Environmental Defender's Office Ltd (NSW)

Technical Fact Sheet: **Air Quality – Dust Monitoring**

INTRODUCTION

About this Fact Sheet

This Fact Sheet on '**Air Quality – Dust Monitoring'** has been prepared by the Environmental Defender's Office Ltd (NSW) (EDO) with assistance from members of the EDO's Expert Register.

The aim of the Fact Sheet is to provide general information on dust issues caused by mining, in particular coal mining in the Hunter Valley. The Fact Sheet also provides a guide on how to undertake dust monitoring using a dust deposition gauge. This method is the easiest and most cost-effective way of undertaking your own dust monitoring.

The Fact Sheet provides information on the following:

- What is dust?
- Sources and types of dust from mining
- Health impacts of dust
- Main methods for monitoring dust
- Monitoring dust deposition rates using a dust deposition gauge in accordance with Australia/New Zealand Standard 3580, including:
    - how to collect a dust sample
    - how to analyze a dust sample
    - how to interpret the results of the analysis
    - how to report on the results of the analysis
- References and further reading

EDO Scientific Advisory Service

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- an in-house Scientific Advisor
- a Technical Advisory Panel, comprising four experts in a range of scientific fields
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If you require expert assistance with an environmental matter, please contact the duty solicitor on our environmental law advice line:

- **Tuesday, Wednesday and Thursday 2.30 pm – 5.30 pm**.

- Call: Sydney callers **(02) 9262 6989**; NSW callers outside the Sydney metropolitan area **1800 626 239**.

WHAT IS DUST?

Dust is a generic term used to describe fine particles that are suspended in the atmosphere.

Dust comes from a wide variety of sources, including soil, vegetation (pollens and fungi), sea salt, fossil fuel combustion, burning of biomass, and industrial activities.

It is formed when fine particles are taken up into the atmosphere (entrained) by the action of wind or other physical disturbances or through the release of particulate-rich gaseous emissions (primary particles). In addition, gases such as sulfur dioxide and oxides of nitrogen may react in the atmosphere over time to form fine particles, such as ammonium sulfate and ammonium nitrate (secondary particles).

Dust is typically classified according to its particle size, as follows:

- Deposited matter refers to any dust that falls out of suspension in the atmosphere.
- Total suspended particles (TSP) typically refers to particles 50µm (micrometers) (0.05mm diameter) in size or less.
- PM_{10} refers to particles 10µm (0.01mm) in size or less.
- $PM_{2.5}$ refers to particles 2.5µm (0.0025mm) in size or less.

Particle size is an important factor influencing the dispersion and transport of dust in the atmosphere and the effects of dust on human health.

Dust particles in the atmosphere can be as small as a few nanometres and as large as 100µm.

Fine particles are typically defined as particles of size PM_{10} or less. Characteristics of these particles include:

- They are easily entrained by wind or disturbances and generally take a long time to settle once airborne, although they may be washed from the air by rain or snow. For example, a recent study found that fine particles of sea salt in the Hunter Valley originated in the Great Australian Bight.
- They may settle permanently on land or only temporarily before being picked up and moved again, and may settle on water, dissolve in water, or both.
- They may stick together or break apart changing the size distribution over time.
- They may undergo chemical changes and reactions with other substances.

Fine particles are not visible to the human eye, although a high concentration of fine particles may appear as a 'haze' in the atmosphere.

Note: Particle size is not an absolute criterion as thin flakes or fibers larger than 10µm may be part of a PM_{10} sample because of their aerodynamic properties.

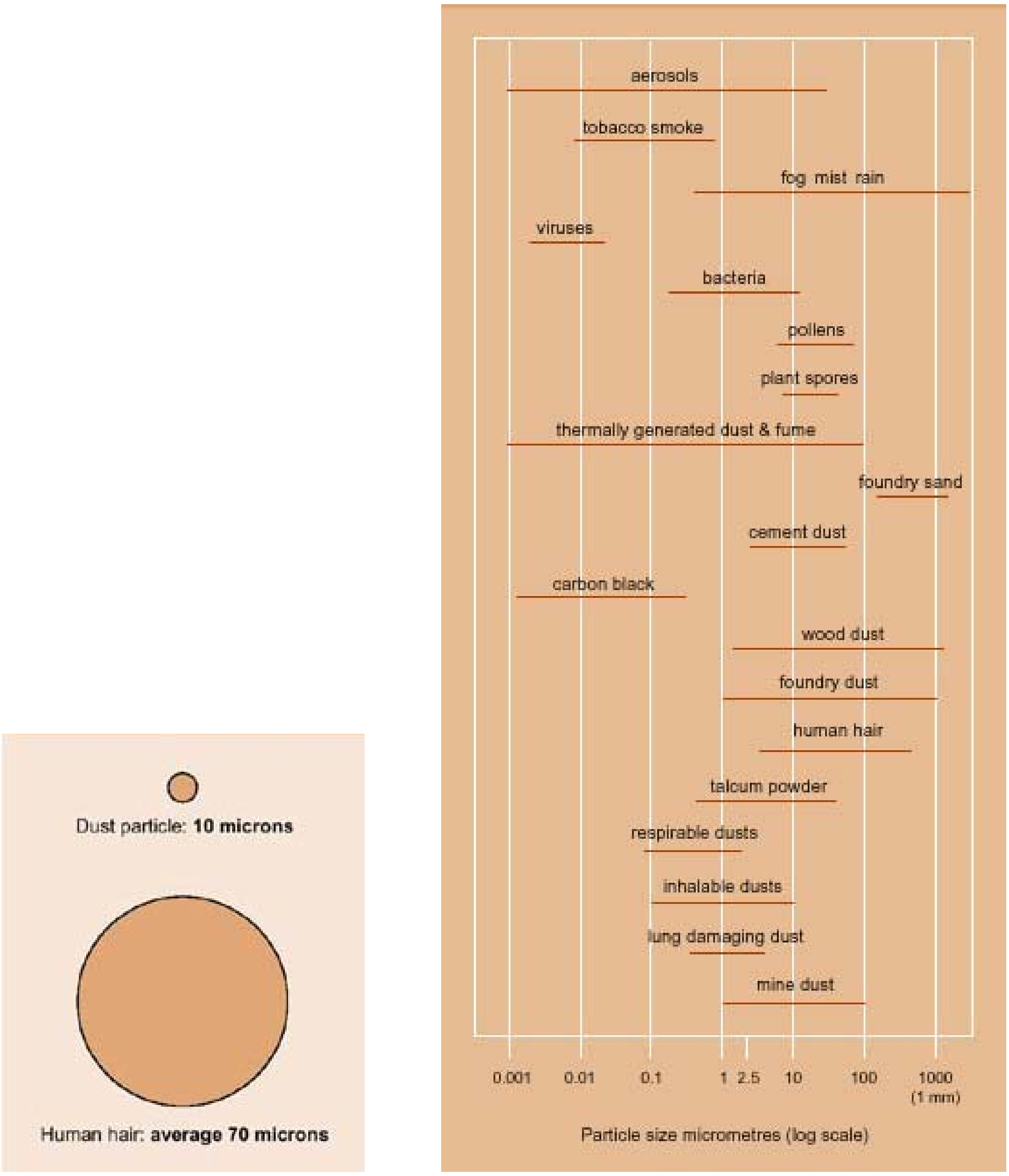

Figure 1: Relative dust particle sizes

Source: Environment Australia (1998) 'Best Practice Environmental Management in Mining Series Environment' Australia, Canberra

DUST FROM MINING

Sources and levels of dust

A wide range of mining activities may generate dust, including:

- removal of vegetation and topsoil
- removal of overburden material
- blasting and drilling operations
- operation of crushing and screening equipment

- loading and unloading of material on-site and subsequent transport off-site
- transport by vehicles on access roads and haul roads
- wind action affecting stockpiles and exposed areas of the site
- spontaneous coal combustion or combustion of other materials (for example, diesel emissions).

Different mines may generate substantially different levels of dust because levels are significantly influenced by climatic factors such as rainfall, temperature, and winds, and because different mining activities generate different amounts of dust.

In open cut coal mining, the removal of topsoil and overburden (the soil and rock that sits on top of the ore body) and the transport of this material is typically the major source of dust emissions (see Table 1).

Table 1 Dust emissions from typical coal mining operations

Sources	**Truck and shovel operation** **Percent of total dust emissions**	**Dragline operation** **Percent of total dust emissions**
Dragline	n/a	27
Haul roads		
Overburden	37	-
Coal	7	42
Loading		
Overburden	12	-
Coal	4	5
Drilling (overburden and coal)	1	2
Blasting (overburden and coal)	5	1
Truck dumping	7	5
Topsoil removal	18	10
Exposed areas	6	7
Haul road repairs	5	1
Total	100	100

Source: Environment Australia (1998) ‘Best Practice Environmental Management in Mining Series Environment’ Australia, Canberra

Dust sources may be localized (for example, from blasting, truck loading, ore crushing, conveyor transfer), or diffuse (for example, from waste rock dumps, areas of disturbed ground) or linear (for example, from haul roads). Mining produces predominantly ‘fugitive dust’ (dust derived from a mixture or not easily defined sources).

Dust particle size and composition

Mining typically generates dust particles between 1μm to 100μm in size. According to a recent article, typical size ranges are:

- submicron size (less than 1μm): 0.2 percent (generally from diesel emissions) of total emissions
- $PM_{2.5}$: 2 to 5 percent of total emissions
- $PM_{2.5}$ to PM_{10}: 15 to 45 percent of total emissions
- greater than 10μm: 50 to 70 percent of total emissions.

A survey of dust particle sizes from coal mines in the United States (sampled up to 100m from the source) found that particles had a median size (the midpoint in a range of sizes) of 24μm. Particles in the range PM_{10} or less comprised between 11 to 23 percent of total dust emissions.

In relation to coal mining in the Hunter Valley, the Metropolitan Air Quality Study (MAQS) identified that mining is a significant source of TSP (50μm or less), contributing 26 percent of human sources in the greater MAQS region. In addition, the National Pollutant Inventory (NPI) estimated the mass of PM_{10} emissions due to coal mining in the Hunter Valley area for the period 2003 – 2004 was 42,000,000kg.

While mining does generate fine dust particles, it appears that the bulk of very fine particles in the atmosphere are typically derived from other sources. Studies in the early 1990s in the Sydney, Newcastle and Wollongong areas estimated that soil particles (sources include mining, but also other activities such as agriculture) make a relatively small contribution (6 percent) to the total ambient level of very fine particles ($PM_{2.5}$) in the atmosphere. This compares to other particle types such as ammonium sulfate (23 percent) and elemental carbon (22 percent), which are derived from combustion processes.

A more recent study in the Hunter region identified that soil particles make an average contribution to the total ambient level of fine particles in the atmosphere of about 10 percent and 22 percent for $PM_{2.5}$ and PM_{10} size fractions respectively. The percentage of soil particles was marginally higher in samples from the Hunter region than in samples from other rural areas in NSW.

The composition of dust particles generated by mining will depend on the geology of the site. The majority of dust generated by mining is typically derived from soil and rock. However, dust may also be derived from the material being mined (for example, coal dust or iron ore dust), or from activities associated with mining (for example, diesel emissions).

Mining dust may contain various metals and other potentially hazardous substances. For example:

- The NPI estimated the mass of emissions to the air of toxic metals and their compounds due to coal mining in the Hunter Valley area for the period 2003 – 2004 as between 14kg and 55,000kg. These metals included arsenic, antimony, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, selenium and zinc.
- Silica is a very common mineral found in most rocks. Dust generated from the crushing of rock that contains a lot of quartz (a form of crystalline silica) may generate silica dust, which is potentially hazardous.

Note: Industrial facilities are required to report emissions to the NPI if they use more than a certain amount of one or more substances on the NPI reporting list. Emissions are estimated by each facility using techniques outlined in industry handbooks. The pollution exposure to humans and the environment cannot be determined solely from the NPI. Many additional factors determine whether a pollutant emission is felt as ground level pollution, such as the nature of the receiving environment, the chemical reactivity of the substance and the prevailing weather conditions. Since the NPI does not attempt to collect information about these additional factors, NPI data can only give an indication of pollutant emissions at the source of the emission.

HEALTH EFFECTS OF DUST

The factors that influence the health effects of dust are:

- size of the dust particles
- composition of the dust particles
- concentration of the dust particles in the air
- duration of exposure (possibly in years) to the dust particles.

There is considerable debate over the relative importance of these factors in relation to health effects.

Generally only fine particles of dust are of health concern. Dust particles PM_{10} or less in size are likely to have the greatest health effects because they may be drawn deep into the lungs. Particles larger than PM_{10} tend to be trapped in the nose, mouth, throat or major bronchi and are typically expelled from the body.

Dust particles may be termed 'inhalable' or 'respirable'. Inhalable particles are usually less than PM_{10} and greater than $PM_{2.5}$ in size. These may be deposited in the upper sections of the lungs. Respirable dust particles are less than $PM_{2.5}$ and may be deposited in the lower sections of the lungs, including the alveoli.

The NPI has given particulate matter of size PM_{10} or less a health hazard rating of 1.2 out of 3. A score of 3 represents a very high hazard to health, a score of 2 represents a medium hazard and a score of 1 is harmful to health.

The health effects of fine particles include:

- Absorption of dust into the blood through the lungs, with potentially toxic effects. Dust particles may contain various metals. Dusts containing mercury, arsenic or cadmium are particularly hazardous to human health.
- Diseases of the lungs, including cancer. Particles that penetrate deeply into the lungs may be permanently lodged, which may result in diseases of the lung.
- Long term negative effect on lung function causing marginally increased death rates and sickness in sensitive people.
- Allergic or hypersensitivity effects.
- Irritation of mucous membranes.

According to NPI, recent health research in relation to dust particles of size PM_{10} or less suggests there is no threshold at which health effects do not occur.

Dust generated from the crushing of rock that contains a lot of quartz may generate silica dust. Long term inhalation of silica dust may lead to the formation of scar tissue in the lungs and can result in silicosis, a serious lung disease. It appears that silicosis is solely a work place issue. A recent Australian Government Senate Committee (2005) report identified that there are no reports in the international literature of individuals developing silicosis as a result of exposure to non-occupational levels (i.e. levels outside the work place) of silica dust, and an expert appearing before the committee confirmed the potential for such an occurrence as being very remote. A United States Environment Protection Authority study (1996), which specifically addressed this issue, also supports this view.

MONITORING DUST

Monitoring by the Department of Environment and Conservation

DEC undertakes air quality monitoring of ambient level pollutants at about 30 monitoring sites within the greater metropolitan area of Sydney, the Illawarra, the Lower Hunter, and selected rural sites around NSW. Various air quality parameters are measured at the sites. Some sites (including three in the Lower Hunter and four in the Illawarra) measure PM_{10} levels. The previous day's monitoring results are provided daily on the DEC website, with PM_{10} being reported as a 24-hour average: <www.epa.nsw.gov.au/air/airdata.htm>

DEC has recently issued a compliance performance report for the coal mines industry sector (DEC 2004), which reported on audits of 16 DEC licensed coal mines in NSW: <www.epa.nsw.gov.au/licensing/complianceaudit.htm>

Main methods for monitoring dust

The main methods for monitoring dust levels are:

- **Dust deposition gauges**: This method measures dust deposition rate and involves the passive deposition and capture of dust within a funnel and bottle arrangement. Data is usually collected over monthly periods and results are expressed in g/m^2/month (ie. the mass of dust deposited per m^2 per month).

  This method enables determination of the relative 'dustiness' of sampling locations. It does not provide data on dust concentrations or enable determination of dust levels from a particular event or source. It does not give an indication of the potential health effects of the dust because it does not measure the amount of fine and very fine particles in the atmosphere.

- **High volume samplers**: This method determines average dust concentrations and comprises the collection of dust by drawing a constant flow rate of ambient air through a filter. Data is usually collected over a 24 hour period and results are expressed in g/m^3/24hr (ie. mass of dust per volume of air per 24 hrs). A selective inlet may be fitted to a high volume sampler to restrict the particle size being sampled (for example, to ensure only PM_{10} particles are sampled).

  When coupled with a wind direction vane or matched with records of wind data, this method enables determination of dust levels from a particular event or source. It also gives an indication of the potential health effects of the dust because it allows measurement of fine and very fine particles in the atmosphere.

- **Continuous particle monitors**: This method determines real-time (continuous) dust concentrations. A number of monitors are available including TEOM and Beta gauges. A selective inlet may be fitted to a particle monitor to restrict the particle size being sampled (for example, to ensure only PM_{10} particles are sampled).

This method enables determination of short term dust events. As for high volume samplers, when matched with records of wind data, this method enables determination of dust levels from a particular event or source. It also gives an indication of the potential health effects of the dust.

MONITORING DUST DEPOSITION RATES USING AS/NZS 3580

The most simple and cost effective method for undertaking your own dust monitoring is to monitor dust deposition rates using a dust deposition gauge. This method is set out in 'Australian/New Zealand Standard: Methods for sampling and analysis of ambient air: Method 10.1: Determination of particulate matter – deposited matter – gravimetric method (AS/NZS 3580).

It is vitally important that dust monitoring is undertaken exactly in accordance with relevant Australian/New Zealand Standards, as these are used to ensure that activities are undertaken in consistent and correct ways. If this is not done, then monitoring results may not be accurate and it is easy for results to be disregarded.

Downloadable copies of Australian/New Zealand Standards, including AS/NZS 3580, are available from SAI Global at a cost: ph - 1300 65 46 46; website: <www.standards.com.au/catalogue/script/search.asp>

Relevant dust criteria

The Department of Environment and Conservation (DEC) sets the criteria for dust deposition rate as follows:

Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Annual	2g/m2/month	4g/m2/month

Source: DEC (2005) 'Approved Methods & Guidance for the Modelling and Assessment of Air Pollutants in NSW'.

The following points apply to the criteria:

- The criteria refer to total insoluble matter, and not total solids. This is the matter that does not dissolve in water, and is determined in a laboratory.
- The $2g/m^2$/month criteria is used when baseline data on deposited dust levels exists, while the $4g/m^2$/month criteria is used when no baseline data exists.
- The criteria refer to all sources of deposited matter (including sources from mines, agriculture, unsealed roads, etc) and cumulative impacts.
- The criteria mean that a mine may be allowed to add a certain amount of dust to the atmosphere. A mine may increase deposited dust levels by up to $2g/m^2$/month. However, the total deposited dust level (including sources from mines, agriculture, unsealed roads, etc) must not exceed $4g/m^2$/month.
- A dust deposition rate of $4g/m^2$/month equates to a visible layer of dust on outdoor furniture or on a clean car deposited each month.

How to collect a dust sample

What equipment should be used and how?

AS/NZS 3580 identifies the equipment to use in collecting a dust sample and how to use it.

The key equipment is:

- A deposit gauge, which comprises a 150 ± 10mm diameter funnel inserted into a glass bottle (at least 4 liters in size) through a rubber stopper (see Figure 2).
- A stand approximately 2m tall and a canister which holds the glass bottle to protect it from sunlight (see Figure 3).
- A tight fitting lid to seal the glass bottle for transport to the laboratory.

The key methods for using the equipment are:

- The bottle should be cleaned prior to use and rinsed with 10mL of copper sulfate solution to prevent algal growth.
- Set up the deposit gauge and stand so that the height of the top of the funnel is 2m ± 0.2m above the ground level of the immediate surrounding area.
- The glass bottle may also collect rainwater and other material such as bugs and leaf litter, etc. This does not contaminate the sample and should not be removed in the field. However, it is recommended that the type of any contamination be noted for each sample on a piece of paper at the time of collection (for example, note the presence of bird droppings, leaf litter, sticks, spider webs, Christmas beetles, etc or whether the bottle was broken). This record may help explain unusual results (such as high insoluble matter) during laboratory analysis.
- After 30 days ± 2 days, wash any deposited matter in the funnel into the glass bottle using distilled water.
- Remove the funnel and seal the glass bottle with a lid.
- Identify the glass bottle with a label showing site location, the date sampling began and ended, and the funnel diameter to the nearest millimetre.
- Insert a clean funnel into a fresh glass bottle containing 10mL of copper sulfate solution.

What is the cost of the equipment and where can it be obtained?

The equipment required is affordable. The total cost would depend on whether all the equipment is bought from retail outlets or whether some of it was 'home-made'.

- The funnel must be bought from a laboratory (for example, from where the samples are taken to be analyzed) to ensure its size is accurate.
- Glass bottles may be obtained from a laboratory (and may be included in the cost of the analysis).

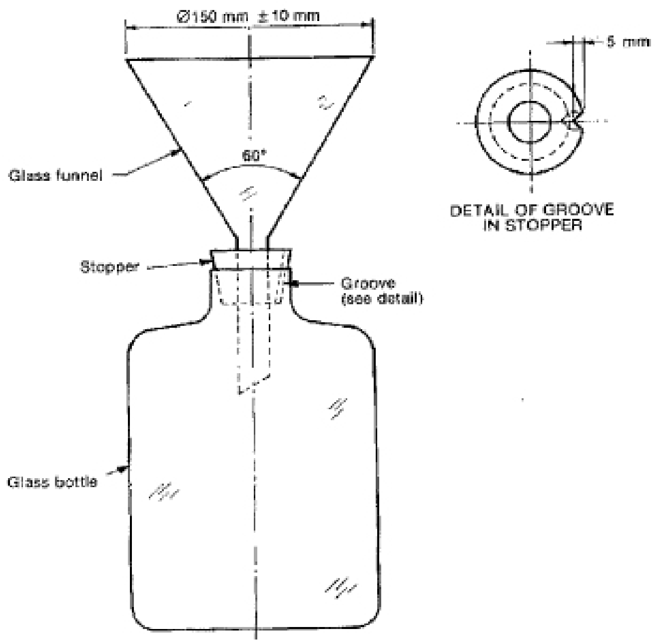

Figure 2: Typical dust deposit gauge

Source: 'Australian/New Zealand Standard: Methods for sampling and analysis of ambient air: Method 10.1: Determination of particulate matter – deposited matter – gravimetric method (AS/NZS 3580).

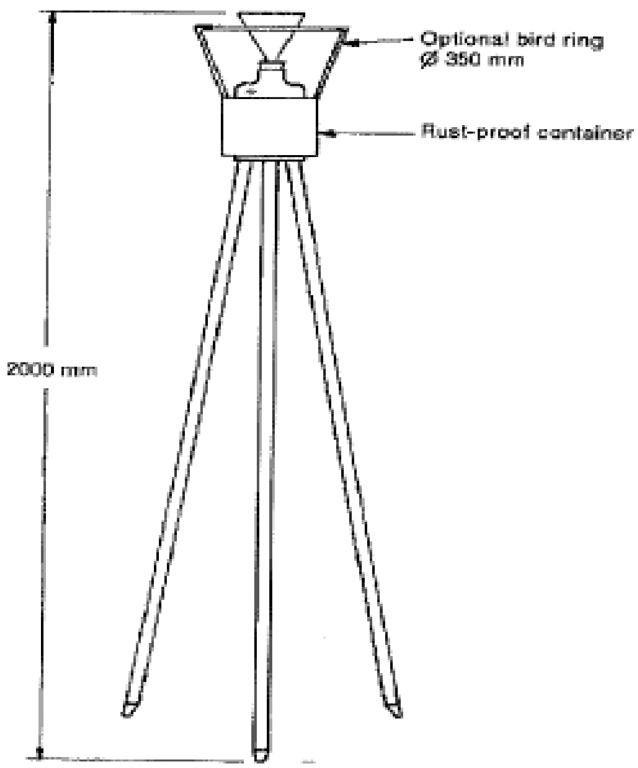

Figure 3: Typical stand with deposit gauge

Source: 'Australian/New Zealand Standard: Methods for sampling and analysis of ambient air: Method 10.1: Determination of particulate matter – deposited matter – gravimetric method (AS/NZS 3580).

- A tripod may be purchased or a fence post may be used as long as it allows the funnel to be horizontal and the height of the top of the funnel to be 2m ± 0.2m above the surrounding ground level.

- The canister can be made of anything as long as it protects the glass bottle from sunlight

- For example, a tin container may be used as a canister, which can be bolted to a fence post.

Within the Hunter region, funnels and bottles may be purchased from Australian Scientific Pty Ltd, 11 McDougall St, Kotara (ph: 02 4956 2299) or ALS Environmental Newcastle (ph: 02 4968 9433; website: <www.alsglobal.com>).

How often should samples be collected?

Samples must be collected every 30 days ± 2 days.

Sampling at each site should be undertaken for a minimum of 3 months, but preferably longer.

AS/NZS 3580 recommends that gauges be changed on or as near to the first day of each month.

At what locations should samples be collected and how much sampling should be undertaken?

Dust gauges should be located at sensitive receivers. DEC defines a sensitive receiver as "a location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area".

If the concern is dust generated from mining, then dust gauges should be located at sensitive receivers near a mine in order to gain a better indication of the contribution of the mine to dust levels. If dust gauges are located across a wider area, it will be more difficult to determine whether the measured dust levels are due to mining or other sources such as agriculture, unsealed roads, etc.

Dust gauges should be located in consideration of surrounding land uses. They should not be located in 'dusty' locations (except where that dust is likely to be generated from mining). For example, dust gauges should not be located on or near bare paddocks or where earth moving or sowing or harvesting is occurring, near landfills, near construction sites, near unsealed roads, etc.

At any particular site, the dust gauge must be located in accordance with the standard AS 2922 - 1987 'Ambient Air - Guide for the Siting of Sample Units'. This provides that the gauge must be located in a clear area (with a clear sky angle of 120 degrees), away from trees, buildings, etc.

The number of dust gauges to be employed depends on the number of sensitive receivers affected. For example, if there are 20 sensitive receivers surrounding a mine, at least 5 dust samples would be required to ensure an adequately representative sample is obtained.

How to analyze dust samples

Samples should be taken to a laboratory and analyzed as soon as possible within 30 days of collection. Prior to taking to a laboratory, the sample should be kept in a cool dark environment to prevent the growth of algae.

Where can samples be taken to be analyzed?

Within the Hunter region, samples may be taken to ALS Environmental Newcastle (ph: 02 4968 9433; website: <www.alsglobal.com>).

What is the cost of analysis per sample?

Analysis costs about $40 per sample, depending on what analysis is undertaken. This cost may include the glass bottle.

What information should be provided to the laboratory?

The following information should be provided to the laboratory:

- Location of samples, including coordinate reference on a topographic map to within 100m.
- Height of the sampling above the surrounding ground level.
- The classification of the area where samples were taken from (for example, industrial, residential, agricultural or urban).
- The date sampling started and finished.
- Any other relevant data (for example, climate conditions, proximity of bushfires, farm ploughing activities, traffic on unsealed roads).

What should the laboratory analyze?

The following should be requested to be analyzed at the laboratory:

- Insoluble solids: this is the matter that does not dissolve in water.
- Ash content: this is the matter that remains after the sample has been combusted in the laboratory.

Ash content provides an indication of the mineral content (or soil dust) of the sample. The mineral content may be attributable to mining, but may also be attributable to other sources such as agriculture, unsealed roads, etc. The material making up the insoluble solids that has been combusted will not be attributable to mining or other sources because this is mostly organic matter.

How to interpret the results of the analysis?

What do the results mean?

Example of analysis results:

Analysis	**Units**	**Location 1**	**Location 2**
Ash content	g/m2/month	2.0	0.5
Total insoluble matter	g/m2/month	2.6	3.2

Location 1: The results indicate that most of the total insoluble matter is mineral content (soil dust) because a large proportion of the insoluble matter is not combustible. This mineral content may be attributable to mining, but may also be attributable to other sources such as agriculture, unsealed roads, etc.

Location 2: The results indicate that only a small proportion of the total insoluble matter is mineral content (soil dust) because a large proportion of the insoluble matter is combustible. Therefore the insoluble matter is mostly organic matter, which is not attributable to mining.

How to report on the results of the analysis?

If the results of the laboratory analysis consistently indicate that dust deposition rates are exceeding the relevant criteria and that most of the total insoluble matter in the samples is mineral content (soil dust) (indicating that mining may be contributing significantly to dust levels, providing that dust gauges were located appropriately), then you may wish to report this finding to DEC. This is best done by letter. Prior to writing to DEC, it is best to gather data for a period of at least 3 months, so that DEC can see that criteria are consistently being exceeded.

A letter to DEC should include:

- the results of the laboratory reports
- the location of samples, including coordinate reference on a topographic map and the proximity of the samples to mines
- the classification of the area where samples were taken from (for example, industrial, residential, agricultural or urban)
- any other relevant data (for example, climate conditions, proximity of bushfires, farm ploughing activities, traffic on unsealed roads).

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Prepared by Tom Holden, EDO Scientific Advisor (January 2006).