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***Long Gully Wind Farm
Windflow Technology Ltd***

***Civil Assessment of
Environmental Effects***

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Appendix 1 – Site Plans

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SK01	Proposed Turbine Sites, 1 of 11	06
SK02	Proposed Turbine Sites, 2 of 11	07
SK03	Proposed Turbine Sites, 3 of 11	06
SK04	Proposed Turbine Sites, 4 of 11	06
SK05	Proposed Turbine Sites, 5 of 11	06
SK06	Proposed Turbine Sites, 6 of 11	06
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1. Introduction

Aurecon was commissioned by Windflow Technology Ltd (Windflow) to complete the civil assessment of environmental effects for the proposed Long Gully Wind Farm, as part of the overall Assessment of Environmental Effects to support a Resource Consent application.

The Long Gully Wind Farm site is located on the hills south of Brooklyn and Karori, Wellington. The proposal is for up to 25 wind turbines, 17 on the ridge to the south of Long Gully (Hawkins Ridge) and 8 on the ridge to the north of Long Gully. The proposed turbines are all Windflow 500, 500kW rated turbines.

This civil assessment includes the following:

1. assessment of the parameters required to evaluate the magnitude of civil works;
2. confirmation of the overall civil works magnitude, including an assessment of the expected earthwork, roading, water and wastewater requirements associated with the project;
3. an assessment of the civil management measures that will be required with respect to the above; and
4. review of the above following confirmation of the other key project assessments, including the landscape and visual, ecological and geotechnical assessment of the project.

The impact of the project on the roading network outside of the site is being assessed by Traffic Concepts Ltd.

The proposed site location is depicted on SK00, Appendix 1.

2. Parameters required for civil assessment of environmental effects

In order to complete the civil assessment of environmental effects for the project, it was necessary to:

1. confirm the project requirements: i.e. the project scope, to enable confirmation of what civil services will be necessary to achieve the project requirements (refer scope above);
2. confirm the transport requirements of the various vehicles that would be accessing the site and confirm the associated “worst case” parameters;
3. obtain sufficient topographical and site inspection information for the site; and
4. confirm the geotechnical and ecological parameters for the site.

2.1 Transport Requirements

The Windflow W500 wind turbine is the wind turbine that will be utilised for the Long Gully Wind Farm. This wind turbine is approximately 30m to hub height, with a 33m swept blade diameter (two blades). The dimensions of the turbine parts are as follows:

Turbine Component	Length (m)	Width (m)	Height (m)	Net Weight (kg)
Nacelle in transport frame	5.7	2.4	2.5	10,000
Pair of blades in cradles	16.8	1.2	2.3	2,700
Tower top	14.5	1.6	1.6	4,700
Tower bottom	14.5	2.2	2.2	10,700
Electrical cabinet	0.4	1.0	2.3	300

Given the size and mass of these turbine parts they can be transported by trucks similar to semi-trailer units. Windflow and haulage companies have confirmed that these trucks can typically traverse grades of up to 1 (vertical) in 5 (horizontal) (for example about the maximum grade of a forestry road). The straight road width required is around 3m plus drainage channels. At curves in the road there are greater width requirements, depending on curve configuration, grade and road width. There is a significant network of existing farm tracks on the site (refer Section 2.2 below); the proposed wind farm can utilise many of these existing tracks.

It is difficult to model road width requirements on existing curving tracks without being overly conservative. As part of the site investigation works Windflow arranged for an experienced truck driver to drive the existing tracks (albeit not in a truck unit due to access concerns around the radar dome) and make comment on areas where the existing road is too tight and will probably require modification to enable transportation of the turbine pieces. We have supplemented this with our own specific review of the track surveyed geometry and our site observations to form the overall civil opinion regarding the extent of works required. This is discussed further in Section 3.

It is expected that two cranes would be utilised during the erection phase; a 50 to 60 tonne crane and a 100 tonne crane, with the 50 - 60 tonne crane completing the majority of the lifting and the 100 tonne crane completing the nacelle / rotor assembly lift. Windflow have estimated that the 100t crane will be on site for 20% of the construction timeframe, with the smaller 50 - 60 tonne crane on site full time. Although the 50-60 tonne crane will be utilised more on site the larger 100t crane is the governing crane in terms of design parameters for the crane pads (due to its size). Installation of the turbines will require a crane pad of approximately 20m x 10m (on road) or 20m x 7m (no thoroughfare required) for each turbine. Appendix 2 details the W500 Crane Pad Dimensions. It is expected that the crane will crawl between the turbines on each of the ridges. The crane may be broken down and transported between the two ridges due to the lengths of quite steep grades along this intermediate 2.5km length of track.

2.2 Site Visits and Topographical Information

The site is south of Brooklyn and Karori, Wellington. The turbines are positioned on the two ridges either side of Long Gully. The topography is steep, with many surrounding slopes greater than 28 degrees.

5m contour data is available for the wider area around the site. Windflow arranged for the production of 2m contour data (+/- 1m) for the area surrounding the turbines (out to 200 m), from New Zealand Aerial Mapping. Aerial photographs were also obtained for the site.

During initial site visits it was recognised that additional information was required to confirm the details of the significant network of existing farm tracks. Some of the tracks were relatively new and not mapped on existing topographical information or visible from existing aerial photography, there was also no separate as-built information available for these tracks. A basic survey of the tracks was therefore carried out, including the centreline, track edge and associated batters, for use in the preliminary and detailed design stages. Several site visits were also carried out by civil engineers, to validate the office based assessment work.

2.3 Preliminary Geotechnical and Ecological Parameters

The civil assessment assumed parameters of 1V:1H for cut faces and 1V:3H for fill at this preliminary stage. The geotechnical assessment undertaken by Aurecon notes that sites in rock will likely be able to be cut steeper than this.

Immediately east of the Hawkins Hill ridge is the regionally significant Waipapa Stream catchment. Other turbines are also within the Karori Stream catchment. Throughout the site the topography is very steep and on-site erosion and sediment control will form an important part of managing the earthworks. Where possible it will be preferable to keep earthworks offset from steep areas, to help facilitate erosion and sediment control.

There were no other recorded site-specific ecological parameters in the immediate vicinity of likely earthworks (such as Recommended Areas of Protection, Listed Streams etc) that impacted specifically on the civil aspects of the project. The ecological assessment undertaken by Wildland Consultants identifies that disruption to rock outcrops should be avoided in order to protect potential lizard habitats. It is expected that this will be feasible in most cases as the rock outcrops tend to be isolated, allowing the track upgrades to be designed around them; the turbine micro-siting process will also be employed to minimise such disturbance.

3. Civil assessment of environmental effects

This section includes detail on the upgrade to the existing farm tracks that are required as part of the works, as well as detail on the new short access tracks to the turbines and the associated crane pads for construction.

It also summarises the expected magnitude of earthworks for the site, and provides detail on key construction issues such as erosion and sediment control and drainage.

3.1 Access Track Upgrade

For the most part the review by Aurecon and a drive over by an experienced truck driver resulted in confirmation that the existing farm tracks are generally sufficient for construction of the wind farm without modification. To demonstrate the limited amount of new earthworks that are anticipated to be required in the construction of this windfarm, plans have been developed to a higher level of detail than is usual for this type of work at this stage. The plans show the existing farm tracks which have been surveyed on site for accuracy. The road alignments have been reviewed by an experienced roading engineer with respect to the size of vehicles that need to access this site. The most notable potential pinch points (although these are still relatively small in scale) have been identified and shown on the drawings.

In summary, there are several areas where earthworks will be required which include the following:

1. New short access track lengths where the turbine position is offset from the existing road. In total these amount to approximately 500 to 600 m of new track, the design of which is integral with the detailed design of the turbine platform areas. The indicative alignments have been shown on the site layout plans SK01 to SK10. The track lengths are generally short and simply run from the main access track to the turbine platforms such that their grades do not exceed 1V:4H (preferably 1V:5H or flatter). Given their short lengths the above constraints effectively provide the parameters for construction so it is not anticipated that further detailed track design beyond that already shown will be necessary (except possibly for the longest track lengths to the sites that are most distant from the main access road).
2. Around the Radar Station (road has multiple curves and is confined by fence lines and a high wind-shield wall with steep drop offs on both sides of the ridge).

This road will need to be adjusted as part of the civil works. Discussions are ongoing with Airways to confirm the preferred modifications (various scenarios would be acceptable to preferably avoid the need for a retaining or bridging structure over the head of the gully). The most effective solution is expected to be to cut back part of the inside retaining wall and bank as well as remove some of the low wall on the outside of the track. The final solution in this area will need to be agreed with Airways.
3. The road along the floor of Long Gully may be used for access and egress to the site. One hairpin bend (Refer SK13) has been identified that may require some local widening to ease the passage of the largest trucks.

4. Several road lengths are likely to require batter trimming to widen the road and ease corners. The areas where most work is required (although still minor in nature) have been shown on drawings SK01 to SK10. It is expected that many of the finer details will be best resolved on site in consultation with the Engineer ie. fully detailed geometric roading alignment drawings would not usually be developed for the construction of site haul roads in this type of situation.
5. Several road lengths will require “smoothing”, to:
 - reduce the vertical curves on the road and ensure the long trucks do not bottom out (for example at the low point of the track crossing Long Gully), and/or
 - even out the grade to ease truck movement, where the grade exceeds 1V:5H

An example of this is the track from Hawkins Ridge down to Long Gully. It is steeper than 1V:4H in places, on winding sections of road. In general a grade of 1V:5H is the preferred maximum grade. The earthworks required to modify the grade of this road to make it 1V:5H would be significant. It has been assessed, based on turbine layout and available existing farm tracks, that it will be more suitable for unloaded trucks to (where necessary) exit the site via the existing farm track that runs northeast up the base of the gully. This will prevent the need to traverse up this steep and winding access track, thereby minimising the upgrade work required on this existing track. Loaded trucks will navigate down this section of track; with minor upgrade, due care and an adequate running surface this will be achievable.

6. Some minor earthworks coupled with the placement of some areas of hardfill (only in soft zones) will be required to provide vehicle turning areas at the ends of the Hawkins and Northern Ridges. For the longest vehicles on the Hawkins Ridge there is a good turning area adjacent to turbine 17 (Refer SK01). On the Northern Ridge there is space adjacent to Turbine 19. The last turbine (No18) has less room so it may be best to access the last 100m of track by reversing from turbine 19. The majority of vehicles (which will be shorter) can run directly to Turbine 19 and turn (Refer SK10). Detailed procedures will be developed as part of the Construction Management Plan to address these site construction issues.

All of the above-described work is relatively minor, from a civil engineering construction perspective. In general the earthworks associated with these upgrades will be in cut, due to the steep terrain. These earthworks will generate excess cut material that will require disposal (refer Section 4).

The locations of the above works are indicated on plans SK00 – SK10. Sketches of typical cross sections of an access track are shown on SK12. These plans also include photographic references along the access tracks, for clarity. These photographs can be found in Appendix 3. Parameters for the largest vehicles expected on site (lengths and indicative turning circles including allowances for the overhanging load) are included for information in Appendix 4. It should be noted that actual vehicle turning manoeuvres can generally be achieved in a smaller space than that modelled since the turning circles shown are based on a continuous forward movement and 95th percentile vehicle characteristics.

3.2 Crane Pad Construction

Each of the turbines requires a crane pad for construction. It should be noted that for this preliminary level of design a simplistic turbine / crane platform configuration has been used. It is anticipated that earthworks volumes will be reduced during detailed design by melding the platform shape more to the localised site topography e.g. corners can be rounded, platform areas reduced or the degree of crossfall increased to suit the terrain. These pads are indicatively 7m wide x 20m long, with the road width (3m) additional to the 7m width should access past the turbine be required during construction. Many of the turbines have crane pads of 7m x 20m as they are located 10-15m off the road. In some situations it is expected that it will be necessary to temporarily restrict access past a crane pad during construction of the associated turbine, in order to restrict the necessary crane pad width to 7m (for example in the Turbine 7 location). This will be a construction sequence management exercise. Construction of the pads could be described as relatively minor, with the estimated earthworks cut volume for each pad varying from negligible to 300m³, the average being around 100m³ per crane pad.

The indicative crane pad locations are indicated on plans SK00 – SK10, along with estimated earthworks quantities for each crane pad. Some slight modifications to some turbine locations (< 5 metres movement) during the micrositing process would assist with the placement of crane pads and move turbines clear of existing farm tracks, thereby facilitating construction.

The turbine foundations are expected to be mono pile foundations. Pile foundations require a lesser volume of earthworks than shallow pad footings and the smaller footprint reduces their environmental impact when compared to shallow pad footings. For additional information regarding the turbine footings refer to the Aurecon Geotechnical Report.

3.3 Earthworks Volumes

It is expected that the total earthwork volume (including new access tracks, crane pads and pile foundations) are unlikely to exceed 10,000 m³ – the estimate is approximately 7,500m³. It is expected that around 75% of this volume (approx 6,000m³) may need to be disposed of as excess material (with the rest of the material utilised as fill). See section 4.1 regarding earthworks disposal. Earthworks will be minimised as much as possible on site. Indicative locations of the expected earthwork areas are depicted on the plan drawings (SK01 – SK10), located in Appendix 1.

3.4 Services Assessment

There will be water and wastewater requirements on site both during and post construction. During construction it is expected that portaloo's and tankered water will be utilised. A permanent operation and maintenance building of 100-150m² is proposed for the site (site adjacent to T12, refer SK00). It is expected that this building will incorporate permanent water and wastewater facilities.

On-site wastewater disposal may be utilised for this building. The expected usage is very low, such that it is expected that regional resource consent will not be required (depending on final location and soil conditions etc).

4. Civil management measures

4.1 Management of Disposal of Excess Cut Material

The majority of the crane pad construction will need to be in cut, not fill. This need arises due to the difficulty of forming stable, relatively flat, fill slopes in the steep terrain. This approach to crane pad formation will result in a surplus of excavated cut material that will need to be disposed of on site in a controlled manner. Site disposal will also be required for excess spoil associated with the access track upgrade, as discussed in Section 3.1. All excess material will be disposed of carefully in suitable locations, and will require erosion and sediment control, regrassing and permanent stabilisation. Due to the nature of the topography most of the disposal sites will be small blanketing fills (less than 1m depth) that will be rehabilitated and blend in and “smooth out” areas of the ridge-top topography, with no material change to the ridgeline. Where appropriate some material will also be used to landscape around the edges of the crane pads following construction.

It would not be desirable to create fill disposal areas in gullies around the site due to the extremely steep nature of much of the topography; it would be difficult to stabilise fills in these areas, even with benching and other engineering measures. There are also areas throughout the site where the terrain is wider and flatter (for example around T17), areas such as this will be utilised as excess material disposal areas where necessary. The final detailing of the disposal zones will include measures to:

- reflect the existing scale and topography of the site
- ensure rock outcrops or significant natural features or vegetation are avoided and not buried
- ensure the surface compaction is suitable to establish and support re-grassing or other vegetation as necessary
- ensure all stormwater control requirements and erosion and sediment control measures will be met

Within the Long Gully site there is an existing airstrip adjacent to the base of the gully. At the northern end of the airstrip there is a proposed disposal site that can accommodate a large amount of spoil, indicatively more than 7,500m³ (refer SK00 for this location). This site will be utilised as required for excess spoil. If there are any issues on site with respect to locating adequate disposal zones that meet the criteria (based on the parameters above, which will be further expanded during detailed design) it may be necessary to transport some excess cut material off site and dispose of the material in a legal manner in accordance with the Council requirements. This is a worst-case scenario and it is not anticipated that this will be required, due to the large size of the site, the limited amount of excess cut that will be generated, and the large additional disposal area at the northern end of the airstrip.

4.2 Stormwater Management

Stormwater will be managed within the site during construction (and through to site stabilisation following earthworks) to minimise the potential for sediment movement. The existing catchments will be maintained as much as possible. That is, wherever possible the existing topographical shapes that direct stormwater will be retained.

Permanent open drains will be constructed along the base of significant new cut batters for collecting stormwater run-off. It is expected these drains will be mostly unlined. In some areas (for example in areas of steep track grade) erosion control measures may be utilised, such as rock check dams, rock lining or hydroseeding. Detailed design of the stormwater management measures will determine the required location, size and spacing of the culverts required under the access tracks. Any discharge point protection measures required will be designed to minimise the potential for erosion.

Existing vegetation buffer strips will be retained between earthworks and steep slopes where possible, as recommended in the Geotechnical Report.

Due to the location of the turbines on ridge tops, there do not appear to be any continuously flowing watercourses directly affected by the works. However, erosion and sediment control measures (refer below) will be required to ensure that the potential for downstream effects are minimised.

4.3 Erosion and Sediment Control

Erosion and sediment control will form an important part of the earthmoving construction process. All land disturbance activities have the potential to increase erosion and generate sediment discharges, however with appropriate planning and controls in place the impact on the receiving environment can be minimised.

The most effective measure for reducing sediment discharges is to minimise the potential for erosion; this can most effectively be achieved by minimising the size of the disturbed area and maintaining vegetated zones. The construction earthworks being undertaken at any one time will be limited to only the necessary areas, and exposed surfaces will be stabilised as appropriate as the earthworks proceed. Stabilisation of all new slopes and batters will be undertaken as part of the construction works, as well as re-grassing. Where required for the purposes of the wind farm, stabilisation of existing slopes and batters will also be undertaken.

An Erosion and Sediment Control Plan (ESCP) will be prepared pre construction. The plan will detail the way on-site erosion will be minimised and how the treatment of any potential sediment laden overland flow will be undertaken. The general philosophy of the ESCP will be to minimise the overland flow of stormwater through the disturbed areas and to utilise filter materials such as hay bales, silt fences and natural vegetation around the construction boundary to act as a filter zone.

4.4 Civil Construction Materials

Civil construction materials include fill, road pavement materials and turbine foundation materials. Any fill required will likely be sourced on site from suitable cut materials (greywacke that is not too highly weathered). Some of this material may be suitable for use as subbase in the road pavement. Additionally, quality basecourse material may be required to construct suitable running surfaces for vehicle access on new or reconstructed tracks during construction and ongoing maintenance. Some basecourse

material may be imported to the site if the site material is not of sufficient quality. This is most likely to be AP40 rock from an established Wellington quarry. It is expected that the number of truck and trailer unit movements could be 100 – 200. It is not expected that the site roads will be sealed.

It is expected that each turbine foundation will require between 32m³ to 130m³ of concrete, depending on the final foundation type (piled foundation or shallow pad foundation). There are up to 25 proposed wind turbines: the total reinforced concrete requirement is between 800m³ and 3,300m³. As piled foundations are preferred by Windflow it is expected the concrete foundation requirement will be less than 1,200m³ (with the piles at 2.4m diameter and up to 10m deep). Concrete will be transported to site in concrete trucks. Reinforcing steel will also be transported to the site in the form of prefabricated cages.

4.5 Construction Traffic Management Measures

Access to the site for recreational users including walkers and mountain bikers is currently generously allowed by the landowner throughout the majority of the site. Vehicle access to the length of road from the Brooklyn Turbine to the “Castle” is restricted by a locked gate beyond the turbine but is accessible to the public on foot or bicycle at all times. Given that the main access track within the site is essentially already in place, the extent of earthworks required across the site is relatively minor. Heavy trafficking by construction vehicles will thus tend to be sporadic and most works undertaken off the access road. Construction vehicles will also only be moving at slow speeds both approaching and when on the site roads.

On the basis of the above it is anticipated that during construction, public access around parts of the site will only need to be curtailed at particular times for safety reasons. For example this might be when concreting of turbine foundations is being undertaken when there is a concentration of concrete delivery truck movements. Recreational access at the weekends (when work is not being undertaken) should still be possible over the majority of the site. The largest vehicles on site will be standard road legal vehicles (with the longest loads extending slightly over the rear (Refer to Appendix 4 for vehicle parameters). There is no requirement for oversize transporters to deliver turbine components.

It is proposed that a detailed Construction Traffic Management Plan be prepared prior to the commencement of construction. This would be based on the consented turbines positions and would include issues such as:

- Construction vehicle routes and turning areas
- Traffic access and site movement protocols
- Potential conflict areas with the public
- Public safety (Including identification and treatment of potential public/construction conflict points).
- Systems for monitoring and enforcement of traffic behaviour and modification of protocols as required
- Signage to advise the public of construction processes
- Driver education/training for construction personnel
- Public information releases (flyers / signs / advertising etc) to inform the public at different stages of the work.

5. Summary and conclusion

There is a significant network of existing farm tracks on the site; the proposed wind farm can utilise many of these existing tracks. The civil construction work required to upgrade these existing tracks and provide new crane pads (with associated short access tracks as required) is relatively minor in scale.

There are a number of key construction issues that will need to be addressed prior to construction to ensure the effects on the environment are no more than minor. These include:

- management of disposal of excess cut material
- stormwater management (both temporary and permanent)
- erosion and sediment control measures

Employing standard engineering procedures for steep construction sites will ensure that the above issues are adequately managed both during and post construction, ensuring the effects on the environment will be no more than minor. These standard procedures will be developed into site-specific requirements in the detailed design phase of the project.

APPENDIX 1

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APPENDIX 2

Windflow W500 Crane Pad Dimensions

APPENDIX 3

Site photos (referenced on SK01 – SK10)

APPENDIX 4

Indicative Construction Vehicle Parameters