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SITE IDENTIFICATION REPORT FOR THE PROPOSED 60 YEAR KUSILE ASH DUMP

Report No : 12712- Site Screening-v10

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18 May 2012 12712

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1 INTRODUCTION

1.1 Proposed project

Kusile Power Station is a coal fired power station which Eskom is presently constructing as part of the expansion of its power generation fleet. It is envisaged that the power station will employ dry ashing for the disposal of its ash. The new power station is establishing the existing ash dump, however recent investigations have shown that this facility will not be able to cater for the life of the station hence, a larger facility is required for 60 years of operations.

Zitholele has been appointed to undertake the Environmental Impact Assessment (EIA) and Waste Management License (WML) Application in terms of the National Environmental Management Act ([NEMA] Act No 107 of 1998, as amended 2010) and the National Environmental Management: Waste Act ([NEM:WA] Act No 59 of 2008). It is envisaged that the project will include the following components at present:

- A dry ash disposal facility of estimated 1500ha (including associated infrastructure such as stackers, ash water return dams, pipelines and conveyors);
- A conveyor belt for the transportation of ash to the ash dump;
- The waste stream comprises of a combined bottom ash and fly ash waste stream;
- Services including electricity and water supply in the form of power lines, pipelines, and associated infrastructure; and
- Access and maintenance roads to the site.

1.2 Purpose of this report

The purpose of this report is to table an approach undertaken for the consideration of alternatives and selection of suitable sites for further detailed investigations.

2 CONSIDERTATION OF ALTERNATIVES

2.1 Approach taken

The optimal goal in building an ash dump and associated infrastructure (such as conveyors, canals, pipelines and return water dams) is to effectively minimise the negative environmental and social impact while ensuring safety, reliability, and cost savings for the utility.

To ensure that defensible alternatives are identified and considered a structured approach is utilised. Initially, the project team determines the need and motivation for the proposed project (NEMA, 1998). This discussion will identify all the potential solutions that can result in the need being met; at this point no alternatives have been excluded. When dealing with waste related projects, this discussion typically is structured around the waste hierarchy (National Management Waste Strategy [NMWS], 2010) as shown in Figure 1.

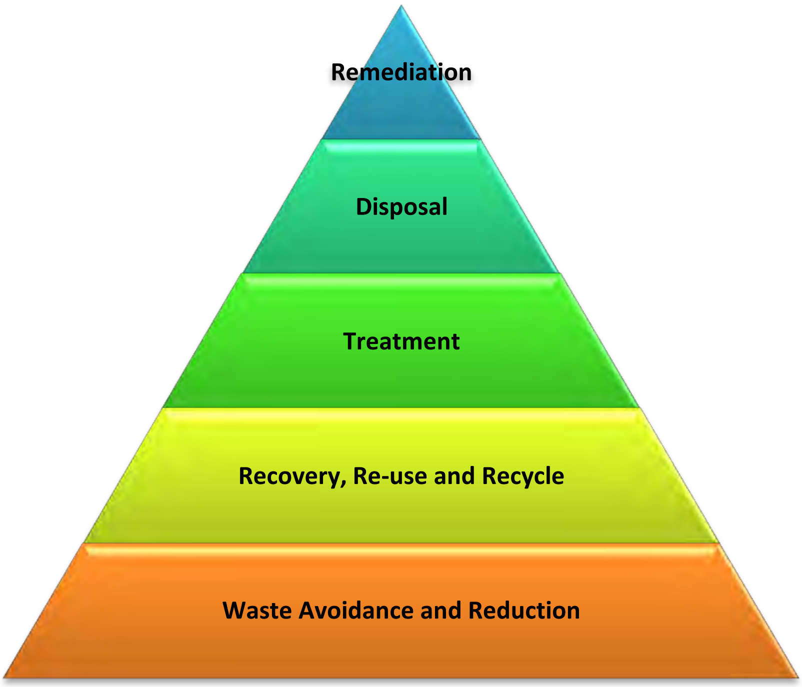


Figure 1: Waste Hierarchy

The essence of the approach is to group waste management measures across the entire value chain in a series of steps, which are applied in descending order of priority. The foundation of the hierarchy, and the first choice of measures in the management of waste, is waste avoidance and reduction. Where waste cannot be avoided, it should be recovered, reused, recycled and treated (NMWS, 2010). Waste should only be disposed of as a last resort.

In working through these systematic hierarchical steps alternative solutions are generated. Waste management could be a single solution best suited to the type of waste, or a combination of several solutions. In each of these steps alternatives can be evaluated and excluded as being not feasible. Technical scientific information is utilised to exclude alternatives in each of these steps. Once feasible alternative solutions are identified a process of evaluation can commence to evaluate the environmental, social, and technical acceptability of these solutions, within each solution alternatives may be considered to improve the positive aspects or reduce the negative aspects of each solution.

2.2 Identification of Alternative Waste Management Solutions

The current status, available information, and further studies required based on the implementation of the Waste Hierarchy is summarised in Table 1. Based on the information available to date the following alternative solutions to the ash waste stream exists:

- **Avoidance and Minimisation:**
  - None.
- **Recovery / Recycling / Re-use:**
  - Use of ash in construction activities i.e. as aggregate in road construction, or as a cement extender;
  - Use of gypsum in agricultural uses such as soil amendment, fertilizer, cattle feeders, soil stabilization in stock feed yards, and agricultural stakes;
  - Other applications include cosmetics, toothpaste, kitchen counter tops, floor and ceiling tiles.
- **Treatment**
  - No feasible alternatives currently available to treat the ash waste.
- **Disposal**
  - Disposal to a suitably designed ash disposal facility.
- **Remediation**
  - Capping of the new facility at the end of life.

Due to the large volumes of ash that will be generated it has been concluded that an ash dump will be required, even with the implementation of all the other alternatives.

Table 1: Waste Hierarchy Current Status, Available Information, and Workshop Results

Waste Hierarchy	Current Status and Information	Workshop Discussion Results
Waste avoidance and reduction	Eskom is currently constructing the Kusile power station to meet the countries energy demand. Kusile is an approved coal fired power station. The power station will generate ash and gypsum waste streams as a result of the energy generation process. The waste generated requires responsible management and disposal. The waste streams are currently a by-product of the technology utilised at the power station. In order to prevent the waste from being generated the power station would require the use of another energy generating technology i.e. nuclear, wind or solar power generating technology. It is considered unfeasible to change the technology, and therefore no preventative measures are available. In order to minimise the generation of ash a low ash-content fuel source can be utilised. The cost of such a fuel source is currently an order of magnitude greater than the current fuel source. This will result in an exponential increase in energy costs, with consequential knock-on effect on the economy. The current fuel source is of too low standard for export, and will result in the coal source not being mined, or spoiled. The spoiling of the lower quality coal will be a waste of the resource, costing the country in lost revenue and waste management costs.	The potential solutions identified to reduce / avoid the generation of waste ash include: 1.) Change the technology utilised to generate power i.e. wind, solar, nuclear power; and 2.) Change the fuel source to a low ash content coal source. Both alternatives are considered to be unfeasible for the following reasons. 1.) The loss of capital invested in the project to date. 2.) The delay in the construction of the Kusile power station thus plunging South Africa into an energy crisis in the near future. 3.) Alternative energy generating technologies are much more costly, or have other technical problems, that will result in the increase of energy costs in South Africa or are technically unfeasible. 4.) The cost of a low ash-content fuel source is currently an order of magnitude greater than the current fuel source. This will result in an exponential increase in energy costs with consequential knock-on effect on the economy. 5.) The current fuel source is of too low standard for export, and will result in the coal source not being mined, or spoiled. The spoiling of the lower quality coal will be a waste of the resource.

Waste Hierarchy	Current Status and Information	Workshop Discussion Results
Recovery / Reuse / Recycling / Energy Recovery	There are many re-use alternatives available for this waste stream, including: 1.) Concrete production; 2.) Embankments and other structural fills; 3.) Grout and flowable fill production; 4.) Waste stabilization and solidification; 5.) Cement clinkers production - (as a substitute material for clay); 6.) Mine reclamation; 7.) Stabilization of soft soils; 8.) As aggregate substitute material (e.g. for brick production); 9.) Mineral filler in asphaltic concrete; 10.) Agricultural uses: soil amendment, fertilizer, cattle feeders, soil stabilization in stock feed yards, and agricultural stakes; 11.) Other applications include cosmetics, toothpaste, kitchen counter tops, floor and ceiling tiles. Eskom is currently sourcing contractors who will re-use the ash. The demand for the ash waste stream is however marginal by comparison to the volume of waste produced. More than 99% of the waste stream will still be left over. The use of the ash waste stream in backfilling mining operations at the New Largo Colliery appears promising to address the majority of the ash waste stream. However, the mining operation is not yet approved. This option is therefore currently not available. In addition, there is not enough information available to determine the extent of environmental impact that may occur as a result of such a use. This option is therefore considered unfeasible at this stage. The ash is the final product from an energy recovery process. The calorific value of the ash waste is too low to recovery additional energy in an economical manner.	After some discussion it was determined that: 1.) These alternatives are feasible and that contracts will be drawn up for the sale of the ash waste stream; and 2.) The combined sales of all the aforementioned uses would not reduce the waste stream by a noticeable volume (less than 0.05%), or even reduce the footprint of a facility required to store the waste stream. The discussion enquired about the separation of the coarse and fine ash waste stream, thus allowing the coarse ash to be utilised as an aggregate in road construction. Eskom indicated that because of the high ash content of the fuel source only 8% of the ash stream consisted of coarse ash, and that separation at source is not possible.
Treatment	Currently no viable treatment options have been identified	Coal ash is typically not treated. The leachate from coal ash can be treated using ion exchange or reverse osmosis. It is possible to treat the coal ash for the purpose of delisting the waste in order to reduce the liner requirements of a disposal facility, however this cost is excessive and requires additional research to determine if this is a feasible alternative. The waste generated by the treatment process would require a disposal facility meeting more stringent standards due to the concentration of the waste stream.

Waste Hierarchy	Current Status and Information	Workshop Discussion Results
Disposal	Given the aforementioned it is reasonable to assert that a waste disposal facility to accommodate the ash will need to be constructed. It is envisaged based on the design of the Kusile power station, the anticipated coal ash content, and the through put of fuel that a facility in the region of 1500ha including supporting infrastructure may be required (depending on the length of the conveyor and piping systems(.	Having considered alternative solutions along the waste hierarchy it was agreed that a disposal facility would be required for the majority of the waste stream. This being the only remaining feasible solution to address the majority of the waste stream. Two alternative disposal solutions were identified for the disposal of the waste stream: 1.) In-pit Ash Disposal; and a 2.) Separate Ash Disposal Facility; Specific solution alternatives are discussed and are documented below. **<u>In-pit Ash Disposal</u>** The ash generated by the power plant could possibly be disposed of in the open void created by the adjacent proposed New Largo Mine. The following conditions however prevent this alternative from being explored further at this juncture: 1.) The New Largo Mine is not yet approved and as such it is unclear if the mine would be able to receive the waste stream. 2.) The mine plan has not yet been finalised and as such the mechanics of receiving the waste stream cannot be considered even theoretically. 3.) There is insufficient information at present to accurately model the impacts of the ash waste stream on the groundwater regime if in-pit ashing is undertaken. 4.) There is currently insufficient information of the predicted outcome of the mining operation on the groundwater regime. 5.) The costs to undertake a theoretical prediction of the impact to the environment from in-pit ashing is not warranted as it will not increase the certainty of the decision. 6.) The costs to undertake a theoretical prediction of the impact are high, and will not increase the certainty of the decision to undertake in-pit ashing at this stage.

Waste Hierarchy	Current Status and Information	Workshop Discussion Results
Disposal		In-pit ashing will be included into the Scoping Report and EIA as an alternative and provide the motivation for why this option is not feasible at this juncture, but was not prepared to exclude this possible solution entirely, and would recommend that studies be undertaken in future when the conditions are more favourable.
Disposal		**<u>Operational Alternatives</u>** Having exhausted all the options it was agreed by the team that the most feasible solution for the waste stream at this point in time is the disposal of the waste in a surface disposal facility. <u>Separation of the ash and gypsum waste stream</u> Enquiries were made into the possible separation of the ash and gypsum stream at source. Eskom indicated that for the first five years the ash and gypsum waste stream will be combined, and that thereafter these waste streams will be separated. Gypsum will then be deposited on the existing small ash dump facility. It was agreed that the 60 year facility would therefore only receive the ash waste. <u>Multi-stacking</u> Based on the known geology that occurs over 80% of the study area it seems that multi-stacking with a 5m front running bench would be feasible. An increase of the stack-height could be achieved because of the additional stability and as such the dump height could be increase from the typical 40m to a height of 50m, reducing the estimated 1500ha dump to 900ha – a footprint reduction of 600ha. It was asked if the cost of the additional machinery would warrant such an operation. It was indicated that the additional cost is easily covered by the savings in the liner system due to the smaller footprint. It was agreed that this alternative should be further investigated. <u>Mass transportation of the waste stream</u> Eskom indicated that one of the major factors to consider in the selection of the waste site is the conveying system. Factors to take into account includes: 1.) Length: The length of the conveyor system must be as short as possible because:

Waste Hierarchy	Current Status and Information	Workshop Discussion Results
		a. The cost becomes prohibitive; and b. The preferred conveyor system is open, ash is dampened for transportation but tends to dry out over the conveyor. The longer the conveyor the higher the risk of dust dispersion. 2.) Bends: Straight lines and long radius curves are preferred because transfer points a prone to spillage and higher costs for maintenance.
Disposal		**<u>Design Alternatives</u>** Based on the aforementioned discussion it was determined that the design of the facility would take into account the following: <u>Single facility vs. Multiple facilities</u> It was agreed that should a single facility of sufficient size not be found the following criteria will apply: 1.) A maximum of two facilities will be identified; and 2.) A facility may not be smaller than 400ha. <u>Minimum standards</u> The design requirements for the ash facility are in the process of being revised by government (Minimum Requirements to Waste Regulations), and the most recent design requirements will be taken into account when designing the facility. <u>Footprint of the facility</u> It is desirable from an environmental perspective that the footprint of the facility be reduced from the outset to the smallest possible footprint and as such supports the implementation of the multi-stacking option as the preferred alternative. It was agreed that for the purpose of the EIA a trade-off between a single stack and multi-stack facility be evaluated.
Disposal		**<u>Location Alternatives</u>** The site selection methodology consists of four major phases:

Waste Hierarchy	Current Status and Information	Workshop Discussion Results
		1.) Delineation of the study area; 2.) Delineation of developable area; 3.) Rating of the developable area on the basis of engineering suitability, environmental and social sensitivity; 4.) Overlay analysis and site selection. A more comprehensive description of the site selection methodology is given in Section 2.3 of this document. At the workshop the developable area was determined through the identification and mapping of "No-Go" areas. A number of "No-Go" areas were tabulated, and buffer zones around each were agreed. These no-go areas were excluded from the developable land in the study area, reviewed by the team and adjusted through an iterative process until suitable sites could be identified. This process is presented in more detail below.
Remediation	This phase of the waste treatment hierarchy is included particularly to address existing waste facilities that have not applied the previous steps of the waste hierarchy correctly, and additional measures are required to now manage the resulting impact. This phase does not apply to the Kusile Ash project as this will be a new facility.	Ensure that capping and rehabilitation of the ash facility is addressed as a component of the design of the Kusile Ash Dump.

2.3 Ash Disposal Facility – solution specific alternatives

Having determined that an ash disposal facility will be required, further work was invested in the consideration of alternatives specific to this solution. As mentioned above this consisted of a three primary activities:

1.) **Waste disposal operations:** determine if waste will be disposed of separately according to the two waste streams generated. Factors taken into account here will be the classification of the various waste streams, the envisaged impact of waste separation to the classification of either of the waste streams or combined waste streams, the implications to the overall Kusile power station construction time frame as a result of waste separation requirements, and the implication to the design of waste disposal facilities as a result of the waste classification of the separate and combined waste streams.
2.) **Design:** determine the design requirements for each of the aforementioned waste disposal operations and the costs associated with each (in a rough order of magnitude) to assist in the selection of the preferred option, determine the technical suitability of developable areas for the siting of the waste disposal facility, identify suitable sites for the waste facility based on technical and economic suitability, determine the extent of foot print optimization that can be achieved, determine the waste and deposition and transportation system, and compile conceptual designs of the waste facility and associated infrastructure of the three selected suitable options (taking into account environmental and social sensitivity).
3.) **Location:** undertake an evaluation of the study area and identify the most suitable site taking into account the technical and economic feasibility, environmental and social sensitivity of the site. This was undertaken according to the process shown in Figure 2.

An Iterative approach was utilised to determine the aforementioned. Initially available and general information is to be used, and as more information is generated through specialist studies the alternatives will be refined. Five planning iterations were required to generate the final three alternatives that will be assessed in the EIA, of which one will be finally selected as the preferred alternative.

3 SITE SCREENING / SELECTION

3.1 Defining the study area

The first step in the site selection process has been completed and a study area has been identified. The study area was identified using the following criteria, and shown in Figure 3:

1.) The study area must coincide with farm boundaries;
2.) The study area is located within a 15km radius from Kusile Power Station;
3.) The study area is limited in extent to the north by the N4 and unsuitable topography north of the N4.
4.) The study area is limited to the south by the N12.

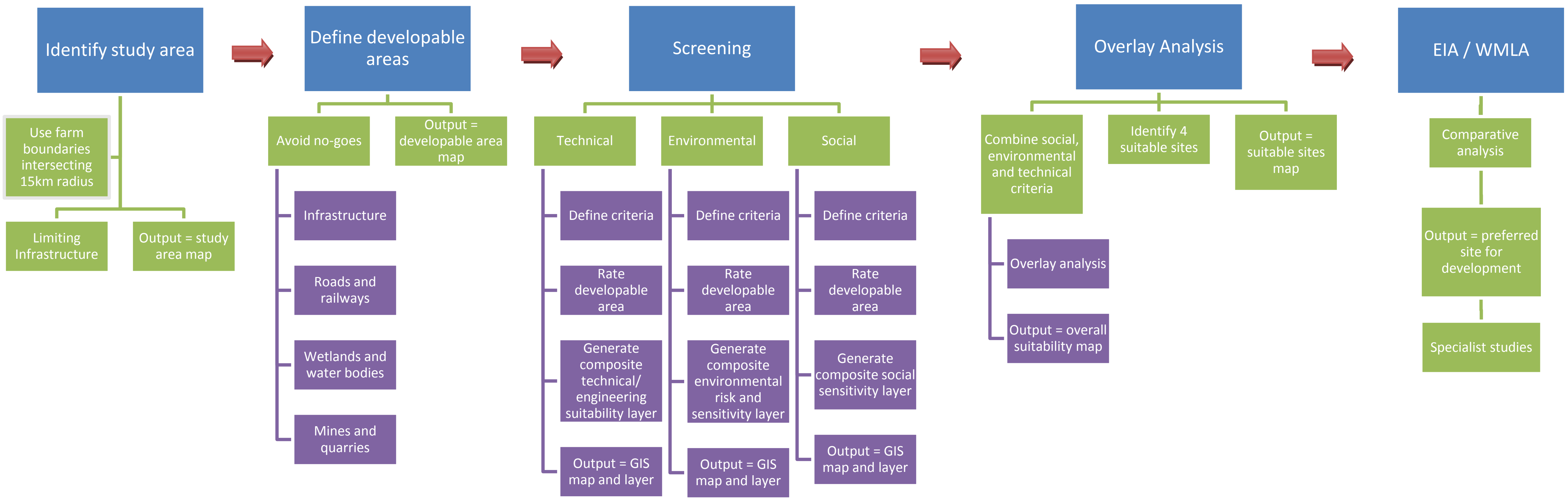
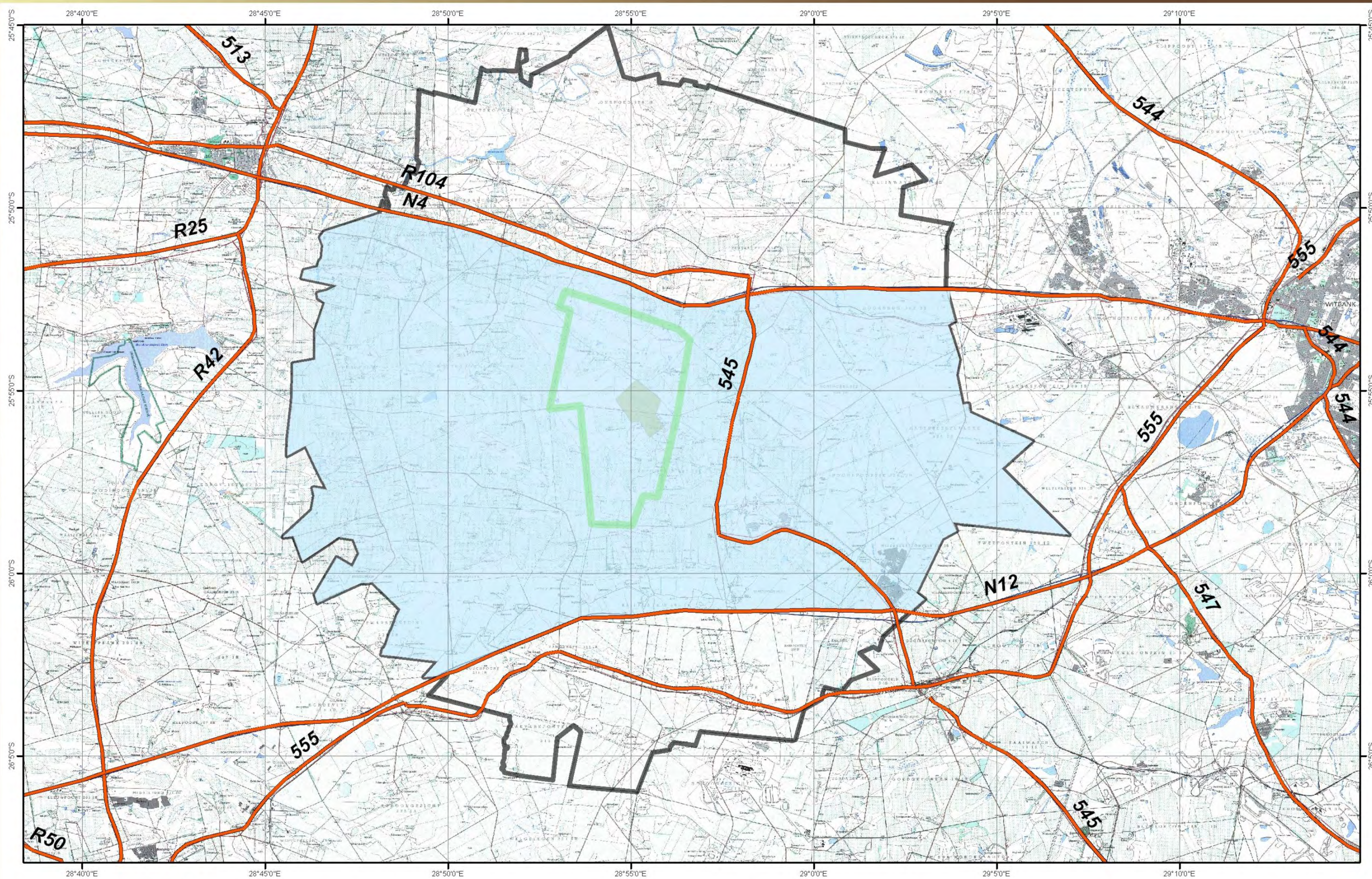


Figure 2: Site Selection Methodology.



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12721	Ver 1	AUTHOR: K. Kruger	WGS 84 Hartebeesthoek	1:175,000	Topo Mapsheets Surveyor General

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Figure 3: Study area for the Kusile Ash Dump project.

7 3.5 0 7 Kilometers

N W E S

3.2 Defining the developable areas

The next step in the process is to define the developable areas. This was be done by using negative mapping in such a way as to exclude all areas within the study area that conflict with the proposed ash dump. A draft list of "Limiting Factors" was drawn up and is shown in Table 2 below.

Table 2: Areas of avoidance (No-Go)

Built Environment		Engineering Requirements		Natural Environment	
Features	**Buffer**	**Features**	**Buffer**	**Features**	**Buffer**
Farmsteads	200m	Open Pits	100m	Rivers / Streams	500m
Schools	200m	Undermined Areas	100m	Wetlands / Dams	500m
Cemeteries	200m	Overhead Power lines	Serv	Parks	100m
Church's	200m	Gas Pipeline	Serv	Protected Areas	100m
Military Facilities	200m	Water Pipeline	Serv	Red Data Species	100m
Railway Lines	50m				
Tarred Roads	100m				
Farm Roads	100m				
Air strips	3km				
Archaeological Sites	100m				
Monuments / Heritage Areas	100m				
Culturally Significant Areas	100m				
Conveyor Belt	50m				

This list was finalised and a map showing the developable area remaining was generated (refer Figure 4). The potential developable areas were then evaluated for their technical suitability in terms of size available to see if any potential sites could be identified. The following iterations of the negative mapping took place:

- Iteration 1 – Buffers as per Table 2, no suitable sites were identified (Fig 4);
- Iteration 2 – Roads buffers removed, no suitable sites identified (Fig 5);
- Iteration 3 – Built buffers reduced to 100m, no suitable sites identified (Fig 6);
- Iteration 4 – Wetland and river buffers reduced to 100m, several potential sites but very fragmented (Fig 7); and
- Iteration 5 – Built environment buffers removed, 11 potential developable areas identified (Fig 8).

The resultant 11 potential developable areas are shown in the map in Figure 9. Note that the areas have been numbered from A – I and due to the small size of some areas – combination sites have been identified e.g. area H1 + H2 + H3 will form one site. Table 3 below gives all the potential areas and their associated sizes.

Table 3: List of potential sites and associated areas

Potential Sites	
Individual Sites:	
Site:	**Area (Ha):**
Site A	1 477
Site B	1 330
Site C	1 590
Site F	1 303
Site G	1 180
Site I	1 297
Area Combinations:	
Area D1&2	1 035 + 723 = 1 758
Areas G & D1	1 035 + 1 180 = 2 215
Areas H1 & H2	729 + 1 087 = 1 818
Areas H1 & H3	729 + 931 = 1 660
Areas H2 & H3	1 087 + 931 = 2 018
Sites A &G	1 857
Sites F & G	1303 + 1180 = 2 483

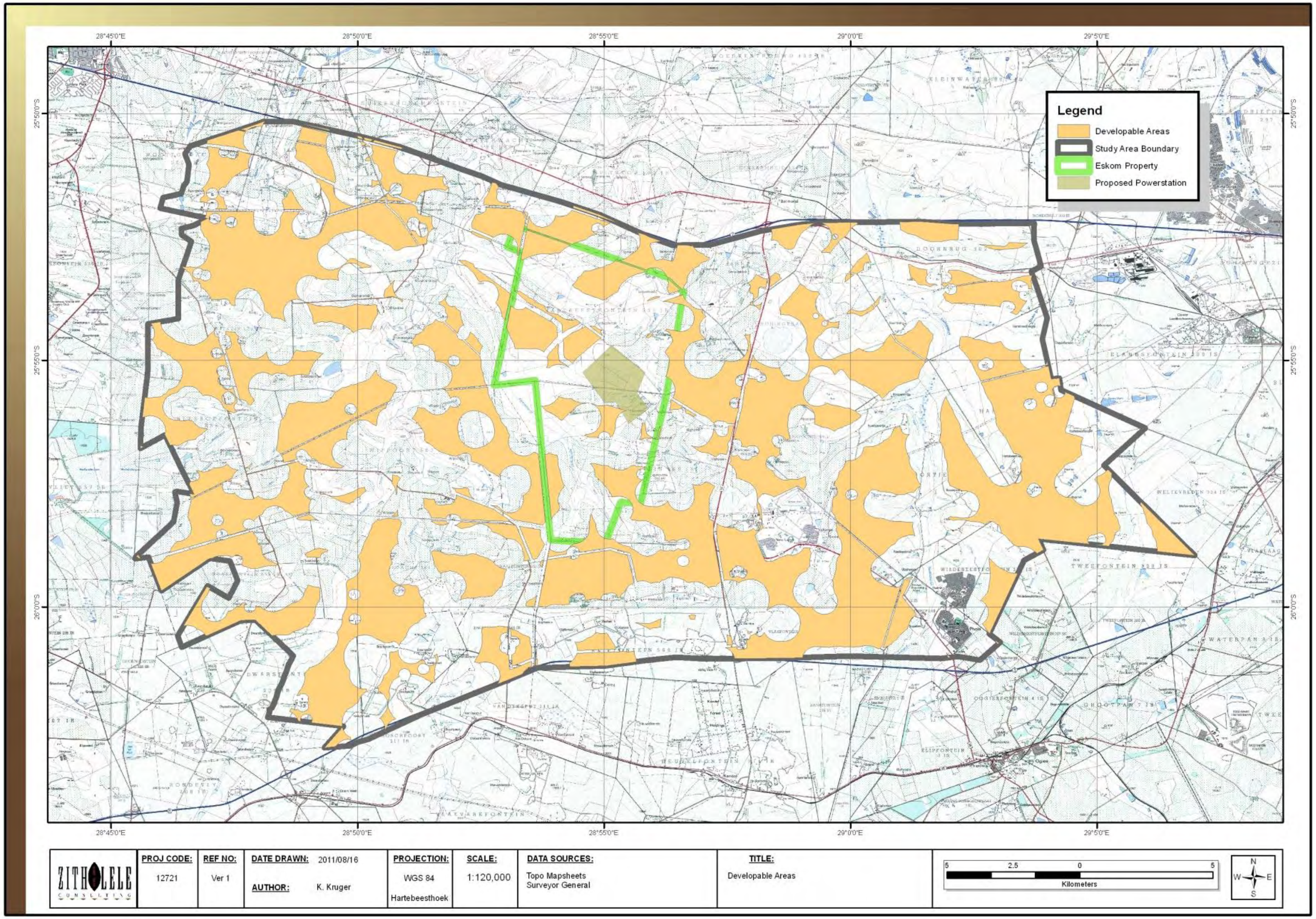


Figure 4: First Negative Mapping Iteration

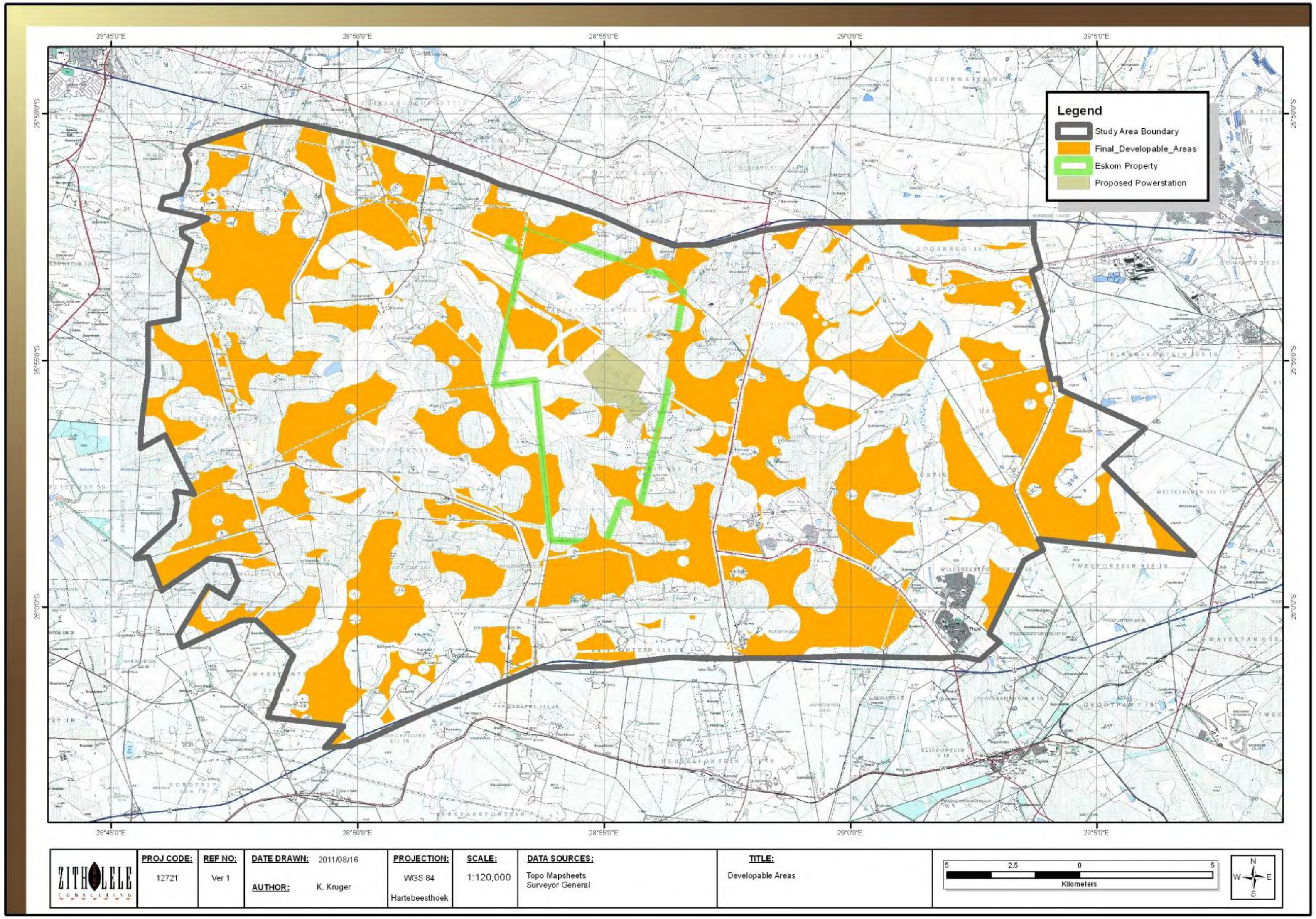


Figure 5: Second Negative Mapping Iteration

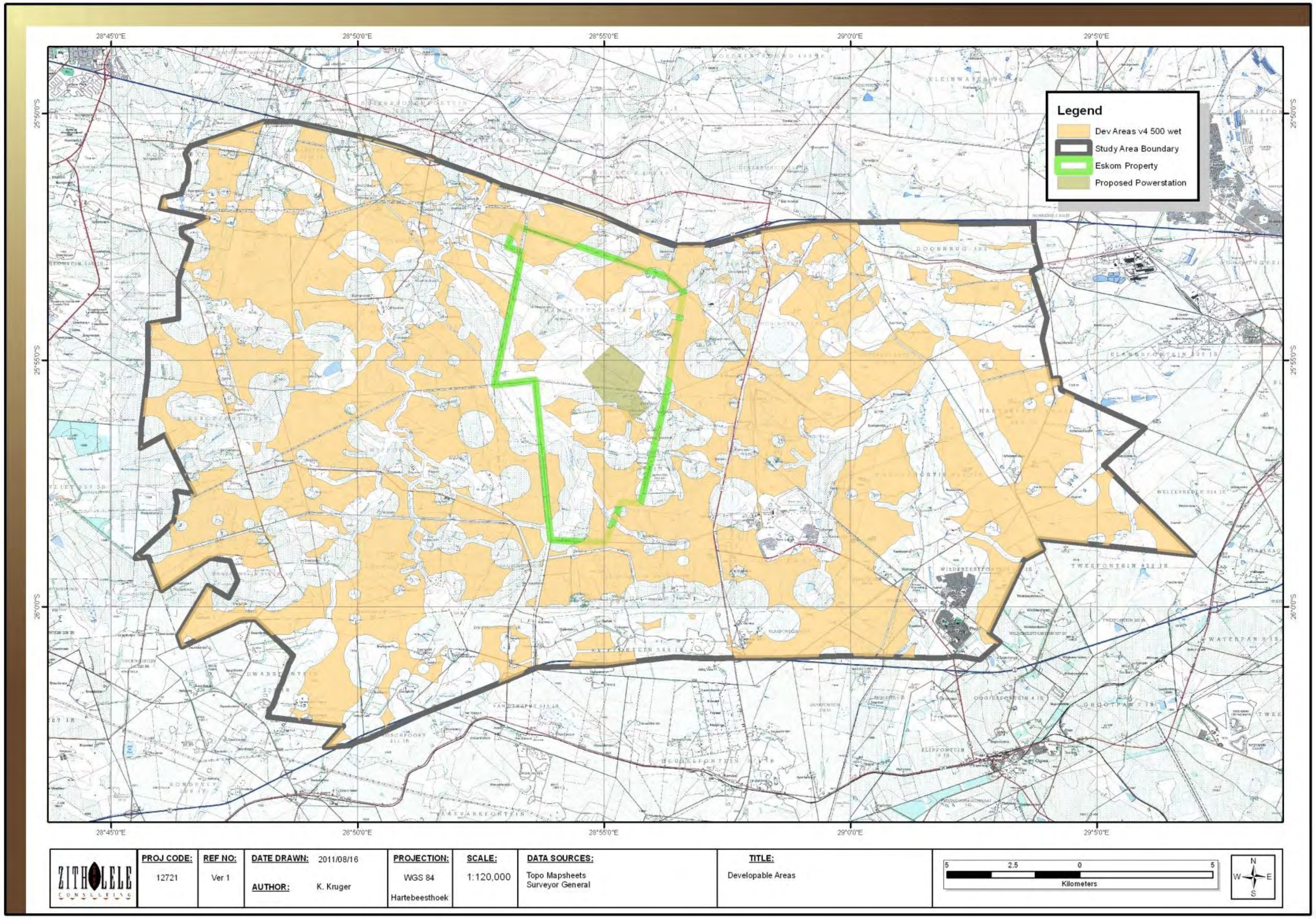


Figure 6: Third Negative Mapping Iteration

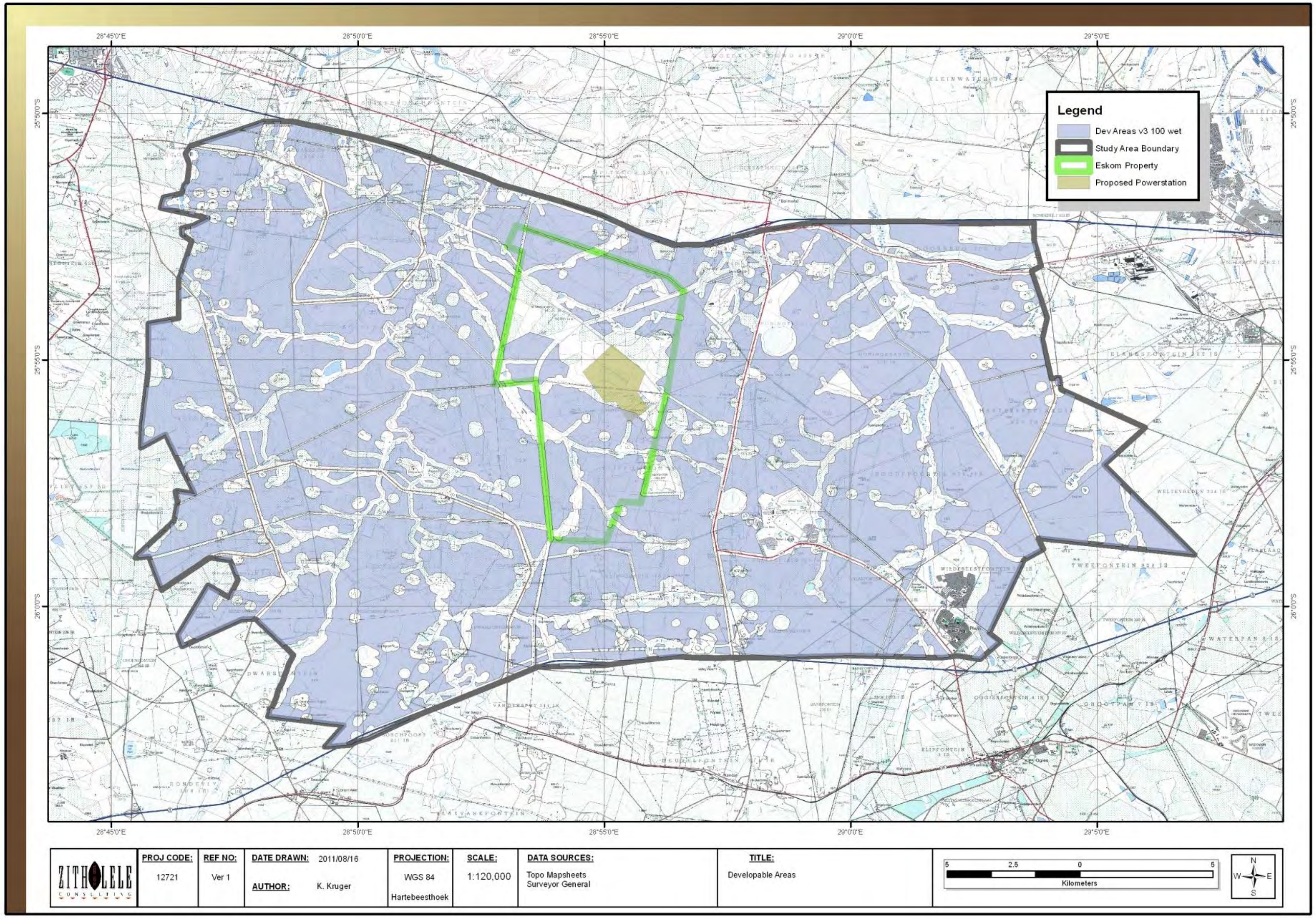


Figure 7: Fourth Negative Mapping Iteration

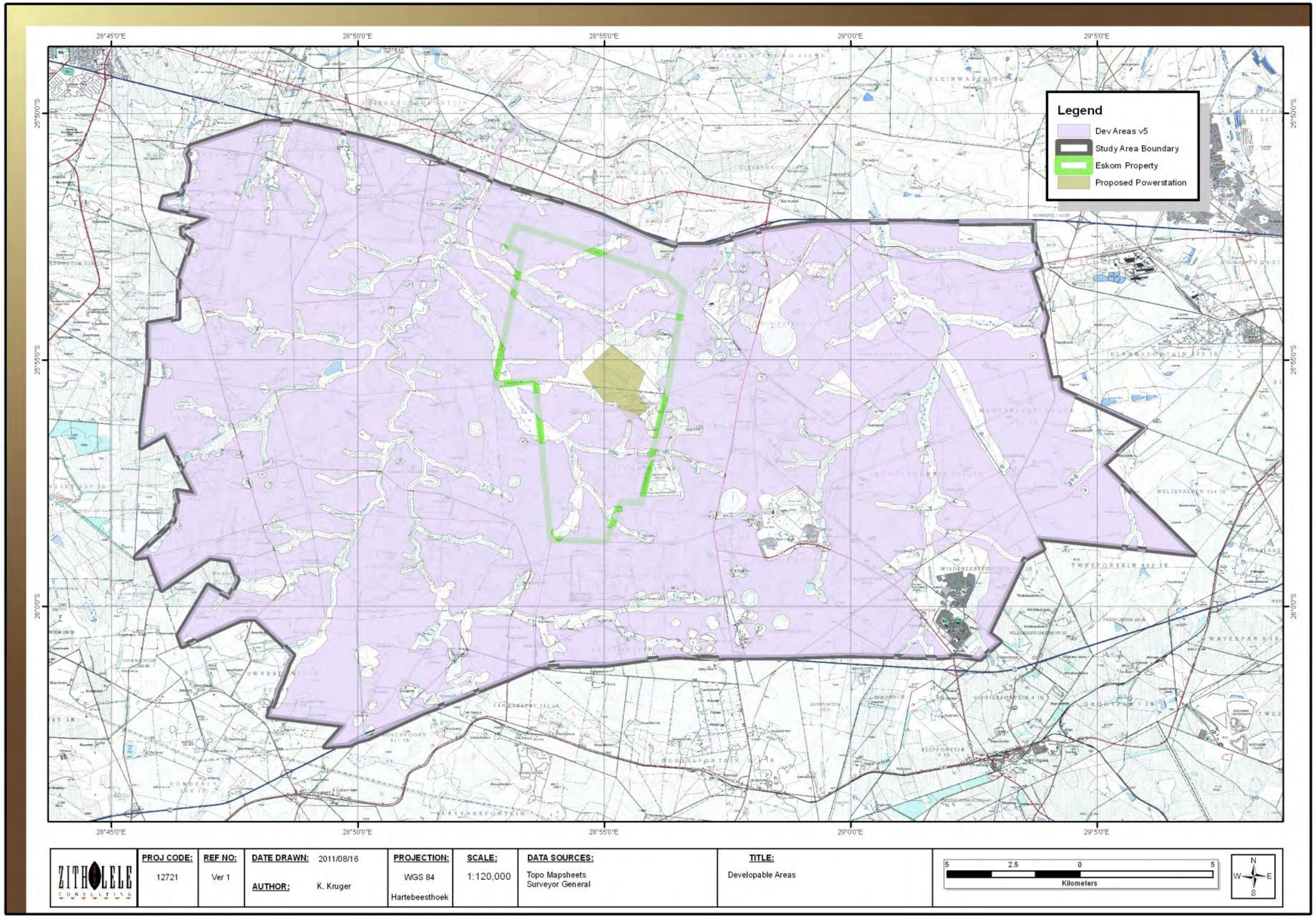
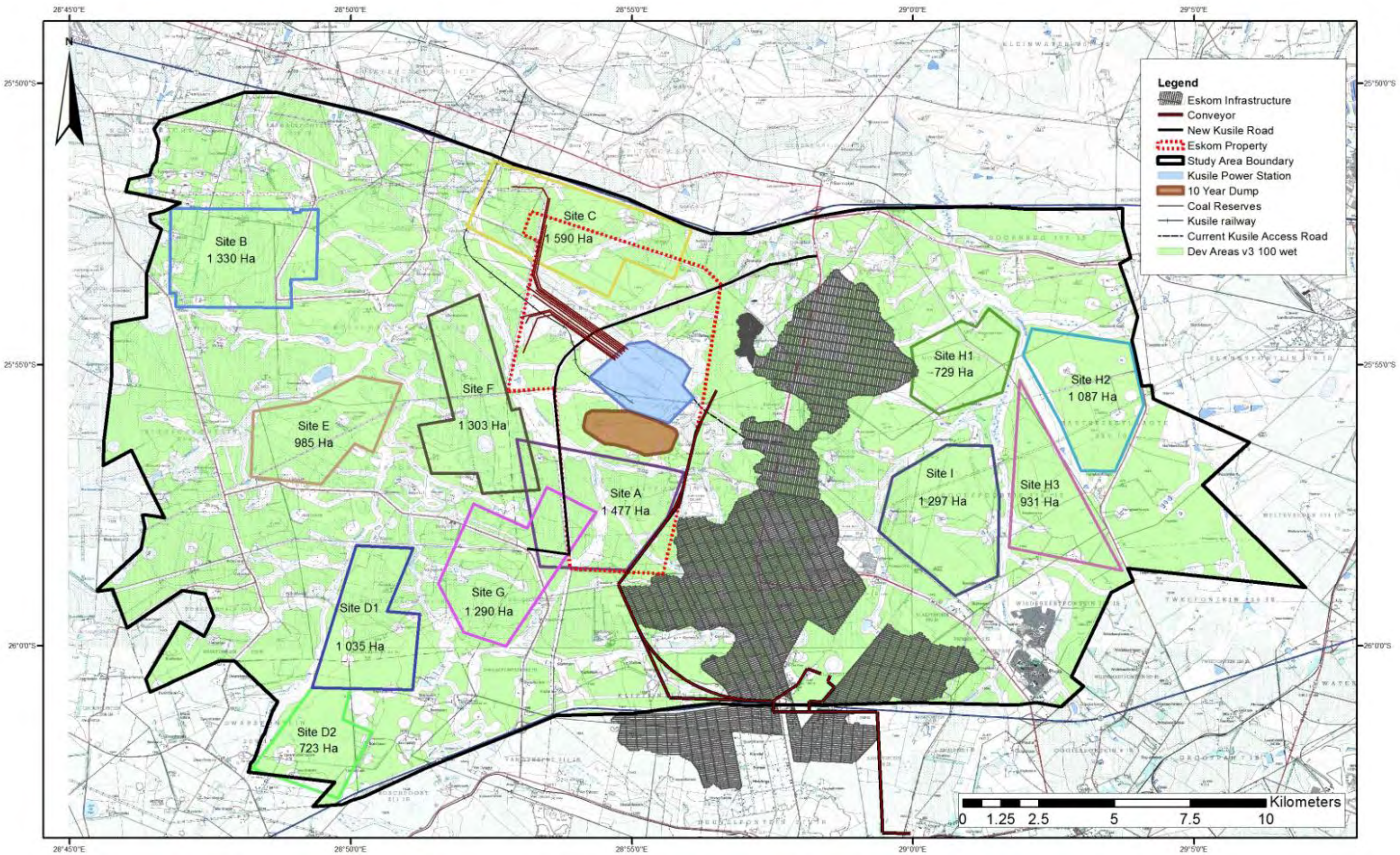


Figure 8: Fifth Negative Mapping Iteration



Jones & Wagener Consulting Civil Engineers	J&W JOB NUMBER: D121	REV NO D	DATE DRAWN: 26/09/2011 AUTHOR: C. Nienaber	PROJECTION WGS 84	Final Developable Areas v3 and proposed site locations

Figure 9: Potential Developable Areas

3.3 Environmental and Social Sensitivity Rating

Once the 13 developable areas were identified each of these were rated according to their environmental and social sensitivity and their technical / geotechnical suitability. This section will give a summary on how these ratings were undertaken.

Environmental Rating

The environmental features on the sites were rated using the following information data sources:

- Mpumalanga Biodiversity Conservation Plan;
  - Fauna;
  - Flora;
  - Soils;
- Department of Water Affairs – National Freshwater Ecosystem Priority Areas (NFEPA) (wetlands and rivers);
- Gauteng Ridges Database; and
- Red data species locations.

The biodiversity conservation plan is a layer that rates the conservation value of any piece of land in the study area, the higher the rating the more sensitive the piece of land. This rating takes into consideration fauna, flora and soils as well as enough space around the features to allow them to be sustainable. In addition to the conservation plan rating the Department of Water Affairs' NFEPA data was used to identify wetlands and rivers of conservation importance. In addition any know red data species locations were seen as a 'no – go' or fatally flawed area and buffered by 100m.

The above features were rated from 0 – 4 with 0 being the most sensitive feature that is seen as irreplaceable and a 'No-Go' area. The resultant overlay map is shown in Figure 10 below. It should be noted were two features of equal score were overlaid e.g. a C-Plan rating of 3 and a wetland rating of 3 – the sensitivity rating of that area were changed to a rating of 2. This way the combination of sensitivities in areas is highlighted.

Social Rating

For the social rating of the sites the starting point was the land use of the area. The higher the density of the land use the higher the sensitivity. Furthermore an aerial photo survey was used to identify all buildings and structures found in the study area and these were rated as very sensitive within 100m of the structure and sensitive up and till 1 000m. Lastly all know heritage features were rated as no-go areas and buffered by 100m.

- Land Use;
  - Grassland (Low - 4)
  - Cultivation / plantations (Moderate – 3)
  - Wetlands, dams, pans, streams (High – 2)

  - Mines and quarries (Very High – 1)
  - Built-up/residential (No-go - 0)
- Farms houses, worker houses (buffered – 100 m – very high / 1000 m high)
- Heritage features (No – go)

The resultant social rating is shown in Figure 11 below.

Combined Environmental and Social Ratings per area

In order to summarise the ratings a table was compiled (Table 4) showing the individual ratings for each area. These were totalled to give an overall rating of the areas. From the table it can be seen that the best rated area (highest score) is Area A with an overall score of 27. Second best is Sites C, G and A+G with a score of 26 followed by B, and then F+G Sites H 1-3 and I have been excluded due to too many sensitive features in the area .

Table 4: Environmental and Social Sensitivity Matrix

Element	A	B	C	D1+2	E	F	A+G	H1-3	I	G	F+G
Wetlands / Rivers	1	4	1	1	1	1	1	0	0	1	1
Biodiversity	2	3	2	2	1	1	3	2	2	4	2
Ridges	4	4	4	4	4	1	4	4	4	4	4
Red Data Species	4	4	4	4	4	4	4	4	4	4	4
Land use	3	3	3	3	3	3	3	3	3	3	3
Homesteads	2	1	1	1	1	1	1	1	1	1	1
Heritage Features	4	4	4	4	4	4	4	4	4	4	4
Zone of Influence (Total Impact of Station and Dump)	3	1	3	2	2	2	2	1	1	1	1
Impact of Associated Structures (Conveyor, Pipelines, Road)	4	1	4	1	1	1	4	1	1	4	3
Total	**27**	**25**	**26**	**22**	**21**	**18**	**26**	**No-go**	**No-go**	**26**	**23**

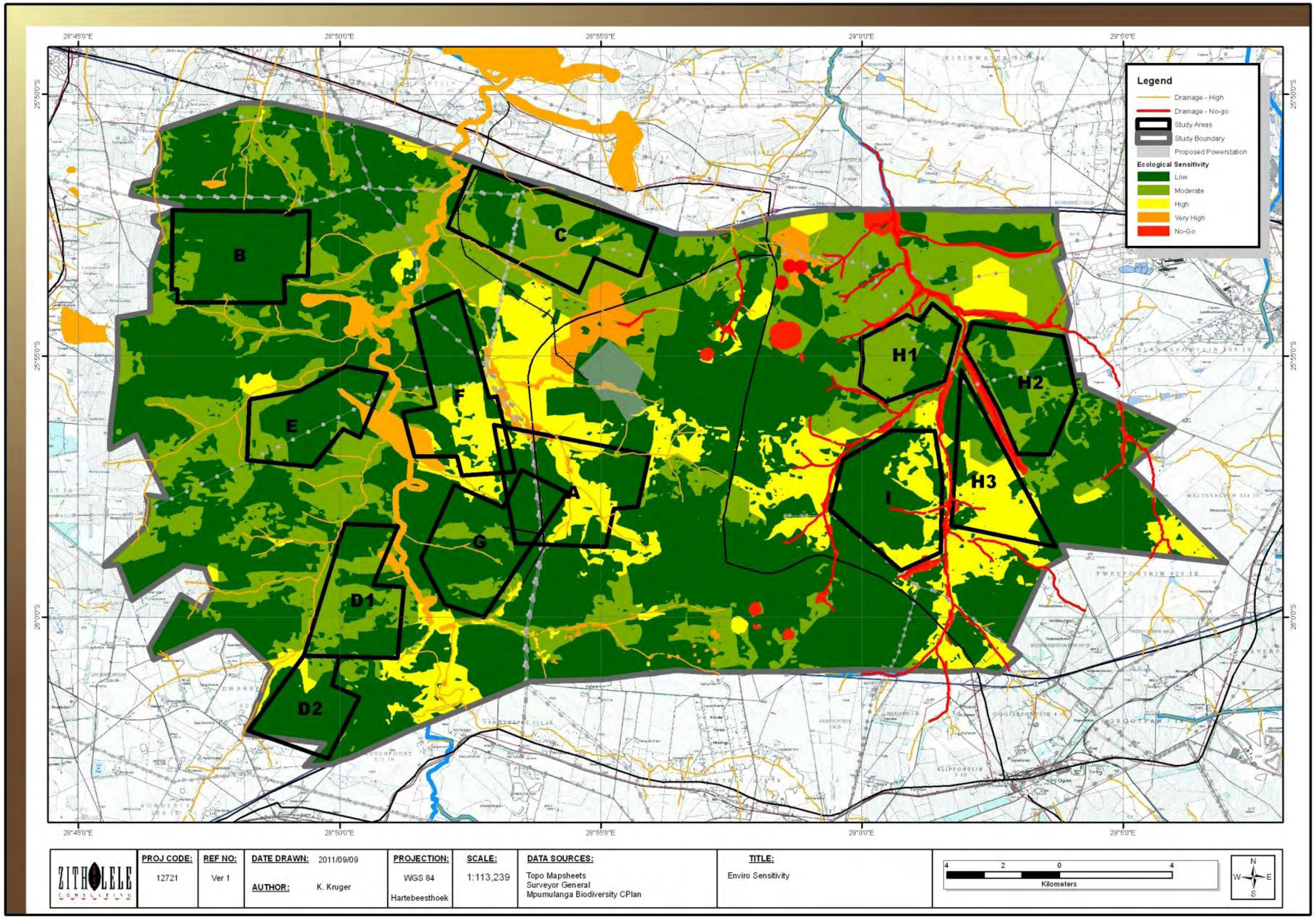


Figure 10: Environmental Sensitivity Rating

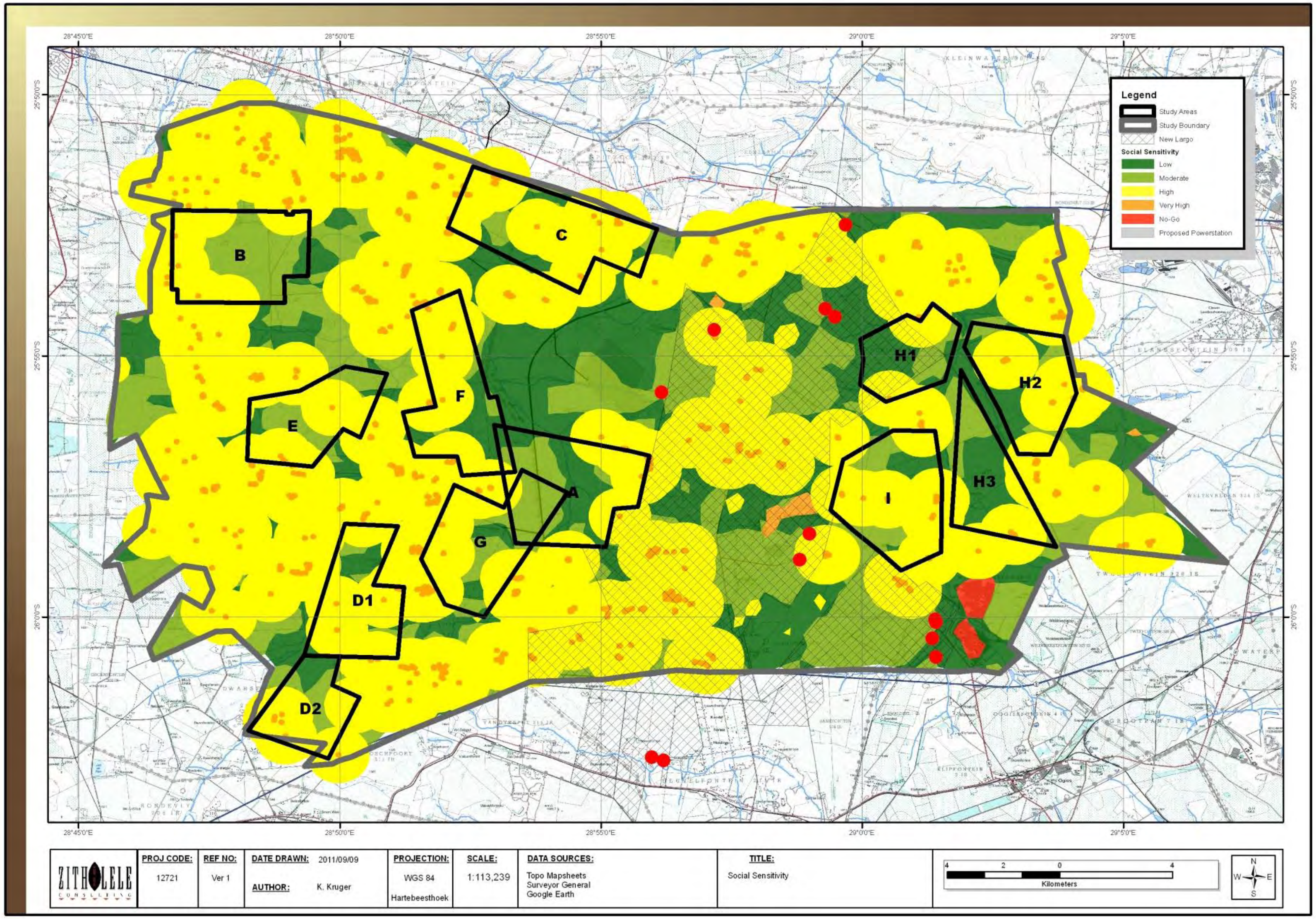


Figure 11: Social Sensitivity Rating

3.4 Technical Suitability Rating

3.4.1 Design Assumptions and Information

In order to rank the site for technical suitability certain design assumptions and information was required. These are described below.

Stacker Philosophy

The initial ash stack will be a truck and haul operation. This is not feasible for the main 60 year stack due to the high placement rate required and excessive costs. Thus the 60 year stack must make use of mechanised stackers.

Due to the underlying geology not offering sufficient strength to support a front stack of more than 15m [Kusile 10 year Ash Dump Stability Report, August 2009], it was assumed that a multi-level stacker setup, similar to the one at Majuba Power Station, would be used.

This setup would allow the initial stacker to place an estimated 15m front stack and 12m back stack, which will consolidate the underlying clay layers, increasing their strength in time to support the second stacker's 21m front stack and 12m back stack as shown in Figure 12.

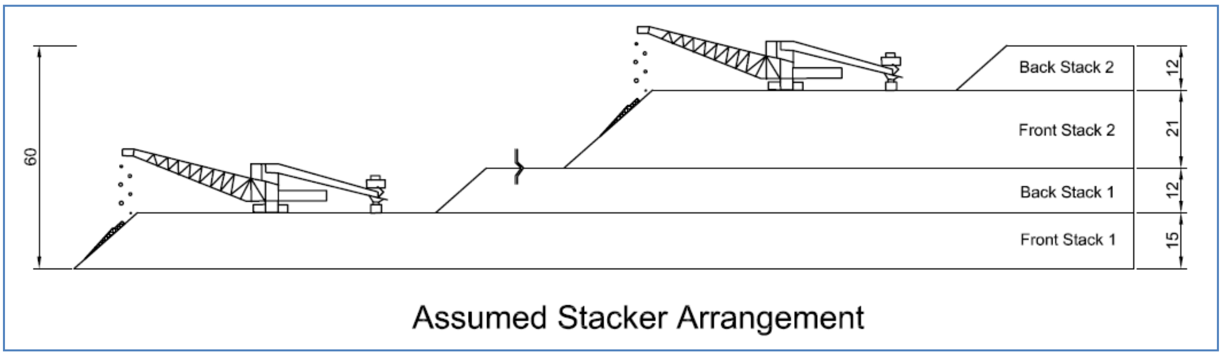
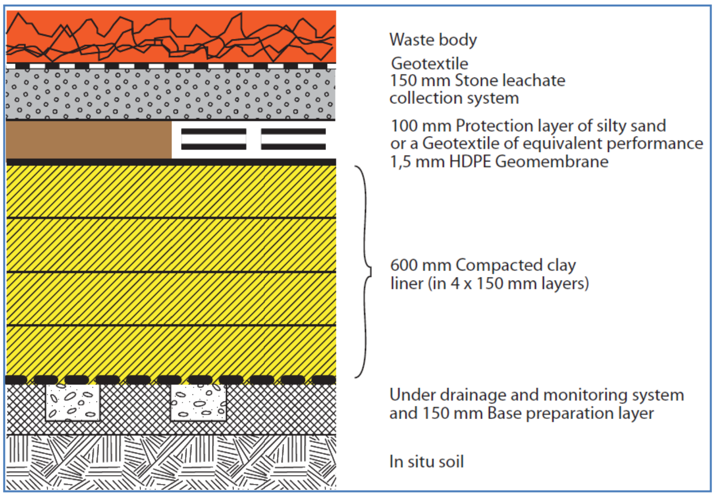


Figure 12: Multi Stacker Philosophy

Ash Classification and Liner Type

A preliminary ash classification was carried out on the same test results that were used for the design of the current ash dump at Kusile [Kusile Detail Design Report, December 2010]. The result was that the ash classified as a Type 2 waste which would result in a Class B liner system which is shown in Figure 13. A detailed ash classification will be carried out as part of the conceptual design of the 60 year ash stack later in the EIA process.



The approximate cost of this Liner Type is R270 / m^2

Figure 13: Class B Liner Type [Government Notice 432 of 2011, Draft Regulations]

Co-disposal of waste

If the ash and gypsum, resulting from the Flue Gas Desulpherisation (FGD) process, is co-disposed, a more stringent liner specification, Class A as shown in Figure 14, will most probably be required due to a more stringent classification process.

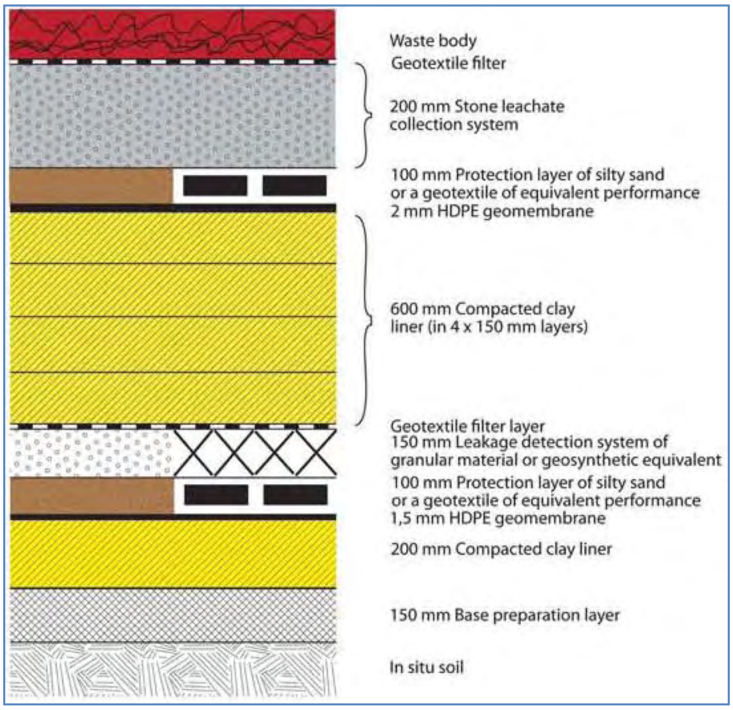


Figure 14: Class A Liner Type [Government Notice 432 of 2011, Draft Regulations]

The approximate cost of the Class A Liner Type is R450/m^2 which is a 66% increase in cost. Therefore this confirms the rationale for the preliminary project criteria whereby it was assumed that only ash will be placed on the 60 year ash stack.

Ash Volumes and Densities

As no further refined data exists, this study made use of the ash production data in the current ash dump stack design as shown in the following table:

Table 5: Tonnages and volumes used in the design of the ash facility

Tonnages per year (tonnes per 6 units per year):	7,095,600
Density (tonnes per m^3):	0.8
Volume per year (m^3 per 6 units per year):	8,869,500
Desired lifespan (years):	60
Desired total volume(m^3 per 6 units per 60 years):	532,170,000

It was calculated that for a 60 year life, an ash volume of 532 Million m^3 would require a stack with a footprint of 1 300 ha and a dump height of 60m. Side Slopes of 1[v]:5[h] were used with an approach slope of 1[v]:20[h].

3.4.2 Technical matrix

Methodology

The following process of selecting the most feasible sites was used:

1. Formulate the list of selection criteria that will form the base of the comparison between the different alternatives.
2. Apply a weighting to each criteria as per the list below:

Table 6: Criteria Weightings

Weighting:	Description:
1	Nice to have
2	Significant
3	Important
5	Technical Priority

3. Score each of the objectives for every alternative using the following scale:

Table 7: Objective Scoring Scale

Score:	Description:
1	Un-acceptable
2	Tolerable

Score:	Description:
3	Acceptable
4	Good site
5	Ideal

4. Sum the scores of all the objectives for each alternative before applying the weighting. This will provide an un-weighted ranking which is the first indication of the preferable sites.
5. Apply the weightings and sum the scores again. This will provide a weighted ranking which is the final indication of the preferable sites.

The Site Selection Criteria

Table 8 provides the list of criteria and their associated description and weighting, followed by the complete decision matrix in Table 9.

Table 8: List of Technical Objectives and associated weightings

No.:	Criteria:	Description:	Weighting:
1	Distance to Powerstation (Conveyor routes)	Capital costs based on a feasible routing.	5
2	Topography	Amount of levelling, excavation and fill required.	2
3	Storage and Expansion potential	Possibility of extension onto facility for power station life longer than 60 years.	1
4	Land ownership	Area owned by Eskom is preferable in terms of project risk.	3
5	Accessibility	Access to site in terms of conveyors and general vehicle access-includes consideration of river, railway and road crossings.	3
6	Capacity of site	Amount of ash to be accommodated on site, life of ash stack and height.	5
7	Storage Efficiency	Efficiency of land usage: Higher dumps with smaller footprints are more economical in terms of liner costs.	3
8	Drainage direction	One way drainage more suitable than two or more directional drainage.	2
9	Slope	Balance between slope stability and drainage.	3
10	Geotechnical	Geology, seepage potential, soil profile and properties, founding conditions, influence of wetlands and material for liner system.	5
11	Cost	Capital costs.	5
12	Cost	Operational costs.	5
13	Direction to Powerstation (wind)	The wind direction is from the North West. It will be undesirable to have ash blowing into the power station and/or built-up areas.	1

No.:	Criteria:	Description:	Weighting:
14	Diversion of natural or major infrastructure	Includes diversion of roads or power lines and streams.	5
15	Operability	Ease of operations	5
16	Rehabilitation	Ease of rehabilitation	5

The Ranking Matrix

Table 9: The Technical Site Selection Matrix

Objective	Weight	A	A(small) +G	B	C	D1+D2	E	F+G	H1	H2	H3	I
1	5	5	4	2	4	2	3	4	3	1	1	1
2	2	1	1	5	4	3	2	3	2	3	3	4
3	1	3	3	3	3	2	3	3	1	1	1	1
4	3	3	3	2	3	2	2	2	2	2	2	2
5	3	5	4	1	4	2	3	4	2	2	1	1
6	5	4	5	5	4	4	3	5	2	3	3	3
7	3	4	4	5	4	3	2	3	3	5	3	4
8	2	5	4	2	5	4	2	3	3	4	3	3
9	3	3	3	5	2	3	1	1	1	4	2	4
10	5	4	4	5	1	1	3	4	3	1	1	2
11	5	5	4	4	4	2	2	3	1	3	2	4
12	5	5	5	2	3	2	2	3	2	1	1	2
13	1	4	4	5	2	4	4	2	3	3	2	2
14	5	1	2	4	2	5	3	1	2	2	2	3
15	5	5	3	5	4	3	3	2	1	1	1	3
16	5	5	3	5	4	3	3	2	1	1	1	3
Score Un-weighted		**62**	**56**	**60**	**53**	**45**	**41**	**45**	**32**	**37**	**29**	**42**
Rank Un –weighted		**1**	**3**	**2**	**4**	**6**	**8**	**5**	**10**	**9**	**11**	**7**
Score Weighted		**234**	**209**	**221**	**192**	**161**	**149**	**167**	**113**	**125**	**99**	**155**
Rank Weighted		**1**	**3**	**2**	**4**	**6**	**8**	**5**	**10**	**9**	**11**	**7**

Table 10 summarises the results of the site selection matrix and provides some positive and negative aspects of each of the top five sites:

Table 10: Matrix results: Top five objectives

Ranking	Site	Notes
1	**A**	Site A is the closest to the power station (~1km), therefore it is less costly in terms of capital costs and operations and is very accessible. Its terrain is very undulating and includes two valleys, therefore large earthworks are expected. The site has good drainage potential as one way drainage occurs. If the full area is used, large infrastructure and river diversion works are needed; however, a second smaller alternative can be sited here within most of the existing constraints. Environmentally Site A is located in an area that is bisected by two streams. The placement of the ash facility in this area will result in the deviation of one of at least these streams. Socially the site is relatively uninhabited and no major relocations of people are expected.
2	**B**	Site B is one of the furthest from the station (~10 km). The terrain is less undulating than other sites and is the most suitable in terms of geology and slope stability. The shape of the dump lends itself to easier operations and rehabilitation. Environmentally Site B is the most suitable site. There are no streams on site and the site also avoids all the desktop sensitivities. It should however be noted that in order to utilise Site B the conveyor and pipeline route will cross over various sensitivities including the Wilge River, it associated wetlands as well as areas of relatively sensitive biodiversity. Socially Site B has several small holdings on the periphery of the site and relocations will be expected. Also as above the conveyor and pipeline route traverses through a populated area that could require further relocations.
3	**A small** **+** **G**	A smaller Site A does not need the costly deviations and the largest river diversion is also not required. Site G is also relatively close (~4km) to the power station and is therefore quite accessible. However, the terrain is very undulating. Environmentally the combination of Site A and G will impact on at least two streams. The reshaped Site A does avoid the larger stream in that area, but these impacts cannot be avoided. Site G is located in an area of relatively low biodiversity sensitivity. Socially Site G has a couple of potential landowners that will have to be relocated as part of the project.

4	**C**	Site C is relatively close (~ 2km) to the power station and the terrain is very suitable for drainage. However, it is a poor site in terms of geotechnical conditions. Environmentally Site C is located in an area with relatively low biodiversity sensitivity, however a small stream bisect the site and some small but sensitive wetlands occur along the stream. Socially this site is recently been identified and used for the relocation of people previously displaced by the power station construction activities. Several relocations will have to take place, including people that have previously been relocated to this area.
5	**F + G**	Site F is relatively close to the powerstation and access is relatively easy. However, the geometrical shape of Site F may lead to operability difficulties. Site G is also relatively close to the power station and is therefore quite accessible. However, the terrain is very undulating. Environmentally the combination of Site F and G will impact on at least one stream. Site G is located in an area of relatively low environmental sensitivity. The environmental sensitivity within Site F ranges from low to high with a more or less even distribution. Further to this a small section of site F is located over a sensitive ridge area. Socially Site G has a couple of potential landowners that will have to be relocated as part of the project. Site F ranges from low to high from a social perspective.

3.4.3 Modelled ash stacks

A digital terrain model was created on all areas that were not identified as having a fatal flaw from the environmental screening assessment. Detailed models of practical stacking systems were sited on areas A through to G to allow the initial assumptions regarding the storage volumes to be verified, as well as determining the appropriate footprint area. Two options for Site A were drawn up, the first makes full use of the site, but this then requires extensive river and infrastructure diversions. The second utilises a smaller footprint, but has less environmental and infrastructure impacts. The models are shown in Figure 7. The following table is a summary of the model information:

Table 11: Model Information

Area:	Max Height from NGL: (m)	Volume (Million m^3)	Footprint Area (ha):	Life (Years):	Conveyor Shift Type:
A	95	525	1 010	59	Parallel Shifts
A(small)	85	260	570	29	Parallel Shifts
B	75	514	1 120	58	Parallel Shifts
C	95	511	1 060	58	Parallel Shifts
D_1+D_2	69	506	1 300	57	Parallel Shifts
E	60	264	634	30	Parallel Shifts
F	80	271	705	31	Parallel Shifts
G	85	271	618	31	Radial Shifts

Site G does not meet the life span requirement of 60 years and therefore should only be carried forward to the EIA as an extension / combination of a small facility on Site A. Similarly, sites E and F also are not suited to single stacks, but may form part of a multi-site arrangement if needs be, for example Site F & G. It should be noted that all models were done on Google Earth accuracy level contours (+/- 5m accuracy), so the storage volumes and lifespans are estimated to be accurate to about 5-8% relative to an exact ground survey.

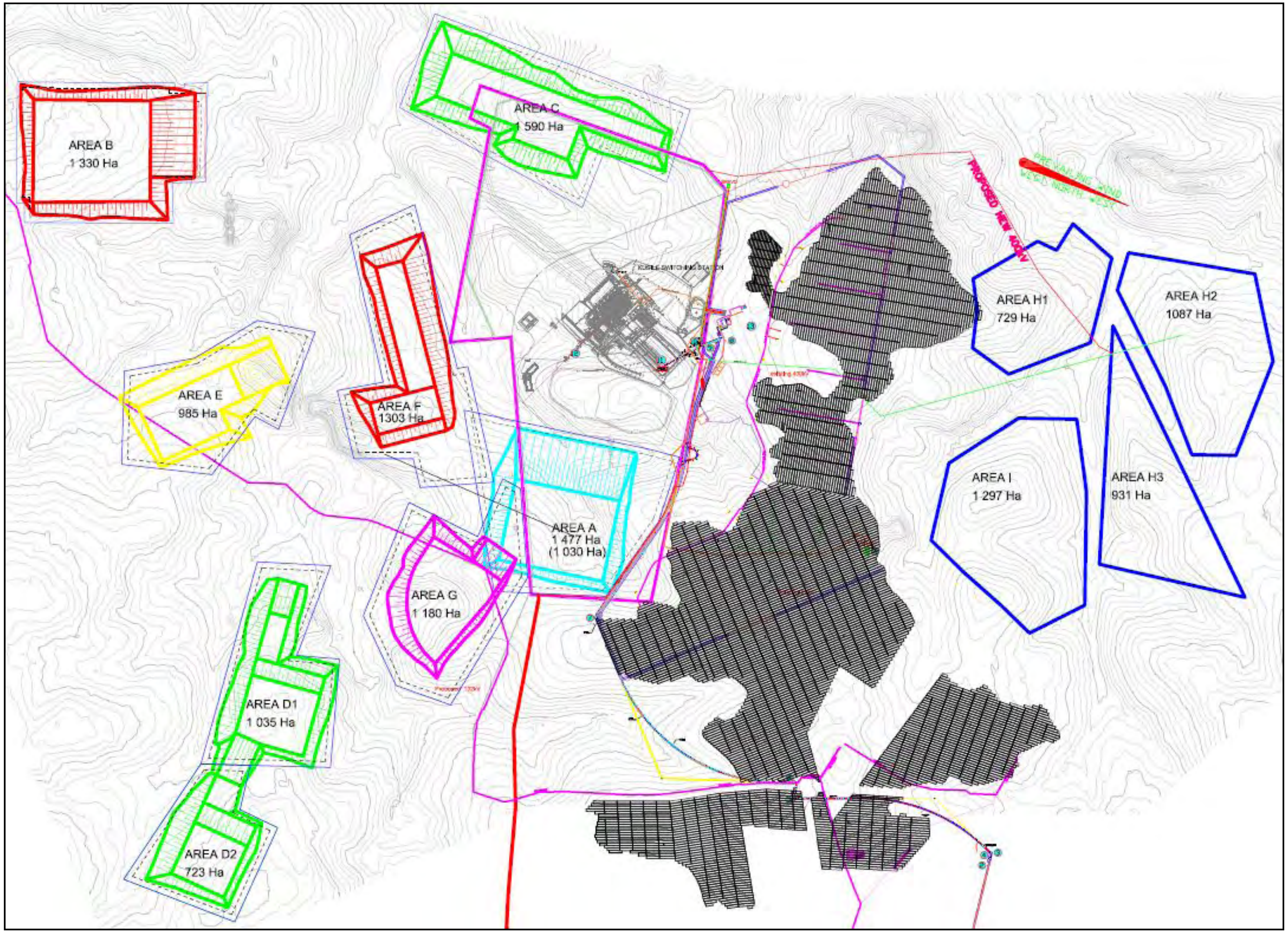


Figure 15: Models of sites west of power station. The model on Site A is designed to maximise storage capacity, therefore local infrastructure such as roads, pipelines and power lines will need to be deviated

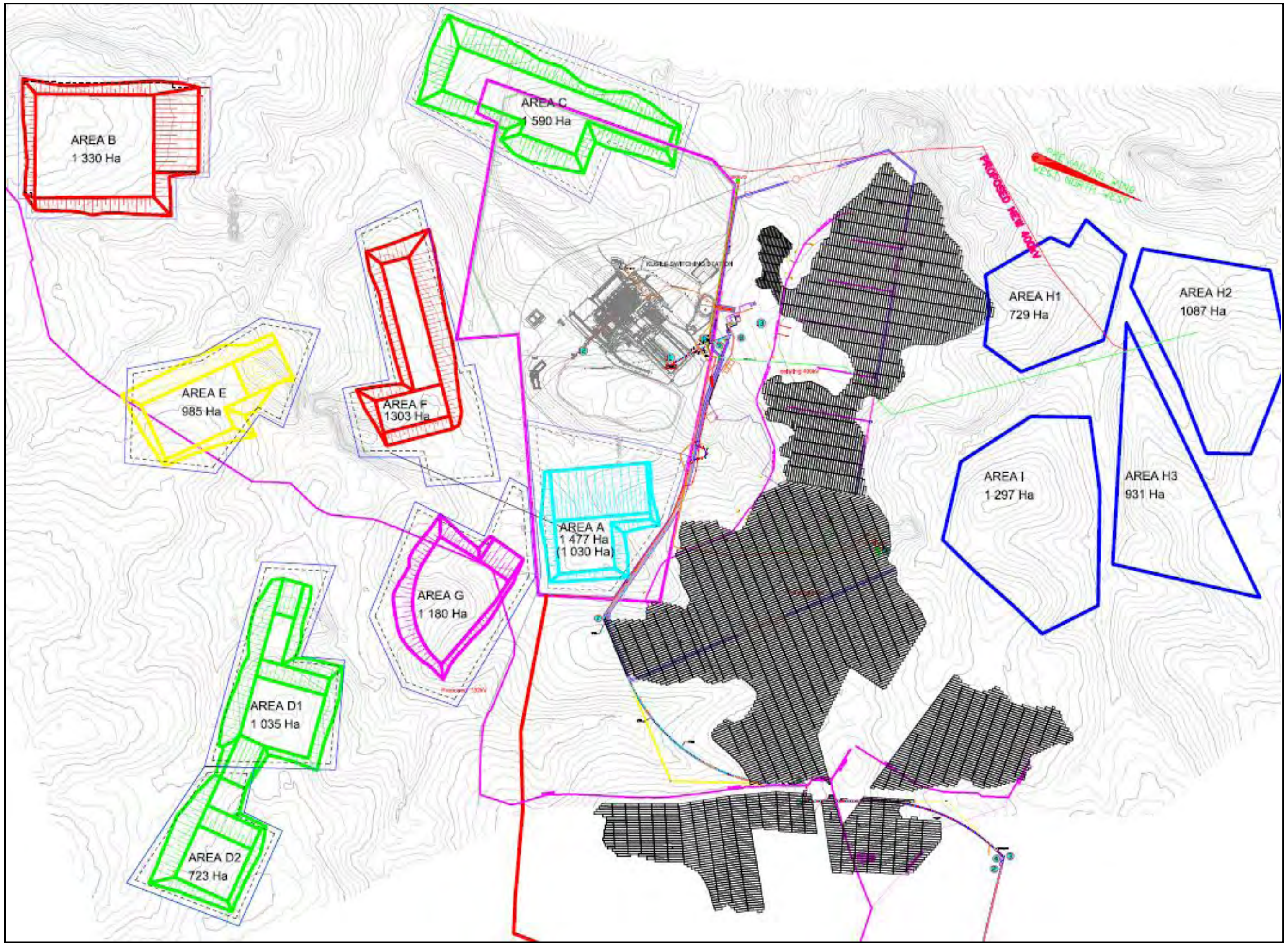


Figure 16: In this figure, a smaller model is designed on Site A to that take into account local infrastructure such as roads, pipelines and power lines as well as the river between Site A and the initial dump.

4 LIFE-CYCLE COSTING

The two components of a life cycle costing comparison of the sites, namely capital costs and operational costs are included in the assessment matrix. Having a separate entry for life-cycle costs would then be allocating a higher weighting to this priority. However, to gain an understanding as to the total magnitude of costing and the relative split between costs of an operational nature and once-off capital costs, the following table is of assistance. The table entries have not been discounted to a Net Present Value and reflect the sum total of the snapshot costings in 2011 values. They also exclude the mechanical cost of the stacking equipment; this would be essentially the same for all options.

Table 12: Top five score with respect to Life Cycle Costing (nominal 60 year life)

Site	A	A_{small}+G	B	C	F+G
Total Capex of stack & conveyors(in Million Rand)	4 900	5 500	5 480	5 110	5 930
Total Opex costs of conveyors(in Million Rands)	820	1 300	3 900	1 530	2 000
Total Costs (in Million Rands)	**5 720**	**6 800**	**9 380**	**6 640**	**7 930**
Unitised to annual costs (in Million rands per annum)	96.7	113.3*	161.7	115*	130
Unitised to cost/m^3 ash storage	R10.90 /m^3	R 12.79 /m^3	R18.24 /m^3	R12.99 /m^3	R14.66 /m^3
Percentage difference from Lowest	0	+17%	+67%	+19%	+34%

*Rounding errors in these options lifespans reflect in arithmetical anomalies, the cost per cubic metre values are a better comparison

As a comparison, Sites D1+D2, E and F have a unit cost of storage of R19.55; R18.45 and R14.61 per cubic metre of ash respectively.

A Net Present Value lifecycle costing was also undertaken at a very broad brush level, at a net project discount rate of 10 %. It was determined that the NPV project value was influenced by upfront access costs, and operational and actual ash stack footprint development costs to a lesser degree. These access costs include costs associated with stream diversions, infrastructure relocations and conveyor construction costs; i.e. all costs that are incurred before a site can accept the ash. This exercise indicated that the smaller Site A and G combination is the most efficient use of capital, as less money is committed up front in order to prepare the site for ashing. The economics of Sites B and C were relatively unchanged by this, as tabulated below.

Table 13: Top five score with respect to Life Cycle Costing by NPV methodology

Site	A	A_{small}+G	B	C	F+G
Total Capex of stack & conveyors(in Million Rand)	4 900	5 500	5 480	5 110	5 930
Total Opex costs of conveyors(in Million Rands)	820	1 300	3 900	1 530	2 000
Total Costs (in Million Rands)	**5 720**	**6 800**	**9 380**	**6 640**	**7 930**
Unitised to annual costs (in Million rands per annum)	96.7	113.3*	161.7	115*	130
Unitised to cost/m^3 ash storage	R10.90 /m^3	R 12.79 /m^3	R18.24 /m^3	R12.99 /m^3	R14.66 /m^3
Percentage difference from Lowest	0	+17%	+67%	+19%	+34%

5 COMBINED RATING OF TECHNICAL, ENVIRONMENTAL, AND SOCIAL CRITERIA

The totals calculated for the Environmental and Social elements, as per table 4 (Environmental & Social Sensitivity Matrix) were added to the weighted Technical totals as per table 9 (Technical Site Selection Matrix), in order to get a combined rating of all elements used as part of the selection criteria. (Table 14)

From the table it can be seen that that the best rated area (highest score) is Area A with a combined score of 261. Second best is Area B with as score of 246, third best Area is A+G with a score of 235 followed by Area C with 218. Area F+G have a combined score of 190, followed by D1+2 and then E. Area H1 -3 and I have been excluded due to too many sensitive features in the area.

Table 14: Top five Combined environmental, social and technical ratings

Element	A	B	C	D1+2	E	F	A+G	H1-3	I	G	F+G
Technical (weighted)	234	221	192	160	149		209	99	155		167
Environmental	18	17	18	14	13	10	18	12	12	18	15
Social	9	8	8	8	8	8	8	8	8	8	8
Combined Rating	261	246	218	182	170	18	235	No-go	No-go	26	190

6 DISCUSSION OF RESULTS

When considering the results of the technical suitability scoring and the environmental and social sensitivity scoring the following sites show promise (in no order of preference):

Table 15: Results of technical and environmental results of the top 5 sites

Site	Comments
Site A	Site A is located just south of the power station and within close proximity of the existing ash dump.
Site B	Site B is located west of the power station with minimal sensitivities and topographical constraints.
Site C	Site C is located to the north of the power station with some geotechnical and environmental constraints.
Site A remodelled in combination with G	Site G is too small to be a site on its own and can only be considered in combination with an optimized and reshaped Site A.
Site F remodelled in combination with Site G	Both these sites do not fill the lifespan requirement of 60 years, it is recommended that they be taken forward to the EIA as a possible combination of smaller stacks, either together or in combination with Site A. This can be either as a set of two 30 year facilities, or three 20 year facilities on reduced footprints. The latter option is not desirable from an operational perspective, but should not be excluded until the specialist studies are complete.

The rest of the sites are not considered suitable due to the following main reasons:

- Site D1+2 – Geotechnical constraints;
- Site E – Size constraints;
- Site F (not in conjunction with Site G / A) – Size constraint, ridge, environmental sensitivity and geotechnical constraints;
- Site H1-3 – Geotechnical constraints and sensitive wetlands; and
- Site I - Geotechnical constraints and sensitive wetlands.

It is the suggestion of this report that Sites A, B, C ,A+G and F+G combined be taken forward to the Scoping and EIR phase of this project.

7 WAY FORWARD

In conclusion the following steps are required to move forward on:

1.) Distribute this document for review and comment;
2.) Incorporate the comments and prepare presentation;
3.) Present the final reviewed Site Selection Report to Eskom Senior Management;
4.) Incorporate comments and results;
5.) Once final Site Selection Report is approved by Eskom Management include in the Scoping Report; and
6.) Undertake EIA and associated specialist studies on the proposed sites.