Technical report

Hazelwood Recovery Program water, soil and ash assessment – Morwell and surrounds

February 2014 – May 2015

Publication 1600 June, 2015.
Authorised and published by Environment Protection Authority Victoria.
200 Victoria Street, Carlton, 3053.

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1 About this report

This report is based on the Hazelwood Recovery Program's water, soil and ash sampling data collected by the Environment Protection Authority (EPA) Victoria during the Hazelwood mine fire and in the 14-month period since the fire was declared safe on 25 March 2014. For the purpose of this report, the collection of data has been classified into two phases: the Response Phase (mid-February to 7 April 2014) and the Recovery Phase (8 April 2014 to 21 May 2015).

The data in this report has already been made available on EPA's website:

www.epa.vic.gov.au/hazelwood/environmental-reporting

www.epa.vic.gov.au/hazelwood/hazelwood-mine-fire/testing-during-the-hazelwood-fire

As part of the writing process, this report has been reviewed by EPA, external scientific experts and relevant government agencies. A draft of this report was also reviewed by members of the Latrobe Valley community at an EPA engagement event on 10 June 2015. Following this event changes were made to the text and overall community feedback about the report has been included in the appendices.

This publication is a technical report. For further details about any aspect of this report, or to access data, please contact EPA Victoria on 1300 372 842 or email contact@epa.vic.gov.au

2 Aim of water, soil and ash monitoring program

The aim of the Hazelwood Recovery water, soil and ash assessment was to demonstrate if there have been any changes to the chemical composition of water and soil in the Morwell region as a result of the Hazelwood mine fire. In order to do this, EPA has compared the water and soil sampling data collected during the Recovery Phase, with the water, soil and ash data collected during the Response Phase. To better understand the extent of any impacts, this report also compares data from sites close to the fire with a site that was further away from the fire.

This report also aims to give the community an overview of the water, soil, and ash sampling and analysis processes used by EPA during the Response and Recovery Phases. The report focuses on the pollutants that had the potential to be released into the environment from ash during and after the coal mine fire.

3 Background

The Hazelwood Recovery Program is a state government-funded EPA initiative in response to the Hazelwood mine fire that occurred in February and March 2014. As part of EPA's commitment to the Hazelwood recovery effort, EPA has conducted air, water and soil testing across Morwell and the Latrobe Valley throughout the Recovery Phase. Information about air quality over the same period is available in a companion report (EPA publication 1601: Air quality assessment – Morwell and surrounds February 2014 – May 2015).

During the Hazelwood mine fire, EPA Victoria conducted regular water and soil sampling at a number of sites surrounding the fire as well as at sites expected to be outside of the area impacted by the fire. Ash samples were also collected when ash was found in sufficient quantities during the Response Phase.

After the fire was declared safe on 25 March 2015, EPA designed a year-long environmental monitoring program as part of the Recovery Phase. The sampling locations, the extent of the area monitored, and the main chemicals analysed (known as analytes) were kept largely the same as those during the mine fire. This consistency has allowed EPA to compare water and soil data from the Recovery Phase to data collected during the Response Phase.

4 Overview of water and soil Environmental sampling program

EPA tested the waterways and soils in and around Morwell for chemicals which may have come from the mine fire, including those from the ash. These chemicals can be deposited on the soil and in the water when the ash falls to the ground. This report considers ash as the larger, visible particles, released during the fire, which fell from the air column and were deposited in and around Morwell. For information regarding the particles which remained airborne, see EPA publication 1601: Air quality assessment – Morwell and surrounds February 2014 – May 2015. EPA tested for a range of chemicals that potentially could be associated with brown coal, the burning of the brown coal and the chemicals used for fire extinguishment. They included heavy metals (such as zinc and lead), organic compounds from incomplete combustion (such as polycyclic aromatic hydrocarbons, known as PAHs), surfactants and many other compounds. In all, EPA tested the water and soil for up to 90 different chemicals.

During the Response Phase EPA tested water and soil from a number of locations further away from Morwell for the same chemicals. These results were used to compare water and soils from locations that were not expected to be impacted by the ash from the fire with the results from those areas where ash was known to have been deposited.

The intention of this Recovery Phase sampling program was to indicate any potential changes caused by the fire. At times, the sampling program was modified (for example, some site locations were changed slightly and the testing of some chemicals ceased when the laboratory analyses of these substances were too low to measure). Sampling locations for the Recovery Phase can be seen in Figure 1.

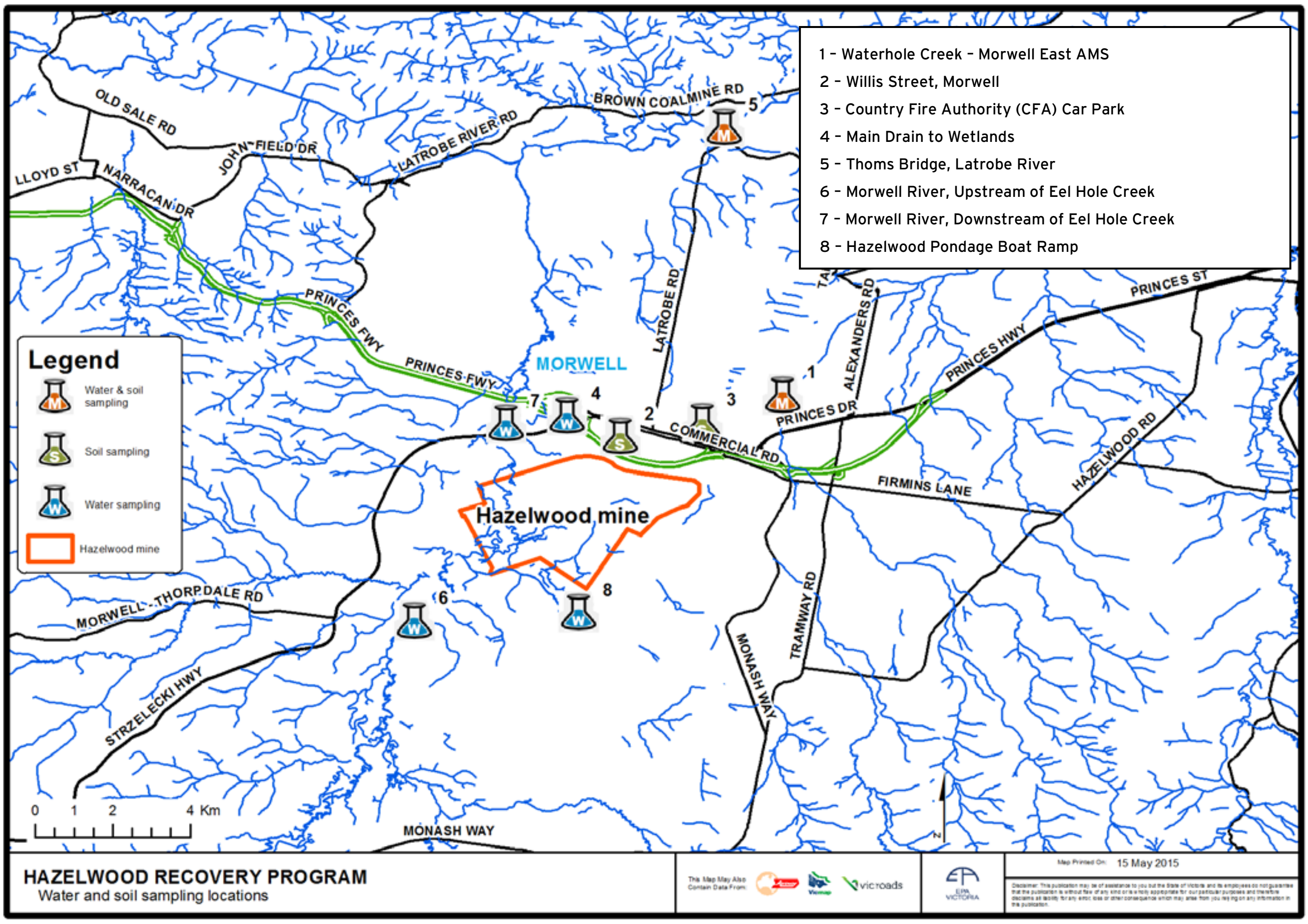

Figure 1. Water and soil sites sampled during the Hazelwood Recovery Program (September 2014 onwards)

Hazelwood brown coal contains many chemicals that had the potential to be released into the environment from the ash during the fire. Figure 2 shows the typical composition of brown coal from the Hazelwood coal mine along with its average inorganic and trace metal proportions.

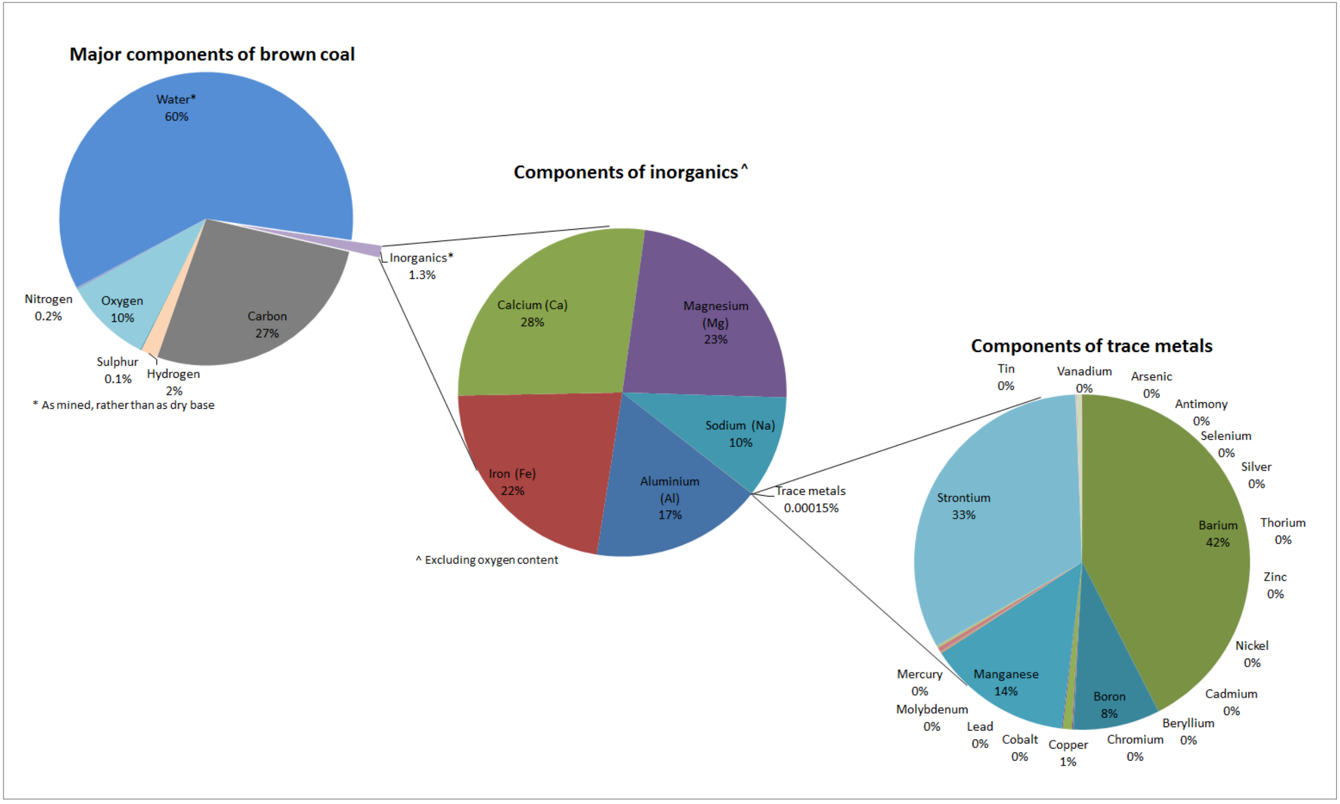

Figure 2. Typical composition in brown coal at Hazelwood Coal Mine and its average proportions of inorganic and trace metals (Durie, 1991)

5 Sampling design

During the Response Phase, from February to April 2014, EPA sampled surface and subsurface soils both within and outside the affected area at weekly intervals while the mine fire was burning, and for a number of weeks after the mine fire was declared safe. Ash samples were also collected during the fire at locations where there were significant deposits of ash. These deposits were predominantly in sheds, driveways and under eaves. Until 18 March 2014, a total of 12 ash samples were collected. After this date, the fire was no longer producing sufficient ash for collection.

EPA also sampled waterways during the Response Phase at various locations both within and outside the zone affected by the fire. This occurred at weekly intervals from late February until 7 April 2014, after the mine fire was declared safe. Sampling was conducted both before and after significant rainfall events, to detect if rain had washed any contaminants from the land into waterways.

5.1 Recovery Phase sampling locations

Environmental sampling in the Recovery Phase consisted of quarterly sampling of water and soil (surface and subsurface) from the Morwell area (See Figure 1).

5.1.1 Soil

Sampling of surface soil and subsurface soil occurred at key sites based on a variety factors including their proximity or distance to the mine, and whether they were areas of local concern. These sites include:

- Morwell East Air Quality Monitoring Station (AMS)
- Willis Street – adjacent reserve
- Morwell Country Fire Authority (CFA) car park
- Thoms Bridge on the Latrobe River.

Quarterly monitoring occurred in September/October, December, and March. These results are available on the EPA website: www.epa.vic.gov.au/hazelwood/environmental-reporting. The final round of sampling took place in May and June 2015. These results will be made available on EPA's website in July 2015.

The Willis Street site in Morwell is a residential property. Between April and September 2014, this sampling site was relocated to an adjacent reserve (20–30 metres away) to minimise impact on residents.

Thoms Bridge was considered to be outside the area affected by ash deposition and was included to provide comparative results for the area. Figure 1 shows the sample locations for soil sampling during the Recovery Phase.

Subsurface soil was sampled to provide a basis for comparison for the surface soil samples; if the chemical composition was similar in both the surface and subsurface soil samples, it was likely to be representative of the normal variation in soil at that site. It also allowed us to assess whether chemicals from the ash had moved into the subsurface soils over time.

It must be noted that some of these sites have a potential for contamination from other sources. For example, the CFA car park was initially chosen due to its accessibility and the presence of ash deposits; however, this site is used for storing heavy machinery and fire-fighting equipment, raising the potential for heightened readings of metals, fire-fighting chemicals and hydrocarbons.

5.1.2 Water

Water sampling occurred at six key sites based on a variety factors including their proximity or distance to the mine, and whether they were areas of local concern. These sites include:

- Waterhole Creek – adjacent to Morwell East AMS
- Hazelwood Pondage boat ramp – adjacent to the entrance to Eel Hole Creek
- Thoms Bridge on the Latrobe River
- The main drain to the Morwell Wetlands
- Morwell River – upstream of Eel Hole Creek
- Morwell River – downstream of Eel Hole Creek.

Quarterly monitoring occurred in September, December, and March. These results are available on the EPA website: www.epa.vic.gov.au/hazelwood/environmental-reporting. The final round of sampling took place in May and June 2015. These results will be made available on EPA's website in July 2015

Water sampling was complemented by passive sampling in April 2014 using granular activated carbon (GAC) bags, which absorb dissolved contaminants and metals in water. Sampling was conducted at the same sample sites as above.

The Latrobe River at Thoms Bridge was considered outside of the area affected by ash deposition and was included to provide comparative results for the area. While all sites could potentially have received flows from ash-affected water, Thoms Bridge is approximately 15 km downstream from the fire, and as such should have received delayed or diminished effects if ash had been present in the water. Also, the Latrobe River is a large waterway and its size would have a diluting effect against possible changes in water quality.

5.2 Sampling methods

The samples were collected by EPA staff according to EPA's documented processes and in line with a data quality management plan. Sampling was conducted under EPA's *Sampling and Analysis of Waters, Wastewaters, Soils and Wastes Guidelines*.

Once collected, the samples were analysed by independent laboratory service providers, who are accredited by the National Association of Testing Authorities (NATA).

5.3 Sample analytes

The analytes EPA tested for were based on groups of chemicals that may be common in the environment, as well as those associated with the coal, the burning of the coal and the chemicals used for fire extinguishment. These included:

Soil and ash:

- 27 metals suite (including sampling for Chromium VI)
- 16 polycyclic aromatic hydrocarbons (PAHs)
- 7 monocyclic aromatic hydrocarbons (MAHs)
- 34 halogenated volatile organic compounds
- 6 solvents.

Water:

- 25 total metals (including sampling for Chromium VI)
- 16 polycyclic aromatic hydrocarbons (PAHs)
- 7 monocyclic aromatic hydrocarbons (MAHs)
- 34 halogenated volatile organic compounds
- 6 solvents
- 4 nutrients.

This program was not conducted to assess the overall water and soil quality in the area but to demonstrate whether any changes occurred due to the Hazelwood mine fire event. We are therefore not reporting on commonly used water quality measures such as pH, salinity or dissolved oxygen.

Polycyclic aromatic hydrocarbons (PAHs) and monocyclic aromatic hydrocarbons (MAHs) are produced as a result of the incomplete combustion of organic matter, such as brown coal. The Hazelwood mine fire burned at varying temperatures and fluctuating oxygen concentrations, which potentially resulted in the production of aromatic hydrocarbons, such as benzene, toluene, benzo[a]pyrene and naphthalene.

Concentrations of the organic compounds and metals relevant to the combustion process were measured, including the heavy metals and metalloids – arsenic, cadmium, chromium, lead and mercury.

Semi-volatile compounds (semivols), which include solvents and halogenated volatile organic compounds, are found in a wide variety of industrial substances including fire-fighting chemicals, pesticides, degreasers and paint thinners.

5.4 Guidelines and standards

The following guidelines were used for guidance and reference during the Response Phase to assess potential health considerations. However, as these guidelines do not assist in determining if the water or soils had been directly impacted by the ash from the Hazelwood mine fire, they have not been used as a basis for comparison to results in this report.

Soil and ash:

- National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM)
- EPA Victoria, Soil Hazard Categorisation and Management (IWRG 621).

Water:

- Australia and New Zealand Guidelines for fresh and marine water quality, 95% species protection level (ANZECC/ARMCANZ – 95% species protection level) relating to slightly-moderately disturbed systems
- Australian Recreational Water Quality Guidelines (ARWQG)
- Australian Drinking Water Quality Guidelines (ADWG).

The above-mentioned guidelines provide the following values for metal concentrations in water. These have been included in this report to provide context and a point of comparison for the water sampling results, rather than to assess if ash from the mine fire has impacted on water quality.

Table 1. Water Quality Guidelines values

		ANZECC/ARMCANZ – 95% species protection	Australian Drinking Water Quality	Australian Recreational Water Quality
Aluminium	mg/L	0.055	-	-
Antimony	mg/L	-	0.003	0.03
Arsenic	mg/L	0.024 (as As III)	0.01	0.1
Barium	mg/L	-	2	20
Beryllium	mg/L	-	0.06	0.6
Boron	mg/L	0.37	4	40
Cadmium	mg/L	0.0002	0.002	0.02
Chromium	mg/L	0.001 (as Cr VI)	0.05	0.5
Cobalt	mg/L	-	-	-
Copper	mg/L	0.0014	2	20
Iron	mg/L	-	-	-
Lead	mg/L	0.0034	0.01	0.1
Manganese	mg/L	1.9	0.5	5
Mercury	mg/L	0.0006	0.001	0.01
Molybdenum	mg/L	-	0.05	0.5
Nickel	mg/L	0.011	0.02	0.2
Selenium	mg/L	0.011	0.01	0.1
Silver	mg/L	0.00005	0.1	1
Strontium	mg/L	-	-	-
Thallium	mg/L	-	-	-
Tin	mg/L	-	-	-
Titanium	mg/L	-	-	-
Vanadium	mg/L	-	-	-
Zinc	mg/L	0.008	-	-

6 Sampling results and discussion

To assess whether there have been any impacts to the local waterways and soils in the Morwell region, this report focused on the comparisons of sites within and outside the ash deposition area (or the impact zone). This report also compares surface and subsurface soils. To track any mine fire impacts, the metals barium, boron, manganese and strontium were identified as key analytes as they were found in significant percentages in early mine fire ash samples, and are common trace metals found in brown coal.

Although semivols were tested for during the Response Phase and into the Recovery Phase, very few semivol compounds were detected in the environmental sampling program. One example of a semivol that was detected was acetone, a solvent that is found both naturally in soils as a by-product of bacterial processes and in air as a product of combustion. It can also be found in a variety of industrial processes. Acetone was found in small amounts in a number of water, soil and ash samples.

Whilst very few semivols were found in the water and soil sampling program, the broad screen that resulted from the initial investigation of the samples yielded a large and diverse group of compounds. While not concerned, EPA is conducting supplementary investigations into understanding the extended semivol compounds identified. As this investigation is ongoing, semivols will be discussed in future reports.

The results for the water, soil and ash samples are discussed below.

6.1 Ash

A number of metals and organic compounds, including PAHs, were found in the ash samples. These compounds were expected as they are either known to be present in brown coal or are products of incomplete coal combustion. The ash samples that were collected are thought to be a combination of ash from the coal mine fire, soil and dust from the ground and ash from nearby bush fires which were happening at the same time. Further research is being undertaken by EPA to understand these ashes and how they can be compared to the materials burned to produce them.

The soil sampling program was established to compare the ash samples with soils at the surface and subsurface within and outside the zone affected by the fire.

6.1.1 Metals

A number of metals (for example, boron, barium, manganese, strontium and zinc) were identified in the ash samples.

This was expected, given these metals are found in brown coal, as well as being present in the soils in the region. The metal results – between the ash and surface and subsurface soil samples, both within and outside the affected zone – show that there has been no significant change on the soils in the region as a result of the ash deposition. Further research is underway by EPA to quantify this natural variability of metals in the soils across Victoria.

6.1.2 Polycyclic aromatic hydrocarbons (PAHs) and other organic compounds

A number of PAHs were detected in the ash samples. PAHs were also seen in an initial surface soil sample taken at Willis Street, Morwell on 18 February 2014. This sample is expected to be mostly ash with a small amount of soil. In contrast, soil samples taken after this time detected only a small number of PAHs. These were at levels far below those originally recorded. These results indicate that while the Morwell region was exposed to ash deposition early on in the fire, it was not sufficient enough to cause any significant changes in the composition of local soils.

6.1.3 Ash comparison to soil

Figure 3 and Table 2 below compare the soil collected in the Response and Recovery phases with ash samples collected during the Response Phase (the last ash sample was collected on 18 March 2014). They compare the chemical compositions by looking at the metal concentrations (Figure 3) and the presence or absence of various PAHs (Table 2).

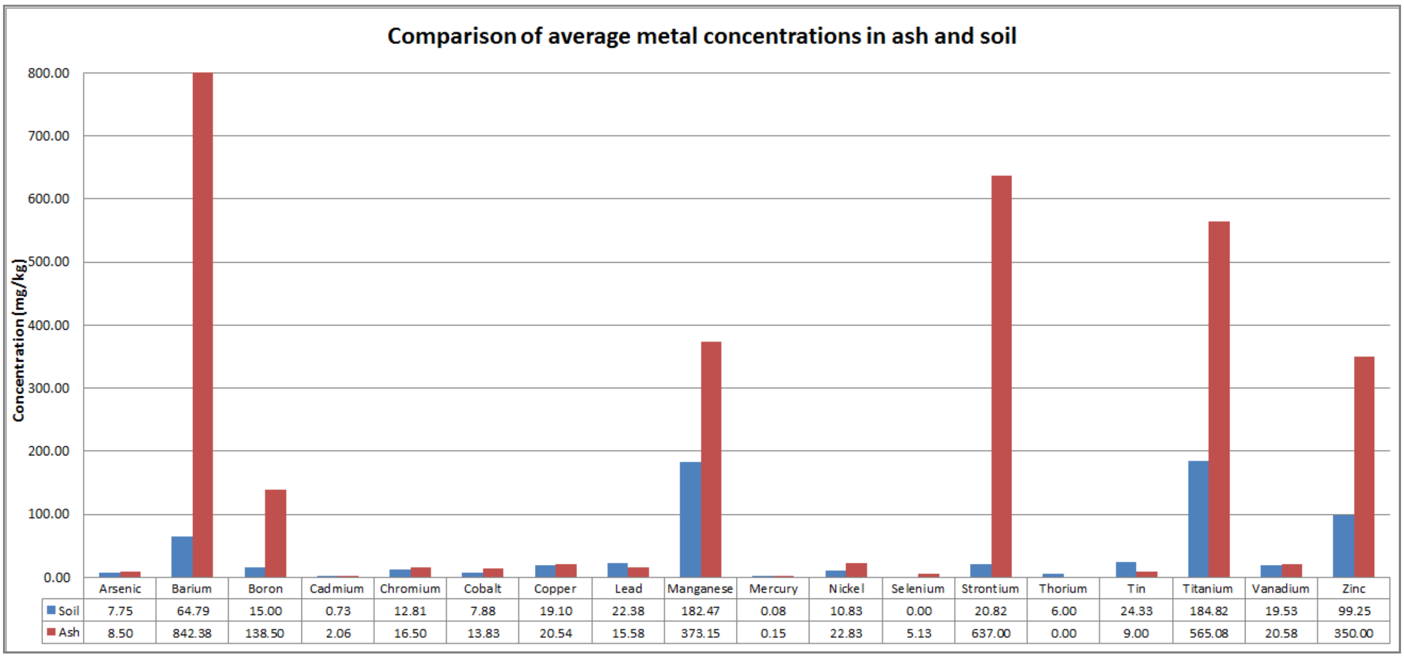

Figure 3. Comparison of metal concentration in soil and ash samples (excluding aluminium and iron for graphical purposes)

Figure 3 uses the surface and subsurface soil samples taken during the Recovery and Response Phases. It does not include the surface soil sample taken during the mine fire at Willis Street on 18 February 2014 which is now believed to have been composed of mine fire ash. This has been included in the ash results instead.

Aluminium and iron were detected in high quantities in both the ash (aluminium: 8,054 mg/kg; iron: 27,469 mg/kg) and the soil (aluminium: 5,726 mg/kg; iron: 10,664 mg/kg). This was expected in the ash due the high percentage of these metals in brown coal, as well as being naturally present in the soils. For graphical reasons, they have not been represented in Figure 3.

Table 2 provides representative data for ash and soil samples taken during the Response Phase. Although soil samples in the table were taken during the Response Phase, they are considered representative of soil samples taken during both phases as PAHs were generally not detected.

The area shaded grey shows that the compound tested was either not present, or was below the level of laboratory detection.

Table 2. Comparison of PAH concentrations between ash and surface soils during the Response Phase.

	Bushfire ash	Mine fire ash						Ash collected on surface soil	Surface soil		
	Club Astoria	Club Astoria	Morwell FC	Hazelwood Rd	Wallace St	Morwell Bowls Club	Willis St	Willis St	Willis St	Thoms Bridge	CFA car park
	13/03/14	13/03/14	13/03/14	18/03/14	13/03/14	13/03/14	3/03/14	18/02/14	24/02/14	10/03/14	17/03/14
Acenaphthene	<0.1	0.2	0.2	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	0.4	0.7	0.8	<0.2	<0.4	<0.1	0.2	0.4	<0.1	<0.1	<0.1
Anthracene	0.3	1.1	1	0.5	0.6	0.1	0.2	0.6	<0.1	<0.1	<0.1
Benzo(a)anthracene	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3
Benzo(a)pyrene	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3
Benzo(b)fluranthene	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4
Benzo(ghi)perylene	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
BenzO(k)fluranthene	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3
Chrysene	0.6	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.4
Dibenz(ah)anthracene	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	1.4	1.2	0.8	0.4	0.7	0.3	0.1	0.4	<0.1	<0.1	0.9
Fluorene	0.2	1.9	1.8	<0.6	1.5	0.1	0.5	0.1	<0.1	<0.1	<0.1
Indeno(123)pyrene	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Naphthalene	0.5	7.5	9.8	3.5	6.3	0.4	5.2	6.5	<0.1	<0.1	0.2
Phenanthrene	1.6	7.6	6.1	3.1	3.9	0.8	1.3	3.7	<0.1	<0.1	0.5
Pyrene	1.2	0.9	0.7	0.3	0.6	0.2	0.1	0.3	<0.1	<0.1	0.7
Total PAHs	11	21	21	7.8	14	2	7.6	13	<0.1	<0.1	4.4

The results in Table 2 show that the majority of ash samples collected during the event have similar PAH compositions but different to the surface and subsurface soil samples. This suggests that any ash deposited on the surface has not changed either the surface or subsurface soils.

An exception to this has been from a surface soil sample taken on Willis Street, Morwell on 18 February 2014, which, as discussed above, had a chemical composition more similar to the mine fire ash samples collected. This sample appears to have been mostly composed of ash, which supports the observation made at the time of sampling that ash was on the surface of the soils at this site.

In contrast, the ash sample from Club Astoria, collected on 13 March 2014, has a different PAH content to both the ash and soil samples and appears to have come from the bush fire that burned around the club rather than from the mine fire.

The right-hand column shows the results from surface soil sample taken from the CFA car park on 17 March 2014 (a result which was replicated again on 7 April 2014). This sample contains a different pattern of PAHs: however, as the CFA complex houses heavy machinery exposed to fires and fire-fighting equipment, the differences in their chemical composition are being attributed to site contamination rather than as a direct result of ash deposition.

Overall, the comparison of soil and ash data demonstrated that most of the soil samples have a similar chemical composition. Importantly, soil samples collected from the surface were not dissimilar from those collected below the surface. By contrast, the chemical composition of ash samples was significantly dissimilar to soil. This suggests that ash deposition did not affect the chemical composition of surface soil.

6.2 Soil

Evidence of ash deposition on surface soil was recorded at Willis Street, close to the mine fire, on 18 February 2014. As discussed above, this sample was determined to be predominantly ash. This sample showed peaks in metals and PAHs that were also high in the mine fire ash samples. These levels were not observed in the other soil samples, which had lower levels which were observed for the rest of the Response Phase and throughout the Recovery Phase. In addition, the results showed no evidence of the chemical constituents found in ash samples moving into the subsoil, as the high levels of these metals and PAHs were not reflected in either the subsequent surface or subsurface soil results.

Whilst the heavy metals and metalloids (arsenic, cadmium, chromium, lead and mercury) and PAHs (benzo[a]pyrene and naphthalene) were found within the soil samples, they were consistently at low levels across surface and subsurface soils. This is considered representative of the local soil composition rather than as a result of the mine fire.

Results from the soil sampling program show that soil has not been significantly changed by ash deposition from of the Hazelwood mine fire event.

6.2.1 Metals

A number of metals (for example, boron, barium, manganese, and strontium) were identified in the soil. They were also found in the ash and are major constituents of Latrobe Valley brown coal. The comparison of metal results – between the ash and surface and subsurface soil samples, within and outside the affected zone – show that the ash deposition has not resulted in significant changes in the soils in the region.

Zinc was found in higher concentrations in many ash and soil samples from Willis Street and CFA car park taken during the Response Phase (with a peak concentration of 1,200 mg kg^{-1}). As Willis Street and the CFA car park sites are closer to the Hazelwood mine fire than Morwell East AMS and Thoms Bridge, it is likely that these higher zinc levels are linked to the high levels found in the ash samples, showing that ash deposition occurred at sample sites closer to the mine fire. However, the zinc levels at all sites decreased to consistently lower levels during the Recovery Phase, indicating that the ash did not change the zinc levels in the soil.

A comparison was conducted between the average concentrations of metals found in ash (Figure 4) and soil samples at Willis Street, Morwell East AMS and Thoms Bridge sites (Figures 5, 6 and 7). The average ash analysis excluded the ash sample from Club Astoria on 13 March, as it is not considered indicative of mine fire ash (as discussed above). Similarly, the soil sample from Willis Street (18 February 2014), which has been determined to be predominantly ash, has been included in the average ash analysis.

Figures 4–7 show that comparative levels of barium, strontium and boron (common metals found in Latrobe Valley brown coal) were high in ash samples, and lower in soil samples. While manganese, another common metal in brown coal, appears to have higher concentrations in soils than in the ash samples collected, particularly at Thoms Bridge.

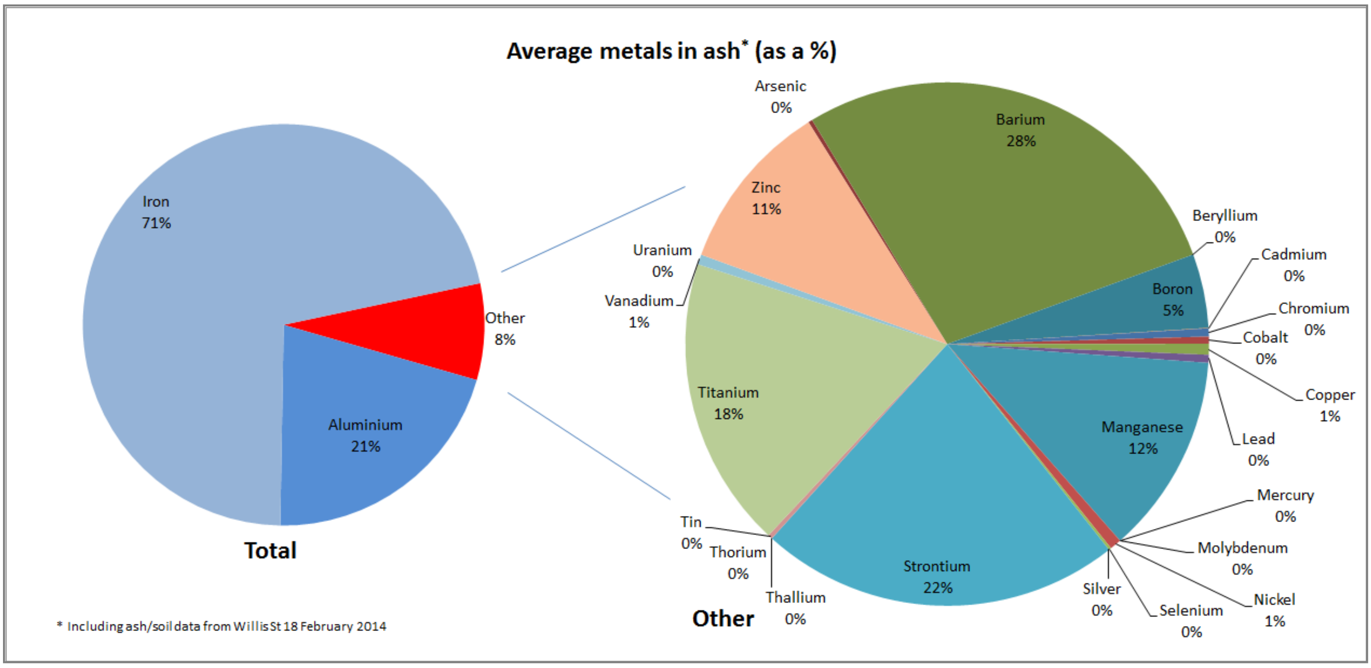

Figure 4. Average concentrations (as a percentage) of the metal component of ash samples during the Response Phase

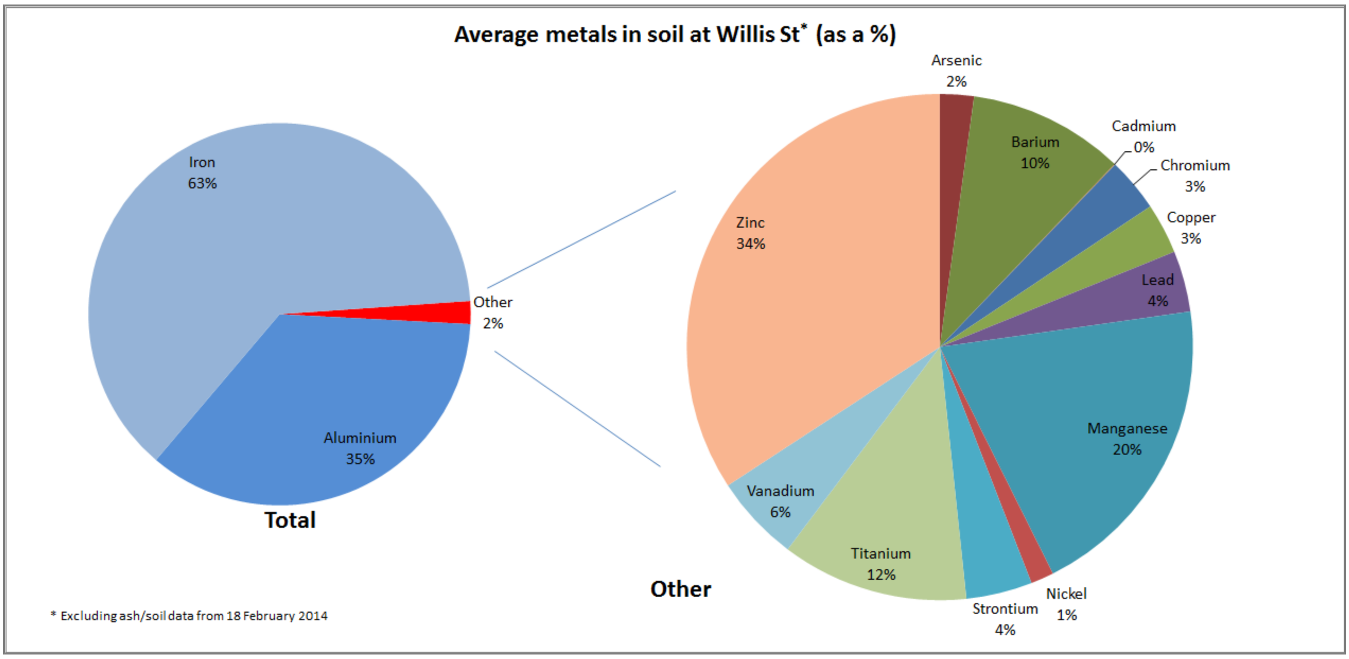

Figure 5. Average concentrations (as a percentage) of the metal component of soil and subsoil samples taken from Willis Street during the Response and Recovery phases

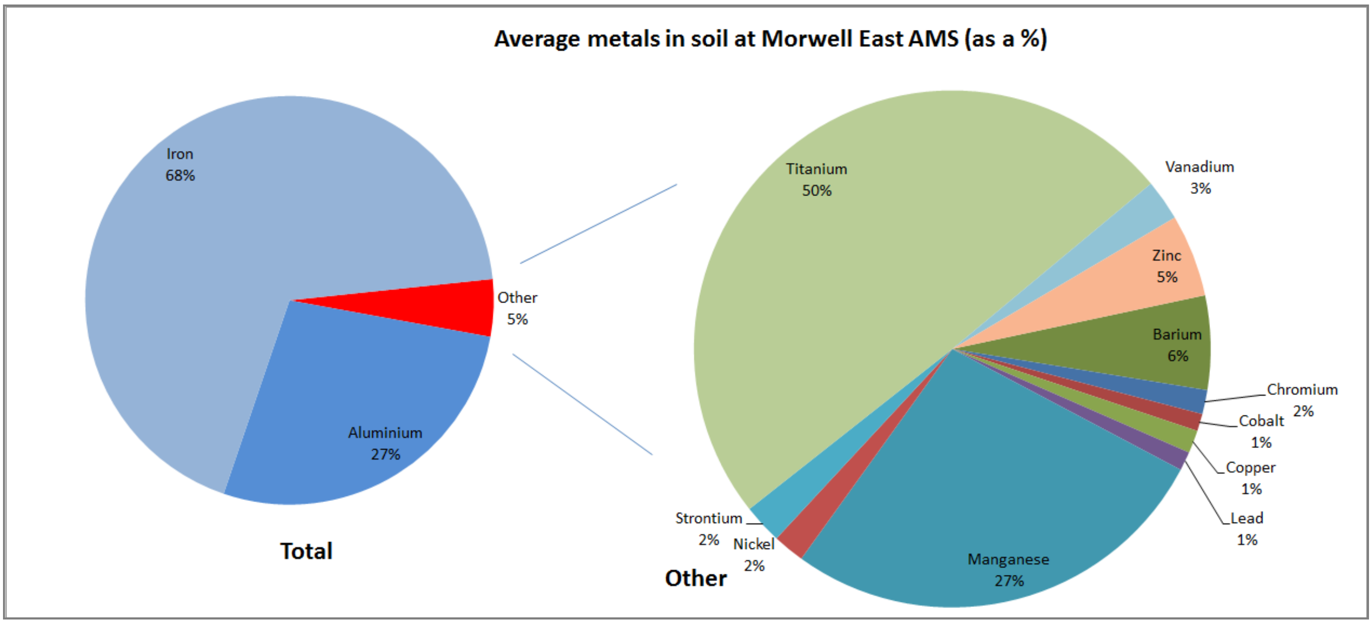

Figure 6. Average concentrations (as a percentage) of the metal component of soil and subsoil samples taken from Morwell East AMS during the Response and Recovery phases

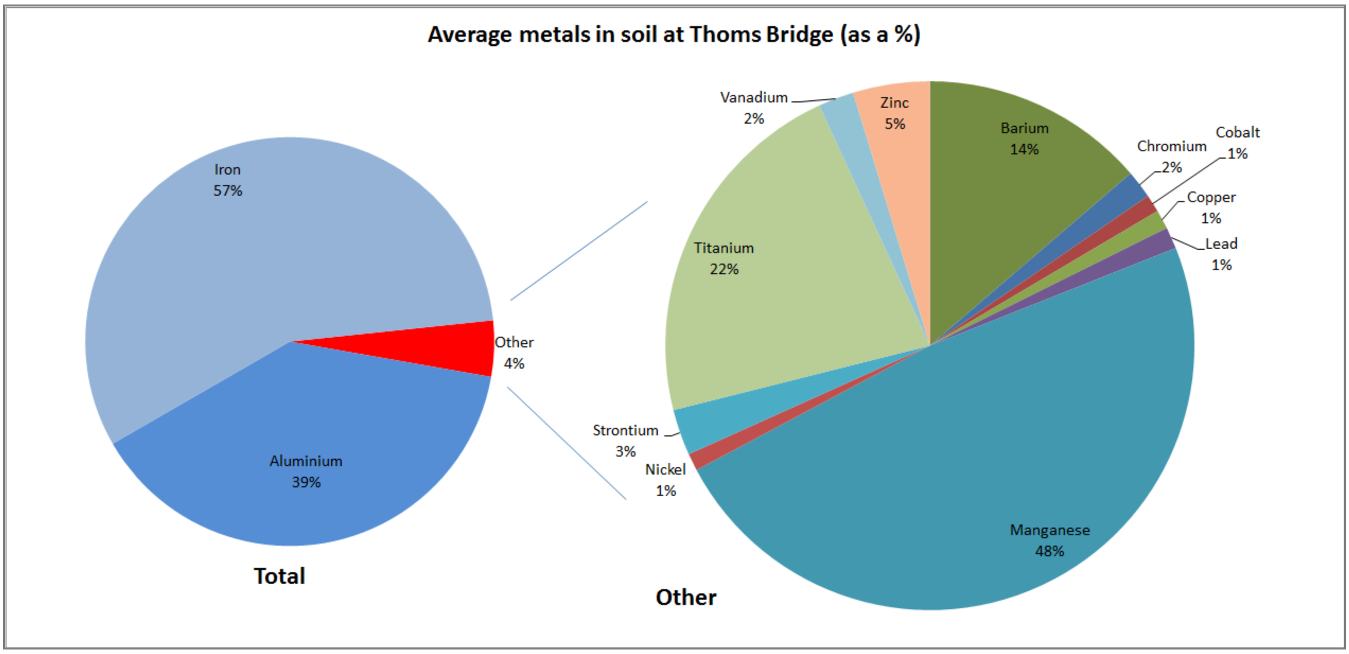

Figure 7. Average concentrations (as a percentage) of the metal component of soil and subsoil samples taken from Thoms Bridge during the Response and Recovery phases

Figures 8–11 show trends for the metals barium, boron, strontium and manganese across the Response and Recovery Phases. These metals were chosen as they were found in significant proportions in the mine fire ash samples and are common trace metals found in brown coal. As a comparison, the result for the ash collected from the surface soil at Willis Street on 18 February 2014 and the average concentration of ash have been included in the figures. This demonstrates the difference between the ash and the soils and further shows that the ash deposition did not significantly impact the soils.

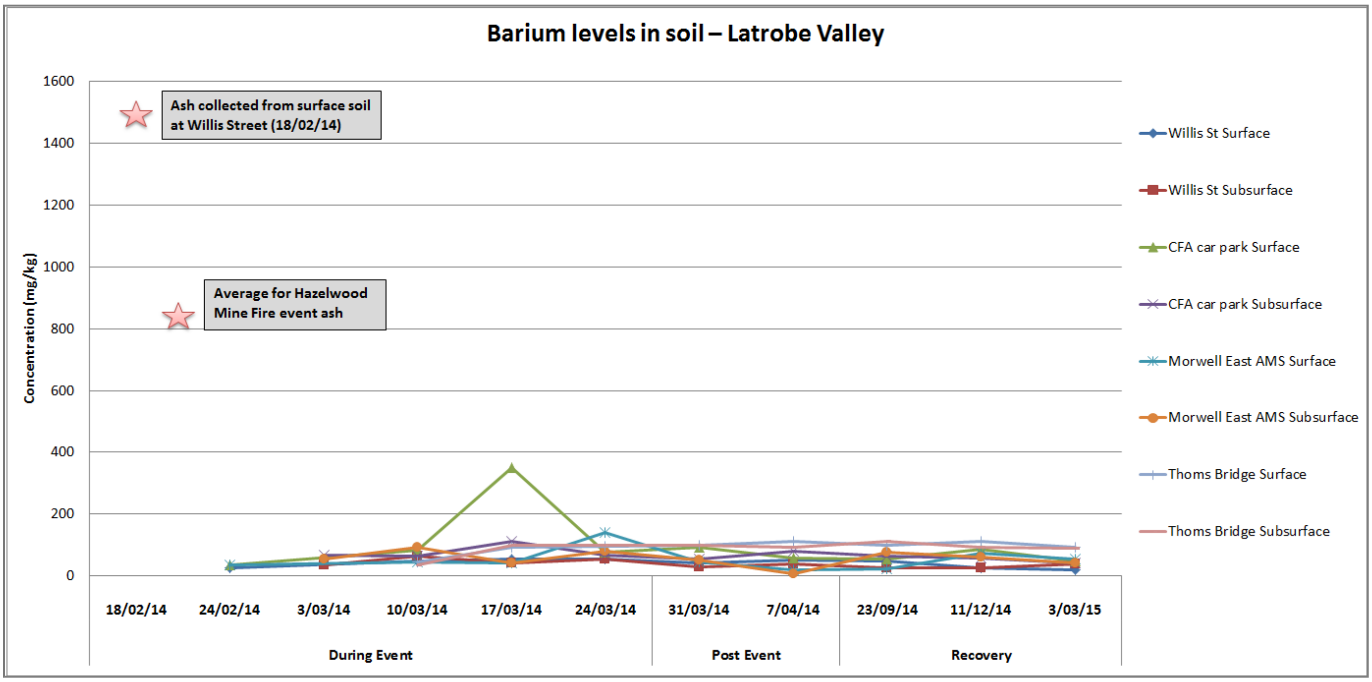

Figure 8. Barium concentrations during and after the Hazelwood mine fire at Recovery Phase soil sample sites

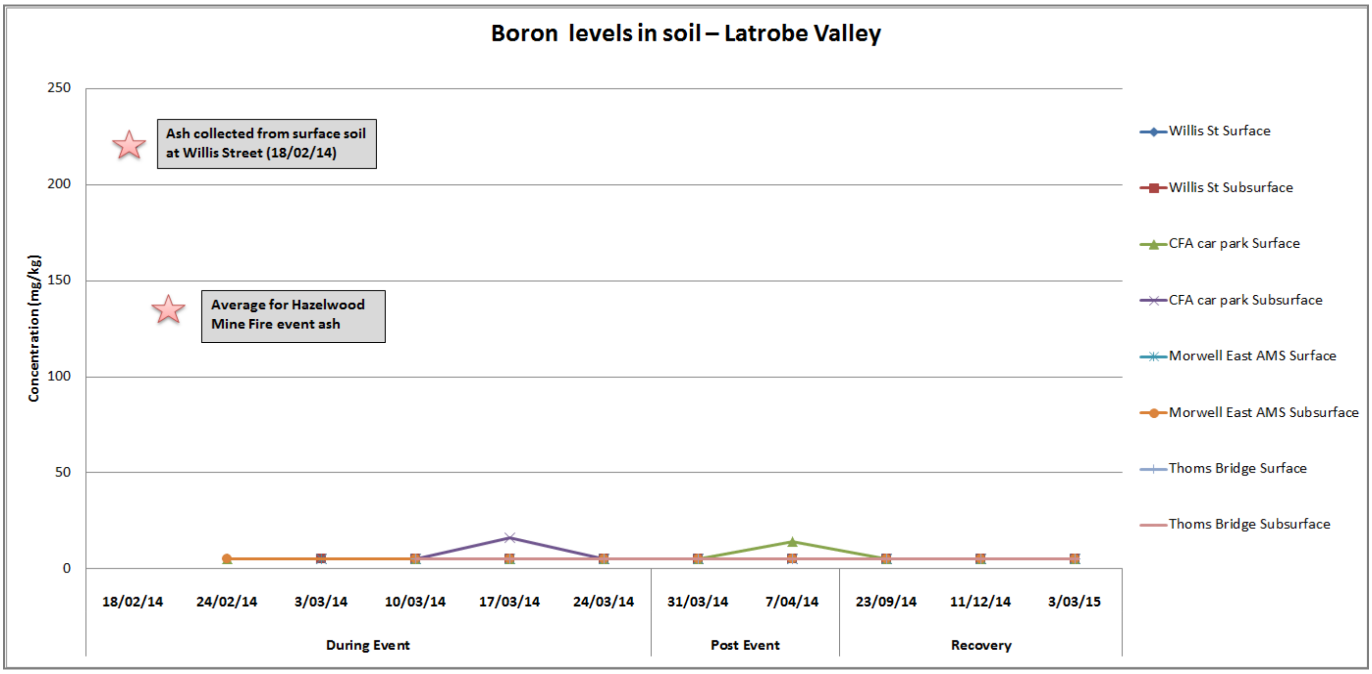

Figure 9. Boron concentrations during and after the Hazelwood mine fire at Recovery Phase soil sample sites
Note: Laboratory detection limit is 10 mg/kg. Concentrations below this detection limit are assigned a value of 5 mg/kg for graphical purposes

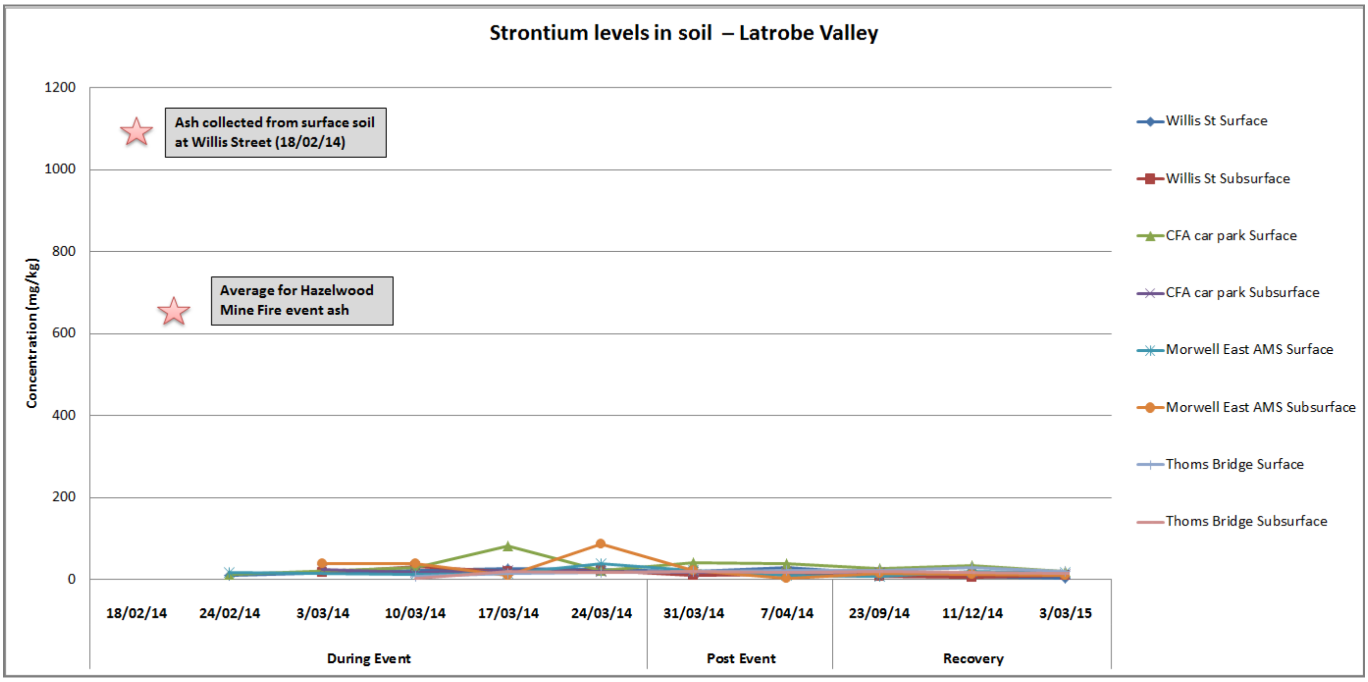

Figure 10. Strontium concentrations during and after the Hazelwood mine fire at Recovery Phase soil sample sites
Note: Laboratory detection limit is 5 mg/kg. Concentrations below this detection limit are assigned a value of 2.5 mg/kg for graphical purposes

While figures 8–10 show similar patterns of levels of barium, boron and strontium, manganese concentrations fluctuated across many sites and showed less of a trend (see Figure 11). For example, manganese levels peaked at 900 mg/kg at Morwell East AMS on 24 March 2014. However, as levels were high in both the surface and subsurface samples average concentrations of manganese across soil sampling sites were high (see figures 5, 6 and 7). Note that the higher levels were seen in subsurface samples. In addition, a few results are higher than those recorded in the ash. Hence these results are considered to be representative of the natural variation of manganese in soils rather than a direct impact from ash deposition.

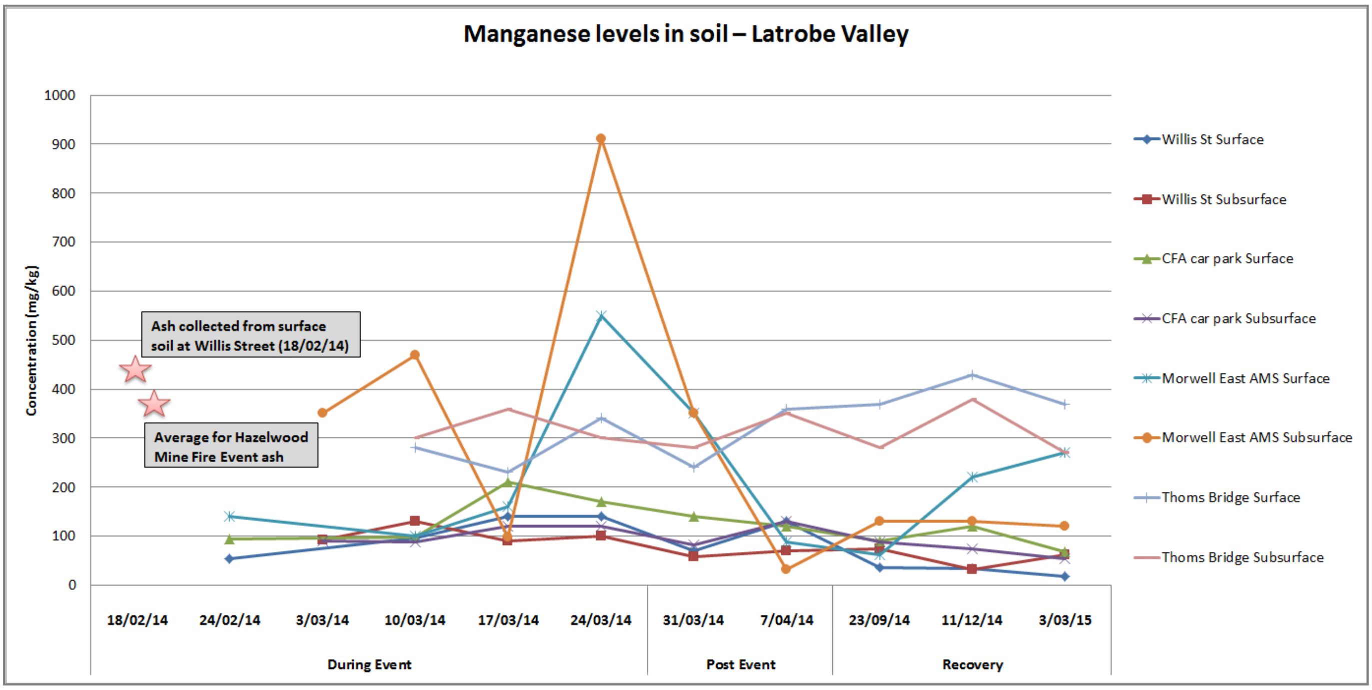

Figure 11. Manganese concentrations during and after the Hazelwood mine fire at Recovery Phase soil sample sites

6.2.2 PAHs, MAHs and semi-volatile organic compounds

As discussed in Section 6.1.2, PAHs were detected in some early soil samples, but these levels quickly diminished. PAHs were detected three times in the surface soil at CFA car park, once in subsurface soil at Willis Street, and once at Morwell East AMS across March and April 2014.

Aside from four detections of acetone at four sampling sites, semivols and MAHs were not detected in the soil samples. This could be that they were either not present or were consistently below the levels of laboratory detection.

6.3 Water

Results from the water sampling program indicate that mine fire ash has not impacted the chemistry of the local waterways. PAHs, semivols and MAHs were not detected in the water samples. This could be that they were either not present or were consistently below the levels of laboratory detection. Metal concentrations show no indication of having been affected by ash deposition or run-off; when detected, the levels are typical of urban run-off in streams.

6.3.1 Metals

The metal results (from both active and passive sampling methods) show no clear trend that would indicate that ash deposition or run-off from ash-affected land has caused impacts to local waterways, as key analyte concentrations (metals commonly found in brown coal and coal mine fire ash) have remained relatively stable since March 2014. This can be seen in Figures 12–15 below where barium, boron, manganese and strontium concentrations in sampled waterways have remained steady since the start of the mine fire and into the Recovery Phase. Slight peaks and troughs occurred, such as peaks of barium and manganese at Thoms Bridge in September 2014 and December 2014, respectively. However, these peaks, which were well below guideline values, were recorded well after the ash deposition and so are unlikely to be due to ash from the mine fire. Of the heavy metals tested, only arsenic, chromium and lead were detected in the water samples, all at low levels and below guideline values. Cadmium and mercury were not detected at all during the sampling program. Other metals that were found (such as zinc and copper) are typical of streams receiving urban run-off.

The levels of barium, boron and strontium were consistently higher (during both Response and Recovery Phases) at the Hazelwood Pondage site than other water sample sites. It is possible that these levels are due to the presence of artesian water which is regularly pumped into Hazelwood Pondage as part of the mine's dewatering process.

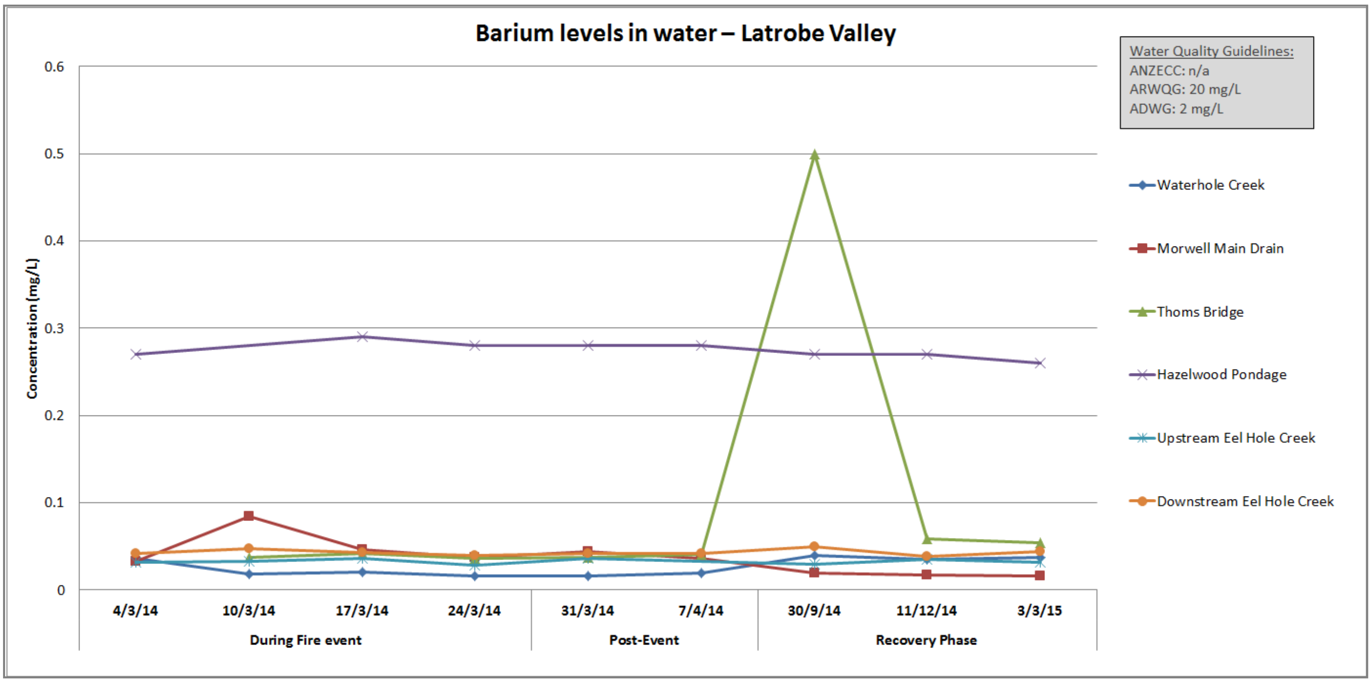

Figure 12. Barium concentrations during and after the Hazelwood mine fire at Recovery Phase water sample sites

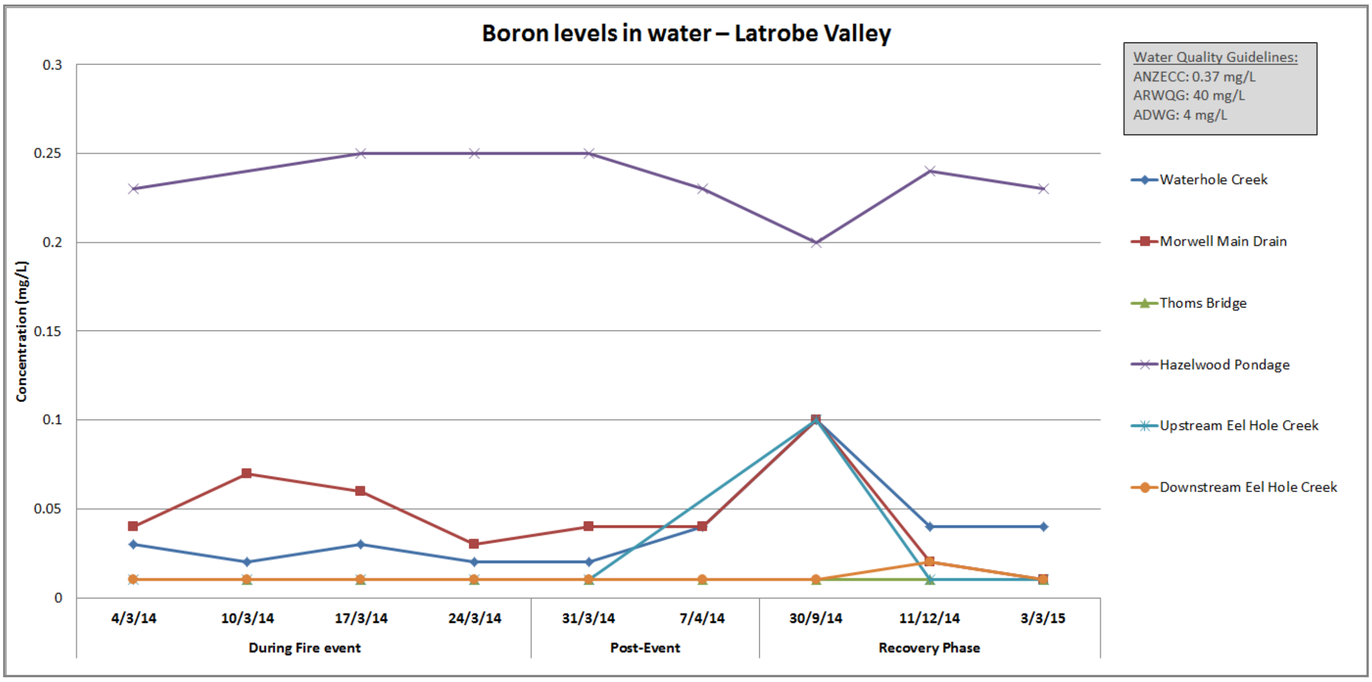

Figure 13. Boron concentrations during and after the Hazelwood mine fire at Recovery Phase water sample sites Note: Laboratory detection limit is 0.02 mg/L. Concentrations below this detection limit are assigned a value of 0.01 mg/L for graphical purposes

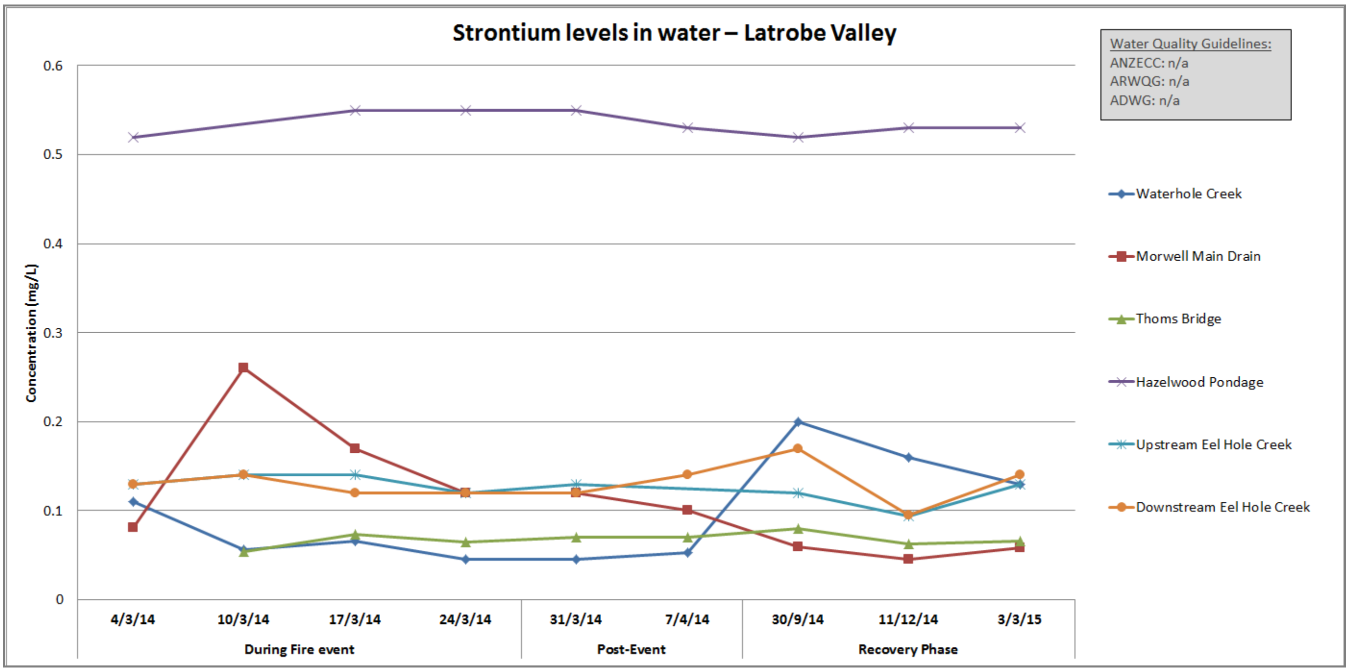

Figure 14. Strontium concentrations during and after the Hazelwood mine fire at Recovery Phase water sample sites

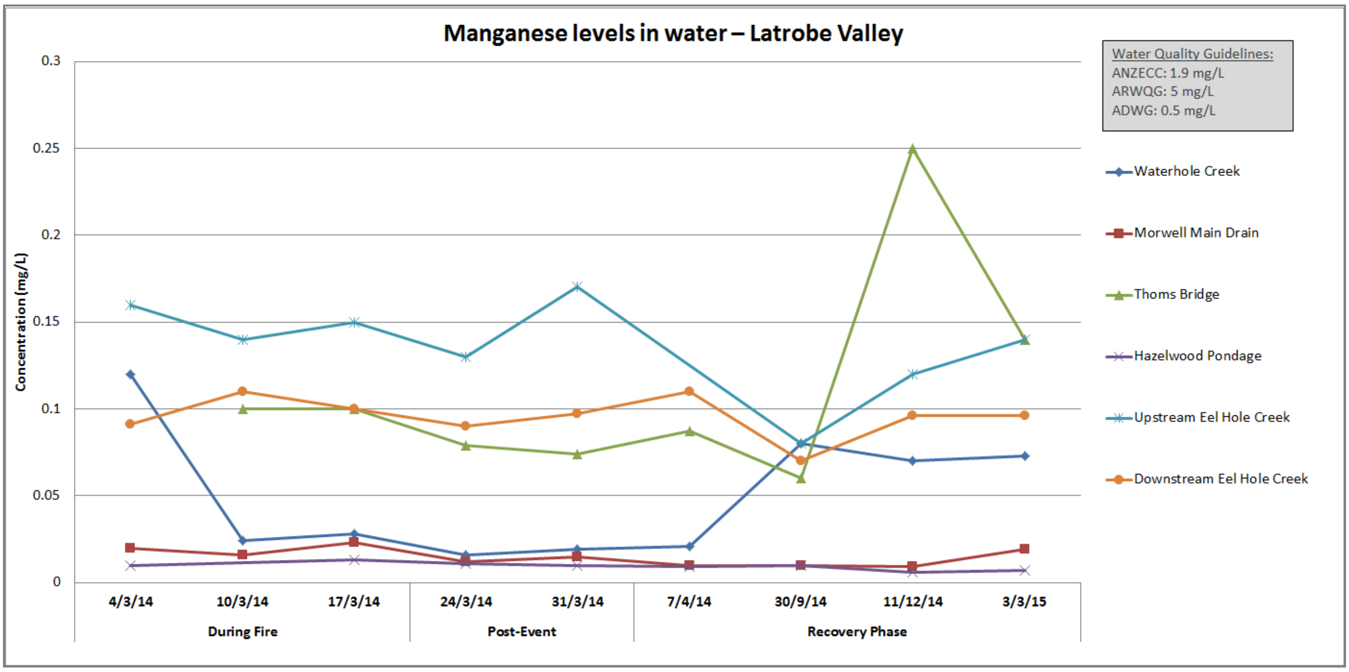

Figure 15. Manganese concentrations during and after the Hazelwood mine fire at Recovery Phase water sample sites

6.3.2 Polycyclic aromatic hydrocarbons (PAHs) and other organic compounds

Analysis of water samples has seen PAHs, semivols and MAHs consistently undetected. Acetone was detected at two sites; however as discussed previously, it is attributed to natural or other sources of acetone in urban and rural environments.

7 Conclusion

The ash collected during the Hazelwood mine fire, including the ash collected from the surface soil at Willis Street on 18 February 2014, have been shown to have different chemical profiles than the surface and subsurface soils within and outside the ash deposition area.

The surface and subsurface soil results for a number of key chemicals showed consistently lower values when compared to the results of these chemicals in the ash.

The ash deposition on the soil was not sufficient to change the soil chemical composition.

No chemical evidence of ash was found in the waterways in the Morwell region at any stage during the sampling period.

Overall, the comparison of water and soil sampling data collected during the Recovery Phase with the data collected during the Response Phase shows that water and soil quality in the region do not appear to have been changed by the Hazelwood coal mine fire.

To see the full set of water and soil sampling data collected during the Hazelwood fire, go to: www.epa.vic.gov.au/hazelwood/hazelwood-mine-fire/testing-during-the-hazelwood-fire

To see the full set of water and soil sampling collected during the recovery period, go to: www.epa.vic.gov.au/hazelwood/environmental-reporting

8 References

Durie, R.A., (1991) *The Science of Victorian Brown Coal: Structure, Properties and Consequences for Utilization*, 1, North Ryde: CSIRO

Appendices – Community Feedback

On 10 June 2015, EPA held a community engagement event to seek feedback from Latrobe Valley community members about draft versions of the reports: *Hazelwood Recovery Program Air Quality Assessment – Morwell and Surrounds, February 2014 – May 2015* (publication 1601) and *EPA Hazelwood Recovery Program water, soil and ash assessment – Morwell and surrounds, February 2014 – May 2015* (publication 1600). EPA received a wealth of excellent and detailed feedback on the draft publications. The community feedback received that is directly relevant to these reports is listed in the table below.

Community Feedback	EPA Comments
EPA should explain more clearly about the ash that was airborne during the fire, and the ash that settled on the ground. For example, particle size explanation in report would be helpful.	In response to this feedback, EPA has further clarified about the size of ash particles on page 2 of the water, soil and ash report (publication 1600).
Further explanation is needed for some graphs in the water, soil and ash graphs.	In response to this feedback, graphs on pages 9-15 of water, soil and ash report (publication 1600) were modified to make them easier to understand, or in some cases, more text was added to explain the meaning of the graphs.
Showing only trace metals components of brown coal is confusing.	In response to this feedback, further charts were added on page 4 and figure 2 of the water, soil and ash report (publication 1600) to show the other components of brown coal.
Could drinking water and recreational standards be included in the reports, either on graphs or listed separately?	In response to this feedback, figures have been updated on pages 13–15 of the water, soil and ash report (publication 1600).
Heavy metals detected at very low levels, zinc, lead, arsenic – why aren't they included in graphs?	In response to this feedback, text has been modified to page 13 of the water, soil and ash report (publication 1600) to explain why these metals haven't been included in the graph.
Clearer explanation is needed for some of the metal graphs in the water results section	In response to this feedback, figures have been updated on pages 13–15 of the water, soil and ash report (publication 1600).
Is there is a World Health Organization (WHO) standard that can be included in the graphs in the report?	EPA reports against the relevant national or state environmental guidelines for air, water and soil. There are also standards set by WHO or the Department of Health and Human Services. Often they influence national or state environmental standards. For more information about the standards EPA reports against, visit: http://www.epa.vic.gov.au/about-us/legislation/air-legislation
Where is the information about the history of air monitoring data in the Latrobe Valley?	See information given by then CEO John Merritt as evidence during the Hazelwood Mine Fire enquiry for a discussion of the history of air monitoring in the Latrobe Valley http://report.hazelwoodinquiry.vic.gov.au/part-four-health-wellbeing/environmental-effects-response/epa-latrobe-valley
Where is the detailed information about what EPA did during the mine fire?	This has been published in a separate report that focuses on EPA's response and air quality data during the mine fire: *Summarising the air monitoring and conditions during the Hazelwood mine fire, 9 February to 31 March 2014* (publication 1598). http://www.epa.vic.gov.au/our-work/publications/publication/2015/june/1598
What lessons have EPA learnt from the mine fire?	In accordance with specific recommendations from the Hazelwood Mine Inquiry, EPA has made a number of changes to its procedures and procedures about how we monitor air quality and communicate that data with the community: http://www.parliament.vic.gov.au/file_uploads/_Hazelwood_Mine_Fire_Inquiry_Report__dprsnQjH.pdf The approach taken with engaging the community early with the results from these publications is another concrete example of learning and doing things differently.

Some of the metal graphs in the air report are difficult to understand	In response to this feedback, some text has been added to figures 11–13 pages 21–22 of the air report (publication 1601), and some graphs have been modified or removed.
Some annual guidelines were missing on the metal tables in the air report	In response to this feedback, the guideline values were added to page 7 of the air report (publication 1601).
Why is only $PM_{2.5}$ been monitored at the Moe and Churchill air monitoring stations?	In response to this feedback, a sentence has been added to page 3 the air report (publication 1601) to explain the decision behind monitoring $PM_{2.5}$ more clearly.
Some information about what happened with air monitoring during the fire is not clear, such as number of breaches of $PM_{2.5}$ and when monitoring started.	This has been published in a separate report that focuses on EPA's response and air quality data during the mine fire: *Summarising the air monitoring and conditions during the Hazelwood mine fire, 9 February to 31 March 2014* (publication 1598). http://www.epa.vic.gov.au/our-work/publications/publication/2015/june/1598
The report is technical and quite difficult to understand at times.	Publications 1600 and 1601 are technical reports. EPA will be looking at other ways to communicate the results to a general audience. EPA has asked for direct feedback from the community on what format this should take. To date ideas have included short plain-English information bulletins, short YouTube videos and public talks.