GHD Advisory

Bushfire Cost Pass Though Application – Independent Verification and Assessment

TransGrid

13 November 2020

Contents

Figures

Tables

Appendices

1. Executive summary

TransGrid have prepared a bushfire pass through application in relation to the additional expenditure that have incurred as a results of the 2019-20 bushfire season. Their bushfire cost pass through application details that TransGrid has incurred $10.6 million ($Real 2017-18) and expects to incur a further $39.2 ($Real 2017-18) in additional expenditure as a result of the 2019-20 bushfires, which is not included in their 2018-23 Revenue Determination.

The following table summarises TransGrid's pass through application request.

Table 1 Incremental expenditure increase from 2019-20 bushfires event ($M, Real 2017-18)

Expenditure category	2019	2020	2021	2022	Total ($ million)
Opex	-	8.8	11.9	28.1	48.8
Capex	-	1.0	-	-	1.0
Total	**-**	**9.8**	**11.9**	**28.1**	**49.8**

The unprecedented nature of the 2019-20 bushfire season has been well documented. The independent NSW Bushfire Inquiry Final Report (NSW Inquiry Final Report) described the 2019-20 bushfires as[1]:

"…extreme, and extremely unusual. It showed us bushfires through forested regions on a scale that we have not seen in Australia in recorded history, and fire behaviour that took even experienced firefighters by surprise"

TransGrid's Cost Pass Through Application 2019-20 Bushfires (Application) executive summary, summarises the resulting impact on their network. Across the remainder of this document and the supporting Expenditure Forecasting Methodology for 2019-20 Bushfires, this impact is further detailed.

In response to the bushfire events, TransGrid took prudent and efficient actions in incurring emergency expenditure to make the network safe and to restore services.

These immediate actions also included detailed condition assessments to determine the extent of network damage. The results of these condition assessments were recorded in the Asset Inspection Manager System (ASIMS) for further assessment / analysis and underpin the forecasted expenditure included in the pass through application.

GHD has independently assessed the 2019-20 bushfire season and the impact on TransGrid's network in section 3 to confirm the unprecedented nature of the event.

GHD has also independently assessed the regulatory requirements for pass though applications in section 4.

This analysis confirms that:

[1] *Final Report of the NSW Bushfire Inquiry, 31 July 2020 p. iv (NSW Bushfire Inquiry).*

- TransGrid has experienced a positive change event elevating costs materially higher than Business as Usual (BAU) than it would have incur but for that event
- The quantum of the incremental expenditure incurred and forecasted, exceeds the regulatory threshold for materiality
- Our selection testing confirms that expenditure incurred and forecasted relates to the positive change event and is incremental to BAU
- Our consideration of the forecasting methodology and selection testing of forecast elements indicates that the identification of remediation requirements was prudent and cost forecasting efficient
- Nothing has come to GHD's attention that would suggest that the expenditure contained in TransGrid's bushfire pass through application relates to contingent projects or an associated trigger event.

2. Scope

The scope of the assessment includes:

- Detailed analysis of the drought / rainfall and fire weather severity conditions in NSW which led to the severe / unprecedented conditions during the bushfire season
- Analysis of the scale of fire occurrence, size and impact in NSW which greatly contributed to those fires becoming uncontrollable, resulting in the large and abnormal scale of network impact and damage
- Comparative analysis of the scale and cost of the bushfire damage (to TransGrid's network) in the 2019-20 fire season relative to recent years, based upon data provided by TransGrid
- Independent assessment of the incremental costs incurred as a result of the 2019-20 fire season.

This report has been prepared by GHD for TransGrid and may only be used and relied on by TransGrid for the purpose agreed between GHD and the TransGrid as set out above.

GHD otherwise disclaims responsibility to any person other than TransGrid arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described throughout this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by TransGrid and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has prepared comparative estimates using information reasonably available to the GHD employee(s) who prepared this Report, and based on assumptions and judgments made by GHD.

The comparative estimates has been prepared for the purpose of supporting TransGrid in their CPA submission and must not be used for any other purpose.

The comparative estimates are a preliminary estimate only in 2019 real Australian dollars. Actual prices, costs and other variables may be different to those used to prepare the comparative estimates and may change. Unless as otherwise specified in this Report, no detailed quotation has been obtained for matters identified in this Report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the comparative estimates.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for expenditure modelling purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

3. Severity analysis of 2019/20 bushfire season

In Appendix A of the report GHD has undertaken:

- Detailed analysis of the drought / rainfall and fire weather severity conditions in NSW which led to the severity / unprecedented conditions during the bushfire season
- Analysis of the scale of fire occurrence, size and impact in NSW which greatly contributed to those fires becoming uncontrollable and resulting in the large and abnormal scale of network impact and damage.

GHD considers there is very strong evidence that the fire events of 2019-20 in NSW are unprecedented, with the scale of very high severity fire not seen on such a scale in NSW before.

GHD considers that a very high proportion of the bushfire damage incurred by TransGrid occurred during Severe to Catastrophic Forest Fire Danger Index (FFDI) conditions, on account of the timing of network fault and outage incidents being coincident with such conditions.

Further, a very high proportion of the fire damage incurred by TransGrid, occurred at fires declared by the NSW Rural Fire Service (RFS) to be Section 44 fires. These fires are incapable of control or suppression by the fire fighting authority and requiring the RFS Commissioner to take control and responsibility for those fires under Section 44 of the Rural Fires Act.

GHD also notes that during the periods in which damage to TransGrid's network was occasioned, a State of Emergency was declared at those times by the NSW Premier, there being three such 7 day periods during the 2019/20 fire season, the first declared on 11 November 2019, the second on 19 December 2019, and the third on 2 January 2020.

For the above reasons, and based on the evidence presented in Appendix A, GHD agrees with TransGrid's assessment that the 2019-20 fires in NSW were, collectively, a 'natural disaster' cost pass through event which occurred during the 2018/19 – 2022/23 regulatory control period.

4. Cost independent verification and assessment

As detailed in Section 3 and supported by the evidence presented in Appendix A, the 2019/20 bushfire season was seen as unprecedented.

TransGrid has incurred and has forecasted additional opex and capex as a direct result of the 2019-20 bushfires.

The Application outlines that TransGrid will incur additional expenditure, over BAU expenditure as a direct result of the season's bushfires, as listed in Table 2 and Table 3 below.

Table 2 Incremental expenditure increase from 2019-20 bushfires event ($M, Real 2017-18)

Expenditure category	2019	2020	2021	2022	Total ($ million)
Opex	-	8.8	11.9	28.1	48.8
Capex	-	1.0	-	-	1.0
Total	**-**	**9.8**	**11.9**	**28.1**	**49.8**

Table 3 Incremental cost increase breakdown from 2019-20 bushfires ($M, Real 2017-18)

Category	Reference	2019	2020	2021	2022	Total ($ million)
Opex						
Transmission lines	Section 4.4	-	7.5	7.0	28.0	42.5
Easements	Section 4.5	-	0.9	4.8	0.1	5.8
Substations	-	-	0.2	-	-	0.2
Communication and protection	-	-	0.1	-	-	0.1
Property	-	-	0.1	-	-	0.1
Pass-through Application	-	-	-	0.1	-	0.1
Capex						
Transmission lines	Section 4.4	-	1.0	-	-	1.0
Total		**-**	**9.8**	**11.9**	**28.1**	**49.8**

4.1 Regulatory requirements

The National Electricity Rules (NER), details in Section 6A.7.3[2] the types of events relevant for transmission cost pass throughs, including:

- **A positive change event** which is defined[3] as "*a pass through event which entails the Transmission Network Service Provider incurring materially higher costs in providing prescribed transmission services than it would have incurred but for that event, but does not include a contingent project or an associated trigger event*"

[2] Ref. [3], pp. 908-915[3],

[3] Ref. [3], Chapter 10, p. 1298

- Any other event specified in a transmission determination as a pass through event for the determination[4] (**pass** through **event**) which includes a 'natural disaster' event as per TransGrid's 2018-23 revenue determination[5] *"Natural Disaster Event means any natural disaster including but not limited to fire, flood or earthquake that occurs during the 2018/19 – 2022/23 regulatory control period that increases the costs to TransGrid in providing prescribed transmission services, provided the fire, flood or other event was not a consequence of the acts or omissions of the service provider"*

The NER defines[6] the **eligible pass through amount** as "*In respect of a positive change event for a Transmission Network Service Provider, the increase in costs in the provision of prescribed transmission services that, as a result of that positive change event, the Transmission Network Service Provider has incurred and is likely to incur (as opposed to the revenue impact of that event) until:*

(a) unless paragraph (b) applies – the end of the regulatory control period in which the positive change event occurred; or

(b) if the transmission determination for the regulatory control period following that in which the positive change event occurred does not make any allowance for the recovery of that increase in costs (whether or not in the forecast operating expenditure or forecast capital expenditure accepted or substituted by the AER for that regulatory control period) – the end of the regulatory control period following that in which the positive change event occurred."

4.1.1 Regulatory requirements assessment

GHD's independent verification and assessment has considered the regulatory requirements detailed in the section above, and has summarised our assessment in Table 4 below.

Table 4 Assessment considerations

Topic	Consideration	Report section
Pass through event	Section 3 and Appendix A support the occurrence of a pass through event.	Section 3 and Appendix A
Positive change event	GHD independently verified the materiality threshold performed by TransGrid and we are satisfied the materiality threshold is met for the 2019-20 bushfires to be defined as a pass through event.	Section 4.1.2
	To verify that the expenditure relates to the pass through event, GHD has tested selections, detailed in the following sections to confirm the cause and to consider if is it incremental to BAU. The following sections include selection testing deigned to validate that the expenditure relates to the bushfire events and whether the forecasts represent a prudent and efficient solution. • Actual expenditure • Transmission lines	 Section 4.3 Section 4.4

[4] Ref. [3], clause 6A.7.3(a1)(5), p. 900

[5] Ref. [4], p. 37

[6] Ref. [3], Chapter 10, p. 1267

Topic	Consideration	Report section
	• Vegetation management	Section 4.5
	Nothing has come to GHD's attention that would indicate that the expenditure incurred and forecasted to be incurred relates to a contingent project or an associated trigger event.	Section 4.6
Eligible pass through amount	Is the pass through amount requested by TransGrid supported?	Satisfaction of the assessments detailed in the rows above will support the pass through amount requested by TransGrid.

4.1.2 Pass through materiality threshold

TransGrid's Application details the calculation of the pass through amount as detailed in Table 5 below. Their pass through claim is $49.8 million ($Real 2017-18) in expenditure terms, or $53.2 million ($Nominal) in building block cost terms.

Table 5 Building block costs for eligible pass through amount ($M, Nominal)

	2018-19	2019-20	2020-21	2021-22	2022-23	Total ($ million)
Return on capital	-	-	0.1	0.1	0.1	**0.2**
Return of capital	-	-	(0.0)	(0.0)	(0.0)	**(0.0)**
Opex	-	9.2	12.8	31.0	0.0	**53.0**
Tax allowance	-	-	0.0	0.0	0.0	**0.0**
Maximum allowance revenue (unsmoothed)	-	**9.2**	**12.9**	**31.0**	**0.1**	**53.2**
Maximum allowance revenue (Smoothed)	-	**-**	**-**	**50.2**	**5.3**	**55.5**

As detailed in the Application, TransGrid can only make a claim if the event has led to 'incurring materially higher costs in providing prescribed transmission services'.

The NER defines the term 'materially' as a 'change in costs (as opposed to the revenue impact)' that 'exceeds one per cent of the maximum allowable revenue for the Transmission Network Service for that regulatory year'[7].

The analysis included in the Application details that they have satisfied this test.

Table 6 Pass through application thresholds – incremental building block costs

	2018-19	2019-20	2020-21	2021-22	2022-23	Total ($ million)
Maximum Allowable Revenue (MAR)	734.3	759.5	779.5	828.2	865.2	3,966.7
Incremental costs – 2019-20 bushfires plus MAR	734.3	768.8	792.4	859.2	865.3	**4,019.9**
Difference	-	9.2	12.9	31.0	0.1	**53.2**
Materiality of bushfire event (%)	**0.0%**	**1.2%**	**1.7%**	**3.7%**	**0.0%**	**1.3%**

To support TransGrid's assertion, GHD has:

- Confirmed that the calculation of the materiality threshold is suitable
- Confirmed that the MAR amounts to TransGrid's Post Tax Revenue Model (PTRM)
- Validated that the incremental costs to expenditure incurred and forecasted to be incurred relate only to the pass though event (as described in the following sections)

4.2 Expenditure incurred and forecasted

To present an understanding of the pass through application amount, GHD has:

- Detailed TransGrid's immediate response to the bushfire events in Section 4.2.1. This is relevant as it creates an understanding of the expenditure incurred to date in Section 4.2.2
- Detailed expenditure incurred and forecasted to be incurred in the following sections.

4.2.1 TransGrid's immediate response overview

The Application details the immediate activities undertaken by TransGrid to make assets safe and to restore services. These activities included:

- Emergency works to make hazardous situations safe and restore assets which were rendered inoperable. This included establishing safe access to the transmission lines, replacing burnt out wood poles, restoring broken conductors, replacing damaged insulators and restoring auxiliary supplies to switching stations and communications sites. These emergency works have been recorded as actual expenditure detailed in section 4.3 below.

[7] Ref. [3], p. 1292

- TransGrid also conducted condition assessments in two stages:
  - Stage 1 – network integrity assessment to determine the immediate integrity of the network in January 2020 and to inform the extension or removal of market constraints imposed by AEMO.
  - Stage 2 – detailed condition assessments to determine the extent of network damage. The results were recorded in the ASIMS where work orders for repairs were then issued in accordance with TransGrid's corrective maintenance process.

4.3 Actual expenditure

The Application details that TransGrid incurred actual expenditure of $10.6 million ($Real 2017-18) between 1 July 2019 and 30 September 2020 as a direct result of the 2019-20 bushfires.

The actual expenditure detailed in Table 7 were extracted from the Ellipse Enterprise Resource Planning (ERP) system and represent the expenditure booked to work orders created specifically to record the costs of the 2019-20 bushfire event.

Table 7 Actual costs for the 2019-20 bushfires *(Real $2017-18)*

Expenditure category	2019	2020	2021	2022	Total ($ million)
Opex	-	8.8	0.8	-	9.6
Capex	-	1.0	-	-	1.0
Total	**–**	**9.8**	**0.8**	**–**	**10.6**

***Table 8 Breakdown of actual expenditure* (Real $2017-18)**

Expenditure category	2019	2020	2021	2022	Total ($ million)
Opex					
Transmission lines	-	7.6	0.6	-	8.2
Sub stations	-	0.2	-	-	0.2
Communication and protection	-	0.1	-	-	0.1
Property	-	0.1	-	-	0.1
Easements	-	0.9	0.2	-	1.0
Capex					
Transmission lines	-	1.0	-	-	1.0

Expenditure category	2019	2020	2021	2022	Total ($ million)
Total					**10.6**

To verify that the actual expenditure incurred related to the pass through event, GHD made a selection from the ERP data set representing the actual expenditure. Our selection testing of 2 asset types covering 40% of the supporting data set found the activities carried were as a result of 2019-20 bushfires. Our selection testing found that the expenditure related to the 2019-20 bushfire event and was not BAU.

4.4 Transmission lines forecast expenditure

As detailed in the Application, TransGrid's impacted zones included 999 km in route length and 9000 km of line conductors and earth wires (9 per cent of TransGrid's transmission line route length) and 2,681 transmission line structures comprising 1,822 steel lattice tower and pole structures, 596 wood poles structures and 263 concrete structures.

All forecasted expenditure associated with transmission line are opex.

In forecasting the required remediation expenditure, TransGrid has used the combination of recent transmission line capital project delivery experience (including remediation works on 2019-20 bushfire damage assets) and its BAU cost estimation processes applied to its prescribed expenditure.

Generally, the basis for the cost estimate (unit rates, contractor cost, lump sum allowance etc.) is summarised as follows:

- TransGrid referred to the project experience of stage 1 remediation works for the damaged [redacted] to derive the estimates for contractor civil work, contractor electrical work and duration based project set-up costs. It also used this experience to factor its estimate for network topography and location based civil, accessibility and outage management costs. Finally, it used this recent experience to refine / revise its BAU or existing cost information stored in the Success Estimator Database and / or Ellipse Inventory Management System for new transmission lines material items.
- TransGrid referred to schedule of rates for various cost items from its existing contractor panel members and market sourced information.
- Geospatial information and aerial photography were analysed, along with project experience of stage 1 remediation works for the damaged [redacted], to estimate the allowance for access risk. Additional risk allowance is also calculated and added to the estimate to incorporate the unknown factors and variables such as weather, material cost, geotechnical information, project delays, and the ongoing COVID-19 pandemic restriction to provide an expected P50 cost.

Generally, the basis for the volumetric or material quantities (labour hours, distances, item count, duration etc.) is summarised as follows:

- TransGrid referred to the project delivery plan and schedule prepared by its Work Delivery business unit

- TransGrid referred to its established project and safety management systems and requirements to estimate the required labour hours (internal and outsourced) to deliver the planned remediation works
- Identified through inspection and condition assessment and sourced from Asset Manager List of work orders, post bushfire aerial photography of the defects, spatial Information, and asset drawings and records, such as line schedules.

This approach to determining the forecast expenditure is detailed in Section 5.2 of the Forecasting Methodology for 2019-20 Bushfires. This document details that in developing remediation expenditure estimates TransGrid has:

- Only included the minimum works needed to return the assets to the condition they were in prior to the bushfire event. For example, replacing only the affected phases
- Only included works where the risk of leaving the asset in its current state would compromise the safety or performance of the transmission network within the timeframe of the current regulatory control period. That is, damage which has been deemed non-urgent will continue to be monitored by TransGrid rather than repaired
- Deducted from the costings any avoided vegetation maintenance activities that would have been incurred had the bushfires not occurred. For example, vegetation clearing costs in locations where the fires have effectively eliminated the encroaching vegetation
- Excluded from the scope any opportunistic replacement and maintenance activities. The scope only includes activities for damages directly caused by the 2019-20 bushfires event.

The following Table 9 summarises the total cost estimated and forecasted to occur from Autumn of 2021 to Autumn of 2022.

Table 9 Summary of forecasted transmission line costs

Transmission Line	Section reference	Total ($ million)
Forecasted expenditure* (Real $2020-21)*:		
[redacted]	5.7.1	10.8
[redacted]	5.7.2	6.5
[redacted]	5.7.3	3.4
[redacted]	5.7.4	8.4
[redacted]	5.7.5	5.7
Other Lines	-	0.8
Total forecasted expenditure (Real $2020-21)		**35.6**
Total forecasted expenditure (Real $2017-18)		**34.3**
Actual expenditure (Real $2017-18)	Table 8	8.2 (opex) 1.0 (capex)
Total (Real $2017-18)		**42.5 (opex)**

Transmission Line	Section reference	Total ($ million)
		1.0 (capex)

The total estimate in the above table includes all cost components (i.e. incremental internal and outsourced labour hours, expenses, contractor costs, unitised costs, non-unitised costs, and risk allowance) and is expressed in 2017-18 Real dollar terms in order to align the cost values with the same terms in TransGrid's current regulatory period PTRM.

Detailed information on each of the transmission line listed in the above table including the respective damage summary (including photographs), scope of repair work, material cost estimate, labour cost estimate and risk cost estimate is provided in the Expenditure Forecasting Methodology for 2019-20 Bushfires. This information are not replicated in this report in the interests of brevity.

In order to independently verify the build-up of these transmission line forecast expenditure, GHD examine the following aspects of the investment decision and cost estimation:

- The enduring need to retain these damaged assets
- The basis of expenditure decision to repair these damaged assets
- Review the formulation of the cost estimate (unit rates, contractor cost, lump sum allowance etc.) and corroborate from its reference sources and assumptions
- Review the identification of the volumetric or material quantities (labour hours, distances, item count, duration etc.) and corroborate from its reference sources and assumptions
- Review the inputs and underlying assumptions for risk allowance build-up and its interaction with project management and controls allowance
- Determine if the proposed cost estimates are consistent with the approach that TransGrid described in its Expenditure Forecasting Methodology document (i.e. including only minimum work, risk based repair decision, avoiding double counting and opportunistic expenditure)
- Scope to optimise the delivery of these remediation work in terms of work scheduling and in leveraging BAU asset management functions.

These aspects were examined by reviewing the following selected samples of transmission lines:

[redacted]

These selections constitute 72% of the total proposed forecast expenditure and also includes maximum diversity of cost estimate inputs allowing us to gain confidence in the overall expenditure forecasting process followed. Our observations are documented in the following Table 10.

Table 10 Examination of various aspects for selected transmission line forecast expenditure

Aspects	Observations
Need	The examined (and also the remaining) transmission lines forms part of NSW and ACT electricity transmission backbone and form part of the NEM grid that allow inter region energy trading, especially between NSW and Victoria. They are crucial infrastructures that

Aspects	Observations
	transport electricity generated by Snowy Hydro to the load centres in NSW and ACT. The [redacted] and therefore is an important link to the VNI interconnector. Review of TransGrid's 2020 Transmission Annual Planning Report indicate fairly utilised transmission lines given their location in the wider network topography and allowing for the N-1 contingency.
Decision	We examined the expenditure decision by reviewing the basis such as evidence of damages to the asset, the impact of those damages to its functional performance and the corrective maintenance process which is aligned to ISO55001 certified asset management system. We reviewed the photographs of damaged assets, metallurgical test report of damaged conductors that formed the basis of TransGrid's engineering condition assessments, and the records of defect work order prioritisation process. We are satisfied that the expenditure decision made by TransGrid is reasonable and that the decisions related to activities incremental to BAU.
Timing	We reviewed the proposed timeline and duration of the repair work considering the nature of work, geographical location, resource availability/ constraints (including internal, outsourced and contractor), outage window constraints due to Snowy Hydro generation, and the seasonal demand profile of Southern NSW and Northern Victoria. We are satisfied that the expenditure timeline and duration proposed by TransGrid is reasonable.
Cost estimates	We reviewed the build-up of cost items from past project records, competitive market quotes and unitised cost information saved in TransGrid's Success Estimation database used in formulating the contractor costs (for e.g. weekly labour rate, per km track access rate and weekly establishment rate) and material unitised rates (for e.g. conductor rate, insulator rate, fittings, construction pad set-up rate and gravel). We also reviewed hourly labour rates of various types of skill sets (managers, engineers, switching, HSE etc.), penalty rates, allowance and expenses in delivering these damage repair works. We are satisfied that the cost estimates and their underlying build-up used in forecasting the expenditure are reasonable.
Volumetric or quantity estimate	We reviewed the build-up of material and duration quantities (km, unit item, weeks) and their respective basis such as geo-spatial inputs, asset condition assessment, engineering judgement and assumption, outage and operational constraints, HSE requirements, and the proposed workforce capability. We also reviewed the build-up of internal and outsourced labour hours and its basis such as scope of work, type of activities, project team set-up, need for multiple site work fronts, and TransGrid's construction risk and HSE system requirements. We are satisfied that the volumetric or quantity estimate and their underlying basis used in forecasting the expenditure are reasonable.

<table>
<tr><th>Aspects</th><th>Observations</th></tr>
<tr><td>Risk</td><td> As indicated above the transmission line repair expenditure forecast is based upon the best estimate of the extent of the damage, site accessibility for construction purpose and the ground condition for building set-up pads. The expenditure forecast is also based on TransGrid's engineering assessment of work and outage duration and project team set-up.
We note that it is not until progress and access is made for contractor site establishment and construction set-up, the expenditure variables become more definitive as unknown variables (such as plant access or geotech condition) are quantified. The other unknown expenditure variables (such as weather conditions, NSW park access, environmental issues) continues to become definitive as the project runs it course.
Presently, TransGrid has included mark-ups ranging from 16% to 23% to each of its repair project cost estimate sub-total or direct cost to allow for the following risk variables:

Weather delay
Track condition uncertainty
High content of hard rock
External delays and restriction due to NSW Parks (Snowy Mountains), Environment, Aboriginal Heritage site and Endangered species affairs
Materials/equipment price and demand-supply fluctuation
Pandemic restriction

These risk variables are unknown at this stage, and as explained above they will start to become more definitive and be able to be quantified as the project progresses on site.
Based on our experience of brownfield transmission line restringing work with multiple work fronts, on mountainous terrains, and on environmentally sensitive national park land, we believe this level of risk allowance is reasonable in TransGrid's expenditure forecast.
GHD also reviewed the cost and risk components using our own comparative estimates for the general scope of work. It is usual for brownfield projects to have risk (or contingency costs allocations) up to 25% or higher commensurate with the current scope definition. Our comparative estimates indicated a higher cost, hence this indicates the direct costs and risk allocation cost is reasonable. </td></tr>
<tr><td>Prudency</td><td> We reviewed the scope of proposed work and the Asset Manager work order priority in proposing the repair work with assigned level of varying urgency (and therefore the proposed timelines) to appreciate the amount of work and risk based repair decision included in the expenditure forecast. We examined the scope for over-engineered solution, duplication of work with BAU maintenance practice, and opportunity to deliver these repair works in an efficient manner with weighing against the residual risks.
We are satisfied that the proposed repair works are prudent. </td></tr>
</table>

4.5 Easements - vegetation management

As detailed in TransGrid's Application, approximately 9% of network route length and 830 kilometres of access track, have been impacted by the 2019/20 bushfires across NSW.

To address further bushfire exposures and network integrity, TransGrid:

- Has engaged suitably qualified Arborists from various vegetation management contractors (Active, ETS and Asplundh) to perform Visual Tree Assessment (VTA). The Application indicates that by September 2020, 80% impacted spans had been inspected and scoped with approximately trees identified as requiring remediation. Further on-site inspections identified that on average 14% of hazard tree are 'unacceptable', and require management to limit the risk to the electricity network on top of the 7.5% managed through the hazard trees maintenance program.
- Incurred expenditure to create the required safe access for crews.

The Expenditure Forecasting Methodology for 2019-20 Bushfires details that forecast costs for easement remediation works are based on current vegetation contractor rates for management of hazard trees and access tracks. All works are undertaken by contractors. Each of the components of the costs for easements were sourced as follows:

- Access track costs were based on $[redacted] per km using our current standard panel contractor rate.
- Hazard tree costs were based on $[redacted] per tree removed also using our current standard panel contractor rate.

GHD has validated both access tracks and hazard tree costs are based on based on contractor estimates.

To verify the incurred costs related to easements and vegetation, GHD made a selection from the easements data set representing the actual costs. Our selection testing of 4 items (transmission lines) covering 10% of whole data found out that all actual costs relates to easements. The easement cost is dependent on the following factors

- A = Quantity of hazard trees impacted by bushfires
- B = Percentage of unacceptable trees x A
- C = Calculated distance using spatial system
- D = Cost of addressing hazard trees ($[redacted]/tree) x B
- E = Cost of addressing access tracks ($[redacted]/access track) x C

The easement cost were calculated as:

Direct costs = (B x D) + (C x E)

Easement cost = Direct costs + Risk costs

Using the formula above, GHD has confirmed that the easement costs add up to total expected cost as shown in

Table 12.

Table 11 Forecasted vegetation management remediation costs for the 2019-20 bushfires (Real $2017-18)

Expenditure category	Reference	Total ($ million)
Actual expenditure	Table 8	1.0
Forecasted	Table 11	4.8
Total (Real $2017-18)		**5.8**

Table 12 Bushfire damage summary – Hazard Trees (Real $2020-21)

Line	Span	Quantity of Hazard Trees Impacted	Quantity of Hazard Trees to Remove	Vegetation Cost	Access track Cost
Easement				[redacted]	[redacted]
5A1/5A2	Central region of TL5A1/5A1 up to str. 152	10	1	[redacted]	[redacted]
31/32	393-472	299	42	[redacted]	[redacted]
76/77	Northern region of 76/77 up to str. 226	1173	164	[redacted]	[redacted]
5A3/5A4	Central region of TL5A3/5A4 up to str. 228	26	4	[redacted]	[redacted]
5A3/5A5	426-443	57	8	[redacted]	[redacted]
5A6/5A7	Mt. Piper to Bannaby Str 279 to str 295	26	4	[redacted]	[redacted]
76/77	Central region of 76/77 from str. 105	45	6	[redacted]	[redacted]
5A1/5A2	Northern region of TL5A1/5A1 from str. 92	79	11	[redacted]	[redacted]
5A3/5A4	Northern region of TL5A3/5A4 from str. 170	8	1	[redacted]	[redacted]
22	16-19 & 113-137	29	4	[redacted]	[redacted]
25/26	103-168A/168B	0	0	[redacted]	[redacted]
31/32	103-267	319	45	[redacted]	[redacted]
87	Armidale to Coffs Harbour	394	55	[redacted]	[redacted]
96C	Armidale to Coffs Harbour	274	38	[redacted]	[redacted]

Line	Span	Quantity of Hazard Trees Impacted	Quantity of Hazard Trees to Remove	Vegetation Cost	Access track Cost
96L	Tenterfield to Lismore	990	139	[redacted]	[redacted]
89	550-603	703	98	[redacted]	[redacted]
963	Tomago to Taree 428-473	720	101	[redacted]	[redacted]
964	PMQ-232	34	5	[redacted]	[redacted]
965	186-353	991	139	[redacted]	[redacted]
966	Armidale to Koolkhan	2600	364	[redacted]	[redacted]
967	103-193	320	45	[redacted]	[redacted]
51	LTSS-125	239	33	[redacted]	[redacted]
2	UTSS-159	477	67	[redacted]	[redacted]
3	LTSS-60	171	24	[redacted]	[redacted]
7	LTSS-40	0	0	[redacted]	[redacted]
U1	UTSS-T1	125	18	[redacted]	[redacted]
U3	UTSS-T1	18	3	[redacted]	[redacted]
U5	UTSS-T1	192	27	[redacted]	[redacted]
U7	UTSS-T2	1465	205	[redacted]	[redacted]
3W	Capital WF (Str 278) to KVSS	340	48	[redacted]	[redacted]
39	Bannaby to Sydney West	514	72	[redacted]	[redacted]
L1	Entire Line	0	0	[redacted]	[redacted]
L3	Entire Line	0	0	[redacted]	[redacted]
L5	LTSS-Tumut5	0	0	[redacted]	[redacted]
YY	Entire Line	11	2	[redacted]	[redacted]
97D	Str 251 to 296	152	21	[redacted]	[redacted]
978	Str 248 to 342	22	3	[redacted]	[redacted]
64	Entire Line	1283	180	[redacted]	[redacted]
65	Entire Line	1286	180	[redacted]	[redacted]
66	Entire Line	2017	282	[redacted]	[redacted]
993	49-92	112	16	[redacted]	[redacted]
1	UTSS-96	196	27	[redacted]	[redacted]
Direct Cost				**$4,627,267**	

Line	Span	Quantity of Hazard Trees Impacted	Quantity of Hazard Trees to Remove	Vegetation Cost	Access track Cost
Risk Cost				$379,296	
Total Expected Cost (Real $2020-21)				**$5,006,563**	
Total Expected Cost (Real $2017-18)				**4.8 million**	

4.6 Contingent project or an associated trigger event

Nothing has come to GHD's attention that would suggest that the expenditure contained in TransGrid's Application relates to contingent projects or an associated trigger event.

GHD Advisory

Appendices

Appendix A - Severity analysis of 2019/20 bushfire season

In this section of the report GHD has undertaken:

- Detailed analysis of the drought / rainfall and fire weather severity conditions in NSW which led to the severity / unprecedented conditions during the bushfire season.
- Analysis of the scale of fire occurrence, size and impact in NSW which greatly contributed to those fires becoming uncontrollable and resulting in the large and abnormal scale of network impact and damage.

A.1 Drought influence bushfire activity and severity

It is well established through scientific research and operational experience that drought is a most significant causal factor contributing to fire season severity, particularly in forested landscape areas.

GHD considers that the leading factor contributing to the frequency, intensity, timing and location of bushfires in NSW in the 2019-20 bushfire season was the severe drought affecting a very high proportion of NSW.

Drought increases the amount of fuel available to burn during a bushfire, increases the frequency of ignitions through making the landscape more conduce to ignition and spread, and lengthens the period of time when bushfires can start and spread.

Drought serves to increase the amount of forest fuel available to burn. Drought does this by:

- Increasing the quantity of fuel on the forest floor by causing severe moisture stress in trees and understorey shrubs causing increased leaf fall as plants shed leaves to conserve moisture
- Increasing the propensity for live shrub layers to burn due to reducing live fuel moisture content and increasing the proportion of dead fuel retained in understorey shrub canopies
- Increasing the proportion of forest fuels available to burn
- The increased fuel contributes to increasing fire intensity, rate of spread, and spotting.

Drought affects the timing of bushfires by creating conditions conducive to bushfire ignition and spread earlier in the year than occurs in more average or above average rainfall years. Historically (not just during 2019-20), in severe drought-affected years, adverse bushfires can occur along the north and mid north coast and ranges as early as August with peak fire conditions occurring in September and October and extending until the arrival of late-onset summer rainfall. This was the case during the 2019-20 fire season, and it has also been the case during many previous severe drought-affected fire seasons.

A.2 Drought severity in 2019

The extent and severity of drought conditions affecting NSW leading up to and during the 2019-20 bushfire season is unprecedented. Using Bureau of Meteorology (BoM) rainfall data, GHD has analysed rainfall data to determine the severity of rainfall deficits during 2019.

When considered at the full calendar year timescale, rainfall deficiencies across NSW were severe. A most substantial proportion of coastal and inland areas north of the Hunter Valley into southern Queensland and from the coast to the north and central west slopes and plains experienced their driest year on record.

From the Sydney basin/Central Tablelands south into northern Victoria, conditions were in the first (lowest) decile. Figure 1 shows rainfall deciles across NSW for the calendar year for 2019.

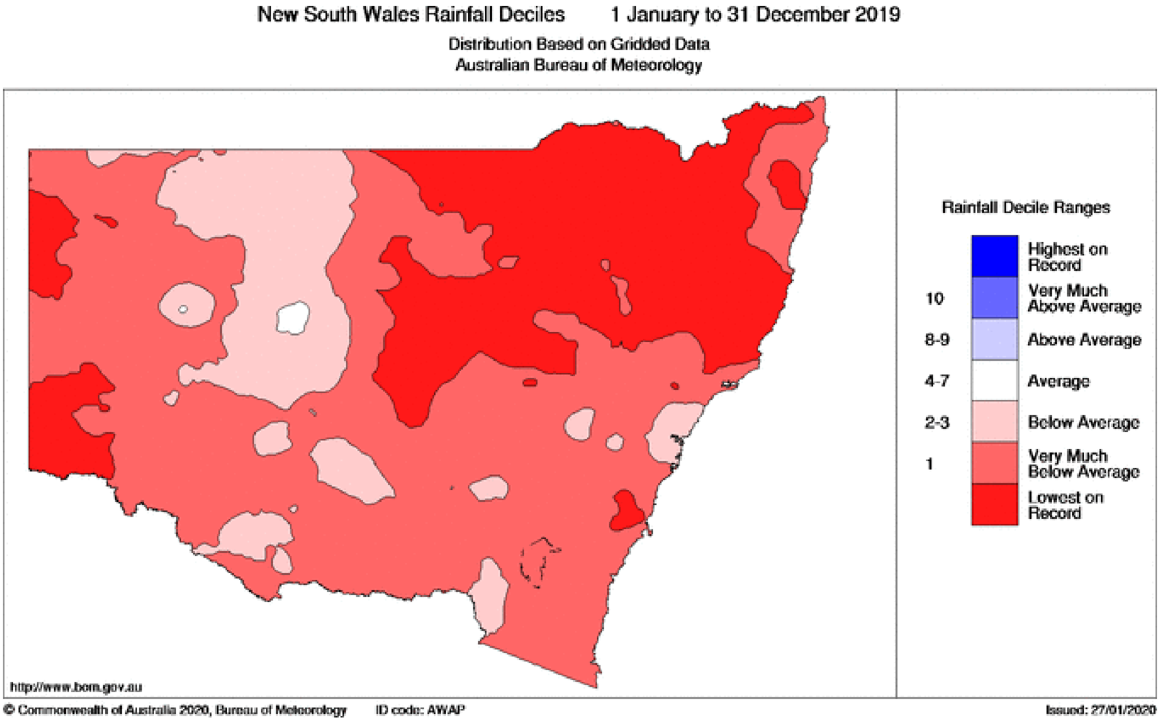

Figure 1 Annual rainfall deciles map 2019

Drought effects can be even more acute when they extend over longer periods. Drought conditions in NSW effectively commenced in early 2017. Figure 2 shows rainfall deciles across NSW for the two year period spanning 2018 and 2019.

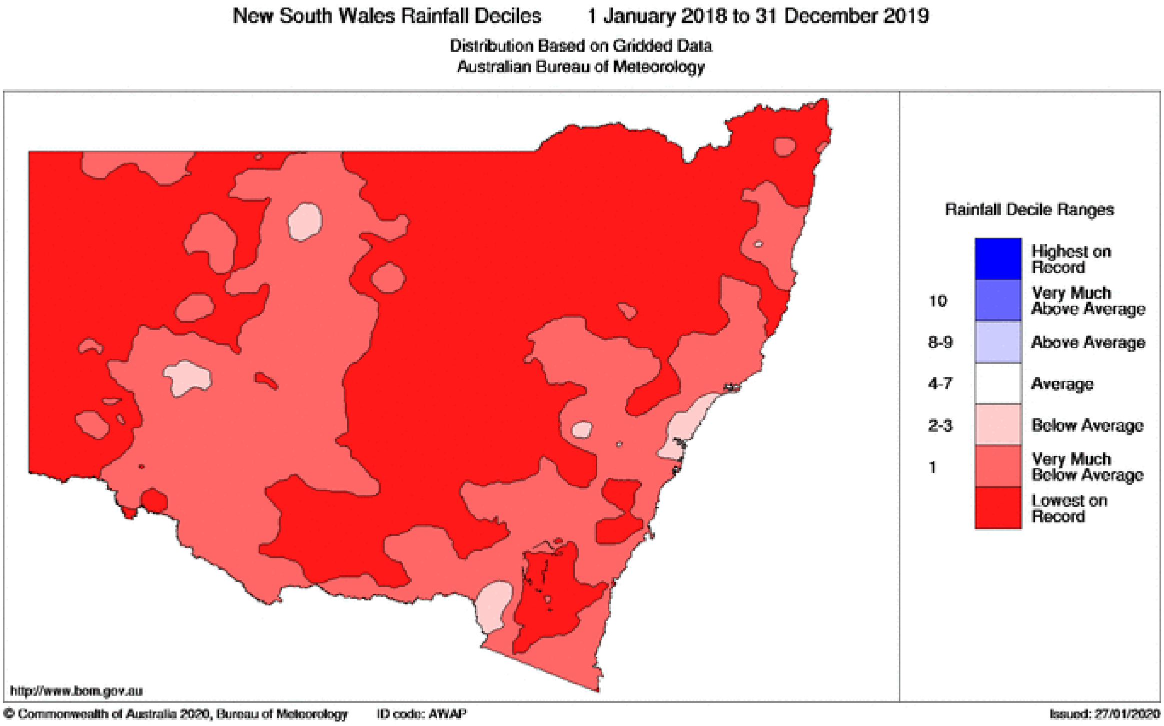

Figure 2 Rainfall deciles map 1 Jan 2018 to 31 Dec 2019

Considered in the broader Australian context of rainfall deciles spanning 3 consecutive “southern wet seasons’ (APR-OCT) the period leading into the 2019/20 NSW fire season was exceptionally dry, with most of the state recording lowest on record rainfall (Figure 3).

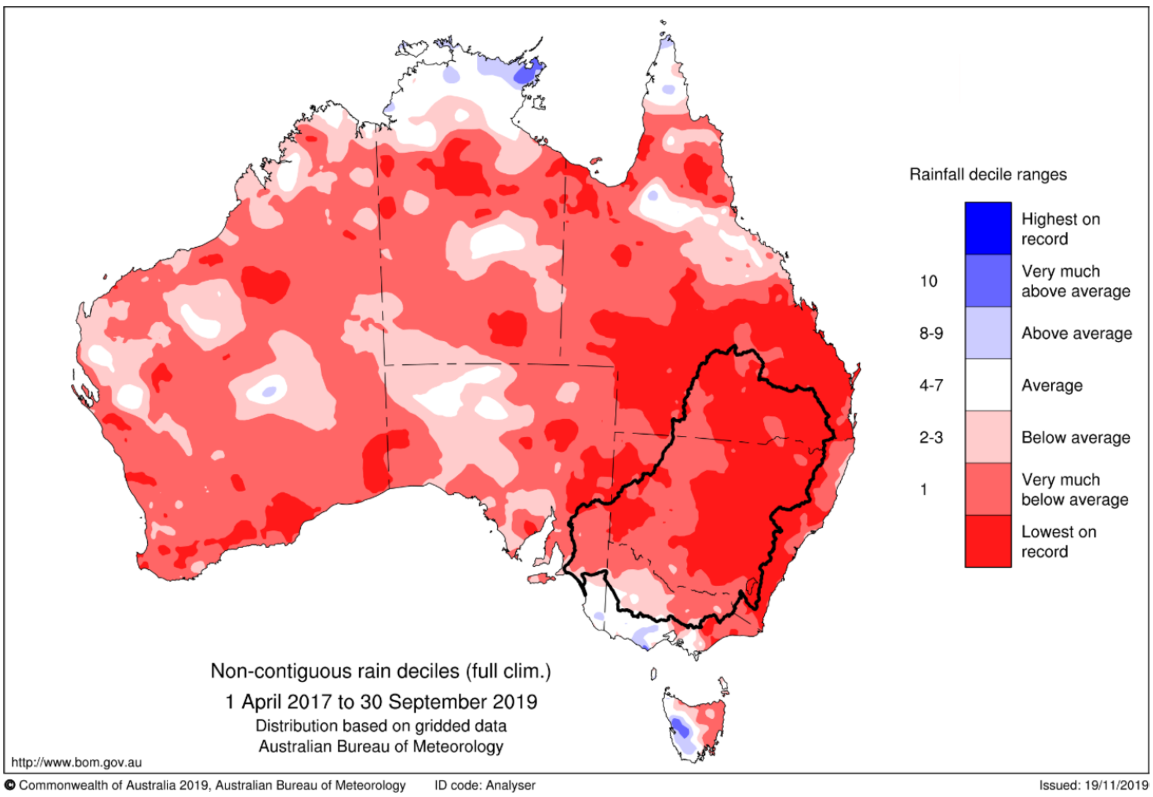

Figure 3 Australian rainfall deciles 1 Apr 2017 to 30 Sep 2019

A.3 2018/2019 two year rainfall deficit comparison with previous severe fire seasons

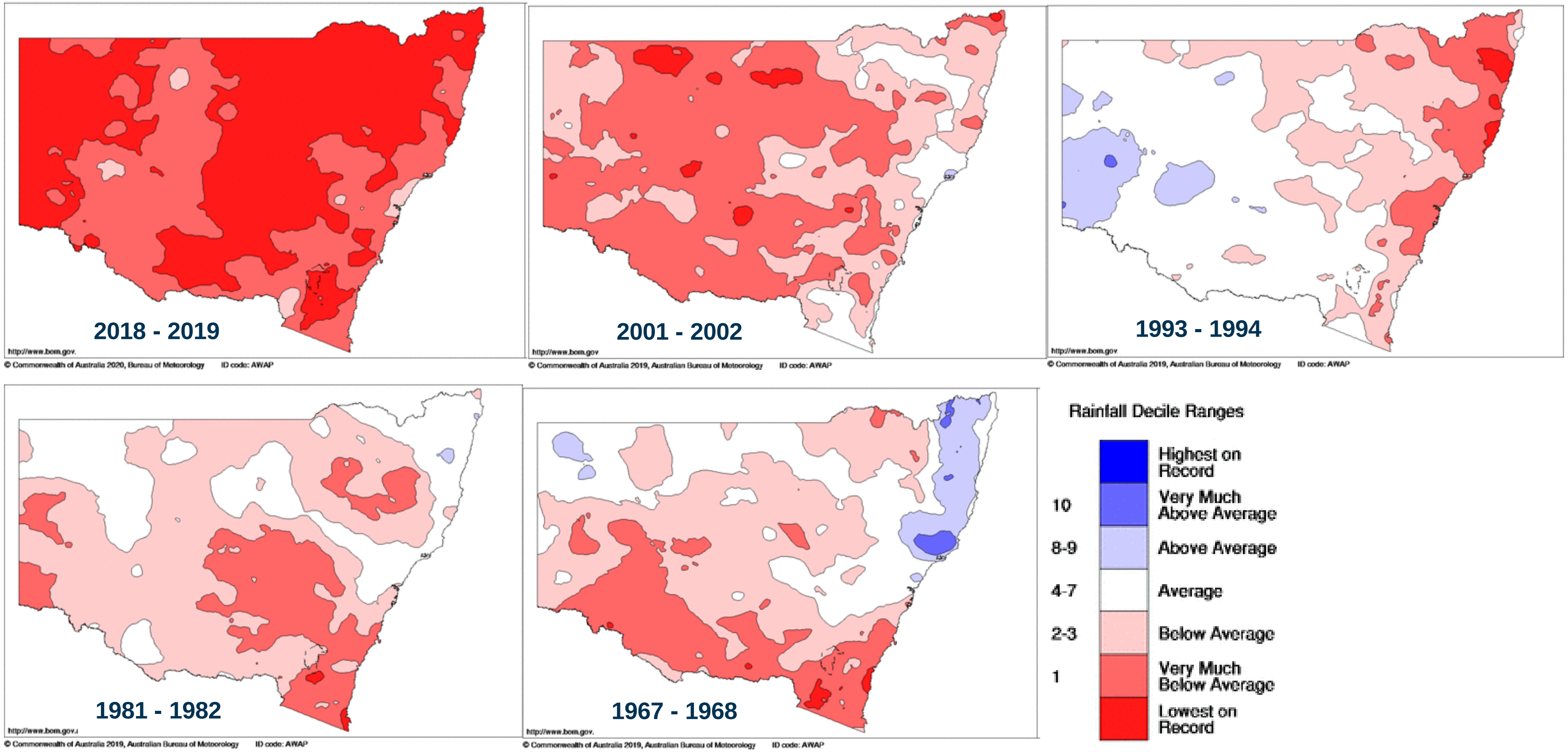

Figure 4 Two year rainfall decile map comparison for NSW severe fire seasons

Figure 4 shows two year rainfall decile map comparisons for historically severe/crisis fire seasons affecting NSW.

The two year rainfall decile maps (Figure 4) show that the extent and severity of drought leading into the 2019/20 fire season was greater in extent and severity than conditions leading into any of the historically severe fire seasons in NSW.

At the annual rainfall scale, annual rainfall for 2019 can be ranked against all other previous years. In Table 13, selected weather stations with long-term rainfall records in or near fire-impacted areas are examined.

Table 13 Rainfall rank against all years for long-term weather stations near fire-impacted areas

Weather Station	Number	Number of years record	Mean annual rainfall (mm)	Lowest on record rain (mm)	2017 annual (rank)	2018 annual (rank)	2019 annual (rank)	1 Apr to 31 Dec rainfall (rank)
Eden (Timbillica)	069029	60	961.5	513.4	9	6	8	2
Bega (Newtown Rd)	069002	135	857.7	398.9	48	31	13	**1**
Bombala (Therry St)	070005	135	645.3	304.7	61	27	3	**1**
Batemans Bay (Buckenbowra)	069052	60	996.6	428	19	11	3	**1**
Braidwood (Krawaree)	070057	132	715.7	340	13	31	6	**1**
Tumut (Simpson St)	072044	60	813.6	33.9	17	4	5	5
Bathurst (Ag Stn)	063005	60	636.8	214.2	10	13	5	2
Branxton	061014	157	811.6	378.7	38	79	5	**1**
Bulahdelah	060002	114	1325.7	563.3	31	34	2	**1**
Wingham	060036	131	1092.7	**378.8**	78	45	**1**	**1**
Walcha (Kaori)	057119	75	913.5	**474.5**	40	23	**1**	**1**
Telegraph Point (Farrawells Rd)	060031	110	1304.4	**411.6**	64	50	**1**	**1**
Nana Glen (Cowling Close)	059139	62	1358.3	**663.2**	42	35	**1**	6
Tenterfield	056032	149	844.4	**254.6**	67	9	**1**	**1**
Tabulam PO	057018	131	975.7	**425**	68	32	**1**	**1**
Woodenbong	057024	86	997.1	**335**	60	12	**1**	**1**

The fire season in NSW generally starts in spring in north coastal/tableland districts, and progressively moves south, with the south coast and southern ranges/slopes generally the last to see significant fire potential commencement from around December (or earlier in drought years). Accordingly, rainfall over the last 9 months of the year (1 April to 31 December) has the most significant influence on the severity of conditions leading into each bushfire season. Rainfall in the January to March period has relatively less influence (relative to winter and spring rainfall) on fuel drying over the following spring and summer. Hence it can be instructive to look at rainfall deficiencies over the 1 April to 31 December period to consider fire season severity potential.

From the rainfall analyses presented in Table 13, the following conclusions can be drawn:

- With two exceptions (Eden and Tumut) annual rainfall deficits in 2019 were considerably worse than in both 2018 and 2017 which were also drought-affected years
- In the mid north coast and ranges areas of Wingham, Walcha and Telegraph Point, 2019 annual rainfall was the lowest on record (noting Wingham records go back 131 years)
- In the north coast/northern rivers/ranges areas of Nana Glen (inland from Coffs Harbour); Tabulam (near Casino), Tenterfield and Woodenbong (near the QLD border) annual rainfall was the lowest on record (noting Tenterfield records go back 149 years)
- When measured over the 1 April to 31 December period (the period most greatly affecting fire season conditions) 12 out of 16 long-term stations analysed recorded the lowest rainfall on record for that period. A further 2 had their second driest period on record
- Those stations registering lowest on record rainfall in 2019 recorded, at worst, less than a third of their mean annual rainfall, and at best just over half.

A.4 The effect of drought on soil and fuel moisture

The effect of drought on fuels is to dry them out so that they are available to burn. In severe droughts, even large logs on the forest floor can dry out sufficiently to burn away completely once ignited. Soil moisture is also depleted which causes vegetation stress.

The progression of the fuel and soil drying effects of the drought leading into the 2019/20 bush fire season can be gleaned from modelled soil moisture maps produced by the BoM.

Root zone soil moisture maps covering NSW sourced from the BoM's Australian Water Resources Assessment Landscape (AWRA-L) modelling for September and December 2019 are copied at Figures 5 and 6.

The modelling takes account of rainfall, evapotranspiration, runoff and deep drainage. It is evident that soil dryness in the fire-affected areas north of the Hunter was already at very much below average to lowest percentile (worst 1%) levels in September (as it was also in August), and except for some largely coastal rainfall in the lower Hunter and Sydney basin, conditions remained that way in those areas through to December.

Along the South Coast and ranges soil moisture was already very much below average in September, and progressively worsened to widespread lowest percentile conditions by December. Alpine areas and the south west slopes progressively worsened from below average/very much below average to very much below average/lowest percentile conditions by December when large fires broke out in that area.

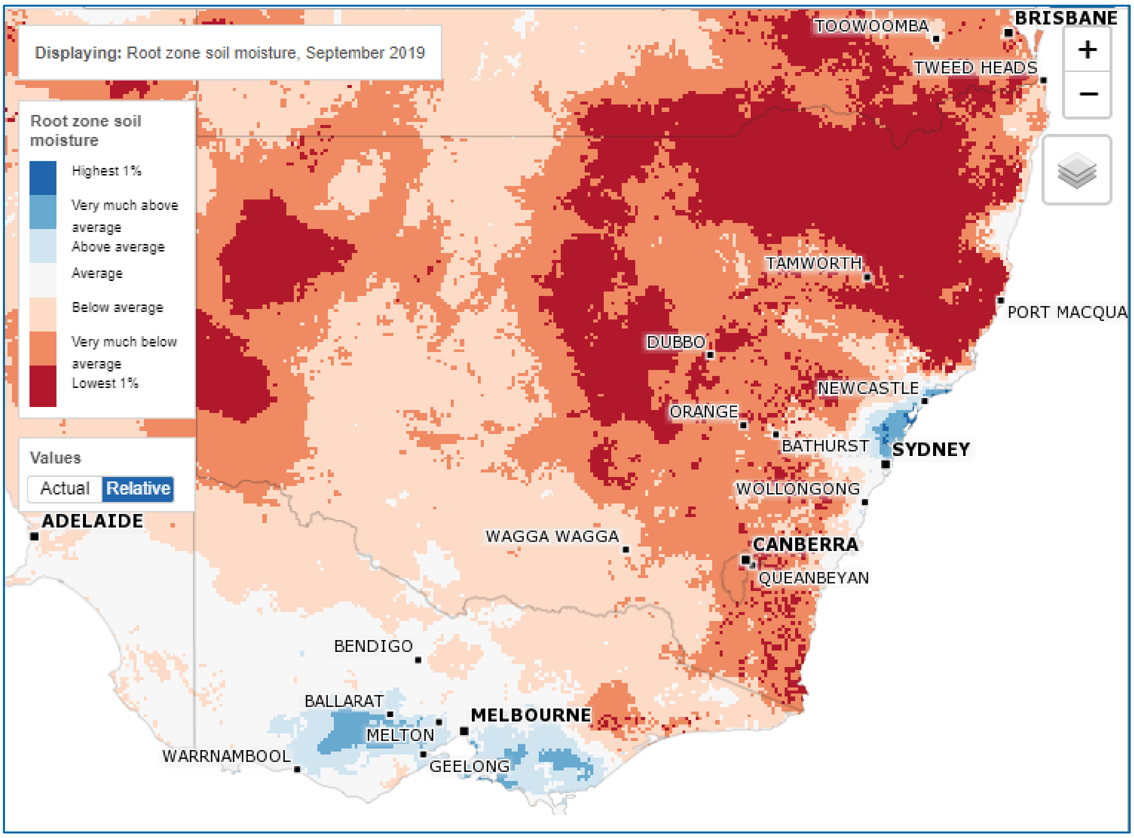

Figure 5 Modelled root zone soil moisture – September 2019

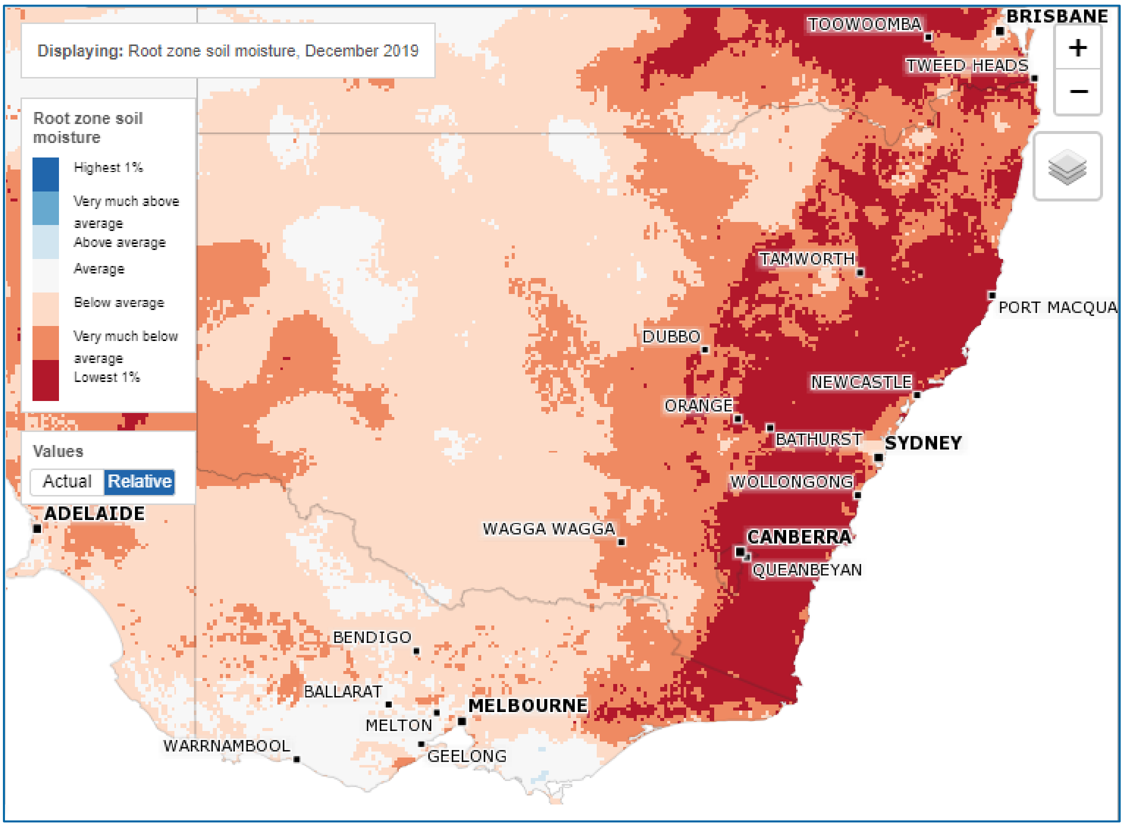

Figure 6 Modelled root zone soil moisture – December 2019

A.5 Effects of drought on forests and forest fuels

Native tree species such as eucalypts make physiological adjustments in response to declining water supply, through an initial reduction in tree growth, leaf development and stem growth. Where deficits extend into short term drought, to enhance survival chances, vegetation may shed leaves and buds, and roots, shoots and stems may 'recess' through withering. Where droughts become prolonged whole plant mortality may result, although more complex processes than moisture deficiency may also be involved.

During the 2019/20 bushfire season in NSW the physiological response of drought-induced defoliation was clearly evident in severe drought-affected forest areas.

The photos at Figures 7 and 8 show severe drought-stressed forests around the Towamba Valley west of Eden.

Dead and dying shrubs are evident in the understory, and tree crowns are clearly suffering severe stress with foliage turned brown (dead), and thinned canopies from leaf shed.

Drought induced leaf fall has added to the surface fuels on the forest floor (and across tracks) with a proportion suspended in shrub layers. The appearance of the forest understory and canopy in these severe drought-stressed forests is similar to the appearance of crown scorch which occurs when heat convection and radiation from a hot surface fire kills the leaves in tree crowns and understory vegetation – except there has been no fire in these images – just drought.

The full depth of the leaf litter profile on the forest floor, and the soil underneath is 'bone' dry – fuel availability is maximized. Similar drought effects were observed in other parts of the southern ranges, extensive parts of the ranges between the Hunter and Hastings valleys, and extensively along the northern tablelands and ranges from the Clarence Valley to the Queensland border.

These severe drought effects make forests much more fire prone than usual. Lightning has an increased probability of starting fires, fires grow and spread more readily, fires are more intense due to the maximized fuel availability, and fire can climb into tree crowns more readily due desiccated bark, and dead and drought stressed shrubs and canopy fuels.

Figure 7 Severe drought stress evident in forest near Burragate (Towamba Valley)

Figure 8 Severe drought stress impact on tree canopies near Burragate (Towamba Valley)

A.6 Weather severity

The principal weather factors which influence bushfire behaviour and severity are recent rainfall, air temperature, relative humidity and wind speed.

In considering the effect of weather on the severity of fire impacts, there are two dimensions relevant to consider. The peak fire weather on a given day, and in particular on the most adverse days, being those which give rise to the most severe fire behaviour is one dimension often used to compare fire event severity. This is useful for comparing extreme events which may take place over a period of hours or potentially a few days, noting that the greatest proportion of fire growth and impact generally occurs on the more severe days. However, it is also relevant to consider the more cumulative effects of weather patterns over longer periods such as weeks or even months, as the weather over such periods influences the areas which fires impact, and certainly impacts fire containment and suppression difficulty.

In considering the 2019/20 fire season in NSW, some insights into the more cumulative effects of weather on fires can be gleaned from looking at weather parameter averages over monthly timeframes compared to average conditions. For rainfall, the commentary on drought effects contained in Sections A2 to A4 are relevant. The influence of temperatures and relative humidity can be appraised through examining:

- For temperature impacts: monthly mean temperature deciles; and
- For relative humidity impacts: 3pm Vapour Pressure Anomaly (noting that low vapour pressure anomalies are indicative of low relative humidity anomalies)

Observed temperature effects on fires

Review of BoM monthly mean temperature deciles maps for August to December 2019 (Figure 9) confirms:

- During August, temperatures along the Mid North Coast and ranges and Northern Tablelands were very much above average (10th decile), and above average (8th & 9th deciles) in the Northern Rivers, North West Slopes and Plains, Hunter and Sydney basin, and northern parts of the central Tablelands
- Warmer than average conditions continued in September
- Heat built further during October with very much above average temperatures prevailing west of the ranges, and above average temperatures along the coast and ranges and Victorian border areas (exceptions being the far north east and parts of the South Coast which were average)
- During November very much above average temperatures affected coastal and tableland areas from the Illawarra to the lower Mid North Coast, extending to the Central and Southern Tablelands areas, and also most of the Northern Rivers. Other forested areas experienced above average temperatures
- December was especially hot with extensive areas of hottest on record mean monthly temperatures inland, with the coast and ranges and southern Riverina dominated by very much above average temperatures. Almost all of NSW experienced record high temperatures during December, with repeated bursts of very hot days (heat waves).

In combination with low relative humidity and drought, the effect was to desiccate fuels

.

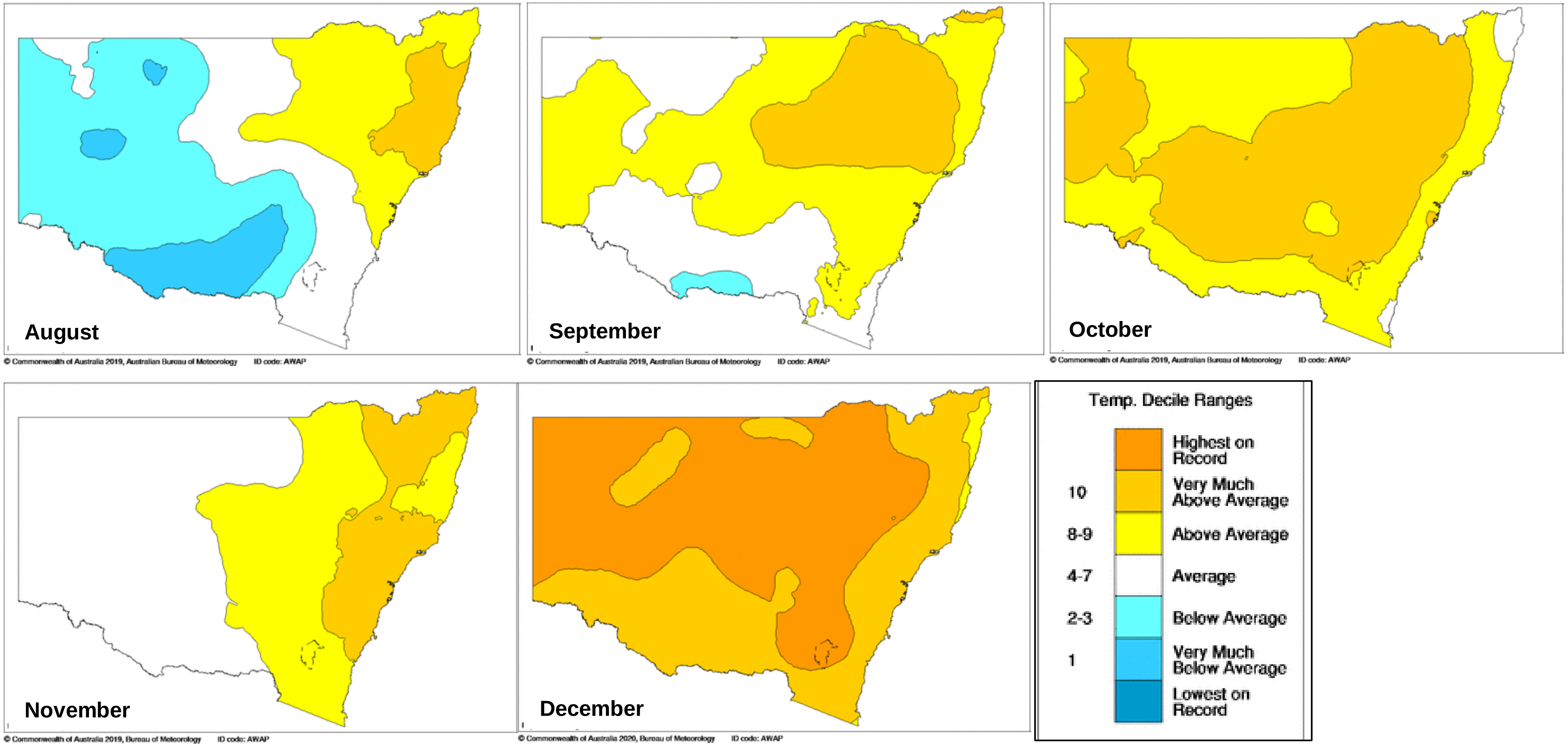

Figure 9 NSW monthly mean temperature decile maps August – December 2019

Observed relative humidity effects on fires

Relative humidity affects fire behaviour through influencing the moisture content of dead fine fuels (<6mm diameter) such as cured grass, leaf litter beds and elevated/suspended material dead leaves, twigs and bark. At low relative humidity levels there is less moisture in the atmosphere available for adsorption into fine fuels. At low relative humidity, dead fine fuels in forests are very dry and typically 'crunch' underfoot, and are readily ignited, while at high relative humidity fuels are more limp and moist, requiring much more heat energy to ignite.

Relative humidity is derived from atmospheric vapour pressure, being a measure of observed vapour pressure as a proportion of saturation vapour pressure at the prevailing air temperature. Accordingly, the Bureau of Meteorology's vapour pressure anomaly map products can provide insight into relative humidity anomalies.

Review of BoM 3pm vapour pressure anomaly maps for August to December 2019 (Figure 10) confirms:Figure 10) confirms:

- During August, relative humidity (RH) anomalies (as indicated by vapour pressure anomaly) during the mid-afternoon period (3PM) were below average levels across NSW - the most significant low RH anomalies were in the northern inland
- During September, low RH anomalies strengthened with coastal ranges and hinterland areas experiencing significant negative anomalies, with more severe negative anomalies prevailing across the northern inland, in particular the fire-affected Northern Tablelands and North West Slopes and Plains
- The pattern of low RH anomalies extended into October, with very similar patterns to those experienced in September
- During November the distribution of low RH anomalies deteriorated further; with serious low RH anomalies extending along the ranges and hinterland areas from the Illawarra to Queensland, with particularly low anomalies affecting Northern Tablelands and North West Slopes and Plains.
- The adverse pattern of low RH anomalies experienced in November extended through December, intensifying further in the Northern Tablelands and North West Slopes and Plains

Figure 11 shows the 3PM vapour pressure deciles over the spring period as a whole (1 September to 30 November 2019). It is clearly evident that across most of NSW 3pm vapour pressure over the 2019 spring season was the lowest on record, and where it was not lowest on record, conditions in the lowest decile were experienced (except for some small coastal fringe areas on the central and north coastal fringe).

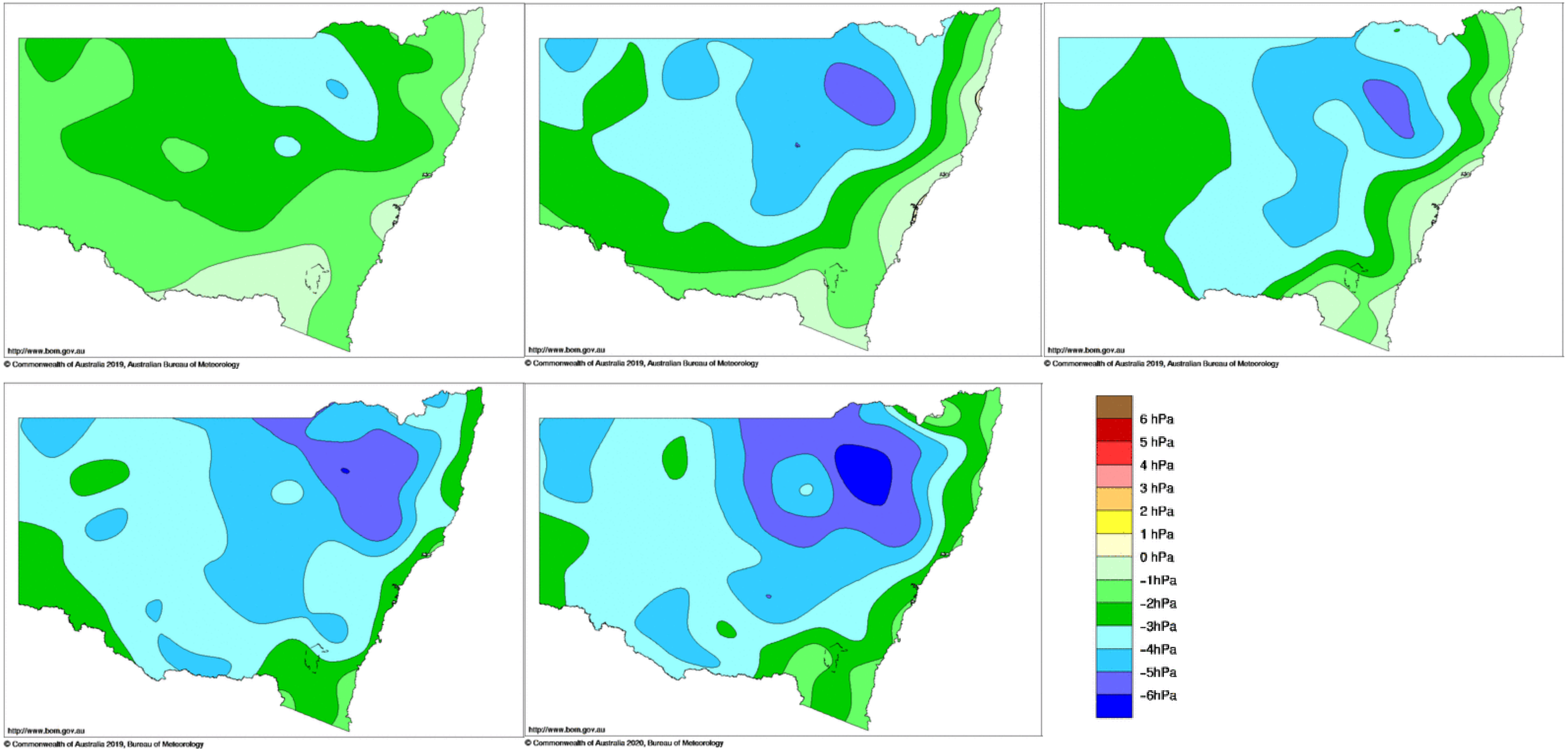

Figure 10 NSW monthly 3pm vapour pressure anomaly – August to December 2019

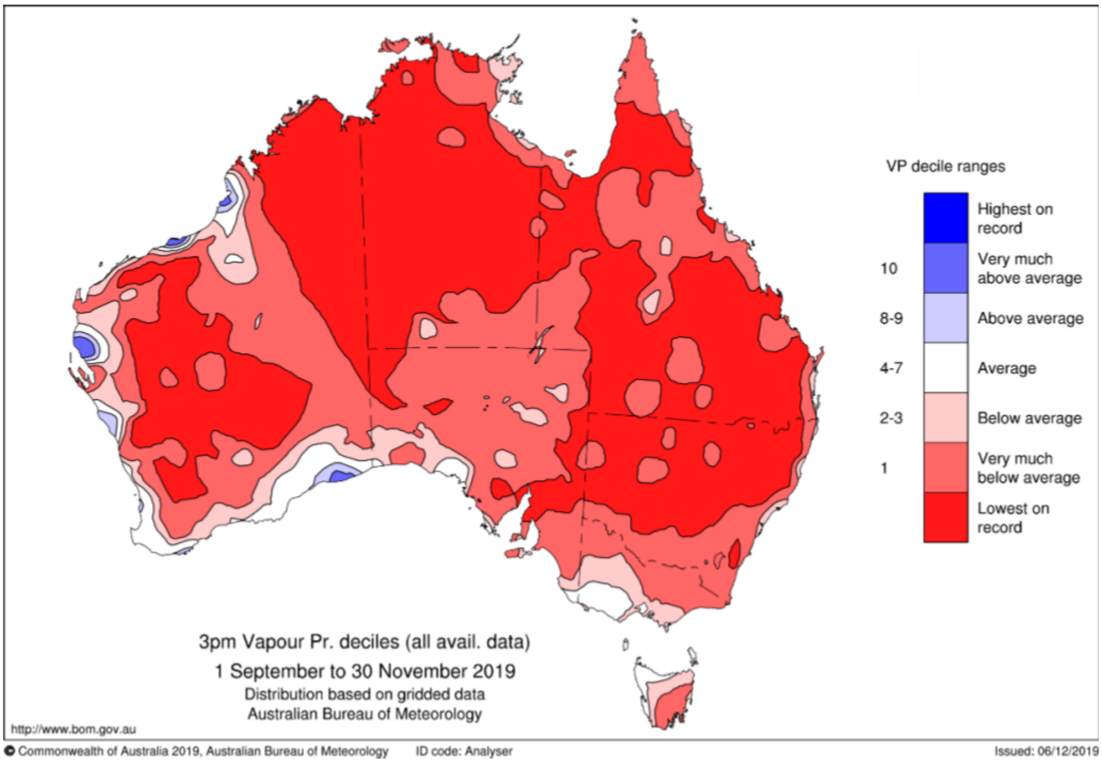

Figure 11 3PM vapour pressure 'humidity' deciles for spring 2019[8]

The deciles depicted in Figure 11 are based on all years since 1950.

Wind conditions and forest fire danger index

Wind speed has a major influence on bushfire spread and intensity. On dry windy days fire growth can be substantial but is much more constrained on days with light winds. Thus during periods with windier than usual weather, fire growth and impact can be expected to be greater than usual. Days when bushfires make long runs (potentially tens of kilometres) burning at high intensity are invariably subject to strong winds. These do not always have to be from the west or north-west – strong southerly winds prevailing after wind changes have historically been responsible for long high-impact runs, as occurred overnight on 4/5 January 2019 when the Border Fire made a run of more than 35 km north from the Victorian border area to Twofold Bay near Eden.

The BoM does not publish products comparing observed 'windiness' with average winds for particular time periods such as months or seasons. For such purposes, analysis of the FFDI can provide some insight as FFDI is quite sensitive to changes in wind speed.

The BoM prepared an FFDI decile map for the spring 2019 period (Figure 12). It shows that accumulated FFDI In much of the NSW fire-affected areas north of Sydney and along the far South Coast were the highest on record, and in the worst decile in other NSW fire affected areas.

At a continental level, an exceptionally high proportion of Australia experienced highest-on-record accumulated FFDI in spring 2019.Figure 12). It shows that accumulated FFDI In much of the NSW fire-affected areas north of Sydney and along the far South Coast were the highest on record, and in the worst

[8] Sourced from Ref. [5]

decile in other NSW fire affected areas. At a continental level, an exceptionally high proportion of Australia experienced highest-on-record accumulated FFDI in spring 2019. Figure 12

The exceptionally high accumulated FFDI for spring was a significant contributing factor in the persistence and growth of fires and the difficulties experienced in containing and extinguishing them. FFDI is an index of the difficulty of controlling fires – the higher the FFDI, the more difficult fires are to control.

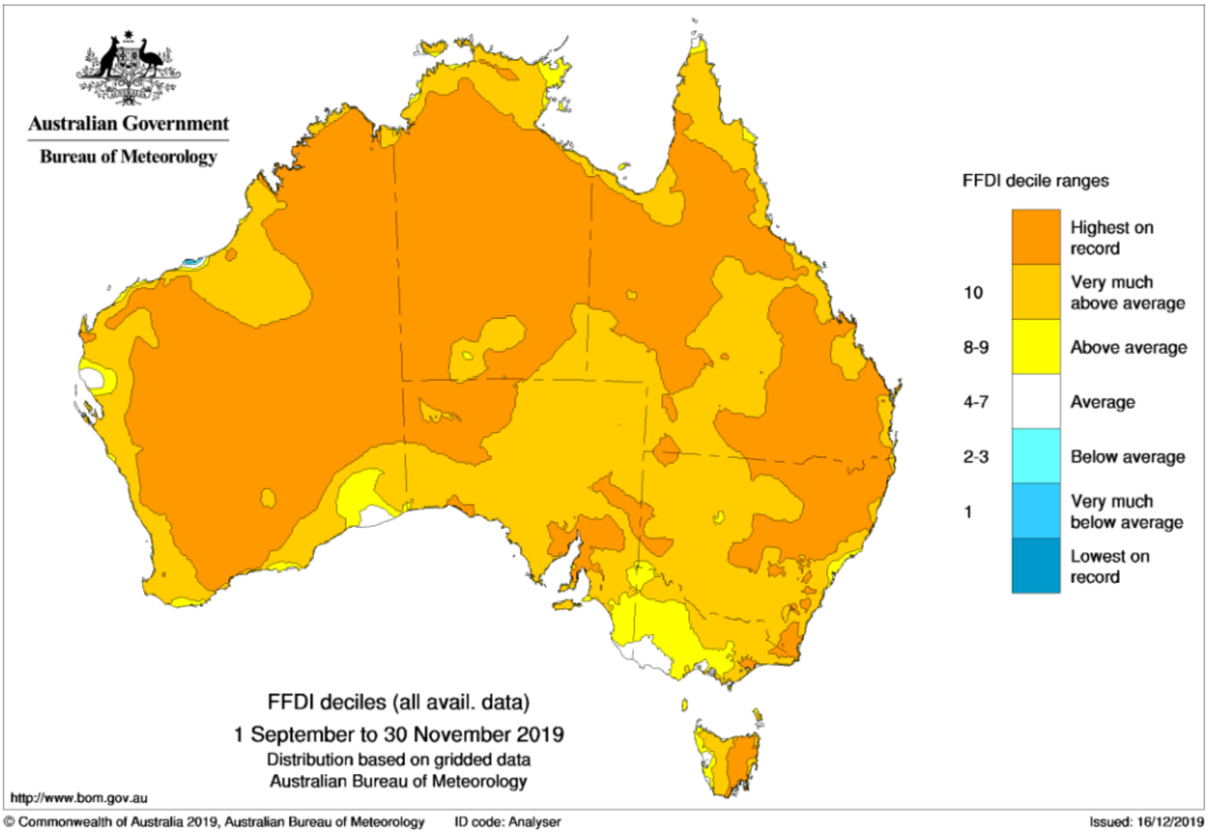

Figure 12 Accumulated FFDI deciles – spring 2019

A.7 Extreme fire weather event days

The foregoing analysis has examined the unprecedented severity and effects of drought and weather at monthly and spring season timescales and into December 2019. In south-east Australia, a very high proportion of fatalities, house losses and large-scale bushfire occur on days of extreme and catastrophic fire weather when very high intensity fire fronts can develop and spread across large areas.

During the 2019/20 fire season in NSW, the worst four days / periods in terms of fire weather were (in order of occurrence):

- **12 November 2019** – Catastrophic Fire Danger was forecast for Greater Sydney and Hunter Fire Districts. It was predicted that fires already burning from the Hunter/Hawkesbury area to the Clarence Valley in the Northern Rivers District had the potential to make major, high intensity runs and potentially cause very high levels of property loss and damage:
  - At Richmond (in Greater Sydney); **FFDI peak 87.3** (Extreme) at 16:30, and was in the 'Extreme' FDR range (75+) from 16:00 to 17:00.

- At Singleton (Hunter); **FFDI peak 97.5** (Extreme) at 14:30, first reaching the 'Extreme' FDR range (75+) by 13:00 and then again from 14:00 to 16:30

- **21 December 2019** - Catastrophic Fire Danger was again forecast for Greater Sydney (including Blue Mountains), the Illawarra/Shoalhaven and Southern Ranges, Metropolitan and Hunter District:
  - At Nowra (Illawarra/Shoalhaven); **FFDI peak 97.7** (Extreme) at 13:30, remaining in the 'Extreme' FDR range (75+) until 14:30
  - At Goulburn Airport (Southern Ranges); **FFDI peak 96.5** (Extreme) at 15:00, and was in the 'Extreme' FDR range (75+) from 12:30 until 16:30
- **30 & 31 December 2019** – On 30 December Severe fire danger was forecast for the Southern Riverina, Southern Slopes, Southern Ranges, ACT Monaro Alpine and Far South Coast, followed on 31 December by the Extreme Fire Danger across the Illawarra/Shoalhaven, Southern Ranges and ACT:
  - At Wagga Wagga (Eastern Riverina); on 30 December **FFDI peaked at 95.1** (Extreme) at 15:30, being in the 'Extreme' FDR range (75+) from 14:30 until 18:00; On 31 December the **FFDI peaked at 68.3** (Severe) at 10:00
  - At Braidwood (Southern Tablelands); on 30 December the **FFDI peaked at 74** (Severe) at 17:00 (did not quite reach Extreme), but was in the 'Severe' FDR range (50- 74) from 15:30 until 19:30; On 31 December, the **FFDI peaked at 75** (Extreme) at 13:00 and had remained in the Severe FFDI Range from 10:00 to 15:00. The most noteworthy aspect of the 30/31 December weather was the overnight conditions – Relative Humidity recovered to only 28% overnight (in fact it was below 20% until midnight and then again from 07:00) – by 08:30 on 31/12, the temperature was above 30 degrees, and relative humidity was just 14%.
- **4 January 2020** - On 4 January 2020 Extreme fire danger was forecast for the NSW South Coast, Illawarra/Shoalhaven, Southern Ranges, Snowy Monaro and Snowy Valleys, Southern Slopes, Eastern Riverina and ACT:
  - At Wagga Wagga (Eastern Riverina); on 4 January **FFDI peaked at 118.5** (Catastrophic) at 16:00, being in the 'Catastrophic' FDR range (100+) from 14:30 until 16:30, plus a further 2 hours during the afternoon in the Extreme range (75-100)
  - At Braidwood (Southern Tablelands); on 4 January **FFDI peaked at 88.2** (Extreme) at 14:00, having been in the Extreme range (75-100) from 12:30 until 13:30 and in the Severe range (50 – 75) from 12:00 – 12:30 and 14:30 to 18:00.

In summary, there were numerous days during the 2019/20 season fires on which the weather conditions experienced were highly adverse for fire control and which give rise to extreme fire behavior. The highest FFDI was experienced on 4 January when the Dunns Road Fire made strong eastward runs into Batlow, Talbingo and up the western fall of Kosciuszko National Park.

A.8 2019/20 NSW fire season - drought and weather summary

The foregoing analyses at sections A.1 to A.7 demonstrate that leading into and during the 2019-20 fire season, NSW experienced a combination of drought and fire weather conditions that are unprecedented.

Worst-on-record rainfall deficits across much of the area which came to be impacted by fires caused forest fuels to dry out through the full depth of their profile and suffer acute drought-stress adding further to fuel loads. These forest fuel conditions were much more conducive than normal to lightning fire ignition and spread, and made the resulting fires far more difficult than normal to contain and control. Recurrent heatwaves and bouts of extreme fire weather from November 2019 to January 2020 generated extreme fire behaviour. These conditions resulted in loss of human life, and property loss/damage at levels never before experienced in NSW.

GHD's analysis is supported by both the scientific literature and the official findings of inquiries. A study of weather and fire impacts was undertaken by a team from the University of Melbourne, the Bushfire and Natural Hazards Cooperative Research Centre and the NSW Rural Fire Service (Filcov et al, 2020) found that :

Much of central and northern NSW has experienced very much below average rainfall for most of 2019,with some areas experiencing driest on record conditions. Long-term rainfall deficiencies, record low for some areas in the north of the state, have severely impacted on water resources and firefighting tactics. At the beginning of August (end of Australian winter) nearly all of NSW was in of the following categories: drought affected (55%), experiencing drought (23%), and experiencing intense drought (17%). The first 'Section 44' emergency declaration of the fire season was made on 10 August 2019, one of the earliest on record. Significant soil moisture deficit and windy conditions resulted in a significant number of bushfires.

The Report of the NSW Bush Fire Inquiry (Owens and O'Kane, 2020) identified that:

For historical context, the BoM indicated that the rainfall deficiencies of the recent drought are comparable with the multi-year Federation and World War II droughts. But the BoM also pointed out that the recent drought coincided with the warmest period on record.

The BoM has highlighted that the combination of rainfall and maximum temperatures for NSW in 2019 makes that year a significant outlier for high temperature and low rainfall and that the combination of record low rainfall and high temperatures resulted in "prolonged and record-breaking 12-month drought factors".

With regard to fire weather, on advice from the Bureau of Meteorology, the NSW Bush Fire Inquiry found:

As noted by the BoM, large areas experienced record fire weather driven by the combination of drought and extreme heat, with individual spike days linked to the onset of strong westerly winds. The combination of these risk factors – temperature, low humidity, wind speed and dryness of fuel – is brought together in the Forest Fire Danger Index (FFDI), which informs the six Fire Danger Ratings used to communicate fire risks to the public: Low-Moderate, High, Very High, Severe, Extreme and Catastrophic. The FFDI levels were persistently high throughout the season. For example:

- *from October to December 2019, FFDI levels were at record high levels a Catastrophic rating was recorded on 6 September 2019 – the earliest ever recorded since that rating was initiated in 2009*
- *FFDI values for north-east NSW were Very High for 21 days during spring (previous highest count was 11)*
- *the season saw six* days of Catastrophic fire danger, 22 days of Extreme fire danger and 72 days of Severe fire danger.

A.9 The scale of fire occurrence, size and impact

Influenced by the drought and weather factors outlined in the previous sections, NSW experienced its worst fires, and fire impacts, on record. The NSW bushfire inquiry identified that the 2019/20 bushfire season was "*unprecedented in its intensity and scale" (Report of the NSW Bush Fire Inquiry; p 1).*

In summarising the scale of losses and damage in NSW during the 2019-20 fire season, the Report of the NSW Bush Fire Inquiry (Owens and O'Kane, 2020) found:

The losses from the 2019-20 fires have been significant. Tragically 26 lives were lost, including three NSW RFS members and three international aerial fire fighting crew.

The community suffered huge losses. Not only the loss of lives and homes, but there was also significant loss of property, wildlife, farming equipment, fencing and agricultural land, stock and crops.

The fires burnt over 5.52 million hectares of land, destroyed 2,476 houses, 3 schools, 284 facilities and 5,559 outbuildings. In addition to the losses, there were 1,034 homes, 196 facilities and 2,017 outbuildings damaged (Report of the NSW Bush Fire Inquiry; p 2).

The scale of the 2019/20 loss and damage attributable to bushfires in NSW is unprecedented in terms of lives lost, properties destroyed and damaged, and the scale of forested landscapes which burnt.

With regard to the spatial scale of fire impact during the 2019/20 fire season, a study by Filcov et al (2020) found that a total of 5,595,739 hectares were burned in NSW. This is more than 3 times the area burnt in NSW during the severe 2002-03 fire season, and more area than any single NSW fire season in recorded history.

Filcov et al (2020) identified that two 'mega-blazes' were recorded in NSW. The Gospers Mountain fire started on 26 October 2019 and burned approximately 512,626 hectares, becoming one of the biggest forest fires in Australian history. By 11 January 2020, three fires on the border of NSW and Victoria – the Dunns Road fire, the East Ournie Creek, and the Riverina's Green Valley merged and created a second mega-fire which burned through 895,744 hectares.

Fire Intensity

Due to the extremely dry state of fuels across the areas where fires burnt, in combination with extreme fire weather conditions, fires were more intense than in previous fire seasons. Those fires which were driven by extreme to catastrophic fire weather conditions burnt at the upper levels of intensity possible for the vegetation types they were burning in. In many such cases where large fires were burning through forest-dominated landscapes fanned by strong dry winds, pyroconvective thunderstorms developed which amplify winds at the fire front, with wind speeds greatly exceeding those of the prevailing winds measured by BoM instruments at weather stations remote from the fire. The Dunns Road fire which impacted large areas of TransGrid's transmission network was one of the fires which developed pyroconvective behaviour, crossing major reservoirs (Blowering and Talbingo) and making very high intensity runs up steep slopes to alpine elevations and generating lightning storms which started new fires around Adaminaby and Yaouk.

With regard to the occurrence of extreme fire behaviour, the NSW Bush Fire Inquiry (Owens and O'Kane, 2020) noted:

The 2019-20 bush fire season was extreme, and extremely unusual. It showed us bush fires through forested regions on a scale that we have not seen in Australia in recorded history, and fire behaviour that took even experienced firefighters by surprise. The total tally of fire-generated thunderstorms in south-eastern Australia since the early 1980s increased from 60 at the end of 2018-19 to almost 90 at the end of *the 2019-20 bush fire season – an increase of almost 50% in one bush fire season. Fire-generated thunderstorms are extremely dangerous phenomena that produce extreme winds, lightning, tornadoes and black hail*.

The days of extreme fire weather and behaviour correspond strongly with the timing of major damage events on TransGrid's network.

On 8 October 2019, a number of uncontrolled fires were burning in the Northern Rivers region of NSW in rugged forested terrain west of the Summerland Way between Grafton and Casino. Major fires included the Busby's Flat and Long Gully fires. The weather on 8 October 2019 was severe, with the temperature in Casino exceeding 40ºC, the relative humidity falling below 10% and strong winds gusting to 63 km/h. The FFDI peaked in the Extreme range. Extreme fire behaviour was reported and fires made major runs, expanding further from very long uncontained perimeters on the days following the extreme fire weather. TransGrid assets west of the Summerland Way and in other parts of the Richmond Valley, Tenterfield and Clarence Valley local Government areas in which Section 44 emergency declared fires were burning, were directly in the fires' path.

November was dominated by periods of highly adverse fire weather. New records were set for days subject to Total Fire Ban (15) with an unprecedented 17 fires at Emergency Warning level simultaneously on 8 November when severe fire weather prevailed over two consecutive days on 7 and 8 November. Ahead of forecast catastrophic fire danger forecast on 12 November, a State of Emergency lasting for 7 days was declared on 11 November 2019. Major fires extending from northern NSW to the Hawkesbury were impacted by the extreme weather, including the Gospers Mountain fire which undertook major high intensity runs. The Gospers Mountain Fire was one of the fires which impacted TransGrid's network. On 26 November, lightning started the Currowan Fire west of the Clyde River on the NSW south coast which would ultimately grow to nearly 500,000 hectares and cause significant damage TransGrid assets in the Kangaroo Valley area.

December 2019 commenced with a week of generally mild but dry and windy conditions in areas from the Hunter Valley to the Victorian border – the Currowan fire made a major run across the Clyde River and Princes Highway impacting townships between Ulladulla and Batemans Bay on 5 December. Conditions worsened considerably thereafter and the remainder of December was dominated by heatwave conditions (with 22 days of Total Fire Ban conditions) and negligible rainfall across southern and central NSW where fire activity was most active. On 19 December 2019, a second State of Emergency was declared in anticipation of forecast catastrophic fire weather from the Greater Sydney basin to the southern ranges. Temperatures exceeded 40ºC across broad areas from Sydney to the Victorian border on both 19 and 21 December with similar conditions returning on 28 December 2019. Lightning started the Dunns Road fire (first reported on 28 December 2019) and other fires on the south west slopes. On 30 and 31 December extraordinary fire conditions prevailed in southern NSW where the major fire activity was occurring. During this period, the Dunns Road fire made an unpredicted run of approximately 90 kilometres impacting the TransGrid network under conditions which remained in the very high range throughout the night of 30/31 December returning to severe by 9am on 31 December (for comparison - not even any of the extreme 2009 Victorian 'Black Saturday' fires, which killed 173 people, made runs of this length). The same weather conditions caused the Currowan fire to run 39 kilometres from the escarpment south-east of Braidwood to the coast at Batemans Bay.

In January, a third State of Emergency was declared in anticipation of catastrophic fire weather. As it turned out, the worst fire danger conditions of the NSW summer arrived on 4 January 2020, to impact the very long flanks of major fires which had made unprecedented runs just 4 days earlier, including both the Dunns Road fire and the Currowan Fire. At Wagga Wagga near the Dunns Road fire, the temperature reached 46.1ºC and the FFDI peaked at 118.5 at 4pm – well above the Catastrophic FFDI threshold of 100, and one of the worst fire danger days recorded in NSW. Under these highly adverse conditions, the 90 km long eastern flank of the Dunns Road Fire made an extreme high intensity run to the east, jumping across the Blowering and Talbingo reservoirs, and burning as an intense crown fire up the western fall of the Great Dividing Range deep into Kosciuszko National Park. Substantial sections of TransGrid's transmission lines were in the fires path, and impacted by high intensity crown fires with flame lengths exceeding 70 metres in many locations, sufficient to breach transmission line easements in areas impacted by crown fires. Later the same day at the Currowan fire, a vigorous southerly wind change sent the Currowan fire on a very high intensity run up the western slopes of Kangaroo Valley impacting TransGrid's network assets in that location.

Adverse fire conditions continued across most active fire grounds until at least the third week of January, but would not reach the catastrophic levels seen in November, December and early January.

A very high proportion of the bushfire damage incurred by TransGrid was a result of fires burning under the exceptionally severe fire incidents outlined above. The major fires which impacted TransGrid lines were declared (under Section 44 of the Rural Fires Act 1997) emergency fires incapable of control or suppression by the fire fighting authorities in whose area or locality they were burning. Section 44 fire declarations were declared in all of the fire areas where TransGrid's network incurred significant damage, including Tenterfield, Richmond Valley, Clarence Valley, Kempsey, Nambucca, Mid Coast, Hawkesbury, Blue Mountains, Wollondilly, Wingecaribee, Eurobodalla, Shoalhaven, Bega Valley, Snowy Monaro, Snowy Valleys and Greater Hume.

A.10 Bushfire damage to TransGrid assets

The nature of the network damage which is the subject of the cost pass through application reviewed by GHD is set out in TransGrid's Application.

The nature of the damage incurred is consistent with impact by very high intensity bushfire.

Wooden pole assets

For wooden pole suspended assets such as 132kV lines impacted in northern NSW, high intensity forest fires burning into transmission line easements from adjacent forest under adverse fire weather conditions typically burn at very high intensity, with flame lengths which can readily breach the distance from the easement edge to poles (typical easement widths for 132kV lines spanning 15 to 20 metres either side of the centreline). Applying the Bushfire Attack Level determination methodology incorporated in Australian Standard *AS 3959:2018 Construction of buildings in bushfire prone areas*, structures within 20 metres of a forest fire burning on gently sloping land in the >0 to 5 degree slope class, at a Forest Fire Danger Index (FFDI) of 80 are deemed to be within the Flame Zone.

For wooden pole suspended assets such as 132kV lines running through grasslands or grassy easements, vigorous flames from grassfires burning under adverse fire danger conditions can also engulf wooden poles causing pole ignition. In areas of southern NSW such as near Adelong where TransGrid suffered significant damage to 132kV lines supported by wooden poles, applying the Bushfire Attack Level determination methodology incorporated in Australian Standard *AS 3959:2018 Construction of buildings in bushfire prone areas*, structures within 7 metres of a grass fire burning on gently sloping land in the >0 to 5 degree slope class, at a FFDI of 100 are deemed to be within the flame zone (or 6 metres for FFDI 80). It is not industry practice anywhere in Australia to clear remove grass cover in transmission line easements through rural areas.

Additionally, during large scale high intensity fire events such as those which impacted TransGrid's assets during the 2019/20 fire season, it can take many hours or days before fire ground areas impacted by the fires are deemed safe by fire authorities to enter. Under severe, extreme and catastrophic FFDI conditions, firefighters rarely if ever attempt to control running fires, instead falling back to community and property protection working from areas of defensible space around assets or from identified clear areas. For these reasons slow-burning or smouldering poles are often not able to be attended to prevent collapse for many hours or potentially days by which time they have burnt to failure point.

500kV and 330kV assets

The nature of damage incurred to 500kV and 330kV transmission lines suspended by steel lattice towers, in wide cleared easements, and with the highest ground clearance standards of all line voltage classes, is evidence of impact by very high intensity bushfire.

TransGrid's cost pass through application identifies that conductor repairs contribute the bulk of network repair costs. From the results of asset inspections, TransGrid has reported extensive conductor damage in the Snowy Mountains region where the bushfires were most intense. GHD concurs with TransGrid's inference that the conductor damage in the Snowy Mountains region was due to high intensity fire impact. Figure 5 in TransGrid's cost pass through application depicts the location of network faults which rendered network assets inoperable of 4 January 2020. Figure 12 in TransGrid's cost pass through application depicts the locations where conductor damage was concentrated. The locations depicted are within the large area burnt during the eastward spread of the Dunns Road Fire on 4 January 2020 when the worst fire weather conditions of the 2019/20 fire season occurred, and in landscape areas occupied by forests known to be capable of supporting very high intensity fires, particularly in drought conditions. The wooden poles associated with 132kV transmission lines near Adelong were also within the area burn on 4 January 2020 when fire broke away from the north-western end of the Dunns Road Fire and made a high intensity run toward Adelong.

The nature of conductor damage referred to in TransGrid's cost pass through application, provides evidence of broken strands, some melting of aluminium, and more extensive annealing of aluminium conductors. These forms of conductor damage typically occur at temperatures exceeding 300^{o}C, only being possible at the temperatures reached in or near flame tips and/or from electrical arcs involved in phase to earth faults arising from fire interaction with conductors.

Damage to PVC spiral vibration dampers can occur at lower temperatures than discussed in relation to conductor damage. The melting point of PolyVinyl Chloride (PVC) varies (typically in the range of 100 to 260 ^{o}C) depending on what additives are used in the production process. However, the melting point is the point at which it becomes liquid, and PVC can lose its rigidity, shape and deform at much lower temperatures, as low as 80 ^{o}C, again depending on additives in the PVC. In relation to bushfire impact, flame contact is not required to cause deformation in PVC components, and this can occur under exposure to radiant heat from the bushfire. Much of the bushfire damage to PVC spiral vibration dampers is likely to have occurred via exposure to high levels of radiant heat. PVC dampers exhibiting melting and combustion are more likely to have been subject to direct or close flame contact.

Hazardous trees and vegetation

High intensity bushfires such as those which burnt across large areas on NSW during the 2019/20 fire season, cause extensive damage to vegetation. In the more fine-sensitive forests occupying alpine and sub-alpine areas, which typically have thinner bark and fewer adaptations for surviving fire, a very high degree of tree mortality can result. The result is typically stands of dead trees left adjacent to transmission line easements which will degrade and progressively become more structurally unsound over time until they ultimately fail – this can take many years or decades.

Many more fire-resilient tree species may be injured by the fire but not die. The injuries sustained can include major stem or branch wounds where the live cambium is killed and peels off exposing dead wood. Many trees have such damage from previous fire damage incurred during their lifespan. In such trees, the entry of fire into stems via hollows or exposed deadwood sections can substantially weaken trees further by burning way internal structural wood in the stem or branch. Thus it is very common to see large numbers of fire damaged trees fall as a result of fire, and many more to be weakened such that they are vulnerable to failure, particularly in high winds. Typically after bushfires large numbers of trees fallen across access tracks and into easements require clearance, and many more still-standing trees are extensively damaged such that they are potentially a hazard to the network (depending in height, lean direction and proximity to the lines) or a hazard to workers working on the network or using affected access trails.

Given the unprecedented area of forest burnt during the 2019/20 fires in NSW, it is to be expected that a greatly increased volume of vegetation management works will be required in fire-impacted areas to clear access tracks, and to find and make-safe hazardous trees.

GHD also expects that in burnt areas with forest adjacent to transmission line easements, the exposure of soil by the fire within the easement, in combination with the favourable rainfall which has followed the fires (and is forecast to continue with La Nina conditions already declared in place by the BoM), GHD expects that there will major pulse-regeneration events in substantial proportion of fire-affected easements. Many Eucalypt species require a mineral earth or ash bed for seed to germinate and seedlings to become established (this is a key reason why forest managers apply silvicultural burning practices after timber harvesting to promote good forest regrowth). TransGrid can expect a much more vigorous than usual tree regeneration event in burnt easements abutting forest over the next 2 to three years. If not cleared early, established regrowth can grow quickly, particularly in high rainfall areas and reach a size and density where clearance treatment is made substantially more expensive. Easement burnt in the 2019/20 fire season will be a high priority for vegetation management in FY 20 and FY 21.

A.11 Inter-annual bushfire damage comparison

The quantum and types of bushfire damage incurred in years/fire seasons previous to 2019/20 was not available for GHD to review. However, inter-annual outage rates attributable to bushfire are incorporated in TransGrid's cost pass through application (copied below).

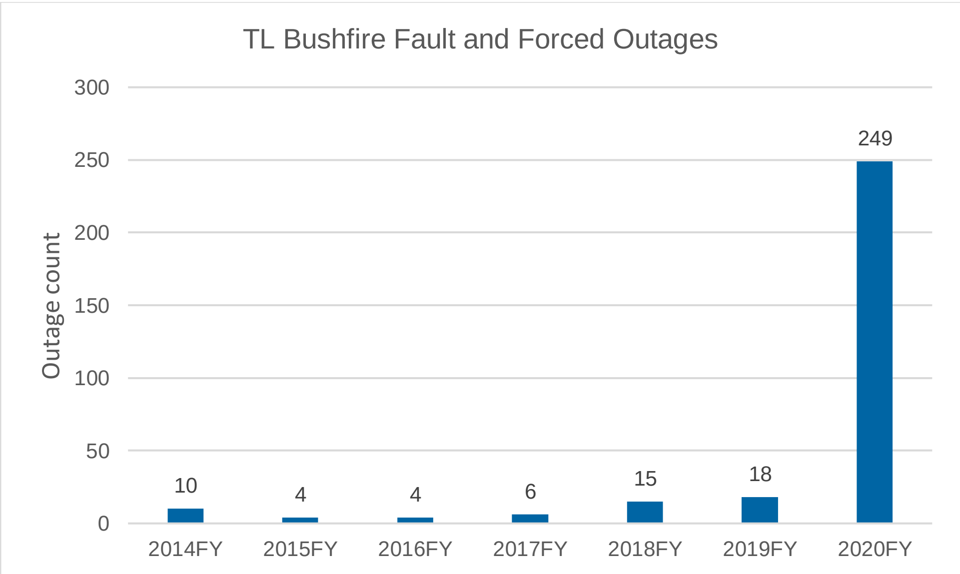

Figure 13 Copy of Figure 3 from TransGrid Cost Pass Through Application

A highly significant difference in the count of bushfire fault and forced outage occurrences in 2020FY relative to in financial years back to 2014 is evident. GHD notes that 2018 was also a drought-affected year, although not as serious from a bushfire risk perspective due to differences in rainfall timing and distribution.

The count of bushfire fault and forced outages in FY20 is more than 13 times the next-worst year (FY2019).

GHD expects that the relative difference in bushfire damage costs between FY20 and previous years back to 2014 is likely to be greater, and potentially significantly greater, than the relative difference in bushfire faults and forced outages. This is principally because the severity of bushfires which resulted in faults in 2020, in many cases is likely to be much greater than the severity of fires which caused faults in earlier years. The evidence supporting this opinion is that it is known that a high proportion of the faults and damage resulting from fires in FY2020 was from large scale fire burning on 4 January 2020 (a Catastrophic FFDI day and one of the worst FFDI days in NSW in recorded history), and other high intensity fire events, and thus the degree of damage which can be caused in association with such faults is potentially much higher than that occasioned by fires burning in substantially less severe conditions in earlier years.

Appendix B - Transmission line forecasts

B.1 Forecasted expenditure [redacted]

Table 14 Forecasted expenditure [redacted]

Cost Estimation Model – [redacted]	Reference	Total
Labour Cost		
Contractor Costs		[redacted]
Outsourced Labour		[redacted]
Internal Normal Labour		[redacted]
Internal Overtime Labour, Sustenance, and Expenses		[redacted]
Total		[redacted]
Materials		
Unitised Costs		[redacted]
Non Unitised		[redacted]
Total		[redacted]
Risk Cost		[redacted]
Direct Cost (excludes internal labour and risk)		[redacted]
Total Expected Cost (Real $2020-21)	**Table 10.9**	[redacted]
Total Expected Cost (Real $2017-18)		[redacted]

Table 15 Labour costs [redacted]

Labour Costs - [redacted]	Volume	Unit Cost	Total
Contractor Costs			
Contract Labour	[redacted]	[redacted]	[redacted]
Medium Track and Access Work	[redacted]	[redacted]	[redacted]
Heavy Track and Access Work	[redacted]	[redacted]	[redacted]
Establishment cost per week (remote etc)	[redacted]	[redacted]	[redacted]

Labour Costs - [redacted]	Volume	Unit Cost	Total
Total contractor costs			[redacted]
Internal and Outsourced Labour Cost Overheads			
Internal Normal Labour			[redacted]
Contracted Out Internal Labour			[redacted]
Internal Overtime Labour, Sustenance, and Expenses			[redacted]
Total labour costs			[redacted]
Total (Real $2020-21)			[redacted]
Total (Real $2017-18)			[redacted]

Table 16 Material costs [redacted]

Material Costs - [redacted]	Volume	UOM	Unit Cost	UOM	Total
Unitised Costs					
Conductor Twin Bison/Mango	53	km	[redacted]	per m	[redacted]
Conductor Single Jarrah	7.5	km	[redacted]	per m	[redacted]
Insulators	92	suspension	[redacted]	each	[redacted]
Insulators	122	tension	[redacted]	each	[redacted]
Fittings	214	off	[redacted]	each	[redacted]
Pad setups - EWP	14	off	[redacted]	each	[redacted]
Pad setup - Winch	16	off	[redacted]	each	[redacted]
Creek Crossing	1	off	[redacted]	each	[redacted]
Gravel	9	km	[redacted]	per km	[redacted]
Total					[redacted]
Non-Unitised Costs					
Nil					[redacted]
Total (Real $2020-21)					[redacted]
Total (Real $2017-18)					[redacted]

Table 17 Risk costs [redacted]

Risk Costs - [redacted]	Likelihood	Delay Consequence	Total
Weather delay	[redacted]	[redacted]	[redacted]
Track condition uncertainty	[redacted]	[redacted]	[redacted]
High content of hard rock	[redacted]	[redacted]	[redacted]
External delays and restrictions	[redacted]	[redacted]	[redacted]
Cost increase in materials risk	[redacted]	[redacted]	[redacted]
Pandemic (COVID-19) risk	[redacted]	[redacted]	[redacted]
Total (Real $2020-21)			[redacted]
Total (Real $2017-18)			[redacted]

B.2 Forecasted expenditure [redacted]

Table 18 Forecasted expenditure [redacted]

Cost Estimation Model - [redacted]	Reference	Total
Labour Cost		
Contractor Costs		[redacted]
Outsourced Labour		[redacted]
Internal Normal Labour		[redacted]
Internal Overtime Labour, Sustenance, and Expenses		[redacted]
Total		[redacted]
Materials		
Unitised Costs		[redacted]
Non Unitised		[redacted]
Total		[redacted]
Risk Cost		[redacted]
Direct Cost (excludes internal labour and risk)		[redacted]
Total Expected Cost (Real $2020-21)	**Table 9**	[redacted]
Total Expected Cost (Real $2017-18)		[redacted]

Table 19 Labour costs [redacted]

Labour Costs - [redacted]	Volume	UOM	Unit Cost	UOM	Total
Contractor Costs					
Contract Labour	[redacted]	weeks	[redacted]	per week	[redacted]
Medium Track and Access Work	[redacted]	km	[redacted]	per km	[redacted]
Establishment cost per week (remote etc)	[redacted]	weeks	[redacted]	per week	[redacted]
Total contractor costs					[redacted]
Internal and Outsourced Labour Costs					
Internal Normal Labour					[redacted]
Contracted Out Internal Labour					[redacted]
Internal Overtime Labour, Sustenance, and Expenses					[redacted]
Total labour costs					[redacted]
Total (Real $2020-21)					[redacted]
Total (Real $2017-18)					[redacted]

Table 20 Material costs [redacted]

Material Costs - [redacted]	Volume	UOM	Unit Cost	UOM	Total
Unitised Costs					
Conductor Twin Bison/Mango	55	km	[redacted]	per m	[redacted]
Conductor OHEW Single 7/0.144	55	km	[redacted]	per m	[redacted]
Sag and clip-in materials 228-off Insulator Dead-ends etc.	228	off	[redacted]	per fittings	[redacted]
Pad setups - EWP	7	off	[redacted]	each	[redacted]
Pad setup - Winch	1	off	[redacted]	each	[redacted]
Total					[redacted]
Non-Unitised Costs					
Nil					[redacted]
Total (Real $2020-21)					[redacted]

Material Costs - [redacted]	Volume	UOM	Unit Cost	UOM	Total
Total (Real $2017-18)					[redacted]

Table 21 Risk costs [redacted]

Risk Cost Model - [redacted]	Likelihood	Delay Consequence	Total
Weather delay	[redacted]	[redacted]	[redacted]
Track condition uncertainty	[redacted]	[redacted]	[redacted]
High content of hard rock	[redacted]	[redacted]	[redacted]
External delays and restrictions	[redacted]	[redacted]	[redacted]
Cost increase in materials risk	[redacted]	[redacted]	[redacted]
Pandemic (COVID-19) risk	[redacted]	[redacted]	[redacted]
Total (Real $2020-21)			[redacted]
Total (Real $2017-18)			[redacted]

B.3 Forecast expenditure [redacted]

Table 22 Forecasted expenditure [redacted]

Cost Estimation Model - [redacted]	Reference	Total
Labour Cost		
Contractor Costs		[redacted]
Outsourced Labour		[redacted]
Internal Normal Labour		[redacted]
Internal Overtime Labour, Sustenance, and Expenses		[redacted]
Total		[redacted]
Materials		
Unitised Costs		[redacted]
Non Unitised		[redacted]
Total		[redacted]
Risk Cost		[redacted]
Direct Cost (excludes internal labour and risk)		[redacted]
Total Expected Cost (Real $2020-21)	**Table 9**	[redacted]
Total Expected Cost (Real $2017-18)		[redacted]

Table 23 Labour costs [redacted]

Labour Costs - [redacted]	Volume	UOM	Unit Cost	UOM	Total
Contractor Costs					
Contract Labour	[redacted]	weeks	[redacted]	per week	[redacted]
'Medium Track and Access Work	[redacted]	km	[redacted]	per km	[redacted]
Establishment cost per week (remote etc)	[redacted]	weeks	[redacted]	per week	[redacted]
Total contractor costs					[redacted]
Internal and Outsourced Labour Costs					
Internal Normal Labour					[redacted]
Contracted Out Internal Labour					[redacted]
Internal Overtime Labour, Sustenance, and Expenses					[redacted]
Total labour costs					[redacted]
Total (Real $2020-21)					[redacted]
Total (Real $2017-18)					[redacted]

Table 24 Material costs [redacted]

Material Costs - [redacted]	Volume	Unit Cost	Total
Unitised Costs			
Conductor Twin Bison/Mango	[redacted]	[redacted]	[redacted]
Sag and clip-in materials 8-off Insulator Dead-ends	[redacted]	[redacted]	[redacted]
Expected Pad setup	[redacted]	[redacted]	[redacted]
Total			[redacted]
Non-Unitised Costs			
Material Stone			[redacted]
Total			[redacted]
Total (Real $2020-21)			[redacted]
Total (Real $2017-18)			[redacted]

Table 25 Risk costs [redacted]

Risk Cost Model - [redacted]	Likelihood	Delay Consequence	Total
Weather delay	[redacted]	[redacted]	[redacted]
Track condition uncertainty	[redacted]	[redacted]	[redacted]
High content of hard rock	[redacted]	[redacted]	[redacted]
External delays and restrictions	[redacted]	[redacted]	[redacted]
Cost increase in materials risk	[redacted]	[redacted]	[redacted]
Pandemic (COVID-19) risk	[redacted]	[redacted]	[redacted]
Total (Real $2020-21)			[redacted]
Total (Real $2017-18)			[redacted]

B.4 Forecasted expenditure [redacted]

Table 26 Forecasted expenditure [redacted]

Cost Estimation Model - [redacted]	Reference	Total
Labour Cost		
Contractor Costs		[redacted]
Outsourced Labour		[redacted]
Internal Normal Labour		[redacted]
Internal Overtime Labour, Sustenance, and Expenses		[redacted]
Total		[redacted]
Materials		
Unitised Costs		[redacted]
Non Unitised		[redacted]
Total		[redacted]
Risk Cost		[redacted]
Direct Cost (excludes internal labour and risk)		[redacted]
Total Expected Cost (Real $2020-21)	**Table 9**	[redacted]
Total Expected Cost (Real $2017-18)		[redacted]

Table 27 Labour costs [redacted]

Labour Costs [redacted]	Volume	Unit Cost	Total
Contractor Costs			
Contract Labour and Equipment	[redacted]	[redacted]	[redacted]
Medium Track and Access Work	[redacted]	[redacted]	[redacted]
Heavy Track and Access Work	[redacted]	[redacted]	[redacted]
Extreme Track and Access Work	[redacted]		[redacted]
Establishment cost per week (remote etc)	[redacted]	[redacted]	[redacted]
Total contractor costs			[redacted]
Internal and Outsourced Labour Cost Overheads			
Internal Normal Labour			[redacted]
Contracted Out Internal Labour			[redacted]
Internal Overtime Labour, Sustenance, and Expenses			[redacted]
Total labour costs			[redacted]
Total (Real $2020-21)			[redacted]
Total (Real $2017-18)			[redacted]

Table 28 Material costs [redacted]

Material Costs - [redacted]	Volume	UOM	Unit Cost	UOM	Total
Unitised Costs					
Conductor OHEW Single 7/0.144	2.6	kms	[redacted]	per m	[redacted]
Conductor Single Jarrah	31.0	kms	[redacted]	per m	[redacted]
Sag and clip-in materials 55-	55	off	[redacted]	per fittings	[redacted]

Material Costs - [redacted]	Volume	UOM	Unit Cost	UOM	Total
off Insulator Dead-ends etc.					
Pad setup - Complex	6	off	[redacted]	each	[redacted]
Total					[redacted]
Non-Unitised Costs					
Material Stone					[redacted]
Total					[redacted]
Total (Real $2020-21)					[redacted]
Total (Real $2017-18)					[redacted]

Table 29 Risk costs [redacted]

Risk Cost Model - [redacted]	Likelihood	Delay Consequence	Total
Weather delay	[redacted]	[redacted]	[redacted]
Track condition uncertainty	[redacted]	[redacted]	[redacted]
High content of hard rock	[redacted]	[redacted]	[redacted]
External delays and restrictions	[redacted]	[redacted]	[redacted]
Cost increase in materials risk	[redacted]	[redacted]	[redacted]
Pandemic (COVID-19) risk	[redacted]	[redacted]	[redacted]
Damaged OPGW on line	[redacted]	[redacted]	[redacted]
Total (Real $2020-21)			[redacted]
Total (Real $2017-18)			[redacted]

B.5 Forecasted expenditure [redacted]

Table 30 Forecasted expenditure [redacted]

Cost Estimation Model - [redacted]	Reference	Total
Labour Cost		

Cost Estimation Model - [redacted]	Reference	Total
Contractor Costs		[redacted]
Outsourced Labour		[redacted]
Internal Normal Labour		[redacted]
Internal Overtime Labour, Sustenance, and Expenses		[redacted]
Total		[redacted]
Materials		
Unitised Costs		[redacted]
Non Unitised		[redacted]
Total		[redacted]
Risk Cost		[redacted]
Direct Cost (excludes internal labour and risk)		[redacted]
Total Expected Cost (Real $2020-21)	Table 9	[redacted]
Total Expected Cost (Real $2017-18)		[redacted]

Table 31 Labour costs [redacted]

Labour Costs - [redacted]	Volume	UOM	Unit Cost	UOM	Total
Contractor Costs					
Contract Labour	[redacted]	weeks	[redacted]	Per week	[redacted]
Internal and Outsourced Labour Costs					
Internal Normal Labour					[redacted]
Contracted Out Internal Labour					[redacted]
Internal Overtime Labour, Sustenance, and Expenses					[redacted]
Total labour costs					[redacted]

Labour Costs - [redacted]	Volume	UOM	Unit Cost	UOM	Total
Total (Real $2020-21)					[redacted]
Total (Real $2017-18)					[redacted]

Table 32 Material costs [redacted]

Material Costs - [redacted]	Volume	UOM	Unit Cost	UOM	Total
Unitised Costs					
Nil					[redacted]
Non-Unitised Costs					[redacted]
Materials - line fittings, compression dead-ends etc. - Stage 2					[redacted]
Consumables / Miscellaneous - Stage 2					[redacted]
Earth works-including access, pad and winch sites - Stage 2					[redacted]
Materials - conductor, line fittings, compression dead-ends - Stage 3					[redacted]
Consumables / Miscellaneous - Stage 3					[redacted]
Earth works- access, pad and winch site, and equipment hire - Stage 3					[redacted]
Total					[redacted]
Total (Real $2020-21)					[redacted]
Total (Real $2017-18)					[redacted]

Table 33 Risk costs [redacted]

Risk Cost Model - [redacted]	Likelihood	Delay Consequence	Total
Weather delay	[redacted]	[redacted]	[redacted]
Track condition uncertainty	[redacted]	[redacted]	[redacted]
High content of hard rock	[redacted]	[redacted]	[redacted]
External delays and restrictions	[redacted]	[redacted]	[redacted]
Cost increase in materials risk	[redacted]	[redacted]	[redacted]
Pandemic (COVID-19) risk	[redacted]	[redacted]	[redacted]
Networks access and outage restrictions	[redacted]	[redacted]	[redacted]

Risk Cost Model - [redacted]	Likelihood	Delay Consequence	Total
Total (Real $2020-21)			[redacted]
Total (Real $2017-18)			[redacted]

Appendix C – Glossary

Term	Definition
$M	Million dollars
Application	Cost Pass through Application for 2019-20 Bushfire event
AEMO	Australian Energy Market Operator
ASIMS	Asset Inspection Manager System
BAU	Business as Usual
BoM	Bureau of Meteorology
capex	capital expenditure
ERP	Enterprise Resource Planning
EWP	Elevated Work Platform
FFDI	Forest Fire Danger Index
HV	High Voltage
km	kilometres
MAR	Maximum Allowable Revenue
NER	National Electricity Rules
NOSA	Need and Option Screening Assessment
NSW	New South Wales
opex	operating expenditure
PTRM	Post Tax Revenue Model
PVC	Polyvinyl Chloride
RFS	Rural Fire Service
RH	Relative Humidity
TL	Transmission Line

Term	Definition
UOM	Unit of measurement
UT1	Upper Tumut Switching Station
VTA	Visual Tree Assessment

Appendix D – References

[1] NSW Bushfire Inquiry 2020, *Final Report of the NSW Bushfire Inquiry*, NSW Government: Premier & Cabinet, Sydney. (Found at Link)Link)Link)Link)

[2] TransGrid 2020, *Expenditure Forecasting Methodology for 2019-20 Bushfires: Cost Pass through Application for 2019-20 Bushfire event*, working draft provided to GHD on 20/10/2020, TransGrid, Sydney.

[3] Australian Energy Market Commission 2020, *National Electricity Rules*, ver. 152, 29 October 2020, AEMC, Sydney. (Found at Link)Link)Link)Link)

[4] Australian Energy Regulator 2018, *FINAL DECISION: TransGrid transmission determination 2018 to 2023*, Australian Competition and Consumer Commission, Canberra. (Found at Link)Link)Link)Link)

[5] Bureau of Meteorology 2019, *Special Climate Statement 72 — dangerous bushfire weather in spring 2019*, ver. 1, Bureau of Meteorology, Melbourne.

Level 9 145 Ann Street Brisbane QLD 4000 Australia
GPO Box 668 Brisbane QLD 4001 Australia

61 7 3316 3000
advisory@ghd.com

Rev. No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	Paul de Mar Anuraag Mulla Arsh Rattan	Bruce Clarke		Bruce Clarke		13/11/2020

GHD
Advisory