11 September 2014

The Director - Infrastructure Projects
Department of Planning and Environment
Number: SSI 13_6136
Major Projects Assessment
GPO Box 39
SYDNEY NSW 2001

Re: NorthConnex - Application Number: SSI 13_6136

Submitted via: http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=6136

Please find below my submission in response to the exhibition of the EIS for NorthConnex.

Relevant background

My name is Graeme Foley. My family and I have lived at 21 Bareena Avenue, Wahroonga since December 1985, ie before the F3 was constructed in a valley which leads ultimately to the Hawkesbury River.

I hold BSc (Geology) (UWA 1971) and Master of Business Administration (UWA 1978) degrees.

I have worked in various aspects of the natural resources industry for almost 40 years and am familiar with many aspects of project modeling, computer simulation, feasibility studies, project financing and company management.

Position regarding the project

I object to the project as currently proposed in the EIS.

The EIS proposes the northern ventilation stack be located in the middle of a densely populated residential area in Wahroonga, where 9,300 school children, as well as people and families in multiple aged care facilities, hospitals, businesses and private homes will be exposed to emissions from the stack.

Regardless of what NorthConnex (the project's proponent) claims, there is in NSW no precedent for the placement of a ventilation stack in the middle of a residential area comprised of family homes and in which 9,300 children attend schools.

Flaws in the EIS

There are multiple flaws in the EIS. That the EIS presents a project which ostensibly complies with the various rules and regulations which govern the proposed project provides scant comfort to an experienced eye that the project will deliver outcomes beneficial and safe for the community.

Without suggesting this has occurred in the EIS, it is worth noting fine tuning of assumptions which interact can provide very great differences in the end values calculated.

For example:
Multiply 6 x 5 x 4 x 3 x 2 and you'll get 720.
Multiply 5.4 x 4.5 x 3.6 x 2.7 x 1.8 and you'll get 425.15, a 41% decrease.
Multiply 6.6 x 5.5 x 4.4 x 3.3 x 2.2 and you'll get 1,159.57, a 61% increase.

The point is each change was just 10% of the initial figure. A little "improvement" to sensitive inputs, judiciously applied, can produce a result very different from the answer calculated if the original data had not been manipulated.

When doing complex simulation it is absolutely essential all input assumptions are based on the best available data and, when data is not available, assumptions must be conservative. For clarity, all critical assumptions should be presented for assessment. This is not the case in the EIS.

Two areas of the EIS which impact the health and safety of all the people present in the area within 2 km of the northern ventilation stack are the subject of this submission. They are:
1. Dispersion modelling; and
2. In-tunnel pollution level modelling.

Dispersion modelling

Introduction:
On 29 July 2014, NorthConnex hosted an "Air Quality Forum" at Hornsby RSL.

Dr Gerda Kuschel, Principal of Emission Impossible Ltd (see: http://emissionimpossible.co.nz/), addressed the audience in her capacity of NorthConnex's independent air quality expert.

The following is a direct quote of part of Dr Kuschel's address on 29 July 2014:

"…in an urban environment, what's this big deal about dispersion? What do I mean by that? Well, looking at cases of good dispersion, and that would be an example of where you have a very open area with a lot of wind going through, (umm) the emissions are very well dispersed. If you have those emissions you probably wouldn't see much of a change. The box that constrains the emissions - from your topography, from your meteorology – is quite large."

Dr Kuschel then put on the screen a diagram showing a large clear box headed "Good Dispersion" and smaller dirty grey box headed "Poor Dispersion".

Dr Kuschel continued: **"However, if you look at a situation for poor dispersion, and this can happen if you've got a built up, (you know) canyon in an urban environment between buildings, or you've got a topography with valleys, or it's a very calm situation, then for the same amount of emissions the box is much smaller because the emissions can't disperse as freely, so that's the concept around dispersion."**

At the Wahroonga end of the tunnel it is proposed the stack be located in a built-up residential area in the upper reaches of a river valley in an area with no wind.

At the Pennant Hills end it is proposed the stack be located in a built-up residential area in an open basin which traps winds ranging from east through south to west in an area with virtually no wind during morning and evening peak hours.

By Dr Kuschell's definition – and remember, Dr Kuschel is NorthConnex's independent air quality expert – situations primed for poor (or no) dispersion exist at the locations chosen for both the northern and southern ventilation stacks. Indeed, unless a case can be made that each location is windy at virtually all times, the case for adequate dispersion fails.

Topography surrounding the northern stack:
A personal visit to the proposed location of the northern stack would convince all but the most committed zealot that the site is entirely inappropriate for topographical reasons.

The proposed location is in the upper reaches of the river valley in which the F3 was constructed in the 1980s. The headwaters of the river were once 1,000-1,500 metres to the SSW but land development and diversion have all but obliterated nature's footprint.

Immediately to the west of the proposed location the land rises quickly (perhaps 10-12m within 75m) with the ridge line being approximately 20m above the F3 road surface 300-400 to the west.

To the east, the rise in elevation is more gentle, but within 400-500m of the proposed location of the stack it is the same as the ridgeline to the west.

The river valley opens slowly to the north with elevations falling by more than 60m along the F3 as it passes the Hornsby industrial estate to the west of the F3.

To the south, the land rises slowly reaching the original watershed about 25m above the elevation of the proposed location.

The mapping undertaken by NorthConnex is of inadequate resolution (+/- 6m) to determine the land contours with the degree of accuracy required to adequately assess the impact of the stack's location.

Prima facie, it appears:
- easterly winds will blow emissions from the stack into properties located on the slopes to the west of the proposed location of the stack;
- westerly winds will blow emission into properties located on the slopes to the east;
- northerly winds will blow emissions into properties located on the slopes to the south; and
- southerly winds will blow emissions north down the valley where there are comparatively few properties.

Compare the above situation with the M5 East stack located in Turella. People around the M5 East stack live in fear of the wind blowing emissions from the stack into their properties. The consequences of the emissions from the Turella stack hitting an area range from health issues to filthy houses to foul smells to residents having to live like prisoners unable to venture outside simply because the wind is "blowing their way".

The probability of Wahroonga experiencing the same outcomes as the area around the Turella stack is virtually 100% given the proposed location of the northern stack.

In the 21st Century the NSW Government must do better than repeat mistakes made more than a decade ago.

Vegetation surrounding the northern stack:
The EIS fails to take into account the specific vegetation around the proposed location of the northern stack. From the south, to the west to the north of the proposed location there are substantial stands of trees which will undoubtedly affect the velocity of wind from those directions as it nears the stack.

I was at the proposed location for the northern stack on Wednesday 3 September 2014, a particularly windy day as a result of a substantial weather system impacting the state. The tops of 20-25m high trees on the ridge line to the west of the location were whipped about by the strong winds. Conversely, 20-25m high trees on the property where the stack is proposed to be built were hardly reacting to the gusts.

The land use model applied by NorthConnex is not sufficiently fine scale to accommodate the mixture of gardens and high stands of trees around the stack. Therefore, the dispersion model will not produce realistic results.

Wrong simulation model:
Discussions with a number of international air dispersion experts revealed NorthConnex used the wrong model to forecast the dispersion of pollutants from the northern and southern stacks.

Virtually all experts contacted said for studies requiring fine resolution of near field impacts, AERMOD, and not CALPUFF, is the best option. (AERMOD = **A**merican Meteorological Society **E**nvironmental Protection Agency **R**egulatory **Mod**el.)The EIS faithfully regurgitated sales material distributed by the developers of CALPUFF and its add-on products to justify its use, but the experts I spoke to said AERMOD is the preferred simulation package if near-field impacts are to be accurately assessed.

It is worth noting the Victorian EPA recently adopted AERMOD as its primary air dispersion modeling package.

Meteorology – the NorthConnex approach:
Richard P Feynman (http://en.wikipedia.org/wiki/Richard_Feynman) said:
“It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong.”

I would add “data” to experiment.

Good science involves measurement, analysis and prediction – in that order. Once predictions have been made they are constantly checked against actual data.to ensure theory and fact are the same.

I call it the "test of reasonableness". Is "this" prediction reasonable? Having made a prediction I look to gather data as quickly as possible to confirm the prediction is reasonable.

"The wind does not blow in Wahroonga." I can obtain 50 affidavits from people living in Wahroonga who will swear that except on rare occasions there is little to no wind in Wahroonga. The exceptions are when a weather system passes through the state or in summer when a strongly nor-easterly occasionally makes its way in from the coast.

A typical day in Wahroonga starts with no wind before about 10am. As the earth warms, convection begins and gentle breezes develop. They are generally <5ph (1.4m/s) and almost certainly <10kph (2.8m/s). By mid to late afternoon the convective forces run out of energy and the breeze drops away to nothing.

"The wind does not blow in Wahroonga." Based on Gerda Kuschel's comment "**or it's a very calm situation**", prima facie it would seem we have a situation primed for poor dispersion.

"The wind does not blow in Wahroonga." Unfortunately, the EIS says Wahroonga is one of the windiest places in Sydney. The forecasts of wind direction and speed made in the EIS are based on CALMET, an add-on package to CALPUFF. The EIS assures us with words to the effect that CALMET employs very sophisticated algorithms which allows it to take data from regional stations and predict precisely the microclimate in a valley 15km away.

The following is a summary of information presented in Appendix G of the EIS. See Attachment 1 for the complete data.

	Calm periods (#)			
	Nth Stack	**Sth Stack**	**Lindfield**	**Terrey Hills**
Period	(CALMET)	(CALMET)	(Measured)	(Measured)
2009 - annual	49	81	2,361	274
2010 - annual	65	110	2,762	315
2011 - annual	44	66	2,892	105
2009 - Autumn (Mar, Apr, May)	16	18	691	94
2010 - Autumn (Mar, Apr, May)	15	14	815	101
2011 - Autumn (Mar, Apr, May)	12	13	826	82
2009 - Winter (Jun, Jul, Aug)	13	13	796	51
2010 - Winter (Jun, Jul, Aug)	11	21	769	58
2011 - Winter (Jun, Jul, Aug)	6	14	829	53
2009 - Spring (Sep, Oct, Nov)	10	10	516	70
2010 - Spring (Sep, Oct, Nov)	21	36	569	73
2011 - Spring (Sep, Oct, Nov)	16	27	687	37
2009 - Summer (Dec, Jan, Feb)	10	22	368	59
2010 - Summer (Dec, Jan, Feb)	16	39	509	83
2011 - Summer (Dec, Jan, Feb)	10	14	550	83

The above numbers are based on observations taken hourly during each year. For the annual records, the maximum number of observations is 8.760. For each season, the number of observations is 2,190 (without reflecting the exact number of days per season).

Having lived approximately 300m from the proposed location of the northern stack for almost 30 years, I found the above CALMET estimates staggering. They defy the test of reasonableness. Lindfield has almost 50 times as many calm periods as Wahroonga and Terrey Hills 5 times. Has any of the NorthConnex team been to Terrey Hills? Or more importantly, to Wahroonga?

I work from home. My neighbours have several coconut palms in their garden. The one in their front garden fills the western window of my study. It moves with the slightest wind. Since learning CALMET considers the wind always (ie, approximately 99.5% of the time) blows in Wahroonga, I have watched my neighbours' coconut palms like a hawk.

As noted above, there is no wind before about 10am and after about 4pm on a typical day – unless a weather system is moving through the state.

It is clear, on the basis of almost 30 years of personal observations, CALMET's conclusion the wind in Wahroonga blows 99.5% of the time is rubbish.

Friends of ours who live in West Pennant Hills say CALMET's conclusion the wind always blows in that area is also rubbish.

The EIS relies on CALMET's forecasts of wind direction and strength to determine the level of dispersion from the proposed locations for the northern and southern stacks.

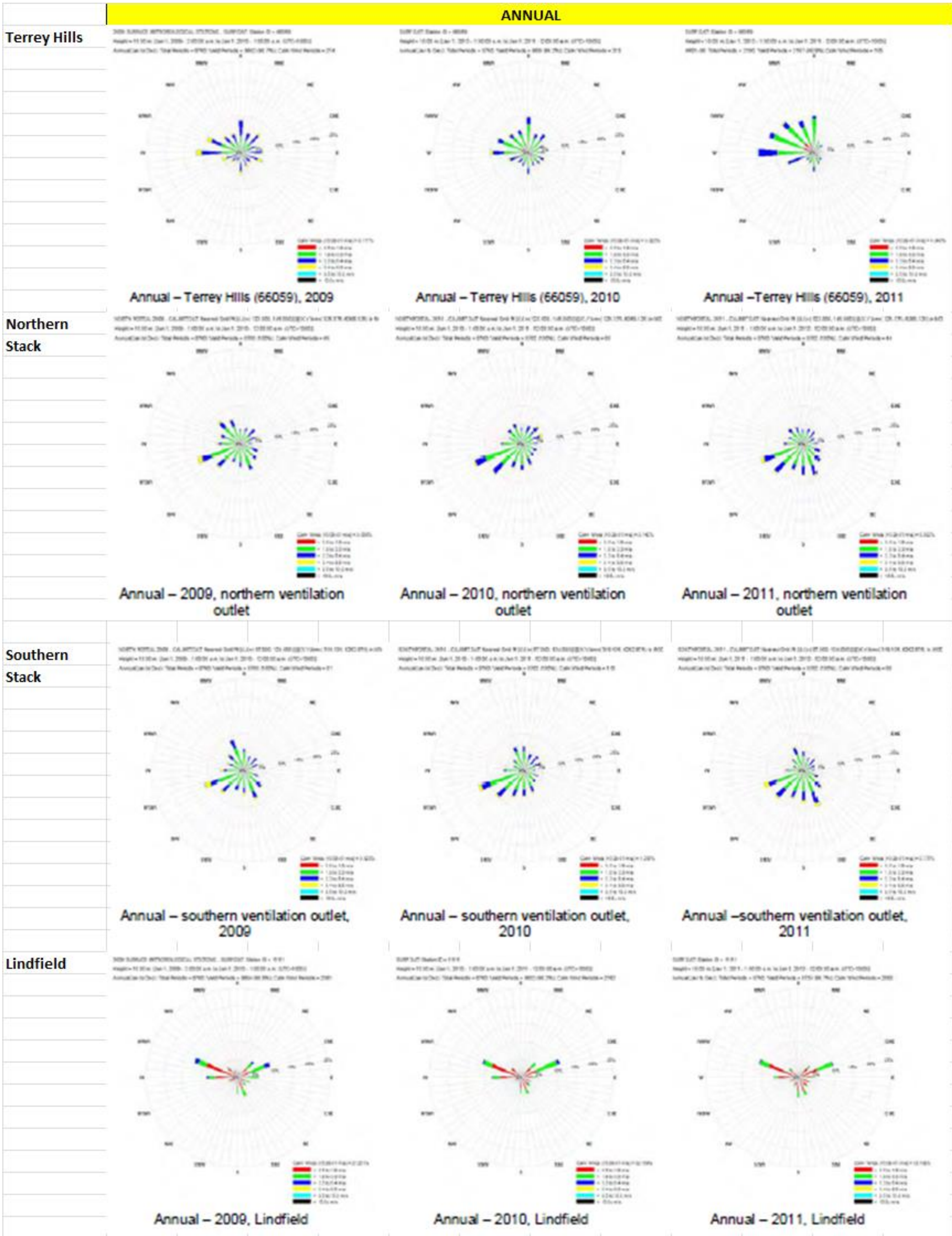
In Appendix G of the EIS, a number of wind roses are presented for 2009, 2010 and 2011. They are:

- Annual – actual and forecast

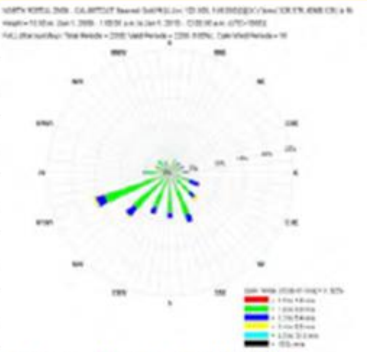
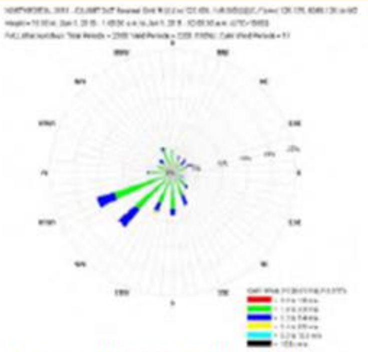
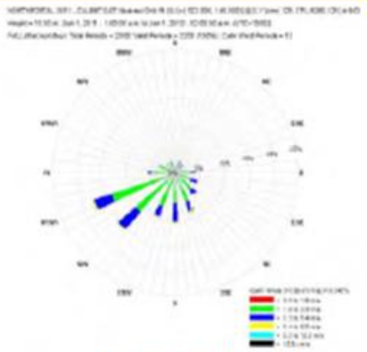
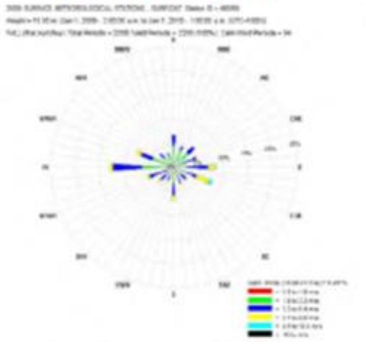
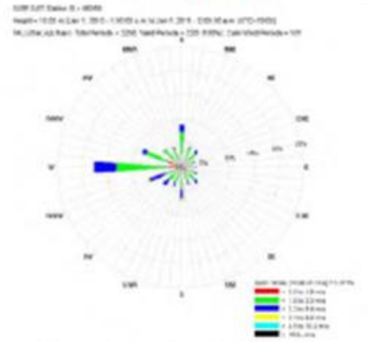
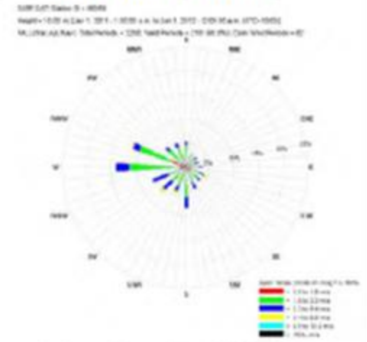
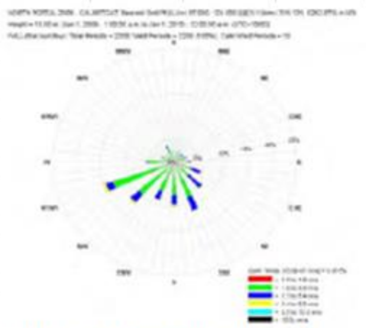
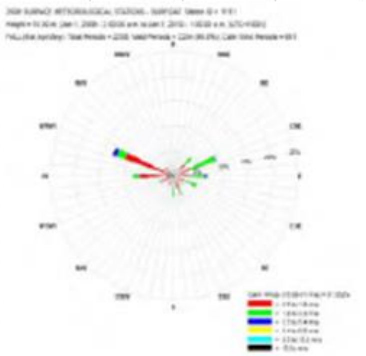
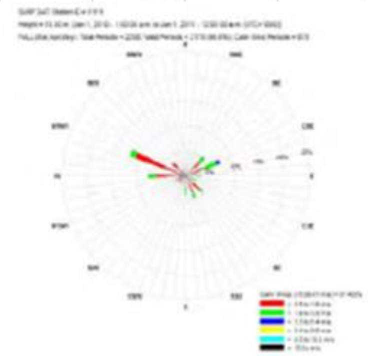
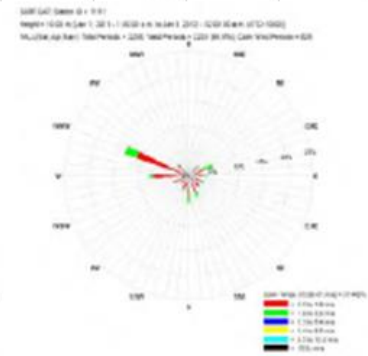
- Autumn – actual and forecast
- Winter – actual and forecast
- Spring – actual and forecast
- Summer– actual and forecast

- Morning (7am-11am)l – actual and forecast
- Afternoon (12pm-6pm) – actual and forecast
- Evening (7pm-12am) – actual and forecast
- Night (1am-6am) – actual and forecast

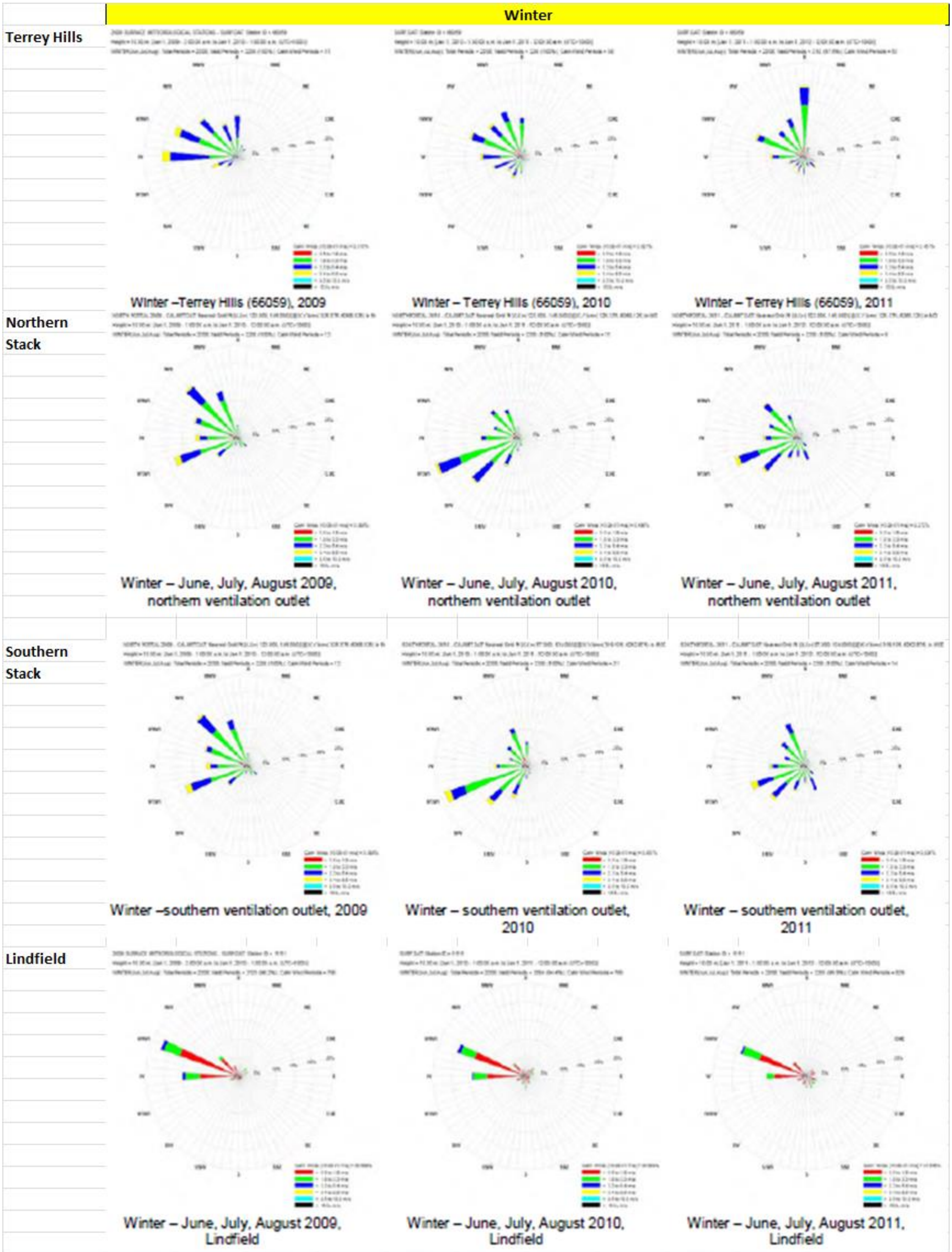
I have grouped the wind roses in a way that allows the forecasts for the northern and southern locations to be easily compared with the actual data from Lindfield and Terrey Hills for the same time frame. Please find the annual and seasonal charts below.



It is clear from the above, the influence of the Lindfield data – the station closest to the proposed location of both the northern and southern stacks - has little impact on CALMET's forecasts which resemble actual data from Terrey Hills which is 11 and 16 km closer to the coast respectively than the proposed locations.

	Autumn		
Terrey Hills	 Autumn – March, April, May 2009, northern ventilation outlet	 Autumn – March, April, May 2010, northern ventilation outlet	 Autumn – March, April, May 2011, northern ventilation outlet
Northern Stack	 Autumn –Terrey Hills (66059), 2009	 Autumn –Terrey Hills (66059), 2010	 Autumn –Terrey Hills (66059), 2011
Southern Stack	 Autumn –southern ventilation outlet, 2009	 Autumn –southern ventilation outlet, 2010	 Autumn –southern ventilation outlet, 2011
Lindfield	 Autumn – March, April, May 2009, Lindfield	 Autumn – March, April, May 2010, Lindfield	 Autumn – March, April, May 2011, Lindfield

It is clear from the above, the influence of the Lindfield data – the station closest to the proposed location of both the northern and southern stacks - has little impact on CALMET's forecasts which resemble actual data from Terrey Hills which is 11 and 16 km closer to the coast respectively than the proposed locations.



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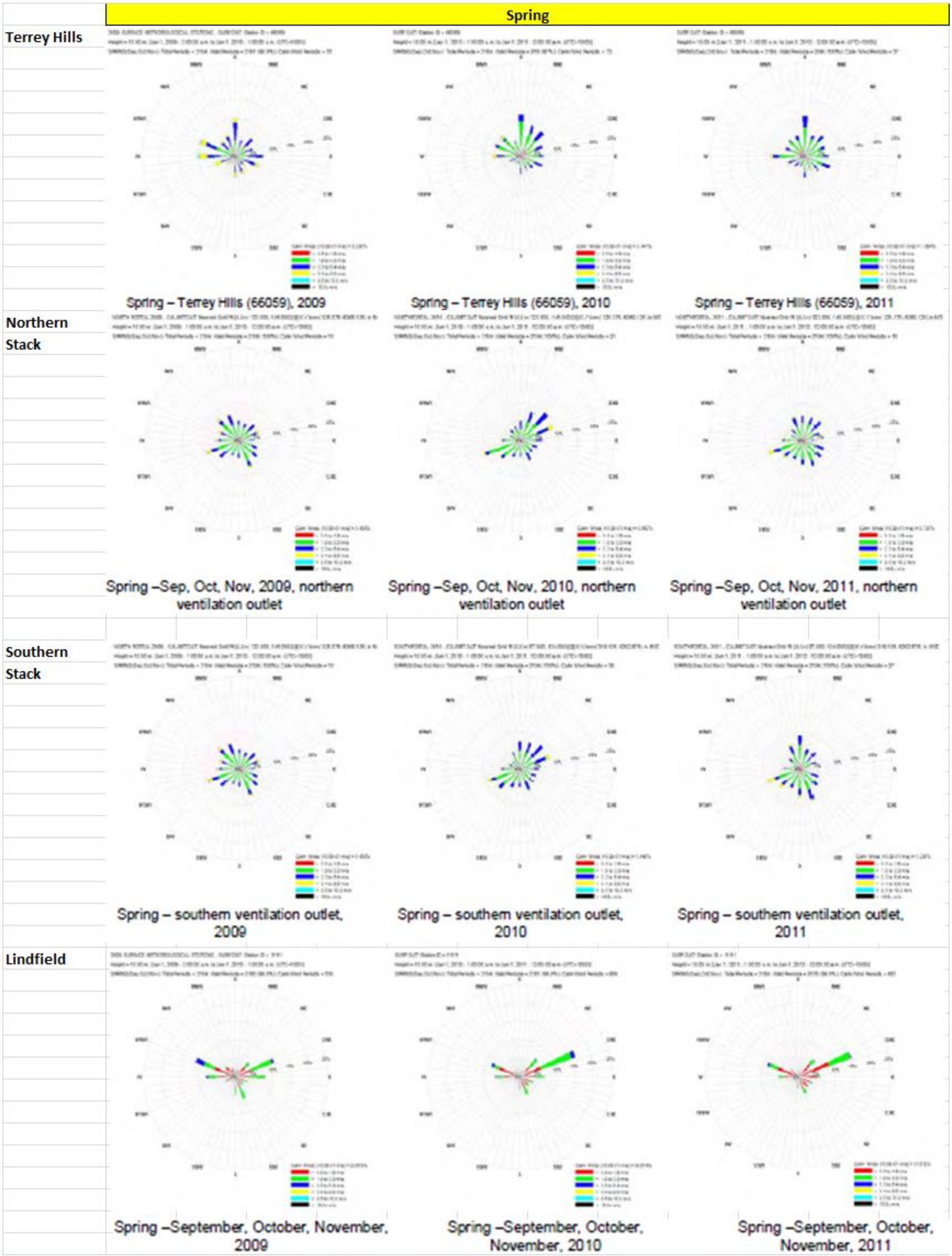

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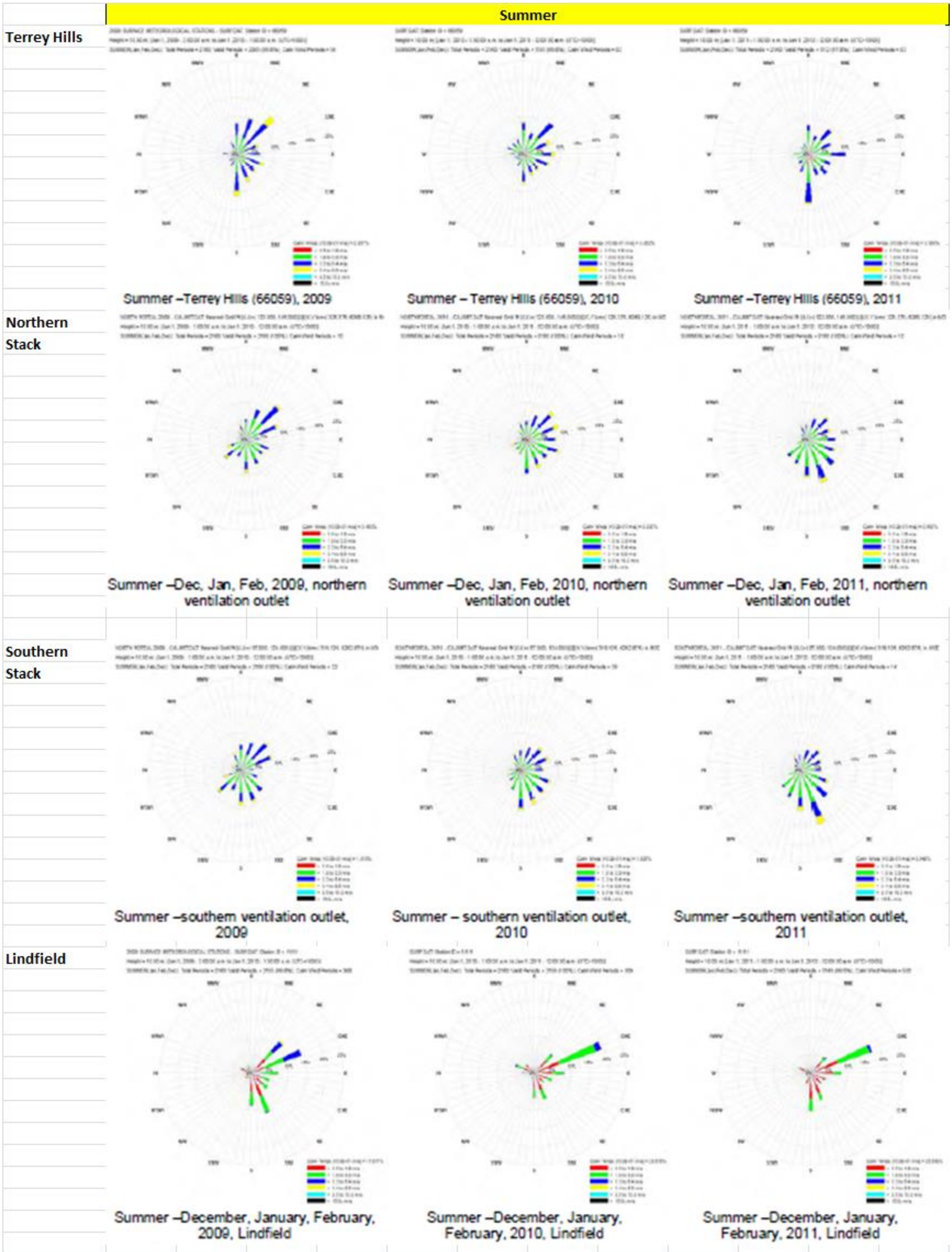


The above charts are extraordinary. Lindfield clearly shows the influence of strong nor-easterly winds in the 2010 and 2011 summers but Terrey Hills – located just 7 km from the coast – does not. That is very strange and worthy of investigation by any professional who wishes to accurately forecast the future.

The remaining wind roses – grouped in the same way to allow easy comparison of actual versus forecast – can be found in Attachment 1.

Conclusion 1: the forecasts by CALMET for the proposed locations of the northern and southern stacks are invalid.

ACTION REQUIRED: NorthConnex must acquire at least 12 months of site-specific data and re-run its meteorological forecasts with real data for each site if the dispersion modelling is to have any validity. It may be that data collected from the stations erected by NorthConnex in December 2013 can contribute useful data, however, in the case of James Park, Hornsby the exposure of the site relative to that of the proposed stack location may make the usefulness of the data questionable.

Meteorology – an alternative approach, ie acquire all available data:
During the last few years owning and operating a private weather station (PWS) has become a popular hobby in many countries. Several groups provide services whereby data from a modern PWS linked to the internet can be uploaded to a website and made available to anyone in the world who wants to look at it. One such network is Weather Underground, part of the Weather Channel (www.wunderground.com). The Weather Underground network has dozens of members in Sydney who upload data continuously.

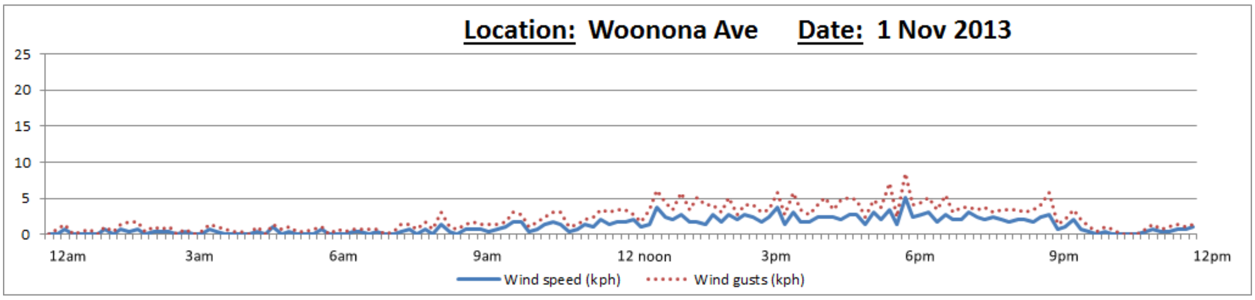
Whilst the type of PWS may vary between locations, there are general rules about locating a station to ensure the data collected represents accurately the actual weather experienced. For example, the PWS should be located 10m above ground level. This is also the requirement for stations which are part of the Bureau of Meteorology's WOW network of private stations.

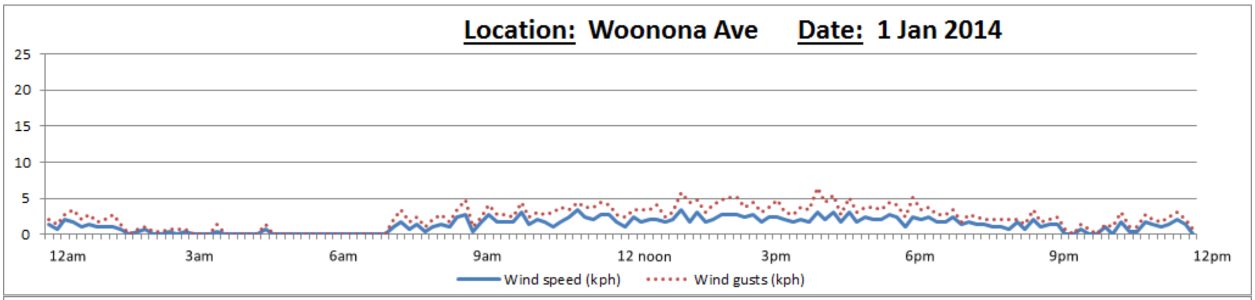
There are a number of PWSs located within 3km of the proposed location of both the northern and southern stacks. I have accessed data from those stations, as well as stations nearer to the ocean and the harbor to identify differences between Wahroonga and West Pennant hills and near coastal locations.

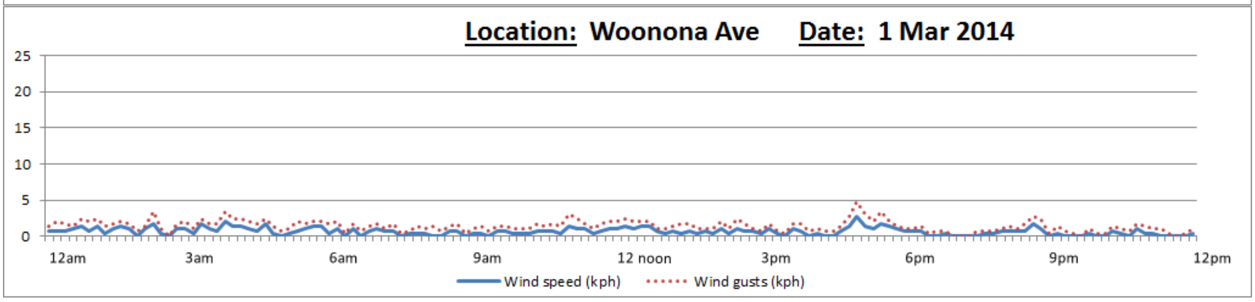
It is acknowledged none of these stations are officially accredited. Further it is acknowledged differences in the technology and sampling frequency used by individual stations exist. For example, some stations sample every 30 minutes, others every 5 or 10 minutes. At the finest resolution, some stations sample every minute making a 24 hour record a considerable size.

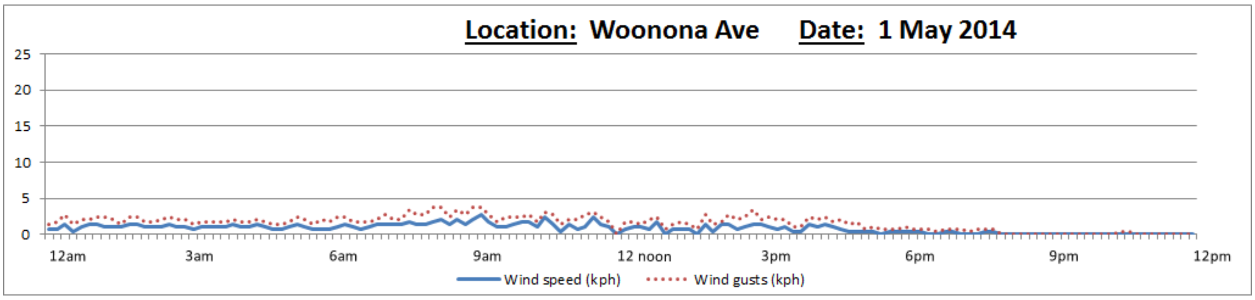
There is a PWS located on the corner of Lochville Street and Woonona North Avenue, Wahroonga approximately 200m from the proposed location of the northern stack. That station is about 10m above the ground and, like the proposed ventilation stack location, in the lee of the topography and vegetation to the west.

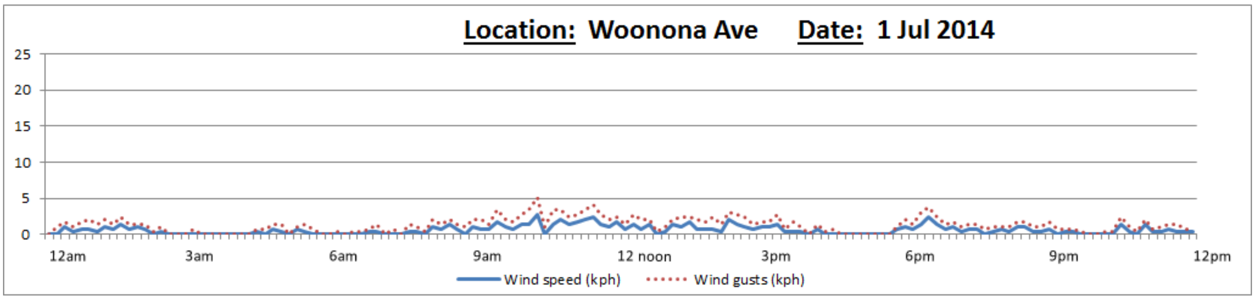
Approximately 3 years of data for this station is available. Six samples – representing all seasons - are presented below:





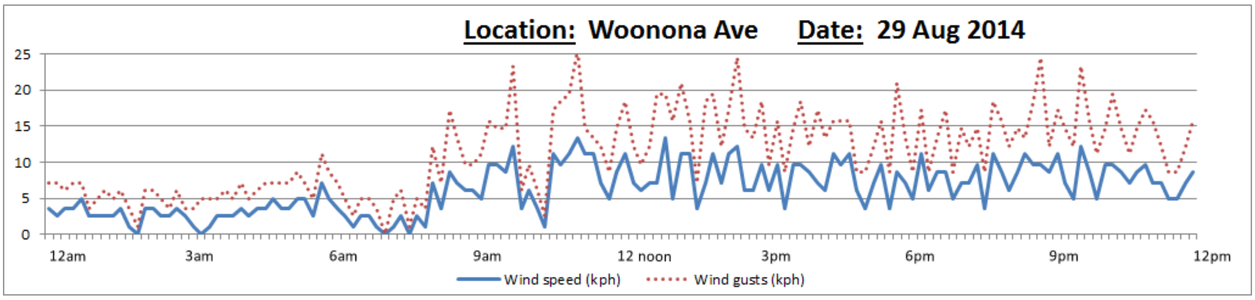






At this stage, the reader may be thinking something along the lines of “This is ridiculous. The PWS is obviously broken.”

The PWS located at the corner of Woonona and Lochville works perfectly, as shown by the following chart:

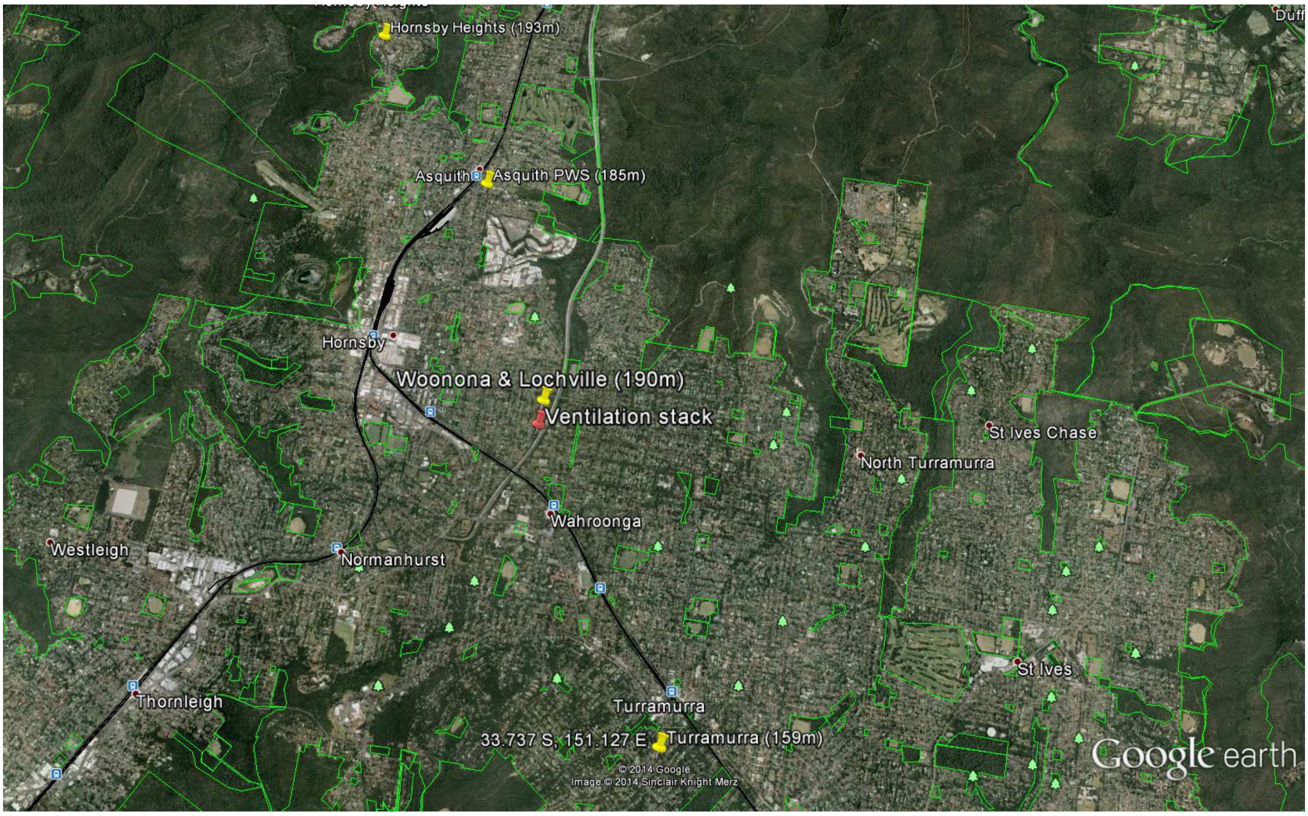


The chart above for 29 August 2014 shows wind gusts up to 25kph. During that week quite a strong weather system moved through NSW. All records for the PWS located at the corner of Lochville and Woonona reflect that weather with wind gust up to 25kph.

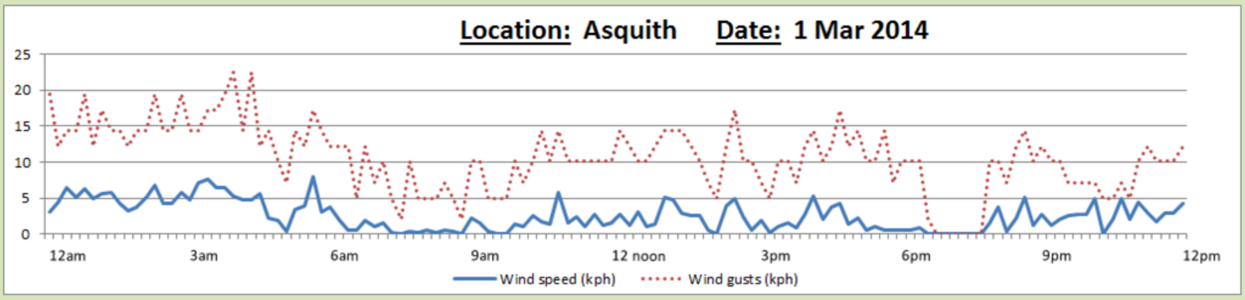
The rest of the time those records confirm our claim "The wind does not blow in Wahroonga." See Attachment 1.

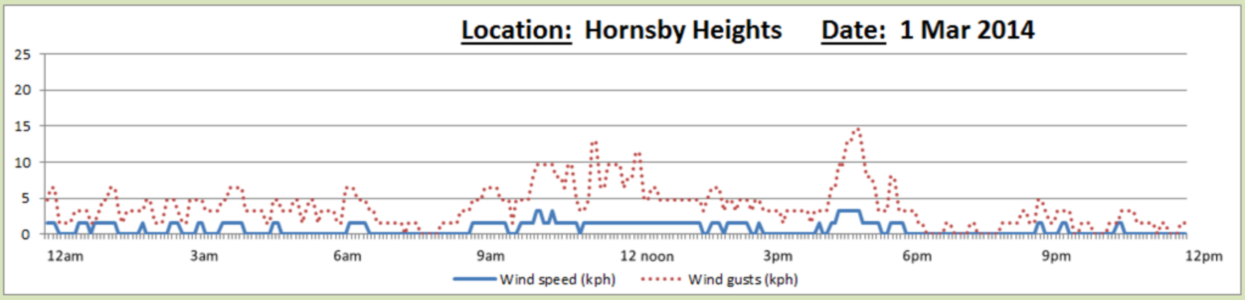
A question which should be asked is how the wind speed varies around the proposed location of each stack. Please find below summaries for both Wahroonga and West Pennant Hills. Two days of records are presented – little wind and strong wind.

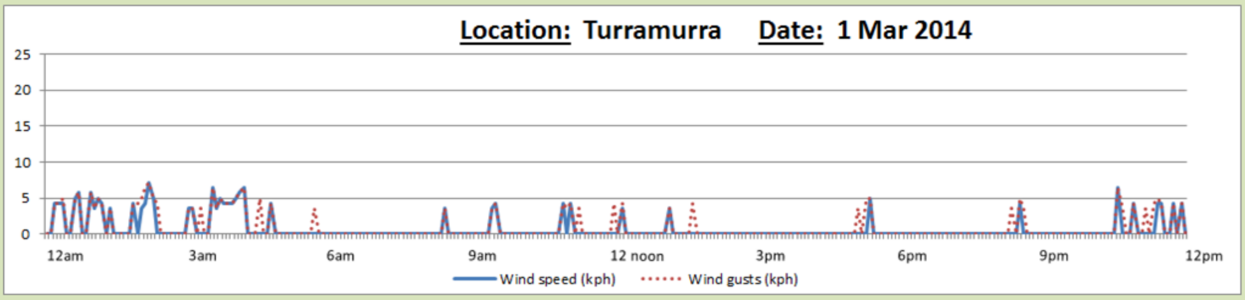
The locations of the stations are shown on the map below:

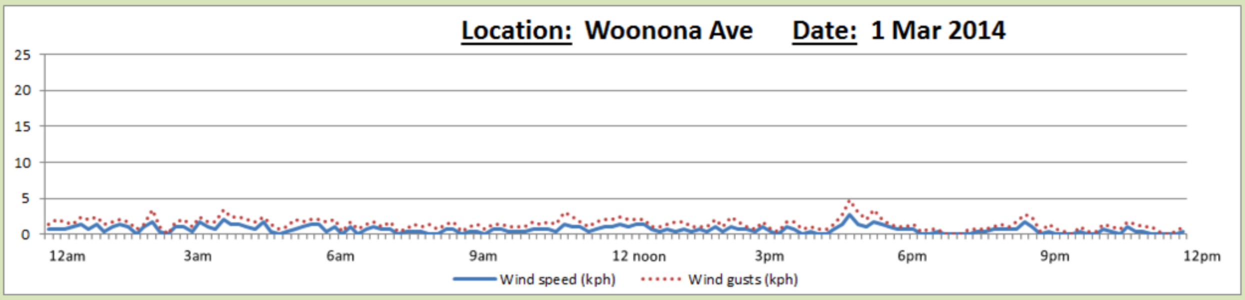


The yellow pin at top is the Hornsby Heights PWS, the pin to the SW of Hornsby Heights is the Asquith PWS. To the SW again is the Woonona & Lochville PWS (200m from the proposed location of the stack). At the bottom of the image is the Turramurra PWS. (There are another 4 stations in the area not shown above.)







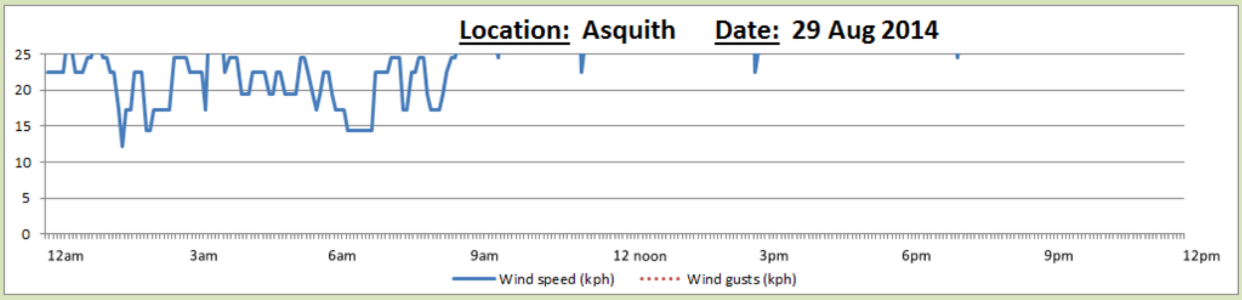


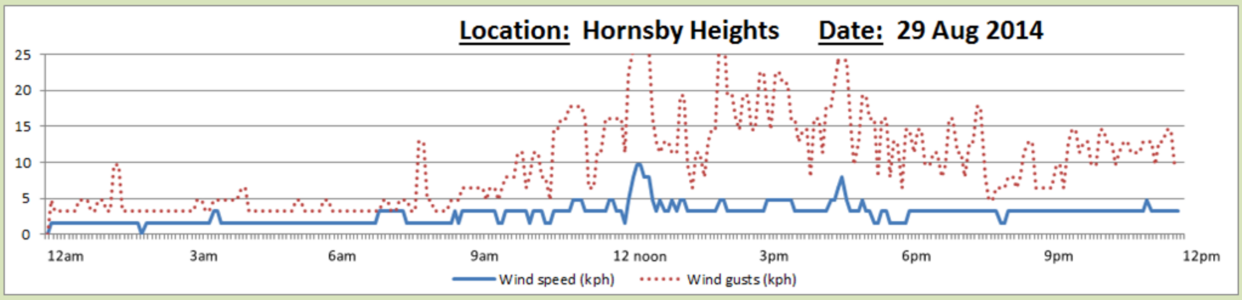
As the charts above show, the Asquith location is windy. This is reflected in all the data collected. Asquith is exposed to the valleys reaching up from the Hawkesbury as well as sitting on top of the plateau. It is particularly influenced by winds from the east, north and north east.

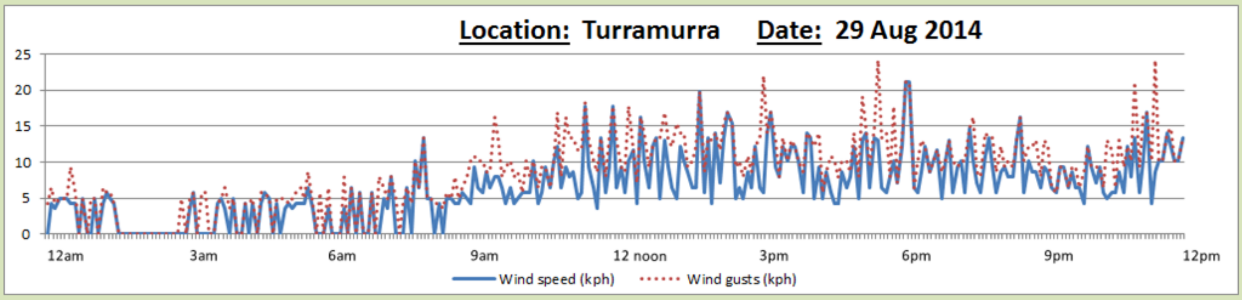
Areas away from the Hawkesbury and the top of the plateau are more sheltered which should have obvious implications for the siting of a ventilation stack.

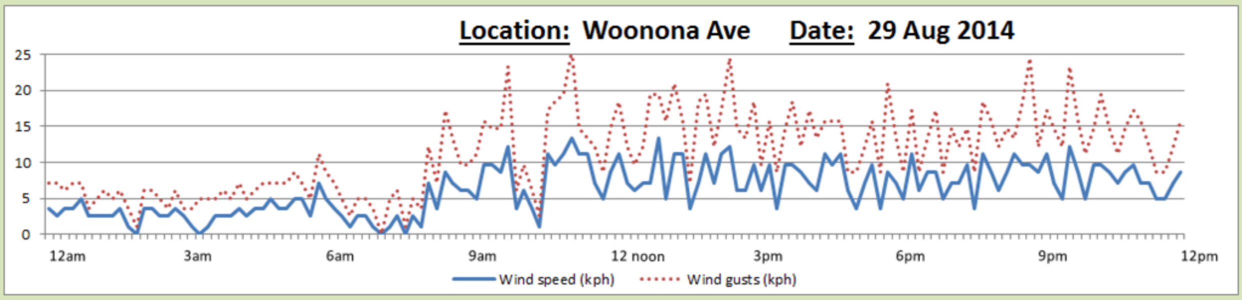
The above charts show there was very little wind during the morning and evening peak hours on 1 March 2014.

Data for each station for different days – which show the same characteristics – can be found in Attachment 3







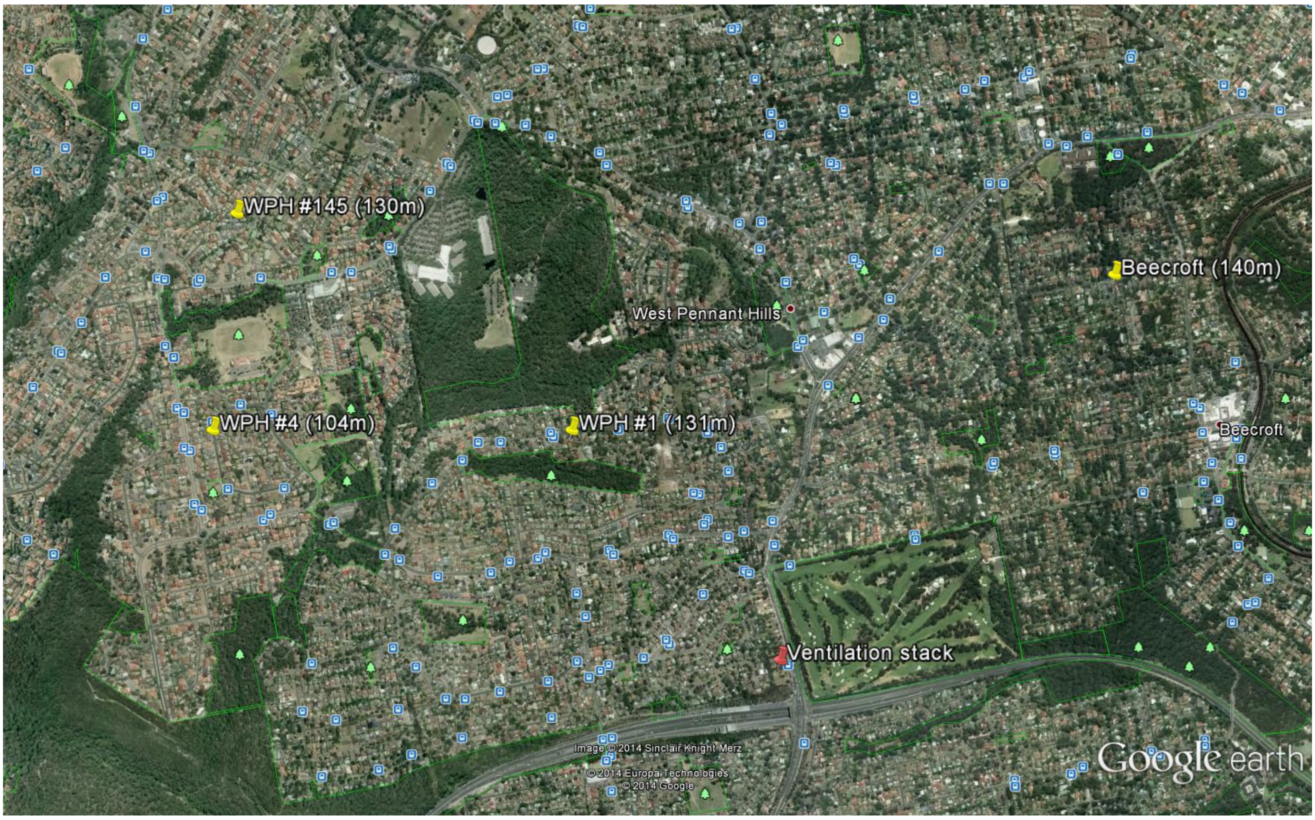


See previous comments about the weather system which passed through the state during the last week of August. All the above stations reacted to the stronger conditions although Asquith was off the fixed scale used for this analysis.

Conclusion 2: the data from all the stations in the area around the proposed location of the northern stack confirms the claim “The wind does not blow in Wahroonga”. With the exception of times when there is a major weather system moving through the state, little wind will be available to disperse emissions from the northern stack – particularly during the morning and evening peak hour periods.

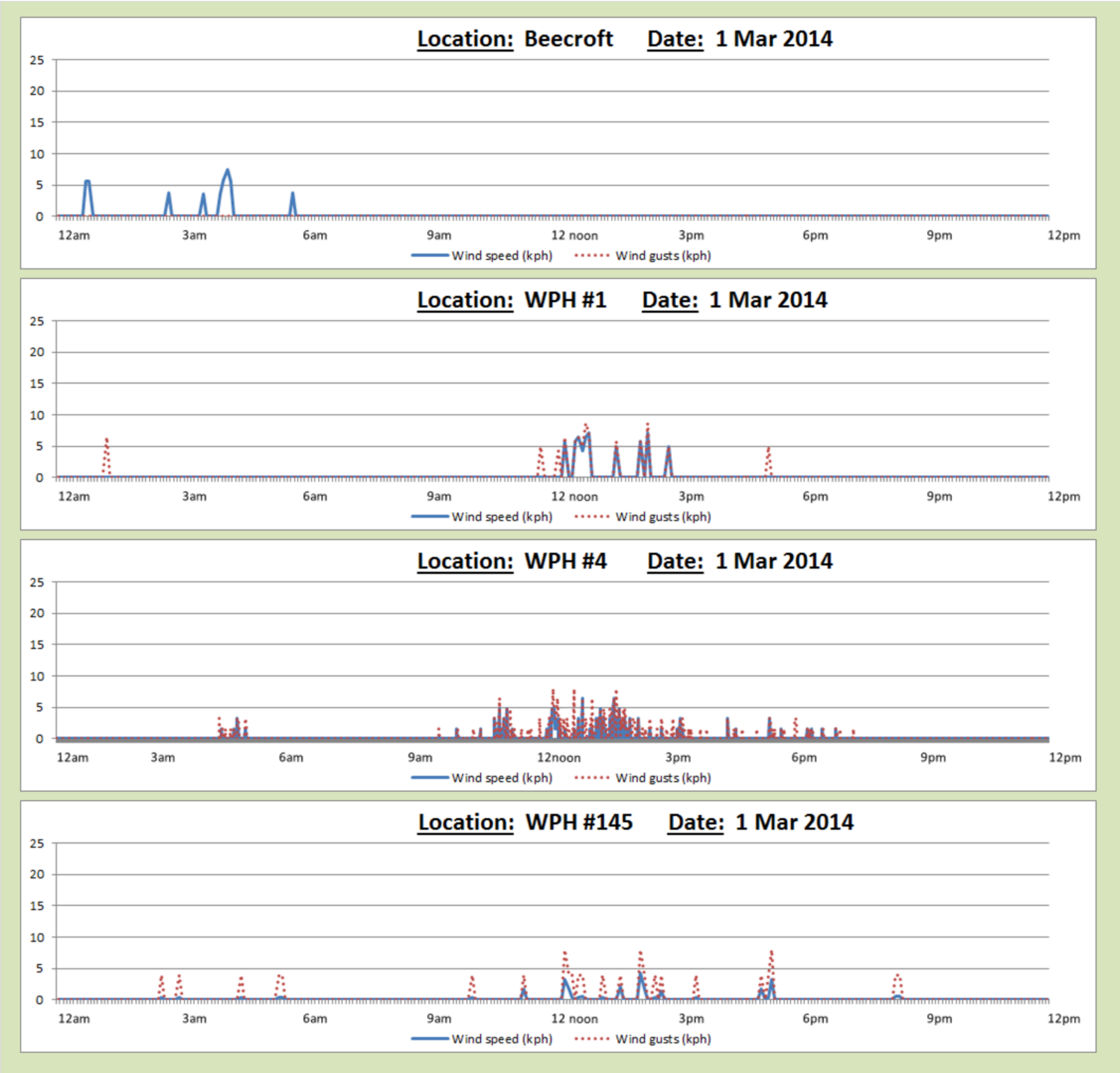
ACTION REQUIRED: NorthConnx must collect site-specific meteorological data and re-run its meteorological forecasts with real data for each site if the dispersion modelling is to have any validity.

The area around the proposed location of the southern stack shows a similar pattern to the northern stack.

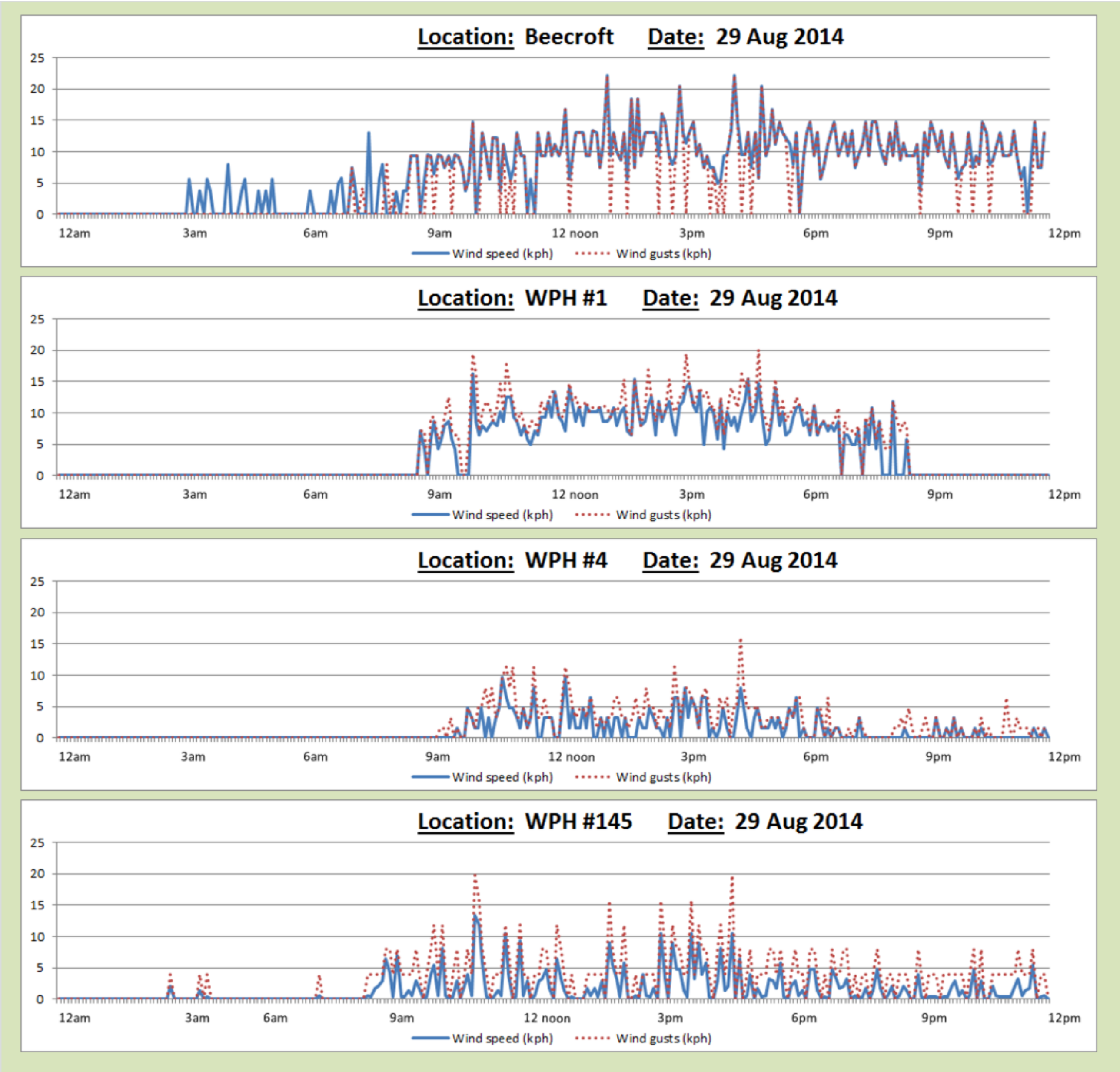


The Beecroft PWS is shown by the yellow pin in the east of the above image. The WPH #1 station is located in the middle of the image and WPH #4 and WPH #145 are in the west of the image. The proposed location for the southern stack is marked by an orange pin in the centre bottom of the image.

In addition to the four stations noted above we have data for two other stations in the area.



The charts above show 1 March 2014 to be a day with virtually no wind at any of the stations monitored.



As shown by the data collected from stations near the proposed location for the northern stack, 29 August 2014 was a windy day all over Sydney. The above charts reflect the weather experienced but tellingly they show little activity in the morning peak hour.

Data for each station for different days – which show the same characteristics – can be found in Attachment 4.

Conclusion 3: the data from all the stations in the area around the proposed location of the southern stack shows that on average there is little wind .With the exception of times when there is a major weather system moving through the state, little wind will be available to disperse emissions from the northern stack – particularly during the morning and evening peak hour periods.

Let's return to Dr Kuschel for a moment. Dr Kuschel – NorthConnex's independent air quality expert – said:

"However, if you look at a situation for poor dispersion, and this can happen if you've got a built up, (you know) canyon in an urban environment between buildings, or you've got a topography with valleys, or it's a very calm situation, then for the same amount of emissions the box is much smaller because the emissions can't disperse as freely, so that's the concept around dispersion."

Conclusion 4: based on common sense and freely available PWS data, it appears it will not be possible to adequately disperse the pollution which comes from both the proposed northern and southern locations as currently configured.

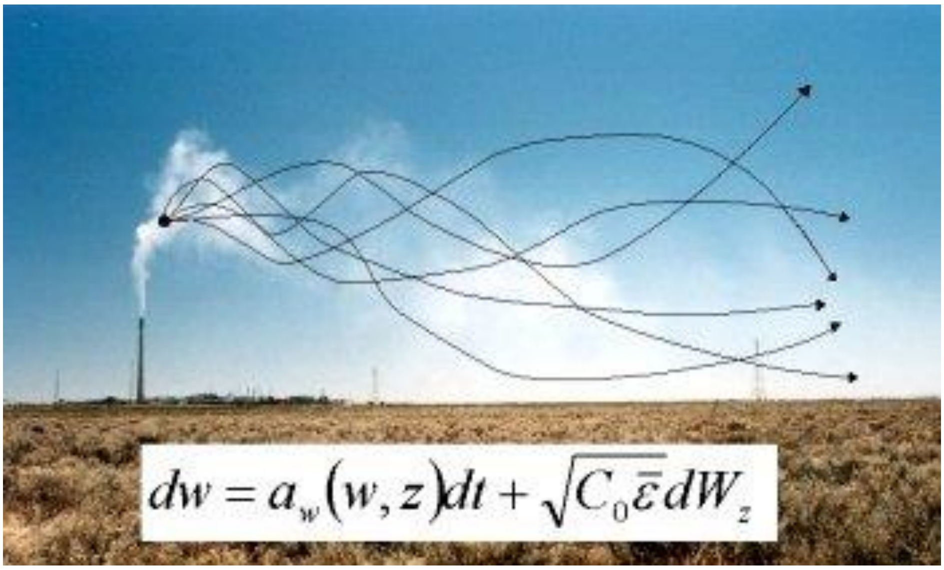
ACTION REQUIRED: NorthConnex must collect site-specific meteorological data and re-run its meteorological forecasts with real data for each site if the dispersion modelling is to have any validity.

Meteorological data for all PWS locations reviewed can be found in Attachments 5-18.

Plume behavior – the CSIRO's meandering plume model

The CSIRO's plume behaviour papers can be found here: http://www.cmar.csiro.au/airquality/

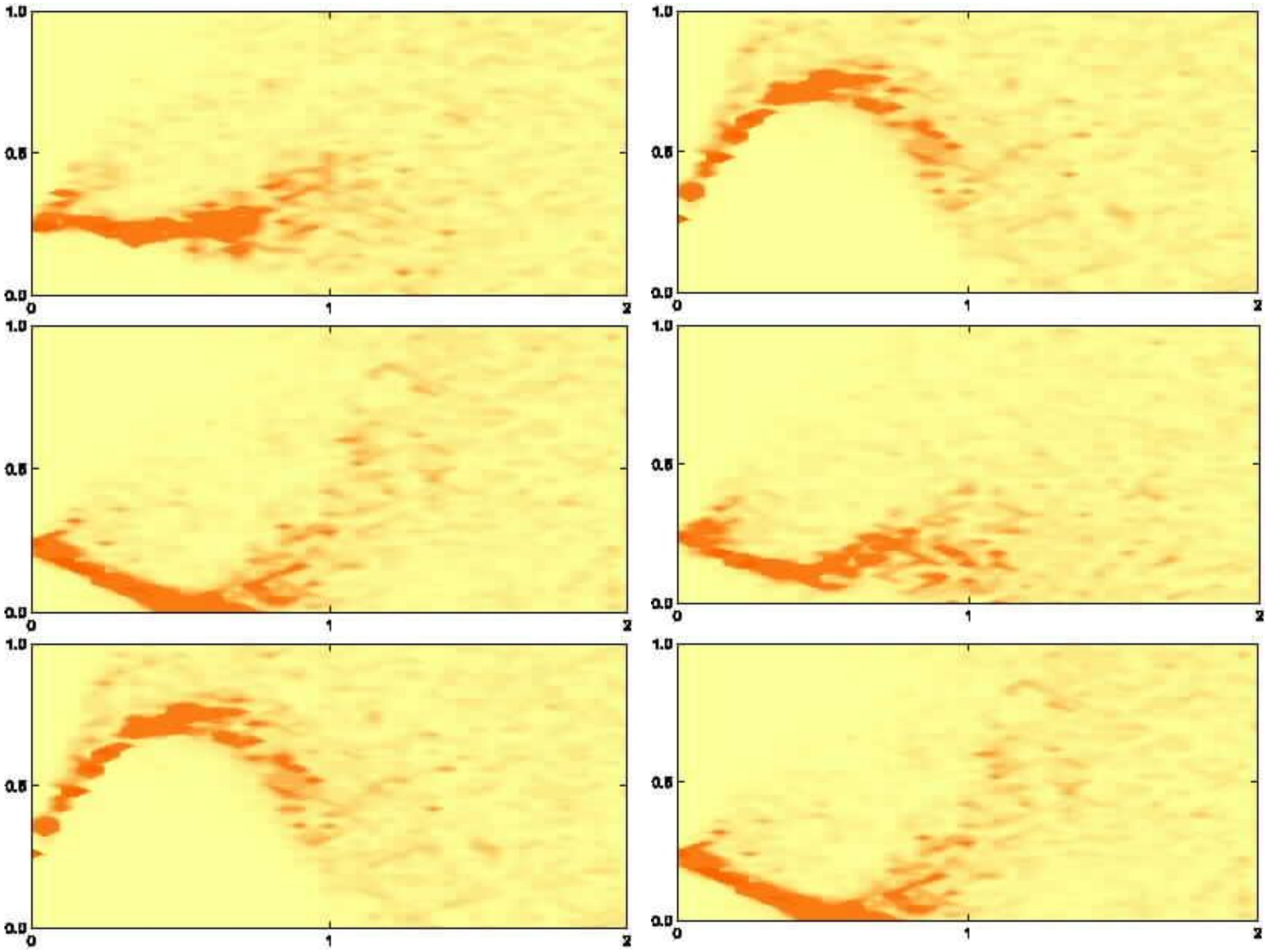
The diagram below has been seen many times before. Nevertheless, it remains informative.



Perhaps the plume behavior of most concern to the populations which live and work within 3km of the proposed locations of the northern and southern stacks is that of meandering plumes. Information can be found here: http://www.cmar.csiro.au/airquality/meander/index.html.

In summary, under certain conditions, highly concentrated plumes of pollutants will hit the ground (a plume strike). A time lapse effect captured from the CSIRO website is presented below.

The order is left to right then down and left to right:



In the above diagrams the figure 1.0 represents the height of the convective boundary layer which might be 1,000m above the land surface. The plume emanates from a stack 0.25 high, ie one quarter of the height of the convective boundary layer. If the convective boundary layer is 1,000m, the stack height is 250m. Even with that height, there is plume strike at about 500m downwind of the stack.

I communicated by email with the CSIRO chap who looks after this simulation model. I asked about the impact on plume strike if the height of the stack was just 25m. He suggested the incidence of plume strike would be increased because the stack height relative to the convective boundary layer was reduced.

Conclusion 5: it appears under certain conditions areas around the proposed locations of the northern and southern stack will be subject to plume strike. The consequences of a highly toxic plume hitting a location occupied by any segment of the population could be disastrous.

ACTION REQUIRED: NorthConnex must run simulations – based on site-specific meteorological data – which predict the frequency, severity and likely location of plume strikes from the proposed locations of the ventilation stacks. The simulations must take into consideration the topography, vegetation, likely wind direction and wind speed at each proposed location.

Plume behavior – CSIRO's ground level concentrations model

The CSIRO also provides a model which calculates the ground level concentrations of pollutants emitted from a stack in strongly convective daytime conditions. The maximum concentration and how it changes with distance downwind is shown in the plot.

The model (found here http://www.cmar.csiro.au/airquality/convmix/index.html) generates interesting results which shows that when wind velocity is low the level of dispersion of a plume after it leaves a stack is very low for a substantial distance.

This suggests the concentration of pollutants in a plume which strikes the ground could be close to the concentration of those pollutants in the stack, ie before ejection.

The combination of high concentrations of pollutions and propensity for plume strike show by the CSIRO models suggests an action plan be implemented whereby people within the zone potentially impacted know what to do on days when meteorological conditions conspire to make the probability of a plume strike significant.

ACTION REQUIRED: if the NorthConnex goes ahead as proposed by the EIS, the population at risk of a plume strike must be advised. Duty of care laws would seem to demand it.

Scene 1: it's morning peak hour, children are playing in a school's grounds prior to classes commencing. The school is located 400m from one of the stacks. There is a gentle breeze – too little to adequately disperse the plume but just enough to generate conditions ideal for plume strike – blowing the stack's emissions directly towards the school.

Should the children be called inside and the windows and doors sealed? Should the school be closed? Should the school have anticipated the adverse conditions and told parents to keep their children at home that day?

Scene 2: it's early afternoon. A park is full of mothers, babies and toddlers – as it is 7 days a week. The park is located 500m from one of the stacks. There is a gentle breeze – too little to adequately disperse the plume but just enough to generate conditions ideal for plume strike – blowing the stack's emissions directly towards the park.

Should the Council responsible for that park put up warning signs whenever the wind blows from the stack towards the park? How will the park's users know they are at risk? Should the Council sound a siren and clear the park?

What about a golf course, or a shopping precinct, or a sports complex, or just a pleasant residential neighbourhood where people walk in the mornings and evenings?

From a public health perspective, it seems reasonable that when conditions are potentially dangerous, people must be told they are exposing themselves and their children so they can make informed decisions as to what actions to take.

In-tunnel pollution levels

Piston effect

The piston effect in the tunnel proposed by NorthConnex will be minimal. By their own admission, NorthConnex has made the tunnel large in terms of width and height.

Trains in tunnels demonstrate the piston effect. Stand on a platform at Town Hall station and you will feel the air rush out of the tunnel as a train approaches. Piston effect is all about the size of the "piston" relative to the "cylinder" in which that piston travels, ie the cross-sectional areas of piston versus cylinder.

The table below shows a typical Sydney train in a typical Sydney tunnel occupies about 57% of the tunnel. Compare that with one car in the M5 East tunnel (6%) and NorthConnex (4%). Two cars running side by side changes the impact marginally.

	Tunnel:		Train	M5 East	NorthConnex
	Height	m	6.50	6.00	6.00
x	Width	m	3.63	8.60	14.00
=	Cross-sectional area	m2	23.60	51.60	84.00
	Cars:				
	Height	m	4.41	1.50	1.50
x	Width	m	3.03	2.00	2.00
=	Cross-sectional area	m2	13.36	3.00	3.00
x	Number	#	1	1	1
=	Total	m2	13.36	3.00	3.00
=>	Percentage occupied	%	57%	6%	4%
x	Number	#		2	2
=	Total	m2		6.00	6.00
=>	Percentage occupied	%		**12%**	**7%**
x	Number	#			3
=	Total	m2			9.00
=>	Percentage occupied	%			**11%**
	Trucks:				
	Height	m		4.30	4.30
x	Width	m		2.50	2.50
=	Cross-sectional area	m2		10.75	10.75
x	Number	#		1	1
=	Total	m2		10.75	10.75
=>	Percentage occupied	%		**21%**	**13%**
x	Number	#		2	2
=	Total	m2		21.50	21.50
=>	Percentage occupied	%		42%	26%
x	Number	#			3
=	Total	m2			32.25
=>	Percentage occupied	%			**38%**

The table above shows for a two lane operation in NorthConnex, the cross-sectional area occupied by two B-doubles would be just 26%. By contrast, the much maligned M5 East tunnel is much more efficient at 42%.

Even with a 3 lane operation, NorthConnex will not be as efficient as the M5 East (38% versus 42%).

So a tunnel ventilation system which relies on the piston effect is going to struggle simply because the piston is too small.

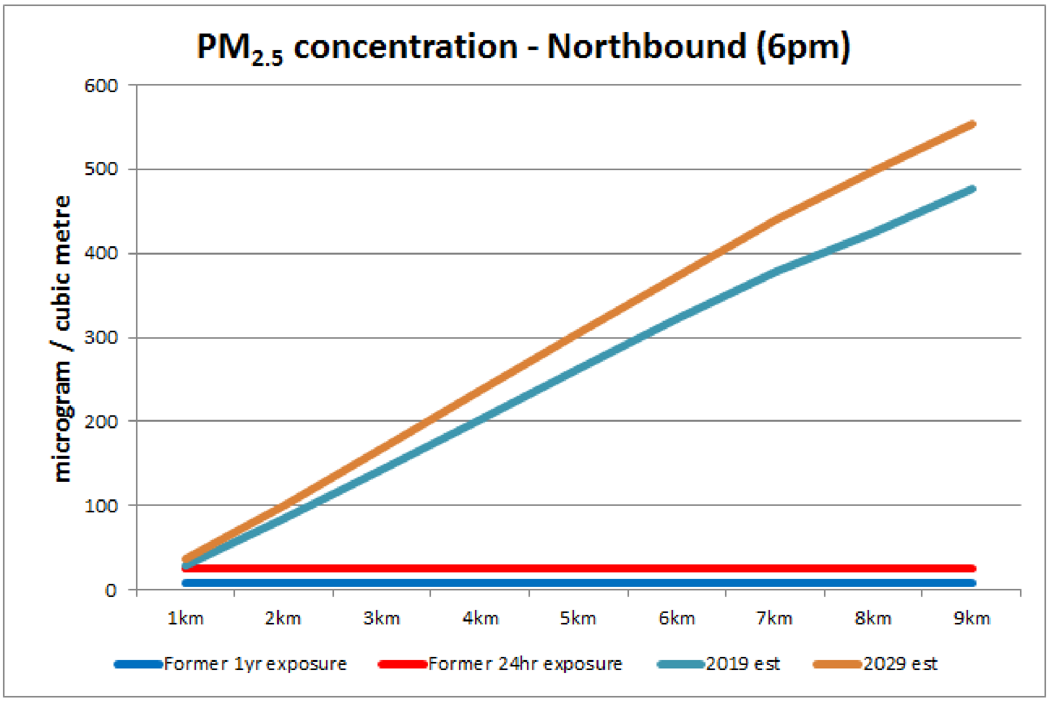
Further, cars are slippery. There are several reasons fuel economy has improved in recent years: better fuels, more efficient engines and much improved aerodynamics. Slippery cars do not drag their emissions with them in a low pressure zone behind them.

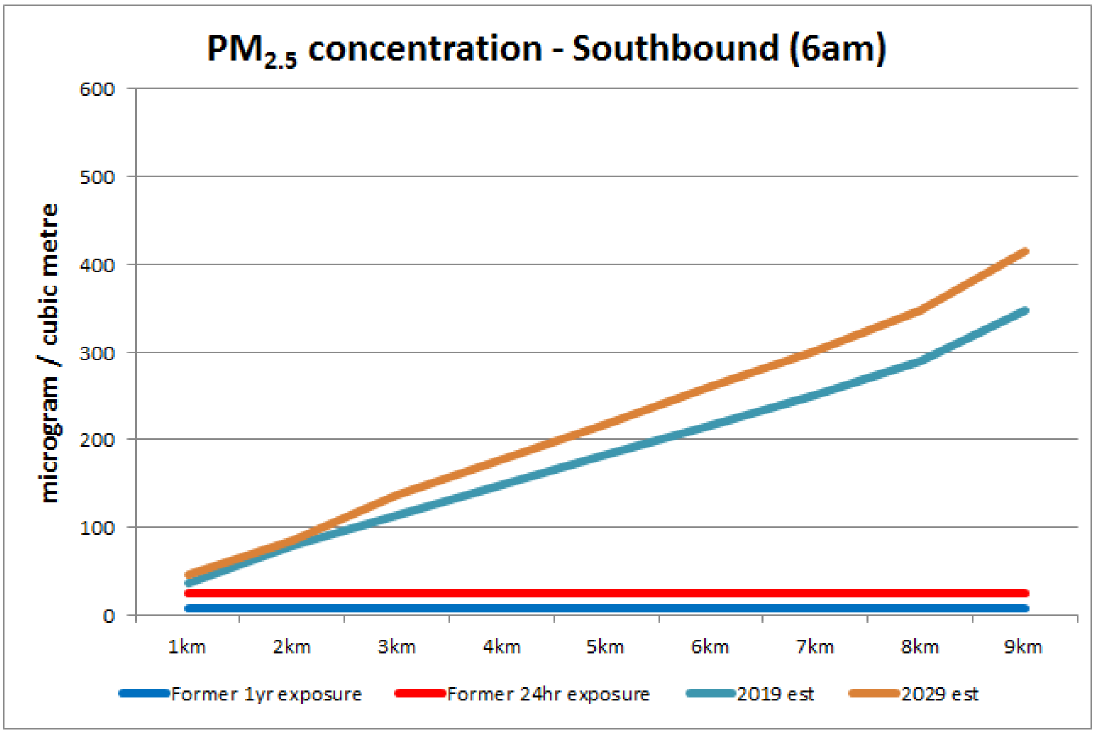
Increasingly articulated trucks are adopting aerodynamically improved shapes to reduce drag. Studies in the US suggest a truck without available skirts and deflectors can use 10% more fuel than a truck with such devices. Fleet managers are acutely conscious of fuel economy so we can expect to see drag mitigation initiatives increasingly used in Australia. Reduction in drag means reduction in piston effect.

So a tunnel ventilation system which relies on the piston effect is going to struggle because cars are slippery and trucks will become increasingly so – even if the cross-sectional are occupied by vehicles is significant.

Conclusion 5: emissions are likely to travel not at the speed of the traffic in normal conditions, but at the speed of the mass of air in the tunnel driven only by the ceiling fans.

Therefore, it is unlikely the estimates of pollution concentrations presented in the EIS (and shown by the charts below) are correct.





ACTION REQUIRED: NorthConnex should recalculate the in-tunnel levels of pollution taking into account the velocity of the air moving the emissions through the tunnel assuming fans alone are effective.

<u>Vehicle mix</u>
The EIS provides estimates of tunnel usage by hour in each direction for 2019 and 2029.

The EIS also says that the mix of vehicles assumed is based on the ABS 2013 motor vehicle census combined with PIARC 2012 Australia-specific emission factor database. An extract from a recent ABS report is presented below. (See: http://www.abs.gov.au/ausstats/abs@.nsf/mf/9309.0)

It shows the proportions of different types of heavy vehicles (trucks and buses) using Australia's roads in 2013.

	2009		2013		2014		Annual
Category	#	%	#	%	#	%	growth
Light rigid trucks	110,763	19%	131,147	20%	135,658	21%	4.3%
Heavy rigid trucks	310,939	53%	325,998	51%	329,464	50%	1.2%
Articulated trucks	81,217	14%	90,904	14%	93,853	14%	3.0%
Buses	84,413	14%	93,034	15%	94,131	14%	2.3%
Total	**587,332**	**100%**	**641,083**	**100%**	**653,106**	**100%**	

The weight of a truck assumed by the 2012 PIARC report is 23 tonnes. It would appear the in-tunnel pollution estimates calculated by NorthConnex rely on the above mix of heavy vehicles and an average weight of 23 tonnes. If this is correct, the level of pollution emitted by the trucks passing north and south through the tunnel has been dramatically understated.

Numerous personal observations of trucks and buses using the F3 resulted in the following estimates:

Buses	0%
Non-articulated (3 & 5 tonnes)	5%
Articulated (single trailer)	50%
Articulated (B-double)	45%
All heavy vehicles	100%

As the F3 will be the main approach road for the proposed tunnel it seems reasonable to assume the above describes the mix of heavy vehicles which will use the tunnel.

Further, it is reasonable that all trucks heading north will be fully loaded, given the only way to make money as a truck owner is to run fully loaded as close 100% of the time as possible. If typical loaded vehicle weights are assumed for the above mix (eg GVM x 90%), the average weight of trucks heading northbound in the tunnel is 44 tonnes, almost double the average weight of 23 tonnes assumed in the PIARC report.

An email discussion with Professor Peter Sturm, one of the authors of the PIARC paper, revealed emissions will increase faster than vehicle weight. So a doubling of the average vehicle weight will result in more than double the emissions.

Conclusion 6: the EIS has understated, probably by a significant amount, the emissions from the truck fleet which will travel both north and south. It may well be that the correct level of PM2.5 at the 9km mark is closer to 1,000µg/m3.

ACTION REQUIRED: NorthConnex must establish the precise mix of heavy vehicles likely to use the tunnel. Advice from a traffic expert suggested the only way to generate an accurate forecast would be personal observations. Once relevant data has been obtained, NorthConnex must recalculate the emissions from the truck fleet and represent the in-tunnel emissions inventory.

The solution to pollution is dilution

We have demonstrated:

A. the meteorology developed by NorthConnex using CALMET for the areas around both the prosed northern and southern locations is invalid because it fails to use site-specific data; and
B. the in-tunnel levels of pollution are likely to be considerably higher than those suggested by NorthConnex in the EIS because of the minor impact of piston effect and the use of lower than actual truck emissions.

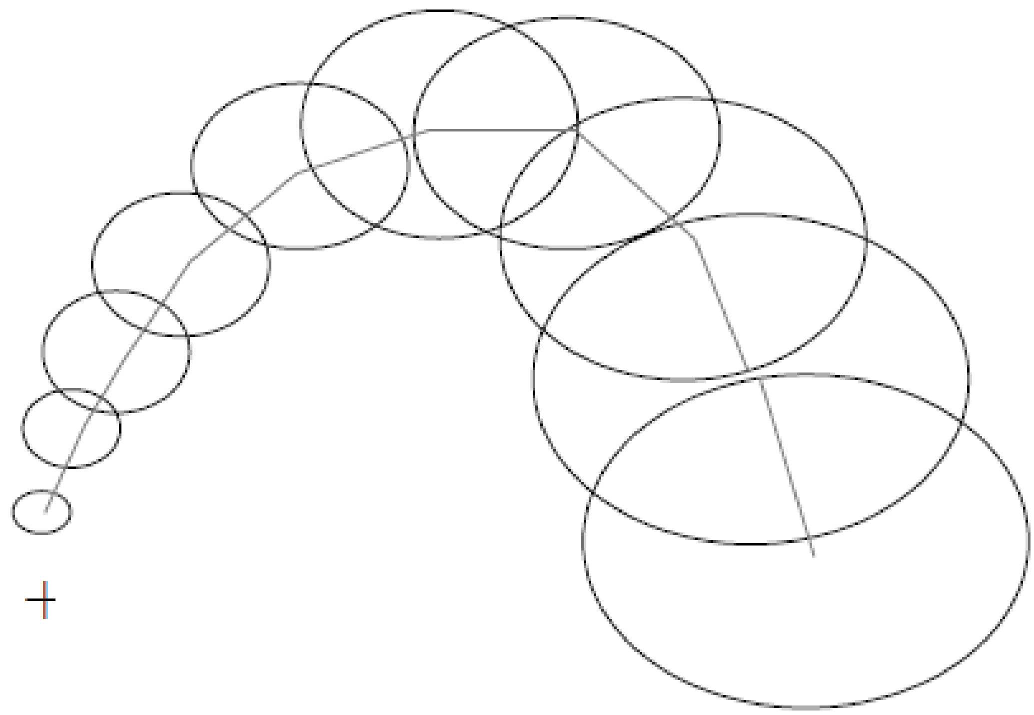
Other submissions will undoubtedly address the health impacts of the pollutants blown up the stack. The ultra-fine particulates raise the most concern. Unfortunately, there is no way to measure the concentrations of these particles. The fact they are recorded under the heading to PM2.5 provides scant comfort because they are not measured in the normal course of tunnel operations.

The message from medical people is there is no minimum dose of PM2.5 and the smaller particulate matter. Any exposure to the material will produce an adverse reaction at some point in time.

In various forums, NorthConnex has used words to the effect of “We know this stuff is bad, that’s why we blow it up the stack and far, far away.” In other words, the solution to pollution is dilution.
Given what is in the tunnel will be what is blown out of the stack, how will the concentration of the pollution in the stack be diluted so that NorthConnex can claim it will be harmless at ground level? I could find no answers in the EIS.

According Gerda Kuschel’s presentation to the forum at the Hornsby RSL, dilution of 100 to 1,000xs will occur. Dr Kuschel did not explain how that would happen but presumably the process relies on the following model:

Figure 2.3: Graphical representation of the puff modelling approach



+ Release point

Source: http://www.mfe.govt.nz/publications/air/atmospheric-dispersion-modelling-jun04/

As shown by the CSIRO simulation discussed earlier, plumes do not necessarily behave like the above – particularly in the near field environment.

The following photos show excellent examples of plumes maintaining almost original level of contaminants until they intersect land or buildings:

Three stable plumes with scarcely any dilution enroute to an encounter with a distant receptor.

The photo on the right is a great example of the impact of buildings on stack dispersion. The residents of the building shown here are affected (exposure from opened windows or air intakes on the building's roof), but some of the nearby neighbors and businesses are in an even more concentrated "cavity recirculation zone" as the pollution washes over the buildings.

This may well be the situation in Wahroonga when a gentle easterly breeze pushes a collapsing plume over two-storey homes near the stack.

The photo on the left demonstrates the impact of a temperature inversion – such as occurs in the Wahroonga area quite regularly.

Source of all photos and text above: http://blog.odotech.com/?Tag=stack+dispersion.

In the above examples, there is little evidence of dilution of the level of contaminants in the plume from the stack. Translate that to the proposed northern and southern stacks and it is possible that plumes containing the maximum levels shown below:

Table 7-101 Calculated in-tunnel air quality – main alignment tunnels during peak hours

Pollutant	Pollutant concentrations (mg/m^3) (peak hour) Approximate distance along main alignment tunnels 1 km	2 km	3 km	4 km	5 km	6 km	7 km	8 km	9 km
Southbound main alignment tunnel at 9 am (2019)									
CO	0.331	0.772	1.06	1.34	1.62	1.90	2.17	2.58	3.45
NO_2*	0.039	0.098	0.124	0.144	0.165	0.186	0.206	0.250	0.374
PM_{10}	0.039	0.084	0.122	0.158	0.193	0.229	0.265	0.307	0.377
$PM_{2.5}$	0.037	0.080	0.115	0.149	0.183	0.217	0.251	0.290	0.347
PAH	0.000006	0.00002	0.00002	0.00003	0.00003	0.00004	0.00004	0.00005	0.00006
VOC	0.033	0.079	0.109	0.136	0.164	0.192	0.219	0.260	0.346
Southbound main alignment tunnel at 9 am (2029)									
CO	0.411	0.956	1.32	1.67	2.01	2.35	2.70	3.20	4.29
NO_2*	0.043	0.108	0.136	0.159	0.182	0.204	0.277	0.276	0.411
PM_{10}	0.047	0.101	0.145	0.189	0.232	0.275	0.319	0.369	0.439
$PM_{2.5}$	0.046	0.095	0.137	0.178	0.219	0.260	0.301	0.348	0.414
PAH	0.000007	0.00002	0.00003	0.00003	0.00003	0.00004	0.00005	0.00005	0.00007
VOC	0.040	0.094	0.129	0.162	0.195	0.228	0.262	0.310	0.413
Northbound main alignment tunnel at 6 pm (2019)									
CO	0.156	0.911	1.76	2.62	3.47	4.32	5.12	5.59	6.26
NO_2*	0.005	0.110	0.231	0.352	0.473	0.594	0.707	0.771	0.860
PM_{10}	0.032	0.090	0.153	0.215	0.278	0.340	0.401	0.450	0.504
$PM_{2.5}$	0.030	0.085	0.144	0.203	0.263	0.322	0.379	0.425	0.477
PAH	0.000002	0.00002	0.00003	0.00005	0.00006	0.00008	0.00009	0.00010	0.0010
VOC	0.014	0.089	0.173	0.258	0.342	0.427	0.506	0.554	0.620
Northbound main alignment tunnel at 6 pm (2029)									
CO	0.195	1.13	2.19	3.25	4.31	5.37	6.35	6.94	7.76
NO_2*	0.005	0.119	0.250	0.381	0.512	0.643	0.765	0.834	0.932
PM_{10}	0.039	0.106	0.178	0.250	0.323	0.395	0.464	0.521	0.585
$PM_{2.5}$	0.037	0.100	0.169	0.237	0.305	0.373	0.439	0.497	0.553
PAH	0.000002	0.00002	0.00003	0.00005	0.00007	0.00008	0.00010	0.00011	0.00012
VOC	0.017	0.106	0.207	0.308	0.408	0.509	0.603	0.661	0.739

*Note: NO_2 has been assumed to be 10% of total nitrogen oxides, consistent with PIARC (2012)

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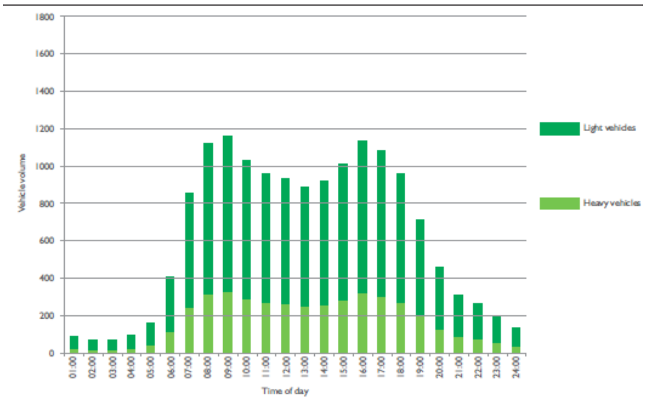
It is worth remembering:

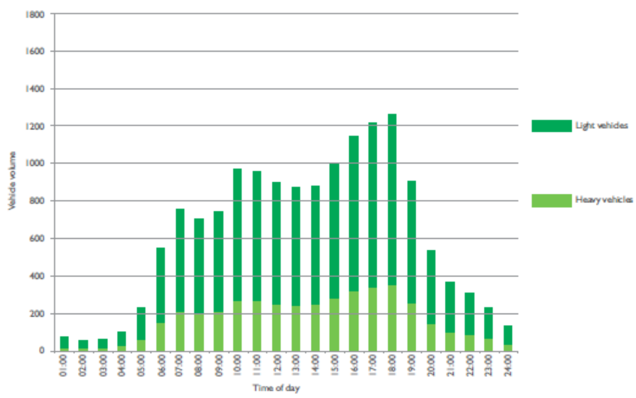
(a) the level of pollutants shown in the above table are likely to be understated; and

(b) during the morning and evening peak hours there is likely to be little to no wind at either end of the proposed tunnel.

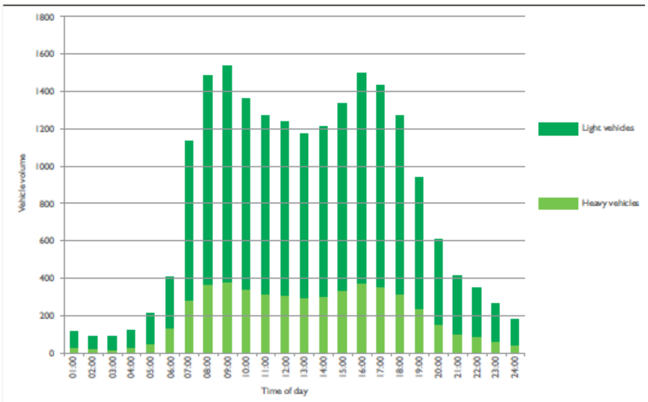
Speaking of peak hours, the traffic forecasts in the EIS suggest "peak hour" is a relative term. The "peaks" are comparatively minor spikes above the average vehicle numbers from



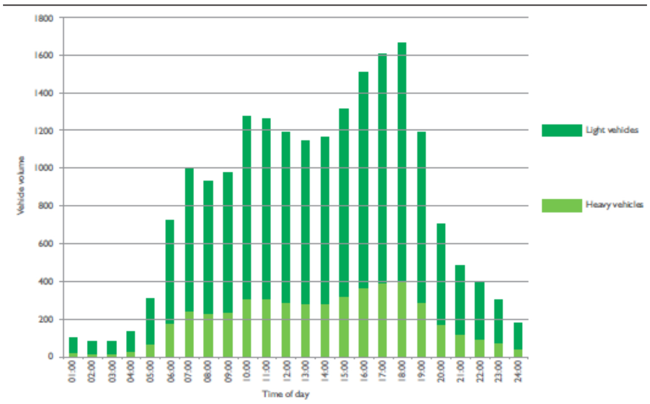
2019 - southbound



2019 - northbound



2029 - southbound

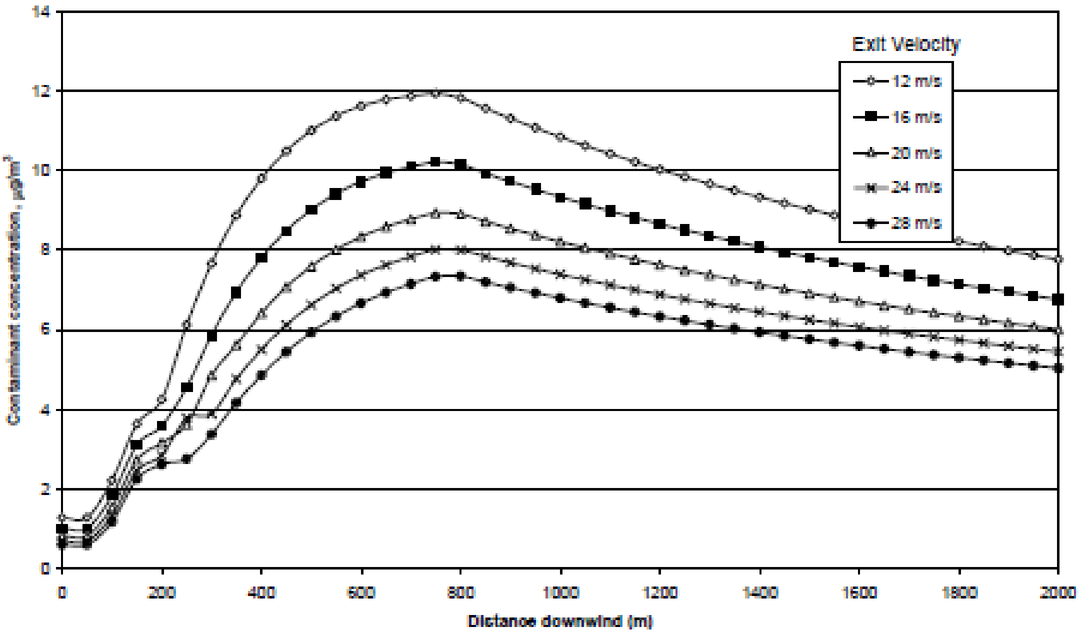


2029 - northbound

Therefore, high levels of pollutants will be ejected from the stack for more than 12 hours per day. I other words, dangerous conditions around the stack will not be confined to peak hour periods. This has enormous consequences for schools.

Finally, this chart must be considered:

Figure 4.2: Example of the effect of exit velocity on dispersion (stack height = 30m)



Source: http://www.mfe.govt.nz/publications/air/atmospheric-dispersion-modelling-jun04/).

The chart shows that down wind of a stack the concentration of a plume barely changes as distance from the stack increases. This supports the evidence of the photos on page 28: once ejected from the stack, the plume will not be magically diluted 100 to 1,000 xs simply because NorthConnex says it will.

Buoyancy effect

NorthConnex states in the EIS that the "buoyancy effect" of the material emitted from the stack will ensure it is carried far downwind. Buoyancy effect is a function of the difference between the temperature of the material ejected from the stack compared to the temperature of the air into which it is ejected. Hot air rises, etc.

NorthConnex states in the EIS that data from the Lane Cove tunnel was used to determine the temperature differential between “tunnel air” and the atmosphere. However, no data appears to have been provided.

A paper by Knibbs, DeDear and Mengersen, Kerrie and Morawska (2009) found the temperature differences between the M5 East tunnel and the atmosphere were 2-4ºC. NorthConnex will be a much larger, longer, deeper and wetter tunnel than the M5 East tunnel. Its ambient temperature at depth will reflect that of the rock surrounding it, ie 16-18ºC. Further, air passing over the wet surfaces will cool quickly as the damp surface will act as a gigantic heat exchanger. It is reasonable to assume that air in the NorthConnex tunnel will emerge from the stack at the temperature of the rock with which it has contact and is surrounded, ie 16-18ºC. Any heat from exhausts will be quickly lost to the mass of air in the tunnel.

Therefore, it is likely that for only brief periods during winter will the temperature of the emissions exceed that of the atmosphere. Therefore, buoyancy effect will be negligible and more likely to be negative than positive.

Conclusion 7: the NorthConnex dispersion model assumes the emissions from the stack are diluted by some factor. It appears from the evidence that dilution of plumes should not be automatically assumed and that on many occasions plumes hardly dilute at all.

ACTION REQUIRED: NorthConnex must explain the methodology and assumptions used to calculate the contaminant concentrations in the plume at specific distances downwind of the stack.

<u>The use of averages</u>
The EIS relies on the use of averages to demonstrate the proposed project has no detrimental impact on air quality around the proposed locations of the northern and southern stacks.

If bridges across rivers were designed only to withstand average flow rates, they would be washed away in the first flood.

If buildings in San Francisco were designed for the average tectonic environment they would not be able to weather an earthquake of the smallest magnitude.

If oil and gas platforms in the Gulf of Mexico were designed for average weather conditions, the first major hurricane would wipe them out.

Averages tell you nothing. Responsible planning takes into consideration the inevitable extreme event. In the case of the proposed tunnel, extreme events will be days when the meteorological conditions conspire with road traffic conditions to produce an undiluted toxic cloud which drops on to a primary school, a park full of babies and toddlers, an outdoor café or a golf club.

ACTION REQUIRED: NorthConnex must demonstrate there will be no extreme events which will jeopardise the health of the populations around the proposed locations of each stack. The population cannot be exposed to even a 1% probability that a plume containing levels of pollutants considered dangerous by the medical profession may strike a sensitive receptor.

Alternatives to the current proposal

This submission addresses only air quality considerations. As a result, only alternatives which will positively impact air quality are proposed:

1. Install filtration. I cannot be bothered to even comment on NorthConnex's ridiculous argument "Filtration does not represent value for money". I am confident at some point that statement will be tested at law;

2. Build a 100m high stack at each end of the tunnel to ensure the pollutants from the tunnel are truly "blown away". The CSIRO will be able to advise exactly how high the stack should be to minimize the risk of plume strike on sensitive receptors (eg schools).

   (It is worth noting emissions from the Sydney Harbour Tunnel are ejected from the northern pylon of the Sydney Harbour Bridge at a height of 89m above ground level. The northern pylon is located on the edge of the harbor where the juxtaposition of land and water ensure almost continual air movement. If an 89m stack was required for the Sydney Harbour Tunnel, a 100m stack (or more) is required for NorthConnex which will not enjoy the meteorological advantages of the Sydney Harbour Tunnel's location.);

3. Locate the stacks away from sensitive receptors (eg schools). In the case of the stack for the northern end of the tunnel, locate the stack in the Hornsby industrial area and make certain the stack is high enough (eg 50m in that location should suffice) to ensure efficient dispersion.

4. Locate the portals for the northern end of the tunnel adjacent to the Hornsby industrial area and the stack in the Hornsby industrial area. (No tunnel in Sydney has ventilation stacks over its portals.)

5. Dilute the in-tunnel air by injecting fresh air at the tunnel's mid way point. It is inevitable that in-tunnel air quality will be shown to be much worse than suggested by the EIS when the calculations are performed correctly. To mitigate the build-up to unacceptable levels, fresh air should be continually injected into the tunnel.

Final comment

If the ventilation system proposed for NorthConnex is so damned good why hasn't it been retro-fitted to the M5 East tunnel?

The EIS assures us the emissions collected inside the NorthConnex tunnel will be "blown away" safely and the areas around the stacks will suffer no ill-effect whatsoever. Therefore, surely, the proposed ventilation system would be perfect to solve the M5 East's problems.

All that is required is for a stack to be built on top of each exit portal and the collection system which vents through the Turella stack shut down. The length of the M5 East tunnel at 3.8km will not cause a build-up of in-tunnel emissions to anything like the levels forecast for NorthConnex.

Given NorthConnex's assurances the proposed ventilation system is world class, why hasn't the government applied it as a solution to the M5 East tunnel's myriad problems?

Graeme Foley
11 September 2014

Private weather stations – data sources

Coastal North:

Beacon Hill	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT344
Mona Vale	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT200
Davidson	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT134
Davidson192	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT192

Coastal South:

Caringbah Sth	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWCARI2
Cronulla	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWSYDN19
Kogarah	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT179
Lilli Pilli	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT125
Matraville	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWMATR2

Near Harbour:

Chatswood	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWSYDN21
Chatswood	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWCHAT1
East Sydney	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT349
Lane Cove	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT83
Lindfield	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT329

Upper North Shore:

Asquith	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWASQU2
Hornsby	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWHORN6
Hornsby Heights	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT309
Thornleigh	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT151
Turramurra	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWTURR3
Turramurra Sth	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWTURR1
Wahroonga	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT355

M2 Area:

Beecroft	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWBEEC1
Marsfield	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT247
Telopea	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT126
West Pennant Hills 1	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWWEST1
West Pennant Hills 4	http://www.wunderground.com/personal-weather-station/dashboard?ID=INSWWEST4
West Pennant Hills 145	http://www.wunderground.com/personal-weather-station/dashboard?ID=INEWSOUT145

I wish to acknowledge the assistance provided by Weather Underground and the owners of some of the weather stations referred to in the analysis.

Attachments

1 Wind rose ecords (EIS)
2 Woonona summary data
3 Wahroonga area summary data
4 West Pennant Hills summary data
5 Asquith private weather station data
6 Beecroft private weather station data
7 Chatswood private weather station data
8 Davidson private weather station data
9 Hornsby private weather station data
10 Hornsby Heights private weather station data
11 Lane Cove private weather station data
12 Lindfield private weather station data
13 Mona Vale private weather station data
14 Turramurra private weather station data
15 Woonona private weather station data
16 WPH #1 private weather station data
17 WPH #4 private weather station data
18 WPH #145 private weather station data