PROPOSED CONSTRUCTION OF THE LEEUWBERG WIND ENERGY FARM NEAR LOERIESFONTEIN, NORTHERN CAPE

PRELIMINARY ENGINEERING SERVICES REPORT

JANUARY 2017

Prepared for:
South Africa Mainstream Renewable Power
4th floor, Mariendahl House
Newlands on Main
Corner Main & Campground Roads
Claremont
7708
021 671 5665

Prepared by:
SMEC South Africa
65 Riebeek street
Cape Town
8001

021 417 2900

Report Title:	Leeuwberg Farm Preliminary Engineering Services Report
Project Name:	Mainstream Preliminary Engineering Service Study
Project Number:	C1643
Report for:	Ms Mercia Grimbeek

REVISIONS

Revision #	Date	Change Overview	Prepared by	Reviewed by
1	Nov 2016	Draft Issue	Glen Randall	Cobus Hendriksz
2	Jan 2017	Final Issue	Glen Randall	Cobus Hendriksz
3	Oct 2017	Revised Issue	Shameez Papathanasiou	Cobus Hendriksz

ISSUE REGISTER

Distribution List	Date Issued	Number of Copies
SMEC staff:		
Associates:		
Office Library (SMEC office location):		
SMEC Project File:		

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

AL – Abnormal Loads

CSW – Continuous Surface Wave

DWA – Department of Water Affairs

Ha – Hectares

HGV's – Heavy Goods Vehicles

LWEF – Leeuwberg Wind Energy Farm

MW – Mega Watts

Ml – Mega Litre

O&M – Operation and Maintenance Phase

OHLs – Overhead Lines

1. TRANSPORTATION STUDY

This Chapter provides a summary of a separate report entitled "Leeuwberg Farm Preliminary Transportation Study" which attempts to address all transport related issues. Both the abnormal and legal vehicles were reviewed in terms of their type of activity; i.e. construction traffic, traffic associated with the transportation of the wind turbine components, or traffic associated with the transportation of materials, equipment and people. The key issues associated with the construction and operational phases of the project that will be assessed as part of the transport study are:

- Increase in traffic generation throughout the lifetime of the project;
- Increase in road maintenance required; and
- Ability to transport wind turbine components to site safely and efficiently.

1.1 Assumptions

The assessment has been based on the traffic information available at this stage of the project. Information was sourced from the Department of Transport for the Northern Cape. In order to predict the likely staffing requirements the nearby Loeriesfontein 2 and Khobab wind farms were used as a guidance, although it is accepted that these values could vary substantially and are project specific. Caution is therefore advised when quoting the staff numbers.

1.2 Existing Traffic Conditions

Table 1.1 below shows a summary of the roads and road segments affected by the LWEF project. The information has been sourced from the Western Cape and Northern Cape Department of Transport to establish the exact kilometre markers.

Table 1.1 – Road Segments Affected by LWEF

Road Segment	Segment Name	Chainage Start	Chainage End	Distance (km)
Atlantis to R358				
R304	Dr1134	Km1	Km0	1
N7	Segment 1	Km36 (Atlantis)	Km52 (Malmesbury)	16
	Segment 2	Km0 (Malmesbury)	Km34 (Moorreesburg)	34
	Segment 3	Km0 (Moorreesburg)	Km31 (Piketberg)	31
R366	MR023/MR531	Km0 (Piketberg)	Km38	38
R365	MR538	Km86	Km0	86
R364	TR5501	Km61	Km0	61
N7	Segment 5	Km0	Km75 (Vanrhynsdorp)	75
	Segment 6	Km0	Km83 (Bitterfontein)	83
	Segment 7	Km0	Km4 (R358 intersection)	4
			Total	429

Road Segment	Segment Name	Chainage Start	Chainage End	Distance (km)
R358 to P2948				
R358	MR736	Km0	Km61 (R355 intersection)	61
	MR736	Km61	Km105 (P2948 intersection)	44

			Total	105
P2948 to LWEF Boundary				
P2948		Km0	Km29	29
Private Access Road		Km0	Km12 (LWEF Boundary)	12
			Total	41
Loerisfontein to R358				
	R355	Km0 (Loerisfontein)	Km84 (R358 intersection)	84

Table 1.2 shows that the Average Daily Traffic (ADT) for the N7 between Vanrhynsdorp and Nuwerus is in the order of 1100 vehicles of which the Average Daily Truck Traffic (ADTT) consist of 300 vehicles. The N7 is only one lane in each direction and is capable of carrying 2000vph. It is furthermore reasonable to assume that this portion of the N7 carries significantly lower volumes of traffic than elsewhere along its length. SMEC are still awaiting additional traffic data from the provincial DoT.

Table 1.2 – Existing Traffic Volumes (2013)

Historic Traffic Trip Generation of N7 (2013)	
Section	Between Vanrhynsdorp and Nuwerus
Average Daily Traffic (ADT)	1038 vehicles
Average Daily Truck Traffic (ADTT)	290 vehicles (27.9% of total)

1.3 Traffic Generation

The traffic generation estimates detailed below have been determined based on a single project.

1.3.1 Construction Phase

These vehicle trips occur during the construction phase and include the transport of materials, equipment and people to site. This phase also includes the civil works required for the construction of the internal roads themselves, the excavations of the footings, and trenching for electrical cables. The delivery of the wind turbine components and lifting cranes would require abnormal vehicles that require access to site via the public road network. The construction traffic typically generates the highest number of vehicular trips.

In order to calculate the amount of traffic generated for this element of works, certain assumptions were made regarding staff and staff travel behaviour. It is estimated that a total of 127 full time employees are required during the construction of the LWEF project. Not all personnel will be required at once since the project will be constructed in phases. It is also assumed that the majority of employees would reside in Loeriesfontein.

Based on this it can be assumed that approximately 40 vehicular trips will be generated during the peak hours of 07:00 – 08:00 and 16:00 – 17:00. The details used to calculate the total labour during the construction of the project is shown in **Table 1.3** below.

Table 1.3 - Assumed Labour Requirements

Construction Phase	Technical Staff	Skilled Labour	Unskilled Labour	TOTAL
Road Construction	3	8	5	16
Foundation Construction	3	15	20	38
Electrical System Construction	2	10	10	22

Substation Construction	2	10	5	17
Wind Turbine Assembly and Installation	4	10	15	34
TOTALS	**14**	**58**	**55**	**127**
Vehicle Trips/Day	**14**	**15**	**14**	**43**

Table 1.4 below shows an assumption made to envisage the number of daily traffic generated by the transportation of materials, equipment and people. It was also assumed that the material required for construction will be obtained from suppliers off-site.

Table 1.4 – Estimated Trip Generation

Activity		Assumptions	Trips/ day
People	Technical and Non-technical Staff	See Table 2.2 above	43
Foundation	Concrete	3675 Bags of 50kg cement required per concrete foundation. One truck capable of carrying 680 bags of cement. Equates to 5 trucks per foundation.	5
	Stone	239m³ required per foundation. One truck capable of carrying 20tonnes of stone. Equates to 12 trucks per foundation.	12
	Sand	239m³ required per foundation. One truck capable of carrying 20tonnes of sand. Equates to 12 trucks per foundation.	12
	Steel	306 tonnes of steel required per foundation based on the assumption that 130kg of concrete requires 100kg of steel to support it. Assuming one truck is capable of carrying 20tonnes per trip, this equates to 15 trucks per foundation construction.	15
Road	Internal Roads	It is assumed that 1.2km of natural gravel roads will be constructed every week in 150mm layers at 0.2km/day using tipper trucks at 10m³/truck to import material.	10
Foundation and Road	Water	Based on preliminary water use calculation discussed further on in this report it is assumed that the following number of 32 000 litre water trucks will be required per day.	8
Electrical	Substations, cables, overhead cables and transmission poles	200 transmission poles (30 poles/week) using an interlink truck	1
		Trucks for carting electrical equipment using an interlink truck.	1
Total Light Motor Vehicles			43
Total Heavy Motor Vehicles			64
TOTAL DAILY TRAFFIC			**107**

Note: Excludes abnormal vehicle trips

From **Table 1.4** it can be seen that the total daily traffic generated by the transport of people, materials and equipment is estimated at approximately 107 vehicles per day (60% being HGV's). It is estimated that the number of heavy vehicles trips, per 235MW Project, during the construction phase would be between 3000 and 4000. These trips would be made over an estimated period of 9 to 12 months.

It has been assumed that the workforce (or a portion thereof) will be based at the construction camp, located some 40km from site. Construction is expected to take place during normal daily working hours (starting 07:00 - 08:00 and ending 17:00 – 18:00) and the workers are expected to arrive from the construction camp over a one hour period in the morning and depart over a one hour period in the afternoon. Assuming a traffic management plan is in place the HGV vehicles are likely to be distributed throughout the day. The HGV vehicle trips have also been excluded from the peak hours as these vehicles would not be allowed on-site prior to the workforce arriving.

Should a dedicated bus system be implemented, the 127 peak hour person trips can be converted to vehicle trips using the bus occupancy rate of 40, which equates to 3 bus round trips per hour. More specific requirements will be determined at the feasibility stage. From a land-use/transportation planning point of view, a bus system would be the preferred method.

The windfarm construction will also require the transportation of large volumes of construction material to site on an ongoing basis throughout the construction period as shown in **Table 1.4**. The approximate daily mass of the material to be transported onto site, as well as the type(s) of vehicle to be used for this purpose, will inform the type of road required to withstand the wear.

In addition to the normal daily demand for construction materials that can be transported using normal heavy construction vehicles, there will also be several abnormally large consignments to be transported by road to the LWEF site. In order to safely accommodate abnormally large vehicles and their loads, the future road intersections between the harbour and site should be designed accordingly.

If there are existing intersections that limit the size of construction vehicles, new routes should be planned or the consignments could be transported in smaller portions and assembled on-site.

As detailed information regarding the construction material and labour requirement becomes available, this transportation component will be analysed in sufficient detail at feasibility level to inform the infrastructure requirements.

In summary, the additional traffic generated during the construction phase will have a low negative impact.

Traffic Generation for the Delivery of the Wind Turbine Components

Table 3.2 below shows the estimated daily traffic that can occur during the delivery of the wind turbine components to site. The calculations are based on the delivery of six complete turbines per week.

Table 3.2- Traffic Generation Rates for the Delivery of Wind Turbine Components

GENERATED TRAFFIC FOR THE DELIVERING OF THE WIND TURBINE COMPONENTS				
Activity	**Assumptions**	**Trips/ Week***	**No. Used**	**Trips /Day**
Turbine Components	3xTower sections per turbine =1 Tower/truck (AV)	18	3	3
	1xNacelle (hub) per turbine = 1 Nacelle/truck (AV)	6	1	1
	3xBlades per turbine= 1 Blade per truck (AV)	18	3	3
Estimated Abnormal Truck per day				**7**

From *Table 3.2* it can be seen that 7 Abnormal Vehicles (AV) will be required for the delivery of one complete wind turbine.

In addition to the construction vehicles, each wind turbine will require at least 9 abnormal loads to transport the individual components. These components consist of 3 Blades, 5 Towers and 1

Nacelle. Since each Project proposes 47 turbines the total number abnormal loads anticipated for LWEF project is estimated to be 423 abnormal vehicles per Project (1692 trips for all four projects). In addition to the wind turbines, some electrical equipment such as the Padmount transformers, Main Transformer and OHL pole segments will also generate abnormal loads. This equipment is estimated to generate approximately 50 additional abnormal loads.

1.3.2 Operational and Maintenance Phase:

This phase involves the operation and maintenance of the LWEF estimated over a 20 year period. Typically the replacement of one of the wind turbine components would require access for cranes and replacement parts delivered using abnormal vehicles, both of whom would arrive to site via the public road network. In terms of vehicle generation this phase generates the least traffic.

It is assumed that a maximum of 10 permanent employees' will be employed per phase to oversee the operation and maintenance of the wind farm. It is therefore assumed that a total of 40 persons will be employed once all the phases are operational.

Assuming the worst case where each worker drives to site, the increase in traffic is estimated at 10 vehicles per day which is negligible.

In addition to private vehicle trips, some additional trips can be expected in the form of water supply, refuse and sanitation collection vehicles. These services are anticipated to collectively generate an additional 3 HGV trips per week.

Some abnormal loads will be generated during this phase, when faulty components need replacing, although this will conducted on an ad-hoc basis and unlikely to have any impact on the overall traffic conditions on the surrounding public roads.

1.3.3 Decommissioning Phase:

It is estimated that the number of heavy vehicles trips, per 235MW Project, during the decommissioning phase would be between 2000 and 3000. The decommissioning phase is assumed to take 12 months.

The significance of the additional traffic generated during this phase would be low negative.

1.3.4 Proposed Mitigation

Even though the traffic generated would not be significant, the following requirements should still be met by the developer during the construction phase:

1. All abnormal loads must be transport under a permit;
2. A route study be undertaken to confirm the most appropriate route to site;
3. Dust suppression techniques should be utilised to reduce the impact on air quality for the surrounding area;
4. A Traffic Management Plan must be prepared once the Project advances to the preliminary phase. This plan should ensure that vehicles arrive in a dispersed manner throughout the day to reduce the impact to other road users. The plan should also promote the use of car sharing, especially from Loeriesfontein and the construction camp. Methods to improve driver safety should also be outlined, e.g. the use of speed cameras or Average Speed Over Distance (ASOD) cameras along particular sections such as the R358 to Loeriesfontein.

A Risk Assessment has been undertaken and included as **Appendix B.**

1.4 Recommended Routes to Site

This section provides a summary of the preferred routes. A more detailed description is provided in the Transportation Study report, also undertaken by SMEC.

1.4.1 Preferred Port

At this stage it is unsure whether the wind turbines will be manufactured locally or imported. It is possible that the wind turbine tower sections will be manufactured locally, ideally in Atlantis in the Western Cape were a dedicated manufacturing facility has been set up to service the wind farm industry and to stimulate economic growth. Items not manufactured locally will be imported from international suppliers. It has been assumed that the wind turbine components are of such size that they would arrive by ship at one of South Africa's ports. Two ports were considered, namely Coega and Saldhana Bay Harbour. Saldhana Bay Harbour is the preferred port due it being 410km closer to the LWEF site than Coega, and has previously accommodated wind turbine components for other wind farm projects.

1.4.2 Preferred Abnormal Vehicle Route

Having established that the wind turbines would enter the country via either the Saldanha Bay Harbour or be generated in Atlantis, a routing exercise was undertaken to determine the most appropriate route to site. The alternatives were either

- Alternative A - via the N1 to Loeriesfontein (1476km); or
- Alternative B - via the N7 towards Kliprand via R358 (630km).

Both alternatives are shown in **Figure 3.1**. Alternative A is required to travel via the N1 through Beauford West because abnormal loads cannot negotiate Vanrhynsdorp Pass due to vehicle traction problems on account of tight geometry and steep gradients.

Figure 1.1 - Abnormal Loads Main Alternatives

The recommended route for abnormal vehicles is via the N7 due to it being significantly shorter as well as carrying significantly less traffic which assists in reducing any safety concerns to other road users. The N7 route has also been discussed with the Western Cape Government Permitting office that supports the N7 route as the preferred option. One key concern was the ability for abnormal loads to pass under an existing railway bridge across the Sout River. SMEC's structural engineers have recently completed a bridge inspection of this structure and conform that the clearance is 5.94m. **Appendix C** provides an extract of the bridge inspection.

Other transport concerns associated with this route were:

1) Piekenierskloof Pass towards Citrusdal; and
2) N7 turn-off onto the R358 towards Kliprand

The Piekernierskloof Pass is an acceptable abnormal route for most loads. However, given that blade lengths could be in the order of up to 80m in length, a detailed route study will need to be conducted to accurately determine whether blades of this length can safely navigate the pass. It is imperative that this limit be established prior to exploring alternative routes as this will negate almost all the benefits of using the N7 corridor all together.

Figure 1.2 shows the existing N7/R358 intersection while **Figure 1.3** shows the swept path of a typical extendable trailer used for transporting blades. It clearly shows that despite rear steerable axles, some local widening at the intersection is required. The following upgrades are therefore proposed:

1) Extend N7 road shoulder of the northbound carriageway by approximately 5m or preferably up to the road reserve fenceline. This local widening should be from the intersection extending 100m south to provide hardstanding for the rear axle group when performing the turn;
2) Widen the southern splay at the N7/R358 intersection to provide additional space for turning;
3) Relocate existing road signs to be outside the turning envelope of the abnormal vehicle swept path;
4) Relocate the existing telephone poles to be outside the operational area of the intersection (see **Figure 1.2**). It is also proposed that the telephone line be buried under the N7 to avoid telkom height clearances being required for every load being transported.in the future.

Figure 1.2 - N7 / R358 Intersection

Figure 1.3 - Swept Path Analysis N7/R358

The transportation of materials, plant and people are envisaged to be transported from the nearest town, Loeriesfontein. Materials sourced from elsewhere will generally arrive via the N7 which further supports this route as the preferred route. Ultimately, the transportation of materials, plant and people will be user dependant.

1.4.3 Preferred Access to Site

Four alternative site accesses were reviewed and are evaluated below. These include

1) Access Option 1 – Northern access via DR2972;
2) Access Option 2 – Eastern access via DR2972;
3) Access Option 3 – Southern access via P2948;
4) Access Option 4 – Western access via P2948

The various access routes are shown in **Figure 3.2** below.

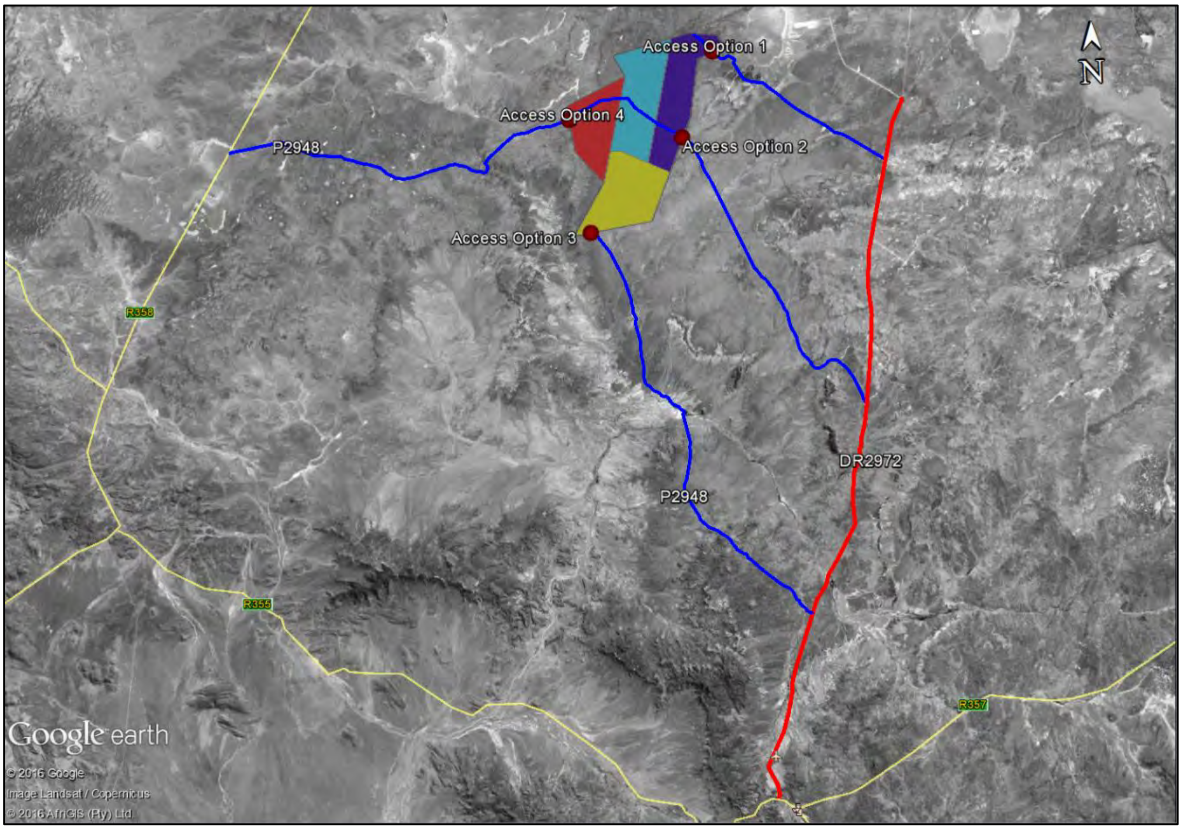

Figure 1.4 – Site Access Route Alternatives

The site observations assisted in evaluating the advantages and disadvantages of each access option and these are summarised in **Table 1.5** below.

Table 1.5 – Evaluation of Accesses

Route Criteria	Access Option 1	Access Option 2	Access Option 3	Access Option 4
Road Gradient	Flat	Steep	Steep	Flat
No of Farms Gates	Few	Numerous	Numerous	Few
No of Structures (bridges)	None	1 major bridge, 1 culvert	1 major bridge,	None

			1 river crossing	
No Farm Buildings Located Close to Road	Few	Numerous	Some	Few
Existing Traffic	High	Medium	Low	Low
Road Conditions	Fair	Fair	Bad	Fair
Likely Road Upgrade Cost	Medium	High	High	Medium
Drivability	Medium	Low	Low	Medium
Distance to Site from N7	Longest	Long	Short	Shortest
Preference Ranking	Unfeasible	Feasible	Least Feasible	Most Feasible
Preferred Access	**Option 4**			

Based on the above Access options 1 and 3 were deemed least unfavourable. The two feasible options were compared against one another and Access option 4 is our preferred option for the following reasons:

1) Access options 2 and 4 are almost equidistance if measured from Vanrhynsdorp, although option 4 route avoids Vanrhynsdorp Pass which is unsuitable for HGV's;
2) Access option 4 provides a single route from the N7 to the site, thereby reducing signage requirements and any confusion to drivers travelling to the site;
3) Having a single access route for all vehicle types reduces costs as only one route needs to be maintained during construction;
4) Access option 4 negates the need to travel through Loeriesfontein; and
5) Utilises the N7 corridor as far as possible, which has the most robust and resilient pavement layers capable of accommodating high HGV volumes.

In summary, the access route (option 4) via the R358 in combination with the N7 is the preferred route both for abnormal vehicles as well as other legal vehicles. Legal vehicle have the added option to utilise the DR2972 (option 2) as an alternative, although allowing multiple site entrances adds additional security/operational complications which might not be desirable.

1.5 Internal Roads

Mainstream engineers provided SMEC with locations of the wind turbines as shown in **Figure 1.5**. Given the extent of land incorporated under the LWEF project several alternative layouts were possible for the internal road arrangements.

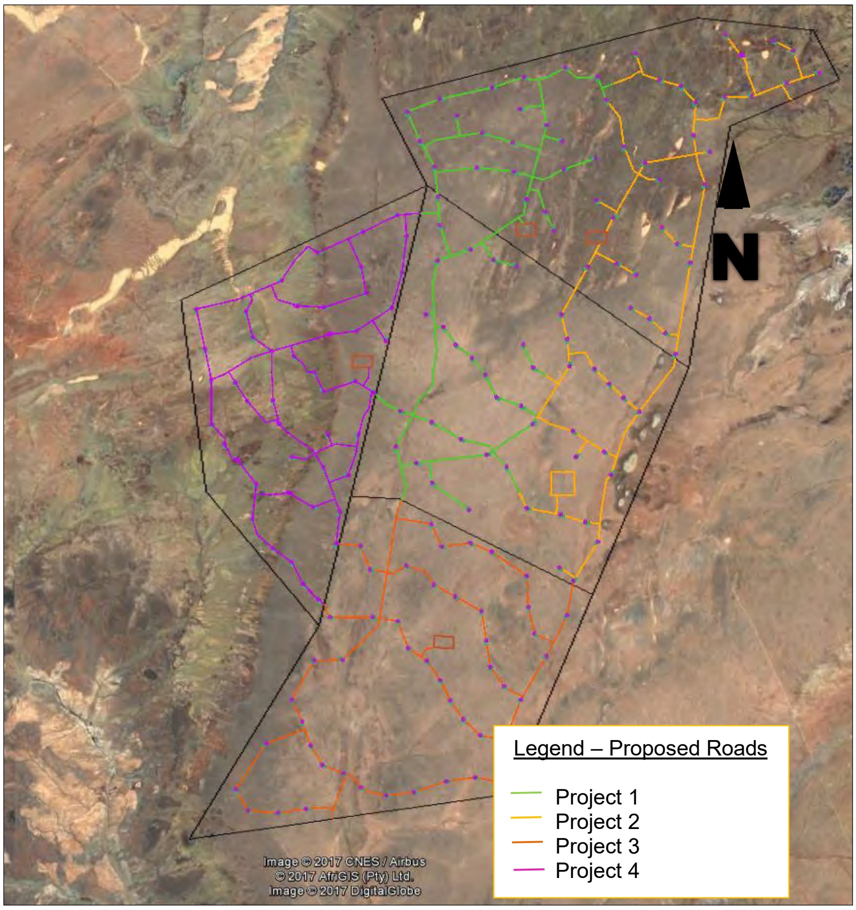

Figure 1.5 – Internal Roads

The following criteria were deemed appropriate for the internal roads.

- Roads to be widened to at least 8m wide together with 2m verges either side to accommodate battered slopes in areas where the road rises or falls below the natural ground level;
- Road surface to be gravel; and
- Local material to be used.

The LWEF project will require a total of 167.9km of road to be constructed of which 32.51km are existing track roads that need to be upgraded. The Internal roads must be constructed with material excavated from turbine foundations to minimise costs. Further details relating to the internal roads are discussed in **Section** Error! Reference source not found..

APPENDIX B – RISK ASSESSMENT

Aspect/ Impact Pathway	Nature of impact	Status	Spatial Extent	Duration	Consequence	Probability	Reversibility	Irreplaceability	Mitigation Measures	Significance of Impact/Risk = Consequence x Probability		Ranking of Impact/ Risk	Confidence Level
										Without Mitigation	*With Mitigation*		
CONSTRUCTION AND DECOMMISSIONING PHASES													
Access Points	Various alternatives to access site	Negative	Local	Long term	Slight	Likely	No	Replaceable	• Three alternative access points were originally considered i. Access via DR2972 to eastern boundary of LWEF ii. Access via DR2972 to southern boundary of LWEF iii. Access via R358 to western boundary of LWEF • Option iii was preferred option because i. Most suitable route for abnormal loads; ii. It allows all vehicle types to use the same route; iii. Only 1 access point needed; iv. Maximum use of N7 which is most suitable for HGV use; v. N7 currently not heavily utilised and therefore attractive.	Low	Low	3	
Abnormal Vehicle Generation	Increase in the number of abnormally sized vehicles travelling along the N7 and R358	Negative	Regional	Short term	Moderate	Very likely	No	Replaceable	• New abnormal route proposed along N7 instead of N1, saving 1000km per trip • N7 more suited for abnormal vehicles due to lower vehicle volumes • N7 shortest route from Saldanha and Atlantis • Local improvements proposed to enable route for abnormal vehicle use. • Disruption to other road users minimised.	High	Low	5	
Traffic Generation	Increase in traffic	Negative	Region al	Short term	Moderate	Very likely	Yes	Replaceable	• All abnormal vehicles will need to obtain a permit from the Provincial Government of Northern Cape and Western Cape at least 2 months in advance of transporting the first wind turbine components; • Ensure that roadworthy and safety standards are implemented at all times for all construction vehicles; • Plan trips so as to avoid travelling during the peak hours as far as possible (06:00-08:00 and 16:00-17:00).	Low	Low	4	
	Accidents with pedestrians, animals and other drivers on the surrounding tarred/gravel roads	Negative	Local	Long term	Extreme	Likely	No	High irreplaceability	• Road kill monitoring programme (inclusive of wildlife collisions record keeping) should be established and fences (such as Animal fences) installed, if needed to direct animals to safe road crossings along the primary access roads to the site; • Adhere to all speed limits applicable to all roads used; • Implement clear and visible signage at the intersection of the N7 and the R358.	High	Moderate	3	
	Impact on air quality due to dust generation, noise and release of air pollutants from vehicles and construction equipment	Negative	Local	Medium term	Moderate	Unlikely	Yes	Replaceable	• Implement management strategies for dust generation e.g. apply dust suppressant along the affected road segments, exposed areas and stockpiles; • Postpone or reduce dust-generating activities during periods with strong wind; • Earthworks may need to be rescheduled or the frequency of application of dust control/suppressant increased; • Ensure that all construction vehicles are roadworthy and drivers adhere to any additional safety standards imposed by the Health and Safety Manager; • Ensure that all construction equipment is well maintained and serviced regularly.	Moderate	Low	4	
	Change in quality of surface condition of the roads	Positive	Local	Long term	Slight	Likely	Yes	Replaceable	• Construction activities will have a higher impact than the normal road activity and therefore the road should be inspected on a weekly basis for structural damage; • Implement management strategies for dust generation e.g. apply dust suppressant on gravel roads, exposed areas and stockpiles; and • Develop a Road Maintenance Plan for the primary access to the site to addresses the following: vi. Grading requirements; vii. Dust suppressant requirements; viii. Drainage requirements; ix. Signage; and x. Speed limits.	Low	Low	4	
OPERATION AND MAINTANANCE PHASE													
Traffic Generation	Increase in traffic	Negative	Region al	Short term	Slight	Very likely	High	Replaceable	• Adhere to requirements made within Traffic Management Plan; • Restricted access to site; and • Ensure that where possible, staff members carpool to site.	Very low	Very low	5	
	Accidents with pedestrians, animals and other drivers on the surrounding tarred/gravel roads	Negative	Local	Long term	Extreme	Likely	No	High irreplaceable	• Adhere to all speed limits applicable to all roads used; • Ensure clear and visible signage is present. • Install speed cameras along R358 between Loeriesfontein and the site	High	Moderate	3	
	Impact on air quality due to dust generation, noise and release of air pollutants from vehicles and construction equipment	Negative	Local	Medium term	Moderate	Unlikely	Yes	Replaceable	• Implement management strategies to reduce dust generation; • Limit noisy maintenance/operational activities to daytime only.	Moderate	Low	4	

Aspect/ Impact Pathway	Nature of impact	Status	Spatial Extent	Duration	Consequence	Probability	Reversibility	Irreplaceability	Mitigation Measures	Significance of Impact/Risk = Consequence x Probability		Ranking of Impact/ Risk	Confidence Level
										Without Mitigation	*With Mitigation*		
	Change in quality of surface condition of the roads	Positive	Local	Long term	Slight	Likely	Yes	Replaceable	• Execute Road Maintenance Plan.	Low	Low	4	
CUMULATIVE IMPACTS													
Traffic Generation	Increase in traffic	Negative	Regional	Long term	Moderate	Very likely	High	Replaceable	N/A	Low	Low	4	
GEOTECHNICAL IMPACTS													
Foundation Excavatibility	Hardpan calcrete / soft rock shale encountered during excavation	Negative	Local	Short term	Slight	Very likely	No	Replaceable	• Preliminary geotechnical investigation has identified possible locations of calcrete/shale deposits; • Wind turbine foundations positioned to avoid areas requiring excavation of hardpan calcrete; • Foundations can be constructed above hardpan calcrete if bearing capacities of 200 - 500kPa can be achieved during testing.	Very low	Very low	5	
Foundation Excavatibility	Dolerite rock / hard rock shale encountered during excavation	Negative	Local	Short term	Extreme	Likely	No	Replaceable	• Preliminary geotechnical investigation has identified possible locations of dolerite outcrops; • Wind turbine foundations positioned to avoid excessive excavation of dolerite material due to high excavation costs; • Foundations can be constructed above dolerite/shale in-situ material if the bearing capacities are greater than 1000kPa.	High	Moderate	3	
Foundation Excavatibility	Instability of excavation side walls within fractured bedrock	Negative	Local	Short term	Moderate	Unlikely	Yes	Replaceable	• Precautionary measures to be incorporated in the design and construction of the proposed foundations.	Moderate	Low	4	
MATERIAL													
Material Availability	Material Source	Positive	Local	Long term	Moderate	Very likely	Yes	Replaceable	• Make use of possible quarry on site for concrete aggregate that includes the use of the hard rock dolerite sill.	Very low	Very low	5	
Material Availability	Material Quantities and Qualities	Negative	Local	Long term	Extreme	Likely	Yes	Replaceable	• Ensure that the site is drilled to access the material quantities; and • Carry out laboratory testing to confirm the durability of the material.	High	Moderate	3	
STORMWATER IMPACTS													
Increased Stormwater	Flooding of site / access road	Negative	Local	Short term	Slight	Very likely	High	Replaceable	• Adhere to requirements made within Stormwater Management Plan; • Stormwater runoff be directed to the lower edge of gravel road;	Moderate	Very low	4	
Increased Stormwater	Erosion of land	Negative	Local	Long term	Extreme	Likely	No	High irreplaceable	• Ensure water courses follow natural terrain as far as possible; • Ensure initial road upgrades consider drainage to limit extent of erosion.	High	Moderate	3	