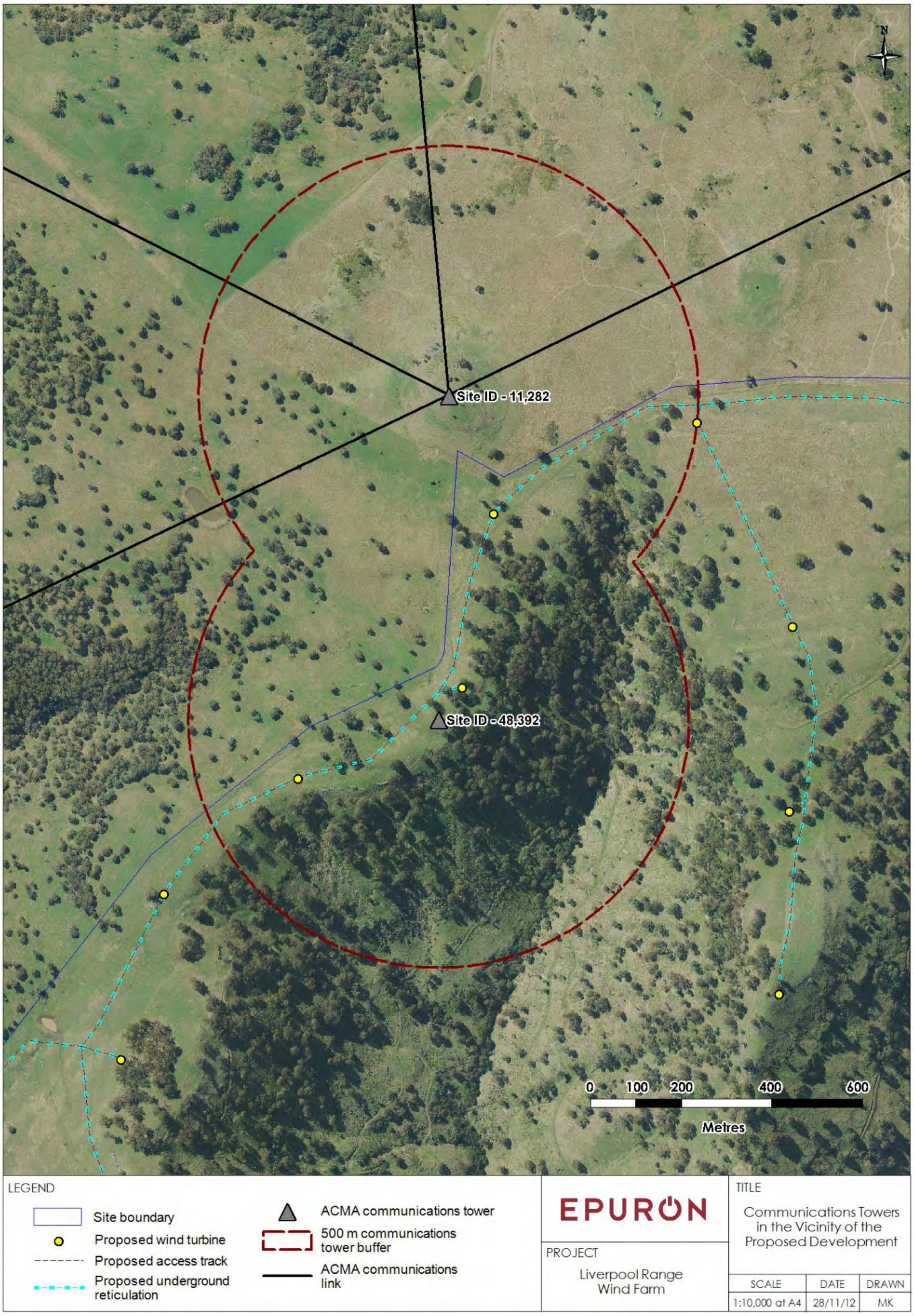

Figure 14-8 Radio Communication Towers within 500 m of wind turbines

14.2.5 Mitigation Measures

As a result of the exclusion zones established in planning the wind farm, the possibility of impacts to existing point to point communication links is reduced. However, in the unlikely event that interference is predicted or observed, the proponent is confident that impacts will be able to be mitigated using the following techniques:

- relocation or removal of wind turbine locations prior to construction;
- modifications to or relocation of the existing antennae;
- installation of a directional antennae to reroute the existing signal;
- installation of an amplifier to boost the signal, and/or;
- utilisation of onsite optical cable to reroute the original signal.

14.3 Electromagnetic Fields

14.3.1 Background

Electromagnetic fields (EMF) (having both electric and magnetic components) are generated by all electrical devices including household appliances (televisions, lights, electric blankets etc.), powerlines, substations and wind turbines. Generally, scientific evidence does not firmly establish that exposure to 50 Hz electric and magnetic fields from these sources are a hazard to human health. Current science would suggest that if any risk exists, it is small (ARPANSA, 2011a).

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) has produced fact sheets which state that studies to date have consistently shown that there is no evidence that exposure to low level electric fields (such as those found in the home or in most workplaces) are a health hazard. In the same text, it states the possibility remains that intense and prolonged exposure of magnetic fields may increase health risks (ARPANSA, 2011a).

In relation to EMF, the issues associated with wind farms are no different to the issues associated with the electricity industry in general and the use of industry best practice (and in particular the appropriate location of associated powerlines and related easements) should ensure EMF risk is adequately managed.

ARPANSA was formed in 1998 as a Federal Government agency charged with the responsibility of protecting the health and safety of people and the environment, from the harmful effects of ionising and non-ionising radiation. ARPANSA is currently developing guidelines on exposure limits to EMFs but in the meantime they still refer to the National Health and Medical Research Council Interim Guidelines (ARPANSA, 2011b).

The *National Health and Medical Research Council Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields* recommend a limit for 24 hour exposure of 1000 mG for magnetic fields and 5 kV/m for continuous public exposure to electrical fields (NHMRC, 1989). These values are consistent with the 50 Hz values of the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998). They note that research suggests that health effects are associated with prolonged exposure; measurements at one point in time do not accurately reflect prolonged exposure levels. As an update in 2009, the ICNIRP stated that based on the latest scientific literature, these recommended limits above remain in place.

Electric fields can be reduced both by shielding and with distance from operating electrical equipment. Magnetic fields are reduced more effectively with distance from the equipment.

Potential for EMF impacts occurs only during the operational phase of the wind farm when electrical infrastructure is capable of generating electromagnetic fields. The electromagnetic fields produced by the wind farm infrastructure would vary at different locations onsite, as discussed below. No impact mitigation is considered to be required for the construction and decommissioning phases.

14.3.2 Assessment

Powerlines

The maximum voltage of the underground and overhead powerline cables connecting turbines to the collection substations within the site would be either 22 kV or 33 kV. At the collection substations, the voltage would be stepped up to a maximum 330 kV, and transmitted along 330 kV overhead powerlines to a connection substation which will be connected to a new adjacent TransGrid connection switchyard, also adjacent to the existing TransGrid transmission network, where it would connect into the existing Wollar to Wellington 330 kV powerline.

The magnetic fields associated with a powerline at any moment in time depend on a range of factors, including the amount of current flowing in the line and the distance of the measurement point from the conductors. The electric field strength created by powerlines is dependent upon the height of the wires above the ground and their geometric arrangement.

Table 14-7 shows maximum electrical and magnetic field strengths for the various types of powerlines expected to be used in the project (National Grid, 2011):

Table 14-7 Maximum electrical and magnetic field strength of various powerlines

Voltage and Type	Maximum electrical field strength under powerline (or over cable) (kV/m)	Maximum magnetic field strength directly under line (over cable) (mG)
33 kV overhead powerline	0.897	257
33 kV underground cable	--	10
330 kV overhead powerline	3.6	304

Note that underground cables do not produce any external electric fields.

All these values are well within the limits of 5 kV/m and 1000 mG recommended for 24 hour exposure mentioned previously (NHMRC, 1989). These values are maximum values and those measured in the project are expected to be less. Furthermore, the strength of both electric and magnetic fields falls away rapidly with distance from the line (National Grid, 2011)

Any off-site electricity lines will be located and designed in accordance with Essential Energy's Easement Requirements (Essential Energy, 2012). This guideline provides requirements for how powerline easements are to be constructed, when they are required and how they are obtained in New South Wales. The electricity cables will be located away from residences, where practical, to minimise magnetic fields from any off-site powerlines.

Substations

Electricity substations are a source of electric fields, although those encountered at the boundary of substations are usually very weak due to effective screening. They are certainly no more than a few hundred volts per meter near the largest installations, well below the 5 kV/m limit.

Magnetic fields from substations occur at their maximum opposite feed pillars, transformers and switching units (Maslanyj, 1996). Fencing around the substations and the location of the substations and control buildings would ensure that the magnetic field exposure to receivers including the public, property owners and workers are well below the 1,000 mG levels determined to be the maximum to safeguard for public health.

Wind Turbines

The areas proposed for the installation of wind farm infrastructure with potential EMI would have limited public access. Access to these areas by the general public would be restricted, with periodic access by appropriately trained and qualified maintenance staff only. Property owners accessing the sites would have no reason to spend extended periods near the infrastructure, which is not located near frequent use areas such as sheds, yards and residences. Should property owners require access to control buildings or other wind farm infrastructure, they would be accompanied by an appropriately trained and qualified maintenance staff member.

A report investigated the expected magnetic field for proposed wind turbines for Windrush Energy in 2004 (Iravani et al., 2004). The study was based on research and measurements of an existing wind turbine. The measured flux density at the door of the existing turbine was 0.4 mG and the typical value around the wind turbine was 0.04 mG. The acceptable level as stated by the International Commission on Non-Ionizing Radiation

Protection (at 60 Hz in this case) is 833 mG (ICNIRP, 1998). The results also concluded that no measurable magnetic field would be expected at a distance of eight metres from the 1,650 kW wind turbine, and hence the magnetic fields produced by generation of electricity from turbines would not pose a threat to public health.

14.3.3 Mitigation

Overhead powerlines and underground cables would generally be located as far as practical from residences and in accordance with the minimum distances set out in Essential Energy's Procedural Guideline – Easement Requirements.

14.4 Shadow Flicker

14.4.1 Introduction

Due to their height, wind turbines can cast shadows on the areas around them. Coupled with this, the moving blades create moving shadows. When viewed from a stationary position, when the turbine is between the viewer and the sun, the moving shadows appear as a flicker giving rise to the phenomenon of 'shadow flicker'. This is similar to the strobe effect often experienced when driving through scattered trees on a rural highway.

For a particular position, shadow flicker will only occur during periods when the sun's rays pass directly through the swept area of the turbine blades to the viewpoint. The extent of the shadow flicker is dependent on the time of day, geographical location, meteorological conditions of the site and local vegetation.

There are a number of factors influencing the effect and duration of shadow flicker including:

- position of the sun in relation to the turbine;
- time of year (season) and time of day;
- turbine height and rotor diameter;
- viewer's distance from turbine;
- topography of the area;
- vegetation cover;
- weather patterns, number of cloudy days per year; and
- airborne particles, haze

The effect of 'chopping the light' attenuates with distance and is not considered by assessors of shadow flicker to be noticed beyond 500-1,000 m from a turbine (Osten and Pahlke, 1998).

In NSW there are currently no guidelines on which to assess shadow flicker generated by wind turbines. The Victorian Planning Guidelines limit the duration of shadow flicker to a maximum of 30 hours per year (SEAV, 2003). The South Australian Planning Bulletin suggests that shadow flicker is insignificant once a separation of 500m between the turbine and house is exceeded.

14.4.2 Background

Shadow flicker is usually an amenity issue rather than a health risk. Given it is a daytime event; it does not interrupt sleep patterns. However, two issues have been raised as potential health concerns in relation to shadow flicker:

Flicker vertigo

Flicker vertigo is an imbalance in brain cell activity caused by exposure to low frequency flickering or flashing of a light or sunlight seen through a rotating propeller (Rash, 2004). It can result in nausea, dizziness, headache, panic, confusion and – in rare cases – loss of consciousness. Flicker vertigo is usually associated with a light flashing sequence, or flicker frequency, of between approximately 4 Hz (cycles per second) and 20 Hz (NASA, 2001; Rash, 2004).

Photosensitive Epilepsy

Flicker from turbines that interrupt or reflect sunlight at frequencies greater than 3 Hz poses a potential risk of inducing photosensitive seizures. At 3 hertz and below the cumulative risk of inducing a seizure should be 1.7 per 100,000 of the photosensitive population. The risk is maintained over considerable distances from the turbine. It is therefore important to keep rotation speeds to a minimum, and in the case of turbines with three blades ensure that the maximum speed of rotation does not exceed 60 rpm, which is well beyond the normal range for large wind turbines. The layout of wind farms should ensure that shadows cast by one turbine upon another should not be readily visible to the general public. The shadows should not fall upon the windows of nearby buildings (Harding et al., 2008).

In both cases, the cause of the health effect is a flashing of light with the flash frequency in the range of 3 – 30 hertz. Therefore, wind turbines would only provide a health risk of the shadow flicker created was within this range.

14.4.3 Assessment

A detailed analysis of the potential for shadow flicker and blade glint to affect dwellings has been carried out by Epuron. Modelling of the shadow flicker was conducted using specialist industry software, assessing the largest turbine (maximum tip height) proposed for the project to represent the worst case impact scenario. The maximum number of annual hours at each of the nearby houses where shadow flicker may be experienced was calculated using this model.

The number of annual hours of shadow flicker at a given location can be calculated using simple geometrical models incorporating data such as the sun path, the topographic variation and wind turbine details such as rotor diameter and hub height. In such models, the wind turbine rotor is modelled as a disc and assumed to be in the worst case (i.e. perpendicular) to sun-turbine vector. Furthermore, the sun is assumed to be a point light source.

Shadow flicker calculated in this manner overestimates the number of annual hours of shadow flicker experienced at a specified location due to several reasons.

- The occurrence of cloud cover has the potential to significantly reduce the number of hours of shadow flicker.
- The probability of wind turbines consistently yawing to the ‘worst case’ scenario where the wind turbine is facing into or away from the sun- wind turbine vector is less than 1 (i.e. less than 100% of the time).
- The amount of aerosols in the atmosphere has the ability to influence shadows cast due to the following reasons.
- Firstly, the distance from a wind turbine that a shadow can be cast is dependent on the degree to which direct sunlight is diffused, which is in turn dependent on the amount of dispersants (humidity, smoke and other aerosols) in the path between the light source (sun) and the receiver [2].
- Secondly, the quantity of aerosols in the air is known to vary with time and it has the potential to vary the air density, thereby affecting the refraction of light. This in turn affects the intensity of direct light to cause shadows.
- The modelling of the wind turbine blades as discs to determine shadow path overestimates the shadow flicker effect.
- The blades are of non-uniform width with the thickest viewable blade width (maximum chord) occurring closer to the hub and the thinnest being located at the tip of the blade. As outlined in point 3 above, the direct sunlight is diffused resulting in a maximum distance from the wind turbine that a shadow can be cast. This maximum distance is dependent on the human threshold which variation in light intensity can be perceived. When the blade tip causes shadow, the diffusion of direct sunlight means that the light variation threshold occurs closer to the wind turbine than when a shadow is caused by the maximum chord. That is, the maximum shadow length cast by the blade tip is less than by the maximum chord.
- Modelling the sun as a point light source rather than a disc has an effect similar to that of point 4 above.

- Firstly, situations arise where the light rays from different portions of the sun disc superimpose around a shadow resulting in light intensity variations less than human perception.
- Secondly, when the sun is positioned directly behind the wind turbine hub, there is no variation in light intensity at the receiver location and therefore no shadow flicker. However, when the sun is modelled as a point source, shadow flicker still arises.
- The presence of vegetation shields incidences of shadow flicker.
- Periods where the wind turbine is not in operation due to low winds, high winds or operational and maintenance reasons.

Taking the above issues into account, the modelling of shadow flicker has been conducted using simple geometric analyses. The wind turbine has been modelled assuming all wind turbines are disc objects positioned in the worst case with respect to shadow flicker. The sun has been assumed to be a point light source.

To carry out the shadow flicker assessment, the Victorian Planning Guidelines and the South Australian Planning Bulletin discussed earlier were used to determine the inputs to the model. They were:

- a maximum duration of shadow flicker at any residence of 30 hours per year; and
- a conservative assessment distance of 1 km (twice the distance suggested to be affected by shadow flicker).

Therefore, the modelling conducted here represents a very conservative scenario and is believed to overestimate the actual annual hours of shadow flicker experienced at a location.

14.4.4 Actual Conditions at Liverpool Range

When the actual conditions of the Liverpool Range wind farm site are taken into consideration, the number of hours of shadow flicker should be reduced. The major consideration in this respect is the weather patterns and particularly the number of cloudy days experienced that result in no shadow flicker.

Based on 41 years (1967 – 2010) of daily weather observations in Dunedoo (Dunedoo Post Office, Bureau of Meteorology), the nearest source of data, the average number of cloudy days experienced is 94 days/year. The average number of clear days experienced is 104.2 days/year. These are based on observations at 9am and 3pm each day.

Accordingly based on 94 days/year of cloud the number of shadow flicker hours should be reduced by 25%. Further reductions for vegetation screening should be considered and applied where appropriate on a case by case basis.

Dunedoo data was used at it showed the lowest number of cloud cover per year compared to the four closest weather stations in the area: Connabarabran, Mudgee, Gulgong and Dunedoo. This made the calculation more conservative than if another site was chosen.

14.4.5 Results

The modelling has calculated the number of annual hours at each of the nearby houses and the results are presented in

Table 14-8. The second column represents the theoretical maximum hours of shadow flicker, as discussed above and shown in Figure 14-10. This approach is based upon the assumption that the wind turbine is yawed to the worst case position of facing into or away from the sun. Using twelve years of onsite wind rose measurements, the probability of occurrence of various wind directions can be incorporated in the assessment to increase the accuracy. The results are shown in the third column. Additionally a reduction of the theoretical maximum number of hours can be assumed based on the long term observation of cloudy days shown in the fourth column.

Table 14-8 Result of shadow flicker assessment

Residence ID	Theoretical maximum shadow flicker (hrs/yr)	Reduced due to turbine orientation (hrs/yr)	Reduced due to cloud cover (hrs/yr)
F7-1	33	23	17
F7-2	16	10	8
F7-3	17	10	0
G4-1	0	0	0

Only one dwelling has greater than 30 hours per year theoretical shadow flicker F7-1. The two turbines that contribute to shadow flicker to dwelling F7-1 is turbine F7-1 and F7-2. Turbine F7-1 and F7-2 are located 104° and 84° from dwelling F7-1. There is significant vegetation covering the Northern and Eastern sides of the dwelling which would provide additional screening from the wind turbines and hence shadow flicker, this can be seen in Figure 14-9.

In addition based on the 41 years of data the standard deviation is 22.4 days resulting in a 99% likelihood that the cloud cover will exceed 41.9 days per year. Based on 41.9 days of cloud cover per year this reduces the number of shadow flicker hours by 11.5% which would result in shadow flicker below 30 hours per year for dwelling F7-1.

Figure 14-9 Aerial view of F7-1

14.4.6 Health Effects from Shadow Flicker

Flicker frequency of rotating propellers, including wind farm rotors, is derived by multiplying the hub rotation frequency by the number of blades. Based on the rotation speed of the 3 bladed wind turbines proposed for the project, the maximum shadow flicker frequency would be 1 cycle per second (1 Hz), well outside the frequency range associated with flicker vertigo or photosensitive epilepsy.

The operational wind turbines are not anticipated to produce a flicker frequency high enough to pose a health risk. Comparable turbines have been rated 0.45 to 0.95 Hz, significantly below critical levels of 3-30 Hz for public health. The project is therefore unlikely to represent a health risk to local residents in relation to flicker vertigo or photosensitive epilepsy.

This sentiment is also reflected in a recent public statement by the National Health and Medical Research Council titled ‘Wind Turbines and Health’ has stated that the evidence on shadow flicker does not support a health concern (NHMRC, 2010).

14.4.7 Blade Glint

Blade glint occurs when sunlight is reflected off turbine blades. The concern is that this may affect some motorists or cause annoyance at dwellings.

Turbine manufacturers have acknowledged the possibility of blade glint and use a low reflectivity gel finish to reduce any reflectivity. The turbines proposed for this project would be finished in a matte, non-reflective finish to ensure blade glint impacts do not occur.

14.4.8 Conclusion

The worst case predicted shadow flicker at each dwelling within 1 km of the proposed wind turbines is shown in

Table 14-8. Only one dwelling, F7-1 has greater than 30 hours per year theoretical shadow flicker. Figure 14-10 (below) has been focused on these residences within 1 km to give a visual representation of the worst case shadow flicker results. Additionally an assessment has been made on the level of conservatism associated with the worst case results by reduction in shadow flicker due to turbine orientation based on wind direction occurrences measured on site and cloud cover. The adjusted results are shown in the table and indicate that all dwellings are within the accepted limit of 30 hours per year. In addition to this there is significant vegetation screening at dwelling F7-1 which would further block shadow flicker and likely reduce the theoretical shadow flicker to below 30 hours per year without considering wind direction and cloud cover impacts.

14.4.9 Mitigation Measures

- If shadow flicker is found to be a nuisance at a particular residence at a known location a physical screen can be placed between the location and the wind turbines. Additional trees or other vegetation can be used to accomplish this.
- If shadow flicker is found to be a nuisance at a particular residence, conditions could be pre-programmed into the control system so that individual wind turbines automatically shut down whenever these conditions are present.
- Shadow flicker effects on motorists would be monitored following commissioning and any remedial measures to address concerns would be developed in consultation with the RMS and the Department of Planning.

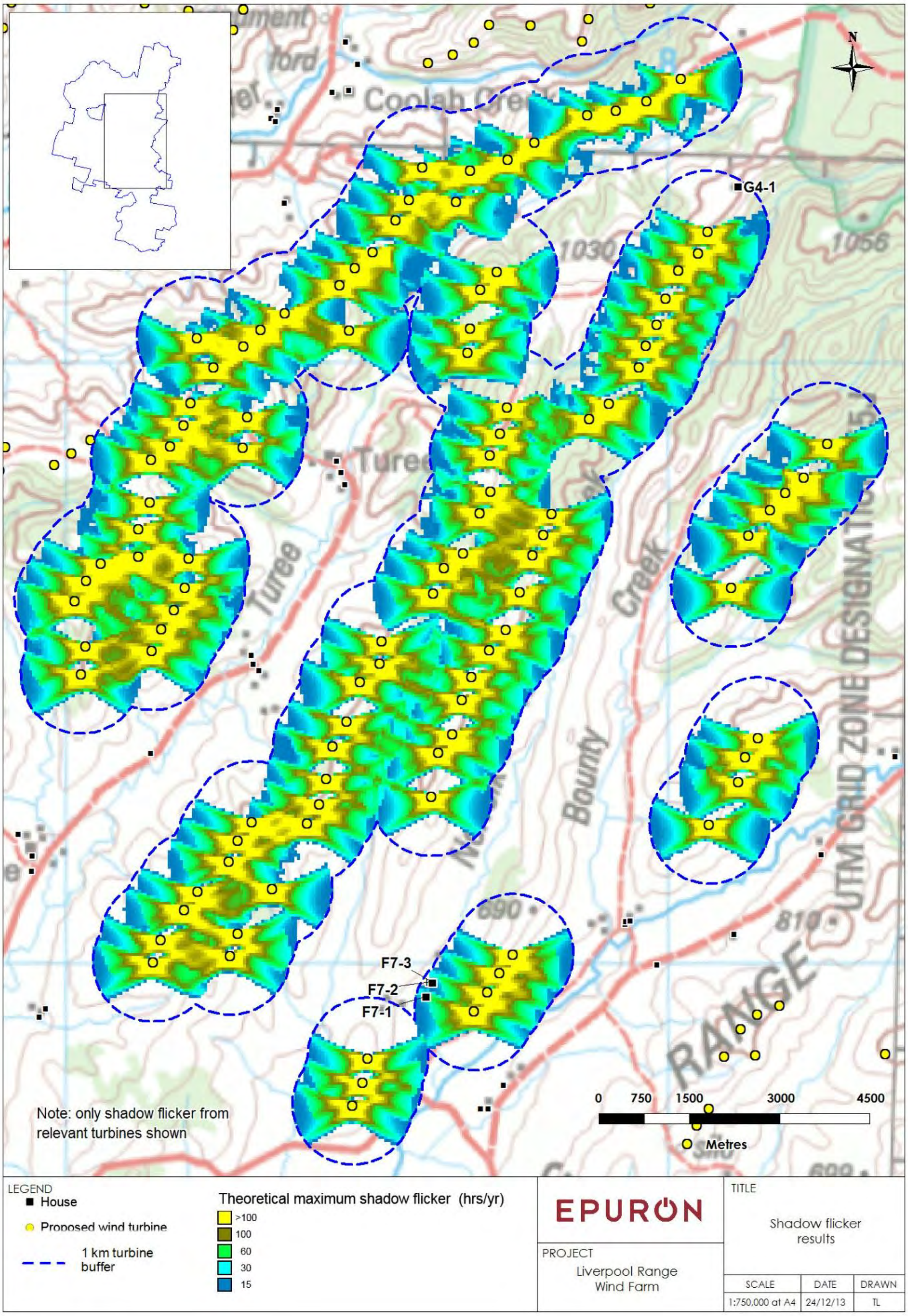

Figure 14-10 Theoretical shadow flicker

14.5 Fire and Bushfire Risks

14.5.1 Background

A bushfire management plan would be prepared prior to construction and included within the Construction and Operational Environmental Management Plans. Bushfire safety Issues that are associated with wind farms include:

- the potential for wind farm infrastructure to cause a fire that may or may not result in a bush fire;
- the potential for the wind farm to be affected by a passing bush fire and the impact the existence of turbines may have on fire management; and,
- the presence of additional ignition sources as a result of the construction, operation or decommissioning of the wind farm.

14.5.2 Existing environment

The development envelope for the project is predominately pasture with patches of remnant Box Gum Woodlands also present.

The bushfire danger period stated by the NSW Rural Fire Service (RFS) is generally between 1st October and 31st March, but can vary subject to local conditions. Summer conditions in these LGAs can be dry and hot with high wind speeds. Existing ignition sources include farm machinery and vehicles, hay storage, vehicles stopping in long grass on road verges, cigarette butts thrown from car windows and lightning strikes. The elevated position of the sites may increase the frequency of lightning strike. The steep topography and absence of built areas or natural fire breaks such as large water bodies may assist the rate of spread of wildfires.

Factors mitigating fire risks within the site include the sparse and fragmented nature of woodland and forest remnants flanking the development envelope and the continued grazing regimes, which acts to reduce fuel loads. However grass fires can spread rapidly and threaten life and property.

The NSW Fire Brigade has the authority to attend, combat and render safe any land-based or inland waterway spillage of hazardous materials within the State. The NSW Fire Brigade defines hazardous materials as (F&R NSW, 2007):

> *"anything that, when produced, stored, moved, used or otherwise dealt with without adequate safeguards to prevent it from escaping, may cause injury or death or damage to life, property or the environment".*

The fuels and lubricants required to construct and operate the wind farm constitute hazardous materials under this definition, and any fire at the wind farm would come under management of NSW Fire Brigade supported by the RFS.

All NSW Fire Brigade fire stations are equipped with trained personnel and resources for dealing with hazmat incidents. The closest NSW fire brigades to the site are Coolah Fire Station (5 km from the site) and Merriwa Station (40km from centre of the site), in addition to a RFS brigade in Cassilis.

The Hazardous Materials Response Unit has a 24 hour phone contact (Tel: 02 9742 7155). Intermediate hazardous materials response is delivered by 20 strategically located units; each unit is equipped with detection equipment and has the capability to access chemical databases with information on chemical, biological, radiological and toxic industrial chemical substances.

14.5.3 Assessment

Construction Activities

Flammable materials and ignition sources brought onto the site, such as fuels, would increase the risk of fire during the construction period. Correct handling and storage procedures would mitigate against the risk of ignition. Appropriate fire fighting equipment would need to be held on site when the fire danger is very high to extreme, and a minimum of one person on site would be trained in its use.

The RFS would continue to be consulted in regard to the adequacy of bushfire prevention procedures to be implemented on site during construction, operation and decommissioning. These procedures would in particular cover hot-work procedures and response measures to control any incident.

Operational Activities

Being electrical equipment and containing petrochemicals, there is potential for the wind turbines, substations, control buildings and powerlines to start or influence the spread of fire. For the wind turbines themselves, the risk of fire can be associated with malfunctioning turbine bearings, inadequate crankcase lubrication, electrical distribution facilities, electrical shorting or arcing occurring in transmission and cable damage during rotation (AusWEA, 2001).

The ready visibility of the turbines and local presence of RFS equipment and personnel would assist detection, response time and control. In addition, shut down mechanisms are installed in the wind turbines, and remote alarming and maintenance procedures would also be used to minimise risks.

Lightning conductors are installed in turbines to ground lightning strikes in order to minimise risk of damage to the turbines and risk of ignition of a wildfire. Relatively minor damage to turbines may occur from lightning strike. At the existing Crookwell I site, a direct strike resulted in damage to one of the turbine blades, which was repaired onsite. No wildfire resulted. The risk of turbine ignition is considered to be low, based on the low likelihood of electrical failure or over-heating and a range of factors mitigating the fire hazard.

Transmission and powerlines would be installed to connect the wind farm to the electricity grid. The powerlines are underground across most of the site and overhead to connect strings of turbines to the substation. The overhead lines have been routed to avoid trees and forest fragments where possible, reducing the need for clearing and eliminating ongoing fire risks from tree growth and in the event of a line breakage. Cable routes would be periodically inspected to monitor any regrowth.

The transformers located in the substation facilities would contain transformer oil for the purpose of cooling and insulation. These facilities would be bunded with a capacity exceeding the volume of the transformer oil to contain the oil in the event of a major leak or fire and would be regularly inspected and maintained to ensure leaks do not present a fire hazard, and to ensure the bunded area is clear (including removing any rainwater). Transformer oil would be changed regularly at appropriate intervals by qualified staff to minimise the potential for fire caused by contaminated oil. The oil would be removed from the site and disposed of appropriately.

The substations would be surrounded by a gravel and concrete area free of vegetation to prevent the spread of fire from the substation and reduce the impact of bushfire on the structure. The substation areas would also be surrounded by a security fence as a safety precaution to prevent trespassers and stock ingress. An asset protection zone would be maintained around the control room and substation buildings, compliant with the RFS Planning for Bushfire Protection guidelines. Workplace health and safety protocols would be developed to minimise the risk of fire for workers during construction and during maintenance in the control room and amenities.

Impacts on fire-fighting operations

The turbines have the potential to present a hazard to fire fighting helicopters and planes, however, the access tracks installed to build and maintain the wind farm would increase the accessibility onsite and would therefore have a positive impact on the response time and ability to fight fires onsite or on neighbouring properties.

The RFS have participated in the environmental assessment process of several wind farms in NSW. Representatives of the RFS have stated that, due to the hazardous materials stored onsite (hydrocarbons within turbines and the substation); the local RFS would only ever act in a support capacity to the NSW Fire Brigade, in the event of an infrastructure related fire onsite. The RFS and NSW Fire Brigade would be consulted regarding safety, communication, site access and response protocols in the event of a fire originating in the wind farm infrastructure, and also in the event of an external wildfire threatening the wind farm. They have also stated that wind farm infrastructure is no different, with regard to bush fire risk, from similar large scale infrastructure developments.

While the risk of bushfires would be increased by the construction and operational activities of the wind farm, the cleared nature of the land and the improvements to site access would aid fire fighters on site.

14.5.4 Mitigation

- Ensure that all project components on the site are designed, constructed and operated to minimise ignition risks, provide for asset protection consistent with relevant RFS design guidelines (NSW RFS, 2006; NSW RFS, 2010) and provide for necessary emergency management including appropriate fire-fighting equipment and water supplies on site to respond to a bush fire.
- Regularly consult with the local RFS to ensure familiarity with the project, including the construction timetable and the final location of the entire infrastructure on the site. The Proponent will comply with any reasonable requests of the local RFS to reduce the risk of bushfire and to enable fast access in emergencies.
- Prepare a Bushfire Management Plan as part of the Construction Environmental Management plan. The RFS and NSW Fire Brigade would be consulted in regards to its adequacy to manage bushfire risks during construction, operation and decommissioning. As a minimum the plan would establish hot-work procedures, asset protection zones, safety, communication, site access and response protocols in the event of a fire originating in the wind farm infrastructure. All flammable materials and ignition sources brought onto the site, such as hydrocarbons, would be handled and stored as per manufacturer's instructions
- During the construction phase, appropriate fire fighting equipment would be held on site when the fire danger is very high to catastrophic, and training in its use would be provided as necessary. Fire extinguishers would be stored onsite in the control building and within any substations.
- Substations would be bunded with a capacity exceeding the volume of the transformer oil to contain the oil in the event of a major leak or fire. The facilities would be regularly inspected and maintained to ensure leaks do not present a fire hazard, and to ensure the bunded area is clear (including removing any rainwater).
- Shut down of turbine components would commence if the components reach critical temperatures or if directed by the RFS in the case of a nearby wildfire being declared (all hours contact points would be available to the RFS during the bushfire period. Remote alarming and maintenance procedures would also minimise the risk. Overhead powerline easements would be periodically inspected to monitor regrowth of encroaching vegetation.

14.6 Blade Throw

Blade throw refers to the event in which ice or a turbine blade itself becomes separated from the nacelle into the surrounding environment. On the occasions where part of the blade has become separated from the tower, the most common causes are lightning strikes, storms, material fatigue or poor operation and maintenance practices. Wind turbines manufacturers have been implementing new design features to reduce the risk of these events occurring even further. Some of these advances include increasing lightning protection along the blades to reduce the damage from strikes and developing greater control systems to monitor any decrease in structural integrity and implement an automatic shutdown. Furthermore, modern turbines have an automatic braking system when wind speeds exceed a set value. For the case of the Vestas V112 as proposed in this environmental assessment, the cut-out speed for high winds is 25 m/s (90 km/h).

Ice throw occurs when the surrounding environment drops below freezing temperature and ice develops on the turbine blade. The ice is then dislodged when the turbine blade begins to rotate or the surrounding temperature increases. The Liverpool Plains and surrounding regions are not known to regularly have sub-zero nights throughout winter and therefore this must be considered as a very low possibility for the winter months.

While there is a possibility of these events occurring, the likelihood of a landowner being near a turbine during storms or freezing conditions is considered low; however, land owners will be advised to avoid turbines during these conditions.

14.7 Health

Some areas of the community, particularly those proximate to proposed or operating wind farms, have raised concerns for the potential impacts of wind turbine noise on human health. These concerns appear to relate to emissions from either low frequency noise or infrasound which is the two areas generally raised regarding potential health impacts from wind farm noise. Both these potential noise related impacts are addressed in further detail in Section 10 of this EA.

Other areas of concerns for human health related impacts from wind farms include electromagnetic radiation, shadow flicker and blade glint produced by wind turbines. While a range of effects such as annoyance, anxiety, hearing loss, and interference with sleep, speech and learning have been reported anecdotally, there is no published scientific evidence to support adverse effects of wind turbines on human health. There have been a number of studies into the perceived health impacts to humans from wind farms over the last few years and an outline of the key points from some of these studies include:

Environmental Protection Authority of South Australia

In January 2013, the South Australian Environmental Protection Authority (EPA) released findings of a study into the level of infrasound within typical environments in South Australia, with a particular focus on comparing wind farm environments to urban and rural environments away from wind farms.

The study concluded that the level of infrasound at houses near the wind turbines assessed is no greater than that experienced in other urban and rural environments, and that the contribution of wind turbines to the measured infrasound levels is insignificant in comparison with the background level of infrasound in the environment.

National Health and Medical Research Council

In 2010, Australia's peak body for undertaking health and medical research, the National Health and Medical Research Council (NHMRC), undertook a study of available literature on the potential impacts of wind turbines on human health. The objective of the study was to ascertain if the following statement could be supported by the evidence: There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines.

The study findings noted that: Based on current evidence, it can be concluded that wind turbines do not pose a threat to health if planning guidelines are followed, and concluded by stating that: The health effects of many forms of renewable energy generation, such as wind farms, have not been assessed to the same extent as those from traditional sources. However, renewable energy generation is associated with few adverse health effects compared with the well-documented health burdens of polluting forms of electricity generation. This review of the available evidence, including journal articles, surveys, literature reviews and government reports, supports the statement that: There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines.

The NHMRC public statement accompanying the study also concluded that: It is recommended that relevant authorities take a precautionary approach and continue to monitor research outcomes. Complying with standards relating to wind turbine design, manufacture, and site evaluation will minimise any potential impacts of wind turbines on surrounding areas.

World Health Organisation

The World Health Organisation (WHO) has developed guideline exposure values for various types of community noise emissions. These noise values are designed to avoid long term deterioration in physical or psychological functioning. The guideline of most relevance to the potential impacts of wind farm noise is that for sleep disturbance. The WHO considers that night-time noise levels at the outside façade of a dwelling should not exceed 45dBA with open windows. The noise assessment using different wind turbine models indicates that residences at the project would experience night time noise levels that are unlikely to exceed the WHO recommended levels.

NSW Parliament Inquiry

In 2009 the NSW Parliament conducted an inquiry into rural wind farms in 2009, which included consideration of the potential health impacts of wind farms. The inquiry report (New South Wales Parliament Legislative Council General Purpose Standing Committee No. 5, 2009) noted that "…the health effects associated with wind farm noise appear to be the most common concern…" and observed that "…it was clear that some people are significantly affected by their experience of wind farms, both existing and proposed". However, the inquiry report concluded that "…many purported impacts have created little more than unfounded fear in local communities, for example vibroacoustic disease, wind turbine safety, shadow flicker and 'Wind Turbine Syndrome'" and that "…the level of concern for many impacts is not supported by evidence" with "…such impacts being promoted to support arguments against wind power in general, rather than being used to highlight fundamental problems with wind farms." Notwithstanding that current research has been unable to establish a direct relationship between wind farm noise emissions and health, the NHMRC review (citing Chapman, 2010), note that:

> *"It has been suggested that if people are worried about their health they may become anxious, causing stress related illnesses. These are genuine health effects arising from their worry, which arises from the wind turbine, even though the turbine may not objectively be a risk to health."*

The Proponent will establish a complaints management system to be implemented prior to the construction phase and maintained throughout the operation phase of the development to register noise and other health complaints and concerns about the Proposal from the community.

15 Water Supply, Water Quality and Hydrology

15.1 Catchment Management Regions

The Liverpool Range Wind Farm is located across three Catchment Management Authority (CMA) regions. The majority of the wind farm is located within the Central West CMA region, with a small portion of the south-east corner of the project located in the Hunter/Central Rivers CMA region, and a small portion of the north-east corner of the project located in the Namoi CMA region. Figure 15-1 highlights the location of the wind farm in relation to the surrounding CMA regions.

15.1.1 Central West Catchment Management Authority

The Central West catchment covers an area of approximately 84,800 km^2 and has a population greater than 183,000 people. The catchment encompasses 14 local government areas and is located in central New South Wales, flanked by the Hunter/Central Rivers catchments to the east, Western to the west, Namoi to the north, the Lachlan catchment to the south, and the Hawkesbury/Nepean to the south-east (LCMA, 2007).

15.1.2 Hunter/Central Rivers Catchment Management Authority

The Hunter-Central Rivers CMA region covers 37,000 square kilometres on the east coast of NSW—extending from Taree in the north to Gosford and the coastal waterways of the Central Coast in the south, and from Newcastle in the east to the Merriwa Plateau and Great Dividing Range in the west. The CMA's area of operation also includes an area 1,500 square kilometres three nautical miles offshore to the NSW state limit. The Hunter-Central Rivers region has a population of approximately 1,000,000 people.

The catchment encompasses 13 local government areas and is located in eastern New South Wales, flanked by the Central West catchment area to the west, Northern Rivers and Namoi to the north, and the Hawkesbury/Nepean catchment to the south (LCMA, 2007).

15.1.3 Namoi Catchment Management Authority

The Namoi CMA catchment area is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south, and the Nandewar Ranges and Mt. Kaputar to the North. Major tributaries of the Namoi River include Cox's Creek and the Moki, Peel, Cockburn, Manilla, and McDonald Rivers, all of which join the Namoi upstream of Boggabri. Stretching from Bendemeer in the east to Walgett on the western boundary the Catchment is over 350 kilometres long. The Namoi CMA catchment area is home to approximately 100,000 people concentrated mostly along the Namoi River and has an area of approximately 42,000 square kilometres.

The catchment encompasses 4 local government areas and is located in central New South Wales, flanked by the Hunter/Central Rivers and Northern Rivers catchments to the east, Western to the west, Central West to the south-west, Border Rivers/Gwydir to the north, and the Hunter/Central Rivers catchment to the south-east (LCMA, 2007).

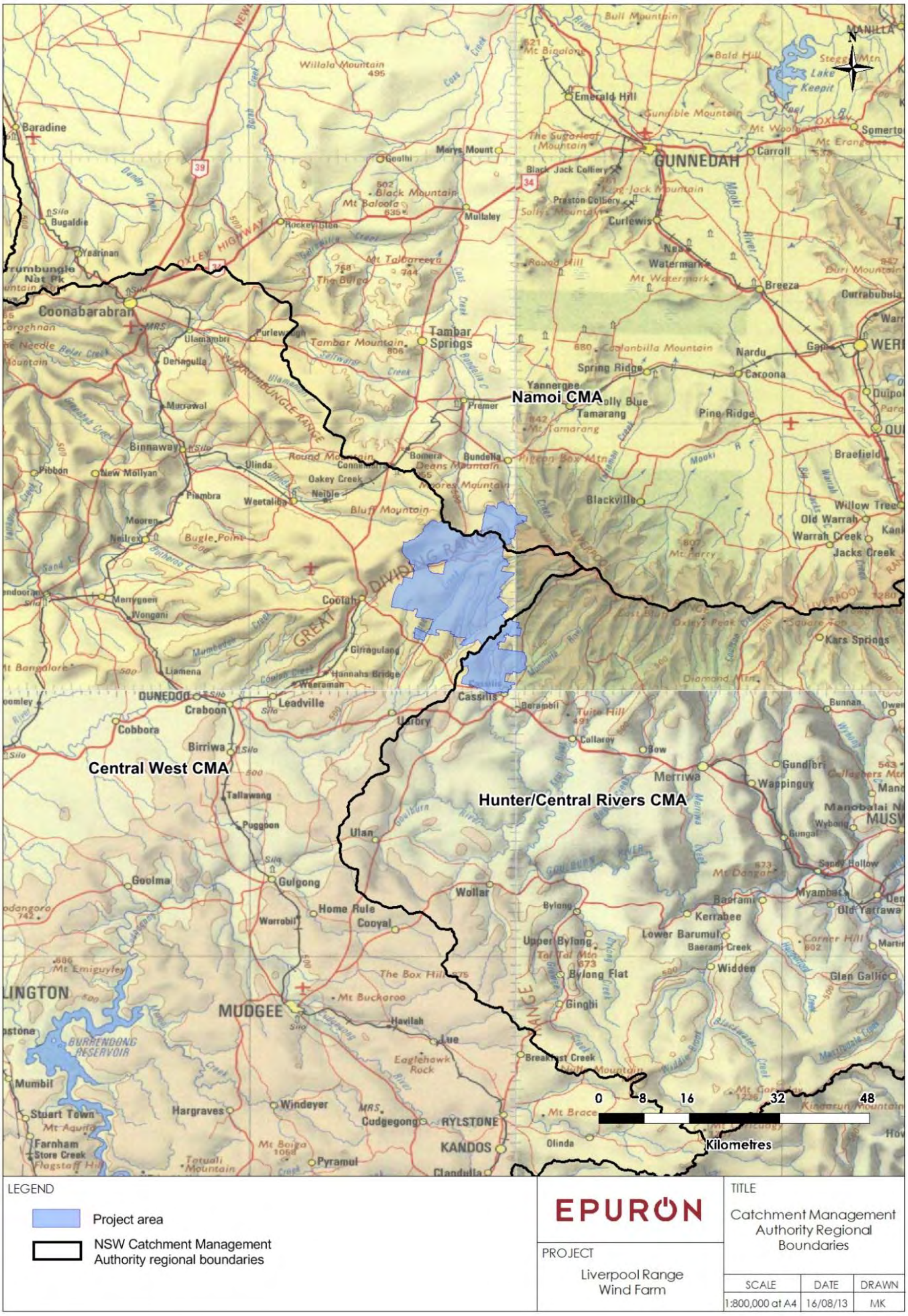

Figure 15-1 Surrounding Catchment Management Authority regions

15.2 Local Water Supplies

15.2.1 Regional Water Sources

The project is situated on the border of the Macquarie-Bogan, Castlereagh, Namoi and Hunter water catchment areas, with the principle water courses nearby being the Coolaburragundy River and the Talbragar River which both cross the site.

Watercourses in the catchment area generally flow in a south-westerly direction until they form with the principle rivers in the catchment. To the west of the site the catchments of the Coolaburragundy River and Talbragar River combine.

The closest reservoirs to the site are:

Lake Burrendong	100 km to the south-west
Lake Windamere	90 km to the south
Lake Glenbawn	90 km to the east
Lake Keepit	100 km to the north

The Macquarie-Bogan catchment area, where the closest towns to the project Coolah and Cassilis reside, utilises Burrendong Dam, located on the Macquarie River 30 kilometres south east of Wellington NSW, which is the largest storage in the catchment with a capacity of 1,188,000 megalitres. It provides storage for irrigation, town water, stock and domestic use.

Windemere Dam located 19 kilometres south west of Rylestone on the Cudegong River in the North Coast Valley has a capacity of 368,120 megalitres, provides town water, as well as water for irrigators and other water users.

Burrendong Dam operates in conjunction with Windamere Dam to supply water to the Cudgegong and Macquarie valleys. Together there are 1,505 licences with a 724,345ML entitlement within 920km of the river.

- High security/industry entitlements 18,000ML
- General security entitlements 631,716ML
- Stock and domestic requirements 5,568ML
- Town water supplies 18,845ML
- Supplementary flows 50,000ML

Burrendong Dam also provides 50,000ML a year to the Macquarie Marshes which also has first call on any surplus water in the river (State Water Corporation 2009). In addition, there are a number of smaller dams within the catchment area providing town water supplies.

15.2.2 Site Surface Water

The use of aerial photographs, topographical and surface water overlays for any creeks, watercourses and wetland areas were utilised to identify any significant watercourses, standing water bodies, lakes and wetland areas within the study area. No significant water bodies or wetlands have been identified within or around the wind farm site. Some small stock dams are interspersed across the site area. The watercourses through the site and the access track layout are illustrated in Figure 15-2.

The watercourses on site have been assessed based on their stream order. The order of streams was determined based on the Strahler method of stream ordering classification. This method of stream ordering involves labelling all upper tributaries as first order streams, which when two first order streams converge they combine to form a second order stream. Consequently where two second order streams converge they form a third order stream. When a stream of lower order joins a stream of higher order the downstream section of the stream will retain the order of the higher order upstream section (Yang and Kwan, 2001).

The site contains a number of watercourses which are predominantly first order streams with some second order streams. The turbines are generally located on higher ground and the access tracks and underground cabling generally follow the higher ground locations. The layout of the wind turbines, the access tracks and underground cabling has been designed to avoid crossing known watercourses where possible. Three third order watercourses shown in Figure 15-3 are proposed to be crossed on site:

- Coolaburragundy River to be crossed by overhead power line and existing track as shown in Figure 15-4,
- Turee Creek to be crossed by overhead power line as shown in Figure 15-5; and
- Bounty Creek to be crossed by overhead power line and a new access track as shown in Figure 15-6.

Goulburn River is also proposed to be crossed by the overhead power line south of the site. All watercourse crossings, especially Coolaburragundy River due to its relative significance, are sensitive to impacts on hydrology, geomorphology and riparian aquatic ecology. Due to the design of the project to avoid watercourses and adhering to the NSW Office of Water Guidelines for Controlled Activities (August 2010), as well as discussions with NSW Office of Water, impacts on watercourses, hydrology and riparian aquatic ecology will be minimal. Some access tracks on site join with the existing road network of the area, which minimises the requirement to connect all turbine locations via internal access tracks. No underground water crossings will be constructed, all water crossings will either be via overhead electrical powerlines or small bridges.

The location of the substations and switchyard are also positioned away from any watercourses. Overhead powerlines are proposed to connect different segments of the project. The use of overhead powerlines will also be used to avoid the requirement to place underground cables through existing watercourses. Therefore overhead powerline watercourse crossings such as shown in Figures 15-5 and 15-6 will have no impact on the watercourse.

Each watercourse crossing will be designed to be consistent with the ‘Guidelines for Controlled Activities on Waterfront Land’ as specified by Water NSW. This includes but is not limited to:

- Identify the full width of the riparian corridor and its functions in the design and construction of crossings,
- Minimise the design and construction footprint and extent of proposed disturbances within the watercourse and riparian corridor,
- Maintain existing or natural hydraulic, hydrologic, geomorphic and ecological functions of the watercourse,
- Protect against scour, and,
- Where possible stabilise and rehabilitate all disturbed areas including topsoiling, revegetation, mulching, weed control and maintenance to adequately restore the integrity of the riparian corridor.

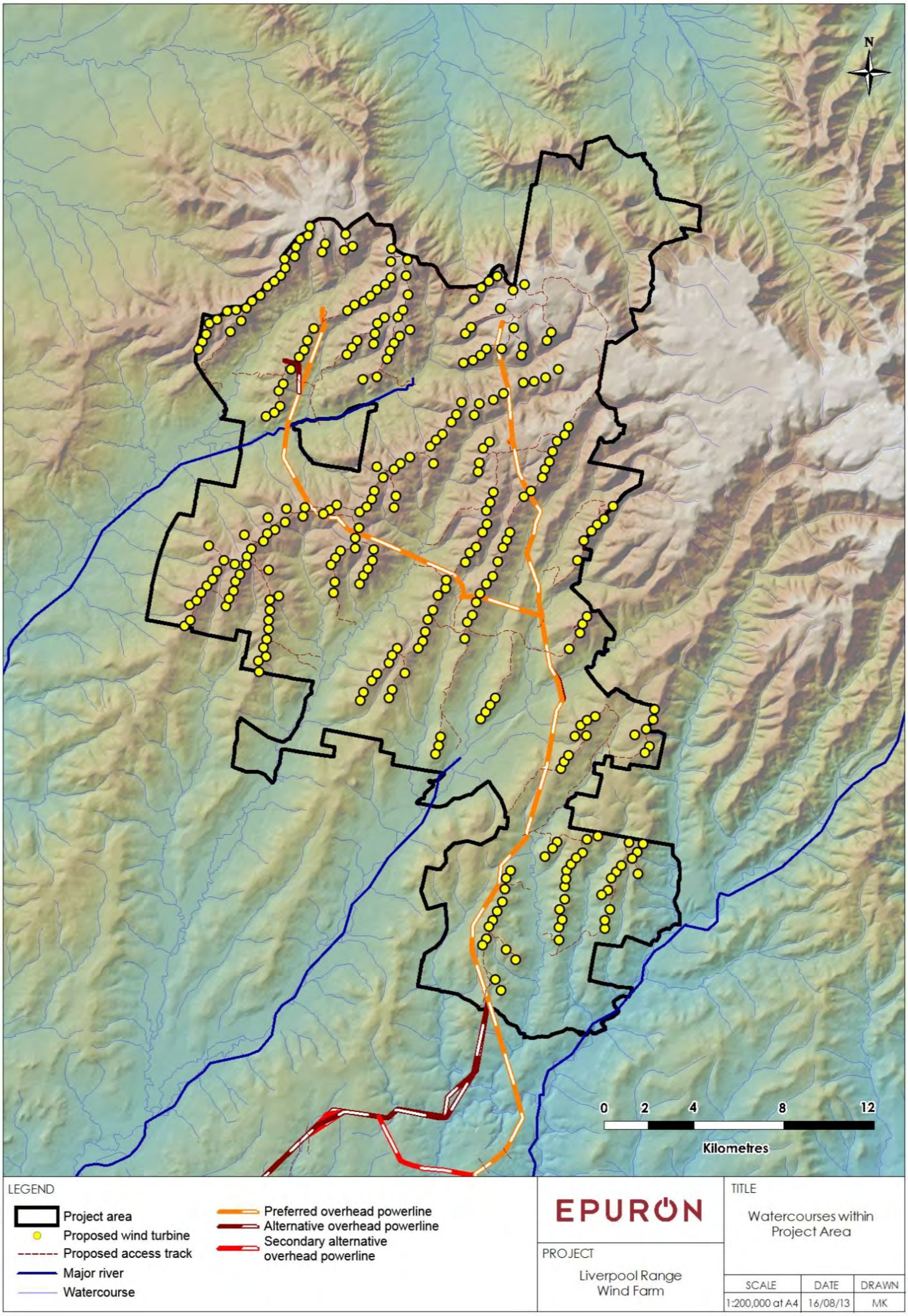

Figure 15-2 Watercourses within project boundary

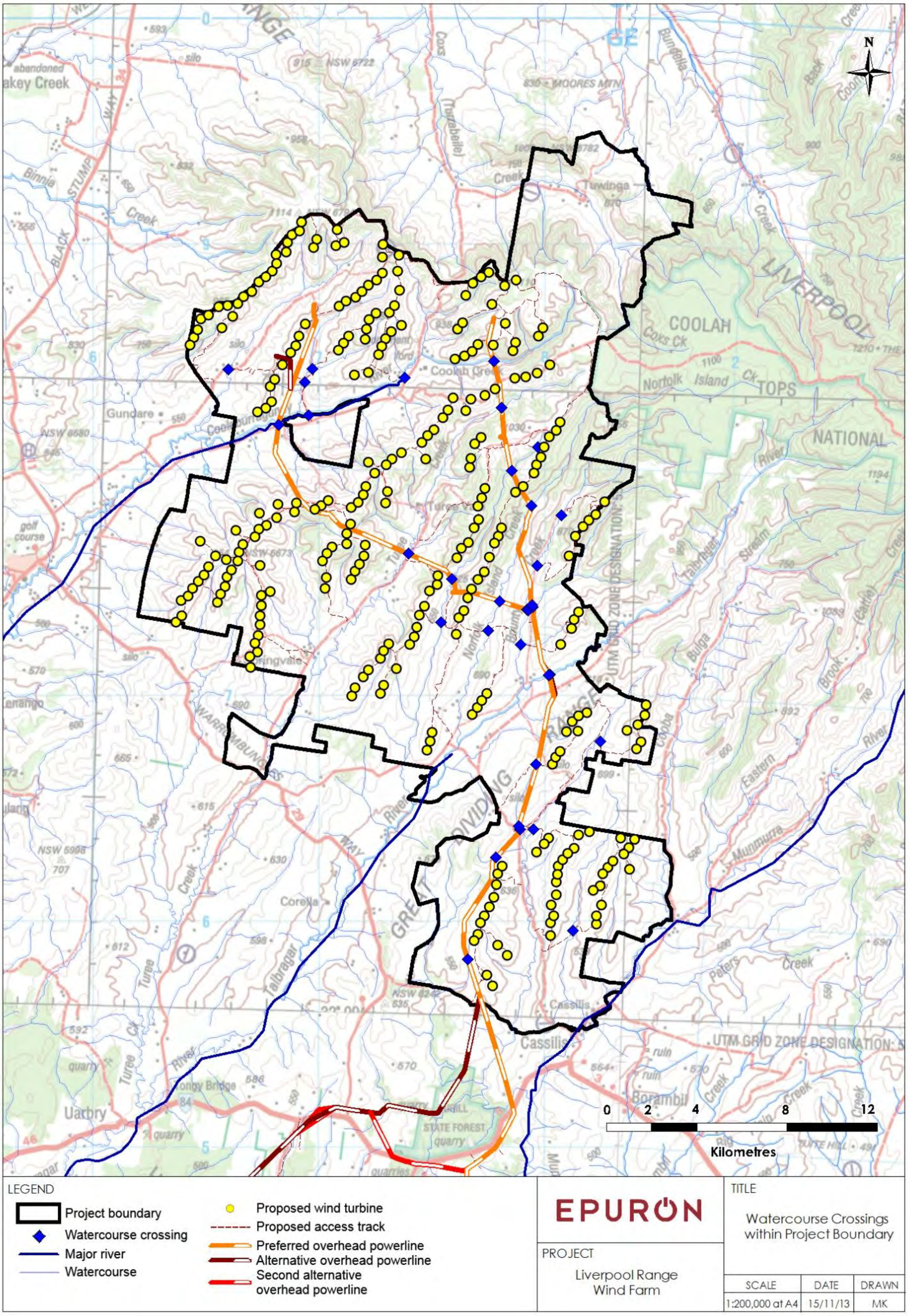

Figure 15-3 Watercourse crossings within project boundary

Figure 15-4 Coolaburragundy River watercourse crossing

Figure 15-5 Turee Creek watercourse crossing

Figure 15-6 Bounty Creek watercourse crossing

15.2.3 Groundwater

The Liverpool Range Wind Farm falls within the ‘Liverpool Ranges Basalt MDB Groundwater Source’ Water Sharing Plan for the NSW Murray-Darling Basin (MDB) Fractured Rock Groundwater Sources which includes rules for protecting the environment, extractions, managing licence holders' water accounts, and water trading in the plan area. The Liverpool Range Wind Farm will comply with the relevant requirements of this water sharing plan as discussed below.

The Liverpool Ranges Basalt MDB Groundwater Source covers an area of 286,000 hectares. The Liverpool Ranges volcanic lava-field province comprises alkali basalt formed 70 to 30 million years ago. The ranges start from the volcanic plateau of Barrington Tops and runs for approximately 100 km westwards, forming the northern boundary of the Hunter Valley district. Parts of the Liverpool Range from the watershed between the coastal and inland drainage of New South Wales and thus form a component of the Great Dividing Range. The western end of the Liverpool Range merges into the Warrumbungle Range.[7]

No impact on current groundwater levels or groundwater users is expected from the project primarily due to significant elevation differences between existing groundwater and proposed turbines regardless of whether a gravity type or rock anchor type foundation is used. For the purposes of this groundwater assessment a worst case scenario has been adopted using only rock anchor type foundations to 20m deep. Suitable steps will be taken to ensure construction run-off and oil does not contaminate local groundwater, and local groundwater will not be used as a water supply source for the project. Water supply for project construction will be sourced from local water supply dams and transported to site.

An assessment of groundwater bores within the project site indicates groundwater levels are generally located in lower lying country, not on the top of ridges where wind turbines are proposed. An example groundwater bore close to wind turbine locations is approximately 1.4km south of proposed turbine locations at the Hinman property (Groundwater number GW043621). Figure 15-7 shows location of the groundwater bore. This groundwater bore has an elevation of 560m above sea level, and the closest turbines have an elevation of 700m above sea level, an increase of 140m. This groundwater bore is 11.6m deep, with water found at 7.01m (NSW Government, National Resource Atlas 2013). As a wind turbine rock anchor type foundation is approximately 20m deep, there is no expected impact on this groundwater bore as there is more than 100m elevation difference between the water level and the proposed turbine.

Figure 15-8 shows all existing groundwater bores within the Liverpool Range Wind Farm project boundary. Of these 57 groundwater bores, the average water depth is 25.1m, and all groundwater bores have water depth levels over 100m deeper than the elevation of the closest turbines.

Table 15-1 examines the elevation difference between all 57 groundwater bores within the project boundary of the Liverpool Range Wind Farm and the closest turbines, and shows that the Liverpool Range Wind Farm will not impact, displace or intercept local groundwater. The Liverpool Range Wind Farm therefore will not impact on existing licenced groundwater users or basic groundwater landholder rights.

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[7] NSW Office of Water, January 2012

Figure 15-7 Example groundwater bore location