



KAIMAI WIND FARM



Kaimai Wind Farm Limited

Project Development Rationale

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Document Control Record

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<i>Report Title</i>		Kaimai Wind Farm Project Rationale				
<i>Document ID</i>		Kaimai Rationale	<i>Project Number</i>		Kaimai 01	
<i>File Path</i>		P:\CUSTOMERS\Ventus Energy\Kaimai Project\Project Outline				
<i>Client</i>		Ventus Energy	<i>Client Contact</i>		Glenn Starr	
<i>Rev</i>	<i>Date</i>	<i>Revision Details/Status</i>	<i>Prepared</i>	<i>Author</i>	<i>Verifier</i>	<i>Approver</i>
0	9 February 2018	Revision 0, draft	TC	TC	MB	MB
1	20 February 2018	Revision 1, draft	MB	MB	TC	TC
2	26 March 2018	Revision 2, draft	MB	MB	TC	TC
3	28 March 2018	Revision 3, grammatical amendments, draft	MB	MB	TC	TC
4	13 June 2018	Site Selection extended, Layout history	GS	GS	TC	TC
5	15 June 2018	Review changes	TC	TC	MB	MB
<i>Current Revision</i>		5				

<i>Approval</i>			
<i>Author Signature</i>		<i>Approver Signature</i>	
<i>Name</i>		<i>Name</i>	
<i>Title</i>		<i>Title</i>	



Executive Summary

The provision of a secure and reliable electricity supply to New Zealanders is a constant challenge being faced by the electricity generation industry. As long-term demand for electricity continues to increase, additional electricity generation facilities are required to be built.

Recently in the order of 1000MW of thermal plant has been decommissioned in the Auckland region, this action significantly increases the “dry year” risk of electricity supply shortfall. The thermal plants were decommissioned as the respective projects had reached the end of their economic life.

There is no central supply planning authority in New Zealand, and as such each project owner or developer must formulate their own view on the capacity required to fill electrical demand for an economic return. The market therefore decides when new plant is built to meet demand, and often this occurs hastily following a crisis of supply (e.g. 1992, 2003).

Kaimai Wind Farm Limited proposes to construct a wind farm of 24 turbines with an aggregate capacity of approximately 100MW on the north western end of the Kaimai Ranges. The Kaimai Wind Farm Site comprising a total area of 1,304Ha is approximately 8 km to the north of Te Aroha.

The Site is characterised by grassed rolling hills, and ranges from 10 to 500m above sea level. The Site is largely covered by exotic grazing grasses and adapted weed species. The topography is generally suitable for a wind farm development if appropriate contours are followed for roading and turbine locations.

The Kaimai Site consists of a strongly defined south-west/north east facing ridgeline, and a lower plateau to the north west of the main Kaimai Range ridgeline, both are suitably aligned to the wind resource. The Site, given its topography, has the benefit of being relatively distant from surrounding dwellings, mitigating potential noise impacts from construction and operation of the wind farm.

Ventus Energy has carried out extensive wind monitoring since 2005 using various sized tall wind monitoring masts in the intervening years (20m, 50m and 60m towers). The variety of meteorological masts that have been installed at different locations on the Site, have supplied wind data suitable to calculate accurate energy yield estimates of potential turbine types. The lower elevation areas of the Site feature mean annual wind speeds in the order of 7.5 m/s, while the higher elevation areas of the Site have higher wind speeds, these are in the order of 9.5 m/s. In addition measured turbulence levels are relatively low, an important consideration when considering structural loadings on turbines. The recorded wind flow parameters collectively indicate a good wind regime for wind turbine power generation.

The inclusion of the upper ridgeline turbines are essential to the overall project viability. From the measured wind resource it is estimated they will produce on average 28% more electricity per turbine than the lower elevation turbines. The lower turbines in isolation, representing a smaller project, do not constitute a viable project given that the highly expensive grid connection cost to



the Transpower network is effectively a fixed cost, regardless of project size. The higher elevation turbines also provide a form of “cross subsidisation” in terms of energy yield averaged over the entire project, due to the fact that they are significantly more productive on account of the higher wind speeds they receive.

The principal of Kaimai Wind Farm Limited, Ventus Energy (NZ) Limited, which is owned by Glenn Starr, has pursued a wind farm development at the Site since 2005. The project has gone through many design iterations over the years. Initially starting with a project of 11 turbines of 2MW capacity, then subsequently expanding to a larger project comprising 60 turbines of 3MW capacity, and extending over the entire expanse of the agricultural land at the northern end of the Kaimai Ranges.

After significant consideration and stakeholder involvement, the final design iteration of the project for which consent is sought has been reduced considerably in size. The reduction is primarily due to the following factors:

- An increase in available turbine sizes (both physical and power output) meaning increased generation from reduced turbine numbers.
- Results from ecological monitoring, particularly increased bat populations.
- Definition of an ONL on DoC land to the east of the Site.
- Advice from local stakeholders, landscape consultants, and planners.
- Complications with respect to landholdings.

As a result the project site was condensed to only include land north of the TransPower 110kV transmission line, and at lower elevations compared to the more southerly turbine sites considered in prior design iterations. The reviewed project design has therefore significantly reduced potential environmental effects, those most notably being ecological and landscape impacts.

Key benefits of the project include:

- The Kaimai Range Site has some of the best wind generation potential of any site close to Auckland, Hamilton, and Tauranga, which are major electrical load centres.
- Building significant generation close to load centres increases the value of energy, namely by mitigating transmission losses that arise from electrical transmission from distant generation plants.
- Locally sourced generation increases security of supply within the region, as imports from distant generating plants have an increased risk of transmission failure or constraint.
- The Site has the significant development advantage in that a 110kV transmission line passes directly through the Site at its southern end. No additional transmission lines



external to the Site are required to be built, completely avoiding the associated environmental impact.

- The development of the Kaimai Wind Farm project is consistent with the Government's overall policy framework to secure energy supply with the development of renewable electricity generation projects.
- The development aligns with the Government's policy towards reducing climate change inducing greenhouse gas emissions.
- The Kaimai Wind Farm will help reduce security of supply risks by providing further diversification in electricity generation supply.



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1. Introduction

This document outlines key electricity market drivers, site selection, and development rationale for new wind energy generation projects in New Zealand, as well as at the proposed projects specific location and type.

Overall, as long-term demand for electricity continues to increase, it is essential that additional electricity generation facilities need to be built to satisfy demand and provide price stability. This is especially important in light of the retirement of fossil fuel-based generation. These key factors provide the principal rationale for the proposed development of the Kaimai Wind Farm.

2. Drivers for Electricity

This section outlines various drivers for electricity supply in New Zealand such as supply security, forecast growth of demand, and considers ways in which the supply for this growth can be managed effectively.

2.1. Electricity Supply and Demand in New Zealand

The majority of electricity generation in New Zealand is from hydroelectric sources, this is followed secondly by geothermal generation, gas and coal thirdly, and finally wind. The most recent relative percentages calculated by the Ministry of Business Innovation and Employment (MBIE) are as follows:

- Hydro 64%
- Geothermal 18%
- Gas and Coal 12%
- Wind 6%

Significant differences exist in the distribution, scale, and type of generation plant between the two islands. The South Island notably has the majority of the countries hydroelectric generation capacity, and has proportionally higher levels of hydroelectric storage than the hydroelectric schemes in the North Island.

Annual storage levels are highly dependent on rainfall and snow melt over spring, giving rise to significant annual fluctuations, these can be higher than 40%. The proportionally higher level of storage to generating capacity does however provide an increased buffer relative to the collective North Island hydroelectric generation schemes. The South Islands only other generation source is wind energy, the wind farms in the South Island are relatively modest in size and contribute approximately 3% of the Islands total generation.

The South Island has three major hydroelectric power schemes, the Waitaki, Clutha, and Manapouri. The schemes are located respectively in Waitaki, Otago, and Fiordland, all in the lower South Island. There is no significant generation in the top of the South Island. The larger scale wind farms are also located in Otago and Southland.



The high voltage DC link originating at the Benmore Dam serves as an important transmission path to the North Island, largely enabling the export of excess hydro generation capacity in the South Island to supplement supply in the North Island. Occasionally the power flow may be reversed in times of energy shortages in the South Island, or due to plant outages (planned or unplanned).

Generation of electricity in the North Island is achieved from a wider range of generation types, and which are proportionally more equal than those of the South Island. Geothermal and gas generation provide the highest proportion of electricity and contribute a relatively equal amount of generation that is collectively in the order of 60% of total generation. This is closely followed by hydroelectric generation which contributes approximately 26% to the total North Island power generation. Wind contributes approximately 12%, and coal now only 2%.

The respective plants are clustered to some degree, with gas generation concentrated in the Taranaki region, and geothermal within the Taupo volcanic zone. There are two major hydroelectric schemes, the Waikato River Scheme in the Waikato, and the Tongariro Scheme in the Taranaki.

Wind generation is focused in the Manawatu, although the Wellington region now has significant installed capacity, and the Waikato also has a medium sized wind farm (Te Uku rated at 64MW).

The Huntly power station is the sole coal generation plant in New Zealand, however coal usage has declined sharply in recent years, and has to some degree been substituted by gas. The power station is located in the Waikato.

Consumption ranges from large industrial sites, commercial operations, to residential consumers. The North Island accounts for approximately two thirds of the total national power consumption, having a greater population than the South Island, and a greater number of industrial operations.

The most notable consumer in the South Island is the Tiwai Point Aluminium smelter near Bluff, in Southland. The smelter accounts for up to one third of total demand in the South Island, and approximately 12% of total national demand.

Total national installed generation capacity as reported by MBIE in 2017 was 8,875 MW. Total generated electricity from these sources was 40,527 GWh. Of note 6% of the total was derived from wind generation, which continues to increase as a generation component to displace nonrenewable generation sources.

Renewable generation electricity generation sources collectively continue to increase their percentage of total supply, in 2016 the renewables share was 85% of total supply, compared to 81% the prior year.

The percentage of electricity derived from renewable sources has been trending up over time, this is primarily due to the following reasons:

- The continual development of the electricity market.
- The downgrading of Maui natural gas reserves which lead to a sharp drop in production in 2003.
- Declining capital costs of renewable technologies in conjunction with much lower operating costs compared to generation using fossil fuels.
- A general market commitment to reduce CO₂ emissions.

The proposed Kaimai Wind Farm would add the equivalent of 0.97% of installed generation capacity and 0.99% of net annual generation output, which is a material contribution.

Since 2014 electricity generation companies have announced the impending de-commissioning of over 1,000 MW of thermal capacity. This has largely arisen as a consequence of new geothermal generation displacing baseload gas and coal fired generation. In this regard:

- Mighty River Power announced the closure of the 175 MW gas-fired Southdown Power Station in March 2015;
- Contact Energy announced the closure of the 380 MW gas-fired Otahuhu B Power Station in September 2015; and
- Genesis Energy announced a timetable to permanently close the remaining 500 MW of gas / coal fired units at the Huntly Power Station by 2019.

A significant uncertainty identified in the New Zealand electricity market is the future of the Tiwai Point Aluminium Smelter, and its resultant impact on demand. As the plant currently consumes approximately 12% of New Zealand's electricity generation per annum, a permanent shutdown would result in an excess of supply for a number of years. The smelter is contracted to run until at least 2018 but has a firm electricity purchase agreement with Meridian Energy contracted out until 2030. Aluminium prices have risen recently to a level of approximately USD 2,200 per ton based on increased demand and have been trending upwards generally, furthermore the operation is still profitable, with a sizable profit recently reported for the last financial year. The general industry view is that the smelter will remain. As expected by commentators, pot line number 4 has been restarted which has created a substantial additional electrical demand of 50 MW.

As of January 2017, from industry surveys, Transpower assessed that there was the potential for 3,200 MW of generation to be built leading up to 2026. Earliest commissioning dates for the new electricity generation capacity range between 2018 and 2020. Of this new capacity, 52% would be wind powered, 16% geothermal and 6% hydro.

While in theory there is a significant amount of new electricity generation capacity that could be built if market conditions were favourable, these projects are not necessarily in a position to proceed immediately, or proceed as forecast in the future, and potentially may never be built for a variety of reasons. As a result it is important to continue to develop new potential generation

projects. Often new projects may be more favourable than those on hold or previously planned due to the modelled lower cost of electricity generated, or for example by having less environmental impact. The Government has shown a clear preference for further increasing the level of renewable generation within New Zealand, and as a result, a continual pool of potential renewable projects need to be developed.

Demand grew by 1.6% in 2015 but faltered in 2016 reducing to 0.9% on the back of high winter temperatures and low irrigation demand. Notwithstanding 2016, ongoing population growth has provided a level of confidence around growth and this is certainly evident in MBIE Electricity Demand and Generation Scenarios published last year which forecasts annual growth rates ranging from 0.4% to 1.3%.

2.2. Security of Supply

Electricity is an essential input for modern lifestyles, and for commercial and industrial activity. Industrial, commercial and domestic activities are all dependent on electricity, including manufacturing, retail, health services, transportation, lighting, water supply and wastewater treatment and disposal.

In New Zealand, because of its geographically isolated electricity system and reliance on hydro generation, the main risk to security of supply is low hydro lake levels. This is especially so as a high proportion of storage is attributable to the Waitaki Scheme in a single geographic location.

System security margins are calculated by Transpower as the winter percentage proportion of supply divided by demand minus one. These margins have fallen from pre-2015 historic levels of 25-30% to less than 17% today.

In the base-case scenario analysed by Transpower, the New Zealand and South Island security margins are forecast to remain above or within the security standards of 14-16% and 25.5 - 30% until 2018 and 2021 respectively, with existing and committed generation.

To continue to meet the New Zealand winter energy security of supply standard, increasing levels of new generation are required to be built:

- The high probability generation (or equivalent) would need to be commissioned prior to the winter of 2020.
- Increasing levels of medium probability generation would be required prior to the winters of 2021 and 2022.
- After decommissioning of the Huntly Rankine units at the end of 2022 most, if not all, medium probability, including non-dated projects, would be required through 2023 to 2026.

In the medium to long-term, the supply security forecasts are sensitive to the future plans for the Huntly Rankine units, and, to a lesser extent, Tiwai Point smelter demand. The base-case scenario



assumes the Huntly Rankine units will be decommissioned at the end of 2022. In this scenario the New Zealand and South Island security of supply margins are expected to fall below the security of supply standard for energy.

TransPower found in the base-case assessment that significant generation investment would be needed to maintain energy security margins within the security standards beyond 2022.

2.3. Forecast Growth in Electricity Demand

Analysis of New Zealand's net generation output between 1974 and 2016 highlights an increase from a base of 19,751 GWh to 40,547 GWh, an average annual compound growth rate of 1.7%. Historically electricity demand growth in New Zealand has been closely aligned to economic growth, as with other developed countries.

Following a number of years of successively increasing demand, the established trend was reversed in 2007, and since then demand growth has been relatively flat at 0.4% per annum on average to date. The fall in demand is partially attributed to the Global Financial Crisis, but also to increasing winter temperatures which have reduced residential demand. In addition increases in the minimum efficiency for appliances, and increased performance standards for new buildings are contributing factors to the fall in demand. Energy intensity, a measure of energy efficiency, has also improved over this time.

MBIE published new electricity and demand scenarios for the years 2016-2050 recently, five potential future scenarios were analysed. The various scenarios assessed key variables that contribute to demand such as; joint high GDP and population growth, high future carbon prices, the future of Tiwai Point Aluminium Smelter, and a disruptive scenario where electric vehicles achieve a high level of consumer uptake, resulting in displacement of internal combustion engine vehicles. These forecasts envisaged an annual average growth in demand of between 0.4% and 1.3%.

Demand is expected to grow under all scenarios over time as population, the economy, and household incomes grow. It was found grid demand is higher in the disruptive scenario than all other scenarios except the high growth scenario. This is due to charging of the estimated 1.77 million electric vehicles in this scenario by 2040. However, this higher grid demand is partly offset by the estimated 1,600 GWh of household Solar PV generation in 2040. Total consumer demand, which includes the demand met by household solar PV, is at a very similar level in the disruptive and high growth scenarios by the early 2040's.

The MBIE demand forecasts are conservative when viewed against the average growth rate over the last 43 years, however it is extremely difficult to predict future demand. The rate of technological change is progressing rapidly and is often related to electrical consumption, thus compounding prediction inaccuracies. The general move to increasing electrification of New Zealand vehicle fleet is a major new area of demand not seen before by the electrical system which will increase overall demand in the long term.



Transpower recently released its Energy Futures white paper in June this year. The paper was commissioned to assess the impact of a de-carbonized economy in conjunction with increased grid-connected renewable generating plant, and how they may affect New Zealand's power system. A key finding of the paper is that electricity demand will double by 2050, Transpower stressed that in order to meet this demand, significant and frequent investment in New Zealand's generation portfolio will be necessary in the coming years.

Transpower also found that New Zealand also has a stronger incentive to electrify than most other countries. This is because the majority of generation, and future generation, can continue to be derived from non-fossil fuel sources. Most other countries lack the natural resources required for renewable generation potential, and therefore electricity is much more likely to continue relying on generation using fossil fuels in those countries.

In its estimations based on a low carbon future, Transpower gave the example that in order to meet its predictions of 60TWh of new generation requirement by 2050, the equivalent of 4.5 wind farms with an average size of 60MW would be required to be built each year.

These forecasts reinforce the need for the development of projects such as the proposed Kaimai Wind Farm.

2.4. Supply Considerations

For a stable power system that is able to meet demand in the future, it is crucial that New Zealand has an active pool of potential generation projects that have been investigated and consented. One of the important drivers is to have new projects available for construction which align with the Government's desire to increase the proportion of electricity derived from renewable generation sources. The new projects may be developed either to offset increasing demand, to substitute generation from sources which are nonrenewable, or offset lost generation capacity from retired generation plant.

It is also important to consider further electricity generation diversification as a positive implication of new developments. As New Zealand is highly reliant on hydroelectric generation, years of modest inflow into the storage lakes can cause the potential for national power shortages. This is compounded by the fact that most of the storage is in a relatively small geographic location, so that storage inflows are not averaged of the entire country where multiple weather patterns may reduce seasonal variations at any one time. The problem typically manifests when low hydro storage levels and low inflows in the winter correspond with national peak yearly demand. If this situation occurs, generation is curtailed so that the hydro storage lakes do not fall below minimum consented operating levels. Wholesale prices are driven upwards by the reduction in supply, as generating plant with higher operating costs must be run to meet any shortfall, and that the market responds in a typical manner to scarcity.

Notable “Dry” year events have occurred in 2001, 2003, 2006, 2008, 2012, and 2017.

Nevertheless the amplitude of the price fluctuations due to low hydro storage levels has decreased in recent years due to several contributory factors. These include; the commissioning of new geothermal and wind generation capacity, and improvements to the HVDC inter-island link and the transmission grid in the North Island.

The addition of electricity generation capacity with output that is not closely correlated with the weather patterns that feed the main hydro lakes in the South Island will improve the diversity of the national electricity generation capacity and strengthen resilience against dry year events.

Electricity generation from gas is the second biggest contributor to New Zealand's supply following hydroelectric power. Gas generation is unlikely to increase its proportion to overall generation as firstly, consumer demand for non-energy use is increasing thus competing for currently available supply. Secondly, it is projected that without new discoveries and at current consumption rates that remaining reserves will be exhausted within 11 years. It is possible that further gas may be extracted from the existing reserves if through higher gas prices it is economic to employ advanced gas extraction techniques.

Investment in gas exploration has declined markedly worldwide, and New Zealand has followed that trend despite favourable exploration incentives from the prior Government. Permits declined in step with only one permit issued in 2016, compared to 9 in 2015. There have been no significant



discoveries in recent years that materially increase reserves that might favour increased gas generation. Furthermore the current government has recently banned all new oil gas permits, severely limiting gas generation possibilities in the future.

Gas generation plants may have a place as peaking plants in the future, for example Contact Energy recently constructed a 200 MW gas turbine plant at Stratford, with this intent in mind. This plant only operates at times of high electricity prices which may occur during hydro generation shortages, or plant outages. Peaking plants have decreased fuel requirements given they are only run periodically, and can bear a higher fuel cost if electricity prices are high.

Base-load gas generation plant is likely to become less viable as gas supply is constrained over time and prices logically increase. The recent closures of base-load gas plant indicate that they are uneconomic to operate.

As a further example, Nova Energy is yet to develop its planned 360MW gas fired power plant near New Plymouth that has been consented for some time.

Another important consideration in terms of future supply is that many currently consented wind farm projects that have not been built have a shortening development window until the existing consents lapse. Some of these projects may struggle to obtain renewed consents if they do lapse, reducing the pool of potential future generation. Furthermore a number of these projects have been consented with turbines that are now considered small or obsolete, and as such would need to be re-consented, in which a favourable outcome could not be guaranteed.

2.5. Generation Development Options

There are a range of possible generation options available to increase total electricity supply in the future, these include; wind, hydro, gas-fired, geothermal, coal, and new and developing generation options such as solar, wave and tidal.

New Zealand is recognized as having a world class wind resource, primarily because of the country's isolated geographic position in the Southern Ocean. While wind generation in New Zealand has grown substantially in the last 20 years, it only contributes a relatively small proportion of total electricity supply (6% in 2016).

Over the last 15 years larger scale electricity generation developments in New Zealand have typically been either geothermal, wind, or gas-fired. However as discussed, the outlook for gas supply in New Zealand has changed significantly, especially since gas production from the Maui gas field has declined, and new permits are now banned.

For other options, such as hydroelectricity generation which currently provides the majority of New Zealand's electricity supply, there is potential for further development, however, the opportunity for new large-scale hydroelectricity projects is limited due to environmental concerns associated with the damming of large rivers.



Generation options, such as geothermal generation, can only occur at a commercial scale where significant proven geothermal resources are located, notably being a close proximity to the North Island's central plateau.

Technical performance of all generation types has improved, particularly so for some technologies. Over the last 10-15 years there have been major technological advances in Wind Turbines and Photovoltaic Solar. Gains have been made in terms of efficiency, reliability, and cost.

Despite advances in solar energy technology and relatively rapid domestic uptake, it is likely that it will be some time before projects at utility scale are commercially viable in New Zealand.

Alternative technologies that may have commercial potential in future include wave and tidal power, however these technologies are still firmly in the developmental stage and are not likely to be commercially viable for a number of years.



3. Site Considerations and Rationale

This section investigates site development considerations, and provides further rationale for the Kaimai Wind Farm Site.

3.1. Identification of Wind Farm Sites

Ventus Energy (NZ) Ltd (owner of Kaimai Wind Farm Limited) has historically had an active program focused on investigating and developing new renewable electricity generation opportunities throughout the upper North Island. Kaimai Wind Farm Limited has used both traditional site assessment methods and modelling techniques to identify potential wind farm sites. This analysis has identified the Kaimai Range area as being the most suitable site in the region for wind farm development.

The investigation of the wind resource at a number of sites throughout New Zealand has formed the basis for Kaimai Wind Farm Limited's consideration in determining general and specific areas that may be viable for the development of utility scale wind farms.

As part of the selection process for a potential site which warrants further investigation, and the possible development of a wind farm, several technical matters relative to the site are evaluated.

While every potential location for a wind farm has its individual nuances, it is generally accepted that a site which has the collective following attributes will be a suitable candidate for wind generation at a commercial scale:

- Availability of a good wind resource (typically an average annual wind speed greater than 7.5 m/s, ideally associated with low turbulence).
- Availability of land suitable for the construction of turbines.
- Close proximity to locations of high energy demand.
- Suitable distance from large population centres.
- Practical access for transporting equipment and materials to the Site.
- Ability to connect to the national grid.
- Avoidance of sensitive environmental areas.

Kaimai Wind Farm Limited has considered each of these matters in detail when selecting the Kaimai Site as a feasible development project. Each criterion is discussed in further detail as follows.

3.2. Wind Resource

Areas with wind speeds sufficient for commercial wind farm projects in New Zealand are found in a number of select locations, including the Kaimai Ranges. Not all of the greater Kaimai region is suitable however, due to steep and difficult terrain that not only precludes access, but also gives rise to high levels of wind turbulence which can be structurally damaging to wind turbines.

The Kaimai Site was first identified by the principals of Kaimai Wind Farm Limited in 2005 as the outcome of a site screening process. The assessment was undertaken to identify likely areas of higher wind speeds that were also practical from a buildability perspective, had potential for grid connection, and that were located in close proximity to an area of high electrical demand.

An initial assessment of the area was undertaken utilising specific desktop studies, wind modelling, and a terrain assessment. In addition, Site visits and consultation with local landowners were also undertaken to assess the potential for development of a wind farm in the area.

The favourable outcome of the initial site assessment and landowner meeting led to the commencement of a detailed wind monitoring campaign commencing in 2006.

The wind resource assessment of the Kaimai project was conducted by physical wind monitoring across the Site. Data was collected from a number of monitoring masts and associated meteorological recording equipment, installed on representative turbine locations across the Site. The analysed meteorological measurements have been used to understand Site specific wind conditions in detail with respect to wind generation potential.

Modeling using the recorded data in conjunction with specialised software has enabled the selection of suitable wind turbine models, and the spatial placement of wind turbines to maximise potential energy yield. The key output of the modelling software is to provide an estimation of potential net annual energy production of the overall Site.

A number of the proposed wind turbine sites have an average wind speed of more than 9 m/s, and some are approaching 9.5 m/s, in addition turbulence levels are relatively low which is favourable. The recorded meteorological parameters indicate an excellent wind regime relative to both local and international wind farms.

In terms of Site classification, the wind speed and turbulence predominantly fit within International Electrotechnical Commission (“IEC”) Class IB and Class IIB parameters and Class IIIB parameters. The IEC identifies a range of wind turbine classes based on the wind resource, with Class IB being the highest wind speed class, with low turbulence, Class IIB being an intermediate wind speed with low turbulence, and Class IIIB being an intermediate wind speed with low turbulence.

It is important to note that turbines with larger rotors in Class II conditions can often out produce turbines with smaller rotors in Class I conditions. This is due to the fact that Class I Sites usually require smaller rotor diameters in order to reduce structural loadings brought about by periodic “extreme” wind speeds which are often encountered in Class I Sites.

The following map created by NIWA illustrates the above average wind resource experienced in the Kaimai ranges relative to the general region (Note the actual measured wind speed is higher than modelled by NIWA, reinforcing the Sites suitability). It is clear from the map that the Kaimai Range Site has some of the best wind generation potential close to Auckland, Hamilton, and Tauranga, which are major electrical load centres.

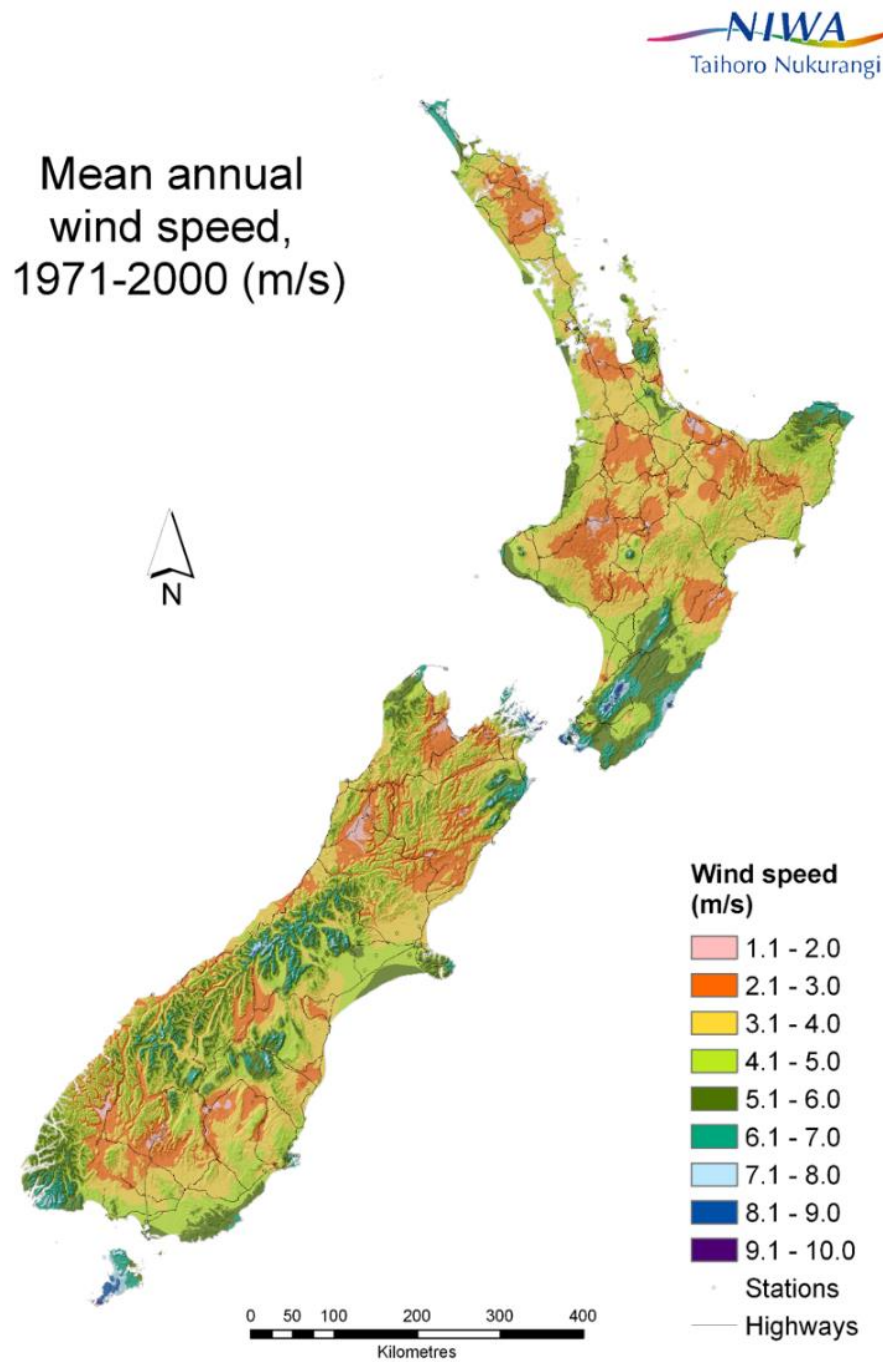


Figure 1 - Mean Annual Wind Speeds in New Zealand

The following map created by the Electricity Authority illustrates main load centres, transmission lines, and generation within New Zealand, it clearly defines the Kaimai Sites' close proximity to major load centres.

TRANSPOWER TRANSMISSION NETWORK : NORTH ISLAND

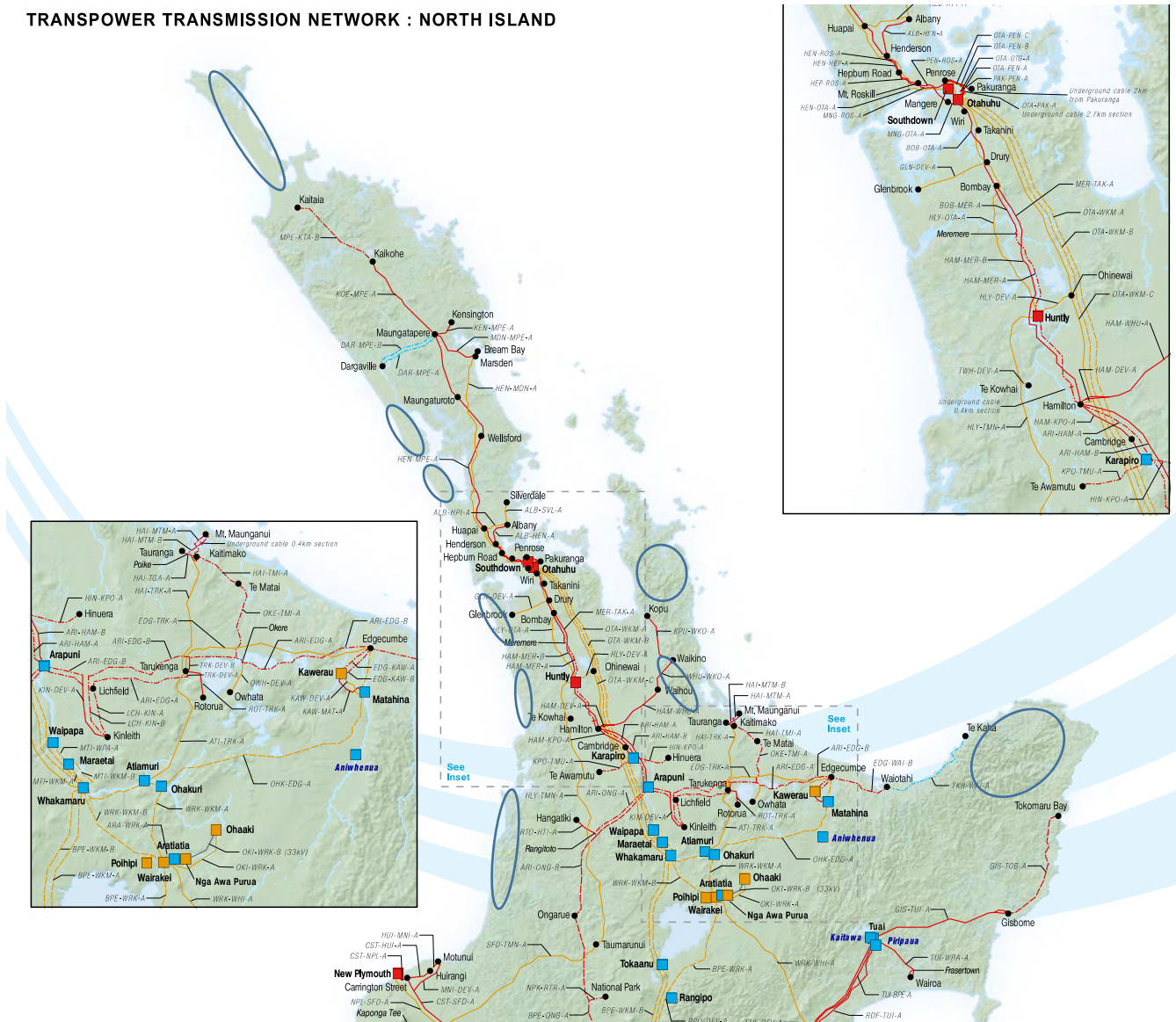


Figure 2 – Main Load Centres, Transmission Lines, and Generation (TransPower)

The current generally agreed locations that feature a viable wind resource are shown by the purple oval highlights in Figure 2. The diagram illustrates that the majority of areas that feature a suitable wind resource are a relatively distant from the existing Transpower network. Therefore to develop any project at scale in the upper north island requires a new high voltage grid corridor and associated infrastructure. This creates three major hurdles to achieve a successful development:

- Consenting a transmission corridor.
- Obtaining the legal right from numerous landowners to occupy the land.
- Installation costs are considerable, and often will make the wind energy project unviable, or will force the development of very large projects to make the connection economic.

3.3. Suitable Land Availability

The Kaimai Site consists of a predominantly north-west facing ridgeline, and a lower plateau on the west side of the ridgeline, both are suitably aligned to the wind resource. The landforms of the proposed Site within the Kaimai Ranges are elevated, but not dominant, over the surrounding area which encompasses higher elevation topography such as the Te Aroha peak with its associated telecommunications tower.

The Site, given its topography, has the benefit of being relatively distant from surrounding dwellings, mitigating potential noise impacts.

Overall, the topography of the area allows for practical access to be developed for construction purposes and is suitable for turbine placement. Much of the proposed Site already has developed farm tracks which will be upgraded to allow access of the required components and machinery.

While some of the topography is relatively steep, impacting access roading and turbine placement, these aspects have been adequately identified and assessed in the initial site design work. The topographical features of the Site can be readily managed through appropriate engineering design and construction techniques.

3.4. Proximity to Locations of High Energy Demand

Proximity to major load centres is an important consideration in the development of a potential site. The Kaimai Site is located close to Tauranga, Hamilton, and Auckland, which are all major load centres.

Building significant generation close to load centres increases the value of energy, this is achieved firstly by mitigating transmission losses that arise from transmission from distant generators. Secondly locally sourced generation increases security of supply within the region, as imports from distance generating plants have an increased risk of transmission failure. For example, in 2010 the Makara Wind Farm supported Wellington's electrical load when the HVDC link tripped, without the contribution from the wind farm, Wellington would have faced an electrical energy shortage resulting in a potential blackout.

3.5. Distance from Large Population Centres

It is important that sites are suitably located away from large residential populations, such that any potential noise or visual effects of the wind farm are minimised.

The Kaimai Site is located in a rural area that is relatively sparsely populated. The surrounding area is rural in nature, comprising land used for primary production. The population centres



located close to the Site are relatively modest in size. Paeroa is the nearest town (population 3,900) at a distance of 7KM, followed by Te Aroha (population also 3,900) at a distance of 9KM. Seven small rural settlements are located around the Site, these include; Waihou, Elstow, Mangiti, Tirohia, Mackaytown, Karangahake, and Waikino.

3.6. Accessibility

The Turbine components to be used for the Kaimai Wind Farm (i.e. blades, tower sections and nacelle) are manufactured overseas and will need to be shipped to New Zealand. A suitable route has been identified to transport these components from the Port of Tauranga, being relatively close at a distance of approximately 103km. By far the majority of the route is arterial (State Highway 29, State Highway 26, and State Highway 26), other than the turn in off to Rawhiti Road which is a short straight stretch of road (4.8km until site turn-in). Given the route is on major arterial Highways and the secondary road has no corners until the site turn-in, no major road upgrades are envisaged.

Other External Roads in the vicinity of the Kaimai Wind Farm are suitable for site access for Heavy Commercial Vehicles (“HCV’s”) and other construction traffic, although may require some upgrading (such as curve straightening, widening or sealing).

Internal Roads on private land will also be required to access the Turbine locations within the Site. Where possible, existing farm access tracks will be used, although such tracks will need to be upgraded (including widening, sealing and/or strengthening in some places), to enable transportation of the Turbine components to the required locations within the Site.

Overall, appropriate access to the Kaimai Site for both the construction phase, and the ongoing operational phase can be achieved in a relatively straightforward manner.

3.7. Ability to Connect to the National Grid

The Site has the substantial development advantage that a 110kV Transpower line passes directly through the Site at its southern end. This means that no additional transmission lines external to the Site are required to be built, completely avoiding the associated environmental impact.

The TransPower connection feeds electricity into the upper North Island region via various sub stations, a significant net demand location.

3.8. Avoidance of Sensitive Environmental Areas

The Kaimai Wind Farm Site is not identified in the planning documents as being within or part of an outstanding natural feature or landscape. However, the Site borders the Karangahake National Park to the East.

The majority of the Kaimai Site is covered with exotic pasture used for pastoral farming, although there is some scattered remnant indigenous vegetation at the Site. These areas are not located



within the construction area for the Kaimai Wind Farm and will continue to be avoided through careful project design and implementation.

4. Design Approach

4.1. Design Iterations

2005 to April 2008 - 11 turbines (2MW)

Ventus Energy has been working on the project design on the Site since 2005, where initial data was collected from the first temporary monitoring mast installed and preliminary development plans researched. This was a preliminary scoping monitoring mast that was installed on the top ridgeline. At that time only one landowner, being Waitoki Downs Ltd (owned by Mr. Jim Shallue) was involved in the project (the previous owner to the Denize Brothers property).

October 2008 to 2012 - 27 to 32 turbines (3MW)

Waitoki Downs Ltd subsequently purchased the property to the south of the initial project area, thus in conjunction with discussion with the landowner, potential layouts were extended onto that property (Pukeroa Station). A 50m tall monitoring mast was installed upon the main ridgeline to confirm the wind resource. Project development became focused and concentrated on the main ridgeline adjacent to the DoC boundary in order to maximise energy yields and economic viability.

At this time the most productive turbines available were 3MW machines with rotor sizes of 90 to 100m diameter.

2013 to 2015 – 54 to 60 turbines (3MW)

As newer turbine designs that are suited to lower wind speed areas became available, the decision was made to extend the project footprint to the north of the original development area, hence Rotokohu Farms Ltd farm was included in the project. At this time the landowner to the south of Pukeroa Station also signaled their interest in the project. Extending the road south to include another 5 turbines was seen a small practical increment.

Bird and bat monitoring was extended along the entire main ridgeline. However it became apparent from the studies that a higher degree of bat activity was present to the south of the project. As evidenced in the Kessels Ecology report Attachment B6 in the AEE.

During 2015 the DoC estate to the east was designated as an ONL under the Waikato RPS. In conversation with landscape consultants and planning consultants it transpired that the further south the project extended, then the greater were the perceived effects on landscape.

Lastly, Waitoki Downs Ltd came under financial stress and as a result both properties were sold to different owners, Pukeroa Station was purchased for the purposes of a piggery development by



Kaimai Pork Ltd. Kaimai Pork itself became financially distressed and was sold in a bank liquidation. No development rights exist on Pukeroa Station currently.

As a result of landowner changes, and feedback from specialist reports a decision was made to curtail the project, and thereby significantly reduce the effects on landscape and bat habitat. Furthermore the changes enable the project to be located in the jurisdiction of one local authority to simplify the resource consent application process.

End 2015 to Early 2018 – 24 to 26 turbines (3+ MW)

A 60m monitoring mast (location A1) was installed on the Rotokohu Farms property in July 2016 to confirm financial viability of extending the wind farm site north. The wind resource was found to be suitable for the new generation of large rotor diameter Class III turbines, with mean annual wind speeds in the order of 7 to 8m/s.

The monitoring mast on the Denize property, (location A3) was re furnished and re installed in April 2016, and which has subsequently confirmed an excellent mean annual wind speed of approximately 9.5m/s. The combined average wind speed over the site is therefore calculated at 7.8m/s which then allows the project to be economically viable.

Hence a clear two stage type project has arisen with two defined areas, a lower ridgeline cluster and an upper ridgeline cluster. Collectively the wind turbines can produce sufficient output which supports the economic viability.

Within this period Maureen Jackson's landholding was also brought in to the project, allowing the placement of 26 turbines.

After consultation with stakeholders two turbines were removed from the project:

- The most northerly turbine due to its proximity to housing.
- A turbine between the lower ridgeline and upper ridgeline to make safer passage for gliders.

Historical design layouts can be found in the appendix of this report that show the design evolution.

Final Design Approach – 24 turbines (4+MW)

The proposal by Kaimai Wind Farm Limited comprises of a 24-turbine wind farm, built over 3 private landholdings. Of the 24 turbines, 17 are on the lower reaches of the Kaimai Range, and 7 are on the ridgeline. The turbine layout and number were arrived upon to optimise the Site utilisation for wind generation while mitigating potential impacts described in previous iterations.

With the size of turbine increasing over time it has become possible to reduce the number of wind turbines (and therefore increase spacing). This evolution is evident on the upper ridge, for example early turbine iterations on the top ridgeline allowed for 11 wind turbines, numbers were

reduced to 9 wind turbines, and finally now only 7 are proposed. Generally, fewer larger turbines that rotate more slowly are seen as more visually appealing, as opposed to greater numbers of smaller machines. Typically larger turbines also improve the project economics.

Two turbine sizes are utilised, the lower turbines experience lower wind speeds to those of the ridge line turbines, therefore machines with larger rotors are modelled (up to 160m diameter), and a slightly higher hub height (up to 132m). The ridgeline turbines are modelled with up to 146m diameter rotors and up to 112m hub heights. The smaller rotor size and lower hub height of the ridgeline turbines helps to reduce the visual impact relative to using larger models.

The turbine placement has been undertaken considering the various Site constraints, and aesthetics, in conjunction with the wind resource. A crucial aspect of the design is that turbines need to be suitably spaced for generation efficiency and operational reasons, so that an upwind turbine does not “shade” the wind from one downwind, reducing its capability to generate electricity. With respect to this requirement, any wind turbines within the project envelope are to be separated in so much as possible so that an ellipse drawn around each wind turbine does not overlap the ellipse drawn around any other wind turbine. The ellipse is orientated to the prevailing wind at 225 degrees from due north, with the major axis of the ellipse being 5 times the diameter of the rotor, and the minor axis being 2.3 times that of the rotor diameter.

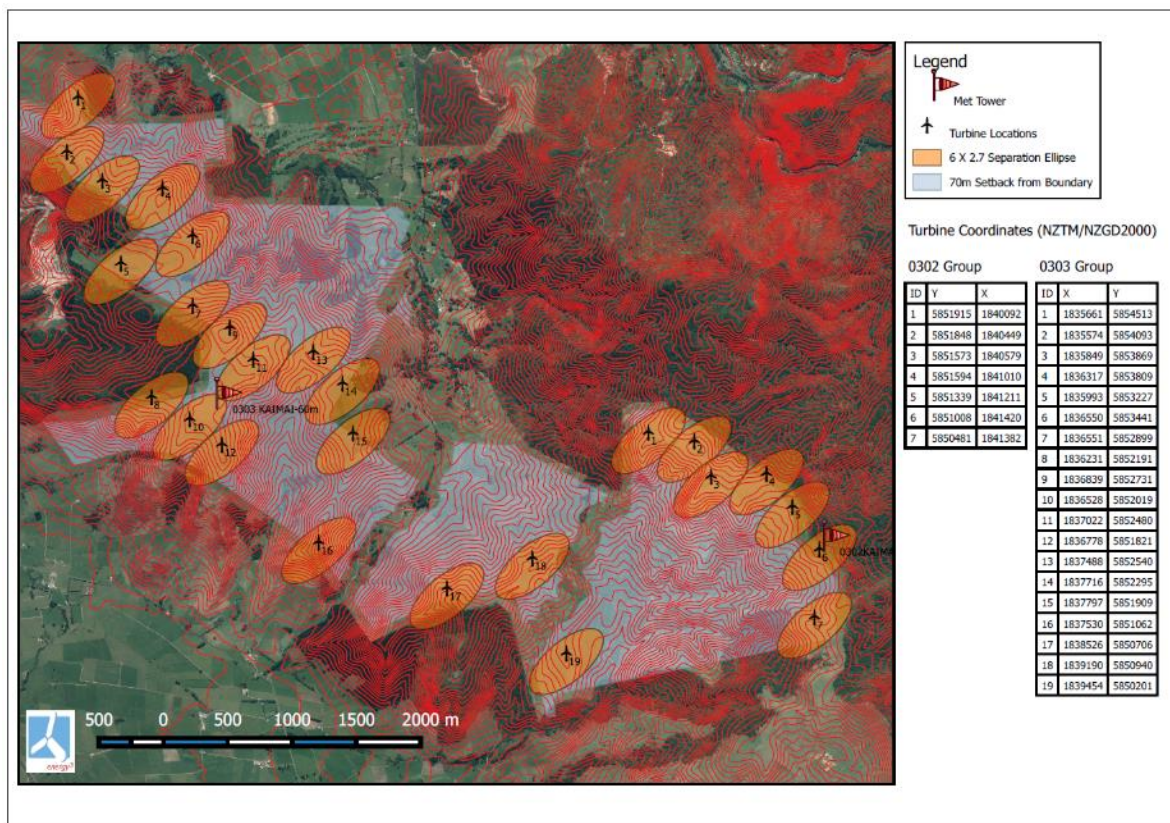


Figure 3: Ellipsoid spacing methodology which reflects dominant wind directions

5. Project Economics

5.1. Key Factors

A key analysis of generation projects is a discounted cash flow analysis to calculate financial feasibility. This is used to determine the Internal Rate of Return (IRR), a metric of financial viability. The financial models require key inputs to determine the IRR, these include:

- Power price, location in the national grid is a key factor
- DEVEX (Development Expense)
- CAPEX (Capital Expense)
- OPEX (Operational Expense)
- Annual generation output (a function of wind speed, turbulence and turbine type)
- FOREX rates – factored to calculate eventual CAPEX

If a project is expensive to build, for example it requires long access roads, must transverse very steep country, and has long distance to a suitable grid connection, then generally the generation output must be higher to fund the higher CAPEX.

Prior to the recent technological advances that have given rise towards larger turbines that are optimised for lower wind speeds (developed over past 2 years or so), a successful NZ project required an average wind speed of at least 8.5 m/s. Technological advances have now made it possible to justify a project with wind speeds as low as 7.5 m/s.

5.2. Kaimai CAPEX

The Balance of Plant (BOP) CAPEX (all other capital expenses other than wind turbines) for the Kaimai Wind Farm project is relatively low. This is due to relatively benign access largely utilising existing roadways, and very close proximity to the national grid requiring no external grid infrastructure. Another factor is that the planned capacity is sufficient to economically connect into the 110kV national grid, an expensive exercise.

5.3. Power Price

This aspect is covered in detail with the ERS report focusing on the Electricity Market. In summary the location of a wind energy project in NZ makes a significant difference on the revenue received.

For example, as there is a considerable amount of wind generation in the bottom of the north island, when the turbines are at full production, the wholesale electricity price drops by approximately 15% in that region due to the market forces of supply and demand. This produces a large impediment to building more generation in that part of the country. Curiously, this is where most of New Zealand's consented projects are located.

The geographic location of the Kaimai wind farm near major North Island load centres, and in isolation from other developments enables the project to receive proportionally higher electricity prices, contributing to a highly positive project.

5.4. Generation Output

Installing the largest rotor possible on any wind farm site benefits the generation output enormously. Every potential wind turbine location is therefore considered against the various manufacturer’s power curves and turbines, however structural loading must stay with the design parameters of the proposed wind turbine model.

The upper ridge turbines with a proposed hub height of 112m have an estimated wind speed of 9.5 m/s with low turbulence. It is therefore possible to install a Class II machine on this main ridgeline.

A power production chart relative to mean annual wind speed for the Vestas 4.2-136m model is show below, using a linear extrapolation it can be deduced that the energy output estimate is 20.5 GWhr/year/turbine. Which is an excellent annual production figure for such a turbine, consequently it is estimated that the 7 turbines on the upper ridgeline will produce approximately 144 GWhr/year.

ANNUAL ENERGY PRODUCTION

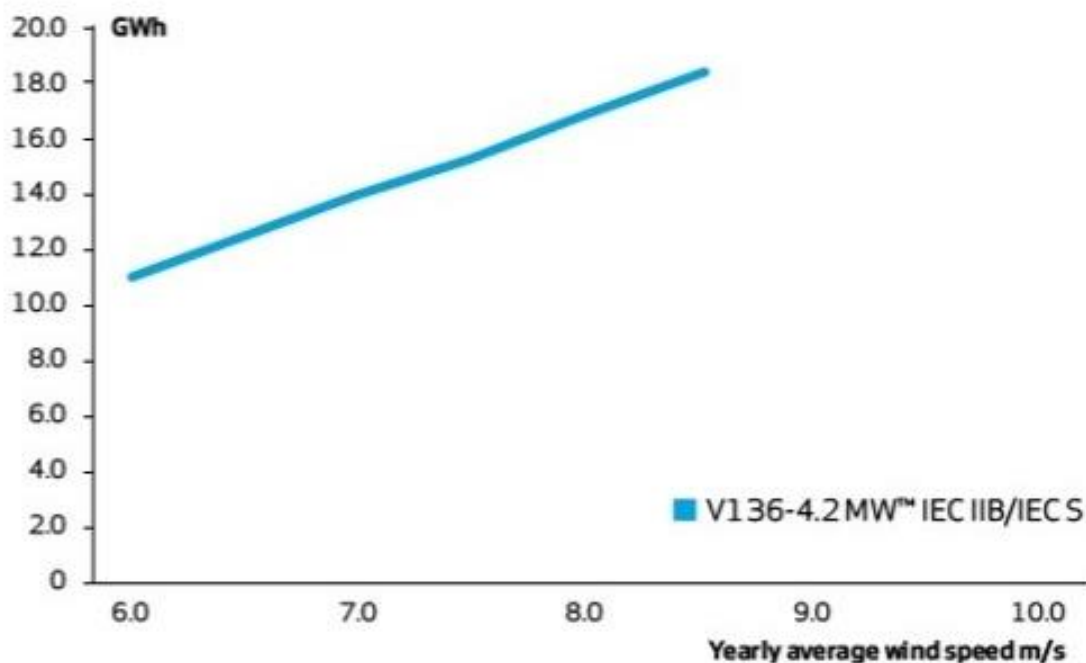


Figure 4: V136 Annual Energy Yield Relative to Mean Annual Wind Speed

The Vestas 4.2 – 150m is an appropriate machine to install on the lower ridgelines (turbine 1 to 17) where the average wind speed is 7.5m/s at the proposed hub height of 132m. This wind speed is at the upper end of the type classification of that turbine model, and will furnish an output of



approximately 16 GWhr/year. Applying the average yield across 17 turbines will yield in the order of 272 GWhr/year.

Gross output for the total wind farm is therefore estimated at 416 GWhr/year. Average gross output per turbines is factored at the level of 17.3 GWhr/year. This level of output/turbine pushes the project into financial viability.

The positive yield impact of the upper ridgeline turbines is therefore essential to the overall economic viability of the project.

ANNUAL ENERGY PRODUCTION

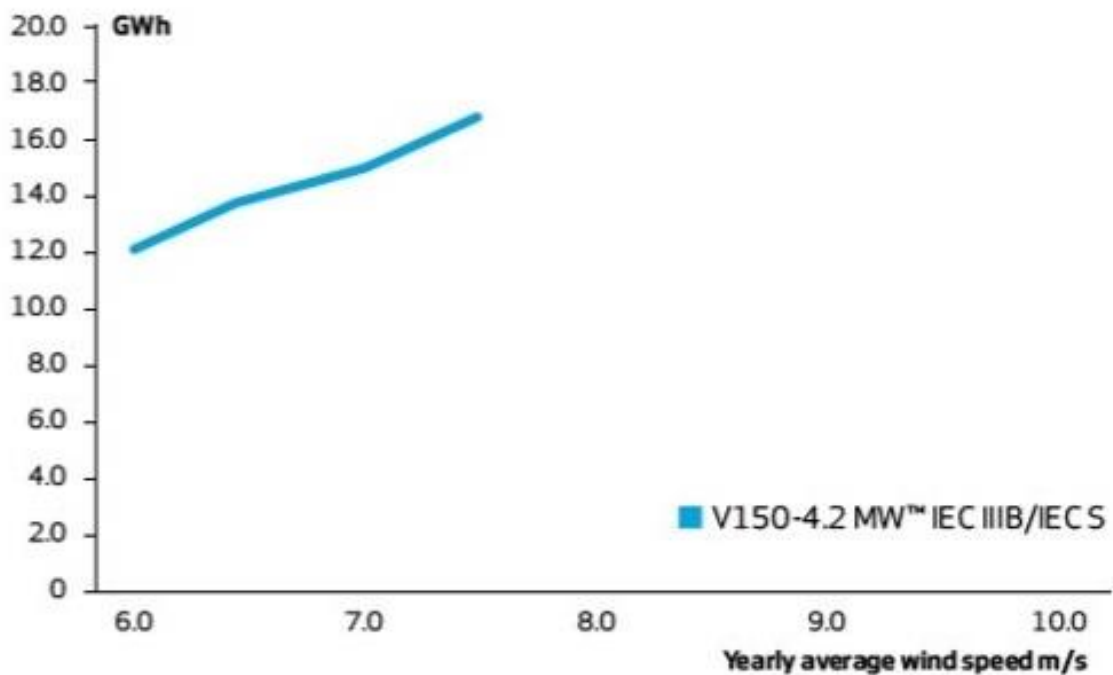


Figure 5: V150 Annual Energy Yield Relative to Mean Annual Wind Speed



5.5. New Zealand Economy Benefits

The expected Full Time Equivalent FTE jobs for wind farms are reported by BERL in a report commissioned by the Wind Energy Association. The phases and FTE requirements are as follows:

- Planning/Design/Project Management: 0.81FTE/MW
 - This timeframe is estimated as 18 months duration
 - Based on the metric supplied by BERL this creates approximately 81 FTE positions
- Construction: 1.79FTE/MW
 - This timeframe is estimated as 18 months duration
 - Based on the metric supplied by BERL this creates approximately 179 FTE positions
- Operation: 0.15 FTE/MW
 - This timeframe is estimated as 30 years duration
 - Based on the metric supplied by BERL this creates approximately 15 permanent FTE positions

Generally there will be a limited number of foreign specialists from the wind turbine supplier involved in commissioning and training, however otherwise all other FTE's will be NZ resident staff.

The total expected capex of the project is \$180M. This is made up of turbines, transport, and balance of plant at values of \$126M, \$12.6M and \$41.4M respectively. The balance of plant will be sourced locally.

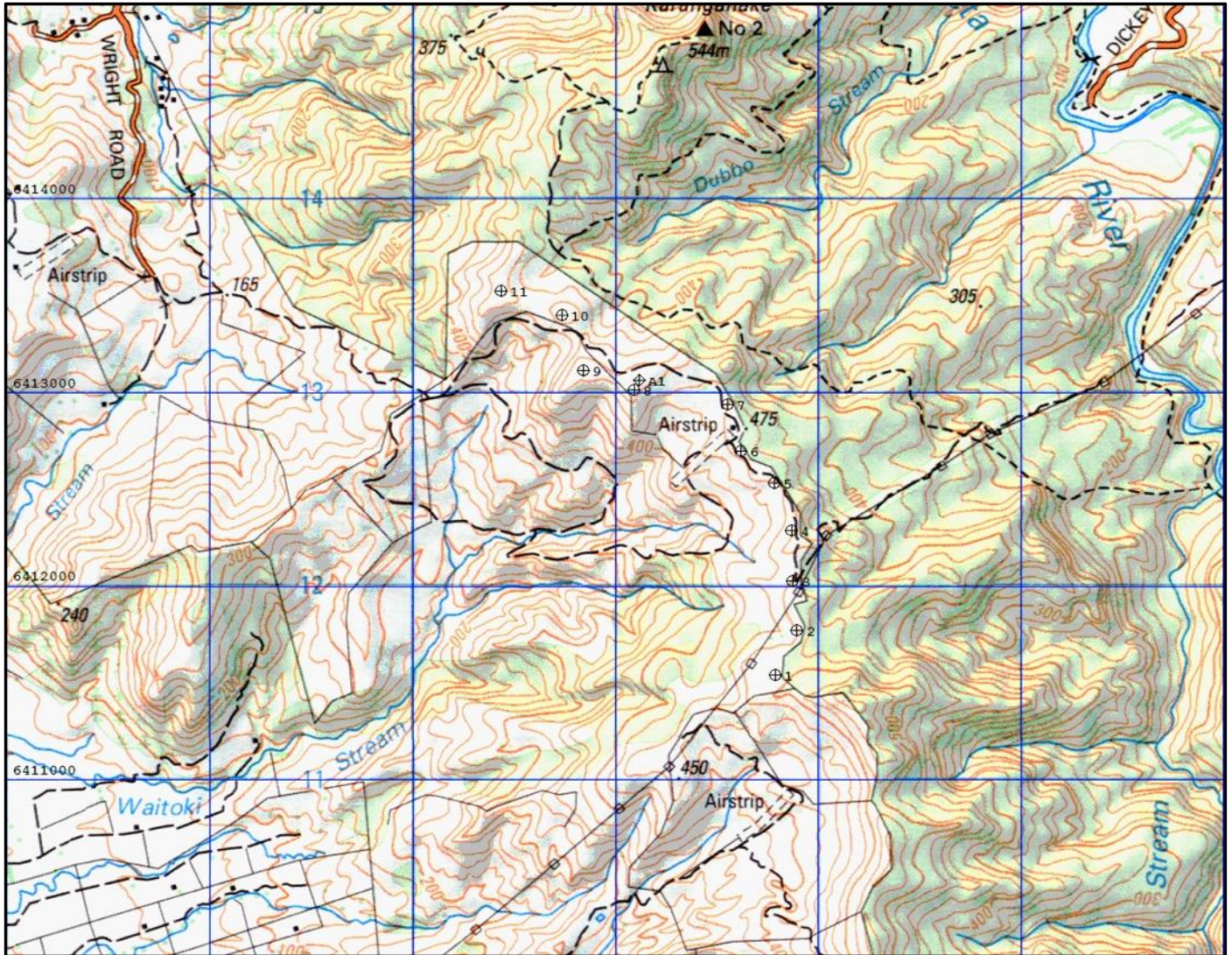


Figure 6: December 2007 Preliminary Layout – 11 turbines

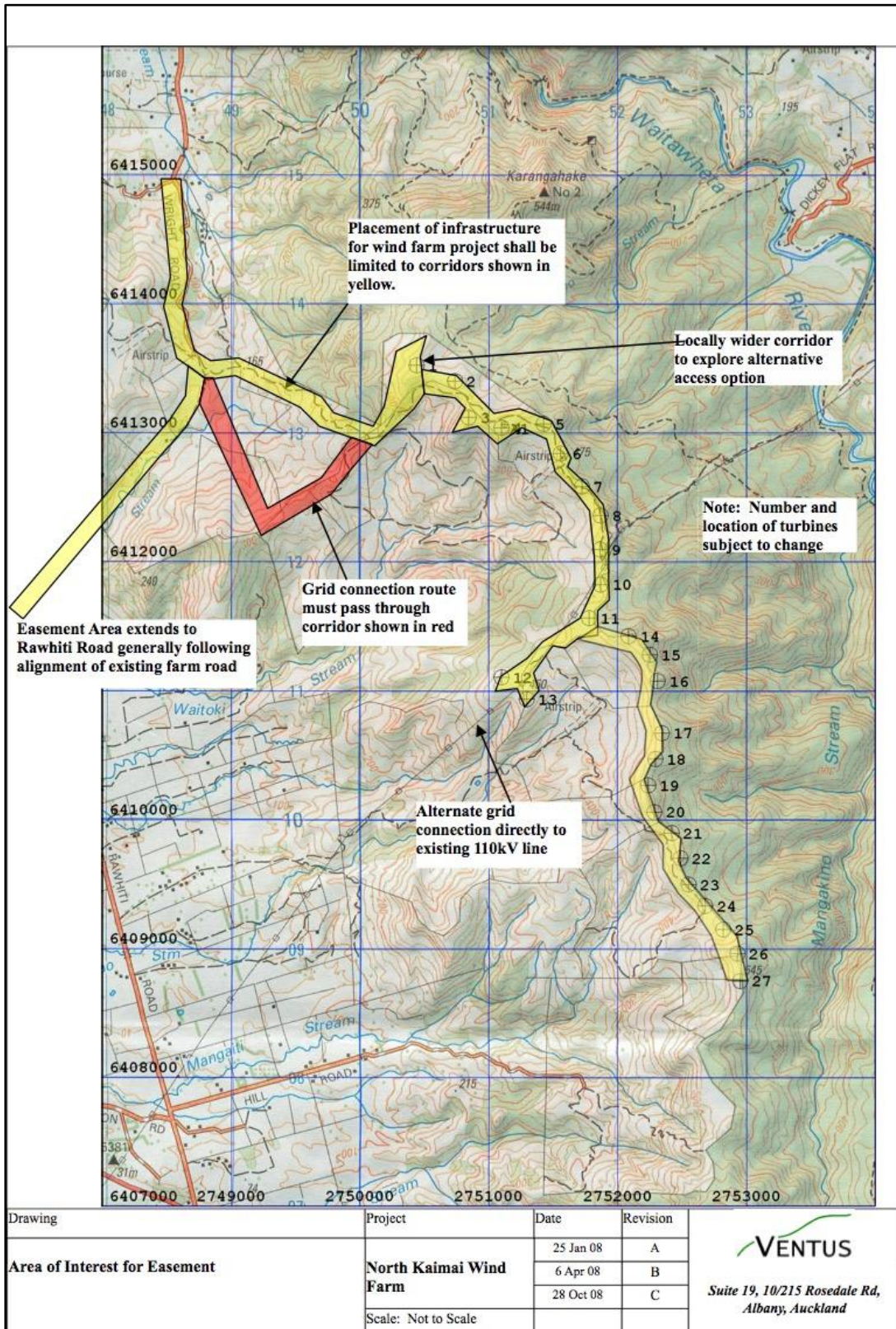


Figure 7: Oct 2008 layout – 27 Turbines

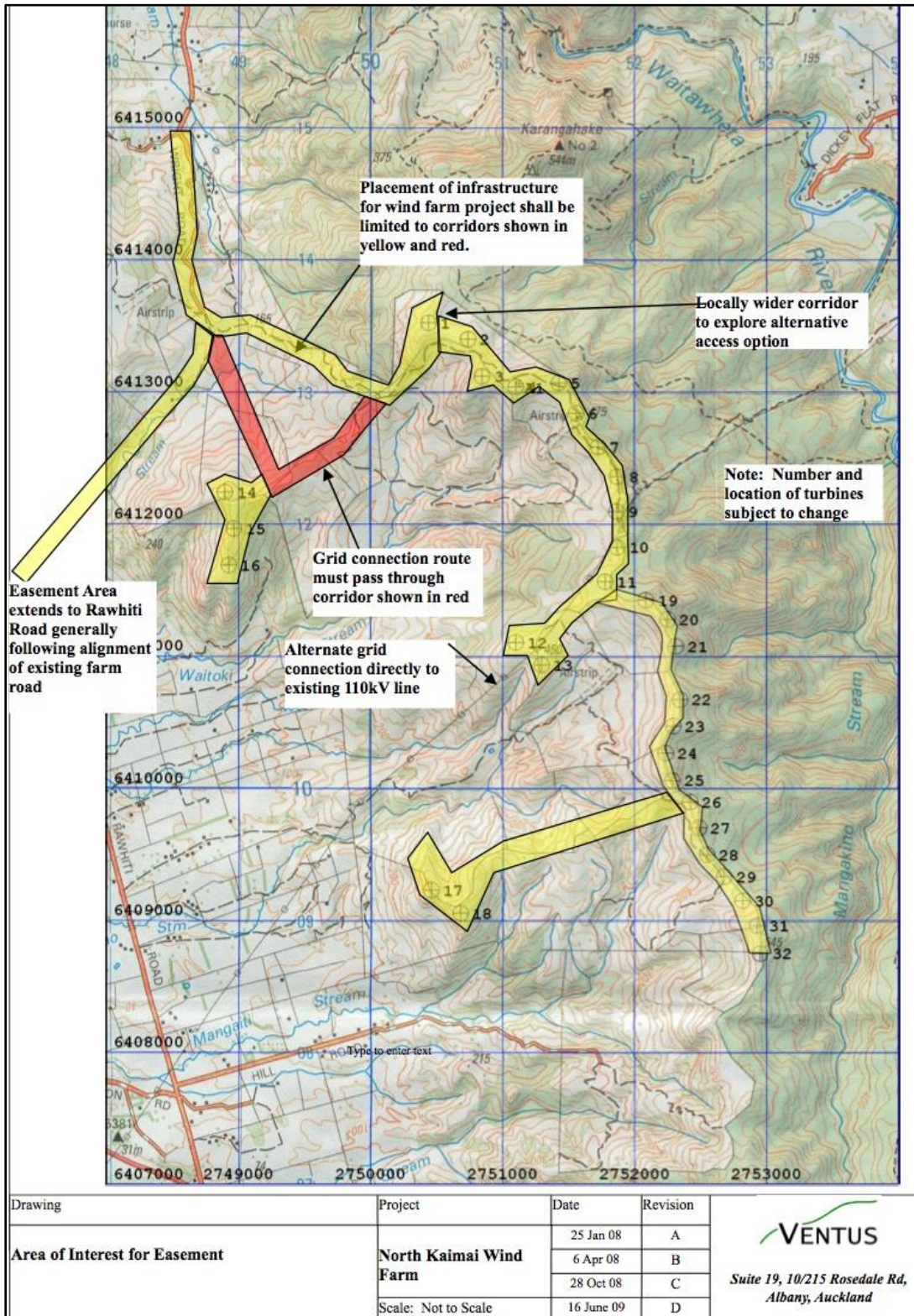
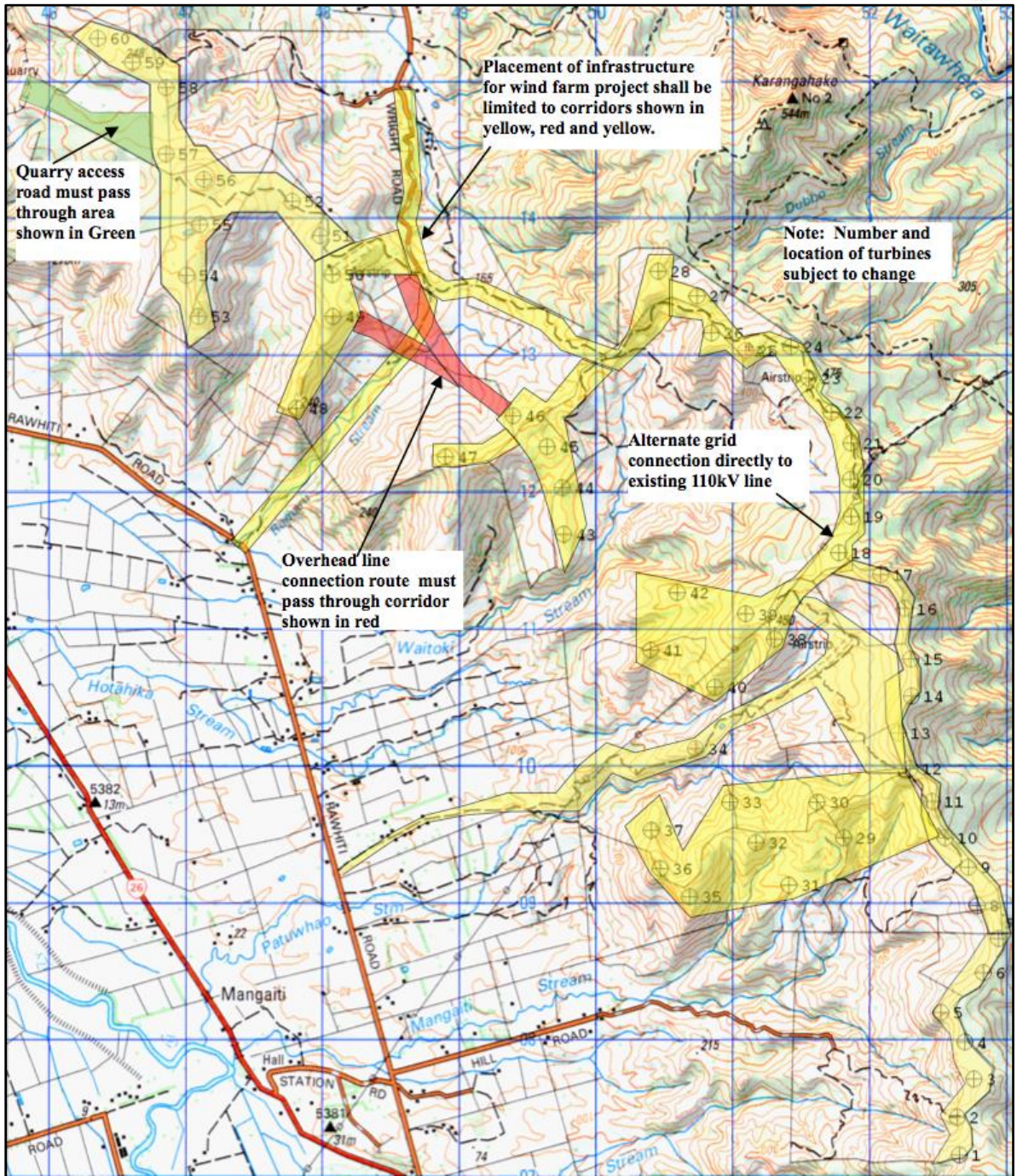


Figure 8: June 2009 layout – 32 Turbines




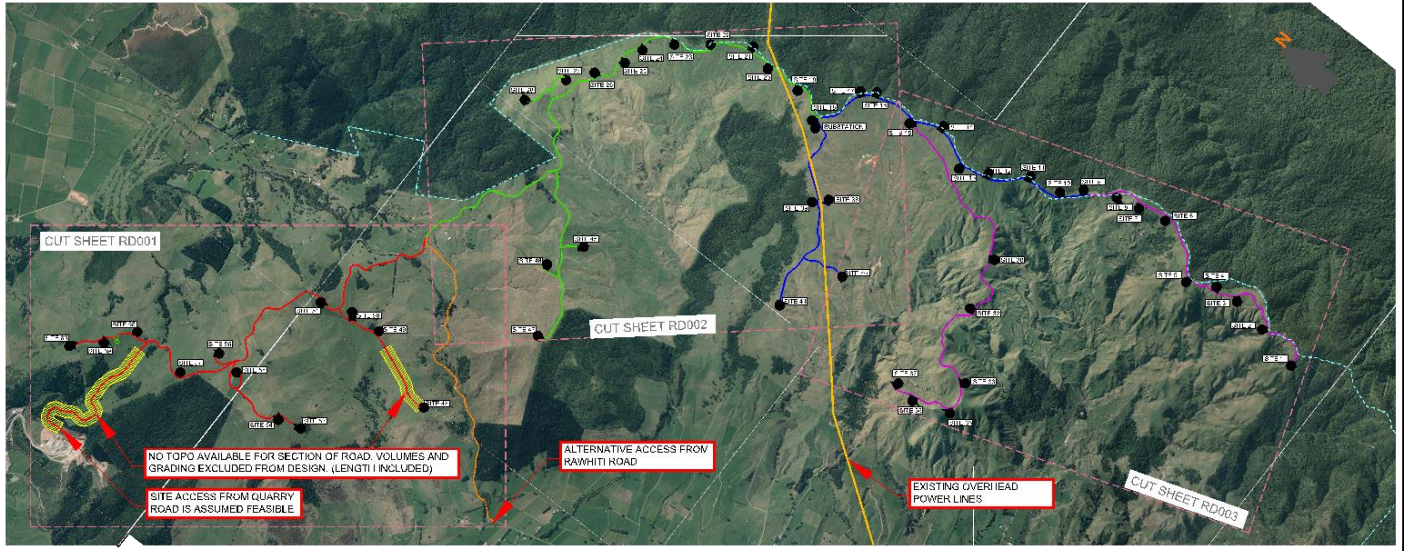
Drawing	Project	Date	Revision	 VENTUS Suite 19, 10/215 Rosedale Rd, Albany, Auckland
Area of Interest for Easement	Kaimai Wind Farm	19 Dec 12	E	
		15 Apr 13	F	
		22 Apr 13	G	
Scale: Not to Scale				

Figure 9: April 2013 layout – 60 Turbines



STAGING

STAGE	LEGEND	No OF SITES	TURBINE SITES	LENGTH OF ROAD	ROAD VOLUMES		PAD VOLUMES (40m X 30m)	COMMENT
					CUT	FILL		
STAGE 1		12	44 TO 45, 46 TO 60	8,300m	26,292m ³	16,537m ³	42,000m ³	NO TOPO AVAILABLE FOR SECTION OF ROAD. VOLUMES FOR TOTAL ROAD & 30 M PAD VOLUMES FOR SECTION ROAD EXCLUDED FROM TOTAL VOLUMES
STAGE 2		14 + Substation	45 TO 47, 18 TO 28	7,250m	126,526m ³	32,516m ³	52,500m ³	
STAGE 3		13	38 TO 41, 9 TO 17	4,855m	103,670m ³	19,195m ³	45,900m ³	
STAGE 4		14	11 O R, 30, 32, 33, 35 TO 37	6,180m	128,116m ³	83,211m ³	49,000m ³	
TOTAL		53		28,885m	384,504m ³	153,519m ³	185,900m ³	

ALTERNATIVE ACCESS

NAME	LEGEND	ACCESS FROM	LENGTH OF ROAD	ROAD VOLUMES	
				CUT	FILL
ACCESS B		RAWHITI ROAD	2,790m	10,759m ³	9,049m ³

LEGEND

DOC BOUNDARY


REV DESCRIPTION 1 LOCATION REVISIONS & SHT LOCATIONS REVISIONS 2 BOUNDARY ADDED	APPRD DATE JG 29/7/2013 JFG 29/04/15		PROJECT KAIMAI WINDFARM ROADING PLANS OVERALL ROAD LAYOUT	CLIENT VENTUS ENERGY LTD	DESIGN LOG DRAWN LD CHECK APPVD	SCALE 1:500 @ A3	DATE ISSUED 19/07/2011	PROJECT NO. 9147	DRAWING NO. RD000	REVISION (2)
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Figure 10: April 2015 layout – 54 Turbines

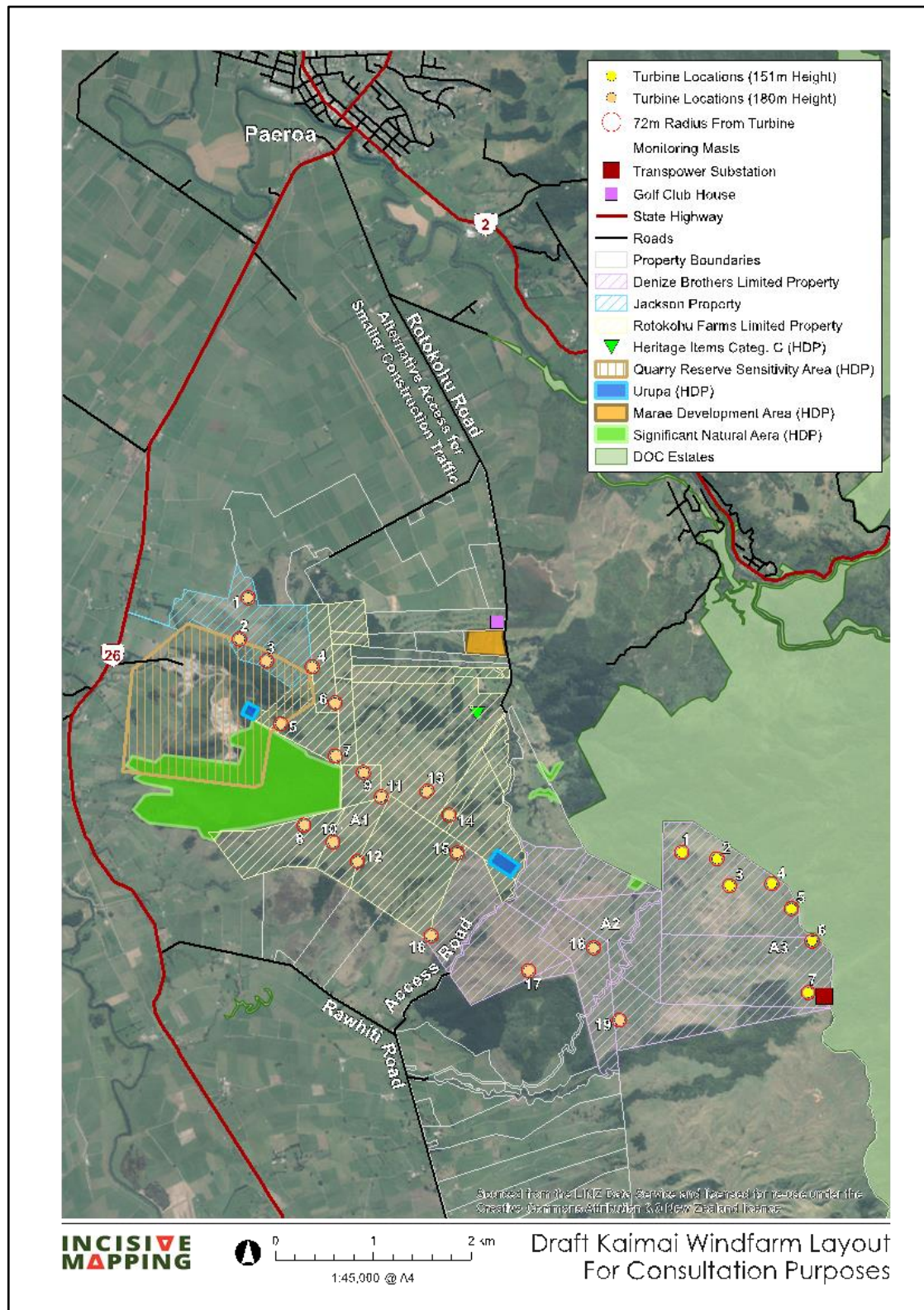


Figure 11: Dec 2016 layout – 26 Turbines

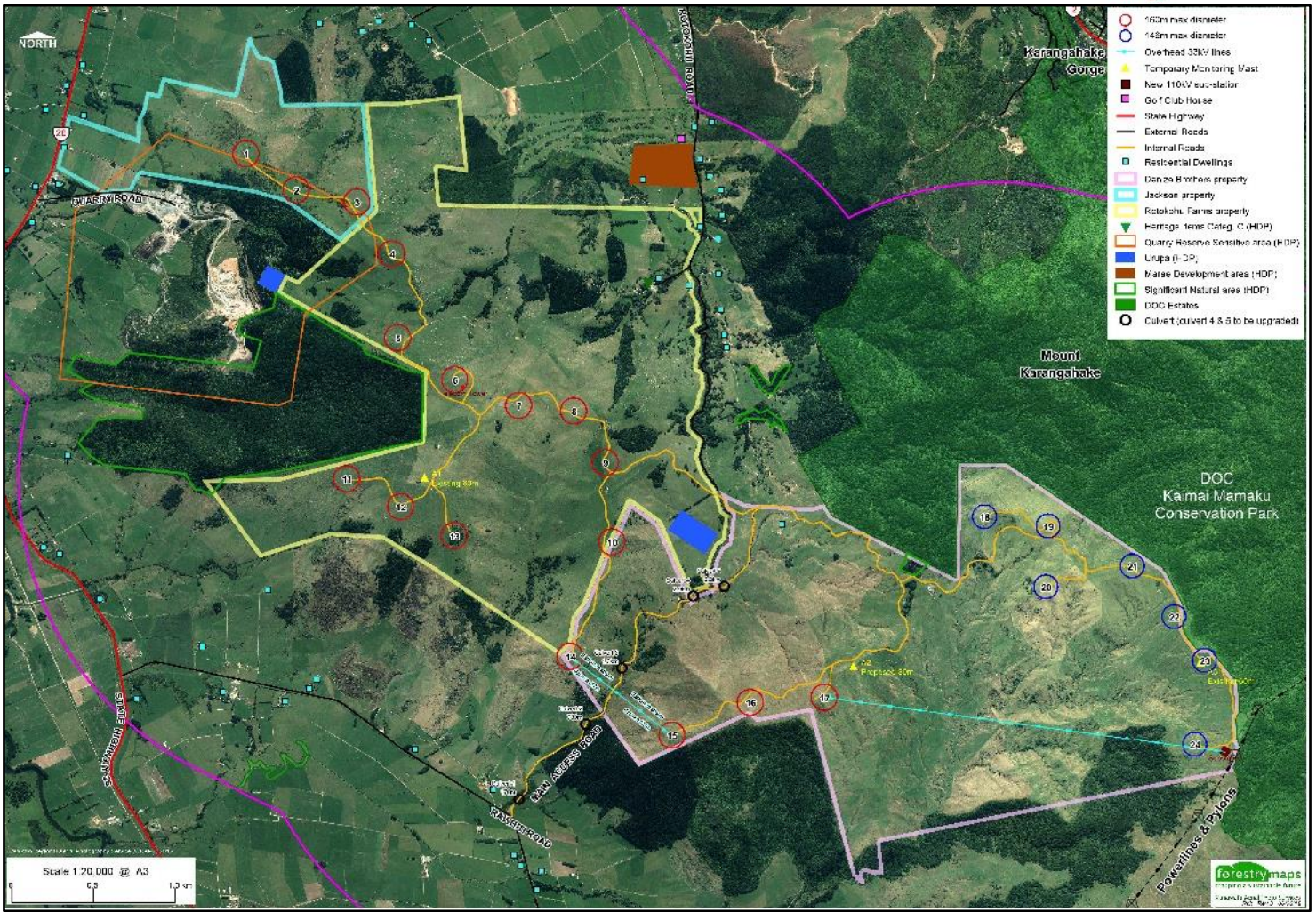


Figure 12: June 2018 layout – 24 Turbines