Before the proposed Waimakariri
Proposed District Plan Hearings Panel

Under the	Resource Management Act 1991
In the matter	of submissions lodged on the proposed Waimakariri Proposed District Plan (Hearing Stream 5: Energy and Infrastructure)

EVIDENCE IN CHIEF OF JORDAN BRETT-ALLEN SHORTLAND-WITEHIRA ON BEHALF OF TRANSPOWER NEW ZEALAND LIMITED (SUBMITTER NUMBER 195)

ENGINEERING

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1. SUMMARY OF EVIDENCE

1.1 Transpower New Zealand Limited (**Transpower**) manages and maintains its existing transmission line fleet to have a perpetual life. It is vital that Transpower is able to operate, maintain, develop and upgrade the National Grid (**Grid**) lines in order to deliver a reliable, secure supply of electricity nationally and to the Waimakariri District.

1.2 Transmission line components corrode and wear as any similar steel infrastructure does in the New Zealand environment. This corrosion and wear come about by the constant exposure of the line to elements, such as wind, rain and various pollutants. Transmission line aging, corrosion and wear all mean that ongoing inspection and routine maintenance work is constantly required.

1.3 Routine maintenance in Waimakariri District mainly includes inspections and patrols, foundation repair and replacement, insulator and steel replacement, and conductor repairs – these are generally works associated with aging, wear and tear, environment, and wilful damage.

1.4 Prudently designing buildings, structures or activities with the transmission line in mind (including beneath conductors (i.e. the wires)) ensures vital Grid infrastructure is protected and can be maintained and upgraded. 'Under-build' can delay, restrict or compromise the ability of Transpower to undertake maintenance or project work.

1.5 When a system fault occurs, the Grid needs to be restored quickly to reduce impacts on businesses and communities throughout the Waimakariri District, and beyond. Restoring supply becomes challenging if transmission lines are difficult to access due to intensive developments that may be constructed under and around them. Undergrounded transmission lines can have significantly longer restoration times.

1.6 Physical access to transmission lines is required for all routine and urgent maintenance and project work, including for staff, vehicles, and at times, helicopters and large construction equipment. The very nature of the works can significantly inconvenience people if they work or live near lines where the works are being carried out.

1.7 I consider that a regulated transmission corridor is essential for providing adequate access and working space at the poles, towers and mid-span.

1.8 Transpower operates its assets as safely as possible, but there are risks due to the high voltages being carried on the network. Lethal electric shocks can be caused by earth potential rise (step, touch and transferred voltages), conductor drop and flashovers. Hazards can also be caused by trees, mobile plant and other materials coming into contact with overhead lines.

1.9 Earthworks need to be managed to take the lines into account, in all areas. Earthworks can prevent physical access to transmission lines and undermine the structural integrity of support structures or reduce conductor to ground clearances to unsafe levels.

1.10 The 10m to 12m Grid Yard (either side of the centerline) is the area (measured horizontally) beneath the conductors in "everyday" wind conditions, being the conditions when line maintenance can be carried out. A 12m setback around Grid support structure is also required for access, maintenance, and safety purposes. The wider Grid Subdivision Corridor is the area sought for subdivision which extends to the width defined by the swing of the conductors in high wind conditions. These areas are the bare minimum to ensure that Transpower's maintenance, repair, upgrade, and operation activities are not compromised.

1.11 While the New Zealand Electrical Code of Practice for Electrical Safe Distances (NZECP 34:2001) prescribes minimum safe distances, it does not provide a comprehensive system for the management of these distances. This is to say, it does not prevent under-build and does not ensure that the operation, maintenance, upgrade and development of the Grid is not compromised.

2. QUALIFICATIONS AND EXPERIENCE

2.1 My full name is Jordan Brett-Allen Shortland-Witehira.

2.2 I am employed by Transpower as an Engineer – Lines within the Tactical Engineering Team.

2.3 I have a Bachelor of Engineering (Hons) in Mechanical Engineering from the University of Waikato. I am a member of Engineering New Zealand.

2.4 I have four and a half years' experience in transmission line engineering work. I currently work in the Grid Development Division of Transpower. My role involves providing transmission line engineering advice and support, writing, and reviewing standards and specifications for design, construction and procurement, supporting projects, reviewing design deliverables and ensuring construction quality.

2.5 I am familiar with the Grid assets within Waimakariri District Council's jurisdiction.

2.6 I have read the statements of evidence of Ms McLeod for this hearing, and the evidence of Ms Eng for hearing streams 1 and 2 and have taken these statements into account in preparing this statement of evidence. I support the planning solutions which the evidence of Ms McLeod recommends.

Code of Conduct

2.7 I confirm that I have prepared this evidence in accordance with the Code of Conduct for Expert Witnesses contained in Part 7 of the Environment

Court Practice Note 2023. As I am employed by Transpower, I acknowledge I am not independent. However, I have sought to comply with the Code of Conduct.

2.8 The issues addressed in this statement of evidence are within my area of expertise except where I state that I am relying on the evidence or advice of another person. The data, information, facts and assumptions I have considered in forming my opinions are set out in the part of the evidence in which I express my opinions. I have not omitted to consider material facts known to me that might alter or detract from the opinions I have expressed.

3. SCOPE OF EVIDENCE

3.1 My evidence will cover:

(a) An overview of Transpower's assets in the Waimakariri district;

(b) The basic components of an overhead transmission line, as well as a description of the factors relevant to undergrounding lines;

(c) How Transpower operates, maintains and upgrades the Grid, including the activities commonly carried out;

(d) Why access and clear working space are important for operating, maintaining and upgrading the Grid;

(e) The risks to third party activities arising from the Grid (such as electric shock, earth potential rise, conductor drop, flashovers and structure failures);

(f) The risks to transmission infrastructure arising from the activities (such as earthworks or vegetation) of third parties undertaken close to the Grid;

(g) The potential impacts of other activities on the Grid, including those sensitive to the Grid or otherwise incompatible;

(h) How risks can best be managed, including through the use of corridors; and

(i) An overview of NZECP34:2001, including its purpose and limitations of its application.

4. THE LOCATION OF EXISTING NATIONAL GRID ASSETS

4.1 In the Waimakariri District, Transpower has eight existing overhead transmission lines, traversing approximately 136km. These lines are 66 kV, 220kV and 350 kV. These lines provide local, regional and national benefit. The 350kV HVDC BEN-HAY (**HVDC**) linetransports electricity to the North Island via cables in Cook Strait. Part of the 66kV Kaiapoi-Southbrook line has been placed underground in the urban area around the Kaiapoi Substation.

4.2 In addition to the lines, there are three Grid substations – Kaipoi, Southbrook and Ashley. Ms Eng's Hearing 1 evidence includes a map showing the location of these existing assets.

4.3 The vast majority of Transpower's overhead line infrastructure is on private land. Despite this location, most of this infrastructure is not designated, nor is it protected by easements. Transpower relies on rights of access and occupation under the Electricity Act 1992. While Transpower has rights to lawfully occupy, and (subject to certain processes and notice requirements) access its infrastructure, this state creates challenges for Transpower.

4.4 Transpower continues to invest in the Grid both in terms of maintenance and enhancement of its asset base. Transpower's development and investment strategy is centred on maximising the use of existing infrastructure, therefore maintaining the environmental footprint for as long as possible before the introduction of new infrastructure. In the Waimakariri District, the focus for the next 10 years will generally be on maintaining and enhancing the assets we have.

5. BASIC COMPONENTS OF AN OVERHEAD TRANSMISSION LINE

5.1 Overhead transmission lines consist of five basic components:

(a) conductors (wires);
(b) structures;
(c) insulator sets;
(d) foundations; and
(e) earthwires.

5.2 These components are described in greater detail in **Appendix A** to my evidence. Transmission line components are designed to perform particular functions, and it is often difficult (or impossible) to change their look, location, or size to minimise adverse effects, without compromising that function. The majority of components used on a transmission line are manufactured to standard designs which are used all around the world.

5.3 When determining structure requirements, a compromise is made between the number of structures, structure strength and the structure height. The taller and stronger the structures, the fewer structures that are required. This is evident when you compare a typical pole line to a tower line - significantly more poles are required than towers to traverse a given distance. Generally, the higher the voltage of the transmission line, the taller the structures needed to support the conductors, due to electrical clearance requirements.

6. OPERATION AND MAINTENANCE OF TRANSMISSION LINES

Inspections of our assets

6.1 Maintaining the Grid is a core part of Transpower's business. To ensure the Grid delivers a safe, secure and reliable electricity supply, all assets need to be patrolled and inspected on a regular cycle that reflects the asset's age and type, its environment and geographic location, and high risk areas (such as where lines are over major roads, rail and urban areas). It is important that appropriate access to the Grid is retained. This is particularly relevant to changing land-use and subdivisions that I understand will be the subject of a future hearing.

6.2 Transpower carries out routine patrols and condition assessments to determine maintenance, refurbishment or upgrade requirements.

Routine patrols

6.3 A routine patrol involves viewing every asset frequently to identify any short-term defects or situations that may affect the operation or safety of the Grid in the shorter term. Items identified on patrols include damaged or broken insulators, impediments on the conductors, broken climb guards, faded signs, vegetation growth, access issues, land subsidence, and developments or activities under or near the line that may affect its safe and reliable operation.

6.4 I emphasise in particular that developments or activities under or near the lines, which are unsafe, will potentially only be identified by Transpower once per year (assuming that the activity occurs on the day of the patrol and is identified by the patrol team).

Condition assessments

6.5 A full condition assessment involves every line component being inspected and, in some cases, tested on a time-based schedule (mainly 3-7 yearly depending on the asset type and environment). Condition assessments require access to all transmission line structures and conductors. From these detailed inspections, a work programme is developed to ensure components are replaced or refurbished well in advance of their failure point.

How patrols and assessments are undertaken

6.6 Routine patrols and condition assessments of towers are carried out by field staff or contractors using a 4x4 utility or all-terrain vehicle to get as close as possible to the base of each structure.

6.7 Transpower also undertakes mid-span inspections of conductors, conductor joints and hardware as part of the condition assessment programme. Conductor tests are also carried out by a remote controlled conductor robot that travels down the span taking images and data and relaying this to a computer on the ground. Alternatively, it can be done by line mechanics accessing the conductor via a conductor trolley or by drone/helicopter. Helicopters are also used to take thermal images, high resolution photos, mid-span joint resistance tests or direct visual inspection.

Maintenance activities

6.8 From these routine patrols and condition assessment inspections, a wide range of maintenance work is identified and incorporated into a consolidated work programme. The work programmes are developed to ensure components are replaced or refurbished well in advance of their failure point.

6.9 Transmission line structures can be maintained almost indefinitely by practices such as painting of towers, concrete encasement of existing grillage foundations and replacement of insulators and conductors.

6.10 The maintenance activities that occur most frequently (some of which involve earthworks) are:

(a) Foundation refurbishment;

(b) Tower refurbishment including abrasive blasting and painting;

(c) All aspects of tower conductor and insulator (and associated hardware) maintenance or replacement; and

(d) Vegetation and tree control.

(e) Earth Potential Rise (**EPR**) mitigation.

6.11 Transpower has an ongoing programme of planned maintenance work to be undertaken in the Waimakariri District.

6.12 Within Waimakariri, planned maintenance works include those listed above, noting that the assets will need to be maintained beyond the life of the District Plan and therefore any buildings, structures and activities allowed now (or during the life of the Proposed Plan) will have long-term implications for the Grid. The conductor sections on the ASY-DEV-A and ISL-SBK-A have been identified as needing to be replaced.

Foundation refurbishment

6.13 Tower foundations include grillage foundations i.e. directly buried steel. Inspecting these foundations requires the whole foundation to be dug out on all four legs using earth moving machinery such as excavators. If the foundation needs to be excavated, the tower must, at times, first be supported via props or guy wires before excavation.

6.14 **Figures 1 and 2** below give an indication of the amount of spoil and land disturbance required for a typical grillage foundation strengthening project. Note the machinery required on site.

Figure 1: Grillage foundation replacement

Figure 2: Land disturbance during foundation replacement

Tower refurbishment

6.15 Tower painting is a significant on-going maintenance project for Transpower. Painted transmission towers have a coating life of approximately 14-18 years. The timing varies, depending on the environment where the tower is located. The HVDC Line was painted last year.

6.16 Once the galvanising on a tower reaches its end life (depending on the environment) the bare steel shows a combination of alloying with rust breakout in more corrosive areas (see **Figure 3**).

6.17 The longer a tower is left to corrode the more extensive the preparation is, therefore increasing the cost of the painting work (additional steel and bolt replacement may also increase with time).

Figure 3: Tower Corrosion

6.18 Tower painting can be disruptive for people who live and work near towers because of the preparatory activities required.

6.19 Prior to painting towers, wet abrasive blasting may be undertaken. This can cause material to become airborne. People and property located near this activity (i.e. where lines are "under-built") need to be protected from this material. **Figures 4** and **5** (below) show houses and cars being draped with protective covers during abrasive blasting. As seen from these photos, not all effects (such as debris and emissions of airborne particles) can be eliminated or fully mitigated using covers due to the complex terrain.

Figure 4: Tower painting in an urban setting, note the extensive polythene sheet protection

Figure 5: Tower painting in an industrial setting showing garnet debris falling onto covered cars

6.20 In under-built areas, Transpower's resource consents often require that less intensive blasting or painting processes are used. Not only does this increase costs (by $10,000-$25,000 per structure), it also reduces the quality and life of the paint system. As a result, towers need to be painted more frequently (almost every 7-10 years, instead of every 14-18 years), leading to more frequent disruption of people living or working under the lines.

6.21 By comparison, in areas where there is no under-build, methods such as geotextile matting laid under the electricity transmission structures can more easily capture debris from tower painting (see **Figure 6** below).

Figure 6: Abrasive blasting in area with no under-build

Conductor and insulator (and associated hardware) maintenance or replacement

6.22 Conductor repair and replacement is a significant and key part of transmission lines management. Conductors corrode or wear as they age, until reconductoring either all or part of the line is required.

6.23 Repair and replacement work involves:

(a) building, stringing and tensioning work sites to locate pullers and tensioners, laying down sites, storage, as well as an area for working;

(b) accessing each tower to remove the existing insulators and installing stringing equipment such as running blocks;

(c) tower and foundation strengthening where necessary

(d) rewiring (using the old conductor to pull out the new conductor);

(e) sagging operations at each tower to ensure even and consistent sag profiles;

(f) reinstalling the insulators, including clipping in the conductor;

(g) removal of plant and reinstatement of land.

6.24 In order to undertake maintenance work, and upgrades if required, appropriate access to the Grid must be retained. This is particularly important to consider when consent authorities are assessing proposals to change land use or to subdivide land.

Figure 7: Maintenance work being carried out using helicopters

Figure 8: Parallel Body Extension being installed on the BPE-WRK-A line

6.25 Access for maintenance work on simplex conductors presents some additional challenges compared to working on a duplex conductor[1]. For example, access to simplex conductors is usually limited to ground base operation using elevated work platforms or cranes, or lowering the conductor to the ground. In some cases, it is possible to suspend line workers from helicopters but this involves long periods of helicopter time while the work is being carried out below.

6.26 In the case of duplex conductors, access can be arranged using conductor trolleys as shown below in **Figure 9**. Conductor trolleys or helipads are suspended using both conductors of a duplex configuration to hold the trolley in place. The trolleys have four wheels which allows them to be moved along the spans between towers.

1 The difference between a simplex and duplex conductor is shown on the diagrams contained in Appendix A.

Figure 9: Depiction of conductor trolleys in use on a Duplex conductor

6.27 From time to time, Transpower needs to access the conductors at mid-span for inspection purposes or to carry out repairs. Mid-span damage can be caused by lightning or corrosion damage or could be caused by third party activities under the line from smoke or fires, vehicle or mobile plant contact/flashover;[2] or vegetation touching causing flashovers.

6.28 Conductor replacement or mid-span conductor repairs include inserting new sections of conductors, new joints, mid-span repair joints or sleeves. This work requires a relatively clear area under the line where the works are being carried out. In some cases, this may be the entire line.

6.29 Conductor repair methods include inserting new sections of conductors, new joints, mid-span repair joints or sleeves and removing impediments

2 A 'flashover' means coming into contact with the line conductors or where the electricity arcs from a conductor onto an object such as a structure or vegetation that is too close to a line.

such as kites, balloons, and electric fence wires. In all cases access to the conductor is necessary.

6.30 Mid-span under-build, particularly dwellings and buildings for intensive development (where people are most inconvenienced) creates significant additional costs for Transpower in carrying out any reconductoring or mid-span repair works.

6.31 There will be cases where this work could not be undertaken efficiently due to the presence of people or an inability to position plant where required. Alternatives (such as a new or bypass line) may need to be considered. In some instances it may be necessary to consider evacuating people living and working under the line, at huge inconvenience and cost (to Transpower as well as individuals and businesses).

6.32 In an urban or industrial environment, the reconductoring operation can cause inconvenience to the public by restricting vehicle access and even access to public or commercial areas such as schools, businesses, and parks.

6.33 In an urban environment, a reconductoring operation can cause inconvenience to the community by restricting vehicle and pedestrian access to public or commercial areas such as schools, businesses, and parks. Some commercial and industrial activities may need to shut down during conductor repairs, and/or can be affected by helicopter use. To provide a safe work site where work is being undertaken in a span where there is potential for inadvertent loss of control of load or machinery failure there the relevant work area may need to be closed off.

6.34 Intensively used buildings and commercial operations pose a real risk during maintenance. This includes buildings such as high level storage facilities, factories, large scale industrial buildings, commercial operations that emit dense smoke, dust or chemicals and high density lifting operations involving forklifts, cranes, tip trucks and similar vehicles. These buildings and activities either are at greater risk of effects from the transmission lines, or put the line itself at greater risk.

6.35 Intensively used buildings and commercial operations are at higher risk from electrical hazards during their day to day operations (due to number of people on site and the use of large mobile plant). The emissions (such as smoke) produced by the activities undertaken under the line, and large mobile plant operating, can put the line itself at greater risk of damage or deterioration. Examples include high-level storage facilities, factories, large scale industrial buildings, commercial operations that emit dense smoke, dust or chemicals and high-density lifting operations involving forklifts, cranes, tip trucks and similar vehicles.

6.36 If allowed to be constructed under conductors, these intensively used buildings and commercial operations would need to either be vacated during reconductoring operations or protected by constructing high cost scaffolding and nets (see **Figure 10** below[3]). This assumes that there is sufficient space, and air clearance, on site for the construction of such structures, which is not always the case. Constructing and dismantling the scaffolding and netting needed to protect the undercrossing line in **Figure 10**, cost in excess of $350,000.

3 Figure 10 shows live line scaffolding needed to protect the 110kV network while a 400kV line is being wired overhead.

Figure 10: Scaffolding protection structure for stringing

6.37 Reconductoring a typical existing line strain section would likely take 2-3 weeks depending on the asset. Even smaller maintenance work typically takes 8-12 hours. It is therefore practically very difficult, if not impossible, for Transpower to work around intensive industry operations without incurring large time or financial costs to both parties.

6.38 I acknowledge that less intensively used agricultural and horticultural buildings are less vulnerable to disruption and may be able to be located beneath conductors – mid-span, subject to compliance with NZECP 34:2001 and provided that any associated activities do not pose risk to either the operator or the line (i.e. mobile plant intruding on the MAD).[4] These types of buildings can easily be vacated (or kept uninhabited) while maintenance activities are undertaken.

Undergrounding transmission lines

6.39 Transmission lines can be undergrounded in some situations to minimise impacts on sensitive activities. Usually lines are undergrounded before

4 MAD refers to the minimum approach distance which the Electricity Code of Practice defines as the minimum approach distances in and around transmission structures and conductors to avoid flashovers.

residential or commercial development is undertaken, as the process of installing underground cables at transmission voltages can require significant earthworks as shown in **Figure 11**. This was the case for the Kaiapoi underground cable, which enabled land to be used for future developments.

6.40 Fault finding and repair on underground cables is significantly more difficult, costly and time consuming than on overhead transmission lines. It can take a considerably longer amount of time to locate and repair an underground fault compared with an overhead line. This can place increased pressure on the rest of the network and reduce its resilience to subsequent events.

6.41 Undergrounding transmission lines may not always be technically feasible, because of ground conditions (such as fault lines, groundwater, streams/wetlands or geothermal activity). Even where is possible, undergrounding can be orders of magnitude more expensive.

6.42 The undergrounding of transmission lines can sometimes compromise the performance of the Grid due to the different electrical characteristics of a cable circuit.

6.43 In addition, where lines are undergrounded, it is important to control structures, activities and vegetation above the cables, to ensure they are not damaged, and can continue to be accessed. Cables are generally placed 1.5m – 2m below the surface and in addition to construction requirements, require an ongoing clear corridor above and around them of approximately 11-14 metres wide for physical and access reasons, and to minimise the impact of magnetic fields.

Figure 11: 110kV underground cable installation

Scheduling of maintenance works

6.44 Transpower seeks to schedule its works, including any outages, to cause the least inconvenience to landowners and the public. However, this is not always possible meaning that it is sometimes necessary to access lines at short notice, for example to restore a circuit after an outage.

Vegetation and tree control

6.51 Trees and vegetation need to be monitored to ensure they are not growing too close to the lines. Transpower undertakes vegetation clearance in accordance with the Electricity (Hazards from Trees) Regulations. It also considers risks of trees falling into lines.

Maintenance work equipment

6.52 Depending on the type of maintenance work, the use of lifting machinery, stringing equipment, elevated work platforms or helicopters may be involved. Earth moving machinery, such as excavators or diggers, are required to expose or extract tower foundations or carry out tower refurbishment works.

6.53 For substantial works, a wide range of plant and equipment is sometimes necessary (see **Figures 12** and **13** below).

Figure 12: Removal of copper conductor on Pakuranga- Penrose A line

Figure 13: Crane being used for conductor stringing

Clearing Work Areas

6.54 As discussed earlier, Transpower's asset strategy for its line fleet is that all lines have a perpetual life. Transmission line structures can be maintained almost indefinitely by practices such as painting of towers, concrete encasement of existing grillage foundations and replacement of insulators and conductors. Conductors are replaced and increased in size and, at times, in the number of conductors per phase to meet additional carrying capacity. As an example, the ISK-KIK lines were reconductored in 2005.

6.55 A clear working space and good access is required, particularly around the base of support structures and in some cases under conductors, to move the plant and equipment in and set it up correctly. Cordons must be installed around the work site to minimise hazards and restrict access to everyone other than the trained work party. When work is carried out on a support structure, the effective work area for health and safety purposes includes the spans of conductor either side of that structure.

6.56 For some projects, such as wiring or where alterations are being made to structures, temporary hurdles or bypass lines may be required, or properties may need to be evacuated to protect against potential conductor drop hazards. Replacing a conductor is the time when the risk of conductor drop is greatest. **Figure 14** below shows a tensioning site on the ISL-KIK-B where a new conductor is being installed.

6.57 This particular project introduced a second circuit to the existing double circuit towers in this district. Construction works took place in 2005 as a fast tracked project conductoring sections from Islington to the Kikiwa substation.

Figure 14: Reconductoring site from an ISL-KIK-B stringing project

6.58 **Figures 15 and 16** below show hurdles established at a work site, including the space required, and their mid-span location. Hurdles are installed to protect traffic on access roads from risks associated with dropped conductors (mainly during re-stringing or installing conductors). Similar projects in urban and industrial developments have required the evacuation of residents or workers for periods of up to a week.

Figure 15: Hurdles installed to mitigate potential conductor drop during wiring

Figure 16: More substantial hurdles installed to mitigate potential conductor drop during wiring

6.59 Depending on the location and type of maintenance work proposed, the time taken to travel to a site, establish and set up equipment and prepare and secure the site ready for the maintenance work can be significant. It can take several hours simply to transport and establish cranes or excavators on site and set them up on a suitable platform (see **Figure 17** below). It also takes time to apply safety devices and hold work briefings. There may be delays during the planned work periods because weather or environmental conditions may restrict crane or excavator operations due to safety concerns.

Figure 17: Reconductoring in an urban setting

6.60 **Figure 17** depicts the challenges of an urban environment and is an example where historical subdivision development has occurred under existing transmission lines originally in place, which limits future works for maintaining the Grid. As is shown in **Figure 17** additional machinery and safety precautions are required when development (particularly more sensitive urban development such as residential dwellings) is constructed under the Grid.

Access for Planned Works

6.61 Transpower has:

(a) statutory rights to access its assets on private land under the provisions set out in the Electricity Act 1992. The Act provides for access to maintain, inspect and operate the Grid; and

(b) in some cases, contractual or property rights to access new assets constructed on private land.

6.62 It is important to note that my evidence is about the physical ability to access Transpower's assets. Issues regarding establishing legal access are distinct issues that are handled by other divisions in Transpower.

6.63 In my view, it would be ideal to have unimpeded physical access to all transmission line structures. However, in a practical sense this is not always possible. Physical barriers and natural obstacles, such as waterways, valleys, and undulating ground and including through earthworks, require Transpower to use alternative access options, for example helicopters and/or walking in.

6.64 Intensive or sensitive development constitute additional physical barriers to accessing transmission line support structures, increasing the costs and difficulties associated with gaining access.

6.65 The quality of access is important as some construction plant, for example cranes and concrete trucks, require wider and lower gradient tracks than what are traversable by smaller vehicles, an appreciation for this can be seen in **Figure 18**. The existing access is usually the most suitable as it was generally used to construct the line and for ongoing maintenance. If the landowner decides that they wish to change the access, Transpower should be consulted to ensure that the new route will not impede future works on the Grid.

6.66 If the planning regime ensures continuation of existing access, this will avoid the need (and associated cost and delay) to dismantle fences and other structures, temporarily bridge waterways, carry out excavation or vegetation removal, just to access the Grid.

Figure 18: Example crane access required for cross arm and insulator works

6.67 **Figure 19** (below) shows construction works and the space required for relocating conductors to temporary pole structures on the HVDC line. It should be noted that the construction space here not only considers the machinery/equipment occupying the site, but also the area spanning further by the guy wires/anchors to stabilise the temporary pole structures. This was the area required to safely conduct works on a single structure.

Figure 19: Example of access and construction space required on the HVDC line. Installing more structures on the line.

6.68 The works shown above are also occurring under live line conditions meaning that the safety risk of the construction is considerably high.

6.69 The scope of these works were to install more structures to improve the resilience of the line

6.70 The need to conduct these works under live line conditions with the poles on either side are due to the outage limitation that the Grid has with the HVDC line.

Access for Emergency Works

6.71 In the event of a fault, Transpower must always be able to quickly access its lines to find and fix the fault. Businesses and communities are heavily reliant on electricity, so it is crucial that faults are identified and fixed as soon as possible.

6.72 While Transpower's assets perform well in storm events or natural disasters, excessive winds and rivers changing course do at times break or collapse Grid infrastructure and emergency repairs need to be carried out to get these back into operation. During these times there is often a heightened requirement for electricity. The Grid is a lifeline utility.[5]

6.73 Suitable, known and agreed access routes are important so as to not delay the restoration of services.

7. Managing the activities of others

7.1 The transmission network gives rise to specific risks such as lethal electric shocks. These risks increase if there are incompatible activities located under the electricity transmission lines or other Grid assets, or in close proximity to them.

7.2 Preventing sensitive and incompatible activities from establishing under the transmission lines, along with controls on activities that will occur near electricity transmission lines, will assist the Grid to be reliable and safe while serving future generations.

7.3 A preventative approach to the management of the transmission corridors and a proactive approach to ensure safety for high risk activities regularly occurring under Grid lines would lead to better outcomes for the Grid assets and for third parties, as they would suffer less disruption from their activities.

7.4 The following section of my evidence discusses potential effects on the Grid arising from third party activities.

5 Under the Civil Defence Emergency Management Act 2002.

Direct effects

7.5 I discuss the National Policy Statement on Electricity Transmission (**NPSET**) in the next section of my evidence, however note here that it seeks to prevent inappropriate development occurring in proximity to Grid assets. Although it was published over 12 years ago, under-build and inappropriate development continues to occur under and around Grid assets and overhead transmission lines in particular. Below, and in **Appendix B**, I discuss some additional activities that can have direct effects on the Grid, which should be avoided in close proximity to transmission lines.

Activities sensitive to National Grid assets

7.6 There are a range of activities that have particular sensitivities to Transpower's assets. In particular, I understand that:

(a) electrical interference could have serious implications for places such as hospitals or rest homes which rely on the proper functioning of electrical equipment 24 hours a day; and

(b) radio controlled systems and global positioning systems are also known to be affected by the close proximity of transmission lines. These systems are being used more commonly for communications and automated control systems in industrial processes.

7.7 Of further concern is any residential development or intensification of other activities under transmission lines or close to support structures. The main hazard associated with high voltage transmission lines is receiving an electric shock. This is a risk which cannot be mitigated from an engineering perspective; it can only be avoided. This is discussed further in later sections of my evidence.

7.8 As noted earlier, people living or working in buildings under transmission lines create significant difficulties when Transpower needs to do maintenance, upgrade and development work. A lot of work has been done with the lines energised, which usually requires people to vacate the buildings while the work is underway. Even when works are conducted with the lines de-energised, there are risks to people and property under the line.

Preventing Transpower's access

7.9 Both land use and subdivision can prevent physical access to structures and the area of mid-span. **Figure 30** in **Appendix B** shows a dwelling constructed in Auckland that prevented Transpower accessing the tower for grillage refurbishment (foundation) work.

Reverse sensitivity

7.10 Reverse sensitivity effects are caused by activities which are located near lines. They often relate to noise, visual, electrical interference, and perceived health and safety effects (humans and animals), as well as the limitations placed on land use in close proximity to the lines.

7.11 Physical separation of third-party activities from transmission lines can reduce the incidence of people who live and work nearby complaining about the line and requesting changes (i.e., limits or restrictions) to its operation.

7.12 The area or distance from the lines within which reverse sensitivity effects can arise may vary according to the type of issue raised, but they are most noticeable in the area to where the conductor swings out. Depending on asset type, this area can be out to 39m either side of the centreline.

Types of concerns and complaints raised about transmission lines

7.13 I have discussed above the importance of physical separation of third party activities from transmission lines for safety, access and sufficient working space. A further reason why physical separation is important from Transpower's perspective, is to reduce incidents of people who live or work nearby complaining about the line and requesting changes (i.e. limits and restrictions) to its operation.

7.14 The presence of a transmission line can give rise to perceived health concerns and visual amenity issues, even some distance from the line.

7.15 In addition to general complaints arising from the presence of transmission infrastructure, Transpower also receives requests from landowners to underground existing overhead lines, raise conductors, or restrict future Grid works, particularly if they involve changes in visual appearance. Although the distances these types of effects are experienced at vary according to the type of effect, I expect they are most noticeable within 12m of the centreline.

7.16 At the North Island Grid Upgrade Project ('NIGUP') Board of Inquiry into the then proposed 400kV capable Brownhill Road – Whakamaru North A line, a number of submitters raised concerns about both potential mechanical and electrical noise, and the potential effect on milking dairy herds in close proximity to the lines, as well as on the operation of sensitive electronic equipment such as radio-controlled systems. In most cases, these concerns were addressed by Transpower moving existing buildings away from the proposed line. It is noted that in general, Transpower seeks to avoid these existing activities where practical.

7.17 These complaints are much more difficult to address where new activities are located close to an existing transmission line, perhaps without understanding the effects that lines can have.

7.18 Noise can also give rise to complaints. Noise from a transmission line usually comes in two forms; mechanical noise and electrical noise:

(a) Mechanical noise can come from vibration which causes a rattle of the line hardware (insulator attachments, steel members) or from environmental events such as high winds (wind whistling through conductors or over steel works).

(b) Electrical noise usually comes from some form of electrical discharge, or leakage. This generally can be heard discharging down insulators when it starts raining after a long spell of fine weather. In some cases this corona discharge may be seen at night when insulators are polluted and electricity is seen discharging down from the conductor to the tower steel.

7.19 In some areas of New Zealand, landowners/occupiers have also raised concerns about electric and magnetic fields (**EMF**) from transmission lines. I note that Transpower's assets operate well within the limits in the International Commission on Non-ionising Radiation Protection Guidelines for limiting exposure to time varying electric magnetic fields (1Hz – 100kHz) (known as the ICNIRP Guidelines). These Guidelines are recognised by the Ministry of Health and the World Health Organisation

7.20 Transpower’s telecommunication assets comply with NZS2772.1:1999 Radiofrequency fields - Maximum exposure levels - 3kHz to 300 GHz. Other users of Transpower sites are also required to comply with this standard.

Earthworks

7.21 Earthworks adjacent to towers or poles can undermine the stability of the structure foundations, causing the structure to lean or, worse, collapse.

7.22 Excavations or mounding mid-span can also increase risks by reducing the clearance between the ground and conductors. **Appendix B** includes some examples of earthworks activities that have created unstable batters or resulted in ground to conductor clearance violations, causing significant safety risks, as well as risks to security of supply.

7.23 One of the reasons Transpower seeks to manage earthworks undertaken by third parties (which includes quarry and landfill operators) is to mitigate, or at least significantly reduce, the safety risks described above. Physical separation from transmission infrastructure greatly reduces the likelihood of harm or damage occurring to people or property. However, Transpower is comfortable with provisions that align in part with NZECP34:2001 (albeit that the physical separation standards are sought in the plan for broader reasons than safe electrical separation distances)

7.24 Earthworks can cause dust which results in the build-up of material on the Grid lines and contributes towards the degradation of the equipment thus reducing its useable lifespan.

7.25 Excavated areas or piles of earthworks soil can also restrict Transpower's ability to access and locate the heavy machinery required to maintain and upgrade support structures. This can lead to potential line component failure and significant constraints on the operation of the lines, such as increased power outages. Earthworks can also undermine the stability of support structures.

7.26 For these reasons, Transpower seeks controls on earthworks near the Grid.

7.27 In determining appropriate setback distances for earthworks from Grid support structures, a common assumption is the Grid is not compromised if the earthworks comply with NZECP 34:2001. This is not the case. The example below (see **Figure 20**Figure) illustrates that NZECP 34:2001, on its own, does not adequately ensure that the Grid is not compromised.

Figure 20: NZECP34 compliant earthworks around a pole on the ARI-HAM-A line

7.28 **Figure 20** shows earthworks near a transmission line pole that are technically compliant with NZECP 34:2001. As a result of the earthworks near the pole structure, Transpower's ability to operate and maintain the line and structure at that location has been compromised. The batter slope may become unstable as a result of erosion and slipping. Access to the site is now severely restricted and there is no ability for Transpower to operate heavy plant on the elevated platform. Ongoing engineering checks are required to monitor the effects of erosion and to ensure the stability of the foundations.

8. THE REASONS FOR NATIONAL GRID CORRIDORS

Health and Safety Risks

Electric Shock

8.1 The main hazard associated with high voltage transmission lines is receiving an electric shock. The risk and severity of electric shocks varies depending on the transmission voltage and type of exposure (e.g. direct human contact, mobile plant, or vegetation). Risks are most likely to be highest within 12 metres of the line. However, some associated effects can be transferred further than this.

8.2 Lethal electric shocks can be caused by:

(a) earth potential rise;
(b) step and touch voltages;
(c) induction voltages;
(d) conductor drop;
(e) flashovers (coming into contact with the line conductors or where the electricity arcs from a conductor onto an object such as a structure or fence); and
(f) vegetation growing too close to a line and causing a flashover

8.3 These hazards can occur as a result of third party activities (such as mobile plant or machinery) coming into contact with conductors, or earthworks occurring too close to structures or mid-span thereby reducing clearance distances, and excavations occurring too close to structures or mid-span thereby reducing clearance distances. All of these things can endanger safety and affect the operation of the Grid. I discuss these hazards in more detail below.

Earth potential rise

8.4 EPR is usually caused by an earth fault at a tower or pole. An earth fault occurs when an energised conductor comes into contact with, or flashes over to, the tower, pole, or any earthed object. This can occur through an insulation failure as a result of lightning, pollution or foreign objects.

8.5 During an earth fault, there is a significant current flowing in the faulted line from the power source into the fault point. These fault currents are highest either near the electricity source (generator) or substation as the current returns through the ground.

8.6 The return current causes momentarily high voltages to appear on both the tower and the ground around the base of the tower. The voltages are highest on the faulted tower or pole and decrease on the ground as you move further away from the faulted tower. In other words, the risks of EPR lessens with distance from the support structures. Voltages can appear on any conductive object on the ground (such as a fence) that bridges the voltage contours.

8.7 The earth fault current causes EPR around the faulted tower, which in turn results in step and touch voltage hazards and transferred voltage hazards as discussed below.

8.8 EPR can cause electric current to flow through people in the affected area at the time. The impact of that ranges from a discomforting feeling through to serious injury or death.

8.9 Transferred voltage hazards can occur where continuous long conductive structures or fences are located close to the tower. High current and voltage may transfer to them from the tower through the ground, and then travel some distance down these structures, causing an electrical hazard some distance from the faulted tower.

8.10 **Figure 21** shows potential EPR scenarios.

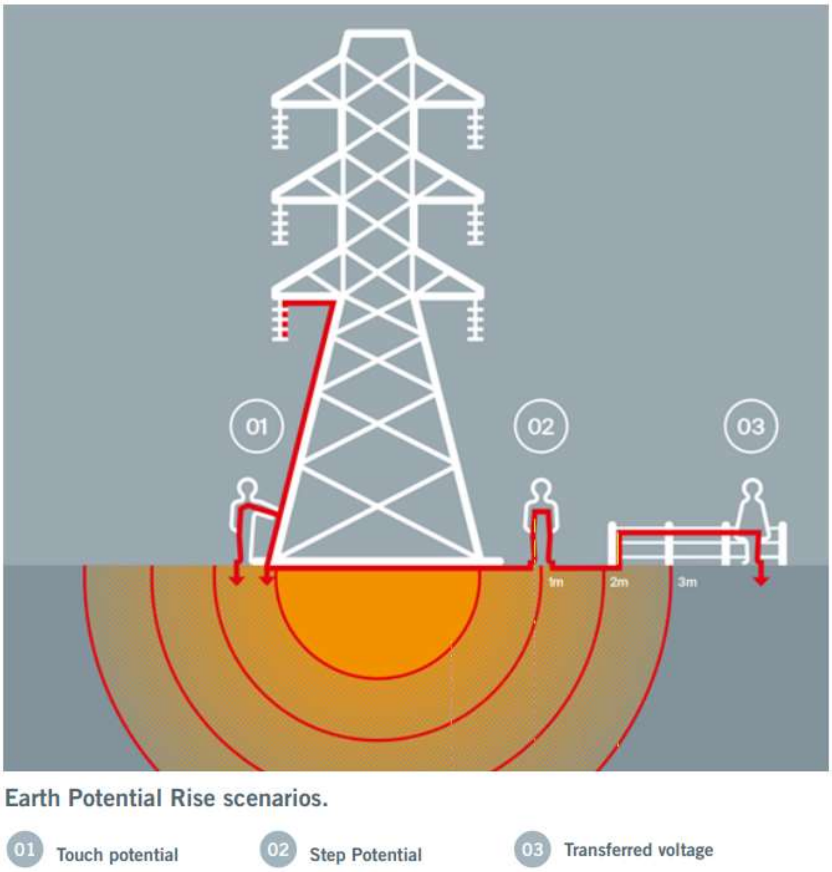

Figure 21: Earth potential rise scenarios

Step and touch voltages

8.11 Step and touch voltages can arise due to a fault at a tower or pole and, as explained above, momentarily raise the voltage at the tower or pole base and the surrounding ground. A step voltage hazard can occur when a step is taken in this area, or a person or animal is in contact with the tower or pole and standing on the ground, thus causing a voltage difference between the feet or between the feet and hands. Where conductive buildings, structures or fences, for example, are located close to the tower or pole, high current and voltage may transfer from the tower or pole, via the ground and travel some distance down these structures causing an electrical hazard some distance from the faulted tower or pole and causing the same effect.

Induction voltages

8.12 Induction voltages can cause irritation to a person or animal and nuisance from conductive materials such as fences, wires or large industrial buildings. Induction is caused through a magnetic coupling between the conductors and any metallic wires or fences installed over longer distances, generally those running parallel to the circuit itself. People may experience inductive shocks between the metallic wires and ground.

Conductor drop

8.13 The conductor can drop to the ground should a mechanical failure occur to the support structures, supporting insulators and hardware, or the failure of pressed mid-span joints. In addition, electrical failure can lead to the mechanical failure of the conductor or the pressed mid-span joints.

8.14 While it is rare for a support structure, conductor, or the conductor hardware to fail causing the conductor to drop to the ground, it can happen.

8.15 Historically, the majority of line drops have occurred in rural areas, but there have been rare occasions where a line drop has occurred in an urban setting (where the generally more intensive and sensitive development places more people and property at risk). When a line drop does occur, the consequences can be fairly wide ranging for activities under the line. **Figure 22** below shows impacts within a dwelling, following a line drop. The internal electrical switchboard and appliances have been damaged by the significant transfer of voltages to earth from an adjacent transmission line.

Figure 22: Electrical damage following a conductor drop

Figure 23: A conductor drop

8.16 As well as the electrical aspect of a conductor drop (see **Figure 23** above), there is also a mechanical aspect of a large load dropping. Conductors on a typical duplex 220kV line weigh approximately 3.0kg/m, therefore for a typical span the weight of the conductor at the point of impact could be as high as 750kg.

Flashovers

8.17 A flashover is a major electrical discharge, usually in the form of an electric arc, which leaps or arcs from the conductor across the insulator string to the tower (or from the conductor to another object) resulting in a short circuit.

8.18 Flashovers can occur from lightning strike, contamination of the insulator or when a person/object is too close to, or comes into contact with, the conductors.

8.19 Third party activities involving mobile plant or machinery such as excavators, hi-abs and cranes have the potential to reach up to, or above, the height of the conductors. It is essential that the use and location of this machinery is carefully considered to avoid contact with the conductor. **Figure 24** show the minimum clearance required between a conductor and mobile plant to avoid flashover.

8.20 Coming into close proximity to a live conductor and causing a flashover (i.e. the flashover will occur prior to contact) can:

(a) Compromise the safety of the machinery operators or workers or members of the public in or near the machinery and result in electric shock;

(b) damage the machinery or the line itself; and

(c) affect the operation of the Grid and the security of supply.

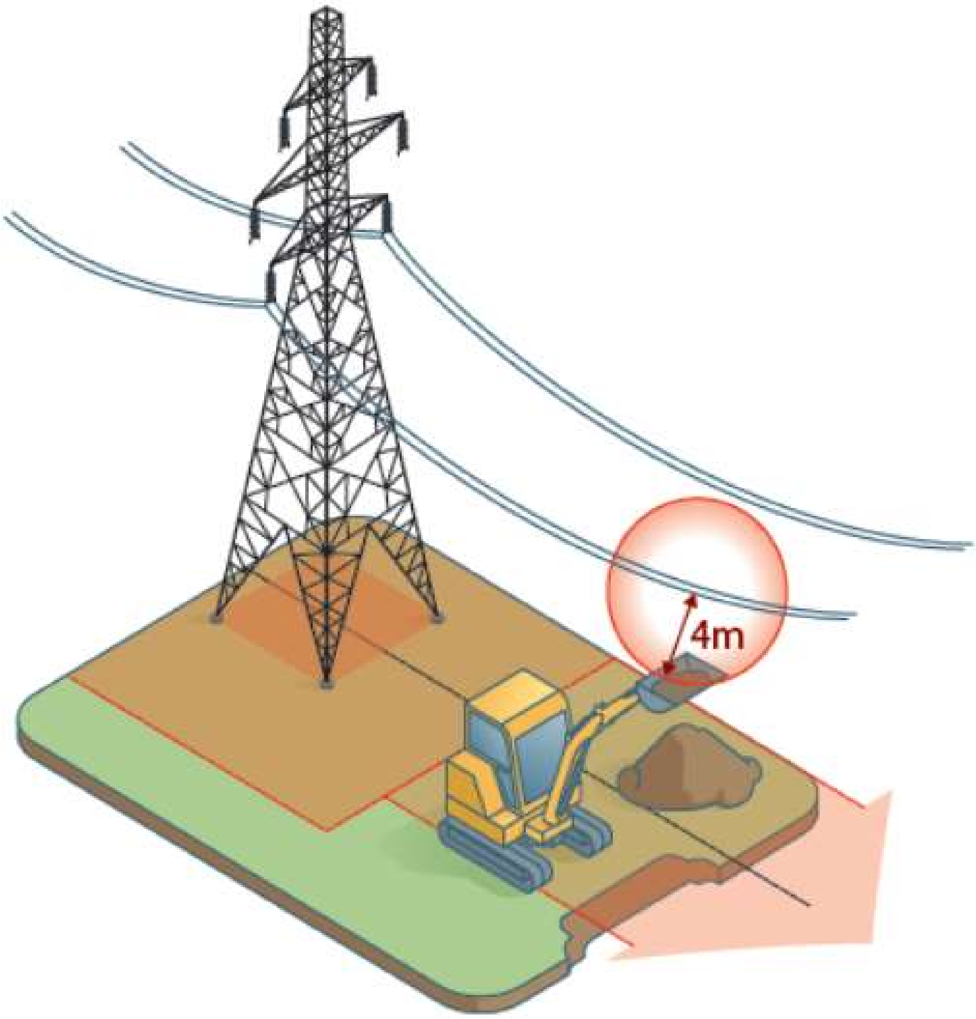

Figure 24: Minimum clearance required between conductor and mobile plant to avoid flashover

8.21 The risk of incidents such as these occurring increases if incompatible activities are allowed to be undertaken or are intensified under or near electricity transmission lines.

Vegetation

8.22 It is important to note that the conductor (wire) sag (amount of droop) changes as it heats up with high electrical load (current). This change in sag impacts clearances to the ground, under-built structures and vegetation. This change in sag, and therefore clearance, is not visibly noticeable or well understood by the public, as the maximum loading conditions occur infrequently.

8.23 Trees growing close to a line, and which cause a flashover from the conductor to the tree, may cause:

(a) a circuit fault that affects the operation and supply of the Grid;

(b) injury or death to anyone who may be near the tree at the time of the fault; or

(c) damage to the tree, land or property.

8.24 I understand that vegetation clearances are not part of Transpower's request for a transmission corridor, however the effects of failing to comply with clearly specified vegetation growth distances provides a similar context to that of buildings or other activities.

8.25 If a tree touches or comes close to touching the high voltage conductors and causes a flashover, dangerous voltages may arise on the tree itself or in the ground area around the tree. These voltages have the potential to cause serious injury or death. Flashover to a tree where high voltages are involved can cause the tree to ignite and cause a wider fire hazard if the tree is near buildings or forests.

8.26 It is therefore vital that trees and all other vegetation are trimmed or cut to ensure they do not encroach into a "Growth Limit Zone" around the conductors under all situations (i.e., taking into account the effect of wind on the conductors and trees, and the sag and swing of the conductors under various ambient temperatures and load). For voltages of 110kV and higher, the tree "Growth Limit Zone" is 4 metres from the conductors under worst case conditions.

8.27 In practice, the regulations empower Transpower to give notice to trim a tree once it reaches a distance of 5m from the conductors.

Other hazards

8.28 Other hazards and issues associated with transmission infrastructure include equipment or structure failure, earthworks, electrical and wind noise, and the perceived effects of EMF.

Equipment or structure failure

8.29 Transmission lines, similar to buildings, are designed to withstand specified levels of climatic conditions (e.g. wind speed, snow thickness). If these levels are exceeded, it is likely that failure will occur. Failure events include broken or fallen conductors, collapsed towers or poles, or any other substantial component failure which results in high risk of property damage or injury and electricity disruption.

8.30 Transpower sets high design criteria for its infrastructure given the importance of supply to the country. Although the probability of a failure event is low, there is the possibility that injury or damage could occur if a person, animal or item of equipment is in the wrong place at the wrong time.

8.31 **Figure 25**, illustrates the scale of a failed structure on the BEN-HAY line that passes through the Waimakariri District

Figure 25: Failed tower on the Benmore-Haywards A line

9. Management of risks

9.1 Transpower manages risks when designing and constructing new assets, and through continuous assessments and maintenance of the existing assets. For example, when earth faults occur, the current is interrupted by protective devices at each end of the line to clear the fault in a fraction of a second.

9.2 However, engineering solutions such as this are only part of the answer. It is also vital that third parties do not interfere with the proper operation of the line, and that appropriate maintenance and upgrade work can be carried out when required.

9.3 This risk can be minimised by ensuring development is either avoided or is compatible with the electricity transmission lines. Where large scale development (such as subdivision) is proposed it can, and in my opinion it should, be designed to ensure that only appropriate activities occur under the lines. Appropriate activities include carparks, roads, stormwater infrastructure, or open space that does not involve buildings or structures.

9.4 Proper design of any underlying activities, including consultation with Transpower, is essential to manage risk.

9.5 Where the decision is still to develop in the vicinity of transmission line, consideration should be given to the following issues:

(a) the safety of workers during any construction or build stages of the development (e.g. builders, earth movers, and electricians);
(b) the safety of residents, workers and the public who may be working, living or recreating in the area after the development is completed;
(c) the safety of the line maintenance workers who are required to access the Grid assets both during the development's construction and after its completion;
(d) whether the proposed development follows construction industry best practice; and
(e) access to structures and lines by emergency vehicles (ambulances, fire engines etc).

9.6 In addition, the planning, installation and use of buildings, structures as well as heavy lifting plant operations must take into consideration a number of key elements, including:

(a) the location and configuration of the transmission line support structures;

(b) the inductive voltages that may be present and possible mitigation measures that may need to be applied;

(c) the vehicle movements, location of construction materials and height restrictions of both vehicles and workers necessary to avoid entering the conductor flashover zone;

(d) the transferred voltage hazards; and

(e) the EPR issues associated with workers in and around transmission line structures.

10. National Grid Corridors

10.1 The importance of transmission corridors has been recognised by Government policy makers. The NPSET, introduced in 2008, requires councils to give effect to its provisions in the plans they adopt under the RMA.

10.2 As explained by Ms McLeod, Transpower is seeking a Grid Corridor within the Waimakariri District for undesignated overhead transmission lines, to provide for:

(a) A 10m corridor either side of the centreline of an overhead 66kV Grid transmission line, where specified activities are restricted (Grid Yard);

(b) A 12m corridor either side of the centreline of an overhead 220kV or 350kV Grid transmission line, where specified activities are restricted (Grid Yard);

(c) A 12m setback around Grid support structures, measured from the foundation (Grid Yard); and

(d) A wider corridor where subdivision is managed (Grid Subdivision Corridor), namely:

(i) 32m either side of the centreline of above ground 66kV transmission lines on towers;

(ii) 37m either side of the centreline of above ground 220kV transmission lines; and

(iii) 39m either side of the centreline of above ground 350kV transmission lines.

10.3 The 10m or 12m Grid Yard is the general area beneath the conductors in "everyday" wind conditions, being the conditions when line maintenance can be carried out. A 12m setback around each support structure is also sought for access, maintenance and safety purposes.

10.4 The distance a transmission conductor swings in the wind is dependent on the ambient temperature, the power being carried, the wind speed, the type and size of conductor, the tension the conductor is strung at, the supporting structure configuration (cross arm length) and the length of the span (distance between two towers or poles).

10.5 To calculate appropriate corridor widths, a set of standard line types, based on voltage and structural configuration have been developed by Transpower. Following analysis, it was determined that the swing is most sensitive to the wind speed and span length.

10.6 An ambient temperature of 10ºC, a wind pressure of 100Pa (46km/hr), full electrical load and the conductor type applicable for the line type were assumed for each transmission corridor. A range of swings was then determined for each line type.

10.7 The width of transmission corridors was then determined by the swing of the 95th percentile span across the country and access requirements for maintenance purposes.

10.8 Specific to the Grid Subdivision Corridor, the width of the subdivision corridor is based on the extent of the swing of the conductors in high winds. The distance a transmission conductor swings in the wind is dependent on the ambient temperature, the power being carried, the wind speed, the type and size of conductor, the tension the conductor is strung at, the supporting structure configuration (cross arm length) and the length of the span (distance between two towers or poles). As such the subdivision corridor width increases for higher voltage lines and towers as generally the span (distance between support structures) is greater for towers and combined with a higher voltage which makes the transmission lines heavier, means the conductor swing in high winds increases. The derived Grid Subdivision Corridor widths are based on a 95th percentile span across the country.

10.9 The Grid Corridor approach has several important purposes:

(a) To enable uncompromised access and maintenance;
(b) To avoid reverse sensitivity effects;
(c) To provide a consistent approach to managing the potential for adverse effects in the Grid;
(d) To reduce risks of damage to structures and their foundations as a result of adjacent structures and land disturbance; and
(e) To avoid safety hazards.

10.10 The Grid Corridor is also important for the following reasons:

(a) To protect the infrastructure corridor itself. As land uses become more intense, it is increasingly difficult to identify routes for new assets. If a transmission line is compromised by encroaching land uses, it can sometimes be impossible to optimise the capability of existing lines (which defers the need to build new lines). If new lines are required, it can be difficult to identify an alternative route which would disrupt landowners less.

(b) To alert landowners to the constraints the Grid lines impose on land use. It also clearly indicates how they can manage their own activities.

10.11 The corridors Transpower seeks reflect the minimum areas considered necessary for the protection and operation/maintenance of the Grid. The corridors have not been sized to provide for major rebuilds or new lines. The proposed areas do not fully address such matters as amenity and reverse sensitivity.

11. NZECP 34:2001 - PURPOSE AND LIMITATIONS

11.1 Compliance with NZECP34:2001 is often raised as being sufficient to address risks and issues associated with development near the Grid. In this part of my evidence, I briefly comment on the purpose and limitations of NZECP34:2001.

11.2 NZECP34:2001 serves an important purpose in prescribing minimum safe distances for the construction of buildings and structures, for the use of mobile plant, and for excavation near transmission line support structures and overhead lines. It does not address the wider third-party effects that compromise the Grid, which are managed by the NPSET. As such, while NZECP34:2001 sets a baseline of standards, it does not address other issues in respect of the Grid and therefore does not form the baseline for the District Plan to give effect to the NPSET.

11.3 Of importance, minimum safety requirements in NZECP34:2001 neither seek to protect the integrity of the Grid from the effects of third parties, nor prevent development (including sensitive and intensive development) from occurring directly underneath transmission lines. As discussed above, such development can constrain operational and maintenance activities on lines.

11.4 Further, NZECP34:2001 does not adequately account for EPR hazard contours. Clause 5 of NZECP34 specifies four metres as the minimum distance that must be kept between live overhead lines and any part of any mobile plant or load carried by that plant (without Transpower's prior written approval). In my experience, the four-metre distance is very difficult to monitor and enforce. Mobile plant operators such as forklift drivers, concentrating on the load they are carrying, may not look up and be aware of live conductors as low as 7 metres above the ground.

11.5 While NZECP34:2001 is a good base document for the determination of safe clearances, experience has found that the document is not well understood by the public. Even relatively sophisticated commercial entities often do not understand compliance requirements.

11.6 Usually, Transpower's contractors will patrol every line and structure once a year. If an NZECP34:2001 violation is discovered, then the Transpower contractor will discuss this with the landowner and come back to check the problem has been rectified. If a regular patrol does not discover any minimum distance violations, a breach could occur the following week but may not be picked up until the next patrol (which could be a year later) This means that it can be very difficult to enforce the minimum distances in NZECP34:2001.

12. Conclusion

12.1 The Grid is enduring critical infrastructure, both locally and nationally. It is critical that there is a planning framework in place that will enable development and other asset maintenance to occur efficiently.

12.2 Preventing sensitive and incompatible activities (including earthworks) from establishing under the transmission lines, along with controls on activities that will occur near lines, will assist the Grid to be reliable, and to have a managed environmental footprint while serving future generations.

12.3 It is critical that a preventative approach is taken to the management of the transmission corridors and a proactive approach is taken to ensure safety for high-risk activities regularly occurring under Grid assets.

Jordan Brett-Allen Shortland-Witehira

Date: 7 August 2023

Appendix A

Basic components of an overhead transmission line

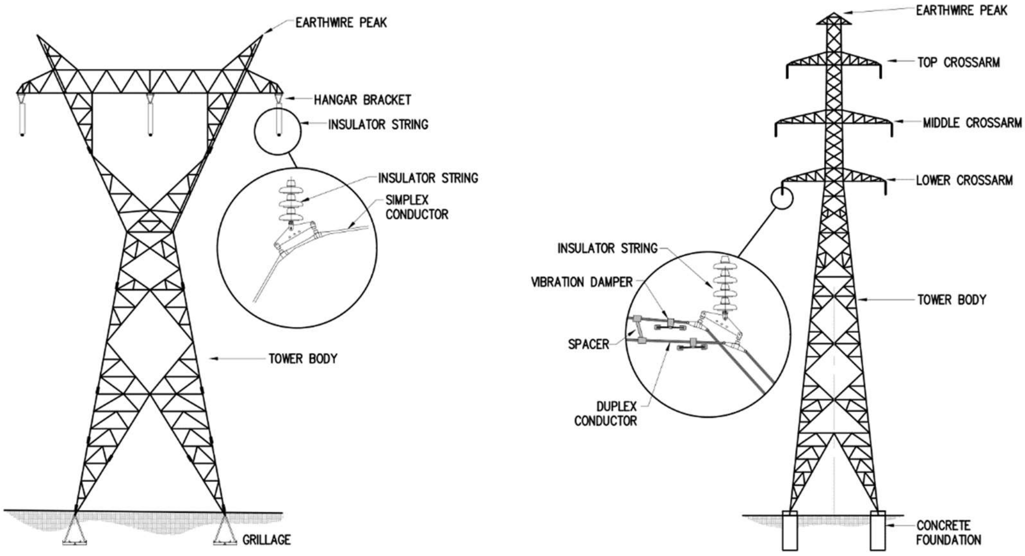

Figure 26: Tower component diagram

Conductors

1 Conductors (wires) are the physical conductive connections that transport live electrical energy at high voltages between substations (that is, between generators and substation supply points). Conductors usually consist of a number of aluminium stranded wires wrapped around an internal stranded steel support wire. In some cases aluminium or hard drawn copper alone is used, the latter being phased out as they age.

2 Conductors are arranged in different configurations and with different spacing between them depending on the structure types and circuit voltage. 220kV lines typically have a 5.5m, and 110kV lines a 3.25m, vertical conductor separation. Where conductors are duplexed (two conductors per phase), sub-conductor spacers are installed to separate the two wires to prevent the two parallel wires twisting and clashing, particularly in windy conditions.

Structures

3 Structures support the conductors and earth wires above the ground or other obstacles to maintain safe electrical clearances. Structures take many forms; for example, self-supporting lattice steel towers, concrete and wood poles, and steel tubular poles (monopoles). In the Selwyn District, the structures are predominantly steel lattice towers.

4 Transmission line structures are designed for specific line characteristics, including voltage, conductor size, conductor tension, climatic conditions (wind and snow) and topographic criteria (span length, line angle and tower height). Upgrading of line capacity or replacement of conductors typically requires the strengthening of towers (addition of steel members), raising of towers (insertion of complete tower sections), and in some cases complete replacement of the structure to ensure modern design standards are met.

Insulator sets

5 Insulators electrically insulate the live conductors from the earthed structures and prevent loss of energy to earth. Each phase on each structure requires an insulator set. The sets consist of insulators that may be manufactured from glass, ceramic porcelain or a composite material, and the steel hardware assemblies which attach the insulators to the structure and the conductors. In most cases the insulators are suspended from the pole or tower crossarms.

Foundations

6 Foundations form the base on which each tower sits. Foundations for steel lattice towers typically consist of three main designs:

(a) Directly buried lattice steel (grillages), where a lattice steel configuration sits on a formed platform below the ground and the entire configuration is directly backfilled and buried;

(b) Concrete encased buried lattice steel (grillages), where a corroded or understrength buried steel grillage is retrofitted with a buried concrete foundation; and

(c) Formed concrete foundations that connect the tower by either a bolted base plate arrangement or a concrete encased steel connection.

7 Poles are generally directly buried.

Earthwires

8 Earthwires are used to bond all conductive structures together and form a protective shield to help mitigate lightning strikes on the conductors. In some parts of the Transpower network, fibre optics are encased in the earthwire and serve as a communication system by utilising an internal fibre capability and providing signalling for protection systems and a communication link between substations.

9 Not all assets have full length earthwires installed. They are, however, typically installed in at least the first 5 structures out from all substations and generating sites.

APPENDIX B

EXAMPLES of THIRD-PARTY activities AFFECTING transmission lines

Earthworks

Uncontrolled earthworks can undermine the support structures or generate dust. The dust can result in the build-up of material on the Grid lines and increase the wear on the equipment reducing its useable lifespan. Excavations or mounding mid-span can increase risks by reducing the clearance between the ground and conductors.

Example 1: Subdivision earthworks compromising National Grid support structure

Figure 27 shows earthworks that occurred around a tower as part of development for an urban subdivision in Whitby, Porirua. The earthworks were well within 12m of the support structure.

Figure 27: Earthworks in Porirua compromising the foundations of the tower

As well as possibly undermining the stability of the tower structure, the earthworks in the photograph have also restricted vehicular access to the tower and the area where Transpower can place machinery required to maintain the tower. This compromises Transpower's ability to maintain the existing transmission line.

In this instance, Transpower worked with the developer retrospectively to ensure that the constraints on the line introduced by the developer were mitigated and the long-term stability of the towers would be retained. This required the installation of a shotcrete surface on the cut batter. Such works are an example of how earthworks conducted close to the Grid can undermine Transpower's ability to operate and maintain the network effectively and efficiently. Ultimately, the manner in which Transpower carries out maintenance at this tower will need to change to address the effects.

Example 2: Hastings District earthworks – ground clearance violations

Another example of earthworks adversely impacting on the operation of existing Grid assets is earthworks undertaken in Hastings (**Figure 28** and **Figure 29**). Transpower investigated the clearances from the conductor to ground for two Hastings properties and found the minimum clearance was only 5.3m from the ground to conductor at everyday conditions (instead of 6.5m required under NZECP34). This violation occurred as a result of earthworks – that is due to a build-up of soil under the conductors. The soil had been excavated onsite, spread under the line and reduced the required ground clearance to an unacceptable distance. As a result of the earthworks people and property were at risk.

Transpower needed to arrange temporary fencing of the two earthworks sites to prevent any further access under the conductors until rectification works were completed. Mitigation included installing a new set of cross arms on the poles. The top and bottom crossarms were changed to shorter steel crossarms with new Horizontal Line Posts (HLPs) attached. This lifts the conductor into a clamp on the end of the HLPs on the same pole by approximately 1200mm and prevented the need to replace the poles. Transpower then carried out ground works to cut the edge of the bench/track back to ensure the regulation 6.5m ground clearance at maximum operating temperature was complied with i.e. remediating the site back to original ground level and achieving compliance with NZECP34:2001.

Figure 1. Hastings ground clearance violations

Figure 29. Hastings ground clearance violations

Example 3: Buildings and Structures Preventing Access to the National Grid

In 2014 a grillage refurbishment crew was carrying out a pre-works inspection at Tower 48 on the Henderson to Roskill 110kV transmission line. The crew discovered a dwelling was under construction directly below the line and Transpower had not been consulted on the proposal. This dwelling blocked access to the tower site, meaning that Transpower had to secure alternative access across four separate properties. This required the removal of fencing and vegetation. **Figure 30** clearly illustrates the difficulties now arising at the site.

Figure 30. Dwelling blocking access to tower