Review of GHD's Modeling Assessment and Analysis of the Coal-fired Power Stations in the Latrobe Valley

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September 19, 2018

Introduction

My name is Dr. H. Andrew Gray. I am an atmospheric scientist and dispersion modeling expert from San Rafael, California. I have a Ph.D. from the California Institute of Technology (Caltech) in Environmental Engineering Science and over 40 years' experience as an air quality modeler in academic, regulatory and consulting settings. As the manager of the PM and visibility programs at the South Coast Air Quality Management District (Southern California) in the late 1980s, I was responsible for developing and applying air quality models to assess particulate matter (PM) in the Los Angeles air basin. The methodologies that I developed for evaluating PM control strategies were used by the District for numerous air quality management plan revisions. I have been the principal of Gray Sky Solutions, a private consulting firm specializing in particulate matter modeling, regional haze, and other related analyses, since 1997. Further details of my experience and qualifications can be found in my resume which is attached.

I have been asked by Environmental Justice Australia to review the modeling assessment performed by GHD for the Coal-fired Power Stations in the Latrobe Valley of Victoria, Australia. I obtained GHD's summary report[1] for review on 14 August 2018. Subsequently, I received a number of GHD's CALPUFF modeling files.

[1] AGL Loy Yang, Loy Yang B, and Energy Australia Yallourn, Latrobe Valley Coal Fired Power Stations Licence review Community Summary Report. GHD Pty Ltd. August 2018.

Figure 1. Loy Yang Power Station

I have discovered a number of issues regarding GHD's modeling exercise and summary report. Many of these issues represent either weaknesses or major flaws in the modeling approach and/or interpretation of the model results. My detailed comments are presented below, organized by the sections of GHD's report (starting with Section 5).

Summary of Findings

In summary, I have found that:

<u>Sulfur Dioxide (SO_2) Ambient Monitoring Data</u>

- On page 16 of the GHD report, it is indicated that the 1-hour and daily (24-hour) standards for SO_2 were met at all EPA monitoring stations in 2016. However, Figure 13 of the GHD report shows that the maximum observed 1-hour average SO_2 concentration at Jeeralang Hill exceeded the NEPM standard level (523 $\mu g/m^3$) during four of the five years between 2013 and 2017 – including 2016.

- The GHD report indicates that Jeeralang Hill experienced between 0 and 5 exceedances of the 1-hour SO2 standard level per year, typically in early morning hours during warmer months (page 17). GHD indicates that this area has been known for more than 20 years to experience elevated SO_2 concentrations and that the high observed SO_2 concentrations are due to the Latrobe Valley Power Station emissions. The fact that this feature of the air basin has been well understood, or that the Jeeralang monitor was placed to capture "peak" concentrations from the Power Stations, does not in any way excuse those exceedances from consideration against the ambient air quality standards.

<u>Particulate Matter (PM) Ambient Monitoring Data</u>

- The five monitoring locations shown in Figures 15 through 18 of the GHD report have recorded PM_{10} and $PM_{2.5}$ concentrations that have been either above, or below but close to, *both* the NEPM 24-hour and annual average standard levels.

- Figure 15 of the GHD report demonstrates that the maximum daily (24-hour average) PM_{10} concentration exceeded the NEPM standard level at Traralgon, Morwell East, and Jeeralang Hill in 2013 and 2014, and either exceeded or was very close to the standard level at these three sites during the years 2015 through 2017.

- Figure 17 shows that the maximum 24-hour average $PM_{2.5}$ concentration exceeded the NEPM standard level at Traralgon for all four years (2014 through 2017). The observed maximum 24-hour average $PM_{2.5}$ concentration also exceeded the NEPM standard level at the other four monitoring sites shown (Morwell South, Morwell East, Moe and Churchill) during at least two of the four years shown in Figure 17 (2014 – 2017). GHD acknowledges that the daily (24-hour) average standard for $PM_{2.5}$ is "occasionally exceeded at population centres in the Latrobe Valley" (page 24). However, the short-term NEPM standard for

$PM_{2.5}$ requires that the 24-hour average concentration be below 50 µg/m^3, with NO allowable exceedances.

- Figure 18 shows that the annual average $PM_{2.5}$ concentration at Traralgon has been very close to the NEPM standard level (i.e., greater than about 95 percent of the standard level).

Review of Previous Modeling

- GHD reported that previous dispersion modeling (conducted between 2012 and 2016) resulted in predicted exceedances of the PM_{10} and $PM_{2.5}$ standard levels, however the GHD report indicates that such modeled exceedances were "only due to minor contributions from the Power Station emissions" (page 20). It is not clear how this conclusion was reached, especially since the contributions from sources other than the Power Stations were not actually modeled in the current study, and no supporting evidence from previous modeling studies was presented to support this conclusion.

Particulate Matter Assessment

- Elevated ambient PM concentrations are due to contributions from a variety of source types. No single point source of particulate matter would ever be expected to cause a violation of the 24-hour or annual average PM standards.

- Since ambient particulate matter is caused by a number of different sources (with varying spatial and temporal emission rates), it is not appropriate to argue that a single source (or source sector) is *not responsible* for the observed exceedances of the PM standards simply because it is a "minor" contributor.

- The Power Stations, while maybe not a major contributor to peak PM levels *in Traralgon*, do in fact contribute a significant portion, (e.g., up to half of the $PM_{2.5}$ NEPM standard level) of the ambient PM levels at other locations in the air basin.

- GHD refers to “new assessments undertaken by GHD for this study” that supposedly support the conclusion that the “Power Stations emissions are a minor contributor to the ambient levels of particulates” (page 24). It is unclear what “new assessments” are being referred to in this statement. If GHD is referring to the current modeling study (presented in section 8), their conclusion that the Power Stations are a minor contributor to ambient levels of PM is erroneous.

- If there are previous (and/or new) air quality assessments that demonstrate that the Power Stations are in fact “a minor contributor” to ambient PM levels *across the entire air basin*, the evidence for such a conclusion was not presented or described in the GHD report.

- In fact, the Power Stations are shown to be a *major* contributor at many locations in the air basin during periods of peak modeled $PM_{2.5}$ impacts.

- The GHD report presents PM source attribution data for Hunter Valley (NSW) to support the conclusion that the Power Stations are minor contributors to PM levels in the Latrobe Valley. However, the source attribution data for Hunter Valley (Figure 20, page 25) may not be representative of Latrobe Valley PM source impacts. To adequately understand the mix of sources contributing to elevated PM levels in the Latrobe Valley, one would need to construct a similar attribution analysis specifically for the Latrobe Valley, and at a number of locations across the air basin.

<u>Dispersion Modeling</u>

- The GHD report describes its modeling methodology as including “[v]arious techniques to include and compare background data” (page 28), however the report never explains how “background” contributions of either SO_2 or PM were considered, either from other local sources or from regional background PM

levels. No other sources, other than the five Power Station units, were modeled using the CALPUFF dispersion model. No external estimation of the contributions of other sources to SO_2 or PM ambient air quality (including appropriate seasonal and temporal variability) were made and added to the modeled impacts from the Power Sources.

- It is also necessary to estimate *regional background* SO_2 and PM levels and to also add these to the modeled source contributions. If any "techniques" were, in fact, used to "include and compare background levels" (page 28), there is no documentation of such activities in the GHD report, and absolutely no evidence of any such consideration of background levels within the CALPUFF modeling files (and summary spreadsheets).

- The 2013 model results for ALL pollutants other than SO2 erroneously used meteorological data from 2016. The model results for all pollutants other than SO2 are therefore based on four years of meteorological data, rather than five years.

- The peak modeled value (maximum impacted grid cell) must be used as the design value since the ambient air quality standards require that concentrations be below the standard level at ALL locations in the air basin, not just at the monitoring locations, and not just in the highly populated portions of the valley.

<u>Model Results for SO_2</u>

- GHD presented "maximum" modeled 1-hour average SO_2 concentrations that were actually the 99.9th percentile (9th highest 1-hour average concentrations), without any discussion concerning the justification for using the 9th highest metric. The 9th highest 1-hour concentration does NOT correspond to the design value for the NEPM 1-hour SO_2 standard. The proper design value for the NEPM 1-hour SO_2 standard is the 2nd highest daily peak 1-hour SO_2 concentration (i.e.,

the highest 1-hour average SO_2 concentration that occurs on a *different day* than the maximum 1-hour value).

- GHD's modeling of SO_2 using the permitted (license limit) level produced a 1-hour SO_2 design value of **1,260 µg/m^3**, which is more than twice the NEPM AQ standard of 523 µg/m^3. Using the dispersion model results, one can conclude that the 1-hour SO_2 standard would be exceeded even if actual emission SO_2 rates had been modeled.

- In discussing the model results, the GHD report stated that 2014 "produced the highest one-hour impacts while all other years produced lower predictions" (page 30). Examination of the GHD model results shows that 2014 did **NOT** produce the "highest one-hour impacts" if one considers either the 99.9th percentile (9th highest, which is the metric that GHD was citing as the "maximum" values), or the actual maximum 1-hour average concentrations.

- The United States 1-hour NAAQS for SO_2 requires that the 99th percentile daily peak (4th highest daily peak) 1-hour average be below the standard level of 75 ppb (196 µg/m^3). GHD's model results indicate that for 2014, the 4th highest daily peak 1-hour average SO_2 concentration was **726.25 µg/m^3**, which is close to *four* times the acceptable level in the US.

- Including background levels of SO_2 would also increase the predictions of 24-hour average SO_2 concentrations so that the resulting total 24-hour average SO_2 concentrations would likely have been predicted to exceed the NEPM 24-hour SO_2 standards during all four modeled years.

<u>Model Results for PM</u>

- The GHD modeling demonstrates that the Power Stations are, in fact, a significant contributor to PM concentrations in the Latrobe Valley. After consideration for the size fractions, the model results showed that the Power

Stations were responsible for about 35 percent of the 24-hour NEPM standard level for PM_{10} at the highest modeled impact location, and almost half of the 24-hour NEPM $PM_{2.5}$ standard level.

- As was the case with the SO_2 1-hour average model results, GHD presented "maximum" modeled 1-hour average PM concentrations that were actually the 99.9th percentile (9th highest 1-hour average concentrations). The report provides no apparent justification for mis-representing the maximum 1-hour average values with the 9th highest 1-hour values. The actual modeled maximum 1-hour average PM concentration for each modeled year were about 3 to 4 times larger than the 9th highest 1-hour average values.

- The bottom-up modeling approach for PM presented in the GHD report is severely flawed. The "scaling-up" calculation to determine the maximum amount of emissions that would just meet the ambient air quality standard **assumes that no other sources would contribute** towards the standard design value. The bottom-up scaling of the unit emissions from ONLY the Power Stations, without first reducing the design concentration to account for the contributions from other sources (and background), incorrectly assumes that the Power Sources can "consume" the entire design value concentration.

- Not considering the impacts of all PM sources throughout the modeling domain and regional background represents a significant inadequacy of the analysis prepared by GHD.

<u>Model Results for Mercury</u>

- The top-down modeling that was performed for mercury, using a mercury emissions "concentration" of 100 µg/m^3, which corresponded to emission rates between 1.6 and 2.0 tons per year for each of the five modeled Power Source units, predicted significant short-term mercury concentration impacts in the Latrobe Valley, with peak 3-minute average concentrations as high as 338 ng/m^3.

- Similarly to the SO_2 and PM 1-hour average model results, GHD presented the "maximum" modeled 3-minute average mercury concentration that actually corresponds to the 99.9th percentile modeled value (9th highest *1-hour* average concentration, multiplied by a peak-to-mean ratio of 1.82). The report provides no apparent justification for this misrepresentation. The *actual* modeled maximum 3-minute average mercury concentration for 2017 (338 ng/m^3) was more than 3.5 times the "maximum" value reported in the GHD report.

- Using the unity dispersion modeling results, GHD computed the "allowable" emission rate of mercury from the Power Stations (using the bottom-up modeling approach) that would just meet the 3.3 µg/m^3 3-minute SEPP AQM design criteria. The resulting emission rate of 9 g/s (313 tons per year) for each unit at the three Power Sources represents an *enormous* amount of mercury – *each* of the five units would emit more mercury than all US sources combined. A long-term ambient mercury concentration of 3.3 µg/m^3 would likely lead to extremely high mercury deposition rates.

<u>Emission Controls</u>

- Although electrostatic precipitators (ESP) are "effective in reducing particulate emissions" (page 38), baghouse technologies offer a much higher level of PM removal for coal-fired power plant PM emissions.

Comments on Section 5

Emission profiles are presented in section 5.2 of the GHD report which display statistics (percentiles) of the frequency distribution for sulfur dioxide (SO_2) and particulate matter emissions for each of the Power Stations (Loy Yang A, Loy Yang B, and Yallourn) during the period 2013-2017. These statistics are compared against the maximum emission limits (license limits) for each facility. (For example, Figure 6 indicates that the

90th percentile SO_2 emissions level at Loy Yang A was approximately 2,720 g/s, which was under the required 90th percentile licence limit of 3,333 g/s.)

GHD presented Figures 6 through 10 to demonstrate that "actual operating conditions are typically lower than those permitted by licence limits" (page 13). Unfortunately, the averaging time for the observed (and permitted) emission levels is not identified in the GHD report. Although the emission levels are reported in units of g/s, it is likely that these are not *one-second* average emission rates, but are rather hourly averages or 24-hour averages. However, there is a substantial difference between the maximum (or 90th percentile) 1-hour average emission rate and the maximum (or 90th percentile) 24-hour average emission rate.

The GHD report (section 8.1) indicates that US EPA modeling guidelines were followed in assessing the impacts from the Latrobe Valley Power Stations. US EPA guidelines require, when using dispersion models to assess air quality concentration impacts and when comparing those modeled impacts to ambient air quality standards (for example, when permitting a new source), that the *maximum 24-hour emission rate* be used as input for every hour of the model simulation. This requirement essentially matches the highest daily emissions period with the "worst-case" meteorology -- as a built-in conservatism for insuring that the ambient air quality standard will be attained in the future under the modeled emission levels.[2]

Although the Loy Yang A and Loy Yang B facilities emitted less than their permitted (allowable) SO_2 levels (according to Figures 6 and 8), the maximum SO_2 emissions emission levels were not much lower than the permitted levels (at least about 80 percent of the permitted levels), and are also "close" to the required 90th and 50th percentile emission levels. Modeling SO_2 using the permitted (license limit) level (as GHD did in section 8.2.1) may therefore be slightly conservative, however the model results produced a very high 1-hour SO_2 design value of 1,260 $\mu g/m^3$, which is more

[2] To ensure that the ambient air quality standards are not violated in future years (with unknown meteorological conditions), it is reasonable to evaluate (model) the impact of a source's emissions as if it were emitting at its maximum level at all times.

than twice the NEPM AQ standard of 523 µg/m^3 (see discussion on SO_2 modeling results in section 8, below).

Using the dispersion model results, one can conclude that the 1-hour SO_2 standard would be exceeded even if actual emission rates had been modeled.

Comments on Section 6

Particulate Matter (PM)

The GHD report identifies observed exceedances of the 24-hour $PM_{2.5}$ NEPM air quality standard (25 µg/m^3) during 2013-2017, which were apparently attributable to "'planned burns'" (page 16), however there is no accounting of the source attribution during these exceedance event(s) or justification for discounting these occurrences.

On page 16 of the GHD report, a summary of ambient air monitoring data from 2016 is presented that shows that: (1) the maximum 24-hour average PM_{10} concentration recorded at Traralgon was 98.4% of the NEPM standard (50 µg/m^3); and (2) the maximum 24-hour average $PM_{2.5}$ concentration measured at Traralgon was 103% of the NEPM standard (25 µg/m^3).

However, if one looks ahead to Figure 15 in section 7.1 of the report, it is evident that the maximum daily (24-hour average) PM_{10} concentration exceeded the NEPM standard level at Traralgon, Morwell East, and Jeeralang Hill in 2013 and 2014, and either exceeded or was very close to the standard level at these three sites during the years 2015 through 2017. Figure 17 shows that the maximum 24-hour average $PM_{2.5}$ concentration exceeded the NEPM standard level at Traralgon for all four years (2014 through 2017). The observed maximum 24-hour average $PM_{2.5}$ concentration also exceeded the NEPM standard level (100%) at the other four monitoring sites shown (Morwell South, Morwell East, Moe and Churchill) during at least two of the four years shown in Figure 17.

An examination of Figures 15 through 18 (in section 7) of the GHD report demonstrates that these five monitoring locations have recorded PM_{10} and $PM_{2.5}$ concentrations that

have been either above, or below but close to, both the NEPM 24-hour and annual average standard levels. Figure 18 shows that the annual average $PM_{2.5}$ concentration at Traralgon has been very close to the NEPM standard level. Referring to Figure 17, GHD admits that the daily (24-hour) average standard for $PM_{2.5}$ is "occasionally exceeded at population centres in the Latrobe Valley" (page 24). However, the short-term NEPM standard for $PM_{2.5}$ requires that the 24-hour average concentration be below 50 µg/m^3, with NO allowable exceedances.

Sulfur Dioxide (SO_2)

On page 16 of their report, GHD indicates that the 1-hour and daily (24-hour) standards for SO_2 were met at all EPA monitoring stations in 2016. However, Figure 13 shows that the maximum observed 1-hour average SO_2 concentration at Jeeralang Hill exceeded the NEPM standard level (523 µg/m^3) during four of the five years between 2013 and 2017 – including 2016 (which contradicts their earlier statement). The peak recorded 1-hour average SO_2 concentration in 2017 at Jeeralang Hill was approximately 900 µg/m^3.

Figures 13 and 14 display 1-hour and annual average SO_2 data for five monitoring stations in the Latrobe Valley, compared to the NEPM standard level. There is also a 24-hour SO_2 NEPM standard (209 µg/m^3, with one allowed exceedance day per year) however, the peak 24-hour average SO_2 monitoring data are not shown (or summarized) in the GHD report.

The GHD report indicates that Jeeralang Hill experienced between 0 and 5 exceedances of the 1-hour SO_2 standard level per year, typically in early morning hours during warmer months (page 17). GHD indicates that this area has been known for more than 20 years to experience elevated SO_2 concentrations and that the high observed SO_2 concentrations are due to the Latrobe Valley Power Station emissions. The fact that this feature of the air basin has been well understood, or that the monitor was placed to capture "peak" concentrations from the Power Stations, does not in any way excuse those exceedances from consideration against the ambient air quality standards.

According to the NEPM ambient air quality standards, it is NOT acceptable to have a small number of exceedances, and/or exceedances that occur only at night or in the early morning. The form of the NEPM 1-hour SO_2 standard requires that the standard level (523 µg/m^3) be exceeded at most on only one day per year.[3] The NEPM 1-hour SO_2 standard allows multiple hours on the same day to exceed the standard level -- which implies that the "design value" corresponding to the 1-hour standard is the 2nd highest daily 1-hour peak. This design value metric should be used to examine the monitoring data when determining compliance with the NEPM 1-hour SO_2 standard.

Review of Previous Modeling

In section 6.1 of the GHD report, it is stated that GHD reviewed previous dispersion modeling that was performed to assess the air quality impacts from Latrobe Valley power sources for the period 2011 through 2015. GHD concluded that the modeling approach followed "good industry practice" (page 20), however there are very few specifics provided[4] regarding the modeling to support that conclusion, including which dispersion model was used, which sources other than the power sources (if any) were modeled, how the meteorological data were developed, and whether appropriate design value metrics were extracted from the model results.

The previous dispersion modeling apparently resulted in predicted exceedances of the PM_{10} and $PM_{2.5}$ standard levels, however the GHD report indicates that such modeled exceedances were "only due to minor contributions from the Power Station emissions" (page 20).

It is not clear how this conclusion could have been reached, especially as the contributions from sources of PM other than from the Power Stations were not actually modeled.

And if the other significant PM sources (e.g., mobile sources, wood smoke, agriculture, etc.) were evaluated (in some manner) during these previous modeling studies, then

[3] State Environmental Protection Policy (Ambient Air Quality), Environmental Protection Agency (EPA) Victoria. 2016.
[4] The previous modeling reports described on page 20 of the GHD report were not made available to me for review.

that would have resulted in a suitable source apportionment for PM (which GHD later regrets not having available).

Comments on Section 7

As the GHD report indicates, ambient PM in most urban areas is due to a combination of a variety of source types, including mobile sources (vehicle exhaust and road/tire dust), industrial source emissions, windblown dust, wood smoke, agricultural activities, etc. The ambient air quality standards for PM are therefore designed to control the entire urban mix of PM sources, rather than an individual point source.

No single point source of particulate matter would ever be expected to cause a violation of the 24-hour or annual average PM standards.[5]

Violations of the short-term (24-hour) PM standard often occur when daily emissions levels are particularly elevated (for example due to peaking seasonal sources), combined with periods when the atmospheric mixing is limited (for example, during low wind speed, low inversion events).

After making note of the mix of sources and the ambient PM monitoring data for Traralgon (relative to Churchill), the GHD report observes that there are likely higher levels of PM emissions in Traralgon relative to other locations in the air basin. They use this information to conclude that the Power Stations are "ultimately minor contributors to ground level concentrations" (page 21), although further support for this conclusion is promised in section 8.3 of the GHD report.

As discussed below, the model results in section 8.3 of the GHD report demonstrate that the Power Stations, while maybe not a major contributor to peak PM levels in

[5] I have modeled many of the largest point sources in the US to assess their PM impacts. There are NO point sources in the US for which the predicted impact of the modeled source *alone* would violate the 24-hour or annual $PM_{2.5}$ (or PM_{10}) US NAAQS.

Traralgon, do in fact contribute a significant portion of the ambient PM levels at other locations in the air basin.[6]

Since ambient particulate matter is caused by a number of different sources (with varying spatial and temporal emission rates), it is not appropriate to argue that a single source (or source sector) is *not responsible* for the observed exceedances of the PM standards simply because it is a "minor" contributor.

To illustrate this point, consider the following hypothetical situation: Assume an air basin has 10 different sources (or source types) that *each* contribute 20 percent of the design value PM concentration (at the peak modeled location). The resulting air quality in the air basin from all sources would be 200% of the standard level, and yet each source could rightfully claim that it was only a "minor" source, contributing only one tenth of the total observed (or modeled) PM. In this case, an effective PM control plan would necessarily need to reduce emissions from a number of different source types in order to achieve the acceptable ambient standard level. The "best" strategy for controlling PM in this situation would depend on the effectiveness of potential emission controls within each source sector, i.e., which control measures result in the greatest benefit (reduction in design value concentration) for the least cost.

Other sources of PM are certainly important to assess when developing and evaluating a plan for controlling PM air quality. However, the modeling conducted by GHD did not account for the impacts of other sources of PM in the Latrobe Valley.

Figures 15 through 18 show the maximum 24-hour and annual average concentrations recorded at three monitoring locations for PM_{10}, and at five monitoring locations for $PM_{2.5}$. As discussed above, the maximum daily (24-hour average) PM_{10} concentration exceeded the NEPM standard level at Traralgon, Morwell East, and Jeeralang Hill in 2013 and 2014, and either exceeded or was very close to the standard level at these three sites during the years 2015 through 2017. Figure 17[7] shows that the maximum

[6] The modeling results from section 8.3 of the GHD report demonstrate that the modeled Power Stations are responsible for up to half of the 24-hour NEPM $PM_{2.5}$ standard level at the location of maximum modeled impact. This hardly represents a "minor source".
[7] Figure 17 is quite difficult to read because the y-axis extends up to 1800% of the NEPM standard level.

24-hour average $PM_{2.5}$ concentration exceeded the NEPM standard level at Traralgon for all four years (2014 through 2017). The observed maximum 24-hour average $PM_{2.5}$ concentration also exceeded the NEPM standard level (100%) at the other four monitoring sites shown (Morwell South, Morwell East, Moe and Churchill) during at least two of the four years shown in Figure 17.[8]

An examination of Figures 15 through 18 of the GHD report demonstrates that these five monitoring locations have recorded PM_{10} and $PM_{2.5}$ concentrations that have been either above, or below but close to, both the NEPM 24-hour and annual average standard levels.

On page 24 of the GHD report, it states,

> "**Air quality assessments, undertaken in the Latrobe Valley over many years, and confirmed by new assessments undertaken by GHD for this study, conclude that Power Station emissions are a minor contributor to the ambient levels of particulates.**"

It is unclear what "new assessments" are being referred to in this statement.

If GHD is referring to the current modeling study (presented in section 8), their conclusion that the Power Stations are a minor contributor to ambient levels of PM is erroneous. GHD's argument is that because there are higher observed PM concentrations at Traralgon (the most urbanized location in the air basin), then sources other than the Power Stations must be the "major contributors to levels of particulates across the Latrobe Valley" (page 24).

It may very well be that the Power Sources contribute a minor portion of the ambient PM in Traralgon, especially during peak concentration periods. However elsewhere in the Latrobe Valley, the Power Stations contribute significant portions of the peak ambient PM levels, as demonstrated by GHD's model results. In fact, the Power Stations are

[8] The peak 24-hour average $PM_{2.5}$ concentration at Morwell South in 2014 shown in Figure 17 (between 16 and 18 times the acceptable NEPM level) was apparently due to a mine fire. If this event was excused as an "exceptional" event, then Figure 17 should instead show the highest recorded 24-hour average $PM_{2.5}$ concentration that did NOT occur during an exceptional event.

shown to be a *major* contributor at many locations in the air basin during periods of peak modeled $PM_{2.5}$ impacts.

Despite the fact that Traralgon is a large population center in the Latrobe Valley, one cannot conclude that the Power Stations do not contribute to adverse PM air quality in the entire Latrobe Valley by simply examining air quality impacts in Traralgon. The NEPM air quality standards require that air quality throughout the air basin be maintained below the acceptable standard levels.

If there are previous (and/or new) air quality assessments that demonstrate that the Power Stations are in fact "a minor contributor" to ambient PM levels *across the entire air basin*, the evidence for such a conclusion was not presented or described in the GHD report (page 24). To reach such a conclusion would require a proper assessment of the contributions of all important PM sources throughout the Latrobe Valley, which would have presumably resulted in valuable PM source attribution data (similar to the information provided in Figure 20 for Hunter Valley).

No such information was presented for the Latrobe Valley and the GHD modeling only included PM emissions from the five Power Station units, notwithstanding GHD's contention that the Power Stations are only minor contibutors.

The GHD report presents PM source attribution data for Hunter Valley (NSW). GHD suggests that, "It is suspected that a similar scenario may be occurring in the Latrobe Valley" (page 25). Unfortunately there are no modeling data or other evidence presented to support this assertion. Although there may be some similarities between the Latrobe Valley and the Hunter Valley, including an observed spike in wood burning PM emissions in populated areas of the valleys during the colder months, the data in Figure 20 may not necessarily be representative of Latrobe Valley PM source impacts.

To adequately understand the mix of sources contributing to elevated PM levels in the Latrobe Valley, one would need to construct a similar attribution analysis specifically for the Latrobe Valley – which could be done, for example, by (1) modeling ALL important PM sources throughout the air basin, or (2) conducting a thorough receptor modeling

study (such as Chemical Mass Balance) at a number of locations across the air basin (and not just at Traralgon).

Comments on Section 8

The GHD report (page 28) indicates that a formal modeling protocol was submitted to the EPA in May 2018 for approval,[9] and that the methodology follows US EPA guidance for assessing emissions from multiple sources.

The methodology described in the GHD report includes:

(1) The use of the CALPUFF model in preference to the AERMOD model. The AERMOD model can be used reliably up to 50 km from the source (not 20 km, as implied in the GHD report), and although CALPUFF has the ability to consider horizontally non-uniform wind patterns and hour-by-hour transport, the meteorological data that are input to the model must support such detailed calculations. Without sufficient documentation in the GHD report regarding the meteorological data that were used as input to CALMET (and the resulting wind and other meteorological fields), it is impossible to meaningfully assess the quality of the meteorological data.

(2) Three-dimensional meteorological fields. The GHD report does not document the preparation of the meteorological data (using CALMET)[10], including how many surface stations (answer: 10) and upper air stations (answer: none!) were used, whether prognostic data were used (answer: yes), including the horizontal and vertical resolution and domain (answers: 70 x70 km, 0.5 km horizontal grid spacing, 10 vertical layers), and also a number of CALMET options.

[9] The modeling protocol was not made available to me for review.
[10] I was able to review GHD's CALPUFF dispersion modeling files and associated postprocessors, including the CALMET input files, which provided a number of the meteorological modeling details.

(3) Fixed-emission rates. The GHD report does not provide any documentation regarding the stack parameters of the modeled Power Station units (stack height and diameter, exit velocity and temperature).

(4) Assessment at grid locations to cover all the region. The square modeling domain is shown in the GHD report (see Figure 21, for example). However, the resolution of the gridded receptors is not indicated in the report. In reviewing the CALPUFF modeling files, I have discovered that a 70 km x 70 km square domain was used for both the CALMET and CALPUFF modeling, and that the gridded receptors were placed every 0.5 km within the CALPUFF domain (resulting in a 140x140 array of gridded receptors).

(5) Various techniques to include and compare background data. It is important to consider other sources of emissions within the modeling domain as well as background levels of each modeled pollutant in order to fully appreciate the impacts of the modeled sources within the air basin.

Other than the bullet point (on page 28), however, it is unclear how “background” sources of either SO_2 or PM were considered.

No other sources, other than the five Power Station units, were modeled using the CALPUFF dispersion model. No external estimation of the contributions of other sources to SO_2 or PM ambient air quality (including appropriate seasonal and temporal variability) were made and added to the modeled impacts from the Power Sources.

There are not likely to be many large sources of SO_2 in the region other than the Power Stations, so it is reasonable to consider only the Power Station sources in the SO_2 modeling assessment. Even if other sources were modeled, they would likely contribute only small amounts to the modeled peak 1-hour SO_2 impacts. However, a reasonable estimate of the regional background SO_2 levels, even if small, should still be added to the modeled concentrations before comparing the modeled impacts to the ambient air quality standards.

For PM, a number of different sources can contribute significant amounts to the PM air quality in the region, especially when 24-hour averages are considered. Furthermore, the mix of sources varies both spatially and temporally.

Not including the impacts of all the other PM sources throughout the modeling domain represents a significant inadequacy of the modeling approach used by GHD.

The US EPA modeling guidelines require that all important local sources be considered when modeling for PM. Without such an assessment, one cannot determine the appropriate concentrations to add to the modeled Power Station concentrations at each grid cell location during each modeled hour (or day). Without an estimate of the total impact from all sources, one cannot determine whether the air basin would be in compliance with the required ambient air quality standard *throughout* the region. In addition to the PM impacts from other sources in the region, it is also necessary to estimate regional background PM levels and to also add these to the modeled source contributions.

If any “techniques” were, in fact, used to “include and compare background levels” (page 28), there is no documentation of such activities in the GHD report, and absolutely no evidence of any such consideration of background levels within the CALPUFF modeling files (and summary spreadsheets).

As described below, the bottom-up modeling approach that GHD used for PM is a flawed exercise because no other sources (or background) were considered in the modeling, or in the scaling calculation.

There were a few other issues regarding GHD’s modeling protocol.

Many important modeling details were left out of GHD’s modeling report. In addition to there being no documentation whatsoever regarding the meteorological data preparation (CALMET), many details regarding the CALPUFF dispersion model are also missing (although most of these details were discovered after I examined GHD’s modeling files). For example, was formation of secondary aerosols considered in the modeling? (No.) Was stack-tip downwash included? (Yes.) What method was used for computing plume rise? (Briggs.) Was puff splitting allowed? (No.) Was wet and

dry removal (deposition) included in the modeling? (No.) Were default regulatory options used? (No.) What was the spacing for the gridded receptors? (0.5 km)

There was no consideration of secondary aerosol formation within the PM modeling assessment, including sulfates and nitrates that are formed in the atmosphere from SO_2 and NO_X precursors. Although not expected to add a very large amount to the overall modeled PM impacts, there are certain times of the year in which secondary formation can be non-negligible, which could be important especially considering the high ambient concentrations of SO_2 that exist due to the Power Sources.

The CALPUFF model is capable of estimating the secondary formation of PM due to the SO_2 and NO_X emitted by the Power Stations, however this was not done in GHD's CALPUFF modeling.

There are separate CALPUFF modeling files for the Loy Yang Power Station units, labeled LYA-E and LYA-W (presumably corresponding to East and West). However, the modeled UTM coordinates for the LYA-E stack (462753, 5766154) are to the west of the LYA-W stack (462955, 5766033). The labels for the two units may have been switched.[11]

In reviewing the model output files, I observed that the model results for ALL pollutants other than SO_2 had *completely identical* results for 2013 and 2016 (for example, note that the rows of model results for 2013 are the same as for 2016 in Tables 5, 6, 7, and 8). Further investigation of the CALSUM and CALPOST output (.LST) files revealed that the 2013 model results had erroneously used meteorological data from 2016.[12]

The model results for all pollutants other than SO_2 are therefore based on four years of meteorological data, rather than five years.

[11] Switching the locations of the Loy Yang units has no effect on the model results because the two units have identical stack parameters and modeled emission rates.

[12] Within each CALSUM.lst file, the header (TIMEHEAD) from the meteorological file that was used to create the concentration data (CALPUFF output) is displayed. Similarly, in each CALPOST.lst output file, the contents of the HEADER of the model output file (CALPUFF.DAT) are shown. For the 2013 modeling of CO, NO_2, TSP, PM, and mercury (i.e., all modeled pollutants other than SO_2), the CALSUM and CALPOST files indicate that meteorological data from 2016 was used, rather than data from 2013.

The modeling protocol should include specification of the metrics[13] that will be used to examine the output of the model (predicted concentrations). Each ambient air quality standard has (1) a concentration level (maximum allowable concentration), (2) an averaging time, and (3) a form, which indicates the number of allowed exceedances of the concentration level (if any). For example, the NEPM SO_2 standards for both the 1-hour and 24-hour average allow one day each year to exceed the maximum allowable concentration. The design value metric corresponding to the 1-hour SO_2 standard is therefore the 2nd highest peak daily 1-hour average (within each year of model simulation). Similarly, the appropriate design value metric for the 24-hour SO_2 standard is the 2nd highest 24-hour average (out of a complete annual model run). In addition to any other desired output metrics, the design value metrics corresponding to each ambient standard should be used to compare the model results to the NEPM standards.

Model Results for SO_2

Figure 21 of the GHD report shows a contour plot of modeled 1-hour average SO_2 concentrations for 2014 (the same contour plot appears in Figure 22). The plot is captioned "Predicted maximum one-hour SO_2 for 2014 – maximum emissions." However, despite the caption that appears below Figure 21 (and as also cited in the text), the modeled concentrations shown in the figure are actually *the 9th highest* 1-hour SO_2 concentration at each grid cell receptor.

The form of the NEPM 1-hour SO_2 air quality standard requires that the 1-hour SO_2 concentration be below 523 µg/m^3, however there is an allowable exceedance of "one day per year". GHD failed to discuss the form of the 1-hour standard or the appropriate design value metric that corresponds to this standard. Modeled 1-hour average SO_2 concentration values are labelled as "maximum", when in fact they are the 99.9th

[13] The "metrics" refer to the various statistical measures of the concentration output data that can be used to describe the data, such as annual averages, maximum daily averages, 99th percentile hourly averages, maximum 2nd high hourly averages, etc.

percentile, or the 9th highest (out of all hours per year),[14] without any discussion concerning the justification for using the 9th highest metric.

The 9th highest 1-hour concentration does not correspond to the design value for the NEPM 1-hour SO_2 standard. The proper design value (DV) for the NEPM 1-hour SO_2 standard is the 2nd highest daily peak 1-hour SO_2 concentration (i.e., the highest 1-hour average SO_2 concentration that occurs on a *different day* than the maximum 1-hour value).

I calculated a number of metrics using GHD's model-predicted 1-hour average SO_2 concentrations for 2014 at every modeled grid cell, including (1) the absolute maximum 1-hour average concentration, (2) the 99.9th percentile 1-hour average concentration (9th highest, (3) the 2nd highest daily peak 1-hour average (design value corresponding to the NEPM 1-hour SO_2 standard), and (4) the 4th highest daily peak 1-hour average (design value corresponding to the US 1-hour NAAQS for SO_2), as shown in Table 1, below. As can be seen in the table, the modeled design value for 2014 corresponding to the NEPM 1-hour SO_2 standard was **1,259.8 µg/m^3**, which is more than twice the allowable DV concentration (523 µg/m^3).

Table 1. Modeled 1-hour average SO_2 concentrations, 2014

Metric	Modeled Value (µg/m^3)
Maximum 1-hour average	1,698.5
99.9th percentile 1-hour average (9th highest)	546.4
2nd highest daily peak 1-hour average (NEPM DV)	**1,259.8**
4th highest daily peak 1-hour average (US NAAQS DV)	726.3

[14] Examination of the GHD modeling files and model output summary spreadsheets confirms that the data in the summary tables were developed corresponding to the 9th highest, or 99.9th percentile 1-hour SO_2 averages, and not the maximum 1-hour average.

It should be noted that is not sufficient to examine the model results at only a few monitoring stations – the model provides information about the variability of impacts across the *entire* modeling domain. The peak modeled value (maximum impacted grid cell) must be used as the design value since the ambient air quality standards require that concentrations be below the standard level at ALL locations in the air basin, not just at the monitoring locations, and not just in the highly populated portions of the valley.

On page 30 (above Figure 22), the GHD report states: "2014 Plots for SO_2 are shown in Figure 22 as they produced the highest one-hour impacts while all other years produced lower predictions." Table 2, below, shows GHD's modeled SO_2 concentrations at the location of the maximum gridded impact using a number of different SO_2 metrics.

Table 2. Modeled SO_2 metrics for each model year

Metric	2013	2014	2015	2016	2017
Maximum 1-hour average	973	1,699	1,578	**2,153**	1,464
99.9th percentile 1-hour average (9th high)	478	546	472	553	**614**
Maximum 24-hour average	180	196	191	206	**218**
Annual Average	7.7	7.1	6.3	7.2	**8.1**

As can be seen from the model results in Table 2, 2014 did **NOT** produce the "highest one-hour impacts" if one considers the 99.9th percentile, or 9th highest (which is the

metric that GHD was citing as the “maximum” values). The modeled peak 9th highest 1-hour average SO_2 concentration was 614 µg/m^3 (in 2017).

Similarly, the modeled maximum gridded 1-hour average SO_2 concentration was 2,153 µg/m^3, which occurred in 2016. 2014 did not produce the “highest one-hour impacts” if one considers the maximum concentration metric.

Figure 22 of the GHD report shows the modeled maximum daily (24-hour) average SO_2 concentration for 2014. The gridded maximum daily average concentration of 196 µg/m^3 for 2014 was slightly below the NEPM standard level (209 µg/m^3), however the model predicts that the 24-hour SO_2 standard would be exceeded in the year of maximum impact (2017). Clearly 2014 was not the maximum year for the daily peak either.

Figure 22 also shows the modeled annual average SO_2 concentration for 2014. The maximum gridded annual average was 7.1 µg/m^3 (the NEPM annual SO_2 standard level is 20 µg/m^3). As shown in Table 2, above, the modeled annual average at the maximum gridded location in 2014 (7.1 µg/m^3) was not the highest annual average value between 2013 and 2017. The highest annual average was modeled to be 8.1 µg/m^3 in 2017.

The CALPUFF model results for 2014 indicate that exceedances of the 1–hour SO_2 standard occurred at numerous locations in the modeling domain. The model predicted that the 1-hour SO_2 design value (2nd highest daily peak 1-hour average SO_2 concentration) was exceeded at 1,383 gridded receptor locations, accounting for an area of approximately 346 km^2 (equivalent to a circular area with a radius of 10.5 km).

The United States 1-hour NAAQS for SO_2 requires that the 99th percentile daily peak (4th highest daily peak) 1-hour average be below the standard level of 75 ppb (196 µg/m^3). GHD’s model results indicate that for 2014, the 4th highest daily peak 1-hour average SO_2 concentration was 726.25 µg/m^3, which is close to *four* times the acceptable level in the US. Clearly the US 1-hour SO_2 standard would be violated in the Latrobe Valley due solely to contributions from the modeled Power Stations (this would also be true for all the other modeled years).

The GHD modeling did not include impacts from other sources or regional background SO_2 levels in the model assessment. Although the ambient SO_2 levels due to the Power Stations were predicted to exceed the NEPM air quality standards (by themselves, without the contribution from any other source or regional background), adding even a small amount of SO_2 corresponding to a realistic estimate of regional background SO_2 levels would increase the predicted concentrations at the maximum gridded location.

Including background levels of SO_2 would also increase the predictions of 24-hour average SO_2 concentrations so that the resulting total 24-hour average SO_2 concentrations would likely have been predicted to exceed the NEPM 24-hour SO_2 standards during all four modeled years.

The NEPM air quality standards (as well as the US NAAQS) require that NO location be shown to exceed the allowable design value level -- it is not acceptable to argue that, as was stated on page 29 of the GHD report, "the predicted air quality remains within air quality standards for the majority of the airshed – with the exception of a few hours each year." Such model results would still result in a nonattainment designation.

Model Results for PM

The GHD modeling demonstrates that the Power Stations are, in fact, a significant contributor to PM concentrations in the Latrobe Valley.

For example, the model results in Table 6 of the GHD report show that, at the highest impact grid point, the maximum 1-hour PM concentration (assumed for this analysis to be all PM_{10} or $PM_{2.5}$) was greater than 50 ug/m in two of the four modeled years.[15] The 24-hour average PM impacts from the Power Stations were shown to be within the acceptable NEPM standard limits, however even if an appropriate size fraction is applied to the PM_{10} and $PM_{2.5}$ emissions, it can be seen that peak impacts from the

[15] The 2013 and 2016 PM modeling both used the 2016 meteorological data, resulting in only four *different* modeled years, not five.

Power Stations often contribute a substantial portion of the standard concentration levels.

After consideration for the size fractions, the model results showed that the Power Stations were responsible for about 35 percent (17.7 µg/m^3) of the 24-hour NEPM standard level for PM_{10} (50 µg/m^3) at the highest modeled impact location (see Figure 24), and almost half (11.80 µg/m^3) of the 24-hour NEPM standard level for $PM_{2.5}$ (25 µg/m^3; see Figure 26).

Although the Power Stations, on their own, are not predicted to cause a violation of the ambient air quality standards, the Power Stations do contribute a significant portion of the standard in some parts of the air basin, and along with the other sources of PM in the air basin, are responsible for the observed (and predicted) violations of the standards.

As was the case with the SO_2 1-hour average model results, GHD presented "maximum" modeled 1-hour average PM concentrations that were actually the 99.9th percentile (9th highest 1-hour average concentrations). The report provides no apparent justification for mis-representing the maximum 1-hour average values with the 9th highest 1-hour values. The actual modeled maximum 1-hour average PM concentration for each modeled year, as shown in Table 3,[16] below, can be seen to be about 3 to 4 times larger than the 9th highest 1-hour average values.[17]

Table 3. Modeled TSP metrics for each model year

Metric	2013	2014	2015	2016	2017
Maximum 1-hour average	**198.6**	160.5	144.1	**198.6**	153.1
99.9th percentile 1-hour average (9th high)	51.2	47.9	42.4	51.2	**56.0**

[16] The second, third, and fourth row of Table 3 are identical to the model results shown in Table 6 of GHD's report.
[17] The model results for 2013 erroneously used meteorological data for 2016, and are therefore not representative of 2013 meteorological conditions.

Maximum 24-hour average	18.7	18.2	17.1	18.7	**19.6**
Annual Average	0.76	0.80	0.68	0.76	**0.88**

The top-down modeling approach (section 8.2.1) modeled the license emission limits for TSP (for this modeling approach, it was assumed that both PM_{10} and $PM_{2.5}$ equal TSP). The peak 24-hour average at the maximum impacted grid point was predicted to be 19.6 µg/m^3 (the value was rounded to 20 µg/m^3 in Table 6 of the GHD report).

The model results in Table 6 of GHD's report are compared against the applicable ambient air quality standards, so contributions from other PM sources, plus background, *should have been added* to the modeled 24-hour concentrations.

Contributions from sources of particulate matter, other than the Power Stations, were NOT included in the modeling described in the GHD report. If the modeling had included other sources[18] -- or if those sources were reasonably accounted for in some other way, then the modeling would likely demonstrate, when the contributions of the Power Stations are added to the contributions from all other sources in the region (plus regional background levels), that the 24-hour NEPM standards for both PM_{10} and $PM_{2.5}$ would be violated – not necessarily at the location of one of the monitoring sites, but at some other location(s) in the modeling domain.

Violations of the ambient PM standards typically occur when the mix of emitted pollutants contains amplified levels of seasonal sources (such as wood smoke) combined with "worst-case" (limited dispersion) meteorological conditions. While it may be true that the wood smoke contribution is higher during observed exceedance periods, there are still likely a number of other source types that also contribute significant amounts to the ambient air (especially outside of the populated centers) on those days, including the power sources.

[18] Modeling all important sources of PM typically requires considerable effort in order to accurately represent the spatial and temporal variability of a variety of source types, including on-road motor vehicles, agricultural activities, wood burning, wind-blown dust, etc.

A “key finding” from the top-down modeling approach appears at the top of page 32 of the GHD report:

> “**As expected, the model predictions are generally higher than measured at air monitoring stations due to the Power Station emission profiles (as examples shown in section 5.2) being lower than the emission rate at maximum licence limits at all times.**”

The point of this statement is unclear.

Firstly, the model predictions (modeled concentrations) are NOT generally lower than the measured concentrations at the monitoring stations. For example, the GHD report makes it quite clear that the modeled PM concentrations only account for a *small portion* of the measured PM levels at Traralgon. The second part of the statement refers to the fact that the top-down modeling was conducted with emission rates set to maximum license limits, which are somewhat higher than the actual emission rates from the five modeled Power Station units. If the point is that the top-down modeling would be expected to slightly over-predict historical concentration impacts due to the use of allowable emission rates (relative to the actual emission rates), then the first part of the sentence should be re-stated.

The bottom-up modeling approach presented in the GHD report is severely flawed. The “scaling-up” calculation to determine the maximum amount of emissions that would just meet the ambient air quality standard **assumes that no other sources would contribute** towards the standard design value.

For example, footnote 23 on page 32 of the GHD report describes the calculation for the 1-hour PM_{10} standard (SEPP AQM criterion of 80 µg/m^3). The modeled maximum 1-hour average PM_{10} concentration (using unit emissions), as reported in the GHD report,[19] (0.195 µg/m^3) was divided into the SEPP AQM design concentration for PM_{10} (80 µg/m^3) to arrive at the "allowable" rate (for all Power Stations) of 410 g/s (i.e., 80/0.195). This calculation assumes that the Power Stations (at 410 g/s) would

[19] As discussed below, the value that was identified in the GHD report as the modeled “maximum” 1-hour average PM_{10} concentration was actually the 99th percentile (9th highest) concentration. The maximum modeled 1-hour average concentration due to the Power Stations was 0.788 µg/m^3, as shown in Table 4.

contribute the entire 80 µg/m^3 to the 1-hour standard -- i.e., there are NO contributions from other PM_{10} sources or background. If other PM_{10} sources within the Latrobe Valley (and regional background) contribute *some portion* of the standard design value, then the Power Stations can only contribute the *remainder*.

The unity emissions modeling did not include contributions from any sources other than the Power Stations (or background). The bottom-up scaling of the unit emissions from ONLY the Power Stations, without first reducing the design concentration (to which the Power Stations can contribute) to account for the contributions from other sources (and background), assumes that the Power Sources can “consume” the entire design value concentration. The bottom-up scaling methodology is flawed because it is necessary to account for the contributions from other PM sources (and background).

The proper way to perform the bottom-up approach would be to first model (or otherwise estimate) the impact of ALL OTHER sources, and then subtract that impact from the standard design concentration (during peak events) before scaling up the Power Stations’ emissions to account for the remaining concentration. For example: if "other sources" accounted for 50 µg/m^3 against the 1-hour PM_{10} design concentration of 80 µg/m^3, then the Power Stations could only contribute an additional 30 µg/m^3 before the standard would be violated -- and although the Power Stations would not be "completely" responsible for the violation, they would need to emit less than 30 / 0.195 = 154 g/s -- rather than the 410 g/s, as in the GHD report, in which the Power Stations would contribute the entire 80 µg/m^3 (with no other sources contributing anything).

Not only is the bottom-up method flawed because the contributions from other sources were ignored, but GHD’s calculation of the maximum emission rates that would just achieve the 1-hour standard uses the 99.9th percentile 1-hour average instead of the modeled maximum 1-hour average.

Table 4 shows the modeled maximum gridded 1-hour average concentration from the unity emission modeling, along with the 99.9th percentile (9th highest) value that GHD has mis-represented as the “maximum”. If the calculation on page 32 (see footnote 23) for the 1-hour average for PM_{10} were performed with the actual maximum modeled unity emissions impact (rather than the 99th percentile value), the allowable emission rate for

PM_{10} (from each modeled unit) would have been **102 g/s** (rather than 410 g/s, as reported in the GHD report. Similarly, the allowable emissions rate for $PM_{2.5}$ (from each modeled stack) would be 50 / 0.788 = **63.5 g/s**, which is far less than the allowable $PM_{2.5}$ emissions rate of 256 g/s that was reported in Table 7 of the GHD report.

Table 4. Modeled unity emissions: grid maximum vs. 99.9th percentile for each model year. The GHD report incorrectly used the 99.9th percentile 1-hour value to calculate "allowable" emissions when it should have used the maximum 1-hour average, which is much higher. This significantly skewed the maximum allowable emission rate calculations.

Metric	2013	2014	2015	2016	2017
Maximum 1-hour average	0.650	**0.788**	0.474	0.650	0.762
99.9th percentile 1-hour average (9th high)	0.187	0.193	0.176	0.187	**0.195**

When conducting a PM nonattainment analysis, it is customary to first identify all the modeled periods that exceeded the standard level (or simply the peak end of the distribution), and then to construct a **source attribution** (using the modeled impacts for each source or source type) for each of those high concentration periods, or peak events. (It sometimes happens that different source mixes contribute to the various modeled exceedances.) Then one can determine what the effect of any mix of controls would have on those exceedance days (and the idea is that a control strategy should be sought that would bring down ALL of the exceedance periods under the standard).

In section 7 of the GHD report, the results of a particle characterization study for Hunter Valley are presented, which provided such a "source attribution" (in time series) for that region. Later in the report, GHD admits that such a source attribution doesn't exist for

the Latrobe Valley[20] (although they do recommend, in section 10 of the GHD report, that a particle characterization study be carried out in order to provide such information).

Estimating the spatial and temporal variation of PM concentrations throughout the Latrobe Valley is not a simple task. Either a comprehensive particle characterization study must be conducted in which the source mix of observed PM levels are estimated, or a dispersion modeling study can be performed, in which all important sources of PM in the Latrobe Valley are included.

The first option requires the collection and (often expensive) laboratory analyses of PM samples (at numerous locations and times), followed by a source attribution analysis (which can be uncertain). The second option (modeling) requires an equally daunting task of developing a reliable inventory of all sources of PM emissions, including the necessary spatial and temporal variabilities.

Even without such a comprehensive analysis that adequately describes the PM source impacts contributing to PM exceedances across the Latrobe Valley, one can still conclude that additional PM controls are warranted at the three modeled Power Stations. The model results demonstrated that the Power Stations contribute a significant *portion* of the PM_{10} and $PM_{2.5}$ standard levels (e.g., up to half of the $PM_{2.5}$ NEPM standard level).

Although the Power Stations are not predicted to exceed the PM standard levels on their own, the contributions to PM air quality is predicted by the model to constitute a large fraction of the standard level, at certain times and locations within the modeling domain. A strategy aimed at reducing PM emissions from the Power Stations via the installation of emission control equipment will therefore have a significant effect on the PM air quality in the Latrobe Valley.

<u>Model Results for Mercury</u>

[20] GHD claimed (several times in the GHD report) to have supporting *evidence* (including "[a]ir quality assessments, undertaken in the Latrobe Valley over many years") for the conclusion that the Power Stations are "minor contributors to ground level PM concentrations" (page 21). However, none of this apparent evidence, such as the results of a previous PM source apportionment study, was presented in the current GHD report.

For mercury, the proper analysis (for it more appropriately evaluates the real environmental concern of mercury in the environment) would be to model the *long-term* deposition to sensitive watersheds within the modeling domain and then compare to existing mercury levels in streams and waterways.

The modeling that was done, using a mercury emission "concentration" of 100 µg/m^3, showed significant mercury concentration impacts in the Latrobe Valley (3-minute averages). The mass/time mercury emission rates were not presented in the GHD report; however, a review of the modeling files shows that the modeled mercury emission rates were between 0.23 and 0.28 g/s for each of the five modeled Power Source units (equivalent to between 1.6 and 2.0 tons per year).

Similarly to the SO_2 and PM 1-hour average model results, GHD presented the "maximum" modeled 3-minute average mercury concentration that actually corresponds to the 99.9th percentile modeled value (9th highest *1-hour* average concentration, multiplied by a peak-to-mean ratio of 1.82). The report provides no apparent justification for this misrepresentation.

The *actual* modeled maximum 3-minute average mercury concentration for 2017 was 338.3 ng/m^3, which is more than 3.5 times the value reported in the GHD report (96.5 ng/m^3).

Using the unity dispersion modeling results, GHD computed the "allowable" emission rate of mercury from the Power Stations (using the bottom-up modeling approach) that would just meet the 3.3 µg/m^3 3-minute SEPP AQM design criteria.

The resulting emission rate of 9 g/s (313 tons per year) for each unit at the three Power Sources represents an *enormous* amount of mercury.

To put these emission rates into context, ALL point sources of mercury in all 50 US states combined emit less than 44 tons per year of mercury, and all US coal-fired power plants combined emit less than 23 tons per year of mercury. This result implies that the 3-minute mercury criteria of 3.3 µg/m^3 is of little value when considering long-term mercury impacts.

A long-term ambient mercury concentration of 3.3 µg/m^3 would likely lead to extremely high mercury deposition rates.

Comments on Section 9

Although electrostatic precipitators (ESP) are “effective in reducing particulate emissions” (page 38), baghouse technologies offer a much higher level of PM removal for coal-fired power plant PM emissions. Baghouse have also been shown to be quite cost-effective ($/ton removal) when compared to other PM control technologies.