme.

The proposed establishment of the hydroelectric power generation plant known as Lower Kruisvallei (LK) will have a footprint area of ±8.9 ha, and will generate up to 2.5 MW, on the Northern-most corner of the farm Kruisvallei 190 and on the eastern boundary of the farm Middelvallei 130.
The hydroelectric power generation plant requires the construction of a short canal. The total length of the canal (566 m) consists of the headrace (380 m), powerhouse (24 m) and the tailrace (16 m). The width of the canal will be 33 m at the headrace and 30 m at the tailrace. The depth of the canal, depending on actual rock bed level, is estimated to be ± 3.2 m.

The proposed connection of the power line to the Eskom grid is at the Node substation.

7. PHYSICAL DESCRIPTION OF THE SITE

7.1. Locality

The farm Kruisvallei 190 lies two kilometres west of the tarred road linking Bethlehem and Clarens (R711).

![Image](image1.png)

**Figure 1: Locality map**

The proposed site of development, Lower Kruisvallei, is situated on the Northern-most corner of Kruisvallei 190 in the Ash River.

This unit is situated across the border of the farms of Middelvallei 130 and Kruisvallei 190.

A portion of 4.97 ha of Middelvallei 130 will be used to accommodate Weir 34 and headrace. A 3.93 ha portion will be utilised for the powerhouse and tailrace on Kruisvallei 190. The final footprint of the LK Scheme and all associated infrastructure will be 8.9 ha. This is demonstrated by Error! Reference source not found..
7.2. Natural Agricultural Resources

7.2.1. Climate

See Table 1 for available information about the climate of the site.

Table 1: Climate of the site

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation</th>
<th>Evaporation</th>
<th>Temperature</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>107 mm</td>
<td>5mm/day</td>
<td>Mean Max</td>
<td>25.1-27° C</td>
</tr>
<tr>
<td>February</td>
<td>87 mm</td>
<td>4.9mm/day</td>
<td>Mean Min</td>
<td>&lt;0° C</td>
</tr>
<tr>
<td>March</td>
<td>77 mm</td>
<td>3.9mm/day</td>
<td>Start frost</td>
<td>01 – 10 May</td>
</tr>
<tr>
<td>April</td>
<td>37 mm</td>
<td>2.6mm/day</td>
<td>End Frost</td>
<td>11 - 20 Sept</td>
</tr>
<tr>
<td>May</td>
<td>20 mm</td>
<td>1.7mm/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>8 mm</td>
<td>1.3mm/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>6 mm</td>
<td>1.5mm/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td>18 mm</td>
<td>1.8mm/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>36 mm</td>
<td>2.6mm/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td>59 mm</td>
<td>3.7mm/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>79 mm</td>
<td>4.5mm/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td>90 mm</td>
<td>4.9mm/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual</td>
<td>624 mm</td>
<td>1152.3mm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Institute for Soil Climate and Water: Land Type Memoir

7.2.2. Topography

From the topographical map 2828 JORDAAN RIVIER, the local topography was interpreted as plains and wetlands with high hills. The plains are utilised as arable land and the wetlands and hills for grazing. The Ash River flows through the farm towards the Sol Plaatjies Dam. Two prominent weir structures in the Ash River are noticed: one on farm Kruisvallei 190, weir
26, and one on Middelvallei 130, weir 34. The streams draining towards the river also have weir structures. A marsh area upstream of these structures, exist. The lowest contour line is at 1700 m above sea level.

### 7.2.3. Terrain

"Terrain" describes the relief or variation in height of the land surface. The surface is divided into morphological units as shown in Figure 3.

Figure 3: Terrain morphological units

The terrain form of the site on Lower Kruisvallei is illustrated in Error! Reference source not found.
The cross section in Figure 4 provides information regarding the shape of the slope of the development footprint. It shows a lower mid slope (3\(^{1}\)), which eventually evens into a straight shape for the foot slope (4).

This information is valuable when interpreting the land type data as this will indicate what soil forms can be expected in each terrain unit.

The terrain slope can be calculated using the difference in vertical height (1720 m - 1700 m) divided by difference in horizontal distance (1401 - 1063) X 100. The slope is 5.9% for the 3\(^{1}\)-section and 2.3% for the 4 and 3\(^{1}\) slope combination.

It is expected to find shallower soils on convex slopes and deeper soils on concave soils with water locked soils at foot slopes and valley bottoms.

When planning the water run-off outlay, the information obtained is used to guide the planning. The water run-off is influenced by the size of the catchment. This area is contained within the boundaries from the ridge to the valley bottom.

The placing of the conservation structures is also influenced by the terrain features:

- **Waterway**
  The preferred position to place the waterway is on the natural drainage line (Valley bottom). Run off must be conveyed on the quickest way downslope and that is perpendicular on the contour line that ends in the valley bottom. Waterways must be able to except all deposits of contour banks. The shape of a land could prevent this and special techniques are required to enable it to happen.

- **Stormwater furrow**
  The stormwater furrow must be placed as close possible to the top of the land to divert run-off into waterway. Design specifications such as size of catchment, basal cover and slope, depend on terrain data.

- **Contour bank**
  Must deposit run-off in a waterway. Ensure the contour outlet is placed so that it will not deposit run-off water onto the contour underneath. Keep contours within the catchment area.

When assessing the impact the proposed construction will have on the existing farming practices, these principles will be applied.

**7.2.4. Soils**

Soils do not occur randomly in the landscape, but follow a pattern determined by factors such as geology and topographic position. Normally, soil forms follow each other downhill in a specific sequence. This is called a catena, with well-drained soils on top and water-locked soils at the bottom.

Such a system, where terrain form and soil pattern displays a marked degree of uniformity, is called a pedosystem.
This inter-relationship between soils and landform is a good reason for relating soils to the landscape position in which they occur.

The land type map 2828 HARRISMITH of the Department of Agriculture and it accompanying memoir was used in the desktop study for this project.

The map shows that the pedosystem Bd53 was allocated to the two locations. **Bd** represents the land type in respect of the terrain form, soil pattern and climate. This indicates a plinthic catena with upland duplex and margalitic soils (rare) and valley bottoms occupied by one or other gley soil type. The catena or sequence in which soil forms are predicted to follow from highest (crest) to lowest (valley bottom). In this case, it would be Hutton, Bainsvlei, Avalon and Longlands, while Rensburg, Willowbrook and Katspruit would occur in the valley bottom.

The **53** indicates numerical number of occurrence of this pedosystem and soils expected on site (according to the inventory) will be one or more of those indicated in Table 2.

Refer to Figures 5 and 6, which indicate that the affected area will be on the lower mid slope (3), including the foot slope (4) and valley bottom (5).
Table 2: Possible soil types on site

<table>
<thead>
<tr>
<th>Terrain unit</th>
<th>Dominant soil</th>
<th>Effective depth</th>
<th>Clay A</th>
<th>Clay B</th>
<th>Limiting</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>Avalon</td>
<td>450-1000mm</td>
<td>8-20%</td>
<td>13-35%</td>
<td>Plinthic</td>
</tr>
<tr>
<td>4</td>
<td>Estcourt</td>
<td>250-600mm</td>
<td>9-20%</td>
<td>40-65%</td>
<td>Structured</td>
</tr>
<tr>
<td>5</td>
<td>Inhoek</td>
<td>1000-1500mm</td>
<td>10-40%</td>
<td>15-35%</td>
<td>Saprolite</td>
</tr>
</tbody>
</table>

7.2.5. Geology

Literature describes the geology as Elliot mudstone and sandstone: Molteno grit and sandstone with inliers of Tarkastad Subgroup mudstone and sandstone at places. Narrow dolerite dykes may be present. Several very small outliers of Clarens sandstone may occur.

7.2.6. Vegetation

Information from the Department of Agriculture, Forestry and Fisheries and other relevant literature indicate that the site may have some of the following vegetation characteristics:

- Acocks veld type: Pure grassveld types
- Vegetation biome: Grassland.
- NDVI (Normalized Difference Vegetation Index) long term annual average: Moderate to high
- Grazing capacity: 3-4 ha/LSU (large stock unit)

7.2.7. Land Capability

Land Capability classification is applied to rain fed agriculture and distinguish between land suited for cultivation (Classes I II III and IV) and land generally not suited for cultivation. (Classes V VI VII and VIII) See Appendix C for a complete description of the different capability classes.

According to Land Type Map 2828 HARRISMITH, the land capability of the site is Class III. This indicates soils with severe limitations that reduce the choice of crops or require special conservation practices or both. These limitations may include:

- Moderately steep slopes;
- High susceptibility to water erosion or wind erosion or severe adverse effects of past erosion;
• Frequent flooding accompanied by some crop damage;
• Very slow permeability of subsoil;
• Wetness or some continuing waterlogging after drainage;
• Shallow soil depth to bedrock, hardpan, fragipan or claypan that limit the rooting zone and water storage;
• Low water holding capacity;
• Low fertility, not easily corrected;
• Moderate salinity or sodicity; and
• Moderate climatic limitations.

One, or a combination, of these limitations restrict the choice of crops; cultivation time of planting, tillage and harvesting.

The land may be used for cultivating crops, but conservation practices are usually difficult to apply and maintain and the number of practical alternatives for average farmers is restricted to a few.

With the climate and soil combination of this site, the expected yields of suitable crops are predicted as follows:

• Maize: 30 % (suitable expected yield of 3-4 ton/ha);
• Sorghum: 10% suitable;
• Soya beans: 50% suitable.

7.3. Past and Present agricultural activities

Past and present agricultural activities were established by comparing an orthophoto dated 2001 to a satellite image of 2016. The comparison includes Lower Kruisvallei (C) and Middle Kruisvallei (B). As discussed earlier, Middle Kruisvallei is the other component of the proposed hydroelectric development, but is not the subject of this report. See Figure 7 and Figure 8.

The general agricultural activity of the area in which this study was conducted was mixed farming. Dryland cash crop production and livestock farming on non-arable areas. Production of crops under cover also takes place.

The agricultural activities did not change much from 2001 to 2016, except for the new shade structures (N) and removal of trees (T).
Figure 7: Orthophoto 2001

Figure 8: Satellite image 2016
Looking on a bigger scale and more specifically at Lower Kruisvallei, several differences were identified.

**Figure 9: Ortophoto 2001**

**Figure 10: Satellite 2016**

The agricultural activities have not changed, although structures were changed. These include:
1. Access road to Merino Hydro Powerhouse;
2. Labour housing replaced by cultivated pastures;
3. Visible erosion;
4. Wind brake removed on ridge.

8. FIELD SURVEY

The field survey took place on 24 July 2017. In the following sections, the desktop findings are compared to the findings of the field survey.

8.1. Existing infrastructure

The existing infrastructure, as shown in Figure 11, includes:

- Access road T563 with bridge over Ash River;
- Access roads exit from T563;
- Cultivated land with centre pivot and erosion control measures;
- Border fence;
- Weir 34 in Ash River.

This infrastructure was developed to enable formal agricultural practices. With the proposed development, the possible impact on their existence has to be assessed.
Access to the Lower Kruisvallei hydroelectric power facility will be obtained by using the T563 provincial road, which exits from the R712 Bethlehem/Clarence road.

This is a well-maintained provincial dirt road. The road was constructed according to civil engineering specifications with the proper culvert and bridge structures as required. The road gives access to landowners inland.

The road is designed to carry heavy vehicles as required for agricultural cultivation equipment and transporting purposes.

![Figure 12: Access road T563](image)

![Figure 13: Bridge over Ash River](image)
The bridge across the Ash River marks the end of the journey to the proposed development site.

Figure 14: Exit north from T563 to Merino Hydro Powerhouse

The maintenance road passes over very low potential soil (litosols). The road is maintained by owners of the Merino Hydro electrical facility, north of the site. This road will give access to the temporary laydown area.

A new road is proposed for access to the powerhouse, west of this road.

Figure 15: Exit south from T563
The T563 will provide access to the weir and Lower Kruisvallei Hydro power station. It is a maintained service road and is accessible by heavy agricultural traffic as well as light motor vehicles.

**Figure 16: Cultivated land - Kruisvallei 190**

The cultivated land east of the project on the farm Kruisvallei 190 is used to produce maize. Only the lowest section of the land will be effected by the construction, in total not more than a hectare in size. On the land, erosion conservation structures were installed as well as a centre pivot irrigation system.

**Figure 17: Border fence**
Except for the sandstone standards, the fencing material is deteriorated, but still capable to fence in cattle.

The border fence almost marks the area required to construct the headrace of the proposed hydro system and change in soil type.

Figure 18: Weir 34 in Ash River

The weir is the centre pin for the existence of the hydro system. The position is fixed and only the height of the weir could be increased within permissible parameters.

8.2. Assessment of soil potential

The field study was done on a larger area (see figure 19) which included a centre pivot irrigation system. The field study provided exact coordinates so that the lease area could be changed and reduced not to encroach on the centre pivot footprint.

The site was augered on a random basis and observations noted on a prescribed Soil Observation Form for each augering point. Photos were also taken at most augering points. The soil observation forms were then used to compile inventories of soils. The map in Figure 19 shows the augering points, while the inventory for the soil types appears in Table 3.

In the tables, photos taken at the observation point are shown first, followed by a copy of the Soil Observation Form. Then follows a description of the soil properties.

NOTE: Only one augering point of a specific soil type appears in the table, representing all other occurrences of the same soil type on site.
Figure 19: Soil observation points for Lower Kruisvallei

Table 3: Inventory of soils on Lower Kruisvallei

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Agricultural Impact Assessment for farms Middelvallei 130 and Kruisvallei 190

Lower Kruisvallei hydroelectrical plant

February 2018

Terrain position Riparian zone
Geology Shale parent material
Slope shape Undulating
Slope gradient 2%
Moisture availability Low
Erosion potential Severe
Soil Form Glenrosa
Soil Family Dumisa

**Mispa Myhill**

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## Willowbrook Ottawa

![Image of Willowbrook Ottawa]
### Soil Properties

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### Avalon Avondale

![Image of soil properties](image-url)

### Soil Properties

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**Agricultural Impact Assessment for farms Middelvallei 130 and Kruisvallei 190**

February 2018

**Lower Kruisvallei hydroelectrical plant**

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**Oakleaf Buchuberg**

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**Soil Properties**

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<td></td>
</tr>
<tr>
<td>Geology</td>
<td>Sandstone</td>
<td></td>
</tr>
<tr>
<td>Slope shape</td>
<td>Concave</td>
<td></td>
</tr>
<tr>
<td>Slope gradient</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Moisture availability</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Erosion potential</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Soil Form</td>
<td>Oakleaf</td>
<td></td>
</tr>
<tr>
<td>Soil Family</td>
<td>Buchuberg</td>
<td></td>
</tr>
</tbody>
</table>

### Soil Properties

<table>
<thead>
<tr>
<th>Texture</th>
<th>Fine loam sand</th>
<th>Fine Sandy clay loam</th>
<th>Saprolite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistency</td>
<td>Crumbly</td>
<td>Crumbly</td>
<td></td>
</tr>
<tr>
<td>Structure</td>
<td>Weak crumbly</td>
<td>Apedal</td>
<td></td>
</tr>
<tr>
<td>Colour</td>
<td>Yellowish brown</td>
<td>Yellowish Red</td>
<td></td>
</tr>
<tr>
<td>Horizon Depth</td>
<td>200mm</td>
<td>500mm</td>
<td>&gt;700mm</td>
</tr>
<tr>
<td>Depth limitation</td>
<td>Saprolite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective Depth</td>
<td>700mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrain position</td>
<td>Lower mid slope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geology</td>
<td>Sandstone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope shape</td>
<td>Convex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope gradient</td>
<td>4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture availability</td>
<td>Optimum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erosion potential</td>
<td>Moderate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Soil Form | Hutton
---|---
Soil Family | Hayfield

From the information in the tables, soils were grouped and a soil map compiled to indicate the occurrence of the various soil types on Lower Kruisvallei. See Figure 20.

**Figure 20: Lower Kruisvallei soil groups**

### 8.3. Land Capability

The soils found on site were assigned to their appropriate classes, as shown in Table 4.

**Table 4: Soil classes**

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Soils with few limitations that restrict their use</td>
</tr>
<tr>
<td>II</td>
<td>Soils with some limitations that reduce the choice of plants or require moderate conservation practices</td>
</tr>
<tr>
<td></td>
<td><strong>Hutton, Clovelly</strong></td>
</tr>
<tr>
<td>III</td>
<td>Soils with severe limitations that reduce the choice of crops or require special conservation practices</td>
</tr>
</tbody>
</table>
### Land suitability for agriculture

Suitability depends on the soil properties such as effective rooting depth and permeability as key factors and climate attributes such as rainfall and temperature. High wind, frost and hail pose constraints to suitability.

#### 8.4.1. Soil

Effective rooting depth is the depth to which roots can penetrate into the soil profile without any obstructions. In the example of the Avalon profile (Figure 21) the effective depth is within the orthic top soil. It further shows yellow apedal sub soil and Soft Plinthic as the depth restriction layer.

Figure 21 shows the diagnostic soil horizons and positions in profile where the porosity samples are taken.
Permeability refers to the ease with which roots and liquids penetrate and pass through soil and is influenced by the properties of the soil profile. The permeability of each soil layer is calculated using the Loxton table (Table 5).

**Table 5: Loxton Table**

<table>
<thead>
<tr>
<th>Permeability Class</th>
<th>Extreme</th>
<th>Moderate</th>
<th>Slightly</th>
<th>Good</th>
<th>Fast</th>
<th>Extremely Fast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>2</td>
<td>0,2</td>
<td>3</td>
<td>0,3</td>
<td>4</td>
<td>0,4</td>
</tr>
<tr>
<td>Texture</td>
<td>Clay</td>
<td>SaCl</td>
<td>CLm</td>
<td>SaClm</td>
<td>Sa</td>
<td>Gravel</td>
</tr>
<tr>
<td>Structure</td>
<td>Strong developed</td>
<td>Moderate</td>
<td>Weak</td>
<td>Structureless</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colour</td>
<td>Blue-olive</td>
<td>Black</td>
<td>Yellow-brown</td>
<td>Red</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motley</td>
<td>Strong</td>
<td>Moderate</td>
<td>Weak</td>
<td>Absent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water absorption tempo</td>
<td>Ultra slow</td>
<td>Very slow</td>
<td>Slow</td>
<td>Moderate</td>
<td>Fast</td>
<td>Very fast</td>
</tr>
</tbody>
</table>

The effective rooting depth and permeability calculation for the soils identified on site is set out in Table 6. P1 refers to the top layer and P2 to the sub layer. With this information known, a correction factor can be calculated for the term yield of a specific crop.
Table 6: Effective depth and permeability

<table>
<thead>
<tr>
<th>Soil form</th>
<th>Effective Depth</th>
<th>Permeability</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hutton</td>
<td>700mm</td>
<td>Good</td>
<td>2.8</td>
</tr>
<tr>
<td>Clovelly, Pinedene</td>
<td>700mm</td>
<td>Good</td>
<td>2.19</td>
</tr>
<tr>
<td>Avalon</td>
<td>600mm</td>
<td>Good</td>
<td>4.4</td>
</tr>
<tr>
<td>Glenrosa</td>
<td>400mm</td>
<td>Slightly slow</td>
<td>2.4</td>
</tr>
<tr>
<td>Oakleaf</td>
<td>600mm</td>
<td>Slightly slow</td>
<td>6.4</td>
</tr>
<tr>
<td>Sterkspruit, Willowbrook, Arcadia</td>
<td>300-400mm</td>
<td>Extremely slow</td>
<td>16.45</td>
</tr>
<tr>
<td>Mispah</td>
<td>300mm</td>
<td>Good</td>
<td>1.1</td>
</tr>
</tbody>
</table>

8.4.2. Land Capability

This climate restricts the choice of crops to be cultivated. The rainfall is 624 mm annually with a low temperature as indicated in Table 1.

8.4.3. Expected yield

The average yield for Maize is a good reference to determine agriculture potential.

**Example: Maize production**

Production potential (kg/ha) according to Möhr (1977):

\[
\text{Mean annual rainfall} \times \text{soil depth in cm} = 12,8
\]

Taking the best soil, namely Hutton, with a loamy sand texture and an average soil depth of 70cm,

\[
624 \times 70 \text{ cm} = 12,8
\]

The result would be 3412.5 kg/ha (3.4 ton).

The same calculation for the structured soils would result in a long-term yield of less than a ton per hectare for dryland production.

Although irrigation is possible and therefore makes the structured soils manageable, the terrain position still poses a high risk for cultivation. Permanent pastures are rather recommended.

Local information on expected yield is 4 ton/ha dry land and 6 ton/ha irrigated land.

8.4.4. Soil Utilization

Lower Kruisvallei can be divided into three utilisation units, as indicated on Figure 22. The characteristics of these units are described below.
Figure 22: Utilisation map –Lower Kruisvallei

Unit 1

This unit is characterised by very shallow soils and rock outcrops. Table 7 shows soil and veld property details at point 3 on the site.

Table 7: Unit 1 Soil and veld details

<table>
<thead>
<tr>
<th>OBS</th>
<th>LATT</th>
<th>LONG</th>
<th>FORM</th>
<th>TSD</th>
<th>WET</th>
<th>SLOPE SHAPE</th>
<th>SLOPE GRAD</th>
<th>MOISTURE</th>
<th>EROSION</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28.3787</td>
<td>28.3683</td>
<td>Gs</td>
<td>40</td>
<td>C</td>
<td>X</td>
<td>4</td>
<td>L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>28.3787</td>
<td>28.3683</td>
<td>ESD</td>
<td>40</td>
<td>C</td>
<td>X</td>
<td>4</td>
<td>L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>28.3787</td>
<td>28.3683</td>
<td>TSD</td>
<td>40</td>
<td>C</td>
<td>X</td>
<td>4</td>
<td>L</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The soil properties indicate that the area has low potential non-arable land due to shallow soils with rocky outcrops rendering mechanical restrictions with cultivation. The soils have a land capability classification VI because of these restrictions.

The site was assessed for visible veld condition and the result was a carrying capacity of 18 ha/LSU. The reasons for this yield are the bare patches of rock outcrop, sandy texture of topsoil and bush encroachment.

Because of its size, agricultural potential, and that it is separated from the farming activities by road T653, the loss for agriculture will be of low impact.
Unit 2

This unit is characterised by structured soil with a wetness hazard. The wetness is caused by the terrain position and gleyed horizon under the structured layer.

Table 8: Unit 2 Soil and veld details

<table>
<thead>
<tr>
<th>OBS</th>
<th>1</th>
<th>COMMENT</th>
<th>LAT</th>
<th>SLOPE GRAD</th>
<th>SLOPE SHAPE</th>
<th>WET</th>
<th>HORIZON</th>
<th>TYPE</th>
<th>DEPTH</th>
<th>COL</th>
<th>CLAY</th>
<th>S-GR</th>
<th>CONS</th>
<th>STRUC</th>
<th>STONE</th>
<th>L</th>
<th>MOISTURE</th>
<th>EROSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td></td>
<td></td>
<td>28.3817</td>
<td>4</td>
<td>C</td>
<td>100</td>
<td>A</td>
<td>1</td>
<td>20</td>
<td>10</td>
<td>54</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>

This is a duplex soil because of the abrupt change between A and B-horizons in texture (15% clay increased to 45% clay) and structure from weak crumbly to strong blocky. These characteristics restrict water infiltration and root development, and have high erodibility risk. The terrain position increases the possibility for water logging because of the flat footslope. The soils have a land capability classification V because of these restrictions.

Ridge or furrow cultivation can be practised to improve drainage or sub surfaced drains could be installed, but the cost must be weighed against the expected increase in yield. The size of the area and its position does not justify such measures.

This area would best be utilised as a cultivated pasture unit.

Unit 3

This is medium to low potential soil due to medium depth and limiting layers of soft plinthic or a lithocutanic B-horizons. The land is irrigated but soil properties relating to permeability, and effective depth, deprive it from being ideal for irrigation. The soils have a land capability classification III because of these restrictions.

Table 9: Unit 3 Soil and veld details

<table>
<thead>
<tr>
<th>OBS</th>
<th>1</th>
<th>COMMENT</th>
<th>LAT</th>
<th>SLOPE GRAD</th>
<th>SLOPE SHAPE</th>
<th>WET</th>
<th>HORIZON</th>
<th>TYPE</th>
<th>DEPTH</th>
<th>COL</th>
<th>CLAY</th>
<th>S-GR</th>
<th>CONS</th>
<th>STRUC</th>
<th>STONE</th>
<th>L</th>
<th>MOISTURE</th>
<th>EROSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td></td>
<td></td>
<td>28.38092</td>
<td>4</td>
<td>C</td>
<td>100</td>
<td>A</td>
<td>1</td>
<td>20</td>
<td>10</td>
<td>54</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>

This unit is utilised to cultivate maize under centre pivot irrigation. With the necessary scheduling, the moisture regime can be adjusted for higher yields. The problem is that the land does not have a uniform soil composition which make scheduling problematic.

The run-off control is not efficient. If the 2001 photo is compared with the 2016 image, erosion is noticed which could be a result of mismanagement of the water regime.

Only a small portion of this land (1 ha) will be used for the construction of the canal. The original scoping size was adjusted so as not to interfere with the movement of the centre pivot.

The effect that the construction of the canal will have on the flow pattern of the run-off will need to be accounted for.
9. ASSESSMENT OF POTENTIAL IMPACTS ON THE AGRICULTURAL ENVIRONMENT

The aim with the assessment will be to outline and describe fully the impact anticipated that the interaction of the proposed development may inflict on the existing agricultural environment.

9.1. Sensitive areas

Sensitive areas are important in the agricultural environment. It relates to soil conservation, which is an inherent part of agricultural management. Several sensitive areas were identified within the site.

The sensitivity map shows (Figure 23) areas where possible impacts may be inflicted on the agricultural environment during construction of the LK hydroelectric power generation plant. Construction must be carried out with the necessary care, and mitigation measures proposed within this report must be implemented.

Figure 23: Sensitive areas
Area 1
Erosion is caused by the absence of a waterway at the point of discharge of the contour banks. This results in the top contours draining down onto the bottom contours. The cumulative runoff cannot be handled by the bottom contour and the contour brakes. A chain reaction follows with more and severe erosion as the result. The combined discharge of the contour banks drains towards the river.

The construction of the canal will act in the same way as the contours, namely, block the down flow and causing erosion. An uninterrupted passage for runoff is required to discharge in the river.

To explain how the canal will effect the flow of the runoff, the calculation for a channel to convey water is used. The equation to determine the dimensions of a channel is as follows:

\[ Q = A^*v \]

\( Q \) is the discharge in the channel. \( A \) is the area in contact with the water in the channel and \( v \) the allowable flow speed. The dimensions of \( A \) is determined finding an equilibrium where the cross section of the channel is capable to convey \( Q \) at a permitted flow speed for the surface conditions. When \( A \) decreases, \( v \) increases and causes erosion. This is also applicable to road culverts that are blocked or designed with too small diameter pipe.

The sensitivity impact on the development is rated high, unless mitigated.

Area 2
This area is on the natural drainage line (a natural topographic feature). This would be the correct position to place an artificial waterway. At the moment it is used as a waterway without protective cover and severe erosion is taking place.

The sensitivity is rated medium but the impact of the development is low because the discharge following this line, will not be interrupted by the canal.

Area 3
Wetland (as defined by the National Water Act): 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, which, under normal circumstances, supports or would support vegetation typically adapted to life in saturated soil.

This is especially true of the Willowbrook soil form identified at observation point 54. The existing DWS 34 weir enhances the aquatic appearance.

Wetlands are sensitive to pollution. Petroleum based products are predominantly non-polar compounds with low water solubilities. With spillages they tend to bond with soil organic matter, which leaches to the wetland and reaches humans through the food chain (water to human, water to animal to human, water to plant to human). The heavier compounds is a serious threat because they remain in the soil and effect plant growth. Therefore, spillage on or near a wetland should be regarded very hazardous.

The inlet sill will be constructed in the wetland and the necessary precautions to avoid soil pollution must be applied during the construction period.

The sensitivity rating is low to medium.
Area 4
The terrain position makes this area sensitive. It is a floodplain in the valley bottom wetland. Undisturbed, this floodplain would naturally regulate run-off flow speed and stabilises river banks by the aid of its vegetation. However, the land has been cultivated, without measures to control run-off.

The powerline and service road will run on the border of the delineated area and will cross the drainage line once, where an existing gully erosion meet sensitive area. Provision for the road to cross, without blocking the water may include a culvert, bridge or low water crossing.

An out-slope shape constructed road will allow water to sheet-flow in a dispersed manner, draining the water from the road surface quickly without letting it concentrate.

Construction of the powerline and service road will have a low impact if the mitigation measures are applied.

Area 5
The terrain position makes this area sensitive. It is a floodplain in the valley bottom wetland. Cultivation did take place in the past but was later revegetated with a good basal cover. Construction of the powerline and service road will have impact on land due to consecration of runoff water from the road, if not constructed properly. Because of the vertic nature of the soil, gully erosion will result when disturbed.

The impact will be low if the mitigation measures are applied.

9.2. The proposed development
Figure 24 shows how the proposed development will interact with existing infrastructure and the environment.

Figure 24: Interaction of existing infrastructure and hydroelectrical plant
9.2.1. Laydown area

A temporary site office, stockpile area, storage area, concrete mixing plant and chemical ablution facilities, will be established during the construction phase for the development of the project. The construction and stockpile areas will be established adjacent to the construction site, on unit 1 and will be fenced for the duration of the construction phase. These structures will be temporary and will be removed on completion of construction works and all the disturbed areas will be re-instated.

9.2.2. Access road

During the construction phase of the proposed LK hydroelectric power generation plant, a temporary access road (±150m) will need to be established to gain access to the construction site. This route will run from the existing farm road on Kruisvallei to the banks of the Ash River on unit 1. The temporary access route will be rehabilitated after the cessation of construction. During the operation phase, the power plant will be reached by means of a new access road (±90m) constructed from the existing farm road on the farm Middelvallei 130 to the Ash River on unit 1. All gravel, necessary for the establishment of any roads will be sourced from a licensed borrow area or bought from licensed suppliers.

9.2.3. Hydro electrical plant

![Diagram of inlet sill]

The inlet sill will be constructed on Unit 2 inside the boundary of Middelvallei 130 on the waterside of the weir. It will be ±170 m long, 5 m wide and 5 m deep.

The excavation will be in sensitive area 3. This is a wetland and are considered and assessed as part of the Aquatic Impact Assessment.

A coffer dam will also be needed to allow excavation works during the construction phase.
Figure 26: Headrace canal

The hydroelectric power generation plant requires the construction of a short canal. The total length of the canal (566 m) consists of the headrace (380 m), inlet sill (170 m) and the tailrace (16 m). The powerhouse will be 24 m. The width of the canal will be 33 m at the headrace. The depth of the canal, dependent on actual rock bed level, is estimated to be ±3.2 m at the headrace.

The headrace will be excavated on units 1 and 2 and across provincial road T563.

Excavations in unit 1 may need the use of explosives through the rocky area.

Figure 27: Powerhouse

The basic technical specification for the powerhouse (height of 10m) is one Kaplan turbine (a double or single regulated highly flexible turbine for low head high flow sites). The turbine will be fed by means of the straight off-take from the river. The temperature of the water, through the turbine, is expected to change by ±1.5°C.
All water diverted into the headrace canal is returned into the river via the tailrace canal; hence, the flow rate in the Ash River before and after the site is the same. The flow-rate in the Ash River between the abstraction and return points (base-flow) will be minimal, set to match the requirements of the Department of Water Affairs and likely to be in the vicinity of 0.1 m$^3$/s.

9.2.4. **Power line**

An internal power line will connect Lower Kruisvallei Hydro with Middle Kruisvallei Hydro, traversing both properties – see Figure 28. The line will be ±3.2 km, on the same alignment as the service road.

![Internal Power line](image)

**Figure 28: Internal Power line**

The internal powerline assessment for Lower Kruisvallei is covered in this report, while the section of the power line from Middle Kruisvallei to Node substation will be addressed in the report for the Middle Kruisvallei Scheme.

The powerline alignment was not subjected to a field study per se, but general observations during the field study was incorporated into a desktop study. The field study for an alternative powerline was executed on the opposite side of the river. The photos show the relevance between the alternative and the chosen route and assumptions made during the desktop study is accepted as correct.

When determining whether a development may have negative impacts on the agricultural milieu (for this purpose the alignment of the powerline), the themes shown in Figure 29 play a dominant part.
Figure 29: Agricultural sensitive themes

- **Land Capability**
  Land Capability is the comprehensive result of soil and climate. A soil with limitless properties but in an area with harsh climate conditions won’t be able to produce the same as one with in a temperate climate zone. Assessment must focus on what extent the loss of this land will have on the farming enterprise as a whole.

- **Land Cover.**
  This shows the habitat of the land and what the expected agricultural activity is. The denser populated the land cover is, the higher projected value of exclusiveness is awarded to the land. The focus will be on the compilation of the land cover and how the development will effect the cultivation practices.

- **Wetlands**
  Wetlands are sensitive areas. Development near wetland areas has to be investigated for possible impacts of erosion, pollution and change of drainage lines.

- **Vegetation**
  The vegetation biome reflects the potential for grazing and is normally associated with soil and climate. This will be important when rehabilitation of effected land is considered.

The desktop assessment of possible impacts along the powerline route indicated the following:

**Stretch AB**
This stretch of the powerline will be constructed on Middelvallei 130 along an existing road used for farming activities.

**Land capability:** The alignment is on the transition of two capability classes. Classification class VI refers to steep and rocky terrain associated with Glenrosa and Mispah soils. Class III refers to soils with severe limitations that reduce the choice of crops or require special conservation practices. These soils are predicted as soils with a plinthic catena with effective
depth <750 mm. This prediction correlates with the soil survey. No high potential soils will be
effected when establishing the powerline on this alignment.

**Land Cover:** The alignment does not pass through cultivated land (green on map).

**Wetlands:** The powerline passes on the border of the wetland and parallel to the drainage line.

**Vegetation:** The line is on the transition between two biomes. Orange indicates Basotho and
Montane Shrubland. It is associated with Capability class VI, where the soil properties may
have a limiting effect on rehabilitation after construction and the soil is susceptible to erosion.
The light purple represents Eastern Free State Sandy Grassland and is associated with
Capability Class III, cultivated as well as non-cultivated land. There could be mechanical or
other depth restricting layers.

**Stretch BC**

This stretch of the powerline will be constructed on Kruisvallei 190 along an existing road
used for farming activities.

**Land Capability:** The powerline alignment is on the transition of two capability classes.
Classification class VI referrers to steep and rocky terrain associated with Glenrosa and Mispah
soils. Class III refer to soils with severe limitations that reduce the choice of crops or require
special conservation practices. These soils are predicted as soils with a plinthic catena with
effective depth <750 mm. The field study show this is actually a flood plain with capability V
due to the restrictions of the structured soil type and wetness hazard.

**Land Cover:** The map shows that the alignment does not pass through cultivated land (green
on map).

**Wetlands:** The powerline passes on the border of the wetland and parallel to the drainage line.

**Vegetation Biome:** The line is on the transition between two biomes. Orange indicates Basotho
and Montane Shrubland. It is associated with Capability class VI, where the soil properties
may have a limiting effect on rehabilitation after construction and the soil is susceptible to erosion.
The light purple represents Eastern Free State Sandy Grassland and is associated with
Capability Class III cultivated as well as non-cultivated land. There could be mechanical or
other depth restricting layers.

**Stretch CD**

This stretch of the powerline will be constructed on Kruisvallei 190 along an existing road
used for farming activities.

**Land capability:** The map predicts land capability Class III, which refers to soils with severe
limitations that reduce the choice of crops or require special conservation practices. These
soils may have a plinthic catena with effective depth <750 mm. The field study, adjacent
show this is actually a flood plain with capability V due to the restrictions of the structured
soil type and wetness hazard.

**Land Cover:** The map shows that the alignment does not pass through cultivated land (green
on map).
Wetlands: The powerline passes through the wetland. It is however on the transitional line on the lower mid slope.

Vegetation Biome: The light purple represents Eastern Free State Sandy Grassland and is associated with Capability Class III cultivated as well as non-cultivated land. There could be mechanical or other depth restricting layers which are structured soil with wetness hazard.

9.3. Methodology to assess impacts

Potential impacts of the proposed project on agriculture were identified and evaluated. Impacts identified through the study were rated in terms of the following criteria:

- The nature, which shall include a description of what causes the effect, what will be affected and how it will be affected.

- The extent, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high):
  - the lifetime of the impact will be of a very short duration (0–1 years) –assigned a score of 1;
  - the lifetime of the impact will be of a short duration (2-5 years) -assigned a score of 2;
  - medium-term (5–15 years) – assigned a score of 3;
  - long-term (> 15 years) - assigned a score of 4; or
  - permanent - assigned a score of 5;

- The magnitude, quantified on a scale from 0-10, where a score is assigned:
  - 0 is small and will have no effect on the environment
  - 2 is minor and will not result in an impact on processes
  - 4 is low and will cause a slight impact on processes
  - 6 is moderate and will result in processes continuing but in a modified way
  - 8 is high (processes are altered to the extent that they temporarily cease)
  - 10 is very high and results in complete destruction of patterns and permanent cessation of processes

- The probability of occurrence, which describes the likelihood of the impact actually occurring. Probability is estimated on a scale, and a score assigned:
  - Assigned a score of 1–5, where 1 is very improbable (probably will not happen)
  - Assigned a score of 2 is improbable (some possibility, but low likelihood)
  - Assigned a score of 3 is probable (distinct possibility)
  - Assigned a score of 4 is highly probable (most likely)
  - Assigned a score of 5 is definite (impact will occur regardless of any prevention measures)
• the significance, which shall be determined through a synthesis of the characteristics
described above and can be assessed as low, medium or high; and
• the status, which will be described as either positive, negative or neutral,
• the degree to which the impact can be reversed,
• the degree to which the impact may cause irreplaceable loss of resources,
• the degree to which the impact can be mitigated.

The significance is calculated by combining the criteria in the following formula:

\[ S = (E+D+M)P \]

S = Significance weighting
E = Extent
D = Duration
M = Magnitude
P = Probability

The significance weightings for each potential impact are as follows:

• <30 points: Low (i.e. where this impact would not have a direct influence on the decision
to develop in the area),
• 30-60 points: Medium (i.e. where the impact could influence the decision to develop in
the area unless it is effectively mitigated),
• >60 points: High (i.e. where the impact must have an influence on the decision process
to develop in the area).

9.4. Possible impacts during construction

Potential impacts during the construction phase include:

• Destruction of habitat and loss of arable soil;
• Disturbance of cultivating practices;
• Alteration and degradation of soil;
• Increased erosion potential.

9.4.1. Destruction of habitat and loss of arable soil

Unit 1

The soil properties indicate that the area has low potential non-arable land due to shallow
soils with rocky outcrops rendering mechanical restrictions with cultivation. The soils have a
land capability classification VI because of these restrictions. However, this is the habitat of
natural grass and used as grazing.

The, laydown area, new access road powerhouse and tailrace will be constructed within this
unit.

Destruction of this habitat will include:
clearing of vegetation;
• Store and be exposed to hazardous materials;
• Use of explosives to excavate canal.

There is no significant loss of arable soil due to the soil characteristics of this unit.

**Unit 2**

This is a duplex soil because of the abrupt change between A and B-horizons in texture (15% clay increased to 45% clay) and structure from weak crumbly to strong blocky. The sub soil has vertic properties, having a tendency to alternate from being either too dry and hard or excessively wet and sticky. These characteristics restrict water infiltration and root development and have a high erodibility risk. The terrain position increase the possibility for water logging because of the flat foot slope

This unit hosts the largest stretch of the headrace canal, while being the habitat of cultivated pastures. Destruction will comprise:

• Clearing of vegetation;
• Excavation for the canal;
• Construction of an access road;
• Exposure to hazardous material (fuel and cement).

The loss of arable soil is low because of the extreme soil characteristics, which makes management difficult because of the short workable period.

**Unit 3**

This is medium to low potential soil due to medium depth and limiting layers of soft plinthic or a lithocutanic B-horizons. The land is irrigated, but soil properties relating to permeability, and effective depth, deprive it from being ideal for irrigation. This unit is used for the production of cash crops under centre pivot irrigation. The Hydroelectric power generation plant will occupy a very small portion at the bottom of the land, which makes the land loss moderate.

Destruction will comprise of:

• Excavation for the canal;
• Exposure to hazardous material (fuel and cement).

**9.4.2. Disturbance of cultivation practices**

**Unit 1** is not arable and separated from farming activities by road T563. Therefore, no disturbance of cultivating practices will take place.

**Unit 2** is separated from cultivation practices by the boundary on one side and the Ash River on the other side. The characteristic abrupt change of a vertic soil to a weak structured soil separates this unit for cultivating practices. The boundary follows this division in soil structure. Because the management of soil properties differs from other areas, this unit is best cultivated on its own. The disturbance of cultivating practices is therefore of low magnitude.

**Unit 3** will be obstructed by the canal at the bottom of the land. The canal follows the alignment of the contours and is therefore no severe disturbance of cultivating practices will
take place. The lease area was adjusted to allow the centre pivot to move free with no
obstruction in the way. The disturbance is of low significant.

**9.4.3. Alteration and degradation of soil**

Alteration and degradation will take place in all the units with same effect.

The impact will be local and the effect on less than 2 ha. The alteration is related to the
excavation of the canal and the management of the excavated soil. The degradation is inflicted
by hazardous material (fuel and cement) and increased traffic movement.

**Unit 1**

The following impacts are possible:

- The use of explosives in rocky areas to excavate the canal may result in rocks landing
  in the river.
- Wrong placement of spoil material generated during construction.
- Exposure of soil to hazardous spillage because of the position of the laydown area in
  relation to the river.
- Erosion of river banks due to construction of tailrace back to river

**Unit 2**

The headrace is predominately excavated in this unit. Impacts will be caused by the
movement of construction vehicles on site and the surrounding area. Spillages of fuel and
cement may take place and may contaminate soil and leach into the river. Excess material
will be generated from the canal profile, which will have to be stockpiled. This leads to
degradation.

**Unit 3**

Only a small portion at the bottom of the cultivated land will be effected. The current entrance
from the T563 will have to be replaced as the canal’s alignment follows that route. The short
diversion and cut of drain will fall in unit 3.

Hazardous spillage may contaminate the soil and leach to the river.

**9.4.4. Increased erosion potential**

**Unit 1**

During preparation of the laydown area, the vegetation will be cleared, exposing the area to
potential erosion. Normal run-off-control measures will be sufficient to protect the area
against erosion. The possible contamination from hazardous materials should be prevented
by providing a designated area for refuelling and storing of materials.

The constructing of a temporary and permanent access road may increase erosion potential
if the construction does not comply with the necessary road building specifications.
Unit 2

As a precaution to possible erosion, run-off-water from the construction areas of the inlet sill and headrace must be diverted with a cut-off drain. Because of the flat slope, erosion potential will be low between the construction area and river.

Unit 3

Stormwater should be properly managed. The soil is not ideal for irrigation, mainly because of properties relating to permeability, drainage and effective depth. Irrigation applied to this soil may cause vertical erosion and change the physical characteristics of the texture when clay particles are loosened from coarser sand and washed down the soil profile. The result is then a top soil more prone to erosion. This will increase the delivery ratio of silt.

Figure 30: Stormwater management

The land is equipped with contour banks to combat stormwater erosion. See Figure 30. The catchment for this land is from the ridge (red dotted line) towards the Ash River and T563 north and the natural waterway south.

The current contours convey part of the stormwater to the North (1). The stormwater released by the contours flow perpendicular down and deposited on the lower contour. The lower
The contour is not designed to manage the extra load and will break. Thus, a chain action develops with erosion as result as in this case.

The water diverted South (3) drain into a natural waterway and exit correctly with no effect on the downward contours.

The sensitive area indicated as (2) is positioned on the streamline or lowest point of the land – see Figure 31. It would be correct to construct a waterway in this position with the provision that it is established with vegetation or constructed with concrete. This option would be a perfect mitigation measure to solve the problem conveying stormwater past the canal to the river. It actually already exists, but without vegetative protection.

Figure 31: Waterway in cultivated land

Figure 32 shows the configuration of contour banks.

Figure 32: Change of flow direction
Point 1 shows the contour bank stopping in the middle of the land (waterway).

At point 2, (red dotted line) a contour bank section is removed, which changes the flow direction.

At point 3, the gradient in contour is too steep and the flowrate too high, which causes erosion, resulting in high silt deposits in the Ash River.

The existing water management system must be redesigned, also taking into account the impact that the canal for the hydro system will have on stormwater. There are 2 scenarios for changing the water management system.

**Scenario 1**

In this scenario, the original layout is adapted.

The service road and canal will cross the drainage line squarely. If not mitigated, this will result in erosion and destruction of the canal.

For the water management system to perform efficiently, the contour bank must discharge in a waterway designed for conveying the stormwater and release it at a controlled speed in the Ash River. The system is required to convey all stormwater from the land safely and discharge it into the river without an erosion hazard, without spillage in the canal and provide a safe drive over for all agricultural equipment on the T563 access road over the waterway and the canal.

Constructing a concrete waterway would be the best, because it is an existing system. A vegetated waterway would be difficult to construct while stormwater runs in the system.

Figure 33 and Figure 34 show two scenarios for structures to incorporate in the service and access road.
Figure 33: Stormwater management Scenario 1

**Scenario 2**

In this scenario, the waterway must be protected and the direction of flow changed. An extra contour bank will act as cut-off drain, protecting the service road and divert water away from the canal.

A bridge over the waterway and canal is still needed to cross over.

Figure 34: Storm water management Scenario 2
The ineffective control of run-off will influence the construction of the hydroelectric power generation plant. Effective stormwater management will keep the silt ratio as low as possible and protect the structure against destruction forces.

9.5. **Summary of impacts and mitigation measures during the construction phase**

9.5.1. **Construction Phase: Destruction of habitat and loss of arable soil;**

9.5.1.1. **Loss of agricultural land.**

**Nature:** The establishment of the Hydro electrical plant will be done at the expense of agricultural land. Area to be lost would be for the construction of canal and powerhouse structure, internal service roads and temporary laydown area.

<table>
<thead>
<tr>
<th></th>
<th>Without mitigation</th>
<th>With mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extent</strong></td>
<td>Local (2)</td>
<td>Local (1)</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>Short term (2)</td>
<td>Short term (2)</td>
</tr>
<tr>
<td><strong>Magnitude</strong></td>
<td>Low (4)</td>
<td>Low (4)</td>
</tr>
<tr>
<td><strong>Probability</strong></td>
<td>Probable (3)</td>
<td>Probable (3)</td>
</tr>
<tr>
<td><strong>Significance</strong></td>
<td>Low (24)</td>
<td>Low (21)</td>
</tr>
<tr>
<td><strong>Status (positive or negative)</strong></td>
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<td>Negative</td>
</tr>
<tr>
<td><strong>Reversibility</strong></td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Irreplaceable loss of resources?</strong></td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Can impacts be mitigated?</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Mitigation:** Respect all existing conservation and agricultural practices. Maintain all structures and prevent interference with normal farming activities as far as possible.

**Cumulative impacts:**
No, all impacts will be site bounded.

**Residual Risks:**
No. Effected areas will be rehabilitated as the impact will only be applicable during construction phase and be non-existent once construction has ceased.

9.5.1.2. ** Destruction of river bank**

**Nature:** Constructing the tailrace takes place on the edge of the river and require the altering of shape and composition of the river bank. This can lead to erosion of the river bank.

<table>
<thead>
<tr>
<th></th>
<th>Without mitigation</th>
<th>With mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extent</strong></td>
<td>Local (3)</td>
<td>Local (1)</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>Short-term (2)</td>
<td>Short-term (2)</td>
</tr>
<tr>
<td><strong>Magnitude</strong></td>
<td>Moderate (6)</td>
<td>Low (4)</td>
</tr>
<tr>
<td><strong>Probability</strong></td>
<td>Probable (3)</td>
<td>Probable (3)</td>
</tr>
<tr>
<td><strong>Significance</strong></td>
<td>Medium (33)</td>
<td>Low (21)</td>
</tr>
<tr>
<td><strong>Status (positive or negative)</strong></td>
<td>Negative</td>
<td>Negative</td>
</tr>
</tbody>
</table>
9.5.1.3. Destruction of river bed

**Nature:** The releasing of water from the powerhouse back to the river will have an erosive effect on the river bed.

<table>
<thead>
<tr>
<th></th>
<th>Without mitigation</th>
<th>With mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extent</strong></td>
<td>Local (3)</td>
<td>Local (1)</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>Long-term (4)</td>
<td>Long-term (4)</td>
</tr>
<tr>
<td><strong>Magnitude</strong></td>
<td>Moderate (6)</td>
<td>Low (4)</td>
</tr>
<tr>
<td><strong>Probability</strong></td>
<td>Probable (3)</td>
<td>Probable (3)</td>
</tr>
<tr>
<td><strong>Significance</strong></td>
<td>Medium (39)</td>
<td>Low (27)</td>
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<tr>
<td><strong>Status (positive or negative)</strong></td>
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<td>Negative</td>
</tr>
<tr>
<td><strong>Reversibility</strong></td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Irreplaceable loss of resources?</strong></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Can impacts be mitigated?</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Mitigation:** Regular site specific inspection of the riverbed and banks is required to monitor...
the status of the river. Impacts can be identified and treated appropriately. The integrity of riparian vegetation must be protected at all times to prevent or minimise riverbank erosion. It is recommended that the river banks surrounding the headrace canal inlet be protected with riprap. Appropriately designed riprap protection of the canal invert and walls, or a concrete lined canal, at the tailrace canal would prevent erosion occurring in this reach. It is recommended that the river banks surrounding the tailrace canal outlet be protected with riprap, except where erosion-resistant bedrock is exposed. All the areas disturbed during the construction work need to be landscaped to a standard similar or better than previously, on completion of the works.

**Cumulative impacts:**
Yes, rubble may be generated on the river bed and transported downstream by the Scheme and by other facilities.

**Residual Risks:**
Yes, river bank has new shape.

### 9.5.2. Disturbance of cultivating practices;
#### 9.5.2.1. Accumulation of spoil material on unwanted area

| Nature: The excavation of the canal will produce a large amount of soil and rock. The construction and surrounding area will be cluttered with heaps of soil and rubble interrupting construction and cultivating activities. |
|---|---|---|
| **Without mitigation** | **With mitigation** |
| **Extent** | Local(2) | Local (1) |
| **Duration** | Short term(2) | Short term (2) |
| **Magnitude** | Low (4) | Minor (2) |
| **Probability** | Probable (3) | Probable (3) |
| **Significance** | Low (24) | Low (15) |
| **Status (positive or negative)** | Negative | Negative |
| **Reversibility** | Low | Low |
| **Irreplaceable loss of resources?** | No | No |
| **Can impacts be mitigated?** | Yes | Yes |

**Mitigation:**
Use rubble as filling where possible. Transport excess rubble to licenced landfill facility.

**Cumulative impacts:**
No, site bounded

**Residual Risks:**
No, if the spoil material will not been used, would be transported from the site.
9.5.3. Alteration and degradation of soil

9.5.3.1. Soil pollution by construction vehicles and building materials

| Nature: Construction machinery and building materials used in the development of the hydro electrical plant will pollute the soil during the construction phase with contaminants such as spillages of hydrocarbon (fuel oil) and cement leaving an unproductive growing medium. |
|---|---|---|---|---|---|---|---|---|
| **Without mitigation** | **With mitigation** |
| **Extent** | Local (1) | Local (1) |
| **Duration** | Short duration (2) | Short duration (2) |
| **Magnitude** | Low (4) | Minor (2) |
| **Probability** | Probable (3) | Probable (3) |
| **Significance** | Low (21) | Low (15) |
| **Status (positive or negative)** | Negative | Negative |
| **Reversibility** | Low | Low |
| **Irreplaceable loss of resources?** | Yes | No |
| **Can impacts be mitigated?** | Yes | Yes |

**Mitigation:** Refuelling normally takes place in the laydown area. Proactive measures must be taken which include constructing of a designated area where refuelling can take place. This area must have an impervious floor with low wall that will keep the spillage inside. This area should be cleaned with absorbent material on a regular basis. The use of cut-off drains must be incorporated to divert upslope clean stormwater around the site into a natural drainage system. On the downslope, polluted water must be collected via a cut-off drain into a leachate collection and recovery system. When spillage accidently takes place, it should be removed and replaced with unpolluted soil. The clean soil can be sourced from excavations nearby. The polluted soil must be piled at a temporary storage facility with a firm waterproof base and is protected from inflow of stormwater. It must have an effective drainage system to a waterproof spillage collection area. Contaminated soil must be disposed of at a hazardous waste storage facility.

**Cumulative impacts:** No site bounded.

**Residual Risks:** Yes, it is impossible to clear the affected area totally.

9.5.4. Increased erosion potential

9.5.4.1. Loss of topsoil

| Nature: The excavation of canal, construction of access roads and clearing of laydown area will remove the top soil, leaving an unproductive subsoil prone to be eroded. |
|---|---|---|---|---|---|---|---|---|
| **Without mitigation** | **With mitigation** |
| **Extent** | Local (2) | Local (1) |
### Duration
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<th>Short term (2)</th>
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### Magnitude
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### Probability
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### Significance
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### Status (positive or negative)
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### Irreplaceable loss of resources?
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### Can impacts be mitigated?
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### Mitigation:
Topsoil that has been excavated for the clearing of laydown area, footprint of canal and service roads must be stockpiled. This soil must be reused with the rehabilitation at the end of the construction process.

Roads will be constructed with specifications including roadway preparation, stormwater controls and placing gravel where needed. Where possible, gravel from areas of excavated (cut) will be used to provide material where it is required (fill) and to surface the road.

### Cumulative impacts:
No, site bounded

### Residual Risks:
No. Effected areas will be rehabilitated once construction has ceased.

#### 9.5.4.2. Development obstructs flow in drainage line.

### Nature:
Road and canal crossing of the drainage line will block the flow and cause erosion.

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### Extent
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<th></th>
<th>Local (3)</th>
<th>Local (1)</th>
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### Duration
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### Significance
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### Status (positive or negative)
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### Reversibility
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### Irreplaceable loss of resources?
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### Can impacts be mitigated?
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<th>Yes</th>
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### Mitigation:
Roads must be constructed with specifications including roadway preparation, stormwater controls and placing gravel where needed. Where possible, gravel from areas of excavation (cut) will be used to provide material where it is required (fill) and to surface the road.
Where roads have to cross existing wetlands or drainage lines, structures to convey water underneath roads (culverts) or vehicles over stream or canals (bridge) must be incorporated in the design to control overland flow and minimise the erosion risk.

Bridge over canal.

Cumulative impacts:
No, site bounded

Residual Risks:
Yes, culverts will have to be cleaned regularly, to prevent water blockages.

9.6. Possible impacts during operation
9.6.1. Soil pollution by maintenance vehicles and building materials

<table>
<thead>
<tr>
<th>Nature: Maintenance to service roads and hydro plant will cause a soil pollution impact on adjacent agricultural land by means of spillages of fuel and cement.</th>
<th>Without mitigation</th>
<th>With mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>Local (2)</td>
<td>Local (1)</td>
</tr>
<tr>
<td>Duration</td>
<td>Long term (4)</td>
<td>Long term (4)</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Low (4)</td>
<td>Minor (2)</td>
</tr>
<tr>
<td>Probability</td>
<td>Probable (3)</td>
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<td>Low</td>
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<tr>
<td>Irreplaceable loss of resources?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Can impacts be mitigated?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Mitigation: Refuelling must take place in a designated area. This area must have an impervious floor with low wall that will keep the spillage inside. This area should be cleaned with absorbent material on a regular basis. When spillage accidently takes place, it should be removed and replaced with unpolluted soil.

Cumulative impacts:
No, site bounded
Residual Risks:
Yes. It is impossible to clear the affected area completely.

9.7. Possible impacts during upgrading and refurbishing
The aim of the developer is to refurbish the plant after twenty years and not to remove structures.

9.7.1. Soil pollution by maintenance vehicles and building materials

| Nature: Maintenance to service roads and hydro plant will cause soil pollution impacts on adjacent agricultural land by means of spillages of fuel and cement. |
|---|---|---|
| **Without mitigation** | **With mitigation** |
| Extent | Local (2) | Local (1) |
| Duration | Long term (4) | Long term (4) |
| Magnitude | Low (4) | Minor (2) |
| Probability | Probable (3) | Probable (3) |
| Significance | Medium (30) | Low (21) |
| Status (positive or negative) | Negative | Negative |
| Reversibility | Low | Low |
| Irreplaceable loss of resources? | Yes | No |
| Can impacts be mitigated? | Yes | Yes |

Mitigation: Refuelling must take place in a designated area. This area must have an impervious floor with low wall that will keep the spillage inside. This area should be cleaned with absorbent material on a regular basis. When spillage accidently takes place, it should be removed and replaced with unpolluted soil.

Cumulative impacts:
No, site bounded

Residual Risks:
Yes. It is impossible to clear the affected area completely.

9.7.2. Destruction of river bed and riverbanks

| Nature: The release of water from the powerhouse back to the river will have an erosive effect on the river bed and river banks. |
|---|---|---|
| **Without mitigation** | **With mitigation** |
| Extent | Local (3) | Local (1) |
| Duration | Long-term (4) | Long-term (4) |
| Magnitude | Moderate (6) | Low (4) |
| Probability | Probable (3) | Probable (3) |
| Significance | Medium (39) | Low (27) |
| Status (positive or negative) | Negative | Negative |
Reversibility | Low | Low
---|---|---
Irreplaceable loss of resources? | Yes | No
Can impacts be mitigated? | Yes | Yes

**Mitigation:** Regular site specific inspection of the riverbed and banks is required to monitor the status of the river. Impacts can be identified and treated appropriately. The integrity of riparian vegetation must be protected at all times to prevent or minimise riverbank erosion. It is recommended that the river banks surrounding the headrace canal inlet be protected with riprap. Appropriately designed riprap protection of the canal invert and walls, or a concrete lined canal, at the tailrace canal would prevent erosion occurring in this reach. It is recommended that the river banks surrounding the tailrace canal outlet be protected with riprap, except where erosion-resistant bedrock is exposed. All the areas disturbed during the construction work need to be landscaped to a standard similar or better than previously, on completion of the works.

**Cumulative impacts:**
Yes, rubble may be generated on the river bed and transported downstream by the Scheme and other facilities in the area.

**Residual Risks:**
Yes, cannot rehabilitate to original state.

### 9.8. Possible impacts during decommissioning

Should the plant not be refurbished and upgraded, the plant will be decommissioned. The aim of decommissioning (the closure plan) is to restore the site to a similar condition as before construction. All components of the facility should be dissembled and roads demolished. Rehabilitation should focus on:

- Demolish and removal of structures
- Demolish related roads
- Establish cultivation environment
- Stabilisation of erosion

Rehabilitation is an ongoing process, starting at construction.

All areas disturbed by destruction related activities such as access roads, construction platforms, workshop area should be rehabilitated.

### 9.8.1. Disturbance of cultivating practices;

**Nature:** The placement of spoil material accumulated from destruction of the powerhouse and filling material required for rehabilitation of canal will interfere with the agricultural activities if rubble and filling material is stockpiled randomly.

<table>
<thead>
<tr>
<th>Extent</th>
<th>Without mitigation</th>
<th>With mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local (2)</td>
<td>Local (1)</td>
<td></td>
</tr>
</tbody>
</table>
Duration | Short term (2) | Short term (2)
---|---|---
Magnitude | Low (4) | Minor (2)
Probability | Probable (3) | Probable (3)
Significance | Low (24) | Low (15)
Status (positive or negative) | Negative | Negative
Reversibility | Low | Low
Irreplaceable loss of resources? | No | No
Can impacts be mitigated? | Yes | Yes

**Mitigation:** Schedule procedure of demolition. Start with powerhouse and end with service road. Demolish and relocate rubble to temporary stockpile area, from where licenced contractors can haul to dump on licenced land fill area. Rehabilitate foundation site used for infrastructure, landscape and revegetate river bank where tail race operated. Buy filling to rehabilitate canal, demolish and rehabilitate service roads and stockpile area.

**Cumulative impacts:**
No, site bounded

**Residual Risks:**
Yes, cannot rehabilitate to original state.

### 9.8.2. Soil pollution by construction vehicles and building materials

**Nature:** Soil pollution by contaminant spillages during the decommissioning phase may take place. This is possible during the deconstruction of all facets of the facility: concrete foundations and canal linings, main access and internal service roads.

<table>
<thead>
<tr>
<th>Without mitigation</th>
<th>With mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>Local (1)</td>
</tr>
<tr>
<td>Duration</td>
<td>Short duration (2)</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Low (4)</td>
</tr>
<tr>
<td>Probability</td>
<td>Probable (3)</td>
</tr>
<tr>
<td>Significance</td>
<td>Low (21)</td>
</tr>
<tr>
<td>Status (positive or negative)</td>
<td>Negative</td>
</tr>
<tr>
<td>Reversibility</td>
<td>Low</td>
</tr>
<tr>
<td>Irreplaceable loss of resources?</td>
<td>Yes</td>
</tr>
<tr>
<td>Can impacts be mitigated?</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Mitigation:** Refuelling must take place in a designated area. This area must have an impervious floor with low wall that will keep the spillage inside. This area should be cleaned with absorbent material on a regular basis. When spillage accidently takes place, it should be removed and replaced with unpolluted soil.

**Cumulative impacts:**
No site bounded.
10. CUMULATIVE IMPACT ASSESSMENT

The Ash River is fed by the Trans Caledon Transfer Tunnel, which transfers water from the Katse Dam high up in the Maluti Mountains in Lesotho. Being very predictable, this is one of the greatest small hydro resources in the country, allowing for conditions perfectly suited to electricity production. In addition (also a result of the flow regulation), comprehensive information on current and future flow is available, making the potential highly predictable. For the purpose of the cumulative impact assessment, the LK and Mk will be considered as one project as both facilities form part of the Kruisvallei Hydroelectric Power Generation Scheme.

This made the construction of Hydro electrical generating plants possible and in a 30 km radius from the Kruisvallei Hydroelectric Power Generation Scheme, the following developments were established between Bethlehem and Clarens:

- Sol Plaatjies Hydro Powerplant, operational since 2009;
- Merino Hydro Powerplant, operational since 2010;
- Stortemelk Hydro Powerplant, operational since 2016;
- Boston Hydro Powerplant, authorised, not in operation yet.

Figure 35 shows the distances between these developments.

By comparing photo images of this whole area between 2001 and 2017, there were very few differences in agricultural development. The most substantial was near the northern outlet of the tunnel, where irrigation developments took place.
10.1. Decrease in quantity and quality of soils

The hydro plants will be constructed in the dam wall as in the case of Sol Plaatjies and Stortemelk or as a run of river such as Merino, Boston and the Kruisvallei Hydroelectric Power Generation Scheme. For the purpose of cumulative impacts, the Kruisvallei Hydroelectric Power Generation Scheme has been considered as a whole as the LK Scheme and MK Scheme form one project.

The area loss will be incorporated within the footprint of the dam wall or at the valley bottom of the land.

Soils at the valley bottom will be restricted with a wetness hazard, disqualifying them as high potential soils.

The locality of the structure will always be at the bottom of the land with low influence on the existing cultivation practices.
10.2. Changes in hydrological regimes

The change in Hydrological regime will be low, because all water used will be returned to the river. Impacts that may develop is the decrease in quality of the water.

Construction phase will always be at the cost of river banks and operating phase at the cost of the river bed.

Construction and operational phases will also have the possibilities of pollution from fuel and cement effecting the river system.

10.3. Summary of possible cumulative impacts

10.3.1. Nature: Decrease in quantity and quality of soils

The quantity of soil decreases as result of the size footprint structures and associated infrastructure occupy to generate electric power. The quality of soil decreases in the way the construction of these structures alters the workability of the soil. This includes the physical deformation in soil profile, surface layout and interference with cultivation practises. Within the lifespan of the facilities unproductive portions will build up that is unavailable for agricultural use.

<table>
<thead>
<tr>
<th>Extent</th>
<th>Overall impact of proposed project considered in isolation</th>
<th>Cumulative impact of the projects in the area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>Local (3)</td>
<td>Regional (4)</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Long Term (4)</td>
<td>Long Term (4)</td>
</tr>
<tr>
<td>Probability</td>
<td>Moderate (6)</td>
<td>Moderate (6)</td>
</tr>
<tr>
<td>Significance</td>
<td>Probable (3)</td>
<td>Highly probable (4)</td>
</tr>
<tr>
<td>Status (Positive or negative)</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Reversibility</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Irreplaceable loss of Resources?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Confidence in findings</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Can impacts be mitigated?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Mitigation:** Source transformed or non-arable land for development. Import stormwater management as an integral planning and guideline for positioning of structures. Use existing roads and conservation structures to the maximum in the planning and operation phases. Rehabilitate disturbed areas as soon as possible after construction.

**Residual** Yes not possible to rehabilitate original status completely.
10.3.2. Nature: Changes in hydrological regimes

Potential impacts that would change rate and quality of run off:
- Scouring of river beds and loss of riverbanks due to the erroneous release of water back in the river.
- Clearing of vegetation: increase flow speed, lower infiltration tempo increase silt transport
- Pollution by chemicals and hazardous substances and waste

<table>
<thead>
<tr>
<th>Extent</th>
<th>Overall impact of proposed project considered in isolation</th>
<th>Cumulative impact of the projects in the area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>Long Term (4)</td>
<td>Long Term (4)</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Low (4)</td>
<td>low (4)</td>
</tr>
<tr>
<td>Probability</td>
<td>Probable (3)</td>
<td>Probable (3)</td>
</tr>
<tr>
<td>Status</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Reversibility</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Irreplaceable loss of Resources?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Can impacts be mitigated?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Mitigation:** The integrity of riparian vegetation must be protected at all times to prevent or minimise riverbank erosion.
It is recommended that the river banks surrounding the head-race canal inlet be protected with riprap.
Appropriately designed riprap protection of the canal invert and walls, or a concrete lined canal, at the tail-race canal would prevent erosion occurring in this reach.
It is recommended that the river banks surrounding the tail-race canal outlet be protected with riprap, except where erosion-resistant bedrock is exposed.
The river banks immediately downstream of the weir should be provided with significant protection, in the form of either concrete training walls or heavy riprap.
All the areas disturbed during the construction work need to be landscaped to a standard similar or better than previously, on completion of the works.
Erosion and sediment control with proper water run-off control planning.
Appropriate handling and storage of chemicals and hazardous substances and waste.

**Residual Risk:** Yes not possible to rehabilitate original status completely.

11. ENVIRONMENTAL MANAGEMENT PROGRAMME

The following should be included in the Environmental Management Programme:

11.1. Objective: Placement of spoil material generated from construction related excavations.

<table>
<thead>
<tr>
<th>Project components</th>
<th>Construction: Excavation of canal and foundation of powerhouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential impact</td>
<td>Unplanned placement of spoil material will disrupt construction processes and occupy agricultural land.</td>
</tr>
<tr>
<td>Activity/risk source</td>
<td>Spoil material will end up in inappropriate places.</td>
</tr>
<tr>
<td>Mitigation: Target/Objective</td>
<td>To clear site from spoil material piles.</td>
</tr>
</tbody>
</table>
### Mitigation: Action/Control

- **Use rubble as filling where possible**
- **Transport excess rubble to licenced landfill facility**

### Responsibility
- EPC Contractor
- Environmental officer

### Timeframe
- Construction phase

### Performance Indicator
- No spoil material piles.

### Monitoring
- Continual inspections of the site by ECO.
- An incident reporting system must record non-conformances to the EMP.

---

#### 11.2. Objective: Prevent and clean up soil pollution

<table>
<thead>
<tr>
<th>Project components</th>
<th>Potential impact</th>
</tr>
</thead>
</table>
| • Headrace and tail race;  
  • Powerhouse;  
  • Access roads;  
  • Power line;  
  • Watercourse crossing, i.e. access roads and culverts; and  
  • All other infrastructure. | Pollution of soil by fuel, cement and other toxic materials. 
Negative impacts on wetlands. |

### Activity/risk source
- Soil will become contaminated

### Mitigation: Target/Objective
- No contamination of soil.

### Mitigation: Action/Control
- All solid waste must be collected at a central location at each construction site and stored temporary until it can be removed to an appropriate landfill site in the vicinity. The target should be to minimise spillages and soil contamination.

### Responsibility
- EPC Contractor
- Maintenance team

### Timeframe
- Lifespan of facility

### Performance Indicator
- No spillages

### Monitoring
- Regular inspections of terrain and various infrastructure units.

---

#### 11.3. Objective: Conservation of soil

<table>
<thead>
<tr>
<th>Project components</th>
<th>Potential impact</th>
</tr>
</thead>
</table>
| • Headrace and tail race;  
  • Powerhouse  
  • Access roads;  
  • Power line;  
  • Watercourse crossing, i.e. access roads and culverts. | Erosion of cultivated land |

### Activity/risk source
- Soil get unusable and unproductive
Mitigation:
Target/Objective
To minimise erosion of cultivated land.
To minimise soil degradation.

<table>
<thead>
<tr>
<th>Mitigation: Action/control</th>
<th>Responsibility</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respect and maintain existing conservation structures on cultivated land. Maintain access roads. Establish vegetation between canal and river. Monitor river banks and river bed for erosion and act to protect.</td>
<td>EPC Contractor, Maintenance team, Environmental manager</td>
<td>Lifespan of facility</td>
</tr>
</tbody>
</table>

Performance Indicator
No water run-off problems / erosion
Minimal level of soil erosion around site.

Monitoring
Regular inspections of terrain by ECO.

12. CONCLUSION AND RECOMMENDATION

When studying possible agricultural impacts on Lower Kruisvallei as a proposed site for constructing a Hydroelectric Power Station, the following also had to be kept in mind:

- A hydro plant requires a sustainable and predictable water source to operate efficiently and a terrain where the water head was economically viable.
- The Lesotho Highlands Water Project provided the predictable water source and Middelvallei’s existing weir a perfect re-entering into the river.

The aim with the study was to establish what impacts this facility would have on the existing agricultural milieu and natural resources.

The soil survey identified three utilization units within the site:

Unit 1 (on Kruisvallei 190 - size 3.38ha) has low potential non-arable land due to shallow soils with rocky outcrops rendering mechanical restrictions for cultivation. Therefore, the land capability classification is VI.

The veld has a carrying capacity of 18 ha/LSU, because of the bare patches of rock outcrop, sandy texture of topsoil and bush encroachment.

Unit 2 (Middelvallei 130 - size 4.6 ha) is characterised by structured soil with a wetness hazard, due to a gleyed horizon under the structured layer. The abrupt change between A and B-horizons in texture (15% clay increased to 45% clay) and crumbly to strong blocky structure restricts water infiltration and root development and has a high erodibility risk. The terrain position (flat foot slope) increases the possibility for water logging.

Unit 3 (Kruisvallei 190 - size 0.9 ha) has a medium to low potential soil due to medium depth and limiting layers of soft plinthic or a lithocutanic B-horizons. The land is irrigated but the soil properties deprive its potential for irrigation.
The headrace of the facility will predominately be constructed on Unit 2, the powerhouse and tailrace on Unit 1 and Unit 3 will mainly be used for a service road.

Two constraints are foreseen:

- The canal of the headrace will cross the T563 road. Provision must be made for heavy agricultural equipment and transport vehicles to cross the canal. Stormwater run-off must be prevented from entering the canal. This could be achieved by building a bridge with wings and kerbs as indicated in Figure 33 and Figure 34.
- Excavation through rock may result in rubble entering the river. With the necessary care and professionalism, this could be prevented.

The water run-off control on Unit 3 is not effective and mitigation measures must be applied as recommended.

From an environmental and land use perspective, no fatal flaws are associated with the project, if the mitigation measures are applied as recommended.

The hydroelectric power plant will have a low impact on the environment on the site identified and could therefore be authorised from a soil and agricultural perspective.

C R LUBBE 26 February 2018
AGRICULTURAL SPECIALIST
LIMITATIONS

This Document has been provided subject to the following limitations:

(i) This Document has been prepared for the particular purpose outlined in the proposal and no responsibility is accepted for the use of this Document in other contexts or for any other purpose.

(ii) CR Lubbe did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Document.

(iii) Conditions may exist which were undetectable given the limited nature of the enquiry CR Lubbe was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

(iv) It is recognised that the passage of time affects the information and assessment provided in this Document. CR Lubbe’s opinions are based upon information that existed at the time of the production of the Document. CR Lubbe’s opinion rests on the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site.

(v) Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

(vi) Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted for incomplete or inaccurate data supplied by others.

(viii) This Document is provided for sole use by the Client and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. CR Lubbe accepts no responsibility for damages, if any, suffered by any third party because of decisions made or actions based on this Document.
REFERENCES


Appendix A

Declaration of Independence

CR Lubbe was appointed by Building Energy South Africa (Pty) Ltd, on behalf of Zevobuzz (Pty) Ltd, who is the owner of Kruisvallei Hydro Project, to conduct an independent agricultural potential study for the proposed rezoning of land near Bethlehem in the Free State.

He is not a subsidiary or in any way affiliated to Building Energy South Africa (Pty) Ltd or Zevobuzz (Pty) Ltd. CR Lubbe also does not have any interest in secondary developments that may arise from the authorisation of the proposed rezoning.

CR Lubbe

26 February 2018
Specialist Curriculum Vitae – C R Lubbe

Appendix B

KEY QUALIFICATIONS:
National Higher Diploma in Agriculture (Irrigation), Technikon Pretoria, 1982
Certificate in Stereoscopic Interpretation, Geology and Resource Classification and Utilisation, Department of Agriculture, 1979
National Diploma in Agriculture, Technikon Pretoria, 1976

OTHER EDUCATION:
Certificate in Landscape Management, Technikon Pretoria, 1988
Cultivated pastures (Mod 320), University of Pretoria, 1995
FSC Auditors Course (Woodmark, UK), Sappi Ltd, 2003
NOSA Health and Safety Certificate, 1996
Certificate of Competence. Civil Designer - Design Centre and Survey and Design (Knowledge Base, August 2005)

EMPLOYMENT RECORD:

<table>
<thead>
<tr>
<th>Date</th>
<th>Position and Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2006</td>
<td>CR LUBBE, Self employed for various projects (see project related experience)</td>
</tr>
<tr>
<td>June 2006</td>
<td>Gauteng Department of Agriculture Conservation and Environment</td>
</tr>
<tr>
<td></td>
<td>Component: Technology Development and Support, Acting Assistant Director: Resource Planning and Utilization</td>
</tr>
<tr>
<td></td>
<td>Johannesburg, SA</td>
</tr>
<tr>
<td>Jan 1997 -</td>
<td>CR LUBBE, Self employed</td>
</tr>
<tr>
<td>May 2004</td>
<td>Gauteng Department of Agriculture Conservation and Environment</td>
</tr>
<tr>
<td>1980 to 1996</td>
<td>Technikon Pretoria, Lecturer, Teaching Agricultural Engineering and Land Use Planning subjects</td>
</tr>
<tr>
<td>1974 - 1979</td>
<td>Department of Agriculture (Transvaal Region)</td>
</tr>
<tr>
<td></td>
<td>Senior Extension Technician, Farm Planning, Surveying, Design of soil conservation systems, Agricultural Extension</td>
</tr>
</tbody>
</table>

SUMMARY OF EXPERIENCE
Has 42 years of experience in planning and managing natural resources to ensure optimal utilisation, without exploiting such resources to the detriment of future generations.
Fourteen years experience as a soil consultant, doing mainly soil surveys, terrain classification and agricultural potential studies. Reports include a variety of maps and GIS aspects thus play a large role in these surveys and studies.
Seventeen years of lecturing agricultural engineering subjects: Soil Conservation Techniques I, II and III, which dealt with the surveying, design and drawing of soil conservation structures; Farm Planning, which dealt with optimal resource utilization and Agricultural Mechanization, which dealt with the implements and machinery used to mechanize farming.
Ten years experience in the survey, design and supervising the construction of soil conservation structures in the agricultural field, mainly for farm planning.

PROJECT RELATED EXPERIENCE
PROJECTS UNDERTAKEN IN INDIVIDUAL CAPACITY

Cape EA
Agricultural Impact Assessment: EIA for the Construction and Operation of two Photovoltaic Power Stations at Kathu in the Northern Cape. Apr 2015

Savannah Environmental
Agricultural Impact Assessment: EIA for the Construction and Operation of a Wind Farm near Moorreesburg, Western Cape. Mar 2015

Department of Agriculture, Forestry and Fisheries

Department of Agriculture, Forestry and Fisheries
Western Cape Land Capability Verification Survey. Dec 2014
Agricultural Impact Assessment for farms Middelvallei 130 and Kruisvallei 190

Lower Kruisvallei hydroelectrical plant

Cape EA
Agricultural Impact Assessment : EIA for the Construction and Operation of a Photovoltaic Power Station at Upington (RE Cap 5) in the Northern Cape. Aug 2014

Cape EA

Cape EA
Agricultural Impact Assessment : EIA for the Construction and Operation of a Photovoltaic Power Station at Upington (Joram) in the Northern Cape. Aug 2014

Cape EA
Agricultural Impact Assessment : EIA for the Construction and Operation of a Photovoltaic Power Station at Upington (Joram) in the Northern Cape. Aug 2014

Cape EA
Agricultural Impact Assessment : EIA for the Construction and Operation of a Photovoltaic Power Station at Upington in the Northern Cape. Aug 2014

Cape EA

Macroplan
Agricultural Impact Assessment: Application for rezoning of Agricultural land at Upington (Sweet Sensation), Northern Cape. Jun 2014

Macroplan
Agricultural Potential Study: Application for change of land use at Upington (McTaggarts), Northern Cape. Mar 2014

Agricultural Development Corporation

Design of Feedlot infrastructure and stock watering systems for Kenana Sugar in Sudan.

Cape EA

Cape EA
Agricultural Impact Assessment : EIA for the Construction and Operation of a Photovoltaic Power Station at Upington in the Northern Cape. Jul 2013

Cape EA

Senter360

Africa Livestock Project Development Consortium

Van Zyl Environmental Consultants

Bushveld Eco Services
Design and cost estimate of a stock watering system in the Lephalale district. Nov 2011

WSM Leshika
Soil suitability survey for two new upcoming farmers at Vhuawela & Tshoga in the Limpopo Province. Sep 2011

National Department of Agriculture
Soil survey investigating soil potential for change of land use at the Levendal Development in the Paarl district, Western Cape. Aug 2011

Van Zyl Environmental Consultants

WSM Leshika
Potential assessments and land use plans for four new upcoming farmers in the Limpopo Province. Nov 2010

FP Botha
Potential assessments and land use plans for various new Limpopo agricultural development hubs Apr 2010
Golder Associates Africa (Pty) Ltd  
Potential assessments and Land use plans for the resettlement of land tenants at Mafube Coal Mine in the Belfast district of the Mpumalanga Province  
May 2009 – Apr 2010  
Vryheid, RSA

Sappi  
Undertook reconnaissance soil surveys on various plantations and farms in the Vryheid and Piet Retief districts to establish forestation potential and evaluation for species choice (covering a total area of 5173 ha).  
Vryheid, RSA

Environnementek, CSIR  
Undertook soil and terrain classification surveys on the Jessievale (8313 ha) and New Agatha (1 700 ha) plantations.  
Nelspruit, RSA

Safcol (Komatieland)  
Undertook environmental, soil and terrain classification surveys on the Thatevondo (4 500 ha), Matela (920 ha) and Mmamatola (1 263 ha) plantations.  
Limpopo Province

Measured Farming  
Undertook soil and terrain classification surveys on Ranch Lope and Ranch Suba in Gabon, Kubuta Farm in Swaziland and on the farms Madikwe in the Limpopo Province and Stoffelsrus in the Free State, South Africa.  
Gabon, Swaziland & RSA

Loxton Venn and Associates  
Assess comparative soils and area for relocating Village Ga-Sekhaolelo on Overysel 815LR to Rooibokfontein 812LR and Village Ga-Puka on Swartfontein 818 LR to Armoed on Potgietersrus Platinum Mine.  
Potgietersrus, RSA

Department of Water Affairs and Forestry  
GPS survey and alien identification for mapping of Jukskei and Swartspruit areas, as part of the Working for Water Program.  
Gauteng

Sustainable Forestry Management Ltd  
Participated in a due diligence audit on various SAFCOL plantations in the Limpopo and Mpumalanga Provinces as part of the preparation of a British company’s tender to purchase these plantations.  
Limpopo and Mpumalanga

Mustek Engineering  
Survey to provide a detailed inventory of the forest resources in 17 specified Forest Reserves in Ghana to develop a practical and operationally sound methodology for monitoring the natural forest resources in Ghana, based on satellite imagery for the Ghana Forestry Commission.  
Ghana

Afrigis Environmental Solutions, Pretoria  
Various Soil Surveys and Landuse Plannings – Domestic and Neighbouring Countries  
Various Soil Surveys and Landuse Plannings  
Lectures at Basic Farm Planning Course (Limpopo and Gauteng)
5. METHODOLOGY

For purposes of international and national technology transfer and simplicity, the methodology was aimed at reflecting the classic concepts of land capability, as established by Klingebiel and Montgomery (1961) as far as possible. These concepts were to be brought under parameters suited to South African conditions and the local availability of data.

The original concepts (Klingebiel & Montgomery, 1961) are as follows:

5.1 CONCEPTS: LAND SUITED TO CULTIVATION

5.1.1 Class I

- Land in Class I has few limitations that restrict its use.
- It may be used safely and profitably for cultivated crops.
- The soils are nearly level and deep.
- They hold water well and are generally well drained.
- They are easily worked, and are either fairly well supplied with plant nutrients or are highly responsive to inputs of fertilizer.
- When used for crops, the soils need ordinary management practices to maintain productivity.
- The climate is favourable for growing many of the common field crops.

Note: “Highly responsive to inputs of fertilizer” is taken to imply that strongly acid soils in need of liming are excluded from Class I.

5.1.2 Class II

- Land in Class II have some limitations that reduce the choice of plants or require moderate conservation practices.
- It may be used for cultivated crops, but with less latitude in the choice of crops or management practices than Class I.
- The limitations are few and the practices are easy to apply.
- Limitations may include singly or in combination the effects of:
  - Gentle slopes.
  - Moderate susceptibility to wind and water erosion.
  - Less than ideal soil depth.
  - Somewhat unfavourable soil structure and workability.
  - Slight to moderate salinity or sodicity easily corrected but likely to recur.
  - Occasional damaging flooding.
  - Wetness correctable by drainage but existing permanently as a moderate limitation.
  - Slight climatic limitations on soil use and management.
- Limitations may cause special soil-conserving cropping systems, soil conservation practices, water-control devices or tillage methods to be required when used for cultivated crops.

Note: “Slight to moderate salinity or sodicity, easily corrected, but likely to recur” is taken to imply that strong subsoil acidity, costly to correct and likely to recur, would disqualify land from Class II.
5.1.3 Class III

- Land in Class III has severe limitations that reduce the choice of plants or require special conservation practices, or both.
- It may be used for cultivated crops, but has more restrictions than Class II. When used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain.
- The number of practical alternatives for average farmers is less than that for soils in Class II.
- Limitations restrict, singly or in combination, the amount of clean cultivation, time of planting, tillage, harvesting, choice of crops.
- Limitations may result from the effects of one or more of the following:
  - Moderately steep slopes.
  - High susceptibility to water or wind erosion or severe adverse effects of past erosion.
  - Frequent flooding accompanied by some crop damage.
  - Very slow permeability of the subsoil.
  - Wetness or some continuing waterlogging after drainage.
  - Shallow soil depth to bedrock, hardpan, fragipan or claypan that limit the rooting zone and the water storage.
  - Low water-holding capacity.
  - Low fertility not easily corrected.
  - Moderate salinity or sodicity.
  - Moderate climatic limitations.

Note: "Severe limitations" and "Low fertility not easily corrected" are taken to imply that land dominated by soils with severe subsoil acidity belongs in Class III.

5.1.4 Class IV

- Land in Class IV has very severe limitations that restrict the choice of plants, require very careful management, or both.
- It may be used for cultivated crops, but more careful management is required than for Class III and conservation practices are more difficult to apply and maintain.
- Restrictions to land use are greater than those in Class III and the choice of plants is more limited.
- It may be well suited to only two or three of the common crops or the harvest produced may be low in relation to inputs over long period of time.
- In sub-humid and semiarid areas, land in Class IV may produce good yields of adapted cultivated crops during years of above average rainfall and failures during years of below average rainfall.
- Use for cultivated crops is limited as a result of the effects of one or more permanent features such as:
  - Steep slopes.
  - Severe susceptibility to water or wind erosion or severe effects of past erosion.
  - Shallow soils.
  - Low water-holding capacity.
  - Frequent flooding accompanied by severe crop damage
  - Excessive wetness with continuing hazard of waterlogging after drainage.
- Severe salinity or sodicity.
- Moderately adverse climate.

5.2 CONCEPTS: LAND WITH LIMITED USE – GENERALLY NOT SUITED TO CULTIVATION

5.2.1 Class V

- Land in Class V has little or no erosion hazard but have other limitations impractical to remove that limit its use largely to pasture, range, woodland or wildlife food and cover. These limitations restrict the kind of plants that can be grown and prevent normal tillage of cultivated crops. Pastures can be improved and benefits from proper management can be expected.
- It is nearly level. Some occurrences are wet or frequently flooded. Other are stony, have climatic limitations, or have some combination of these limitations.
- Examples of Class V are:
  - Bottomlands subject to frequent flooding that prevents the normal production of cultivated crops.
  - Nearly level land with a growing season that prevents the normal production of cultivated crops.
  - Level or nearly level stony or rocky land.
  - Ponded areas where drainage for cultivated crops is not feasible but which are suitable for grasses or trees.

5.2.2 Class VI

- Land in Class VI has severe limitations that make it generally unsuited to cultivation and limit its use largely to pasture and range, woodland or wildlife food and cover.
- Land in Class VI has continuing limitations that cannot be corrected, such as:
  - Steep slope.
  - Severe erosion hazard.
  - Effects of past erosion.
  - Stoniness.
  - Shallow rooting zone.
  - Excessive wetness or flooding.
  - Low water-holding capacity.
  - Salinity or sodicity.
  - Severe climate.
- Physical conditions are such that it is practical to apply range or pasture improvements, if needed, such as seeding, liming and fertilizing.
- Some occurrences can be safely used for the common crops, provided unusually intensive management is used. Some occurrences are adapted to special crops. Depending on soil features and climate, land in Class VI may be well to poorly suited to woodlands.

5.2.3 Class VII

- Land in Class VII has very severe limitations that make it unsuited to cultivation and that restrict its use largely to grazing, woodland or wildlife.
• Restrictions are more severe than those for Class VI because of one or more continuing limitations that cannot be corrected, such as:
  - Very steep slopes.
  - Erosion.
  - Shallow soil.
  - Stones.
  - Wet soil.
  - Salts or sodicity.
  - Unfavourable climate.
• Physical conditions are such that it is impractical to apply such pasture or range improvements as seeding, liming and fertilizing.
• Depending on soil characteristics and climate, land in Class VII may be well or poorly suited to woodland.
• In unusual instances some occurrences may be used for special crops under unusual management practices.

5.2.4 Class VIII

• Land in Class VIII have limitations that preclude its use for commercial plant production and restrict its use to recreation, wildlife, water supply or aesthetic purposes.
• Limitations that cannot be corrected may result from the effects of one or more of:
  - Erosion or erosion hazard.
  - Severe climate.
  - Wet soil.
  - Stones.
  - Low water-holding capacity.
  - Salinity or sodicity.
• Land in Class VIII cannot be expected to return significant on-site benefits from management for crops, grasses or trees, although benefits from wildlife use, watershed protection or recreation may be possible.
• Badlands, rock outcrop, sandy beaches, river wash, mine tailings and other nearly barren lands are included in Class VIII.

The number of land use options decreases from Class I to VIII as illustrated in Table 5.2.