NATIONAL BURNING PROJECT

Australasian Fire and Emergency Service Authorities Council (AFAC)
***and* Forest Fire Management Group (FFMG)**

National Guidelines for Prescribed Burning Operations:
Case Study 1 – Bush-urban interface burning in the Blue Mountains of NSW

National Burning Project: Sub-Project 4

An Australian Government Initiative

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This document is constructed by GHD from consultation and research between Forest Fire Management Group (FFMG) and AFAC, its member agencies and stakeholders. It is intended to address matters relevant to fire, land management and emergency services across Australia and New Zealand.

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This case study has been prepared by Paul de Mar (GHD) and Richard Kingswood, Glenn Meade, Arthur Henry and Duncan Scott-Lawson (NSW National Parks and Wildlife Service). It incorporates burn operations planning and implementation practice information as well as the relevant fire science on which current procedures have been founded. It focuses on prescribed burning in public land managed by NSW National Parks and Wildlife Service (NPWS).

1 Risk management overview

The NSW Blue Mountains area is one of the most complex and challenging landscapes in Australia to plan and carry out fire management. Factors contributing to the high level of fire management complexity include:

- Communities and assets that are embedded in a highly fire prone landscape in which large fires can, and do develop;
- Thousands of dwellings at the perimeter of urban areas with high fire-vulnerability (built before regulations for planning and building in bushfire prone areas were introduced);
- Settlements situated on ridges above steep slopes with dry sclerophyll vegetation supporting runs of fire;
- Complex topography with exposed plateaus dissected by deep inaccessible gorges restricting safe ground access;
- Summer season weather patterns in which widespread electrical storms cause multiple fire ignitions, which can then be followed within a few days by severe fire weather;
- Extensive World Heritage and Wilderness declared areas with high biodiversity and heritage conservation values surrounding mountain townships;
- Landscapes with iconic tourism values which attract a wide range of tourism types including multi-day walkers and adventure tourism activities which can situate visitors in remote parts of the fire-prone landscape;
- Very high water catchment values, being Sydney’s main drinking water catchment;
- A history of frequent, large, high-consequence fires, with bushfire related deaths and major property loss events occurring on a roughly decadal basis;
- Multiple and complex smoke management issues including tourism industry sensitivity to smoke impacting visual amenity; smoke hazards impacting major arterial roads and public transport routes, and landform which can carry concentrated smoke drifts down to densely populated areas in the Sydney basin; and
- Widely varying community views regarding the utility of prescribed burning with many urban-edge communities preferring the visual amenity of long-unburnt vegetation over recently burnt vegetation.

With regard to prescribed burn planning and implementation, issues around access difficulty, close proximity to fire-vulnerable urban assets and communities, variable mountain weather, wide altitudinal range effects, a necessity to rely on natural containment lines for remote and some interface burns, and fuel complexity conspire to make prescribed burning a high-risk and resource-intensive operation. However, the alternative risks of not conducting any program of fuel reduction will be accumulation of dry sclerophyll forest and woodland fuels across broad areas including those adjacent to fire-vulnerable communities. When bushfires inevitably occur and escape control efforts under adverse fire weather conditions, community protection difficulty is maximised and catastrophic consequence likelihood is increased.

A major complexity factor applying to burning in the Blue Mountains is the wide variety of stakeholders that expect consultation and demand up to 7 days advance notification. These requirements do not sit comfortably with the need for land and fire management agencies to be ready at short notice to take advantage of the limited and often short opportunities for safe burning in the mountains.

Figure 1 shows a prescribed burn being undertaken in the vicinity of Wentworth Falls in the Blue Mountains. It illustrates some of complexities associated with burning in these areas, such as the nature of the interface where dwellings back directly into bushland without perimeter roads, the Great Western Highway and Blue Mountains rail line which carry thousands of commuters to and from Sydney daily (also presenting potentially high-consequence smoke management issues), along with challenging topography with deep gullies incised into broad plateaus creating access difficulties and substantial variability in vegetation types and moisture regimes.

Figure 1 Urban-interface burning near Wentworth Falls

1.1 Fuel dynamics and fire behaviour context

The Blue Mountains has a high diversity of vegetation types with great variability in fuel characteristics. Some vegetation types such as tall wet forest will not burn except during summer in drought affected years, on adverse fire weather days. Other vegetation types such as open dry sclerophyll forests on plateaus exposed to sun and wind can burn under a wide range of conditions. Variability in topography, drainage features and soils can result in fine-grained mosaics of different vegetation types, posing significant challenges for fire management. Prescribed burning is mostly applied in the dryer vegetation communities which can support low intensity fires in mild weather conditions.

Figure 2 shows shrubby open dry forest typical of those on plateaus and exposed slopes in the Blue Mountains. When the sclerophyllous shrub layer is ignited (in uncontrolled situations) flame heights flare up and long-unburnt rough fibrous barked eucalypt species cause spotting issues.

Figure 2 Shrubby open dry forest

The Blue Mountains has relatively high rainfall, with annual average rainfall varying from around 850mm in the dryer lower mountains to above 1200mm in the wetter upper mountain. Therefore vegetation growth and fuel accumulation following fire commonly recovers relatively quickly. Surface and near-surface fuels will recover to the High range in 5 to 7 years, whilst elevated and bark fuels typically take significantly longer. As a consequence, treating Asset Protection Zones at the urban interface needs to be done on a cycle of less than 3 years if fuel hazard levels are to be kept in the low to moderate fuel hazard range. In Strategic Fire Advantage Zones, burning at intervals typically around 8 to 12 years will be required.

From a practical perspective it is near impossible to conduct effective low intensity prescribed burning in shrubby Blue Mountains forest types less than 5 years after the last fire, particularly where the previous fire was a moderate to high intensity wildfire. This is due to there being insufficient dead fine surface and near surface fuel to carry fire under mild prescribed burning conditions. However, once fuels are around 5 years old, sufficient surface fuel has usually accumulated to carry low intensity fire, shrubs are still predominantly in the near surface layer and are yet to accumulate significant dead fine fuel. Fuels in the 5 to 10 year age range are generally in the easiest state to burn with sufficient fuel quantity and continuity to carry low intensity fire, but before an elevated fuel layer has developed to the point that it can readily promote vertical flame propagation and increases in rate of spread.

In older-aged shrub fuels more than 12 years old the proportion of dead to live fine fuel is increased by suspended litter/bark ribbon accumulations and dead retained branch/twig material in mature and over-mature shrubs. Low intensity burning in these heavier fuels becomes difficult and resource-intensive in interface areas as flare-ups occur more frequently in denser elevated fuel patches and short distance spotting becomes more prevalent.

For practical reasons, surface fuel moisture content in the range of 12% to 16% is required in dry forest for successful burning. A two metre wind speed of 10 km/h or less is desirable. Under such conditions, in 5 to 10 year old fuels, headfire behaviour will normally involve a steady surface fire with intermittent flare-ups in heavier fuel patches.

Burning conducted in 10+ year old fuels with moisture content in the 9 to 12% range will generally produce a vigorous surface fire which will burn at the upper bounds of fire behaviour prescriptions, with frequent flare-ups in heavier fuel patches and on up-hill runs. Burns in these older fuels can be expected to be significantly more difficult to control than burns in younger fuels. Therefore, burning of older fuels should be conducted when wind speeds are at the lower end of the prescribed range, and/or when fuel moisture has begun to increase in response to rising humidity late in the day in the last 1 or 2 hours of daylight. Special care needs to be taken in attempting to moderate fire behaviour through selection of burn-timing as moisture absorption lag-effects can be quite variable in the Blue Mountains environment.

1.2 General issues, opportunities and constraints

The greatest point of difference between planning and undertaking prescribed burns in the Blue Mountains relative to many other areas with less complex issues is the extent and degree of community consultation, notification, coordination and approval activity required. Most burns will have extensive notification requirements, many with long lead times of up to a week ahead. Thus a major constraint on burn program and activity delivery is the constant tension between maintaining the necessary flexibility to quickly mobilise resources and take advantage of safe burning opportunities when they arise, and satisfying the expectations of many and varied stakeholders with respect to advance notification, consultation and coordination requirements. Local burn practitioners consider that the technical aspects of implementing burns (while technically quite challenging) are easier in many respects than planning and getting through all the consultation, notification and pre-burn public safety management preparations associated with planning and implementing each burn.

For example, the Great Western Highway and the Sydney Trains railway line carry many thousands of commuters daily from mountain townships and villages to and from Sydney. Any interruptions to the functioning of these critical transport routes can have major consequences, including an increase in motor vehicle accidents and major commuter delays, and is certain to generate adverse publicity for government agencies and the NSW Government. Accordingly, these risks are closely managed with requirements for a minimum of seven days notice of burning to Sydney Trains and the preparation of Traffic Management Plans for every burn, which must be submitted and approved by the Blue Mountains City Council before burning can be conducted. Additionally, bus network operators, tourism business operators and numerous other stakeholders are provided advance notice of burning operations. Community consultation requirements include significant burn schedule mail-out programs which generate additional workloads and costs. Executing these stakeholder consultation and notification activities in a timely manner requires well organised systems of work, and project management discipline.

A further local issue is the great extent of bush-urban interface in the Blue Mountains and that many interface areas have long-unburnt fuels which are difficult to burn at low intensity. In such situations, mechanical treatments along edges to thin-out dense shrubs and reduce near surface and elevated fuels may be required before low intensity burning can be safely reintroduced.

In other interface locations, steep topography and difficult access to adjacent bush areas may necessitate higher-risk unbounded interface burns, with fire-vulnerable houses situated above unbounded burning activity, and reliance on moist gullies to prevent fire reaching interface settlements.

An additional technical constraint is that currently there remains no scientifically researched prescribed burning guidelines developed specifically for Blue Mountains fuel types. This means that local burn practitioners, by necessity, use generic fire behaviour prediction models (some not developed for prescribed burning application), and use local experience to interpret and modify predictions to take account of local fuel variability factors. Thus prescribed burning practitioners in the Blue Mountains have a key dependency on knowledge developed from practical experience when considering how fire will behave in different fuel, seasonal and weather conditions.

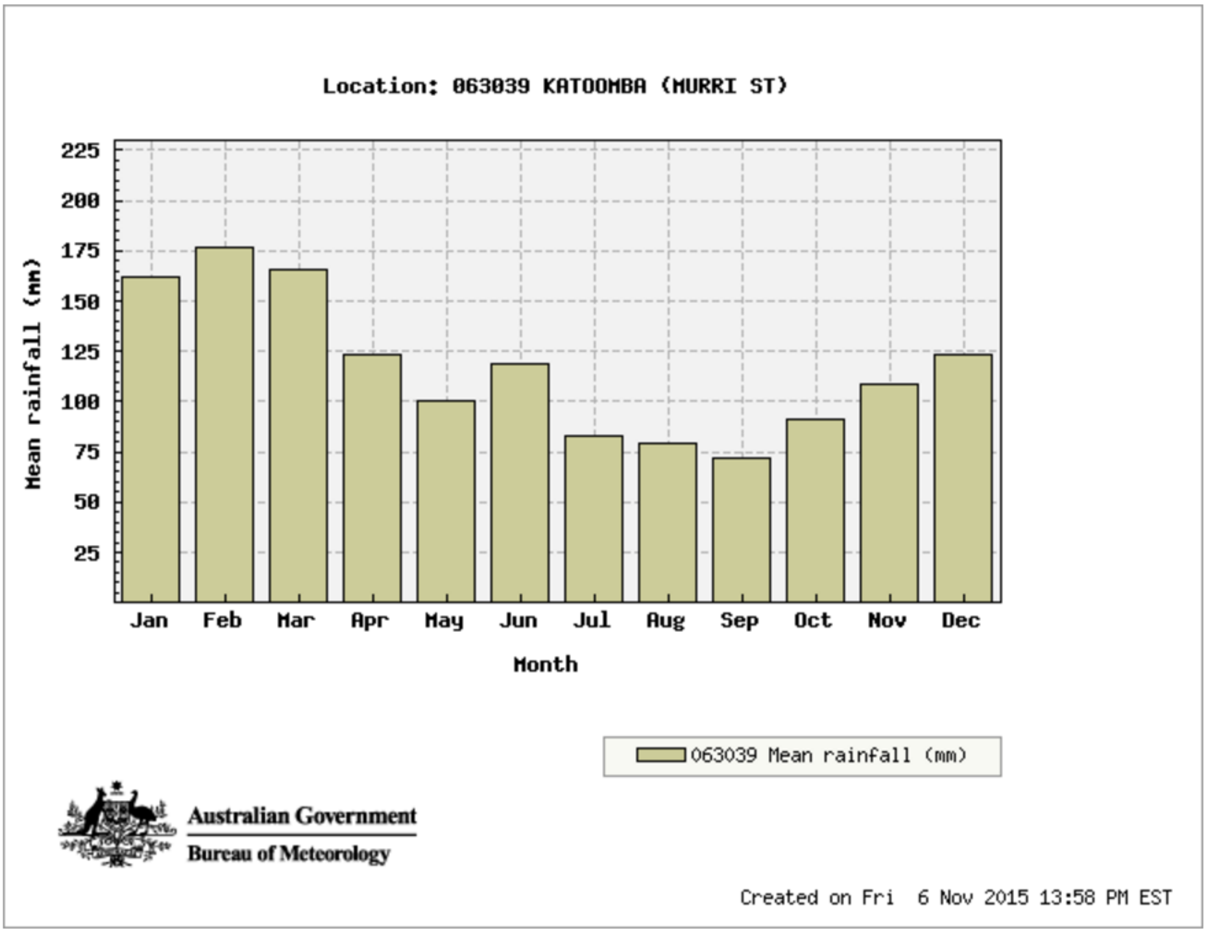
2 Planning considerations and general approach

The NPWS has a standard inter-agency Prescribed Burn Plan template used for all burns including interface burns. Planning of prescribed burns must use the standard template and is only undertaken by personnel with appropriate competencies (pre-requisite Crew Leader and Prescribed Burn Planner qualifications).

2.1 Burning season selection

In the Blue Mountains the annual rainfall peak is in summer when rainfall contribution from thunderstorm activity is prominent. Generally, from around late March a reducing rainfall trend begins and conditions become favourable for low intensity burning in dry forest types.

Figure 3 Average monthly rainfall at Katoomba



(Source: BoM 2015)

March to May is the favoured burning period in the Blue Mountains, and on a case-by-case basis, burning may be commenced before or continued beyond this period. The reasons this period is favoured include:

- Autumn weather patterns are generally more stable and less windy than spring;
- Fuels are typically on a drying trend so commonly used natural containment features such as gullies are still holding soil/surface fuel moisture levels which restrict fire spread;
- Day length is shortening and overnight conditions becoming progressively cooler so overnight self-extinguishment likelihood is significantly increased;
- With winter approaching the likelihood of adverse fire weather developing diminishes greatly; and
- From an ecological perspective burning in autumn is generally less interruptive of flora and fauna life/reproductive cycles than burning in spring.

After the cool mountain winter period, when the lowest rainfall months occur, opportunities for burning progressively improve during late spring, with a relatively short spring burning season emerging in September/October. Spring in the Blue Mountains is a characteristically windy time of year, and historically, adverse fire events mostly occur in November to early January. Accordingly, for spring burn programs, low escape-risk burns of smaller scale and with constructed mineral earth containment lines are preferred.

Optimal burning conditions are generally provided in years when good late summer rains are followed by a steady drying out period with sustained clear and stable weather periods in autumn so that gullies remain moist and target fuels on ridges and mid-slopes are in the target fuel moisture range for sustained periods.

If dryer than normal conditions persist from late summer into autumn, conditions during the customary autumn burning season may be unfavourable due to conditions being too dry. If recurring rains occur through the customary autumn burning period, burning program delivery can be substantially impeded due to fuels being too wet.

2.2 Planning of burn area dimensions

Burn size range at the interface ranges from small sub-hectare blocks providing protection to one or a small number of assets, to larger burns up to around 1,000 hectares providing protection along broader landscape features immediately adjacent to township margins. The majority of bush-urban interface burns are in the 100 to 200 hectare size range.

2.3 Burn timeframe and duration

Interface burns are generally planned to have a single day burn-out timeframe (although some smouldering combustion may persist beyond this timeframe – particularly in older fuels). It is strongly preferred that mop-up timeframes do not extend beyond 2 to 3 days. To reduce the potential for burns to reignite in windy weather on days following the planned burning period, interface burns are usually limited to relatively small areas, and aim to burn out a high proportion of fuels during the planned burn period. In this way, remaining unburnt fuel patches within the burn area are not of sufficient size to develop into running fires likely to throw embers beyond the burn boundaries.

During autumn when most burning is undertaken in the Blue Mountains, surface fuel moisture conditions appropriate to sustaining fire spread are not usually attained before around 11:00 AM. On some exposed aspects (e.g. north-east aspects exposed to sustained periods of morning sun), earlier ignition may be possible.

In autumn, on days when the Forest Danger Rating (FDR) peaks in the Moderate range, the most active period of fire spread is typically between 11:00 AM and 4 to 5:00 PM, with a continuing but declining spread period generally persisting for up to three hours thereafter depending on conditions. Thus an effective sustained fire spread period of around 5 to 6 hours through the afternoon is typical, extending an hour or two longer in drier conditions. Burning can be undertaken on days when the Forest Fire Danger Index (FFDI) peaks above 12, but on such days burning is only commenced after the FFDI peak has been already reached and has declined below 12 and is continuing to decline.

Spring is the windiest season in the Blue Mountains, and it is relatively common for wind speeds in the range of 15 to 20 km/h to be attained during the afternoon, most commonly from the NW to SW quadrant. Winds typically decline significantly after sunset (although there are exceptions to this pattern when wind speeds will stay high into the night, and care needs to be taken to properly assess the potential for this to occur).

Figure 4 NPWS burn crew tending a burn in shrubby forest

2.4 Limiting conditions

There are conditions in which interface burning in the Blue Mountains should not be conducted:

- At times when the FFDI is forecast to exceed 12 burning is too risky, and fire behaviour prescription are likely to be exceeded – burning after the FFDI has peaked and is on a declining trend may be possible with appropriate risk control measures in place;
- When the relative humidity (RH) falls below 30%; or
- During autumn periods when the Keetch-Byram drought index (KBDI) exceeds 80 or the spring KBDI exceeds 30 (in dry sclerophyll forests).

The key to successful burning in dry sclerophyll forests in the Blue Mountains is choosing conditions in which:

- Forward fire spread can be sustained;
- Wind direction during the burn period is relatively consistent; and
- Fire behaviour remains within acceptable parameters with flame heights in the range of 0.8 – 3 metres flame height.

2.5 Determining the burn prescription

There are no standard burn prescriptions developed specifically for the Blue Mountains – burn prescriptions are developed on a case-by-case basis. For each burn limiting conditions are prescribed for relative humidity, temperature, wind speed (and in some cases direction) and timeframe. An overarching prescription applied is for a FDR in the Low to Moderate Range (FDI <12).

3 Burn plan preparation

The NPWS burn planning process and standards are summarised below:

3.1 Burn Planning Process

- Specify the burn context and objectives;
- Determine vegetation types, and hazard levels within the burn area and in adjacent areas;
- Determine minimum and maximum fire behaviour to achieve burn objectives, level and patterns of desired fuel modification, and the fire behaviour likely during the burn (based on standard prescriptions and lighting practice assumptions);
- Identify the range of risks associated with undertaking the burn (public and firefighter safety, property, infrastructure, assets, economic and environmental) – including both fire and smoke impact dimensions;
- Identify and plan how to manage the burn risks identified in the above step and record risk control action requirements in the burn plan (including resources required to implement actions);
- Plan the stakeholder consultation and notification process requirements;
- Complete the rest of the standard burn plan template sections and checklists; including preparation of the operations map, preparation and notification requirements, command and control arrangements, contingencies and logistics, and record keeping requirements; and
- Prepare a pre-burn operations brief and submit plan for peer review and approval process.

The result of the burn planning process is a site-specific prescribed burn plan, prepared using NPWS standard burn plan template, which is suitable for internal review and approval processes.

4 Operational preparations

Depending on site circumstances, where an interface burn is to be undertaken, there will be many preparations to be completed before a burn can be approved and commenced. The last two days leading up to the burn can be particularly resource and action intensive – not dissimilar in many ways from the initial stages of scaling-up resourcing for wildfire operations. These typically include:

- Preparing containment lines/edges and/or contingency lines;
- Conducting protective works around at-risk assets, utilities and facilities etc.;
- Organising and mobilising agency and local partner resources, and specialised equipment for the burn – for larger scale burns this can be a substantial task involving out-of-area resources, aerial ignition helicopters, and night-shift resources;
- Ensuring State-level burn scheduling requirements are satisfied and media release arrangements organised;
- Advising neighbours and stakeholders of burn intentions, restrictions and any preparedness actions they should take (a major task in interface burns);
- Ensuring a structured burn planning information transfer process is undertaken between the burn planner and the burn incident controller (IC);
- Setting up command/control points and logistical support facilities (e.g. for aircraft or machinery);
- Ensuring appropriate hazard warning signage is in place and traffic management resources organised;
- Ensuring the burn area has been checked and is clear of visitors and general public; and
- Ensuring preparedness checklists are completed and burn approval obtained.

5 Burning Operations Implementation

5.1 Obtain weather and smoke forecasts for the burn area and verify with on-site conditions

Weather forecasts for the planned burn site should be obtained from the Bureau of Meteorology, relevant for the location(s) where burning will be carried out. Upon arrival at the burn site during the morning, field weather readings should be checked for alignment with or variance from forecast conditions, and fuel moisture readings taken in surface and near-surface fuels.

5.2 Operational preparations and briefings

Routine procedures for staff and equipment checks and preparedness are undertaken and planning information distributed to burn crews. A routine pre-burn operations briefing is conducted and crews dispersed to take up planned sectors and roles as per the burn plan and briefing which follows a standard SMEACS[1] format. Authorisation to proceed with ignition is requested and obtained from the appropriate manager.

Some of the larger interface burns may involve more than 100 personnel from multiple agencies. Briefings of this scale may need to be held at a central location such as a Fire Control Centre or Agency office before resources are deployed out to the burn site.

5.3 Conduct fire behaviour prediction and test fire

Once fuels are within the desired moisture range (as predicted, measured or both), select an exposed area location with fuels representative of those to be burnt, and conduct a test fire.

Based on the test fire results and any fire behaviour predictions provided by fire behaviour analysts, (if necessary) refine the pre-planned lighting schedule and pattern to achieve the burn objectives and desired fire behaviour.

5.4 Implement burning operations

Subject to successful conduct of the test burn (if unsuccessful the test burn is put out), lighting operations are executed in accordance with the burn plan and any lighting pattern modifications arising from the test burn.

Interface burns are typically lit using spot or short line ignitions by ground crews along the edge of containment lines. Good, sustained operational discipline needs to be applied throughout lighting to ensure that burn crews stick to planned lighting patterns and spacing.

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[1] A model used in emergency management for operational briefings. The acronym stands topics to cover in the briefing including Situation, Mission, Execution, Administration, Command/Control/Coordination and Communication and Safety.

Once a successful ignition has been established, monitoring of the fire direction and rate of spread is undertaken. Fire behaviour and on-site weather need to be monitored throughout the burn (with results recorded at least hourly) to ensure conditions remain within prescription, and that where necessary, lighting patterns can be augmented or backed-off if required to achieve desired outcomes. Any significant changes to planned lighting patterns require approval from the burn IC.

Burn security requires continuous monitoring throughout the burn, to identify and address potential weak-points at burn boundaries. For all but the largest interface burns, mop up can usually be completed on the day of burn, with a patrol on the following days, and no further action required. If smouldering in coarse woody fuels is present and persists on vulnerable boundaries, then patrol and mop up can take several days.

Once lighting operations are completed and any edge mop-up activity winds down, the Burn I/C will need to assess the extent of unburnt fuels remaining, and assess overnight fire behaviour potential, to make a decision on patrol requirements, in particular if or when resources can safely depart the burn site overnight and the timing of patrol checks the following day (if any). These decisions need to be made based on forecast weather overnight as well as days following the burn.

Assessment also needs to be made of likely smoke transport and settling locations to inform placement of smoke hazard signs on public roads and any other prudent smoke management actions.

For burns at the interface, it can be assumed that members of the public will raise the alarm about active fire observations after hours, including ringing 000. Action needs to be taken to alert relevant authorities of the burn location and the potential for public reporting of fire to occur.

Prior to declaring burning operations complete and safe, a rigorous assessment of falling tree risk needs to be undertaken and remedial actions taken to address the risks before re-opening the burn area or perimeter for public access.

6 Appraisal

After each burn a post-burn assessment is undertaken to determine if the burn objectives have been met, and the extent to which any follow-up works may be required.

For large burns, burnt area assessment is usually undertaken by an air observer, with burnt areas mapped from a helicopter.

For smaller burns, ground assessment methods are used, with observation of burnt areas made from the perimeter and/or within the burn area to map areas burnt and unburnt, estimate residual fuel levels using the Victorian Overall Fuel Hazard Guide, and from this assign a fire intensity classification to the burn.

Increasingly, post-burn assessment practice includes the taking of geo-referenced photographs within the site to obtain a visual record of the burn results. These photographs are linked to and stored with the burn record.

7 Acknowledgements

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