Invincible Southern Extension Project

EIS Air Quality Assessment

Background, Comments and Criticisms

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Preface

This document seeks to provide an examination of the air quality assessment that forms part of the Invincible Southern Extension Project environmental impact statement. The document begins by explaining the basis of NSW air quality assessments, necessary background for understanding the examination of the assessment that appears in the sections that follow. Closing off the document are suggestions on how the assessment could have been improved, so it would have been more credible.

The author of this document has spent a career in modelling but is not an air quality specialist. For this reason, it may be worthwhile consulting specialists, like those that reside in the Hawkesbury campus of the University of Western Sydney, to validate or otherwise the suggestions made here.

A query was emailed to the US Environmental Protection Agency, regulators in US use of the CALPUFF air dispersion modelling software that was used by the authors of the Invincible air quality assessment. The query was of a general nature and did not identify the Invincible project. The US EPA response appears in Appendix 1.

Basis of Air Quality Assessments in NSW

Dust particles emitted from industrial operations can spread to neighbouring areas, potentially causing harm to the health of humans and the environment's flora, fauna, insects and so on. The principal concern for health and regulatory authorities are the smallest of dust particles due to their capacity to harm human health. There are two classes of these small particles, those whose diameter measures less than one hundred of a millimetre, dubbed PM_{10} particles, and those even smaller, less than one four hundredth of a millimetre, dubbed, $PM_{2.5}$ particles. These small particles can penetrate and lodge deep in the lungs and can cause cardiovascular and respiratory disease, and cancers.

The World Health Organisation (WHO) has declared[1] that there is no known safe level of either short or long-term exposure to small dust particles. With this uncertainty, it chooses to recommend that human exposure to PM_{10} particles should not exceed a daily average exposure of 20 $\mu g/m^3$ (equivalent to 20 kilograms in a cubic kilometre or two-fiftieth of a gram in the volume of an average home) and that in any year, the maximum of all daily average exposures should not exceed 50 $\mu g/m^3$. For $PM_{2.5}$ particles, the limits are 10 $\mu g/m^3$ (average day) and 25 $\mu g/m^3$ (maximum day). WHO has less stringent interim targets[2], allowing for gradual compliance with the recommended concentration limits.

A variation or perhaps a refinement on WHO's 'no safe small dust concentration' declaration was provided in a paper[3] prepared for the Australian Environment Protection Council. The paper referred to a finding that the health benefits of reducing dust concentration are unrelated to the absolute concentration. Thus, as the paper explained, reducing average-day PM_{10} concentrations from 25 $\mu g/m^3$ to 15 $\mu g/m^3$ (taking it below the WHO limit) has no greater health benefit than reducing the concentration from 15 $\mu g/m^3$ to 5 $\mu g/m^3$.

Critically, the converse would also be true, any increase in dust concentration, even if criteria limits are not exceeded, has detrimental health effects on humans and the environment.

It doesn't follow that upper limits are redundant. Their role is to suppress dust levels to a degree considered sufficient by society and its legislators. Suppression is achieved[4] by industries taking action to ensure they're always below the maximum criteria level. Those actions invariably cause a reduction in overall dust levels across all meteorological conditions (dry, wet, windy etc) and operational conditions (maintenance, full-production, transport phases etc).

Dust limits under NSW regulations (for EIS assessment)[5] are the same as WHO's (except where stated). For PM_{10} the NSW limits are: average day 30 $\mu g/m^3$ (WHO 20 $\mu g/m^3$) and maximum day (50 $\mu g/m^3$); and for $PM_{2.5}$: average day 8 $\mu g/m^3$ (WHO 10 $\mu g/m^3$) and maximum day 25 $\mu g/m^3$.

Before NSW EIS assessments regulations were 'tightened' in January 2017[6], the $PM_{2.5}$ limits were only advisory and the PM_{10} daily maximum limit could be exceeded in up to five days of a calendar year. After January 2017, $PM_{2.5}$ limits came into force and 'zero' exceedances are allowed for both the $PM_{2.5}$ and PM_{10} maximum day limits.

The Invincible Southern Extension Project application was submitted in September 2016 and its EIS needs to only demonstrate compliance with the less restrictive pre-January 2017 air quality regulations.

Under NSW regulations, the proponent of an industrial project needs to address potential air quality impacts in the project's environmental impact statement(EIS). In relation to PM_{10} and $PM_{2.5}$ particles, the proponent needs to demonstrate that dust emissions from the project, when added to existing 'background' emissions (those that are there before the project commences), do not cause the previously mentioned dust concentration limits to be exceeded. This demonstration needs to apply over the 'area of interest'.

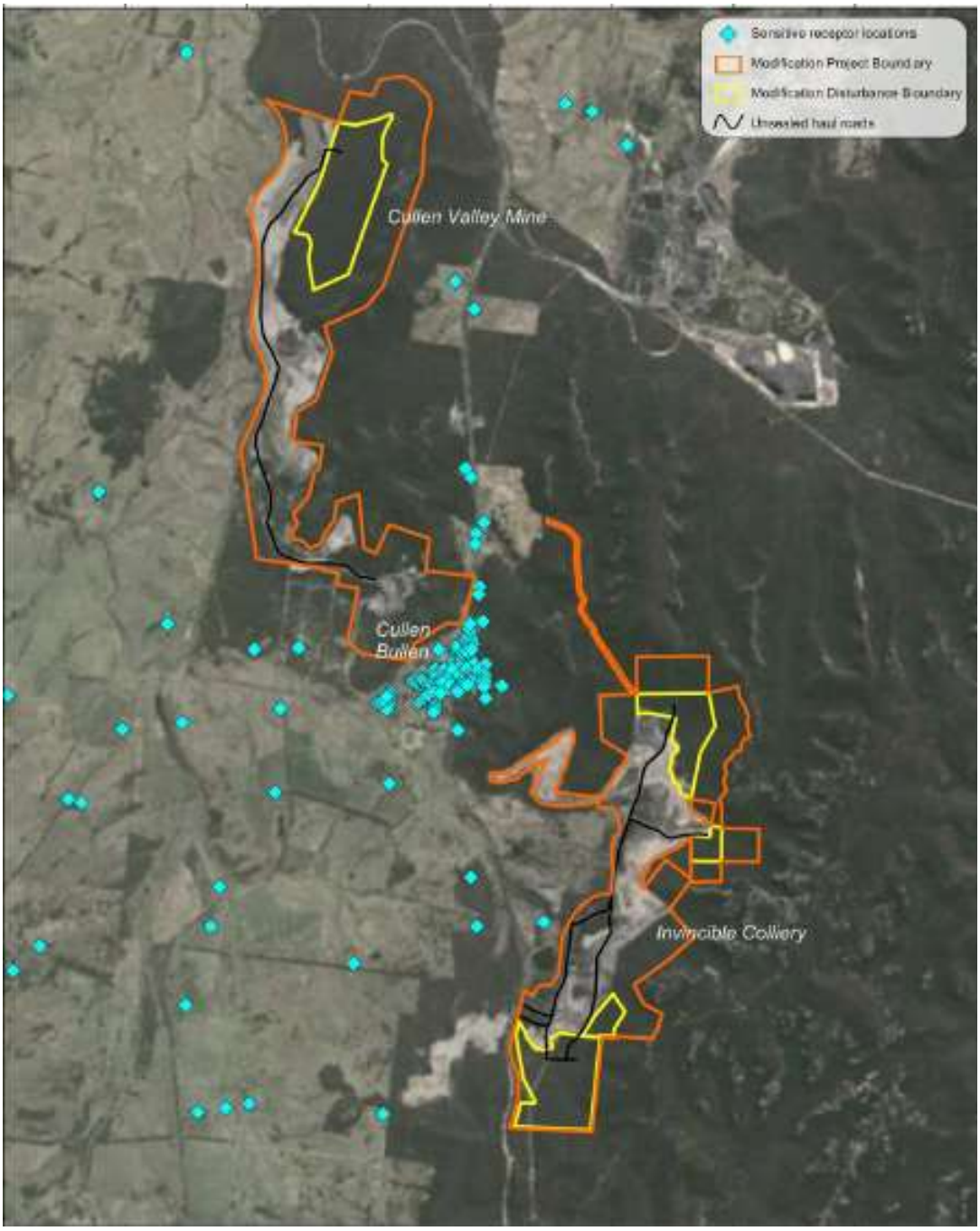

Figure 1 Invincible project area of interest - where houses, schools etc (blue diamonds) are located

NSW regulations, like those in all other Australian states, are framed[7] around human health. There is no focus on dust particles impacts on the environment. The 'area of interest' for an EIS assessment is simply the area of human habitation. In contrast, under US regulations, a secondary set of dust concentration limits apply for what they term 'welfare effects'. The term 'welfare effects' closely aligns with environmental effects, such as those on climate and ecology.

NSW has 'standards' for how the above mentioned project plus background emissions are derived[8]. The standards stipulate how to calculate the spread of dust particles from the project site to the neighbouring 'area of interest'. Computer models are used for the task and the standards stipulate how they are to be set up and run.

The following sections gives comments on the air quality assessment, including its modelling, undertaken for the Invincible Southern Extension Project EIS[9] ('Invincible EIS' from hereon). The 'area of interest' in this context is approximately a 10 kilometres radius semi-circle to the north, west and south of the project's mine site. It includes the town of Cullen Bullen. It's where the blue diamonds appear in Figure 1 (taken from a Pacific Environment Limited Report, dated February 2014, and concerning an earlier EIS proposal - the more northern blue diamonds are of less concern in this context).

Invincible Southern Extension Project EIS Dust spread modelling

Extent of Spread

The Invincible EIS used the CALPUFF model to calculate dust spread. CALPUFF was developed in the US and has been reviewed by their responsible regulatory body, the US Environmental Protect Agency (US EPA[10]). The US EPA set down standards for how CALPUFF is to be applied (in the US). Critically (explained further down), the standards mandate[11] that a default set of model parameters (parameters determine how far modelled dust spreads) should be used. These default parameters were derived by the US EPA through a rigorous research process and therefore the parameters are regarded as reasonably reliable. The US EPA does allow modellers to depart from the default parameters in exceptional circumstances but only if a detailed explanation is provided.

The reason the US EPA frowns upon departures from its default parameters is that in application CALPUFF's predictive power is generally not checked. In other types of modelling, parameters are chosen in a fashion that results in a best match with historical 'project' observed data, what's called *model calibration*. Sometimes the predictive power with the calibrated parameters is checked against additional historical data, what's called *model validation*. With the Invincible EIS CALPUFF modelling incorporating neither calibration nor validation, the only approach that avoids the modelling inadvertently or even fraudulently 'deviating from reality' is to use the US EPA derived default parameters.

The NSW regulation's guide to dust spread modelling (referenced in endnote 5) mentions the option of running the CALPUFF[12] model with the US EPA default parameters. Unlike in the US, however, the guide does not mandate the use of the default parameters unless a detailed explanation is provided. The Invincible EIS is silent on the issue of default parameters, so there is no certainty the defaults were used.

There is some evidence, albeit not overwhelming, that the Invincible EIS modelling didn't use default CALPUFF parameters. The evidence comes in the form of a comparison with two previous EIS CALPUFF

modelling efforts, which were undertaken for mine projects in the same area. All three EIS reports represented dust spread using dust concentration 'contour plots'[13]. The greater the 'slope' shown on these plots, the more rapid the decline in dust concentration away from the projects' locations, meaning the dust spreads less distance and the impact on humans is less severe. A visual inspection appears to show that Invincible EIS contours do have greater slope, supporting the possibility that the CALPUFF parameters (that control degree of spread) used are different from those in the other two EIS studies.

Confidence in the Invincible EIS dust spread modelling could be gained if the use or otherwise of the US EPA default parameters was addressed in the EIS document.

Establishing Background Dust Levels

As mentioned previously, it's the sum of background (without project) dust levels and modelled modelled project dust levels that are compared with $PM_{2.5}$ and PM_{10} criteria bounds. Thus, the Invincible EIS was required to establish background levels.

There are only two dust concentration samplers (called high volume air samplers) in the 'area of interest'. These were established to monitor dust emissions from the old Invincible and Cullen Valley mines (seen in Figure 1). Sampling data for those samplers was available to the Invincible EIS for the years 2009 to the 2015. The data provides PM_{10} concentrations for each day in those years (except for the days the instrumentation failed). $PM_{2.5}$ concentrations are not recorded.

With the Invincible and Cullen Valley mines retired in 2013[14], the data for 2014 and 2015 (and much of 2013) was representative of background PM_{10} concentrations. This was not recognised by the Invincible EIS, which meant the far and away best available data for estimating background dust levels was overlooked.

Instead, for a background level, the Invincible EIS used the 95th percentile (exceeded by 5 percent of values) of the combined Invincible and Cullen Valley daily PM_{10} daily record for 2009 to 2015. In do so, totally disregarded was the fact was that this was a mixture of years with and without mining. The value found for the 95th percentile was 23 $\mu g/m^3$. It was assumed the 23 $\mu g/m^3$ applied both across the area of interest and across all times of the year. This appears to be a conservative choice that overestimates background levels because: the 2009 to 2012 part of the record includes mining emissions as well as the desired background levels; a 95th percentile value is a 'high' value; and the samplers are located close to mines, meaning, when the mines were operating, they were receiving greater dust levels than the 'area of interest'.

The Invincible EIS choice for background level is not as conservative as appears from the above discussion. There were a number of days of higher valued PM_{10} concentrations recorded by the Invincible and Cullen Valley mime samplers[15] when they were only measuring background dust (mid 2013 to end-2015). Those days were likely to have been windy and dry[16], the very conditions that would produce greater dust spread from the project. As such, using the 95th percentile underestimates the possibility of getting a day with a really large 'background plus mine dust' concentration and exceeding the PM_{10} day maximum limit.

The Invincible EIS derived $PM_{2.5}$ background levels from a relationship with PM_{10} concentrations. Putting aside how accurate that relationship is, what can be said is that if the PM_{10} background levels on critical dry and windy days is underestimated then so would be the (related) $PM_{2.5}$ value.

Conclusions

- The Invincible Southern Extension Project will increase dust levels which will detrimentally impact on human health. The degree of impact will depend on the magnitude of dust increase and is independent of whether criteria limits are exceeded.
- Modelling undertaken for the Invincible EIS:
    - would be more credible if an explanation was given as to whether US EPA recommend default parameters values were used, and if not, what parameters were used and why;
    - appears to show less dust spread than other similar EIS studies and therefore may underestimate impacts on properties further away from the project site; and
    - underestimates background dust levels for the type of dry and windy days that maximum day limits could be exceeded.
- Given the importance of human health, the above presents a case for redoing some of the modelling and some of the reporting.
- Consideration should be given to change NSW regulations and standards so that:
    - like in the US, CALPUFF parameters can only be changed when documented reasoning is provided;
    - like in the US, the impact on the environment's health and not just human health is addressed; and
    - approval conditions include placing a requirement on the proponent to finance the installation and maintenance of dust samplers, to be sited in areas where human habitation is sufficiently dense, like for example the town of Cullen Bullen. This would be an acknowledgement that no matter how well a CALPUFF model is set up, it's dust spread predictions will still have a fair degree of uncertainty, including because the model's parameters are never calibrated or verified.

About the Author

I spent a career in hydrological modelling, including of the Sydney Bulk Water Supply Systems, the Murray River System and the Murrumbidgee River System. The latter work was used in the Basin Plan process that aims to improve environmental outcomes in the Murray River and its tributaries. Whilst air quality modelling obviously differs from hydrological modelling, there is sufficient procedural commonality to allow me to comment on the Invincible EIS. The Hawkesbury Campus of the University

of Western Sydney contains researchers with a specialist knowledge of dust spread modelling (technically termed dust dispersion modelling) and it may be useful to gain their expert input on some of the issues I have raised.

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[1] **World Health Organisation (2016).** *Ambient (outdoor) air quality and health.* http://www.who.int/mediacentre/factsheets/fs313/en/

[2] World Health **Organisation (2005).** *Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide*. Interim targets discussed on page 7. http://apps.who.int/iris/bitstream/10665/69477/1/WHO_SDE_PHE_OEH_06.02_eng.pdf

[3] **PAE Holmes (2012).** *Evaluating options for an exposure reduction framework in Australia.* http://www.nepc.gov.au/system/files/pages/18ae5913-2e17-4746-a5d6-ffa972cf4fdb/files/exposure-reduction-framework.pdf

[4] See section 2.2 pf the reference in endnote 3.

[5] **NSW EPA (2017).** *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales [a modification of the 2005 version, as described in endnote 6].* https://gazette.legislation.nsw.gov.au/so/download.w3p?id=Gazette_2017_2017-8.pdf. It refers to the 'National Environment Protection (Ambient Air Quality) Measure as amended (Federal Register of Legislative Instruments F2016C00215), where the $PM_{2.5}$ and PM_{10} concentration limits are found.

[6] **NSW Department of Environment and Conservation (2005).** *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales***.** http://www.environment.nsw.gov.au/resources/air/ammodelling05361.pdf. This 2005 version refers to a 1998 'national environment protection measure' and a 1998 NSW departmental report. It would make more sense if the approved methods document referred generically referred to 'the most current version of dust particle criteria'. Otherwise the EIS can finish up using criteria that will not apply if the project is approved?

[7] **National Environment Protect Council (NEPM, 2016).** *National Environment Protection (Ambient Air Quality) Measure as amended (Federal Register of Legislative Instruments F2016C00215).* https://www.legislation.gov.au/Details/F2016C00215. The Measure's aim is to have "ambient air quality that allows for the adequate protection of human health and well-being" by setting out "standards that consist of quantifiable characteristics of the air against which ambient air quality can be assessed" (quotes are taken from the Measure). There is no mention of life forms other than human.

[8] The standards are the approved methods as described in endnotes 5 and 6.

[9] **NSW Planning and Environment (2017).** *Invincible Coal Mine - Southern Extension Modification.* http://www.majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=7961. The air quality assessment appears as Appendix 8 of the Environmental Assessment.

[10] **US EPA (2016).** *CALPUFF Modelling System*. https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models . The CALPUFF model software was initially reviewed as are all updates to it. The last update review was in 2016.

[11] **US EPA (2016).** *Personal communication***.** See Appendix 1**.**

[12] The reference in endpoint 5. See section 6.5.

[13] Contour maps can be found in air quality appendices:

- Invincible EIS (**Jacobs (2016)**). https://majorprojects.accelo.com/public/a98559ad17a4bc16007b6b8b5e18408e/08.%20Invincible%20Southern%20Extension%20Modification%20EA%20-%20Appendix%208.pdf
- Coalpac Modifications EIS (**Pacific Environment Limited (2014**)). https://majorprojects.accelo.com/public/299f56a4ca4566527ec690a1342c1f10/02.%20Invincible%20MOD%204%20EA%20-%20Appendix%20A%20and%20B.pdf
- Coalpac Consolidation Project EIS (**PA Holmes(2011)**). https://majorprojects.accelo.com/public/7e50dea81cee492b87c4fe9c4261db74/17.%20Coalpac%20Consolidation%20Project%20-%20Appendix%20G%20.pdf.

[14] **Hansley Bailey (2014).** *ENVIRONMENTAL ASSESSMENT INVINCIBLE COLLIERY PA 07_0127 MODIFICATION AND CULLEN VALLEY MINE DA 200-5-2003 MODIFICATION.* https://majorprojects.accelo.com/public/1a7f33bcf3d0ceec55f97fcc86c1b313/01.%20Invincible%20MOD%204%20EA%20-%20Main%20Text.pdf. Search for in 'care and maintenance', which is a form of retirement.

[15] See Figure 6 of Jacobs report referenced in endnote 13.

[16] See for example section 5.2.1 of Jacobs (referenced in endnote 13).

Appendix 1 Personal Communication from the US EPA

-----Original Message-----
From: Bridgers, George [mailto:Bridgers.George@epa.gov]
Sent: Friday, 17 November 2017 3:10 AM
To: Ilan Salbe <isalbe@bigpond.com.au>
Subject: RE: Form submission from: Support Center for Regulatory Atmospheric Modeling (SCRAM) Contact Us about Air Quality Models form

Ilan,

Unfortunately, the U.S. Environmental Protection Agency (US EPA) is not in a position where we can comment on specific aspects of analyses or evaluations related to regulatory actions (e.g., permitting) by a foreign government. This said, you have asked a more general question about quality assurance of models. What we can say is that in the United States, we recommend that all regulatory applications of air quality models include a sufficient modeling protocol outlining the models to be used, options selected in those models, input data, and data handling and processing procedures. There must be an open and transparent understanding of how the compliance demonstration was prepared, including the tools used for the demonstration.

So far as model selected, we have a handful of "preferred" models that we list in our regulatory "Guideline on Air Quality Models," such as AERMOD and CALPUFF. For CALPUFF, there was an extensive set of model performance evaluations that were conducted and documented along with the appropriate scientific basis for the promulgation of this model in our regulations in 2003. The evaluations of this model and model performance metrics were specific to the use of this model for long range transport situations. We did not promulgate CALPUFF for near-field (<50km) demonstrations because we had a separate set of models, ISC and now AERMOD, for these applications. This is not to say CALPUFF isn't appropriate for near-field applications, but we had other models to handle those situations. All of this information went through a required public notice, public comment, and regulatory rule development process. Further, the US EPA set forth a standard set of model settings for CALPUFF that are still in place today for regulatory applications of CALPUFF in the United States. These standard model setting do not preclude alternative setup of the model by the applicant, but it does require an extensive alternative model justification for deviation from these default settings. Otherwise, the 2003 promulgation of the model allows applicants in the United States to use CALPUFF for long range transport situations without having to further justify its development or performance.

We will note that CALPUFF was developed by a company external to our Agency and is currently hosted / owned by a company named, Exponent. You might consider contacting Exponent or looking at the various products and material that they have on their website. Exponent may be able to provide you more information specific to what you seek for the situation that you present. The would likely not be as limited in how they can respond since they are not a governmental agency. Their website address for CALPUFF is http://www.src.com/calpuff/calpuff1.htm.

Our regards,
George

George M. Bridgers, CPM, Environmental Scientist U.S. Environmental Protection Agency Office of Air Quality Planning and Standards AQAD - Air Quality Modeling Group
109 TW Alexander Drive

[redacted]