REPORT ON – "BUSHFIRE BEHAVIOUR AND HOUSE DAMAGE AND DESTRUCTION DURING THE PARKERVILLE. MT HELENA & STONEVILLE BUSHFIRE ON THE 12 JANUARY 2014"

ENVIRONMENTAL PROTECTION BRANCH

AUTHOR: RALPH SMITH

CONTRIBUTING STAFF: JACKSON PARKER, GARY CHONEY, JEFF MOSS, JODIE LIA

EMERGENCY SERVICES COMPLEX
20 STOCKTON BEND
COCKBURN CENTRAL, WA

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1. Executive Summary

This report is based on the post-event survey of the damage, destruction or non-damage that occurred to houses within the fire-affected area and an adjacent area. The surveys were undertaken by the DFES Environmental Protection Branch (EPB) staff. The survey only considered houses and attachments to the house, such as carports and patios (items that are covered by 'Australian Standard 3959 Construction of buildings in bushfire-prone areas') in its assessment. It is acknowledged that 'Australian Standard 3959 Construction of buildings in bushfire-prone areas' did not apply in this area as it was not formally declared as being bushfire prone (and therefore had no legal status as being bushfire prone), but this Standard was the most appropriate reference tool with which to assess the houses as it specifically relates to construction standards and distance from vegetation associated with bushfires. During the post fire assessments and interviews it became apparent that there are some variations between the results of the DFES Urban Search and Rescue (USAR) staff assessments conducted during the fire and the EPB assessments conducted after the fire. This is principally due to building classification variations and to the fact that some homes from the outside appeared to have suffered no obvious damage but were later found to be uninhabitable as a consequence of internal fire damage. There also appears to be a significant number of houses saved by the intervention of firefighters or community members.

Within the survey area there were a total of 48 homes destroyed, seven homes damaged and 25 that suffered no damage.

The bushfire ran through a limited range of vegetation types and land tenures, but primarily through developed private property. There were very few tracks in the bushland areas from which to conduct fire suppression operations. The fuels were basically *Eucalypt* open forest with a scrub, leaf litter and patches of grass. At the time of the fire the fine fuels were reasonably homogenous in nature in that they had a consistent type and structure of fuel. The Bureau of Meteorology (BoM) registered user's webpage showed that the drought factor was 10. The Keetch-Byram Drought Index (KBDI) for Bickley was very close to 160 and Mundaring's was also around 160 – out of a possible total of 200. The KBDI was close to the highest it had been in the last five years and well above the five year average.

The fire started close to and ran through a range of vegetation types, structures and period since last burnt since last burnt, which are primarily a jarrah (*Eucalyptus marginata*) and marri (*Corymbia callophylla*) overstorey with scrub and leaf surface fuels. As the fire progressed through subdivisions, the firefighters had to manage saving lives and property as well as suppressing the fire and minimising the impact on the environment. The fuel load was estimated to average at 15 tonne per hectare (t/ha) with a maximum fuel load estimated at 20 t/ha. These estimates were made from the unburnt pockets within the fire using standard bushfire fuel estimation techniques.

None of the subdivisions affected by this fire had been formally declared as being within a bushfire prone area. There appears to be a correlation between home loss and damage, and to the direction of the head fire. Homes downwind and directly in

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line with the severest section of the head fire appear to have been the ones which suffered the most damage or destruction. Those on the edge of the headfire or primary shoulder of the flank do not appear to have experienced the same impact as houses directly downwind of the fire.

There were homes destroyed or damaged from the fire on the direct interface. Conversely there were homes in this area that suffered no damage. There were also homes destroyed as a direct consequence of the ember attack onto the homes. Generally these homes were older style construction standards, certainly built prior to the current construction standards that would be applied today if the area was declared as bushfire prone. For the homes within the forest/urban interface, the building protection zone (BPZ) and hazard separation zone (HSZ) generally was not to the prescribed fuel levels of 2 t/ha and 5–8 t/ha respectively.

2. Objectives of the study (scope of work)

- To analyse the impact or non-impact of the "Parkerville" fire on homes in the fire area.
- To analyse the fire behaviour, particularly the rate of spread, including the fire direction and intensity.

3. Environmental conditions

The KBDI is an effective tool to indicate the availability of the heavier fuel material that applies as it is utilised across Australia by most fire agencies which facilitates comparisons of bulk fuel dryness and community impacts. At the time of the fire, environmental conditions were at 160 units on the KBDI, which was approximately 20 units above the five year average.This is clearly indicated with the two KBDI graphs for Bickley (Figure 5) and Pearce RAAF (Figure 6).

At the time of the fire the drought factor was 10 at both sites. This effectively indicates that 100% of the forest and woodland fine fuel, the dead fuel less than 6mm diameter and live fuel less than 3mm diameter, was available for the fire to consume. The grass was also 100% cured and therefore it too was also available to burn.

The weather conditions were warm, dry and relatively windy. Table 1 indicates the hourly fire behaviour (determined post-fire by the Bureau of Meteorology). Linked to the total fuel load, which was all available, strong winds with the wind gusts, slopes and houses built amongst the trees with limited access, made bushfire fighting very difficult.

The construction standard of the houses, the absence or presence of effective building protection zones and hazard separation zones, the high fuel load and vegetation structure in the landscape zone were also contributing factors to the impact of the fire on the community assets.

4. Bushfire Behaviour

Weather data supplied post hoc by the Bureau of Meteorology (BoM) for the Parkerville fire has been used during the development of this analysis. This may result in a variation between the fire spread modeling developed during the running fire and this summary.

As there is very little actual fuel load data available for the area in which the fire ran, a default forest fuel load of 15 t/ha has been applied. The drought factor (re-named by BoM to the Forest fuel dryness factor) of 10 has been applied. This equates to the whole of the fine fuel, that is, less than 6mm diameter for dead fuel and less than 3 mm for live fuel, being available. The heat yield from the burning vegetation was deemed to be the standard 18,600kJ/kg.

Using the Forest Fire Danger Meter Mk5 for the determination of the head fire rate of spread and the standard methodology for fireline intensities, the following has been determined:
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Table 1: Hourly weather and estimated fire behaviour from post fire BoM data

Time	Head fire rate of spread (m/hr)	Fire line intensity (kW/m)
1100	758	5710
1200	731	5506
1300	844	6358
1400	855	6441
1500	625	4708
1600	597	4497
1700	475	3578
1800	439	3307
1900	328	2471
2000	174	1311
2100	122	919
2200	83	625
2300	57	429
2400	58	437

The fire line intensities indicate that the head fire could not be directly attacked with any certainty of success until after 20:00 hours, when the head fire intensity dropped below 2,000kW/m. At a head fire intensity of less than 2,000 kW/m direct machine and tanker attack is possible. At less than 800kW/m hand tool attack is possible on the head fire.[1]

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[1] Ralph Smith, 2013, "Fire behaviour formulas. A guide for bushfire managers", Environmental Protection Branch DFES, Cockburn Central

Figure 1: Crown defoliation as an indicator of fire behaviour.

There is a relationship between the bushfire behaviour, flame length, scorch height and defoliation of the trees and scrub. As can be seen in the above photograph, there are areas of defoliation in the 10 metre to 15 metre high trees. The white ash on the ground further confirms a hot fire ran through the area.

The following simulations have been derived from the Aurora System, using the UWA Australis simulator and applying the forecast weather, fuel load and vegetation type within the system. The rate of spread and fire line intensity will change as the fire moves through different vegetation types and different fuel loads.

261576 - Parkerville 11:00hrs
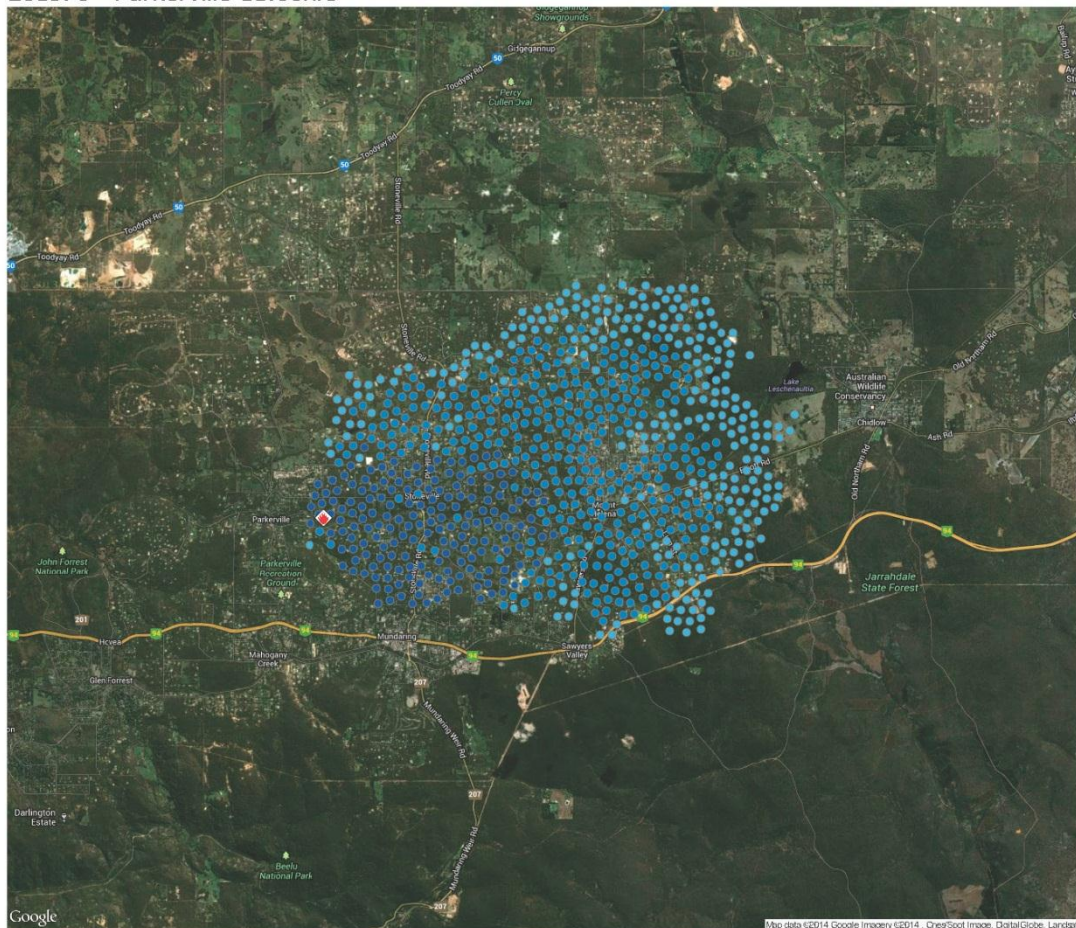
Ignition Sources (Points)
Ignition Sources (Lines)
Firebreaks
Fuel Adjustments
Fire Spread – 0 to 4 hours
Fire Spread – 4 to 8 hours
Fire Spread – 8 to 12 hours
Fire Spread – 12 to 16 hours
Fire Spread – 16 to 20 hours
Fire Spread – 20 to 24 hours

Bounds
116.072895,-31.932964, 116.321289,-31.808612
Notes
12hr Aurora Simulation from point ignition source located at the intersection of Johnston and Granite Roads Parkerville. Simulation details: commencing at 11:00hrs to 23:00hrs on Sunday the 12th of January 2014 using BOM forecast weather.

Created 13/01/2014 18:40:34

http://aurora.landgate.wa.gov.au/?qr&HAab

Figure 2: The Aurora (Australis) fire prediction at 11.00 hours.

In the Aurora (Australis) fire prediction figures, the darker the blue circle the shorter duration of the simulation e.g. dark blue is for the first 4 hours. The resolution of the circles is at 1000 metres. The red symbol is the ignition point of the fire. In subsequent figures the red symbols will indicate the location of the fire and the simulation is undertaken from that boundary.

The Aurora (Australis) fire prediction figures are assessed against other fire spread models and systems to ensure that the figures are as accurate as possible within the constraints of the fire spread models, weather data and fuel load information.

The BoM weather stations are some distance from the fire and therefore may contain some inaccuracies that could be avoided with automatic weather stations placed closer to the fire. This may also enhance the existing and effective BoM spot forecasts.

Table 2: Aurora (Australis) simulation developed at 1100 hours.

Hour	Rate of Spread (m/hr)	Intensity (kW/m)
1	1353	5133
2	1073	3873
3	1310	2425
4	1324	2678
5	1222	3173
6	1378	2314
7	1017	2147
8	807	2225
9 (20:00 hrs)	686	1792
10	418	1377
11	318	986
12	248	1003

The information contained within Table 2 and developed at 11:00 hours supports the prediction that the head fire intensity would be less than 2,000kW/m by around 20:00 hours. At less than 2,000 kW/m fire line intensity, "direct attack tanker attack possible". At 21:00 hours the forecast head fire rate of spread was predicted to be around 400 m/hr, which provided two estimates that successful running fire suppression was possible by mid-evening. This was a reasonably accurate estimation of the events as they occurred.

Figure 3: The Aurora (Australis) fire prediction at 15:00 hours.

Table 3: Aurora (Australis) simulation developed at 15:00 hours.

Hour	Rate of Spread (m/hr)	Intensity (kW/m)
1	900	2221
2	1098	2900
3 (18:00 hrs)	983	1838
4	843	1888
5	651	1314
6	485	1202
7 (21:00 hrs)	367	762
8	230	681
9	221	505
10	142	348
11	220	223
12	181	224

The information contained within Table 3 and developed at 15:00 hours supports the prediction that the head fire intensity would be less than 2,000kW/m by around 18:00 hours. At less than 2,000 kW/m fire line intensity, "direct attack tanker attack possible."

The actual running fire suppression occurred later in the evening, around mid-evening. With the running fire suppression occurring several hours after 18:00 hours assists in confirming that the head fire line intensity calculations are reasonably accurate and within the published parameters.

Figure 4: The Aurora (Australis) fire prediction at 16:30 hours.

Table 4: Aurora (Australis) simulation developed at 16:00 hours.

Hour	Rate of Spread (m/hr)	Intensity (kW/m)
1	966	2086
2	1149	2296
3	808	2021
4	549	2658
5 (21:00 hrs)	512	1673
6 (22:00 hrs)	396	774
7	237	987
8	237	332
9	278	249
10	198	313
11	226	57
12	166	254

Table 5: Aurora (Australis) simulation developed at 16:30 hours.

Hour	Rate of Spread (m/hr)	Intensity (kW/m)
1	480	1487
2	941	1856
3	503	1848
4	406	1210
5	373	1166
6	370	857
7	312	467
8	310	322
9	189	295
10	213	190
11	195	208
12	132	33

The information contained within Table 4 and developed at 16:00 hours, and Table 5 developed at 16:30 hours which aligns to the simulation, support the prediction that the head fire intensity would be less than 2,000kW/m by around 21:00 hours. At less than 2,000 kW/m fire line intensity, "direct attack tanker attack possible". At 22:00 hours the forecast head fire rate of spread was predicted to be less than 400 m/hr.

One of the significant issues associated with the rate of spread and head fire intensity models is the absence of accurate fuel loads in most areas that this bushfire ran. The rate of spread and head fire intensity determinations are based on field estimations of unburnt pockets and data contained within the DFES data base, but there are significant accurate data gaps particularly on private land.
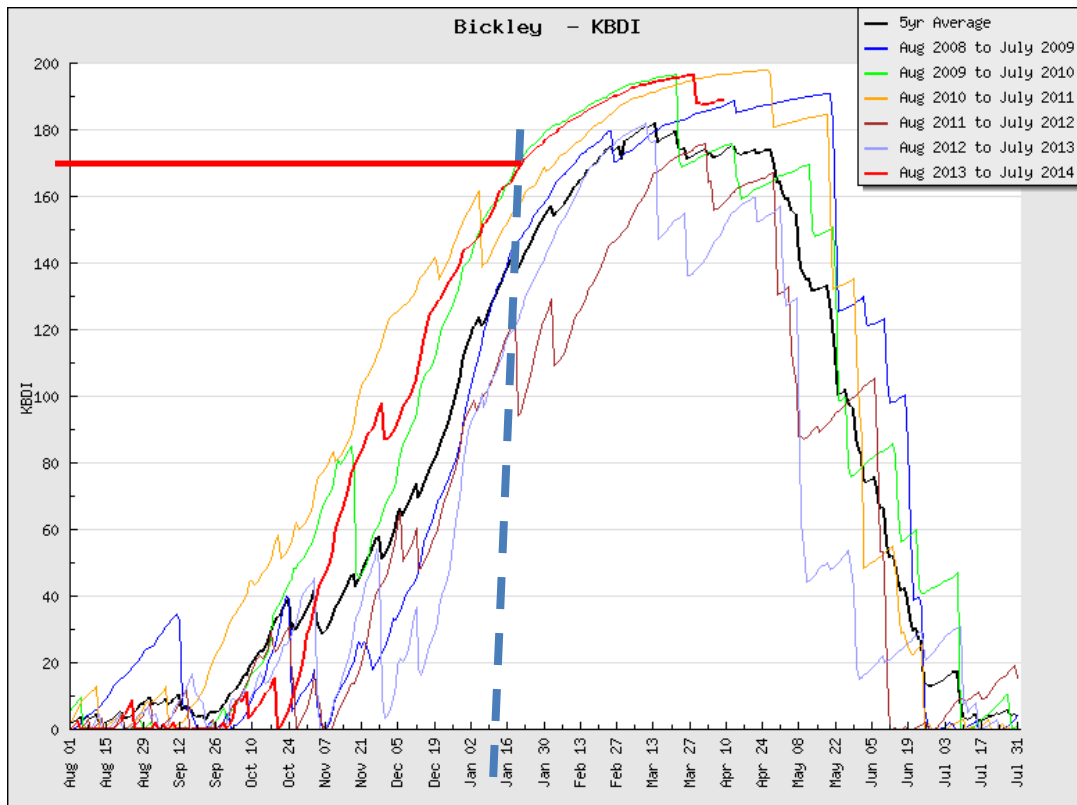
Figure 5: KBDI graph for Bickley.

As can be seen in the Keetch-Byram Drought Index (KBDI) graphs, at the time of the fire the graphs were well above the five year average, and in most cases very close to exceeding the KBDI for the last five years.

The Keetch-Byram Drought Index (KBDI) is a measure of the moisture content of the upper soil and the covering layer of duff, and is an important indicator for the successful fire suppression in bushland areas. The impact of the drought's effect is not solely confined to deep organic soils, but also includes the dried-out organic materials that are frequently imbedded in the shallow upper layers of mineral soils.

During extreme drought conditions the moisture content of the living material, in the scrub, and tree crowns may be reduced. This lowered moisture content may allow the fire to crown more readily and some of the woody vegetation may die.

Effectively the drought index is a guide to the flammability of organic material in the ground. For fire management a useful concept of drought is one that treats drought as a continuous quantity which can be described in numerical terms. The values range from zero, when the soil and duff layer is saturated with water, through to 200.

The significance to fire managers of the drought index changes depends on the type and structure of the fuel. In the light fuel areas, the drought index may be important when in the upper half of the scale. That is above 100. This importance may be

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significant in incidence of crown fires or with the development of grassland curing. [2]

At the time of the fire it is highly probable that the perennial scrub was under drought conditions with moisture content in the leaves at very low moisture levels. As a consequence of this reduced moisture content, the flammability of the fuels was at a very high level. The flammability level indicates that the fuel ignited easily, the fuel burnt well (combustibility) and the fire was sustainable. Most perennial scrub plants were impacted by the fire by either being fully consumed i.e. being defoliated or by suffering significant amounts of leaf and fine matter being consumed and the remainder scorched.

The following KBDI graphs for the surrounding areas of Mundaring, Bickley and Pearce further reinforce that the KBDI was extremely high, and fire suppression extremely difficult with the whole of the leaf litter (surface fuels) and low scrub layer being less than one metre tall (near surface fuels) being available to be consumed by the fire.

Using the BoM spot forecast, the fine fuel moisture content for the forest fuels and grassland was estimated to be 4% and 3% respectively. These conditions align closely to the criteria described by Burrows as being 'blow-up fire' conditions. The fine fuel moisture content is low, less than 6%, the KBDI is greater than 120 and the relative humidity was less than 30% until 2100 hours.[3]
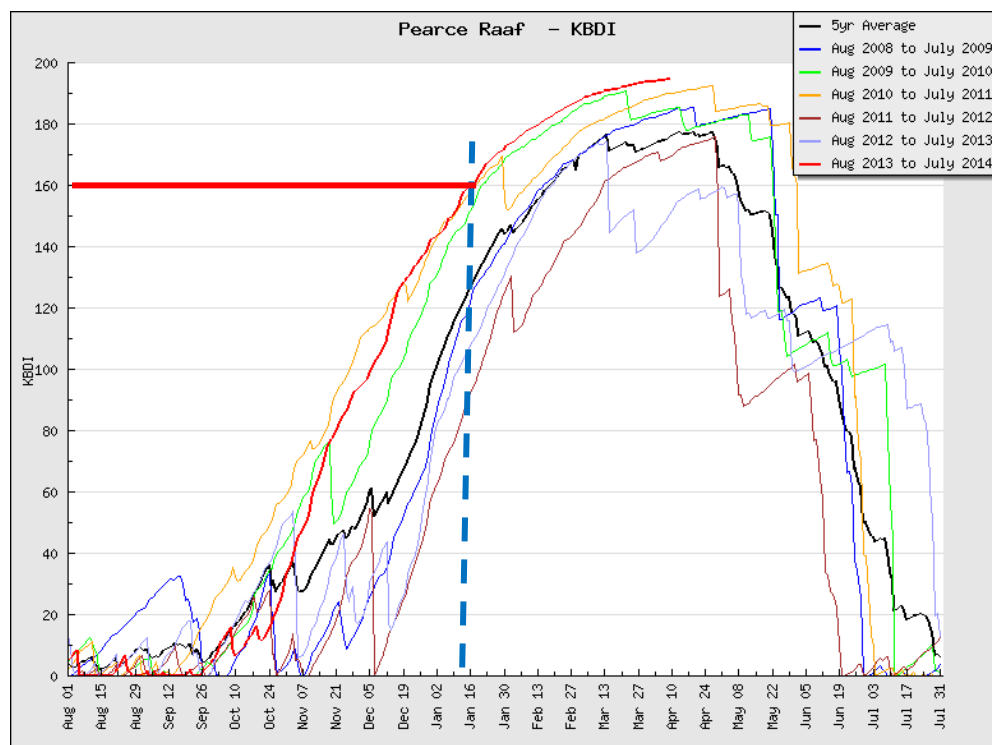

Figure 6: KBDI graph for Pearce RAAF AWS.

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[2] BF & EP Branch, 2009, 'What is the Keetch-Byram Drought Index (KBDI)', Technical Info Note, FESA, Perth.

[3] N.D. Burrows, 1984, 'Predicting blow-up fires in the jarrah forest.,' Technical Paper No12, Forests Department, WA.
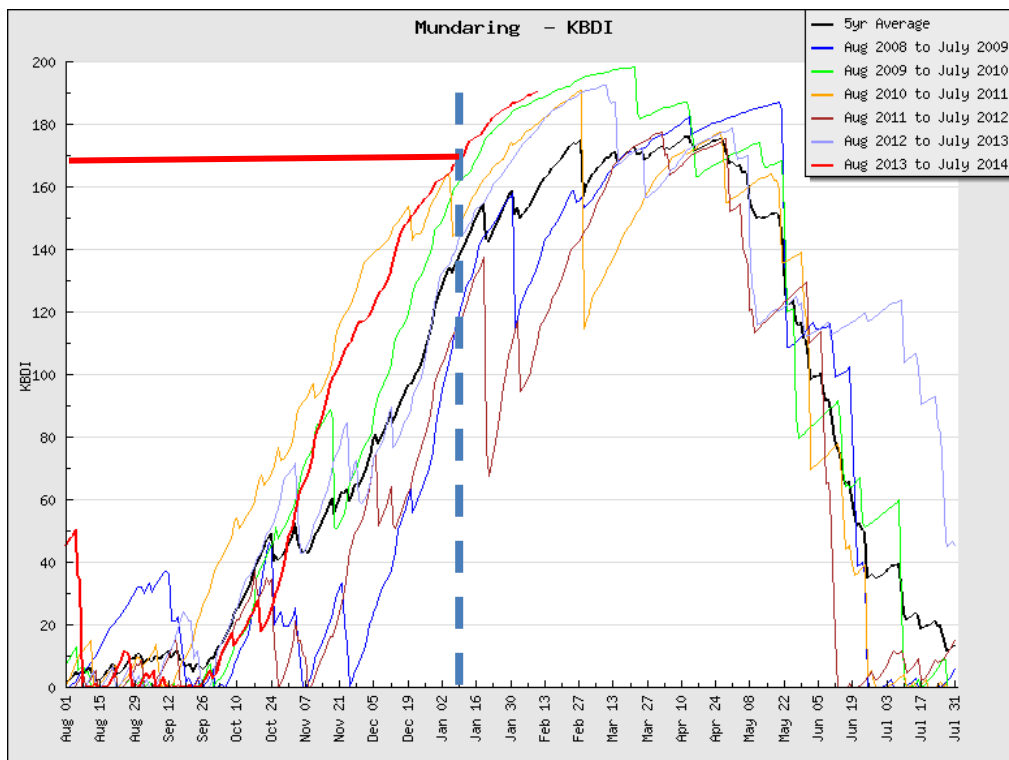
Figure 7: KBDI graph for Mundaring.

Building Protection Zone (BPZ)

The BPZ is defined as the first 20 metres out from the home. Within the BPZ, DFES prescribes a range of considerations for the vegetation. In general the aim of the building protection zone is to ensure that there will be no direct flame contact on the building from a bushfire. By utilising the fuel management options it is also possible to reduce the potential radiant heat or direct flame contact, and therefore reduce the impact on the building. DFES advocates maintaining an available fuel load of 2 t/ha. This figure is chosen as, in most instances where a fire is burning in a forest fuel load of 2 t/ha or less, the fire front intensity will be in the range that it is easily suppressed with water–that is less than 800 kW/m.

By managing the fuel load and the structure of the vegetation, including pruning the fine, dead aerated material in the shrub crowns and the density of shrubs, it is possible to minimise the direct flame contact and radiant heat attack on the building. Whilst also simultaneously making it possible for the fire to be suppressed with nothing more than a competent, active person (appropriately dressed) equipped with a water hose.

The vegetation structure recommended is:
- Maintain a minimum 2 metre gap between trees and the building. Have no trees overhanging the house.

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- Keep the grass short and prune the scrub so that it is not dense, nor does it have fine, dead aerated material in the crown of the scrub.
- Rake up leaf litter and twigs under trees and remove trailing bark.
- Prune lower branches (up to 2 metres off the ground) to stop a surface fire spreading to the canopy of the trees.
- Create a mineral earth firebreak.
- Do not clump shrubs or trees; ensure that there is a gap.
- Have your paths adjacent to the building and driveway placed so that it maximises the protection to the house.
- Keep firewood away from the building.
- Ensure fences that are combustible will not burn down and compromise the integrity of the building by breaking windows.
- Keep gutters free of leaves and other combustible material.
- Ensure that gas bottles will vent away from the building if it is subject to flame contact or radiant heat.

There were 48 homes that were destroyed with tall vegetation within 20 metres (most were within 8 metres) of the home. There were also 25 homes damaged to varying degrees within the BPZ and tall vegetation. Therefore there were 73 homes damaged or destroyed with a fuel load or fuel structure that was not within the criteria advocated by DFES.
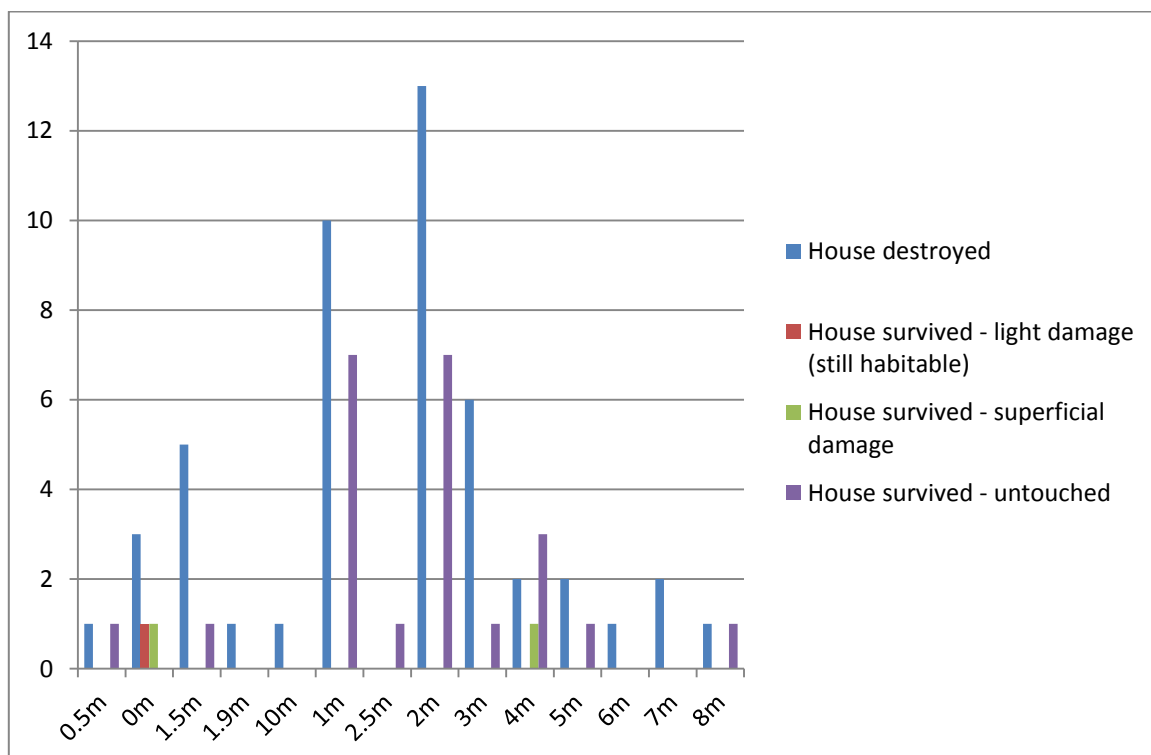

Figure 8: Vegetation distance from the house.

There were 17 homes that were destroyed with tree crowns overhanging the house. There were also 2 homes that suffered a range of damage, from heavy damage to superficial damage, that had a tree overhanging the house. One home had a tree overhanging it and suffered no damage.
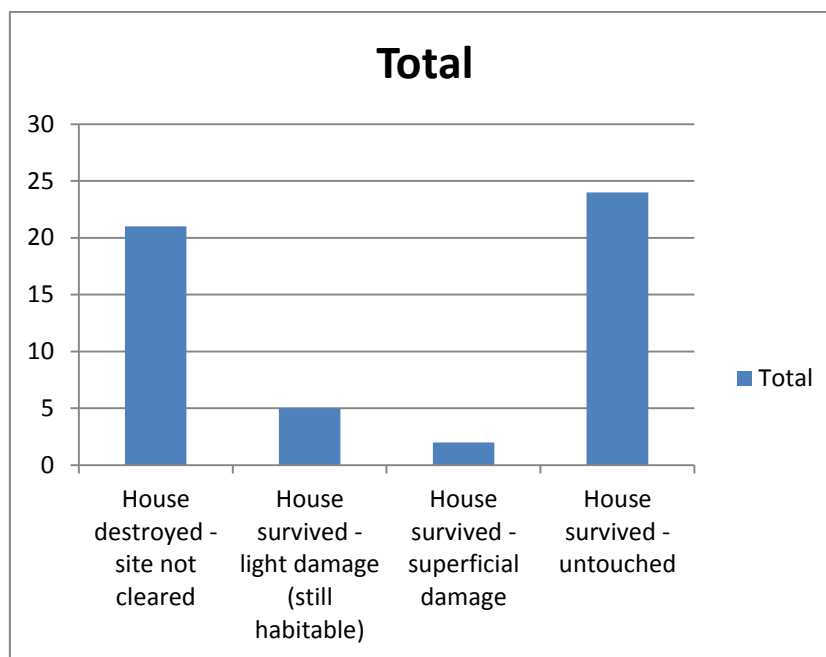
Figure 9: Trees overhanging.

Trees overhanging a house make a significant contribution to the potential damage or destruction of the house. Where a stringy barked tree has limbs overhanging the house, it drops embers from that crown onto the roof of the house. If there are gaps in the roof then these embers can be blown into the roof space and cause damage or destroy the house. Low intensity fires, including backing fires, can cause significant damage through this process.
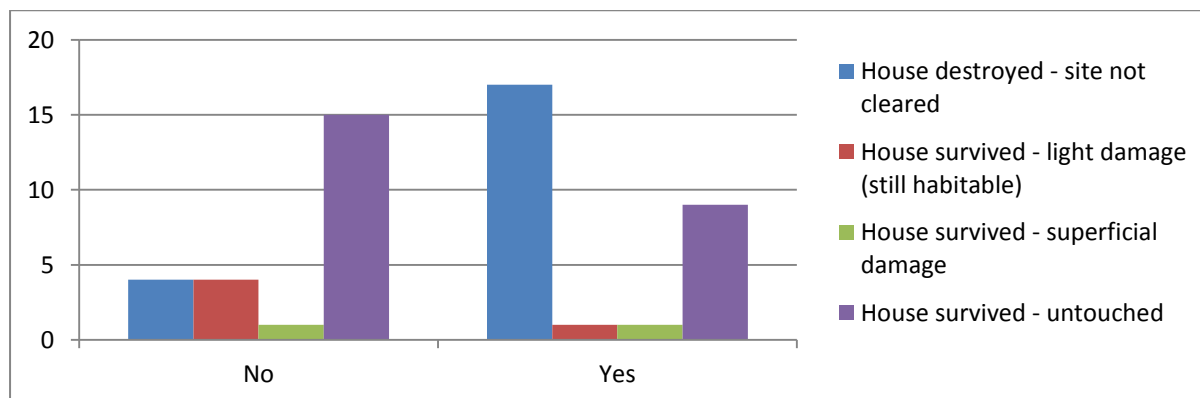

Figure 10: Tree crowns less than 10-15 metres apart

The available fuel load is significant to the level of damage that occurs when a fire runs through a development site. 32 homes had greater than the prescribed 2 t/ha in the BPZ and the houses were destroyed. There were 15 homes with a fuel load less than 2 t/ha that were also destroyed.
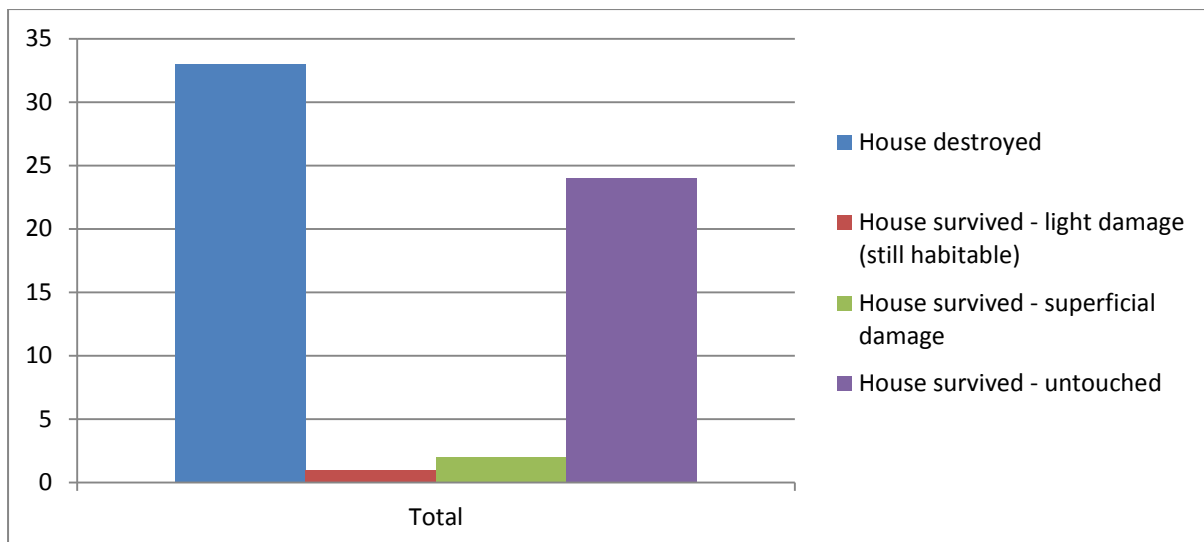
Figure 11: More than 2 t/ha in the BPZ

Most of the homes that suffered direct flame contact or radiant heat damage as a consequence of the bushfire did so because the BPZ was not appropriate. The hazard separation zone was also not at the prescribed level for a number of locations. If the BPZ is 20 metres deep and contains 2 t/ha the bushfire attack level (BAL) would be 2.3 kW/m² (at 20 metres from the building) rising to 10kW/m² at 5 metres from the building. For the same BPZ depth but with an increase of fuel load to 15 t/ha, it would increase the bushfire attack level to 17 kW/m² (at 20 metres from the building).
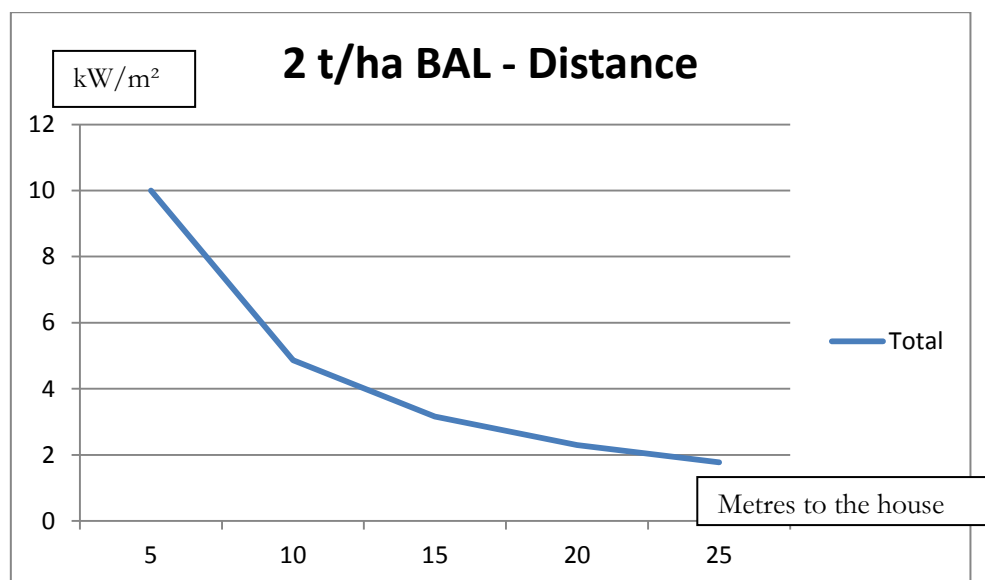

Figure 12: Relationship between BAL and the distance to the house with a 2 t/ha fuel load.

A fairly common theme in regard to the house destruction and damage is that a significant number of homes did not have an appropriate BPZ as prescribed by DFES; these homes suffered damage or destruction.

The distance between the house and the vegetation, and the amount of vegetation were significant contributors as to whether the house was destroyed, damaged or

suffered no damage. In a number of cases, as a consequence of the plant location, the bushfire caused direct flame contact onto the home.

The potential impact of a bushfire on a home is determined by the construction standard, and the quantity and placement of vegetation close to the house. Even with the intervention of the firefighters, the potential impact on the homes in the interface zone was significant. This impact ranged from melting damage to the seals around windows and air vents, through to the cracked and broken cement sheeting.

The impact of the flame and heat induced from the burning vegetation can have subsequent impact on cement sheeting, causing it to break and expose the lining of the house. This gap then creates an opening for embers, radiant heat or direct flame contact to enter the home and ignite any suitable fuels. The cracking and breaking of narrow cement sheets appears to have been a fairly consistent outcome when these products were exposed to reasonable levels of radiant heat or direct flame contact, particularly when they were not lined. Most of the cement sheets were less than 6mm thick.

Figure 13 clearly demonstrate the failure of the cellulose cement wall to withstand the fire. During the analysis care was taken to ensure that the fire travel indicators confirmed that the fire had entered the house from the outside and not from fire within the building. The walls were sarked and it appears that sarking in some instances may not make cellulose cement walls suitable as a construction material where the building will be subject to reasonable level of radiant heat or direct flame contact.

Figure 13: Broken cement sheets.

There were virtually no fences (non-combustible or combustible) or barriers to prevent the radiant heat or direct flame contact impacting directly onto the home in the areas where the vegetation was too close or too heavy. The fuel load was partially managed, with some owner intervention immediately adjacent to some of the dwellings, but generally diminished further out from the dwelling. This type of fuel load management (or lack of it) in many areas of the fire-affected location was fairly consistent and not uniformly applied to the level as recommended by DFES.

Figure 14: Demonstrating the absence of fire restricting fence lines.

There were many homes that survived the fire unscathed or with minimal damage as a direct result of firefighter and/or occupier intervention, and the level of construction standard, such as boxed eaves. This general construction standard and construction era was different to that at the Margaret River and Roleystone/Kelmscott fires, but still not to the required level described in AS 3959.

Figure 15: A house that was saved by firefighter intervention.

The management of the bushfire attack level onto a house is critical in the survivability of that house. The fuel load and structure in the BPZ was virtually continuous and at a level that posed a significant risk to the survivability of the houses. Across the fire zone the fuel loads were generally excessive for the level of construction standard for the houses. These fuel loads (and subsequent fire intensities) directly affected the ability of the firefighters to suppress the fire.

Tree crowns are critical in determining the leaf litter fuel accumulation rate. Heavily stocked locations will produce large amounts of leaf litter, in the vicinity of 1.8 tonne per hectare per annum for a 60% crown overstorey cover. Sparsely spaced trees will produce litter fuel accumulation rates of around 0.8 tonne per hectare per annum[4]. The other component of the fuel load is the scrub fuels. The fuel load is determined as an oven dried weight, and fine fuel is defined as less than 6 mm diameter dead material and less than 3mm live material.

[4] Sneeuwjagt & Peet, 2001, "Forest fire behaviour tables for Western Australia", CALM, Perth.

Figure 16: This is the view of the BPZ and HSZ from near to a house.

Figure 17: This is the view of the BPZ from near to the house.

The house in figure 17 was destroyed and, as can be seen, there is significant vegetation within the BPZ. The HSZ also contained a very high fuel load that was continuous to the house.

Figure 18: Ember impact onto shade cloth.

Figure 19: The effect of embers falling onto green grass.

Figure 20: Embers entering into a roof structure.

Another interesting output of the assessment has been the fire direction and the impact on houses. Many of the houses directly in line with the run of the head fire have been destroyed either through direct flame contact, radiant heat or embers. The head fire did not run consistently in one direction but rather there are areas where there is significant variation in head fire direction. The head fire direction was determined post fire, using standard burn indicators on vegetation and non-combustibles. The arrows on appendix 1 demonstrate the head fire direction and the red house symbols indicate the houses destroyed by the fire. There are a number of anomaly head fire directions.

Construction standards

The following is an assessment of the house construction standards, considering the materials and then the vegetation within the building protection zone (BPZ), which is the closest 20 metres to the house. These components are critical in determining a house's potential survivability when attacked by a bushfire.

The house roof construction materials in the houses that were destroyed appear to be dominated by corrugated iron. As can be seen in the figure 23, houses constructed using tiles and corrugated iron were basically equally affected by the fire or not affected. The survey data includes houses that were not in the fire zone and the houses surveyed that survived untouched may have been outside the fire zone. The houses destroyed without sarking in both corrugated iron and tiles are very similar. It is highly probable that the houses in general regardless of whether they were constructed with either corrugated iron or tiles did not have sarked roofs.

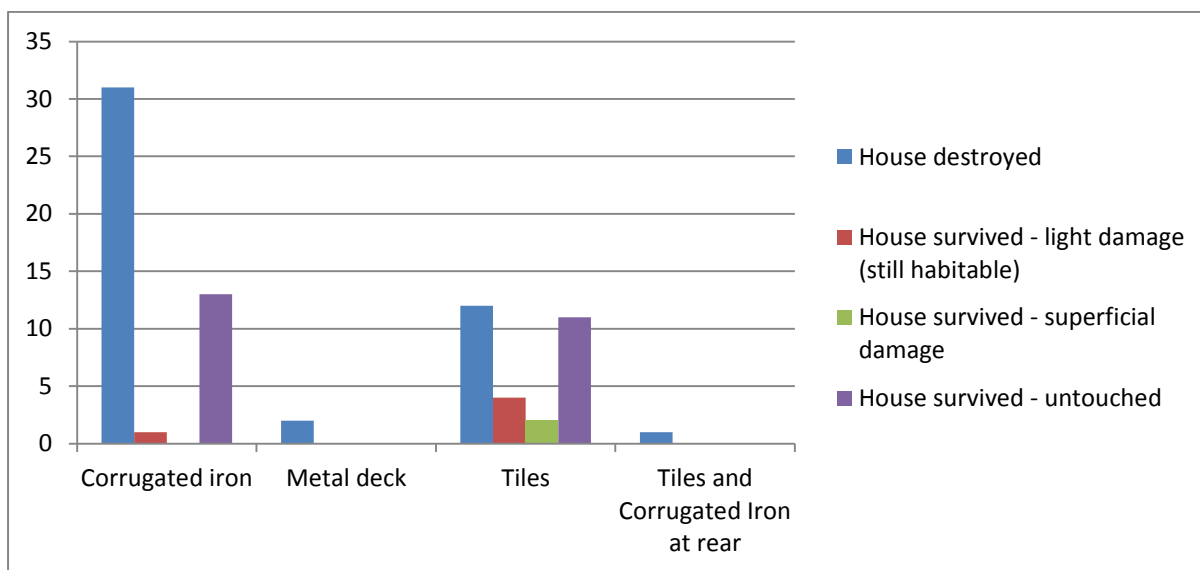Figure 21: Indicative ember attack level.

Figure 22: Roof construction material.

Australian Standard 3959 – Construction of buildings in bushfire-prone areas, identifies that houses that will potentially be attacked from embers should have sarking applied to the roof to prevent embers entering the roof space. Most houses destroyed by this fire did not have the ember protection sarking in place. By not having sarking it is possible for embers to be carried into the roof space; fires in this space may take some time to ignite and be visible from the outside. The construction standard for tiled roofs requires that virtually no gaps remain post construction. As time progresses, it appears that the gap proofing of the houses is diminishing, or was not present at the time of construction.
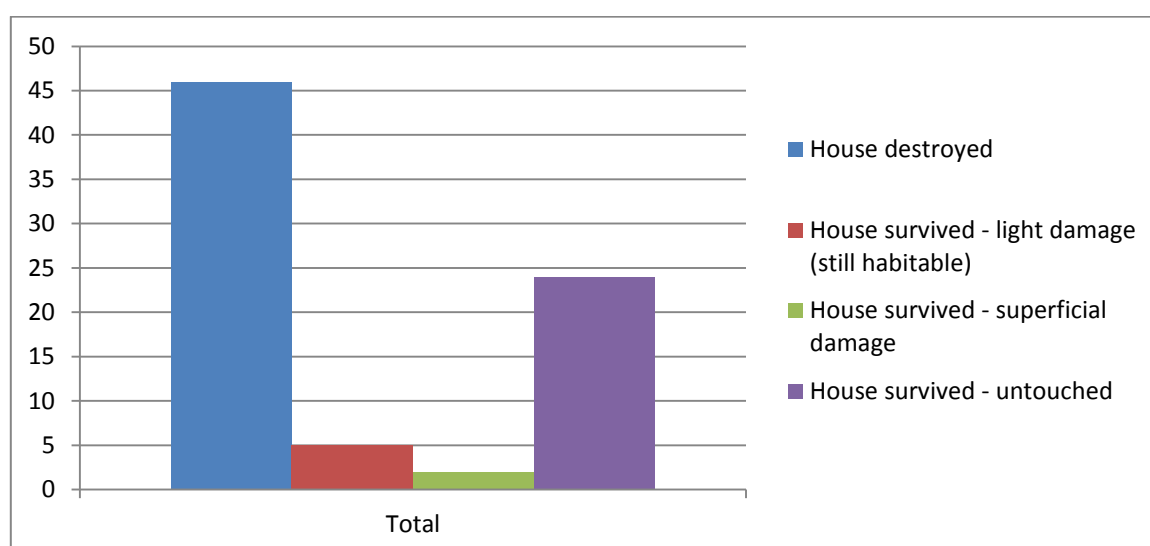

Figure 23: Houses did not have sarking.

Historically in Western Australia, and following the recent bushfire emergencies that has resulted in significant house losses, the fire behavior and house destruction and damage analysis has found that some houses that are destroyed do not have boxed eaves. In many instances it is not possible to identify one single cause, or entry point

of a house being destroyed or damaged during the bushfire, but houses in general without boxed eaves feature significantly in house losses and damage. In this fire the number of houses with boxed eaves and destroyed was significant. The high number of houses with boxed eaves and survived untouched in this bushfire is in part due to the survey technique, which included houses on the edge or periphery of the fire run to also be assessed.
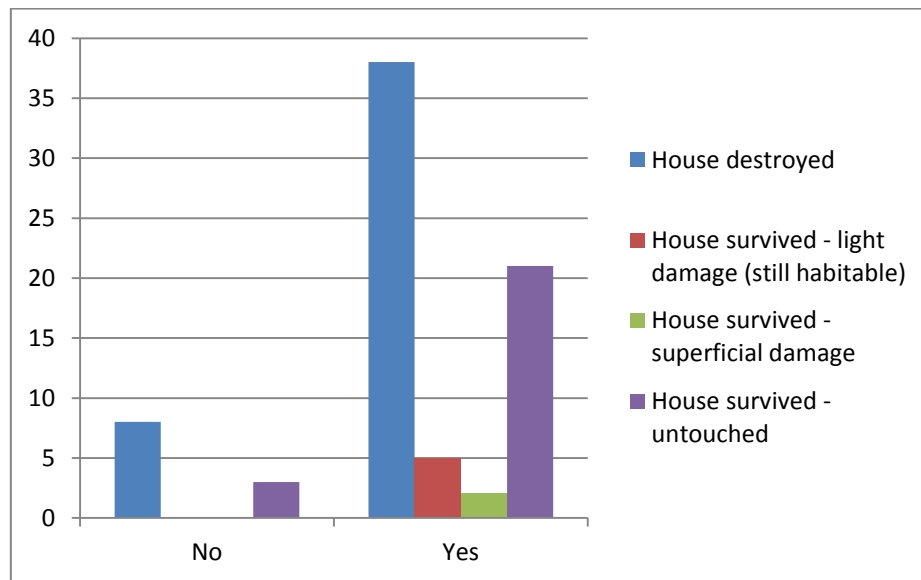

Figure 24: Houses with boxed eaves and unboxed eaves and the impact of the fire?

Figure 25: Boxed eaves in a destroyed house.

The boxed eaves in the destroyed house indicates (as shown in figure 25) a fire entry point other than through the boxed eaves.

Evaporative air conditioners did not generally feature prominently in the fire zone, and consequently do not feature significantly in the house destruction or damage assessments. This situation varies markedly with the Roleystone/Kelmscott fire were houses with evaporative air conditioners featured in the houses that were destroyed.

Figure 26 : Unscreened roof fixing.

There were a significant number of houses destroyed (24) that did not have wire in their insect screens. It is also noted that eight houses did have wire insect screens, but it was not possible to ascertain the single cause of the house destruction or the entry point of the fire.
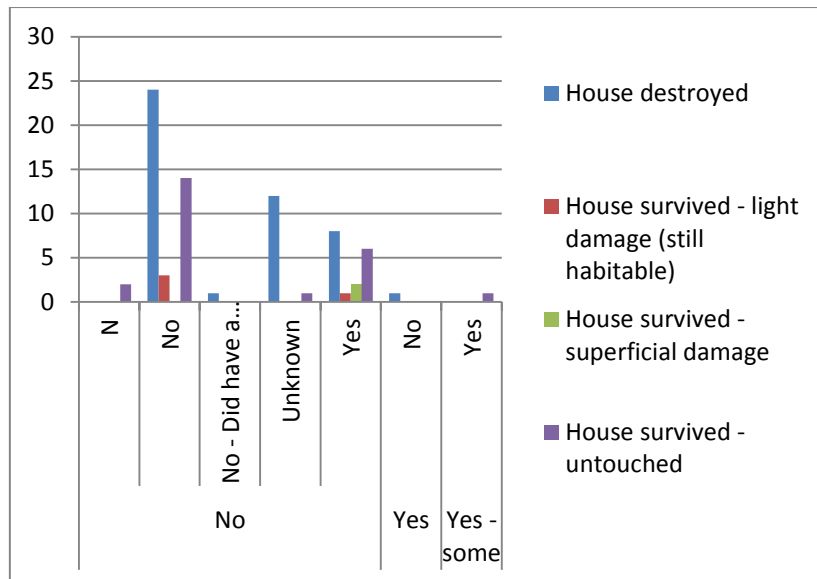
Figure 27: Wire not fibreglass in insect screen on doors and window frames.

The high number of houses that were destroyed and constructed from brick is not surprising, as it is a primary construction material in this region and during the era that the bulk of the hoses were constructed. Again, cellulose cement features prominently in the houses destroyed. This has been a feature in virtually all recent significant bushfire events that have caused a number of destroyed houses. It appears that the fixing mechanism/process where the cellulose cement sheets are fixed to studs does not appear to maintain its integrity, and as a consequence it is failing, resulting in the internal building being exposed to direct flame and radiant heat.
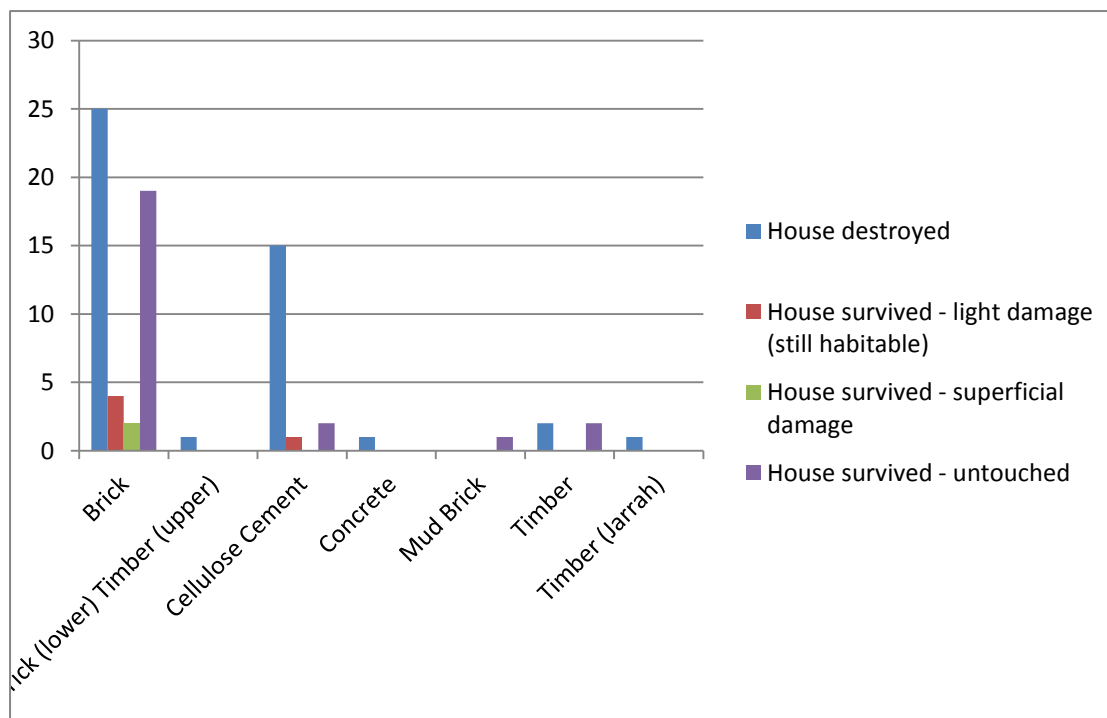

Figure 28: External construction wall materials.

The materials supporting the floor do not appear to have been a significant contributor to the house damage or destruction. The vast majority of the houses were concrete slabs on the ground.
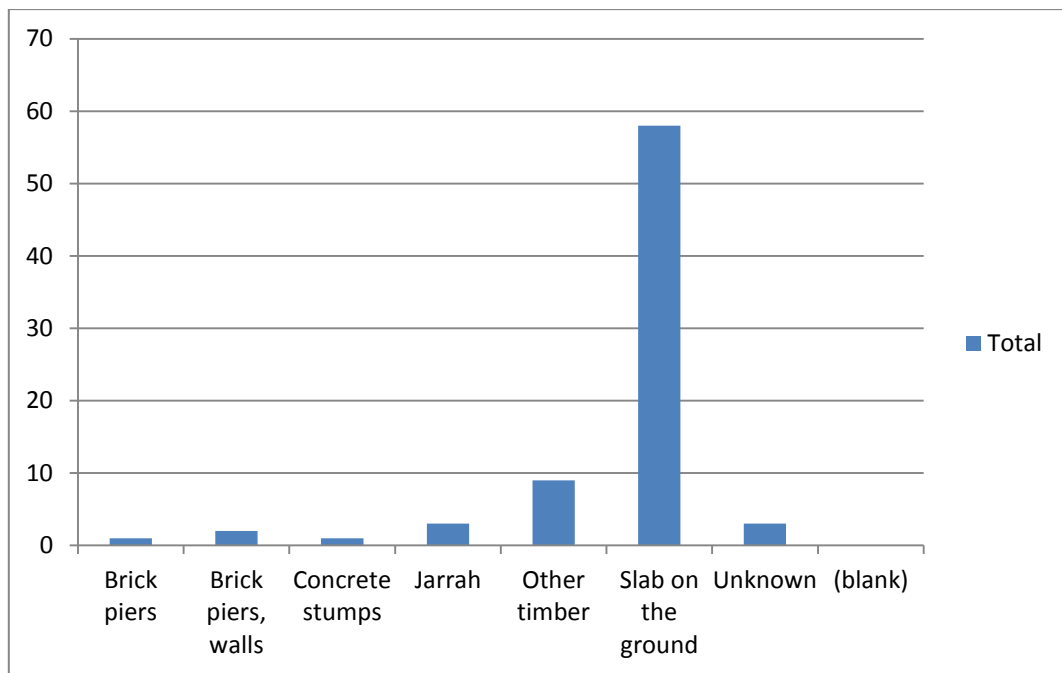

Figure 29: Materials supporting the floor.

The appendices demonstrate the bushfire's growth during the day and the direction of the head fire in relation to a number of the destroyed houses. The houses directly in line with the head fire showed the greatest damage from the range of impacts whether ember attack, radiant heat or direct flame contact. An interesting feature is the micro-changes to the prevailing head fire run that resulted in house damage. This component requires further investigation at future fire events.
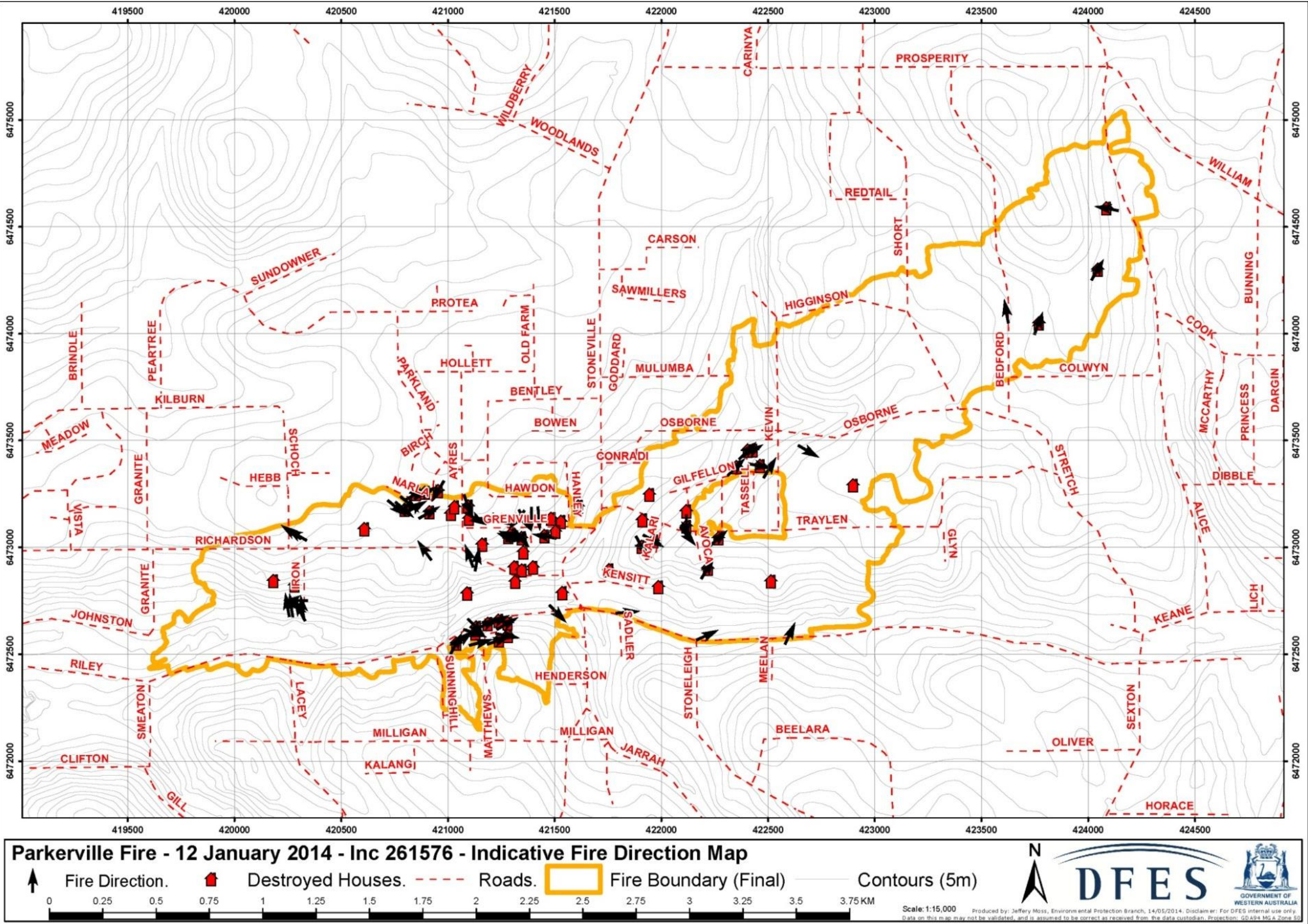
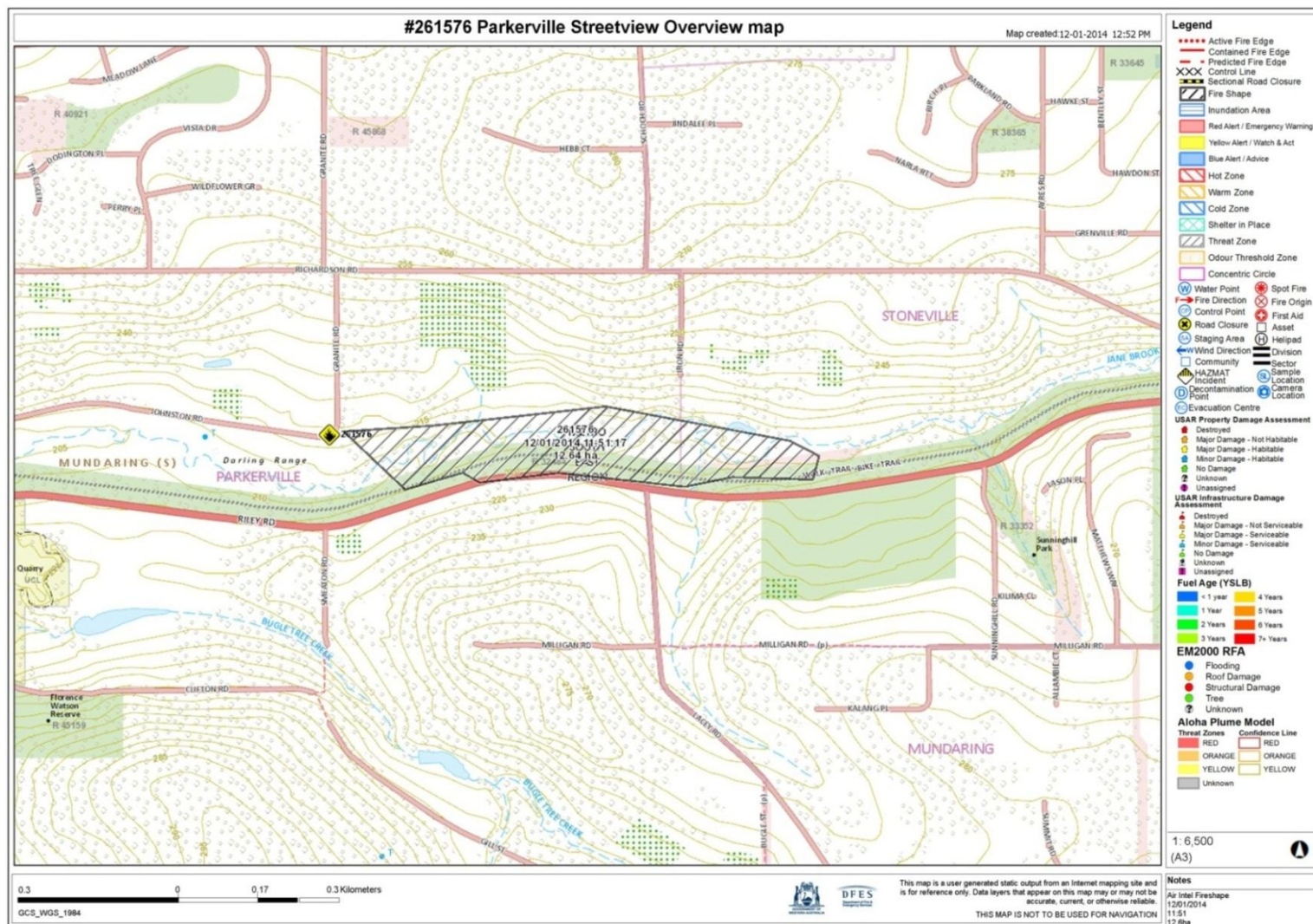Figure 30: Head fire direction and houses destroyed by the fire.
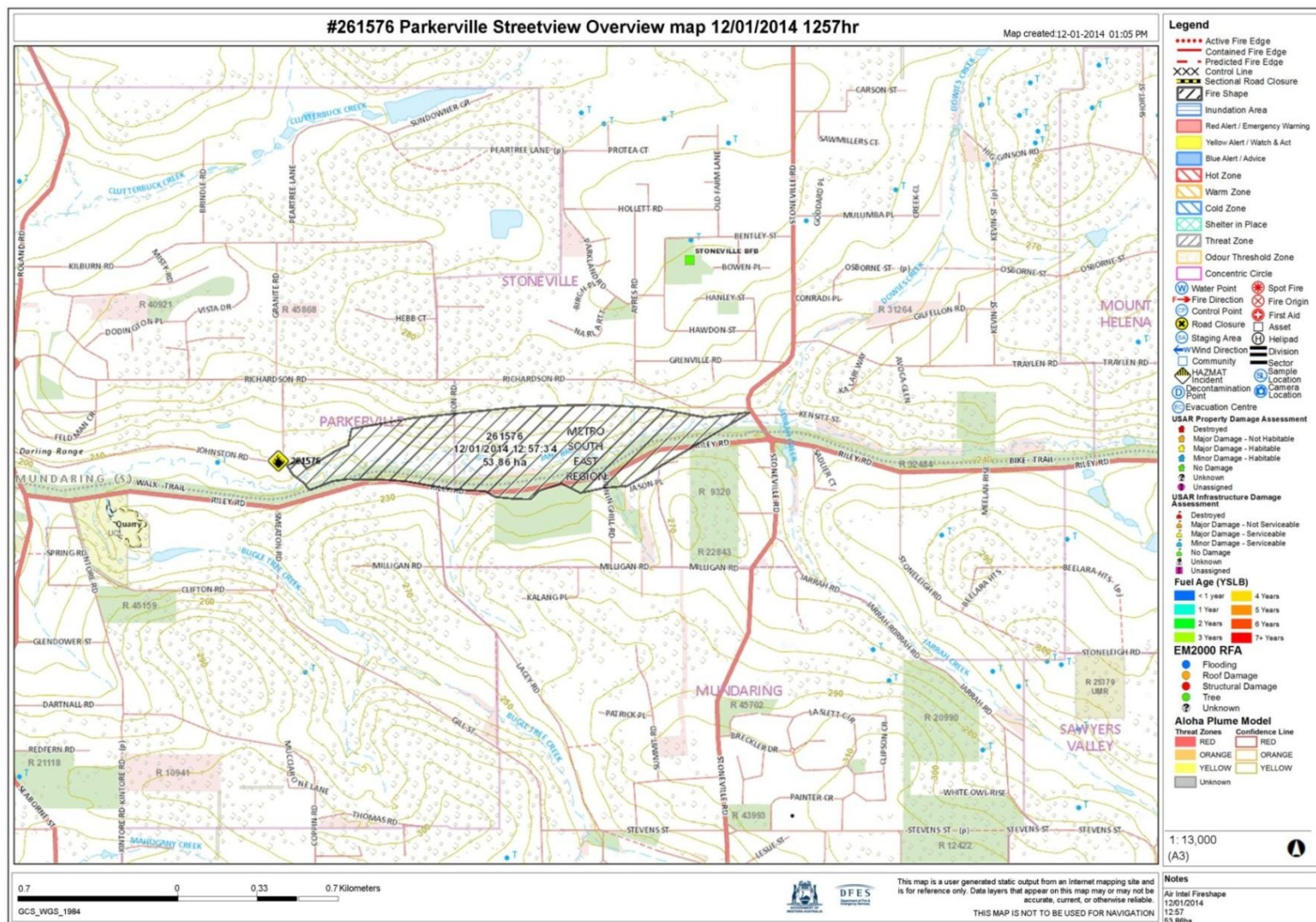
Figure 31: Fire run at 11.51 hours.

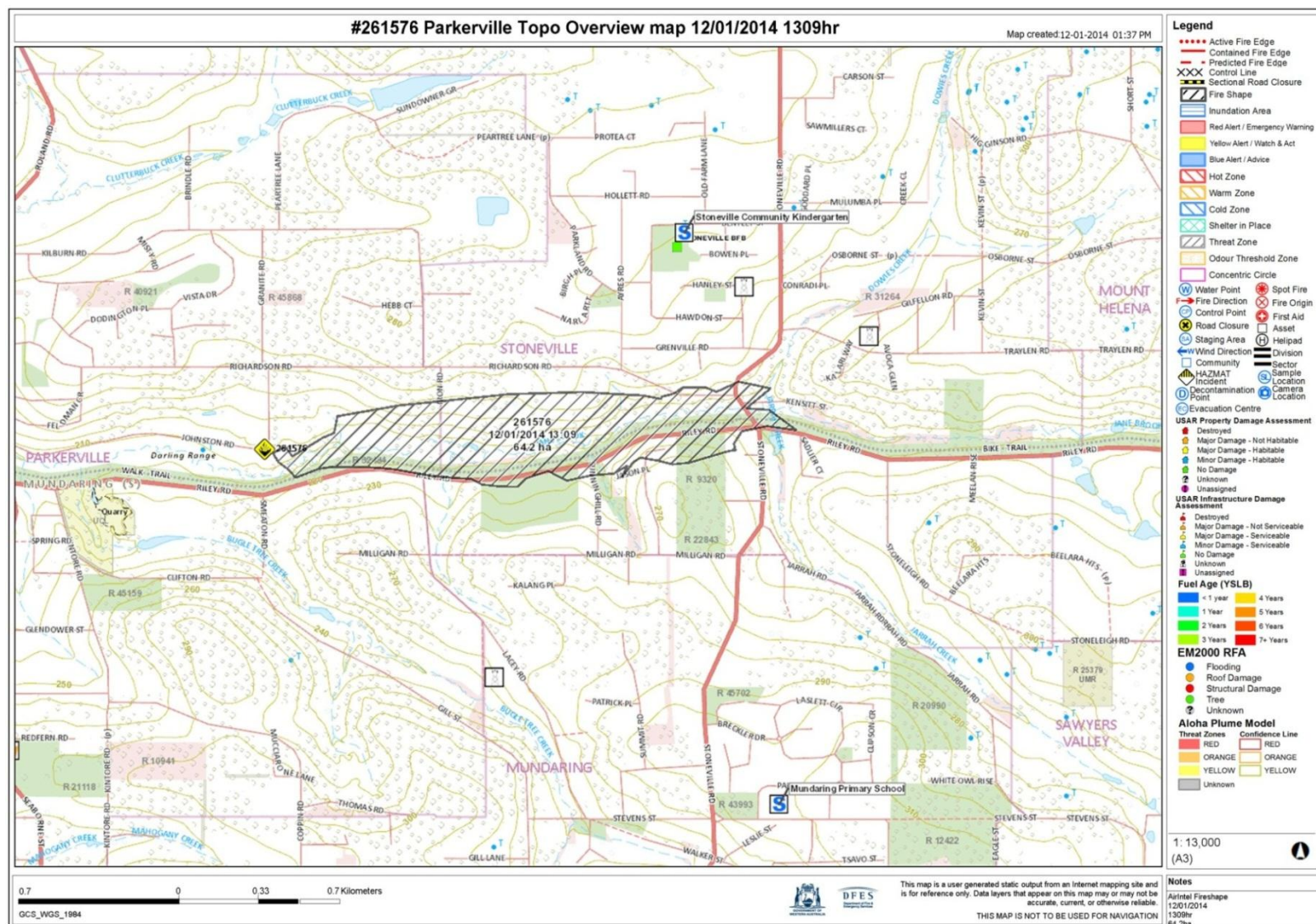Figure 32: Fire run at 12.57 hours

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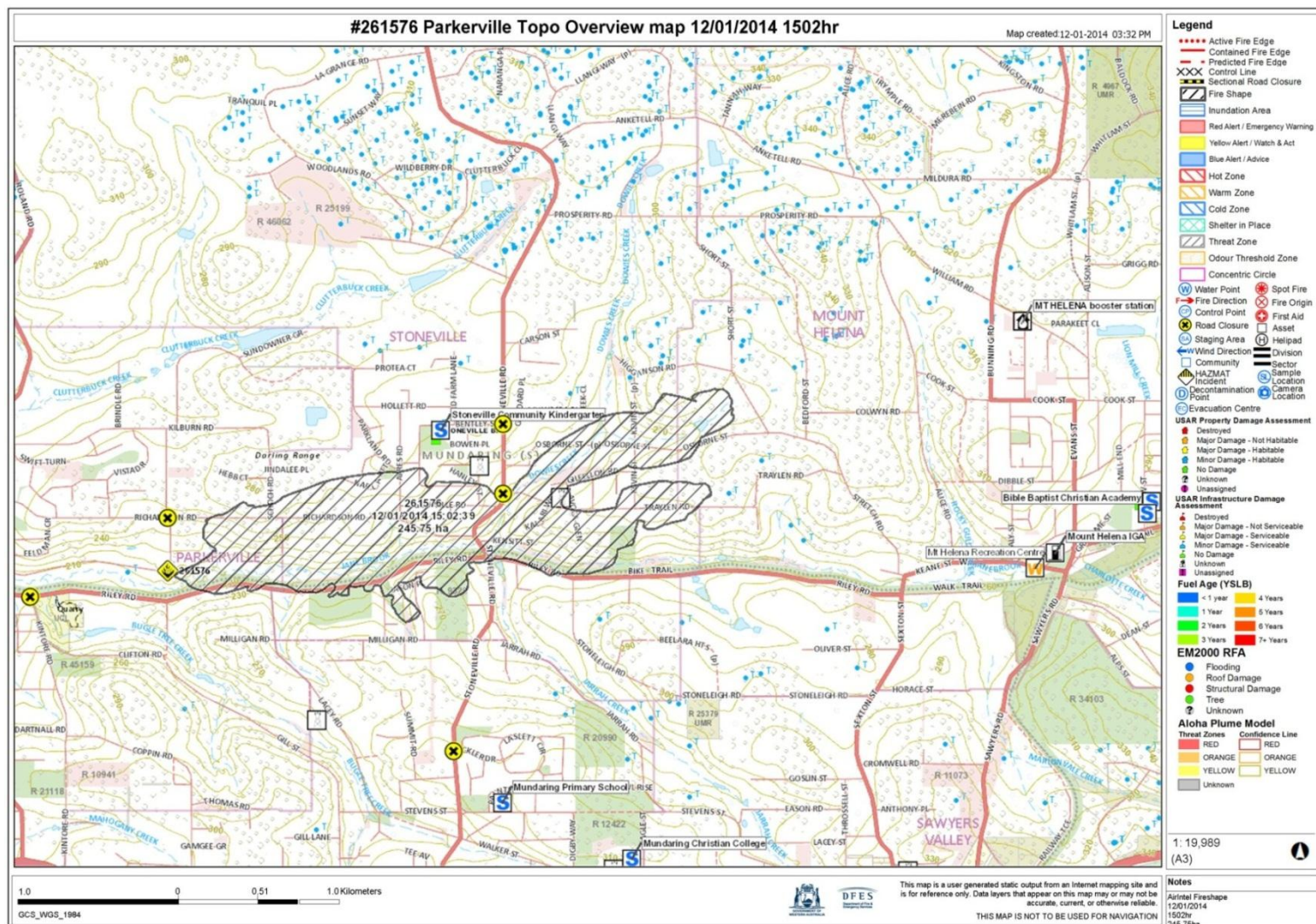Figure 33: Fire run at 13.09 hours

Figure 34: Fire run at 15.02 hours
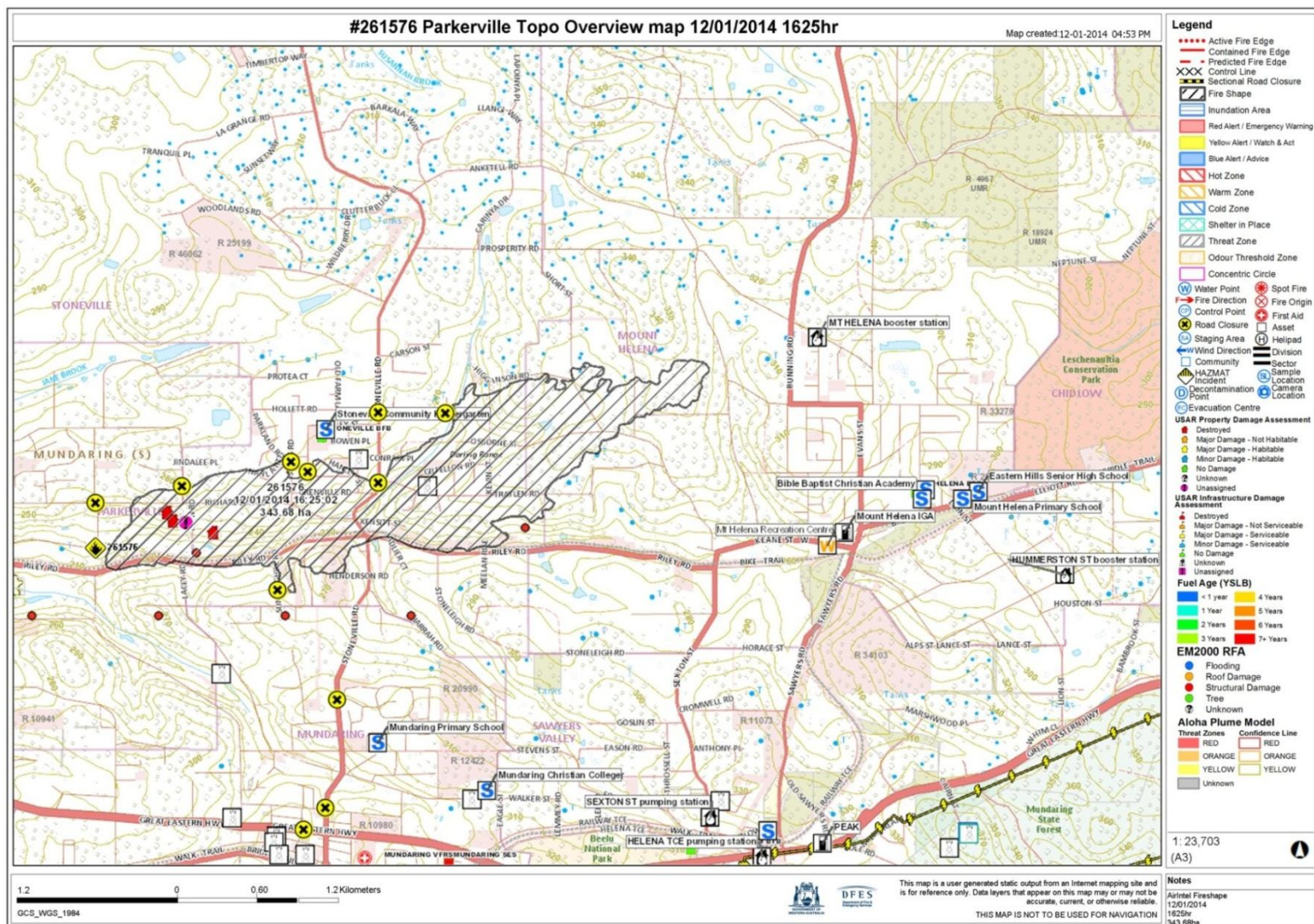
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Figure 35: Fire run at 16.25 hours

SITUATION ANALYSIS – BUSHFIRE PREDICTIONS

Operational Period From 18.00 to 21.00	Incident Name/ Number #261576	Date Prepared 12 Jan 2014	Time Prepared 18.00 hrs	Prepared by Situation Officer

Fuel Factors – Attach a map which identifies fuel locations

Fuel Location	Fuel Type	Quantity (t/ha)	Age	Other
	Northern Jarrah	7-10		
	Grass	<4.5t/ha		

Fire Development

Period	Time-17.00	Time-18.00	Time-19.00	Time-20.00	Time- 21.00
Perimeter at start of period			15000	17175	18645
Headfire rate of spread (m/hr)	680	680	725	490	966
Fire length at end of period	3200	5000	5725	6215	7181
Perimeter at end of period (m)	9800	15000	17175	18645	21543
Perimeter growth in time period (m)		5200	2175	1470	4368
Area at end of period (ha)		640			

Fire Line Construction Capacity- Times should reflect resource availability, slope, terrain, weather changes and fuel changes

Resources	Time-17.00		Time-18.00		Time-19.00		Time-20.00		Time-21.00	
	No.	=m/hr	No.	=m/hr	No.	=m/hr	No.	=m/hr	No.	=m/hr
Water Appliances										
Light Tankers	17	6800	17	6800	17	6800	17	6800	17	6800
1.2 Pumps	7		7		7		7		7	
2.4*	4	6400	4	6400	4	6400	4	6400	4	6400
3.4*	2	4000	2	4000	2	4000	2	4000	2	4000
Earth Moving Machines	3	2100	3	2100	3	2100	3	2100	3	2100
Other										
Total Capacity Available		19300		19300		19300		19300		19300
Total applicable to current situation		8000		8000		8000		80000		19300

Fire Growth vs Fire Line Production

End of Period	Time-17.00	Time-18.00	Time-19.00	Time-20.00	Time-21.00
(A) Perimeter of Fire (m)	9800	15000	17175	18645	21543
(B) Fireline made in period (m)		8000	8000	8000	19300
(C) Total Fireline made (m)			16000	24000	
(D) Fire Perimeter remaining		7000	17175	5355	

* OR EQUIVALENT