C MULLER CONSULTING PTY LTD
Fire and Environmental Planning

Report on

Ellensbrook Prescribed Burn BS520

24 April 2012

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This report has been prepared for Insurance Commission of Western Australia. It examines the background, planning and conduct of prescribed burn BS520 at Ellensbrook and the factors that led to the escapes that caused the destructive "Margaret River Fires".

The report does not examine the conduct of the fire suppression operations for the fire.

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Summary

The Ellensbrook fire escaped from prescribed burn BS520 on the morning of 23 November 2011, a day of very high fire danger conditions. It is likely that mixing of dry air from the upper atmosphere contributed to unexpectedly severe fire behaviour. The fire burnt through coastal vegetation and forest before being eventually controlled on Redgate Road. It destroyed 32 homes, 9 chalets and 4 sheds.

There were also some fires started in the Gnarabup area as a result of spotting from a prescribed burn at Prevelly (BS255) but these did not result in property losses. The fire from BS520 over-ran this area.

The fire started as a re-ignition within the burn. There were large areas still unburnt within the boundaries of BS520 on 22 November. Despite earlier efforts, there was only a very poor edge for much of the boundary, and no edge along the south western boundary. Factors which contributed to this include

- the prescribed fire plan
- the nature of the fuels
- the limited experience in this fuel type of both the staff involved in the prescription preparation and in the conduct of the burn.
- the lack of burning guidelines for heath fuels
- the conditions under which burning was undertaken,
- weather patterns after the initial ignition

There were no fire crews present on the 23 November prior to the fire crossing Ellensbrook Rd. The first crews in attendance were unable to contain the escape. Ultimately this made little difference as the fire spotted over Ellenbrook Rd when there were six units in attendance, and could not be controlled.

The suppression strategy outlined in the prescription did not match the identified risks and proved inadequate.

Whilst there were aspects of the Prescribed Fire Plan and the conduct of the burn that could have been done better, it was primarily the weather conditions before and on the 23rd which had the greatest influence on the outcomes.

Background

The prevailing weather, fuels and topography determine fire behaviour. Of these, the only factor that we can influence is the fuel. Days with hot, dry and windy conditions occur each summer. Fires, whether accidental, deliberate or caused by lightning, will occur. Fuels accumulate over time, and fires that occur in heavy fuels can be difficult or impossible to control under adverse weather conditions.

Following the disastrous 1961 Dwellingup fires, low intensity fire was introduced across large areas to reduce the fuels under conditions when the fires could be readily controlled. The Forest Fire Behaviour Tables for Western Australia were developed based on considerable research, to provide a sound basis for prescribing the conditions which would result in such low intensity fires, hence the term "prescribed burning". The focus of these prescriptions was fuel reduction in SW forests.

Fuel reduction burning does not prevent fires, but reduces their rate of spread and intensity, which greatly increases the ability to control wild fires.

Over time, prescribed burning has extended to other areas, and the purpose is no longer restricted to fuel reduction. The prescription has developed into a very large document that includes the use of fire to meet multiple objectives and constraints, each adding to the complexity of both the burn and the planning process. The workload in completing the document has grown to the extent that there more time spent completing the paperwork than prescribing the conditions. Some requirements affecting burn operations have been imposed by persons with little or no experience in, or accountability for, the conduct of prescribed burns. With increased complexity comes added risk.

In recent years there has been mounting concern about the potential for disastrous fires on the Leeuwin Naturaliste Ridge. Residential developments within bush environments, with many houses having little or no surrounding protective work, were seen to be at great risk. Long unburnt fuels throughout the area meant that there was a potential for a major wildfire along most of the ridge. Fires in such long unburnt fuels are difficult/impossible to control under adverse weather conditions, as was amply demonstrated following the escape from BS520.

BS520 was planned to break up this long run of heavy fuels. The initial prescription for BS520 was for a much smaller area with the western boundary being a central north south track. The central track was found to be in very poor condition and not suitable as a control line. The boundary was subsequently extended to the west as far as the Cape to Cape walking track near the coast. This had an added benefit in breaking up the potential for a future NS fire run.

The vegetation within BS520 grades from coastal heath in the west through a heath with peppermint overstorey to jarrah forest and karri forest in the east.

Practices and procedures for burning forest fuels are well established. The Forest Fire Behavior Tables have proven to be effective in prescribing conditions for burning in forest areas for at least 40 years. These tables were not developed for peppermint heath or coastal heath. There are no equivalent detailed tables for these fuels.

Forest fuels have a continuous ground litter layer which will allow the spread of a low intensity fire under mild conditions. By contrast heath fuels have only a thin and

discontinuous litter layer, making it impossible to prescribe for a low intensity fire based on the litter. Fire spread in heath fuels is through wind driven direct flame contact through the shrubs.

Whilst there has been no research into the fire behaviour on coastal heath there is information available on fire spread in mallee heaths in more arid areas. These heaths are a similar structural type with a thin, discontinuous litter layer, and dead material suspended in the shrubs of the heath. Fire spread in these fuels is highly dependant on the fuel moisture content of suspended dead material in the near surface layer. Above the threshold moisture content, ignition may be possible, but there will be no lateral spread and the head fires will fragment to the extent where propagation is not sustained.

Cruz et al (2010) quote a threshold value of 13% for heath but note that an increase in moisture content may be offset by stronger winds, up to 15% moisture content. McCaw (1997) conducted research into fire behaviour in mallee heath in Western Australia. The results of his research form the basis of Fire Operations Guideline 21 (FOG 21) "Fire behaviour guidelines for mallee heath and other shrublands in south western Australia". These guidelines indicate 10% as the threshold moisture content for sustained fire spread.

Fire spread in heath is predominantly through direct flame contact, and if the moisture content is below the threshold, fire spread is dominated by the wind. There is very little difference between the conditions where a fire will not spread and a fast spreading wildfire. The table below, reproduced from FOG 21, shows how fire spread is dominated by the wind once the moisture content drops below the threshold value.

Table 1 Fire Spread in Shrublands (reproduced from FOG 21)

	WIND SPEED (KM/H)							
at 2 m	4	7	11	14	18	22	25	29
at 10 m	5	10	15	20	25	30	35	40
SURFACE FUEL MOISTURE CONTENT (%)	FORWARD RATE OF SPREAD (M/H)							
>10								
10	350	725	1110	1500	1900	2300	2700	3110
9	390	810	1240	1675	2120	2565	3015	3465
8	435	905	1380	1870	2365	2860	3365	3870
7	485	1010	1545	2090	2640	3195	3755	4320
6	545	1125	1720	2330	2945	3565	4190	4825
5	605	1255	1920	2600	3285	4000	4680	5385
4	675	1400	2145	2900	3670	4445	5225	6010
3	755	1565	2395	3240	4095	4960	5830	6710

With 10% SMC (surface moisture content) and 15 kph wind at 10m, the rate of spread in "standard" (8t/ha) jarrah fuels predicted from the Forest Fire Behaviour Tables is 30 m/hr. This is the rate of spread commonly prescribed for low intensity fires for fuel reduction. By contrast, the rate of spread in heath predicted by FOG 21 for the same conditions is 1110 m/hr.

It is not possible to prescribe for a slow moving, low intensity fire in heath.

A well prepared prescribed fire plan minimises the risk of undesirable outcomes. Thorough pre-planning reduces the risk of errors and omissions under the pressures associated with the conduct of the burn, however the pressures associated with other workload can also lead to things being overlooked both in the preparation of the prescribed fire plan, and in the execution of the burn.

The Initial Plan

The prescribed fire plan for BS520 was first prepared in 2006, and it was proposed to be burnt in Autumn 2007 but no burning was undertaken. The area of the burn was 376ha. Clare Forward was the compiling officer for the prescribed fire plan, and undertook the fuel sampling and completion of the checklists. She did not complete the burn implementation section of the plan (the prescribed conditions) as she considered she had neither the knowledge nor experience to do so.

Nine fuel sample lines were completed. Two of the sample lines were in coastal heath outside the 2006 burn boundary and were subsequently disregarded as being non-representative of the fuels inside the burn. None of the remaining samples were in coastal heath, although three of the sample lines were in a dense coastal peppermint/heath scrub. Fuel loads were estimated using values from the Forest Fire Behaviour Tables.

Rob Turner, the District Fire Coordinator at the time, completed the burn implementation section. He used the Forest Fire Behaviour Tables for the jarrah and karri forest, and in the absence of fire behaviour tables for coastal heath, he used the Jarrah tables with 4:1 and 3:1 wind ratios to predict fire spread in the heath and peppermint heath, on the basis that most of the area had a peppermint over storey with some jarrah.

In the absence of specific fire behaviour tables, valuable information on conditions that were suitable (or unsuitable) for burning in a particular fuel type can be obtained if there are burn records available for previous burns in similar vegetation/fuels. Although burn records form part of the prescription, it appears these are not readily available, and Mr Turner did not refer to such records, but relied on his previous experience.

Fuels dry at different rates. The exposed heath fuels dry far more rapidly than the Jarrah forest, which in turn dries more rapidly than the karri forest. Mr Turner had some prior experience with fire in coastal heath and was well aware that such fires are wind driven. His intent was to take advantage of the fuel moisture differential to control the spread of the fires in the heath. This was the intent behind "any suitable direction" for the wind in the edging prescription, but this was not explicitly stated, relying instead on the knowledge and experience of the person conducting the burn.

The 2011 Plan

BS520 was next proposed to be burnt in Spring 2009. The proposed burn had almost doubled in size to 722 ha with the boundary being extended to the west and north. Again, no burning was undertaken. The burn was carried over for each of the successive seasons until 2011, with the revised boundary remaining unchanged.

The prescribed fire plan is a large document. Much of the initial work in preparing this plan relates to gathering information related to the burn, including compiling the various checklists. This can be an onerous and time consuming task. As the majority of this information is relatively static, it is common where burns are carried over to not prepare a new prescribed fire plan from scratch for each successive season, but to review the existing plan to ensure the information is current. This is efficient and effective where there is no significant change in the burn, but has the potential for errors where there is a marked change in the boundaries.

Maps and Checklist DEC 32

Much of the material contained in the 2011 prescription was a cut and paste from the 2006 prescription. This is obvious from some copies of the prescription having different page numbering (eg. X of 49 compared with X of 52) and was confirmed by Ms D Peachey[1]. In updating the preburn checklist the compliance with Management Plans was overlooked. The extended boundary included an area designated in the Leeuwin Naturaliste National Park Management Plan as a No Planned Burn (NPB) area.

The original burn boundary excluded the NPB areas. These were noted in Part 3 of the DEC 32 Pre Burn Checklist with the notation "prompt response to any hop-overs in the NPB areas. The DEC 32 also noted the burn was compliant with Leeuwin Naturaliste National Park Management Plan. The No Planned Burn areas are also clearly shown on

- Spring 2010 Flight Line Plan
- The areas are shown on the map, but not identified as NPB in the legend.
- BS520 Ellenbrook Operations Map (produced at 11.45am on Feb 22 2011)
- The areas are shown on the map, but not identified as NPB in the legend.
- Blackwood District, Gracetown Townsite, No Planned Burn Areas, Current Management Plan (produced at 12.45pm on Feb 15 2011)
- Blackwood District, Gracetown Townsite (Produced at 12.45pm on Feb 15 2011)
- The proposed burn is shown over the NPB area.
- BS520 Ellenbrook Operations Map (Produced at 12.45pm on Feb 22 2011). This is an aerial image, and whilst the NPB area is shown on the map, it is almost impossible to decipher this in the legend.

The NPB areas do not appear on a number of other undated plans, including plans titled B520 Ellenbrook Operations Map, and including those used operationally during the burn.

In the "cut and paste" from the earlier prescription, Part 3 of the DEC32 checklist was not updated to reflect the changes resulting from the extension of the burn boundary. Whilst this incorrect information in the checklist and the multiple versions of the Operations Map are of concern, they did not contribute directly to the subsequent escape from the burn.

Amongst the operational documents received was a copy of the completed checklist (DEC 32) for each lighting. Three different versions of the checklist were used. For lighting on 6/9/2011 the version "As at 03/06/2011" was used. Although identified as

[1] D Peachey interview 17/2/2012

being for Spring 2011 season, this appears to be the checklist from the previous Autumn prescription, Pp 13-18 of 52. The approvals for the Spring burn were not signed until 13/9/2011, and identify 49 pages in the document in the 2011 document.

For lightings on 10, 11, 15, and 16/11/2011 the checklist "As at 01/09/2011" was used. (Pp 10-15 of 49).

These two checklists are essentially the same, with the version 01/09/2011 including some changed contact numbers handwritten on the earlier checklist.

The checklist used on 20/11/2011 and 21/11/2011 is substantially different. This checklist is for BS255. There was no ignition at BS520 on 20th. On 21st BS520 followed immediately on BS255. The same operations officer was responsible for both burns. The inclusion of the BS255 checklist with the BS520 documents would imply that this checklist was used for both burns. If this is the case, it seriously undermines the purpose of the checklist.

Burn Objectives & Success Criteria

There is a conflict between the stated success criteria for strategic protection (at least 60% of the area burnt) and biodiversity management (not more than 20% of the Agonis flexuosa stands fully scorched). A large portion of the burn is peppermint (A. flexuosa) scrub or low forest over heath. To achieve at least 60% of the area burnt requires this area to be burnt. It is not possible to prescribe for a slow moving, low intensity fire in heath. The fuel samples show scrub heights of 2-3 m. If this scrub is burnt the scorch height would exceed the height of the peppermint.

That this conflict was allowed to remain as part of the prescription indicates a lack of rigour in the planning process and revision process.

Fuel Sampling

The fuel sampling was carried out in 2006. Sampling did not include the coastal heath that comprised the western part of the extended burn. Deb Peachy, who updated the 2011 prescription, would have liked to update the sampling but was under pressure from other work, and was advised it was not necessary to do so[2]. It was considered the sampling in the dense coastal heath/peppermint adequately represented the heath. Had sampling been undertaken in the coastal heath (as distinct from heath/peppermint) it is likely the litter depths would have been much less than recorded where a peppermint over storey was present. This may have highlighted the difficulty of edging in these fuels, and emphasised the need for fuel modification. It would not have materially altered the conditions required for successful core lightings.

The passage of time between the initial sampling and 2011 would not have resulted in a significant increase in fuel loads. There is a rapid increase in fuel accumulation in the first few years after a fire, but the annual increase reduces with time since fire. The majority of the area had not been burnt for thirty years and there would not be a significant change in fuels between 2006 and 2011.

Prescribed Conditions

The weather conditions for a prescribed burn are described in terms of the fire danger index (FDI) and wind. The conditions for BS520 cover the range of FDI 16-22 (Heath

[2] D Peachy interview 19/2/2012

edging 16-20, Jarrah/Peppermint/Heath and core lighting 18-22) with winds < 16 kph. There are a number of combinations of SMC and wind speed that meet these conditions as per the table below, extrapolated from the Forest Fire Behaviour Tables:

Table 2 Wind Speeds for SMC 10-20% and FDI 22, 20, 16

SMC	Wind for FDI 22	Wind for FDI 20	Wind for FDI 16
10	4-8	0-4	N/A (lowest FDI @ 10% is 20)
11	12-14	8-12	N/A (lowest FDI @ 11% is 18)
12	12-15	9-13	0-4
13	12-16	10-14	4-8
14	14-18	12-16	8-12
15	15-19		10-14
16	17-21		12-15
17	18-22		13-17
18	20-24		14-18
19	22-26		16-20
20	24-28		17-21

The FDI and wind adequately describe the range of conditions suitable for burning the forest fuels, but it is only those combinations with an SMC below the threshold for sustained spread that are suitable for the heath fuels. To fully prescribe the conditions for heath, it is necessary to specify an acceptable SMC range in addition to the FDI (or specify the SMC and wind) to avoid attempts to burn when conditions are not suitable. Burning when conditions are not suitable can result in partial removal of the fuel, resulting in poor edges that are difficult to subsequently improve.

The edging prescription states "any suitable" for the wind direction. With the smaller original burn the majority of the heath/peppermint fuels could be burnt so the wind would drive the fire into the forest, and so make use of both the fuel moisture differential and the reduction in under canopy wind speed to control the fire. The enlarged boundaries included a large area of coastal heath to the west. It was no longer possible to edge the western parts of both the northern and southern boundaries such that the fire would run into forest areas. The prescription fails to identify an alternative strategy to safely edge the burn.

Consideration was given to modifying the fuels on the northern and southern boundaries by scrub rolling. There were vocal objection from members of the local community to some narrow scrub rolling that had been carried out on the nearby burn BS521 (Kilcarnup). In addition the Department of Indigenous Affairs prohibited the use of machinery in the vicinity of registered sites on the southern boundary. It is not possible to scrub roll without the use of machinery. Scrub rolling was not included in the prescription.

Scrub rolling modifies the fire behaviour by removing the elevated fuels. Flame length and rate of spread is reduced. Scrub rolling also provides a more continuous fuel layer which, if carried out well in advance of a planned burn and allowed to dry, out can be burned under milder conditions

The lack of scrub rolling in the SW corner was a major contributory factor to the escape from the burn.

Pre-Determined Suppression Strategies

The strategy is inadequate. It appears to be based on suppression of a hop-over on the day of the burn, under mild weather conditions, and does not consider a subsequent escape under more adverse conditions. Even for prescribed burning conditions, the strategy is inadequate, as it fails to consider the high rates of spread likely. Even under mild prescribed burning conditions, if the moisture content of the heath is below the threshold for sustained fire spread, such spread can exceed 1000m/hr with flame lengths exceeding 4m. (FOG 21). The strategy states: "First option in the event of any escape is aggressive direct attack with available resources". Direct attack would be the norm for any escape. It goes on to say this should be achievable in the north east and west, but identifies that fuel loadings to the south are heavy and "may present some issues depending on conditions".

The strategy cautions against the use of trucks and machinery off existing tracks due to the hazards posed by the karst system. It further cautions against the use of machinery due to the presence of Threatened Ecological Community and a rare snail, and Aboriginal Sites. Instead, it proposes the use of existing tracks for indirect attack, but these tracks are not identified.

The potential fire behaviour in the heath fuels under even low wind conditions can present considerable suppression difficulties, and requires good control lines to work from. Tracks to the south are within 500m and 1100m of Ellensbrook Rd. A rate of spread of around 1000m/hr would not allow time to upgrade tracks ahead of the fire. Any such upgrade would need to be carried out in advance.

The preparatory tasks for the burn included upgrade of boundary tracks, but the document does not identify the need to upgrade any other tracks.

The suppression strategy is based more on hope and the expectation of the mild fire behaviour anticipated from a hop-over whilst conducting a prescribed fire in forest than it is on any consideration of the potential in heath fuels, or adverse weather conditions.

Burn Implementation

Monitoring Burning Conditions

There are many burns on a District burn program and the weather conditions prescribed for each burn are not the same. The selection of a burn on a particular day is based on the forecast fire danger index (FDI) and wind, the priority of the burn, and resources available. The predicted surface moisture content (SMC) is calculated daily, using prediction tables in the Forest Fire Behavior Tables. A key component of this calculation is the moisture gained overnight, either as the result of rainfall or overnight humidity. On rainless nights, the moisture gain is calculated from the overnight relative humidity count (ORHC) obtained from a thermohydrograph trace. In the Blackwood District these records are maintained at Kirup.

The predicted SMC and wind determine the FDI for the day. The FDI is calculated daily for Bridgetown and Witchcliffe, using the forecast winds for those centres issued by the Bureau of Meteorology. The SMC used is that calculated at Kirup as there is no thermohydrograph at Margaret River or Bridgetown. Kirup is 80km NE of Margaret River and there can be considerable difference in conditions between the two locations.

Differences in rainfall and overnight humidity can result is significantly different SMC values.

Table 3 shows the daily rainfall for Margaret River (9km SE of BS520), Witchcliffe (15km SSE) and Kirup (84km ENE); the ORHC recorded at Kirup and determined from the Witchcliffe automatic weather station (AWS) data: the SMC calculated at both locations, and the calculated FDI for Witchcliffe using the two sets of SMC data. The SMC at Kirup and the Kirup calculations for the Witchcliffe FDI are those based on the weather conditions recorded, not on the forecast conditions. This provides a direct comparison with the calculations based on the Witchcliffe AWS.

There are significant differences between the calculated SMC and FDI based on overnight conditions at Kirup and those at Witchcliffe, highlighting the need for monitoring conditions closer to the burn site.

Not only are there differences in the SMCs calculated for different locations, but the actual SMC of the fuels may differ considerably from the calculated values, particularly in the days following rain. After rain fuels generally dry more rapidly than predicted by the Forest Fire Behaviour Tables. The accuracy of the SMC predictions can be improved by periodically adjusting the daily SMC based on actual fuel sampling and using this as the new starting value for future predictions. Moisture content readings are frequently taken at prescribed burns and these can be used to make the adjustments. Only one actual correction was recorded (20th October 2011), when the SMC was corrected from 59% to 23%.

Actual SMC readings were taken at Boranup on November 18th 2011, but only recorded on the Operations Room white board, and no records were kept. The Daily Moisture Content Recording Sheet was not amended. There was no fuel moisture sampling at BS520.

Table 3 Comparison of conditions at Kirup and Witchcliffe.

Rainfall and Overnight Relative Humidity SMC and FDI recorded at Kirup for Witchcliffe and SMC and FDI calculated from Witchcliffe AWS									
Date	Kirup Rain	Witchcliffe Rain	Margaret River Rain	Kirup ORHC	Witchcliffe ORHC	Kirup SMC	Witchcliffe SMC	W/clf FDI with Kirup SMC	W/clf FDI from AWS data
1/10/2011		0.2	***						
2/10/2011		19	***						
3/10/2011		4	14.2		52		65		0
4/10/2011		0.2	0		32.5		51		0
5/10/2011		0	0.2		51.4		31		0
6/10/2011		0.8	1.6		84.4		30		0
7/10/2011		0	0		81		25		13
8/10/2011		5	***		86.2		49		0
9/10/2011		11.4	***	36.1	75.6		76		0
10/10/2011		0	9				40		0
11/10/2011		0	0		68.5		28		0
12/10/2011	0.0	0	0	56	43.6	13	20	28	16
13/10/2011		6.2	2.6		33.2		49		0
14/10/2011		0	0		3.2		24		12
15/10/2011		0.2	0		62.1		20		20
16/10/2011		0.2	0		60.2		13		76
17/10/2011	0.0	0	0.6	43	48.1	15	16	26	25
18/10/2011	6.4	5.6	4.2	66	60.5	68	47	0	0
19/10/2011	1.8	1.8	3.8	66	30.8	59	45	0	0
20/10/2011	0.0	0.2	0	35	64.5	27	33	20	0
21/10/2011	0.0	0	0	36	45.9	14	19	48	18
22/10/2011	0.0	0	0	22	52.2	10	15	53	26

Rainfall and Overnight Relative Humidity
SMC and FDI recorded at Kirup for Witchcliffe and SMC and FDI calculated from Witchcliffe AWS

23/10/2011	6.8	0.2	***	76	68.5		16		49
24/10/2011	4.2	1.8	2.8	62	86.5	79	28	0	0
25/10/2011	2.0	0	0	92	28.9	69	17	0	15
26/10/2011	0.1	0.2	0.1	79	41.9	61	16	0	18
27/10/2011	0.0	0.6	0.2	64	85.4	32	19	0	26
28/10/2011	0.0	0.4	0	44	43.1	20	19	12	26
29/10/2011	0.0	0.2	0	20	32.4	14	15	22	28
30/10/2011	0.0	0	0	30	34.5	11	12	39	49
31/10/2011	0.0	0	0	32	35.1	11	11	45	65
1/11/2011	0.0	0	0	30	28.6	9	9	40	72
2/11/2011	0.0	0	0	26	43.9	8	9	48	45
3/11/2011	2.9	0	0	29	17.5	20	11	0	34
4/11/2011	4.0	13.6	14.8	65	85.8	42	61	0	0
5/11/2011	18.5	3.4	***	80	50.2	84	60	0	0
6/11/2011	0.5	0	***	28	65.5	67	35	0	0
7/11/2011	5.0	0.8	6	51	0.5	66	31	0	0
8/11/2011	17.0	8.4	12.2	51	8.5	74	60	0	0
9/11/2011	1.4	2.4	3	50	15.4	63	55	0	0
10/11/2011	0.0	0	0.4	30	5.5	28	26	16	0
11/11/2011	0.0	0.8	0.6	60	62.9	19	25	12	10
12/11/2011	0.0	0	ß	55	71.8	17	21	36	16
13/11/2011	0.0	0.2	ß	14	0	14	18	55	22
14/11/2011	0.0	1.6	0.8	47	37.2	12	27	55	0
15/11/2011	3.6	0.2	0	31	24.6	32	20	0	20
16/11/2011	0.0	0	0	38	37.5	16	15	36	52
17/11/2011	1.0	3.4	0	58	20.1	28	38	0	0
18/11/2011	9.4	6.6	12.6	66	22.6	67	56	0	0
19/11/2011	0.0	0.2	0	51	50.5	32	41	0	0
20/11/2011	0.0	0	0	41	37.8	17	22	25	19
21/11/2011	0.0	0	0	46	51.2	13	17	40	36
22/11/2011	0.0	0.2	0	42	74	10	13	34	23
23/11/2011	0.0	0	0	5	52.8	6	9	130	165

Notes:

Ignition day BS521 (Kilcarnup), BS521 (Ellensbrook), BS255 (Prevelly)

Wildfire

*** No record: rainfall carried forward to to next entry as a cumulative total

Weather Conditions September 2011

First ignition occurred on 6th September 2011. Over the previous five days 24.6 mm rain was recorded at Margaret River and 32.8 mm at Witchcliffe. The SMC was well above the threshold for fire spread in the heath fuels, and even the litter fuels would not carry a fire. The grass tree skirts were able to be burnt to remove elevated flash fuels near the edge.

During September, a total of 119.0 mm rain was recorded at Margaret River and 142.2 mm at Witchcliffe. There were only two occasions where rain did not fall on consecutive days, 23-24/9/2011 and 29-30/9/2011. Although the exposed fuels dry more rapidly it is improbable that the moisture content on the exposed heath would have dropped below the threshold required to sustain fire spread.

Daily moisture calculations for Blackwood District did not commence until early October.

Weather Conditions October/November 2011

During October, a total of 39.3 mm was recorded at Margaret River and 58.6 mm fell at Witchcliffe. There were several periods when there were consecutive days with no rain, and periods when the daily rainfall was 0.2 mm or less.

In the period 1-22 November, 55.8 mm was recorded at Margaret River and 45.4 mm at Witchcliffe. Again, there were periods of no rain, and most of the rain days had less than 1mm rain. Only 7 days in this period had more than 0.8 mm.

With only light rain interspersed with dry periods, the SMC calculated from the Forest Fire Behavior Tables is likely to be too high unless regularly adjusted from the results of field sampling. That the actual SMCs were significantly lower than those calculated is evidenced by the successful ignition and fire spread achieved in the heath fuels on 15/11/2011, when the calculated SMCs for Kirup and Witchcliffe were 32% and 20% respectively. These values are well above the threshold for fire spread, so clearly the actual SMC was much lower.

The days when the SMC at Witchcliffe as calculated from the tables was 20% or less are shown in Table 4. Based on the fire spread on 15/11/2011, the actual SMC on these days may have been below the threshold for heath, and potentially suitable for burning.

Table 4 Days SMC <= 20%

Days Witchcliffe SMC calculated to be <=20%						
Date	**Kirup Rain**	**Witchcliffe Rain**	**Margaret River Rain**	**Kirup SMC**	**Witchcliffe SMC**	**Witchcliffe FDI**
16/10/2011		0.2	0		13	76
17/10/2011	0.0	0	0.6	15	16	25
21/10/2011	0.0	0	0	14	19	18
22/10/2011	0.0	0	0	10	15	26
23/10/2011	6.8	0.2	***		16	49
25/10/2011	2.0	0	0	69	17	15
26/10/2011	0.1	0.2	0.1	61	16	18
27/10/2011	0.0	0.6	0.2	32	19	26
28/10/2011	0.0	0.4	0	20	19	26
29/10/2011	0.0	0.2	0	14	15	28
30/10/2011	0.0	0	0	11	12	49
31/10/2011	0.0	0	0	11	11	65
1/11/2011	0.0	0	0	9	9	72
2/11/2011	0.0	0	0	8	9	45
3/11/2011	2.9	0	0	20	11	34
13/11/2011	0.0	0.2	8	14	18	22
16/11/2011	0.0	0	0	16	15	52
21/11/2011	0.0	0	0	13	17	36
22/11/2011	0.0	0.2	0	10	13	23

Even if the days are suitable, burns may not proceed if resources are committed elsewhere, such on other burns, or attending fires. Only on one of these days was there another burn being conducted in Blackwood District.[3]

[3] DEC 268b records

Opportunities to burn BS52 in October and early November were missed. The analysis of the Witchcliffe AWS data shows the most suitable day for burning throughout October and November was 29th October. SMCs were sufficiently low between 27th October and 3rd November, but wind speeds were above the desired range. It may have been possible to burn late in the day on falling FDI had crews been available, however Blackwood District resources were committed to a fire at Thompsons Brook on 30th and 31st October.

The Commonwealth Heads of Government Meeting took place on 28-30 October. There was a verbal directive to avoid smoke over Perth during CHOGM[4]. Throughout this period there were southerly winds, with some risk of smoke reaching Perth. The FDIs were higher than prescribed due to the lower SMCs but a later lighting would have been an option if required

The opportunity to burn in late October may have been missed through a lack of close monitoring of the conditions, rather than a conscious decision not to burn because of CHOGM, but such a directive may have had an influence also on the degree of monitoring.

Burn Operations

The prescribed conditions for the burn were for an FDI in the range 16-22 (Heath edging 16-20, Jarrah/Peppermint/Heath and core lighting 18-22) and wind < 16 kph.

There is a range of combinations of SMC and wind speed that meets these conditions as per table 5 (extrapolated from the Forest Fire Behaviour Tables). The values highlighted in yellow fall within the prescribed upper wind limits, and below the threshold SMC for sustained fire spread in the heath according to Cruz et al (op cit).

Table 5: SMC and Wind for FDI 16 & 22

SMC and Wind Combinations for FDI 16 and FDI 22		
SMC	**Wind speed resulting in FDI 16**	**Wind speed resulting in FDI 22**
10	N/A (lowest FDI @ 10% is 20)	4-8
11	N/A (lowest FDI @ 11% is 18)	12-14
12	0-4	12-15
13	4-8	12-16
14	8-12	14-18
15	10-14	15-19
16	12-15	17-21
17	13-17	18-22
18	14-18	20-24
19	16-20	22-26
20	17-21	24-28

The conditions on the days when burning was undertaken in BS520 are summarized in table 6.

[4] Keelty Transcripts: Gibson p30,

Table 6: Conditions on when BS520 was lit

Ignition Days SMC and FDI calculated from Witchcliffe AWS							
Date	Margaret River Rain	Witchcliffe Rain	Kirup SMC	Witchcliffe SMC	FDI	Burn Result (from DEC 268b)	Diary Notes
10/11/2011	0.4	0	28	26	0	0.5 km	Not carrying fire. Grass trees burnt.
11/11/2011	0.6	0.8	19	25	10	2.5km	Left Handers Rd good edge. Eastern boundary patchy.
15/11/2011	0	0.2	32	20	20	100ha	Capsules then drip torch. 30-40m/hr. Hop-over Left handers Rd. E boundary and part Ellensbrook Rd edged.
16/11/2011	0	0	16	15	52	620ha	1655hrs 70% take. Heath 5-10m flame height, 5-600m/hr
19/11/2011	0	0.2	32	41	0	Nil	
20/11/2011	0	0	17	22	19	Nil: further ignition required	Prevelly the priority
21/11/2011	0	0	13	17	36	50ha	1131hrs Edging good. 1540 Commenced with drip torch

10th and 11th November

Initial lightings were aimed at establishing an edge along the northern boundary. With the proximity of Gracetown to the north, this was seen as critical before commencing core lightings. As the winds on all burning days except 16/11/2011 were southerly, this was a difficult task. Fire in the heath type fuels is wind driven. In order to create an edge it was necessary to ignite inside the boundary, and let the fires run towards the boundary. To reduce the risk escape from the edging, the grass trees near the edge were first lit to remove the elevated flash fuels.

The edging was carried out under very mild conditions, with the moisture content too high for fire to sustain in the near surface fuels. Intensive lighting resulted in most of the available ground litter being burnt, but not the suspended fuel. This resulted in an edge that would be difficult to re-light to improve the edge, but was vulnerable in the event of a wildfire.

The northern eastern boundary was only a vehicular track. Had edging been attempted with the SMC below the threshold for sustained spread which resulted in wind driven runs, it is almost certain that, in the absence of wide scrub rolling, there would have been hop-overs across the break. It was an almost impossible task to safely get a clean edge on the boundary with southerly winds. However, the burning under the high moisture conditions resulted in a very weak edge. Scrub rolling along this section was subsequently carried out to reduce flame length in the event of a fire. Aerial ignition to strengthen this edge on the 15th and 16th with westerly and north westerly winds and drier conditions resulted in a good edge further in. (Fig 1)

Figure 1: Aerial view NE boundary.

Shows narrow track, unburnt vegetation following initial edging, subsequent scrub rolling, and results of aerial ignition to strengthen the edge.

15th November

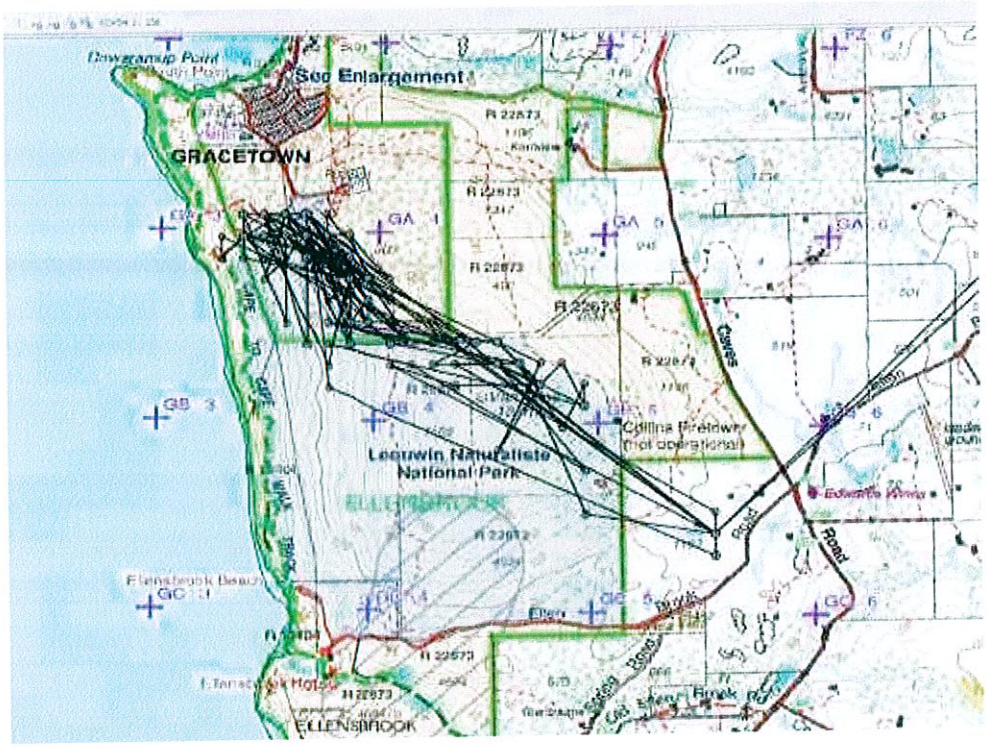

Figure 2: Helicopter track log 15/11/2011

A helicopter was used on 15/11/2011 to increase the depth of the edge on the northern boundary. Initially ignition was attempted using capsules rather than the drip torch because of concerns re adverse public perceptions of the drip torch. Most capsules fall through the shrubs onto the ground, and with the light and patchy litter layer in the heath fuels, there was a predictably low "take".

The drip torch is more effective at igniting the elevated fuels in the heath as the burning gel clings to the shrubs. When the capsule "take" dropped too low, the drip torch was used.

No SMC sampling was done, but the fires confirmed the SMC was low enough for fire spread (i.e. lower than the calculated values). The report from the helicopter at 1300hrs indicates conditions were marginal for the heath at that time, with a reported rate of spread of 30-40m/hr, flame heights of 0.2-0.3m up to 3m, 25% take on capsules.

Burning conditions continued to improve as the SMC fell in the early afternoon. At 1418hrs there was a hop-over along Left Handers Rd.

Edging on the ground was extended down the eastern boundary to Ellensbrook Rd. This included burning in the karri, which was carrying fire through the surface layers. Burning the karri at this time reflects the inexperience with this fuel type of the personnel involved. Whilst there was probably some relief that at last some fire was spreading, this was only a mild fire on the surface, with the profile moisture still being too high for sufficient fuel removal to provide a good edge. The result was an edge that could re-burn as the remaining duff layer dried out.

The helicopter track log below shows the areas where the aerial ignition was concentrated. Note the track log shows all the flight and does not distinguish between

lines where lighting was carried out, and ferry or inspection flights, but the concentration of the tracks is related to the burning.

From the time of the lighting on 15th, the burn was "live" and the District was committed to completing the burn unless there was significant (20-25mm) rain.

16th November

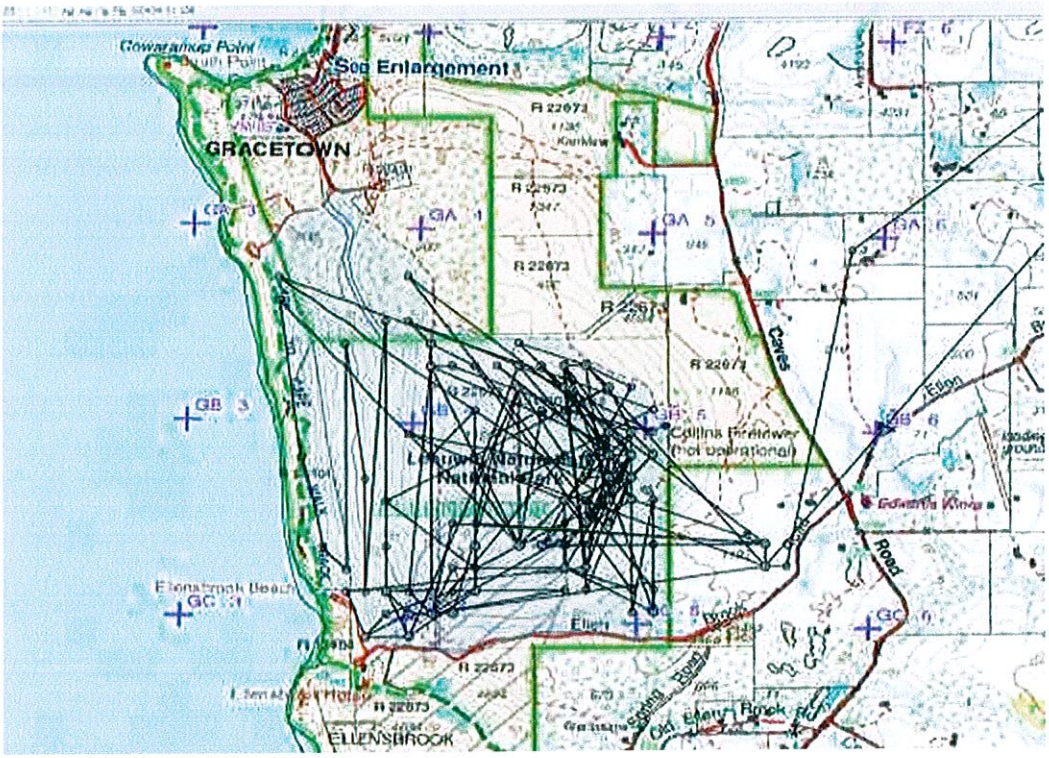

Figure 3: Helicopter track log 16/11/2011

The lighting on 16/11/2011 was carried out with a higher FDI than prescribed. Despite this, the central portion of the area would not burn.

Helicopter ignition commenced at 1153hrs. The last lighting was in the SW, at 1628hrs. Two lines were lit along the southern boundary between 1442hrs and 1449hrs.[5]

Several areas were successfully ignited from NS lines parallel with the Cape to Cape Track. Burning was carried out with WNW winds 20-30 km/hr, and several wind driven strips resulted (Fig 2). These strips burnt in the exposed heath on the western side of the burn, with only one penetrating into the peppermint heath areas.

The Karri areas carried fire, but this was too mild to remove the duff layer.

Ignition along the southern boundary was poor, with the SW corner remaining unburnt despite a concerted effort to light this from both the aircraft and ground ignition.

[5] Operations Officer diary

Figure 4: West to east wind driven strips in coastal heath in the fore ground.

The white areas in the background were burnt in the wildfire on 23/11/2011

17th November

Burn BS520 was reported as being completed[6] despite the fact that large areas remained unburnt. This suggests a breakdown in communications resulting in the District Duty Officer not having a clear picture of the situation.

19th November

Rain fell on 17th and 18th. Burning was planned for the 19th, with priority given to Prevelly, but this lighting was cancelled and so crews could check and consolidate other burns.

There was a flare up within BS520[7] at 1225hrs, indicating that, despite the SMC and FDI calculations, some fuels were dry enough to burn. The burn was definitely "live" and not completed as reported on 17th.

20th November

There was no ignition at BS520 on the 20th. Priority was given to BS255 (Prevelly). The intent was to "set up" Prevelly so both burns could be completed on the following day, thus maximizing the availability of both the helicopter and the suitable burning conditions before the forecast change in the weather.

The decision to proceed with BS255 is surprising in view of the forecast frontal movement and the number of burns that were "live" in the District at the time (BB243 Greenbushes, BS212 Abba, BS225 Boranup, BS520 Ellensbrook, BB105 Donnybrook, BB125 Milyeannup[8]). These six burns had not been inspected and certified to meet the mop-up standards as per FOG 24, and were noted in the District Duty Officer Handover of 22/11/2011 as needing a check. Strong winds and unstable conditions are known to be associated with troughs and frontal movements, and burning when such conditions are forecast is normally avoided. FOG40 (Edging) prohibits edging in unstable conditions ahead of lows and fronts associated with strong and gusty north westerly winds. In this instance it was not intended to leave an edge that could run, and it was considered the burn could be completed and mopped up before the winds swung to the north and the forecast strong winds arrived. Because of the previous lack of suitable burning days and the fact that there were adequate resources to carry out the burn, there was a strong desire to make use of the conditions and resource availability.

In my opinion there was too much focus on the ability to complete this task, and insufficient consideration of the overall picture. Resource requirements were only considered in terms of the requirements to carry out the immediate tasks related to the burns and did not consider the number of live burns and the resources that may be required in the event of escapes.

There are no current guidelines for the permissible number of "live" burns in the SW Region. Such guidelines were in place in the early 90's. They originated in the then Southern Forest Region (now Warren Region), where karri burns could be "live" for many weeks. John Tillman[9] advised he had revised the guidelines for the SW Region when he was Regional Fire Coordinator, to take into account changes subsequent to the

[6] Keelty transcripts: Henderson p5: DEC268b 17/11/2012
[7] Operation Officer Diary
[8] District Duty Officer Handover Statement
[9] J Tillman interview 23/2/2012

amalgamation and restructure of Districts. Neither Murray Mitchell nor Peter Gibson had any knowledge of such guidelines10.

Although there were subsequently escapes from BS255, these did not result directly in property loss. They did, however, divert suppression resources during the fire. The decision to proceed with BS255 also meant there was no attempt to consolidate the southern boundary of BS520 on 20th and commitment to BS255 affected the ability to burn BS520 on the 21st.

Indirectly, the decision to proceed with BS255, whilst well intentioned, contributed significantly to the escapes from BS520. At the same time, the fact that this area had been burnt probably prevented much greater losses in Prevelly when the fire came through.

21st November

On 21st it the Incendiary Operator Grant Eikelbloom was initially advised that ignition at BS520 was planned to commence at 1330hrs and at Prevelly at 1415hrs. This was changed when the helicopter arrived at the burn. The Operations Officer went for a reconnaissance flight at 1230hrs and briefed the navigator that Prevelly would be ignited first. Ignition at Prevelly commenced at 1356hrs and was completed at 1524hrs.[11] Ignition at BS520 commenced at 1527hrs in the northern part of the burn, and was initially successful, however there was little fuel left in the helitorch after ignition at Prevelly, and the helicopter was forced to land to re-fuel the torch.

When ignition operations recommenced at 1614hrs there was little take from the gel dropped. At 1628hrs it was recorded that fire was only burning mildly in ground fuels. The temperature and RH were steady between 1300hrs and 1500hrs, but conditions became cooler after 1500hrs, which would have resulted in an increase in the moisture content of the fine fuels. The temperature and relative humidity recorded at Witchcliffe and the corresponding SMC estimates as per the Field Guide (Gould et al 2007) are shown in table 7.

Table 7 Witchcliffe Temperature and RH% 21/11/2011

Table 5: Witchcliffe AWS 21/11/2011			
Time	Temp	RH	SMC (Vesta Models 1 & 2)
1300	22.2	52	9
1400	22.4	54	9
1500	22.1	53	9
1600	21.2	58	
1700	19.8	62	12.5
1800	18.5	67	14.5

The late lighting adversely affected the burn. Had the helicopter not been committed to the Prevelly burn and ignition had taken place at 1330hrs as planned, more of the area would have been burnt.

The BS520 chronology for the 21st states "continuous lines were established in the western and southern sections..." The southern section was reported as "largely unburnt despite the persistent attempts to achieve ignition in this area". Mr Mitchell also said "We had given it two very good cracks at it, in terms of attempts, and focused in the south-

[10] Keelty Transcripts Gibson p 19: M Mitchell interview 17/2/2012

[11] Incendiary Operations Supervisor Log and Diary

west corner"[12]. The helicopter track (Fig 5) and Incendiary Operations Flight Log/Diary do not support this. Whilst the track log for 16th (Fig 3) shows a concentration in the SW corner, this is not the case on 21st. On this day, four continuous lines were lit along the northern boundary approximately 20-30m apart, and the core lighting was on N-S lines along lines 150m apart, initially with 50m spacing, but then with continuous lines in an attempt to get better burn out. The diary does not refer to ignition in the SW corner, and the track log does not show any concentration of flight lines in this area (in contrast to the track log of 16th).

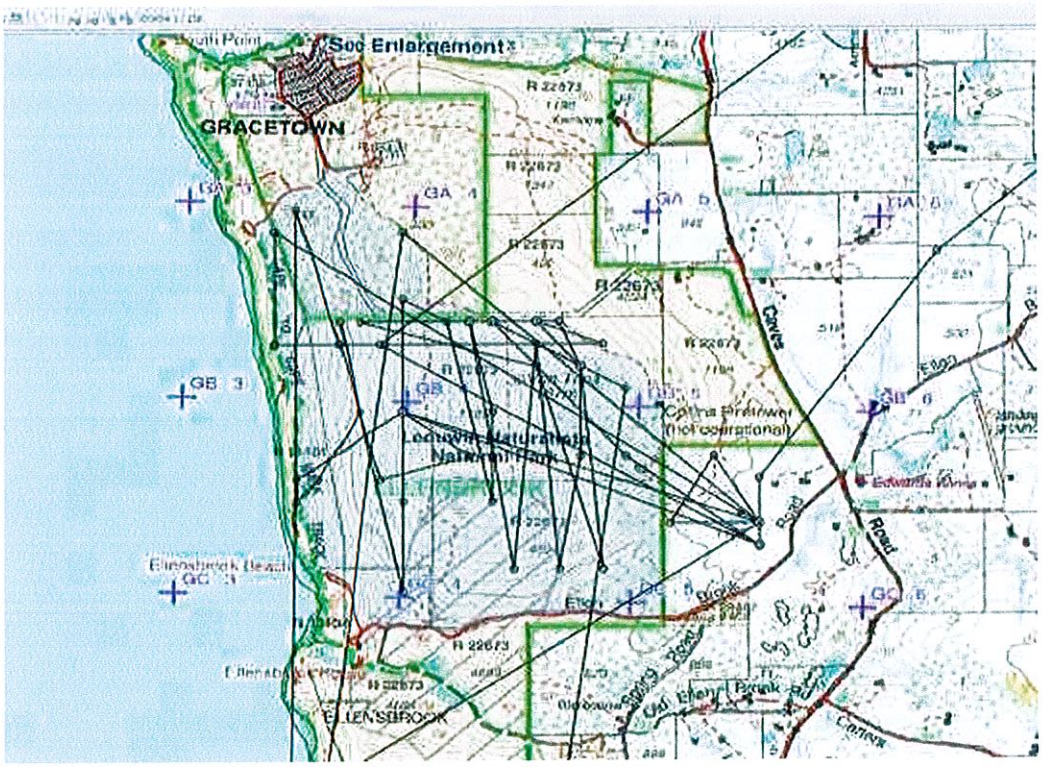

Figure 5: Helicopter track log 21/11/2011

The IO Diary also records that during the reconnaissance flight H1 (Grant Eikelbloom) noted no edge on Ellenbrook Beach car park or along the road from the car park back out to Ellenbrook Rd. B6 (Jeremy Chick) replied that he was not sure it would be done because of visual amenity issues. When interviewed by Mr Keelty, Mr Eikelbloom stated that he now understood he and Mr Chick had been looking at different areas[13]: Mr Chick was apparently referring to the section from the car park to the beach. That such confusion arose is surprising, as the burn boundary was the Cape to Cape walking track, and did not extend to the beach. Irrespective of whether Mr Chick was referring to a different area, it certainly did not reinforce a priority to concentrate lighting in the SW corner to get a good edge in this area.

In his 1700hrs report Mr Eikelbloom noted weak edge in the north, very mild burn in the east, a poor result in the central area, and largely unburnt in the southern half.[14]

[12] Keelty Transcripts: Mitchell p12
[13] Keelty Transcripts: Eikelbloom p3
[14] Incendiary Operations Supervisor Log and Diary

22nd November

No lighting was carried out in BS520 on the 22nd. Some hand lighting was carried out in BS255 to strengthen edges.

The burn was reported as completed in the early morning teleconference with no further ignition required.. After the teleconference Mr Eikelbloom advised the Regional Fire Coordinator Peter Gibson that this was incorrect: there were large areas unburnt, weak edges, and no edge between the Ellenbrook Beach car park and the Ellenbrook Rd.[15]

In view of the forecast, the District Duty Officer decided there should not be any more fire put into BS520. It had not burnt on previous occasions, and it appears he believed attempting to burn it now would also not result in a clean edge, and would only increase the risk of re-ignitions. He wished to have a day to mop up to try and make the burn secure.[16]

This was a difficult decision. Putting more fire in would certainly increase the potential for re-ignition and escape, particularly with fresh fire near the edge. However, there was live fire in the burn, large areas unburnt, and no edge on part of the southern boundary. The spotter reported smouldering logs at 1117hrs, and Ben Lullfitz saw smokes inside the burn that indicated mild running fire at 1300hrs. At 1455hrs the spotter reported no running fire, and "no concerns"[17]. This did not relate to the forecast conditions, but that there was no fire threatening any boundary at that point in time.

Just as it was not possible to mop-up after the ignition on 15th, it was impossible to eliminate all the potential re-ignition points on the 22nd and there was certainly a very high risk of re ignition and a fire run. The instructions to the crews to black out everything within 20m of the edge reduced the risk of an escape from the edging, but did nothing to prevent a fire run from re-ignition inside the burn.

The District Duty Officer (DDO) may not have had a sufficiently clear appreciation of the situation. Whilst he had been told by staff in the field that there were large areas unburnt, and a poor/no edge on parts of the boundary, he did not have the benefit of the coloured map showing the burnt/unburnt areas. The information on the daily program (DEC268) for 21st records only 50ha to be burnt. This indicates the DDO did not have a clear understanding of the size of the unburnt area. Further, he appears to have been under the mistaken impression that the burn on the 21st was far more successful than it was. In his handover notes he states "Burn was rollown 21 November with drip torch with good ignition." The latter part of this statement was incorrect.

The lack of success with the ignition on the 21st was due to the late lighting. Some success was achieved in the short time before the Helitorch ran out of fuel. On the 22nd the forecast conditions for Witchcliffe for issued at 0750hrs were:

Temp	26		
RH	30		
Winds	1300	E	8
1500	SSE	15	
1700	SSE	18	
SMC	9%		

[15] Keelty Transcripts: Eikelbloom p11
[16] Keelty Transcripts: Mitchell p12
[17] BS520 Chronology

The actual weather conditions recorded at Witchcliffe s between 1200hrs and 1700hrs for the 16th, 21st and 22nd of November are shown in Table 8. The SMC values are derived from the Field Guide (2010 op cit). These values are lower than the values calculated from the Forest Fire behaviour Tables.

The burning conditions on 22nd were better than any of the previous days on which burning was undertaken. Had burning been carried out under these conditions, at the very least the large unburnt area can have been expected to be broken up, and an improved edge on the southern boundary achieved. There is no guarantee however, that this would have resulted in a satisfactory edge. In view of the difficulties in getting the heath to burn, particularly on 16th, it is doubtful that a clean edge would have resulted. It could be expected that some wind driven strips would have resulted that would help break the run of any fire that subsequently developed, but it is likely patches of vegetation near the edge would remain unburnt. This means a lot of hot spots near the edge would need to be mopped up, with little time to do so thoroughly.

Table 8: Afternoon weather 16, 21 and 22 November

Witchcliffe AWS Records					
Hr	Temp	RH	Wnd_Spd	Wnd_Dir	Vesta SMC
16/11/2011					
12	19.9	55	24	310	9.5
13	20.8	51	30	330	8.5
14	19.8	53	30	310	9.5
15	20.4	59	22	310	10
16	18.7	65	22	310	10.5
17	18.4	69	21	310	11
21/11/2011					
12	20.7	56	18	110	9.5
13	22.2	52	22	150	9
14	22.4	54	21	130	9
15	22.1	53	21	140	9.5
16	21.2	58	26	170	10
17	19.8	62	28	160	10
22/11/2011					
12	24.5	52	13	250	8.5
13	25.6	50	13	190	8.5
14	25.8	51	17	210	8.5
15	25.8	49	17	170	8.5
16	24.8	50	15	170	8.5
17	23.8	53	13	180	9

23 November 2011

Pre-preparation

The forecast conditions for Witchcliffe issued on the 22nd for the following day were:

Issued at 1615 hrs 22/11/2011

Sunny	
Temp	31
DP	1
RH	18
Wind am	NNE 30
Wind pm	N 30
Issued at 0750hrs 22/11/2011	
0300 hrs wind	ENE 13

The handover statement prepared on 22nd for the incoming duty officer on the 23rd advised that all external crews had returned to their home district. It noted "none of the burns had been tested with north side winds and any temperature."[18] Seven burns were identified as requiring a check.

The outgoing duty officer, Mr Mitchell, set up a structure for the incoming duty officer which predetermined where trucks were going[19]. Two trucks were to go to BS520 departing 8am. Mr Mitchell did not consider it warranted to start crews early based on the forecast conditions and based on the fire behaviour over previous days. The overnight winds were forecast to be 13km/hr, not significantly different from the 10-11km/hr on the previous 6 nights, and considerably less than the 28km/hr forecast for the night of 16th /17th. There were no reports of fire running around on 17th after ignition on 16th.

The decision not to keep crews at Ellensbrook overnight was a reasonable decision. Whilst smokes were noted within BS520 the Blackwood spotter reported no running fire at around 14.55hrs[20]. With increasing humidity overnight there was no expectation of a fire running overnight. Had crews been committed to Ellensbrook overnight they would not have been available the following day.

It would have been prudent to start some crews early in view of the forecast winds and the travel times from Busselton to the burn site. The duty officer was lulled into a false sense of security by a lack of fire activity until later in the day during the previous week. It was a reasonable expectation that there would not be any activity until the temperature rose and the fuels started to dry out. There was no indication in the forecast of unusual overnight conditions.

Overnight Weather Conditions

Weather records from the Witchcliffe AWS show that the relative humidity overnight followed a similar pattern to that of previous nights until early morning when there was a marked drop. Between 0600 and 0800 the RH dropped 49% from 83% to 34%. The *minimum* RH recorded for any day in October and November prior to the 23rd was 32%, and this occurred mid afternoon. There were only 4 days when the *minimum* RH fell below 34% (to 32 or 33%).

Figures 6-8 show the overnight RH trace for the period midnight to 10.00 am for the 21st-23rd November. The traces for all the rainless nights in the preceding several weeks are similar to the traces for the 21st and 22nd and quite markedly different to the 23rd.

[18] Blackwood Duty Officer District handover 22nd Nov 2011

[19] Keelty Transcripts: Mitchell p 13

[20] B520 chronology

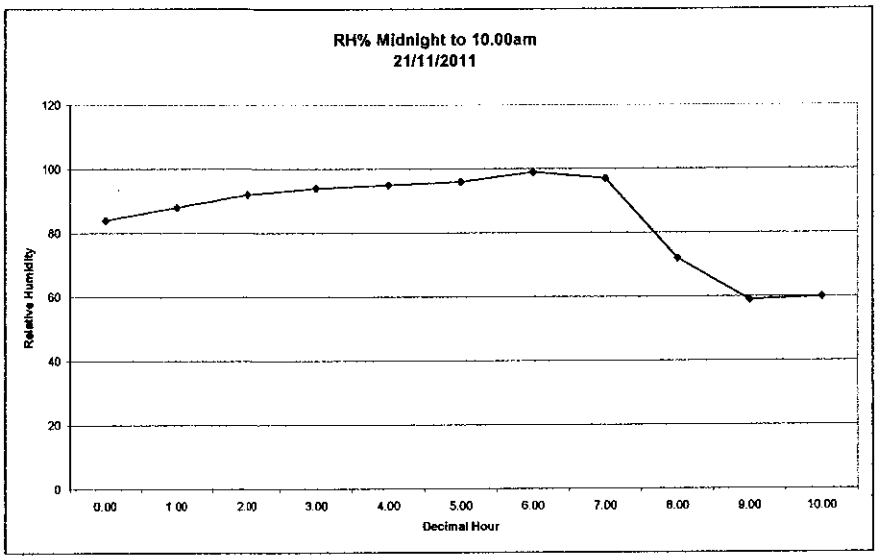

Figure 6: ORH 21 November 2011

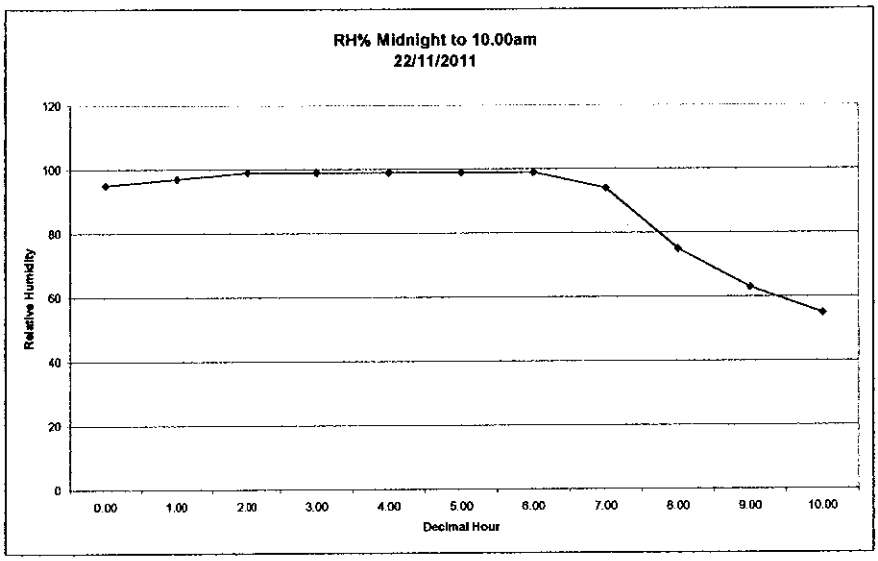

Figure 7: ORH 22 November 2011

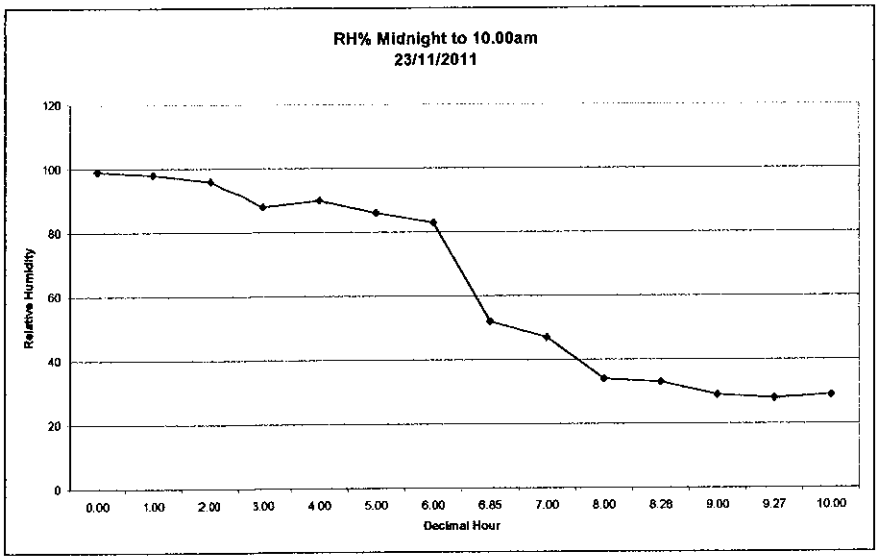

Figure 8: ORH 23 November 2011

The drop in RH resulted in a rapid drying of the fuels. Accompanying the drop in RH was a change in the winds. Until 3.00 am the winds were very light south easterlies, followed by a period of calm. Just before 7 am the north east and then north, rapidly increasing with gusts to 60km/hr.

The conditions between midnight and 10.00am are shown in table 9. The SMC values have been determined from table M3 in the Field Guide (2010)

Table 9 Witchcliffe Weather 00.00 to 10.00 23/11/2011

Hr	Min	Temp	Wet_bulb	RH	Wnd_Spd	Wnd_Dir	Wnd_Gust	Vesta SMC
0	0	15	14.9	99	8	140	9	20+
1	0	13.9	13.7	98	5	140	8	20+
2	0	14.6	14.3	96	5	100	11	20+
3	0	13.7	12.6	88	5	130	8	20
4	0	12.8	12	90	0	0	0	20
5	0	13.1	11.9	86	0	0	0	19
6	0	15.7	14.1	83	0	0	0	18.5
6	51	20.7	15.1	52	11	40	15	12
7	0	21.4	15	47	13	40	24	11
8	0	24.7	15.7	34	24	30	35	8.5
8	17	25.1	15.9	33	28	20	48	8
9	0	27.4	16.8	29	37	10	50	7.5
9	16	27.3	16.6	28	37	10	61	7.5
10	0	28.6	17.7	29	41	10	59	7.5

It is probable that the sudden large drop in relative humidity and rapid increase in wind strength was a result of "mixing down" of dry air from the upper atmosphere. The 22/11/2011 2300UTC aerological diagrams for Perth and Albany airports show a very dry air mass above about 10,000 ft ASL, a weak inversion, and wind shear below the inversion at around 8000 ft., with strong upper level NE winds between 2000 and 6000 ft.

The Haines Index has been used in the US to link vertical atmospheric stability and humidity with erratic fire behaviour. The parameters for this index have been found to be poorly configured to discriminate extreme conditions in SW Australia. An extended Haines Index, C-HAINES has been proposed which may provided additional and independent information to that provided by the traditional fire danger indices, particularly in conditions where unexpected night time flare ups have occurred (Mills & McCaw (2010)). Mills and McCaw found good correlation between C-HAINES and erratic fire behaviour in the limited data set examined. Unfortunately the C-HAINES value is not provided as part of the forecast. Had it been, it may have alerted the Duty Officer to the likelihood of unusual conditions, as there were very high values for C-HAINES on 22nd November, with the 2300UTC values being 11.5 for Perth and 10 for Albany (compared with an upper limit of ~ 13).

By 9.00 am when the first crews arrived, conditions were extreme. The predicted potential rate of spread in shrublands at this time was around 4000m/hr, with flame lengths over 14m.[21]

[21] FOG 21: Fire behaviour guidelines for mallee heath and other shrublands in southern Western Australia

Re-ignitions

Re-ignition resulting in major fire runs occurred from at least three locations (A, B, and C in Fig 9).

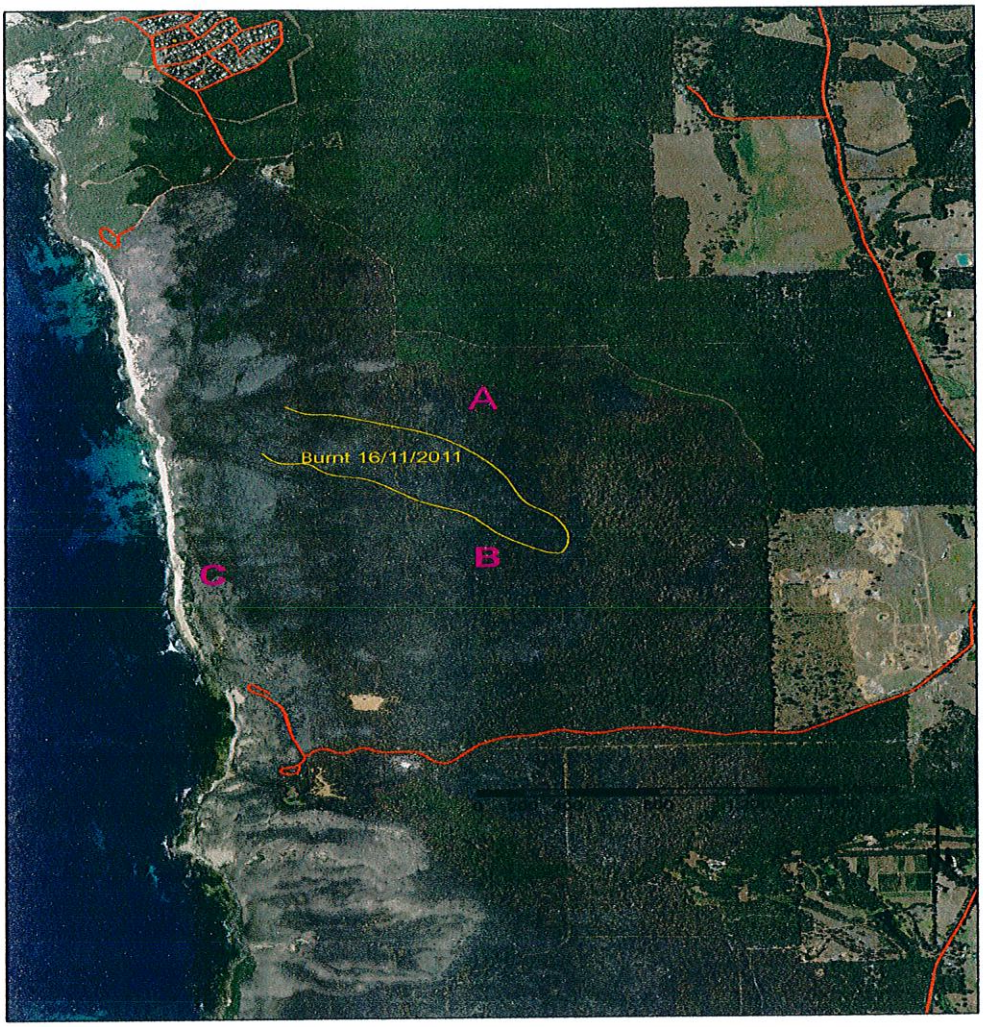

Figure 9: Aerial view BS520 post 23/11/2011

A, B & C indicate areas of re-ignition. W-E fire scars from the burn on 16/11/2011 are evident in the coastal heath. The strip that extended into the peppermint heath is indicated in yellow.

It is likely there were several point of ignition along the north eastern boundary (A). Some of the fire would have run into the wind driven buffer burnt on the 16/11/2011, and this would have stopped the fire run on the western side. There was, however, a N-S fire run that passed to the east of this buffer. Ignition also occurred on the southern side of the buffer, in the vicinity of point B in Fig 9. The distance from point B to the Ellenbrook Rd is over 1100m.

The fire run which crossed the road at the Ellenbrook Beach Carpark originated on the south side of one of the wind driven strips from the prescribed burning at point C. The distance from point C to the car park is approximately 700m.

When fires start, they are small, and can usually be controlled if they can be quickly reached with a fire unit. This was not the case with the fire origins in this case, even had fire crews been present. Under strong wind conditions such as on the morning of

23/11/2011, fires can escalate rapidly. The distance between the origins and Ellenbrook Rd was such that the fires had the opportunity to grow large before they could be tackled.

Initial Response

Melissa Manns checked the Prevelly burn at 0800hrs. She mopped up a smouldering log but there was no other fire activity in the burn at this time. She then proceeded to BS520 and en route saw the column of smoke. She needed to refuel in Margaret River and did not arrive at Ellensbrook until 0920.[22]

Fire Unit 34 (John Paice and Simon Grey) had arrived at the fire before her. They reported the fire was in the beach car park and across the road.

John Paice and Simon Grey[23], the first arrivals at the fire, are relatively inexperienced. John Paice started on a crew in October 2010. Simon started as a seasonal in 2007 and became a permanent crew member in 2010.

On the way the crew was stopped by a member of the public who said there was a car in the car park. They thought this meant the surfers car park (Ellenbrook Beach car park) but it was in fact at the Ellensbrook House car park. When they arrived at the surfers car park the central island was fully engulfed with flames 2 – 3 times the scrub height (6 – 9m)., and with two hop-overs to the south of the road, approximately 6m apart.

The driver, John Paice, considered the fire behaviour was too dangerous to remain there and withdrew to Ellenbrook Rd after checking there was no vehicle in the car park.

The second crew to arrive was a Busselton crew (Julian Harrison, Tim Hutton, Tracey Klingner).[23] Mr Harrison has more than 10 years experience and has been acting overseer for the past 15 months. They were approximately 10 minutes behind the Margaret River crew. When they arrived the central island had been burnt. Simon Gray joined the crew and they attempted to control the hopovers on the south side of the road without success. They also noted a hopover on top of the dune beyond the surfers car park.

Acting Overseer Harrison noted a fire front approaching the road between the car park and Ellenbrook Rd, which he considered posed a threat to the safety of the crew, which then withdrew to Ellenbrook Rd.

The Margaret River and Busselton crews arrived at the fire at approximately 0900. It is possible that had experienced crews been present earlier they may have been able to control the initial hopovers. Even had the initial hop-overs been controlled, the fire would have escaped. The fire was spotting some distance south of the road. The Busselton crew reported spotting around 0900hrs, and at 12.05 M Manns reported " numerous hop-overs south of Ellensbrook Rd, not able to get hop-overs, very deep and large".[22] The fire re-burnt forest areas that had been previously burnt under mild conditions and spotted over Ellenbrook Rd.

When the initial attack failed, Melissa Manns directed John Paice (BW34) to block Ellenbrook Rd and BW30 was assigned to asset protection around Ellensbrook House.

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[22] M Manns Fire Diary and interview notes

[23] Interviews 10/2/2012

The initial attempts were to keep the fire west of the car park. By 11.35 there were six units on the Ellensbrook Rd sector.

The Incident controller noted at 1145hrs the threat to Prevelly and Gnarabup subdivisions with Ellenbrook Rd to the north, and strong, hot NNE winds, and sent resources and a designated operations officer to Prevelly.[24]

At 1200 it was reported by Ben Lullfittz that hopovers (from BS255) at Borden Drive were under control, and no sign of fire behaviour (in the burn?) at the moment.[24]

Spotting across Ellenbrook Rd occurred in several places with M Manns reporting at 12.25 "most eastern hopover 800m west from south east corner" (of the burn).[25]

Discussion and Conclusions

The escapes from BS520 arose from re-ignition of a partly completed prescribed burn under conditions with low humidity and strong winds. The overnight / early morning conditions were unusual and not forecast. The extended Haines index (C-Haines) has been associated with erratic fire behaviour and may provide a forecast tool to warn of the possibility of such conditions favouring such occurrences, but is not currently used.

Large unburnt areas within the boundaries of the burn allowed a long fire runs to develop, with an associated increase in the severity of the fire behaviour. When the fire reached Ellenbrook Rd it could not be controlled. The first crew did not arrive at the fire until after the fire had crossed the road near the Ellenbrook Beach carpark. Whilst it may have been possible for experienced crews to control the initial hop-overs had they arrived earlier, this would not have changed the final outcome. In the conditions on the day, spot fires can be started many hundreds of metres or even kilometers ahead of the fire front. The fire crossed Ellenbrook Rd, with spotting deep into the bush on the south side, whilst there were six units on the sector.

The standards for a burn are defined by the objectives and standards in the prescribed fire plan, and by the fire operations guideline 24 (FOG 24 Prescribed Burn and Bushfire Security). The objectives for BS520 stated the acceptable standard was that at least 60% of the area be burnt. FOG24 states there shall be no unburnt pockets within 100 metres of the boundary irrespective of fuel type. Within 100–200 metres unburnt pockets are not to exceed 0.5 hectares in forest and 2 hectares in heath. From 200-500 metres from the boundary unburnt pockets are not to exceed 5 hectares in forest and 10 hectares in heath. Between 500-1000 metres pockets in hardwood are not to exceed 10 hectares. Beyond these limits the burn should meet the standard set out in the objectives for the burn.

The burn standards are intended to minimize the risk of fire runs developing if there are re-ignitions under adverse weather conditions. Clearly these standards were not met, with an unburnt area of 170 plus hectares extending to the southern boundary. Had the burn been completed to the required standard it is unlikely that it would have escaped the boundaries.

There were a number of contributory factors to the burn not meeting the standard.

- **Weather conditions:** There was an extremely mild start to spring resulting in few days suitable for burning. It is probable that a burning opportunity was

[24] Fire Diary, PA to incident controller.
[25] M Manns Fire Diary

missed in late October. It is also possible that there were other burning opportunities, as decisions were based on SMCs calculated at Kirup, and conditions at the burn were not the same. However, overall there were very limited opportunities for burning.

The officers involved with the burn did not undertake any field fuel moisture sampling at this burn but relied on the predicted SMC and observations of fire behaviour. There was very poor success on most of the ignitions as the SMC was either marginal or above the threshold level for the heath fuels.

- **Burn Implementation Plan**: There were a number of deficiencies in the burn implementation plan that indicate completing the document has become an overly bureaucratic exercise prone to errors, but these did not directly contribute to the escapes. There were three key areas which had a direct impact.
    - The prescribed fire conditions were based on forest fuels. Whilst it is acceptable (and desirable) to relate the burning conditions to the FDI to allow ready comparison with other burns, greater attention needs to be paid to describing the conditions required for heath fuels. Unlike forest fuels, there is only a very narrow range of SMC's that are suitable for burning heath fuels. Had an SMC been specified more attention may have been paid to the fuel moisture conditions on the days of the burn.
    - The lack of scrub rolling on the boundaries made it virtually impossible to obtain a clean edge to meet FOG 24 standards. The difficulties were not identified in the prescription, instead the focus was on reasons why scrub rolling should be avoided. This made the burning a much more difficult and high risk operation than necessary. Even if a clean edge was only possible in the modified (scrub rolled) fuel, it would have provided a break of sufficient width to avoid fire spread through direct flame contact in the heath, and greatly reduced the amount short distance spotting across the break.
    - Pre-suppression strategy. The strategy failed to consider the potential rate of spread in the event of an escape. It considered only the immediate environs, and did not consider the assets at risk in the event direct attack failed. The strategy proposed indirect attack if direct attack failed, but did not consider the requirements for such a strategy to work. Upgrading of tracks was not included as a requirement in the plan. The strategy was seriously flawed.
- **Prevelly Burn:** The impact of the Prevelly burn on BS520 on the subsequent wildfire was twofold. It impacted the conduct of the burn and split resources during suppression. No burning in BS520 was attempted on 20th November because priority was given to burning Prevelly. On 21st it was intended to ignite both Prevelly and BS520, and again priority was given to Prevelly. By the time the helicopter was available for BS520 conditions were less favourable and ignition met with only limited success. Whilst conditions on 20th were probably marginal it is likely there would have been some more break up of fuels with intensive ignition, and would have provided an extra day to mop up before the forecast strong winds. Certainly much more could have been achieved on 21st if efforts had been concentrated during the peak burning time. This would have resulted in a further break up of the unburnt areas reducing the potential for long

fire runs. It is doubtful however, that without the fuel modification of scrub rolling, a satisfactory edge would have been achieved.

- **No Burning on 22nd November:** The decision not to burn on 22n , which presented the best available burning conditions, is understandable. There was a considerable risk from extra fire near the edge, just as there was a risk of re-ignitions resulting in long fire runs. Whatever decision was made on this day had a serious risk attached to it. In my opinion it would have been preferable to burn on 22nd in order to try and prevent major fire runs. It is my view that the additional fire near the edges posed a lesser risk which could be better managed by crews either mopping up all night, or starting early and continuing with mop up on the morning of 23rd. Fires re-igniting near the edge have a lesser potential to develop into large fires with long spotting distances, and are easier to control. I do not, however, criticize the decision that was made. Lighting on 21st would have guaranteed more re-ignition, and if as unsuccessful in breaking up the fuels as the previous ignitions, would have compounded the problems.

- **Staff Experience**: The majority of the staff involved with the burn had very little prior prescribed burning and fire experience, particularly in coastal fuels. Overall the Blackwood District has limited experienced staff with only one Level 3 Fire Operations Officer being available. There has been a high turnover of both staff and fire crews with less than 20% of the crews having more than 10 years experience.[26]

  The lack of experience of the staff contributed to the attempts to burn under conditions that were too mild to achieve burn objectives. Burning under mild conditions in the karri fuels allowed the fire to reburn in this area on 23rd and spot over Ellenbrook Rd.

The fact that the burn was not / could not be completed to the desired standard by the 23rd allowed the fire runs, but it was the strong winds and low humidity that determined the fire behaviour and suppression difficulty. The actual conditions were far more severe than forecast. The temperature and minimum relative humidity were as forecast, albeit the humidity dropped to a low level early in the morning and stayed low, however the wind was 50% stronger than forecast. A 50% increase in wind speed translates into a doubling of the forward rate of spread of a fire. Effectively conditions were twice as bad as forecast.

Ultimately, whilst it may have been possible to have more breakup and a better edge, it was the weather conditions which were the key factor in the escape. Preceding weather conditions were not conducive to the burn meeting the desired standard and this was followed by unusual conditions of very low morning humidity and strong winds that were not forecast.

[26] B Commins interview 17/2/2011

Cruz, M G ,Matthews, S Gould, J, Ellis, P, Henderson, M, Knight, I, Watters, J.(2010) *Fire Dynamics in Mallee Heath.* Bushfire CRC Report No. A.10.01

Gould, J S, McCaw, W L, Cheney N P, Ellis, P F, Matthews, S (2007) *Field Guide: Fuel Assessment and Fire Behaviour Prediction in Dry Eucalypt Forest.* Ensis–CSIRO, Canberra, ACT & Department of Environment and Conservation, Perth WA.

McCaw, W L (1997) *Predicting Fire Spread in Western Australian Mallee Heath Shrublands.* PhD Thesis University College, University of NSW

Mills, G A & McCaw L, (2010) *Atmospheric Stability Environments & Fire Weather in Australia – Extending the Haines Index.* The Centre for Australian Weather and Climate Research Technical Report No. 20, CSIRO & Bureau of Meteorology.

Sneeuwjagt, R J & Peet, G B (1985*) Forest Fire Behaviour Tables for Western Australia,* Department of Conservation & Land Management, Perth WA

Appendix

List of Materials Received

Volume 1

BLACKWOOD FIRES FOLDER

1. Chronology and background for Prescribed Burn BS520
2. Prescribed Fire Plan – BS520
3. Spring Burning XLS spreadsheet
4. Teleconference sheets
5. DEC 268s – Final Programs
6. DEC 268b's – Summary of Yesterday's burns
7. DEC 301s – Daily Aircraft Burn requests
8. AM/PM Forecasts 14-28 Nov 2011
9. Spot Forecasts
10. Weather Warnings
11. Spotter Daily Worksheets
12. Flight Logs
13. Metars
14. Burn Implementation Plan - BS520 Ellensbrook
15. Pre Burn Checklists BS520 as @ 3/6/11 and 1/9/11
16. DDO Diary Notes
17. Blackwood DDO Handover Statement 22/11/11
18. Daily Moisture Content Record Sheets 16-29 Nov 2011
19. Late Lighting Scenario
20. BS520 – Ellensbrook Operations map
21. Prescribed Fire Plan – BS255 Prevelly
22. Burn Strategies – BS255 Prevelly
23. Prevelly Pipeline Infrastructure
24. Prescribed Fire Plan – BS225 Boranup
25. Prescribed Fire Plan – BS125 Milyeannup Sollya
26. Prescribed Fire Plan – BS015 Donnybrook

Volume 2

1. CD Ellensbrook-Prevelly Bushfire Aerial Images

2. Forecasts 1545 20-23 Nov 2011
3. Forecasts 0745 23-24 Nov 2011
4. Spot Forecast 23-24 Nov 2011
5. Witchcliffe Daily Weather Observations
6. Soil Moisture Calculation Sheets 12/10-20/12/2011
7. Bureau of Meteorology Fire Weather Directive
8. Graham Mills – *Easterly changes over elevated terrain in Australia's south east*
9. Bushfire CRC – *Fire Dynamics in Mallee Heath*

Volume 3

1. Prescribed Fire Plan BS520 Ellensbrook
2. Duty Officer's Diary Notes
3. Prescribed Burning Organisational Structure BS520 Ellensbrook
4. Yallingup Local Weather Forecast
5. BS520 Ellensbrook Edging Records
6. Duplicate Burn Implementation Plan BS520 Ellensbrook
7. BS520 Pre Sign Off Action List (pre Spring)
8. Prevelly BS255 Burn Strategies
9. Maps BS520 Ellensbrook Flightline Plan/API plan

Volume 4

1. Bureau of Meteorology *Atmospheric Stability Environments and Fire Weather in Australia- extending the Haines Index*
2. DEC *Review of Fire Weather Services Required to meet the Statewide Operational Requirements of the Department of Environment and Conservation* Draft 1.10 (6/8/2010)
3. *Dry Slots* (1) *Continuous Haines Index* (2) *and Dry Lightning Environments* (3) Graham Mills (1,2,3) Lachie McCaw, DEC (2) Andrew Dowdy (NCC) (3)

Volume 5

1 Copy of Diary Entries – Melissa Manns

2 BS520 Ellensbrook Operations Map – Estimated Burn Area as at 21/11/11

3 BS255 Prevelly Operations Map – Ignition Areas 20/11/2011- 21/11/2011

4 BS520 Ellensbrook Operations Map – Ignition Areas 15/11/2011-21/11/2011

5 Incendiary Operations Flight Log 21/11/2011

Maps

1 Ellenbrook Fire BWD008 - Final boundary

2 Asset loss map as at 15.30 25/11/2011 – Ellenbrook Fire BWD008

3 Indicative prescribed burn program – Spring 2011

Transcripts of Keelty Interviews Vol 1

1. Don Boothey
2. Peter Simmonds
3. John Nguyen
4. Jeremy Chick
5. Robert Klok
6. Grant Eikelbloom
7. Keiran McNamara
8. Bob Chandler
9. Lachlan McCaw
10. Terry Maher
11. Murray Carter
12. Peter Henderson
13. Peter Gibson
14. Brad Commins
15. Brett Trunfall
16. Stephen Graham Tate
17. Murray Mitchell
18. Ian Earl

Transcripts of Keelty Interviews Vol 2

1. Stephen Fraser Blythe
2. John Carter
3. Lyndon Rowe, Christine Rowe
4. Clare Forward
5. Jeremy Chick
6. John Stanley Bradbury
7. Stephen Mills
8. Megan O'Connor
9. Melissa Manns

10. Grant Eikelbloom
11. Ben Lullfitz
12. Tony Byrne
13. John Prins
14. Robert Bootsma
15. Greg Mair
16. John Tillman
17. David Holland
18. Brendan Jordan
19. Graham Reader, Andrew Burton

Electronic Records

1 AWS Data HM01X_hourly_Witchcliffe_2011
2 BoM Report: Meteorological Aspects Margaret River Fires
3 Ellensbrook Fire Nov 2011: Map & Photos from J Tillman
4 Ellensbrook Sign & Fuel Sampling map.
5 Blackwood Spring Burn Summary: Excel spreadsheet
6 Blackwood Spring burn summary map
7 BS521 Map
8 BS520 Map
9 BS520 map portion
10 ISO-31000 Risk Management
11 Weather conditions report BS 520 L McCaw
12 Chronology and background – Prescribed burn BS255
13 FOG 90 Guidelines for Managing Hazardous Trees
14 FOG 80 Rostered Officers 2011 FINAL
15 FOG 79 Prescribed Fire Plan March 2009
16 FOG 67 Protection of Telstra Elevated Joints within CALM's Burn Area
17 FOG 65 Hazardous Trees Walking Roads 2011 FINAL
18 FOG 54 Standards for Coupe Preparation For Post Harvest And Regeneration Burning
19 FOG 45 Burning condition limits for the approval and conduct of Prescribed burns during prohibited burning tables
20 FOG 41 Limitations on application of forest fire behaviour table Calculations
21 FOG 40 Edging
22 FOG 39 Direct measure of surface litter content

23	FOG 38 Measurement of Profile Moisture Content
24	FOG 37 Slash burn guidelines
25	FOG 33 Pine Hazard Plans
26	FOG 30 Liaison with the bush fires service, local authorities and brigades
27	FOG 27 Aerial Burn Plan Legend
28	FOG 24 Mop Up 2011 FINAL
29	FOG 23 Measurement of Forest Fuel Quantity
30	FOG 22 Vesta 2011 FINAL
31	FOG 21 Mallee-Heath 2011 FINAL
32	FOG 18 Forecasts 2011 FINAL
33	Diary Shift 1 IC 23 - 29 Nov
34	Diary Shift 2 IC BWD008
35	Diary PA to IC Shift 1 BWD008
36	Diary PA to IC Shift 2 BWD008
37	Diary Ops Officer Shift 1 BWD008
38	Diary Ops Officer 2 Shift 2 BWD008
39	Witchcliffe AWS Forecasts and Actual Comparison
40	Diary J Chick 15 and 16-11-11_19,20 and 21-11-11
41	FEA Roster
42	Aircraft track 15 Nov Ellenbrook
43	Ellensbrook flight 16 Nov track file
44	Ellenbrook 21 ignition track file
45	DVD Margaret River Fires Dec 2011 Near Real Imagery
46	CD Ellenbrook Fire Boundary, Fuel Age July 2011, Master Burn Plan Spring 2011

Chris Muller

From: "Chris Muller" <cmconsult@gmail.com>
Date: Monday, 16 July 2012 11:52 AM
To: "Andrew Shuy" <a.shuy@sso.wa.gov.au>
Attach: FOG 24 Mop Up 2011 FINAL.pdf
Subject: Ellensbrook Fire

Further to our telephone conversation, it would appear some elaboration/clarification re edging is warranted.

Edging is an essential component of burn security. Without good edges, there is an extremely high risk of the burn escaping.

Edging is normally carried out in advance of the core lighting. Where possible, edging for a spring burn is undertaken the previous autumn, where there is a much lower risk of an uncontained edge continuing to burn and cause control problems with "blow up" conditions. Not only are such conditions less likely, but the increasingly cooler nights and higher humidity mean the edge is less likely to continue to burn.

Edging may be done on the day of the burn, but at least the downwind edge should be established before the core lighting. Undertaking core lightings without a suitable edge first being established carries a very high risk of escape.

There are situations where undertaking core lightings without an edge around the full perimeter is unavoidable. This is primarily the case in "mixed fuel" burns involving karri types which dry far more slowly than the more open jarrah forest and flats.In these situations it is necessary to burn the drier fuels, sometimes several weeks before the karri is sufficiently dry to burn. Because of the difficulty of edging karri fuels with a dense scrub understorey, it is normal to scrub roll the sections of boundary that have such an understorey well in advance of the burn. Theis edge preparation requirement should show in the prescription.

A good edge is critical to a safe burn, but a good edge alone does not guarantee the safety of the burn. It is also essential that the risk of an escape from spotting from within the burn is minimised. Spotting occurs when firebrands are carried aloft and thrown some distance ahead of the fire. The extent of spotting is dependant on suitable material and the energy release of the fire. The higher the energy, the greater the potential spotting distance. This is the reason for the maximum allowable size of unburnt pockets in the mop up standards (FOG 24 attached) being smaller closer to the boundary. Smaller pockets restrict the development of a fire.

The mop up standards also illustrate the differences in fuel types. Karri/Tingle fuels have the greatest potential for distant spotting, grass the least.

Ellensbrook Fire

The lack of edging on the southern western boundary contributed both directly and indirectly to the escape.

Directly: In the "pure" heath fuels the prime method of spread is through direct flame contact. There is limited short distance spotting, usually associated with the scattered low trees. A wide (100m+) clean edge will not only prevent fire spread through flame contact, but will catch the majority of the short distance spotting. Had there been such and edge, and crews present at the burn early in the morning, they may have been able to control any hop-overs in the before they developed.

The only guaranteed way to achieve a suitable edge in the heath/shrubland fuels is to scrub roll well in advance of the burn. It is unlikely 100m wide (or any?) scrub rolling would be acceptable in this area. The narrower the "clean" edge, the greater the likelihood of spotting over the edging.

In the woodland/forest areas the potential spotting distances are much greater. A good edge will reduce the number of hop-overs, but if a fire develops spotting over edging can be expected. The large unburnt areas within the burn allowed the fire to develop, spotting beyond the crews that were present along Ellenbrook Rd later in the morning of the 23rd . In these conditions, better edging alone would not have prevented the escapes.

Indirectly: The lack of edging restricted the ability to break up the core. Initial efforts were directed at establishing an edge along the northern boundary with southerly winds. Until there was an adequate edge the threat to Gracetown from lighting on southerly winds was unacceptable. No lighting was attempted at this time

along the southern boundary (or southern core).

Regards

Chris Muller

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