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100 Eton Road, Lindfield

LINDFIELD LEARNING VILLAGE

BUSHFIRE RADIATION ASSESSMENT REPORT

REPORT 2018/321 R5.0

REVISION CONTROL

Report No.	Issue Date	Report Details		
2018/321 R5.0	22/08/2019	Description:	Original Report	
		Prepared by:	Nick Lee (Graduate Fire Safety Engineer)	
		Verified by:	Stephen Grubits (Special Expert)	
		Approved and Issued by:	Carlos Quaglia (Managing Director, C10 - BPB0334)	

EXECUTIVE SUMMARY

This Bushfire Radiation Assessment Report relates to the likely bushfire radiant heat flux upon the proposed re-development of the Lindfield Learning Village at 100 Eton Road, Lindfield. Stephen Grubits & Associates Pty Ltd prepared this report at the request of NSW Department of Education and School Infrastructure NSW to support the preparation of a Bushfire Hazard Assessment by the bushfire consultant.

Lindfield Learning Village is situated at the former University of Technology Sydney site at 100 Eton Road, Lindfield. The project consists of converting the existing university buildings to school facilities for students from Kindergarten to Year 12.

The subject school is located on bushfire prone land. It has been proposed by relevant stakeholders to create an Asset Protection Zone (APZ) around the periphery of the subject school to reduce the amount of fuel surrounding the building such that in the event of bushfire, the likelihood of building being exposed to high radiant heat flux is mitigated. The purpose of this report is to identify the extent of the APZ required around the subject building façade to achieve a received radiant heat flux level below 10 kW/m^2.

The radiant heat exposure from a bushfire to the subject school building has been assessed for a fire scenario that is consistent with AS 3959-2009 and Methodology Paper [(1)] published by NSW RFS as advised by the bushfire consultant.

The results of the assessment have determined the separation distance required along each Long Section in order to limit the received heat flux to 10 kW/m^2. These separation distances are intended to define the APZ in order to limit the heat flux at the building. Shielding provided by the natural terrain have been included in the assessment however shielding by vegetation has not been included. The Bushfire Hazard Assessment to be undertaken by the bushfire consultant is intended to use the outcome of this assessment to determine the fire protection that may be required to the building façade to limit the likely spread of fire into the building and to assess the impact on fire brigade operations.

It has also been determined that if the fire is permitted to approach to the boundary of the property along Long Section 9, then the radiant heat intensity to be received at the building is increased to 14.9 kW/m^2.

This report is not a performance-based solution assessment. It is expected that a Bushfire Consultant would utilise this report as part of a Bushfire Hazard Assessment.

[1] NSW Rural Fire Service, 2019, 'Short Fire Run – Methodology for Assessing Bush Fire Risk for Low Risk Vegetation', NSW Government.

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LIST OF ACRONYMS

AS	Australian Standard
APZ	Asset Protection Zone
BCA	National Construction Code Series Volume One Building Code of Australia, 2019
FEB	Fire Engineering Brief
RFS	Rural Fire Services NSW
SGA	Stephen Grubits & Associates Pty Ltd

1. INTRODUCTION

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The radiant heat exposure from a bushfire to the subject school building has been assessed for a fire scenario that is consistent with AS 3959-2009 and Methodology Paper [2] published by NSW RFS as advised by the bushfire consultant.

2. LIMITATIONS & ASSUMPTIONS

1. The scope of this report is limited to the technical assessment to quantify the expected radiant heat exposure to the subject building by a potential bushfire. The assessment is not applicable to any other part of the wider project.
2. This report is not a performance-based solution assessment. It is expected that a Bushfire Consultant would utilise this report as part of a Bushfire Hazard Assessment.
3. This report does not consider property damage to the building as a result of the fire scenarios addressed in this report.
4. This report analyses a potential bushfire event, however it does not aim to investigate and quantify the probability associated with such an event.
5. Stephen Grubits & Associates have not specifically reviewed AS 3959 for applicability to the design of the subject building. It is assumed that the aforementioned standard have been agreed upon by stakeholders as representing the accepted level of safety, and that the subject building meets the requirements of these standards.

3. DESIGN DOCUMENTATION

The following drawing sets have been reviewed for the preparation of this report.

Table 1 – Design Documentation (Drawings)

Title / Description	Drawing No.	Revision	Issued By	Issued Date
Façade Elevations – Zone J	AR-2-320J	A	DesignInc	02/07/2019
Façade Elevations – Zone M	AR-2-320M	A	DesignInc	02/07/2019
Façade Elevations – Zone N	AR-2-320N	A	DesignInc	02/07/2019
Façade Elevations – Zone P	AR-2-320P	A	DesignInc	02/07/2019

[2] NSW Rural Fire Service, 2019, 'Short Fire Run – Methodology for Assessing Bush Fire Risk for Low Risk Vegetation', NSW Government.

Façade Elevations – Zone H	AR-2-321H	A	DesignInc	02/07/2019
Façade Elevations – Zone P	AR-2-322P	A	DesignInc	02/07/2019
Façade Elevations – Zone J	AR-2-320M	A	DesignInc	02/07/2019
Façade Elevations – Zone J	AR-2-320M	A	DesignInc	02/07/2019
Showing Tagged Trees at UTS Lindfield	6076-TREES	10	Usher & Company	29/07/2019
Showing Long Sections at UTS Lindfield	6076-LONGSECTIONS	5	Usher & Company	29/07/2019

4. BUILDING DESCRIPTION

4.1. GENERAL CHARACTERISTICS

Lindfield Learning Village is situated at the former University of Technology Sydney site at 100 Eton Road, Lindfield. The project consists of converting the existing university buildings to school facilities for students from Kindergarten to Year 12, as well as administration and support facility. There are three stages to the conversion and construction works, namely Stages 1, 2 and 3. This report relates to all three stages.

4.2. BCA REFERENCE CRITERIA

For the purposes of information, the following BCA criteria have been identified to be applicable to the subject building based on the BCA report by Modern Building Certifiers (BCA Design Compliance Report, dated 12th June 2019):

Table 2 – BCA Reference Criteria

Building Classification	Class 5, 7a, 7b, 9b
Rise in Storeys	Max. 6
Type of Construction	A
Effective Height	<25 m

4.3. OCCUPANT CHARACTERISTICS

Occupants within the building would comprise of students, staff and visitors. It is considered that occupants would have a range of mobility levels. Characteristics are as follows:

- Staff and students are expected to be awake and fully conscious, and familiar with the building and its layout.
- Visitors are expected to be awake and fully conscious, however they may not be familiar with the building and its layout. Visitors are likely to be accompanied by staff in the event of emergency who will be familiar with the building and its layout.

A number of teachers/staff assumed to have emergency training, including specific training on the evacuation plan for a bushfire event.

5. FIRE ENGINEERING BRIEF

5.1. GENERAL

The Fire Engineering Brief (FEB) is a documented process that defines the scope of work for the fire engineering analysis. Its purpose is to set down the basis, as agreed by all the relevant stakeholders, on which the fire engineering analysis will be undertaken. This includes agreement on the objectives, analysis methods and acceptance criteria.

5.2. PROJECT STAKEHOLDERS

The relevant stakeholders for the project are as follows:

Table 3 – Project Stakeholders

Stakeholders Role	Company
Client/Owner	NSW Department of Education
Architect	DesignInc
Bushfire Consultant	BlackAsh Bushfire Consulting
Land Surveyors	Usher & Company
Fire Brigade	Rural Fire Services NSW
Fire Safety Engineer	Stephen Grubits & Associates

5.3. FEB PROCESS

The FEB was conducted by way of the following:

1. Briefing from the client to Stephen Grubits & Associates with regards to the technical issues and client objectives relating to the subject building.
2. Meetings amongst stakeholders of the project with regards to the acceptable methodology of evaluating radiant heat exposed on the building façade – identifying parameters such as flame height and flame temperature.
3. In-house discussions between key staff at Stephen Grubits & Associates with regards to the proposed objectives.

6. METHODOLOGY

6.1. FIRE HAZARDS AND SCENARIOS

Fire hazards may be present within or outside the subject building. Fire hazards and scenarios within the building are not addressed in this report. In general, the internal fire hazards and management is to be addressed in the fire engineering design for the buildings (documented within the Fire Engineering report for the compliance with the BCA).

The fire scenario considered in this report is a bushfire from Lane Cove National Park located on the periphery of the East, South and West boundaries of the subject building. The likely flame front exposure from a bushfire has been provided by the bushfire consultant based on method outlined in AS 3959-2009 (Refer to Appendix A).

Figure 1 illustrates an example of 100 m wide and 43 m high flame front at each long section spreading towards the subject building. Eleven (11) Long Sections have been considered around the building to represent fire fronts travelling towards the building from different directions.

6.2. METHODOLOGY

This report determines the separation distance from a flame front of a bushfire to the subject building façade (as shown in Figure 1) in order to limit the received radiant heat flux to 10 kW/m^2. The topography for each long section as well as the whole school premises has been identified by the land surveyor ("6076-LONGSECTIONS-10 & 6076-TREES-5", dated 29th July 2019 by Usher & Company). The emitted radiant heat flux is based upon experimentally measured flame temperatures.

The calculation methodology adopted for the radiation assessment is as follows:

1. Establish an appropriate flame temperature gradient using literature method outlined in a publication titled "Flame temperature and residence time of fires in dry eucalypt forest" by B. Mike Wotton et al., dated 12 November 2010 (3).
2. Determine the part of the bushfire front that is not obscured by cliffs and visible from the receiver location.
3. Model the flame front as a source of radiant heat taking into account of the characteristics of the topography of the building surroundings.
4. Calculate radiant heat received by the receiving structure using the computer program *"Radiation"* from the *"Firewind* (4)*"* suite of computer programs.
5. Repeat above calculation by changing parameters such as distance and other factors affected by geometrical configuration (e.g. offsets from the centre or shielding of flame) to achieve radiant heat flux received by the topmost opening of the building façade to 10 kW/m^2.
6. Repeat above steps for different locations (for each Long Section as shown in Figure 1).
7. Tabulate calculated radiant heat received as well as the distance from the building façade to the flame front.

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(3) B. M. Wotton et al, "Flame temperature and residence time of fires in dry eucalypt forest', International Journal of Wildland Fire 2012, 21, 270-281.

(4) *Radiation – Firewind 3.6,* Fire Modelling and Computing, NSW, Australia, Version 20, May 2005

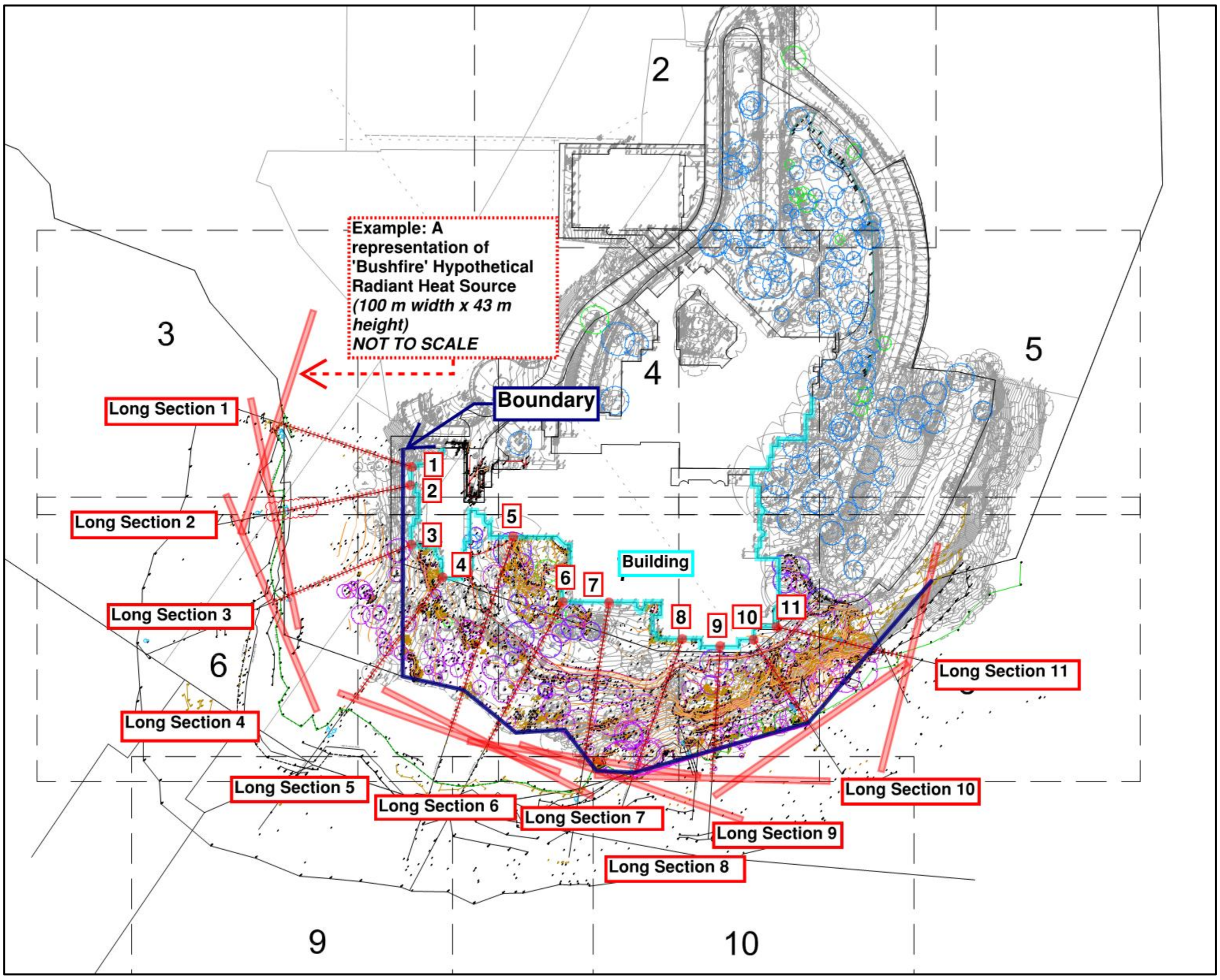

Figure 1 – Fire locations along the APZ boundary of the subject building. A bushfire (radiant heat source) at each long section is analysed.

7. BUSHFIRE RADIATION ASSESSMENT

7.1. INTRODUCTION

Bushfire radiation assessment is intended to quantitatively assess the expected radiant heat exposure from a potential bushfire to the subject building.

7.2. OBJECTIVE

The objective of this bushfire radiation assessment is to determine the radiant heat flux received on the building façade at different locations in the event of the design flame front radiation source.

7.3. ASSESSMENT METHODOLOGY

The approach used to formulate this fire engineering assessment is as follows:

Table 4 – Methodology

Assessment Method	Other verification methods accepted by appropriate authority
Type of Analysis	Quantitative, Deterministic

7.4. FIRE SCENARIOS AND DESIGN FIRES

7.4.1. Temperature of Bushfire Flame Front

A publication titled "Flame temperature and residence time of fires in dry eucalypt forest" by B. Mike Wotton et al., dated 12 November 2010, has conducted experiments to study fire behaviour of wildland fire. The study has derived an equation to predict the temperature of normalised flame height based on their experimental data:

$$T_f(H_t, H_f) = a + b * \ln\left(\frac{H_t}{H_f}\right) - [1]$$

Where, a = 334,

b = -258,

H_t = Height of thermocouple,

H_f = Flame height.

The model fit showed no strong deviation bias for distances up to a full fame length above the tip. Based on the study, the flame temperature gradient against the flame height can be predicted. The study suggests that if the observer is able to see more of the base of the flame, the observer would experience hotter temperature (~1100°C) from the base of the flame, than compared to tip of the flame (~300°C).

The literature states *"In the vertical plane, flames in freely burning wildland fires are typical turbulent diffusion flames with two visually identifiable regions. First, a region of continuous flames directly connected to the burning fuel can be visually characterised by height or length, depth and angle. Above this region are intermittent flame flashes; detached envelopes of burning gas separated from the continuous flame".* Based on the literature, it is considered reasonable to divide flames into many sections to reflect different regions of a flame body. For the purpose of modelling, 43 m flame has been divided into 11 different radiator panels vertically where each radiator panel at different height emits thermal radiation based on Equation [1] and Stefan Boltzmann Law:

$$I_E = \varepsilon * \sigma * T^4 - [2]$$

Where, I_E = Emitted Radiation,

ε = Emissivity of Flames (assumed to be 1),

σ = Stefan Boltzmann's Constant,

T = Absolute Temperature (K).

Figure 2 demonstrates a visual representation of 43 m height flame divided into 11 different radiator panels along its vertical plane. Moreover, the shielding effect by an escarpment is also visually presented in Figure 3 where some of radiator panels at the bottom are shielded by the escarpment. The radiant heat is transferred in the form of electromagnetic waves travelling in a straight line such that when radiant heat hits an escarpment (e.g. rock surface), it would block or absorb radiant heat from travelling any further until the body of mass cannot absorb further thermal energy.

The modelling of radiant heat flux onto building façade will be based on above literature and assumptions outlined.

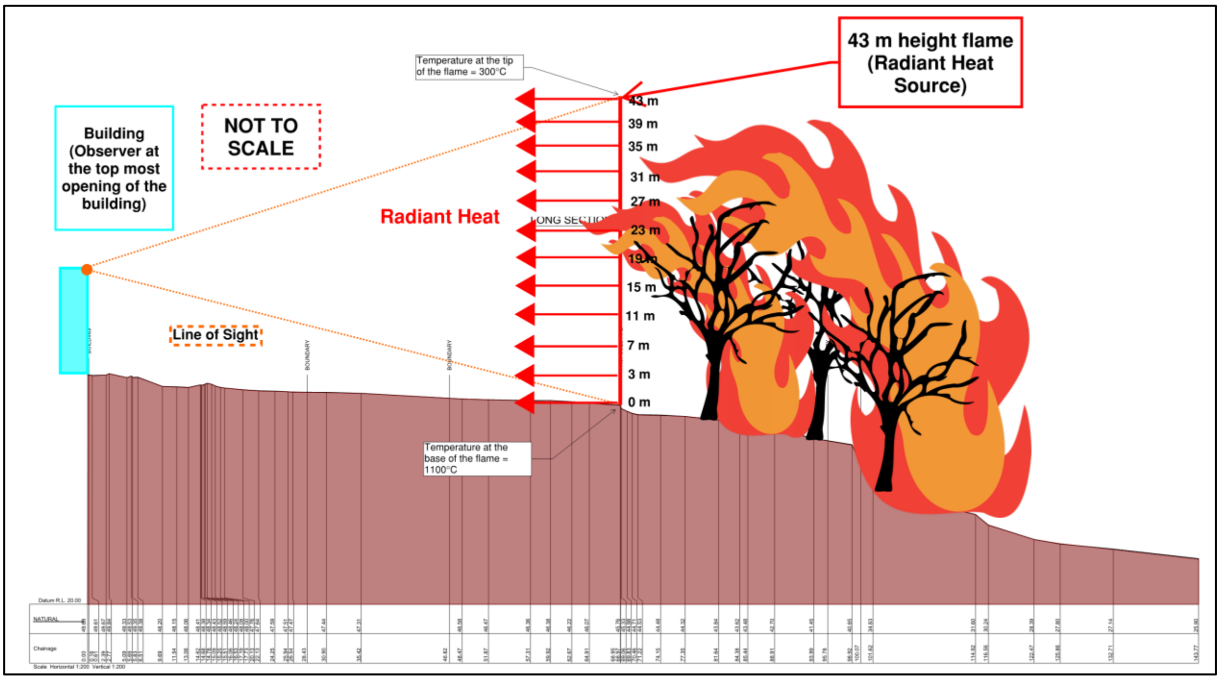

Figure 2 – Flame front in direct sight of the observer.

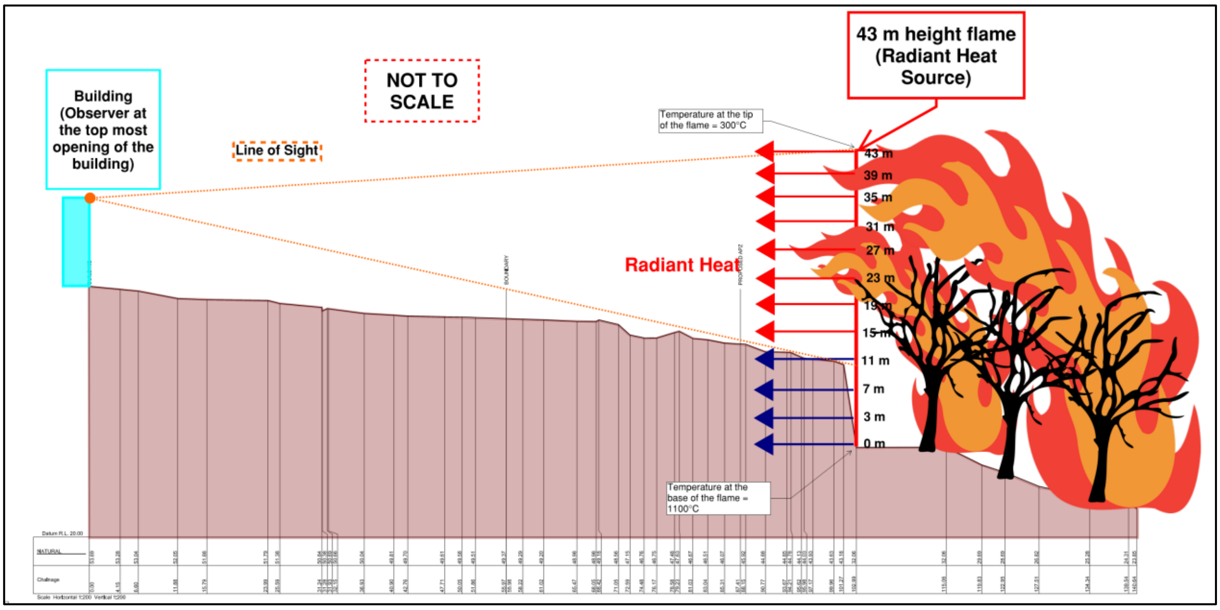

Figure 3 – Flame front shielded by the escarpment from the observer.

7.4.2. Design Fire Scenario and Fire Characteristic

The following fire scenario has been selected for this assessment:

7.4.2.1. Fire Scenario (Worst-Credible Case)

A bushfire spreading up to the APZ boundary of the subject school from the Lane Cove National Park has been considered to be the worst-credible fire scenario. For the purpose of quantifying the radiant heat flux emitted from a bushfire, width and height of flame front has been specified by the bushfire consultant to be 100 m in width and 43 m in height.

7.5. ASSESSMENT

7.5.1. Assessment for Radiant Heat Exposure

The dominant mechanisms for fire spread from a fire source to an external target in an outdoor environment is radiant heat from the flame produced by the combustion process. The flame would act as an emitter of radiant heat whilst the target receives a radiant heat flux based on the distance and geometrical configuration between the emitter and receiver. Radiant heat is transferred in the form of electromagnetic waves travelling in a straight line.

The above issue of potential fire spread by means of radiant heat between the fire source and its surrounding structure is addressed from an engineering perspective using well established computational techniques. The computer program *"Radiation"* from the *"Firewind* [5]*"* suite of computer programs has been used to calculate the radiant heat flux received by the subject building from a bushfire flame front. As shown in Figure 2, the main source of fire exposure to the building is considered to be the radiant heat from the bushfire flame front depicted by the red arrow lines. Moreover, the radiant heat that is blocked by an escarpment is depicted by the blue arrow lines as shown in Figure 3.

It has been agreed amongst relevant stakeholders to determine the separation of flame front from the building façade that is required to limit the radiant heat flux level below 10 kW/m^2. It is to be noted that 11 Long Sections have been surveyed by land surveyor to reflect the geometrical configuration (e.g. topography) of the premises (Refer to Figure 1). This information has been used to calculate the likely radiant heat flux received on the topmost openings of the building.

(5) *Radiation – Firewind 3.6,* Fire Modelling and Computing, NSW, Australia, Version 20, May 2005

7.5.2. Results

For each location (indicated as long sections), radiant heat flux received at the topmost openings of the building have been calculated with the given conditions in this report. The results are shown in Table 6 in Appendix B.

The results have also been depicted in Figure 4. The purpose of this figure is to illustrate the separation required around the subject school building to achieve acceptable radiant heat flux level of less than 10 kW/m² as agreed with relevant stakeholders. The following comments are to be noted:

a) The building façade along Long Section 5 is located further away from the bush area in comparison to Long Section 4 and Long Section 6. The calculated value for Long Section 5 gives separation of 64 m, however, if a flame front is to be placed 64 m away from the building façade along Long Section 5, it is considered that Long Section 4 would most likely receive radiant heat flux level greater than 10 kW/m². Due to the geometry of the building, it has considered necessary to interpolate points between Long Section 4 and Long Section 6 to create a relatively consistent locus around the subject school perimeter.

b) Further calculation at Long Section 9 has been requested by stakeholders to estimate the likely radiant heat flux received if the flame front were placed at the Boundary Line of the subject building, despite the radiant heat flux would exceed 10 kW/m² limit.

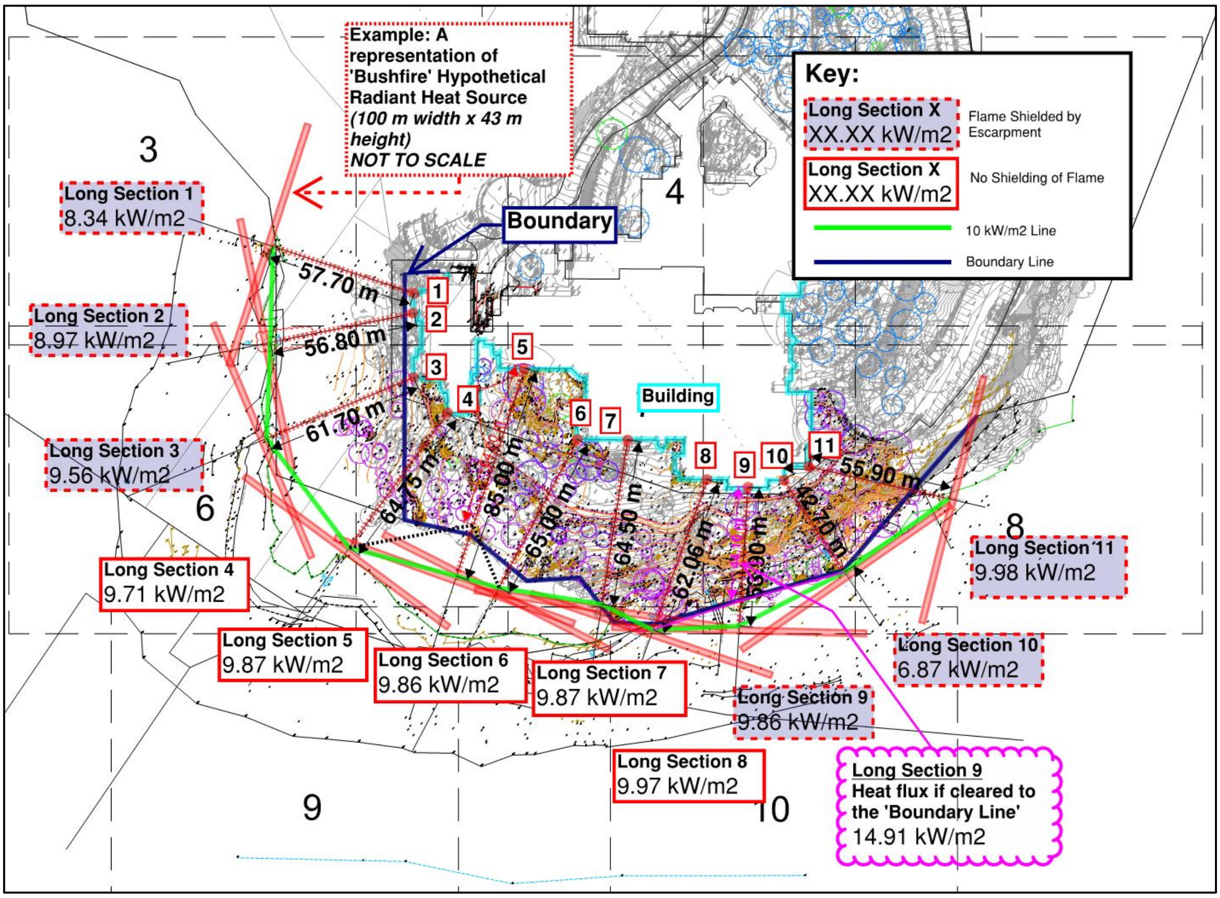

Figure 4 – Separation required to achieve 10 kW/m².

It is recommended that these results are to be used with sufficient conservatism and other considerations to form part of 'Bushfire Hazard Assessment' and to evaluate the adequate fire protection to the building façade to ensure spread of fire into the building is mitigated in the event of a bushfire.

The separation distance required from the building to the bushfire front along each of the Long Sections in order to limit the received heat flux at the building to below 10 kW/m² is tabulated in Table 5 below.

Table 5 – Required separation distance.

Long Sections	Required Separation Distance (m)
1	57.7
2	56.8
3	61.7
4	64.75
5	85
6	65
7	64.5
8	62.06
9	53.9
9* (Up to the Boundary Line)	41.7
10	42.7
11	55.9

8. SUMMARY

The radiant heat exposure of the subject school building to the radiation from a representative flame front has been assessed for the consequences of a worst-credible fire scenario.

The results of the assessment have determined the separation distance required along each Long Section in order to limit the received heat flux to 10 kW/m^2. These separation distances are intended to define the APZ in order to limit the heat flux at the building. Shielding provided by the natural terrain have been included in the assessment however shielding by vegetation has not been included. The Bushfire Hazard Assessment to be undertaken by the bushfire consultant is intended to use the outcome of this assessment to determine the fire protection that may be required to the building façade to limit the likely spread of fire into the building and to assess the impact on fire brigade operations.

It has also been determined that if the fire is permitted to approach to the boundary of the property along Long Section 9, then the radiant heat intensity to be received at the building is increased to 14.9 kW/m^2.

9. REFERENCES

AS3959-2009 – Construction of buildings in bushfire-prone areas.

B. M. Wotton et al, "Flame temperature and residence time of fires in dry eucalypt forest', International Journal of Wildland Fire 2012, 21, 270-281

National Construction Code Series, Volume 1 Amendment 1, Building Code of Australia 2016, Australian Building Codes Board.

APPENDIX A. FLAME LENGTH CALCULATION BY BUSHFIRE CONSULTANT

Bushfire Attack Level calculator - AS3959-2009 (Method 2)			
Inputs		Outputs	
Fire Danger Index	100	Rate of spread	5.98 km/h
Vegetation classification	Forest	Flame length	43.07 m
Surface fuel load	25 t/ha	Flame angle	52 °
Overall fuel load	35 t/ha	Panel height	33.94 m
Vegetation height	n/a	Elevation of receiver	11.68 m
Effective slope	10 °	Fire intensity	108,159 kW/m
Site slope	10 °	Transmissivity	0.848
Distance to vegetation	30 m	Viewfactor	0.6462
Flame width	100 m	Radiant heat flux	61.26 kW/m²
Windspeed	n/a	Bushfire Attack Level	BAL-FZ
Heat of combustion	18,600 kJ/kg		
Flame temperature	1,200 K		

Rate of Spread - Mcarthur, 1973 & Noble et al., 1980

Flame length - NSW Rural Fire Service, 2001 & Noble et al., 1980

Elevation of receiver - Douglas & Tan, 2005

Flame angle - Douglas & Tan, 2005

Radiant heat flux - Drysdale, 1999, Sullivan et al., 2003, Douglas & Tan, 2005

APPENDIX B. RADIANT HEAT CALCULATION

Table 6 – Summary of result of radiant heat calculation received on the subject school building façade from 3 m safety zone.

Long Sections	Height of Observer (m)	Flame Height (m) [Taking into consideration of the escarpment]	Width of Radiant Heat Source (m)	Distance from Heat Source (m)	Radiant Heat Flux Received by the Observer (kW/m2)
1	17.01	41	100	57.7	8.344
2	17.01	41.4	100	56.8	8.973
3	17.01	42.4	100	61.7	9.557
4	17.37	43	100	64.75	9.707
5	16.1	43	100	64	9.866
5* (Interpolated)				85	< 10 kW/m^2
6	12.12	43	100	65	9.857
7	12.07	43	100	64.5	9.867
8	16.07	43	100	62.06	9.971
9	16.07	41.7	100	53.9	9.856
9** (Up to the Boundary Line)	16.07	43	100	41.7	14.91
10	16.07	35.4	100	42.7	6.867
11	16.07	42.1	100	55.9	9.98

Note:

* - this point has been interpolated to create a consistent locus around the school perimeter.

** - further calculation has been requested by stakeholders to represent the likely radiant heat received at the Boundary Line on Long Section 9.