Emissions Estimation Technique Manual

for

Aggregated Emissions from Prescribed Burning and Wildfires

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EMISSIONS ESTIMATION TECHNIQUE MANUAL:
AGGREGATED EMISSIONS FROM PRESCRIBED BURNING AND WILDFIRES

TABLE OF CONTENTS

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LIST OF TABLES

1.0 Introduction

1.1 The NPI

The National Pollutant Inventory (NPI) was established under a National Environment Protection Measure (NEPM) made by the National Environment Protection Council (NEPC) under Commonwealth, State and Territory legislation on 27 February 1998. This Measure is to be implemented progressively through the laws and administrative arrangements of each of these participating jurisdictions (i.e. State and Territory Governments).

The NEPM and an associated Memorandum of Understanding for the NPI, which have been published as a single document by the NEPC, provide more details on the purpose and structure of the NPI, and the arrangements for implementation of the NEPM that have been agreed by the jurisdictions. Users of this Manual should read this publication if they are unfamiliar with the NEPM or the NPI.

1.2 Purpose and Scope of the Manual

The NPI will be developed as an internet database designed to provide information on the types and amounts of certain chemical substances being emitted to the air, land and water environments. If the NPI is to achieve its aim of communicating useful and reliable information to the community, industry and governments on pollutants present in our environment, the emissions estimation techniques (EETs) used to generate inputs to the NPI need to be consistent, and the process for developing these techniques needs to be transparent. This Manual has been developed, reviewed and finalised in this context.

The NEPM contains a list of substances for which emissions will be reported on an annual basis to the Commonwealth Government, which will then compile and publish the NPI. The aggregated emissions manuals, of which this is one, have been prepared to assist State and Territory Governments in preparing these submissions, and to facilitate consistent reporting between these jurisdictions.

State and Territory Governments will also be compiling and submitting emissions data based on annual inputs from reporting facilities. These facilities are primarily industrial enterprises which use (or handle, manufacture or process) more than specified amounts of certain polluting substances, burn more than specified amounts of fuel, or consume more than certain amounts of energy. These amounts or “thresholds” (which are clearly defined in the NEPM) govern whether an industrial facility is required to report and what substances it is required to report on, and industry handbooks are being developed to help industries to prepare the information for these reports.

The aggregated emissions manuals complement these handbooks, and are intended to enable Governments to estimate emissions from non-industrial activities (e.g. transportation, domestic and commercial activities) and

emissions from industry which are not reported because the relevant thresholds are not exceeded.

Annual submissions are also to be prepared and submitted in conformance with the NPI Data Model and Data Transfer Protocol. For emissions to the air environment, this Protocol only requires jurisdictions to submit data on emissions into the particular airsheds that are listed in the Protocol, and not to the rest of each jurisdictional area. For example, in Victoria, emissions data are only required for the Port Phillip and Latrobe Valley Regions. In addition, emissions data are required to be submitted on a gridded basis, with each jurisdiction determining a grid domain and grid cell size appropriate to its needs and responsibilities (e.g. for air quality modelling purposes).

Therefore, in addition to recommending and providing details and examples of appropriate emissions estimation techniques (EETs) for the relevant NPI substances, this Manual provides guidance on the spatial allocation of emissions and the use of area-based surrogates for accurately distributing the activities or sources in question.

1.3 Application of the Manual

Each of the aggregated emissions manuals provides details of:

- the NPI substances that are expected to be emitted from the relevant aggregated source type;
- the origins or sources of the emissions, and the processes that may generate them;
- the impacts of any control equipment or procedures on those emissions;
- the broad approaches that may be employed in the estimation and spatial allocation of emissions;
- details of emission factors to be used in the estimation of emissions; and
- a series of illustrative sample calculations for each estimation technique.

Each of the manuals also contains a section on “Uncertainty Analysis”, which provides information and guidance to users on the reliability of the various estimation techniques, problems and issues associated with their development and application, and recommendations for their improvement. In preparing the aggregated emissions manuals it has been recognised that some jurisdictions already undertake detailed emissions inventories on a regular basis, based on relatively sophisticated methodologies. For these jurisdictions the manuals offer techniques which represent commonly available best practice for emissions estimation in Australia (i.e. techniques of high quality which can be employed by larger or more experienced jurisdictions with an acceptable expenditure of time and effort). The most recent developments in inventory methodology in Australia and overseas have been considered in selecting and documenting these techniques.

Where a more simplified methodology for emissions estimation of acceptable quality is available, it is recommended in the manual for the use of those jurisdictions which may, for the time being at least, lack the data, resources or

expertise to employ a more sophisticated approach, or not see the need for highly reliable estimates in that particular part of the inventory.

2.0 Emissions Covered by the Manual

This manual provides guidance on the estimation of aggregated emissions from prescribed burning (fuel reduction, regeneration and agricultural) and wildfires. These activities can make significant contributions to regional or airshed emissions of a number of substances listed in the NEPM for the NPI, especially particulate matter, metals, carbon monoxide and 1,3-butadiene. Emissions from prescribed burning and wildfires may vary greatly from year to year due to annual variations in the total areas and fuel quantities which are burned, which in turn may be significantly affected by the climatic conditions prevailing in the preceding seasons.

2.1 NPI Substances

Table 1 lists those substances in Table 2 to Annex A of the NEPM which are emitted by prescribed burning and wildfires.

Table 1: NPI Substances Emitted by Prescribed Burning and Wildfires

Antimony and compounds	Manganese and compounds
Arsenic and compounds	Mercury and compounds
1,3-Butadiene	Nickel and compounds
Cadmium and compounds	Oxides of nitrogen
Chromium (VI) compounds	Particulate matter ≤ 10 μm (PM10)
Carbon monoxide	Selenium and compounds
Cobalt and compounds	Total volatile organic compounds
Copper and compounds	Zinc and compounds
Lead and compounds	

It should be noted that speciation profiles are not available to convert estimates of total VOC emissions from these types of sources to emissions of particular organic substances that are listed in the NEPM. This manual therefore only provides EETs for total VOCs.

2.2 Emission Sources and Related Processes

Prescribed burning activities include fires which are intentionally (other than arson) for a variety of reasons, such as fuel reduction for wildfire prevention, regeneration after logging operations, ecosystem maintenance (where systems rely on fires for ecological health), land clearing, and agricultural land management.

Wildfires occur both naturally (e.g. through lightning strikes) and through arson. It is often difficult to determine whether a wildfire has been deliberately lit or has occurred naturally.

The amount and type of prescribed burning and wildfires will vary significantly between different jurisdictions and airsheds. The quantity and composition of emissions from different types of burning are also highly variable.

For forest and grassland fires (both wild and prescribed), the area of land burned will vary greatly depending on climatic conditions. Fuel loadings may

also vary from year to year, and with the time of year that the burn occurs. These two factors combined lead to large variations in the amount of material consumed in fires from one year to the next.

For logging operations, the area subjected to regeneration burning will vary according to the area of land felled each year.

For agricultural burning, the amount of fuel burned will depend on the annual crop harvest and farming practices in the airshed. For example, burning of wheat stubble and cane crops has been decreasing over recent years (DEST 1996). The EET requires knowledge of the annual harvest for each major crop type and the proportion of this crop which is subjected to burn management practices.

The amount of consumable fuel in a particular area has a major impact on emissions from burning. This information is required to be factored into the EET and, for forests and wildfires, is calculated from the area burned and the fuel loading of the area. For agricultural fires, it is determined as a proportion of the total crop harvest.

Different species composition and hence different plant material types have different burning qualities. Thus, forests, grasses, and crops such as wheat and barley have different emission-generating characteristics. Emission factors are provided in this manual for the following vegetation categories: forest wildfires, prescribed hardwood forest burning, grassland (and temperate savanna) fires, and a range of agricultural crop types.

Other factors that influence emissions from burning, but are not factored directly into the EET, include (USEPA 1995):

- stage of burn: emissions may vary with the stage of development of a fire, being higher during earlier stages of burning or when the burn rate or flame intensity is low;

- fuel conditions: *fuel loading geography* will influence burn rate and intensity by causing variations in temperature and air availability, and *moisture content* may also affect burn rate and intensity in the early stages of a fire;

- local weather conditions (e.g. wind speed, ambient temperature, precipitation, and relative humidity); and

- topography (slope and profile of land on which burn takes place).

2.3 Emission Controls and Other Factors Affecting Emissions

There are no emission controls to factor into the EET.

Emissions may be reduced by jurisdictional limitations on prescribed burning, particularly for site clearance where other options such as mulching may be available.

Planning or regulating the timing of prescribed burning can assist in minimising the nuisance and health impacts of emissions by restricting burning to times when dispersion is more likely. However, this does not reduce emissions from the burn itself.

Emissions from wildfires and prescribed burning are seasonal and are also strongly dependent on location. The NPI currently requires reporting of annual emissions only, so seasonal variations are not considered in the EET.

3.0 Emissions Estimation Techniques

The data required to calculate aggregated emissions from prescribed burning and wildfires (excluding agricultural burning) are as follows:

- the size of the area burned for each fire event;
- the fuel loading of that burn area; and
- the location of each fire event (for spatial allocation purposes).

For agricultiral burning the following information is required:

- the annual harvest mass for different crop types by Statistical Local Area (SLA);
- the post-harvest residue fraction of different crop types; and
- the percentage of land used for particular crops which is subject to a burn management regime.

3.1 Approaches Employed

3.1.1 Determination of Emissions of NPI Substances from Forest Wildfires, Forest Prescribed Burning, and Temperate Grassland and Savanna Burning

Burn Areas

Information on areas of land burned under each burn regime (fire type) may be obtained from the State and Territory departments which control and monitor such activities.

There is no default method for deriving this information as the location and scale of burned areas may vary greatly from year to year.

Fuel Loading

Information on fuel loadings for forest wildfires, prescribed forest burning and grassland burning should be sought from Government departments responsible for land and natural resource management. The CSIRO Division of Atmospheric Research may also be able to provide information on typical fuel loadings for different regions.

The EET requires estimation of the actual amount of fuel consumed in each fire type. If estimates of total fuel load only are available, it may be assumed that the burn efficiency rates are 72% for wildfires, 42% for prescribed forest burning and 72% for savanna and temperate grasslands (DEST 1996).

Alternatively, the default loadings contained in Table 2 may be used. It should be noted that these figures may be updated in future editions of the referenced source document and the technique proposed in this manual may need to be updated accordingly.

Table 2: Default Fuel Loadings[a]

Jurisdiction	Forest Wildfires (kg ha^{-1})	Forest Prescribed Burning (kg ha^{-1})	Temperate Grassland and Savanna Burning (kg ha^{-1})
Australian Capital Territory	26.1×10^3	7.60×10^3	7.99×10^3
New South Wales	27.2×10^3	7.94×10^3	7.99×10^3
Northern Territory	4.39×10^3	1.30×10^3	3.60×10^3
Queensland	19.3×10^3	3.91×10^3	2.16×10^3
South Australia	13.8×10^3	4.03×10^3	2.16×10^3
Tasmania	28.8×10^3	8.40×10^3	7.20×10^3
Victoria	24.6×10^3	7.22×10^3	7.92×10^3
Western Australia	29.6×10^3	5.04×10^3	7.20×10^3

[a] DEST (1996).

Once the fuel loading and fire type are known for a particular fire event or burn area, the emissions of NPI substances from this area can be calculated using Equation 1 and the appropriate emission factors from Table 4. In some cases, the fuel loading will be the same for all fires of a particular type in the airshed.

Equation 1: Calculation of emissions of an NPI substance (from either prescribed burning, grassland burning or wildfires) in a particular burn area

$$E_{ij} = A_{ik} * L_{ik} * EF_{jk} * 10^{-3}$$

where

E_{ij} = Emissions of substance j from burn area i, kg
A_{ik} = Size of area i burned under fire type k, ha
L_{ik} = Fuel loading of burn area i for fire type k, kg ha^{-1}
EF_{jk} = Emission factor for substance j from fire type k, g kg^{-1}

3.1.2 Determination of Emissions of NPI Substances from Agricultural Burning

The amounts of material consumed by agricultural burning can be calculated from annual crop harvest figures by applying factors which estimate the residual material available for burning after harvesting and the proportion of crop areas which are subject to burn management.

The major crops covered in this EET include wheat, a variety of coarse grain crops (see Table 3), and sugar cane. Data on annual crop yields can be obtained from industry associations, or from ABS or ABARE which are able to provide crop harvest information by their respective collection districts. ABS is

the preferred source of data as it provides information by Statistical Local Area (SLA), which is derived from periodic farm surveys.

As only a proportion of the crop is available at the time of burning (post-harvest), the total crop harvest must be scaled by an appropriate fraction which is a function of the typical crop residue remaining at burn time, the dry matter content of the residue and the burning efficiency. The residue fractions for different crop types presented in Table 3 are adapted from DEST (1996). These figures may be updated in future editions of the referenced source document, and the technique proposed in this manual will need to be updated accordingly.

The proportions of harvested areas that are subject to burn management are decreasing over time as farm management practices change. If figures for a particular airshed cannot be obtained from the relevant departments in a jurisdiction, a default factor of 0.23 for wheat and coarse grain crops and 0.68 for cane crops can be used (DEST 1996).

Equation 2: Calculation of material burned in agricultural burning in a SLA (or other appropriate area surrogate)

$$M_c = H_c * R_c * F_c$$

where

M_c = Fuel consumed in a SLA by burning crop type c, kg yr^{-1}
H_c = Total harvest of crop type c in the SLA, kg yr^{-1}
R_c = Residue fraction for crop type c
F_c = Fraction of total harvest of crop type c subject to burn Management in the SLA

Table 3: Residue Fractions for Calculation of Material Burned in Agricultural Burning

Crop	Residue Fraction [a]
Wheat	0.648
Coarse Grains[b]	0.576
Sugar Cane	0.048

[a] Adapted from DEST (1996) Tables C.12.90.
[b] Barley, oats, maize, sorghum, rice.

Once the annual mass of fuel burned for each crop type has been derived (Equation 2), the emissions of each NPI substance can be calculated from Equation 3, using the emission factors for agricultural burning associated with particular crop types, which are listed in Table 5.

Equation 3: Calculation of emissions of an NPI substance from agricultural burning in a SLA (or other appropriate area surrogate)

$$E_{cj} = EF_{cj} * M_c * 10^{-3}$$

where

E_{cj} = Total emissions of substance j in a SLA from burning of crop type c, kg yr^{-1}

EF_{cj} = Emission factor for substance j from burning of crop type c, g kg^{-1}

M_c = Fuel consumed in the SLA by burning crop type c, kg yr^{-1}

3.2 Spatial Surrogates and Spatial Allocation

Prescribed Burning and Wildfires

Annual emissions from forest wildfires, prescribed forest burning and grassland fires which are calculated for particular fire events or burn areas should be spatially distributed on the basis of the actual locations of these burn areas.

These locations are usually provided by agencies in Australian Ma Grid (AMG) coordinates, or in latitudes and longitudes for the centroids of the areas burned. Emissions should be allocated to the grid cells which contain these burn areas.

Agricultural Burning

Emissions from agricultural burning should be allocated to the areas in which the particular crops are grown. ABS is able to provide harvest information by Statistical Local Area (SLA), which is the preferred area surrogate for this EET. This information can then be used to spatially allocate emissions according to Equation 4.

Maps of SLAs in Geographic Information System (GIS) format can be obtained from the ABS or the relevant State or Territory department. The location of agricultural land can be found from a land use map or in a GIS from the relevant department in a jurisdiction. The area of agricultural land in a grid cell can be derived relatively easily using a GIS. If a grid cell occupies more than one SLA, emissions from each SLA need to be summed to derive total emissions for the grid cell.

Total emissions of a particular NPI substance in a grid cell can then be calculated by summing the emissions estimates for the burning of each crop type and the gridded emission estimates for prescribed burning and wildfires.

Equation 4: Allocating emissions of an NPI substance from agricultural burning to a grid cell

$$E_{cjn} = E_{cjm} * A_{mn} / A_m$$

where

E_{cjn} = Total emissions of substance j from burning of crop type c in grid cell n, kg yr^{-1}

E_{cjm} = Total emissions of substance j from burning of crop type c in SLA m, kg yr^{-1}

A_{mn} = Area of agricultural land in grid cell n in SLA m, ha

A_m = Total area of agricultural land in SLA m, ha

3.3 Emission Factors

Emission factors for determining aggregated emissions are provided in Tables 4 and 5. Emission factors are provided for a range of different fire and crop types. For agricultural burning, if the amount of burned material for each individual crop type cannot be estimated, the factors applicable to the dominant crop type in the airshed should be used.

Table 4: Emission Factors for Forest Wildfires, Prescribed Forest Burning and Grassland Fires

NPI Substance	Forest Wildfires (g kg^{-1})	Prescribed Forest Burning (g kg^{-1})	Grassland (g kg^{-1})
Antimony and compounds[a]	3.91×10^{-4}	8.28×10^{-4}	4.60×10^{-3}
Arsenic and compounds[a]	2.55×10^{-5}	5.4×10^{-5}	3.00×10^{-5}
1,3-Butadiene[b]	9.48×10^{-2}	5.73×10^{-2}	4.40×10^{-2}
Cadmium and compounds[a]	5.27×10^{-4}	1.12×10^{-3}	6.20×10^{-4}
Chromium (VI) compounds[a]	2.64×10^{-4}	5.58×10^{-4}	3.10×10^{-4}
Carbon monoxide	70[c]	112[c]	83.6[d]
Cobalt and compounds[a]	9.35×10^{-5}	1.98×10^{-4}	1.10×10^{-4}
Copper and compounds[a]	1.87×10^{-4}	3.96×10^{-4}	2.20×10^{-4}
Lead and compounds[a]	4.34×10^{-4}	9.18×10^{-4}	5.10×10^{-4}
Manganese and compounds[a]	1.07×10^{-3}	2.27×10^{-3}	1.26×10^{-3}
Mercury and compounds[a]	1.11×10^{-4}	2.34×10^{-4}	1.30×10^{-4}
Nickel and compounds[a]	1.53×10^{-4}	3.24×10^{-4}	1.80×10^{-4}
Oxides of nitrogen	2[c]	2[c]	6.36[d]
Particulate matter ≤ 10 µm[c]	7.48	12	10
Selenium and compounds[a]	4.25×10^{-5}	9.0×10^{-5}	5.00×10^{-5}

Total volatile organic compounds	10.6[c,b]	6.4[c]	4.90[d]
Zinc and compounds[a]	7.14×10^{-4}	1.52×10^{-3}	8.40×10^{-4}

[a] CARB (1991a).
[b] CARB (1991b).
[c] USEPA (1995).
[d] Derived from DEST (1996).

Table 5: Emission Factors for Agricultural Burning for a Range of Crops

NPI Substance	Wheat ($g\ kg^{-1}$)	Barley ($g\ kg^{-1}$)	Sorghum ($g\ kg^{-1}$)	Oats ($g\ kg^{-1}$)	Rice ($g\ kg^{-1}$)	Maize ($g\ kg^{-1}$)	Sugar Cane ($g\ kg^{-1}$)
Antimony and compounds[a]	3.91×10^{-4}	5.06×10^{-4}	4.14×10^{-4}	7.59×10^{-4}	1.84×10^{-4}	3.22×10^{-4}	1.33×10^{-4}
Arsenic and compounds[a]	2.55×10^{-5}	3.3×10^{-5}	2.70×10^{-5}	4.95×10^{-5}	1.20×10^{-5}	2.10×10^{-5}	8.70×10^{-6}
1,3-Butadiene[b]	4.92×10^{-2}	6.71×10^{-2}	3.13×10^{-2}	8.95×10^{-2}	3.58×10^{-2}	5.37×10^{-2}	3.58×10^{-2}
Cadmium and compounds[a]	5.27×10^{-4}	6.82×10^{-4}	5.58×10^{-4}	1.02×10^{-3}	2.48×10^{-4}	4.34×10^{-4}	1.80×10^{-4}
Chromium (VI) compounds[a]	2.64×10^{-4}	3.41×10^{-4}	2.79×10^{-4}	5.12×10^{-4}	1.24×10^{-4}	2.17×10^{-4}	8.99×10^{-5}
Carbon monoxide[c]	59	78	38	68	41	54	35.5
Cobalt and compounds[a]	9.35×10^{-5}	1.21×10^{-4}	9.90×10^{-5}	1.82×10^{-4}	4.40×10^{-5}	7.70×10^{-5}	3.19×10^{-5}
Copper and compounds[a]	1.87×10^{-4}	2.42×10^{-4}	1.98×10^{-4}	3.63×10^{-4}	8.80×10^{-5}	1.54×10^{-4}	6.38×10^{-5}
Lead and compounds[a]	4.34×10^{-4}	5.61×10^{-4}	4.59×10^{-4}	8.42×10^{-4}	2.04×10^{-4}	3.57×10^{-4}	1.48×10^{-4}
Manganese and compounds[a]	1.07×10^{-3}	1.39×10^{-3}	1.13×10^{-3}	2.08×10^{-3}	5.04×10^{-4}	8.82×10^{-4}	3.65×10^{-4}
Mercury and compounds[a]	1.11×10^{-4}	1.43×10^{-4}	1.17×10^{-4}	2.15×10^{-4}	5.20×10^{-5}	9.10×10^{-5}	3.77×10^{-5}
Nickel and compounds[a]	1.53×10^{-4}	1.98×10^{-4}	1.62×10^{-4}	2.97×10^{-4}	7.20×10^{-5}	1.26×10^{-4}	5.22×10^{-5}
Oxides of nitrogen[d]	2.21	2.21	2.21	2.21	2.21	2.21	6.90
Particulate matter $\leq 10\ \mu m$[a]	8.5	11	9	16.5	4	7	2.9
Selenium and compounds[a]	4.25×10^{-5}	5.5×10^{-5}	4.50×10^{-5}	8.25×10^{-5}	2.0×10^{-5}	3.50×10^{-5}	1.45×10^{-5}
Total volatile organic compounds[c]	5.5	7.5	3.5	10	4	6	4
Zinc and compounds[a]	7.14×10^{-4}	9.24×10^{-4}	7.56×10^{-4}	1.39×10^{-3}	3.36×10^{-4}	5.88×10^{-4}	2.44×10^{-4}

[a] CARB (1991a).
[b] CARB (1991b).
[c] USEPA (1995).
[d] Derived from DEST (1996).

3.4 Sample Calculations

This Section of the manual provides examples of calculations of emissions estimates for various fire types and crop types burned, based on the equations and other data in Sections 3.1 and 3.2, and the emission factors in Section 3.3.

The following data have been used in Example 1:

- burn areas for wildfires, prescribed forest burning and grassland fires of 5000, 1200 and 500 ha respectively;
- the default fuel loadings for South Australia from Table 2; and
- the relevant PM10 emission factors from Table 4.

Example 1: Calculation of PM10 emissions from forest wildfires, prescribed forest burning and grassland fires in a particular burn area

Emissions of PM10 from various fire types can be calculated from Equation 1

$$E_{ij} = A_{ik} * L_{ik} * EF_{jk} * 10^{-3}$$

so

$$E_{PM10,wildfires} = 5 * 10^{3} * 7.48 * 13.8 * 10^{3} * 10^{-3}$$
$$= 5.16 * 10^{5} \text{ kg yr}^{-1}$$

$$E_{PM10,prescribedburning} = 1.2 * 10^{3} * 12 * 4.03 * 10^{3} * 10^{-3}$$
$$= 5.80 * 10^{4} \text{ kg yr}^{-1}$$

$$E_{PM10,grassland} = 5 * 10^{2} * 10 * 2.16 * 10^{3} * 10^{-3}$$
$$= 1.08 * 10^{5} \text{ kg yr}^{-1}$$

The following data have been used in Examples 2 and 3:

- harvests for wheat, barley and oats of 15, 6 and 10 thousand tonnes respectively;
- the residue fractions from Table 3; and
- the default fraction of crops under burn management (0.23) from Section 3.1.2.

Example 2: Calculation of material burned in agricultural burning

The mass of fuel burned for each crop type can be derived from Equation 2 as follows

$$M_c = H_c * R_c * F_c$$

so

$$M_{wheat} = 15 * 10^6 * 0.648 * 0.23$$
$$= 2.24 \times 10^6 \text{ kg yr}^{-1}$$

$$M_{barley} = 6 * 10^6 * 0.576 * 0.23$$
$$= 7.95 \times 10^5 \text{ kg yr}^{-1}$$

$$M_{oats} = 10 * 10^6 * 0.576 * 0.23$$
$$= 1.32 \times 10^6 \text{ kg yr}^{-1}$$

Example 3: Calculation of emissions of PM10 from agricultural burning in a SLA

Estimates of PM10 emissions from the burning of individual agricultural crops can be derived from Equation 3, using the results from Example 2 and emission factors from Table 5

$$E_{cj} = EF_{cj} * M_c * 10^{-3}$$

so

$$E_{PM10,wheat} = 8.5 * 2.24 * 10^6 * 10^{-3}$$
$$= 1.90 * 10^4 \text{ kg yr}^{-1}$$

$$E_{PM10,barley} = 11 * 7.95 * 10^5 * 10^{-3}$$
$$= 8.75 * 10^3 \text{ kg yr}^{-1}$$

$$E_{PM10,oats} = 16.5 * 1.32 * 10^6 * 10^{-3}$$
$$= 2.18 * 10^4 \text{ kg yr}^{-1}$$

4.0 Uncertainty Analysis

4.1 Data Reliability

Fuel loading data from the relevant Government agencies are considered to be of medium reliability. Fuel loadings may vary significantly within an airshed. The accuracy of these data for an airshed will depend on the quality and coverage of the information collected by the relevant agency. However, information on the location and scale of areas burned should be of relatively high reliability.

Fuel loading figures from DEST (1996) are less reliable than those collected directly from the jurisdiction managing agency.

Crop harvest information obtained from ABS or ABARE is considered to be of high to medium reliability. However, due to the various assumptions (and associated factors) that are required to convert total harvest data to amount of material burned, the overall data accuracy of this EET is considered to be low.

4.2 Reliability of Emission Factors

The emission factors for PM10, CO, NO_x and VOC emissions from wildfires and prescribed burning are obtained from USEPA AP-42, and are considered to be of low to medium reliability. In particular, the factors for wildfires are obtained from controlled laboratory experiments and are considered to be of low reliability.

Emission factors for PM10, CO, NO_x and total VOC emissions from grassland fires are drawn from DEST (1996) and are based on measurements of Australian burns. They are considered to be of medium to high reliability.

Emission factors for PM10, CO and total VOCs for a range of agricultural crop types are sourced from USEPA AP-42 and are considered to be of medium reliability. Emission factors for NO_x for agricultural crops are derived from DEST (1996), using emission factors for grassland fires and as such are considered to be of low reliability.

Emission factors for other substances (mainly metals and their compounds) are derived from speciation profiles developed by CARB. These factors are considered to be of low reliability.

4.3 Problems and Issues Encountered

There may be difficulty obtaining information on areas burned if the relevant agency within a jurisdiction does not keep records of this information. As data on areas burned is critical to this EET and varies greatly from year to year, some jurisdictions may need to develop suitable monitoring and data collection programs.

Data on the speciation of VOC emissions from various types of burns are currently not available, so that the emissions of some organic NPI substances cannot be separately estimated with this EET.

4.4 Recommendations for Further Work

Emission factors for prescribed burning are based on fires of American hardwood broadcast logging slash burns and may not be representative of Australian timbers. Further development of emission factors for a range of Australian forest types would increase the accuracy of the emissions estimates.

Similarly, emissions factors for wildfires are from controlled laboratory experiments of unknown timbers. Development of factors for Australian forests would improve accuracy, including VOC speciation data.

5.0 Glossary of Terms and Abbreviations

ABARE	Australian Bureau of Agriculture and Resource Economics
ABS	Australian Bureau of Statistics
AMG	Australian Map Grid
CARB	California Air Resources Board
CO	Carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEST	Department of Environment, Sport and Territories
EET	Emissions estimation technique
EF	Emission factor
EPAV	Environment Protection Authority of Victoria
GIS	Geographic information system
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NO_x	Oxides of nitrogen
NPI	National Pollutant Inventory
PM10	Particulate matter less than or equal to 10 μm
SLA	Statistical Local Area
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound

6.0 References

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