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# TRIAL AND EVALUATION OF A SMOKE MANAGEMENT PROTOCOL IN NSW

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## Introduction

Hazard reduction burning (HRB) is a strategy used by fire and land management agencies to reduce the risk of bush fires impacting life, property and the environment (Australasian Fire and Emergency Services Authorities Council, 2016). Smoke from HRB (and bush and grass fires) has been increasingly linked to adverse health outcomes (e.g., Horsley et al, 2018).

In 2016, the NSW Government released the "Clean Air for NSW Consultation Paper" (NSW Environment Protection Authority and Office of Environment and Heritage, 2016) for public comment. This paper identified the need for NSW state government agencies and research organisations to collaborate further to improve air quality and reduce population exposure in metropolitan and regional communities NSW. As a result, the NSW Government HRB Smoke Steering Committee and two sub working groups, namely, a communications and a smoke modelling and risk assessment working groups were formed in late 2016. The committees comprise representatives from NSW Rural Fire Service, NSW Office of Environment and Heritage, NSW Health, Environment Protection Authority, NSW Fire and Rescue and the Australian Bureau of Meteorology.

The working groups were tasked with drafting protocols for interagency communication, assessment of risk and external communication triggers. Smoke modelling is a key component of the protocol, contributing to air quality forecasting and where required triggering an escalation of communication. In early 2018, drafts of interagency protocols were finalised for a pilot period during the autumn hazard reduction burning period. The aims of the trial were to ensure that the protocols are fit for purpose, to test the proposed workflow, and to determine whether they facilitated better outcomes for the NSW communities.

This paper focuses on the evaluation of the HRB smoke management protocol and the smoke modelling and air quality forecasting that underpins this protocol. Two HRB case studies in the Hornsby and Hawkesbury areas of Sydney, Australia are discussed. It highlights the benefits to the people of NSW in addition to areas for improvement and gaps in the smoke modelling and air quality forecasting research.

## Hazard Reduction Smoke Management Protocol

In 2017, the HRB Smoke Management Protocol (NSW Government, 2017) evolved from an information sharing document to become a tool to trigger communication and active management of smoke from hazard reduction burns. Figure 1 depicts the pilot protocol workflow. The protocol repeats daily, for a rolling 5 days before a HRB or a number of HRBs. It is modelled on a typical Monday to Sunday workflow, adjusted to BD-5 to BD+1 to facilitate reality that burns could be scheduled on any day of the week.

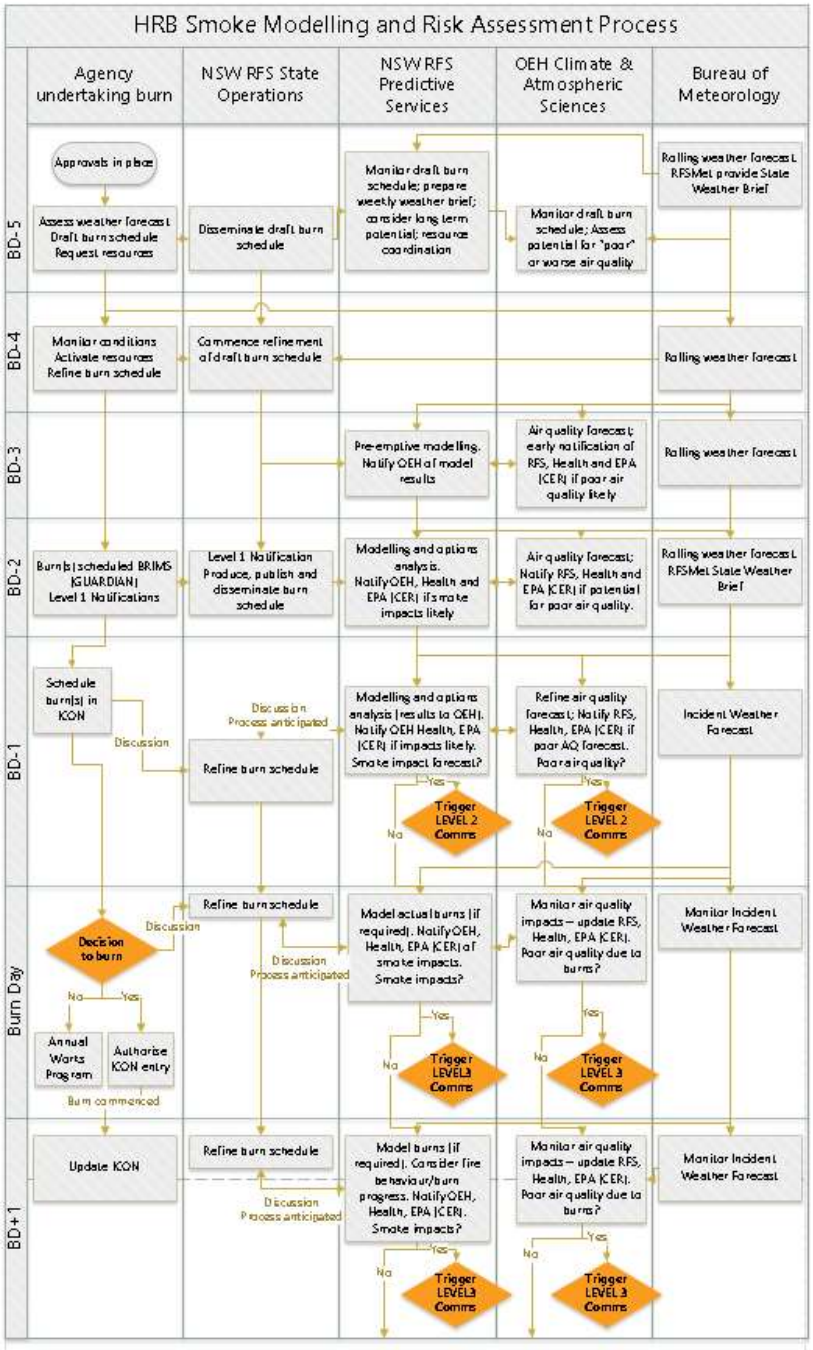



Figure 1 Draft NSW HR Smoke Management Protocol workflow

Smoke modelling typically commences 3 days before HRB ignition. The results of this modelling are shared between agencies as an early indicator of smoke impact potential. Modelling and subsequent analysis occurs from this point until after the notional burn day. The results underpin escalation of communication strategies. In the event of significant smoke impact being forecast, options analysis by NSW RFS Predictive Services may result in adjustments to scheduling and or burn planning. The aim of the protocol is to share information and to determine triggers for escalation of communication as outlined in the communications protocol.

**Links to Communications Protocol**

The Communications Protocol (NSW Government, 2017) is based on 3 levels of escalation corresponding to increasing scale of impact.

The first level (1) relates to local activities where there is minimal impact on the community or the impact is confined to a small area. The second level (2) is for a forecast of significant smoke impact on the community, such as entire suburbs, towns or regions or for a prolonged period of time. It uses smoke modelling as a general guide to inform messaging relating to spread of or density of smoke. This level of activation will trigger joint agency communications functions and community alerts.

The third level (3) is for significant smoke impact on the community. This typically means a large proportion of the population is impacted by smoke, such as entire regions, towns or cities, or for a prolonged period of time. This level of activation recognises that this is not always possible to eliminate the risk of smoke impacting on the community such as when weather conditions change or are not as originally forecast. It prioritises messages relating to reducing the impact on health conditions.

## Methods

A desktop exercise was conducted in early 2018 to identify potential gaps in the protocol and to determine if adjustments were required before pilot implementation commenced in April 2018. As a result of the extension of the pilot implementation from Sep 2018 to June 2019, the Steering Committee has agreed to keep the rolling evaluation of Smoke Management Protocol as a regular agenda item. The two case studies in the following section have been chosen to underpin the rolling evaluation by illustrating the products used and developed by the agencies in addition to the outcomes that occurred as a result of the implementation of the protocol. The results may also contribute to the final evaluation work that was agreed to be a qualitative process evaluation.

## Results

*Case study 1: Hornsby Coba Creek HR - April 2018*

Two significant HRBs with total burn area of 2000 hectares were originally scheduled between 10th to the 14th of April 2018 in this case. A significant smoke impact to the community in Sydney basin on 11th April was predicted by RFS smoke plume modelling. Based on this information and following the workflow proposed in the protocol, NSW OEH air quality forecasters issued an "Early notification (BD-2)" for anticipated poor air quality due to planned HR burns (as shown in Figure 2) to Fire, Health and Environmental agencies. This early notification enabled the fire lead agencies to reconsider their burn schedules or to refine the burn plans to mitigate smoke impacts.

**Early notification (BD-2) for anticipated poor air quality due to planned HR burns**

The HR Smoke Management Protocol entail us providing you with information on HR smoke predicted to result in POOR air quality over the Sydney basin on 11/04/2018 (Wednesday)

Next air quality forecast update for 11/04/2018 (Wednesday) will be issued at 4:00pm on 10/04/2018 (Tuesday)
If you have any questions, please call the Jordan Capnerhurst on 9995 6714 or jordan.capnerhurst@environment.nsw.gov.au

**(1) Planned HR burns schedule**

Major HR burn(s) is (are) potentially to take place in the short term

- Coba Creek in the Hawkesbury (1939 HA) between 11 to 12/04

Source: NSW RFS smoke Dispersion Modelling - Sydney Basin (Tues-Fri) v1

**(2) Current meteorology conditions and weather forecast**

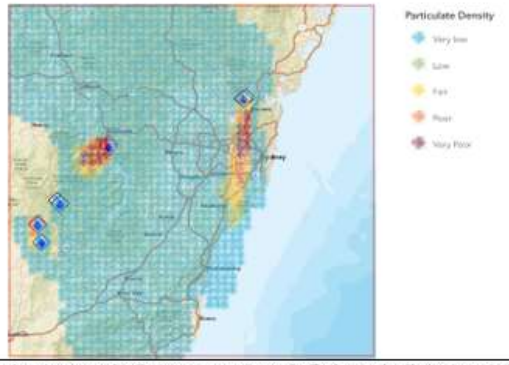
A weak high-pressure ridge and hot, dry airmass lie across New South Wales.
Cold fronts moving through southeastern Australia during Thursday and Friday are expected to bring milder conditions in their wakes. Weak inversion.
Source: BoM Air Pollution Forecast for Tuesday 10/4– Sydney (NSW)

**(3) Current air quality**

The current air quality across Sydney sub-regions are FAIR.
Source: http://www.environment.nsw.gov.au/AQMS/aqi.htm

**(4) Air quality forecast**

The RFS smoke modelling forecast (issued at 09 Apr 2018 15:09) predicted potential smoke impacts on the Sydney basin from 10am on 11/04 onwards. RFS advice below:
*Latest model run shows that on Wednesday morning smoke from Mt Solitary could impact western Sydney. By Wednesday afternoon the combination of the smoke from the Coba Creek and Mt Solitary burns is predicted to impact much of Sydney from western Sydney to the inner west. This impact could continue into Thursday, with the cbd impacted by the smoke from the Coba Creek burn for much of Thursday afternoon, clearing to the northern beaches Thursday night.*




Note: RFS modelling results show incremental pollution concentrations only. Background pollution is not included.

Note: RFS indicate burn start time and end time are difficult to obtain as they depend on fire behavior. Based on the current weather conditions it would be reasonable to assume a 10:00 start time and 17:00 finish time but actual ignition time and lighting patterns will depend on local conditions and safety considerations.

Figure 2 Early notification (BD-2) released by NSW OEH

By the Burn Day (11th April), with the updated information of weather forecast and smoke smodelling results, the operational burn Managers made a decision to adjust burn lighting schedules to reduce smoke impact. Table 1 tracked the estimate of planned and actual ignition areas in hectares in this case. The specific additional cost including staff time and aviation cost associated with the adjustment of operational burn patterns in response to mitigate smoke impact was roughly around AUD$ 65,000.

The NSW OEH air quality modelling results shown in Figure 3 clearly illustrates the smoke impact on regional air quality on 11 April 2018 had significantly reduced due to the change of the burn schedules (from planned 500 to actual 200 ha). The recorded regional air quality in Sydney was also in the category as "Fair" on the day, instead of the predicted "Poor" to "Very Poor" category if the original burn plans went ahead.

Table 1 Estimate of planned and actual ignition area in Hornsby Coba Creek HRB

| Event Name | Date | Planned ignition (ha) | Actual ignition (ha) | Total area burnt (ha) |
|---|---|---|---|---|
| Coba Creek HR | 11 April 2018 | 500 | 200 | 2000 |
| | 12 April 2018 | 1000 | 400 | |
| | 13 April 2018 | 500 | 1000 | |
| | 14 April 2018 | 0 | 400 | |

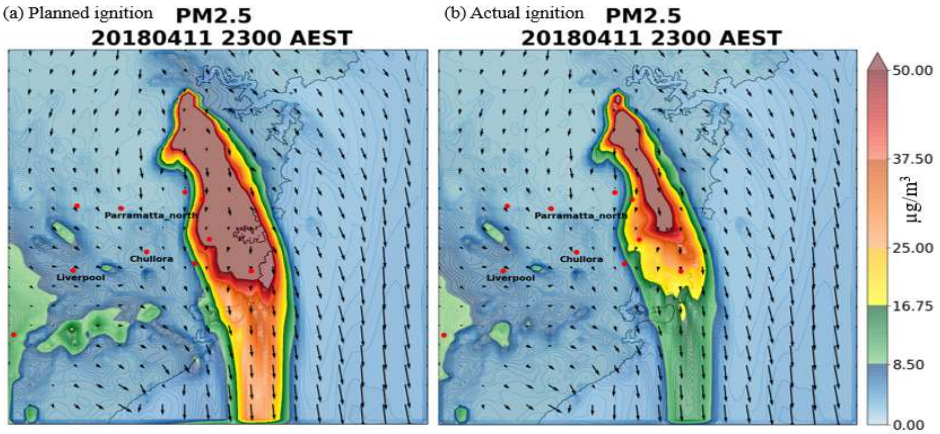



Figure 3 NSW OEH operational air quality modelling predicted hourly $PM_{2.5}$ concentration ($\mu g/m^3$) on 11pm 11 April 2018 in (a) original burn plan and (b) actual ignition

## Case study 2: Hawkesbury Colo Heights HR - May 2018

Dry conditions facilitated a continuation of hazard reduction burning in autumn 2018. A number of HR burns with an area totalling 2500 hectares were scheduled around the Sydney Basin during 26th -27th May 2018. NSW RFS smoke modelling forecasting (Figure 1) predicted that there would be significant smoke impact in the Sydney Basin over the first two days, but this impact was likely to taper off by 28th May.

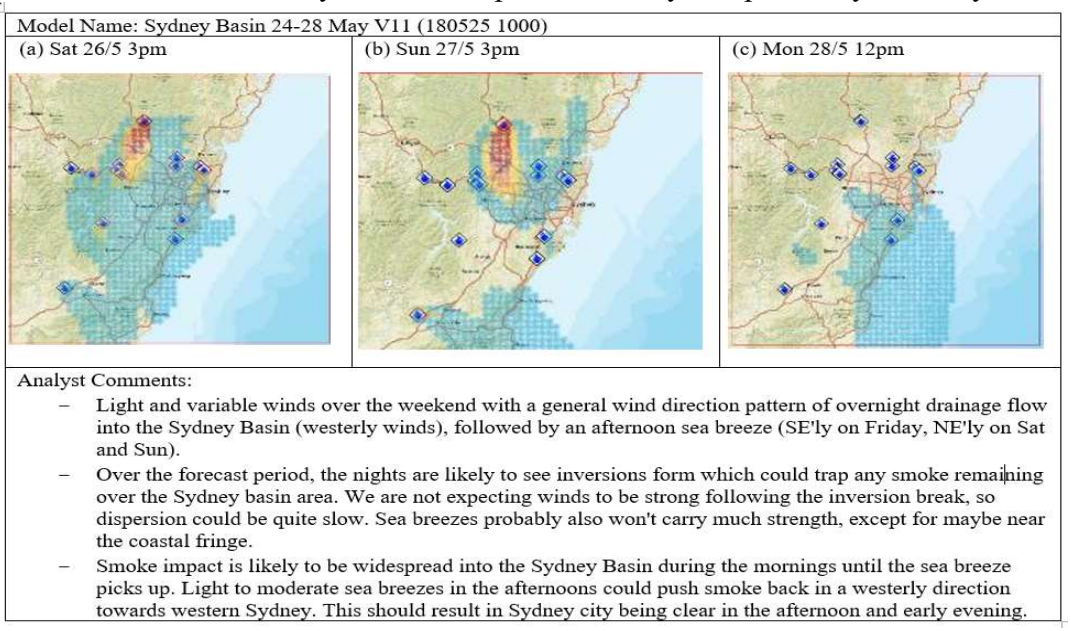



Figure 1 Example of NSW RFS Smoke Modelling and Analysis provided during the Hawkesbury Colo Heights HR - May 2018 event

The 1-hour $PM_{2.5}$ concentrations continued to be at similar levels from 12 pm on 27th till 5 pm on 28th May (Figure 5). However, a sudden ascending of 1-h $PM_{2.5}$ were observed across western Sydney after 5 pm, and it peaked at St Mary's at 6pm (198 µg/m$^3$), then Richmond (205 µg/m$^3$) and Bringelly (157 µg/m$^3$) during 7 to 8 pm of 28th May. The smoke apparently didn't go away as the model predicted in this case, and the impact from HRB smoke significantly reduced visibility on the day as well.

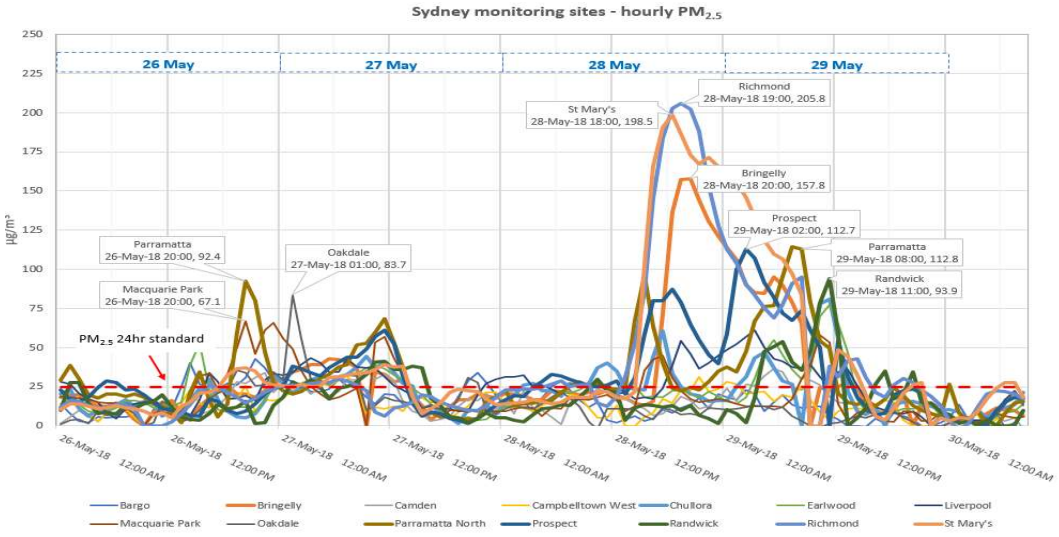



Figure 2 $PM_{2.5}$ 1-hour concentrations at air quality monitoring sites in the Sydney region during 26 to 29 May 2018

## Discussion

Committee reports and the results of the case studies show there is evidence that implementation of the protocol so far has been successful in improving cross agency communication and sharing of information (NSW Office of Environment and Heritage, NSW RFS, Australian Bureau of Meteorology, 2019).

The April 2018 case study demonstrated a successful implementation of the protocol with fire and land management agencies taking actions to reduce the impact of the Coba Creek HRB on air quality. However, altering ignition patterns had a number of implications for the agencies undertaking the burn. Firstly, the HRB ignition plans were pushed closer to a dangerous fire weather window increasing risk of fire escape. The change in burn plan also increased resource costs to the land manager. In this case, the additional costs were estimated to be $65,000(au). These additional costs are probably insignificant when compared to the potential cost of health impacts of going ahead with the original plan.

The May 2018 case study showed that modelling products developed for the protocol were reasonably accurate for the 26th and 27th of May. The events following on the 28th and 29th of May highlight challenges for successful implementation of the protocol. Complex meteorological conditions, limitations in the forecasting capability both fire behaviour and air quality in addition to communication of intelligence gaps contributed to agencies ability to forecast the event. Background pollution and its combined cumulative impact with the HRB smoke, strong inversions, cool weather resulting in the use of wood smoke heaters are also factors contributing the event.

As modelling and air quality forecasting occurs some distance from HRBs, for accurate community messaging and forecasting, communication at all levels of fire agencies is required. Since pilot implementation significant

improvements in the information provided by fire agencies on burn progress has helped to reduce uncertainty as to the model inputs.

Challenges for smoke modelling include scheduling of HRB and characterising emissions. Due to the complex nature of meeting burn objectives (including fire fighter safety and implementation risk) scheduling of burns is dynamic. The current ability for models to be able to characterising HRB ignition patterns accurately is limited. These issues are compounded by safety considerations on the day which means that ignition patterns that although carefully planned, are often dynamic and opportunistic.

Due to the uncertainty associated with the modelling, a more conservative approach to forecasting may be required into the future. This may include the use of forecaster discretion as opposed to relying on absolute numbers when approaching air quality thresholds. A more conservative approach may have been to forecast poor air quality even though the forecast Air Quality Index number was approaching but not exceeding this threshold.

Smoke from bush and grass fires is easily detectable by the community in comparison to other sources of pollution. The community have increasing expectations for accuracy in messaging and minimising impact. Smoke and air quality modelling to underpin operational fire management decisions is a relatively new field that can add to the complexity of achieving HRB targets, however the NSW Government protocol has created a workflow that has improved communication and provides a framework to reduce smoke from HRB impacting on the community.

## Acknowledgements

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