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Port Augusta
CITY COUNCIL

SUBMISSION TO SENATE STANDING COMMITTEES ON COMMUNITY AFFAIRS

Re: The Impacts on Health of Air Quality in Australia

BACKGROUND

The Port Augusta City Council contains the City of Port Augusta with a population of 14000. It is located at the top of Spencer Gulf in South Australia and is within the arid zone of the State. It is in essence a frontier town on the edge of settled areas and on the edge of the desert. The mainstays of the City's economy were the Commonwealth Railways and the brown coal fired power stations established by the South Australian Government. The privatisation of both of these enterprises in the 1980's had a dramatic economic impact on the City, but the community has shown true grit and the City is now established as a service centre for the Far North region of South Australia and a must-stay-place on the grey nomad circuit around Australia.

The brown coal fired power stations are located just 2kms south of the City. The prevailing winds come from that direction and accordingly any outfall from the furnace chimney stacks, any coal dust created when stockpiles are accessed and coal trains unloaded, and any fly ash (a residue of the furnace process) are blown directly over the town and subsequently breathed in by the residents.

Campaigns led by Mayor Joy Baluch AM in the 1970's led to electrostatic precipitators being installed on the chimney stacks however there is still concern that the range of outfalls from the brown coal fired power stations impact the health of our community.

KEY CONCERNS

Cancer Rates

In early 2010 Council raised its concerns regarding what it considered were unusually high numbers of cancer deaths being experienced within the community and sought clarification from the Minister for Health as to whether this anecdotal evidence could be supported by fact. The Minister's letter (**Appendix 1**) indicted that cancer rate in Port Augusta was consistent with the rates in the State…

"except for lung cancer, where the number of cases was double the expected number. This finding, which is statistically unexpected, could result from a combination of many factors, including, most importantly, smoking history".

This response from the Minister raised more questions than it answered and Council accordingly wrote to the Registrar SA Cancer Registry (**Appendix 2**) to seek confirmation that the double lung cancer rate could be attributed to a slightly higher than state average smoking history amongst residents.

A delayed response was subsequently received from the Chief Executive of SA Health (**Appendix 3**) that admitted that "combustion-related fine particulate matter-soot emitted by cars and trucks, brown coal fired power plants and factories-is a known risk factor for lung cancer".

However the summary to that letter still pointed to smoking as the main risk factor. The letter from the Chief Executive of SA Health stated:

"In summary, it is known that more than 80% of lung cancers are due to tobacco smoking. Although combustion related fine particulate matter may contribute to the development of lung cancer, in most cases where this occurs, it would relate to exposures several decades prior to diagnosis."

He continues to state:

"It is important for the City Council of Port Augusta (sic) to make sure that the air quality in Port Augusta is optimal and that local industry conforms to EPA standards".

It is pertinent to point out that earlier in the letter the Chief Executive had stated:

"Although the Environmental Protection Authority (EPA) does not currently monitor ambient air quality in Port Augusta, they license major industry in Port Augusta, and in this licensing requires brown coal fired power stations to undertake air quality monitoring, which is regulated and audited by the EPA".

Standard of Air Monitoring

As confirmed by the Chief Executive of SA Health, the monitoring of the outfalls from the power station are not carried out independently by the Environmental Protection Authority but are organised by the power station operator. Council is not expert in regard to these matters but has been provided with a report from Doctors for the Environment Australia (**Appendix 4**) that analyses the current testing regime and highlights concern at the….

"excessively high exposure in the community in Port Augusta to PM_{10}".

Health of the Community

The Doctors for the Environment Australia have also provided Council with a report on the health of residents of Port Augusta (**Appendix 5**).

This report raises concern in regard to the level of respiratory illness in pre-school children and lung cancer. A key aspect of their report is that it highlights a **lack of attention being given to understanding why there is such a high level of such illnesses in the city**.

In view of the attention being given by the State Government to addressing high lead levels in children in Port Pirie as a result of outfall from the lead smelter in that town, it is disappointing that the same level of concern is not being given to the high level of illnesses in Port Augusta that may be exacerbated by outfall from the brown coal fired power stations. It would seem that being able to put the blame for these illnesses on smoking or car and truck fumes avoids the impact on the community's health of the brown coal fired power stations being more acutely studied.

Health of the Environment

The impact of the power station outfall on the environment should also be understood as this environmental impact is likely to have an impact on the mental health and wellbeing of affected communities.

A paper published in Science magazine Vol 287 10 March 2000 (**Appendix 6**) highlights the impact that outfall from the power stations has on retarding rain fall in the areas over which the outfall covers. The article states –

“Direct evidence demonstrates that urban and industrial air pollution can completely shut off precipitation from clouds that have temperatures at their tops of about -10 degrees centigrade over large areas. Satellite data reveal plumes of reduced cloud particle size and suppressed participation originating from industrial facilities such as power plants.”

The article addresses the specific impact of the Port Augusta Power Stations.

This impact of air pollution from the Port Augusta Power Stations on the rainfall in the Far North and Flinders Ranges region is likely to impact the productiveness of the land for grazing and add to the trials and tribulations and mental health and wellbeing of those hardy souls trying to make a living from this harsh land.

RECOMMENDATIONS

1. **Improve practices to reduce the amount of outfall from brown coal fired power stations.**

2. **Retire the brown coal fired process and replace with solar thermal.**

3. **Require testing to be undertaken independently by the Environmental Protection Authority.**

4. **Improve the testing and analysis of power station outfalls to gain a fuller picture of what is really occurring.**

5. **Undertake serious research focussed on tracking the impact of outfall from the power stations on the health of the community.**

6. **Undertake serious research focussed on tracking the impact of outfall from the power stations on the health of the environment.**

GREG PERKIN
CITY MANAGER
04/02/2013

APPENDIX 1

1734
160/81

Hon John Hill MP

2009MHE-04859

Government of South Australia

Minister for Health
Minister for the Southern Suburbs
Minister Assisting the Premier in the Arts

Level 9
11 Hindmarsh Square
Adelaide SA 5000
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Mr Greg Perkin
City Manager
Port Augusta City Council
PO Box 1704
PORT AUGUSTA SA 5700

Dear Mr ~~Perkin~~ Greg,

Thank you for your letter of 18 December requesting information on the incidence of cancer in Port Augusta.

I asked the staff responsible for the South Australian Cancer Registry within the Department of Health to investigate this matter and, in particular, to report on the number of Port Augusta residents that have been diagnosed with various types of cancer, and to provide a comparison of the incidence rate in Port Augusta, for all cancer types combined, with that elsewhere in South Australia. I am advised as follows:

> *While every case of cancer is deeply concerning, the overall cancer rate for residents of Port Augusta is consistent with the rate for the State as a whole, with the rate for the Adelaide metropolitan area, and with the rates for other South Australian regional cities.*
>
> *Because cancer risk so clearly increases with a person's age, comparisons of Port Augusta to other areas of the State were all done after adjustment for any differences in age distribution. The rate of new cancer diagnosis in Port Augusta was the same as that in Mount Gambier (ratio 1.00), slightly less than that in Whyalla (ratio 0.89), very slightly more than that in Adelaide metro (ratio 1.03), and very slightly more than that in the rest of South Australia (ratio 1.03). None of the differences noted were statistically significant.*
>
> *The table below shows the number of diagnosed cases of common types of cancer in Port Augusta during the three-year period from January 2005 to December 2007. A three-year period is preferred for such analyses, as counts for a single year are subject to too much random variation. More recent data held by the SA Cancer Registry have not yet been finalised. Where fewer than five cases apply to a given category of cancer, the policy of the Registry is not to specify the exact number, in order to avoid inadvertently identifying individual people.*

Newly Diagnosed Cases of Common Cancer Types - Port Augusta
(January 2005 - December 2007)

Cancer Sites	*n*
Lung	*36*
Prostate	*29*
Colon	*28*
Breast	*17*
Melanoma	*15*
Leukaemia	*10*
Non- Hodgkin's lymphoma	*7*
Bladder	*5*
Rectum	*7*
Stomach	*<5*
Uterine	*<5*
Total	*155*

The number of cases of each cancer type that occurred in Port Augusta in this period was close to the number expected from State averages, except for lung cancer, where the number of cases was double the expected number. This finding, which is statistically unexpected, could result from a combination of many factors, including, most importantly, smoking history.

Available data suggest that, in past periods, a greater proportion of Port Augusta residents smoked than was true of South Australian residents generally. Reflecting, for example, on the period 1990-2003, 32.6 per cent of Port August residents aged 15 years or older reported being smokers, while the figure for the state generally was 25.7 per cent.

The number of cases of diagnosed colon cancer, at about one and one-half times the expected number, was also elevated in Port Augusta, while the number of female breast cancer cases was lower than expected, at only 64 per cent of the number that would be expected from State averages. Observed differences like these, of borderline statistical significance, commonly arise when the data of small populations are subjected to multiple comparisons.

Thank you for raising this matter and I trust this information will be of assistance.

Yours sincerely

MINISTER FOR HEALTH

Date: 5.12.10

Council
Correspondence
22/2/10

APPENDIX 2

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Port Augusta
CITY COUNCIL

GJP:MJJ:1734
LEAA20088

25 February 2010

Ms E Morton
Registrar
SA Cancer Registry
Department of Health
PO Box 6 Rundle Mall
ADELAIDE SA 5000

Dear Ms Morton

INCIDENCE OF CANCER IN PORT AUGUSTA

Council recently considered a response it had received from the Minister for Health dated 5th February 2010 relating to the incidence of cancer in Port Augusta.

The information provided in the Minister's letter quoted information from your Registry; and accordingly Council has resolved that I seek further clarification from you. Council in particular would like more information about the incidence of lung cancer in Jan 2005-Dec 2007 "where the number of cases was double the expected number". The information in the Minister's letter identified that "available data suggests that, in past periods, a greater proportion of Port Augusta residents smoked than was true of South Australian residents generally". While not specifically stated there was an inference that the "double" lung cancer rate could be attributed to a slightly higher proportion of smokers in the community.

I therefore ask whether there is a direct correlation between the "double" lung cancer rate and the slightly higher proportion of smokers in the community, or whether there must be some other reason for the unusually high lung cancer rate. The question must be asked as to whether the outfall from the coal fired power stations in the City may have some part to play in this "double" rate of lung cancer.

Council has also asked if you could provide the ages of the 36 people suffering from lung cancer identified in the Jan 2005- Dec 2007 statistics provided in the Minister's letter.

Yours faithfully

GREG PERKIN
CITY MANAGER

APPENDIX 3

Government of South Australia
SA Health

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2010-01757
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CORPORATION OF PORT AUGUSTA
27 APR 2010
RECEIVED

Mr Greg Perkin
City Manager
City of Port Augusta
PO Box 1704
Port Augusta SA 5700

Dear Mr Perkin,

RE: INCIDENCE OF CANCER IN PORT AUGUSTA

Thank you for your letter of 25 February, 2010, to the Registrar, South Australian Cancer Registry.

As previously communicated to you by the Minister for Health, the number of newly diagnosed cases of the most common cancer types that occurred in Port Augusta in the period January 2005 - December 2007 was close to the number expected from state averages, except for lung cancer, where the number of cases (36) was double the expected number (with a confidence interval ranging from 1.41 to 2.78). Also previously communicated were data showing that during the period 1990-2003, 32.6% of Port Augusta residents aged 15 years or older reported being current smokers, while the figure for the state was 25.7%.

In answer to your questions, the 36 Port Augusta residents who were newly diagnosed with lung cancer in the period 2005-2007 were respectively aged:

47,50,54,57,57,58,59,60,62,63,64,64,65,65,66,66,68,68,68,69,71,72,73,73,73,76,77, 77,80,80,81,81,82,84,88,91.

When reviewing contributory risk factors for lung cancer, exposures of interest will have pre-dated the cancer diagnosis by several decades. Often the paucity and poor quality of information regarding personal and/or environmental exposures going back several decades makes attribution difficult to determine.

However, in order to determine the relative contribution of tobacco smoking to lung cancer incidence in Port Augusta, survey data on smoking rates from 1990 to 2003 was used, with the understanding that rates will have decreased over time. To determine the relative contribution to lung cancer incidence of the higher rates of tobacco smoking in Port Augusta, analysis of a longer period of incidence data will provide more robust results. As such, analyses were performed on people in Port Augusta with lung cancer diagnosed between 1998 and 2007, using data from the South Australian Central Cancer Registry.

During this time period 82 Port Augusta residents were diagnosed with lung cancer, whereas 57 would have been expected, making the actual number 1.45 times higher than expected (with a confidence interval ranging from 1.15 to 1.80).

Combustion-related fine particulate matter — soot emitted by cars and trucks, coal-fired power plants and factories — is a known risk factor for lung cancer. However, cases of lung cancer diagnosed in the period 2005-2007 would have resulted from exposures that occurred many decades before, and would not be directly related to present air quality. Although the Environment Protection Authority (EPA) does not currently monitor ambient air quality in Port Augusta, they license major industry in Port Augusta, and this licensing requires coal fired power stations to undertake air quality monitoring, which is regulated and audited by the EPA.

In summary, it is known that more than 80% of lung cancers are due to tobacco smoking. Although combustion related fine particulate matter may contribute to the development of lung cancer, in most cases where this occurs, it would relate to exposures several decades prior to diagnosis. While it is important for the City Council of Port Augusta to make sure that the air quality in Port Augusta is optimal and that local industry conforms to EPA standards, it is also important that the Council continues to support programs that lead to a reduction in tobacco smoking amongst Port Augusta residents.

Yours sincerely,

☐ ACTION
☐ RESPOND
☐ INFO ONLY

DR TONY SHERBON
Chief Executive

23/4/10

Greg 30/4/10

APPENDIX 4

Doctors for the Environment Australia
www.dea.org.au

DEA Particle Assessment Report
Port Augusta 2012

Data supplied by EPA South Australia for the period 2005-2011.

Introduction

Port Augusta is home to South Australia's coal fired power stations that have supplied electricity since 1963 (Playford Power Station) and 1985 (Northern Power Station) and supply greater than 30% of the States power needs.[1]

These power stations utilise brown coal from the Leigh Creek mine, which is transferred via rail to the facility in Port Augusta. The operation stockpiles brown coal to be used in the two power stations between supply transfers via a rail link from Leigh Creek.

DEA is interested in the development of clean and renewable electricity production to reduce the harm to community's health and as such does not support the continued use of coal for energy generation.

http://dea.org.au/images/general/Coal_Policy_Document.pdf

http://dea.org.au/images/general/Briefing_paper_on_coal_2011.pdf

DEA supports and advocates for the installation of available non-fossil fuel technology to replace coal fired power stations eliminating the health burden on Australian communities.

We do not support the use of gas because of its health impacts

http://dea.org.au/images/general/Gas_and_Health_Report_01-2012.pdf

Recently DEA has accessed particle data regarding the operations in Port Augusta and the following is the assessment of the data.

Background

What are particles?

Particles can be a mixture of many different components that can be drawn from multiple sources.

Particles come in a range of sizes and these can be classified by their maximum size. For example a PM_{10} refers to particulate matter less than 10 millionths of a metre in effective diameter, while $PM_{2.5}$ refers to particulate matter less than 2.5 millionths of a metre in effective diameter. This would mean that the particles represented by PM_{10} all have a diameter of between 0.1 and 10 micrometers (0.1 represents the limit of filter pore size).

[1] http://alintaenergy.com.au/assets/generation/flinders/

Why is size important?

Size is important, as it will provide a good guide as to how far a particle will be able to penetrate into the lungs of an individual. For example PM_{10} particles are the cutoff point at which particles will be able to enter the human respiratory anatomy[2], while $PM_{2.5}$ particles are able to enter deeper into the lungs and reach many alveoli (air sacs in the lungs).

Larger particles are effectively removed from the air that is breathed in by physiological mechanisms of the human respiratory tract. These include nose hairs, mucus membranes in the nose and throat and the coughing mechanism used to expel particles from the upper airways.

Why measure particles?

Particles are important to measure as it provides an estimate of risk regarding the potential health effects of particle pollution. There is no safe level of particle pollution at the smaller size fractions. This means that at very low levels , health effects are beginning to occur. The higher the level of fine particle pollution breathed in, the higher the risk of a health effect. This is compounded by the duration and level of exposure to ambient air pollution and other sources of particles experienced at work or socially (smoking).

What are the standard levels to protect health?

The National Environment Protection (Ambient Air Quality) Measure was introduced in all States in Australia in 1998 and aimed to have compliance in 2008.

Revisions to the NEPM included a reporting standard for PM2.5 in 2003 and an investigation standard for Air Toxics (or organic pollutants) in 2004.

This protection measure is aimed at ensuring that undue health effects of air pollution are prevented or appropriately managed in each State to ensure the health of communities that may live in or around major populated centres or pollution sources.

Standards exist for PM_{10} particles and gaseous pollution that provides the higher limits permitted or the number of days these levels can be breached.

These include:

	NEPM Standard	NEPM Goal
PM_{10}	50 μ g/m^3 daily average	Less than 6 days in a year *(Allows for natural events)*

The World Health Organisation also has guidelines for the safe levels of PM10 pollution and assessments against these would be made.

	WHO Standard
PM_{10}	50 μ g/m^3 daily average
PM_{10}	20 μ g/m^3 annual average

The DEA policy on ambient air pollution is at http://dea.org.au/images/general/DEA_Air_Pollution_Policy_03-12.pdf

Why is DEA concerned about Port Augusta?

DEA has become aware of increased rates of lung cancer[3] and levels of childhood asthma in Port Augusta and are concerned that the levels of pollution from the coal fired power stations

[2] Wood-Black F. (2012), Journal of Chemical Health and Safety, Vol 19 Issue 2.

[3] See www.dea.org.au

are contributing to the elevation in these cases. Coal pollution has long been associated with health effects and as such an investigation into the levels of air pollution in Port Augusta was conducted.

Pollution levels - Data analysis

DEA have accessed ambient air particle data form 4 locations in Port Augusta from the EPA in South Australia that have shown high levels of pollution data in the past. The data is for the period from 2005 to 2011 and is measured via a method that provides for 1 day in 6 monitoring.

This method provides for cycling of monitoring throughout the week to ensure that every day of the week is monitored on a number of occasions that will limit bias due to weekday and weekend effects.

However it should be noted that this only provides information regarding 16.67% or the equivalent of 2 months worth of days assessed, with the remainder of the year not assessed.

Data was calculated such that any day that had one or more sites with PM_{10} levels greater than 50 $\mu g/m^3$ indicated the region was in exceedence

Data from 2005 to 2011 outlined in figure 1 below showed numerous events that were above the national standard and in 2007 more than twice the number of days were above the goal that is specified as acceptable under the NEPM (Ambient Air Quality).

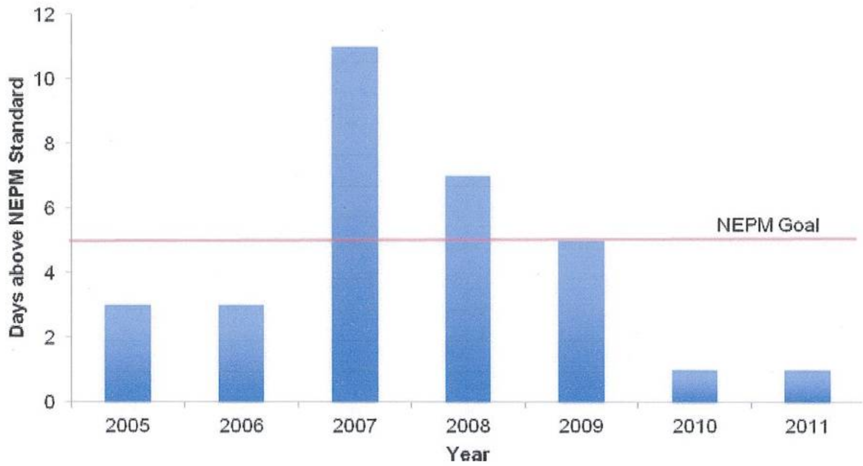

Figure 1: Graph showing the number of days that were above the NEPM (Ambient Air Quality) standard and indicating the goal of 5 exceedences of the standard per year.

As shown in figure 1 the levels of particles measure in 16.67% of the year are in excess of the NEPM goal (2007 and 2008) for the number of days where measured PM_{10} is greater than the National Standard. In 2007 the levels were greater by more than double the levels deemed acceptable thus increasing the risk to community health in Port Augusta. This signifies that nearly one day in five, or almost 20% of the samples, in the Port Augusta region in 2007 were greater than the PM_{10} NEPM Standard. Given the monitoring regime this is the "best case scenario" for PM_{10} particle in Port Augusta in 2007. There is little reason to suggest that exceedences would not have occurred on occasions in the remaining 83.3% of the year that was not monitored.

Unacceptable PM_{10} impact was again observed in 2008 with the number of days being 40% greater than the accepted goal as specified under the NEPM. Other years showed high event days that were less numerous however monitoring would be taken to be representative of the year. On occasions particles noted on filter samples have been coal like and suggested to be coal that has been transported from the facility to the community.

Extrapolation of 1 day in 6 sampling

Extrapolation of any events measured can be applied without affecting the annual average, maximum or minimum levels attained throughout the year. For example if the conditions were to be repeated identically on 5 more occasions each throughout the year the average, maximum and minimum pollution levels would remain the same.

Using the monitored data as a representation of the levels of PM_{10} measured during the year and keeping in mind and there being 6 times as many days in a year as are sampled, a simple extrapolation of data might be carried out to apply the same pattern of pollution levels collected across a year. This is shown in figure 2.

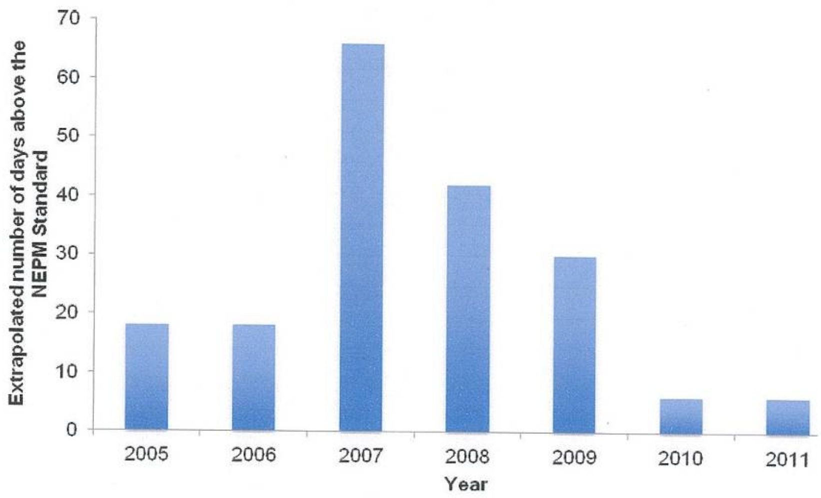

Figure 2: Graph showing the extrapolated number of days that were above the NEPM (Ambient Air Quality) standard and indicating the goal of 5 exceedences of the standard per year.

Clearly if this simple pattern extrapolation is conducted the levels of pollution that are estimated from monitored data show an excessively high exposure of the community in Port Augusta to PM_{10}.

It can also be assumed that there may be more, or less high level events across the year during the non-assessed days. This potentially could increase the number of days of impact above or also decrease the number of events to be as lower than outlined in figure 2, but the number of days would never fall below those outlined in figure 1.

Further analysis of data from the sampling sites in Port Augusta shown in table 1 highlight the level at which the maximum daily value was in Port Augusta in each year.

		PM10 (μ g/m^3)	
Year	Days > NEPM Standard	Region Maximum	Regional Maximum Annual Average
2005	3	195.6	21.3
2006	3	96.9	22.3
2007	11	400.1	36.0
2008	7	78.2	25.2
2009	5	136.4	22.1
2010	1	113.3	15.3
2011	1	113.5	16.0

Table 1: PM_{10} summary table of regional maximum and days above the NEPM Standard.

Regional maximum values can be seen to be up to eight times the daily limit in 2007 and nearly double the daily standard during most other years.

The regional maximum annual averages were calculated to compare to the World Health Organisation's annual average guideline (20 μ g/m^3) and can bee seen to be above this limit from 2005 to 2009.

La Nina weather patterns have been suggested to be a reason for the decreased PM10 levels in 2010 and 2011, however the Bureau of Meteorology has at the time of this report indicate that historically after two years of a La Nina weather pattern there is a 70% chance of reverting to a neutral or El Nino weather pattern. This would likely increase the levels of particles again to unacceptably high levels increasing the PM10 levels in the Port Augusta region.

Conclusion

Data presented in this report show periods of unacceptably elevated PM_{10} levels that increase the health risks for the Port Augusta community.

Monitoring that is indeed designed to be representative (cycling throughout the week) might be further extrapolated and becomes suggestive of excessively high levels indicating a much higher risk toward the health outcomes of the residents within the local community.

Given that power generation is a continuous operation there is limited opportunity for the community to be relieved of background elevation of PM_{10}.

It is for these reasons that DEA continues to seek to support the introduction of renewable generation technologies for electricity within the Australian communities to protect the health of individuals, communities and reduce the public health burden of yesterday's polluting technology.

APPENDIX 5

Doctors for the Environment Australia
www.dea.org.au

Health of residents of Port Augusta

SUMMARY

Respiratory illness in pre-school children in Port Augusta

In 1993, preschool children in Port Augusta had the highest prevalence of asthma, dry cough and hay fever in South Australia; the second highest prevalence of wheeze in the past 12 months and excessive head colds; and third highest prevalence for ever wheezed and bronchitis[1]. There are no published reports exploring the reasons for these high rates in Port Augusta, but exposure to particulates from outdoor air pollution, including coal-fired power stations, is a possible contributory factor. No comparable published studies have been done since that time to assess trends in these rates.

Lung cancer in residents of Port Augusta

In the three years 2005-2007, there were 36 cases of newly diagnosed lung cancer in Port Augusta residents, at a rate double the expected number. When the analysis was extended to cover the period 1998-2007, a total of 82 cases of newly diagnosed lung cancer were identified at a rate 1.45 times that expected[2]. While cigarette smoking in the decades preceding diagnosis is likely to be the major contributing factor for lung cancer, exposure to particulate matter, a known risk factor for lung cancer, during these same decades cannot be excluded as a contributing factor in some of these cases, especially in cases who were not smokers. However, there was inadequate data on the smoking history of the cases to allow for this to be quantitatively assessed.

[1] Volkmer RE, Ruffin RE, Wigg NR, Davies N. The prevalence of respiratory symptoms in South Australian preschool children. 1. Geographic location. *J. Paediatr. Child Health* 1995:31; 112-115.

DISCUSSION

This study was based on data collected in 1993 from 14,124 families in South Australia with a child aged 4 years 3 months to 5 years of age. The sample represented 73% of the State preschool population of that age. Data from this well designed population–based study was analysed to determine the geographical distribution of respiratory symptom prevalence within South Australia.

The Adelaide region prevalence rates for the respiratory symptoms (asthma, ever wheezed, wheeze in the past 12 months, bronchitis, dry cough, hay fever, eczema and excessive head colds) were similar to the State prevalence rates, while the rates in Post Pirie, Port Augusta and Whyalla (the "Iron Triangle") were significantly higher than the State prevalence rate for all symptoms except eczema.

For Port Augusta, the prevalence of asthma was the highest in the State (30.7% [28.1-33.3] compared to the State rate of 22.5% [22.1-22.9]). The prevalence for dry cough was also the highest for the State at 46.1% [43.4-48.9] compared to the State rate of 33.7 [33.3-34.1]. Hay fever prevalence rates in Port Augusta were also the highest in the State (38.8% [36.0-41.6] compared to the State rate of 29.7% [29.3-31.1]).

The prevalence for wheeze in the past 12 months and excessive head colds were the second highest in the State while "ever wheezed" and "bronchitis" rates were the third highest in the State.
The study authors recommended further research to determine potential reasons for the significant geographic variation in prevalence rates, including cultural or social clustering of children at risk, the transfer of populations to sites of perceived lower risk, age of housing, indoor allergen exposure, outdoor industries, indoor and outdoor pollution by particulates and gases and outdoor allergens.

[2] Correspondence between the Port Augusta City Council and SA Health

As a result of concern about higher levels of cancer among residents of Port Augusta, the Port Augusta City Council sent a letter to the Minister for Health on 18 December 2009 requesting information on official statistics for cancer. On behalf of the Minister, the South Australian Cancer Registry responded on 5 February 2010.

While the overall cancer rate (for newly diagnosed cancer) for residents of Post Augusta (for the three years 2005-2007) was consistent with the rates for South Australia as a whole, there was an unexpected and statistically significant increase in the rate of lung cancer for Port Augusta. There were 36 cases of lung cancer newly diagnosed during these 3 years with a rate double the expected number [Confidence Interval 1.41-2.78]. This was attributed to smoking rates being increased in Port Augusta compared to South Australians generally (citing data for the period 1990-2003 where 32.6% of Port Augusta residents aged 15 years or over reported being smokers compared to the State rate of 25.7%).

Subsequent correspondence between the Council and Cancer Registry (Letter from the Council dated 25 February, follow-up letter dated 20 April and reply from the Chief Executive, SA Health dated 23 April 2010) highlighted the fact the exposures of interest for lung cancer will pre-date the diagnosis of cancer by several decades. A further analysis for lung cancer in Port Augusta between 1998 and 2007 was conducted where 82 cases were identified with a rate 1.45 times higher than expected [Confidence Interval 1.15-1.8].

The response acknowledged that fine particulate matter, emitted by cars, trucks and coal-fired power plants and factories, is a known risk factor for lung cancer, but that such exposure would have occurred several decades prior to diagnosis. The letter concluded by stating that

> "[W]hile it is important for the City Council of Port Augusta to make sure that the air quality in Port Augusta is optimal and that local industry conforms to EPA [Environmental Protection Agency] standards, it is also important that the Council continues to support programs that lead to a reduction in tobacco smoking among Port Augusta residents".

The Council, in a subsequent letter to the Minister for Environment and Conservation dated 27 May 2010, noted that the Council had limited authority to ensure that air quality is optimal and that this is rather the role of the EPA. The Minister was asked to provide advice as to how the EPA will ensure that air quality in Port Augusta is optimal and that local industry confirms to EPA standards. At the end of December 2011 no reply had been received from the Minister to this letter.

APPENDIX 6

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Suppression of Rain and Snow by Urban and Industrial Air Pollution

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Direct evidence demonstrates that urban and industrial air pollution can completely shut off precipitation from clouds that have temperatures at their tops of about −10°C over large areas. Satellite data reveal plumes of reduced cloud particle size and suppressed precipitation originating from major urban areas and from industrial facilities such as power plants. Measurements obtained by the Tropical Rainfall Measuring Mission satellite reveal that both cloud droplet coalescence and ice precipitation formation are inhibited in polluted clouds.

The precipitation-forming processes in clouds depend to a large extent on the presence of aerosols, specifically cloud condensation nuclei (CCN) and ice nuclei. The large concentrations of small CCN in the smoke from burning vegetation nucleate many small cloud droplets (*1*, *2*) that coalesce inefficiently into raindrops (*3*, *4*). Although this effect has been suspected for many years (*5*, *6*), conclusive evidence that smoke from burning vegetation suppresses precipitation was obtained recently with the observations of the Tropical Rainfall Measuring Mission (TRMM) (*7*) satellite (*8*).

Much less is known, however, about the impact of aerosols from urban and industrial air pollution on precipitation. It was assumed initially that industrial and urban pollution inhibited precipitation, similar to the smoke from burning vegetation (*9*). Later, reports of enhanced rainfall downwind of paper mills (*10*) and over major urban areas (*11*) suggested that giant CCN enhanced precipitation (*12*), but attempts to correlate the urban-enhanced rainfall to the air pollution sources failed to show any relation (*13*). Another explanation for the urban rain enhancement invoked the heat-island effect and increased friction, both of which would tend to increase the surface convergence, resulting in more cloud growth and rainfall over and downwind of the urban areas (*14*). Furthermore, the recent suggestion (*15*) that air pollution might enhance precipitation on a large scale in northeastern America and the accompanying speculative explanations demonstrate how little is known about the subject.

Space-borne (*16*) and in situ aircraft (*17*) measurements of ship tracks in marine stratocumulus clouds provided the first evidence that effluents from ship stacks change cloud microstructure by redistributing their water into a larger number of smaller droplets. Albrecht (*18*) suggested that the drizzle, which normally occurs in marine stratocumulus clouds in clean air, would be inhibited from the clouds with reduced droplet size,

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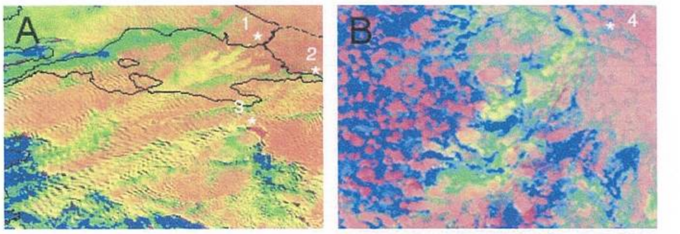

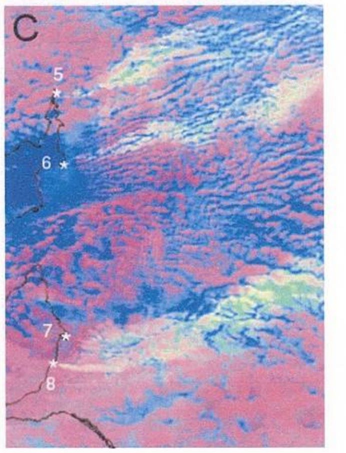

Fig. 1. Satellite visualization of NOAA AVHRR images, showing the microstructure of clouds for three cases over three different continents with streaks of visibly smaller drops due to ingestion of pollution originating from known pollution sources that are marked by white numbered asterisks. **(A)** A 300 km by 200 km cloudy area containing yellow streaks originating from the urban air pollution of Istanbul (*1), Izmit (*2), and Bursa (*3) on 25 December 1998 at 12:43 UT. **(B)** A 150 km by 100 km cloudy area containing yellow streaks showing the impact of the effluents from the Hudson Bay Mining and Smelting compound at Flin-Flon (*4) in Manitoba, Canada (54°46′N 102°06′W), on 4 June 1998 at 20:19 UT. **(C)** An area of about 350 km by 450 km containing pollution tracks over South Australia on 12 August 1997 at 05:26 UT originating from the Port Augusta power plant (*5), the Port Pirie lead smelter (*6), Adelaide port (*7), and the oil refineries (*8). All images are oriented with north at the top. The images are color composites, where the red is modulated by the visible channel; blue is modulated by the thermal infrared (IR); and green is modulated by the solar reflectance component of the 3.7-μm channel, where larger (greener) reflectance indicates smaller droplets. The composition of the channels determines the color of the clouds, where red represents clouds with large drops and yellow represents clouds with small drops. The blue background represents the ground surface below the clouds. A full description of the color palettes and their meaning is provided by Rosenfeld and Lensky (*6*).

thereby increasing the cloud water content and longevity. Extrapolation to clouds that are sufficiently thick for raining (i.e., at least 2 km from base to top) would mean that the effluents have the potential to suppress precipitation over ocean and over land. However, pollution tracks in any clouds over land were not reported in previous studies. Application of the imaging scheme of Rosenfeld and Lensky (*6*) to the Advanced Very High Resolution Radiometer (AVHRR) on board the National Oceanic and Atmospheric Administration (NOAA) orbiting weather satellites revealed numerous ship track–like features in clouds over land, created by major urban and industrial pollution sources. Illustrations of such tracks from Turkey (Fig. 1A), Canada (Fig. 1B), and Australia (Fig. 1C) are shown. Because the tracks clearly originate from pollution sources, they will be called hereafter "pollution tracks."

The pollution tracks in Turkey (Fig. 1A) originate from several sources in and near the cities of Istanbul, Izmit, and Bursa.

The pollution track in Canada (Fig. 1B) originates from Flin-Flon, Manitoba, the home of the Hudson Bay Mining and Smelting Company. That location has been a frequent source for such tracks. Other sources in Canada have been observed, but not reported here.

Study of the pollution tracks emanating from the region of Adelaide, South Australia, Australia, is especially interesting. They received special attention because of their intensity and frequent occurrence. These pollution tracks were identified in the clouds of all 47 AVHRR images on different days examined in which stratocumulus and cumulus clouds with tops warmer than about −12°C existed over the region. The pollution tracks in Fig. 1C coincide with the following major industrial and urban areas: (i) Port Augusta has a 520-MW power plant operating on brown coal, providing electricity to the nearby mines and to the adjacent large steel industry in Whyalla. (ii) Port Pirie is the home of the world's largest lead smelter and refinery. (iii) Adelaide has industry for processing minerals mined in the vicinity. Among these are Australia's largest cement plant, located on the Port Adelaide River. A major oil refinery and a power plant are located 20 km to the south of the city near the origin of the strongest pollution track in Fig. 1C.

The 1998–99 annual average of effluents from the stack of Port Augusta power plant, which is equipped with an electrostatic precipitator, was 43 kg hour^{-1} of submicrometer ash particles with modal diameter of 0.14 μm. The gaseous annual average of effluents for the same time period is 1108 kg hour^{-1} of SO_2 and 1655 kg hour^{-1} of NO_x (*19*). Apparently, part of the ash particles act as CCN at short range, and chemical reactions of the gases produce additional CCN hundreds of kilometers farther downwind from the pollution source, mainly in the form of sulfates.

The AVHRR data were used to retrieve the dependence of the indicated effective radius $r_e = \langle r^3 \rangle / \langle r^2 \rangle$, where r is the radius of the cloud droplets in the measurement volume, on cloud temperature T. The method of Rosenfeld and Lensky (*6*) was used to derive the T-r_e relations for inference of the precipitation-forming processes in the clouds.

The median r_e of the cloud tops in the pollution plumes (Figs. 1 through 3) was considerably less than the precipitation threshold of 14 μm (*20*). Outside the plumes, however, r_e increased steeply with decreasing T to more than 25 μm, indicating that the cloud droplets in the general area were coalescing into precipitation. At the same time, little growth of r_e with decreasing T was indicated within the pollution plumes, indicating a lack of coalescence and, thus, suppressed precipitation.

These inferences are validated using the additional sensors onboard the TRMM satellite. The TRMM instruments used here are the visible and infrared sensor (VIRS), the precipitation radar (PR), and the TRMM passive microwave imager (TMI). The VIRS is similar to the NOAA AVHRR, but it uses a 2-km subsatellite resolution instead of the 1.1-km resolution used by the AVHRR to obtain the T-r_e relations. PR is a 2.2-cm radar with a subsatellite resolution of 250 m vertically by 4 km horizontally. The minimum detectable signal is about 17 dBZ [decibel of Z (mm^{6}m^{-3})], which is equivalent to about 0.7 mm hour^{-1}. The PR is used to measure the precipitation that forms in the clouds. The TMI uses a 85-GHz vertical polarization brightness temperature (T_{85}) to detect the water in nonprecipitating clouds.

The TRMM measurements are validated by an extensive ground validation program (*21*). Preliminary results show variability of about 25% between rain gauges and TRMM rainfall over large areas, with some TRMM underestimation with the heavier rainfall (*22*). The simultaneous spaceborne measurements of

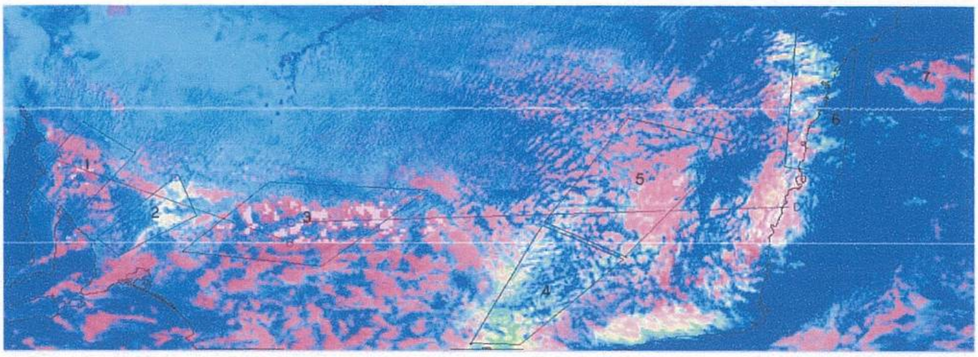

Fig. 2. Satellite visualization of the TRMM VIRS, with the precipitation information in the white overlay. The white patches denote precipitation echoes as observed by the TRMM PR. The two parallel lines delimit the 230-km PR swath. The swath is oriented from west to east (left to right, respectively). The image shows pollution plumes in the clouds over southeastern Australia on 21 October 1998 at 04:44 UT. The lines AB and CD show the locations of the vertical cross sections presented in Fig. 5.

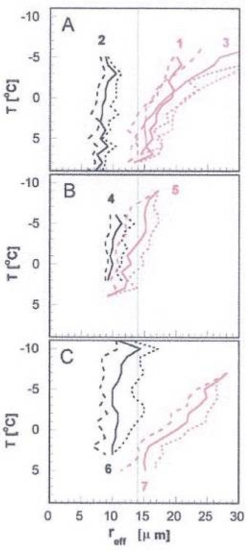

Fig. 3. Analysis of the T-r_e relations, where T is the temperature and r_e (r_{eff}) is the cloud particle effective radius for the clouds in the seven boxes (traces numbered 1 through 7) in Fig. 2. Plotted are the 15th (long dashed line), 50th (solid line), and 85th (short dashed line) percentiles of r_e for each 1°C interval. The black lines correspond to the boxed areas of pollution. The vertical green line marks the 14-μm precipitation threshold. A full description of the T-r_e charts and their meaning is provided by Rosenfeld and Lensky (6).

cloud microphysics (VIRS), cloud water (TMI), and precipitation (PR) make it possible to relate the precipitation to cloud microstructure.

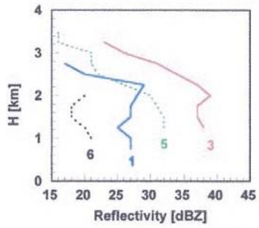

Fig. 4. Vertical profiles of the precipitation echo intensities as measured by the TRMM PR for the various boxes in Fig. 2. The peak near 2 km corresponds to enhanced echoes from snowmelt just below the 0°C isotherm. Box 2 had no detectable precipitation. Boxes 4 and 7 are outside the radar swath. H, cloud height.

The TRMM overpass selected for analysis here is from 21 October 1998 at 04:41 UT, a time of strong pollution-track signatures in the clouds throughout southeastern Australia (Fig. 2). Seven boxes within the image were delimited for analyses of the dependence of r_e (Fig. 3) and the PR reflectivities (Fig. 4) as a function of T. Box 2 encloses a pollution plume that is clearly visible by the yellow coloring, which indicates the small r_e of the cloud particles downwind of Adelaide. According to the T-r_e relations presented in Fig. 3A, the clouds in the plume had little coalescence, had not glaciated, and were without precipitation, whereas the unpolluted clouds in boxes 1 and 3, side-wind of box 2, had strong coalescence and were precipitating. That observation is corroborated by the PR, which recorded precipitation echoes in the clouds outside, but not within, the plume. The PR-measured rain intensities exceeded 10 mm hour^{-1}. Another large area of clouds with extremely small r_e existed in the Melbourne area and extended downwind to the northeast (box 4). The r_e increased gradually farther downwind but did not reach the precipitation threshold. Farther downwind and to the east of the plume (box 5) only a few isolated showers had formed in some of the clouds that reached the −9°C isotherm and barely exceeded the 14-μm precipitation threshold.

Clouds over the Sydney area (box 6) also had a much reduced r_e, apparently because of the pollution there. Clouds over the sea some 150 km away from Sydney (box 7) had a much larger r_e, indicative of strong coalescence and precipitation in the apparently pristine marine air. The TMI-based TRMM rainfall algorithm identified those clouds as precipitating.

The vertical cross sections (Fig. 5) of the plumes show no obvious differences in the cloud top heights and horizontal dimensions in and outside the areas of suppressed precipitation. Furthermore, the depression of the TMI-measured T_{85} in the nonprecipitating clouds indicates that lack of cloud water was not the reason for the lack of precipitation from these clouds.

The vertical profile of the precipitation echoes as measured by the PR has a distinct maximum near the 0°C isotherm, between 2 and 2.5 km above sea level (Fig. 4). This maximum is caused by the enhanced radar returns from melting snowflakes, known as the "bright band." The existence of the bright band shows that much of the precipitation was initiated as snow in the upper parts of the clouds. That means that the pollution suppressed the precipitation not only by inhibiting the coalescence of the cloud droplets into raindrops but also by preventing the formation of ice particles and cold-precipitation processes of the clouds. A likely explanation is that the pollution reduces the radius of the largest cloud droplets below the threshold of 12 μm, which is required for both primary

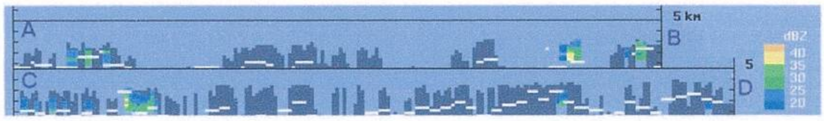

Fig. 5. Vertical cross section along the lines AB and CD in Fig. 2. The dark gray areas represent clouds. The vertical extent of the clouds is converted from the VIRS-measured cloud-top temperatures. The colors represent the precipitation reflectivity in dBZ as measured by the TRMM radar. The white line is the brightness temperature of the TMI 85-GHz vertical polarization (T_{85}), plotted at the altitude of that temperature. A lower T_{85} value is represented as greater height of the white line, and in nonprecipitating clouds it means greater cloud water content. The T_{85} and actual cloud-top temperature have different physical meanings.

and secondary ice generation in clouds (*23*, *24*). Air pollution must be an important factor in determining the precipitation amounts in the Snowy Mountains (east of box 4 in Fig. 2) because it has been observed that most of the winter precipitation events in that region come from clouds with temperature at the tops between −4° and −13°C (*25*). Interestingly, a decreasing trend of the snow cover in the Snowy Mountains was reported for the period 1897–1991 (*25*). However, trend analyses of snow, winter temperature, and total winter rainfall for the period 1910–91 showed statistically insignificant decreases in all three parameters (*26*).

The satellite data provide evidence connecting urban and industrial air pollution to the reduction of precipitation, pinpointing both the sources and the affected clouds. This has become possible with the newly acquired capabilities to observe both cloud microstructure and precipitation over large areas with TRMM satellite observations. It might seem strange that some of the most prominent pollution signatures occur in Australia, which is probably the least polluted inhabited continent. The pollution is perhaps most evident in Australia because it is seen against a background of pristine clouds, whereas in most other places the clouds are already polluted on a very large scale. Such results might indicate that human activity may be altering clouds and natural precipitation on a global scale.

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An Archaeal Iron-Oxidizing Extreme Acidophile Important in Acid Mine Drainage

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A new species of Archaea grows at pH ~0.5 and ~40°C in slime streamers and attached to pyrite surfaces at a sulfide ore body, Iron Mountain, California. This iron-oxidizing Archaeon is capable of growth at pH 0. This species represents a dominant prokaryote in the environment studied (slimes and sediments) and constituted up to 85% of the microbial community when solution concentrations were high (conductivity of 100 to 160 millisiemens per centimeter). The presence of this and other closely related *Thermoplasmales* suggests that these acidophiles are important contributors to acid mine drainage and may substantially impact iron and sulfur cycles.

The oxidative dissolution of metal sulfide minerals causes the formation of acid mine drainage (AMD) and plays an important role in the geochemical sulfur cycle. Sulfides (primarily pyrite, FeS_2) that are exposed to air and water through geological or mining activities undergo oxidative dissolution and generate sulfuric acid by the reaction $FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+$ (*1*). Mining and extraction mobilizes $\sim 150 \times 10^{12}$ g of sulfur per year, contributing ~50% to the net river transport of sulfate to the ocean, which is about half of the sulfate input into the ocean (*2*).

Microorganisms accelerate the rate of pyrite dissolution through regeneration of Fe^{3+} (*1*, *3*), the primary pyrite oxidant at low pH (*4*–*6*). At Iron Mountain, an AMD site in northern California, the iron-oxidizing bacterium *Thiobacillus ferrooxidans*, previously thought to be the most important iron-oxidizing species, played a minor role in pyrite oxidation (*7*, *8*). Instead, Archaea constituted a large proportion (>50%) of the prokaryote population at important sites of acid generation during the dry summer and fall months

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