

Response to Wildfires

Guidelines for Public Health Units

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Introduction

As early as 2005, researchers predicted that New Zealand is likely to experience more severe weather due to global warming, that can contribute to an increased number of wildfires (Pearce et al 2005). Between 1997 and 2019, very high and extreme fire weather days likely, or very likely, increased at 12 and decreased at 8 of 28 sites across New Zealand (Stats NZ 2020). Current modelling predicts that the number of severe fire weather days in New Zealand is likely to increase by an average of 70 percent by 2040. The most marked relative changes are for Wellington and coastal Otago, where the number of severe fire weather days is likely to double to around 30, and triple to 20, per year respectively (Scion 2019).

These predictions appear to be being realised. Significant wildfires in New Zealand in recent years include the Port Hills fire in Canterbury in 2017, the Chatham Island wildfire of 2018, the Pigeon Valley fire near Nelson in 2019, and the Lake Ōhau and the Pukaki Downs fires in 2020. These fires damaged tens of thousands of hectares of bush, destroyed houses and property and resulted in one loss of life.



Figure 1: Lake Ōhau blaze, October 2020 (photo: RNZ/Tess Brunton)

Wildfires produce a large amount of smoke that disperses widely and can affect populations far from the fire source. They can expose people to a range of hazardous substances. In fact, every major fire is a chemical incident (World Health Organization (WHO) 2009). The longer a fire burns, the more products of combustion are formed. The effect of these products on water

quality is influenced by, among other things, the fire's intensity (Canning et al 2020), severity¹ and duration (Chi et al 2013). Changes in the quality of surface waters are greatest immediately after the fire (Chi et al 2013).

In addition to the obvious risks from burning, wildfires can pose a substantial threat because they release smoke, gases and ash into the air that may be hazardous downwind, through inhalation or through deposition on roof or surface water catchments. Further, the dispersion of firefighting water can cause material from the fire and firefighting chemicals to enter waterways. In some instances, hazardous materials (such as asbestos in roofs and agrichemicals stored in barns and rural industrial sites) may be in the pathway of the wildfire and may contaminate land, air or water.

Public health units (PHUs) are involved in the response to wildfires if the fires put public health at risk. For example, people may ask PHUs for advice on health-related matters such as evacuation and sheltering (that is, staying at home if the conditions are safe to do so), as well as temporary cessation of outdoor public activities (such as concerts or sports). Public health units must provide this advice in liaison with the relevant district health board (DHB)'s emergency management lead.

The purpose of these guidelines is to assist PHUs to minimise risks to public health from wildfires. Their objectives are to:

- i. describe air quality categories and corresponding cautionary advice and actions for protecting community health during smoke events
- ii. provide the best available information on what to do to minimise smoke exposure to protect community health, especially for sensitive groups, during significant smoke events. Sensitive groups include people over 65 years, children, pregnant women, people with heart or respiratory conditions including asthma, people in palliative community care, outdoor workers and people of low socioeconomic status
- iii. describe the hazards associated with wildfires that may affect private water supplies
- iv. advise PHUs on steps to take before and after wildfires to ensure the safety and potability of private water supplies.

These guidelines address wildfires, defined as unplanned non-controlled vegetation fires, but they are also relevant for other types of large open fires, such as land clearance and stubble burn-offs, commonly used in agriculture. These guidelines are a companion document to *Response to Major Fires* (Ministry of Health 2014), which focuses on industrial fires.

We would like to acknowledge the Institute of Environmental Science and Research (ESR) and PHU staff who have contributed and shared their experiences in the development of this document. We would also like to thank the Environmental Health Standing Committee in Australia who have completed work on this subject.

¹ 'Fire severity' refers to the ecosystem impacts of a fire, such as mortality of trees or loss in biodiversity. 'Fire intensity' describes the energy released from the fire or characteristics of the fire behaviour, such as flame length and rate of spread (Keeley 2008).

Roles and responsibilities

Being prepared

Public health units should maintain an up-to-date overview of information on cooling and filtration of public buildings and shopping malls where the public can seek shelter during prolonged wildfire smoke events. This information is useful not only for wildfires but also for major urban fires (such as the Auckland Sky Tower fire of 2019), chemical spills and other releases of potential public health significance.

The focus should be on identifying buildings and indoor areas with effective particulate filtration and air conditioning that are suitable for use as a cleaner air space to provide respite from exposure.

PHUs should also have a good understanding of indoor air quality in local schools, to inform decisions on relative risks in the event of school closures.

When a wildfire occurs

Depending on the size of the wildfire, either Fire and Emergency New Zealand (FENZ) or the regional civil defence emergency management group will be the lead agency; FENZ has responsibility for fighting the fire.

Once a PHU is notified of the fire, and the information indicates actual or potential casualties, the DHB emergency manager should be notified (thus forewarning the hospital emergency department). Depending on the scale of the fire, the PHU may activate a public health incident management team (IMT). This should be done early in the process and be well rehearsed. The IMT will follow the Coordinated Incident Management System framework, which sets out standard roles and responsibilities (Officials' Committee for Domestic and External Security Coordination 2019).

The PHU contact person should contact the FENZ incident controller or FENZ's own IMT as soon as practicable, to introduce themselves and receive a safety briefing. The FENZ IMT can provide information about the fire, meteorology and future predictions of fire behaviour that will be critical for a public health risk assessment. The FENZ IMT may also be seeking public health advice from the PHU.

In some circumstances, FENZ may require or request PHU staff to be present at the incident to work from the incident control point. Public health units should rehearse this process with local authorities and document it in their local coordination committee plan.

The main roles and responsibilities of a PHU in relation to a fire are:

- public health risk assessment
- provision of public health advice – to the incident controller and the public, via the media and directly to evacuees (information on air quality and drinking-water safety is often the most requested information)
- liaison with the local DHB IMT and emergency management lead to inform them of the situation, potential threats and risks and to support coordination of the response
- provision of information to Healthline (0800 611 116), general practitioners (GPs) and the hospital emergency department (if required)
- recommendation of additional environmental sampling, if appropriate (sampling should be done by the regional council or unitary authority).

Depending on local circumstances, the medical officer of health may be asked to contribute to a decision on whether to evacuate residents and when evacuated residents are able to return home. Often the former decision will have already been made by emergency services prior to the arrival of PHU staff at the emergency operations centre or coordination centre. In some circumstances, it may also be necessary to consider recommending closure of nearby schools and early childhood centres to prevent public exposure. Section 4 provides further guidance on this.

Unlike FENZ staff, PHU staff are not trained to actively involve themselves in firefighting or rescue incidents. In rare circumstances, FENZ may require PHU staff to enter restricted areas; this will only occur with a FENZ escort and the appropriate personal protective equipment. Such access should be arranged through the FENZ IMT.

PHU staff must not enter the area immediately around the fire or incident. Further, PHU staff must not enter areas that require specialist personal protective equipment or specialist training.

The PHU should notify the Ministry of Health, and other agencies, if applicable, of the incident as soon as practicable.

After the wildfire

Depending on the size and scale of the fire, a PHU may hold internal and external debriefings to identify lessons learnt and, if required, determine which of their procedures should be updated. This may be appropriate, for example, if the wildfire is very large, of long duration (more than a week) or causes smoke or water pollution that affects populated areas.

Public health risks from wildfires

In addition to the immediate hazards wildfires pose (that is, radiant heat and burning), wildfires generate smoke, ash and firefighting residual water that can cause air and water pollution and entail subsequent risks for public health. The following sections discuss these in turn.

Discharges to air

In the immediate vicinity of a wildfire (zone 1), the major risks are from heat, smoke and carbon monoxide, which may be lethal in just a few minutes. This area is most likely to be of major concern to the emergency services.

The area outside the immediate fire zone (zone 2) depends on the size and rate of the fire, current weather conditions (for example, direction and strength of wind and extent of rainfall) and local topography, as these affect dispersion of the smoke plume downwind.

It is important to note that, having been generated by fire, wildfire smoke can be extremely hot. The thermally buoyant plumes generated by large wildfires can travel for long distances – tens or hundreds of kilometres. This may necessitate liaison with PHUs in other regions.

Table 1 summarises the combustion products wildfires generate in zones 1 and 2. The primary pollutant of concern is particulate matter (PM) (smoke).

Table 1: Products of combustion discharged to air from wildfires

Pollutant	Zone 1	Zone 2
Fine particles (PM _{2.5})	+++	++
Carbon monoxide	++	+
Nitrogen dioxide, sulphur dioxide		+
Hydrogen chloride, hydrogen cyanide		+/-
Polycyclic aromatic hydrocarbons (PAHs)		+/-
Hazardous air pollutants (benzene, formaldehyde, acrolein)		+/-
Dioxins (and chlorinated organic compounds)		+/-
Trace metals, including arsenic		+/-

Key:

- +++ Likely to be present in very high quantities
- ++ Likely to be present in high quantities
- + Likely to be present
- +/- May be present at low level

Products of combustion

The combustion of natural biomass releases a complex mixture of particulate matter, water vapour and gases including carbon dioxide and carbon monoxide, as well as:

- inorganic acid gases such as hydrogen chloride (HCl), hydrogen cyanide (HCN), nitrogen dioxide (NO₂) and sulphur dioxide (SO₂)
- organic gases and aerosols including formaldehyde, acrolein, benzene and polycyclic aromatic hydrocarbons (PAHs)
- trace metals
- dioxins (because all plant matter contains chlorine in chlorophyll).

In regard to trace metals, arsenic is elevated in the Taupō Volcanic Zone (which stretches from Mount Ruapehu to Whakaari/White Island), and may also be present on fertilised pasture (Robinson et al 2004). This will likely give rise to increased discharges of arsenic to air during a wildfire of arsenic-laden vegetation. Similarly, mercury is stored in vegetation and will be discharged to air during wildfires. This is particularly a risk in areas where there are peat soils which can have elevated mercury (Taylor 2007). The Waikato region has some significant areas of peat land, as does Southland.

Many hazardous air pollutants are generated in wildfire smoke that can be potent respiratory irritants and carcinogens. The specific effects of these pollutants are extremely difficult to quantify and measure during an active smoke incident. This is primarily because of the technical difficulty of measurement, but also because they are typically only present in some locations for intermittent periods.

Particulate matter (PM) is the contaminant that is present in the highest concentrations in wildfire smoke, and widely monitored in many locations in New Zealand and overseas. It is therefore the focus of this document. This is consistent with regulatory approaches in Australia and the United States, where PM is considered the principal public health threat from short-and longer-term exposure to wildfire smoke (United States Environmental Protection Agency (US EPA) 2019; EnHealth in-press)

'Particulate matter' is a generic term for material in solid or liquid phase suspended in the atmosphere. It comprises multiple components and size fractions, and is typically classified by particle size (by aerodynamic diameter), because this dominates transport and removal processes in the air and inside the human body.

Particulate matter smaller than 10 micrometres (µm) (PM₁₀) is so small that it behaves like a gas: it settles extremely slowly, and it can be easily inhaled into the main body of the lungs. Fine PM (smaller than 2.5 µm: PM_{2.5}) is even smaller, and can reach the alveolar region of the lungs, where inhaled gases can be absorbed by the blood.

Approximately 90 percent of total particle mass emitted from wildfires consists of PM_{2.5} (US EPA 2019). In fact, wildfire smoke particles tend to be exceedingly small (0.4–0.7 µm) with a size range near the wavelength of visible light. This means wildfire smoke efficiently scatters light and impacts on visibility, and can impose serious safety risks when it crosses roads or affects airports.

PM_{2.5} is the preferred indicator of wildfire smoke.

Currently there is significantly more regulatory monitoring with real-time data available for PM₁₀ (more than 100 monitoring sites) than for PM_{2.5} (25 sites).² Regional councils also monitor PM_{2.5}, but this measurement may not be provided to the national database.³

By definition, PM₁₀ *includes* PM_{2.5}, so where there is an absence of PM_{2.5} data, PM₁₀ is also an appropriate indicator for wildfire smoke in New Zealand. These guidelines set out recommended air quality categories for both PM₁₀ and PM_{2.5} (see Section 4 and Appendix 3).

Health effects of particulate matter

As noted above, the primary pollutant of concern for wildfire smoke is PM_{2.5}. Levels of wildfire PM_{2.5} can greatly exceed those of typical ambient PM_{2.5}, spiking episodically within a short period of time (for example, hours after the onset of a wildfire). The symptoms of wildfire smoke inhalation include respiratory symptoms and decreased lung function (US EPA 2009).

There is global scientific consensus on the evidence demonstrating the adverse health effects caused by short-term (daily) exposure to fine particles or PM_{2.5}. This ranges from eye and respiratory tract irritation to more serious effects, including reduced lung function, pulmonary inflammation, bronchitis, exacerbation of asthma and other lung diseases, exacerbation of cardiovascular diseases such as heart failure (via myocardial ischemia) and even premature death (US EPA 2019).

PM_{2.5} is also a respiratory irritant, and exposures to high concentrations can cause persistent cough, phlegm, wheezing and difficulty breathing. Importantly, exposure to PM_{2.5} can also affect healthy people, causing respiratory symptoms, transient reductions in lung function and pulmonary inflammation. Particulate matter may also affect the body's ability to remove inhaled foreign materials, such as pollen and bacteria, from the lungs.

PM_{2.5} is a 'non-threshold' pollutant, which means that adverse health effects are observed at all concentrations (that is, there is no 'safe' threshold). The higher the level of population exposure, the greater likelihood of sensitive groups experiencing health effects. When exposure levels are very high, health effects may occur in everyone (Emergency Management Victoria (EMV) 2019).

² Land Air Water Aotearoa (<https://www.lawa.org.nz/>) is the national database for regulatory air quality monitoring.

³ For example, Auckland Council, Bay of Plenty Regional Council and Greater Wellington Regional Council host environmental data portals: see <https://environmentauckland.org.nz/>, <https://envdata.boprc.govt.nz/Data> and <http://graphs.gw.govt.nz/> respectively.

Health effects of wildfire smoke

Breathing in smoke can cause immediate symptoms including:

- coughing
- trouble breathing
- wheezing
- asthma attacks
- stinging eyes
- scratchy throat
- runny nose
- irritated sinuses
- headaches
- tiredness
- chest pain
- fast heartbeat (Centers for Disease Control and Prevention (CDC) 2020).

Respiratory symptoms such as dry cough, sore throat and difficulty breathing are common to both wildfire smoke exposure and respiratory diseases (such as influenza and COVID-19).

If people are experiencing symptoms unrelated to smoke exposure, such as fever or chills, muscle or body aches or diarrhoea, they should call Healthline (for free) on 0800 611 116 or their doctor immediately.

There is an emerging literature on the effects of wildfire smoke, particularly for respiratory outcomes (Holm et al 2020). Recent research suggests that wildfire smoke may be more harmful than other types of pollution (Aguilera et al 2021a). Though the differential toxicity of wildfire PM_{2.5} as compared to other ambient sources of PM_{2.5} is not well understood, recent animal toxicological studies suggest that PM from wildfires is more toxic than equal doses from other sources, such as ambient pollution (Aguilera et al 2021b).

The vulnerable populations at greatest risk of experiencing health effects from air pollution include:

- children
- pregnant women
- outdoor workers
- adults aged 65 years or older
- children with compromised immune and respiratory systems (premature babies)
- people with chronic health conditions such as heart or lung disease, including asthma and diabetes

- people of low socioeconomic status, including those who are homeless and with limited access to medical care.

Appendix 1 provides further details on populations sensitive to wildfire smoke.

Health effects on children

It has been demonstrated for over 25 years that children – especially infants and very young children – present with a higher rate of asthma emergency department visits and hospital admissions during and after wildfires (Chew et al 1995). Even children without asthma could experience respiratory symptoms, resulting in school absences and other limitations of normal childhood activities (US EPA 2019).

Compared to adults, children spend more time outside, tend to engage in more vigorous activity and inhale more air (and therefore more smoke constituents) per kilogram of body weight — all of which can affect their developing lungs. They also have less nasal deposition of particles, meaning that a higher proportion of particles can penetrate deeply into the lungs. Moreover, adverse effects on the developing lungs in childhood have been demonstrated to have health effects across a person's life course.

Recent research suggests that wildfire smoke may be more harmful than other types of pollution. Wildfire-specific PM_{2.5} was found to be around ten times more harmful on children's respiratory health than PM_{2.5} from other sources, particularly for children aged 0 to 5 years (Aguilera et al 2021a). Even relatively modest wildfires and associated PM_{2.5} produced major health impacts, particularly for younger children, in comparison with ambient PM_{2.5}.

All children, even those without pre-existing illnesses or chronic conditions, are considered to be at risk of experiencing a health effect due to wildfire smoke.

It is therefore important to try to limit children's vigorous outdoor activities during wildfire events (US EPA 2019).

Health effects of prolonged exposure to wildfire smoke

Experience in Australia and the United States suggests that most healthy adults and children will recover quickly from wildfire smoke exposure. However, recent research suggests that smoke from prolonged wildfires can have long-lasting effects on human health.

The Seeley Lake region in Montana experienced six weeks of wildfires in the summer of 2017. For 35 consecutive days, levels of PM_{2.5} were designated as 'very unhealthy', and for nine days levels were deemed 'hazardous'. A longitudinal study comparing the Seeley Lake community exposure with another non-exposed area found that residents exposed to long-duration, elevated levels of wildfire smoke had a significant decrease

in lung function one year following the wildfire event, and this remained decreased two years after the exposure (Orr et al 2020).

Discharges to water

Run-off from catchments affected by wildfires can contaminate drinking-water sources through particulates, chemicals and microorganisms. Surface water (streams, rivers, lakes and wetlands) and water collected on roof catchments is also vulnerable to pollution by chemicals associated with smoke and ash generated by wildfires, and may be polluted by firefighting chemicals.

The following list sets out potential water contaminants and associated health effects.

- **Fire retardants and foams** (Queensland Health 2019a)

Fire retardants and foams are mixed with water to reduce the spread and intensity of fire. The likelihood of health effects arising from firefighting solutions is very low, even for people who are accidentally exposed during their application. However, these chemicals may affect the appearance and taste of rainwater. The concentrate powders used to prepare wildfire fighting solutions can cause minor skin irritation. These health effects do not occur once the powder has been mixed into a slurry.

Class A Firefighting agents ('wetting agents') reduce the surface tension of water, so are retained on surfaces for longer, thus offering longer fire protection. They are usually classified as 'biodegradable' or 'readily biodegradable'. 'Readily biodegradable' means 70 percent of the product can be expected to degrade within 28 days.

Class B Firefighting agents are designed for flammable liquid and fuel fires, and contain fire-retarding chemicals. They are not used for fighting wildfires, but could be used in isolated situations (for example, if a wildfire impacts a petrol station).

Retardants are primarily made of ammonium sulphate and ammonium phosphate (chemicals commonly used as fertilisers and in agricultural chemicals), with thickeners (guar gum) and anti-corrosion inhibitors (to protect spraying equipment).

Foam contains a combination of wetting agents and foaming chemicals (detergents), mixed with water to increase the effectiveness of water used to combat fires.

Some chemicals previously used in Class B agents are no longer permitted in New Zealand, including perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), although they may be present in some form at trace levels. Some Class B firefighting foams may contain some per- and poly-fluoroalkyl substances (PFAS) other than PFOS and PFOA (Environmental Protection Authority (nd)).

- **Nutrients** (Canning et al 2020; Ministry of Health 2017)

Due to the heat generated by wildfires, most of organic matter in the fire is volatilised, resulting in the inorganic nutrients in the leaves leaching out and passing into the soil. The nutrients themselves are not hazardous, but they (particularly phosphorus) increase the likelihood of cyanobacterial (blue-green algae) blooms when flushed into surface water. Cyanobacteria produce a range of toxins that are primarily irritants, hepatotoxins or neurotoxins.

- **Polycyclic aromatic hydrocarbons** (Canning et al 2020; Ministry of Health 2018)

Polycyclic aromatic hydrocarbons (PAHs) are carcinogenic. They are formed from the incomplete combustion of organic matter. The concentrations considered safe for a lifetime of exposure are very low. They will be present on the surface of ash that enters water. However, they are highly hydrophobic, resulting in their ready adsorption onto ash and soils. Consequently, their concentrations in water are very low but they may cause long-term contamination of water tanks through sediment accumulation.

- **Benzene and other volatile organic compounds** (Proctor et al 2020; Denis et al 2012)

In addition to benzene, volatile organics that have been reported in distribution systems following the high-temperature heating and destruction of plastic pipes and water meters in distribution systems include toluene, dichloromethane, styrene and vinyl chloride. Benzene, styrene and vinyl chloride are known or suspected human carcinogens. There is evidence that toluene and dichloromethane are hepatotoxic (causing liver damage). Odours from these compounds may also be detected, and being hydrophobic (similar to PAHs) they may contaminate sediments and remain in water tanks for prolonged periods.

- **Iron and manganese** (Canning et al 2020; Chi et al 2013)

Burnt catchments release higher levels of particulates into the surface waters draining them than unburnt catchments. Iron and manganese are associated with these particles, so that the total concentrations of these metals increase in waters following wildfires. Elevated levels of these metals in water degrade the taste and appearance of the water. Iron is not considered to be a health-significant determinant, and manganese should not present a health concern for the short duration of exposure during a wildfire.

- **Arsenic and heavy metals** (Canning et al 2020; Smith et al 2011; Ministry of Health 2017)

While iron and manganese are the metals primarily released from soil burnt by wildfires, concentrations of arsenic and heavy metals (copper, chromium, lead) have also been reported to increase in surface waters following wildfires.

If a wildfire consumes buildings, structures and wooden fences, arsenic will be released from the combustion of treated timber. Further, lead emissions will occur in the combustion of lead-painted buildings or dwellings, and asbestos fibres may be liberated from burning pre-1980s buildings.

Mercury is also stored by vegetation and released during wildfires. This release is primarily to air, but research suggests it may result in increased levels in fish (Taylor 2007). This is particularly a risk in areas where there are peat soils, which can have elevated mercury. The Waikato region has some significant areas of peat land, as does Southland.

These substances may also be present in ash, making roof catchments vulnerable to their presence.

Arsenic and chromium are both acutely toxic and carcinogenic. Lead has several adverse effects, the most important of which is neurotoxicity, particularly in infants and young children. While exposure to these metals during wildfires is likely to be brief, it should be minimised where possible.

- **Carbon/dissolved organic carbon** (Canning et al 2020)

Low-intensity fires that do not burn the crowns of trees lead to an increase in leaf litter, which in turn increases the dissolved organic carbon (DOC) in water draining from the catchment. The heat generated by high-intensity fires volatilises organic matter, so reducing the availability of organic matter to contribute to DOC in water run-off. Dissolved organic carbon itself is not a hazard to human health.

- **Chloride, sulphate, sodium, calcium, magnesium potassium** (Canning et al 2020; Smith et al 2011)

All of these determinands have been reported to increase in surface waters following wildfires. The effects on water quality are primarily aesthetic, except for sulphate which can act as a purgative if present in concentrations exceeding 500 mg/L.

- **Cyanide** (Canning et al 2020; Smith et al 2011)

Cyanide can form from the combustion of protein containing organic material and arise in ash or deposits from the atmosphere. Its impacts are generally short lived, and confined to initial post-fire rainfall events. Cyanide is acutely toxic. Variable cyanide concentrations have been reported in surface waters following wildfires, but any increases appear to be short-lived.

- **Particulate matter** (Canning et al 2020)

The particle loading in surface waters draining catchments affected by wildfires can be very high, resulting in waters becoming dark brown or black. Large amounts of ash can also accumulate on roofs. Treatment plants in municipal supplies may have trouble reducing turbidity to an acceptable level. This will affect the aesthetic

properties of the water. More significantly, elevated turbidity will interfere with disinfection (chemical and ultra-violet irradiation). In addition, other hazards (for example, PAHs and metals) will be adsorbed to particle surfaces.

Exposure to contaminants in water supplies using roof catchments will be of short duration. However, contamination of soil and waterways through run-off of firefighting water and the deposition of airborne contaminants in surface water catchments can have longer-duration effects on water quality (Smith et al 2011; Chi et al 2013).

Roof catchments

(New South Wales Ministry of Health 2020)

Wildfires generate large amounts of smoke, ash and debris that can settle on roof catchments. Fire retardants or foams may also be deposited on roofs. This material can be washed into tanks, either when water is applied to the roof as part of fire protection activities, or when it rains after a wildfire.

The presence of ash and debris in rainwater drinking supplies is unlikely to pose a health risk, but increased turbidity may compromise the efficacy of disinfection processes (chemical and ultra-violet radiation). Airborne material from the fire could also affect the water's appearance (colour, turbidity and possibly foaming) and taste. If water is not diverted through first-flush mechanisms, sediments containing contaminants may accumulate in tanks and clog filters.

Physical effects on a roof catchment that may result from a fire, or firefighting actions, include burning or melting of plastic tanks and associated plumbing, and an increase in the water level in the tank if water-bombing aircraft have overflowed the roof.

Microbiological hazards from the usual sources (dead animals, animal faeces) may increase as the result of wildfires if animals die and fall onto a roof or into a tank.

Other matters

In emergency situations, access to services and information, including how to manage pre-existing conditions, may be lacking, and this situation can potentially exacerbate health inequalities. For example, vulnerable groups, including people who live in substandard housing, may find it very difficult to follow recommendations to disconnect water supplies and avoid wildfire smoke by staying indoors and using air conditioning.

Wildfires may affect the power supply of remote communities for several days or weeks. The loss of power for refrigeration may increase the risk of salmonella, campylobacter infections or other pathogens from spoiled foods. Loss of power may also affect personal, point-of-use or household drinking-water treatment systems, thereby delaying access to safe drinking water.

Air risk assessment and management

Exposure to wildfire smoke is likely to be greatest in the immediate fire zone (zone 1). Public health unit staff should keep this in mind, and take all necessary precautions (for example, remain upwind and, if necessary, wear personal protective equipment).

Masks need to be fit-tested and worn properly to be effective. Even so, masks will only mitigate some of the effects of smoke, and care should be taken to minimise exposure.

Initial assessment

In undertaking initial assessment, PHU staff should undertake the following procedure.

First, establish the nature and magnitude of the wildfire. This information can be obtained at the incident control point; it should include:

- the size and location of the fire, how long it has been burning, how much undergrowth or fuel is present and the fire's anticipated path
- the type of material being burnt (is it solely vegetation, or are other materials in the pathway of the fire?)
- the proximity to the population – taking note of sensitive locations (such as hospitals, schools, early childhood centres and aged care facilities)
- an estimate of the neighbouring population – this information may be qualitative (for example, 'densely populated' or 'sparsely populated').

Carry out a rapid risk assessment, covering:

- the proximity of the fire to the closest houses and people
- the exposure risk to:
 - the downwind population
 - the population exposed to contaminated run-off or deposited material
- the estimated duration of the fire
- who is most likely to be affected because they live or work near the site of the fire (including outdoor workers)
- who is likely to be most vulnerable to health effects
- besides air quality, what will potentially be affected (for example, drinking-water sources, recreational water, food and soil).

Assessing exposure risk will require consideration of:

- incident controller advice about the anticipated scale and path of the wildfire
- current meteorology (taking note of local mountain and rural forecasts if applicable). FENZ undertakes meteorological monitoring during wildfire events. For a practical guide to wind speed, see Appendix 2. For current predictions, the following websites may be helpful (apps for each are available for iOS and Android):
 - <https://fireweather.niwa.co.nz/> (FENZ's fire danger and fire behaviour site)
 - <https://www.metservice.com/> (MetService: New Zealand weather)
 - <https://www.weatherwatch.co.nz/> (Weather Watch: New Zealand weather)
 - <https://www.windy.com> (international wind information)
- current PM_{2.5} and/or PM₁₀ levels (taking careful note of the location of the monitor in relation to the location of the wildfire). The following websites may be helpful:
 - local regional councils' websites
 - Land Air Water Aotearoa (<https://www.lawa.org.nz>)⁴ (the national database).

Public health unit staff should be aware that real-time data on the national database is not validated. It may contain spikes (for example, for calibration purposes) and should be treated with caution. Liaise with the relevant regional council to understand data limitations. The regional council may also be undertaking additional, short-term monitoring in a specific area of interest.

To assess particulate concentrations, liaise with the regional council and see Appendix 3.

It is important to understand that smoke levels will fluctuate continuously, and that spikes will depend on local conditions such as wind speed and direction. As such, assessing community exposure will require consideration of all the parameters mentioned above (that is, current and predicted meteorology; the anticipated scale, path and behaviour of the wildfire; and current PM_{2.5} and/or PM₁₀ levels).

Real-time PM monitoring data is freely available on certain phone apps (for example, Air Matters, PurpleAir), which may claim to provide data on air quality in New Zealand locations not monitored by regional councils. These services do not use approved methods for equipment calibration or data validation, may not be reliable and should be viewed with caution.

If local air quality monitoring data is not available, the PHU should recommend it to the regional council. Not all regional councils will have the equipment or the capacity to do this. As further information comes to hand, the risk assessment should be refined. Inevitably, some uncertainty will remain because of the influence of meteorology.

Smoke levels in populated areas can be difficult to predict because they depend on local terrain, weather and fire behaviour, all of which can constantly change.

⁴ Select region, select town and zoom in on the map to select a monitoring site and see location and real-time hourly, daily and annual levels of PM₁₀.

Sometimes, by the time officials can issue a warning or smoke advisory, the smoke may already have cleared (US EPA 2019).

Further assessment

Exposure assessment

An exposure assessment is a short report setting out the likely risks of exposure associated with a given wildfire at a given time and place. Public health unit staff should create exposure assessments and include details of when, where and for what purpose.

When conducting an exposure assessment, consider the following aspects of the affected population:

- age (infants, children and older people are more vulnerable)
- health status (for example, pregnant people and those with asthma, chronic obstructive respiratory disease or cardiovascular disease are more vulnerable)
- behaviour and activities (for example, exercising outdoors involves increased physical activity, causing deeper respiration and the inhalation of more fine particles).

It is also important to determine:

- the extent of population exposure during a certain time period
- how many people are exposed.

An exposure assessment should also consider the risks of actions being proposed in response to the wildfire. For example, when considering closing a school due to existing or predicted poor air quality, the relative indoor air quality of homes and people's ability to transport children safely to and from school needs to be considered. In some locations, indoor air quality may be better in schools than in local housing, making school closures less beneficial from a public health perspective.

Dose–response relationship

For recommendations regarding different air quality categories and cautionary public health actions, see Appendix 3.

Risk characterisation

Wind and weather factors will reduce the potential toxicity of a smoke plume. However, wildfire smoke, even when diluted at significant distances (tens of kilometres), can cause significant irritation of the eyes and respiratory tract. This is usually resolved following removal from the exposure, with no long-term consequences.

The generation of toxic compounds such as arsenic, PAHs and dioxins should not represent a significant risk following a single exposure to wildfire smoke. However, if significant quantities of hazardous materials have been in the path of the fire, toxic compounds may be present, and health impacts will need to be assessed separately (see Ministry of Health 2014).

Prolonged wildfires

The longer a smoke event continues, the more likely exposed populations are to experience adverse health effects (US EPA 2019). This means that, as a wildfire continues, it is increasingly important to reduce public exposure to smoke. Prolonged smoke events may require consideration of additional measures to protect the public; especially people who are more susceptible to smoke pollution, such as children or the elderly.

During severe smoke events, people can find temporary relief from smoke, heat or cold, at public cleaner-air spaces for several hours, or the better part of a day. Such spaces could include libraries and shopping malls, or any indoor area with effective particle filtration and air conditioning. They can provide an alternative for people unable to reduce smoke levels in their homes.

Being prepared

If there is a chance residents' tank water supplies could become contaminated, PHUs should work collaboratively with Taumata Arowau (New Zealand's water services regulator since 2021) to inform residents of the potential need to disconnect their tank from the external water source. Public health units should advise residents to seek access to a radio or mobile phone, so that they can receive information about changing conditions and when it is safe to leave the house or open windows.

PHUs should consider providing a help-line number to inform the public of developments. This may be supported by a warning via an emergency mobile alert through the Emergency Management teams. The PHU can also use the emergency mobile alert to notify people if they need to evacuate, or boil water before drinking it.

Deciding whether to evacuate or shelter

Assuming evacuation and sheltering are both feasible, the choice of advising one over the other depends on the balance of risks. This decision will depend on the exposure level and duration.

Experience in the United States is that typically the decision to evacuate during a wildfire is to avoid direct engulfment by fire, rather than to avoid exposure to smoke.

Despite the advantages evacuation offers of protecting at-risk groups from smoke exposure, evacuation remains an unattractive option, due to:

- uncertainty – it is often difficult to predict the duration, intensity and direction of smoke
- people’s likely unwillingness to leave their homes, the stress evacuation can cause and the serious risks it may pose, particularly if poor visibility makes driving hazardous
- impracticality: even if smoky conditions are expected to continue for weeks, it may not be feasible for a large percentage of the population to evacuate.

These guidelines largely adopt the State of Victoria standard for defining air quality categories and recommended actions when air quality becomes hazardous. Specifically, when air quality becomes hazardous, medical officers of health should consider issuing an advisory strongly recommending that sensitive groups temporarily relocating away from the smoke until air quality improves, and for others to also consider this advice.

Air quality is defined as hazardous when PM_{2.5} concentrations are greater than 250 µg/m³ as a 24-hour rolling average for three or more consecutive days.

Aspects to consider when deciding whether to advise evacuation or shelter

Important aspects to consider when deciding whether to advise people to shelter or evacuate include:

- wildfire management:
 - size, scale and likely duration
 - anticipated path
- weather:
 - wind direction and wind speed
 - rain
 - forecast
 - effect on plume movement and height
- topography:
 - effect on plume movement and height
- exposure:
 - distance from wildfire to nearest houses
 - timing (whether exposure has already occurred, is imminent, or will not occur for several hours)
 - likely duration (hours, days)
- population:
 - location
 - size

- characteristics (for example, proportion of people with impaired mobility, elderly people or people at special risk, such as those on home dialysis or oxygen use)
- residential facilities (for example, boarding schools, rest homes, hospitals)
- time available to evacuate
- time of day
- availability of a safe and palatable supply of water if the period of exposure is extended (days)
- transport availability.

Health effects may occur among evacuees from direct exposure to smoke during the process of evacuating. Decision-makers must also consider the psychological impact on evacuees (for example, where people are obliged to leave behind pets or livestock).

Evacuation

The FENZ IMT will make decisions on evacuation in zone 1 (immediate fire environs) in a coordinated approach.

Evacuation is recommended for sensitive groups in zone 2 (downwind of fire) if air quality is, or is predicted to be, hazardous to health (see Section 4.4 and Appendices 3 and 4).

Evacuation may be preferable when a population is not yet exposed but will become exposed due to forecast wind direction, and the likely exposure duration means protection by sheltering may be insufficient. Evacuation may also be a better option where:

- there is a risk of prolonged, or very heavy, smoke exposure
- there is a relatively small number of evacuees

Decision-makers must allow sufficient time for evacuees to:

- learn of the need to evacuate (through door-to-door visits, loud hailers, websites, radio/TV or emergency mobile alerts)
- gather essentials if time permits (such as medication, baby supplies, pets and cash/cards)
- close all doors and windows
- disconnect water tanks and cover any openings
- secure their homes and leave.

It is more difficult to carry out evacuation effectively late at night or in the early hours of the morning. Note that evacuees must evacuate to a location at a sufficient distance that they will not have to move again if the wind changes.

The decision to authorise return depends on adequate information to support the conclusion that the area is safe. It will involve consideration of the negative health effects of evacuation (for example, the psychological impacts).

Before decision-makers authorise the return of evacuees to their homes, the following must occur:

- the wildfire is out or under control and is not expected to flare up again, or be affected by a wind direction change
- residential premises are considered safe
- PM_{2.5} and/or PM₁₀ monitoring shows that air quality is not hazardous
- advice has been provided about actions that evacuees should take on returning home, such as opening windows and doors to ventilate the house for an appropriate time and flushing/reconnecting roof-collected drinking-water supplies
- advice has been provided about whom evacuees should contact if they develop health effects (for example, Healthline or their GP).

Ultimately, the decision to allow evacuees to return will be a matter of judgement, informed, if necessary, by the widespread, real-time, continuous PM_{2.5} and/or PM₁₀ monitoring data,⁵ in conjunction with the guidance in Appendix 3.

Advice for public events

Decisions on postponing or cancelling public events such as concerts and sports activities require consideration of:

- the amount of notice required to call off an event (for example, it may take a significant amount of time to notify attendees that a large concert or national or international sports event has been called off, and attendees' travel time will be a factor)
- the location and duration of the event in relation to potential exposure to wildfire smoke
- local meteorology (for example, the wind could change direction, causing sudden improvement or worsening of air quality)
- the number of attendees and their potential sensitivity (for example, whether young children will be present) and the type of activity involved (for example, sports activities will increase participants' respiration rate)
- possible mitigation strategies or safety measures that could allow the event to continue (for example, air conditioning or high efficiency particulate air (HEPA) filters).
- potential transport routes if evacuation is required, how many people might need to be evacuated, the time it would take to evacuate them, where evacuees would go, how people with disabilities and those without cars would be evacuated.

⁵ See local regional council websites and/or <https://www.lawa.org.nz/>

Public health units are responsible for advising local schools and the Ministry of Education if events such as sports days or sport matches are cancelled.

Appendix 4 provides general public health advice for different air quality categories.

Sheltering

Decision-makers of the IMT should advise the public to shelter rather than evacuate when evacuation would cause a greater risk than staying put, or evacuation cannot be carried out.

International studies have shown that most of the outdoor PM from wildfires is able to infiltrate indoors, resulting in elevated indoor PM concentrations (Barn et al 2008; Sharma et al 2017). This infiltration in turn is affected by the air exchange rate of the building and the presence (or otherwise) of mechanical ventilation. New Zealand houses are highly variable and the older houses are more likely to have higher rates of the infiltration of outdoor PM into the indoors.

Importantly, however, the air quality that residents are exposed to can also be compromised by indoor sources such as cooking, candles, incense, smoking and vaping. Indoor air quality measurements of PM_{2.5} as a 24-hour average above the WHO 2005 guideline (25 µg/m³) due to indoor sources are not uncommon in residential settings in Australia, the United States and Europe (Reisen et al 2019).

These matters have implications for public health advice on sheltering in place, particularly during prolonged smoke events. When advising on sheltering it is important to have a good situational awareness and to think ahead as far as practicable. Evacuation may become the better option if the situation changes.

Houses with no air conditioning

If the advice is to shelter, PHUs should advise people to stay indoors (with their pets) and to close all doors and windows, to prevent outside air entering indoors. Depending on building airtightness, this usually results in a significant reduction in contaminant concentrations inside compared to outside for some hours; the extent of protection depends on the ambient concentration (WHO 2009).

Infiltration may be reduced 10-fold even in poorly airtight buildings, and even more so when people seal windows and doors with tape, damp towels or newspaper. There will be less infiltration in an interior room. However, over time, indoor air will equilibrate with outdoor air.

When advising people to stay inside and close windows and doors, an important caveat is the increased risk of heat stress in homes without air conditioning (US EPA 2019). Even in the absence of smoke, extreme heat poses a substantial health risk. Heat-related illnesses include heat exhaustion, heat stroke and death. Warning signs include heavy sweating, muscle cramps, weakness, headache, nausea, vomiting,

paleness, confusion, fainting (passing out) and dizziness. The groups at risk of heat-stress largely overlap with those at higher risk from smoke exposures.

Public health units should advise people that, to prevent overheating, they should use cool compresses, misting, showers and baths, and drink plenty of water.

Risks should be assessed to balance competing priorities and changes in the situation. For example, the need to stay hydrated in an overheated indoor environment should take priority over the need to disconnect roof water supplies to prevent possible future drinking-water contamination. Similarly, in some high-heat conditions, windows and doors may need to be opened to allow cooling, even if this means that smoke enters.

Houses with air conditioning

Research looking at a cohort of 17 Canadian homes measured PM levels during a forest fire, in homes with and without a portable air cleaner. It found that the mean decrease from use of the air cleaner was 65 percent (Holm et al 2020).

When advising people to stay indoors, tell them to bring in their pets, close all doors and windows and use air conditioning to mitigate smoky air, as follows:

- air conditioning units that bring air from outside should only be used with filters (ideally high-efficiency particulate air (HEPA) filters), to reduce smoke
- filters need to be working effectively; they may need cleaning or replacing during prolonged or heavy smoke events
- alternatively, air conditioning units can be used in recirculation mode. Turn off temperature modulation (that is, ensure the fan is on) to ensure air circulates.

For specific, more detailed, guidance on heating, venting and air conditioning (HVAC) systems, portable air cleaners and humidifiers, PHUs should refer to *Wildfire Smoke: A Guide for Public Health Officials* (US EPA 2019).

Public health units should advise the public that ozone generators, also marketed as personal air purifiers, 'super-oxygen' air purifiers and 'pure air' generators are sold as air cleaners, but considered to do more harm than good; they should not be used (US EPA 2019).

Masks

A filtering facepiece respirator is a device designed to fit tightly to the face and filter inhaled particles. Many countries use similar respirators whose material filters ~95 percent of particles: these respirators have various names (N95 in the United States, FFP2 in European countries, KN95 in China, first class in Korea). In New Zealand, the relevant standard is AS/NZS 1716; P2 respirators, commonly available in retail stores, meet this standard.

By contrast, a surgical mask is designed to minimise the excretion of droplets by the wearer and to protect from splashes of bodily fluids. Surgical masks are not designed for particle filtration for the wearer.

Despite this, while the benefits of surgical masks offer are variable and substantially less than that of respirators, they may be enough to provide some health benefit for the public during wildfires (Holm et al 2020). Similarly, even though protection of respirators is maximised with fit testing, a non-fit tested respirator is still likely provide greater protection than other mask options would (National Institute for Occupational Safety and Health 2020). Employers need to ensure that employees have WorkSafe approved fitted respirators (including police at checkpoints).

On average, surgical masks provide a small (roughly 20 percent) decrease in exposure for both children and adults. Non-fit tested respirators decrease exposure by roughly 80 percent for children and adults (Holm et al 2020). The existing literature suggests that the use of masks and respirators is safe in adults and children.

Cloth masks are not recommended for exposure to wildfire smoke because the amount of exposure to particles inside a cloth mask is incredibly variable. Some cloth materials concentrate fine particles and increase exposures (Patel et al 2016).

It should also be noted that, following the outbreak of COVID-19, a significant number of respirators were found in the New Zealand supply chain that do not meet international standards (WorkSafe 2020). The New Zealand Occupational Hygiene Society provides useful resources, including a guide to buying P2 or equivalent respirators for use in workplaces in New Zealand (Cole and Whitelaw 2020), a checklist (New Zealand Occupational Hygiene Society (nd)) and a webinar (New Zealand Occupational Hygiene Society 2020) on counterfeit respirators.

Communities and residents

This section sets out advice that PHUs should consider passing on to affected communities or residents.

All residents sheltering in their homes should avoid indoor sources of air pollution such as smoking cigarettes or vaping, using gas or wood burners, spraying aerosol products, frying and broiling, burning candles and incense and even vacuuming (unless the home has a HEPA filter), as such activities can significantly increase indoor particulate levels (Reisen et al 2019).

For example, in a closed room of 12 m³, it takes only around 10 minutes for the smoke of four cigarettes to generate hazardous levels of fine particles (644 µg/m³ of PM_{2.5}) (US EPA 2019).

When cleaning, residents should use a damp mop or damp dust cloth, to minimise re-suspending settled particles.

All residents should reduce their physical activity, to reduce inhaled air pollutants and thereby reduce health risks. When exercising, people can increase their air intake 10 to 20 times over their resting level. Increased breathing rates bring more pollution deep into the lungs. People tend to breathe through their mouth during exercise, meaning that air bypasses the natural filtering ability of the nasal passages and delivers more pollution to the lungs (US EPA 2019).

During a wildfire, smoke levels fluctuate, and may be punctuated with periods of relatively clean air. When air quality improves, even temporarily, residents should 'air out' their homes to reduce indoor air pollution.

Residents who are dependent on water stored in a tank for their water supply need to be prepared to disconnect the tank from the external water source in case it becomes contaminated (for example, through downpipes from a roof, gravity or pumped feed from surface water).

Public health units will need to consider appropriate communication channels to advise communities about changing conditions and when it is safe to leave the house or open windows. Such channels may include mobile phones (alerts), radio and door-to-door visits.

The United States CDC (CDC (nd)) and EPA (US EPA (nd)) also provide helpful advice for the public on how to reduce exposure to wildfire smoke. The latter includes a video on how to create a clean room to protect indoor air quality during wildfires.

After the fire

(US EPA 2019)

Ash from wildfires can be deposited on indoor and outdoor surfaces in areas around the fire. This can be irritating to the skin, nose and throat, and may cause coughing. The following rules should help minimise the health effects that may occur due to exposure to smoke and ash during clean up.

- i. Do not consume any food, beverages or medication that has been exposed to burn debris, ash or chemical fire retardant. Food exposed to smoke may also be contaminated and may not be safe to eat. The Ministry of Primary Industries will provide advice to the public on the health risk associated with food that has been exposed to a wildfire.
- ii. Always wear proper personal protective equipment (long-sleeve shirts, pants, gloves and safety glasses) when working around ash. If you do get ash on your skin, wash it off as soon as possible.
- iii. Well-fitting respirators will provide some protection during clean-up.
- iv. If the presence of asbestos, lead or other hazardous material is suspected, do not disturb the area.
- v. Avoid burned items that may contain hazardous chemicals, such as cleaning products, paint and solvent containers.
- vi. Avoid ash from wooden decks, fences and retaining walls pressure treated with copper chrome arsenic, as it may contain lethal amounts of arsenic.

- vii. Do not use leaf blowers or take other actions (for example, dry sweeping) that will put ash and particles into the air. Shop vacuums and other common vacuum cleaners do not filter out small particles; rather, they blow particles out the exhaust into the air. To clean up ash, use vacuums equipped with HEPA filters.

Water risk assessment and management

Risk assessment

Taumata Arowai have the responsibility for registered drinking-water supplies, all queries related to registered water supplies should be forwarded on to Taumata Arowai. The below advice can be given for private water supplies, which need to be made safe before any of the following activities are undertaken:

- drinking
- preparing baby formula
- hand washing
- preparing food and cooking
- brushing teeth
- bathing infants
- making ice
- water for animals.

Drinking-water quality will be at risk where a pathway enabling contaminants to be transported from their source to the water supply is present and active. A risk does not exist in the absence of a pathway. If a pathway is present, then the likelihood of it being active will influence the likelihood of contaminants reaching those on the supply.

The level of risk can be reduced by removing the source of the contaminants (for example, extinguishing the fire) or placing barriers in the pathway to prevent the transport of contaminants.

Qualitative risk assessment also requires consideration of other factors; for example:

- whether the fire or firefighting chemicals may affect catchment areas for municipal supplies, small supplies and self-supplies
- the number of people potentially affected by the fire
- the proximity of the fire and meteorological conditions that may transport material from the fire to threatened supplies
- the firefighting resources available to control the fire and the likelihood of the fire being controlled before it can affect the quality of the water source
- the nature of the water supply source: rainwater or surface water

- whether chemicals are being used as a fire suppressant or are in the fire's path (for example, diesel in storage tanks) and the possible presence of a pathway by which they may reach the water source
- the potential health effects the contaminants could cause
- the potential frequency and severity of those health effects.

Rainwater drinking-water supplies

Before the wildfire

Where there is enough time to advise householders to prepare for smoke from an incoming wildfire, PHUs should advise householders with rainwater supplies as follows.

- i. Disconnect the roof plumbing from roof tanks as soon as the risk of wildfire is apparent. This will prevent contaminated water entering the tank.
- ii. Seal openings to the tank to prevent ingress of contaminants.
- iii. Install leaf strainers in downpipes to prevent larger pieces of debris entering the tanks.

Firefighting chemicals entering the water

(Queensland 2019)

Firefighting chemicals can be coloured (firefighting retardants) or clear (foams). A check of the colour of water in the tank may not show whether the water has been contaminated by these chemicals.

If firefighting chemicals enter the tank, the water will not be suitable as drinking water for humans, pets or livestock. The presence of ammonia and sulphate in the water will make it smell terrible and taste salty.

The water can still be used for irrigation and firefighting purposes.

After the wildfire

After a wildfire, PHUs should advise householders with rainwater supplies as follows.

- i. Inspect the tank for physical damage from the fire. If the integrity of the tank has been compromised, it will require draining and repair or replacement. Care is required when working around rainwater tanks that have been damaged by fire.
- ii. Check for signs of contamination on the roof – unless it is obvious that the roof has been contaminated, water testing should be unnecessary.
- iii. Disconnect downpipes from the tank if this has not already been done. This will allow the first rainfall after the fire to run to waste. If it has rained since the fire, and before downpipes have been disconnected or redirected, it is likely that ash and other contaminants will have flowed into the tank. In most cases, this will mean that the tank will need to be drained and cleaned (note that the water

drained from the tank may be used for non-potable uses, such as watering the garden or dust suppression). Once the tank has been drained and cleaned, it should be refilled with water from a source known to be safe for drinking. The public should be advised to use caution when climbing ladders; only qualified professionals should enter water tanks for cleaning.

- iv. Clean the roof to remove ash and debris (with water known to be safe if possible), if this can be done safely. Scrub the roof with a brush and mild detergent if there is firefighting solution, firefighting foam residue or other residues that will not wash off on the roof. This must be followed by a rinse with clean water. The public should be advised to use caution when climbing on roofs.
- v. Follow up with a pressure wash if removal of the residue proves difficult, provided the roof does not contain asbestos. Pressure washing should not replace scrubbing to remove the residue. Appropriate measures (for example, non-slip shoes) should be taken to prevent slips and falls when cleaning the roof, and gloves should be worn.
- vi. Check the roof and guttering for dead animals and remove if they are present.
- vii. Ensure the first-flush diverter (if installed) is empty and in good working order.
- viii. Obtain and install replacement filter cartridges if water containing ash and debris has been drawn through them, and check all pipes and any treatment systems to ensure they are in working order. The owner should refer to the manual for the equipment or seek advice from the supplier, if other equipment has been affected.
- ix. Once the tank has been refilled (by rain or by carrier), flush all taps until clean water flows.
- x. If the rainwater tastes, looks or smells unusual, or there is reason to believe the water has been contaminated, use an alternative source of water (for example, bottled water).
- xi. Depending on the degree of contamination, rainwater can be used for flushing the toilet, watering the garden, washing clothes, firefighting or washing down surfaces.
- xii. When no other drinking water is available, disinfect rainwater by boiling it or using household bleach (see Section 5.3). Note that this may not improve the appearance or taste of the water.

Surface drinking-water sources

Some private dwellings draw water from surface sources: streams, rivers and lakes.

Groundwater is unlikely to be greatly affected by fire events, but if abstraction of water from groundwater sources could be contaminated by surface run-off, then these too should be regarded as surface waters.

Surface water supplies may need to be sampled more than once to ensure that any plume of contamination is identified (particularly for groundwater sources). The relevant regional council may hold information about the likely flow direction and flow rate for the area; this can be used to determine possible contamination pathways and to identify potential contamination of municipal catchments.

If there is any possibility of a source being contaminated, the water supplier and Taumata Arowai needs to be notified.

After the wildfire

(Queensland Health 2019b)

Before using surface drinking-water for the purposes identified, the following should be noted.

- i. Residents should not rely on boiling water as a way to make it safe from contaminants originating from the wildfire. Wildfires can cause debris and other contaminants (for example, nutrients, metals and other chemicals) to enter surface waters. Boiling water does not remove these kinds of contaminants, and indeed will usually concentrate them.
- ii. Neither should residents rely on a jug-filter as a way to make surface water safe from contaminants originating from the wildfire. Other types of filtration units (for example, point-of-entry and under-sink filters) may or may not be reliable for this purpose; residents should consult manufacturers in this regard.
- iii. Before residents are sure the water is safe, they should obtain water from an alternative source (of lower risk), such as rainwater, so long as that source has not been affected by the fire. If residents are in doubt about the quality of alternative sources, bottled water or treated town water should be tankered in.
- iv. Before use, all pipes and tanks should be checked for damage.
- v. Residents should ensure treatment systems are fully operational after a wildfire: microbiological hazards from the usual sources (dead animals, animal faeces) may increase as the result of wildfires if animals die and fall into source waters.

Immediately after the first rain event following a wildfire

(Queensland Health 2019b)

The following are important considerations when a rain event has occurred following a wildfire.

- i. Run-off during a heavy rain event within the first few weeks after a wildfire can carry sediment and pollutants into a source water. Soils erode more easily following a fire because of the loss of vegetation and the altered soil structure, and this can affect disinfection processes.

- ii. Residents should not use surface waters for any purpose (including clean-up, agriculture and general garden use) if there is a visible change in the water quality: change in colour, increased cloudiness, an unpleasant smell, foaming or an oily sheen on the water.

Making water safe

(Queensland Health 2019a; New South Wales Ministry of Health 2020; Better Health Channel 2020)

Most domestic water supplies are not equipped with treatment processes capable of removing all possible contaminants following a wildfire. If a resident knows water has been contaminated by ash or firefighting chemicals, or suspects it has been, they must find an alternative source, or empty, clean and refill the tank with clean safe water.

When water may contain pathogens

Power outages may affect treatment equipment. Residents should not use water after a power outage until they have checked systems and know them to be in working order. When residents suspect water of containing pathogens, or its microbiological quality is uncertain, they can make it safe by disinfection, as the sections below describe.

Where microbiological contamination of a domestic supply has been possible because of a fire, residents need to treat the water to ensure its safety. They should also undertake treatment if the microbiological quality of the water is in doubt.

Residents may still use water of uncertain microbiological quality for toilet flushing.

Disinfecting by boiling

Residents can disinfect water by bringing it to a rolling boil. If there is a power outage, residents can boil water using a pot on a gas stove, barbeque or portable gas cooker. Boiling of water has the advantage of inactivating all three families of microbiological concern in water: bacteria, viruses and protozoa.

Disinfecting with chlorine

If residents cannot boil water, they can treat it with unscented household bleach (containing 4–5 percent available chlorine) by adding 5 drops of bleach to 1 litre of contaminated rainwater, mixing it well and allowing it to stand for 30 minutes before use.

Recreational waters

Organic matter released into surface water as the result of wildfires will decompose, and could deplete the dissolved oxygen levels in water used for recreation to some degree. Waters in this state are likely to have a dark or black appearance and can cause fish deaths. Although the risk to human health from contact with water appearing black is usually low, people should avoid contact with it. Precautionary washing after contact is recommended.

Nutrient levels in surface waters, and the likelihood of cyanobacterial blooms developing, may be elevated for some time following a wildfire. People should also avoid drinking or coming into contact with water containing algae, and should prevent animals from doing so.

Where recreational waters are affected by wildfires, PHUs should inform the relevant regional council, which should undertake further monitoring of the site.

Private swimming pools and spas may become contaminated, these should be drained and cleaned prior to use. Outdoor commercial pools should have management plans that address contamination from outside sources such as wildfires.

Environmental sampling

Air samples

In New Zealand, regional councils undertake continuous ambient air quality monitoring for PM₁₀, PM_{2.5} or both pollutants (see Section 4.1). Depending on the location of the monitors in relation to a wildfire, this monitoring may provide critical, real-time information for an assessment of public health risk with respect to wildfire smoke.

Regional and local councils may seek public health advice during a wildfire event. They can help to identify any associated risks. Public health units have some responsibilities for the overall assessment of risk in such situations, and for providing advice to councils on management from a public health perspective.

To this end, see Appendix 3 (Assessing air quality during a wildfire).

Water samples

Where a wildfire affects a registered water supply, sampling to establish the safety of the water is the responsibility of the water supplier, with assistance from Taumata Arowai as required.

A water supplier's water safety plan should contain a contingency plan to manage the risks that wildfires pose to the water quality of the supply and its physical safety. This should include a sampling plan. Public health units can rely on the data the water supplier provides for assessing the safety of the supply unless there are clear reasons to seek additional samples.

Communication

This section contains suggested messages for PHUs to pass on to the public during and after a wildfire. In addition to the information within this section, appendices to this document provide further information, as follows.

- Appendix 3 provides guidance for PHUs about measures they can take to protect public health at different air quality categories and corresponding PM levels. This information is intended to help health officials, the media and the general public make decisions about appropriate strategies to mitigate exposure to smoke.
- Appendix 4 provides a general list of health effects and cautionary statements about altering behaviour during wildfires that PHUs can use in public advisories. These are based on air quality categories, as well as experience of and evidence from fire situations (US EPA 2019).
- Appendix 5 provides example advisory notes prepared by Nelson Marlborough DHBs during the Pigeon Valley fire.

Advice for children

All children, even those without pre-existing illnesses or chronic conditions, are considered a higher at risk group. Appendix 3 includes guidelines about when and how to give advice to modify outdoor physical activity or close schools and early childcare centres, based on the air quality category.

During the wildfire

Advice for people with pre-existing health conditions

(EMV 2019)

Public health units should provide the following advice for people with pre-existing health conditions.

- Anyone with a heart or lung condition should follow the treatment plan advised by their doctor and keep at least a five-day supply of medication available.
- Anyone with asthma should ensure their personal asthma plan is up to date, and follow it.
- Anyone who needs to leave their home due to a fire or very smoky conditions should take necessary prescriptions and medications with them.

Advice to help prepare for and avoid smoky conditions

(EMV 2019)

Public health units should provide the following advice to help people prepare for and avoid smoky conditions.

- Whenever possible, stay out of the smoke.
- Stay indoors when it is practical and safe to do so.
- Keep cool and hydrated in hot weather.
- Close all doors and windows to reduce smoke coming into your home.
- Seal gaps under doors or around windows and wall vents with towels, blankets or plastic.
- When indoors:
 - use air conditioners with HEPA filters; if the air conditioner has no filter, use it on recirculation mode only (turn off temperature modulation)
 - avoid other sources of indoor air pollution (such as smoking, vaping, burning candles, using wood burners or stirring up fine dust by sweeping or vacuuming).
- Consider bringing pets inside away from smoke or heat.
- When smoke levels outside clear up, open windows and doors to flush with fresh air.
- If the air in your home is uncomfortable, consider going to an air-conditioned building like a library or shopping centre for a break if it is safe to do so.

Advice for outdoor workers

(US EPA 2019)

Public health units should provide the following advice for outdoor workers in collaboration with WorkSafe.

- If feasible, limit exposure by:
 - postponing or shortening your time outdoors by focusing on high-priority tasks, relocating workers or rescheduling tasks to smoke-free or less smoky areas or times of the day
 - reducing physical activity and exertion levels
 - taking frequent breaks inside cleaner air spaces (such as enclosed structures or vehicles with recirculating or filtered air).
- If working outdoors is necessary, wear a properly fitted respirator that fits closely to the face, to help reduce personal exposure.

Advice when driving

(US EPA 2019)

Public health units should provide the following advice for drivers.

- Keep windows and vents closed and, if available, operate air conditioning in 'recirculate' mode.
- If driving a recent model vehicle for more than a short period of time, briefly open windows or vents occasionally when smoke levels are low, to avoid the build-up of carbon dioxide.⁶
- Do not use vehicles as a shelter, but rather as a means of transportation to.

Advice for everyone

(EMV 2019)

Public health units should provide the following general advice in the event of a wildfire.

- Minimise time spent in smoky conditions whenever practical to do so.
- People aged over 65 years, children 14 years and younger, pregnant women and those with existing heart or lung conditions should reduce prolonged or heavy physical activity. Where possible (and where people are not under direct threat from wildfires), limit time spent outdoors.
- If you are experiencing symptoms that may be due to smoke exposure, or anyone in your care is experiencing such symptoms, call Healthline on 0800 611 116 and seek medical advice.
- If you experience difficulty breathing or heaviness/tightness in the chest, shoulders, abdomen or even back, seek urgent medical assistance – call 111.
- For regular updates on what you should do, listen to your local emergency radio station.

After the wildfire

It is important to assess public concerns about possible environmental contamination and their personal exposure, because these may indicate a need for further investigation.

⁶ Studies have shown that carbon dioxide levels can quickly accumulate to very high levels (possibly >2,500 parts per million) in newer cars due to occupants' exhaled breath when vents and windows are closed and when the recirculation setting is used (Fruin et al 2011; Hudda and Fruin 2018; Lee and Zhu 2014).

Immediately after the fire, PHUs may find it useful to produce a health information sheet for residents. This may give advice on topics including (where relevant):

- house cleaning, including surface soot/dust removal (advise wet wiping rather than sweeping, and use of a vacuum cleaner with HEPA filter)
- cleaning hard and soft furnishings and clothing
- the safety of drinking water, if sourced from roof, surface water or a bore (if ground water is potentially contaminated)
- the safety of home-grown fruit and vegetables
- the safety of gathering puha or watercress
- recreational water use
- how to get further information
- what to do if symptoms or health concerns arise.

Public health units should consider how to most effectively convey this information to residents. For example, attaching the leaflet to the front door of evacuees returning home may be more effective than placing it in the mailbox. It may also be necessary to hold a public meeting in association with other key agencies (for example, local government) in the recovery stage. Appendix 5 provides an example advisory notice for returning residents.

Health monitoring

Whether any form of health monitoring occurs after a wildfire is a matter of judgement, and will depend on the scale of the fire and the potential (including public perception) for significant population exposure. Public health units can initiate health monitoring in either the response or the recovery stage.

Immediate health effects

Immediate symptoms of exposure to wildfire smoke may indicate either high exposure or high toxicity.

There are two main types of effects:

- syndromic conditions (for example, symptoms of respiratory irritation such as cough and sore throat/nose)
- exacerbation of pre-existing diseases (for example, asthma, angina).

Data sources for the type of condition and outcome include:

- ambulance attendances
- general practice or accident and medical clinic attendances
- emergency department attendances
- Healthline calls.

It may also be helpful to poll local school attendance. Experience in Australia and the United States suggests school attendance drops off, and incidence of asthma events increase, with prolonged exposure to wildfire smoke.

Immediate health effects associated with the ingestion of contaminated drinking water are unlikely, because the unpleasant taste and appearance of contaminated water typically deter consumption of health-significant quantities of contaminants.

Existing systems can be used to assess the wildfire's immediate impact as well as monitor for emerging acute health issues. Analysis of effects other than those directly related to the fire (for example, burns and smoke inhalation) require comparative information, ideally from the same population if pre-fire data is available. Alternatively, differences in exposure (for example, based on distance) within the same population could be looked at.

Using online surveys to rapidly obtain information on health effects related to an event, such as wildfires, is a tool that can be used effectively. Such surveys can take place via tools already in place for other purposes. For example, in Australia, people registered with 'FluTracking' (an online tool initially used to detect the potential spread of influenza) were surveyed about respiratory and other symptoms following wildfires (see <https://info.flutracking.net/insights/>).

Long-term health effects

Long term exposure to wildfire smoke at sufficient concentrations and durations may be a contributor to overall lifetime risk for heart disease, lung disease and in rare cases cancer (there is little information on this likelihood). Possible chronic effects would be determined by timing, duration of exposure, and proximity to the fire.

The limited number of epidemiologic studies that have specifically examined the cumulative effect of wildfire smoke exposure have focused on wildfire firefighters. There is initial evidence that continuous occupational wildfire smoke exposure (that is, over multiple days) may have a cumulative effect on lung function; some studies have observed a progressive decline during burn seasons (US EPA 2019). Recent research on community exposure has also found a significant decline in lung function one year following a prolonged wildfire event (Orr et al 2020).

Long-term health effects may also include mental health effects relating to the experience of a major wildfire.

Despite the limited research in this area, experience in the United States and Australia suggests the importance of reducing community smoke exposure during prolonged wildfire events. In simple terms, the longer a smoke event continues, the more people will start to experience adverse health effects. In the case of prolonged smoke events, PHUs need to consider additional measures to protect the public, especially people in at-risk groups (see Appendix 1).

Resources and sources of information

Resources and sources of information that may be useful for managing the public health risks from wildfires include:

- maps – including Google satellite view
- geographic information systems available on district and regional council websites; these provide information on land use, and will provide a clear picture to aid in risk assessment (for example, to plot the fire location, direction of plume, sensitive locations and evacuation zone; to identify drinking-water supplies; to estimate the population living within certain distances of the fire and potentially within the plume; and to map demographic factors such as age)
- FENZ hazmat/command vehicles, which have online access to relevant databases
- online meteorological information, from the sites set out in Section 4.1
- air-quality monitoring data from:
 - the local Civil Defence group website
 - the local regional council website
 - Land Air Water Aotearoa (<https://www.lawa.org.nz/explore-data/air-quality>)
- air dispersion modelling: this takes account of wind speed and direction to predict plume movement; this can then be used to define the population potentially exposed to airborne contaminants and to provide estimates of the number of people exposed to certain levels of contaminants (if necessary, this can be arranged through ESR)
- Drinking-water Online (<https://drinkingwateronline.nz>): account holders can log in to this webpage to obtain geolocation data that will allow PHUs to identify water supply sources potentially affected by wildfire and associated firefighting activities.

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Appendix 1: Populations sensitive to wildfire smoke

This table has been reproduced with minor amendments from *Wildfire Smoke: A Guide for Public Health Officials* (US EPA 2019).

Table A-1: Populations sensitive to wildfire smoke

At risk population	Rationale and potential health effects from wildfire smoke exposure
Children	<p>Rationale: Children’s lungs are still developing and there is a greater likelihood of increased exposure to wildfire smoke resulting from more time spent outdoors, engagement in more vigorous activity, and inhalation of more air per kilogram of body weight compared to adults.</p> <p>Potential health effects: Coughing, wheezing, difficulty breathing, chest tightness, decreased lung function in all children. In children with asthma, worsening of asthma symptoms or heightened risk of asthma attacks may occur.</p>
Older adults	<p>Rationale: Higher prevalence of pre-existing lung and heart disease and decline of physiologic process, such as defence mechanisms.</p> <p>Potential health effects: Exacerbation of heart and lung diseases leading to emergency department visits, hospital admissions and even death.</p>
Pregnant women	<p>Rationale: Pregnancy-related physiologic changes (eg, increased breathing rates) may increase vulnerability to environmental exposures, such as wildfire smoke. In addition, during critical development periods, the fetus may experience increased vulnerability to these exposures.</p> <p>Potential health effects: Limited evidence shows air pollution-related effects on pregnant women and the developing fetus, including low birth weight and preterm birth.</p>
People with asthma and other respiratory diseases	<p>Rationale: Underlying respiratory diseases result in compromised health status that can result in the triggering of severe respiratory responses by wildfire smoke.</p> <p>Potential health effects: Breathing difficulties (eg, coughing, wheezing, and chest tightness) and exacerbations of chronic lung diseases (eg, asthma and chronic obstructive pulmonary disease) leading to increased medication usage, emergency department visits and hospital admissions.</p>
People with cardiovascular disease	<p>Rationale: Underlying circulatory diseases result in compromised health status that can result in the triggering of severe cardiovascular events by wildfire smoke.</p> <p>Potential health effects: Triggering of ischemic events, such as angina pectoris, heart attacks and stroke; worsening of heart failure; or abnormal heart rhythms could lead to emergency department visits, hospital admissions and even death.</p>
People of low socioeconomic status	<p>Rationale: Less access to health care could lead to higher likelihood of untreated or insufficient treatment of underlying health conditions (eg, asthma, diabetes). Less access to measures to reduce exposure (eg, air conditioning) could lead to higher levels of exposure to wildfire smoke.</p> <p>Potential health effects: Greater exposure to wildfire smoke due to less access to measures to reduce exposure, along with higher likelihood of untreated or insufficiently</p>

At risk population	Rationale and potential health effects from wildfire smoke exposure
	treated health conditions, could lead to increased risks of experiencing the health effects described above.
Outdoor workers	Rationale: Extended periods of time exposed to high concentrations of wildfire smoke. Potential health effects: Greater exposure to wildfire smoke can lead to increased risks of experiencing the range of health effects described above.

Appendix 2: Practical guide to wind speed

The Beaufort wind force scale is an empirical measure that relates wind speed to observed conditions on land (and at sea – not reproduced here).

Table A-2: Beaufort wind scale

Beaufort Number	Description	Wind speed	Land conditions
0	Calm	< 0.5 m/s < 2 km/h	Smoke rises vertically
1	Light air	0.5–1.5 m/s 2–5 km/h	Direction shown by smoke drift but not by wind vanes
2	Light breeze	1.6–3.3 m/s 6–11 km/h	Wind felt on face, leaves rustle, wind vane moves
3	Gentle breeze	3.4–5.5 m/s 12–19 km/h	Leaves and small twigs in constant motion; light flags extended
4	Moderate breeze	5.5–7.9 m/s 20–28 km/h	Raises dust and loose paper; small branches moved
5	Fresh breeze	8–10.7 m/s 29–38 km/h	Small trees in leaf begin to sway; crested wavelets form on inland waters
6	Strong breeze	10.8–13.8 m/s 39–49 km/h	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty
7	High wind, moderate gale, near gale	13.9–17.1 m/s 50–61 km/h	Whole trees in motion; inconvenience felt when walking against the wind
8	Gale, fresh gale	17.2–20.7 m/s 62–74 km/h	Twigs break off trees; wind generally impedes progress
9	Strong/severe gale	20.8–24.4 m/s 75–88 km/h	Slight structural damage (chimney pots and slates removed)
10	Storm, whole gale	24.5–28.4 m/s 89–102 km/h	Seldom experienced inland: trees uprooted; considerable structural damage
11	Violent storm	28.5–32.6 m/s 103–117 km/h	Very rarely experienced: accompanied by widespread damage
12	Hurricane force	>32.7 m/s > 118 km/h	Devastation

Notes: 'm/s' = metres per second; 'km/h' = kilometres per hour.

Appendix 3: Assessing air quality during wildfires

Table A-3 and Table A-4 present air quality categories for assessing smoke from wildfires using available PM_{2.5} and PM₁₀ monitoring in New Zealand respectively.

The recommended air quality categories link monitored PM levels to corresponding cautionary health protection advice and recommended actions for the community until air quality improves.

The PM_{2.5} air quality categories are numerically equivalent to those used in all states of Australia (EnHealth, in press). The PM₁₀ hourly air quality categories adopt the state government of Victoria guidelines (EMV 2021). The PM₁₀ daily air quality categories have been based on the proportional relationship between (Australian) national PM_{2.5} hourly and daily air quality categories.

The recommended air categories for PM_{2.5} and PM₁₀ are recommended for use during incidence of wildfire in New Zealand. As such, the PM₁₀ air quality categories in this guide may not be appropriate for assessing air quality under other circumstances. This is because wildfire smoke is heavily dominated by fine particles (US EPA 2019), but this may not be true for other ambient concentrations of PM that may be present at other times in New Zealand.

In New Zealand, concentrations of PM_{2.5} and PM₁₀ measured using approved methods are available at:

- local regional councils' websites
- Land Air Water Aotearoa's website (<https://www.lawa.org.nz>)

In interpreting data from regional councils' websites, PHUs should liaise with the council for up-to-date context (for example, because instrument calibration can result in large data spikes).

As a minimum, the location of the monitor needs to be established relative to the potentially exposed population.

Smoke levels will fluctuate continuously, and spikes will depend on local conditions such as wind speed and direction. In addition to Table B-1 and Table B-2, factors to consider include (US EPA 2019) the following.

- **Fluctuations in PM_{2.5} levels:** Are the peaks of PM_{2.5} occurring relatively infrequently, are they interspersed with longer periods of good air quality, or do they occur multiple times per day, superimposed on higher-than-usual PM_{2.5} levels?

- **Predicted duration of high PM_{2.5} levels:** For instance, if air quality is predicted to be in the 'Poor' range or worse for multiple days to weeks, PHUs might consider opening cleaner air shelters or recommending evacuation plans for at-risk populations, including individuals with chronic lung or heart disease, who cannot take adequate personal protective actions to reduce exposures.
- **Potential indirect effects:** High PM_{2.5} levels can impair visibility and increase the risk of traffic accidents. This may be reason enough to cancel an evening indoor event at a local high school, for example.

Table A-3: Recommended PM_{2.5} air quality categories and actions for consideration by New Zealand public health units⁷

Range	PM _{2.5} (µg/m ³)		Recommended actions for consideration	Potential health effects without following advice or actions
	1-hour average	24-hour average		
Good	0–25	0–12.5	None	None.
Moderate	25–50	12.5–25	If smoke event forecast, issue public alert advising about health effects, symptoms and how to reduce exposure. Distribute information about exposure avoidance.	Little to no health effects.
Poor	50–100	25–50	People in sensitive groups should minimise or avoid prolonged or heavy physical activity and, where possible, limit the amount of time they spend outdoors. Those with a health condition should follow prescribed treatment plans. Everyone else should reduce prolonged or heavy physical outdoor activity if they develop health effects.	Increasing likelihood of health effects in sensitive groups: people aged over 65 years, children aged under 14 years, pregnant women and those with existing heart or lung conditions. Potential occurrence in people not in sensitive groups.
Very poor	100–300	50–150	People in sensitive groups should avoid outdoor physical activity (exercise) and, where possible, stay indoors. Those with a health condition should follow prescribed treatment plans and seek medical advice if symptoms worsen. Everyone else should minimise or avoid prolonged or heavy physical outdoor activity and, where possible, spend more time indoors. Consider closing some or all schools or early childhood centres. Consider rescheduling outdoor events involving physical activity (such as competitive sports) until air quality improves. If PM levels are projected to remain high for a prolonged period, consider evacuation of at-risk population.	Significant aggravation of health effects in sensitive groups. Significant increase in respiratory and other effects in everyone else.

⁷ Public health units should establish the representativeness of the PM_{2.5} monitoring site (location) for the exposed population before consideration the recommended actions.

Range	PM _{2.5} (µg/m ³)		Recommended actions for consideration	Potential health effects without following advice or actions
	1-hour average	24-hour average		
Extremely Poor	>300	>150	<p>Sensitive groups should consider temporarily relocating to stay with a friend or relative living outside the smoke-affected area. If this is not possible and (only if) there is no direct threat from wildfire, they should stay indoors and keep activity levels as low as possible.</p> <p>Everyone should avoid outdoor physical activity as much as possible and, where possible, stay indoors (if not under threat from wildfire).</p> <p>Anyone with symptoms should seek medical advice and take regular breaks out of smoky conditions.</p> <p>Consider closing schools.</p> <p>Cancel all outdoor events (eg, concerts and competitive sports).</p> <p>Consider air quality in indoor workplaces and take measures to protect workers as needed. Consider curtailment of outdoor work activities unless workers have a fully implemented respirator plan in place and clean air respite breaks.</p>	<p>Serious aggravation of health effects in sensitive groups.</p> <p>Serious risk of respiratory effects in everyone else.</p>
Hazardous (Medical Officer of Health)	Not applicable	> 250	<p>As for the 'Hazardous' range above and</p> <p>If PM_{2.5} levels (ie, rolling 24-hour average) are predicted to be above 250 µg/m³ for two consecutive days and are predicted to continue at or above this level, strongly recommend that sensitive groups temporarily relocate away from smoky conditions until there is a sustained improvement in air quality.</p> <p>Everyone else should consider this advice.</p>	As for Hazardous poor (above)

Table A-4: Recommended PM₁₀ air quality categories and actions for consideration by New Zealand public health units⁸

Range	PM ₁₀ (µg/m ³)		Recommended actions for consideration	Potential health effects without following advice or actions
	1-hour average	24-hour average		
Good	0–40	0–20	None	None.
Moderate	40–80	20–40	If smoke event forecast, issue public alert advising about health effects, symptoms and how to reduce exposure. Distribute information about exposure avoidance.	Little to no health effects.
Poor	80–120	40–60	People in sensitive groups should minimise or avoid prolonged or heavy physical activity and, where possible, limit the amount of time spent outdoors. Those with a health condition should follow prescribed treatment plans. Everyone else should reduce prolonged or heavy physical outdoor activity if they develop health effects.	Increasing likelihood of health effects in sensitive groups: people aged over 65 years, children aged under 14 years, pregnant women and those with existing heart or lung conditions. Potential occurrence in people not in sensitive groups.
Very poor	120–300	60–150	People in sensitive groups should avoid outdoor physical activity (exercise) and, where possible, stay indoors. Those with a health condition should follow prescribed treatment plans and seek medical advice if symptoms worsen. Everyone else should minimise or avoid prolonged or heavy physical outdoor activity and, where possible, spend more time indoors. Consider closing some or all schools or early childhood centres. Consider rescheduling outdoor events involving physical activity (such as competitive sports) until air quality improves. If PM levels are projected to remain high for a prolonged period, consider evacuation of at-risk population.	Significant aggravation of health effects in sensitive groups. Significant increase in respiratory and other effects in everyone else.

⁸ Public health units should establish the representativeness of the PM_{2.5} monitoring site (location) for the exposed population before consideration the recommended actions.

Range	PM ₁₀ (µg/m ³)		Recommended actions for consideration	Potential health effects without following advice or actions
	1-hour average	24-hour average		
Extremely Poor	> 300	> 150	<p>Sensitive groups should consider temporarily relocating to stay with a friend or relative living outside the smoke-affected area. If this is not possible and (only if) there is no direct threat from wildfire, they should stay indoors and keep activity levels as low as possible.</p> <p>Everyone should avoid outdoor physical activity as much as possible and, where possible, stay indoors (if not under threat from wildfire).</p> <p>Anyone with symptoms should seek medical advice and take regular breaks out of smoky conditions.</p> <p>Consider closing schools.</p> <p>Cancel all outdoor events (eg, concerts and competitive sports).</p> <p>Consider air quality in indoor workplaces and take measures to protect workers as needed. Consider curtailment of outdoor work activities unless workers have a fully implemented respirator plan in place and clean air respite breaks.</p> <p>If PM levels are projected to remain high for a prolonged period, consider evacuation of population.</p>	<p>Serious aggravation of health effects in sensitive groups.</p> <p>Serious risk of respiratory effects in everyone else.</p>
Hazardous (Medical Officer of Health)	Not applicable	> 250	<p>As for the 'Hazardous' range above and</p> <p>If PM_{2.5} levels (ie, rolling 24-hour average) are predicted to be above 250 µg/m³ for two consecutive days and are predicted to continue at or above this level, strongly recommend that sensitive groups temporarily relocate away from smoky conditions until there is a sustained improvement in air quality.</p> <p>Everyone else should consider this advice.</p>	As for Hazardous Poor (above)

Appendix 4: General health messages during wildfires

This table has been adapted from *Standard for Smoke, Air Quality and Community Health: Significant fires with fine particles as the primary smoke component of health concern* (EMV 2019). It sets out air quality categories and corresponding explanations.

Table A-5: Air quality categories and corresponding explanations

Air quality Category	Explanation
<p>Good</p>	<p>Air quality at this station is good.</p> <p>What this means:</p> <ul style="list-style-type: none"> • Outside activities can be had and enjoyed. <p>The air quality where you are might not be the same as the air quality at this monitoring location.</p>
<p>Fair</p>	<p>Air quality at this station is moderate.</p> <p>What this means:</p> <ul style="list-style-type: none"> • the air is probably a bit smoky or dusty here • air quality is okay now, but it could change soon. <p>What you can do:</p> <ul style="list-style-type: none"> • it's okay to be outside but watch for changes in air quality around you • if you are sensitive to air pollution, follow your treatment plan. <p>The air quality where you are might not be the same as the air quality at this monitoring location.</p>
<p>Poor</p>	<p>Air quality at this station is poor.</p> <p>What this means:</p> <ul style="list-style-type: none"> • the air is probably smoky or dusty here • people who are sensitive to air pollution could have symptoms like coughing or shortness of breath. <p>What you can do:</p> <ul style="list-style-type: none"> • if you are coughing or have shortness of breath, avoid being outside in the smoke or dust • if you are sensitive to air pollution, spend less time outside in the smoke or dust and follow your treatment plan • close your windows and doors to reduce smoke and dust coming into your home.

Air quality Category	Explanation
	<ul style="list-style-type: none"> • if you are worried about your symptoms, see your doctor or call Healthline on 0800 611 116 • seek urgent medical help if anyone around you has trouble breathing or heaviness/tightness in the chest, shoulders, abdomen or even back. Call 111 for an ambulance. <p>The air quality where you are might not be the same as the air quality at this monitoring location.</p>
Very poor	<p>Air quality at this station is very poor.</p> <p>What this means:</p> <ul style="list-style-type: none"> • the air is probably very smoky or dusty here • many people might have symptoms like coughing or shortness of breath. <p>What you can do:</p> <ul style="list-style-type: none"> • listen to your local emergency radio station or visit https://www.health.govt.nz for advice • avoid being outside in the smoke or dust <p>When inside:</p> <ul style="list-style-type: none"> • close your windows and doors to reduce smoke and dust coming into your home • use air conditioners with HEPA filters or, in the absence of a HEPA filter, use on recirculation mode only (turn off temperature modulation). • if the air in your home is uncomfortable, consider going to an air-conditioned building like a library or shopping centre for a break if it's safe to do so <p>When smoke levels outside clear up, open windows and doors to flush with fresh air.</p> <ul style="list-style-type: none"> • if you are sensitive to air pollution, follow your treatment plan • if you are worried about your symptoms, see your doctor or call Healthline on 0800 611 116 • seek urgent medical help if anyone around you has trouble breathing or heaviness/tightness in the chest shoulders, abdomen or even back. Call 111 for an ambulance. <p>The air quality where you are might not be the same as the air quality at this monitoring location.</p>
Extremely Poor	<p>Air quality at this station is hazardous.</p> <p>What this means:</p> <ul style="list-style-type: none"> • the air is smoky or dusty here • everyone might have symptoms like coughing or shortness of breath <p>What you can do:</p> <ul style="list-style-type: none"> • listen to your local emergency radio station or visit https://www.health.govt.nz for advice • stay indoors away from smoke and dust • close your windows and doors to reduce smoke and dust coming into your home

Air quality Category	Explanation
	<ul style="list-style-type: none"> • use air conditioners with HEPA filters, or, in the absence of a HEPA filter, use on recirculation mode only (turn off temperature modulation). • if the air in your home is uncomfortable, consider going to an air-conditioned building like a library or shopping centre for a break if it's safe to do so <p>When smoke levels outside clear up, open windows and doors to flush with fresh air.</p> <ul style="list-style-type: none"> • if you have asthma, follow your asthma action plan • if you have a heart or lung condition, follow your treatment plan • if you are worried about your symptoms, see your doctor or call Healthline on 0800 611 116 • seek urgent medical help if anyone around you has trouble breathing or heaviness/tightness in the chest, shoulders, abdomen or even back. Call 111 for an ambulance. <p>The air quality where you are might not be the same as the air quality at this monitoring location.</p>

Appendix 5: Example advisory notes

Information in this appendix has been reproduced with minor modifications from a document Nelson Marlborough DHB published in 2019 in response to the Pigeon Valley wildfire. Public health units may adapt it for use in local contexts.

Example returning residents advisory note

Public health advice for residents returning after evacuation to their homes in Redwood, Eves, Teapot, Pigeon Valleys and Golden Hills Rd

Returning to a home affected by forest fires may be difficult both emotionally and physically. The information below should help you make a start. Not all the information will apply to you.

General advice

When returning home, think about your personal health and safety, and that of your family. Ash and other debris may have been disturbed and released into the air.

If you have young children, consider whether they should be present during the clean-up. Children are more likely to be affected by, and are less able to avoid, hazards (for example, ash or smoke residue inside your home).

People with asthma, bronchitis, emphysema or other lung disease are at greatest risk. Those with angina or other heart disease might also be affected.

- If you start to develop symptoms, use the medicines prescribed to you by your doctor.
- If your symptoms worsen and do not respond to usual measures, call your general practice or Healthline on 0800 611 116.
- If you experience breathlessness or chest pain, call 111.

Drinking-water supplies

If you are on a Tasman District Council (TDC) reticulated water supply, and are returning to Redwood, Eves, Teapot, Pigeon Valleys and Golden Hills Rd, be aware that the Wakefield, Redwoods and Hope/Brightwater reticulated water supplies are all currently operational, and will be safe to use.

If you are not on a TDC supply, and are returning to Redwood, Eves, Teapot, Pigeon Valleys and Golden Hills Rd, and use your own roof-water collection as your drinking-water supply:

- Inspect the roof and rainwater storage tanks for evidence of ash, fire retardants (red colouring) or foams.
- There is a (very small) likelihood that fire retardants and foams have been deposited on a few roofs close to the fires.
- If you see evidence of ash, fire retardants or foam on the roof, disconnect the downpipe to the water tank.
- Allow the next good flush of rain to clean the roof. Don't reconnect the tank until the roof is clean.
- If you find ash in your water tank or the water has an unusual taste, odour or appearance (possibly indicating the presence of retardants or foams), don't use the water for drinking, preparing food or personal hygiene (cleaning teeth, bathing).
- Disinfecting or boiling will not remove ash, retardants or foams.
- If your water tank is contaminated, you will need to thoroughly clean it after it has been emptied.
- Contaminated water can be used for flushing toilets and watering flower beds, shrubs and trees.
- You can use roof water in tanks that has not been affected by ash, retardants or foams as normal.

Health and cleaning

If you have a respiratory condition, such as asthma or bronchitis, you may wish to stay away from your house until it has been cleaned.

If weather conditions allow, ventilate your home by opening all the doors and windows. Smoke odour can linger for several days. This should not cause any ongoing harm.

Wash your hands regularly, particularly after clean-up and before eating.

When cleaning up, remember ash deposited by forest fires is relatively non-toxic but may be:

- irritating to the skin, especially to those with sensitive skin
- irritating to the nose and throat and cause coughing
- a trigger for asthmatic attacks in people who already have asthma.

During clean-up, use:

- a disposable N95 mask (available through health and safety and retail hardware outlets): these masks offer better respiratory protection than simple dust masks
- rubber or latex gloves
- long-sleeved shirts and pants or overalls
- normal cleaning products to wipe surfaces that have ash deposits on them; wet wiping is safer and more effective than dry wiping.

If your house has been heavily contaminated, consider using a professional cleaner, and check with your insurance company to see if your policy covers smoke damage and clean-up.

Young children should not be involved in any clean-up work.

Fire retardants and foams

Specialist firefighting retardants and foams have been used to help fight the fire. These do not present a significant risk to health, and will break down with rain. They may have left a pink or soapy residue on a few properties inside or near the perimeter of the fire. Firefighters have made an effort to prevent homes and waterways from being exposed to these. It is very unlikely that any homes have been affected.

In the unlikely event that your property has been affected, you can minimise your exposure by following the drinking-water and cleaning advice in this document.

The firefighting chemicals used in this emergency are designed for vegetation fires. They do not contain the chemicals (PFOS, PFAS or PFOA) that have previously been in the news relating to firefighting at airforce bases.

Food safety

If you've lost electricity, this may affect food you've had in freezers or refrigerators. Refer to the Ministry for Primary Industries' webpage 'Food safety in natural disasters and emergencies' (<https://www.mpi.govt.nz/funding-rural-support/adverse-events/food-safety-in-natural-disasters-and-emergencies/>).

Mental wellbeing

Anxiety is very common during an emergency event such as an uncontrolled fire. This is a normal response to a very stressful situation. Talking to people and helping others can be both therapeutic and useful.

If you need further support for yourself or for others:

- call your GP, after-hours practice or Healthline on 0800 611 116. General practice appointments and pharmacy prescription fees are free for fire-related appointments
- free-call or text 1737 to talk to a trained counsellor
- in an emergency, call 111.

For more public health information

Check the DHB website (www.nmdhb.govt.nz).

Example schools advisory note

To: Ministry of Education

Advice to schools and early childhood education centres regarding closing institutions

Pigeon Valley Fire

Date: 11:30 hours, 8 February 2019

The following should be considered in any decision-making on the public health risk around air quality:

1. How close is the school or early childhood education centre (ECEC) to the nearest part of the fire? Obviously, if a school is close to the fire front, sensible decisions must be made about the personal safety of pupils and staff. If in doubt, the school or ECEC should close.
2. Currently a lot of smoke is present from the Wakefield/Appleby/Mapua areas through to Nelson city. Staff and pupils with asthma, bronchitis, emphysema or other lung disease are at greater risk from smoke inhalation, as smoke can irritate the airways and provoke an attack. Those with angina or other heart disease might also be more affected. While smoke persists:
 - keep staff and students indoors (walking classroom to classroom is fine)
 - avoid outside play
 - cancel school sports
 - close all the windows and doors
 - turn off ventilation, air conditioning and heating systems that draw air from outside.

If any people with the above conditions start to develop symptoms, they should use the medicines their doctor has prescribed. If their symptoms do not subside, they should be removed to a place away from the school that is free of smoke and remain there until school ends. If symptoms continue to worsen, call Healthline on 0800 611 116.

Ultimately, the greatest risk is to those in the path of the fire, who must follow the directions of the emergency services for their immediate safety. This includes schools.

The air quality will continue to change depending on wind speed and direction. It is suggested that someone at the school monitor online newsfeeds from a media organisation.

Public health contact:

Simon Baker, Medical Officer of Health

Example information sheet on firefighting chemicals

Forest fires and firefighting chemicals Pigeon Valley Fire, Nelson

What are firefighting chemicals?

Firefighting chemicals can generally be divided into fire retardants or foams. They slow the spread or intensity of a fire. In this current emergency, fire retardant (Phos-Chek) has been aerially applied inside the fire perimeter, and foams (Firebreak and Forexpan) have been used by firefighters on the ground.

The firefighting chemicals used in this current emergency are designed for vegetation fires.

They do not contain the chemical substances (PFOS, PFAS or PFOA) that have previously been in the news relating to firefighting at airforce bases.

How do they work?

Firefighters mix long-term fire retardants like Phos-Chek with water before they disperse them over the target area. When the water is completely evaporated, the remaining chemical residue helps prevent vegetation or other materials from igniting, until rain or erosion removes it. Fire retardants also work by binding to plant material (cellulose) and preventing combustion.

Firefighters apply foams directly to help extinguish the fire.

What are fire retardants made of?

Long-term fire retardants are essentially fertilisers (ammonium and diammonium sulphate and ammonium phosphate) with thickeners (guar gum) and corrosion inhibitors (for aircraft safety). The retardant used in this emergency was coloured with a red pigment, so that those spraying can see where they have released the retardant.

What are the human health effects of firefighting chemicals?

The recommended concentrations of the commonly used fire retardants and foams should not present a significant risk to health, but they may affect the taste and odour of water.

Testing shows retardants can produce minor irritant effects, particularly to the eyes. The concentrated powder (which residents would not be exposed to on returning home) may cause minor respiratory irritation to workers who are handling it. Once it is mixed into slurry this health effect does not occur.

Risk assessments carried out in the United States and in Victoria demonstrated that the risk of health effects was very low, even to people who are accidentally exposed to the fire retardants during their application.

This information has been taken from factsheets prepared by the Victorian and Queensland Departments of Health (Victoria Department of Health 2015; Queensland Health 2019a).

Example media release

PHS media release No: 3

Date: 9 February 2019

The Pigeon Valley Fire; what you need to know

Smoke exposure advice

For those closest to the fire, smoke from the fire may irritate the eyes, nose, throat and airways. These symptoms will quickly pass after you remove yourself from the smoke with no long-term consequences.

People with asthma, bronchitis, emphysema or other lung disease are at greatest risk from smoke inhalation. Those with angina or other heart disease might also be more affected. You should avoid exposure if possible. If you have any of these conditions and you are being exposed to smoke, you should:

- remain indoors
- close all the windows and doors
- turn off ventilation, air conditioning and heating systems that draw air from outside until the plume has dispersed or moved away and you can no longer smell smoke. Most heat pumps will not bring air in from outside when in cooling mode. Check the user manual for more details. Heat pumps and ventilation systems with a HEPA filter can be left on, as the filter will remove most smoke particles

In healthy people, most symptoms will disappear soon after the exposure to smoke has ended without any long-term consequences.

Advice for people needing health advice or health care

The usual fees for GP visits and pharmacy prescriptions will be waived for fire-related appointments.

If you have existing medical conditions and start to develop symptoms:

- use the medicines your doctor has prescribed
- if your symptoms worsen and do not respond to their usual measures, call your GP or Healthline (0800 611 116). If you experience breathlessness or chest pain, call 111.

For immediate health needs the following options are available:

- i. For Saturday 9 and Sunday 10 February:
 - call Healthline (0800 611 116)
 - call or visit after-hours GPs at the Medical and Injury Centre (Nelson) and Greenwood Health (Motueka) (Central Medical Motueka is closed 9 and 10 February)

- ii. On 11–15 February (weekdays):
 - call Healthline (0800 611 116)
 - call or visit your usual GP practice
 - after-hours, call or visit the Medical and Injury Centre (Nelson) and either Greenwood Health or Central Medical Motueka (Motueka)
- iii. On 16–17 February (weekend):
 - call Healthline (0800 611 116)
 - call or visit after-hours GPs at the Medical and Injury Centre (Nelson) and either Greenwood Health or Central Medical Motueka (Motueka)
- iv. At any time: call 111 or the emergency department for emergencies.

Advice for mental health and mental wellbeing

In the interests of your mental health and mental wellbeing at this stressful time, here are some tips.

- Try to get a good sleep: there are good tips on the Health Navigator website (<https://www.healthnavigator.org.nz/healthy-living/sleep/sleep-tips/>)
- Talk to your children – explain to them what is going on and listen to their concerns: there are good tips on the KidsHealth website (<https://www.kidshealth.org.nz/coping-natural-disaster>).
- Be aware that anxiety is very common during an emergency event and a normal response to a stressful situation. Talking to people and helping others can be both therapeutic and useful.
- If you need further support for yourself or for others:
 - call your general practice, after-hours GP practice or Healthline on 0800 611 116
 - free-call or text 1737 to talk to a trained counsellor
 - in an emergency, call 111.

General advice

The greatest risk is to those in the path of the fire, who must follow the directions of the emergency services for their immediate safety. Keep up to date via the Nelson Tasman Civil Defence website and Facebook pages. Turn on a radio and keep it tuned to news of the fire or keep a news live feed open on your computer.

Avoid exercising outdoors while smoke is present.

If you are on a roof water tank supply and a lot of ash is falling on your roof, it might be best to disconnect the pipe to the tank, and only reconnect it after the next heavy rain (discarding the 'first flush'), to avoid getting ash in your water supply. Look out for your neighbours, especially the elderly, those in ill-health and those who live alone.

If you can, get a break away from the smoke by relocating to an area unaffected by the current smoke plume.

Be aware that dust masks available from hardware stores will only screen out the largest smoke particles, so they are unlikely to provide much protection.

Contacts and information

You can find the most up-to-date information about the fires, evacuation and the emergency response from the following sources:

- Nelson Tasman Civil Defence website:
www.nelsontasmancivildefence.co.nz/news
- Nelson Tasman Civil Defence Facebook page:
<https://www.facebook.com/nelsontasmancivildefenceandemergencymanagement>
- NZ Transport Agency traffic pages (for information about road closures):
<http://www.journeys.nzta.govt.nz/traffic/regions/10>
- Brian FM (for Civil Defence information): 106.2 FM
- your child's school, via its website or Facebook page
- the Ministry of Social Development (for advice on financial support): 0800 559 009
- the Ministry of Primary Industries (for advice on animal welfare concerns): 0800 008 333 (option 4).

Nelson Marlborough Public Health Service contact:

Dr [Insert name here] [mobile number provided]